# UPDATE OF INITIAL ASSESSMENT OF THE ENVIRONMENTAL STATUS OF MARINE WATERS

**List of abbreviations for the terms used in the update of the initial assessment of the environmental status of sea water:**

| Abbreviation | Explanation |
|---|---|
| AIS | Automatic Identification System - the AIS system is installed in accordance with the requirements of the SOLAS convention on larger vessels, on all passenger ships, and also voluntarily on many smaller ships and yachts |
| BAU | Business as Usual - "Hypothetical development of the situation if the programme of measures (POM) proposed under KPOWM has not been adopted and implemented" |
| BCT | Baltic Container Terminal |
| BIAS | Baltic Sea Information on the Acoustic Soundscape |
| BSAP | Baltic Sea Action Plan |
| BSII | Baltic Sea Impact Index |
| BSPI | Baltic Sea Pressure Index |
| $BZT_5$ | Biochemical Oxygen Demand - a conventional biological indicator oxygen demand, i.e. the amount of oxygen required to oxidize organic compounds by microorganisms (aerobic bacteria). This value is obtained in the result of measuring oxygen consumption by the tested sample of water or sewage within 5 days.<br>$BZT_5$ is an indicator of the purity of water and the quality of treated wastewater |
| CN | Combined Commodity Tradename nomenclature |
| DCT | Deepwater Container Terminal - Container terminal located at the sea port of Gdańsk |
| DWT | Load capacity - the weight that the ship can take while immersing itself into the summer load line in sea water |
| EKG ONZ | United Nations Economic Commission for Europe |
| EMEP | European Monitoring Environmental Programme - a monitoring program developed by the UN Economic Commission for Europe in cooperation with the World Meteorological Organization (WMO), aimed at obtaining information on the participation of individual states in environmental pollution of other countries, including to control the implementation of international arrangements and agreements on a strategy to reduce pollution in Europe |
| ETO | European Court of Auditors |
| EU ETS | European Union Emissions Trading System - EU Emissions Trading System |
| GES | Good Environmental Status |
| GIOŚ | Chief Inspectorate for Environmental Protection |
| GIS | Chief Sanitary Inspector |
| GT | Gross ship capacity - in accordance with the International Convention on Measurement capacity of vessels from 1969 is a measure of the total capacity of closed spaces inside the hull and superstructures |
| GTK | Deepwater Container Terminal Gdańsk |
| GUS | Statistics Poland |
| HELCOM | Baltic Marine Environment Protection Commission, also known as the Helsinki Commission or HELCOM - an international organization proclaimed by the so-called the Helsinki Convention of 1974 as its executive body |
| HOLAS | Holistic Assessment of the State of the Baltic Sea Environment |
| IMGW-PIB | Institute of Meteorology and Water Management - National Research Institute |

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|---|---|
| IOŚ-PIB | Institute of Environment Protection - National Research Institute |
| WB | waterbody |
| EU | European Commission |
| KOBIZE | National Centre for Emissions Management |
| KPOŚK | National municipal wastewater treatment program |
| KPOWM | The National Marine Water Protection Program adopted by the Council of Ministers on 2nd December 2016 |
| CLRTAP | Convention on Long-range Transboundary Air Pollution |
| MGMiŻŚ | Ministry of Marine Economy and Inland Navigation |
| NACE | statistical classification of economic activities in the European Union |
| NMLZO | non-methane volatile organic compounds |
| NPK | NPK fertilizers - multi-component mineral fertilizers containing nitrogen (N), phosphorus (P) and potassium (K) in the form absorbed by plants |
| NT | ship's net tonnage |
| PKB | Gross domestic product |
| PKBWM | State Marine Accident Investigation Commission |
| PKD | Polish Classification of Business Activities |
| PLC | Pollution Load Compilation - compilation of pollution load |
| PM | particulate matter |
| PMŚ | State Environmental Monitoring |
| PO RYBY 2014-2020 | Operational Programme Fisheries and the Sea |
| POM | Polish Marine Areas |
| PPP | Purchasing power parity |
| MSFD | Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive) (OJ L 164 of 25.06.2008, p. 19, as amended), also referred to as the "Marine Strategy Framework Directive " |
| WFD | Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (OJ L 327, 22.12.2000, p. 1, as amended - Official Journal of the EU, Polish special edition, chapter 15, vol. 5 , p. 275,), referred to as the "Water Framework Directive" |
| RLM | Equivalent number of inhabitants - a number expressing a multiple of the pollution load in sewage discharged from industrial and service facilities in relation to the unit load of pollutants in household sewage, discharged from one inhabitant within 24 hours |
| SMIOUG | Marine Station of the Institute of Oceanography of the University of Gdańsk |
| subGES | sub Good Environmental Status |
| SUZPPOM | Study of conditions for spatial development of the Polish Marine Areas |
| TAC | Total Allowable Catch |
| TEU | twenty-feet equivalent unit - standard unit, corresponding to the capacity of a 20-foot ISO container |
| TZO | Persistent Organic Pollutants |
| EU | European Union |
| WTP | Willingness to pay |
| WWF | World Wide Fund for Nature - international and non-governmental organization was established in 1961 |
| ZMPG S.A. | Port of Gdańsk Authority SA |
| ZMPG-a S.A. | Port of Gdynia Authority SA |
| ZMPSiŚ S.A. | Port of Szczecin and Świnoujście Authority SA |

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# UPDATE OF INITIAL ASSESSMENT OF THE ENVIRONMENTAL STATUS OF MARINE WATERS IN 2011-2016

## Introduction

The Baltic Sea plays an important role in the national economy and determines the existence of sectors such as maritime transport, fishing, regional tourism and is a potential area for the development of wind energy. The threat to the state of the marine environment can limit the development of the above mentioned sectors, which at the same time may significantly contribute to its degradation.

Continued efforts to improve and maintain the good environmental status of the Baltic Sea are not only a formal requirement, but also a goal for sustainable use of resources of the marine ecosystem by humans. The formal framework for achieving this objective is defined by MSFD, which refers to the sustainable use of seas integrated with the conservation of marine ecosystems in the least changed state. MSFD has been amended by Commission Directive (EU) 2017/845 of 17 May 2017 amending Directive 2008/56 / EC of the European Parliament and of the Council with reference to exemplary lists of elements taken into account in the development of marine strategies (Official Journal of the EU L 125 of 18/05/2017, page 27), hereinafter referred to as "Directive 2017/845", which gave the new wording of Annex III to MSFD. In accordance with MSFD, it is required to achieve good environmental status (GES) within European marine waters by 2020. The executive act for MSFD is Commission Decision (EU) 2017/848 of 17 May 2017 establishing criteria and methodological standards for good environmental status of marine waters as well as specifications and standardized monitoring and assessment methods, and repealing Decision 2010/477 / EU (OJ L 125, 18/05/2017, p. 43), hereinafter referred to as "Decision 2017/848".

The good environmental status of the marine environment according to MSFD means " the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations".

Achieving good environmental status of marine waters will be possible thanks to the development and implementation of the marine strategy, which is a set of typical environmental protection measures aimed at protecting the marine environment, which consists of the following elements:

1) preparation of an initial assessment of the environmental status of marine waters,
2) development of a set of characteristics for good environmental status of marine waters,
3) development of a set of environmental targets and associated indicators for marine waters,
4) development and implementation of the monitoring programmes for marine waters,
5) development and implementation of the programmes of measures.

The development of MSFD was the result of many years of EU efforts to create a legal framework that allows comprehensive, consistent and effective measures to be taken to protect the marine environment. MSFD's goals should be achieved through the development and implementation of marine strategies that are coherent for individual marine regions or sub-regions. Each EU Member State, in accordance with the schedule in MSFD, is required to develop a maritime strategy for its own marine waters, bearing in mind that sea waters are used jointly with other countries, and the marine environment is transboundary. Therefore, each EU Member State should carry out its activities in cooperation with other Member States of a given marine region or sub-region, and in some cases also with third countries. In the Baltic Sea area regional cooperation took place within the framework of HELCOM, establishing the division of the Baltic Sea into sub-basins subject to assessment and agreeing threshold values of good environmental status. These arrangements concerned, in particular, biological elements, biogenic pollutants and hazardous substances, and the joint development of a second holistic assessment of the state of the Baltic Sea environment.

One of the most important tasks of the EU Member States is the obligation to periodically update the assessment of their marine waters in accordance with Art. 17 MSFD. This requires that in 2018 an update of the initial assessment of the environmental state prepared in 2012 in accordance with Art. 8 (1) of MSFD, updating the assessment of human pressures (Article 8 (1) (b) of MSFD) and the economic and social analyses of the use of marine waters (Article 8 (1) (c) of the MSFD), taking into account Art. 1 (3) of MSFD relating to the ecosystem approach to environmental management.

In 2014, in accordance with art. 11 MSFD GIOŚ developed a marine water monitoring programme, the implementation of which enabled obtaining data on the state of the marine environment within the PMŚ to update the initial assessment of the marine environment and to prepare current assessments of the state of the marine environment.

The current update of the initial assessment of the environmental status of marine waters covers the period from January 1, 2011 to December 31, 2016. The implementation of this task enable to update the set of environmental targets in accordance with Art. 10 MSFD, the establishment of updated monitoring programmes in accordance with art. 11 MSFD and designing future activities in accordance with art. 13 MSFD, which should minimize the negative impact of anthropogenic impact on the marine environment.

The legal basis for the update of the initial assessment of the environmental status of marine waters is art. 555 sec. 2 point 8 of the Act of 20 July 2017 - Water Law (Journal of Laws item 1566, as amended), hereinafter referred to as the "Water Law Act".

According to art. 151 sec. 1 of the Water Law Act, an updated assessment of the environmental status of marine waters is prepared by the competent authority of the Environmental Protection Inspection in consultation with the minister competent for construction, spatial planning and housing, minister competent for maritime affairs, minister competent for fisheries and minister responsible for water management.

The obligation to update the assessment of the environmental status of marine waters concerns marine areas that cover the sea area from the baseline of the territorial sea to the border of the furthest area under the jurisdiction of an EU Member State as defined in MSFD. In Poland, these areas include waters of the territorial sea, the exclusive economic zone and coastal waters in accordance with art. 143 of the Water Law Act.

In the case of coastal, transitional and territorial waters, ecological status assessments in accordance with the WFD were used to update the initial assessment of the environmental status of marine waters. Pursuant to Directive 2017/845, Tables 1 and 2 in Annex III to MSFD have been clarified to refer to status elements (Table 1) and to elements related to pressures and their impacts (Table 2a and 2b), as well the elements listed in both tables with the quality indicators specified in MSFD Annex I, and therefore also with the criteria defined by the EC on the basis of MSFD art. 9 sec. 3.

The update of the initial assessment will be carried out in accordance with the adopted division into the assessment of marine ecosystems, their structure, functions and processes of particular importance for updating the assessment in accordance with art. 8 (1)(a) of MSFD, taking into account anthropogenic pressures, ways of use and human activity in the marine environment or having an impact on the marine environment, which refers to art. 8 (1)(b) (c) of MSFD.

One of the mandatory elements of updating the initial assessment of the status of the marine environment is to determine the environmental status in relation to a set of threshold values for individual criteria set at European, regional or national level.

Decision 2017/848 introduced a division of indicators that should be included in the assessment of the state of the marine environment into two groups. Article 153 (1) (1) of the Water Law Act defines all 11 descriptors of good environmental status of marine waters (Figure 1). Pursuant to Decision 2017/848, the group of pressure descriptors includes: D2, D3, D5, D6, D7, D8, D9, D10 and D11, the group of Descriptors of the status include: D1, D4 and D6 concerning elements of the ecosystem: mammals, fish, birds, pelagic habitats and benthic habitats. In the document of the initial assessment of the status of the marine environment, the naming of symbols for descriptors and criteria has been preserved following the English version of MSFD, i.e. D - for the descriptor, C - for the criterion.


Fig. 1 Scheme of the assessment of the state of the Baltic marine environment (based on decision 2017/848)

For each descriptor, the criteria for the assessment update have been determined. An important change compared to the previous decision 2010/477/EU is the introduced division of criteria into primary and secondary criteria, of which the first ones regarding the most important pressures and impacts are required in all EU Member States. Possible removal of individual criteria requires submitting a justification to the Commission under the notification prepared in accordance with Article 9 (2) or art. 17 (3) MSFD.

The secondary criteria and associated methodological standards, specifications and harmonized methods set out in the Annex are used to supplement the primary ones or, when there is a risk that the marine environment will not achieve, or will not maintain good environmental status for the criterion. The application of the secondary criterion is decided on by any EU Member States, unless otherwise specified in the Annex. Therefore, the resignation from a given secondary criterion should be preceded by an assessment of the risk of failure to achieve good environmental status for this criterion or primary criteria.

Indicators related to specific parameters and properties describing the status of the environment and pressures have been developed for individual criteria.

Implementing the requirement of coordinated actions as part of updating the initial assessment of the status of the marine environment, Poland has an obligation to cooperate within the Baltic Sea region to carry out the holistic assessment of the environmental status of marine waters. The first version of the second holistic assessment (HOLAS II) was published in June 2017 and covered the years 2011-2015 (HELCOM 2017a). Its update to the whole assessment period (2011-2016) was carried out in spring 2018. Holistic assessments support the reporting by EU Member States as part of their obligation to update the initial assessment of the environmental status of marine waters for the EC, in particularly regarding the applied indicators and assessment methods, which have undergone significant changes during the preparation of the second holistic assessment, compared to the previous assessment, also due to changes in the applicable EU law. For the purpose of a uniform approach to the initial assessment of the environmental status of marine waters, HELCOM adopted a modified division of the Baltic Sea into subregions, i.e. Marine Reporting Units (MRUs) subject to assessment.

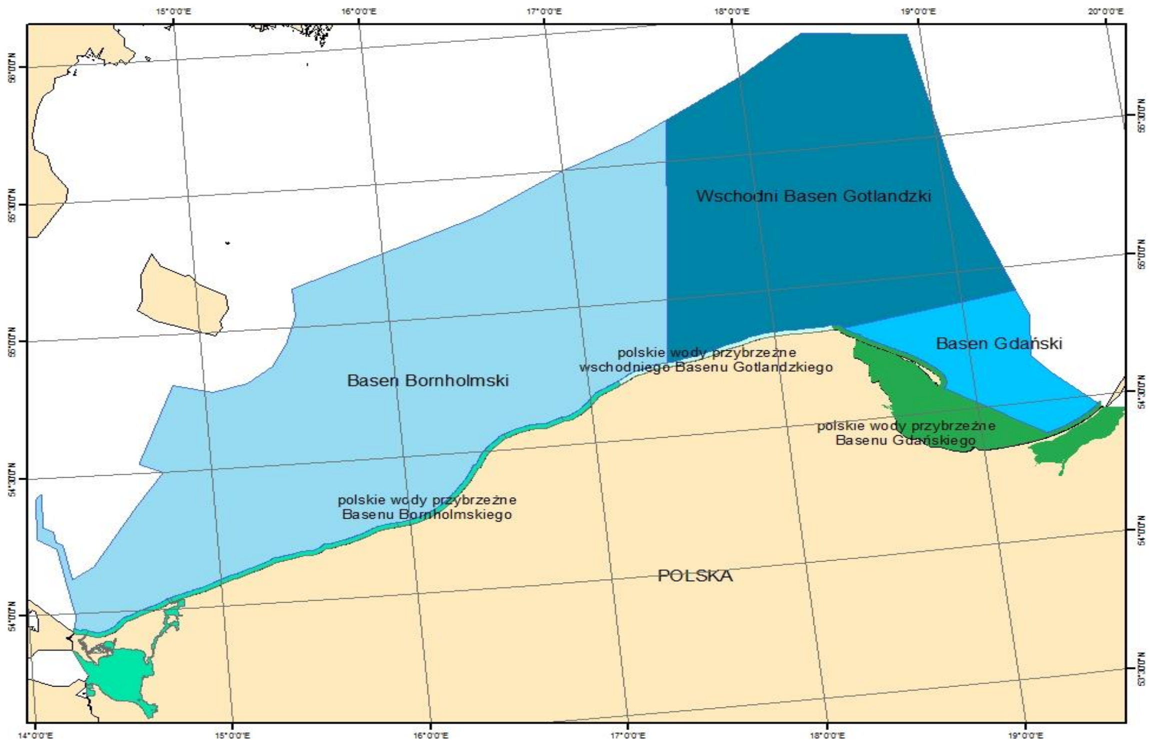



Fig. 2. Baltic Sea sub-basins designated in POM according to HELCOM MAS (HELCOM 2013)

In the case of selected indicators and descriptors, the areas to be assessed include both parts of the open sea sub-basins as well as coastal water bodies. For example, the assessment of ichthyofauna in the areas of the Baltic Sea in sub-areas (see Fig. 2.1.62) adopted by the International Council for the Exploration of the Sea (ICES) is substantiated. It is associated with the stock's living areas, which are assessed.

The update of the initial assessment of the environmental status of marine waters includes three aspects:

1) analysis of basic features and properties as well as the current status of the environment;

2) analysis of dominant pressures and impacts;

3) economic and social analysis and the analysis of costs of environmental degradation.

Points 1 and 2 relate to the classification of the marine environment and are determined in two classes: good status (GES) and sub-good status (subGES), while point 3 explains the interactions between elements of the environment and society in terms of both business and broadly understood social security.

**Indicators used in the update of the initial assessment of the environmental status of marine waters**

| No. | | Indicators to assess criteria | Descriptors of the state | | | Descriptors of pressures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | D1 | D4 | D6 | D2 | D3 | D5 | D6 | D7 | D8 | D9 | D10 | D11 |
| **Ecosystem components** | | | | | | | | | | | | | | |
| 1 | Mammals | By-catch of marine mammals | x | | | | | | | | | | | |
| 2 | | The population size and trend of abundance of the grey seal | x | x | | | | | | | | | | |
| 3 | | Reproduction status of the grey seal | x | x | | | | | | | | | | |
| 4 | | Distribution of the grey seal | x | x | | | | | | | | | | |
| 5 | Birds | White-tailed eagle productivity indicator | x | x | | | | | | | x | | | |
| 6 | | Abundance of waterbirds in the wintering season | x | x | | | | | | | | | | |
| 7 | | Abundance of waterbirds in the breeding season | x | x | | | | | | | | | | |
| 8 | Fish | Large Fish Index - LFI1 | x | x | | | | | | | | | | |
| 9 | | Index of the state of ichthyofauna SI in transitional waters | x | | | | | | | | | | | |
| 10 | Benthic habitats | B – multimetric macrozoobenthos index | x | x | x | | | x | | | | | | |
| 11 | | Macrophyte status index - $SM_1$ | x | | x | | | x | | | | | | |
| 12 | | Index of ecological status of macrophytes in lagoons – ESMIz | x | | x | | | x | | | | | | |
| 13 | Pelagic habitats | MSTS index - zooplankton mean size and total stock | x | x | | | | | | | | | | |
| 14 | | Dia/Dino – Diatom/Dinoflagellate index | x | x | | | | | | | | | | |
| 15 | | Cyanobacterial bloom index - CyaBl | x | | | | | x | | | | | | |
| 16 | | Chlorophyll-a - average summer concentration (VI-IX) | x | | | | | x | | | | | | |
| 17 | | Chlorophyll-a - average annual concentration | x | | | | | x | | | | | | |
| **Pressures** | | | | | | | | | | | | | | |
| 18 | | Trends in arrival of non-indigenous species | | | | x | | | | | | | | |
| 19 | | Fishing mortality index of commercially exploited species | | | | | x | | | | | | | |
| 20 | | Biomass indicators of commercially exploited species | | | | | x | | | | | | | |
| 21 | | DIN - average winter concentration (XII-II) | | | | | | x | | | | | | |
| 22 | | DIN - average annual concentration | | | | | | x | | | | | | |
| 23 | | TN - average concentration in summer (VI-IX) | | | | | | x | | | | | | |
| 24 | | TN - average annual concentration | | | | | | x | | | | | | |
| 25 | | DIP - average winter concentration (XII-II) | | | | | | x | | | | | | |
| 26 | | DIP - average annual concentration | | | | | | x | | | | | | |
| 27 | | TP - average concentration in summer (VI-IX) | | | | | | x | | | | | | |
| 28 | | TP - average annual concentration | | | | | | x | | | | | | |
| 29 | | Water transparency - summer (VI-IX) | | | | | | x | | | | | | |
| 30 | | Water transparency - annual average | | | | | | x | | | | | | |
| 31 | | Oxygen near bottom - minimum in summer (VI-IX) | | | | | | x | | | | | | |
| 32 | | Oxygen debt | | | | | | x | | | | | | |

| No. | | Indicators to assess criteria | Descriptors of the state | | | Descriptors of pressures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | D1 | D4 | D6 | D2 | D3 | D5 | D6 | D7 | D8 | D9 | D10 | D11 |
| 33 | | Spatial extent and distribution of physical loss of the natural seabed | | | | | | | x | | | | | |
| 34 | | Spatial extent and distribution of physical disturbance pressures on the seabed | | | | | | | x | | | | | |
| 35 | | The surface of the seabed affected by permanent hydromorphological changes | | | | | | | | x | | | | |
| 36 | | Formaldehyde - water | | | | | | | | | x | | | |
| 37 | | Arsenic – water | | | | | | | | | x | | | |
| 38 | | Barium – water | | | | | | | | | x | | | |
| 39 | | Boron – water | | | | | | | | | x | | | |
| 40 | | Chromium 6+ - water | | | | | | | | | x | | | |
| 41 | | Chromium - water | | | | | | | | | x | | | |
| 42 | | Zinc - water | | | | | | | | | x | | | |
| 43 | | Cooper - water | | | | | | | | | x | | | |
| 44 | | Phenol index - water | | | | | | | | | x | | | |
| 45 | | Oil index - water | | | | | | | | | x | | | |
| 46 | | Aluminium - water | | | | | | | | | x | | | |
| 47 | | Free cyanides - water | | | | | | | | | x | | | |
| 48 | | Metal cyanide complexes - water | | | | | | | | | x | | | |
| 49 | | Molybdenum - water | | | | | | | | | x | | | |
| 50 | | Selenium - water | | | | | | | | | x | | | |
| 51 | | Silver - water | | | | | | | | | x | | | |
| 52 | | Thallium - water | | | | | | | | | x | | | |
| 53 | | Titanium - water | | | | | | | | | x | | | |
| 54 | | Vanadium - water | | | | | | | | | x | | | |
| 55 | | Antimony - water | | | | | | | | | x | | | |
| 56 | | Fluoride - water | | | | | | | | | x | | | |
| 57 | | Beryllium - water | | | | | | | | | x | | | |
| 58 | | Cobalt - water | | | | | | | | | x | | | |
| 59 | | Alachlor - water | | | | | | | | | x | | | |
| 60 | | Anthracene - water | | | | | | | | | x | | | |
| 61 | | Atrazine - water | | | | | | | | | x | | | |
| 62 | | Benzene - water | | | | | | | | | x | | | |
| 63 | | Brominated diphenylethers (ΣPBDE – congeners 28, 47, 99, 100, 153, 154) – water, biota | | | | | | | | | x | x | | |
| 64 | | Cadmium and its compounds – water, biota, sediment | | | | | | | | | x | x | | |
| 65 | | C10-13 Chloroalkanes - water | | | | | | | | | x | | | |
| 66 | | Chlorfenvinphos - water | | | | | | | | | x | | | |
| 67 | | Chlorpyrifos - water | | | | | | | | | x | | | |
| 68 | | 1,2-Dichloroethane (EDC) - water | | | | | | | | | x | | | |
| 69 | | Dichloromethane - water | | | | | | | | | x | | | |

| No. | | Indicators to assess criteria | Descriptors of the state | | | Descriptors of pressures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | D1 | D4 | D6 | D2 | D3 | D5 | D6 | D7 | D8 | D9 | D10 | D11 |
| 70 | | Di (2-ethylhexyl) phthalate (DEHP) - water | | | | | | | | | x | | | |
| 71 | | Diuron - water | | | | | | | | | x | | | |
| 72 | | Endosulfan - water | | | | | | | | | x | | | |
| 73 | | Fluoranthene - water, biota, sediment | | | | | | | | | x | | | |
| 74 | | Hexachlorobenzene (HCB) – water, biota | | | | | | | | | x | | | |
| 75 | | Hexachlorobutadiene (HCBD) – water, biota | | | | | | | | | x | | | |
| 76 | | Hexachlorocyclohexsane (HCH) - water | | | | | | | | | x | | | |
| 77 | | Isoproturon - water | | | | | | | | | x | | | |
| 78 | | Lead and its compounds – water, biota, sediment | | | | | | | | | x | x | | |
| 79 | | Mercury and its compounds – water, biota, sediment | | | | | | | | | x | x | | |
| 80 | | Naphthalene - water | | | | | | | | | x | | | |
| 81 | | Nickel and its compounds - water | | | | | | | | | x | | | |
| 82 | | Nonylphenols - water | | | | | | | | | x | | | |
| 83 | | Octylphenols - water | | | | | | | | | x | | | |
| 84 | | Pentachlorobenzene - water | | | | | | | | | x | | | |
| 85 | | Pentachlorophenol (PCP) - water | | | | | | | | | x | | | |
| 86 | | Benzo(a)pyrene – water, biota | | | | | | | | | x | | | |
| 87 | | Benzo(b)fluoranthene - water | | | | | | | | | x | | | |
| 88 | | Benzo(k)fluoranthene - water | | | | | | | | | x | | | |
| 89 | | Benzo(g,h,i)perylene – water, sediment | | | | | | | | | x | | | |
| 90 | | Indeno(1,2,3-cd)piren - sediment | | | | | | | | | x | | | |
| 91 | | Simazine - water | | | | | | | | | x | | | |
| 92 | | Tributyltin compounds – water, biota | | | | | | | | | x | x | | |
| 93 | | Trichlorobenzenes (TCB) - water | | | | | | | | | x | | | |
| 94 | | Trichloromethane (chloroform) - water | | | | | | | | | x | | | |
| 95 | | Trifluralin - water | | | | | | | | | x | | | |
| 96 | | Dicofol – water, biota | | | | | | | | | x | | | |
| 97 | | Perfluorooctane sulfonic acid and its derivatives (PFOS) – biota | | | | | | | | | x | x | | |
| 98 | | Dioxins and dioxin-like compounds - biota | | | | | | | | | x | | | |
| 99 | | Hexabromocyclododecane (HBCDD)- biota | | | | | | | | | x | x | | |
| 100 | | Heptachlor and heptachlor epoxide - biota | | | | | | | | | x | | | |
| 101 | | Tetrachloromethane - water | | | | | | | | | x | | | |
| 102 | | SUM Aldrin , Dieldrin , Endrin, Isodrin- water | | | | | | | | | x | | | |
| 103 | | Para-para-DDT - water | | | | | | | | | x | | | |
| 104 | | DDT total - water | | | | | | | | | x | | | |
| 105 | | Trichloroethylene (TRI) - water | | | | | | | | | x | | | |
| 106 | | Tetrachloroethylene (PER) - water | | | | | | | | | x | | | |

| No. | | Indicators to assess criteria | Descriptors of the state | | | Descriptors of pressures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | D1 | D4 | D6 | D2 | D3 | D5 | D6 | D7 | D8 | D9 | D10 | D11 |
| 107 | | Cesium-137 – water, biota | | | | | | | | | x | | | |
| 108 | | 1-hydroxypyrene - biota | | | | | | | | | x | | | |
| 109 | | Dioxins and dioxin-like compounds (sum PCDD+PCDF+PCB-DL) - biota | | | | | | | | | x | x | | |
| 110 | | Polychlorinated biphenyls (ΣPCB - congeners 28, 52, 101, 138, 153, 180) - biota | | | | | | | | | x | x | | |
| 111 | | CB118 (congener PCB) - biota | | | | | | | | | x | | | |
| 112 | | Diclofenac - water | | | | | | | | | x | | | |
| 113 | | Micronucleus test | | | | | | | | | x | | | |
| 114 | | Operational oil spills from ships | | | | | | | | | x | | | |
| 115 | | Marine litter on the coast (beach litter) | | | | | | | | | | | x | |
| 116 | | Litter - microparticles in seawater | | | | | | | | | | | x | |
| 117 | | Underwater impulse noise - Explosions | | | | | | | | | | | | x |
| 118 | | Underwater continuous noise | | | | | | | | | | | | x |

The assessment of individual descriptors according to the adopted criteria can be made in two ways, depending on the availability of data and information:

1) quantitatively - on the basis of indicators in relation to threshold values,

2) qualitatively - on the basis of an expert assessment, if a threshold value at the European or regional level has not been set for a given indicator.

The assessment takes into account the status boundaries and values of indicators used to assess ecological status for transitional and coastal waters developed in accordance with the WFD, while the good environmental status (GES) is considered to be 3/5 of the value of the maximum WFD rating scale that a given indicator can achieve. This corresponds to the determination of the boundary between "good and very good" and "bad, poor and moderate", according to WFD.

| Water Framework Directive (WFD) | Marine Strategy Framework Directive (MSFD) |
|---|---|
| Very good state | Good Environmental Status (GES) |
| good state | |
| moderate state | |
| poor state | Unsatisfactory Environmental Status (subGES) |
| bad state | |

The final result will be expressed in only two classes corresponding to the achievement (GES) or failure to achieve good environmental status (subGES).

As part of the assessment of the Descriptors of the state (D1, D4, D6), a separate assessment is carried out for each of the ecosystem components, i.e. for groups of species of birds, mammals, fish and benthic and pelagic habitats. In the preparation of the method for assessing the Baltic Sea environment in the area of Polish marine areas (POM), the findings and recommendations arising from the work of HELCOM working groups and projects were taken into account, such as: State & Conservation, SEAL, IN Benthic habitat, HOLAS II, SPICE, TAPAS, IN EUTRO, GEAR and European Commission WG DIKE, WG GES, TG DATA and MSCG.

The developed method of assessment of the three mentioned status descriptors for POM is in many aspects convergent with the method proposed in the second holistic assessment HELCOM and also refers to the technical guidance given in the current working version of the guidelines to Article 8 MSFD (Walmsley at all 2017).

The main difference in the method of assessing the state in relation to the initial assessment of the state of the marine environment in the Polish Baltic Sea zone (GIOŚ 2014) is currently proposed "integrated assessment of biodiversity" carried out within each of the ecosystem components referring simultaneously to Descriptors 1, 4 and 6, which, on the one hand, affects the lack of the possibility of unambiguous comparison of the results of this assessment with the previous one, on the other hand the compliance of the assessment methodology in the Baltic Sea region in cooperation between Poland (Chief Inspector for Environmental Protection) and the Helsinki Commission (HELCOM). However, it is possible to summarize changes taking place in the environment compared to the initial assessment of the state of marine waters in 2012 at the level of some indicators (GIOŚ 2014) and reference to the second holistic assessment (HELCOM 2017a).

The assessment of pressure descriptors is performed on the basis of primary and secondary criteria separately for each of the descriptors. Compared to the initial assessment of the status of the marine waters of the Polish Baltic Sea zone (GIOŚ 2014) there is no integration of the assessment between pressure descriptors.

The last stage of updating the assessment will be identification and, if possible, quantification of pressures related to the different uses of the marine environment, resulting in the failure to achieve GES, in accordance with their list set out in Table 1 of Annex III and the results of analyses carried out in accordance with Art. 8 (1) (b) of MSFD. The assessment of the use of the marine environment and impacts is an important basis for risk analysis, and thus a cost-benefit analysis of taking action in accordance with MSFD.

The first step will determine the degree of use of the marine environment in the context of socio-economic benefits based on statistical data in relation to the main sectors of the maritime economy, including both production and employment:

1) sea shipping;
2) sea ports;
3) shipbuilding industry;
4) sea fishing;
5) sea and coastal tourism;
6) offshore industry;
7) municipal sector;
8) agriculture;
9) renewable energy - wind farms;
10) offshore wind tourism;
11) military activities;
12) research, analysis and educational activities.

The estimation of the economic benefits of the marine environment (marine water accounting approach) will be the total economic value of marine waters associated with the use of the environment, its current state, pressures and human impact. Conducting an economic analysis for individual subregions will allow to determine economic benefits and to determine the share in the growth of the population's wealth, creating the basis for determining the priorities for remedial actions.

Linking the results of economic analysis with the sea goods and services will allow to determine the costs of its degradation, which may be the basis for further assessment of the benefits of remedial actions taken (Article 13 MSFD) or provide a basis for possible exceptions (Article 14 MSFD) and be the basis for updating KPOWM.

One of the methods of assessing the costs of degradation is an approach based on the analysis of ecosystem services (ecosystem services approach). In this variant, pressures are identified as factors affecting the state of the marine ecosystem, so it is possible to directly link specific pressures to elements of the ecosystem.

The value of ecosystem services calculated as the potential difference between good environmental status (GES) and the situation that may occur in the absence of actions to obtain GES using the BAU scenario, can be interpreted as the cost of degradation. In this way, the basics will be identified at an early stage to formulate recommendations for undertaking actions in accordance with MSFD. In this approach, it is possible to identify ecosystem services in connection with benefits that may potentially be lost in the unchanged unfavorable state of the natural environment. These potentially lost benefits from achieving GES can then be compared to the costs of achieving MSFD goals set out in the programmes of remedial measures.

# 1. Characteristics of the marine ecosystem in Polish marine areas

## 1.1. Physiographic condition

The intercontinental Baltic Sea is shielded from the north-west by the Scandinavian Peninsula and connected to the Atlantic Ocean by the North Sea and Skagerrak via the Straits: the Great and Small Belt, the Sund and the Kattegat. The sea border, separating the Kattegat from the Skagerrak, leads from the northern headland of Jutland - Cape Grenen to the Pater Noster area and the Tjorn island on the Swedish shore (Majewski, 1994). The total exchange of waters in the proper Baltic Sea lasts from 25 to 30 years.

The entire Baltic Sea is situated on a shelf with uneven bottom of generally small depth, but it is divided into deeper basins, separated by sills and shoals. Within POM there are the following main morphological elements of the bottom: part of Odra Bank and Bornholm Basin (105 m), Słupsk Furrow – 65 m deep, separated from the latter by the crosswise sills hindering the movement of waters flowing from the North Sea. In the central part there is the Słupsk Bank, and in the east – the southern part of the Gotland Basin as well as the Gdańsk Basin 118 m deep (Fig. 1.1.1).

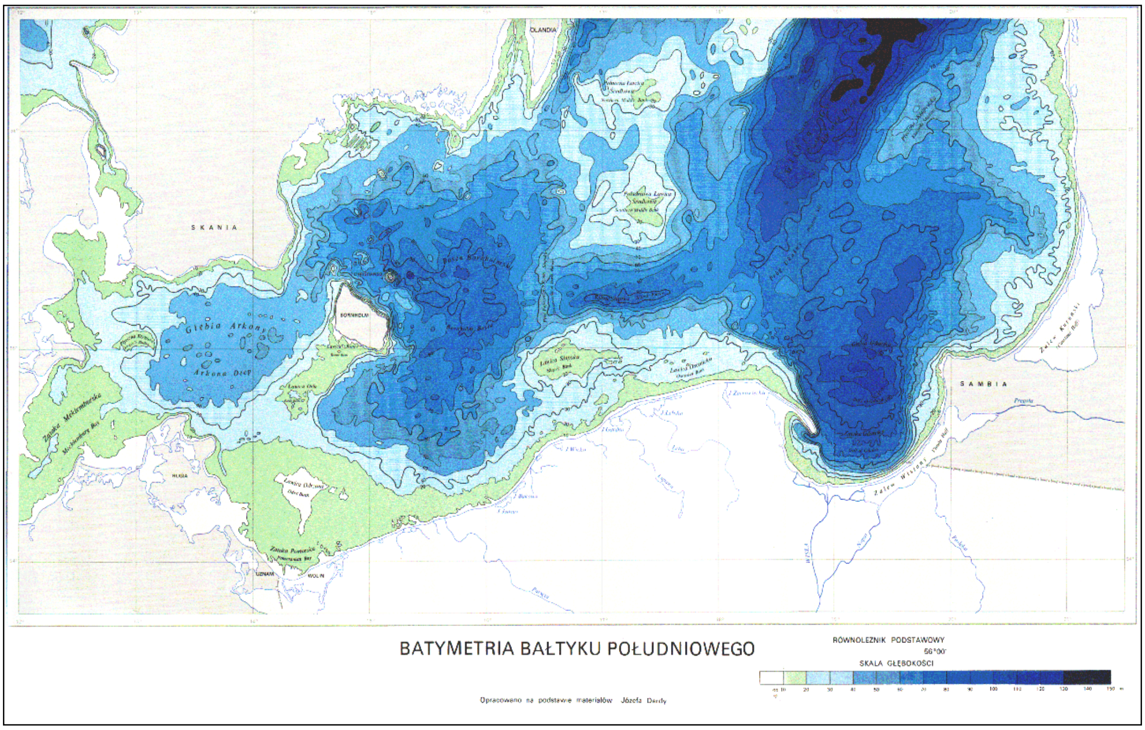



Fig. 1.1.1. Bathymetry of the Southern Baltic (according to Bathymetry of the South Baltic, 1994, [in:] Atlas of resources, values and threats of the geographical environment of Poland, IGiPZ PAN Warsaw)[in Polish]

The main route of water exchange between the Baltic Sea and the North Sea is the Great Belt, which in the shallowest places is 15 m deep. The currents coming out of the Baltic are mainly driven by the Sund, which is 12 m deep on Drogden's shallows. Kiel Bay has a major hydrographical significance since during inflows ocean waters flow through it along the Langeland and here, in accordance with the Coriolis phenomenon, they turn west, and after filling the bay with salt water they move further through the Fehrmarn Belt and the Bay of Mecklenburg towards the Arkona Basin flowing over Gedser-Darsser Ort. Greater inflows occur irregularly, usually in intervals from one to five years. They are episodic and intense. Oceanic inflow waters are directed to the Bornholm Basin via the Bornholm Strait. The revitalizing of deep waters of the Gotland and Gdańsk Basins in terms of oxygenation takes place after a few months of the strong and long-lasting oceanic inflows through the Danish Straits. During periods of stagnation, the sea floor conditions there are usually anoxic.

The morphological structure of the Polish Baltic coasts are related to the period of the last glaciation and the phases of the southern Baltic development. On the shore sections built of Pleistocene sediments, there are cliffs of varying activity. In the Pleistocene area depressions mostly coastal lakes were formed, cut off by spits of a different amount of littoral deposits. Low shores have developed in the valleys parts neighbouring the Gulf of Gdańsk or the Baltic Sea. They predominate in the coastal zone of the Vistula and Szczecin Lagoons.

The coast of the open sea is composed of the dunes – in 77% and the cliffs – in 19%. Dune banks dominate in the Gulf of Gdańsk (73%) with a significant share of low banks (8%).

The cliffs of the southern Baltic coast are mainly composed of clay glacial deposits, fluvial sands and gravels, and silts (Subotowicz, 1984). Depending on the hydrodynamic intensity, the faster or slower process of destroying cliffs takes place. It occurs mainly in the western part of the Gulf of Gdańsk and along the open sea shore, on the sections Cetniewo-Jastrzębia Góra, Rowy-Ustka, Jarosławiec, Niechorze-Dziwnówek and Wolin Island.

The spit shores, excluding the Hel Peninsula, amount to 109 km, which is 22% of the open sea coast. Spits are located mainly along sea-ward margins of the valley and/or depression, hence they cut off coastal lakes or lagoons from the open sea.

The southern Baltic spits, formed in various dynamics, present three different morphogenetic types. The structure of the Vistula Spit reflects the development of a large littoral cover in the conditions of underwater accumulation in the sea regression (Rosa, 1980). Spits of the central and partly western parts are characterized by the occurrence of extended dune fields (e.g. Łebsko Lake spit), formed in conditions of stabilization of the sea level. Spits of the west coast can be regarded as the simple spit forms with small sand resources, that were formed in the transgression conditions, e.g. Bukowska Spit.

The erosion of the spit shores in the period 1889-1975 covered 64% of their length. The shore of the Hel Peninsula, which has been subject to systematic artificial supplementation since 1989, was particularly intensely damaged. An increase in the speed and range of the areas of the destroyed spit is expected due to the increase of intense storms and rising the sea level.

## 1.2.Meteorological and hydrological conditions

### *Wind*

One of the elements supporting the assessment of the ecological status of transitional and coastal waters is exposure to waves. The absolute measure of this parameter is the extent of the wind impact, i.e. the length of the wind pathway over the sea, and thus the ability to generate waves. The most favourable conditions for the formation of wind waves, affecting the shallow water zone of the Polish shore, occur during strong winds from the western winds through the north to the north-east.

The impact of wind wave on the shore in the years 2011-2016 are presented indirectly, using measurements of wind direction and speed at selected stations, representing areas of coastal and transitional waters. The characteristics of wind and sea levels were compiled on the basis of measurement data from 2011-2016, collected within the hydrological and meteorological service of IMGW-PIB.

The distribution of average wind speed in the eight sectors of direction in 2011-2016 (Fig. 1.2.1) shows similar distribution of wind direction frequencies. The prevailing wind directions were south-west, with the dominance of the south. The frequencies of the other directions at both stations are three times smaller, with the majority of eastern directions. However, in Świnoujscie the strongest, however relatively fewer are winds from the northern sectors (NW, NE and N). In the western part of the Bornholm Basin (Ustka) the strongest winds occur from the western direction, and the next from the northern sector. The average wind speed in the eastern part of the Bornholm Basin is much higher than in the west.

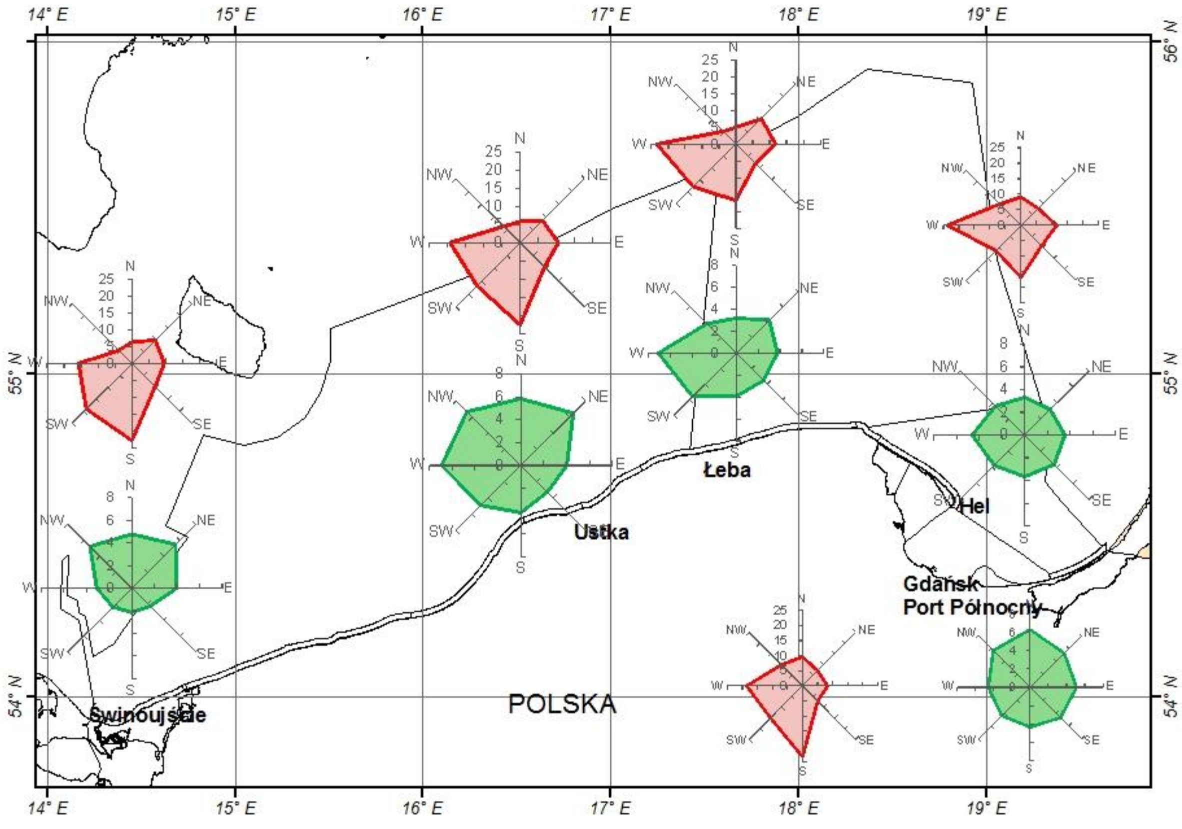



Fig. 1.2.1. Wind roses on selected stations along Polish coast; upper roses: frequency of directions lower roses – average velocity in sectors, years 2011-2016

In the east of the Gotland Basin (Łeba station), to a greater extent than in Ustka, winds from the western (the highest frequency) and south-western as well as southern directions prevailed. In other wind sectors, the situation is similar to that in the Bornholm Basin. The average wind speed over the Gotland Basin is also the highest for western and south-western winds. The remaining wind directions are characterized by a similar average speed.

In the area of the Gdańsk Basin (Hel station) the most frequent winds, similarly to Ustka occurred from the western and, to a lesser extent, southern directions, the other directions have similar frequencies. The distribution of average wind speeds for all directions is similar, and strong winds can occur from any direction.

On the other hand, in the Gdańsk Basin Polish coastal waters (Gdańsk North Port station) winds from the southern and western directions occur with the highest frequency. Winds from directions NW, N, NE, E to SE occur with similar, but much lower frequency. The distribution of average wind speeds for all directions is also quite similar, however the strongest regard north and north-west winds.

Table 1.2.1. Average wind speed (m $s^{-1}$) on selected stations along the Polish coast in 2011-2016

| Station / Years | Świnoujście | Ustka | Łeba | Hel | Gdańsk North Port |
|---|---|---|---|---|---|
| 2011-2016 | 3.3 | 4.7 | 3.9 | 3.3 | 4.5 |

The average wind speed at stations along the Polish coast varied depending on the basin. In Ustka and Gdańsk North Port average wind speed was the largest, while the weakest average wind was in Świnoujście and Hel, less by approx. 1,4 m $s^{-1}$ (Table 1.2.1).

The maximum average wind speed and the corresponding direction changed at individual stations along the Polish coast (Table 1.2.2) and for example in Łeba the highest speed of 7,1 m $s^{-1}$ occurred at the western (W) wind directions, and in Gdańsk North Port with northern winds - 6,3 m $s^{-1}$ .

Table 1.2.2. The maximum average wind speed (m $s^{-1}$) and the corresponding wind direction at selected stations along the Polish coast in 2011-2016

| Station / Years | Świnoujście | Ustka | Łeba | Hel | Gdańsk North Port |
|---|---|---|---|---|---|
| 2011-2016 | 5.5 - **NE** | 6.9 - **W** | 7.1 - **W** | 4.6 - **W** | 6.3 - **N** |

The frequency of lack of wind in 2011-2016 is evidence of the diverse anemobaric conditions prevailing throughout the year in the coastal zone. The highest value occurs in Świnoujście, and successively in Łeba. However, the smallest frequency of low wind was in Hel (Table 1.2.3), as in a station surrounded on three sides by water.

Table 1.2.3. Frequency (%) of silent occurrence at selected stations along the Polish coast in the years 2011-2016

| Station / Years | Świnoujście | Ustka | Łeba | Hel | Port of Gdańsk |
|---|---|---|---|---|---|
| 2011-2016 | 1.6 | 0.5 | 1.1 | 0.4 | 0.7 |

*Mixing of water*

The effect of wind and thermohaline convection, in addition to the formation of waves, is the vertical mixing of the upper layers of sea water. Irrespective of the season, the water

temperature in the shallow water zone is often uniform from the surface to the bottom as a result of wind mixing. Convection, in turn, occurs during the autumn cooling of the surface layer and causes the colder and more dense masses of water to drop into the depths. Under the layer of cooler water, a warmer layer of demersal waters occurs. The largest ranges of separation between these layers occur in late autumn, in winter and early spring. The smallest, from late spring (April or May) to August (Fig. 1.2.2).

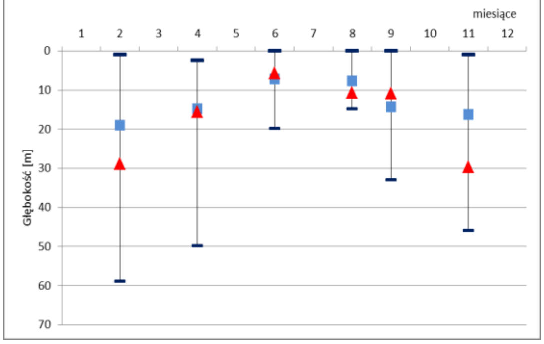
This phenomenon occurs especially in regions of significant depths such as: the Gdańsk Basin, the Eastern Gotland Basin or the Bornholm Basin. They also include the "Gdańsk Basin Polish Coastal waters" area, defined by HELCOM MAS (HELCOM 2013), as it covers the Inner Gulf of Gdańsk, where substantial depths occur. In the figure concerning the Gdańsk Basin the vertical the mixing range is larger than in the case of other water bodies.

During most cruises in 2016, the average depth of the mixing layer in the Bornholm Basin was higher than the average of the previous decade except June and September. In February and November its depth differed by more than 10 m from the long-term average (Fig. 1.2.2a).

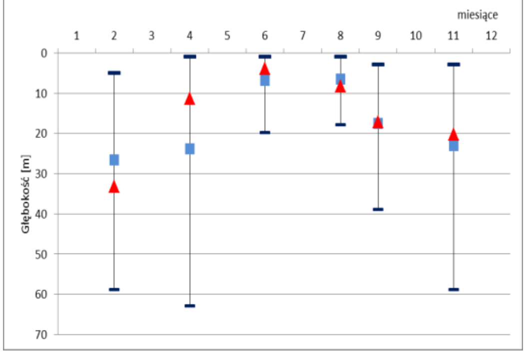
Larger differences in relation to the long-term average occurred in April 2016 in the Eastern Gotland Basin, when the average depth of the layer was only around 10 m. In the remaining months, the average values were similar in both periods (Fig. 1.2.2b).

The conditions of mixing of waters in the Gdańsk Basin were different, both in the open part and its coastal waters. A large part of this area is open to the wind from the northern directions. In turn, the shallow zone of the western part of the Gulf of Gdańsk is very shallow, which limits the possibility of deep mixing and, at the same time, is sheltered from most wind directions, except the east. The general characteristics of the variation of the depth of mixing layer in the Gdańsk Basin is similar to other open sea areas with different deviations from the long-term average and the largest depth range reaching over 80 meters in February (Fig. 1.2.2c). In turn, in the Gdańsk Basin Polish coastal waters the maximum depth of the mixing layer is limited to approximately 15 m from May to August and in March and October. In the remaining months, the average values are smaller, only in November 2016 a much deeper depth was recorded compared to the long-term average (Fig. 1.2.2d) differing by approximately 15 m.

a)




b)



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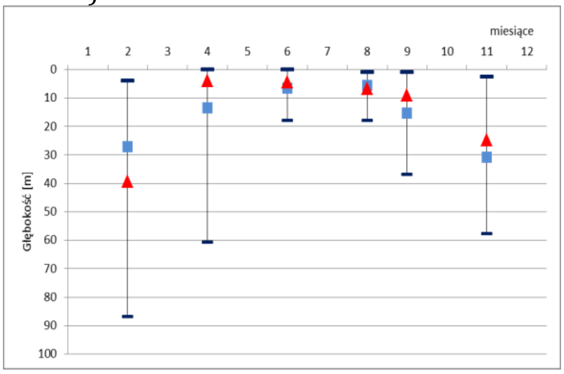



d)

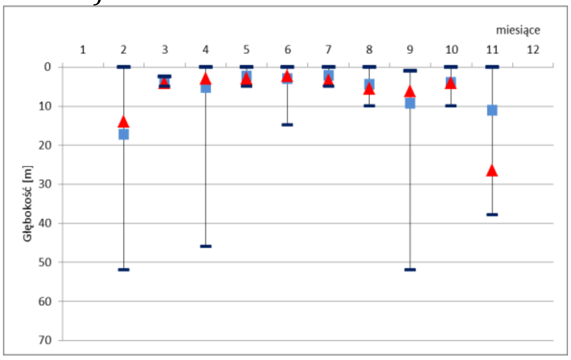



Fig. 1.2.2. Range of variability of mixing layer depth [m] in 2016 and average depth in 2016 (triangles) and for many years (squares) in separated areas of POM Baltic Sea: a) Bornholm Basin, b) Eastern Gotland Basin, c) Gdańsk Basin, d) Gdańsk Basin Polish coastal waters

### ***Sea level***

Hydrodynamic processes occurring in the southern Baltic are altered in the shallow and coastal zone, both by the bottom and shore configuration. Also the level of threat to the shore in situations of increasingly intense storms affects the areas at its back. In the transitional and coastal waters, the sea level changes, waves and currents in the coastal zone affect both the transport of matter as well as hydro-morphological conditions. Especially changes in sea level during storms (storm surges) make it necessary to develop infrastructure to protect coastal areas from flooding. The measure of threats to this zone is the frequency of levels reaching or exceeding safe levels.

The characteristics of sea level changes were elaborated on the basis of measurement data from the period 2011-2016, collected within the hydrological and meteorological service of IMGW-PIB .

In the discussed period, the highest frequency of warning levels per year (Table 1.2.4) was characterized by the eastern part of the Polish coast (the area of the Gulf of Gdańsk - a station in Gdańsk in the North Port and Władysławowo). Almost three times lower frequency of occurrence of warning levels was recorded in the western part of the coast (Świnoujście and Kołobrzeg stations).

Comparing the frequency of occurrence of alarm conditions in the years 2011-2016 in particular regions of the coast, also on the eastern coast alarm conditions occurred more often (about two times) compared to the western coast.

Table 1.2.4. Frequency (%) of occurrence of sea levels reaching or exceeding the warning and alarm levels (cm) at Polish coast stations in the long-term 2011-2016

| Station / Levels | Świnoujście | Ustka | Łeba | Hel | Gdańsk North Port |
|---|---|---|---|---|---|
| Warning | 0.80 | 0.61 | 0.53 | 2.37 | 3.06 |
| Alarm | 0.27 | 0.07 | 0.07 | 0.52 | 0.65 |

In particular months, the most common occurrence of warning levels was noted in winter months: December and January. This applies to the entire coast (Table 1.2.5). A typical period when there are storms and associated high water levels as well as warning and alarm levels were autumn and winter. Summer storms, which are rare, caused the occurrence of warning levels in the eastern part of the coast (station Gdańsk-North Port and Władysławowo) in the summer period (July, August). In May and June, warning levels did not occur at all along the coast. In the months from March to September, 2011-2016, no alarm conditions were recorded at all along the coast (Table 1.2.6).

The least often, both warning and alarm levels were recorded in the central part of the coast, from Kołobrzeg to Ustka, that is within the eastern Bornholm Basin. The most common occurrence of alarm levels occurs in winter months: January and December, it regards the entire coast.

Table 1.2.5. Frequency (%) of occurrence of sea levels reaching or exceeding the warning level (cm) in individual months at Polish coast stations, 2011-2016

| Station | Warning state | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Świnoujście<br>west Bornholm Basin | 560 | 2.89 | 0.27 | 0.45 | 0.3 | | | | | 0.12 | 1.88 | 0.99 | 2.73 |
| Kołobrzeg<br>west Bornholm Basin | 570 | 3.02 | 0.91 | 0.09 | 0.05 | | | | | | 0.2 | 0.49 | 2.53 |
| Ustka<br>Eastern Bornholm Basin | 570 | 2.64 | 0.69 | | 0.02 | | | | | | 0.16 | 0.44 | 2.35 |
| Władysławowo<br>Eastern Gotland Basin | 550 | 9.45 | 0.93 | 0.11 | 0.21 | | | 0.04 | 0.07 | 0.9 | 3.05 | 2.45 | 10.87 |
| Gdańsk - Port Północny<br>Gdańsk Basin | 550 | 11.36 | 1.5 | 0.25 | 0.37 | | | 0.09 | 0.27 | 1.94 | 4.14 | 3.15 | 13.26 |

Table 1.2.6. Frequency (%) of occurrence of sea levels reaching or exceeding the alarm level (cm) in individual months, at Polish coast stations, 2011-2016

| Station | Alarm state | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Świnoujście<br>west Bornholm Basin | 580 | 1.21 | 0.51 | | | | | | | | 0.47 | 0.35 | 0.74 |
| Kołobrzeg<br>west Bornholm Basin | 610 | 0.56 | 0.02 | | | | | | | | | | 0.25 |
| Ustka<br>Eastern Bornholm Basin | 600 | 0.65 | | | | | | | | | | | 0.22 |
| Władysławowo<br>Eastern Gotland Basin | 570 | 2.71 | 0.66 | | | | | | | | 0.27 | 0.37 | 2.17 |
| Gdańsk - Port Północny<br>Gdańsk Basin | 570 | 3.38 | 0.59 | | | | | | | | 0.78 | 0.39 | 2.53 |

*Ice cover*

A natural factor that affects the development of biological processes and the distribution of pollution from land is the occurrence of ice cover in water areas.

The occurrence of ice phenomena in the southern Baltic is limited (the number of days with ice, the length of the ice season, the date of ice forming and its disappearance) in comparison with the rest of the Baltic Sea. In the Polish coastal zone, ice-cover occurs only during moderate and severe winters. Its intensity in individual sub-basins is diverse.

The Polish coastal zone is divided into several regions regarding the ice formation: Polish coastal waters of the western Bornholm Basin (coastal area of the Pomeranian Bay), Eastern Bornholm Basin and Gotland Basin and Gdańsk Basin Polish Coastal waters, lagoons: the Szczecin Lagoon and Vistula Lagoon and the open area the sea of all basins. Ice occurrence in the area of the open sea is a rare phenomenon. In the Polish coastal zone, the most common ice formations are the initial forms of ice and floe, also originated from the rivers. During cold winters along the Polish coast, the ice may appear at the end of November and remain until the second half of March, sometimes until the beginning of April. The outflow of ice from the coast occurs on average at the end of February and the beginning of March.

The average sum of average sub-zero daily air temperatures in the Polish coastal waters allows to assess the severity of particular ice seasons.

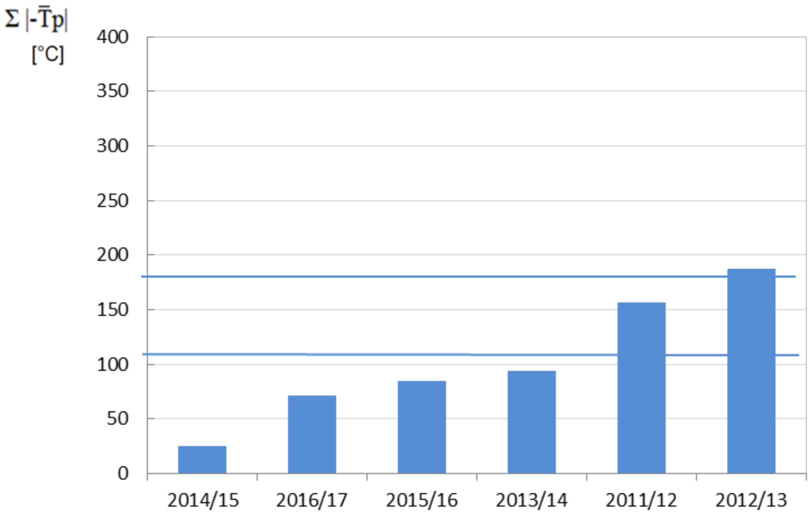



Fig. 1.2.3. Sum of average sub zero daily air temperatures - "sum of cold" for the Polish coast, 2011-2017

Fig. 1.2.3 shows the occurrence of winters from the hottest to the coldest in the years 2011-2017. The warmest winter was observed in 2014/2015, while the coldest winter in 2012/2013, although none of the winter from this period was severe.

The number of days with ice in individual ice seasons is presented in Table 1.2.7. In 2011-2017, the number of days with ice observed in the Polish coastal zone varies from about 12 days in Świnoujście to 1 day (for winters in which ice occurred in a given area).

The regions of the middle coast, i.e. eastern part of Polish Coastal waters of the: Bornholm Basin, the Gotland Basin and the Gdańsk Basin, belong to the most frequently ice-free areas in the Polish coastal zone.

Table 1.2.7. Number of days with ice * on Polish coastal waters in 2011-2017

| Basin | 2011/2012 | 2012/2013 | 2013/2014 | 2014/2015 | 2015/2016 | 2016/2017 |
|---|---|---|---|---|---|---|
| Bornholm Basin Polish Coastal waters | | | | | | |
| Świnoujście | 12 | 3 | 6 | 0 | 1 | 0 |
| Szczecin Lagoon | 26 | 75 | 34 | 0 | 32 | 50 |
| Eastern Gotland Basin Polish Coastal waters | | | | | | |
| Lt. Rozewie | 6 | 0 | 0 | 0 | 0 | 0 |
| Gdańsk Basin Polish Coastal waters | | | | | | |
| Gdynia | 5 | 0 | 0 | 0 | 0 | 0 |
| Vistula lagoon | 34 | 119 | 48 | 11 | 32 | 53 |

*I. Stanisławczyk 2012-2017

The Polish part of the Vistula Lagoon and the Polish part of the Szczecin Lagoon belong to the most ice-covered reservoirs in the Polish coastal and transitional waters. In Fig. 1.2.4. a long-term data (2011-2017) of the number of days with ice on the Vistula and Szczecin Lagoon is presented .

The Vistula Lagoon is one of the reservoirs on which ice occurs annually, it is a good indicator of changes in ice conditions over the years, even when there was no ice in the coastal zone. In the Vistula Lagoon, the largest number of ice days in the entire Polish coastal zone was also recorded - 146 days. The next example is the Puck Bay - 128 days and later the Szczecin Lagoon - 115 days. It is almost twice as many as the highest number of days with ice in the open sea.

Ice cover in the Szczecin Lagoon is a phenomenon that occurs every year and is a major obstacle to shipping. Very rarely - in extremely warm winters - ice phenomena do not occur. In the 100 years (in the twentieth century) it happened only six times.

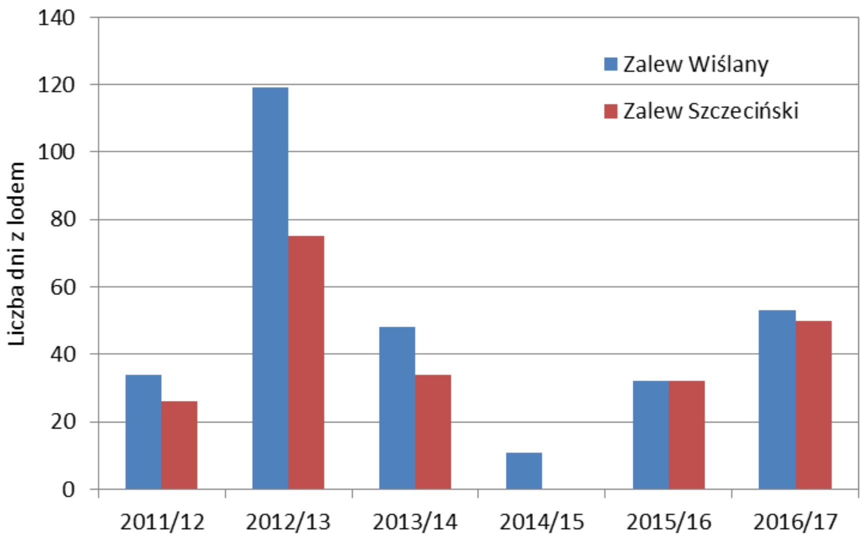



Fig. 1.2.4. The number of days with ice in the Szczecin Lagoon (red) and the Vistula Lagoon (blue) in 2011-2017

In this basin within 100 year period (XX century) the difficult navigation conditions prevailed, while the number of days when shipping was unhindered (during the occurrence of ice) was limited, which was due to the nature of icing in the Szczecin Lagoon - the occurrence of solid ice and impediments related to this. On the other hand, during the harsh winter, difficulties in shipping increase to a large extent, both in the Szczecin Lagoon and in the Świnoujście off-shore area.

## 1.3.General hydrographic conditions

***Sea water temperature***

The average water temperature in the surface sea layer of deep-water basins in individual months in 2016, in most cases was higher than the average in 2006-2015 (Fig. 1.3.1). The standard deviation (SD) of the average in 2016 was close to the limit of the range determined by the standard deviation value. Only in the Eastern Gotland Basin and the Gdańsk Basin the average water temperature was lower in June and November.

The maximum surface water temperature (4.764 °C) in the Bornholm Basin was in February 2016 – the closest to the long-term maximum (4.730 °C), while in Eastern Gotland Basin the maximum in 2016 was higher than the long-term by 1,553 °C in September. The minimum SD (-6.339 °C) occurred in May 2016 in the Gdańsk Basin.

Coastal waters of the Gulf of Gdańsk in 2016 were warmer than in multi-annual period, and the minimum values of water temperature were higher than the minima except in August when the difference was -2.062 °C. In turn, the maximum values were in most cases lower, even by 5.964 °C i.e. in October of this year.

Average water temperatures in particular months reflect the above characteristics, where large positive deviations of mean value are associated with higher extreme temperatures in 2016 compared to multiannual values, and negative deviations with much smaller values of maximum temperature.

The minimum water temperature in all waters was in individual months higher than the minimum multiannual temperatures, except for August in the Gdańsk Basin Polish coastal waters, which shows that 2016 was the warmest in the studied period.

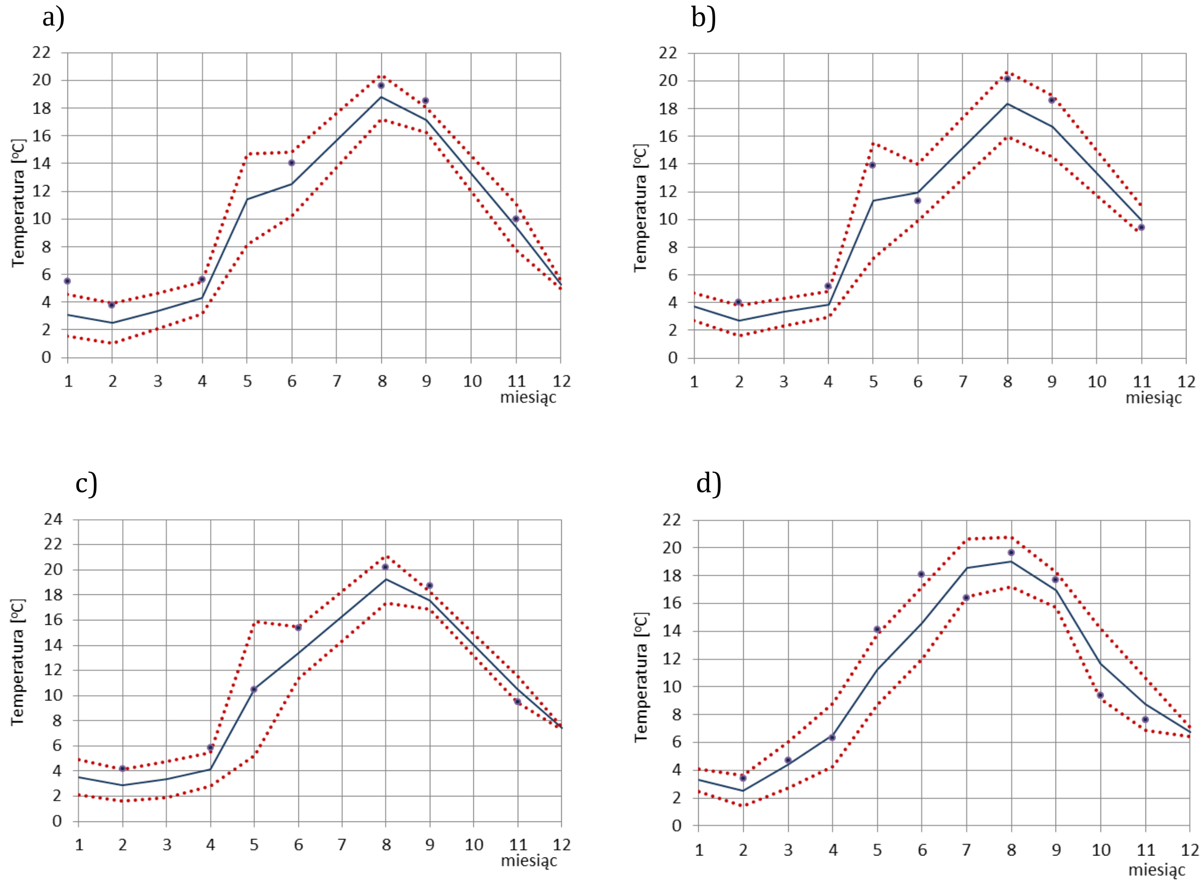



Fig. 1.3.1. The sea surface water temperature in 2016 in the areas of the POM: a) Bornholm Basin, b) Eastern Gotland Basin, c) Gdańsk Basin, d) Gdańsk Basin Polish Coastal waters; solid line -

average in 2006-2015; dashed lines - average ± standard deviation in 2006-2015; points - 2016 (note - different scaling of temperature values) (Data source: PMŚ)

The spatial characteristics of changes in sea surface temperature (SST) in 2011-2016 are presented on the basis of satellite maps supplemented, in the absence of EO data, with the results of the PM3D model (Kowalewski and Kowalewska-Kalkowska, 2017). Such maps are saved in the SatBałtyk System four times a day, based on current satellite images. In the absence of satellite data, due to cloudiness, the algorithm of combining earlier satellite data and a hydrodynamic model is used (Konik et al. 2018). The PM3D model continuously assimilates the observed satellite SST, which results in a significant reduction of errors.

In order to characterize the spatial variability of SST, average SST distributions and standard deviation were determined based on all maps from 2011-2016 (Fig. 1.3.2). The highest average temperatures in the discussed six-year period were observed in the Szczecin Lagoon and Vistula Lagoon, as well as in the Gulf of Gdańsk and Pomeranian Bay. In these areas, also higher variability was observed expressing higher values of standard deviation. In the coastal zone, the average temperature was slightly lower than that of the open sea, but the variability was higher. The exception was the area of Hel Peninsula where the upwelling events occurred, which was characterized by lower average annual temperature and a smaller standard deviation. This is due to the fact that in summer the upwelling is much colder than the surrounding water, with a temperature close to the annual average. In the winter, however, it is slightly warmer, which causes a decrease in the average annual temperature and a reduction of deviations from the average.

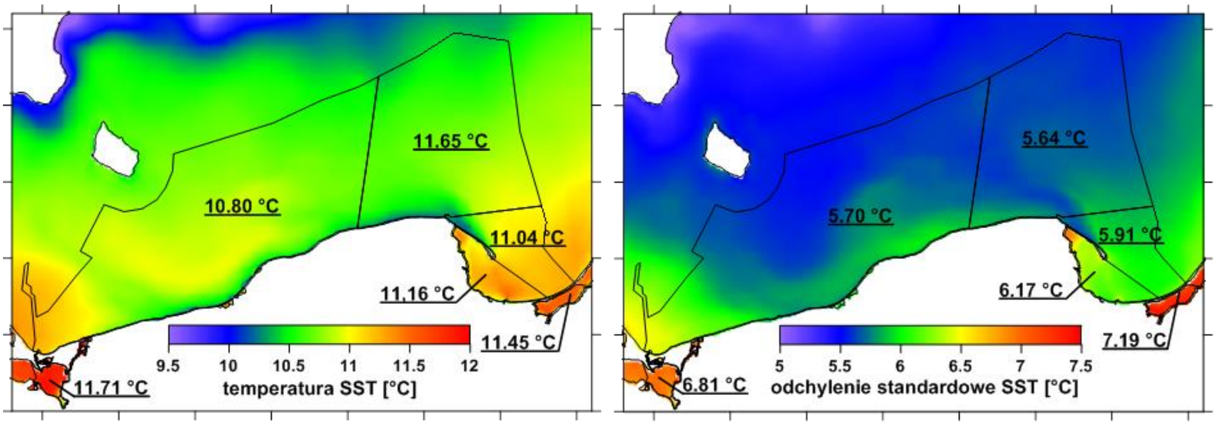



Fig. 1.3.2. Distribution of mean sea surface temperature (SST) and standard deviation based on data from the SatBałtyk System for 2011-2016 as well as average values and standard deviations for individual reporting units

The spatial distribution of the average surface temperature in the summer period, i.e. for the months from June to September, was similar to the annual average (Fig. 1.3.3) at higher values by about 6-7 °C. The spatial diversity of standard deviation, however, differed significantly. The smallest values, indicating low variability, were recorded in the Pomeranian Bay. Higher temperature variability was recorded in the Vistula and Szczecin Lagoons, in the Puck Bay and in the upwelling area of Hel Penninsula.

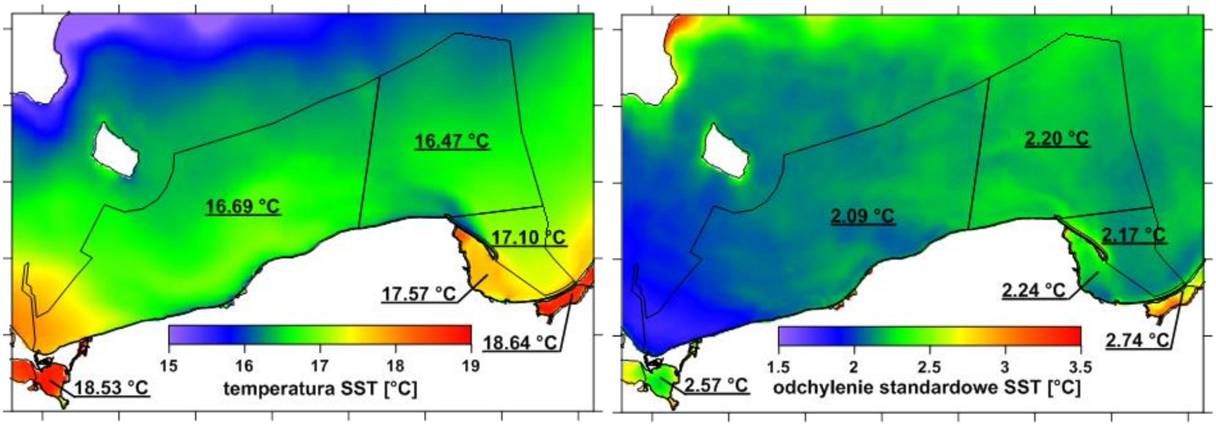



Fig. 1.3.3. Distribution of average sea surface temperature (SST) in the summer months (June-September) and its standard deviation based on data from the SatBałtyk System for 2011-2016 as well as average values and standard deviations for individual reporting units

Subtracting the distribution of the average SST temperature in a given year from the average of 2011-2016, spatial distribution of SST anomalies for particular years was determined (Fig. 1.3.4). In 2011 and 2012, lower temperatures were observed compared to the six year average for the majority of POM. Only in 2012, higher temperatures were recorded in the Vistula, Szczecin and Puck lagoons. In subsequent years (2013-2015) average annual temperatures were higher than multiannual values, although somewhat lower values occurred in the upwelling area of Hel Peninsula in 2014 and 2015. This proves its greater activity in these years. The largest spatial differentiation of the anomaly was recorded in 2016. In the entire coastal zone there were temperatures lower than the average, while in open waters - higher.

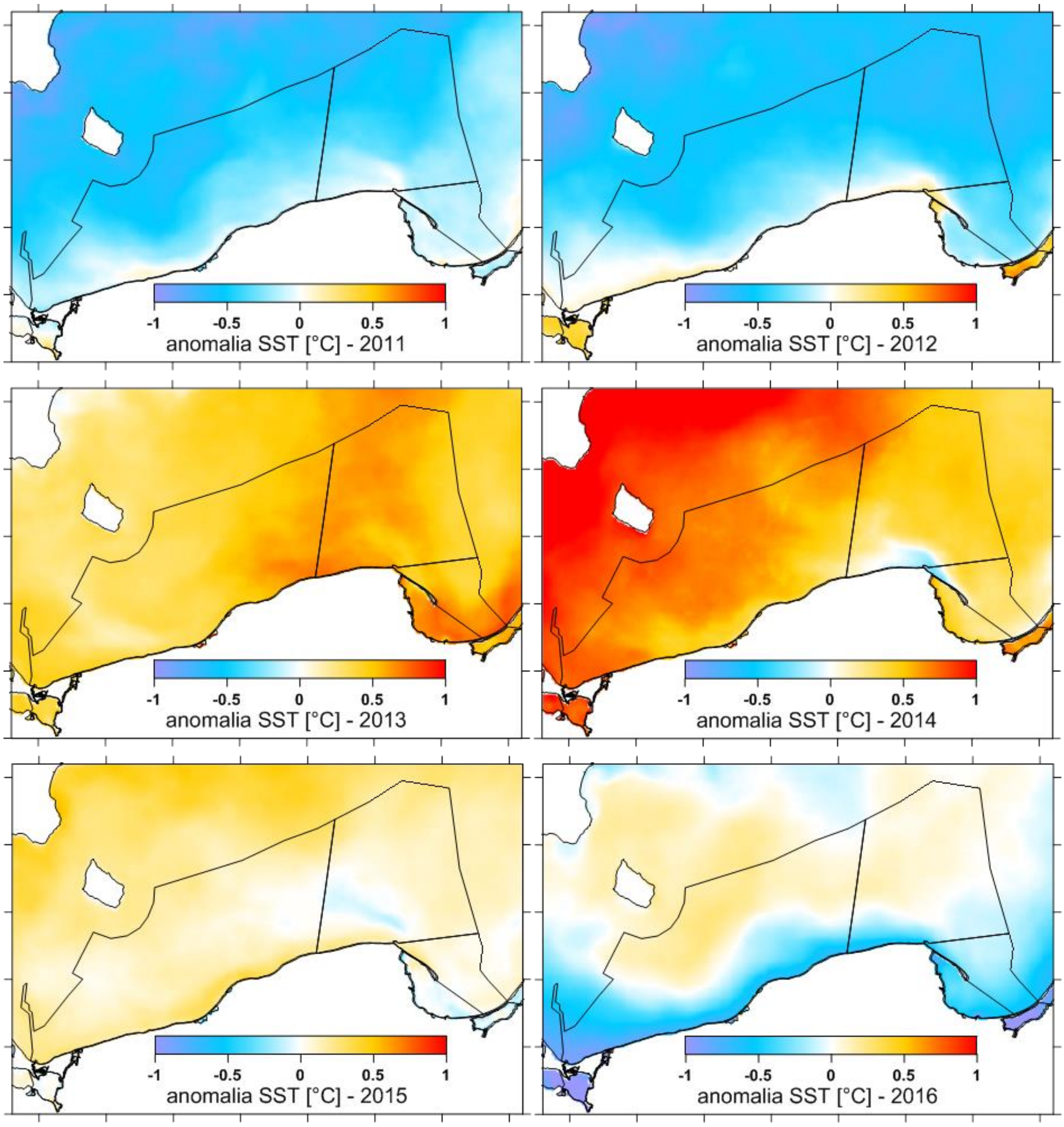



Fig. 1.3.4. Average annual sea surface temperature anomalies (SST) in 2011-2016 compared to multi annual average from the period.

In addition, average annual sea surface temperatures were determined for the sub-basins adopted in the assessment of the state of Polish marine areas of Baltic Sea. Average values were calculated by averaging over annual periods SST values from all map pixels contained in a given sub-basin (Fig. 1.3.5, Table 1.3.1). Changes in average sea surface temperatures in individual sub-basins have a similar course over time, but the values vary. The lowest ones are usually found in Eastern Gotland Basin, higher in the Bornholm Basin, in the open waters of the Gdańsk Basin, in the Gdańsk Basin Polish Coastal waters, in the Vistula Lagoon, and the highest in the Szczecin Lagoon. Exceptionally in 2016, the sea surface temperatures in individual sub-basins were similar, which was the result of an anomaly consisting in the reduction of average values in the coastal zone (Fig. 1.3.5) and their increase in open waters. Changes in the annual deviations of the standard sea surface temperature in individual sub-basins have shown that the lowest variability occurred in 2015, and the highest in 2013. (Table 1.3.2).

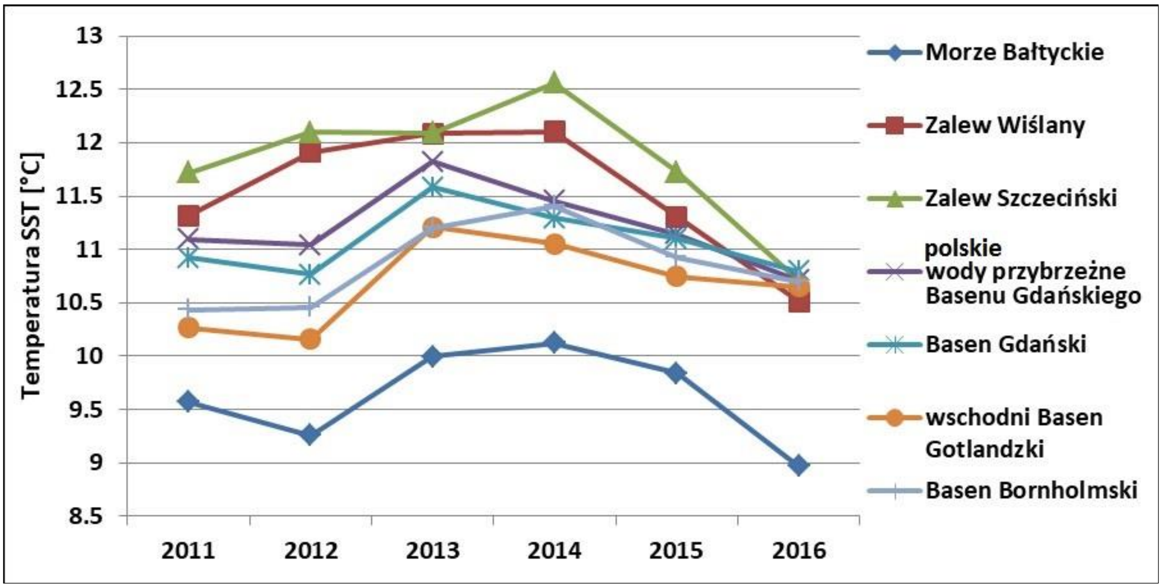



Fig. 1.3.5. Changes in the average annual sea surface temperature (SST) in 2011-2016 for individual sub-basins and the entire Baltic Sea area.

Table 1.3.1. Changes in the average annual sea surface temperature (SST) in 2011-2016 for individual sub-basins and the entire Baltic Sea.

| Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| **Vistula Lagoon** | 11.32 | 11.91 | 12.09 | 12.11 | 11.31 | 10.51 |
| **Szczecin Lagoon** | 11.72 | 12.10 | 12.09 | 12.56 | 11.73 | 10.70 |
| **Gdańsk Basin Polish coastal waters** | 11.10 | 11.04 | 11.82 | 11.45 | 11.14 | 10.71 |
| **Gdańsk Basin** | 10.92 | 10.76 | 11.58 | 11.30 | 11.10 | 10.79 |
| **Eastern Gotland Basin** | 10.27 | 10.16 | 11.21 | 11.05 | 10.75 | 10.65 |
| **Bornholm Basin** | 10.44 | 10.46 | 11.21 | 11.41 | 10.93 | 10.70 |
| **Baltic Sea** | 9.57 | 9.26 | 9.99 | 10.12 | 9.84 | 8.97 |

Table 1.3.2. Changes in standard sea surface temperature deviation (SST) in 2011-2016 for individual sub-basins and the entire Baltic Sea.

| Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| **Vistula Lagoon** | 7.07 | 7.43 | 7.57 | 7.29 | 6.32 | 7.49 |
| **Szczecin Lagoon** | 6.66 | 6.60 | 7.30 | 6.82 | 6.14 | 7.35 |
| **Gdańsk Basin Polish coastal waters** | 6.26 | 6.50 | 6.53 | 6.05 | 5.39 | 6.28 |
| **Gdańsk Basin** | 6.13 | 6.25 | 6.23 | 5.87 | 5.15 | 5.80 |
| **Eastern Gotland Basin** | 5.72 | 5.86 | 5.98 | 5.79 | 4.98 | 5.51 |
| **Bornholm Basin** | 5.87 | 6.03 | 6.17 | 5.68 | 4.77 | 5.66 |
| **Baltic Sea** | 6.08 | 5.89 | 6.09 | 6.07 | 5.10 | 5.73 |

Average sea surface temperatures for individual sub-basins were also determined for summer months, from June to September (Fig. 1.3.6, Table 1.3.3). Their changes in particular years were similar to changes in annual averages except for 2016, when the highest summer temperatures were observed, although the annual averages were rather low (the average annual temperature of SST in the Baltic Sea was the lowest in the entire six-year period). Standard deviations were the lowest in 2011 except for the Vistula Lagoon, where slightly lower variability occurred in 2015. (Table 1.3.4).

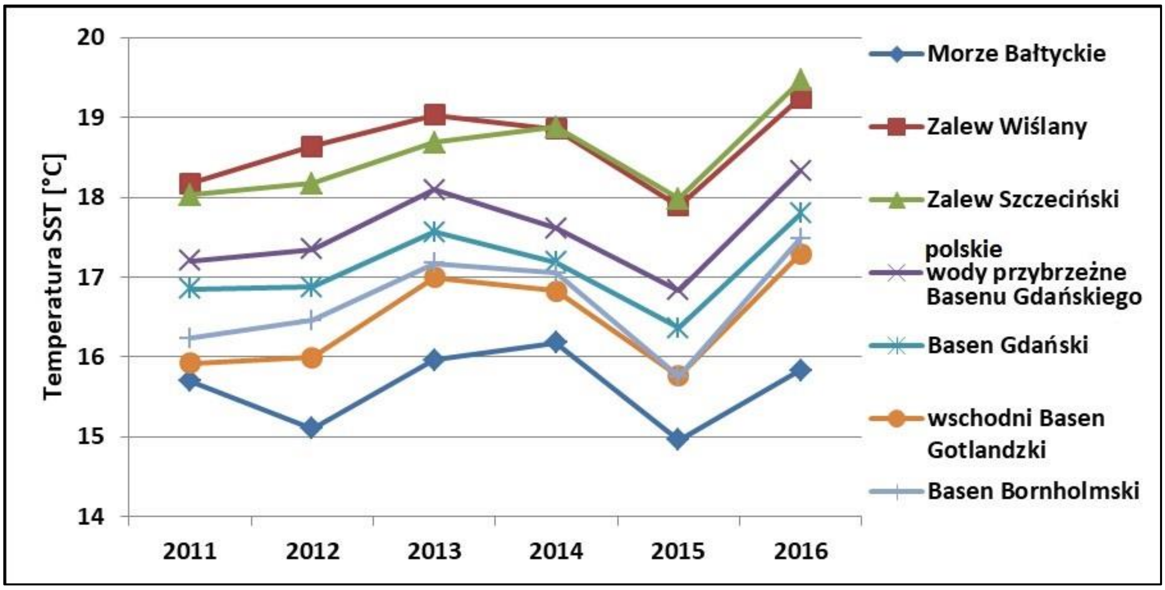



Fig. 1.3.6. Changes in the average sea surface temperature (SST) in the summer (VI - IX) in 2010-2016 for individual sub-basins and the entire Baltic Sea area.

Table 1.3.3. Changes in the average annual sea surface temperature (SST) in the summer period (VI - IX) in 2011-2016 for individual bodies of water and the entire Baltic Sea.

| Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| **Vistula Lagoon** | 18.18 | 18.64 | 19.03 | 18.85 | 17.89 | 19.24 |
| **Szczecin Lagoon** | 18.03 | 18.17 | 18.68 | 18.87 | 17.98 | 19.46 |
| **Gdańsk Basin Polish coastal waters** | 17.21 | 17.35 | 18.09 | 17.61 | 16.83 | 18.33 |
| **Gdańsk Basin** | 16.85 | 16.87 | 17.56 | 17.19 | 16.36 | 17.80 |
| **Eastern Gotland Basin** | 15.92 | 16.00 | 16.99 | 16.83 | 15.77 | 17.29 |
| **Bornholm Basin** | 16.23 | 16.46 | 17.17 | 17.05 | 15.75 | 17.49 |
| **Baltic Sea** | 15.70 | 15.11 | 15.97 | 16.18 | 14.96 | 15.84 |

Table 1.3.4. Changes in standard sea surface temperature deviation (SST) in summer (VI - IX) in 2011-2016 for individual sub-basins and the entire Baltic Sea.

| Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| **Vistula Lagoon** | 2.55 | 2.71 | 2.96 | 3.27 | 2.42 | 2.56 |
| **Szczecin Lagoon** | 2.38 | 2.39 | 3.09 | 2.99 | 2.66 | 1.89 |
| **Gdańsk Basin Polish coastal waters** | 1.74 | 2.41 | 2.42 | 2.59 | 2.08 | 2.21 |
| **Gdańsk Basin** | 1.69 | 2.33 | 2.14 | 2.63 | 2.13 | 2.09 |
| **Eastern Gotland Basin** | 1.70 | 2.35 | 2.14 | 2.78 | 2.43 | 1.80 |
| **Bornholm Basin** | 1.55 | 2.25 | 2.35 | 2.35 | 2.03 | 2.01 |
| **Baltic Sea** | 2.38 | 2.42 | 2.17 | 3.20 | 2.53 | 2.07 |

While the method using satellite data is a valuable complement to information obtained from monitoring measurements on spatial changes in temperature of water in the surface layer, for deep layers measurements are the only reliable source of information (Fig. 1.3.7).

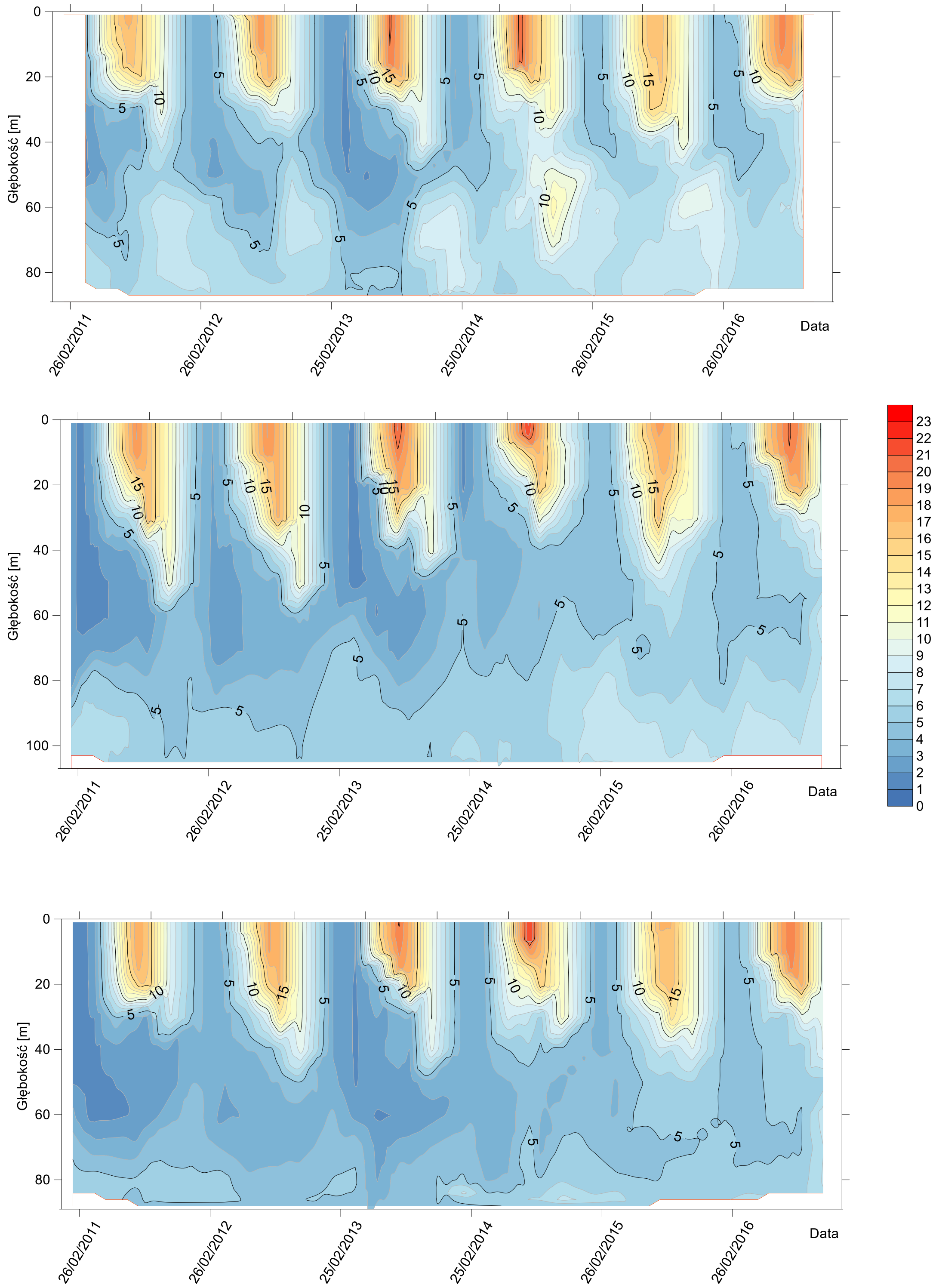



Fig. 1.3.7. Changes in water temperature in the area of three deeps: Bornholm, Gdańsk and the east slope of Gotland in 2011-2016 (Data source: PMŚ)

***Salinity***

The average water salinity in the surface layer of the Bornholm Basin throughout 2016, apart from February, was higher by about 0.5 than the average salinity of the period 2006-2015, with a decreasing tendency to September (Fig. 1.3.8a). ). At the same time, in all months the minimum salinity values were higher than the multi-annual minima. In August the difference was the highest - 3.936.

In the Eastern Gotland Basin the deviations were smaller with no clear direction of change (Fig. 1.3.8b), which was also reflected in smaller differences in the minimal values for which the average value was 0,447.

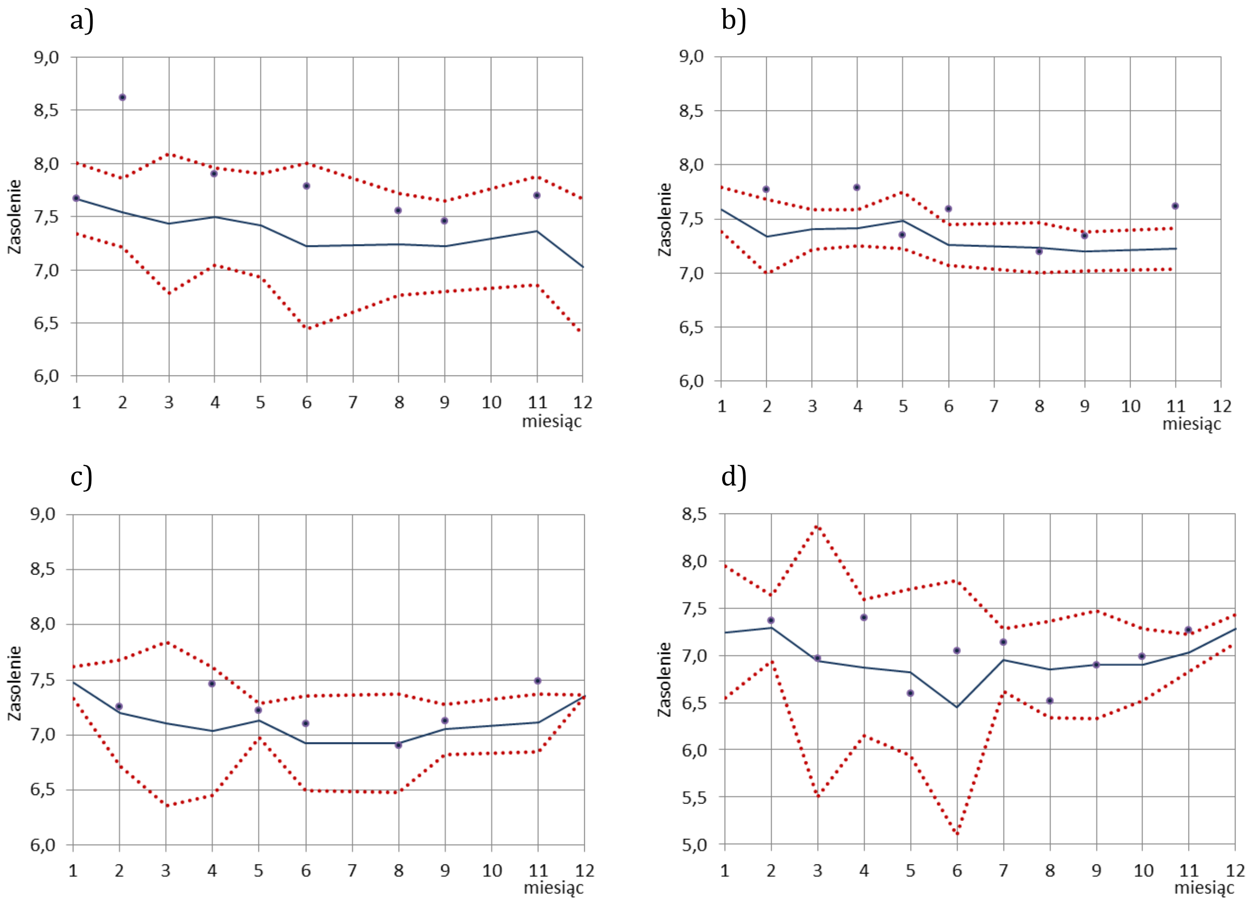



Fig. 1.3.8. Salinity in the surface layer in 2016 in the sub-basins of the Polish sea area: a) Bornholm Basin, b) Eastern Gotland Basin, c) Gdańsk Basin, d) Gdańsk Basin Polish Coastal waters; solid line - average 2006-2015; dashed line - mean ± standard deviation 2006-2015; points - 2016 (note - different scaling of salinity values) (Data source: PMŚ)

In the Gdańsk Basin the salinity in the spring and at the turn of summer and autumn of 2016 was higher than multi-annual values (Fig. 1.3.8c). In coastal waters of this basin salinity fluctuated during the year, and significantly decreased in August (Fig. 1.3.8d).

Salinity of bottom waters of the deep water zone of the southern Baltic in 2011-2016 was shaped by a weak inflow of saline waters from the North Sea. The largest increase in salinity (18.881) was found in the Bornholm Deep in April, followed by a gradual decrease until September (Fig. 1.3.9a).

In the demersal waters of the Eastern Gotland Basin the salinity increased from the beginning of the year to May 2016, and then remained at a similar level until August. After a short-term drop, it increased in November (Fig. 1.3.9b).

In the Gdańsk Deep the highest salinity (14.318) of demersal waters of 2016 occurred at the beginning of April (Fig. 1.3.9c) and then remained at a lower level until November (13.726).

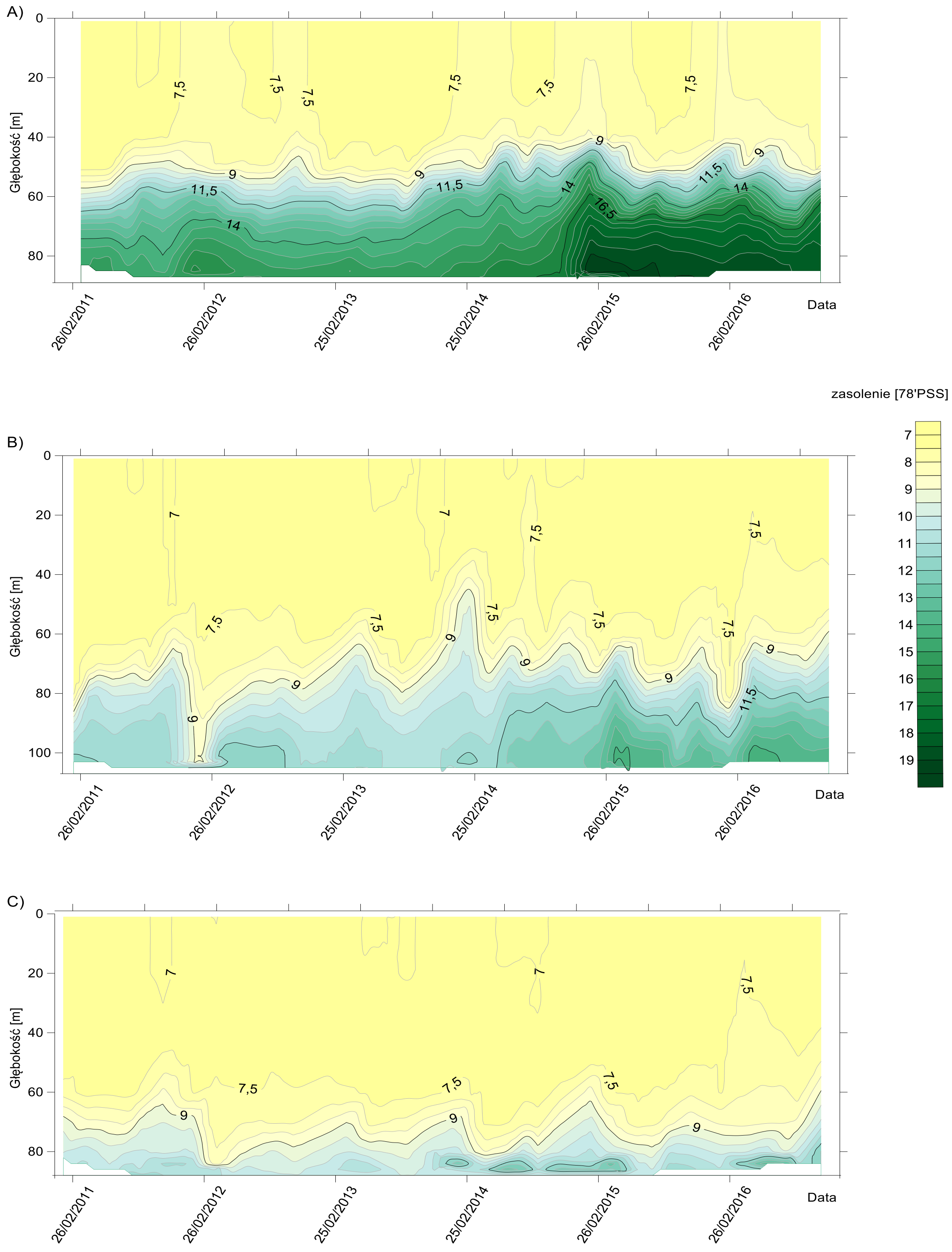



Fig. 1.3.9. Changes in salinity in selected deep water areas of POM in the years 2011-2016; A) Bornholm Deep, B) south-east Gotland Basin, C) Gdańsk Deep (Data source: PMŚ)

### *Seawater pH*

The parameter describing the acidity/alkalinity of seawater is its pH. This indicator is used to assess the scale of the potential acidification of the world's ocean, mainly due to the increased inflow of carbon dioxide from the atmosphere. Monitoring of pH of the marine environment is the basis for determination of the trends of temporal and spatial changes, resulting both from human activity (mainly fossil fuel combustion) as well as natural (geological, hydrodynamic, climate/meteorological) factors and possible changes in the functioning of marine ecosystems.

The measurement data used to analyse pH changes in seawater were collected in 2006-2016 during research cruises conducted in the Polish exclusive economic zone (EEZ) with a frequency of 6 times a year.

The pH values measured during cruises in 2016 throughout the study area and throughout the entire depth range (from the surface to the bottom) varied from 7.04 to 9.23, and the range of this variability was greater than in the previous year (7.16-8.85), (Łysiak-Pastuszak 2016). In 2016, the average pH value of waters in the entire study area was 8.17 and was higher than the average for 2015 (8.16).

The range of pH variability of sea water in individual sub-basins was higher than that observed in the previous year, and the average annual values differed from those recorded in 2015 (Table 1.3.5).

Table 1.3.5. Extreme and average pH values in the waters of POM sub-basins in 2016 as compared to 2015

| Basin | Minimum | | Maximum | | Average | |
|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
| Gdańsk Basin | 7.16 | 7.04 | 8.85 | 9.22 | 8.12 | 8.12 |
| Eastern Gotland Basin | 7.28 | 7.20 | 8.63 | 9.00 | 8.30 | 8.20 |
| Bornholm Basin | 7.42 | 7.14 | 8.76 | 9.23 | 8.12 | 8.18 |

Considering the data received in 2016 against the background of the last ten years, a weak tendency of growing seawater pH has been observed, both in the whole area covered by the research and at the level of particular sub-basins. The average pH in 2016 in individual sub-basins was higher than the 10 year average (Fig. 1.3.10).

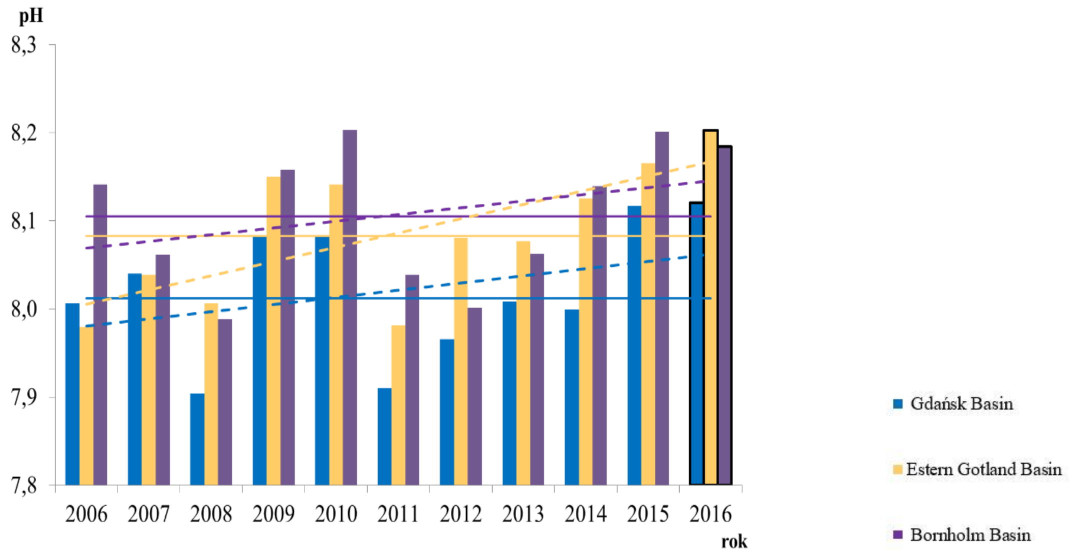


Fig. 1.3.10. Average annual pH values in the entire water column in 2006-2016 in the particular sub-basins of POM; solid line - average 2006-2015, dashed line - change trend (Data source: PMŚ)

The time variability of pH in the surface layer of the sea (0-10 m), which is a direct receptor of possible changes in the atmosphere, showed similar patterns as observed in the last decade for the entire water column (Figure 1.3.11).

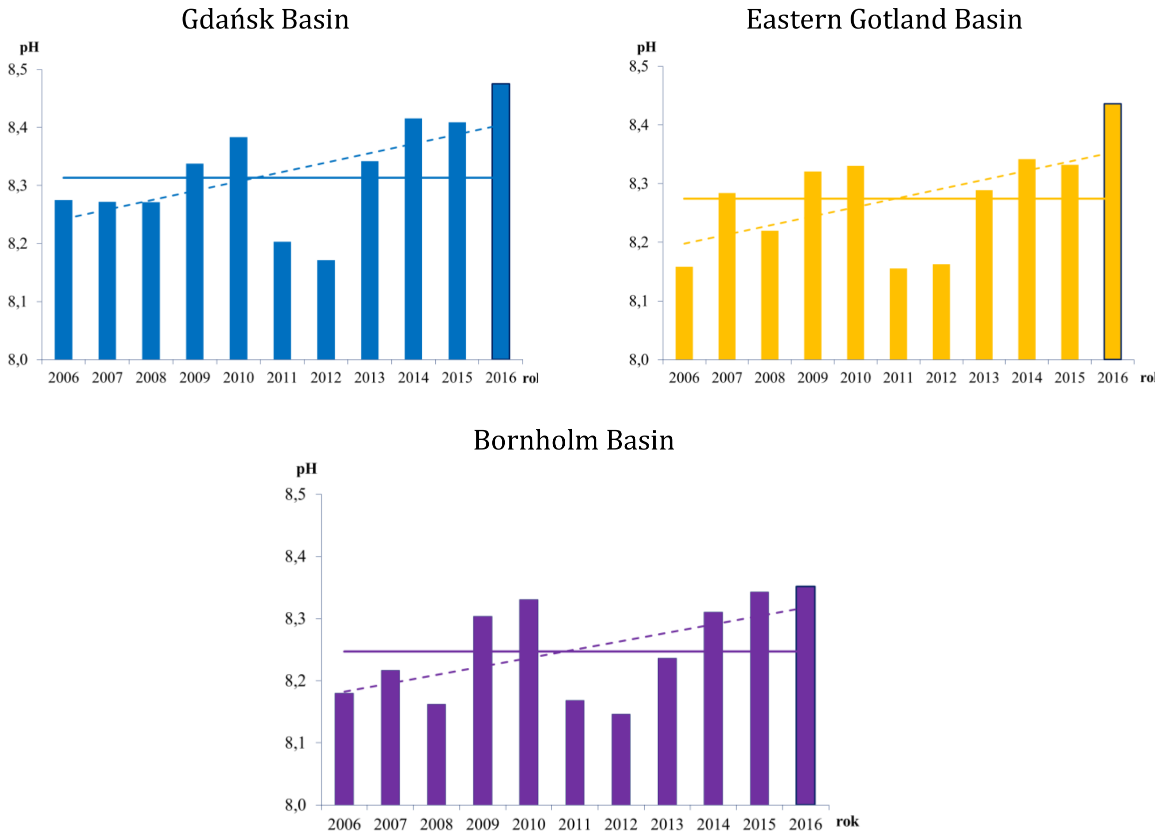



Fig. 1.3.11. Average values of pH in 2006-2016 in the surface layer (0-10 m) of individual areas of POM Baltic Sea (continuous line - average 2006-2015, dashed line - tendency) (Data source: PMŚ)

Changes in the pH of seawater are mainly the result of biological processes occurring in surface waters. During intense phytoplankton blooms, in the process of photosynthesis, carbon dioxide is absorbed from the environment and the oxygen released. Therefore, one can expect a correlation between the oxygen concentration and the pH value as well as spatial and temporal variability of this parameter related to the geographical and seasonal variability of photosynthesis intensity (Wesslander 2011).

Changes in the intensity of primary production were associated with seasonal changes in pH. In 2016, the highest pH values were measured during intensive vegetation (April-June). Characteristic vertical distribution of sea water pH, i.e. a drop in pH from the surface to the bottom, associated, among others, with the reduction of the amount of dissolved oxygen consumed in the deeper layers of the sea in chemical processes, e.g. the decomposition of dead organic matter, is illustrated in Fig. 1.3.12. However, this natural vertical distribution of sea water pH may be disturbed by extraordinary physical phenomena occurring in the sea, such as ocean water inflows or upwelling events. In 2016, the upwelling phenomenon was noted at the beginning of June in the shallow central coastal zone, when water, from the deeper layers with lower pH, was raised towards the surface (Drgas 2016).

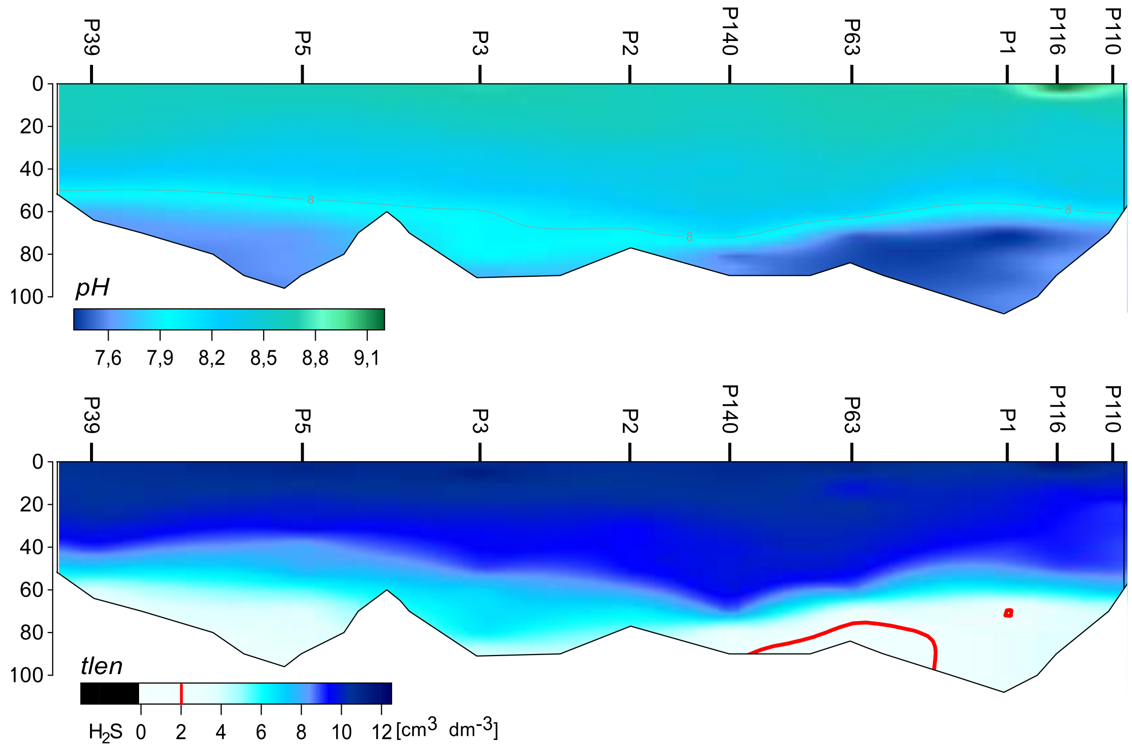



Fig. 1.3.12. Vertical distribution of pH and oxygen concentration in Polish EEZ waters along the deep sea section from the Bornholm Basin to the Gulf of Gdańsk (an example of the situation from April 2016) (Data source: PMŚ)

### *Sea currents and water exchange*

#### Sea currents

To present the hydrodynamic conditions in POM, measurements from the Baltic Sea Monitoring were used. The measurements were obtained using an ADCP RDI current meter during the ship's movement, which was carried out from 2006 to 2016. In shallow areas, subsurface currents were usually measured in layers of a 2.5 meter thickness from about 9.8 m to 12.3 m depths, while in regions with a depths greater than 25 m - in the layer from about 7.5 to 12.5 m.

The general characteristics of the distribution of currents for the period 2006-2015 is presented in the form of the currents roses determined for individual Baltic squares (Fig. 1.3.13).

The maximum range of the percentage scale of directions in all drawings is 30%.

The directions of subsurface currents in the Polish coastal zone were in the narrow range along the north-east-south-west axis. In the K02 square in the coastal zone of the Gulf of Gdańsk, generally long-term south-west and north-east currents were recorded, while in the L02 square in most cases they were currents directed to the shore. In the Pomeranian Bay, the northern and longitudinal direction prevailed.

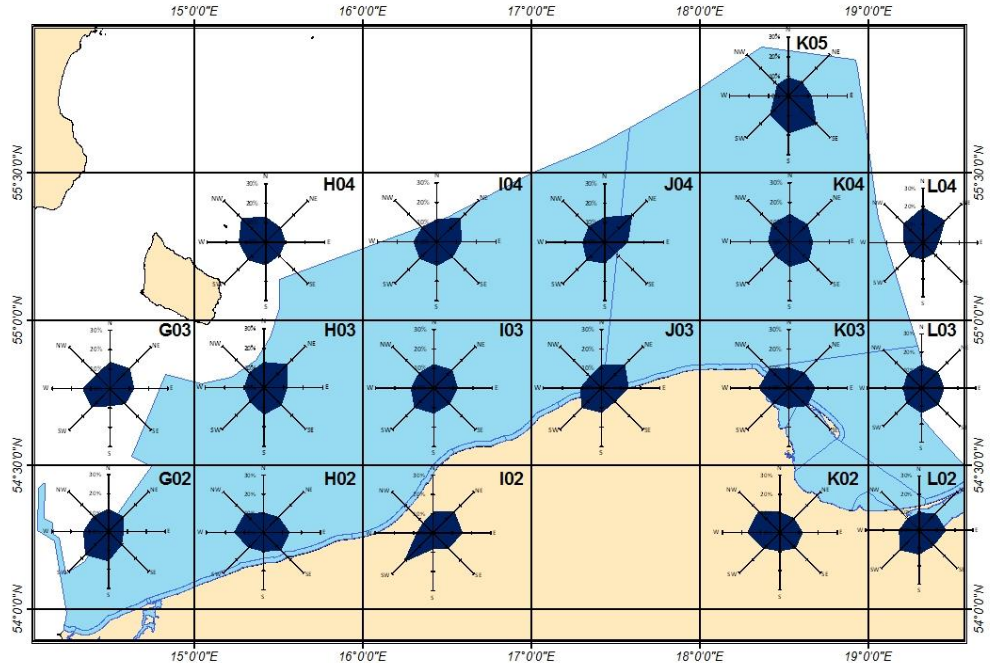



Fig. 1.3.13. Roses of currents in squares in the subsurface layer 7.5-12.5 m based on measurements from 2006-2015

The distribution of currents in the area of the Gdańsk Deep, located within the square L03, is mainly influenced by cyclone or counter-cyclone water flow systems created during the wind from different directions. As a result, there are currents with a similar percentage share for all directions, which is particularly evident in the case of long-term measurements.

In the Bornholm Basin for many years, in most cases these were the Northwest sector currents. Within the south-eastern slope of the Gotland Basin, southern currents dominated over many years.

In the squares covering the Słupsk Furrow (I04 and J04), north-eastern currents prevailed with a small, comparable share of other directions.

While measurements performed during cruises provide information on the conditions prevailing during the measurement of other parameters, a more complete picture of the hydrodynamics of the Baltic waters throughout the period covered by the update of assessment can be provided by the methods used to combine satellite data with numerical modelling.

The average sea current speeds in 2011-2016 were determined based on the results of the PM3D hydrodynamic model with a resolution of about 1 km in the southern part of the Baltic Sea (Kowalewski and Kowalewska-Kalkowska, 2017). This model assimilates satellite data (SST) and uses data on solar radiation input based on satellite information.

Based on the maps of surface and subsurface currents calculated using the model and collected with the 6 hour interval in the SatBałtyk System, average vector speeds V→ were determined on the surface and at a depth of 20 m in 2011-2016 by averaging temporal components u and v in each node of the computational grid:

$$\bar{u} = \frac{1}{N}\sum_{i=1}^{N} u_i \ , \quad \bar{v} = \frac{1}{N}\sum_{i=1}^{N} v_i \qquad (1)$$

The average module in a given computational node of a numerical grid was determined based on the formula:

$$\bar{V} = \frac{1}{N}\sum_{i=1}^{N} \sqrt{u_i^2 + v_i^2} \qquad (2)$$

Current stability (Lehmann and Hindrichsen, 2000) is the ratio of the mean module vector speed to the medium speed module:

$$S = \frac{|\overline{V}|}{\overline{V}} = \frac{\sqrt{\overline{u}^2+\overline{v}^2}}{\frac{1}{N}\sum_{i=1}^{N}\sqrt{u_i^2+v_i^2}} \quad (3)$$

Stability is characterized by numerical variability of the current and assumes values in the range from 0 to 1. The value of 1 would mean that in a given place (node of the computational grid) the current flowed throughout the analysed period in the same direction and at a constant speed.

On the basis of current maps from the PM3D model accumulated in the SatBałtyk System, the long-term average (for the period 2011-2016) of velocity modules, average vector velocities and surface current stability were determined (Fig. 1.3.14). The highest current velocities were recorded for the area located north of the Hel Peninsula, where the shoreline configuration stimulates intensification of currents, which results in the formation of upwelling and downwelling events. Although it is the most dynamic part of Polish sea area, the average vector speed and flow stability is small there. This is due to the alternating occurrence of opposite currents: in the south-east and north-west directions. These currents cause, respectively, the formation of down-welling and upwelling, and their resultant vector is directed at the south-east direction. The highest stability is characterized by surface currents flowing east along the shores of the central coast, which are determined by western winds prevailing throughout the year.

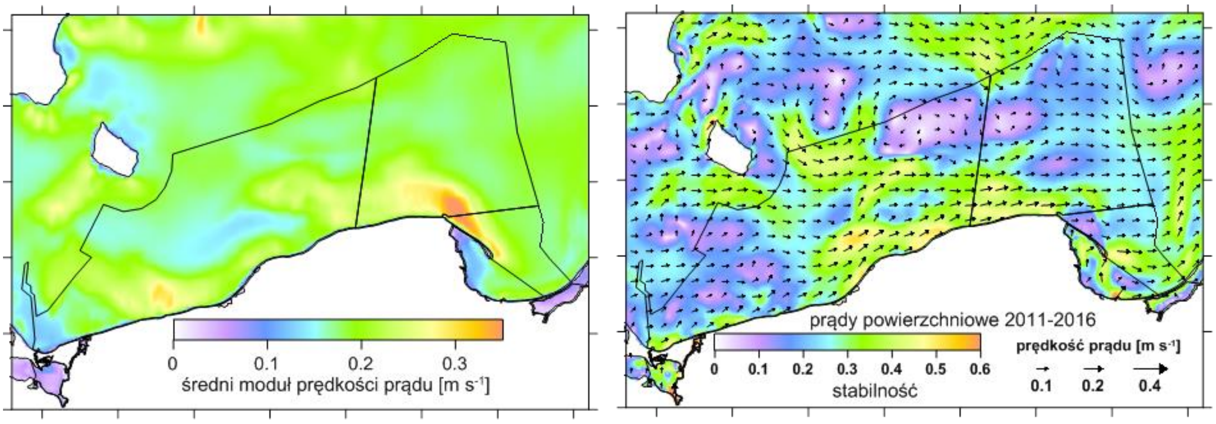



Fig. 1.3.14. Average surface currents and their stability in 2011-2016.

In the summer period (Fig. 1.3.15) the spatial distribution of currents is very similar to the annual system. Eastern trends prevail, slightly weaker and less stable than average annual.

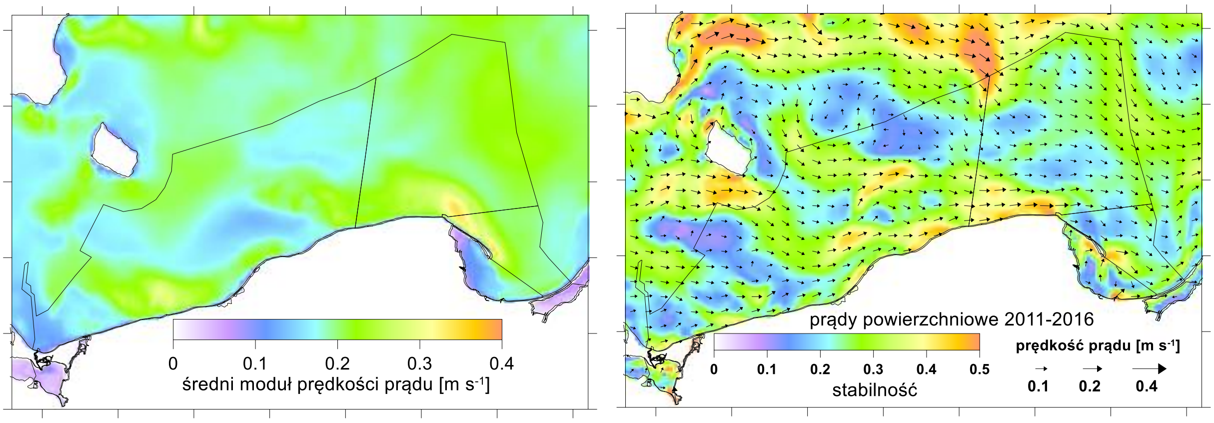



Fig. 1.3.15. Average surface currents and their stability in the summer months (V - IX) in 2011-2016.

The distribution of average subsurface currents (Fig. 1.3.16), at a depth of 20 m shows much smaller average speed modules in relation to the surface values. As in the case of surface currents, the intensification of flows is only visible in the area of upwelling/down-welling in Hel Peninsula. At the depth of 20 m, however, the currents were more stable, which means that the resulting current vectors have similar values, and sometimes even higher than at the surface ones. It is most noticeable in the case of a cyclone vortex east of Bornholm, which is much less distinct in the case of surface currents than at a depth of 20 m. Just like on the surface, along the central coast the resultant current flows towards the east and is characterized by relatively high stability. In the western part of the Gulf of Gdańsk, a subsurface current flowing in the north-west direction with increased stability appears, which together with the opposite directed current in the area of the Gdańsk Deep creates a counter-cyclone turbulence.

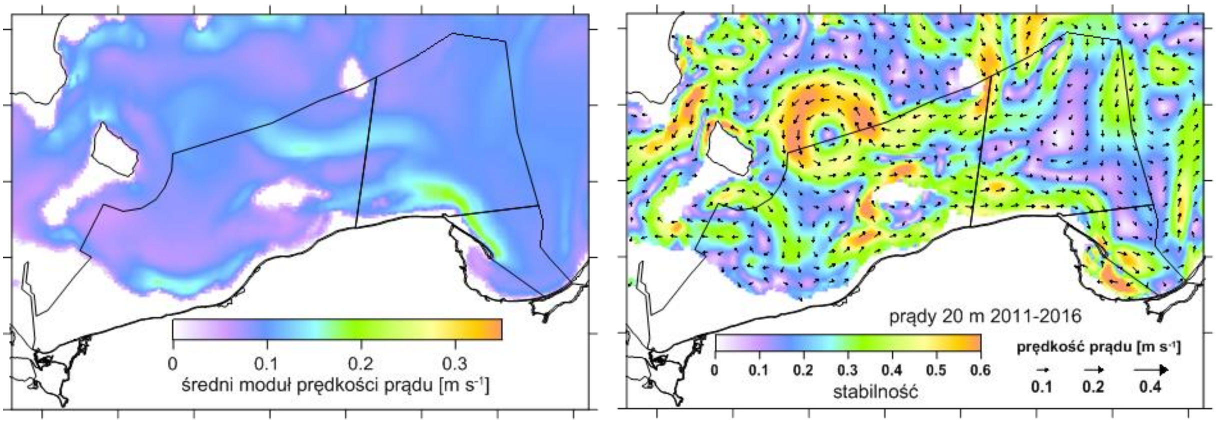



Fig. 1.3.16. The average velocity module, the average vector velocity and the stability of subsurface currents (at a depth of 20 m) in 2011-2016.

**Water exchange**

Water exchange in the Polish zone of the Baltic Sea occurs both at the local scale, in the surface layer of coastal regions, as well as regional in near-bottom layer. In the first case, it involves the inflow of river waters to the sea and rainfall, in the second case - it results from the occurrence of irregular inflows of saline waters from the North Sea through the Kattegat. The Baltic Sea is connected to the North Sea with shallow and narrow straits. The water exchange takes place over shallow underwater thresholds in the Sund (8 m deep) and the Great Belt (15-16 m deep). Revival of waters in the Southern Baltic deeps can only take place in case of extreme inflows into the Baltic Sea.

In the period from 2011 to 2015, one of the largest inflows to the Baltic Sea occurred (in 2014), and there were other, less significant, moderate and medium ones.

In 2011, considerable inflows occurred (however, those belonging to moderate): at the turn of January and February, March and April, in May and at the turn of November and December 2011. The inflow at the turn of November and December 2011, affected the thermohaline in the Polish near-bottom waters still in 2012. It also revitalised the waters of the Bornholm and Gdańsk Basins. In autumn 2014, one of the largest inflows of salt water from the North Sea began. According to the Leibniz-Institut für Ostseeforschung Warnemünde (www.io-warnemuende.de), the inflow volume was 198 $km^3$, while the amount of transported salt was around 4 Gt (IOW 2015a). At the time of this inflow at station P5, the highest measured salinity was 19.6. The inflow was even noticed in the central Baltic Sea. The effects of this event were visible in the following year, and during the monitoring cruises very high salinity values were recorded in the bottom waters of the Bornholm Basin. Subsequently, several weak and medium inflows occurred: in March 2015, November 2015, which had an impact on the conditions of salinity, oxygen and temperature conditions.

In 2016 there were no large inflows, only medium in February 2016 and weak at the turn of November and December 2016. During monitoring cruises only slightly higher salinity values were recorded in the bottom waters of the Bornholm Basin. At stations located further east

(P140), only the slight salinity increase in the bottom layers was observed during the April cruise.

Hindered inflow of sea waters and a large inflow of freshwater (several large rivers flowing into the Baltic Sea) significantly determines not only the physicochemical parameters of water in this basin, such as salinity, temperature or oxygenation, but also makes the Baltic Sea particularly susceptible for pollution and eutrophication. The specificity of this reservoir also affects the relatively low number of species inhabiting it, while favouring the introduction of alien species. This in turn is considered one of the most important threats to biodiversity[1].

[1] from the justification for the application for the ratification by Poland of the International Convention for the Control and Management of Ships' Ballast Water and Sediments

## 1.4.Habitats and species

### *Marine mammals*

Four species of marine mammals occur in the Baltic Sea: grey seal (*Halichoerus grypus*), common seal (*Phoca vitulina*), ringed seal (*Pusa hispida*) and harbour porpoise (*Phocoena phocoena*). In 2015 new Polish names of seals were proposed: 'szarytka morska' for *Halichoerus grypus* and 'nerpa obrączkowana' for *Pusa hispida* (Cichocki et al. 2015). Marine mammals play an important role in the functioning of the food web, but as all top predators, they are sensitive to pressures and alterations occurring at all trophic levels. Exposure to cumulative pressures makes marine mammals important indicators of the condition of the Baltic Sea ecosystem.

Populations of all mentioned species underwent a significant decline in the Baltic Sea at the turn of the 19th century, mainly due to hunting (HELCOM 2017a) and strong pressure from chemical pollution of the marine environment (Helle 1980), and only the grey seal population is currently above the Limit Reference Level (LRL), defined for the Baltic seals at the level of 10,000 individuals (HELCOM 2017a). Historical data does not provide an opportunity to accurately determine the size of marine mammals population in the Polish Marine Areas (POM) before the period of rapid decline in the population of grey seal and harbour porpoise, but these species were permanent and numerous components of fauna in the Polish zone of the Baltic Sea back then. By-catches of the porpoise in the 1920s and 1930s amounted of several hundred individuals per year. Seals were caught in significant quantities during this period. The data comes from the register of fishermen compensations. In the post-war period no regular information on marine mammals was available, and the first information about the porpoise by-catch was presented in the 1950s (Ropelewski 1952, Pawliczka et al. 2013).

Fot. 1.4.1. Seals resting on the sandbar – the place of permanent occurrence of the species (haul-out) in the area of Vistula mouth, (photo: Maritime Institute in Gdańsk)

Of the three species of Baltic seals, only the grey seal is permanently present in waters of the POM and occupies a permanent haul-out place (the place where seals go ashore to rest between feeding periods, to mate and moult) in the area of Vistula mouth. Since 2007 individuals of this species have been systematically registered, and since 2010 the site has been under constant surveillance of cameras as part of joint projects to support the conservation of marine mammals by WWF Poland, Marine Station of the University of Gdańsk (SMIOUG) and the Foundation for the Development of the University of Gdańsk (FRUG) (Pawliczka 2012, Hylla-Wawryniuk 2017). Males of grey seals were observed several times, and in 2016 the birth was observed for the first time., A new-born puppy of the common seal was recorded in 2011 (Pawliczka 2012, Hylla-Wawryniuk 2017). It should be emphasized that both camera observations and observations done by observers (so-called 'reports' in the WWF database) are not compatible with the state environmental monitoring (PMŚ) as well as not fully compatible with the HELCOM methods recommended for monitoring of grey seals (HELCOM 2017b). Gray seal monitoring in 2016-2017 was performed as part of the "Pilot implementation of species and marine habitats monitoring in 2015-2018" (PMŚ), along the Polish coast with the use of aerial observations recommended by the HELCOM, which confirmed the regular occurrence of a grey seal in the area of Vistula mouth.

The remaining seal species: common and ringed seals are monitored at places of permanent occurrence (haul-outs), which are located outside POM.

The common seal forms two meta-populations in the Baltic Sea: the south-western Baltic and Kattegat, and Kalmarsund. Numerous individuals were regularly recorded in POM. Some 90 reports on the occurrence of this species were recorded between 2010 and 2016 (Hylla-Wawryniuk 2017). Several common seals were observed on haul-out of grey seals in the Vistula mouth area (Pawliczka 2012, Hylla-Wawryniuk 2017, Opioła et all. 2017). However, taking into account the recommended monitoring methods of this species and the indicators adopted for the assessment of the population (HELCOM 2017b), it is not possible to perform the common seal parametric assessment in the POM.

The Gulf of Bothnia and the Archipelago Sea, Gulf of Finland, Gulf of Riga and coastal waters of Estonia are the areas in which ringed seals occur. This species occurs sporadically in POM. Since 2010 only 3 specimens has been found in the area of Vistula mouth and 19 reports on observations were published in 2011-2016 in the remaining area (Hylla- Wawryniuk 2017). Since the aerial monitoring of ringed seals is conducted in areas of the Baltic Sea covered with ice during the breeding season, it is not possible to use the data from incidental observations for parametric assessment of the ringed seal condition in POM.

In the case of the only representative of cetaceans (Cetacea) occurring in POM – harbour porpoise, the population size in the Baltic can only be estimated by acoustic monitoring. The SCANS (Small Cetaceans in European Atlantic and North Sea) projects implemented within the framework of the 'Life' programme, including the western part of the Baltic Sea (SCANS I) and mini-SCANS projects implemented individually by EU countries, did not give a definite answer to the questions regarding the size of the Baltic porpoise population, the population trends and changes. The SAMBAH project, in which underwater sound recorders deployed in almost the entire Baltic area allowed to estimate the size of harbour porpoise population (SAMBAH 2017). The results obtained in this project enabled the delimitation of two sites (Ławica Stilo and Pomeranian Bay) to conduct the state environmental monitoring within POM (Opioła et al. 2016).

Acoustic monitoring of this species carried out at regular intervals will allow to detect changes in the range and abundance of the harbour porpoise occurring at POM.

***Birds***

The monitoring of the populations of sea birds is conducted by Chief Inspectorate for Environmental Protection for the purpose of MSFD implementation report.

Monitoring surveys of birds carried out in sea areas located in POM can be divided into three components:

- monitoring of wintering water birds in the transitional waters ,
- monitoring of wintering water birds in the offshore waters,
- monitoring of breeding birds.

Black-headed gulls *Chroicocephalus ridibundus*

Within the scope of breeding populations monitoring, due to different breeding biology, the research is focussed on individual target species. Dedicated monitoring projects include :

- monitoring of cormorant abundance,
- monitoring of sandwich tern abundance,
- monitoring of dunlin abundance,
- monitoring of the white-tailed eagle productivity.

**Monitoring description**

Field research methods applied in the Polish territory are in accordance with the guidelines for monitoring in the Baltic Sea basin (Herrmann et al. 2013, Wetlands International 2015). Methods of all bird monitoring programms are available at www.monitoringptakow.gios.gov.pl.

***Monitoring of Wintering Water Birds in transitional Waters***

The aim of the Monitoring of Wintering Bird in Transitional Waters (MZPWP) is to determine the abundance of the most numerous species of water birds spending winter in Poland the coastal reservoirs and the coastal zone of the Baltic Sea. Altogether 31 of the most important objects are surveyed, mainly sections of the coast and coastal lagoons. These include the Baltic Sea coastal zone (counting done from the shore), coastal reservoirs and shallow-water lagoons (the Szczecin Lagoon with the Kamieński Lagoon, the Puck Bay, the Vistula Lagoon) as well as the estuary of the Vistula. One counting in each object is performed in mid-January. The time and methods of counting are consistent with the international counting of wintering water birds, the International Water bird Census (IWC), coordinated by Wetlands International (2015). The basic method of counting is observing birds with the binoculars along the banks of the reservoir or section of the river and record all observed water birds (Meissner and Chylarecki 2010).

All species of water birds are registered during counting. For the purposes of this report, the results obtained in 2011-2016 in the Polish transitional waters for 22 species included in the indicator ‘the number of wintering water birds’ used by HELCOM (HELCOM 2018a) are described.

### *Monitoring of Wintering Water Birds*

Monitoring of Wintering Water Birds (MZPWP) includes the counting of water birds wintering in open sea areas. It is conducted from the ship's deck along transects designated in the three divisions in the Polish EEZ of the Baltic Sea : in the 12-mile zone of territorial waters (excluding the 1 km zone off the shore) - 42 transects, in the area of special bird protection (OSOP) Natura 2000 Ławica Słupska, inside the 20 m isobath - 8 transects and in the OSOP Pomeranian Bay, excluding coastal waters - 6 transects.

All observed birds are counted, and their occurrence is assigned to four categories regarding the distance from the ship (distance sampling). For the purpose of calculating population number indicators, the results are summed up to 1 transect of a width of 600 m (300 m on each side of the ship). In addition, at constant intervals, snap-shot counts are performed (counting of all flying birds at intervals of 5 minutes). Each transect is controlled once in the winter season, mid-January (Meissner 2010).

At the planning stage of the monitoring (2010), 10 target species of wintering birds wintering in great numbers were selected for monitoring in the Polish Baltic zone. Rare species and gulls were not included. The monitoring data was used only partially to calculate the wintering bird population indicator (HELCOM 2018a). In subsequent years, the HELCOM indicator is to be developed including species wintering in the open sea.

### *Monitoring of the White-tailed eagle productivity*

Monitoring of the white-tailed eagle productivity (MPB) includes monitoring of recognized breeding sites of the white-tailed Haliaeetus albicilla along the Polish coast of the Baltic Sea in a 10 km wide shoreline zone. The main goal of the program is to determine the reproductive parameters of the coastal population of the species and relation to the environmental status of the Baltic waters. The accumulation of toxic substances in the bodies of birds of prey causes a reduction of their reproduction, therefore the productivity of the white-tailed eagle population in the coastal zone is one of the indicators of the quality of the Baltic waters. The first research in this sub-program under the State Environmental Monitoring was started in 2015. For the purpose of this report, the database was supplemented with unpublished data from 2011-2014 stored in the database of the Eagle Protection Committee.

The productivity of the white-tailed eagle is assessed by 3 indicators :

(1) average number of chicks per breeding pair;
(2) average number of chicks per pair with successful breeding;
(3) breeding success - an index defining the percentage of pairs that raised young in relation to the number of all pairs with the known end-effect of breeding.

In 2015 and 2016, 84 and 97 known breeding sites of the species were inspected respectively, adding newly located sites each year to the data set. Each breeding site was inspected at least twice, in the initial (March/April) and final stage of the clutch (May/June) (Cenian 2015). Observers controlled the inside of the nest by climbing a tree at about half of the nests with known breeding results. If the control of the nest took place in the period when the chicks were just beginning to moult, an additional control was performed. In the areas where the location of the nest was unknown, surveys from observation points were carried out and the habitats suitable for the white-tailed eagle were searched in forests and tree stands.

***Monitoring of Cormorant***

Monitoring of Cormorant (MKO) has been conducted since 2015, and its purpose is to assess the abundance of the cormorant *Phalacrocorax carbo* population, including the size of the coastal population of the species, nesting in the coastal zone within 10 km from the Baltic shoreline. The basic method used in the program is the counting of nests (breeding pairs) in known cormorant colonies in monitoring areas of 10 x 10 km and finding new colonies (Bzoma 2015). Each colony was inspected once a year, between April 20th and May 20th. The occupied nests were counted, on each tree separately, then the trees were marked in order to avoid re-counting.

Cormorant colony *Phalacrocorax carbo*

***Monitoring of Sandwich tern***

The main goal of the Sandwich Tern Monitoring (MRC) that started in 2015 is to determine the abundance of the breeding population of the species. The number of nests is recorded at a time that guarantees a result close to the maximum (Bzoma 2015a). The term depends on the phenology of breeding in a given year. The number of nests is treated as the number of breeding pairs in a given colony. In the years 2015 and 2016, the sandwich tern nested in Poland only at one site - in the Mewia Łacha reserve at the mouth of Vistula Przekop.

In MRC, up to 6 inspections of each station are performed. Until the first eggs appear, the observations are carried out using a telescope from a distance of 200-300 m from the potential colony. Controls with the entrance to the colony, combined with the counting of laying down, should be carried out simultaneously by several people in order to maximally shorten the time of visiting the breeding colony (up to one hour).

The number of nests found with eggs or chicks corresponds to the number of breeding pairs in the stand. Due to the large span of the breeding period (at the same time freshly laid eggs and the first hatching chicks appear), the final results of the three controls of the colonies, from the first eggs to one month after this date, should be used for the final pair assessment. Colony size is the maximum number of hatchings counted.

***Monitoring of Dunlin***

The purpose of the Dunlin Monitoring program (MBZ) is to obtain the most complete data on the distribution and abundance of the breeding population of the Baltic subspecies of dunlin *Calidris alpina schinzii*. In the period 2011-2016, 9 research areas, dimensions of 10 x 10 km were covered by inspections. They included breeding sites known from previous years and potential nesting sites located in the coastal zone (10 km from the Baltic shoreline) and in the Biebrza Marshes. Site inspections were performed in species-optimal habitats, wet coastal meadows with halophilous vegetation, conditioned by cattle grazing and regular salt water inflows.

Counting of birds is carried out twice during the breeding season: 10-30 April and 10-31 May (Sikora 2006). Between the 1st and 2nd inspection, the time interval should last about 30 days. The survey includes thoroughly penetrating the patches of potential habitats of the species. During the inspection, the criterion of nesting individual individuals / pairs is recognized. The first inspection is aimed at detecting the tending birds during the highest detection period before the proper breeding. The second control is aimed at detecting and assessing the number of birds during the incubation period. In both inspections, observers spend at least 2-4 hours per day at a given position (depending on the area of the respective habitats), penetrating the area in detail, so that the distance between the crossing routes is not greater than 100 m

**Indicators and abundance trends in the Polish water zone**

***Monitoring of Wintering Water Bird of transitional Waters***

Below, the number and density (number of individuals per km of transect) of 22 species in the number of wintering water birds were presented (Table 1.4.1). The obtained data allowed to calculate population trends for 18 species (the remaining four were recorded in too low numbers) by fitting the exponential curve to the data. In 2011-2016, growth trends dominated among birds wintering in Polish transitional waters (parameter value greater than 1.00), which were found in 11 species (Table 1.4.1, Fig. 1.4.2). On average, birds of this group increased their numbers by 8% per year.

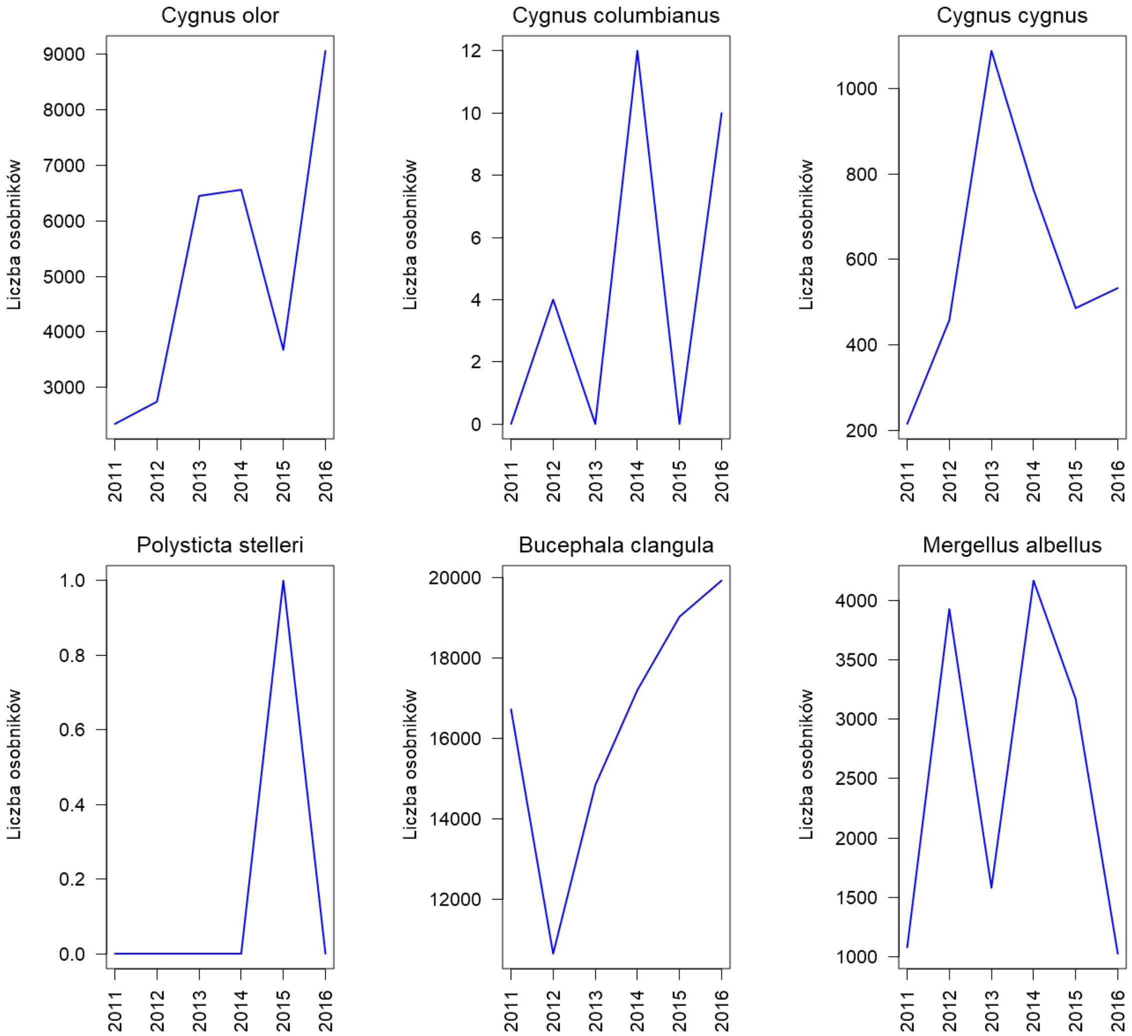
It should be noted that the analysis of long-term trends of individual species is usually made for large geographical units (e.g. Svazas et al. 2001, Nilsson 2008, Musilová et al. 2009, Wetlands International 2015). Depending on the weather conditions prevailing in a given season, in particular the extent of water reservoirs covered with ice in the whole country and in neighbouring countries, water birds travel long distances in search of places suitable for wintering (Ridgill and Fox 1990, Svazas et al. 1994). It can therefore be assumed that the significance of transitional waters grows during severe winters, because transitional waters (mainly the estuary sections of the Vistula and Oder, and the coastal zone of the Baltic Sea) freeze later than inland reservoirs located far from the Baltic Sea coast. Birds migrate there from ice-covered reservoirs, as well as the Baltic coastal lagoons that freeze relatively early (Svazas et al 1994). At the same time, climate change trends are shifting the European wintering grounds of many waterfowls north-east (Lehikoinen et al 2013, Pavon-Jordan et al. 2015). The effect of these changes are strong directional trends observed on a smaller geographic scale with unchanged (or slightly changed) numbers of total wintering populations in Europe.

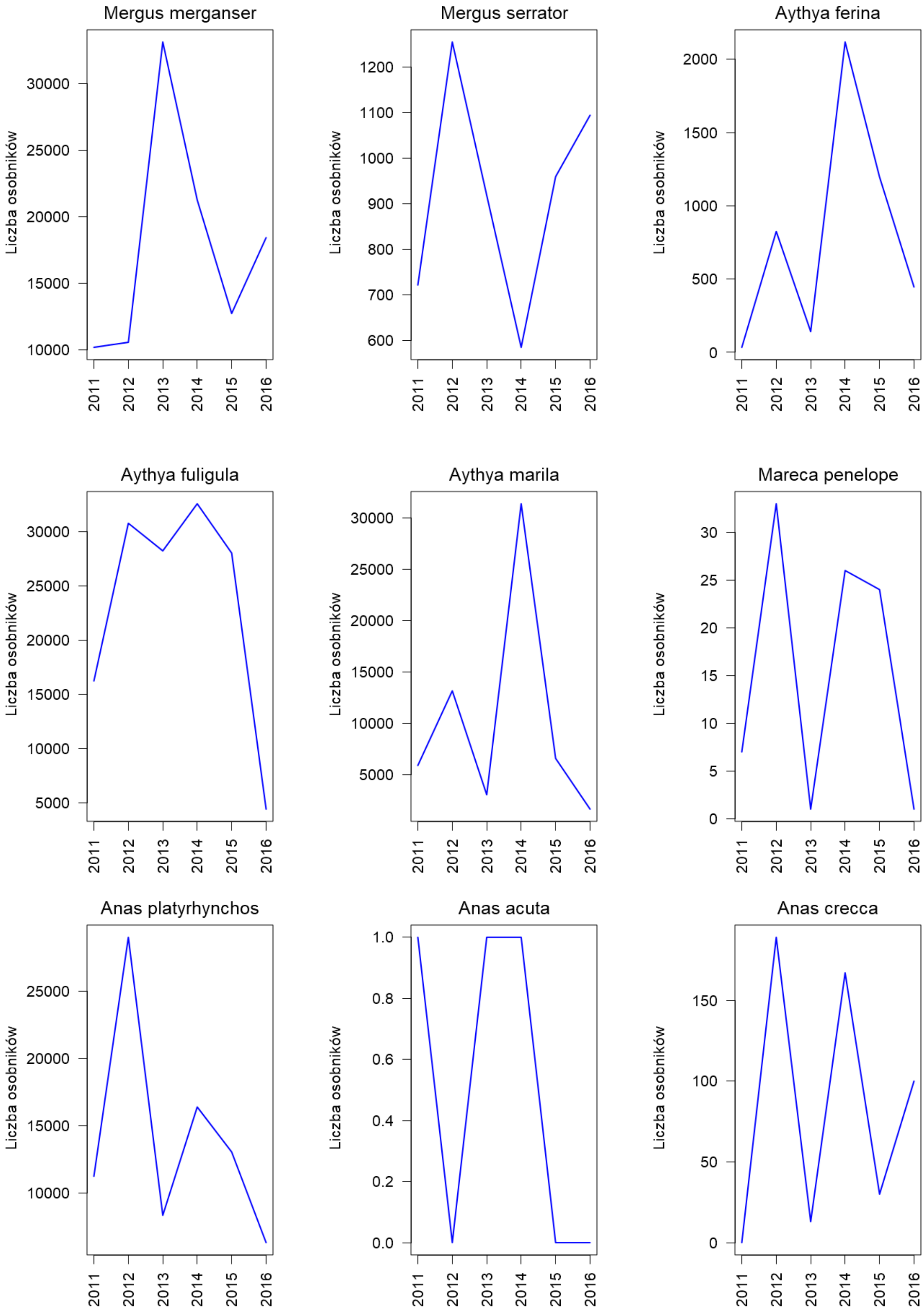
Table 1.4.1. Number of individuals and the trend of changes in the number of 22 species in the Monitoring of wintering birds in transitional waters recorded at 31 sites in 2011-2016.

| Species | Number of individuals per year | | | | | | Trend |
|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | |
| Mute swan *Cygnus olor* | 2345 | 2746 | 6445 | 6557 | 3678 | 9055 | 1.244 |
| Tundra swan *Cygnus columbianus* | 0 | 4 | 0 | 12 | 0 | 10 | - |
| Whooper swan *Cygnus cygnus* | 215 | 458 | 1088 | 763 | 486 | 533 | 1.133 |
| Steller's eider *Polysticta stelleri* | 0 | 0 | 0 | 0 | 1 | 0 | - |
| Common goldeneye *Bucephala clangula* | 16729 | 10649 | 14840 | 17208 | 19032 | 19932 | 1.082 |
| Smew *Mergellus albellus* | 1077 | 3928 | 1580 | 4168 | 3170 | 1024 | 1.002 |
| Common merganser *Mergus merganser* | 10205 | 10585 | 33134 | 21271 | 12750 | 18441 | 1.092 |
| Red-breasted merganser *Mergus serrator* | 721 | 1255 | 918 | 584 | 959 | 1094 | 1.024 |
| Common pochard *Aythya ferina* | 34 | 825 | 142 | 2118 | 1196 | 446 | 1.611 |
| Tufted duck *Aythya fuligula* | 16254 | 30793 | 28248 | 32592 | 28044 | 4435 | 0.827 |
| Greater scaup *Aythya marila* | 5916 | 13170 | 3068 | 31356 | 6600 | 1670 | 0.841 |
| Eurasian wigeon *Mareca penelope* | 7 | 33 | 1 | 26 | 24 | 1 | 0.809 |
| Mallard *Anas platyrhynchos* | 11232 | 29013 | 8325 | 16386 | 13037 | 6292 | 0.876 |
| Pintail *Anas acuta* | 1 | 0 | 1 | 1 | 0 | 0 | - |
| Eurasian teal *Anas crecca* | 0 | 189 | 13 | 167 | 30 | 100 | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Great crested grebe *Podiceps cristatus* | 942 | 734 | 860 | 3507 | 2580 | 2545 | 1.336 |
| Eurasian coot *Fulica atra* | 481 | 11184 | 10359 | 24191 | 5526 | 6617 | 1.403 |
| Black-headed gull *Chroicocephalus ridibundus* | 4640 | 6773 | 4930 | 5461 | 7362 | 6607 | 1.062 |
| Common gull *Larus canus* | 2676 | 6645 | 3754 | 3980 | 4540 | 2445 | 0.957 |
| European herring gull *Larus argentatus* | 19818 | 25144 | 12998 | 15022 | 13388 | 13740 | 0.903 |
| Great black-backed gull *Larus marinus* | 762 | 634 | 438 | 542 | 628 | 502 | 0.947 |
| Cormorant *Phalacrocorax carbo* | 3502 | 3576 | 5164 | 8231 | 5016 | 10966 | 1.228 |

The trend is defined as the average annual rate of change in the size of the population during the study period, estimated using the exponential model. For species listed at very low numbers, the trend was not estimated due to the low confidance of the data.




Mergus merganser
Mergus serrator
Aythya ferina
Aythya fuligula
Aythya marila
Mareca penelope
Anas platyrhynchos
Anas acuta
Anas crecca
Liczba osobników
2011
2012
2013
2014
2015
2016

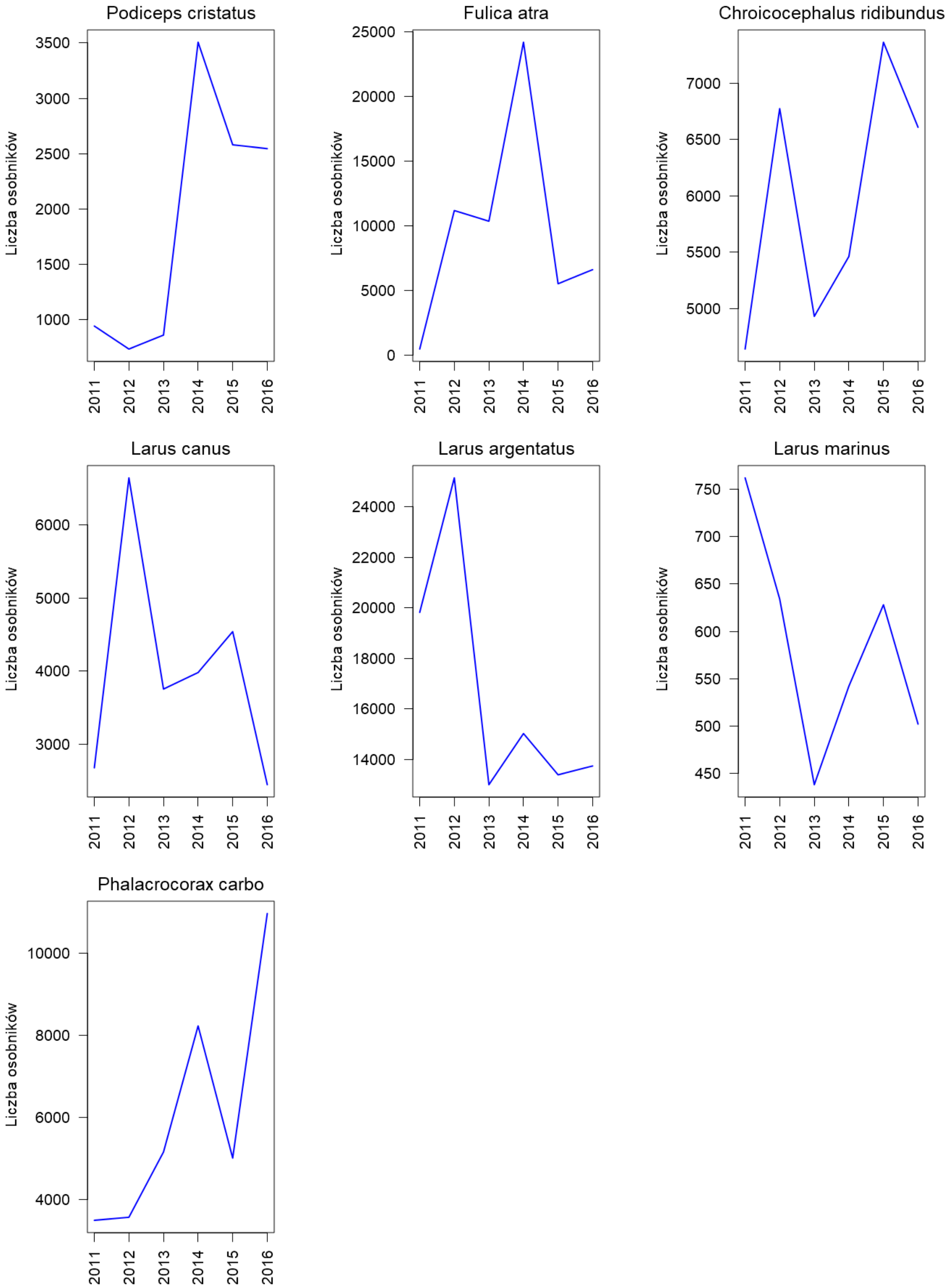



Fig. 1.4.2. Changes in the number of 22 bird species based on the Monitoring Data of Wintering Birds in Transitional Waters, in 2011-2016. (Data source: PMŚ)

**Mute swan *Cygnus olor***

The wintering population in the transitional water zone was assessed on average for about 5,000 individuals, with a clear upward trend - from over 2,000. birds in 2011 and 2012 up to 9,000 individuals in 2016. The average rate of increase in numbers was 24% per year during this period. Over 90% of the mute swans were found in the lagoons, and only 1-4% of the birds were recorded along the shores of the open sea (average of 0.40 indiv./km of the transect, range 0.23-0.77 indiv./km

**Tundra swan *Cygnus columbianus***

Very rarely and not annually, up to 12 birds.

**Whooper swan *Cygnus cygnus***

Species recorded annually, from about 200 to about 1000 birds, with a clear upward trend. In 2011-2016, the wintering population in the transitional water area increased at a rate of 13% per year. Whooper swans were found almost exclusively on lagoons and coastal lakes, and only single birds were recorded on the coast of the open sea.

**Steller's eider *Polysticta stelleri***

Exceptionally stated - only one observation of a single bird in 2015.

**Common goldeneye *Bucephala clangula***

Wintering species in the Polish transitional waters usually amounted 15-20 thousand individuals. Only in 2012, clearly less numerous (slightly over 10,000 birds). The numbers in the last 6 years showed an upward trend and increased at a rate of approx. 8% annually. Most of the goldeneyes were recorded in the lagoons and in the mouth section of the Vistula Przekop (an average of 82% of the population overwintering in transitional waters), although the species was also abundant on coastal sections of the sea (mean density 6.41/km, range 1.32-116.10 indiv./km).

**Smew *Mergellus albellus***

The wintering population in 2011-2016 in transitional waters ranged from 1 to 4 thousand birds. Changes in abundance in this period did not form a directional trend and in subsequent winter seasons the species was recorded alternately in high (> 3000 individuals) or low (<1500) abundances. The overwhelming majority of the wintering population (98% on average) was found on reservoirs (lagoons, estuaries, coastal lakes), and densities on the open sea coastal sections were low (0.14 indiv./km, range 0.04-0.54 indiv./km).

**Common merganser *Mergus merganser***

The wintering population in transitional waters changed in 2011-2016 within wide limits, from about 10,000 up to over 30,000 individuals. Over 80% of birds (in particular seasons 67 to 97%) were recorded in lagoons, while along the shores of the open sea the species was found in densities from 0.58 to 5.08 indiv./km (average 2.52 indiv./km).

**Red-breasted merganser *Mergus serrator***

The smallest of three species of red-breasted merganser, recorded in subsequent seasons in quite similar numbers (from about 600 to about 1,200 birds, on average about 900 individuals). Found mainly (on average 62% of birds, range 42-84%) along the shore of the open sea, in densities of 1.19 indiv./km (range 0.71 to 1.49 indiv./km). One-third of the birds were observed in the lagoons, and observations of this species in coastal lakes and estuary sections of the rivers were exceptional.

**Common pochard *Aythya ferina***

The wintering population in the years 2011-2016 in the transitional waters zone was small (from several dozen to about 2,000 birds, on average about 800 individuals), with the rising number in the upward trend. The common pochards were found mainly in lagoons and coastal lakes (> 90% of observed birds), and records along the shore of the open sea and on the rivers were exceptional.

**Tufted duck *Aythya fuligula***

In 2011-2016, in general, over 15,000 indiv. wintered in the transitional waters up to over 30,000 tufted ducks, only in 2016 there were less than 5 thousand individuals. Most records (on average 86%, range 55-97%) concerned birds in lagoons. In the coastal lakes, relatively few birds were noted (on average 9% of birds, range 0-20%). Observations from coastal waters of the open sea and rivers were limited (in total 6%). The densities of tufted ducks observed along the shores of the Baltic Sea were at the level of 0.83 indiv./km (range 0.06 -1.69 indiv./km).

**Greater scaup *Aythya marila***

The wintering population was usually estimated at approx. up to 13,000 birds, only in 2014 was found over 30 thousand. Almost 90% of birds were found in lagoons (average 89%, range 73-100%). Birds found along the shores of the open sea constituted on average 10% of the wintering population in the transitional waters (range 0-27%) and occurred in densities of the order of 0.45 indiv./km (range 0.06 to 0.98 indiv./km).

**Eurasian wigeon *Mareca penelope***

Species found annually, but in very low numbers, maximum 33 birds in 2012.

**Mallard *Anas platyrhynchos***

The species is wintering abundantly in Polish transitional waters, with quite high variability of the number of birds found in subsequent seasons (from 6-30 thousand birds). In general, in the period covered by the report, the number decreased at a rate of about 13% per year. On average, over 80% of birds were found on reservoirs and only a small fraction was recorded on coastal sections of the open sea, where average density was 3.02 indiv./km (range 0.48-5.63 indiv./km).

**Pintail *Anas acuta***

In the years 2011-2016, three instances of wintering individuals were found.

**Eurasian teal *Anas crecca***

The wintering population in the transitional waters was small (a maximum of over 300 individuals) and less than 30 birds were recorded in the middle of seasons or no species was found at all.

**Great crested grebe *Podiceps cristatus***

In the first half of the research period (2011-2013), the number of 700-900 birds was recorded, while in the next three seasons it was found in numbers exceeding 2,500 individuals. Slightly more than half of the birds (54% on average, 18-82%) stayed on lagoons, and 44% (range 17-87%) wintered on the coastal waters of the open sea. The average density of the great crested grebes recorded along the sea shore was at the level of 2.31 indiv./km (range 0.54-5.49 indiv./km). On the sea lakes and rivers the species was rare.

**Eurasian coot *Fulica atra***

The wintering population in 2011-2016 in the national transitional waters fluctuated within wide limits, from about 500 to nearly 25,000 birds (on average, about 9700 individuals). Two-thirds of the Eurasian coots were recorded in lagoons (average 63%, range 6-95%), one third in coastal lakes (average 32%, range 5-92%), and observations from the coast of the open sea and rivers were few. The density of Eurasian coots along the edge of the open sea was on average 0.87 indiv./km, with a wide range of variability from 0.01 to 2.84 indiv./km.

**Black-headed gull *Chroicocephalus ridibundus***

The wintering population was relatively stable and ranged from around 5,000 up to 7,000 individuals. Two thirds of birds of this species occurred in lagoons (on average 64%, range 45-73%). About 35% of birds of this species were recorded along the shore of the open sea (range 25-54%), with densities amounting to an average of 2.59 indiv./km (range 1.77-4.54 indiv./km). The total number of wintering black-headed gulls showed an upward trend and increased at a rate of about 6% per year.

**Common gull *Larus canus***

The wintering population was about 2.5 thousand up to approx. 6.5 thousand individuals, but usually less than 5,000 birds. The most frequent in 2012, when there were a total of 6645 individuals. Usually found in lagoons (on average 75% of individuals, range 64-87%). Along the shore of the open sea, encountered less frequently (23% of individuals, range 10-34%) in densities between 0.91 and 3.45 indiv./km (average 1.61 indiv./km).

**European herring gull *Larus argentatus***

The most numerous of the European herring gulls in the transitional water zone. In the first two seasons of research (2011 and 2012), the number was at the level of 20,000 - 25,000 birds, after which it dropped to the level of 13,000-15,000. Almost half of the birds (48% on average, range 31-59%) were noted in the lagoons. 46% of birds of this species were present along the open sea (range 36-68%), with densities amounting to an average of 11.18 indiv./km (range 6.72 to 24.08 indiv./km).

**Great black-backed gull *Larus marinus***

The number of species throughout the entire study period showed a relatively small variability, from about 450 to about 750 birds, the most frequently observed in the first two seasons (2011 and 2012). Half of the birds (on average 54%, range 33-72%) were noted in the lagoons. Along the shore of the open sea, encountered less frequently (34% of individuals, range 22-44%), in densities ranging from 0.16 indiv./km to 0.61 indiv./km (average 0.36 indiv./km).

**Cormorant *Phalacrocorax carbo***

In the first two seasons of research, the number was estimated at about 3,500 birds, in subsequent seasons increasing in number and in 2016, about 11,000 individuals were found. It occurred mainly in lagoons (on average 82% of individuals, range 70-94%). Along the shores of the open Baltic Sea, it was found in densities amounting to an average of 1.75 indiv./km (range: 0.28 - 4.83 indiv./km). Despite the temporary decline in the number in 2015, the average population growth rate was estimated at nearly 23% per annum.

***Monitoring of Wintering Waterbirds***

The number of 10 species on transects tested in the Monitoring of Wintering Sea Birds is summarized in Table 1.4.2. The obtained data allowed to estimate the change in abundance for the three largest species constituting 90 to 94% of the grouping: long-tailed duck, velvet scoter and common scoter. Only for velvet scoter, a statistically significant small decreasing trend was found (-6% per year; λ= 0,945, SE= 0,024).

Table 1.4.2. Number of individuals of 10 basic species in the Monitoring of Wintering Sea Birds recorded on 56 transects in 2011-2016. (Data source: PMŚ)

| Species | Number of individuals | | | | | |
|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| Red-throated loon *Gavia stellata* | 1 | 7 | 22 | 12 | 23 | 15 |
| Black-throated loon *Gavia arctica* | 21 | 39 | 10 | 16 | 17 | 15 |
| Red-necked grebe *Podiceps grisegena* | 8 | 4 | 4 | 14 | 8 | 4 |
| Horned grebe *Podiceps auritus* | 35 | 22 | 16 | 26 | 30 | 24 |
| Long-tailed duck *Clangula hyemalis* | 15270 | 29529 | 14737 | 20788 | 12043 | 16103 |
| Common scoter *Melanitta nigra* | 724 | 1256 | 644 | 1060 | 699 | 1368 |
| Velvet scoter *Melanitta fusca* | 9775 | 12482 | 11707 | 6794 | 7626 | 5989 |
| Common murre *Uria aalge* | 1 | 33 | 9 | 13 | 39 | 8 |
| Razorbill *Alca torda* | 51 | 717 | 94 | 73 | 88 | 78 |
| Black guillemot *Cepphus grylle* | 10 | 11 | 10 | 9 | 12 | 8 |

The abundance of the long-tailed duck and common scoter in the studied period can be considered as stable, as no statistically significant change in abundance has been found (Fig. 1.4.3). In the last dozen or so years, the number of sea ducks wintering in the Baltic showed a strong decreasing trend (Skov et al. 2011). The results obtained during the six years of monitoring in POM indicated that only in the case of velvet scoter there was a statistically significant decrease in the number. The other two species seem stable in this respect, but wide confidence range does not allow for unambiguous conclusions.

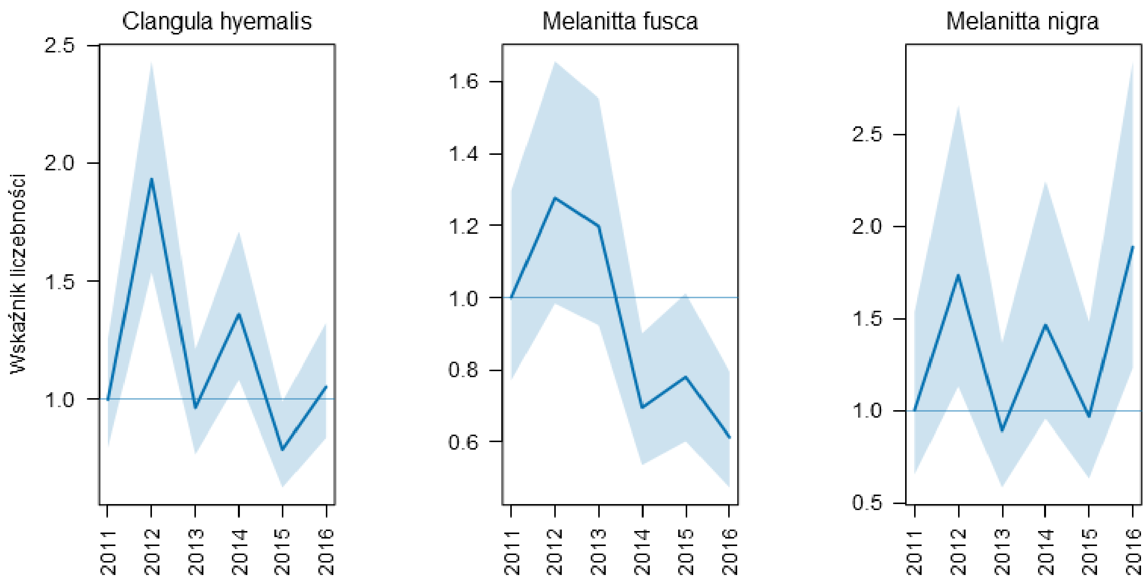



Fig. 1.4.3. Changes in the number of 3 species of the most numerous sea ducks: long-tailed ducks (left), velvet scoters (middle) and common scoters (right) based on the results of the Monitoring of Wintering Sea Birds in 2011-2016. The blue band on the graph indicates a standard error. (Data source: PMŚ)

***Monitoring of the White-tailed eagle productivity***

In 2015, the results of control of 79 positions were used to assess the breeding success, for which the final breeding result was established. In 48 cases, the breeding was successful - breeding success amounted to 60.8%. Of the 31 nests in which brood losses were found, 7 were inspected by climbing trees. It was found that there were no padding in the three nests, so these pairs did not start breeding at all.

In order to assess breeding success in 2016, the results of control of 69 sites with a fixed final breeding result were used. In 33 cases (47.8% of pairs) broods were successful. The breeding success in 2016 was 13% lower than in the previous year. Of the 36 nests in which brood losses were found, 21 were inspected by climbing trees. It was found that in 3 cases, couples did not start breeding at all. In the remaining 18, the presence of lining, eggs or egg shells was found, and in one case traces of the presence of small chicks. This may mean that the birds were in good condition in 2016 and most of them started breeding, but in the initial phase there were significant losses. Couples occupying breeding sites, but not breeding in 2016 constituted only 4% (3 pairs out of 69 with a known breeding result).

**Number of young birds and productivity calculated for all controlled positions**

In 48 nests out of 79 inspected in 2015, the presence of young was determined by carrying out control from the ground. In the case of nests in which the young could not be observed, but the appearance of the nest and surroundings indicated breeding success, it was assumed that there were at least 1 brood in the nest. Taking into account all breeding sites inspected in 2015 from the ground, in 48 nests, a total of 77 raised juveniles were successfully identified. Young production calculated by this method amounted to 1.60 young per pair with success and 0.97 per breeding pair.

In 2016, in 33 out of 69 visited nests, young were found using the from the ground control method, estimating their number in total at 56. Young production calculated with this method was 1.70 young per pair with success and 0.81 per breeding pair. Despite the low breeding success, it turned out that the production of young on a pair with success was close to the result from 2015. In 11 nests, 2 young were found, and in 22 one.

**The number of young and productivity calculated for the sections where the inside inspection of the nest was performed**

In order to use the data to calculate the productivity rate of the white-tailed eagle in the entire Baltic Sea basin, additional nest checks were made by climbing trees (only HELCOM uses this data to calculate the indicator). In 2015, 33 nests were inspected in this way, while in 2016, 40 nests. The results obtained in both years indicate that the controls from the ground lower the number of chicks by about 25-30%.

The actual productivity of the white-tailed eagle (number of juveniles per nest with success) in 2015 was 1.81, while the number of chicks per breeding pair was 1.42. In 2016, both of these parameters were 1.84 and 0.88, respectively.

***Cormorant monitoring***

During the monitoring period, i.e. in 2015 and 2016, the number of breeding pairs of cormorants in Poland increased from 28354 to 30091, including the increase from 12,999 to 13,459 pairs in a 10 km coastal belt.

In the zone of 10 km from the Baltic Sea coastline in the years 2015-2016 there were six colonies. In 2016, they constituted 10% of known cormorant colonies in Poland and they nested 45% of the breeding population (1% less than in the previous year). The increase in the number of birds in coastal colonies between 2015 and 2016 amounted to 3.5%, while outside this zone - 7.5%. A clear increase in the number of breeding pairs took place in the area of the Szczecin Lagoon and the Dąbie lake (+ 11%), the abundance decreased in Kąty Rybackie in the Gulf of Gdańsk (-11%).

***Monitoring of Sandwich tern***

In 2015, two inspections were carried out at the mouth of the Vistula River, during which all the sandwich terns were counted. The largest number, 493 pairs, was recorded during the second inspection (06/06/2015). The sandwich terns started laying eggs around May 3. The first inspection was carried out on May 5 and 48 nests with eggs were recorded. It was an exceptionally early period during their current presence in the Vistula estuary and allowed for a high breeding success. As a result of building a land road to the island on May 12, the colony began to be plundered by predators. Foxes and minks initially destroyed most of the common terns and a large part of the little terns, but at the end of May, when sandwich tern began breeding, all the chicks were eaten. In the face of large losses in broods, some birds re-entered the breeding season at the beginning of June (including 200 pairs of terns and 100 pairs of river terns), but these broods also ended in failure, also because pressure from land predators including silver gulls.

In 2016, seven controls were carried out combined with the counting of nests. On May 1, adult terns were present in the colony in the number of several dozen individuals, but no eggs were found. On May 16, 190 cases of egg presence were counted, and by June 4, the number of nests rose to 330, including the first hatching. The largest number, 440 hatching of the terns, was recorded during the control a month later, on July 3. It was a control connected with the ringing of chicks, 466 of which were ringed until that day (269 on 18.06 and 197 on day 3.07). Also a few dozen small chicks were left without ringing. It should be acknowledged that 330 couples counted on June 4 were successful in breeding and did not repeat their breeding, and 440 nests from July 3 occupied breeding pairs. So the colony inhabited in total not less than 770 couples. On July 11, around 11:00 am, there was a rapid and short-time phenomenon of high water flooding the sandbank with the tern colony. On this day, the water level in the Gulf of Gdańsk was high and a flat wave about 30 cm high, which came from the east, poured through the tern colony. As a result, almost all nests with eggs were destroyed and eggs were rinsed in water. About 200 non-flying chicks remained, but these were lost in the next few days as a result of the violent storms and rainfall. On July 16, there were no traces of colonies - neither eggs nor non-flying chicks. During the inspection of July 30, eight new nests with eggs were found in a small colony of black-headed gulls and river terns. All these cases consisted of one egg and disappeared (most likely eaten by predators) by mid-August.

***Monitoring of Dunlin***

In the years 2011-2016, no breeding pairs of the Dunlin *Calidris alpina schinzii* were found in the country. The only statement of a single bird was from 2011.

*Fish*

The species structure of ichthyofauna depends, inter alia, on abiotic conditions, especially salinity and depth. The tolerance of individual species to changes in salinity is important in shaping of the fish complex. The transition zone is inhabited by both marine and freshwater species. In the latter case, the salinity of waters at which a given species can exist, as well as the limit value of salinity at which it can successfully reproduce are both important. Most of the freshwater species found in the Polish transitional waters have developed a spawning migration mechanism to more freshwater areas (e.g. estuaries). Species representig higher tolerance to increased salinity are perch fish (pike perch, perch, ruff) and smaller - cyprinids (e.g. bream, roach). Salinity also limits the frequency of Occurrence of Atlantic species. Most of them (e.g. dab, glaucoma, saithe, haddock, polluter) can be found in the western part of POM.

An important feature of fish complexes is their mobility. With the exception of the physiological barriers associated with too low or too high salinity, most fish species travel even at considerable distances during feeding or spawning trips. Fish occurring in the transitional zone of Polish waters are mostly food opportunists, which means that they are not strongly dependent on the presence of a specific taxon of benthic invertebrates. The depth of the bottom is more important factor which influences the ability of penetration of food resources by particular species of benthos-eating fish.

The fish constantly found in POM belong to over 60 species. Some of the species listed in Table 1.4.3 are relatively rarely recorded. This list does not include all species of fish observed occasionally by fishermen or scientists from other institutions collecting ichthyofauna data (e.g. individual specimens of non-native species or fish migrating occasionally from rivers, lakes and Atlantic fish) and should be treated as an open list, however, containing a typical species composition in POM. Commercial fishing is limited to over a dozen species: the largest catches are registered for sprat, herring, cod and flounder. Other flatfish that are frequent by-caught are plaice and turbot. Most targeted fish species are salmonids (salmon, trout) and eel.

Table 1.4.3 List of fish species and lampreys registered in POM produced for the purpose of the initial assessment of the environmental status of marine waters (based on fisheries statistics, observations of fishing and MIR-PIB research fisheries) - elaboration by I. Psuty (GIOŚ, 2014)

| English name | Latin name | Commercial use / protection status | Area of occurrence / attention |
|---|---|---|---|
| Atlantic herring | *Clupea harengus membras* (Linnaeus, 1758) | targetted catch | Open sea waters, offshore waters, loccaly and periodically transitional waters |
| European sprat | *Sprattus sprattus* (Schneider, 1904) | targetted catch | Open sea waters, offshore waters, some parts of transitional waters |
| Atlantic cod | *Gadus morhua Linnaeus*, 1758 | targetted catch | Open sea waters, offshore waters, some parts of transitional waters |
| European flounder | *Platichthys flesus* (Linnaeus, 1758) | targetted catch | Open sea waters, offshore waters, some parts of transitional waters |
| European plaice | *Pleuronectes platessa* Linnaeus, 1758 | by-catch from demersal catches | Open sea waters, offshore waters, some parts of transitional |

| English name | Latin name | Commercial use / protection status | Area of occurrence / attention |
|---|---|---|---|
| | | | waters |
| Turbot | *Psetta maxima* (Linnaeus, 1758) | by-catch from demersal catches, targetted catch | Open sea waters, offshore waters, some parts of transitional waters |
| Atlantic salmon | *Salmo salar Linnaeus*, 1758 | targetted catch | All types of water (anadromous species) |
| Sea trout | *Salmo trutta trutta* Linnaeus, 1758 | targetted catch | All types of water (anadromous species) |
| Rainbow trout | *Oncorhynchus mykiss* (Walbaum, 1792) | by-catch | All types of waters, species introduced by restocking |
| Eelpout | *Zoarces viviparus* (Linnaeus, 1758) | Non-commercial | Open sea waters, offshore waters, some parts of transitional waters |
| Fourbeard rockling | *Enchelyopus cimbrius* (Linnaeus, 1766) | Non-commercial | Open sea waters, offshore waters |
| Whiting | *Merlangius merlangus* (Linnaeus, 1758) | Occasionally commercial, by-catch | Open sea waters, offshore waters |
| Haddock | *Melanogrammus aeglefinus* (Linnaeus, 1758) | Rare, by-catch | Open sea waters,western part |
| Saithe | *Pollachius virens* (Linnaeus, 1758) | Rare, by-catch | Open sea waters,western part |
| Pollack | *Pollachius pollachius* (Linnaeus, 1758) | Rare, by-catch | Open sea waters,western part |
| Atlantic horse mackerel | *Trachurus trachurus* (Linnaeus, 1758) | Rare, by-catch | Open sea waters,western part |
| Common dab | *Limanda limanda* (Linnaeus, 1758) | Rare, by-catch | Open sea waters, offshore waters, western part |
| Brill | *Scophthalmus rhombus* (Linnaeus, 1758) | Rare, by-catch | Open sea waters, offshore waters, western part |
| Small sandeel | *Ammodytes tobianus* Linnaeus, 1758 | occasionally commercial | Open sea waters, offshore waters, |
| Great sandeel | *Hyperoplus lanceolatus* Le Sauvage, 1824 | occasionally commercial | Open sea waters, offshore waters, some parts of transitional waters |
| Shorthorn sculpin | *Myoxocephalus scorpius* (Linnaeus, 1758) | non-commercial | Open sea waters, offshore waters, some parts of transitional waters |
| Lumpfish | *Cyclopterus lumpus* Linnaeus, 1758 | Non-commercial | Open sea waters, offshore waters, some parts of transitional waters |
| Atlantic | *Scomber scombrus* Linnaeus, | occasionally | Open sea waters, |

| English name | Latin name | Commercial use / protection status | Area of occurrence / attention |
|---|---|---|---|
| mackerel | 1758 | commercial | offshore waters |
| Twaite shad | *Alosa fallax* (Lacepede, 1803) | protected species, by-catch | Open sea waters, offshore waters, local and periodical transitional waters (anadromous species) |
| Allis shad | *Alosa alosa* (Linnaeus, 1758) | protected species, rare | Open sea waters, offshore waters, local and periodical transitional waters - western part (anadromous species) |
| European eel | *Anguilla anguilla* (Linnaeus, 1758) | Locally directed fishing | Transitional waters, offshore, occasionally in open sea (catadromous species) |
| Garfish | *Belone belone* (Linnaeus, 1761) | Locally directed fishing, by-catch | Open sea waters, offshore waters, some parts of transitional waters (Pucka Bay) |
| Pike-perch | *Sander lucioperca* (Linnaeus, 1758) | Locally directed fishing, by-catch | Offshore waters, transitional, found in the waters of the open sea |
| European perch | *Perca fluviatilis* Linnaeus, 1758 | Locally directed fishing, by-catch | Offshore waters, transitional, found in the waters of the open sea |
| European smelt | *Osmerus eperlanus* (Linnaeus, 1758) | occasionally commercial, by-catch | Offshore waters, transitional, found in the waters of the open sea |
| Three-spined stickleback | *Gasterosteus aculeatus* Linnaeus, 1758 | Non-commercial | Offshore waters, transitional, found in the waters of the open sea |
| Ninespine stickleback | *Pungitius pungitius* (Linnaeus, 1758) | Non-commercial | transitional waters, offshore |
| Round goby | *Neogobius melanostomus* Pallas, 1814 | occasionally commercial, invasive alien, by-catch | Offshore waters, transitional, found in the waters of the open sea non-indigenous species |
| Common goby | *Pomatoschistus microps* (Kr0yer, 1838) | Non-commercial, protected species | all types of water |
| Sand goby | *Pomatoschistus minutus* (Pallas, 1770) | Non-commercial, protected species | all types of water |
| Black goby | *Gobius niger* Linnaeus, 1758 | Non-commercia, rare, protected species | all types of water |
| Two-spotted goby | *Gobiusculus flavescens* (Fabricius, 1779) | Non-commercial, rare, protected species | all types of water |
| Monkey goby | *Neogobius fluviatilis* (Pallas, 1814) | Non-commercial, invasive alien | transitional waters, non-indigenous species, fresh-salty-water |

| English name | Latin name | Commercial use / protection status | Area of occurrence / attention |
|---|---|---|---|
| Racer goby | *Babka gymnotrachelus* (Kessler, 1857) | Non-commercial, invasive alien | transitional waters, non-indigenous species, fresh-salty-water |
| Hooknose | *Agonus cataphractus* (Linnaeus, 1758) | Non-commercial, rare | Open sea waters, offshore waters, some parts of transitional waters |
| Striped seasnail | *Liparis liparis* (Linnaeus, 1766) | Non-commercial, rare, protected species | Open sea waters, offshore waters, some parts of transitional waters (Gdańsk Gulf) |
| Rock gunnel | *Pholis gunnellus* (Linnaeus, 1758) | Non-commercial, rare | Open sea waters, offshore waters, some parts of transitional waters |
| Snakeblenny | *Lumpenus lamptetaeformis* (Walbaum, 1792) | Non-commercial, rare, protected species | Open sea waters, offshore waters, some parts of transitional waters (Gdańsk Gulf) |
| Longspined bullhead | *Taurulus bubalis* (Euphrasen, 1786) | Non-commercial, rare | Open sea waters, offshore, western part |
| Tub gurnard | *Chelidonichthys lucerna* (Linnaeus, 1758) | Non-commercial, rare | Open sea waters, offshore, western part |
| Grey gurnard | *Eutrigla gurnardus* (Linnaeus, 1758) | Non-commercial, rare | Open sea waters, offshore, western part |
| European anchovy | *Engraulis encrasicolus* (Linnaeus, 1758) | by-catch, rare | Open sea waters, offshore waters, some parts of transitional waters |
| Broadnosed pipefish | *Sygnathus typhle* Linnaeus, 1758 | Non-commercial, protected species | transitional waters, offshore |
| Straightnose pipefish | *Nerophis ophidion* (Linnaeus, 1758) | Non-commercial, protected species | transitional waters, offshore |
| Sea stickleback | *Spinachia spinachia* (Linnaeus, 1758) | Non-commercial, protected species | transitional waters, offshore |
| River lamprey | *Lampetra fluviatilis* (Linnaeus, 1758) | Non-commercial, protected species | transitional waters, offshore, anadromous species |
| Sea lamprey | *Petromyzon marinus* Linnaeus, 1758 | Non-commercial, rare, protected species | transitional waters, offshore, anadromous species |
| Northern pike | *Esox lucius* Linnaeus, 1758 | Locally targetted catch, catch-off | transitional waters, offshore, freshwater species |
| Maraena whitefish | *Coregonus maraena* (Bloch, 1779) | Locally targetted catch, catch-off | transitional waters, offshore, semi-anadromous species |
| Burbot | *Lota lota* (Linnaeus, 1758) | local by-catch | transitional waters, offshore, freshwater |

| English name | Latin name | Commercial use / protection status | Area of occurrence / attention |
|---|---|---|---|
| | | | species |
| Ruffe | *Gymnocephalus cernua* (Linnaeus, 1758) | Non-commercial | transitional waters, offshore |
| Sichel | *Pelecus cultratus* Linnaeus, 1758 | Locally targetted, apart from the Vistula Lagoon protected species | transitional waters, offshore |
| Vimba | *Vimba vimba* (Linnaeus, 1758) | Locally caught | Transitional, coastal waters, anadromous species |
| Roach | *Rutilus rutilus* (Linnaeus, 1758) | Locally targetted catch, caught up | Transitional, coastal waters, freshwater species |
| Freshwater bream | *Abramis brama* (Linnaeus, 1758) | Locally targetted catch, caught up | Transitional, coastal waters, freshwater species |
| Asp | *Leucuscus aspius* (Linnaeus, 1758) | Locally caught (rare) | Transitional, coastal waters, freshwater species |
| Barbel | *Barbus barbus* (Linnaeus, 1758) | Locally caught (rare) | Transitional, coastal waters, freshwater species |
| Prussian carp | *Carassiusgibelio* (Bloch, 1782) | Locally targetted catch, caught up | Transitional, coastal waters, freshwater species |
| Crucian carp | *Carassius carassius* (Linnaeus, 1758) | Locally caught (rare) | Transitional, coastal waters, freshwater species |
| Common carp | *Cyprinus carpio* (Linnaeus, 1758) | Locally caught (rare) | Transitional, coastal waters, freshwater species, fish stocks |
| Tench | *Tinca tinca* (Linnaeus, 1758) | Locally directed fishing, caught up | Transitional, coastal waters, freshwater species |
| Chub | *Squalius cephalus* (Linnaeus, 1758) | Non-commercial, locally caught | Transitional, coastal waters, freshwater species |
| White bream | *Blicca bjoerkna* (Linnaeus, 1758) | Locally caught | Transitional, coastal waters, freshwater species |
| White-eye bream | *Ballerus sapa* (Pallas, 1814) | Locally caught (rare) | Transitional, coastal waters, freshwater, non-native species |
| Bleak | *Alburnus alburnus* (Linnaeus, 1758) | Non-commercial, locally caught | Transitional, coastal waters, freshwater species |
| Zope | *Ballerus ballerus* (Linnaeus, 1758) | Non-commercial, locally caught | Transitional, coastal waters, freshwater species |

| English name | Latin name | Commercial use / protection status | Area of occurrence / attention |
|---|---|---|---|
| Rudd | *Scardinius erythrophthalmus* (Linnaeus, 1758) | locally caught | Transitional, coastal waters, freshwater species |
| European bitterling | *Rhodeus amarus* (Bloch, 1782J | Non-commercial, occurs locally, protected species | Transitional waters, freshwater species |
| Spined loach | *Cobitis taenia* Linnaeus, 1758 | Non-commercial, occurs locally, protected species | Transitional waters, freshwater species |
| Weatherfish | *Misgurnus fossilis* (Linnaeus, 1758) | Non-commercial, occurs locally, protected species | Transitional waters, freshwater species |
| Gudgeon | *Gobio gobio* (Linnaeus, 1758) | Non-commercial, occurs locally, protected species | Transitional waters, freshwater species |
| Schneider | *Alburnoides bipunctatus* (Bloch, 1782) | Non-commercial, occurs locally, protected species | Transitional waters, freshwater species |
| Belica | *Leucaspius delineatus* (Heckel, 1843) | Non-commercial, occurs locally, | Transitional waters, freshwater species |
| Dace | *Leuciscus leuciscus* (Linnaeus, 1758) | Non-commercial, occurs locally, | Transitional waters, freshwater species |
| Ide | *Leuciscus idus* (Linnaeus, 1758) | Non-commercial, occurs locally, | Transitional waters, freshwater species |
| Wels catfish | *Silurus glanis* Linnaeus, 1758 | Locally caught (rare) | Transitional waters, freshwater species |
| River trout | *Salmo trutta fario* Linnaeus, 1758 | Locally caught (rare) | Transitional waters, freshwater species |
| Sturgeon | *Acipenser oxyrinchus* Mitchill, 1815 | Protected species, prohibited by fishing, locally caught (rare) | Transitional, coastal waters, anadromous species, restituted by stocking |

Locally, in transitional and coastal waters (the Vistula Lagoon, the Szczecin Lagoon, the Puck Bay), such species like pikeperch, perch, roach and bream play a big role in fishing. Temporally and spatially limited are catches of garfish (spring, Puck Bay) or sichels (the Vistula Lagoon). ThePuck Bay is an area of strongly degraded and transformed ichthyofauna structure in terms of fish species occurring there. In the 1970s, mainly freshwater and bi-environmental fish were caught there - eel, perch, roach and pike. Currently, this basin is inhabited mainly by non-commercial fish species ( three-spined stickleback, ninespine stickleback, round goby) and fishing is considerably limited. Almost 95% of fishing landings in this basin fall into five species: cod, flounder, garfish, herring and perch. There are often found species characteristic of underwater meadows - a broadnosed pipefish and a straightnose pipefish, which have found suitable living conditions in filamentous algae. The Estuary of the Odra River, which includes the Szczecin Lagoon together with the adjacent waters, is an extremely diverse environment both in terms of hydrogeology and biological conditions. This is an area of high anthropogenic pressure associated with transport (vessel traffic between Świnoujście-Szczecin), recreational and fishing activities. The fish complex of the Szczecin Lagoon consists mainly of freshwater species (carp, perch) and migrating species - anadromous whitefish, salmonids and catadromous eel. In the Szczecin Lagoon, almost 95% of landings correspond to four species: roach, bream, perch and zander. The Vistula Lagoon is a shallow, much-eutrophicated water reservoir, characterized by a gradient of water salinity in the axis from west to east. About 1/3 of the Lagoon area belongs to Poland. The ichthyofauna complex is quite diverse, with the predominance of cyprinids in the western part and the predominance of pericidae fish in the eastern part. In addition Osmerus and mass quantities of spring spawning herring migrate here seasonally. In the Vistula Lagoon, almost 95% percent of fish landings fall into five species: herring, roach, bream, zander and perch.

Due to the important role of ecological corridors for freshwater and diadromous fish species (anadromous and catadromous), the estuaries of the largest Polish rivers - the Vistula and Odra as well as coastal rivers are important. In the area of mixing of fresh and saline waters, both freshwater and marine fish species are present. The most common species are herring, carp fish (bream, roach), perch (perch, zander), flounder, smelt and diadromous fish - sea trout, salmon, vimba bream. The Odra river mouth (in particular Świna), unlike the Vistula mouth, is heavily modified by human activities (the Szczecin-Świnoujście port complex), which may change the migration behaviour of fish. The estuaries of the coastal rivers in Mrzeżyno, Kołobrzeg, Darłówek, Ustka, Rowy and Łeba are also significantly modified by the existing port infrastructure.

Despite the large amount of data describing ichthyofauna in POM, their suitability for describing fish complexes is significantly reduced. The fishing effect (sampling of the complex) is determined primarily by the fishing tools used and the selection of assessment date. There are no data from standardized catches, which could be the basis for building a biotic typology as well as assessing the state and changes in fish communities. In the period 2013-2016, the diagnostic monitoring of ichthyofauna was carried out in all transitional waterbodies and selected coastal waterbodies for the purpose of cooperation with HELCOM.

**Biotic types of fish complexes**

As part of the work carried out as part of the initial assessment of the environmental status of marine waters (GIOŚ 2014), the pre-classification of Polish Marine Waters for biotic types of fish assemblies was initially determined (Fig. 1.4.4.). Building a typology was based on available sources, including:

- The results of the monitoring of ichthyofauna of transitional and coastal waters conducted in 2011,
- Descriptions of ichthyofauna, if they were based on research catches, published in public scientific literature,
- Data series from long-term fisheries statistics,
- Data available in reports on the implementation of various types of projects including MIR-PIB research cruises,
- Data from fishing observations conducted under the Multiannual Program for the Collection of Fishing Data (national program for the years 2007-2013 as set out in the Annex to Resolution No. 212/2007 of the Council of Ministers of 19 October 2007 on the establishment of a Multi-annual Program for the Collection of Fishing Data for 2007-2013, amended by Resolution No. 84/2010 of the Council of Ministers of June 1, 2010 and earlier programs).

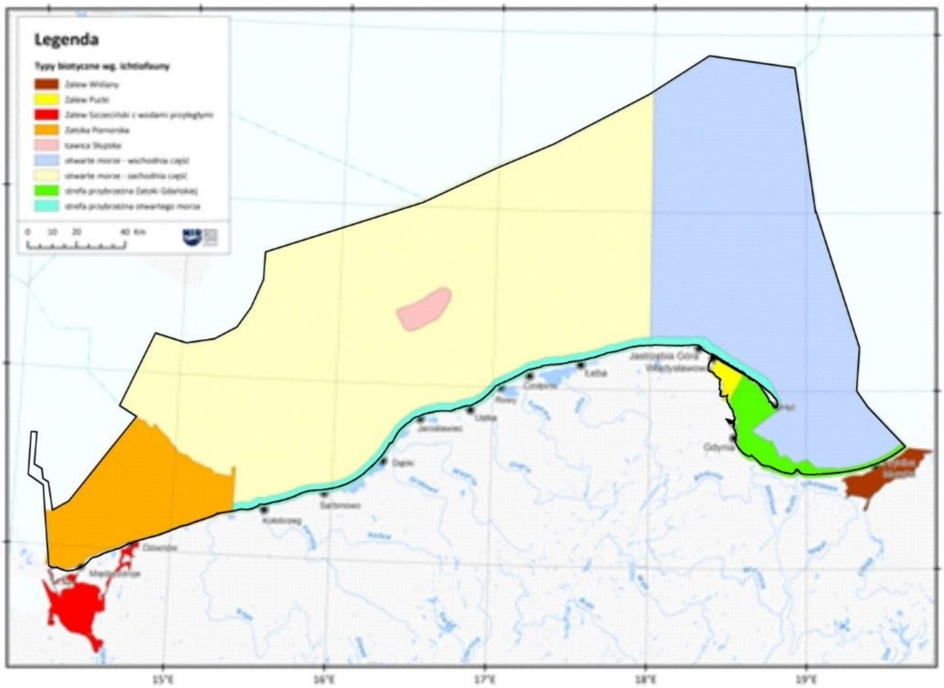



Fig. 1.4.4. Biotic types of fish communities in POM (own elaboration by Psuty and Szymanek, MIR-PIB)

Due to the relatively low species diversity of ichthyofauna, fish assemblages of particular biotic types are not characterized by a completely separate species composition. The following biotic types of fish assemblies were distinguished:

**The fish complex of the Puck Lagoon**

The range covering the Puck Lagoon and the Puck Bay (up to a depth of 20 m), dominated by spiny stickleback (three-spined stickleback, ninespine stickleback), perch, round goby and flounder. There are often species characteristic of underwater meadows - a broadnosed pipefish and a straightnose pipefish, which have found suitable living conditions in filamentous algae.

**The fish complex of the Szczecinski Lagoon and adjacent waters**

The range covering the Szczecin Lagoon, Kamieński Lagoon, Świna Mouth and Dziwna Mouth. The fish complex consists mainly of freshwater species (carp, perch) and migrating species - anadromous whitefish, salmonids and catadromous eel. An important area for reproduction and rearing of freshwater fish fry (zander, bream, perch, roach) and ecological corridor of diadromous fish.

**The fish complex of the Vistula Lagoon**

About 1/3 of the Lagoon area belongs to Poland. The ichthyofauna complex is quite diverse, with the predominance of cyprinids in the western part and the predominance of pericidae fish in the eastern part. In addition, smelts and mass quantities of spring spawning herring migrate here seasonally. An important area for reproduction and rearing of freshwater fish fry (zander, bream, perch, roach) and ecological corridor (Vistula basin) of diadromous fish.

**The fish complex of the coastal zone of the Gulf of Gdańsk with Vistula mouth**

Covering the deeper part (over 20 m) of the Puck Outer Bay and the Inner Gulf of Gdańsk. There are mainly sea fish (herring, sprat, cod, flounder) with a significant share of freshwater fish (zander, bream, perch) and diadromous fish (salmonidae). In the area of mixing of fresh and saline waters, both freshwater and marine fish are present. The most common species are herring, carp fish (bream, roach), perch (perch, zander), flounder, smelt and diadromous fish - sea trout, salmon, vimba bream.

**The fish complex of the coastal zone of the open sea**

Covering the zone of 2 nautical miles from the shore, to an average depth of 20 m. Marine fish predominate here, but especially in the vicinity of estuaries and canals, the share of freshwater and diadromous fish in the ichthyofauna structure increases. Currently, there is a lack of knowledge about the locations of the most important spawning grounds and the growth of fry.

**The fish complex of Pomeranian Bay**

Covering an open basin, of which only a part is located in POM, with a depth not exceeding 20 m. The south-western part of the Bay belongs to the Odra estuary and remains under the influence of fresh waters. In the area of mixing of fresh and saline waters, both freshwater and marine fish are present. The most common species are herring, carp fish (bream, roach), perch fish (perch, zander), flounder, smelt and bivalve fish - sea trout, salmon, vimba vimba. Fish characteristic of the western Baltic are often noted.

**The fish complex of Słupsk Bank**

Covering diverse and valuable natural habitats in the middle part of POM. The characteristics of the ichthyofauna of this region are relatively unknown, however, due to the specific habitat conditions, this area should be distinguished in the typology of fish complexes due to the potentially large role in the reproduction of some fish species (e.g. herring, turbot, Gobiidae fish).

**The fish complex of open sea**

Includes not mentioned parts of POM. Due to the gradient of salinity, the variability of species composition of ichthyofauna from the west (frequent observations of migrating fish from the West Baltic Sea) to the east is noticeable. There are also differences in the size of the fish of the same species caught in large amounts (e.g. flounder). Due to the above, the western part was distinguished (including statistical squares according to ICES 24 and 25) and eastern (statistical square according to ICES 26).

### *Benthic habitats*

The EUSeaMap map of the distribution of benthic habitats in the Baltic Sea was elaborated as part of the EMODnet project (European Marine Observation Data Network; www.emodnet-seabedhabitats.eu) funded by the European Commission's Directorate- General for Maritime Affairs and Fisheries (DG MARE), which were implemented in 2009-2013 (the first stage of the project) and in the years 2013-2016 (the second stage of the project) based on data from environmental research as well as on the basis of model habitat distribution maps. The map was created to meet the requirements of European directives, such as MSFD, but also as part of the Horizon 2020 project (under the third stage of the project for the years 2017-2020). The method used in the development of the map and its confidance are presented in the technical report (Populus et al. 2017), while general habitat types in accordance with MSFD are listed in the annex to the technical report (Manca et al. 2017). These general habitat types are assessed within benthic habitats in accordance with the requirements of Decision 2017/848 based on the EUNIS habitat classification indicated in the above Decision, modified for MSFD purposes (Evans et al. 2016). This classification was the initiative of the European Environment Agency (EEA) and in this case refers to the 3rd and 4th level, and thus the characteristics of the abiotic environment: the type of substrate of the seabed divided into littoral and circalittoral zone together with the associated communities of organisms (macrozoobenthos, macrophytes). According to the definition used in the study by Evans et al. (2016) the infralittoral zone is characterized by sufficient light for the growth of vascular plants, such as Zostera spp. and green algae. The range of occurrence of this zone is limited by the penetration of light to 1%. In the circalittoral zone, there is not enough light for vascular plants and green algae, but is sufficient for brown and red algae.

Fig. 1.4.5 presents broad habitat types, while in Table 1.4.4. they are listed within assessment areas in POM in the order of dominance in terms of the area occupied, on which representative monitoring stations of macrophytes and macrozoobenthos are located.

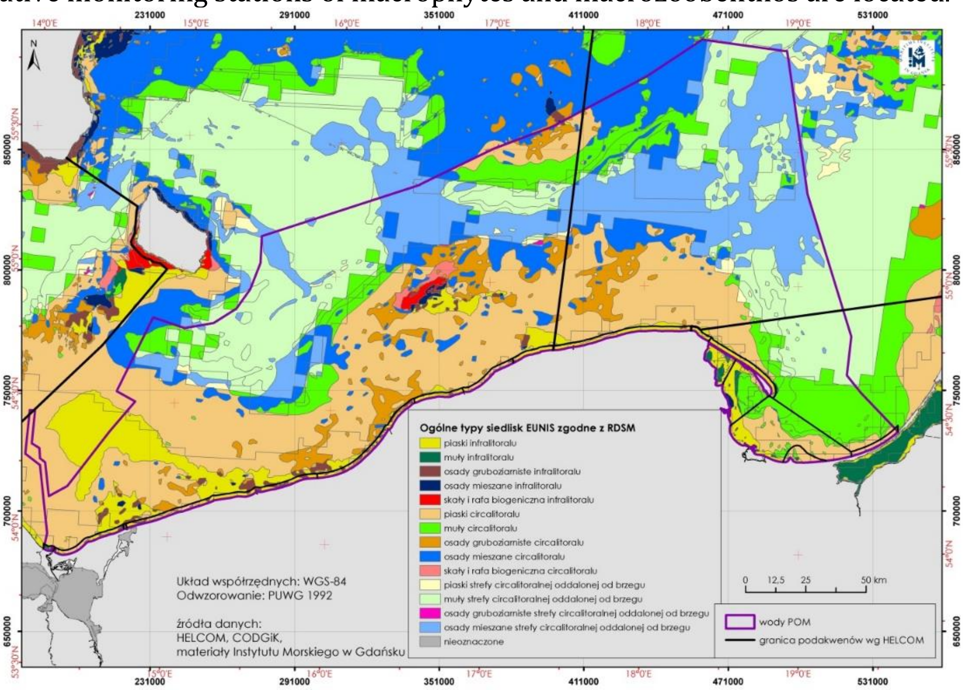



Fig. 1.4.5. Broad habitat types of EUNIS occurring in POM based on GIS data from the Europe Marine Observation Data Network (EMODnet) project Seabed Habitats (www.emodnet-seabedhabitats.eu)

Table 1.4.4. Broad habitat types included in the assessment of benthic habitats in POM

| Rated ecosystem element | Assessment area in POM | Area of the assessment area / boulder field* / mixed bottom* [km$^2$] | The broad habitat type (based on the EUNIS classification according to Decision 2017/848) | Code for the broad habitat | Area of the broad habitat type [km$^2$]; (- no data) | Indicator/set of organisms |
|---|---|---|---|---|---|---|
| benthic habitat of the soft bottom | Gdańsk Basin | 2105.83 | circalittoral silt | MC6 | 1001.57 | B/ macrozoobenthos |
| | | | circalittoral silt zone from the shore | MD6 | 815.41 | |
| | | | circalittoral sands | MC5 | 260.76 | |
| | Eastern Gotland Basin | 10897.62 | mixed sediments of the circalittoral zone from the shore | MD4 | 3502.60 | B/ macrozoobenthos |
| | | | circalittoral silt zone from the shore | MD6 | 2437.82 | |
| | | | circalittoral sands | MC5 | 2174.48 | |
| | Bornholm Basin | 17784.55 | circalittoral sands | MC5 | 6909.66 | B/ macrozoobenthos |
| | | | circalittoral silt zone from the shore | MD6 | 3340.86 | |
| | | | mixed sediments of the circalittoral zone from the shore | MD4 | 1837.16 | |
| | | | infralittoral sands | MB5 | 1293.37 | |
| | Kamieński Lagoon | 43.59 | infralittoral silt | MB6 | - | B/ macrozoobenthos |
| | Szczecin Lagoon | 407.28 | infralittoral silt | MB6 | - | B/ macrozoobenthos |
| | Vistula Lagoon | 301.74 | infralittoral silt | MB6 | 222.54 | B/ macrozoobenthos |
| | Puck Lagoon | 111.12 | infralittoral sands | MB5 | 75.48 | B/ macrozoobenthos and $SM_1$ (macrophytes ) |
| | | | infralittoral silt | MB6 | 26.67 | |
| | Outer Puck Bay | 285.92 | circalittoral silt | MC6 | 114.11 | B/ macrozoobenthos |
| | | | infralittoral sands | MB5 | 100.79 | |
| | | | infralittoral silt | MB6 | 21.69 | |
| | Inner Gulf of Gdańsk | 710.28 | circalittoral sands | MC5 | 355.76 | B/ macrozoobenthos |
| | | | circalittoral silt | MC6 | 241.37 | |
| | | | infralittoral sands | MB5 | 94.42 | |
| | Dziwna mouth | 2.38 | mixed sediments of infralittoral | MB4 | 2.38 | B/ macrozoobenthos |
| | Wisła Przekop mouth | 64.23 | circalittoral sands | MC5 | 44.85 | B/ macrozoobenthos |
| | | | silt | MC6 | 8.16 | |
| | Świna mouth | 8.92 | mixed sediments of infralittoral | MB4 | 8.92 | B/ macrozoobenthos |
| | Vistula Spit | 41.33 | circalittoral sands | MC5 | 41.33 | B/ macrozoobenthos |
| | Hel Peninsula | 70.15 | infralittoral sands | MB5 | 70.15 | B/ macrozoobenthos |
| | Władysławowo Port | 0.13 | infralittoral silt | MB6 | 0.13 | B/ macrozoobenthos |

| Rated ecosystem element | Assessment area in POM | Area of the assessment area / boulder field* / mixed bottom* [km²] | The broad habitat type (based on the EUNIS classification according to Decision 2017/848) | Code for the broad habitat | Area of the broad habitat type [km²]; (- no data) | Indicator/set of organisms |
|---|---|---|---|---|---|---|
| | Władysławowo-Jastrzębia Góra | 17.43 | infralittoral sands | MB5 | 17.43 | B/macrozoobenthos |
| | Jastrzębia Góra-Rowy | 140.99 | infralittoral sands | MB5 | 140.99 | B/macrozoobenthos |
| | Rowy-Jarosławiec West | 38.78 | infralittoral sands | MB5 | 32.45 | B/macrozoobenthos |
| | | | infralittoral coarse silt | MB3 | 2.05 | |
| | Rowy-Jarosławiec East | 46.02 | infralittoral sands | MB5 | 46.02 | B/macrozoobenthos |
| | Jarosławiec-Sarbinowo | 98.58 | infralittoral sands | MB5 | 98.58 | B/macrozoobenthos |
| | Sarbinowo-Dziwna | 153.67 | infralittoral sands | MB5 | 153.67 | B/macrozoobenthos |
| | Dziwna-Świna | 58.83 | infralittoral sands | MB5 | 30.46 | B/macrozoobenthos |
| | | | circalittoral sands | MC5 | 20.37 | |
| benthic habitat of the hard bottom | Bornholm Basin - Słupsk Bank boulder area | 111.3* | rocks and biogenic reef infralittoral / rocky and stony seabed | MA1 | | SM1/macrophytes |
| | Rowy-Jarosławiec East - Rowy boulder area | 2.57* | rocks and biogenic reef infralittoral / rocky and stony seabed | MA1 | | SM1/macrophytes |
| benthic habitat of the mixed bottom | Outer Puck Bay (coastal waters of the Klif Orłowski) | 1.99* | rocks and biogenic reef infralittoral and mixed sediments of infralittoral | MB1, MB4 | | SM1/macrophytes |
| benthic habitat of macrophytes in lagoons | Kamieński Lagoon | 43.59 | infralittoral sands | MB5 | - | ESMIz/macrophytes |
| | Szczecin Lagoon | 407.28 | infralittoral sands | MB5 | - | ESMIz/macrophytes |
| | Vistula Lagoon | 301.74 | infralittoral sands | MB5 | 52.55 | ESMIz/macrophytes |

* means the surface of the boulder area or the surface of the mixed bottom (these areas are smaller than the surface of the area under assessment)

The following is a description of the biotic elements forming benthic habitats and used to assess the state of the environment: macrophytes and invertebrate organisms.

Within POM, macrophytes occur in two areas of the hard bottom: the Słupsk Bank boulder area and the Rowy Boulder area (Table 1.4.4), occupying a total of 113.874 km², which is 4.37% of the POM area (Fig. 1.4.6.), on the mixed bottom (sandy and stony) in the coastal waters of the Orłowo cliff in Gdynia (Outer Puck Bay), and also on the soft bottom: in the Puck Bay and in the lagoons.

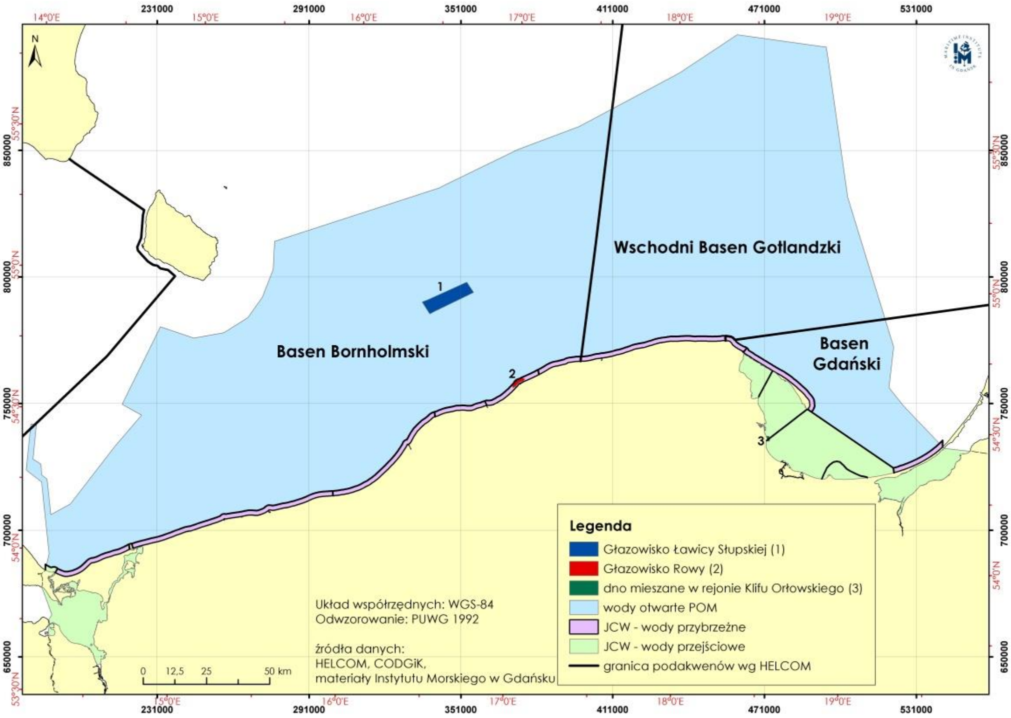



Fig. 1.4.6. Location of POM hard bottom habitat: Słupsk Bank boulder and Rowy boulder areas and mixed bottom habitat in the area of Klif Orłowski

The Słupsk Bank boulder area is located in the north-western part of the Słupsk Bank (geographic coordinates of the centre point 54°58271 N, 16°35.0512), within depth range of 8-20 m, about 46 km north of the coastal town Ustka (Fig. 1.4.6). The area of the boulder is 111.3 km² and constitutes 14% of the entire protected area of Natura 2000 - Ławica Słupska PLC990001. The bottom configuration is diversified, distinguishing the area from other parts of the southern Baltic. A characteristic element of morphology are the rows of mounds built mostly of rock blocks and boulders resistant to erosion (Kruk-Dowgiałło et al. 2011). The hard bottom and the relatively high water transparency create favourable conditions for the development of species-rich benthic communities, among which are naturally valuable in the marine ecosystem, so-called habitat-forming species (Andrulewicz et al. 2004, Brzeska 2009, Kruk-Dowgiałło et al. 2011). These include species of red algae: *Furcellaria lumbricalis*, *Ceramium diaphanum* (protected species), *Polysiphonia fucoides* and blue mussel *Mytilus trossulus*. In many areas of Słupsk Bank species of macroalgae rare not only in POM, e.g. *Coccotylus truncatus*, *Desmarestia viridis*, *Rhodomela confervoides*, but also in the entire Baltic Proper, e.g. *Delesseria sanguinea* can be found (Kruk-Dowgiałło et al. 2011, data from State Environmental Monitoring 2008-2017).

The Rowy boulder area is situated in the coastal zone of the central Polish coast, at a depth of 2 to 18 m, about 1.5 km north of the locality of Rowy (geographical coordinates of the centre point 54°40,900'N, 17°02,810'E) (Fig. 1.4.6). The current map - EUSeaMap (Fig. 1.4.5) does not contain information about the location of the Rowy boulder area, which was identified in POM for the first time in 1997 (Kruk-Dowgiałło 2000). In the following years, benthic community on the hard bottom were studied comprehensively (Osowiecki and Kruk-Dowgiałło 2006, Kruk-Dowgiałło et al. 2008, Brzeska 2009, Barańska et al. 2016), and since 2010 macroalgae of the boulder area have been regularly monitored within the State Environmental Monitoring (2010-2017). Rowy is situated in the vicinity of the Słowiński National Park and is protected under the Natura 2000 network as the PLH220023 Ostoja Słowińska (SDF area PLH220023) and the PLB990002 Baltic Sea coastal waters (SDF area PLB990002). Habitat is the abrasive platform area with numerous boulders and pebble fields forming a compact abrasive pavement. Its surface is inhabited by species-rich and abundant benthic organisms. Species of red algae predominate, such as *Polysiphonia fucoides* and *Furcellaria lumbricalis*, sporadically occur rare species, such as *Sphacelaria cirrosa* and *Ceramium tenuicorne* (Osowiecki and Kruk-Dowgiałło 2006, Kruk-Dowgiałło et al. 2008, Brzeska 2009, State Environmental Monitoring 2010-2017)

In POM, among the large areas of the soft bottom, there are only a few places covered with vascular plants. These include, among others, the Bay of Puck. Its internal part (the Puck Lagoon) and coastal areas of the outer part is considered a unique natural area in the Polish Baltic zone, primarily due to the extent of underwater meadows and the diversity of macrophyte species ( Kruk-Dowgiałło and Brzeska 2009). In addition to the largest number of protected species (8), there are many rare species here (6). The Puck Bay is the only region in POM, where *Chara baltica*, *Tolypella nidifica* and *Nitella capillaris*, and vascular plants that form single-, two- or three-species meadows on sandy bottoms. The most valuable and at the same time the most endangered component of underwater meadows is the sea grass *Zostera marina*, strictly protection.

The area of stony and sandy bottom in coastal waters at the foot of Orłowo cliff in the Puck Outer Bay, unique in terms of natural values has been investigated within the State Environmental Monitoring since 2002. It is not included in the EUSeaMap (Fig. 1.4.5) The sediments constitute medium- and coarse sands, numerous stones and boulders scattered on the bottom (Uścinowicz and Zachowicz 1992, Osowiecki and Żmudziński 2000), which do not form extensive and dense stony structures, as in the case of the Rowy boulder or Słupsk Bang boulder area. In the EUNIS classification included in the decision 2017/848 there is no habitat characterized by this type of sediment. It is mentioned, however, in the classification of Baltic habitats (HELCOM 2013f) and is characterized by the diversity of sediment types, without strong dominance of one of them, classified as the Baltic photic mixed substrate. In the coastal waters of the Orłowo cliff there is also a habitat: rocks and biogenic reef of the infralittoral, created by an artificial substrate - underwater thresholds, which formed an excellent substrate on which macroalgae and abundant fauna developed (Kruk-Dowgiałło et al. 2009). The coastal area of the Orłowo cliff is the only place in the Puck Bay, where the location of the protected form of red algae *Furcellaria lumbricalis*, rare in POM species of *Sphacelaria cirrosa*, *Protohalopteris radicans* and very rare species of red algae *Ceramium virgatum* has been identified. Stones and boulders are abundantly overgrown with green algae of the genus Ulva and Cladophora and the red algae *Polysiphonia fucoides*. On the sandy bottom, however, there are underwater meadows formed mainly by the protected species of *Zostera marina* (Osowiecki and Żmudziński 2000, Kruk-Dowgiałło et al. 2009, State Environmental Monitoring 2002-2017).

Underwater vegetation occurring on the soft bottom is also noted in the Vistula, Szczecin and the Kamieński lagoons. Generally, it is poorly developed due to poor water transparency (from 0.4 to 1 m) and strong waving (Zalewska-Gałosz 2010). The majority of the Vistula Lagoon is covered by silty-clay deposits in the central part, whereas in the coastal zone sandy sediments predominate, especially in the eastern, marginal batch and at the southern shore - the Elbląg Upland and at the northern shore - the Vistula Spit (Fig. 1.4.5., Olenycz i Barańska 2014). The bottom in the coastal zone of the Szczecin and Kamieński lagoons is also sandy, while in the deeper regions - muddy (Ławicki et al. 2012). The banks of the lagoon are overgrown with vascular vegetation communities characteristic of freshwater reservoirs. In the belt of emergent plants, rush vegetation, which is developed in the form of extensive and compact phytocoenoses, dominates. The most common elements are reed rushes (*Phragmitetum australis*) and bulrushes (*Scirpetum lacustris*), other communities from the Phragmition association and phytocoenoses from the Magnocaricion compound are also widespread. In more secluded places sheltered from waving, favourable development conditions are found for *Nuphar lutea*, *Nymphaea alba*, and *Limnanthemum nymphoides*. These plants form their own phytocoenoses and are also an element of reed phytocoenoses. Among the submerged plants dominate such species as *Potamogeton sp.* Pondweed, *Myatophyllum spicatum*, or stiff horn *Ceratophyllum demersum*. A much less frequent element of vegetation in the reservoirs are Characeae (Nagengast and Warzocha 2004). In the Vistula Lagoon, the influence of salinity is observed, which results in the largest, compared to other lagoons, the share of saltwater species (Zalewska-Gałosz 2010) not present in the Szczecin and Kamieński lagoon (Nagengast and Warzocha 2004)

The benthic habitat on the soft bottom of open, coastal and transitional waters in POM is also represented by macrozoobenthos, which is a good indicator for the quality assessment of water reservoirs (Rosenberg and Loo 1988, Rosenberg et al. 1992, Diaz and Rosenberg 1995). Macrozoobenthos consists of a set of invertebrate animals over 1 mm in size living on the surface of bottom sediments (epifauna) and within (infauna). These are mostly sedentary species with a long (at least one-year) life cycle. The characteristics of macrozoobenthos, i.e. its taxonomic composition, abundance and biomass, is shaped primarily by the physical and chemical factors of the marine environment. The most important natural factors include salinity, oxygen content in the water layer above the bottom and the type of bottom sediments.

Salinity in POM corresponds to the lower range of the mesohaline water (7-9) in the water layer above the halocline and over 13 in the bottom layer of the South Baltic depths. Most bottom invertebrates of the southern Baltic are euryhaline species that are highly tolerant to changes in salinity. The most resistant in this respect is the *Limecola balthica*, which inhabits almost the entire Baltic area. The narrow tolerance range regards the so-called relict species preferring higher salinity, inhabiting deeper and colder areas of the bottom: *Astarte borealis* and *A. elliptica*, *Saduria entomon*, *Priapulus caudatus* and *Halicryptus spinulosus*. Species that prefer low salinity (e.g. snails from the Hydrobiidae family *Theodoxus fluviatilis*, *Radix labiata* , *Gammarus duebeni* and *G. zaddachi*) usually inhabit areas of river mouths and lagoons.

The oxygen content in the bottom layer of water is an important factor limiting the occurrence of macrozoobenthos. In the shallow bottom zone (0-25 m), waving, bottom and surface water currents and vertical mixing cause that the water above the bottom and sediments are well saturated with oxygen. At the deeper bottom, below the halocline (50-70 m), the water temperature is lower than in the surface layer, and the salinity and water density are higher. Because the mixing of bottom water with well-oxygenated surface water is difficult, the only source of oxygen above the bottom are the inflows of oxygenated salty water from the North Sea. However, as a result of the process of mineralization of organic matter falling from the euphotic surface layer, oxygen dissolved in water is exhausted over time (Feistel et al. 2008). Hydrogen sulphide is produced as a result of anaerobic decomposition of organic matter. Deficiency of oxygen (hypoxia) or lack of it (anoxia) concerns mainly the regions of the south-Baltic depth located within the POM - Gdańsk, Bornholm and to a lesser extent the southern slope of the Gotland Deep. The silty bottom of these depths and the areas below the halocline is usually deprived of macroscopic life. After inflows, until oxygen depletes, they are settled by the most resistant to its deficit, opportunistic species of polychaetes: *Scoloplos armiger* and *Bylgides sarsi* and half-pelagic *Saduria entomon*.

The dynamics of waters is a factor shaping bottom zoocenoses in the coastal zone of the open sea. Intense water currents in this zone hinders mass colonization of macrozoobenthos. The bottom fauna is poor in qualitative and quantitative terms. A typical representative of macrozoobenthos inhabiting sand is the small crustacean *Bathyporeia pilosa*.

The sediment type significantly shapes the structure of macrozoobenthic species. Within POM, depending on the area and depth, there are clays and mules, sands, gravels and locally concentrations of stones. The bottom of the shallower areas near the southern shores and the south-Baltic banks - Pomeranian, partly Słupsk and Middle is sandy. There are soft muds in deeper places. On the border of sands and muds (from 20 to 70 m) there is a whole range of transient sediments, from silty sands to sandy muds. In places, there are clusters of stones, or there is a clay with gravel. The muddy bottom, especially in sheltered bays and river estuaries, is rich in particulate and partially decomposed plant matter called detritus.

Each type of sediment of the seabed inhabits a characteristic set of invertebrate organisms. Typical inhabitants of the shallow sandy bottom are: a small crustacean *Bathyporeia pilosa*, *Pygospio elegans* and a mussel - *Cerastoderma glaucum*. With the increase of depth and concentration of organic matter in the sediments, the share of species preferring the sand-silt bottom increases: *Limecola balthica*, *Mya arenaria*, the crustaceans of the genus Corophium and *Diastylis rathkei*. The stony bottom is inhabited by species permanently attached to the surface of stones: Mytilus trossulus, Amphibalanus improvisus and *Einhornia crustulenta*. These species are included in the group of so-called habitat-forming species, because they create habitats for other species, e.g.: gammarids and snails. The macrozoobenthos found in the Rowy boulder area, compared to other coastal areas of the open Baltic, should be considered extremely rich in terms of taxonomic diversity and macroinvertebrate abundance.

Only a few research projects have been carried out in the history of the studies of zoobenthos of the Southern Baltic, as a result of which the surface distribution of dominant zoobenthos species and assemblages was presented. The most important ones include the results of research carried out in 1948-1954 at 272 research stations (Demel and Mańkowski 1951, Demel and Mulicki 1954). As a result, maps of the distribution of dominant species and the distribution of macrozoobenthos biomass were created. In the years 1956-1957, Mulicki and Żmudziński (1969), studying the decomposition of macrozoobenthos biomass, first discovered the presence of large surface "benthic deserts" (azoic areas) in the area of the Bornholm Deep and the Gdańsk Deep. The state of deficit or lack of oxygen at the bottom of the southern-Baltic depths is still present. The study of macrozoobenthos covering the POM area was carried out in the years 1978-1983 by Warzocha (1995). The author provided a description of the structure and classification of the bottom macrofauna communities:

1. *Macoma (Limecola) balthica – Mya arenaria* – sandy bottom community occurring down to a depth of 20 m in the Pomeranian Bay and down to 25 m in the open sea. In composition there are 22 taxa. In terms of numbers, the snails Hydrobiidae and *Pygospio elegans* predominate, in terms of biomass - mussels.
2. *Mytilus edulis* (*trossulus*) – *Gammarus salinus* – community of the bottom of the stony Słupsk Bank at a depth of 14-20 m. Includes 18 taxons (11 belonging to Malacostraca) inhabiting a boulder covered with algae.
3. *Macoma (Limecola) balthica – Mesidotea (Saduria) entomon* – community reaching to the depth of the halocline (50-60 m in the Bornholm Basin and the western part of Słupsk Furrow, 70 m in the eastern part of Słupsk Furrow, 80 m in the Gdańsk Basin and Gotland Basin. It consists of 12-20 taxons on the slopes of Słupsk Furrow and 14 in the Gulf of Gdańsk. In terms of biomass, *Macoma (Limecola) balthica* dominates.
4. *Astarte borealis – Astarte elliptica* – community inhabiting the clay-sand and gravel bottom of the Słupsk Furrow at a depth of 60-90 m. The complex consists of 20 taxa. *Astarte spp*., *Saduria entomon*, *Scoloplos armiger* and *Terebellides stroemi*.
5. *Scoloplos armiger – Macoma (Limecola) balthica* – community inhabiting the southern slope of the Bornholm Basin (below 40-60 m), slopes of the Gdańsk Basin (below 75 m) and Gotland basin (below 80 m). It consists of 11 taxa, mainly polychaetes. *Scoloplos armiger* dominates.

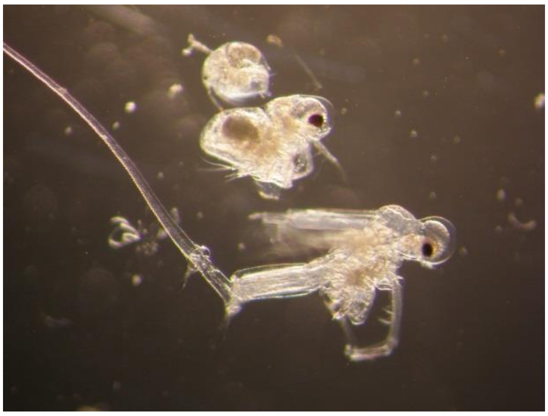
### *Pelagic habitats*

The open sea waters are the main habitat where the primary production takes place, giving the basis of the trophic pyramid. Microscopic phytoplankton organisms enable the development of zooplankton, which in turn is a food base for fish, at least at some stage of their life. Chlorophyll is a commonly used approximation of phytoplankton biomass, due to the ease of analysis and measurement of the content in the aquatic environment, and its concentration is strongly dependent on the concentration of nutrients in the sea (Fleming-Lehtinen et al. 2008, Łysiak-Pastuszak et al. 2009 ), and therefore strongly related to anthropogenic pressure in the form of loads of these substances coming from land and atmosphere (HELCOM 2009). Chlorophyll represents the general measure of the ecosystem productivity level, characterizing fluctuations in phytoplankton biomass.

The blooms of cyanobacteria (Cyanophyceae) assimilating atmospheric nitrogen observed on the sea surface are a natural phenomenon, but as a result of eutrophication in many regions of the Baltic Sea they became more intense and appear more frequently, especially from the late 1980s (Mazur and Pliński 2003 , Mazur-Marzec et al. 2012, Kahru and Elmgren 2014a). One of the main components of these blooms is the toxic species Nodularia spumigena (Nehring 1993, Sipiä et al. 2001). N. spumigena and other species of cyanobacteria adversely affect zooplankton (Sellner et al. 1994, Engström et al. 2000, Sopanen et al. 2009) and other phytoplankton species (Suikkanen et al 2004, 2005), as well as fish and other organisms (Nehring 1993, Sipiä et al. 2001, Mazur-Marzec et al. 2006, Mazur-Marzec et al. 2012). When the majority of cyanobacterial biomass produced during blooms falls to the seabed, the hypoxia of the bottom waters in the deep-water areas is potentially increased (Conley et al. 2011). This means that the mass blooms of cyanobacteria have a negative impact on the biodiversity of both pelagic and benthic communities. The reason for the increase in the intensity of blooms of cyanobacteria is to a large extent the enrichment of the marine environment with nutrients as a result of anthropogenic activity, and especially a disproportionate increase in phosphorus content.

Phytoplankton is the primary producer in marine ecosystems and an important component in the food web. The taxonomic composition of phytoplankton and its seasonal succession depend strongly on environmental conditions such as: light, temperature, salinity, pH, carbon dioxide and the availability of nutrients (Wasmund et al. 2011, Klains et al. 2011, Klains et al 2017). Phytoplankton taxa of the Baltic Sea are mainly diatoms (Diatomophyceae) and dinoflows (Dinophyceae). In recent years, cyanobacteria have been increasing in size and biomass - especially in the summer months, and the least significant groups in terms of numbers and biomass are planktonic cryptophytes (Cryptophyceae) and green algae (Chlorophyceae) (Klains et al. 2011, Wasmund 2011). The list of phytoplankton species of the Baltic Sea contains over 2600 items (PEG Biovolume 2017, GIOŚ 2014), of which about 100 species occur in Polish waters (GIOŚ 2014). The spring is dominated by the diatoms of the species *Pauliella taeniata* or *Chaetoceros wighamii* and fissures *Peridiniella catenata*, summer cyanobacteria *Aphanizomenon flos-aquae* and *Nodularia spumigena* with various cryptophytes, and autumn diatoms *Coscinodiscus granii* and *Thalassiosira baltica* and cryptophyte *Plagioselmis nannoplanctica* (Jaanus et al. 2011, Klains et al. 2011, 2013). Periods of occurrence of particular phytoplankton groups are related to their environmental requirements. The annual cycle of phytoplankton is conditioned by the concentration of nutrients in water, and its distribution is similar throughout the entire Baltic area (Wasmund et al 2011, Wasmund 2017). During spring bloom diatoms quickly reach high biomass and are the dominant component during the so-called new primary production in marine ecosystems (they dominate at a time when the water is relatively cold but rich in biogenic substances) and form the basis in the trophic chain as food for the mesozooplankton. This one is a direct source of food for higher levels. Due to the sedimentary properties, diatoms are also food for benthic organisms (Heiskanen 1998, Fleming and Kaitala 2006, Kownacka 2017). In summer, cyanobacteria dominate in the Baltic. The autumn diatom bloom and the lack of winter production allow full regeneration of nutrients in the euphotic zone (Andrulewicz et al. 2008, Klains et al. 2013, Pastuszak et al. 2016). Phytoplankton also includes ciliopsis (Ciliophora) *Mesodinium rubrum*. Since the 1990s, its quantity in the phytoplankton of the Gulf of Gdańsk has increased (Hansen and Fenchel 2006, Ameryk et al. 2012). Phytoplankton species composition and biomass in the Baltic indicate in recent years a decrease in diatom biomass and a simultaneous increase in biomass of diatoms (Wasmund and Uhlig 2003)

Mesozooplankton is composed of animal pelagic organisms with a body size of 0.2 to 2.0 mm. In POM, they represent small animal organisms that spend their entire life in the water (holoplankton), mainly crustaceans - Copepods and Cladocera, as well as rotifers (Rotifera) and organisms temporarily present in the water (meroplankton), i.e. larval stages of fish, polychaetes, crustaceans and molluscs (Telesh et al. 2008). The taxonomic composition of mesozooplankton in POM is poor and results from the relatively low salinity in this part of the Baltic from about 7.0 to about 7.5 PSU. In POM, there are usually several mesozooplankton species appearing regularly, while in the south-western region of the Baltic Sea, where the salinity is above 10 [PSS'78] their number is about 30 (Andrulewicz et al. 1998).



Most of the mesozooplankton biomass is formed by euryhaline marine species: the Temora longicornis copepods, three species of the genus Acartia and *Pseudocalanus acuspes*, and the Cladocera: *Bosmina coregoni*, *Evadne nordmanni* and *Pleopsis polyphaemoides*. Seasonally, an important component of mesozooplankton are also Rotifera - *Synchaeta spp*. Massively appearing in May and *Keratella spp*. Appearing at the end of summer (Wiktor 1990, Andrulewicz et al., 1998). In the mouths of large rivers and in the coastal zone, an important component of mesozooplankton are also euryhaline freshwater species, such as freshwater rotifers and cladocerans (Chojnacki 1984, Koszteyn 1985, Wiktor 1990). Another parameter of the environment, which is of great importance in shaping the taxonomic and quantitative composition (abundance and biomass) of mesozooplankton is the temperature of water, whose seasonal fluctuations result mainly from changes in air temperature. Changes in water temperature directly affect the composition of mesozooplankton - cold winter taxa such as the Pseudocalanus elongatus and *Fritillaria borealis* appear in the winter months, while in summer thermophilic ones appear, especially *Bosmina coregoni* (Mańkowski 1978, Chojnacki 1984). The temperature of water influences the composition of mesozooplankton, also indirectly, because it determines the development of phytoplankton - the food base. In spring and summer, when the resources of phytoplankton are increasing, the number and biomass of rotifers feeding on it also increases (Chojnacki 1984, Wiktor 1990). Seasonal changes in the taxonomic and quantitative composition of mesozooplankton are most distinctive in shallow waters, and in deep areas above the thermocline layer, where temperature fluctuations are the greatest. The composition of mesozooplankton depends also on local conditions and episodic events. The first of these factors is the inflow of freshwater brought in by rivers and the local decrease in the salinity of sea waters, which results in the presence of freshwater species of mesozooplankton in the marine waters, e.g. Cladocera and rotifers. The second factor is the inflow of salty waters from the North Sea through the Danish Straits. Their range may be manifested by the periodic occurrence in POM of saltwater species, such as *Oithona similis* (Krzymiński 2017).

In the composition of the mesozooplankton in the Gdańsk Basin dominate, as in the rest of POM, copepods, cladocera, rotifers and meroplankton (PMŚ data for the years 2011-2016). Among the copepods the largest numbers and biomass belongs to the genus Acartia - *A. longiremis*, *A. bifilosa* and *A. tonsa* (order from the taxon characterized by the highest numbers and biomass), *Pseudocalanus elongatus*, *P. minutus* and *Temora longicornis*. In addition to these species in the Gdańsk Basin there are regular, though in smaller quantities, *Eurytemora sp*. and *Oithona similis*. Numerous are *Bosmina coregoni* and *Evadne nordmanni*. Seasonally, in large numbers there genera of Synchaeta and Keratella. Similarly to rotifers, representatives of meroplankton can periodically appear in the mesozooplankton composition, among which the most frequent are the larvae of Bivalvia and Polychaeta and in fewer Cirripedia and Gastropoda.

In the Polish zone of the Baltic Sea, the distribution of chlorophyll-a in sea water is uneven. A decisive gradient is observed decreasing from land, from the zone of transitional and coastal waters towards the open sea areas (Łysiak-Pastuszak et al. 2009, Kraśniewski and Łysiak-Pastuszak 2012). The highest concentrations of chlorophyll-a, and therefore the highest values of phytoplankton biomass are recorded in coastal waters (Łysiak-Pastuszak 2012, Łysiak-Pastuszak et al. 2016). Measurements of chlorophyll-a as part of the monitoring of Baltic waters are carried out in the open sea zone since 1993, and in the transitional and coastal waters zone they were included in monitoring only in 1999 with the launch of a monitoring program in accordance with HELCOM COMBINE in Polish waters. In the years 1999-2005 an increase in chlorophyll-a concentrations was observed in the summer months (June-September) and in several sub-basins in POM, statistically significant trends of changes in the chlorophyll-a content were observed at this time of the year, which remained over a longer period of time, e.g. in Eastern Gotland Basin (Kraśniewski et al. 2011).

In the decade 2006-2015 (Łysiak-Pastuszak et al. 2016) no increase in chlorophyll-a concentrations in sea waters was observed in the summer months in the form of statistically significant, positive trends that were noted in previous years, but in many regions there was still an upward trend, also with reference to average annual concentrations. In general, the average annual concentrations of chlorophyll in the open waters of the Baltic Sea show greater stability than concentrations during the summer, which is primarily affected by meteorological conditions. For example, in the years 2002-2008 a number of extremely intense blooms of cyanobacteria were recorded in the Polish Baltic Sea area, for example in August 2007 in the Eastern Gotland Basin 9741,3 $mm^3 \cdot m^{-3}$ which constituted 95.4% of the total phytoplankton biomass (Kraśniewski et al. 2012).

In the currently assessed period (2011-2016), measurements of chlorophyll-a content show certain stabilization - despite the continued increase trend of chlorophyll-a in the summer months, in principle no statistically significant change trends have been observed, while in some Polish regions of the Baltic Sea, e.g. in the western part of the shallow central Baltic Sea region or the Eastern Gotland Basin (P140 station), there have been observed decreasing trends in the in chlorophyll-a concentrations in the summer months (Łysiak-Pastuszak et al. 2016).

## 1.5. Non-indigenous species in Polish Marine Areas

The term non-indigenous species (NIS, alien species, non-native, allochthonus) refers to a species, subspecies or a lower taxonomic level that has been introduced beyond its natural range and beyond its natural spreading potential. This applies to any form of organism that can survive, reproduce and create a population. The emergence of a foreign species in a new region is always related to the intentional or unintentional human activity. Natural changes in the range of occurrence do not qualify the species as alien species. They can, however, play an important role in further dissemination from the site of introduction (Olenin et al., 2017).

This information is very important in the context of considering alien species as one of the important elements determining good environmental status in accordance with Annex I of MSFD (Descriptor 2).

Qualification of a species as alien in a given region is based on special criteria recommended by experts who co-create the AquaNIS database. The AquaNIS database is an online database of alien species of Europe and adjacent regions adopted by HELCOM. Meeting at least 3-4 criteria allows for giving a given species to be assigned alien status, the most important of which are:

1. The arrival of a new species.
2. The range of discontinuous occurrence.
3. Very local occurrence in the vicinity of a well-known species introduction route (eg in a port, marina, near aquaculture installations).
4. A sudden expansion of the range of the occurrence of a species which until now has occurred very locally, and its current distribution of occurrence would be impossible to achieve through natural disperse.
5. Dependence on non-native species (co-existing with them on the basis of commensalism or parasitism).
6. There are genetic indications that the species is a representative of a distant population.
7. The species represents a component of the taxonomic group that is not at all or is poorly represented in the area.

***Fish***

Among the species of ichthyofauna that meet the above criteria and observed in 2011-2016 in the transitional, coastal waters and deep sea areas of POM zone, the following can be mentioned:

- round goby *Neogobius melanostomus* and monkey goby *Neogobius fluviatilis* – in POM observed from the end of the last century (Skóra i Stolarski 1993, Wandzel, 2003, Witkowski and Grabowska 2012, Lejk et al., 2013),

- carp *Cyprinus carpio* – observed from 1200-1300 (Witkowski and Grabowska, 2012; Grabowska, Kotusz, Witkowski, 2010),

- prussian carp *Carassius gibelio* – observed from 1930-1933 (Witkowski and Grabowska, 2012),

- sterlet *Acipenser ruthenus* – observed from 1937 (Witkowski and Grabowska, 2012).

The above species have been present in POM for a very long time, going beyond the period 2011-2016. One species, which appeared in the MIR-PIB catches conducted during the BITS-Q1 research voyage in February 2015, was not listed on the list above, as it was submitted for verification by AquaNIS database experts for taxonomic identification and criteria compliance with NIS status in the Baltic Sea. There was a difference of opinion whether this is the native species of horse mackerel *Trachurus trachurus* (Linnaeus, 1758) or the non-native species False scad (chippies, hawthorn shank) *Caranx rhonchus* Geoffroy Saint-Hilaire, 1817, both of the Carangidae horse-thistle family. The natural range of occurrence of the False scad reaches the eastern Atlantic (from Morocco to Angola), including the Mediterranean Sea area along the African coast. Caught in 2015 are juveniles. Considering the AquaNIS base criteria, these fish have so far met two criteria: (1 and 7), and three others (2, 4 and 6) were still analysed. After the final verification it turned out that this is not a new species of non-native species, therefore in the period 2011-2016 in POM no new species of non-indigenous ichthyofauna were observed.

Each year in the period 2011-2016 in fish caught in POM species visiting the Baltic Sea were observed, i.e. those migrating mainly from the North Sea, due to the changes in the hydrological parameters of some regions of the Baltic Sea, which may be associated with climate change. Unfavourable environmental conditions, such as low salinity, do not allow these species to set up a self-sufficient population in the Baltic Sea. The native area of the occurrence of species that visit the Baltic Sea is usually the region of the North-East Atlantic covering the North Sea. Their arrival in the Baltic area is usually (though not always) related to the inflows of saline waters and always takes place in a natural way, is not related to human activity. An additional common feature of these species is the continuous nature of their natural occurrence, i.e. entering the Baltic Sea does not cause the discontinuity of its occurrence. Examples of alien and visiting species are listed in Table 1.5.1.

The following tables (Table 1.5.2 –Table 1.5.7) present observations of alien and visiting species. Data are derived from different types of fishing conducted in POM in the years 2011-2016 as part of MIR-PIB's own research and conducted under agreements with the Chief Inspectorate for Environmental Protection.

Table 1.5.1. List of alien and visiting species observed in MIR-PIB's own research in 2011-2016 carried out in POM.

| Species name | Latin name | Literature |
|---|---|---|
| monkey goby | *Neogobius fluviatilis* (Pallas, 1814) | Grabowska, J., J. Kotusz, A. Witkowski 2010. Alien invasive fish species in Polish waters: an overview. Folia Zool., 59 (1); 73-85. |
| | | Lejk, A. M., M. Żdanowicz, M. R. Sapota, I. Psuty 2013. The settlement of *Neogobius fluviatilis* (Pallas, 1814) in Vistula River estuaries (southern Baltic Sea, Poland). J. Appl. Ichthyol., 29; 1154-1157. |
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| | | Grygiel, W. 2017. Ryby rzadko spotykane, mało liczne i chronione w południowym Bałtyku - na podstawie monitorowanych (2013-2015) polskich połowów komercyjnych. Wiadomości Rybackie, nr 3-4 (216) 2017, Mor. Inst. Ryb. - Pań. Inst. Badaw., Gdynia; 18-21. |
| round goby | *Neogobius melanostomus* (Pallas, 1814) | Czugała, A., A. Woźniczka 2010. The River Odra estuary - another Baltic Sea area colonized by the round goby *Neogobius melanostomus* Pallas, 1811. Aquatic Invasions, vol. 5 (Suppl. 1); 61-65; http://www.aquaticinvasions.net/2010/Supplement/AI_2010_5_S1_Czu |
| | | Grygiel, W., K. Trella, A. Grelowski 2004. Variation in the occurrence of visiting, non-numerous, and alien fish species in the autumn-winter seasons of 1976-2004 in the southern Baltic Sea. Poster No. 69/PH02 - Alien Fish Species Symposium (6-10.09.2004, Tallinn); [in:] XI European Congress of Ichthyology, Abstract volume, p. 179. |

| Species name | Latin name | Literature |
|---|---|---|
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| | | Grygiel, W. 2008. Gatunki inwazyjne w Morzu Bałtyckim, ze szczególnym uwzględnieniem babki byczej. Wiadomości Rybackie nr 7/8 (164), Pismo Mor. Inst. Ryb., Gdynia; 18-22. |
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| | | Kuczyński, J. 1995. Babka krągła *Neogobius melanostomus* (Pallas, 1811) - emigrant z basenu ponto-kaspijskiego w Zatoce Gdańskiej. Biul. Mor. Inst. Ryb., Gdynia, 2(135); 68-71. |
| | | Sapota, M. R. 2005. Biologia i ekologia babki byczej Neogobius melanostomus (Pallas 1811), gatunku inwazyjnego w Zatoce Gdańskiej. Monografia, Wydaw. Uniwersytet Gdański, Gdańsk; 117 s. |
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| Whiting | *Merlangius merlangus* (Linnaeus, 1758), | Demel, K. 1933. Wykaz bezkręgowców i ryb Bałtyku naszego. Fragmenta Faunistica Musei Zoologici Polonici, Warszawa, t. II, nr 13; 121-136. |
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| Species name | Latin name | Literature |
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| Species name | Latin name | Literature |
|---|---|---|
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| Common dab | *Limanda limanda* (Linnaeus, 1758) | Grygiel, W., K. Trella, A. Grelowski 2004. Variation in the occurrence of visiting, non-numerous, and alien fish species in the autumn-winter seasons of 1976-2004 in the southern Baltic Sea. Poster No. 69/PH02 - Alien Fish Species Symposium (6-10.09.2004, Tallinn); [in: XI European Congress of Ichthyology, Abstract volume], p. 179. |
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| Saithe | *Pollachius virens* | Grygiel, W. and B. Witalis 2014. Research report from the Baltic International Trawl Survey (BITS-1Q) in the Polish marine waters (r.v. "Baltica"; 10.02. – |

| Species name | Latin name | Literature |
|---|---|---|
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| | | Rembiszewski, J. M., H. Rolik 1975. Krągłouste i ryby *Cyclostomata et Pisces*. Katalog Fauny Polski, nr 24, PAN – Inst. Zoologii, PWN, Warszawa; 251 s. |
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| Atlantic horse mackerel | *Trachurus trachurus* (Linnaeus, 1758) | Elwertowski, J. 1957. Biologiczna charakterystyka polskich połowów szprota w Bałtyku Południowym w latach 1950-1954. Pr. Mor. Inst. Ryb., Gdynia, 9; 175-219. |
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| Haddock | *Melanogrammus aeglefinus* (Linnaeus, 1758) | Grygiel, W., T. Wodzinowski 2013. Research report from the Baltic International Trawl Survey (BITS-4q) in the Polish part of the southern Baltic (16-28 Nov. 2012). Working paper on the WGBIFS meeting in Tartu (Estonia); 21-25.03.2013; [in:] ICES CM 2013/SSGESST:08; Annex 7; 145-164. |
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| Species name | Latin name | Literature |
|---|---|---|
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| | | Grygiel, W. 2016. Popularne i rzadkie gatunki ryb w Bałtyku - występowanie i zróżnicowanie nazw (część 2). Wiadomości Rybackie nr 1-2 (209), Pismo Mor. Inst. Ryb. - Pań. Inst. Badaw., Gdynia; 19-23. |
| Poor cod | *Trisopterus minutus* (Linnaeus, 1758) | Grygiel, W. 2015. Popularne i rzadkie gatunki ryb w Bałtyku - zróżnicowanie nazw (część 1). Wiadomości Rybackie, nr 5-6; Pismo Mor. Inst. Ryb.-PIB, Gdynia; 16-21. |
| European hake | *Merluccius merluccius* (Linnaeus, 1758) | Grygiel, W. 2009. „Tymczasowi przybysze" w polskich połowach ryb na Bałtyku. *Wiadomości Rybackie* nr 7-8(170)/2009, Pismo Mor. Inst. Ryb., Gdynia; 16-18. |
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| Common sole | *Solea solea* (Linnaeus, 1758) | Skóra, K. 1998. Chelon *Chelon labrosus* (Risso). Stacja Mor. Inst. Oceano. Uniw. Gdańskiego; http://www.hel.univ.gda.pl/aktu/archiwum/ch.html. |
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| | | Grygiel, W. 2017. Ryby rzadko spotykane, mało liczne i chronione w południowym Bałtyku - na podstawie monitorowanych (2013-2015) polskich połowów komercyjnych. Wiadomości Rybackie, nr 3-4 (216) 2017, Mor. Inst. Ryb. - Pań. Inst. Badaw., Gdynia; 18-21. |

Table 1.5.2. Data from Polish commercial fishing in 2013-2015 monitored by scientific observers from MIR-PIB, Gdynia (according to W. Grygiel, MIR-PIB). Species marked with bold font are alien in the Baltic Sea.

| | | 2013 | 2014 | 2015 | Total | Month of a record |
|---|---|---|---|---|---|---|
| **round goby** | catch (kg) | 13.75 | 30.86 | 6.17 | 50.78 | 4, 6-11 |
| | catch (number of individuals) | 224 | 415 | 114 | 753 | |
| | number of records | 9 | 17 | 6 | 32 | |
| **monkey goby** | catch (kg) | 0.05 | | 0.02 | 0.07 | 7, 9 |
| | catch (number of individuals) | 2 | | 1 | 3 | |
| | number of records | 2 | | 1 | 3 | |
| Whiting | catch (kg) | 97.94 | 228.24 | 345.23 | 671.41 | 1-12 (exlc. 9) |
| | catch (number of individuals) | 214 | 623 | 1905 | 2742 | |
| | number of records | 10 | 23 | 23 | 56 | |
| European anchovy | catch (kg) | | | 509.44 | 509.44 | 2-4, 12 |
| | catch (number of individuals) | | | 30334 | 30334 | |
| | number of records | | | 10 | 10 | |
| Atlantic mackerel | catch (kg) | 5.30 | 43.84 | 29.69 | 78.83 | 2-8 |
| | catch (number of individuals) | 10 | 90 | 69 | 169 | |
| | number of records | 4 | 6 | 15 | 25 | |
| Saithe | catch (kg) | 0.40 | 53.81 | 6.11 | 60.32 | 1-2, 5-12 |
| | catch (number of individuals) | 1 | 52 | 5 | 58 | |
| | number of records | 1 | 21 | 5 | 27 | |
| Atlantic horse mackerel | catch (kg) | | | 4.8 | 4.8 | 2 |
| | catch (number of individuals) | | | 480 | 480 | |
| | number of records | | | 1 | 1 | |
| Haddock | catch (kg) | 1.00 | 0.26 | 0.59 | 1.85 | 6-8 |
| | catch (number of individuals) | 1 | 1 | 1 | 3 | |
| | number of records | 1 | 1 | 1 | 3 | |
| European hake | catch (kg) | | 0.46 | 1.20 | 1.66 | 5, 8 |
| | catch (number of individuals) | | 1 | 1 | 2 | |
| | number of records | | 1 | 1 | 2 | |
| Common dab | catch (kg) | 0.21 | 0.14 | 0.38 | 0.73 | 1-2, 7-8 |
| | catch (number of individuals) | 1 | 1 | 2 | 4 | |
| | number of records | 1 | 1 | 2 | 4 | |
| Common sole | catch (kg) | | | 0.44 | 0.44 | 8 |
| | catch (number of individuals) | | | 1 | 1 | |
| | number of records | | | 1 | 1 | |

Table 1.5.3. List of visiting fish species caught in POM on BITS research flights in 2011-2016 (according to W. Grygiel, MIR-PIB)

| | | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **Total** | **Month of a record** |
|---|---|---|---|---|---|---|---|---|---|
| Whiting | catch (kg) | 0.55 | | | 0.39 | 1.14 | | 2.08 | 6, 9, 10 |
| | catch (number of individuals) | | | | 2.00 | 6.00 | | 8.00 | |
| | number of records | 5.00 | | | 2.00 | 4.00 | | 11.00 | |
| European anchovy | catch (kg) | | | | | 0.06 | | 0.06 | 9 |
| | catch (number of individuals) | | | | | 2.00 | | 2.00 | |
| | number of records | | | | | 1.00 | | 1.00 | |
| Atlantic mackerel | catch (kg) | 0.26 | 1.95 | 1.06 | | | 3.43 | 6.69 | 9 |
| | catch (number of individuals) | | 7.00 | 3.00 | | | | 10.00 | |
| | number of records | 1.00 | 6.00 | 2.00 | | | 1.00 | 10.00 | |

Table 1.5.4. List of alien and visiting fish caught in POM on BITS research flights in 2011-2016 (according to W. Grygiel, MIR-PIB).

| | | 2011 | 2012 | 2013 | | 2014 | 2015 | 2016 | Total | Month of a record |
|---|---|---|---|---|---|---|---|---|---|---|
| round goby | catch (kg) | 0.10 | | 0.07 | | | 0.08 | 0.43 | 0.69 | 2, 11 |
| | catch (number of individuals) | | | | | | 6 | 9* | 15 | |
| | number of records | 1 | | 2 | | | 3 | 11 | 17 | |
| Whiting | catch (kg) | 6.40 | 9.16 | 1.91 | | 10.42 | 13.22 | 8.19 | 49.29 | 2, 11 |
| | catch (number of individuals) | | 4* | 3* | | 39 | 58 | 19 | 123 | |
| | number of records | 16 | 9 | 5 | | 11 | 16 | 12 | 69 | |
| European anchovy | catch (kg) | 0.04 | | 0.05 | | 0.57 | 16.07 | 3.00 | 19.73 | 2, 11 |
| | catch (number of individuals) | | | 3 | | 39 | 423 | 39* | 504 | |
| | number of records | 2 | | 2 | | 7 | 11 | 16 | 38 | |
| Atlantic mackerel | catch (kg) | | 1.10 | | | | 0.26 | | 1.35 | 2 |
| | catch (number of individuals) | | | | | | 2 | | 2 | |
| | number of records | | 1 | | | | 2 | 2 | 5 | |
| Saithe | catch (kg) | | | | | 6.23 | | | 6.23 | 2, 11 |
| | catch (number of individuals) | | | | | 10 | | | 10 | |
| | number of records | | | | | 7 | | | 7 | |
| Atlantic horse mackerel | catch (kg) | | | | | | 0.42 | 2.00 | 2.42 | 2, 11 |
| | catch (number of individuals) | | | | | | 1 | 3* | 4 | |
| | number of records | | | | | | 1 | 3* | 4 | |
| Haddock | catch (kg) | | 0.36 | | | | 0.42 | | 0.78 | 2, 11 |
| | catch (number of individuals) | | 1 | | | | 1 | | 2 | |

| | | 2011 | 2012 | 2013 | | 2014 | 2015 | 2016 | Total | Month of a record |
|---|---|---|---|---|---|---|---|---|---|---|
| | number of records | | 1 | | | | 1 | | 2 | |
| Common dab | catch (kg) | 0.18 | | | | 0.06 | 0.06 | 0.17 | 0.47 | 2 |
| | catch (number of individuals) | | | | | 1 | 1 | | 2 | |
| | number of records | 1 | | | | 1 | 1 | 1 | 4 | |
| Poor cod | catch (kg) | | | | | | 0.03 | 0.07 | 0.10 | 2 |
| | catch (number of individuals) | | | | | | 1 | | 1 | |
| | number of records | | | | | | 1 | 1 | 2 | |

** no information from the first quarter*

Table 1.5.5. Visiting species in POM in years 2011-2016 (wg W. Grygiel).

| **Species name** | **Latin name** | **Observation** |
|---|---|---|
| thicklip grey mullet | *Chelon labrosus* (Risso, 1827) | On 20-21.09. 1998 in the Puck Bay, a thicklip grey mullet length of 64 cm and a weight of 2.61 kg (after evisceration, Leather 1998) was caught. Based on Grygiel (2009) - on 14.11. 2007 in the northern part of Lake Dąbie (near Szczecin) - north of Stołczyn, Polish fishermen caught thicklip grey mullet with their eels (age 2+) with a total length of 26.7 cm and a weight of 176.8 g (according to P. Czerniejewski - personal communication). In the aforementioned During this period, fishermen from Świnoujście also caught thicklip grey mullet.. |
| greater weever | *Trachinus draco* (Linnaeus, 1758) | On 01.08. In 2016, the UST-52 cutter, in the N-7 fishing square, caught with the cod fixed net, a greater weever with a length of 21 cm and a weight of 70 g (data from MIR-NRI, Gdynia). Greater weevers are very rarely found in the Polish waters of the Baltic (Kraczkiewicz 1971, Obara 2009, Skóra 2009, Grygiel 2015). On 17.09.2008 in Skagerrak (Norway) during acoustic calibration for r / v "Baltica", a 40 cm long greater weever was caught with the rod (W. Grygiel - personal communication). |
| Atlantic bonito | *Sarda sarda* (Bloch, 1793) | Caught in Fyke net, in the Puck Bay between Kuźnica and Jastarnia, 24/08. 2016 by the crew of the JAS-107 cutter, it was about 50 cm long, it weighed about 2 kg. A few days earlier, the crew of KUŹ-47 cutter also caught the Atlantic bonito (S. Smoliński - personal communication). |
| ocean sunfish | *Mola mola* Linnaeus, 1758 | According to M. Bała (2016), young fish about 60 cm in length in the Gulf of Puck were caught by fishermen from Kuźnica in 2014. Single small, young ocean sunfish very sporadically also occurred earlier in the Baltic Sea, including Polish coasts (Siedlecki 1947, Leather 2005, Anon. 2009a, 2010c for Leather 2005). According to Grygiel (2010) - on 12.10. 2010, fishermen from the ŁEB-12 boat cutter, Łeba caught a young man with a length of 75 cm and a weight of 17.2 kg. |
| Swordfish | *Xiphias gladius* Linnaeus, 1758 | According to M. Bała (2016) - in 2015 and 2016, two swordfish- 250 cm long - were caught at the Polish Baltic coasts. On 02.11. In 2005, Polish fishermen from Unieście cod fishing trawls caught a male swordfish with a total length of 189 cm and a mass of 30.5 kg (Wyszyński and Pelczarski 2005). On November 15. 2015 boat crew KRS-27 in the southern part of the hunt. the Odrzańskis caught a swordfish with a length of 239 cm (according to MIR-PIB, 2015). |
| Atlantic mackerel | *Scomber scombrus* Linnaeus, 1758 | A foreign species in POM, young and adult fish periodically visit POM. For example - for W. Grygiel (2013) - on 19 and 29/09. In 2013, during the BIAS voyage on r / v "Baltica" three Atlantic mackerels with a length of 32 cm were caught with a total mass of 1.1 kg in the area of the southern part of the Gdańsk Deep (depth 20-65 m from the surface) and near Kołobrzeg (14-20 m from the surface). |
| European hake | *Merluccius merluccius* (Linnaeus, 1758) | According to Grygiel (2009) - fishermen from the "WŁA-112" cutter on 16.05.2009 during cod fishing in the Słupsk trough caught European hake, it was a 4-year-old fish, with a total length of 57 cm and a weight of 1175 g (eviscerated Similar two European hakes were found by the crew of the above-mentioned boat in other fisheries not monitored by the MIR. |

Table 1.5.6. Detailed list of alien fish species caught in coastal and transitional watebodies under agreements with GIOŚ in years 2011-2016

| | | | **2011** | **2013** | **2014** | **2015** | **2016** | **Total** | **Month of a record** |
|---|---|---|---|---|---|---|---|---|---|
| **DZIWNA - SARBINOWO** | round goby | catch (kg) | 6.44 | | | | | 6.44 | 8 |
| | | catch (number of individuals) | 82 | | | | | 82 | |
| **DZIWNA - ŚWINA** | round goby | catch (kg) | 37.05 | | | | | 37.05 | 9 |
| | | catch (number of individuals) | 477 | | | | | 477 | |
| **JAROSŁAWIEC - SARBINOWO** | round goby | catch (kg) | 1.35 | | | 6.58 | | 7.93 | 7, 8 |
| | | catch (number of individuals) | 17 | | | 74 | | 91.00 | |
| | common carp | catch (kg) | 0.26 | | | | | 0 | 7 |
| | | catch (number of individuals) | 1 | | | | | 1.00 | |
| **VISTULA SPIT** | round goby | catch (kg) | 0.11 | | | | | 0 | 7 |
| | | catch (number of individuals) | 2 | | | | | 2.00 | |
| **HEL PENINSULA** | round goby | catch (kg) | 0.12 | | | | | 0.12 | 8 |
| | | catch (number of individuals) | 4 | | | | | 4 | |
| **ROWY - JAROSŁAWIEC EAST** | round goby | catch (kg) | 28.63 | | | | | 28.63 | 7 |
| | | catch (number of individuals) | 390 | | | | | 390 | |
| **ROWY - JAROSŁAWIEC WEST** | round goby | catch (kg) | 0.96 | | | | | 0.96 | 8 |
| | | catch (number of individuals) | 12 | | | | | 12.00 | |
| **WŁADYSŁAWOWO - JASTRZĘBIA GÓRA** | round goby | catch (kg) | 1.07 | | | | | 1 | 8 |

| | | | 2011 | 2013 | 2014 | 2015 | 2016 | Total | Month of a record |
|---|---|---|---|---|---|---|---|---|---|
| | | catch (number of individuals) | 14 | | | | | 14.00 | |
| ŚWINA MOUTH | round goby | catch (kg) | 0.35 | | | | | 0 | 6 |
| | | catch (number of individuals) | 27 | | | | | 27.00 | |
| WISŁA PRZEKOP MOUTH | round goby | catch (kg) | 81.37 | | 3.78 | 7.31 | | 92.46 | 7, 8, 10 |
| | | catch (number of individuals) | 2855 | | 98 | 369 | | 3322 | |
| | monkey goby | catch (kg) | 4.62 | | | 7.52 | | 12.14 | 7, 8, 10 |
| | | catch (number of individuals) | 319 | | | 632 | | 951 | |
| KAMIEŃSKI LAGOON | Prussian carp | catch (kg) | 0.62 | | | | | 0.62 | 8 |
| | | catch (number of individuals) | 1 | | | | | 1.00 | 7, 8, 10, 11 |
| PUCK LAGOON | round goby | catch (kg) | 444.30 | 132.45 | 67.59 | 108.35 | 414.09 | 1167 | 8 |
| | | catch (number of individuals) | 38203 | 10210 | 5027 | 9905 | 29409 | 92754.00 | |
| | Prussian carp | catch (kg) | 8.72 | | | | | 9 | 8 |
| | | catch (number of individuals) | 69 | | | | | 69.00 | |
| SZCZECIN LAGOON | round goby | catch (kg) | 0.35 | | 0.75 | 7.33 | | 8 | 7, 8, 10 |
| | | catch (number of individuals) | 16 | | 70 | 712 | | 798.00 | |
| | Prussian carp | catch (kg) | 0.13 | | | 0.29 | | 0.42 | 7 |
| | | catch (number of individuals) | 1 | | | 1 | | 2 | |
| VISTULA LAGOON | round goby | catch (kg) | 0.11 | | 0.30 | 1.03 | 3.28 | 4.72 | 8, 1 |

| | | | 2011 | 2013 | 2014 | 2015 | 2016 | Total | Month of a record |
|---|---|---|---|---|---|---|---|---|---|
| | | catch (number of individuals) | 2 | | 38 | 133 | 231 | 404 | |
| | monkey goby | catch (kg) | | | 0.13 | 0.14 | 1.82 | 2.10 | 8 |
| | | catch (number of individuals) | | | 13 | 17 | 141 | 171.00 | |
| | Prussian carp | catch (kg) | 3.33 | | 176.40 | 36.97 | 379.37 | 596 | 8 |
| | | catch (number of individuals) | 23 | | 710 | 108 | 1033 | 1874.00 | |
| | sterlet | catch (kg) | 0.46 | | | | | 0 | 10 |
| | | catch (number of individuals) | 1 | | | | | 1.00 | |
| **INNER GULF OF GDANSK** | round goby | catch (kg) | 135.04 | | 54.90 | 174.95 | | 364.89 | 6, 7, 8, 10, 11 |
| | | catch (number of individuals) | 3027 | | 2059 | 7634 | | 12720.00 | |
| | monkey goby | catch (kg) | 0.23 | | | 1.11 | | 1 | 8 |
| | | catch (number of individuals) | 9 | | | 93 | | 102.00 | |
| **OUTER PUCK BAY** | round goby | catch (kg) | 443.13 | 52.48 | 179.91 | 1043.30 | 1283.18 | 3002 | 7, 8, 9, 10, 11 |
| | | catch (number of individuals) | 14763 | 1538 | 10452 | 40363 | 54627 | 121743.00 | |

Table 1.5.7. List of sum of alien fish species caught in the coastal and transitional waters under the agreements with GIOŚ in 2011-2016 (MIR-PIB).

| | | | **2011** | **2013** | **2014** | **2015** | **2016** |
|---|---|---|---|---|---|---|---|
| **Total coastal and transitional waters** | round goby | catch (kg) | 1180.39 | 184.93 | 307.23 | 1348.85 | 1700.93 |
| | | catch (number of individuals) | 59891 | 11748 | 17744 | 59191 | 84311 |
| | monkey goby | catch (kg) | 4.84 | | 0.13 | 8.77 | 1.82 |
| | | catch (number of individuals) | 328 | | 13 | 742 | 141 |
| | Prussian carp | catch (kg) | 12.80 | | 176.40 | 37.27 | 379.37 |
| | | catch (number of individuals) | 94 | | 710 | 109 | 1033 |
| | sterlet | catch (kg) | 0.46 | | | | |
| | | catch (number of individuals) | 1 | | | | |
| | common carp | catch (kg) | 0.26 | | | | |
| | | catch (number of individuals) | 1 | | | | |

### *Phytoplankton, macrophytes, macrozoobenthos and zooplankton*

Until 2011, 30 non-native species belonging to phytoplankton, zooplankton, macrophytes, zoobenthos and avifauna (Table 1.5.8) were noted within POM (GIOŚ 2014).

Table 1.5.8. List of alien species registered in POM until 2010.

| **No.** | **Species name** | **Date of first observation in Poland** | **Place of occurrence in Polish maritime areas** | **Literature / Source** |
|---|---|---|---|---|
| **PHYTOPLANKTON** | | | | |
| 1. | *Alexandrium ostenfeldii* | 2001 | Puck Lagoon | http://hel.univ.gda.pl/aktu/2003/luminescencja.htm; HELCOM (2004) |
| 2. | *Prorocentrum minimum* | 1989 | Gulf of Gdańsk, open waters of the Bornholm Basin | Olenina i in. (2010); Grzebyk i in. (2007); Report of the ICES (2009) |
| 3. | *Pseudochattonella farcimen* | 2001 | Gulf of Gdańsk | Olenina i in. (2010); Report of the ICES; Łotocka (2009) |
| **MACROPHYTES** | | | | |
| 4. | *Elodea canadensis* | 1870 | Szczecin Lagoon, Vistula Lagoon | Garbacik-Wesołowska (1969); Pliński (1978) |
| 5. | *Chara connivens* | 1975 | Szczecin Lagoon, Vistula Lagoon | Brzeska (inf. ustna); Pliński i in. (1978) |
| **ZOOPLANKTON** | | | | |
| 6. | *Acartia tonsa* | 1925 | all southern Baltic Sea | Rzoska (1938); Zaiko i in. (2011) |

| | | | | |
|---|---|---|---|---|
| 7. | *Cercopagis pengoi* | koniec lat. 90 | Baltic Sea, Gulf of Gdańsk, Vistula Lagoon, Szczecin Lagoon, Open waters of the Bornholm Basin | http://www.iop.krakow.pl/gatunkiobce/; Żmudziński (1999); Zaiko i in. (2011); Olszewska (2006) |
| 8. | *Mnemiopsis leidyi* | 2007 | Puck Bay, western part of Gulf of Gdańsk | http://www.iop.krakow.pl/gatunkiobce/; Zaiko i in. (2011); Janas i Zgrundo (2007) |
| **ZOOBENTHOS** | | | | |
| 9. | *Anguillicola crassus* | 1988 | Vistula Lagoon, Gulf of Gdańsk | Zaiko i in. (2011); biodiv.mos.gov.pl |
| 10. | *Balanus improvisus* | 1844 | all southern Baltic Sea | http://www.iop.krakow.pl/gatunkiobce/; Zaiko i in. (2011) |
| 11. | *Cordylophora caspia* | <1840 | Szczeciń Lagoon, Vistula Lagoon | http://www.nobanis.org/NationalInfo.asp?countryID=PL&taxaID=195; Jażdżewski i Konopacka (2002) |
| 12. | *Chaetogammarus ischnus* | 1928 | Vistula Lagoon | http://www.iop.krakow.pl/gatunkiobce/; Jażdżewski i in. (2005); Grabowski i in. (2007) |
| 13. | *Chelicorophium curvispinum* | 1920 | Szczecin Lagoon, Vistula Lagoon | Jażdżewski i in. (2005); Jażdżewski i Konopacka (1995); Konopacka (2004) |
| 14. | *Dikerogammarus villosus* | 2003 | Szczecin Lagoon, Vistula Lagoon, Gulf of Gdańsk | Jażdżewski i Konopacka (2000, 2002); Dobrzycka-Krahel i Rzemykowska (2010) |
| 15. | *Dikerogammarus haemobaphes* | 1996 | Vistula Lagoon, Gulf of Gdańsk | Konopacka (2004); Dobrzycka-Krahel i Rzemykowska (2010) |
| 16. | *Dreissena polymorpha* | ok. 1800 | Vistula Lagoon, Szczecin Lagoon, | http://www.iop.krakow.pl/gatunkiobce/; Zaiko i in. (2011); Wiktor (1969); Stańczykowska i in. (2010) |
| 17. | *Eriocheir sinensis* | 1928 | along Hel Peninsula, Puck Bay, Gulf of Gdańsk, Szczecin Lagoon | Jażdżewski i in. (2005); Grabowski i in. (2005); Normant i in. (2000); Normant i in. (2002); Czerniejewski i Filipiak (2001) |
| 18. | *Gammarus tigrinus* | 1988 | Puck Bay, Szczecin Lagoon, Vistula Lagoon | http://www.iop.krakow.pl/gatunkiobce/; Grabowski i in. (2007); Packalen i in. (2008); Szaniawska i in. (2003); Jażdżewski i in. (2004); Jażdżewski i in. (2005) |
| 19. | *Hemimysis anomala* | 2005 | Gulf of Gdańsk | Janas i Wysocki (2005) |
| 20. | *Hypania invalida* | 2010 | Szczecin Lagoon | Woźniczka i in. (2011) |
| 21. | *Lithoglyphus naticoides* | 1873 | Szczecin Lagoon, Vistula Lagoon | http://www.iop.krakow.pl/pckz |
| 22. | *Marenzelleria neglecta* | 1986 | all southern Baltic Sea Szczecin Lagoon, Vistula Lagoon | http://www.iop.krakow.pl/gatunkiobce/; Zaiko i in. (2011); Warzocha i in. (2005); Ezhova i in. (2005); Bastrop i in. (1995); Gruszka (1991); Żmudziński i in. (1996) |
| 23. | *Mya arenaria* | Średniowiecze | all southern Baltic Sea | http://www.iop.krakow.pl/gatunkiobce/; Zaiko i in. (2011) |
| 24. | *Obesogammarus crassus* | ok. 1990 | Szczecin Lagoon, Vistula Lagoon, Gulf of Gdańsk | Konopacka (2003, 2004); Konopacka i Jażdżewski (2002); Dobrzycka-Krahel i Rzemykowska (2010) |
| 25. | *Orconectes limosus* | 1890 | Odra mouth , Szczecin Lagoon, Vistula Lagoon | http://www.iop.krakow.pl/gatunkiobce/; Zaiko i in. (2011) |

| | | | | |
|---|---|---|---|---|
| 26. | *Palaemon elegans* | 2002 | Gulf of Gdańsk, Pomeranian Bay Vistula Lagoon, along the open coast | http://www.iop.krakow.pl/gatunkiobce/; Janas i in. (2004a); Grabowski (2006); Janas i Bruska (2010) |
| 27. | *Pontogammarus robustoides* | 1988 | Vistula Lagoon, Szczecin Lagoon, Gulf of Gdańsk | Konopacka (2004); Dobrzycka-Krahel i Rzemykowska (2010) |
| 28. | *Potamopyrgus antipodarum* | po 1900 | Szczecin Lagoon, Gulf of Gdańsk | http://www.iop.krakow.pl/gatunkiobce/; Janas i in. (2004b) Zaiko i in. (2011) |
| 29. | *Rhithropanopeus harrisi* | przed 1951 | Gulf of Gdańsk, Vistula Lagoon, Szczecin Lagoon | http://www.iop.krakow.pl/gatunkiobce/; Jażdżewski i in. (2005); Czerniejewski (2009) |
| **AVIFAUNA** | | | | |
| 30. | *Branta canadensis* | 1935 | Vistula Lagoon, Gulf of Gdańsk | http://www.iop.krakow.pl/gatunkiobce/; Meissner i Bzoma (2009) |

As a result of research conducted as part of the PMŚ in 2011-2016, in the transitional and coastal waters as well as in the open sea, a number of non-native species were recorded, the occurrence of which is presented in Table 1.5.9. For comparative purposes, the species were additionally ordered taking into account the division of assessment units, which was used in the initial assessment of the environmental state of the marine waters of the Polish Baltic Sea zone.

Table 1.5.9. List of alien species of phytoplankton, zooplankton and macrozoobenthos within POM in 2011-2016.

| HOLAS II Sub-basin | Sub-basin initial assessment 2005-2010 | Station | Species | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|
| Gdańsk Basin | **33 Gulf of Gdańsk open waters** | P110 | *Marenzelleria neglecta* | | | x | | | x |
| | | P110 | *Cercopagis pengoi* | | | | | | x |
| | | P110 | *Prorocentrum minimum* | x | | x | x | x | x |
| | | ZN4 | *Mya arenaria* | | | | x | x | |
| | | ZN4 | *Marenzelleria neglecta* | | x | x | x | x | x |
| | **35 Gulf of Gdańsk Polish Coastal waters** | P104 | *Marenzelleria neglecta* | x | x | x | x | x | x |
| | | ZP6 | *Balanus improvisus* | | x | x | x | x | x |
| | | ZP6 | *Marenzelleria neglecta* | | x | x | x | x | x |
| | | ZP6 | *Mya arenaria* | | x | x | x | x | x |
| | | ZP6 | *Rhithropanopeus harrisii* | | x | | x | | |
| | | ZP6 | *Acartia tonsa* | | | | | x | |
| | | ZP6 | *Cercopagis pengoi* | | | x | x | x | x |
| | | ZP6 | *Prorocentrum minimum* | x | | | x | x | x |
| | | OM1P | *Balanus improvisus* | | | | | x | |
| | | OM1P | *Marenzelleria neglecta* | x | | | x | x | |
| | | OM1P | *Mya arenaria* | x | | | | x | |
| | | OM3P | *Dreissena polymorpha* | | | | x | | |
| | | OM3P | *Marenzelleria neglecta* | x | | | x | x | |
| | | OM3P | *Mya arenaria* | x | | | x | x | |
| | | T12P | *Mya arenaria* | x | | | | | |
| | | T6aP | *Balanus improvisus* | | | | x | x | |
| | | T6aP | *Marenzelleria neglecta* | | | | | x | |

| HOLAS II Sub-basin | Sub-basin initial assessment 2005-2010 | Station | Species | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|
| | | T6aP | *Mya arenaria* | | | | | x | |
| | | T6P | *Marenzelleria neglecta* | x | | | | | |
| | | T6P | *Mya arenaria* | x | | | | | |
| | | ZGP | *Balanus improvisus* | | | | x | | |
| | | ZGP | *Marenzelleria neglecta* | | | | x | x | |
| | | ZGP | *Mya arenaria* | | | | x | x | |
| | | C19P | *Balanus improvisus* | | | | x | | |
| | | C19P | *Marenzelleria neglecta* | x | | | x | x | |
| | | C19P | *Mya arenaria* | x | | | x | x | |
| | **35A Polish part of Vistula Lagoon** | 10WM | *Dreissena polymorpha* | | | x | | | |
| | | 10WM | ***Rangia cuneata**** | | | x | | | |
| | | 1WM | *Marenzelleria neglecta* | | | x | | | |
| | | 2WM | *Marenzelleria neglecta* | | x | x | | | |
| | | 2WM | ***Rangia cuneata**** | | x | | | | |
| | | 3WM | *Marenzelleria neglecta* | | | x | | | |
| | | 5WM | *Marenzelleria neglecta* | | | x | | | |
| | | 6WM | *Marenzelleria neglecta* | | x | x | | | |
| | | 8WM | *Marenzelleria neglecta* | | x | x | | | |
| | | T2WM | *Dreissena polymorpha* | | | x | | | |
| **Bornholm Basin** | **36 Bornholm Basin – open waters** | M3 | *Marenzelleria neglecta* | x | x | x | x | x | x |
| | | M3 | *Mya arenaria* | | x | x | x | | x |
| | | K6 | *Marenzelleria neglecta* | x | x | x | x | x | x |
| | | K6 | *Mya arenaria* | | x | x | x | x | x |
| | | K6 | *Prorocentrum minimum* | x | | | | x | x |
| | | P16 | *Balanus improvisus* | | | | | | x |
| | | P16 | *Marenzelleria neglecta* | x | x | x | x | x | x |
| | | P16 | *Mya arenaria* | x | x | x | x | x | x |
| | | P16 | *Prorocentrum minimum* | x | | | x | x | x |
| | | B13 | *Balanus improvisus* | x | x | x | x | x | x |
| | | B13 | *Gammarus tigrinus* | x | | | | | |
| | | B13 | *Marenzelleria neglecta* | x | x | x | x | x | x |
| | | B13 | *Mya arenaria* | x | x | x | x | x | x |
| | | B13 | *Cercopagis pengoi* | | | x | | | |
| | | B13 | *Prorocentrum minimum* | x | x | | x | x | x |
| | | P5 | *Gammarus tigrinus* | x | | | | | |
| | | P5 | *Prorocentrum minimum* | | | x | x | | x |
| | **38 Bornholm Basin Polish Coastal waters** | IVZP | *Balanus improvisus* | | | | | x | x |
| | | IVZP | *Marenzelleria neglecta* | | | | | x | x |
| | | IVZP | *Mya arenaria* | | | | | x | x |
| | | SWZP | *Balanus improvisus* | x | x | | | x | x |
| | | SWZP | *Marenzelleria* | x | x | | | x | x |

| HOLAS II Sub-basin | Sub-basin initial assessment 2005-2010 | Station | Species | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|
| | | | *neglecta* | | | | | | |
| | | SWZP | *Mya arenaria* | x | x | | | x | x |
| | | 1ZP | *Marenzelleria neglecta* | | | | | | x |
| | | 1ZP | *Mya arenaria* | | | | | | x |
| | | 2ZP | *Balanus improvisus* | | x | | | x | |
| | | 2ZP | *Marenzelleria neglecta* | | x | | | x | x |
| | | 2ZP | *Mya arenaria* | | x | | | x | x |
| | | 3ZP | *Marenzelleria neglecta* | | x | | | | |
| | | 3ZP | *Mya arenaria* | | x | | | x | |
| | | 4ZP | *Marenzelleria neglecta* | | x | | | | |
| | | 4ZP | *Mya arenaria* | | x | | | x | |
| | | 5ZP | *Balanus improvisus* | | x | | | | |
| | | 5ZP | *Marenzelleria neglecta* | | x | | | | |
| | | 5ZP | *Mya arenaria* | | x | | | x | |
| | | 6ZP | *Balanus improvisus* | | x | | | x | |
| | | 6ZP | *Marenzelleria neglecta* | | x | | | | |
| | | 6ZP | *Mya arenaria* | | x | | | x | |
| | | 7ZP | *Marenzelleria neglecta* | | x | | | | |
| | | 7ZP | *Mya arenaria* | | x | | | x | |
| | | C11P | *Balanus improvisus* | | | | x | | |
| | | C11P | *Marenzelleria neglecta* | x | | | x | x | |
| | | C11P | *Mya arenaria* | | | | | x | |
| | | C8P | *Balanus improvisus* | | | | x | | |
| | | C8P | *Marenzelleria neglecta* | | | | x | x | |
| | | C8P | *Mya arenaria* | | | | x | x | |
| | | C9P | *Balanus improvisus* | x | | | | | |
| | | C9P | *Marenzelleria neglecta* | x | | | | | |
| | **38A Polish part of Szczecin Lagoon** | B2ZP | *Balanus improvisus* | | | | x | | |
| | | B2ZP | *Dreissena polymorpha* | x | | | | | |
| | | B2ZP | *Marenzelleria neglecta* | x | | | x | | |
| | | DZRZP | *Balanus improvisus* | x | | | | x | x |
| | | DZRZP | *Marenzelleria neglecta* | x | | | | x | x |
| | | DZRZP | *Mya arenaria* | | | | | x | x |
| | | DZZP | *Balanus improvisus* | | | | | x | x |
| | | DZZP | *Marenzelleria neglecta* | | | | | x | x |
| | | DZZP | *Mya arenaria* | | | | | x | x |
| | | EZP | *Dreissena polymorpha* | | x | | | x | x |
| | | EZP | *Potamopyrgus antipodarum* | | x | | | | |
| | | FZP | *Dreissena polymorpha* | x | | | | | |
| | | HZP | *Potamopyrgus antipodarum* | | x | | | | |
| | | JWWZP | *Dreissena polymorpha* | | | | x | | |
| | | SWIZP | *Balanus improvisus* | | | | | x | x |

| HOLAS II Sub-basin | Sub-basin initial assessment 2005-2010 | Station | Species | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|
| | | SWIZP | *Marenzelleria neglecta* | | | | | x | x |
| | | SWIZP | *Mya arenaria* | | | | | x | x |
| | | SWRZP | *Balanus improvisus* | x | x | | | x | x |
| | | SWRZP | *Dreissena polymorpha* | x | | | | | |
| | | SWRZP | *Marenzelleria neglecta* | x | x | | | x | x |
| | | SWRZP | *Mya arenaria* | | x | | | x | x |
| | | WLZP | *Dreissena polymorpha* | | x | | | x | x |
| | | WLZP | *Marenzelleria neglecta* | | | | | x | |
| | | WLZP | *Potamopyrgus antipodarum* | x | | | | | |
| **Eastern Gotland Basin** | **62 Eastern Baltic Proper Polish Coastal waters** | C12P | *Marenzelleria neglecta* | | x | | | | |
| | | C12P | *Mya arenaria* | | x | | | | |
| | | C13a | *Balanus improvisus* | | | | x | | |
| | | C13a | *Marenzelleria neglecta* | | | | x | x | |
| | | C13a | *Mya arenaria* | | | | x | x | |
| | | C13P | *Marenzelleria neglecta* | | x | | | | |
| | | C13P | *Mya arenaria* | | x | | | | |
| | | C15P | *Balanus improvisus* | | x | | | | |
| | | C15P | *Marenzelleria neglecta* | | x | | x | x | |
| | | C15P | *Mya arenaria* | | x | | x | x | |
| | | C16P | *Balanus improvisus* | | | | x | x | |
| | | C16P | *Marenzelleria neglecta* | | | | x | | |
| | | C16P | *Mya arenaria* | | | | x | | |
| | | C18P | *Balanus improvisus* | | x | | x | x | |
| | | C18P | *Marenzelleria neglecta* | | x | | x | x | |
| | | C18P | *Mya arenaria* | | x | | x | | |
| | **27 Eastern Baltic Proper – open sea** | P140 | - | | | | | | |
| | | Ł7 | *Balanus improvisus* | | | | | | x |
| | | Ł7 | *Marenzelleria neglecta* | x | x | x | x | x | x |
| | | Ł7 | *Mya arenaria* | x | x | | | x | x |
| | | Ł7 | *Cercopagis pengoi* | | | | x | | |
| | | Ł7 | *Prorocentrum minimum* | x | | x | x | x | x |
| | | Z | *Mya arenaria* | x | x | x | x | x | x |
| | | Z | *Marenzelleria neglecta* | x | x | x | x | x | x |

* new alien species in POM in the period 2011-2016

The non-native species of phytoplankton and zooplankton were found in negligible quantities representing in the vast majority of cases below 1% of the total amount and biomass in the samples in which these species occurred. The exception is the measurements from October 2014 when the *Prorocentrum minimum* species accounted for 70% biomass (with a 3% share in abundance) at the ZP6 station in the Puck Bay region, but this was a single case beyond which this species did not exceed 14% of the total biomass in the samples. In addition, the occurrence of non-native phytoplankton species and zooplankton within the Polish Baltic Sea waters was incidental in contrast to non-native macrozoobenthos species, whose share in the total abundance and biomass was significant. To illustrate the share of listed non-native species in the macrozoobenthos structure in the HOLAS II assessment units, i.e. in the Bornholm Basin, Eastern Gotland Basin and the Gdańsk Basin, graphs of abundance and biomass were produced for 2011-2016 (Fig.1.5.1 – Fig. 1.5.3).

In all study areas, the major species found in significant numbers is the *Marenzelleria neglecta* polychaetes and the representative of the *Mya arenaria* mussel, which due to its size has a significant share in the biomass structure, especially in the shallow areas of Bornholm Basin (Fig.1.5.1) and the Eastern Gotland Basin (Fig.1.5.2). The *Marenzelleria neglecta* species was the largest share in the macrozoobenthos population in the deep-water zone of the Gdańsk Basin (Fig. 1.5.3).


Fig.1.5.1. Share of non-indigenous species in the total abundance and biomass of macrozoobenthos of the Bornholm Basin (Data source: PMŚ)

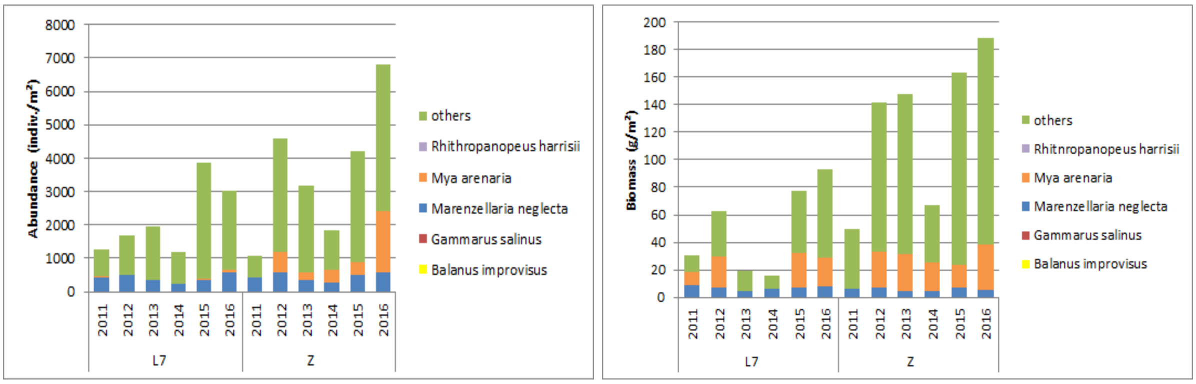



Fig.1.5.2. Share of non-native species in the total abundance and biomass of macrozoobenthos of the Eastern Gotland Basin (Data source: PMŚ)

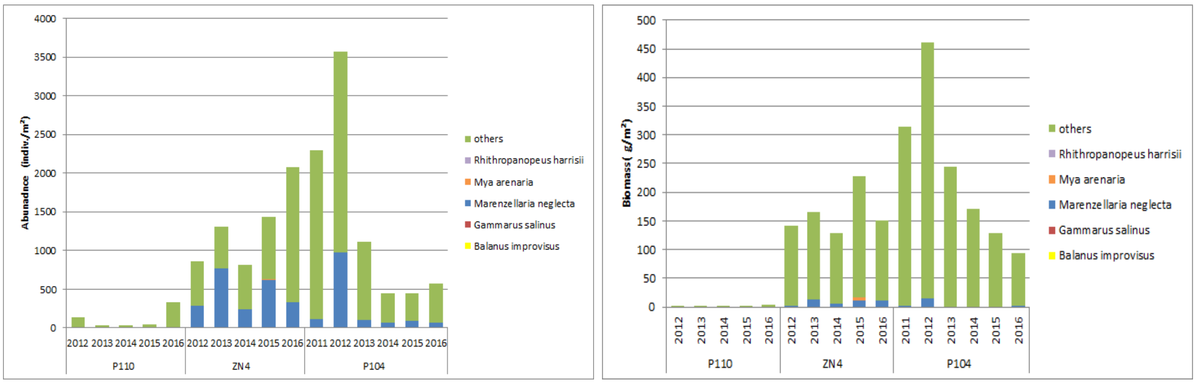
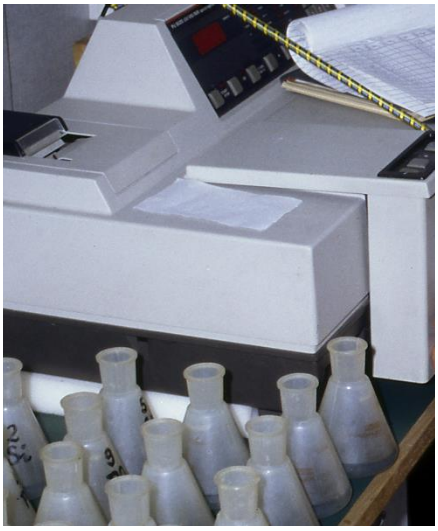



Fig. 1.5.3. Share of non-indigenous species in the total abundance and biomass of macrozoobenthos of the Gdańsk Basin (source of PMŚ data)

## 1.6. Drivers and effects of eutrophication

Concentrations of nutrients and oxygen in seawater as well as chlorophyll-a concentrations and transparency have been studied regularly for many years as part of the State Environmental Monitoring (PMŚ), according to HELCOM COMBINE guidelines. The analysis of variability of nutrients, oxygen, chlorophyll-a a concentrations transparency was carried out for the HOLAS sub-basins against the background of the decade preceding the last year which included the preparation of an update of the initial assessment of the environmental status of marine waters.

***Drivers***



The most important indicator describing the eutrophication process of the Baltic Sea is the nutrient concentration in seawater. These substances have the greatest, direct or indirect impact on other eutrophication indices i. e.g.. on the growth of phytoplankton. When analysing the amount of nutrient load, one should take into account the impact of unusual natural phenomena that occurred during the period considered, such as North Sea inflows with apogee in 2014 (IMGW-PIB 2015), outflow of flood waves through the Vistula River waters to the Gulf of Gdańsk in 2010 r. (Łysiak-Pastuszak 2011). They may disrupt the image of long-term changes affecting the average values or the course of the trend line.
The content of phosphates (DIP) and inorganic nitrogen (DIN) is studied mainly in the winter period when, according to the natural seasonal cycle, primary production disappears and the values of biogenic salt concentrations are the highest during the year. This winter basis of nutrients largely determines the intensity of primary production in the proceeding growing season.

The control of the state of marine environment of the Polish EEZ carried out before the beginning of the growing season, at the beginning of February 2016, showed a significant (in the Bornholm Basin even two fold) increase in concentrations of inorganic phosphates in the surface layer of individual sub-basins compared to the average observed for winter values, both in the previous year and in the years 2006-2015. The increasing trend in the winter inorganic phosphorus compounds has been observed especially since 2014, which can be indirectly attributed to the effects of North Sea water inflows (Feistel 2016). Also the average annual concentrations, demonstrating the availability of these compounds in the year-round cycle, in the surface layer in individual sub-basins in 2016, remained high, and were higher than the average of the last decade and only slightly lower than the corresponding values from the previous year (Fig. 1.6.1).
A different situation was observed in the case of inorganic nitrogen in the surface layer, whose concentrations in the winter of 2016 were comparable with 2015 in the Bornholm Basin and the Eastern Gotland Basin and much higher in the Gdańsk Basin, however lower than the average of the preceding decade (Table 1.6.1). The average annual concentrations of this parameter in 2016 were lower than those recorded last year for all, with the exception of the Gdańsk Basin, regions, and also lower than the averages of the previous decade (Fig. 1.6.2). A positive trend of changes is observed in the entire studied area - a decreasing trend in mineral nitrogen concentrations, most marked in the Gdańsk Basin in relation to the winter pool of these compounds.

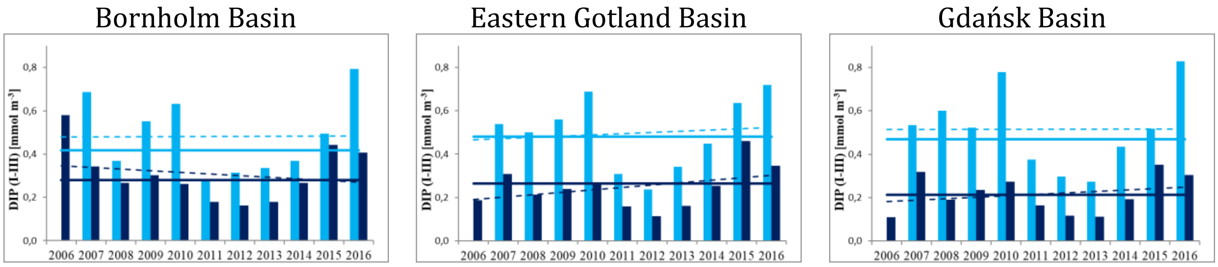



Fig. 1.6.1. Changes in phosphate concentrations (DIP) in POM: winter (I-III) (lighter bar) and annual (darker bars) mean in 2006-2015 and in 2016 continuous lines - averages from 2006-2015, dotted lines - trends (Data source: PMŚ)

Table 1.6.1. Average concentrations [mmol $m^{-3}$] in 2016 in the surface layer (0-10 m) of mineral phosphorus (DIP) and nitrogen (DIN) compounds in the winter months (I-III) and average concentrations of phosphorus (TP) and total nitrogen (TN) in the summer months (June-September) (average from the decade 2006-2015) (Data source: PMŚ)

| **Sub-basin** | **DIP** | **DIN** | **TP** | **TN** |
|---|---|---|---|---|
| Bornholm Basin | 0.80 | 3.24 | 0.55 | 25.91 |
| | (0.42) | (5.52) | (0.85) | (25.6) |
| Eastern Gotland Basin | 0.72 | 2.85 | 0.45 | 26.20 |
| | (0.48) | (3.75) | (0.74) | (23.93) |
| Gdańsk Basin | 0.83 | 5.75 | 0.60 | 29.92 |
| | (0.47) | (5.75) | (0.72) | (26.65) |

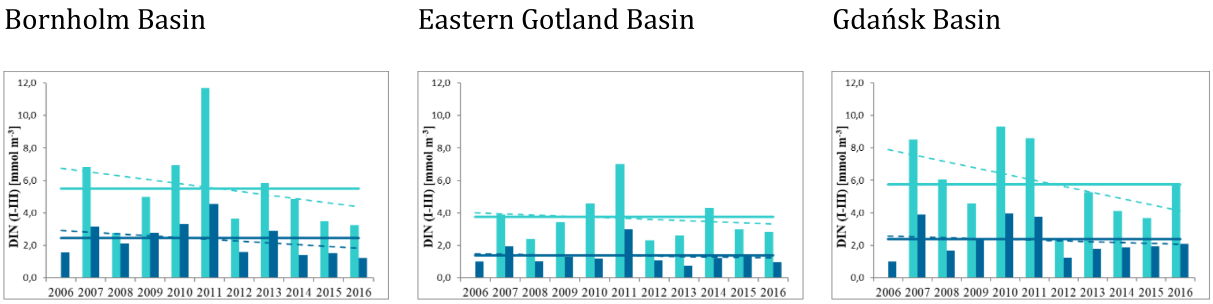



Fig. 1.6.2. Changes in concentrations of inorganic nitrogen (DIN) in POM: winter (I-III) (lighter bar) and annual (darker bar) mean in 2006-2015 and in 2016 continuous lines - averages from 2006-2015, dashed lines - trends (Data source: PMŚ)

It is worth noting the difference in defining the period for which the basin of winter nutrients is calculated. In previous studies (Zalewska et al 2015, Łysiak-Pastuszak and others 2016), the months from January to March were accepted as the winter period. On the other hand, in the current version of the HELCOM Eutrophication Assessment Guideline (HELCOM 2015c), December, January and February are treated as winter months. Thus, there is a possibility of differences in the nutrient concentrations calculated for these two, differently defined periods. This may occur, for example, when the March cruise, included in the winter period, took place during or after the early spring blooming. Therefore, for the purposes of comparison, in the framework of the description of environmental conditions as winter, period I-III was used, while in the update of assessment of open sea waters to calculate the winter nutrient concentrations, months were adopted in accordance with the HOLAS II report, i.e. XII-II.

Other indicators of eutrophication are concentrations of total phosphorus (TP) and total nitrogen (TN), which during the growing season approximate the amount of primary production. Their variability in sub-basins is shown in Fig. 1.6.3 and Fig. 1.6.4. Average total phosphorus concentrations from summer months in the 0-10 m layer were in 2016 much lower than in summer 2015 for all sub-basins. They also remained below the average values for the last decade. Similar relationships were found in relation to the average annual concentrations of total phosphorus. A slight improvement appeared in the Bornholm Basin - a decreasing trend in total phosphorus concentrations, while the remaining area maintained a very weak increasing trend.

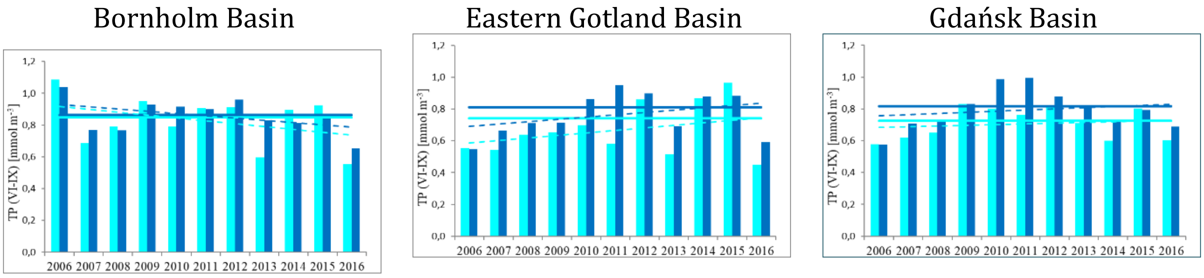



Fig. 1.6.3. Changes in total phosphorus concentrations in POM (0-10m): summer (June-September) (brighter bar) and annual (darker bar) mean in 2006-2015 and in 2016 continuous lines - averages from the period 2006-2015, dotted lines - tendencies (Data source: PMŚ)

The values of total nitrogen concentrations, both in the summer of 2016 and in the year-round cycle, were higher than the long-term average, and also from 2015, in all monitored areas except the Bornholm Basin. This was confirmed by the increasing trend of the averages from the summer months and annual concentrations of total nitrogen in these areas. The exception was the Bornholm Basin, where changes in the total nitrogen content were not conclusive.

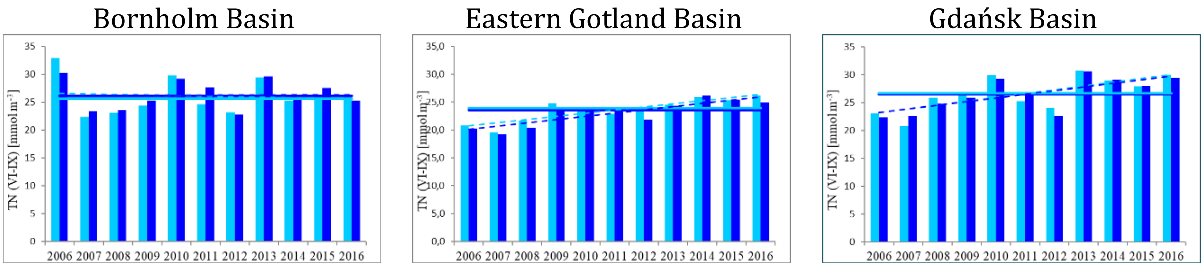



Fig. 1.6.4. Changes in total nitrogen concentrations: summer (June-September) (lighter bar) and annual (darker bars) mean in 2006-2015 and in 2016 continuous lines - averages from 2006-2015, dashed lines - trends (data source PMŚ)

### *Direct effects*

The increased availability of nutrients in the marine environment results in intensive phytoplankton blooms which in most cases result in increase of chlorophyll-a concentrations in seawater. Chlorophyll-a changes are analysed in two time ranges: the average concentration in the summer months: from June to September and the annual average for the entire growing season, including spring and late autumn, during which significant chlorophyll-a contents may also appear in the sea water.

Phytoplankton bloom (photo: IMGW-PIB)

In the Bornholm Basin and the Eastern Gotland Basin, the concentrations of chlorophyll-a in 2016 in the summer period fluctuated around the average values from the last decade of 2006-2015, it was also similar to the previous year. It was part of the previously observed weak decreasing trend, in contrast to the Gdańsk Basin, where much higher concentrations of chlorophyll-a in the summer months of 2016 resulted in an increasing trend observed in previous years (Fig. 1.6.5).

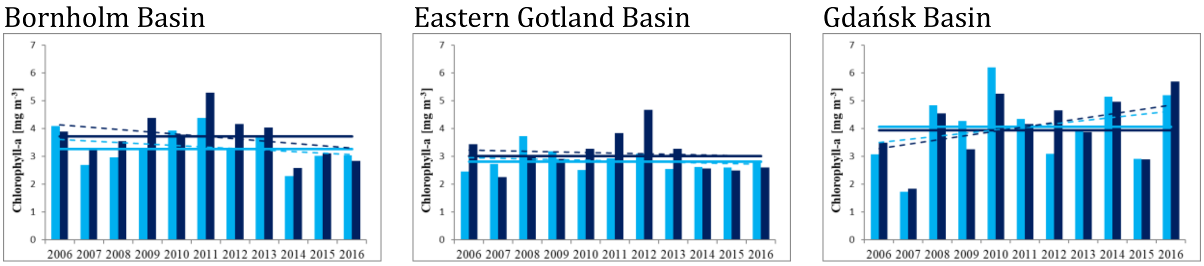



Fig. 1.6.5. Changes in chlorophyll-a concentrations in POM: summer (June-September) (lighter bar) and annual (darker bars) mean in 2006-2015 and in 2016 continuous lines - averages from 2006-2015, dotted lines - trends (source of PMŚ data).

The average annual chlorophyll-a concentrations in 2016 in the Bornholm Basin and the Eastern Gotland Basin were similar and remained lower than in the previous decade which is in line with the weak decreasing trend observed for the last decade. These values did not differ significantly from those for the previous year. In contrast, in the Gdańsk Basin very high concentrations of pigment significantly (> 25%) exceeded the average from the period 2006-2015, and was almost twice as high as the value from 2015 (Fig. 1.6.5, Table 1.6.2).

Table 1.6.2. Average chlorophyll-a concentration [mg m⁻³] in the summer (June-September) and annual average (a.a.) in POM in 2016; (averages from the period 2006-2015) (Data source: PMŚ)

| sub-basin | Chl-a (VI–IX) | Chl-a (a.a.) |
|---|---|---|
| Bornholm Basin | 3.03 | 2.85 |
| | (3.27) | (3.71) |
| Eastern Gotland Basin | 2.83 | 2.60 |
| | (2.82) | (3.01) |
| Gdańsk Basin | 5.20 | 5.70 |
| | (4.06) | (3.94) |

In 2016, the most intense primary production took place in the Gdańsk Basin during spring phytoplankton bloom. In the remaining area, the largest bloom occurred in the late-autumn period (Fig. 1.6.6).

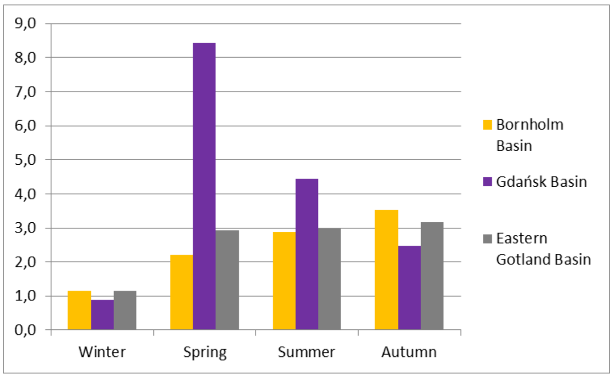



Fig. 1.6.6. Seasonal changes in average chlorophyll-a concentration [mg m$^{-3}$] in POM sub-basins in 2016 (source of PMŚ data)

As part of testing of the average concentration of chlorophyll-a in the summer months indicator, analysis was performed based on data provided in the SatBałtyk System (Woźniak et al. 2011 a, b) in the form of daily maps of chlorophyll-a concentrations at various depths for the entire Baltic Sea area. These include surface chlorophyll-a concentrations determined using data from the satellite measurement (MODIS) and the EcoSat model used in the absence of satellite information. Values at selected depths in the 0-10 meters layer are estimated based on a statistical model that takes into account the main features characterizing the vertical distributions of chlorophyll concentration in the Baltic waters:

$$C_a(z) = C_a(0)\frac{A + Bexp[-(z - z_m)^2\sigma]}{A + Bexp[-(z)^2\sigma]}$$

where:

$A = 10^{(1.38log(C_a(0))+0.0883)}$

$B = 10^{(0.714log(C_a(0))+0.0233)}$

$z_m = -4.61log\big(C_a(0)\big) + 8.86$

$\sigma = 0.0052$

This formula reflects the occurrence of a maximum concentration of chlorophyll-a at a depth at which the two main limiting factors, i.e. the level of radiation reaching the surface and the content of biogenic substances in the water column, create optimal conditions for photosynthesis. At the same time, statistical coefficients of statistical analyses determined in the formula are related to the general, universal shape of vertical distributions of chlorophyll-a concentration with environmental conditions prevailing in the Baltic Sea (Ostrowska et. al. 2007).

The average values of chlorophyll-a concentrations for each pixel with a side length of 1 km were determined by numerically integrating the vertical concentrations of chlorophyll-a by the trapezoid method in the range of 0-10 m with a step of 1 m. The resulting maps were then averaged annually and for the summer months from June until September, each year separately (Fig. 1.6.7).

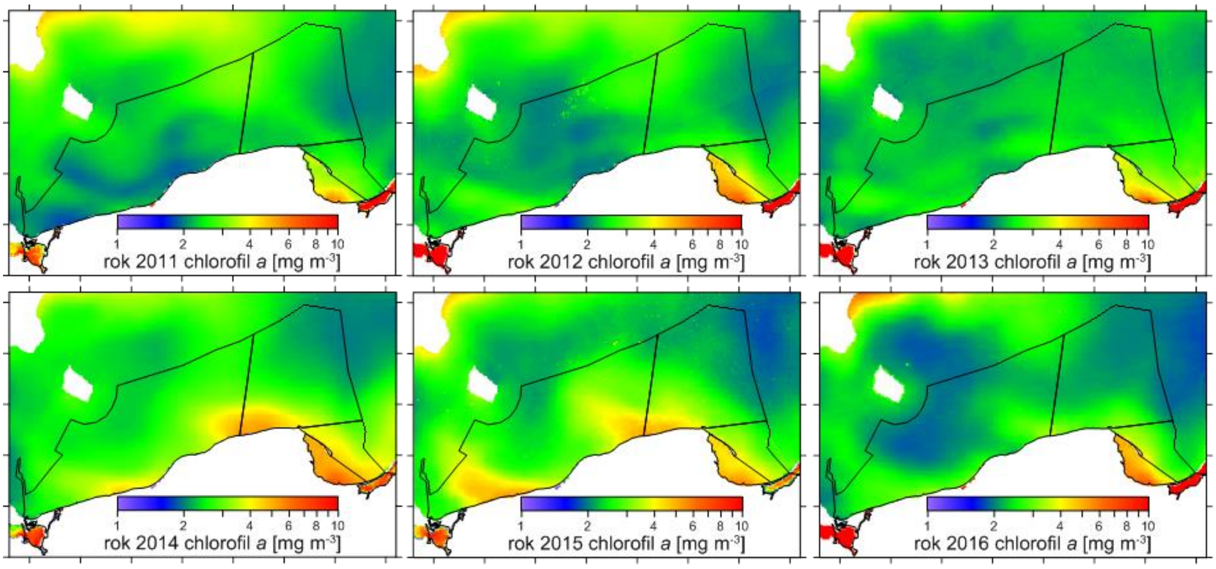



Fig. 1.6.7. Average chlorophyll-a concentrations in the summer months (June-September), calculated on the basis of data from the SatBałtyk System

In all analysed areas, spatial heterogeneity of chlorophyll-a concentrations within individual sub-basins is visible (Fig. 1.6.7), whereby the distribution of their maximum and minimum values varies in individual years. In extreme cases, areas significantly differing from the values determined for the entire sub-basin can be distinguished, such as high concentrations of chlorophyll-a in the coastal region of the Eastern Gotland basin in 2014. This certainly affected the observed increase in the average value calculated for the entire sub-basin. On the other hand, the strong decrease in the average value determined for the Bornholm Basin in 2016 reflects the lowest average values recorded in the in the central and western region of this area. In 2014 and 2015, higher concentrations of chlorophyll-a along the central coast occured in areas of upwelling events. This is undoubtedly associated with increased upwelling activity in these years, visible on the maps of the surface temperature anomaly (Fig. 1.3.4).

The average chlorophyll-a concentrations in the 0-10 m layer in individual sub-basins in 2011-2016 was determined in relation to summer months (VI - IX) and the whole year period (I - XII) on the basis of average values maps determined for each year from the analysed period (Fig. 1.6.8). The analyses used similarly calculated mean values of chlorophyll-a concentration for the entire Baltic Sea area.

In the summer, the values of the average chlorophyll-a concentrations in the analysed areas changed from 2.24 (Eastern Gotland Basin, 2016) to 5.23 mg $m^{-3}$ (Gdańsk Basin Polish Coastal waters, 2014). There is clearly noticeable persistence of high values in the Gdańsk Basin Polish coastal waters, where the average chlorophyll-a concentration only once (in 2011) fell slightly below 4 mg $m^{-3}$ in the entire analysed period, while in the Eastern Gotland Basin and the Bornholm Basin mean concentration of chlorophyll-a was significantly lower (from 2.24 to 2.68 mg $m^{-3}$ and from 2.28 to 3.06 mg $m^{-3}$ respectively) and remained at a similar level to the average concentrations determined for the entire Baltic Sea (Fig. 1.6.8).

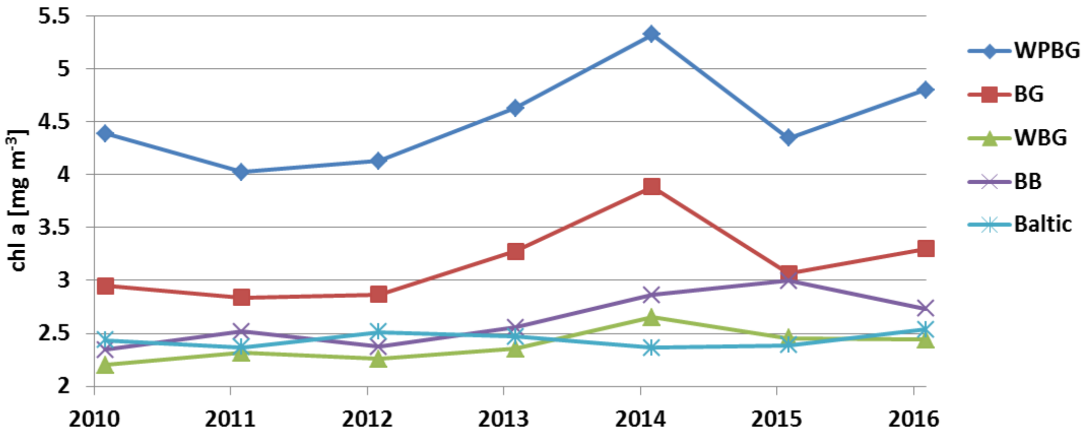



Fig. 1.6.8. Average chlorophyll-a concentrations in the 0-10m layer in the summer months (VI-IX), calculated on the basis of data from the SatBałtyk System, for: Gdańsk Basin Polish Coastal waters (WPBG), the Gdańsk Basin (BG), Bornholm Basin (BB), Eastern Gotland Basin (WBG), and for the entire Baltic Sea

In all sub-basins, the highest variation in the calculated average values of chlorophyll-a concentrations occurred in the second half of the analyzed period, with the most significant increase in 2014. It should be concluded that at that time the most favorable environmental conditions in the analyzed period had an impact on phytoplankton development. In the Bornholm Basin, this trend continued until the following year (2015) when the average value of chlorophyll-a concentration increased again (from 2.85 to 3.06 mg $m^{-3}$). It is worth noting that in the same period the average for the entire Baltic Sea area showed a slight decreasing trend. A slight increase is visible only in 2016, while in all analyzed areas (except for Gdańsk Basin Polish Coastal waters), the average values of chlorophyll-a in 2016 are smaller than in the previous year and returned to the level from the beginning of the analyzed period.

Subsequent calculations were made for the whole year, i.e. based on all maps in a given calendar year (Fig. 1.6.9, Fig. 1.6.10). As in the case of average values of chlorophyll-a concentrations from the summer period, the spatial variation of annual averages is clearly visible. It can be noted that in subsequent years and in each sub-basin there is a clear decreasing tendency in values along with the distance from the shore. It is also worth noting the clear division of the Eastern Gotland Basin into the Southwestern region with higher average annual chlorophyll-a concentrations than in the Northeast. A similar tendency can be observed in the summer period (Fig. 1.6.7), but it is not so evident.

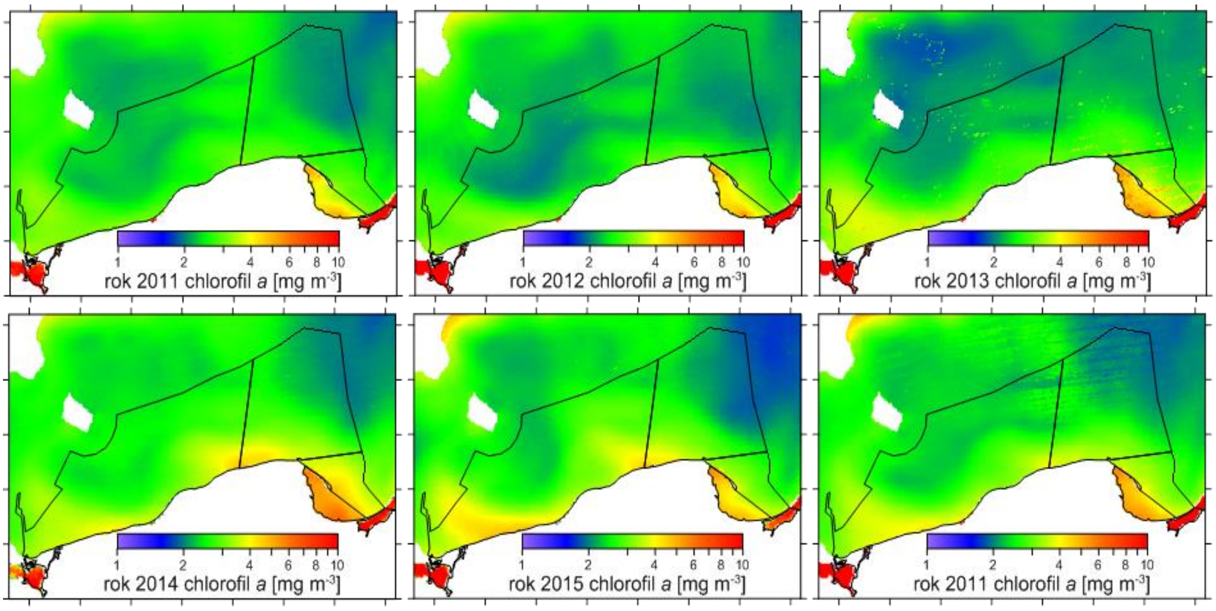



Fig. 1.6.9. Average annual chlorophyll-a concentrations calculated on the basis of data from the SatBałtyk System for the 0-10 m layer.

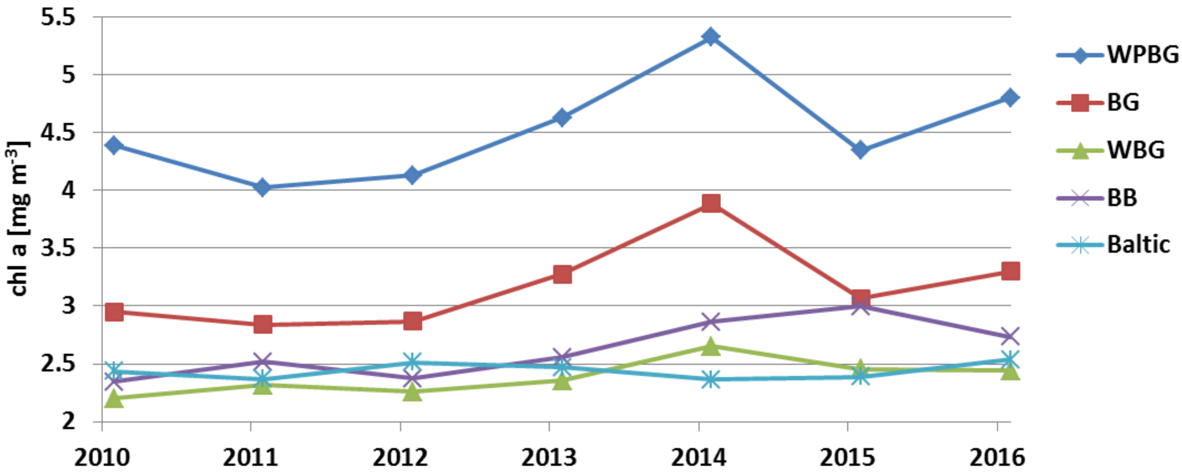



Fig. 1.6.10. Average annual chlorophyll-a concentrations calculated on the basis of the SatBałtyk System for the 0-10 m layer, for: Gdańsk Basin Polish Coastal waters (WPBG), the Gdańsk Basin (BG), the Bornholm Basin (BB), the Eastern Gotland Basin (WBG), and for the entire Baltic Sea

The average annual chlorophyll-a concentrations determined for individual sub-basins varied from 2.26 mg $m^{-3}$ (Eastern Gotland Basin, 2012) to 5.33 mg $m^{-3}$ (Gdańsk Basin Polish Coastal waters , 2016), thus it had similar range as in the case of summer averages. Similarly, in each sub-basin there was a significant increase in the average chlorophyll-a concentration in 2014, which in the Bornholm Basin lasted until 2015. The Bornholm Basin and the Eastern Gotland Basin were characterized by the lowest variability of average chlorophyll-a concentrations, which were similar to summer values for the entire Baltic Sea during this period. The highest mean values of chlorophyll-a concentration were recorded in the Gdańsk Basin Polish Coastal waters, as in the case of summer values they were nearly twice as large as the Baltic average. It is worth noting that the values determined for the Gdańsk Basin in the whole analyzed period are lower than those in the Gdańsk Basin Polish Coastal waters, but their variability is identical and the difference in their respective absolute values ranges from 1.18 mg $m^{-3}$ (2011) to 1,5 mg $m^{-3}$ (2016).

The comparison of spatial distribution of summer and annual average chlorophyll-a concentrations in the analyzed areas in 2011-2016 is presented in Fig. 1.6.11. In both analyzed periods, regions with similar tendencies can be distinguished. For example, in the central and north-western areas of the Bornholm Basin and the northeast region of the Eastern Gotland Basin, there are clearly lower average chlorophyll-a concentrations than in other areas of these basins. The average values determined for the summer months and the whole year in relation to entire water bodies are slightly different

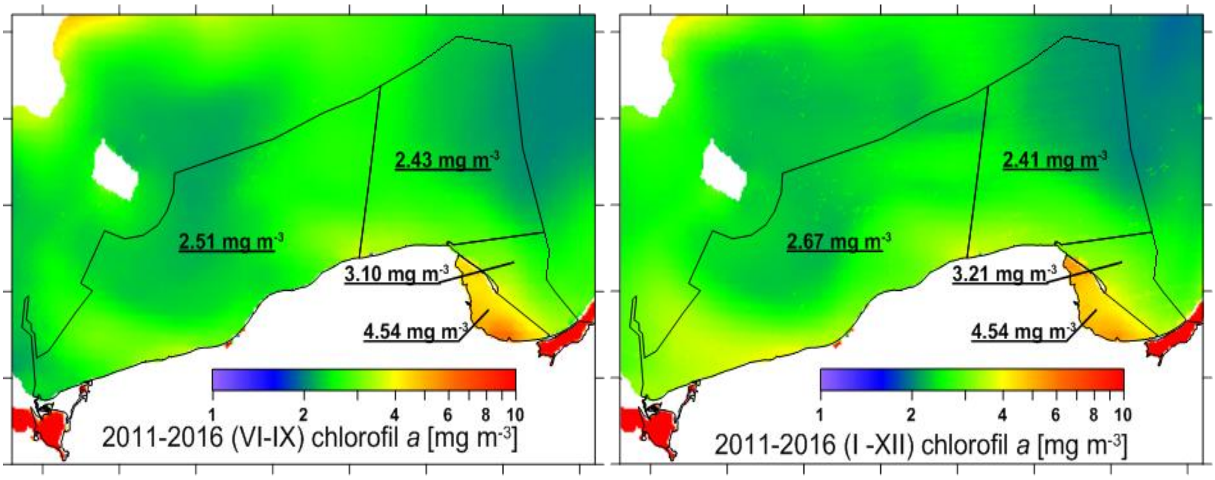



Fig. 1.6.11. Distribution of the average chlorophyll-a concentrations in the summer months (June-September) and throughout the year based on data from the SatBałtyk System for 2011-2016 and average values for individual basins

The degree of seawater transparency is one of the most important parameters, not only informing about the state of the environment, but also determining many processes occurring in the water column. The primary process is the distribution of radiation useful in the process of photosynthesis, shaped not only by external conditions, determining how much of this radiation reaches the surface of water but also, to the greatest extent, by the degree of transparency of the water itself. The greater the transparency, the deeper the solar energy goes and the bigger the layer in which photosynthesis takes place.

The transparency of water is, like the chlorophyll-a concentration, a parameter related to primary production. The decrease in the transparency of water, caused by an increase in the amount of algae floating in the water column, is also indirectly the result of the increase in the nutrient concentration that limit the phytoplankton blooms. Decreasing transparency may cause a decrease in the thickness of the euphotic zone where primary production takes place.

Seasonal variability of transparency is therefore related to the intensity of primary production, and its changes, expressed by the visibility of the Secchi disc, are assessed for the same periods as for the chlorophyll-a content.

The primary parameters on the basis of which the transparency of seawater can be directly determined are the spectral distributions of absorption and solar scattering coefficients, determined in the water column at individual depths (Dera, 2003). The use of such a method, however, requires quite an advanced measuring equipment and an experienced operator. For this reason, in sea conditions, it is often used to determine the range of visibility of a white disc, 30 cm in diameter, called Secchi disc depth, after the Italian researcher Pietro Angelo Secchi, who introduced this parameter in his research in the Mediterranean already in 1865 (Preisendorfer, 1986, Davies-Colley et al., 1993).

The depth of the Secchi disk is a parameter describing the basic optical properties in the near-surface layer of water in an integrated manner, which is particularly important for the biological productivity of a given sub-basin. This parameter can be, of course, with limited accuracy, related to the range of the euphotic zone in the sea, understood as a water column in which the vast majority of photosynthesis of organic matter in the sea takes place.

In 2016, the transparency in POM changed from 3 m during summer blooms in the Gdańsk Basin, up to 17 m, just before the spring bloom, in the shallow waters of the Eastern Gotland Basin. The lowest average (for both summer and annual months) transparency was recorded in the Gdańsk Basin, while the highest values were found in the Eastern Gotland Basin (Table 1.6.3).

Table 1.6.3. Average seawater transparency [m] in the summer months (June-September) and average annual (average year) transparencies in POM in 2016 (average from 2006-2015) (Data source: PMŚ)

| Sub-basin | Secchi (VI–IX) | Secchi (ann.avr.) |
|---|---|---|
| Bornholm Basin | 6.7 | 7.9 |
| | (6.7) | (7.2) |
| Eastern Gotland Basin | 7.3 | 8.2 |
| | (7.0) | (7.9) |
| Gdańsk Basin | 5.2 | 6.4 |
| | (5.5) | (6.8) |

The average transparency from the summer months in 2016 was at a level similar to the average from the previous year and the average from the last decade. With regard to the average annual values from 2016, they oscillated around the average of the last decade. They were also comparable to the 2015 average, with the exception of the Gdańsk Basin, where the transparency was clearly lower (Fig. 1.6.12).

Despite the differences between the sub-basins described above, in the whole monitored area, an increasing tendency of transparency of varying intensity was found, both for the summer period and for the whole year. The strongest was observed in the Bornholm Basin, especially for all-year average. In the Eastern Gotland Basin also the positive inclination for the averages for the whole year was stronger. In the Gdańsk Basin, the negative tendency has disappeared and a very weak tendency of the growth of transparency has appeared. Summarizing, it should be stated that in POM the positive direction of observed changes - improving the transparency of sea waters is observed.

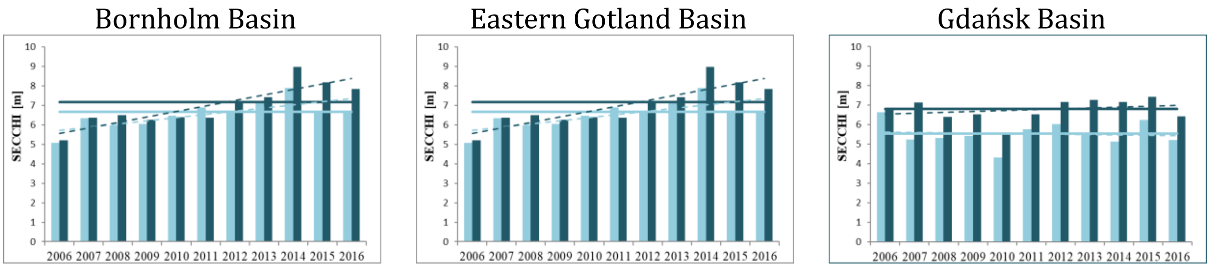



Fig. 1.6.12. Changes in seawater transparency in the summer months (June-September) (brighter bars) and annual averages (darker bars) in 2006-2015 and in 2016; continuous lines - averages from 2006-2015, dashed lines - trends (Data source: PMŚ)

Due to the direct relationship of transparency with the absorption and scattering of sunlight in the water, it is possible to link it with the spectral characteristics of the radiation stream coming out of the water surface layer, measured by radiometers placed on environmental satellites. This allows for the remote determination of this parameter, using the available satellite information. Due to the specific optical properties of various sub-basins, the relationship between the bottom stream characteristics (referred to as so-called contactless reflectance, defined as the ratio of radiation coming from the water column to lighting falling on the water surface) and the depth of the Secchi disc are local.

The analyzes presented below are based on depth values of the Secchi disc, determined using an algorithm developed for the Baltic waters and implemented in the SatBałtyk System. The algorithm used satellite determined reflectance in two spectral channels 531 nm and 654 nm. The depth of Secchi's disk was calculated on the basis of the following formula:

$$\text{Secchi [m]} = 1{,}59 + 8{,}6\,x + 3{,}04 * x^2$$

where $x=\log(Rrs(531nm)/Rrsr(645nm))$

The regression equation used in this algorithm was developed based on the synchronous measurements of the Secchi disc and non-contact reflectance carried out during a number of research flights on s/y Oceania by the Institute of Oceanology of the Polish Academy of Sciences in the Baltic Sea.

Currently, the estimated values of the Secchi disk depth in the SatBałtyk System are not supported by eco-hydrodynamic modelling, which means that the averages presented here are obtained only on the basis of satellite data acquired for cloudless days over the tested sub-basins. Therefore, average values are calculated here based on data from a different number of points, depending on the state and frequency of cloud cover over a given sub-basin. In practice, this may have some impact on the average values presented here, especially in areas characterized by an increased number of cloudy days (e.g. coastal zone). Despite this limitation, the statistics presented here are based on numerous data, significantly exceeding the number of data obtainable by classical methods only on the basis of in-situ measurements.

Fig. 1.6.13 shows the spatial distributions of the average annual Secchi disk depth values, in the summer season, calculated for individual years from the period 2011-2016

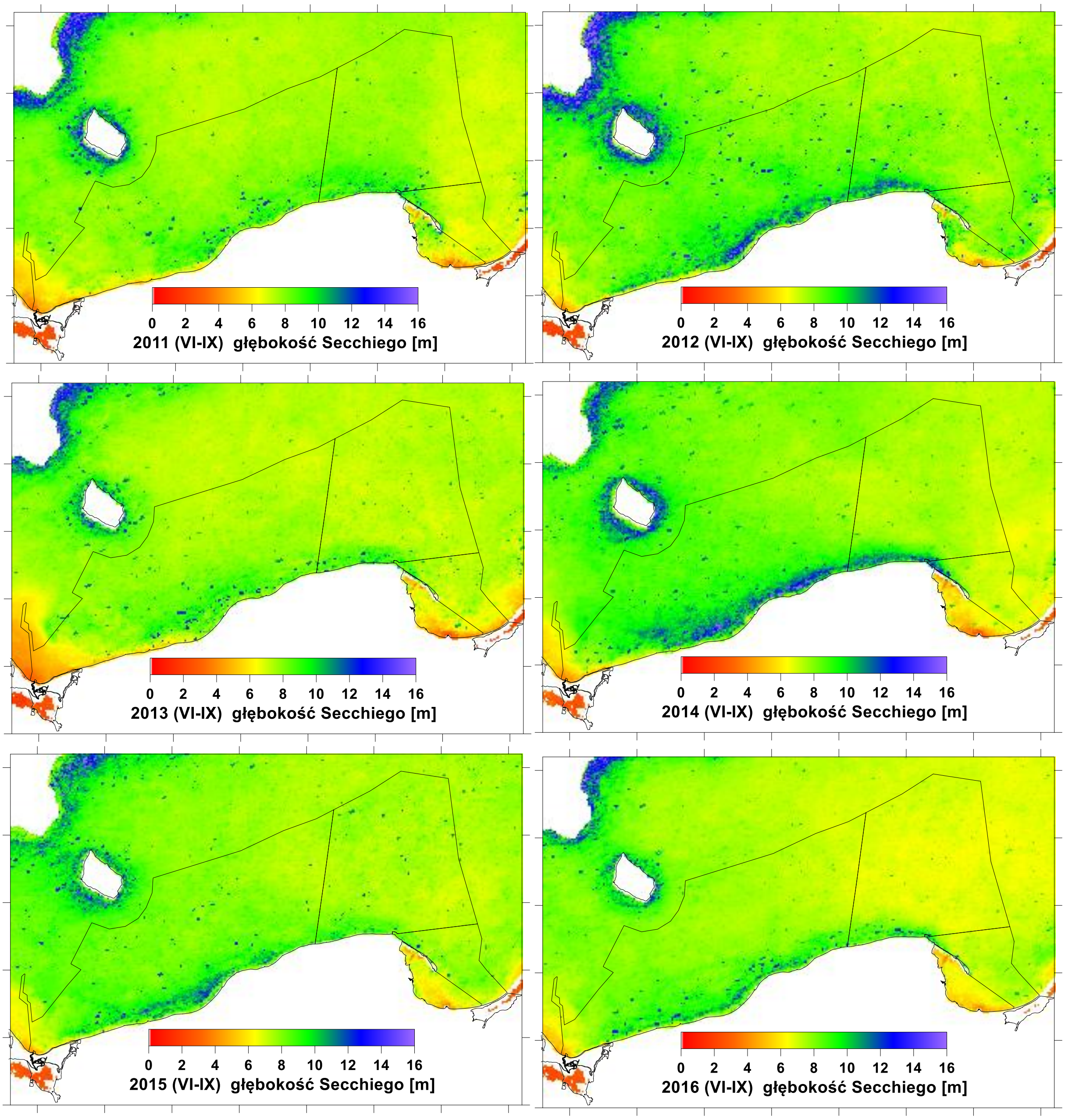



Fig. 1.6.13. Spatial distributions of the average annual Secchi depth for individual years in the summer season determined on the basis of data from the SatBałtyk System.

In addition to significantly higher values in Gulf of Gdańsk and Pomeranian Bay waters, we do not see very strong variation in other areas, although it is still clear and persist over all years, as shown in Fig. 1.6.14 and in Table 1.6.4. Visible especially in 2012 and 2014, the relatively high values of water transparency in small areas near the shore may be the result of upwelling, in these regions, of relatively clean waters from deeper layers. However, these areas were characterized by a higher number of days with cloud cover, and hence a smaller number of data, on the basis of which average values were calculated. These areas are so small that this situation has practically no effect on the average values calculated for individual sub-basins and relevant from the point of view of the purpose of this study.

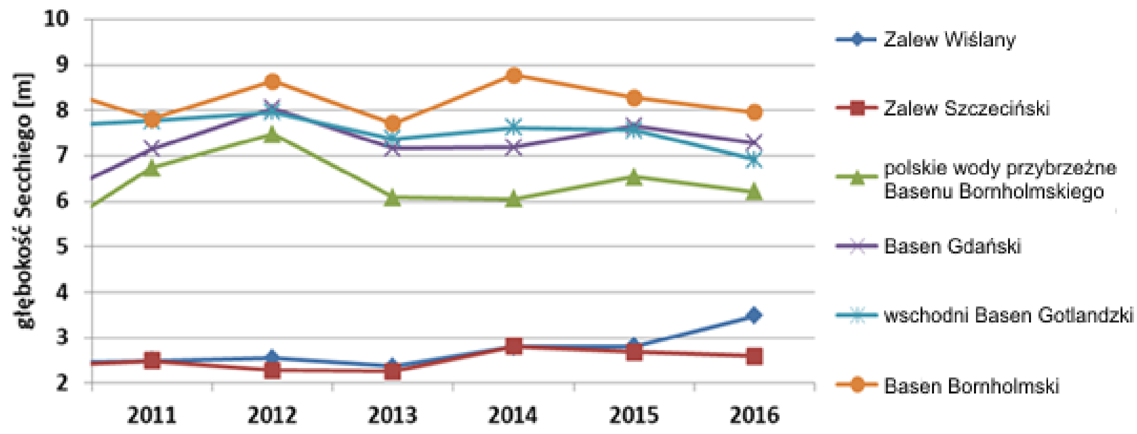



Fig. 1.6.14. The average Secchi depth in selected POM sub-basins in the summer months (June-September) for individual years, calculated on the basis of satellite data from the SatBałtyk System.

In Fig. 1.6.14, it can be seen that the Bornholm Basin was characterized by the highest water transparency in the entire assessment period, and the remaining sub-basins by slightly smaller. The transparency of the Gdańsk Basin Polish coastal waters was about 1 meter lower due to the influence of open sea waters, whereas in the waters of both sub-basins the transparency was the smallest.

The comparison of results from the SatBałtyk system (Table 1.6.4) with the calculation of the average of monitoring measurements (Table 1.6.3) shows that in the case of the Bornholm Basin and the Gdańsk Basin they are higher than 1.5 to 2 meters, while in Eastern Gotland Basin they were lower around 0,5 meters.

Table 1.6.4. Average Secchi depth in selected sub-basins of POM in the summer months (June-September) for individual years, calculated on the basis of satellite data from the SatBałtyk System.

| Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2011-2016 |
|---|---|---|---|---|---|---|---|
| Gdańsk Basin Polish Coastal waters | 6.7 | 7.5 | 6.1 | 6.1 | 6.5 | 6.2 | 6.5 |
| Gdańsk Basin | 7.1 | 8.0 | 7.2 | 7.2 | 7.7 | 7.3 | 7.4 |
| Eastern Gotland Basin | 7.8 | 8.0 | 7.4 | 7.6 | 7.6 | 6.9 | 7.5 |
| Bornholm Basin | 7.8 | 8.6 | 7.7 | 8.8 | 8.3 | 8.0 | 8.2 |

### *Indirect effects*

The secondary effect of excess of nutrients in the marine environment of the Baltic Sea is the decrease in oxygen concentration in near-bottom waters. Oxygenation of bottom layers is dependent on hydrodynamic processes. In the shallow water zone, it is mainly wind mixing, in the deep water zone, the inflows of well oxygenated waters from the North Sea are responsible for the supply of oxygen to the bottom layer (Hansson 2009, Conley 2011).

Despite the fact that for the purpose of the assessment of oxygenation of near bottom layers of the open sea, the HELCOM primary indicator- oxygen debt is used, annual assessments of oxygen deficiency level, due to methodological difficulties, are performed on the basis of analysis of changes in dissolved oxygen concentrations in the bottom layer. The primary indicator is the minimum oxygen concentration at the bottom during the summer period, in the months from June to September.

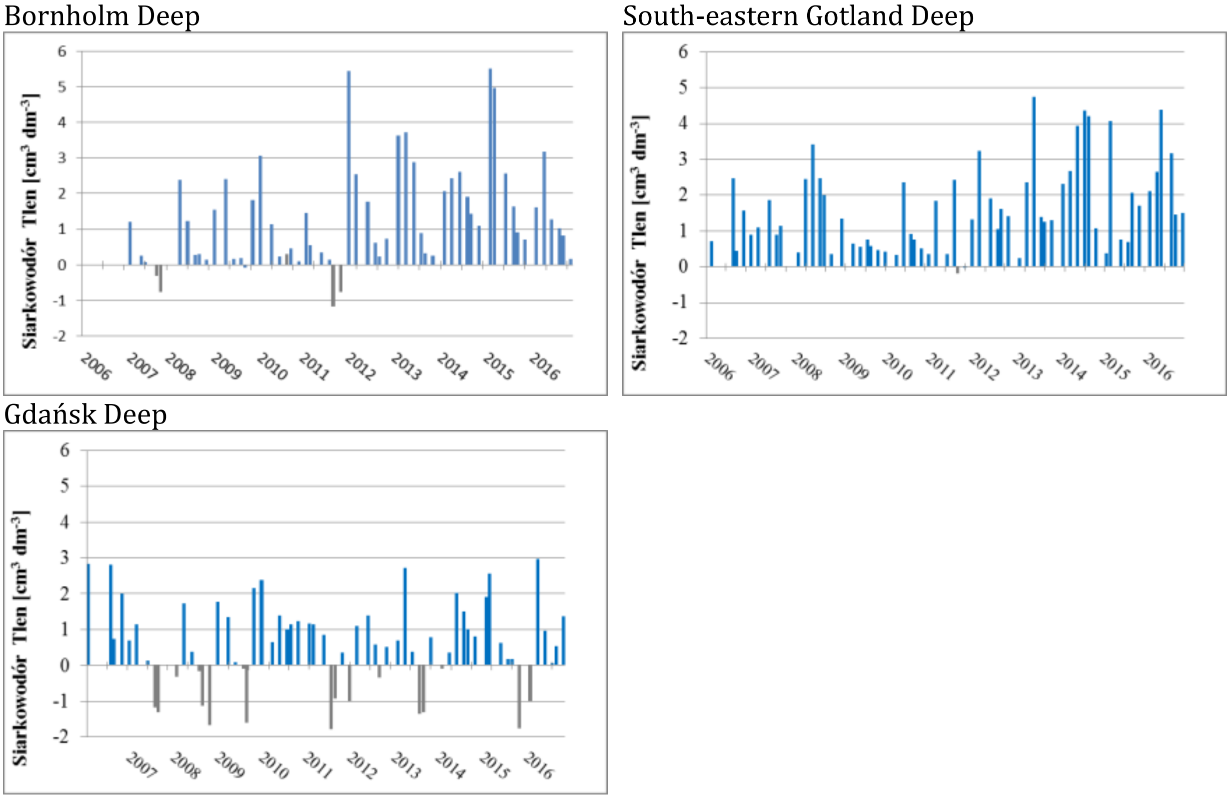



Fig. 1.6.15. Changes in oxygenation of bottom waters of POM in 2006-2016 (negative values indicate the presence of hydrogen sulphide) (Data source: PMŚ)

In 2016, oxygen conditions at the bottom of deep water areas were still shaped by water inflows from the Kattegat region (Fiestel 2016). After a huge inflow in December 2014 (IMGW-PIB 2015) there were subsequent, weak or moderate ones, of which those from November 2015 and from the turn of January and February 2016, influenced the oxygen situation at the bottom of the southern Baltic in 2016 r. (IOW 2016abc, SMHI 2016) (Fig. 1.6.15).

At the end of 2015, oxygen, supplied with the waters of the Major Baltic Inflow (MBI) from 2014, was almost exhausted from the bottom layers of the POM deep water zone, and hydrogen sulphide appeared in the Gdańsk Deep. With the inflow in November 2015, the oxygenation conditions in the Bornholm Deep improved relatively quickly, where the oxygen concentration increased from trace amounts of 0.7 $cm^3\ dm^{-3}$ in November to 1.7 $cm^3\ dm^{-3}$ in January 2016. The next inflow from the beginning of 2016 caused the disappearance of oxygen deficiency layer in this region, increasing the oxygen content to 3 $cm^3\ dm^{-3}$. On the other hand, to the Gdańsk Deep, the deepest water area furthest from the source of inflowing waters, the inflow only reached in April, causing the disappearance of the azoic zone and an increase in oxygen concentration to 3.2 $cm^3\ dm^{-3}$. On the south-eastern slope of the Gotland Basin, good oxygen conditions were maintained until August 2016, reaching the annual maximum of 4.3 $cm^3\ dm^{-3}$ at the beginning of the summer. An oxygen deficit zone has already appeared in September (Drgas 2016).

The results of the conducted research show that inflows that occurred in the winter of 2015/2016, like the flood from 2014, caused only a short-term improvement in the oxygenation of the bottom layer of the deep water area. In the following months after the inflow a gradual decrease in oxygen concentration was observed, which led to the return of the oxygen deficiency at the end of 2016 in the bottom zone in all depths of all POM.

Near-bottom waters of shallow areas, due to circulation and good water exchange (no picnocline, upwelling), were well oxygenated in the assessment year, the oxygen concentration at the bottom remained above 4.0 $cm^3\ dm^{-3}$ (Table 1.6.5).

Table 1.6.5. The minimal oxygen concentration near the bottom in summer 2016 in POM (min 2006-2015) (Data source: PMŚ)

| Sub- basins | zone | $O_2$ min (VI–IX) |
|---|---|---|
| Bornholm Basin | Deep water | 0.8<br>(–1.2) |
| | Shallow water | 5.0<br>(4.6) |
| | Pomeranian Bay | 4.2<br>(5.1) |
| Eastern Gotland Basin | Deep water | 1.4<br>(–0.2) |
| | Shallow water | 5.9<br>(4.5) |
| Gdańsk Basin | Deep water | 0.1<br>(–1.8) |
| | Shallow water | 5.1<br>(4.3) |

hydrogen sulphide as a proxy for negative oxygen concentration

## 1.7. Litter in the marine environment in 2015-2016

In 2015 and 2016 a pilot program was implemented to monitor litter in the marine environment. This program focused primarily on monitoring of litter collected on the coastline, but also included monitoring of litter on the seabed and monitoring of microparticles in the surface water and in bottom sediments.

### *Marine litter on the coast (beach litter)*

Monitoring of marine litter on the coast was carried out on 15 sections with a length of 1 km (Fig. 1.7.1). On each episode, all litter items was monitored on the entire width of the monitored section, from the water line to the beach border. Monitoring includes identification and counting of a specific type of litter. Monitoring of beach litter, on designated sections was carried out four times each year: in April (spring), at the turn of June and July (summer), at the turn of September and October (autumn), at the turn of December and January (winter).

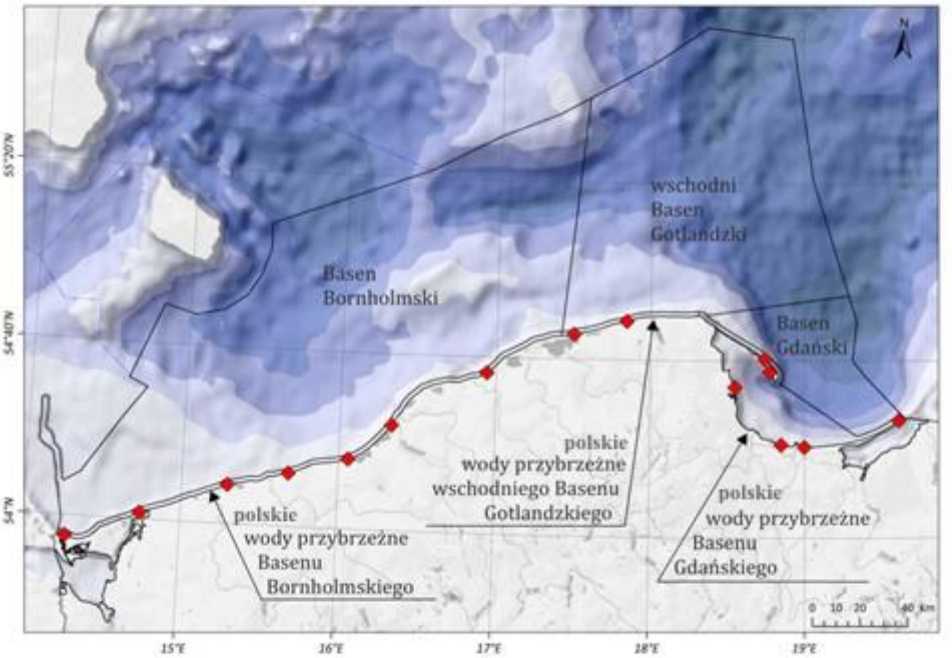



Fig. 1.7.1. Location of litter monitoring sections collected on the shoreline of the Polish coast in 2015 and 2016

The total number of litter items from the four study periods recorded on individual sections in seven main categories: rubber, paper/cardboard, processed/worked wood, metal, glass/ceramics and artificial polymer materials (plastics) as well as cloth/textiles is shown in Fig. 1.7.2. The predominant type of litter was artificial polymer materials - plastics, which in 2015 amounted to 11,209. In the same year, a relatively large number of wood items (3,850) and subsequently metal (1395) were also reported. The number of other categories items remained below 1000. However, it should be emphasized that the share of plastics in the total amount of waste was the largest and amounted to 58%. In 2016, this share was 69%. In the same year there was also an increase in the number of waste on the coastline of the Polish Coast compared to the previous year from 17702 to 20429. Considering the total number of waste on all sections, the largest share in addition to plastic waste (14104) was characterized by metal waste (1807), glass and ceramics (968), as well as a significant share of waste from the group other wastes (383), whose turnout in 2015 was 92.

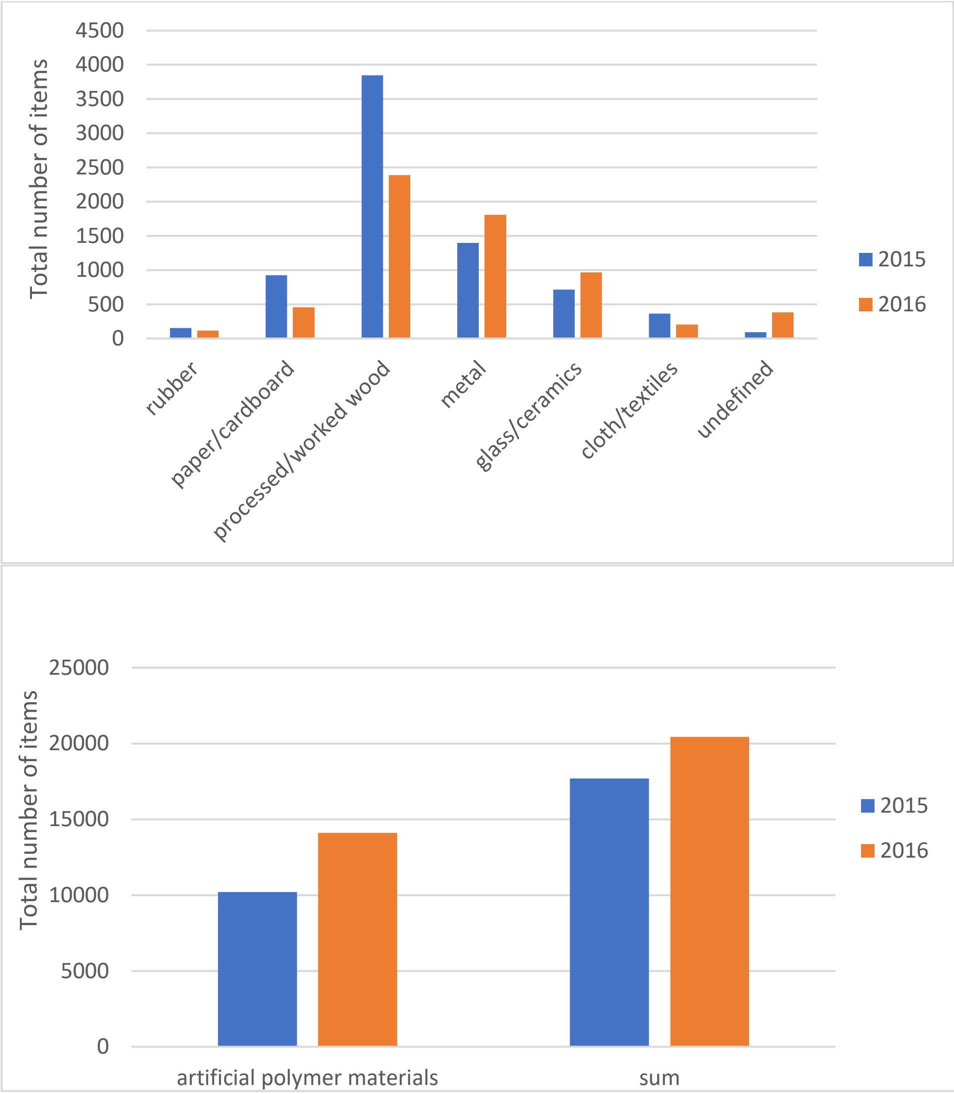



Fig. 1.7.2. Total number of litter items (from four periods) recorded on individual sections in seven main categories and sum in 2015 and 2016 (Data source: PMŚ)

Monitoring in terms of the number of litter discharged ashore or collected along the shoreline was carried out on urban and rural beaches, which theoretically are subjected to other pressures and the litter present there come from various sources. However, most areas of the Polish Coast are intensively used for tourism. As expected, the largest number of litter items was found in urban type beaches (Fig. 1.7.3). In 2015, the total number of litter items on urban beaches was 12 106, and a year later increased to 15284. In the case of rural beaches, the number of litter items in 2015 and 2016 was similar and amounted to 5595 and 5145 respectively. Significant differences in the number of litter items in urban and rural areas it has its source in tourism, the impact of which is particularly visible in tourist-attractive periods (Fig. 1.7.4).

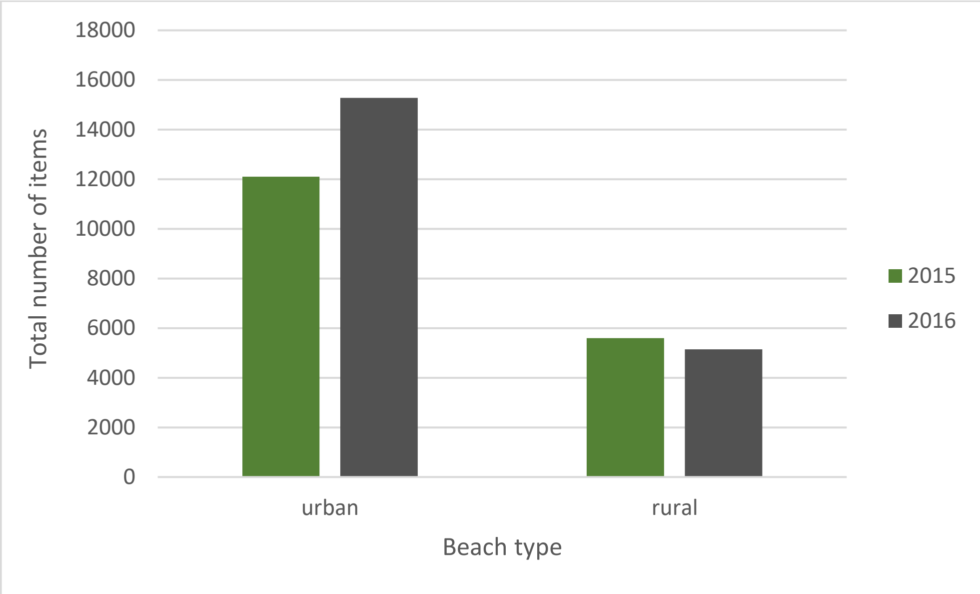



Fig. 1.7.3. Total number of litter items on urban and rural beaches in 2015 and 2016 (Data source: PMŚ)

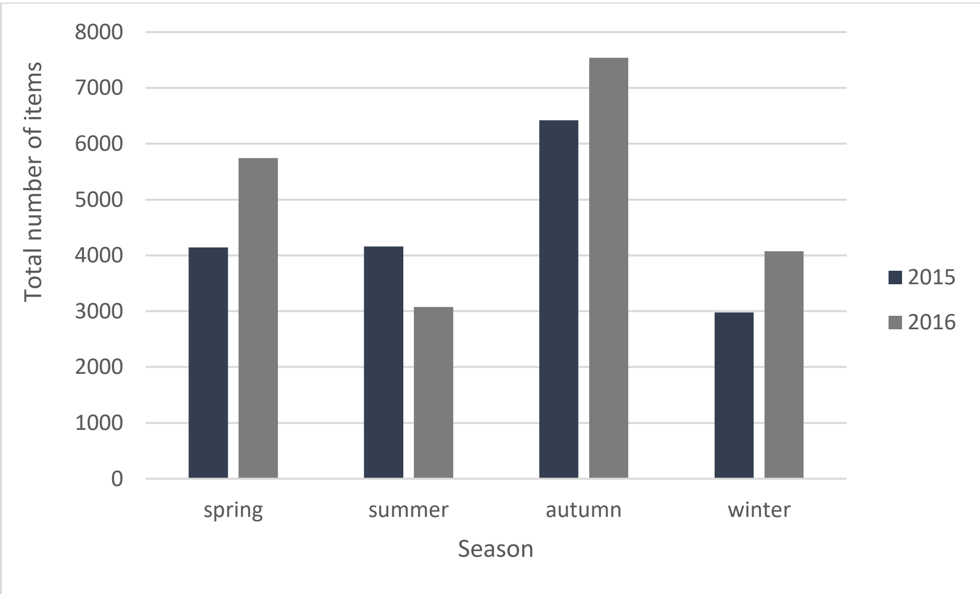



Fig. 1.7.4. Total number of litter items in individual seasons in 2015 and 2016 (Data source: PMŚ)

In 2015, the number of litter items in the spring and summer was about 4,100, while in 2016 in the spring the number of litter items (5741) was higher than that recorded in the summer (3076). The largest increase in the number of litter items in both years occurred in the autumn. Such characteristics may be related to the fact that the majority of sections are covered by systematic cleaning, which are carried out by the relevant municipalities, especially during the most attractive tourist periods.

The number of litter items in individual categories recorded on 15 sections in 2016 was compared with data from 2015 (Fig. 1.7.5). In 2016, the number of litter items on the Polish Coast line increased. A fourfold increase in the number of rubber items was recorded on the Ustka section (from 10 to 43 items), a slight increase was also found at the following stations: Mielno, Choczewo, Hel, Gdańsk, Stegna and Krynica Morska. However, at the Świnoujście station, a much smaller number of this type of litter was counted. In 2015, the amount of rubber litter recorded in this section was 28, while in 2016 only three rubber elements were counted. The decline was also recorded at the Darłowo, Smołdzino, Hel and Gdynia stations.

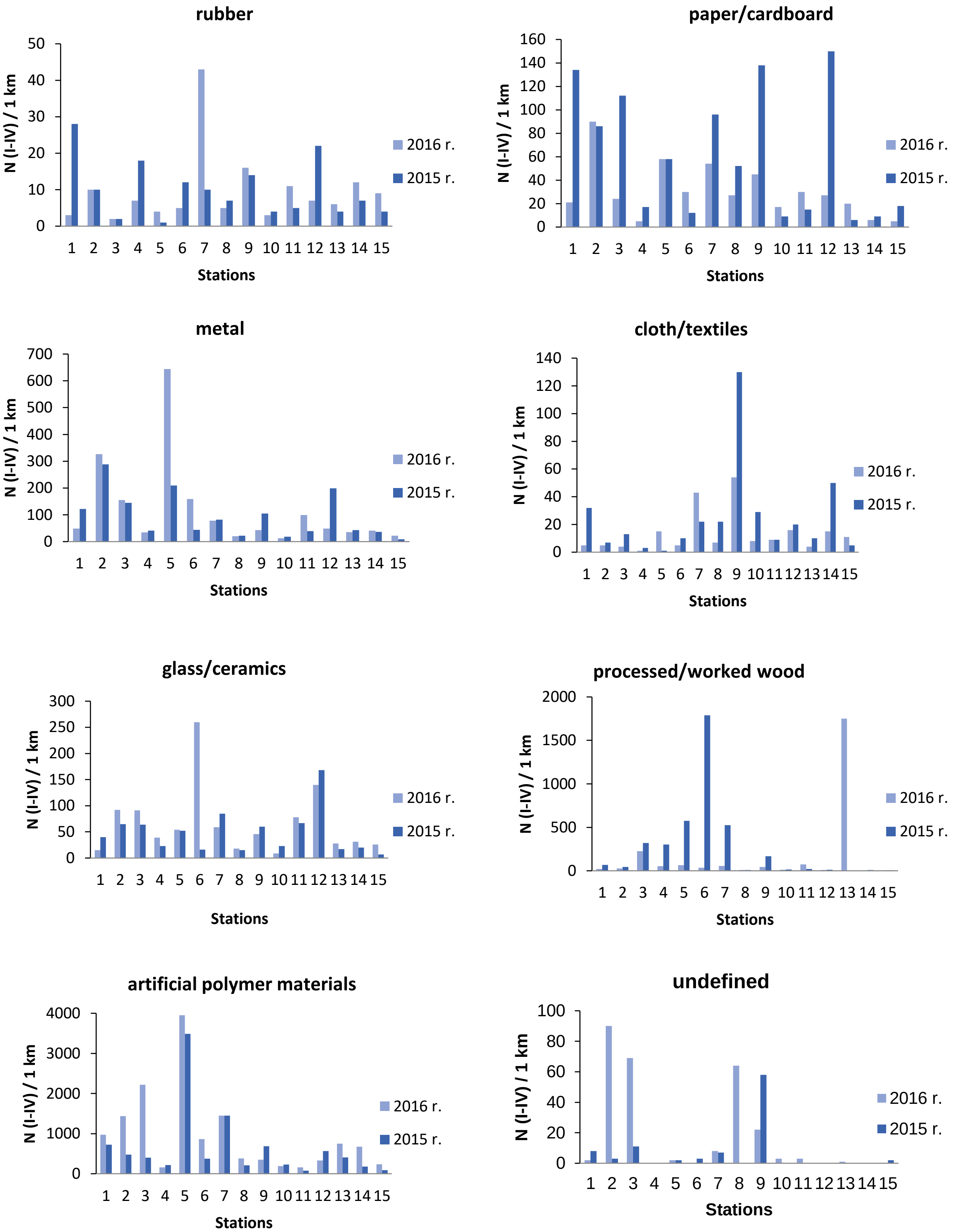


Fig. 1.7.5. Number of wastes (from four periods of research) recorded on individual sections in seven main categories in 2015 and 2016. Station numbers correspond to individual sections: 1- Świnoujście, 2- Dziwnów, 3-Trzebiatów, 4-Kołobrzeg, 5-Mielno, 6-Darłowo, 7-Ustka, 8- Smołdzino, 9- Choczewo, 10, 11- Hel, 12-Gdynia, 13- Gdańsk, 14-Stegna, 15- Krynica Morska. Different scales were used in the diagrams (Data source: PMŚ)

In the case of paper items, practically all stations recorded a decrease in their quantity in 2016 compared to the previous year. The biggest differences were found on the beach in Gdynia, on which 27 items from this category were counted (150 items in 2015). Mielno section has seen a threefold increase in metal items compared to the previous year from 209 items in 2015 the number of items increased to 644 in 2016. An increase in number of items within this category was also found on the beach in Dziwnów, Darłowo and Hel. On the other sections, the number of metal items remained at a similar level or slightly decreased. In the case of cloth and textiles, an increase in the number of items was recorded in 11 out of 15 sections in 2016 as compared to 2015. Most of this type of litter items were counted in Choczewo. However, the largest number of glass and ceramic items was found in Darłowo, and the number plastics in Mielno. The number of glass/ceramics items increased from 16 in 2015 to 260 in 2016. A significant increase was also observed in the case of wood items at the following stations: Trzebiatów, Kołobrzeg, Mielno, Darłowo, Ustka and Choczewo. However, it should be emphasized that the identification of wood litter sources (natural or anthropogenic), especially for small pieces, is difficult.

The litter items that were not qualified for any of the category were assigned to the group "undefined." In 2015, on the seven sections they did not appear at all, on five sections they occurred in a number of items, and only on the Choczewo section the number of items in this category was 58. In the subsequent year an increase in the number of undefined items was noted, on five sections they did not appear at all, on the six sections there were quantities of several items. However, at four stations, the numbers between 22 and 90 units were counted. Most number of items in this category was recorded in Dziwnów (Fig. 1.7.5).

***TOP 20***

Based on the data on specific types of litter items, statistical analyses were carried out to select the types of litter with the largest numbers (Table 1.7.1). The most numerous were cigarette butts and filters (11220), whose share in the total amount of waste was as much as 30%. The next one contains pieces of wood classified into the group of other wood. Their number was 2998, which corresponded to a share of 8%. In third place there were bottle caps, lid caps and lid representing 4.7% of 20 top types of litter items.

Table 1.7.1. List of the twenty most numerous litter types on the coastline in 2015 and 2016 (source of PMŚ data)

| TOP | Category | Litter type | Total number of items | Percentage |
|---|---|---|---|---|
| 1 | Artificial polymer material | cigarette butts and filters | 11220 | 30.1 |
| 2 | Processed/worked wood | other wood | 2998 | 8.0 |
| 3 | Metal | caps from bottles and lids | 1740 | 4.7 |
| 4 | Processed/worked wood | other wood < 50 cm | 1374 | 3.7 |
| 5 | Artificial polymer material | cutlery, trays, straws, agitators | 1302 | 3.5 |
| 6 | Artificial polymer material | caps, covers, rings | 1240 | 3.3 |
| 7 | Artificial polymer material | bottles >0.5l | 1177 | 3.2 |
| 8 | Processed/worked wood | other wood > 50 cm | 1142 | 3.1 |
| 9 | Glass/ceramics | bottles (pieces of bottles) | 1051 | 2.8 |
| 10 | Artificial polymer material | packaging for sweets | 819 | 2.2 |
| 11 | Artificial polymer material | pieces of plastic 2.5 cm > < 50cm | 818 | 2.2 |
| 12 | Artificial polymer material | shopping bags, plastic multi-packs | 743 | 2.0 |

| TOP | Category | Litter type | Total number of items | Percentage |
|---|---|---|---|---|
| | | from cans | | |
| 13 | Artificial polymer material | pens and tops | 742 | 2.0 |
| 14 | Metal | beverage cans | 741 | 2.0 |
| 15 | Artificial polymer material | other plastics | 622 | 1.7 |
| 16 | Paper/cardboard | pieces of paper | 613 | 1.6 |
| 17 | Artificial polymer material | beverage bottles <=0.5l | 592 | 1.6 |
| 18 | Artificial polymer material | cups and covers | 433 | 1.2 |
| 19 | Artificial polymer material | Ear sticks | 402 | 1.1 |
| 20 | Artificial polymer material | plastic / polystyrene pieces 2.5 cm > < 50cm | 359 | 1.0 |

Taking into account the basic categories of litter, plastics items accounted for the highest share at the level of 68%, the share of wood category was 18%, metal - 8%, glass/ceramics - 3% and paper/cardboard - 2% (Fig. 1.7.6). Among the individual litter types making up the list of the 20 most common litter, there were no litter from the category: cloth/textiles and rubber.

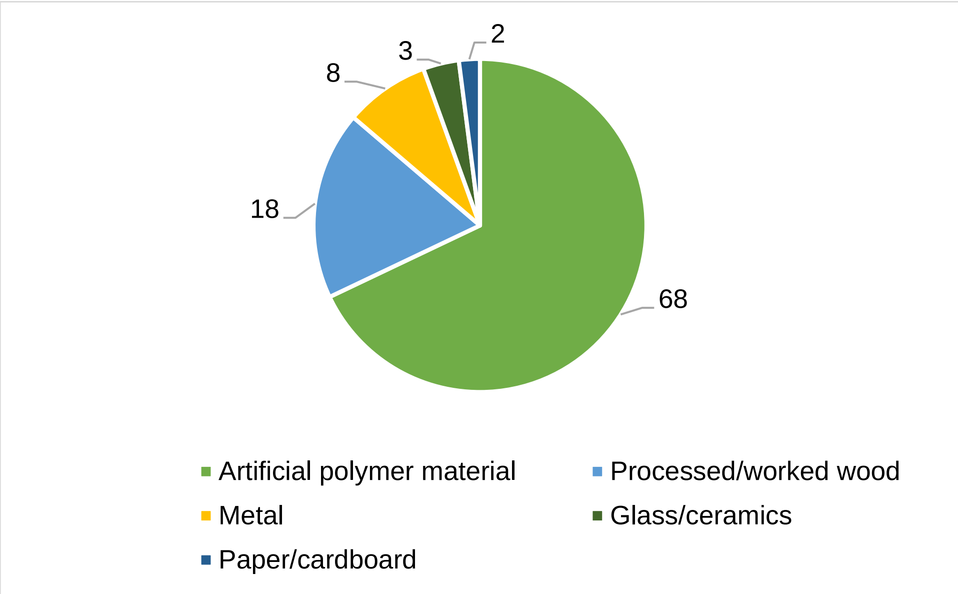



Fig. 1.7.6. Percentage of five groups of the largest number of litter items in 2015 and 2016 (source of PMŚ data)

***Marine litter deposited on the seabed***

Data on litter deposited at the seabed from 2015 and 2016 was obtained from the ICES database (source: http://www.ices.dk/marine-data/data-portals / pages / DATRAS.aspx ). Data reported by the National Marine Fisheries Research Institute is obtained during trawling conducted as part of the Multiannual Program for the Collection of Fishing Data conducted by MIR-PIB (Fig. 1.7.7).

The total weight of litter identified in 2015 was 2.45 kg, while in 2016 it was 17.5 kg (Table 1.7.2). Of course, the final result - the mass of identified litter depends on the area covered by the research.

Table 1.7.2. Results of investigations of waste accumulated at the bottom in the regions of the southern Baltic Sea in 2015 and 2016

| Year | Depth [m] | Trawling time [min] | Weight [kg] | Number of hauls |
|---|---|---|---|---|
| 2015 | 19-112 | about 30 | 2.449 | 33 |
| 2016 | | | 17.459 | 51 |

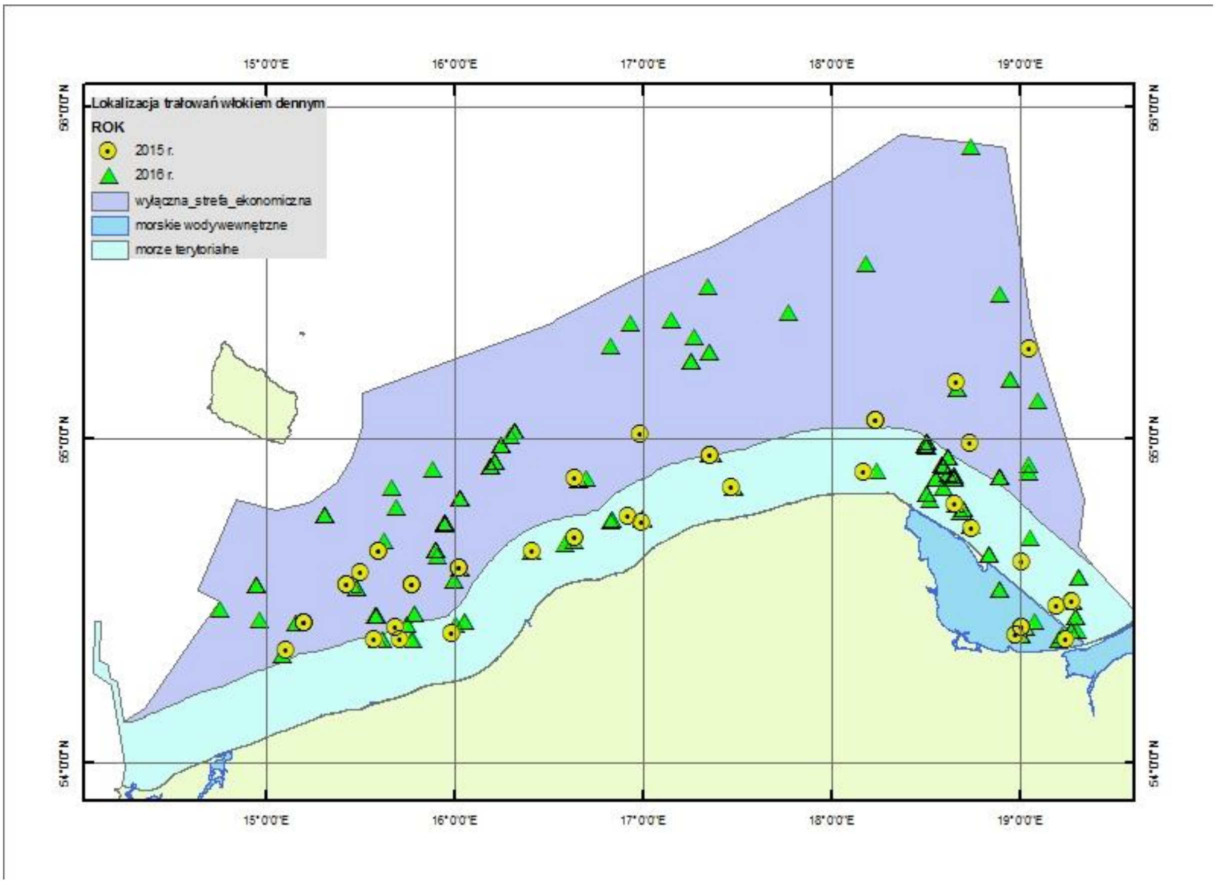



Fig. 1.7.7. Location of identification areas for litter deposited on the seabed

### *Microparticles in seawater and bottom sediments*

The term microparticle is used for litter particles smaller than 5 mm, but they can also be much smaller. Studies of microparticles include both synthetic and non-synthetic particles (such as plastic, cellulose, cotton, wool, rubber, metal, glass). Particles can come from primary sources or come from the decomposition of larger litter elements (so-called secondary particles). Microparticles can be found in all elements - matrices of the environment, in sea water, bottom sediments, in organisms, on the shore.

In 2016, seawater and bottom sediment samples were collected for microparticles in locations:

- 4 in the area of the open sea: Gdańsk Deep - P1, Eastern Gotland Basin - P140, Bornholm Deep - P5 and Gdańsk Basin - P110 during the cruise in 2016,
- in the Szczecin Lagoon - ZSZ,
- in the Vistula Lagoon - KW.

The largest number of microparticles was identified in water in the Bornholm Deep (52) - Fig. 1.7.8. Subsequently, the areas of the Vistula Lagoon (37) and Szczecin (36) were found. In the Gulf of Gdańsk (P110), Gdańsk Deep (P1) and the Eastern Gotland Basin (P140) the number of microparticles in seawater was similar (16-18).

In the case of sediments besides the Eastern Gotland Basin, where only 1 microparticle was identified, in the remaining areas the number of microparticles remained in the narrow range from 7 to 10.

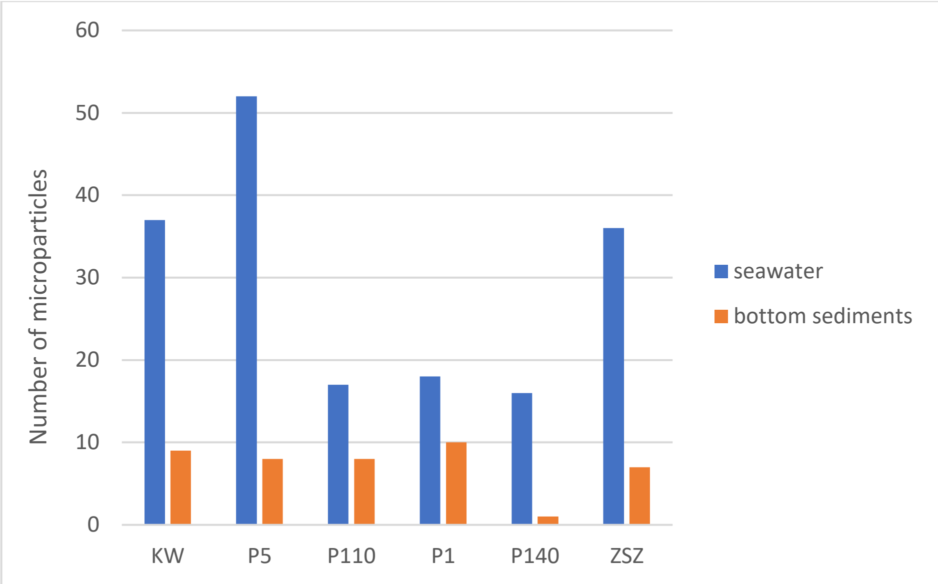



Fig. 1.7.8. Number of microparticles in seawater and bottom sediments in 2016 (source of PMŚ data)

## 1.8. Hazardous substances in marine environment elements and in fish intended for consumption, the effects of their impact on marine organisms

Monitoring conducted in the Polish zone of the Baltic Sea in the field of hazardous substances in the marine environment and their effects includes three groups of chemical substances: heavy metals, persistent organic compounds and radionuclides, taking into account recommendations of the directive on priority substances and recommendations resulting from work carried out under the HELCOM HOLAS II project aimed at carrying out a holistic assessment of the Baltic Sea environmental status covering the years 2011-2016 and based on regionally agreed core indicators. Concentration levels of individual substances are determined in various elements of the marine ecosystem: seawater, organisms and bottom sediments selected on the basis of their adequacy in assessing the status of the environment. Obtained data as part of the State Environmental Monitoring, ordered by the Chief Inspector for Environmental Protection and financed by the National Fund for Environmental Protection and Water Management, allow for the assessment of the status of the environment in terms of two indicators: D8 - Concentrations of contaminants are at levels not giving rise to pollution effects and D9 – Contaminants in fish and other seafood for human consumption do not exceed levels established by the Union legislation or other relevant standards legislation or other relevant standards as per MSFD.

Concentrations of the majority of substances: heavy metals (Pb, Cd and Hg) and chloroorganic compounds in fish, mussel and bottom sediments as well as $^{137}Cs$ and $^{90}Sr$ (representing radioactive isotopes) in sea water have been systematically monitored for many years as part of the State Environmental Monitoring. Organobromide compounds, organic tin compounds and polycyclic aromatic hydrocarbons have been monitored since 2012, and from 2014, monitoring of perfluorinated sodium sulfonate (PFOS) in fish and pharmaceuticals in water has been included in the monitoring program.

In the area of transitional and coastal waters, priority substances are monitored in accordance with the WFD requirements.

In 2014, a micronucleus test method was included in the monitoring program to enable the fish condition to be assessed in the context of the assessment of harmful effects of hazardous substances on marine organisms.

***Radionuclides***

**Water**

In 2011-2016, as in previous years, monitoring of two radioactive isotopes was continued in the Polish part of the southern Baltic: cesium - $^{137}Cs$ and strontium - $^{90}Sr$ present in the marine environment. These are isotopes of anthropogenic origin, characterized by a relatively long half-life of radioactive decay equal to 30 and 28 years, which are mainly responsible for shaping the level of radioactivity in the waters of the Baltic Sea. The main sources of monitored isotopes are nuclear weapons tests, which intensify in the 1950s and 1960s and the accident in the Chernobyl nuclear power plant, which took place in 1986. Changes in their activities in the marine environment are mainly caused by radioactive decay, bioaccumulation processes in organisms of marine fauna and flora, sedimentation processes and water exchange with the North Sea.

The average $^{137}Cs$ radioactive concentration in sea water in 2016, calculated on the basis of results from 17 stations located in the Polish economic zone of the Baltic Sea, amounted to 22.3 Bq $m^{-3}$ and was slightly higher than the average concentration recorded in the previous year 19.2 Bq $m^{-3}$, but at the same time the average activity of the discussed isotope in 2016 was about 1/5 of the maximum value recorded in 1991 and resulting from the accident in the Chernobyl power plant. In 2016, concentrations of $^{137}Cs$ in the waters of the southern Baltic remained in the range of 9.4 Bq $m^{-3}$ to 28.0 Bq $m^{-3}$. The smallest value occurred, similarly as in the previous years in the area of the Vistula estuary, where the share of river waters is significant, as evidenced by the low salinity observed in this region. The largest value of 28 Bq $m^{-3}$ was recorded in the area of the Eastern Gotland Basin at a depth of 40 m. Concentrations below 20 Bq $m^{-3}$ were recorded in the surface waters of the Pomeranian Bay and in the near waters of the Bornholm Basin.

In 2016, the average concentrations of $^{137}Cs$ in the three areas assessed, in the Bornholm Basin, the Eastern Gotland Basin and the Gdańsk Basin were slightly higher than in the previous year (Fig. 1.8.1). They were respectively 21.5 Bq $m^{-3}$, 24.1 Bq $m^{-3}$ and 23.3 Bq $m^{-3}$. The average concentration of $^{137}Cs$, practically unchanged compared to the previous year, but also significantly lower than in other areas of assessment, occurred in the Gdańsk Basin Polish coastal waters (15,6 Bq $m^{-3}$). Essentially, in all areas there is a decrease in $^{137}Cs$ radioactive concentrations compared to 2011, which is the beginning of the assessment period, where the average concentrations in three areas: Bornholm Basin, Eastern Gotland Basin and Gdańsk Basin were very even and remained in the range 31.1 – 31.9 Bq $m^{-3}$. In 2011, in the Gdańsk Basin Polish coastal waters, the average concentration of $^{137}Cs$ was 25.1 Bq $m^{-3}$ and was higher by about 10 Bq $m^{-3}$ than observed in this area in 2016.

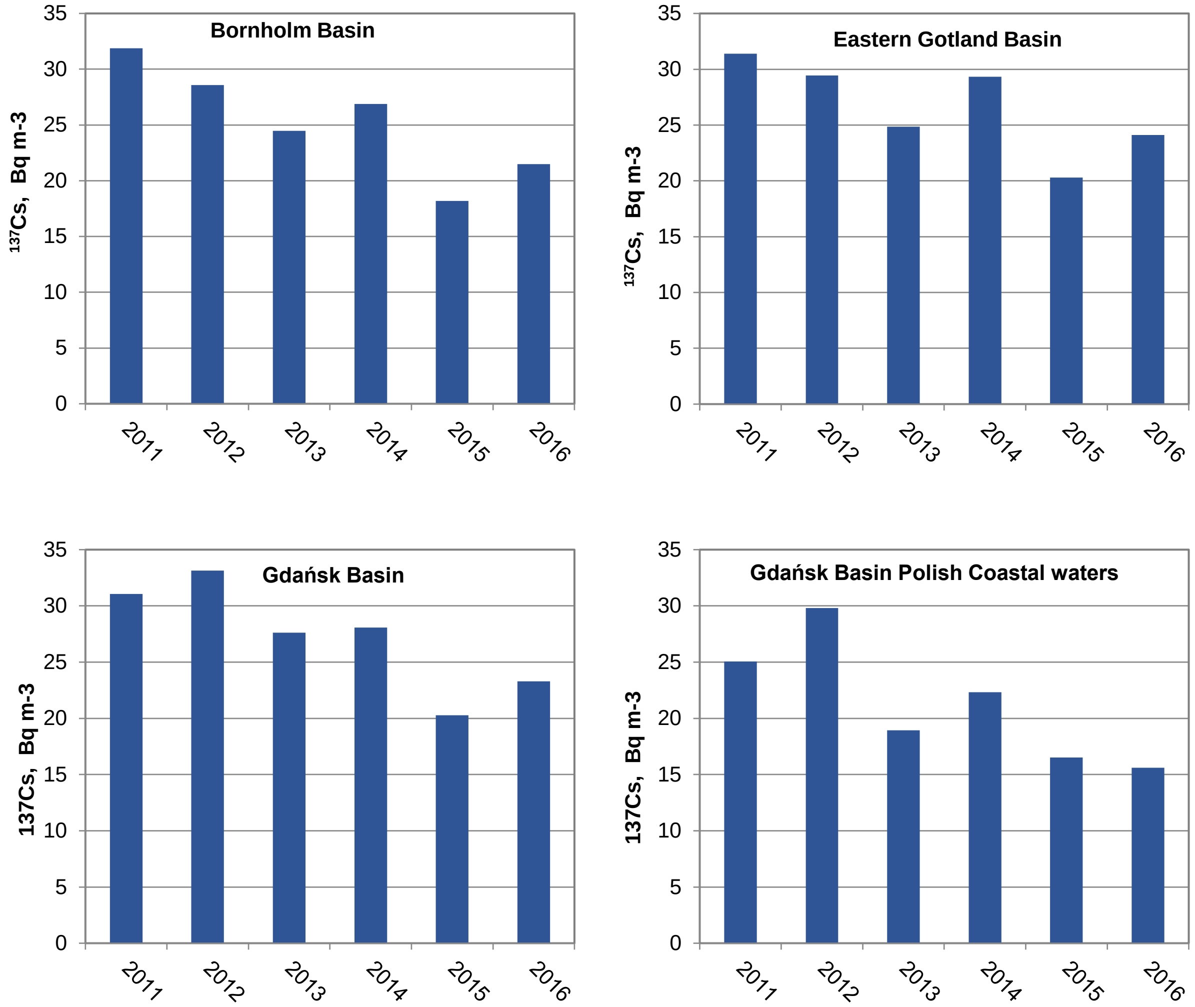



Fig. 1.8.1. Average concentration of $^{137}$Cs (Bq m$^{-3}$) in seawater in assessment areas (source: PMŚ data)

In the case of $^{90}$Sr, there are no unequivocal trends of changes in any of the assessed areas where the average activity in 2016 was very even (Fig. 1.8.2). The smallest value (5.6 Bq m$^{-3}$) was detected the Gdańsk Basin Polish coastal waters. In other basins, the values were practically identical: 6.0 Bq m-3 in the Bornholm Basin, 6.2 Bq m$^{-3}$ in the Eastern Gotland Basin and 6.3 Bq m$^{-3}$ in the Gdańsk Basin. These values were lower by 0.5 to 4.5 Bq m$^{-3}$ from the values recorded in 2011, in which the average concentrations of $^{90}$Sr were 8.29 Bq m$^{-3}$ in the Bornholm Basin, 10.7 Bq m$^{-3}$, respectively in Eastern Gotland Basin, 7.6 Bq m$^{-3}$ in the Gdańsk Basin and 6.1 Bq m$^{-3}$ in the Gdańsk Basin Polish coastal waters. The most visible change concerned the Eastern Gotland Basin, where the average concentration decreased by 4.5 Bq m$^{-3}$.

In 2016, the average activity of $^{90}$Sr characteristic of the entire southern Baltic area was 6.1 Bq m$^{-3}$. The lowest concentration of $^{90}$Sr, equal to 3.9 Bq m$^{-3}$, was recorded in the bottom waters of the Gdańsk Deep, while the highest (9.4 Bq m$^{-3}$) in the bottom waters of the Gdańsk Basin at the P110 station.

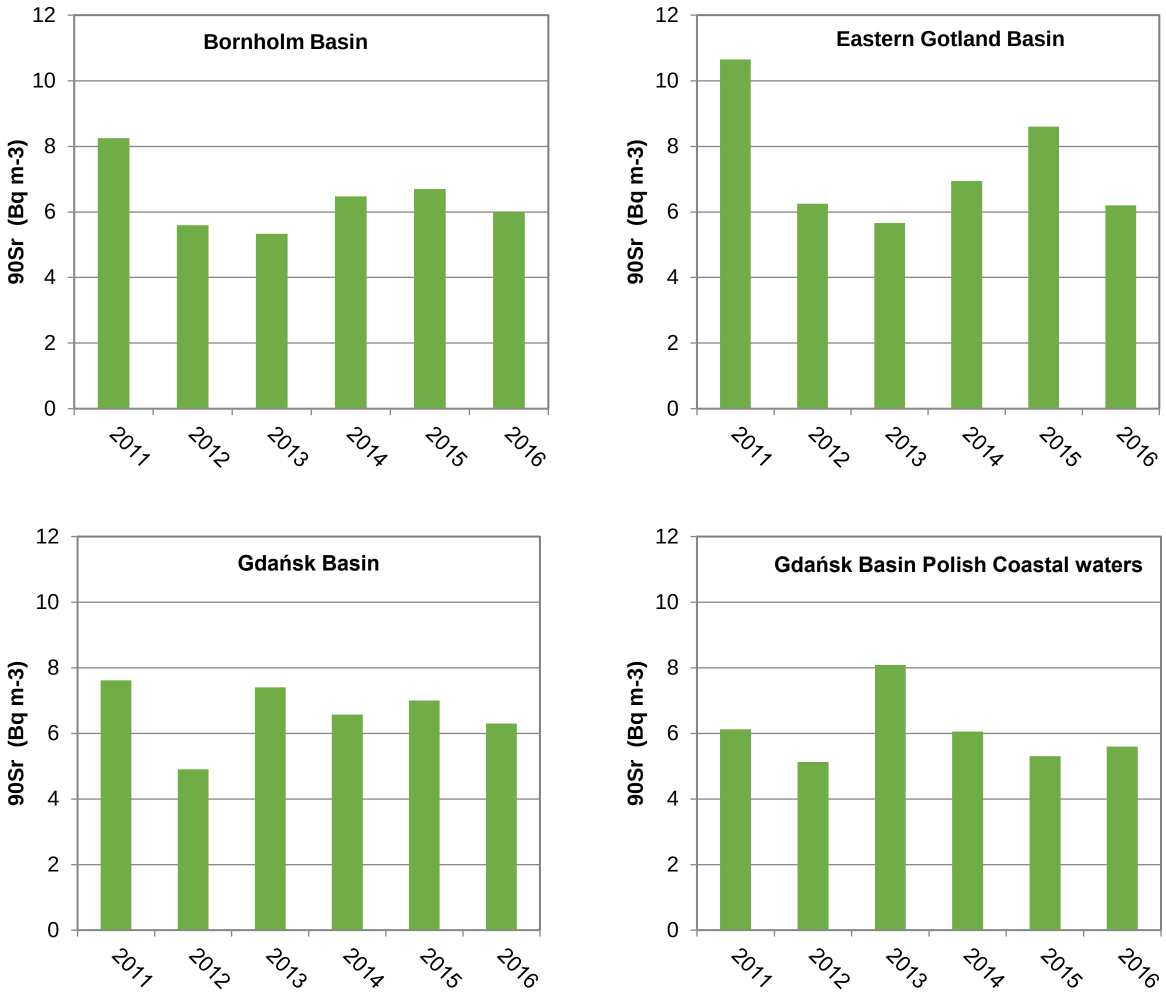



Fig. 1.8.2 Average concentrations of $^{90}Sr$ (Bq $m^{-3}$) in seawater in assessment areas (Data source: PMŚ)

### Fish

In the years 2014-2016, analyzes were carried out to determine the concentrations of cesium - $^{137}Cs$ in perch (*Perca fluviatilis*) caught in the Vistula Lagoon and the Szczecin Lagoon. In 2016, $^{137}Cs$ activity in fish from the Vistula Lagoon changed in a narrower range than it was in the previous year: from 3.6 to 6.2 Bq $kg^{-1}$ ww. in the case of females and from 3.1 to 6.6 Bq $kg^{-1}$ ww. in the case of males (Fig. 1.8.3). The mean values for both sexes were very even and amounted to 4.5 Bq $kg^{-1}$ ww - females and 4.6 Bq $kg^{-1}$ ww - males and were slightly lower than observed in the previous year: 6.3 Bq $kg^{-1}$ ww and 7.4 Bq $kg^{-1}$ ww. Taking into consideration the period of research from 2014 to 2016, one can conclude a certain decreasing trend in the concentration of $^{137}Cs$ in perch from the Szczecin Lagoon (Fig. 1.8.3). In the Vistula Lagoon, the concentrations in both sexes remained at lower levels, the average values were respectively 2.1 Bq $kg^{-1}$ ww (female) and 2.6 Bq $kg^{-1}$ ww (male) and were very close to the values observed in the previous year: 2.9 Bq $kg^{-1}$ ww (female) and 2.8 Bq $kg^{-1}$ ww (males).

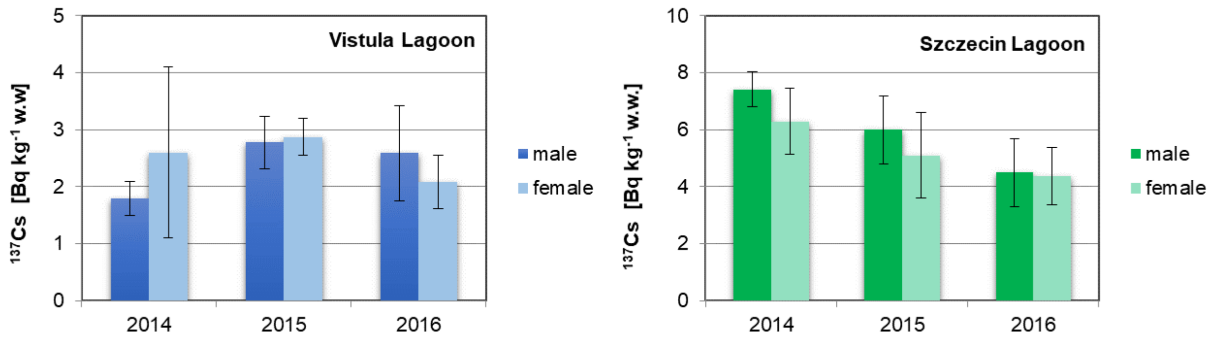



Fig. 1.8.3 Average concentration of $^{137}Cs$ in perch (*Perca fluviatilis*) in the years 2014-2016 (source of PMŚ data)

***Heavy metals***

**Macrophytobethic plants**

In the years 2014 - 2016, heavy metals concentrations: cadmium (Cd), lead (Pb), mercury (Hg) and nickel (Ni) as well as radioactive cesium isotope - $^{137}Cs$ were measured in selected species of macrophytobenthic plants. The research involved the use of plants collected in four locations: Klif Orłowski, Jama Kuźnicka, Głazowisko Rowy and Ławica Słupska in two seasons (June and September) as part of monitoring the state of macrofitobenthos. Seven species were selected for the study: four representing red algae: *Polysiphonia fucoides, Furcellaria lumbricalis, Coccotylus truncatus* and *Ceramium dipahanum*, one representing charophyte - *Chara baltica* and two belonging to vascular plants - *Stuckenia pectinata* and *Zanichellia palustris. P. fucoides* and *F. lumbricalis* are species specific to Klif Orłowski, Rowy boulder area and Słupsk Bank boulder area (Ławica Słupska), while *S. pectinata*, *Z. palustris* and *C. baltica* occur in the area of Jama Kuźnicka.

The data presented in the charts show average values calculated on the basis of individual results obtained for each species occurring at different depths and different seasons (Fig. 1.8.4 – Fig. 1.8.8).

In 2016, as in previous years, *P. fucoides* was characterized by the highest concentrations of both heavy metals and $^{137}Cs$. The average activity of $^{137}Cs$ in the area of Klif Orłowski and Rowy was respectively 19.8 Bq kg$^{-1}$ dw and 6.8 Bq kg$^{-1}$ dw and were slightly lower than those observed in the previous year. For the remaining species and locations, concentrations of $^{137}Cs$ remained below the limit of quantification of the method used, with the exception of the *Ch. baltica* species occurring in the area of Jama Kuźnicka, in the tissues of which the activity of $^{137}Cs$ was 3.5 Bq kg$^{-1}$ dw.

The highest mean Hg concentrations occurred, as in previous years, in *P. fucoides*. They amounted to 39.1 µg kg$^{-1}$ dw in the area of Klif Orłowski, 27.9 µg kg$^{-1}$ dw in the area of Rowy and 26.4 µg kg$^{-1}$ dw in the region of Słupsk Bank. Similar values of Hg content, exceeding 20 µg kg$^{-1}$ dw were found in other red algae in the Rowy area, while in the area of Klif Orłowski and Słupsk Bank the concentrations of Hg in *F. lumbricalis, C. truncatus* and *C. diaphanum* varied from 14 to 19 µg kg$^{-1}$ dw. The tissues of vascular plants from the area of Jama Kuźnicka were characterized by the Hg content at a level similar to the level observed in the case of algae. Concentrations Hg were 21.3 µg kg$^{-1}$ dw in the case of *Z. palustris*, 17.9 µg kg$^{-1}$ dw in the case of *S. pectinata*.

The concentration of Pb in *P. fucoides* in the areas of Klif Orłowski amounted to 7.6 mg kg$^{-1}$ dw and it was definitely higher than that recorded in the Rowy region (1.8 mg kg$^{-1}$ dw). Very low Pb concentration was recorded in the case of other red algae. It varied from 0.4 mg kg$^{-1}$ dw in the case of *F. lumbricalis* in the area of Rowy and *C. diapanum* in the region of Słupsk Bank, up to 1.8 mg kg$^{-1}$ dw - the value recorded in *F. lumbricalis* in the area of Klif Orłowski. Pb concentrations in *Ch. baltica* and vascular plants in the Jama Kuźnicka remained at the level of 1 mg kg$^{-1}$ dw.

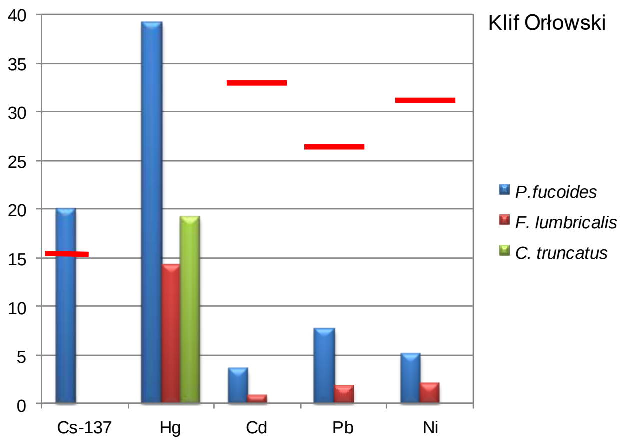



Fig. 1.8.4 137Cs concentrations [Bq kg$^{-1}$ dw], Hg [µg kg$^{-1}$ dw] and Cd, Pb and Ni [mg kg$^{-1}$ dw] in three species of macrophytobenthic plants in the area of Klif Orłowski in 2016 (red lines define the threshold value of good environmental status - in the case of Hg, the limit outside the scope of the axis) (Data source: PMŚ)

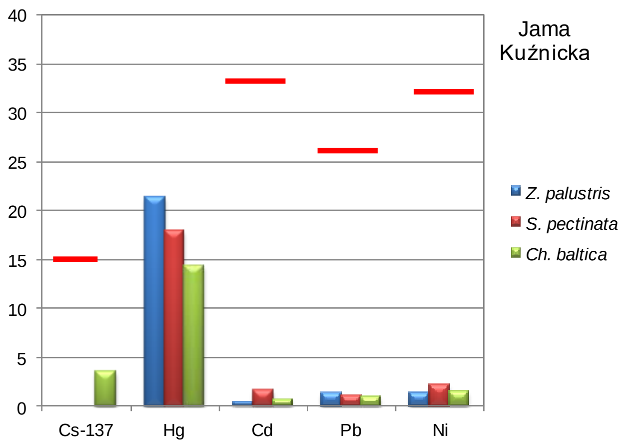



Fig. 1.8.5. 137Cs concentrations [Bq kg$^{-1}$ dw], Hg [µg kg$^{-1}$ dw] and Cd, Pb and Ni [mg kg$^{-1}$ dw] in three species of macrophytobenthic plants in the vicinity of Jama Kuźnicka in 2016 (red lines define the threshold value of good environmental status - in the case of Hg, the limit outside the scope of the axis) (Data source: PMŚ)

Also in the case of Cd, concentrations remained at a relatively low level. The lowest concentrations in a very narrow range from 0.3 to 0.4 mg kg$^{-1}$ dw occurred in three species of red algae in the area of the Ławica Słupska. Only slightly higher values at the level of 0.7 - 0.8 mg kg$^{-1}$ dw characterized these species in the area of Rowy and Klif Orłowski. However, in the case of plants found in the Jama Kuźnicka, the lowest concentration was recorded in *Z. palustris* (0.5 mg kg$^{-1}$ dw), and the highest was in *S. pectinata* (1.6 mg kg$^{-1}$ dw).

The highest concentrations of Ni occurred in *F. lumbricalis* (12.9 mg kg$^{-1}$ dw) and *C. truncatus* (9.9 mg kg$^{-1}$ dw) in the area of the Słupsk Bank. In the case of the other two locations, specific for the occurrence of red algae, Ni concentrations remained in the range of 2 to 5 mg kg$^{-1}$ dw. The lowest Ni contents were specific to tissues of vascular plants: *Z. palustris* 1.3 mg kg$^{-1}$ dw. and *S. pectinata*- 2.2 mg kg$^{-1}$ dw. and species *Ch. baltica* - 1.5 mg kg$^{-1}$ dw.

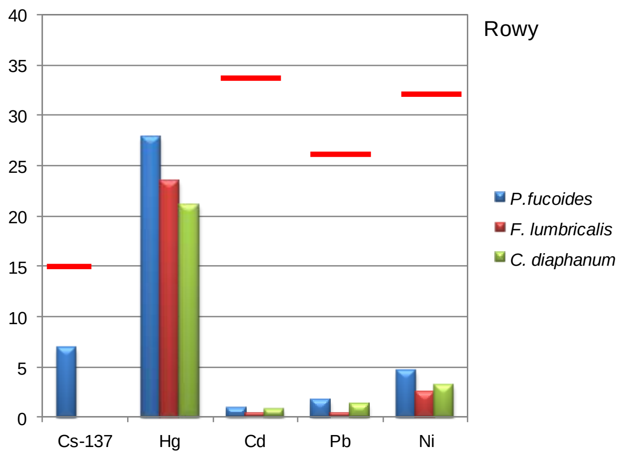



Fig. 1.8.6 137Cs concentrations [Bq kg$^{-1}$ sm], Hg [µg kg$^{-1}$ dw] and Cd, Pb and Ni [mg kg$^{-1}$ dw] in three species of macrophytobenthic plants in the area of Rowy in 2016 (red lines define the threshold value of good environmental status - in the case of Hg, the limit outside the scope of the axis) (Data source: PMŚ)

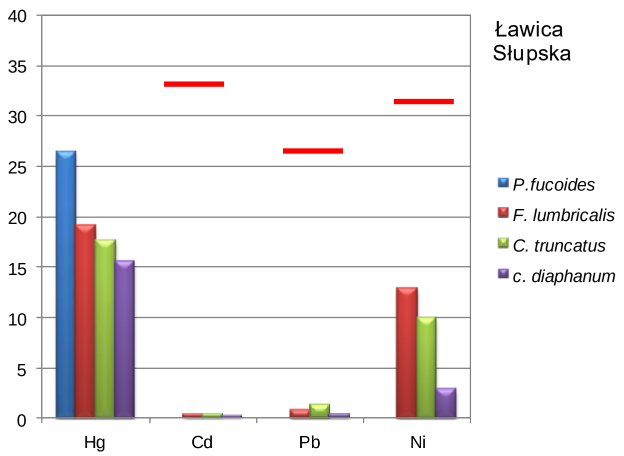



Fig. 1.8.7 Hg [µg kg$^{-1}$ dw] and Cd, Pb and Ni [mg kg$^{-1}$ dw] in four species of macrophytobenthic plants in the area of the Słupsk Bank in 2016(red lines define the threshold value of good environmental status - in the case of Hg, the limit outside the scope of the axis) (Data source: PMŚ)

The comparison of concentrations of hazardous substances monitored in 2014-2016 in *P. fucoides* from Klif Orłowski region (Fig. 1.8.8) shows that these concentrations vary within certain limits, but there are no unambiguous changes that would indicate specific changes in the environment. Only in the case of $^{137}$Cs one can expect a decrease mainly related to radioactive decay, but this applies to a longer monitoring period.

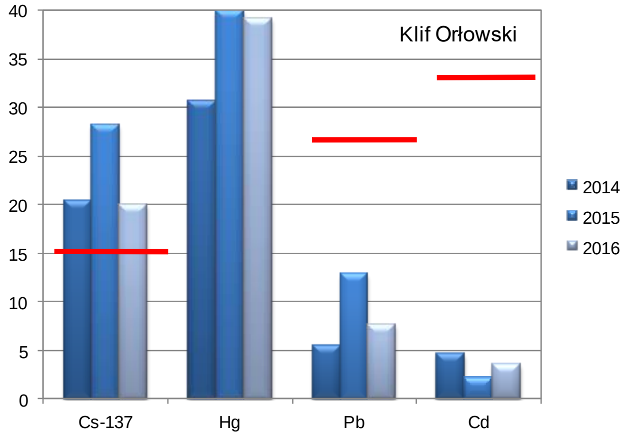



Fig. 1.8.8 Concentrations 137Cs [Bq kg$^{-1}$ dw], Hg [μg kg$^{-1}$ dw] and Cd and Pb [mg kg$^{-1}$ dw] in P. fucoides in the area of Klif Orłowski in the years 2014-2016 (red lines define the threshold value of good environmental status - in the case of Hg, the limit outside the scope of the axis) (Data source: PMŚ)

Considering the location of macrofitobenthic vegetation areas, the environmental status of the Gdańsk Basin Polish coastal waters can be described on the basis of results obtained for the Klif Orłowski and Jama Kuźnicka regions, the Rowy area is characterized by coastal waters of the Bornholm Basin, while the Słupsk Bank may be representative of the Bornholm Basin, which was used in the marine environments assessment.

**Fish and mussel**

In 2011-2016, monitoring in terms of contamination of organisms with heavy metals: cadmium (Cd), lead (Pb) and mercury (Hg) was continued in the Polish part of the southern Baltic. It was commenced in 1998. The longest series of data covering period 1998 - 2016 concerns herring from Eastern Gotland Basin and bivalves from the Gulf of Gdańsk, that is the Gdańsk Basin Polish coastal waters. In subsequent years, the scope of monitoring was expanded to include new areas and species. Metal concentrations were determined in the tissues of herring (*Clupea harengus*), flounder (*Platichthysflesus*), perch (*Perca fluviatilis*) and bivalves (*Mytilus trossulus*). Mercury was determined in the muscle tissue of fish, whereas cadmium and lead in the liver.

Cadmium concentrations in fish livers were dependent on the species studied throughout the study period (Fig. 1.8.9). In 2016, measurements showed that herring liver from the Gotland and Bornholm Basin were characterized by the highest cadmium concentration - 0.585 and 0.500 mg kg$^{-1}$ ww, respectively. Cadmium concentrations in the fish livers from the Szczecin and the Vistula Lagoons were many times lower - 0.040 and 0.091 mg kg$^{-1}$ ww. Cadmium concentrations in the flounder liver (0.263 and 0.217 mg kg$^{-1}$ ww.) were approximately 50% lower compared to the concentration in herring. In 2011-2016, the average concentration of cadmium in mussels from the coastal zone of the Bornholm Basin (0.109 mg kg$^{-1}$ ww) is significantly lower than the average concentration in mussels from the Gulf of Gdańsk (0.184 mg kg$^{-1}$ ww), but in 2016, cadmium concentrations they were more evenly aligned and amounted to 0,123 and 0,143 mg kg$^{-1}$ ww respectively.

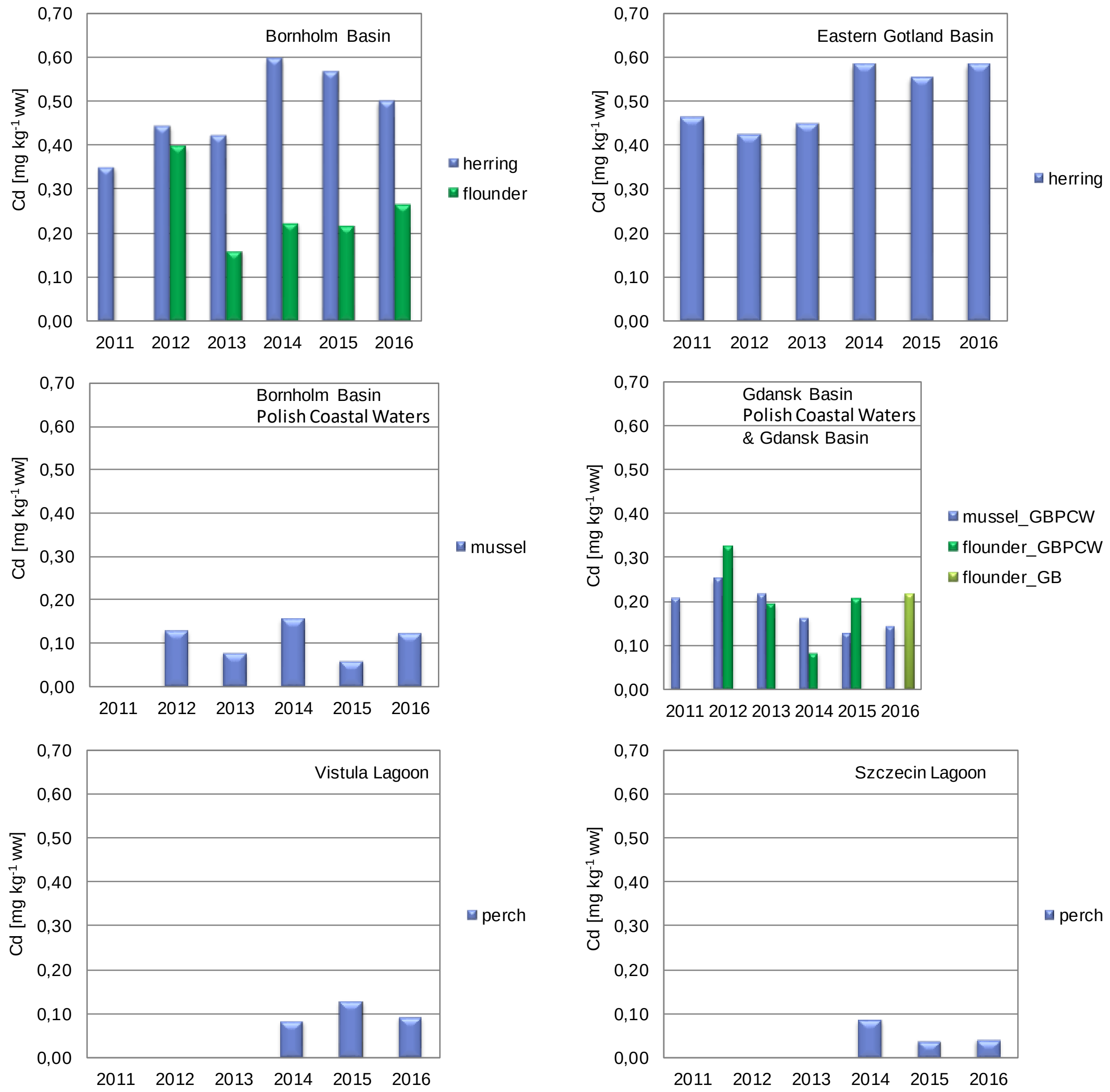



Fig. 1.8.9 Concentration of cadmium [mg kg$^{-1}$ ww] in organisms in the years 2011 - 2016 (Data source: PMŚ)

The concentration of lead (Fig. 1.8.10) in 2016 in the herring, flounder and perch livers, regardless of the species and the region of origin of the fish, were at a similar level and ranged between 0.028-0.043 mg kg$^{-1}$ ww. Similar levels of lead concentrations in fish liver can be observed throughout the period 2011-2016. However, this condition applies to recent years. Taking into consideration the whole period of measurements (1998 - 2016) in the case of herring from the Eastern Gotland Basin, a statistically significant decreasing trend was found. In mussels collected in the Bornholm Basin Polish coastal waters, the lead concentration in 2016 was 40% lower compared to the concentration in the mussels from the Gulf of Gdańsk.

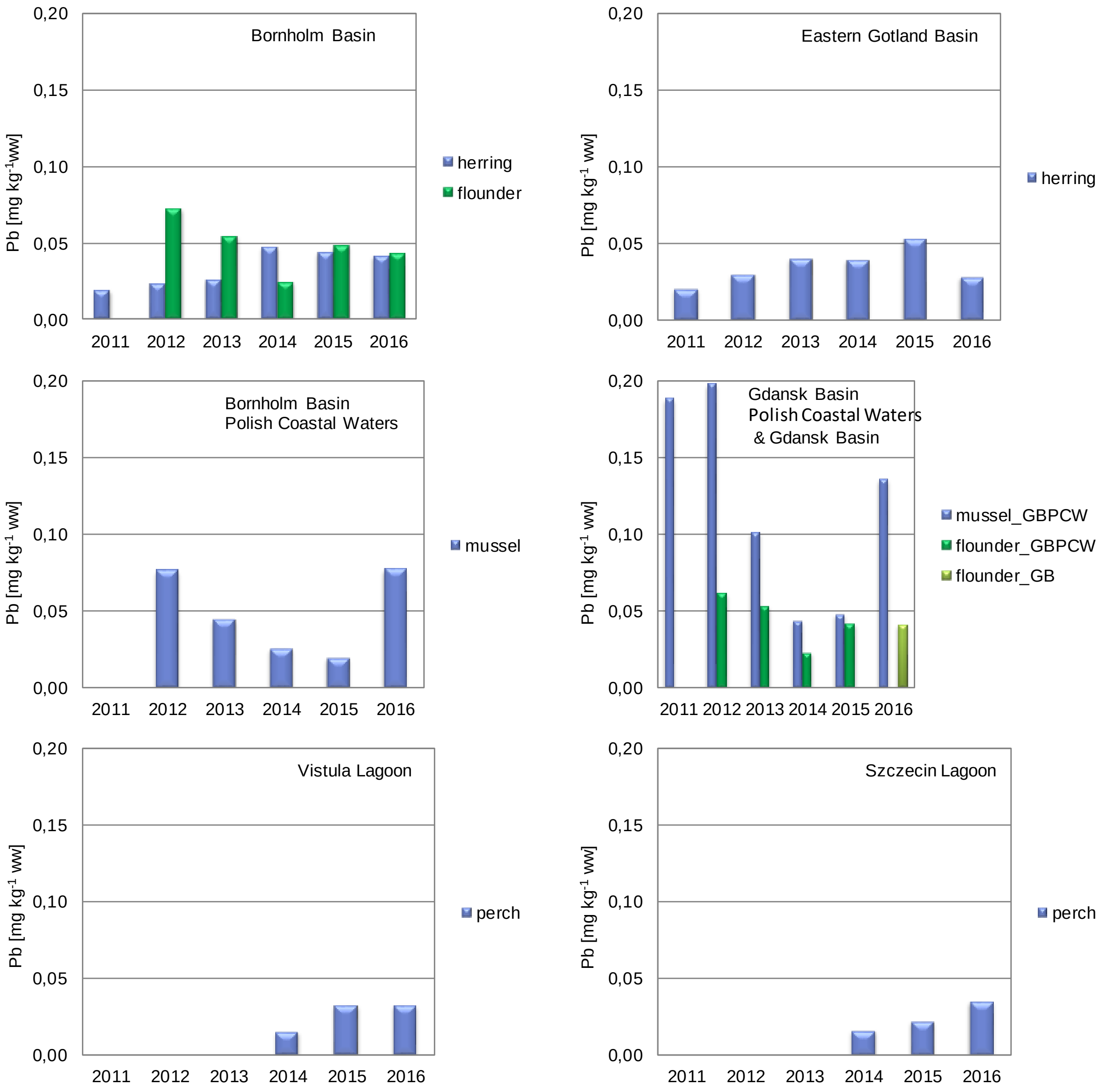



Fig. 1.8.10 Concentration of lead [mg kg$^{-1}$ ww] in organisms in the years 2011 - 2016 (Data source: PMŚ)

In the case of mercury (Fig. 1.8.11) ) in muscle tissue of fish, its concentration in herring in 2016 was clearly at a lower level (0.022 - 0.034 mg kg$^{-1}$ ww) in comparison with muscle tissues of perch and flounder, which were characterized by concentrations in the range from 0.040 to 0.069 mg kg$^{-1}$ ww. The tissue of all fish species is characterized by a higher concentration of mercury than the tissue of mussels. The concentration of mercury, as in the case of lead and cadmium, in mussel caught in the Bornholm Basin Polish coastal waters(0.004 mg kg$^{-1}$ ww.) is lower than the concentration of mercury in the Gulf of Gdańsk mussel (0.006 mg kg-1 ww).

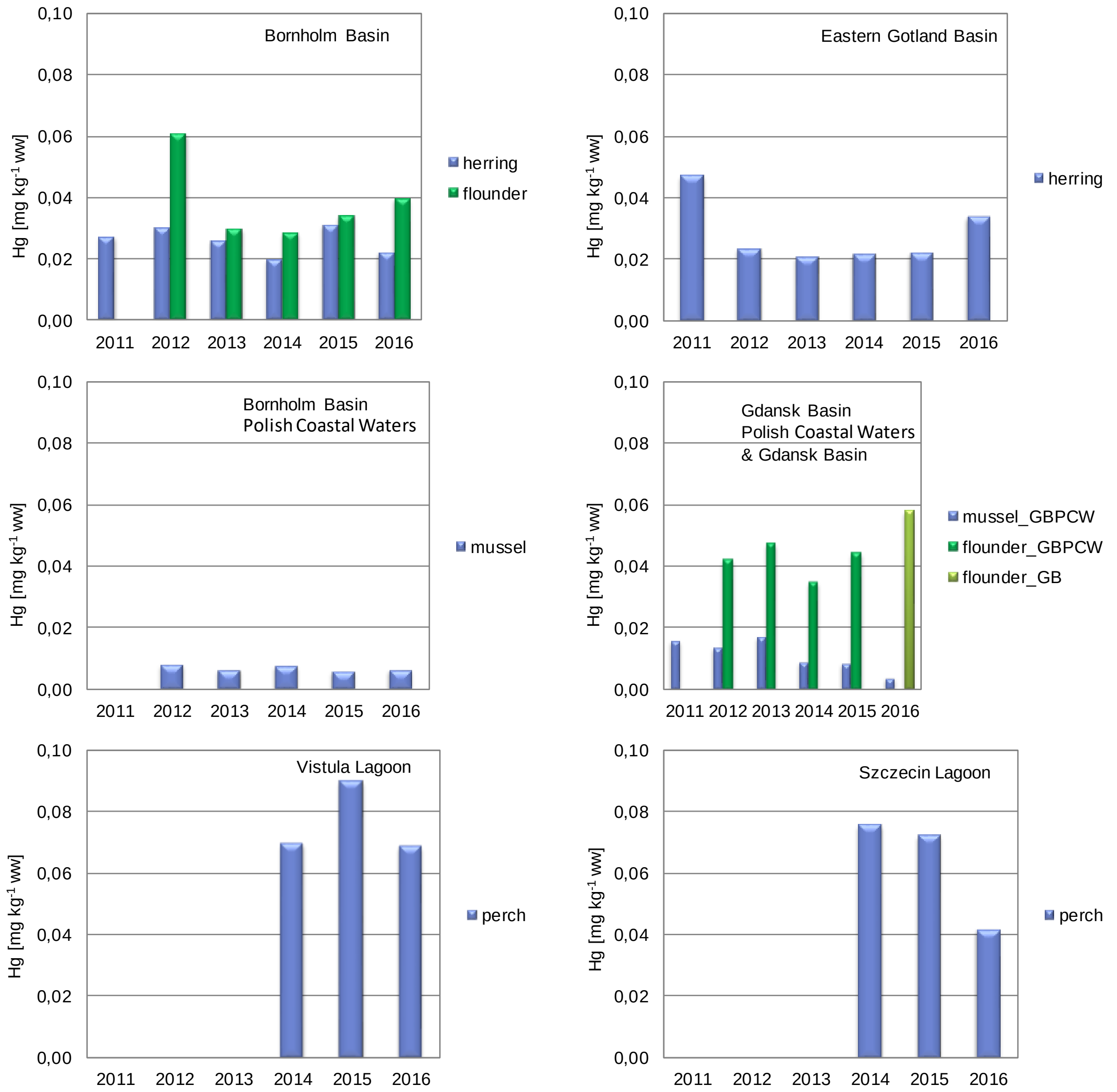



Fig. 1.8.11 Concentration of mercury [mg $kg^{-1}$ ww] in organisms in the years 2011 - 2016 (Data source: PMŚ)

## Sediments

Heavy metals introduced into the natural environment as a result of human activity get into the seas and oceans, where they undergo biochemical changes and ultimately accumulate in bottom sediments. The condition of the Baltic Sea environment in terms of contamination of bottom sediments by cadmium, lead and mercury in the 2 cm thick surface layer varies depending on the region. Measurements of metal content in sediments from three basins of the Baltic Sea: Eastern Gotland Basin (Gotland Deep - P140), the Gdańsk Basin (Deep Gdańsk - P1) and the Bornholm Basin (Bornholm Deep - P5 and P39) (Fig. 1.8.12) showed that the most contaminated are sediments in the Gdańsk Deep (P1), which is undoubtedly the influence of the discharges by the Vistula River. The ratios of cadmium, lead and mercury content in the surface layer of sediment collected in 2012 in the Gdańsk Deep to their contents in the Gotland Deep are 3.4, 1.2 and 2.2 respectively. In the case of the Bornholm Deep (P5) and Gotland Deep (P140), concentrations of lead and mercury in both areas were at a similar level, except for 2007 when the concentration of mercury in the Bornholm Deep was more than 50% higher than its concentration in the sediment of Gotland Basin. In the case of cadmium, its content in sediment from the Bornholm Deep was twice as high in 2012 and 2016 and three times higher in 2007. In the case of measurements of metal content in coastal sediments: Szczecin Lagoon (GJ) and the Vistula Lagoon (KW) (Fig. 1.8.12), they showed that much more metals are deposited in the Szczecin Lagoon, and undoubtedly it is influenced by the fact that this basin is part of the extended Odra estuary system. The ratios of cadmium, lead and mercury content in the surface layer of sediment collected in 2015 from the Szczecin Lagoon to their content in the Vistula Lagoon are 10.7, 5.6 and 5.6 respectively.

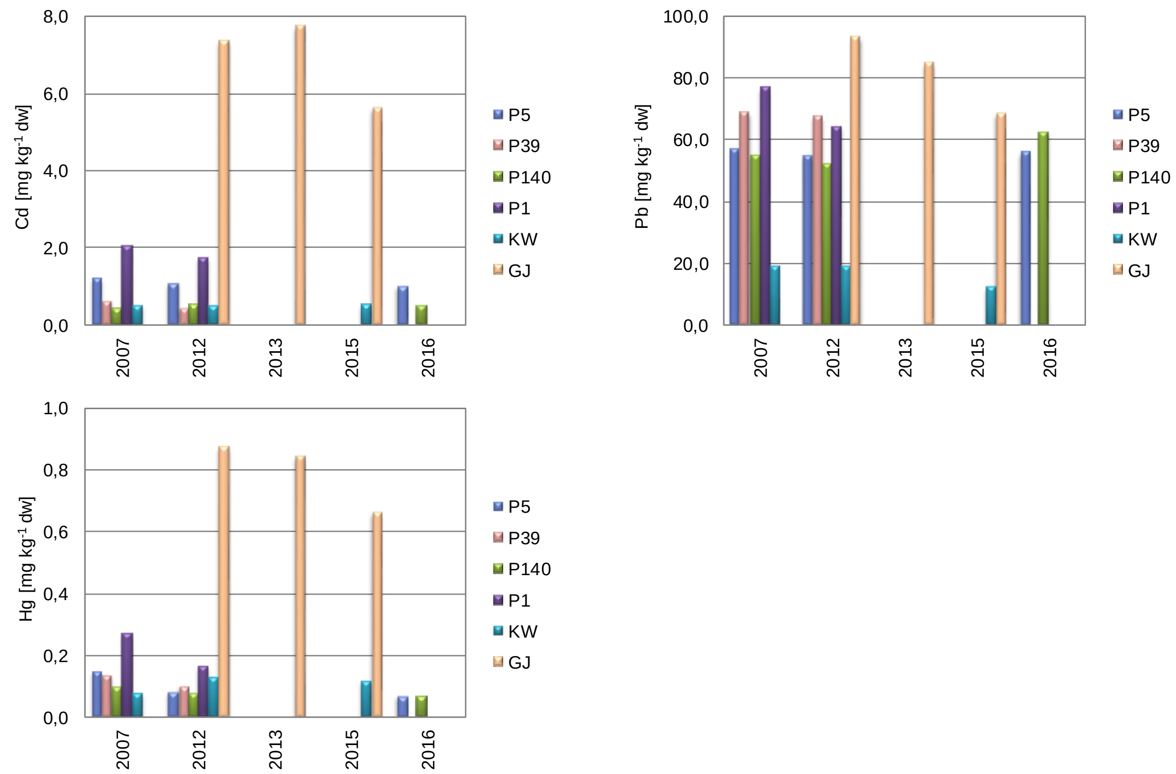



Fig. 1.8.12 Concentration of cadmium, lead and mercury [mg kg$^{-1}$ dw] in the surface layer (0-2 cm) of bottom sediments in the years 2007 - 2016 (source of PMŚ data)

### *Persistent organic pollutants*

This description discusses the most important substances or groups of organic substances in fish and mussel organisms taking into account the assessment purposes. It includes brominated diphenylethers (sum of congeners 28, 47, 99, 100, 153, 154) - PBDE, hexabromocyclododecane - HBCDD, perfluoroctane sulfonic acid and its derivatives - PFOS, tributyltin compounds (tributyltin cation), polychlorinated biphenyls (sum 28, 52, 101, 138, 153), CB 118 congener, benzo (a) pyrene and 1-hydroxypiren - representing a group of polycyclic aromatic hydrocarbons and their metabolites – PAHs.

#### Polybrominated diphenylethers – PBDE

Polybrominated diphenylethers have been monitored since 2012 in the muscle of three fish species: herring (*Clupea harengus*), flounder (*Platichtys flesus*) and perch (*Perca fluviatilis*). The highest concentration of the sum of PBDE congeners was determined in the herring in 2013, in the Bornholm Basin - 1.37µg kg$^{-1}$ ww and in the Eastern Gotland Basin - 4.49 µg kg$^{-1}$ ww (Fig. 1.8.13). In subsequent years, a decrease in PBDE concentrations in herring was observed in both areas, in 2016 these concentrations reached the value of 0.23 μg kg$^{-1}$ ww and 0.30 μg kg$^{-1}$ ww. PBDE concentrations in flounder remained at lower levels, in the Bornholm Basin between 20 μg kg$^{-1}$ ww and 49 μg kg$^{-1}$ ww while in 2016 they fell to 0.02 μg kg$^{-1}$ ww. In the Gdańsk Basin Polish coastal waters and in the Gdańsk Basin they were in the range of 0.15 - 0.22 μg kg$^{-1}$ ww. In the Szczecin Lagoon PBDE concentrations were at the lowest levels from 0.01 μg kg$^{-1}$ ww to 0.06 μg kg$^{-1}$ ww.

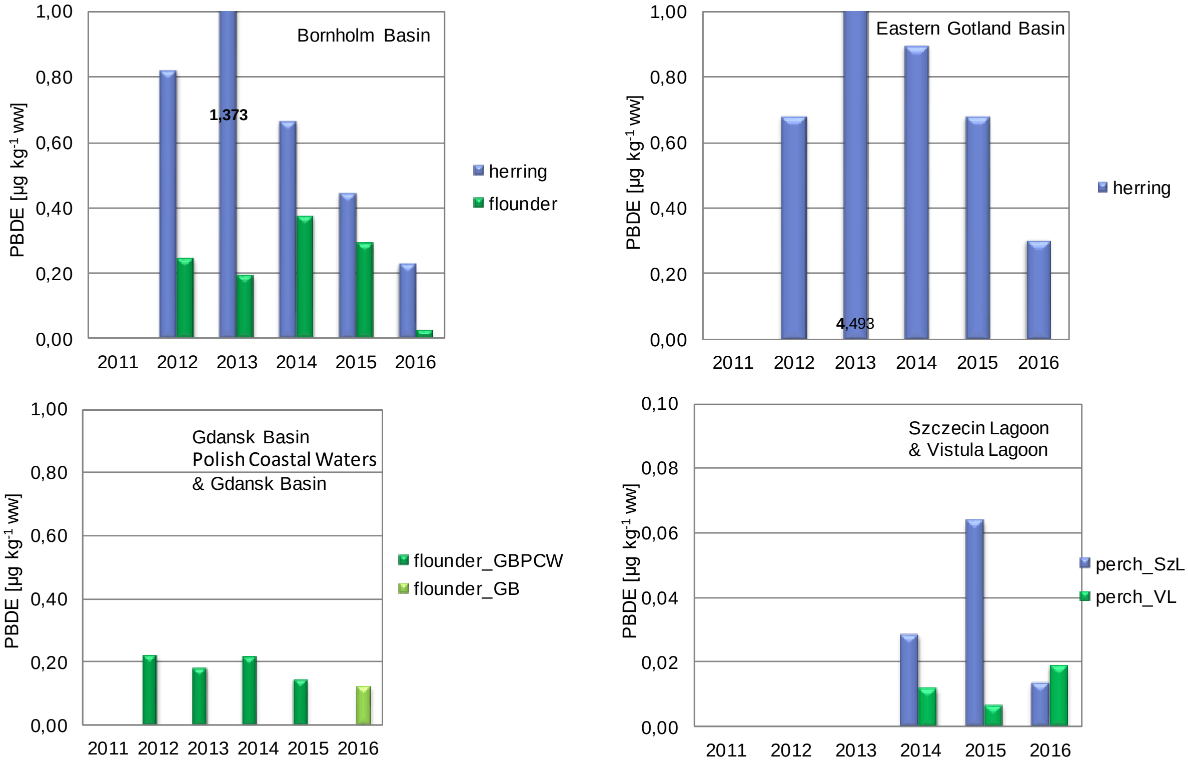



Fig. 1.8.13 Concentration of PBDE [μg kg$^{-1}$ ww] in fish in 2012-2016 (source of PMŚ data)

### Perfluorooctane sulfonic acid - PFOS

Perfluorooctane sulfonic acid - PFOS has been monitored since 2014 in the muscles of three fish species: herring (*Clupea harengus*), flounder (*Platichtys flesus*) and perch (*Perca fluviatilis*). The highest concentrations of PFOS occurred in perch (Fig. 1.8.14). In the Szczecin Lagoon, the PFOS concentrations in the years 2014-2016 remained at the level of 2-3 μg kg$^{-1}$ ww, while in the Vistula Lagoon the maximum concentration was 4.6 μg kg$^{-1}$ ww in 2016. Visibly lower PFOS concentrations at the level of 1 μg kg$^{-1}$ ww and below are marked in the herring in the Bornholm Basin and in the Eastern Gotland Basin. Similar values were also noted in the flounder in the Gdańsk Basin Polish coastal waters and in the Gdańsk Basin, while the lowest PFOS concentrations ranged from 0.37 to 0.77 μg kg$^{-1}$ ww was recorded in the flatfish from the Bornholm Basin.

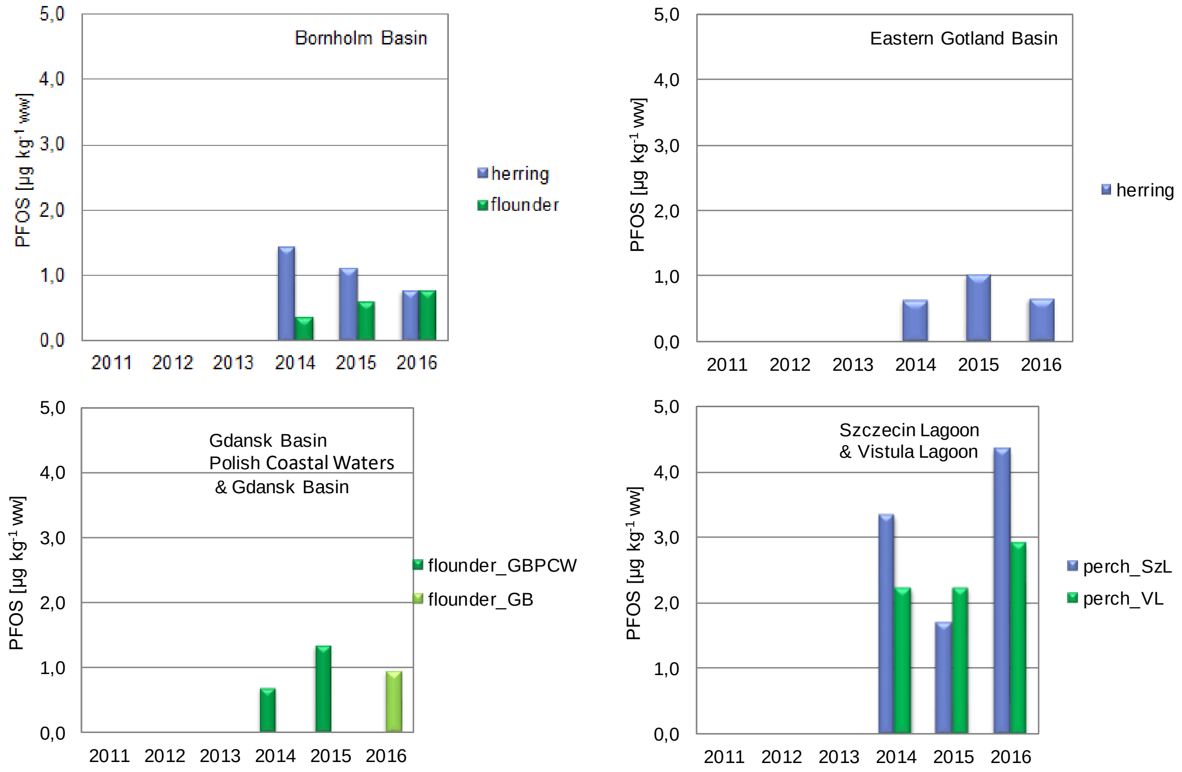
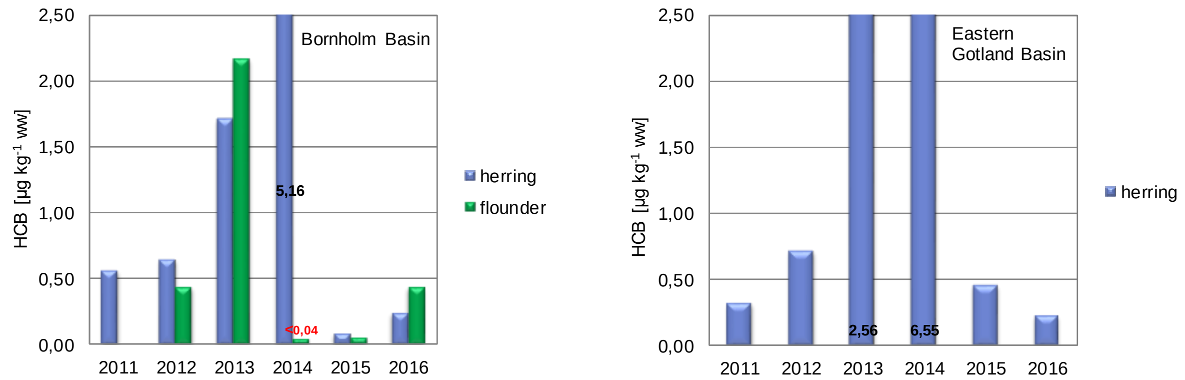



Fig. 1.8.14 Concentration of PFOS [µg $kg^{-1}$ ww] in fish in 2014-2016 (source: PMŚ)

### Hexachlorobenzene - HCB

Hexachlorobenzene is monitored in the muscles of three fish species: herring (*Clupea harengus*), flounder (*Platichtys flesus*) and perch (*Perca fluviatilis*) and in mussels. Its highest concentrations in the discussed period occurred in the tissues of herring caught in the Bornholm Basin and the Eastern Gotland Basin (Fig. 1.8.15). They amounted to 5.16 µg $kg^{-1}$ ww and 6.55 µg $kg^{-1}$ ww, respectively. The values recorded in 2013 were lower and remained at 1.72 µg $kg^{-1}$ ww and 2.56 µg $kg^{-1}$ ww. In the same year, the concentration in the Bornholm Basin was 2.17 µg $kg^{-1}$ ww, and in the Gdańsk Basin Polish coastal waters - 2.69 µg $kg^{-1}$ ww. In the other years, the concentration of HCB in fish remained lower reaching, in 2016, the level of 0,2 µg $kg^{-1}$ ww in herring and 0.4 µg $kg^{-1}$ ww (Bornholm Basin) and 0.3 µg $kg^{-1}$ ww (Gdański Basin) in the flounder. In the case of perch the maximum concentration of HCB at the level of 0.4 µg $kg^{-1}$ ww was noted in 2016 in the Szczecin Lagoon. The maximum HCB concentration in the case of mussel was recorded in 2013 in the Gdańsk Basin Polish coastal waters (2.1 µg $kg^{-1}$ ww.), in other cases the concentrations remained below 1 µg $kg^{-1}$ ww.



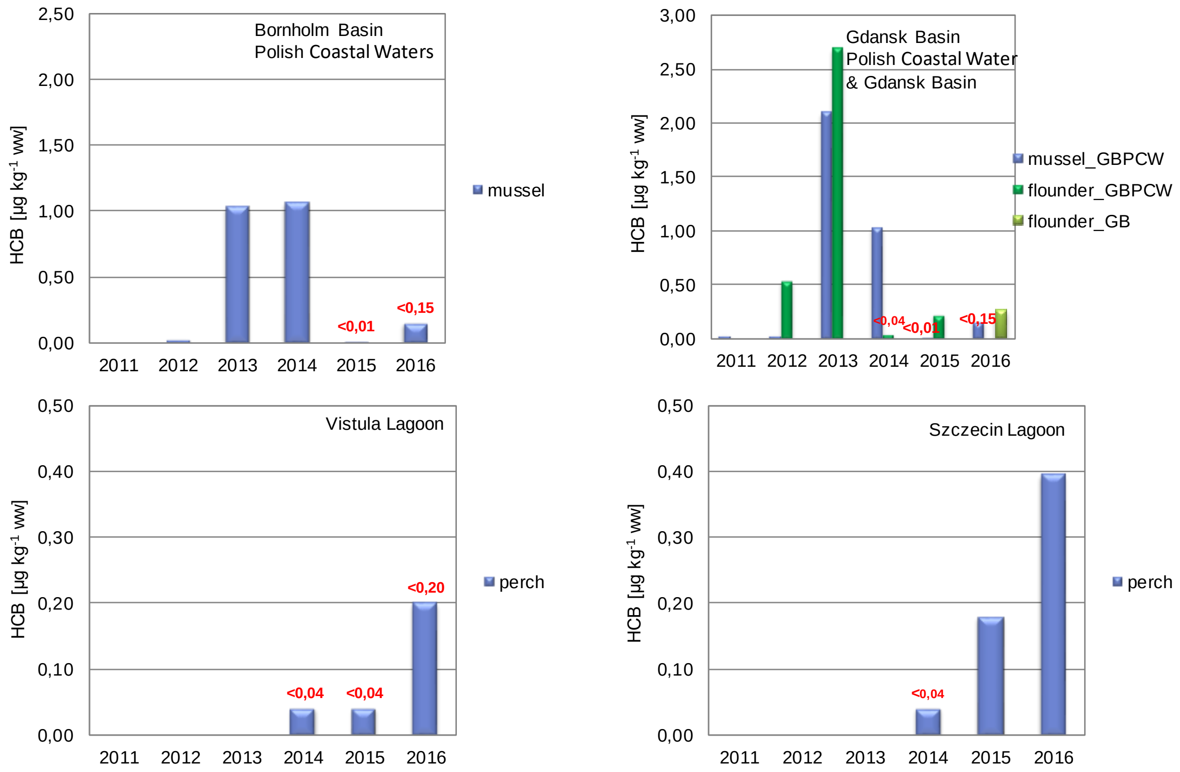
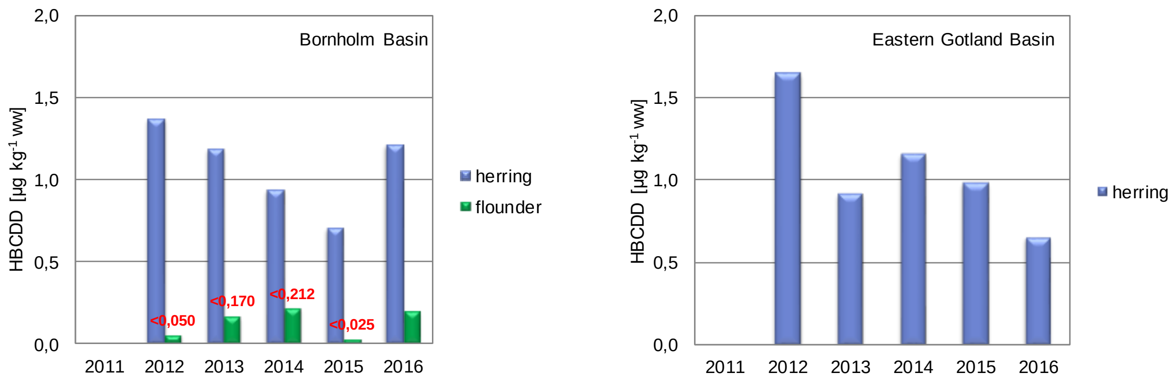



Fig. 1.8.15 Concentration of HCB [µg kg-1 ww] in fish in 2011-2016, red numbers preceded by the sign „<„ indicate the limits of quantification, black numbers correspond to concentration values beyond the range of the axis (source: PMŚ)

### Hexabromocyclododecane – HBCDD

Hexabromocyclododecane has been monitored since 2012 in the muscle of three fish species: herring (*Clupea harengus*), flounder (*Platichtysflesus*) and perch (*Perca fluviatilis*) and in mussels. Its highest values were found in muscles of herring and remained in the range of 0.71 µg kg-1 ww up to 1.37 µg kg-1 ww in the Bornholm Basin and from 0.65 µg kg-1 ww up to 1.65 µg kg-1 ww in Eastern Gotland Basin (Fig. 1.8.16). In the case of the flounder the highest concentration - 0.42 µg kg-1 ww of HBCDD was recorded in 2013 in the Gdańsk Basin Polish coastal waters. The concentration of HBCDD in perch remained below the level of quantification of the method used, except for the year 2016, when it reached the value of 0.015 µg kg-1 ww in the Vistula Lagoon and 0.037 µg kg-1 ww in the Szczecin Lagoon. In the case of mussel, relatively high values were recorded only in 2012 and 2013 in the Gdańsk Basin Polish coastal waters, while in 2016 they remained low and amounted to 0.013 µg kg-1 ww in Bornholm Basin Polish coastal watersand 0.076 µg kg-1 ww in the Gdańsk Basin Polish coastal waters.



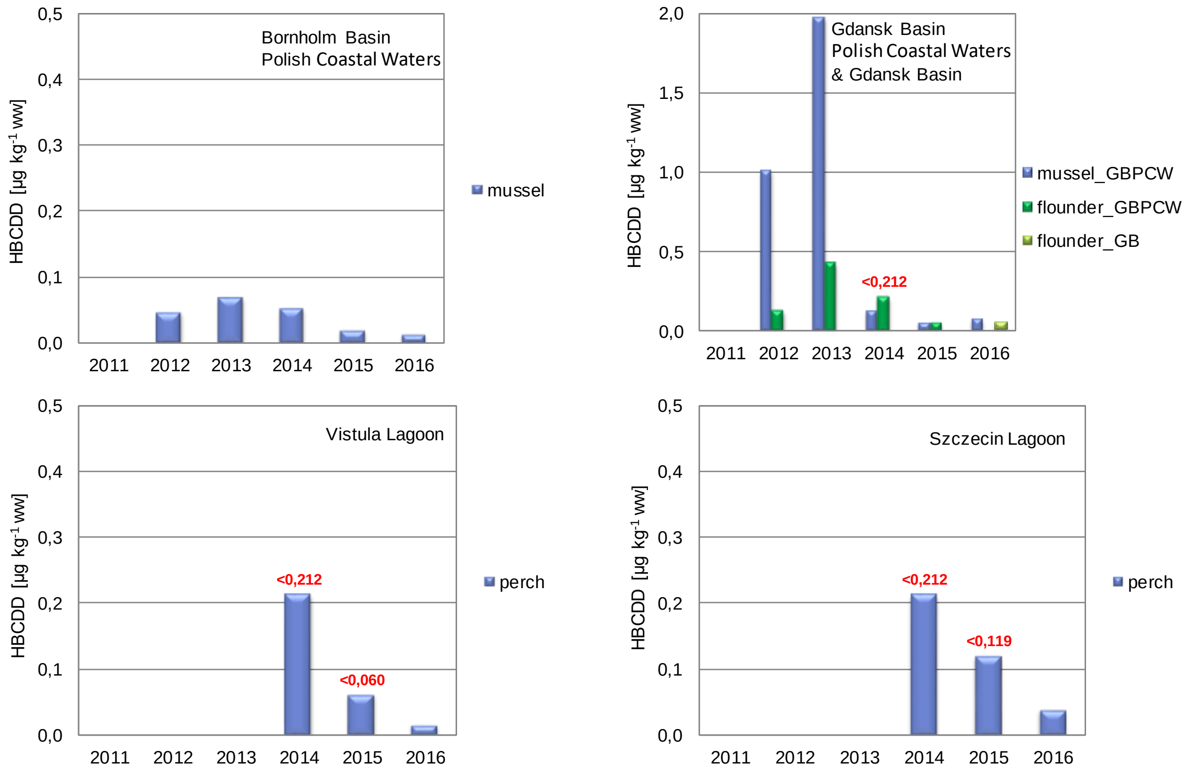



Fig. 1.8.16 Concentration of HBCDD [µg $kg^{-1}$ ww] in organisms in 2012-2016, red numbers preceded by the sign „<„ indicate the limit of quantification (source: PMŚ)

## Benzo(a)pyrene

Benzo(a)pyrene is only analyzed in soft mussel tissue and is considered as a primary indicator of the level of polycyclic aromatic hydrocarbons. The highest concentration of benzo(a)pyrene at 7.5 µg $kg^{-1}$ ww was recorded in 2014 in mussels from the coastal area of the Gdańsk Basin (Fig. 1.8.17). In other cases, concentrations of benzo(a)pyrene remained below unity except in 2016, where concentrations were below the level of quantification of the method, which increased to 3 µg $kg^{-1}$ ww.

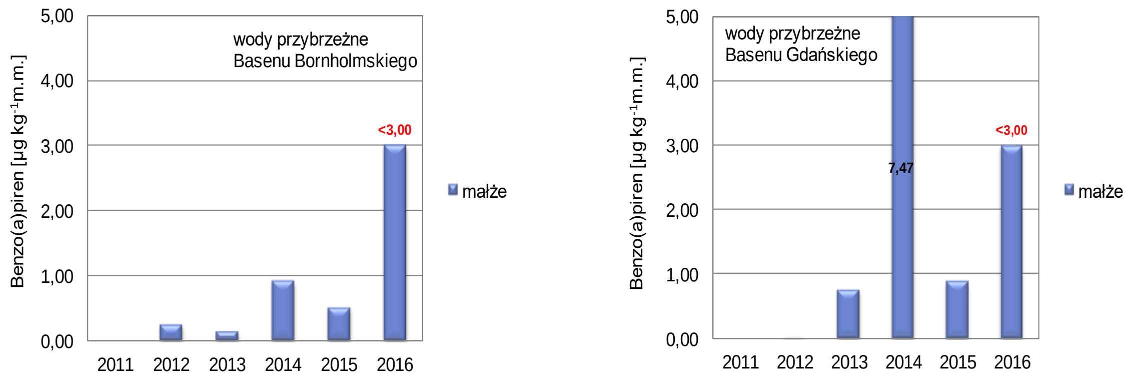



Fig. 1.8.17 Concentration benzo (a) pyrene [µg $kg^{-1}$ ww] in mussels in 2012-2016, red numbers preceded by the sign „<„ indicate the limit of quantification, black numbers correspond to concentration values beyond the range of the axis (source: PMŚ)

## 1 –hydroxypyrene

1 - hydroxypyrene is a metabolite of polycyclic aromatic hydrocarbons produced by the fish and determined in the bile. In the case of herring from both areas: the Bornholm Basin and Eastern Gotland Basin, and the perch from Szczecin Lagoon and the Vistula Lagoon, concentrations of 1- hydroxypyrene were below the limit of quantification of the applied method throughout the study period (from 2012) (Fig. 1.8.18).

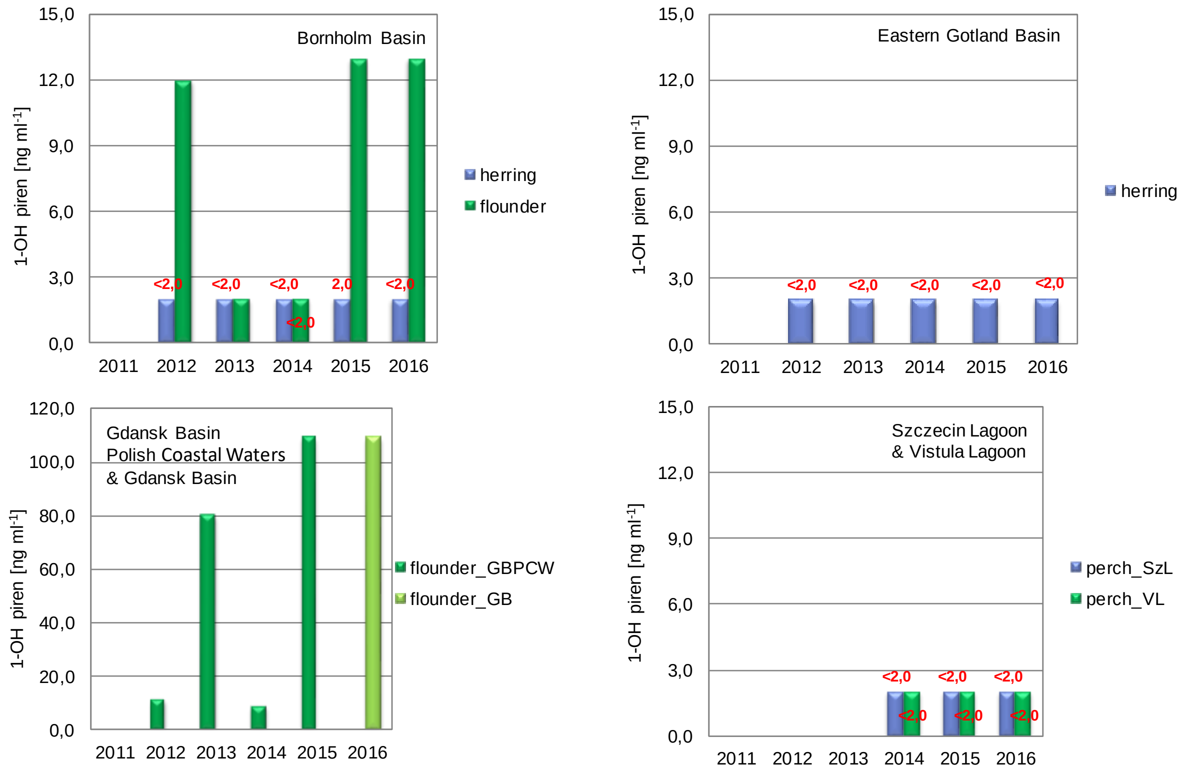



Fig. 1.8.18 Concentration of 1- hydroxypyrene [ng $ml^{-1}$] in fish in 2012-2016, red numbers preceded by the „<„ mark indicate the limit of quantification (source: PMŚ)

In the case of flounder in the Bornholm Basin, values of 12-13 ng $ml^{-1}$ were recorded in 2012, 2015 and 2016, while relatively high values were found in fish from the area of the Gdańsk Basin and Gdańsk Basin Polish coastal waters, where the concentration of 1- hydroxypyrene reached 109 ng $ml^{-1}$ in 2015 and 2016.

### Congeners of polychlorinated biphenyls - (sum of 28, 52, 101, 138, 153, 180) - PCBs

The sum of the concentrations of six polychlorinated biphenyls congeners (28, 52, 101, 138, 153, 180) is determined on the basis of concentrations of individual congeners in the muscle tissue of three fish species. The highest concentrations occurred in 2013, reaching the value of 11.5 μg $kg^{-1}$ ww for herring and 10.3 μg $kg^{-1}$ ww in the case of the flounder from the Bornholm Basin and 13.7 μg $kg^{-1}$ ww in the case of herring from Eastern Gotland Basin and 9.9 μg $kg^{-1}$ ww in the case of flounder from the Gdańsk Basin Polish coastal waters (Fig. 1.8.19). In 2016, the concentration of the sum of six congeners was at the level of 1.6 μg $kg^{-1}$ ww and 1.2 μg $kg^{-1}$ ww in the case of herring, 1.5 μg $kg^{-1}$ ww and 3,0 μg $kg^{-1}$ ww in the case of flounder and 1.4 μg $kg^{-1}$ ww and 2.1 μg $kg^{-1}$ ww in the case of perch respectively from the Vistula Lagoon and the Szczecin Lagoon.

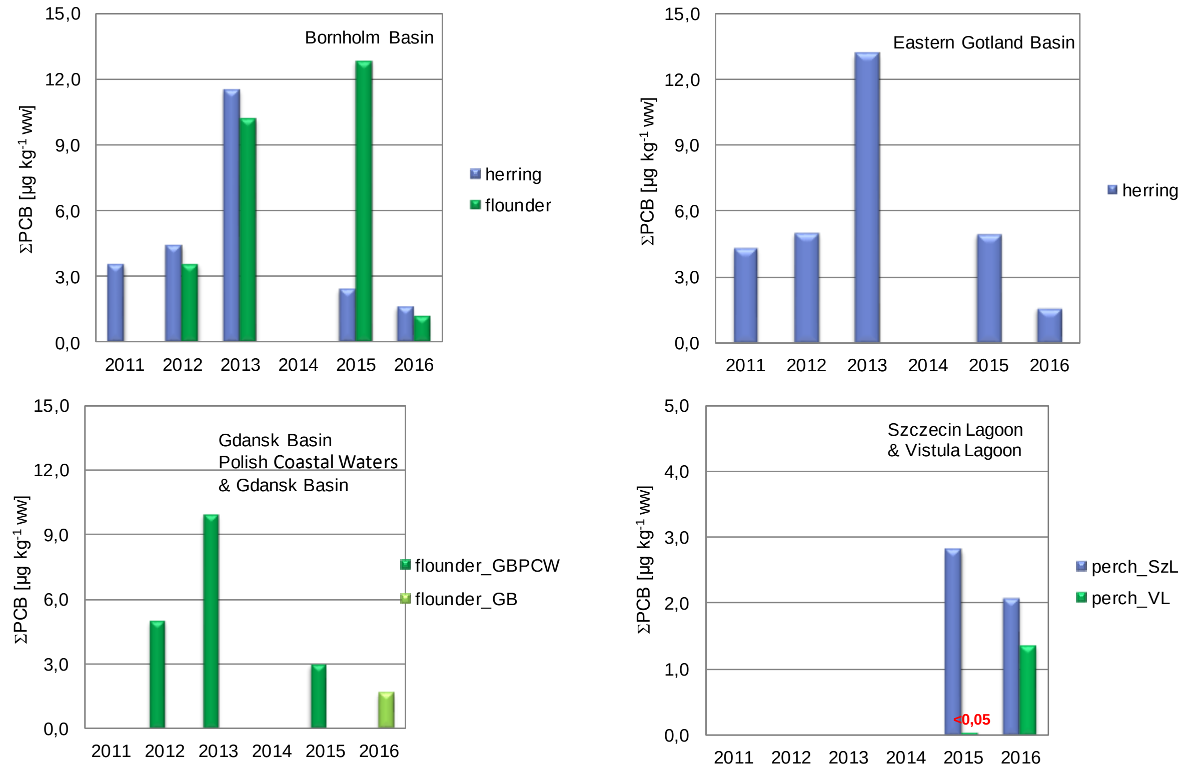
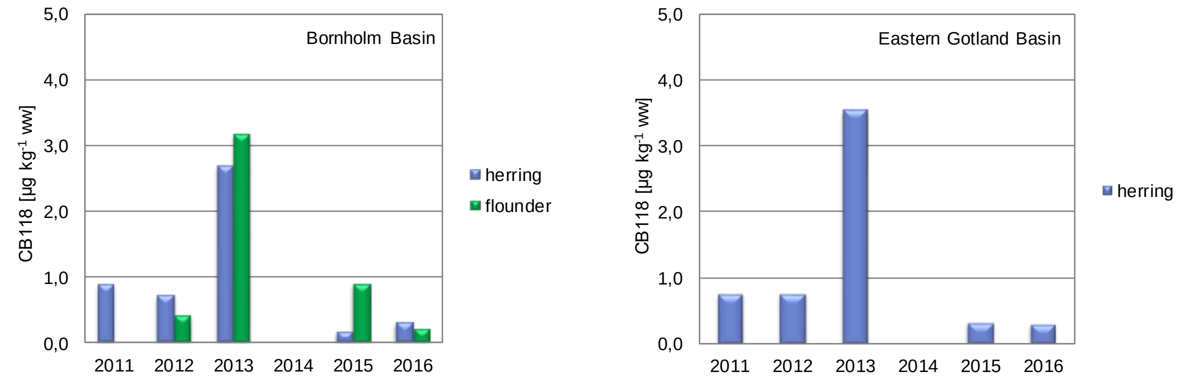



Fig. 1.8.19 Concentration of the sum of six PCB congeners [µg kg-1 ww] in fish in 2011-2016, red numbers preceded by the sign „<„ indicate the limit of quantification (source: PMŚ)

### Congener CB118

The CB118 congener as particularly harmful was excluded from joint assessment of polychlorinated biphenyls. As in the case of other congeners, its highest concentrations were identified in 2013. Its concentrations in herring and flounder remained in the range of 2.7 µg kg$^{-1}$ ww up to 3.5 µg kg$^{-1}$ ww with the exception of the flounder from the coastal area of the Gdańsk Basin, for which the concentration of CB118 remained below the limit of quantification of the method used (0.02 µg kg$^{-1}$ ww) (Fig. 1.8.20). In 2016, CB118 concentrations in all species were at a similar level and remained in the range of 0.2 µg kg$^{-1}$ ww up to 0.46 µg kg$^{-1}$ ww.



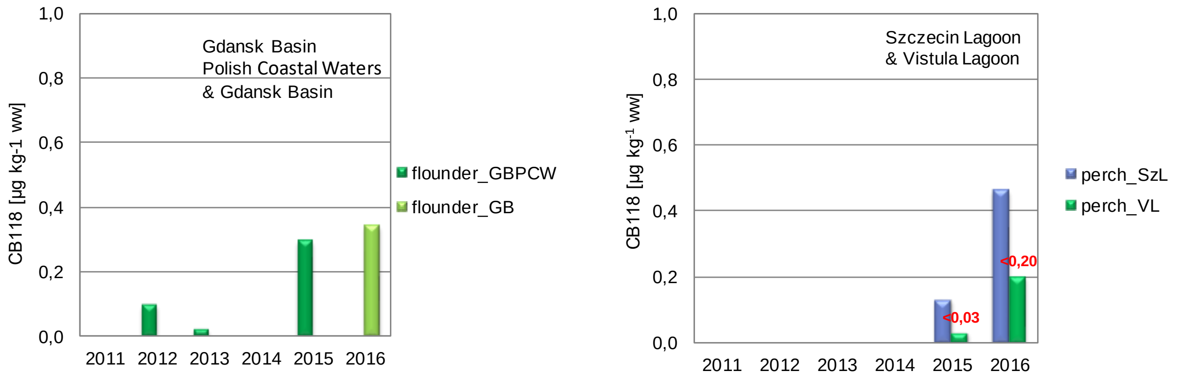



Fig. 1.8.20 Concentration of CB118 [µg kg$^{-1}$ ww] in fish in 2011-2016, red numbers preceded by the sign „<„ indicate the limit of quantification (source: PMŚ)

### *The micronucleus test*

The micronucleus test is the most commonly used test for the assessment of cytogenetic damage at the cellular level caused by the interaction of hazardous substances. The number of micronuclei originating from chromosomes or their fragments as a result of cell division delay is a measure of the genotoxicity of certain substances present in the environment. Therefore, this indicator was introduced in 2014 to the Baltic Sea monitoring program. The research is carried out on the blood of fish caught in locations assigned to four areas: Gdańsk Basin Polish coastal waters, the Gdańsk Basin, Eastern Gotland Basin and the Bornholm Basin. The analysis consists in counting irregularities occurring within the cell according to established criteria. The number of counted changes converted to 1000 erythrocytes is an assessed parameter which is a measure of the harmfulness of the impact of hazardous substances on the organism being tested. Examples of microscopic photographs showing examples of micronuclei structures are presented in Fig. 1.8.21.

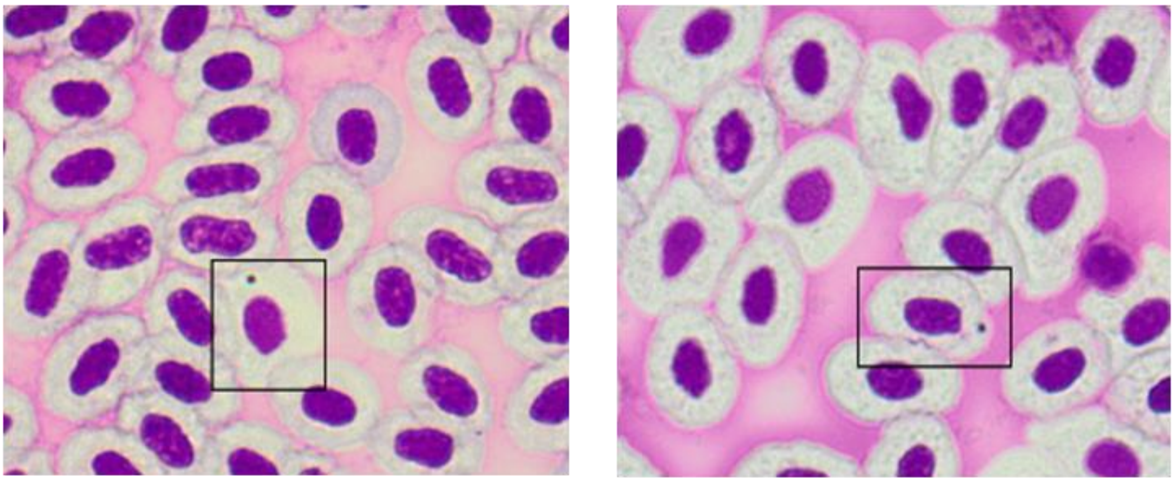


Fig. 1.8.21 Blood Erythrocytes of Baltic herring caught in the Bornholm Basin area in November 2016; cells with irregularities were marked in the square - micronuclei (MN) (source: PMŚ)

A comparison of results for three years of research from four locations shows that the smallest frequency of changes in blood cells was found in fish caught in the Gdańsk Basin Polish coastal waters (Fig. 1.8.22). It was 0.23 and 0.35 MN/1000, respectively, in 2014 and 2015. The largest number of micronuclei was detected in fish from the Gdańsk Basin and was 0.92 and 1.34 MN/1000 in 2015 and 2016 respectively. In the case of the Eastern Gotland Basin the highest variability was noted. In 2014 and 2016, the number of micronuclei did not exceed 0.40

MN/1000, while in 2015 an increase to 1.0 MN/1000 was recorded. In the Bornholm Basin, the number of changes per 1000 erythrocytes remained relatively low, however, a slight increase from 0.16 MN/1000 in 2014 to 0.63 MN/1000 in 2016 can be observed.

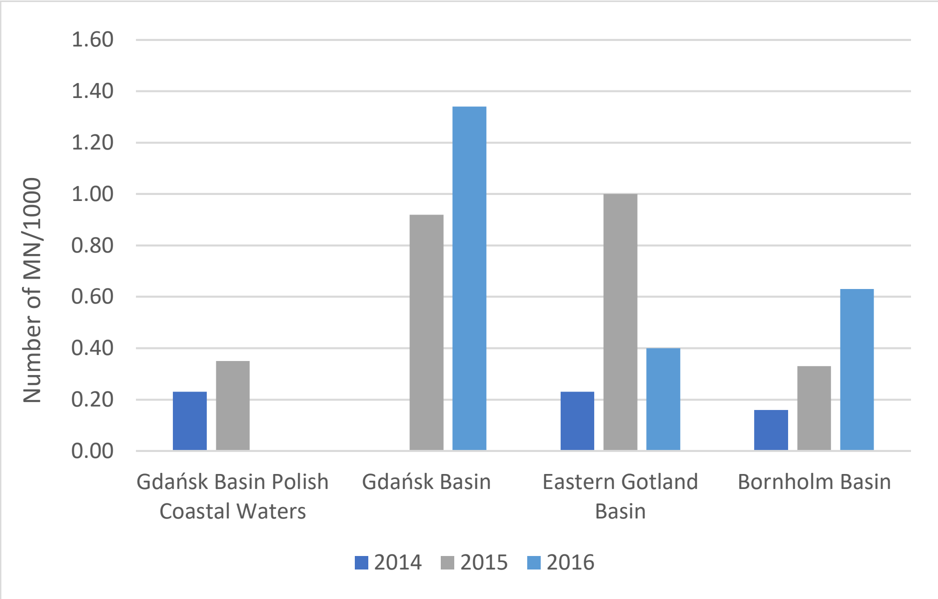



Fig. 1.8.22 Number of micronuclei (MN) per 1,000 herring blood cells from selected regions of the South Baltic in the years 2014-2016 (source: PMŚ)

*Fish diseases*

**Elements of the ecosystem**

The problem of occurrence of diseases concerns many fish species, also those of significant economic importance. The presence of pathological changes plays an important role when assessing the consumption values of fish, which may result in a decrease in the quality of fishery products or their elimination from the market. Fish diseases are not only an economic problem, but they are a reflection of adverse changes taking place in the Baltic Sea environment.

Registration of external symptoms of fish diseases has been used for many years in integrated programs for monitoring of the health of the ecosystem. The first reports on the occurrence of pathological changes in Baltic fish appeared already at the beginning of the last century (Bergman 1912, Lundbeck 1928). In later years, their scope was extended, taking into account the temporal and spatial trends in the occurrence of fish diseases (Dethlefsen and Watermann 1982, Lang and Dethlefsen 1994). Due to the high costs of research aimed at integrated monitoring of the marine environment, the current participation of MIR-PIB is limited to the analysis of only some categories of external pathological changes in fish. These analyzes are carried out additionally during cruises performed for other research purposes. On the basis of the obtained data, reports on occurrence of external fish symptoms are made, which are presented at the meeting of the Working Group on fish diseases (ICES Working Group on Pathology and Diseases of Marine Organisms, WGPDMO).

The presence of ulcers in fish is one of the well-known indicators of marine environment pollution (Noga 2000), and monitoring of the occurrence of this type of pathological changes is recommended by ICES (Bucke et al 1996). This disease occurs in many fish species and is one of the most frequently observed in flounder and Baltic cod.

Ulcers are classified according to the following scale:

1. Epidermal necrosis, scaling of the epidermis, exudation and loss of scales, redness without wounds.
2. Defects in the dermis.
3. Necrotic foci and cavities that penetrate into the muscles.
4. Cicatrizing of ulcers.
5. Scar.

The list of diseases recommended by ICES for monitoring pathological changes in fish (Sindermann et al 1980, Bucke et al. 1996) also includes lymphocystosis and skeletal deformities. The most common types of deformation include:

**- dwarfism,**
**- spinal deformities**:
lordosis - arched bending of the spine in the abdominal direction,
kyphosis - arched curvature of the spine in the dorsal side,
shortening of the vertebrae,

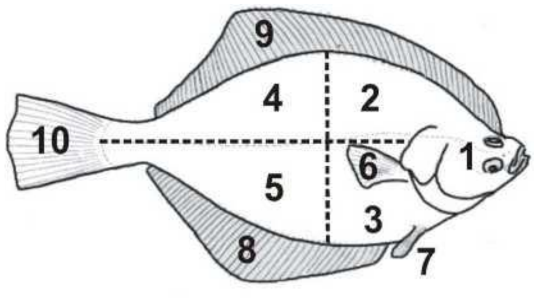
**- mopsform** shortening the upper jaw or mandible.

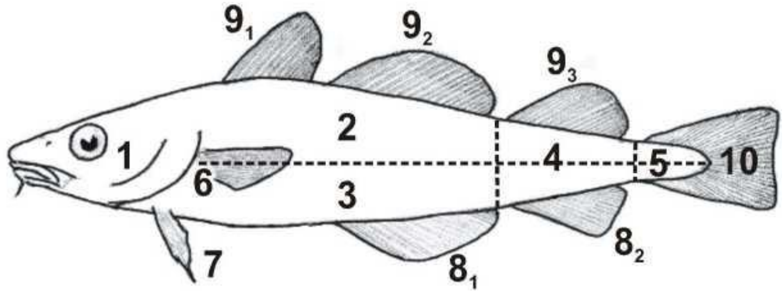
The presence of skeletal deformation in fish is recognized by many authors as a good bioindicator of the presence of impurities, recommended by ICES for use in monitoring studies (Bengtsson 1979, Bucke et al 1996, Klumpp et al. 2002).

The research material was obtained during research cruises (in the months of: February, September, October and November) on the ship r/v „Baltica". Sampling was carried out in POM (sub-areas ICES 25 - 26).

In the years 2011-2016, the study of pathological changes covered a total of over 300,000. fish - cod, herring, sprats and flatfish. Observations of lesions were carried out during standard fish length measurements. Changes were observed on the skin surface and just below it, as well as macroscopic changes in the morphological and anatomical structure of the fish, including deformation of the spine, head and fins.

Fish classified as ill, after determining the type of disease and location of changes according to the standard code (Table 1.8.1, Fig. 1.8.23), were subjected to biological analysis. Identification of symptoms of fish lesions, their classification and registration in a computer database was carried out in accordance with ICES recommendations (Dethlefsen et al 1986, ICES 1989).



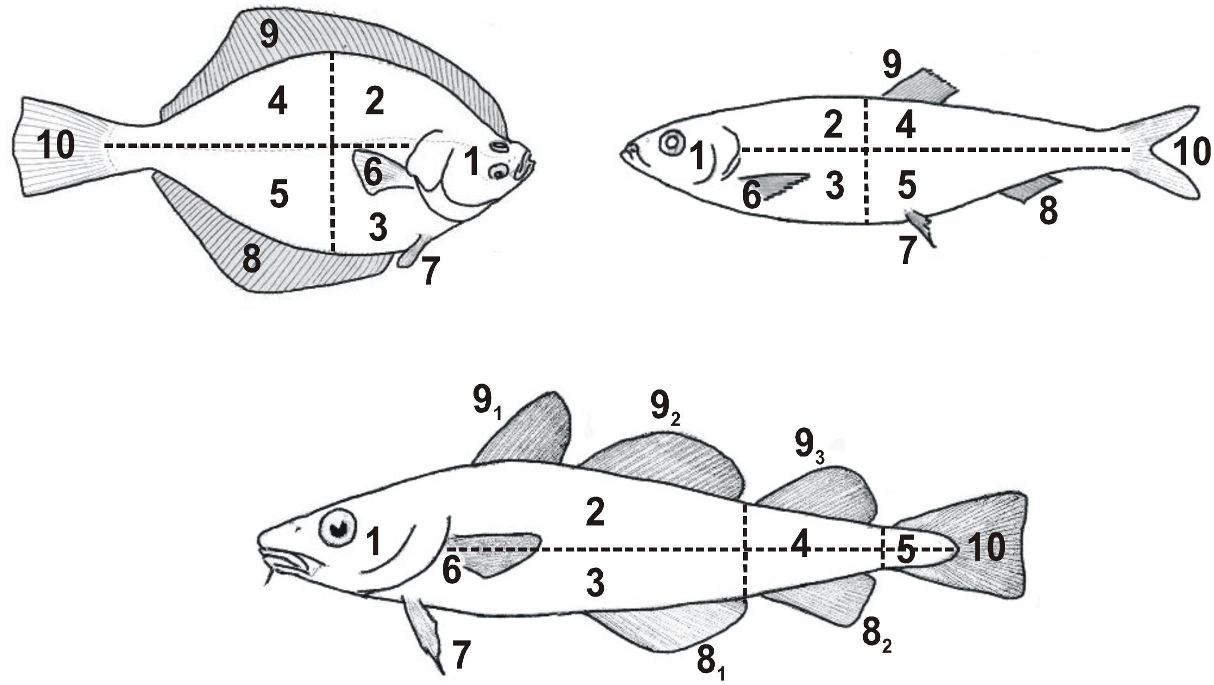



Fig. 1.8.23 Diagram of morphological structure of fish (flounder, sprat/herring, cod); particular batches of fish were marked with symbols used in international monitoring of external lesions; symbols of the studied parts of the fish body: 1 - head, 2 - torso (dorsal part), 3 - torso (ventral part), 4 - torso (posterior dorsal/forequarters), 5 - torso (posterior abdominal/caudal part), 6 - thorax (P), 7 - ventral (V) fin, 8 - anal fin (A) (1, 2 in cod), 9 - dorsal fin (D) (1, 2, 3 in cod), 10 - caudal fin (C).

Table 1.8.1. FISH DISEASES - markings and codes

| Markings of body parts | Codes of body parts |
|---|---|
| Head | 1 |
| Corpus | 2 |
| Corpus | 3 |
| Corpus | 4 |
| Corpus | 5 |
| Pectoral fins | 6 |
| Pelvic fins | 7 |
| Anal fin | 8 |
| Dorsal fin | 9 |
| Caudal fin | 10 |
| Adipose fin | 11 |
| Left side | 12 |
| Right side | 13 |
| Upside | 14 |
| Underside | 15 |

| Fish species | Codes of species |
|---|---|
| Cod | COD |
| Flounder | FLE |

| Name of the disease | Codes of disease |
|---|---|
| **Lymphocystis** | **10** |
| **Ulcerations** | **21-25** |
| 1/ dead epidermis | 21 |
| 2/ skin defects | 22 |
| 3/ necrotic foci | 23 |
| 4/ ulceration | 24 |
| 5/ scar | 25 |
| **Skeletal deformities** | **51-53** |
| 1/ dwarfism | 51 |
| 2/ anomalies of the spine | 52 |
| 3/ mopsform | 53 |

**Assessement areas**

According to the system adopted by the International Council for the Exploration of the Sea (ICES), the Baltic Sea area has been divided into 12 sub-areas (*ICES Subdivisions*). Individual parts of the Baltic Sea are marked with the following numbers: SD 21 - Kattegat, SD 22 and 23 - Danish Straits, SD 24-29 - Baltic, SD 30 and 31 - Bothnian Bay and SD 32 - Gulf of Finland. The POM cover a part of sub-areas 24, 25 and 26.

The research material was obtained during research flights (in months: February, September, October and November) on the r/v "Baltica" ship. Sampling was carried out in POM (sub-areas ICES 25 - 26).

**Descriptive assessment**

In the years 2011-2016, the following disease symptoms were registered in the studied fish: ulcerations, lymphocystosis and skeletal deformities. The increase in disease severity was higher in bottom fish (cod, flounder) than in pelagic fish (sprat and herring) (Table 1.8.2).

The most frequently reported disease entity in the cod was ulcerations - the extensiveness of this disease was higher in subarea 26 than 25 (Table 1.8.2). The highest percentage (9%) of cod with ulcerations was demonstrated in 2013 in subarea ICES 26. In the subsequent years, this percentage was systematically decreasing, taking the lowest values in 2016 (Fig. 1.8.24).

The percentage of flukes with ulcers also showed a decreasing trend in 2011 - 2016. The highest extensiveness was found in 2011 for fish caught in ICES subarea 26 (2.1%). In 2016, the extensiveness of ulceration did not exceed 1% in both ICES sub-areas. The dominant disease entity in the flounder was lymphocystosis. In 2014, the highest extensiveness of flounder (3.9%) in subarea 26 was demonstrated. Extentionality was also high in 2015 and 2016 (3.7 and 3.3%) (Fig. 1.8.24)

Cases of lymphocystosis were also found in herring - the highest extensiveness was found in 2014 (0.3%). In 2016, the percentage of cod with symptoms of lymphocystosis did not exceed 0.1%. The presence of skeletal deformation was relatively rare in the flap - in the years 2012-2014, a small percentage of individuals showed this disease (0.03 - 0.06%). The percentage of cod with skeletal deformities was ten times higher than in the flounder - the highest extensiveness was found in 2015 and 2016 (0.62 and 0.47%) (Fig. 1.8.24).

One of the etiological factors leading to the formation of ulcers in fish are infections caused by bacteria, most commonly from the genus Vibrio and Aeromonas (Larsen et al. 1978). Microbiological tests carried out in 2007 and 2008 on samples of ulcerated cod tissue showed the presence of bacteria representing the Pseudomonadaceae, Aeromonadaceae, Shewanellaceae and Vibrionaceae families. Chryseobacterium meningosepticum and *Acinetobacter spp*. were isolated from several samples, which may be pathogenic to humans

(Grawiński et al. 2009). A number of other factors may also contribute to the development of this disease in fish. Many scientific reports indicate that exposure to toxic substances (pesticides, polycyclic aromatic hydrocarbons - PAHs, polychlorinated biphenyls - PCBs and heavy metals) can lead to skin damage, increasing its susceptibility to bacterial, viral and fungal infections (Sindermann 1977; Larsen et al. 1978, Austin 2007). Secondary infections can also develop in mechanical skin lesions, caused for example by fishing gear (Mellergaard and Bagge 1998). The formation of ulcers in fish may also be favoured by adverse environmental conditions (pH, ultraviolet radiation, changes in salinity and water temperature). In addition to direct toxic effects on the skin, chemicals can impair hormonal balance, leading to the excessive release of glucocorticosteroids, known as "stress hormones". Steroid hormones regulate many physiological processes, among others an immune response, the disorder of which may promote increased susceptibility of fish to infections (Barton and Iwama 1991, Noga 2000).

Skeletal deformations may have a genetic basis or arise in the early stages of fish life as a result of a deficiency of vitamins and minerals, or adverse environmental conditions (e.g. temperature) and exposure to chemical pollutants (some heavy metals, mainly cadmium) present in seawater. Lang and Dethlefsen (1987) showed a higher content of cadmium in Baltic cod with skeletal deformities, in comparison with well-developed individuals.

Lymphocystosis is a viral disease caused by iridovirus (Wolf et al 1966). Lymphocystosis in the initial stage of infection is manifested by the formation of individual small nodules (white or pinkish) on the surface of the skin and fins of fish (mainly flatfish). In advanced stages of the disease, the nodules are often present in the clusters and can cover a large fish body area.

Summary and Conclusions

1. The increased occurrence of diseases was higher in fish caught in ICES subarea 26 than in 25.
2. The most frequently reported external lesions in fish were ulcers, the highest extensiveness of which was found in cod.
3. Extent of ulcer occurrence in the cod showed a declining trend in 2013 - 2016, and at the flock in 2011-2016.

The most frequently observed disease at the flounder was lymphocystosis. Lymphocystosis prevalence showed a decreasing trend in 2014 -2016 in both studied fish species, although in the case of flounder and the entire assessment period (2011-2016) an upward trend was observed.

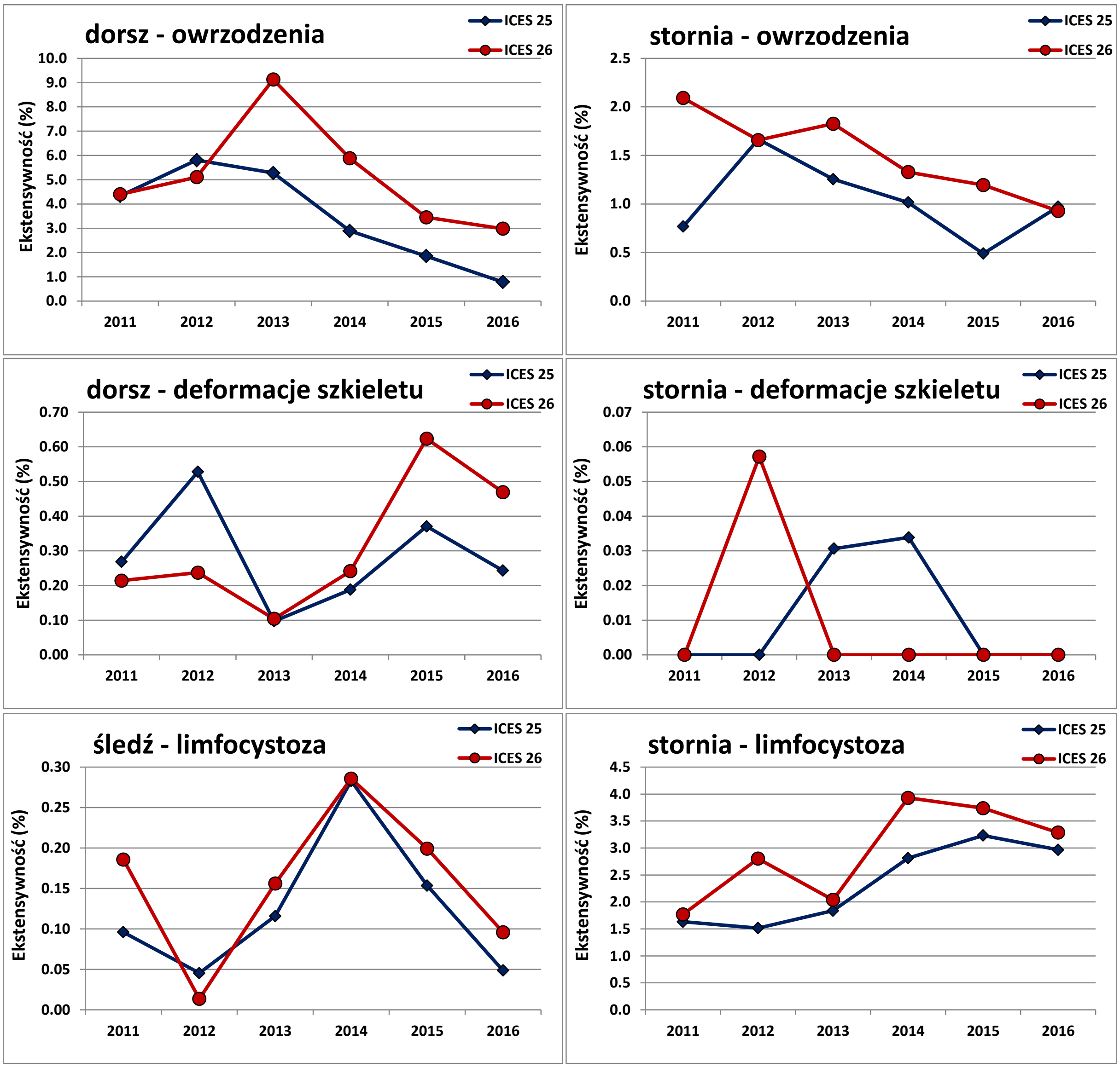



Fig. 1.8.24 Extensiveness of occurrence of fish diseases in POM Baltic Sea in 2011-2016, according to ICES sub-areas. (Data source: PMŚ)

Table 1.8.2. Extensiveness of occurrence of fish diseases in POM Baltic Sea in 2011-2016 (source of PMŚ data)

| Species | Year | Number fish | Extensity (%) | | |
|---|---|---|---|---|---|
| | | | Ulcerations | Lymphocystis | Skeletal deformities |
| cod | 2011 | 14831 | 4.36 | 0.00 | 0.25 |
| | 2012 | 8139 | 5.33 | 0.00 | 0.33 |
| | 2013 | 13998 | 6.87 | 0.10 | 0.10 |
| | 2014 | 18393 | 3.63 | 0.00 | 0.20 |
| | 2015 | 17748 | 2.51 | 0.00 | 0.47 |
| | 2016 | 20805 | 1.67 | 0.00 | 0.33 |
| **cod total** | | **93914** | **2.52** | **0.01** | **0.40** |
| herring | 2011 | 18496 | 0.00 | 0.13 | 0.00 |
| | 2012 | 16571 | 0.00 | 0.03 | 0.00 |
| | 2013 | 15479 | 0.03 | 0.13 | 0.01 |
| | 2014 | 14711 | 0.01 | 0.28 | 0.00 |
| | 2015 | 16384 | 0.01 | 0.18 | 0.01 |
| | 2016 | 20250 | 0.00 | 0.07 | 0.00 |
| **herring total** | | **101891** | **0.01** | **0.17** | **0.00** |
| flounder | 2011 | 2285 | 1.49 | 1.71 | 0.00 |
| | 2012 | 2409 | 1.66 | 2.45 | 0.04 |
| | 2013 | 5620 | 1.49 | 1.92 | 0.02 |
| | 2014 | 4760 | 1.13 | 3.24 | 0.02 |
| | 2015 | 6996 | 0.89 | 3.52 | 0.00 |
| | 2016 | 9147 | 0.93 | 3.10 | 0.00 |
| **flounder total** | | **31217** | **0.78** | **1.79** | **0.02** |
| sprat | 2011 | 14753 | 0.01 | 0.00 | 0.03 |
| | 2012 | 10704 | 0.00 | 0.00 | 0.02 |
| | 2013 | 10368 | 0.00 | 0.00 | 0.01 |
| | 2014 | 11800 | 0.00 | 0.00 | 0.01 |
| | 2015 | 13765 | 0.00 | 0.00 | 0.01 |
| | 2016 | 15929 | 0.00 | 0.01 | 0.01 |
| **sprat total** | | **77319** | **0.00** | **0.00** | **0.02** |
| **Total** | | **304341** | | | |

# 2. Assessment of the state of the Polish waters of the Baltic Sea

## 2.1. Characteristic of the status - Descriptors

The developed method of assessing state descriptors for POM is in many aspects convergent with the method proposed in the second holistic assessment of the Baltic Sea (HELCOM) and also refers to the technical guidance given in the current working version of the guide to Art 8 MSFD (Walmsley and others 2017).

The main difference in the method of assessment in relation to the previous initial assessment of the marine environment in the Polish Baltic Sea zone(GIOŚ 2014) is 'integrated assessment of biodiversity, referring simultaneously to Descriptors 1, 4 and 6, which on the one hand affects the lack of the possibility of a clear comparison of the results of this assessment with the previous one, on the other hand, enables compliance of the assessment methodology in the Baltic Sea region – the Chief Inspector of Environmental Protection Poland with the Helsinki Commission (HELCOM). However, it is possible to summarize any changes taking place in the environment compared to the initial assessment of the state of marine waters in 2012 at the level of some indicators (GIOŚ 2014) and reference to the second holistic assessment (HELCOM 2017a). The data from the implementation of the National Environmental Monitoring Program in the period from 01/01/2011 to 31/12/2016 were used for the assessment.

**Ecosystem elements**

The Annex to Decision 2017/848 in Part II concerning the assessment of the essential elements and properties, and the current state of the marine environment based on Art. 8 (1)(a) of MSFD lists the elements of the ecosystem that are assessed within individual descriptors/quality indicators. Therefore, in this update of the initial assessment of the marine environment, five ecosystem elements have been assessed:

- groups of bird species,
- groups of marine mammals species,
- groups of fish species,
- benthic habitats,
- pelagic habitats

and ecosystems, including food webs.

The final result of the assessment of 'biodiversity' as opposed to the previous initial assessment of the environmental status (GIOŚ 2014) is not presented in terms of individual descriptors of the state of the environment in POM, but the indication of separate assessments for each element of the ecosystem, without further integration between these assessments and determination of one value of the 'biodiversity' assessment at the highest level. Carrying out assessments for 5 elements of the ecosystem meets at the same time the requirement to use the descriptors to determine the good environmental status of Annex I to MSFD:

- D1 – biodiversity,
- D4 – food webs,
- D6 – seafloor integrity.

**Assessment units**

Pursuant to MSFD and Decision 2017/848, Member States were required to prepare the initial environmental assessment at a specific geographic scale to ensure consistency and to allow comparison of assessments. As part of regional cooperation in the Baltic Sea, assessment areas have been delimited according to the hierarchical division prepared by HELCOM (HELCOM 2013a, update of Annex 4 - 2014) in a 4-grade scale:

1. no division: the entire Baltic Sea area is assessed,
2. division into 17 sub-basins in the Baltic Sea,

3. division into 17 sub-basins of the open sea and 40 areas including coastal waters,
4. division into 17 sub-basins of the open sea and transitional and coastal waterbodies (according to WFD, Anon. 2000).

As part of the "integrated assessment of biodiversity", individual elements of the ecosystem (birds, marine mammals, fish, benthic and pelagic habitats) are assessed at various scales of the Baltic Sea division into the sub-assigned by HELCOM (2013a, update of Annex 4 - 2017). The selection of appropriate assessment areas results from the need to appropriately characterize the status of species, groups of habitat species or ecosystems in relation to the smallest possible territorial unit. Each result of the integrated assessment for a single element of the ecosystem was obtained separately considering the division into assessment in open water according to HELCOM (2013a, update of Annex 4 -2017) and in coastal and transitional waters, in this category - including the division into uniform water bodies used in the WFD. Therefore, there is no spatial aggregation of the assessment results.

In the case of marine mammals, the assessment of seal population status refers to the entire Baltic Sea area, in the POM part. The bird status assessment is determined at level 2, while the fish species of transitional waters, pelagic and benthic habitats in POM are assessed at the level 4 of the Baltic Sea division, for 22 assessment areas, i.e. for 19 water bodies according to the WFD and for 3 deep-water sea basins, which are shared with neighbouring Member States.

Separated assessment areas in POM are convergent with those used in the second holistic assessment of the environment of the Baltic Sea HOLAS II (HELCOM 2017a). The division of the Polish Baltic zone into the areas of assessment used in this "integrated assessment of biodiversity" is presented Fig. 2.1.1 and in Table 2.1.1.

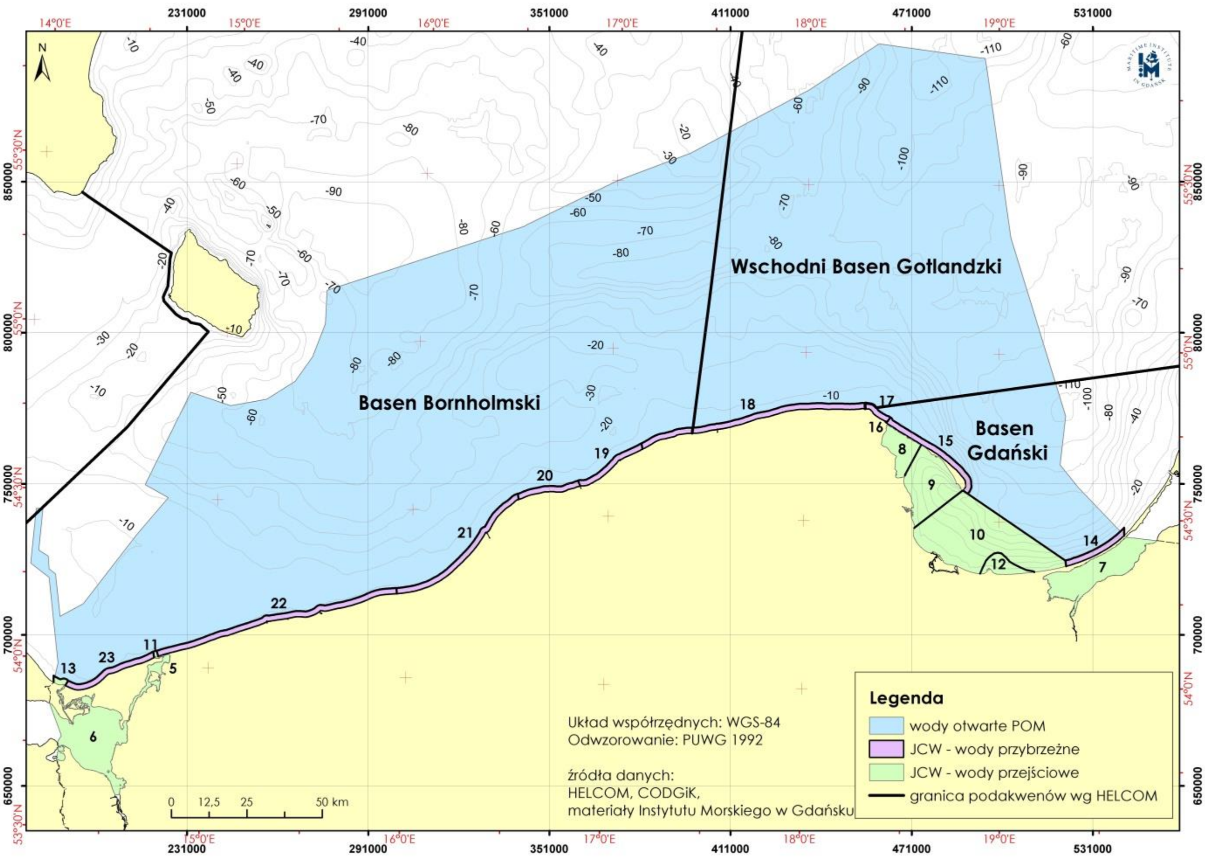



Fig. 2.1.1. Division of POM into assessment units used in the assessment of the status of marine mammals, benthic and pelagic habitats in the Polish Baltic zone (No. 5-23 - areas of the JCWP assessment listed in Table 2.1.1.)

Table 2.1.1. Assessment units used in the assessment of the status of marine mammals, benthic and pelagic habitats in the Polish Baltic zone (No. 5-23 - areas of the JCWP assessment marked in Fig. 2.1.1.)

| No. | Assessment unit in POM (Baltic Sea sub-basin) | Code of the assessment unit | Water type (waterbodies) | Area [km2] | Ecosystem element assessed |
|---|---|---|---|---|---|
| 1. | Baltic Sea | - | All POM excluding lagoons | | marine mammals |
| 2. | Gdańsk Basin | - | open sea | 2102.97 | benthic and pelagic habitats |
| 3. | Eastern Gotland Basin | - | open sea | 10881.74 | |
| 4. | Bornholm Basin | - | open sea | 17766.07 | |
| 5. | Kamieński Lagoon | PL TW I WB 9 | waterbody - transitional waters | 43.60 | |
| 6. | Szczecin Lagoon | PL TW I WB 8 | waterbody - transitional waters | 407.28 | |
| 7. | Vistula Lagoon | PL TW I WB 1 | waterbody - transitional waters | 301.74 | |
| 8. | Puck Lagoon | PL TW II WB 2 | waterbody - transitional waters | 111.03 | |
| 9. | Outer Puck Bay | PL TW III WB 3 | waterbody - transitional waters | 285.57 | |
| 10. | Inner Gulf of Gdańsk | PL TW IV WB 4 | waterbody - transitional waters | 709.43 | |
| 11. | Dziwna mouth | PL TW V WB 6 | waterbody - transitional waters | 2.34 | |
| 12. | Vistula Mouth | PL TW V WB 5 | waterbody - transitional waters | 64.12 | |
| 13. | Świna mouth | PL TW V WB 7 | waterbody - transitional waters | 8.35 | |
| 14. | Vistula Spit | PL CW I WB 1 | waterbody – coastal waters | 39.57 | |
| 15. | Hel Peninsula | PL CW I WB 2 | waterbody – coastal waters | 69.67 | |
| 16. | Władysławowo Port | PL CW I WB 3 | waterbody – coastal waters | 0.13 | |
| 17. | Władysławowo-Jastrzębia Góra | PL CW II WB 4 | waterbody – coastal waters | 17.29 | |
| 18. | Jastrzębia Góra-Rowy | PL CW II WB 5 | waterbody – coastal waters | 139.91 | |
| 19. | Rowy-Jarosławiec West | PL CW II WB 6W | waterbody – coastal waters | 45.79 | |
| 20. | Rowy-Jarosławiec East | PL CW II WB 6E | waterbody – coastal waters | 38.48 | |
| 21. | Jarosławiec-Sarbinowo | PL CW III WB 7 | waterbody – coastal waters | 98.36 | |
| 22. | Sarbinowo-Dziwna | PL CW II WB 8 | waterbody – coastal waters | 153.33 | |

| No. | Assessment unit in POM (Baltic Sea sub-basin) | Code of the assessment unit | Water type (waterbodies) | Area [km2] | Ecosystem element assessed |
|---|---|---|---|---|---|
| 23. | Dziwna-Świna | PL CW III WB 9 | waterbody – coastal waters | 58.69 | |

**Method of assessing the state of the Polish zone of the Baltic Sea**

In order to assess the environmental status of marine waters for the years 2011-2016, a modified method was developed based on the methodology used in the assessment of HOLAS II report.

In the adopted method, separate assessments for mammals, seabirds, fish, benthic habitats and pelagic habitats refer to Descriptor D1 (biodiversity), assessment of benthic habitats is common to D1 and D6 (seafloor integrity), assessment of pelagic habitats is characterized by D1, and the assessment of ecosystems, including food chains, refers to the characteristics of D1 and D4 (food webs).

Pursuant to the decision 2017/848, the Descriptor D6 – seafloor integrity at the same time assesses the condition of benthic habitats as well as physical pressures. In the status description, two criteria are distinguished: D6C4 (the extent of loss of the habitat type, resulting from anthropogenic pressures, does not exceed a specified proportion of the natural extent of the habitat type in the assessment area), for which this assessment, as in the second holistic assessment (HELCOM 2017a), has not yet been developed the indicator and criterion D6C5 (the extent of adverse effects from anthropogenic pressures on the condition of the habitat type, including alteration to its biotic and abiotic structure and its functions e.g. typical species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species, does not exceed a specified proportion of the natural extent of the habitat type in the assessment area)

In relation to the pressure, the assessment of the seabed integrity was carried out for three criteria of pressure and impact: D6C1, D6C2, D6C3, which will be discussed in 2.2.

Some of the indicators used in the assessment of the condition of benthic and pelagic habitats also meet the criteria within Descriptor D4 (Table 2.1.2.). Pursuant to Decision 2017/848, the assessment of ecosystems, including food chains, should be based on the assessment of at least three trophic groups (two of these trophic groups not including fish, at least one trophic group containing the primary producer). Due to the fact that the above decision came into force only in May 2017, and the guide to carry out the assessment in accordance with art. 8 MSFD (Walmsley et al. 2017) treats the way the assessment for ecosystems is carried out quite generally; in the national assessment, ecosystem assessments were made only in a descriptive way. This aspect was also treated in the first version of the 2nd holistic assessment (HELCOM 2017a), i.e. as a summary of the assessment for habitats, fish, mammals and birds (based on various indicators) characterizing different trophic levels in the Baltic ecosystem, pointing to interdependencies, connections and changes occurring in food webs. In this study, the assessment of food chains is included in the chapter ”Ecosystems and food webs”.

**Indicators**

The basis for the assessment of the environmental status in POM in accordance with the Decision 2017/848 are the indicators recommended by HELCOM working groups. Depending on the degree of development, HELCOM indicators have obtained the status:

**Core indicator** – an indicator developed jointly and accepted by the Member States of the Helsinki Convention as part of the implementation of the HELCOM Baltic Sea Action Plan (BSAP) and the criteria set out in MSFD, characterized by a specific threshold value of good environmental status in the whole Baltic Sea area, if it is ecologically appropriate, or in individual assessment areas according to the HELCOM division (2013a). The core indicator refers to the state or pressure. The environmental objective or threshold value is described in detail for each operational core indicator, and the methods for its assessment are also agreed.

**Pre-core indicator** – indicated by the Helsinki Convention member states as necessary to meet the BSAP objectives and MSFD requirements. Has not yet obtained the status of a core indicator, mainly due to the fact that not all aspects of the indicator have been refined and hence it has not been fully accepted by the member states of the Convention. The parameters necessary to determine the indicator should be monitored, however it is recognized that the data necessary for its calculation may come from sources other than HELCOM monitoring.

**Candidate indicator** – an indicator being in the process of development, having a conceptual character, an unfinished testing process, ultimately leading to obtaining the status of a core indicator. Elements of the indicator (e.g. the assessment procedure, threshold values) still show serious deficiencies and there is no general acceptance of the indicator by the States of the Convention. It is assumed that the list of candidate indicators is an open document, where at the expert level proposals of new core indicators are presented.

The assessment of the environmental status in POM proposes the use of core and pre-core indicators developed by experts of HELCOM groups, typical of the assessment of "biodiversity" based on biotic data, supplemented by a set of national indicators, as well as indicators relevant for the assessment of eutrophication, characterizing the abiotic environment that is used in accordance with the WFD guidelines.

The indicators should meet different criteria and methodological standards for the determination of good environmental status (Article 9 (3) MSFD, listed in Part II of the Annex to Decision 2017/848) and should meet the requirements of Decision 2017/848 regarding Descriptors D1, D4 and D6.

The indicators used for the national assessment for the years 2011-2016 were assigned to the relevant criteria in accordance with the Decision 2017/848 and are presented in Table 2.1.2. Amendments to the content of Annex III to MSFD replaced in Directive 2017/845 by Annex I to the above Directive were necessary to facilitate the implementation and ensure better linkage of elements of the ecosystem, anthropogenic pressures and impacts on the marine environment with quality indicators. For descriptors (quality indicators) D1, D4 and D6, for which criteria were defined in accordance with Article 9 paragraph 3 MSFD, appropriate anthropogenic pressures, manners of use and human activity in the marine environment were listed in Table 2.1.2. on the basis of Annex III to Directive 2017/845 (Tab. 2 (2a i 2b)).

Table 2.1.2. Indicators used in the national assessment (2011-2016) in the "integrated assessment of biodiversity" in POM taking into account marine mammals, benthic habitats and pelagic habitats and anthropogenic pressures, uses and human activities in the marine environment were assigned to the relevant criteria of decision 2017/848

| Criteria elements | Descriptor | Primary criterion | Secondary criterion | Description of the criterion in accordance with the Decision 2017/848 | Indicator: core (P), pre-core (W), national (K), biodiversity (B), eutrophication (E) | Dominant anthropogenic pressures, human activities (Tab. 2, Anon. 2017a) |
|---|---|---|---|---|---|---|
| Marine mammals | D1-biodiversity | D1C1 | - | The mortality rate per species from incidental by-catch is below levels which threaten the species, such that its long-term viability is ensured. | By-catch of marine mammals (P, B) | Extraction of, or mortality/injury to, wild species (by commercial and recreational fishing and other activities);<br>Disturbance of species (e.g. where they breed, rest and feed) due to human presence. |
| | | D1C2 | - | The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured. | Population size and trend of abundance of grey seal(P, B) | Disturbance of species (e.g. where they breed, rest and feed) due to human presence;<br>Extraction of, or mortality/injury to, wild species (by commercial and recreational fishing and other activities);<br>Input of other substances (e.g. synthetic substances, non-synthetic substances, radionuclides) — diffuse sources, point sources, atmospheric deposition, acute events;<br>Input of litter (solid waste matter, including micro-sized |
| | | - | D1C3 | The population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures.. | Reproductive status of grey seal (P, B) | |

| Criteria elements | Descriptor | Primary criterion | Secondary criterion | Description of the criterion in accordance with the Decision 2017/848 | Indicator: core (P), pre-core (W), national (K), biodiversity (B), eutrophication (E) | Dominant anthropogenic pressures, human activities (Tab. 2, Anon. 2017a) |
|---|---|---|---|---|---|---|
| | | D1C4 | - | The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions. | Distribution of grey seal (P, B) | litter);<br>Input of anthropogenic sound (impulsive, continuous). |
| Birds | | D1C2 | | The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured. | Abundance of waterbirds in the wintering season (P, B)<br>Abundance of waterbirds in the breeding season (P, B) | Extraction of, or mortality/injury to, wild species (by commercial and recreational fishing and other activities);<br>Disturbance of species (e.g. where they breed, rest and feed) due to human presence; |
| | | D1C3 | | The population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures. | White-tailed eagle productivity (P, B) | Input of other substances (e.g. synthetic substances, non-synthetic substances, radionuclides) — diffuse sources, point sources, atmospheric deposition, acute events;<br>Disturbance of species (e.g. where they breed, rest and feed) due to human presence; |

| Criteria elements | Descriptor | Primary criterion | Secondary criterion | Description of the criterion in accordance with the Decision 2017/848 | Indicator: core (P), pre-core (W), national (K), biodiversity (B), eutrophication (E) | Dominant anthropogenic pressures, human activities (Tab. 2, Anon. 2017a) |
|---|---|---|---|---|---|---|
| Fish | | D1C3 | | The population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures. | Large fish index (LFI1) (K, B) | Extraction of, or mortality/injury to, wild species (by commercial and recreational fishing and other activities); |
| | | D1C2<br>D1C3 | | The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured. | Index of the state of ichthyofauna SI in transitional waters (K, B) | Extraction of, or mortality/injury to, wild species (by commercial and recreational fishing and other activities); |

| Criteria elements | Descriptor | Primary criterion | Secondary criterion | Description of the criterion in accordance with the Decision 2017/848 | Indicator:<br>core (P),<br>pre-core (W),<br>national (K),<br>biodiversity (B),<br>eutrophication (E) | Dominant anthropogenic pressures, human activities (Tab. 2, Anon. 2017a) |
|---|---|---|---|---|---|---|
| Benthic habitats | D1- biodiversity and D6- seaflor integrity | D6C5 | - | The extent of adverse effects from anthropogenic pressures on the condition of the habitat type, including alteration to its biotic and abiotic structure and its functions (e.g. its typical species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), does not exceed a specified proportion of the natural extent of the habitat type in the assessment area. | B – multi-metric index for macrozoobenthos (K, B) | Input of nutrients — diffuse sources, point sources, atmospheric deposition;<br>Input of organic matter — diffuse sources and point sources;<br>Input of other substances (e.g. synthetic substances, non-synthetic substances, radionuclides) — diffuse sources, point sources, atmospheric deposition, acute events;<br>Extraction of, or mortality/injury to, wild species (by commercial and recreational fishing and other activities) – as a result of the exploitation of living (commercial) and recreational fish (commercial fishing) resources;<br>Physical disturbance to seabed (temporary or reversible). |
| | | | | | $SM_1$ – state of macrophyte index (K, B) | Input of nutrients — diffuse sources, point sources, atmospheric deposition,;<br>Input of organic matter — diffuse sources and point sources;<br>Input of other substances (e.g. |

| Criteria elements | Descriptor | Primary criterion | Secondary criterion | Description of the criterion in accordance with the Decision 2017/848 | Indicator: core (P), pre-core (W), national (K), biodiversity (B), eutrophication (E) | Dominant anthropogenic pressures, human activities (Tab. 2, Anon. 2017a) |
|---|---|---|---|---|---|---|
| | | | | | ESMIz – macrophyte state index in lagoons (K, B) | synthetic substances, non-synthetic substances, radionuclides) — diffuse sources, point sources, atmospheric deposition, acute events;<br>Physical disturbance to seabed (temporary or reversible). |
| Pelagic habitats | D1-biodiversity | D1C6 | - | The condition of the habitat type, including its biotic and abiotic structure and its functions (e.g. its typical species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), is not adversely affected due to anthropogenic pressures. | MSTS – zooplankton mean size and total stock(P, B) | Extraction of, or mortality/injury to, wild species (by commercial and recreational fishing and other activities) – as a result of the exploitation of living (commercial) and recreational fish (commercial fishing) resources;<br>Input of nutrients — diffuse sources, point sources, atmospheric deposition;<br>Input of organic matter — diffuse sources and point sources. |
| | | | | | Chlorophyll -a (P, E or K, E) | Input of nutrients — diffuse sources, point sources, atmospheric deposition;<br>Input of organic matter — diffuse sources and point sources. |
| | | | | | CyaBI-Cyanobacterial Bloom Index (W, E) | |

| Criteria elements | Descriptor | Primary criterion | Secondary criterion | Description of the criterion in accordance with the Decision 2017/848 | Indicator: core (P), pre-core (W), national (K), biodiversity (B), eutrophication (E) | Dominant anthropogenic pressures, human activities (Tab. 2, Anon. 2017a) |
|---|---|---|---|---|---|---|
| Ecosystems including food webs | D1- biodiversity and D4 - food webs | D4C1 | - | The diversity (species composition and their relative abundance) of the trophic guild is not adversely affected due to anthropogenic pressures. | B - multi-metric index for macrozoobenthos (K, B)<br>Index of the state of ichthyofauna SI in transitional waters (K, B) | Input of nutrients — diffuse sources, point sources, atmospheric deposition;<br>Input of organic matter — diffuse sources and point sources;<br>Input of other substances (e.g. synthetic substances, non-synthetic substances, radionuclides) — diffuse sources, point sources, atmospheric deposition, acute events;<br>Extraction of, or mortality/injury to, wild species (by commercial and recreational fishing and other activities) – as a result of the exploitation of living (commercial) and recreational fish (commercial fishing) resources;<br>Physical disturbance to seabed (temporary or reversible). |

| Criteria elements | Descriptor | Primary criterion | Secondary criterion | Description of the criterion in accordance with the Decision 2017/848 | Indicator: core (P), pre-core (W), national (K), biodiversity (B), eutrophication (E) | Dominant anthropogenic pressures, human activities (Tab. 2, Anon. 2017a) |
|---|---|---|---|---|---|---|
| | | D4C2 | - | The balance of total abundance between the trophic guilds is not adversely affected due to anthropogenic pressures. | Dia/Dino-Diatom/Dinnoflagellate index (W, B) | Input of nutrients — diffuse sources, point sources, atmospheric deposition; Input of organic matter — diffuse sources and point sources; Changes to hydrological conditions (min. water temperature in winter). |
| | | - | D4C3 | The size distribution of individuals across the trophic guild is not adversely affected due to anthropogenic pressures. | MSTS zooplankton mean size and total stock (P, B) Large fish index (LFI1) (K, B) | Extraction of, or mortality/injury to, wild species (by commercial and recreational fishing and other activities) – as a result of the exploitation of living (commercial) and recreational fish (commercial fishing) resources; Input of nutrients — diffuse sources, point sources, atmospheric deposition; Input of organic matter — diffuse sources and point sources. |
| | | | D4C4 | Productivity of the trophic guild is not adversely affected due to anthropogenic pressures. | White-tailed eagle productivity (P, B) | Input of other substances (e.g. synthetic substances, non-synthetic substances, radionuclides) — diffuse sources, point sources, atmospheric deposition, acute events; |

**Descriptor D1** – Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions of the Baltic Sea.

**Descriptor D4** – All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.

**Descriptor D6** – Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.

**Primary criterion** a criterion for mandatory application by Member States in defining a set of properties typical of good environmental status in order to assess to what extent good environmental status is achieved.

**Secondary criterion**– to complement a primary criterion or when, for a particular criterion, the marine environment is at risk of not achieving or not maintaining good environmental status.

**Criteria elements** – constituent elements of an ecosystem, particularly its biological elements (species, habitats and their communities), or aspects of pressures on the marine environment (biological, physical, substances, litter and energy), which are assessed under each criterion.

Fulfilling the criteria of Decision 2017/848 in the report in 2018 regarding MSFD, the condition of the Baltic Sea environment is presented on the basis of the following information on specific criteria (DIKE_16-2017-08):

- D1C1 (incidental by-catch) – the mortality rate per species from incidental by-catch;
- D1C2-C5 (species groups of birds, mammals and fish) – the state of the species and a list of species that show or have achieved good status in a given group of species in the area of assessment against all species assessed;
- D1C6 (pelagic broad habitat types) – a list of habitats that show or have reached a good condition in the assessment area against all assessed habitats;
- D6C4 (benthic broad habitat types) – extent of habitat loss (%) in comparison with all assessed habitats;
- D6C5 (benthic broad habitat types) – extent of adverse effect (%) on the background of all assessed habitat.

**„Integrated biodiversity assessment"**

"Integrated biodiversity assessment" consists in carrying out the state assessment for designated assessment areas in POM, separately for individual ecosystem elements and by using several indicators simultaneously (core, pre-core, national and eutrophication indicators) in the assessment area, which in total refer to Descriptors D1, D4 and D6. Each indicator is assigned to the assessment of the appropriate species, group of species or a given type of habitat. A specific indicator can be used only once in the assessment. The possibility of using various indicators in the integrated assessment and their comparability is possible by normalizing the values of indicators in the range from 0 to 1, with the indication of the minimum and maximum value for a given indicator.

In the case of marine mammals, the assessment of the status refers to level 1, i.e. the entire Baltic Sea area, in the part covering POM. Marine mammals present in POM are grey seal (*Halichoerus grypus*), harbour seal (*Phoca vitulina*), ringed seal (*Pusa hispida*) and (*Phocoena phocoena*). However, due to the lack of reliable data and agreed limit values for harbour porpoise, this species was excluded from the "integrated assessment of biodiversity" and its assessment was carried out in a descriptive manner. Of the three species of Baltic seals, only the grey seal is still present in national waters and occupies a permanent haul-out place (resting place) in the area of Vistula estuary. For this reason, only the grey seal has been subjected to a multiannual assessment, as the other two species (harbour seal and ringed seal) occur sporadically in the POM. The WWF report (Hylla-Wawryniuk 2017), which includes the years from 2009 to 2016, states that harbour seals and ringed seals were recorded sporadically in POM, also within the haul-out of the grey seal. Overall, the observations of these two species accounted for 4% and 0.8% respectively of all seal observations recorded in the WWF database. For this reason, the "integrated assessment of biodiversity" in the field of marine mammals in POM mainly concerns only the grey seal. A general scheme for assessing marine mammals is presented in Fig. 2.1.2.

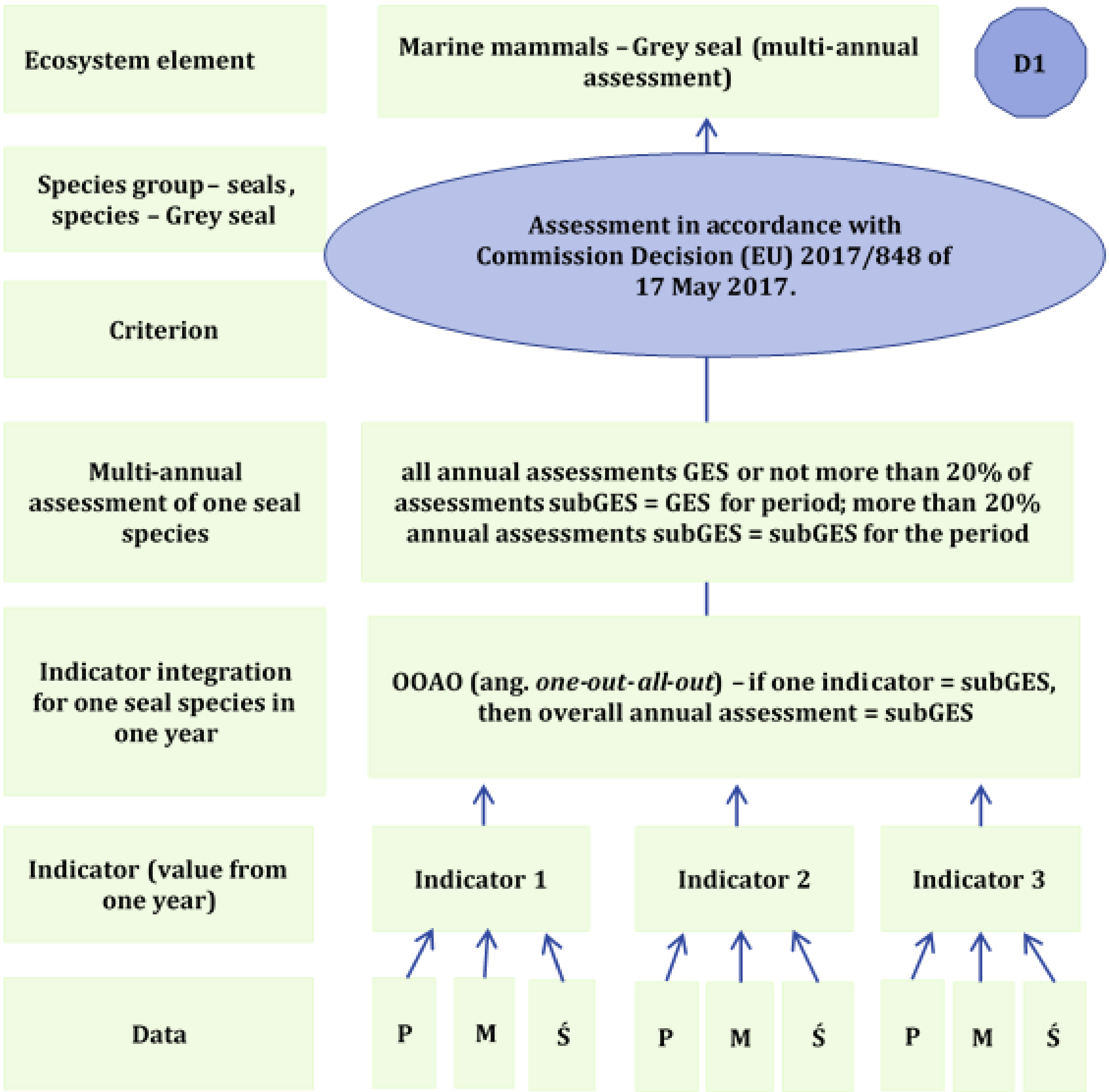



Fig. 2.1.2. General scheme of "integrated assessment of biodiversity" in the field of marine mammals - seals (Descriptor D1 - biodiversity, PMŚ - State Environmental Monitoring, number of indicators given, for example, marine mammals are one of the 5 elements of the ecosystem within Descriptor D1)

The assessment of the status of benthic and pelagic habitats in POM was carried out at the level 4 of the division of the Baltic Sea, for 19 waterbodies in accordance with the WFD and for three open sea-basins. The general scheme of "integrated assessment of biodiversity" in the field of benthic and pelagic habitats is shown in Fig. 2.1.3.

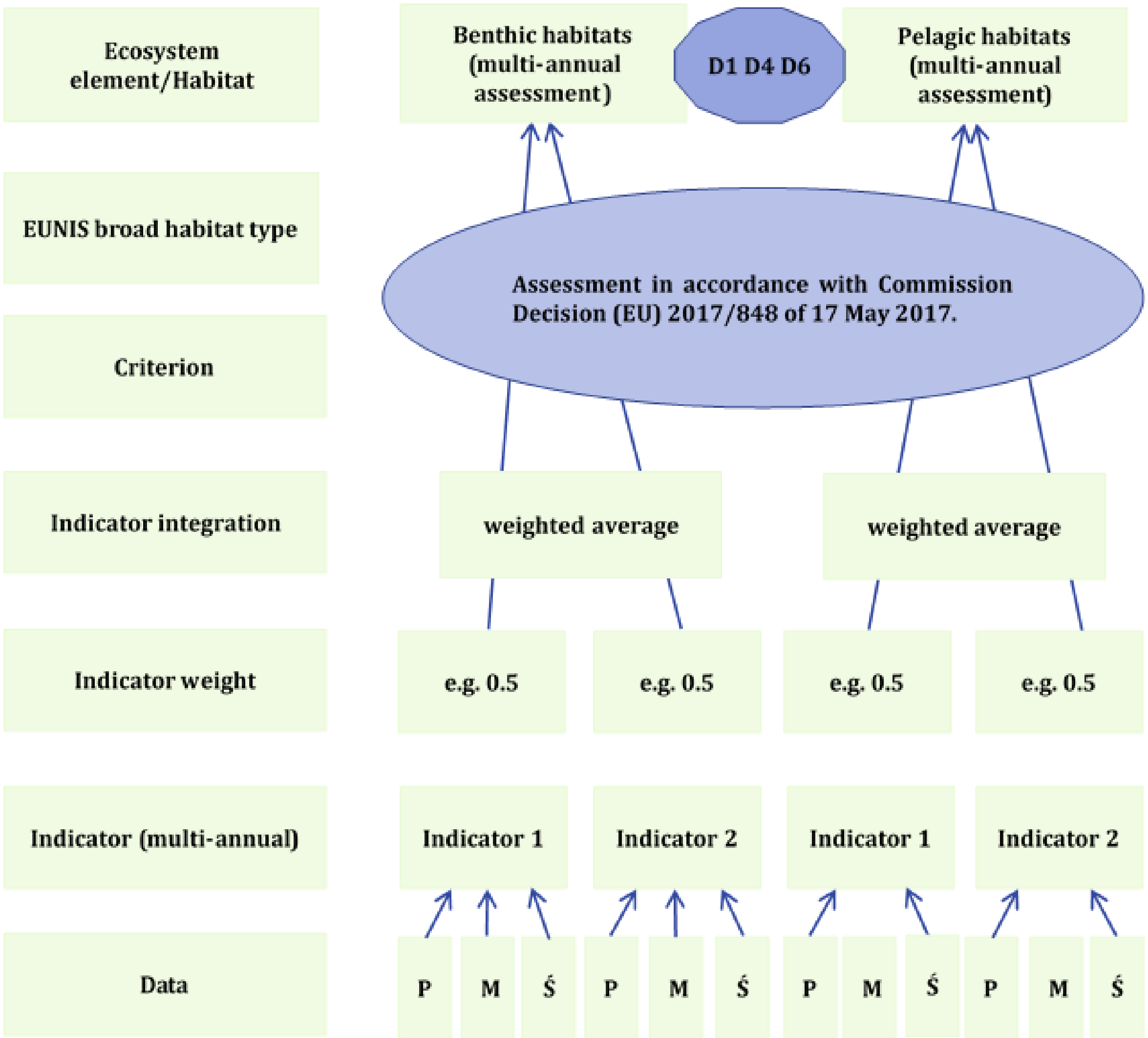



Fig. 2.1.3. General scheme of "integrated assessment of biodiversity" in the field of benthic and pelagic habitats in POM (Descriptor D1 - biodiversity, D4 Descriptor - food webs, D6 Descriptor - seafloor integrity, PMŚ - State Environmental Monitoring, number of indicators and their weight within the habitat given for example, benthic and pelagic habitats are 2 out of 5 elements of the ecosystem as part of Descriptor D1)

**Confidence assessment**

For the multiannual assessment 2011-2016, a confidence assessment is carried out in parallel to the status assessment. First of all, the confidence of a single indicator in the area of assessment in 2011-2016 should be assessed on the basis of 4 components: temporal confidence, spatial confidence, confidence of the methodology and confidence of the methodology by assigning each of these components to a low or medium or high class and corresponding numerical values, which should be averaged to obtain one indicator confidence value. In order to determine the confidence of the indicator, one should answer the questions given in Table 2.1.3.

Table 2.1.3. The method of determining the average confidence of the indicator for one area of assessment

| Confidence aspect | Class | | |
|---|---|---|---|
| | High | Medium | Low |
| **Temporal coverage** | Does the monitoring data fully cover the assessment period: 2011-2016? If the indicator shows changes from year to year, are the results from all years from 2011-2016 included? If the variability from year to year does not occur, are the requirements of the time frequency of monitoring met (e.g. monitoring of macrozoobenthos in WFD waters once every 3 years)? | Does the monitoring data cover the majority of the assessment period: 2011-2016? If the indicator shows changes from year to year, are the results from 3 to 4 years taken into account? | Is the monitoring data from the assessment period 2011-2016 insufficient? If the indicator shows changes from year to year, are the results from 1 to 2 years taken into account? |
| Indicate the answer "YES" at one of the classes: high or medium or low for temporal coverage | 1 | 0,5 | 0 |
| **Spatial representation** | Are monitoring stations adequately located in a given area of assessment, to calculate a specific indicator in this area based on data from these stations? Do the data obtained from these stations represent credibly at least 80% of a given habitat in the assessment area? If the indicator shows a marked gradient or irregularity, does the distribution of monitoring stations cover at least 90% of this variation? | Are monitoring stations mostly distributed in a given area of assessment, so that on the basis of data from these stations, calculate the indicator in this area? Does received data from these stations represent reliably at least 60-80% of a given habitat in the assessment area? If the indicator shows a marked gradient or irregularity, does the distribution of monitoring stations cover at least 90% of this variation? | Do monitoring stations fail to adequately cover a given area of assessment, so that on the basis of data from these stations, calculate the indicator in this area? Does the received data from these stations represent reliably less than 60% of a given habitat in the assessment area? If the indicator shows a marked gradient or irregularity, does the distribution of monitoring stations cover at least 90% of this variation? |
| Indicate the answer "YES" at one of the classes: high or medium or low for spatial representation | 1 | 0,5 | 0 |
| **Classification confidence** | Is the comparison with the threshold clearly indicating that GES has been achieved or has GES not been achieved with a probability of at least 90%? In the case of assessment of indicators used in the WFD, is the answer | Does the comparison with the threshold value indicate that the values are generally in the GES / subGES range, but there are some outliers in the data series, i.e. GES has been achieved or not reached with a | Is the comparison with the threshold value does not indicate whether the data is in the GES / subGES scope, i.e. GES has been achieved or has not been achieved with a probability of less than 70%? In the case of the assessment of |

| Confidence aspect | Class | | |
|---|---|---|---|
| | whether the indicator has completed intercalibration? | probability of 70-89%? When assessing indicators used in the WFD, is the answer whether the indicator has been subjected to effective intercalibration? | indicators used in the WFD, is the answer whether the indicator has not passed through effective intercalibration? |
| Indicate the answer "YES" at one of the classes: high or medium or low for the classification confidence | 1 | 0,5 | 0 |
| **Methodological confidence** | Are the parameters of the indicator for which there is a HELCOM methodological guide been monitored according to the guidelines of this guide? Was the quality control carried out according to the HELCOM principles or other international guides to ensure the quality of measurements? In the case of assessment of indicators used in the WFD, is the answer whether the indicator has completed intercalibration? | Are the parameters of the indicator for which there is a HELCOM methodological guide only partly monitored according to these guidelines? Was quality control carried out, but according to local rules? When assessing indicators used in the WFD, is the answer whether the indicator is intercalibrated? | Are the parameters of the indicator for which there is a HELCOM methodological guide not monitored according to these guidelines? Has the data not been subjected to quality control? In the case of the assessment of indicators used in the WFD, is the answer whether the indicator has not passed through effective intercalibration? |
| Indicate the answer "YES" at one of the classes: high or medium or low for the methodological confidence | 1 | 0,5 | 0 |
| **Average value of the confidence of the indicator (WW) - average values for which "YES" was indicated** | example: (1+1+0,5+0,5)/4=0,75 | | |

*Own study based on the method used in the second holistic assessment "State of the Baltic Sea. The Integrated assessment of biodiversity. Report 2017"*

In the next step, the average values of the confidence of individual indicators (WW) should be integrated.

In the case of marine mammals - grey seals, the average confidence of the assessment area (CA), ie the entire POM excluding the lagoons, is calculated as the arithmetic mean of the confidence of indicators (WW).

For benthic and pelagic habitats in a given area of assessment, in order to determine the average confidence for assessment areas, indicators will be subject to integration on the basis of the method of assessment, i.e. the weighted average based on weights assigned to indicators. In addition, if there is no indicator to assess species groups or the general type of habitat occurring in a given area, the final assessment of confidence for a given assessment area should be reduced by 25%.

As a result, the result of the confidence status (WO) of a given ecosystem element for a given assessment area is obtained in accordance with the classification presented in Table 2.1.4.

Table 2.1.4. Classification of the result of the confidence assessment (the colors indicate the confidence status used to present the assessment on the maps)

| Average confidence value in the assessment unit (WO) | Confidence status |
|---|---|
| ≥ 0,75 | high |
| 0,5 – 0,74 | medium |
| < 0,5 | low |

***Marine mammals***

**Indicators**

To carry out the assessment of the environmental condition based on the seals under the second holistic assessment for 2011-2016, the following four core indicators have been developed: ‘Population trends and abundance, Occurrence, Reproduction and Nutrition status’ (HELCOM 2017a). The first three indicators were included in the PMŚ in POM (Opioła et al. 2016) due to a uniform methodology of work (photographic analysis / flights), while the indicator 'Nutrition Status' (HELCOM 2017c) due to the pilot nature of the project in POM and the commenced process of changing this indicator (or its reference levels) within the HELCOM SEAL group has not been monitored. It should also be emphasized that for the correct application of this indicator, a material is necessary that allows for statistical processing of the obtained results, and therefore representative of both the number of individuals for analysis, as well as age or gender. Such work is currently being carried out by the Maritime Station of the University of Gdańsk in Hel in cooperation with partners from the HELCOM SEAL group. The lack of one of the indicators does not, however, prevent the assessment of the species.

At the same time, it should be emphasized that pressures on marine mammals, which have not been qualified for parametric assessment as indicators, are a particularly serious threat to all species of marine mammals of the Baltic Sea. The by-catch of marine mammals has been recognized as one of the most important factors related to anthropogenic pressure and limiting populations (ICES 2016a). Nevertheless, at the HELCOM level it was not used to assess the conservation status of species, and is only presented in the general description of the pressure. By catch, as an indicator of pressure, is based on the number of animals found dead by fishermen in nets. The data is collected by the National Marine Fisheries Research Institute in Gdynia (MIR-PIB). By-catch refers directly to the trends calculated from data for the last 10 years. The data necessary to determine this indicator is to MIR-PIB or to the Fisheries Department of the Ministry of Maritime Economy and Inland Navigation. Since 2006, there has not been recorded a single case of by-catch of the harbour porpoise, while in the case of a grey seal, 4 individuals caught in 2011-2016 were reported (MIR-PIB 2017). The authors of the MIR-PIB report point to a small number of reported, caught animals (birds and marine mammals) in relation to the high fishing effort. The number recorded in the report is in contrast to the available data collected in the WWF/SMIOUG database (www.fokarium.pl) - in the period 2011-2017 more than 200 dead seals and a dozen porpoises were found on the beaches, some of which had traces indicating the possibility of by-catch. In the case of porpoise, the by-catch was defined as a critical threat to the species, in particular for the Baltic Sea population. It has been assumed that by-catch at the level of one individual is a significant threat to the porpoise population in this region (Harkonen et al. 2013, HELCOM 2017d). In July 2016, in the Pomeranian Bay, the female porpoise by-catch was recorded, while two dead porpoises with traces of mutilation and body injuries pointing to by-catch were recorded (WWF/SMOIUG database).

Drowning as a result of entanglement in fishing equipment is one of the main causes of the death of porpoises in the Baltic, but the problem also concerns seals (Korpinen and Braeger 2013). The risk of incidental by-catch is greatest for various types of gillnets, it also occurs when using other methods of fishing, such as trap nets (ICES 2013a, Vanhatalo et al., 2014).

The incidental by-catch of the harbour porpoise in the Kattegat area and the Danish straits was estimated at 165-263 individuals in 2014 mainly based on information from CCTV cameras, information from commercial fishing boats and fishing intensity data (ICES 2016b). However, these estimations must be treated with caution, taking into account the sources of data used for calculations. The documentation of incidental by-catch of porpoises in the Baltic is fragmentary, usually affecting individuals throughout the year. In Poland, from 2011 to 2016, a total of 22 porpoise reports from by-catch were recorded (data from 2011-2015 based on the WWF report, data from 2016 based on SMIOUG data).

In the case of a grey seal, in addition to pressure from the fishery, it should be noted that its position (haul-out) in the Vistula mouth is an unstable habitat located on sandy shores. Due to significant fluctuations in the water level, (which can be modified by human activities - such as hydrotechnical investments in Vistula mouth), the amount of space available for seals is not permanent (Photo. 2.1.1), in contrast to the situation in Sweden or Finland, where the shores are rocky. Pressure from this side may also be critical for the stock in POM, and above all for the use of haul-out in Vistula mouth as a place of permanent reproduction of the species. During the monitoring of the PMŚ, resting seals were also observed on concrete constructions, which could potentially be used by the species as a "replacement" haul-out (Photo. 2.1.2) in case of very high water level or other phenomena limiting access to sand area. The washout is recorded every year during monitoring activities, but it is not possible to subject this factor to parametric assessment, let alone forecasting the condition of the habitat or its valorisation (Pawliczka 2012).

Photo. 2.1.1 Seals resting on a small sandy haul-out in the area of Vistula Estuary in March 2017.

Photo. 2.1.2. Seals resting on a concrete construction in the area of Vistula Estuary in April 2017.

### *Indicator 'Population trends and abundance of grey seal'*

The size of the population determines the number of all grey seal individuals occurring on land at the haul-out site and in the water at a short distance from this place. The data necessary to determine the size of a grey seal is obtained from aerial observations. They take place at the turn of May, that is, during the moulting of grey seals. The number of animals is determined on the basis of aerial observations made by two observers from a plane flying at a speed of about 110 km/h at an altitude of 150-200 m. Observers perform photographic documentation of each observation flight, so that the exact number of seals can be determined. It is also possible to identify the seal to the species. Grey seal monitoring currently conducted in Poland is consistent with the HELCOM recommendations regarding the consistent methodology used by all Baltic states (HELCOM 2017b). Synchronization of aerial surveys, 2 weeks at the turn of May, allows to reduce the risk of double counting of the same individuals. Table 2.1.5 presents the criteria for determining a good population status for this indicator.

Table 2.1.5 The criterion for determining the good status of the grey seal population based on the indicator '*Population trends and abundance of grey seal*'

| Indicator | GES | subGES |
|---|---|---|
| Population trends and abundance of grey seal | An increase in abundance equal to or higher than 10% from the value of the previous year | Population growth below 10% or its decline |

In the second holistic assessment, the reference level for the indicator was assumed to be a 10% increase in the total population. For the good state (GES), the value of population growth was agreed as not lower than 3 percentage points from the reference level – i.e. at 7% (HELCOM 2015). It should be emphasized that the reference level (10%) refers to the maximum possible increase in population for fully isolated populations. The Baltic population of grey seal fulfils this condition - however, in the case of the POM stock, this is not the case. A flock of grey seals, which occurs on a haul-out in Vistula Estuary is not an "isolated" group of animals. The increase in abundance (year to year) is not the result of reproduction of individuals because individuals from the Vistula Estuary do not regularly breed in this area and are in the early stages of re-colonization and the increase is mainly achieved by supplying the stock from outside. Thus, to achieve the level of good environmental status (GES) in the case of grey seals occurring in POM, the condition of growth above 10% should be met.

A similar situation of rapid population growth in the initial re-colonisation phase has been observed in Bornholm since 2007, when the first grey seals (3 specimens) were recorded. In 2008, it was 80 individuals and the first reproduction of this species was found on the island.

The effect of a significant initial phase increase in the number of stocks on recolonized areas was also described in the case of a grey seal in the Wadden Sea. It was also estimated that seal migration from other colonies could account for up to 35% of the total population increase in 1985-2013 (Brasseur 2015).

Due to dynamic changes in the stock size and uncertainty as to the breeding status of grey seals in POM, the proposed criteria for these indicators should be adopted only for the years 2011-2016. The monitoring carried out in the following years should be the basis for a possible revision of threshold values based on the results obtained, as well as the status of the entire population of the species in the Baltic Sea. Preliminary data from 2015 and 2016 indicate possible flattening of the population growth trend in the Baltic, which may entail significant changes for seals found in waters of the POM.

***Indicator 'Grey seal distribution'***

The presence of grey seals is confirmed on the basis of aerial monitoring in the period from March to July. Monitoring of grey seal occurrence covers the entire Polish coast, including the sandbanks of Vistula Estuary and Ryf Mew on the Puck Bay. At the same time, aerial photographs allow the definition of haul-out areas on the Polish coast. During the surveys, there was confirmed one haul-out site in POM in Vistula mouth. From the available data (Pawliczka 2012, Hylla-Wawryniuk 2017) this place has been visited by grey seals for years. Table 2.1.6 presents the criteria for determining good environmental status in POM for the indicator, which are in accordance with the HELCOM recommendations (HELCOM 2017b)

Table 2.1.6. Criterion for determining the good status of the grey seal population based on the '*Grey seal distribution*' indicator

| Indicator | GES | subGES |
| --- | --- | --- |
| Grey seal distribution | Presence of a grey seal in all defined haul-out areas during the monitoring period during moulting | The presence of a grey seal is not found on at least one of the defined haul-out areas during the monitoring period during moulting |

***Indicator 'Reproductive status of grey seal'***

Grey seal reproductive status is determined on the basis of the presence of pregnant, lactating females or juvenile in the "lanugo" as determined by aerial monitoring in March and April. Currently, such data during the period under review are not available since no monitoring was carried out in accordance with the HELCOM recommendations. The regular reproduction of grey seals in Vistula mouth was not confirmed in the monitoring of WWF Polska and SMIOUG, carried out with cameras, although in the period covered by the assessment there were cases of individuals in "lanugo". Table 2.1.7 presents the criteria for determining good environmental status for the indicator.

Table 2.1.7. The criterion for determining the good status of the grey seal population based on the indicator '*Reproductive status of grey seal*'

| Indicator | GES | subGES |
| --- | --- | --- |
| Reproductive status of grey seal | The number of lactating or pregnant females and pregnant females represents at least 5% of the population (school) | The number of nursing or young mothers and pregnant females represents less than 5% of the population (school) |

For the entire Baltic population of grey seals in the second holistic assessment, HELCOM adopted the reference value of the indicator at the level of 95% of the total number of females at least 6 years old (HELCOM 2017e). For the national assessment, based on the previously determined level of the indicator '*Population trends and abundance of grey seal'* it was assumed that GES occurs when at least 5% of the observed stock are individuals in lanugo/nursing females or pregnant females. This would mean that half of the assumed, minimal increase in the population size (year to year) in POM is a possible effect of feeding the internal local population.

**Assessment method of the status of grey seal**

The method of integration of indicators in population assessment in POM is based on the principle: OOAO ("one-out-all-out"), in which the result with the lowest rating determines the total score (HELCOM 2017a). In the case of a single subGES in a given year, the subGES assessment for the grey seal status is finally adopted this year. Multiannual assessment as a result of integration between annual assessments will achieve good environmental status (GES) if all GES annual assessments occur in a given period or no more than 20% of assessments show a subGES status. The structure of the integrated grey seal assessment in POM for the years 2011-2016 is presented in Table 2.1.8.

Table 2.1.8 Structure of the integrated grey seal assessment in POM as part of the multi-annual assessment 2011-2016

| Assessment unit | Indicator used in the national "integrated assessment of biodiversity" | Integration between indicators - annual assessment | Multiannual assessment |
| --- | --- | --- | --- |
| POM, excluding lagoons | Population trends and abundance of grey seal | OOAO (*one-out-all-out*) - if one result of the | during the assessment period, all GES annual |

| Assessment unit | Indicator used in the national "integrated assessment of biodiversity" | Integration between indicators - annual assessment | Multiannual assessment |
|---|---|---|---|
| | Grey seal distribution | indicator = subGES, then the annual grade = subGES | assessments or no more than 20% of subGES = GES; over 20% of annual ratings of subGES = subGES |
| | Reproductive status of grey seal | | |

**Grey seal assessment for 2011-2016**

For the purpose of the national assessment of the marine environment in the field of marine mammals - grey seals, the following three indicators were used: '*Population trends and abundance of grey seal*', '*Grey seal occurrence*' and '*Reproductive status of grey seal*' based on the data presented in Table 2.1.9. The occupation of haul-outs at the Polish coast was indicated on the basis of available data and aerial observations in 2016 as part of the pilot implementation of monitoring of marine species and habitats - PMŚ conducted in 2015-2018 (Opioła et al. 2016), (Fig. 2.1.4, Table 2.1.10). Currently, the only haul-out of grey seals in the Vistula Estuary was found, the geographical coordinates of the haul-out centre point are 54,3694° N i 18,9495° E designated on the basis of observations carried out on 22 March 2017.

Table 2.1.9. Data source to assess the status of a grey seal in POM

| Assessment unit | Station | Indicator/Data source | | |
|---|---|---|---|---|
| | | Population trends and abundance | Occurrence | Reproductive status |
| POM, excluding lagoons | Vistula mouth – currently the only haul-out site of grey seals found | 2011-2016 – WWF Poland database<br>2016 - PMŚ | 2011-2016 – Poland database, SMIOUG<br>2016 - PMŚ | 2011-2016 – Poland database, SMIOUG |

Table 2.1.10 Results of aerial monitoring carried out as part of the PMŚ in 2016 in POM (Opioła et. al 2016)

| Date of flight | The number of seals in the area of Vistula Estuary (haul-out) | The number of dead individuals |
|---|---|---|
| 28.04.2016 | 168 | 0 |
| 23.05.2016 | 120 | 0 |
| 4-5.06.2016 | 4 | 0 |
| 25.07.2016 | 8 | 0 |

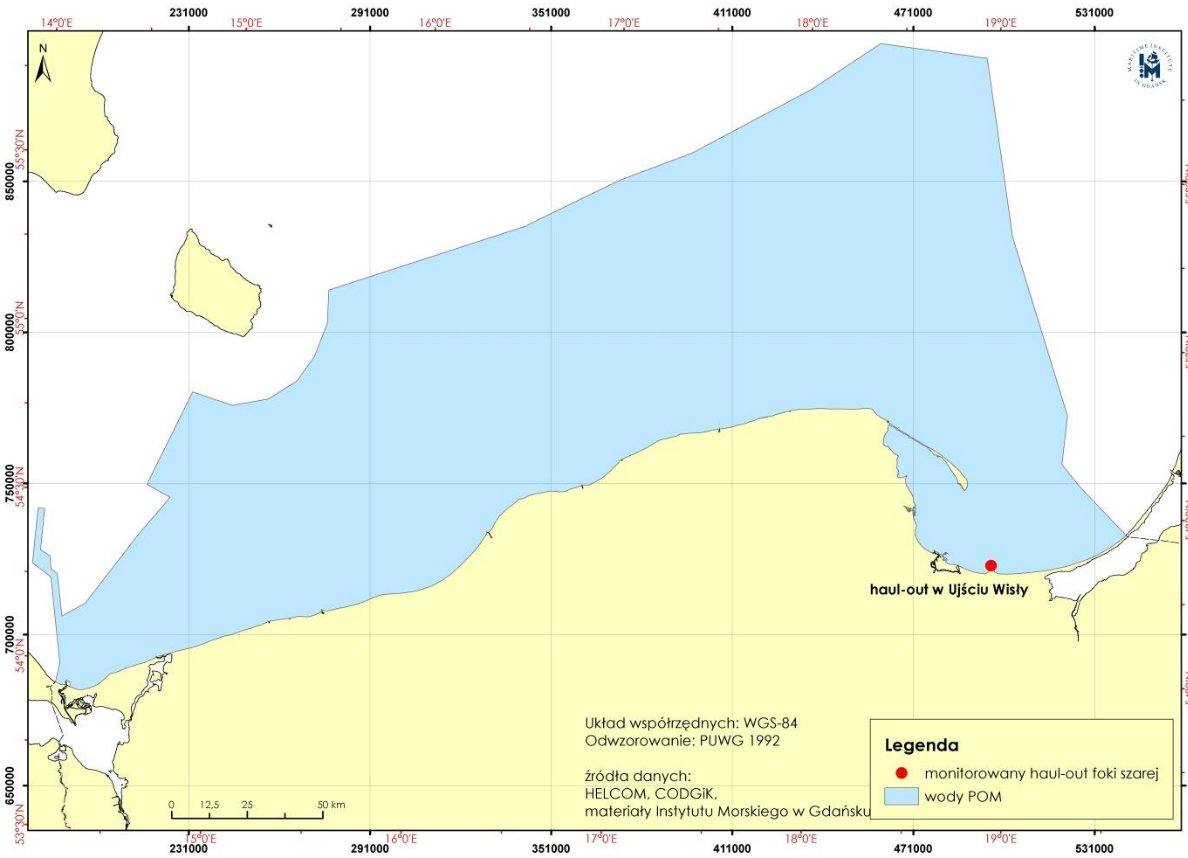



Fig. 2.1.4 Assessment area and grey seal haul-out site monitored in POM

The grey seal haul-out of the estuary of the Vistula is monitored (since 2010) by WWF Poland and the Marine Station of the University of Gdańsk (SMIOUG). Data from the model (SMIOUG), are different from that collected according to HELCOM and PMŚ methods (observations from the plane, maxima from 2 flights performed on the turn of May and June). WWF data can be used for the indicator '*Population trends and abundance of grey seal*', while SMIOUG data is not available for the assessment period 2011-2016.

Based on the available data (WWF Poland, SMIOUG), the initial character of recolonization should be characterised by:

- • Very low share of observed animals - assuming 30,000. individuals – in the entire Baltic Sea area in 2016 (HELCOM 2017a), the grey seal in Poland accounts for 1% of the population. In the case of the highest number of 120 individuals this is 0.4% of the Baltic population;
- High year to year and seasonal variability of abundance of the seal (Table 2.1.11) indicating migration of individuals from other Baltic Sea regions;
- Lack of confirmed reproduction of the species in 2011-2016 (WWF Polska, SMIOUG).

Table 2.1.11. The maximum number of seals recorded at the Vistula mouth. Data for all seal species based on WWF Poland haul-out monitoring. The maximum number of common seals observed simultaneously in this region is 2, ringed seals - 1. Yellow is marked May-June, which correspond to a monitoring interval in accordance with the HELCOM guidelines

| Month | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| January | 4 | 4 | 3 | 12 | 12 | 13 | 30 | 100 |
| February | 2 | - | 3 | 1 | 6 | 18 | 20 | 150 |
| March | 2 | 1 | 1 | 2 | 12 | 40 | 19 | 120 |
| April | 1 | 3 | 4 | 7 | 40 | 111 | 100 | 290 |
| May | 7 | 4 | 19 | 25 | 51 | 70 | 60 | 170 |
| June | 4 | 6 | 23 | 41 | 35 | 50 | 30 | 150 |
| July | 6 | 15 | 22 | 55 | 77 | 50 | 120 | 5 |
| August | 6 | 12 | 22 | 49 | 94 | 70 | 12 | 100 |
| September | 12 | 9 | 20 | 61 | 31 | 91 | 12 | 100 |
| October | 13 | 12 | 21 | 22 | 23 | 60 | 100 | 80 |
| November | 4 | 8 | 12 | 28 | 24 | 165 | 205 | 130 |
| December | 4 | 4 | 25 | 10 | 42 | 57 | 150 | 100 |
| Maximum year | 13 | 15 | 25 | 61 | 94 | 165 | 205 | 290 |

Data source: WWF Poland

Based on the trend curve (Fig. 2.1.5) it can be concluded that the initial phase of re-colonization by seals began in POM. It should be emphasized that this is an exponential model with a relatively high ($R^2$), however, it does not include mortality (number of individuals or percentage) of population that die of various reasons (including natural causes) in a given time unit (year), natural increase (difference between the number of births and mortality) - or migration (number of individuals joining a given population from the outside).

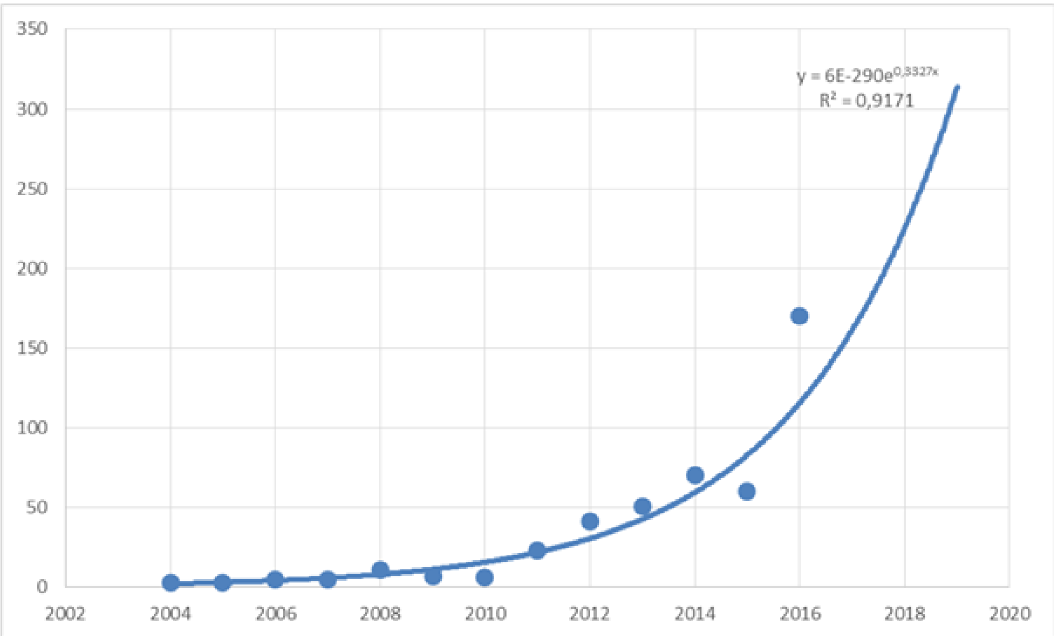



Fig. 2.1.5. Trend curve of the grey seal population in the Vistula Estuary (years 2004-2008 based on - Pawliczka et al. 2012, years 2009-2016 based on the maximum values of May-June from Table 2.1.11.)

**Assessment based on the indicator '*Population trends and abundance of grey seal*'**

Data for the years 2011-2016 presented by WWF Polska, although not consistent with the HELCOM methodology, are developed in a constant manner, i.e. ensuring a constant error of the applied method. Such data are in line with the principles of trend determination and clearly indicate a systematic increase in the size of the species in the haul-out site. Both data from the months of May-June and for the whole year (maximum numbers were not always present in these months) indicate a growing trend in abundance. At the same time, the average annual increase in the grey seal population in this region in 2011-2016 was around 90%.

However, these data can not be compared with PMŚ data collected in accordance with the HELCOM methodology, when in 2016 there were 168 specimens. Therefore, an assessment for this indicator can not be made based on the total PMŚ and WWF data, however, the data for the increase in the stock size can only be compiled based on WWF Poland data without including the absolute number of seals in the assessment. In this case, with the growing population trend and the average annual growth at the level above the assumed 10%, the assessment of this indicator indicates GES (Table 2.1.12).

Table 2.1.12. Assessment of grey seal status based on the '*Population trends and abundance of grey seal*' indicator for the period 2011-2016 in POM (GES, subGES)

| Assessment unit | 2011-2016 |
|---|---|
| POM, excluding lagoons | GES |

In the initial assessment of the state of Polish marine waters in the years 2005-2010, no assessment was made based on this indicator due to the lack of sufficient data (GIOŚ 2014).

**Assessment based on '*Grey seal distribution*' indicator**

In 2011-2016, the grey seal occurred every year on the only haul-out of the species in the Vistula Estuary. The data of WWF Polska indicate permanent occupation of this place during the whole year. In 2011-2016, the grey seal was systematically noted in this area in each of the 12 months. Monitoring of the PMŚ confirmed the systematic occurrence of the species in the haul-out area in 2016 (Table 2.1.10.) and the assessment of this indicator indicates GES (Table 2.1.13).

Table 2.1.13. Assessment of the grey seal status based on the '*Grey seal distribution*' indicator for the period 2011-2016 in POM (GES, subGES)

| Assessment unit | 2011-2016 |
|---|---|
| POM, excluding lagoons | GES |

In the initial assessment of the state of Polish marine areas for the years 2005-2010 due to the lack of the developed indicator, it was not included in the assessment (GIOŚ 2014).

**Assessment based on indicator '*Reproductive status of grey seal*'**

No reproduction of the species was recorded during PMŚ monitoring. At the same time, occasional occurrence of young seal in lanugo was recorded (in 2011 and in 2016 the birth of the seal was recorded in the area of Vistula Estuary) as part of the monitoring of WWF Polska/SMIOUG. The available information, cited earlier, indicates that it is a stable breeding but at a level below 5% of the population of a colony (Table 2.1.14.).

Table 2.1.14. Assessment of grey seal status based on the '*Reproductive status of grey seal*' indicator for the period 2011-2016 in POM (GES, subGES)

| Assessment unit | 2011-2016 |
|---|---|
| POM, excluding lagoons | subGES |

In the initial assessment of the state of the Polish marine areas in 2005-2010 no assessment was performed based on this indicator due to the lack of sufficient data (GIOŚ 2014).

**Integrated assessment of grey seal**

Taking into account the results of assessments for particular years in the period from 2011 to 2016 and the adopted principles for conducting the multiannual assessment presented in Table 2.1.15. and in Fig. 2.1.6. – multi-annual integrated final assessment for 2011-2016 for grey seal indicates a subGES status.

Table 2.1.15. Integrated assessment of the status of the grey seal (*Halichoerus grypus*) in POM for the years 2011-2016 (Data source: PMŚ, WWF, SMIOUG, HELCOM)

| Haul-out Vistula mouth | | Annual assessment of indicator | | | Integrated annual assessment |
|---|---|---|---|---|---|
| Year | Number of individuals/ Trend %* | Indicator '*Population trends and abundance of grey seal*' | Indicator '*Grey seal distribution*' | Indicator '*Reproductive status of grey seal*' | |
| 2011 | 23/283% | - | GES | subGES | subGES |
| 2012 | 41/78% | GES | GES | subGES | subGES |
| 2013 | 51/24% | GES | GES | subGES | subGES |
| 2014 | 70/37% | GES | GES | subGES | subGES |
| 2015 | 60/-14% | subGES | GES | subGES | subGES |
| 2016 | 170 (168**)/183% | GES | GES | subGES | subGES |
| **Assessment period 2011-2016** | | | | | subGES |

* WWF Poland data - maximum from May-June months = 293 (also applies to the table on page 161);
** values recorded in accordance with the HELCOM methodology within the PMŚ

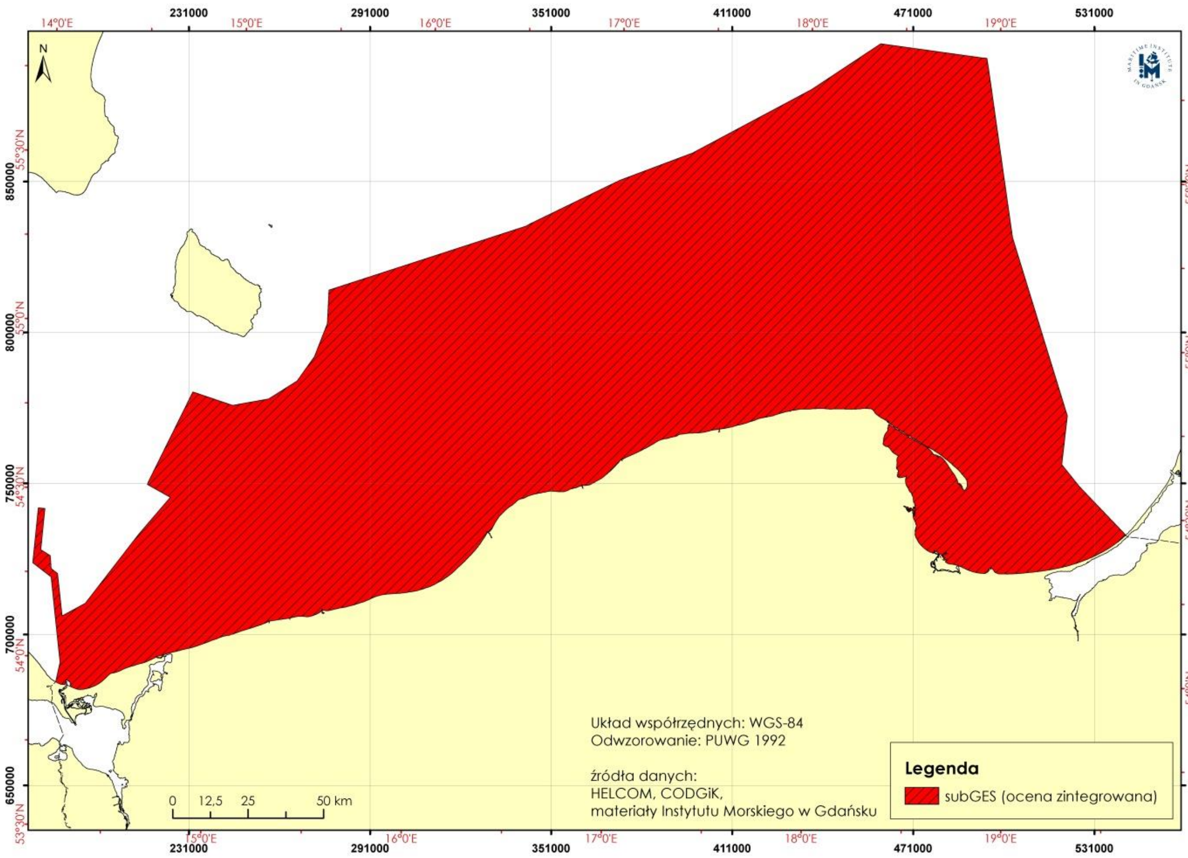



Fig. 2.1.6. Integrated assessment of the state of grey seals in the Polish Baltic zone for the years 2011-2016

#### Confidence of grey seal assessment in 2011-2016

The result of the confidence of the grey seal assessment in 2011-2016 done for each of the indicators and for the overall assessment is presented (Table 2.1.16).

Table 2.1.16. The result of the confidence of the grey seal assessment in 2011-2016 in POM

| confidence aspect | Indicator '*Population trends and abundance of grey seal*' | Indicator '*Grey seal distribution*' | Indicator '*Reproductive status of grey seal*' |
|---|---|---|---|
| Temporal coverage | 1 | 1 | 1 |
| Spatial representation | 1 | 1 | 1 |
| Classification confidence | 1 | 1 | 0.5 |
| Methodological confidence | 0.5 | 1 | 0.5 |
| Averaged indicator confidence (WW) | 0.87 | 1 | 0.75 |
| Confidence assessment for the assessment area (WO) – POM, 2011-2016 | 0.66 – status confidence: average | | |

For all indicators, the temporal and spatial confidence is 1, because all of them were monitored during the assessment period and within the only haul-out site in the Vistula Estuary (WWF Polska, SMIOUG, PMŚ). For the indicator '*Reproductive status of grey seal*' the methodological confidence is 0.5, as the assessment was based only on information from monitoring centres using cameras (WWF Polska, SMIOUG) and not on the numerical data reported to HELCOM (SMIOUG during this period did not report this parameter). The above analysis of confidence shows that its status for grey seal within POM is medium and amounts to 0.66 (Table 2.1.16,Fig. 2.1.7).

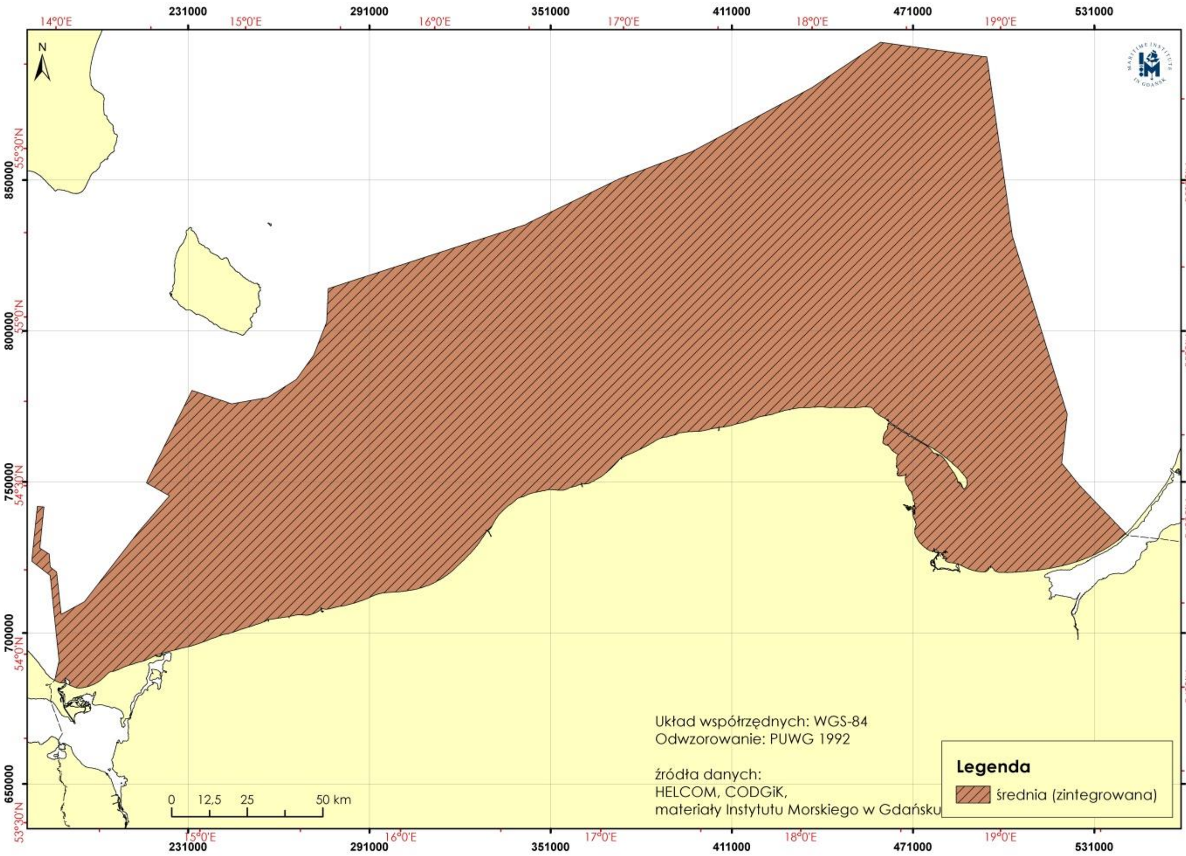



Fig. 2.1.7 Confidence of the assessment of the status of grey seals in the Polish Baltic zone for the years 2011-2016

### Assessment of harbour porpoise in 2011-2016

Harbour porpoise monitoring within the framework of the State Environmental Monitoring (PMŚ) started in POM in 2016, hence its results do not constitute the basis for the parametric assessment for the years 2011-2016. At the same time, due to the lack of agreed reference levels and indicators recommended by HELCOM and the thresholds for GES/subGES, and above all the lack of reliable data for the assessment of this species, it was excluded from the "integrated assessment of biodiversity" for the component of the "marine mammals" ecosystem, and its assessment within POM for the years 2011-2016 was made in a descriptive manner based on the 2nd holistic assessment (HELCOM 2017a).

At present, there is insufficient data on the population of the harbour porpoise for the years to be assessed, and their possible acquisition based on the algorithm developed under the SAMBAH project is, on the one hand, marked by a large error (SAMBAH 2017), on the other hand, it may refer to only up to the first season (2016), when PMŚ monitoring was carried out. Thus it is not possible to calculate, and hence, the application of the trend curve of population size, as well as calculations based on this basis. At the same time, it is not possible to use the '*The distribution of Harbour porpoise*' indicator, due to the lack of annual monitoring and literature data confirming the occurrence of the species from year to year in the areas designated for monitoring in POM.

The holistic assessment adopted entirely for harbour porpoise in the national assessment is certainly the best solution, on the one hand due to the lack of continuous monitoring in the POM allowing such a parametric assessment, on the other hand, to cover the entire populations of the Baltic and the western Baltic, of which individuals are recorded in the POM. Pointing to the legitimacy of such an approach, the main criterion was the quality of data and the possibility of using it with a high confidance ratio. It should be emphasized here that the very fact of such an approach does not mean giving up the monitoring in POM - on the contrary - the results so far indicate that only the systematic monitoring of the porpoise and in accordance with the HELCOM methodology (Michałek et al. 2016) will allow in the next years assessment of their condition in POM.

Most of the research conducted in 2011-2013 was focused on passive acoustic monitoring (SAMBAH 2017) and confirmed the presence of two harbour porpoise subpopulations in the Baltic: one occurring mainly to the east of Bornholm in the Baltic and the other, in the area of the southern Kattegat, the Danish Straits (Great Belt) and the South-West Baltic (SAMBAH 2017, Fig. 2.1.8.). Population genomics research showed noticeable differences between porpoises from the above-mentioned areas (Lah et al 2016).

Subpopulation of the Baltic harbour porpoise was considered critically endangered and placed on the HELCOM Red List (HELCOM 2013b). The number of animals in this subpopulation is estimated at approximately 500 individuals (the confidence interval of the estimation is 95% in the range of 80 - 1091 individuals). A large part of this subpopulation occurs in the summer, during mating and breeding, on shallows south-east of Gotland.

Subpopulation from the Kattegat, Great Belt and West Baltic areas was estimated at approximately 40,500 individuals (95% confidence interval for estimation between 25614 and 65041 individuals) during transect visual inspections (Viquerat et al. 2013). This subpopulation was considered to be endangered by HELCOM, but with a lower threat status referred to as "vulnerable".

Porpoises require strict protection under Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Official Journal EC 206, 22.07.1992, page 7, as amended) Polish special edition, chapter 15, vol. 2, page 102, as amended), hereinafter referred to as the "Habitats Directive", are listed in Annex IV to the Habitats Directive (animals and plants that require strict protection).

The conservation status of the porpoise population in the assessment prepared for the Habitats Directive for the years 2007-2012 was assessed as bad by all Baltic countries reporting porpoise data, i.e. Denmark, Germany, Poland and Sweden. The porpoise status in the Baltic Sea is included in the Baltic Porpoise Recovery Plan (Jastarnia Plan, ASCOBANS 2009) and in the HELCOM 17/2 recommendation (HELCOM 2013c).

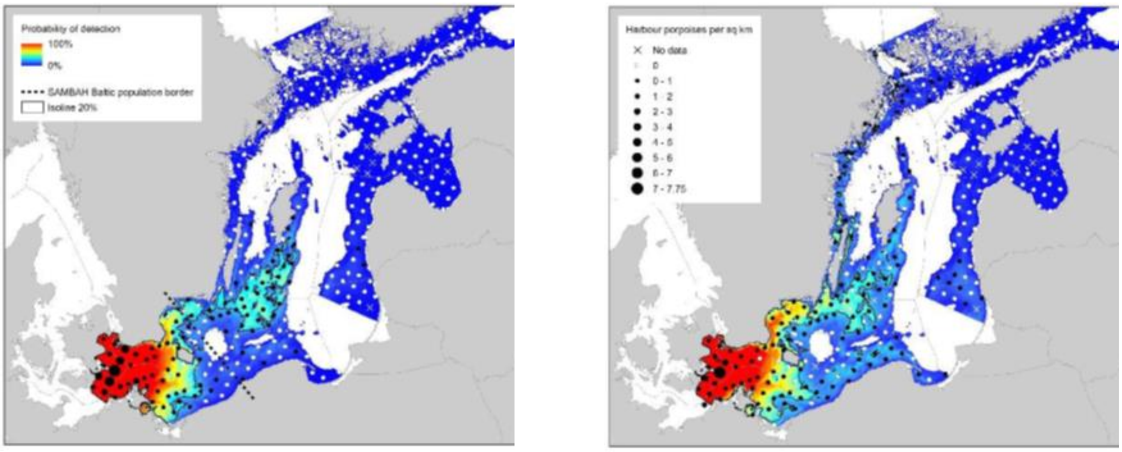



Fig. 2.1.8. Predicted probability of harbour porpoise detection in the period of May-October (left map) and November-April (right map ).Black isolines indicate the area where the probability of detection is 20% (20% isoline in the map legend separating light blue and blue), which covers the area of about 30% of the entire harbour porpoise population. This border is often used to designate areas with high density of porpoises. The dotted line on the left shows the boundary between the porpoise population from the Danish Straits (Great Belt) and the Baltic population during the May-October observation (SAMBAH 2017). It is also the border between neighbouring Baltic management areas during the summer. White area - was not tested in the SAMBAH project (Source: SAMBAH 2017)

***Birds***

### HELCOM indicators for individual basins and the entire Baltic Sea

Data obtained in individual Baltic countries, including Poland as part of monitoring programs, are aggregated by scientists cooperating with HELCOM up to three core indicators describing the state of avifauna:

1) *Abundance of waterbirds in the wintering season* (HELCOM 2018a),
2) *Abundance of waterbirds in the breeding season* (HELCOM 2018b),
3) *White-tailed eagle productivity* (HELCOM 2015a).

The results published within the assessment come from the three documents mentioned above.

The indicators meet the criteria and methodological standards for determining good environmental status (Article 9 (3) MSFD, listed in Part II of the Annex to Decision 2017/848) and should comply with the requirements of Directive 2017/845 regarding descriptors 1, 4 and 6 relating to state. The indicators recommended for the national assessment for the years 2011-2016 have been assigned to the relevant criteria in accordance with the decision 2017/848 and are presented in Table 2.1.17. Only primary criteria apply to POM.

The criterion D1C2 referring to the population size is represented by two core indicators: Abundance of water birds in the wintering season and Abundance of water birds in the breeding season. The consequence of this are two values of population indexes for 2011-2016 for species that are included in both indicators. However, according to Decision 2017/848, EU Member States should eventually provide one assessment of good environmental status for the species. Until 12.06.2018, the EC did not provide clear guidelines as to the method of integration of species results in both indicators. This report uses the OOAO method ("one-out-all-out"), and a detailed description of integration can be found in the chapter on the method of assessing the condition of birds.

Table 2.1.17. Indicators used for the assessment of avifauna in accordance with the decision 2017/848 Crit1 - primary criterion, Crit2 - secondary criterion. In the "integrated assessment of biodiversity" in 2011-2016, core indicators were used.

| Criteria elements | Descriptor | Crit1 | Crit2 | Criterion description acc. to Decision 2017/848 | Core indicator |
|---|---|---|---|---|---|
| Birds | D1 - biodiversity | D1C2 | | The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured | Abundance of waterbirds in the wintering season |
| | | | D1C4 | The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions. | |
| | D4 - Ecosystems, including food webs | | D4C1 | The diversity (species composition and their relative abundance) of the trophic guild is not adversely affected due to anthropogenic pressures. | |
| | | | D4C2 | The balance of total abundance between the trophic guilds is not adversely affected due to anthropogenic pressures. | |
| | D1 - biodiversity | D1C2 | | The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured | Abundance of waterbirds in the breeding season |
| | | | D1C3 | The population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures | |
| | | | D1C4 | The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions. | |
| | D4 - Ecosystems, including food webs | | D4C1 | The diversity (species composition and their relative abundance) of the trophic guild is not adversely affected due to anthropogenic pressures | |
| | | | D4C2 | The balance of total abundance between the trophic guilds is not adversely affected due to anthropogenic pressures. | |
| | | | D4C4 | Productivity of the trophic guild is not adversely affected due to anthropogenic pressures. | |
| Species and habitats which are at risk from contaminants | D8 - Concentrations of contaminants | D8C2 | | The health of species and the condition of habitats (such as their species composition and relative abundance at locations of chronic pollution) are not adversely affected due to contaminants including cumulative and synergetic effects. | White-tailed eagle productivity |
| | D1 - biodiversity | D1C3 | | The population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures. | |

| Criteria elements | Descriptor | Crit1 | Crit2 | Criterion description acc. to Decision 2017/848 | Core indicator |
| --- | --- | --- | --- | --- | --- |
| | | | D1C2 | The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured. | |
| | | | D1C4 | The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions. | |
| | D4 - Ecosystems, including food webs | - | D4C4 | Productivity of the trophic guild is not adversely affected due to anthropogenic pressures. | |
| | | D4C1 | | The diversity (species composition and their relative abundance) of the trophic guild is not adversely affected due to anthropogenic pressures. | |
| | | D4C2 | | The balance of total abundance between the trophic guilds is not adversely affected due to anthropogenic pressures. | |

***Indicator Abundance of waterbirds in the wintering season***

Indicator Abundance of waterbirds in the wintering season presents data on the number of 22 species of waterbirds in the reporting period covering the years 2011-2016 (Table 2.1.18). Data from Poland included in the indicator come from two monitoring programs: Monitoring of Wintering Birds of Transitional Water (31 objects located in transitional waters) and Monitoring of Wintering Sea Birds (56 transects in territorial waters). Both programs are conducted as part of the State Environmental Monitoring, coordinated by GIOŚ and financed by the National Fund for Environmental Protection and Water Management.

Table 2.1.18. Species included in the indicator of changes in the number of wintering waterbirds along with information on the functional group. Functional group: *wading, surface, pelagic, benthic, grazing* . Species are ranked in systematic order (KF 2018).

| Species | scientific name | Functional group |
|---|---|---|
| Mute swan | *Cygnus olor* | *grazing* |
| Tundra swan | *Cygnus columbianus* | *grazing* |
| Whooper swan | *Cygnus cygnus* | *grazing* |
| Steller's eider | *Polysticta stelleri* | *benthic* |
| Common goldeneye | *Bucephala clangula* | *benthic* |
| Smew | *Mergellus albellus* | *pelagic* |
| Common merganser | *Mergus merganser* | *pelagic* |
| Red-breasted merganser | *Mergus serrator* | *pelagic* |
| Common pochard | *Aythya ferina* | *benthic* |
| Tufted duck | *Aythya fuligula* | *benthic* |
| Greater scaup | *Aythya marila* | *benthic* |
| Eurasian wigeon | *Mareca penelope* | *grazing* |
| Mallard | *Anas platyrhynchos* | *grazing* |
| Pintail | *Anas acuta* | *grazing* |
| Eurasian teal | *Anas crecca* | *wading* |
| Great crested grebe | *Podiceps cristatus* | *pelagic* |
| Eurasian coot | *Fulica atra* | *grazing* |
| Black-headed gull | *Chroicocephalus ridibundus* | *surface* |
| Common gull | *Larus canus* | *surface* |
| European herring gull | *Larus argentatus* | *surface* |
| Great black-backed gull | *Larus marinus* | *surface* |
| Cormorant | *Phalacrocorax carbo* | *pelagic* |

The population of water birds wintering in the Baltic Sea is limited by a number of anthropogenic factors, the most important of which are :

- mortality due to by-catch,
- mortality caused by leaks of petroleum substances,
- mortality caused by hunting,
- reducing the area of available habitats due to disturbance by vessels and infrastructure objects,
- changes in food availability resulting from fishing exploitation of fish populations,
- eutrophication of waters affecting the structure and functioning of the food web.

Among the anthropogenic impacts causing losses in populations of individual water birds, mortality (as a result of drowning) in fishing nets is a serious problem. Estimates regarding the number of birds caught accidentally in fisheries are uncertain, but are probably 100,000-200,000 birds annually on the whole Baltic Sea (Žydelis et al. 2009). More importantly, even far less intense by-catch may still cover up to 5% of sea ducks present in the wintering season (Bellebaum et al. 2013), which causes rapid decreases in their population size.

In addition, in some Baltic countries, a large number of sea ducks, especially eider and goldeneye, are killed in hunting (Mooij 2005, Skov and others 2011). Although the number of oil spills in the Baltic Sea has decreased, there is still an oiling of the feathers and, consequently, of hypothermia and ultimately death of birds affected by this impact (Larsson and Tydén 2005; Żydelis et al. 2006). Birds also die as a result of consumption of pollutants (Broman et al. 1990, Rubarth et al. 2011, Pilarczyk et al. 2012).

Some species of water birds are susceptible to habitat loss due to human activity, which can reduce the ability of the wintering site to maintain a large population of birds. It was found that the avoidance of offshore wind farms affects the spatial distribution of birds (Petersen et al. 2011, Dierschke et al. 2016). These species, like other sea ducks, also avoid shipping routes (Bellebaum et al. 2006, Schwemmer et al. 2011). In the case of benthic species, additional habitat loss is caused by physical damage to the seabed, caused both by fishing and mining.

It should be noted that all the above-mentioned factors have a cumulative effect on populations of water birds, not only in the winter season, but also in the breeding season (e.g. affecting breeding success). On the other hand, water birds wintering in the Baltic Sea may be subject to pressure in breeding areas and during migration (OSPAR / HELCOM / ICES 2017). The cumulative impact on water birds has been analysed on the example of the red-throated and black-eyed divers (Dierschke et al. 2012). The number of wintering water birds published here combines the effects of various impacts.

**Method of data analysis**

The indicator is calculated based on data on the number of water birds in the coastal zone, provided by the International Waterbird Census (IWC) counting coordinators for HELCOM. The objects on which birds were counted were mainly sections of the sea coast, lagoons or sea bays. Poland (MZPM) and Finland are the only countries that have additionally provided data from the areas of the open sea. Ultimately (until 2018) the indicator will be based on this type of data also from other countries, and the species composition of the indicator will also include wintering species in the open sea areas. The raw data contain for each species the position code, its coordinates, the year of observation and the registered number of individuals. For objects for which calculations were carried out, data on air temperature were also obtained based on the E-OBS database (v. 13.1, Haylock et al. 2008). On this basis, the average air temperature for the entire week before the counting date recommended by the IWC was calculated.

Population indices for individual species were calculated using generalized additive models (GAM), taking into account the position effect, year and average temperature (for 7 species the models did not take into account the temperature). Then, for each species, the average value of the indicator in the years 1991-2000 was calculated, which served as a reference point (value of the indicator equal to 1). In order to calculate the index, the estimated values in each year were divided by the reference value. The values thus obtained mean that if the index is above 1, the population has increased numerically, and if below this value, it was characterized by a decrease. In the last step, the geometric mean of indicators from 2011-2016 was calculated, which was then compared with the reference value (see Method for assessing the condition of birds). Using the MSI tool in the R environment (Soldaat et al 2017), annual abundance ratios were fitted to the exponential model and the mean annual population growth rate (λ) was calculated with its standard error and 95% confidence intervals. The rate of population growth has been used to classify trends within six categories:

- strong growth (lower limit of 95%PU for is greater than 1.05),
- moderate increase (lower limit of 95%PU for λ ranges from 1.00-1.05),
- stable (lower limit of 95% 95%PU for λ is greater than 0.95 and upper limit less than 1.05),

- moderate decrease (upper limit of 95%PU for λ ranges from 0.95-1.00),
- strong decrease (upper limit of 95%PU for λ is less than 0.95),
- unspecified (the lower limit of 95%PU for λ is less than 0.95 or the upper limit is greater than 1.05, and at the same time the range includes the value 1.00).

***Indicator Abundance of waterbirds in the breeding season***

Indicator Abundance of waterbirds in the breeding season aggregates information on changes in the number of 30 species of waterbirds in the reporting period covering the years 2011-2016 (Table 2.1.19). It includes data for Poland for three species from the following programs: Cormorant Monitoring, Sandwich tern Monitoring and Dunlin Monitoring (Table 2.1.19**,** Fig. 2.1.9). These programs are conducted as part of the State Environmental Monitoring, coordinated by GIOŚ and financed by the National Fund for Environmental Protection and Water Management.

Table 2.1.19. Species included in indicator Abundance of waterbirds in the breeding season including information on whether they are breeding in Poland and which monitoring program provides information on changes in abundance in the coastal belt in Poland. Functional group: wading, surface, pelagic, benthic, grazing. Species were ranked in systematic order (KF 2018).

| Species | | Functional group | Clutches in PL | Monitoring programme |
|---|---|---|---|---|
| Mute swan | *Cygnus olor* | *grazing* | yes | - |
| barnacle goose | *Branta leucopsis* | *grazing* | no | - |
| greylag goose | *Anser anser* | *grazing* | yes | - |
| common eider | *Somateria mollissima* | *benthic* | occasionally | - |
| Velvet scoter | *Melanitta fusca* | *benthic* | no | - |
| Common merganser | *Mergus merganser* | *pelagic* | yes | - |
| Red-breasted merganser | *Mergus serrator* | *pelagic* | no | - |
| common shelduck | *Tadorna tadorna* | *wading* | yes | - |
| Tufted duck | *Aythya fuligula* | *benthic* | yes | - |
| Greater scaup | *Aythya marila* | *benthic* | no | - |
| Great crested grebe | *Podiceps cristatus* | *pelagic* | yes | - |
| Eurasian oystercatcher | *Haematopus ostralegus* | *wading* | yes | - |
| pied avocet | *Recurvirostra avosetta* | *wading* | occasionally | - |
| ringed plover | *Charadrius hiaticula* | *wading* | yes | - |
| ruddy turnstone | *Arenaria interpres* | *wading* | no | - |
| dunlin | *Calidris alpina* | *wading* | yes | MBZ, from 2007 |
| Black guillemot | *Cepphus grylle* | *pelagic* | no | - |
| Common murre | *Uria aalge* | *pelagic* | no | - |
| Razorbill | *Alca torda* | *pelagic* | no | - |
| parasitic jaeger | *Stercorarius parasiticus* | *surface* | no | - |
| Common gull | *Larus canus* | *surface* | yes | - |
| lesser black-backed gull | *Larus fuscus* | *surface* | occasionally | - |
| European herring gull | *Larus argentatus* | *surface* | yes | - |
| Great black-backed gull | *Larus marinus* | *surface* | no | - |
| Caspian tern | *Hydroprogne caspia* | *surface* | no | - |
| Sandwich tern | *Thalasseus sandvicensis* | *surface* | yes | MRC, from 2015 |

| Species | | Functional group | Clutches in PL | Monitoring programme |
|---|---|---|---|---|
| common tern | *Sterna hirundo* | *surface* | yes | - |
| Arctic tern | *Sterna paradisaea* | *surface* | no | - |
| little tern | *Sternula albifrons* | *surface* | yes | - |
| Cormorant | *Phalacrocorax carbo* | *pelagic* | yes | MKO, from 2015 |

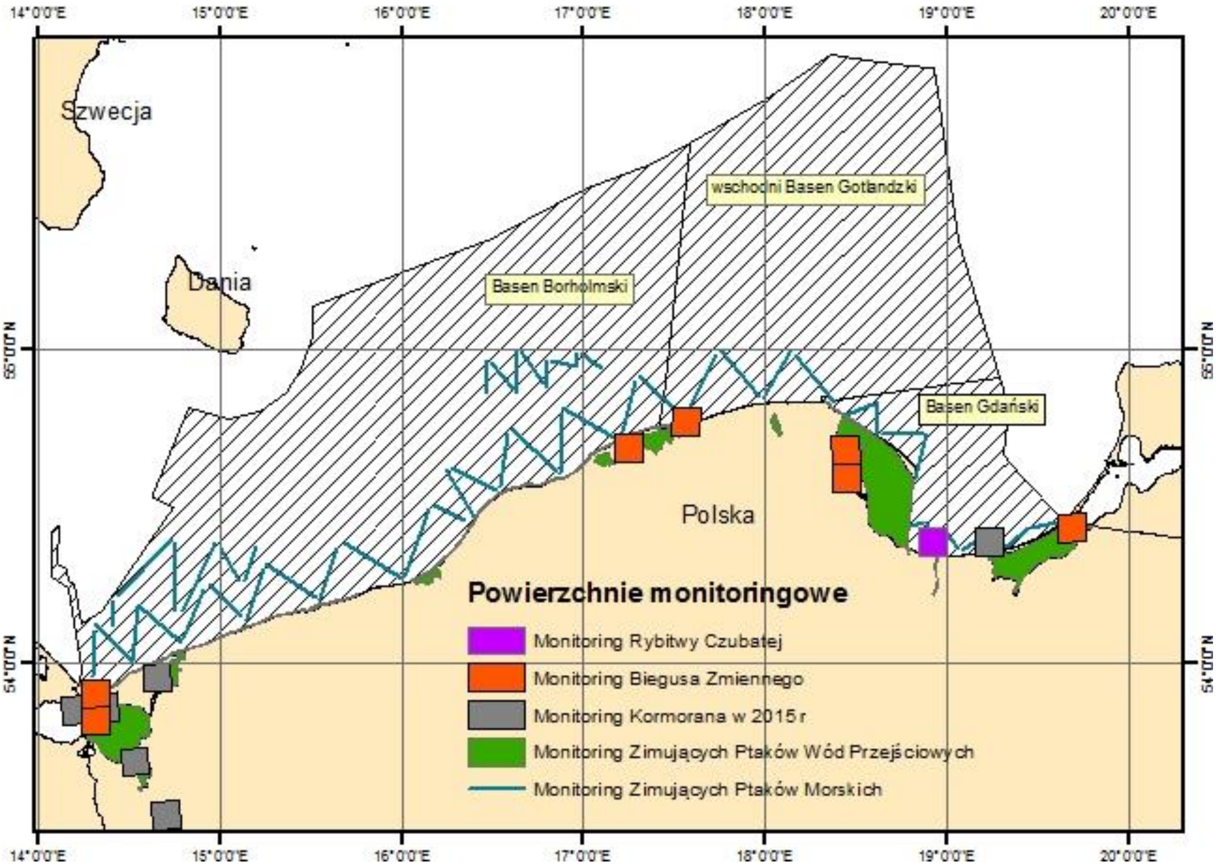



Fig. 2.1.9. Monitoring areas and transects in Bird Monitoring in Poland for Species included in the indicators used to assess the state of avifauna in POM

Populations of breeding birds, the number of which is included in the D1C2 criterion, are exposed to a number of adverse pressure factors, both anthropogenic and natural. The most important of them are:

- effective habitat loss as a result of increased human presence,
- reduced breeding success caused by scaring by people,
- eutrophication of waters affecting the structure and functioning of the food web,
- loss of habitats as a result of infrastructure development,
- loss of habitats as a result of overgrowth of coastal meadows,
- high losses of broods and adults caused by predators,
- high losses in breeding caused by catastrophic storms or high seas.

The leading factor in the loss of habitats of birds nesting on coastal beaches is the intensive recreational use of coastal areas by people. Areas intensively and frequently penetrated by humans are perceived by birds as unfit for nesting, because humans are treated as predators (Frid, Dill 2002; Beale, Monaghan 2004). As a result, nesting of key bird species is usually limited to fragments of the coast protected as reserves, where human pressure is somewhat lower. However, widespread violation of prohibitions on access to reserves results in a decrease in breeding success in these areas (GBPW Kuling, unpublished data). Ground broods are trampled by people and dogs, and the disturbance of incubating birds increases the exposure of the breeding sites to the predation of crows and gulls and possible overheating of eggs and chicks.

The breeding success of seabirds is critically low in many sites due to very high breeding losses caused by predation by American mink (invasive species) and fox, locally also hooded crow (GBPW Kuling, unpublished data). Predators' activity is facilitated by the concentration of breeding birds on small, limited areas, which are the object of intensified penetration of predators.

Habitat changes associated with overgrowth of coastal meadows are an element of rapid loss of breeding habitats of Charadriiformes birds (e.g. the dunlin). Abandonment of cattle grazing or mowing the meadows leads to rapid overgrowing of these habitats by the reed, assisted by growing eutrophication of waters (Herrmann 2011, MBZ - unpublished data).

**Method of data analysis**

The assessment is based on the number of breeding pairs of selected species of water birds, counted in breeding colonies or on trial plots. For the calculation of annual indicators and trends, raw data, provided by national monitoring programs, are used for each species. The raw data contain for each species the position code, its coordinates, the year of observation, the registered number and the unit in which it was expressed (usually breeding pairs).

TRIM program (Pannekoek and van Strien 2001) was used to calculate annual indicators and trends. For each species, a model was developed to explain the observed number using the position effect and the effect of the year. The method is based on Poisson's regression and is able to assign the values to missing observations (ter Braak et al. 1994, van Strien et al. 2001, 2004). For each year, the linear trend indicators and the average annual population growth rate (λ) were obtained along with the standard error and 95% confidence intervals. For each species, a trend category was determined based on parameter λ and its 95% confidence intervals (six categories as in the case of wintering water birds). As reference value for the trend, the average value of indicators for the years 1991-2000 was adopted and the whole series of the scale was calibrated to assume 1. As in the case of wintering birds, the geometric mean of the values of indicators from 2011-2016 was calculated, which was compared with the reference value, to determine the conservation status (see *Method for assessing the condition of birds*).

***White-tailed eagle productivity indicator***

The productivity rate of the white-tailed eagle is assessed using three reproduction parameters of the species. The breeding success, productivity (number of nestlings per nest occupied) and the number of chicks (understood as the number of nestlings with nesting success) are assessed.

Data for Poland from 2015-2016 come from the White-tailed eagle Productivity Monitoring carried out as part of the State Environmental Monitoring, coordinated by GIOŚ and financed by the National Fund for Environmental Protection and Water Management. Data from 2011-2014 are unpublished data of the Eagle Protection Committee.

The productivity of the white-tailed eagle is affected by several anthropogenic factors that affect the number of nestlings in the nest and breeding success. These are: food availability, chemical pollution, predation, weather, human disturbance near nest sites, collisions and intentional poisoning (HELCOM 2015a).

The anthropogenic pressure, which apparently affected the white-tailed eagle after its legal protection, was the introduction of dangerous chemical substances, mainly chloro-organic substances, into the environment. Their negative impact on the reproduction of white-tailed eagles has been documented well over the years and became the basis for inclusion of indicators of the breeding success of the white-tailed eagle in HELCOM indicators.

The bird tissue and egg samples contain some of the highest concentrations of organochlorine compounds (e.g. DDT and PCB) and heavy metals in the Baltic and in the world ever documented (Henriksson et al 1966, Jensen 1966, Jensen et al. 1972, Koivusaari et al. 1980, Helander 1994b, Helander et al. 1982, 2002, 2008, Olsson et al. 2000, Nordlöf et al 2010). In addition, studies of individual white-tailed eagles showed that females that were exposed to high concentrations of pollutants in the 1960s and 1970s remained unproductive after concentrations of contaminants in their eggs decreased, indicating a lasting effect from previous exposure (Helander et al 2002).

Trends in the productivity and concentration of DDE and PCB residues indicate that DDE concentrations have now fallen below the estimated critical threshold level affecting reproduction, but cases of very high concentrations appeared in 2009-2003 among white-tailed eagles from the Gulf of Bothnia.

Concentrations of brominated flame retardants were tested in samples of eggs from Sweden (Nordlöf et al 2010). Concentrations in samples from the Baltic Sea were three and six times higher than in inland samples originating from southern Sweden and Lapland, respectively.

Recent studies including data from 1965-2011 showed that the average productivity showed a statistically significant negative correlation with the content of DDE in the egg and with the index of exposure to sPCB, sDDT, sPCDD/F (Faxneld et al. 2014). There was no correlation between productivity and PBDE concentrations in eggs. In North American pandion (Pandion haliaetus) PBDE concentrations in eggs exceeding 1000 ng/g (Henny et al 2009) had an unfavourable effect on reproduction, i.e. 2-3 times higher than concentrations found in Baltic Sea eagle eggs. There was no negative correlation between productivity and PFOS in eggs (Faxneld et al. 2014). However, PFOS concentrations were in the same range as in cormorant eggs (Phalacrocorax carbo sinensis) from Lake Vänern, for which the risk assessment indicates the possibility of affecting the survival of embryos (Nordén 2013).

Particular attention should be paid to cases of poisoning of eagles as a result of the consumption of lead ammunition. Of the 11 individuals examined in Finland in 1994-2001, two (18%) died of lead poisoning (Krone et al., 2006). In Germany, reports from three overlapping periods may point to an upward trend: 12% in 1990-2000 (Krone et al 2002), 23% in 1996-2007 (Krone et al. 2009), 27% in 1999- 2010 (Herrmann et al. 2011). In Sweden, the results of the analyses did not show a decrease in the concentration of lead in 1981-2004, but showed that at least 14% of the specimens examined were fatally poisoned during this period by consuming lead ammunition (Helander et al., 2009). Preliminary results of subsequent surveys from 2005-2012 indicated a lack of improvement despite the partial ban on the use of lead ammunition since 2002, and 20% of white-tailed eagles from the coast were terminally poisoned (Helander et al., 2012). The analysis of the cause of the death of 90 dead sea eagles found in Finland in 2003-2013 showed that 30% died due to lead poisoning (Isomurso et al., 2014). All of this data suggests that lead poisoning is an important cause of marine mortality in the Baltic basin, the size and significance of which have not been fully recognized so far.

The huge development of wind farms may lead to a significant increase in mortality among white-tailed eagles and manifested in a decrease in breeding success and productivity (Dahl et al 2012), but not a reduction in the number of nestlings. Weather conditions can have an impact on breeding success and productivity, and with the possible effects of climate change should be investigated. It will also be possible to estimate the impact of conflicts between pairs of sea eagles. Recent studies in Germany have shown a significant, dependent on density, negative impact on breeding success (and thus on productivity), but no impact on the number of nestlings (Heuck and Albrecht 2012).

Theoretically, the size of brood and breeding success is also affected by shortages of food, but so far no such phenomenon has been observed in the Baltic white-tailed population.

### Data analysis method

Only data from nests for which the number of chicks was determined after climbing into the nest was used for calculations. If n0 is the number of nested nests in which no hatch or outlet has not come, n1 is the number of nests containing 1 hatchling, n2 - containing 2 hatchlings, and n3 - containing 3 hatchlings, then the parameter values were calculated as below:

*Nesting success*

Proportion of nests containing at least 1 hatchling at least 3 weeks of age from all occupied nests:

*(n1 + n2 + n3) / (n0 + n1 + n2 + n3)*

*Productivity*

The average number of chicks, at least 3 weeks old, from all occupied nests:

*(n1 + [n2x2] + [n3x3]) / (n0 + n1 + n2 + n3)*

*Number of chicks*

The average number of hatchlings at the age of at least 3 weeks in nests containing young:

*(n1 + [n2x2] + [n3x3]) / (n1 + n2 + n3)*

Only data from nests controlled by climbing into a tree was used.

**Assessment unit**

The assessment for the Baltic division units used in the 2nd holistic assessment of the environmental condition of the Baltic Sea HOLAS II is considered the most appropriate. However, in the case of several countries, subpopulations in the coastal zone of such units are too small from a statistical point of view and in such cases it is possible to combine data from neighbouring units. In Poland, the number of subpopulations inhabiting each of the two units is too low from a statistical point of view. In connection with the above, the assessment for Poland was carried out in the whole belt of the sea coast in the country.

### Method of assessing state of birds

#### *Indicators of changes in abundance of wintering and breeding waterbirds*

The assessment of the environmental status of *Abundance of waterbirds in the breeding season* and *Abundance of waterbirds in the wintering season* was determined by calculating the percentage of all species included in the indicator have species that have reached good environmental status (GES). The species achieves GES when its current abundance in relation to the reference period (1991-2000) does not differ by more than 30% (or 20% for species that lays 1 egg), i.e. at least 0,7 (or 0,8) reference quantity. Good environmental status (GES) for the indicator is achieved when these species account for ≥ 75% of all species. Deviations of the species in relation to the reference population (> 30% or > 20%) are not treated as failure to reach the threshold indicating good environmental status (GES), but should be treated as a possible manifestation of imbalance in the ecosystem. This approach is used for i) multi-species assessment or ii) assessment for individual functional groups of species. The assessment is carried out on a scale of seven geographical areas, whereby Poland concerns two: the Bornholm Basin and the Gotland Basin. In addition, the report provides the value of the indicator on the Baltic scale.

The rating for functional groups is created in MSFD in accordance with Decision 2017/848. In each case, the threshold value is considered to have been reached when the number of 75% of species is lower by ≤30% (or 20% for species lying 1 egg) from the reference value. As it is difficult to determine the reference level characteristic of the primary conditions, this level is considered as the number reached at the beginning of the data collection period (1991-2000). The population in a single year may be subject to random influences, so the average number of species in the years 1991-2000 was considered as the reference.

When the status assessment concerns groups of species, the threshold value of 75% of species whose number does not fall down by more than 30% (20% for species lying 1 egg) from the reference value is referred directly to the number of species forming the group. For marine habitats in Europe, ICES (2015) defined functional groups of species, distinguished mainly by the method of obtaining food (Table 2.1.20). OSPAR / HELCOM / ICES (2016) identified species suitable for inclusion in the breeding bird population index and the wintering birds index, and two additional species (Tundra swan and Black-headed gull) were identified in the course of the current assessment.

The indicator " *Abundance of waterbirds in the wintering season* " provides an assessment of the condition for 22 species, including:

(1) 5 benthic feeders: Steller's eider, common goldeneye, common pochard, tufted duck, greater scaup,
(2) 7 grazing feeders: mute swan, tundra swan, whooper swan, widgeon, mallard, pintail, Eurasian coot,
(3) 5 pelagic feeders: smew, goosander, red-breasted merganser, great crested grebe, cormorant,
(4) 4 surface feeders: black-headed gull, common gull, great black-backed gull, European herring gull,
(5) 1 wading feeder: common teal.

*Abundance of waterbirds in the breeding season* indicator provides an assessment of the condition for 30 species, including:

(1) 4 benthic feeders: tufted duck, scaup, common eider, velvet scoter,
(2) 3 grazing feeders: mute swan, barnacle goose, greylag goose,
(3) 7 pelagic feeders: goosander, red-breasted merganser, great crested grebe, cormorant, black guillemot, common murre, razorbill
(4) 10 surface feeders: common gull, great black-backed gull, European herring gull, lesser black-backed gull, parasitic jaeger, Caspian tern, Sandwich tern, common tern, Arctic tern, little tern,
(5) 6 wading feeders: common shelduck, oystercatcher, pied avocet, common ringed plover, ruddy turnstone, dunlin

Pursuant to Decision 2017/848, EU Member States should provide one assessment of good environmental status for the species. The results from both bird indicators have therefore been integrated using the OOAO (One-Out-All-Out) method, in which the result with the lowest rating determines the overall assessment. This means that if one of the indexes for a given species is below the good state (subGES) in the analysed period (2011-2016), the subGES assessment for the species is finally adopted. Subsequently, an assessment was made for five functional groups, according to the principle of proportionality described above, that the integrated assessment for aquatic birds is in good condition if more than 75% of species are in good condition (GES). The final step is to set an integrated assessment for Criterion D1C2 for a population of water birds in the basin scale based on the principle of proportionality (GES is achieved when ≥ 75% of species are in good condition).

Table 2.1.20. Functional groups of water birds distinguished by ICES (2015): wading feeders, surface feeders, pelagic feeders, benthic feeders, and grazing feeders.

| Group | The way of getting food | Type of food | Comments |
|---|---|---|---|
| *benthic feeders* | feeding on the bottom of the sea | invertebrates (e.g. Mollusca, urchins) | |
| *grazing feeders* | feeding in the tidal zone and in shallow water | plants (e.g. seagrasses , halophyte ), algae | geese, swans, floating ducks, coot |
| *pelagic feeders* | feeding in a wide range of water depth | pelagic and bottom fish and invertebrates (squid, zooplankton) | only species that are usually actively swimming underwater, including the sulidae/northern gannet; also includes species feeding on benthic fish (e.g. flatfish). |
| *surface feeders* | feeding in the surface (1-2 m) layer of water | small fish, zooplankton and other invertebrates | fish (eg flatfish). |
| *wading feeders* | layer of water | invertebrates (Mollusca, Polychaeta , etc.) | |

### *White-tailed eagle productivity indicator*

Good environmental status (GES) is assessed using 3 parameters of reproduction of the white-tailed eagles: breeding success, productivity and number of chicks. The assessment of the productivity of the white-tailed eagle is based on the principle: the result with the lowest rating determines the total score (OOAO), i.e. in the case of a single reproduction result of the assessment below the good state (subGES) in the analysed period, the subGES assessment is finally adopted

Individual reproduction parameters were calculated as averages for the 6-year range for 2011-2016. For the GES assessment, a comparison of the mean values of three parameters from the 2011-2016 period with the reference values is used.

The reference level was determined based on data collected on the Swedish Baltic coast (Helander 1994a, 2003): about the breeding success of 1915-1953 and the number of chicks from 1858-1950 (productivity is derived from both these parameters). Reference levels therefore refer to birds that inhabit marine ecosystems. Due to the lack of data from other regions of the Baltic Sea, the same reference level was initially applied in the index for the entire Baltic Sea zone.

**Nesting success**

Understood as a percentage of successful broods. The reference level was established on the basis of data from 43 years (1915-1953). On average, the percentage of successful broods was 72%, and the 95% confidence interval covered values ranging from 59% to 86%.

**Productivity**

The reference level for productivity (number of chicks per occupied nest) was obtained by multiplying the reference levels for the number of nestlings and breeding success. This gave the value of average productivity at 1,84 x 0,72 = 1,32, with 95% confidence interval from 1,64 x 0,59 = 0,97 to 2,04 x 0.86 = 1,75.

**Number of chicks**

The reference level for the number of chicks (in nests with success, i.e. containing cubs) was determined on the basis of ringing results and literature data covering 91 hatches from 1858-1950. The arithmetic mean of the number of chicks in this population was 1,84. The 95% confidence limits were estimated using the bootstrap method and amounted to 1,64 and 2,04.

The lower limit of the 95% confidence interval from the reference period is taken as the target value for good environmental status. The limit value for GES for breeding success was therefore 0,59 (59%), for productivity 0,97 chick, for the number of chicks – 1,64 hatchlings.

**Assessment of wintering birds in 2011-2016**

The assessment of good status was carried out for 22 species included in the indicator of abundance of wintering water birds within two basins lying partly in Polish sea waters: the Bornholm Basin and the Gotland Basin. All analyzed species occurred in the years 2011-2016 in Polish sea waters, although the abundance of 4 of them was very low (see: Monitoring of Wintering Water Bird of transitional Waters). In addition, an assessment was carried out throughout the entire Baltic Sea.

For each species information on the population trend in the years 1991-2016 in the whole Baltic Sea and the two above-mentioned basins were given (

Table 2.1.21). The results for individual species can be found in Table 2.1.22 and in Fig. 2.1.10– Fig. 2.1.31.

The assessment was made for 5 functional groups, and the results as well as the final good state assessment for POM are presented in Table 2.1.23.

Table 2.1.21 Trends in the number of wintering waterbirds across the Baltic Sea and in the Bornholm and Gotland Basins in the years 1991-2016.

| | | The entire Baltic Sea | | | Bornholm Basin | | | Gotland Basin | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Species | group | Trend | SE | Kat | Trend | SE | Kat | Trend | SE | Kat |
| Steller's eider *Polysticta stelleri** | *benthic* | 0.9222 | 0.0104 | ↓↓ | | | | | | |
| Common goldeneye *Bucephala clangula* | *benthic* | 1.0203 | 0.0014 | ↑ | 1.0099 | 0.0025 | ↑ | 1.0366 | 0.0032 | ↑ |
| Common pochard *Aythya ferina* | *benthic* | 0.9729 | 0.0031 | ↓ | 0.9687 | 0.0050 | ↓ | 0.9696 | 0.0135 | ↓ |
| Tufted duck *Aythya fuligula* | *benthic* | 0.9958 | 0.0028 | → | 1.0043 | 0.0059 | → | 1.0120 | 0.0054 | ↑ |
| Greater scaup *Aythya marila** | *benthic* | 0.9974 | 0.0033 | → | 0.9962 | 0.0048 | → | 1.0898 | 0.0201 | ↑↑ |
| Mute swan *Cygnus olor* | *grazing* | 1.0005 | 0.0011 | → | 1.0104 | 0.0018 | ↑ | 1.0223 | 0.0028 | ↑ |
| Tundra swan *Cygnus columbianus** | *grazing* | 0.9745 | 0.0233 | ? | 0.9088 | 0.0290 | ↓ | | | |
| Whooper swan *Cygnus cygnus* | *grazing* | 1.0213 | 0.0026 | ↑ | 1.0104 | 0.0038 | ↑ | 1.0590 | 0.0077 | ↑ |
| Eurasian wigeon *Mareca penelope** | *grazing* | 1.0220 | 0.0057 | ↑ | 1.0441 | 0.0070 | ↑ | | | |
| Mallard *Anas platyrhynchos* | *grazing* | 1.0045 | 0.0014 | ↑ | 1.0078 | 0.0038 | ↑ | 1.0321 | 0.0032 | ↑ |
| Pintail *Anas acuta* | *grazing* | 0.9962 | 0.0074 | → | 0.9802 | 0.0198 | ? | | | |
| Eurasian coot *Fulica atra* | *grazing* | 0.9678 | 0.0022 | ↓ | 1.0094 | 0.0047 | ↑ | 0.9806 | 0.005 | ↓ |
| Smew *Mergellus albellus** | *pelagic* | 1.0596 | 0.0042 | ↑↑ | 1.0423 | 0.0064 | ↑ | 1.0715 | 0.0084 | ↑↑ |
| Common merganser *Mergus merganser* | *pelagic* | 0.9951 | 0.0016 | ↓ | 0.9919 | 0.0032 | ↓ | 0.9921 | 0.0034 | ↓ |
| Red-breasted merganser *Mergus serrator* | *pelagic* | 0.9965 | 0.0019 | → | 0.9977 | 0.0033 | → | 1.0127 | 0.0048 | ↑ |
| Great crested grebe *Podiceps cristatus* | *pelagic* | 1.0319 | 0.0118 | ↑ | 1.0210 | 0.0040 | ↑ | 1.0470 | 0.0047 | ↑ |
| Cormorant *Phalacrocorax carbo** | *pelagic* | 1.0260 | 0.0030 | ↑ | 1.0260 | 0.0040 | ↑ | 1.0687 | 0.0157 | ↑ |
| Black-headed gull *Chroicocephalus ridibundus* | *surface* | 1.0397 | 0.0184 | ↑ | 1.0006 | 0.0036 | - | 1.0486 | 0.0404 | ? |
| Common gull *Larus canus* | *surface* | 0.9984 | 0.0043 | → | | | | 1.0619 | 0.0980 | ? |
| European herring gull *Larus argentatus* | *surface* | 1.0078 | 0.0052 | → | | | | 1.0305 | 0.0824 | ? |
| Great black-backed gull *Larus marinus** | *surface* | 1.0002 | 0.0061 | → | | | | 0.9941 | 0.0262 | ? |

| Species | group | The entire Baltic Sea Trend | SE | Kat | Bornholm Basin Trend | SE | Kat | Gotland Basin Trend | SE | Kat |
|---|---|---|---|---|---|---|---|---|---|---|
| Eurasian teal *Anas crecca* | *wading* | 0.9915 | 0.0119 | → | 1.0193 | 0.0098 | ↑ | | | |

The average annual rate of change in number (**Trend**) and standard error (**SE**) were reported for each species. No entry means that the assessment was not possible due to lack of species or very low numbers. Species marked * were modeled without temperature effects. Number trend category (**Kat**): ↑↑ – strong growth, ↑ – - moderate growth, → – stable, ↓↓ – strong decline, and, ↓ – moderate decline, ? – unspecified. Function group see Table 2.1.20.

. Species are ranked in functional groups according to the systematic order (KF 2018).

Table 2.1.22. Average values of the abundance index in 2011-2016 for 22 wintering bird species throughout the Baltic Sea, Bornholm Basin and Gotland Basin.

| Species | functional group | Indicator for 2011-2016: The entire Baltic Sea | Bornholm Basin | Gotland Basin |
|---|---|---|---|---|
| Steller's eider *Polysticta stelleri* | *benthic* | 0.223 | | |
| Common goldeneye *Bucephala clangula* | *benthic* | 1.418 | 1.064 | 1.867 |
| Common pochard *Aythya ferina* | *benthic* | 0.553 | 0.519 | 0.295 |
| Tufted duck *Aythya fuligula* | *benthic* | 0.906 | 1.05 | 1.083 |
| Greater scaup *Aythya marila* | *benthic* | 0.865 | 0.837 | 1.279 |
| Eurasian coot *Fulica atra* | *grazing* | 0.575 | 0.825 | 0.431 |
| Mute swan *Cygnus olor* | *grazing* | 0.96 | 1.178 | 1.132 |
| Tundra swan *Cygnus columbianus* | *grazing* | 0.471 | 0.537 | |
| Whooper swan *Cygnus cygnus* | *grazing* | 1.209 | 1.112 | 2.199 |
| Eurasian wigeon *Mareca penelope* | *grazing* | 1.186 | 1.61 | |
| Mallard *Anas platyrhynchos* | *grazing* | 1.075 | 1.131 | 1.778 |
| Pintail *Anas acuta* | *grazing* | 0.738 | 1.103 | |
| Smew *Mergellus albellus* | *pelagic* | 2.746 | 1.747 | 3.437 |
| Common merganser *Mergus merganser* | *pelagic* | 0.959 | 0.804 | 0.919 |
| Red-breasted merganser *Mergus serrator* | *pelagic* | 0.978 | 0.914 | 1.075 |
| Great crested grebe *Podiceps cristatus* | *pelagic* | 1.156 | 1.165 | 1.869 |
| Cormorant *Phalacrocorax carbo* | *pelagic* | 1.389 | 1.431 | 1.791 |
| Black-headed gull *Chroicocephalus ridibundus* | *surface* | 2.209 | | 4.945 |
| Common gull *Larus canus* | *surface* | 0.799 | | 0.674 |
| European herring gull *Larus argentatus* | *surface* | 1.048 | | 1.124 |
| Great black-backed gull *Larus marinus* | *surface* | 0.891 | 0.781 | 0.727 |
| Eurasian teal *Anas crecca* | *wading* | 1.479 | 1.296 | |

No entry means that the assessment was not possible due to the lack of species or very low numbers. Indicators that have achieved good environmental status (GES) are marked in green (value> 0.7) and indicators that did not reach good status (subGES) in red. Functional group see Table 2.1.20

. Species are ranked in function groups according to the systematic order (KF 2018).

**Mute swan *Cygnus olor***

The Mute Swan in 2011-2016 achieved good environmental status (GES) both on the scale of the whole Baltic Sea (value of the index 0.96), as well as within the Bornholm Basin (index value of 1.178) and Gotland Basin (index value of 1.132).

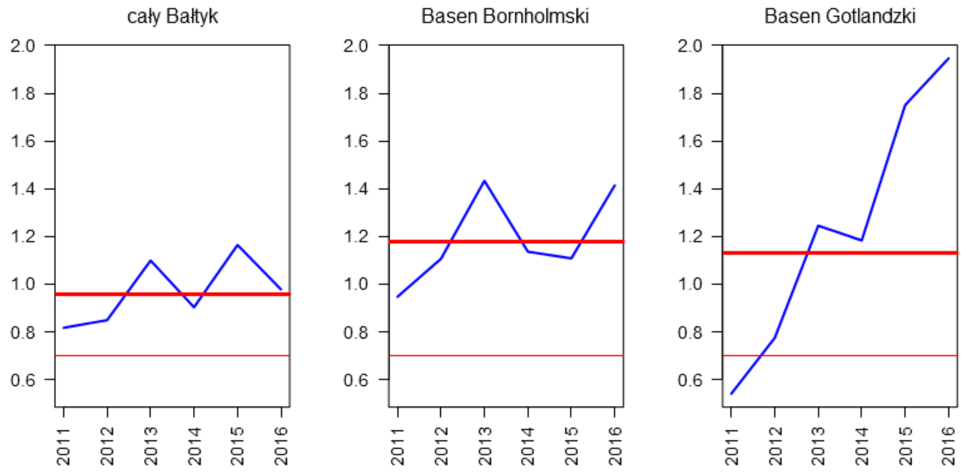



Fig. 2.1.10. Annual index values of mute swan abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good condition (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Tundra swan *Cygnus columbianus***

The tundra swan in 2011-2016 did not achieve good environmental status (GES) for the entire Baltic Sea (0.471 index value) nor within the Bornholm Basin (index value of 0.537). The species was not assessed in the Gotland Basin because of its low abundance.

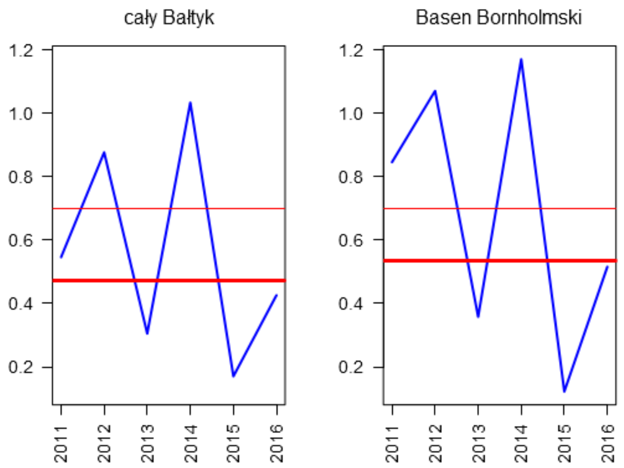



Fig. 2.1.11. Annual index values of tundra swan abundance (blue line) in the whole Baltic Sea (left) and the Bornholm Basin (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the good environmental status threshold (GES) (0.7; thin red line) (data source: PMŚ, HELCOM)

**Whooper swan *Cygnus cygnus***

The Whooper Swan in 2011-2016 achieved good environmental status (GES) both in the whole Baltic Sea area (index value of 1.209) and in the Bornholm (index value of 1.112) and Gotland basins (index value of 2.199).

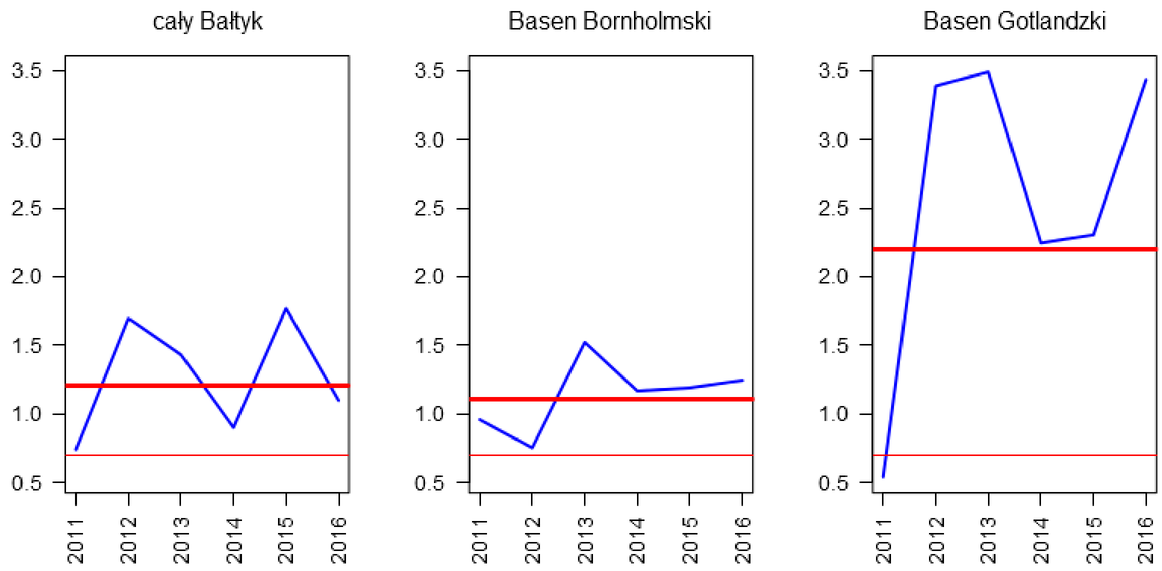



Fig. 2.1.12. Annual index values of whooper swan abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Steller's eider *Polysticta stelleri***

The abundance of Steller's eider in the entire Baltic Sea in the years 2011-2016 was below good environmental status (subGES) (index value of 0.2223). The species was not assessed on a smaller spatial scale due to the low abundance.

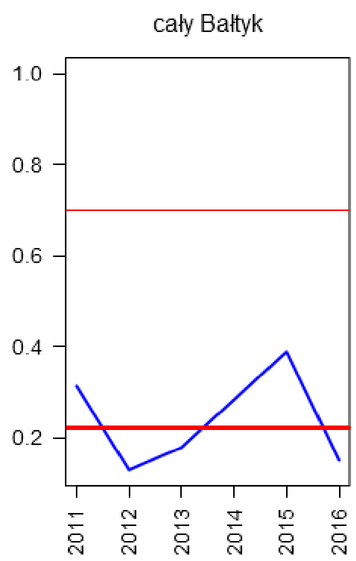



Fig. 2.1.13. Annual index values of Steller's eider abundance (blue line) in the whole Baltic Sea with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Common goldeneye *Bucephala clangula***

Common goldeneye in 2011-2016 achieved good environmental status (GES) both in the whole Baltic Sea (index value 1.418), and within two sub-basins: Bornholm Basin (index value of 1.064) and Gotland Basin (index value of 1.867).

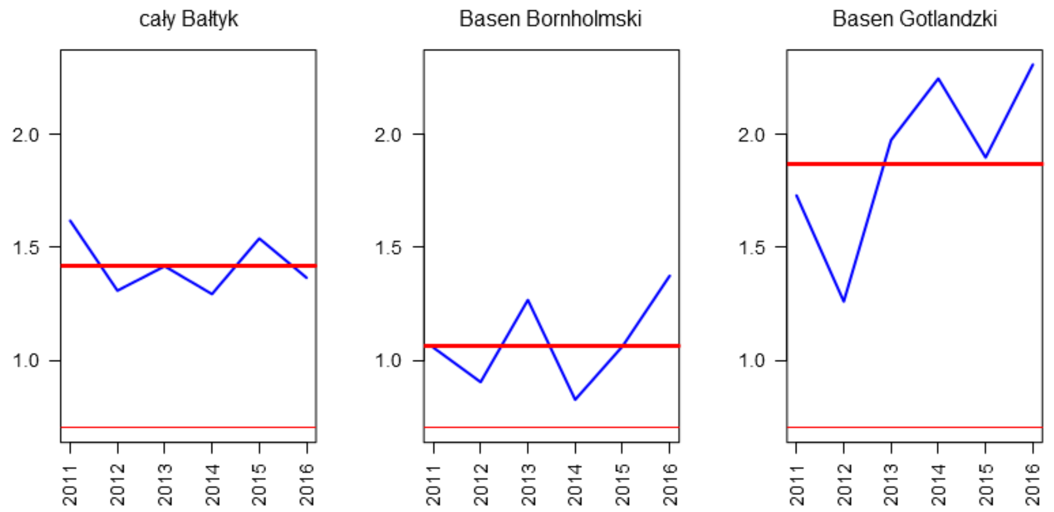



Fig. 2.1.14. Annual index values of Common goldeneye abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Smew *Mergellus albellus***

Smew in 2011-2016 achieved good environmental status (GES) both in the whole Baltic Sea (index value of 2.746) and in the following Basins: Bornholm (index value of 1.747) and Gotland (index value of 3.437).

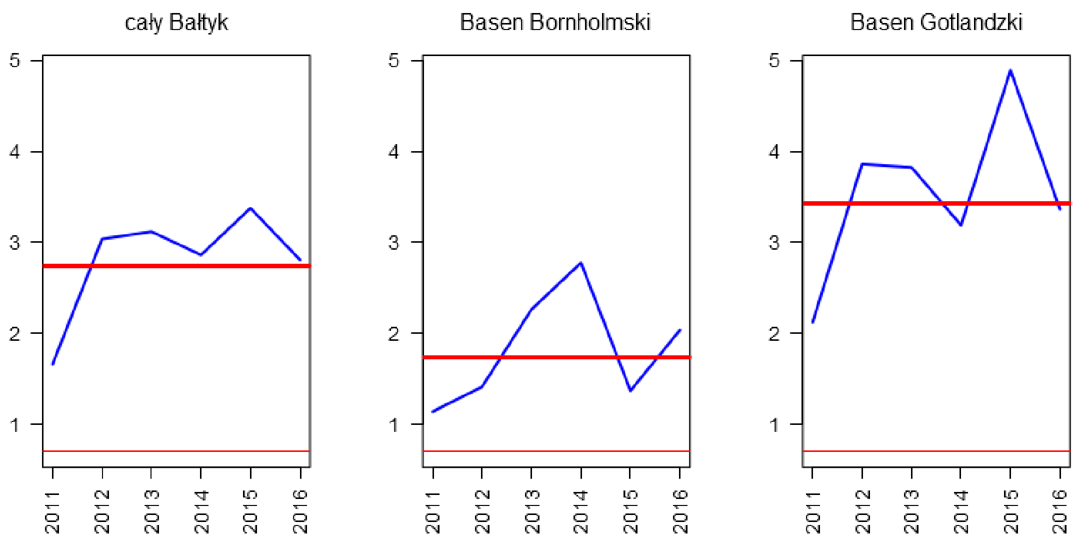



Fig. 2.1.15. Annual index values of smew abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Common merganser *Mergus merganser***

In 2011-2016, Common merganser achieved good environmental status (GES) both in the entire Baltic Sea (index value of 0.959) and in the Bornholm (0.804) and Gotland Basins (index value of 0.919).

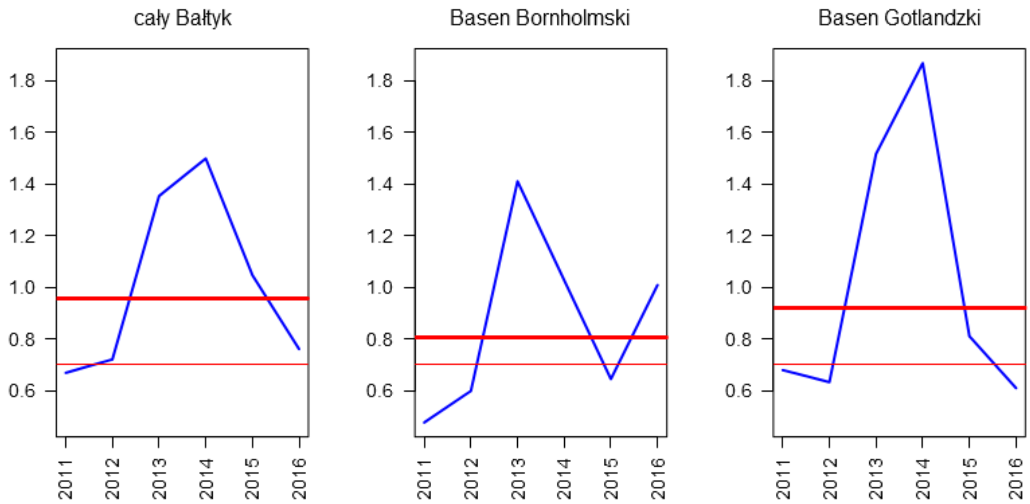



Fig. 2.1.16. Annual index values of Common merganser abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Red-breasted merganser *Mergus serrator***

In 2011-2016, the red-breasted merganser achieved good environmental status (GES) both in the entire Baltic Sea (index value of 0.978) and in the Bornholm (0.914) and Gotland Basins (1.075).

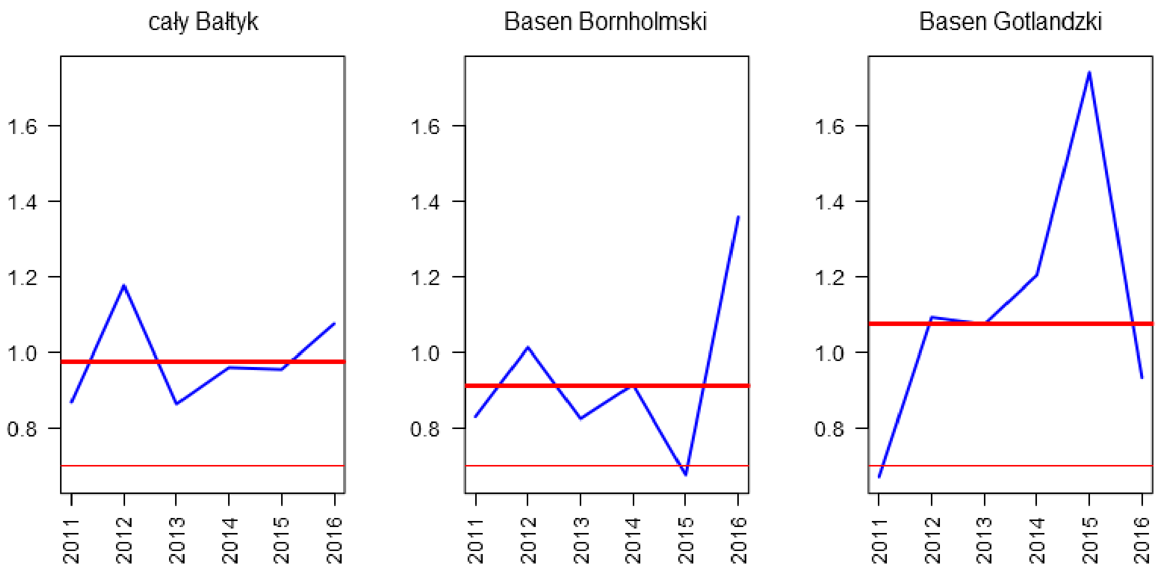



Fig. 2.1.17. Annual index values of red-breasted merganser abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Common pochard *Aythya ferina***

The abundance of the common pochard in the winter season in 2011-2016 was below the level indicating good environmental status (GES) both in the whole Baltic Sea (indicator value of 0.553), and Bornholm (indicator value of 0.519) and Gotland (indicator value of 0.295) Basins.

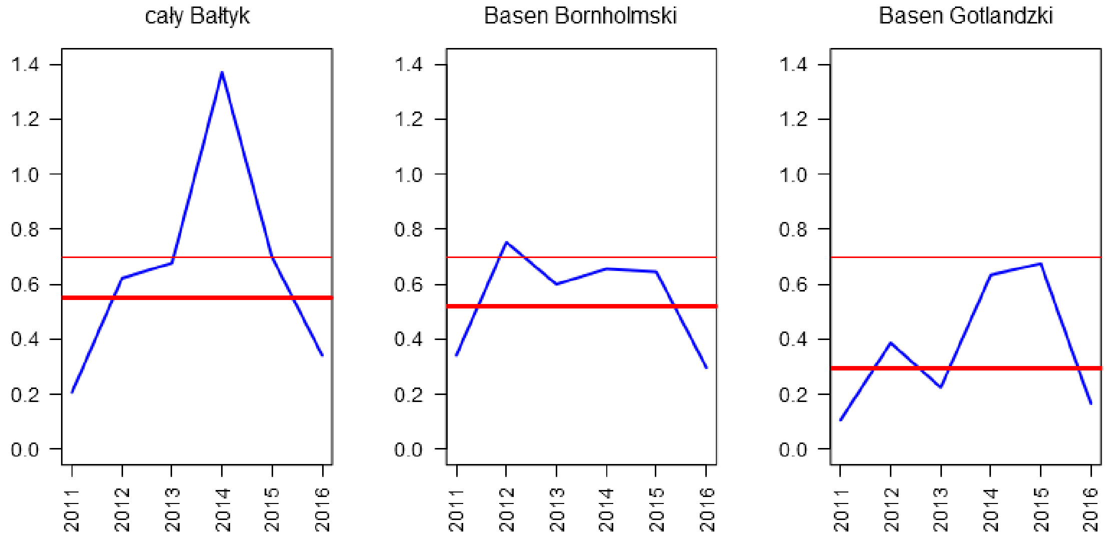



Fig. 2.1.18. Annual index values of common pochard abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0,7, thin red line) (data source: PMŚ, HELCOM)

**Tufted duck *Aythya fuligula***

In 2011-2016 tufted duck achieved good environmental status (GES) both in the entire Baltic Sea (0.906 index value) and in the Bornholm (indicator value of 1.05) and Gotland Basins (indicator value of 1.083).

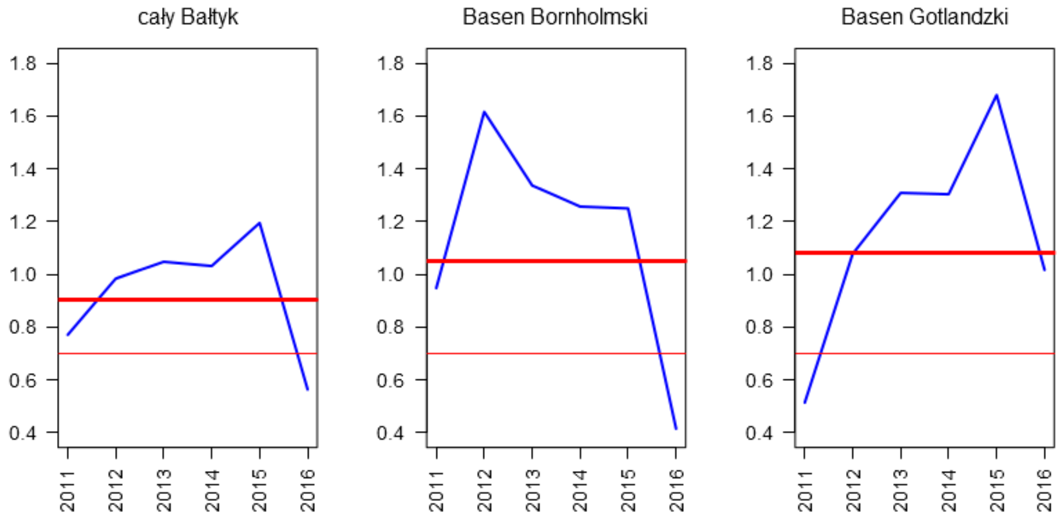



Fig. 2.1.19. Annual index values of the tufted duck abundance (blue line in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Greater scaup *Aythya marila***

In 2011-2016 the greater scaup achieved good environmental status (GES) both in the whole Baltic Sea (0.865 index value) and in the Bornholm (0.837) and Gotland (1.279) Basins.

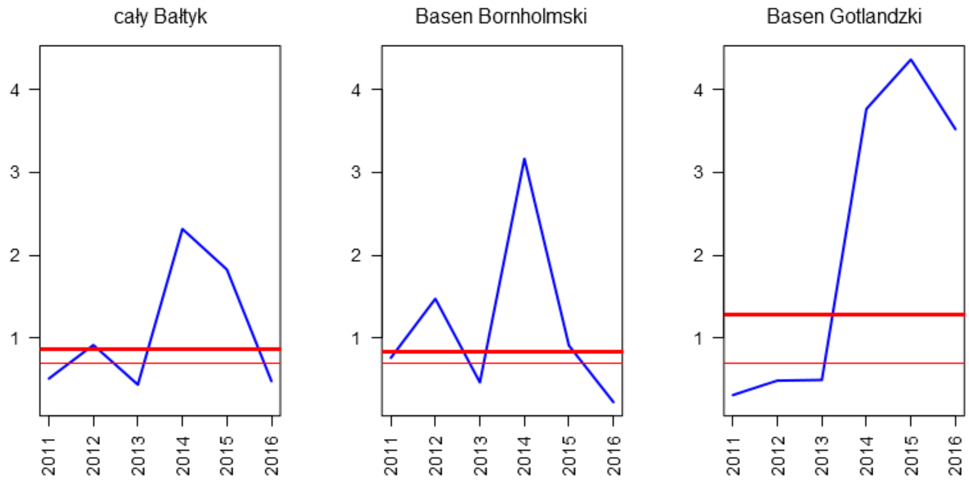



Fig. 2.1.20. Annual index values of greater scaup abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Eurasian wigeon *Mareca penelope***

Eurasian widgeon in 2011-2016 achieved good environmental status (GES) both in the scale of the entire Baltic Sea (index value of 1.186) and in the Bornholm Basin (index value of 1.61). The species was not assessed in the Gotland Basin because of its low abundance.

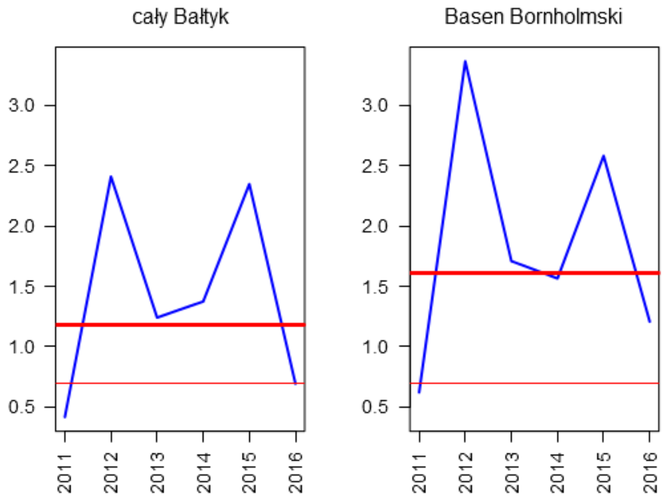



Fig. 2.1.21. Annual index values of Eurasian wigeon abundance (blue line) in the whole Baltic Sea (left) and Bornholm Basin (right) with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7; thin red line) (data source: PMŚ, HELCOM)

**Mallard *Anas platyrhynchos***

The mallard in 2011-2016 achieved good environmental status (GES) both on the scale of the entire Baltic Sea (index value 1.075), and within the following Basins: Bornholm (index value of 1.131) and Gotland (index value of 1.778).

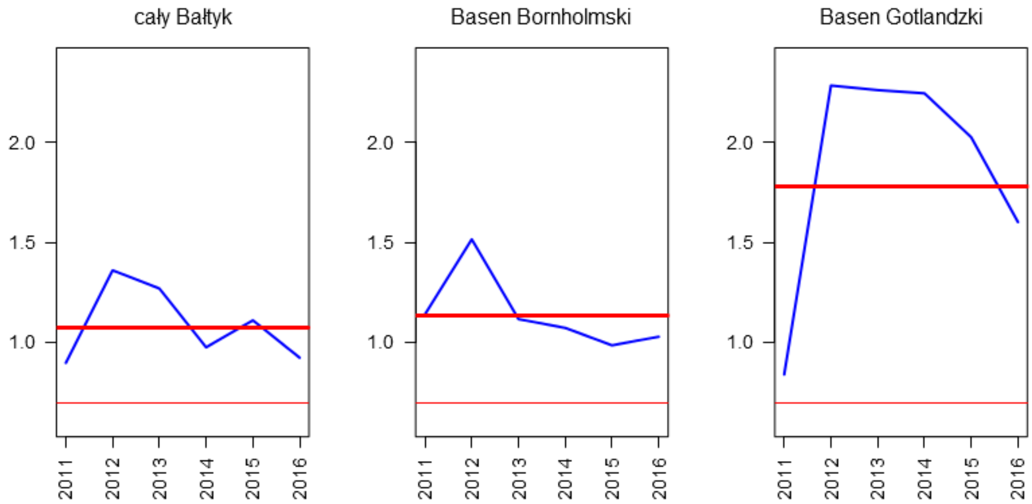



Fig. 2.1.22. Annual index values of mallard abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Pintail *Anas acuta***

In 2011-2016, pintail achieved good environmental status (GES) both in the entire Baltic Sea (0.738 index value) and in the Bornholm Basin (index value of 1.103). The species was not assessed in the Gotland Basin because of its low abundance.

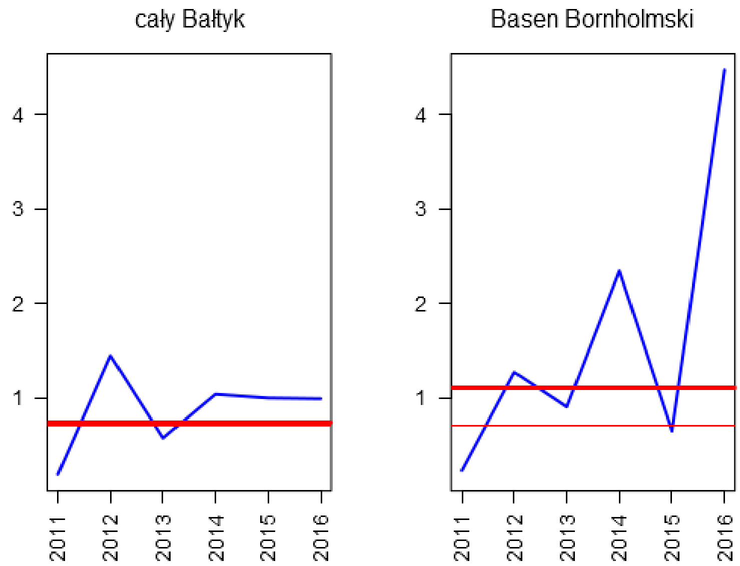



Fig. 2.1.23. Annual index values of pintail abundance (blue line) in the whole Baltic Sea (left) and Bornholm Basin (right) with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7; thin red line) (data source: PMŚ, HELCOM)

**Eurasian teal *Anas crecca***

The Eurasian teal in 2011-2016 achieved good environmental status (GES) both in the whole Baltic Sea (index value of 1.479) and in the Bornholm Basin (index value of 1.296). The species was not assessed in the Gotland Basin because of its low abundance.

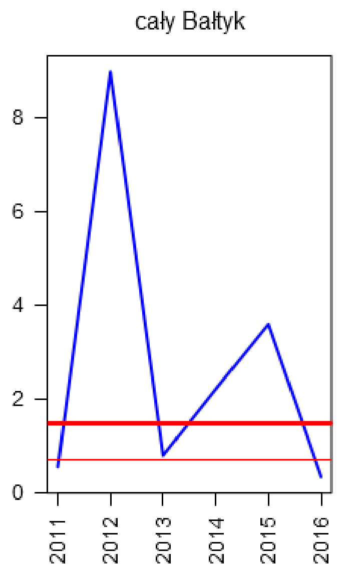



Fig. 2.1.24. Annual index values of Eurasian teal abundance (blue line) in the whole Baltic Sea (left) and Bornholm Basin (right) with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7; thin red line) (data source: PMŚ, HELCOM)

**Great crested grebe *Podiceps cristatus***

The great crested grebe in 2011-2016 achieved good environmental status (GES) both in the entire Baltic Sea (index value of 1.156) and within two Basins: Bornholm (index value 1.165) and Gotland (index value 1.869).

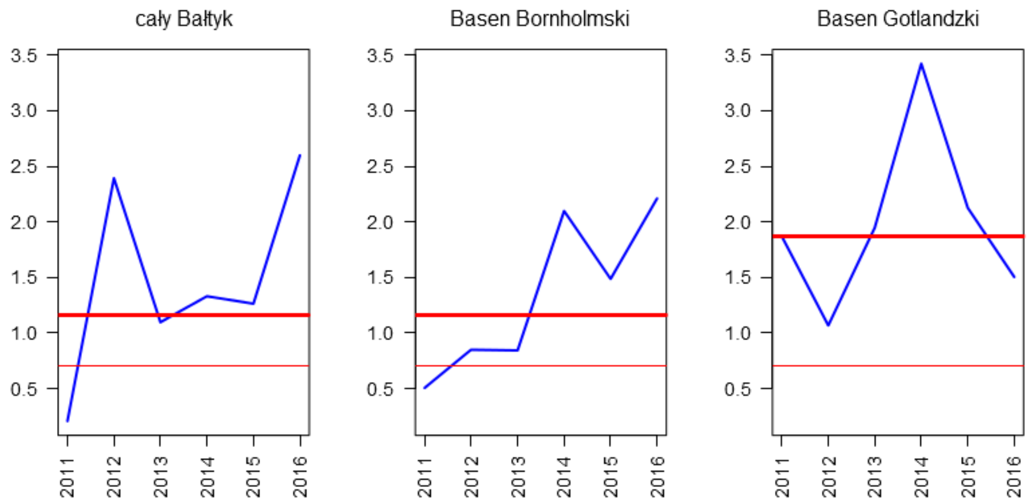



Fig. 2.1.25. Annual index values of great crested grebe abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Eurasian coot *Fulica atra***

In 2011-2016, the Eurasian coot achieved good environmental status (GES) only within the Bornholm Basin (index value 0.825). The values of the indicator in the entire Baltic Sea (0.575) and the Gotland Basin (0.431) were below the GES threshold.

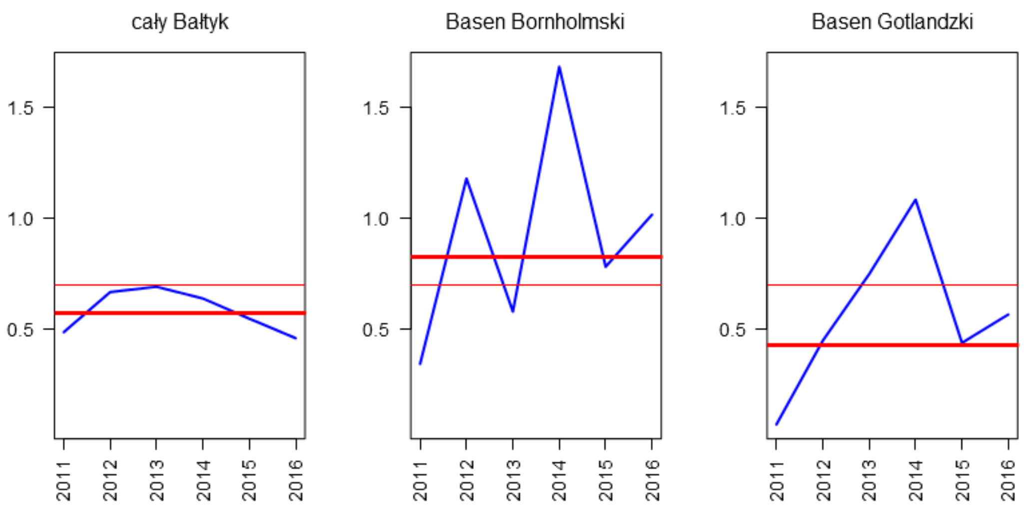



Fig. 2.1.26 Annual index values of the Eurasian coot abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Black-headed gull *Chroicocephalus ridibundus***

The black-headed gull in 2011-2016 achieved good environmental status (GES) both in the whole Baltic Sea (index value 2.209) and in the Gotland Basin (index value 4.945). The species was not assessed in the Bornholm Basin due to its low abundance.

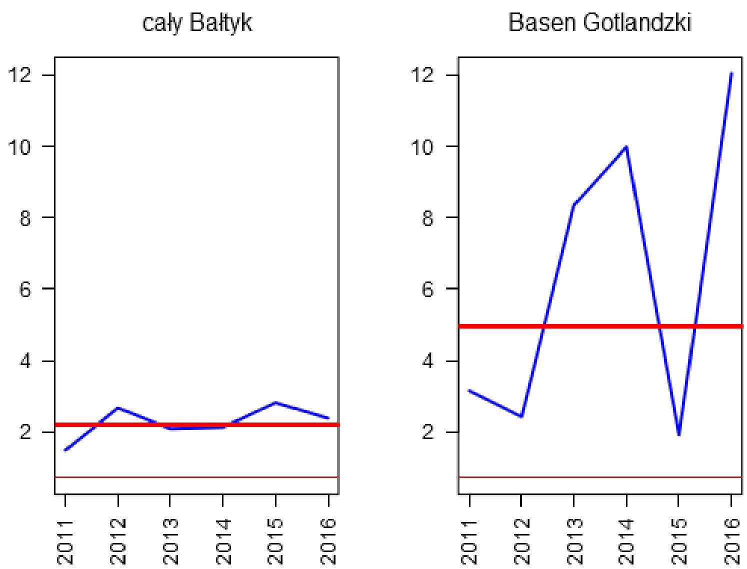



Fig. 2.1.27. Annual index values of the black-headed gull abundance (blue line) in the whole Baltic Sea (left) and Gotland Basin (right) with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7; thin red line) (data source: PMŚ, HELCOM)

**Common gull *Larus canus***

In 2011-2016, the common gull achieved good environmental status (GES) in the entire Baltic Sea (0.799 index value). Within the Gotland Basin the abundance of common gulls was below the limit of GES (index value 0.674). The species was not assessed in the Bornholm Basin due to its low abundance.

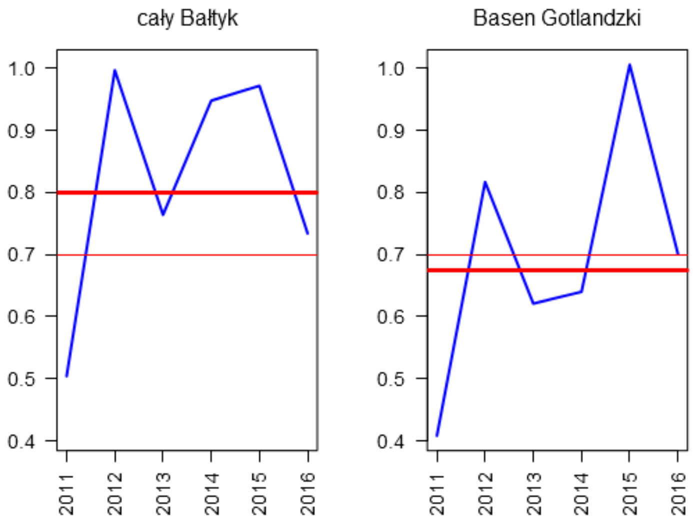



Fig. 2.1.28. Annual index values of common gull abundance (blue line) in the whole Baltic Sea (left) and Gotland Basin (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7; thin red line) (data source: PMŚ, HELCOM)

**European herring gull *Larus argentatus***

The European herring gull in 2011-2016 achieved good environmental status (GES) both in the entire Baltic Sea (index value 1.048) and in the Gotland Basin (index value 1.124). The species was not assessed in the Bornholm Basin due to its low abundance.

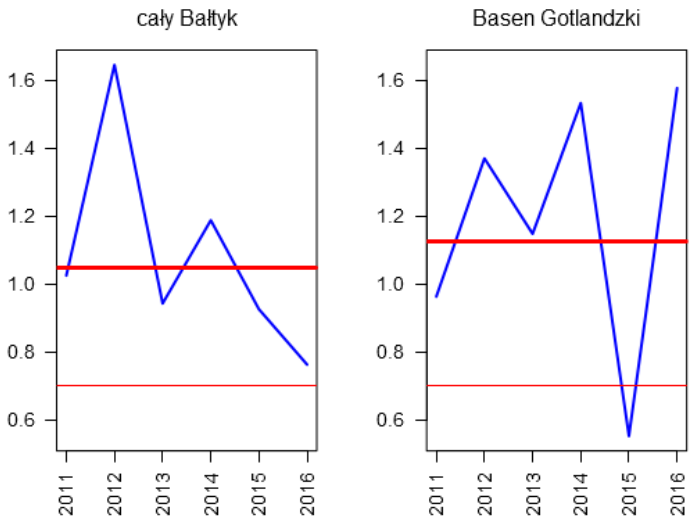



Fig. 2.1.29. Annual index values of the European herring gull abundance (blue line) in the whole Baltic Sea (left) and Gotland Basin (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7; thin red line) (data source: PMŚ, HELCOM)

**Great black-backed gull *Larus marinus***

In 2011-2016, the great black-backed gull achieved good environmental status (GES) both in the entire Baltic Sea (index value 0.891) and in the Bornholm (0.781) and Gotland Basins (0.727 index value).

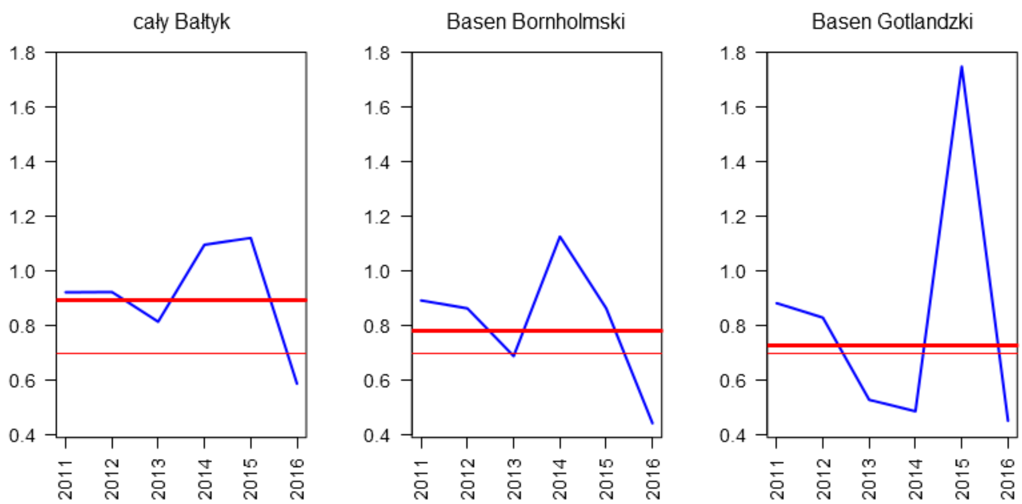



Fig. 2.1.30. Annual index values of great black-backed gulls abundance (blue line in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Cormorant *Phalacrocorax carbo***

The great cormorant in 2011-2016 achieved good environmental status (GES) both in the scale of the entire Baltic Sea (index value 1.389) and in the Bornholm (indicator value 1.431) and Gotland (1.791 index value) Basins.

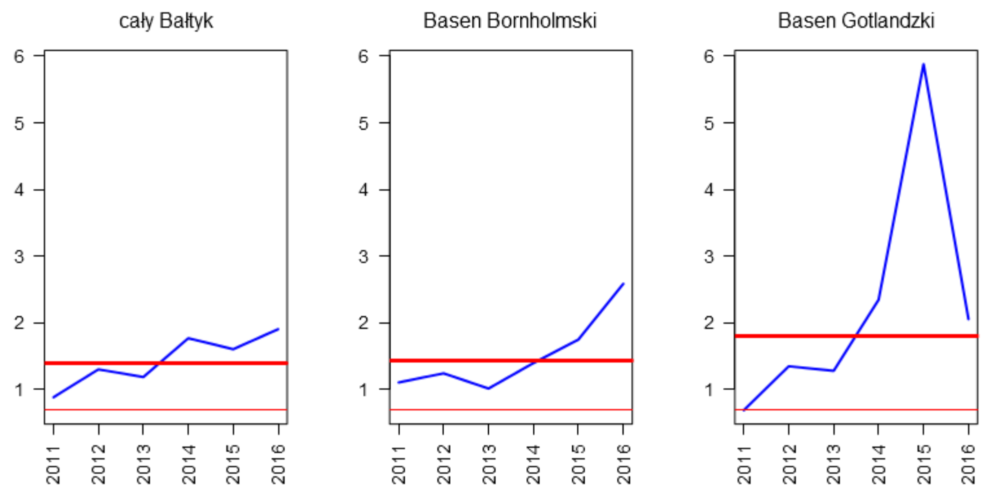



Fig. 2.1.31. Annual index values of the great cormorant abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the good environmental status (GES) threshold (0.7, thin red line) (data source: PMŚ, HELCOM)

Within the Bornholm Basin, 16 of the 18 species found there (89%) achieved good environmental status. In the Gotland basin, 14 out of 17 species (82%) achieved good status. This means that the number of wintering waterbirds in both studied basins covering Polish sea waters has reached a good state (GES threshold is 75%, Table 2.1.23). A similar analysis was also made for each of the 5 functional groups. In both of the basins studied, the indicators for functional groups reached a good status (Table 2.1.23).

In the whole Baltic Sea, the indicator also achieved good environmental status (GES), as 18 out of 22 studied species were in good status (82%). *Wading feeders, surface feeders* and *pelagic feeders* have achieved good status, while *benthic feeders* and *grazing feeders* are below the good environmental status boundary (Table 2.1.23).

Table 2.1.23. Average values of indicator of Abundance of waterbirds in the wintering season in 2011-2016 for all species and 5 functional groups: throughout the Baltic Sea, Bornholm Basin and Gotland Basin.

| Type of indicator | Entire Baltic Sea | Bornholm Basin | Gotland Basin |
|---|---|---|---|
| all species | 0.82 | 0.89 | 0.82 |
| *benthic feeders* | 0.60 | 0.75 | 0.75 |
| *grazing feeders* | 0.71 | 0.86 | 0.75 |
| *pelagic feeders* | 1.00 | 1.00 | 1.00 |
| *surface feeders* | 1.00 | 1.00 | 0.75 |
| *wading feeders* | 1.00 | 1.00 | |

No entry means that the assessment was not possible due to lack of species or very low abundance. Indicators that achieved good environmental status (GES) were marked in green (value ≥0.75) and indicators that did not reach good status (subGES) in red. Function group see Table 2.1.20.

### Assessment of breeding birds in 2011-2016

The assessment of good environmental status was carried out for 30 species included in *Abundance of waterbirds in the breeding season* indicator within two areas - the Bornholm and Gotland Basins and additionally within the entire Baltic Sea. The assessment was also made for 5 functional groups.

For each species information on the population trend in the years 1991-2016 in the whole Baltic Sea and the two above-mentioned basins were given (Table 2.1.24**)**

The results for individual species can be found in Table 2.1.25 and in Fig. 2.1.32-Fig. 2.1.61.

Table 2.1.24 Trends in changes of Abundance of waterbirds in the breeding season index in the entire Baltic Sea, Bornholm Basin and Gotland Basin in 1991-2016. (data source: PMŚ, HELCOM)

| | | Entire Baltic Sea | | | Bornholm Basin | | | Gotland Basin | | |
|---|---|---|---|---|---|---|---|---|---|---|
| species | Group | Trend | SE | Kat | Trend | SE | Kat | Trend | SE | Kat |
| common eider<br>*Somateria mollissima* | *benthic* | 0.8963 | 0.0031 | ↓↓ | 1.0185 | 0.009 | ↑ | 0.9285 | 0.0026 | ↓↓ |
| Velvet scoter<br>*Melanitta fusca* | *benthic* | 0.9639 | 0.0045 | ↓ | | | | 0.963 | 0.0031 | ↓ |
| **Tufted duck**<br>***Aythya fuligula*** | ***benthic*** | **1.0173** | **0.0036** | ↑ | **0.9745** | **0.0113** | ↓ | **1.0072** | **0.0029** | ↑ |
| Greater scaup<br>*Aythya marila* | *benthic* | | | | | | | 0.9617 | 0.044 | ? |
| **Mute swan**<br>***Cygnus olor*** | ***grazing*** | **1.036** | **0.0023** | ↑ | **0.9893** | **0.0035** | ↓ | **1.0124** | **0.0017** | ↓ |
| barnacle goose<br>*Branta leucopsis* | *grazing* | 0.9453 | 0.01 | ↓ | | | | | | |
| **greylag goose**<br>***Anser anser*** | ***grazing*** | **0.9888** | **0.0029** | ↓ | **1.0447** | **0.0079** | ↑ | **1.0124** | **0.0026** | ↑ |
| **Common merganser**<br>***Mergus merganser*** | ***pelagic*** | **0.9889** | **0.0044** | ↓ | **1.0647** | **0.0179** | ↑ | **0.9939** | **0.0021** | ↓ |
| Red-breasted merganser<br>*Mergus serrator* | *pelagic* | 1.0159 | 0.0031 | ↑ | 0.9635 | 0.0045 | ↓ | 1.0085 | 0.0048 | → |
| **Great crested grebe**<br>***Podiceps cristatus*** | ***pelagic*** | **1.0697** | **0.01** | ↑ | **1.0368** | **0.0121** | ↑ | **1.0576** | **0.007** | ↑ |
| Black guillemot<br>*Cepphus grylle* | *pelagic* | 0.9348 | 0.0202 | ↓ | | | | 1.0432 | 0.0094 | ↑ |
| Common murre<br>*Uria aalge* | *pelagic* | 1.05 | 0.0128 | ↑ | 0.9035 | 0.329 | ? | 1.0359 | 0.0127 | ↑ |

| species | Group | Entire Baltic Sea Trend | SE | Kat | Bornholm Basin Trend | SE | Kat | Gotland Basin Trend | SE | Kat |
|---|---|---|---|---|---|---|---|---|---|---|
| Razorbill *Alca torda* | *pelagic* | 1.0597 | 0.0051 | ↑ | 0.9744 | 0.0464 | ? | 1.0085 | 0.0037 | ↑ |
| **Cormorant *Phalacrocorax carbo*** | ***pelagic*** | **1.0531** | **0.0129** | **↑** | **1.0108** | **0.0067** | **→** | **1.0019** | **0.0035** | **→** |
| parasitic jaeger *Stercorarius parasiticus* | *surface* | | | | | | | 1.011 | 0.0093 | → |
| **Common gull *Larus canus*** | ***surface*** | **1.0011** | **0.0025** | **→** | **0.955** | **0.0033** | **↓** | **0.9846** | **0.0034** | **↓** |
| lesser black-backed gull *Larus fuscus* | *surface* | 0.9014 | 0.0136 | ↓↓ | 1.0952 | 0.0175 | ↑↑ | 1.0028 | 0.0113 | → |
| **European herring gull *Larus argentatus*** | ***surface*** | **0.9439** | **0.0026** | **↓↓** | **1.0055** | **0.0031** | **→** | **0.9988** | **0.0032** | **→** |
| Great black-backed gull *Larus marinus* | *surface* | 0.9352 | 0.0021 | ↓↓ | 1.0548 | 0.0177 | ↑ | 0.9439 | 0.0018 | ↓↓ |
| Caspian tern *Hydroprogne caspia* | *surface* | 1.0076 | 0.009 | → | 0.9037 | 0.0291 | ↓ | 1.0099 | 0.0074 | → |
| **Sandwich tern *Thalasseus sandvicensis*** | ***surface*** | | | | **0.9652** | **0.0175** | **?** | **1.016** | **0.0071** | **↑** |
| **common tern *Sterna hirundo*** | ***surface*** | **1.0628** | **0.0061** | **↑** | **0.9772** | **0.0052** | **↓** | **1.0614** | **0.0263** | **↑** |
| Arctic tern *Sterna paradisaea* | *surface* | 1.0503 | 0.0042 | ↑ | 0.9407 | 0.0068 | ↓ | 1.0338 | 0.0057 | ↑ |
| **little tern *Sternula albifrons*** | ***surface*** | **1.0154** | **0.0111** | **→** | **0.9921** | **0.0064** | **→** | **0.9954** | **0.0036** | **→** |
| **common shelduck *Tadorna tadorna*** | ***wading*** | **0.962** | **0.0054** | **↓** | **1.0003** | **0.0045** | **→** | **0.9976** | **0.0027** | **→** |
| **Eurasian oystercatcher *Haematopus ostralegus*** | ***wading*** | **0.9979** | **0.0019** | **→** | **0.982** | **0.0033** | **↓** | **1.0148** | **0.003** | **↑** |
| pied avocet *Recurvirostra avosetta* | *wading* | 0.9596 | 0.0167 | ↓ | 0.9805 | 0.006 | ↓ | 0.979 | 0.0031 | ↓ |
| **ringed plover *Charadrius hiaticula*** | ***wading*** | **1.0166** | **0.0036** | **↑** | **0.9799** | **0.0041** | **↓** | **1.0019** | **0.01** | **→** |
| ruddy turnstone *Arenaria interpres* | *wading* | 0.9374 | 0.0051 | ↓↓ | | | | 0.9452 | 0.0031 | ↓ |
| dunlin *Calidris alpina* | *wading* | 0.9116 | 0.0274 | ↓↓ | 0.8806 | 0.0117 | ↓↓ | 0.9072 | 0.0077 | ↓↓ |

The average annual rate of change in number (**Trend**) and standard error (**SE**) were reported for each species. Species that regularly nest in Poland during the study period have been bolded. No entry means that the assessment was not possible due to lack of species or very low numbers. Abundance trend category (**Kat**): ↑↑ – strong growth, ↑ – moderate growth, → – stable, ↓↓ – strong decline, and, ↓ – moderate decline, ? – unspecified. Function group see Table 2.1.20
Species ranked in function groups according to the systematic order (KF 2018).

Table 2.1.25. Average values of indicators in 2011-2016 for the assessment of good status for 30 bird breeding species throughout the Baltic Sea, Bornholm Basin and Gotland Basin. (data source: PMŚ, HELCOM)

| Species | Functional group | Indicator values for 2011-2016 The entire Baltic Sea | Bornholm Basin | Gotland Basin |
|---|---|---|---|---|
| common eider *Somateria mollissima* | benthic | 0.973 | 1.442 | 0.131 |
| Velvet scoter *Melanitta fusca* | benthic | 0.521 | | 0.495 |
| **Tufted duck *Aythya fuligula*** | **benthic** | **1.214** | **0.598** | **1.438** |
| Greater scaup *Aythya marila* | benthic | 1.159 | | |
| **Mute swan *Cygnus olor*** | **grazing** | **1.188** | **0.749** | **1.834** |
| barnacle goose *Branta leucopsis* | grazing | | | 0.315 |
| **greylag goose *Anser anser*** | **grazing** | **1.219** | **2.1** | **0.843** |
| **Common merganser *Mergus merganser*** | **pelagic** | **0.858** | **1.875** | **0.852** |
| Red-breasted merganser *Mergus serrator* | pelagic | 0.973 | 0.522 | 1.309 |
| **Great crested grebe *Podiceps cristatus*** | **pelagic** | **2.759** | **1.791** | **3.067** |
| Black guillemot *Cepphus grylle* | pelagic | 2.063 | | 0.284 |
| Common murre *Uria aalge* | pelagic | 1.721 | 0.088 | 2.306 |
| Razorbill *Alca torda* | pelagic | 1.143 | 0.465 | 2.442 |
| **Cormorant *Phalacrocorax carbo*** | **pelagic** | **0.977** | **1.154** | **2.05** |
| parasitic jaeger *Stercorarius parasiticus* | surface | 1.188 | | |
| **Common gull *Larus canus*** | **surface** | **0.752** | **0.423** | **1.049** |
| lesser black-backed gull *Larus fuscus* | surface | 0.973 | 4.401 | 0.141 |
| **European herring gull *Larus argentatus*** | **surface** | **0.948** | **1.097** | **0.351** |
| Great black-backed gull *Larus marinus* | surface | 0.327 | 1.669 | 0.273 |
| Caspian tern *Hydroprogne caspia* | surface | 1.176 | 0.124 | 1.186 |
| **Sandwich tern *Thalasseus sandvicensis*** | **surface** | **1.445** | **0.486** | |
| **common tern *Sterna hirundo*** | **surface** | **2.919** | **0.69** | **3.298** |
| Arctic tern *Sterna paradisaea* | surface | 1.894 | 0.307 | 2.62 |
| **little tern *Sternula albifrons*** | **surface** | **0.951** | **0.878** | **1.242** |
| **common shelduck *Tadorna tadorna*** | **wading** | **0.996** | **1.033** | **0.498** |
| **Eurasian oystercatcher *Haematopus ostralegus*** | **wading** | **1.284** | **0.719** | **0.964** |
| pied avocet *Recurvirostra avosetta* | wading | 0.623 | 0.677 | 0.523 |
| **ringed plover *Charadrius hiaticula*** | **wading** | **1.027** | **0.699** | **1.285** |
| ruddy turnstone *Arenaria interpres* | wading | 0.377 | | 0.31 |
| dunlin *Calidris alpina* | wading | 0.151 | 0.092 | 0.093 |

Species that regularly nest in Poland during the study period have been bolded. No entry means that the assessment was not possible due to the lack of species or very low numbers. Indicators that have achieved good environmental status (GES) are marked in green (value ≥ 0.7, and for species consisting of 1 egg per year - 0.8), and indicators that did not reach good status (subGES) in red. Function group see Table 2.1.20
Species in function groups according to the systematic order (KF 2018).

**Mute swan *Cygnus olor***

The mute swan in 2011-2016 achieved good environmental status (GES) both in the entire Baltic Sea (index value 1.188) and in the Bornholm and Gotland Basins (index values 0.479 and 1.834, respectively). This species is breeding on the Polish coast of the Baltic Sea, but it is not monitored by the breeding population in the coast. The data comes from other Baltic countries.

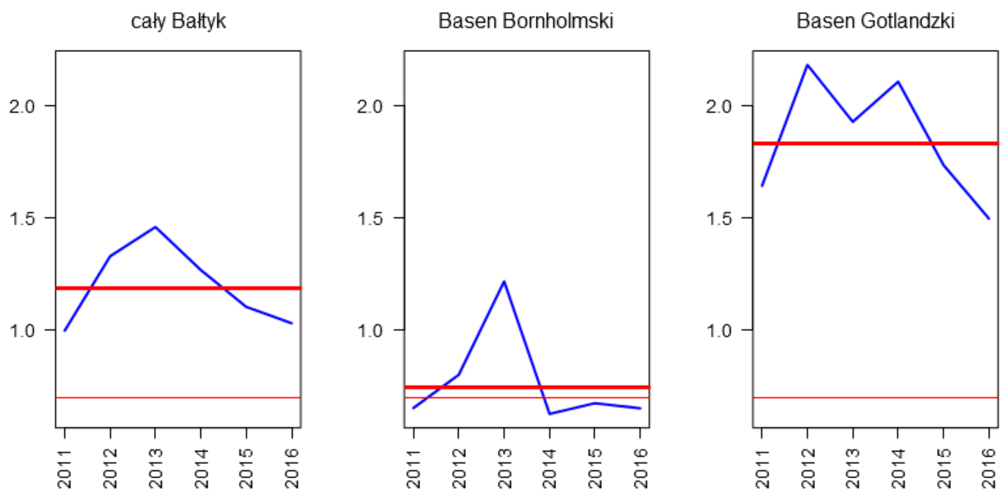



Fig. 2.1.32. Annual index values of mute swan abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Barnacle goose *Branta leucopsis***

Barnacle goose is a northern species of geese that does not breed in Poland. At the Baltic Sea, it is breeding only in the Gotland Basin. In 2011-2016, it did not achieve good environmental status (GES), as the index value was 0.315.

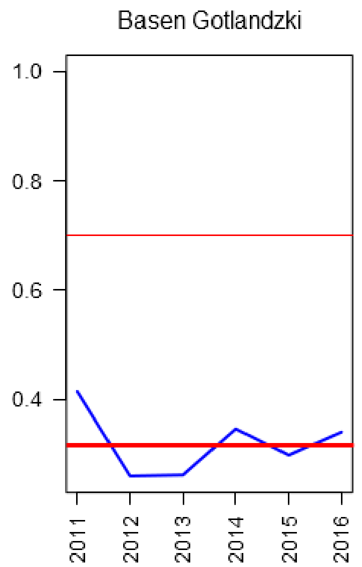



Fig. 2.1.33. Annual index values of the barnacle goose abundance (blue line) in the Gotland Basin together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7; thin red line ) (data source: PMŚ, HELCOM)

**Greylag goose *Anser anser***

Greylag goose in 2011-2016 achieved good environmental status (GES) both in the whole Baltic Sea (index 1.219) and in the Bornholm and Gotland Basins (index values 2.1 and 0.843 respectively). This species is breeding on the Polish coast of the Baltic Sea, but it is not monitored within the monitoring of the breeding population in the coastal belt. The data comes from other Baltic countries.

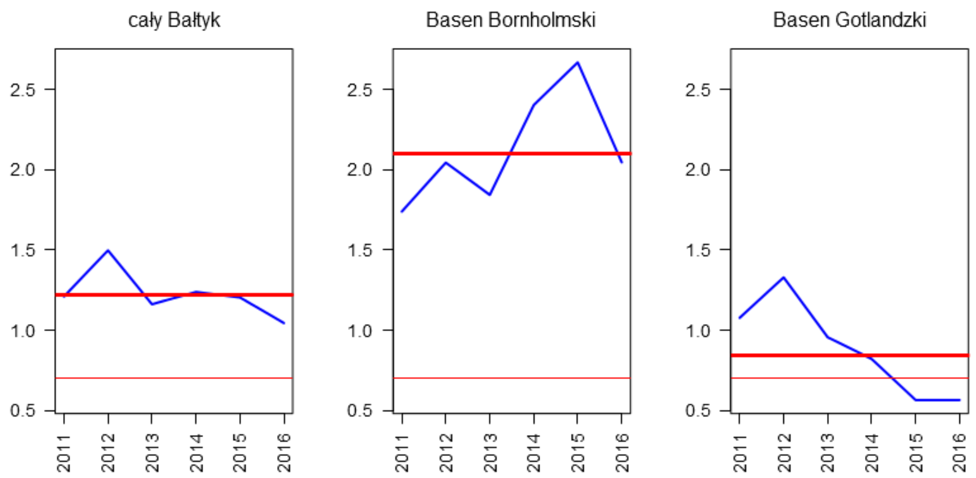



Fig. 2.1.34. Annual index values of greylag goose abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Common eider *Somateria molissima***

Common eider achieved good environmental status (GES) in the entire Baltic Sea (index value 0.973) and within the Bornholm Basin in 2011-2016 (index value 1.442), however, it did not reach GES within the Gotland Basin (index of 0.131). This species breeds occasionally on the Polish coast of the Baltic Sea, the data comes from other Baltic states.

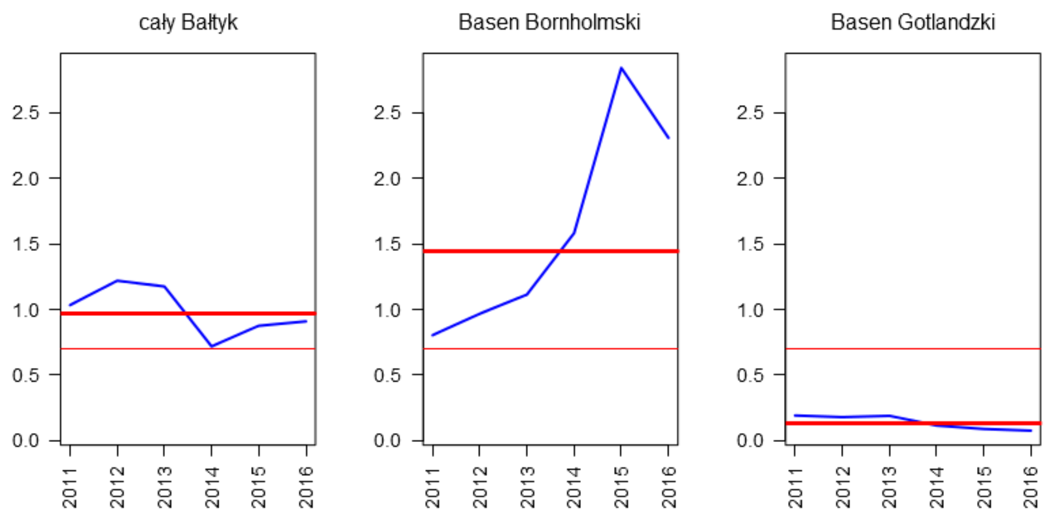



Fig. 2.1.35. Annual index values of common eider abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Velvet scoter *Melanitta fusca***

Velvet scoter in 2011-2016 did not achieve good environmental status (GES) both in the scale of the entire Baltic Sea (index value 0.521) and in the Gotland Basin (the index value 0.495). The species does not breed in the Bornholm Basin nor in Poland. The data comes from other Baltic countries.

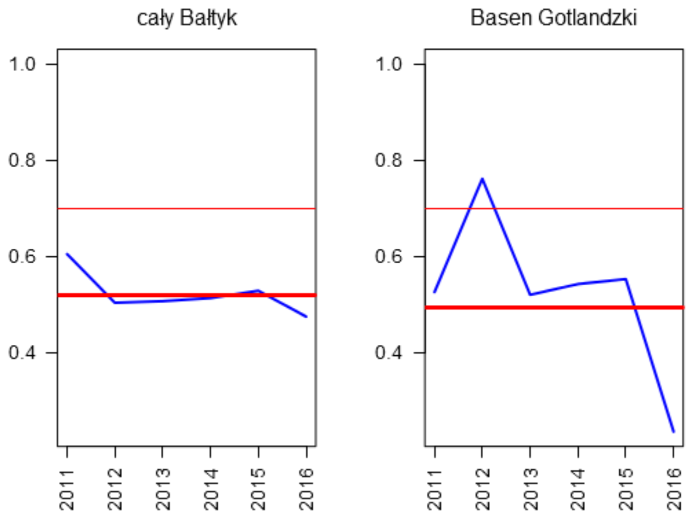



Fig. 2.1.36. Annual index values of velvet scoter abundance (blue line) in the whole Baltic Sea (left) and Gotland Basin (right) together with the average index value in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7; thin red line) (data source: PMŚ, HELCOM)

**Common merganser *Mergus merganser***

In 2011-2016, common merganser achieved good environmental status (GES) both in the entire Baltic Sea (0.858 index value) and in the Bornholm and Gotland Basins (index values 1.875 and 0.852, respectively). This species is breeding on the Polish coast of the Baltic Sea, but it is not monitored within the monitoring of the breeding population in the coastal belt. The data comes from other Baltic countries.

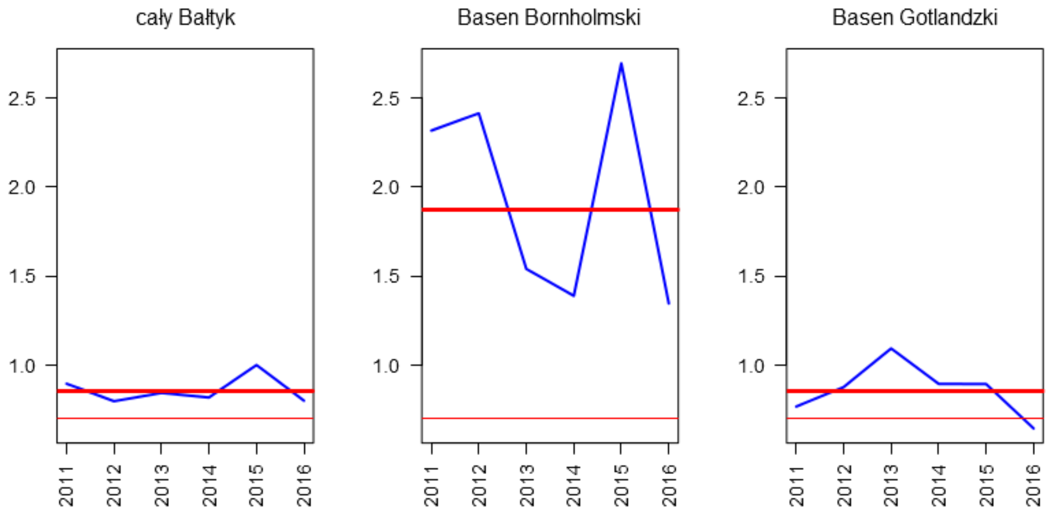



Fig. 2.1.37. Annual index values of common merganser abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Red-breasted merganser *Mergus serrator***

In 2011-2016, the red-breasted merganser achieved good environmental status (GES) in the entire Baltic Sea (index value 0.973) and the Gotland Basin (value 1.309), however, it did not reach GES on the Bornholm Basin scale (index value 0.522). This species does not breed on the Polish coast of the Baltic Sea, data comes from other Baltic countries.

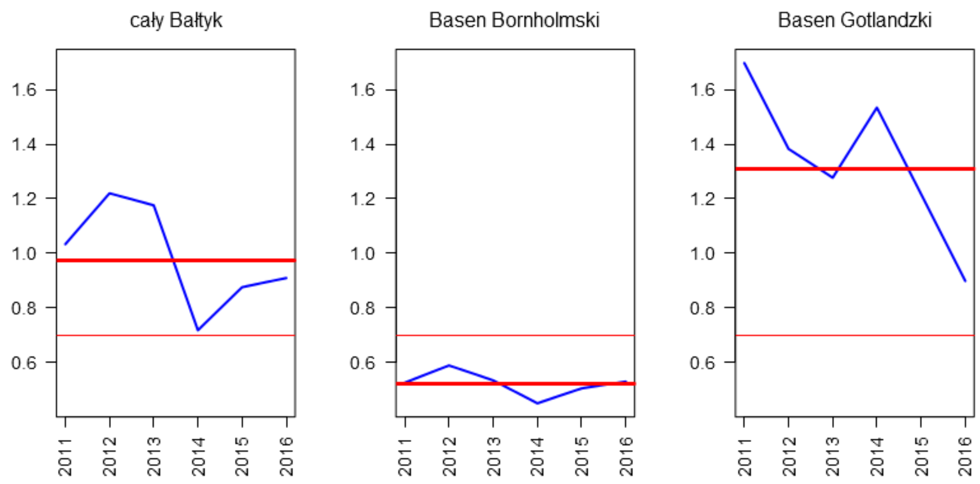



Fig. 2.1.38. Annual index values of red-breasted merganser abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Common shelduck *Tadorna tadorna***

The common shelduck in 2011-2016 achieved good environmental status (GES) on the scale of the entire Baltic Sea (index value 0.996) and the Bornholm Basin (index value 1.033), however, it did not reach GES in the Gotland Basin scale (the value of the index is 0.498). This species is breeding on the Polish coast of the Baltic Sea, but it is not monitored within the monitoring of the breeding population in the coastal belt. The data comes from other Baltic countries.

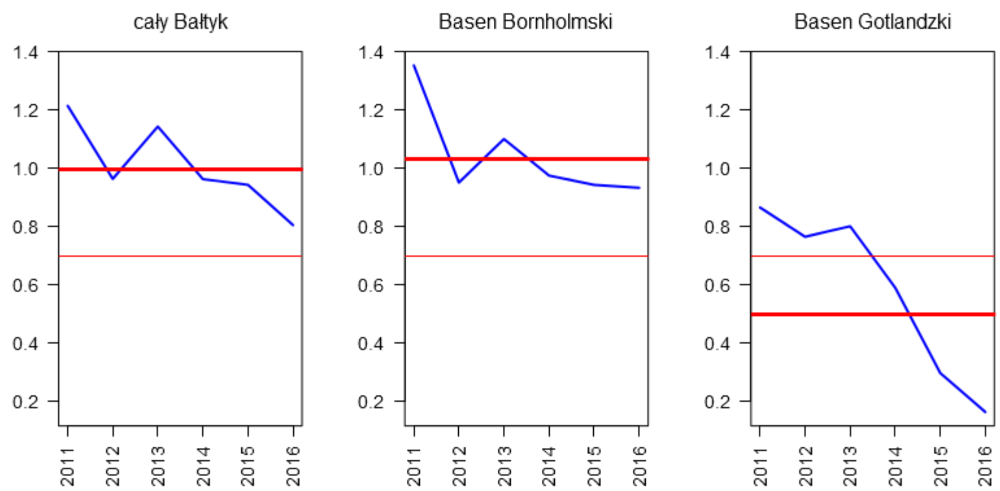



Fig. 2.1.39. Annual index values of common shelduck abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Tufted duck *Aythya fuligula***

In 2011-2016 the tufted duck achieved good environmental status (GES) in the entire Baltic Sea (1.214 index value) and Gotland Basin (1.438 index value), but it did not achieve GES on the Bornholm Basin scale (value of 0.598). This species is breeding on the Polish coast of the Baltic Sea, but it is not monitored within the monitoring of the breeding population in the coastal belt. The data comes from other Baltic countries.

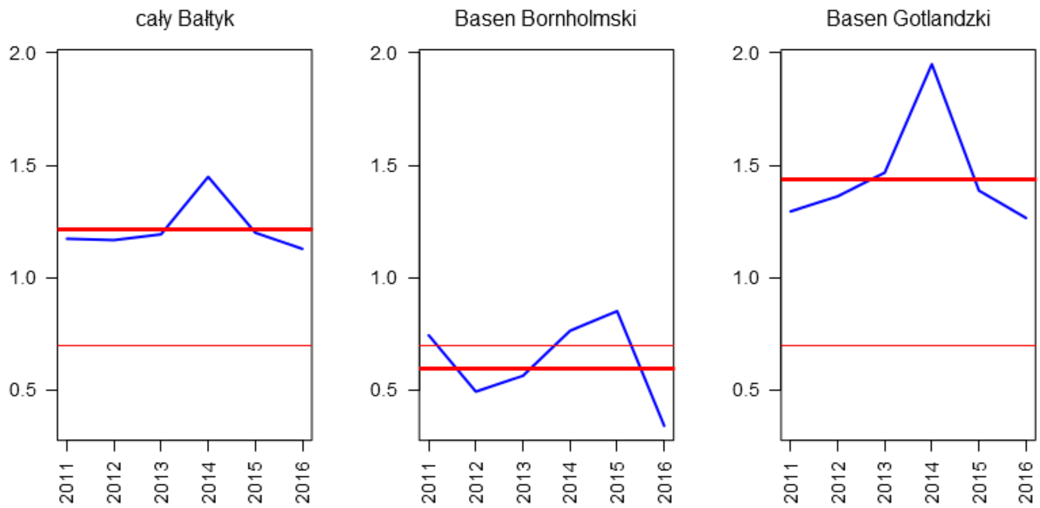



Fig. 2.1.40. Annual index values of tufted duck abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Greater scaup *Aythya marila***

The greater scaup in 2011-2016 achieved good environmental status (GES) on the scale of the entire Baltic Sea (index value 1.159). The species was not assessed on a smaller spatial scale due to insufficient abundance. This species does not breed on the Polish coast of the Baltic Sea, data comes from other Baltic countries.

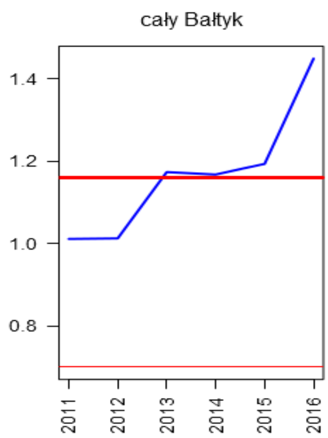



Fig. 2.1.41. Annual index values of greater scaup abundance (blue line) in the entire Baltic Sea, with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Great crested grebe *Podiceps cristatus***

The great crested grebe in 2011-2016 achieved good environmental status (GES) both in the whole Baltic Sea area (index value 2.759) and in the Bornholm and Gotland Basins (index values 1.791 and 3.067 respectively). This species is breeding on the Polish coast of the Baltic Sea, but it is not monitored within the monitoring of the breeding population in the coastal belt. The data comes from other Baltic countries.

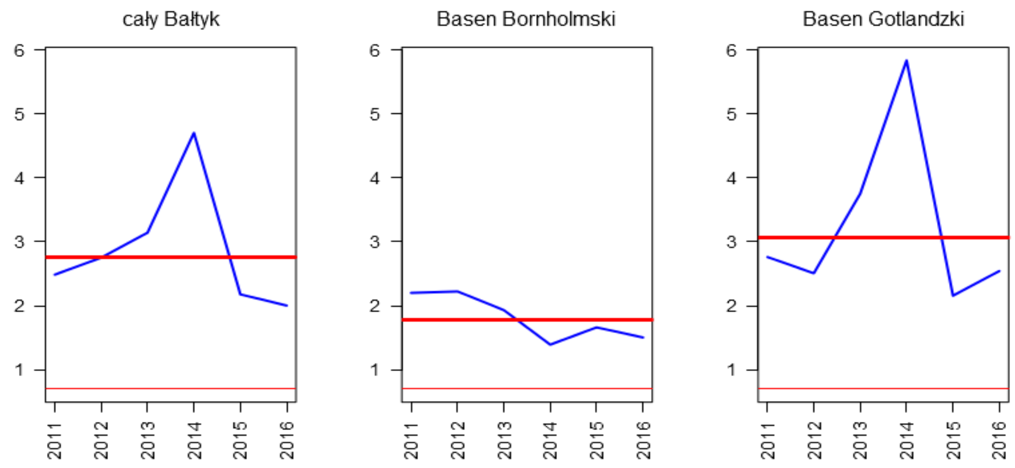



Fig. 2.1.42. Annual index values of great crested grebe abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Eurasian oystercatcher *Haematopus ostralegus***

In 2011-2016, Eurasian oystercatcher achieved good environmental status (GES) both in the whole Baltic Sea (index value 1.284) and in the Bornholm and Gotland Basins (values of 0.719 and 0.964 respectively). This species is breeding on the Polish coast of the Baltic Sea, but it is not monitored within the monitoring of the breeding population in the coastal belt. The data comes from other Baltic countries.

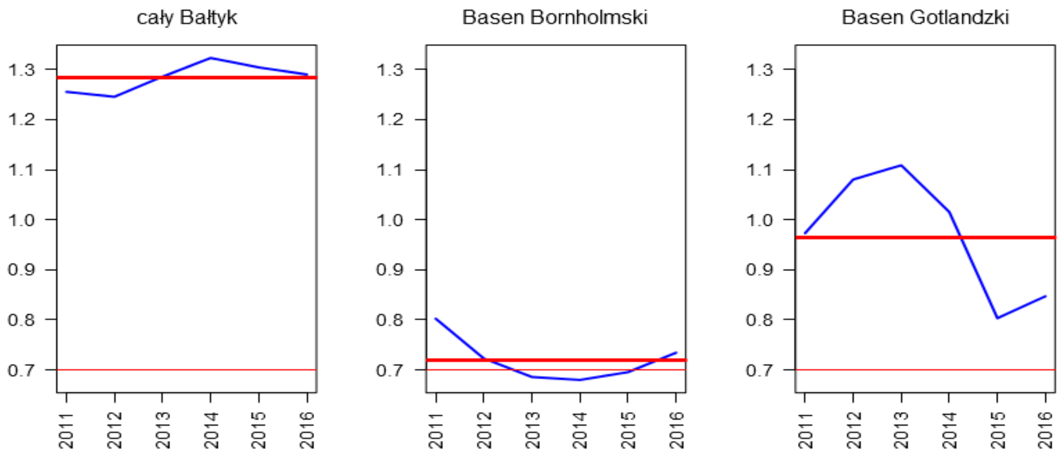



Fig. 2.1.43. Annual index values of Eurasian oystercatcher abundance (blue line in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Pied avocet *Recurvirostra avosetta***

In 2011-2016, the pied avocet did not achieve a good environmental status (GES) in the entire Baltic Sea (index value 0.623), nor within the Bornholm and Gotland Basins (index values 0.677 and 0.523, respectively). This species breeds on the Polish coast of the Baltic exceptionally, data comes from other Baltic states.

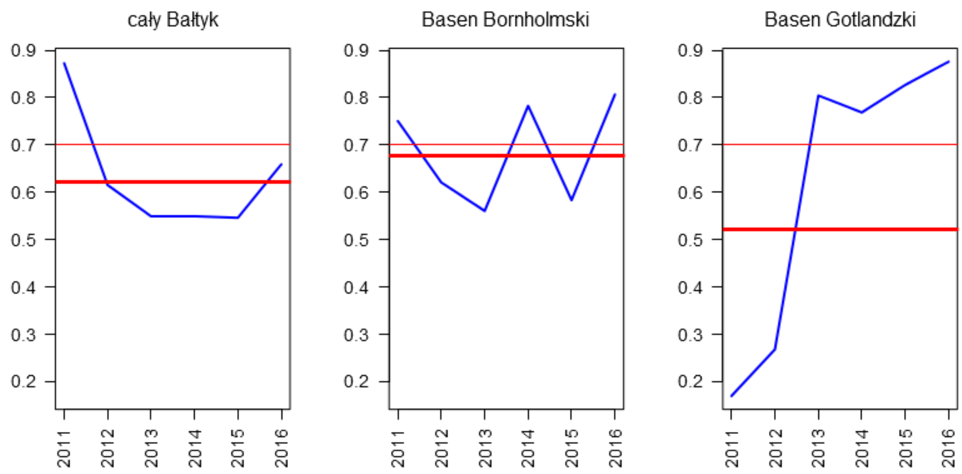



Fig. 2.1.44. Annual index values of pied avocet abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Ringed plover *Charadrius hiaticula***

In 2011-2016, the common ringed plover achieved good environmental status (GES) in the entire Baltic Sea (index value 1.027) and in the Gotland Basin (1.285 index value), while it did not reach GES boundary at the Bornholm Basin scale (0.699 index value). This species is breeding on the Polish coast of the Baltic Sea, but it is not monitored within the monitoring of the breeding population in the coastal belt. The data comes from other Baltic countries.

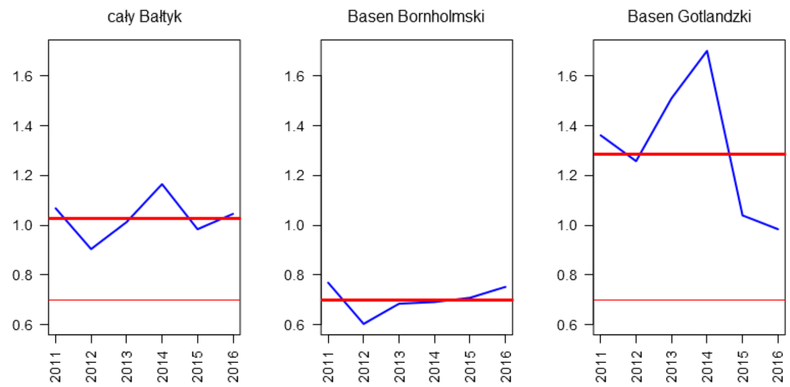



Fig. 2.1.45. Annual index values of ringed plover abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Ruddy turnstone *Arenaria interpres***

Ruddy turnstone in 2011-2016 did not achieve good environmental status (GES) in the entire Baltic Sea (index value 0.37) nor within the Gotland Basin (index value 0.31). The species was not assessed in the Bornholm Basin due to its low abundance. This species does not breed on the Polish coast of the Baltic Sea, data comes from other Baltic countries.

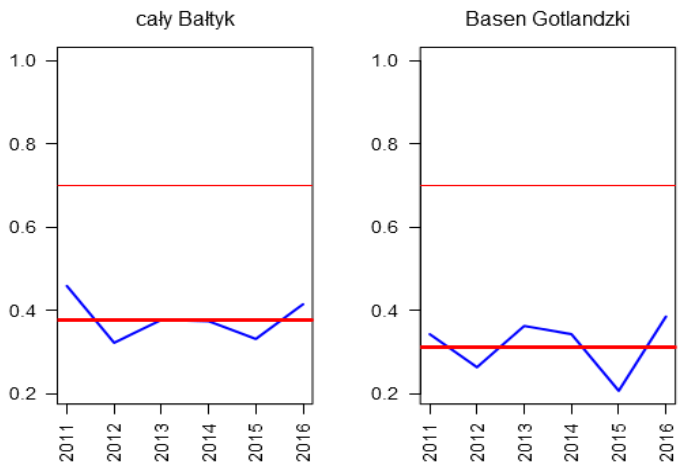



Fig. 2.1.46. Annual index values of ruddy turnstone abundance (blue line) in the whole Baltic Sea (left) and Gotland Basin (right) with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Dunlin *Calidris alpina***

Dunlin in 2011-2016 did not achieve good environmental status (GES) in the entire Baltic Sea (index value of 0.151), nor within the Bornholm and Gotland basins (index values 0.092 and 0.093 respectively). Currently, this species is probably no longer breeding on the Polish Baltic Sea coast (results of the MBZ program). In Poland, it is covered by annual monitoring as part of the State Environmental Monitoring.

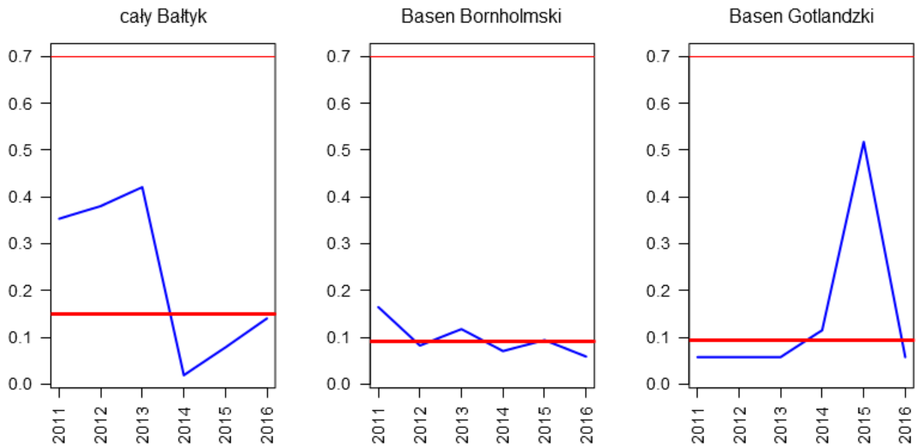



Fig. 2.1.47. Annual index values of dunlin abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Black guillemot *Cepphus grylle***

In 2011-2016, the black guillemot achieved good environmental status (GES) in the entire Baltic Sea (index value 2.063), but did not reach it within the Gotland Basin (index value 0.284). The species was not assessed in the Bornholm Basin due to its low abundance. This species does not breed on the Polish coast of the Baltic Sea, data comes from other Baltic countries.

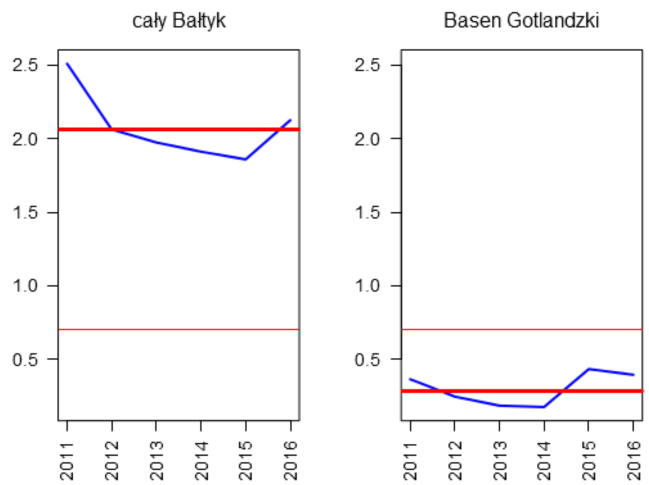



Fig. 2.1.48. Annual index values of black guillemot abundance (blue line) in the whole Baltic Sea (left) and Gotland Basin (right) with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Common murre *Uria aalge***

In 2011-2016, common murre achieved good environmental status (GES) in the entire Baltic Sea (1.721 value) and Gotland Basin (2.306 index value), but it did not reach it on the Bornholm Basin scale (index value 0.08). This species does not breed on the Polish coast of the Baltic Sea, data comes from other Baltic countries.

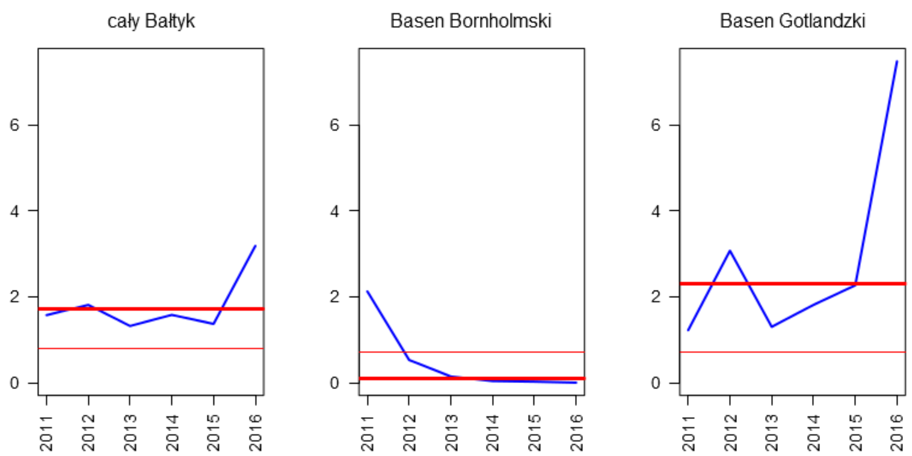



Fig. 2.1.49. Annual index values of common murre abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the limit value of good status (thin red line, species consisting of 1 egg, therefore 0.8) (data source: PMŚ, HELCOM)

**Razorbill *Alca torda***

In the years 2011-2016, razorbill achieved good environmental status (GES) in the entire Baltic Sea (value 1.143) and Gotland Basin (index value of 2.442), however, it did not reach it on the Bornholm Basin scale (index value 0.465). This species does not breed on the Polish coast of the Baltic Sea, data comes from other Baltic countries.

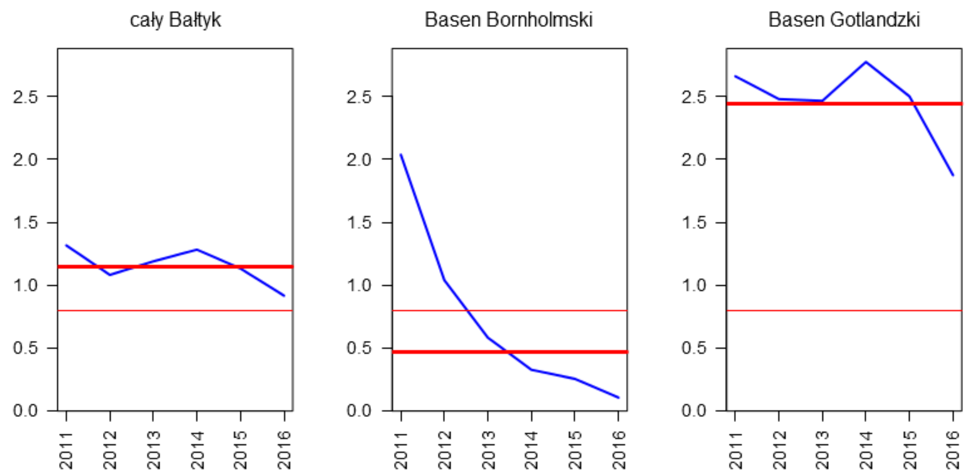



Fig. 2.1.50. Annual index values of razorbill abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the limit value of good status (thin red line, species consisting of 1 egg, therefore 0.8) (data source: PMŚ, HELCOM)

### Parasitic jaeger *Stercorarius parasiticus*

The parasitic jaeger does not breed in the Gotland and Bornholm Basins, so it is not assessed there. In 2011-2016, this species has achieved good environmental status (GES) in the entire Baltic Sea scale (index value 1.188).

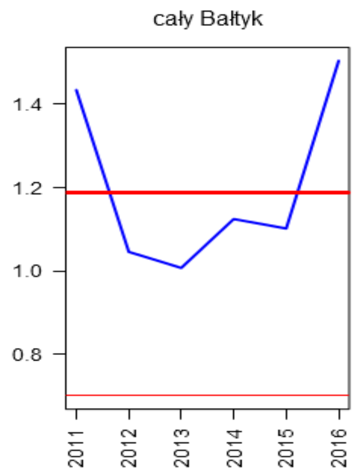



Fig. 2.1.51. Annual index values of parasitic jaeger abundance (blue line) in the entire Baltic Sea, with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

### Common gull *Larus canus*

In 2011-2016, the common gull achieved good environmental status (GES) in the entire Baltic Sea (0.752 index value) and Gotland Basin (1.049 index value), but it did not reach the Bornholm Basin scale (value of the index 0.423). This species is breeding on the Polish coast of the Baltic Sea, it is not monitored within the monitoring of the breeding population in the coastal belt. The data comes from other Baltic countries.

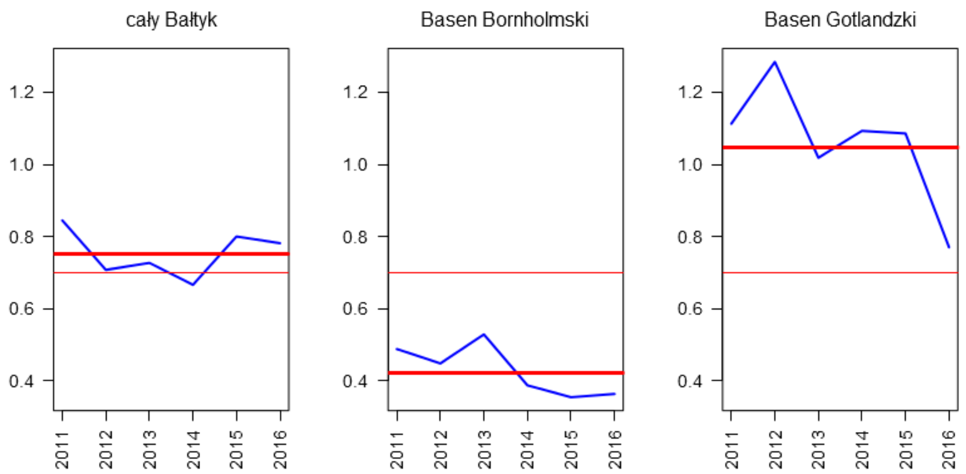



Fig. 2.1.52. Annual index values of common gull abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Lesser black-backed gull *Larus fuscus***

In 2011-2016, the lesser black-backed gull achieved good environmental status (GES) in the entire Baltic Sea (0.973 index value) and the Bornholm Basin (4.401 index value), however, it did not reach the Gotland Basin scale (index value 0.141). This species very rarely breeds on the Polish coast of the Baltic Sea, and as such it is not covered by breeding population monitoring, and the data comes from other Baltic countries

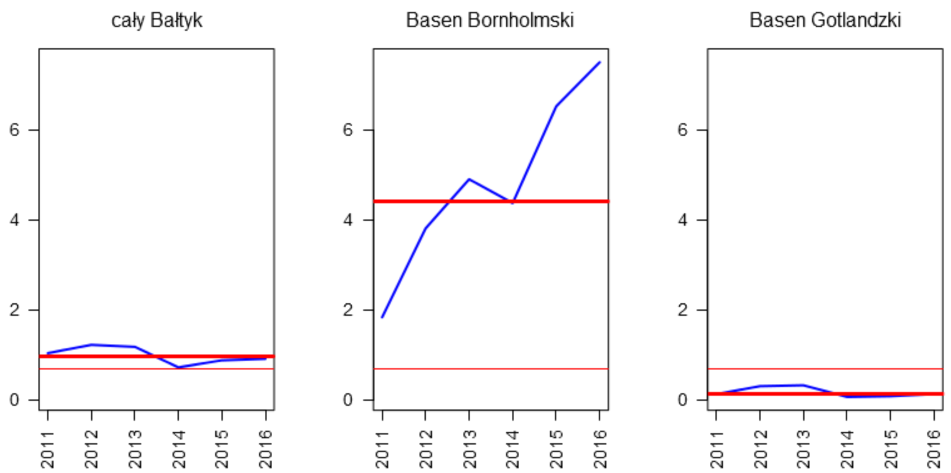



Fig. 2.1.53. Annual index values of lesser black-backed gull abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**European herring gull *Larus argentatus***

European herring gull in 2011-2016 achieved good environmental status (GES) in the whole Baltic Sea area (0.948 index value) and Bornholm Basin (1.097 index value), however, it did not reach it in the Gotland Basin scale (index value 0.31). This species is breeding on the Polish coast of the Baltic Sea, it is not monitored within the monitoring of the breeding population in the coastal belt. The data comes from other Baltic countries.

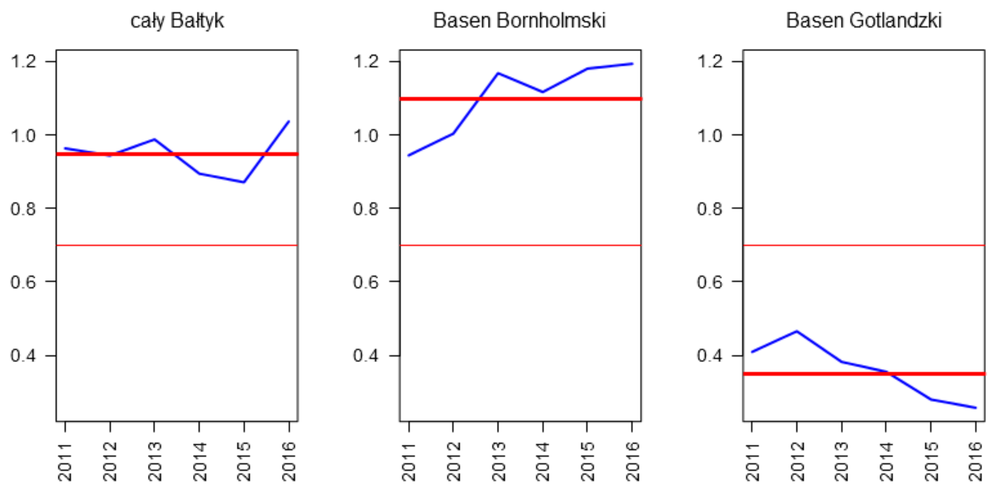



Fig. 2.1.54. Annual index values of herring gull abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Great black-backed gull *Larus marinus***

In 2011-2016, the great black-backed gull achieved good environmental status (GES) only on the Bornholm Basin scale (index value of 1.669), it did not achieve GES on the scale of the entire Baltic Sea (index value of 0.322) nor in the Gotland Basin (index value 0.273). This species does not breed on the Polish coast of the Baltic Sea, data comes from other Baltic countries.

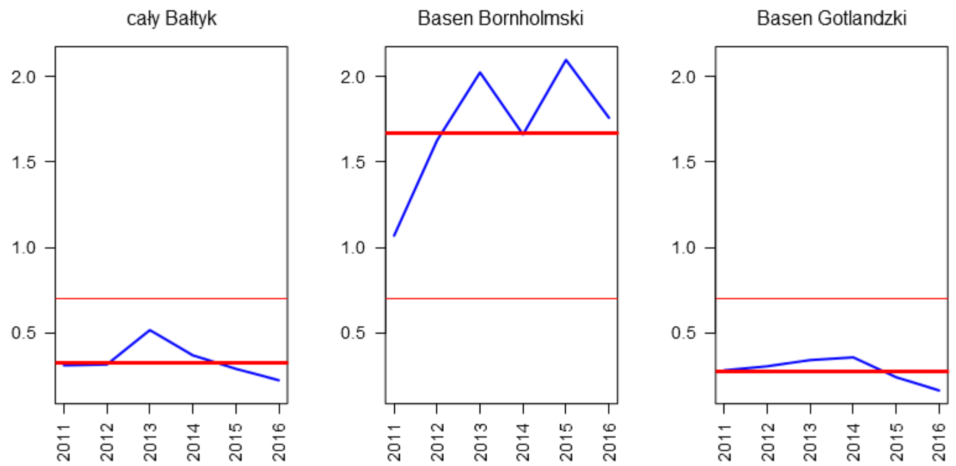



Fig. 2.1.55. Annual index values of great black-backed gull abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Caspian tern *Hydroprogne caspia***

Caspian tern in 2011-2016 achieved good environmental status (GES) in the entire Baltic Sea (value of 1.176) and Gotland Basin (value of 1.186), however, it did not reach GES on the Bornholm Basin scale (index value of 0.124). This species does not breed on the Polish coast of the Baltic Sea, data comes from other Baltic countries.

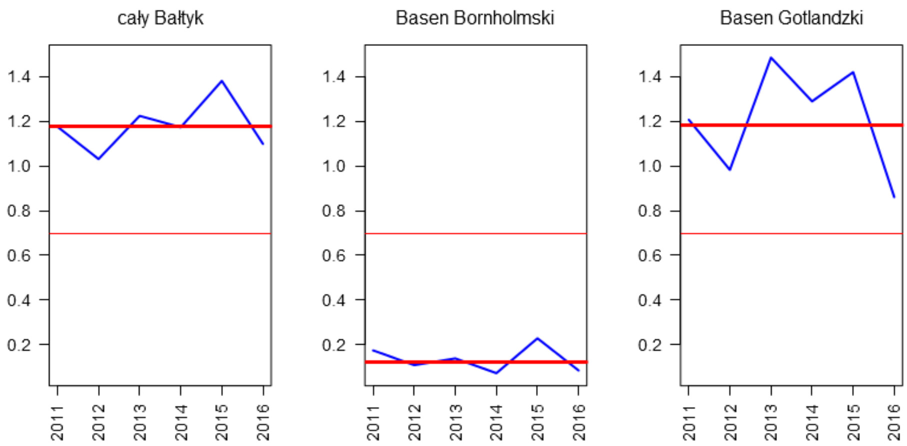



Fig. 2.1.56. Annual index values of caspian tern abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Sandwich tern *Thalasseus sandvicensis***

In 2011-2016, the Sandwich tern achieved good state of the environment (GES) in the entire Baltic Sea (index value 1.445), but it did not reach GES on the Bornholm Basin scale (index value 0.486). The species was not assessed in the Gotland Basin because of its low abundance. This species is breeding on the Polish coast of the Baltic Sea and since 2015 it has been monitored as part of the State Environmental Monitoring.

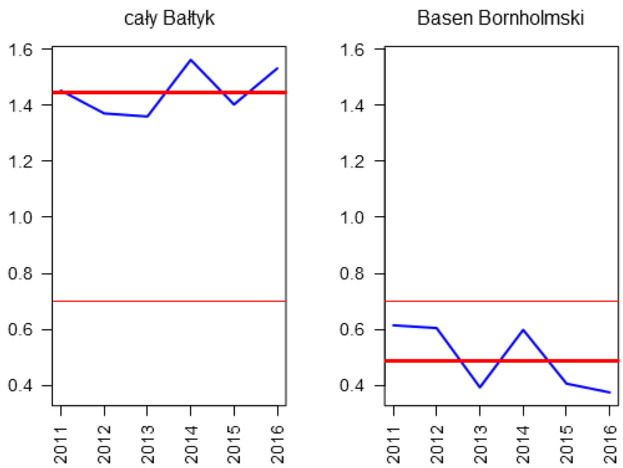



Fig. 2.1.57. Annual index values of Sandwich tern abundance (blue line) in the whole Baltic Sea (left) and Bornholm Basin (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Common tern *Sterna hirundo***

The common tern in 2011-2016 achieved good environmental status (GES) in the entire Baltic Sea area (index value 2.919) and in the Gotland Basin (index value 3.298), however, it did not reach GES on the Bornholm Basin scale (index value of 0.307). This species is breeding on the Polish coast of the Baltic Sea, but it is not monitored within the breeding population in the coastal belt. The data comes from other Baltic countries.

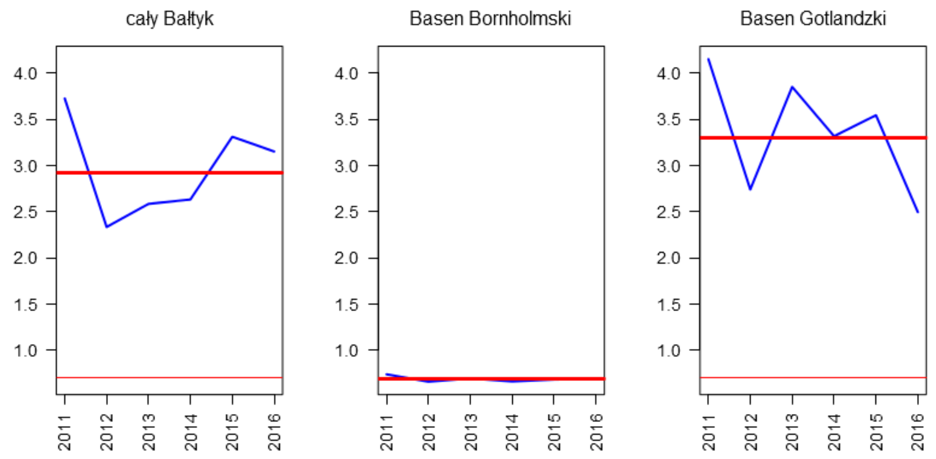



Fig. 2.1.58. Annual index values of common tern abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Arctic tern *Sterna paradisea***

Arctic tern in 2011-2016 achieved good status of the environment (GES) in the whole Baltic Sea (index value 1.894) and Gotland Basin (index value 2.62), however it did not reach it in the Bornholm Basin scale (index value 0.307). This species does not breed on the Polish coast of the Baltic Sea, data comes from other Baltic countrie.

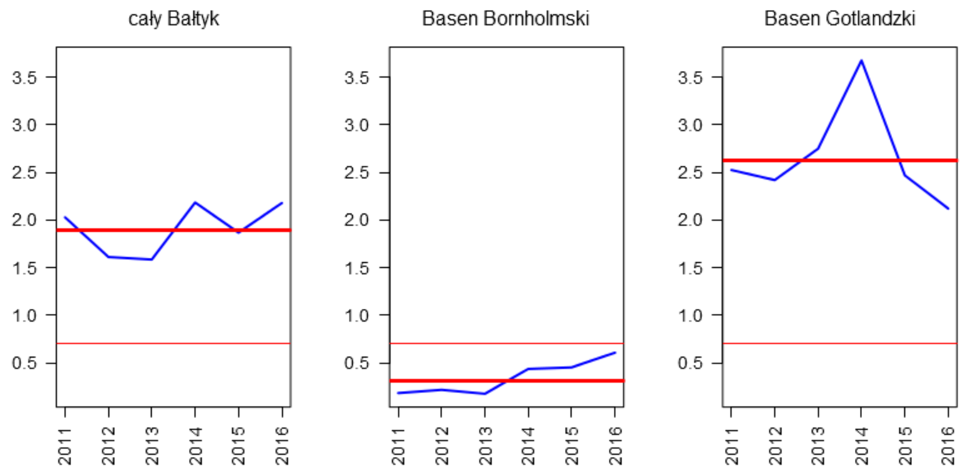



Fig. 2.1.59. Annual index values of Arctic tern abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Little tern *Sternula albifrons***

The little tern in 2011-2016 achieved good environmental status (GES) both in the entire Baltic Sea (0.977 index value) and in the Bornholm and Gotland basins (index values 0.878 and 1.242 respectively). This species is breeding on the Polish coast of the Baltic Sea, but it is not currently monitored within the breeding population monitoring in the coastal belt. The data comes from other Baltic countries.

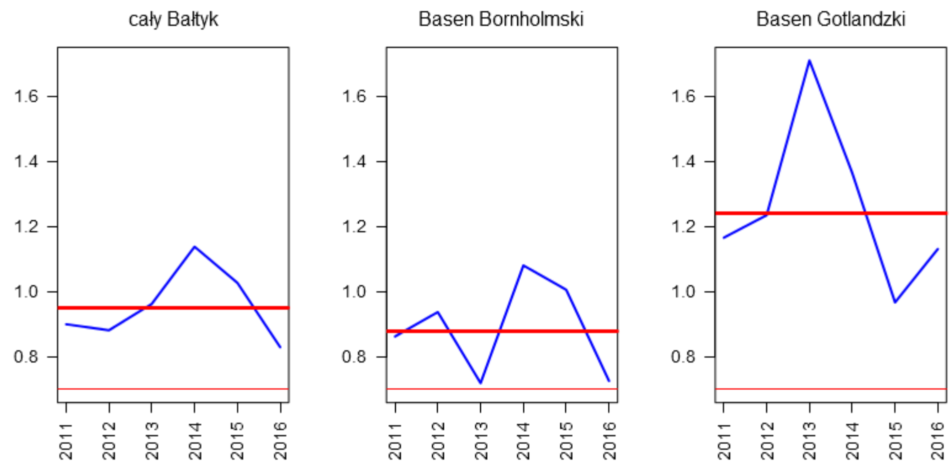



Fig. 2.1.60. Annual index values of little tern abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

**Cormorant *Phalacrocorax carbo***

The great cormorant in 2011-2016 achieved good environmental status (GES) both on the scale of the entire Baltic Sea (index value 0.977) and within the Bornholm and Gotland Basins (index values 1.154 and 2.05 respectively). This species is breeding on the Polish coast of the Baltic Sea, and data from 2015 and 2016 for Poland come from the great cormorant Monitoring in the State Environmental Monitoring.

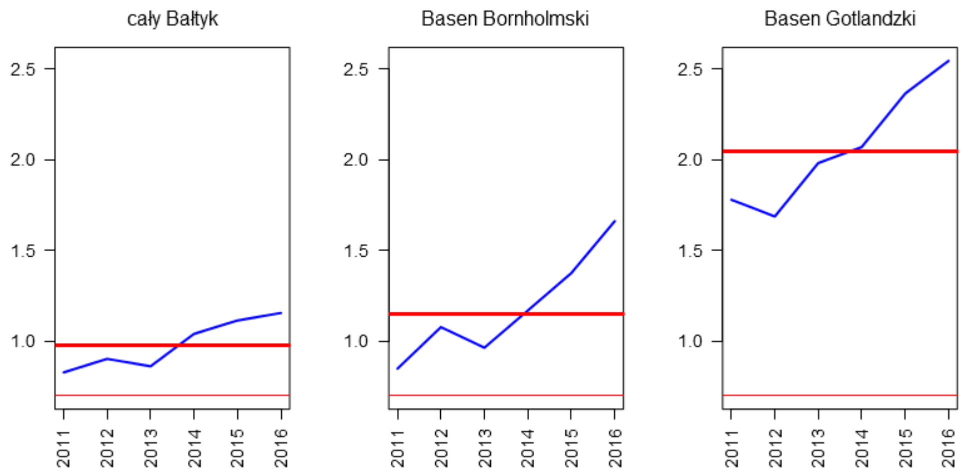



Fig. 2.1.61. Annual index values of great cormorant abundance (blue line) in the whole Baltic Sea (left) and two basins: Bornholm (middle) and Gotland (right) together with the average value of the index in 2011-2016 used in the assessment of good status (thick red line) and the threshold of good environmental status (GES) (0.7, thin red line) (data source: PMŚ, HELCOM)

In the Bornholm and Gotland Basins, the index based on number of breeding birds was below the good environmental status. The GES status reached 50% and 59% of species in these areas respectively (the threshold value is 75%). SubGES was also found for the specified functional groups, except for herbivorous birds (*grazing feeders*) in the Bornholm Basin and pelagic species (*pelagic feeders*) in the Gotland Basin.

In the entire Baltic area, only 5 species did not achieve good environmental status. The number of breeding birds shows a good status of birds of this group, as 83% of species have reached GES (threshold of 75%, Table 2.1.26). A similar situation took place among five functional groups, four of which achieved good status: *surface feeders, pelagic feeders, benthic feeders* and *grazing feeders*. Only *wading feeders* were below the GES threshold.

Table 2.1.26. Average index values of Abundance of waterbirds in the breeding season indicator in 2011-2016 for all species and 5 functional groups throughout the Baltic Sea, Bornholm Basin and Gotland Basin. (data source: PMŚ, HELCOM)

| Species group | Baltic Sea | Bornholm Basin | Gotland Basin |
|---|---|---|---|
| all species | 0.83 | 0.50 | 0.59 |
| *benthic feeders* | 0.75 | 0.50 | 0.33 |
| *grazing feeders* | 1.00 | 1.00 | 0.67 |
| *pelagic feeders* | 1.00 | 0.50 | 0.86 |
| *surface feeders* | 0.90 | 0.44 | 0.63 |
| *wading feeders* | 0.50 | 0.40 | 0.33 |

Indicators that achieved good environmental status (GES) were marked in green (value ≥ 0.75) and indicators that did not reach good status (subGES) in red. For a functional group, see Table 2.1.20

### Integrated assessment of water birds

The integrated assessment of water birds for the years 2011-2016 was based on the abovementioned results of population abundace change rates in the breeding and wintering seasons in two areas: in the Gotland and Bornholm basins. In both areas, the results for 35 species were included in the integrated assessment, with the species composition between the basins being different, which was due to the different distribution of species in the Baltic Sea basin. The assessment was carried out in two stages. In the first stage, the data from the indicators Abundance of waterbirds in the breeding season and Abundance of waterbirds in the wintering season using the OOAO method were integrated (Table 2.1.27 and Table 2.1.28). In the second stage, assessment was carried out for all water birds and for five functional groups in the Bornholm and Gotland Basin proportionality method proposed by HELCOM (good status in the group can be determined if more than 75% of the species achieved GES). The final results are presented Table 2.1.27.

Table 2.1.27. Integrated assessment of the status of water birds in the Bornholm Basin for the years 2011-2016. No entry means that the assessment was not possible due to the lack of species or very low numbers. Indicators that have achieved good environmental status (GES) are highlighted in green, and indicators that did not reach good status (subGES) in red. For a functional group, see Table 2.1.20. Species are ranked in functional groups according to the systematic order (KF 2018).

| Species | Functional group | Abundance of waterbirds in the wintering season | Abundance of waterbirds in the breeding season | Integrated assessment |
|---|---|---|---|---|
| common eider *Somateria mollissima* | *benthic* | - | GES | GES |
| Common goldeneye *Bucephala clangula* | *benthic* | GES | - | GES |
| Common pochard *Aythya ferina* | *benthic* | subGES | - | subGES |
| Tufted duck *Aythya fuligula* | *benthic* | GES | subGES | subGES |
| Greater scaup *Aythya marila* | *benthic* | GES | - | GES |
| Mute swan *Cygnus olor* | *grazing* | GES | GES | GES |

| Species | Functional group | Abundance of waterbirds in the wintering season | Abundance of waterbirds in the breeding season | Integrated assessment |
|---|---|---|---|---|
| Tundra swan *Cygnus columbianus* | *grazing* | subGES | - | subGES |
| Whooper swan *Cygnus cygnus* | *grazing* | GES | - | GES |
| greylag goose *Anser anser* | *grazing* | - | GES | GES |
| Eurasian wigeon *Mareca penelope* | *grazing* | GES | - | GES |
| Mallard *Anas platyrhynchos* | *grazing* | GES | - | GES |
| Pintail *Anas acuta* | *grazing* | GES | - | GES |
| Eurasian coot *Fulica atra* | *grazing* | GES | - | GES |
| Smew *Mergellus albellus* | *pelagic* | GES | - | GES |
| Common merganser *Mergus merganser* | *pelagic* | GES | GES | GES |
| Red-breasted merganser *Mergus serrator* | *pelagic* | GES | subGES | subGES |
| Great crested grebe *Podiceps cristatus* | *pelagic* | GES | GES | GES |
| Razorbill *Alca torda* | *pelagic* | - | subGES | subGES |
| Common murre *Uria aalge* | *pelagic* | - | subGES | subGES |
| Cormorant *Phalacrocorax carbo* | *pelagic* | GES | GES | GES |
| Common gull *Larus canus* | *surface* | - | subGES | subGES |
| lesser black-backed gull *Larus fuscus* | *surface* | - | GES | GES |
| European herring gull *Larus argentatus* | *surface* | - | GES | GES |
| Great black-backed gull *Larus marinus* | *surface* | GES | GES | GES |
| Caspian tern *Hydroprogne caspia* | *surface* | - | subGES | subGES |
| Sandwich tern *Thalasseus sandvicensis* | *surface* | - | subGES | subGES |
| common tern *Sterna hirundo* | *surface* | - | subGES | subGES |
| Arctic tern *Sterna paradisaea* | *surface* | - | subGES | subGES |
| little tern *Sternula albifrons* | *surface* | - | GES | GES |
| common shelduck *Tadorna tadorna* | *wading* | - | GES | GES |
| Eurasian teal *Anas crecca* | *wading* | GES | - | GES |
| Eurasian oystercatcher *Haematopus ostralegus* | *wading* | - | GES | GES |
| pied avocet *Recurvirostra avosetta* | *wading* | - | subGES | subGES |
| ringed plover *Charadrius hiaticula* | *wading* | - | subGES | subGES |
| dunlin *Calidris alpina* | *wading* | - | subGES | subGES |

Table 2.1.28. Integrated assessment of the state of waterbirds in the Gotland Basin for the years 2011-2016. No entry means that the assessment was not possible due to the lack of species or very low numbers. Indicators that have achieved good environmental status (GES) are highlighted in green, and indicators that did not reach good status (subGES) in red. For a functional group, see Table 2.1.20. Species are ranked in functional groups according to the systematic order (KF 2018).

| Species | Functional group | Abundance of waterbirds in the wintering season | Abundance of waterbirds in the breeding season | Integrated assessment |
|---|---|---|---|---|
| common eider *Somateria mollissima* | *benthic* | - | subGES | subGES |
| Velvet scoter *Melanitta fusca* | *benthic* | - | subGES | subGES |

| Species | Functional group | Abundance of waterbirds in the wintering season | Abundance of waterbirds in the breeding season | Integrated assessment |
|---|---|---|---|---|
| Common goldeneye *Bucephala clangula* | *benthic* | GES | - | GES |
| Common pochard *Aythya ferina* | *benthic* | subGES | - | subGES |
| Tufted duck *Aythya fuligula* | *benthic* | GES | GES | GES |
| Greater scaup *Aythya marila* | *benthic* | GES | - | GES |
| Mute swan *Cygnus olor* | *grazing* | GES | GES | GES |
| Whooper swan *Cygnus cygnus* | *grazing* | GES | - | GES |
| barnacle goose *Branta leucopsis* | *grazing* | - | subGES | subGES |
| greylag goose *Anser anser* | *grazing* | - | GES | GES |
| Mallard *Anas platyrhynchos* | *grazing* | GES | - | GES |
| Eurasian coot *Fulica atra* | *grazing* | subGES | - | subGES |
| Smew *Mergellus albellus* | *pelagic* | GES | - | GES |
| Common merganser *Mergus merganser* | *pelagic* | GES | GES | GES |
| Red-breasted merganser *Mergus serrator* | *pelagic* | GES | GES | GES |
| Great crested grebe *Podiceps cristatus* | *pelagic* | GES | GES | GES |
| Black guillemot *Cepphus grylle* | *pelagic* | - | subGES | subGES |
| Razorbill *Alca torda* | *pelagic* | - | GES | GES |
| Common murre *Uria aalge* | *pelagic* | - | GES | GES |
| Cormorant *Phalacrocorax carbo* | *pelagic* | GES | GES | GES |
| Black-headed gull *Chroicocephalus ridibundus* | *surface* | GES | - | GES |
| Common gull *Larus canus* | *surface* | subGES | GES | subGES |
| lesser black-backed gull *Larus fuscus* | *surface* | - | subGES | subGES |
| European herring gull *Larus argentatus* | *surface* | GES | subGES | subGES |
| Great black-backed gull *Larus marinus* | *surface* | GES | subGES | subGES |
| Caspian tern *Hydroprogne caspia* | *surface* | - | GES | GES |
| common tern *Sterna hirundo* | *surface* | - | GES | GES |
| Arctic tern *Sterna paradisaea* | *surface* | - | GES | GES |
| little tern *Sternula albifrons* | *surface* | - | GES | GES |
| common shelduck *Tadorna tadorna* | *wading* | - | subGES | subGES |
| Eurasian oystercatcher *Haematopus ostralegus* | *wading* | - | GES | GES |
| pied avocet *Recurvirostra avosetta* | *wading* | - | subGES | subGES |
| ringed plover *Charadrius hiaticula* | *wading* | - | GES | GES |
| ruddy turnstone *Arenaria interpres* | *wading* | - | subGES | subGES |
| dunlin *Calidris alpina* | *wading* | - | subGES | subGES |

The entire grouping of waterbirds did not reach good environmental status in the Bornholm and Gotland Basins. In the Bornholm Basin, only *grazing feeders* achieved good status, while in the Gotland Basin only *pelagic feeders* achieved GES.

Table 2.1.29. Integrated assessment of the status of water birds in the Bornholm Basin and Gotland Basin for 5 functional groups for the years 2011-2016. Indicators that have achieved good environmental status (GES) are highlighted in green, and indicators that did not reach good status (subGES) in red. For a functional group, see Table 2.1.20.

| Region | Functional group | Assessment |
|---|---|---|
| Bornholm Basin | *all species* | 60% |
| | *benthic feeders* | 60% |
| | *grazing feeders* | 88% |
| | *pelagic feeders* | 57% |
| | *surface feeders* | 44% |
| | *wading feeders* | 50% |
| Gotland Basin | *all species* | 60% |
| | *benthic feeders* | 50% |
| | *grazing feeders* | 67% |
| | *pelagic feeders* | 88% |
| | *surface feeders* | 56% |
| | *wading feeders* | 33% |

**The assessment of white-tailed eagle productivity in 2011-2016**

In the years 2011-2016, all three analyzed parameters of white-tailed eagle reproduction were above the threshold value of a good state:

(1) breeding success was 59% (GES threshold value is 59%),
(2) productivity (number of hatchlings per occupied nest) was 1.07 (threshold value 0.97),
(3) the number of young per success pair was 1.81 (threshold value 1.64).

All three parameters were in good status, therefore the final assessment of white-tailed eagle productivity index was also above the GES threshold.

Table 2.1.30. Parameters of reproduction of white-tailed eagle (Haliaeetus albicilla) in the 10 km belt to the Baltic shoreline in Poland in individual years in the period 2011-2016 and average values of three parameters to be assessed in the entire analyzed period. (Data source: PMŚ)

| Year | The number of nests with the specified nesting result | Proportion of nests with interior control | Nesting success | Productivity | Number of chicks |
|---|---|---|---|---|---|
| 2011 | 8 | 0% | 88% | - | - |
| 2012 | 6 | 17% | 67% | 1.33 | 2.00 |
| 2013 | 5 | 20% | 100% | 1.00 | 1.00 |
| 2014 | 27 | 19% | 67% | 1.20 | 1.80 |
| 2015 | 79 | 42% | 61% | 1.10 | 1.81 |
| 2016 | 69 | 58% | 48% | 0.88 | 1.84 |
| 2011-2016 | 194 | 41% | 59% | 1.07 | 1.81 |

Indicators that achieved good environmental status (GES) were marked in green (value ≥0.75) and indicators that did not reach good status (subGES) in red. The data for 2011-2014 come from the Eagle Protection Committee, and the data from 2015 and 2016 from White-tailed Eagle Productivity Monitoring (GIOŚ). In 2011, the inside of the nest was not inspected, hence it was only possible to calculate breeding success.

**Confidence assessment**

The confidence of the assessment is presented in Table 2.1.31.

Table 2.1.31. Assessment of the confidence of the assessment of indicators: *Abundance of waterbirds in the wintering season* and *Abundance of waterbirds in the breeding season'*and *White-tailed eagle productivity'* in 2011-2016

| confidence aspect | Indicator '*Abundance of waterbirds in the wintering season* | Indicator '*Abundance of waterbirds in the breeding season'* | Indicator '*White-tailed eagle productivity'* |
|---|---|---|---|
| Temporal coverage | 1 | 1 | 1 |
| Spatial representation | 0 | 0.5 | 1 |
| Classification confidence | 1 | 1 | 1 |
| Methodological confidence | 0.5 | 0.5 | 1 |
| Averaged indicator confidence (WW) | 0.63 | 0.75 | 1 |
| Confidence assessment for the assessment area (WO) – POM, 2011-2016 | 0.79 – confidence: high | | |

The confidence assessment of the number of wintering waterbirds was reduced mainly due to the fact that in the spatial units accepted by HELCOM, only some of the countries performed counting of birds on the open sea. Poland distinguished itself against this background by counting winter water birds both in the area directly adjacent to the coast and in the area far from the coast (offshore, from vessels), but the overall assessment must take into account the fact that in other areas of both basins counting from vessels was not performed. In addition, some of the wintering species occurred in low abundance enough to make it impossible to assess indicators in a reliable way.

The confidence of the breeding bird population assessment was higher than that of wintering birds, but some constituent species were not counted on all of the areas covered by the assessment, reducing spatial representativeness and derogating from the adopted methodology.

The productivity rate of the white-tailed eagle concerned only the area of Poland and was assessed as reliable.

The number of breeding species for which data is currently collected in Poland is incomplete and this issue should be addressed when planning of bird monitoring for the purposes of assessing the status of marine waters in the near future is performed. Currently there is no monitoring of the abundance of breeding populations of common ringed plover, Eurasian oystercatcher, common tern, little tern, European herring gull, common gull, mute swan, greylag goose, common shelduck, tufted duck, goosander, and great crested grebe in the coastal area. For some of these species counting of populations nesting in the coastal zone is logistically very difficult, due to the high abundance or hardly available habitats. For several species in this group, however, it is possible to obtain reliable estimates of abundance in the area included in the study with relatively low monitoring costs (Eurasian oystercatcher, common ringed plover, common tern, little tern, common shelduck)

Suggested by expert groups to extend the indicators of breeding bird populations by taking into account the results of performed reproduction (B3, ICES 2015) is practically unfeasible for the vast majority of species, due to the huge labor-intensity and high methodological requirements associated with obtaining reliable estimates. In addition, the acquisition of this type of data in a large spatial scale can be a threat to breeding success. Consequently, it is suggested that in the near future monitoring does not include indicators of the breeding success of the silver-winged plover and silver-footed birds.

### Comparison with the previous reporting period

The wintering bird abundance indexes presented in the initial assessment of the environmental status of Polish marine waters (GIOŚ 2014) referred to other geographical areas than those adopted in this report and comprised only 3 out of 22 species of birds assessed in the current study. Consequently, comparing these indicators is unjustified. Indicators of abundance of breeding bird species were not assessed at all in the previous report. Productivity rates of the white-tailed eagle presented in the initial report concerned a different reporting period and another zone of distance from the sea shore (up to 15 km). In the current report, this zone includes a 10 km wide belt, which makes it impossible to compare values directly. Considering the above, it should be noted that the breeding success of the white-tailed eagle in 2005-2009 was higher (73%) than in 2011-2016 (59%), while the productivity was lower (0.99) than currently (1.07). Similarly, the number of chicks per pair with successful breeding was lower in the previous reporting period (1.37) than in 2011-2016 (1.81). However, the direct comparison of these indicators is unjustified due to the fact that the number of chicks and productivity were undervalued in the previous decade due to the lack of direct control of the nest content.

***Fish***

Two national indices - the Large Fish Index LFI1 and the SI Status Index - were used to assess the fish status (Table 2.1.32).

Table 2.1.32. Indicators used in the national assessment (2011-2016) in the "integrated assessment of biodiversity" in POM including ichthyofauna

| Ecosystem element | Descriptor | Primary criterion | Secondary criterion | Description of the criterion in accordance with the decision 2017/848 | Indicator: core (P), alternative (A), pre-core (W), national (K), biodiversity (B), eutrophication (E) |
|---|---|---|---|---|---|
| ichthyofauna | D1 - Biodiversity | D1C3 | D4C3 | The population demographic characteristics | Large Fish index (LFI1) |
| | | D1C2* | D4C1* | The population abundance | Index of the state of ichthyofauna SI in transitional waters |
| | | D1C3* | | | |

** Index of the state of ichthyofauna SI in transitional waters was developed for the WFD*

**LFI1 index** refers to the group of fish in open waters, observed in research catches, performing tasks related to the assessment of the demersal fish stocks (Baltic International Trawl Surveys - BITS). The LFI1 index meets the criteria for Descriptors D1C3 and D4C3 (Table 2.1.32) set out in Decision 2017/848. It is well-developed for a group of demersal fish from the North Sea.

Originally, the **Index of the state of ichthyofauna SI in transitional waters (SI index)**was produced for the purpose of assessing the ecological status according to the WFD. In this study it was also used in the context of MSFD.

**Ecosystem elements**

For the Baltic, the LFI1 index includes only the group of bottom fish, excluding pelagic fish, including 5 species: (cod, whiting, European flounder, European plaice, turbot). On the other hand, the SI index of ichthyofauna status for transitional waters includes a number of fish species occurring in particular waterbodies.

**Assessment area**

***Large Fish Index LFI1***

According to the system adopted by the International Council for the Exploration of the Sea (ICES), the Baltic Sea area has been divided into 12 subareas (*ICES Subdivisions,* Fig. 2.1.62). Individual parts of the Baltic Sea are marked with the following numbers: SD 21 - Kattegat, SD 22 and 23 - Danish Straits, SD 24-29 - Baltic Sea, SD 30 and 31 - Bothnian Bay and SD 32 - Gulf of Finland. The POM cover a part of sub-areas 24, 25 and 26.

The assessment for the LFI1 index is made for ICES subareas 25 and 26 in POM.

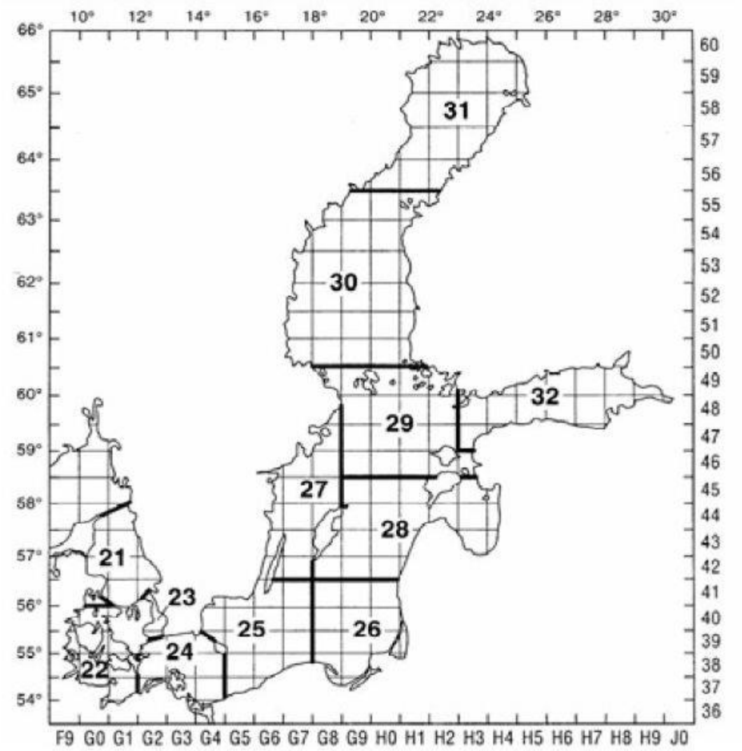



Fig. 2.1.62. Division of the Baltic Sea into sub-areas adopted by the International Council for the Exploration of the Sea (ICES).

Table 2.1.33. Areas used for the aseessment of the state of fish (Descriptor 1) for LFI1 index in (POM)

| No. | Name of sub-basin for the Baltis Sea | sub-basin code | element assessed |
|---|---|---|---|
| 1. | Sub-basin ICES 25 | SD 25 | ichthyofauna |
| 2. | Sub-basin ICES 26 | SD 26 | ichthyofauna |

***Index of the state of ichthyofauna SI in transitional waters***

In the years 2011-2016, in POM, within surface water bodies (WB) included in the transitional water type, fish monitoring was carried out in accordance with the developed Ichthyofauna diagnostic monitoring program. The works included fishing in 9 WB: Dziwna Mouth, Świna Mouth, Wisła Przekop Mouth, Kamieński Lagoon, Puck Lagoon, Szczecin Lagoon, the Vistula Lagoon, the Inner Gulf of Gdańsk and the Outer Puck Bay (Table 2.1.34). Ichthyofauna of the Kamieński Lagoon, Dziwna Lagoon and Świna Lagoon underwent biological monitoring only during the first, pilot research works in 2011. Due to the limited number of observations (one year) for the three above-mentioned WBs, no assessment was carried out for the period 2011-2016.

Table 2.1.34. Polish transitional waterbodies

| | The code of the waterbody | waterbody name | Area [km²] |
|---|---|---|---|
| 1 | PLTW_I_WB_1 | Vistula Lagoon* | 365.8 |
| 2 | PLTW_IV_WB_4 | Gulf of Gdańsk (Inner)* | 710.5 |
| 3 | PLTW_III_WB_3 | Puck Bay (Outer)* | 285.8 |
| 4 | PLTW_II_WB_2 | Puck Lagoon* | 110.9 |
| 5 | PLTW_V_WB_5 | Wisła Przekop Mouth* | 64.8 |
| 6 | PLTW_I_WB_8 | Szczecin Lagoon* | 466.7 |
| 7 | PLTW_I_WB_9 | Kamieński Lagoon | 43.6 |
| 8 | PLTW_V_WB_6 | Dziwna Mouth | 2.4 |
| 9 | PLTW_V_WB_7 | Świna Mouth | 10.5 |

* Assessment performed for the 2011-2016 period

### Indicators

### *Large Fish Index LFI1*

The Large Fish index reflects the general size structure at the level of communities and is assessed on the basis of large fish biomass[2]. It is expressed in the CPUE unit (catch per effort unit). The LFI1 index was recognized as the core indicator in the HELCOM CORESET II studies. Research to date on the LFI1 index for Baltic fish has shown that it is a good indicator of human pressure on the marine ecosystem. Fishery, having a direct impact on the structure of fish communities, may lead to an increase in the number of small fish and a reduction in the average length of fish, thus changing the LFI1 value.

Large fish, present in research fisheries, indicates good condition of the Baltic Sea. The index is intended to express changes in fishing mortality at the level of the population. Low index values express high fishing mortality. On the other hand, with low fishing mortality, but in the absence of adequate food resources, there may be a phenomenon of overcrowding of the population and reduction of average individual lengths, which is also reflected in the fall in the value of the index.

Other environmental conditions, such as temperature or concentrations of nutrients, may also affect the value of the index. The response of the indicator to anthropogenic pressure was the subject of the HELCOM CORESET II group. Until the relationship between LFI1 and fishing pressure is verified, the boundary between subGES and GES will be determined in 2011.

Used in 2011 (at the stage of development and testing of the indicator), the data came from bottom trawls realized as part of the international BITS program from the first quarter of a given calendar year. To calculate the value of the index in the twelve-year period (2000-2008 and 2009-2011), data from the DATRAS database and own database created for the project were used in the Polish fishing zone. In addition to Polish data, data from Danish cruises were also used, which came from fishing in the Polish exclusive economic zone. Data from 476 Polish and 261 Danish sampling points were used for the calculations. Due to the incompleteness of information about the by-catch of all bottom species, it is not possible to use data from before 2000 to estimate this indicator.

In order to make a precise assessment containing data for describing specific parts of the Polish coast, a separate assessment is made for: the eastern part of the open sea (corresponding to ICES subarea 26) and the western part (corresponding to ICES subarea 25). Calculation of the indicator for the Polish part of ICES subarea 24, was not developed, because it is not possible to

2 The term "large fish" means fish above the total length (longitudo totalis) defined specifically for each area. In the case of POM, "large fish" are individuals over 30 cm l.t

assess the fish community on the basis of results from only a small subdivision within POM border. Dominating in ICES 22-24 sub-areas cod forms a separate western stock there.

At the HELCOM forum, no GES limits have been set for the large fish indicator in the Baltic sea bottom ichthyofauna. Indicator testing has shown that since 2008 the value of the index has been increasing, which indicates an increasing share of large fish. These trends were observed both for cod and for other demersal species of the Baltic Sea. The increase in the LFI1 index was demonstrated in the period when the cod fishing started to be reduced, which resulted in the reduction of fishing mortality of this species.

In 2012, it was decided that for the purposes of the initial assessment of the marine environment, the LFI1 index in the period of high fishing mortality of cod (2000-2008) will be subGES, while the assessment based on the 2009-2011 data series, indicating the improvement of marine environment in the area of open waters, it will present the level of GES.

During the analysis of the results of research conducted in 2011-2016, the analogous principle of assessing the condition of the marine environment was adopted - it was based on the previously used level of the GES reference value.

**Sub-basin ICES 25**

The value of the LFI1 index in 2009-2011 was 0.85 (SD = 0.05), and was significantly higher than the calculated average value 0.60 (SD = 0.12) for the years 2000-2008. The difference between means was statistically significant. The threshold value was set at 0.8.

The value of LFI1 in 2011 was high and reached a higher level (0.82) than the threshold value, which for this area is 0.8. In 2012, it remained at the same level. In 2013, it was only 0.59, in the following year it decreased, a year later it increased again, so as to drop again in 2016 to the value of 0.45. The value of the LFI1 index for demersal species excluding cod first increased from 0.38 in 2011 to 0.42 in 2012, and then dropped to a record low of 0.10. This means that the share of biomass of flat fish in the population, mainly flounder larger than 30 cm, decreased significantly (Fig. 2.1.63).

**Sub-basin ICES 26**

The value of the LFI1 index in 2009-2011 was 0.80 (SD = 0.10), and was higher than the calculated average value of 0.36 (SD = 0.10) for the years 2000-2008. The difference between means was statistically significant. The threshold value was set at 0.7.

In 2011, the value of the LFI1 index was much higher than the designated threshold value (0.7). In 2012, it fell, but it was still higher than the threshold value. In 2013, it reached the level below the threshold value. The following year was only 0.47. In 2015, it increased again to 0.67, thus close to the threshold value, and in the following year to 0.6. The value of the LFI1 index for demersal species excluding cod from 2011 first increased - to the level of 0.32 in 2012 - and then decreased and in 2016 reached the value of 0.14 (Fig. 2.1.64.).

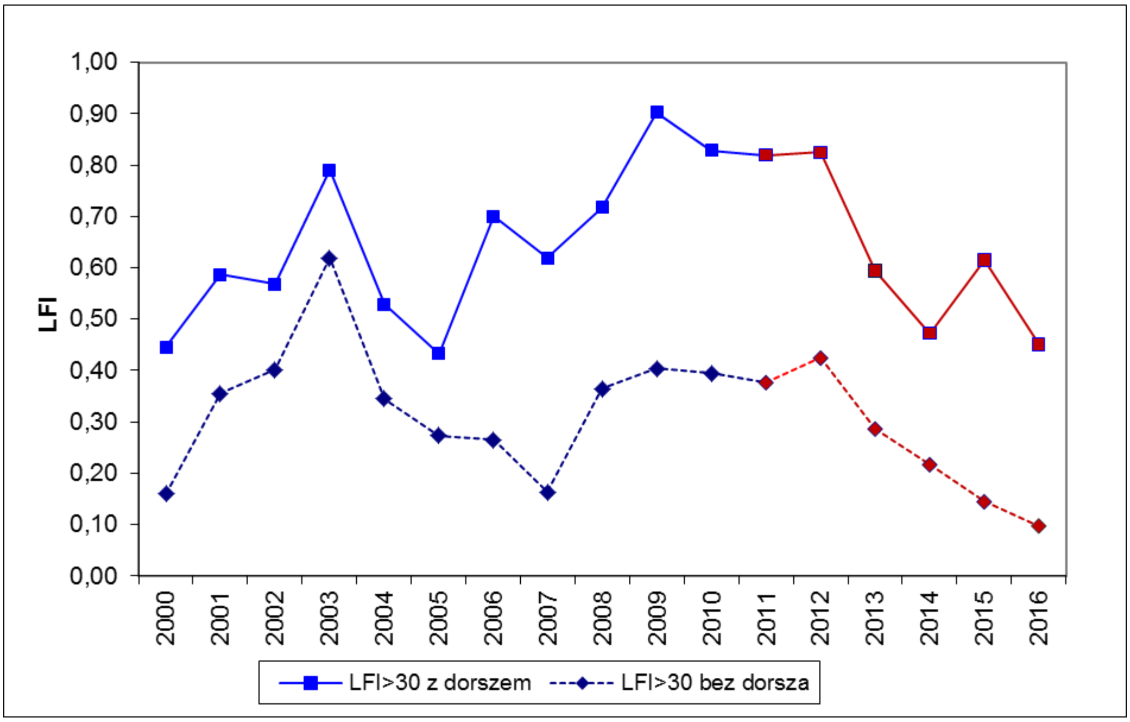



Fig. 2.1.63 Changes in the LFI1 index (calculated including cod and without) in 2000-2010 and in 2011-2016 (marked in red) in ICES subarea 25

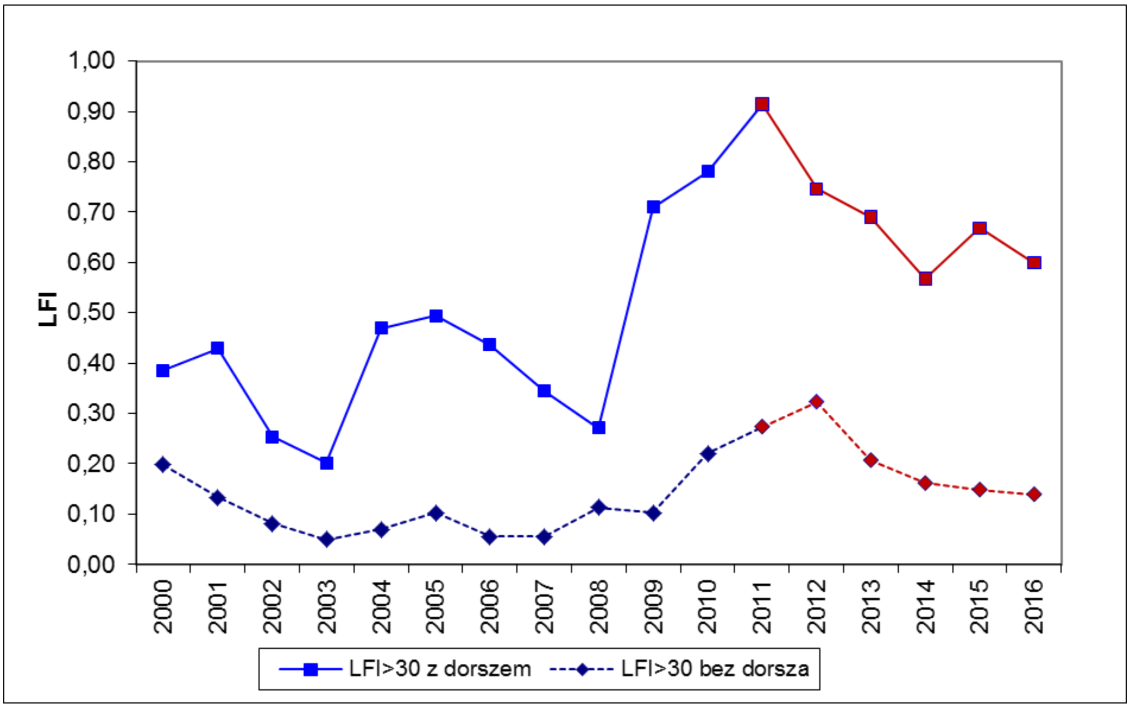



Fig. 2.1.64. Changes in the LFI1 index (calculated including cod and without) in 2000-2010 and in 2011-2016 (marked in red) in ICES subarea 26

### *Index of the state of ichthyofauna SI in transitional waters*

To assess the ecological status of waters based on the characteristics of fish communities, the ichthyofauna status index (SI) has been formulated. The index is calculated on the basis of a number of partial indices, indicated for each waterbody.

Due to the diversity of ichthyofauna assemblages in particular biotic types and different methods of fishing, indicators selected for the biotic characterization of a given type of water were used. Indicators include the following range of catch data:

- species composition,
- abundance of key species or species groups,
- size structure of key species or species groups,
- age structure of key species or species groups.

The assessment of the state and ecological potential monitored in WBs was made on the basis of the methodology presented in the "Methodological guide to assess the ecological status and classification of transitional waters", prepared as part of the task "Monitoring of ichthyofauna in the transitional and coastal waters zone" in 2010-2012, taking into account the indicators referring to fishing data from the summer period (in 2014, 2015 and 2016, according to the HELCOM recommendations, research fishing took place only during the summer). The final assessment was based on a set of partial indicators, taking into account the scope of necessary data determined by the WFD requirements and Polish law. For proper interpretation of results, short names of individual partial indicators are given in brackets:

- number of species found in catches with a share exceeding the average of 5% of the catches in the summer season (**Number of species**);
- average number per unit of fishing effort of the key species: perch in catches in the summer season (**CPUE perch**);
- average number per unit of fishing effort of the key species: flounder, in catches in the summer season (**CPUE flounder**);
- average number per unit of fishing effort of predatory fish in catches in the summer season (**CPE predators**);
- average number per unit of fishing effort of large fish (over 30 cm long lt. T.) in catches in the summer season (**CPE large fish**);
- average share of perch in the age above 3 age groups in catches in the summer season **(% perch> 3**);
- average share of perch in the age above 2 age groups in catches in the summer season **(% perch> 2**);

The final assessment was based on the proposed ichthyofauna index (SI). The index values have been calculated separately for each waterbody, based on a set of scaled indices in accordance with the following equation:

$$SI = \frac{\sum W_1 \times 3 + \sum W_2 \times 2 + \sum W_3}{\sum n_1 \times 3 + \sum n_2 \times 2 + \sum n_3}$$

where:

$W_1$, $W_2$, $W_3$ - value (on a five-point scale) of partial indices with the rank of 1, 2, 3 respectively

$n_1$, $n_2$, $n_3$ - number of partial indices with the rank of 1, 2, 3 respectively

The reference value of the ecological quality index (EQR) for all waterbodies in 2011-2016 was defined as SI = 5. At the same time, it is the maximum value that the SI status index can obtain, calculated on the basis of graduated partial indices. In order to make a final assessment of the quality of the aquatic environment based on ichthyofauna elements, the values of the ichthyofauna index (SI) and the corresponding values of the ecological quality index (EQR) presented in the table below were used (Table 2.1.35.).

Table 2.1.35. Value ranges of the SI and EQR index for individual assessments of the ecological status of transitional waters or the ecological potential of heavily modified waterbodies

| Assessment of ecological status | Assessment of ecological potential | Range of SI values | The range of EQR values |
|---|---|---|---|
| Very good | Maximal | 4.4-5 | 0.88- 1.0 |
| Good | Good | 3.4-4.3 | 0.68-0.87 |
| Moderate | Moderate | 2.4-3.3 | 0.48-0.67 |
| Poor | Poor | 1.4-2.3 | 0.28-0.47 |
| Bad | Bad | 1-1.3 | less than 0.28 |

It should be taken into account the fact that due to the lack of a long series of monitoring data referring to ichthyofauna of transitional waterbodies, the currently used class boundaries of individual partial indicators are a preliminary proposal and should be verified during subsequent years of research.

**„Integrated biodiversity assessment - fish"**

***Large Fish Index LFI1***

In the case of the LFI1 index, within six years throughout the entire examined area of open waters, the status determined on the basis of the LFI1 index gradually deteriorated. The analysis of the LFI1 index shows that cod biomass larger than 30 cm in the six-year period gradually decreased. The LFI1 index initially indicated good environmental status, but since 2013 it has fallen below the threshold value. In the analysed period, the share of biomass of large flat fish decreased. At the end of this period, in 2016, the share of biomass of large cod in the population in both ICES sub-areas decreased. This indicates deterioration of the marine environment in terms of the share of large fish biomass.

As described above, the status of the marine environment in relation to the LFI1 index was assessed as subGES (Table 2.1.36, Fig. 2.1.69).

Table 2.1.36. LFI1 index assessment for ICES subareas 25 and 26 in particular years.

| ICES subarea | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Integrated assessment 2011-2016 |
|---|---|---|---|---|---|---|---|
| open sea - eastern part (ICES 26) | GES | GES | subGES | subGES | subGES | subGES | subGES |
| open sea - western part (ICES 25) | GES | GES | subGES | subGES | subGES | subGES | subGES |

***Index of the state of ichthyofauna SI in transitional waters***

Changes in the value of partial indicators were presented in the form of a line chart (Fig. 2.1.65.). A tendency that can be observed in all water bodies by 2015 is the decline in the number of predators and the decline in the abundance of perch in the fishery. However, the results of ichthyofauna monitoring carried out in 2016 in the area of the Puck Lagoon, the Vistula Lagoon and the Outer Bay of Puck indicate a slight increase in the number of predators and perch. In the assessed period within the Wisła Przekop mouth waterbody there was a decrease in the number of large fish, related to the specific hydrological conditions observed in the monitoring stations during the fishing. In trawls made in Wisła Przekop mouth in 2014 and 2015, pelagic fish dominated (herring, sprat, and smelt), while the number of large fish (including large predatory fish) was low. Similarly, the number of flounders at sites located in Wisła Przekop mouth was low compared to previous years.

Until 2015, a decline was observed in the size of large fish in the Vistula Lagoon, the Puck Lagoon and the Puck Bay. The values of this indicator for these water bodies increased slightly in 2016. In 2014 and 2015, in the fishery monitoring carried out on the Vistula Lagoon, a strong group of perches belonging to age groups above 2 was recorded. The value of this indicator at the Vistula Lagoon in 2016 decreased compared to 2015. Similarly, in 2015 a high share of perch, belonging to age groups over 3 was observed at the Puck Lagoon and the Puck Bay. The number of species with a share exceeding on average 5% of the total catch in the analysed period does not show significant trends and ranges from 2 to 5.

It should be borne in mind that the observed changes in the value of indicators may be of short (several-year) fluctuations, related to the natural dynamics of fish populations occurring in transitional waters. Therefore, it seems impossible to predict long-term significant trends in the structure and functioning of ichthyofauna based on limited data.

The values of the presented partial indicators in the years 2011-2016 were reflected in the form of partial assessments of the ichthyofauna index (SI) within monitored waterbodies (Fig. 2.1.66.). Changes in partial assessments, in turn, were important in the context of the final value of the SI index (Fig. 2.1.67.) and assessment of the status of transitional waters based on the fish communities there. In the years 2011-2015, a drop in the SI index value was observed within the majority of waterbodies. It was particularly visible in the case of the Vistula Przekop Estuary, the Puck Outer Bay and the Inner Gulf of Gdańsk. The value of the index increased in 2013-2016 in the case of the Puck Lagoon. The value of the SI index calculated on the basis of data from 2016 increased in relation to 2015 also for the Puck Outer Bay and the Vistula Lagoon.

In ichthyologic research there is uncertainty of results associated with high mobility of fish and their behaviour as well as difficulties in adapting research methodology to different environmental conditions. An unambiguous interpretation of the presented results as evidence for the deterioration of the ecological status of the discussed waterbodies is not recommended. It is necessary to obtain a proper series of data, enabling testing of used methods for assessing ecological status in a time scale and to track long-lasting changes taking place in the environment. The presented results should be considered in conjunction with indicators based on other biological elements used to assess the ecological status of aquatic ecosystems.

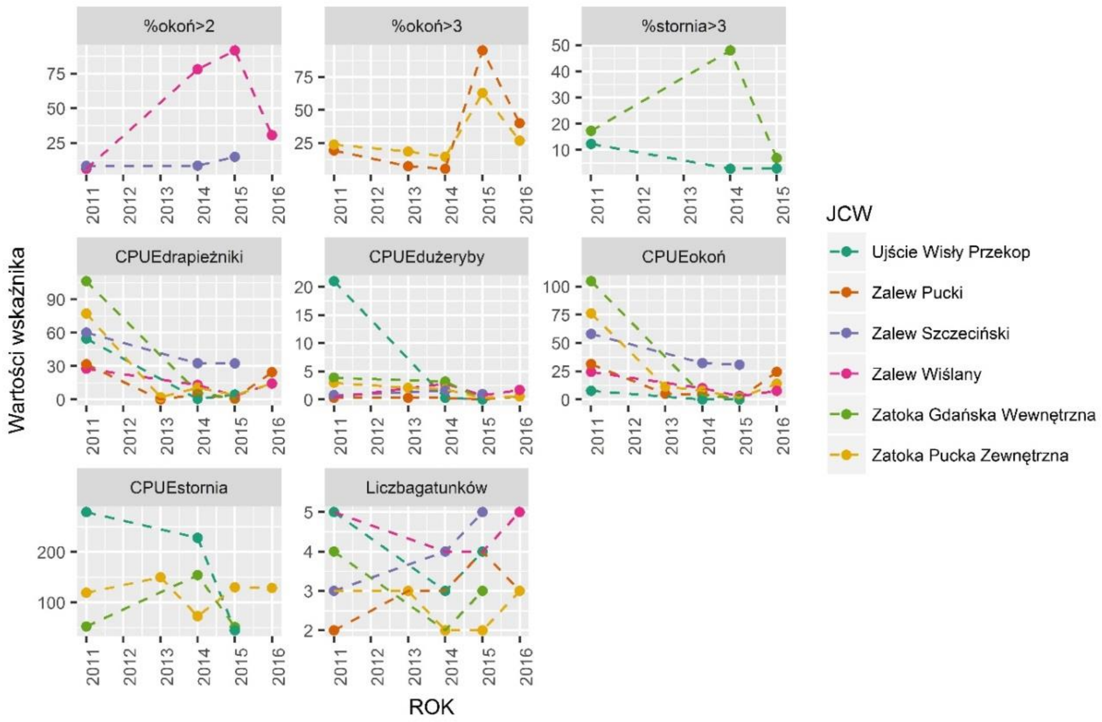



Fig. 2.1.65. Changes in the value of selected partial indicators within the ichthyofauna index (SI) in individual waterbodies. (Data source: PMŚ)

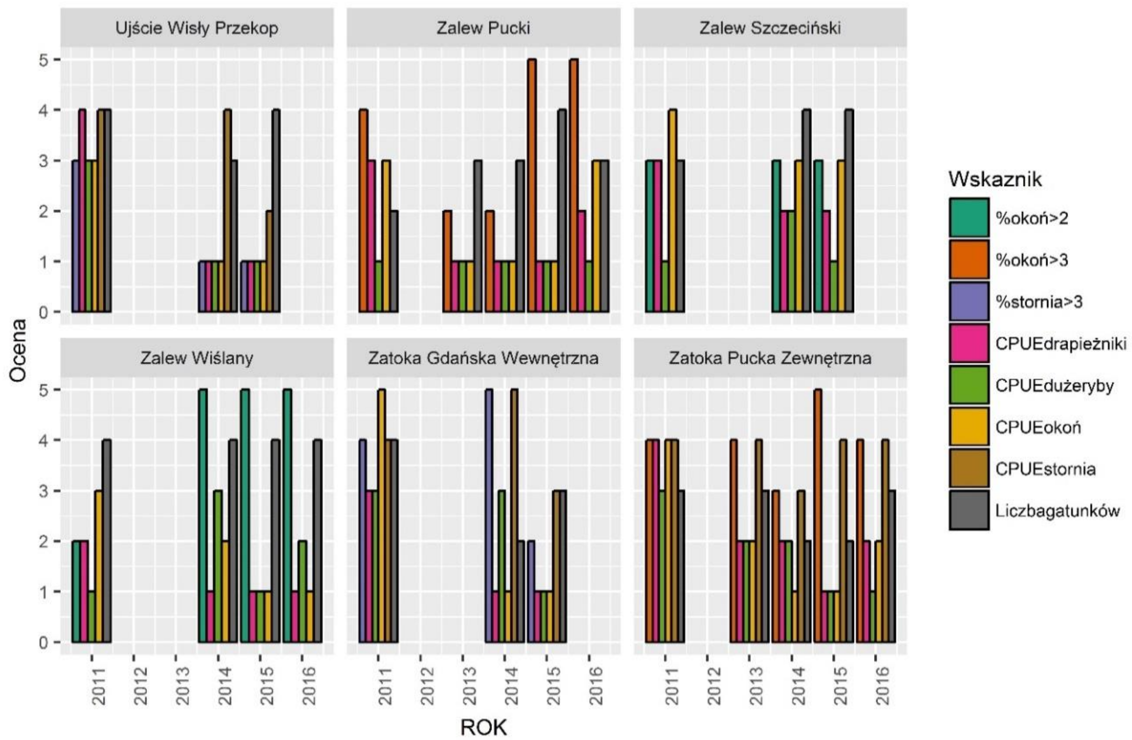



Fig. 2.1.66. Changes in the assessment of selected partial indicators within the ichthyofauna index (SI) in individual waterbodies. (Data source: PMŚ)

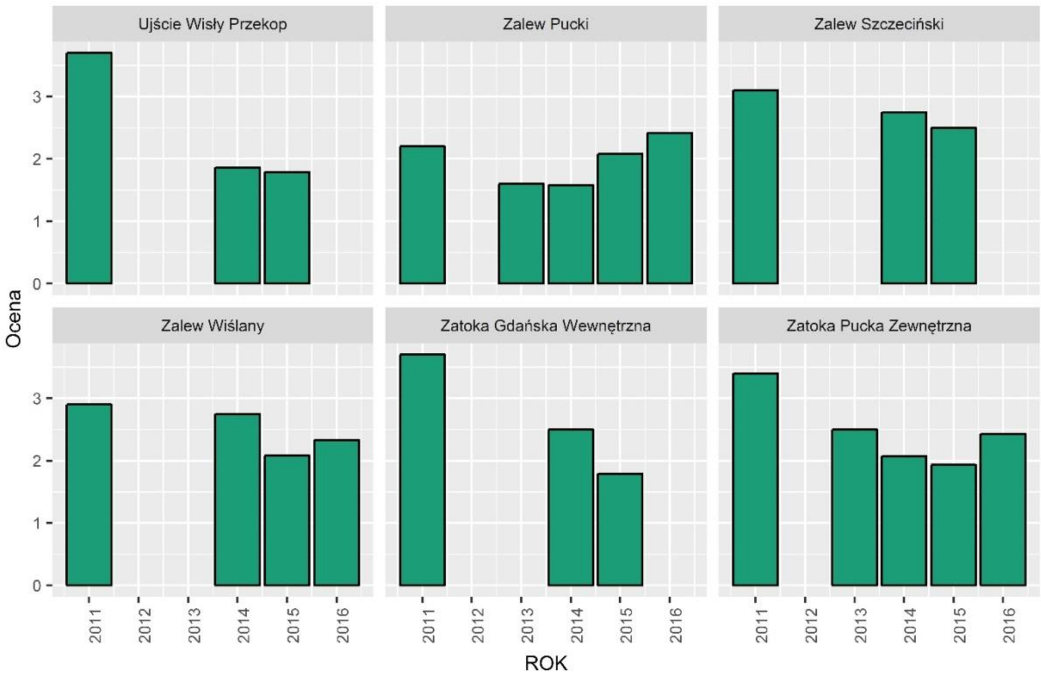



Fig. 2.1.67. Changes in the value of the ichthyofauna index (SI) in individual water bodies. (Data source: PMŚ)

The assessment of ecological status on the basis of ichthyofauna in 2011-2016 for transitional waterbodies was made taking into account the "one-out, all-out" principle. This means that the final assessment for 2011-2016 took into account the lowest rating recorded in the analyzed period (Table 2.1.37). The SI index was also used to assess the D1 Descriptor (SI principles meet the following criteria of MSFD D1C2 'population abundance' and D1C3 'population demographic'). In the case of 3 waterbodies, the overall assessment was not made because the available data only concern the samples collected in 2011.

Table 2.1.37. The value of the ichthyofauna index (SI) in transitional waterbodies in 2011-2016. Colours present the assessment of ecological status in subsequent years and the overall assessment in 2011-2016: red - bad, yellow - moderate, green - good, white (Bd) - no data, gray - no overall rating.

| waterbody name | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Average SI from the period 2011-2016 | Overall rating according to MSFD |
|---|---|---|---|---|---|---|---|---|
| Dziwna Mouth | 3.6 | Bd | Bd | Bd | Bd | Bd | 3.60 | * |
| Świna Mouth | 3.4 | Bd | Bd | Bd | Bd | Bd | 3.40 | * |
| Wisła Przekop mouth | 3.7 | Bd | Bd | 1.86 | 1.79 | Bd | 2.45 | |
| Kamieński lagoon | 3.0 | Bd | Bd | Bd | Bd | Bd | 3.00 | * |
| Puck lagoon | 2.2 | Bd | 1.6 | 1.58 | 2.08 | 2.42 | 1.97 | |
| Szczecin lagoon | 3.1 | Bd | Bd | 2.75 | 2.5 | Bd | 2.78 | |
| Vistula lagoon | 2.9 | Bd | Bd | 2.75 | 2.08 | 2.33 | 2.51 | |
| Inner Gulf of Gdańsk | 3.7 | Bd | Bd | 2.5 | 1.79 | Bd | 2.66 | |
| Outer Puck Bay | 3.4 | Bd | 2.5 | 2.07 | 1.93 | 2.43 | 2.47 | |

* * In the case of 3 waterbodies, the overall assessment was not performed because the available data only concern the samples collected in 2011

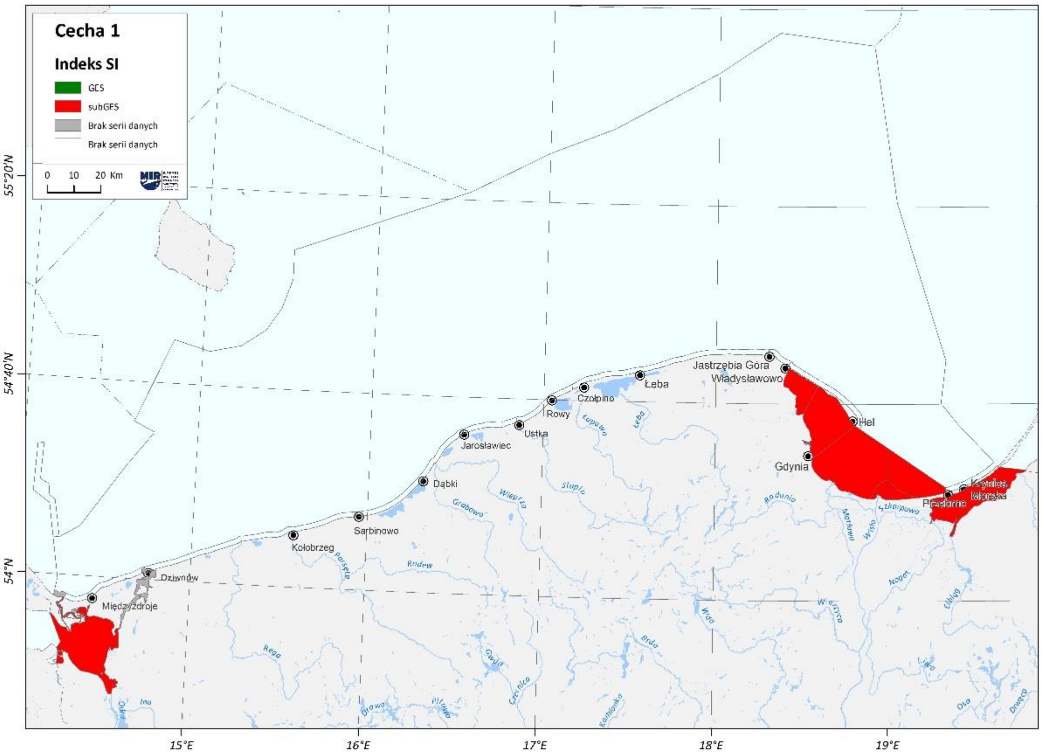



Fig. 2.1.68. Assessment of the state of the marine environment of transitional waters according to the WFD in 2011-2016

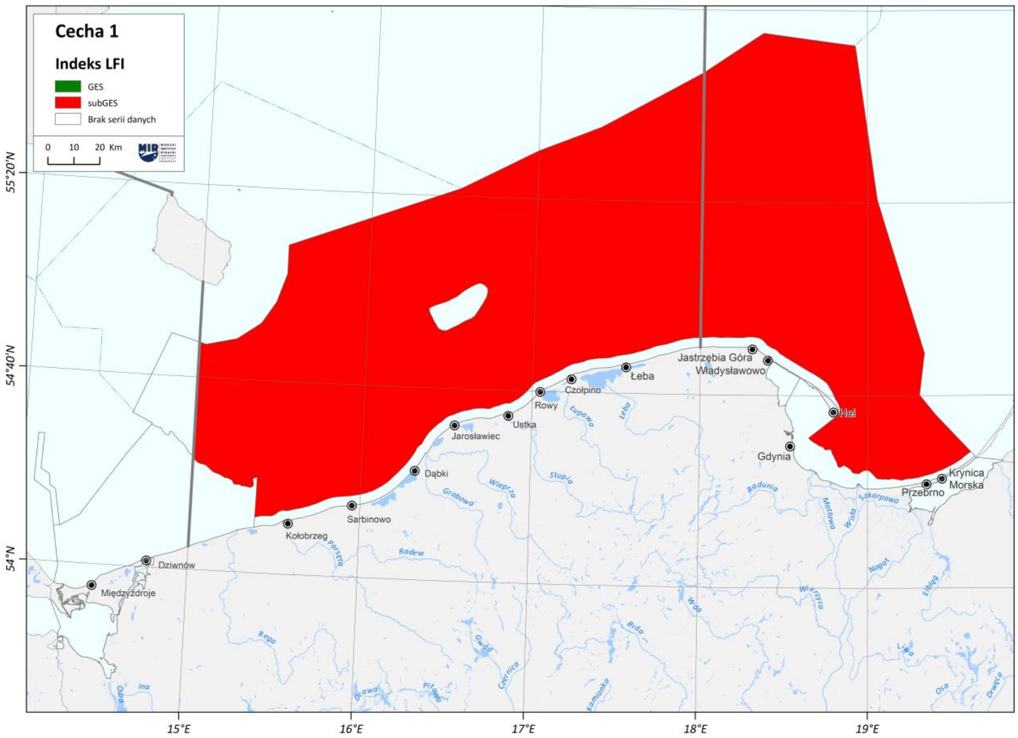



Fig. 2.1.69. Assessment of the state of the marine environment based on LFI1 for ichthyofauna in 2011-2016

**Confidence of the assessment**

***Large Fish Index LFI1***

The assessment of the environmental status of open waters was based on data from several years of research. In each year, the samples were obtained from several dozen stations, which quite well cover ICES sub-areas 25 and 26. The methods of fishing at stations were the same every year. For this reason, the confidence of the status assessment of open waters based on the LFI1 index should be considered high.

A reservation can only be made to the currently accepted threshold values between good and bad environmental status. They are temporary and may change. Then the current interpretation of results and the resulting assessment of state of open waters may change. Nevertheless, even when the threshold values are changed, the decreasing trend of the LFI1 index is already clearly visible, indicating the deterioration of the environment since 2011.

Table 2.1.38. The method of determining the average confidence of the indicator for single area of assessment

| Confidence for the assessment area | LFI1 | |
|---|---|---|
| assessment area | SD25 | SD26 |
| Temporal coverage | 1 | 1 |
| Spatial representation | 1 | 1 |
| Classification confidence | 0.5* | 0.5* |
| Methodological confidence | 1 | 1 |
| Averaged indicator confidence (WW) | 0.875 | 0.875 |

** The reduced rating in the case of classification results from the arbitrary adoption of threshold values.*

***Index of the state of ichthyofauna SI in transitional waters***

In 2011-2016, research aimed at monitoring the ichthyofauna status were conducted in 18 water bodies (WB) within POM. Most areas belonging to the coastal water type were examined only in one year (2011), and WB Jarosławiec - Sarbinowo in two years (2011 and 2015). The remaining WB, belonging to the transitional water type, were subjected to research in the period from 1 year to 5 years, with intervals (Table 2.1.37). According to MSFD and the HELCOM (FISH-PRO II) findings, two indicators in the assessment of the marine environment under D1 apply: *Abundance of coastal fish key functional groups* and *Abundance of key coastal fish species, including key functional groups of coastal fish* (predators and cyprinids) and *key species of coastal fish* (flounder or perch). The assessment is carried out separately for individual monitoring stations, thanks to which the impact of environmental conditions (e.g. water salinity, water temperature, etc.) and fishing tools on condition assessment are minimized. It can be carried out with two methods, and the choice of method depends on the availability of data. If a sufficiently long time series are available, representing the values of these indicators (15 and more years of a series), it is possible to use the basic approach based on comparing the current values of the ratios with the values observed in the reference period (the so-called "baseline approach"). If these requirements are not met (e.g. time series <15 years), it is possible to use a substitute methodology, based on trend analysis. Therefore, the assessment is not possible for data covering the results of one or two years of ichthyofauna research for the two aforementioned indicators. In turn, the use of a short time series is related to the low statistical power of the test due to the low number of observations (values of the indicator in particular years) and is not recommended in the assessment of the condition of the marine environment based on the coastal zone ichthyofauna. In accordance with the HELCOM FISH PRO II methodological assumptions, the assessment carried out on a data series not exceeding 10 years has a low confidence (HELCOM, in prep.).

Taking into account the above information and arguments, the assessment on the basis of HELCOM (Abundance of coastal fish key functional groups and Abundance of key coastal fish species) indicators was not possible. However, the SI index was used to assess Descriptor 1 according to MSFD (SI assumptions meet the following criteria of MSFD D1C2 'population abundance' and D1C3 'population demographic'), which allowed to assess six transitional waterbodies (Table 2.1.37, Fig. 2.1.68).

Table 2.1.39. The method of determining the average confidence of the SI index for one area of assessment

| Confidence for the assessment area | Wisła Przekop mouth | Puck Lagoon | Szczecin Lagoon | Vistula Lagoon | Gulf of Gdańsk (Inner) | Puck Bay (Outer) |
|---|---|---|---|---|---|---|
| Temporal coverage | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Spatial representation | 1 | 1 | 1 | 1 | 1 | 1 |
| Classification confidence | 0 | 0 | 0 | 0 | 0 | 0 |
| Methodological confidence | 0 | 0 | 0 | 0 | 0 | 0 |
| Averaged indicator confidence (WW) | 0.375 | 0.375 | 0.375 | 0.375 | 0.375 | 0.375 |

In the case of ichthyofauna, the confidence for the assessment area (WO), that is for the entire POM, is the arithmetic mean of the confidence of the indicators (WW). High confidence (0.875) was obtained for the LFI1 index and low (0.375) for the SI index.

As a result, in the biodiversity assessment for ichthyofauna, the result of confidence (WO) was obtained (mean) (0.625) according to the classification presented in Table 2.1.40.

Table 2.1.40. Classification of the result of the confidence assessment

| Confidence assessment for the assessment area (WO) – POM, 2011-2016 | Confidence status |
|---|---|
| ≥ 0,75 | high |
| 0,5 – 0,74 | medium |
| < 0,5 | low |

## *Benthic habitats*

### Indicators

In the first version of the HELCOM HOLAS II holistic assessment, not all indicators were used, which in recent years were developed by the appropriate groups implementing HELCOM projects (HELCOM 2017a), because they still need to specify the calculation method, set threshold values in all assessment areas and test indicators based for relevant monitoring data. Thus, they were not used in the national assessment in POM.

In the 2nd Holistic Review for the years 2011-2015, in the "State of the Baltic Sea: The second HELCOM holistic assessment of the ecosystem health of the Baltic Sea - first version" report (HELCOM 2017a), benthic habitats were assessed using simultaneously:

In open waters:

- Indicator '*State of the soft-bottom macrofauna community*' – BQI above the halocline, that was set arbitrarily at a depth of about 60 m;
- eutrophication indicator – '*Oxygen debt*' defining oxygen deficit, for a zone deeper than 60 m.

In transitional and coastal waters:

- national indicators of the state of benthic macroinvertebrates and national indicators of the state of macrophytes;
- eutrophication indicator '*Transparency - visibility of the Secchi disc*';
- eutrophication indicator '*Dissolved oxygen concentrations at the bottom'*.

However, in this national assessment, the status of benthic habitats in open waters as well as in the transitional and coastal water bodies in the POM area was assessed on the basis of three national indicators: B, $SM_1$ and ESMIz. To assess the soft bottom habitat, the indicator B was used to determine the state of benthic organisms and the $SM_1$ index defining the state of macrophytes. The assessment of the state of the hard bottom habitat and the condition of the mixed bottom habitat was carried out using the $SM_1$ indicator. The habitat of the soft bottom covered with macrophytes in the Vistula, Szczecin and Kamieński Lagoons was assessed on the basis of the ESMIz index.

The SMi index was developed in 2009 (Osowiecki et al 2009, GIOŚ 2014), justifying its use in POM in detail and the specific character of the POM environment. This indicator was used to assess the initial state of the environment of the Polish Baltic economic zone for the years 2005-2010 (GIOŚ 2014). Pursuant to the Regulation of the Minister of the Environment of 21 July 2016 on the method of classification of the surface water bodies and environmental quality standards for priority substances (Journal of Laws, item 1187), it is used to assess the state of macrophytes in transitional waters (Puck Lagoon, Outer Puck Bay) and coastal POM. In other parts of transitional waters, such as the Vistula Lagoon, the Szczecin Lagoon and the Kamieński Lagoon, the ESMIz index was used (Ciecierska i Kolada 2014, Bociąg 2016). The ESMIz index has been implemented into the classification and assessment system of transitional and coastal waters in POM by the decision of the Chief Environmental Protection Inspector, included in the document "Guidelines for voivodship environmental protection inspectorates to assess the condition of surface water bodies and to assess additional requirements for waters that are protected areas" in May 2017.

The concept of using a single, universal indicator to assess the condition of benthic habitats on the basis of zoobenthos, on the soft bottom in open Baltic waters for the purposes of the second holistic assessment was developed as a result of the HELCOM CORESET II project. A modified multi-metric BQI (Benthic Quality Index) was chosen, which is now synonymous with the "*State of the soft-bottom macrofauna community*" indicator, which excluded the assessment of benthic indicators developed in most of the Baltic countries. (BQI, DKI, MarBIT, ZKI, BBI and B).

The core indicator "Status of soft bottom macrofauna communities" - BQI has not been approved by all Baltic countries (including Denmark, Germany and Sweden) and has not been used for assessment in all sub basins in POM. The HELCOM TAPAS project decision was to apply in assessing the state of macrozoobenthos only at stations with a depth not exceeding 60 m, which means excluding the assessment of water bodies represented by monitoring stations at depths greater than 60 m. For the latter areas, the use of an index taken from the eutrophication assessment - *"Oxygen Debt"* was recommended. In contrast, the national assessment assessed the benthic habitat in open sea waters only on the basis of the B index based on data from stations located both above and below the halocline, thanks to which additional use in the assessment of the national indicator *"Oxygen Debt"* is unnecessary.

The BQI indicator assumes that the sensitivity of particular macrozoobenthos species, which are a component of the indicator algorithm and have a significant impact on the calculated value, depend on taxonomic diversity, which is a derivative of salinity. In POM, this statement should be considered an over-simplification, because taxonomic diversity and the presence of sensitive species are shaped by many other factors. The most important are the following eutrophication factors: low quality of bottom sediments resulting from excess organic matter and oxygen conditions in the bottom layer of water. In the region of the south-Baltic depths, salinity increases with increasing depth, while the number of zoobenthos species - especially sensitive ones - decreases.

Sensitivity values were determined by Schiele et al. (2016) for 329 macrozoobenthos species in 19 geographical subdivisions of the Baltic Sea, taking into account differences in salinity, depth and sampling tools. No threshold values were set for sub-basins within the POM limits, i.e. the Bornholm Basin and the Gdańsk Basin, and for Eastern Gotland Basin the threshold value was initially determined. The status of benthic habitats in open waters of POM in the second holistic assessment (HELCOM 2017a), i.e. the Bornholm Basin and the Gdańsk Basin was assessed only using the "Oxygen Debt" indicator, because for these sub-areas there were no threshold values for good environmental status for BQI.

The selection of the set of indicators used in the report of the second holistic assessment (HELCOM 2017a) for the assessment of the condition of benthic habitats in coastal and transitional waters is debatable. The following indicators proposed by the expert team of the BalticBOOST and SPICE project: "Oxygen dissolved at the bottom" and "Transparency of seawater - Secchi disc visibility" will not be used in assessing the national state of benthic habitats. These indicators are an objective tool to determine the status of pelagic habitats, however, their use for the assessment of seabed habitats and benthos raises substantive doubts.

The "Sea water transparency - Secchi disc visibility" indicator applies only to the surface layer of water (down to about 6-7 m), so it has an indirect and only limited relationship with the quality of seabed habitats. Water transparency is characterized by natural variability in time and space (momentary post-storm water turbidity, intense river runoff, moving phytoplankton blooms, etc.) Increased concentrations of suspended matter and plankton in the dynamic, near-surface layer of water - limiting its transparency - affect the seabed habitats and the zoobenthos inhabiting them at most, indirectly .

The "dissolved oxygen at the bottom" indicator in the bottom water layer belongs to a group of factors important for benthos, but in coastal and transitional waters oxygen in the bottom layer of water is not a limiting factor for the zoobenthos communities, because the shallow water depth allows vertical mixing of water masses and good direct exchange with the atmosphere, thanks to which there are no oxygen deficits in the bottom zone. Oxygen is a limiting factor for the occurrence of zoobenthos communities inhabiting the deeper bottom, below the halocline layer (50-60 m), where the mineralization of falling organic matter may result in depletion of oxygen in the bottom The disadvantage of the indicator is that it shows the state at the time of the in situ measurement and does not reflect retrospectively the effects of changes in environmental conditions that have shaped the current benthic community. Persistent state of hypoxia (or anoxia) causes gradual elimination of zoobenthos, however, after inflow of oxygenated waters from the North Sea, a temporary increase in oxygen concentration in the bottom layer of water causes that the living conditions of zoobenthos at the moment of oxygen measurement may have optimal values, which does not mean that benthic organisms are going to be present because repopulation does not take place immediately after aerobic conditions improve. This condition lasts until the exhaustion of oxygen in the process of mineralization of organic matter falling from the water column. The oxygen indicator immediately after inflow of oxygenated waters shows good habitat status, while biotic indicators that directly assess the condition of the benthos can give an unfavourable result.

Assuming that the quality of zoobenthos communities is a derivative of the quality of seabed habitats, biotic indicators based on the qualitative and quantitative structure of zoobenthos should be considered the most suitable measure for the assessment of bottom habitats, taking into account the sensitivity of taxa to pressure factors, and not the assessment of a set of selected factors physical and chemical features. The obtained value of the biotic index of zoobenthos reflects the cumulative effects of all, not just selected, physical and chemical factors. In the Baltic States for over a dozen years, biotic indicators dedicated directly to the assessment of the condition of bottom habitats and benthos inhabiting them have been widely used.

The concept of assessing the state of benthic habitats in the 2nd holistic assessment with the use of the indicator "Status of soft bottom macrofauna aggregates" - BQI - for open waters has not been analysed so far in the context of coherence of assessments done by national indicators versus BQI. Also in terms of substantive assessment principles, the proposed indicator raises concerns regarding possible consequences of methodological inconsistencies in the application of indicators, of which the most important are:

- the division into WFD waterbodies and open sea waters subject to assessment in MSFD is an artificial, typically administrative division (waterbodies and HELCOM sub-basins are basic management unit subject to separate assessments and resulting consequences). does not take into account the continuity of the seabed habitats that maintain the same biotic and physical and chemical features, although they have been separated into territorial units by different methods;
- the BQI indicator is based on other sensitivities of zoobenthos species than national indices, which may result in a different assessment value;
- the reference values for the BQI ratio were determined in a different way than for national indicators, which may result in differences between assessments;
- division into quality classes (good state threshold value - GES/sub-good state - subGES) for the BQI index was determined in a different way than for national indicators.

In the 2nd Holistic Assessment for the years 2011-2015, the BQI biotic indicator and the "Oxygen Debt" indicator were used in the assessment of the condition of benthic habitats in open waters, while the national B index developed in Poland for the purpose of the national ecological status assessment in transitional an coastal waters was used in the implementation of the WFD (Osowiecki et al. 2012, ordinance of the Minister of the Environment of 21 July 2016 on the method of classification of the surface water bodies and environmental quality standards for priority substances.) This method is currently also used in PMŚ in the open sea for MSFD purposes. The B index has been tested and used to assess the environmental status of open waters in the assessment of the initial state of the environment of Polish marine waters (Osowiecki and others 2012, GIOŚ 2014). BQI and B indicators, although based on the same criteria, differ in methodology in terms of their application (Table 2.1.41 i Table 2.1.42).

Table 2.1.41. Characteristics of the criteria used in the national assessment and in the 2nd Holistic assessment using the B and BQI indicators

| No. | Criteria | National assessment<br>B index | Holistic assessment<br>BQI indicator |
|---|---|---|---|
| 1. | The territorial range | Soft bottom POM in the entire depth range | Soft bottom to a depth of 60 m (average depth of the halocline) |
| 2. | Determination of the degree of sensibility / tolerance of taxa (including alien species) | Expert method (based on knowledge about ecology and the occurrence of taxa) | Mathematical calculation (Hulbert index) |
| 3. | The method of determining the reference value | The highest value of the indicator in the territorial unit of assessment | The median of the highest 10% of the BQI value in the territorial salt cell by Schiele et al. (2016) |
| 4. | The method of determining the threshold value - the GES / subGES boundary | Statistical method Jenks-Caspal (1971) | The method depends on the assessment area:<br>- determined with statistical or expert method,<br>- determined as 0.6 of 10th percentile of all BQI values in territorial salinity unit |

Table 2.1.42. Comparative analysis of the application of Indicators B and BQI for individual criteria used in the national assessment and in the 2nd holistic assessment together with recommendations

| Criterion | Indicator B | Indicator BQI | Explanation | Recommendation |
|---|---|---|---|---|
| Justification for the applicability | B index was intercalibrated within the coastal water type BC7. | At present, there are no boundaries of BQI status for 2 out of 3 assessment units in POM, therefore it is not possible to use Indicator in the national assessment. | | |
| Territorial range | The national assessment based on B index will take into account all the results of the PMŚ in the field of macrozoobenthos research, collected during the assessment period (2011-2016), at all stations where zoobenthos was studied, in the entire POM depth range. | Holistic assessment based on BQI will take into account the results of PMŚ in the field of macrozoobenthos research to a depth of 60 m (mean depth of halocline), as a result of the large fragments of the POM sea bottom, on which zoobenthos monitoring is performed, are excluded from the assessment . | The boundary depth of the halocline, 60 m, is not a natural boundary that differentiates bottom habitats in terms of character, properties and integrity. The application of the depth criterion - in the case of the BQI index - results in elimination of monitoring stations located at greater depths from the Bornholm Basin assessment. The depth of the halocline defined at 60 m, including P5 station (91 m) and P3 station (89-90 m), which is located is on the western sill of the Słupsk Furrow and whose bottom is inhabited by a diverse and valuable macrozoobenthos group; quoted: "In 2015, as in the previous year, benthic fauna samples were collected in the area of Słupsk Furrow (stations P2 and P3), where station P3 belongs to the Bornholm basin area, and station P2 to the Gotland basin. The obtained B index values indicated good (P3) and even very good (P2) state of the environment, despite the significant depth of these stations (P2 - 74 m, P3 - 89 m) "(Łysiak - Pastuszak et al. (ed.) 2016 ). Arbitrary determination of the depth of the halocline at 60 m is negatively | The data of macrozoobenthos research obtained in PMŚ from the entire POM area were included in the assessment. |

| Criterion | Indicator B | Indicator BQI | Explanation | Recommendation |
|---|---|---|---|---|
| | | | verified by the results of monitoring survey. Data from the PMŚ in 2012 (source: IMGW-PIB) indicate that: "Closest to the sea surface, at the level of approx. 40 m, the halocline was located in the Bornholm Deep in November, and in other measurement periods it was at a depth of about 45 m ... "(Kamińska 2013). | |
| Determination of the degree of sensitivity / tolerance of taxa (including alien species) | In the national assessment carried out on the basis of B index, the degree of sensitivity / tolerance of zoobenthos taxa to stress factors was determined by expert assessment on the basis of literature data and results of own research on the frequency of occurrence of taxa in particular biotic types. The lowest sensitivity value was given to the alien / invasive species. | In the holistic assessment made on the basis of the BQI index, the sensitivity / tolerance level of zoobenthos taxa is determined using the Hulbert index. The method gives the opportunistic and invasive species high sensitivity values. [in:] (Kownacka and Warzocha 2015): Tab. 1. column "class4_all. Species typical of clean, sandy bottom (*Cerastoderma glaucum* 4.17, *Bathyporeia pilosa* 4.77, *Pygospio elegans* 4.36) have been assigned approximate or lower sensitivity values than the opportunistic indicator species of the degraded bottom (*Hediste diversicolor* 4.17, *Corophium volutator* 6.41 ). Alien species - invasive (e.g. *Marenzelleria* spp. 7.61) also have high sensitive value | Degree of species sensitivity / tolerance, according to the authors of the BQI Index method, depends on salinity (Schiele et al., 2016). Thus, the same individual of a given species, in the same basin, obtains a different sensitivity value along with a change in salinity, e.g. after salty water inflow. | An expert judgment method was adopted to determine the sensitivity of zoobenthos taxa. Invasive and opportunistic species have been assigned the lowest degree of sensitivity. |
| The method of determining the reference value | The reference value of B is the highest value of the index calculated in a given assessment period. | A holistic assessment based on BQI assumes that the reference value of Indicator is the median of the highest 10% of the BQI value in the territorial salinity unit according to Schiele et al. (2016). | The method for determining the reference value proposed for the BQI assessment means that approximately 5% of the highest Index values will exceed the reference value and the EQR (which is the quotient of the calculated Index value and reference value) for | The reference value was determined at the level of the highest Index value measured during the assessment period. |

| Criterion | Indicator B | Indicator BQI | Explanation | Recommendation |
|---|---|---|---|---|
| | | | these values will exceed 1. This is contrary to the definition which specifies the EQR as a standardized non-quantified value that is a fraction of the Index reference value, within the range of 0-1. | |
| The method of determining the threshold value - the GES / subGES boundary | In the national assessment based on B index, numerical limits defining particular ecological quality states, according to the WFD principles, were determined by the natural breaks method, (Jenks and Caspall 1971). It is a method based on optimizing the division of data into groups due to their intra-group similarity and the diversity between them. The threshold value according to MSFD - the boundary between a good state of the environment and a state below good (GES / subGES) - was adopted at the level of the boundary between good and moderate status defined for the needs of WFD assessment. | In the holistic assessment, based on the BQI, the GES / subGES limit determines the product of 0.6 and the value of the 10th percentile (the upper 10% of all BQI values) in the territorial salinity unit according to Schiele et al. (2016). | - | In order to determine the boundary of the GES / subGES status, the natural grouping method was used to assess the status of benthic habitats. |

B and BQI indicators were tested based on monitoring data and BQI index values calculated by HELCOM TAPAS group experts, taking into account the methodology used in the second holistic assessment, i.e. the saline-dependent sensitivity of species in sub-basins defined by Schiele et al. (2016), for stations located above the halocline. The only stations that met the above criteria in POM, and for which BQI indexes were calculated were stations Ł7 and Z, located in the Eastern Gotland Basin. For comparative purposes, from the same data set B index was calculated separately for each of the zoobenthos samples collected at stations Ł7 and Z in 2011-2015.

At the Z station, the values of B and BQI indicators showed that the zoobenthos status characterized by both indicators as good - GES. At the Ł7 station, the BQI indicator in all years and in all samples indicated good environmental status (GES), while the average value of the B index in the assessment period showed that the zoobenthos status was subGES.

The dependence of B and BQI indicators on pressure factors, i.e. eutrophication indicators, was examined for a series of data from the holistic assessment period (2011-2016). The dependencies of multi-metric indicators with the following eutrophication indices were analysed (concentrations of biogenic substances refer to the surface layer of the sea 0-10 m, concentration of chlorophyll-a to the layer of 0-20 m):

- average seawater transparency in the summer months (Secchi disc visibility); Secchi (June-September ),
- transparency of sea water in annual resolution - annual average; Secchi (year),
- average phosphate concentration [$PO4^{3-}$] in the winter months; DIP (I-III),
- average annual phosphate concentration; DIP (year),
- average concentration of total phosphorus in the summer months; TP (June-September),
- average annual concentration of total phosphorus; TP (year),
- average concentration of mineral nitrogen in the winter months; DIN (I-III) [DIN = $NO^{3-}$ + $NO^{2-}$ + $NH_4^+$],
- average annual concentration of mineral nitrogen; DIN (year),
- average concentration of total nitrogen in the summer months; TN (June-September),
- average annual concentration of total nitrogen; TN (year),
- average concentration of chlorophyll-a in the summer months; Chl-a (June-September),
- average annual chlorophyll-a concentration; Chl-a (year),
- average minimum oxygen concentration in the near bottom layer in the summer months; $O_2$ (June-September).

An analysis of the variability of B and BQI indicators over time was also carried out (e.g. index B vs. time). In the five-year data series, virtually no statistically significant relationship was found, with the exception of the relationship between BQI and total nitrogen (TN). Bearing in mind that stations Ł7 and Z are located on a shallow bottom (depth: 21 m and 17 m respectively), this relationship should be considered as accidental. The lack of correlation with other pressure factors may result from the environmental conditions favourable for zoobenthos in this depth zone, but first of all from the poor data set and the very short data series. In such a short period of time, none of the pressure factors potentially affecting zoobenthos communities has proved to be a limiting factor for their development.

Further analysis of the correlation for this POM region was made only for the B index, due to the lack of BQI data in the area. The dependence of the B index in the following data sets was tested:

- dependence on temporary concentrations of eutrophication factors in the bottom layer;
- dependence on eutrophication indicators;

In the system of instantaneous concentrations of nutrients and oxygen in the near-bottom water for the results obtained at stations L7 and Z in the longer term (1999-2016), similarly to the assessment period (2011-2016), no statistically significant dependencies could be demonstrated between indicator B and eutrophication factors (Fig. 2.1.70).

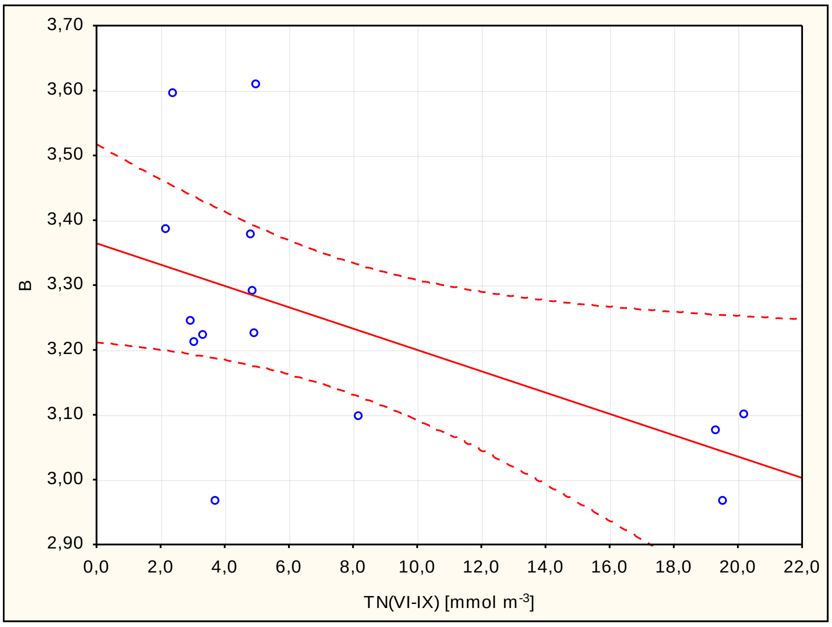



Fig. 2.1.70. Relationship between the indicator (B) and total nitrogen in seawater in the summer months (TN (VI-IX)) in the shallow POM area (stations Ł7, Z), data from 1999-2016

As part of the study of B index dependence on eutrophication indices, in the series of data from 1987-2016, the only statistically significant relationship was found between the B index and the total nitrogen content, which is often treated as an proxy of the organic matter content. Therefore, even in this shallow and dynamic area of the sea, the influence of excess organic matter on the community of organisms living on the bottom is marked.

The only significant dependence occurred between the B index and the pressure factor - total nitrogen (during the vegetation season - months VI-IX), which means that the zoobenthos in the shallow bottom zone limits mainly the availability of organic matter for filtering organisms and feeding on organic matter deposited on the seabed.

Zoobenthos of the deep-water area (under the halocline) in the Polish part of the Eastern Gotland Basin represent the community at station P140. Generally, in deep-water stations environmental conditions for zoobenthos are less favourable than in the shallow bottom zone, moreover they undergo changes of unpredictable frequency caused, above all, by inflows of oxygenated and dense waters from the North Sea. Pressure factors affect macrozoobenthos communities with varying intensity. In this depth zone, pressure factors affect zoobenthos in a definitely limiting manner, therefore the relationships between the values of pressure measurements and the value of the B index are much stronger.

The study of correlation of the B index from the deep-water area with the eutrophication factors was carried out in the same way as in the case of the shallow water zone. The dependence on instantaneous concentrations of eutrophication factors in the near-bottom water layer and dependence on eutrophication indices were investigated. Measurement data from the bottom layer of concentrations of nutrients and oxygen from 1999-2016 did not include the period 2011-2013.

Study of the correlation of the B index with pressure factors - eutrophication indices - showed some significant relationships, the strongest of which is the relation between the B index and the total nitrogen content in the summer months (TN VI-IX; $r = -0.82$; $n = 28$ $p = 0.000$) (Fig. 2.1.70), as well as throughout the entire year (TN-year, $r = -0.90$, $n = 27$, $p = 0.000$), and corresponding to the general nitrogen as an proxy of the suspended matter in the water column - Secchi disc visibility in the summer months (Secchi VI-IX; r = -0,600, n = 28, p = 0.000). Slightly weaker, however statistically significant relation, of the B index was found to the oxygenation of the bottom layer (r = 0.610, n = 28, p = 0.0018) (Fig. 2.1.72). However, the dependence of the B index on the concentrations of mineral nitrogen in the winter months (DIN I-III) should be considered poor. The conducted correlation test showed unequivocally that the state of zoobenthos in the deep-water area is dependent on the eutrophication factors - an excess of organic matter, approximated by the total nitrogen content, is an unfavourable factor. Similarly, oxygen deficiency in the bottom water due to the excess of organic matter.

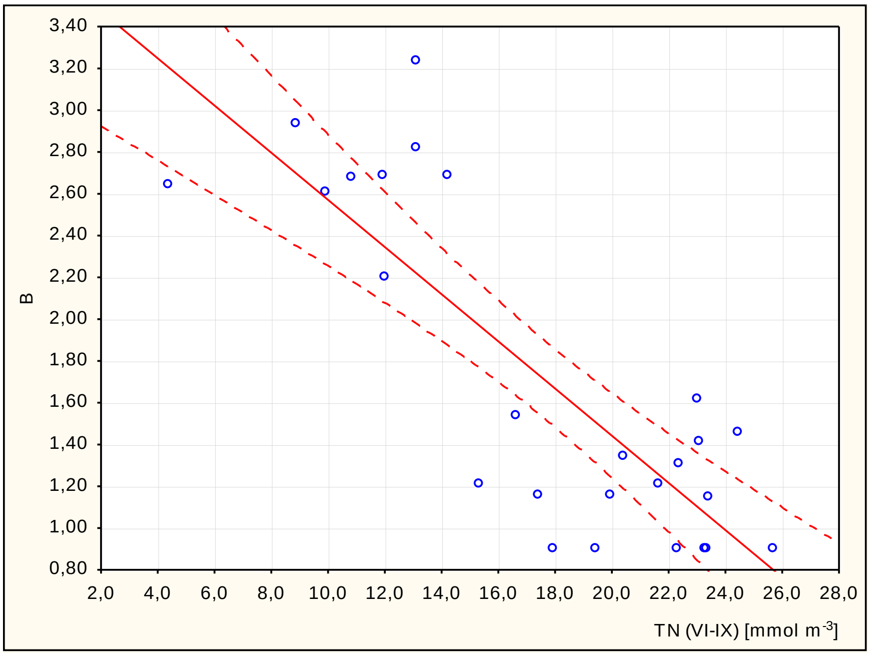



Fig. 2.1.71. Relationship between the macrozoobenthos indicator (B) and the content of total nitrogen in seawater in the summer months (TN (VI-IX)) in south-east Gotland basin (station P140), data from 1987-2016

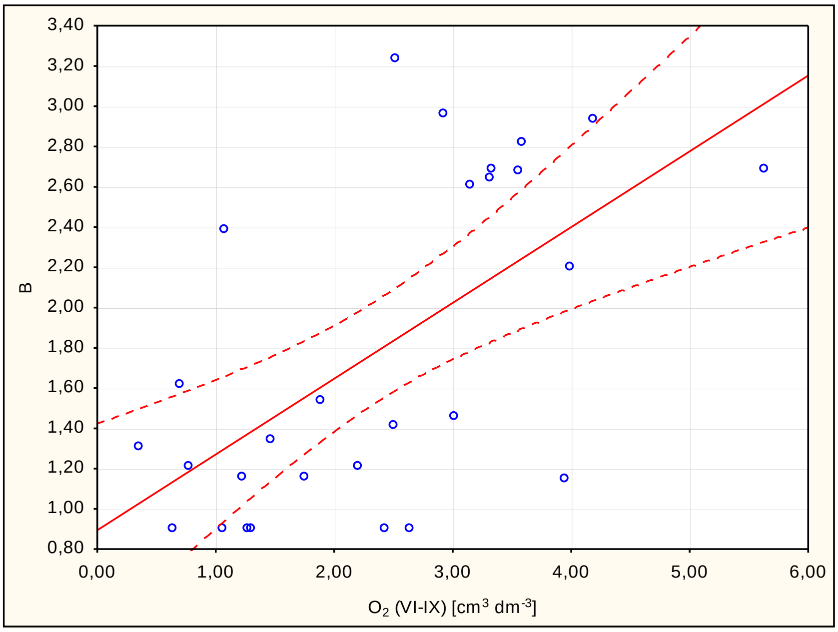


Fig. 2.1.72. Relationship between the macrozoobenthos indicator (B) and the oxygen content in the near-bottom water in the summer months (O2 (VI-IX)) in south-east Gotland Basin (station P140), data from 1987-2016

Summarizing, a comparative analysis of environmental status assessments using B and BQI indicators showed that index B is more selective than BQI, i.e. in contrast to BQI, it differentiates the state of zoobenthos at stations in the shallow water zone of the Polish Baltic. In addition, the B index shows strong links with pressure factors, especially in the deep water zone. The above-mentioned results show that the multi-metric B index well characterizes the state of macrozoobenthos communities in the Polish Baltic, both in the shallow and deep-water zone. Therefore, the B index is used in the assessment of benthic habitats.

For the assessment of the state of the soft bottom habitat in the lagoons, in addition to the B index, a new national index - "Macrophyte Ecological Status Index", so-called ESMIz, was adapted to assess the quality of the Szczecin Lagoon, the Kamieński Lagoon and the Vistula Lagoon macrophytes (Ciecierska and Kolada 2014, Bociąg 2016).).

**Macrophyte status indicator – $SM_1$**

**Characteristics and formula**

The $SM_1$ indicator for the assessment of the environmental condition based on macrophytes in POM determines the ratio of biomass of positive taxa (*Bp*) (Table 2.1.43.) to the total biomass of macrophytes (*Bc*). The formula takes into account the percentage of coverage of the bottom by these taxa (*pd*), and also indicates the months from which the data are used (Osowiecki et al. 2012a). In the $SM_1$ indicator model, used in the initial assessment for the years 2005-2010 (GIOŚ 2014), the component "percent coverage of the bottom" and information about the months from which the data are taken, were not marked in the formula, but only in the description of the indicator and the method of its calculation. For unambiguity, the following formula of the $SM_1$ index indicates the above-mentioned component and information about months.

$$SM_1 = \frac{\sum_1^n (B_p * pd_p)_{VI} + \sum_1^n (B_p * pd_p)_{IX}}{\sum_1^z (B_t * pd_t)_{VI} + \sum_1^z (B_t * pd_t)_{IX}}$$

$B_p$ – biomass [g s.m.] positive taxon (taxon 1÷n)

$pd_p$ – coverage of the bottom by positive taxon (taxon 1÷n) (Table 2.1.43.)

$B_t$ – biomass [g s.m.] all taxa (taxon 1÷z)

$pd_t$ – coverage of the bottom by all taxa(taxon 1÷z)

VI – data from June

IX – data from September

Table 2.1.43. List of positive macrophyte taxa included in the $SM_1$ index

| Posistive taxa for $SM_{1\ (VI,\ IX)}$ |
|---|
| *Chara* sp. |
| *Tolypella nidifica* |
| *Desmarestia viridis* |
| *Dictyosiphon foeniculaceus* |
| *Sphacelaria cirrosa* |
| *Delesseria sanguinea* |
| *Ceramium diaphanum* |
| *Ceramium tenuicorne* |
| *Ceramium virgatum* |
| *Coccotylus truncatus* |

| Posistive taxa for $SM_1$ (VI, IX) |
|---|
| *Furcellaria lumbricalis* |
| *Polysiphonia elongata* |
| *Vertebrata fucoides-(Polysiphonia fucoides)* |
| *Rhodomela confervoides* |
| *Ceratophyllum demersum* |
| *Myriophyllum spicatum* |
| *Potamogeton filiformis* |
| *Potamogeton perfoliatus* |
| *Ranunculus baudotii* |
| *Ruppia maritima* |
| *Potamogeton pectinatus -(Stuckenia pectinata)* |
| *Zannichellia palustris* |
| *Zostera marina* |

The assessment of the condition for 2011-2016 using the $SM_1$ index is the average of all $SM_1$ index values calculated at particular stations, in particular years, for a given area of assessment.

The $SM_1$ index was used at the stage of initial assessment of the environmental condition in POM, with the exception of sea lagoons for the years 2005-2010 (GIOŚ 2014) and also used to assess the state of POM for the years 2011-2016.

$SM_1$ meets the criterion D6C5 (Table 2.1.2.) as part of the Descriptors D1 - biodiversity and D6 – seafloor integrity according to the guidelines of Decision 2017/848, as well as BSAP ecological objectives - thriving and balanced populations of plants and animals, and the natural marine landscape, and above all, are used to assess the ecological status of transitional waters in POM, as part of the implementation of the WFD recommendations.

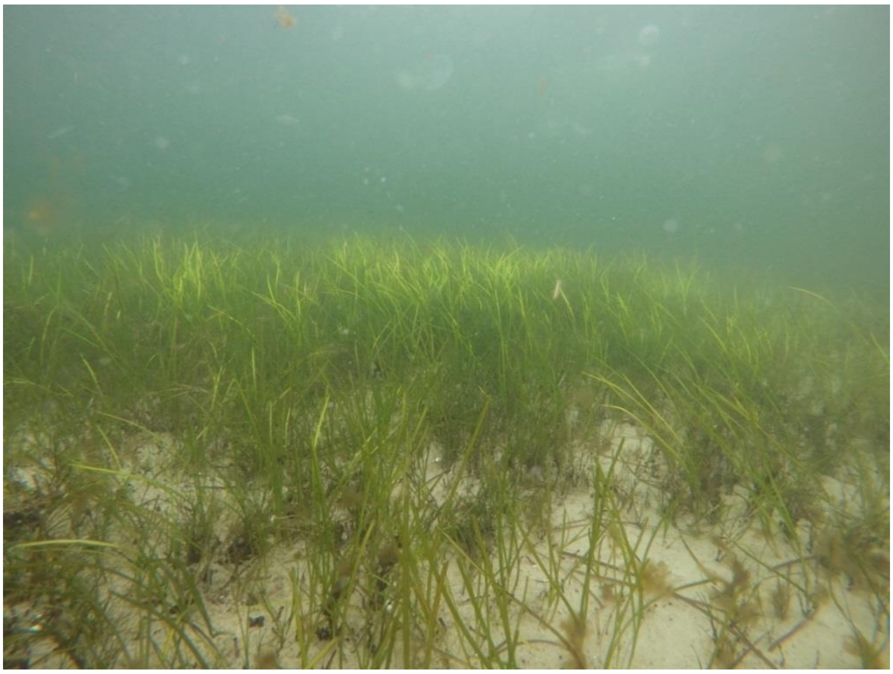


Fig. 2.1.73. Macrophytes in the Puck Bay (photo by the Maritime Institute in Gdańsk).

### Threshold value of good environmental status

The threshold value, i.e. the boundary between the good state - GES and the state below good - subGES determined on the basis of the $SM_1$ index is 0.80 (Table 2.1.44.).

Table 2.1.44. Classification of the ecological status of the environment based on the $SM_1$ value according to WFD and MSFD

| The ranges of the $SM_1$ values | Ecological status | |
|---|---|---|
| | according to WFD | according to MSFD |
| $0.95 < SM_1 \leq 1.0$ | very good (1) | GES |
| $0.80 < SM_1 \leq 0.95$ | good (2) | |
| $0.57 < SM_1 \leq 0.80$ | moderate (3) | subGES |
| $0.20 < SM_1 \leq 0.57$ | poor (4) | |
| $0 \leq SM_1 \leq 0.20$ | bad (5) | |

### Pressure factors related to the indicator

The $SM_1$ index is based on the dynamics of mutual dependencies between biomass of positive taxa and total biomass, including the biomass of opportunistic taxa (also the area that they cover), which reflects the ecological status of the ecosystem. Positive species include habitat-forming species, susceptible to changes in water quality, associated with the bottom, e.g. *Furcellaria lumbricalis*, growing on stony bottom, or *Zostera marina* growing on the sandy bottom. Their biomass and the surface of occurrence are the bigger, the better the ecological status of the basin (the $SM_1$ values are then close to 1). Changes in the occurrence of positive species may occur under the influence of direct factors, such as physical and chemical changes in sediments or changes in water transparency and indirect causes - the occurrence of opportunistic (negative) species, such as annual species with broad tolerance for changing environmental conditions, including the deterioration of the ecological status of the environment (increased eutrophication). These species, such as *Pylaiella littoralis*, *Ectocarpus siliculosus* or *Chaetomorpha linum*, occur most often in the form not attached to the bottom and may reside on different types of sediments. In response to increased concentrations of nutrients in water, these species increase their biomass and bottom cover, limiting positive species. Their mass occurrence, e.g. in the form of algal mats lying on the bottom, is a serious threat to other components of biocenosis, causing, among other things, reduction of water transparency, shading effect or oxygen deficits in the near-bottom waters, and even the presence of hydrogen sulphide in bottom sediments due to their mass decomposition. Such changes in the state of the environment adversely affect the development of many-year and sensitive species of macrophytes. A larger percentage of annual species in the total biomass of macrophytes ($SM_1$ values are close to 0) indicates that the trophic conditions of the environment have deteriorated.

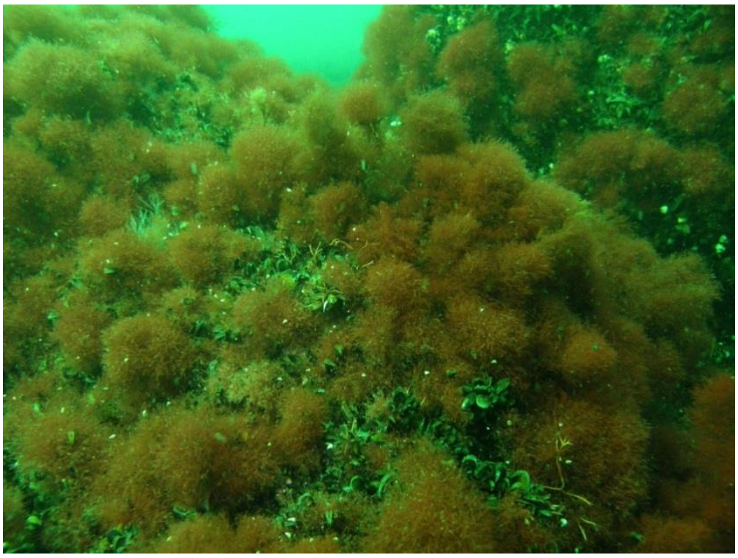


Fig. 2.1.74. Hard bottom benthic habitat with macrophytes on the Słupsk Bank boulder area (photo by the Maritime Institute in Gdańsk)

**Multi-metric B index**

**Characteristics and formula**

The multi-metric B index determines the ecological condition of the soft seabed on the basis of macrozoobenthos (Osowiecki et al. 2012). In its algorithm it contains the most important criteria for assessing the values of the community, i.e. the taxonomic diversity and abundance of particular taxa, as well as qualitative information on ecological sensitivity/ tolerance of these taxa. The index takes on the higher values, the higher the taxonomic diversity and the share of sensitive taxa, and the share of taxa in the total population structure is balanced. The indicator is determined according to the equation:

$$B = \frac{\sum_{i=1}^{3}(w_i Q_i sn_i)}{\sum_{i=1}^{3} D_i} - log\left(1 + \sum_{i=1}^{3} D_i\right)$$

where:

- $w_i$ – class dominance weight:
- $w_1$ = 3 for dominance class $D_1$ (share > 10%),
- $w_2$ = 2 for dominance class $D_2$ (5% ≤ share ≤ 10%),
- $w_3$ = 1 for dominance class $D_3$ (share < 5%),
- $D_i$ - the number of taxa belonging to particular domince class $D_1$, $D_2$, $D_3$,
- $sn_i = \Sigma sens_i$
- coefficient $Q_i$=0 if $D_i$=0; $Q_i$=1 if $D_i \neq 0$
- sensi – coefficient of sensitivity and tolerance of taxa to stress caused by pressure (3 - sensitive taxa, 2 - intermediate taxa, 1 - tolerant taxa), (Table 2.1.45.)

The status of macrozoobenthos communities measured by the B index is determined for each station. When several samples are taken or repetitions are made at the station, the value of the indicator is averaged.

The range of tolerance and sensitivity of taxa to stress caused by excessive content of organic matter in the sediment resulting from progressive eutrophication was determined using expert judgement based on literature data (Leppakoski 1975, Pearson and Rosenberg 1978, Ostrowski 1985, Okołotowicz 1985, Żmudziński 1990, Rumohr and others 1996, Janas 1998, Rosenberg et al. 2004, Blomqvist et al. 2006, Osowiecki et al. 2008) and the results of own research on the stability of occurrence of taxa in particular biotic types in the Polish zone of the Baltic Sea. Alien and invasive species have been given the lowest sensitivity value. Not all species included in the biocenosis form its character and functioning in the same way (Odum 1982). Therefore, the basis of the indicator algorithm is the assumption that the dominating species shape the quality of bottom communities to a greater extent than the species that occur only occasionally. The indicator used the classification of Trojan domination (1980), according to which the species occurring in a given team were divided into: dominants (D1) - the most numerous, influents (D2) - medium-numbered and accessory species (D3). Each of the domination class is assigned a weight corresponding to the role they play in the environment. The dominants (constituting more than 10% of the total number in the sample) were given a weight of 3, because they shape the bottom zoocenosis character to the greatest extent. Influents, constituting from 5 to 10% of the total number in the sample, were given a weight correspondingly lower - 2, and the least numerous species (constituting less than 5% of the total number) were assigned a weight of 1.

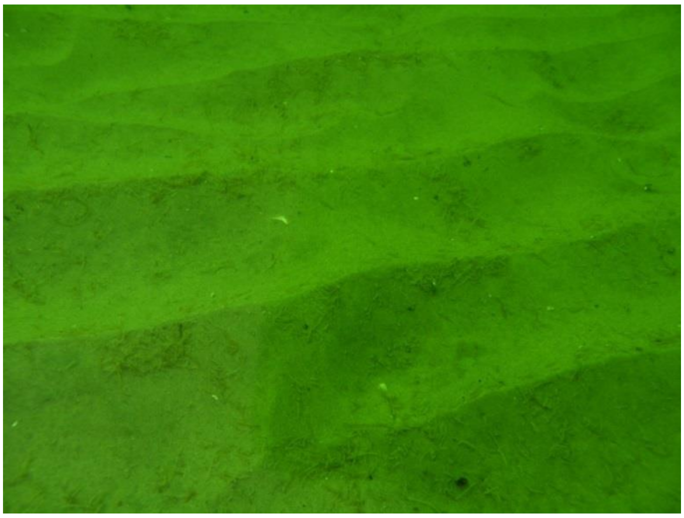


Fig. 2.1.75. Soft bottom benthic habitat (photo: Maritime Institute in Gdańsk)

A three-grade scale of tolerance/sensitivity was used, according to which taxa noted in the Polish zone of the Baltic Sea (Table 2.1.45) were divided into:

- taxa with a narrow tolerance range, so-called indicators of undisturbed bottom (Sensi = 3);
- taxa, whose occurrence is not strictly correlated with the content of organic matter in bottom sediments (Sensi = 2);
- taxa with a wide tolerance range, resistant to a significant content of organic matter in the sediment (Sensi = 1).

Table 2.1.45. Sensitivity of zoobenthos taxa used in B index calculation

| Senitive species (Sensi = 3) | semi – tolerant species (Sensi = 2) | Tolerant species (Sensi = 1) |
|---|---|---|
| *Anodonta anatina* | Ampharete | *Bylgides sarsi* |
| *Astarte borealis* | *Ampharete finmarchica* | *Capitella capitata* |
| *Astarte elliptica* | *Ampharete baltica* | Chironomidae |
| Astartidae | *Apocorophium lacustre* | Chironomini |
| *Bathyporeia pilosa* | Aricidea | *Chironomus plumosus* |
| *Cerastoderma glaucum* | *Aricidea cerrutii* | Corophium |

| Senitive species (Sensi = 3) | semi – tolerant species (Sensi = 2) | Tolerant species (Sensi = 1) |
|---|---|---|
| *Cyathura carinata* | *Acmira cerrutii* | *Corophium multisetosum* |
| *Ecrobia ventrosa* | Bezzia | *Corophium volutator* |
| *Eurydice pulchra* | Bithynia | *Crassicorophium crassicorne* |
| *Fabricia stellaris* | *Bithynia tentaculata* | *Gammarus tigrinus* |
| *Heterotanais oerstedii* | Chelicerata | *Hediste diversicolor* |
| Hydrozoa | *Cyanophthalma obscura* | Insecta |
| Idotea | Dendrocoelum | *Limecola balthica* |
| *Idotea balthica* | *Diastylis rathkei* | *Marenzelleria neglecta* |
| *Idotea chelipes* | Diptera | *Marenzelleria viridis* |
| *Idotea granulosa* | *Dreissena polymorpha* | Marenzelleria |
| *Jaera albifrons* | *Dyopedos monacanthus* | *Mya arenaria* |
| Jaera | *Ephydatia fluviatilis* | Oligochaeta |
| *Leptocheirus pilosus* | Gammarus | *Pholoe minuta* |
| *Monoporeia affinis* | *Gammarus duebeni* | *Rangia cuneata* |
| *Nymphon brevirostre* | *Gammarus inaequicauda* | *Rhithropanopeus harrisii* |
| Piscicola | *Gammarus oceanicus* | *Saduria entomon* |
| *Pontoporeia femorata* | *Gammarus salinus* | *Scoloplos armiger* |
| *Priapulus caudatus* | *Gammarus zaddachi* | *Streblospio shrubsolii* |
| *Pygospio elegans* | *Halicryptus spinulosus* | *Trochochaeta multisetosa* |
| *Travisia forbesii* | *Halitholus cirratus* | – |
| Unio | Hydrobia | – |
| – | *Lekanesphaera hookeri* | – |
| – | *Manayunkia aestuarina* | – |
| – | *Mytilus edulis* | – |
| – | *Mytilus trossulus* | – |
| – | Nemertea | – |
| – | *Peringia ulvae* | – |
| – | Pisidium | – |
| – | *Planaria torva* | – |
| – | Potamopyrgus | – |
| – | *Potamopyrgus antipodarum* | – |
| – | *Praunus flexuosus* | – |
| – | *Procerodes littoralis* | – |
| – | *Radix labiata* | – |
| – | Sphaerium | – |
| – | Tanypodinae | – |
| – | Tanytarsini | – |
| – | *Terebellides stroemii* | – |
| – | *Theodoxus fluviatilis* | – |
| – | *Valvata piscinalis* | – |
| – | *Viviparus viviparus* | – |

*Source: own study; Taxa names acc. to: World Register from Marine Species, http://www.marinespecies.org, date of entry on page: 11.08.2017*

B index meets the criterion D6C5 (Table 2.1.2.) of Descriptors D1 - biodiversity and D6 – seafloor integrity and the D4C1 criterion of Descriptor 4 - food webs according to Decision 2017/848, and is used for the assessment of ecological status in transitional and coastal waters under the WFD (Osowiecki et al. 2012, Anon. 2016).

### Threshold value of good environmental status

The reference value of the B index is the highest indicator value calculated in a series of historical data. In the case that a higher B index value is obtained in the subsequent assessment period, it becomes a new (updated) reference value. It is then recommended to update the classification of ecological quality status by the Jenks and Caspall method (1971).

The threshold value according to MSFD - the boundary between a good state of the environment and a state below good (GES/subGES) - was adopted at the level of the boundary between good and moderate status defined for the needs of the WFD assessment.

There is a five-grade classification that has been introduced into the legal system in the ordinance of the Minister of the Environment of July 21, 2016 on the method of classification of the surface water bodies and environmental quality standards for priority substances (Office Journal. 2016 pos. 1187), (Table 2.1.46.).

Table 2.1.46. Classification of the ecological status of soft bottom zoobenthos communities based on the B index value according to WFD and MSFD (GIOŚ 2014)

| B index value | EQR | ecological status | |
|---|---|---|---|
| | | according to WFD | according to MSFD |
| > 3.72 | > 0.765 | very good (1) | GES |
| ≥ 3.18 | ≥ 0.647 | good (2) | |
| ≥ 2.70 | ≥ 0.546 | moderate (3) | subGES |
| ≥ 1.91 | ≥ 0.395 | poor (4) | |
| < 1.91 | < 0.395 | bad (5) | |

### Pressure factors related to the indicator

The B index well characterizes the state of the macrozoobenthos community in the Polish Baltic zone - it shows the diversity between shallow and deep-water areas, and more strongly and less exposed to the impact of eutrophication. It also shows a strong connection with pressure factors - concentrations of biogenic substances and oxygenation of bottom waters.

In the shallow Baltic Sea zone in POM, as part of the study of the dependence of the B index on eutrophication indices, in the series of data from 1987-2016, a statistically significant relationship was found between B index and total nitrogen content, which is often treated as an proxy of organic matter content. Therefore, even in this shallow and dynamic area of the sea, an unfavourable (dependence is inversely proportional) influence of the excess of organic matter on the community of organisms living on the bottom can be found. The state of zoobenthos in the shallow bottom zone limits first of all the availability of suspended organic matter for filtering organisms and organic matter deposited on the surface of sediments of the seabed for deposit feeders (Lysiak-Pastuszak and Osowiecki 2017).

B index shows strong links with pressure factors, especially in the deep-sea zone of the Baltic Sea. Study of B index correlation with pressure factors - eutrophication indices - showed some important relationships, the strongest of which is the relationship between B index and total nitrogen content in summer months, as well as corresponding with general nitrogen as an approximation of the suspended matter in the water column - visibility of the Secchi disc in the summer months. Slightly weaker, however, statistically significant dependence of the B index was found relative to the oxygenation of the bottom layer. Excess organic matter and shortage of oxygen in the bottom water are unfavourable factors (Łysiak-Pastuszak and Osowiecki 2017).

**Index of ecological status of macrophytes in lagoons – ESMIz**

**Characteristics and formula**

Index of ecological status of macrophytes in lagoons, the so-called ESMIz is a modified ESMI indicator (assessing the ecological status of Polish lakes), adapted to assess the state of the quality of the lagoon environment, such as the Szczecin Lagoon, the Kamieński Lagoon and the Vistula Lagoon, based on macrophytes (Ciecierska and Kolada 2014, Bociąg 2016).

$$ESMIz = 1 - \exp\left[-\frac{H}{H_{maks.}} \times Z \times \exp\left(\frac{N}{P}\right)\right]$$

Index of ecological status of macrophytes in lagoons is a multi-metric indicator, constructed from two indicators:

1. index of phytocoenotic diversity (H) taking into account the species composition, calculated from the Shannon-Wiener formula (1946), where the quantitative features are the areas of individual communities:

$$H = -\sum \frac{n_i}{N} \times \ln \frac{n_i}{N}$$

where:

- **H** – index of phytocoenotic diversity;
- **$n_i$** – surface of the patches of a specific plant community, expressed as a percentage of the total area of phytolittoral ;
- **N** – the area of the lake's phytolittal was accepted for 100%.

The value of the H index depends on the number of plant communities in the phytolittoral and their mutual quantitative relation. In the absence of factors limiting the possibilities of vegetation development (no or very low anthropogenic pressure), the share of individual plant communities in the phytolittoral is balanced and the H coefficient reaches high values. In the situation of disturbing the phytocoenotic balance, e.g. due to pressure, plant systems tend to simplify, some communities withdraw, others start to dominate, and the value of H decreases.

The measure of structural simplifications of vegetation under the influence of anthropogenic pressure is the ratio of the actual phytocoenotic diversity (H) to the theoretically possible maximum variation of $H_{max.}$, calculated from the formula:

$$H_{\text{maks.}} = \ln S$$

where:

- **$H_{maks.}$** – theoretical maximum phytocoenotic diversity coefficient;
- **S** – number of congeries forming phytolittoral

2. inhabitance indicator (Z) taking into account the abundance of macrophytes, expressing the ratio of the area actually occupied by macrophytes (phytolittoral surface) to the surface potentially available for plants:

$$Z = \frac{N}{P - izob.2,5}$$

where:

- **Z** – inhabitance indicator;
- **izob. 2,5** – water surface limited by 2.5 m isobath (read from the bathymetric card);

- **N** – phytolittoral area;
- **P** – area of the entire lagoon.

The rate of settlement takes on the higher values, the higher the maximum depth of occurrence of plants.

Additionally, in the ESMIz model, the size was introduced, taking into account the typological differences of the waters, i.e. the ratio of the phytolittoral surface (N) to the surface of the entire tank (P).

Data for the assessment of the ESMIz index for lagoons is obtained on the basis of observations in transects, used to assess the conservation status of a natural habitat. Coastal lakes and lagoons (1150) in accordance with the requirements of the Habitats Directive. The ESMIz index meets the criterion D6C5 (Table 2.1.2.) of Descriptors D1 - biodiversity and D6 – seafloor integrity in accordance with the decision 2017/848, as well as WFD requirements for ecological quality indicators.

**Threshold value of good environmental status**

The ESMIz threshold value is reduced in relation to the original value determined for the ESMI indicator. Based on the theoretical model of the ESMI value of reference systems for lagoons (0.306), limit values of ecological status classes based on ESMI, applicable in the PMŚ on the basis of the ordinance of the Minister of the Environment of July 21, 2016 on the method of classification of the surface water bodies and environmental quality standards for priority substances have been modified accordingly. The conversion factor for the calibration of ecological class boundaries was assumed to be 0.3 (Bociąg 2016). This classification well reflects the diversity of plant systems in lagoons.

Fot. 2.1.76. Common calamus Acorus calamus among submerged and floating leaves in the Elbląg Bay reserve - the Vistula Lagoon (photo by the Maritime Institute in Gdańsk)

The threshold value according to MSFD - the boundary between a good state of the environment and a state below the good (GES/subGES) was adopted at the level of the boundary between good and moderate defined for the needs of the WFD, which is 0.123 (Table 2.1.47.). This threshold has been set as a reduced environmental target for this type of waters.

Table 2.1.47. Classification of the ecological status of the ESMIz index according to the modified scale (Bociąg 2016), adapted in MSFD (author's study)

| ESMIz index value | Ecological status | |
|---|---|---|
| | according to WFD | according to MSFD |
| ≥ 0.204 | very good (1) | GES |
| 0.203 – 0.123 | good (2) | |
| 0.122 – 0.060 | moderate (3) | subGES |
| 0.059 – 0.002 | poor (4) | |
| < 0.002 | bad (5) | |

**Pressure factors related to the indicator**

Index of ecological status of macrophytes in lagoons clearly and in a directional way reacts to anthropogenic pressure. The use of this indicator allows the estimation of the impact of pressures such as degradation, pollution with organic substances and transformation of the coastal zone (Hering et al 2014) and, above all, eutrophication (Hobot et al. 2013, Chilińska 2015).

Both the cumulative index and individual indicators, taking into account the taxonomic composition and abundance of macrophytes included in it, clearly correlate with the trophic state of the reservoir, that is with the trophic indicators: average chlorophyll concentration, Secchi disc visibility, total phosphorus or nitrogen content (Ciecierska et al. 2006, Ciecierska i Kolada 2014, Chilińska 2015). ESMIz strongly correlates with the visibility of the Secchi disc - the better visibility, the higher the index value, slightly less with the content of nitrogen and phosphorus compounds - the higher the content, the lower the index (Ciecierska and Kolada 2014). The H coefficient included in the ESMIz multi-metric index shows a small but statistically significant correlation with SOJJ score and an equally low or even statistically insignificant correlation with other analysed pressure parameters. Whereas the Z settlement index shows a strong correlation with all analysed pressure indicators and the higher the values, the higher the maximum planting depth (Ciecierska et al., 2006).

### Method for assessing the state of benthic habitats

The assessment of the condition of benthic habitats is carried out on the basis of individual indicators, as well as on the principle of index integration. The method of integration between indicators is a weighted average including the weights assigned to them. According to the HELCOM recommendation, the weightings of indicators within the assessment area are equal (HELCOM SPICE 2017). Integration between indicators should be carried out within one assessment area and the same general habitat types as indicated in Decision 2017/848, based on the EUNIS classification modified by Evans et al. (2016) for the needs of MSFD. According to the guide to assess the state of the marine environment for the purposes of the report on art. 8 MSFD (Walmsley et al. 2017) one does not integrate indicators that evaluate different habitat types in one assessment area.

Under the conditions prevailing in POM, this means that a separate assessment should be made for a soft bottom benthic habitat using the B index and in one case integration with the $SM_1$ index (Puck Lagoon) and for the benthic hard bottom habitat (boulder area of Słupsk Bank and boulder area of Rowy), and also the habitats of the benthic mixed bottom (Klif Orłowski region) using only the $SM_1$ index.

The assessment of benthic habitats in the Szczecin Lagoon, Kamieński Lagoon and the Vistula Lagoon was carried out using the B index and separately using the ESMIz index without taking into account the integration between these indicators. Macrophytes in lagoons are associated with the infralittoral sands occurring there (Table 1.4.4.). Therefore the ESMIz index evaluating the state of the environment on macrophyte basis cannot be integrated with the B index assessing the state of the soft bottom based on macrozoobenthos in the same assessment areas, which is mainly associated with infralittoral muds (Table 1.4.4).

The structure of the integrated assessment taking into account the applied indicators and their weights in POM for benthic habitats is given in Table 2.1.48.

Table 2.1.48. Structure of the integrated assessment of benthic habitats in POM as part of the multi-annual assessment 2011-2016

| Assessment area | | Indicator used in the national 'integrated assessment of biodiversity' | Indicator status | Indicator weight | Integration between normalized indicators (if there are 2 indicators in the assessment area) | Multi-annual assessment |
|---|---|---|---|---|---|---|
| The division of the Baltic Sea into the basins - 4th level according to HELCOM | sub-basins in POM | | | | | |
| open waters | Gdańsk Basin, Eastern Gotland Basin, Bornholm Basin - soft bottom | B | national | 1 | lack of integration | if non-integrated assessment (1 indicator) - result based on the classification of this indicator; if the integrated assessment - the result based on the BQR (Biological Quality Ratio) classification |
| | Bornholm Basin - hard bottom | $SM_1$ | national | 1 | lack of integration | |
| transitional and coastal waters | 17 waterbodies soft bottom | B | national | 1 | lack of integration | if non-integrated assessment (1 indicator) - result based on the classification of this indicator; if the integrated assessment - the result based on the BQR (Biological Quality Ratio) classification |
| | Puck Lagoon – soft bottom | $SM_1$ | national | 0.5 | weighted average | |
| | | B | national | 0.5 | | |
| | Vistula Lagoon, Szczecin Lagoon, Kamieński Lagoon - soft bottom | ESMIz | national | 1 | lack of integration | |
| | | B | national | 1 | lack of integration | |
| | Rowy - Jarosławiec East - hard bottom | $SM_1$ | national | 1 | lack of integration | |
| | Outer Puck Bay – mixed bottom | $SM_1$ | national | 1 | lack of integration | |

To integrate at least two indicators in the assessment area, normalized values of indicators should be used. In order to obtain the value of the indicator in the range from 0 to 1, it should be normalized taking into account the minimum and maximum values of a given indicator and taking into account the limit value for BQR equal to 0.6.

In the assessment of benthic habitats, the B index value should be normalized in case of integration with the $SM_1$ value. The standardization method was developed based on the method used in the second holistic assessment (IT tool BEAT 3.0) (HELCOM 2017a) (Table 2.1.49., Table 2.1.50.).

Table 2.1.49. B index normalization method

| B index value(WB) | BQR Boundary | Normalisation |
|---|---|---|
| 0 – 1.90 | 0.2 | 0.2*(WB/1.91) |
| 1.91 – 2.69 | 0.4 | 0.2 + 0.2*((WB-1.91)/0.79) |
| 2.7 – 3.17 | 0.6 | 0.4 + 0.2*((WB-2.7)/0.48) |
| 3.18 – 3.72 | 0.8 | 0.6 + 0.2*((WB-3.18)/0.54) |
| 3.73 – 4.9 | 1 | 0.8 + 0.2*((WB-3.72)/1.18) |

Table 2.1.50. $SM_1$ index normalization method

| $SM_1$ index value | Normalisation |
|---|---|
| if $SM_1$ (2011-2016) < threshold value | 0.6*( $SM_1$ – min. value)/( threshold value – min. value) |
| if $SM_1$ (2011-2016) > threshold value | 0.6+0.4*( $SM_1$ – threshold value)/( max. value– threshold value) |

If at least two indicators were used to assess the condition in a given area of assessment, BQR (Biological Quality Ratio) was calculated for them and their integration was performed, the result of such an integrated assessment should be classified as follows (Table 2.1.51):

Table 2.1.51. Classification of the result of the assessment of the status of benthic habitats - BQR as part of the "integrated assessment of biodiversity"

| threshold value BQR | result BQR | Status of "integrated assessment of biodiversity" - benthic habitats |
|---|---|---|
| ≥ 0.6 | 0.6 – 1.0 | good – GES |
| < 0.6 | 0 – 0.59 | below good – subGES |

If the assessment of the status of a given area is carried out using only one indicator, the result of such an assessment is classified on the basis of the threshold value of this indicator between the state of GES - good and the state of subGES - below good. This applies both to the use of the $SM_1$ indicator in the area assessment (Table 2.1.52), B index (Table 2.1.53.) or ESMIz index (Table 2.1.54).

Table 2.1.52. .Classification of the result of the assessment of the condition of benthic habitats based on the $SM_1$ index

| $SM_1$ index value | State |
|---|---|
| > 0,80 | good – GES |
| ≤ 0,80 | below good – subGES |

Table 2.1.53. Classification of the result of the assessment of the condition of benthic habitats based on the B index

| B index value | State |
|---|---|
| ≥ 3,18 | good – GES |
| < 3,18 | below good – subGES |

Table 2.1.54. Classification of the result of the assessment of the condition of benthic habitats based on the ESMIz index

| ESMIz index value | State |
|---|---|
| ≥ 0.123 | good – GES |
| < 0.123 | below good – subGES |

**Assessment of benthic habitats for the years 2011-2016**

For the purpose of the national assessment of the marine environment in the field of benthic habitats, partial assessments of national indicators were used: macrophyte status index – $SM_1$, multi-metric B index and macrophyte index of ecological status in flood waters - ESMIz. Only domestic data from State Environmental Monitoring were used for the calculation of indicators (PMŚ) from the macrozoobenthos research station, macrophytes on the boulder areas in the Puck Lagoon and the Outer Puck Bay (Fig. 2.1.77.) and the macrophyte research station in the Vistula Lagoon, Szczecin Lagoon and Kamieński Lagoon (Fig. 2.1.78.). A list of the above stations together with geographic coordinates can be found in Fig. 2.1.77.

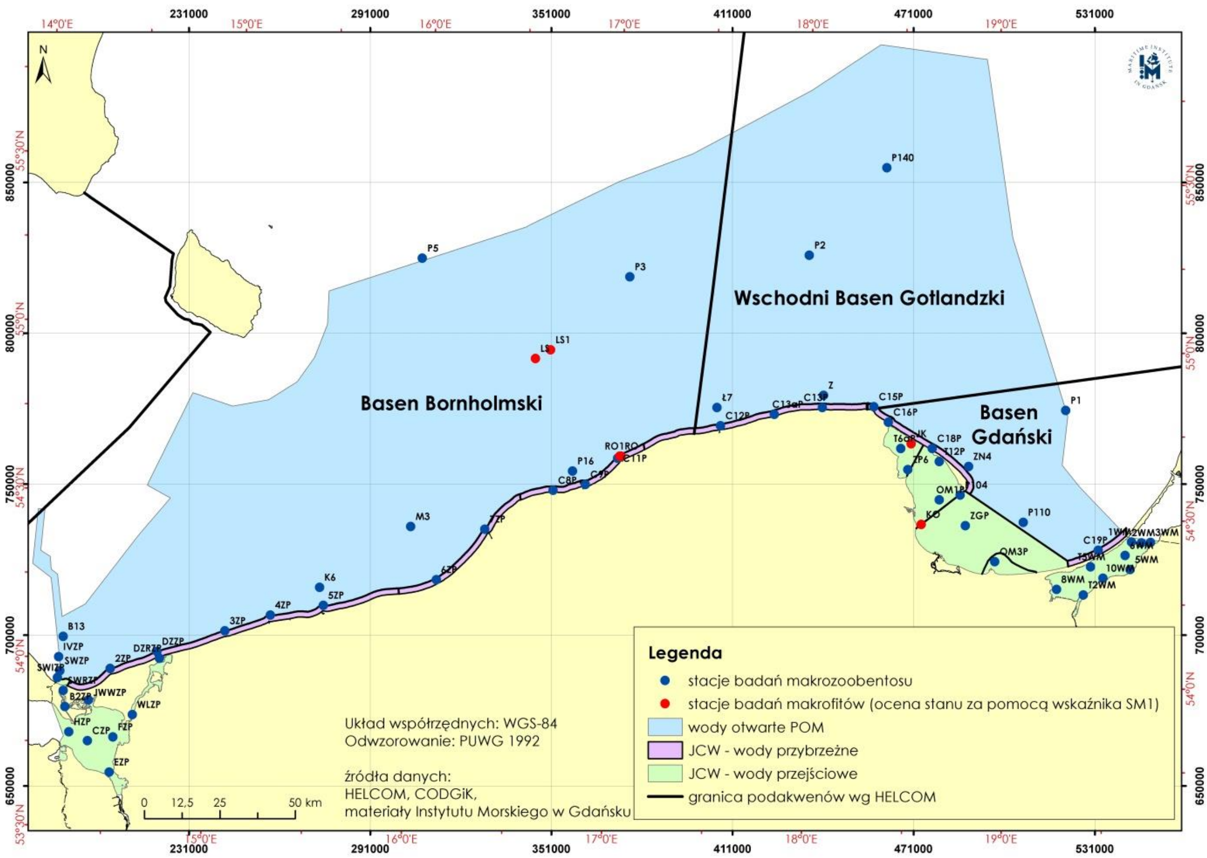



Fig. 2.1.77. Location of macrophyte and macrozoobenthos research stations within the PMŚ, providing data for the assessment of the status of benthic habitats in POM based on index $SM_1$ and B

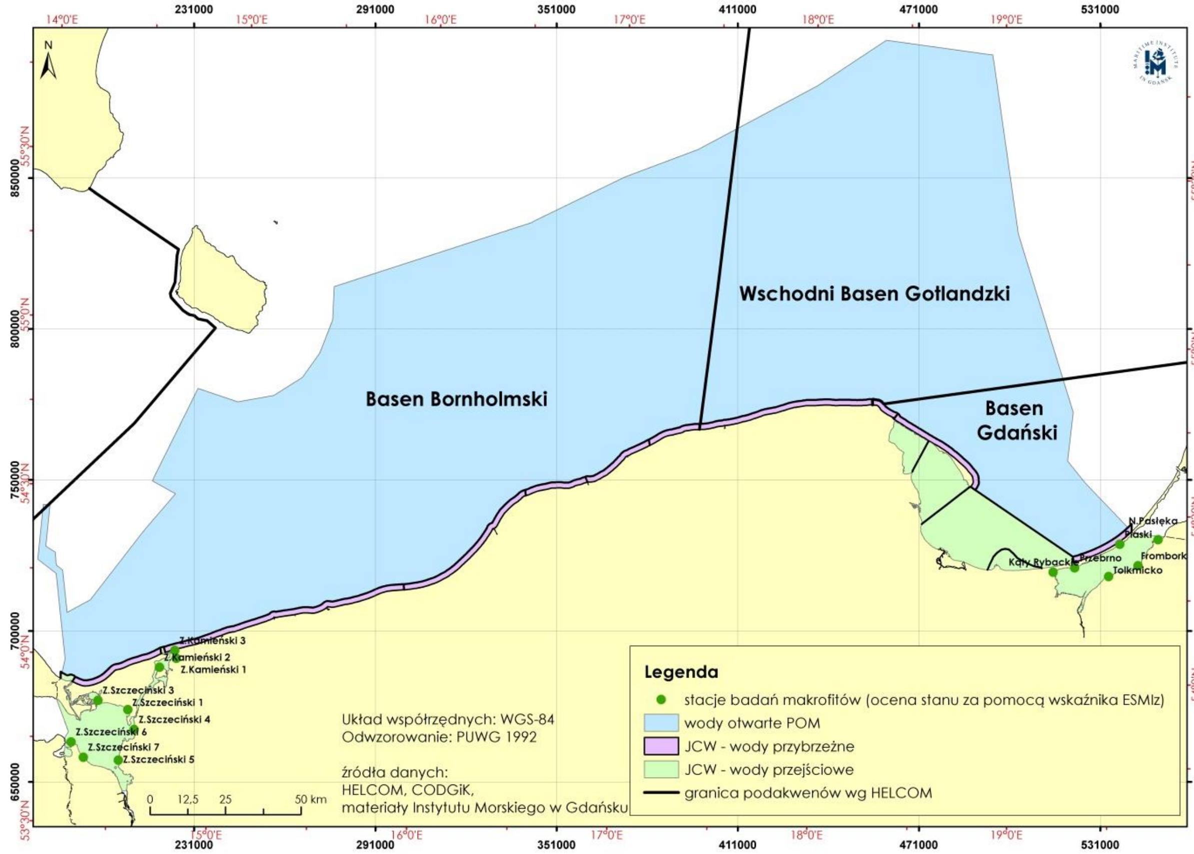



Fig. 2.1.78. Location of the macrophyte sampling stations within the PMŚ, providing data for the assessment of the status of benthic habitats in the Vistula Lagoon, Szczecin Lagoon and Kamieński Lagoon on the basis of the ESMIz index

Table 2.1.55. Characteristics of monitoring stations from which data for the assessment of benthic habitats (source of PMŚ data) were obtained

| Assessment area | Water type | Name of the station | Station code according to ICES | Latitude [N] | Longitude [E] |
|---|---|---|---|---|---|
| Bornholm Basin | open sea/HELCOM sub-basin | P5 | BMPK2 | 55.2500 | 15.9833 |
| Bornholm Basin | open sea/HELCOM sub-basin | P3 | PL-P3 | 55.2166 | 17.0666 |
| Bornholm Basin | open sea/HELCOM sub-basin | B13 | BMPK14 | 54.0666 | 14.2500 |
| Bornholm Basin | open sea/HELCOM sub-basin | M3 | BMPK13 | 54.4500 | 15.9833 |
| Bornholm Basin | open sea/HELCOM sub-basin | P16 | BMPK12 | 54.6333 | 16.8000 |
| Bornholm Basin | open sea/HELCOM sub-basin | K6 | BMPK56 | 54.2566 | 15.5333 |
| Bornholm Basin | open sea/HELCOM sub-basin | LS | PL-LS | 54.9647 | 16.5905 |
| Bornholm Basin | open sea/HELCOM sub-basin | LS1 | PL-LS1 | 54.9916 | 16.6669 |
| Gdańsk Basin | open sea/HELCOM sub-basin | P1 | BMPL1 | 54.8333 | 19.3333 |
| Gdańsk Basin | open sea/HELCOM sub-basin | ZN4 | PL-ZN4 | 54.6666 | 18.8333 |
| Gdańsk Basin | open sea/HELCOM sub-basin | P110 | BMPL6 | 54.5000 | 19.1133 |
| Eastern Gotland Basin | open sea/HELCOM sub-basin | L7 | BMPK51 | 54.8333 | 17.5350 |
| Eastern Gotland Basin | open sea/HELCOM sub-basin | Z | BMPK11 | 54.8750 | 18.0833 |
| Eastern Gotland Basin | open sea/HELCOM sub-basin | P140 | BMPK1 | 55.5550 | 18.4000 |
| Eastern Gotland Basin | open sea/HELCOM sub-basin | P2 | BMPK43 | 55.2916 | 18.0000 |
| Kamieński Lagoon | PL TW I WB 9 | WL | WLZP | 53.8480 | 14.6230 |
| Kamieński Lagoon | PL TW I WB 9 | DZR | DZRZP | 54.0198 | 14.7425 |
| Kamieński Lagoon | PL TW I WB 9 | Kamieński Lagoon 1 | - | 54.0099 | 14.8034 |
| Kamieński Lagoon | PL TW I WB 9 | Kamieński Lagoon 2 | - | 53.9801 | 14.7211 |
| Kamieński Lagoon | PL TW I WB 9 | Kamieński Lagoon 3 | - | 54.0327 | 14.7938 |
| Szczecin Lagoon | PL TW I WB 8 | C | CZP | 53.7620 | 14.4060 |
| Szczecin Lagoon | PL TW I WB 8 | E | EZP | 53.6730 | 14.5250 |
| Szczecin Lagoon | PL TW I WB 8 | F | FZP | 53.7780 | 14.5330 |
| Szczecin Lagoon | PL TW I WB 8 | H | HZP | 53.7850 | 14.3100 |
| Szczecin Lagoon | PL TW I WB 8 | JWW | JWWZP | 53.8830 | 14.3980 |
| Szczecin Lagoon | PL TW I WB 8 | B2 | B2ZP | 53.8590 | 14.2820 |

| Assessment area | Water type | Name of the station | Station code according to ICES | Latitude [N] | Longitude [E] |
|---|---|---|---|---|---|
| Szczecin Lagoon | PL TW I WB 8 | SWR | SWRZP | 53.9063 | 14.2682 |
| Szczecin Lagoon | PL TW I WB 8 | Szczecin Lagoon 1 | - | 53.8484 | 14.5752 |
| Szczecin Lagoon | PL TW I WB 8 | Szczecin Lagoon 3 | - | 53.8709 | 14.4232 |
| Szczecin Lagoon | PL TW I WB 8 | Szczecin Lagoon 4 | - | 53.7907 | 14.6131 |
| Szczecin Lagoon | PL TW I WB 8 | Szczecin Lagoon 5 | - | 53.6969 | 14.5440 |
| Szczecin Lagoon | PL TW I WB 8 | Szczecin Lagoon 6 | - | 53.7422 | 14.3016 |
| Szczecin Lagoon | PL TW I WB 8 | Szczecin Lagoon 7 | - | 53.6990 | 14.3681 |
| Vistula Lagoon | PL TW I WB 1 | 1 | 1WM | 54.4400 | 19.6670 |
| Vistula Lagoon | PL TW I WB 1 | 2 | 2WM | 54.4370 | 19.7170 |
| Vistula Lagoon | PL TW I WB 1 | 3 | 3WM | 54.4380 | 19.7640 |
| Vistula Lagoon | PL TW I WB 1 | 5 | 5WM | 54.3580 | 19.6580 |
| Vistula Lagoon | PL TW I WB 1 | 6 | 6WM | 54.4000 | 19.6330 |
| Vistula Lagoon | PL TW I WB 1 | T5 | T5WM | 54.3670 | 19.4560 |
| Vistula Lagoon | PL TW I WB 1 | 8 | 8WM | 54.3000 | 19.2830 |
| Vistula Lagoon | PL TW I WB 1 | T2 | T2WM | 54.2830 | 19.4190 |
| Vistula Lagoon | PL TW I WB 1 | 10 | 10WM | 54.3330 | 19.5190 |
| Vistula Lagoon | PL TW I WB 1 | Vistula Lagoon - Piaski | - | 54.4210 | 19.5782 |
| Vistula Lagoon | PL TW I WB 1 | Vistula Lagoon - Przebrno | - | 54.3515 | 19.3481 |
| Vistula Lagoon | PL TW I WB 1 | Vistula Lagoon - Frombork | - | 54.3393 | 19.2373 |
| Vistula Lagoon | PL TW I WB 1 | Vistula Lagoon – Kąty Rybackie | - | 54.4336 | 19.7748 |
| Vistula Lagoon | PL TW I WB 1 | Vistula Lagoon – Nowa Pasłęka | - | 54.3564 | 19.6707 |
| Vistula Lagoon | PL TW I WB 1 | Vistula Lagoon - Tolkmicko | - | 54.3251 | 19.5204 |
| Puck Lagoon | PL TW II WB2 | T6a | T6aP | 54.7190 | 18.4841 |
| Puck Lagoon | PL TW II WB2 | ZP6 | BMPL5 | 54.6566 | 18.5216 |
| Puck Lagoon | PL TW II WB2 | JK (starting point of a transect) | P-JK | 54.7355 | 18.5675 |
| Puck Lagoon | PL TW II WB2 | JK (ending point of a transect) | P-JK | 54.7331 | 18.5658 |
| Outer Puck Bay | PL TW III WB3 | OM1 | OM1P | 54.5670 | 18.6830 |
| Outer Puck Bay | PL TW III WB3 | T12 | T12P | 54.6810 | 18.6830 |

| Assessment area | Water type | Name of the station | Station code according to ICES | Latitude [N] | Longitude [E] |
|---|---|---|---|---|---|
| Outer Puck Bay | PL TW III WB3 | KO (starting point of a transect) | PL-KO | 54.4848 | 18.5720 |
| Outer Puck Bay | PL TW III WB3 | KO (ending point of a transect) | PL-KO | 54.4871 | 18.5763 |
| Inner Gulf of Gdańsk | PL TW IV WB 4 | ZG | ZGP | 54.4899 | 18.8175 |
| Inner Gulf of Gdańsk | PL TW IV WB 4 | P104 | PL-P104 | 54.5816 | 18.7900 |
| Dziwna Mouth | PL TW V WB 6 | DZ | DZZP | 54.0400 | 14.7280 |
| Wisła Przekop mouth | PL TW V WB 5 | OM3 | OM3P | 54.3830 | 18.9680 |
| Świna Mouth | PL TW V WB 7 | SWI | SWI | 53.9434 | 14.2352 |
| Świna Mouth | PL TW V WB 7 | SW | SWZP | 53.9640 | 14.2450 |
| Świna Mouth | PL TW V WB 7 | IV | IVZP | 54.0059 | 14.2335 |
| Hel Peninsula | PL CWI WB2 | C18 | C18P | 54.7200 | 18.6460 |
| Vistula Spit | PL CWI WB1 | C19 | C19P | 54.4159 | 19.4958 |
| Władysławowo harbour | PL CWI WB3 | C16 | C16P | 54.7970 | 18.4190 |
| Sarbinowo-Dziwna | PL CW II WB 8 | 3 | 3ZP | 54.1130 | 15.0650 |
| Sarbinowo-Dziwna | PL CW II WB 8 | 4 | 4ZP | 54.1670 | 15.2910 |
| Sarbinowo-Dziwna | PL CW II WB 8 | 5 | 5ZP | 54.2040 | 15.5570 |
| Rowy-Jarosławiec West | PL CW II WB 6W | C8 | C8P | 54.5737 | 16.7038 |
| Rowy-Jarosławiec East | PL CW II WB 6E | C9 | C9P | 54.5940 | 16.8680 |
| Rowy-Jarosławiec East | PL CW II WB 6E | C11 | C11P | 54.6750 | 17.0300 |
| Rowy-Jarosławiec East | PL CW II WB 6E | RO | PL-RO | 54.6813 | 17.0405 |
| Rowy-Jarosławiec East | PL CW II WB 6E | RO1 | PL-RO1 | 54.6816 | 17.0466 |
| Jastrzębia Góra-Rowy | PL CWII WB 5 | C12 | C12P | 54.7794 | 17.5551 |
| Jastrzębia Góra-Rowy | PL CWII WB 5 | C13 | C13P | 54.8390 | 18.0780 |
| Jastrzębia Góra-Rowy | PL CWII WB 5 | C13a | C13aP | 54.8166 | 17.8305 |
| Władysławowo-Jastrzębia Góra | PL CWII WB 4 | C15 | C15P | 54.8430 | 18.3440 |
| Dziwna-Świna | PL CW III WB 9 | 2 | 2ZP | 53.9810 | 14.4980 |
| Jarosławiec-Sarbinowo | PL CW III WB 7 | 6 | 6ZP | 54.2950 | 16.1250 |
| Jarosławiec-Sarbinowo | PL CW III WB 7 | 7 | 7ZP | 54.4510 | 16.3610 |

### *$SM_1$ index assessment*

To assess the state of the environment using the $SM_1$ index, data from the State Environmental Monitoring collected in 2011-2016 regarding biomass and bottom coverage by macrophyte taxa in four assessment areas in POM were used (Table 2.1.56).

Table 2.1.56. Assessment of the benthic habitat condition based on the $SM_1$ index for the period 2011-2013 in the four assessment areas in POM (GES, subGES)

| Assessment area | Station | Type of monitoring |
|---|---|---|
| Bornholm Basin (Słupsk bank boulder area) | LS, LS1 | HELCOM COMBINE MSFD |
| Rowy-Jarosławiec East (Rowy boulder area) | RO, RO1 | HELCOM COMBINE MSFD |
| Puck Bay | JK profile JK (7 stations arranged on the profile every 1 m in depth ) | HELCOM COMBINE MSFD |
| Outer Puck Bay (mixed bottom in the area of Orłowo Cliff) | profile KO (8 stations arranged on the profile every 1 m in depth ) | HELCOM COMBINE MSFD |

The assessment of the status of a benthic habitat based on macrophytes in the analysed areas of assessment was made on the basis of a total of 98 values of the $SM_1$ index from 2011-2016 calculated for individual research stations. In 2011-2016, the condition of the environment was below good - subGES in three areas of assessment, except for Słupsk Bank boulder area (Bornholm Basin), where good environmental status was achieved - GES (Table 2.1.57).

Table 2.1.57. Assessment of the benthic habitat condition based on the $SM_1$ index for the period 2011-2013 in the four assessment areas in POM (GES, subGES)

| Assessment area | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2011-2016 |
|---|---|---|---|---|---|---|---|
| | $SM_1$ index value | | | | | | |
| Bornholm Basin (Słupsk Bank boulder area) | 0.46 | 0.84 | 1 | 1 | 1 | 1 | 0.88* |
| Rowy-Jarosławiec East (Rowy boulder area) | 1 | 0.17 | 0.26 | 1 | 1 | 1 | 0.74* |
| Puck Bay | 0.77 | 0.41 | 0.62 | 0.99 | 0.92 | 0.43 | 0.69* |
| Outer Puck Bay (mixed bottom in the area of Orłowo Cliff ) | 0.75 | 0.78 | 0.62 | 0.71 | 0.87 | 0.66 | 0.74* |

* average of all $SM_1$ values calculated at individual stations, in particular years, in a given area of assessment

In all the discussed areas, the assessment of the status of benthic habitats measured by the SM1 index is higher in 2011-2016 than that in the years 2005-2010 (Table 2.1.58). Differences in the assessment of the state of the environment between the two assessment periods are significant. The value of the SM1 indicator for Słupsk Bank boulder area (Bornholm Basin) and Rowy boulder area (WB: Rowy-Jarosławiec-East) is higher for the period 2011-2016 than for the period 2005-2010 by 42% and 40% respectively. In the Puck Bay, the SM1 index reached a higher value by 25%, while in the Outer Puck Bay (mixed bottom in the area of Orłowo Cliff) by 6%. Only in one area of assessment - in the Bornholm Basin there was a change in the quality class from subGES to GES.

Table 2.1.58. Comparison of the results of the assessment of the state of the environment in 2010-2011 (initial assessment of the marine environment in the Polish Baltic Sea zone) and in 2011-2016 (update of the initial assessment of the marine environment in the Polish Baltic Sea zone) based on the $SM_1$ index in the Baltic Sea sub-basins in POM

| Assessment area | Initial assessment (2010-2011) | Update of the initial assessment (2011-2016) | The direction of change:<br>↗ improvement of the state<br>↘ deterioration of the state |
|---|---|---|---|
| Bornholm Basin (Słupsk Bank boulder area) | 0.62 | 0.88 | ↗ |
| Rowy-Jarosławiec East (Rowy boulder area) | 0.53 | 0.74 | ↗ |
| Puck Bay | 0.55 | 0.69 | ↗ |
| Outer Puck Bay (mixed bottom in the area of Orłowo Cliff ) | 0.70 | 0.74 | ↗ |

Comparing the state of the POM environment in 2011-2016 ($SM_1$ = 0.74 - subGES) with the state in 2010-2011 ($SM_1$ = 0.58 - subGES), it can be seen that it improved.

***B index assessment***

The national assessment based on the B index, including the PMŚ in terms of macrozoobenthos collected during the assessment period (2011-2016), was performed for all (22) assessment areas in POM, covering both open and transitional and coastal waters (Table 2.1.59.).

Table 2.1.59. Stations from which the necessary macrosoobenthic data were used to carry out the environmental assessment in POM using the B index for the period 2011-2016

| Assessment area | Station | Type of monitoring |
|---|---|---|
| Bornholm Basin | P5, P3, B13, M3, P16, K6 | HELCOM COMBINE |
| Gdańsk Basin | P1, ZN4, P110 | HELCOM COMBINE |
| Eastern Gotland Basin | Ł7, Z, P140, P2 | HELCOM COMBINE |
| Kamieński Lagoon | WL, DZR | WFD |
| Szczecin Lagoon | C, E, F, H, JWW, B2, SWR | WFD |
| Vistula Lagoon | 1, 2, 3, 5, 6, T5, 8, T2, 10 | WFD |
| Puck Lagoon | T6a, ZP6 | st. T6a - WFD, st. ZP6 - HELCOM COMBINE |
| Outer Puck Bay | OM1, T12 | WFD |
| Inner Gulf of Gdańsk | ZG, P104 | st. ZG - WFD, st. P104 - HELCOM COMBINE |
| Dziwna Mouth | DZ | WFD |
| Wisła Przekop mouth | OM3 | WFD |
| Świna Mouth | SWI, SW, IV | WFD |
| Hel Peninsula | C18 | WFD |
| Vistula Spit | C19 | WFD |
| Władysławowo harbour | C16 | WFD |
| Sarbinowo-Dziwna | 3ZP, 4ZP, 5ZP | WFD |
| Rowy-Jarosławiec West | C8 | WFD |
| Rowy-Jarosławiec East | C9, C11 | WFD |
| Jastrzębia Góra-Rowy | C12, C13, C13a | WFD |
| Władysławowo-Jastrzębia Góra | C15 | WFD |
| Dziwna-Świna | 2ZP | WFD |
| Jarosławiec-Sarbinowo | 6ZP,7ZP | WFD |

The assessment of the benthic habitat (soft bottom) made using the B index for 22 assessment areas in POM showed that only four sub-basins presented a good status - GES (B≥ 3.18) (Table 2.1.60.). These were WBs of coastal waters (Hel Peninsula, Władysławowo - Jastrzębia Góra, Jastrzębia Góra - Rowy, Rowy - Jarosławiec-West), located in the sea zone of the mid-coast, far from sources of anthropogenic pollution.

The worst condition (subGES) was found in the following Basins: Gdańsk, Bornholm and the Eastern Gotland Basin, which within their borders include the south-Baltic deeps, from which the basins took their names. Macroscopic life at the bottom of the deep is poor in terms of taxonomy and quantity. It appears periodically, following the inflow of oxygenated waters from the North Sea and lasts until oxygen depletes in the near bottom waters. This affects the state of water quality, which reflects the low value of the B index.

The state below good - subGES was also found in the studied lagoons: Szczecin, Kamieński, and especially in the Vistula Lagoon. They are heavily eutrophic reservoirs, which are the receivers of river waters that carry a large load of biogenic substances and despite their relative shallowness, having poor oxygen conditions in the near-bottom waters and sediments. The area of assessment that distinguished positively from the others is the Puck Bay (the inner part of the Puck Bay), in which good conditions prevailed for four years (GES status). However, the weak state recorded in 2011 meant lowering the total assessment in the period 2011-2016 to the subGES status.

Table 2.1.60. Assessment of the habitat of the benthic soft bottom based on the value of the B index for the period 2011-2016 in the 22 assessment areas in POM (GES, subGES)

| Assessment area | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Period 2011-2016* |
|---|---|---|---|---|---|---|---|
| | B index value | | | | | | |
| Gdańsk Basin | 0 | 1.41 | 1.9 | 0.9 | 1.9 | 1.88 | 1.33 |
| Eastern Gotland Basin | 2.36 | 2.46 | 2.52 | 2.82 | 2.92 | 3.01 | 2.86 |
| Bornholm Basin | 2.71 | 2.58 | 2.6 | 2.55 | 2.8 | 2.7 | 2.7 |
| Kamieński Lagoon | 1.73 | 2.64 | - | - | 2.97 | 2.41 | 2.52 |
| Szczecin Lagoon | 2.03 | 2.42 | - | 2.6 | 1.91 | 2 | 2.25 |
| Vistula Lagoon | - | 1.08 | 1.13 | - | - | - | 1.15 |
| Puck Lagoon | 2.16 | 3.34 | 3.3 | 3.23 | 3.44 | 3.17 | 2.92 |
| Outer Puck Bay | 2.8 | - | - | 2.92 | 2.44 | - | 2.69 |
| Inner Gulf of Gdańsk | 2.72 | 2.57 | 2.21 | 2.51 | 2.58 | 2.84 | 2.6 |
| Dziwna Mouth | - | - | - | - | 2.43 | 2.75 | 2.59 |
| Wisła Przekop mouth | 2.02 | - | - | 2.22 | 2.73 | - | 2.32 |
| Świna Mouth | 2.6 | 3.09 | - | - | 3.27 | 3.03 | 3.11 |
| Vistula sandbar | 1.96 | - | - | 2.63 | 2.08 | - | 2.22 |
| Hel Penisula | - | 3.58 | - | 3.47 | 3.41 | - | 3.49 |
| Port Władysławowo | - | - | - | 1.73 | 2.36 | - | 2.04 |
| Władysławowo-Jastrzębia Góra | - | 3.02 | - | 3.13 | 3.48 | - | 3.21 |
| Jastrzębia Góra-Rowy | - | 3.6 | - | 3.04 | 2.82 | - | 3.38 |
| Rowy-Jarosławiec West | - | - | - | 2.84 | 4.11 | - | 3.48 |
| Rowy-Jarosławiec east | 2.51 | - | - | 3.47 | 4.37 | - | 2.91 |
| Jarosławiec-Sarbinowo | - | 1.81 | - | - | 2.5 | - | 2.16 |
| Sarbinowo-Dziwna | - | 2.53 | - | - | 1.79 | - | 2.16 |
| Dziwna-Świna | - | 2.36 | - | - | - | 2.61 | 2.56 |

* average of all B index values calculated at individual stations, in particular years, in a given assessment area

Determining the direction of changes in the quality of the environment measured by the B index, which occurred in the period from the initial assessment of the marine environment in the Polish Baltic Sea zone (GIOŚ 2014) to the end of this initial update of the assessment is difficult, as the 17 borders of 22 sub-areas (assessment areas) designated in Initial assessment differ from the borders set in the current assessment (HELCOM 2013a). The initial assessment was performed at the level 3. of the division of the Baltic Sea into sub-basins, and in the current update of the assessment - at level 4 (HELCOM 2013a, update of annex 4 -2017). Table 2.1.61 presents a change in state (improvement or deterioration) in sub-areas whose boundaries in this assessment are the same as in the previous assessment.

Table 2.1.61. Comparison of the results of the assessment of the state of the environment in 2005-2010 (initial assessment of the marine environment in the Polish Baltic Sea zone) and in 2011-2016 (update of the initial assessment of the marine environment in the Polish Baltic Sea zone) on the basis of the B index in the Baltic Sea subregions designated in POM

| Assessment area | Initial assessment (2010-2011) | Update of the initial assessment (2011-2016) | The direction of change: ↗ improvement of the state ↘ deterioration of the state |
|---|---|---|---|
| Bornholm Basin | 2.82 | 2.70 | ↘ |
| Eastern Gotland Basin | 2.60 | 2.86 | ↗ |
| Gdańsk Basin | 1.63 | 1.33 | ↘ |
| Vistula Lagoon | 1.75 | 1.15 | ↘ |
| Szczecin Lagoon | 2.13 | 2.25 | ↗ |

Differences in the assessment of the state of the environment measured by the B index in both assessment periods were small. In none of the sub-basins there was a change in the quality class (GES/subGES). The biggest change occurred in the Vistula Lagoon, where the B index decreased by 0.6.

**ESMIz index assessment**

To assess the state of the benthic habitat (infralittoral sands) in the Vistula, Szczecin and Kamieński lagoons on the basis of macrophytes using the ESMIz index, the data from the State Environmental Monitoring were collected in 2016 at 15 research stations (Table 2.1.62.).

Table 2.1.62. Stations from which the necessary data on macrophytes in the lagoons were used to carry out the environmental assessment in POM using the ESMIz index for the period 2011-2016

| Assessment area | Station | Type of monitoring |
|---|---|---|
| Vistula lagoon | Zalew Wiślany – Piaski, Zalew Wiślany – Przebrno, Zalew Wiślany – Frombork, Zalew Wiślany – Kąty Rybackie, Zalew Wiślany – Nowa Pasłęka, Zalew Wiślany - Tolkmicko | WFD |
| Szczecin lagoon | Zalew Szczeciński 1, Zalew Szczeciński 3, Zalew Szczeciński 4, Zalew Szczeciński 5, Zalew Szczeciński 6, Zalew Szczeciński 7 | WFD |
| Kamieński lagoon | Zalew Kamieński 1, Zalew Kamieński 2, Zalew Kamieński 3 | WFD |

The assessment of lagoons made with the ESMIz index for the 3 assessment areas in POM showed a sub-good status - subGES (ESMIz <0,123) (Table 2.1.63). Lagoon ecosystems are characterized by large surface area, very low depth, are located in the estuaries of rivers and are subjected to the influence of large, strongly anthropogenically changed catchment areas. All these features make them very susceptible to degradation (Cieśliński 2010, 2011)

Table 2.1.63. Assessment of the soft bottom benthic habitat in lagoons based on the value of ESMIz index for the period 2011-2016 (data only from 2016) in 3 assessment areas in POM (GES, subGES)

| Assessment unit | Period 2011-2016 |
|---|---|
| Vistula lagoon | 0.029 |
| Szczecin lagoon | 0.036 |
| Kamieński lagoon | 0.027 |

The current assessment of macrophyte state in the lagoon using the ESMIz index was performed in POM for the first time, so it is not possible to refer to the initial assessment (GIOŚ 2014).

**Integrated assessment of benthic habitats**

According to the assessment method, the status of benthic habitats in POM as part of the multiannual assessment 2011-2016 is divided into 4 types of habitats, differing in the structure of flora and fauna communities associated with a specific type of bottom:

1. assessment of the benthic habitat on the soft bottom in 22 assessment areas in POM (for broad habitat types based on the EUNIS classification according to the decision 2017/848 – Table 1.4.4), including 21 areas based on the classification of the assessment result according to threshold values for indicator B (Table 2.1.53) and for the Puck Lagoon waterbody, where an integrated assessment between $SM_1$ and B index (Table 2.1.64) was applied, and then the classification of the assessment result - BQR as part of the "integrated assessment of biodiversity" was used (Table 2.1.51.). The assessment of the state of this habitat is presented on the map (Fig. 2.1.79.)

Table 2.1.64. Integrated assessment of the state of benthic habitats on the soft bottom, taking into account the $SM_1$ and B index in the period 2011-2016

| Assessment area | Indicator | The normalized value of the indicator for the years 2011-2016 | Indicator weight | BQR | Assessment |
|---|---|---|---|---|---|
| Puck Lagoon | $SM_1$ | 0.52 | 0.5 | 0.50 | subGES |
| | B | 0.49 | 0.5 | | |

Assessment of the benthic habitat (soft bottom) showed that in 2011-2016, the majority (18) of the assessment areas in POM, constituting 99% of the area, showed sub-good status - subGES, and only 4 coastal waterbodies (1% of POM area): Hel Peninsula, Władysławowo - Jastrzębia Góra, Jastrzębia Góra - Rowy, Rowy - Jarosławiec West were in good condition - GES.

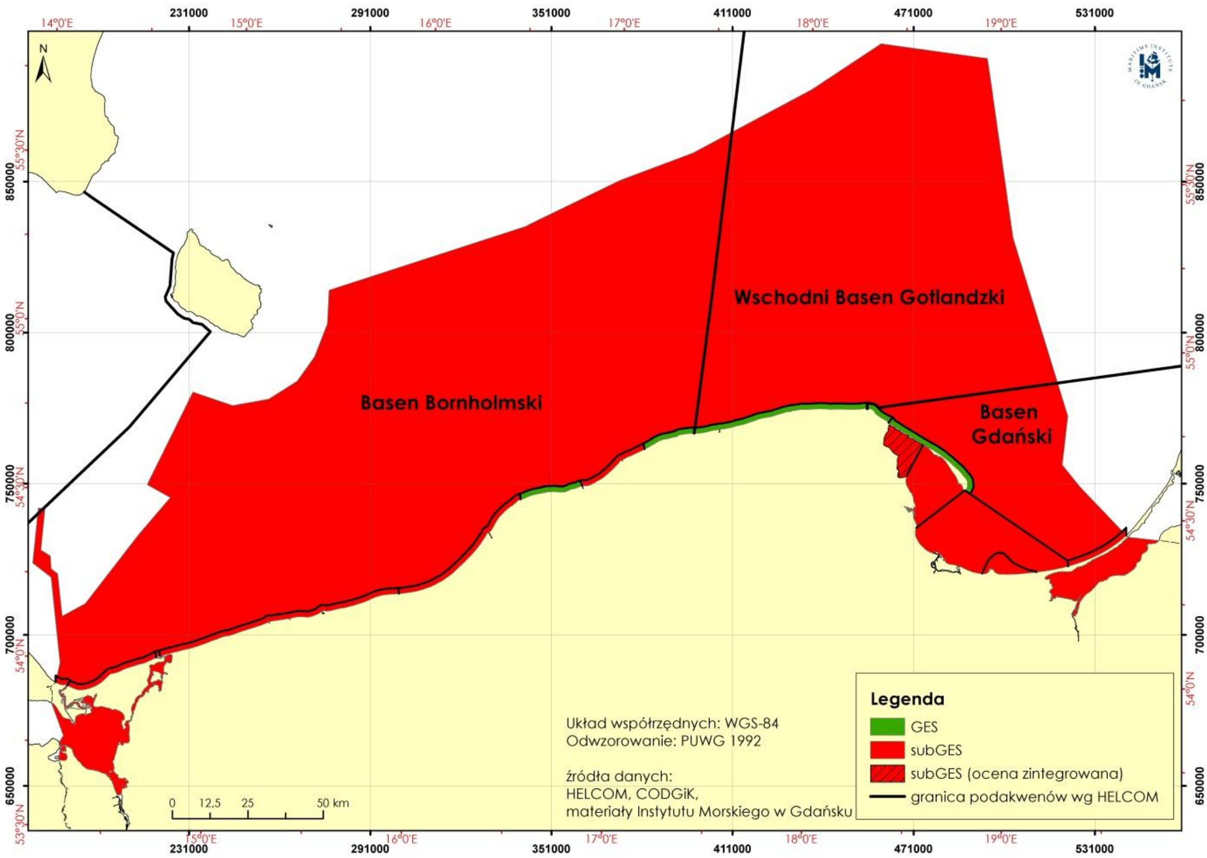



Fig. 2.1.79. Integrated assessment of the state of benthic habitat - soft bottom for many years 2011-2016 in POM (Data source: PMŚ)

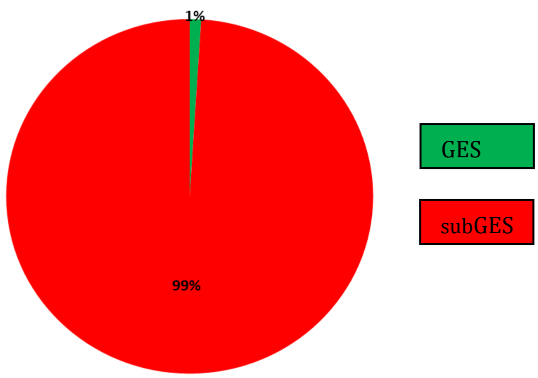



Fig. 2.1.80. Benthic habitat of soft bottom showing good status - GES and below good - subGES with respect to POM area in 2011-2016 (Data source: PMŚ)

2. assessment of the benthic habitat on hard bottom in two assessment areas in the POM: on Słupsk Bank boulder area (in Bornholm Basin) and on Rowy boulder area (in the area of waterbody: Rowy - Jarosławiec-East) on the basis of the assessment result according to threshold values for the $SM_1$ index (Table 2.1.52.), which is presented in Fig. 2.1.81.

Assessment of the benthic habitat (hard bottom) showed that in 2011-2016 Słupsk Bank boulder area of an area of 111.3 $km^2$ showed a good status - GES, whereas Rowy boulder area (2.57 $km^2$ area) was below the good status - subGES (Fig. 2.1.81.).

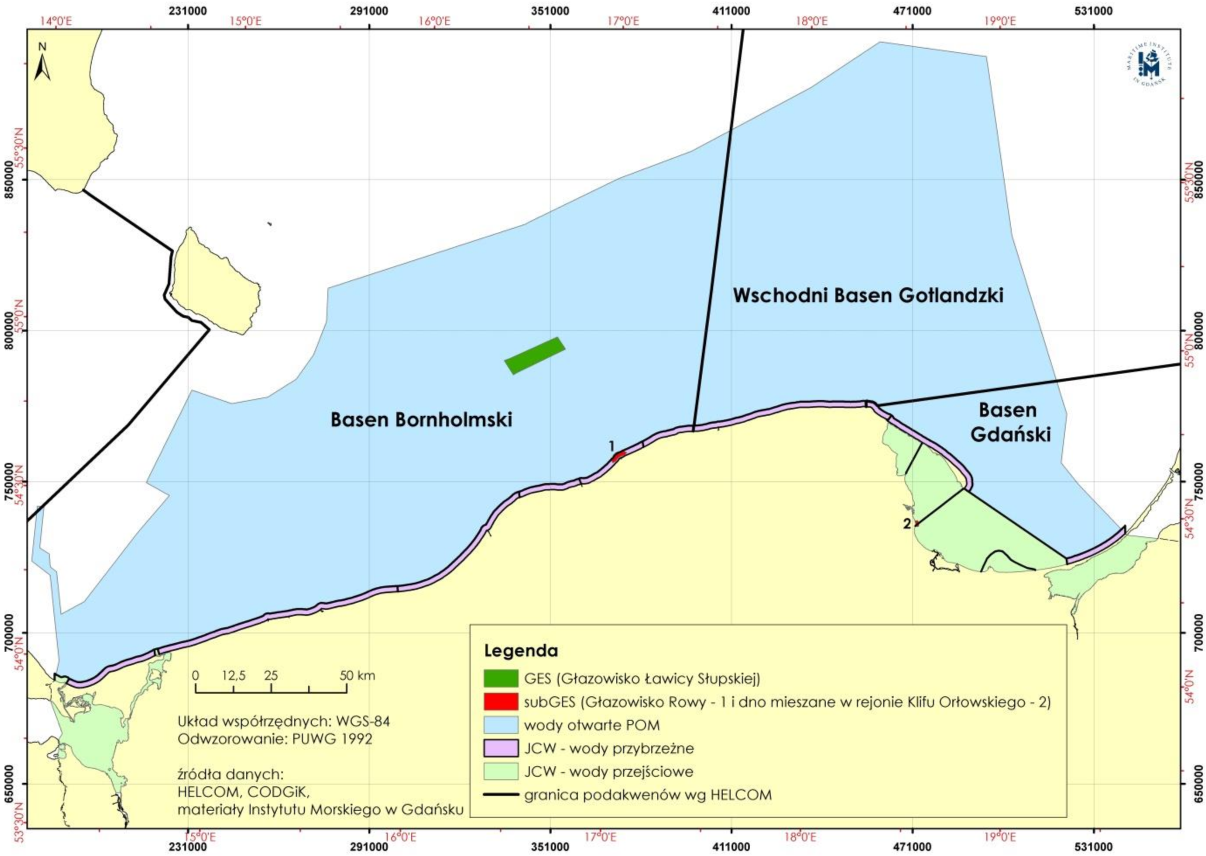



Fig. 2.1.81. Assessment of the benthic habitat - hard bottom (boulder) and mixed bottom (Cliff Orłowski region) for the years 2011-2016 in POM

3. assessment of the state of benthic habitat on the mixed bottom in the area of Outer Puck Bay in the area of Cliff Orłowski based on the classification of the result of the assessment in line with the threshold values for the $SM_1$ index (Table 2.1.52)

In the Klif Orłowski area of 1.99 km², the assessment habitat showed a sub-good status - subGES (Fig. 2.1.81)

4. assessment of the macrophyte habitat status in lagoons in 3 assessment areas in the POM: the Vistula Lagoon, Szczecin Lagoon and Kamieński Lagoon on the basis of classification of the assessment result in accordance with the threshold values for the ESMIz index (Table 2.1.54.), is presented in Fig. 2.1.82.

The assessment of macrophytes in lagoons with a total area of 752.61 km² showed a sub-good status - subGES in each of these waterbodies (Fig. 2.1.82.).

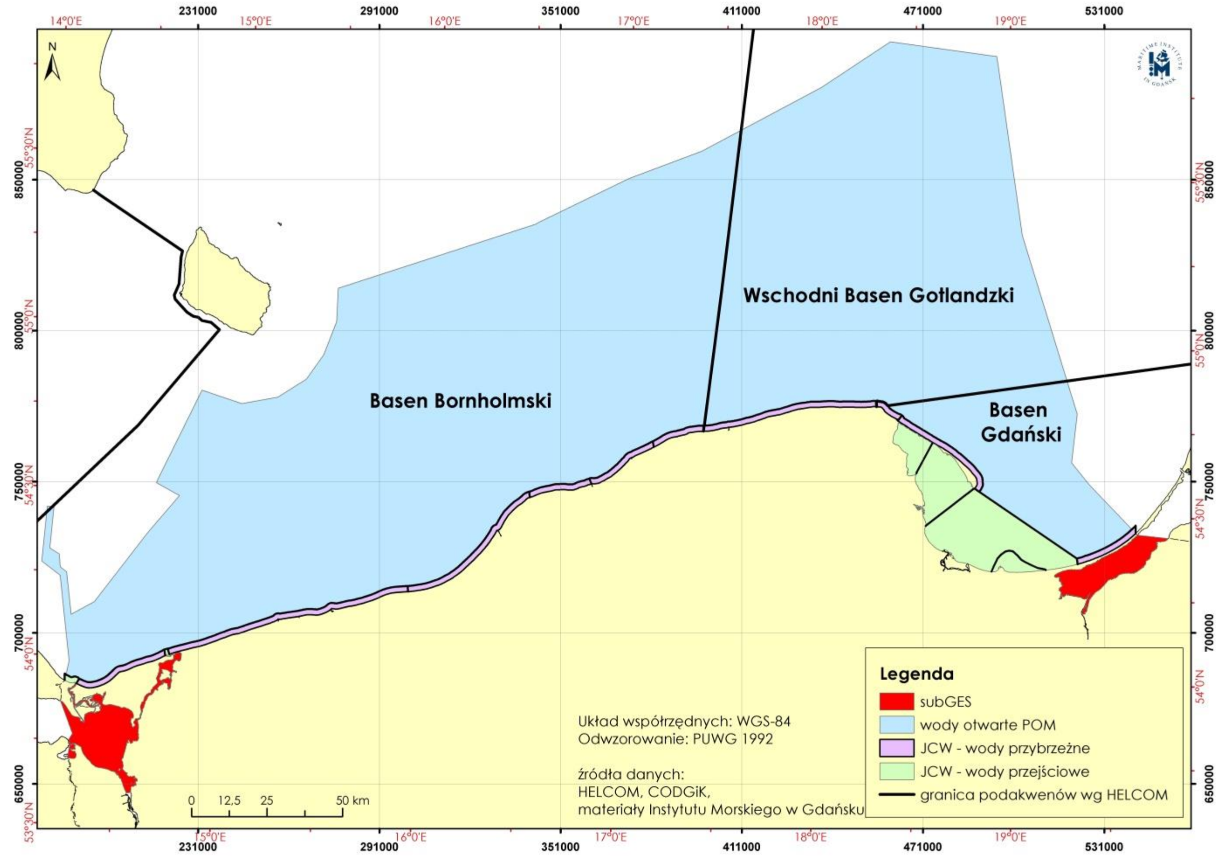



Fig. 2.1.82. Assessment of macrophyte habitat condition in lagoons in 2016 in POM (Data source: PMŚ)

**Confidence of assessment of benthic habitats for 2011-2016**

The confidence status of the assessment for benthic habitats on the soft bottom using the B index and in the integration with the $SM_1$ indicator (Puck Bay) is high (Fig. 2.1.83).

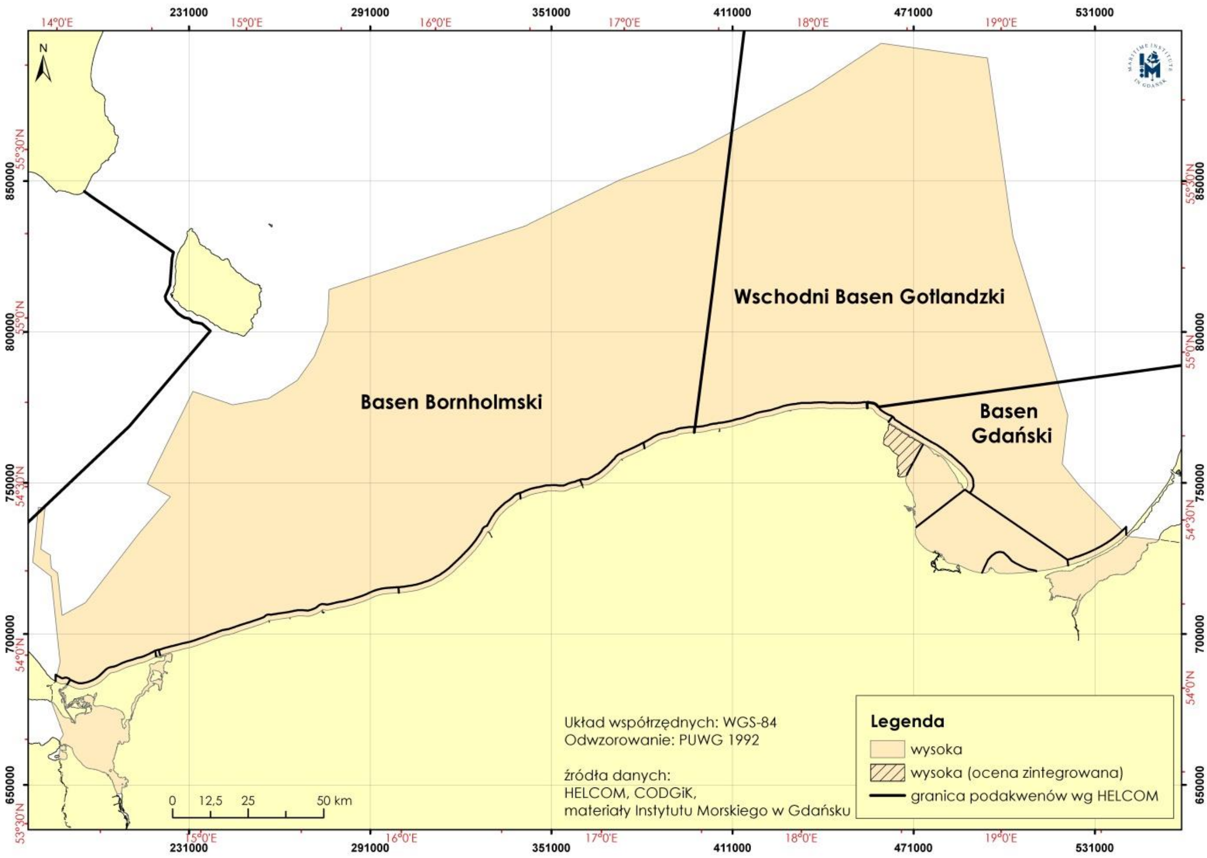



Fig. 2.1.83. Confidence status of the integrated assessment of the benthic habitat - soft bottom for the years 2011-2016 in POM

Similarly, in the case of the confidence of the assessment of benthic habitats on the hard bottom (Słupsk Bank boulder area and Rowy boulder area) and on the mixed bottom in the area of Cliff Orłowski – confidence status was also determined as high (Fig. 2.1.84.)

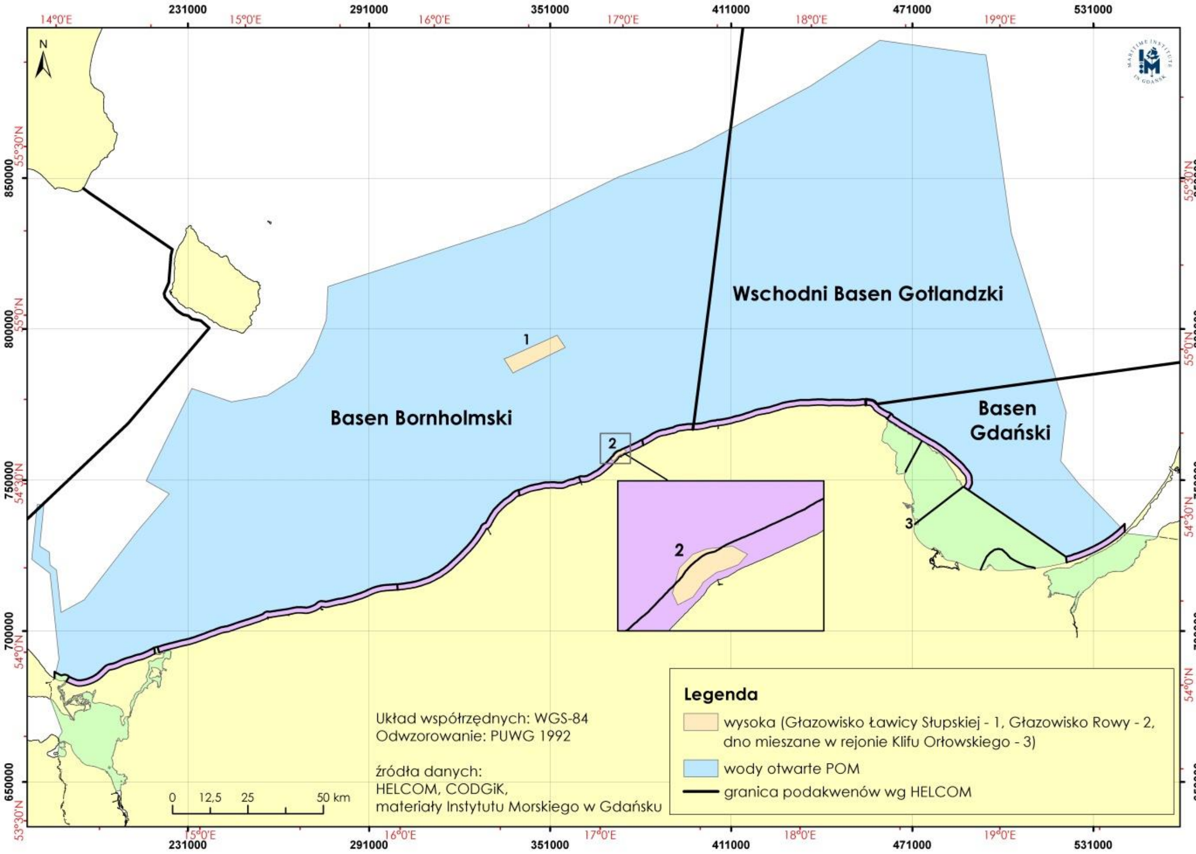



Fig. 2.1.84. Confidence status of the assessment of the benthic habitat condition - hard bottom (boulder fields) and mixed bottom in the area of Cliff Orłowski for multiannual period 2011-2016 in POM

***Pelagic habitats***

### Indicators

The status of pelagic habitats in open waters of POM was assessed on the basis of the primary indicator 'Size structure and total resources of zooplankton' (applied only in the Gdańsk Basin) and preliminary ratio 'Diatom/Dinoflagellate', typical of biotic assessment of the habitat. In addition to the assessment of these habitats, two eutrophication indices were used: the initial indicator 'Index of cyanobacteria blooms' and the core indicator 'Chlorophyll-a'. The last two indicators were included in the assessment mainly to present changes at the lowest basic level of biological production - changes in primary production. The 'Chlorophyll-a' indicator characterizes the overall level of primary production by approximating the variability of the phytoplankton biomass and is one of the primary indicators of eutrophication assessment.

For 19 transitional and coastal waterbodies, the national indicator 'Chlorophyll-a', which meets the requirements of the WFD (Anon 2000), was used to determine the state of pelagic habitats.

The above selection of indicators to assess the pelagic habitat status in POM is similar to that used in the second holistic assessment of the Baltic Sea (HELCOM 2017a).

***Indicator 'Zooplankton mean size and total stock (MSTS)'***

### Characteristics and formula

The index 'Zooplankton mean size and totalstock – MSTS' is a core indicator of HELCOM. It allows to assess the state of lower trophic levels of the pelagic food web and its indirect structure. Zooplankton is a link between primary producers and consumers of higher order, and its structure determines the energy flow to higher trophic levels. Changes in the qualitative and quantitative composition of zooplankton affect the phytoplankton resources and the state and size of fish stocks (Jeppsen et al 2011).

To calculate the MSTS index, we need data describing the total number of zooplankton (number of individuals in $1m^3$ of water – indiv. $m^{-3}$) and total biomass of zooplankton (milligrams or micrograms of wet biomass of zooplankton in 1 $m^3$ of water - mg $m^{-3}$ or µg $m^{-3}$) from June to September from the assessment period. These are the months in which the most monitoring studies of zooplankton are performed and are characterized by the largest production of plankton and the greatest pressure of predators on zooplankton resources. Data from research carried out at stations located within one assessment area can only be used to assess this sub-basin. Only the data according to the list of zooplankton taxa developed by the HELCOM ZEN-ZIIM group may be used for the calculation of the indicator, although some taxa names differ from the ZEN-ZIIM list in the ICES database, which should be verified before calculations are made. The data used for the assessment should be characterized by normal distribution (e.g. the Kolmogorow-Smirnow/Shapiro-Wilk test), and if the results deviate significantly from the curve, they should be normalized using the Box-Cox transformation. For this purpose, the calculator available online (http://www.wessa.net/rwasp_boxcoxnorm.wasp; Wessa 2017) can be used. As a result, two components of the indicator should be obtained:

- Size of the zooplankton, i.e. the ratio of the total number (the sum of individual values of the taxa of zooplankton taxa) to the total biomass [µg $m^{-3}$] – **MS**,
- Total biomass of zooplankton (total stock), i.e. the sum of individual biomass values of zooplankton taxa [mg $m^{-3}$] – **TS**.

The MSTS indicator meets the criterion D1C6 (Table 2.1.2.) of the Descriptor D1 - biodiversity and D4C3 criterion of Descriptor D4 - food webs according to the Decision 2017/848, as well as the requirements of the Baltic Sea Action Plan for environmental objectives - well developing and balance of plant and animal populations, which has a direct link to the structure of the food web.

**Threshold value of good environmental status**

The methodology for determining the boundary of good environmental status (GES) was adopted on the basis of the HELCOM report on the MSTS indicator (Gorokhova et al. 2015). The limits for both components of the index (TS, MS) are determined based on data from the reference period (based on the chlorophyll-a - RefConChl content or condition of pelagic fish in the regions analogous to the location of zooplankton stations - RefConfish), i.e. a time interval when the effect of eutrophication on the structure of the food network was still observed and there were favourable food conditions for fish. The lack of the observed effect of eutrophication is defined as an acceptable concentration of chlorophyll-a at a low level, while favourable food conditions for fish mean that the condition of herring fish (based on indicators describing the condition of fish) and their population are relatively high. The limit values of both components of the indicator (TS, MS) are considered to be the same as the lower limit of 99% confidence interval for data after normalization using the Box-Cox method. The MSTS threshold values in the Gdańsk Basin were determined based on data from the reference period related to the condition of pelagic fish (RefConfish) from 1986-2016. The concept of assessing the state of the environment based on the MSTS indicator is presented in Fig. 2.1.85.

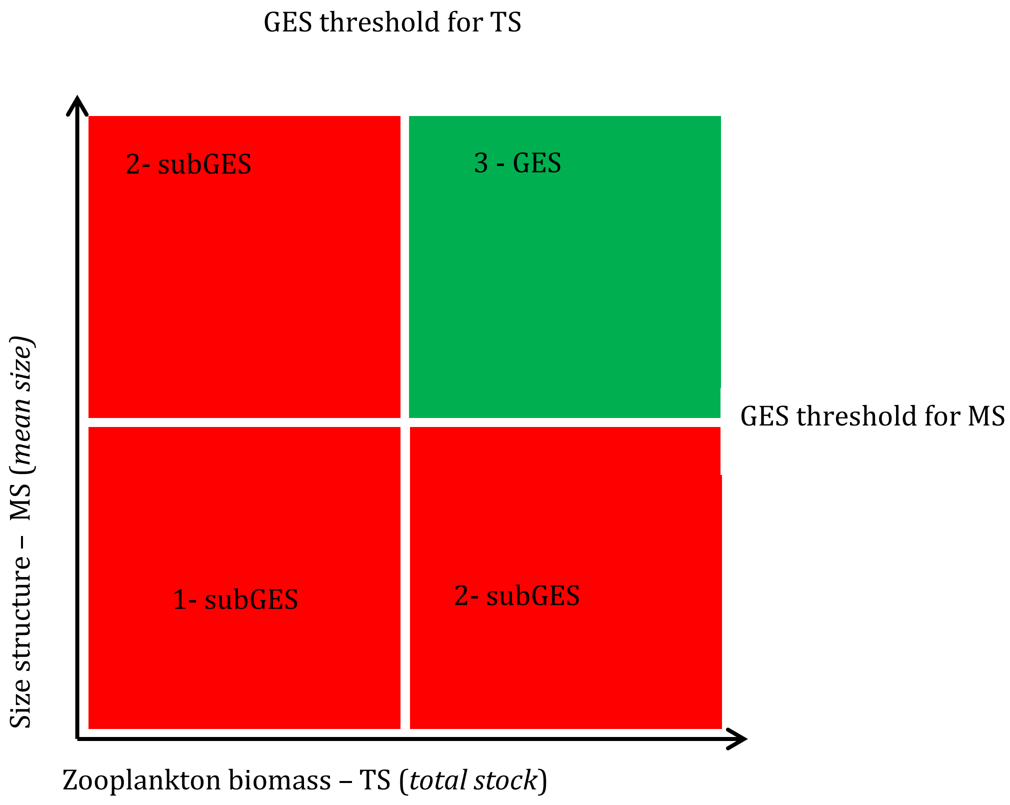



Fig. 2.1.85. GES threshold values for both components of the MSTS indicator: MS (*mean size*) and TS (*total stock*)

In case when the index value of 1 in the figure (values of both components of the index are lower than the limits for these components: MS and TS) or when the indicator value is 2 in the figure (at least one value of the index component is lower than the designated limit of GES for this component) - this state of the environment is rated as below good - subGES. Only if the index value is marked as 3 in the figure (values of both components of the index are higher than the limits for these components: MS and TS) - then the state of the environment can be assessed as good - GES.

The value of the MSTS indicator is not normalized. For the assessment areas in POM, the threshold value was set and adopted for use in the assessment for the Gdańsk Basin (Table 2.1.65.). In the Bornholm Basin and in Eastern Gotland Basin threshold values have not been set (HELCOM 2017f).

Table 2.1.65. Threshold value of good environmental status - GES of the "Zooplankton mean size and total stock" indicator for the assessment area in POM

| Assessment area | Threshold value for the zooplankton size structure – MS [$\mu g\ m^{-3}$] | Threshold value for the zooplankton size structure – TS [$mg\ m^{-3}$] |
|---|---|---|
| Gdańsk Basin | 10.2 | 103 |

Source: based on a study by Margoński and Całkiewicz (2017)

### Pressures related to the indicator

The two most important factors of anthropogenic pressure related to the state of zooplankton are fishery and eutrophication. Fisheries based, like in the Baltic region, on intensive cod catches, lead to a decrease in the size of its population, and thus to an increase in the development of planktivorous fish, which are increasingly limiting the largest zooplankton resources. Other pressures related to human activity that can regulate the qualitative and quantitative resources of zooplankton are (following Gorokhova and others 2015):

- change in water temperature - as a result of climate change (higher temperature of water favours the development of microfag zooplankton),
- change in oxygen concentration in water,
- water pollution,
- the emergence of invasive species.

### *Indicator 'Diatom/Dinoflagellate ratio'*

### Characteristics and formula

The "Diatom/Dinoflagellate" is an indicator showing changes in the state of the environment as a result of the impact of anthropogenic and global factors, e.g. climate change (Alheit et al. 2005, HELCOM 2017g), leading simultaneously to transformation in the food chain (Kownacka 2016, Wasmund et al 2017) This indicator can be used wherever there are spring bloom diatoms or dinoflagellates (Wasmund et al. 1998, 2013). The definition of bloom and its duration in various sub-basins of the Baltic Sea have been determined by HELCOM (1996) and Wasmund et al. (1998) Bloom is a mass increase in the amount of phytoplankton in water. For specific phytoplankton groups, threshold values have been set, the exceeding of which indicates bloom. For diatoms and dinoflagellates, this value is 1000 $\mu g\ l^{-1}$ (Kownacka 2017). Many factors affect the intensity of bloom, such as: nutrient content, availability of light, degree of water mixing, temperature and salinity.

The "Diatom/Dinoflagellate" ratio is based on the biomass of autotrophic diatoms to auto- and mixotrophic dinoflagellates ratio based on the formula developed by Wasmund et al (2013.) In POM, to meet the requirements of this indicator, phytoplankton should be monitored from February to May The indicator formula given below is applicable with the assumption that the limit value for biomass diatoms and dinoflagellates of 1000 $\mu g\ l^{-1}$ will be exceeded in at least one sample in the season by diatoms and dinoflagellates, which means that sampling took place during the bloom in the South Baltic region (Wasmund 2017).

$$\textbf{\textit{wskaźnik okrzemkowo – bruzdnicowy}} = \frac{\text{biomasa okrzemek}}{\text{biomasa okrzemek + biomasa bruzdnic (auto + miksotroficznych)}}$$

The average is recommended for calculating the 'Diatom/Dinoflagellate' ratio wet seasonal biomass of diatoms and dinoflagellates. If diatoms in a given year were collected more than once in the period from February to May, the average monthly biomass of diatoms and dinoflagellates (auto- and mixotrophic) at each research station should be calculated first, whereas the formula should use average seasonal values of wet diatoms and dinoflagellates, which are calculated from monthly averages. The biomass must be calculated as a wet mass or as a biomass expressed in the carbon content of the cell and given in the same units both in the numerator and in the denominator of the formula. The higher the frequency of sampling, the greater the probability of encountering blooms and greater confidance of the indicator (Kownacka 2016, Wasmund et al 2017). In order to calculate the multiannual indicator, the indicator values from selected years should be averaged.

The 'diatom' indicator meets the criterion D4C2 (Table 2.1.2.) of the Descriptor D4 - food webs and the D5C1 criterion of Descriptor D5 - eutrophication in accordance with the guidelines of Decision 2017/848 as well as the requirements of the Baltic Food Chain Action Plan, eutrophication, natural distribution and occurrence of plants and animals, and balance in plant and animal communities.

### Threshold value of good environmental status

The value of the 'Diatom/Dinoflagellate' ratio is normalized, i.e. in the range from 0 to 1, where 1 indicates the domination of diatoms in the absence of dinoflagellates. The threshold value was determined and tested in the second holistic assessment for the Eastern Gotland Basin (HELCOM 2017g). The threshold values for the 'Diatom/Dinoflagellate' ratio are presented in Table 2.1.66. Values equal to or higher than the threshold mean good environmental status - GES.

Table 2.1.66. Threshold values for good environmental status - GES of the 'Diatom/Dinoflagellate' regular ratio for the assessment areas in POM

| Assessment area | threshold value GES [μg $l^{-1}$] |
|---|---|
| Gdańsk Basin | 0.6 |
| Eastern Gotland Basin | 0.5 |
| Bornholm Basin | 0.6 |

Source: based on the Kownacka study (2017)

### Pressures related to the indicator

During spring bloom, among all phytoplankton groups in sea water, diatoms and dinoflagellates predominate (HELCOM 2002, Danielsson and Papush 2008). Its intensity is determined mainly by the amount of nutrients accumulated during winter. Then the transfer of energy and organic matter takes place in the ecosystem (Krzymiński 2017). The ratio of the number of diatoms to dinoflagellates reflects the state of the ecosystem and the quality of the phytoplankton complex as a food for the remaining elements in the food chain.

During the bloom diatoms quickly reach high biomass because they intensively absorb the nutrients needed for growth. Due to their sedimentation properties, their amount in the water column is rapidly decreasing, and at the bottom they are also food for benthic organisms (Heiskanen 1998). Dinoflagellates grow slower than diatoms and due to their ability to migrate vertically in the water, they can use nutrients from the lower layers of water. They remain in the water column for a long time, making them the preferred food for zooplankton (Horn et al. 2015, Pastuszak et al. 2016, Kownacka 2017, Wasmund et al. 2017).

Observations of changes in the ratio of diatom to dinoflagellates biomass during spring bloom and their significance for the whole ecosystem in the Baltic Sea area have been conducted for a long time (Klais et al., 2011, 2013, Wasmund et al., 1998, 2008). Changes in phytoplankton dominant groups may be caused by human activity as well as by global climate change, so-called "Regime shift" (Kownacka 2016).

The main factor of anthropogenic pressure related to the phytoplankton state: diatoms and dinoflagellates is eutrophication (Wasmund et al. 1998, Kownacka 2016, Krzymiński 2017). The enrichment of the Baltic Sea with nitrates and phosphates causes a general increase in the amount of phytoplankton biomass, including some diatoms and dinoflagellates, resulting in increased water turbidity, reduced oxygen in the bottom water, changes in the algae taxonomic composition leading to changes in the food chain structure (Wasmund et al. 1998). The drop in silicon content occurs from winter to summer, which is why the "diatom and dinoflagellate" rate may indicate a limitation of diatom growth in water (Wasmund et al., 1998, 2013).

Quantitative and qualitative changes in the phytoplankton structure are also affected by climate change, so-called "Regime shift". In the spring, a drastic decrease in diatom biomass in the Bornholm Basin and the Eastern Gotland Basin is observed, with the simultaneous increase in the biomass of flagellates and dinoflagellates (PMŚ data for 2011-2016, Wasmund and Uhlig 2003, Pastuszak et al., 2016). The cause of the decline in diatom biomass may be overfishing (Pastuszak et al., 2016). Unsustainable fishing for large predators (cod) in the Baltic Sea in the 1980s combined with reduced recruitment of this species led to reduced pressure on planktivorous fish and, as a result, a very significant increase in sprat biomass. Increased biomass of planktonic fish causes increased consumption of zooplankton, and thus the pressure on phytoplankton decreases. The unused phytoplankton contributes to increased sedimentation at the bottom of the Baltic Sea, therefore it is an element contributing to the deterioration of aerobic conditions in the near-bottom waters - the situation attributed to the eutrophication process (Pastuszak et al. 2016).

***Indicator 'Cyanobacterial bloom index (CyaBI)'***

**Characteristics and formula**

The Cyanobacterial bloom index (CyaBI) is a preliminary indicator for eutrophication, used for assessment in open sea waters, on the basis of cyanobacteria bloom in the summer months The indicator was developed by experts from the Finnish Institute of the Environment (SYKE) ( HELCOM 2012, HELCOM 2017h).

Both satellite data (CSA parameter, cyanobacterial surface accumulations) and in situ measurement data (parameter - cyanobacterial biomass) (HELCOM 2017h) can be used to determine the indicator and assess the state of the environment.

The main source of data for the development of the CSA parameter were data on chlorophyll-a and seawater transparency, derived from daily analyses of satellite images at the Finnish Institute of the Environment (SYKE) (Kahru and Elmgren 2014b, HELCOM 2017h). Satellite data is characterized by a very high frequency of measurement, so that the formation, course and duration of blooms of cyanobacteria in the surface layer of the sea can be traced in an optimal way. However, this parameter is strongly dependent not only on eutrophication factors, but also on climate-related changes, e.g. wind conditions. The methodology for developing this parameter has been described in the HELCOM report from the CORESET project (HELCOM 2017h). Biomass of cyanobacteria completes the CSA parameter, providing information on the actual number and biomass of cyanobacteria in the surface (0-10 m) layer of water (HELCOM 2017i). This data is collected as part of monitoring by all Baltic countries, in accordance with the national Baltic Sea monitoring programs. Methods of monitoring and methodological principles of taxonomic analysis and determination of cyanobacteria biomass are described in the "HELCOM Manual for Marine Monitoring" (HELCOM 2014a) in the section on phytoplankton monitoring in terms of species structure, abundance and biomass Due to the significantly lower time resolution of in situ monitoring , thresholds for biomass and the level determined on their basis do not meet the requirements of adequate confidance for the primary indicator.

Combining the two parameters into one index provides a more reliable determination of the pelagic habitat condition. The CyaBI index changes in the opposite way in relation to the increase in eutrophication, i.e. the low values of the index indicate a strong eutrophication of the environment.

The indicator "cyanobacterial blooms" meets the criterion D1C6 (Table 2.1.2.) of the Descriptor D1 - biodiversity and D5C3 criterion Descriptor D5 - eutrophication in accordance with the decision 2017/848, as well as the requirements of the Baltic Sea Action Plan - reduction of eutrophication in the Baltic Sea.

**Threshold value of good environmental status**

The threshold values for individual assessment areas in the Baltic Sea (HELCOM 2014b, 2017h) have been determined separately for each parameter forming the indicator on the basis of collected long-term data series, including satellite data (CSA) concerning cyanobacterial blooms in the Baltic Sea in 1979-2014 ( Kahru and Elmgren 2014b) and data from in-situ observation (biomass of cyanobacteria) in the years 1990-2015, collected by the HELCOM PEG group (Wasmund et al., 2015). Threshold values were determined using a combination of statistical analysis of long-term data series with expert judgment, because the biggest problem in this task was the lack of reliable and consistent historical data. Data from 1970 or 1980 in the available series do not correspond to the characteristics of "no human impact or only a small impact of this activity", so they could not be used as reference values. Especially that the blooms of cyanobacteria are a natural phenomenon in the Baltic Sea, so threshold values do not have to determine the state - no blooms, but rather a state where there are no intense blooms, and above all - there are no potentially toxic blooms. This state of cyanobacterial blooms should be compatible with the sustainable use of the sea by humans.

In order to determine threshold values, periods of low intensity of blooms were identified in a series of available data, even though they already referred to the eutrophicated environment. Periods with lower intensity of blooms, compared to the general level, were determined using the method of detection of rapid environmental changes (regime shift detection) with the Rodionov algorithm (2004). In the absence of periods with low intensity of blooms, the mean for particular years was calculated using the quartile method.

The method of detecting environmental changes was applied in all areas of assessment for the CSA parameter - cyanobacteria in the surface layer of the sea. In the Bornholm Basin, Eastern Gotland Basin and the Gdańsk Basin, which include the Polish Baltic zone, where biomass of cyanobacteria from before the significant increase in their blooms were not available, threshold values were estimated using quartiles characterizing the lowest biomass. From the data from individual measurements, monthly averages were calculated, followed by seasonal averages (for the period June 20 - August 31) (HELCOM 2017a, 2017h). The calculations include the biomass of cyanobacteria from the genus Nodularia, Aphanizomenon and Dolichospermum (formerly Anabaena).

The value of the "cyanobacterial bloom index" is normalized, i.e. it ranges from 0 to 1, where 1 means good environmental status Threshold values are determined for both parameters characterizing this indicator and the integrated threshold value as the average of the normalized results of both parameters (CSA and biomass), are presented in Table 2.1.67. Indicator results above the threshold value indicate good environmental status. If in a given area of assessment one of the parameters was not possible, the assessment is made based on the threshold value determined only for the remaining parameter, e.g. as in the case of the Gdańsk Basin, where the assessment can only be applied to the CSA parameter in the absence of an in situ threshold for in situ biomass.

Table 2.1.67. Threshold values of good environmental status - GES for CSA parameters and cyanobacteria biomass and integrated CyaBI index assessment for assessment areas in POM

| Assessment area | Threshold value GES (integrated) | GES threshold for the parameter - CSA | GES threshold for the parameter - biomass |
|---|---|---|---|
| Gdańsk Basin | 0.98 | 0.98 | - |

| | | | |
|---|---|---|---|
| Eastern Gotland Basin | 0.84 | 0.84 | 0.84 |
| Bornholm Basin | 0.87 | 0.86 | 0.87 |

**Pressures related to the indicator**

Studies on the proportions of stable nitrogen and carbon isotopes and the organic carbon content in bottom sediments showed that the increase in nutrient levels in the Baltic Sea and the related increase in productivity were initiated already in the 1950s and 1960s (Andrén et al. 2000, Struck et al. 2000, Poutanen and Nikkilä 2001). According to Finni et al. (2001) blooms of cyanobacteria have become a phenomenon common in the Baltic Sea waters and in the Gulf of Finland in the 1960s. It is believed that intense blooms of cyanobacteria are one of the symptoms of eutrophication, fuelled by an increase in the supply of nutrients to the marine environment (Bianchi et al., 2000). In the case of this indicator, the main factor of anthropogenic pressure are phosphorus loads related to with agriculture and industry. Excess nitrogen and phosphorus in the marine environment leads to intensive growth of phytoplankton, including cyanobacteria in the water, which in turn reduces the transparency of seawater, causes oxygen deficits in the near-sea waters, and consequently causes changes in the species structure (Hällfors et al. 2013, HELCOM 2013d). The intensification of cyanobacteria blooms is only partly the result of enriching the environment with biogenic substances and as mentioned above - in particular the disproportionate increase in the dissolved phosphorus content. Many authors also point to other causes, not related to eutrophication, e.g. hydrographical changes such as temperature rise, salinity decrease and more effective vertical mixing or changes in the content of trace elements and microelements, as well as changes in the phytoplankton relation to zooplankton (Kahru and 1994). Intense blooms of cyanobacteria, due to their possible toxicity, have a potentially negative effect on the diversity of marine ecosystems and their socio-economic value.

***Indicator 'Chlorophyll-a'***

**Characteristics and formula**

Chlorophyll-a is a commonly used approximator of phytoplankton biomass. In the open sea, i.e. outside the 1-mile coastal waters (HELCOM 2013a), the core indicator – 'Chlorophyll-a' - applies to the assessment in the Gdańsk Basin, Eastern Gotland Basin and the Bornholm Basin. It characterizes average concentrations of this pigment in surface waters (0-10 m) in the summer period, in the months of June-September (HELCOM 2006a). Both in-situ measurement and satellite data can be used to determine the indicator and assess the state of the environment. The principles of integration of both types of data are described in the assessment report (HELCOM 2017k). Collection of water samples and the analytical process for the determination of the chlorophyll-a concentration is carried out in accordance with the guidelines of the HELCOM COMBINE guide (HELCOM 2014a). In situ measurement data is collected as part of national monitoring programs and transferred to the ICES database. In the national assessment, the data for the 'Chlorophyll-a' indicator came from in situ measurements within the PMŚ.

It is also possible to include data from maintenance-free measuring devices, e.g. Ferry Box or buoy. The dataset on chlorophyll-a based on satellite images (Earth Observation Data) as part of the second holistic assessment was prepared by the Finnish Environmental Institute (SYKE) using the ENVISAT/MERIS instrument for observation - a bio-optical model (Schröder et al., 2007). The accuracy of the bio-optical algorithm was verified against the measurement data from HELCOM COMBINE monitoring stations as part of the HELCOM EUTRO-OPER project (HELCOM 2013e, 2014b). Data on chlorophyll-a from satellite images refer to the surface layer of the sea, where the transparency of sea water has a big influence on the data. EO data was reported as daily statistics in a mesh with a mesh size of 20 km. That dataset has been removed from the data set.

In coastal and transitional waters, an analogous indicator applies "Chlorophyll-a" included in the national system of classification of waterbodies (WB) (Anon. 2016), according to WFD guidelines (Anon. 2000), also in situ data from June-September are used for 15 JCWP with the exception of: the Vistula Lagoon, Puck Bay, Kamieński Lagoon and Szczecin Lagoon, where the index is calculated as the annual average.

The 'Chlorophyll-a' indicator meets the criterion D1C6 (Table 2.1.2.) of Descriptor D1 - biodiversity and criterion D5C2 of Descriptor D5 - eutrophication in accordance with the Decision 2017/848, as well as the requirements of the Baltic Sea Action Plan for the environmental objective - reduction of eutrophication in the Baltic Sea.

### Threshold value of good environmental status

Good environmental status is determined for individual assessment areas based on scientific principles and threshold values approved by the Baltic countries, which define the permissible chlorophyll-a content in seawater (HELCOM 2017d) in terms of average concentrations in the summer, i.e. June-September. Threshold values in individual assessment areas were determined within the TARGREV project (HELCOM 2013e), taking into account the results of the HELCOM EUTRO PRO project (HELCOM 2006a, 2009) and national work related to the implementation of the WFD. The final set of threshold values has been set by a team of experts within the HELCOM IN-EUTROPHICATION group and accepted by HELCOM HOD. Specific threshold values for the 'Chlorophyll-a' index agreed for the assessment areas including POM are presented in Table 2.1.68 and Table 2.1.69. Values equal to or lower than the threshold mean good environmental status - GES.

Table 2.1.68. Threshold values of good environmental status - GES of the 'Chlorophyll-a' indicator for the assessment areas in POM - open waters

| Assessment area | Threshold value GES [$\mu g\ l^{-1}$] |
|---|---|
| Gdańsk Basin | 2.2 |
| Eastern Gotland Basin | 1.9 |
| Bornholm Basin | 1.8 |

Table 2.1.69. Threshold values of good environmental status - GES of the 'Chlorophyll-a' indicator for the assessment areas in POM - uniform water bodies

| Assessment area | Threshold value GES [$\mu g\ l^{-1}$] |
|---|---|
| Szczecin and Kamieński Lagoons | 20 |
| Vistula Lagoon | 23.20 |
| Puck lagoon | 2.00 |
| Outer Puck Bay , Inner Gulf of Gdańsk | 3.76 |
| Dziwna Mouth | 3.80 |
| Wisła Przekop mouth | 5.50 |
| Świna Mouth | 7.50 |
| Hel Peninsula Władysławowo harbout, Sarbinowo-Dziwna, Rowy-Jarosławiec Zachód, Rowy-Jarosławiec Wschód, Jastrzębia Góra-Rowy, Władysławowo-Jastrzębia Góra, Jarosławiec-Sarbinowo | 1.90 |
| Vistula Spit, Dziwna-Świna | 3.15 |

### Pressures related to the indicator

Chlorophyll-a is a commonly used approximation of phytoplankton biomass due to its ease of analysis and measurement in water. Concentration of chlorophyll-a is indirectly strongly dependent on nutrient concentrations in the sea (Fleming-Lehtinen et al. 2008, Łysiak-Pastuszak et al. 2009), and therefore strongly related to anthropogenic pressure in the form of charges of these substances coming from land and atmosphere (HELCOM 2009). The indicator shows the direction of changes consistent with the increase in eutrophication. Phytoplankton is the primary oceanic/marine biomass producer. Phytoplankton growth depends on the availability of factors needed for photosynthesis (light and carbon dioxide) and inorganic compounds, mainly nitrogen and phosphorus salts. As a result of the over-fertilization with these compounds of water reservoirs (eutrophication), there is usually an increase in phytoplankton biomass. In the Baltic Sea, the external load of nutrients is further increased by the internal inflow of phosphorus from bottom sediments in the areas covered by the oxygen deficit. The increase in the biomass of phytoplankton, as a result of sedimentation, ultimately leads to an increase in the oxygen deficit in the bottom waters - so-called vicious circle of eutrophication. Changes in biotic and abiotic elements, e.g. climate change or changes in the structure of organisms feeding on phytoplankton, also affect the resources of this ecological element.

**A method of assessing the state of pelagic habitats**

The assessment of pelagic habitats is carried out on the principle of integration of indicators. The method of integration between the indicators used to assess pelagic habitats is the weighted average including the weights assigned to them. Indicators supplementing assessment of pelagic habitats (including eutrophication indicators) and having a lower status are characterized by lower weight than other indicators. Integration between indicators should be carried out within one assessment area and one general type of habitat: pelagic open waters or pelagic transitional and coastal waters. Under the conditions prevailing in POM, this means that a separate assessment should be performed for a pelagic open water habitat using four indicators: MSTS, Dia/Dino, Chl (VI-IX) and CyaBI in the Gdańsk Basin or three indicators: Dia/Dino, Chl a (VI-IX) and CyaBI in the Eastern Basin and the Bornholm Basin and separately for the pelagic habitat in transitional and coastal waters only taking into account the 'Chlorophyll-a' indicator.

The structure of the integrated assessment and the indicators used and their weights in POM for pelagic habitats is presented in Table 2.1.70.

To integrate at least two indicators in the assessment area, normalized values of indicators should be used. In order to obtain the value of the indicator in the range from 0 to 1, normalization should be carried out taking into account the minimum and maximum values of a given indicator, and taking into account the BQR limit equal to 0.6.

The standardization method for the MSTS indicator in the Gdańsk Basin has been developed based on the method used in the 2nd holistic assessment (IT tool BEAT 3.0) (HELCOM 2017a) and presented in Table 2.1.72, which uses the minimum and maximum values for the zooplankton size structure (MS ) and total zooplankton biomass (TS) given in Table 2.1.71. and threshold values determined for the Gdańsk Basin (Table 2.1.65.).

Table 2.1.70. Structure of the integrated assessment of pelagic habitats at POM as part of the multi-annual assessment 2011-2016

| Assessment area | | Indicator used in the national 'integrated assessment of biodiversity' | Indicator status | Indicator weight | Integration between normalized indicators | Multi annual assessment |
|---|---|---|---|---|---|---|
| Broad habitat type according to Decision 2017/848 | POM sub-basin | | | | | |
| pelagic open waters | Gdańsk Basin | MSTS | core 'biodiversity' | 0.3 | weighted average | result based on the BQR (Biological Quality Ratio) classification) |
| | | Dia/Dino | pre-core 'biodiversity' | 0.3 | | |
| | | Chl a (VI-IX) | core 'eutrophication' | 0.3 | | |
| | | CyaBI | pre -core 'eutrophication' | 0.1 | | |
| | Eastern Gotland Basin | Dia/Dino | pre-core 'biodiversity' | 0.4 | weighted average | result based on the BQR (Biological Quality Ratio) classification |
| | | Chl a (VI-IX) | core 'eutrophication' | 0.4 | | |
| | | CyaBI | pre -core 'eutrophication' | 0.2 | | |
| | Bornholm Basin | Dia/Dino | pre-core 'biodiversity' | 0.4 | weighted average | result based on the BQR (Biological Quality Ratio) classification |
| | | Chl a (VI-IX) | core 'eutrophication' | 0.4 | | |
| | | CyaBI | pre -core 'eutrophication' | 0.2 | | |
| pelagic transitional and coastal waters | 15 waterbodies (JCWP) with the exception of lagoons | Chl a (VI-IX) | national 'eutrophication' | 1 | weighted average | the result based on the classification of this indicator in the area of assessment |
| | 4 waterbodies: the Vistula Lagoon, Puck Bay, Kamieński Lagoon, Szczecin Lagoon | Chl a (annual average) | national 'eutrophication' | | | |

For further integration with the remaining indicators in the Gdańsk Basin (Dia/Dino, Chl a and CyaBI), only one of the two MSTS values should be taken into account: standardized MS or standardized TS on the principle of choosing the lower value.

Table 2.1.71. The minimum and maximum values for the components of the MSTS indicator necessary to carry out normalization of the indicator

| value | MS - size structure of zooplankton | TS - total biomass of zooplankton |
|---|---|---|
| min. | 7.4 | 25.7 |
| max. | 17.8 | 1041.6 |

Table 2.1.72. The MSTS standard normalization method in the Gdańsk Basin

| Calculated MS (MSobs) and calculated TS (TSobs) | Normalization |
|---|---|
| if MSobs < threshold value for MS | 0.6 * (MSobs – 7.4)/(10.2 – 7.4) |
| if MSobs > threshold value for MS | 0.6 + 0.4 * (MSobs – 10.2)/(17.8 – 10.2) |
| if TSobs < threshold value for TS | 0.6 * (TSobs – 25.7)/(103 – 25.7) |
| if TSobs > threshold value for TS | 0.6 + 0.4 * (TSobs – 102.8)/(1041.6 – 103) |

Dia/Dino and CyaBI ratios, whose values range from 0 to 1, should be converted to include the limit value for BQR equal to 0.6 (Table 2.1.74.).

Table 2.1.73. Standardization method for the Dia / Dino or CyaBI index

| Value of the indicator Dia/Dino or CyaBI | Normalization |
|---|---|
| if Dia/Dino/ CyaBI (2011-2016) < threshold value | 0.6*(Dia/Dino/ CyaBI – min. value)/( threshold value a – min. value.) |
| if Dia/Dino/ CyaBI (2011-2016) > threshold value | 0.6+0.4*(Dia/Dino/ CyaBI – threshold value)/( max. value – threshold value) |

The Chlorophyll-a index calculated for open waters: the Bornholm Basin, Gdańsk Basin and Eastern Gotland Basin should be normalized for integration with other indicators. 'Chlorophyll-a' is primarily an indicator of eutrophication and changes with the increase in environmental degradation differently than MSTS or Dia/Dino ratios, i.e. its value increases, so it was not possible to apply the solution identical to those for the above indicators. For this reason, the method of normalization of data in the range of 0-1 (feature scaling), commonly used in statistics, was adopted, introducing a 0.6 conversion factor taking into account the limit value for BQR. This method was also adopted due to the fact that the detailed methodology for normalizing the indicator in the BEAT 3.0 tool has not been sufficiently explained or made available on the HELCOM forum, as work is still underway, among others over agreeing the rules for the selection of scaling values - maximum and minimum for individual rating basins.

The calculations were made using the equation:

Chl-a (norm) = 0,6*(Obs-min)/(max-min)
where:

- Chl-a (norm) – indicator normalized in the range 0-1 including the limit value 0.6;
- Obs - mean concentration of chlorophyll-a in months (June-September) in 2011-2016 calculated as an average of data for individual stations;
- min - minimum concentration calculated as the average of the minimum concentrations for individual stations during the assessment period (2011-2016);
- max - maximum concentration calculated as the average of the maximum concentrations for individual stations during the assessment period (2011-2016).

If at least two indicators were used to assess the state in a given area of assessment, BQR (Biological Quality Ratio) was calculated for them and integration was carried out, the result of the integrated assessment should be classified as follows (Table 2.1.74.):

Table 2.1.74. Classification of the pelagic habitat assessment result - BQR as part of the "integrated assessment of biodiversity"

| BQR limit value | BQR result | Status of "integrated assessment of biodiversity" - pelagic habitats |
|---|---|---|
| ≥ 0.6 | 0.6 – 1.0 | good – GES |
| < 0.6 | 0 – 0.59 | below good – subGES |

If the assessment of the status of a given area is carried out only with one indicator, the result of the assessment is classified on the basis of the threshold value of this indicator between the state of GES - good and subGES status - below good. In POM, this applies only to the 'Chlorophyll-a' indicator in transitional and coastal waters (Table 2.1.75.).

Table 2.1.75. Classification of the assessment of the pelagic habitat condition in transitional and coastal waters based on the "Chlorophyll-a" indicator

| Waterbody | The value of the indicator Chl a | assessment status |
|---|---|---|
| Szczeciński and Kamieński Lagoon | ≤ 20.0 | good – GES |
| | > 20 | below good – subGES |
| Vistula lagoon | ≤ 23.20 | good – GES |
| | > 23.20 | below good – subGES |
| Puck Lagoon | ≤ 2.00 | good – GES |
| | > 2.00 | below good – subGES |
| Outer Puck Bay, Inner Gulf of Gdańsk | ≤ 3.76 | good – GES |
| | > 3.76 | below good – subGES |
| Dziwna Mouth | ≤ 3.8 | good – GES |
| | > 3.8 | below good – subGES |
| Wisła Przekop mouth | ≤ 5.5 | good – GES |
| | > 5.5 | below good – subGES |
| Świna Mouth | ≤ 7.5 | good – GES |
| | > 7.5 | below good – subGES |
| Hel Peninsula, Władysławowo harbour, Sarbinowo - Dziwna, Rowy - Jarosławiec Zachód, Rowy - Jarosławiec Wschód, Jastrzębia Góra - Rowy, Władysławowo - Jastrzębia Góra, Jarosławiec - Sarbinowo | ≤ 1.9 | good – GES |
| | > 1.9 | below good – subGES |
| Vistula Spit, Dziwna - Świna | ≤ 3.15 | good – GES |
| | > 3.15 | below good – subGES |

**Assessment of pelagic habitats for the years 2011-2016**

For the purpose of the national assessment of the marine environment in the field of pelagic habitats, partial assessments of indicators: MSTS, 'diatoms – dinoflagellates' and 'Chlorophyll-a' were used based on national data from the State Environmental Monitoring (PMŚ), collected at zooplankton and phytoplankton monitoring stations chlorophyll-a (Fig. 2.1.86) with the exception of 'the index of cyanobacteria blooms', to which the data calculated as part of the second holistic assessment - HOLAS II (HELCOM 2017a) were used.

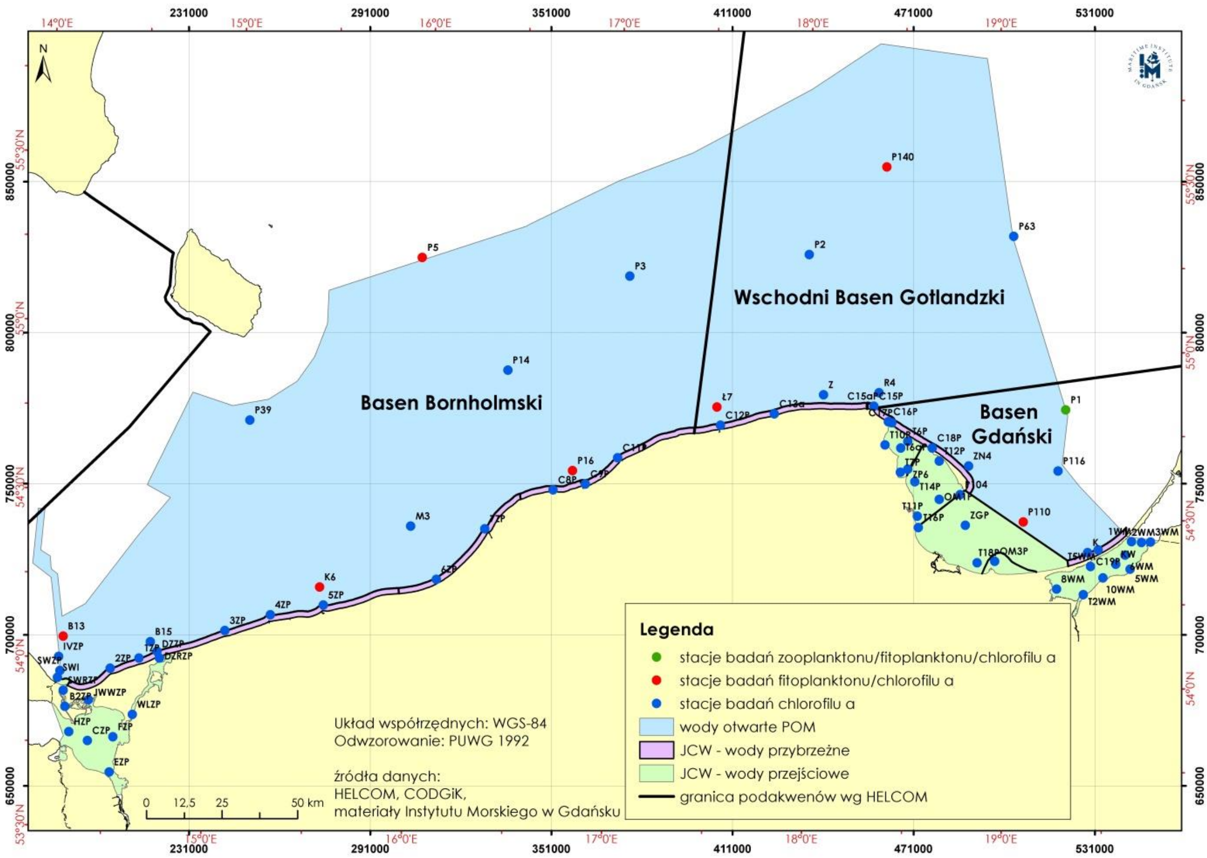



Fig. 2.1.86. Location of the zooplankton, phytoplankton and chlorophyll-a research station in the PMŚ, providing data for assessing the pelagic habitats in POM

**'Zooplankton mean size and total stock (MSTS)' indicator assessment**

The national assessment based on the MSTS indicator, taking into account the PMŚ data regarding zooplankton collected during the assessment period (2011-2016), was performed only for the Gdańsk Basin (Table 2.1.76.) for which threshold values were set in the POM.

Table 2.1.76. The station from which the necessary data on zooplankton was obtained, used to carry out the status assessment in POM using the MSTS indicator for the period 2011-2016

| assessment area | Station | Type of monitoring |
|---|---|---|
| Gdańsk Basin | P1 | HELCOM COMBINE |

The status of pelagic habitat in the Gdańsk Basin in 2011-2016, determined on the basis of the MSTS indicator, was considered good - GES (Table 2.1.77). According to the assessment methodology using the MSTS indicator, if both components (MS and TS) or one of them are lower than the threshold values the resultant MSTS assessment indicates a sub-good state - subGES. Such a situation took place only in 2011 and 2013, when the component of the indicator - the zooplankton size structure (MS) reached a value lower than the threshold value (10.2). On this basis, it can be stated that the structure of zooplankton in the Gdańsk Basin was dominated in those two years by organisms of small size, which are not the optimal food base for planktivorous fish (Arrhenius and Hansson 1993, Cardinale and others 2002, Möllmann et al. 2003). As indicated by the assessment of the second component of the MSTS index - the total biomass of zooplankton (TS), it was above the good state (103) in all years of the assessment period (Table 2.1.77).

The current assessment of the condition of pelagic habitats on the basis of zooplankton using the MSTS indicator was performed in POM for the first time, so it is not possible to refer to the initial assessment (GIOŚ 2014).

Table 2.1.77. Assessment of the pelagic habitat status based on the value of the MSTS indicator for the period 2011-2016 in the Gdańsk Basin (GES, subGES)

| Assessment unit | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Period 2011-2016 |
|---|---|---|---|---|---|---|---|
| | values of the MSTS indicator components: MS - size structure [μg indiv.$^{-1}$]/TS - total biomass [mg m$^{-3}$] | | | | | | |
| Gdańsk Basin | 9.7/243 | 15.5/158 | 9.3/285 | 15.8/182 | 16.1/156 | 17.8/395 | 14/236 |

***Assessment based on the 'Diatom/Dinoflagellate ratio'***

To calculate the 'Diatom/Dinoflagellate ratio', the data obtained during the monitoring research from 2011-2016 were used, from the database of the State Environmental Monitoring (PMŚ) from the Bornholm Basin, the Gdańsk Basin and the Eastern Gotland Basin. The national assessment for these assessment areas was calculated on the basis of data from 8 research stations (Table 2.1.78.). Phytoplankton samples from the assessment period were collected and analyzed microscopically according to the HELCOM methodology (2016), and the abundance and biomass calculations made in accordance with the recommendation by Edler (1979) and Olenina et al. (2006).

Table 2.1.78. Stations from which data on phytoplankton were obtained, used to carry out the environmental assessment in POM using the Dia/Dino indicator for the period 2011-2016

| Assessment area | Station | Type of monitoring |
|---|---|---|
| Bornholm Basin | B13, K6, P16, P5 | HELCOM COMBINE |
| Gdańsk Basin | P1, P110 | HELCOM COMBINE |
| Eastern Gotland Basin | Ł7, P140 | HELCOM COMBINE |

In order to obtain reliable results for calculating the 'Diatom/Dinoflagellate' ratio for 2011-2016, it has been checked beforehand whether the given PMŚ data from this period meet the assumptions necessary to carry out the assessment (biomass of diatom or dinoflagellate must be higher than threshold value of 1000 μg l$^{-1}$ in at least one sample in the season), (Kownacka 2016, Wasmund et al. 2017.) The maximum values for the wet weight of diatoms and dinoflagellate in 2011-2016 are presented below (Table 2.1.79.).

Table 2.1.79. List of maximum values of wet biomass of diatoms and dinoflagellates [μg1$^{-1}$ ] in 2011-2016 in 3 assessment areas in POM

| Division | Year | Gdańsk Basin | Eastern Gotland Basin | Bornholm Basin |
|---|---|---|---|---|
| diatoms | **2011** | 1718.23 | 3182.244 | 5396.63 |
| | **2012** | 555.85 | 772.67 | 1106.86 |
| | **2013** | 5305.62 | 10229.11 | 5455.96 |
| | **2014** | 1210.73 | 3376.97 | 1878.49 |
| | **2015** | 600.95 | 209.37 | 957.65 |
| | **2016** | 159.76 | 123.66 | 179.35 |
| dinoflagellates | **2011** | 10.89 | 16.69 | 7.11 |
| | **2012** | 86.22 | 1.96 | 69.52 |
| | **2013** | 213.95 | 278.12 | 175.75 |
| | **2014** | 2663.67 | 168.19 | 884.84 |
| | **2015** | 38.54 | 36.29 | 33.39 |
| | **2016** | 511.67 | 470.93 | 319.55 |

The values of the 'Diatom-Dinoflagellate' ratio in 2011-2016 are presented in Table 2.1.80. The analysis of data from 2011-2016 in three sub-basins examined showed that in 2015 and 2016 no bloom was found during the sampling, as both the diatoms and dinoflagellates biomass did not exceed the limit of 1000 [µg1$^{-1}$] in any of the samples in the given season. Similarly, in 2012, in the Gdańsk Basin and the Eastern Gotland Basin, no spring blooms were observed (Table 2.1.79). These years were not taken into account when calculating the Dia/Dino ratio for the years 2011-2016. The average values of the Dia/Dino index in the period 2011-2016, excluding three years that did not meet the assumptions, amounted 0.75 for the Gdańsk Basin, Gotland Basin - 0.97 and Bornholm Basin - 0.91, which indicates good environmental status - GES (Table 2.1.80.). Only in 2014 in the Gdańsk Basin the value of Dia/Dino was below the threshold value (0.6) (Table 2.1.65.) which indicates a poor condition of the environment this year.

Table 2.1.80. Assessment of the state of pelagic habitat based on the value of the 'Diatom-Dinoflagellate' ratio for the period 2011-2016 in three assessment areas in POM (GES, subGES)

| Assessment area | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Period 2011-2016 |
|---|---|---|---|---|---|---|---|
| | The value of the "Diatom-Dinoflagellate" ratio | | | | | | |
| Bornholm Basin | 1 | 0.96 | 0.97 | 0.77 | * | * | 0.93 |
| Eastern Gotland Basin | 0.99 | * | 0.97 | 0.95 | * | * | 0.97 |
| Gdańsk Basin | 0.99 | * | 0.94 | 0.31 | * | * | 0.75 |

* years excluded from the total assessment of the pelagic habitats in the period 2011-2016 due to the assumption of exceeding the wet weight of diatoms or dinoflagellates above 1000 µg l $^{-1}$/lack of bloom

The current assessment of pelagic habitats based on phytoplankton using the 'diatom-dinoflagellate' ratio was performed in POM for the first time, so it cannot be referred to the initial assessment (GIOŚ 2014). In the Bornholm Basin, the highest wet biomass of both algae divisions was 9842 µg l$^{-1}$ in 2011. In this area, diatoms have been the predominant in wet biomass. In Eastern Gotland Basin, the maximum value of wet biomass of diatoms and dinoflagellates was recorded in 2013 (11278 µg l$^{-1}$). In each year with algae bloom, diatoms dominated in wet biomass which is confirmed by the result of the Dia/Dino ratio. In Gdańsk Basin in 2014, when the result of the indicator indicated subGES, the diatom biomass amounted to 928 µg l$^{-1}$, and the dinoflagellate biomass up to 2050 µg l$^{-1}$ (Table 2.1.79.). Good environmental status means that phytoplankton blooms occur with frequency and intensity consistent with the physical and chemical conditions specific for a given type of water, or there may be a slight increase in their frequency and intensity (according to WFD). The development of phytoplankton is also subject to very strong influences of meteorological conditions (GIOŚ 2014).

***'Cyanobacteria bloom index' indicator assessment***

The 'Cyanobacteria bloom index' indicator (HELCOM 2017g) was adopted in the national assessment in POM from the second holistic assessment (HELCOM 2017a), in which it was applied on the principle of testing, therefore the results of the assessment can be considered ambiguous. For the biomass parameter of the CyaBI index, the data from Estonia, Finland, Lithuania, Latvia, Germany, Poland and Sweden were used. These data were analyzed by experts from the HELCOM PEG group before being used as part of pelagic habitat assessment. The assessment of the 'Cyanobacteria bloom index' in POM was implemented in the first version of the integrated assessment of eutrofication report of HELCOM HOLAS II, covering the period 2011-2015 for which data were usable (HELCOM 2017i).

In the years 2011-2015, the status of the marine environment in the assessment areas assessed in the POM: Bornholm Basin, Eastern Gotland Basin and the Gdańsk Basin on the basis of the 'Cyanobacteria bloom index' did not exceed the established threshold values, indicating the status below good - subGES (Table 2.1.81.).

Table 2.1.81. Assessment of the state of pelagic habitat based on the value of the indicator of 'Cyanobacteria bloom index' for the period 2011-2015 in 3 assessment areas in POM (GES, subGES)

| Assessment area | Threshold value GES | CyaBI index values in 2011-2015 |
|---|---|---|
| Bornholm Basin | 0.87 | 0.80 |
| Eastern Gotland Basin | 0.84 | 0.76 |
| Gdańsk Basin | 0.98 | 0.83 |

The current assessment of pelagic habitats using the 'Cyanobacteria bloom index' was performed in POM for the first time, so it is not possible to refer to the initial assessment (GIOŚ 2014).

***Assessment based on the 'Chlorophyll-a' indicator***

The national assessment based on the 'Chlorophyll-a' indicator, taking into account the PMŚ data collected during the assessment period (2011-2016), was performed for all (22) assessment areas in POM, covering both open and transitional and coastal waters (Table 2.1.82.).

Table 2.1.82. Stations from which the necessary data on chlorophyll-a obtained in the assessment of the environmental status in POM using the 'Chlorophyll-a' indicator for the period 2011-2016 were obtained

| Assessment area | Station | Type of monitoring |
|---|---|---|
| Bornholm Basin | B13, B15, K6, P16, P5, P39, P3, P14, M3 | HELCOM COMBINE |
| Gdańsk Basin | P1, P110, P116, K, ZN4 | HELCOM COMBINE |
| Eastern Gotland Basin | Ł7, Z, R4, P2, P63, P140 | HELCOM COMBINE |
| Kamieński Lagoon | WL , DZR | WFD |
| Szczecin Lagoon | C, E, F, H, JWW, B2, SWR | WFD |
| Vistula Lagoon | 1, 2, 3, 5, 6, 8, 10, T2, T5, KW | WFD with the exception of st. KW - HELCOM COMBINE |
| Puck Lagoon | ZP6, T6a, T7, T10, T6 | WFD with the exception of st. ZP6 - HELCOM COMBINE |
| Outer Puck Bay | OM1, T11, T12, T14 | WFD |
| Inner Gulf of Gdańsk | P104, ZG, T16, T18 | WFD with the exception of st. P104 - HELCOM COMBINE |
| Dziwna Mouth | DZ | WFD |
| Wisła Przekop Mouth | OM3 | WFD |
| Świna Mouth | SWI, SW, IV | WFD |
| Hel Peninsula | C17, C18 | WFD |
| Vistula Spit | C19 | WFD |
| Władysławowo Port | C16 | WFD |
| Sarbinowo-Dziwna | 3ZP, 4ZP, 5ZP | WFD |
| Rowy-Jarosławiec West | C8 | WFD |
| Rowy-Jarosławiec East | C9, C11 | WFD |
| Jastrzębia Góra-Rowy | C12, C13a | WFD |
| Władysławowo-Jastrzębia Góra | C15, C15a | WFD |
| Dziwna-Świna | 1ZP, 2ZP | WFD |
| Jarosławiec-Sarbinowo | 6ZP,7ZP | WFD |

In the current assessment cycle (2011-2016), the status of the marine environment of virtually all assessed areas within POM did not meet the conditions of good environmental status with respect to the chlorophyll-a concentration during the summer or during the year in the case of the Vistula Lagoon, Szczecin Lagoon and Kamieński Lagoon. The only exception is the part of transitional waters - Outer Puck Bay, where the threshold value was achieved and the good state was determined - GES (Table 2.1.83.).

A detailed assessment of the marine environment in POM in terms of chlorophyll-a concentration has been presented in Descriptor 5 - eutrophication assessment (assessment - Descriptor D5 - Eutrophication).

Table 2.1.83. Assessment of the status of pelagic habitat based on the Chlorophyll-a value for the period 2011-2016 in the 22 assessment areas in POM (GES, subGES)

| Assessment area | Threshold value | The value of the 'Chlorophyll-a' [ µg dm-3] indicator for the years 2011-2016 |
|---|---|---|
| Gdańsk Basin | 2.2 | 4.09 |
| Eastern Gotland Basin | 1.9 | 2.76 |
| Bornholm Basin | 1.8 | 3.14 |
| Kamieński Lagoon | 20.00 | 28.11 |
| Szczecin Lagoon | 20.00 | 31.87 |
| Vistula Lagoon | 23.20 | 57.28 |
| Puck Lagoon | 2.00 | 6.67 |
| Outer Puck Bay | 3.76 | 3.67 |
| Inner Gulf of Gdańsk | 3.76 | 4.25 |
| Dziwna Mouth | 3.80 | 10.32 |
| Wisła Przekop mouth | 5.50 | 10.73 |
| Świna Mouth | 7.50 | 11.09 |
| Hel Peninsula | 3.15 | 6.85 |
| Vistula Spit | 1.90 | 3.11 |
| Władysławowo Port | 1.90 | 6.85 |
| Władysławowo-Jastrzębia Góra | 1.90 | 4.58 |
| Jastrzębia Góra-Rowy | 1.90 | 5.86 |
| Rowy-Jarosławiec West | 1.90 | 4.83 |
| Rowy-Jarosławiec East | 1.90 | 5.63 |
| Jarosławiec-Sarbinowo | 1.90 | 3.57 |
| Sarbinowo-Dziwna | 1.90 | 4.17 |
| Dziwna-Świna | 3.15 | 6.63 |

Direct comparison of the results of the current assessment of the marine environment for the 2011-2016 period in open sea sub-basins (Bornholm Basin, Eastern Gotland Basin, Gdańsk Basin) in terms of chlorophyll-a content with the results of the previous assessment cycle (GIOŚ 2014) is impossible, as different methods were applied. In the previous assessment, the classification of the state of the environment was carried out in a system of 5 quality classes, referring the current value of the indicator to the national reference value (Łysiak-Pastuszak et al. 2009), whereby good environmental status was also determined on the basis of national threshold values (Bornholm Basin – $TR_{PL}$ = 1.80 µg $dm^{-3}$, Eastern Gotland Basin – $TR_{PL}$ = 1.54 µg $dm^{-3}$, Gdańsk Basin – $TR_{PL}$ = 2.64 µg $dm^{-3}$). On the other hand, in the current assessment, the status was referred to the threshold values agreed for individual assessment areas (Table 2.1.1) based on the results of the HELCOM TARGREV project (HELCOM 2013e) as part of the HELCOM international cooperation, accepted by HELCOM Heads of Delegation in 2012. Irrespective of the more or less restrictive threshold values applied, negative results were obtained in both assessment cycles. The open sea areas located within the POM (Bornholm Basin, Eastern Gotland Basin, Gdańsk Basin) in the period 2011-2016 still show a sub-good status (subGES) in relation to the chlorophyll-a content in summer.

In relation to transitional and coastal waters, the assessment of the 'Chlorophyll-a' indicator cannot be compared with the previous assessment cycle (GIOŚ 2014), because these areas were then assessed in the areas 38 and 62 - aggregated assessment units of the WFD, which included coastal waters of the sub-basins of the Baltic Proper and the Bornholm Basin.

**Integrated assessment of pelagic habitats**

The state of pelagic habitats in POM as part of the multi-annual assessment 2011-2016 is broken down into 2 different types of habitats, according to the assessment method and Decision 2017/848:

1. assessment of the pelagic habitat of open waters in 3 assessment areas in POM, in which an integrated assessment was used between the following indicators: MSTS, Dia/Dino, CyaBI and Chlorophyll-a (Gdańsk Basin) and integrated assessment between indicators: Dia/Dino, CyaBI and Chlorophyll-a (Eastern Gotland Basin and Bornholm Basin) (Table 2.1.85.), followed by the classification of the assessment result - BQR as part of the 'integrated assessment of biodiversity' (Table 2.1.74.). In Table 2.1.84 standardization of the 'Chlorophyll-a' index was carried out, while the integrated assessment of pelagic habitat status is presented in Table 2.1.85.

Table 2.1.84. Data summary for the 'Chlorophyll-a' indicator from the open sea basins used for its standardization

| Assessment area | Obs (average from 2011-2016) | Threshold value [μg dm$^{-3}$] | Min | Assessment area | Obs (average from 2011-2016) | Threshold value [μg dm$^{-3}$] |
|---|---|---|---|---|---|---|
| Bornholm Basin | 3.14 | 1.80 | 2.21 | 4.09 | 0.297 | 1.75 |
| Gdańsk Basin | 4.09 | 2.20 | 2.74 | 5.91 | 0.256 | 1.86 |
| Eastern Gotland Basin | 2.76 | 1.90 | 1.76 | 3.74 | 0.304 | 1.46 |

The obtained BQR values for the 'Chlorophyll-a' indicator are consistent with the values of eutrophication coefficients (ER), the lowest ER, indicating the state closest to good environmental status, corresponds to the highest BQR (the closest to the BQR limit = 0.6) - the state of the environment characterized in Eastern Gotland Basin. The highest ER value corresponds to the lowest BQR value - both describing the state furthest from the good environmental status threshold value in the Gdańsk Basin.

Table 2.1.85. Integrated assessment of the state of pelagic habitats including the following indicators: MSTS, Dia / Dino, CyaBI, and Chl-a in the period 2011-2016

| Assessment area | Indicator | The normalized value of the indicator for the years 2011-2016 | Indicator weight | BQR | Assessment |
|---|---|---|---|---|---|
| Gdańsk Basin | MSTS | 0.66 | 0.3 | 0.55 | subGES |
| | Dia/Dino | 0.75 | 0.3 | | |
| | CyaBI | 0.50 | 0.1 | | |
| | Chl-a | 0.26 | 0.3 | | |
| Eastern Gotland Basin | Dia/Dino | 0.97 | 0.4 | 0.62 | GES |
| | CyaBI | 0.54 | 0.2 | | |
| | Chl-a | 0.30 | 0.4 | | |
| Bornholm Basin | Dia/Dino | 0.93 | 0.4 | 0.60 | GES |
| | CyaBI | 0.55 | 0.2 | | |

| | | | | | |
|---|---|---|---|---|---|
| | Chl-a | 0.30 | 0.4 | | |

Assessment of the pelagic habitat of the open sea showed that in 2011-2016 the Eastern Gotland Basin and the Bornholm Basin were in good status - GES, while the Gdańsk Basin was below the good status - subGES (Fig. 2.1.87).

2. assessment of the status of pelagic habitats in transitional and coastal waters in 19 waterbodies in POM, where the classification of the assessment result was applied in line with the threshold values for the 'Chlorophyll-a' indicator (Table 2.1.75.).

Almost all waterbodies (18) in transitional and coastal waters presented the status below good - subGES with the exception of Outer Puck Bay, where good environmental status was achieved (Fig. 2.1.87).

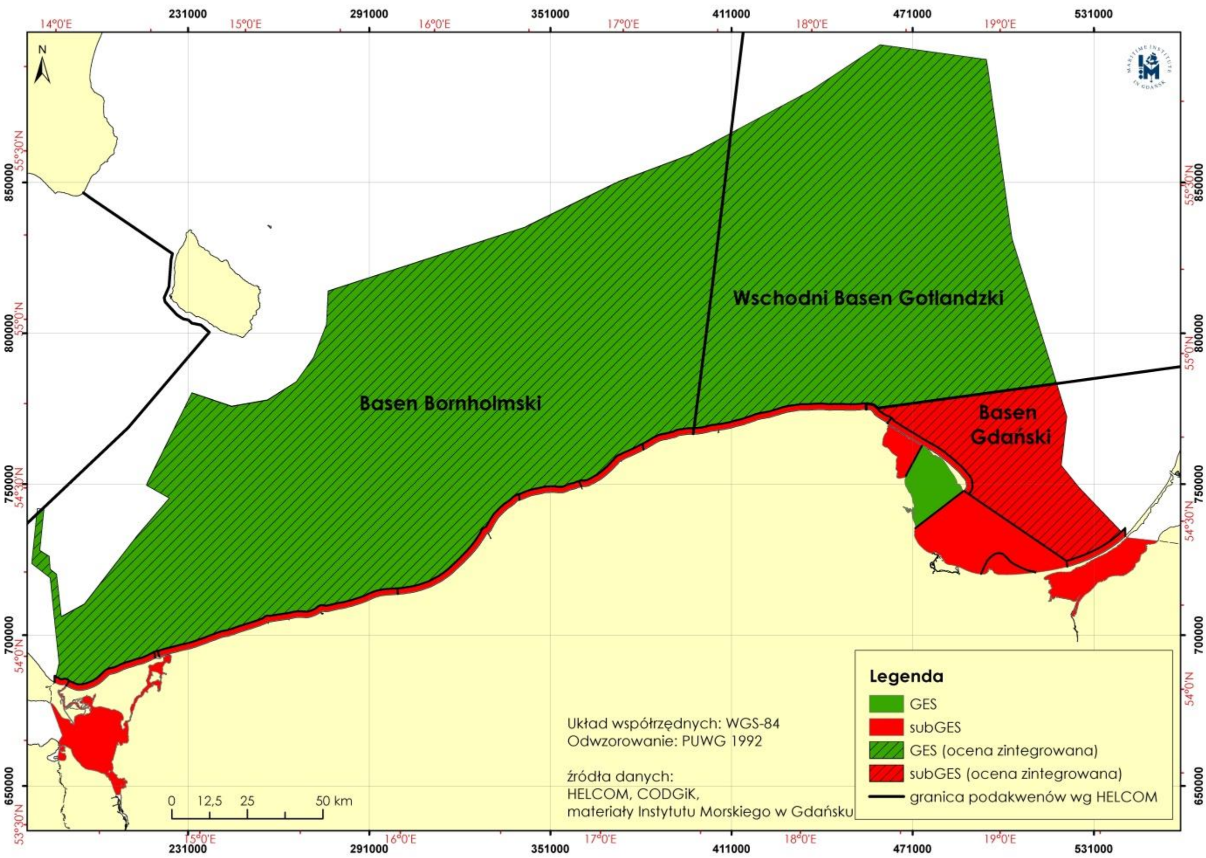



Fig. 2.1.87. Integrated assessment of the state of pelagic habitat for 2011-2016 period in POM (Data source: PMŚ)

Three areas of assessment in POM, including 2 open sea basins: Bornholm Basin and Eastern Gotland Basin, as well as Outer Puck Bay, constituting 87% of POM area, presented good condition - GES, while in other areas of assessment, including the Gdańsk Basin (13% area of POM) an environment below the good (subGES) was observed (Fig. 2.1.88).

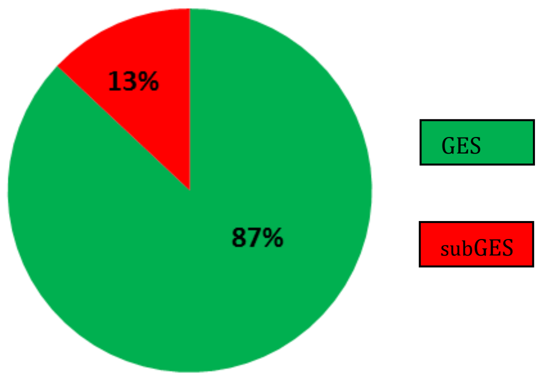



Fig. 2.1.88. Pelagic habitat showing good status - GES and below good - subGES for POM area in 2011-2016 (Data source: PMŚ)

### Confidence of assessment of pelagic habitats for the years 2011-2016

For pelagic habitats, an integrated assessment of confidence was carried out in open waters of POM based on the indicators: 'MSTS', 'Dia/Dino' and 'Chlorophyll-a' in Gdańsk Basin and on the basis of 'Dia/Dino' and 'Chlorophyll-a' indicators in the Bornholm Basin and Eastern Gotland Basin. The confidence of assessment of pelagic habitats in these basins indicates the medium status (Fig. 2.1.89). In the case of assessing the confidence of 'MSTS' and 'Dia/Dino' ratios, the method presented in Section 2.1. On the other hand, the assessment of confidence of the 'Chlorophyll-a' indicator was made on the basis of the method used in the assessment of eutrophication indices and taken from the 2nd holistic assessment of the report on the integrated assessment of eutrophication (HELCOM 2017i). The confidence of assessment of pelagic habitats does not take into account the CyaBI index, because in the 2nd holistic assessment, the status of its confidence has not been determined (HELCOM 2017i).

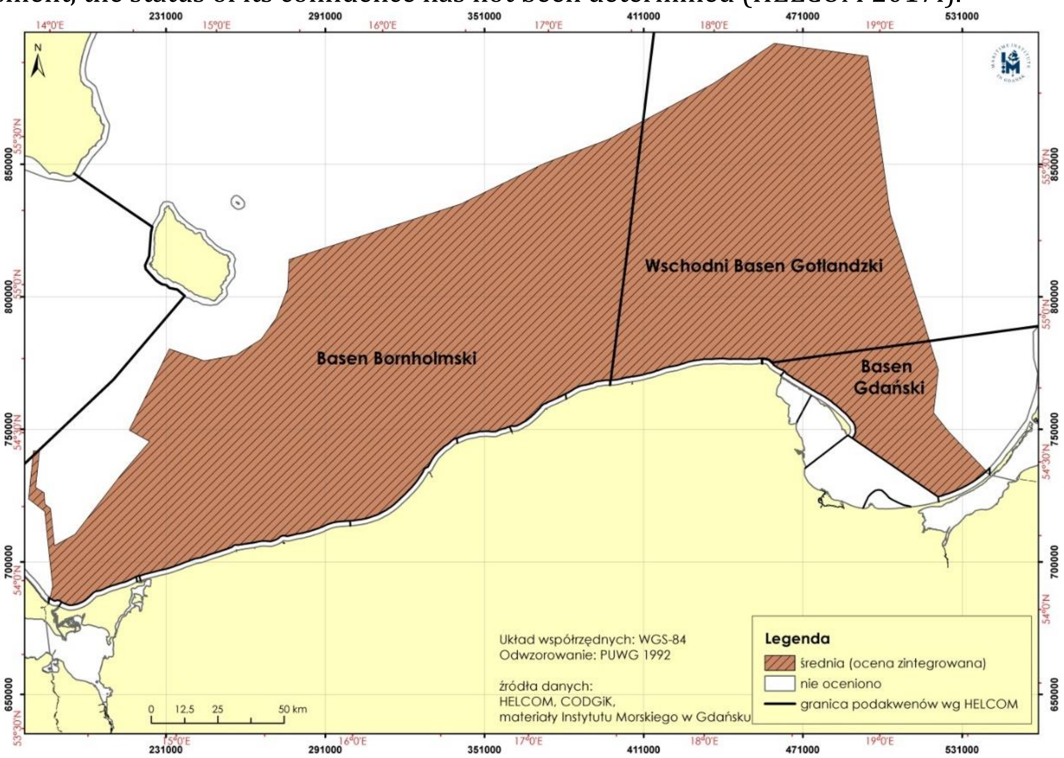



Fig. 2.1.89. Confidence status of the integrated assessment of pelagic habitat status for 2011-2016 in POM

***Ecosystems and food webs***

Descriptor D4 - food webs (Anon 2017b) in the context of the guide to art. 8 MSFD (Walmsley and others 2017) should indicate maintaining the natural abundance, diversity and full reproductive capacity of species as elements of marine food webs. The structure and functioning of ecosystems can be characterized by the so-called trophic guilds (ICES 2014). The trophic groups contain predators and their victims. For example, a trophic group includes phytoplankton, zooplankton, planktivorous fish or phytoplankton, filtering benthic invertebrate organisms and demersal fish feeding on benthos. According to the guide (Walmsley et al 2017), the indicators agreed at the regional level should be used to assess ecosystems and food webs.

Indicators describing the condition of the Baltic ecosystem on lower trophic levels are important because they can explain the causes of large-scale changes. At the same time, their significance cannot be overestimated from the point of view of environmental management, because they can give the opportunity to detect significant changes at a very early stage. For example, the core indicator 'Zooplankton mean size and total stock' - MSTS (for which the threshold values for the Bornholm Basin and the Eastern Gotland Basin within POM limits are not defined and accepted at the HELCOM forum) functions as an indicator of food webs by monitoring changes in both numbers and in the size structure of primary consumers.

Most of the core indicators used in the 'integrated assessment of biodiversity' by HELCOM (HELCOM 2017a) characterize changes in the abundance of species or species groups or their biomass , which gives the opportunity to assess potential impacts in food webs, because species remain in mutual food dependencies and relationships. Predatory species depend on the production of victims that allow their populations to be maintained. From the so-called top-down perspective, also the shortage of predators can lead to excessive numbers of victims and destabilization of the structure of the food web and its functioning. Species from the top trophic levels can be good indicators of changes occurring in food webs, because they are not only subjected to the direct impact of pressure, but also cumulate the impacts from the whole food web through food.

In addition to changes in the size or biomass of species, changes in the size structure of individuals are an equally important signal of the state of biodiversity and can have a strong impact on the productivity of food webs and their stability

As part of the national assessment, an attempt was made to characterize selected food chains in three sub-regions of the Polish Baltic zone in a manner of descriptive assessment of the state of the ecosystem. For this purpose, three trophic guilds were selected, for which appropriate indicators were assigned to assess the D4 trait in individual open sea sub-basins in POM (Table 2.1.86.).

According to the recommendation of the guide to art. 8 MSFD (Walmsley et al. 2017) it is preferred to present the assessment for individual ecosystem elements as components in selected trophic guilds (A, B, C) (Table 2.1.86.) without the need to integrate jointly at the descriptor level. At the same time, the criteria from Decision 2017/848 under Descriptor D4 and the indicators assigned to them should be used as a tool to identify changes in the food web.

Table 2.1.86. The trophic guilds and indicators together with their assessment status for the years 2011-2016, selected for the assessment of the Descriptor D4 in POM

| Trophic groups | Elements of the ecosystem | Indicator | Bornholm Basin | Eastern Gotland Basin | Gdańsk Basin |
|---|---|---|---|---|---|
| Trophic group A | Phytoplankton (primary producers) | Dia/Dino | GES | GES | GES |
| | Macrozoobenthos | B | subGES | subGES | subGES |
| | Demersal fish | LFI | subGES | subGES | subGES |

| Trophic groups | Elements of the ecosystem | Indicator | Bornholm Basin | Eastern Gotland Basin | Gdańsk Basin |
|---|---|---|---|---|---|
| Trophic group B | Phytoplankton (primary producers) | Dia/Dino | GES | GES | GES |
| | Macrozoobenthos | B | subGES | subGES | subGES |
| | Birds benthic feeding | breeding birds | subGES | subGES | - |
| | | wintering birds | GES | GES | - |
| Trophic group C | Phytoplankton (primary producers) | Dia/Dino | GES | GES | GES |
| | Zooplankton (secondary producers) | MSTS | - | - | GES |
| | planktivorous fish | - | - | - | - |
| | grey seals | Population size and trend of abundance | subGES | | |
| | | Occurrence | | | |
| | | Reproductive status | | | |

The above assumptions for the assessment of the food web in POM are not fully met. Although the assessed elements of the ecosystem within particular trophic guilds remain in the mutual food dependencies and connections, it is not possible to draw conclusions about the energy flow through the indicated food chains. First, a set of indicators that could characterize all levels of the trophic pyramid in POM is insufficient, e.g. no indicator to assess the status of planktivorous fish. In addition, the results of assessments at individual levels in the trophic pyramid depend more on other factors and anthropogenic pressures than on factors affecting primarily the productivity at individual food web levels.

In each of the presented trophic guilds to present primary producers - the basis of the trophic pyramid, the only indicator developed by HELCOM, used in the national assessment, is the 'diatom-dinoflagellate' ratio, which is based on estimating the ratio of diatom biomass to dinoflagellate biomass during spring bloom. Both phytoplankton groups are an important food source for higher trophic levels, so shifts in the proportions of both groups may influence the nutritional status of zooplankton and lead to gradual changes at other levels of the Baltic food web. Despite the fact that in 2011-2016 this ratio indicated good environmental status in POM, it is characterized by the structure of the phytoplankton community only to a limited extent and does not provide sufficient information on the amount of organic matter available for the next level of the pyramid, i.e. macrozoobenthos.

It should be noted that the development and functioning of organisms at the lowest trophic levels depends on current meteorological conditions, which is reflected by significant fluctuations in their abundance and biomass from year to year, e.g. in 2011-2016, prolonged periods of cold spring were recorded (Łysiak- Pastuszak 2012, Łysiak-Pastuszak and others 2016, Krzymiński 2017), which promoted the development of diatoms.

In the case of zooplankton, the assessment of the state based on the MSTS indicator may indicate the energy flow from primary producers (phytoplankton) to higher trophic levels (planktivorous fish). The MSTS index consists of two components - one is characterized by the individual size of zooplankton in the assessment period, and the other describes the total biomass of zooplankton. The first one indicates whether zooplankton during the assessment period was the optimal food base for planktivorous fish - the dominance of individuals with relatively large body sizes. The second one informs about whether the zooplankton resources were sufficient to reduce the resources of phytoplankton. The MSTS indicator indicated good condition in the Gdańsk Basin during the national assessment period, but already on the decrease in the share of zooplankton species and species groups of large sizes in all areas of the Baltic Sea, where they did not reach the threshold values (in the Aland Sea, North Baltic Proper and in the Gulf of Finland) (HELCOM 2017a). It should also be noted that measurements of parameters relating to various indicators are carried out at different time resolutions, so it is impossible to directly interpret the flow of energy from a lower to a higher level.

The level of macrozoobenthos has been characterized by the multi-metric B index. On the one hand, this index in its algorithm takes into account the taxonomic diversity and number of individual taxa and qualitative information on the ecological sensitivity and tolerance of individual taxa, on the other hand the use of B index in the context of its applicability to the chain assessment is limited due to the specific selection of parameters used in its algorithm. These parameters determine the state of the zoobenthos complex in the context of assessing its welfare - an optimal qualitative and quantitative structure. B index disregards the key elements of zoobenthos functioning as an element of the food chain, i.e. the biomass of organisms and their structure broken down by diet (filtrators, organisms collecting organic matter from the surface of the sediment, infaunal organisms, etc.). The inadequate state of the benthic community during the POM assessment period is also due to the fact that in the Polish Baltic Sea area in the open sub-basins the deeps are also monitored (Bornholm Deep and Gdańsk Deep and south-east edge of the Gotland Deep), where the macroscopic life on the bottom is poor in terms of taxonomy and quantity, and since the 1990s there are virtually permanent conditions of oxygen deficit or anoxia (HELCOM 2017a) and poor condition of zoobenthos communities in these areas has a decisive influence on the assessment.

The LFI index, whose value depends on the share in biomass of selected species of demersal, predatory, commercially exploited fish species, reaching a length above 30 cm, illustrates the ichthyofauna state and thus indirectly the state of the food web. During the assessment period in POM, it indicated the subGES status. The value of the LFI index is influenced by the increased biomass of fish, including cod. However, taking into account the fact that the index depends on commercially exploited species, such as cod, whose exploitation depends on the fisheries sector and its regulations, its value depends primarily on this factor, and not on natural processes, indicating direct dependence on the entire food chain assessed in this study (B). The problem is also the lack of proper valorisation of the index for the entire Baltic Sea area, where the individual values of selected fish species depend on zonal salinity changes.

The recently observed decline in the nutritional status of some Baltic fish is an important symptom of the impact on a larger scale, and not just a reflection of changes at the species level. The condition and size structure of Eastern Baltic cod stock has significantly deteriorated in recent years, indicating potential changes that have occurred at other levels in the ecosystem. Similar changes were observed in the case of pelagic fish in the 1990s, and currently these fish are characterized by lower abundance and biomass than those recorded in previous decades (HELCOM 2017a).

Various possible explanations for these negative changes are considered, ranging from overfishing, the presence of contaminants and parasitic infections, to many other likely pressures. Of a particular concern is the increasing coverage and distribution of areas with oxygen deficit at the bottom of the Baltic Sea, the causes of which should be sought in both anthropogenic impacts - accumulation of biogenic substances as well as in hydrodynamic and climatic changes. This leads to changes in the pelagic and benthic productivity. Long-term measurement series indicate that the oxygen debt below the halocline, caused mainly by the increase in eutrophication, increased in the last century in the Baltic Sea area. However, the causes of the main pressures are not only anthropogenic impacts, but also climate changes that are predicted to affect species directly (including temperature increase or changes in other hydrological conditions may directly determine the increase in the population size of species and their spread) and indirectly through interactions between species on changes in food availability.

The changes are also noticeable at the highest level of the trophic pyramid among the assessed groups of species, e.g. the core indicator of the nutritional status of the grey seal did not reach the threshold for a good state in the entire Baltic area (HELCOM 2017a).

On the other hand, in the national assessment, grey seals were assessed on the basis of three indicators, neither of which alone allows to determine the condition of the food chain leading to this top predator, and hence, cannot provide a basis for assessing the food web in POM. This is due to the special situation of the population of this species in POM - the initial stage of recolonization of the site in the Vistula Mouth is characterized by a rapid increase in the population size based primarily on the migration of animals from other waters of the Baltic Sea. Thus, despite the fact that the ‘Number and abundance’ index reached the level of GES, along with the lack of breeding at the level guaranteeing stable growth (or even keeping the population at a constant level - the ‘State of reproduction’ indicator as subGES) and the lack of assessment of the ‘nutritional status’ indicator, which could be the most important element in the assessment of the food chain, it is practically impossible to interpret the C guild on the basis of the final result of the species assessment. Drawing conclusions solely on the basis of the assessment of the status of grey seal population taking into account the dependence of population from POM on migration of individuals from other Baltic Sea areas and the lack of assessment of planktivorous fish, would be subjected to significant error.

## 2.3.Pressure Descriptors

### *Descriptor D2 – Non-indigenous species*

Non-indigenous species are organisms whose presence is not related to the natural spread of their range, and is caused by intentional or accidental introduction into the environment as a result of human activity.

The most probable vector for introduction of alien species into the Baltic Sea is aquaculture and sea transport (First version of the State of the Baltic Sea report - June 2017). Alien species are introduced with ship's ballast waters and sediments or grow on hulls and other structural elements of ships. Many alien species have reached the Baltic Sea, spreading with ships that used, among others, canals connecting sea basins, e.g. Black, Caspian.

Invasive alien species pose a threat not only to biodiversity, which may lead to significant changes in the structure and functioning of invaded ecosystems. They can also negatively affect human health, creating the risk of disease and even epidemics and negatively affect the economy, incl. cause losses in fishing and aquaculture, cause fouling of submerged structures (e.g. water intakes) or blocking shipping channels.

The areas particularly exposed to the introduction are ports and marinas where, ships whose ballast water can be contaminated with various types of plant and animal organisms, as well as pathogens imported from all parts of the world arrive. Therefore, more effective control of the paths of the unintentional introduction of alien species is of primary importance in the first place, including conducting regular monitoring of ecosystems particularly exposed to the introduction of alien species in order to ensure the possibility of registering newly appearing non-native species in POM[3]. The methodology recommended by HELCOM[4] [5] for conducting research on alien species in seaports is indicated in "Joint HELCOM/OSPAR Guidelines on the Control and Management of Ships' Ballast Water and Sediments, Regulation A-4", also the "Guidelines for non-indigenous species monitoring by Extended Rapid Assessment Survey (eRAS)".

To this day, the procedures were used in the POM only to carry out research on alien species at the Sea Port of Gdynia as part of the Baltic Sea Pilot Project BALSAM "Testing methods for monitoring alien species in the Port of Gdynia". Port monitoring in terms of occurrence of alien species was only considered as an optional measure in the Marine Water Monitoring Program, adopted on the basis of art. 155c para. 7 of the Act of 18 July 2001 - Water Law (Journal of Laws of 2017, item 1566). Currently, the only possibility is to make an assessment based on information collected as part of the State Environmental Monitoring when monitoring individual types of natural habitats, as well as research carried out by state institutions (e.g. University of Gdańsk).

The assessment of Descriptor D2 was carried out based on Decision 2017/848 and the proposed indicators together with Directive 2017/845. A set of primary and secondary criteria together with indicators assigned for their assessment are presented in Table 2.3.1.

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[3] From the justification to the application for the ratification by Poland of The International Convention for the Control and Management of Ships' Ballast Water and Sediments

[4] http://www.helcom.fi/baltic-sea-trends/indicators/trends-in-arrival-of-new-non-indigenous-species/monitoring-requirements/

[5] http://www.helcom.fi/baltic-sea-trends/indicators/trends-in-arrival-of-new-non-indigenous-species/

**Indicators used**

As there is no information on the impact of non-indigenous species on native species and habitats in Polish waters hence the assessment of Descriptor D2 was based only on two criteria – primary criterion D2C1 and secondary criterion D2C2, both of the criteria are used in the assessment of HELCOM core indicator – *'Trends in arrival of new non-indigenous species'* (HELCOM, 2017v). The indicator consists of 3 parameters :

1. Introduction of new non-indigenous species
2. Inventory-Parameter (IP)
3. Spreading of non-native species

The main parameter used for the assessment of the above mentioned indicator is 'Introduction of new non-indigenous species' caused by human activity in the assessment area within the assessment period (2011-2016). However in order to provide regional integrity and comparability of the HELCOM (Baltic Sea) and OSPAR (Atlantic) areas assessments there were 2 additional parameters used: Inventory-Parameter (IP) and Spreading of non-native species in the assessment units. The assessment is performed on level 2 of HELCOM subdivision of Baltic Sea, for 17 sub-basins what in Polish waters of Baltic Sea means assessment in 3 sub-basins:

- Bornholm Basin
- Eastern Gotland Basin
- Gdańsk Basin

and separately for Vistula and Szczecin lagoons.

As a reference period an initial assessment results were used 2005-2010 and present assessment covers 2011-2016 period.

Table 2.3.1. A set of criteria in accordance with Decision 2017/848 relating to the assessment of Descriptor D2

| Descriptor | Primary criterion | Secondary criterion | Description of the criterion in accordance with the decision 2017/848 | Indicator: core (P), pre-core (W), national (K), biodiversity (B), eutrophication (E) |
|---|---|---|---|---|
| D2 - Non-indigenous species | D2C1 | | The number of non-indigenous species which are newly introduced via human activity into the wild, per assessment period (6 years), measured from the reference year as reported for the initial assessment under Article 8(1) of Directive 2008/56/EC, is minimised and where possible reduced to zero.). | Trends in arrival of new non-indigenous species (P) Parameter: Introduction of new non-indigenous species |
| | | D2C2 | Abundance and spatial distribution of established non-indigenous species, particularly of invasive species, contributing significantly to adverse effects on particular species groups or broad habitat types | Trends in arrival of new non-indigenous species (P) Inventory-Parameter (IP) |

| Descriptor | Primary criterion | Secondary criterion | Description of the criterion in accordance with the decision 2017/848 | Indicator: core (P), pre-core (W), national (K), biodiversity (B), eutrophication (E) |
|---|---|---|---|---|
| | | D2C3 | Proportion of the species group or spatial extent of the broad habitat type which is adversely altered due to non-indigenous species, particularly invasive non-indigenous species. | |

***Parameters used in the indicator assessment:***

**Introduction of new non-indigenous species**

This is the primary parameter determining how many new alien species were recorded in the assessment units in relation to human activities.

In the data from the PMŚ, in 2011-2016, the appearance of one new alien species in the area of the Vistula Lagoon was found (in 2012-2013). It was a bivalve species *Rangia cuneata*, which was first noted in this region in 2011 (Warzocha and Drgas, 2013). In addition, as part of the work carried out, the literature was reviewed to identify the introduction of new alien species in POM. The main basis for the assessment of the indicator were research works carried out by employees of the University of Gdańsk in the area of the port of Gdynia and the estuary of the Vistula River (Table 2.3.2). All newly observed non-indigenous species belonged to representatives of macrozoobenthos. A complete list of new non-indigenous species is presented in Table 2.3.2. Although it is not possible to clearly determine the way of introduction of new species, it was decided to include them all in the current assessment.

Table 2.3.2. List of new introductions of non-indigenous species in 2011-2016.

| No. | Taxon | The first observation in Poland | Place of Observation | Literature / Source | The probable way of introduction |
|---|---|---|---|---|---|
| macrozoobenthos | | | | | |
| 1 | *Palemon macrodactyluls* | 2014 | yacht port on Vistula Śmiała | Janas i Tutak, 2014 | sea transport in ships, possible natural spread, channels from the North Sea |
| 2 | *Rangia cuneata* | 2011 | Vistula Lagoon | Warzocha i Drgas, 2013 | the species has probably spread from the Russian part of the lagoon |
| 3 | *Rangia cuneata* | 2014 | Vistula Śmiała | Janas i in., 2014 | spreading from the area of the Vistula Lagoon |
| 4 | *Melita nitida* | 2014 | Port in Gdynia | Normant-Saremba i in. 2017 | maritime transport in ships |
| 5 | *Dreissena rostriformis* | 2011 | Szczecin Lagoon | Woźniczka i in. 2016 | maritime transport in ships, possible |

| No. | Taxon | The first observation in Poland | Place of Observation | Literature / Source | The probable way of introduction |
|---|---|---|---|---|---|
| macrozoobenthos | | | | | |
| | *bugensis* | | | | natural spread by waterway from the North Sea |
| 6 | *Limnodrilus profundicola* | 2013 | Port in Gdynia | Marszewska i in, 2017 | possible natural spreading from the waters of the western Baltic |

In 2011-2016, five newly introduced alien species were recorded in the Polish Baltic Sea zone, of which the *Rangia cuneata* species was earlier (2010) recorded in the Russian part of the Vistula Lagoon. The vast majority of listed introductions took place in the Gulf of Gdańsk region, which was related to the research carried out as part of Gdynia port monitoring in 2013 and 2014. Although the introductions in the lagoon regions probably had a natural way of spread of the species from places of previous introduction (Szczecin - from the German part of the lagoon, Vistula - from the Russian part of the lagoon), and the parameter used includes only species whose appearance in the assessment unit is related to direct human activity, it was decided to include the introductions in these areas in the final assessment of the indicator.

*GES threshold*

The threshold value for the parameter is **lack of new introductions of non-indigenous species during the assessment period**

*Parameter assessment*

The final parameter assessment was classified as subGES - below the good state in the assessment units in which the occurrence of these species was found. The areas in which no new introductions were found were assigned the GES value (Table 2.3.3).

Table 2.3.3. A summary of the assessments of the state of the POM environment in the HELCOM water areas for the parameter - introductions of new non-indigenous species.

| Basin | Criterion D2C1 |
|---|---|
| Gdańsk Basin | subGES |
| Polish part of the Vistula Lagoon – 35A | subGES |
| Polish part of Szczecin Lagoon – 38A | subGES |
| Bornholm Basin (Polish waters) | GES |
| Eastern Gotland Basin (Polish waters) | GES |

**Inventory parameter (IP)**

This parameter is treated as a supporting in describing the state of the environment related to the presence of alien species. Its formula is as follows:

IP = number of alien and cryptogenic species in the assessment unit (2011-2016) - number of alien and cryptogenic species in the assessment unit for the previous period (2005-2010)

This formula defines the difference between the number of non-native species recorded during the update of initial assessment and the number of non-native species recorded in the previous reporting cycle.

*GES threshold*

The parameter assesses changes in the number of alien species in the assessment unit between successive reporting periods. A good state is the situation in which the parameter **gets values smaller or equal to 0**, which is associated with an increased process of disappearance of non-native species in relation to new registrations (HELCOM, 2017s).

*Parameter assessment*

Based on the reference lists and species inventory carried out as part of the initial assessment (GIOŚ 2014) and using the list of species made as part of the current update of initial assessment (Table 1.5.9) the POM indicator values were calculated.

Table 2.3.4. Results of calculations of the IP parameter in accordance with the current division of HELCOM HOLAS II and in lagoons (Data source: PMŚ)

| Basin | 2008-2010 | 2011-2016 | IP (Criterion D2C2) |
|---|---|---|---|
| Gdańsk Basin (Polish waters) | 6 | 9 | 3 (subGES) |
| Eastern Gotland Basin (Polish waters) | 4 | 5 | 1 (subGES) |
| Bornholm Basin (Polish waters) | 5 | 6 | 1 (subGES) |
| Polish part of the Vistula Lagoon | 3 | 3 | 0 (GES) |
| Polish part of Szczecin Lagoon | 4 | 5 | 1 (subGES) |

The values of the IP parameter indicate the poor state of the environment in all waters assessed, except for the waters of the Vistula Lagoon, where the number of registered non-native species did not change, despite the *Rangia cuneata* species recorded for the first time in this area. In the case of this basin, in the period 2011-2016 no species of a Harris Mud Crab (*Rhithropanopeus harrisii*) was noted, which was recorded in the years of initial assessment. It may be related to the considerable mobility of this species, which makes it rare to notice it in monitoring samples.

**Spreading of non-indigenous species**

It is a supporting parameter that allows the assessment of the spread of alien species in the assessment units and gives information on whether the species recorded in the initial assessment increased the range of its occurrence in the assessment unit. The parameter is calculated separately for each non-indigenous species and due to the lack of a fixed method of integration of results it is not a basis for status assessment, but is calculated to provide additional information on the distribution and expansion of alien species in the assessed areas.

The parameter is calculated separately for each species using the following formula:

$$\frac{Number\ of\ monitoring\ stations\ on\ which\ the\ species\ was\ recorded\ in\ the\ assessment\ unit}{total\ number\ of\ monitoring\ stations\ in\ the\ assessment\ unit}(initial\ assessment)$$

$$-$$

$$\frac{Number\ of\ monitoring\ stations\ on\ which\ the\ species\ was\ recorded\ in\ the\ assessment\ unit}{total\ number\ of\ monitoring\ stations\ in\ the\ assessment\ unit}(current\ assessment)$$

As part of the formula used, the difference between the spread of non-indigenous species in the assessment unit between the reporting periods is determined.

A positive value of the spreading parameter indicates that a given species decreases its range, whereas a negative value indicates the occurrence of a species for the first time or in a larger number of locations, which indicates an increase in its range. Table 2.3.5 presents the values of the parameter for the spread of recorded alien species in POM for assessment units in accordance with HOLAS II and for the Vistula and Szczecin Lagoons.

Table 2.3.5. Values of the spreading of non- indigenous species parameter in POM (Data source: PMŚ)

| Species | Bornholm Basin (Polish waters) | Gdańsk Basin (Polish waters) | Eastern Gotland Basin (Polish waters) | Polish part of Szczecin Lagoon | Polish part of the Vistula Lagoon |
|---|---|---|---|---|---|
| *Balanus improvisus* | -0.203 | -0.331 | -0.161 | -0.255 | |
| *Cercopagis pengoi* | 0 | 0.333 | 0 | | |
| *Dreissena polymorpha* | | -0.071 | | -0.145 | 0.778 |
| *Marenzelleria neglecta* | -0.536 | -0.209 | -0.089 | -0.545 | 0.111 |
| *Mya arenaria* | -0.304 | -0.217 | -0.214 | -0.164 | |
| *Potamopyrgus antipodarum* | | 0.16 | | -0.173 | |
| *Prorocentrum minimum* | 0.013 | -0.143 | -0.143 | | |
| *Rhithropanopeus harrisii* | | -0.071 | | | 0.333 |
| *Acartia tonsa* | | -0.333 | | | |
| *Alexandrium ostenfeldii* | | -0.048 | | | |
| *Gammarus tigrinus* | -0.111 | | | | |

The analysis of the dissemination parameter shows that in the case of the majority of recorded species and the majority of waterbodies, an increase in the spread of alien species in POM was observed, especially in the case of the *Marenzelleria neglecta* and *Mya arenaria* species. The exception is the zooplankton species *Cercopagis pengoi*, whose range in Bornholm Basin and Eastern Gotland Basin has not changed, and in the Gdańsk Basin has decreased. The only reservoir within which there was a decrease in the size of non-native species spread was the Vistula Lagoon, where the *Marenzelleria neglecta*, *Dreissena polymorpha* species occurred on a smaller number of stations, while the *Rhithropanopeus harrisii* species was not recorded in the 2011-2016 period in this basin, however it should be noted that this species is rarely found in monitoring samples due to its mobility.

**Integrated assessment of Descriptor D2**

In the current assessment it was decided to use an approach whereby the worst state of any of the two parameters used to assess the indicator ('Introduction of new non-indigenous species', 'Inventory parameter') determines the final assessment of Descriptor D2.

Taking into account the results of the assessment carried out under the parameter Introduction of new non-indigenous species and the Inventory parameter, the state of the POM environment in the scope of Descriptor D2 was assessed as subGES in all assessment units (Fig. 2.3.1).

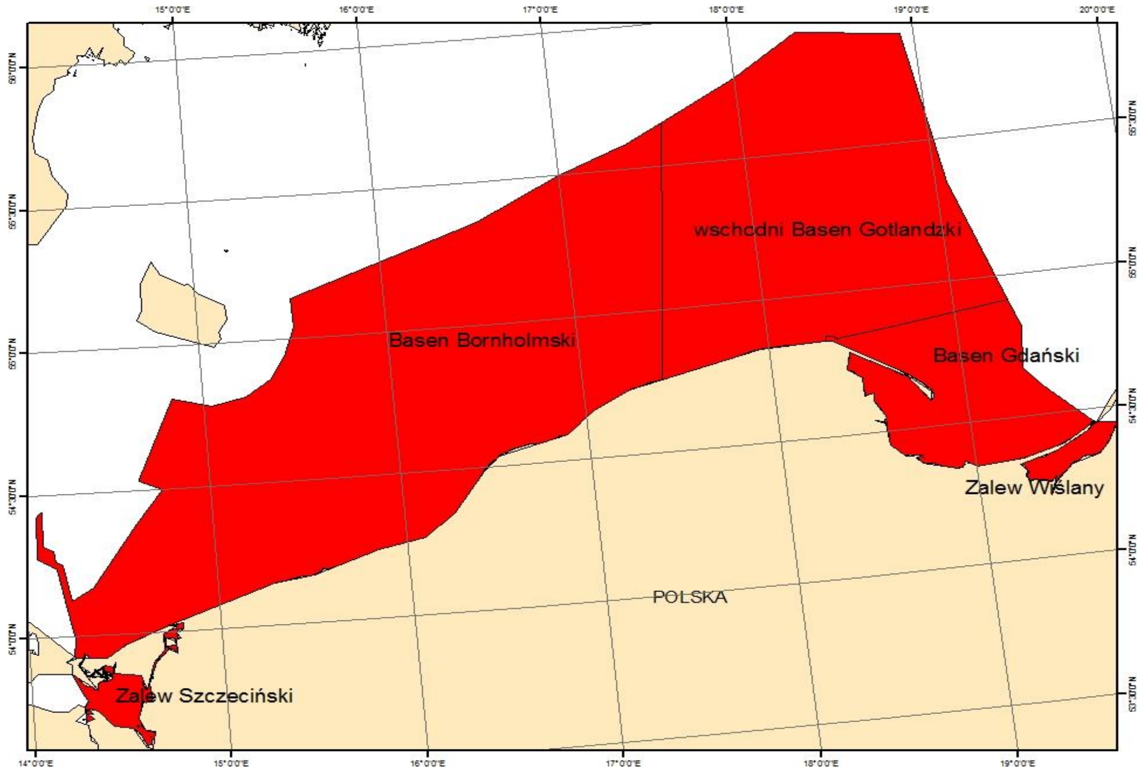



Fig. 2.3.1. Assessment of Descriptor D2 within POM. (Data source: PMŚ)

**Confidence of the assessment**

The confidence assessment was carried out in accordance with the proposed methodology in the section on the assessment of status indicators (Confidence assessment).

Due to the fact that Descriptor D2 uses a single core indicator assessed on the basis of two parameters - 'Introduction of new alien species' and 'Inventory parameter (IP)', the average confidence of the assessment of both parameters determines the final confidence and assessment of the whole descriptor. In the assessment area in the period 2011-2016, the assessment of confidence was based on 4 components: temporal confidence, spatial confidence, confidence of the classification and confidence of the methodology by assigning each of these components of a low, medium or high class and corresponding numerical values, which were then averaged, to obtain one value of the indicator's confidence (WW). Due to the lack of implementation of appropriate monitoring aimed at the registration of new introductions of alien species, the value of spatial and methodological confidence for the Bornholm Basin and Eastern Gotland Basin was reduced in the scope of the parameter 'Introduction of new alien species'. For other basins, the level of confidence of both parameters was assessed as high, due to the presence of reliable published information on the registration cases of new non-indigenous species. Information on the occurrence of alien species in these basins comes from the PMŚ or port monitoring carried out as part of the HELCOM BALSAM project. The monitoring was carried out in accordance with the HELCOM methodology. The monitoring in the port was carried out in accordance with the guidelines 'Guidelines for non-indigenous species monitoring by extended Rapid Assessment Survey (eRAS)'. In addition, publication of the fact of occurrence in a scientific article, raises confidence in the presented research results. The final values of the confidence of the assessment are presented in Table 2.3.6.

Table 2.3.6. Confidence of assessment of Descriptor D2.

| Confidence for the assessment area | Bornholm Basin (Polish waters) | Eastern Gotland Basin (Polish waters) | Gdańsk Basin (Polish waters) | Polish part of Szczecin Lagoon | Polish part of the Vistula Lagoon |
|---|---|---|---|---|---|

| Confidence for the assessment area | Bornholm Basin (Polish waters) | | Eastern Gotland Basin (Polish waters) | | Gdańsk Basin (Polish waters) | | Polish part of Szczecin Lagoon | | Polish part of the Vistula Lagoon | |
|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Introduction of new non-indigenous species | IP | Introduction of new non-indigenous species | IP | Introduction of new non-indigenous species | IP | Introduction of new non-indigenous species | IP | Introduction of new non-indigenous species | IP |
| Temporal | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Spatial | 0.25 | 1 | 0.25 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Classification confidence | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Methodological confidence | 0.5 | 1 | 0.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Averaged indicator confidence (WW) | 0.6875 | 1 | 0.6875 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Confidence assessment for the assessment area (WO) – POM, 2011-2016 | 0.84 | | 0.84 | | 1 | | 1 | | 1 | |

In case of Descriptor D2, the confidence for the assessment area (WO) is equivalent to the average confidence of the indicators (WW). In all areas of assessment, the high confidence status of the assessment according to the classification presented in Table 2.3.7.

Table 2.3.7. Classification of the result of the confidence assessment

| Average confidence value in the assessment area (WO) | Confidence status |
|---|---|
| ≥ 0.75 | high |
| 0.5 – 0.74 | medium |
| < 0.5 | low |

***Descriptor D3 - Commercially-exploited fish and shellfish***

The assessment of Descriptor D3 was carried out based on Decision 2017/848 and the proposed indicators.).

**Assessment methodology**

In the Baltic Sea area, 95% of catches consist of three species: cod, sprat and herring (HELCOM 2017), while in Polish catches in the last four years, the share of these species was about 85%. This result differs mainly due to intensive Polish catches of flounder stocks, which in the period 2011-2016 were on average around 10%. Flounder significantly dominate in flatfish catches. Fishing for European plaice and turbot together makes up about 0.1% of Polish catches. Therefore, stocks in the Polish Economic Zone consisting of four species: cod, flounder, sprat and herring were selected for the assessment on the basis of Descriptor D3.

The selection of these stocks also coincides with the latest recommendations of the International Council for the Exploration of the Sea (ICES 2016). The list of commercially exploited fish should be based on the DCF (Data Collection Framework) list of all EU Member States and contain stocks whose biomass consists at least 90% of landings of a given country. The longest data series should be selected for this purpose to include species whose catches have decreased over the years due to overfishing. In addition, each country may include stocks that are important from a local point of view (ICES 2016).

Data on fish stocks, on the basis of which the assessment of the state of the marine environment is performed, were obtained from ICES Advice documents, created by ICES Baltic Fisheries Assessment Working Group (ICES 2017a-e).

**Stocks covered by the assessment:**

**Cod stock in subdivisions 24-32**

The Eastern Baltic cod stock began to decline in the 1980s, in 2016 it amounted to less than 30,000 tonnes (Fig. 2.3.2). Since 2007, the TAC has not been fulfilled. This is due, inter alia, to the market price of cod associated with low fish quality (low weight or poor condition), reduction of the cod fleet in some countries as a result of the policy of scrapping fishing boats (ICES 2017a).

Due to numerous doubts as to the factors affecting the dynamics of the cod stock, it was decided to suspend the assessment of resources for this stock using analytical models based on the age structure. The stocks was qualified to the group of stocks for which only the biomass index and the rate of fishing pressure are determined, in 2017 the values of $F_{MSYproxy}$ and $B_{MSYproxy}$ (ICES 2017a) were calculated for the first time using the SPiCT model (stochastic surplus production model; Pedersen and Berg, 2017).

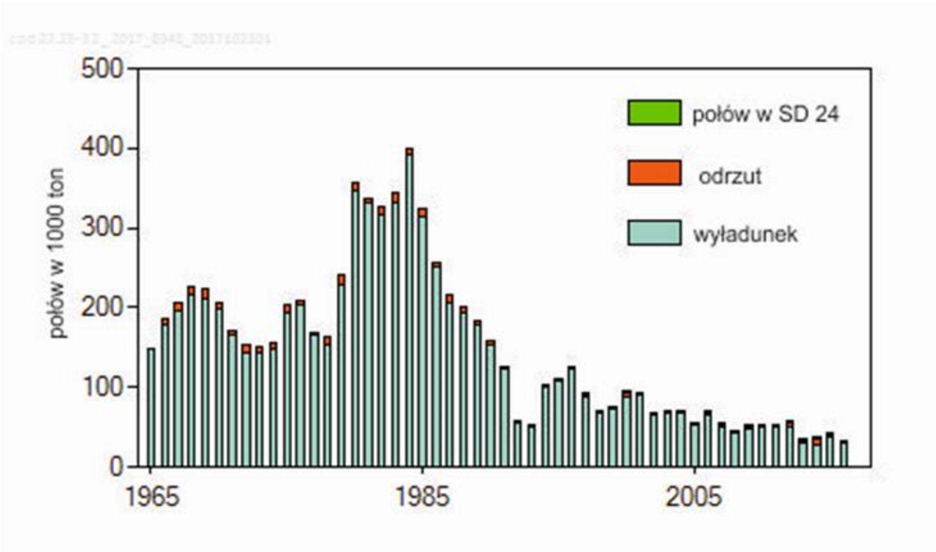



Fig. 2.3.2. Cod 24-32. Catch in thousands of tons (vertical axis), blue colour means landing, red discard, and green catch coming from subarea 24 made on Eastern Baltic cod stock (source: ICES 2017a).

### Flounder stock in subareas 26 and 28

During the WKFLABA meeting (Workshop on Flatfish in the Baltic Sea, ICES 2010), the method of reading the age used so far for flat fish was questioned due to the lack of consistency in the assessment of biomass made from year to year. The "strong" generation from the previous year was not visible in the results of biomass estimates a year later. Therefore, ICES recommended re-reading the age using the recommended methodology. Only Poland has performed a read-back to 2000 - the remaining countries have a much shorter database of "corrected" data.

Another problem that prevents the analytical assessment of flounder resources is the lack of historical discard data. Therefore, management of flounder resources is based on observing the size of the biomass index and standardized fishing effort. In addition, for flounder present in subdivisions 24-25 from 2017, FMSYproxy is determined using the LBI (Length-based indicators) method (ICES 2017b-c).

Landings of flounder stock in subdivision 24-25 have been increasing since the 1990s, thereby compensating for the economic losses associated with introducing restrictions on cod fishing. In 2014, a discard for this stock was estimated for the first time (Fig. 2.3.3; ICES 2017b).

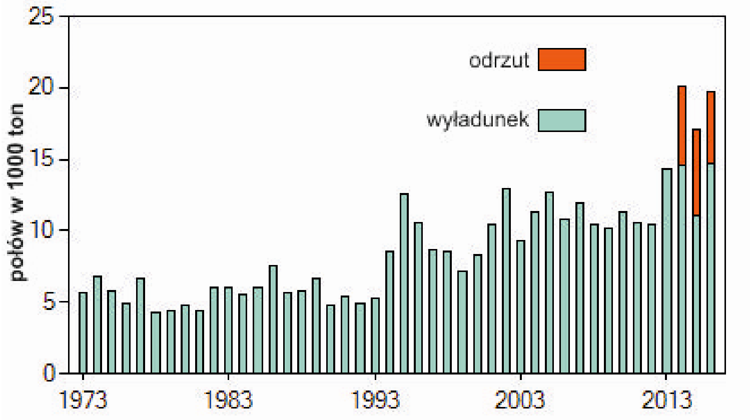



Fig. 2.3.3. Flounder 24-25. Catch in thousands of tons (vertical axis), blue colour means landing and red discard determined from 2014 (source: ICES 2017b).

### Flounder stock in subareas 26 and 28

Landings of flounder stocks in subareas 26 and 28 were at the level of 4-6 thousand tons in the last 20 years, reaching the maximum value in 2005. From 2015, the discard for this stock is estimated (Fig. 2.3.4; ICES 2017c).

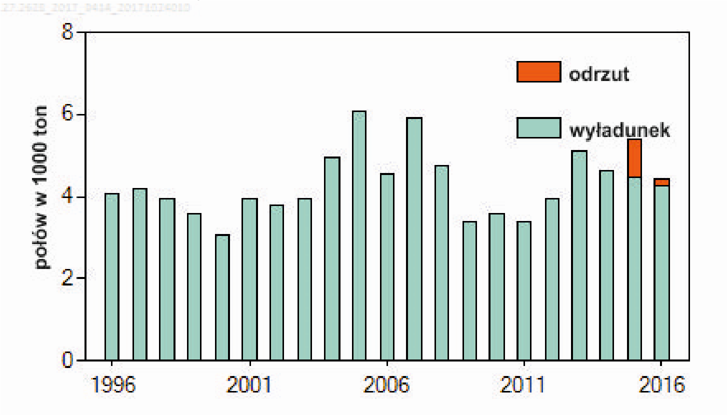
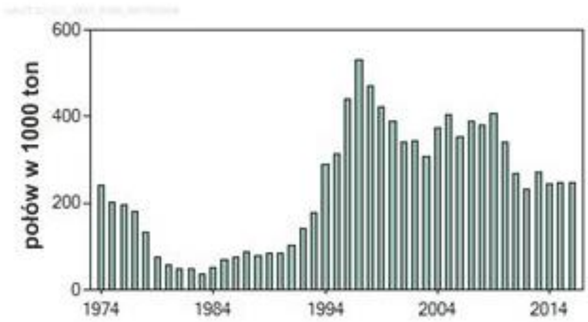



Fig. 2.3.4. Flounders 26 and 28. Catch in thousands of tons (vertical axis), blue color means landing and red discard estimated from 2015 (source: ICES 2017c).

### Sprat stock in Subdivisions 22-32

Catches of sprat increased significantly in the 1990s, from less than 100,000 tons to over 500,000 tone. In the past few years, their value has decreased, in 2016 it reached about 250,000 tone. In the 1990s, several generations of very large numbers appeared in the stock of sprat. Also in 2004, 2009 and 2015 a relatively good recruitment was observed (Fig. 2.3.5, ICES 2017d).



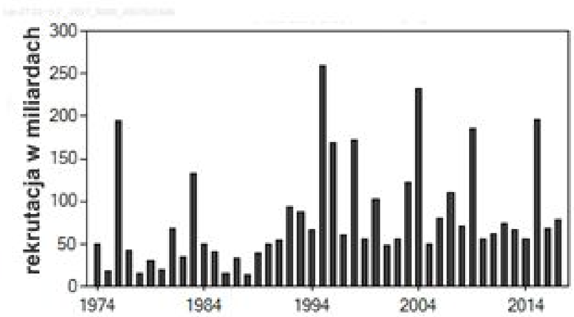




Fig. 2.3.5. Sprat 22-32. Catch in thousands of tons (vertical axis) (left graph) and recruitment in billions (vertical axis) (right graph) (ICES source 2017d).

### Herring stock in subdivisions 25-29 and 32 Ex GoR

The size of the Central Baltic herring stock catches decreased from 350,000 tons in the 1970s to around 100,000 tone. In 2016, it was almost 200,000 tones. Whereas recruitment varies from year to year, in 2014 a very strong generation appeared (Fig. 2.3.6).

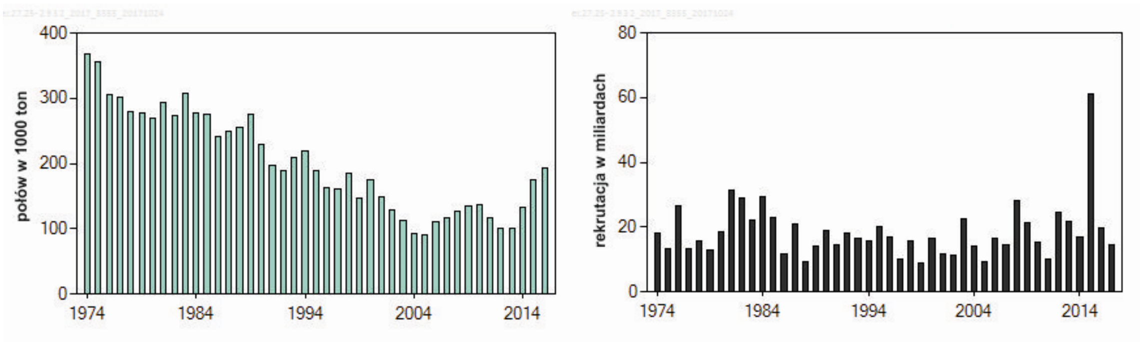



Fig. 2.3.6. Herring 25-29 and 32 Ex GoR. Catch in thousands of tons (vertical axis) (left graph) and recruitment in billions (vertical axis) (right graph) (source: ICES 2017e).

### Assessment area

According to the system adopted by the International Council for the Exploration of the Sea (ICES), the Baltic Sea area has been divided into 12 subareas (*ICES Subdivisions,* Fig. 2.3.7). Individual parts of the Baltic Sea are marked with the following numbers: SD 21 - Kattegat, SD 22 and 23 - the Danish straits, SD 24-29 - the Baltic Sea, SD 30 and 31 - The Gulf of Bothnia and SD 32 - The Gulf of Finland. The POM cover part of subareas 24, 25 and 26. The assessments of stocks made by ICES relate to the so-called management units, which constitute a certain compromise between knowledge about biology, ecology and the spread of the species or population and the availability of data constituting the basis for resource estimation. Each time the assessment is made for a specific management unit, therefore for Descriptor D3 it is not possible to assess only POM area.

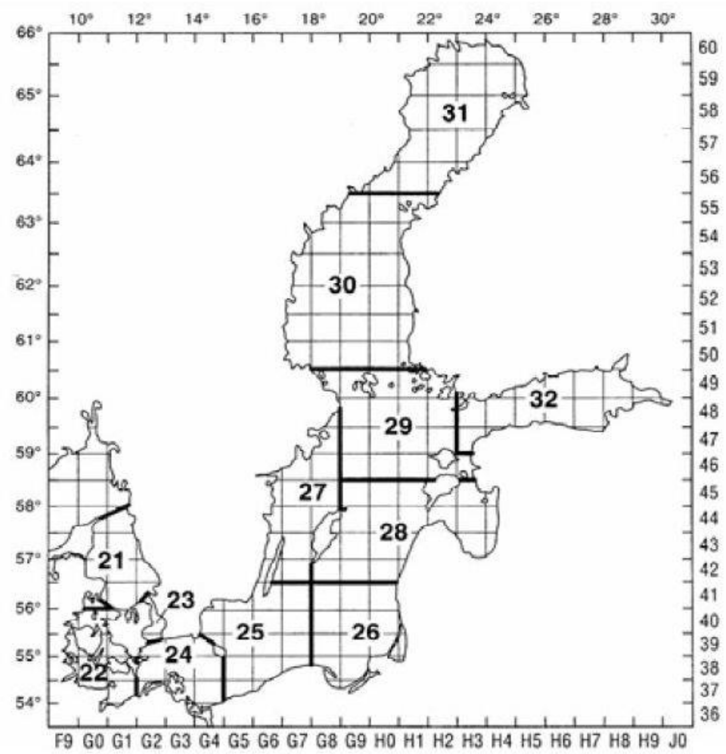



Fig. 2.3.7. Division of the Baltic Sea into subareas adopted by the International Council for the Exploration of the Sea (ICES).

Table 2.3.8. Assessment areas used in the assessment of ichthyofauna status (Descriptor D3) in POM

| No. | Assessment area name (Baltic Sea sub-basin) in POM | Area code of the assessment | Ecosystem element |
|---|---|---|---|
| 1. | sub-basin ICES 24 | SD 24 | ichthyofauna |
| 2. | sub-basin ICES 25 | SD 25 | ichthyofauna |
| 3. | sub-basin ICES 26 | SD 26 | ichthyofauna |

**Analysis of basic features and properties as well as the current state of the environment**

Three types of criteria have been determined for Descriptor D3 (Table 2.3.9):

- D3C1 – the level of fishing pressure,
- D3C2 - breeding capacity of the stock,
- D3C3 - age and length distribution of population.

Under the first criterion, the fishing mortality rate (F) is determined. If the stock does not have an analytical assessment, and hence there is no estimated value of F, then the ratio of catch to biomass indicator can be used as an alternative indicator.

The second criterion is described by the spawning stock biomass indicator (SSB). If this parameter is not determined for a specific stock, it can be replaced by the biomass indicator.

The third criterion requires further work on the methodology. According to Decision 2017/848, D3C3 may not be available for use when updating the initial assessment of the marine environment in 2018. The assessment on the basis of this criterion concerns the analysis of the stock's distribution by calculating the proportion of fish larger than the average length of fish entering for spawning for the first time, and 95th percentile from the distribution of the length observed in research fisheries, as well as analysis of the genetic effects of the exploitation of species, such as the length of fish accessing for the first time for spawning, but only when it has a scientific justification.

Table 2.3.9. Indicators used in the national assessment (2011-2016) in the "integrated assessment of Descriptor D3" in POM taking into account ichthyofauna

| Descriptor | Primary criterion | Description of the criterion in accordance with the Decision 2017/848 | Indicator:<br>core (P),<br>pre-core (W),<br>national (K),<br>biodiversity (B),<br>eutrophication (E) |
|---|---|---|---|
| D3 - Commercially-exploited fish and shellfish | D3C1 | The Fishing mortality rate of populations of commercially-exploited species is at or below levels which can produce the maximum sustainable yield (MSY) | Fishing mortality (P),<br>Catch to biomass indicator ratio(A) |

| Descriptor | Primary criterion | Description of the criterion in accordance with the Decision 2017/848 | Indicator: core (P), pre-core (W) |
|---|---|---|---|
| | D3C2 | The Spawning Stock Biomass of populations of commercially-exploited species are above biomass levels capable of producing maximum sustainable yield. | Spawning Stock Biomass (P), Biomass indicator (A) |
| | D3C3 | The age and size distribution of individuals in the populations of commercially-exploited species is indicative of a healthy population. This shall include a high proportion of old/large individuals and limited adverse effects of exploitation on genetic diversity. | Proportion of fish larger than the average length of fish entering for spawning for the first time (P), 95th percentile from the distribution of the length observed in research catches (P), Genetic effects of species exploitation, such as the length of fish spawning for the first time - when it is scientific justification (A) |

**Criterion D3C1. The level of fishing pressure**

Fishing mortality (F)

The preferred reference value for the assessment of the state of commercially-exploited fish and shellfish is fishing mortality consistent with achieving Maximum Sustainable Yield $F_{MSY}$.

$F_{MSY}$ is the level of fishing mortality ensuring that maximum sustainable yield is maintained for many subsequent years.

If the information collected on a given stock is not sufficient to determine $F_{MSY}$, it is recommended to use other fishing mortality rates:

$F_{lim}$ - limit reference point for fishing mortality. Long-term exceedance of this value reduces the abundance to the level in which the stock's reproductive capacity is reduced.

$F_{pa}$ - takes into account the potential error in the assessment of resources resulting from the quality of the data, or limited knowledge of the processes studied. For this reason, the precautionary fishing mortality value F is determined to prevent the crossing of $F_{lim}$.

$F_{max}$ - fishing mortality rate that maximizes equilibrium yield per recruit (i.e. from a fish which in a given year is included in the exploited stock for the first time, i.e. fish that can potentially be caught using a standard fishing gear), differing from $F_{MSY}$ with the lack of considering the stock-recruitment dependence.

$F_{0,1}$ - more conservative (lower) fishing mortality rate than $F_{max}$. Just like $F_{max}$, $F_{01}$ is based on the average multi-annual yield per recruit, $F_{01}$ is used when $F_{max}$ is not well defined or a more conservative F level is needed.

Catch to biomass indicator ratio

This is an alternative method, used only for the assessment of stocks that do not have set reference values for fishing mortality. For its calculation, data such as the size of the catch per unit effort (CPE) are needed. If only the information on landings is available (catch = landing + discard+ illegal, unreported or unregulated catch), it is possible to try to estimate the approximate value of the catch, provided that the data on the landings and biomass indicator are coherent e.g. in terms of the area from which they originate.

**Criterion D3C2. Reproductive capacity of the stock**

Spawning stock biomass (SSB)

The spawning stock biomass determined by $B_{MSYtrigger}$ is the preferred reference value for assessing the state of commercially-exploited fish and shellfish. This is the value determined based on the analysis of $SSB_{MSY}$ changes. $SSB_{MSY}$ is the spawning stock biomass level that ensures maximum sustainable catch. For stocks permanently fished at the $F_{MSY}$ level, $SSB_{MSY}$ is maintained in the long term. The $SSB_{MSY}$ value is not constant, but changes due to changes in environmental factors or interactions between species. $B_{MSYtrigger}$ sets the lower limit of the $SSB_{MSY}$ changing in the series of years, constituting its reference point.

The proper determination of $B_{MSYtrigger}$ requires the use of data from at least a few years, in which catches were carried out at the level of $F_{MSY}$, so as to be able to observe the range of SSB fluctuations. Unfortunately, not many flocks are fished at the MSY level, so as long as there is not enough data, $B_{pa}$ is treated as the best $B_{MSYtrigger}$ approximation, although the calculation concept for these two indicators is completely different.

The following $B_{MSYtrigger}$ alternatives for safe levels for a biomass stock are shown below:

$B_{lim}$ - spawning stock biomass limit point below which there is a high risk of reduction of the stock reproductive capacity.

$B_{pa}$ - takes into account the potential error in the assessment of resources resulting from the quality of the data, or limited knowledge of the processes studied. It complies with the precautionary principle, which assumes that due to an error of assessment, the estimated biomass value is greater than the size of the actual biomass, the $B_{pa}$ value is used as the reference point in order to prevent the crossing of the $B_{lim}$.

Biomass indicator

It is an alternative method, used for the assessment of stocks that do not have designated spawning stock biomass reference values. It refers to sexually mature fish, therefore, in order to calculate this parameter, information about the average length of fish at the time of reaching puberty is needed. If there is no such data, the total biomass index can be treated as an approximation of the spawning stock biomass indicator.

**Criterion D3C3. The age and size distribution**

The proportion of fish larger than the average length of fish entering spawning for the first time

This indicator can be calculated on the basis of biomass or abundance of research catches, however, the use of biomass is recommended, due to which greater importance is attached to older and larger fish. Due to the presentation of the presence of mature fish in the stock in the form of proportion, the value of this indicator is influenced by the number of young fish in research catch. The declining value of the indicator may suggest a bad situation, i.e. a part of the stock that is sexually mature, decreasing as a result of catches, as well as may indicate good recruitment and thus a large number of young fish in the stock.

95th percentile from the distribution of length observed in research catches.

It is used for stocks for which information on the distribution of length in the population is collected. It carries the information on the real impact of fishing pressure on the environment. The disadvantage is that the decrease in the value of this indicator may indicate a declining of part of the stock containing larger individuals as well as good recruitment, and thus a large number of young fish in the fishery.

The genetic effects of species exploitation, such as the length of fish entering for spawning for the first time.

With this indicator it is possible to observe the range of undesirable genetic effects resulting from exploitation. These effects may be visible, however, only after a few decades, while returning to the previous state may not be possible in many cases. Only indicated if there is scientific justification.

The average maximum length of species recorded on research catches

Indicator not included in Decision 2017/848. Derived from the von Bertalanffy individual growth model.

**GES assessment based on stocks**

Only sprat stocks in subareas 22-32 and herring in subdivisions 25-29 and 32 exGoR are estimated on the basis of analytical models, and thus their status can be assessed by indicators of the primary criteria 3.1 and 3.2. The remaining stocks do not have sufficient data.

***Cod stock in subdivisions 24-32***

**Criterion 3.1 (level of fishing pressure)**

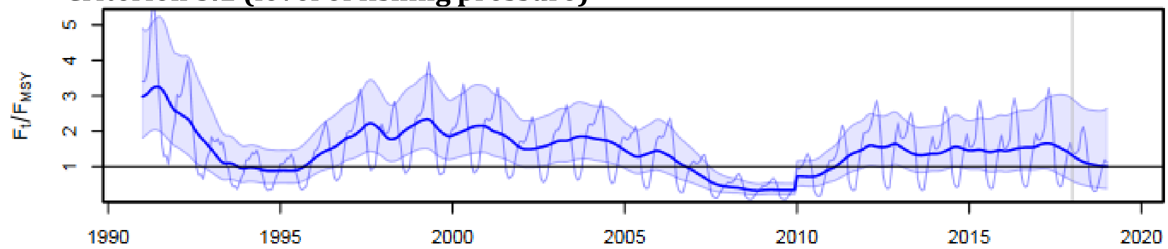



Fig. 2.3.8. Ratio of relative fishing mortality to $F_{MSYproxy}$ (source: ICES 2017 a).

The ratio of relative fishing mortality to $F_{MSYproxy}$ ($F_{MSY}$ approximation) determined on the basis of the SPiCT model is more than 1 since 2012. It means too much fishing pressure on this stock (Fig. 2.3.8; ICES 2017a).

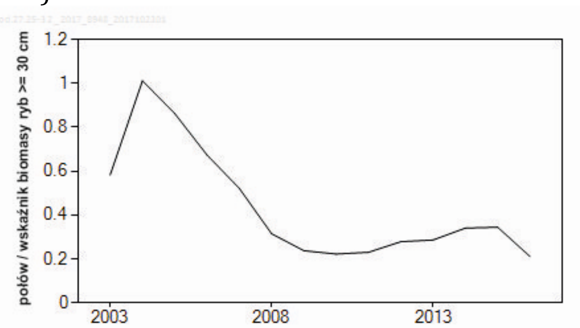



Fig. 2.3.9. Cod 24-32. Ratio of catches to the biomass indicator of fish> = 30cm (ICES source 2017a).

The ratio of the catch to the biomass index has been increasing since 2011, while in 2016 it reached the lowest value in the entire data series. This indicator gives a different signal than FMSYproxy in 2011 and 2016 (Fig. 2.3.9; ICES 2017a).

**Criterion 3.2 (stock reproductive capacity)**

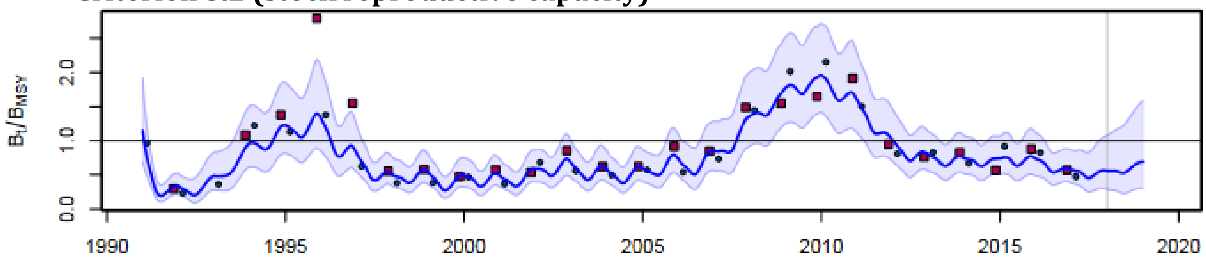



Fig. 2.3.10. Cod 24-32. Ratio of relative biomass to $B_{MSYproxy}$ (source: ICES 2017a).

The ratio of relative biomass to $B_{MSYproxy}$ ($B_{MSY}$ approximation) determined on the basis of the SPiCT model is less than 1 since 2013. This means that the stock is below the reproductive capacity to maintain MSY (Fig. 2.3.10; ICES 2017a).

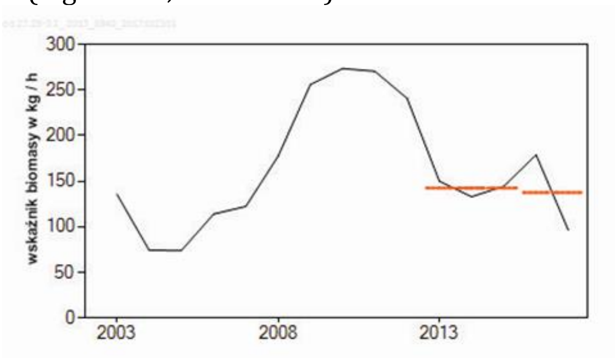



Fig. 2.3.11. Cod 24-32. Fish biomass indicator> = 30 cm (source: ICES 2017a).

The biomass indicator has been decreasing since 2011, however, from 2014 to 2015, its small increase was recorded. In 2016, the lowest level in 10 years was observed. The ratio of the last two years to three previous (used as an indicator for resource assessment in the absence of SSB) is 0.97 and therefore the catch recommended for 2018 equals the catch recommended for 2017 multiplied by 0.97. The biomass indicator gives a different signal than BMSYproxy in 2011 and 2012 and in 2015 and 2016 (Fig. 2.3.11; ICES 2017a).

### Criterion 3.3 Age and size distribution

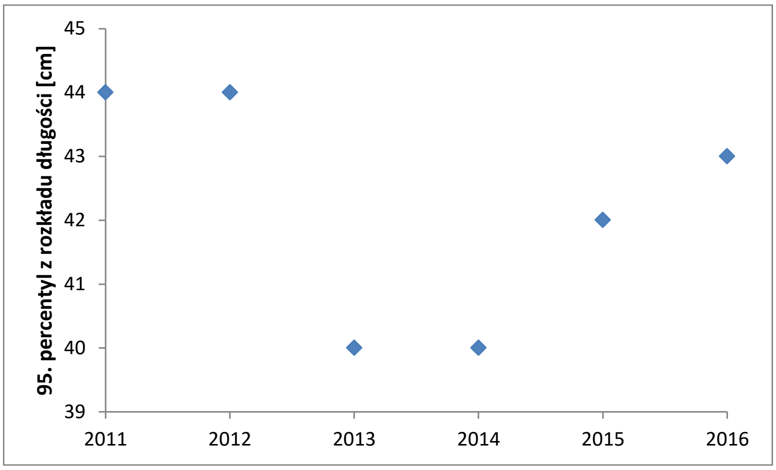



Fig. 2.3.12. Cod 24-32. 95th percentile from the distribution of length observed in research catches.

The 95th percentile of the distribution of length observed in research catches dropped from 44 cm in 2011 and 2012 to 40 cm in 2013 and 2014 (Fig. 2.3.12). Currently, this indicator is 43 cm. The increase in the ratio may be caused by a drop in the small fish index (less than 30 cm), which may suggest weak recruitment in the last three years.

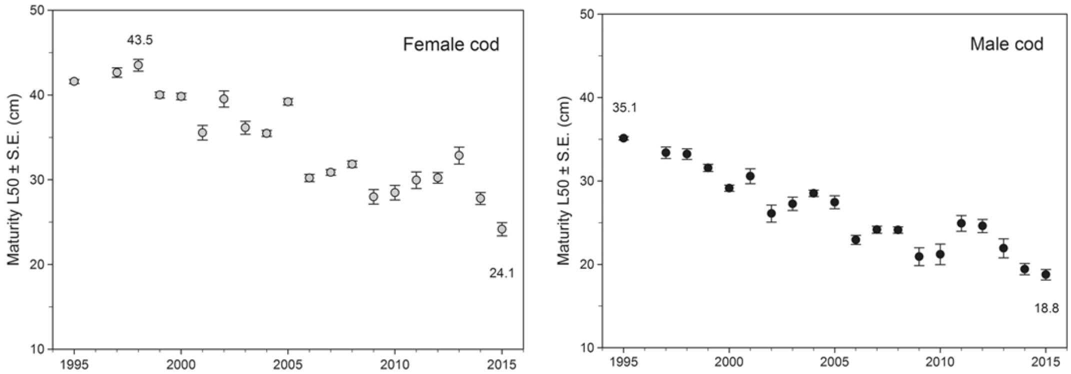



Fig. 2.3.13. Cod 24-32. The length of fish entering for spawning for the first time, for cod occurring in subarea 25 (source: Köster et al., 2016).

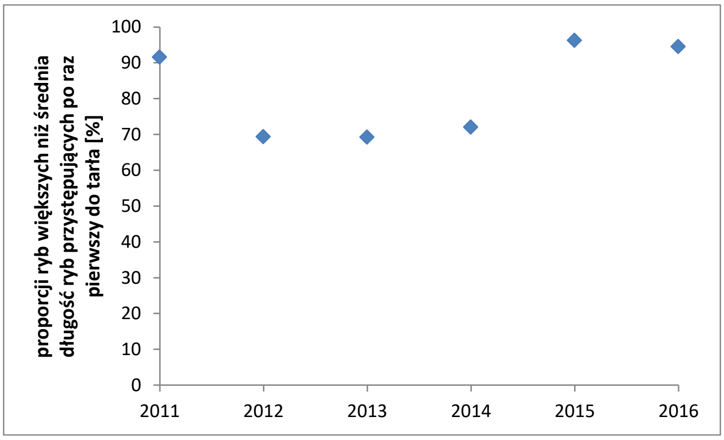



Fig. 2.3.14. Cod 24-32. The proportion of fish larger than the average length of fish entering spawning for the first time.

Due to the significantly decreasing condition of cod and its growth rate the L50 (the length of fish entering spawning for the first time) is decreasing, from 40 cm in 1991 to 20 cm in 2016

(Köster et al., 2016; Fig. 2.3.13). Considering the large variation of L50, the ratio of fish larger than the average length of fish entering spawning for the first time is difficult to interpret (Fig. 2.3.14).

The average maximum length ($L_{av}$)recorded in research cruises could not be recalculated due to the inability to use the von Bertalanffy individual growth model (no length data in age groups for recent years).

***Flounder stock in Subdivisions 24-25***

**Criterion 3.1 (level of fishing pressure)**

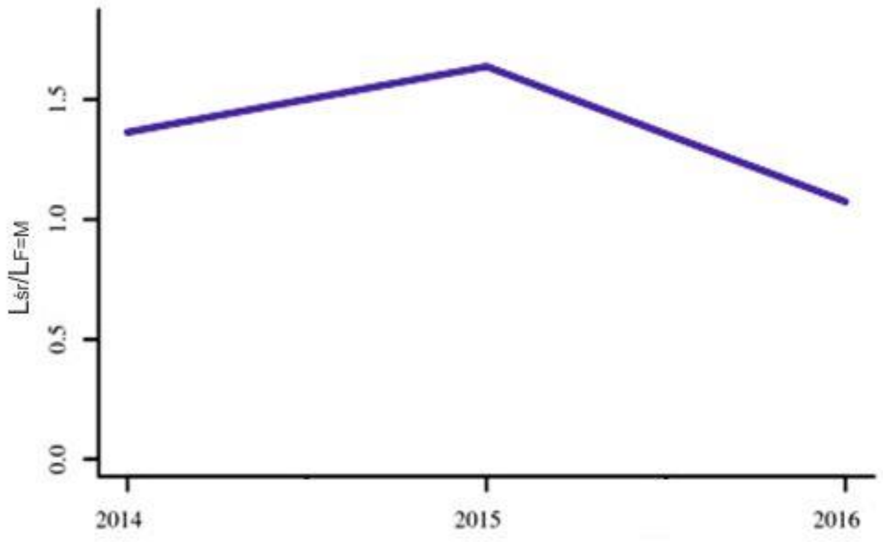



Fig. 2.3.15. Flounder 24-25. Ratio of $L_{av}$ to $L_{F=M}$ (vertical axis), as an approximation of F, where $F_{MSYproxy}$ = 1 (data source: ICES 2017b).

$L_{av}$ should be greater than or equal to $L_{F=M}$, i.e. the ratio of the average length of individuals to the average length in catch when fishing mortality equals natural mortality should not be lower than 1. For this stock, the values determined for the last three years (no data available for previous years) indicate the proper fishing pressure, $L_{av}/L_{F=M}$ is larger than the reference point (FMSYproxy = 1) (Figure 2.2.15, ICES 2017b (Fig. 2.3.15; ICES 2017b).

**Criterion 3.2 (stock reproductive capacity)**

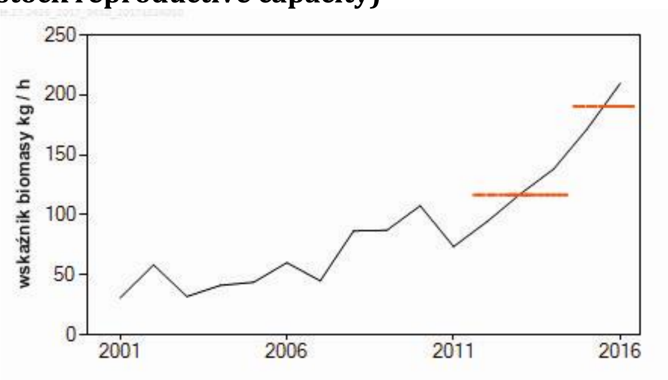



Fig. 2.3.16. Flounder 24-25. Fish biomass indicator >= 20 cm (data source: ICES 2017b).

The biomass index has been increasing since 2012. The ratio of the last two years to the previous three is 1.63 and therefore the amount of fishing recommended for 2018 could be increased in relation to the value recommended for 2017 by 20% (Fig. 2.3.16; ICES 2017b).

### Criterion 3.3 Age and size distribution

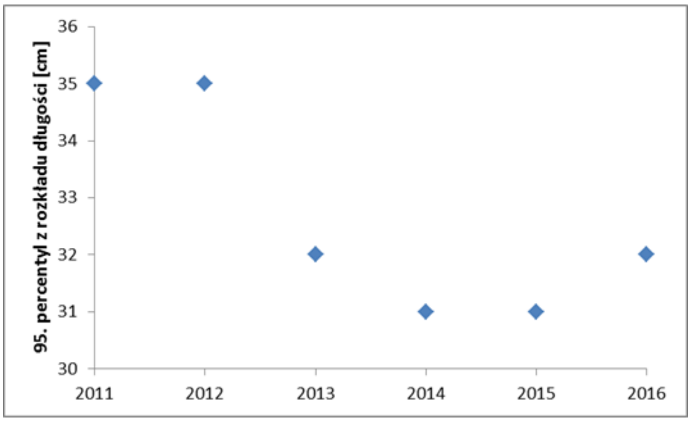



Fig. 2.3.17. Flounder 24-25. 95th percentile from the distribution of length observed in research catches.

The 95th percentile from the distribution of length observed in research catches dropped from 35 cm in 2011 and 2012 to 31 cm in 2014 and 2015 (Fig. 2.3.17). At present, this indicator is 32 cm.

International research cruises on the Baltic Sea do not include the coastal zone (shallow waters) in which juveniles of flounder are found. The biomass indicator is calculated for fish larger than or equal to 20 cm. The average length of fish entering for spawning for the first time is 22cm for females and 17cm for males (average for 2011-2016). Most of the juveniles are therefore not caught on international research cruises. Therefore, this indicator does not reflect the present proportion of fish larger than the average length of fish entering for spawning for the first time.

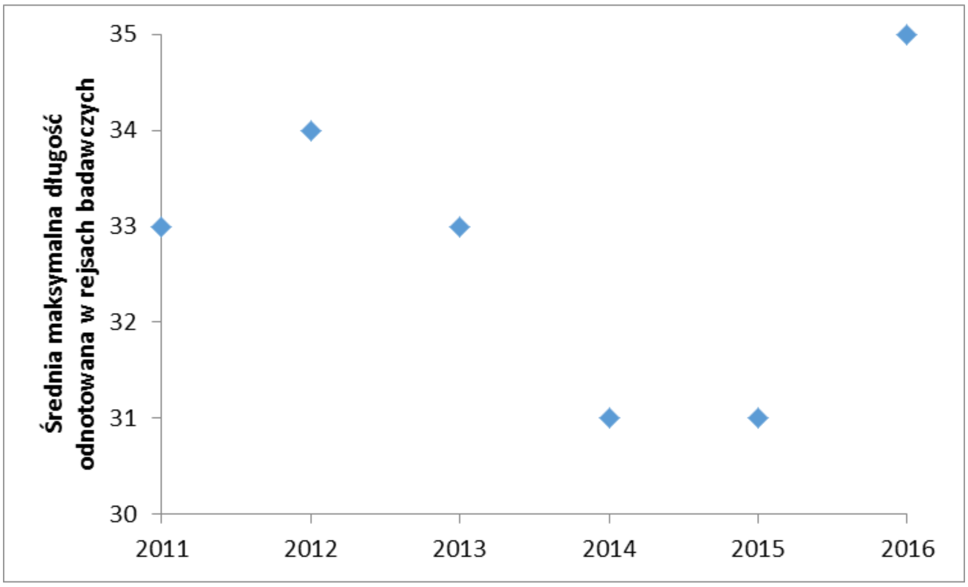



Fig. 2.3.18. Flounder 24-25. The average maximum length recorded in research cruises.

The average maximum length recorded in research cruises ranged from 31-35 cm in 2011-2016. The value of the index decreased until 2015, then in 2016 the highest value of 35 cm was recorded (Fig. 2.3.18).

*Sprat stock in Subdivisions 22-32*

**Criterion 3.1 (level of fishing pressure)**

Reference values: fishing mortality at the Maximum Sustainable Yield is 0.26 (ICES 2015), $F_{lim}$ = 0.39, $F_{pa}$ = 0.32 (ICES 2013). The fishing mortality rate in 2016 was estimated at 0.22, which is lower than $F_{MSY}$. GES was therefore achieved in terms of the fishing pressure indicator for this stock in 2016, in previous years the pressure from the fisheries was too high (Fig. 2.3.19, ICES 2017d).

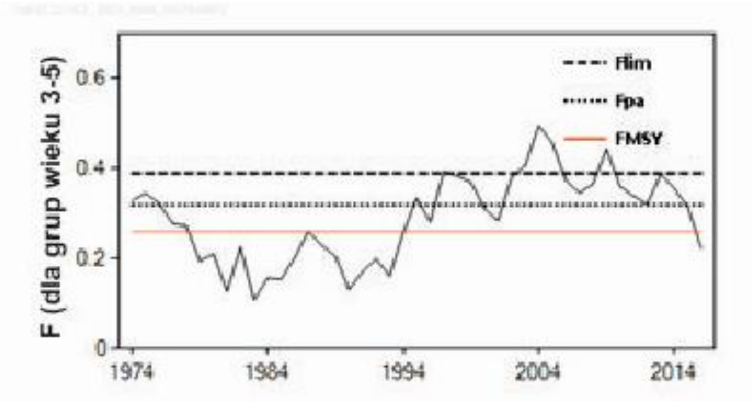



Fig. 2.3.19. Sprat 22-32. Fishing mortality for 3-5 age group together with the reference values (source: ICES 2017d).

**Criterion 3.2 (stock reproductive capacity)**

Cod has a large impact on the biomass of sprat stock, through the existing strong predator-prey dependence. In the 1980s, when large numbers of cod were observed, sprat biomass was at a relatively low level. At the beginning of the 1990s, the sprat biomass began to increase rapidly and reached the maximum observed level of 1.9 million tonnes in 1996. The stock increased mainly due to the interaction of two factors: strong recruitment and decrease in natural mortality (effect of the low biomass of cod stock). The high increase in the abundance of sprat has resulted in a decrease in the average individual biomass, which resulted in a decrease in the stock biomass, which since 2001 fluctuates at the level of 0.8-1.3 million tonnes (ICES 2017d).

Reference values: $MSY_{Btrigger}$ = 570,000 t (ICES 2015), while $B_{pa}$ = 570000 t and $B_{lim}$ = 410,000 t (ICES 2013). SSB estimated for 2016 is 1,176,000 t and is larger than MSY $_{Btrigger}$. GES has been achieved in terms of fertility rate for sprat stock in recent years (Fig. 2.3.20; ICES 2017d).

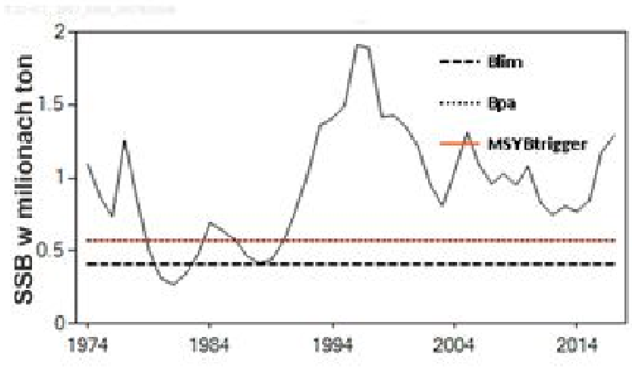



Fig. 2.3.20. Sprat 22-32. Spawning stock biomass (in millions of tonnes) with reference values (source: ICES 2017d).

### Criterion 3.3 Age and size distribution

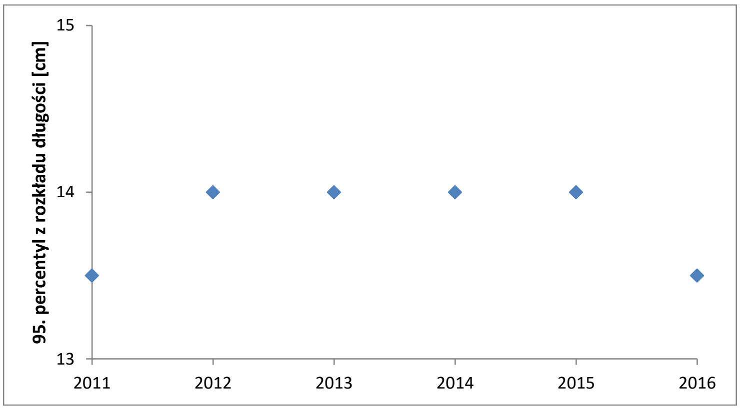



Fig. 2.3.21. Sprat 22-32. 95th percentile from the distribution of length observed in research catches.

The 95th percentile of the distribution of length observed in research catches is at a very stable level of 13.5 - 14 cm. In 2014, a very fertile generation appeared, which, however, did not significantly affect the value of the index (from 14 to 13.5 in 2016) (Fig. 2.3.21).

Due to the spatial spawning of sprat (Haslob et al., 2013), it is difficult to determine the average length of fish entering for spawning for the first time. Therefore, the proportion ratio of fish larger than the average length of fish entering for spawning for the first time is not presented.

The average maximum length recorded on research cruises could not be recalculated due to the inability to match von Bertalanffy's individual growth pattern to the data.

***Herring stock in subdivisions 25-29 and 32 Ex GoR***

### Criterion 3.1 (level of fishing pressure) - Fishing mortality (F)

Reference values: fishing mortality at the Maximum Sustainable Yeald is 0.22, while $F_{lim}$ = 0.52, $F_{pa}$ = 0.41 (ICES 2013). The fishing mortality rate in 2016 was estimated at 0.20, which is lower than $F_{MSY}$ (Fig. 2.3.22). GES has been achieved for this stock in terms of the fishing pressure index since 2004 (ICES 2017e).

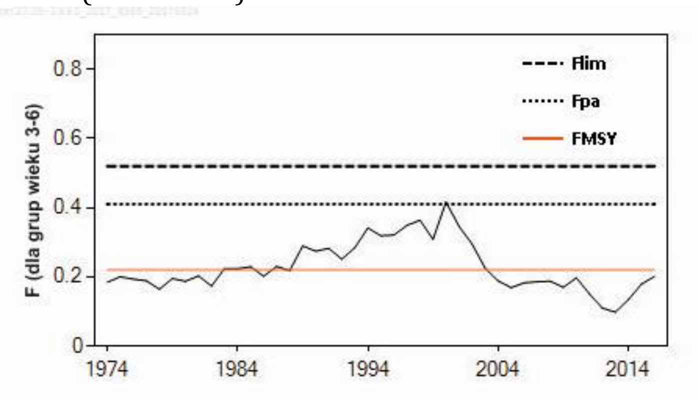



Fig. 2.3.22. Herring 25-29 and 32 Ex GoR. fishing mortality for age group 3-6 with references (source: ICES 2017 e).

**Criterion 3.2 (breeding capacity of the stock) - spawning stock biomass**

The herring biomass depends on the size of the cod stock, which is its main predator, and sprat, through the phenomenon of competition. Among other things, due to the existence of these links, there are spatial differences in the growth rate of herring, with large individuals in subdivisions 25 and 26 and small in the north of the Central Baltic Sea. The decrease in the individual herring mass in the north was due to the increase in sprat population in the region, and thus increased competition for food resources. This phenomenon had an impact on the biomass reduction of the herring stock. It should be noted, however, that the decline in the herring biomass occurred at the turn of the 1990s, while currently the average value, though low, has been stable for around 20 years (ICES 2017e).

Reference values: $MSY_{Btrigger}$ = 600,000 t (ICES 2015), while $B_{pa}$ = 600,000 t and $B_{lim}$ = 430,000 t (ICES 2013). SSB estimated for 2016 is over 1 million tonnes and is larger than $MSY_{Btrigger}$. GES has been achieved in terms of the fertility rate since 2006 (Fig. 2.3.23; ICES 2017e).

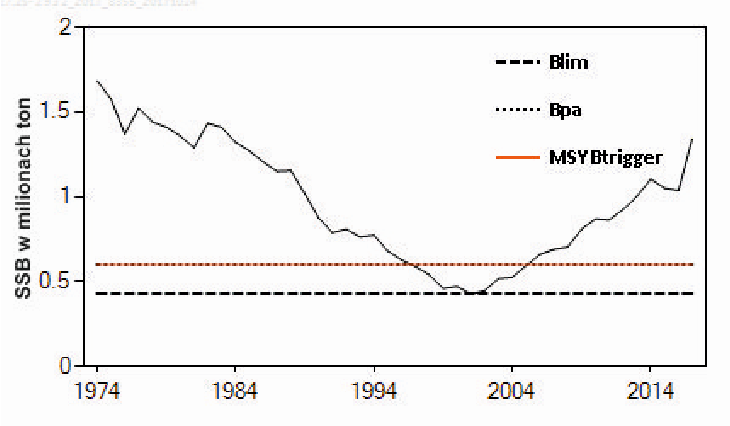



Fig. 2.3.23. Herring 25-29 and 32 Ex GoR. Spawning stock biomass (in millions tonnes) with reference values (source: ICES 2017e).

**Criterion 3.3. Age and size distribution**

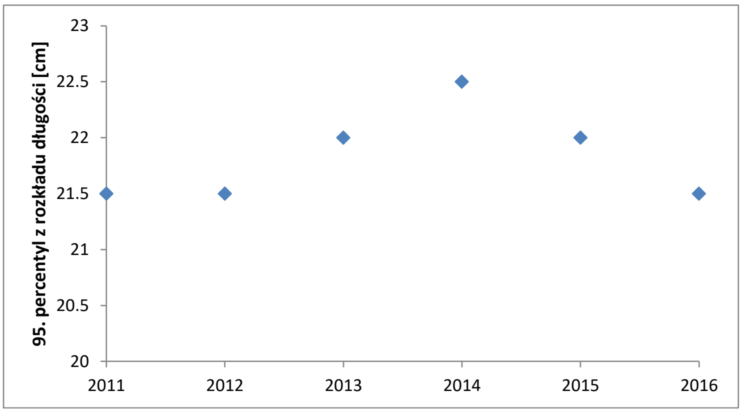



Fig. 2.3.24. Herring 25-29 and 32 Ex GoR. 95th percentile from the distribution of length observed in research catches.

The 95th percentile of the distribution of length observed in research catches is at the level of 21.5 - 22.5 cm. In 2014, a very fertile generation appeared, the index dropped to 21.5 cm in the last 2 years (Fig. 2.3.24).

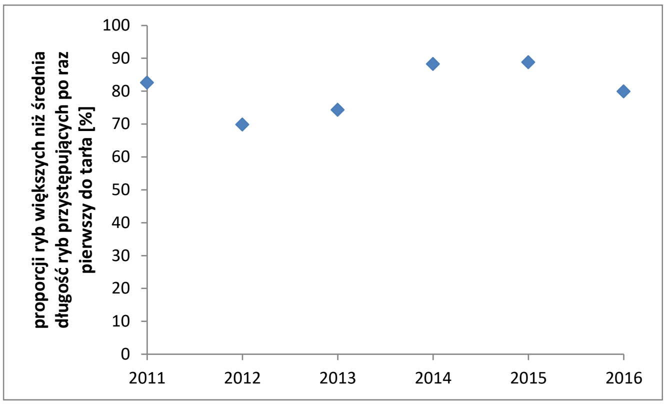



Fig. 2.3.25. Herring 25-29 and 32 Ex GoR. The proportion of fish larger than the average length of fish entering spawning for the first time.

The ratio of fish larger than the average length of fish entering spawning for the first time varied from 70% in 2012 to almost 90% in 2014 and 2015. Meanwhile, the average length of fish entering spawning for the first time for 2011-2016 vary in the range of 1 cm (Fig. 2.3.25).

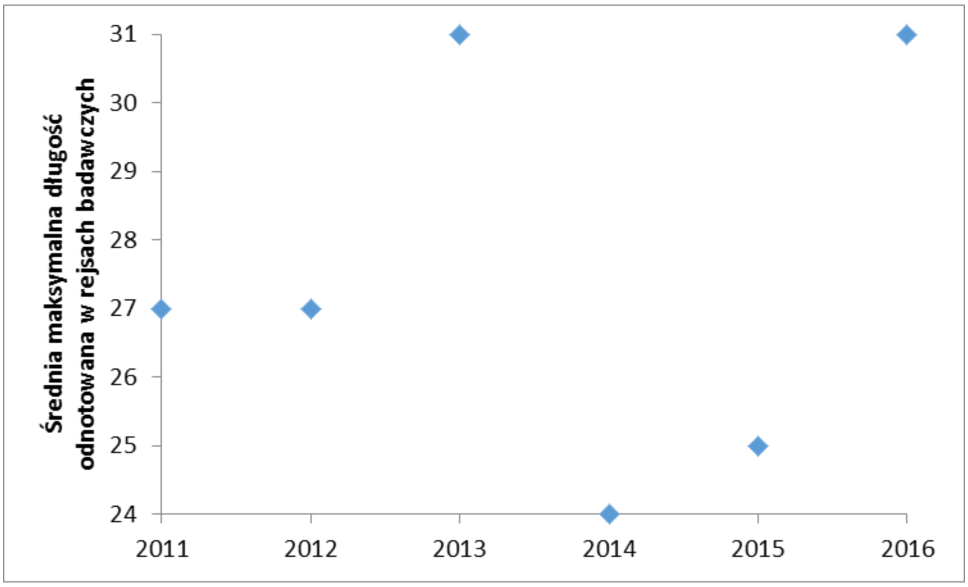



Fig. 2.3.26. Herring 25-29 and 32 Ex GoR. The average maximum length recorded on scientific cruises.

The average maximum length recorded in research cruises was between 24-31 cm in 2011-2016. The value of the indicator changed without a visible trend, in 2016 one of the highest values of 31 cm was recorded (Fig. 2.3.26).

**Integrated assessment of Descriptor D3**

Descriptor D3 has been used to assess the state of the marine environment of the Baltic Sea. The assessment was based on: cod stock, two stocks of flounder, one sprat stock, and one herring stock. Selected stocks account for over 90% of landings in Poland. The combination of assessments at the criterion level and then at the level of the entire Descriptor D3 is not a simple task. Until now, at the international level, the methodology of combining assessments created using individual indicators within one criterion has not been developed (e.g. designation of a common GES for criterion 3.1 on the basis of indicators 3.1.1 and 3.1.2). Work on this issue is still ongoing, therefore the presentation of aggregate assessment for Descriptor D3 is not possible at the moment (Fig. 2.3.27). In addition, the criterion regarding age distribution and population length distribution requires further work on the methodology. Pursuant to Decision 2017/848, D3C3 was not available for use when updating the initial assessment of the environmental status of marine waters in 2018.

Therefore, the assessment of GES was carried out on the basis of core indicators with criteria 3.1 and 3.2 and was presented on the basis of the methodology developed by ICES (ICES 2016). The criterion of the level of fishing pressure and the stock spawning capacity criterion was met for two flocks: sprat (22-32) and herring (25-29 and 32 Ex GoR) only in 2016, in earlier years, FMSY sprat (22-32) was exceeded. As many as 3 stocks had an unknown status (Table 2.3.10).

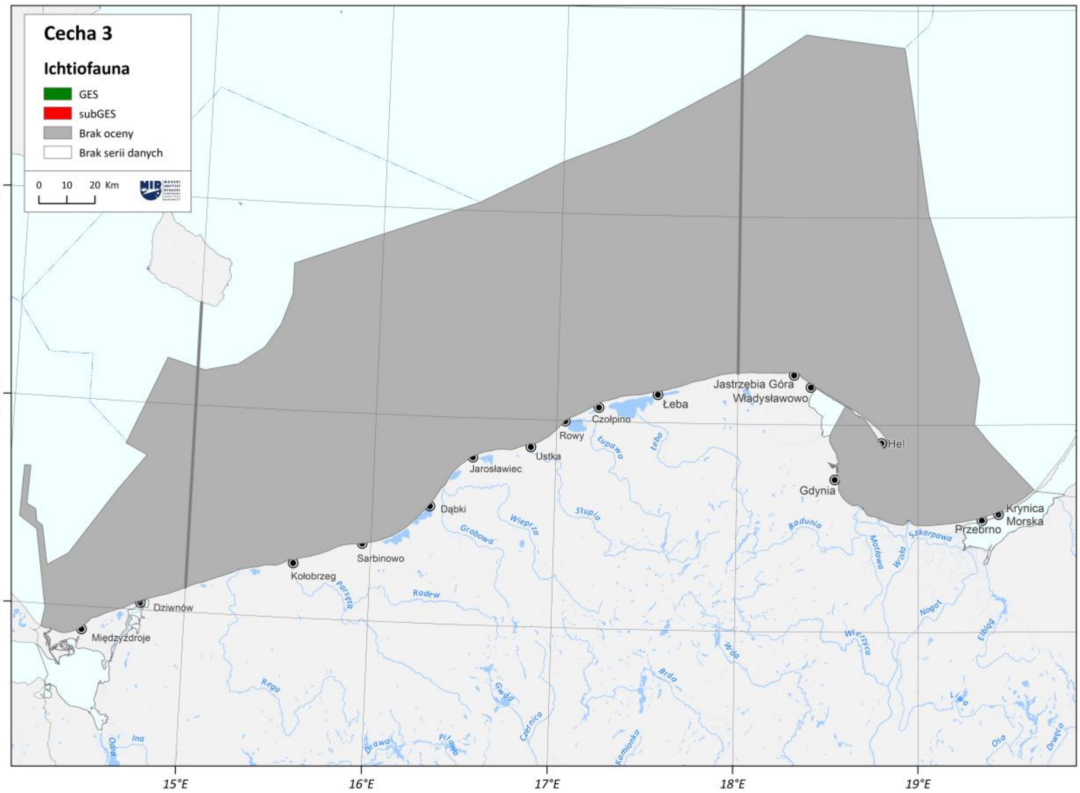



Fig. 2.3.27. Assessment of the state of the marine environment in the scope of ichthyofauna for Descriptor D3 made in accordance with MSFD for the years 2011-2016. Green colour indicates GES, red colour subGES, gray colour – lack of integrated assessment (source: PMŚ, ICES)

Table 2.3.10. Assessment of stocks by means of core indicators. Descriptor D3 for the years 2011-2016 according to the methodology proposed by ICES 2016. Green colour indicates that a good state of the environment has been achieved, whereas a red indicates that good status has not been achieved, gray - means that the data do not allow the use of core indicators.

| | 2011 | | | 2012 | | | 2013 | | | 2014 | | | 2015 | | | 2016 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Criterion | | GES | Criterion | | GES | Criterion | | GES | Criterion | | GES | Criterion | | GES | Criterion | | GES |
| Stock | 3.1 | 3.2 | | 3.1 | 3.2 | | 3.1 | 3.2 | | 3.1 | 3.2 | | 3.1 | 3.2 | | 3.1 | 3.2 | |
| cod 24-32 | | | ? | | | ? | | | ? | | | ? | | | ? | | | ? |
| flounder 24-25 | | | ? | | | ? | | | ? | | | ? | | | ? | | | ? |
| flounder 26 and 28 | | | ? | | | ? | | | ? | | | ? | | | ? | | | ? |
| sprat 22-32 | | GES | | | GES | | | GES | | | GES | | | GES | | GES | GES | GES |
| herring 25-29 and 32 Ex GoR | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES |
| Proportion of stocks achieving GES | 1 from 2 | 2 from 2 | 1 from 2 | 1 from 2 | 2 from 2 | 1 from 2 | 1 from 2 | 2 from 2 | 1 from 2 | 1 from 2 | 2 from 2 | 1 from 2 | 1 from 2 | 2 from 2 | 1 from 2 | 2 from 2 | 2 from 2 | 2 from 2 |
| Proportion of landings of stocks from GES to the total Polish landings | 28206t from 110390 t | 84314t from 110390 t | | 24622t from 120173t | 87504t from 120173t | | 20498 t from 133575t | 100842t from 133575t | | 25896 t from 119437t | 84320t from 119437 t | | 35387 t from 135613t | 99360 t from 135613 t | | 101520 t from 139313 t | 101520 t from 139313 t | |
| Proportions of stocks with unknown status | 3 from 5 | 3 from 5 | | 3 from 5 | 3 from 5 | | 3 from 5 | 3 from 5 | | 3 from 5 | 3 from 5 | | 3 from 5 | 3 from 5 | | 3 from 5 | 3 from 5 | |

? – question mark in the table means that the assessment could not be performed due to lack of ICES advice, the same way of presenting the assessment was used in the HELCOM report "State of the Baltic Sea: The second HELCOM holistic assessment of the ecosystem health of the Baltic Sea - first version "(June 2017), HELCOM (2017)

**Confidence of the assessment**

There is no methodology that would allow one assessment for Descriptor D3 that takes all three criteria into account. Despite the work of many experts, there is also no method that allows combining assessments created using individual indicators within a single criterion.

The criterion for the level of fishing pressure includes two indicators, fishing mortality and the ratio of catches to the biomass index. Fishing mortality is estimated using analytical models with proven confidence of calculations. This indicator also has a number of reference points. The ratio of the catch to the biomass index is, however, an indicator treated only as an approximation of the intensity of fishery, used in a situation where there is insufficient data to calculate fishing mortality. This indicator has no designated reference points. The same situation occurs in the case of spawning stock criterion, the spawning stock biomass comes from calculations made using proven analytical models and its confidence is high. In addition, it is possible to carry out the GES assessment by referring to reference points. The biomass index, on the other hand, is only an approximation of the reproductive power of the stock, used when there is insufficient data to determine the biomass of the spawning stock. Therefore, the assessment developed for criteria 3.1 and 3.2 contains only information on the F and SSB index, without the possibility of integrating the assessment within the criterion.

The criterion regarding age distribution and population length distribution requires further work on the methodology. According to Decision 2017/848, D3C3 was not available for use when updating the initial assessment of the marine environment in 2018. The indicators proposed by the Commission for this criterion do not have reference points. Both the ratio of fish larger than the average length of fish entering spawning for the first time and the 95th percentile from the distribution of length observed in research catches are sensitive to the number of young fish in the stock. The decreasing value of these two indicators may suggest a bad situation, i.e. a part of the stock that is sexually mature, larger individuals, declining as a result of catches, as well as a good recruitment and thus a high number of young fish in the stock. An alternative indicator of the length of fish entering spawning for the first time is difficult to calculate and interpret. The effect of strong fishing pressure on the length of fish entering spawning for the first time may be visible only after a few decades, while returning to the previous state may not be possible in many cases.

Table 2.3.11. Averaged confidence of the indicator for single area of assessment

| Confidance of the assessment area | Cod 24-32 | | Flounder 24-25 | | Flounder 26 and 28 | | Sprat 22-32 | | Herring 25-29 and Ex GoR | |
|---|---|---|---|---|---|---|---|---|---|---|
| | D3C1 | D3C2 | D3C1 | D3C2 | D3C1 | D3C2 | D3C1 | D3C2 | D3C1 | D3C2 |
| Temporal coverage | | | | | | | 1 | 1 | 1 | 1 |
| Spatial representation | | | | | | | 1 | 1 | 1 | 1 |
| Classification confidence | | | | | | | 1 | 1 | 1 | 1 |
| Methodological confidence | | | | | | | 1 | 1 | 1 | 1 |
| Averaged indicator confidence (WW) | | | | | | | 1 | 1 | 1 | 1 |

The assessment was made on the basis of indicators representing criteria C1 and C2, in case of using core indicators. Grey means stocks assessed with alternative indicators (no rating).

In the case of ichthyofauna, the confidence for the assessment area (WO), that is for the entire POM, is the arithmetic mean of the confidance of the indicators (WW).

As a result, a high confidence status score (WO) of a given ecosystem element is obtained (taking into account only those stocks for which the assessment was possible) for a given assessment area according to the classification presented in Table 2.3.12.

Table 2.3.12. Classification of the result of the confidence assessment

| Confidence assessment for the assessment area (WO) | Confidence status |
|---|---|
| ≥ 0.75 | high |
| 0.5 – 0.74 | moderate |
| < 0.5 | low |

***Descriptor D5 - Eutrophication***

The assessment of the environmental status for the Descriptor D5 for which the goal is to minimize the eutrophication caused by human activity, in particular its adverse effects, such as loss of biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in the lower parts of water for 2011-2016 is based on the criteria contained in Decision 2017/848 (Table 2.2.13), including the division of criteria into primary and secondary criteria for the assessment of nutrient and organic matter inflow. According to Art. 3 para. 1 of the Decision 2017/848, the inclusion of primary criteria for the most important pressures and impacts is obligatory. On the other hand, the secondary criteria and associated methodological standards, specifications and harmonized methods set out in the Annex are used to supplement the primary criterion or when there is a risk that the marine environment will not achieve or will not maintain good environmental status for a given criterion.

Table 2.3.13. Types of criteria and indicators to assess eutrophication in accordance with Decision 2017/848

| Descriptor | Priamary criterion | Secondary criterion | Description of the criterion in accordance with the decision 2017/848 | Indicator: core (P), alternative (A), preliminary (W), national (K), biodiversity (B), eutrophication (E) |
|---|---|---|---|---|
| D5 – Eutrophication | D5C1 | | Nutrient concentrations are not at levels that indicate adverse eutrophication effects. | DIN - average winter concentration * (P, K, E)<br>DIN - average annual concentration (K, E)<br>TN- average summer concentration (VI-IX) (K, E)<br>TN - average annual concentration (P, K, E)<br>DIP - average winter concentration * (P, K, E)<br>DIP - average annual concentration (K, E)<br>TP - average concentration in summer (June-September) (K, E)<br>TP - average annual concentration (P, K, E)<br>* concentrations from the months XII-II for open waters and I-III for transitional and coastal waters |
| | D5C2 | | Chlorophyll a concentrations are not at levels that indicate adverse effects of nutrient enrichment | Chlorophyll "a" - average summer concentration (VI-IX) (P)<br>Chlorophyll "a" - average annual concentration (K) |
| | | D5C3 | The number, spatial extent and duration of harmful algal bloom events are not at levels that indicate adverse effects of nutrient enrichment. | In the assessment, the results for the Helcom index were used:<br>CyaBl – Cyanobacterial Bloom Index (pre-core) |

| Descriptor | Priamary criterion | Secondary criterion | Description of the criterion in accordance with the decision 2017/848 | Indicator: core (P), alternative (A), preliminary (W), national (K), biodiversity (B), eutrophication (E) |
|---|---|---|---|---|
| D5 - Eutrophication | | D5C4 | The photic limit (transparency) of the water column is not reduced, due to increases in suspended algae, to a level that indicates adverse effects of nutrient enrichment. | Water transparency in summer (June-September) (P, K, E) |
| | D5C5 | | The concentration of dissolved oxygen is not reduced, due to nutrient enrichment, to levels that indicate adverse effects on benthic habitats (including on associated biota and mobile species) or other eutrophication effects. | Oxygen debt (P, E)<br>Oxygen near bottom – minimum in summer (VI-IX) (K, E) |
| | | D5C6 | The abundance of opportunistic macroalgae is not at levels that indicate adverse effects of nutrient enrichment. | Macrophyte indicators $SM_1$ * and ESMIz * (K, B) |
| | | D5C7 | The species composition and relative abundance or depth distribution of macrophyte communities achieve values that indicate there is no adverse effect due to nutrient enrichment including via a decrease in water transparency. | Macrophyte indicators $SM_1$ * and ESMIz * (K, B) |
| | | D5C8 | The species composition and relative abundance of macrofaunal communities, achieve values that indicate that there is no adverse effect due to nutrient and organic enrichment. | Multi-metric B index** (K, B) |

* indicators used for assessment only in transitional and coastal waters, results of indicators imported from the assessment of benthic habitats

** indicator indicators imported from the assessment of benthic habitats

### Assessment methodology

The basis for the assessment of eutrophication is the manual for assessment of eutrophication developed as part of the HOLAS project (HELCOM 2015c).

**Areas of assessment**

The eutrophication assessment was carried out at HELCOM level 4, for 22 assessment areas, i.e. for 19 waterbodies according to the WFD and 3 deep water sub-basins convergent with the basins used in the second holistic assessment of the Baltic Sea HOLAS II (HELCOM 2017a). The division of the Polish Baltic zone into national assessment areas and HELCOM areas is presented in Table 2.2.14.

Table 2.3.14. Areas of assessment used in the assessment of the Descriptor D5 in the Polish zone of the Baltic Sea

| No. | Name of the assessment area (sub-basin of Baltic Sea) in POM | waterbody code | HELCOM assessment area code | Water type (WB - waterbodies) |
|---|---|---|---|---|
| 1. | Gdańsk Basin | | SEA-008- | unenclosed waters |
| 2. | Eastern Gotland Basin | | SEA-009- | unenclosed waters |
| 3. | Bornholm Basin | | SEA-007- | unenclosed waters |
| 4. | Kamieński Lagoon | PL TW I WB 9 | POL-001 | WB - transitional waters |
| 5. | Szczecin Lagoon | PL TW I WB 8 | POL-002 | WB - transitional waters |
| 6. | Vistula Lagoon | PL TW I WB 1 | POL-003 | WB - transitional waters |
| 7. | Puck Lagoon | PL TW II WB 2 | POL-004 | WB - transitional waters |
| 8. | Outer Puck Bay | PL TW III WB 3 | POL-005 | WB - transitional waters |
| 9. | Inner Gulf of Gdańsk | PL TW IV WB 4 | POL-006 | WB - transitional waters |
| 10. | Dziwna Mouth | PL TW V WB 6 | POL-007 | WB - transitional waters |
| 11. | Wisła Przekop mouth | PL TW V WB 5 | POL-008 | WB - transitional waters |
| 12. | Świna Mouth | PL TW V WB 7 | POL-009 | WB - transitional waters |
| 13. | Vistula Spit | PL CW I WB 1 | POL-011 | WB - coastal waters |
| 14. | Hel Peninsula | PL CW I WB 2 | POL-010 | WB - coastal waters |
| 15. | Władysławowo Port | PL CW I WB 3 | POL-012 | WB - coastal waters |
| 16. | Władysławowo-Jastrzębia Góra | PL CW II WB 4 | POL-017 | WB - coastal waters |
| 17. | Jastrzębia Góra-Rowy | PL CW II WB 5 | POL-016 | WB - coastal waters |
| 18. | Rowy-Jarosławiec West | PL CW II WB 6W | POL-014 | WB - coastal waters |
| 19. | Rowy-Jarosławiec East | PL CW II WB 6E | POL-015 | WB - coastal waters |
| 20. | Jarosławiec-Sarbinowo | PL CW III WB 7 | POL-019 | WB - coastal waters |
| 21. | Sarbinowo-Dziwna | PL CW II WB 8 | POL-013 | WB - coastal waters |
| 22. | Dziwna-Świna | PL CW III WB 9 | POL-018 | WB - coastal waters |

**Indicators used**

**The open sea waters**

The assessment of the state of the environment in 2011-2016 in the field of eutrophication in POM was carried out in accordance with the MSFD recommendations. The results of research carried out in the COMBINE water quality monitoring program were used for the assessment purposes. The assessment was carried out on the basis of indicators produced for the Descriptor D5-Eutrophication, as one of the pressure descriptors. The indicators have been arranged in a causal sequence for driving factors, direct effects and indirect effects. The analysis of the dominant pressures and impacts on the marine environment under the Descriptor D5 has been characterized by indicators related to three groups of criteria:

*Driving factors*

In order to assess the level of nutrients, core indicators relating to the concentrations of nitrogen and phosphorus, which the organisms associated with primary production use for growth, were used. The dissolved inorganic forms of nitrogen (DIN) and phosphorus (DIP) are available for use by phytoplankton and are measured in the winter months when negligible primary production occurs. Measurements of total nitrogen (TN) and phosphorus (TP) take into account compounds that are tied in phytoplankton cells as well as in suspended matter in water, and therefore describe the total level of enrichment of marine waters with nutrients. The inclusion of total forms in the calculations of nutrient levels makes it possible to include climate change in the assessment , as it is expected that the increase in winter temperatures will result in the production of phytoplankton throughout the year, and consequently binding of a greater proportion of nutrients in phytoplankton cells than in dissolved form.

*Direct effects*

In order to determine the direct effects of eutrophication, the chlorophyll concentration indicator (summer concentration) and the transparency of water (measured as Secchi disc visibility) were used in the assessment. In addition, the results of cyanobacterial blooms (CyaBl) used in the assessment of pelagic habitats in open waters were included in the assessment.

*Indirect effects*

To assess the indirect effects in open waters, the core indicator oxygen debt (HELCOM 2017) was used, which describes the oxygenation status of bottom water layer in deep regions of the Baltic Sea, including those belonging to the Polish area of Bornholm Basin, Gdańsk Basin and the south-east Gotland Basin. This parameter estimates the so-called oxygen debt below the halocline, i.e. how much oxygen is lacking to fully oxygenate the water column below the halocline under given temperature and salinity conditions. In addition, in the assessment of all water bodies with regard to the indirect effects of eutrophication, the multi-metric B index for zoobenthos was included.

***Transitional and coastal waters***

In the case of transitional and coastal waters, the division into groups of criteria was identical to the division adopted for open sea sub-basins, and the results of national indicators compliant with the WFD were used to assess the state of transitional and coastal waters and for transitional waters in the area of the Vistula Lagoon and Szczecin Lagoon index for macrophyte ecological status in lagoons – ESMIz was used.

**Method of assessment calculation**

As the threshold values for good environmental status for transitional and coastal waters, the boundaries between moderate and good status were used in accordance with the ordinance of the Minister of the Environment of July 21, 2016 on the method of classification of the surface waterbodies and environmental quality standards for priority substances, while thresholds for open sea waters were adopted from the HELCOM core indicator reports (HELCOM 2017h, HELCOM 2017k-r). Due to the lack of established thresholds, at the HELCOM level, for the TN indicator in the Bornholm Basin area and TP in the Bornholm Basin and the Eastern Gotland Basin, the national threshold values proposed in the initial assessment (GIOŚ, 2014) and for the purpose of development of a set of environmental targets for marine waters (KZGW, 2016) were used. The GES thresholds, the way of result integration under the criteria and the way the final assessment is carried out are presented in Table 2.3.15 and Table 2.3.16.

***Normalization of indicators***

Assessment of the state of the marine environment in the field of eutrophication is carried out by averaging the value of a given indicator in 2011-2016 and calculating the value of eutrophication coefficients (ER) in accordance with the formula:

1. for indicators whose value increases with the increase of eutrophication:

$$ER = ES/ET,$$

2. for indicators whose value decreases with the increase of eutrophication:

$$ER = ET/ES,$$

where,
ES – indicator value for the 2011-2016 assessment period
ET – target, boundary of good environmental status, "threshold value"

The threshold values of good environmental status for transitional and coastal waters as well as open sea sub-basins are presented in Table 2.3.15 and Table 2.3.16

Good environmental status **(GES)** have **ER values less than 1.**

***Integrated assessment of eutrophication***

The obtained ER indicator values were averaged within the groups of criteria according to the scheme (Fig. 2.3.28) using weights that were equivalent for each indicator used within the groups of criteria. The lowest condition among the assessment criteria (OOAO) determined the final status of the assessment.

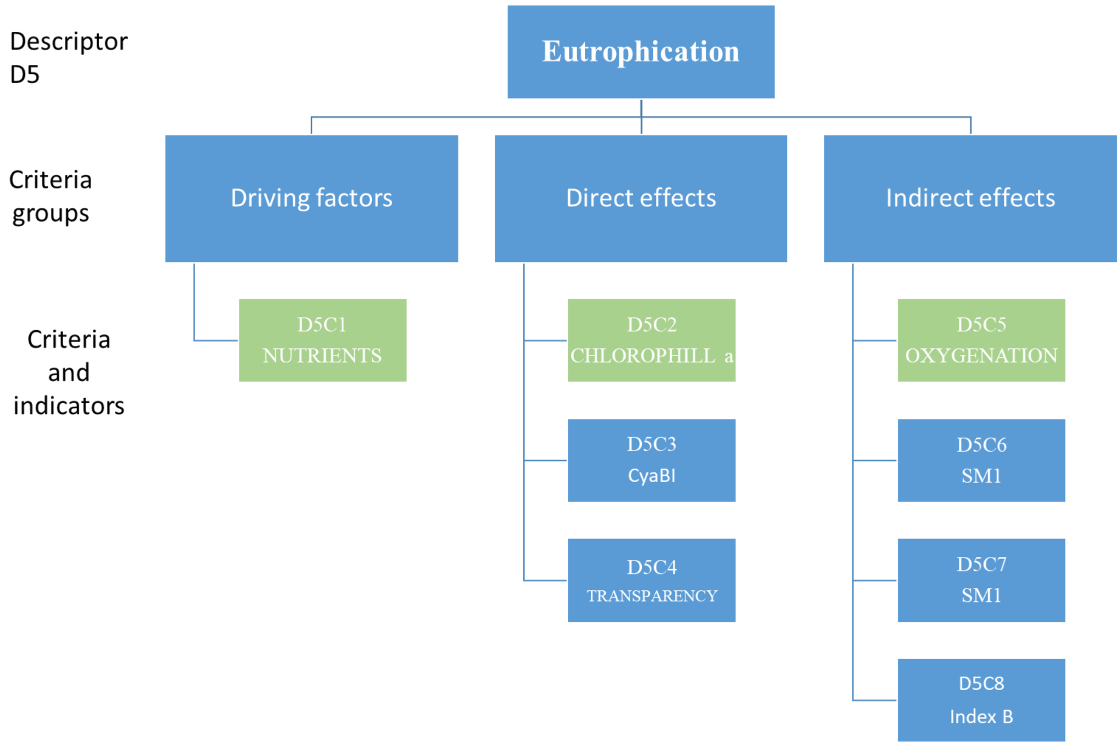



Fig. 2.3.28. Descriptor D5 assessment scheme, green colour - primary criteria, blue - secondary criteria.

Table 2.3.15. Threshold values of good environmental status and the procedure of assessing open water areas within the Descriptor D5

| Sub-basin | Driving factors | | | | Direct effects | | | Indirect effects | |
|---|---|---|---|---|---|---|---|---|---|
| | DIN (XII-II) (µM dm$^{-3}$) | DIP (XII-II) (µM dm$^{-3}$) | TN year) (µM dm$^{-3}$) | TP (year) (µM dm$^{-3}$) | CHL a (VI-IX) ( µg·dm$^{-3}$) | SECCHI (VI-IX) | CyaBl Index | Oxygen debt (mg dm$^{-3}$) | B Index |
| | GES threshold values | | | | | | | | |
| Bornholm Basin Polish waters | 2.50 | 0.30 | 14.43* | 0.61* | 1.8 | 7.10 | 0.89 | 6.37 | 3.18* |
| Gdańsk Basin Polish waters | 4.20 | 0.36 | 18.8 | 0.6 | 2.2 | 6.50 | 0.98 | 8.66 | 3.18* |
| Eastern Gotland Basin Polish waters | 2.60 | 0.29 | 16.5 | 0.68* | 1.9 | 7.60 | 0.84 | 8.66 | 3.18* |
| indicator weights | | | | | | | | | |
| Bornholm Basin | 25% | 25% | 25% | 25% | 33% | 33% | 33% | 50% | 50% |
| Gdańsk Basin | 25% | 25% | 25% | 25% | 33% | 33% | 33% | 50% | 50% |
| Eastern Gotland Basin | 25% | 25% | 25% | 25% | 33% | 33% | 33% | 50% | 50% |
| criterion assessment | weighted average of indicators | | | | weighted average of indicators | | | weighted average of indicators | |
| Final assessment | OAOO (the value of the criterion in the worst status ) | | | | | | | | |

*national threshold values

Table 2.3.16. Threshold values of good environmental status and the procedure of assessing WFD waterbodies within the Descriptor D5

| Waterbody code | Driving factors | | | | | | | | Direct effects | | | | Indirect effects | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DIN (mgN $dm^{-3}$) | | DIP (mgP $dm^{-3}$) | | TN (mgN $dm^{-3}$) | | TP (mgP $dm^{-3}$) | | CHL a (µg $dm^{-3}$) | | SECCHI (m) | | $O_2$ min (mg$O_2$ $dm^{-3}$) | B index | $SM_1$ | ESMIz |
| | year | I-III | year | I-III | year | VI-IX | year | VI-IX | year | VI-IX | year | VI-IX | VI-IX | | | |
| GES threshold values | | | | | | | | | | | | | | | | |
| PL TW I WB 9 | 1.05 | | | 0.045 | 1.9 | | 0.15 | | 20 | | 1.9 | | 4.2 | 3.18 | | 0.123 |
| PL TW I WB 8 | 1.05 | | | 0.045 | 1.9 | | 0.15 | | 20 | | 1.9 | | 4.2 | 3.18 | | 0.123 |
| PL TW I WB 1 | 0.38 | | | 0.035 | 0.98 | | 0.12 | | 23.2 | | 0.75 | | 4.2 | 3.18 | | 0.123 |
| PL TW II WB 2 | 0.026 | | | 0.090 | 0.3 | | 0.03 | | 2.0 | | 3.4 | | 4.2 | 3.18 | 0.8 | |
| PL TW III WB 3 | | 0.15 | | 0.018 | | 0.4 | | 0.035 | | 3.76 | | 4.5 | 4.2 | 3.18 | 0.8 | |
| PL TW IV WB 4 | | 0.15 | | 0.018 | | 0.4 | | 0.035 | | 3.76 | | 4.5 | 4.2 | 3.18 | 0.8 | |
| PL TW V WB 6 | | 0.18 | | 0.035 | | 0.27 | | 0.042 | | 3.8 | | 4.5 | 4.2 | 3.18 | 0.8 | |
| PL TW V WB 5 | | 0.225 | | 0.035 | | 0.4 | | 0.045 | | 5.5 | | 3.0 | 4.2 | 3.18 | 0.8 | |
| PL TW V WB 7 | | 0.32 | | 0.035 | | 0.53 | | 0.045 | | 7.5 | | 3.75 | 4.2 | 3.18 | 0.8 | |
| PL CW I WB 2 | | 0.1 | | 0.015 | | 0.3 | | 0.03 | | 1.9 | | 5.6 | 4.2 | 3.18 | 0.8 | |
| PL CW I WB 1 | | 0.15 | | 0.024 | | 0.4 | | 0.033 | | 3.15 | | 3.5 | 4.2 | 3.18 | 0.8 | |
| PL CW I WB 3 | | 0.1 | | 0.015 | | 0.3 | | 0.03 | | 1.9 | | 5.6 | 4.2 | 3.18 | 0.8 | |
| PL CW II WB 8 | | 0.1 | | 0.015 | | 0.3 | | 0.03 | | 1.9 | | 5.6 | 4.2 | 3.18 | 0.8 | |
| PL CW II WB 6W | | 0.1 | | 0.015 | | 0.3 | | 0.03 | | 1.9 | | 5.6 | 4.2 | 3.18 | 0.8 | |
| PL CW II WB 6E | | 0.1 | | 0.015 | | 0.3 | | 0.03 | | 1.9 | | 5.6 | 4.2 | 3.18 | 0.8 | |
| PL CW II WB 5 | | 0.1 | | 0.015 | | 0.3 | | 0.03 | | 1.9 | | 5.6 | 4.2 | 3.18 | 0.8 | |
| PL CW II WB 4 | | 0.1 | | 0.015 | | 0.3 | | 0.03 | | 1.9 | | 5.6 | 4.2 | 3.18 | 0.8 | |
| PL CW III WB 9 | | 0.23 | | 0.024 | | 0.4 | | 0.024 | | 3.15 | | 3.8 | 4.2 | 3.18 | 0.8 | |
| PL CW III WB 7 | | 0.1 | | 0.015 | | 0.3 | | 0.03 | | 1.9 | | 5.6 | 4.2 | 3.18 | 0.8 | |
| criterion assessment | weighted average | | | | | | | | weighted average | | | | weighted average | | | |
| Final assessment | OOAO (the value of the criterion in the worst status) | | | | | | | | | | | | | | | |

**Assessment results**

***Transitional and coastal waters***

The results of the assessment of indicators used to assess eutrophication in 2011-2016 are presented in Table 2.3.17. The results were grouped by groups of criteria. For each indicator within a given waterbody, the average value from the given assessment year was calculated, and then the values from individual years were averaged to the final value of the indicator from the assessment period. In the next step, index values were brought to the value of EQR coefficients by comparison with threshold values for good status according to WFD. The EQR values within the groups of criteria were then averaged to the final assessment value for the criterion (Table 2.3.18).

The final assessment of transitional and coastal waters for the years 2011-2016 was determined according to the OOAO principle based on the worst criterion result and is presented in Table 2.3.19.

None of the transitional and coastal JCWPs has achieved good environmental status during the 2011-2016 period. The overall status of all transitional and coastal waterbodies was defined as subGES.

Table 2.3.17. Results of eutrophication indices for transitional and coastal waters in 2011-2016 (data source: PMŚ).

| Waterbody code | Driving factors | | | | | | | | Direct effects | | | | Indirect effects | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DIN (mgN dm$^{-3}$) | | DIP (mgP dm$^{-3}$) | | TN (mgN dm$^{-3}$) | | TP (mgP dm$^{-3}$) | | CHL a (µg dm$^{-3}$) | | SECCHI (m) | | $O_2$ min (mg$O_2$ dm$^{-3}$) | B index | $SM_1$ | ESMIz |
| | year | I-III | year | I-III | year | VI-IX | year | VI-IX | year | VI-IX | year | VI-IX | VI-IX | - | - | - |
| PL TW I WB 9 | 0.359 | - | - | 0.023 | 1.53 | - | 0.128 | - | 27.43 | - | 1.1 | - | 5.4 | 2.52 | - | 0.027 |
| PL TW I WB 8 | 0.442 | - | - | 0.021 | 1.66 | - | 0.136 | - | 34.16 | - | 1.1 | - | 4.4 | 2.25 | - | 0.036 |
| PL TW I WB 1 | 0.103 | - | - | 0.01 | 0.9 | - | 0.062 | - | 51.49 | - | 0.6 | - | 2.9 | 1.15 | - | 0.029 |
| PL TW II WB 2 | 0.036 | - | - | 0.062 | 0.41 | - | 0.033 | - | 5.14 | - | 4.2 | - | 5.8 | 2.92 | 0.69 | - |
| PL TW III WB 3 | - | 0.124 | - | 0.046 | - | 0.486 | - | 0.08 | - | 3.67 | - | 4.2 | 3.7 | 2.69 | 0.74 | - |
| PL TW IV WB 4 | - | 0.097 | - | 0.024 | - | 0.353 | - | 0.034 | - | 4.25 | - | 4.7 | 3.5 | 2.60 | - | - |
| PL TW V WB 6 | - | 0.31 | - | 0.021 | - | 0.771 | - | 0.062 | - | 10.32 | - | 1.9 | 5.8 | 2.59 | - | - |
| PL TW V WB 5 | - | 0.806 | - | 0.081 | - | 0.646 | - | 0.09 | - | 10.73 | - | 1.9 | 3.4 | 2.32 | - | - |
| PL TW V WB 7 | - | 0.499 | - | 0.025 | - | 0.835 | - | 0.074 | - | 11.09 | - | 1.7 | 5.3 | 3.11 | - | - |
| PL CW I WB 2 | - | 0.123 | - | 0.045 | - | 0.491 | - | 0.054 | - | 3.11 | - | 4.6 | 6.9 | 3.49 | - | - |
| PL CW I WB 1 | - | 0.282 | - | 0.038 | - | 0.447 | - | 0.065 | - | 6.85 | - | 4.5 | 6.4 | 2.22 | - | - |
| PL CW I WB 3 | - | 0.136 | - | 0.06 | - | 0.524 | - | 0.078 | - | 6.85 | - | 2.6 | 5.9 | 2.04 | - | - |
| PL CW II WB 8 | - | 0.185 | - | 0.036 | - | 0.366 | - | 0.039 | - | 4.17 | - | 3.3 | 5.2 | 2.16 | - | - |
| PL CW II WB 6W | - | 0.368 | - | 0.01 | - | 0.528 | - | 0.029 | - | 4.83 | - | 3.9 | 7 | 3.48 | - | - |
| PL CW II WB 6E | - | 0.096 | - | 0.007 | - | 0.821 | - | 0.022 | - | 5.63 | - | 4.4 | 7 | 2.91 | 0.74 | - |
| PL CW II WB 5 | - | 0.063 | - | 0.05 | - | 0.535 | - | 0.068 | - | 5.86 | - | 4 | 6.7 | 3.38 | - | - |
| PL CW II WB 4 | - | 0.072 | - | 0.043 | - | 0.505 | - | 0.078 | - | 4.58 | - | 4.8 | 6.8 | 3.21 | - | - |
| PL CW III WB 9 | - | 0.188 | - | 0.021 | - | 0.697 | - | 0.044 | - | 6.63 | - | 2.3 | 4.5 | 2.56 | - | - |
| PL CW III WB 7 | - | 0.117 | - | 0.028 | - | 0.34 | - | 0.037 | - | 3.57 | - | 3.4 | 4.6 | 2.16 | - | - |

**-** the indicator is not applicable in the assessment of a given waterbody

Table 2.3.18. Results of eutrophication indices for transitional and coastal waters in 2011-2016 (data source: PMŚ).

| Waterbody code | Driving factors | | | | | | | | | Direct effects | | | | | Indirect effects | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DIN | | DIP | | TN | | TP | | avg. EQR | CHL a | | SECCHI | | avg. EQR | O2 min | B | $SM_1$ | ESMIz | avg. EQR |
| | year | I-III | year | I-III | year | VI-IX | year | VI-IX | | year | VI-IX | year | VI-IX | | VI-IX | | | | |
| PL TW I WB 9 | 0.34 | - | - | 0.51 | 0.81 | - | 0.85 | - | 0.63 | 1.37 | - | 1.73 | - | 1.55 | 0.78 | 1.26 | - | 4.55 | 2.20 |
| PL TW I WB 8 | 0.42 | - | - | 0.47 | 0.87 | - | 0.91 | - | 0.67 | 1.71 | - | 1.73 | - | 1.72 | 0.95 | 1.41 | - | 3.42 | 1.93 |
| PL TW I WB 1 | 0.27 | - | - | 0.22 | 0.92 | - | 0.52 | - | 0.48 | 1.65 | - | 1.25 | - | 1.45 | 1.45 | 2.77 | | 4.24 | 2.82 |
| PL TW II WB 2 | 1.38 | - | - | 0.69 | 1.37 | - | 1.1 | - | 1.14 | 2.57 | - | 0.81 | - | 1.69 | 0.72 | 1.0.9 | 1.15 | | 0.94 |
| PL TW III WB 3 | - | 0.83 | - | 2.56 | - | 1.22 | - | 2.29 | 1.73 | - | 0.98 | - | 1.07 | 1.03 | 1.14 | 1.18 | 1.08 | - | 1.13 |
| PL TW IV WB 4 | - | 0.65 | - | 1.33 | - | 0.88 | - | 0.97 | 0.96 | - | 1.13 | - | 0.96 | 1.05 | 1.2 | 1.22 | - | - | 1.21 |
| PL TW V WB 6 | - | 1.72 | - | 0.6 | - | 2.86 | - | 1.48 | 1.67 | - | 2.72 | - | 2.37 | 2.55 | 0.72 | 1.23 | - | - | 0.98 |
| PL TW V WB 5 | - | 3.58 | - | 2.31 | - | 1.62 | - | 2 | 2.38 | - | 1.95 | - | 1.58 | 1.77 | 1.24 | 1.37 | - | - | 1.31 |
| PL TW V WB 7 | - | 1.56 | - | 0.71 | - | 1.58 | - | 1.64 | 1.37 | - | 1.48 | - | 2.21 | 1.85 | 0.79 | 1.02 | - | - | 0.91 |
| PL CW I WB 2 | - | 1.23 | - | 3 | - | 1.64 | - | 1.8 | 1.92 | - | 1.64 | - | 1.22 | 1.43 | 0.61 | 0.91 | - | - | 0.76 |
| PL CW I WB 1 | - | 1.88 | - | 1.58 | - | 1.12 | - | 1.97 | 1.64 | - | 2.17 | - | 0.78 | 1.48 | 0.66 | 1.43 | - | - | 1.05 |
| PL CW I WB 3 | - | 1.36 | - | 4 | - | 1.75 | - | 2.6 | 2.43 | - | 3.61 | - | 2.15 | 2.88 | 0.71 | 1.56 | - | - | 1.14 |
| PL CW II WB 8 | - | 1.85 | - | 2.4 | - | 1.22 | - | 1.3 | 1.69 | - | 2.19 | - | 1.7 | 1.95 | 0.81 | 1.47 | - | - | 1.14 |
| PL CW II WB 6W | - | 3.68 | - | 0.67 | - | 1.76 | - | 0.97 | 1.77 | - | 2.54 | - | 1.44 | 1.99 | 0.6 | 0.91 | - | - | 0.76 |
| PL CW II WB 6E | - | 0.96 | - | 0.47 | - | 2.74 | - | 0.73 | 1.23 | - | 2.96 | - | 1.27 | 2.12 | 0.6 | 1.09 | 1.08 | - | 0.84 |
| PL CW II WB 5 | - | 0.63 | - | 3.33 | - | 1.78 | - | 2.27 | 2 | - | 3.08 | - | 1.4 | 2.24 | 0.63 | 0.94 | - | - | 0.79 |
| PL CW II WB 4 | - | 0.72 | - | 2.87 | - | 1.68 | - | 2.6 | 1.97 | - | 2.41 | - | 1.17 | 1.79 | 0.62 | 0.99 | - | - | 0.81 |
| PL CW III WB 9 | - | 0.82 | - | 0.88 | - | 1.74 | - | 1.83 | 1.32 | - | 2.1 | - | 1.65 | 1.88 | 0.93 | 1.24 | - | - | 1.09 |
| PL CW III WB 7 | - | 1.17 | - | 1.87 | - | 1.13 | - | 1.23 | 1.35 | - | 1.88 | - | 1.65 | 1.77 | 0.91 | 1.47 | - | - | 1.19 |

- the indicator is not applicable in the assessment of a given waterbody

Table 2.3.19. Assessment of Descriptor D5 for transitional and coastal waters in 2011-2016 (data source: PMŚ).

| Waterbody code | Driving factors | Direct effects | Indirect effects | waterbody assessment |
|---|---|---|---|---|
| PL TW I WB 9 | 0.63 | 1.55 | 2.20 | subGES |
| PL TW I WB 8 | 0.67 | 1.72 | 1.93 | subGES |
| PL TW I WB 1 | 0.48 | 1.45 | 2.82 | subGES |
| PL TW II WB 2 | 1.14 | 1.69 | 0.94 | subGES |
| PL TW III WB 3 | 1.73 | 1.03 | 1.13 | subGES |
| PL TW IV WB 4 | 0.96 | 1.05 | 1.21 | subGES |
| PL TW V WB 6 | 1.67 | 2.55 | 0.98 | subGES |
| PL TW V WB 5 | 2.38 | 1.77 | 1.31 | subGES |
| PL TW V WB 7 | 1.37 | 1.85 | 0.91 | subGES |
| PL CW I WB 2 | 1.92 | 1.43 | 0.76 | subGES |
| PL CW I WB 1 | 1.64 | 1.48 | 1.05 | subGES |
| PL CW I WB 3 | 2.43 | 2.88 | 1.14 | subGES |
| PL CW II WB 8 | 1.69 | 1.95 | 1.14 | subGES |
| PL CW II WB 6W | 1.77 | 1.99 | 0.76 | subGES |
| PL CW II WB 6E | 1.23 | 2.12 | 0.84 | subGES |
| PL CW II WB 5 | 2.00 | 2.24 | 0.79 | subGES |
| PL CW II WB 4 | 1.97 | 1.79 | 0.81 | subGES |
| PL CW III WB 9 | 1.32 | 1.88 | 1.09 | subGES |
| PL CW III WB 7 | 1.35 | 1.77 | 1.19 | subGES |

***Open sea***

The results of index calculations for open sea sub-basin are presented in Table 2.3.20. Calculated annual ER values and average ER values of indicators in 2011-2016 are presented in Table 2.3.21. Due to the lack of threshold values agreed at the regional level for the TN indicator for Bornholm Basin (SEA-007) and TP for Bornholm Basin (SEA-007) and Eastern Gotland Basin (SEA- 009), the ER values were calculated based on national threshold values for good status for the above three indicators. The integrated results of the indicators within groups of criteria and the final assessment of Descriptor D5 in open sea sub-basins are presented in Table 2.3.22.

None of the indicators reached the GES value in 2011-2016, and consequently none of the groups of criteria reached GES. The final classification of the open sea was defined as subGES for all sub-basins.

Table 2.3.20. Results of eutrophication indices for open sea waters in 2011-2016 (data source: PMŚ)

| Sub-basin | Year | Driving factors | | | | Direct effects | | | Indirect effects | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | DIN (XII-II) (μM dm-3) | DIP (XII-II) (μM dm-3) | TN (year) (μM dm-3) | TP (year) (μM dm-3) | CHL a (VI-IX) (μg dm-3) | SECCHI (VI-IX) | CyaBl index | Oxygen debt (mg dm-3) | B index |
| Bornholm Basin Polish waters | 2011 | 6.55 | 0.33 | 27.59 | 0.9 | 4.381 | 6.6 | 0.8 | 8.10 | 2.71 |
| | 2012 | 6.1 | 0.43 | 22.81 | 0.96 | 3.222 | 6.7 | | | 2.58 |
| | 2013 | 5.84 | 0.34 | 29.68 | 0.83 | 3.735 | 7 | | | 2.6 |
| | 2014 | 4.86 | 0.37 | 25.44 | 0.81 | 2.299 | 7.7 | | | 2.55 |
| | 2015 | 5.64 | 0.61 | 27.54 | 0.86 | 3.024 | 6.7 | | | 2.8 |
| | 2016 | 3.24 | 0.8 | 25.32 | 0.66 | 3.030 | 6.6 | | | 2.7 |
| Gdańsk Basin Polish waters | 2011 | 7.73 | 0.46 | 26.62 | 0.99 | 4.342 | 5.8 | 0.83 | 10.85 | 0 |
| | 2012 | 2.61 | 0.38 | 22.6 | 0.88 | 3.091 | 6 | | | 1.41 |
| | 2013 | 5.25 | 0.27 | 30.2 | 0.82 | 3.904 | 5.4 | | | 1.9 |
| | 2014 | 4.12 | 0.43 | 29.03 | 0.72 | 5.15 | 5.1 | | | 0.9 |
| | 2015 | 5.95 | 0.7 | 27.92 | 0.79 | 2.903 | 6.2 | | | 1.9 |
| | 2016 | 5.75 | 0.83 | 29.44 | 0.7 | 5.199 | 5.2 | | | 1.88 |
| Eastern Gotland Basin Polish waters | 2011 | 9.83 | 0.4 | 23.36 | 0.95 | 2.921 | 7.7 | 0.76 | 10.85 | 2.36 |
| | 2012 | 3.17 | 0.33 | 21.81 | 0.9 | 3.086 | 7 | | | 2.46 |
| | 2013 | 2.62 | 0.34 | 24.25 | 0.69 | 2.548 | 8.4 | | | 2.52 |
| | 2014 | 4.3 | 0.45 | 26.15 | 0.88 | 2.629 | 7 | | | 2.82 |
| | 2015 | 4.52 | 0.71 | 25.5 | 0.88 | 2.603 | 6.8 | | | 2.92 |
| | 2016 | 2.85 | 0.72 | 24.9 | 0.61 | 2.825 | 7.3 | | | 3.01 |

Table 2.3.21. Assessment results of eutrophication indicators (ER) in the open sea in 2011-2016 (data source: PMŚ).

| Sub-basin | Year | Driving factors | | | | Direct effects | | | Indirect effects | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | DIN (XII-II) | DIP (XII-II) | TN (year) | TP (year) | CHL a (VI-IX) | SECCHI (VI-IX) | CyaBl index | Oxygen debt | B index |
| Bornholm Basin Polish waters | 2011 | 2.62 | 1.1 | 1.91 | 1.48 | 2.43 | 1.08 | 1.12 | 1.27 | 1.17 |
| | 2012 | 2.44 | 1.43 | 1.58 | 1.57 | 1.79 | 1.06 | | | 1.23 |
| | 2013 | 2.34 | 1.12 | 2.06 | 1.36 | 2.08 | 1.01 | | | 1.22 |
| | 2014 | 1.94 | 1.23 | 1.76 | 1.33 | 1.28 | 0.92 | | | 1.25 |
| | 2015 | 2.26 | 2.04 | 1.91 | 1.41 | 1.68 | 1.06 | | | 1.14 |
| | 2016 | 1.29 | 2.65 | 1.75 | 1.08 | 1.68 | 1.08 | | | 1.18 |
| | 2011-2016 | 2.15 | 1.59 | 1.83 | 1.37 | 1.82 | 1.03 | | | 1.18 |
| Gdańsk Basin Polish waters | 2011 | 1.84 | 1.29 | 1.42 | 1.66 | 1.97 | 1.12 | 1.19 | 1.25 | 0 |
| | 2012 | 0.62 | 1.06 | 1.2 | 1.47 | 1.41 | 1.08 | | | 2.26 |
| | 2013 | 1.25 | 0.76 | 1.61 | 1.36 | 1.77 | 1.2 | | | 1.67 |
| | 2014 | 0.98 | 1.21 | 1.54 | 1.2 | 2.34 | 1.27 | | | 3.53 |
| | 2015 | 1.42 | 1.95 | 1.49 | 1.32 | 1.32 | 1.05 | | | 1.67 |
| | 2016 | 1.37 | 2.3 | 1.57 | 1.17 | 2.36 | 1.25 | | | 1.69 |
| | 2011-2016 | 1.25 | 1.43 | 1.47 | 1.36 | 1.86 | 1.16 | | | 1.33 |
| Eastern Gotland Basin Polish waters | 2011 | 3.78 | 1.37 | 1.42 | 1.40 | 1.54 | 0.99 | 1.10 | 1.25 | 1.35 |
| | 2012 | 1.22 | 1.14 | 1.32 | 1.32 | 1.62 | 1.09 | | | 1.29 |
| | 2013 | 1.01 | 1.18 | 1.47 | 1.01 | 1.34 | 0.9 | | | 1.26 |
| | 2014 | 1.66 | 1.54 | 1.58 | 1.29 | 1.38 | 1.09 | | | 1.13 |
| | 2015 | 1.74 | 2.43 | 1.55 | 1.29 | 1.37 | 1.12 | | | 1.09 |
| | 2016 | 1.09 | 2.48 | 1.51 | 0.90 | 1.49 | 1.04 | | | 1.06 |
| | 2011-2016 | 1.75 | 1.69 | 1.47 | 1.20 | 1.46 | 1.04 | | | 1.11 |

Table 2.3.22. Final assessment results of Descriptor D5 in open sea in 2011-2016 (data source: PMŚ).

| Sub-basin | Driving factors | | | | | Direct effects | | | | Indirect effects | | | Assessment of Descriptor D5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DIN | DIP | TN | TP | avg. EQR | CHL a | SECCHI | CyaBl | avg. EQR | Oxygen debt | B index | avg. EQR | |
| | 2011-2016 | | | | | | | | | | | | |
| Bornholm Basin Polish waters | 2.15 | 1.59 | 1.83 | 1.37 | 1.74 | 1.82 | 1.03 | 1.12 | 1.32 | 1.27 | 1.18 | 1.22 | sub GES (1.74) |
| Gdańsk Basin Polish waters | 1.25 | 1.43 | 1.47 | 1.36 | 1.38 | 1.86 | 1.16 | 1.19 | 1.40 | 1.25 | 1.92 | 1.82 | sub GES (1.82) |
| Eastern Gotland Basin Polish waters | 1.75 | 1.69 | 1.47 | 1.20 | 1.53 | 1.46 | 1.04 | 1.10 | 1.20 | 1.25 | 1.11 | 1.18 | sub GES (1.53) |

### Comparison with the initial assessment for the years 2005-2010

Due to methodological differences referring to the indicators used to in the assessment, the method of integration of indicator results and differences in applied threshold values within the assessed sub-basins and waterbodies, it is not possible to relate the results of the current assessment to the results of the initial assessment of 2005-2010.

### Confidence of eutrophication assessment

Parallel to the assessment of the state of the environment under Descriptor D5, the assessment of confidence was carried out in the assessment units in accordance with the manual for the assessment of eutrophication of the Baltic Sea (HELCOM 2015c). According to the manual, each of the indicators used in the assessment was assigned a level of confidence based on two criteria:

1. Confidence of the status assessment (ES - status)

The criterion is calculated based on the number of observations under which the indicator was assessed in accordance with the rules:

- low value (= 0%) is assigned to the indicator, if the maximum of 5 annual status observations (expressed as the number of measurements made in the assessment season) in each assessment year were used for the assessment within a given unit,
- medium value (= 50%) is assigned if 5 to 15 observations of the status in each assessment year were used for the assessment within a given unit,
- high value (= 100%) is assigned when more than 15 state observations in each assessment year were used for the assessment within a given unit.

2. confidence of the threshold determination procedure (ET – status)

- high - when the threshold value was determined based on numerous observations made before the 1950s, preferably in combination with modelling,
- medium - when the threshold value was determined based on observations from before the 1980s and / or on the basis of modelling
- low - when the threshold value was determined as an expert opinion, or based on data from the period after the 1980s.

The value of the confidence of indicator (I-score) is the average value from ES-score and ET-score. The confidence values of the indicators used for the assessment within the groups of criteria were averaged using the weights used in the assessment of eutrophication. The final value of the confidence of the assessment is calculated as the average of the value of the confidence of the groups of criteria.

If a given group of criteria has been assessed on the basis of a single indicator, the assessment of the confidence of this group is reduced by 25%.

If the assessment was based only on a single criterion, the final confidence value is reduced by 50%.

In the case of transitional and coastal waters, the value of the confidence assessment was set on similar principles. The assessment of the confidence of the procedure for establishing the threshold value of indicators used in the assessment of Polish transitional and coastal waters was defined as low, only in the case of macrozoobenthos B and chlorophyll-a the value of ET score due to the intercalibration procedure was assigned as an average. Table 2.3.23 presents the values of confidence of indicators used in the assessment of transitional and coastal waters (I score), while in Table 2.3.24, final values of the confidence of the assessment.

The results of the final confidence of Descriptor D5 assessment in the open sea are given in Table 2.3.25.

Table 2.3.23.Confidence of eutrophication indicator assessment in transitional and coastal waters .

| Assessment unit | Driving factors | | | | | | | | Direct effects | | | | Indirect effects | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DIN | | DIP | | TN | | TP | | CHL a | | SECCHI | | O2 min | B index | $SM_1$ | ESMIz |
| | year | I-III | year | I-III | year | VI-IX | year | VI-IX | year | VI-IX | year | VI-IX | VI-IX | | | |
| Confidence of indicator (I score) | | | | | | | | | | | | | | | | |
| PL TW I WB 9 | 50% | - | - | 50% | 50% | - | 50% | - | - | 50% | - | 50% | 50% | - | - | 50% |
| PL TW I WB 8 | 50% | - | - | 50% | 50% | - | 50% | - | - | 50% | - | 50% | 50% | - | - | 50% |
| PL TW I WB 1 | 50% | - | - | 50% | 50% | - | 50% | - | - | 50% | - | 50% | 50% | - | - | 50% |
| PL TW II WB 2 | 50% | - | - | 50% | 50% | - | 50% | - | - | 50% | - | 50% | 50% | - | 50% | |
| PL TW III WB 3 | - | 50% | - | 50% | - | 50% | - | 50% | 50% | - | 50% | 50% | 50% | 50% | 50% | |
| PL TW IV WB 4 | - | 50% | - | 50% | - | 50% | - | 50% | 50% | - | 50% | 50% | 50% | 50% | - | |
| PL TW V WB 6 | - | 50% | - | 50% | - | 50% | - | 50% | 50% | - | 50% | 50% | 50% | 50% | - | |
| PL TW V WB 5 | - | 50% | - | 50% | - | 50% | - | 50% | 50% | - | 50% | 50% | 50% | 50% | - | |
| PL TW V WB 7 | - | 50% | - | 50% | - | 50% | - | 50% | 50% | - | 50% | 50% | 50% | 50% | - | |
| PL CW I WB 2 | - | 50% | - | 50% | - | 50% | - | 50% | 75% | - | 50% | 50% | 75% | 75% | - | |
| PL CW I WB 1 | - | 50% | - | 50% | - | 50% | - | 50% | 75% | - | 50% | 50% | 75% | 75% | - | |
| PL CW I WB 3 | - | 50% | - | 50% | - | 50% | - | 50% | 75% | - | 50% | 50% | 75% | 75% | - | |
| PL CW II WB 8 | - | 50% | - | 50% | - | 50% | - | 50% | 75% | - | 50% | 50% | 75% | 75% | - | |
| PL CW II WB 6W | - | 50% | - | 50% | - | 50% | - | 50% | 75% | - | 50% | 50% | 75% | 75% | - | |
| PL CW II WB 6E | - | 50% | - | 50% | - | 50% | - | 50% | 75% | - | 50% | 50% | 75% | 75% | 50% | |
| PL CW II WB 5 | - | 50% | - | 50% | - | 50% | - | 50% | 75% | - | 50% | 50% | 75% | 75% | - | |
| PL CW II WB 4 | - | 50% | - | 50% | - | 50% | - | 50% | 75% | - | 50% | 50% | 75% | 75% | - | |
| PL CW III WB 9 | - | 50% | - | 50% | - | 50% | - | 50% | 75% | - | 50% | 50% | 75% | 75% | - | |
| PL CW III WB 7 | - | 50% | - | 50% | - | 50% | - | 50% | 75% | - | 50% | 50% | 75% | 75% | - | |

-indicator is not applicable in the assessment of waterbody

Table 2.3.24. The final assessment of the confidence of eutrophication assessment in transitional and coastal waters.

| Waterbody code | Driving factors | Direct effects | Indirect effects | Final confidence assessment |
|---|---|---|---|---|
| | Confidence of the criteria group assessment | | | |
| PL TW I WB 9 | 50% | 50% | 50% | medium |
| PL TW I WB 8 | 50% | 50% | 50% | medium |
| PL TW I WB 1 | 50% | 62.5% | 50% | medium |
| PL TW II WB 2 | 50% | 50% | 50% | medium |
| PL TW III WB 3 | 50% | 50% | 50% | medium |
| PL TW IV WB 4 | 50% | 50% | 50% | medium |
| PL TW V WB 6 | 50% | 50% | 50% | medium |
| PL TW V WB 5 | 50% | 50% | 50% | medium |
| PL TW V WB 7 | 50% | 50% | 50% | medium |
| PL CW I WB 2 | 50% | 62.5% | 62.5% | medium |
| PL CW I WB 1 | 50% | 62.5% | 62.5% | medium |
| PL CW I WB 3 | 50% | 62.5% | 62.5% | medium |
| PL CW II WB 8 | 50% | 62.5% | 62.5% | medium |
| PL CW II WB 6W | 50% | 62.5% | 62.5% | medium |
| PL CW II WB 6E | 50% | 62.5% | 58.3% | medium |
| PL CW II WB 5 | 50% | 62.5% | 62.5% | medium |
| PL CW II WB 4 | 50% | 62.5% | 62.5% | medium |
| PL CW III WB 9 | 50% | 62.5% | 62.5% | medium |
| PL CW III WB 7 | 50% | 62.5% | 62.5% | medium |

Table 2.3.25. The assessment of the confidence of eutrophication assessment in open sea

| Sub-basin | Driving factors | | | | Direct effects | | | Indirect effects | |
|---|---|---|---|---|---|---|---|---|---|
| | DIN (XII-II)* | DIP (XII-II)* | TN (year) | TP (year) | CHL a (VI-IX) | SECCHI (VI-IX) | CyaBl | Oxygen debt | B index |
| | ES score | | | | | | | | |
| Bornholm Basin Polish waters | 50% | 50% | 100% | 100% | 100% | 100% | | 100% | 100% |
| Gdańsk Basin Polish waters | 0% | 0% | 100% | 100% | 50% | 50% | | 100% | 50% |
| Eastern Gotland Basin Polish waters | 50% | 50% | 100% | 100% | 100% | 100% | | 100% | 100% |
| ET score | | | | | | | | | |
| Bornholm Basin Polish waters | 50% | 50% | no | no | 50% | 50% | | 100% | 0% |
| Gdańsk Basin Polish waters | 50% | 50% | no | no | 50% | 50% | | 100% | 0% |
| Eastern Gotland Basin Polish waters | 50% | 50% | no | no | 50% | 50% | | 100% | 0% |
| I score | | | | | | | | | |
| Bornholm Basin Polish waters | 50% | 50% | 50% | 50% | 75% | 75% | | 100% | 50% |
| Gdańsk Basin Polish waters | 25% | 25% | 50% | 50% | 50% | 50% | | 100% | 25% |
| Eastern Gotland Basin Polish waters | 50% | 50% | 50% | 50% | 75% | 75% | | 100% | 50% |
| Confidence of criteria group assessment | | | | | | | | | |
| Bornholm Basin Polish waters | 50% | | | | 75% | | | 75% | |
| Gdańsk Basin Polish waters | 37.5% | | | | 50% | | | 62.5% | |
| Eastern Gotland Basin Polish waters | 50% | | | | 75% | | | 75% | |
| Final confidence assessment | | | | | | | | | |
| Bornholm Basin Polish waters | medium (66%) | | | | | | | | |
| Gdańsk Basin Polish waters | medium (50%) | | | | | | | | |
| Eastern Gotland Basin Polish waters | medium (66%) | | | | | | | | |

* Confidence assessment results from single measurements in XII-II

***Descriptor D6 - Seafloor integrity***

The seafloor integrity remains at a level that guarantees the protection of the structure and function of ecosystems and the lack of adverse effects especially on benthic ecosystems.

Pursuant to Decision 2017/848, five criteria were selected for Descriptor D6, all of which are primary criteria, i.e. they have to be included in the assessment of the state of the environment.

The first three criteria relate only to elements of pressure affecting the seabed, while the D6C4 and D6C5 criteria refer to the overall assessment of Descriptor D1 and are used independently of the assessment of Descriptor D6.

| Criteria elements | Description of the criterion in accordance with the decision 2017/848 | Methodological standards |
| --- | --- | --- |
| Physical loss of the seabed (including intertidal areas). | D6C1 — Primary:<br><br>Spatial extent and distribution of physical loss (permanent change) of the natural seabed. | *Scale of assessment*:<br>As used for assessment of the benthic broad habitat types under Descriptors 1 and 6.<br>*Use of criteria*:<br>The outcomes of assessment of criterion D6C1 (the distribution and an estimate of the extent of physical loss) shall be used to assess criteria D6C4 and D7C1.<br>The outcomes of assessment of criterion D6C2 (the distribution and an estimate of the extent of physical disturbance pressures) shall be used to assess criterion D6C3.<br>The outcomes of assessment of criterion D6C3 (an estimate of the extent of adverse effect by physical disturbance per habitat type in each assessment area) shall contribute to the assessment of criterion D6C5. |
| Physical disturbance to the seabed (including intertidal areas). | D6C2 — Primary:<br><br>Spatial extent and distribution of physical disturbance pressures on the seabed. | |
| Benthic broad habitat types or other habitat types, as used under Descriptors 1 and 6. | D6C3 — Primary:<br><br>Spatial extent of each habitat type which is adversely affected, through change in its biotic and abiotic structure and its functions (e.g. through changes in species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), by physical disturbance.<br>Member States shall establish threshold values for the adverse effects of physical disturbance, through regional or subregional cooperation | |
| Benthic broad habitat types as listed in Table 2 and if present in the region or subregion, and other habitat types as defined in the second paragraph.<br>Member States may select, through regional or subregional cooperation, additional habitat types, according to the criteria laid down under 'specifications for the selection of species and habitats', and which may include habitat types listed under Directive 92/43/EEC or international agreements such as Regional Sea Conventions, for the purposes of: a) assessing each broad habitat type under criterion D6C5; b) | D6C4 — Primary:<br><br>The extent of loss of the habitat type, resulting from anthropogenic pressures, does not exceed a specified proportion of the natural extent of the habitat type in the assessment area.<br>Member States shall establish the maximum allowable extent of habitat loss as a proportion of the total natural extent of the habitat type, through cooperation at Union level, taking into account regional or subregional specificities. | *Scale of assessment*:<br>Subdivision of region or subregion, reflecting biogeographic differences in species composition of the broad habitat type.<br>*Use of criteria*:<br>A single assessment per habitat type, using criteria D6C4 and D6C5, shall serve the purpose of assessments of both benthic habitats under Descriptor 1 and sea-floor integrity under Descriptor 6.<br>The extent to which good environmental status has been achieved shall be expressed for each area assessed as:<br>a) for D6C4, an estimate of the proportion and extent of loss per habitat type and whether this has achieved the extent value set;<br>b) for D6C5, an estimate of the proportion and extent of adverse effects, including the proportion lost from point (a), per habitat type and |

| Criteria elements | Description of the criterion in accordance with the decision 2017/848 | Methodological standards |
|---|---|---|
| assessing these habitat types.<br>A single set of habitat types shall serve the purpose of assessments of both benthic habitats under Descriptor 1 and sea-floor integrity under Descriptor 6 | | whether this has achieved the extent value set;<br>c) overall status of the habitat type, using a method agreed at Union level based on points (a) and (b), and a list of broad habitat types in the assessment area that were not assessed. |
| | D6C5 — Primary:<br><br>The extent of adverse effects from anthropogenic pressures on the condition of the habitat type, including alteration to its biotic and abiotic structure and its functions (e.g. its typical species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), does not exceed a specified proportion of the natural extent of the habitat type in the assessment area.<br>Member States shall establish threshold values for adverse effects on the condition of each habitat type, ensuring compatibility with related values set under Descriptors 2, 5, 6, 7 and 8, through cooperation at Union level, taking into account regional or subregional specificities.<br>Member States shall establish the maximum allowable extent of those adverse effects as a proportion of the total natural extent of the habitat type, through cooperation at Union level, taking into account regional or subregional specificities. | |

The following criteria are applicable as part of the Descriptor D1 assessment:

- for D6C1, permanent changes in the seabed due to different types of human activity will be assessed (including permanent changes in natural seabed substrates or morphology through physical restructuring, infrastructure development and substrate loss through the extraction of materials from the seabed);
- physical disturbances due to different types of human activities (such as bottom trawling) will be assessed for D6C2);
- data on hydromorphology and relevant assessments carried out in accordance with the WFD will be used for coastal waters. In addition to coastal waters, data may come from infrastructure mapping and licensed extraction sites.

The scale of the assessment is analogous to the assessment of general benthic habitat types within Descriptor D1 and D6.

Criteria D6C4 and D6C5 are assessed on the basis of relevant indicators directly within the Descriptor D1.

Regarding assessment methods, data should be aggregated so that D6C1 criterion is assessed as a area lost with respect to the total size of all natural benthic habitats in the assessed area (e.g. through the scope of anthropogenic changes), and D6C3 criterion was assessed against the total natural range of each type of benthic habitats assessed.

Physical loss is understood as a permanent change in the seabed, which continues or is expected to last for a period of two management cycles (12 years) or longer. Physical disturbance, on the other hand, is understood as change in the seabed, which can be reversed if the activity causing the interference ceases.

Relevant core indicators should be expressed in units of the bottom area subjected to loss or disturbances or the coverage of any type of habitat adversely affected by the impact, or as a percentage of the total natural extent of the habitat in the assessed area.

The assessment of the WFD coastal waters was carried out in accordance with the developed method presented in "The development of methodologies for monitoring and classification of hydrological elements of the quality of transitional and coastal waterbodies as required by the WFD" (GIOŚ, 2009) being part of the planned hydromorphological monitoring together with the available inventory of elements of maritime infrastructure directly affecting the seabed. This method has been modified as part of the verification of the methodology for the determination of heavily modified parts of transitional and coastal waterbodies, and presented in the "Development of a methodology for verification of heavily modified and artificial waterbodies" (KZGW, 2011). The modification concerned, first of all, a change in the value of significance indicators of infrastructure elements and the introduction of a new element - the length of fairways (KZGW 2011).

The list of occurrence of permanent structures of hydrotechnical infrastructure meets the methodological requirements of criterion D6C1 - spatial extent and distribution of permanent changes in the natural seabed. Due to the fact that hydrotechnical building has both surface ($km^2$) and linear (km) constructions, the applied method of assessment links the effect of these structures to the relevant part of the marine ecosystem, as an indicator of changes in ecosystem resilience, which indirectly corresponds to the criterion D6C3.

Linear infrastructure include hydrotechnical facilities such as waterfront and shore bands, used to protect the shore against abrasion and breakwaters protecting the ports. Linear objects can also include underwater thresholds, which serve to weaken and dissipate wave energy. Transverse buildings are mainly piers, steering wheels on the foreshore of river estuaries and sea-going jetties (Table 2.3.26).

In the case of objects consisting of many elements along the coast, e.g. spurs, the total surface area at which they are found or the total length of the shore is taken into account.

The assessment method in summing up the relevant types of changes included in: "Development of a methodology for verification of heavily modified and artificial waterbodies" (KZGW, 2011) multiplied by relevance indicators included in this study (Table 2.3.27 and Table 2.3.28), and then determination of the ratio of values obtained to the surface of waterbody or the length of the shoreline. The results are summed up and expressed as a percentage. The obtained value is an indicator of changes in the resistance of the ecosystem (WskZM), for which the limit values of 5% and 10% corresponding to the very good and good environment status have been accepted. The value of the index lower than 10%, but higher than 30% means moderate condition. The 30% limit means a change in the case of which the waterbody is considered to be heavily modified.

By transferring the above values to the MSFD assessment scale, a threshold of 10% was adopted for the Index, which means achieving good status (GES) for values lower than 10%.

The available data on technical infrastructure within transitional and coastal waterbodies collected as part of the pressure assessment in 2015 (KZGW 2015) was used for the assessment. The data have been updated in the scope of shore supply with the list from Chapter 4.

Table 2.3.26. Types of hydromorphological changes (**Zm**) in transitional and coastal waters

| Type of changes - Zm | Description of changes | Unit Zm |
|---|---|---|
| Changes in the flow = inflow of fresh water | | |
| Change in the input of freshwater | Occurrence of historogical morphological changes that completely change the flow of freshwater - construction of estuaries, cutting off river estuaries | Yes/No |
| Change in the input of freshwater | Change in the amount of freshwater inflow. | Qn95% |
| Change in the input of other waters | Water discharge from wastewater treatment plants or sewers and brine. | $m^3/s$ |
| Disturbance of seabed and sediment | | |
| Deepening of existing waterways. | Maintaining a specific depth of an existing waterway. | Area [$km^2$] |
| Changes of surface bottom sediments. | Underwater works, e.g. trawling or other activities affecting surface sediments. | Area [$km^2$] |
| Deposition of dredged material. | Storage of sludge from dredging or shore supply. | Area [$km^2$] |
| Hydrotechnical construction – seabed loss | | |
| Piers, Groynes | Different structures on one or many foundations entering the sea. Also single buildings, wind farms | Length [km] |
| Changes in the flow direction. | Permanent structures that significantly change the direction of waves and littoral currents. Breakers, breakwaters. Barriers, breakwaters facing the sea, with intervals <20% of the total length. | Length [km] |
| Changes in the flow direction. | The occurrence of fairway with a significant depth in relation to the depth of the basin only on the lagoons (JCWP transitional) | Length [km] |
| Protective/blocking constructions. | Constructions across the canal, locks etc. | Length [km] |
| Waterfront wharfs. | Coastal constructions | Length [km] |
| Changes on the shore | | |
| Strengthening of the shore - permanent | Constructions created to protect the shore from abrasion with constant, significant impact on currents and waves, gabion, concrete and other bands. | Length [km] |
| Strengthening of the shore - not permanent | Supplying shore, beaches, also using synthetic materials, refulation. | Length [km] |
| Flood embankments within 500 m from the shore | Artificial embankments to protect the land against water impact. | Length [km] |

Table 2.3.27. Indicators of the significance of hydromorphological changes **(WskZn)** for transitional waters

| Type of morphological changes | **WskZn** | |
|---|---|---|
| | Open waters | Lagoons |
| Disturbance of seafloor and sediments | | |
| Deepening of existing waterways. | 0.50 | 0.67 |
| Changes of surface sediments. | 0.15 | 0.20 |
| Deposition of dredged material. | 0.19 | 0.50 |
| Hydrotechnical construction | | |
| Piers, Groynes | 0.20 | 0.25 |
| Changes in the flow direction - breakwaters | 0.20 | 0.40 |
| Changes in the flow direction - fairways and shipping channels of considerable depth on the lagoons | 0.10 | 0.40 |
| Protective/blocking constructions. | 0.25 | 0.50 |
| Waterfront wharfs. | 0.25 | 0.50 |
| Changes on the shore | | |
| Strengthening of the shore – permanent (seawalls) | 0.20 | 0.20 |
| Strengthening of the shore – not permanent (supply) | 0.08 | 0.08 |
| Flood embankments | 0.13 | 0.13 |

Table 2.3.28. Indicators of the significance of hydromorphological changes (**WskZn**) for two types of coast of coastal waters

| Type of morphological changes | WskZn | |
|---|---|---|
| | Cliff type | Dune type |
| Disturbance of seabed and sediment | | |
| Fairways | 0.05 | 0.10 |
| Deepening of existing waterways | 0.05 | 0.10 |
| Deposit of dredged material | 0.05 | 0.10 |
| Other changes of surface sediments | 0.05 | 0.05 |
| Hydrotechnical construction | | |
| Piers**,** Groynes | 0.15 | 0.10 |
| Changes in the flow direction - breakwaters | 0.15 | 0.25 |
| Protective/blocking constructions. | 0.25 | 0.25 |
| Wharfs, tidal barrages | 0.30 | 0.30 |
| Changes on the shore | | |
| Strengthening of the shore – permanent (seawalls) | 0.25 | 0.10 |
| Strengthening of the shore – not permanent (supply) | 0.05 | 0.05 |
| Flood embankments | --- | 0.05 |

The following tables contain the results of hydromorphic status assessment of individual waterbodies (WB) in the Vistula and Odra river basin districts, without heavily modified waterbodies, which were assigned the value of subGES assessment according to MSFD.

In tables, the total values of "Changes" for linear objects correspond to the requirements of criterion D6C1 in relation to individual waterbodies, while the total value of bottom disturbance meets the requirements of criterion D6C2. The total value of **WskZm** refers to criterion D6C3.

## Vistula river basin district

| Transitional waterbody - Puck Lagoon – TWII WB2 | | | | |
|---|---|---|---|---|
| Area [km$^2$] | 111.13 | Length of the shorline [km] | | 52.94 |
| | | | | |
| **Linear objects** | Area [km$^2$] | Length [km] | Significance indicator | **Change** [km] |
| Beach replenishment | | 1.3 | 0.08 | 0.10 |
| Sea walls | | 21.960 | 0.20 | 4.392 |
| | | | Total | **4.492** |
| Total change in ecosystem resistance **- WskZm** | | | | 8.50% |
| **Assessment** | | | | **Good status** |

| Transitional waterbody Outher Puck Bay – TWII WB3 | | | | |
|---|---|---|---|---|
| Area [km$^2$] | 286.0 | Length of the shorline [km] | | 67.96 |
| | | | | |
| **Disturbance to the surface of sediments** | Area [km$^2$] | Length [km] | Significance indicator | **Change** [km$^2$] |
| Anchoring | 15 | | 0.15 | 3 |
| Dredged material disposal sites | 2.5 | | 0.19 | 1.25 |
| Fairway | 0.7 | 6 | 0.50 | 0.469 |
| | | | Total | **4.719** |
| Resistance change | | | | 1.65% |
| | | | | |
| **Linear objects** | Area [km$^2$] | Length [km] | Significance indicator | **Change** [km] |
| Beach replenishment | | 4.29 | 0.08 | 0.343 |
| Sea walls | | 9.63 | 0.20 | 1.93 |
| Breakwaters | | 0.33 | 0.20 | 0.066 |
| Groynes | | 0.58 | 0.20 | 0.035 |

| | | | | |
|---|---|---|---|---|
| Platforms | | 0.400 | 0.20 | 0.08 |
| | | | Total | **2.45** |
| Total change in ecosystem resistance - **WskZm** | | | | 3.61% |
| **Assessment** | | | | **Good status** |

| | | | | |
|---|---|---|---|---|
| Transitional waterbody Inner Gulf of Gdańsk – TWIV WB4 | | | | |
| Area [km²] | 710.28 | Length of the shorline [km] | | 130.21 |
| | | | | |
| **Linear objects** | Area [km²] | Length [km] | Significance indicator | Change [km] |
| Beach replenishment | | 2.58 | 0.08 | 0.21 |
| Sea walls | | 1.81 | 0.20 | 0.362 |
| Groynes, weirs | | 0.160 | 0.20 | 0.032 |
| | | | Total | **0.604** |
| Total change in ecosystem resistance - **WskZm** | | | | 0.5% |
| **Assessment** | | | | **Very good status** |

| | | | | |
|---|---|---|---|---|
| Coastal waterbody Vistula Spit CWI WB1 | | | | |
| Area [km²] | 41.33 | Length of the shorline [km] | | 49.16/2 |
| | | | | |
| **Disturbance of seafloor** | | | | |
| | Area [km²] | Length [km] | Significance indicator | Change [km²] |
| Anchoring | 0 | | 0.15 | |
| Dredged material disposal sites | 0 | | 0.19 | |
| Fairway | 0 | | 0.50 | |
| | | | Total | |
| | | | Resistance change | |
| | | | | |
| **Linear objects** | | | | |
| Sea walls | 0 | | 0.20 | |
| Breakwaters | 0 | | 0.25 | |
| Groynes | 0 | | 0.10 | |
| Platforms. quays | | | 0.25 | |
| | | | Total | **0** |
| Total change in ecosystem resistance - **WskZm** | | | | 0% |
| **Assessment** | | | | **Very good status** |

| | | | | |
|---|---|---|---|---|
| Coastal waterbody Hel Peninsula CWI WB2 | | | | |
| Area [km²] | 70.15 | Length of the shorline [km] | | 39.94 |
| | | | | |
| **Linear objects** | Area [km²] | Length [km] | Significance indicator | Change [km] |
| Beach replenishment | | 23.2 | 0.05 | 1.16 |
| Sea walls | | 1.580 | 0.10 | 0.158 |
| Groynes | | 12.300 | 0.10 | 1.23 |
| | | | Total | **3.94** |
| Total change in ecosystem resistance - **WskZm** | | | | 9.85% |
| **Assessment** | | | | **Good status** |

| | | | | |
|---|---|---|---|---|
| Coastal waterbody Władysławowo - Jastrzębia Góra CWII WB4 | | | | |
| Area [km²] | 17.438 | Length of the shorline [km] | | 9.49 |
| | | | | |
| **Linear objects** | Area [km²] | Length [km] | Significance indicator | Change [km] |
| Sea walls | | 1.950 | 0.10 | 0.195 |

| | | | | |
|---|---|---|---|---|
| Breakwaters | | | 0.25 | |
| Groynes | | | 0.10 | |
| Platforms, quays | | | 0.25 | |
| | | | Total | **0.195** |
| Total change in ecosystem resistance - **WskZm** | | | | 2.05% |
| **Assessment** | | | | **Very good status** |

| Coastal waterbody Jastrzębia Góra - Rowy CWIII WB5 | | | | |
|---|---|---|---|---|
| Area [km2] | 141.0 | Length of the shorline [km] | | 78.095 |
| | | | | |
| Linear objects | Area [km2] | Length [km] | Significance indicator | Change [km] |
| Beach replenishment | | 1.5 | 0.05 | 0.075 |
| Sea walls | | 2.77 | 0.25 | 0.693 |
| Groynes | | 0.4 | 0.15 | 0.06 |
| | | | Total | **0.828** |
| Total change in ecosystem resistance - **WskZm** | | | | 1.06% |
| Assessment | | | | **Very good status** |

| Coastal waterbody Rowy - Jarosławiec East CWII WB6E | | | | |
|---|---|---|---|---|
| Area [km$^2$] | 46.01 | Length of the shorline [km] | | 24.93 |
| | | | | |
| Linear objects | Area [km$^2$] | Length [km] | Significance indicator | Change [km] |
| Beach replenishment | | 1.5 | 0.08 | 0.12 |
| Embankment/Groynes | | 1.67 | 0.10 | 0.17 |
| Groynes | | 1.6 | 0.10 | 0.16 |
| | | | Total | **0.49** |
| Total change in ecosystem resistance - **WskZm** | | | | 1.96% |
| Assessment | | | | **Very good status** |

## Odra river basin district

| Transitional waterbody Kamieński Lagoon– TWI WB9 | | | | |
|---|---|---|---|---|
| Area [km$^2$] | 436.0 | Length of the shorline [km] | | 105.42 |
| | | | | |
| **Linear objects** | Area [km$^2$] | Length [km] | Significance indicator | Change [km] |
| Sea walls | | 1.253 | 0.50 | 0.627 |
| Breakwaters | | 0.961 | 0.40 | 0.384 |
| Flood banks | | 2.486 | 0.13 | 0.323 |
| Total | | | | **1.334** |
| Total change in ecosystem resistance - **WskZm** | | | | 1.2% |
| **Assessment** | | | | **Good status** |

| Coastal waterbody Rowy - Jarosławiec West CWII WB6W | | | | |
|---|---|---|---|---|
| Area [km$^2$] | 38.78 | Length of the shorline [km] | | 20.99 |
| | | | | |
| **Linear objects** | Area [km$^2$] | Length [km] | Significance indicator | Change [km] |
| Sea walls | | | 0.20 | |
| Breakwaters | | | 0.25 | |
| Groynes | | 1.464 | 0.15 | 0.220 |
| Platforms. quays | | 0.127 | 0.10 | 0.013 |
| Flood banks | | 0.270 | 0.05 | 0.013 |
| | | | Total | **0.246** |

| | |
|---|---|
| Total change in ecosystem resistance - **WskZm** | 1.2% |
| **Assessment** | **Very good status** |

| Coastal waterbody Jarosławiec - Sarbinowo CWIII WB7 | | | | |
|---|---|---|---|---|
| Area [km$^2$] | 98.58 | Length of the shorline [km] | | 53.538 |
| | | | | |
| **Linear objects** | Area [km$^2$] | Length [km] | Significance indicator | Change [km] |
| Beach replenishment | 0.02 | 1.1 | 0.08 | 0.09 |
| Sea walls | | 15.517 | 0.10 | 1.55 |
| Breakwaters | | 0.751 | 0.25 | 0.19 |
| Groynes | | 29.490 | 0.10 | 2.95 |
| Flood banks | | 4.740 | 0.05 | 0.24 |
| | | | Total | **5.02** |
| Total change in ecosystem resistance – **WskZm** | | | | 9.37% |
| **Assessment** | | | | **Good status** |

| Coastal waterbody Sarbinowo - Dziwna CWII WB8 | | | | |
|---|---|---|---|---|
| Area [km$^2$] | 153.67 | Length of the shorline [km] | | 83.438 |
| | | | | |
| **Linear objects** | Area [km$^2$] | Length [km] | Significance indicator | Change [km] |
| Beach replenishment | | 9.1 | 0.08 | 0.728 |
| Sea walls | | 15.621 | 0.10 | 1.562 |
| Breakwaters | | 1.055 | 0.25 | 0.388 |
| Groynes | | 27.07 | 0.10 | 2.701 |
| | | | Total | **5.379** |
| Total change in ecosystem resistance – **WskZm** | | | | 6.44% |
| **Assessment** | | | | **Good status** |

| Coastal waterbody Dziwna – Świna CWIII WB9 | | | | |
|---|---|---|---|---|
| Area [km$^2$] | 58.83 | Length of the shorline [km] | | 31.843 |
| | | | | |
| **Linear objects** | Area [km$^2$] | Length [km] | Significance indicator | Change [km] |
| Beach replenishment | | 0.55 | 0.08 | 0.044 |
| Breakwaters | | 0.165 | 0.25 | 0.41 |
| Groynes | | 1.48 | 0.10 | 0.148 |
| Platforms. quays | | 0.165 | 0.25 | 0.41 |
| | | | Total | **1.012** |
| Total change in ecosystem resistance - **WskZm** | | | | 3.17% |
| **Assessment** | | | | **Very good status** |

In the open sea areas, physical loss of the seabed, according to the results of the analysis of marine pressures on the sea (Chapter 4), is not a significant factor in the assessment, and therefore the Bornholm Basin, the Eastern Gotland Basin and the Gdask Basin can be assigned according to this criterion GES status.

The assessment according to the criterion D6C1 for particular transitional and coastal waterbodies as well as for the open sea is presented in Table 2.3.29, according to the color scheme for the WFD and MSFD assessments respectively.

Table 2.3.29. Assessment of transitional and coastal waterbodies (WB) and open sea areas according to criterion D6C1. (Data source: PMŚ)

| **Assessment of permanent changes** | | |
|---|---|---|
| **Waterbodies** | WFD asssessment | GES |
| WB transitional Puck lagoon – TWII WB2 | | |
| WB transitional Outer Puck Bay– TWII WB3 | | |
| WB transitional Inner Gulf of Gdańsk – TWIV WB4 | | |
| WB coastal Vistula Spit CWI WB1 | | |
| WB coastal Hel Penninsula CWI WB2 | | |
| WB coastal Władysławowo - Jastrzębia Góra CWII WB4 | | |
| WB coastal Jastrzębia Góra - Rowy CWIII WB5 | | |
| WB coastal Rowy - Jarosławiec East CWII WB6E | | |
| WB transitional Kamieński lagoon – TWI WB9 | | |
| WB coastal Rowy - Jarosławiec West CWII WB6W | | |
| WB coastal Jarosławiec - Sarbinowo CWIII WB7 | | |
| WB coastal Sarbinowo - Dziwna CWII WB8 | | |
| WB coastal Dziwna – Świna CWIII WB9 | | |
| Highly modified WB Wisła Przekop mouth TWII WB5 | | |
| Highly modified WB Vistula lagoon TWI WB1 | | |
| Highly modified WB Władysławowo Port CWI WB3 | | |
| Highly modified WB Dziwna mouth TWII WB6 | | |
| Highly modified WB Świna mouth TWII WB7 | | |
| Highly modified WB Szczecin lagoon TWI WB8 | | |
| **Open sea waters** | | |
| Gdańsk Basin | | |
| Eastern Gotland Basin | | |
| Bornholm Basin | | |

In the case of transitional and coastal waterbodies, information on the area of anchorages, site of deposition of dredged material and shore supply with regard to the size of the coastal active zone as disturbances of the seabed (D6C2) was used (Table 2.3.30).

Table 2.3.30. Assessment of transitional and coastal waterbodies (WB) according to the D6C2 criterion, marked according to the color scheme for the assessment according to WFD and MSFD (Data source: PMŚ)

| Assessment of disturbance | | |
|---|---|---|
| Waterbodies | WFD assessment | Ocean MSFD assessment |
| WB transitional Puck lagoon – TWII WB2 | | |
| WB transitional Inner Puck Bay– TWII WB3 | | |
| WB transitional Inner Gulf of Gdańsk – TWIV WB4 | | |
| WB coastal Vistula Spit CWI WB1 | | |
| WB coastal Hel Penninsula CWI WB2 | | |
| WB coastal Władysławowo - Jastrzębia Góra CWII WB4 | | |
| WB coastal Jastrzębia Góra - Rowy CWIII WB5 | | |
| WB coastal Rowy - Jarosławiec East CWII WB6E | | |
| WB transitional Kamieński lagoon – TWI WB9 | | |
| WB coastal Rowy - Jarosławiec West CWII WB6W | | |
| WB coastal Jarosławiec - Sarbinowo CWIII WB7 | | |
| WB coastal Sarbinowo - Dziwna CWII WB8 | | |
| WB coastal Dziwna – Świna CWIII WB9 | | |

For the open sea area, one of the core indicators that can be used in the D6C2 criterion is the spatial extent and distribution of the physical pressures of disturbances to the seabed determined on the basis of available data on benthic trawling. According to the list of pressures (Chapter 4), this is the most important element of pressure on the seabed. The fishing effort presented there, in individual ICES squares, however, does not refer to the surface of the bottom subjected to disturbance as a result of trawling.

As part of the development of the update of initial assessment, an attempt was made to estimate this ratio in accordance with Decision 2017/848. On the basis of data from the Fisheries Monitoring Centre, the seafloor area subjected to trawling was tested in 2016. With the information on trawling vessel location and trawl time and the type of fishing gear used , taking into calculations the trawl mouth width of 15 meters and the trawling speed of 3 knots the probable total surface of trawling in individual ICES squares in 2016 was determined (Fig. 2.3.29).

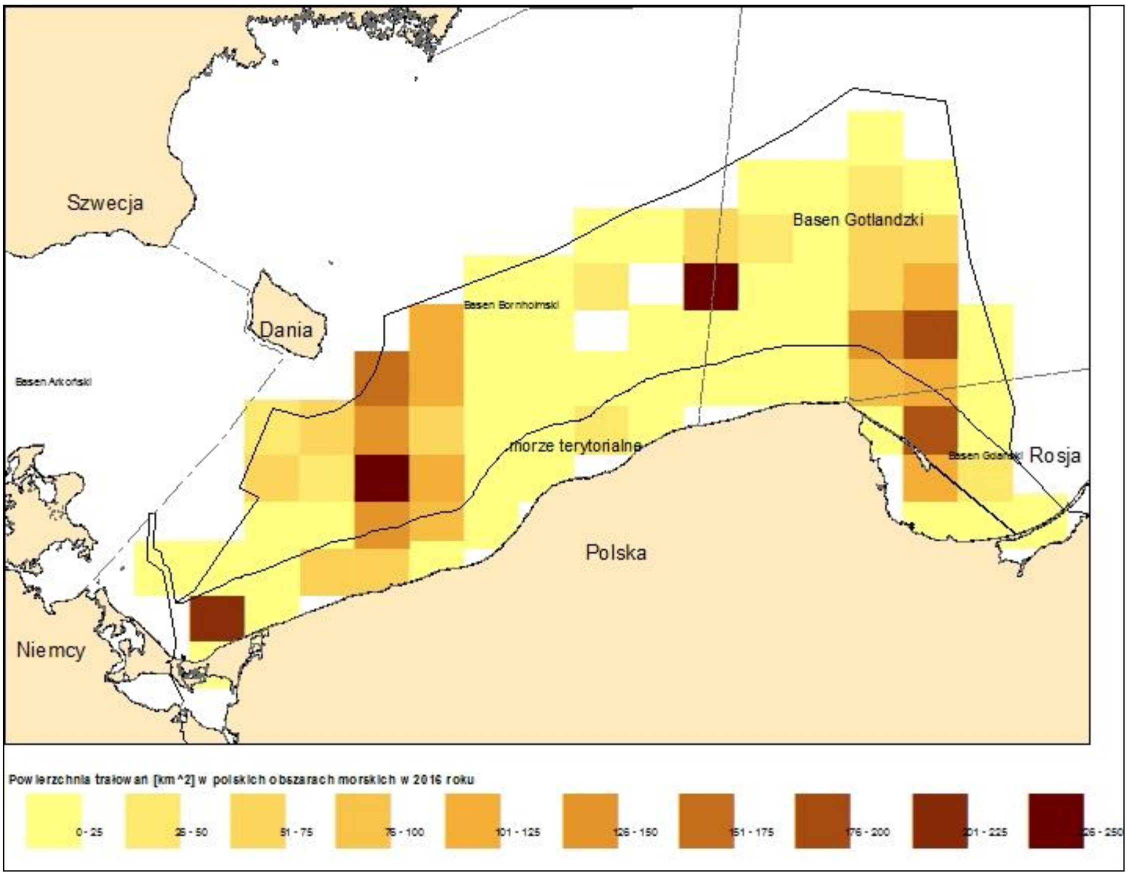



Fig. 2.3.29. Surface of benthic trawling in POM in 2016.

The assessment of fishing intensity in 2016 is presented in Fig. 2.3.30. The figure shows that, on average, the surface of the bottom subjected to trawling each year was less than 1 km$^2$. Despite this, the open issue is the accumulation of many cruises within individual squares, which can be assessed negatively as frequent bottom disturbance.

Considering that the above estimation is subject to a large error, the data used by ICES for the holistic assessment of HELCOM HOLAS II project and published in the technical report (ICES 2017) were used for the assessment. The report was prepared in 2015 in accordance with the method developed by Eigaard O. R. et al. (2015) and presented in the 2016 technical report (ICES 2016) taking into account the data from 2016 supplemented by the Baltic states as part of the assessment update process.

Spatial data on fishing intensity as pressure on the seabed in 0.05 x 0.05 degree c-squares has been developed in accordance with the method described by Eigaard et al. (2016) for various fishing gear. To determine the bottom area, data from logbooks and position data of fishing vessels from the VMS (vessel monitoring system) system were used (ICES 2017). The absolute surface subjected to trawling as well as the ratio of this area to the surface of c-squares determined as the relative value of SAR (swept area ratio) for each fishing gear and the total gear were determined. The data concerned the surface with a penetration of fishing gear of depth less than 2 cm (surface) and more than 2 cm (subsurface).

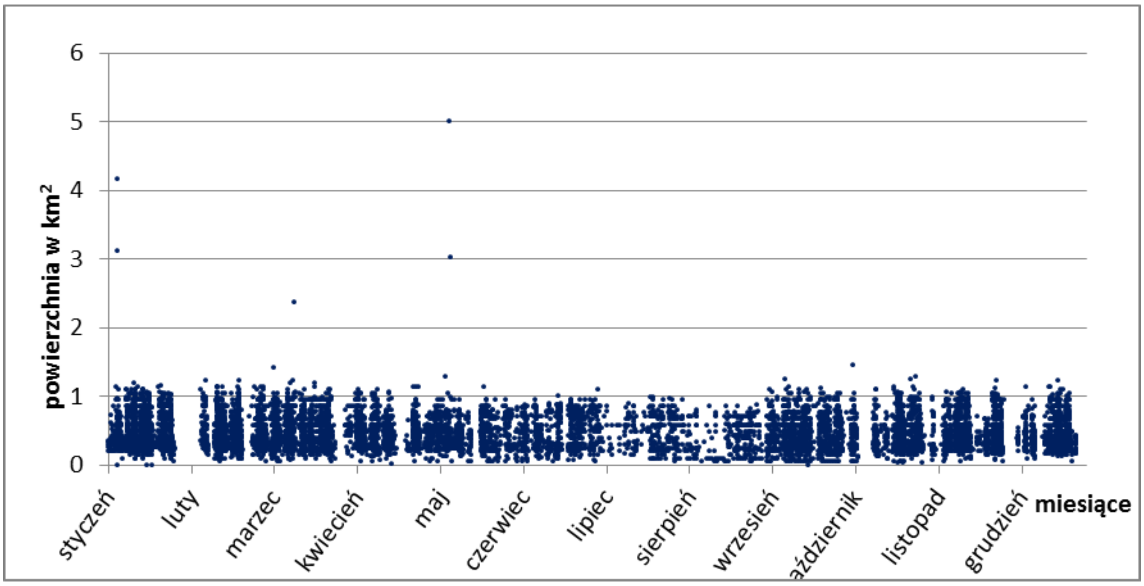



Fig. 2.3.30. Area of the disturbed bottom (km$^2$) (vertical axis) during individual fishing cruises (months Jan-Dec - horizontal axis) in 2016

The fishing intensity in the years 2011-2016 determined on the basis of the above data is presented in Fig. 2.3.31, in turn an example of a relative seabed disturbance in 2016 in Fig. 2.3.32. The main areas of pressure, both in terms of fishing intensity and the relative surface area of SAR, often more than ten times the surface of c-squares, are found in the western part of Bornholm Basin, north-eastern part of Eastern Gotland Basin and in the area of Gdańsk Basin and partly of its coastal waters.

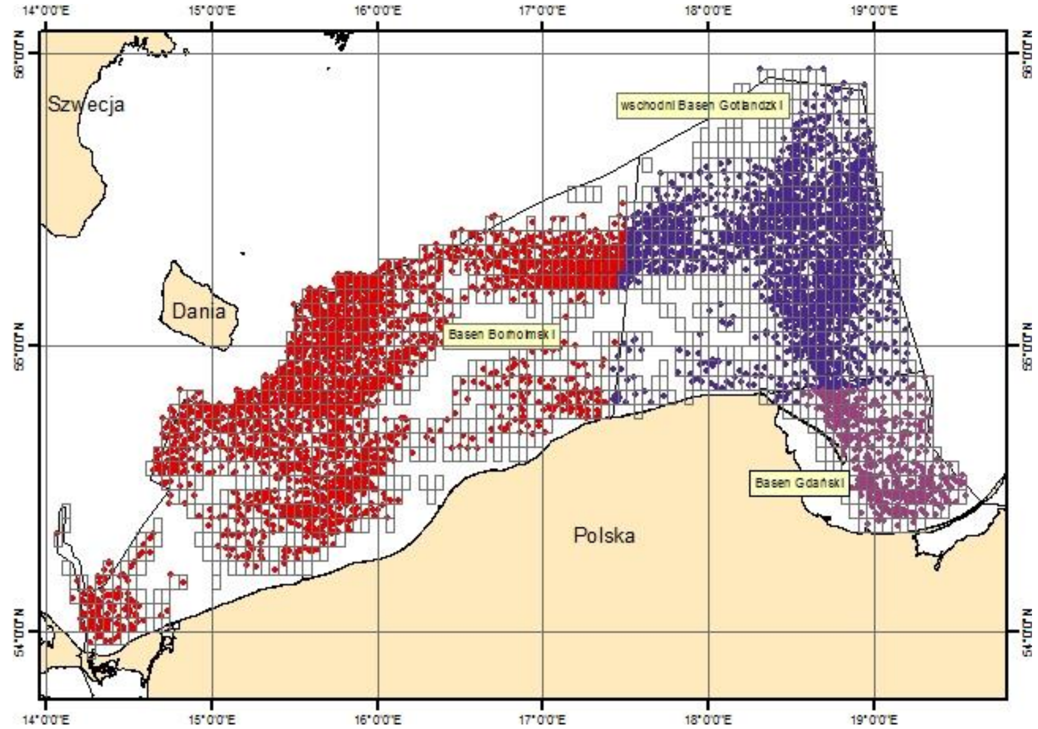



Fig. 2.3.31. Fishing intensity (subsurface bottom trawling) in 2011-2016 in individual basins within POM. The dots represent the frequency of individual benthic trawling. The colours mean trawling in a particular sub-basin.

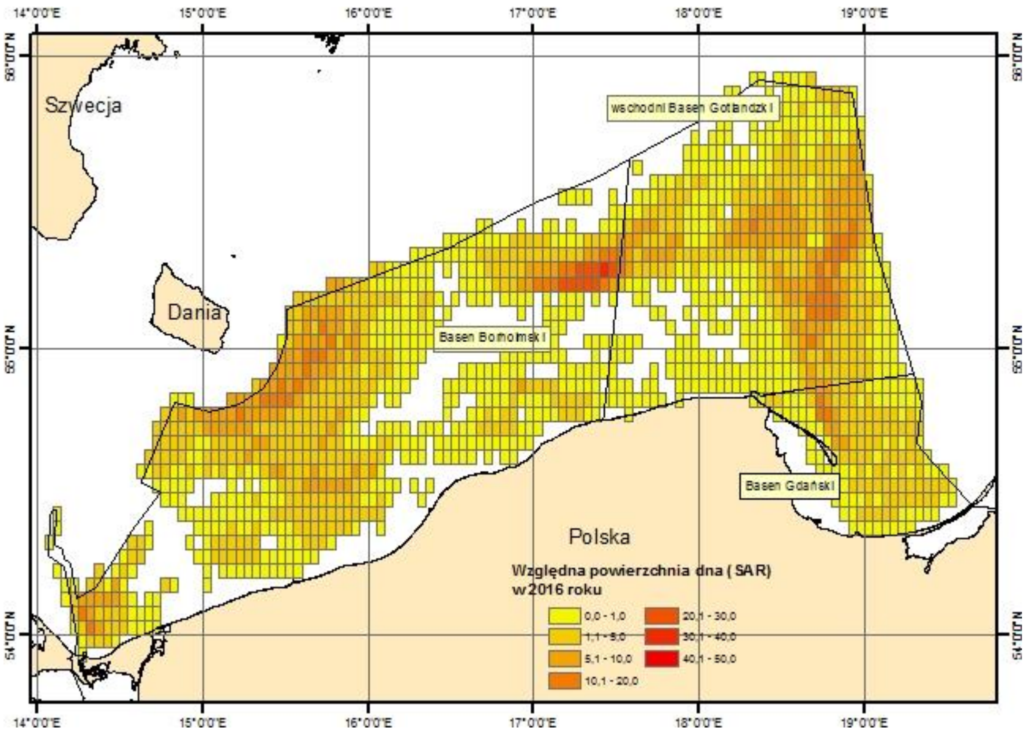



Fig. 2.3.32. Swept area ratio (SAR) of seabed subjected to surface trawling with different fishing gear in 2016 in the POM area.

Table 2.3.31. Average surface and subsurface SAR values within individual sub-basins in POM in subsequent years of assessment

| Year/sub-basin | SurfaceSAR | Subsurface |
|---|---|---|
| **2011** | **2.33** | **0.18** |
| Bornholm Basin | 2.14 | 0.16 |
| Gdańsk Basin | 1.42 | 0.09 |
| Eastern Gotland Basin | 2.83 | 0.22 |
| **2012** | **3.68** | **0.28** |
| Bornholm Basin | 3.91 | 0.30 |
| Gdańsk Basin | 2.96 | 0.21 |
| Eastern Gotland Basin | 3.55 | 0.28 |
| **2013** | **3.33** | **0.26** |
| Bornholm Basin | 3.27 | 0.25 |
| Gdańsk Basin | 3.73 | 0.28 |
| Eastern Gotland Basin | 3.31 | 0.26 |
| **2014** | **3.35** | **0.26** |
| Bornholm Basin | 3.92 | 0.30 |
| Gdańsk Basin | 2.69 | 0.19 |
| Eastern Gotland Basin | 2.74 | 0.21 |
| **2015** | **3.03** | **0.23** |
| Bornholm Basin | 3.18 | 0.24 |
| Gdańsk Basin | 2.24 | 0.17 |
| Eastern Gotland Basin | 3.02 | 0.24 |
| **2016** | **2.57** | **0.20** |
| Bornholm Basin | 2.67 | 0.21 |
| Gdańsk Basin | 1.68 | 0.12 |
| Eastern Gotland Basin | 2.68 | 0.21 |
| **Average in 2011- 2016** | **3.29** | **0.25** |

Table 2.3.31 presents average SAR values in subsequent years in individual sub-basins, while the SAR distribution in subsequent years for all c-squares is presented in Fig. 2.3.34. Analyzing the data, attention is paid to a significant concentration of fishing intensity in a dozen or so c-squares, where there were few, but very intense trawl surveys (Fig. 2.3.33). These squares are located in the region between 17.2 and 17.48 degrees of eastern longitude and between 55.23 and 55.27 north latitude, north of the Słupsk Bank.
It is also noteworthy that such a large area of the bottom was subjected to cumulative pressure during only a few cruises each year:

| **Year** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
|---|---|---|---|---|---|---|
| **Number of cruises** | 1.00 | 5.00 | 4.00 | 3.00 | 2.00 | 1.00 |

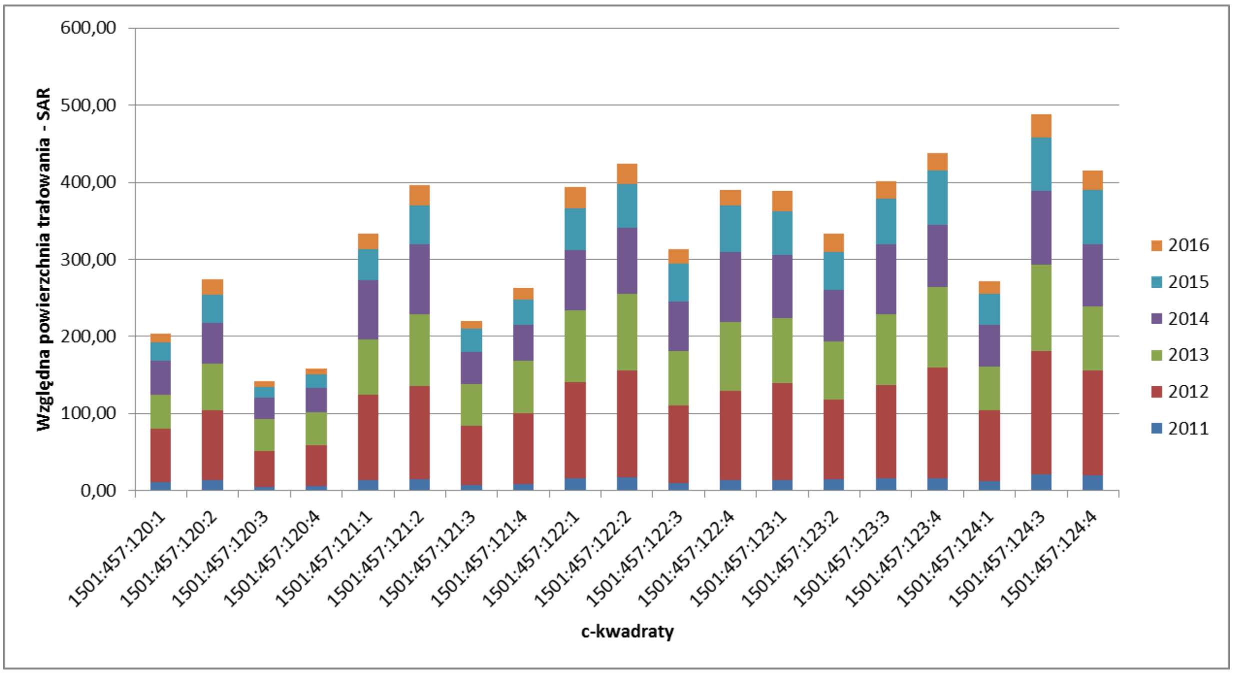



Fig. 2.3.33. Swept Area Ratio - SAR (vertical axis) in selected c-squares (horizontal axis) of the Bornholm Basin in 2011-2016 within POM.

Due to the lack of threshold values set at EU and regional level, as well as ICES reservations, as to the accuracy of the calculations performed (ICES 2017), the D6C2 criterion for the open sea areas was not included in the final assessment.

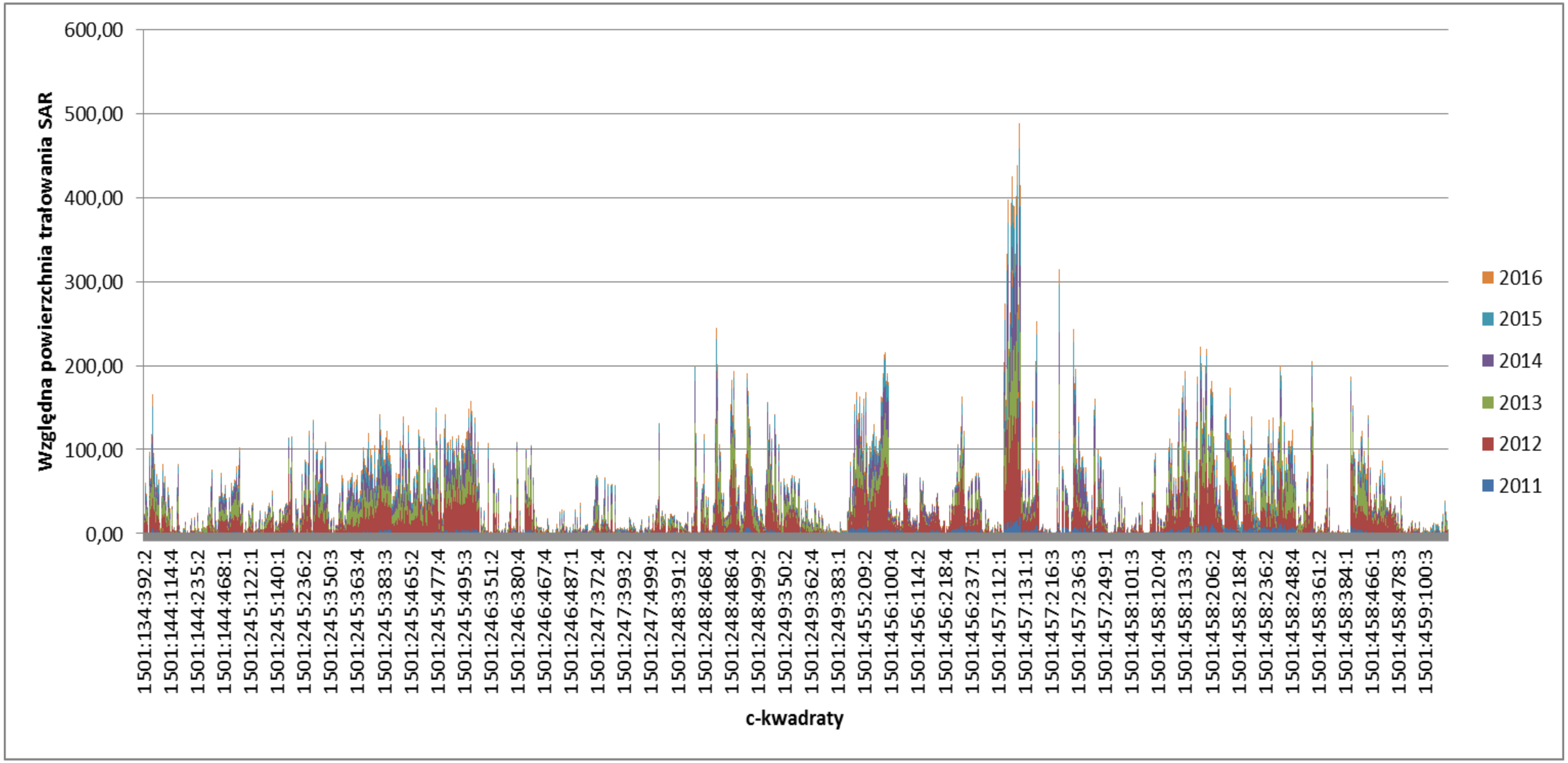



Fig. 2.3.34. Swept area ratio (SAR) (vertical axis) in all c-squares (horizontal axis) in 2011-2016 in POM.

### Comparison with the 2005-2010 initial assessment

Due to methodological differences referring to the indicators used to conduct the assessment, the method of integration of indicator results within the assessed sub-basins and waterbodies, it is not possible to relate the results of the current assessment to the results of the initial assessment of 2005-2010.

### Confidence of the assessment of seafloor integrity

The confidence of the assessment in terms of criteria D6C1 and D6C2 for which areas of loss or disturbance have been determined are very different. While in the first case it can be concluded that the inventory of permanent objects of hydrotechnical infrastructure for waterbodies is reliable, in the second case the method of estimating the disturbance of the bottom of the open sea areas has not been agreed at the regional level and should be assessed as low due to lack of reference to habitats benthic.

The assessment of criterion D6C3 in accordance with the method used for determining the index of changes in ecosystem resilience for waterbodies can be considered high.

The results of confidence of assessments of the environmental state of individual areas are presented in Table 2.3.32. The assessment for Polish coastal waters according to the HOLAS II division was given jointly for all waterbodies.

Table 2.3.32. Results confidence of assessments for individual areas.

| Confidacne for the assessment area | Bornholm Basin | | Eastern Gotland Basin | | Gdańsk Basin | | Polish coastal waters | |
|---|---|---|---|---|---|---|---|---|
| Joint assessment of criteria D6C1 i D6C2 | | | | | | | | |
| Temporal | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Spatial | 0.5 | 0.5 | 0.5 | 0.5 | 0,5 | 0,5 | 1 | 1 |
| Classification | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0,5 | < 0,5 | 1 | 1 |
| Methodology | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0,5 | < 0,5 | 1 | 1 |
| Average value of the confidence of the indicator (WW) | medium | medium | medium | medium | medium | medium | high | high |
| Criterion D6C3 | | | | | | | | |
| Temporal | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Spatial | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0,5 | < 0,5 | 1 | 1 |
| Classification | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0,5 | < 0,5 | 1 | 1 |
| Methodology | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0,5 | < 0,5 | 1 | 1 |
| Average value of the confidence of the indicator (WW) | medium | medium | medium | medium | medium | medium | high | high |
| Confidacne of the assessment (WO) | 0.625 | | 0.625 | | 0.625 | | 1 | |

***Descriptor D7 - Permanent alteration of hydrographical conditions***

Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.

Pursuant to Decision 2017/848, for Descriptor D7, two secondary criteria are set.

<table>
<tr><th>Criterion</th><th>Description of the criterion in accordance with the decision 2017/848</th><th>Scale of assessment</th></tr>
<tr><td>D7C1 - secondary</td><td>Spatial extent and distribution of permanent alteration of hydrographical conditions (e.g. changes in wave action, currents, salinity, temperature) to the seabed and water column, associated in particular with physical loss of the natural seabed</td><td rowspan="2">Scale of assessment:<br>As used for assessment of the benthic broad habitat types under Descriptors 1 and 6.<br><br>Use of criteria:<br>The outcomes of assessment of criterion D7C1 (the distribution and an estimate of the extent of hydrographical changes) shall be used to assess criterion D7C2.The outcomes of assessment of criterion D7C2 (an estimate of the extent of adverse effect per habitat type in each assessment area) shall contribute to the assessment of criterion D6C5</td></tr>
<tr><td>D7C2 - secondary</td><td>Spatial extent of each benthic habitat type adversely affected (physical and hydrographical characteristics and associated biological communities) due to permanent alteration of hydrographical conditions.</td></tr>
</table>

Spatial range and distribution of permanent changes in hydrographic conditions (e.g. changes in activity of waves, currents, salinity, temperature) of the seabed and water column related in particular to the physical loss of the natural seabed (D7C1), in the case of Poland concerns mainly coastal and transitional waters, which is practically the same as the Descriptor D6 and the D6C1 criterion assessment. Pursuant to Decision 2017/848, the results of the assessment of criterion D6C1 (Spatial extent and distribution of physical loss) are used to assess criterion D7C1. Therefore, for the individual reporting units, the same assessment as for criterion D7C1 was adopted.

Assessment of the indicator according to the D7C2 criterion - Spatial extent of each benthic habitat type adversely affected (physical and hydrographical characteristics and associated biological communities) is practically identical with the assessment according to criterion D6C3.

For Descriptor D7, Member States have not set threshold values for the negative effects of permanent changes in hydrographic conditions under regional or subregional cooperation, resulting in a lack of quantitative assessment.

***Descriptor D8 - Concentrations of contaminants are at a levels not giving rise to pollution effects.***

According to Commission Decision (EU) 848/2017, for Descriptor D8, four criteria were selected, two of which are primary, i.e. they must be included in the assessment of the status of marine environment, two more are the secondary criteria, the application of which must be justified (Table 2.3.33).

Table 2.3.33 Criteria of Descriptor D8

| Descriptor | Primary criteria | Secondary criteria | Description of criteria according to the Commission Decision 848/2017 | Scale of assessment |
|---|---|---|---|---|
| D8 - Concentrations of contaminants are at levels not giving rise to pollution effects | D8C1 | | Within coastal and territorial waters and beyond territorial waters concentrations of contaminants do no exceed the defined threshold values while recommendations regarding substances subject to monitoring in specific areas as well as threshold values are described in Commission Decision 848/2017 | Within coastal and territorial as recommended by WFD, beyond territorial waters subdivisions of the region or sub-region, if necessary divided by national boundaries. |
| | | D8C2 | The health of species and the condition of habitats (such as their species composition and relative abundance at locations of chronic pollution) are not adversely affected due to contaminants including cumulative and synergetic effects. Member States shall establish those adverse effects and their threshold values through regional or subregional cooperation. | |
| | D8C3 | | The spatial extent and duration of significant acute pollution events is minimized, while significant acute pollution with an occurrence of contaminants are defined in art. 2 p. 2 of Directive 2005/35/EC of the European Parliament and of the Council, including crude oil and similar components. | Regional or subregional level, divided where needed by national boundaries |
| | | D8C4 | The adverse effects of significant acute pollution events on the health of species and on the condition | As used for assessment of the species groups or benthic broad habitat types under Descriptors |

| | | | | |
|---|---|---|---|---|
| | | | of habitats (such as their species composition and relative abundance) are minimised and, where possible, eliminated. Criterion should be used when a significant acute pollution event has occurred. | 1 and 6. |

The assessment of the environmental status of the Baltic Sea in areas under the jurisdiction of Poland was carried out in the scope of two primary criteria: D8C1 and D8C3 and one secondary criterion D8C2. There was no assessment of the status within the criterion D8C4, due to the lack of data on the effects of significant acute contamination effects that occurred during the period covered by the assessment.

**Criterion D8C1**

The assessment within criterion D8C1 was based on data for indicators (concentrations of substances in specific matrices) selected during the testing carried out in stage I of the contract implementation in the scope of updating the Initial Assessment of the Baltic Sea environment status. All substances were assigned to the appropriate assessment areas in which these data were obtained. The assessment of the status of the environment was carried out in the areas of coastal and transitional waters as well as in the areas of the open sea.

## *Area of coastal and transitional waters*

In the area of coastal and transitional waters, the assessment of the status of the environment was carried out in accordance with WFD requirements in nineteen waterbodies (WB), including ten coastal and nine transitional units (Table 2.3.34, Fig. 2.3.35). In the case of assessments from years other than 2016, the results of assessments are inherited and they have been carried out in accordance with the rules being in force then.

Table 2.3.34. Waterbodies included in the assessment

| No. | Waterbody - name | Waterbody - code | Waterbody - type |
|---|---|---|---|
| 1. | Szczecin lagoon | PL TWI WB8 | Transitional waters |
| 2. | Kamieński lagoon | PL TWI WB9 | Transitional waters |
| 3. | Świna Mouth | PL TWV WB7 | Transitional waters |
| 4. | Dziwna Mouth | PL TWV WB6 | Transitional waters |
| 5. | Dziwna - Świna | PL CWIII WB9 | Coastal waters |
| 6. | Sarbinowo - Dziwna | PL CWII WB8 | Coastal waters |
| 7. | Jarosławiec - Sarbinowo | PL CWIII WB7 | Coastal waters |
| 8. | Outer Puck Bay | PL TWIII WB3 | Transitional waters |
| 9. | Wisła Przekop mouth | PL TWV WB5 | Transitional waters |
| 10. | Rowy - Jarosławiec East | PL CWII WB6E | Coastal waters |
| 11. | Władysławowo - Jastrzębia Góra | PL CWII WB4 | Coastal waters |
| 12. | Władysławowo Port | PL CWI WB3 | Coastal waters |
| 13. | Hel Peninsula | PL CWI WB2 | Coastal waters |
| 14. | Vistula Spit | PL CWI WB1 | Coastal waters |
| 15. | Puck lagoon | PL TWII WB2 | Transitional waters |
| 16. | Inner Gulf of Gdańsk | PL TWIV WB4 | Transitional waters |
| 17. | Rowy - Jarosławiec West | PL CWII WB6W | Coastal waters |
| 18. | Jastrzębia Góra - Rowy | PL CWIII WB5 | Coastal waters |
| 19 | Vistula lagoon | PL TWI WB1 | Transitional waters |

The assessment included particularly harmful substances - specific synthetic and non-synthetic pollutants, which were also used to assess the ecological potential (3.6), priority substances (4.1) and other pollutants, which were used to assess the chemical status (4.2). The data for the assessment come from the period 2011 - 2016. A list of all substances used to assess the environmental status of coastal and transitional waters in individual areas is provided in the following tables (Table 2.3.35 –Table 2.3.66), where the matrices in which the substances were analyzed are also given as well as threshold values for individual substances. Threshold values for the group: particularly harmful substances - specific synthetic and non-synthetic pollutants were adopted in accordance with Annex 6 to the Regulation of the Minister of Environment of 21st July 2016 on the method of classification of the surface water bodies and environmental quality standards for priority substances. The source document for threshold values for priority substances (environmental quality standards - EQS) is Directive 2013/39/EU of the European Parliament and of the Council of 12th August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy (OJ L 226, 24/08/2013, p. 1), hereinafter referred to as "Directive 2013/39/EU".

The results of the assessment are presented in tabular form for each area of water bodies, except for the areas of Władysławowo Port and Rowy - Jarosławiec West, for which no assessment was carried out for any of the substance groups due to lack of data for the period covered by the assessment. For the areas of Wisła Przekop mouth and Vistula Spit, the assessment covers only groups of substances - specific synthetic and non-synthetic pollutants. The assessment was also presented in the form of graphic diagrams indicating the number of indicators (substances in the relevant matrices) assigned to the appropriate class in the case of a group of substances - specific synthetic and non-synthetic pollutants and the number of indicators (substances in appropriate matrices) that meet the requirements for good chemical status and the number those that do not meet this requirement.

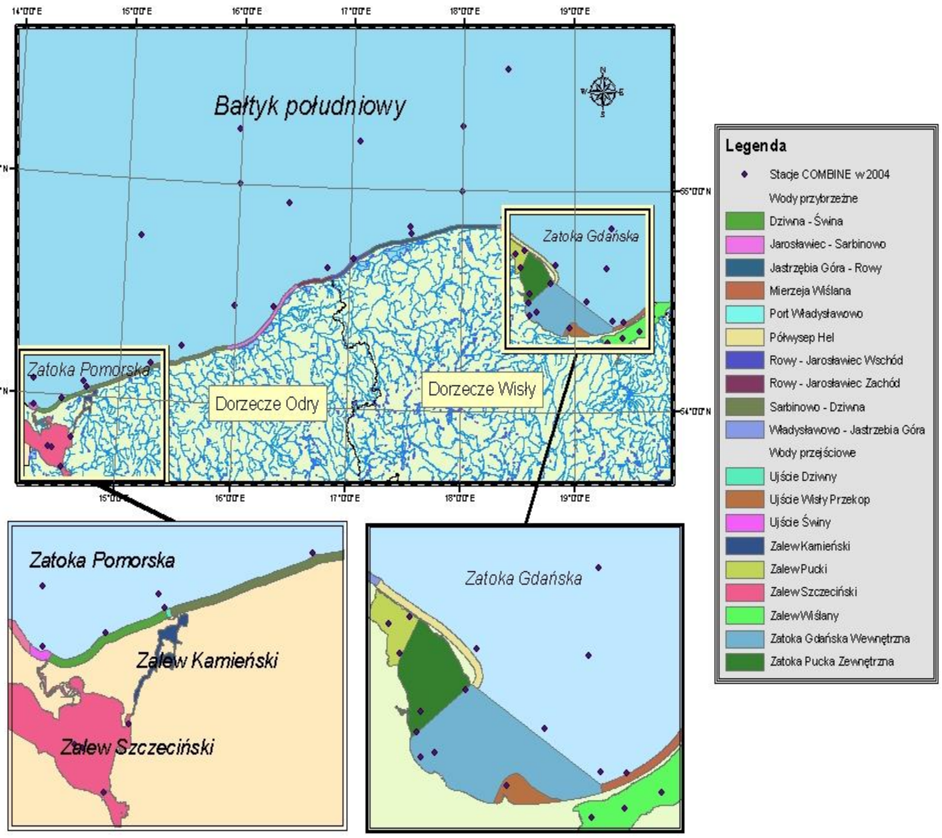



Fig. 2.3.35. Coastal and transitional waterbodies in the Polish Baltic zone (Osowiecki et al. 2012)

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 1 and 2, which means a **good status of Szczecin lagoon environment**, with 14 substances meeting the requirements for class 1 and 9 for class 2 (Table 2.3.35, Fig. 2.3.36).

Within the group of **priority substances** (group 4.1) **and other pollutants** (group 4.2) only polybrominated diphenylethers, mercury and heptachlor in organisms indicate chemical status below good, other substances meet the requirements for good chemical status (Table 2.3.36, Fig. 2.3.36).

Table 2.3.35. Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Formaldehyde | water | ≤ 0.05 | mg/l | 0.009 | 2 | 2016 |
| Arsenic | water | ≤ 0.05 | mg As/l | 0.001 | 2 | 2016 |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.04 | 2 | 2016 |
| Boron | water | ≤ 2 | mg B/l | 0.2 | 2 | 2016 |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | < 0.001 | 1 | 2016 |
| Chromium | water | ≤ 0.05 | mg Cr/l | < 0.001 | 1 | 2016 |
| Zinc | water | ≤ 1 | mg Zn/l | 0.02 | 2 | 2016 |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.01 | 2 | 2016 |
| Phenol index | water | ≤ 0.01 | mg/l | 0.0011 | 2 | 2016 |
| Oil index | water | ≤ 0.2 | mg/l | < 0.05 | 1 | 2016 |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.004 | 2 | 2016 |
| Free cyanides | water | ≤ 0.05 | mg CN/l | < 0.015 | 1 | 2016 |
| Metal cyanide complexes | water | ≤ 0.05 | mg Me (CN)x/l | < 0.015 | 1 | 2016 |
| Molybdenum | water | ≤ 0.04 | mg Mo/l | < 0.01 | 1 | 2016 |
| Selenium | water | ≤ 0.02 | mg Se/l | < 0.002 | 1 | 2016 |
| Silver | water | ≤ 0.005 | mg Ag/l | < 0.001 | 1 | 2016 |
| Thallium | water | ≤ 0.002 | mg Tl/l | < 0.0005 | 1 | 2016 |
| Titanium | water | ≤ 0.05 | mg Ti/l | < 0.01 | 1 | 2016 |
| Vanadium | water | ≤ 0.05 | mg V/l | < 0.01 | 1 | 2016 |
| Antimony | water | ≤ 0.002 | mg Sb/l | < 0.0005 | 1 | 2016 |
| Fluoride | water | ≤ 1.5 | mg F/l | 0.3 | 2 | 2016 |
| Beryllium | water | ≤ 0.0008 | mg Be/l | <0.0002 | 1 | 2016 |
| Cobalt | water | ≤ 0.05 | mg Co/l | <0.01 | 1 | 2016 |

< - below the limit of quantification

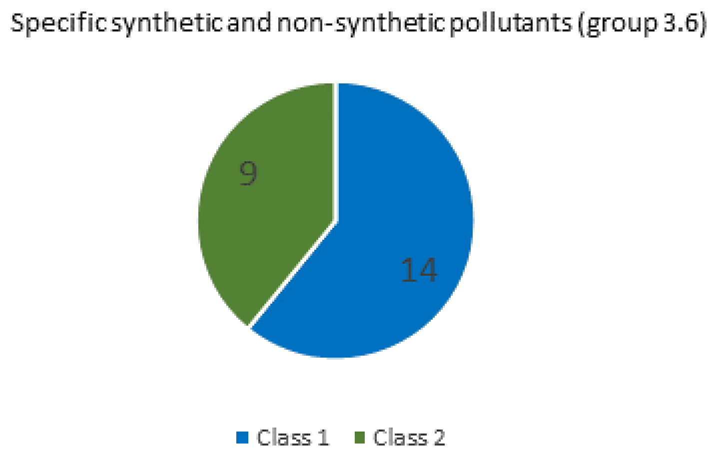
Table 2.3.36. Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Anthracene | water | 0.1 | 0.1 | µg/l | 0.0006 | 0.001 | 1 | 2016 |
| Atrazine | water | 0.6 | 2.0 | µg/l | <0.18 | <0.18 | 1 | 2016 |
| Benzene | water | 8 | 50 | µg/l | <1.0 | <1.0 | 1 | 2016 |
| Brominated diphenylethers | biota | 0.0085 | | µg/kg ww | 0.0136 | | > 1 | 2016 |
| Brominated diphenylethers | water | - | 0.14 | µg/l | | <0.00005 | 1 | 2016 |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | 0.03 | 0.09 | 1 | 2016 |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.1 | 0.1 | 1 | 2016 |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.005 | <0.005 | 1 | 2011* |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | <1.25 | | 1 | 2016 |
| Dichloromethane | water | 20 | | µg/l | <1.25 | | 1 | 2016 |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 | | µg/l | <0.1 | | 1 | 2016 |
| Diuron | water | 0.2 | 1.8 | µg/l | <0.06 | <0.06 | 1 | 2016 |
| Endosulfan | water | 0.0005 | 0.004 | µg/l | 0.0002 | 0.001 | 1 | 2016 |
| Fluoranthene | biota | 30 | | µg/kg ww | 5 | | 1 | 2016 |
| Fluoranthene | water | 0.0063 | 0.12 | µg/l | 0.0030 | 0.0050 | 1 | 2011* |
| Hexachlorobenzene (HCB) | biota | 10 | | µg/kg ww | 0.38 | | 1 | 2016 |
| Hexachlorobenzene (HCB) | water | | 0.05 | µg/l | | <0.001 | 1 | 2011* |
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | µg/l | <0.0006 | 0.0018 | 1 | 2016 |
| Isoproturon | water | 0.3 | 1.0 | µg/l | <0.09 | <0.09 | 1 | 2016 |
| Lead and its compounds | water | 1.3 | 14 | µg/l | <0.36 | <0.36 | 1 | 2016 |
| Mercury and its compounds | biota | 20 | | µg/kg ww | 41.5 | | > 1 | 2016 |
| Mercury and its compounds | water | - | 0.07 | µg/l | | <0.013 | 1 | 2016 |
| Naphthalene | water | 2 | 130 | µg/l | <0.087 | <0.087 | 1 | 2016 |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | 1.5 | 2.5 | 1 | 2016 |
| Nonylphenols | water | 0.3 | 2.0 | µg/l | 0.013 | 0.043 | 1 | 2016 |
| Octylphenols | water | 0.01 | | µg/l | 0.001 | | 1 | 2016 |
| Pentachlorobenzene | water | 0.0007 | | µg/l | <0.0002 | | 1 | 2016 |
| Pentachlorophenol (PCP) | water | 0.4 | 1.0 | µg/l | <0.05 | <0.05 | 1 | 2016 |
| Benzo(a)pyrene | biota | 5 | | µg/kg ww | <1.5 | | 1 | 2016 |
| Benzo(a)pyrene | water | $1.7x10^{-4}$ | 0.027 | µg/l | <0.001 | <0.001 | 1 | 2011* |
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | <0.002 | 1 | 2011* |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | <0.002 | 1 | 2011* |
| Benzo(g,h,i)perylene | water | | $8.2x10^{-4}$ | µg/l | | 0.001 | 1 | 2011* |
| Simazine | water | 1 | 4 | µg/l | <0.3 | <0.3 | 1 | 2016 |
| Tributyltin compounds | water | 0.0002 | 0.0015 | µg/l | <0.00005 | <0.00005 | 1 | 2016 |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | <0.001 | | 1 | 2016 |
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | <0.5 | | 1 | 2016 |
| Trifluralin | water | 0.03 | | µg/l | <0.005 | | 1 | 2016 |
| Dicofol | biota | 33 | | µg/kg ww | <10 | | 1 | 2016 |
| Perfluorooctane sulfonic acid and its derivatives (PFOS) | biota | 9.1 | | µg/kg ww | 4.4 | | 1 | 2016 |
| Dioxins and dioxin-like compounds | biota | 0.0065 | | µg/kg ww | 0.0025 | | 1 | 2016 |
| Hexabromocyclododecane | biota | 167 | | µg/kg ww | 0.037 | | 1 | 2016 |
| Heptachlor and heptachlor epoxide | biota | 0.0067 | | µg/kg ww | 0.046 | | > 1 | 2016 |
| Tetrachloromethane | water | 12 | | µg/l | <0.5 | | 1 | 2016 |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | <0.001 | | 1 | 2016 |
| Para-para-DDT | water | 0.01 | | µg/l | 0.0014 | | 1 | 2016 |
| DDT total | water | 0.025 | | µg/l | 0.004 | | 1 | 2016 |
| Trichloroethylene (TRI) | water | 10 | | µg/l | <0.5 | | 1 | 2016 |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | <0.5 | | 1 | 2016 |

AA – annual average

EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable
* - inherited assessment



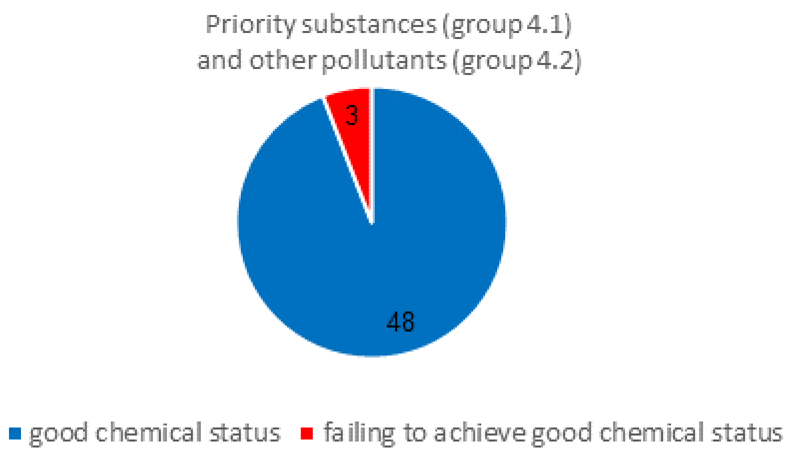




Fig. 2.3.36. Summary of the assessment of the environmental status of Szczecin lagoon waterbody in the scope of specific synthetic and non-synthetic pollutants (group 3.6) and groups of priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

### *Kamieński lagoon*

Within the group of specific synthetic and non-synthetic pollutants (group 3.6) all substances indicate class 1 and 2, which means a **good status of Kamieński lagoon environment**, with 16 substances meeting the requirements for class 1 and 7 for class 2 (Table 2.3.37, Fig. 2.3.37).

Within the group of **priority substances** (group 4.1) and **other pollutants** (group 4.2) all substances were analyzed in water and meet the requirements for good chemical status (Table 2.3.38, Fig. 2.3.37).

Table 2.3.37. Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Formaldehyde | water | ≤ 0.05 | mg/l | <0.015 | 1 | 2016 |
| Arsenic | water | ≤ 0.05 | mg As/l | 0.001 | 2 | 2016 |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.04 | 2 | 2016 |
| Boron | water | ≤ 2 | mg B/l | 0.2 | 2 | 2016 |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.001 | 1 | 2016 |
| Chromium | water | ≤ 0.05 | mg Cr/l | <0.001 | 1 | 2016 |
| Zinc | water | ≤ 1 | mg Zn/l | <0.005 | 1 | 2016 |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.001 | 2 | 2016 |
| Phenol index | water | ≤ 0.01 | mg/l | 0.001 | 2 | 2016 |
| Oil index | water | ≤ 0.2 | mg/l | <0.05 | 1 | 2016 |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.006 | 2 | 2016 |
| Free cyanides | water | ≤ 0.05 | mg CN/l | <0.015 | 1 | 2016 |
| Metal cyanide complexes | water | ≤ 0.05 | mg Me (CN)x/l | <0.015 | 1 | 2016 |
| Molybdenum | water | ≤ 0.04 | mg Mo/l | <0.01 | 1 | 2016 |
| Selenium | water | ≤ 0.02 | mg Se/l | <0.002 | 1 | 2016 |
| Silver | water | ≤ 0.005 | mg Ag/l | <0.001 | 1 | 2016 |
| Thallium | water | ≤ 0.002 | mg Tl/l | <0.0005 | 1 | 2016 |
| Titanium | water | ≤ 0.05 | mg Ti/l | <0.01 | 1 | 2016 |
| Vanadium | water | ≤ 0.05 | mg V/l | <0.01 | 1 | 2016 |
| Antimony | water | ≤ 0.002 | mg Sb/l | <0.0005 | 1 | 2016 |
| Fluoride | water | ≤ 1.5 | mg F/l | 0.3 | 2 | 2016 |
| Beryllium | water | ≤ 0.0008 | mg Be/l | <0.0002 | 1 | 2016 |
| Cobalt | water | ≤ 0.05 | mg Co/l | <0.01 | 1 | 2016 |

< - below the limit of quantification

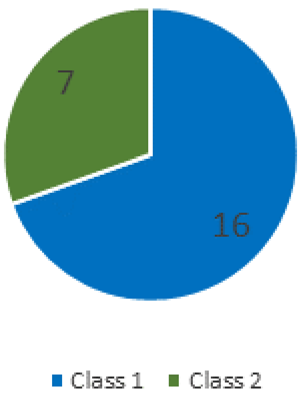
Table 2.3.38. Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Anthracene | water | 0.1 | 0.1 | µg/l | 0.0006 | 0.001 | 1 | 2016 |
| Atrazine | water | 0.6 | 2.0 | µg/l | <0.18 | <0.18 | 1 | 2016 |
| Benzene | water | 8 | 50 | µg/l | <1.0 | <1.0 | 1 | 2016 |
| Brominated diphenylethers | water | - | 0.14 | µg/l | | <0.00005 | 1 | 2016 |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | 0.03 | 0.08 | 1 | 2016 |
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.1 | 0.1 | 1 | 2016 |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.005 | <0.005 | 1 | 2012* |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | <1.25 | | 1 | 2016 |
| Dichloromethane | water | 20 | | µg/l | <1.25 | | 1 | 2016 |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 | | µg/l | <0.1 | | 1 | 2016 |
| Diuron | water | 0.2 | 1.8 | µg/l | <0.06 | <0.06 | 1 | 2016 |
| Endosulfan | water | 0.0005 | 0.004 | µg/l | 0.00009 | 0.00024 | 1 | 2016 |
| Fluoranthene | water | 0.0063 | 0.12 | µg/l | 0.0035 | 0.0045 | 1 | 2012* |
| Hexachlorobenzene (HCB) | water | | 0.05 | µg/l | | <0.001 | 1 | 2012* |
| Hexachlorobutadiene (HCBD) | water | | 0.6 | µg/l | | <0.03 | 1 | 2012* |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | μg/l | <0.0006 | 0.0024 | 1 | 2016 |
| Isoproturon | water | 0.3 | 1.0 | μg/l | <0.09 | <0.09 | 1 | 2016 |
| Lead and its compounds | water | 1.3 | 14 | μg/l | 0.2 | 0.6 | 1 | 2016 |
| Mercury and its compounds | water | - | 0.07 | μg/l | | 0.02 | 1 | 2016 |
| Naphthalene | water | 2 | 130 | μg/l | <0.087 | <0.087 | 1 | 2016 |
| Nickel and its compounds | water | 8.6 | 34 | μg/l | 1.5 | 2.6 | 1 | 2016 |
| Nonylphenols | water | 0.3 | 2.0 | μg/l | 0.020 | 0.100 | 1 | 2016 |
| Octylphenols | water | 0.01 | | μg/l | 0.001 | | 1 | 2016 |
| Pentachlorobenzene | water | 0.0007 | | μg/l | <0.0002 | | 1 | 2016 |
| Pentachlorophenol (PCP) | water | 0.4 | 1.0 | μg/l | <0.05 | <0.05 | 1 | 2016 |
| Benzo(a)pyrene | water | $1.7x10^{-4}$ | 0.027 | μg/l | <0.001 | <0.001 | 1 | 2012* |
| Benzo(b)fluoranthene | water | | 0.017 | μg/l | | <0.002 | 1 | 2012* |
| Benzo(k)fluoranthene | water | | 0.017 | μg/l | | <0.002 | 1 | 2012* |
| Benzo(g,h,i)perylene | water | | $8.2x10^{-4}$ | μg/l | | 0.0008 | 1 | 2012* |
| Simazine | water | 1 | 4 | μg/l | <0.3 | <0.3 | 1 | 2016 |
| Tributyltin compounds | water | 0.0002 | 0.0015 | μg/l | <0.00005 | <0.00005 | 1 | 2016 |
| Trichlorobenzenes (TCB) | water | 0.4 | | μg/l | <0.001 | | 1 | 2016 |
| Trichloromethane (chloroform) | water | 2.5 | | μg/l | <0.5 | | 1 | 2016 |
| Trifluralin | water | 0.03 | | μg/l | <0.005 | | 1 | 2016 |
| Tetrachloromethane | water | 12 | | μg/l | <0.5 | | 1 | 2016 |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | μg/l | <0.001 | | 1 | 2016 |
| Para-para-DDT | water | 0.01 | | μg/l | 0.0007 | | 1 | 2016 |
| DDT total | water | 0.025 | | μg/l | 0.001 | | 1 | 2016 |
| Trichloroethylene (TRI) | water | 10 | | μg/l | <0.5 | | 1 | 2016 |
| Tetrachloroethylene (PER) | water | 10 | | μg/l | <0.5 | | 1 | 2016 |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable
* - inherited assessment

Specific synthetic and non-synthetic pollutants (group 3.6)



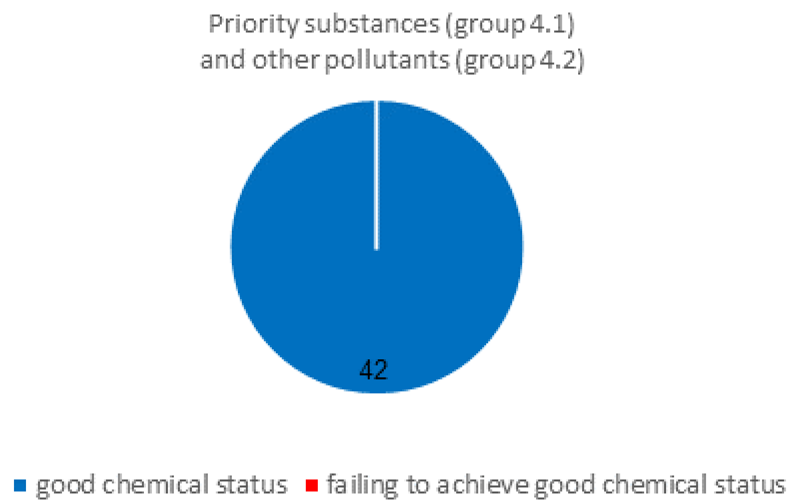



Fig. 2.3.37. Summary of the assessment of the environmental status of Kamieński lagoon area in the scope of specific synthetic and non-synthetic pollutants (group 3.6) and groups of priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

### *Świna mouth*

Within the group of **specific synthetic and non-synthetic pollutants** (group3.6) all substances indicate class 1 and 2, which means **good environmental status in Świna Mouth area**, with 13 substances meeting the requirements for class 1 and 10 for class 2 (Table 2.3.39, Fig. 2.3.38).

Within the group of **priority substances** (group 4.1) and **other pollutants**(group 4.2) all substances were analyzed in water and meet the requirements for good chemical status (Table 2.3.40, Fig. 2.3.38).

Table 2.3.39 Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Formaldehyde | water | ≤ 0.05 | mg/l | <0.015 | 1 | 2016 |
| Arsenic | water | ≤ 0.05 | mg As/l | 0.001 | 2 | 2016 |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.02 | 2 | 2016 |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2016 |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.001 | 1 | 2016 |
| Chromium | water | ≤ 0.05 | mg Cr/l | <0.001 | 1 | 2016 |
| Zinc | water | ≤ 1 | mg Zn/l | 0.06 | 2 | 2016 |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.004 | 2 | 2016 |
| Phenol index | water | ≤ 0.01 | mg/l | 0.0013 | 2 | 2016 |
| Oil index | water | ≤ 0.2 | mg/l | 0.043 | 2 | 2016 |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.004 | 2 | 2016 |
| Free cyanides | water | ≤ 0.05 | mg CN/l | <0.015 | 1 | 2016 |
| Metal cyanide complexes | water | ≤ 0.05 | mg Me (CN)x/l | <0.015 | 1 | 2016 |
| Molybdenum | water | ≤ 0.04 | mg Mo/l | <0.01 | 1 | 2016 |
| Selenium | water | ≤ 0.02 | mg Se/l | 0.0014 | 2 | 2016 |
| Silver | water | ≤ 0.005 | mg Ag/l | <0.001 | 1 | 2016 |
| Thallium | water | ≤ 0.002 | mg Tl/l | <0.0005 | 1 | 2016 |

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Titanium | water | ≤ 0.05 | mg Ti/l | <0.01 | 1 | 2016 |
| Vanadium | water | ≤ 0.05 | mg V/l | <0.01 | 1 | 2016 |
| Antimony | water | ≤ 0.002 | mg Sb/l | <0.0005 | 1 | 2016 |
| Fluoride | water | ≤ 1.5 | mg F/l | 0.4 | 2 | 2016 |
| Beryllium | water | ≤ 0.0008 | mg Be/l | <0.0002 | 1 | 2016 |
| Cobalt | water | ≤ 0.05 | mg Co/l | <0.01 | 1 | 2016 |

< - below the limit of quantification

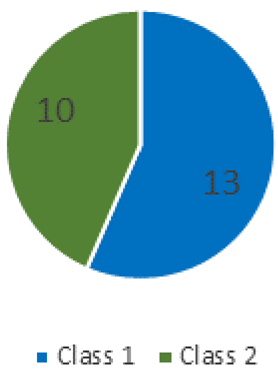
Table 2.3.40 Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Anthracene | water | 0.1 | 0.1 | µg/l | 0.0007 | 0.001 | 1 | 2016 |
| Atrazyna | water | 0.6 | 2.0 | µg/l | <0.18 | <0.18 | 1 | 2016 |
| Benzene | water | 8 | 50 | µg/l | <1.0 | <1.0 | 1 | 2016 |
| Brominated diphenylethers | water | - | 0.14 | µg/l |  | <0.00005 | 1 | 2016 |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | 0.1 | 0.3 | 1 | 2016 |
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.1 | 0.2 | 1 | 2016 |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.005 | <0.005 | 1 | 2012* |
| 1,2-Dichloroethane (EDC) | water | 10 |  | µg/l | <1.25 |  | 1 | 2016 |
| Dichloromethane | water | 20 |  | µg/l | <1.25 |  | 1 | 2016 |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 |  | µg/l | <0.1 |  | 1 | 2016 |
| Diuron | water | 0.2 | 1.8 | µg/l | <0.06 | 0.2 | 1 | 2016 |
| Endosulfan | water | 0.0005 | 0.004 | µg/l | 0.0003 | 0.002 | 1 | 2016 |
| Fluoranthene | water | 0.0063 | 0.12 | µg/l | 0.0010 | 0.0016 | 1 | 2012* |
| Hexachlorobenzene (HCB) | water |  | 0.05 | µg/l |  | <0.001 | 1 | 2012* |
| Hexachlorobutadiene (HCBD) | water |  | 0.6 | µg/l |  | <0.03 | 1 | 2012* |
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | µg/l | <0.0006 | 0.0026 | 1 | 2016 |
| Isoproturon | water | 0.3 | 1.0 | µg/l | <0.09 | <0.09 | 1 | 2016 |
| Lead and its compounds | water | 1.3 | 14 | µg/l | 0.27 | 1.3 | 1 | 2016 |
| Mercury and its compounds | water | - | 0.07 | µg/l |  | 0.02 | 1 | 2016 |
| Naphthalene | water | 2 | 130 | µg/l | <0.087 | <0.087 | 1 | 2016 |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | 0.8 | 1.8 | 1 | 2016 |
| Nonylphenols | water | 0.3 | 2.0 | µg/l | 0.011 | 0.033 | 1 | 2016 |
| Octylphenols | water | 0.01 |  | µg/l | 0.001 |  | 1 | 2016 |
| Pentachlorobenzene | water | 0.0007 |  | µg/l | <0.0002 |  | 1 | 2016 |
| Pentachlorofenol (PCP) | water | 0.4 | 1.0 | µg/l | <0.05 | <0.05 | 1 | 2016 |
| Benzo(a)pyrene | water | $1.7x10^{-4}$ | 0.027 | µg/l | <0.001 | <0.001 | 1 | 2012* |
| Benzo(b)fluoranthene | water |  | 0.017 | µg/l |  | <0.002 | 1 | 2012* |
| Benzo(k)fluoranthene | water |  | 0.017 | µg/l |  | <0.002 | 1 | 2012* |
| Benzo(g,h,i)perylene | water |  | $8.2x10^{-4}$ | µg/l |  | 0.0006 | 1 | 2012* |
| Simazine | water | 1 | 4 | µg/l | <0.3 | <0.3 | 1 | 2016 |
| Tributyltin compounds | water | 0.0002 | 0.0015 | µg/l | <0.00005 | <0.00005 | 1 | 2016 |
| Trichlorobenzenes (TCB) | water | 0.4 |  | µg/l | <0.001 |  | 1 | 2016 |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | <0.5 | | 1 | 2016 |
| Trifluralin | water | 0.03 | | µg/l | <0.005 | | 1 | 2016 |
| Tetrachloromethane | water | 12 | | µg/l | <0.5 | | 1 | 2016 |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | <0.001 | | 1 | 2016 |
| Para-para-DDT | water | 0.01 | | µg/l | 0.0014 | | 1 | 2016 |
| DDT total | water | 0.025 | | µg/l | 0.004 | | 1 | 2016 |
| Trichloroethylene (TRI) | water | 10 | | µg/l | <0.5 | | 1 | 2016 |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | <0.5 | | 1 | 2016 |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable
* - inherited assessment

Specific synthetic and non-synthetic pollutants (group 3.6)




Priority substances (group 4.1)
and other pollutants (group 4.2)

Fig. 2.3.38. Summary of the assessment of the environmental status of Świna Mouth area in the scope of specific synthetic and non-synthetic pollutants (group 3.6) and the group of priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

### *Dziwna mouth*

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 1 and 2, which means a **good environmental status of the Dziwna Mouth** area, with 13 substances meeting the requirements for class 1 and 10 for class 2 (Table 2.3.41, Fig. 2.3.39).

Within the group of **priority substances** (group 4.1) and **other pollutants** (group 4.2) all substances were analyzed in water and meet the requirements for good chemical status (Table 2.3.42, Fig. 2.3.39).

Table 2.3.41 Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Formaldehyde | water | ≤ 0.05 | mg/l | 0.010 | 2 | 2016 |
| Arsenic | water | ≤ 0.05 | mg As/l | 0.001 | 2 | 2016 |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.02 | 2 | 2016 |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2016 |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.001 | 1 | 2016 |
| Chromium | water | ≤ 0.05 | mg Cr/l | <0.001 | 1 | 2016 |
| Zinc | water | ≤ 1 | mg Zn/l | <0.005 | 2 | 2016 |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.002 | 2 | 2016 |
| Phenol index | water | ≤ 0.01 | mg/l | 0.0013 | 2 | 2016 |
| Oil index | water | ≤ 0.2 | mg/l | 0.037 | 2 | 2016 |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.005 | 2 | 2016 |
| Free cyanides | water | ≤ 0.05 | mg CN/l | <0.015 | 1 | 2016 |
| Metal cyanide complexes | water | ≤ 0.05 | mg Me (CN)x/l | <0.015 | 1 | 2016 |
| Molybdenum | water | ≤ 0.04 | mg Mo/l | <0.01 | 1 | 2016 |
| Selenium | water | ≤ 0.02 | mg Se/l | <0.002 | 1 | 2016 |
| Silver | water | ≤ 0.005 | mg Ag/l | <0.001 | 1 | 2016 |
| Thallium | water | ≤ 0.002 | mg Tl/l | <0.0005 | 1 | 2016 |
| Titanium | water | ≤ 0.05 | mg Ti/l | <0.01 | 1 | 2016 |
| Vanadium | water | ≤ 0.05 | mg V/l | <0.01 | 1 | 2016 |
| Antimony | water | ≤ 0.002 | mg Sb/l | <0.0005 | 1 | 2016 |
| Fluoride | water | ≤ 1.5 | mg F/l | 0.4 | 2 | 2016 |
| Beryllium | water | ≤ 0.0008 | mg Be/l | <0.0002 | 1 | 2016 |
| Cobalt | water | ≤ 0.05 | mg Co/l | <0.01 | 1 | 2016 |

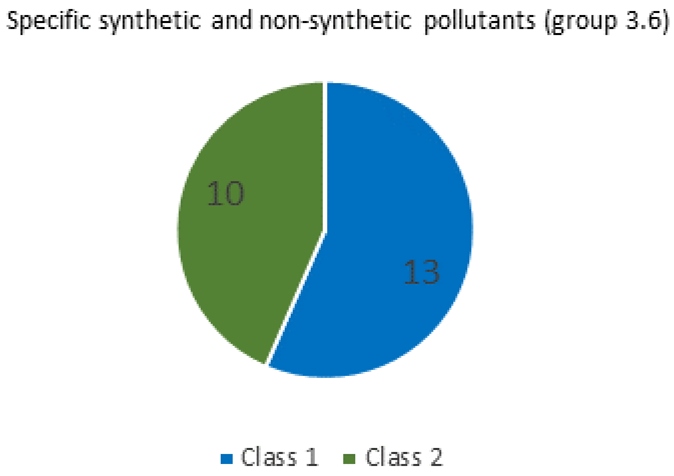
< - below the limit of quantification

Table 2.3.42 Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Anthracene | water | 0.1 | 0.1 | µg/l | 0.0007 | 0.002 | 1 | 2016 |
| Atrazine | water | 0.6 | 2.0 | µg/l | <0.18 | <0.18 | 1 | 2016 |
| Benzene | water | 8 | 50 | µg/l | <1.0 | <1.0 | 1 | 2016 |
| Brominated | water | - | 0.14 | µg/l | | <0.00005 | 1 | 2016 |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| diphenylethers | | | | | | | | |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | 0.08 | 0.16 | 1 | 2016 |
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.1 | 0.1 | 1 | 2016 |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | <1.25 | | 1 | 2016 |
| Dichloromethane | water | 20 | | µg/l | <1.25 | | 1 | 2016 |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 | | µg/l | <0.1 | | 1 | 2016 |
| Diuron | water | 0.2 | 1.8 | µg/l | <0.06 | <0.06 | 1 | 2016 |
| Endosulfan | water | 0.0005 | 0.004 | µg/l | 0.0001 | <0.00015 | 1 | 2016 |
| Fluoranthene | water | 0.0063 | 0.12 | µg/l | 0.0032 | 0.0050 | 1 | 2012* |
| Hexachlorobenzene (HCB) | water | | 0.05 | µg/l | | <0.001 | 1 | 2012* |
| Hexachlorobutadiene (HCBD) | water | | 0.6 | µg/l | | <0.03 | 1 | 2012* |
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | µg/l | <0.0006 | 0.0016 | 1 | 2016 |
| Isoproturon | water | 0.3 | 1.0 | µg/l | <0.09 | <0.09 | 1 | 2016 |
| Lead and its compounds | water | 1.3 | 14 | µg/l | <0.36 | <0.36 | 1 | 2016 |
| Mercury and its compounds | water | - | 0.07 | µg/l | | <0.013 | 1 | 2016 |
| Naphthalene | water | 2 | 130 | µg/l | <0.087 | <0.087 | 1 | 2016 |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | 1.8 | 11.3 | 1 | 2016 |
| Nonylphenols | water | 0.3 | 2.0 | µg/l | 0.017 | 0.052 | 1 | 2016 |
| Octylphenols | water | 0.01 | | µg/l | 0.002 | | 1 | 2016 |
| Pentachlorobenzene | water | 0.0007 | | µg/l | <0.0002 | | 1 | 2016 |
| Pentachlorophenol (PCP) | water | 0.4 | 1.0 | µg/l | <0.05 | <0.05 | 1 | 2016 |
| Benzo(a)pyrene | water | $1.7x10^{-4}$ | 0.027 | µg/l | <0.001 | 0.001 | 1 | 2012* |
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | <0.002 | 1 | 2012* |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | <0.002 | 1 | 2012* |
| Benzo(g,h,i)perylene | water | | $8.2x10^{-4}$ | µg/l | | 0.0011 | 1 | 2012* |
| Simazine | water | 1 | 4 | µg/l | <0.3 | <0.3 | 1 | 2016 |
| Tributyltin compounds | water | 0.0002 | 0.0015 | µg/l | <0.00005 | <0.00005 | 1 | 2016 |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | <0.001 | | 1 | 2016 |
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | <0.5 | | 1 | 2016 |
| Trifluralin | water | 0.03 | | µg/l | <0.005 | | 1 | 2016 |
| Tetrachloromethane | water | 12 | | µg/l | <0.5 | | 1 | 2016 |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | <0.001 | | 1 | 2016 |
| Para-para-DDT | water | 0.01 | | µg/l | 0.0010 | | 1 | 2016 |
| DDT total | water | 0.025 | | µg/l | 0.003 | | 1 | 2016 |
| Trichloroethylene (TRI) | water | 10 | | µg/l | <0.5 | | 1 | 2016 |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | <0.5 | | 1 | 2016 |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable
* - inherited assessment



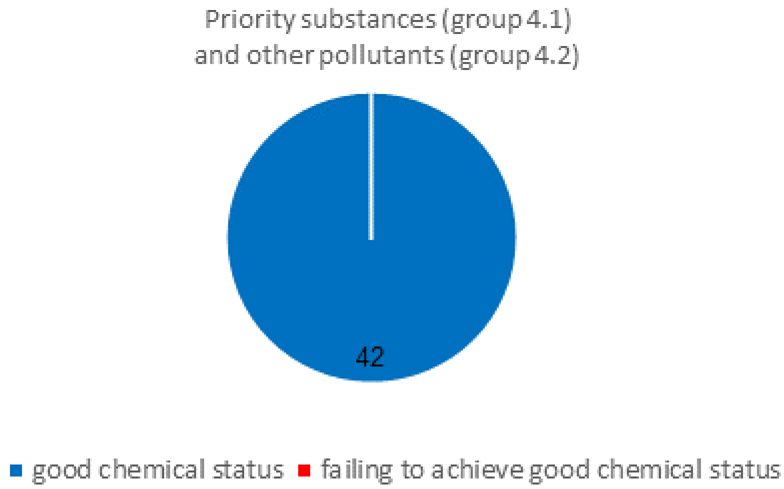




Fig. 2.3.39. Summary of the assessment of the environmental status of Dziwna Mouth area in the scope of specific synthetic and non-synthetic pollutants (group 3.6) and priority substances group (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ).

## *Dziwna – Świna*

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 1 and 2, which means a **good status of the Dziwna - Świna environment**, with 15 substances meeting the requirements for class 1 and 8 for class 2 (Table 2.3.43, Fig. 2.3.40).

Within the group of **priority substances** (group 4.1) and **other pollutants** (group 4.2) only polybrominated diphenylethers, mercury and heptachlor in organisms indicate chemical status below good, other substances meet the requirements for good chemical status (Table 2.3.44, Fig. 2.3.40).

Table 2.3.43. Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Formaldehyde | water | ≤ 0.05 | mg/l | <0.015 | 1 | 2016 |
| Arsenic | water | ≤ 0.05 | mg As/l | 0.001 | 2 | 2016 |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.01 | 2 | 2016 |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2016 |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.001 | 1 | 2016 |
| Chromium | water | ≤ 0.05 | mg Cr/l | <0.001 | 1 | 2016 |
| Zinc | water | ≤ 1 | mg Zn/l | <0.005 | 1 | 2016 |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.001 | 2 | 2016 |
| Phenol index | water | ≤ 0.01 | mg/l | 0.0015 | 2 | 2016 |
| Oil index | water | ≤ 0.2 | mg/l | 0.035 | 2 | 2016 |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.011 | 2 | 2016 |
| Free cyanides | water | ≤ 0.05 | mg CN/l | <0.015 | 1 | 2016 |
| Metal cyanide complexes | water | ≤ 0.05 | mg Me (CN)x/l | <0.015 | 1 | 2016 |
| Molybdenum | water | ≤ 0.04 | mg Mo/l | <0.01 | 1 | 2016 |
| Selenium | water | ≤ 0.02 | mg Se/l | <0.002 | 1 | 2016 |
| Silver | water | ≤ 0.005 | mg Ag/l | <0.001 | 1 | 2016 |
| Thallium | water | ≤ 0.002 | mg Tl/l | <0.0005 | 1 | 2016 |
| Titanium | water | ≤ 0.05 | mg Ti/l | <0.01 | 1 | 2016 |
| Vanadium | water | ≤ 0.05 | mg V/l | <0.01 | 1 | 2016 |
| Antimony | water | ≤ 0.002 | mg Sb/l | <0.0005 | 1 | 2016 |
| Fluoride | water | ≤ 1.5 | mg F/l | 0.4 | 2 | 2016 |
| Beryllium | water | ≤ 0.0008 | mg Be/l | <0.0002 | 1 | 2016 |
| Cobalt | water | ≤ 0.05 | mg Co/l | <0.01 | 1 | 2016 |

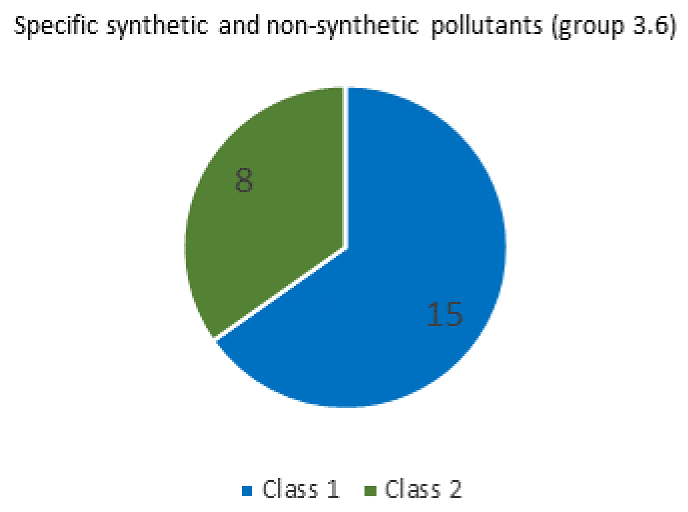
< - below the limit of quantification

Table 2.3.44. Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Anthracene | water | 0.1 | 0.1 | µg/l | 0.0009 | 0.0030 | 1 | 2016 |
| Atrazyna | water | 0.6 | 2.0 | µg/l | <0.18 | <0.18 | 1 | 2016 |
| Benzene | water | 8 | 50 | µg/l | <1.0 | <1.0 | 1 | 2016 |
| Brominated diphenylethers | biota | 0.0085 | | µg/kg ww | 0.31 | | > 1 | 2016 |
| Brominated diphenylethers | water | - | 0.14 | µg/l | | <0.00005 | 1 | 2016 |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | 0.14 | 0.36 | 1 | 2016 |
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.1 | 0.1 | 1 | 2016 |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.005 | <0.005 | 1 | 2012* |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | <1.25 | | 1 | 2016 |
| Dichloromethane | water | 20 | | µg/l | <1.25 | | 1 | 2016 |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 | | µg/l | <0.1 | | 1 | 2016 |
| Diuron | water | 0.2 | 1.8 | µg/l | <0.06 | <0.06 | 1 | 2016 |
| Endosulfan | water | 0.0005 | 0.004 | µg/l | 0.0001 | 0.0003 | 1 | 2016 |
| Fluoranthene | biota | 30 | | µg/kg ww | 5 | | 1 | 2016 |
| Fluoranthene | water | 0.0063 | 0.12 | µg/l | 0.0022 | 0.0025 | 1 | 2012* |
| Hexachlorobenzene (HCB) | biota | 10 | | µg/kg ww | <3.0 | | 1 | 2016 |
| Hexachlorobenzene (HCB) | water | | 0.05 | µg/l | | <0.001 | 1 | 2012* |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Hexachlorobutadiene (HCBD) | biota | 55 | | µg/kg ww | <3.0 | | 1 | 2016 |
| Hexachlorobutadiene (HCBD) | water | | 0.6 | µg/l | | <0.03 | 1 | 2012* |
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | µg/l | <0.36 | <0.36 | 1 | 2016 |
| Lead and its compounds | water | 1.3 | 14 | µg/l | <0.36 | <0.36 | 1 | 2016 |
| Mercury and its compounds | biota | 20 | | µg/kg ww | 39.2 | | > 1 | 2016 |
| Mercury and its compounds | water | - | 0.07 | µg/l | | 0.018 | 1 | 2016 |
| Naphthalene | water | 2 | 130 | µg/l | <0.087 | <0.087 | 1 | 2016 |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | 0.6 | 1.3 | 1 | 2016 |
| Nonylphenols | water | 0.3 | 2.0 | µg/l | 0.016 | 0.086 | 1 | 2016 |
| Octylphenols | water | 0.01 | | µg/l | 0.002 | | 1 | 2016 |
| Pentachlorobenzene | water | 0.0007 | | µg/l | <0.0002 | | 1 | 2016 |
| Pentachlorofenol (PCP) | water | 0.4 | 1.0 | µg/l | <0.05 | <0.05 | 1 | 2016 |
| Benzo(a)pyrene | biota | 5 | | µg/kg ww | <1.5 | | 1 | 2016 |
| Benzo(a)pyrene | water | $1.7 \times 10^{-4}$ | 0.027 | µg/l | <0.001 | <0.001 | 1 | 2012* |
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | <0.002 | 1 | 2012* |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | <0.002 | 1 | 2012* |
| Benzo(g,h,i)perylene | water | | $8.2 \times 10^{-4}$ | µg/l | | 0.0005 | 1 | 2012* |
| Simazine | water | 1 | 4 | µg/l | <0.3 | <0.3 | 1 | 2016 |
| Tributyltin compounds | water | 0.0002 | 0.0015 | µg/l | <0.00005 | <0.00005 | 1 | 2016 |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | <0.001 | | 1 | 2016 |
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | <0.5 | | 1 | 2016 |
| Trifluralin | water | 0.03 | | µg/l | <0.005 | | 1 | 2016 |
| Dicofol | biota | 33 | | µg/kg ww | <10 | | 1 | 2016 |
| Perfluorooctane sulfonic acid and its derivatives (PFOS) | biota | 9.1 | | µg/kg ww | 6.9 | | 1 | 2016 |
| Dioxins and dioxin-like compounds | biota | 0.0065 | | µg/kg ww | 0.0018 | | 1 | 2016 |
| Heksabromocyklodekan | biota | 167 | | µg/kg ww | 0.09 | | 1 | 2016 |
| Heptachlor and heptachlor epoxide | biota | 0.0067 | | µg/kg ww | 0.045 | | > 1 | 2016 |
| Tetrachloromethane | water | 12 | | µg/l | <0.5 | | 1 | 2016 |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | <0.001 | | 1 | 2016 |
| Para-para-DDT | water | 0.01 | | µg/l | 0.001 | | 1 | 2016 |
| DDT total | water | 0.025 | | µg/l | 0.003 | | 1 | 2016 |
| Trichloroethylene (TRI) | water | 10 | | µg/l | <0.5 | | 1 | 2016 |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | <0.5 | | 1 | 2016 |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable
* - inherited assessment



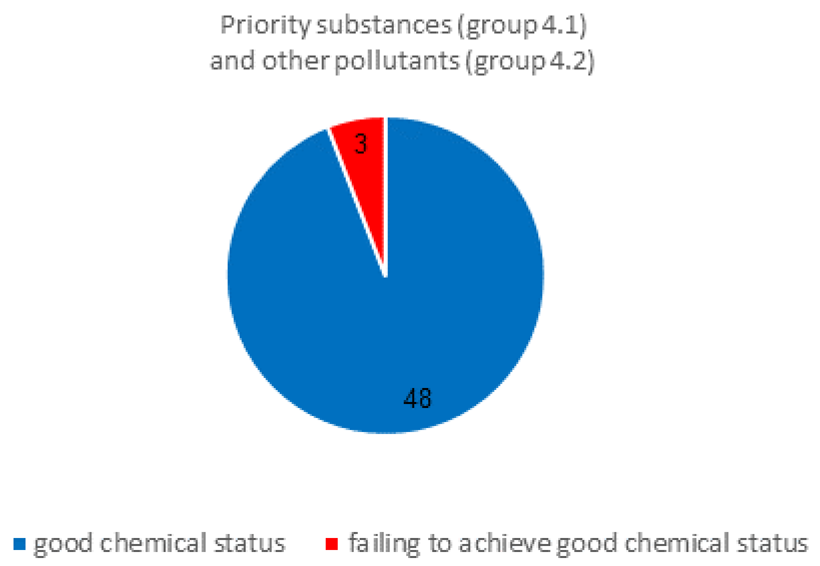




Fig. 2.3.40. Summary of the assessment of the environmental status of the Dziwna-Świna area in the scope of specific synthetic and non-synthetic pollutants (group 3.6) and priority substances group (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

*Sarbinowo - Dziwna*

Within the group of **specific synthetic** and **non-synthetic pollutants** (group 3.6) all substances indicate class 1 and 2, which means **good status of the Sarbinowo - Dziwna environment**, with 10 substances meeting the requirements for class 1 and 1 for class 2 (Table 2.3.45, Fig. 2.3.41).

Within the group of **priority substances** (group 4.1) and **other pollutants** (group 4.2) only polybrominated diphenylethers in organisms and in water, mercury and heptachlor in organisms indicate chemical status below good, other substances meet the requirements for good chemical status (Table 2.3.46, Fig. 2.3.41).

Table 2.3.45. Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Arsenic | water | ≤ 0.05 | mg As/l | <0.005 | 1 | 2012* |
| Barium | water | ≤ 0.5 | mg Ba/l | <0.011 | 1 | 2012* |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2012* |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.0013 | 1 | 2012* |
| Chromium | water | ≤ 0.05 | mg Cr/l | <0.0013 | 1 | 2012* |
| Zinc | water | ≤ 1 | mg Zn/l | 0.045 | 1 | 2012* |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.018 | 1 | 2012* |
| Phenol index | water | ≤ 0.01 | mg/l | <0.001 | 1 | 2012* |
| Oil index | water | ≤ 0.2 | mg/l | 0.004 | 1 | 2012* |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.009 | 1 | 2012* |
| Free cyanides | water | ≤ 0.05 | mg CN/l | <0.005 | 1 | 2012* |

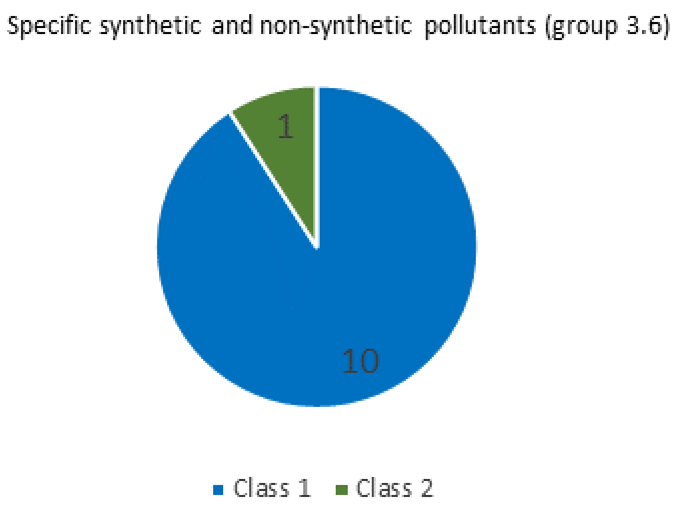
< - below the limit of quantification
* - inherited assessment

Table 2.3.46. Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | <0.001 | <0.001 | 1 | 2012* |
| Atrazine | water | 0.6 | 2.0 | µg/l | <0.11 | <0.11 | 1 | 2012* |
| Benzene | water | 8 | 50 | µg/l | <1.0 | <1.0 | 1 | 2012* |
| Brominated diphenylethers | biota | 0.0085 |  | µg/kg ww | 0.18 |  | > 1 | 2016 |
| Brominated diphenylethers | water | - | 0.14 | µg/l |  | 0.75 | > 1 | 2012* |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | <1.0 | <1.0 | 1 | 2012* |
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.4 | <0.4 | 1 | 2012* |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.01 | <0.01 | 1 | 2012* |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.01 | <0.01 | 1 | 2012* |
| 1,2-Dichloroethane (EDC) | water | 10 |  | µg/l | <4.0 |  | 1 | 2012* |
| Dichloromethane | water | 20 |  | µg/l | <6.0 |  | 1 | 2012* |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 |  | µg/l | <0.65 |  | 1 | 2012* |
| Diuron | water | 0.2 | 1.8 | µg/l | <0.04 | <0.04 | 1 | 2012* |
| Fluoranthene | biota | 30 |  | µg/kg ww | 5 |  | 1 | 2016 |
| Fluoranthene | water | 0.0063 | 0.12 | µg/l | 0.0011 | 0.0025 | 1 | 2012* |
| Hexachlorobenzene (HCB) | biota | 10 |  | µg/kg ww | <3.0 |  | 1 | 2016 |
| Hexachlorobenzene (HCB) | water |  | 0.05 | µg/l |  | <3.0 | 1 | 2012* |
| Hexachlorobutadiene (HCBD) | biota | 55 |  | µg/kg ww | <3.0 |  | 1 | 2016 |
| Hexachlorobutadiene (HCBD) | water |  | 0.6 | µg/l |  | <0.03 | 1 | 2012* |
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | µg/l | <0.001 | <0.001 | 1 | 2012* |
| Isoproturon | water | 0.3 | 1.0 | µg/l | <0.03 | <0.03 | 1 | 2012* |
| Lead and its compounds | water | 1.3 | 14 | µg/l | <0.36 | <0.36 | 1 | 2016 |
| Mercury and its compounds | biota | 20 |  | µg/kg ww | 36.3 |  | > 1 | 2016 |
| Mercury and its compounds | water | - | 0.07 | µg/l |  | <0.015 | 1 | 2016 |
| Naphthalene | water | 2 | 130 | µg/l | <0.087 | <0.087 | 1 | 2012* |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Nickel and its compounds | water | 8.6 | 34 | µg/l | 2.2 | 3.9 | 1 | 2016 |
| Octylphenols | water | 0.01 | | µg/l | 0.003 | | 1 | 2016 |
| Pentachlorobenzene | water | 0.0007 | | µg/l | <0.0002 | | 1 | 2012* |
| Pentachlorophenol (PCP) | water | 0.4 | 1.0 | µg/l | <0.3 | <0.3 | 1 | 2012* |
| Benzo(a)pyrene | biota | 5 | | µg/kg ww | <1.5 | | 1 | 2016 |
| Benzo(a)pyrene | water | $1.7x10^{-4}$ | 0.027 | µg/l | <0.001 | <0.001 | 1 | 2012* |
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | <0.002 | 1 | 2012* |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | <0.002 | 1 | 2012* |
| Benzo(g,h,i)perylene | water | | $8.2x10^{-4}$ | µg/l | | <0.0002 | 1 | 2012* |
| Simazine | water | 1 | 4 | µg/l | <0.3 | <0.3 | 1 | 2012* |
| Tributyltin compounds | water | 0.0002 | 0.0015 | µg/l | <0.00005 | <0.00005 | 1 | 2016 |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | <0.001 | | 1 | 2012* |
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | <0.5 | | 1 | 2012* |
| Trifluralin | water | 0.03 | | µg/l | <0.001 | | 1 | 2012* |
| Dicofol | biota | 33 | | µg/kg ww | <10 | | 1 | 2016 |
| Perfluorooctane sulfonic acid and its derivatives (PFOS) | biota | 9.1 | | µg/kg ww | 3.0 | | 1 | 2016 |
| Dioxins and dioxin-like compounds | biota | 0.0065 | | µg/kg ww | 0.0029 | | 1 | 2016 |
| Heksabromocyklodekan | biota | 167 | | µg/kg ww | 0.12 | | 1 | 2016 |
| Heptachlor and heptachlor epoxide | biota | 0.0067 | | µg/kg ww | 0.038 | | > 1 | 2016 |
| Tetrachloromethane | water | 12 | | µg/l | <0.5 | | 1 | 2012* |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | <0.001 | | 1 | 2012* |
| Para-para-DDT | water | 0.01 | | µg/l | <0.001 | | 1 | 2012* |
| DDT total | water | 0.025 | | µg/l | <0.001 | | 1 | 2012* |
| Trichloroethylene (TRI) | water | 10 | | µg/l | <0.3 | | 1 | 2012* |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | <0.22 | | 1 | 2012* |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable
* - inherited assessment



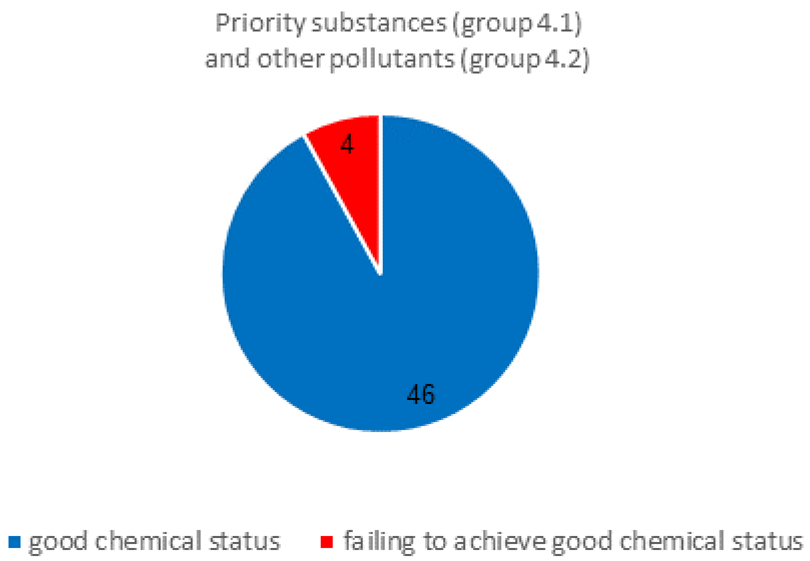




Fig. 2.3.41. Summary of the assessment of the environmental status of the Sarbinowo-Dziwna area in the scope of specific synthetic and non-synthetic pollutants (group 3.6) and priority substances group (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

### *Jarosławiec - Sarbinowo*

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 1 and 2, which means **good environmental status of the Jarosławiec - Sarbinowo area**, with 10 substances meeting the requirements for class 1 and 1 for class 2 (Table 2.3.47, Fig. 2.3.42).

Within the group of **priority substances** (group 4.1) and **other pollutants**(group 4.2) all substances were analyzed in water and meet the requirements for good chemical status(Table 2.3.48, Fig. 2.3.42).

Table 2.3.47. Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Arsenic | water | ≤ 0.05 | mg As/l | <0.005 | 1 | 2012* |
| Barium | water | ≤ 0.5 | mg Ba/l | <0.011 | 1 | 2012* |
| Boron | water | ≤ 2 | mg B/l | 0.92 | 2 | 2012* |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.0013 | 1 | 2012* |
| Chromium | water | ≤ 0.05 | mg Cr/l | <0.0013 | 1 | 2012* |
| Zinc | water | ≤ 1 | mg Zn/l | <0.025 | 1 | 2012* |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.005 | 1 | 2012* |
| Phenol index | water | ≤ 0.01 | mg/l | 0.0014 | 1 | 2012* |
| Oil index | water | ≤ 0.2 | mg/l | <0.004 | 1 | 2012* |
| Aluminium | water | ≤ 0.4 | mg Al/l | <0.003 | 1 | 2012* |
| Free cyanides | water | ≤ 0.05 | mg CN/l | <0.005 | 1 | 2012* |

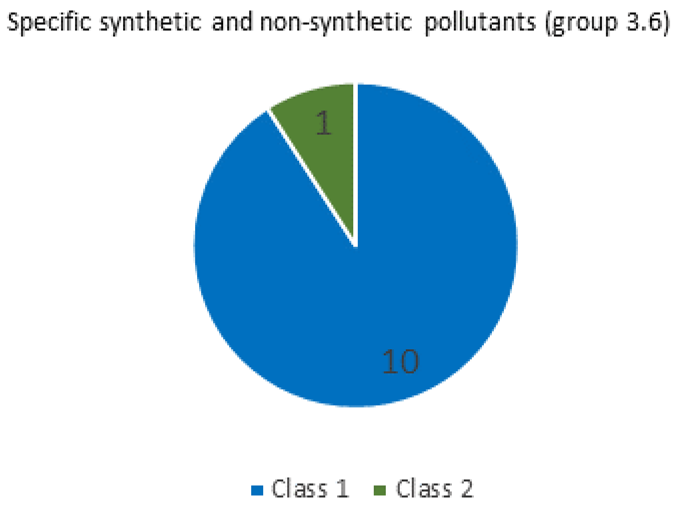
< - below the limit of quantification
* - inherited assessment

Table 2.3.48. Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | <0.001 | <0.001 | 1 | 2012* |
| Anthracene | water | 0.1 | 0.1 | µg/l | <0.001 | <0.001 | 1 | 2012* |
| Atrazine | water | 0.6 | 2.0 | µg/l | <0.11 | <0.11 | 1 | 2012* |
| Benzene | water | 8 | 50 | µg/l | <1.0 | <1.0 | 1 | 2012* |
| Brominated diphenylethers | water | - | 0.14 | µg/l | | <0.00005 | 1 | 2016 |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | <1.0 | <1.0 | 1 | 2012* |
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.4 | <0.4 | 1 | 2012* |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.01 | <0.01 | 1 | 2012* |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.01 | <0.01 | 1 | 2012* |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | <4.0 | | 1 | 2012* |
| Dichloromethane | water | 20 | | µg/l | <6.0 | | 1 | 2012* |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 | | µg/l | <0.65 | | 1 | 2012* |
| Diuron | water | 0.2 | 1.8 | µg/l | <0.04 | <0.04 | 1 | 2012* |
| Fluoranthene | water | 0.0063 | 0.12 | µg/l | 0.0009 | 0.0010 | 1 | 2012* |
| Hexachlorobenzene (HCB) | water | | 0.05 | µg/l | | <0.001 | 1 | 2012* |
| Hexachlorobutadiene (HCBD) | water | | 0.6 | µg/l | | <0.03 | 1 | 2012* |
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | µg/l | <0.001 | <0.001 | 1 | 2012* |
| Isoproturon | water | 0.3 | 1.0 | µg/l | <0.03 | <0.03 | 1 | 2012* |
| Lead and its compounds | water | 1.3 | 14 | µg/l | <2.0 | <2.0 | 1 | 2012* |
| Mercury and its compounds | water | - | 0.07 | µg/l | | 0.04 | 1 | 2012* |
| Naphthalene | water | 2 | 130 | µg/l | <0.087 | <0.087 | 1 | 2012* |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | <1.0 | <1.0 | 1 | 2012* |
| Octylphenols | water | 0.01 | | µg/l | 0.004 | | 1 | 2016 |
| Pentachlorobenzene | water | 0.0007 | | µg/l | <0.0002 | | 1 | 2012* |
| Pentachlorophenol (PCP) | water | 0.4 | 1.0 | µg/l | <0.3 | <0.3 | 1 | 2012* |
| Benzo(a)pyrene | water | $1.7x10^{-4}$ | 0.027 | µg/l | <0.001 | <0.001 | 1 | 2012* |
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | <0.002 | 1 | 2012* |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | <0.002 | 1 | 2012* |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Benzo(g,h,i)perylene | water | | $8.2x10^{-4}$ | µg/l | | <0.0002 | 1 | 2012* |
| Simazine | water | 1 | 4 | µg/l | <0.3 | <0.3 | 1 | 2012* |
| Tributyltin compounds | water | 0.0002 | 0.0015 | µg/l | <0.00005 | <0.00005 | 1 | 2016 |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | <0.001 | | 1 | 2012* |
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | <0.5 | | 1 | 2012* |
| Trifluralin | water | 0.03 | | µg/l | <0.001 | | 1 | 2012* |
| Tetrachloromethane | water | 12 | | µg/l | <0.5 | | 1 | 2012* |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | <0.001 | | 1 | 2012* |
| Para-para-DDT | water | 0.01 | | µg/l | <0.001 | | 1 | 2012* |
| DDT total | water | 0.025 | | µg/l | <0.001 | | 1 | 2012* |
| Trichloroethylene (TRI) | water | 10 | | µg/l | <0.3 | | 1 | 2012* |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | <0.22 | | 1 | 2012* |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable
* - inherited assessment



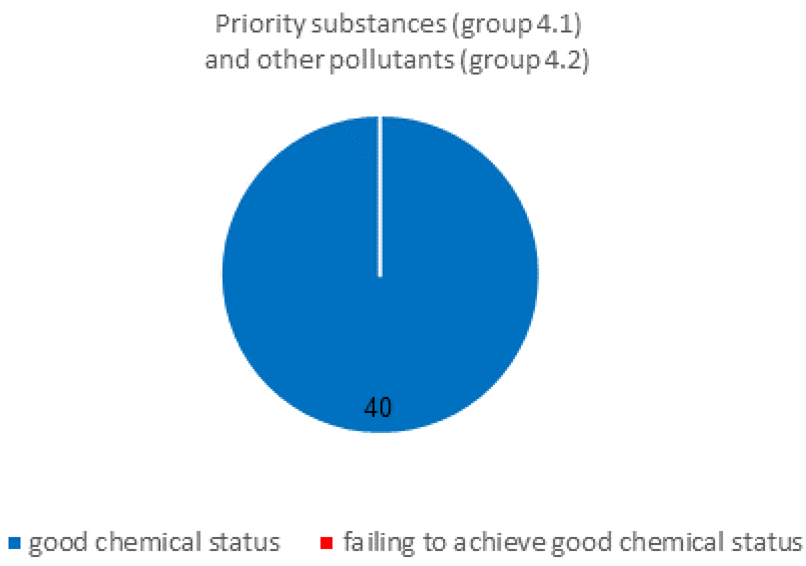



Fig. 2.3.42. Summary of the assessment of the environmental status of the Jarosławiec - Sarbinowo area in the scope of specific synthetic and non-synthetic pollutants (group 3.6) and the group of priority substances (group 4.1) and other pollutants (group 4.2). (Data source: PMŚ)

## *Outer Puck Bay*

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 1 and 2, which means **good environmental status in the area of the Outer Puck Bay**, with 10 substances meeting the requirements for class 1 and 13 for class 2 (Table 2.3.49, Fig. 2.3.43).

Within the group of **priority substances** (group 4.1) and **other pollutants** (group 4.2) all substances were analyzed in water and meet the requirements for good chemical status (Table 2.3.50, Fig. 2.3.43).

Table 2.3.49. Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Formaldehyde | water | ≤ 0.05 | mg/l | <0.05 | 1 | 2016 |
| Arsenic | water | ≤ 0.05 | mg As/l | 0.01 | 2 | 2016 |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.02 | 2 | 2016 |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2016 |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.0001 | 2 | 2016 |
| Chromium | water | ≤ 0.05 | mg Cr/l | <0.0001 | 2 | 2016 |
| Zinc | water | ≤ 1 | mg Zn/l | 1 | 2 | 2016 |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.001 | 2 | 2016 |
| Phenol index | water | ≤ 0.01 | mg/l | <0.002 | 1 | 2016 |
| Oil index | water | ≤ 0.2 | mg/l | <0.05 | 1 | 2016 |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.01 | 2 | 2016 |
| Free cyanides | water | ≤ 0.05 | mg CN/l | <0.01 | 1 | 2016 |
| Metal cyanide complexes | water | ≤ 0.05 | mg Me (CN)x/l | <0.01 | 1 | 2016 |
| Molybdenum | water | ≤ 0.04 | mg Mo/l | 0.03 | 2 | 2016 |
| Selenium | water | ≤ 0.02 | mg Se/l | <0.001 | 1 | 2016 |
| Silver | water | ≤ 0.005 | mg Ag/l | 0.003 | 1 | 2016 |

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Thallium | water | ≤ 0.002 | mg Tl/l | 0.00007 | 2 | 2016 |
| Titanium | water | ≤ 0.05 | mg Ti/l | 0.02 | 1 | 2016 |
| Vanadium | water | ≤ 0.05 | mg V/l | 0.004 | 1 | 2016 |
| Antimony | water | ≤ 0.002 | mg Sb/l | 0.001 | 2 | 2016 |
| Fluoride | water | ≤ 1.5 | mg F/l | 0.003 | 2 | 2016 |
| Beryllium | water | ≤ 0.0008 | mg Be/l | <0.0001 | 1 | 2016 |
| Cobalt | water | ≤ 0.05 | mg Co/l | 0.01 | 2 | 2016 |

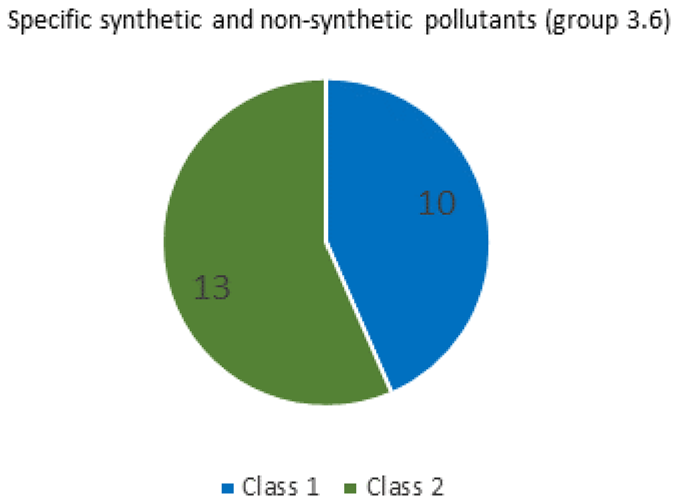
< - below the limit of quantification

Table 2.3.50. Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Anthracene | water | 0.1 | 0.1 | µg/l | <0.001 | <0.001 | 1 | 2016 |
| Atrazine | water | 0.6 | 2.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Benzene | water | 8 | 50 | µg/l | <1.0 | <1.0 | 1 | 2016 |
| Brominated diphenylethers | water | - | 0.14 | µg/l | | <0.00015 | 1 | 2016 |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | < 0.05 | < 0.05 | 1 | 2016 |
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.2 | <0.2 | 1 | 2016 |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.03 | <0.03 | 1 | 2016 |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.01 | <0.01 | 1 | 2016 |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |
| Dichloromethane | water | 20 | | µg/l | <1.0 | | 1 | 2016 |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 | | µg/l | <0.4 | | 1 | 2016 |
| Diuron | water | 0.2 | 1.8 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Endosulfan | water | 0.0005 | 0.004 | µg/l | <0.0002 | <0.0002 | 1 | 2016 |
| Hexachlorobenzene (HCB) | water | | 0.05 | µg/l | | 0.002 | 1 | 2011* |
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | µg/l | <0.0002 | <0.0002 | 1 | 2016 |
| Isoproturon | water | 0.3 | 1.0 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Lead and its compounds | water | 1.3 | 14 | µg/l | <0.4 | <0.4 | 1 | 2016 |
| Mercury and its compounds | water | - | 0.07 | µg/l | | 0.02 | 1 | 2011* |
| Naphthalene | water | 2 | 130 | µg/l | <0.5 | <0.5 | 1 | 2016 |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | 2 | 9 | 1 | 2016 |
| Octylphenols | water | 0.01 | | µg/l | <0.003 | | 1 | 2016 |
| Pentachlorobenzene | water | 0.0007 | | µg/l | <0.0002 | | 1 | 2016 |
| Pentachlorophenol (PCP) | water | 0.4 | 1.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Benzo(a)pyrene | water | $1.7x10^{-4}$ | 0.027 | µg/l | 0.002 | 0.002 | 1 | 2011* |
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | <0.001 | 1 | 2016 |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | <0.001 | 1 | 2016 |
| Benzo(g,h,i)perylene | water | | $8.2x10^{-4}$ | µg/l | | <0.0003 | 1 | 2016 |
| Simazine | water | 1 | 4 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Tributyltin compounds | water | 0.0002 | 0.0015 | µg/l | 0.0001 | 0.0003 | 1 | 2016 |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | <0.005 | | 1 | 2016 |
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | <1.0 | | 1 | 2016 |
| Trifluralin | water | 0.03 | | µg/l | <0.01 | | 1 | 2016 |
| Tetrachloromethane | water | 12 | | µg/l | <1.0 | | 1 | 2016 |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | <0.0002 | | 1 | 2016 |
| Para-para-DDT | water | 0.01 | | µg/l | <0.001 | | 1 | 2016 |
| DDT total | water | 0.025 | | µg/l | <0.001 | | 1 | 2016 |
| Trichloroethylene (TRI) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable
* - inherited assessment



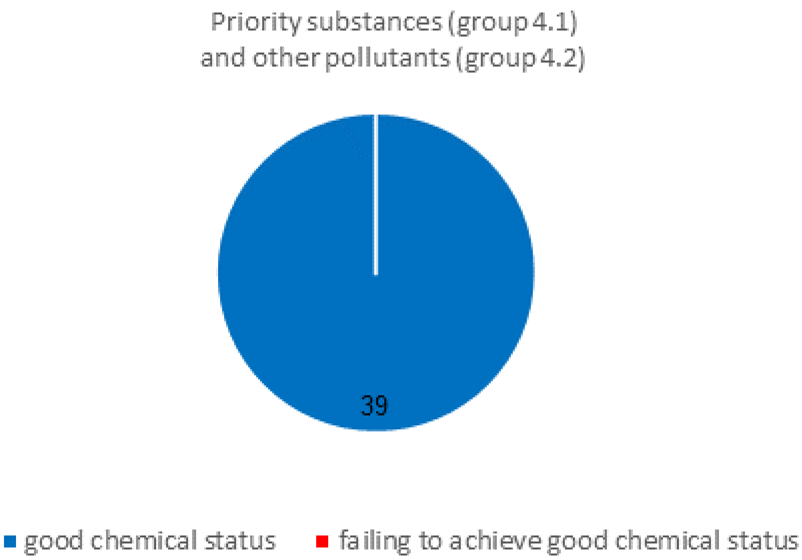



Fig. 2.3.43. Summary of the assessment of the environmental status of the Outer Puck Bay area in terms of specific synthetic and non-synthetic pollutants (group 3.6) and priority substances group (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

### *Wisła Przekop mouth*

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 2, which means **good environmental status in the Wisła Przekop mouth** (Table 2.3.51, Fig. 2.3.44).

Table 2.3.51. Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Arsenic | water | ≤ 0.05 | mg As/l | 0.01 | 2 | 2011* |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.03 | 2 | 2011* |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2011* |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | 0.001 | 2 | 2011* |
| Chromium | water | ≤ 0.05 | mg Cr/l | 0.001 | 2 | 2011* |
| Zinc | water | ≤ 1 | mg Zn/l | 0.01 | 2 | 2011* |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.01 | 2 | 2011* |
| Phenol index | water | ≤ 0.01 | mg/l | 0.002 | 2 | 2011* |
| Oil index | water | ≤ 0.2 | mg/l | 0.1 | 2 | 2011* |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.04 | 2 | 2011* |
| Free cyanides | water | ≤ 0.05 | mg CN/l | 0.001 | 2 | 2011* |

< - below the limit of quantification
* - inherited assessment

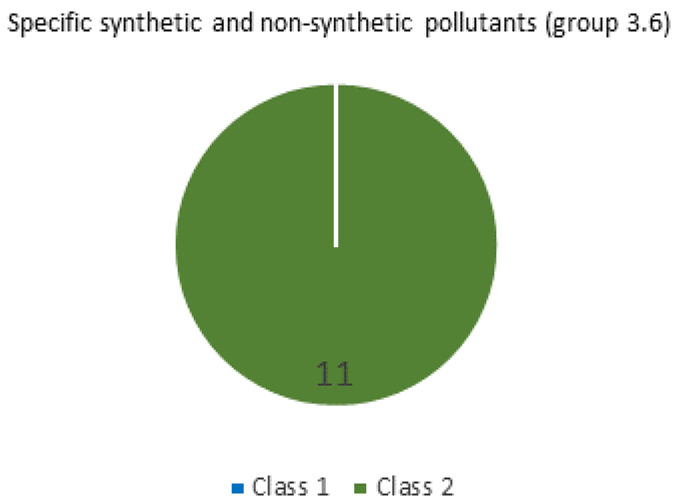



Fig. 2.3.44. Summary of the assessment of the environmental status of the Wisła Przekop mouth area within the scope of specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 2, which means **good environmental status in the Rowy - Jarosławiec East area** (Table 2.3.52, Fig. 2.3.45).
Within the group of **priority substances** (group 4.1) and **other pollutants** (group 4.2) only polybrominated diphenylethers, mercury and heptachlor in organisms indicate chemical status below good, other substances meet the requirements for good chemical status (Table 2.3.53, Fig. 2.3.45).

Table 2.3.52. Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Arsenic | water | ≤ 0.05 | mg As/l | 0.01 | 2 | 2011* |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.02 | 2 | 2011* |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2011* |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.001 | 2 | 2011* |
| Chromium | water | ≤ 0.05 | mg Cr/l | 0.002 | 2 | 2011* |
| Zinc | water | ≤ 1 | mg Zn/l | 0.01 | 2 | 2011* |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.01 | 2 | 2011* |
| Phenol index | water | ≤ 0.01 | mg/l | 0.002 | 2 | 2011* |
| Oil index | water | ≤ 0.2 | mg/l | 0.1 | 2 | 2011* |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.02 | 2 | 2011* |
| Free cyanides | water | ≤ 0.05 | mg CN/l | 0.001 | 2 | 2011* |

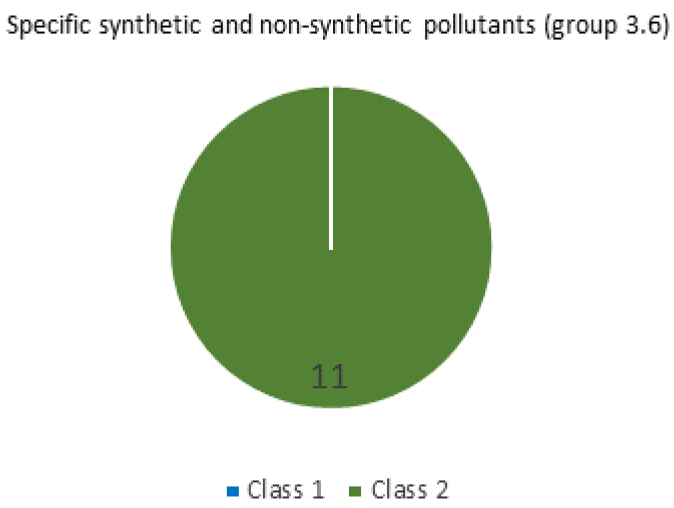
< - below the limit of quantification
* - inherited assessment

Table 2.3.53. Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Anthracene | water | 0.1 | 0.1 | µg/l | <0.002 | 0.1 | 1 | 2011* |
| Atrazine | water | 0.6 | 2.0 | µg/l | 0.05 | 0.05 | 1 | 2011* |
| Benzene | water | 8 | 50 | µg/l | 2.5 | 2.5 | 1 | 2011* |
| Brominated diphenylethers | biota | 0.0085 | | µg/kg ww | 0.29 | | >1 | 2016 |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | 5 | | 1 | 2011* |
| Dichloromethane | water | 20 | | µg/l | 3 | | 1 | 2011* |
| Diuron | water | 0.2 | 1.8 | µg/l | 0.1 | 0.1 | 1 | 2011* |
| Fluoranthene | biota | 30 | | µg/kg ww | <9.0 | | 1 | 2016 |
| Fluoranthene | water | 0.0063 | 0.12 | µg/l | 0.0075 | 0.02 | 1 | 2011* |
| Hexachlorobenzene (HCB) | biota | 10 | | µg/kg ww | <3.0 | | 1 | 2016 |
| Hexachlorobutadiene (HCBD) | biota | 55 | | µg/kg ww | <3.0 | | 1 | 2016 |
| Isoproturon | water | 0.3 | 1.0 | µg/l | 0.05 | 0.05 | 1 | 2011* |
| Lead and its compounds | water | 1.3 | 14 | µg/l | 2.5 | | 1 | 2015* |
| Mercury and its compounds | biota | 20 | | µg/kg ww | 26 | | >1 | 2016 |
| Naphthalene | water | 2 | 130 | µg/l | 0.5 | | 1 | 2011* |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | 2 | | 1 | 2011* |
| Benzo(a)pyrene | biota | 5 | | µg/kg ww | <1.5 | | 1 | 2016 |
| Benzo(a)pyrene | water | $1.7 \times 10^{-4}$ | 0.027 | µg/l | 0.00083 | 0.0013 | 1 | 2011* |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | 0.00033 | 1 | 2011* |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | 0.00033 | 1 | 2011* |
| Benzo(g,h,i)perylene | water | | 8.2x10$^{-4}$ | µg/l | | 0.00033 | 1 | 2015* |
| Simazine | water | 1 | 4 | µg/l | 0.05 | 0.05 | 1 | 2011* |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | 0.2 | | 1 | 2011* |
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | 1.25 | | 1 | 2011* |
| Trifluralin | water | 0.03 | | µg/l | 0.01 | | 1 | 2011* |
| Dicofol | biota | 33 | | µg/kg ww | <10.0 | | 1 | 2016 |
| Perfluorooctane sulfonic acid and its derivatives (PFOS) | biota | 9.1 | | µg/kg ww | 4.3 | | 1 | 2016 |
| Dioxins and dioxin-like compounds | biota | 0.0065 | | µg/kg ww | 0.0019 | | 1 | 2016 |
| Heksabromocyklodekan | biota | 167 | | µg/kg ww | 0.13 | | 1 | 2016 |
| Heptachlor and heptachlor epoxide | biota | 0.0067 | | µg/kg ww | 0.044 | | >1 | 2016 |
| Tetrachloromethane | water | 12 | | µg/l | 2.5 | | 1 | 2011* |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | 0.001 | | 1 | 2011* |
| Para-para-DDT | water | 0.01 | | µg/l | 0.001 | | 1 | 2011* |
| DDT total | water | 0.025 | | µg/l | 0.001 | | 1 | 2011* |
| Trichloroethylene (TRI) | water | 10 | | µg/l | 5 | | 1 | 2011* |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | 5 | | 1 | 2011* |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable
* - inherited assessment



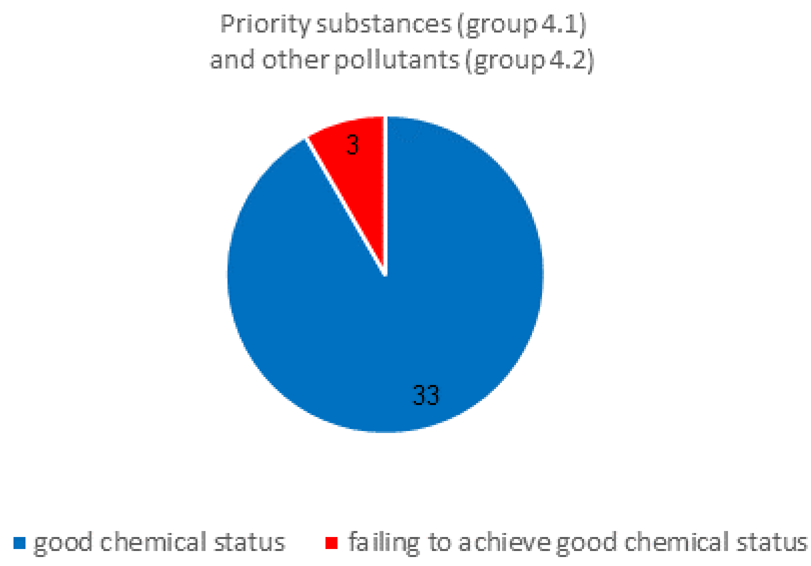



Fig. 2.3.45. Summary of the assessment of the environmental status of the Rowy Jarosławiec East area in the scope of specific synthetic and non-synthetic pollutants (group 3.6) and groups of priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

### *Władysławowo - Jastrzębia Góra*

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 1 and 2, which means **good environmental status in the area of Władysławowo - Jastrzębia Góra**, with 10 substances meeting the requirements for class 1 and 13 for class 2 (Table 2.3.54, Fig. 2.3.46).

Within the group of **priority substances** (group 4.1) and **other pollutants** (group 4.2) only polybrominated diphenylethers, mercury and heptachlor in organisms indicate chemical status below good, other substances meet the requirements for good chemical status (Table 2.3.55, Fig. 2.3.46).

Table 2.3.54. Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Formaldehyde | water | ≤ 0.05 | mg/l | <0.05 | 1 | 2016 |
| Arsenic | water | ≤ 0.05 | mg As/l | 0.02 | 2 | 2016 |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.02 | 2 | 2016 |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2016 |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.0001 | 2 | 2016 |
| Chromium | water | ≤ 0.05 | mg Cr/l | <0.0001 | 2 | 2016 |
| Zinc | water | ≤ 1 | mg Zn/l | 0.001 | 2 | 2016 |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.001 | 2 | 2016 |
| Phenol index | water | ≤ 0.01 | mg/l | <0.002 | 1 | 2016 |
| Oil index | water | ≤ 0.2 | mg/l | <0.05 | 1 | 2016 |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.01 | 2 | 2016 |
| Free cyanides | water | ≤ 0.05 | mg CN/l | <0.01 | 1 | 2016 |
| Metal cyanide complexes | water | ≤ 0.05 | mg Me (CN)x/l | <0.01 | 1 | 2016 |
| Molybdenum | water | ≤ 0.04 | mg Mo/l | 0.02 | 2 | 2016 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Selenium | water | ≤ 0.02 | mg Se/l | <0.001 | 1 | 2016 |
| Silver | water | ≤ 0.005 | mg Ag/l | 0.003 | 1 | 2016 |
| Thallium | water | ≤ 0.002 | mg Tl/l | <0.00001 | 1 | 2016 |
| Titanium | water | ≤ 0.05 | mg Ti/l | 0.02 | 1 | 2016 |
| Vanadium | water | ≤ 0.05 | mg V/l | 0.01 | 2 | 2016 |
| Antimony | water | ≤ 0.002 | mg Sb/l | 0.001 | 2 | 2016 |
| Fluoride | water | ≤ 1.5 | mg F/l | 0.003 | 2 | 2016 |
| Beryllium | water | ≤ 0.0008 | mg Be/l | <0.0001 | 1 | 2016 |
| Cobalt | water | ≤ 0.05 | mg Co/l | 0.01 | 2 | 2016 |

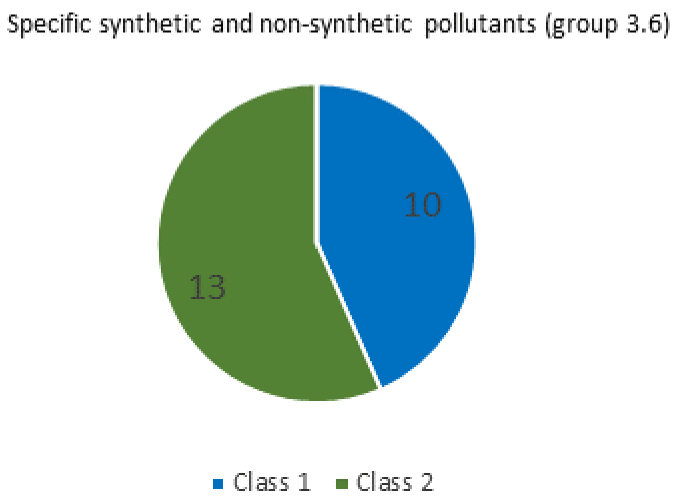
< - below the limit of quantification

Table 2.3.55. Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| **Indicator** | **Matrix** | **AA-EQS (water)/ EQS (biota)** | **MAC-EQS** | **Unit** | **Annual average** | **Maximum concentration** | **Class** | **A year of research** |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Anthracene | water | 0.1 | 0.1 | µg/l | <0.001 | <0.001 | 1 | 2016 |
| Atrazine | water | 0.6 | 2.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Benzen | water | 8 | 50 | µg/l | <1.0 | <1.0 | 1 | 2016 |
| Brominated diphenylethers | biota | 0.0085 | | µg/kg ww | 0.11 | | >1 | 2016 |
| Brominated diphenylethers | water | - | 0.14 | µg/l | | <0.00015 | 1 | 2016 |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | <0.05 | <0.05 | 1 | 2016 |
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.2 | <0.2 | 1 | 2016 |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.03 | <0.03 | 1 | 2016 |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.01 | <0.01 | 1 | 2016 |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |
| Dichloromethane | water | 20 | | µg/l | <1.0 | | 1 | 2016 |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 | | µg/l | <0.4 | | 1 | 2016 |
| Diuron | water | 0.2 | 1.8 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Endosulfan | water | 0.0005 | 0.004 | µg/l | <0.0002 | <0.0002 | 1 | 2016 |
| Fluoranthene | biota | 30 | | µg/kg ww | <9.0 | | 1 | 2016 |
| Hexachlorobenzene (HCB) | biota | 10 | | µg/kg ww | <3.0 | | 1 | 2016 |
| Hexachlorobutadiene (HCBD) | biota | 55 | | µg/kg ww | <3.0 | | 1 | 2016 |
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | µg/l | <0.0002 | <0.0002 | 1 | 2016 |
| Isoproturon | water | 0.3 | 1.0 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Lead and its compounds | water | 1.3 | 14 | µg/l | <0.4 | <0.4 | 1 | 2016 |
| Mercury and its compounds | biota | 20 | | µg/kg ww | 39 | | >1 | 2016 |
| Naphthalene | water | 2 | 130 | µg/l | <0.5 | <0.5 | 1 | 2016 |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | 3 | 7 | 1 | 2016 |
| Nonylphenols | water | 0.3 | 2.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Octylphenols | water | 0.01 | | µg/l | <0.003 | | 1 | 2016 |
| Pentachlorobenzene | water | 0.0007 | | µg/l | <0.0002 | | 1 | 2016 |
| Pentachlorophenol (PCP) | water | 0.4 | 1.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Benzo(a)pyrene | biota | 5 | | µg/kg ww | <1.5 | | 1 | 2016 |
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | <0.001 | 1 | 2016 |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | <0.001 | 1 | 2016 |
| Benzo(g,h,i)perylene | water | | $8.2 \times 10^{-4}$ | µg/l | | 0.0008 | 1 | 2016 |
| Simazine | water | 1 | 4 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Tributyltin compounds | water | 0.0002 | 0.0015 | µg/l | 0.0001 | 0.0002 | 1 | 2016 |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | <0.005 | | 1 | 2016 |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | <1.0 | | 1 | 2016 |
| Trifluralin | water | 0.03 | | µg/l | <0.01 | | 1 | 2016 |
| Dicofol | biota | 33 | | µg/kg ww | <10.0 | | 1 | 2016 |
| Perfluorooctane sulfonic acid and its derivatives (PFOS) | biota | 9.1 | | µg/kg ww | 4.3 | | 1 | 2016 |
| Dioxins and dioxin-like compounds | biota | 0.0065 | | µg/kg ww | 0.0028 | | 1 | 2016 |
| Heksabromocyklodekan | biota | 167 | | µg/kg ww | 0.067 | | 1 | 2016 |
| Heptachlor and heptachlor epoxide | biota | 0.0067 | | µg/kg ww | 0.036 | | >1 | 2016 |
| Tetrachloromethane | water | 12 | | µg/l | <1.0 | | 1 | 2016 |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | <0.0002 | | 1 | 2016 |
| Para-para-DDT | water | 0.01 | | µg/l | <0.001 | | 1 | 2016 |
| DDT total | water | 0.025 | | µg/l | <0.001 | | 1 | 2016 |
| Trichloroethylene (TRI) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable



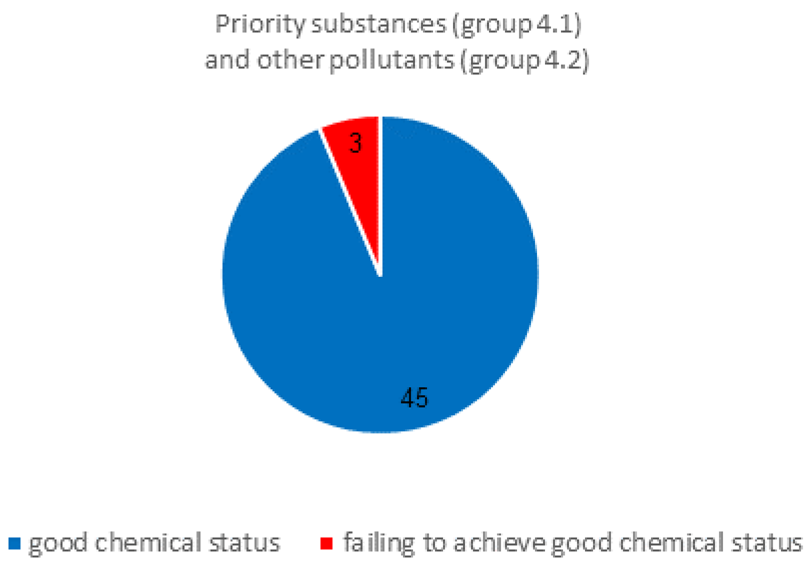



Fig. 2.3.46. Summary of the assessment of the environmental status of the Władysławowo-Jastrzębia Góra area in the scope of specific synthetic and non-synthetic pollutants (group 3.6) and priority substances group (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

## *Hel Peninsula*

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 2, which means **good environmental status of Hel Peninsula** in this respect (Table 2.3.56, Fig. 2.3.47).

Within the group of **priority substances** (group 4.1) and **other pollutants** (group 4.2) all substances were analyzed in water and meet the requirements for good chemical status(Table 2.3.57, Fig. 2.3.47).

Table 2.3.56 Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

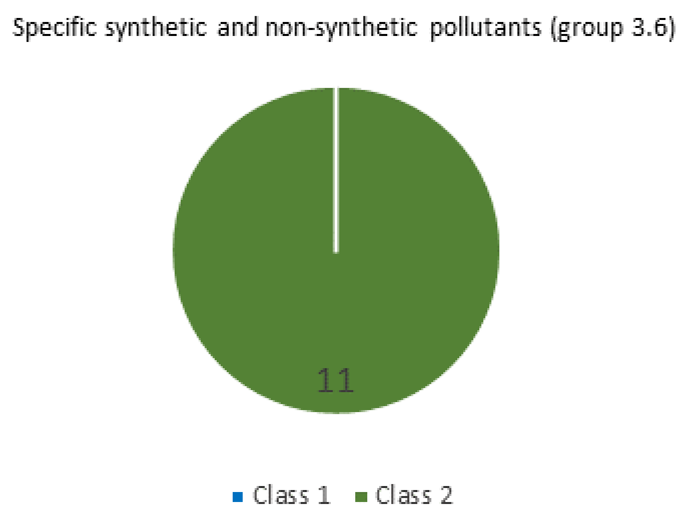
| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Arsenic | water | ≤ 0.05 | mg As/l | 0.01 | 2 | 2012* |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.02 | 2 | 2012* |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2012* |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.001 | 2 | 2012* |
| Chromium | water | ≤ 0.05 | mg Cr/l | <0.001 | 2 | 2012* |
| Zinc | water | ≤ 1 | mg Zn/l | 0.01 | 2 | 2012* |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.002 | 2 | 2012* |
| Phenol index | water | ≤ 0.01 | mg/l | 0.001 | 2 | 2012* |
| Oil index | water | ≤ 0.2 | mg/l | 0.1 | 2 | 2012* |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.02 | 2 | 2012* |
| Free cyanides | water | ≤ 0.05 | mg CN/l | 0.003 | 2 | 2012* |

< - below the limit of quantification
* - inherited assessment

Table 2.3.57 Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | | 0.07 | 1 | 2012* |
| Anthracene | water | 0.1 | 0.1 | µg/l | 0.1 | 0.1 | 1 | 2012* |
| Atrazine | water | 0.6 | 2.0 | µg/l | 0.05 | 0.05 | 1 | 2012* |
| Benzene | water | 8 | 50 | µg/l | 0.5 | 0.5 | 1 | 2012* |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | 0.18 | 0.25 | 1 | 2012* |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | 0.01 | 0.02 | 1 | 2012* |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | 0.01 | 0.02 | 1 | 2012* |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | 1 | | 1 | 2012* |
| Dichloromethane | water | 20 | | µg/l | 1 | | 1 | 2012* |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 | | µg/l | 0.5 | | 1 | 2012* |
| Fluoranthene | water | 0.0063 | 0.12 | µg/l | 0.001 | 0.001 | 1 | 2012* |
| Hexachlorobenzene (HCB) | water | | 0.05 | µg/l | | 0.001 | 1 | 2012* |
| Hexachlorobutadiene (HCBD) | water | | 0.6 | µg/l | | 0.1 | 1 | 2012* |
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | µg/l | 0.001 | 0.001 | 1 | 2012* |
| Lead and its compounds | water | 1.3 | 14 | µg/l | 2 | | 1 | 2012* |
| Mercury and its compounds | water | - | 0.07 | µg/l | | 0.01 | 1 | 2012* |
| Naphthalene | water | 2 | 130 | µg/l | 0.5 | | 1 | 2012* |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | 3 | | 1 | 2012* |
| Nonylphenols | water | 0.3 | 2.0 | µg/l | 0.1 | 0.1 | 1 | 2012* |
| Octylphenols | water | 0.01 | | µg/l | 0.007 | | 1 | 2012* |
| Pentachlorophenol (PCP) | water | 0.4 | 1.0 | µg/l | 0.1 | 0.1 | 1 | 2012* |
| Benzo(a)pyrene | water | $1.7 \times 10^{-4}$ | 0.027 | µg/l | 0.001 | 0.001 | 1 | 2012* |
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | 0.001 | 1 | 2012* |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | 0.001 | 1 | 2012* |
| Benzo(g,h,i)perylene | water | | $8.2 \times 10^{-4}$ | µg/l | | 0.001 | 1 | 2012* |
| Simazine | water | 1 | 4 | µg/l | 0.05 | 0.05 | 1 | 2012* |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | 0.01 | | 1 | 2012* |
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | 0.5 | | 1 | 2012* |
| Trifluralin | water | 0.03 | | µg/l | 0.5 | | 1 | 2012* |
| Tetrachloromethane | water | 12 | | µg/l | 0.5 | | 1 | 2012* |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | 0.001 | | 1 | 2012* |
| Para-para-DDT | water | 0.01 | | µg/l | 0.001 | | 1 | 2012* |
| DDT total | water | 0.025 | | µg/l | 0.001 | | 1 | 2012* |
| Trichloroethylene (TRI) | water | 10 | | µg/l | 0.5 | | 1 | 2012* |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | 0.5 | | 1 | 2012* |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable
* - inherited assessment



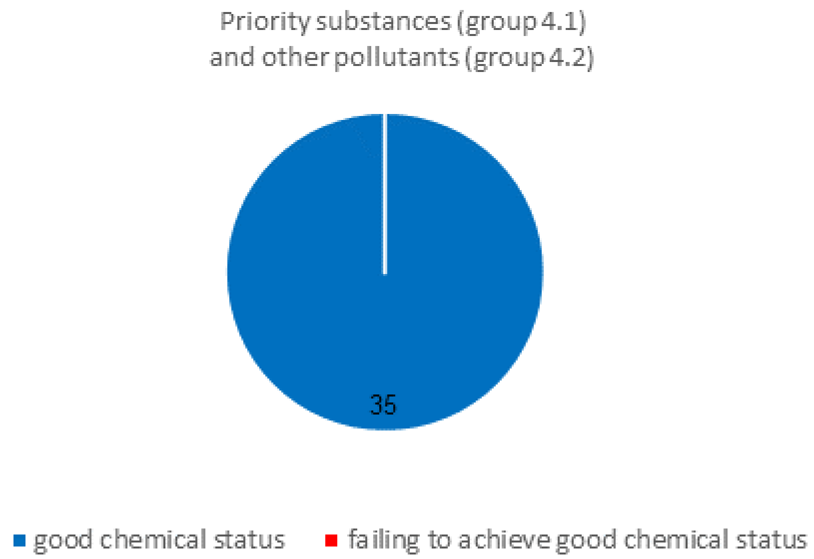




Fig. 2.3.47 Summary of the assessment of the environmental status of Hel Peninsula regarding specific synthetic and non-synthetic pollutants (group 3.6) and groups of priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

## *Vistula Spit*

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 2, which means a **good environmental status of the Vistula Spit area** (Table 2.3.58, Fig. 2.3.48).

Table 2.3.58 Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Arsenic | water | ≤ 0.05 | mg As/l | 0.01 | 2 | 2011* |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.02 | 2 | 2011* |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2011* |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | 0.001 | 2 | 2011* |

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Chromium | water | ≤ 0.05 | mg Cr/l | 0.001 | 2 | 2011* |
| Zinc | water | ≤ 1 | mg Zn/l | 0.01 | 2 | 2011* |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.01 | 2 | 2011* |
| Phenol index | water | ≤ 0.01 | mg/l | 0.003 | 2 | 2011* |
| Oil index | water | ≤ 0.2 | mg/l | 0.1 | 2 | 2011* |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.03 | 2 | 2011* |
| Free cyanides | water | ≤ 0.05 | mg CN/l | 0.02 | 2 | 2011* |

< - below the limit of quantification
* - inherited assessment

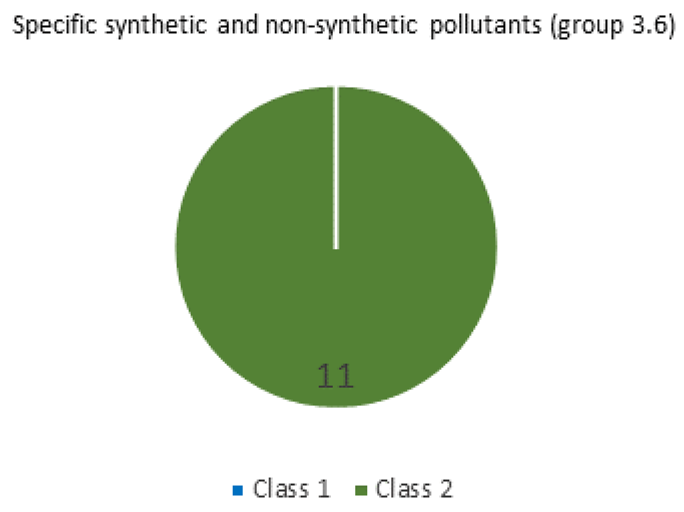



Fig. 2.3.48 Summary of the environmental status assessment of the Vistula Spit in the area of specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

## *Puck lagoon*

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 1 and 2, which means a **good status of Puck lagoon environment**, with 10 substances meeting the requirements for class 1 and 13 for class 2 (Table 2.3.59, Fig. 2.3.49).

Within the group of **priority substances** (group 4.1) and **other pollutants** (group 4.2) all substances were analyzed in water and meet the requirements for good chemical status(Table 2.3.60, Fig. 2.3.49).

Table 2.3.59 Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Formaldehyde | water | ≤ 0.05 | mg/l | <0.05 | 1 | 2016 |
| Arsenic | water | ≤ 0.05 | mg As/l | 0.003 | 2 | 2016 |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.02 | 2 | 2016 |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2016 |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.0001 | 2 | 2016 |
| Chromium | water | ≤ 0.05 | mg Cr/l | <0.0001 | 2 | 2016 |
| Zinc | water | ≤ 1 | mg Zn/l | 0.001 | 2 | 2016 |

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.001 | 2 | 2016 |
| Phenol index | water | ≤ 0.01 | mg/l | <0.002 | 1 | 2016 |
| Oil index | water | ≤ 0.2 | mg/l | <0.05 | 1 | 2016 |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.01 | 2 | 2016 |
| Free cyanides | water | ≤ 0.05 | mg CN/l | <0.01 | 1 | 2016 |
| Metal cyanide complexes | water | ≤ 0.05 | mg Me (CN)x/l | <0.01 | 1 | 2016 |
| Molybdenum | water | ≤ 0.04 | mg Mo/l | 0.01 | 2 | 2016 |
| Selenium | water | ≤ 0.02 | mg Se/l | <0.001 | 1 | 2016 |
| Silver | water | ≤ 0.005 | mg Ag/l | <0.001 | 1 | 2016 |
| Thallium | water | ≤ 0.002 | mg Tl/l | <0.00001 | 1 | 2016 |
| Titanium | water | ≤ 0.05 | mg Ti/l | 0.02 | 1 | 2016 |
| Vanadium | water | ≤ 0.05 | mg V/l | 0.01 | 2 | 2016 |
| Antimony | water | ≤ 0.002 | mg Sb/l | 0.001 | 2 | 2016 |
| Fluoride | water | ≤ 1.5 | mg F/l | 0.003 | 2 | 2016 |
| Beryllium | water | ≤ 0.0008 | mg Be/l | <0.0001 | 1 | 2016 |
| Cobalt | water | ≤ 0.05 | mg Co/l | <0.001 | 1 | 2016 |

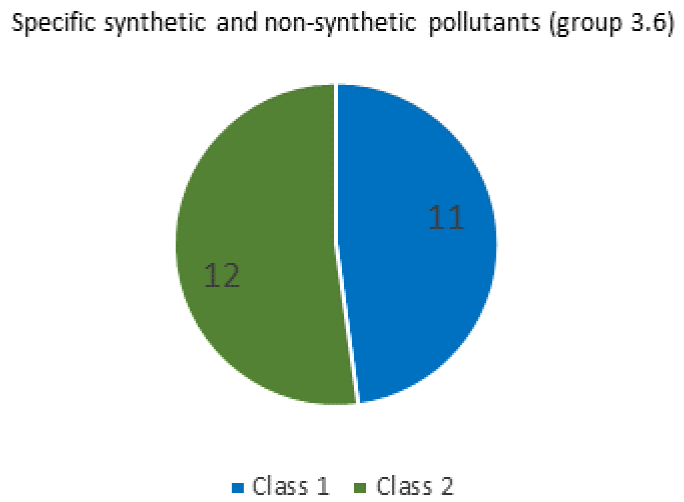
< - below the limit of quantification

Table 2.3.60 Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Anthracene | water | 0.1 | 0.1 | µg/l | <0.001 | <0.001 | 1 | 2016 |
| Atrazine | water | 0.6 | 2.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Benzene | water | 8 | 50 | µg/l | <1.0 | <1.0 | 1 | 2016 |
| Brominated diphenylethers | water | - | 0.14 | µg/l | | <0.00015 | 1 | 2016 |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | <0.05 | <0.05 | 1 | 2016 |
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.2 | <0.2 | 1 | 2016 |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.03 | <0.03 | 1 | 2016 |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.01 | <0.01 | 1 | 2016 |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |
| Dichloromethane | water | 20 | | µg/l | <1.0 | | 1 | 2016 |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 | | µg/l | <0.4 | | 1 | 2016 |
| Diuron | water | 0.2 | 1.8 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Endosulfan | water | 0.0005 | 0.004 | µg/l | <0.0002 | <0.0002 | 1 | 2016 |
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | µg/l | <0.0002 | <0.0002 | 1 | 2016 |
| Isoproturon | water | 0.3 | 1.0 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Lead and its compounds | water | 1.3 | 14 | µg/l | <0.4 | <0.4 | 1 | 2016 |
| Naphthalene | water | 2 | 130 | µg/l | <0.5 | <0.5 | 1 | 2016 |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | 2 | 5 | 1 | 2016 |
| Nonylphenols | water | 0.3 | 2.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Octylphenols | water | 0.01 | | µg/l | <0.003 | | 1 | 2016 |
| Pentachlorobenzene | water | 0.0007 | | µg/l | <0.0002 | | 1 | 2016 |
| Pentachlorophenol (PCP) | water | 0.4 | 1.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | <0.001 | 1 | 2016 |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | <0.001 | 1 | 2016 |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Benzo(g,h,i)perylene | water | | $8.2x10^{-4}$ | µg/l | | 0.0003 | 1 | 2016 |
| Simazine | water | 1 | 4 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Tributyltin compounds | water | 0.0002 | 0.0015 | µg/l | 0.0001 | 0.0002 | 1 | 2016 |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | <0.005 | | 1 | 2016 |
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | <1.0 | | 1 | 2016 |
| Trifluralin | water | 0.03 | | µg/l | <0.01 | | 1 | 2016 |
| Tetrachloromethane | water | 12 | | µg/l | <1.0 | | 1 | 2016 |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | <0.0002 | | 1 | 2016 |
| Para-para-DDT | water | 0.01 | | µg/l | <0.001 | | 1 | 2016 |
| DDT total | water | 0.025 | | µg/l | <0.001 | | 1 | 2016 |
| Trichloroethylene (TRI) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable



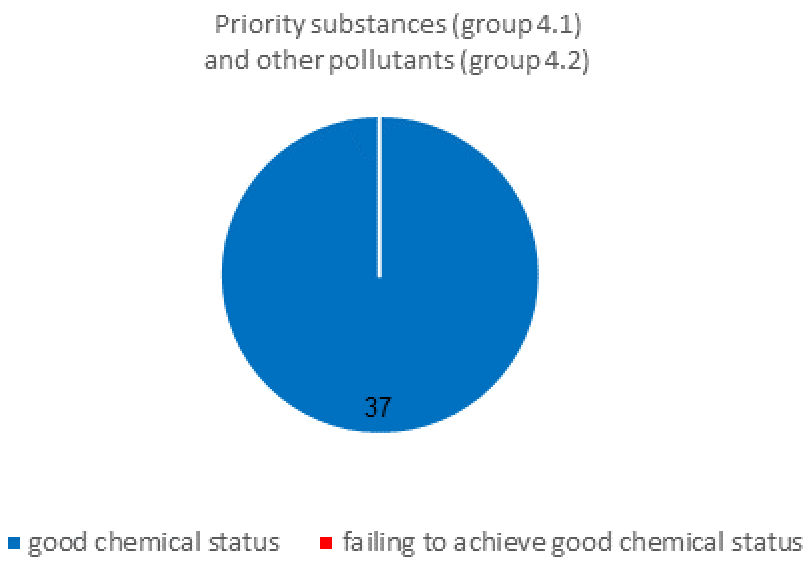



Fig. 2.3.49 Summary of the assessment of the environmental status of Puck Lagoon area in the scope of specific synthetic and non-synthetic pollutants (group 3.6) and priority substances group (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

*Inner Gulf of Gdańsk*

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 1 and 2, which means a **good status of the environment of Inner Gulf of Gdańsk area**, with 8 substances meeting the requirements for class 1 and 15 for class 2 (Table 2.3.61, Fig. 2.3.50).

Within the group of **priority substances** (group 4.1) and **other pollutants** (group 4.2) only heptachlor in organisms indicates chemical status below good, other substances meet the requirements for good chemical status (Table 2.3.62, Fig. 2.3.50).

Table 2.3.61 Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Formaldehyde | water | ≤ 0.05 | mg/l | <0.05 | 1 | 2016 |
| Arsenic | water | ≤ 0.05 | mg As/l | 0.01 | 2 | 2016 |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.04 | 2 | 2016 |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2016 |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.0001 | 2 | 2016 |
| Chromium | water | ≤ 0.05 | mg Cr/l | <0.0001 | 2 | 2016 |
| Zinc | water | ≤ 1 | mg Zn/l | 0.002 | 2 | 2016 |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.001 | 2 | 2016 |
| Phenol index | water | ≤ 0.01 | mg/l | <0.002 | 1 | 2016 |
| Oil index | water | ≤ 0.2 | mg/l | <0.05 | 1 | 2016 |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.01 | 2 | 2016 |
| Free cyanides | water | ≤ 0.05 | mg CN/l | <0.01 | 1 | 2016 |
| Metal cyanide complexes | water | ≤ 0.05 | mg Me (CN)x/l | <0.01 | 2 | 2016 |
| Molybdenum | water | ≤ 0.04 | mg Mo/l | 0.02 | 2 | 2016 |
| Selenium | water | ≤ 0.02 | mg Se/l | <0.001 | 1 | 2016 |

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Silver | water | ≤ 0.005 | mg Ag/l | 0.003 | 1 | 2016 |
| Thallium | water | ≤ 0.002 | mg Tl/l | 0.00009 | 2 | 2016 |
| Titanium | water | ≤ 0.05 | mg Ti/l | <0.001 | 1 | 2016 |
| Vanadium | water | ≤ 0.05 | mg V/l | 0.01 | 2 | 2016 |
| Antimony | water | ≤ 0.002 | mg Sb/l | 0.001 | 2 | 2016 |
| Fluoride | water | ≤ 1.5 | mg F/l | 0.003 | 2 | 2016 |
| Beryllium | water | ≤ 0.0008 | mg Be/l | <0.0001 | 1 | 2016 |
| Cobalt | water | ≤ 0.05 | mg Co/l | 0.01 | 2 | 2016 |

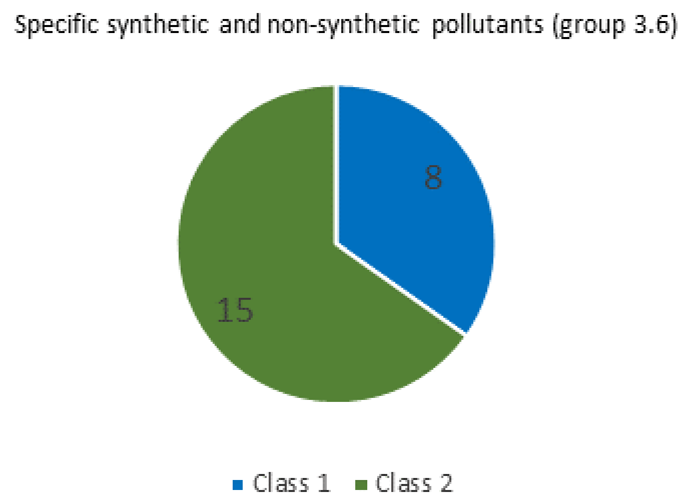
< - below the limit of quantification

Table 2.3.62 Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Anthracene | water | 0.1 | 0.1 | µg/l | <0.001 | <0.001 | 1 | 2016 |
| Atrazine | water | 0.6 | 2.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Benzene | water | 8 | 50 | µg/l | <1.0 | <1.0 | 1 | 2016 |
| Brominated diphenylethers | water | - | 0.14 | µg/l | | <0.00015 | 1 | 2016 |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | <0.05 | <0.05 | 1 | 2016 |
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.2 | <0.2 | 1 | 2016 |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.03 | <0.03 | 1 | 2016 |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.01 | <0.01 | 1 | 2016 |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |
| Dichloromethane | water | 20 | | µg/l | <1.0 | | 1 | 2016 |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 | | µg/l | <0.4 | | 1 | 2016 |
| Diuron | water | 0.2 | 1.8 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Endosulfan | water | 0.0005 | 0.004 | µg/l | <0.0002 | <0.0002 | 1 | 2016 |
| Fluoranthene | biota | 30 | | µg/kg ww | 30 | | 1 | 2016 |
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | µg/l | <0.0002 | <0.0002 | 1 | 2016 |
| Isoproturon | water | 0.3 | 1.0 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Lead and its compounds | water | 1.3 | 14 | µg/l | <0.4 | <0.4 | 1 | 2016 |
| Naphthalene | water | 2 | 130 | µg/l | <0.5 | <0.5 | 1 | 2016 |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | 3 | 8 | 1 | 2016 |
| Nonylphenols | water | 0.3 | 2.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Octylphenols | water | 0.01 | | µg/l | <0.003 | | 1 | 2016 |
| Pentachlorobenzene | water | 0.0007 | | µg/l | <0.0002 | | 1 | 2016 |
| Pentachlorophenol (PCP) | water | 0.4 | 1.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Benzo(a)pyrene | biota | 5 | | µg/kg ww | <1.5 | | 1 | 2016 |
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | <0.001 | 1 | 2016 |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | <0.001 | 1 | 2016 |
| Benzo(g,h,i)perylene | water | | $8.2x10^{-4}$ | µg/l | | <0.0003 | 1 | 2016 |
| Simazine | water | 1 | 4 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Tributyltin compounds | water | 0.0002 | 0.0015 | µg/l | 0.0001 | 0.0002 | 1 | 2016 |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | <0.005 | | 1 | 2016 |
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | <1.0 | | 1 | 2016 |
| Trifluralin | water | 0.03 | | µg/l | <0.01 | | 1 | 2016 |
| Dicofol | biota | 33 | | µg/kg ww | <10.0 | | 1 | 2016 |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Dioxins and dioxin-like compounds | biota | 0.0065 | | µg/kg ww | 0.0041 | | 1 | 2016 |
| Heptachlor and heptachlor epoxide | biota | 0.0067 | | µg/kg ww | 0.056 | | >1 | 2016 |
| Tetrachloromethane | water | 12 | | µg/l | <1.0 | | 1 | 2016 |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | <0.0002 | | 1 | 2016 |
| Para-para-DDT | water | 0.01 | | µg/l | <0.001 | | 1 | 2016 |
| DDT total | water | 0.025 | | µg/l | <0.001 | | 1 | 2016 |
| Trichloroethylene (TRI) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable



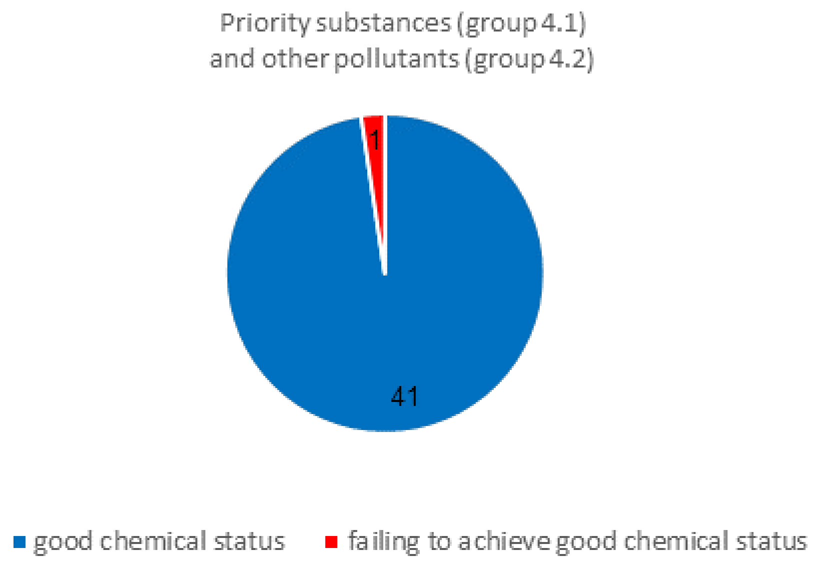



Fig. 2.3.50 Summary of the assessment of the status of the environment of Inner Gulf of Gdańsk area in the scope of specific synthetic and non-synthetic pollutants (group 3.6) and priority substances group (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

## *Jastrzębia Góra – Rowy*

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) all substances indicate class 1 and 2, which means **good environmental status of the Jastrzębia Góra - Rowy area**, with 9 substances meeting the requirements for class 1 and 14 for class 2 (Table 2.3.63, Fig. 2.3.51).

Within the group of **priority substances** (group 4.1) and **other pollutants** (group 4.2) all substances were analyzed in water and meet the requirements for good chemical status (Table 2.3.64, Fig. 2.3.51).

Table 2.3.63 Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Formaldehyde | water | ≤ 0.05 | mg/l | <0.05 | 1 | 2016 |
| Arsenic | water | ≤ 0.05 | mg As/l | 0.01 | 2 | 2016 |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.02 | 2 | 2016 |
| Boron | water | ≤ 2 | mg B/l | 1 | 2 | 2016 |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | 0.0005 | 2 | 2016 |
| Chromium | water | ≤ 0.05 | mg Cr/l | 0.0005 | 2 | 2016 |
| Zinc | water | ≤ 1 | mg Zn/l | 0.001 | 2 | 2016 |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.001 | 2 | 2016 |
| Phenol index | water | ≤ 0.01 | mg/l | <0.002 | 1 | 2016 |
| Oil index | water | ≤ 0.2 | mg/l | <0.05 | 1 | 2016 |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.02 | 2 | 2016 |
| Free cyanides | water | ≤ 0.05 | mg CN/l | <0.01 | 1 | 2016 |
| Metal cyanide complexes | water | ≤ 0.05 | mg Me (CN)x/l | <0.01 | 1 | 2016 |
| Molybdenum | water | ≤ 0.04 | mg Mo/l | 0.03 | 2 | 2016 |
| Selenium | water | ≤ 0.02 | mg Se/l | <0.001 | 1 | 2016 |
| Silver | water | ≤ 0.005 | mg Ag/l | <0.001 | 1 | 2016 |
| Thallium | water | ≤ 0.002 | mg Tl/l | 0.00028 | 2 | 2016 |
| Titanium | water | ≤ 0.05 | mg Ti/l | 0.03 | 2 | 2016 |
| Vanadium | water | ≤ 0.05 | mg V/l | 0.004 | 1 | 2016 |
| Antimony | water | ≤ 0.002 | mg Sb/l | 0.001 | 2 | 2016 |
| Fluoride | water | ≤ 1.5 | mg F/l | 0.003 | 2 | 2016 |
| Beryllium | water | ≤ 0.0008 | mg Be/l | <0.0001 | 1 | 2016 |
| Cobalt | water | ≤ 0.05 | mg Co/l | 0.01 | 2 | 2016 |

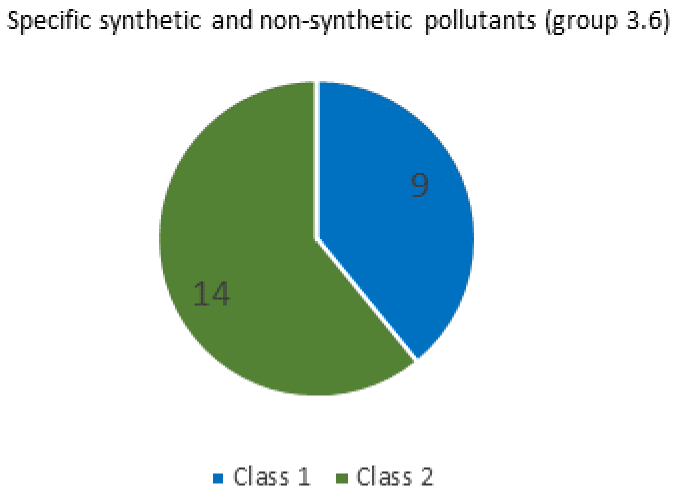
< - below the limit of quantification

Table 2.3.64 Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | μg/l | <0.1 | <0.1 | 1 | 2016 |
| Anthracene | water | 0.1 | 0.1 | μg/l | <0.001 | <0.001 | 1 | 2016 |
| Atrazine | water | 0.6 | 2.0 | μg/l | <0.1 | <0.1 | 1 | 2016 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Benzene | water | 8 | 50 | µg/l | <1.0 | <1.0 | 1 | 2016 |
| Brominated diphenylethers | water | - | 0.14 | µg/l | | <0.00015 | 1 | 2016 |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | <0.05 | <0.05 | 1 | 2016 |
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.2 | <0.2 | 1 | 2016 |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.03 | <0.03 | 1 | 2016 |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.01 | <0.01 | 1 | 2016 |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |
| Dichloromethane | water | 20 | | µg/l | <1.0 | | 1 | 2016 |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 | | µg/l | <0.4 | | 1 | 2016 |
| Diuron | water | 0.2 | 1.8 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Endosulfan | water | 0.0005 | 0.004 | µg/l | <0.0002 | <0.0002 | 1 | 2016 |
| Fluoranthene | water | 0.0063 | 0.12 | µg/l | 0.001 | 0.001 | 1 | 2012* |
| Hexachlorobenzene (HCB) | water | | 0.05 | µg/l | | 0.001 | 1 | 2012* |
| Hexachlorobutadiene (HCBD) | water | | 0.6 | µg/l | | 0.1 | 1 | 2012* |
| Hexachlorocyclohexane (HCH) | water | 0.002 | 0.02 | µg/l | <0.0002 | <0.0002 | 1 | 2016 |
| Isoproturon | water | 0.3 | 1.0 | µg/l | <0.005 | <0.005 | 1 | 2016 |
| Lead and its compounds | water | 1.3 | 14 | µg/l | <0.4 | <0.4 | 1 | 2016 |
| Mercury and its compounds | water | - | 0.07 | µg/l | | 0.01 | 1 | 2012* |
| Naphthalene | water | 2 | 130 | µg/l | <0.5 | <0.5 | 1 | 2016 |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | 3 | 7 | 1 | 2016 |
| Nonylphenols | water | 0.3 | 2.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Octylphenols | water | 0.01 | | µg/l | <0.003 | | 1 | 2016 |
| Pentachlorobenzene | water | 0.0007 | | µg/l | <0.0002 | | 1 | 2016 |
| Pentachlorophenol (PCP) | water | 0.4 | 1.0 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Benzo(a)pyrene | water | $1.7x10^{-4}$ | 0.027 | µg/l | 0.001 | 0.001 | 1 | 2012* |
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | <0.001 | 1 | 2016 |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | <0.001 | 1 | 2016 |
| Benzo(g,h,i)perylene | water | | $8.2x10^{-4}$ | µg/l | | <0.0003 | 1 | 2016 |
| Simazine | water | 1 | 4 | µg/l | <0.1 | <0.1 | 1 | 2016 |
| Tributyltin compounds | water | 0.0002 | 0.0015 | µg/l | 0.0001 | 0.0003 | 1 | 2016 |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | <0.005 | | 1 | 2016 |
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | <1.0 | | 1 | 2016 |
| Trifluralin | water | 0.03 | | µg/l | <0.01 | | 1 | 2016 |
| Tetrachloromethane | water | 12 | | µg/l | <1.0 | | 1 | 2016 |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | <0.0002 | | 1 | 2016 |
| Para-para-DDT | water | 0.01 | | µg/l | <0.001 | | 1 | 2016 |
| DDT total | water | 0.025 | | µg/l | <0.001 | | 1 | 2016 |
| Trichloroethylene (TRI) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | <1.0 | | 1 | 2016 |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable
* - inherited assessment



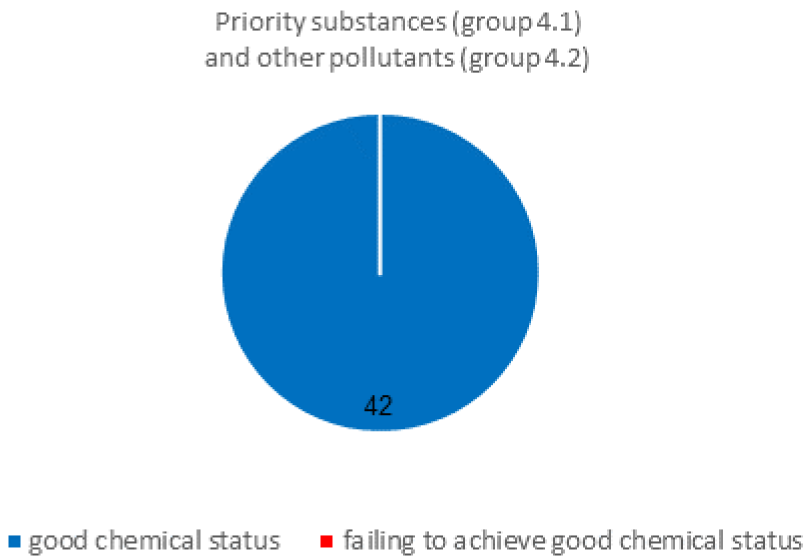




Fig. 2.3.51 Summary of the assessment of the status of the environment of Jastrzębia Góra - Rowy area in the scope of specific synthetic and non-synthetic pollutants (group 3.6) and priority substances group (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

*Vistula lagoon*

Within the group of **specific synthetic and non-synthetic pollutants** (group 3.6) 17 substances meet the requirements for class 1 (12) and 2 (5), however, concentrations of one substance (formaldehyde) indicate a class below 2, which means that **good environmental status in the area of the Vistula lagoon have not been achieved** (Table 2.3.65, Fig. 2.3.52).
Within the group of **priority substances** (group 4.1) and **other pollutants**(group 4.2) only polybrominated diphenylethers, mercury and heptachlor in organisms indicate chemical status below good, other substances meet the requirements for good chemical status (Table 2.3.66* - inherited assessment

Table 2.3.66, Fig. 2.3.52).

Table 2.3.65 Specific synthetic and non-synthetic pollutants (group 3.6) (Data source: PMŚ)

| Indicator | Matrix | Threshold value | Unit | Annual average | Class | A year of research |
|---|---|---|---|---|---|---|
| Formaldehyde | water | ≤ 0.05 | mg/l | 0.1 | >2 | 2016 |
| Arsenic | water | ≤ 0.05 | mg As/l | 0.01 | 1 | 2014* |
| Barium | water | ≤ 0.5 | mg Ba/l | 0.027 | 1 | 2014* |
| Boron | water | ≤ 2 | mg B/l | 0.36 | 2 | 2014* |
| Chromium 6+ | water | ≤ 0.02 | mg Cr+6/l | <0.0005 | 1 | 2014* |
| Chromium | water | ≤ 0.05 | mg Cr/l | <0.0005 | 1 | 2014* |
| Zinc | water | ≤ 1 | mg Zn/l | 0.004 | 1 | 2014* |
| Cooper | water | ≤ 0.05 | mg Cu/l | 0.003 | 1 | 2014* |
| Phenol index | water | ≤ 0.01 | mg/l | 0.01 | 2 | 2016 |
| Oil index | water | ≤ 0.2 | mg/l | 0.2 | 2 | 2016 |
| Aluminium | water | ≤ 0.4 | mg Al/l | 0.042 | 1 | 2014* |
| Free cyanides | water | ≤ 0.05 | mg CN/l | 0.007 | 1 | 2014* |
| Molybdenum | water | ≤ 0.04 | mg Mo/l | <0.005 | 1 | 2014* |
| Selenium | water | ≤ 0.02 | mg Se/l | 0.006 | 2 | 2014* |
| Silver | water | ≤ 0.005 | mg Ag/l | 0.0006 | 1 | 2014* |
| Vanadium | water | ≤ 0.05 | mg V/l | 0.031 | 2 | 2014* |
| Fluoride | water | ≤ 1.5 | mg F/l | 0.1 | 1 | 2016 |
| Beryllium | water | ≤ 0.0008 | mg Be/l | <0.000125 | 1 | 2014* |
| Cobalt | water | ≤ 0.05 | mg Co/l | <0.001 | 1 | 2014* |

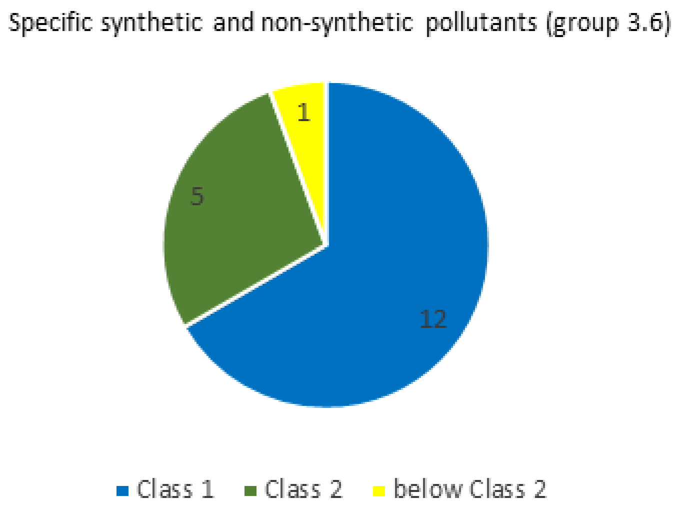
< - below the limit of quantification
* - inherited assessment

Table 2.3.66 Priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| Alachlor | water | 0.3 | 0.7 | µg/l | <0.05 | 0.05 | 1 | 2014* |
| Anthracene | water | 0.1 | 0.1 | µg/l | 0.0006 | 0.0005 | 1 | 2014* |
| Atrazine | water | 0.6 | 2.0 | µg/l | <0.05 | 0.05 | 1 | 2014* |
| Brominated diphenylethers | biota | 0.0085 | | µg/kg ww | 0.019 | | >1 | 2016 |
| Cadmium and its compounds | water | 0.2 | 0.45<br>0.60<br>0.90<br>1.50 | µg/l | <0.05 | <0.05 | 1 | 2016 |
| C10-13 Chloroalkanes | water | 0.4 | 1.4 | µg/l | <0.05 | 0.05 | 1 | 2014* |
| Chlorfenvinphos | water | 0.1 | 0.3 | µg/l | <0.005 | 0.005 | 1 | 2014* |
| Chlorpyrifos | water | 0.03 | 0.1 | µg/l | <0.005 | 0.005 | 1 | 2014* |
| 1,2-Dichloroethane (EDC) | water | 10 | | µg/l | <0.0005 | | 1 | 2014* |
| Dichloromethane | water | 20 | | µg/l | <0.0005 | | 1 | 2014* |
| Di(2-ethylhexyl)-phthalate (DEHP) | water | 1.3 | | µg/l | <1.0 | | 1 | 2014* |
| Endosulfan | water | 0.0005 | 0.004 | µg/l | <0.00005 | 0.00005 | 1 | 2014* |
| Fluoranthene | biota | 30 | | µg/kg ww | 11 | | 1 | 2016 |
| Fluoranthene | water | 0.0063 | 0.12 | µg/l | 0.0012 | 0.0022 | 1 | 2014* |
| Hexachlorobenzene (HCB) | biota | 10 | | µg/kg ww | 0.12 | | 1 | 2016 |
| Hexachlorobenzene (HCB) | water | | 0.05 | µg/l | | 0.0005 | 1 | 2014* |
| Hexachlorobutadiene (HCBD) | water | | 0.6 | µg/l | | 0.0013 | 1 | 2014* |
| Hexachlorocyclohexane | water | 0.002 | 0.02 | µg/l | <0.00025 | 0.00025 | 1 | 2014* |

| Indicator | Matrix | AA-EQS (water)/ EQS (biota) | MAC-EQS | Unit | Annual average | Maximum concentration | Class | A year of research |
|---|---|---|---|---|---|---|---|---|
| (HCH) | | | | | | | | |
| Lead and its compounds | water | 1.3 | 14 | µg/l | 0.5 | 1.5 | 1 | 2014* |
| Mercury and its compounds | biota | 20 | | µg/kg ww | 68.1 | | >1 | 2016 |
| Mercury and its compounds | water | - | 0.07 | µg/l | | 0.06 | 1 | 2016 |
| Naphthalene | water | 2 | 130 | µg/l | 0.009 | 0.036 | 1 | 2014* |
| Nickel and its compounds | water | 8.6 | 34 | µg/l | <1.5 | 1.5 | 1 | 2014* |
| Nonylphenols | water | 0.3 | 2.0 | µg/l | <0.03 | 0.03 | 1 | 2016 |
| Octylphenols | water | 0.01 | | µg/l | <0.0015 | | 1 | 2014* |
| Pentachlorophenol (PCP) | water | 0.4 | 1.0 | µg/l | <0.0005 | 0.0005 | 1 | 2014* |
| Benzo(a)pyrene | biota | 5 | | µg/kg ww | 1 | | 1 | 2016 |
| Benzo(b)fluoranthene | water | | 0.017 | µg/l | | 0.0012 | 1 | 2014* |
| Benzo(k)fluoranthene | water | | 0.017 | µg/l | | 0.0005 | 1 | 2014* |
| Benzo(g,h,i)perylene | water | | $8.2x10^{-4}$ | µg/l | | 0.0018 | 1 | 2016 |
| Simazine | water | 1 | 4 | µg/l | <0.05 | 0.05 | 1 | 2014* |
| Tributyltin compounds | water | 0.0002 | 0.0015 | µg/l | 0.000013 | 0.0003 | 1 | 2012* |
| Trichlorobenzenes (TCB) | water | 0.4 | | µg/l | 0.0006 | | 1 | 2014* |
| Trichloromethane (chloroform) | water | 2.5 | | µg/l | <0.0005 | | 1 | 2014* |
| Trifluralin | water | 0.03 | | µg/l | <0.005 | | 1 | 2014* |
| Dicofol | biota | 33 | | µg/kg ww | <10 | | 1 | 2016 |
| Perfluorooctane sulfonic acid and its derivatives (PFOS) | biota | 9.1 | | µg/kg ww | 2.9 | | 1 | 2016 |
| Dioxins and dioxin-like compounds | biota | 0.0065 | | µg/kg ww | 0.0025 | | 1 | 2016 |
| Heksabromocyklodekan | biota | 167 | | µg/kg ww | 0.014 | | 1 | 2016 |
| Heptachlor and heptachlor epoxide | biota | 0.0067 | | µg/kg ww | 0.023 | | >1 | 2016 |
| Tetrachloromethane | water | 12 | | µg/l | 0.0045 | | 1 | 2014* |
| SUM Aldrin, Dieldrin, Endrin, Isodrin | water | 0.005 | | µg/l | 0 | | 1 | 2014* |
| Para-para-DDT | water | 0.01 | | µg/l | <0.0005 | | 1 | 2014* |
| DDT total | water | 0.025 | | µg/l | 0.005 | | 1 | 2016 |
| Trichloroethylene (TRI) | water | 10 | | µg/l | 0.002 | | 1 | 2014* |
| Tetrachloroethylene (PER) | water | 10 | | µg/l | 0.0023 | | 1 | 2014* |

AA – annual average
EQS – environmental quality standard
MAC – maximum annual concentration
< - below the limit of quantification
gray color - not applicable
* - inherited assessment



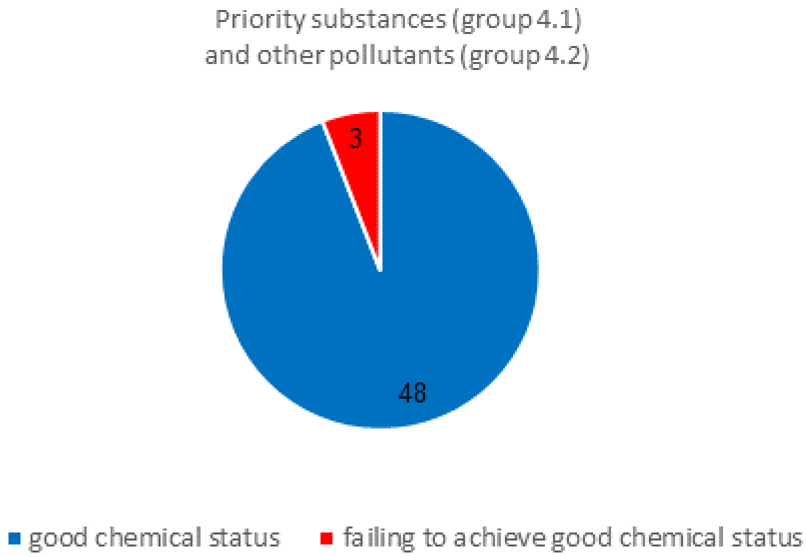




Fig. 2.3.52 Summary of the assessment of the status of the environment of Vistula Lagoon in terms of specific synthetic and non-synthetic pollutants (group 3.6) and the group of priority substances (group 4.1) and other pollutants (group 4.2) (Data source: PMŚ)

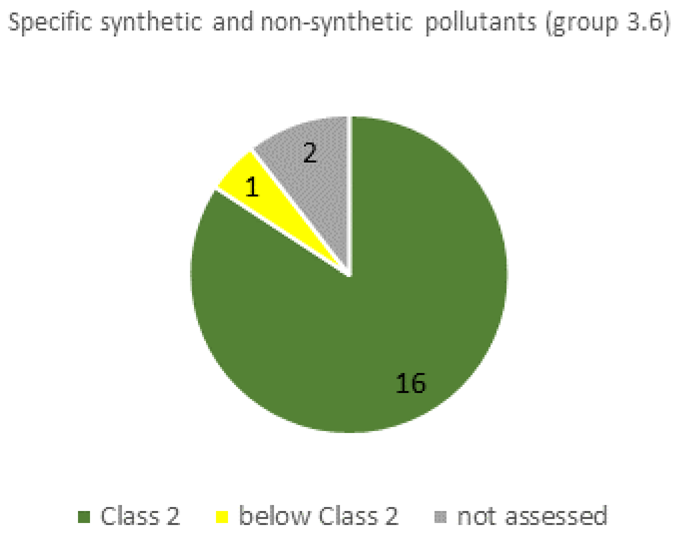
## Summary of the assessment of the environmental status of coastal and transitional water bodies

Out of seventeen assessed, within specific synthetic and non-synthetic pollutants, waterbodies, sixteen obtained class 2, which means good environmental status, only the area of the Vistula lagoon has reached the class below 2 (Table 2.3.67, Fig. 2.3.53)

Out of the fifteen assessed, in terms of priority substances and other contaminants, waterbodies, good chemical status was achieved in eight, while the chemical status below good occurred in seven areas (Table 2.3.67, Fig. 2.3.53).

Table 2.3.67 Summary of the assessment of the environmental status of unit water bodies (Data source: PMŚ)

| Waterbodies | | Specific synthetic and non-synthetic pollutants (group 3.6) | | | Priority substances (group 4.1) and other pollutants (group 4.2) | | |
|---|---|---|---|---|---|---|---|
| | | The year of the oldest research | The year of the latest research | Class | The year of the oldest research | The year of the latest research | Chemical status |
| PLTWIWB8 | Szczecin lagoon | 2016 | 2016 | 2 | 2011 | 2016 | failing to achieve good chemical status |
| PLTWIWB9 | Kamieński lagoon | 2016 | 2016 | 2 | 2012 | 2016 | good chemical status |
| PLTWVWB7 | Świna Mouth | 2016 | 2016 | 2 | 2012 | 2016 | good chemical status |
| PLTWVWB6 | Dziwna Mouth | 2016 | 2016 | 2 | 2012 | 2016 | good chemical status |
| PLCWIIIWB9 | Dziwna - Świna | 2016 | 2016 | 2 | 2012 | 2016 | failing to achieve good chemical status |
| PLCWIIWB8 | Sarbinowo - Dziwna | 2012 | 2012 | 2 | 2012 | 2016 | failing to achieve good chemical status |
| PLCWIIIWB7 | Jarosławiec - Sarbinowo | 2012 | 2012 | 2 | 2012 | 2016 | good chemical status |
| PLTWIIIWB3 | Outer Puck Bay | 2016 | 2016 | 2 | 2011 | 2016 | good chemical status |
| PLTWVWB5 | Wisła Przekop mouth | 2011 | 2011 | 2 | | | |
| PLCWIIWB6E | Rowy - Jarosławiec East | 2011 | 2011 | 2 | 2011 | 2015 | failing to achieve good chemical status |
| PLCWIIWB4 | Władysławowo - Jastrzębia Góra | 2016 | 2016 | 2 | 2016 | 2016 | failing to achieve good chemical status |
| PLCWIWB3 | Władysławowo Port | | | | | | |
| PLCWIWB2 | Hel Peninsula | 2012 | 2012 | 2 | 2012 | 2012 | good chemical status |
| PLCWIWB1 | Vistula Spit | 2011 | 2011 | 2 | | | |
| PLTWIIWB2 | Puck lagoon | 2016 | 2016 | 2 | 2016 | 2016 | good chemical status |
| PLTWIVWB4 | Inner Gulf of Gdańsk | 2016 | 2016 | 2 | 2016 | 2016 | failing to achieve good chemical status |
| PLCWIIWB6W | Rowy - Jarosławiec West | | | | | | |
| PLCWIIIWB5 | Jastrzębia Góra - Rowy | 2016 | 2016 | 2 | 2012 | 2016 | good chemical status |
| PLTWIWB1 | Vistula lagoon | 2014 | 2016 | >2 | 2014 | 2016 | failing to achieve good chemical status |



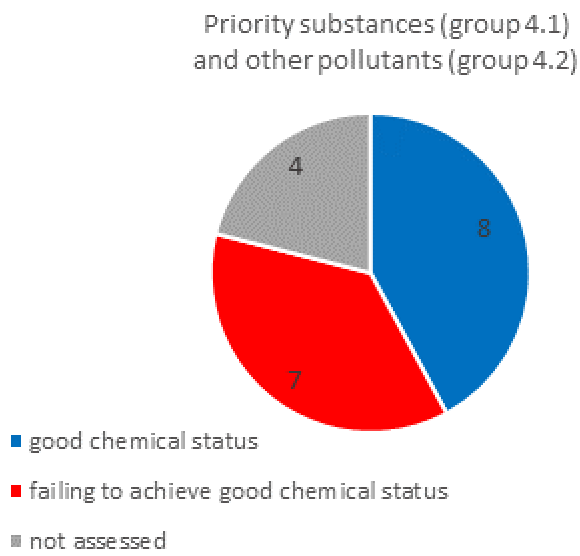




Fig. 2.3.53 Summary of the assessment of the environmental status of waterbodies, the figures presented refer to the number of areas with class 2 – green, below the second class - yellow, no assessment - gray in the specific synthetic and non-synthetic pollution and refer to the number of areas characterized by good chemical status – blue color, chemical status below good - red color and lack of assessment - gray color in the range of priority substances and other pollutants (source of PMŚ data)

**Confidence of the assessment of the environmental status of coastal and transitional water bodies within the scope of criterion D8C1**

The confidence of the D8C1 criterion, within which the assessment of the environmental status of water bodies in the coastal and transitional waters was conducted, was carried out using an expert assessment based on the two parameters: the number and confidance of data included in the assessment and confidence and adequacy of threshold values. The assessment assumes that high confidence can only be given in those areas where data on priority substances for which environmental quality standards are used as threshold values. It has been assumed that the minimum number of priority substances included in the assessment for high confidence is the number 35 and above. In addition, it was assumed that the share of data for the biota matrix increases confidance. In addition, a larger number of substances from the group of 3.6 - Specific synthetic and non-synthetic pollutants increases the confidence of the assessment..

The results of assessing the confidence of assessments of the environmental state of individual areas are presented in Table 2.3.68

Table 2.3.68 Assessment of the confidence of assessments of the environmental status of water bodies in coastal and transitional waters

| | **Specific synthetic and non-synthetic pollutants (group 3.6)** | | **Priority substances (group 4.1) and other pollutants (group 4.2)** | | **Matrix** | **Confidence of assessment** |
|---|---|---|---|---|---|---|
| | **Number of parameters assessed** | **Threshold value** | **Number of parameters assessed** | **Threshold value** | | |
| Szczecin lagoon | 23 | Threshold values recommended by national legal regulation - REGULATION OF THE MINISTER OF THE ENVIRONMENT of 21 July 2016 on the classification of the status of waterbodies and environmental quality standards for priority substances. | 51 | Threshold values for priority substances - DIRECTIVE 2013/39/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC 2000/60/EC as regards priority substances in the field of water policy | water, biota | high |
| Kamieński lagoon | 23 | | 42 | | water | high |
| Świna Mouth | 23 | | 42 | | water | high |
| Dziwna Mouth | 23 | | 42 | | water | high |
| Dziwna - Świna | 23 | | 51 | | water, biota | high |
| Sarbinowo - Dziwna | 11 | | 50 | | water, biota | high |
| Jarosławiec - Sarbinowo | 11 | | 40 | | water | high |
| Outer Puck Bay | 23 | | 39 | | water | high |
| Wisła Przekop mouth | 11 | | 0 | | water | low |
| Rowy - Jarosławiec East | 11 | | 25 | | water | moderate |
| Władysławowo - Jastrzębia Góra | 23 | | 48 | | water, biota | high |
| Władysławowo Port | 0 | | 0 | | | not assessed |
| Hel Peninsula | 11 | | 35 | | water | high |
| Vistula Spit | 11 | | 0 | | water | low |
| Puck lagoon | 23 | | 37 | | water | high |
| Inner Gulf of Gdańsk | 23 | | 42 | | water, biota | high |
| Rowy - Jarosławiec West | 0 | | 0 | | | not assessed |
| Jastrzębia Góra - Rowy | 23 | | 42 | | water | high |
| Vistula lagoon | 19 | | 46 | | water, biota | high |

### *Areas of the open sea*

In the open sea, the areas designated regionally and indicated in the HELCOM Monitoring and Assessment Strategy (HELCOM 2013) were indicated as the areas covered by the assessment. Belong to them:

1. Bornholm Basin
2. Eastern Gotland Basin
3. Gdańsk Basin

It should be emphasized, however, that the assessment areas cover only those parts that remain under the jurisdiction of Poland (Table 2.3.69, Fig. 2.3.54).

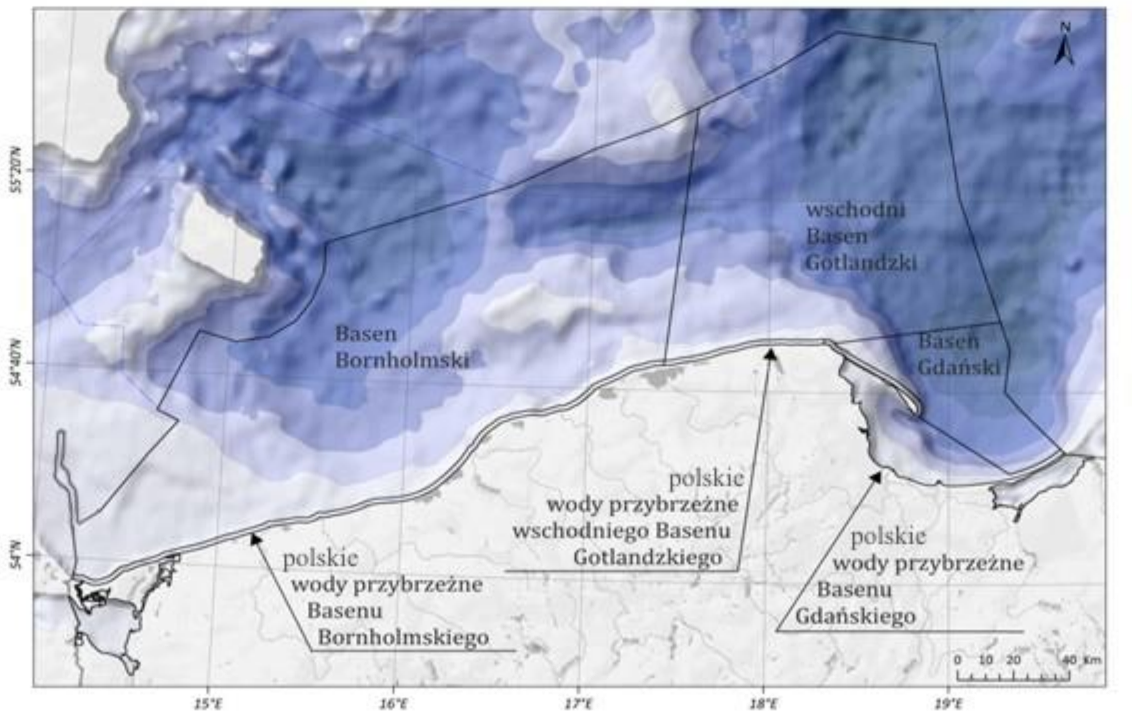



Fig. 2.3.54 Basins for assessment in the open sea area (Basen Bornholmski – Bornholm Basin, wschodni Basen Gotlandzki – Eastern Gotland Basin, Basen Gdański – Gdańsk Basin, polskie wody przybrzeżne Basenu Bronholmskiego – Bornholm Basin Polish coastal waters, polskie wody przybrzeżne wschodniego Basenu Gotlandzkiego – Eastern Gotland Basin Polish coastal waters, polskie wody przybrzeżne Basenu Gdańskiego – Gdański Basin Polish coastal waters).

The assessment in these areas was carried out in accordance with the Commission Decision 848/2017 with a guide (Article 8 MSFD Assessment Guidance 2017), that is for each substance in each of the relevant matrices an assessment was carried out referring concentration values to threshold values and indicating if the threshold values were exceeded, or not. Threshold values were adopted on the basis of existing legal acts (Directive 2013/39 / EU), some of them result from the agreements made at the regional level (HELCOM HOLAS II) and in the case of heavy metals in marine plants, the values determined at the national level were adopted (Zalewska and Danowska 2017). References for each threshold are given in the Table 2.3.70. The assessment identified a group of ubiquitous, persistent, toxic and bioaccumulated substances (u-PTB). Finally, the number of substances that meets the requirements of good status is given, taking into account all substances as well as u-PTB. It should be emphasized that the most up-to-date data were used for the assessment, in most cases the data from 2016, while the data from the period 2011-2016 were used to assess the trends, in some cases reaching for earlier data. The average values of concentrations of specific substances in specific matrices calculated on the basis of data from each area were used for the assessments if the samples for the same analyzes were taken from more than one location. In other cases, individual data was used for the assessment. In the Bornholm Basin fish samples came from two fisheries (Table 2.3.69), also sediment samples came from two locations.

Table 2.3.69 Sampling locations in individual assessment areas

| **Area** | **Organisms - fish** | **Organisms-plants** | **Sediment** | **Water** |
|---|---|---|---|---|
| Bornholm Basin | Pomeranian Bay, darłowsko – kołobrzeskie fishery | Słupsk Bank | P5 and P39 | P39, P5, P3, P16, M3, K6, B15, B13, SW3 |
| Eastern Gotland Basin | władysławowskie fishery | - | P140 | P140, P2, Ł7 |
| Gdańsk Basin | Gulf of Gdańsk | - | P1 | P1, P110, P116, ZN4 |

Table 2.3.70 List of substances with matrices and threshold values used to assess the state of the environment in three areas of assessment: Gdańsk Basin, Eastern Gotland Basin and Bornholm Basin.

| **Group of substances** | **Indicator** | **Matrix** | **Priority substances** | **u - PBT** | **HELCOM HOLAS II Indicators** | **National indicator** | **Threshold value** | **Reference** | **Gdańsk Basin** | **Eastern Gotland Basin** | **Bornholm Basin** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Radioactive substances | Cesium 137 - $^{137}$Cs | water | | | Primary | | 15 Bq m$^{-3}$ | HELCOM 2017 a | | | |
| | Cesium 137 - $^{137}$Cs | biota (plants) | | | | | 15 Bq kg$^{-1}$ dw | Zalewska i Danowska, 2017 | | | |
| Heavy metals | Cadmium - Cd | biota (fish - liver) | | | | | 26 µg kg$^{-1}$ ww | OSPAR BAC (OSPAR 2009) | | | |
| | Cadmium - Cd | biota (plants) | | | | | 33 mg kg$^{-1}$ dw | Zalewska i Danowska, 2017 | | | |
| | Cadmium - Cd | sediment | | | Secondary | | 2.3 mg kg$^{-1}$ dw | $QS_{sediment}$ (WFD_1) HELCOM 2017b | | | |
| | Lead - Pb | biota (fish - liver) | | | Secondary | | 26 µg kg$^{-1}$ ww | OSPAR BAC (OSPAR 2009), HELCOM 2017b | | | |
| | Lead - Pb | biota (plants) | | | | | 26 mg kg$^{-1}$ dw | Zalewska i Danowska, 2017 | | | |
| | Lead - Pb | sediment | | | Secondary | | 120 mg kg$^{-1}$ dw | $QS_{sediment}$ (WFD_2) HELCOM 2017b | | | |
| | Mercury - Hg | biota (fish - liver) | | | Primary | | 20 µg kg$^{-1}$ ww | EQS, Directive 2013/39/UE, HELCOM 2017b | | | |
| | Mercury - Hg | biota (plants) | | | | | 0.4 mg kg$^{-1}$ dw | Zalewska i Danowska, 2017 | | | |
| | Mercury - Hg | sediment | | | | | 0.07 mg kg$^{-1}$ dw | OSPAR 2009 | | | |
| Persistant organic pollutants | Brominateddiphenylethers PBDE (sum congeners 28, 47, 99, 100, 153, 154) | biota (fish - muscles) | | | Primary | | 0.0085 µg kg$^{-1}$ ww | EQS biota and human health, Directive 2013/39/UE, WFD_3 HELCOM 2017c | | | |
| | Fluoranthene -PAH | sediment | | | | | 2000 µg kg$^{-1}$ sm | $QS_{sediment}$ WFD_4 | | | |

| Group of substances | Indicator | Matrix | Priority substances | u - PBT | HELCOM HOLAS II Indicators | National indicator | Threshold value | Reference | Gdańsk Basin | Eastern Gotland Basin | Bornholm Basin |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Benzo(g,h,i)perylene - PAH | sediment | | | | | 85 µg $kg^{-1}$ dw | ERL (OSPAR 2009) | | | |
| | Indeno(1,2,3-cd)pyrene - PAH | sediment | | | | | 240 µg $kg^{-1}$ dw | ERL (OSPAR 2009) | | | |
| | 1-hydroxypyrene - metabolites PAH | biota (fish - bile) | | | | | 483 ng $l^{-1}$ | HELCOM 2017 d | | | |
| | Hexachlorobenzene - HCB | biota (fish - muscles) | | | | | 10 µg $kg^{-1}$ ww | QS rounded value, WFD_5 | | | |
| | Tributyltin compounds (tributyltin cation) | biota (fish - muscles) | | | | | 15.2 µg $kg^{-1}$ ww | $QS_{seafood}$ WFD_6 | | | |
| | Perfluorooctane sulfonic acid and its derivatives - PFOS | biota (fish - muscles) | | | Primary | | 9.1 µg $kg^{-1}$ ww | EQS, Directive 2013/39/UE WFD_7 HELCOM 2017e | | | |
| | Dioxins and dioxin-like compounds (sum PCDD+PCDF+PCB-DL) | biota (fish) | | | Primary | | 0.0065 µg $kg^{-1}$ TEQ | EQS, Directive 2013/39/UE, HELCOM 2017f | | | |
| | Polychlorinated biphenyls PCB (sum 28, 52, 101, 138, 153, 180) | biota (fish - muscles) | | | Primary | | 75 µg $kg^{-1}$ ww | EC 1881/2016 OSPAR 2009, HELCOM 2017f | | | |
| | CB 118 | biota (fish - muscles) | | | Primary | | 24 µg $kg^{-1}$ ww | OSPAR 2009, HELCOM 2017f | | | |
| | Hexabromocyclododecane- HBCDD | biota (fish) | | | Primary - | | 167 µg $kg^{-1}$ ww | EQS, Directive 2013/39/UE, WFD_8 HELCOM 2017g | | | |
| | Diclofenac - pharmaceuticals | water | | | | | 0.01 µg $l^{-1}$ | WFD_9 | | | |

The colors indicates matrix and subbasins in which specific indicators were used:

| | | | | | |
|---|---|---|---|---|---|
| | water | | biota | | sediment |

dw – dry weight
ww – wet weight
ERL - effect range low

EQS - environmental quality standard)

**References to** Table 2.3.70
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HELCOM 2017d, https://portal.helcom.fi/meetings/EN-HZ%207-2017-497/MeetingDocuments/12-1%20Outcomes%20of%20EN-HZ%207-2017.pdf
HELCOM 2017e, http://www.helcom.fi/Core%20Indicators/PFOS_HELCOM%20core%20indicator-HOLAS%20II%20component_June%202017.pdf
HELCOM 2017f, http://www.helcom.fi/Core%20Indicators/PCB%20dioxin%20and%20furan%20-%20HELCOM%20core%20indicator%20report%20-%20HOLAS%20II%20component.pdf
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WFD_2 https://circabc.europa.eu/sd/a/be12c5a9-19b2-40eb-87ce-f62eb3b43b39/Lead%20and%20its%20compounds%20EQS%20dossier%202011.pdf
WFD_3 https://circabc.europa.eu/sd/a/d07ed9f5-0760-4561-b642-04bc1e4a580e/PBDE%20EQS%20dossier%202011.pdf
WFD_4 https://circabc.europa.eu/sd/a/4336e1e5-ba0c-4545-abee-7743d2085bc3/Fluoranthene%20EQS%20dossier%202011.pdf
WFD_5 Common Implementation Strategy for the Water Framework Directive, Environmental Quality Standards (EQS), Substance Data Sheet, Hexachlorobenzene, EQS dossier 2005
WFD_6 Common Implementation Strategy for the Water Framework Directive, Environmental Quality Standards (EQS), Substance Data Sheet, Tributyltin compounds (TBT-ion) EQS dossier 2005
WFD_7 https://circabc.europa.eu/sd/a/027ff47c-038b-4929-a84c-da3359acecee/PFOS%20EQS%20dossier%202011.pdf
WFD_8 https://circabc.europa.eu/sd/a/086ffe7c-8e63-4893-baac-994f3ff0eb34/HBCDD%20EQS%20dossier%202011.pdf
WFD_9 https://circabc.europa.eu/sd/a/d88900c0-68ef-4d34-8bb1-baa9af220afd/Diclofenac%20EQS%20dossier%202011.pdf
Zalewska T., Danowska B., 2017, Marine environment status assessment based on macrophytobenthic plants as bio-indicator of heavy metals pollution, Marine Pollution Bulletin 118 (1-2), 281-288.

**Methodology for conducting an integrated assessment for assessment areas - in line with the HOLAS II assessment guidelines**

In addition to the assessment carried out according to the guide, which does not assume the integration of the assessment in individual areas, an assessment was carried out assuming the integration of all data enabling the indication of the state of the entire area in the scope of criterion D8C1. The aim of this assessment was to refer to the assessment of the status of entire areas compliant with the HELCOM Monitoring and Assessment Strategy carried out as part of the HELCOM HOLAS II Project. The integration of the assessment was carried out in accordance with the methodology used in the HELCOM HOLAS II Project.

1. For the assessments there was used data for each of the assessed areas: concentrations of substances or groups of substances in specific matrices, where the data for each group of matrices: water, organisms (biota), sediments were grouped separately (Table 2.3.71, Table 2.3.73 i Table 2.3.75).
2. For each substance in the appropriate matrices, the contamination ratio (WS) was determined expressing the ratio of concentration in the environment to the threshold value defining the boundary between good and unsuitable state. Threshold values were adopted in accordance with Decision 848/2017 or regional or national solutions.
$$WS_{iM} = \frac{C_{iM}}{WP_{iM}}$$
3. Based on WS values, the values of integrated chemical score (ZWC) for each matrix were determined: organisms - biota, sediments, water for each area. This solution was adopted on the basis of the CHASE assessment system used in HOLAS II, where the "Chemical Score" is determined. If the value of ZWC is less than 1, then the state of the environment in terms of substances assessed for a given matrix can be considered good.
$$ZWC_M = \frac{\sum_1^n WS_{iM}}{\sqrt{n}}$$
4. The status of the entire assessed area, including all matrices, is determined by the "one out all out" method, which means that if at least good status for one matrix has not been reached, then the status of the entire area is subGES.

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*Bornholm Basin*

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Table 2.3.71 presents the results of the assessment carried out for the area of Bornholm Basin within D8C1 criterion including three type of matrices used. The assessment was based on data for 24 core indicators, 6 of which did not meet the requirements of good environmental status (Fig. 2.3.55). These include: $^{137}$Cs in seawater (however, it should be emphasized that the trend for this indicator is definitely decreasing), Cd and Pb in fish livers and Hg and PBDE in fish muscles and Hg in sediments. 18 indicators were at levels below the threshold of good status. Three out of ten uPTBsubstances (Hg and PBDE in fish muscle and Hg in sediment) did not meet the requirements of good status.

In the Bornholm Basin a decreasing trend is observed in concentrations of $^{137}$Cs in seawater and in the case of a sum of 6 PBDE congeners in fish muscle. In the case of heavy metal concentrations in fish, there was no unambiguous trend, as in the case of HCB, the sum of 6 PCBs, CB 118 and HBCDD. In the case of other substances in different matrices, the number of data does not allow to determine time changes.

In relation to the previous assessment, the same **good environmental status** occurred in the case of:

- ✓ Dioxin and dioxin-like compounds (sum of PCDD + PCDF + PCB-DL),
- ✓ PCBs in fish, with the difference that in 2012 it was the sum of 7 congeners, and in 2016 it is the sum of 6 congeners, but the CB118 congener excluded also indicates good state,
- ✓ Cd and Hg in sediments.

In relation to the previous assessment, the same **not-good environmental status** occurred in the case of:

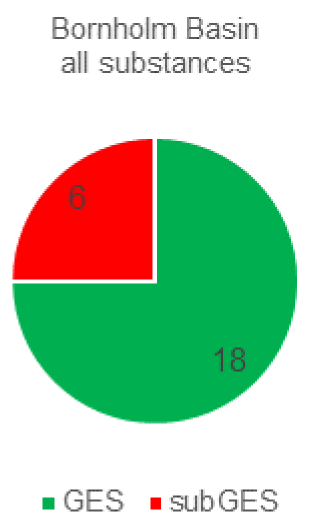
- ✓ Hg in fish,
- ✓ Cd in fish,
- ✓ $^{137}Cs$ in seawater.
- ✓ In relation to the previous assessment, the **change in the status of the environment** occurred in the case of:
- ✓ PBDE in fish (from good to bad), but this is closely related to the changed (lowered) threshold value,
- ✓ Pb in fish (from good to bad), but the concentration values are close to the threshold value,
- ✓ Pb in sediments (from bad to good), HBCDD, PFOS and PAHs and its derivatives were not assessed in 2012.

Table 2.3.71 Results of the environmental assessment of Bornholm Basin in 2011-2016 (Data source: PMŚ)

| Matrix | Substance | Matrix | Threshold value | Unit | Year | Average concentration | GES | Trend | WS | ZWC |
|---|---|---|---|---|---|---|---|---|---|---|
| Water | Cesium 137 - $^{137}Cs$ | water | 15 | $Bq/m^3$ | 2016 | 21.5 | no | ↘ | 1.43 | 1.02 |
| | Diclofenac - pharmaceuticals | water | 10 | $ng/dm^3$ | 2016 | 0.08 | yes | X | 0.01 | |
| Sediment | Cadmium - Cd | sediment | 2.3 | mg/kg dw | 2012, 2016 | 0.8 | yes | X | 0.37 | 0.85 |
| | Lead - Pb | sediment | 120 | mg/kg dw | 2012, 2016 | 59.22 | yes | X | 0.49 | |
| | Mercury - Hg* | sediment | 0.07 | mg/kg dw | 2012, 2016 | 0.08 | no | X | 1.18 | |
| | Fluoranthene -PAH | sediment | 2000 | µg/kg dw | 2012, 2016 | 27.80 | yes | X | 0.01 | |
| | Benzo(g,h,i)perylene – PAH* | sediment | 85 | µg/kg dw | 2012, 2016 | 1.92 | yes | X | 0.02 | |
| | Indeno(1,2,3-cd)pyrene – PAH* | sediment | 240 | µg/kg dw | 2012, 2016 | 2.21 | yes | X | 0.01 | |
| Biota | Cesium 137 - $^{137}Cs$ | biota (plants) | 15 | Bq /kg dw | 2015 | 0.83 | yes | X | 0.06 | 8.3 |
| | Cadmium - Cd | biota (fish - liver) | 26 | µg/kg ww | 2016 | 382.00 | no | ↔ | 14.69 | |
| | Cadmium - Cd | biota (plants) | 33 | mg/kg dw | 2016 | 0.34 | yes | X | 0.01 | |
| | Lead - Pb | biota (fish - liver) | 26 | µg/kg ww | 2016 | 42.15 | no | ↔ | 1.62 | |
| | Lead - Pb | biota (plants) | 26 | mg/kg dw | 2016 | 0.85 | yes | X | 0.03 | |
| | Mercury - Hg* | biota (fish - muscle) | 20 | µg/kg ww | 2016 | 31.00 | no | ↔ | 1.55 | |
| | Mercury - Hg* | biota (plants) | 400 | µg/kg dw | 2016 | 19.66 | yes | X | 0.05 | |
| | Brominated diphenylethers PBDE (sum congeners 28, 47, 99, 100, 153, 154)* | biota (fish - muscle) | 0.0085 | µg/kg ww | 2016 | 0.13 | no | ↘ | 14.84 | |

| Matrix | Substance | Matrix | Threshold value | Unit | Year | Average concentration | GES | Trend | WS | ZWC |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hexachlorobenzene_HCB | biota (fish - muscle) | 10 | µg/kg ww | 2016 | 0.34 | yes | ↔ | 0.03 | |
| | 1-hydroxypyrene - metabolites PAH | biota (fish - bile) | 483 | ng/ml | 2016 | 7.00 | yes | X | 0.01 | |
| | Tributyltin compounds (tributyltin cation)* | biota (fish) | 15.2 | µg/kg ww | 2016 | 1.02 | yes | X | 0.07 | |
| | Perfluorooctane sulfonic acid and its derivatives – PFOS* | biota (fish - muscle) | 9.1 | µg/kg ww | 2016 | 0.77 | yes | X | 0.08 | |
| | Dioxins and dioxin-like compounds (sum PCDD+PCDF+PCB-DL)* | biota (fish) | 0.0065 | µg/kg TEQ | 2016 | 0.0018 | yes | X | 0.28 | |
| | Polychlorinated biphenyls (sum 28, 52, 101, 138, 153, 180) | biota (fish - muscle) | 75 | µg/kg ww | 2016 | 1.40 | yes | ↔ | 0.02 | |
| | CB118 | biota (fish - muscle) | 24 | µg/kg ww | 2016 | 0.26 | yes | ↔ | 0.01 | |
| | Hexabromocyclododecane-HBCDD* | biota (fish - muscle) | 167 | µg/kg ww | 2016 | 0.71 | yes | ↔ | 0.00 | |

* – uPTB substances
GES – whether good environmental status has been achieved
WS – contamination factor
ZWC – integrated chemical indicator
Trend – deteriorating (↘), improving (↗), stable (↔) or an unknown trend most often due to too short data series (X)



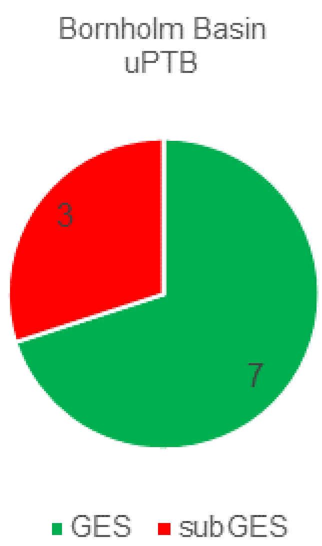




Fig. 2.3.55 Graphical presentation of the result of the assessment for the Bornholm Basin - the number of indicators that meet the criteria of good environmental status - green and not-good environmental status - red (Data source: PMŚ)

As a result of an integrated assessment of the status of the environment in accordance with the method proposed under the HELCOM HOLAS II Project, contamination ratios and integrated chemical scores were determined (Table 2.3.72). The not-good status was found in the case of organisms for which the ZWC value amounted to as much as 8.3 and resulted mainly from very low threshold values established for PBDE and Cd in fish. A ZWC value only slightly above 1 was reported for water and this was related to $^{137}Cs$ levels. In the case of sediments, the value of ZWC remained below 1. Finally, the status of the Bornholm Basin should be considered not-good.

Table 2.3.72 The result of the integrated assessment for Bornholm Basin under criterion D8C1

| | ZWC | Number of indicators with WS < 1 | Number of indicators with WS > 1 | Status within matrix |
|---|---|---|---|---|
| Biota | 8.3 | 12 | 4 | subGES |
| Sediment | 0.85 | 5 | 0 | GES |
| Water | 1.02 | 1 | 1 | subGES |
| Status of the Bornholm Basin | | | | subGES |

## *Eastern Gotland Basin*

Table 2.3.73 presents the results of the assessment carried out for the Eastern Gotland Basin within D8C1 criterion including three matrix types. The assessment was based on data for 20 indicators, 6 of which did not met the requirements of good environmental status (Figure 2.2.56). These include: $^{137}Cs$ in seawater, Cd and Pb in fish liver, Hg and PBDE in fish muscle and Hg in sediments. 14 indicators were at levels below the threshold values of good environmental status. Three of nine substances of uPTB(Hg and PBDE in fish muscle and Hg in sediments did not meet the requirements of good environmental status.

In the Eastern Gotland Basin, the decreasing trend is observed in the case of $^{137}Cs$ concentrations in seawater and the sum of 6 PBDE congeners, a sum of 6 PCB congeners, HBCDD in fish muscle and Pb in fish liver. In the case of Cd and Hg concentrations in fish livers no unambiguous trend was recorded, as was the case for HCB and CB118. In the case of other substances in different matrices, the number of data is insufficient to determined time trends.

In relation to the previous assessment, the same good environmental status occurred in the case of:

- ✓ Dioxins and dioxin-like compounds (sum of PCDD + PCDF + PCB-DL),
- ✓ Sums of PCBs in fish, with the difference that in 2012 it was the sum of 7 congeners, and in 2016 it is the sum of 6 congeners, but the CB118 congener excluded also indicates good status,
- ✓ Cd in sediments.

In relation to the previous assessment, the same **not-good environmental status** occurred in the case of:

- ✓ Hg in fish,
- ✓ Cd in fish,
- ✓ $^{137}Cs$ in seawater.

In relation to the previous assessment, the **change in the status of the environment** occurred in the case of:

- ✓ PBDE in fish (from good to bad), but this is closely related to the changed (lowered) threshold value,
- ✓ Pb in fish (from good to bad), but the concentration values are close to the threshold value,
- ✓ Pb in sediments (from bad to good),
- ✓ Hg in sediments (from bad to good).

HBCDD, PFOS and PAHs and its derivatives were not assessed in 2012.

Table 2.3.73 Results of the environmental assessment of Eastern Gotland Basin in 2011-2016 (Data source: PMŚ)

| Matrix | Substance | Matrix | Threshold value | Unit | Year | Average concentration | GES | Trend | WS | ZWC |
|---|---|---|---|---|---|---|---|---|---|---|
| Water | Cesium 137 – $^{137}Cs$ | water | 15 | $Bq/m^3$ | 2016 | 24.2 | no | ↘ | 1.613 | 1.15 |
| | Diclofenac - pharmaceuticals | water | 10 | $ng/dm^3$ | 2016 | 0.08 | yes | X | 0.008 | |
| Sediment | Cadmium - Cd | sediment | 2.3 | mg/kg dw | 2012, 2016 | 0.52 | yes | X | 0.226 | 0.72 |
| | Lead - Pb | sediment | 120 | mg/kg dw | 2012, 2016 | 57.5 | yes | X | 0.479 | |
| | Mercury - Hg* | sediment | 0.07 | mg/kg dw | 2012, 2016 | 0.07 | no | X | 1.029 | |
| | Fluoranthene -PAH | sediment | 2000 | µg/kg dw | 2012 | 28.28 | yes | X | 0.014 | |
| | Benzo(g,h,i)perylene – PAH* | sediment | 85 | µg/kg dw | 2012 | 1.70 | yes | X | 0.020 | |
| | Indeno(1,2,3-cd)pyrene – PAH* | sediment | 240 | µg/kg dw | 2012 | 1.40 | yes | X | 0.006 | |
| Biota | Cadmium - Cd | biota (fish - liver) | 26 | µg/kg ww | 2016 | 585.0 | no | ↔ | 22.50 | 18.1 |
| | Lead - Pb | biota (fish - liver) | 26 | µg/kg ww | 2016 | 53.0 | no | ↘ | 2.038 | |
| | Mercury - Hg* | biota (fish - muscle) | 20 | µg/kg ww | 2016 | 33.90 | no | ↔ | 1.695 | |
| | Brominated diphenylethers PBDE (sum congeners 28, 47, 99, 100, 153, 154)* | biota (fish - muscle) | 0.0085 | µg/kg ww | 2016 | 0.30 | no | ↘ | 35.71 | |
| | Hexachlorobenzene_ HCB | biota (fish - muscle) | 10 | µg/kg ww | 2016 | 0.23 | yes | ↔ | 0.023 | |
| | 1-hydroxypyrene - metabolites PAH | biota (fish - bile) | 483 | ng/ml | 2016 | 1.00 | yes | X | 0.002 | |
| | Tributyltin compounds (tributyltin cation)* | biota (fish - muscle) | 15.2 | µg/kg ww | 2016 | 1.01 | yes | X | 0.066 | |
| | Perfluorooctane sulfonic acid and its derivatives –PFOS* | biota (fish - muscle) | 9.1 | µg/kg ww | 2016 | 0.65 | yes | X | 0.071 | |
| | Dioxins and dioxin-like compounds (sum PCDD+PCDF+PCB-DL)* | biota (fish - muscle) | 0.0065 | µg/kg TEQ | 2016 | 0.0036 | yes | X | 0.554 | |
| | Polychlorinated biphenyls (sum 28, 52, 101, 138, 153, 180) | biota (fish - muscle) | 75 | µg/kg ww | 2016 | 1.54 | yes | ↘ | 0.021 | |
| | CB118 | biota (fish - muscle) | 24 | µg/kg ww | 2016 | 0.30 | yes | ↔ | 0.013 | |
| | Hexabromocyclododecane-HBCDD* | biota (fish - muscle) | 167 | µg/kg ww | 2016 | 0.65 | yes | ↘ | 0.004 | |

* – uPTB substances
GES – whether good environmental status has been achieved
WS – contamination factor
ZWC – integrated chemical indicator

Trend – deteriorating (↘), improving (↗), stable (↔) or an unknown trend most often due to too short data series (X)

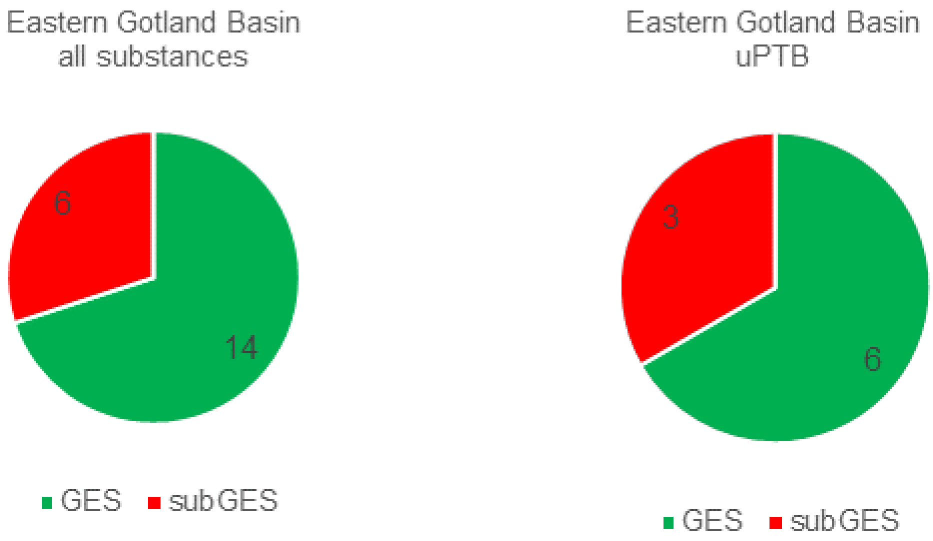



Fig. 2.3.56. Graphical presentation of the result of the assessment of the Eastern Gotland Basin - the number of indicators meeting the criteria of good environmental status - green and not-good environmental status - red (Data source: PMŚ)

As a result of the integrated environmental assessment of the Eastern Gotland Basin, the subGES status was found in the case of organisms for which the ZWC value for the biota matrix was as much as 18.1 which was mainly due to the very low thresholds for PBDE and Cd in fish (Table 2.3.75). A ZWC value only slightly above 1 was reported for water and this was related to $^{137}Cs$ levels. In the case of sediments, the value of ZWC remained below 1. Finally, the eastern area of the Gotland Basin should be considered not-good.

Table 2.3.74 The result of the integrated assessment for Eastern Gotland Basin under criterion D8C1

| | ZWC | Number of indicators with WS < 1 | Number of indicators with WS > 1 | Status within matrix |
|---|---|---|---|---|
| Biota | 18.1 | 8 | 4 | subGES |
| Sediment | 0.72 | 5 | 1 | GES |
| Water | 1.15 | 1 | 1 | subGES |
| Status of the environment of the Eastern Gotland Basin | | | | subGES |

## *Gdańsk Basin*

Table 2.3.75 presents the results of the assessment carried out for the Gdańsk Basin within criterion D8C1 including three types of matrices. The assessment was based on data for 20 core indicators, 6 of which did not meet the requirements for good environmental status (Fig. 2.3.57). These include: $^{137}Cs$ in seawater, Hg in sediments, Cd and Pb in fish livers, and Hg and PBDE in fish muscle. The 14 indicators were at levels below the threshold values of good environmental status. Three of the nine substances uPTB(Hg and PBDE in fish muscle and Hg in sediments) did not meet the requirements of good environmental status.

In Gdańsk Basin, a decreasing trend is observed in the case of $^{137}Cs$ concentrations in seawater, while in the case of other contaminants, the length of time series from a single location does not allow to determine the tendency of time changes. Despite the short time series, the confidance of the data was confirmed by comparing concentrations of individual substances in fish from the area of Gdańsk Basin with data from a different, but close location (coastal waters of Gdańsk Basin). The results for individual substances from the two locations are very similar, which is why data from 2016 from the station located in Gdańsk Basin were considered representative.

In relation to the previous assessment, the **good status of the environment** was valid in the case of:

- ✓ Dioxins and dioxin-like compounds (sum of PCDD + PCDF + PCB-DL),
- ✓ HBCDD in fish,
- ✓ PFOS in fish,
- ✓ PCBs in fish, with the difference that in 2012 it was the sum of 7 congeners, and in 2016 it is the sum of 6 congeners, but the CB118 congener excluded also indicates good status,
- ✓ PAH and PAH metabolites
- ✓ Cd i Pb in sediment.

In relation to the previous assessment, the same **not-good environmental status** was detected in the case of:

- ✓ Hg in fish,
- ✓ $^{137}Cs$ in water

In relation to the previous assessment, the same **not-good environmental status** was detected in the case of:

- ✓ PBDE in fish (from good to bad), but this is closely related to the lowered threshold value,
- ✓ Cd in fish (from good to bad) due to the change of the threshold value,
- ✓ Pb in fish (from good to bad), but the concentration values are close to the threshold value,
- ✓ Hg in sediments (from good to bad).

Table 2.3.75 Results of the assessment of the environmental state of the Gdańsk Basin in 2011-2016 (source of PMŚ data)

| Matrix | Substance | Matrix | Threshold value | Unit | Year | Average concentration | GES | Trend | WS | ZWC |
|---|---|---|---|---|---|---|---|---|---|---|
| Water | Cesium-137 | water | 15 | Bq/m³ | 2016 | 23.0 | no | ↘ | 1.535 | 1.09 |
| | Diclofenac - pharmaceuticals | water | 10 | ng/dm³ | 2016 | 0.08 | yes | X | 0.008 | |
| Sediment | Cadmium - Cd | sediment | 2.3 | mg/kg dw | 2012 | 1.8 | yes | X | 0.762 | 1.5 |
| | Lead - Pb | sediment | 120 | mg/kg dw | 2012 | 64.21 | yes | X | 0.535 | |
| | Mercury - Hg* | sediment | 0.07 | mg/kg dw | 2012 | 0.17 | no | X | 2.357 | |
| | Fluoranthene -PAH | sediment | 2000 | µg/kg dw | 2012 | 12.95 | tak | X | 0.006 | |
| | Benzo(g,h,i)perylene – PAH* | sediment | 85 | µg/kg dw | 2012 | 1.35 | tak | X | 0.016 | |
| | Indeno(1,2,3-cd)pyrene – PAH* | sediment | 240 | µg/kg dw | 2012 | 1.25 | yes | X | 0.005 | |
| Biota | Cadmium - Cd | biota (fish - liver) | 26 | µg/kg ww | 2016 | 220.00 | no | X | 8.462 | 8.1 |
| | Lead - Pb | biota (fish - liver) | 26 | µg/kg ww | 2016 | 40.6 | no | X | 1.562 | |

| Matrix | Substance | Matrix | Threshold value | Unit | Year | Average concentration | GES | Trend | WS | ZWC |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mercury - Hg* | biota (fish - muscle) | 20 | µg/kg ww | 2016 | 58.00 | no | X | 2.900 | |
| | Brominated diphenylethers PBDE (sum congeners 28, 47, 99, 100, 153, 154) | biota (fish - muscle) | 0.0085 | µg/kg ww | 2016 | 0.12 | no | X | 14.235 | |
| | Hexachlorobenzene_HCB | biota (fish - muscle) | 10 | µg/kg ww | 2016 | 0.26 | yes | X | 0.026 | |
| | 1-hydroxypyrene - metabolites PAH | biota (fish - bile) | 483 | ng/ml | 2016 | 109.00 | yes | X | 0.226 | |
| | Tributyltin compounds (tributyltin cation)* | biota (fish) | 15.2 | µg/kg ww | 2016 | 1.01 | yes | X | 0.066 | |
| | Perfluorooctane sulfonic acid and its derivatives – PFOS* | biota (fish - muscle) | 9.1 | µg/kg ww | 2016 | 0.94 | yes | X | 0.103 | |
| | Dioxins and dioxin-like compounds (sum PCDD+PCDF+PCB-DL)* | biota (fish - muscle) | 0.0065 | µg/kg TEQ | 2016 | 0.0018 | yes | X | 0.277 | |
| | Polychlorinated biphenyls (sum 28, 52, 101, 138, 153, 180) | biota (fish - muscle) | 75 | µg/kg ww | 2016 | 1.62 | yes | X | 0.022 | |
| | CB118 | biota (fish - muscle) | 24 | µg/kg ww | 2016 | 0.34 | yes | X | 0.014 | |
| | Hexabromocyclododecane-HBCDD* | biota (fish - muscle) | 167 | µg/kg ww | 2016 | 0.05 | yes | X | 0.000 | |

* – uPTB substances
GES – whether good environmental status has been achieved
WS – contamination factor
ZWC – integrated chemical indicator
Trend – deteriorating (↘), improving (↗), stable (↔) or an unknown trend most often due to too short data series (X)

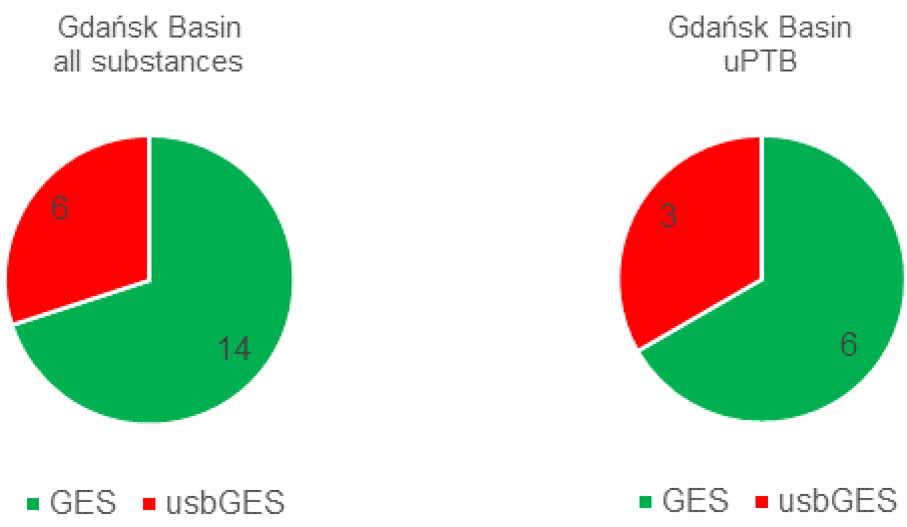



Fig. 2.3.57 Graphical presentation of the result of the assessment for the Gdańsk Basin - the number of indicators that meet the criteria of good environmental status - green and non-good environmental status - red (Data source: PMŚ)

As a result of the integrated assessment of the environmental status of the area of the Gdańsk Basin, the not-good status was found in the case of organisms for which the ZWC value for the biota matrix was as much as 8.1 and was mainly due to the very low thresholds for PBDE and Cd in fish (Table 2.3.76). A ZWC value only slightly above 1 was reported for water and this was related to $^{137}$Cs levels. In the case of sediments, the value of ZWC also exceeded the value of 1, which was responsible for increased Hg concentrations in sediments. Ultimately, the condition of the area of the Gdańsk Basin should be considered unsuitable.

Table 2.3.76 The result of the integrated assessment for the Gdańsk Basin under criterion D8C1)

| | **ZWC** | **Number of indicators with WS < 1** | **Number of indicators with WS > 1** | **Status within matrix** |
|---|---|---|---|---|
| Biota | 8.1 | 8 | 4 | subGES |
| Sediment | 1.50 | 5 | 1 | subGES |
| Water | 1.09 | 1 | 1 | subGES |
| Status of the environment of Gdańsk Basin | | | | subGES |

**Confidence of the assessment of the open water environment's environmental status within the scope of the criterion**

The confidence of the assessment carried out for the three areas of the open sea within D8C1 criterion was determined using an expert judgment based on the basic two parameters: the number, representativeness and confidance of the data included in the assessment and the confidance and adequacy of the threshold values. The assessment assumes that the number of indicators used in the assessment, from 20 to 24 is sufficient to accept high confidence. It has been assumed that the full number of years (the entire period covered by the assessment) of monitoring and data acquisition in a given area is sufficient to assume high confidence. Only in Gdańsk Basin the data for organisms come from one year of research (2016), which is why the confidance has been reduced to the average. The use of data for three matrices, which is valid in all areas of assessment, is sufficient to assume high confidence in this respect. Confidance for threshold values has been lowered to the average due to the fact that they are used outside the environmental quality standards - EQS, also other regional recommended limits and national values. This is an approach adopted as part of the holistic assessment of the Baltic Sea. Taking into account the four components, it was finally established that the environmental assessment of the Bornholm Basin and Eastern Gotland Basin is highly confident, while the confidence of the Gdańsk Basin environmental assessment was considered as medium.

The results of assessing the confidence of assessments of the state of the environment in particular areas are presented in Table 2.3.77.

Table 2.3.77. Assessment of the confidence of environmental status assessments of areas of the open sea in the scope of criterion D8C1

| | Number of assessed indicators | Years of monitoring in a given area | Matrix | Threshold values | Confidence of the assessment |
|---|---|---|---|---|---|
| Bornholm Basin | 24 -high confidence | 2011-2016 -high confidence | water, biota (fish and plants), sediment -high confidence | Threshold values - EQS values, regional values (HELCOM, OSPAR), national values– moderate confidence | high |

| | | | | | |
|---|---|---|---|---|---|
| Eastern Gotland Basin | 20 -high confidence | 2011-2016 -high confidence | water, biota (fish), sediment - high confidence | Threshold values - EQS values, regional values (HELCOM, OSPAR), national values– moderate confidence | high |
| Gdańsk Basin | 20 -high confidence | 2011-2016, organisms only in 2016 -moderate confidence | water, biota (fish), sediment -high confidence | Threshold values - EQS values, regional values (HELCOM, OSPAR), national values– moderate confidence | moderate |

**Criterion D8C2**

The assessment within criterion D8C2 was carried out upon two indicators used to assess the effects of hazardous substances on organisms:

1. Indicator - micronucleus test
2. Indicator - the productivity of the white-tailed eagle

**Micronucleus test**

Although the micronucleus test, which is an indicator of the effects of hazardous substances on marine organisms, has the status pre-core indicator in the HELCOM HOLAS II Project, it was used in the assessment of the environment status in the Polish waters. This indicator was introduced to monitoring program in 2014.

The micronucleus test is the most commonly used test for the assessment of cytogenetic damage at the cellular level caused by the interaction of hazardous substances. The number of micronuclei originating from chromosomes or their fragments as a result of cell division delay is a measure of the genotoxicity of certain substances present in the environment.

Analysis using the micronucleus test consists in counting aberrations occurring in the cells of blood erythrocytes of Baltic herring caught in various areas, and the number of counted changes converted to 1000 erythrocytes is a parameter constituting the measure of harmful effects of hazardous substances on fish. In order to obtain reliable results, the analysis is carried out in 10 samples originating from one location, and the number of analyzed erythrocytes remains within the range of 3000 to 5000 as recommended (HELCOM 2012).

The average values of results obtained in the years 2014-2016 were used for the assessment. The use of average values from the whole research period is aimed at enhancing the confidance of the assessment based on a limited number of data. For each assessment area: Gdańsk Basin Polish Coastal waters, Gdańsk Basin, Eastern Gotland Basin and Bornholm Basin calculated mean aberration values were compared to the threshold value established for herring species (HELCOM 2012) –Table 2.3.78.

The obtained results indicate that good environmental status in terms of the micronucleus test was achieved in the Polish coastal waters of Gdańsk Basin and Bornholm Basin, however in the Eastern Gotland Basin the threshold value was exceeded only slightly.

Table 2.3.78 Results of the assessment of the environmental condition based on measurements carried out using the micronucleus test (Data source: PMŚ)

| Assessment Area | Year | MN/1000 | Average number of micronuclei/1000 erythrocytes | Threshold value - number of micronuclei/1000 erythrocytes | GES |
|---|---|---|---|---|---|
| Gdańsk Basin Polish Coastal waters | 2014 | 0.23 | 0.29 | 0.39 | yes |
| | 2015 | 0.35 | | | |
| Gdańsk Basin | 2015 | 0.92 | 1.13 | | no |
| | 2016 | 1.34 | | | |
| Eastern Gotland Basin | 2014 | 0.23 | 0.54 | | no |
| | 2015 | 1.00 | | | |
| | 2016 | 0.40 | | | |
| Bornholm Basin | 2014 | 0.16 | 0.37 | | yes |
| | 2015 | 0.33 | | | |
| | 2016 | 0.63 | | | |

The confidence of the status assessment in terms of the effects of hazardous substances on marine organisms based on the micronucleus test should be considered as medium, mainly due to the threshold value, which was developed by experts and based on measurement data.

### White-tailed eagle productivity

The 'White-tailed eagle productivity' indicator is the core indicator recommended for the assessment of the environmental status under the HELCOM HOLAS II Project and is used as an indicator of the effects of hazardous substances.

This indicator consists mainly of the parameter:

(1) nestling success - determining the percentage share of couples who raised chicks in relation to the number of all pairs with the known final hatch effect, which is supplemented by two additional parameters:

(2) nestling brood size - the number of chicks per nest with success - the average number of chicks per pair with effective hatches,

(3) number of chicks per breeding pair - average number of chicks per breeding pair.

The details of the assessment are described in the chapter on birds, while the final assessment of the state of the environment under this indicator is provided in the sub-section "Assessment of white-tailed eagle 's productivity in 2011-2016".

The assessment was conducted for coastal areas, and the average result was considered representative for three areas: Bornholm Basin Polish Coastal waters, Eastern Gotland Basin Polish Coastal waters, and Gdańsk Basin Polish Coastal Waters based on data from 2011-2016. The assessment was achieved by the relation of the values characterizing the three parameters to the threshold values determined within the HELCOM HOLAS II Project.

The results of the assessment, summarized in Table 2.3.79, indicate good environmental status in terms of three parameters in all areas of assessment.

Table 2.3.79 Results of the assessment for white-tailed eagle in three assessment areas (Data source: PMŚ)

| **Assessment Area (level 3 in accordance with HELCOM MAS)** | **Nesting success** | | **The number of chicks on the nest with success** | | **The number of chicks for breeding pair** | | **GES** |
|---|---|---|---|---|---|---|---|
| | **value** | **threshold value** | **value** | **threshold value** | **value** | **threshold value** | |
| Polish coastal waters of Eastern Gotland Basin | 0.59 | 0.59 | 1.81 | 1.64 | 1.07 | 0.97 | yes |
| Polish coastal waters of Gdańsk Basin | 0.59 | 0.59 | 1.81 | 1.64 | 1.07 | 0.97 | yes |
| Polish coastal waters of Bornholm Basin | 0.59 | 0.59 | 1.81 | 1.64 | 1.07 | 0.97 | yes |

**Criterion D8C3**

The assessment within criterion D8C3 is based on the results of the assessment carried out as part of the HELCOM core indicator (HELCOM Core Indicator: Operational oil spills from ships (www.helcom.fi/Baltic Sea trends/Indicators). The data for the assessment on oil spills for the period 2011-2015 for individual assessment basins are based on information coming from air observations. In 2015 flights being a part of monitoring of oil spills in Poland, lasted in total about 240 hours. On the basis of information obtained also from other countries, the status of the environment was assessed by relating the average value for individual basins to the threshold values set as average volume of oil spills that took place in the same areas in 2008 - 2013. Table 2.3.80 presents the results of the assessment for the three basins.

Table 2.3.80 Assessment of the status of the environment within criterion D8C3 (Data source: PMŚ)

| Basin | Threshold value - annual average for the 2008-2013 assessment period [$m^3$] | Annual average for the 2011-2015 assessment period [$m^3$] | Status of the environment |
|---|---|---|---|
| Gdańsk Basin | 0.1038 | 0.0981 | GES |
| Eastern Gotland Basin | 1.8503 | 2.8722 | subGES |
| Bornholm Basin | 2.8667 | 1.4121 | GES |

The confidence of the assessment of the environmental status within criterion D8C3 should be considered as moderate, mainly due to the threshold value, which was developed by experts and is based on measurement data and limited representativeness of data resulting from the monitoring process.

## Summary of the assessment within Descriptor D8

The assessment of the environmental status within Descriptor D8 has been carried out taking into account three criteria, whereby such a full assessment concerns only the areas of the open sea:

- In the Bornholm Basin, within the criterion D8C1, 18 of 24 indicators - substances in appropriate matrices - met the requirements for good environmental status, including 7 of 10 ubiquitous, persistent, toxic and bioaccumulated substances that met the requirements for good environmental status. Using the adopted method of assessment integration, the status of the Bornholm Basin within criterion D8C1 should be considered not-good (Fig. 2.3.58). Within criterion D8C2 (indicator of the effects of hazardous substances) the good status of the environment was achieved, as well as within criterion D8C3 (the oil spill index).
- In the Eastern Gotland Basin, within criterion D8C1, 14 out of 20 indicators - substances in appropriate matrices - met the requirements for good environmental status, including 6 out of 9 ubiquitous, persistent, toxic and bioaccumulated substances met the requirements for good environmental status. Using the adopted integration method, the status of the Eastern Gotland Basin environment within criterion D8C1 should be considered not-good (Fig. 2.3.59). Within criterion D8C2 (indicator of the effects of hazardous substances) the good status of the environment was not achieved, as well as within criterion D8C3 (the oil spill index).
- In the Gdańsk Basin, within criterion D8C1, 14 out of 20 indicators - substances in appropriate matrices - met the requirements for good environmental status, of which 6 out of 9 ubiquitous, persistent, toxic and bioaccumulated substances met the requirements for good environmental status. Using the adopted method of integration, the status of the Gdańsk Basin environment within criterion D8C1 should be considered not good (Fig. 2.3.60). Within criterion D8C2 (indicator of the effects of hazardous substances) the good status of the environment was not achieved, while the oil spills index assessed within criterion D8C3 indicates good environmental status.

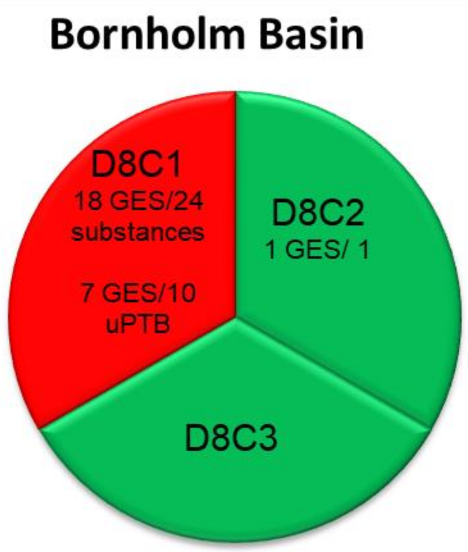



Fig. 2.3.58. Summary of the environmental assessment of the Bornholm Basin in the scope of Descriptor 8 (Data source: PMŚ)

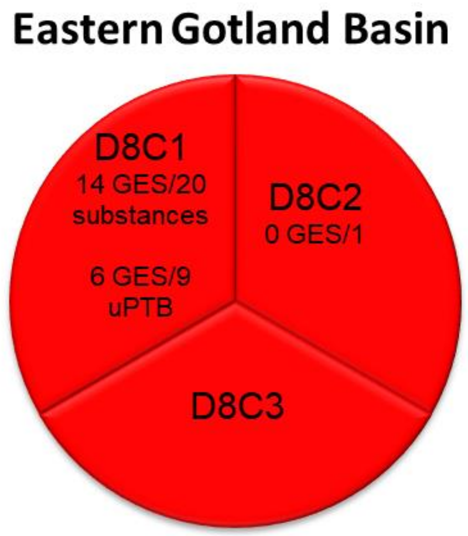



Fig. 2.3.59. Summary of the assessment of Eastern Gotland Basin's environmental condition regarding Descriptor 8 (Data source: PMŚ)

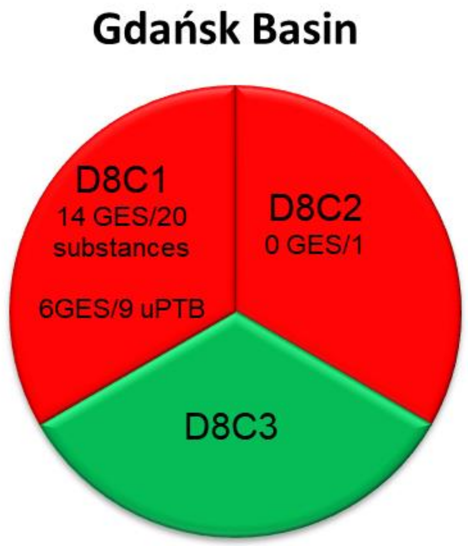



Fig. 2.3.60. Summary of the assessment of the condition of Gdańsk Basin environment in the scope of Descriptor 8 (Data source: PMŚ)

***Descriptor D9 - Contaminants in fish and other seafood for human consumption do not exceed levels established by Union legislation or other relevant standards***

According to the Commission Decision 848/2017, for the assessment within Descriptor D9 one primary criterion D9C1 was used (Table 2.3.81)

Table 2.3.81 The assessment criterion for Descriptor 9

| Descriptor | Primary criteria | Description of criteria according to the Commission Decision 848/2017 | Assessment scale |
|---|---|---|---|
| D9 - Contaminants in fish and other seafood for human consumption do not exceed levels established by Union legislation or other relevant standards | D9C1 | The level of contaminants in edible tissues (muscle, liver, roe, flesh or other soft parts, as appropriate) of seafood (including fish, crustaceans, molluscs, echinoderms, seaweed and other marine plants) caught or harvested in the wild (excluding fin-fish from mariculture) does not exceed:<br>(a) for contaminants listed in Regulation (EC) No 1881/2006, the maximum levels laid down in that Regulation, which are the threshold values for the purposes of this Decision;<br>(b) for additional contaminants, not listed in Regulation (EC) No 1881/2006, threshold values, which Member States shall establish through regional or subregional cooperation. | The catch or production area in accordance with Article 38 of Regulation (EU) No 1379/2013 of the European Parliament and of the Council of 11 December 2013 on the common organization of the markets in fishery and aquaculture products, amending Council Regulations (EC) No 1184/2006 and (EC) No 1224/2009 and repealing Council Regulation (EC) No. 104/2000 (OJ L 354, 28.12.2013, p. 1, as amended) |

Level of contaminants in the edible tissues (muscles, liver, roes, meat or other soft parts) of fish and seafood (including fish, crustaceans, molluscs, echinoderms, seaweeds and other marine plants) caught or harvested in nature (excluding fish from mariculture) does not exceed:

a) for pollutants listed in Regulation 1881/2006, the maximum levels set in Regulation 1881/2006, which are threshold values for the purposes of Decision 848/2017;
b) for additional pollutants not mentioned in Regulation No. 1881/2006, threshold values that Member States shall establish in the framework of regional cooperation.

**Criterion D9C1**

The assessment within descriptor 9, criterion D9C1 was based on data for indicators (concentrations of substances in fish muscle) selected during the testing carried out in stage I of the contract on updating the initial assessment of the Baltic Sea environment status. All substances were assigned to the appropriate assessment areas in which these data were obtained. The final set of substances assigned to areas is shown in Table 2.3.82. However, it should be emphasized that according to decision 848/2017, the assessment areas are FAO areas and, therefore, the individual areas of the division of POM have been assigned to the relevant FAO areas (Table 2.3.84).

The assessment in these areas was carried out in accordance with the decision 848/2017 with a guide (Article 8 MSFD Assessment Guidance 2017), meaning that for each substance in fish muscle tissue the assessment was carried out, taking concentration values to the threshold values and indicating if the threshold values were exceeded, or not. Threshold values have been adopted on the basis of existing legal acts (Regulation 1881/2006) or arrangements at the regional level. References for each threshold are given in Table 2.3.82. Finally, the number of substances that meets the requirements of good status and the number of substances that do not meet this requirement for each assessment area is given. It should be emphasized that the most up-to-date data was used in the assessment, in most cases the data from 2016. The average concentrations of specific substances calculated on the basis of data from each area were used for the assessment, if samples for the same analyzes were taken from more than one location. In other cases, individual data was used for the assessment, as for example in the FAO 25 area

Table 2.3.82. Assignment of assessment areas to areas FAO

| **Substance** | **Matrix** | **Threshold value** | **Unit** | **Reference** | **Szczecin Lagoon** | **Bornholm Basin** | **Polish coastal water Bornholm Basin** | **Gdańsk Basin** | **Eastern Gotland Basin** | **Vistula Lagoon** |
|---|---|---|---|---|---|---|---|---|---|---|
| Cadmium - Cd | fish - liver | **1** | mg/kg ww | Regulation No.1881/2006 OSPAR 2009 | x | x | x | x | x | x |
| Lead - Pb | fish - liver | **0.3** | mg/kg ww | Regulation No.1881/2006 | x | x | x | x | x | x |
| Mercury - Hg | fish - muscle | **0.5** | mg/kg ww | Regulation No.1881/2006 | x | x | x | x | x | x |
| Brominated diphenylethers PBDE (sum congeners 28, 47, 99, 100, 153, 154) | fish - muscle | **0.0085** | µg/kg ww | EQS biota and human health, Directive 2013/39/UE, WFD_3 | x | x | x | x | x | x |
| Tributyltin compounds (tributyltin cation) | fish - muscle | **15.2** | µg/kg ww | $QS_{seafood}$ WFD_6 | x | x | x | x | x | x |
| Perfluorooctane sulfonic acid and its derivatives (PFOS) | fish - muscle | **9.1** | µg/kg ww | EQS, Directive 2013/39/UE WFD_7 | x | x | x | x | x | x |
| Dioxins and dioxin-like (sum PCDD+PCDF+PCB-DL) | fish - muscle | **0.008** | µg/kg TEQ | Regulation No.1881/2006 | | x | | x | x | |
| Polychlorinated biphenyls( sum 28, 52, 101, 138, 153) | fish - muscle | **75** | µg/kg ww | Regulation No.1881/2006 | x | x | x | x | x | x |
| Hexabromocyclodo decane- HBCDD | fish - muscle | **167** | µg/kg ww | EQS, Directive 2013/39/UE, WFD_8 | x | x | x | x | x | x |

**Reference to** Table 2.3.83:
Regulation No.1881/2006 http://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:32006R1881&from=EN
Directive 2013/39/UE http://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:32013L0039&from=PL
WFD_3 https://circabc.europa.eu/sd/a/d07ed9f5-0760-4561-b642-04bc1e4a580e/PBDE%20EQS%20dossier%202011.pdf
WFD_6 Common Implementation Strategy for the Water Framework Directive, Environmental Quality Standards (EQS), Substance Data Sheet, Tributyltin compounds (TBT-ion) EQS dossier 2005
WFD_7 https://circabc.europa.eu/sd/a/027ff47c-038b-4929-a84c-da3359acecee/PFOS%20EQS%20dossier%202011.pdf
WFD_8 https://circabc.europa.eu/sd/a/086ffe7c-8e63-4893-baac-994f3ff0eb34/HBCDD%20EQS%20dossier%202011.pdf

Table 2.3.84 Sampling locations in individual assessment FAO areas

| Assessment Area | Matrix | Parameters | Fishery | Years of data acquisition | FAO area |
|---|---|---|---|---|---|
| Szczecin Lagoon | fish | HM, POP | fishery LZSZ | 2011-2016 | 27.3d.24 |
| Bornholm Basin | fish | HM, POP | fishery ZPOM | 2011-2016 | 27.3d.24 |
| Bornholm Basin | fish | HM, POP | fishery KOL | 2011-2016 | 27.3d.25 |
| Eastern Gotland Basin | fish | HM, POP | fishery LWLA | 2011-2016 | 27.3d.26 |
| Gdańsk Basin | fish | HM, POP | fishery BGDA | 2016 | 27.3d.26 |
| Polish coastal water Gdańsk Basin | fish | HM, POP | fishery ZGDA | 2011-2015 | 27.3d.26 |
| Vistula Lagoon | fish | HM, POP | fishery LZWI | 2011-2016 | 27.3d.26 |

The results of the assessment (Table 2.3.85) indicate that out of the nine substances, only the sum of PBDE congeners does not meet the criteria for good environmental status in terms of the descriptor 9. This applies to all three assessment areas and is mainly due to the very low threshold values set for PBDEs.

Table 2.3.85 Assessment results within the D9 Descriptor (Data source: PMŚ, PIWET)

| Area | Substance | Matrix | Threshold value | Unit | Average concentration | GES |
|---|---|---|---|---|---|---|
| FAO 27.3d.24 | Cadmium - Cd | fish - liver | **1** | mg/kg ww | **0.15** | yes |
| | Lead - Pb | fish - liver | **0.3** | mg/kg ww | **0.04** | yes |
| | Mercury - Hg | fish - muscle | **0.5** | mg/kg ww | **0.04** | yes |
| | Brominated diphenylethers PBDE (sum congeners 28, 47, 99, 100, 153, 154) | fish - muscle | **0.0085** | µg/kg ww | **0.02** | no |
| | Tributyltin compounds (tributyltin cation) | fish - muscle | **15.2** | µg/kg ww | **2.02** | yes |
| | Perfluorooctane sulfonic acid and its derivatives - PFOS | fish - muscle | **9.1** | µg/kg ww | **2.56** | yes |
| | Polychlorinated biphenyls (sum 28, 52, 101, 138, 153, 154 180) | fish - muscle | **75** | µg/kg ww | **1.61** | yes |
| | Hexabromocyclododecane-HBCDD | fish - muscle | **167** | µg/kg ww | **0.12** | yes |
| | Dioxins and dioxin-like compounds (sum PCDD+PCDF+PCB-DL) | fish - muscle | **0.0085** | µg/kg TEQ | **0.0014** | yes |
| FAO 27.3d.25 | Cadmium - Cd | fish - liver | **1** | mg/kg ww | **0.5** | yes |
| | Lead - Pb | fish - liver | **0.3** | mg/kg ww | **0.041** | yes |
| | Mercury - Hg | fish - muscle | **0.5** | mg/kg ww | **0.022** | yes |
| | Brominated diphenylethers PBDE (sum congeners 28, 47, 99, 100, 153, 154) | fish - muscle | **0.0085** | µg/kg ww | **0.228** | no |
| | Tributyltin compounds (tributyltin cation) | fish - muscle | **15.2** | µg/kg ww | **2.02** | yes |
| | Perfluorooctane sulfonic acid and its derivatives - PFOS | fish - muscle | **9.1** | µg/kg ww | **0.78** | yes |
| | Polychlorinated biphenyls (sum 28, 52, 101, 138, 153, 154 180) | fish - muscle | **75** | µg/kg ww | **1.64** | yes |

| Area | Substance | Matrix | Threshold value | Unit | Average concentration | GES |
|---|---|---|---|---|---|---|
| | Hexabromocyclododecane-HBCDD | fish - muscle | **167** | µg/kg ww | **1.21** | yes |
| | Dioxins and dioxin-like compounds (sum PCDD+PCDF+PCB-DL) | fish - muscle | **0.0085** | µg/kg TEQ | **0.002** | yes |
| FAO 27.3d.26 | Cadmium - Cd | fish - liver | **1** | mg/kg ww | **0.275** | yes |
| | Lead - Pb | fish - liver | **0.3** | mg/kg ww | **0.042** | yes |
| | Mercury - Hg | fish - muscle | **0.5** | mg/kg ww | **0.051** | yes |
| | Brominated diphenylethers PBDE (sum congeners 28, 47, 99, 100, 153, 154) | fish - muscle | **0.0085** | µg/kg ww | **0.147** | no |
| | Tributyltin compounds (tributyltin cation) | fish - muscle | **15.2** | µg/kg ww | **3.15** | yes |
| | Perfluorooctane sulfonic acid and its derivatives - PFOS | fish - muscle | **9.1** | µg/kg ww | **1.24** | yes |
| | Polychlorinated biphenyls (sum 28, 52, 101, 138, 153, 180) | fish - muscle | **75** | µg/kg ww | **1.88** | yes |
| | Hexabromocyclododecane-HBCDD | fish - muscle | **167** | µg/kg ww | **0.19** | yes |
| | Dioxins and dioxin-like compounds (sum PCDD+PCDF+PCB-DL) | fish - muscle | **0.0085** | µg/kg TEQ | **0.0018** | yes |


Fig. 2.3.61. Graphical presentation of the result of the assessment for the assessment areas - the number of indicators meeting the criteria of good environmental status - green and not meeting criteria forgood environmental status - red (Data source: PMŚ, PIWET)

**Confidence of the assessment of the open water areas environmental status within criterion D9C1**

The confidence of the environmental status assessment within criterion D9C1 criterion carried out for three areas of the open sea, was determined using an expert judgment based on the two parameters: the number, representativeness and confidance of the data included in the assessment and the confidance and adequacy of the threshold values. It was stated that the number of indicators used in the assessment is sufficient to assume high confidence. It has been also stated that the full number of years (the entire period covered by the assessment) of monitoring and data acquisition in a given area is sufficient to assume high confidance. Confidence for threshold values was considered high taking into account their source. Considering the three components, it was finally determined that the assessment of the environmental status of FAO24, FAO25 and FAO26 areas is highly confident.

The results of assessing the confidence of assessments of the status of the environment in particular areas are presented in Table 2.3.86.

Table 2.3.86 Assessment of the confidece of the FAO area status assessments under D9C1 criterion

| | Number of assessed indicators | Years of monitoring in a given area | Threshold values | Confidence of the assessment |
|---|---|---|---|---|
| FAO 27.3d.24 | 10<br>-high confidence | 2011-2016<br>-high confidence | Values from Regulation No. 1881/2006 EQS and QS values<br>-high confidence | high |
| FAO 27.3d.25 | 10<br>-high confidence | 2011-2016<br>-high confidence | | high |
| FAO 27.3d.26 | 10<br>-high confidence | 2011-2016,<br>-high confidence | | high |

***Descriptor D10 - Properties and quantities of marine litter do not cause harm to the coastal and marine environment***

According to the Commission Decision 848/2017, four criteria were set for descriptor 10, two of which are primary, i.e. they must be included in the environmental status assessment, two other are secondary criteria whose application must be justified (Table 2.3.87).

Table 2.3.87 Criteria for assessment for Descriptor 10

| Descriptor | Primary criterion | Secondary criterion | Description of criteria in accordance with Decision 848/2017 | Assessment scale |
|---|---|---|---|---|
| D10 - Properties and quantities of marine litter do not cause harm to the coastal and marine environment | D10C1 | | The composition, amount and spatial distribution of litter on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment.<br>An element of this criterion is litter (excluding micro-litter) classified into one of the following categories: artificial polymer materials, rubber, cloth/textiles, paper/cardboard, processed/worked wood, metal, glass/ceramics, chemicals, unidentified litter and food waste. | Subdivisions of the region or sub-region, if necessary divided by national boundaries. |
| | D10C2 | | The composition, amount and spatial distribution of micro-litter on the coastline, in the surface layer of the water column, and in seabed sediment, are at levels that do not cause harm to the coastal and marine environment.<br>An element of this criterion are micro-litter, i.e. particles smaller than 5 mm in size, classified in two categories: "artificial polymer materials" and "other". | |
| | | D10C3 | The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned.<br>An element of this criterion are micro-litter, i.e. particles smaller than 5 mm in size, classified in two categories: "artificial polymer materials" and "other", which number is specified in any species from the following groups: birds, mammals, reptiles, fish or invertebrates. Species subjected for assessment should be selected at the regional level. | |
| | | D10C4 | The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects. | Such as used to assess the group of species. |

This study attempts to assess the environmental condition of the Baltic Sea areas under the jurisdiction of Poland in terms of two primary criteria: D10C1 and D10C2. No attempt was made to assess the status of the environment regarding the secondary criteria: D10C3 and D10C4, mainly due to the lack of data. However, it should be emphasized that due to the fact that threshold values for any criterion were not defined at the EU level, the presented assessments are of quantitative nature. The qualitative assessment carried out is of a test nature and has been proposed as a national solution, as in line with Decision 848/2017, the threshold values for individual elements of all four criteria should be determined through cooperation at the EU level, taking into account regional specificity.

**Criterion D10C1**

The assessment within criterion D10C1 was based on data from the monitoring of litter collected on the coastline carried out in 2015 and 2016.

Monitoring of beach litter was carried out on 15 sections of 1 km length selected to reflect the status of the entire coast and represented various types of beaches: urban, rural, with various tourist traffic (Fig. 2.3.62). These sections were assigned to relevant assessment areas (Table 2.3.88) selected regionally and indicated in the HELCOM Monitoring and Assessment Strategy (HELCOM 2013). Belong to them:

1. Bornholm Basin Polish coastal waters
2. Eastern Gotland Basin Polish coastal waters
3. Gdańsk Basin Polish coastal waters

In each episode, all marine litter items from the entire width (from the water line to the beach border) of the monitored section were counted, and their identification was carried out in the scope of the type of material and size in accordance with the unified classification. Monitoring of marine litter on the shoreline, on designated sections, was carried out four times per year: in April, at the turn of June and July, at the turn of September and at the turn of December and January.

Each type of litter item was counted and assigned to one of seven categories: artificial polymer materials, rubber, cloth/textiles, paper/cardboard, glass/ceramics, wood, metal. Other litter items whose attribution was not possible to identified were treated as unclassified. The assessment of the status of the environment was carried out for the above categories of litter and for the sum of all items.

Table 2.3.88 Assessment areas and monitored sections

| Assessment Area | The name of the section | Number of sections |
|---|---|---|
| Bornholm BasinPolish Coastal waters | Darłowo<br>Dziwnów<br>Kołobrzeg/Ustronie Morskie<br>Mielno<br>Świnoujście<br>Trzebiatów<br>Ustka | 7 (5 urban, 2 rural) |
| Eastern Gotland Basin Polish Coastal waters | Choczewo<br>Smołdzino | 2 (2 rural) |
| Gdańsk Basin Polish Coastal waters | Gdańsk<br>Gdynia<br>Hel (24-25)<br>Hel (40-41)<br>Krynica Morska<br>Stegna | 6 (2 urban, 4 rural) |

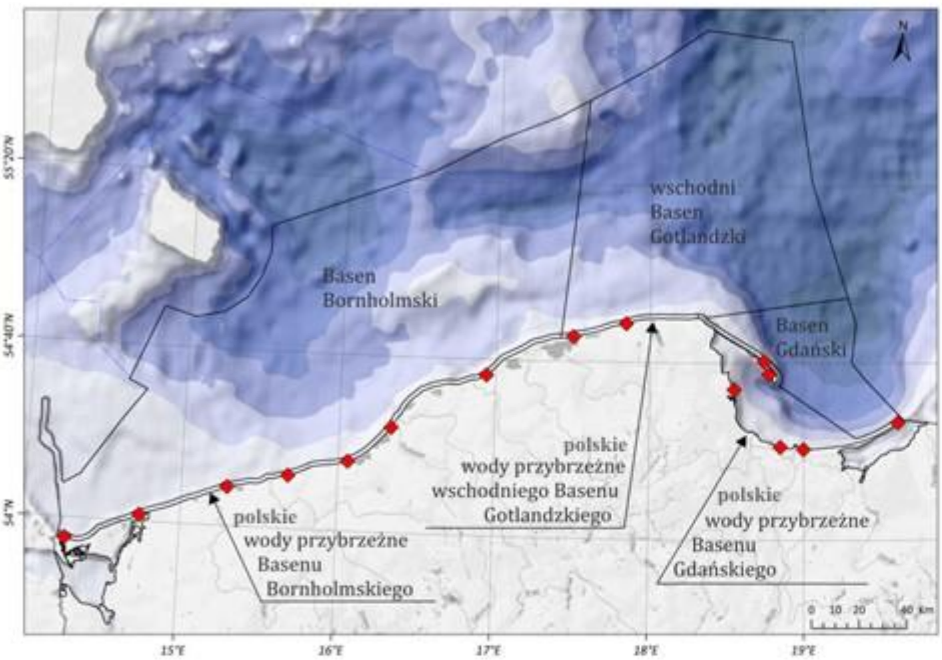



Fig. 2.3.62. Location of litter monitoring sections on the shoreline of the Polish coast in 2015 and 2016

**The basic parameter that is assessed is the number of marine litter items in each category and the sum of all items per 100 m. This parameter can be defined as the frequency of occurrence of a given type of litter and the sum of all litter.**

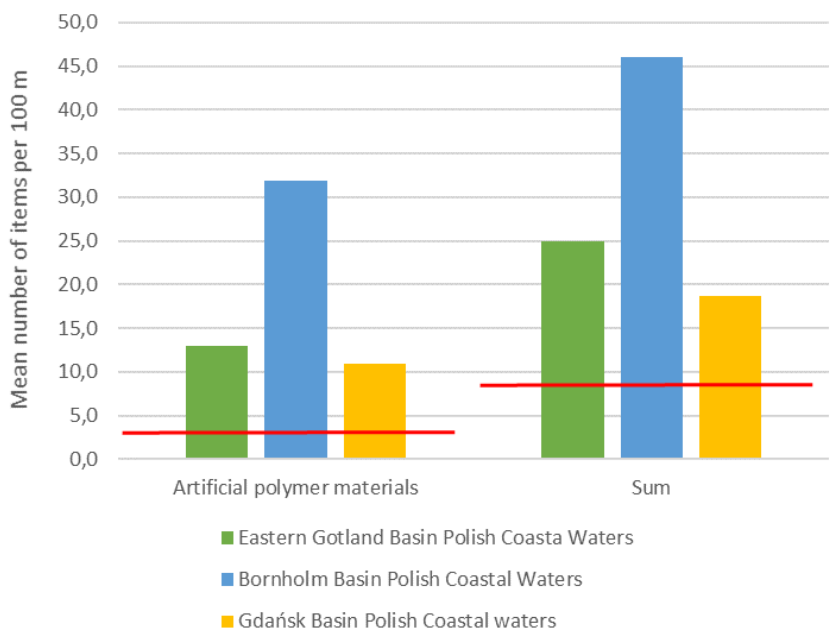
This parameter is determined by converting the results obtained for any segment length to 100 m. In the case of Polish data, this meant dividing the number of litter items from each monitored category over the length of 1000m by 10. This approach allows regional comparability and has been used in the HELCOM SPICE Project: Implementation of the second cycle of the Marine Strategy Framework Directive: Achievement of co-ordination, initial assessments and environmental targets. For each area of the assessment, the average number of marine litter items in each category and the sum of all items per 100 m was determined. These averages were calculated based on data from both years of monitoring in order to increase the confidance and representativeness of the results. The results are summarized in the form of a table (Table 2.3.89) and diagrams (Fig. 2.3.63)

Table 2.3.89. Frequency of litter items of individual categories, unclassified and sum of all items (source of PMŚ data)

| Area | Litter category | N | Min | Max | Frequency of waste (average number of waste / 100m) | Threshold value | GES |
|---|---|---|---|---|---|---|---|
| Eastern Gotland Basin Polish Coastal waters | Artificial polymer materials | 16 | 4.4 | 24.5 | 10.2 | 3.0 | no |
| | Rubber | 16 | 0.0 | 0.8 | 0.3 | 1.0 | yes |
| | Clothing / textiles | 16 | 0.0 | 6.2 | 1.3 | 1.0 | no |
| | Paper / cardboard | 16 | 0.1 | 8.2 | 1.6 | 1.0 | no |
| | Wood | 16 | 0.0 | 6.5 | 1.4 | 1.0 | no |
| | Metal | 16 | 0.0 | 3.5 | 1.2 | 1.0 | no |
| | Glass / ceramics | 16 | 0.0 | 1.8 | 0.9 | 1.0 | yes |
| | Unclassified | 16 | 0.0 | 6.0 | 0.9 | | |

| Area | Litter category | N | Min | Max | Frequency of waste (average number of waste / 100m) | Threshold value | GES |
|---|---|---|---|---|---|---|---|
| | Sum | 16 | 5.8 | 52.5 | 17.8 | 9.0 | no |
| Bornholm Basin Polish Coastal waters | Artificial polymer materials | 56 | 0.0 | 251.4 | 35.4 | 3.0 | no |
| | Rubber | 56 | 0.0 | 1.8 | 0.2 | 1.0 | yes |
| | Clothing / textiles | 56 | 0.0 | 3.5 | 0.3 | 1.0 | yes |
| | Paper / cardboard | 56 | 0.0 | 6.1 | 1.4 | 1.0 | no |
| | Wood | 56 | 0.0 | 150.0 | 7.3 | 1.0 | no |
| | Metal | 56 | 0.0 | 31.6 | 4.3 | 1.0 | no |
| | Glass / ceramics | 56 | 0.0 | 24.3 | 1.7 | 1.0 | no |
| | Unclassified | 56 | 0.0 | 6.7 | 0.4 | | |
| | Sum | 56 | 0.9 | 275.8 | 51.1 | 9.0 | no |
| Gdańsk Basin Polish Coastal waters | Artificial polymer materials | 48 | 0.0 | 149.8 | 10.9 | 3.0 | no |
| | Rubber | 48 | 0.0 | 1.2 | 0.2 | 1.0 | yes |
| | Clothing / textiles | 48 | 0.0 | 3.2 | 0.4 | 1.0 | yes |
| | Paper / cardboard | 48 | 0.0 | 5.3 | 0.7 | 1.0 | yes |
| | Wood | 48 | 0.0 | 175.1 | 4.0 | 1.0 | no |
| | Metal | 48 | 0.0 | 8.4 | 1.3 | 1.0 | no |
| | Glass / ceramics | 48 | 0.0 | 6.4 | 1.3 | 1.0 | no |
| | Unclassified | 48 | 0.0 | 0.3 | 0.0 | | |
| | Sum | 48 | 1.0 | 216.7 | 18.7 | 9.0 | no |

N - number of monitoring carried out in a given area, including four seasons



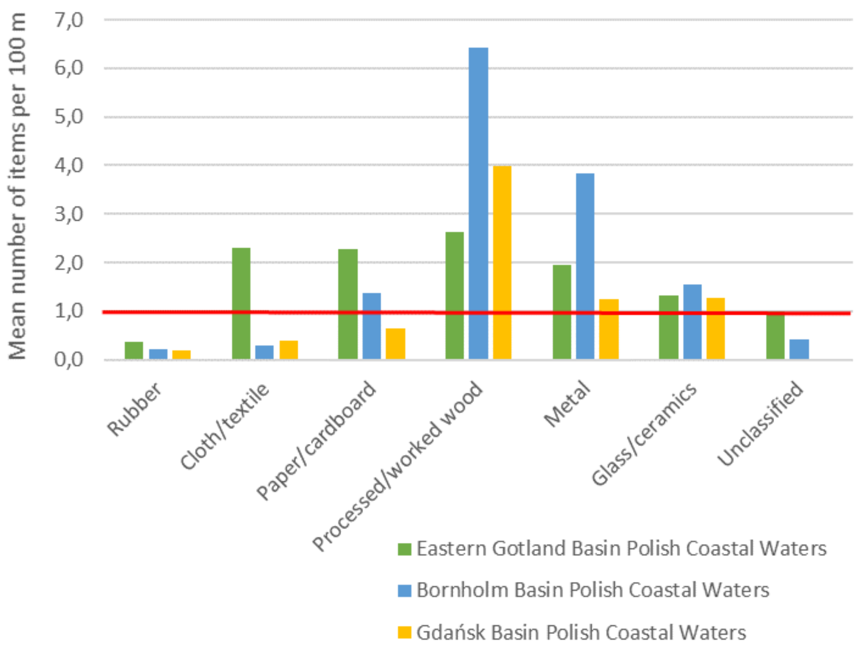



Fig. 2.3.63. The frequency of waste of individual categories, unclassified and the sum of all waste designated for the three areas of assessment; the red line indicates the threshold value. (Data source: PMŚ)

The highest average number of litter items per 100 m in all areas of assessment was specific to polymer materials, with the largest frequency at 35.4 reported in Polish coastal waters of the Bornholm Basin. In the other two areas their frequencies were at a similar level and were respectively 10.2 in Polish coastal waters of the Eastern Gotland Basin and 10.9 in Polish Gdańsk Basin Polish coastal waters. These results directly affected the sum of all litter items in individual areas, because the percentage of polymer materials amounted to about 69% in the area of Polish coastal waters of Bornholm Basin and about 58% in the remaining areas. The attendance of other litter items of other categories remained in the following ranges: from 0.3 to 1.6 in Polish coastal waters of Eastern Gotland Basin, from 0.2 to 4 in Polish coastal waters of Gdańsk Basin and from 0.2 to 7.3 in Polish coastal waters Bornholm Basin.

The highest share of urban areas in the monitored sections is responsible for the largest frequency of all categories of litter observed in the area of Bornholm Basin Polish coastal waters (Table 2.3.88).

Although, according to the Commission Decision 848/2017, threshold values for individual elements of all four criteria should be determined through cooperation at the EU level, taking into account regional specificity in the presented assessment, thresholds were proposed based on Polish monitoring data from 2015 and 2016 The values of the 15th percentile designated for each category of litter were used as the starting values for the determination of threshold values. At the same time, it was assumed that for all categories apart from polymer materials, the threshold value will be one item per 100m. The threshold value for the sum of all litter, which is 9 items per 100m, results from the sum of threshold values for litter in all categories. In the case when a part of particular categories can reach a good status, the sum of all litter items is decisive (Table 2.3.90).

Table 2.3.90 Threshold values for particular litter categories and sum of all items

| Litter category | Frequency of the litter items (average value of number of items /100m) | Min | Max | Percentile 15 | Percentile 25 | Threshold value |
|---|---|---|---|---|---|---|
| Artificial polymer material | 22.3 | 0.0 | 251.4 | 3.0 | 3.9 | 3.0 |
| Gum | 0.2 | 0.0 | 1.8 | 0.0 | 0.0 | 1.0 |
| Cloth/textile | 0.5 | 0.0 | 6.2 | 0.0 | 0.0 | 1.0 |
| Paper/Cardboard | 1.1 | 0.0 | 8.2 | 0.1 | 0.2 | 1.0 |
| Processed/worked wood | 5.2 | 0.0 | 175.1 | 0.0 | 0.1 | 1.0 |
| Metal | 2.7 | 0.0 | 31.6 | 0.3 | 0.5 | 1.0 |
| Glass/ceramics | 1.4 | 0.0 | 24.3 | 0.2 | 0.3 | 1.0 |
| Unclassified | 0.3 | 0.0 | 6.7 | 0.0 | 0.0 | |
| Sum | 33.7 | 0.9 | 275.8 | 4.8 | 7.6 | 9.0 |

Taking into account the proposed threshold values, good environmental status was achieved in the categories: rubber in all areas, clothes/textiles in Gdańsk Basin Polish coastal waters and Bornholm Basin, paper/carboard in Gdańsk Basin Polish coastal waters and glass/ceramics in Polish coastal waters of the Eastern Gotland Basin. However, taking into account the results for all categories and the sum of litter items, good environmental status was not achieved in any of the areas. The confidence of the assessment within criterion D10C1 should be considered as low, mainly due to the threshold value, which was developed at the national level and is based on measurement data and limited representativeness of data resulting from the monitoring process.

**Criterion D10C2**

The assessment carried out within criterion D10C2 is only quantitative due to the lack of threshold values for the number of microparticles in seawater and sediments and is based on data obtained from pilot studies conducted in 2016. Samples of surface sea water and surface bottom sediments were taken from six locations: Szczecin and Vistula Lagoon, in the area of Gdańsk Basin, Eastern Gotland Basin and Bornholm Basin. The individual stations were assigned to the assessment areas (Table 2.3.91).

Table 2.3.91 Number of microparticles in seawater and bottom sediments in the assessment areas (Data source: PMŚ)

| Assessment area | Station | The number of microparticles in seawater | The number of microparticles in sediments |
|---|---|---|---|
| Szczecin Lagoon | ZSZ | 35.5 | 7 |
| Vistula Lagoon | KW | 37 | 9 |
| Bornholm Basin | P5 | 52 | 8 |
| Eastern Gotland Basin | P140 | 16.7 | 5.5 |
| Gdańsk Basin | P110, P1 | 17.5 | 9 |

The highest number of microparticles (at level of 50) was found in waters of the Bornholm Basin, slightly lower values (35) were recorded in Szczecin Lagoon and in Vistula Lagoon, while in the Eastern Gotland Basin and the Gdańsk Basin the number of microparticles was the smallest and was about 17. In the case of bottom sediments, the number of microparticles in all areas were very similar and remained in the range of 7-9, only in the Eastern Gotland Basin it was 5.5.

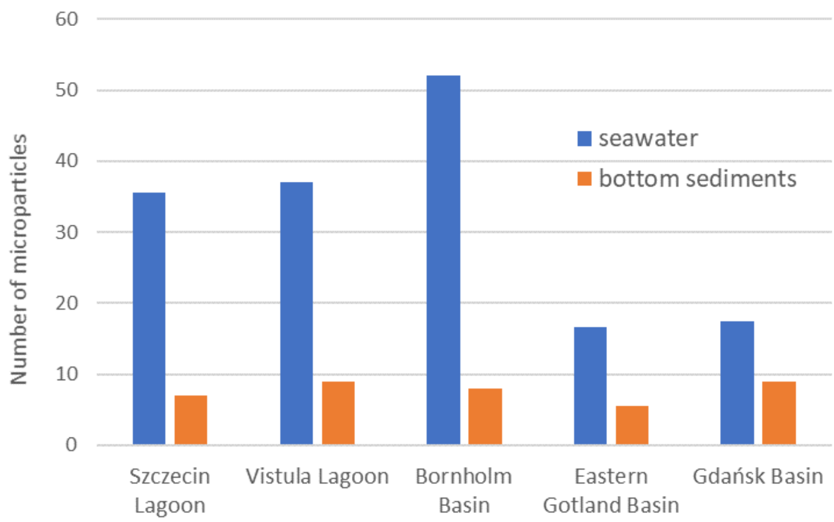



Fig. 2.3.64. Number of microparticles in sea water and bottom sediments in the assessment areas (Data source: PMŚ)

***Descriptor D11 - Underwater noise***

According to MSFD and Decision 2017/848, underwater noise (impulsive and continuous) is defined as pollution caused by human activity, which causes or can cause adverse effects in living marine resources and ecosystems. Criteria and methodological standards for the quality of determining good environmental status for Descriptor D11 are outlined below.

| Elements of criteria | Criteria | Methodological standards |
|---|---|---|
| Anthropogenic impulsive sound in water. | D11C1 - primary:<br>The spatial distribution, temporal extent, and levels of anthropogenic impulsive sound sources do not exceed levels that adversely affect populations of marine animals.<br><br>Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or subregional specificities. | Scale of assessment:<br>Region, sub-region or subdivisions<br><br>Use of criteria:<br>The extent to which good environmental status has been achieved shall be expressed for each area assessed as follows:<br>a) for D11C1, the duration per calendar year of impulsive sound sources, their distribution within the year and spatially within the assessment area, and whether the threshold values set have been achieved;<br>b) for D11C2, the annual average of the sound level, or other suitable temporal metric agreed at regional or subregional level, per unit area and its spatial distribution within the assessment area, and the extent (%, km2) of the assessment area over which the threshold values set have been achieved.<br><br>The use of criteria D11C1 and D11C2 in the assessment of good environmental status for Descriptor 11 shall be agreed at Union level.<br><br>The outcomes of these criteria shall also contribute to assessments under Descriptor 1 |
| Anthropogenic continuous low-frequency sound in water | D11C2 - primary: The spatial distribution, temporal extent and levels of anthropogenic continuous low-frequency sound do not exceed levels that adversely affect populations of marine animals.<br><br>Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or subregional specificities | |

In both cases, threshold values for these levels and their application should be set by EU Member States through cooperation at EU level, taking into account regional or sub-regional specificities. In the absence of the above values, the assessment is descriptive only.

Two indicators were analyzed: impulsive sound and continuous low frequency sound. With reference to the impulsive sound, the description of the state of the environment was determined on the basis of data on explosions in POM in the years 2011-2016, obtained from the Ministry of National Defence.

**Criterion D11C1 - Impulsive Sound**

Based on MSFD, impulsive sound belongs to the group of anthropogenic pressures affecting the marine environment, which makes it an indicator suitable for assessing the environmental status of marine waters. One of the sources of underwater impulse noise is the detonation of explosives. Explosions are a direct result of a violent chemical reaction that triggers a shock wave. Characteristic for the shockwave is a rapid increase in pressure achieved in just a few seconds, and then exponential its disappearance in less than several hundred ms (Weston, 1960, Cole, 1965). The characteristic feature of the shockwave is its propagation in all directions at the same time, with an approximate speed of 1500 $ms^{-1}$ and the possibility of producing secondary impulses resulting from the bouncing of the shock wave from the seabed and from the surface. The strength of the impulse generated by the explosion is determined on the basis of the maximum shockwave pressure and instantaneous velocity of the water particles after the shock wave passes through the medium. Due to the fact that the shape of explosive impulses changes with distance, the more accurate characteristic for this type of sound is the estimated level of energy source (SLE) (Ainslie, 2010), recorded defined using the following equation:

$$SLE=231+10\log10(W)\ [\text{dB re } \mu Pa^2\ m^2\ s]$$

where W - means the amount of explosives used

In the available literature for noise caused by explosions, an average level of energy source (SLE) of 164.3 dB re 1 $\mu Pa^2$ s has been proposed that has a potential impact on the reactions of marine mammals (Lucke et al., 2009). However, in the report TSG Noise (2013), the proposed minimum threshold for the level of energy source for pulsed sound from explosion of explosives, for the purpose of its registration has been raised to the value of 210.3 dB re 1 $\mu Pa^2\ m^2$ s, which is equivalent to using 8 g of TNT to the explosion. This value was established in relation to SLE (Lucke et al., 2009), including sound dampening attenuation in water for a distance of 1000 m. According to Ainslie (2010), the energy level of an explosion resulting from an explosion equals approximately one megajoule of acoustic energy for every kilogram of explosive. Determination of the minimum amount of cargo, gave the foundation to create a five-point scale referring to the types of force of explosion (Monitoring Guidance for Underwater Noise in European Seas - Part III, 2013), which correlated with the amount of explosive used each time (Table 2.3.92).

Table 2.3.92. List of five types of explosions, giving the energy levels of the explosion for specific ranges of TNT and taking into account the ranges of the level of energy source produced by a given type of explosion. (Data source: MON)

| Type of explosion | The amount of explosives [TNT] | Explosion energy level [MJ $kg^{-1}$] | The level of energy source ($SL_E$) |
|---|---|---|---|
| Very small explosions | 8 g - 210 g | 0,008 – 0.210 | 210.3 dB – 224.4 dB |
| Small explosions | 210 g - 2.1 kg | 0.210 - 2.1 | 224.4 dB - 234.2 dB |
| Medium explosions | 2.1-21 kg | 2.1 – 21 | 234.2 dB – 244.4 dB |
| High explosions | 21-210 kg | 21 - 210 | 244.4 dB – 254.2 dB |
| Very high explosions | exceeding 210 kg | > 210 | > 254.2 dB |

The data on impulsive noise comes from seven military polygons (P-9, P-10, P-20, P-21, P-32, P-33, P-34), on which detonations of explosives took place (Fig. 2.3.65). Data regarding the explosion contained information on the location of individual polygons, the number of days during which explosions were performed, the type and amount of TNT charge used, without information on the intensity of the generated impulse noise emitted to the marine environment.

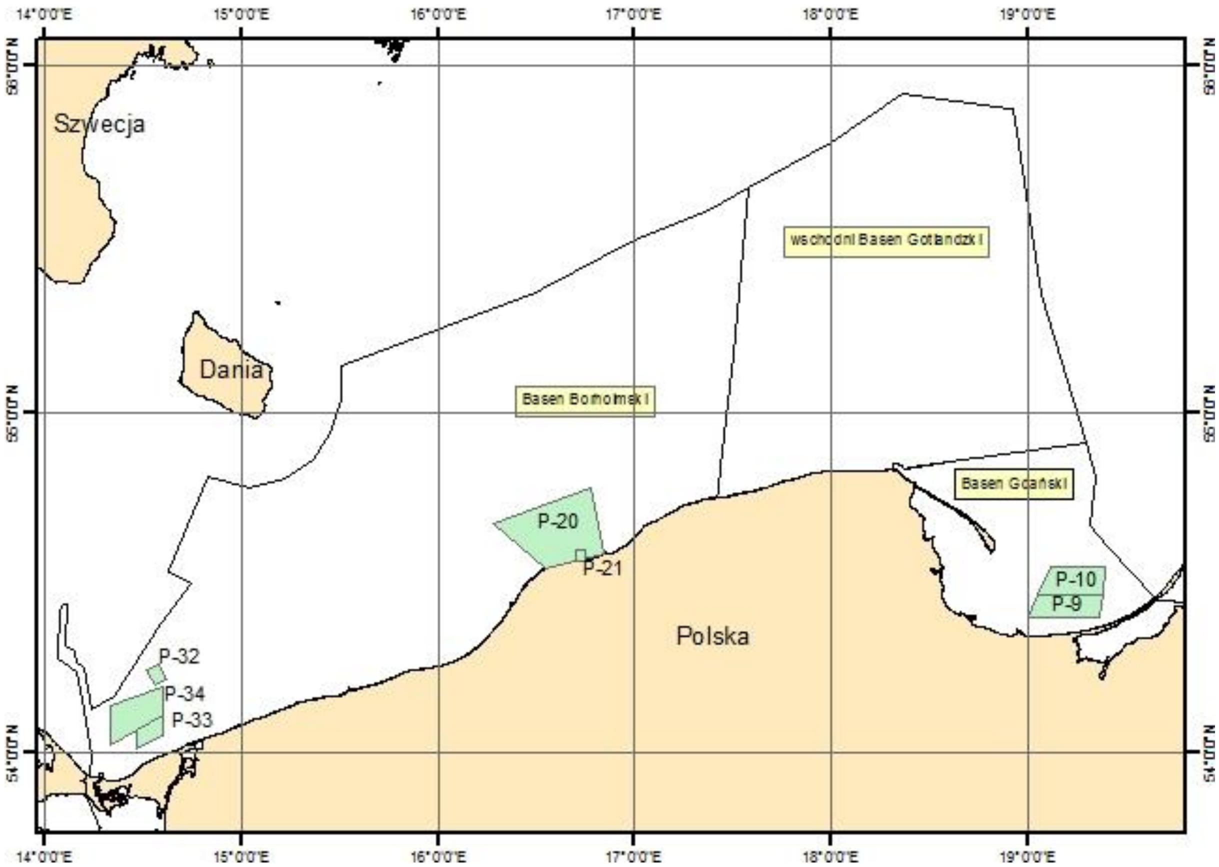



Fig. 2.3.65. Location of military polygons on which security and defence activities were carried out affecting the marine environment in 2011-2016

The map (Fig. 2.3.65) presents the location of polygons in which security and defence activities have taken place affecting the marine environment in 2011-2016, in particular as sources of noise. Most of these activities were carried out within the P-20 training ground, located in the maritime zone west of Słupsk. The main source of sound here were bombing and artillery rocket shooting - a total of 790 days. There is no information on the intensity of the generated impulse noise. Data on the amount of explosives given in [kg] TNT refer to four types of military activities in the marine environment:

1. Artillery and rocket shooting
2. Situational shooting
3. Bombardment
4. The launch of a large elongated load

The spatial distribution of military polygons, where the activities in the field of security and defence of the country were carried out in the period 2011-2016, clearly indicates data on impulsive sound, mainly in two areas of the Baltic Sea. Data from polygons P-32, P-33, P-34 and P-20, P-21 are located in the area of Bornholm Basin, while polygons P-9 and P-10 are located in the area of Gdańsk Basin. The results presented below relate to underwater explosions related to a five-point scale of explosion force types (Table 2.3.92).

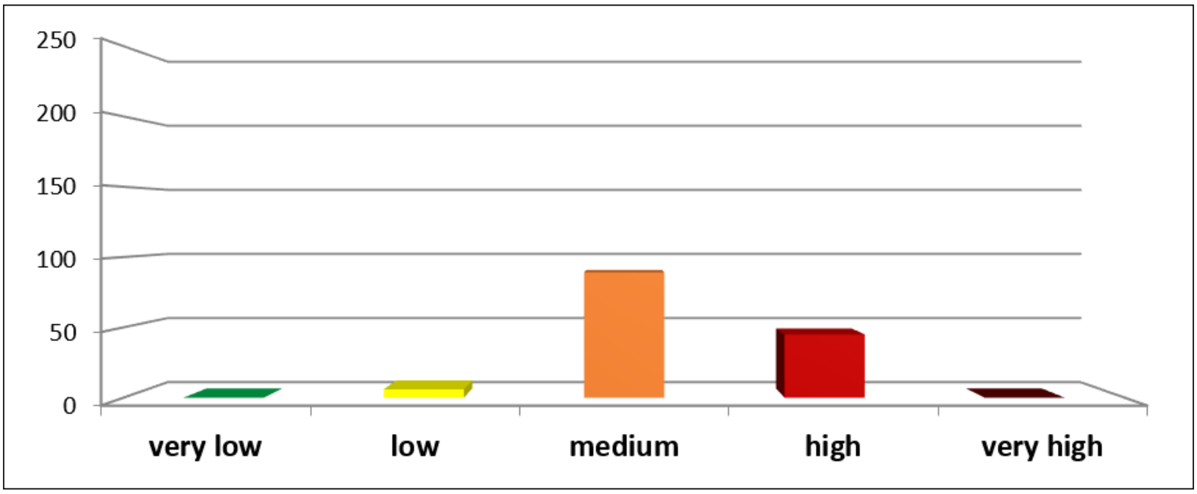



Fig. 2.3.66. Number of days of occurrence of individual explosion levels registered in the area of the Gdańsk Basin in the period 2011-2016 (Data source: MON)

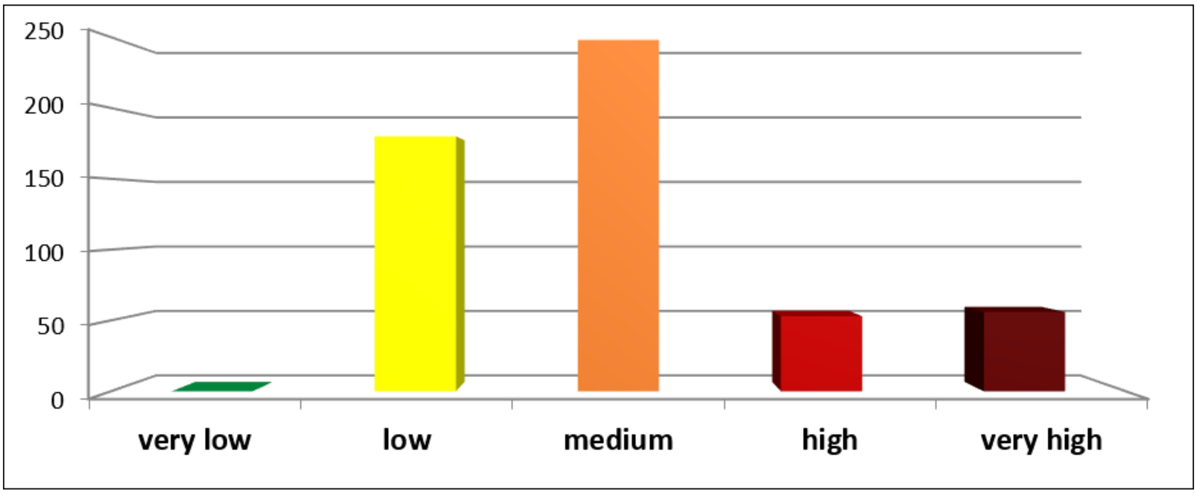



Fig. 2.3.67. Number of days of occurrence of individual explosion levels registered in the Bornholm Basin in the period 2011 - 2016 (Data source: MON)

The comparison of the number of days in which the explosion was made, starting from very low to very high levels in the period 2011-2016 (Fig. 2.3.66, Fig. 2.3.67) indicates some differences in terms of the number of days of explosions in both regions. First of all, attention should be paid to the quantitative advantage of individual types of explosions in Bornholm Basin in comparison with those registered in Gdańsk Basin. The main difference is the lack of very large explosions in Gdańsk Basin. The type of explosions in both areas directly translate into the amount of acoustic energy introduced in the entire period considered to areas of interest. Therefore, on military training grounds located in Gdańsk Basin, in the period 2011-2016, for a 45-day period, single explosions with a very high level and a total weight of 3064 kg TNT were registered. For the same area, explosions at medium level were recorded for 89 days and 6 days were recorded with low explosions, in both cases approximately 702 kg of TNT were used in total. These values allow to calculate the estimated maximum for the total acoustic energy released as a result of explosion of explosives in Gdańsk Basin, which is approximately 3.7 GJ of energy introduced within six years of registration and an average of 624 MJ per year. In Bornholm Basin, low-level explosions were recorded for 180 days (amount of charge used 302 kg TNT), while explosions with medium level (1104 kg TNT) and high (3523 kg TNT) were recorded for 248 and 53 days, respectively. It is noteworthy that explosions of very high level were recorded for 56 days, whose total explosive charge was 31364 kg TNT. To sum up, the military acoustic energy deployed in Bornholm Basin was about 36 GJ in the period 2011-2016, which equates to 6 GJ of the energy introduced into the environment per year. For comparison, data on the introduced energy of explosions in North Sea area (Ainslie et al., 2009) were in the order of 14 GJ per year.

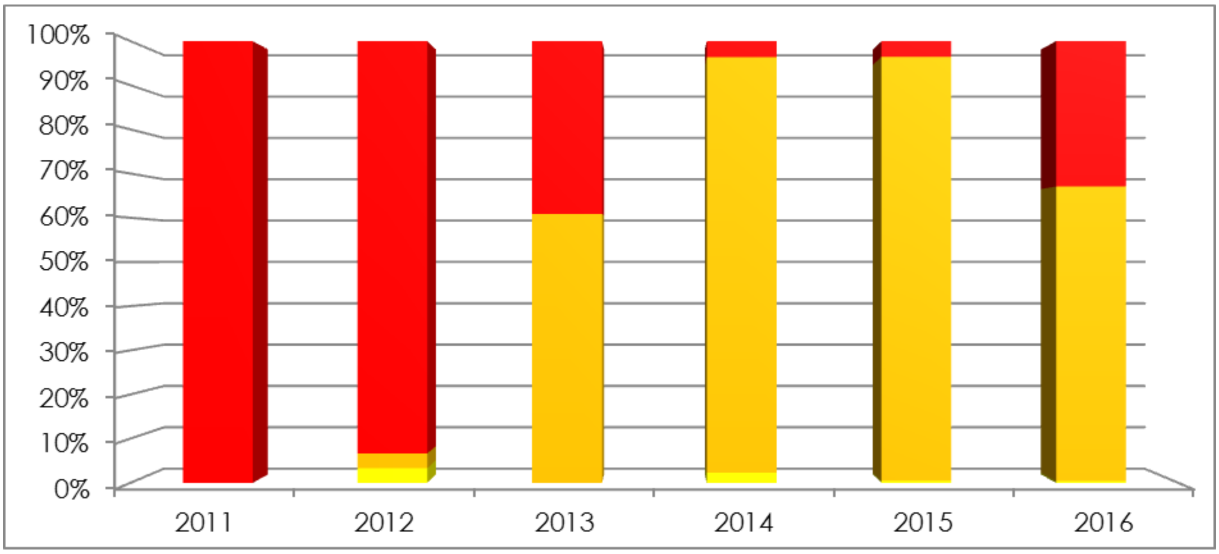



Fig. 2.3.68. Percentage share of individual explosion levels in the area of Gdańsk Basin in the period 2011 - 2016 (red - high, dark yellow - medium, yellow - low) (Data source: MON)

Fig. 2.3.68 illustrates the percentage of all recorded levels of explosions in relation to the incidence of explosions in the year under consideration. In the area of Gdańsk Basin in 2011 and 2012, high explosions prevailed, for which the level of energy emitted as a result of the explosion was estimated to be almost 100% within the range of 21 to 210 kg of TNT. In 2013, the amount of high-level explosion dropped to about 38% for an average force explosion. On the other hand, in 2014 and 2015, the average level of explosions prevailed, for which the amount of TNT charge did not exceed 21 kg. A new increase in the high annual explosion rate was observed in 2016. Fig. 2.3.69 illustrates the percentage of all recorded levels of explosions in relation to the frequency of explotions in Bornholm Basin area. Most of the low level explosions were recorded in 2011 and 2015, the percentage of which in relation to other types of explosions was 52% and 38% respectively in the analyzed year. The vast majority of the percentage share in the entire period 2011-2016 are medium-level explosions, the share of which was over 85% in 2014 and 2016. The characteristic feature of Bornholm Basin is the occurrence of strong high and very strong high explosions during the entire period considered. In the case of a very strong high explosion, the minimum energy level is 210 MJ. By far the largest percentage of very strong high explosions was recorded in 2012, which was 10% of all explosions noted. Since 2013, a slow but steady drop has been seen in relation to other types of explosions, which is synonymous with some limitation of the negative impact of noise on the marine environment caused by very large explosive charges.

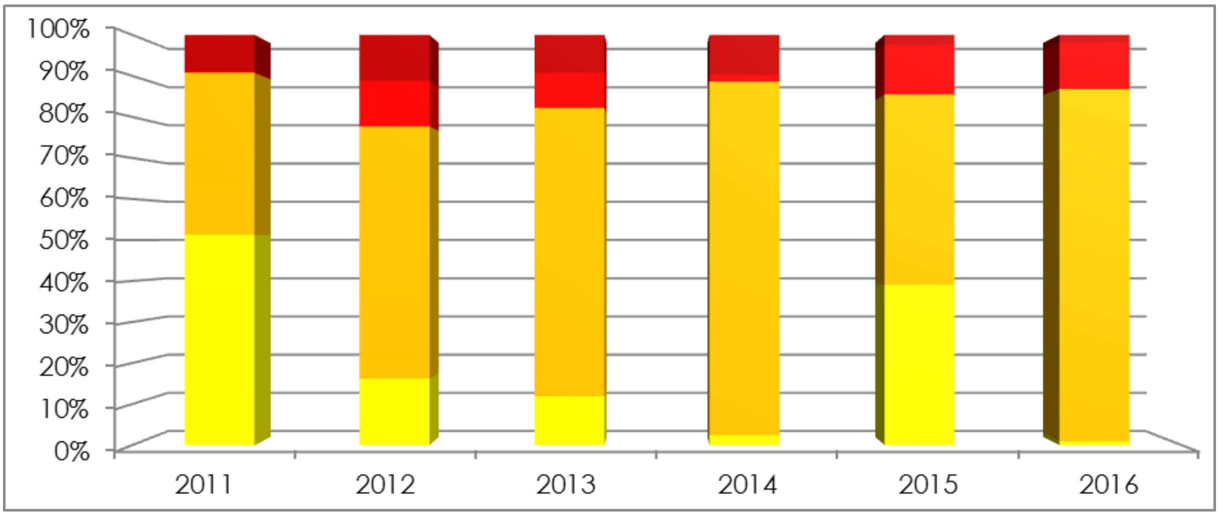



Fig. 2.3.69. Percentage of individual types of explosion strength in Bornholm Basin area in the period 2011-2016 (dark red color – very high level, red color – high level, dark yellow – medium level, yellow – low level ) (Data source: MON)

In conclusion in the Polish areas of the Baltic Sea, based on data from the country's security and defence activities, we are dealing with a whole spectrum of explosions ranging from small to very high explosions. In addition, the frequency of individual types of explosions indicate that impulse sounds induced by explosions of missiles during military exercises are relatively rare recurring events. Particularly noteworthy are the very high explosions caused mainly by the explosion of the elongated explosives, the incidence of which, although very rare, is characterized by enormous energy that is released in the marine environment. Particularly exposed areas in which extended loads are used are found in the western part of the Bornholm Basin. In the period 2011 - 2016, 33 x 500 kg of TNT and 5 x 1000 kg TNT of large elongated charge shots were performed in this area. Due to the lack of accurate data, it is not possible to determine the magnitude of the impact of such large explosive charges on the marine environment and the organisms living in it.

In addition to data on defence activities, in terms of the number of days of occurrence of impulsive sounds exceeding the noise threshold affecting the marine fauna, one report on the use of seismic equipment on board a German research vessel r/v "Maria S. Merian " has been received in the period covering the assessment updates in the Polish zone of the Baltic Sea from 02-03-2016 to 25-03-2016. The data is presented in Table 2.3.93 and in Fig. 2.3.70. The occurrence of impulse noise was limited in this case to the Bornholm Basin area. As can be seen from the statement, the level of sound pressure generated significantly exceeded the limit causing damage to the internal organs of marine organisms SEL (sound exposure level) on the order of 187 dB re 1 $\mu Pa^2 s$.

Table 2.3.93. List of noise measurements caused by the use of seismic equipment during the Danish voyage on r/v "Maria S. Merian" (Data source: Maritime Office in Słupsk)

| Date | The beginning of the transect | The end of the transect | Time of using devices [h] | Sound pressure level [dB re 1 μ Pa 1m] | frequency range [Hz] |
|---|---|---|---|---|---|
| 02-03-2016 | 54 46'N 15 51'E | 55 05'N 16 23'E | 5.5 | 247 | 5-200 |
| 03-03-2016 | 55 05'N 16 23'E | 55 23'N 16 38'E | 18 | 247 | 5-200 |
| 06-03-2016 | 55 30'N 17 02'E | 55 01'N 16 17'E | 7.5 | 247 | 5-200 |
| 07-03-2016 | 55 01'N 16 17'E | 54 03'N 14 22'E | 18 | 247 | 5-200 |
| 10-03-2016 | 54 06' N 14 29' E | 55 05' N 16 22' E | 22.5 | 247 | 4-100 |
| 11-03-2016 | 55 05' N 16 22' E | 55 25' N 17 00' E | 7 | 247 | 4-100 |
| 24-03-2016 | 54 47' N 15 03' E | 54 14' N 15 10' E | 10 | 247 | 5-200 |
| 25-03-2016 | 54 14'N 15 07'E | 54 48'N 14 53 E | 13 | 247 | 5-200 |

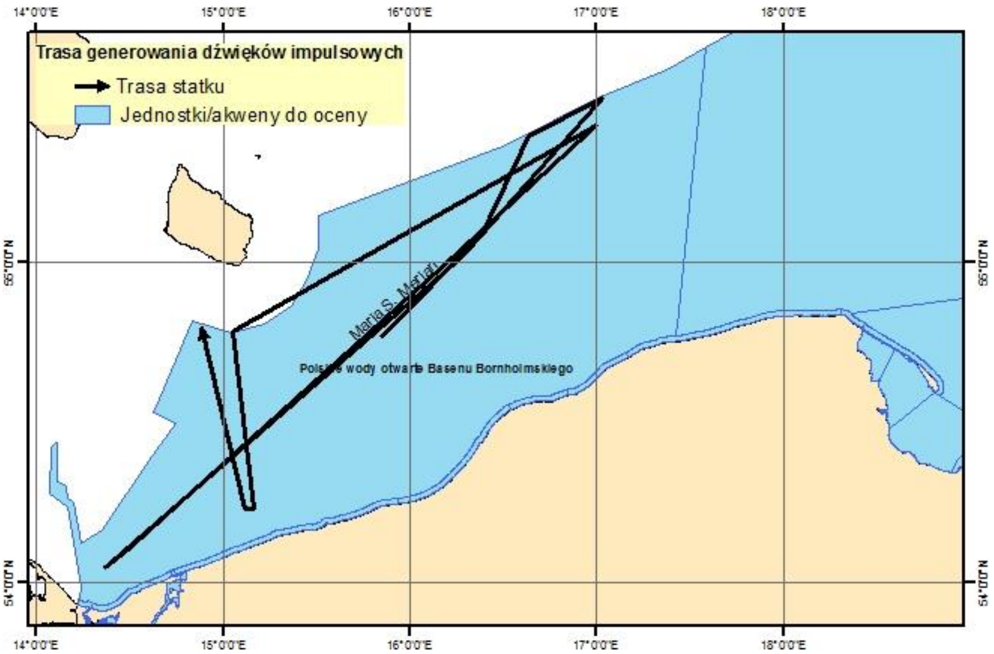



Fig. 2.3.70. The cruise route of the German research vessel r/v "Maria S. Merian" using seismic surveying equipment.

Based on the guidelines for criterion D11C1, an attempt to assess the state of the environment was made in the Decision 2017/848, referring to the duration of the emission of impulsive sounds in a calendar year. However, due to the lack of any threshold values for both primary criteria relating to Descriptor D11 - underwater noise, threshold values for POM were proposed, which were determined based on data measured in the Polish Baltic Sea zone and literature data Schack et al. (HELCOM 2016g) on behavioural reactions of marine mammals: harbour porpoise (*Phocoena phocoena*), grey seal (*Phoca vitulina vitulina*), Baltic ringed seal (*Phoca hispida botnica*) and fish: cod (*Gadus morhua*), herring (*Clupea harengus*), sprat (*Sprattus sprattus*). According to the TSG Noise report from 2013, which states that each load of 8g or more has a real impact on the behavioural reactions of marine organisms, a threshold for GES has been proposed, with the value 1. The proposed value means that if the average number of explosions in a calendar year (per one day), will amount to 1, it may have an direct impact on the marine environment. More reliable in relation to impulsive noise seems to be an approach in which the number of days in which the explosion was made would be related to porpoise breeding periods. In this way, it could be accurately determined whether and how explosions of explosives can affect these organisms, and not necessarily show only the number of days in which there is a pulsed underwater noise. It should also be noted that the data regarding the explosion concern military polygons whose area in relation to the surface of basins is small. Table 2.3.94 presents an environmental assessment based on the proposed threshold for impulse noise from explosive explosions.

Eastern Gotland Basin was excluded from the assessment, since there is no data regarding the emission of impulsive sounds in this sub-basin.

Table 2.3.94. Proposed assessment of the environmental status based on Descriptor D11 - underwater noise (criterion D11C1) in POM based on data from registered explosions (data source MON)

| Assessment area | Type of explosion power | Duration 2011 - 2016 [days] | Average time of occurrence [days/year] | Average number of explosions in the year 2011-2016 [explosions / day ] | Threshold value | GES |
|---|---|---|---|---|---|---|
| Gdańsk Basin | Very Low | 0 | 0 | 0 | 1 | yes |
| | Low | 6 | 1 | 0.25 | 1 | yes |
| | Medium | 89 | 14.8 | 1.5 | 1 | no |
| | High | 45 | 7.5 | 0.6 | 1 | yes |
| | Very High | 0 | 0 | 0 | 1 | yes |
| | **Sum** | **140** | **23.3** | **2.35** | **1** | **no** |
| Bornholm Basin | Very Low | 0 | 0 | 0 | 1 | yes |
| | Low | 180 | 30 | 0.81 | 1 | yes |
| | Medium | 248 | 41.3 | 2.16 | 1 | no |
| | High | 53 | 8.8 | 1.25 | 1 | no |
| | Very High | 56 | 9.3 | 1 | 1 | yes |
| | **Sum** | **537** | **89.4** | **5.22** | **1** | **no** |
| Eastern Gotland Basin | Very Low | | | | 1 | No data |
| | Low | | | | 1 | |
| | Medium | | | | 1 | |
| | High | | | | 1 | |
| | Very High | | | | 1 | |
| | **Sum** | | | | **1** | |

### Criterion D11C2 - Continuous Noise

There is both natural and anthropogenic noise in the marine environment. The first short-term one is generated by wind and wave motion, while the noise of anthropogenic origin is continuous or impulsive. The continuous noise is generated in the sea, inter alia, by sea navigation. Shipping is an important source of underwater noise, leading to permanent load in specific areas. It is estimated that there are between 1800 and 2000 ships on the Baltic Sea at one time. Depending on the type and size of the unit, the intensity and frequency of the noise varies between 158 and 190 dB and 7 - 430 Hz, respectively. (Simmonds and in 2003).

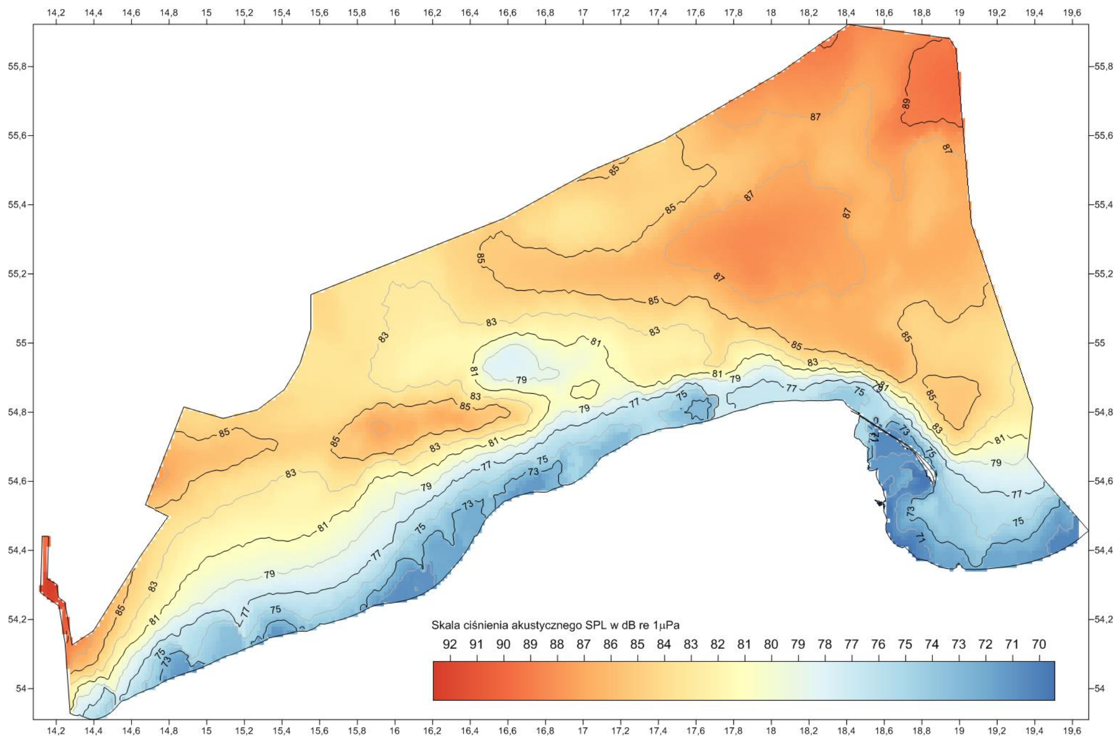



Fig. 2.3.71. Distribution of sound pressure SPL in the whole water column in POM areas, developed on the basis of data provided from the BIAS project (HELCOM, 2017).

Currently, only a few measurements of noise in POM are available for relatively short periods. Continuous measurements, in accordance with the method indicated in Decision 2017/848, were carried out as part of the BIAS project throughout the Baltic Sea. However, they cover only one year. Based on data from the BIAS project, a map of the spatial distribution of continuous noise for the year 2014 in POM was generated (Fig. 2.3.71).

These results indicate a low level of continuous noise reaching an average of 72 dB in the Polish coastal waters of Gdańsk Basin, Bornholm Basin and Eastern Gotland Basin. The highest level of continuous noise has been registered in the Eastern Gotland basin reaching values above 92 dB. Ship traffic brings a virtually constant contribution to the field of ambient noise, especially in the band from 50 to 5000 Hz. However, in the case of ships passing close, the noise may exceed the natural noise level of the sea (own noise) even in the 25 kHz frequency range. For example, in Pomeranian Bay, the threshold of hearing for herring, especially at 63 Hz and 125 Hz, is exceeded at a distance of 500 m from waterways, even by 30 dB, which has a significant and detrimental effect on individuals of this species. As part of the Baltic monitoring, measurements were made at three stations where continuous noise recording was carried out. All measuring stations were located close to waterways characterized by a constant presence of flowing watercraft. Although the data relate to relatively short measurement periods, they allow the assessment of the situation with regard to sound intensity in various POM sub-areas. There is a noticeable lower level of continuous noise at station H13 (Pomeranian Bay) with respect to station H39a (Bornholm Basin), which may depend both on the season of the year and on the length of the measurement period. Fig. 2.3.72 to Fig. 2.3.75 present the results of the evaluation of changes in continuous underwater noise for two frequencies: 63 Hz, 125 Hz at the above stations.

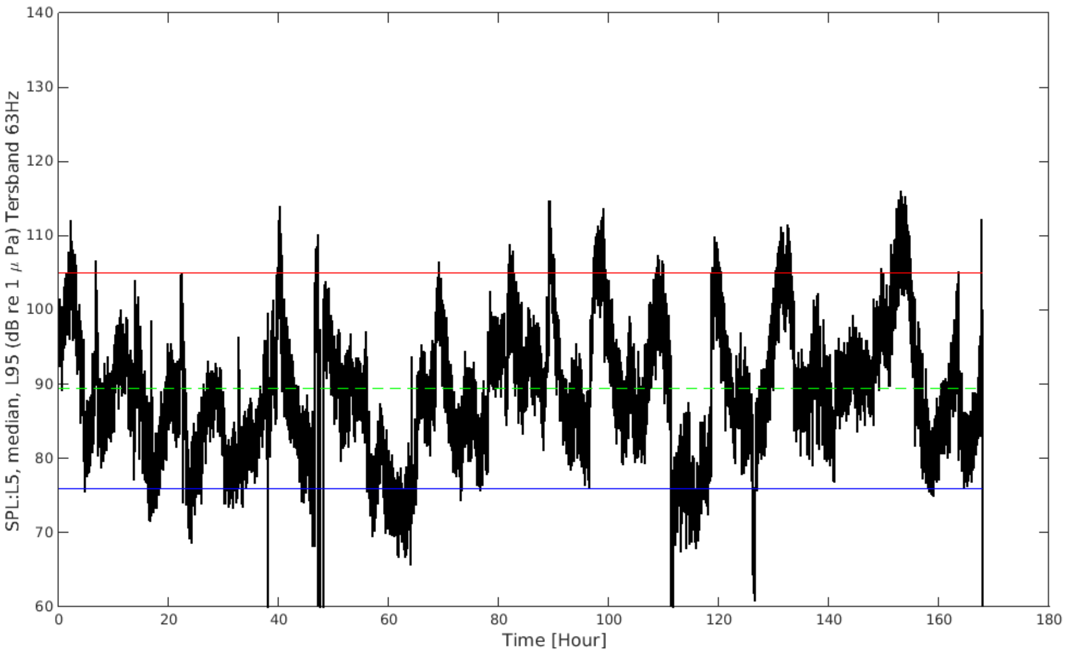



Fig. 2.3.72. Changes in continuous noise in August 2015 at station H13 (Bornholm Basin) at 63Hz in the 1/3 octave band. The statistics were calculated based on 20-second SPL measurements: blue line - percentile 5, red line - percentile 95, green line - median. (Data source: PMŚ).

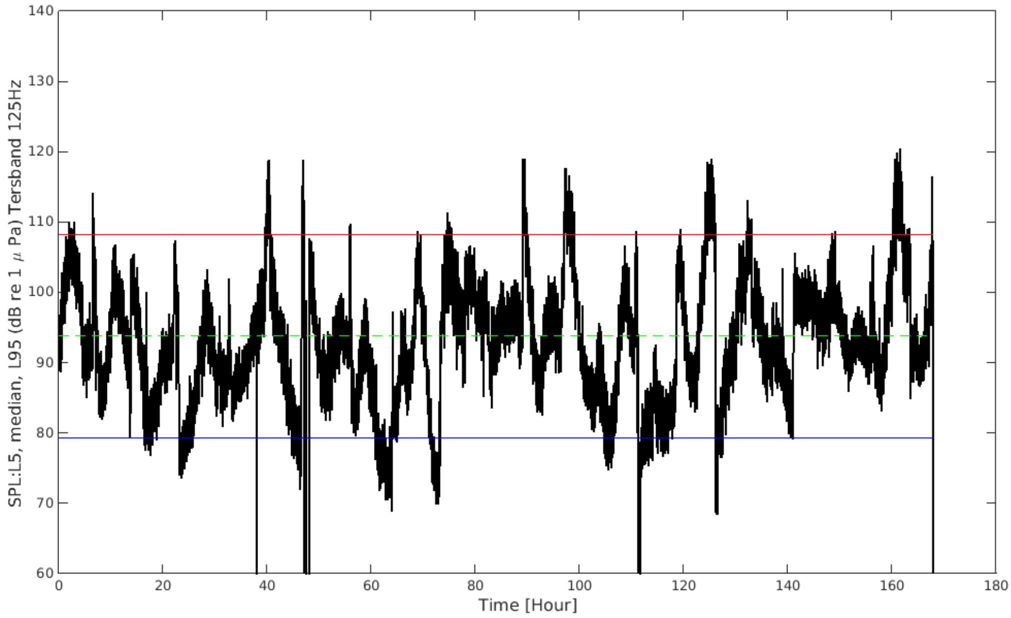



Fig. 2.3.73. Changes in continuous noise in August 2015 at station H13 (Bornholm Basin) for 125Hz in the 1/3 octave band. The statistics were calculated based on 20-second SPL measurements: blue line - percentile 5, red line - percentile 95, green line - median. (Data source: PMŚ)

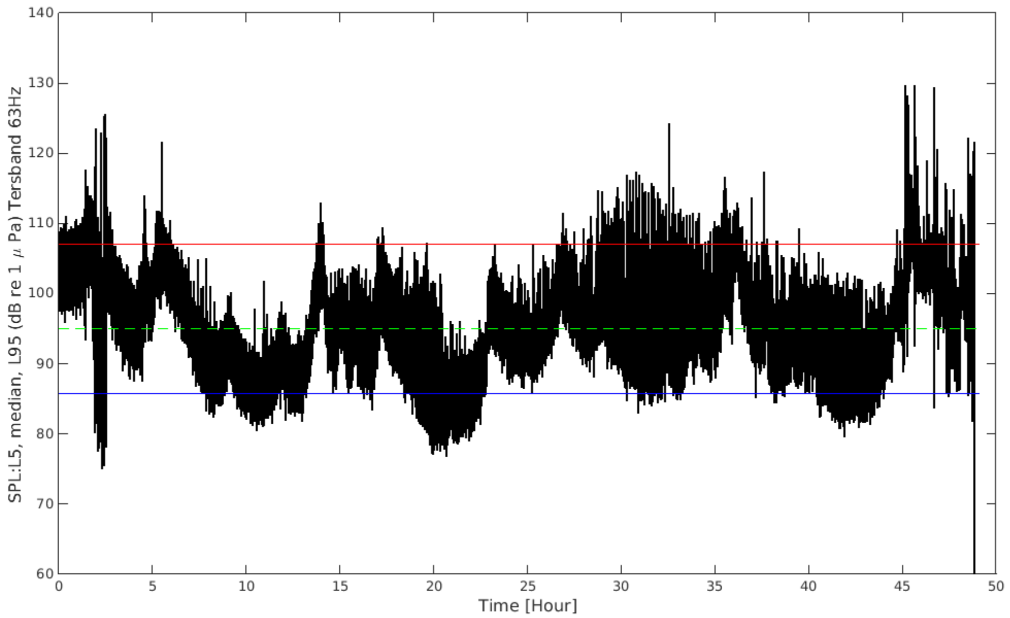



Fig. 2.3.74. Changes of continuous noise in March 2016 at station H39a (Bornholm Basin) at 63Hz in the 1/3 octave band. The statistics were calculated based on 20-second SPL measurements: blue line - percentile 5, red line - percentile 95, green line - median. (Data source: PMŚ)

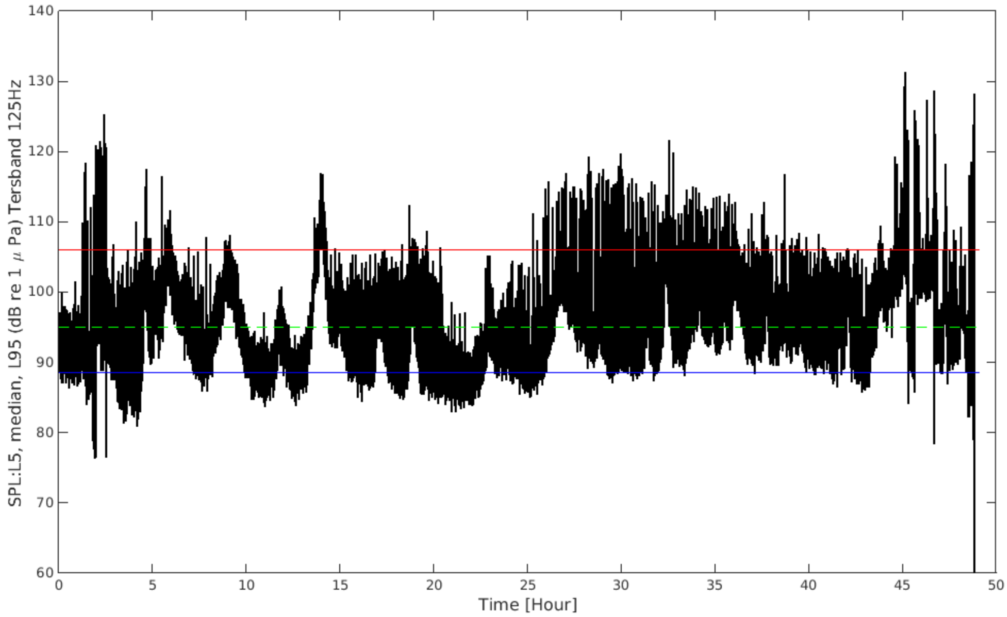



Fig. 2.3.75. Changes of continuous noise in March 2016 at station H39a (Bornholm Basin) for 125Hz in the 1/3 octave band. The statistics were calculated based on 20-second SPL measurements: blue line - percentile 5, red line - percentile 95, green line - median. (Data source: PMŚ)

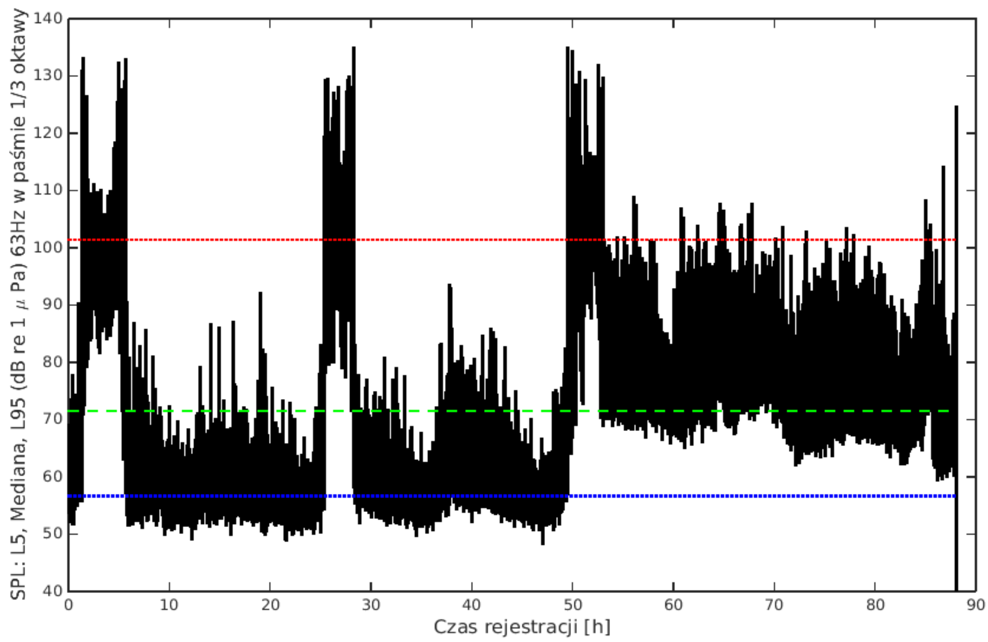



Fig. 2.3.76. Changes in continuous noise in November 2016 at HZN4 (Gdańsk Basin) for 63Hz in the 1/3 octave band. The statistics were calculated based on 20-second SPL measurements: blue line - percentile 5, red line - percentile 95, green line - median. (Data source: PMŚ)

Regarding data from Gdańsk Basin (Fig. 2.3.76 and Fig. 2.3.77) it should be noted that periodic noise peaks at the HZN4 station are related to the hydrophones installation method, which consisted of transport of measuring equipment on-board the research vessel and then its deployment for several hours of measurement. As a result, hydrophone transport became the source of additional noise in the form of these peaks. Considering only the measurement periods between peaks, it can be seen that the noise level is very low, very rarely reaching 110 dB, compared to data from Bornholm Basin.

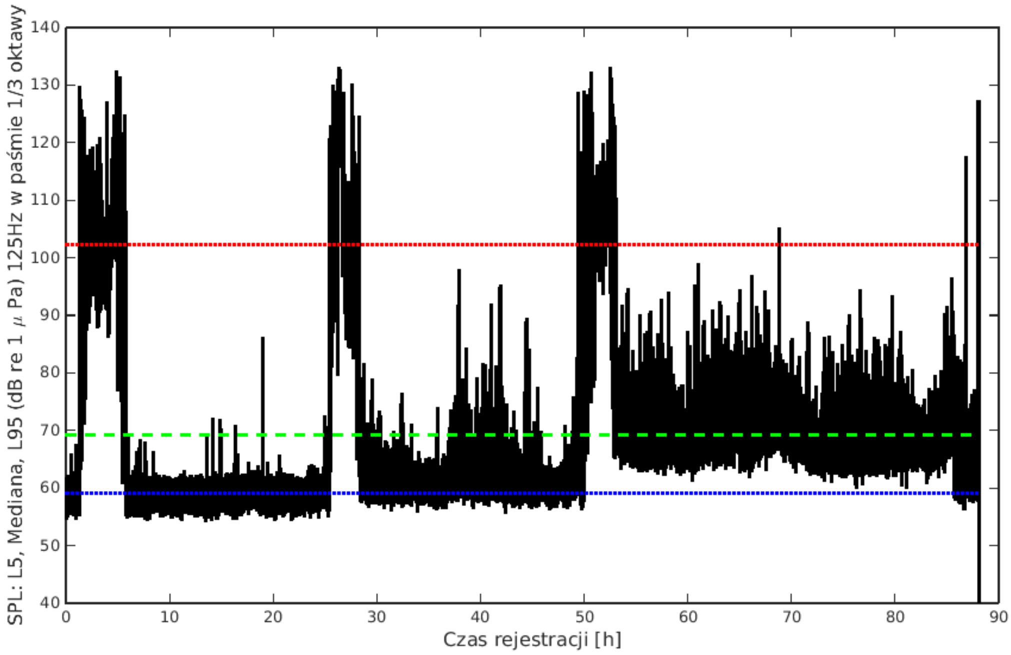



Fig. 2.3.77. Changes of continuous noise in November 2016 at HZN4 (Gdańsk Basin) for 125Hz in the 1/3 octave band. The statistics were calculated on the basis of 20-second SPL measurements: blue line - percentile 5%, red line - 95% percentile, green line - median. (Data source: PMŚ)

Summarizing, the highest values of the level of continuous noise related to human activity were found in Bornholm Basin, Eastern Gotland Basin and Gdańsk Basin. Based on the results of the measurements, however, it was found that in none of these places the level that could lead to damage to the internal organs of the fish was exceeded. According to the results of the BIAS project and the comparison of areas where the highest level of anthropogenic underwater noise is recorded with "sensitive" areas, it appears that in POM only the northern and western parts of the Polish part of the Bornholm Basin are places where harmful impact of noise can occur on occasionally dwell porpoise (green hatching) and areas of cod existence (dark pink hatching) (Fig. 2.3.78). Despite the absence of threshold values set at the EU level for the criterion of continuous noise and very short records of measurement data, it was proposed to adopt a threshold value for criterion D11C2 at the level of 95 percentile averaged from the above data, equal to 108 dB. In this way, it was possible to quantify the state of the environment for particular areas of the open sea based on this criterion (Table 2.3.95).

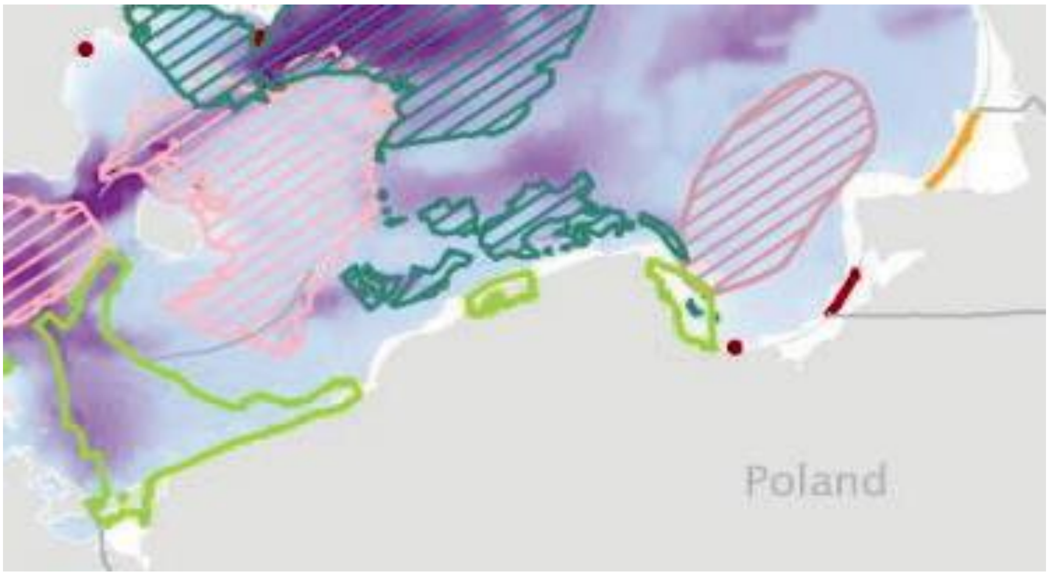



Fig. 2.3.78. Overlapping spatial distribution of underwater noise with the areas of living species sensitive to sound in POM based on Schack and others. The harbour porpoise range (green hatching), the area of cod existence (dark pink hatching) (2016, HELCOM 2016g)

Table 2.3.95. Proposed assessment of the environmental status regarding Descriptor D11 - Underwater noise (D11C2 criteria) for the Polish Exclusive Economic Zone based on data from the BIAS project and monitoring measurements

| Assessment area | Assessed criterion | Threshold value | GES |
|---|---|---|---|
| Eastern Gotland Basin | D11C2 | 108 dB | yes |
| Bornholm Basin | D11C2 | 108 dB | no |
| Gdańsk Basin | D11C2 | 108 dB | yes |

### Final conclusions

The criteria elements relating to underwater noise associated with human activities set out in Decision 2017/848, impulsive sound (D11C1) and continuous low frequency sound (D11C2) are mainly focused on the determination of threshold values indicating no negative impact noise to populations of animals living in the marine environment. In order to define the above criteria, unified methodological standards were established in which a strong emphasis was placed on the characteristics of the above-defined types of sounds (D11C1, D11C2).

So far, no threshold values have been set for the criteria of Descriptor D11 at European level. Nevertheless, the available measurement data allow the assessment of the continuous noise in the assessment areas in POM. This assessment coincides with the results obtained under the BIAS project.

## 3. Summary of the assessment of the state of environment

### 3.1. Law basics

The initial assessment of the POM marine environment was updated in accordance with Article 17 and Article 8 (1)(a – c) MSFD for features, characteristics and the current status of marine waters, taking into account anthropogenic pressures, types of use and human activities in the marine environment or having an impact on the marine environment as well as an economic and social analysis of their use and of the cost of degradation of the marine environment.

The current assessment update covers the period from 01/01/2011 to 31/12/2016. The implementation of this task is aimed at defining environmental targets in accordance with Article 10 MSFD, establishing updated monitoring programms in accordance with Article 11 of MSFD and designing future programmes of measures in accordance with MSFD Article 13, which will minimize the negative anthropogenic impact on the marine environment.

The legal basis for updating the initial assessment of the state of the environment is the Water Law Act - Article 555 Act 2 point 8 of this Act.

The obligation to update the assessment of the environmental status of marine waters concerns marine areas that cover the sea area from the baseline of the territorial sea to the border of the furthest area under the jurisdiction of an EU Member State as defined in MSFD. In Poland, these areas include waters of the territorial sea, the exclusive economic zone and coastal waters in accordance with Article 143 of the Water Law Act. In the case of coastal, transitional and territorial waters, ecological status assessments in accordance with the WFD were used to update the initial assessment of the environmental status of marine waters.

According to art. 151 (1) of the Water Law Act, an updated assessment of the environmental status of marine waters is prepared by the competent authority of the Environmental Protection Inspection in consultation with the minister competent for construction, spatial planning and housing, minister competent for maritime affairs, minister competent for fisheries and minister responsible for water management.

At this point, it should be emphasized that the update of the initial assessment of the state of the environment differs fundamentally from the initial assessment, both in the number of data used for its development, as well as substantive input, in the scope of individual elements of the assessment in relation to state and pressure descriptors , and socio-economic analysis. This was largely due to the results of all monitoring programs performed within the framework of the State Environmental Monitoring coordinated by the GIOŚ in the assessment periodand all data provided by various state administrative units and research institutes.

The update takes into consideration the new version of Annex III to MSFD (2017/845/EU) relating to the indicative lists of elements to be taken into account for the preparation of marine strategies, changing Tables 1 and 2 from Annex III to MSFD to better address state elements (Table 1) and the elements related to pressures and their impacts (Table 2a and b), and directly connect the elements listed in both lists with the quality indicators set out in Annex I to that Directive, and therefore also with the criteria set by the Commission pursuant to Article 9 (3) of MSFD.

Decision 2017/848 introduced a division of indicators that should be included in the assessment of the state of the marine environment into two groups. Article 153 (1) (1) of the Water Law Act defines all 11 descriptors of good environmental status of marine waters (Figure 1). Pursuant to Decision 2017/848, the group of pressure descriptors includes: D2, D3, D5, D6, D7, D8, D9, D10 and D11, the group of Descriptors of the status include: D1, D4 and D6 concerning elements of the ecosystem: mammals, fish, birds, pelagic habitats and benthic habitats. In the document of the initial assessment of the status of the marine environment, the naming of symbols for descriptors and criteria has been preserved following the English version of MSFD, i.e. D - for the descriptor, C - for the criterion).

One of the mandatory elements of updating the initial assessment of the status of the marine environment is to determine the environmental status in relation to a set of threshold values for individual criteria set at European, regional or national level. In the update of the initial assessment for POM, 119 indicators were used to assess individual criteria.

For the purpose of a uniform approach to the assessment within HELCOM, a modified division of the Baltic Sea into sub-basins, i.e. maritime reporting units (MRU) subject to assessment, was adopted (Fig. 3.1.1). The assessment units have been separated according to the hierarchical division prepared by HELOM (HELCOM 2013a, update of annex 4 -2017) on a 4-level scale:

1. no division: the entire Baltic Sea area is assessed,
2. division into 17 sub-basins in the Baltic Sea,
3. division into 17 sub-basins of the open sea and 40 areas of coastal waters,
4. division into 17 sub-basins of the open sea and transitional and coastal waterbodies (WB according to WFD, Anon. 2000).

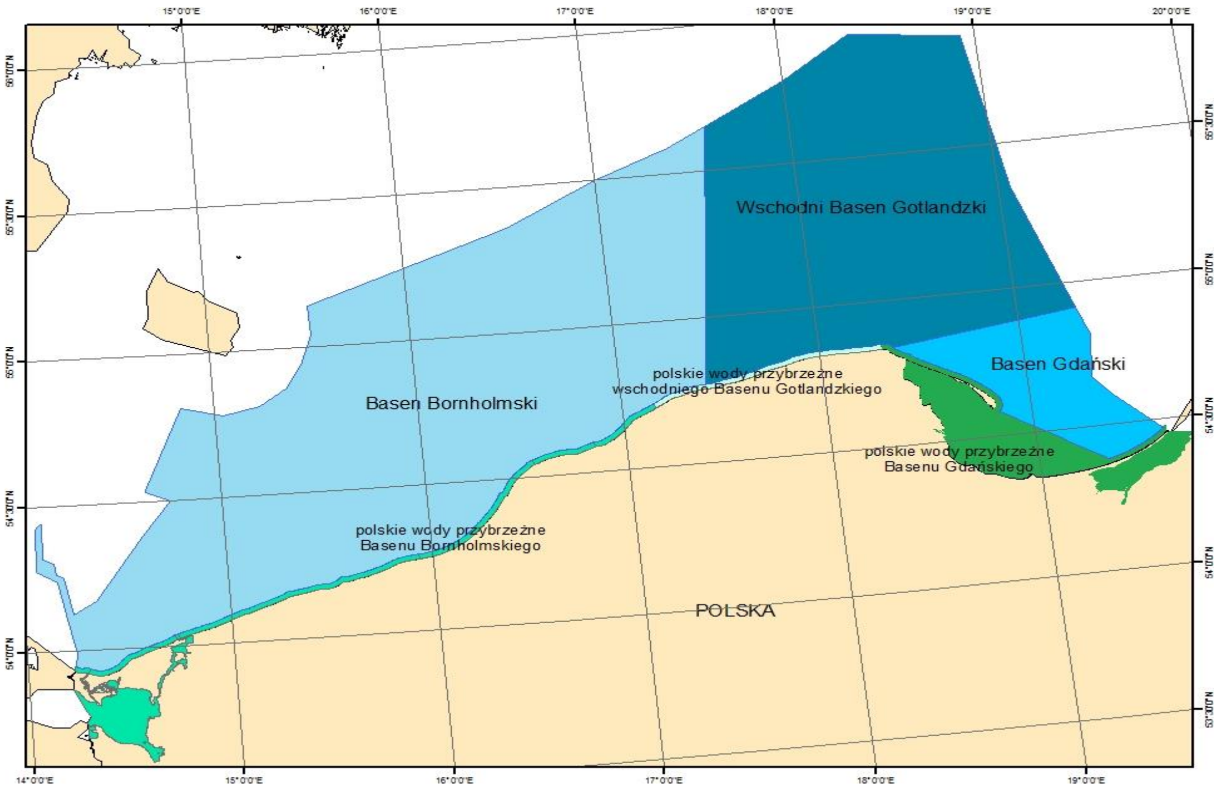



Fig. 3.1.1. Baltic Sea sub-basins designated in POM according to HELCOM MAS (HELCOM 2013) according to level 3 division.

In the case of ichtyofauna assessment, the areas to be assessed include both parts of the open sea sub-basins as well as individual parts of coastal waters.

As part of the assessment of the Descriptors of the state (D1, D4, D6), a separate assessment is carried out for each of the ecosystem components, i.e. for groups of species of birds, mammals, fish and benthic and pelagic habitats. In the preparation of the method for assessing the Baltic Sea environment in the area of Polish marine areas (POM), the findings and recommendations arising from the work of HELCOM working groups and projects were taken into account, such as: State & Conservation, SEAL, IN Benthic habitat, HOLAS II, SPICE, TAPAS, IN EUTRO, GEAR and European Commission WG DIKE, WG GES, TG DATA and MSCG.

The developed method of assessment of the three mentioned status descriptors for POM is in many aspects convergent with the method proposed in the HELCOM second holistic assessment and also refers to the technical guidance given in the current working version of the guidelines to Article 8 MSFD (Walmsley at all 2017).

The main difference in the method of assessing the state in relation to the initial assessment of the state of the marine environment in the Polish Baltic Sea zone (GIOŚ 2014) is currently proposed "integrated assessment of biodiversity" carried out within each of the ecosystem components referring simultaneously to Descriptors 1, 4 and 6, which, on the one hand, affects the lack of the possibility of unambiguous comparison of the results of this assessment with the previous one, on the other hand the compliance of the assessment methodology in the Baltic Sea region. However, it is possible to summarize changes taking place in the environment compared to the initial assessment of the state of marine waters in 2012 at the level of some indicators (GIOŚ 2014) and reference to the second holistic assessment (HELCOM 2017a).

The assessment of pressure descriptors is performed on the basis of primary and secondary criteria separately for each of the descriptors. Compared to the initial assessment of the status of the marine waters of the Polish Baltic Sea zone (GIOŚ 2014) there is no integration of the assessment between pressure descriptors especially since some criteria are used directly in the assessment of the state.

## 3.2.Descriptors of the state

In order to assess the environmental status of marine waters for the years 2011-2016, a modified method was developed based on the methodology used in the assessment of HOLAS II report.

In the adopted method, separate assessments for mammals, seabirds, fish, benthic habitats and pelagic habitats refer to Descriptor D1 (biodiversity), assessment of benthic habitats is common to D1 and D6 (seafloor integrity), assessment of pelagic habitats is characterized by D1, and the assessment of ecosystems, including food chains, refers to the characteristics of D1 and D4 (food webs).

Pursuant to the decision 2017/848, the Descriptor D6 – seafloor integrity at the same time assesses the condition of benthic habitats as well as physical pressures. In the status description, two criteria are distinguished: D6C4 (the extent of loss of the habitat type, resulting from anthropogenic pressures, does not exceed a specified proportion of the natural extent of the habitat type in the assessment area), for which this assessment, as in the second holistic assessment (HELCOM 2017a), has not yet been developed the indicator and criterion D6C5 (the extent of adverse effects from anthropogenic pressures on the condition of the habitat type, including alteration to its biotic and abiotic structure and its functions e.g. typical species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species, does not exceed a specified proportion of the natural extent of the habitat type in the assessment area).

Some of the indicators used in the assessment of the condition of benthic and pelagic habitats also meet the criteria within Descriptor D4. Pursuant to Decision 2017/848, the assessment of ecosystems, including food chains, should be based on the assessment of at least three trophic groups (two of these trophic groups not including fish, at least one trophic group containing the primary producer). Due to the fact that the above decision came into force only in May 2017, and the guide to carry out the assessment in accordance with art. 8 MSFD (Walmsley et al. 2017) treats the way the assessment for ecosystems is carried out quite generally; in the national assessment, ecosystem assessments were made only in a descriptive way.

Integrated biodiversity assessment" consists in carrying out the state assessment for designated assessment areas in POM, separately for individual ecosystem elements and by using several indicators simultaneously (core, pre-core, national and eutrophication indicators) in the assessment area, which in total refer to Descriptors D1, D4 and D6. Each indicator is assigned to the assessment of the appropriate species, group of species or a given type of habitat. A specific indicator can be used only once in the assessment. The possibility of using various indicators in the integrated assessment and their comparability is possible by normalizing the values of indicators in the range from 0 to 1, with the indication of the minimum and maximum value for a given indicator.

***Mammals***

### Integrated assessment of grey seal

Taking into account the results of assessments for particular years in the period from 2011 to 2016 and the adopted principles for conducting the multiannual assessment presented in Table 3.2.1 ond in Fig. 3.2.1. – multi-annual assessment for 2011-2016 for grey seal indicates a subGES status.

Table 3.2.1. Integrated assessment of the status of the grey seal (*Halichoerus grypus*) in POM for the years 2011-2016 (Data source: PMŚ, WWF, SMIOUG, HELCOM)

| Haul-out Vistula mouth | | Annual assessment of indicator | | | Integrated annual assessment |
|---|---|---|---|---|---|
| Year | Number of individuals/ Trend %* | Indicator *'Population trends and abundance of grey seal'* | Indicator *'Grey seal distribution'* | Indicator *'Reproductive status of grey seal'* | |
| 2011 | 23/283% | - | GES | subGES | subGES |
| 2012 | 41/78% | GES | GES | subGES | subGES |
| 2013 | 51/24% | GES | GES | subGES | subGES |
| 2014 | 70/37% | GES | GES | subGES | subGES |
| 2015 | 60/14% | subGES | GES | subGES | subGES |
| 2016 | 170 (168**)/183% | GES | GES | subGES | subGES |
| **Assessment period 2011-2016** | | | | | subGES |

* WWF Poland data - maximum from May-June months;
** values recorded in accordance with the HELCOM methodology within the PMŚ

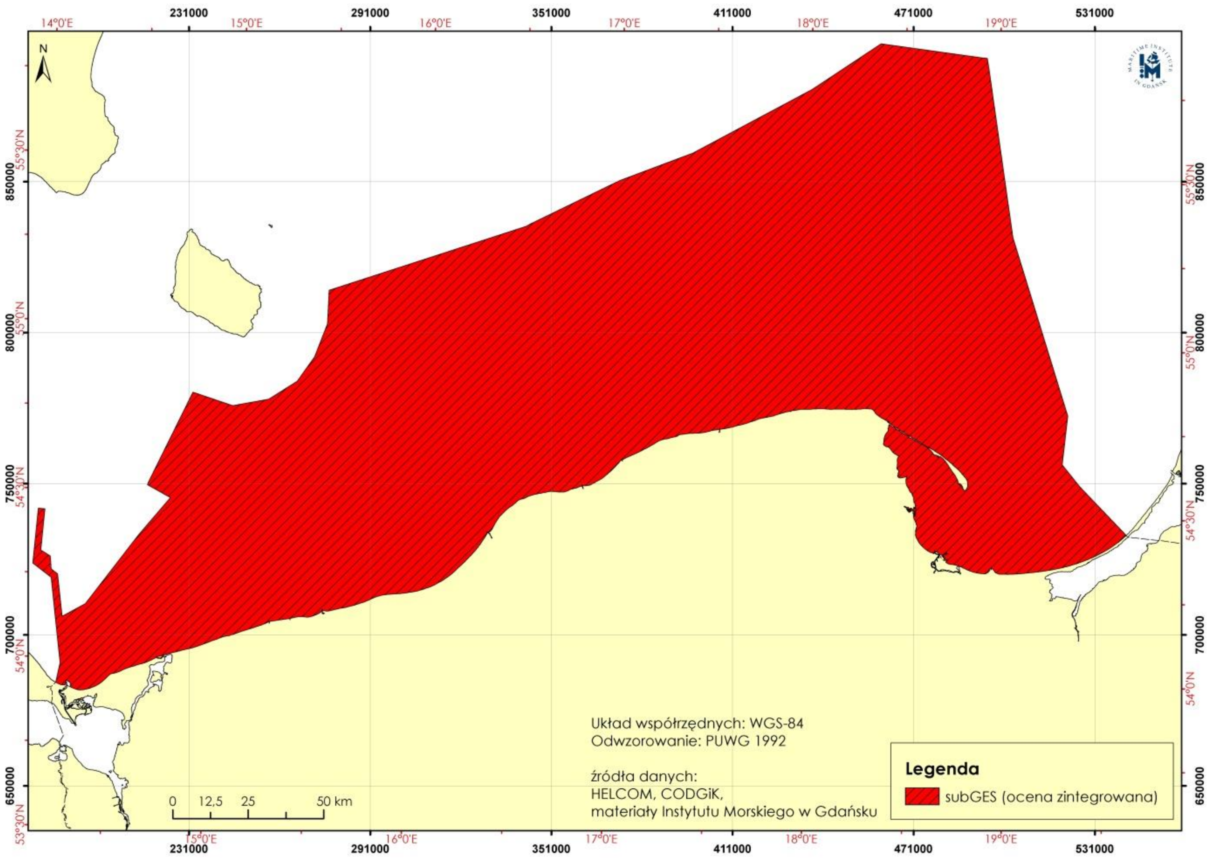



Fig. 3.2.1. Integrated assessment of the state of grey seals in the Polish Baltic zone for the years 2011-2016 (Data source: PMŚ, WWF, SMIOUG, HELCOM)

***Birds***

**Assessment of wintering birds in 2011-2016**

The assessment of good status was carried out for 22 species included in the indicator of abundance of wintering water birds within two basins lying partly in Polish sea waters: the Bornholm Basin and the Gotland Basin. All analyzed species occurred in the years 2011-2016 in Polish sea waters, although the abundance of 4 of them was very low (see. Monitoring of Wintering Waterbirds). In addition, an assessment was carried out throughout the entire Baltic Sea. The assessment was made for 5 functional groups.

Within the Bornholm Basin, 16 of the 18 species found there (89%) achieved good environmental status. In the Gotland Basin, 14 out of 17 species (82%) achieved good status. This means that the number of wintering waterbirds in both studied basins covering Polish sea waters has reached a good state (GES threshold is 75%, Table 3.2.5). A similar analysis was also made for each of the 5 functional groups. In both of the basins studied, the indicators for functional groups reached a good status (Table 3.2.2).

In the whole Baltic Sea, the indicator also achieved good environmental status (GES), as 18 out of 22 studied species were in good status (82%). *Wading feeders*, *surface feeders* and *pelagic feeders* have achieved good status, while *benthic feeders* and *grazing feeders* are below the good environmental status boundary.

Table 3.2.2. Average values of indicator of Abundance of waterbirds in the wintering season in 2011-2016 for all species and 5 functional groups: throughout the Baltic Sea, Bornholm Basin and Gotland Basin. (Data source: PMŚ, HELCOM)

| Indicator type | Entire Baltic Sea | Bornholm Basin | Gotland Basin |
|---|---|---|---|
| all species | 0.82 | 0.89 | 0.82 |
| *benthic feeders* | 0.60 | 0.75 | 0.75 |
| *grazing feeders* | 0.71 | 0.86 | 0.75 |
| *pelagic feeders* | 1.00 | 1.00 | 1.00 |
| *surface feeders* | 1.00 | 1.00 | 0.75 |
| *wading feeders* | 1.00 | 1.00 | |

No entry means that the assessment was not possible due to lack of species or very low abundance. Indicators that achieved good environmental status (GES) were marked in green (value ≥0.75) and indicators that did not reach good status (subGES) in red. Function group see Table 2.1.21.

### Assessment of breeding birds in 2011-2016

The assessment of good environmental status was carried out for 30 species included in Abundance of waterbirds in the breeding season indicator within two areas - the Bornholm and Gotland Basins. The assessment was also made for 5 functional groups.

In the Bornholm and Gotland Basins, the index based on number of breeding birds was below the good environmental status. The GES status reached 50% and 59% of species in these areas respectively (the threshold value is 75%). SubGES was also found for the specified functional groups, except for herbivorous birds (*grazing feeders)* in the Bornholm Basin and pelagic species (*pelagic feeders*) in the Gotland Basin.

In the entire Baltic area, only 5 species did not achieve good environmental status. The number of breeding birds shows a good status of birds of this group, as 83% of species have reached GES (threshold of 75%, Table 3.2.3). A similar situation took place among five functional groups, four of which achieved good status: *surface feeders*, *pelagic feeders*, *benthic feeders* and *grazing feeders*. Only *wading feeders* were below the GES threshold.

Table 3.2.3. Average index values of Abundance of waterbirds in the breeding season indicator in 2011-2016 for all species and 5 functional groups throughout the Baltic Sea, Bornholm Basin and Gotland Basin. (Data source: PMŚ, HELCOM)

| Indicator type | Entire Baltic Sea | Bornholm Basin | Gotland Basin |
|---|---|---|---|
| all species | 0.83 | 0.50 | 0.59 |
| *benthic feeders* | 0.75 | 0.50 | 0.33 |
| *grazing feeders* | 1.00 | 1.00 | 0.67 |
| *pelagic feeders* | 1.00 | 0.50 | 0.86 |
| *surface feeders* | 0.90 | 0.44 | 0.63 |
| *wading feeders* | 0.50 | 0.40 | 0.33 |

Indicators that achieved good environmental status (GES) were marked in green (value ≥ 0.75) and indicators that did not reach good status (subGES) in red. For a functional group, see Table 2.1.20

### Integrated assessment of water birds

The integrated assessment of water birds for the years 2011-2016 was based on the abovementioned results of population abundace change rates in the breeding and wintering seasons in two areas: in the Gotland and Bornholm basins. The assessment was carried out in two stages. In the first stage, the data from the indicators 'Abundance of waterbirds in the breeding season' and 'Abundance of waterbirds in the wintering season' using the OOAO method were integrated. In the second stage, assessment was carried out for all water birds and for five functional groups in the Bornholm and Gotland Basin proportionality method proposed by HELCOM (good status in the group can be determined if more than 75% of the species achieved GES). The entire grouping of waterbirds did not reach good environmental status in the Bornholm and Gotland Basins. In the Bornholm Basin, only *grazing feeders* achieved good status, while in the Gotland Basin only *pelagic feeders* achieved GES.

Table 3.2.4. Integrated assessment of the status of water birds in the Bornholm Basin and Gotland Basin for 5 functional groups for the years 2011-2016. Indicators that have achieved good environmental status (GES) are highlighted in green, and indicators that did not reach good status (subGES) in red. For a functional group, seeTable 2.1.20.

| Region | Functional group | Assessment |
|---|---|---|
| Bornholm Basin | *all species* | 60% |
| | *benthic feeders* | 60% |
| | *grazing feeders* | 88% |
| | *pelagic feeders* | 57% |
| | *surface feeders* | 44% |
| | *wading feeders* | 50% |
| Gotland Basin | *all species* | 60% |
| | *benthic feeders* | 50% |
| | *grazing feeders* | 67% |
| | *pelagic feeders* | 88% |
| | *surface feeders* | 56% |
| | *wading feeders* | 33% |

### The assessment of white-tailed eagle productivity in 2011-2016

In the years 2011-2016, all three analyzed parameters of white-tailed eagle reproduction were above the threshold value of a good state:

(1) breeding success was 59% (GES threshold value is 59%),

(2) productivity (number of hatchlings per occupied nest) was 1.07 (threshold value 0.97),

(3) the number of young per success pair was 1.81 (threshold value 1.64).

All three parameters were in good status, therefore the final assessment of white-tailed eagle productivity index was also above the GES threshold (Table 3.2.5).

Table 3.2.5. Parameters of reproduction of white-tailed eagle (*Haliaeetus albicilla*) in the 10 km belt to the Baltic shoreline in Poland in individual years in the period 2011-2016 and average values of three parameters to be assessed in the entire analyzed period. (Data source: PMŚ)

| Year | The number of nests with the specified nesting result | Proportion of nests with interior control | Nesting success | Productivity | Number of chicks |
|---|---|---|---|---|---|
| 2011 | 8 | 0% | 88% | - | - |
| 2012 | 6 | 17% | 67% | 1.33 | 2.00 |
| 2013 | 5 | 20% | 100% | 1.00 | 1.00 |

| Year | The number of nests with the specified nesting result | Proportion of nests with interior control | Nesting success | Productivity | Number of chicks |
|---|---|---|---|---|---|
| 2014 | 27 | 19% | 67% | 1.20 | 1.80 |
| 2015 | 79 | 42% | 61% | 1.10 | 1.81 |
| 2016 | 69 | 58% | 48% | 0.88 | 1.84 |
| 2011-2016 | 194 | 41% | 59% | 1.07 | 1.81 |

Indicators that achieved good environmental status (GES) were marked in green (value ≥0.75) and indicators that did not reach good status (subGES) in red. The data for 2011-2014 come from the Eagle Protection Committee, and the data from 2015 and 2016 from White-tailed Eagle Productivity Monitoring (GIOŚ).

***Fish***

Two national indices - the Large Fish Index LFI1 and the Index of the state of ichthyofauna SI in transitional waters - were used to assess the fish status.

**LFI1 index** refers to the group of fish in open waters, observed in research catches, performing tasks related to the assessment of the demersal fish stocks (Baltic International Trawl Surveys - BITS). The LFI1 index meets the criteria for Descriptors D1C3 and D4C3 set out in Decision 2017/848. It is well-developed for a group of demersal fish from the North Sea.

**Large Fish Index LFI1**

In the case of the LFI1 index, within six years throughout the entire examined area of open waters, the status determined on the basis of the LFI1 index gradually deteriorated. The analysis of the LFI1 index shows that cod biomass larger than 30 cm in the six-year period gradually decreased. The LFI1 index initially indicated good environmental status, but since 2013 it has fallen below the threshold value. In the analysed period, the share of biomass of large flat fish decreased. At the end of this period, in 2016, the share of biomass of large cod in the population in both ICES sub-areas decreased. This indicates deterioration of the marine environment in terms of the share of large fish biomass.

As described above, the status of the marine environment in relation to the LFI1 index was assessed as subGES (Table 3.2.6).

Table 3.2.6. LFI1 index assessment for ICES subareas 25 and 26 in particular years.

| ICES subdivision | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Integrated assessment 2011-2016 |
|---|---|---|---|---|---|---|---|
| open sea - eastern part (ICES 26) | GES | GES | subGES | subGES | subGES | subGES | subGES |
| open sea - western part (ICES 25) | GES | GES | subGES | subGES | subGES | subGES | subGES |

**Index of the state of ichthyofauna SI in transitional waters**

Originally, the **SI status index** for transitional waters was produced for the purpose of assessing the ecological status according to the WFD. In this study it was also used in the context of MSFD.

The assessment of ecological status on the basis of ichthyofauna in 2011-2016 for transitional waterbodies was made taking into account the "one-out, all-out" principle. This means that the final assessment for 2011-2016 took into account the lowest rating recorded in the analyzed period (Table 3.2.7, Fig. 3.2.2). The SI indicator was also used to assess the D1 Descriptor (SI principles meet the following criteria of MSFD D1C2 'population abundance' and D1C3 'population demographic'). In the case of 3 waterbodies, the overall assessment was not made because the available data only concern the samples collected in 2011.

Table 3.2.7. The value of the ichthyofauna index (SI) in transitional waterbodiess in 2011-2016. Colors present the assessment of ecological status in subsequent years and the overall assessment in 2011-2016: red - bad, yellow - moderate, green - good, white (Bd) - no data, gray - no overall assessment

| waterbody name | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Average SI from the period 2011-2016 | Overall assessment according to MSFD |
|---|---|---|---|---|---|---|---|---|
| Dziwna Mouth | 3.6 | Bd | Bd | Bd | Bd | Bd | 3.60 | * |
| Świna Mouth | 3.4 | Bd | Bd | Bd | Bd | Bd | 3.40 | * |
| Wisła Przekop mouth | 3.7 | Bd | Bd | 1.86 | 1.79 | Bd | 2.45 | |
| Kamieński lagoon | 3.0 | Bd | Bd | Bd | Bd | Bd | 3.00 | * |
| Puck lagoon | 2.2 | Bd | 1.6 | 1.58 | 2.08 | 2.42 | 1.97 | |
| Szczecin lagoon | 3.1 | Bd | Bd | 2.75 | 2.5 | Bd | 2.78 | |
| Vistula lagoon | 2.9 | Bd | Bd | 2.75 | 2.08 | 2.33 | 2.51 | |
| Inner Gulf of Gdańsk | 3.7 | Bd | Bd | 2.5 | 1.79 | Bd | 2.66 | |
| Outer Puck Bay | 3.4 | Bd | 2.5 | 2.07 | 1.93 | 2.43 | 2.47 | |

* In the case of 3 waterbodies, the overall assessment was not performed because the available data only concern the samples collected in 2011

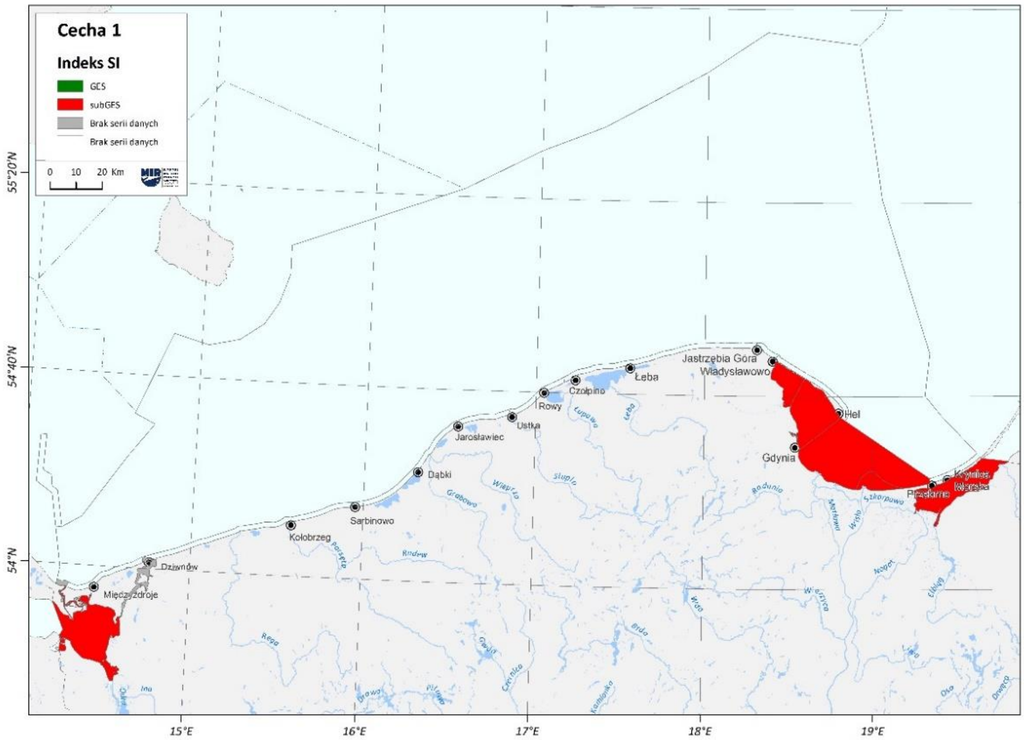



Fig. 3.2.2. Assessment of the state of the marine environment of transitional waters according to the WFD in 2011-2016 (Data source: PMŚ)

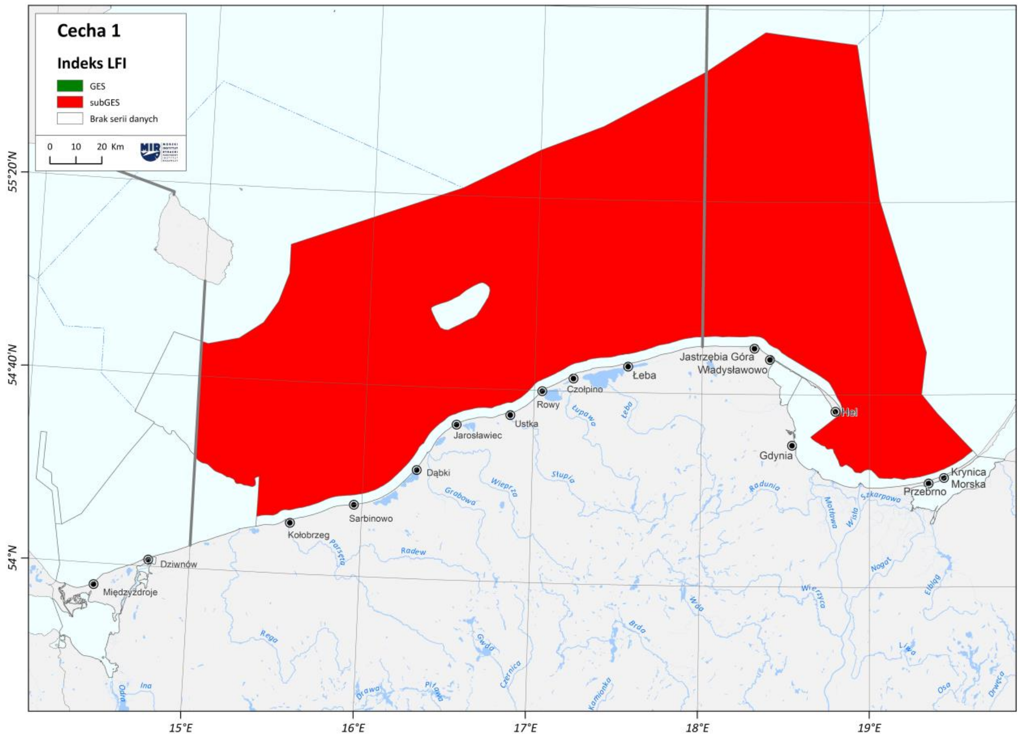



Fig. 3.2.3. Assessment of the state of the marine environment based on LFI1 for ichthyofauna in 2011-2016 (Data source: PMŚ)

***Benthic habitats***

According to the assessment method (Chapter 2.2.2.), the status of benthic habitats in POM as part of the multiannual assessment 2011-2016 is divided into 4 types of habitats, differing in the structure of flora and fauna communities associated with a specific type of bottom.

**Soft bottom habitat**

Assessment of the benthic habitat on the soft bottom in 22 assessment areas in POM (for broad habitat types based on the EUNIS classification according to the Decision 2017/848), including 21 areas based on the classification of the assessment result according to threshold values for indicator B and for the Puck Lagoon waterbody, where an integrated assessment between SM1 and B index was applied. The assessment of the state of this habitat is presented on the map (Fig. 3.2.4). Assessment of the benthic habitat (soft bottom) showed that in 2011-2016, the majority (18) of the assessment areas in POM, constituting 99% of the area, showed sub-good status - subGES, and only 4 coastal waterbodies (1% of POM area): Hel Peninsula, Władysławowo - Jastrzębia Góra, Jastrzębia Góra - Rowy, Rowy - Jarosławiec West were in good condition - GES (Fig. 3.2.5).

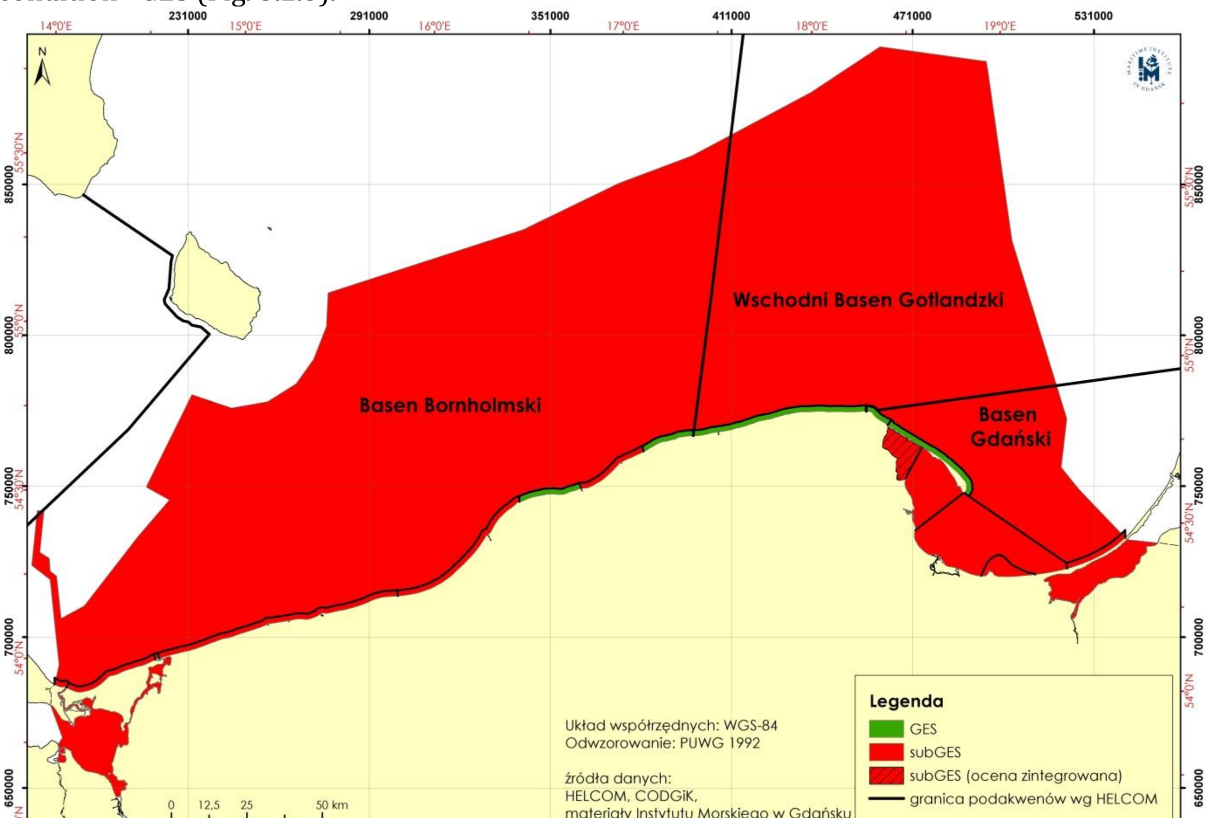



Fig. 3.2.4. Integrated assessment of the state of benthic habitat - soft bottom for many years 2011-2016 in POM (Data source: PMŚ)

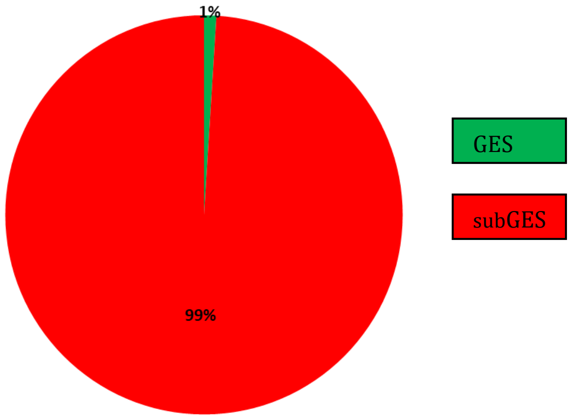



Fig. 3.2.5. Benthic habitat of soft bottom showing good status - GES and below good - subGES within POM in 2011-2016 (Data source: PMŚ)

### Hard bottom habitat

Assessment of the benthic habitat on hard bottom in two assessment areas in the POM: on Słupsk Bank boulder area (in Bornholm Basin) and on Rowy boulder area (in the area of waterbody: Rowy - Jarosławiec-East) on the basis of the assessment result according to threshold values for the $SM_1$ index. Assessment of the benthic habitat (hard bottom) showed that in 2011-2016 Słupsk Bank boulder area of an area of 111.3 km² showed a good status - GES, whereas Rowy boulder area (2.57 km² area) was below the good status - subGES (Fig. 3.2.6).

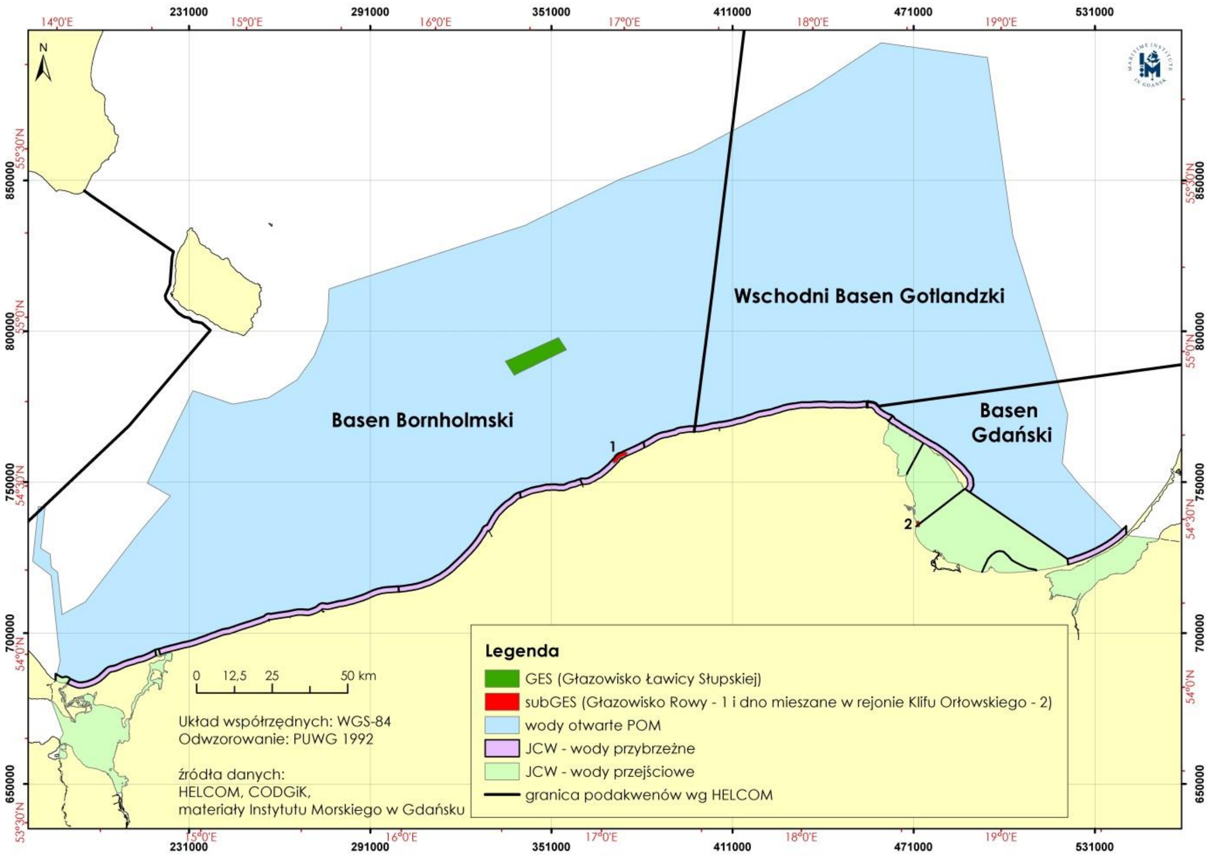


Fig. 3.2.6. Assessment of the benthic habitat - hard bottom (boulder) and mixed bottom (Cliff Orłowski region) for the years 2011-2016 in POM) (Data source: PMŚ)

**Mixed bottom habitat**

Assessment of the state of benthic habitat on the mixed bottom in the area of Outer Puck Bay in the area of Cliff Orłowski based on the classification of the result of the assessment in line with the threshold values for the $SM_1$ index.

In the Klif Orłowski area of 1.99 $km^2$, the assessment habitat showed a sub-good status - subGES (Fig. 3.2.6).

**Macrophyte habitat in lagoons**

Assessment of the macrophyte habitat status in lagoons in 3 assessment areas in the POM: the Vistula Lagoon, Szczecin Lagoon and Kamieński Lagoon was performed on the basis of classification of the assessment result in accordance with the threshold values for the ESMIz index. The assessment of macrophytes in lagoons with a total area of 752.61 $km^2$ showed a sub-good status - subGES in each of these waterbodies (Fig. 3.2.7).

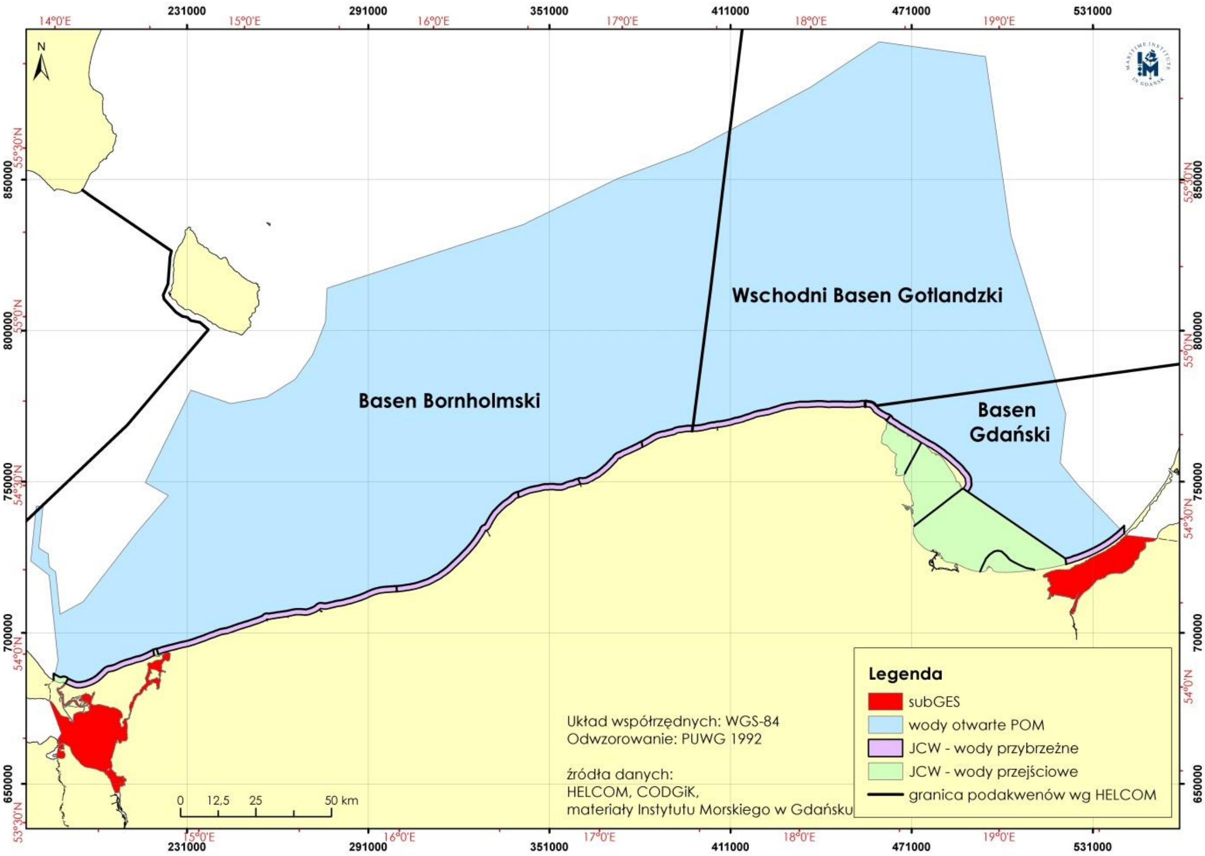



Fig. 3.2.7. Assessment of macrophyte habitat condition in lagoons in 2016 in POM (Data source: PMŚ)

***Pelagic habitats***

The state of pelagic habitats in POM as part of the multi-annual assessment 2011-2016 is devided into 2 different types of habitats, according to the assessment method and Decision 2017/848.

#### Pelagic habitat of open waters

Assessment of the pelagic habitat of open waters in 3 assessment areas in POM, in which an integrated assessment was used between the following indicators: MSTS, Dia/Dino, CyaBI and Chlorophyll- a (Gdańsk Basin) and integrated assessment between indicators: Dia/Dino, CyaBI and Chlorophyll- a (Eastern Gotland Basin and Bornholm Basin), followed by the classification of the assessment result - BQR as part of the "integrated assessment of biodiversity". The integrated assessment of pelagic habitat status is presented in Table 3.2.8.

Table 3.2.8. Integrated assessment of the state of pelagic habitats including the following indicators: MSTS, Dia/Dino, CyaBI, and Chl-a in the period 2011-2016 (Data source: PMŚ)

| Assessment Area | Indicator | The normalized value of the indicator for the years 2011-2016 | Indicator weight | BQR | Assessment |
|---|---|---|---|---|---|
| Gdańsk Basin | MSTS | 0.66 | 0.3 | 0.55 | subGES |
| | Dia/Dino | 0.75 | 0.3 | | |
| | CyaBI | 0.50 | 0.1 | | |
| | Chl-a | 0.26 | 0.3 | | |
| Eastern Gotland Basin | Dia/Dino | 0.97 | 0.4 | 0.62 | GES |
| | CyaBI | 0.54 | 0.2 | | |
| | Chl-a | 0.30 | 0.4 | | |
| Bornholm Basin | Dia/Dino | 0.93 | 0.4 | 0.60 | GES |
| | CyaBI | 0.55 | 0.2 | | |
| | Chl-a | 0.30 | 0.4 | | |

Assessment of the pelagic habitat of the open sea showed that in 2011-2016 the Eastern Gotland Basin and the Bornholm Basin were in good status - GES, while the Gdańsk Basin was below the good status - subGES (Fig. 3.2.8).

#### Pelagic habitat of transitional and coastal waters

Assessment of the status of pelagic habitats in transitional and coastal waters in 19 waterbodies in POM, where the classification of the assessment result was applied in line with the threshold values for the '*Chlorophyll-a'* indicator.

Almost all waterbodies (18) of transitional and coastal waters presented the status below good - subGES with the exception of Outer Puck Bay, where good environmental status was achieved (Fig. 3.2.8).

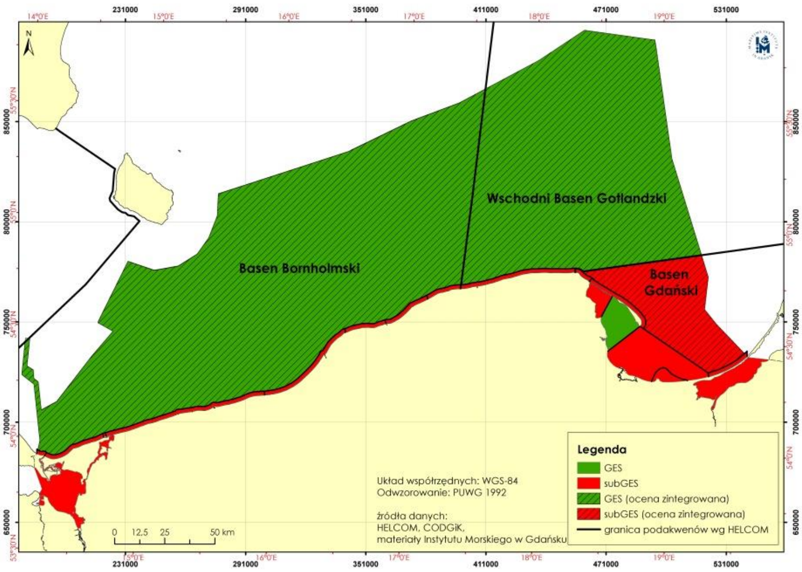



Fig. 3.2.8. Integrated assessment of the state of pelagic habitat for 2011-2016 period in POM (Data source: PMŚ)

Three areas of assessment in POM, including 2 open sea basins: Bornholm Basin and Eastern Gotland Basin, as well as Outer Puck Bay, constituting 87% of POM area, presented good condition - GES, while in other areas of assessment, including the Gdańsk Basin (13% area of POM) an environment below the good (subGES) was observed (Fig. 3.2.9).

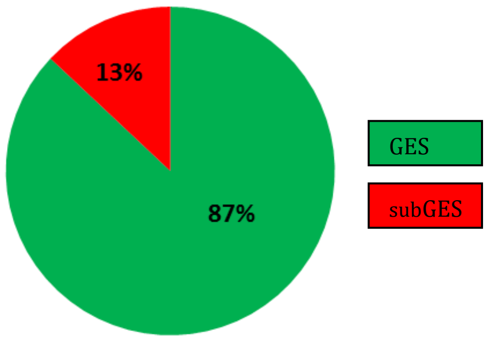



Fig. 3.2.9. Pelagic habitat showing good status - GES and below good - subGES for POM area in 2011-2016 (Data source: PMŚ)

### *Descriptor D4 – food webs*

Descriptor D4 - food webs (Anon 2017b) in the context of the guide to art. 8 MSFD (Walmsley and others 2017) should indicate maintaining the natural abundance, diversity and full reproductive capacity of species as elements of marine food webs. The structure and functioning of ecosystems can be characterized by the so-called trophic guilds (ICES 2014). The trophic groups contain predators and their victims. For example, a trophic group includes phytoplankton, zooplankton, planktivorous fish or phytoplankton, filtering benthic invertebrate organisms and demersal fish feeding on benthos. According to the guide (Walmsley et al 2017), the indicators agreed at the regional level should be used to assess ecosystems and food webs.

According to the recommendation of the guide to art. 8 MSFD (Walmsley et al. 2017) it is preferred to present the assessment for individual ecosystem elements as components in selected trophic guilds (A, B, C, (Table 3.2.9) without the need to integrate jointly at the descriptor level. At the same time, the criteria from Decision 2017/848 under Descriptor D4 and the indicators assigned to them should be used as a tool to identify changes in the food web.

Table 3.2.9. The trophic guilds and indicators together with their assessment status for the years 2011-2016, selected for the assessment of the Descriptor D4 in POM (Data source: PMŚ)

| Trophic guilds | Elements of the ecosystem | Indicator | Bornholm Basin | Eastern Gotland Basin | Gdańsk Basin |
|---|---|---|---|---|---|
| Trophic guild A | Phytoplankton (primary producers) | Dia/Dino | GES | GES | GES |
| | Macrozoobenthos | B | subGES | subGES | subGES |
| | Demersal fish | LFI | subGES | subGES | subGES |
| Trophic guild B | Phytoplankton (primary producers) | Dia/Dino | GES | GES | GES |
| | Macrozoobenthos | B | subGES | subGES | subGES |
| | Birds benthic feeding | breeding birds | subGES | subGES | - |
| | | wintering birds | GES | GES | - |
| Trophic guild C | Phytoplankton (primary producers) | Dia/Dino | GES | GES | GES |
| | Zooplankton (secondary producers) | MSTS | - | - | GES |
| | planktivorous fish | - | - | - | - |
| | grey seals | Population size and trend of abundance | subGES | | |
| | | Occurrence | | | |
| | | Reproductive status | | | |

In the recapitulation of the update of the initial assessment of the state of the environment in the Polish Baltic area for the years 2011-2016 in the field of "biodiversity", it should be noted that a lot of effort has been made both on the national level and within regional cooperation under the Helsinki Convention for the study to be prepared in a reliable way, based on the best expert knowledge and experience. The support of the EC in the form of standardization documents and guides was not without significance. Despite this, the prepared assessment is to a large extent a of test character. This is due to several reasons. In the presented integrated form, the environmental state assessment for POM (Descriptors D1, D4 and D6) was performed for the first time and therefore differs from the initial assessment for the years 2005-2010. In addition, several indicators (e.g. indicators related to the assessment of marine mammals and indexes 'ESMIz', 'MSTS', 'Dia/Dino', 'CyaBl') were used for the first time to assess elements of the ecosystem within biodiversity, trophic webs and the integrity of the seabed. Not all HELCOM indicators have been fully developed by experts, and for some of them, only temporary thresholds have been set or the rules for the determination of thresholds have not yet been sufficiently thoroughly analyzed, and in some cases no threshold values have been set at all for the assessment areas within the POM. Doubts arise also in the field of normalization methods of indicators developed at the HELCOM forum at the regional level. It should be noted that a set of indicators that could characterize all trophic pyramid levels in the Polish Baltic Sea zone is insufficient, and direct assessment of energy flow through the indicated levels in trophic guilds is not possible.

## 3.3.Pressure Descriptors

***Descriptor D2***

In the current assessment it was decided to use an approach whereby the worst state of any of the two parameters used to assess the indicator (‘Introduction of new non-indigenous species’, ‘Inventory parameter’) determines the final assessment of Descriptor D2.

Taking into account the results of the assessment carried out under the parameter Introduction of new non-indigenous species and the Inventory parameter, the state of the POM environment in the scope of Descriptor D2 was assessed as subGES in all assessment units (Fig. 3.3.1).

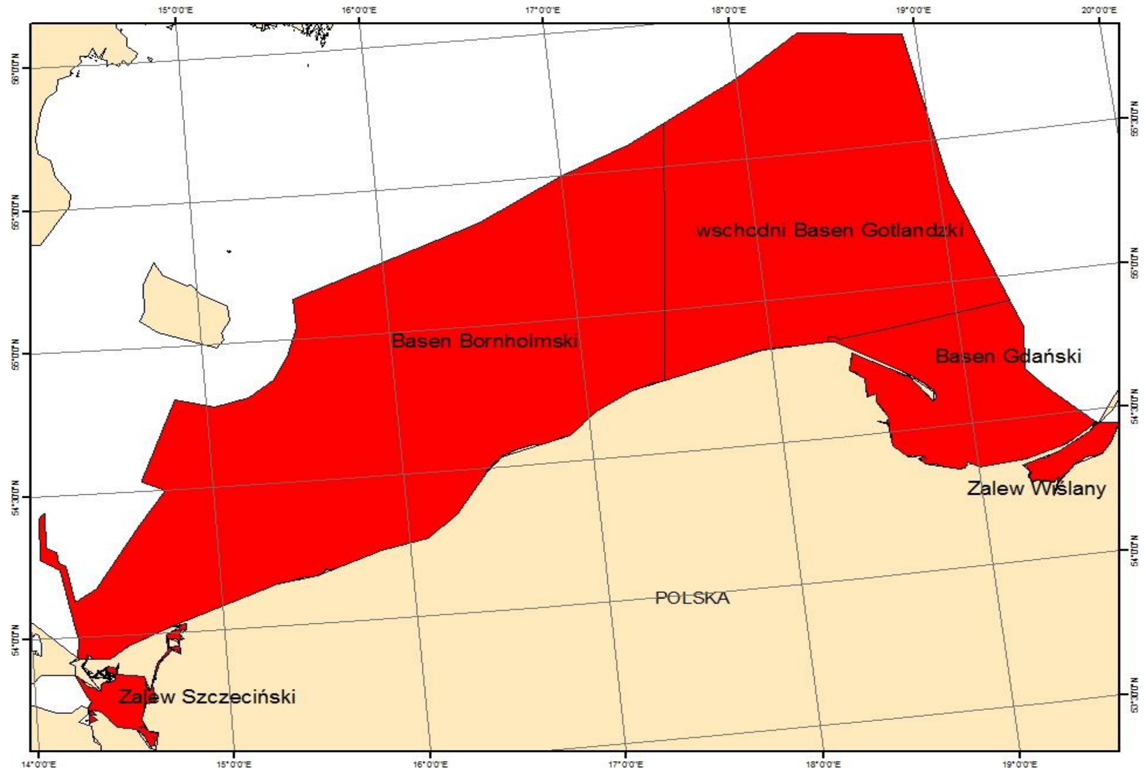



Fig. 3.3.1. Assessment of Descriptor D2 within POM (Data source: PMŚ).

***Descriptor D3***

Descriptor D3 has been used to assess the state of the marine environment of the Baltic Sea. The assessment was based on: cod stock, two stocks of flounder, one sprat stock, and one herring stock. Selected stocks account for over 90% of landings in Poland.

The combination of assessments at the criterion level and then at the level of the entire Descriptor D3 is not a simple task. Until now, at the international level, the methodology of combining assessments created using individual indicators within one criterion has not been developed (e.g. designation of a common GES for criterion 3.1 on the basis of indicators 3.1.1 and 3.1.2). Work on this issue is still ongoing, therefore the presentation of aggregate assessment for Descriptor D3 is not possible at the moment. In addition, the criterion regarding age distribution and population length distribution requires further work on the methodology. Pursuant to Decision 2017/848, D3C3 was not available for use when updating the initial assessment of the environmental status of marine waters in 2018.

Therefore, the assessment of GES was carried out on the basis of core indicators with criteria 3.1 and 3.2 and was presented on the basis of the methodology developed by ICES (ICES 2016). The criterion of the level of fishing pressure and the stock spawning capacity criterion was met for two stocks: sprat (22-32) and herring (25-29 and 32 Ex GoR) only in 2016, in earlier years, FMSY sprat (22-32) was exceeded. As many as 3 stocks had an unknown status (Table 3.3.1).

Table 3.3.1. Assessment of stocks by means of core indicators. Descriptors D3 for the years 2011-2016 according to the methodology proposed by ICES 2016. Green color indicates that a good state of the environment has been achieved, whereas a red lack of good status, gray - means that the data do not allow the use of core indicators. (PMŚ, ICES data source)

| | 2011 | | | 2012 | | | 2013 | | | 2014 | | | 2015 | | | 2016 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stock | Criterion | | GES | Criterion | | GES | Criterion | | GES | Criterion | | GES | Criterion | | GES | Criterion | | GES |
| | 3.1 | 3.2 | | 3.1 | 3.2 | | 3.1 | 3.2 | | 3.1 | 3.2 | | 3.1 | 3.2 | | 3.1 | 3.2 | |
| cod 24-32 | | | ? | | | ? | | | ? | | | ? | | | ? | | | ? |
| flounder 24-25 | | | ? | | | ? | | | ? | | | ? | | | ? | | | ? |
| flounder 26 i 28 | | | ? | | | ? | | | ? | | | ? | | | ? | | | ? |
| sprat 22-32 | | GES | | | GES | | | GES | | | GES | | | GES | | GES | GES | GES |
| herring 25-29 and 32 Ex GoR | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES | GES |
| Proportion of stocks achieving GES | 1 from 2 | 2 from 2 | 1 from 2 | 1 from 2 | 2 from 2 | 1 from 2 | 1 from 2 | 2 from 2 | 1 from 2 | 1 from 2 | 2 from 2 | 1 from 2 | 1 from 2 | 2 from 2 | 1 from 2 | 2 from 2 | 2 from 2 | 2 from 2 |
| Proportion of landings of stocks from GES to the total Polish landings | 28206t from 110390 t | 84314t from 110390 t | | 24622t from 120173t | 87504t from 120173t | | 20498 t from 133575t | 100842t from 133575t | | 25896 t from 119437t | 84320t from 119437 t | | 35387 t from 135613t | 99360 t from 135613 t | | 101520 t from 139313 t | 101520 t from 139313 t | |
| Proportions of stocks with unknown status | 3 from 5 | 3 from 5 | | 3 from 5 | 3 from 5 | | 3 from 5 | 3 from 5 | | 3 from 5 | 3 from 5 | | 3 from 5 | 3 from 5 | | 3 from 5 | 3 from 5 | |

? – question mark in the table means that the assessment could not be performed due to lack of ICES advice, the same way of presenting the assessment was used in the HELCOM report "State of the Baltic Sea: The second HELCOM holistic assessment of the ecosystem health of the Baltic Sea - first version "(June 2017), HELCOM (2017))

***Descriptor C5***

The assessment of the state of the environment in 2011-2016 in the field of eutrophication in POM was carried out in accordance with the MSFD recommendations. The results of research carried out in the COMBINE water quality monitoring program were used for the assessment purposes. The assessment was carried out on the basis of indicators produced for the Descriptor D5-Eutrophication, as one of the pressure descriptors. The indicators have been arranged in a causal sequence for driving factors, direct effects and indirect effects.

**Transitional and coastal waters**

The results were grouped by groups of criteria. For each indicator within a given waterbody, the average value from the given assessment year was calculated, and then the values from individual years were averaged to the final value of the indicator from the assessment period. In the next step, index values were brought to the value of EQR coefficients by comparison with threshold values for good status according to WFD. The EQR values within the groups of criteria were then averaged to the final assessment value for the criterion.

The final assessment of transitional and coastal waters for the years 2011-2016 was determined according to the OOAO principle based on the worst criterion result and is presented in Table 3.3.2.

None of the transitional and coastal waterbodies has achieved good environmental status during the 2011-2016 period. The final state of all transitional and coastal waterbodies was defined as subGES.

Table 3.3.2. Assessment of Descriptor D5 for transitional and coastal waters in 2011-2016 (Data source: PMŚ).

| Waterbody code | Driving factors | Direct effects | Indirect effects | waterbody assessment |
|---|---|---|---|---|
| PL TW I WB 9 | 0.63 | 1.55 | 2.20 | subGES |
| PL TW I WB 8 | 0.67 | 1.72 | 1.93 | subGES |
| PL TW I WB 1 | 0.48 | 1.45 | 2.82 | subGES |
| PL TW II WB 2 | 1.14 | 1.69 | 0.94 | subGES |
| PL TW III WB 3 | 1.73 | 1.03 | 1.13 | subGES |
| PL TW IV WB 4 | 0.96 | 1.05 | 1.21 | subGES |
| PL TW V WB 6 | 1.67 | 2.55 | 0.98 | subGES |
| PL TW V WB 5 | 2.38 | 1.77 | 1.31 | subGES |
| PL TW V WB 7 | 1.37 | 1.85 | 0.91 | subGES |
| PL CW I WB 2 | 1.92 | 1.43 | 0.76 | subGES |
| PL CW I WB 1 | 1.64 | 1.48 | 1.05 | subGES |
| PL CW I WB 3 | 2.43 | 2.88 | 1.14 | subGES |
| PL CW II WB 8 | 1.69 | 1.95 | 1.14 | subGES |
| PL CW II WB 6W | 1.77 | 1.99 | 0.76 | subGES |
| PL CW II WB 6E | 1.23 | 2.12 | 0.84 | subGES |
| PL CW II WB 5 | 2.00 | 2.24 | 0.79 | subGES |
| PL CW II WB 4 | 1.97 | 1.79 | 0.81 | subGES |
| PL CW III WB 9 | 1.32 | 1.88 | 1.09 | subGES |
| PL CW III WB 7 | 1.35 | 1.77 | 1.19 | subGES |

**Open sea**

The integrated results of the indicators within groups of criteria and the final assessment of Descriptor D5 in open sea sub-basins are presented in Table 3.3.3.

None of the indicators reached the GES value in 2011-2016, and consequently none of the groups of criteria reached GES. The final classification of the open sea was defined as subGES for all sub-basins.

Table 3.3.3. Assessment results of Descriptor D5 in open sea in 2011-2016 (Data source: PMŚ).

| Sub-basin | Driving factors | | | | | Direct effects | | | | Indirect effects | | | Assessment of Descriptor D5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DIN | DIP | TN | TP | avg. EQR | CHL a | SECCHI | CyaBl | avg. EQR | Oxygen debt | B index | avg EQR | |
| | 2011-2016 | | | | | | | | | | | | |
| Bornholm Basin Polish waters | 2.15 | 1.59 | 1.83 | 1.37 | 1.74 | 1.82 | 1.03 | 1.12 | 1.32 | 1.27 | 1.18 | 1.22 | sub GES (1.74) |
| Gdańsk Basin Polish waters | 1.25 | 1.43 | 1.47 | 1.36 | 1.38 | 1.86 | 1.16 | 1.19 | 1.40 | 1.25 | 1.92 | 1.82 | sub GES (1.82) |
| Eastern Gotland Basin Polish waters | 1.75 | 1.69 | 1.47 | 1.20 | 1.53 | 1.46 | 1.04 | 1.10 | 1.20 | 1.25 | 1.11 | 1.18 | sub GES (1.53) |

***Descriptor D6***

The initial assessment of marine waters of **Descriptor D6** – Seafloor integrity in POM, was performed based on the B index (core indicator) (Chapter 2.1.1.9) and $SM_1$ (candidate indicator) (Chapter 2.1.1.8) and indicates subGES status.

Assessment of criterion D6C1 for coastal and transitional waterbodies as well as for open sea is presented in Table 3.3.4 according to colour schemes of WFD and MSFD.

Table 3.3.4. Assessment of transitional and coastal waterbodies (WB) and open sea areas according to criterion D6C1 (Data source: PMŚ).

| **Assesment of permanent changes** | | |
|---|---|---|
| **Waterbodies** | WFD Assessment | GES |
| WB transitional Puck lagoon – TWII WB2 | | |
| WB transitional Inner Puck Bay– TWII WB3 | | |
| WB transitional Inner Gulf of Gdańsk – TWIV WB4 | | |
| WB coastal Vistula Spit CWI WB1 | | |
| WB coastal Hel Penninsula CWI WB2 | | |
| WB coastal Władysławowo - Jastrzębia Góra CWII WB4 | | |
| WB coastal Jastrzębia Góra - Rowy CWIII WB5 | | |
| WB coastal Rowy - Jarosławiec East CWII WB6E | | |
| WB transitional Kamieński lagoon – TWI WB9 | | |
| WB coastal Rowy - Jarosławiec West CWII WB6W | | |
| WB coastal Jarosławiec - Sarbinowo CWIII WB7 | | |
| WB coastal Sarbinowo - Dziwna CWII WB8 | | |
| WB coastal Dziwna – Świna CWIII WB9 | | |
| Highly modified WB Wisła Przekop mouth TWII WB5 | | |
| Highly modified WB Vistula lagoon TWI WB1 | | |
| Highly modified WB Władysławowo Port CWI WB3 | | |
| Highly modified WB Dziwna mouth TWII WB6 | | |
| Highly modified WB Świna mouth TWII WB7 | | |
| Highly modified WB Szczecin lagoon TWI WB8 | | |
| **Open sea** | | |
| Gdańsk Basin | | |
| Eastern Gotland Basin | | |
| Bornholm Basin | | |

In the case of transitional and coastal waterbodies, information on the area of anchorages, site of deposition of dredged material and shore supply with regard to the size of the coastal active zone as disturbances of the seabed (D6C2) was used (Table 3.3.5).

Table 3.3.5. Assessment of transitional and coastal waterbodies (WB) according to the D6C2 criterion, marked according to the color scheme for the assessment according to WFD and MSFD (Data source: PMŚ)

| Assessment of disturbance | | |
|---|---|---|
| Waterbodies | WFD Assesment | MSFD Assesment |
| WB transitional Puck lagoon – TWII WB2 | | |
| WB transitional Inner Puck Bay– TWII WB3 | | |
| WB transitional Inner Gulf of Gdańsk – TWIV WB4 | | |
| WB coastal Vistula Spit CWI WB1 | | |
| WB coastal Hel Penninsula CWI WB2 | | |
| WB coastal Władysławowo - Jastrzębia Góra CWII WB4 | | |
| WB coastal Jastrzębia Góra - Rowy CWIII WB5 | | |
| WB coastal Rowy - Jarosławiec East CWII WB6E | | |

| | | |
|---|---|---|
| WB transitional Kamieński lagoon – TWI WB9 | | |
| WB coastal Rowy - Jarosławiec West CWII WB6W | | |
| WB coastal Jarosławiec - Sarbinowo CWIII WB7 | | |
| WB coastal Sarbinowo - Dziwna CWII WB8 | | |
| WB coastal Dziwna – Świna CWIII WB9 | | |

Due to the lack of threshold values set at EU level the D6C3 criterion for the open sea areas was not included in the final assessment.

***Descriptor D7***

Spatial range and distribution of permanent changes in hydrographic conditions (e.g. changes in activity of waves, currents, salinity, temperature) of the seabed and water column related in particular to the physical loss of the natural seabed (D7C1), in the case of Poland concerns mainly coastal and transitional waters, which is practically the same as the Descriptor D6 and the D6C1 criterion assessment. Pursuant to Decision 2017/848, the results of the assessment of criterion D6C1 (Spatial extent and distribution of physical loss) are used to assess criterion D7C1. Therefore, for the individual reporting units, the same assessment as for criterion D7C1 was adopted.

Assessment of the indicator according to the D7C2 criterion - Spatial extent of each benthic habitat type adversely affected (physical and hydrographical characteristics and associated biological communities) is practically identical with the assessment according to criterion D6C3.

For Descriptor D7, Member States have not set threshold values for the negative effects of permanent changes in hydrographic conditions under regional or subregional cooperation, resulting in a lack of quantitative assessment.

***Descriptor D8***

The assessment of the environmental status within Descriptor D8 has been carried out taking into account three criteria, whereby such a full assessment concerns only the areas of the open sea:

- In the Bornholm Basin, within the criterion D8C1, 18 of 24 indicators - substances in appropriate matrices - met the requirements for good environmental status, including 7 of the 10 ubiquitous, persistent, toxic and bioaccumulated substances that met the requirements for good environmental status. Using the adopted method of assessment integration, the status of the Bornholm Basin within criterion D8C1 should be considered not-good (Fig. 3.3.2). Within criterion D8C2 (indicator of the effects of hazardous substances) the good status of the environment was achieved, as well as within criterion D8C3 (the oil spill index).
- In the Eastern Gotland Basin, within criterion D8C1, 14 out of 20 indicators - substances in appropriate matrices - met the requirements for good environmental status, including 6 out of 9 ubiquitous, persistent, toxic and bioaccumulated substances met the requirements for good environmental status. Using the adopted integration method, the status of the Eastern Gotland Basin environment within criterion D8C1 should be considered not-good (Fig. 3.3.3). Within criterion D8C2 (indicator of the effects of hazardous substances) the good status of the environment was not achieved, as well as within criterion D8C3 (the oil spill index).
- In the Gdańsk Basin, within criterion D8C1, 14 out of 20 indicators - substances in appropriate matrices - met the requirements for good environmental status, of which 6 out of 9 omnipresent, persistent, toxic and bioaccumulated substances met the requirements for good environmental status. Using the adopted method of integration, the status of the Gdańsk Basin environment within criterion D8C1 should be considered not good (Fig. 3.3.4). Within criterion D8C2 (indicator of the effects of hazardous substances) the good status of the environment was not achieved, while the oil spills index assessed within criterion D8C3 indicates good environmental status.

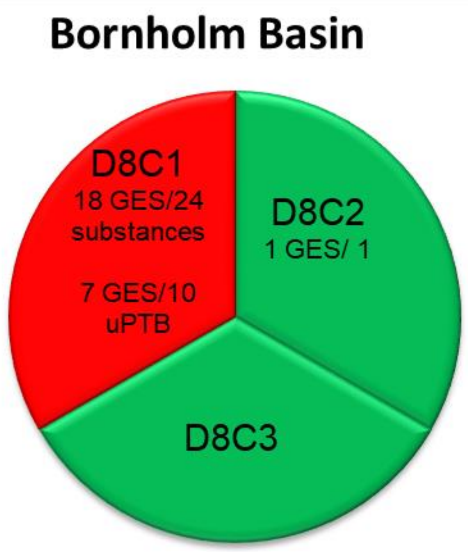



Fig. 3.3.2. Summary of the assessment of the state of Bornholm Basin based on Descriptor D8 (Data source: PMŚ)

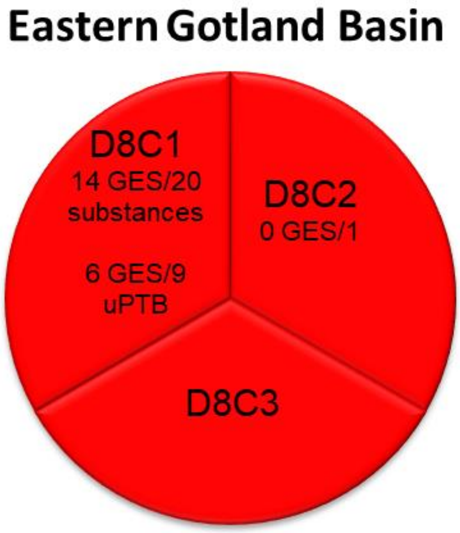



Fig. 3.3.3. Summary of the assessment of the state of Eastern Gotland Basin based on Descriptor D8 (Data source: PMŚ)

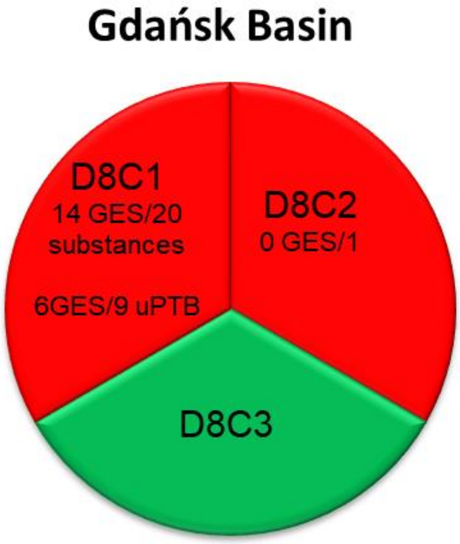



Fig. 3.3.4. Summary of the assessment of the state of Gdańsk Basin based on Descriptor D8 (Data source: PMŚ)

***Descriptor D9***

The results of the assessment (Fig. 3.3.5) indicate that out of the nine substances, only the sum of PBDE congeners does not meet the criteria for good environmental status in terms of the Descriptor D9. This applies to all three assessment areas and is mainly due to the very low threshold values set for PBDEs.


Fig. 3.3.5. Graphical presentation of the result of the assessment for the assessment areas - the number of indicators meeting the criteria of good environmental status - green and not meeting the criteria for good environmental status - red (Data source: PMŚ, PIWET)

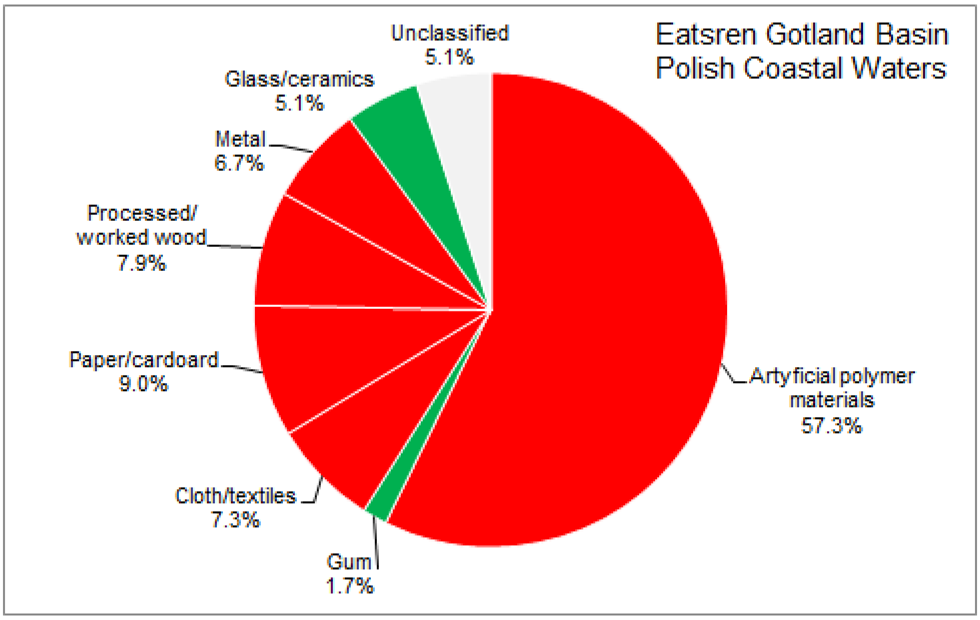
***Descriptor D10***

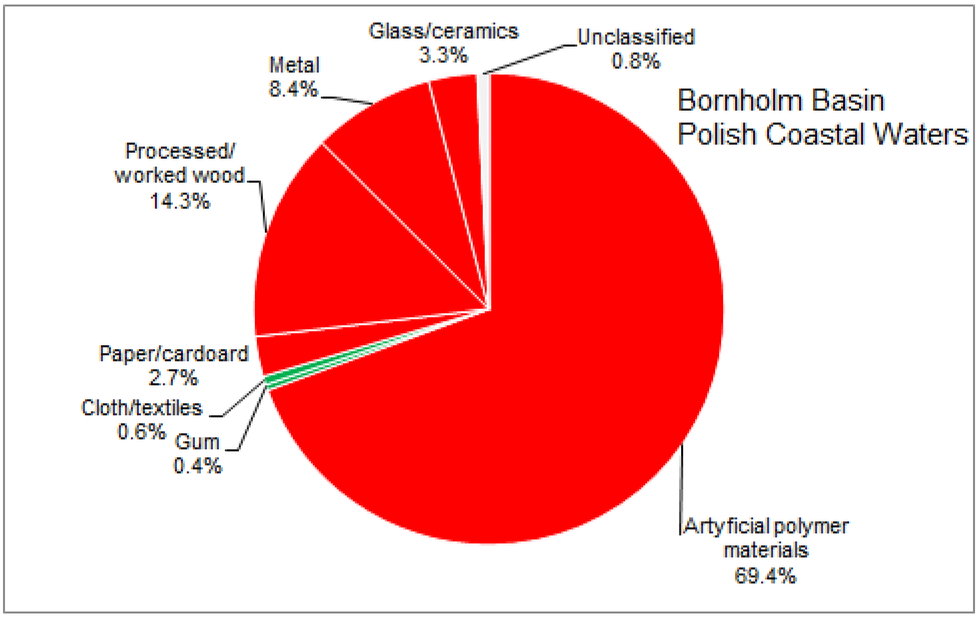
The assessment od Descriptor D10 was carried out for two primary criteria: D10C1 and D10C2, with only the first criterion: litter collected on the shoreline, a qualitative assessment has been carried out, which is of a test nature and is based on the proposed threshold values determined at the national level. There was no assessment of the state of the environment regarding the secondary criteria D10C3 and D10C4, mainly due to the lack of data.

The assessment of criterion D10C1 was based on data on litter collected on the coastline in the years 2015-2016. The assessment was carried out for three areas: Bornholm Basin Polish Coastal waters, Eastern Gotland Basin Polish Coastal waters and Gdańsk Basin Polish Coastal waters recommended by the HELCOM Monitoring and Assessment Strategy.

The primary parameter assessed was the number of litters in each category: polymer materials, rubber, clothing/textiles, paper/cardboard, glass/ceramics, wood, metal and the sum of all litter per 100 m. For each assessment area, averages number of litters in each category and the sum of all litter per 100 m was determined and aplying the proposed threshold values, it was specified that good condition was met for the category of rubber in all assessment areas, in the clothes/textiles category in Gdańsk Basin Polish Coastal waters and Bornholm Basin Polish Coastal waters, paper/cardboard category in the Gdańsk Basin Polish Coastal waters and in the glass/ceramics category in Eastern Gotland Basin Polish Coastal waters (Fig. 3.3.6).

However, taking into account the results for all categories and the sum of litter, good environmental status was not achieved in any of the areas.





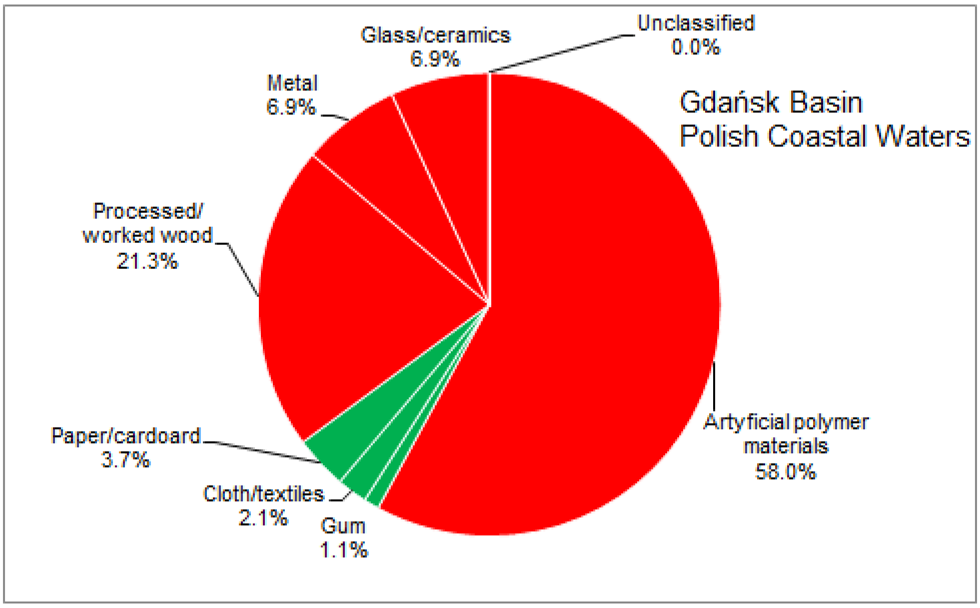




Fig. 3.3.6. Assessment of the status of Polish coastal waters for individual litter categories

***Descriptor D11***

The assessment of criterion D11C1 (Table 3.3.6) was made on the basis of data on impulsive sounds generated by defence activity, and criterion D11C2 (Table 3.3.7) based on the results of the BIAS project (HELCOM 2017a) and monitoring measurements.

Table 3.3.6. Proposed assessment of the status based on Descriptor D11 - underwater noise (criterion D11C1) in POM based on data from registered explosions

| Assessment Area | Type of explosion power | Duration 2011 - 2016 [days] | Average time of occurrence [days/year] | Average number of explosions in the year 2011-2016 [explosions/day] | Threshold value | GES |
|---|---|---|---|---|---|---|
| Gdańsk Basin | Very low | 0 | 0 | 0 | 1 | yes |
| | Low | 6 | 1 | 0.25 | 1 | yes |
| | Medium | 89 | 14.8 | 1.5 | 1 | no |
| | High | 45 | 7.5 | 0.6 | 1 | yes |
| | Very High | 0 | 0 | 0 | 1 | yes |
| | **Sum** | **140** | **23.3** | **2.35** | **1** | **no** |
| Bornholm Basin | Very low | 0 | 0 | 0 | 1 | yes |
| | Low | 180 | 30 | 0.81 | 1 | yes |
| | Medium | 248 | 41.3 | 2.16 | 1 | no |
| | High | 53 | 8.8 | 1.25 | 1 | no |
| | Very High | 56 | 9.3 | 1 | 1 | yes |
| | **Sum** | **537** | **89.4** | **5.22** | **1** | **no** |
| Eastern Gotland Basin | Very low | 0 | 0 | 0 | 1 | yes |
| | Low | 0 | 0 | 0 | 1 | yes |
| | Medium | 0 | 0 | 0 | 1 | yes |
| | High | 0 | 0 | 0 | 1 | yes |
| | Very High | 0 | 0 | 0 | 1 | yes |
| | **Sum** | **0** | **0** | **0** | **1** | **yes** |

Table 3.3.7. Proposed assessment of the environmental status regarding Descriptor D11 - Underwater noise (D11C2 criteria) for the Polish Exclusive Economic Zone based on data from the BIAS project and monitoring measurements

| Assessment area | Assessed criterion | Threshold value | GES |
|---|---|---|---|
| Eastern Gotland Basin | D11C2 | 108 dB | yes |
| Bornholm Basin | D11C2 | 108 dB | no |
| Gdańsk Basin | D11C2 | 108 dB | yes |

The criteria elements relating to underwater noise associated with human activities set out in Decision 2017/848, impulsive sound (D11C1) and continuous low frequency sound (D11C2) are mainly focused on the determination of threshold values indicating no negative impact noise to populations of animals living in the marine environment. In order to define the above criteria, unified methodological standards were established in which a strong emphasis was placed on the characteristics of the above-defined types of sounds (D11C1, D11C2).

So far, no threshold values have been set for the criteria of Descriptor D11 at European level. Nevertheless, the available measurement data allow the assessment of the continuous noise in the assessment areas in POM. This assessment coincides with the results obtained under the BIAS project.

In relation to the initial assessment from 2005-2010, obtaining data as part of the implementation of the Monitoring Program of Marine Waters is a major advance in the scope of the possibility of conducting an assessment.

The list of assessment for particular sub-basins is presented below, separately for elements of the ecosystem (Table 3.3.8 and Table 3.3.9) and pressure descriptors (Table 3.3.10). For each of the sub-basins, the arithmetic mean was determined from the sum of the component assessments expressed in the assessment: good (1) or bad (0). The summary does not apply to POM as a whole, because in some cases the same assessments are presented for sub-basins. For clarity, the results of the assessment of fish (D3) and hazardous substances (D9) carried out with respect to the boundaries of ICES subareas were assigned to the relevant sub-basins according to the HELCOM division.

In the case of Descriptor D4 (Table 3.3.8) the assessment can only be presented for a given indicator for the ecosystem element, because integration is not carried out within the trophic groups, nor for this Descriptor as a whole.

Table 3.3.8. Assessment od Descriptor D4 – Food webs.

| Trophic guilds | Elements of the ecosystem | Indicator | Bornholm Basin | Eastern Gotland Basin | Gdańsk Basin |
|---|---|---|---|---|---|
| Trophic guild A | Phytoplankton (primary producers) | Dia/Dino | GES | GES | GES |
| | Macrozoobenthos | B | subGES | subGES | subGES |
| | Demersal fish | LFI | subGES | subGES | subGES |
| Trophic guild B | Phytoplankton (primary producers) | Dia/Dino | GES | GES | GES |
| | Macrozoobenthos | B | subGES | subGES | subGES |
| | Birds benthic feeding | breeding birds | subGES | subGES | - |
| | | wintering birds | GES | GES | - |
| Trophic guild C | Phytoplankton (primary producers) | Dia/Dino | GES | GES | GES |
| | Zooplankton (secondary producers) | MSTS | - | - | GES |
| | planktivorous fish | - | - | - | - |
| | grey seals | Population size and trend of abundance | subGES | | |
| | | Occurrence | | | |
| | | Reproductive status | | | |

The comparison of Descriptors D1 and D6 (Table 3.3.9) shows that the status of ecosystem elements is the best in the Eastern Gotland Basin and its Polish coastal waters. A significant impact on the final result comes from good status of bird assessment and varied pelagic and benthic habitats assessment, but also a bad assessment of mammals and fish, which is determined by a bad assessment according to one of the criteria.

In the assessment of pressure descriptors (Table 3.3.10) the worst result was achieved for non-indigenous species (D2), eutrophication (D5) and sprat in all sub-basins considered. At the same time, the Polish coastal waters of the Bornholm and Gdańsk Basins achieved poor assessment results for all of the pressure descriptors. The poor condition of hydromorphological elements has some influence on such a result, mainly due to the strongly modified waterbodies occurring there.

Table 3.3.9. Assessment of the state of environment for Descriptors: D1 i D6 – integrated biodiversity assessment

| **Sub-basin** | **Element of ecosystem** | | | | | |
|---|---|---|---|---|---|---|
| | **Descriptor D1** | | | | | **Descriptor D6** |
| | Mammals | Wintering birds | Breeding birds | Fish | Pelagic habitat | Benthic habitat |
| POM | | | | | | |
| Bornholm Basin - Polish waters | | | | | | |
| Eastern Gotland Basin - Polish waters | | | | | | |
| Gdańsk Basin - Polish waters | | | | | | |
| Bornholm Basin Polish Coastal waters | | | | | | |
| Eastern Gotland Basin Polish Coastal waters | | | | | | |
| Gdańsk Basin Polish Coastal waters | | | | | | |

Table 3.3.10. Assessment of the state of environment for pressure Descriptors: D2, D3, D5, D6 (part), D7, D8, D9, D10, D11

| **Sub-basin** | **Pressure descriptors** | | | | | | | | | | Average from assessments of all descriptors |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | D2 | D3 | | D5 | D6 | D7 | D8 | D9 | D10 | D11 | |
| | | sprat | herring | | | | | | | | |
| POM | | | | | | | | | | | |
| Bornholm Basin - Polish waters | | | | | | | | | | | 0.55 |
| Eastern Gotland Basin - Polish waters | | | | | | | | | | | 0.55 |
| Gdańsk Basin - Polish waters | | | | | | | | | | | 0.55 |
| Bornholm Basin Polish Coastal waters | | | | | | | | | | | 0.00 |
| Eastern Gotland Basin Polish Coastal waters | | | | | | | | | | | 0.40 |
| Gdańsk Basin Polish Coastal waters | | | | | | | | | | | 0.00 |
| **Summary according to pressure descriptors** | | | | | | | | | | | **0.55** |

# 4. Pressure on the marine environment
## 4.1.Pressures from land

***Input of heat to water***

In the Vistula catchment one source located close enough to the estuary to potentially affect the temperature of sea water is the Gdańsk Heat and Power Plant, located at the Martwa Wisła. Gdańsk's heat and power plant distributes about 17 million cubic meters of cooling water to Martwa Wisła [EDF Polska S.A. 2014], which is about 1/4of the flow in Martwa Wisła and less than the flow of water in the Vistula in Tczew [IMGWPIB 2015].

The results of the monitoring at the control point below the discharge of heated waters from the Gdańsk Heat and Power Plant do not indicate that the water temperatures are significantly higher than in the Vistula in Kiezmark [PMŚ 2015]. The share of cooling water from EC Gdańsk in waters supplied to the Gulf of Gdańsk from the Vistula catchment is so small that the level of pressure on elements of marine ecosystems can be considered insignificant.

In the light of the data presented above, the pressure related to the introduction of heat into waters was considered non-existent. Thus, it was considered that there are no impacts associated with this pressure.

***Introduction of hazardous substances***

In the context of the BSPI / BSII index, hazardous substances should be understood primarily as heavy and persistent metals (difficult to decompose) synthetic or non-synthetic organic compounds, capable of causing even serious intoxication, malignant neoplasms and other potentially fatal or health-threatening changes in living organisms even at low doses. .

Sources of dangerous substances are very diverse. The main source of heavy metals, such as cadmium or mercury, are fossil fuel combustion processes as well as smelting processes in the metallurgical industry. Until relatively recently, lead gasoline was the largest source of lead [EEA 2007]. Metals are emitted into the air with fumes, and they reach the sea either directly with rainfall or indirect, migrating with rainwater to the rivers. Similarly, many dangerous organic compounds are entering the sea, being the products of incomplete combustion processes of fossil fuels, litter, etc. This category includes, among others, dioxins and benzo-a-pyrene. Another very important group are persistent organic compounds being active substances or derivatives of active substances of various types of pesticides. This group includes both end-of-life compounds such as DDT, hexachlorobenzene or atrazine as well as compounds used today. Another important group of stable organic compounds are polychlorinated biphenyls (PCB), used in transformer oils, hydraulic fluids, greases, paints, etc. This information comes from the registers of fees for using the environment, maintained by marshal offices, hereinafter referred to as "registers".

**Discharges of sewage to waters**

One of the sources of information on discharges of hazardous substances are water and legal permits. Their serious disadvantage, however, is that they essentially contain information about the maximum allowable, and not real, concentrations and flows (much less - loads). Building on this source in the estimation of loads would have to lead to an overestimation of results, without the possibility of even approximating the scale of these overstatements without contact with the entities that were granted permits. Given the very poor response to the survey of large industrial plants, it was decided to limit the analysis of permits only to determine the number of permits granted to individual substances. The results are presented in Table 4.1.1. It does not include several thousand licenses for the discharge of petroleum substances, generally concerning the discharge of rainfall sewage. The table is highlighted by regional differences, which do not appear to be justified as regions' economies. For example, in the area of operation of regional water management boards (RZGW) operating on the basis of the Act of 18 July 2001 - Water Law, issued: in the area of RZGW Warszawa activity, 32% of all permits for the discharge of heavy metals were issued, while permits from the RZGW area Gliwice and RZGW Kraków, where the metallurgical industry is concentrated, accounted for a total of 28%. The permits for discharge of copper in the RZGW Warszawa were 300, and in the RZGW Wrocław, where mining and copper metallurgy are located - only 10. Only in the RZGW Warszawa permits were issued for the discharge of benzo(a)pyrene. In turn, polycyclic aromatic hydrocarbons appeared in permits from three water regions, but there were none or phenols in the Central Vistula region despite the presence of, among others, the Płock refinery. In conclusion, the usefulness and confidance of the source of information, which are water law permits, is limited in the context of the objectives of this study.

Table 4.1.1. The number of dangerous substances discharges in the areas of operation of individual RZGW according to data from water permits

| Substance | Gdańsk | Gliwice | Kraków | Poznań | Szczecin | Warszawa | Wrocław | TotaL |
|---|---|---|---|---|---|---|---|---|
| 1,2-dichloroethane | 3 | | 2 | 6 | | | | 11 |
| Adsorbable Organic Halides AOX | 7 | 3 | 11 | 13 | 5 | | | 39 |
| Acrylonitrile | 1 | | 1 | 3 | | | | 5 |
| Aldrin | | | 1 | | | | 1 | 2 |
| Antimony | | 11 | 5 | 20 | 1 | | 6 | 43 |
| Arsenic | | 26 | 5 | 31 | 6 | | 2 | 70 |
| Benzene, toluene, xylene (BTX) | 6 | 15 | 7 | 12 | 1 | | | 41 |
| Benzo[a]pyrene | | | | | | 12 | | 12 |
| Chromium | 48 | 141 | 23 | 277 | 17 | 145 | 10 | 661 |
| Chromium +3 | 2 | 2 | 1 | | | 117 | | 122 |
| Chromium +6 | 44 | 70 | 17 | 159 | 13 | 88 | 2 | 393 |
| Zinc | 48 | 203 | 29 | 402 | 27 | | 12 | 721 |
| Phenols | | 4 | 1 | | | | 8 | 13 |
| Volatile phenols | | 114 | 25 | 100 | 12 | | 4 | 255 |
| Hexachlorobenzene | 3 | 1 | 2 | 2 | | | 1 | 9 |
| Hexachlorobutadiene | 3 | | 1 | 3 | | | | 7 |
| Hexachlorcyclohexane | 2 | | 1 | | | | | 3 |
| Organophosphorus and carbamate insecticides | 1 | 1 | 5 | 3 | | 1 | | 11 |
| Insecticides from the group of chlorinated hydrocarbons | 1 | | 1 | 2 | | 1 | | 5 |
| Cadmium | 25 | 94 | 12 | 157 | 15 | 123 | 3 | 429 |
| Caprolactam | | | | | | 1 | | 1 |
| Cobalt | | 22 | 6 | 27 | | | 1 | 56 |
| Volatile Organic Halogens (VOX) | 4 | | 4 | | | | | 8 |
| Copper | 60 | 160 | 23 | 317 | 26 | 300 | 10 | 896 |
| Molybdenum | | 23 | 5 | 28 | 2 | | 1 | 59 |
| Nickel | 63 | 127 | 20 | 248 | 16 | 263 | 7 | 744 |
| Lead | 39 | 181 | 31 | 379 | 26 | 369 | 11 | 1036 |
| Pentachlorophenol | 3 | | 2 | 2 | | | | 7 |
| Mercury | 12 | 62 | 8 | 109 | 17 | 82 | 3 | 293 |
| Silver | | 36 | 6 | 40 | 4 | | 3 | 89 |
| Thallium | | 5 | 5 | 12 | 2 | | 1 | 25 |
| Tetrachloroethylene | | 2 | 2 | 10 | | | | 14 |
| Tetrachlorometan | 6 | 4 | 2 | 5 | | | | 17 |
| Trichlorobenzene | 3 | | 3 | 2 | | | 1 | 9 |
| trichloroethylene | 3 | 4 | 3 | 3 | | | 1 | 14 |
| *trichloromethane* | 3 | 6 | 3 | 7 | | | 1 | 20 |
| Vanadium | | 24 | 6 | 25 | 6 | 23 | 1 | 85 |
| *polycyclic aromatic hydrocarbons* WWA | 1 | 3 | 4 | | | | | 8 |
| Total | 391 | 1344 | 283 | 2404 | 199 | 1525 | 90 | 6236 |

The information from the registers of fees for using the environment, conducted by marshal offices give an overview on the scale of discharges of dangerous substances into waters (Table 4.1.2). However, these registers are conducted without classifying sources according to sectors of the economy or in other ways, which makes it difficult to deduce about the importance of particular types of sources. In addition, the mere deployment of polluting entities raises concerns about the quality of data collected in the registers. A good example of this is zinc, the emission of which according to [MSC-E 2017] is 56% in the Kuyavian-Pomeranian Voivodeship, while in Silesia and Małopolska, where zinc mines and smelters are located, the total emission is about 40 kg Zn / year and constitutes 0.6% of the national emission. The same applies to volatile phenols, which have not been demonstrated in Mazovia despite the presence of petrochemistry in Płock, and which in the province Silesian Silesia are discharged in the amount of 15 kg/year (1% of the national emission) despite the presence of coke industry. In general, the quantities provided in the registers seem very small, and the entities paying the fees - quite accidental. For example, in the Zachodniopomorskie Voivodship, a significant part of the volatile phenolic cargo comes from small rural municipalities that discharge more phenols than the Śląskie Voivodship.

Table 4.1.2. Tha amount of discharges of volatile phenols and metals into waters in 2015 according to data on environmental fees

| Voivodeship | Volatile phenols | Mercury | Cadmium | Copper | Zinc | Nickel | Lead | Chromium |
|---|---|---|---|---|---|---|---|---|
| | [kg/year] | | | | | | | |
| pomorskie | 0.0 | 0.0 | 0.1 | 1.6 | 8.4 | 1.5 | 0.8 | 1.0 |
| warmińsko-mazurskie | 12.4 | 0.0 | 0.0 | 0.2 | 0.6 | 0.0 | 0.1 | 0.1 |
| zachodniopomorskie | 345.1 | 2.5 | 3.4 | 24.5 | 137.6 | 6.3 | 10.0 | 10.9 |

**Emissions to the air**

Emissions to the air play a very important role in the overall emission of hazardous substances into the environment. Some of the emitted substances are deposited either directly on the surface of the sea or on the surface of inland waters and migrate to the sea with them. Some contribution to the sea-feeding charges, depending on the mobility of substances in the soil environment, has deposition of emitted substances on land surfaces.

Emissions of air pollution in Poland is conducted by the National Center for Emissions Management (KOBIZE). KOBIZE data for 2015 are presented in Table 4.1.3. (heavy metals) and Table 4.1.4. (organic substances). When it comes to heavy metals, their primary source are combustion processes in the municipal sector and in the professional power industry. Only in the case of mercury, combustion processes in industry prevail. Heavy metals are contained in the basic fossil fuel used in Poland - hard coal as well as in lignite. After the combustion of coal, some of them are emitted into the air, and some, in high concentrations, remain in the ashes, which, if improperly stored, can get into the water [Kalembasa et al. 2008].

Comparison of data on the quantities of metals discharged to water and into the air shows that they are mainly emissions to air, and actually the burning of solid fossil fuels, and the share of discharges with sewage is in the order of a percentile. Even considering that as a result of dispersion in the air, immobilisation in soils, etc., only a small proportion of metals emitted into the air gets into the water, it seems that emissions to the air, not sewage, are the main cause of anthropogenic pollution of waters with heavy metals.

Since the withdrawal from use of the most dangerous pesticides, including all chloroorganic pesticides, the most important way of emission to the environment of persistent organic compounds in Poland are emissions to the air, where, as in the case of heavy metals, the combustion process in the municipal sector is responsible for almost half of the emissions of dioxins and furans, two-thirds of PCB emissions and nearly 9/10 emissions of polycyclic aromatic hydrocarbons (WWA). All these substances result from incomplete combustion. For the formation of dioxins, furans and PCB, the presence of chlorine is essential, which in the home of the boiler room, as well as the litter incineration plant, comes mainly from plastics and paper bleached with chlorine. In professional power plants and combined heat and power plants, combustion processes are conducted under strict control and in conditions that largely eliminate the formation of strong toxins. As a result, the amount of dioxins generated by power plants per tonnes of fuel burned is several orders of magnitude smaller than the amount produced in the home boiler room.

Table 4.1.3. Heavy metals emission to air in 2015 [KOBiZE 2017]

| Sector | Cd | | Hg | | Pb | | As | | Cr | | Cu | | Ni | | Zn | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | [t] | [%] | [kg] | [%] | [t] | [%] | [kg] | [%] | [kg] | [%] | [t] | [%] | [t] | [%] | [t] | [%] |
| 01. Combustion processes in the energy production and transformation sector | 1291.6 | 9.4 | 5248.6 | 49.6 | 22.8 | 4.4 | 4999.6 | 11.5 | 6103 | 12.9 | 17.3 | 4.2 | 26.6 | 19.9 | 86.6 | 6.2 |
| 02. Combustion processes outside the industry | 2323.4 | 17.0 | 984.0 | 9.3 | 140.9 | 27.4 | 16308.9 | 37.5 | 19649 | 41.5 | 86.5 | 20.8 | 75.1 | 56.1 | 597.8 | 42.5 |
| 03. Combustion processes in industry | 7680.1 | 56.1 | 3713.5 | 35.1 | 252.4 | 49.1 | 21266.3 | 48.8 | 8882 | 18.8 | 202.8 | 48.8 | 23.5 | 17.6 | 491.1 | 34.9 |
| 04. Production processes | 2039.0 | 14.9 | 594.9 | 5.6 | 85.5 | 16.6 | 971.2 | 2.2 | 8193 | 17.3 | 17.8 | 4.3 | 7.0 | 5.2 | 169.9 | 12.1 |
| 05. Extraction and distribution of fossil fuels | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 06. Use of solvents and other products | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 07. Road transport | 174.7 | 1.3 | 0.0 | 0.0 | 11.1 | 2.2 | 0.0 | 0.0 | 4455 | 9.4 | 90.4 | 21.8 | 0.8 | 0.6 | 61.0 | 4.3 |
| 08. Other vehicles and equipment | 89.3 | 0.7 | 1.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0 | 0.0 | 0.5 | 0.1 | 0.9 | 0.7 | 0.0 | 0.0 |
| 09. Litter management | 94.8 | 0.7 | 34.8 | 0.3 | 1.1 | 0.2 | 1.6 | 0.0 | 10 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 |
| 10. Agriculture | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11. Other sources | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 13692.9 | 100.0 | 10576.8 | 100.0 | 513.789 | 100.0 | 43547.7 | 100.0 | 47293 | 100.0 | 415.6 | 100.0 | 133.9 | 100.0 | 1407.1 | 100.0 |

Table 4.1.4. Emission of organic hazardous substances to air in 2015r. according to [KOBiZE 2017]

| Sector | PCDD/F | | HCB | | PCB | | WWA | | NMLZO | |
|---|---|---|---|---|---|---|---|---|---|---|
| | [kg] | [%] | [kg] | [%] | [kg] | [%] | [kg] | [%] | [t] | [%] |
| 01. Combustion processes in the energy production and transformation sector | 12.6 | 4.3 | 0.9 | 6.7 | 130.6 | 19.3 | 0.2 | 0.1 | 19.9 | 3.7 |
| 02. Combustion processes outside the industry | 139.5 | 47.9 | 1.8 | 13.4 | 448.1 | 66.1 | 121.9 | 87.4 | 110.2 | 20.7 |
| 03. Combustion processes in industry | 61.2 | 21.0 | 7.7 | 57.5 | 15.6 | 2.3 | 0.7 | 0.5 | 10.6 | 2.0 |
| 04. Production processes | 15.7 | 5.4 | 0.0 | 0.0 | 33.6 | 5.0 | 15.2 | 10.9 | 50.2 | 9.4 |
| 05. Extraction and distribution of fossil fuels | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 36.8 | 6.9 |
| 06. Use of solvents and other products | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 219.2 | 41.1 |
| 07. Road transport | 6.6 | 2.3 | 2.2 | 16.4 | 49.4 | 7.3 | 0.9 | 0.6 | 75.1 | 14.1 |
| 08. Other vehicles and equipment | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.4 | 8.9 | 1.7 |
| 09. Litter management | 38.3 | 13.2 | 0.8 | 6.0 | 0.8 | 0.1 | 0.0 | 0.0 | 2.5 | 0.5 |
| 10. Agriculture | 16.3 | 5.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11. Other sources | 0.9 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 291.2 | 100.0 | 13.4 | 100.0 | 678.1 | 100.0 | 139.4 | 100.0 | 533.3 | 100.0 |

PCDD/F - polychlorinated dioxins and furans;
HCB - hexachorobenzene;
PCB - polychlorinated biphenyls;
NMLZO - non-methane volatile organic compounds.

In addition to all types of combustion processes an important organic source of pollutants are processes in which organic solvents are used. They generally contain low molecular weight compounds such as benzene, toluene, phenol, etc.

Over the last decades, there has been a significant decrease in heavy metals emissions to air (Fig. 4.1.1). This is related, inter alia, to the reduction of coal consumption as a result of increased energy efficiency in occupational energy, industrial processes and the municipal sector (including thermomodernization), as well as the dissemination and improvement of coal enrichment methods, as a result of which a significant proportion of pollutants, including metals, is removed from the coal before it is burned.

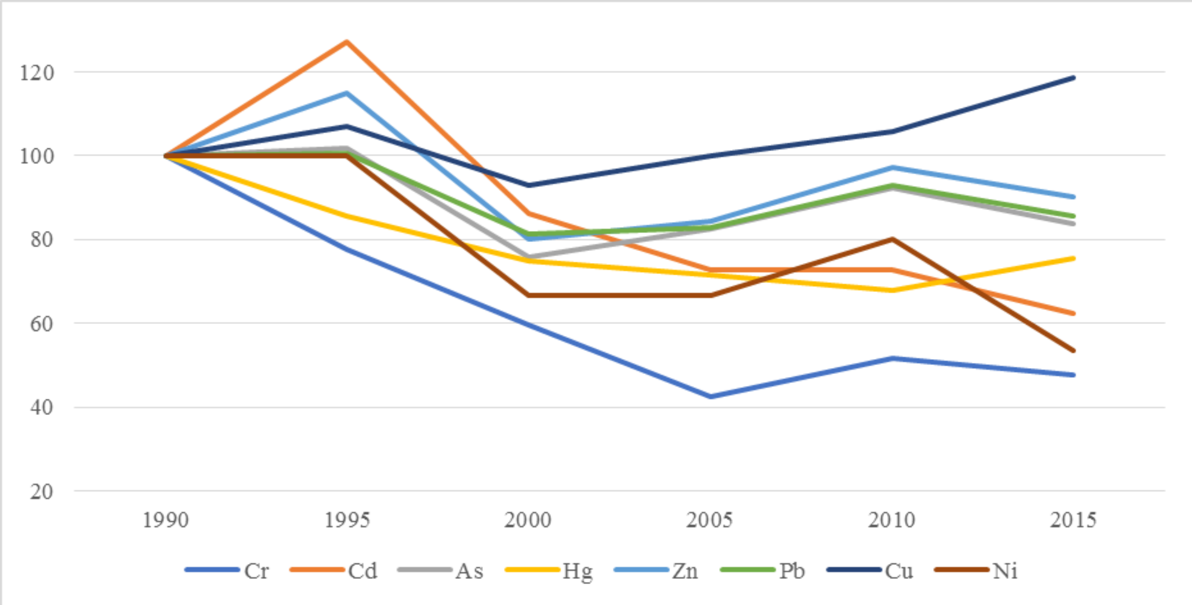



Fig. 4.1.1. Trends in emission of heavy metals to air

According to [KOBiZE 2017], in the period 1990-2015, the emission of monitored metals decreased by between 10% (Zn) and 52% (Cr). Only in the case of copper there was an increase in emissions. In the case of dangerous organic compounds, trends are less pronounced (Fig. 4.1.2). There has been a certain decrease in WWA and PCB emissions associated with the increase of energy efficiency and improvement of combustion processes in all sectors, but especially in the power industry, towards elimination of incomplete combustion and formation of persistent organic compounds. On the other hand, there has been an increase in HCB emissions, the sources of which are mainly industrial processes, including the production of chlorinated solvents, sintering of iron ores and secondary production of copper [Olendrzyński et al.].

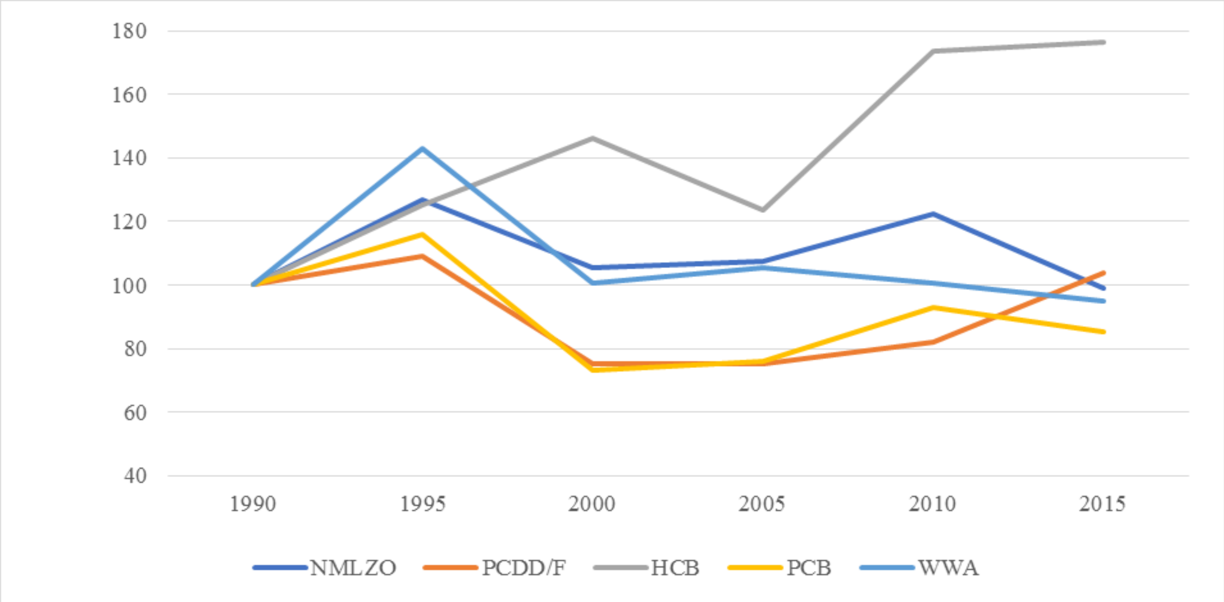



Fig. 4.1.2. Trends in emission of organic hazardous substances to air

**Atmospheric deposition**

According to maps published by EMEP [ESC-E 2017], the approximate values of deposition of heavy hazardous substances in the Polish part of the Baltic Sea are as follows:

- cadmium 17 – 25 g Cd/km$^{-2}$·year,
- lead 0,5 – 0,8 kg Pb/ km$^{-2}$·year,
- benzo(a)pyrene 7 – 20 g/ km$^{-2}$·year,
- PCDD/F (dioxins and furans) 0,15 – 3 ng TEQ/ km$^{-2}$·year,
- HCB 0,19 – 2,0 g/ km$^{-2}$·year,
- PCB-153 0,01 – 0,2 g/ km$^{-2}$·year.

The distribution of deposition is in all cases similar in general terms, i.e. the largest values are concentrated in the area of the Szczecin Lagoon and the Vistula Lagoon and the Gulf of Gdańsk, while the smallest ones usually occur in the area of the central coast.

PMŚ data indicate a systematic and significant decrease in the deposition of heavy metals both on the national scale and in the coastal zone. Changes in deposition of cadmium, lead and chromium in the period 2005-2015 are presented in Fig. 4.1.3 and Fig. 4.1.5. The average deposition of these elements on the coast decreased by 89%, 74% and 73%, respectively. In the case of nickel, zinc and copper, the reductions were 62%, 50% and 18% respectively

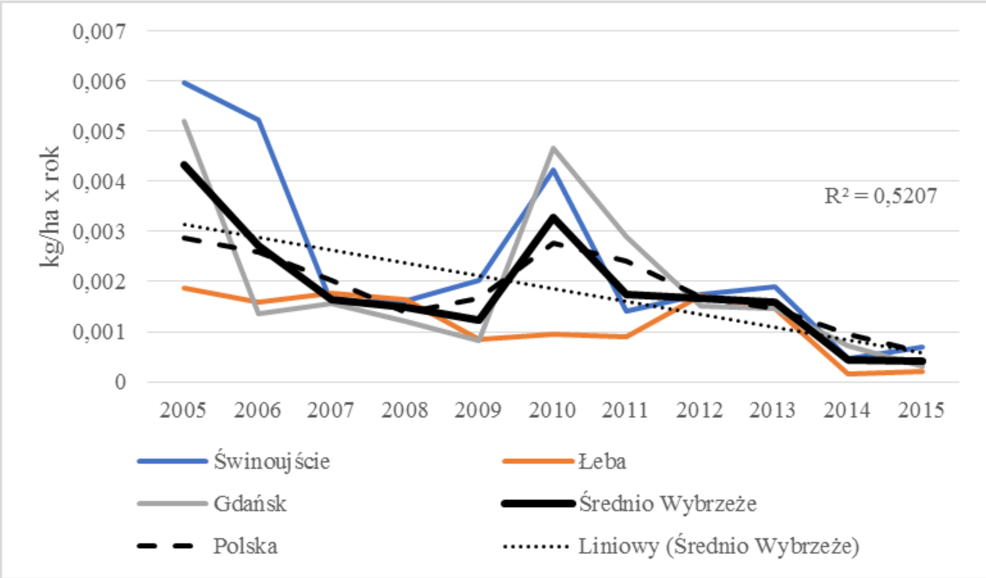



Fig. 4.1.3. Changes in cadmium deposition (vertical axis – kg/ha x year) in 2005-2015 (source: PMŚ)

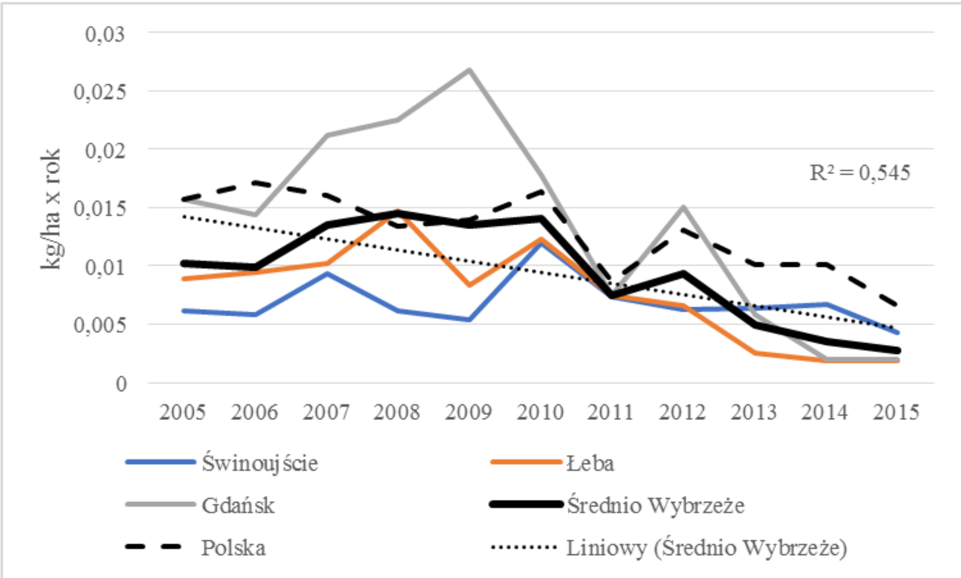



Fig. 4.1.4. Changes in lead deposition(vertical axis – kg/ha x year) in 2005-2015 (source: PMŚ)

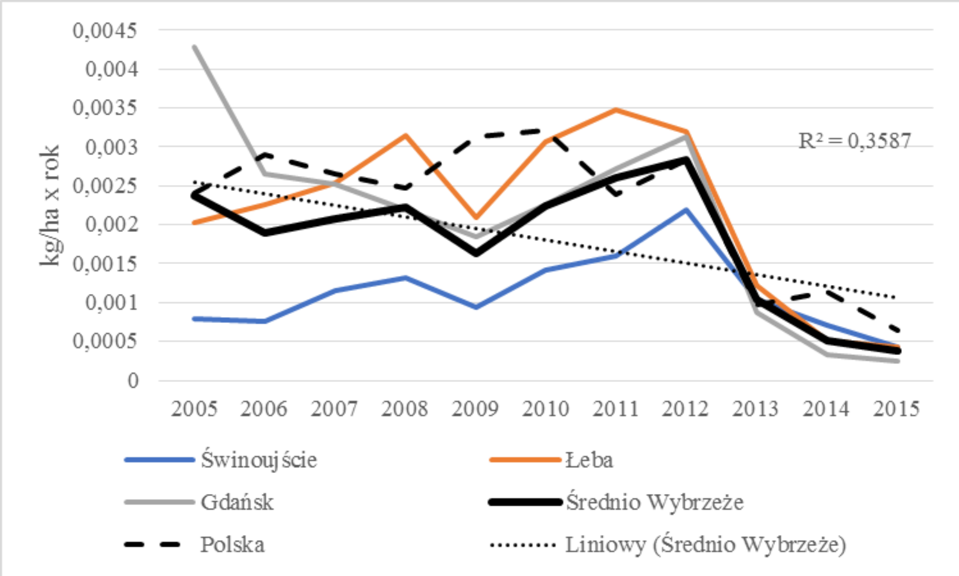



Fig. 4.1.5. Changes in chromium deposition (vertical axis – kg/ha x year) in 2005-2015 (source: PMŚ)

**Concentrations in rivers**

In order to sketch the situation in rivers, the results of monitoring of dangerous substances in 2010 and 2015 were analyzed. Table 4.1.5. shows the ratio of the measured maximum concentrations to the maximum allowable concentrations, and Table 4.1.5 – the ratio of the measured annual average to the permissible mean annual concentrations. Most of the tested substances were in concentrations much below permissible, and some concentrations were below the detection thresholds. Nevertheless, in 2015 in the Oder very large exceedances of some WWA were noted, in Łeba - slight exceedances of some WWA, in Wisła and Odra - increased, although acceptable concentrations of nickel, and in the Pasłęka markedly elevated concentrations of mercury. In turn, in 2010 some of the WWA were exceeded in Wisła, whereas in Reda, concentrations of some WWA reached the acceptance threshold, in Pasłęka there was an increased, although permissible concentration of mercury and nickel, and in Łupawa, Reda and Słupia - elevated concentrations of volatile phenols (Table 4.1.6 and Table 4.1.7).

Table 4.1.5. Ratio of the maximal measured concentrations of hazardous substances to maximal permissible concentrations in estuary sections of rivers in 2015 (Data source: PMŚ)

| Substance | Reda | Vistula | Słupia | Łeba | Łupawa | Pasłęka | Oder | Ina | Rega | Parsęta | Wieprza | Grabowa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | | | | | | | 4.00 | | | | | |
| Benzo(a)pyrene | | | | 2.40 | | | 29.00 | | | | | |
| Benzo(b)fluoranthene + Benzo(k)fluoranthene | | | | 4.00 | | | 213.33 | | | | | |
| Benzo(g, h, i)perylene + indeno(1,2,3)pyrene | | | | 110.00 | | | 3695.00 | | | | | |
| Chromium | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Zinc | 1.26 | 0.26 | 1.15 | 1.45 | 0.91 | 0.30 | 0.80 | 0.90 | | | | |
| Cadmium | 16.47 | 1.80 | 12.44 | 14.89 | 11.44 | 0.30 | 2.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Copper | | | 3.64 | 3.90 | | 6.00 | 6.00 | 6.00 | 1.00 | 1.00 | 8.00 | 8.00 |
| Nickel | 1.45 | 19.10 | 0.00 | 0.00 | 12.50 | 0.00 | 1.50 | 11.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lead | 3.00 | 1.89 | 1.28 | 4.26 | 4.54 | | | | | | | |
| Mercury | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 68.57 | 24.29 | 44.29 | 0.00 | 0.00 | 0.00 | 0.00 |

Table 4.1.6. Ratio of average annual measured concentrations of hazardous substances to average annual permissible concentrations in estuary sections of rivers in 2015 (source: PMŚ)

| Substance | Reda | Vistula | Słupia | Łeba | Łupawa | Pasłęka | Oder | Ina | Rega | Parsęta | Wieprza | Grabowa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | | | | | | | 1.50 | | | | | |
| Benzo(a)pyrene | | | | 0.37 | | | 10.67 | | | | | |
| Benzo(b)fluoranthene + Benzo(k)fluoranthene | | | | 0.76 | | | 32.59 | | | | | |
| Benzo(g, h, i)perylene + indeno(1,2,3)pyrene | | | | 13.13 | | | 767.92 | | | | | |
| Chromium | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Zinc | 0.11 | 0.09 | 0.49 | 0.60 | 0.45 | 0.19 | 0.16 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cadmium | 8.80 | 5.23 | 24.00 | 32.00 | 22.83 | 0.00 | 2.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Copper | 0.00 | 0.00 | 0.30 | 0.33 | 0.00 | 1.00 | 3.50 | 2.33 | 6.00 | 4.83 | 5.00 | 5.33 |
| Nickel | 7.26 | 53.06 | 0.00 | 0.00 | 8.37 | 0.00 | 43.06 | 12.85 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lead | 0.86 | 0.83 | 3.14 | 2.65 | 2.48 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mercury | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 39.50 | 2.83 | 7.33 | 0.00 | 0.00 | 0.00 | 0.00 |

Table 4.1.7. Ratio of maximal measured concentrations of hazardous substances to maximal permissible concentrations in estuary sections of rivers in 2010 (source: PMŚ)

| Row labels | Łeba | Łupawa | Grabowa | Ina | The Oder | Parsęta | Pasłęka | Reda | Rega | Słupia | Wieprza | The Vistula |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 10.00 | 20.00 | | | 0.00 | | 0.00 | 0.00 | | 0.00 | | 0.00 |
| Barium | | | | | | | 10.00 | 6.72 | | | | 8.92 |
| benzo(a)pyrene | 4.00 | | | | | | | 5.00 | | | | 11.00 |
| Benzo(b)fluoranthene + Benzo(k)fluoranthene | 0.00 | | | | | | | 21.00 | | | | 50.00 |
| Benzo(g,h,i)perylene + Indeno(1,2,3)pyrene | 0.00 | | | | | | | 100.00 | | | | 350.00 |
| Chromium6+ | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Chromium | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Boron | | | | | | | 6.00 | 2.02 | | | | 3.10 |
| Zinc | 1.00 | 1.00 | 5.00 | 0.60 | 0.80 | 7.00 | | 0.67 | | 1.30 | | 0.93 |
| Volatile phenols | 70.00 | 90.00 | | | | | | | | 70.00 | | |
| Cadmium | 0.00 | | 0.00 | 0.00 | 0.01 | 0.00 | 23.73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cobalt | 0.00 | | | | | | | | | 0.00 | | |
| Copper | 8.00 | 8.00 | 40.00 | 10.00 | 6.00 | 24.00 | 10.00 | 6.82 | 14.00 | 8.00 | 14.00 | 12.58 |
| Molybdenum | 3.00 | 3.08 | | | | | | | | 3.50 | | |
| Nickel | 7.00 | | | 0.01 | 0.02 | | 92.00 | 11.55 | | | | 15.70 |
| Lead | 0.00 | | 0.00 | 0.03 | 0.00 | 0.00 | 45.69 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mercury | | | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 5.31 | 0.00 | 0.00 | 0.00 | 45.16 |

Table 4.1.8. Ratio of average annual measured concentrations of hazardous substances to average annual permissible concentrations in estuary sections of rivers in 2010 (source: PMŚ)

| Etykiety wierszy | Łeba | Łupawa | Grabowa | Ina | Oder | Parsęta | Pasłęka | Reda | Rega | Słupia | Wieprza | Vistula |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 10.00 | 20.00 | | | | | | | | | | |
| Barium | | | | | | | 3.53 | 3.63 | | | | 8.01 |
| Benzo(a)pyrene | 1.33 | | | | | | | 2.68 | | | | 3.50 |
| Benzo(b)fluoranthene + Benzo(k)fluoranthene | 9.07 | | | | | | | 3.68 | | | | 9.69 |
| Benzo(g, h, i)perylene + indeno(1,2,3)pyrene | 0.00 | | | | | | | 8.33 | | | | 58.33 |
| Chromium6+ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Chromium | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Boron | | | | | | | 6.00 | 1.29 | | | | 2.43 |
| Zinc | 1.00 | 1.00 | 5.00 | 0.28 | 0.35 | 7.00 | | 0.45 | | 1.08 | | 0.52 |
| Volatile phenols | 60.00 | 90.00 | | | | | | | | 70.00 | | |
| Cadmium | 0.00 | | 0.00 | 0.00 | 0.08 | 0.00 | 48.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cobalt | | | | | | | | | | 0.00 | | |
| Copper | 5.00 | 5.11 | 10.73 | 4.22 | 4.33 | 8.73 | 5.33 | 4.70 | 6.18 | 5.11 | 6.55 | 7.71 |
| Molybdenum | 3.00 | 3.08 | | | | | | | | 3.50 | | |
| Nickel | 35.00 | | | 0.01 | 0.01 | | 22.38 | 11.55 | | | | 12.74 |

**Loads from rivers**

Data on heavy metal loads carried to the Baltic Sea by Polish rivers comes from monitoring for the needs of HELCOM [KZGW 2016] and covers the period from 1994. The resulting large variation of loads over time suggests treating this information with caution. For example, in 2011 and 2012 on the Vistula, the cadmium load dropped more than 11 times, and the mercury load on the Odra over 10 times. More than 10-fold decreases in chromium loads from year to year were recorded on the Vistula in 1994 and 1995, 1998 and 1999. In the case of copper in 2010, its cargo carried by the Vistula was almost 4 times larger than the load from the Oder, although Odra dehydrates it. mining areas of this metal. Data regarding cadmium, lead and mercury, i.e. key HELCOM indicators, are shown in Fig. 4.1.6, Fig. 4.1.7 and Fig. 4.1.8. In spite of the strong fluctuations described above, concerning mainly metals occurring in very low concentrations, it can be assumed that there is a general tendency for the decrease of metal loads carried by rivers from the territory of Poland, as indicated by, among others, comparison of means from the first 3 years and the last 3 years of the time series (Table 4.1.9.). These averages decreased by nearly a half in the case of chromium, nickel and copper, about five times in the case of zinc and lead and almost 10 times in the case of cadmium. These data correspond well with the decrease in atmospheric deposition of these metals, so it should be assumed that they are caused not only by activities in the sewage economy, but also in air protection. This is also supported by the fact that the charges estimated for rivers are many times higher than those that result from the registers of fees for the use of the environment.

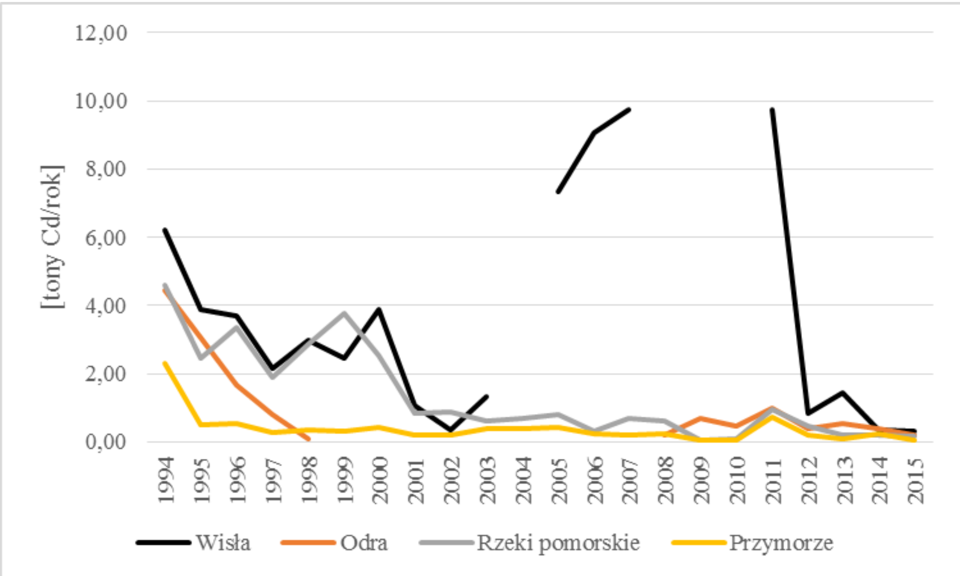



Fig. 4.1.6. Cadmium loads (tonnes/year – vertical axis) the Baltic Sea from Polish rivers according to (KZGW 2016)

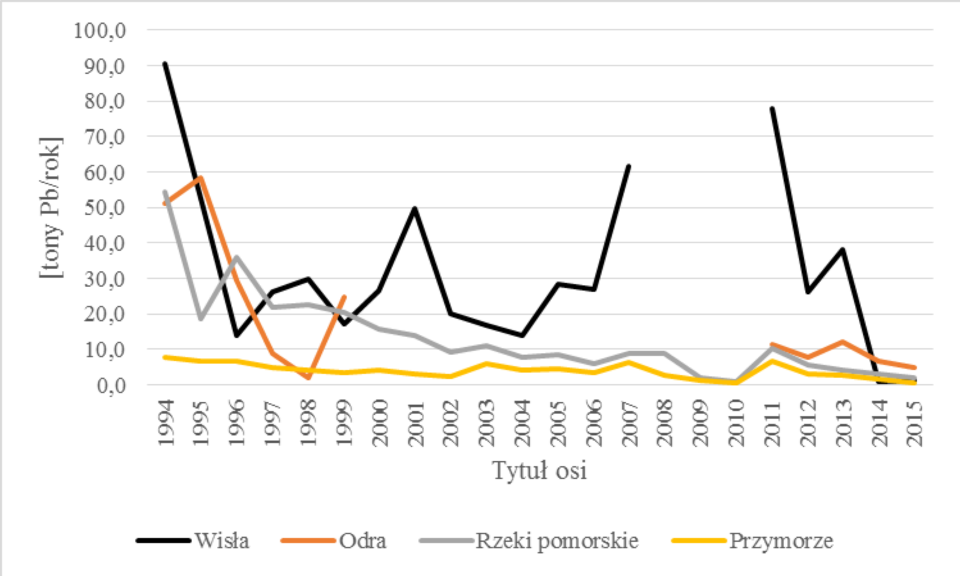



Fig. 4.1.7. Lead loads (tonnes/year – vertical axis) the Baltic Sea from Polish rivers according to (KZGW 2016)

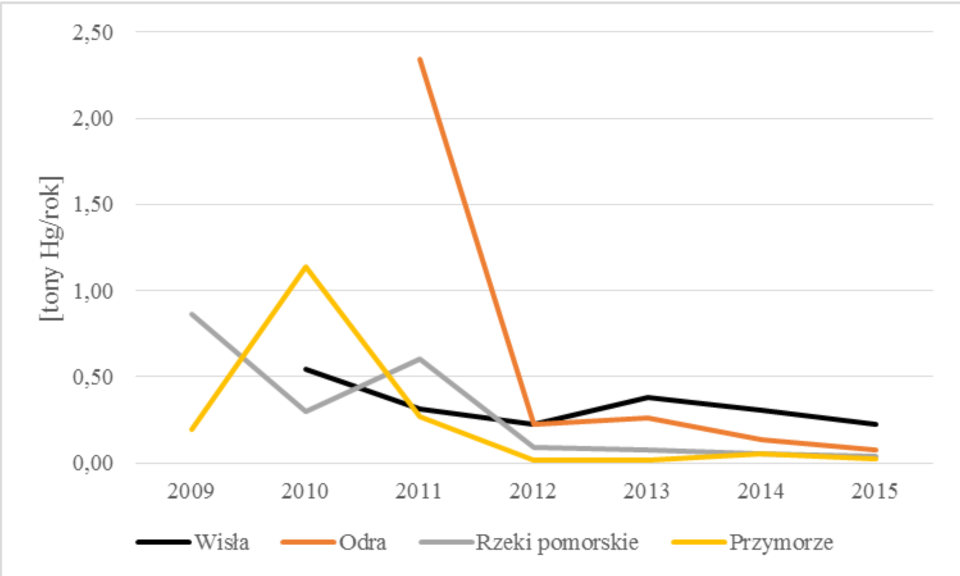



Fig. 4.1.8. Mercury loads (tonnes/year – vertical axis) the Baltic Sea from Polish rivers according to (KZGW 2016)

Table 4.1.9. Long-term changes of heavy metal loads carried by rivers to the Baltic Sea (source: PMŚ)

| Specification | Average annual load [tonnes] | | Change [%] |
|---|---|---|---|
| | 1995-97 | 2013-15 | |
| Chromium (without Przymorze) | 48.0 | 25.6 | -47 |
| Cadmium | 12.2 | 1.4 | -89 |
| Copper | 146.8 | 83.5 | -43 |
| Lead | 141.8 | 26.1 | -82 |
| Zinc | 808.0 | 172.6 | -79 |
| Nickel | 128.0 | 75.7 | -41 |
| Mercury | - | 0.5 | - |

*Introduction of nutrients*

**Typical sources of nitrogen**

Anthropogenic sources of nitrogen in waters, including marine waters, are mainly manure and animal manure as well as mineral fertilizers used in agriculture. An important source of nitrogen is also fumes from means of transport and all stationary sources, mainly from the combustion of fuels for energy purposes. Some contribution to the nitrogen load discharged into waters may have a chemical industry, especially fertilizer.

Nitrogen contained in sewage discharged into the sewage treatment plant is removed in various ways, mainly by means of nitrification and denitrification.

Fuel combustion processes generate nitrogen oxides due to the reaction of molecular nitrogen with oxygen (only at very high temperatures), with hydrocarbon radicals present in the flame, and then with oxygen, and as a result of oxidation of nitrogen forms present in the fuel itself. Nitrogen oxides react with water contained in the air, forming nitric acid, which by dissociating gives nitrates. The nitrates then fall into the waters with rainfall.

**Typical sources of phosphorus**

Anthropogenic sources of phosphorus in waters, including marine waters, are primarily manure and farm animals as well as mineral fertilizers used in agriculture.

Phosphorus in sewage discharged from the treatment plant is in the vast majority in the form of dissolved and immediately absorbable phosphates, and therefore it can be assumed that virtually all phosphorus discharged to surface waters from sewage treatment plants directly contributes to eutrophication.

In some situations, an important element of the phosphorus load from agricultural areas is phosphorus released from organic soils subject to mineralization as a result of drying (drainage drainage). Such soils also release significant amounts of mineral nitrogen.

**Emissions to the aquatic environment from agricultural areas**

The GUS keeps statistics on the consumption of plant protection products in Poland. These data show that the consumption of these funds, calculated for the active substance, increased in the period 2005-2015 by 50%, up to 24 thousand tonnes per year (Fig. 4.1.9). Due to their intended use, the most dominant group of plant protection products are herbicides, followed by fungicides (Statistical Yearbook of Agriculture, 2016). It should be emphasized that the increase in the use of pesticides is not synonymous with the increase of negative impacts on the environment, because as knowledge about the environmental effects of agricultural chemistry increases, regulations are tightened, as a result of which the most dangerous substances disappear from the market. Among other things, organochlorine pesticides have been completely withdrawn from the market. In general, the changes are primarily aimed at eliminating persistent or hardly decomposable, bioaccumulative and carcinogenic substances, for substances which degradation occurs quickly in the environment, so their action, even if not selective, is limited to a specific time and the region in which it was applied. Among popular protection measures plants in Poland are dominated by agents based on heterocyclic compounds, i.e. those organic ring compounds in which there is at least one atom other than the carbon atom in the ring (most often it is nitrogen). A significant part of these compounds resembles biologically active compounds found in living organisms, including nucleic acids. This is one of the reasons why they are relatively easily biodegradable. Another important group are organophosphate insecticides that act on the nervous system. They are also impermanent, but some of them are being phased out, among others due to the strong toxicity towards bees, as well as concerns about potential carcinogenic effects. Among the herbicides, phenoxyacids have a wide application, acting selectively on dicotyledonous plants, such as growth hormone, in appropriate doses causing uncontrolled growth, leading to death. Also this group is short-term relationships, decaying after a few weeks or months. Inorganic compounds include fungicides based on inorganic copper compounds. Organic mercury fungicides have been withdrawn.

The above review leads to the conclusion that despite the increase in the use of plant protection products, their overall environmental impact, including the aquatic environment, is decreasing. This does not mean, however, that modern measures do not threaten water at all, or that the effects of their use have been fully recognized. From the point of view of the protection of the sea, it is important, among others, that due to the fast decay time, these compounds mostly do not have the possibility of migration from the mainland to the Baltic Sea, so if they pose a threat to the aquatic environment (e.g. as a result of misusing), it is it is rather a threat to inland waters than marine waters.

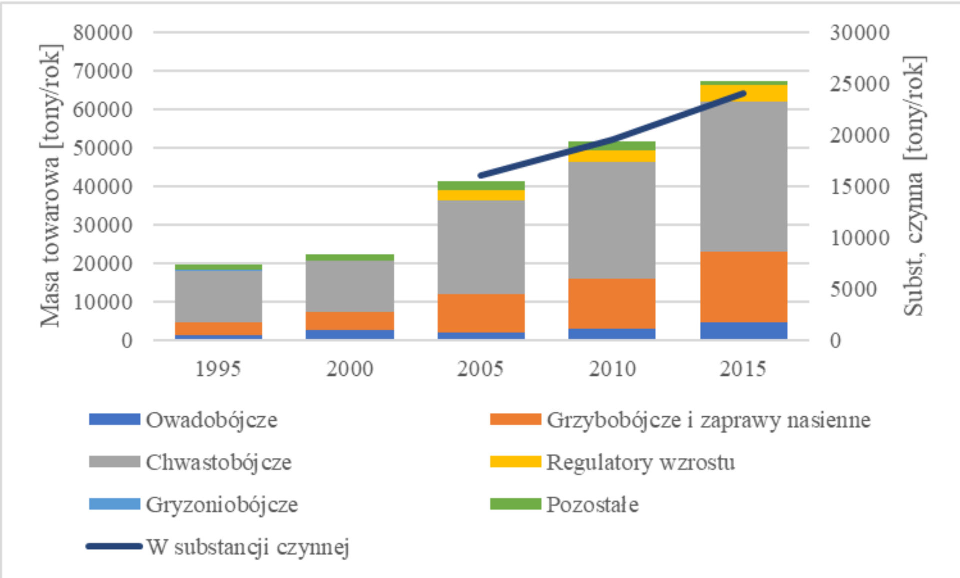



Fig. 4.1.9. The consumption of pesticides in Poland according to GUS.

### Atmospheric deposition

Direct atmospheric deposition into sea plays an important role in supplying nitrogen to the Baltic Sea and much smaller in supplying the sea with phosphorus. The intensity of nitrogen deposition in Poland in the years 2005-2015 showed a declining trend (decrease from approx. 12 kg N / ha x year to approx. 8 kg N / ha x year), but on the Coast this trend did not become visible, and unit loads both at the beginning and at the end of the period, on average, less than 7 kg N / ha x year (Fig. 4.1.10). In 2015, ammonia had the largest proportion of the nitrogen basin on the Coast, the sum of nitrites and nitrates accounted for 27%, and the remaining (organic) forms of nitrogen - 32% (Fig. 4.1.11 and Fig. 4.1.12).

The average deposition of total phosphorus over the sea fell from 0.31 kg P / ha in 2005 to 0.21 kg P / ha in 2015, reflecting the dominant tendency in the whole country (Fig. 4.1.13).

Nitrogen deposition to the Baltic Sea is modeled as part of the EMEP program as part of the implementation of the Convention on Transboundary Air Pollution (MSC-E 2017). Fig. 4.1.13 was drawn up based on EMEP data for 2015. Modeling results indicate a clear negative deposition gradient in the north-east direction. The Szczecin Lagoon receives a load of over 12 kg N / ha x year, while the open waters of the eastern Baltic Sea - only about 6 kg N / ha x year. The total nitrogen load deposited in POM in 2015 amounted to 27.2 thousand according to the EMEP model tonnes of N. This is 22% less than 34.9 thousand. N tonnes recorded in 2005.

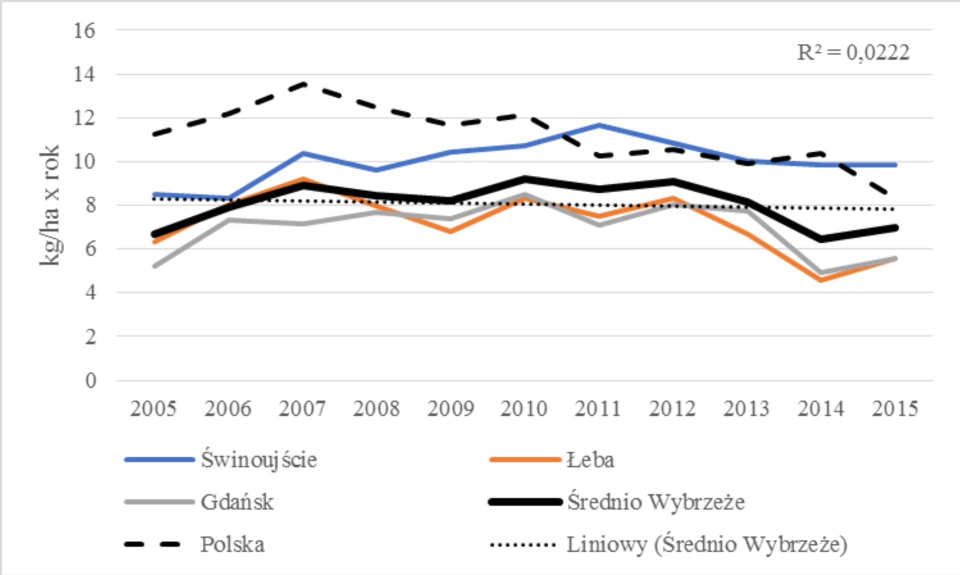



Fig. 4.1.10. Trends in total nitrogen deposition (vertical axis – kg/ha x year) on the Polish coast (source: PMŚ)

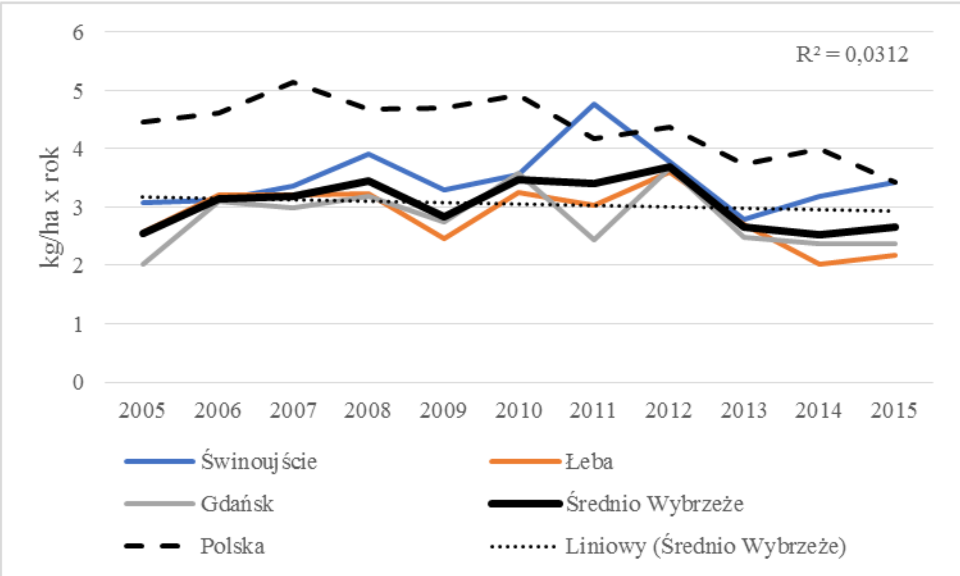



Fig. 4.1.11. Trends of total deposition of ammonia (vertical axis – kg/ha x year) on the Polish coast (source: PMŚ)

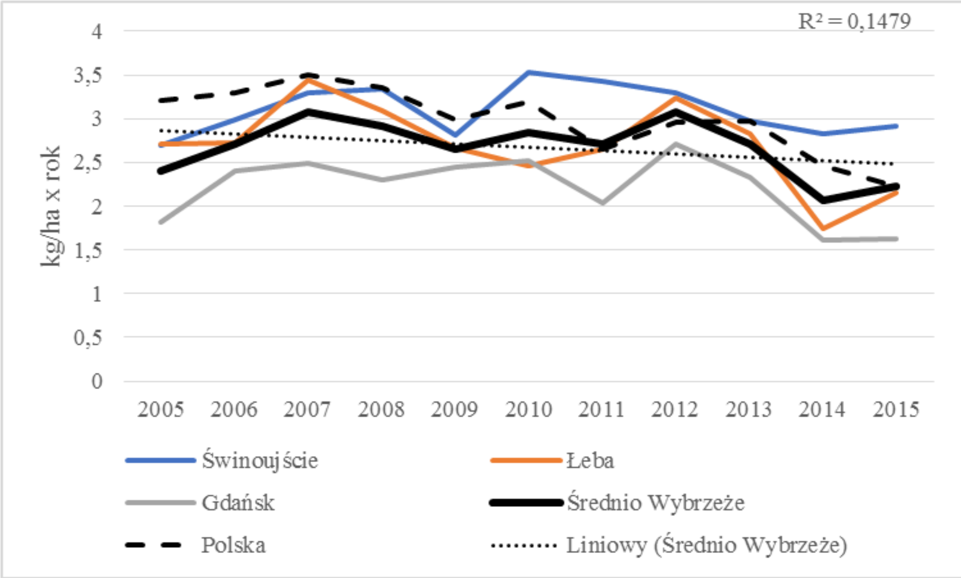



Fig. 4.1.12. Trends in total deposition of the sum of nitrate and nitrite nitrogen (vertical axis – kg/ha x year) on the Polish coast (source: PMŚ)

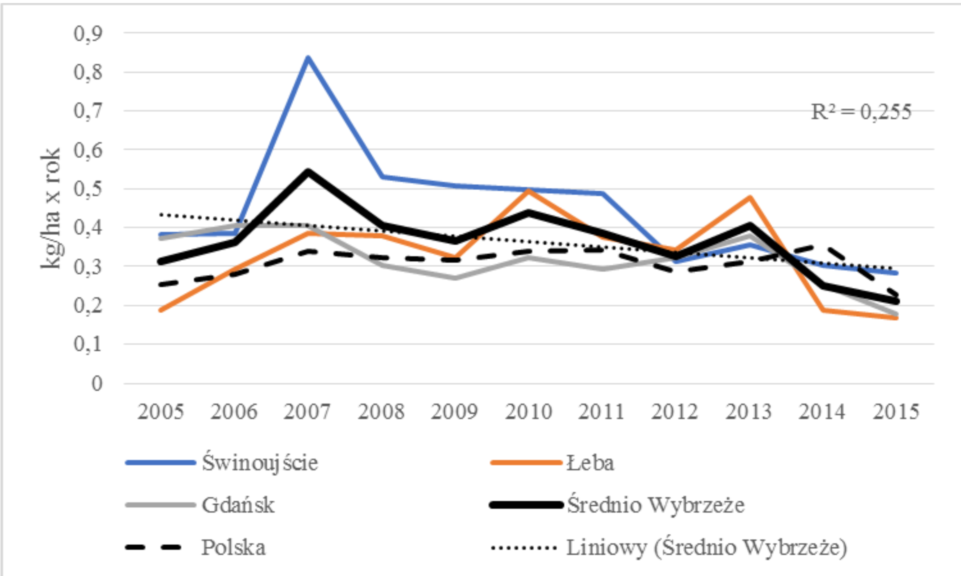



Fig. 4.1.13. Trends of total deposition of total phosphorus (vertical axis – kg/ha x year) on the Polish coast (source: PMŚ)

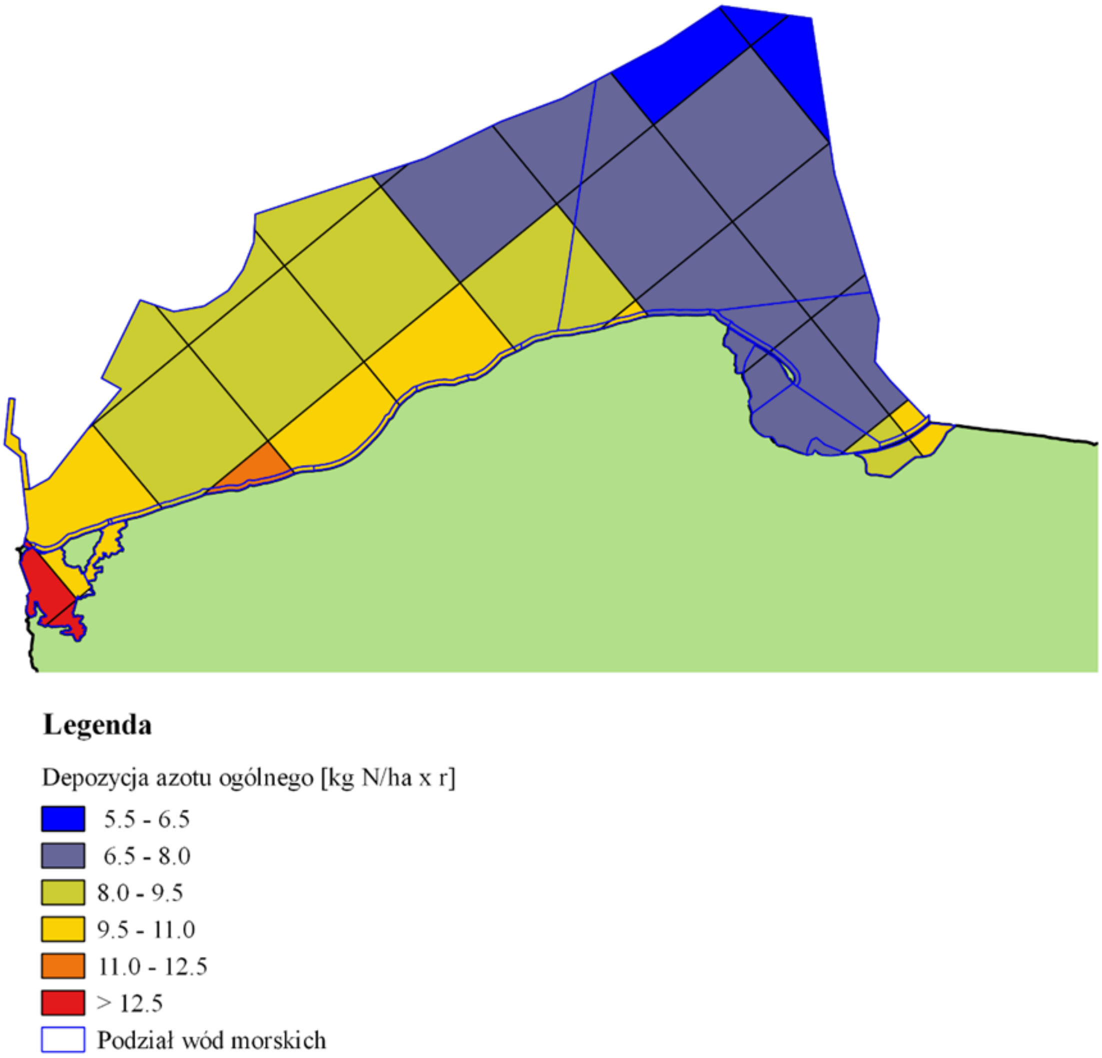



Fig. 4.1.14. Atmospheric deposition of total nitrogen (kg/ha x year) in POM in 2015

### Loads from rivers

Loads of nitrogen and phosphorus discharged by Polish rivers to the Baltic Sea have been regularly monitored since 1994 as part of obligations under the Helsinki Convention. These charges are the resultant on the one hand changes taking place at the source of emissions, and on the other hand - the changing hydrological conditions, largely shaping the processes of transporting nutrients from their sources to inland waters, and then to the sea. Due to the dominant influence of nitrogen and phosphorus area sources, there is a clear relationship between instantaneous, seasonal and annual volumes of flow and temporary, seasonal and annual loads of these pollutants. To eliminate the impact of fluctuations in flows on the image of changes in the Baltic external load, nutrients are normalized with respect to the flow of nutrients. This study uses the standardization method recommended by HELCOM [HELCOM 2015], based on the following equation:

$$LiN = \exp\left(LnLi \cdot \frac{\alpha + \beta \cdot logQsr}{\alpha + \beta \cdot logQi}\right) \cdot \exp^{0,5 \cdot MSE}$$

where:

LiN – normalized load in year i,

Li – actual charge in a year and,

α – intersection with the y axis of the Li regression equation from logQi,
β – the slope of the Li regression equation from logQi,
Qsr – average annual flow in the surveyed multi-year period,
Qi – annual flow in the year i,
MSE – mean square error of the LnLi value predicted by the regression equation.

**Nitrogen**

In the Vistula river basin district (Fig. 4.1.15) annual real loads of nitrogen changed from 131.1 thous. tonnes in 1994 to 42.7 thousand tonnes in 2015, the highest value (162.4 thousand tonnes) was recorded in 1996, and the lowest (43.7 thousand tonnes) in 2015. Standardized load changed from PLN 138.9 thousand tonnes in 1994 to 72.3 thousand tonnes in 2015, the highest value (151.1 thousand tonnes) was recorded in 1996, and the lowest (70.3 thousand tonnes) in 2012. The time trend of normalized load was decreasing with the correlation coefficient $r^2 = 0.46$. The observed trend was statistically significant (p value = 0.0006).

In the Odra river basin district (Fig. 4.1.16) annual real loads of nitrogen varied from 105.4 thousand tonnes in 1994 to 26.3 thousand. tons in 2015, while at the same time they were the most extreme values recorded in the entire long-term. Standardized load changed from 84.2 thousand tonnes in 1994 to 56.2 thousand tonnes in 2015, with the highest value (84.2 thousand tonnes) recorded in 1994, and the lowest (50.8 thousand tonnes) in 1997. The time trend of normalized load was decreasing with the correlation coefficient $r^2$ 0.23. The observed trend was statistically significant (p value = 0.02).

In the catchments of the Pomeranian rivers considered together with the Przymorze (Fig. 4.1.17) the annual loads of nitrogen varied from 18.2 thousand tonnes in 1994 to 9.8 thousand tonnes in 2015, the highest value (19.3 thousand tonnes) was recorded in 1998, and the lowest (8.1 thousand tonnes) in 2009. Standardized load changed from 16.2 thousand tonnes in 1994 to 13.1 thousand tonnes in 2015, the highest value (16.1 thousand tonnes) was recorded in 1994, and the lowest (9.1 thousand tonnes) in 2009. The time constraint of normalized load was decreasing with the correlation coefficient $r^2 = 0.31$. The observed trend was statistically significant (p-value = 0.007).

The total annual nitrogen load discharged from Poland directly to the Baltic Sea varied from 264.8 thous. tonnes in 1994 to 83.1 thousand tonnes in 2015, the highest value (277.4 thousand tonnes) was recorded in 1998, and the lowest (83.1 thousand tonnes) in 2015 (Table 4.1.10.). Normalized loads (Fig. 4.1.18) changed from 249.4 thousand tonnes in 1994 to 148.0 thousand tonnes in 2015, with the highest value (249.4 thousand tonnes) recorded in 1994, and the lowest (142.9 thousand tonnes) in 2012. The time trend of normalized load was decreasing with the correlation coefficient $r^2 = 0.51$. The observed trend was statistically significant (p value = 0.0002).

The nitrogen load discharged from the Polish part of the Pregoła river basin amounted to 2071 tonnes in 2015.

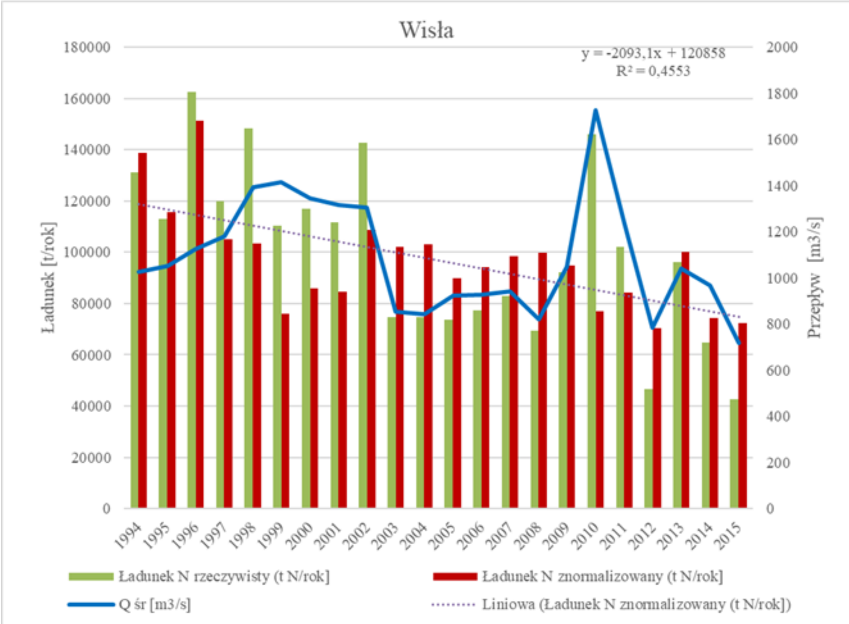



Fig. 4.1.15. Actual and normalized total nitrogen loads (tonnes/year) to the Baltic Sea from the Vistula river in the years 1994 - 2015. Right vertical axis (flow m³/s). Own elaboration based on data. (source: PMŚ, IMGW-PIB).

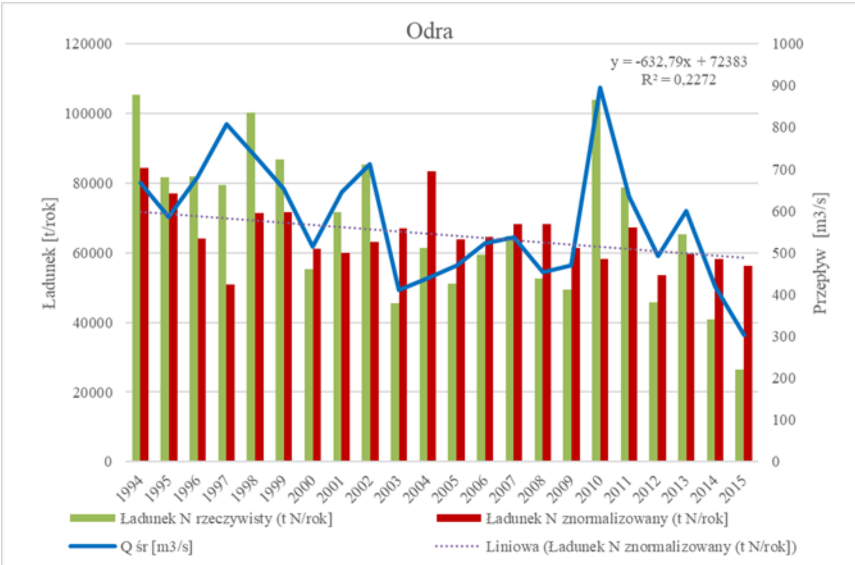



Fig. 4.1.16. Actual and normalized total nitrogen loads (tonnes/year) carried to the Baltic Sea by Odra river in the years 1994-2015. Right vertical axis (flow m³/s). Own elaboration based on data (source: PMŚ, IMGW-PIB)

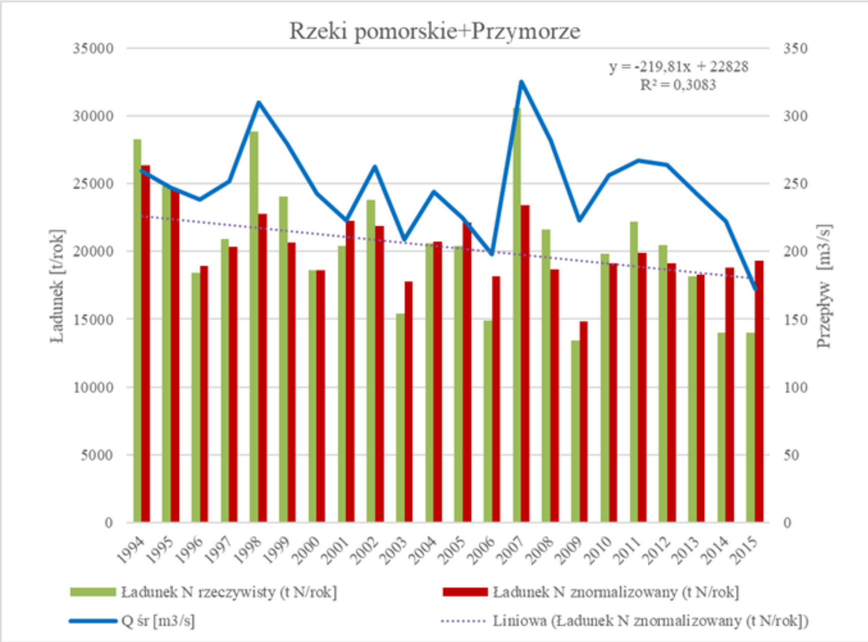



Fig. 4.1.17. Actual and normalized total nitrogen loads (tonnes/year) to the Baltic Sea from the Pomeranian rivers and the Przymorze region in the years 1994-2015. Right vertical axis (flow m³/s). Own elaboration based on data (source: PMŚ, IMGW-PIB)

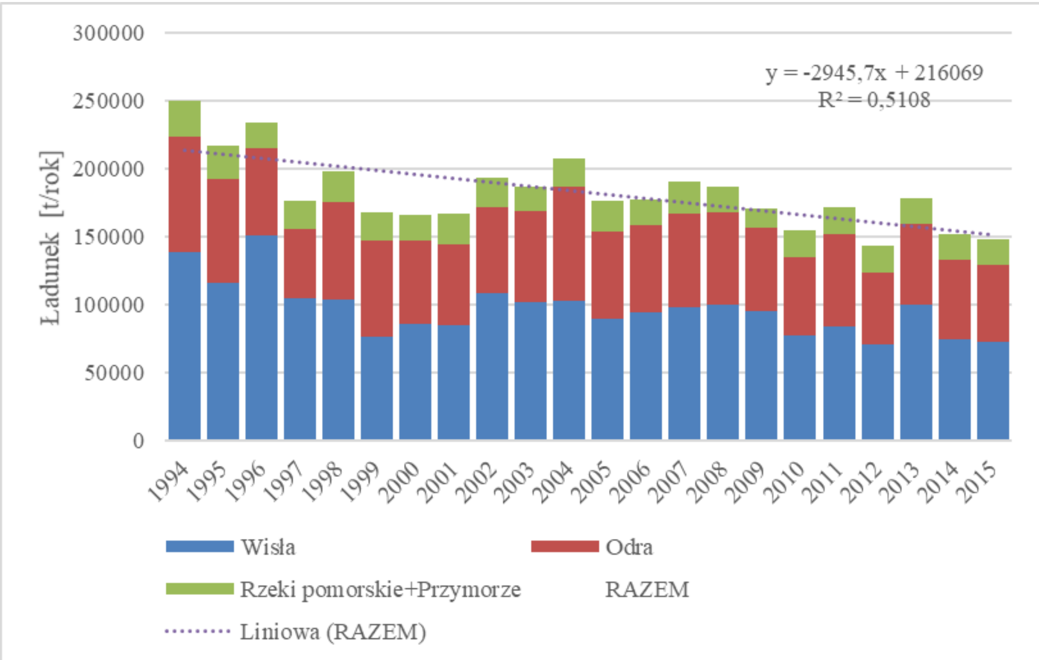



Fig. 4.1.18. Total nitrogen load (tonnes/year) from Poland to the Baltic Sea (source: PMŚ)

Table 4.1.10. List of actual flows and loads and normalized loads of total nitrogen from Vistula, Oder, Pomeranian rivers and Przymorze region to the Baltic Sea in 1994-2015 (PMŚ, IMGW-PIB data source)

| Rzeka | Wyszczególnienie/Rok | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grabowa | Q śr [m3/s] | 8,0 | 9,0 | 10,2 | 8,7 | 10,6 | 8,5 | 8,3 | 8,7 | 8,2 | 7,6 | 8,0 | 8,2 | 7,5 | 8,9 | 9,5 | 9,2 | 8,9 | 8,0 | 9,1 | 7,6 | 21,7 | 6,3 |
| | Ład. N rzecz. [t N/rok] | 604 | 612 | 477 | 513 | 757 | 536 | 490 | 691 | 537 | 468 | 543 | 565 | 481 | 636 | 566 | 412 | 553 | 500 | 578 | 544 | 716 | 450 |
| | Ład. N norm. [t N/rok] | 627 | 610 | 454 | 516 | 708 | 543 | 502 | 696 | 552 | 494 | 565 | 582 | 510 | 635 | 553 | 406 | 552 | 517 | 573 | 575 | 523 | 508 |
| Ina | Q śr [m3/s] | 16,8 | 13,2 | 12,1 | 14,8 | 19,0 | 20,7 | 19,6 | 17,9 | 22,1 | 14,6 | 12,6 | 8,3 | 8,8 | 13,9 | 13,9 | 10,9 | 15,1 | 16,8 | 13,5 | 11,3 | 8,0 | 9,2 |
| | Ład. N rzecz. [t N/rok] | 2732 | 1903 | 1311 | 1518 | 3006 | 2813 | 1793 | 2195 | 3094 | 1301 | 1913 | 1215 | 881 | 2038 | 1898 | 1396 | 2318 | 2275 | 1806 | 1613 | 1058 | 1207 |
| | Ład. N norm. [t N/rok] | 2206 | 1975 | 1485 | 1408 | 2132 | 1839 | 1265 | 1673 | 1890 | 1224 | 2094 | 2039 | 1362 | 2015 | 1874 | 1774 | 2093 | 1842 | 1836 | 1963 | 1843 | 1817 |
| Łeba | Q śr [m3/s] | 22,3 | 22,4 | 20,0 | 20,4 | 28,6 | 21,9 | 18,3 | 20,9 | 21,0 | 16,6 | 19,9 | 17,7 | 16,6 | 22,9 | 22,2 | 20,4 | 22,2 | 19,8 | 23,3 | 21,3 | 22,1 | 16,0 |
| | Ład. N rzecz. [t N/rok] | 2391 | 2295 | 1702 | 1850 | 1976 | 1559 | 1406 | 1746 | 1636 | 1298 | 1664 | 1428 | 1312 | 2301 | 1613 | 1205 | 1574 | 1527 | 1642 | 1429 | 1114 | 1245 |
| | Ład. N norm. [t N/rok] | 2232 | 2137 | 1755 | 1873 | 1487 | 1484 | 1568 | 1734 | 1615 | 1581 | 1729 | 1647 | 1597 | 2097 | 1520 | 1221 | 1480 | 1588 | 1481 | 1393 | 1056 | 1567 |
| Łupawa | Q śr [m3/s] | 9,5 | 11,7 | 8,9 | 10,1 | 12,0 | 9,1 | 10,7 | 9,3 | 12,1 | 9,0 | 8,1 | 9,2 | 8,9 | 12,4 | 10,8 | 10,1 | 10,3 | 9,3 | 9,9 | 9,9 | 5,0 | 8,1 |
| | Ład. N rzecz. [t N/rok] | 1029 | 1144 | 849 | 964 | 872 | 631 | 940 | 855 | 967 | 750 | 683 | 827 | 834 | 1300 | 926 | 785 | 878 | 837 | 817 | 815 | 705 | 697 |
| | Ład. N norm. [t N/rok] | 1040 | 1015 | 891 | 935 | 767 | 650 | 882 | 874 | 846 | 780 | 753 | 848 | 873 | 1115 | 868 | 763 | 843 | 851 | 805 | 803 | 1049 | 771 |
| Odra | Q śr [m3/s] | 666,3 | 585,7 | 681,7 | 806,8 | 731,0 | 652,1 | 514,8 | 644,8 | 712,3 | 411,3 | 439,7 | 468,7 | 522,8 | 536,7 | 453,9 | 468,7 | 894,9 | 633,8 | 492,9 | 600,7 | 418,8 | 302,1 |
| | Ład. N rzecz. [t N/rok] | 105414 | 81628 | 81881 | 79500 | 100138 | 86862 | 55182 | 71546 | 85233 | 45619 | 61441 | 51191 | 59319 | 64822 | 52468 | 49289 | 103865 | 78749 | 45816 | 65219 | 40766 | 26343 |
| | Ład. N norm. [t N/rok] | 84234 | 76943 | 63949 | 50814 | 71439 | 71551 | 61120 | 59945 | 63040 | 66961 | 83452 | 63751 | 64484 | 68216 | 68114 | 61338 | 58084 | 67299 | 53462 | 59665 | 58246 | 56221 |
| Parsęta | Q śr [m3/s] | 33,6 | 30,5 | 26,5 | 26,3 | 42,1 | 37,2 | 30,0 | 26,2 | 37,5 | 22,2 | 27,2 | 27,1 | 23,5 | 40,1 | 28,1 | 27,5 | 29,5 | 27,3 | 27,7 | 24,1 | 12,2 | 19,6 |
| | Ład. N rzecz. [t N/rok] | 2983 | 2664 | 1720 | 1898 | 3946 | 2752 | 2134 | 2176 | 2946 | 1453 | 2148 | 2861 | 1624 | 3435 | 1869 | 454 | 2062 | 1723 | 2394 | 1744 | 1382 | 1568 |
| | Ład. N norm. [t N/rok] | 2482 | 2428 | 1787 | 1991 | 2647 | 2094 | 1984 | 2288 | 2221 | 1770 | 2186 | 2921 | 1888 | 2425 | 1847 | 455 | 1945 | 1743 | 2388 | 1978 | 3049 | 2164 |
| Pasłęka | Q śr [m3/s] | 18,9 | 17,5 | 11,9 | 14,6 | 21,6 | 24,3 | 20,0 | 16,1 | 18,5 | 13,7 | 19,6 | 15,0 | 12,1 | 24,4 | 25,7 | 12,2 | 11,6 | 12,8 | 15,4 | 15,8 | 11,2 | 7,9 |
| | Ład. N rzecz. [t N/rok] | 1850 | 1480 | 1147 | 1593 | 2271 | 2179 | 1413 | 1334 | 1346 | 1168 | 1674 | 1168 | 1216 | 3131 | 2584 | 1040 | 1250 | 1259 | 1516 | 1127 | 923 | 884 |
| | Ład. N norm. [t N/rok] | 1551 | 1339 | 1500 | 1715 | 1666 | 1434 | 1130 | 1307 | 1156 | 1337 | 1358 | 1220 | 1575 | 2015 | 1602 | 1325 | 1687 | 1541 | 1545 | 1122 | 1271 | 1745 |
| Reda | Q śr [m3/s] | 5,4 | 5,9 | 5,2 | 4,4 | 5,4 | 5,7 | 6,7 | 5,0 | 5,2 | 4,1 | 5,6 | 4,8 | 3,8 | 6,7 | 5,0 | 4,6 | 5,7 | 5,3 | 4,3 | 4,4 | 14,1 | 3,7 |
| | Ład. N rzecz. [t N/rok] | 376 | 379 | 511 | 249 | 319 | 381 | 364 | 257 | 253 | 228 | 310 | 236 | 195 | 429 | 312 | 254 | 346 | 357 | 220 | 233 | 172 | 203 |
| | Ład. N norm. [t N/rok] | 376 | 375 | 514 | 255 | 320 | 378 | 355 | 259 | 254 | 235 | 309 | 239 | 203 | 418 | 315 | 259 | 344 | 358 | 225 | 239 | 156 | 212 |
| Rega | Q śr [m3/s] | 23,6 | 21,0 | 20,6 | 18,5 | 26,0 | 25,9 | 22,7 | 17,4 | 24,8 | 13,8 | 17,2 | 19,8 | 14,0 | 23,8 | 21,8 | 17,4 | 18,7 | 24,6 | 20,7 | 20,5 | 10,9 | 16,3 |
| | Ład. N rzecz. [t N/rok] | 2697 | 2632 | 2045 | 1741 | 3338 | 2726 | 1874 | 1795 | 2628 | 1200 | 1635 | 2215 | 1095 | 2603 | 1730 | 1160 | 1580 | 2856 | 1575 | 1693 | 1176 | 1604 |
| | Ład. N norm. [t N/rok] | 2125 | 2409 | 1914 | 1872 | 2319 | 1920 | 1564 | 2091 | 1952 | 1866 | 1925 | 2175 | 1657 | 2030 | 1516 | 1333 | 1670 | 2129 | 1468 | 1603 | 2509 | 2014 |
| Słupia | Q śr [m3/s] | 16,4 | 17,3 | 15,5 | 16,8 | 22,3 | 18,2 | 16,3 | 16,6 | 18,3 | 14,3 | 16,1 | 13,7 | 13,7 | 19,5 | 17,4 | 16,2 | 18,1 | 17,2 | 19,9 | 16,5 | 15,9 | 14,5 |
| | Ład. N rzecz. [t N/rok] | 1826 | 1727 | 1316 | 1512 | 1380 | 1005 | 1231 | 1147 | 1061 | 905 | 1007 | 880 | 900 | 1531 | 826 | 823 | 1136 | 1248 | 1260 | 983 | 864 | 1034 |
| | Ład. N norm. [t N/rok] | 1882 | 1693 | 1430 | 1524 | 1083 | 947 | 1280 | 1167 | 994 | 1055 | 1053 | 1060 | 1086 | 1347 | 811 | 857 | 1073 | 1230 | 1093 | 1007 | 916 | 1193 |
| Wieprza | Q śr [m3/s] | 17,5 | 19,0 | 18,2 | 18,1 | 23,0 | 20,7 | 19,6 | 16,1 | 19,4 | 14,5 | 17,9 | 16,3 | 14,3 | 20,2 | 17,8 | 13,7 | 14,6 | 16,8 | 18,5 | 17,4 | 8,2 | 13,9 |
| | Ład. N rzecz. [t N/rok] | 1725 | 1737 | 1444 | 1452 | 1463 | 1334 | 1222 | 1230 | 1260 | 849 | 1256 | 1281 | 861 | 1338 | 986 | 607 | 827 | 982 | 1084 | 970 | 633 | 920 |
| | Ład. N norm. [t N/rok] | 1659 | 1521 | 1328 | 1348 | 1062 | 1079 | 1047 | 1297 | 1087 | 993 | 1179 | 1328 | 1021 | 1109 | 936 | 749 | 959 | 987 | 984 | 943 | 1385 | 1126 |
| Wisła | Q śr [m3/s] | 1027,4 | 1051,4 | 1125,4 | 1178,5 | 1391,2 | 1415,5 | 1345,3 | 1314,9 | 1303,9 | 851,8 | 843,9 | 924,5 | 926,8 | 942,8 | 820,6 | 1047,7 | 1726,7 | 1235,7 | 785,4 | 1039,9 | 966,8 | 718,4 |
| | Ład. N rzecz. [t N/rok] | 131117 | 112799 | 162425 | 119796 | 148368 | 110336 | 117021 | 111618 | 142547 | 74792 | 74510 | 73840 | 77444 | 82865 | 69512 | 92107 | 145867 | 102089 | 46680 | 96174 | 64873 | 42699 |
| | Ład. N norm. [t N/rok] | 138745 | 115533 | 151140 | 104892 | 103505 | 75959 | 85919 | 84549 | 108550 | 102168 | 103116 | 89984 | 94122 | 98456 | 99872 | 94761 | 76979 | 84088 | 70308 | 99972 | 74243 | 72480 |
| Przymorze | Q śr [m3/s] | 87,1 | 79,8 | 89,3 | 98,9 | 99,1 | 86,7 | 70,7 | 68,5 | 75,7 | 78,7 | 91,7 | 84,4 | 74,8 | 132,6 | 110,0 | 81,0 | 101,3 | 109,1 | 101,6 | 94,2 | 93,2 | 57,0 |
| | Ład. N rzecz. [t N/rok] | 10049 | 8226 | 5919 | 7638 | 9552 | 8131 | 5740 | 7008 | 8058 | 5813 | 7794 | 7708 | 5521 | 11840 | 8284 | 5278 | 7302 | 8609 | 7591 | 7045 | 5290 | 4209 |
| | Ład. N norm. [t N/rok] | 10192 | 9049 | 5869 | 6914 | 8604 | 8280 | 7019 | 8861 | 9311 | 6452 | 7545 | 8046 | 6409 | 8186 | 6818 | 5702 | 6476 | 7131 | 6710 | 6660 | 5059 | 6212 |
| RAZEM | Q śr [m3/s] | 1952,8 | 1884,3 | 2045,6 | 2236,9 | 2431,9 | 2346,6 | 2103,0 | 2182,4 | 2279,1 | 1472,2 | 1527,4 | 1617,8 | 1647,6 | 1804,8 | 1556,5 | 1739,6 | 2877,6 | 2136,7 | 1542,3 | 1883,6 | 1608,2 | 1192,9 |
| | Ład. N rzecz. [t N/rok] | 264795 | 219224 | 262746 | 220225 | 277385 | 221244 | 190811 | 203597 | 251566 | 135845 | 156579 | 145415 | 151684 | 178269 | 143576 | 154809 | 269559 | 203008 | 112978 | 179589 | 119672 | 83063 |
| | Ład. N norm. [t N/rok] | 249351 | 217027 | 234016 | 176056 | 197739 | 168158 | 165635 | 166743 | 193468 | 186915 | 207263 | 175841 | 176787 | 190064 | 186645 | 170942 | 154186 | 171304 | 142878 | 177924 | 151305 | 148030 |

**Phosphorus**

In the Vistula river basin district (Fig. 4.1.19) the annual actual phosphorus loads changed from 6.00 thous. tonnes in 1994 to 3.00 thousand tonnes in 2015, the highest value (9.22 thousand tonnes) was recorded in 2010, and the lowest (3.00 thousand tonnes) in 2015. Standardized loads changed from 6.25 thousand tonnes in 1994 to 4.66 thous. tonnes in 2015, with the highest value (8.95 thousand tonnes), recorded in 2014, and the lowest (4.66 thousand tonnes) in 2015. From the statistical point of view, the trend of the normalized load was practically absent ($r^2$ = 0.006, p value = 0.74).

In the Oder river basin district (Fig. 4.1.20) annual actual phosphorus loads have changed from 5.55 thousand tonnes in 1994 to 1.48 thousand tonnes in 2015, the highest value (7.54 thousand tonnes) was recorded in 1997, and the lowest (1.48 thousand tonnes) in 2015. Standardized loads changed from 4.37 thousand tonnes in 1994 to 3.27 thousand tonnes in 2015, with the highest value (4.89 thousand tonnes) recorded in 1995, and the lowest (2.47 thousand tonnes) in 2010. The time trend of the normalized cargo was clear and decreasing at a rate correlation r2 = 0.60. The observed trend was statistically significant (p value = 0.00002).

In the catchments of the Pomeranian rivers considered together with the Przymorze area (Fig. 4.1.21) the annual real loads of phosphorus changed from 1.62 thousand tonnes in 1994 to 0.80 thousand tonnes in 2015, the highest value (1.77 thousand tonnes) was recorded in 1998, and the lowest (0.80 thousand tonnes) in 2015. Standardized loads changed from 1.52 thousand tonnes in 1994 to 1,02 thousand tonnes in 2015, the highest value (1.60 thousand tonnes) was recorded in 1997, and the lowest (0.94 thousand tonnes) in 20111. The time trend of the normalized load was clear and decreasing with the coefficient correlation $r^2$ = 0.75. The observed trend was statistically significant (p value = 0.00000016).

The total annual phosphorus load discharged from Poland directly to the Baltic Sea changed from 13.12 thousand. tons in 1994 to 5.28 thousand tonnes in 2015, with the highest value (168,000 tonnes) recorded in 1997, and the lowest (5,28 thousand tonnes) in 2015 (Table 4.1.11.) Standardized loads (Fig. 4.1.22) changed from 12,14 thousand tonnes in 1994 to 8.97 thousand tonnes in 2015, with the highest value (13.87 thousand tonnes) recorded in 1995, and the lowest (8.89 thousand tonnes) in 2010. The time constraint of the normalized load was clear and decreasing with correlation coefficient $r^2$ = 0.30. The observed trend was statistically significant (p-value = 0.008).

The load of phosphorus discharged from the Polish part of the Pregoła river basin amounted to 92 tonnes in 2015.

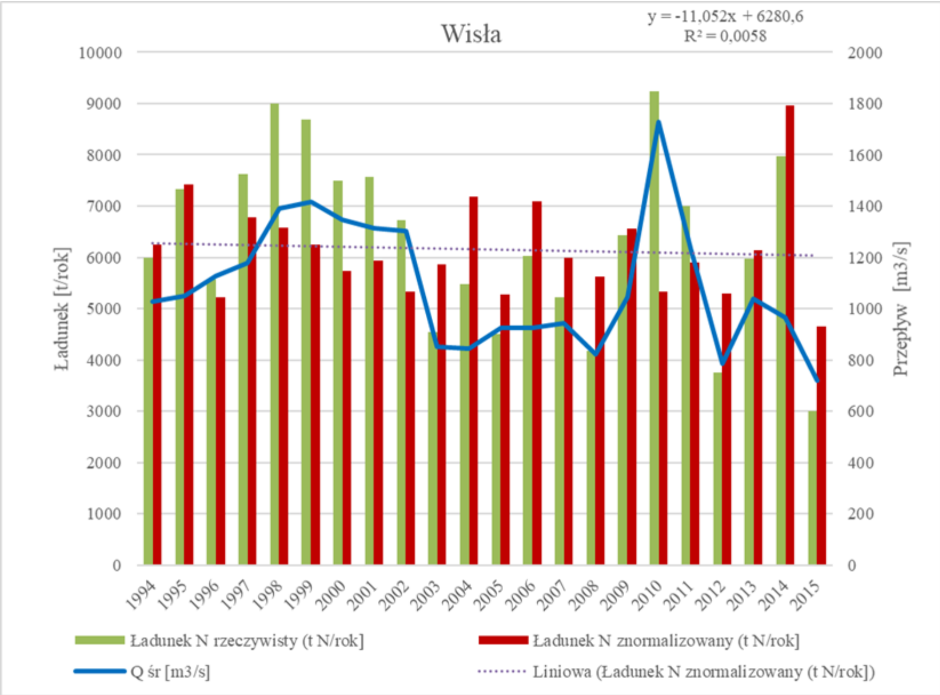



Fig. 4.1.19. Actual and normalized total phosphorus loads (tonnes/year) to the Baltic Sea from the Vistula river in the period 1994 - 2015. Right vertical axis (flow m³/s). Own elaboration based on data (source: PMŚ, IMGW-PIB)

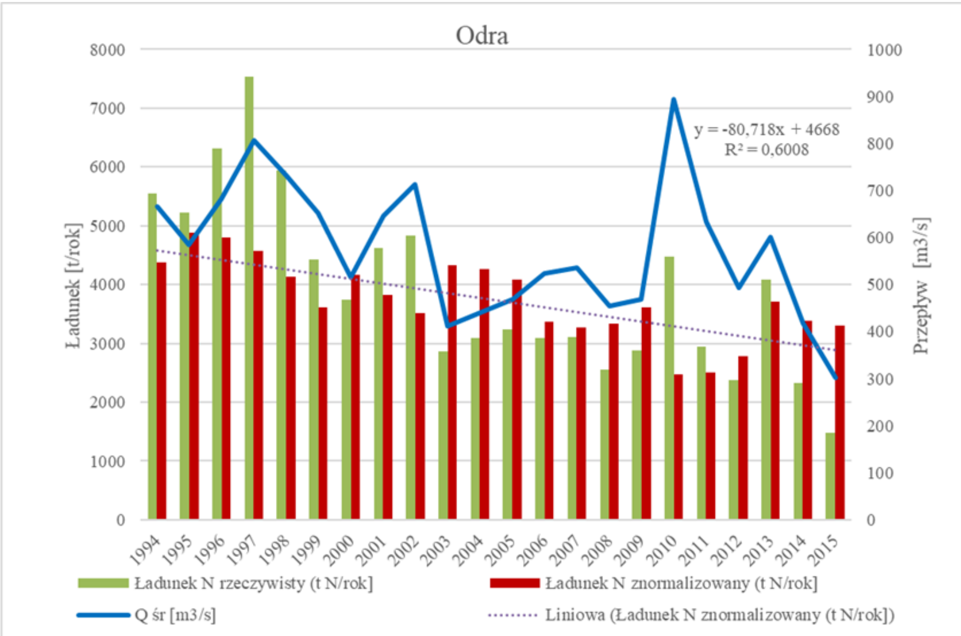



Fig. 4.1.20. Actual and normalized total phosphorus loads (tonnes/year) carried to the Baltic Sea by Odra river in the years 1994-2015. Right vertical axis (flow m³/s). Own elaboration based on data (source: PMŚ, IMGW-PIB)

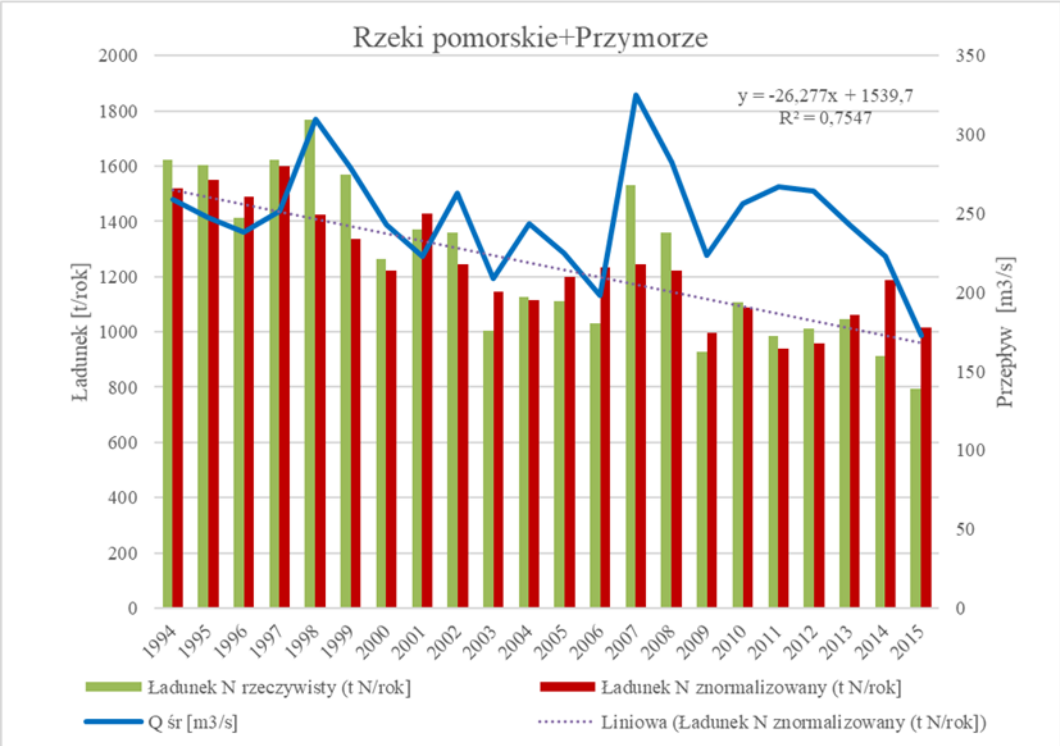



Fig. 4.1.21. Actual and normalized total phosphorus loads (tonnes/year) to the Baltic Sea from the Pomeranian rivers and the Przymorze region in the years 1994-2015. Right vertical axis (flow $m^3/s$). Own elaboration based on data (source: PMŚ, IMGW-PIB)

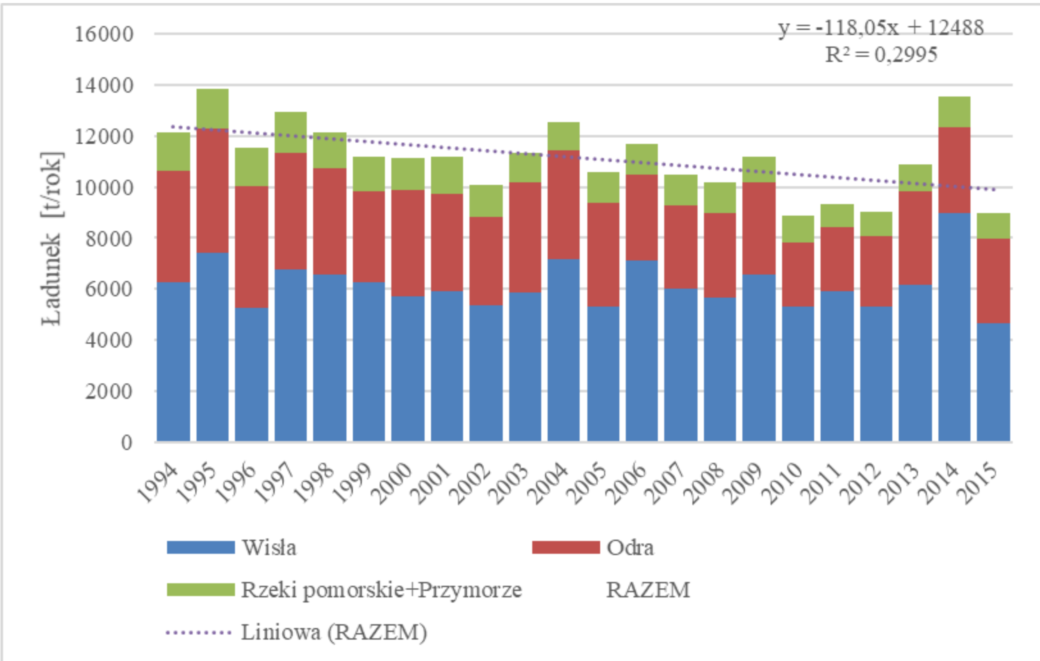



Fig. 4.1.22. Total phosphorus load (tonnes/year) from Poland to the Baltic Sea (source: PMŚ)

Table 4.1.11. List of actual flows and loads and normalized loads of total phosphorus from Vistula, Oder, Pomeranian rivers and Przymorze region to the Baltic Sea in 1994-2015 (PMŚ, IMGW-PIB data source)

| Rzeka | Wyszczególnienie/Rok | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grabowa | Q śr [m3/s] | 8,0 | 9,0 | 10,2 | 8,7 | 10,6 | 8,5 | 8,3 | 8,7 | 8,2 | 7,6 | 8,0 | 8,2 | 7,5 | 8,9 | 9,5 | 9,2 | 8,9 | 8,0 | 9,1 | 7,6 | 21,7 | 6,3 |
| | Ład. P rzecz. [t P/rok] | 36 | 28 | 31 | 36 | 60 | 49 | 40 | 53 | 37 | 27 | 28 | 33 | 39 | 42 | 55 | 42 | 44 | 34 | 37 | 33 | 45 | 30 |
| | Ład. P norm. [t P/rok] | 37 | 28 | 29 | 37 | 55 | 50 | 41 | 54 | 38 | 29 | 29 | 34 | 42 | 42 | 53 | 42 | 44 | 35 | 37 | 34 | 32 | 34 |
| Ina | Q śr [m3/s] | 16,8 | 13,2 | 12,1 | 14,8 | 19,0 | 20,7 | 19,6 | 17,9 | 22,1 | 14,6 | 12,6 | 8,3 | 8,8 | 13,9 | 13,9 | 10,9 | 15,1 | 16,8 | 13,5 | 11,3 | 8,0 | 9,2 |
| | Ład. P rzecz. [t P/rok] | 162 | 144 | 126 | 142 | 142 | 132 | 119 | 124 | 140 | 88 | 66 | 69 | 72 | 105 | 97 | 70 | 104 | 96 | 69 | 97 | 72 | 55 |
| | Ład. P norm. [t P/rok] | 137 | 149 | 140 | 133 | 109 | 95 | 90 | 100 | 96 | 84 | 71 | 104 | 103 | 105 | 96 | 85 | 97 | 82 | 70 | 114 | 112 | 74 |
| Łeba | Q śr [m3/s] | 22,3 | 22,4 | 20,0 | 20,4 | 28,6 | 21,9 | 18,3 | 20,9 | 21,0 | 16,6 | 19,9 | 17,7 | 16,6 | 22,9 | 22,2 | 20,4 | 22,2 | 19,8 | 23,3 | 21,3 | 22,1 | 16,0 |
| | Ład. P rzecz. [t P/rok] | 159 | 164 | 141 | 145 | 177 | 110 | 89 | 119 | 105 | 89 | 115 | 80 | 70 | 98 | 89 | 76 | 92 | 72 | 93 | 80 | 61 | 57 |
| | Ład. P norm. [t P/rok] | 143 | 146 | 148 | 148 | 113 | 102 | 105 | 117 | 103 | 122 | 121 | 99 | 94 | 86 | 81 | 77 | 84 | 76 | 80 | 77 | 57 | 79 |
| Łupawa | Q śr [m3/s] | 9,5 | 11,7 | 8,9 | 10,1 | 12,0 | 9,1 | 10,7 | 9,3 | 12,1 | 9,0 | 8,1 | 9,2 | 8,9 | 12,4 | 10,8 | 10,1 | 10,3 | 9,3 | 9,9 | 9,9 | 5,0 | 8,1 |
| | Ład. P rzecz. [t P/rok] | 57 | 77 | 45 | 57 | 95 | 34 | 44 | 49 | 51 | 38 | 36 | 37 | 38 | 54 | 43 | 37 | 38 | 33 | 46 | 37 | 30 | 32 |
| | Ład. P norm. [t P/rok] | 58 | 62 | 49 | 54 | 75 | 36 | 40 | 51 | 41 | 40 | 42 | 39 | 41 | 43 | 39 | 36 | 35 | 34 | 45 | 36 | 61 | 38 |
| Odra | Q śr [m3/s] | 666,3 | 585,7 | 681,7 | 806,8 | 731,0 | 652,1 | 514,8 | 644,8 | 712,3 | 411,3 | 439,7 | 468,7 | 522,8 | 536,7 | 453,9 | 468,7 | 894,9 | 633,8 | 492,9 | 600,7 | 418,8 | 302,1 |
| | Ład. P rzecz. [t P/rok] | 5547 | 5220 | 6309 | 7540 | 5939 | 4433 | 3737 | 4628 | 4833 | 2867 | 3092 | 3238 | 3096 | 3103 | 2548 | 2871 | 4469 | 2936 | 2375 | 4084 | 2331 | 1483 |
| | Ład. P norm. [t P/rok] | 4369 | 4886 | 4804 | 4577 | 4138 | 3612 | 4163 | 3821 | 3509 | 4321 | 4257 | 4087 | 3370 | 3264 | 3335 | 3612 | 2471 | 2502 | 2782 | 3705 | 3391 | 3296 |
| Parsęta | Q śr [m3/s] | 33,6 | 30,5 | 26,5 | 26,3 | 42,1 | 37,2 | 30,0 | 26,2 | 37,5 | 22,2 | 27,2 | 27,1 | 23,5 | 40,1 | 28,1 | 27,5 | 29,5 | 27,3 | 27,7 | 24,1 | 12,2 | 19,6 |
| | Ład. P rzecz. [t P/rok] | 139 | 113 | 128 | 139 | 234 | 234 | 154 | 143 | 150 | 88 | 94 | 133 | 118 | 157 | 152 | 43 | 149 | 94 | 76 | 81 | 99 | 75 |
| | Ład. P norm. [t P/rok] | 119 | 105 | 132 | 145 | 164 | 181 | 144 | 149 | 118 | 104 | 95 | 135 | 135 | 117 | 150 | 43 | 141 | 95 | 76 | 89 | 203 | 97 |
| Pasłęka | Q śr [m3/s] | 18,9 | 17,5 | 11,9 | 14,6 | 21,6 | 24,3 | 20,0 | 16,1 | 18,5 | 13,7 | 19,6 | 15,0 | 12,1 | 24,4 | 25,7 | 12,2 | 11,6 | 12,8 | 15,4 | 15,8 | 11,2 | 7,9 |
| | Ład. P rzecz. [t P/rok] | 93 | 131 | 105 | 82 | 92 | 185 | 129 | 120 | 127 | 97 | 142 | 98 | 79 | 160 | 128 | 54 | 50 | 42 | 81 | 63 | 62 | 31 |
| | Ład. P norm. [t P/rok] | 74 | 114 | 155 | 91 | 64 | 105 | 95 | 117 | 103 | 117 | 107 | 104 | 112 | 92 | 71 | 74 | 73 | 53 | 84 | 63 | 95 | 71 |
| Reda | Q śr [m3/s] | 5,4 | 5,9 | 5,2 | 4,4 | 5,4 | 5,7 | 6,7 | 5,0 | 5,2 | 4,1 | 5,6 | 4,8 | 3,8 | 6,7 | 5,0 | 4,6 | 5,7 | 5,3 | 4,3 | 4,4 | 14,1 | 3,7 |
| | Ład. P rzecz. [t P/rok] | 24 | 25 | 17 | 13 | 24 | 37 | 35 | 24 | 19 | 20 | 26 | 25 | 18 | 32 | 27 | 28 | 23 | 21 | 15 | 34 | 23 | 14 |
| | Ład. P norm. [t P/rok] | 23 | 23 | 17 | 14 | 24 | 35 | 31 | 25 | 19 | 21 | 26 | 26 | 21 | 29 | 27 | 29 | 22 | 21 | 16 | 36 | 16 | 16 |
| Rega | Q śr [m3/s] | 23,6 | 21,0 | 20,6 | 18,5 | 26,0 | 25,9 | 22,7 | 17,4 | 24,8 | 13,8 | 17,2 | 19,8 | 14,0 | 23,8 | 21,8 | 17,4 | 18,7 | 24,6 | 20,7 | 20,5 | 10,9 | 16,3 |
| | Ład. P rzecz. [t P/rok] | 155 | 140 | 160 | 114 | 145 | 135 | 83 | 89 | 113 | 59 | 68 | 83 | 60 | 92 | 86 | 56 | 63 | 82 | 69 | 60 | 55 | 53 |
| | Ład. P norm. [t P/rok] | 125 | 130 | 151 | 123 | 105 | 99 | 71 | 103 | 88 | 88 | 79 | 82 | 87 | 75 | 77 | 63 | 66 | 65 | 65 | 58 | 109 | 65 |
| Słupia | Q śr [m3/s] | 16,4 | 17,3 | 15,5 | 16,8 | 22,3 | 18,2 | 16,3 | 16,6 | 18,3 | 14,3 | 16,1 | 13,7 | 13,7 | 19,5 | 17,4 | 16,2 | 18,1 | 17,2 | 19,9 | 16,5 | 15,9 | 14,5 |
| | Ład. P rzecz. [t P/rok] | 132 | 136 | 118 | 122 | 119 | 71 | 72 | 77 | 66 | 54 | 59 | 48 | 52 | 72 | 56 | 51 | 59 | 69 | 65 | 67 | 47 | 43 |
| | Ład. P norm. [t P/rok] | 138 | 132 | 134 | 124 | 84 | 66 | 76 | 79 | 60 | 67 | 63 | 62 | 68 | 61 | 55 | 54 | 55 | 68 | 54 | 70 | 52 | 52 |
| Wieprza | Q śr [m3/s] | 17,5 | 19,0 | 18,2 | 18,1 | 23,0 | 20,7 | 19,6 | 16,1 | 19,4 | 14,5 | 17,9 | 16,3 | 14,3 | 20,2 | 17,8 | 13,7 | 14,6 | 16,8 | 18,5 | 17,4 | 8,2 | 13,9 |
| | Ład. P rzecz. [t P/rok] | 118 | 117 | 93 | 86 | 86 | 129 | 120 | 108 | 87 | 65 | 71 | 85 | 77 | 90 | 98 | 58 | 72 | 70 | 74 | 63 | 52 | 58 |
| | Ład. P norm. [t P/rok] | 114 | 106 | 87 | 82 | 67 | 108 | 106 | 113 | 78 | 73 | 68 | 88 | 88 | 78 | 94 | 68 | 81 | 71 | 68 | 62 | 96 | 68 |
| Wisła | Q śr [m3/s] | 1027,4 | 1051,4 | 1125,4 | 1178,5 | 1391,2 | 1415,5 | 1345,3 | 1314,9 | 1303,9 | 851,8 | 843,9 | 924,5 | 926,8 | 942,8 | 820,6 | 1047,7 | 1726,7 | 1235,7 | 785,4 | 1039,9 | 966,8 | 718,4 |
| | Ład. P rzecz. [t P/rok] | 6000 | 7321 | 5572 | 7630 | 8990 | 8680 | 7490 | 7563 | 6721 | 4538 | 5470 | 4502 | 6035 | 5213 | 4183 | 6437 | 9233 | 7003 | 3751 | 5977 | 7976 | 3002 |
| | Ład. P norm. [t P/rok] | 6250 | 7427 | 5230 | 6774 | 6582 | 6241 | 5726 | 5930 | 5336 | 5861 | 7186 | 5283 | 7099 | 5993 | 5632 | 6555 | 5328 | 5898 | 5296 | 6139 | 8954 | 4658 |
| Przymorze | Q śr [m3/s] | 87,1 | 79,8 | 89,3 | 98,9 | 99,1 | 86,7 | 70,7 | 68,5 | 75,7 | 78,7 | 91,7 | 84,4 | 74,8 | 132,6 | 110,0 | 81,0 | 101,3 | 109,1 | 101,6 | 94,2 | 93,2 | 57,0 |
| | Ład. P rzecz. [t P/rok] | 549 | 531 | 451 | 688 | 595 | 455 | 381 | 462 | 465 | 377 | 422 | 419 | 408 | 627 | 529 | 411 | 414 | 373 | 387 | 432 | 364 | 347 |
| | Ład. P norm. [t P/rok] | 553 | 557 | 448 | 651 | 563 | 459 | 421 | 520 | 500 | 397 | 415 | 428 | 440 | 519 | 478 | 428 | 389 | 341 | 364 | 420 | 355 | 423 |
| RAZEM | Q śr [m3/s] | 1952,8 | 1884,3 | 2045,6 | 2236,9 | 2431,9 | 2346,6 | 2103,0 | 2182,4 | 2279,1 | 1472,2 | 1527,4 | 1617,8 | 1647,6 | 1804,8 | 1556,5 | 1739,6 | 2877,6 | 2136,7 | 1542,3 | 1883,6 | 1608,2 | 1192,9 |
| | Ład. P rzecz. [t P/rok] | 13170 | 14146 | 13294 | 16795 | 16697 | 14684 | 12493 | 13561 | 12914 | 8409 | 9689 | 8850 | 10164 | 9846 | 8092 | 10235 | 14809 | 10924 | 7139 | 11108 | 11219 | 5281 |
| | Ład. P norm. [t P/rok] | 12140 | 13866 | 11525 | 12951 | 12143 | 11188 | 11110 | 11180 | 10089 | 11326 | 12558 | 10569 | 11702 | 10504 | 10190 | 11166 | 8886 | 9339 | 9038 | 10904 | 13534 | 8971 |

**The structure of nutrient load**

The assignment of particular types of nutrient sources to inland surface waters and then to the sea, from the point of view of planning protective measures, is one of the most important elements of pressure analysis, and at the same time it is an element burdened with a high degree of uncertainty. It results firstly from the uncertainty of estimating the size of loads at source, secondly from the very sometimes complex processes of pollutant transport, as a result of which only some of them reach the waters, thirdly from very limited possibilities of monitoring nutrient transport at the land-water interface, and fourthly with even more limited possibilities of direct monitoring of nutrient retention processes in waters. Due to these circumstances, regardless of the method adopted, the allocation of charges is always based to some extent on certain assumptions that are arbitrary even if they reflect expert knowledge.

The load allocation method adopted in this study outlined the following steps in general:

1) adopting the division of the Baltic Sea basin into computational basins
2) developing a dynamic hydrological model and calibrating it, taking into account measurement data on flows from 2015.
3) balancing of anthropogenic nutrient loads at source
4) selection of measurement and control points of the PMŚ located so that they could form the basis for balancing of pollutant loads in the final cross-sections of computational catchments
5) flow regression analysis - load and estimation of nutrient loads in the final cross-sections of computational basins
6) analysis of multiple regression analysis for a group of selected drainage basins to investigate the relationship between river loads and the loads generated by individual sources
7) adopting, on the basis of multiple regression results, of load allocation coefficients for individual sources
8) construction of a model of transport of nutrients from sources to waters and waters to the sea
9) calibration of the nutrient transport model
10) final allocation of loads based on a calibrated model of nutrient transport.

The model includes:

1) The Vistula river basin district with parts located outside the country
2) The Odra river basin district with parts located outside the country and together with Ina
3) catchments of the main Pomeranian rivers entering directly into the Baltic Sea (Rega, Parsęta, Grabowa, Wieprz, Słupia, Łupawa, Łeba, Reda, Pasłęka)
4) the Łyna, Gubra and Węgorapa catchments on the Polish side in the Pregoła river basin district.

**Nitrogen**

The structure of nitrogen loads, which reached the Baltic Sea in 2015, is presented in detail in Table 4.1.12. In total, from the monitored catchments about 77.5 thousand tonnes of nitrogen reached the Baltic Sea or (in the case of the Pregoła catchment) the Polish boader, of which 19% was attributed to the background levels, 42% to agriculture (including mineral and natural fertilizers), 20% to sewage treatment plants, 11% to cross-border loads and 8% to other sources. Out of total load, Vistula contributed 54%, Odra 36% and the Przymorze and the Pregoła basin rivers 10%. The share of agriculture amounted to 36% in the load from the Vistula, 48% in the load from the Odra and 44% in the load from the rivers of the Przymorze and the Pregoła basin. The share of sewage treatment plants was 23%, 18% and 11%, respectively.

Fig. 4.1.23 i Fig. 4.1.24 show the structure of actual and standardized loads, respectively. The structure of normalized loads reaching the sea was estimated on the basis of the ratio between normalized and measured loads assuming that loads from sewage treatment plants are not changed when converted into normalized conditions, and transboundary loads change in proportionally to the basis of the ratio between normalized and measured loads. As a result, the share of background, agriculture and sewage treatment for standard conditions was estimated for Poland at 21%, 48% and 11%, for the Vistula at 24%, 42% and 14%, Odra at 15%, 56% and 9%, and for the Przymorze and Pregoła rivers, 35%, 44% and 8%

Table 4.1.12. Structure of the nitrogen load to the Baltic Sea in 2015 from the monitored rivers of Poland.

| Sources of nitrogen | Vistula | | | Oder | | | Przymorze+Pregoła | | | In total without unmonitored catchment | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | t N/ year | % | mg N/l | t N/ year | % | mg N/l | t N/ year | % | mg N/l | t N/ year | % | mg N/l |
| In total | 41 704 | 100.0 | 1.74 | 28 351 | 100.0 | 2.80 | 7 463 | 100.0 | 2.28 | 77 519 | 100.0 | 2.05 |
| Background | 8 833 | 21.2 | 0.37 | 3 668 | 12.9 | 0.36 | 2 545 | 34.1 | 0.78 | 15 046 | 19.4 | 0.40 |
| Deposition on land | 1 016 | 2.4 | 0.04 | 765 | 2.7 | 0.08 | 276 | 3.7 | 0.08 | 2 057 | 2.7 | 0.05 |
| Deposition on water | 341 | 0.8 | 0.01 | 755 | 2.7 | 0.07 | 460 | 6.2 | 0.14 | 1 556 | 2.0 | 0.04 |
| Mineral fertilizers | 6 693 | 16.0 | 0.28 | 7 915 | 27.9 | 0.78 | 1 879 | 25.2 | 0.57 | 16 488 | 21.3 | 0.44 |
| Natural fertilizers | 8 470 | 20.3 | 0.35 | 5 961 | 21.0 | 0.59 | 1 368 | 18.3 | 0.42 | 15 799 | 20.4 | 0.42 |
| Flow from urban areas | 446 | 1.1 | 0.02 | 289 | 1.0 | 0.03 | 54 | 0.7 | 0.02 | 789 | 1.0 | 0.02 |
| Sewage from non-drained development | 974 | 2.3 | 0.04 | 580 | 2.0 | 0.06 | 96 | 1.3 | 0.03 | 1 649 | 2.1 | 0.04 |
| Sewage treatment plants | 9 571 | 22.9 | 0.40 | 5 176 | 18.3 | 0.51 | 785 | 10.5 | 0.24 | 15 532 | 20.0 | 0.41 |
| Trans-boundary loads | 5 361 | 12.9 | 0.22 | 3 242 | 11.4 | 0.32 | 0 | 0.0 | 0.00 | 8 603 | 11.1 | 0.23 |

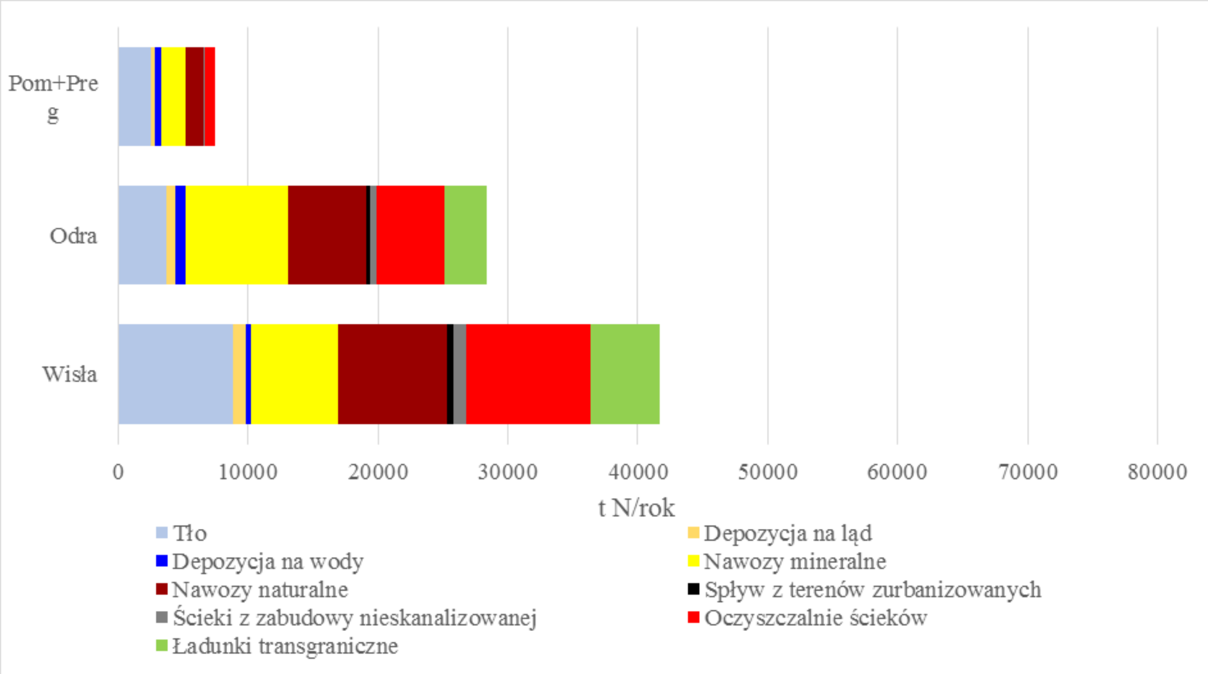



Fig. 4.1.23. The structure of actual nitrogen loads (tonnes/year, horizontal axis) to the Baltic Sea in 2015 from the monitored rivers of Poland.

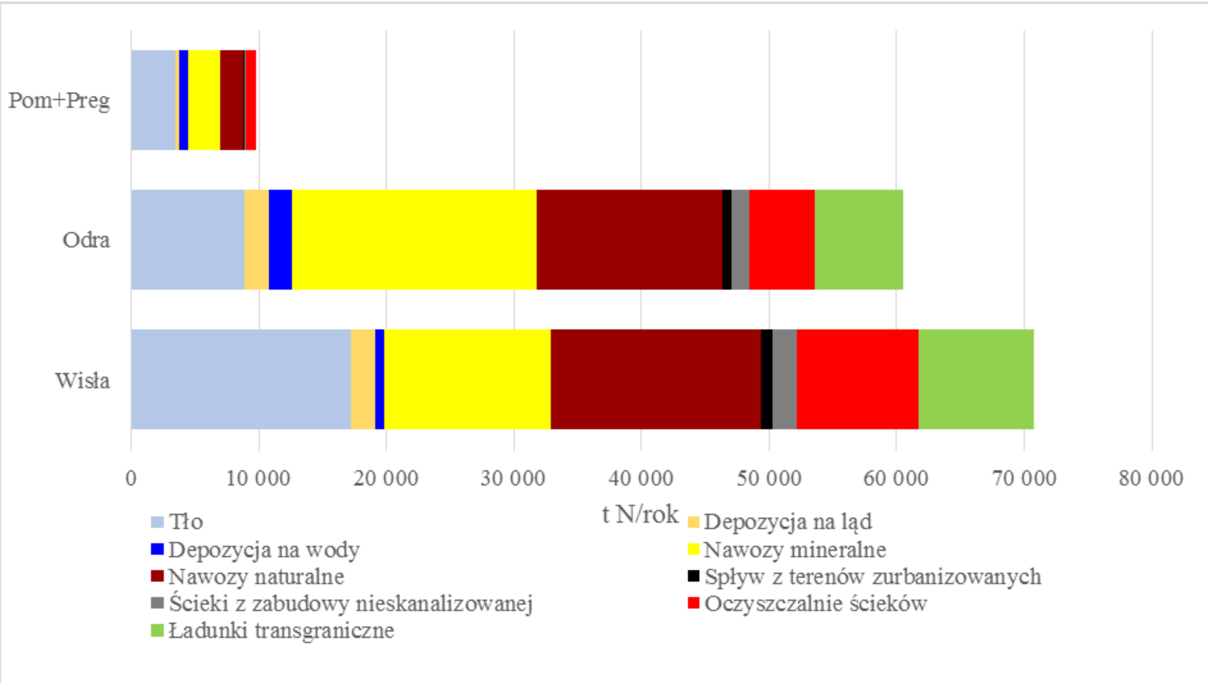



Fig. 4.1.24. The structure of normalized nitrogen loads (tonnes/year, horizontal axis) to the Baltic Sea in 2015 from the monitored Polish rivers.

**Phosphorus**

The structure of phosphorus loads to the Baltic Sea in 2015, is presented in detail in Table 4.1.13. In total, from the monitored catchments about 5090 tonnes of phosphorus reached the Baltic Sea or (in the case of the Pregoła catchment) the Polish boader, 18% of which was attributed to oil, 27% to agriculture (total mineral and natural fertilizers), 37% sewage treatment plants, 15% cross-border loads 3% of the remaining sources combined. Out of total loads Vistula contributed 60%, Odra 32% and the Przymorze and the Pregoła basin rivers 8%. The share of agriculture amounted to 27% in the load from the Vistula, 25% in the load from the Odra and 27% in the load from the rivers of the Przymorze and the Pregoła basin. The share of sewage treatment plants was 36%, 43% and 37% respectively.

Fig. 4.1.25 and Fig. 4.1.26 show the structure of actual loads and standardized loads, respectively. The structure of normalized loads to the sea was estimated on the basis of the ratio between normalized and measured values assuming that loads from sewage treatment plants are converted into standardized conditions, and the transboundary loads change in direct proportion to the basis of the ratio between normalized and measured loads. As a result, the share of background, agriculture and sewage treatment for standard conditions was estimated for Poland at 22%, 37% and 21%, for the Vistula at 22%, 35% and 23%, and Odra at 19%, 40% and 19%, and for the Przymorze and Pregoła rivers, 47%, 20% and 19%..

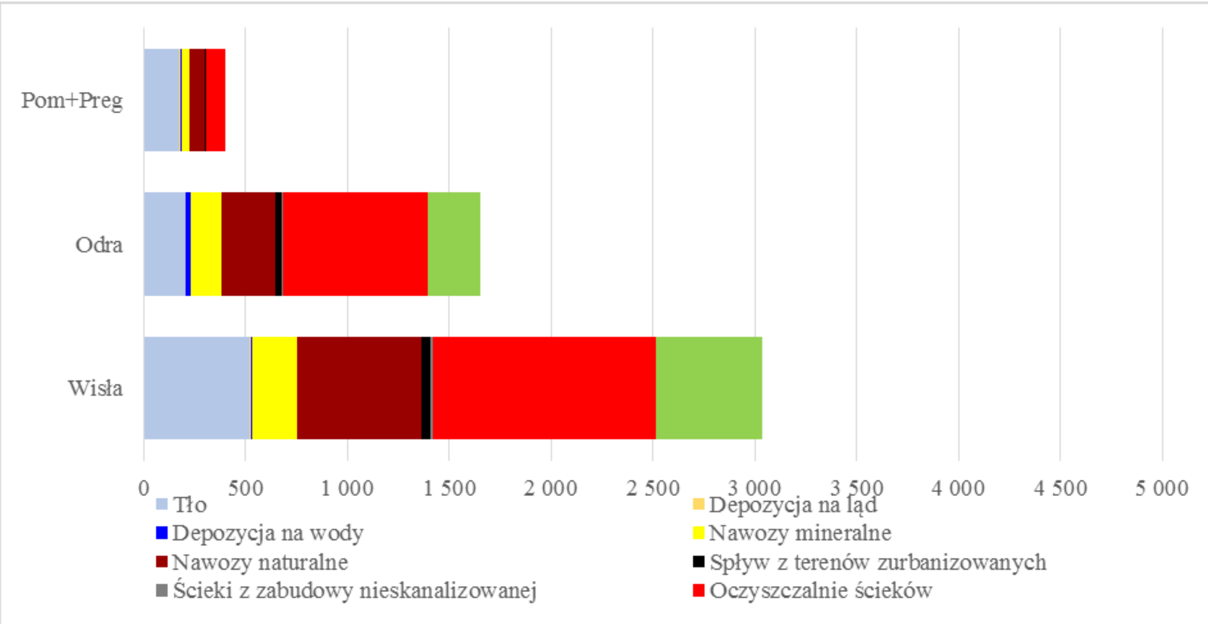



Fig. 4.1.25. The structure of the actual phosphorus loads (tonnes/year, horizontal axis) to the Baltic Sea in 2015 from the monitored rivers of Poland.

Table 4.1.13. The structure of the actual phosphorus loads discharged to the Baltic Sea in 2015 from the monitored rivers of Poland.

| Sources of nitrogen | Vistula | | | Oder | | | Przymorze+Pregoła | | | In total without unmonitored catchment | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | t P/ year | % | mg P/l | t P/ year | % | mg P/l | t P/ year | % | mg P/l | t P/ year | % | mg P/l |
| In total | 3 032 | 100.0 | 0.1269 | 1 655 | 100.0 | 0.1634 | 403 | 100.0 | 0.1230 | 5 090 | 100.0 | 0.1345 |
| Background | 520 | 17.2 | 0.0218 | 203 | 12.3 | 0.0200 | 177 | 44.0 | 0.0541 | 900 | 17.7 | 0.0238 |
| Deposition on land | 6 | 0.2 | 0.0002 | 5 | 0.3 | 0.0005 | 2 | 0.4 | 0.0005 | 12 | 0.2 | 0.0003 |
| Deposition on water | 5 | 0.2 | 0.0002 | 25 | 1.5 | 0.0025 | 10 | 2.6 | 0.0032 | 41 | 0.8 | 0.0011 |
| Mineral fertilizers | 218 | 7.2 | 0.0091 | 148 | 9.0 | 0.0146 | 34 | 8.5 | 0.0105 | 401 | 7.9 | 0.0106 |
| Natural fertilizers | 613 | 20.2 | 0.0256 | 267 | 16.1 | 0.0264 | 74 | 18.3 | 0.0225 | 954 | 18.7 | 0.0252 |
| Flow from urban areas | 45 | 1.5 | 0.0019 | 28 | 1.7 | 0.0028 | 6 | 1.5 | 0.0019 | 79 | 1.5 | 0.0021 |
| Sewage from non-drained development | 12 | 0.4 | 0.0005 | 7 | 0.4 | 0.0007 | 1 | 0.3 | 0.0004 | 20 | 0.4 | 0.0005 |
| Sewage treatment plants | 1 093 | 36.0 | 0.0457 | 714 | 43.1 | 0.0705 | 98 | 24.4 | 0.0301 | 1 905 | 37.4 | 0.0503 |
| Trans-boundary loads | 521 | 17.2 | 0.0218 | 258 | 15.6 | 0.0255 | 0 | 0.0 | 0.0000 | 779 | 15.3 | 0.0206 |

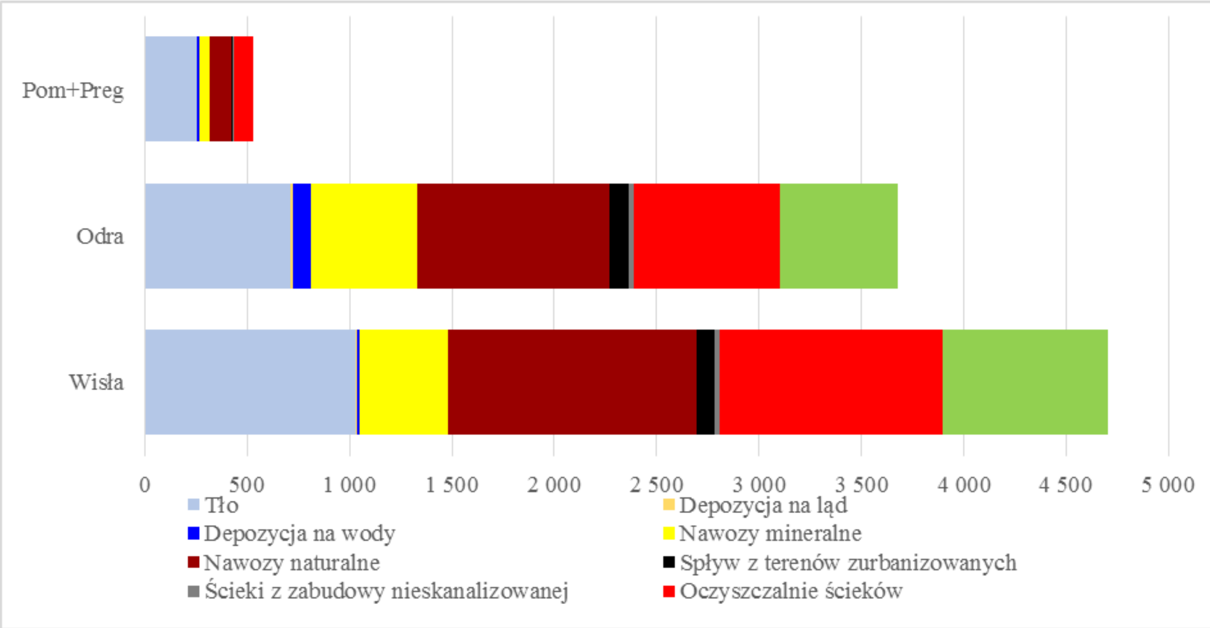



Fig. 4.1.26. The structure of normalized loads (tonnes/year, horizontal axis) of phosphorus to the Baltic Sea in 2015 from the monitored rivers of Poland.

### *Introduction of radionuclides*

In the case of the Baltic Sea, the most important radionuclides of anthropogenic origin are definitely (137Cs) and strontium (90Sr) [HELCOM, 2013].

The largest inflow of artificial radionuclides to the Baltic Sea occurred as a result of the Chernobyl nuclear power plant disaster in 1986. The most important radionuclides that got into the sea were 137Cs and 134Cs. The total 137Cs load from Chernobyl to the Baltic Sea is estimated at 4700 TBq. The 134Cs isotope is no longer detectable in sediments due to the short half-life (about 2 years) [HELCOM, 2013]. Radionuclides from Chernobyl reached the Baltic Sea with atmospheric deposition and rivers. Chernobyl is responsible for 82% 137Cs and 13% 90Sr in the Baltic Sea by 2010 (Fig. 4.1.27).

The second source of these elements in the environment are tests with nuclear weapons, which number was on average around 80 per year in the 1960s and around 50 per year in the 1980s. Explosions of nuclear weapons are the source of 13% 137Cs and 81% of 90Sr in the Baltic Sea by 2010.

Nuclear installations located outside its basin are a much less important source of radiation in the Baltic Sea. These are the treatment plants for spent nuclear fuel in Great Britain and France, dumping process water into the sea. About 1% of the radiation contained in these waters hits inflows into the Baltic Sea [HELCOM, 2009]. In addition, several nuclear power plants operate in the Baltic Sea catchment, discharging certain amounts of tritium into the sea, but very small amounts of heavier radioactive elements [HELCOM, 2013, HELCOM, 2009]. In total, the installations in the Baltic Sea catchment are responsible for 0.01% of the total amount of cesium and 0.04% of strontium released to the Baltic Sea by 2010 [HELCOM, 2013].

Another source of radionuclides was the dumping of radioactive litter in the sea. According to [EEA 1999], two such operations were carried out by Sweden at the turn of the 1950s and 1960s, and according to [HELCOM, 2016] at the same time, the Soviet Union also landed the litter several times. According to [HELCOM, 2009], the sunk quantities were small, and the current radiation emissions from these sources are negligible from the point of view of protecting human health. In addition to the elements already mentioned in the Baltic Sea, cobalt (60Co), antimony (125Sb), silver (110Ag), zinc (65Zn) and other elements also come from nuclear installations.

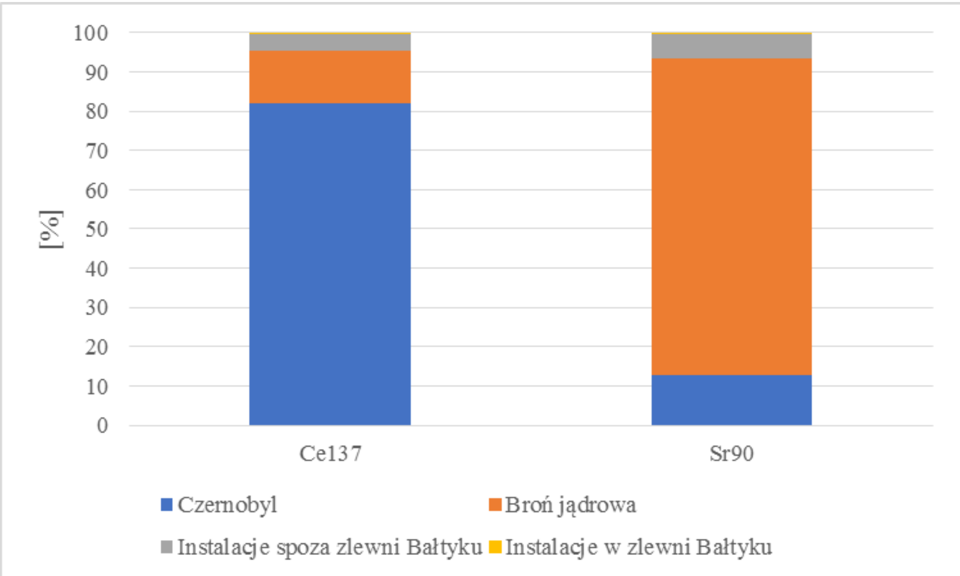



Fig. 4.1.27. Structure of anthropogenic 137Cs and 90Sr isotopes emitted to the Baltic Sea by 2010.

***Introduction of litter***

Solid litter reaches to the sea in various ways. They are carried by rivers, carried away by wind from dumps and unprotected containers, abandoned by tourists on beaches and thrown from ships. The composition of litter reaching the sea is very diverse, however, the largest share and potentially the greatest importance for ecosystems are plastics. Litter of this category, which is a major part of the litter stream generated on land, is easily carried with wind and water and practically does not degrade, which makes their share in the structure of litter found in the sea or on beaches even higher than on land. Plastics, although they do not decompose, are gradually fragmented into smaller and smaller particles. Microplastics are pieces of plastics smaller than 5 mm in size. A distinction is made between secondary microplastics being the effect of photodegradation of large plastic fragments and primary ones, introduced into the environment with sewage discharged from sewerage, and coming from cleaning agents and cosmetics containing plastic microgranules that increase the effectiveness of these products. This type of litter goes to the sea with river waters in the amount of 13-39 tonnes per year within the entire Baltic Sea [Broeg K. 2015].

The important land categories of plastic macro landfills include various types of retail packaging, including plastic bags, used household appliances, films, bags, etc. from agriculture and construction litter. Fishing (lost and damaged nets, fishing lines, etc.) is a serious source of macro- litter. Microplastics come from the products of the cosmetics industry and household chemicals, textile products, abrasive tire treads and plastics industry, using granules as a raw material.

Negative impacts of litter on elements of marine ecosystems include, among others, killing and mutilating animals that have become entangled with abandoned nets or plastic packaging, or swallowed fragments of plastics. The presence of microplastics has been found in many species of fish, crustaceans, bivalves and other marine animals. The range and nature of the negative impacts associated with it is largely unrecognized, but it is already known that microplastics can penetrate into the tissues and cells of some invertebrates (bivalves, polychaetes) and thus potentially reach higher trophic levels. It is also known that in invertebrate studies there have been cases of cell and tissue damage by microplastics, and data have been gathered that the effects on tissues are not only mechanical, but can be related to the toxic effects of various additives contained in plastics [IAEA , 1999, GESAMP, 2015], as well as in connection with the hydrophobic surface of plastic that attracts dirt to its surface and thus penetrates into aquatic organisms (e.g. PVC, [Rowland SJ, Galloway TS, Thompson RC, 2007]. Research conducted on northern fulmars off the North Sea by van Franeker et al. [Franeker J.A. Van et al., 2011] showed that of the examined birds, 95% had plastic in the stomach (35 pieces on average with an average weight of 0.31 g). Plastic has also been found in the digestive system of various species of fish from the North Sea, while plastic has been found in cod in as many as 13% of all abdicated fish [ Foekema EM, et al 2013], in 19.8% of fish tested off the coast of Portugal [Neves D., Sobral P., Lia J., Pereira T., 2015], 36.5% of fish tested in the English Channel [ Lusher AL, Mchugh M., Thompson RC, 2013].

***Inputs of organic matter***

Organic matter, often used for monitoring in form of BZT5, ChZT and TOC indicators reaches the sea primarily with river waters. Additional sources may include direct discharges of raw or treated wastewater from seaside treatment plants, discharges of raw wastewater from passenger ships as well as fodders and excreta from marine fish aquacultures. The sources of organic matter in rivers are very diverse. Much of the organic matter is phytoplankton that uses nutrients and carbon dioxide contained in river waters. River waters, especially from forest and marshy areas, can carry significant amounts of hardly decomposable humic substances, which, although they affect the total amount of organic matter, contribute to negative impacts to a relatively small extent precisely because they are hardly decomposable and thus do not cause significant oxygen consumption. Organic matter brought in with raw sewage is potentially the most dangerous due to high concentrations and thus the generation of significant local oxygen demand. Emissions from intense fish aquacultures at sea may also be dangerous. Organic matter may also reach waters as a result of washing away fields of natural fertilizers (manure, slurry) or grazing animals in the immediate vicinity of watercourses. The mechanism of direct negative impact of organic matter consists of depleting the resources of oxygen contained in water, used for the decomposition of matter. In addition, organic matter contributes a portion of the nutrient load to waters. Negative impact of organic matter, if it is a sedimentary matter, may also consist in creating a layer of sediments on the bottom of the receiver, which, if the natural substrate is sandy or stony, radically change the habitat conditions, which results in a change in the nature of biocenosis. However, it should be remembered that sedimentation of suspended matter, often with a high content of organic matter, is a natural process in the estuaries, leading to the formation of so-called estuary cones, where the thickest factions closest to the land are deposited closest to the land, and as the water slows down - finer and more fractions containing more organic matter. Until the mid-nineteenth century, one-third of the Vistula waters were sent to the Vistula Lagoon, contributing to its shallowing and fertilization. Since then, analogous processes have been taking place and occurring at estuaries created by man [Łomniewski K., 1960].

Research carried out in the 1980s showed that in this period in the organic matter introduced by the Vistula into the Baltic Sea, the share of labile matter, i.e., susceptible to biodegradation, ranged from 20% to 40% depending on the season and sampling site. In winter, the fraction of the labile fraction increased due to the slowing down of bacterial degradation processes, and in the summer it was the lowest [Pempkowiak J., 1985]. The share of humic substances, i.e. mainly from the decomposition of dead plants, was about 44% of the total organic matter. These substances are generally difficult to decompose, and therefore do not contribute to the deoxidation of water. Some of them fall to the bottom, but a significant part (including dissolved substances) remains in the water. One can easily assume that the sources of organic matter, potentially dangerous for ecosystems, such as sewage, are primarily associated with the labile part of the basin of organic matter carried by the rivers. Also, biogens getting into waters from anthropogenic sources, stimulating the production of phytoplankton, contribute primarily to the increase of the amount of easily decomposed organic matter. The only easy to quantify the direct anthropogenic source of easily decomposed organic matter are the discharges of wastewater from the treatment plant. Based on data from [KZGW 2016], the total BZT5 cargo discharged from sewage treatment plants servicing agglomerations in 2015 was estimated at 10,000. tonnes of $O_2$. To this should be added about 2.2 thousand tonnes of $O_2$ originating from municipal wastewater treatment plants that do not serve agglomerations - based on data obtained from Marshal Offices. The largest sources of BZT5 from the treatment plant are the most densely populated areas, including the Wisła Górny Śląsk, Krajków, Warszawa, Bydgoszcz, Toruń, Kwidzyn (cellulose plants) and Tricity areas, and the Odra Górny Śląsk, Wrocław, Łódź, Poznań and Szczecin catchments. It should be remembered that the organic matter from the discharges away from the sea decomposes to a large extent, releasing nutrients used in subsequent organic matter circulation cycles. On the basis of the same sources, the total BZT load discharged from the municipal sewage treatment plant in 2006 was estimated at 28.4 thousand tonnes of $O_2$.

Another important anthropogenic source of organic matter reaching the waters are natural fertilizers, which are characterized by a fraction of labile organic matter that is even higher than the sewage. The size and spatial distribution of the BZT5 load generated by animal husbandry in 2015 was estimated in an analogous manner to nitrogen and phosphorus loads, with the following assumptions regarding individual loads adopted on the basis of [MidWest Plan Service, 2004]:

Monitoring of estuary sections of rivers, conducted for the needs of HELCOM, shows that in 1994-2015 there was a clear decrease in the total amount of organic matter introduced into the Baltic Sea with Polish rivers. The BZT5 total load decreased from 244,000 tonnes to 167,000 tonnes, while the decreasing trend was clear until 2010, and since then the amounts of BZT5 inflow have stabilized (Fig. 4.1.28). In the discussed period, the proportions between loads carried by the main rivers did not change significantly (Table 4.1.14.) – at the beginning and end of period the Vistula and Oder contributed around 56% and about 34% of the total load, respectively. Due to the increases recorded on the Oder in the middle of the period, the decreasing trend on this river was the weakest ($r^2$ = 0.23), while on the Vistula and Pomeranian rivers - very pronounced ($r^2$ = 0.73, $r^2$ = 0.77).

The absolute decrease of BZT5 load carried to the sea amounted to 77 thousand tonnes, while the relative decrease of about 32%, in comparison with the decline of BZT5 from the treatment plant, in absolute terms, about 16 thousand tonnes, and in relative terms - 57%. Of course, it is important to remember about the changes of matter on the way from the sources of the load and then in the waters themselves, nevertheless the proportions described suggest that the reduction of BZT5 loads from the treatment plant is not sufficient to explain the decline of cargo reaching the sea.

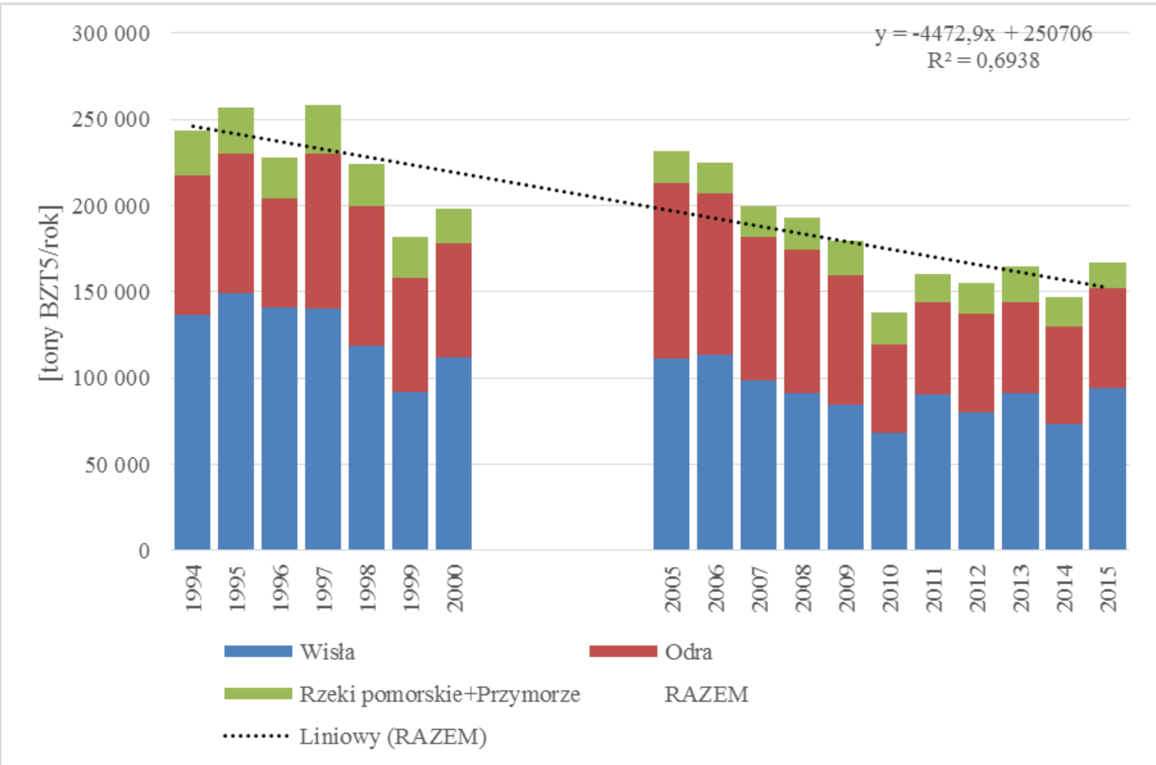



Fig. 4.1.28. Changes of BZT5 load (tonnes/year) from rivers (Vistula – blue, Oder – red, coastal rivers – green) flowing to POM areas of Baltic Sea (source: PMŚ)

Table 4.1.14. Structure of BZT5 load from rivers to the Baltic Sea in 1994 (source: PMŚ)

| Area | 1994 | 2015 |
|---|---|---|
| | [%] | |
| Vistula | 56.1 | 56.5 |
| Oder | 33.1 | 34.5 |
| Pomeranian rivers | 6.5 | 5.5 |
| Przymorze | 4.3 | 3.5 |

In addition to loads from rivers, organic matter reaches the Baltic sea directly from sewage treatment plants. The BZT5 load from this source in 2015 was estimated at 166 tonnes, which is negligible in comparison with the quantities carried with rivers. There are no aquacultures on Polish sea areas that could be another anthropogenic source of organic matter.

### *Introduction and spread of alien species*

The introduction and spread of alien species are currently considered one of the greatest threats both to the Baltic Sea ecosystem, but also to the global ecosystem. The enormous scale of the problem results, among other things, from the fact that it is the least predictable and at the same time very dynamic process related to human impact. In addition, "biological invasions" remain one of the least researched and least recognized threats to biodiversity.

In 2015, Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species (O.J. EU L 317, 04/11/2014, p. 35, as amended), hereinafter referred to as the "IAS Regulation", which should be applied directly in the EU Member States. This document regulates issues related to the prevention of the spread and introduction of alien species, the detection of their appearance and the control of population size, when the species is already widespread. On 13 July 2016, Commission Implementing Regulation (EU) 2016/1141 of 13 July 2016 was published, adopting a list of invasive alien species identified as posing a threat to the Union in accordance with Regulation (EU) No 1143/2014 of the European Parliament and of the Council (O.J. EU L 189 of 14.07.2016, page 4, as amended). That list was extended by a further 12 species by Commission Implementing Regulation (EU) 2017/1263 of 12 July 2017 updating the list of invasive alien species of Union concern established by Implementing Regulation (EU) 2016/1141 pursuant to Regulation (EU) No 1143/2014 of the European Parliament and of the Council (O.J. EU L 182, 13.07.2017, p. 37). Currently, the list includes two invasive species living in the Baltic Sea: American crayfish (*Orconectes limosus*) and Chinese mitten crab (*Eriocheir sinensis*).

The problem with alien species is that when the aquatic organism has been introduced and settled in a new environment, it is very difficult to eliminate it. The consequence is that the area status is classified as a "bad" area, depending on the presence of invasive species, which means that the area is likely to remain in poor condition with no possibility of improvement.

Considering the above, the goal is always to minimize the introduction of non-indigenous species, and the description of GES for non-native species should be "no new species" as defined in the HELCOM management objectives. Similarly, for the indicator in question, the GES description should be "No new non-indigenous species with known effects" means that an assessment is made for a given period, covering only those species that were introduced during this period and species which effects have changed after the previous assessment. They cause significant long-term impact, but in the event of a change in environmental conditions, they suddenly become invasive and cause adverse effects, therefore the assessment for new alien species, as well as for previously settled species should be updated.

Of the 119 registered alien species in the Baltic Sea, 79 were established as settled (maintenance of a determined reproductive population), 43 of them are species with a documented ecological impact. Others were considered to have little or no effect (Zaiko 2011). The share of alien species varies from 0% among birds and mammals to over 5% among fish (Table 4.1.15).

Table 4.1.15. Share of alien species in the total number of species in the Baltic Sea (Olenina et al 2010)

| **Specification** | **The number of alien species** | **Number of all species** | **Ratio** |
|---|---|---|---|
| Mammals | 0 | 5 | 0 |
| Birds | 0 | 57 | 0 |
| Fish | 13 | 239 | 0.054 |
| Macrophytes | 17 | 531 | 0.032 |
| Invertabrates | 69 | 1898 | 0.036 |

In the period covered by the initial assessment update in POM, 5 new alien species were recorded (Table 2.3.2).

The most species inhabits the Szczecin Lagoon and the Vistula Lagoon, and their number generally decreases as they move towards the open sea.

Alien species in the Baltic Sea ecosystem have a negative impact on biodiversity, causing strong competition in relation to the food base and habitat, which often involves the displacement of native species. On the other hand, they can also provide an additional food base for fish (including industrial species), as is the case for phyto- and zooplankton species. It also happens that alien species cause large financial losses caused by the destruction of fishing gear or seaboard security and port quays. It is difficult to clearly determine the importance and role of alien species in the Baltic Sea ecosystem, as they have reached the body of water relatively recently. It should be remembered that earlier alien species have also been introduced into the Baltic Sea, which are now considered to be an inseparable part of the Baltic Sea ecosystem (e.g., soft-shell clams *Mya arenaria*).

Alien species that have the strongest influence on the Baltic Sea ecosystem or the most widespread are:

a) Round goby *Neogobius melanostomus*. The first specimen was recorded near the Hel Peninsula in 1990. It strongly competes with native species of fish.
b) *Marenzelleria neglecta*, a polychaete species found for the first time in the 1980s, within a few years it spread throughout the entire coastal zone of the Polish Baltic Sea and in the lagoons. In the estuarial regions of the Oder and the Vistula and in the Vistula Lagoon it belongs to the dominant species, constituting from several to several dozen percent of the total biomass of macrozoobenthos, however, no significant negative impact on other bottom invertebrates has been found.
c) *Gammarus tigrinus,* a species almost completely supplanted the native species of gammarus from the waters of the Vistula Lagoon and the Gulf of Gdańsk (Surowiec and Dobrzycka 2008).
d) Fishhook waterflea *Cercopagi pengoi*. An unfavorable influence of mass appearances of the fishhook waterfleas on the number of native species of fishhook waterflea was observed. Due to the high predatory pressure on zooplankton, it may be an important food competitor for the fry and may contribute to the growth of eutrophication. The adverse impact of mass emergents on fishery was also reported. On the other hand, fishhook waterflea is an important element of the food of some fish species (http://www.iop.krakow.pl/gatunkiobce).
e) *Prorocentrum minimum,* a species of dinoflagellate. Present in the Baltic Sea since the 1980s, in recent years dominant in the structure of phytoplankton in coastal waters [Olenina I. et al. 2010].
f) Zebra mussel *Dreissena polymorpha*. There are no unambiguous data indicating the negative impact of the zebra mussel on the ecosystems of the Baltic Sea.
g) Bay barnacle *Balanus improvises*. There is no clear data indicating the negative impact of this species on the ecosystems of the Baltic Sea.

The impact of the above species is noticeable primarily in shallow coastal waters, where they have a significant impact primarily on benthic organisms and ichthyofauna. The lagoons most affected by the invasions of alien species include the Vistula Lagoon, the Szczecin Lagoon and the Gulf of Gdańsk.

The matrix of identified impacts is presented in Table 4.1.16.

Considering the information presented in the previous points, it was assessed that **the scale of pressure related to the introduction of alien species varies in the Polish Baltic Sea from strong in the: Polish waters of the Vistula Lagoon, Bornholm Basin Polish coastal watersand Polish Gdańsk Basin Polish coastal waters to significant in coastal waters, Bornholm Basin Polish coastal watersand Polish coastal waters of the eastern Gotland Basin and low but clearly noticeable in open waters.**

After analyzing the results obtained with the use of sensitivity indicators proposed by HELCOM, it was decided to correct them so that the impact indicators, constituting the product of pressure indicators and sensitivity indicators, better reflect the current knowledge on the interaction between pressure from alien species and elements of the marine ecosystem. Accordingly, the adjustments consisted primarily of:

a) increasing the sensitivity indicators of benthic communities (large-scale habitats of infralitoral and circalitoral), which are most easily controlled by alien species,

b) a significant reduction in the sensitivity indicators related to marine mammals, birds and cod spawning ground, since alien species, at least to date, have practically no effect on these elements of the ecosystem.

Values after correction are highlighted in greasy blue font.

With the assumed values of pressure and sensitivity indicators, the method identifies as benthic habitats of the Vistula Lagoon, the Szczecin Lagoon and the Gdańsk Basin and the same body of waters as lagoons, estuaries and shallow bays.

Table 4.1.16. List of impacts related to the introduction and spread of alien species

| Nr. | Water type | Sensitivity indicator | | Open waters | | | Coastal waters | | | Transitional waters | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-basin name | According to HELCOM | Corrected | Bornholm Basin | Eastern Gotland Basin | Gdańsk Basin | Bornholm Basin Polish Coastal waters | Eastern Gotland Basin Polish Coastal waters | Gdańsk Basin Polish Coastal waters | Polish waters of Szczecin Lagoon | Polish waters of Vistula Lagoon | Average impact |
| | **The level of pressure** | | | **2.0** | **2.0** | **2.0** | **3.0** | **3.0** | **4.0** | **4.0** | **4.0** | |
| 1. | Productive surface waters | 1 | 1 | 2.0 | 2.0 | 2.0 | 3.0 | 3.0 | 4.0 | 4.0 | 4.0 | 3.0 |
| 2. | Oxygenated deep waters | 0.7 | 0.7 | 1.4 | 1.4 | 1.4 | - | - | 2.8 | - | - | 1.8 |
| 3. | infralitoral hard bottom | 1.1 | **1.3** | 2.6 | 2.6 | 2.6 | 3.9 | 3.9 | - | - | - | 3.1 |
| 4. | infralitoral sand | 0.9 | **1.3** | 2.6 | 2.6 | 2.6 | 3.9 | 3.9 | 5.2 | 5.2 | 5.2 | 3.9 |
| 5. | infralitoral mud | 0.9 | **1.3** | - | - | 2.6 | - | - | 5.2 | 5.2 | 5.2 | 4.6 |
| 6. | circalittoral hard bottom | 1.2 | **1.3** | 2.6 | 2.6 | - | - | 3.9 | 5.2 | - | - | 3.6 |
| 7. | circalittoral sand | 1 | **1.3** | 2.6 | 2.6 | 2.6 | 3.9 | 3.9 | 5.2 | - | - | 3.5 |
| 8. | circalittoral mud | 0.9 | **1.3** | 2.6 | 2.6 | 2.6 | - | - | 5.2 | - | - | 3.3 |
| 9. | *Furcellaria lumbricalis* | 0.8 | **0.7** | 1.4 | 1.4 | 1.4 | 2.1 | 2.1 | 2.8 | - | - | 1.9 |
| 10. | *Zostera marina* | 0.7 | 0.7 | - | - | - | - | - | 2.8 | - | - | 2.8 |
| 11. | Charophytes | 0.9 | **0.7** | - | - | - | - | - | 2.8 | - | - | 2.8 |

| Nr. | Water type | Sensitivity indicator | | Open waters | | | Coastal waters | | | Transitional waters | | Average impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-basin name | According to HELCOM | Corrected | Bornholm Basin | Eastern Gotland Basin | Gdańsk Basin | Bornholm Basin Polish Coastal waters | Eastern Gotland Basin Polish Coastal waters | Gdańsk Basin Polish Coastal waters | Polish waters of Szczecin Lagoon | Polish waters of Vistula Lagoon | |
| | **The level of pressure** | | | **2.0** | **2.0** | **2.0** | **3.0** | **3.0** | **4.0** | **4.0** | **4.0** | |
| 12. | *Mytilus edulis* | 0.9 | **0.7** | 1.4 | 1.4 | 1.4 | 2.1 | 2.1 | 2.8 | 2.8 | 2.8 | 2.1 |
| 13. | *Fucus sp.* | 0.8 | **0.7** | - | - | - | - | - | - | - | - | - |
| 14. | Sandbanks slightly covered by seawater at all time (1110) | 0.9 | 0.9 | 1.8 | - | - | - | - | - | - | - | 1.8 |
| 15. | Estuaries (1130) | 1.3 | 1.3 | - | - | - | 3.9 | 3.9 | 5.2 | 5.2 | 5.2 | 4.7 |
| 16. | Coastal lagoons and lakes (1150) | 1.4 | **1.3** | - | - | - | - | - | - | 5.2 | 5.2 | 5.2 |
| 17. | Large shallow inlets and bays (1160) | 1.3 | 1.3 | - | - | - | - | - | 5.2 | - | - | 5.2 |
| 18. | Reefs (1170) | 1.2 | **1.3** | 2.6 | - | - | - | - | - | - | - | 2.6 |
| 19. | Cod abundance | 0.6 | 0.6 | 1.2 | 1.2 | 1.2 | 1.8 | 1.8 | 2.4 | - | - | 1.6 |
| 20. | Cod spawning area | 0.4 | **0.3** | 0.6 | 0.6 | 0.6 | - | - | - | - | - | 0.6 |
| 21. | Herring abundance | 0.6 | 0.6 | 1.2 | 1.2 | 1.2 | 1.8 | 1.8 | 2.4 | 2.4 | 2.4 | 1.8 |
| 22. | Sprat abundance | 0.6 | 0.6 | 1.2 | 1.2 | 1.2 | 1.8 | 1.8 | 2.4 | 2.4 | 2.4 | 1.8 |
| 23. | Distribution of pelagic spawning flounder | 0.9 | **0.8** | 1.6 | 1.6 | 1.6 | 2.4 | 2.4 | 3.2 | - | - | 2.1 |
| 24. | Abundance of pelagic spawning flounder | 0.8 | 0.8 | 1.6 | 1.6 | 1.6 | 2.4 | 2.4 | 3.2 | - | - | 2.1 |
| 25. | Recruitment areas of perch | 1 | 1 | - | - | - | 3.0 | 3.0 | 4.0 | 4.0 | 4.0 | 3.6 |
| 26. | Recruitment areas of pikeperch | 0.9 | 0.9 | - | - | - | 2.7 | 2.7 | 3.6 | 3.6 | 3.6 | 3.2 |
| 27. | Recruitment | 0.9 | 0.9 | - | - | - | 2.7 | 2.7 | 3.6 | 3.6 | 3.6 | 3.2 |

| Nr. | Water type | Sensitivity indicator | | Open waters | | | Coastal waters | | | Transitional waters | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-basin name | According to HELCOM | Corrected | Bornholm Basin | Eastern Gotland Basin | Gdańsk Basin | Bornholm Basin Polish Coastal waters | Eastern Gotland Basin Polish Coastal waters | Gdańsk Basin Polish Coastal waters | Polish waters of Szczecin Lagoon | Polish waters of Vistula Lagoon | Average impact |
| | The level of pressure | | | 2.0 | 2.0 | 2.0 | 3.0 | 3.0 | 4.0 | 4.0 | 4.0 | |
| | areas of roach | | | | | | | | | | | |
| 28. | Wintering seabirds | 0.6 | **0.3** | 0.6 | 0.6 | 0.6 | 0.9 | 0.9 | 1.2 | 1.2 | 1.2 | 0.9 |
| 29. | Breeding seabird colonies | 0.8 | **0.3** | - | - | - | 0.9 | 0.9 | 1.2 | 1.2 | 1.2 | 1.1 |
| 30. | Migration routes for birds | 0.3 | 0.3 | 0.6 | 0.6 | 0.6 | 0.9 | 0.9 | 1.2 | 1.2 | 1.2 | 0.9 |
| 31. | Grey seal abundance | 0.8 | **0.3** | 0.6 | - | - | 0.9 | 0.9 | 1.2 | - | - | 0.9 |
| 32. | Grey seal haulouts | 0.5 | **0.3** | - | - | - | 0.9 | 0.9 | 1.2 | - | - | 1.0 |
| 33. | Harbour seal abundance | 0.8 | **0.3** | 0.6 | - | 0.6 | 0.9 | - | 1.2 | - | - | 0.8 |
| 34. | Harbour seal haulouts | 0.5 | **0.3** | - | - | - | 0.9 | - | 1.2 | - | - | 1.1 |
| 35. | Distribution/abundance of Harbour porpoise | 1.1 | **0.3** | 0.6 | 0.6 | 0.6 | 0.9 | 0.9 | 1.2 | - | - | 0.8 |
| | Average impact | | | 1.5 | 1.6 | 1.5 | 2.1 | 2.3 | 3.1 | 3.4 | 3.4 | |

### *Climate change*

There is very strong evidence that global climate changes observed in recent decades, manifesting itself, among others, by warming, are a phenomenon that is primarily caused by man. Combustion of fossil fuels that underpin the global economy, as well as agricultural intensification and massive deforestation, led to a 20-fold increase in $CO_2$ emissions from anthropogenic sources, from around 500 million tonnes in 1900 to around 10,000 million tonnes in 2014 [EPA 2017] $CO_2$ concentrations in the atmosphere before the beginning of the industrial era were 260 - 290 ppm, and currently (2017) reached 404 ppm, and the process is constantly accelerating - currently annual increases in $CO_2$ concentration are on average 2.5 ppm/year, while still in 1960 it was about 0.7 ppm/year (Fig. 4.1.29) [NOAA, 2017]. There was also a significant increase in a number of other so-called greenhouse gases, in particular methane and nitrous oxide (mainly from agriculture).

The greenhouse effect caused by them results from the fact that these gases absorb a part of the heat radiated by the earth's surface, thus changing the heat exchange balance between the planet and space and making more heat stay in the atmosphere. It is estimated that without the presence of greenhouse gases, including $CO_2$ and water vapor, in the Earth's atmosphere, the average planet temperature would be -19°C [Le Treut et al., 2007] instead of around 14°C. Hitherto, anthropogenic greenhouse gas emissions have caused an average global temperature increase of around 1°C (Fig. 4.1.30), although this increase is not evenly distributed, focusing in recent decades on the massive land masses of the Northern Hemisphere and the Arctic, where anomalies have already approached 2°C [NASA 2017].

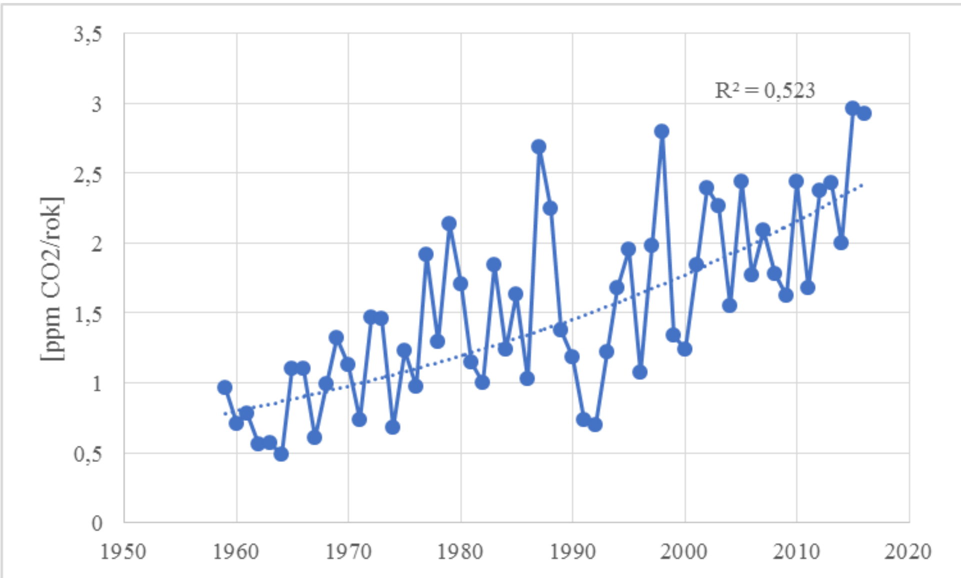



Fig. 4.1.29. Growth rate of average global $CO_2$ concentrations (ppm$CO_2$/year) in the atmosphere

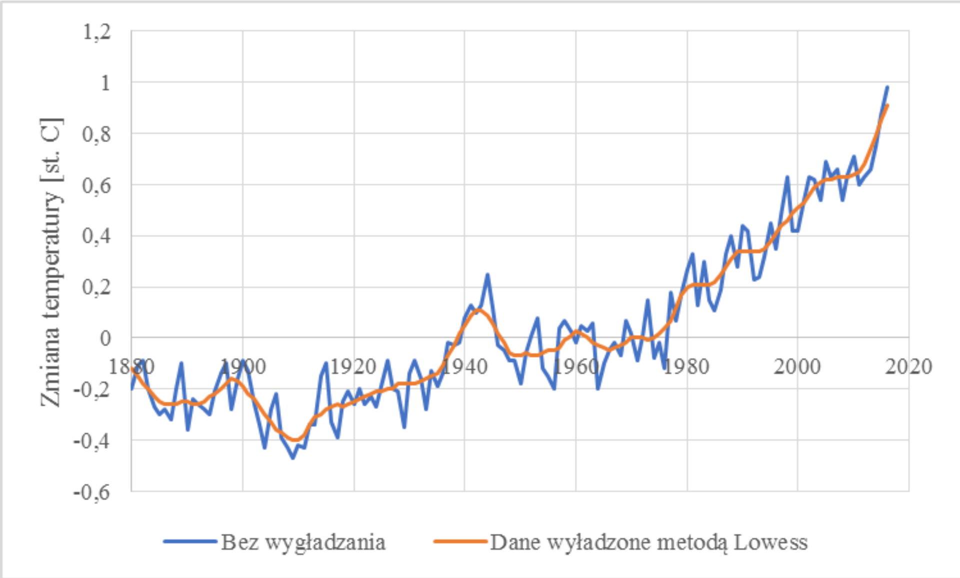



Fig. 4.1.30. Changes in global average temperatures (°C) in the period 1880-2016 (NASA 2017)

Significant climate changes, primarily based on its warming as a result of greenhouse gas emissions, may have a profound impact on the functioning of all ecosystems, including the Baltic Sea ecosystems. Higher temperatures attract or may entail, inter alia:

- changes in the species structure caused directly by the expansion of thermophilic species and the withdrawal of cold-water species,
- further changes in the species structure and the food web as a direct consequence of the relationship between thermophilic and cold-water species,
- an increase in the metabolic rate of poikilotherm organisms, which constitute the overwhelming majority of aquatic organisms,
- an increase in the rate of circulation of elements in the ecosystem as a result of, inter alia, acceleration of the distribution of organic matter by microorganisms,
- decrease in oxygen solubility,
- faster deoxidation of bottom layers as a result of increased plankton production and reduced oxygen solubility,
- the spread of alien species, previously associated with other climatic zones,
- an increase in the frequency of violent weather events, including heavy rains and floods, which may increase the processes of transport of matter, including nutrients from the catchment to the sea,
- significant changes in water circulation caused by the disappearance of the ice cover,
- significant changes in water circulation caused by changes in wind and rainfall distributions.

**Surface temperature**

Average temperatures in the Baltic Sea in the period 1880-2012 increased by about 1°C, although this increase was not uniform - in 1920, among others, and in 1982, there were drops to the level from the end of the 19th century (Fig. 4.1.31). The years 1982-2004 were a period of almost constant high temperature increase. Since then, average annual temperatures have stabilized more or less at the level of 1°C higher than in 1890 and 1982 (Fig. 4.1.32). In the Polish part of the sea, average annual surface temperatures fluctuate in recent years, depending on the year and position, within 9-13°C, and maximum temperatures - within 16-24°C (Fig. 4.1.33 and Fig. 4.1.34).

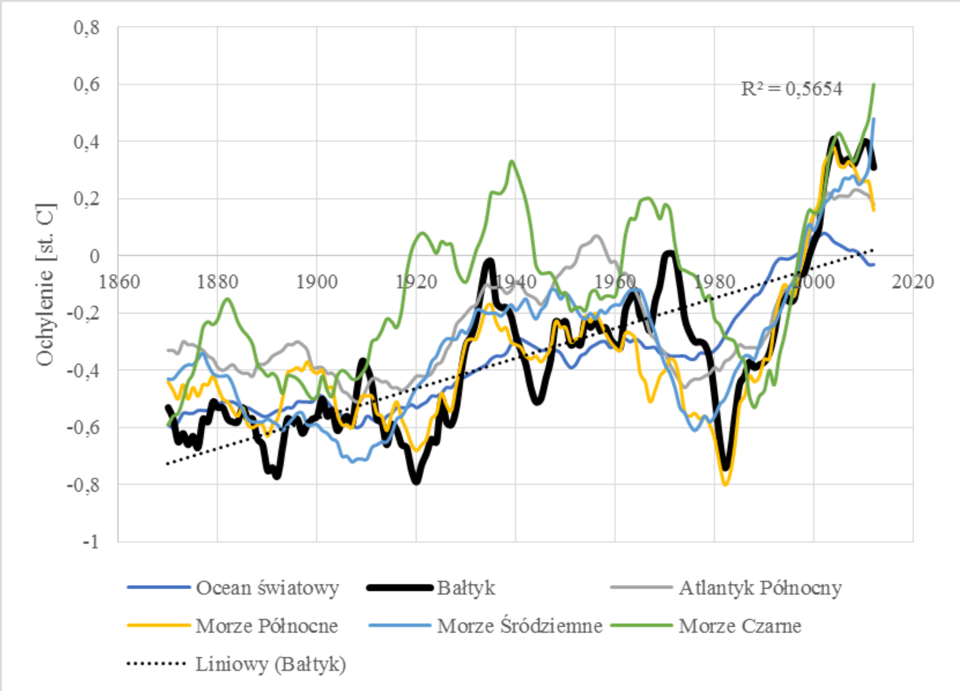



Fig. 4.1.31. Trends in surface temperature (°C) changes of the World Ocean and European seas in the years 1880 - 2012 according to (EEA 2018)

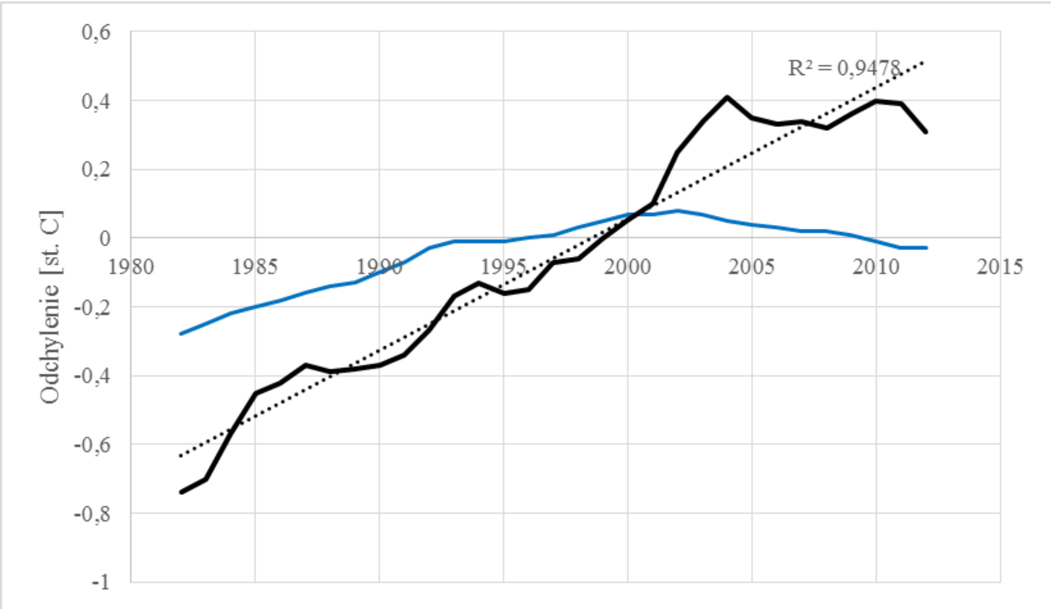



Fig. 4.1.32. Trends in surface temperature changes (°C) of the World Ocean and the Baltic Sea in the years 1982 - 2012 according to (EEA 2018)

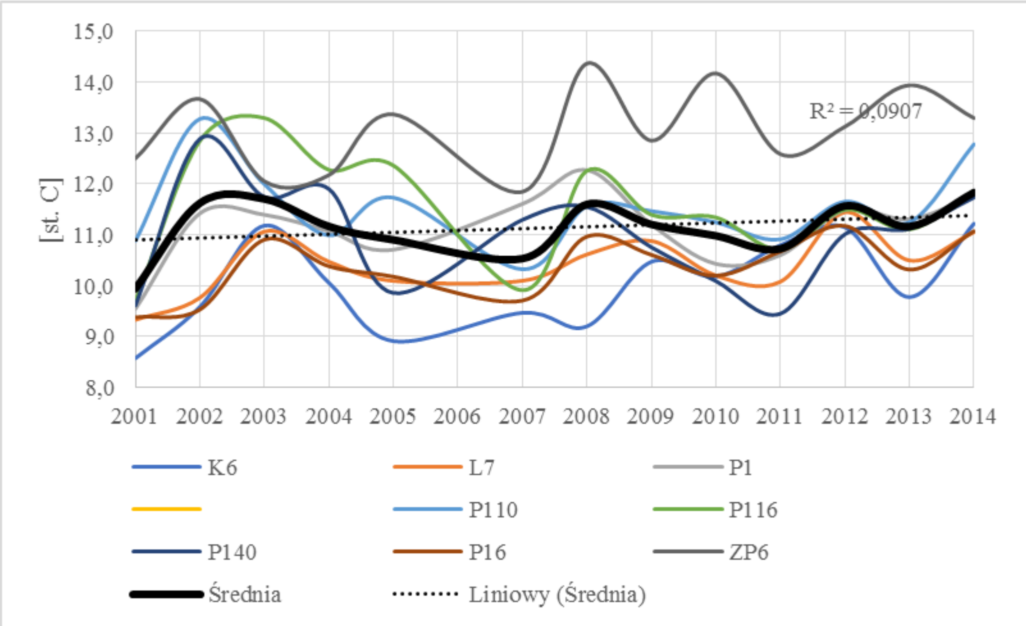



Fig. 4.1.33. Changes in the surface temperature (°C) of the Polish part of the Baltic Sea in the years 2001 - 2014 (source: PMŚ). Average annual temperatures

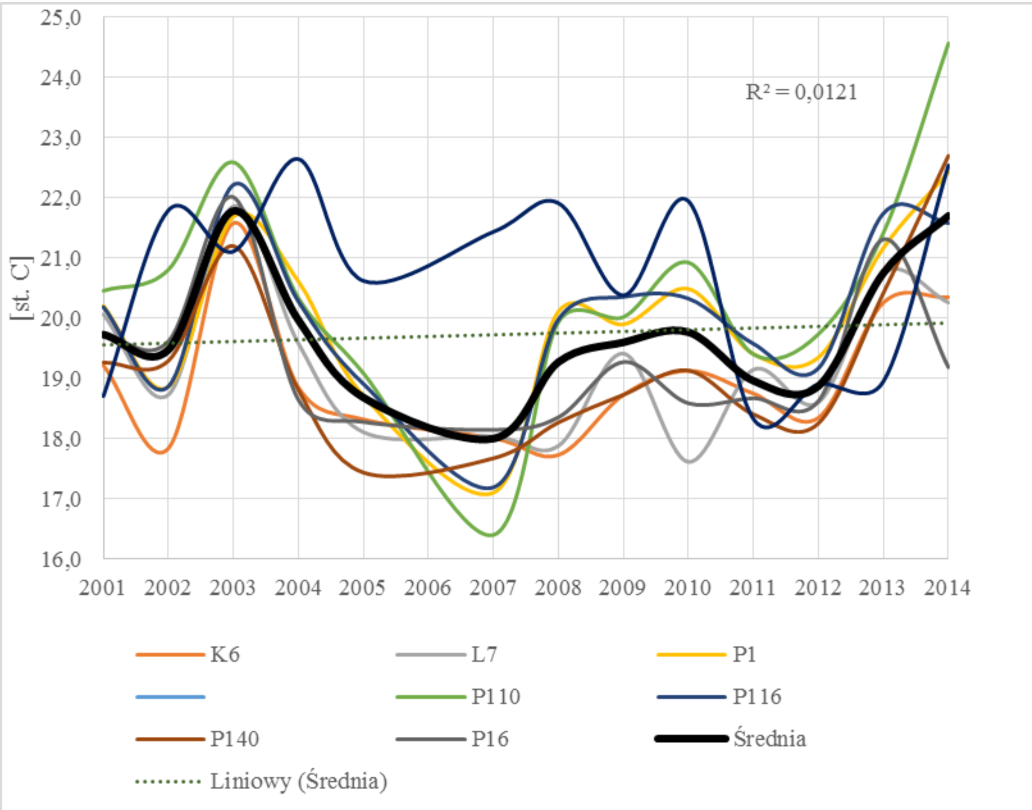



Fig. 4.1.34. Changes in surface temperature (°C) changes in the Polish part of the Baltic Sea in the years 2001 - 2014 (source: PMŚ). Maximum temperatures

The impacts of climate change in the Baltic Sea conditions may consist above all in:

- increasing the symptoms of eutrophication by reducing the solubility of oxygen and accelerating the circulation of elements,

- favoring the expansion of thermophilic species,
- reduction of cold-water species.

Data analysis for the Bornholm Deep and Gotland Deep from 1898 - 2012 showed that in the period the average the Baltic Sea temperature at the bottom increased by about 2°C [Carstensen J. et al., 2014]. This increase alone caused that the oxygen concentration corresponding to the saturation decreased by 0.5 mg $O_2$/L, which contributed to the expansion of dead zones and increased internal sea supply with nutrients from bottom sediments. A change of great importance was the expansion of cyanobacteria, which, apart from high trophies, are also favored by higher temperatures. This change had consequences for the structure of both phytoplankton and zooplankton, and consequently also for higher elements of the trophic chain. Examples of alien species, which seem to be favored by rising temperatures, are round goby, originating from the Caspian Sea and Chinese mitten crab from the South China Sea. The cold-blooded species, which may not be favored in the long term, is *Monoporeia affinis*.

### Salinity changes

Fluctuations of the river's outflow are, in addition to surface evaporation, the circulation of air masses, precipitation on the surface of the sea and salty inflows, one of the elements affecting the observed fluctuations in the salinity of the Baltic Sea. These fluctuations in Polish waters have not shown a clear trend in recent years (Fig. 4.1.35, Table 4.1.17).

Table 4.1.17. Average changes in the concentration of total chlorides and sulphates in river waters discharged from Poland to the Baltic Sea, based on data (GUS 2015)

| Year | Load of Cl-, SO4- in saline waters | | Discharge rate | Change in Cl-, SO4- concentration in the estuaries caused by saline water discharges |
|---|---|---|---|---|
| | Total | discharged | | |
| | [thous. tonnes Cl-, SO4-] | | $m^3/s$ | $g/m^3$ |
| 2007 | 3234 | 2899 | 1805 | 5.1 |
| 2014 | 3459 | 2808 | 1608 | 5.5 |

The influence of saline water from the mine and other point discharges on the composition of waters at the river mouth is very small, as illustrated in Table 4.1.17. It is estimated that these sources cause an increase in the salinity of water discharged to the Baltic Sea by about 5 g (Cl-, SO4-)$m^{-3}$. For comparison, in 2015 the sum of chlorides and sulphates was 133 g $m^{-3}$, respectively, in Wisła near Płock and 207 g $m^{-3}$ in Oder in Widuchowa. Thus, point discharge of saline water probably accounts for 2-4% of the salt load reaching the Baltic Sea from the territory of Poland. The surface layers of the Baltic Sea at Polish shores are 30-60 times more saline than river waters. With such proportions, the load of salt from point anthropogenic sources is negligible, as well as its impact on the sea.

It can be assumed that in the pre-industrial era, and especially before the mass extermination of forests in the Middle Ages, fluctuations in river outflow were smaller than at present due to the greater retention capacity of forests, swamps and natural river valleys compared to agricultural or built-up areas. This change in the outflow characteristics was likely to have a significant impact (apart from land use changes in itself) on the intensification of the processes of leaching of nutrients and other substances from the catchment, and thus, inter alia, on the intensity of eutrophication. However, the modification of short-term salinity fluctuations associated with the change of river outflow characteristics could not have a noticeable negative impact on key elements of the ecosystem included in the BSII index.

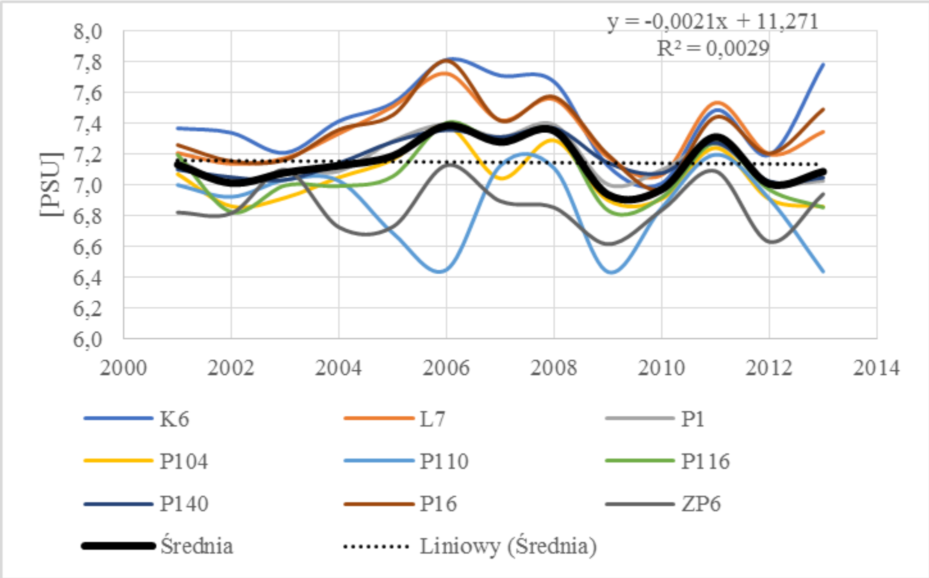



Fig. 4.1.35. Changes in salinity of the Polish Marine Areas in 2001-2014 (source: PMŚ).

***Microbial pathogens***

The term „microbial pathogens" is contained narrowly and includes microorganisms that can penetrate the human body and cause disease. Thus, it does not include, among others, cyanobacteria, many of which produce exotoxins that can cause various types of adverse reactions in humans.

In 2015, as part of the PMŚ, in points located near river mouths, there were no exceedances of the permissible amount of Escherichia coli (1000 cells/100 ml) except for the Western Oder and Ina, where over 3000 cells/100 ml were recorded. The largest number of exceedances was recorded in the foothill regions.

Although the sanitary status of waters is tested in bathing areas and places used for bathing, studies regarding the presence of pathogenic bacteria are not part of the PMŚ. For these reasons, there is no data on the sanitary condition of the Vistula waters discharged to the Baltic Sea. Bathing in the Gulf of Gdańsk, however, is usually closed due to the blooms of cyanobacteria and not the presence of E. coli. Increased amounts of E. coli in the Gulf of Gdańsk are usually recorded as a result of flooding in the Tri-City, as a result of which rainwater, ditches and the Vistula get into the sea, heavily polluted waters from urban areas.

No information has been found in recent years about cases of contagious diseases as a result of bathing in the Baltic Sea. Nevertheless, the statistics of unsuitability for bathing water (Table 4.1.18. ) induce pressure to be considered significant in the Vistula Lagoon and clear in the Bornholm Basin Polish coastal watersand the Gdańsk Basin Polish coastal waters.

There were no instances of unsuitability for bathing in the Stepnica bathing resort on the Szczecin Lagoon (the only official basin, examined by the State Sanitary Inspection bodies), despite the fact that it is located near the mouth of the Oder to the Lagoon, and in the lower Oder there are exceeded the permissible quantities of faecal bacteria. In addition, it should be noted that the above comparison does not present optimal results due to the fact that in 2005 different regulations were in force than in 2010 and 2015, including microbiological tests of water.

Table 4.1.18. Closing of sea bathing areas due to the presence of bacteria in 2005, 2010 and 2015, based on data [WSSE]

| Akwen | 2005 | | | 2010 | | | 2015 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Liczba: | | | | | | | | |
| | zamknię-tych kapielisk | zamknięć | dni zamknięcia | zamknię-tych kapielisk | zamknięć | dni zamknięcia | zamknię-tych kapielisk | zamknięć | dni zamknięcia |
| Zalew Wiślany* | 3 | 4 | 120** | 6 | 6 | 364** | 0 | 0 | 0 |
| Zalew Szczeciński | b.d. | b.d. | b.d. | 0 | 0 | 0 | 0 | 0 | 0 |
| Zatoka Pucka Zewnętrzna | 0 | 0 | 0 | 1 | 2 | 17 | 0 | 0 | 0 |
| Zatoka Gdańska Zewnętrzna | 0 | 0 | 0 | 1 | 1 | 14 | 0 | 0 | 0 |
| Wody przybrzeżne Basenu Bornholmskiego | 0 | 0 | 0 | 8 | 8 | 47 | 8 | 9 | 43 |
| Wody przybrzeżne wschodniej części Bałtyku Właściwego | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

* Data from the Vistula Lagoon from 2005 incomplete - no information from the county of Braniewo.

** On the Vistula Lagoon, most of the data concerns unofficial bathing areas, but places traditionally used for bathing. In these places the lack of suitability of bathing water was found, the number of days of confinement means in this case the number of days during which abnormal quantities of bacteria were present in water, estimated on the basis of materials from the WSSE Olsztyn. Data from the Vistula Lagoon incomplete - missing.

No information has been found in recent years about people becoming ill with infectious diseases due to bathing in the Baltic Sea. Hence, the impact of bacterial contamination on human health can be considered insignificant.

## 4.2.Pressures of marine origin on the waters of the Polish zone of the Baltic Sea

The summary has been developed for the purpose of updating data on dominant pressures and impacts, including anthropogenic ones, of marine origin on waters of the Polish Baltic Sea zone and concerns the period from 01/01/2011 to 31/12/2016.

The list does not take into account pressures and impacts of marine origin on sea waters resulting from fishing activities listed in art. 150 sec. 3 points 3 of the Water Law Act, which is included in the next chapter.

The list includes all types of pressures and impacts listed in art. 150 sec. 3 point 2 of the Water Law Act and Table 2 of the Directive 2017/845 related to:

- physical loss,
- physical demage,
- interference with hydrological processes,
- contamination by hazardous substances,
- systematic and/or intentional release of substances, including nutrients and organic matter,
- biological disturbance.
- smothering by artificial islands, structures and devices, underwater cables and pipelines or disposal of dredge spoil,
- sealing, including artificial islands, structures and devices, underwater cables and pipelines,
- changes in water transparency inclugding by outfalls, increased run-off, dredging/disposal of dredge spoil,
- abrasion e.g. impact on the seabed of commercial fishing, boating, anchoring,
- selective extraction e.g. exploration and exploitation of non-living resources on seabed and subsoil,
- Underwater noise e.g. from shipping, artificial islands, structures and equipment, including underwater acoustic equipment and submarine cables and pipelines,
- marine litter,
- introduction of synthetic compounds, including anti-fouling agents used on ships,
- introduction of non-synthetic substances and compounds e.g. heavy metals, hydrocarbons, resulting, for example, from pollution by ships and oil, gas and mineral exploration and exploitation,
- introduction of other substances, whether solid, liquid or gas, in marine waters, resulting from their systematic and/or intentional release into the marine environment.

The results of monitoring carried out in accordance with the Maritime Waters Monitoring Program 2015 (GIOŚ 2015b), which meets the requirements of the EC and HELCOM as well as previously conducted monitoring programs agreed at the regional level (HELCOM), were also taken into account.

The guidelines for the conducted analyzes were also conclusions from the expert opinions, documents and planning documents prepared so far on the subject under consideration. This separate list of conditions is provided by:

- reports of technical groups appointed by the European Commission, available results of HELCOM projects (in particular HELCOM HOLAS II and TAPAS);
- an approach to pressure setting, applied by other EU countries, in particular HELCOM member states;
- qualitative and quantitative presentation of pressures and impacts of marine origin on the waters of the Baltic Sea and clearly distinguishable trends;
- cross-border aspect of the examined pressures.

The analysis of data was carried out within the framework of POM, as defined in the Act of March 21, 1991 on Maritime Areas of the Republic of Poland and Maritime Administration (Journal of Laws of 2017, item 2205, as amended) and in accordance with the Regulation of the Council of Ministers of 13 January 2017 on the detailed course of the base line, external border of the territorial sea and the external border of the adjacent zone of the Republic of Poland (Journal of Laws, item 183).

***Biological pressures***

**Alien species**

Currently, alien species are perceived as one of the greatest threats to ecosystems on earth, because their introduction and spread are the least predictable and belong to the most dynamic natural processes occurring under the influence of human activity. At the same time, biological invasions remain one of the least researched and least recognized threats to biodiversity (IOP PAN, 2009).

The phenomenon of primary introduction occurs through intentional or unintentional human activity. In general, the following categories of possible introduction vectors are listed for all aquatic environments, i.e .: 1. vessels, 2. canals, 3. fishing, 4. aquaculture, 5. food trade, 6. activities related to leisure, 7. research and education, 8. biological control of parasites, 9. changes in natural water flow (HELCOM, 2017d).

Many alien species do not spread in a significant way and do not reach significant numbers in new habitats beyond the reach of their natural occurrence. Embedded alien species are always potentially a threat to the marine environment, because they can lead to negative changes in the structure and functioning of ecosystems, as well as have a negative impact on the health or life of the population. In general, the interactions of alien species are complex and can be difficult to distinguish from the impact of other factors. In most cases, their impact on biodiversity and the functioning of ecosystems, however, is positive or neutral. Due to the fact that it is difficult to predict their impact, it is recommended to introduce appropriate measures to prevent introductions (Katsanevakis et al., 2014). Only a small part of alien species becomes an invasive species, i.e. alien species which introduction and/or spread threatens the biodiversity of the region of resettlement. Globally invasive alien species pose a threat to the structure and functioning of ecosystems, economic use of the sea and human health (e.g., Mack et al., 2000, Ojaveer et al., 2015). Among environmental impacts of invasive alien species, there are changes in habitats and communities and the functioning of trophic networks, and in extreme cases even the elimination of native species (Galil, 2007). The impacts of major importance for the economy include losses in fisheries and industry associated with the treatment of overgrown hydrotechnical constructions (e.g. water intakes and outflows) and ship hulls (Williams et al., 2010, Ojaveer et al., 2016). The additional threat associated with the introduction and spread of alien species, especially for the health and life of the population, are pathogens and algae that create toxic blooms (Zaiko et al., 2011). Mass blooms or the disappearance of valuable attributes of the marine environment may also lead to tourism losses. Although research on the impact of alien species on marine ecosystems already has a history, it is still insufficient to fully assess their impacts (Ojaveer et al., 2015, Ojaveer et al., 2016; Squaysrz et al., 2016). In this context, it seems reasonable to take a comprehensive approach to the problems related to preventing the introduction of invasive alien species and the establishment of a common system of control and management of alien species at the level of the whole country.

A large proportion of invasive alien species are introduced unintentionally. In the case of establishment and spreading of alien species in a larger area, its eradication is practically impossible and unprofitable (Sambrook et al., 2014), especially in the case of sea waters. For this reason, the eradication of the alien species has not yet been reported in European seas (Genovesi 2005). When invasive alien species are introduced, early detection and rapid elimination measures are crucial to prevent them from becoming settled and spread. Therefore, more effective control of the paths of their unintentional introduction is of primary importance in the first place, including by conducting regular monitoring of ecosystems particularly vulnerable to introductions of alien species. Hence, many surveillance and control instruments have been introduced in recent years to prevent undesirable introductions. One of them of the colossal significance for the Baltic Sea basin is the International Convention on the Control and

Management of Ballast Water and Sediments (BWM), the so-called International Convention for the Control and Management of Ballast Water and Sediments. the ballast convention, which was adopted in February 2004 in London under the auspices of IMO (International Maritime Organization) and entered into force on 08/09/2017. Its introduction aims to prevent the introduction of harmful aquatic organisms and pathogens into alien marine environment (mainly port and coastal waters). All commercial vessels operating in international waters will have to manage ballast water and sediment, using specific standards, to discharge only ballast water meeting the standards set in the BWM. Therefore, on most ships it will be necessary to install ballast water treatment systems. The entry of the BWM Convention into force should result in a reduction in the pressure and risk of introduction of invasive water species and pathogens in the port and coastal areas to the desired minimum, and a global reduction in the possibility of invasive species entering the maritime areas defined as special and particularly sensitive, including among others, the Baltic Sea. To date, Germany, Russia, Denmark, Sweden and Finland have ratified the convention among HELCOM countries (HELCOM, 2017e).

Activities in the field of identifying, controlling and eliminating alien species taken at the EU forum are also of great importance. On October 22, 2014, the IAS Regulation was adopted. The IAS Regulation imposes on EU member states, inter alia, the obligation to conduct a comprehensive analysis of the routes of inadvertent introduction or spread of alien species on the national territory, including sea waters, within 18 months from the date of adoption of the Union list of alien species. The list referred to in the IAS Regulation was established on 13 July 2016 by Commission Implementing Regulation (EU) 2016/1141 adopting the list of invasive alien species identified as hazardous to the Union in accordance with Regulation (EU) No 1143 of the European Parliament and of the Council / 2014 and supplemented by Commission Implementing Regulation (EU) No 2017/1263 of 12 July 2017 updating the list of invasive alien species identified as hazardous to the Union established by Commission Implementing Regulation (EU) 2016/1141 pursuant to Regulation of the European Parliament and of the Council (EU) No. 1143/2014.

Sea transport, canals and aquaculture are mentioned as significant vectors of introduction in the Baltic Sea (Wolff et al., 2002, Eero et al., 2014). In POM, deliberate introductions involving the introduction of alien species into the marine environment, e.g. aquaculture, are currently out of place and do not pose a threat to the ecosystems of the Baltic Sea. The real threat is the intensification of sea transport observed in recent years, because ballast water and ship hulls are the main medium facilitating the spread of species. It is estimated that in ballast waters of all ships in the world, up to 3,000 are transported every day. species (MarineBio, 2017). Smaller significance is attributed to artificial channels connecting river systems, although they were probably a vector of the introduction of many Ponto-Caspian species to the Baltic Sea. Currently, the number of alien species including species of unknown introduction vector that appeared in the Baltic Sea since the nineteenth century is estimated at around 140. This number includes 14 new alien species identified in the period 2011-2015 (HELCOM, 2017d).

The main places of introductions of alien species are ports and harbors, not only due to the increased presence of ships and boats from different regions of the world, but also to specific conditions prevailing in them (i.e. shallow, low-dynamic waters with a large number of potential habitats) (e.g. Eero et al., 2014, Lehtiniemi et al., 2015). However, the specific conditions of the Baltic Sea environment (including varied salinity and relatively low temperature as well as freezing during winter) limit the spread and establishment of alien species in its region (eg Holopainen et al., 2016).

The Baltic Sea is susceptible to the settlement of new species. In the Baltic Sea, domesticated alien species constitute 59% of the total number of introduced species and about 30% of the total number of macrofauna taxa in the brackish coastal waters of the Gulf of Gdańsk (Ojaveer et al., 2016, Janas and Kendzierska, 2014). Due to the highly diversified level of knowledge and the availability of data between the individual Baltic Sea basins there are large discrepancies in the assessment of vectors / routes of introduction of alien species, which significantly undermines the confidance of the assessment. In turn, a high degree of uncertainty associated with the typing of introduction vectors makes it difficult to perform detailed analyzes and estimate the size and extent of the introduction under the influence of human activities both to the Baltic Sea and within it. Hence, the index of new introductions developed by HELCOM contains only information on new introductions (primary introductions) to the waters of the Baltic Sea on the scale of lagoons defined in Annex 4 Monitoring and Assessment Strategy (HELCOM, 2013a) and ignores the secondary spread of species in a natural way (migration paths) , water currents, etc.). The limit value for the indicator was related to the primary objective of BSAP which is the lack of introductions of primary alien species caused by human activity in the six-year assessment period. The disadvantage of this approach is the underestimation of the number of introductions of alien species in many areas of the sea and the inability to assess the status of new introductions in smaller (more detailed) units of assessment. However, due to the fact that the number of new alien and cryptogenic species (of unknown origin) for the Baltic Sea and not domesticated, which form persistent populations, the indicator reflects the effectiveness of remedial actions preventing the penetration of alien and cryptogenic species into the Baltic Sea, as well as ecosystem status by indicating areas where the level of unpredictable risk associated with new introductions is high (Olenin et al., 2016).

In recent years, there has been a slowdown in the Baltic Sea in the trend of an increase in the number of alien species observed since the beginning of the 19th century, despite the increasing activity in the field of maritime transport. As already mentioned, after introducing a regular monitoring of marine environment dedicated to alien species, potentially the number of observations of new alien species in the Baltic Sea could be higher and reflect the actual state. Currently, observations of well-recognized groups of organisms (mussels, crustaceans, fish) are over-represented at the expense of organisms of smaller sizes, e.g. meiofauna and microorganisms including microorganisms (HELCOM, 2017d).

An additional source of data were scientific publications resulting from the work carried out within the framework of the Baltic Sea Pilot Project BALSAM project aimed at testing methods of monitoring alien species in the port of Gdynia (Marszewska et al., 2017, Normant-Saremba et al., 2017). In the period 2011-2016, 4 new alien species were identified in the POM region, i.e. Dreissena bugensis, Melita nitida, Palaemon macrodactylus, Rangia cuneata. Only Palaemon macrodactylus is a new species for the Baltic Sea. Other taxa have already been observed in other sea areas.

**Microbial pathogens**

Bathing impurities are treated as land-based pollution and are described in more detail in Chapter 4.1.

**Genetically modified species and translocation of native species**

Commercial culturing of genetically modified species (GMO) in the environment is banned in Poland, as in other 19 EU member states, but their culturing for scientific purposes requires permission of the Minister of the Environment, which is very difficult to obtain (Act of 22 June 2001 on microorganisms and genetically modified organisms along with changes (Journal of Laws of 2017, item 2134, as amended)). Therefore, there is virtually no way of introguction of those species into the marine environment.

Work on the relocation of native species in 2011-2016 took place only as part of the ZOSTERA project. Restitution of key elements of the internal Puck Bay ecosystem. The only marine species (of marine origin) intended for restitution is seagrass (*Zostera marina*), but so far no experiments have been carried out with the introduction or displacement of this plant into new habitats and no optimal restitution technology has been developed.

During the study work, no marine sources of genetically modified species were identified and the native species were intentionally moved in POM.

Conducting intensive maricultures is often associated with the loss of habitats, eg transformation of marching forests into shrimp mariculture or a change of natural biocenoses, eg change in water chemistry, increase of organic matter on the bottom or emergence of microbial pathogens in fish farming. The pressures identified can be both abiotic and biotic.

During the study work, no marine aquaculture was identified in POM.

**Disturbance of species due to human presence**

The common source of pressure related to disturbance of species caused by human presence in the sea is noise, which is classified as marine pollution (Article 3 MSFD) and has been described in detail as described in the chapter "physical pressures". Also the very presence of a man and the activities he undertakes on land, which in the statutory sense is a marine environment, e.g. Ryf Mew and sandbank in Wisła Przekop Estuary, can be considered as an element of pressure related to disturbing species.

There are no environmental impact assessments for pressure related to scaring of seals offshore (Gójska 2012a).

***Physical pressures***

**Physical loss disturbance to seabed**

Physical loss of the seabed is defined as a change in the basis or morphology of the seabed, which lasts or will last for a period of two assessment cycles (12 years) or more, according to decision 2017/848. Among the human activities that can cause physical damage to the seabed are: construction in the sea or along the shoreline, extraction of sand and gravel, dredging and storage of spoil.

Physical disturbance of the seabed is defined as a change in the seabed which can be restored if the activity causing the disturbance ceases. Activities that may cause physical disturbance of the seabed are considered to be in the sea or along the shoreline, sand and gravel extraction, dredging and storage of dregdesd material, as well as sea transport and trawling (HELCOM, 2017a).

Physical loss and disturbance to the seabed, resulting from human activities, lead to potential changes or temporary disturbances in habitats. Examples of such activities can be:

1. Interference in the bottom layer associated with hydrological constructions (e.g. construction of ports, wind farms, installation of cables and pipelines on the seabed). The extent of the loss or disturbance of the bottom depends on the local hydrological conditions, the type of habitat in the area of construction and the type of structure. The important thing is that the impacts are different during the construction phase and after its completion. Depending on the activities carried out, it may not only lead to the destruction of existing habitats, but also the emergence of new ones (as a result of changes in the properties of the ground in the construction area). Cables and pipelines can be placed in the excavation, and then covered with sediment extracted elsewhere, the composition of which is usually different, resulting in local environmental changes. Schwarzer et al. (2014) stated that natural regeneration of the environment is possible on a time scale of decades.
2. Extracting sand and gravel from the seabed associated with, for example, hydrological constructions or extending beaches can cause loss of habitat (partial or total, depending on how much sand or gravel is extracted and what is the mining technique), usually by changing the topography of the seabed, increased turbidity, attenuation of nearby areas (covering with settling sediment). The extracted bottom material is sieved to the desired grain size in the area of extraction, and the undesired substance is deposited. This can lead to a change in the local structure of sediments and, consequently, environmental conditions. Usually, the total loss of habitats occurs directly in the place of extraction (the habitat is removed together with the bottom material), and the disturbance - in the area of the extraction site, where the impact is weaker.
3. Maintenance and deepening of waterways causes various impacts on the seabed, in particular removal of spoil changes physical conditions by changing the topography of

the seabed, increases water turbidity due to picking up sediment from the bottom, it can also flood the bottom with previously raised sediment. Loss of habitats is limited to the dredging site, while disturbances due to sedimentation may have a wider spatial range. The results of the conducted research show that disturbances caused by sedimentation may concern animals and vegetation within a few kilometers from the basic activity. In addition, the remobilization of sediments may contribute to the release of contaminants contained therein and the eutrophication effect (HELCOM, 2017c.

4. Deposition of dredged material, which may lead to weakening of benthic organisms and loss of habitat if the properties of sediments are changed. In addition, the deposited material may contain higher concentrations of hazardous substances and nutrients than the place of storage. The impact of this process on species depends mainly on the type of seabed habitat, type and amount of material and distance from the place of extraction. The burial of benthic organisms by a deposited sediment may be the cause of their death, but some species have the ability to move and re-inhabit the bottom surface (Olenin 1992, Powilleit et al., 2009). The probability of survival is higher for organisms inhabiting the soft bottom (due to their adaptation to an unstable habitat and forcing migration), while organisms (both phyto-and zoobenthos) on rocky substrates disappear if covered with a few centimeters of sediment (due to the inability to conduct life processes) ) (Powilleit et al., 2009). The spatial range of impacts may reach several kilometers from the deposit site (HELCOM, 2017c).
5. Shipping can cause disturbance of the seabed in several ways: (1) currents induced by propellers that can cause sediment pickup, re-suspension and re-sedimentation, (2) waves generated by ships affecting coastal habitats, (3) anchoring causing direct physical disturbance to the seabed. The effects are often local, concentrated on shipping routes and around the ports (HELCOM, 2017a).
6. Use of a bottom trawl which causes disturbance to the surface of the seabed, as a result of bottom species are removed from the habitat or moved.

Therefore, at least some activities can cause serious damage to benthic habitats and species (see Fig. 4.2.1), some by direct contact with the seabed, others - by indirect effects due to increased turbidity or sedimentation. Whether activity results in permanent loss or temporary disturbance of benthic habitats depends on many factors, such as duration and intensity of activity, the technique used and the sensitivity of the affected area. Apart from the loss of natural habitat, new artificial habitats may appear in the place of pressure, which may lead to undesirable changes in marine ecosystems (HELCOM, 2017a).

Based on the available data, it has been found that less than 1% of the Baltic Sea bottom is potentially lost due to human activities, while more than 50% of the seabed area can potentially be affected (information concerns the period 2011-2015). There are currently no clear guidelines for contributing to the regional assessment method of how loss and disturbance of the seabed cause adverse effects on the marine environment (HELCOM, 2017a).

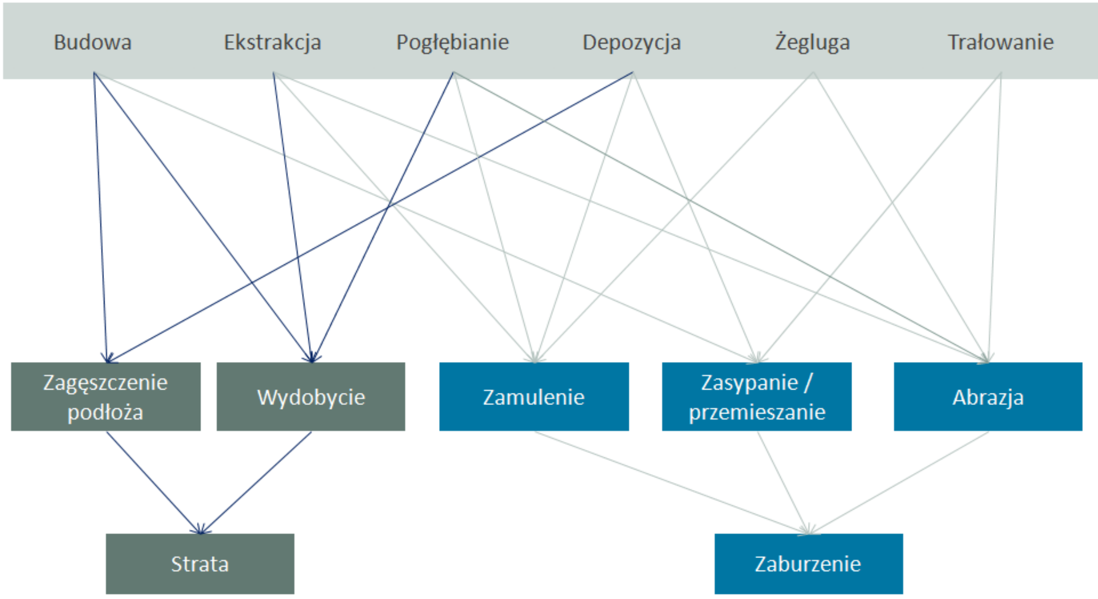



Fig. 4.2.1. General overview of human activities and their effects that may occur on the seabed (based on HELCOM, 2017a).

As part of the TAPAS project, spatial data layers (Table 4.2.1.) were provided, containing information on human activities and likely to affect physical loss and disturbance of the seabed. Using the content of these layers (developed in 2011-2016 and made available by HELCOM) sources of pressure were identified.

Table 4.2.1. List of spatial data layers related to anthropogenic pressures to be used in the determination of BSPI/BSII indices during the second holistic assessment (based on HELCOM 2016a, Annex 2; losses and physical disturbances of the seabed)

| Layer name | Data source | Data validity | Data notes |
|---|---|---|---|
| Physical loss (permanent effects on the seabed or morphology and exploitation of seabed) | | | |
| Land claim | HELCOM based on data provided by the Maritime Office in Szczecin | Last updated: April 2017 | - |
| Water course modification | HELCOM based on data provided by the Maritime Office in Gdynia | Last updated: May 2017 | No modification of the water tracks in the period 2011-2016 |
| Coastal defence and flood protection | HELCOM based on data provided by the Maritime Office in Gdynia, Słupsk and Szczecin | Last updated: April 2017 | - |
| Extraction of sand and gravel | HELCOM based on data provided by the Maritime Office in Słupsk and Szczecin | Data from the period 2011-2015 | Incomplete data, no information at least on the Gdynia I extraction site |
| Oil platforms | HELCOM based on data provided by the Maritime Rescue Coordination Center | Last updated: April 2017 | - |
| Pipelines | HELCOM based on data provided by the Maritime Office in Gdynia | Last updated: June 2017 | - |
| Wind farms | HELCOM | Data from 2016 | Lack of offshore wind farms in POM |
| Cables | HELCOM mainly based on information provided by EWEA 2015, Maritime Institute in | Data collected in 2015 and 2016 | - |

| Layer name | Data source | Data validity | Data notes |
|---|---|---|---|
| | Gdańsk | | |
| Ports | HELCOM based on satellite data, the Baltic Sea Port List 2012 and maps available on port websites | | 2016 |
| Harbours | The Act of December 20, 1996 on Seaports and Marinas (Journal of Laws of 2017, item 1933) | | - |
| Bridges and other construction | HELCOM based on Open Street Maps | Last updated: June 2017 | No sea bridges and other structures in POM |
| Bathing sites | HELCOM based on EEA GIS data | Data from the period 2011-2014 | |
| Oil terminals, refineries | HELCOM based on the Center for Maritime Studies, University of Turku | Data from 1997, 2000-2008 and 2011-2013 (after corrections) | |
| Finfish mariculture | | | Details in chapter 3.3 |
| Shellfish mariculture | | | Not applicable to POM |
| Physical disturbance to seabed (temporary or reversible effects) | | | |
| Shipping | The HELCOM AIS database | Data from the period 2011-2015 | |
| Recreational boating and sports | | | No data |
| Extraction of sand and gravel | HELCOM based on data provided by the Maritime Office in Słupsk and Szczecin | Data from the period 2011-2015 | Incomplete data, no information at least on the Gdynia I extraction site. |
| Dredging | HELCOM based on data provided by the Maritime Office in Gdynia, | Data from the period 2011-2015 | |
| Deposit of dredged material | Słupsk and Szczecin | Data from the period 2011-2015 | |
| Bathing sites | HELCOM based on data provided by experts | Data from the period 2011-2014 | |
| Wind farms (construction) | HELCOM | Data from 2016 | No offshore wind farms in POM |
| Cables (construction) | HELCOM mainly based on information provided by EWEA 2015, Maritime Institute in Gdańsk | Data collected in 2015 and 2016 | - |
| Pipelines (construction) | HELCOM based on data provided by the Maritime Office in Gdynia | Last updated: June 2017 | – |
| Crops | – | – | No data |
| Bottom trawling * | – | – | – |
| Water course modification (construction) | HELCOM based on data provided by the Maritime Office in Gdynia | Last updated: May 2017 | No modification of the water tracks in the period 2011-2016 |
| Coastal defence and flood protection (construction) | HELCOM based on data provided by the Maritime Office in Gdynia,Słupsk and Szczecin | Last updated: April 2017 | – |
| Aquacultures | | | Not applicable to POM |

*italics are marked layers of data which content does not fall within the scope of this study

**Physical loss (permanent change of seabed substrate or morphology and extraction of seabed substrate)**

The land claim was indicated as a source of pressure. Based on the available data, the bottom areas subject to the recultivation in the assessment period were identified - all located in the Pomeranian Bay and related to the breakwater built there (Fig. 4.2.3).

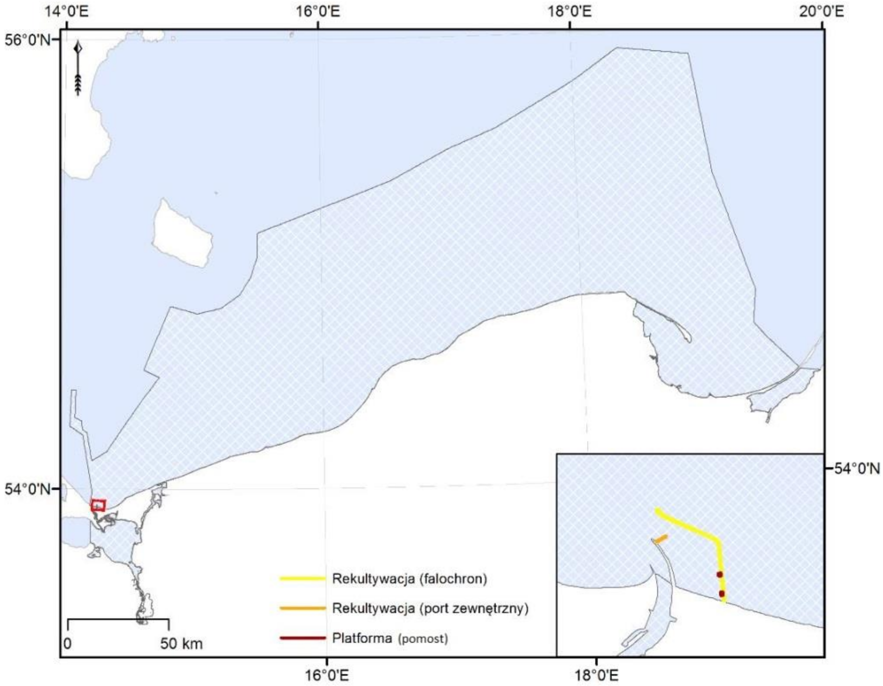



Fig. 4.2.2. Destination of the area (based on national data provided by HELCOM and updated for the purposes of this study).

Another source of pressure are constructions for flood protection and shore protection, such as spurs or breakwaters (Fig. 4.2.3). Most of this type of construction is located in the area of Rozewie, on a ten-kilometer stretch of the Hel Peninsula from the direction of Władysławowo and west of Koszalin.

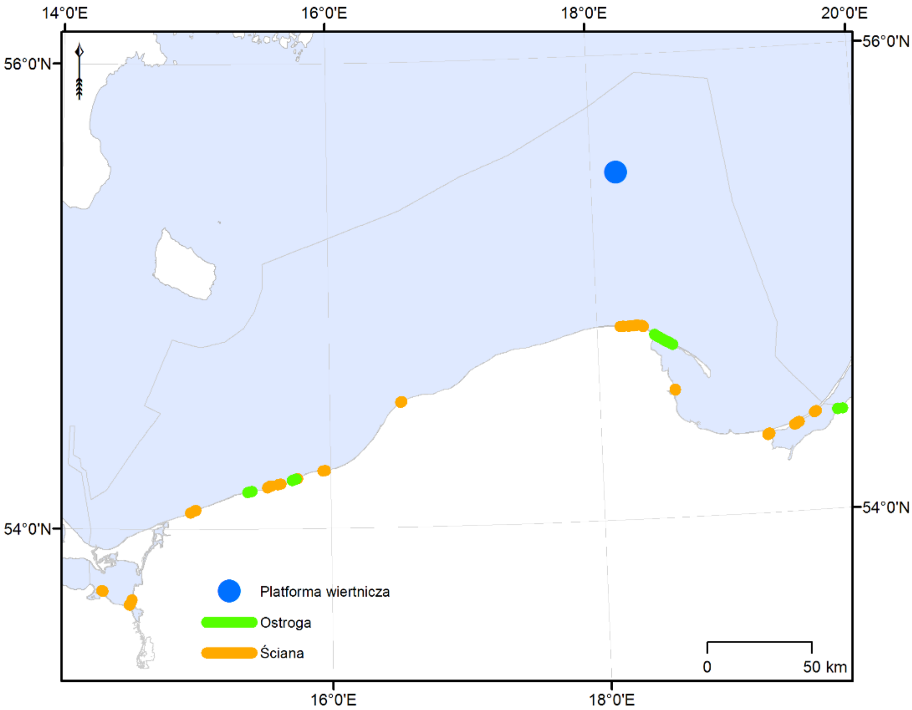



Fig. 4.2.3. Shore and flood protection along with the location of the oil rig (based on national data provided by HELCOM and updated for the purposes of this study).

Fig. 4.2.3 shows the location of two oil rigs - "Baltic Beta" and "LOTOS Petrobaltic" belonging to the LOTOS Petrobaltic SA Capital Group. On the B3 field, at the site of the Baltic Beta oil rig, the extracted reservoir fluid is subjected to separation, and then crude oil is directed to the tanker, while co-occurring gas is transported by a submarine pipeline to Władysławowo, where it is used to drive the local heat and power plant turbine. In order to increase the body of water pressure, a system for injecting water into the bed with directional injection wells was installed on the oil rig[6].

The scheme of oil rig operation is shown Fig.4.2.4. On the B8 field, at the site of the LOTOS Petrobaltic oil rig, the extracted crude oil is directed to the tanker, where it is stored. In order to increase the body of water pressure, a system for injecting water into the bed with directional injection wells was installed on the oil rig.

Another source of physical disturbance of the seabed is the extraction from the bottom of sand and gravel. The location of this type of activities is shown in Fig. 4.2.5. According to information reported by domestic entities to HELCOM and additionally with data coming directly from maritime offices, acquired for the purposes of this study, in 2011-2016 there were 18 mining areas, including the largest Rowy and Łeba 1 with an area of 56,43 $km^2$ and 40.00 $km^2$ respectively (Table 4.2.2.). Most of the material was extracted in 2011-2016 at the position of Wisła Śmiała (518200 $m^3$).

[6] http://www.lotos.pl/347/grupa_kapitalowa/nasze_spolki/lotos_petrobaltic/informacje/produkcja

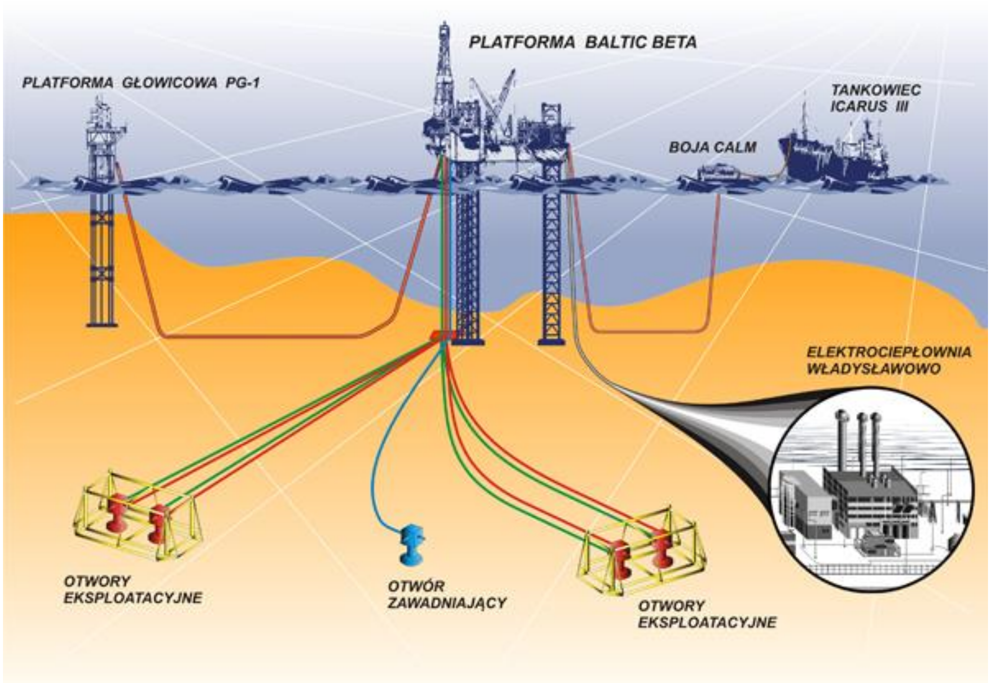



Fig.4.2.4. The scheme of functioning of the Baltic Beta oil terminal (source: GRUPA LOTOS S.A).

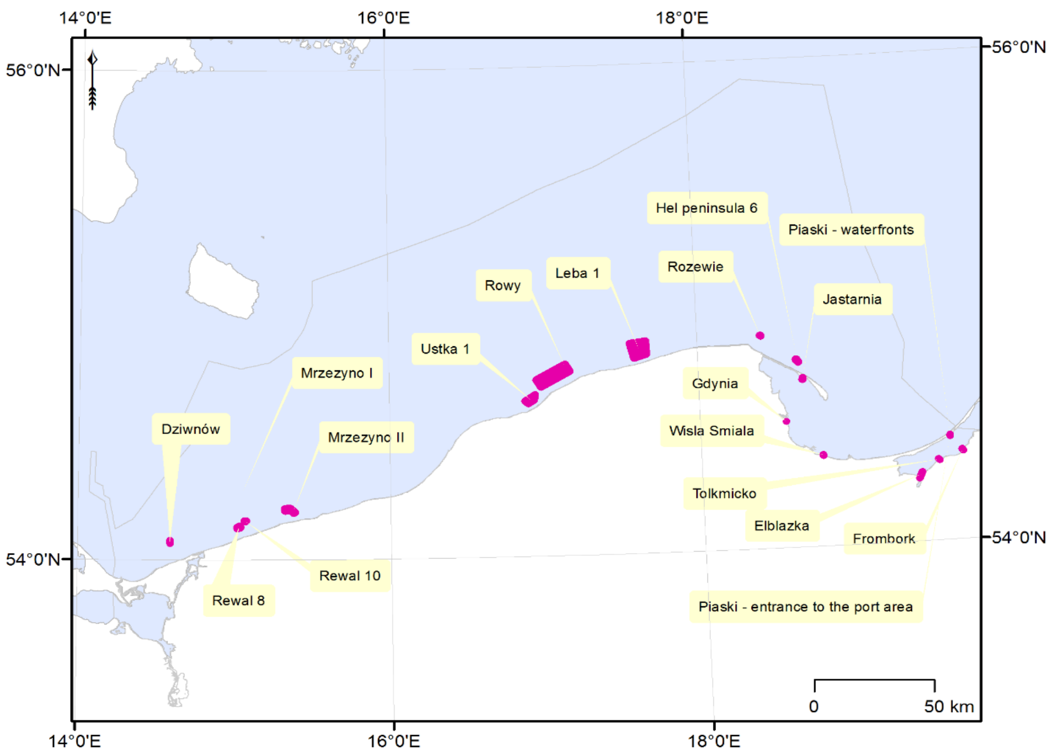



Fig. 4.2.5. Extraction of sand and gravel in 2011-2016 (based on national data provided by HELCOM and updated for the purposes of this study).

Table 4.2.2. Areas of sand and gravel extraction in 2011-2016 (based on national data provided by HELCOM and updated for the purposes of this study)

| Nr. | Area name | Surface [km2] | The volume of the extracted material [m3] |
|---|---|---|---|
| 1 | Ustka 1 | 8.11 | 155500 |
| 2 | Łeba 1 | 40.00 | 120000 |
| 3 | Rowy | 56.43 | 120000 |
| 4 | Mrzeżyno I | 3.16 | 0 |
| 5 | Mrzeżyno II | 1.18 | 0 |
| 6 | Dziwnów | 1.48 | 0 |
| 7 | Rewal 10 | 0.42 | 0 |
| 8 | Rewal 8 | 1.09 | 0 |
| 9 | Półwysep helski 6 | 0.67 | 0 |
| 10 | Jastarnia | 0.18 | 2715 |
| 11 | Rozewie | 0.15 | 0 |
| 12 | Piaski – wejście do portu | 8.80 | 3304 |
| 13 | Tolkmicko | 2.82 | 14375 |
| 14 | Piaski - nabrzeże | 2.30 | 3304 |
| 15 | Gdynia | 4.74 | 6457 |
| 16 | Frombork | 3.13 | 47337 |
| 17 | Elblążka | 0.10 | 50154 |
| 18 | Wisła Śmiała | 2.98 | 518200 |

In the years 2011-2016, pipelines with a total length of about 200 km functioned in POM. One of the two longer pipeline sections (about 80 km) connects Władysławowo with the "Baltic Beta" oil rig (Fig. 4.2.6). ). A number of shorter pipelines operate in the Tri-City area.

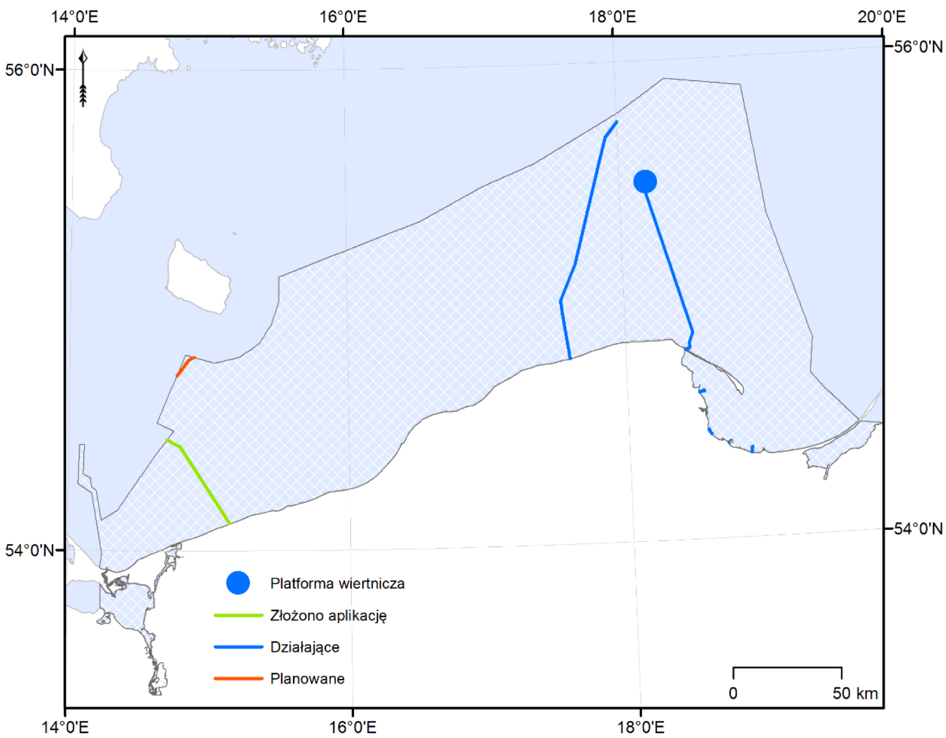



Fig. 4.2.6. Pipelines (based on national data provided by HELCOM and updated for the purposes of this study).

Another line object in POM are submerged telecommunications cables and elements of the power grid (Fig. 4.2.7). In the years 2011-2016, they operated in total around 350 km (data according to HELCOM). In addition, there are also sections of cables resulting from unfinished investments (540 m), but there is no detailed information about them.

The location of the main ports and bathing areas is shown in Fig. 4.2.8. In addition to ports of primary importance for the national economy, i.e. sea ports in Gdańsk, Gdynia, Szczecin and Świnoujście (in accordance with the Act of 20 December 1996 on ports and marinas), the map also presents the location of regional ports: Darłowo, Elbląg , Hel, Kołobrzeg, Łeba, Police, Stepnica, Ustka and Władysławowo and local ports: Frombork, Międzyzdroje (concerns two marinas) and Krynica Morska. Other ports considered to be local are Dziwnów, Dźwirzyno, Jastarnia, Kamień Pomorski, Karsibór, Kąty Rybackie, Lubin, Mrzeżyno, Nowa Pasłęka, Nowe Warpno, Przytór, Puck, Rowy, Sierosław, Tolkmicko, Trzebież, Wapnica and Wolin.

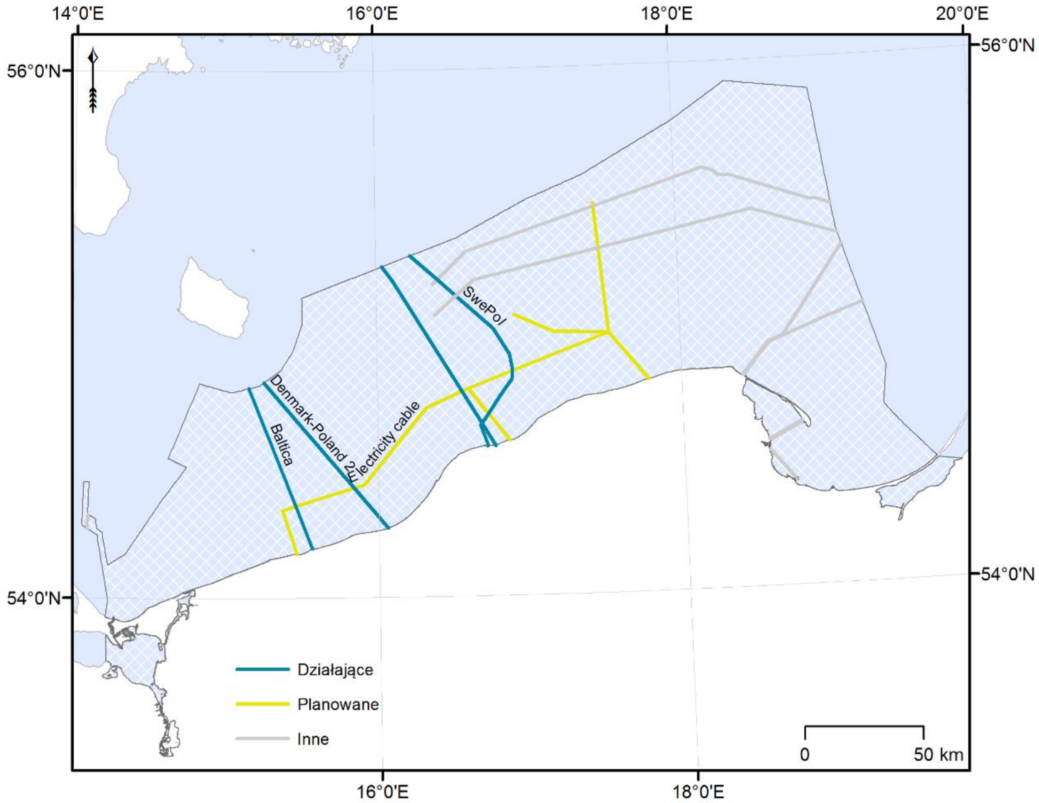



Fig. 4.2.7 Location of submarine cables (based on national data provided by HELCOM and updated for the purposes of this study).

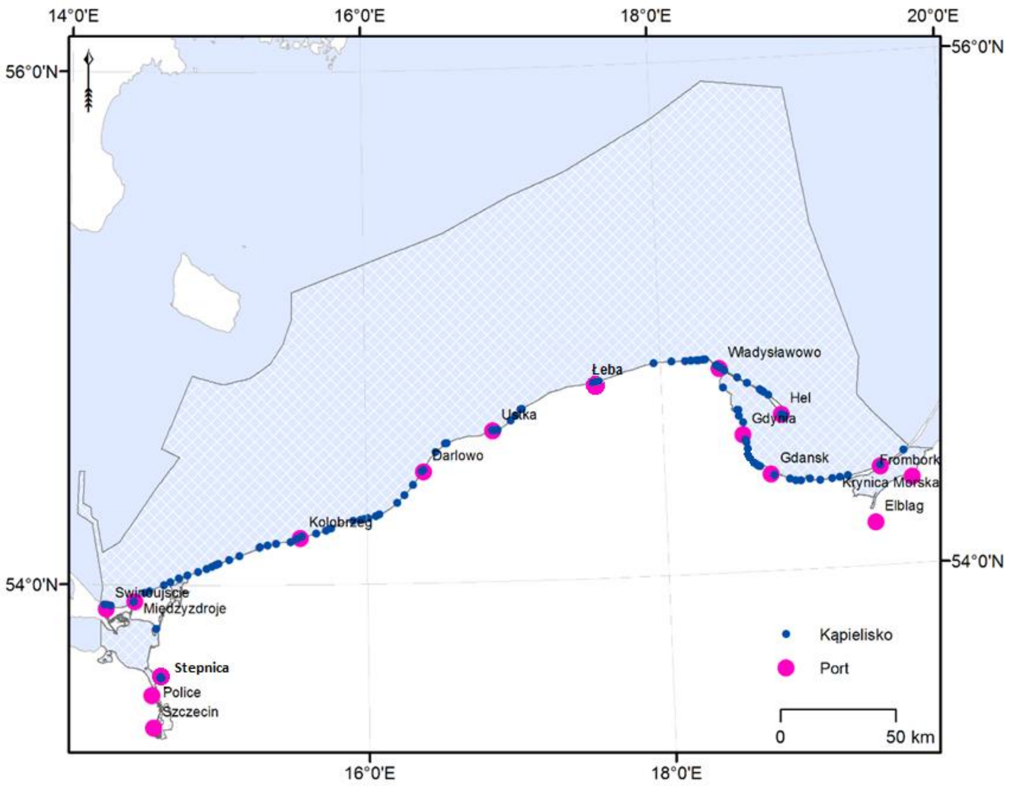



Fig. 4.2.8. Ports and bathing sites (own elaboration based on collected data from 2011-2016).

### Physical disturbance to seabed (temporary or reversible)

One of the main sources of physical disturbance of the seabed is shipping. In Table 4.2.3 information on ships entering Polish seaports, including their number and capacity, is provided. According to the information provided (see also Fig. 4.2.9), the largest number of vessels (including the largest capacity) in 2011-2016 went to Świnoujście, then to Gdynia, Gdańsk and Szczecin (ie over 80% of all ships entering Polish ports). The other ports are less important.

Table 4.2.3. Ships entering seaports in 2011-2016 (GUS 2015 - data for 2011, GUS 2016 - data for 2012 - 2014, CSO 2017c - data for 2015-2016).

| Ports | | Number of ships | Net capacity (NT) in thous. | Gross capacity (GT) in thous. |
|---|---|---|---|---|
| Total | 2011 | 18864 | 71905.3 | 169583.3 |
| | 2012 | 18416 | 73720.2 | 171670.3 |
| | 2013 | 17816 | 76076.1 | 172794.0 |
| | 2014 | 17384 | 84315.5 | 190664.6 |
| | 2015 | 18169 | 83909.2 | 194332.4 |
| | 2016 | 18928 | 89061.6 | 205810.3 |
| Gdańsk | 2011 | 3252 | 16971.8 | 36651.0 |
| | 2012 | 3127 | 17832.8 | 39029.9 |
| | 2013 | 2948 | 17989.1 | 38407.8 |
| | 2014 | 2869 | 19059.3 | 40684.0 |
| | 2015 | 3106 | 20904.1 | 45190.6 |
| | 2016 | 3274 | 23403.4 | 48978.5 |
| Gdynia | 2011 | 3864 | 26391.2 | 59442.5 |
| | 2012 | 3578 | 26917.6 | 58149.1 |
| | 2013 | 3618 | 26437.7 | 55118.2 |

| Ports | | Number of ships | Net capacity (NT) in thous. | Gross capacity (GT) in thous. |
|---|---|---|---|---|
| | 2014 | 3754 | 28690.8 | 59756.6 |
| | 2015 | 3678 | 26852.5 | 56360.8 |
| | 2016 | 3956 | 27959.3 | 59804.7 |
| Szczecin | 2011 | 3084 | 4689.5 | 9804.9 |
| | 2012 | 2822 | 4677.0 | 9798.0 |
| | 2013 | 2872 | 4840.1 | 10083.4 |
| | 2014 | 2619 | 5097.6 | 10404.1 |
| | 2015 | 2830 | 5493.4 | 11040.9 |
| | 2016 | 2939 | 5723.9 | 11452.9 |
| Świnoujście | 2011 | 4904 | 22352.2 | 60429.7 |
| | 2012 | 5118 | 22867.9 | 61574.9 |
| | 2013 | 4913 | 25512.4 | 66445.2 |
| | 2014 | 5079 | 30035.5 | 76917.9 |
| | 2015 | 5354 | 29265.9 | 78610.4 |
| | 2016 | 5548 | 30642.4 | 82582.1 |
| Police | 2011 | 306 | 881.1 | 1741.9 |
| | 2012 | 276 | 753.9 | 1503.8 |
| | 2013 | 220 | 644.2 | 1341.0 |
| | 2014 | 264 | 805.1 | 1619.8 |
| | 2015 | 275 | 772.6 | 1585.2 |
| | 2016 | 323 | 783.2 | 1578.6 |
| Darłowo | 2011 | 56 | 35.5 | 69.5 |
| | 2012 | 99 | 63.0 | 128.3 |
| | 2013 | 69 | 46.6 | 99.3 |
| | 2014 | 79 | 48.4 | 103.0 |
| | 2015 | 163 | 135.7 | 256.7 |
| | 2016 | 44 | 39.2 | 75.6 |
| Elbląg | 2011 | 149 | 64.9 | 134.4 |
| | 2012 | 256 | 118.1 | 221.0 |
| | 2013 | 472 | 244.5 | 359.6 |
| | 2014 | 546 | 226.2 | 311.4 |
| | 2015 | 291 | 113.3 | 164.5 |
| | 2016 | 165 | 69.3 | 103.8 |
| Frombork | 2011 | 385 | 37.8 | 72.3 |
| | 2012 | 370 | 35.2 | 67.0 |
| | 2013 | 325 | 30.8 | 59.0 |
| | 2014 | 253 | 21.8 | 38.1 |
| | 2015 | 248 | 21.2 | 37.1 |
| | 2016 | 211 | 17.5 | 30.6 |
| Hel | 2011 | 1109 | 189.6 | 572.0 |
| | 2012 | 1009 | 159.1 | 502.2 |
| | 2013 | 770 | 107.0 | 330.4 |
| | 2014 | 558 | 92.1 | 266.7 |
| | 2015 | 675 | 127.2 | 381.2 |
| | 2016 | 762 | 143.9 | 451.7 |
| Kołobrzeg | 2011 | 228 | 128.6 | 260.5 |
| | 2012 | 241 | 138.5 | 280.5 |
| | 2013 | 173 | 78.0 | 168.2 |
| | 2014 | 188 | 91.9 | 204.3 |
| | 2015 | 165 | 79.6 | 175.8 |
| | 2016 | 168 | 88.2 | 194.7 |
| Krynica Morska | 2011 | 372 | 33.9 | 60.7 |
| | 2012 | 358 | 31.7 | 56.3 |

| Ports | | Number of ships | Net capacity (NT) in thous. | Gross capacity (GT) in thous. |
|---|---|---|---|---|
| | 2013 | 311 | 26.6 | 46.5 |
| | 2014 | 253 | 21.8 | 38.1 |
| | 2015 | 248 | 21.2 | 37.1 |
| | 2016 | 211 | 17.5 | 30.6 |
| Międzyzdroje | 2011 | 355 | 68 | 182.4 |
| | 2012 | 406 | 71.5 | 186.2 |
| | 2013 | 420 | 71.6 | 186.3 |
| | 2014 | 411 | 73.0 | 189.9 |
| | 2015 | 442 | 76.9 | 200.3 |
| | 2016 | 424 | 73.2 | 190.8 |
| Nowe Warpno | 2014 | 1 | 0.1 | 0.2 |
| Sopot | 2011 | 524 | 41.3 | 104.7 |
| | 2012 | 543 | 30.3 | 107.2 |
| | 2013 | 453 | 28.5 | 91.2 |
| | 2014 | 385 | 35.5 | 91.4 |
| | 2015 | 552 | 71.4 | 237.3 |
| | 2016 | 765 | 86.7 | 289.6 |
| Stepnica | 2015 | 51 | 12.4 | 26.1 |
| | 2016 | 36 | 4.3 | 17.8 |
| Trzebież | 2011 | 93 | 4.5 | 9.6 |
| | 2012 | 33 | 6.7 | 16.5 |
| | 2013 | 66 | 3.5 | 8.7 |
| | 2014 | 25 | 2.0 | 4.8 |
| | 2015 | 19 | 2.2 | 4.9 |
| | 2016 | 19 | 1.9 | 4.7 |
| Ustka | 2011 | 8 | 1.1 | 3.6 |
| | 2012 | 15 | 5.5 | 12.1 |
| | 2013 | 12 | 1.5 | 5.9 |
| | 2014 | 6 | 0.4 | 3.0 |
| | 2015 | 1 | 0.0 | 0.1 |
| | 2016 | 2 | 0.1 | 0.3 |
| Władysławowo | 2011 | 175 | 14.3 | 43.7 |
| | 2012 | 165 | 11.5 | 37.3 |
| | 2013 | 174 | 14.0 | 43.4 |
| | 2014 | 80 | 8.6 | 23.9 |
| | 2015 | 78 | 7.9 | 23.3 |
| | 2016 | 81 | 7.5 | 23.4 |

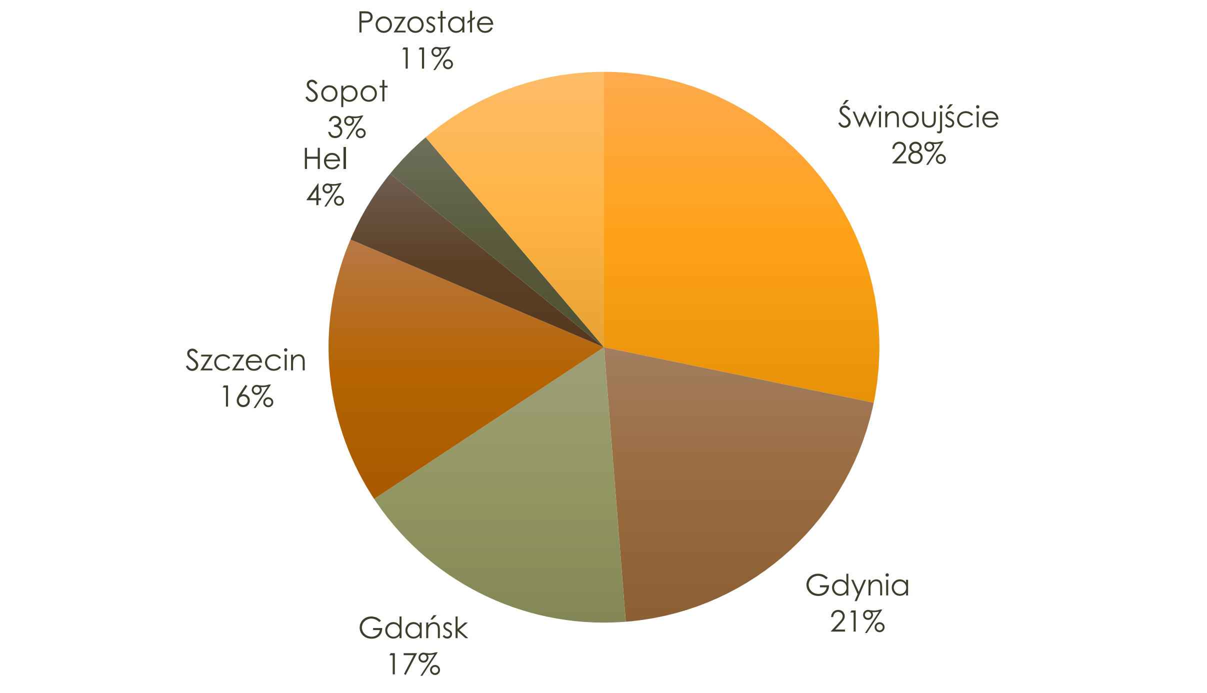



Fig. 4.2.9. Number of ships entering seaports in 2011-2016 (CSO, 2015, 2016, 2017b).

The highest density of ship traffic in 2011-2016 took place in the Gulf of Gdańsk (which is related to the waterways from the ports in Gdynia and Gdańsk, connecting at a distance of about 15 km from the coast, passing Hel Peninsula and turning west), in the Pomeranian Bay and about 10-15 km to the south of the Słupsk Bank. The map (Fig. 4.2.10) presents the average monthly density of ship traffic (based on raster data from 2011-2015, HELCOM). The values presented refer to the mesh size of 1 km x 1km, and the value is the total number of ship routes per cell area per month. Data from individual years (2011-2016) are presented on the Internet portal "Baltic Sea Shipping traffic intensity" (http://maps.helcom.fi/website/AISexplorer/). In addition to shipping, physical disturbances in the seabed may be the result of sand and gravel extraction as well as dredging and excavation related excavations - the location of such activities is shown in Fig. 4.2.11. A total of 10 sites were identified, in which in 2011-2016 dredging of the seabed was carried out, with a total area of 1,2km$^2$ (Table 4.2.4.). During this period, the bottom was deepened by nearly 700,000 m3. The spoil was stored in several places, almost all along the Polish coast (except for the Hel Peninsula and the Vistula Spit) (Table 4.2.5), with the largest amount in the Pomeranian Bay (in total over 5 million m$^3$) and in the Gdańsk area (in total over 4 million m$^3$).

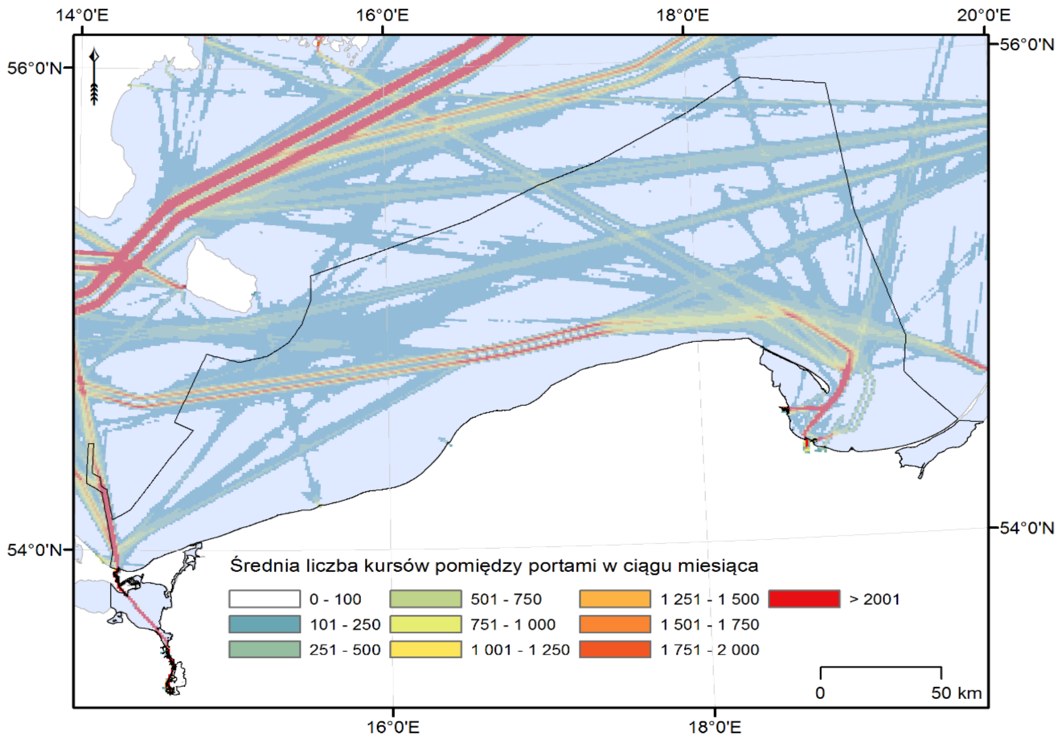



Fig. 4.2.10. Average monthly ship traffic density (based on HELCOM AIS data from 2011-2015)

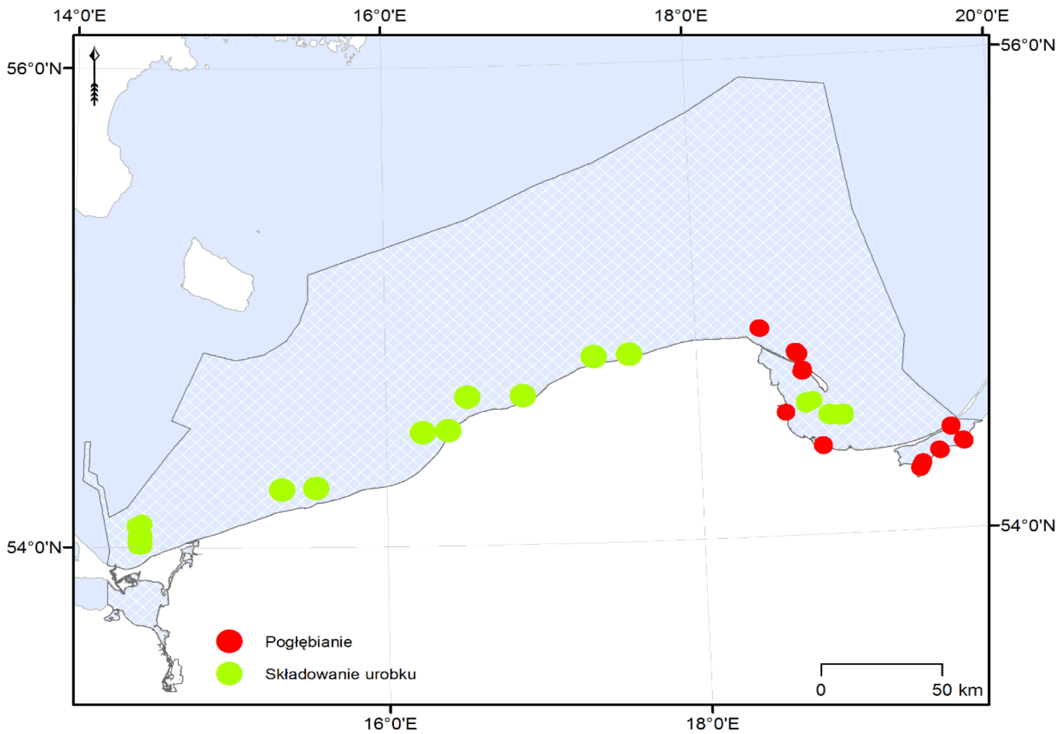



Fig. 4.2.11. Dredging and deposition of dredged material (based on national data provided by HELCOM and updated for the purposes of this study).

Table 4.2.4. Dredging in 2011-2016 (based on data provided by the Gdynia Maritime Office).

| Place name | Area [m2] | 2011 [m3] | 2012 [m3] | 2013 [m3] | 2014 [m3] | 2015 [m3] | 2016 [m3] | total [m3] |
|---|---|---|---|---|---|---|---|---|
| Hel Peninsula | 673513 | 0 | 0 | 0 | 0 | 0 | no data | 0 |
| Jastarnia | 175522 | 0 | 1357.305 | 1357.305 | 0 | 0 | no data | 2714.61 |
| Rozewie | 150243 | 0 | 0 | 0 | 0 | 0 | no data | 0 |
| Piaski – port entrance | 8801 | 0 | 0 | 1652.075 | 1652.075 | 0 | no data | 3304.15 |
| Tolkmicko | 28200 | 0 | 0 | 0 | 14375.49 | 0 | no data | 14375.49 |
| Piaski – waterfront | 2300 | 0 | 0 | 1652.075 | 1652.075 | 0 | no data | 3304.15 |
| Gdynia | 4736 | 0 | 0 | 0 | 6457.42 | 0 | no data | 6457.42 |
| Frombork | 31314 | 0 | 0 | 0 | 47337.03 | 0 | no data | 47337.03 |
| Elblążka | 102081 | 0 | 0 | 25077 | 25077 | 10000 | 37596.97 | 97750.97 |
| Wisła Śmiała | 29771 | 0 | 172733.33 | 172733.33 | 172733.33 | 0 | no data | 518200 |
| Kamienica Elbląska | 20700 | 0 | 0 | 0 | 0 | 0 | 5150.52 | 5150.52 |

Table 4.2.5. Deposit of dredged material in 2011-2016 (based on data provided by maritime offices in Gdynia, Słupsk and Szczecin).

| Place name | HELCOM code* | 2011 [m3] | 2012 [m3] | 2013 [m3] | 2014 [m3] | 2015 [m3] | 2016 [m3] | total [m3] |
|---|---|---|---|---|---|---|---|---|
| Port Kołobrzeg, Baltic proper | | 51677 | 0 | 0 | 0 | 0 | no data | 51677 |
| Port Darłowo Baltic proper | | 39334 | 42000 | 0 | 0 | 0 | no data | 81334 |
| Port Ustka | | 20815 | 18000 | 0 | 0 | 0 | no data | 38815 |
| Port Łeba | | 24391 | 19500 | 0 | 0 | 0 | no data | 43891 |
| Kołobrzeg | PL-004 | 0 | 35250 | 30000 | 21000 | 9000 | 4000 | 99250 |
| Darłowo | PL-005 | 0 | 0 | 122231 | 12000 | 16500 | 9000 | 159731 |
| Ustka | PL-006 | 0 | 0 | 28500 | 18000 | 24000 | 17000 | 87500 |
| Łeba | PL-007 | 0 | 0 | 13500 | 4500 | 0 | no data | 18000 |
| Gdynia | PL-001 | 64750 | 0 | 55500 | 47300 | 0 | no data | 167550 |
| DCT | PL-003 | 0 | 676945 | 0 | 49500 | 1943363 | no data | 2669810 |
| Pomeranian Bay | PL-011 | 0 | 0 | 0 | 1396500 | 0 | no data | 1396500 |
| Pomeranian Bay | PL-013 | 625691 | 2956966 | 18140 | 0 | 127500 | no data | 3728300 |
| Gdańsk | PL-002 | 1415200 | 11700 | 81750 | 4500 | 4550 | no data | 1517700 |
| | | | | | | | | |

* - designation, used in the HELCOM database, to enable statistics and calculations to be carried out throughout the entire Baltic Sea

In the implemented marine environment monitoring program, the parameters that can be used to assess the state of the integrity of the seabed are multimetric indicators of macrozoobenthos and phytobenthos. These indicators include information on not only the size but also the sensitivity of benthic organisms to the adverse impact of human activity, and therefore carry information about the state of the environment in terms of the presence of positive and negative factors shaping living conditions on the seabed (GIOŚ, 2016a).

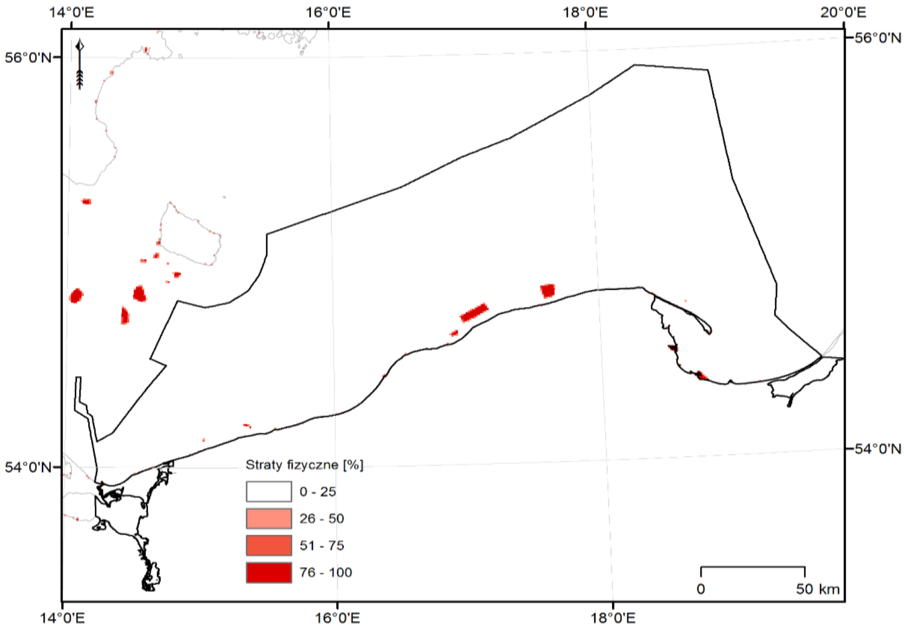



Fig. 4.2.12. Physical loss of the seabed - the level of anthropogenic pressure (based on national data provided by HELCOM and updated for the purposes of this study).

In determining the level of anthropogenic pressure associated with physical disturbances (Fig. 4.2.13) All activities causing periodic change of the sea bed were taken into account. The average level of disorder in POM is 20%. The largest loss was identified in the Pomeranian Bay and they are associated with places of spoil disposal. In the case of the Bornholm Basin, the eastern part of the Gotland Basin, the Gdański Basin, the Gdańsk Basin Polish coastal waters, the Polish part of the Vistula Lagoon pressure is covered by 10 to 25% of the bottom surface; in the remaining cases, the pressure is covered by less than 10% of the area bottom of the body of water.

The identified impacts are presented in the table below (Table 4.2.6.), where the area of habitats lost as a result of anthropogenic pressures was compiled based on available data from the period 2011-2016. Based on the calculations carried out, it was indicated that the habitat marked with the A5.25 or A5.26 code according to the EUNIS classification was subject to the greatest loss (in total almost 90km$^2$).

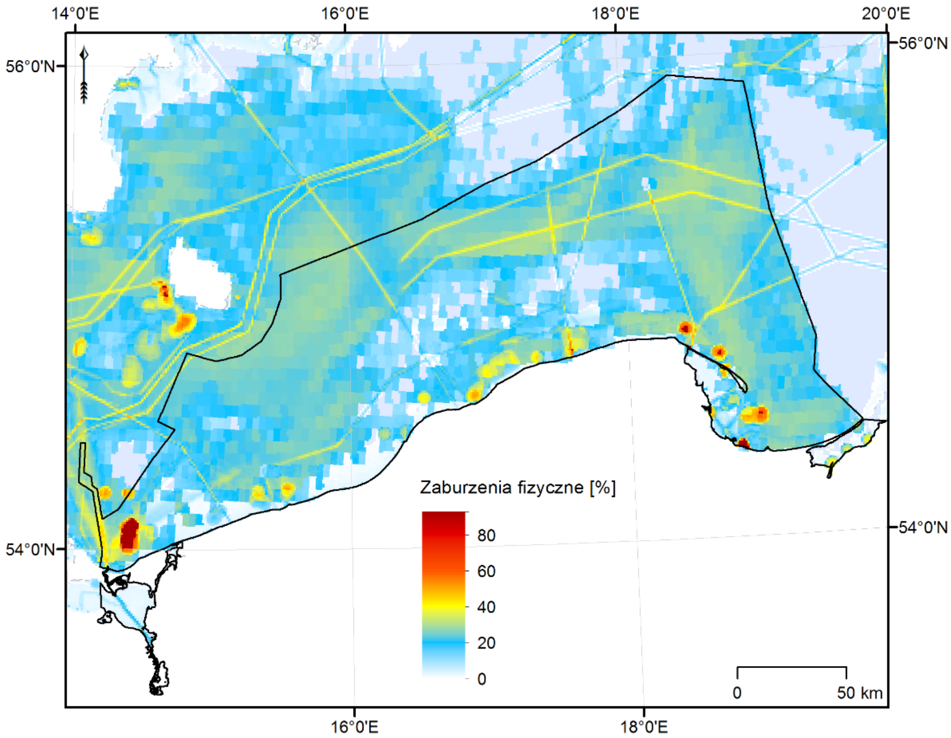



Fig. 4.2.13 Physical disturbance of the seabed - level of anthropogenic pressure (based on national data provided by HELCOM and updated for the purposes of this study).

Table 4.2.6. Total area of habitats lost as a result of physical loss of the sea bottom of anthropogenic origin (own elaboration based on national data provided by HELCOM and updated for the purposes of this study and EMODnet data).

| Habitat type | Habitat code EUSNIS | Habitat name according to MSFD | Area extent of habitat lost [km²] |
|---|---|---|---|
| Mesohaline2 High energy circalittoral sand | A5.25 or A5.26 | Circalittoral Sand | 75.57 |
| Oligohaline High energy circalittoral sand | A5.25 or A5.26 | Circalittoral Sand | 10.77 |
| Mesohaline1 Moderate energy infralittoral sand | A5.23 or A5.24 | Infralittoral Sand | 5.50 |
| Mesohaline1 Low energy infralittoral seabed | Infralittoral seabed | NA | 3.50 |
| Mesohaline2 Moderate energy infralittoral sand | A5.23 or A5.24 | Infralittoral Sand | 2.06 |
| Mesohaline1 Moderate energy infralittoral seabed | Infralittoral seabed | NA | 1.17 |
| Mesohaline1 Moderate energy infralittoral muddy Sand | A5.33 | Infralittoral mud | 1.12 |
| Oligohaline Moderate energy infralittoral sand | A5.23 or A5.24 | Infralittoral sand | 0.82 |
| Oligohaline Low energy infralittoral seabed | Infralittoral seabed | NA | 0.72 |
| Mesohaline2 Moderate energy circalittoral sand | A5.25 or A5.26 | Circalittoral sand | 0.05 |
| Mesohaline1 Moderate energy circalittoral muddy sand | A5.35 | Circalittoral mud | 0.05 |
| Mesohaline1 Low energy infralittoral sand | A5.23 or A5.24 | Infralittoral sand | 0.04 |
| Mesohaline1 Moderate energy circalittoral sand | A5.25 or A5.26 | Circalittoral sand | 0.02 |

Thanks to the calculations made, it was indicated that almost 245 $km^2$ of bottom habitats was subjected to disturbance, while the majority (about 230 $km^2$) concern a small part of habitats (25-50%). It was concluded that 5-25% of the surface area of POM can potentially be subject to physical disturbances in the bottom surface.

Table 4.2.7. The total area of habitats affected by impacts from physical disturbance of the seabed of anthropogenic origin (own elaboration based on HELCOM data and EMODNet).

| % of disturbed area | Habitat type | Habitat code EUSNIS | Area of disturbed habitat [km2] |
|---|---|---|---|
| >50 | Mesohaline1 Moderate energy infralittoral Sand | A5.23 or A5.24 | 1.31 |
| | Oligohaline High energy circalittoral sand | A5.25 or A5.26 | 0.89 |
| 25–50 | Mesohaline2 High energy circalittoral sand | A5.25 or A5.26 | 117.28 |
| | Mesohaline2 High energy deep circalittoral fine mud | A5.37 | 48.99 |
| | Mesohaline2 High energy deep circalittoral mixed sediment | A5.45 | 34.68 |
| | Mesohaline2 Moderate energy infralittoral sand | A5.23 or A5.24 | 9.99 |
| | Mesohaline2 Moderate energy circalittoral sand | A5.25 or A5.26 | 8.29 |
| | Mesohaline2 High energy circalittoral mixed sediment | A5.44 | 5.24 |
| | Mesohaline1 Moderate energy circalittoral sand | A5.25 or A5.26 | 2.20 |
| | Mesohaline3 High energy circalittoral mixed sediment | A5.44 | 2.20 |
| | Mesohaline2 High energy circalittoral muddy sand | A5.35 | 1.79 |
| | Mesohaline1 Moderate energy circalittoral fine mud | A5.36 | 0.89 |
| | Mesohaline2 Moderate energy circalittoral coarse sediment | A5.14 | 0.89 |
| <25 | Mesohaline1 Low energy infralittoral mud and muddy sand | A5.33 or A5.34 | 4.25 |
| | Mesohaline2 High energy circalittoral sand | A5.25 or A5.26 | 2.20 |
| | Mesohaline2 High energy deep circalittoral fine mud | A5.37 | 1.78 |
| | Oligohaline Low energy infralittoral mud and muddy sand | A5.33 or A5.34 | 0.89 |
| | Mesohaline1 High energy circalittoral sand | A5.25 or A5.26 | 0.89 |

The conducted analyzes allowed to assess the pressure which is associated with the Descriptor D6: "*Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected*" In particular with respect to criteria D6C1 and D6C2, the spatial ranges and distribution of physical loss (permanent change) of the seabed and physical pressures of the seabed disturbance were shown (Fig. 4.2.2, Fig. 4.2.3, Fig. 4.2.5–Fig. 4.2.13). Based on calculations (in the GIS environment, using the spatial data set discussed in Table 4.2.1.) it was concluded that physical loss of the seabed in each region (Bornholm Basin, Eastern Gotland Basin, Gdański Basin, Bornholm Basin Polish Coastal waters, Eastern Gotland Basin Polish Coastal waters, Gdańsk Basin Polish Coastal waters, Polish part of the Szczecin Lagoon, Polish part of the Vistula Lagoon) constitute less than 1% of the area. In addition, the habitat sizes potentially subject to negative impacts (Table 4.2.6. and Table 4.2.7. ), are given in relation to criterion D6C3. It was estimated that 5% to 25% of the habitat area in each of the POM sub-basins may be subjected to physical disturbance, the intensity of these disturbances being shown in Fig. 4.2.13.

**Changes in hydrological conditions**

Changes in hydrological conditions of anthropogenic nature can be associated primarily with changes in temperature, salinity, pH of seawater, as well as mixing and exchange of water, changes in the characteristics of the marine currents field and wind-generated waves. Most of these elements are the result of land based anthropogenic pressure (mainly discharges of groundwater, e.g. hot water from cooling of the power plant). Anthropogenic pressures of marine origin include structures in the sea (wind farms, sea oil rigs) and modifications of waterways that may cause local changes in hydrodynamic conditions. Habitats may be subject to significant changes in the event of extreme hydrodynamic conditions leading, for example, to the transport of sediments. Studies and analyzes carried out so far indicate that this mainly concerns shallow water areas, where the impact of wind waves or currents reaches the bottom (Yang and In., 2010).

As part of the TAPAS project, the spatial data layers (Table 4.2.8.) have been indicated, containing information on the activities carried out by man and which may influence changes in hydrological conditions. These are hydroelectric power stations, which are land-based pressure, modifications to fairways, wind farms and oil rigs. Among the elements mentioned above, two oil rigs "Baltic Beta" and "LOTOS Petrobaltic" operate in POM. They are located about 70 km from the shore. The depth at the foundation of oil rigs is approximately 80 m (the location of the oil rigs is shown in (Fig. 4.2.3). Due to the considerable depth, the oil rig does not cause disturbances of hydrodynamic processes significant for the habitats and no other impacts resulting from the oil rig's operation.

Table 4.2.8. List of spatial data layers related to anthropogenic pressures to be used in determining BSPI/BSII indices during the second holistic assessment (based on HELCOM 2016a, Annex 2, changes in hydrological conditions).

| Layer name | Data source | Data validity | Data notes |
|---|---|---|---|
| Changes to hydrological conditions | | | |
| *Hydropower dams** | – | – | – |
| Water course modification | HELCOM based on data provided by the Maritime Office in Gdynia,Słupsk and Szczecin | Latest update: April 2017 | – |
| Wind farms | HELCOM | Data from 2016 | Lack of marine wind farms in POM |
| Oil platforms | HELCOM based on data provided by Maritime Search And Rescue Service | Latest update: April 2017 | – |

* italics are marked data layers which content does not fall within the scope of this study

Within POM borders no activities related to changes in hydrological conditions that could lead to pressures and impacts, including anthropogenic ones, of marine origin on seawater have been identified. Monitoring changes in the field of hydrology should cover all construction activities that may lead to local disturbances of this characteristic.

### Substances, litter and energy

#### Nutrients

Nutrients come from a variety of diffuse and point sources. They are carried mainly by, inland surface waters, through which the contaminated waters burdened with excessive loads of agricultural or communal origin are discharged.

BSEP 125 (HELCOM 2010a) distinguishes the following sources of nutrients, generated in marine waters: aquaculture, atmospheric nitrogen deposition, inflow of nitrogen compounds with water, inflow of phosphorus compounds with water. From these sources, only aquaculture is an anthropogenic marine source of biogenic substances.

In Poland, marine aquaculture is not conducted, hence sources of marine origin have not been identified for the nutrients element. According to the MARPOL Convention, the collection of all litter and sewage from ships is regulated (MARPOL Annex IV and V, HELCOM 2015d).

In POM there are no marine anthropogenic sources of nutrients, the main source of these substances are land pollutants, brought through the rivers.

#### Organic matter

It is generally believed that organic matter in the sea can occur both in suspended and dissolved form. It is an important element in the circulation of matter, has an impact on oxygen conditions as a result of microbial decomposition processes.

POM does not have anthropogenic marine sources of organic matter. The most common sources of organic matter in the Baltic Sea include marine aquaculture and river inflow.

#### Other substances

HELCOM considers substances to be "hazardous" if they meet the following conditions: they are toxic, persistent and bioaccumulating or very persistent and very bioaccumulating. Also substances that affect the endocrine and immune systems are considered hazardous. In addition, the list of hazardous substances has been extended to include radionuclides (HELCOM 2010a).

Hazardous substances enter the Baltic Sea from four main sources: (1) point sources on the coast or inland such as large industrial plants and sewage treatment plants, (2) terrestrial diffuse sources such as discharges from agricultural areas, forests and other landfill, (3) offshore activities such as sea transport, oil rig operations, dredging and other works disturbing the integrity of the seafloor, (4) atmospheric deposition of substances from all types of combustion and volatile toxins such as pesticides. This study only includes sources of marine origin in the period from 01/01/2011 to 31/12/2016.

Several potential sources of hazardous substances of marine origin in the Baltic Sea have been identified for HELCOM (2010a), namely: ship accidents, seafreight spillages and the effects of oil rigs and other human activities affecting the seafloor integrity and the impact of ports and harbors.

#### Ship accidents

Ship traffic in the Baltic Sea is a potential source of pollution. Ships may be subject to accidents and breakdowns, leading to the release of fuels, oils, cooling agents and other technical fluids and contaminants into the environment. Therefore, accidents at sea are monitored and taken into account as a potential source of marine-induced anthropogenic pressure. HELCOM maintains a database of vessel accidents in the Baltic Sea region, reported by Member States since 2000.

According to the agreed procedure, all accidents are reported, regardless of whether there is any environmental pollution. This applies to tankers with a mass exceeding 150 GT (Gross Tonnage) or other ships with a weight exceeding 400 GT, both in territorial waters and in the exclusive economic zones of the Baltic Sea countries. Types of reported incidents include subsidence, collisions with other ships or stationary objects (wharfs, marine constructions), damages such as mechanical failures, fires or explosions. Fig. 4.2.14 presents the places of recorded ship accidents, among others in POM.

Based on the data from the HELCOM annual reports and reports published by the State Marine Accidents Investigation Commission (PKBWM), it was established that in 2011-2015, there were 47 naval ship accidents in the Polish zone of the Baltic Sea. In the list of pressures and indicators, vessels over 150 GT (gross tonnage) were considered for tankers and 400 GT for other types of vessels. Currently, the data for 2016 are incomplete and, according to the information from PKBWM, will be published in 2018. In the case of maritime accidents, the volume (cubic meters) of pollutants entering the environment as a result of the event is considered a pressure (HELCOM 2010b). None of the marine accidents considered in the examined period (2011-2015) ended with the emission of hazardous substances into the environment.

Table 4.2.9. Sea accidents in the Polish zone of the Baltic Sea in 2011-2015 (according to HELCOM and PKBWM) together with a list of pressures and calculated BSPI and BSII indicators for each accident. Data marked with an asterisk in the "Ordinal Number" originate from PKBWM, the others from HELCOM.

| Lp. | Rok | Nazwa | Kategoria | Rozmiar (GT) | Zanieczyszczenie | Presja | BSPI | BSII |
|---|---|---|---|---|---|---|---|---|
| 1 | 2011 | LADY ELLENA, 9167409, Antigua & Barbuda | Tanker | 3465 | nie | 0 | 0 | 0 |
| 2 | 2011 | RUTH THERESA, 9383663, Malta | Tanker | 5713 | nie | 0 | 0 | 0 |
| 3 | 2011 | CRYSTAL DIAMOND, 9327059, Luksemburg | Tanker | 7903 | nie | 0 | 0 | 0 |
| 4 | 2011 | NIDA STAR, 9425227, Malta | Tanker | 8621 | nie | 0 | 0 | 0 |
| 5 | 2011 | FRISIAN SPRING, 9367774, Netherlands | Cargo | 4087 | nie | 0 | 0 | 0 |
| 6 | 2011 | DEBORA, 6501537, Norway | Cargo | 2331 | nie | 0 | 0 | 0 |
| 7 | 2011 | STENA BALTICA, 8416308, Bahama | Passenger | 31910 | nie | 0 | 0 | 0 |
| 8 | 2011 | GALILEUSZ, 9019078, Cyprus | Passenger | 14398 | nie | 0 | 0 | 0 |
| 9 | 2011 | CHRISTINA, 9534262, Liberia | Cargo | 4255 | nie | 0 | 0 | 0 |
| 10 | 2011 | AANTON, 8867442, St. Vincent | Cargo | 2498 | nie | 0 | 0 | 0 |
| 11 | 2011 | MARION K, 8026282, Antiqua & Barbuda | Cargo | 1127 | nie | 0 | 0 | 0 |
| 12 | 2011 | GRYF, 8818300, Bahamas | Passenger | 18653 | nie | 0 | 0 | 0 |
| 13 | 2011 | ONEGO MERCHANT, 9238368, Holland | Cargo | 6301 | nie | 0 | 0 | 0 |
| 14 | 2011 | CHRISTOPHER, 9359260, Antiqua & Barbuda | Cargo | 16023 | nie | 0 | 0 | 0 |
| 15 | 2012 | AARSLEFF 110, Rn 0101906, Danish | Other | 1367 | nie | 0 | 0 | 0 |
| 16 | 2012 | NORMA MARY, 8704808, U.K. | Other | 1833 | nie | 0 | 0 | 0 |
| 17 | 2012 | AHTS GRANIT, 7911260, St. Vincent | Other | 1313 | nie | 0 | 0 | 0 |
| 18 | 2012 | EKEN, 9286827, Norwegia | Tanker | 8829 | nie | 0 | 0 | 0 |
| 19 | 2012 | STENA SPIRIT, IMO 7907661, Bahama | Passenger | 39193 | nie | 0 | 0 | 0 |
| 20 | 2012 | WILSON TYNE, 7915307, Malta | Cargo | 4913 | nie | 0 | 0 | 0 |
| 21 | 2012 | GALILEUSZ, IMO9019078 Cyprus | Cargo | 15848 | nie | 0 | 0 | 0 |
| 22 | 2012 | CITY OF ST. PETERSBURG, 9473456, Panama | Cargo | 21143 | nie | 0 | 0 | 0 |
| 23 | 2012 | WOLIN, IMO8420842 Bahamas | Cargo | 22874 | nie | 0 | 0 | 0 |
| 24 | 2013 | George Buchner, 5068863, Germany | Other | 11060 | nie | 0 | 0 | 0 |
| 25 | 2013 | Twinkle Island, 9512367, Marshall Islands | Cargo | 43013 | nie | 0 | 0 | 0 |
| 26 | 2013 | Clymene, 9307657, UK | Cargo | 40244 | nie | 0 | 0 | 0 |
| 27 | 2013 | NS Energy, 9609732, Liberia | Cargo | 40972 | nie | 0 | 0 | 0 |
| 28 | 2013 | IMI, 9063873, Bahama | Cargo | 2715 | nie | 0 | 0 | 0 |
| 29 | 2013 | CARAT, 9429209, USA | Cargo | 9983 | nie | 0 | 0 | 0 |
| 30 | 2013 | KARSIBĚR III, reg. No.ROS1426, POLAND | Other | 1441,97 | nie | 0 | 0 | 0 |
| 31 | 2013 | City of St. Petersburg, 9473456, Panama | Cargo | 21143 | nie | 0 | 0 | 0 |
| 32 | 2013 | Horizon Aphrodite, 9407366, Liberia | Tanker | 29828 | nie | 0 | 0 | 0 |
| 33 | 2013 | GODAFOSS, 9086796, ANTIQUA&BARBUDA | Cargo | 14664 | nie | 0 | 0 | 0 |
| 34 | 2013 | m/v Andrea Dutch | Cargo | 2409 | nie | 0 | 0 | 0 |
| 35 | 2013 | CERAFINA, 9305087, Marshall Islands | Cargo | 40524 | nie | 0 | 0 | 0 |
| 36 | 2013 | ZOSIA, Reg. No. SZ-01-009, POLAND | Other | 506 | nie | 0 | 0 | 0 |
| 37 | 2013 | SM-PRC-105, reg. PRS-550188, POLAND | Other | 539 | nie | 0 | 0 | 0 |
| 38 | 2013 | ANNEMIEKE, 9147681, ANTIQUA&BARBUDA | Cargo | 8388 | nie | 0 | 0 | 0 |
| 39* | 2015 | Palica | Tanker | 999 | nie | 0 | 0 | 0 |
| 40* | 2014 | Fast Jef | Cargo | 2066 | nie | 0 | 0 | 0 |
| 41* | 2014 | Alora | Chemical | 2918 | nie | 0 | 0 | 0 |
| 42* | 2014 | Langballig | Cargo | 3925 | nie | 0 | 0 | 0 |
| 43* | 2014 | Jutlandia Swan | Tanker | 11711 | nie | 0 | 0 | 0 |
| 44* | 2014 | Achilles | Cargo | 40119 | nie | 0 | 0 | 0 |
| 45* | 2014 | Marichristina | Cargo | brak danych | nie | 0 | 0 | 0 |
| 46* | 2015 | Altamar | Cargo | 2984 | nie | 0 | 0 | 0 |
| 47* | 2015 | Transforza | Cargo | 3244 | nie | 0 | 0 | 0 |

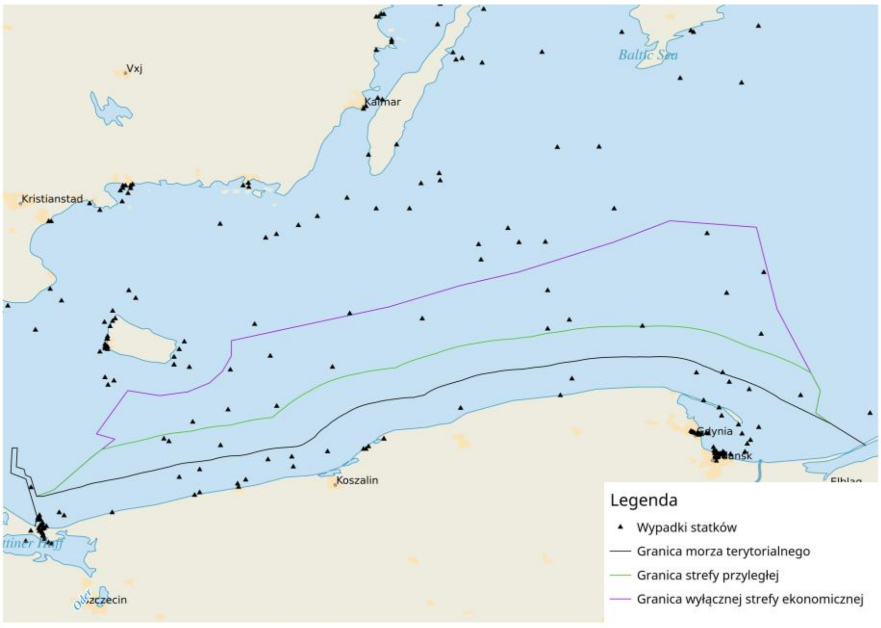



Fig. 4.2.14 Ship accidents in the Polish Baltic Sea zone in 1989-2013 (HELCOM).

**Spills of oil and other hazardous substances registered during air surveillance**

According to the Helsinki Commission's agreements, the waters of the Baltic Sea are monitored from the air using specialized aircraft equipped with remote sensing equipment. The main task of air monitoring is tracking of leaks and identification of potential perpetrators. Air monitoring focuses mainly on oil spills, but also records other pollutants. Recommendation 34E/4 issued by HELCOM advises EU Member States to, as far as possible, cover the entire Baltic Sea region with regular and systematic air surveillance, develop and improve remote sensing systems and coordinate activities with other Member States (Kostianoy 2014).

**Dumped chemical munitions at Baltic Sea**

In the Polish zone of the Baltic Sea, or more precisely in the Gdańsk Deep, there is a munition storage site. The site has a diameter of 0.62 nautical miles and is located at 54°45'N, 19°10'E coordinates (Fig. 4.2.15). Chemical munitions were found not only in the vicinity of the site, but also on the beaches in Dziwnów, Kołobrzeg and Darłów, which suggests the existence of more such sites. In 1954, about 60 tonnes of munition, both conventional explosives and chemical were dumped in this area. The proportion of these munition remains unknown. The area was examined as part of the CHEMSEA project. As a result of magnetometric and acoustic tests, the presence of a sunken barge and many objects that are probably artillery loads were shown. Currently, research on sediment pollution is conducted in this area

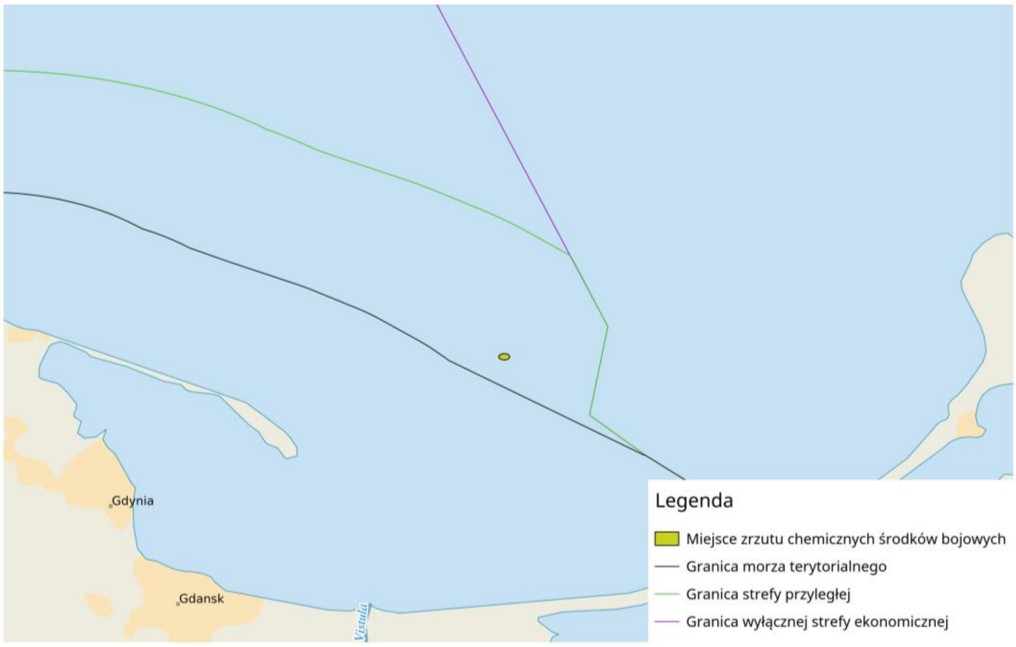



Fig. 4.2.15 Chemical warfare storage station (HELCOM).

According to the latest information, Gdańsk Deep is a minor site containing only a few tonnes of chemical munition next to the dumping site of conventional explosives. The degree of sediment pollution is unknown. It is estimated that due to the depth and anaerobic conditions, the risk of contact between living organisms and these substances is minimal, however, there is a risk of fishermen catching the mentioned materials.

Cases of finding white phosphorus on beaches happen every year, but there is no official data on the number of such cases. White phosphorus is easily confused with amber, which leads to dangerous incidents, as phosphorus after drying spontaneously ignites and burns at 1300 ° C.

Based on the research into chemical munition and explosives dumped in the sea, it has been shown that over time these materials can react with one another and undergo transformations. As a result, the aging process may lead to changes in chemical and physical properties of a given munition, making its behavior in the marine environment complex and difficult to predict. Thanks to this phenomenon on one hand, chemical muniton may lose its dangerous properties, but on the other explosives may become more susceptible to explosions and less safe in manipulation.

Some of the chemical munition undergo rapid transformation in the environment, while other react very slowly, becoming persistent in the environment. In addition, if they are hydrophobic and fat soluble, they have the potential for bioaccumulation and biomagnification in living organisms. As POPs, they can be considered as significant environmental pollution.

In the case of organic substances, the highest degradation is mineralization (decomposition to carbon dioxide, ammonia, water, hydrogen sulphide). In the case of organo-metallic compounds (munition based on organic arsenic compounds) or inorganic compounds (metal from containers or lead II azide from detonators), such transformations may lead to the formation of inorganic compounds of heavy metals, which in turn may undergo further transformations into new organometallic compounds. by microbes. These compounds often occur naturally, and their toxicity depends on the type of metal and the type of compound in which it occurs. However, the fact is that in the natural environment, heavy metal concentrations are very low, and their higher amounts are only introduced as a result of human activity.

Initial results of the CHEMSEA project show deteriorated health, greater susceptibility to skin infections and a greater number of gill parasites and genetic disorders in individuals caught in the discharge areas compared to the control group. In addition, the stability of the lysosome membrane was reduced, which may be the result of arsenic in both fish and mussels in the vicinity of the Bornholm chemical warfare repository (HELCOM 2013f BSEP No XX; BSEP 120B; HELCOM 2013g BSEP 142).

**Ports and harbours**

According to the BSEP 120B report (HELCOM 2010b), ports and harbors may be a source of contaminants due to high concentrations of heavy metals and TBT (Tributylotin) in sediments. Due to repair work taking place in ports and marinas, many pollutants get through.

According to BSEP 125 (HELCOM 2010a) pressures caused by ports and harbors are identical to physical pressures (same data set and calculation method, see chapter 4.2 Physical losses and disturbances of the seabed

**Sea oil rigs**

In the Polish zone of the Baltic Sea, there are currently two oil rigs - "Baltic Beta" at N 55.48143° E 18.1827° and „LOTOS Petrobaltic" at N 55.40035° E 18.7211° (marinetraffic.com, lotos.pl). The value of pressure in the case of oil rigs in the Baltic Sea is the average outflow of discharge water, that for oil rigs was estimated for the maximum value of industrial constructions. If no data is available for discharges of a given structure, the average value shall be assigned.

**Accidental spills of petroleum substances observed during air monitoring**

The annual reports on the course of air pollution monitoring in 2011-2015 published by HELCOM show that 56 cases of seawater pollution due to oil spills were recorded in the Polish Baltic Sea zone (Fig. 4.2.16) The pressure, according to the HELCOM methodology (HELCOM 2010a) is the volume (cubic meters) of petroleum substances released into the Baltic Sea. Next, the values of the BSPI and BSII data layers were calculated. The results are presented in Table 4.2.10.

Fig. 4.2.16. Spills of petroleum substances in the Baltic Sea in 2011-2015 recorded as a result of air monitoring. The numerical values shown in the figure represent the volume of petroleum substances released to the Baltic Sea in 2011-2015.

Table 4.2.10. Pressures [m³] related to accidental releases of pollutants from ships and the data layer of BSPI and BSII related totals. HELCOM assigns a unique identification number (HELCOM ID) to each leak, which is given in the table.

| Lp. | Rok | HELCOM ID | Szer. Geogr. | Dł. Geogr. | Presja | BSPI | BSII |
|---|---|---|---|---|---|---|---|
| 1 | 2011 | 3893 | 55,460800 | 17,962700 | 0,000210 | 0,0005313 | 0,003633 |
| 2 | 2011 | 3895 | 54,664500 | 18,681500 | 0,000400 | 0,001012 | 0,00904 |
| 3 | 2011 | 3896 | 54,488300 | 18,573700 | 0,001000 | 0,00253 | 0,0208 |
| 4 | 2011 | 3892 | 55,472000 | 17,927500 | 0,004000 | 0,01012 | 0,0692 |
| 5 | 2011 | 3894 | 55,313800 | 16,949200 | 1,220000 | 3,0866 | 27,694 |
| 6 | 2012 | 4029 | 54,589500 | 18,812300 | 0,000200 | 0,000506 | 0,00416 |
| 7 | 2012 | 4030 | 54,710000 | 15,683300 | 0,001400 | 0,003542 | 0,03164 |
| 8 | 2012 | 4031 | 54,775000 | 17,583300 | 0,004000 | 0,01012 | 0,0832 |
| 9 | 2012 | 4032 | 55,367900 | 18,160900 | 0,010000 | 0,0253 | 0,173 |
| 10 | 2012 | 4033 | 54,710000 | 15,569300 | 3,300000 | 8,349 | 74,58 |
| 11 | 2013 | 4131 | 54,933700 | 18,528300 | 0,000080 | 0,0002024 | 0,001816 |
| 12 | 2013 | 4132 | 54,933700 | 18,528300 | 0,000200 | 0,000506 | 0,00454 |
| 13 | 2013 | 4133 | 54,933700 | 18,528300 | 0,000200 | 0,000506 | 0,00454 |
| 14 | 2013 | 4134 | 54,933700 | 18,528300 | 0,000200 | 0,000506 | 0,00454 |
| 15 | 2013 | 4135 | 54,933700 | 18,528300 | 0,000230 | 0,0005819 | 0,005221 |
| 16 | 2013 | 4136 | 54,933700 | 18,528300 | 0,000300 | 0,000759 | 0,00681 |
| 17 | 2013 | 4137 | 54,933700 | 18,528300 | 0,000300 | 0,000759 | 0,00681 |
| 18 | 2013 | 4138 | 54,933700 | 18,528300 | 0,000500 | 0,001265 | 0,01135 |
| 19 | 2013 | 4139 | 54,933700 | 18,528300 | 0,000500 | 0,001265 | 0,01135 |
| 20 | 2013 | 4140 | 54,933700 | 18,528300 | 0,000700 | 0,001771 | 0,01589 |
| 21 | 2013 | 4141 | 54,832500 | 15,936700 | 0,001000 | 0,00253 | 0,0226 |
| 22 | 2013 | 4142 | 54,933700 | 18,528300 | 0,001000 | 0,00253 | 0,0227 |
| 23 | 2013 | 4143 | 54,933700 | 18,528300 | 0,001000 | 0,00253 | 0,0227 |
| 24 | 2013 | 4144 | 54,544800 | 19,457300 | 0,001100 | 0,002783 | 0,02497 |
| 25 | 2013 | 4145 | 54,933700 | 18,528300 | 0,001200 | 0,003036 | 0,02724 |
| 26 | 2013 | 4146 | 55,244200 | 17,124200 | 0,002000 | 0,00506 | 0,0454 |
| 27 | 2013 | 4147 | 54,644900 | 18,660400 | 0,002000 | 0,00506 | 0,0452 |
| 28 | 2013 | 4148 | 54,525800 | 18,613300 | 0,002000 | 0,00506 | 0,0454 |
| 29 | 2013 | 4149 | 54,933700 | 18,528300 | 0,004000 | 0,01012 | 0,0908 |
| 30 | 2013 | 4150 | 54,573900 | 18,570900 | 0,006000 | 0,01518 | 0,1362 |
| 31 | 2013 | 4151 | 54,933700 | 18,528300 | 0,010000 | 0,0253 | 0,227 |
| 32 | 2013 | 4152 | 54,866700 | 18,383300 | 0,018400 | 0,046552 | 0,41768 |
| 33 | 2013 | 4153 | 54,933700 | 18,528300 | 0,020000 | 0,0506 | 0,454 |
| 34 | 2013 | 4154 | 54,933700 | 18,528300 | 0,040000 | 0,1012 | 0,908 |
| 35 | 2013 | 4155 | 54,917800 | 18,398500 | 0,050000 | 0,1265 | 1,135 |
| 36 | 2013 | 4156 | 54,847500 | 18,941200 | 0,060000 | 0,1518 | 1,356 |
| 37 | 2013 | 4157 | 54,933700 | 18,528300 | 2,400000 | 6,072 | 54,48 |
| 38 | 2014 | 4327 | 54,933700 | 18,528300 | 0,000016 | 0,00004048 | 0,0003632 |
| 39 | 2014 | 4328 | 55,449200 | 17,630800 | 0,000500 | 0,001265 | 0,00865 |
| 40 | 2014 | 4329 | 54,872000 | 17,284300 | 0,000900 | 0,002277 | 0,02043 |
| 41 | 2014 | 4330 | 55,398800 | 18,724700 | 0,000900 | 0,002277 | 0,01557 |
| 42 | 2014 | 4331 | 55,281800 | 17,717500 | 0,003000 | 0,00759 | 0,0681 |
| 43 | 2014 | 4332 | 55,346300 | 17,387700 | 0,003200 | 0,008096 | 0,07264 |
| 44 | 2014 | 4333 | 54,828400 | 18,916200 | 0,009000 | 0,02277 | 0,2034 |
| 45 | 2014 | 4334 | 54,528400 | 19,397900 | 0,020000 | 0,0506 | 0,454 |
| 46 | 2014 | 4335 | 55,691700 | 18,650000 | 0,045000 | 0,11385 | 0,7785 |
| 47 | 2014 | 4336 | 54,816700 | 18,666700 | 0,112000 | 0,28336 | 2,5424 |
| 48 | 2015 | 4523 | 54,516800 | 18,567700 | 0,001800 | 0,004554 | 0,03744 |
| 49 | 2015 | 4524 | 54,519000 | 18,947200 | 0,009000 | 0,02277 | 0,2034 |
| 50 | 2015 | 4526 | 54,817800 | 18,570000 | 0,012000 | 0,03036 | 0,2724 |
| 51 | 2015 | 4527 | 54,576700 | 18,782200 | 0,024000 | 0,06072 | 0,5424 |
| 52 | 2015 | 4528 | 54,792700 | 18,477800 | 0,030000 | 0,0759 | 0,624 |
| 53 | 2015 | 4529 | 54,722200 | 18,873700 | 0,080000 | 0,2024 | 1,808 |
| 54 | 2015 | 4530 | 55,049000 | 17,985500 | 0,110000 | 0,2783 | 2,497 |
| 55 | 2015 | 4531 | 54,487000 | 18,659200 | 0,120000 | 0,3036 | 2,712 |
| 56 | 2015 | 4532 | 55,363000 | 18,633300 | 7,350000 | 18,5955 | 127,155 |

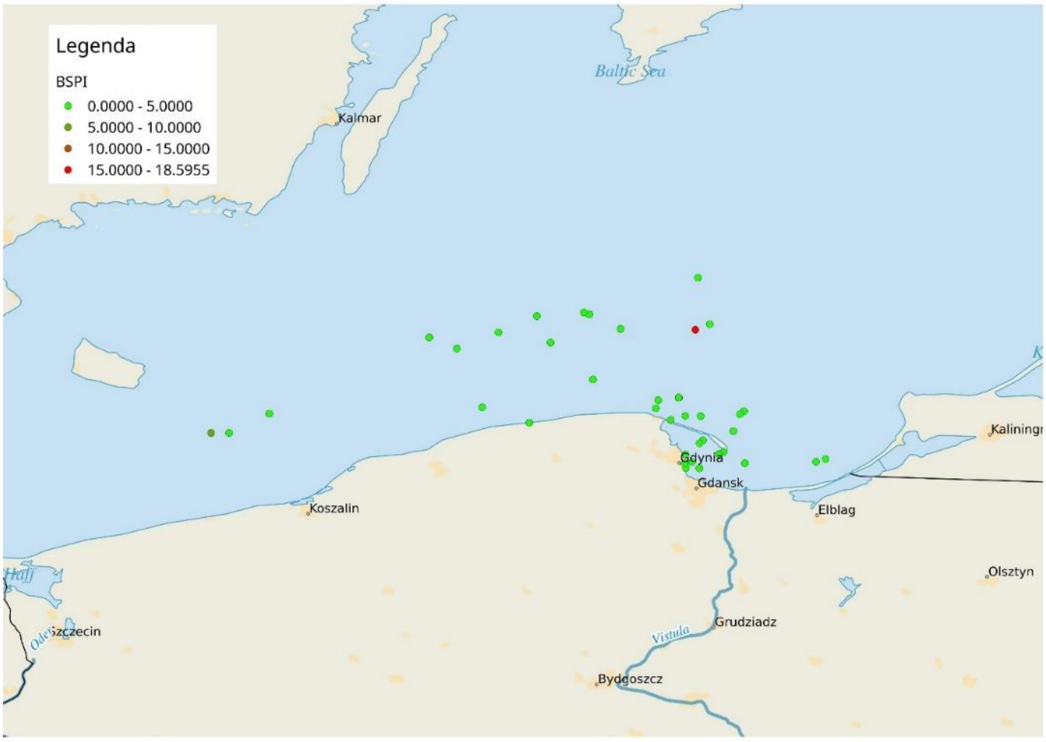



Fig. 4.2.17. The Baltic Sea Pressure Index (BSPI) in the Polish Baltic region in 2011-2015.

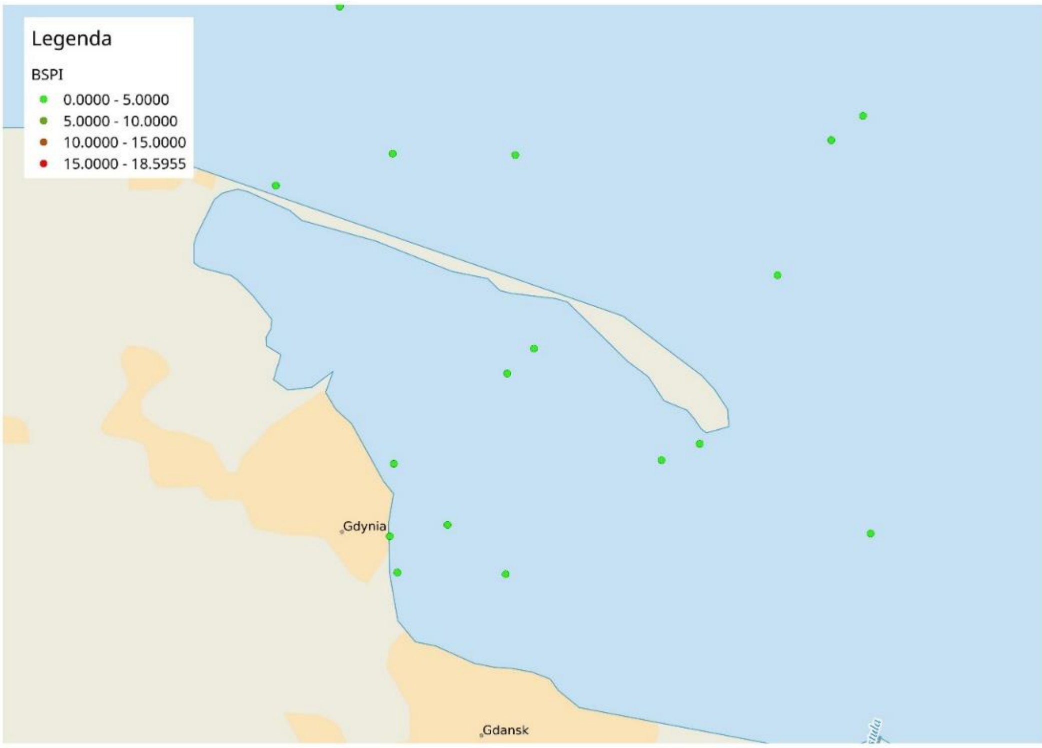



Fig. 4.2.18. The Baltic Sea Pressure Index (BSPI) in the gulf of Gdańsk in 2011-2015.

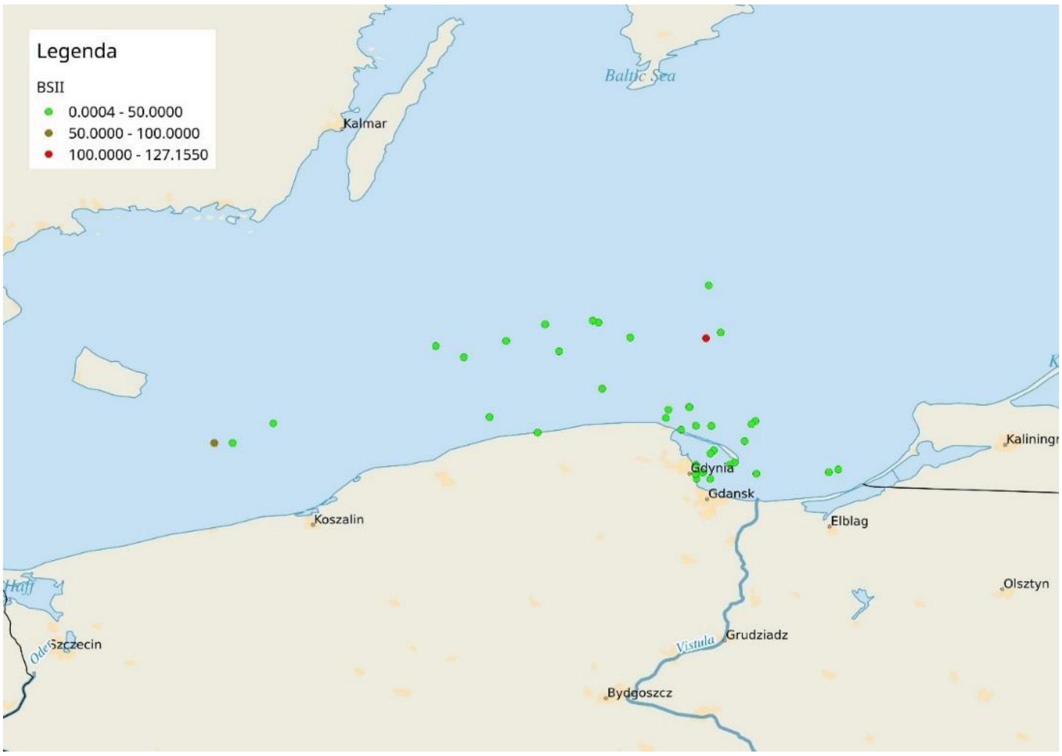



Fig. 4.2.19. Data layer (BSII) in 2011-2015.

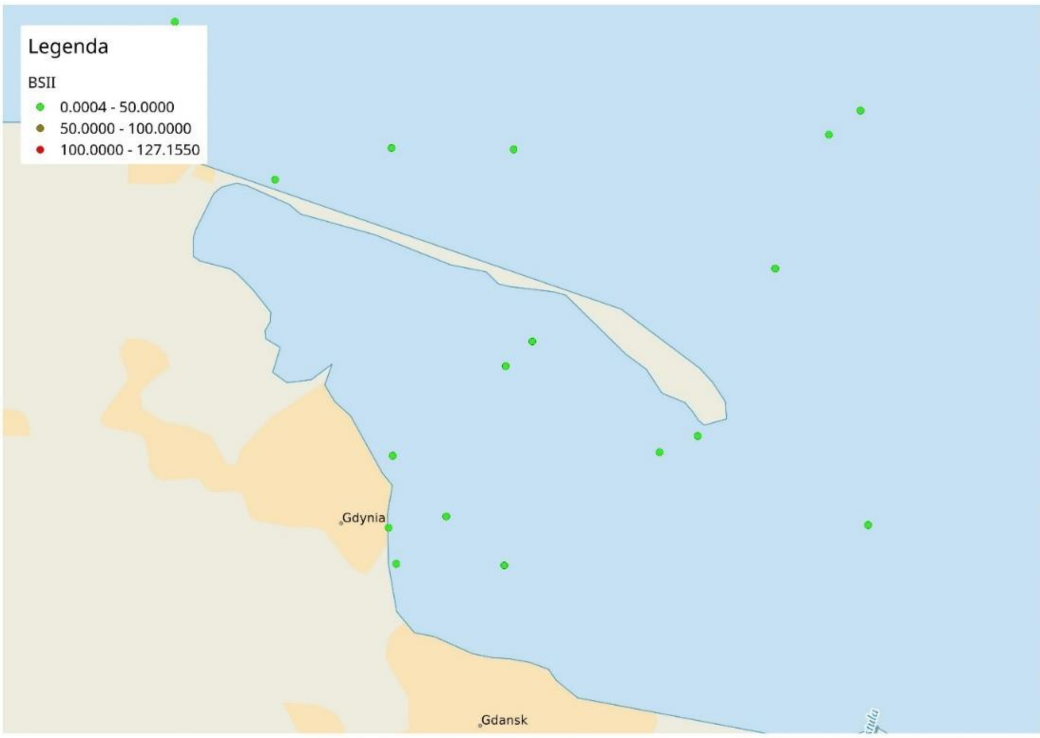



Fig. 4.2.20. Data layer (BSII) in the gulf of Gdańsk from 2011-2015.

Relatively small amount of oil spills into the Baltic Sea environment was recorded, it was additionally spread over time (the data scope covers at least five years). Despite the fact that the Threshold Value of the indicator may be temporarily exceeded, taking into account that any exceedances are incidental and local in nature, it is assumed that the anthropogenic pressure on the Baltic Sea is very low in this respect.

The Baltic Sea, as a special zone, is subject to special protection when it comes to the emission of any pollution into the environment. All contaminants entering the marine environment of POM are the result of accidents, breakdowns or illegal activities. As the analysis of available data shows, hazardous substances appearing in POM are in this case incidental leaks of petroleum substances. In addition to petroleum derivatives, there is still a threat from dumped chemical munition.

**Litter**

Litter in the marine environment is still a relatively poorly researched problem. The litter consists of household rubbish, litter accidentally lost by ships (ropes, metal litter, dunnage) and lost fishing nets. Identification and neutralization of the latter takes place as part of the MARELITT project. According to the MARLIN program (the Baltic Sea Marine Litter 2011-2013), 48% of litter in the Baltic Sea is household litter, while WWF estimates that there are 150-450 tonnes of fishing nets in the POM (WWF Poland 2015). In the Sea Water Monitoring Program, litter C10 (litter on the shore, litter in the water column and litter assimilated by marine animals) is responsible for the litter. The litter monitoring program is being carried out since 2015. The earlier monitoring program did not cover solid litter in the marine environment. The HOLAS project did not develop at the regional level (in line with the KE level regarding the update of the initial assessment, limit values for good state of litter in the marine environment are set at the regional level) of the litter indicator (HELCOM 2010a), which makes it impossible to calculate BSPI and BSII (HELCOM 2010a). Litter in the sea can seriously damage the environment and have an impact on human health. Most of the litter is non-degradable items, mainly plastics, intentionally abandoned or accidentally lost. Small organisms living in the sea often confuse small, potentially toxic particles of plastic garbage with food. Injured plastic particles can then migrate up the food chain and penetrate into other marine animals. (HELCOM 2015e).

The sources of pressure include trash left on the shore, river discharge, tourism and recreation, the result of sea transport activity, lost fishing nets, small recreational units, harbors and marinas.

**Noise**

The sources of underwater noise are usually the work of engines of boats, ships and ships, the work of underwater hydrotechnical equipment (drilling rigs, dredgers, pilots), sonars and echosounders, geological exploration explosions, training detonations at sea military training areas, underwater explosions at the destruction of ammunition. Sound from these sources can propagate over long distances. While the intensity of sound can be easily measured, it is not easy to determine its impact on the natural environment.

For species such as the porpoise (*Phocoena phocoena*), which orientation in the underwater space is due to the advanced evolution of the echolocation system, a strong intensity of alien sounds can cause significant behavioral problems. In extreme cases, underwater explosions lead to the immediate death of animals that are too close to the epicenter of detonation. At further distances or less noise, they may be damaged by the hearing system, resulting in disturbances in the echolocation system (also often with delayed fatal effects), causing navigation errors and impeding the acquisition of food. Dispersal of animals from places of particular importance to their life cycle, e.g. breeding sites, feeding grounds or migration routes, may have particular significance for their life cycle. Anthropogenic, underwater noise of the intensity and frequency audible to porpoises, also causes so-called masking effect. In some situations it drowns the background or other sounds helpful in the life of the porpoise. This causes problems in inter-individual communication (including mother-young, male-female), hinders the accurate location of fish that are food or the identification of obstacles (e.g. nets) (Gójska 2012b).

On the Polish coast, underwater noise can disturb marine mammals (gray seals in particular) from places that are abundant in food, and thus affect the weakening of their condition, which is still lowered, among others due to environmental pollution (Gójska 2012a).

The map below (Fig. 4.2.21) shows the results of the noise field modeling for 2014 (more recent data are not available). The values presented are the average noise level determined for sound. The noise level does not exceed 75 dB re μPa along the shore (belt with a width of approx. 15 km) and in the Gulf of Gdańsk. The noise level increases towards the north, but it does not exceed 90 dB re μPa anywhere.

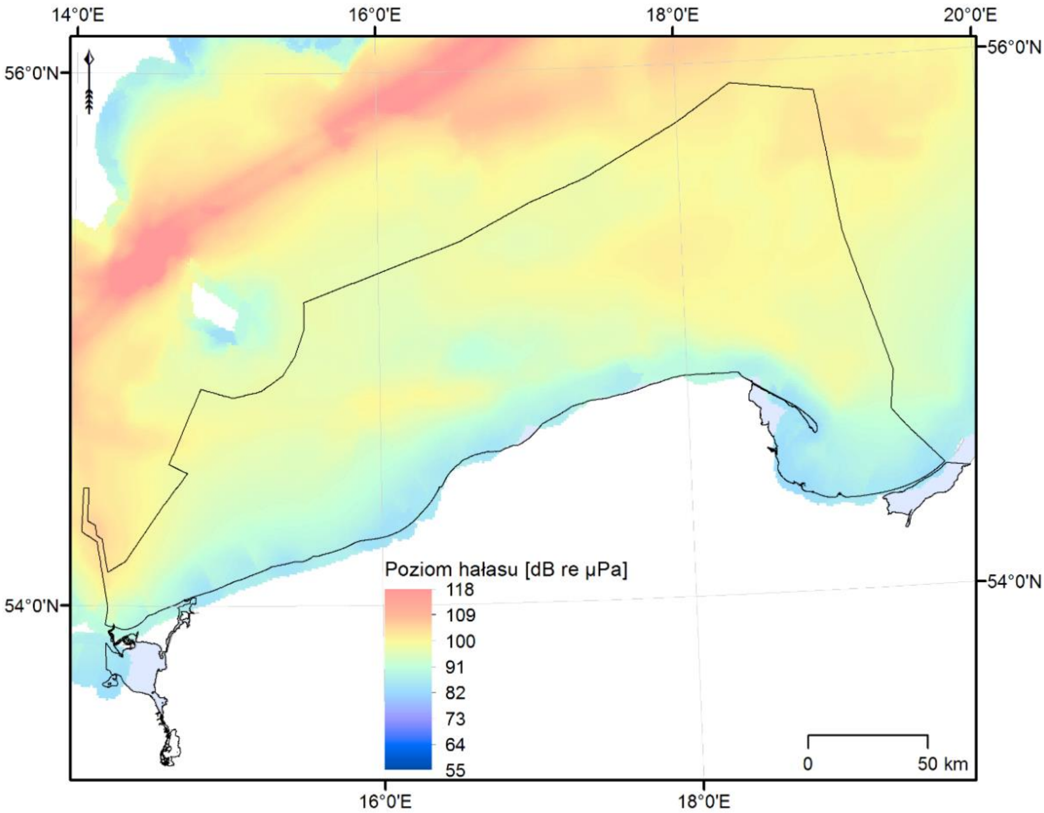



Fig. 4.2.21. The level of continuous noise related to human activity (based on national data provided by HELCOM.

In order to prepare an effective noise monitoring program, in 2015, testing of measuring equipment was started in the sea. The plan of hydrophone deployment in the southern Baltic Sea (Fig. 4.2.22, Table 4.2.11) was agreed with the relevant Maritime Offices in Gdynia, Słupsk and Szczecin so that they were close to the main shipping corridors and to bypass the zones that pose threat to the integrity of anchorage systems (GIOŚ, 2016a).

Table 4.2.11. Information on underwater noise measurements carried out in 2015-2016.

| **Station name** | **Współrzędne geograficzne** | | **Research area** | **The beginning of measurement** | **The end of measurement** | **Immersion depth [m]** |
|---|---|---|---|---|---|---|
| | **Longitude** | **Latitude** | | | | |
| HH13 | 14° 18,387’ | 54° 04,020 | Bornholm Basin | 08-08-2015 | 16-09-2015 | 11,0 |
| H39a | 15° 30,567’ | 54° 45,600’ | Bornholm Basin | 01-03-2016 | 03-03-2016 | 4,0; 65,0 |
| HZN4 | 18° 37,725’ | 54° 31,184’ | Gdańsk Basin | 31-10-2016 | 23-11-2016 | 60,0 |

Table 4.2.12 presents a list, while Fig. 4.2.22 presents the location of activities in the field of security and defense affecting the marine environment in 2011-2016, in particular as a source of noise. Most of these activities were carried out within the P-20 prooving ground, located in the maritime zone west of Słupsk. The main source of sound here were bombing and artillery rocket shooting - a total of 790 days. There is no information on the intensity of the generated impulse noise. The results obtained in August 2015 indicate that the vessel traffic in the area contributes virtually constantly to the current contribution to the field of ambient noise, especially in the band range from 50 to 5000 Hz. In the case of ships passing close, the noise produced may exceed the natural noise level of the sea (own noise).

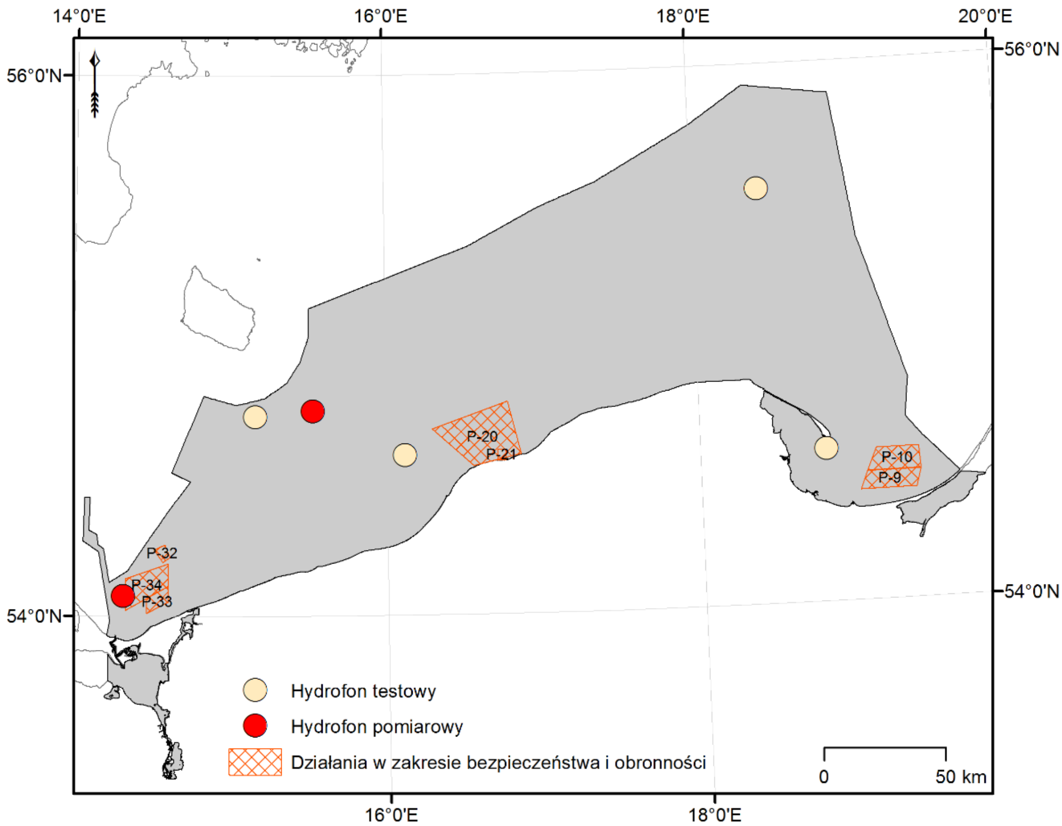



Fig. 4.2.22. Location of hydrophones in the Polish zone of the southern Baltic Sea (GIOŚ, 2016a and data provided by GIOŚ).

Table 4.2.12. The number of days in which security and defense activities were carried out affecting the marine environment in 2011-2016 (source: MON); firing range locations are shown on the map above.

| Proving ground / Activities | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|---|---|---|
| P-20 | 143 | 153 | 118 | 120 | 155 | 101 | 790 |
| Bombing | 16 | 16 | 18 | 22 | 22 | 29 | 123 |
| Artillery and rocket shooting | 127 | 137 | 100 | 98 | 133 | 72 | 667 |
| P-21 | 1 | 1 | 1 | 1 | | 2 | 6 |
| firing a big elongated explosive charge | 1 | 1 | 1 | 1 | | 2 | 6 |
| P-32 | 3 | 5 | 3 | 5 | 3 | 3 | 22 |
| firing a big elongated explosive charge | 3 | 5 | 3 | 5 | 3 | 3 | 22 |
| P-34 | | 3 | | | 3 | | 6 |
| Artillery and rocket shooting | | 3 | | | 3 | | 6 |
| P-34/P-33 | 82 | 68 | 75 | 60 | 72 | 67 | 424 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Artillery and rocket shooting | 76 | 57 | 65 | 54 | 66 | 59 | 377 |
| Situational shooting | 6 | 11 | 10 | 6 | 6 | 8 | 47 |
| P-9 | | | | 4 | 3 | | 7 |
| Artillery and rocket shooting | | | | 4 | | | 4 |
| Situational shooting | | | | | 3 | | 3 |
| P-9/P-10 | 6 | 8 | 11 | 27 | 41 | 27 | 120 |
| Artillery and rocket shooting | 6 | 7 | 11 | 24 | 39 | 25 | 112 |
| Situational shooting | | 1 | | 3 | 2 | 2 | 8 |

**Other types of energy**

Other types of energy that can be introduced into the marine environment as a result of anthropogenic activities include light, heat and energy.

Typical sources of anthropogenic pressure related to the introduction of other types of energy into the marine environment are the discharges of heated water (usually as a result of cooling of the power plant) and the electromagnetic field (caused by the operation of various devices). While the discharges of heated water are of land origin, the electromagnetic field may have marine origin. The source of pressure in this case are undersea cables – mainly elements of the power grid. The change in the intensity of the electromagnetic field is significant in the vicinity of the cable, but at a distance of 20 m from the cable, the intensity of the field does not differ from natural conditions (Andrulewicz et al., 2003). Knowledge about the impact of the (unnatural) electromagnetic field on marine habitats is still small (e.g. Tricas and Gill, 2011). Studies carried out so far indicate that the influence of the electromagnetic field can have both negative and positive effects (depending on the distance from the source, intensity, species of the organism) (Slater et al., 2011).

The location of the submarine cables is shown on the map (Fig. 4.2.7), of which the following are functioning:

- telecommunications cable connecting Poland (Mielno) with Denmark (Gedebak Odde), 110 km in length, including about 80 km within POM
- telecommunications cable connecting Poland (Kołobrzeg) with Denmark (Gedser), about 73 km in length within Polish areas
- SwePol Link - underwater high voltage direct current (HVDC) cable line between the Stärnö peninsula near Karlshamn in Sweden and the village of Wierzbięcin near Słupsk in Poland. Its length is 254.05 km (103 km in POM). The submerged section is 239.28 kilometers long and is landed in Poland near Ustka. The SwePol line was commissioned in 2000 and can conduct a 600 MW power supply at 450 450 kV[7].

HELCOM data contain information about one more functioning cable linking Poland with Sweden (in the near distance from SwePol). However, there is no detailed information about this line. According to Andrulewicz et al. (2003) it is one of the analyzed SwePol routes - not implemented.

Due to the lack of measurement data, no impacts related to the introduction of other types of energy into the sea were identified.

In POM (in the areas of the of the Bornholm Basin Polish Coastal waters and the Bornholm Basin Polish Coastal waters) one electric power cable has been identified that could potentially constitute a significant source of electromagnetic radiation. However, there are no measurement results confirming the impact.

[7] http://new.abb.com/systems/hvdc/references/swepol-link

## 4.3. Marine pressures and impacts on marine waters resulting from fishing activities

The chapter includes information on the size of Polish marine catch and its species structure including description of the exploitation of cod, herring, sprat, salmonidae and flatfish in POM broken down by ICES subareas and fishing gear. Biomass and fishing mortality of stocks (or indicators of these values), the length and age structure of the exploited part of stocks and the share of undersized fish in catches were also presented along with the indication of change trends.

In addition the chapter provides information on Polish recreational cod fishing, including:

1) characteristics of fish exploitation in the Szczecin Lagoon, the Vistula Lagoon and the Puck Bay, broken down by fishing gear; presents the length and age structure of exploited stocks, share of undersized fish in catches and presents change trends.
2) by-catch of non-commercial and protected species.
3) information on the results of observed by-catches of mammals and seabirds in fishing nets of vessels flying the Polish flag.
4) information on fishing pressure on the seabed

The data and its analysis was carried out mainly for the period 2011-2016/2017, however, in some cases, for a more complete picture of the existing dynamics of resources and/or anthropogenic pressure, the results from the above period were also compared to averages or data covering previous years.

The contents of the chapters covering the exploitation of individual fish species from the Szczecin Lagoon, Vistula Lagoon and the Puck Bay, are covered by criteria D3C1, D3C2 and D3C3 of MSFD correspondinf to fishing pressure. All information on the size of the population of species and its demographic characteristics (i.e. body size or age class structure) constitute a contribution to the assessment according to criteria D1C2 and D1C3. Chapters describing by-catch of non-commercial and protected fish species and by-catch of mammals and seabirds - criterion D1C1, and a chapter describing the pressure of fishing on the seabed criterion D6C2.

The following data and materials were used in the study:

1) MIR-PIB's own research.
2) Research and data collected as part of the National Fisheries Data Collection Program.
3) Research and work within the International Council for the Exploration of the Seas (ICES), made available in the reports and monographs of its working groups and committees, in particular in:
    a) Reports of Baltic Fisheries Assessment Working Group (WGBFAS) (i. e. ICES, 2017, CM 2017/ACOM:11.)
    b) Reports of Baltic Salmon and Trout Assessment Working Group (WGBAST), (i.e. ICES 2017, CM 2017/ACOM:10).
    c) Monographs of ICES Advice (i.e. ICES Advice 2017, Book 8)
4) Research commissioned by MGMiŻŚ or previously MRiRW.
5) Fisheries Monitoring Center (CMR).

### *Species structure of Polish landings*

In 2011-2016, the dynamics of the size of Polish marine catches was variable. In the period 2011-2012, the catch remained stable at approx. 179.8 thousand tonnes. In 2013, it increased to 195,500 tonnes, by 8.7%. In turn, 2014 brought a drop of this amount to 170.5 thousand tonnes, (by 12.8%). The years 2015-2016 are a period of systematic growth. In 2015, the catch volume was 187,000 tonnes, 9.7% more than in the previous year, and in 2016 198.9 thousand tonnes (6.4% more). The total Baltic Sea catch in the years 2011-2016 increased, with the exception of 2014. In 2016, Baltic catch amounted to 138.9 thousand tonnes, which represented an increase by 3.1% compared to 2015 and by 25.4% compared to 2011. On the other hand, the dynamics of deep-sea catches in this period was not as uniform (Fig. 4.3.1).

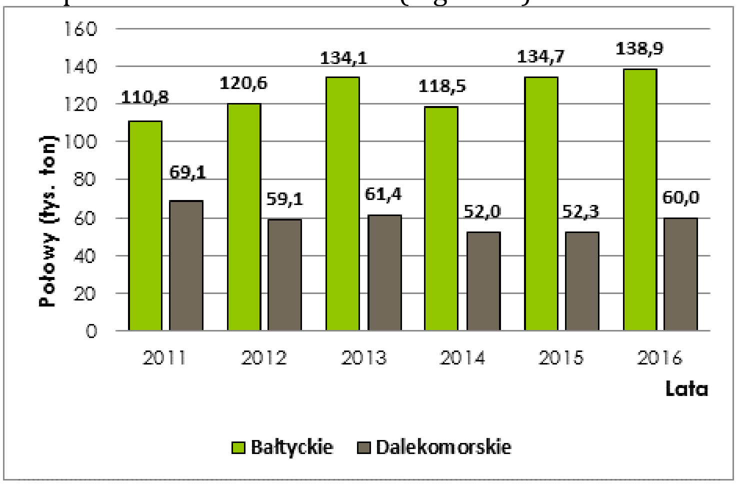



Fig. 4.3.1. The amount of catches in 2011-2016 [in thous. tonnes]. Green colour – Baltic, gray colour – deep sea.

The following species predominated in the species structure of the Baltic Sea catches in 2011-2016: sprat (from 43.2% to 60.3%), herring (from 17.6% to 31.7%), cod (from 7.4 % to 12.3%) and flatfish (from 7.1% to 11%). The share of other fish species was small and ranged from 2.4% to 6.6%. From 2013, an increasing trend of catches of herring and various species of fish aggregated under the heading "Others" is visible (Fig. 4.3.2; Table 4.3.1).

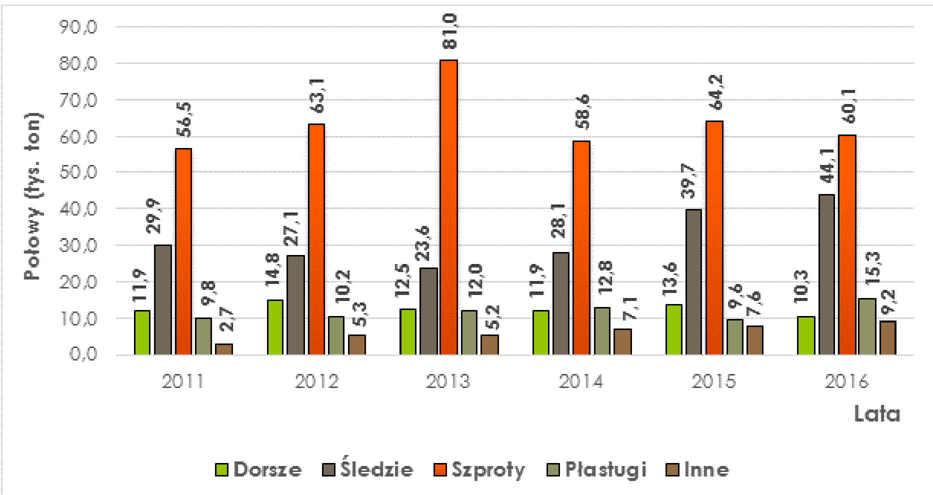



Fig. 4.3.2. Species structure of the Baltic Sea catches in 2011-2016 [in thous. tonnes]. Green colour – cod, gray colour – herring, red colour – spratt, dark green – flatfish, brown - others.

Table 4.3.1. The Baltic Sea catch in 2011-2016 by species [in tonnes].

| Species | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| European sprats | 56 489.6 | 63 119.1 | 80 987.7 | 58 575.6 | 64 175.0 | 60 057.1 |
| Herrings | 29 881.3 | 27 114.4 | 23 581.1 | 28 136.7 | 39 712.4 | 44 055.8 |
| European flounders | 9 725.1 | 10 089.3 | 11 868.7 | 12 640.1 | 9 440.6 | 15 059.9 |
| Cods | 11 861.8 | 14 843.8 | 12 495.8 | 11 895.9 | 13 617.4 | 10 335.0 |
| Great sand eels | 0.4 | 2 338.7 | 1 574.1 | 3 615.9 | 4 324.3 | 5 400.3 |
| Common breams | 651.0 | 544.9 | 616.9 | 517.1 | 779.6 | 1 004.7 |
| Perches | 813.8 | 996.5 | 952.0 | 1 125.5 | 882.1 | 971.9 |
| Common roaches | 617.9 | 644.1 | 993.6 | 984.0 | 866.4 | 719.7 |
| Pike perches | 134.8 | 307.9 | 404.2 | 300.1 | 245.0 | 348.8 |
| Sea trouts | 233.3 | 167.5 | 132.8 | 123.7 | 138.8 | 208.2 |
| Whitings | 7.3 | 21.4 | 7.3 | 4.1 | 16.7 | 204.4 |
| European plaices | 35.4 | 63.8 | 50.2 | 88.2 | 142.0 | 157.2 |
| Eels | 32.1 | 30.8 | 48.6 | 39.5 | 41.6 | 58.8 |
| Turbots | 78.2 | 66.2 | 72.5 | 29.9 | 33.8 | 57.6 |
| Sichels | 22.2 | 28.7 | 30.4 | 73.8 | 61.0 | 53.8 |
| Garfish | 20.7 | 26.3 | 29.6 | 13.6 | 49.2 | 46.7 |
| Crucian carps | 12.3 | 16.2 | 27.7 | 28.1 | 39.8 | 35.8 |
| Common whitefish | 21.9 | 23.5 | 38.6 | 15.4 | 28.1 | 29.0 |
| Atlantic salmon | 34.4 | 34.7 | 31.7 | 18.3 | 22.5 | 21.2 |
| White breams | 44.2 | 30.9 | 54.1 | 20.1 | 35.2 | 12.9 |
| Northern pikes | 12.3 | 12.3 | 22.7 | 16.2 | 14.1 | 8.3 |
| Tenches | 10.3 | 6.6 | 11.0 | 8.1 | 7.2 | 8.1 |
| Burbots | 10.8 | 13.1 | 12.5 | 8.7 | 5.6 | 7.3 |
| Asps | 2.3 | 2.2 | 4.1 | 3.9 | 5.8 | 5.6 |
| Wels catfish | 2.1 | 2.7 | 3.7 | 2.1 | 2.3 | 1.6 |
| Smelts | 0.3 | 6.9 | 0.5 | 1.8 | 1.8 | 0.9 |
| Vimba breams | 0.1 | 0.1 | 1.6 | 6.7 | 1.8 | 0.2 |
| Rainbow trouts | 1.0 | 6.9 | 1.3 | 0.9 | 0.8 | 0.1 |
| Others | 11.4 | 15.4 | 21.2 | 169.0 | 34.4 | 26.9 |
| Total: | 110 768.2 | 120 574.6 | 134 076.2 | 118 462.8 | 134 725.2 | 138 897.8 |

Table 4.3.2 and Table 4.3.3 summarize the catch in the geographical layout by distinguishing the districts marked in the ICES division as subareas 24, 25, 26[8] respectively (west, central and east coast regions) (Fig. 4.3.3).

[8] ICES Subdivision 24 - the west coast region, covers the area west of the meridian of 15° East Longitude (west of Niechorze); ICES subarea 25 - area of the central coast, covers the area between meridians 15° - 18° East longitude (between Niechorze and Białogóra), and ICES subarea 26 - east coast area, covers the area east of meridian 18° East longitude (east of Białogóra)).

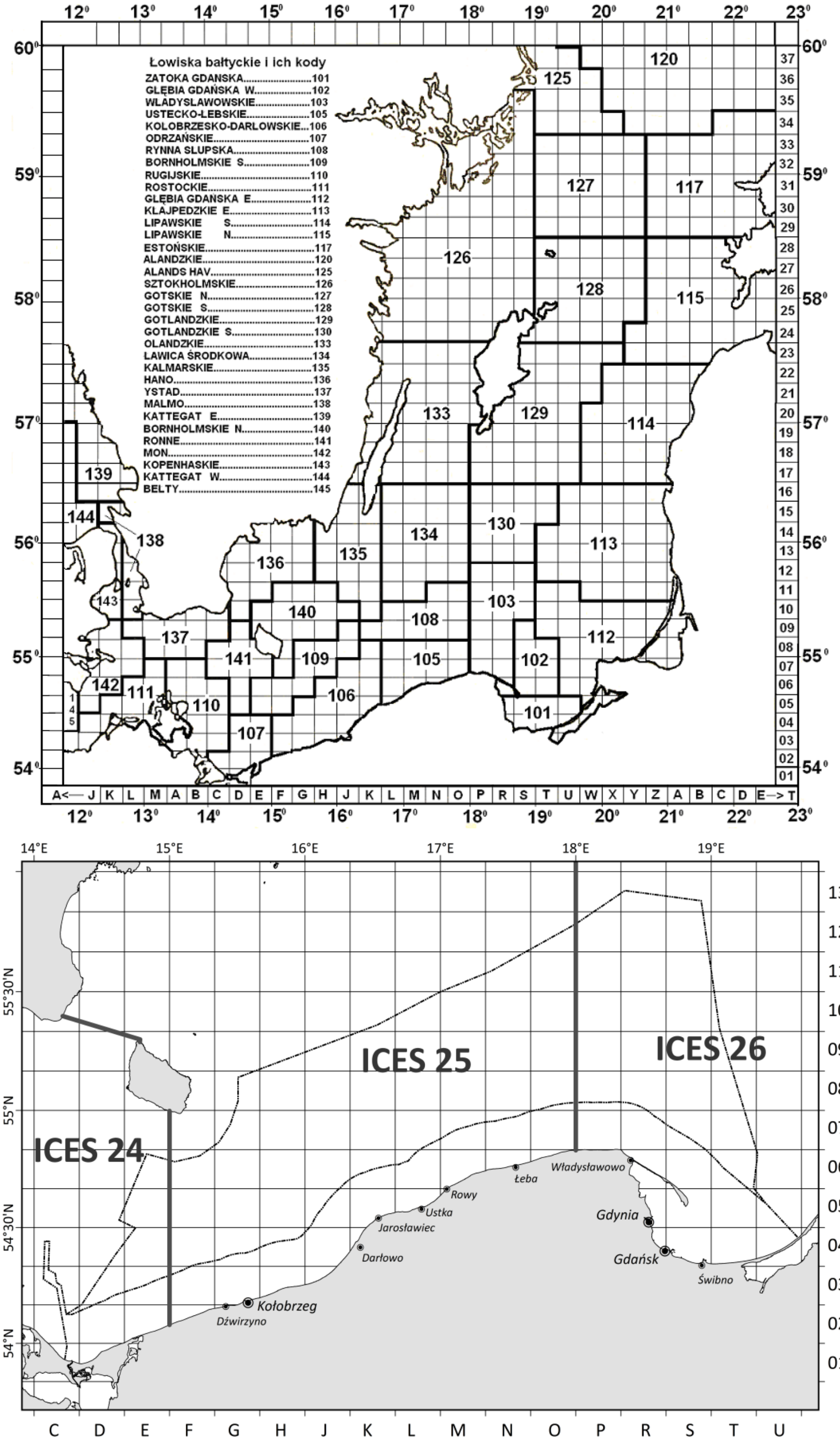



Fig. 4.3.3. Division of POM into Polish statistical fishing squares (letters at the bottom C-W, digits on the right 1-16) and ICES statistical subareas (upper figure) and a schematic map of the Baltic Sea fisheries (bottom figure).

Table 4.3.2. The catches in the Baltic Sea in 2011-2013 by ICES subareas [in tonnes].

| Baltic Sea fisheries | 2011 | | | | 2012 | | | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ICES 24 | ICES 25 | ICES 26 | Other regions[1] | ICES 24 | ICES 25 | ICES 26 | Other regions[1] | ICES 24 | ICES 25 | ICES 26 | Other regions[1] |
| European sprats | 688.5 | 9 877.7 | 38 654.3 | 7 269.1 | 3 592.5 | 24 538.5 | 31 154.5 | 3 833.5 | 973.0 | 19 683.3 | 54 197.5 | 6 134.0 |
| Herrings | 1 790.4 | 19 208.3 | 7 616.1 | 1 266.5 | 2 360.5 | 17 003.1 | 7 666.8 | 84.0 | 3 106.5 | 14 376.7 | 5 222.2 | 875.8 |
| European flounders | 1 568.1 | 6 711.2 | 1 445.7 | 0.1 | 1 324.0 | 7 292.6 | 1 469.9 | 2.7 | 2 145.4 | 8 125.0 | 1 581.8 | 16.5 |
| Cods | 487.7 | 6 646.9 | 4 727.1 | | 816.9 | 8 556.9 | 5 469.3 | 0.7 | 706.6 | 6 789.1 | 4 989.6 | 10.6 |
| Great sand eels | | 0.4 | | | 131.5 | 2 200.3 | 6.8 | | 23.8 | 1 550.3 | | |
| Common breams | 499.2 | 41.1 | 110.5 | 0.3 | 430.7 | 12.2 | 102.0 | | 483.5 | 5.7 | 127.6 | |
| Perches | 724.3 | 20.6 | 69.0 | | 851.2 | 51.5 | 93.8 | | 777.4 | 38.0 | 136.6 | |
| Roaches | 536.9 | 6.5 | 74.4 | | 544.9 | 5.7 | 93.5 | | 882.1 | 8.9 | 102.6 | |
| Pike perches | 53.7 | 14.6 | 66.2 | 0.3 | 202.1 | 42.1 | 63.7 | | 252.3 | 51.7 | 99.7 | |
| Sea trouts | 6.9 | 94.4 | 132.0 | | 10.5 | 65.1 | 91.2 | 0.6 | 4.6 | 32.5 | 95.7 | |
| Whitings | 7.2 | 0.1 | | | 15.0 | 6.4 | | | 6.5 | 0.8 | | |
| European plaices | 3.7 | 30.5 | 1.2 | | 21.1 | 40.7 | 2.0 | | 14.4 | 30.9 | 5.0 | |
| Eels | 23.4 | 0.8 | 7.8 | | 21.1 | 0.6 | 9.1 | | 31.0 | 3.2 | 14.4 | |
| Turbots | 18.5 | 48.8 | 10.8 | | 14.3 | 41.3 | 10.7 | | 18.1 | 42.5 | 11.9 | |
| Sichels | | | 22.2 | | | | 28.7 | | | | 30.4 | |
| Garfish | 0.5 | 1.7 | 18.5 | | 0.1 | 1.7 | 24.5 | | 0.3 | 0.7 | 28.5 | |
| Crucian carps | 1.0 | | 11.3 | | 0.5 | | 15.7 | | 0.6 | | 27.1 | |
| Common whitefish | 19.8 | 1.6 | 0.5 | | 22.4 | 0.4 | 0.7 | | 36.2 | 1.6 | 0.7 | |
| Atlantic salmons | 1.0 | 9.3 | 24.1 | | 0.2 | 14.0 | 20.5 | | | 14.5 | 17.3 | |

| Baltic Sea fisheries | 2011 | | | | 2012 | | | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ICES 24 | ICES 25 | ICES 26 | Other regions[1] | ICES 24 | ICES 25 | ICES 26 | Other regions[1] | ICES 24 | ICES 25 | ICES 26 | Other regions[1] |
| White breams | 34.3 | 1.8 | 8.1 | | 26.4 | | 4.5 | | 46.0 | | 8.1 | |
| Pikes | 11.2 | 0.2 | 0.9 | | 11.4 | | 0.8 | | 15.6 | | 7.1 | |
| Tenches | 9.5 | | 0.8 | | 5.6 | | 1.0 | | 10.6 | | 0.4 | |
| Burbots | 9.6 | | 1.2 | | 10.6 | | 2.5 | | 9.3 | | 3.2 | |
| Others | 11.6 | 0.1 | 5.3 | | 17.0 | 1.0 | 16.0 | 0.1 | 26.4 | 0.4 | 5.4 | |
| Total: | 6 507.0 | 42 716.7 | 53 008.2 | 8 536.3 | 10 430.7 | 59 874.3 | 46 348.1 | 3 921.6 | 9 570.2 | 50 755.9 | 66 712.6 | 7 037.5 |

[1]Subareas ICES 27,28 i 29

Table 4.3.3. Catches in the Baltic Sea in years 2014-2016 by ICES subareas [in tonnes].

| Species | 2014 | | | | 2015 | | | | 2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ICES 24 | ICES 25 | ICES 26 | Other regions[1] | ICES 24 | ICES 25 | ICES 26 | Other regions[1] | ICES 24 | ICES 25 | ICES 26 | Other regions[1] |
| European sprats | 1 518.0 | 23 347.5 | 31 198.9 | 2 511.3 | 2 714.5 | 27 112.9 | 33 959.3 | 388.3 | 3 783.2 | 24 614.8 | 29 488.5 | 2 170.6 |
| Herrings | 2 313.8 | 16 213.3 | 9 346.8 | 262.7 | 2 641.5 | 20 416.2 | 16 441.5 | 213.2 | 2 844.4 | 23 056.3 | 17 427.2 | 727.9 |
| European flounders | 1 501.4 | 9 918.6 | 1 199.5 | 20.6 | 1 122.6 | 7 340.4 | 977.2 | 0.4 | 2 423.5 | 11 703.0 | 933.3 | |
| Cods | 848.3 | 7 198.5 | 3 846.6 | 2.4 | 744.7 | 8 067.5 | 4 805.0 | 0.1 | 703.4 | 5 554.0 | 4 063.6 | 14.0 |
| Great sand eels | 1 751.5 | 1 855.7 | 8.6 | | 1 027.8 | 3 231.4 | 65.0 | | 1 081.7 | 4 318.6 | | |
| Common breams | 371.9 | 4.4 | 140.8 | | 645.8 | 0.9 | 132.9 | | 625.1 | 2.6 | 377.0 | |
| Perches | 950.8 | 23.6 | 151.1 | | 743.2 | 5.3 | 133.6 | | 803.7 | 12.8 | 155.4 | |
| Roaches | 852.2 | 2.6 | 129.2 | | 711.4 | 3.0 | 152.0 | | 609.7 | 5.8 | 104.2 | |
| Pike perches | 157.1 | 25.5 | 117.5 | | 138.6 | 19.5 | 86.9 | | 82.3 | 8.2 | 258.3 | |
| Sea trouts | 2.6 | 29.6 | 90.3 | 1.1 | 2.7 | 18.3 | 117.8 | | 2.1 | 39.0 | 167.1 | |

| Species | 2014 | | | | 2015 | | | | 2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ICES 24 | ICES 25 | ICES 26 | Other regions[1] | ICES 24 | ICES 25 | ICES 26 | Other regions[1] | ICES 24 | ICES 25 | ICES 26 | Other regions[1] |
| Whitings | 4.1 | | | | 5.0 | 11.7 | | | 89.8 | 114.6 | | |
| European plaices | 22.4 | 59.2 | 6.6 | | 38.8 | 99.0 | 4.3 | | 51.5 | 102.5 | 3.2 | |
| Eels | 19.8 | 1.0 | 18.7 | | 15.0 | 0.8 | 25.8 | | 22.3 | 0.6 | 35.9 | |
| Turbots | 7.1 | 18.0 | 4.8 | | 6.8 | 18.6 | 8.4 | | 12.2 | 32.2 | 13.2 | |
| Sichels | | | 73.8 | | | | 61.0 | | | | 53.8 | |
| Garfish | 0.7 | 0.5 | 12.4 | | | 2.0 | 47.2 | | 0.1 | 0.2 | 46.3 | |
| Crucian carps | 0.7 | | 27.3 | | 1.2 | | 38.5 | | 1.9 | | 33.9 | |
| Common whitefish | 14.3 | 0.2 | 0.9 | | 27.2 | 0.2 | 0.7 | | 28.1 | 0.1 | 0.7 | |
| Atlantic salmons | 0.1 | 11.2 | 6.9 | | 0.1 | 10.7 | 11.7 | | 0.1 | 6.5 | 14.7 | |
| White breams | 16.3 | | 3.8 | | 34.3 | | 0.9 | | 6.3 | | 6.6 | |
| Pikes | 14.1 | | 2.1 | | 13.5 | | 0.6 | | 7.3 | | 1.0 | |
| Tenches | 7.6 | | 0.5 | | 6.8 | | 0.4 | | 6.8 | | 1.3 | |
| Burbots | 7.8 | | 0.9 | | 3.8 | | 1.8 | | 6.4 | | 0.9 | |
| Others | 171.2 | 1.2 | 11.9 | | 40.3 | 0.4 | 6.1 | | 31.0 | 0.2 | 3.9 | |
| Total: | 10 554.0 | 58 710.8 | 46 399.9 | 2 798.1 | 10 685.7 | 66 358.8 | 57 078.7 | 602.0 | 13 222.8 | 69 572.2 | 53 190.3 | 2 912.5 |

[1]Subareas ICES 27,28 i 29

An analysis of the Baltic Sea catches by main fishing areas showed that from 2013, the volume of catches in the ICES subarea 25 (the region of the central Baltic Sea coast) was gradually increasing) (Fig. 4.3.4). Since 2014, ICES subarea 25 became the main fishing area in the Baltic Sea with 49.5% of total catches. The share of ICES Subarea 26 (east coast) decreased to 39.2%. ICES 24 subarea (west coast) accounted for 8.9% of total catches, and 2.4% for other areas.

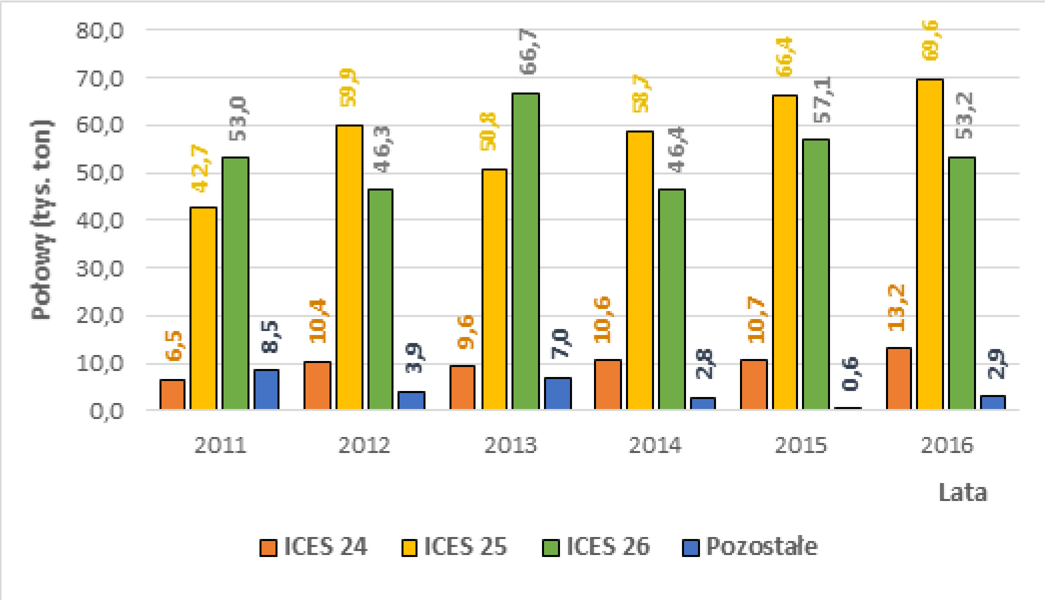



Fig. 4.3.4. Catches in the Baltic Sea in the years 2011-2016 by ICES subareas [in thous. tonnes]. Blue colour - other

In 2011-2016, the ICES 25 subarea was the main fishing area for cod, constituing from 53.7% and to 60.5% of the total catches of cod. The vast majority of herring also came from ICES subarea 25, from 51.4% in 2015 to 64.3% in 2011. Similarly, the majority of European flounder were caught in this subarea, from 68.5% in 2013 to 78,5% in 2014.

ICES subarea 26 was the main area for sprat exploitation, constituing from 49.1% in 2016 to 68.4% in 2011, of total catches of this species.

The catches in the Szczecin Lagoon and Vistula Lagoon increased within 2011-2014 up to 5132,1 tonnes (by 32.8%), and decreased in 2015 by 3.3% to 4960.4 tonnes and remains at this level in 2016. In 2011-2016 catches from Szczecin Lagoon changed from 1443,1 tonnes in 2015 to 2218.5 tonnes in 2012, and on the Vistula Lagoon from 2186.3 tonnes in 2011 to 3517.3 tonnes in 2015. The share of the Vistula Lagoon in total catch increased to 70% in 2015-2016. (Table 4.3.4, Fig. 4.3.5).

Analysis of the species structure of catches conducted in Szczecin Lagoon and the Vistula Lagoon showed domination of herring in the years 2011-2016, with a total of 12.9 thousand tonnes (Fig. 4.3.6; Table 4.3.4), mainly on the Vistula Lagoon (from 94% to 100% of the total catch in the lagoon). The herring catch varied from year to year and ranged from 1.8 thousand tonnes in 2011 to 2.5 thousand tonnes in the 2014-2015 period. In the case of bream in 2013-2016, there was a decreasing trend in catches to the level of 413.8 tonnes in 2016, (by 54.3%). On the other hand, in the case of common bream, an increase in catches of up to 804.8 tonnes was observed in 2016, i.e. by 59.7% compared to 2014. Catches of other species remained stable except for minor changes, including drop in European flounder catches and increased perch catch in 2014

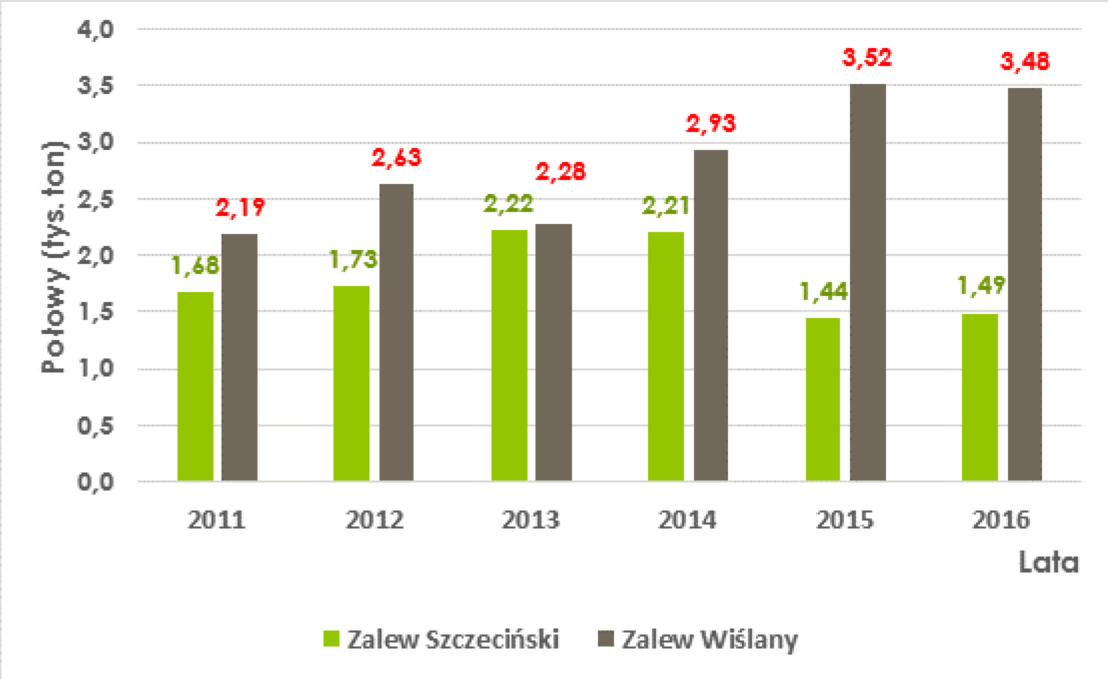



Fig. 4.3.5. Catches in Vistula Lagoon [gray] and Szczecin Lagoon [green] in the years 2011-2016 [in thous. tonnes].

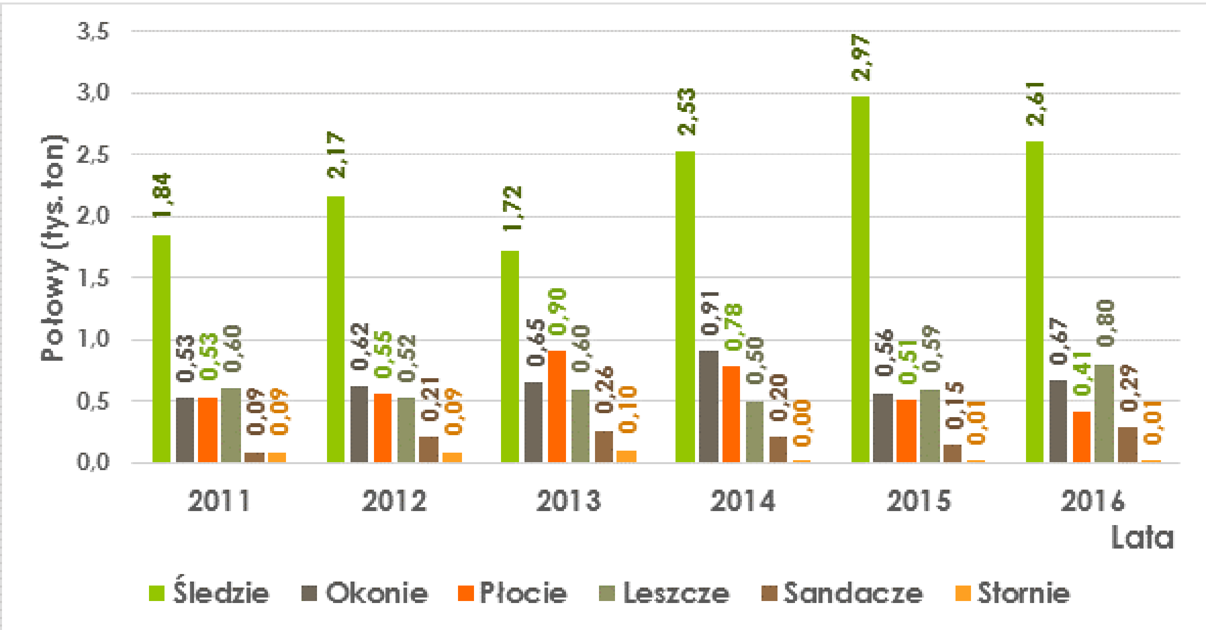



Fig. 4.3.6. Catches of selected fish species in Szczecin Lagoon and Vistula Lagoon in 2011-2016 [in thous. tonnes]. Colours: green – herring, black – perch, red – roach, grey – bream, brown – pike perch, orange- flounder.

The catch structure on the Vistula Lagoon and Szczecin Lagoon was different. On the Vistula Lagoon herring dominated, with the share in total catches up to 73% in 2016 and 84% in 2017, followed by bream and pike perch, which share increased to 10.3% and 7.1% respectively in 2016. Whereas in Szczecin Lagoon, mainly perch was tatrgeted, the share of which increased to 37.7% in 2016, then bream with the share in 2015-2016 amounting to 32.5% and 30.1%, respectively, and also the roach, with decreasing share in the catch structure to 21% in 2016.

Table 4.3.4. Catches in Szczecin Lagoon and the Vistula Lagoon by fish species in 2011-2016 [in tonnes]

| Species | 2011 | | | 2012 | | | 2013 | | | 2014 | | | 2015 | | | 2016 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Szczecin | Vistula | Total | Szczecin | Vistula | Total | Szczecin | Vistula | Total | Szczecin | Vistula | Total | Szczecin | Vistula | Total | Szczecin | Vistula | Total |
| Herrings | 25. 0 | 1818.6 | 1 843.6 | | 2170.0 | 2170.0 | 0.3 | 1720.5 | 1720.8 | 151.1 | 2375.1 | 2526.2 | 27.7 | 2944.2 | 2971.9 | 74.3 | 2532.3 | 2606.6 |
| perches | 466.6 | 58.5 | 525.1 | 571.4 | 48.6 | 620.0 | 570.0 | 81.0 | 651.0 | 800.9 | 108.4 | 909.3 | 456.9 | 105.1 | 562.0 | 560.0 | 106.6 | 666.6 |
| roaches | 462.4 | 72.0 | 534.3 | 463.4 | 90.5 | 554.0 | 807.0 | 97.6 | 904.6 | 654.4 | 120.9 | 775.3 | 372.7 | 135.6 | 508.3 | 314.1 | 99.7 | 413.8 |
| breams | 495.6 | 108.8 | 604.4 | 423.5 | 99.5 | 523.0 | 480.2 | 118.4 | 598.6 | 370.6 | 133.4 | 504.0 | 469.3 | 124.6 | 593.9 | 447.5 | 357.3 | 804.8 |
| zanders | 33.0 | 57.7 | 90.7 | 154.3 | 55.7 | 210.1 | 188.3 | 76.6 | 264.9 | 134.8 | 70.0 | 204.8 | 71.0 | 74.2 | 145.2 | 39.5 | 248.5 | 288.0 |
| European flounders | 70.5 | 18.1 | 88.6 | 0.7 | 91.9 | 92.6 | 0.1 | 102.7 | 102.8 | | 3.2 | 3.2 | | 14.0 | 14.0 | 0.3 | 12.7 | 13.0 |
| sichels | | 22.2 | 22.2 | | 28.7 | 28.7 | | 30.4 | 30.4 | | 67.2 | 67.2 | | 57.6 | 57.6 | | 53.6 | 53.6 |
| white breams | 34.3 | 7.3 | 41.7 | 26.0 | 3.9 | 29.9 | 45.9 | 7.5 | 53.4 | 16.0 | 4.2 | 20.2 | 11.1 | 0.9 | 12.0 | | 6.5 | 6.5 |
| Eels | 20.8 | 3.7 | 24.5 | 18.4 | 5.7 | 24.1 | 27.8 | 8.9 | 36.7 | 19.0 | 12.4 | 31.4 | 10.3 | 17.9 | 28.2 | 21.6 | 26.9 | 48.5 |
| crucian carps | 1.0 | 11.2 | 12.2 | 0.5 | 15.5 | 15.9 | 0.6 | 26.3 | 26.9 | | 26.3 | 26.3 | 0.3 | 37.5 | 37.8 | 0.5 | 33.4 | 33.9 |
| common whitefish | 14.5 | | 14.5 | 15.4 | | 15.4 | 33.1 | | 33.1 | 9.6 | | 9.6 | 11.8 | | 11.8 | 14.7 | | 14.7 |
| sea trouts | 8.9 | 3.4 | 12.3 | 9.2 | 7.9 | 17.1 | 4.1 | 2.1 | 6.2 | 1.6 | 1.3 | 2.9 | 1.0 | 5.1 | 6.1 | 0.9 | 0.6 | 1.5 |
| northern pikes | 11.2 | 0.5 | 11.7 | 11.4 | 0.2 | 11.6 | 15.5 | 0.8 | 16.3 | 15.5 | 0.3 | 15.8 | 4.5 | 0.1 | 4.6 | 3.3 | 0.8 | 4.1 |
| burbots | 9.6 | 1.2 | 10.8 | 10.5 | 2.5 | 13.0 | 9.3 | 3.1 | 12.4 | 7.8 | 0.8 | 8.6 | 2.9 | | 2.9 | 4.6 | 0.9 | 5.5 |
| tench | 9.6 | 0.8 | 10.3 | 5.6 | 0.9 | 6.5 | 10.6 | 0.4 | 11.0 | 8.6 | 0.3 | 8.9 | 1.0 | 0.4 | 1.4 | 1.1 | 1.3 | 2.4 |
| asps | 2.3 | | 2.3 | 2.2 | | 2.2 | 3.9 | | 3.9 | 3.7 | | 3.7 | 2.7 | | 2.7 | 2.8 | | 2.8 |
| wels catfishs | 2.1 | | 2.1 | 2.7 | | 2.7 | 3.7 | | 3.7 | 2.1 | | 2.1 | | | | | | |
| smelts | | 0.3 | 0.3 | | 6.9 | 6.9 | | 0.5 | 0.5 | | 1.9 | 1.9 | | | | | 0.9 | 0.9 |
| turbots | 2.2 | | 2.2 | | 0.6 | 0.6 | | | | | | | | | | | | |
| common carps | 0.2 | 0.8 | 1.0 | 0.1 | 0.1 | 0.2 | 0.1 | 0.9 | 1.0 | | | | | | | | | |
| Eurasian ruffe | 0.2 | 0.2 | 0.4 | 0.2 | 1.0 | 1.2 | 0.2 | | 0.2 | | | | | | | | | |
| Atlantic salmon | 0.2 | 0.1 | 0.3 | | 0.1 | 0.1 | | 0.1 | 0.1 | | | | | | | | | |
| Others | 6.8 | 1.1 | 7.9 | 11.8 | 1.1 | 12.8 | 17.8 | 0.5 | 18.3 | 9.7 | 1.0 | 10.7 | | | | | | |
| Total: | 1677.0 | 2186.3 | 3863.4 | 1727.3 | 2631.3 | 4358.6 | 2218.5 | 2278.3 | 4496.8 | 2205.4 | 2926.7 | 5132.1 | 1443.1 | 3517.3 | 4960.4 | 1485.1 | 3482.0 | 4967.1 |

## Exploitation of Cod

The management of the Baltic Sea fish stocks, including cod stocks (a stock from 22-24 subbasins, i.e. the Western Baltic Sea and a stock from 25-32 subbasins, i.e. the Eastern Baltic Sea) is regulated by the so-called Multiannual Management Plan for the stocks of cod, herring and sprat in the Baltic Sea (the so-called Baltic MAP) (Regulation (EU) 2016/1139 of the European Parliament and of the Council of 6 July 2016 establishing a multiannual plan for the stocks of cod, herring and sprat in the Baltic Sea and the fisheries exploiting those stocks, amending Council Regulation (EC) No 2187/2005 and repealing Council Regulation (EC) No 1098/2007 (O.J. EU L 191 of 15.07.2016, page 1, with later amendments). Cod is a species which catch is limited, and the current control (Fisheries Monitoring Center in Gdynia) is subject to the use of the fishing quota allocated to Polish fisheries. If it is depleted, a total ban on fishing is introduced. The multiannual plan requires EU Member States to designate ports where cod landings are permitted. If the catch exceeds 750 kg, then unloading is only possible in ports designated for this purpose. However, if you have cod on a fishing vessel in the amount of 300 kg and more, you should report this fact to the inspection before calling the vessel to the port. In addition to the regulations regarding the strategy for determining the size of TAC, an important element of the Multiannual Plan's operation are various forms of limiting the fishing effort targetted at cod.

Up to 2016, EU fishing prohibition periods were in force during the period from 1 to 30 April and from 1 July to 31 August respectively in subareas 22-24 and 25-28 respectively, which corresponded approximately to the peaks of the cod stock spawning period west and east. The multiannual management plan does not contain provisions on protection periods, therefore, after its entry into force, these measures have ceased to apply to fishermen of the Baltic Sea region. However, Poland is aware of the poor condition of eastern cod stock under the Regulation of the Minister of Maritime Economy and Inland Navigation of 16 September 2016 on the dimensions and protective periods of marine organisms and detailed conditions for commercial fishing (Journal of Laws, item 1494, with later amendments) introduced protection periods for cod in periods from 15 February to 31 March in subareas 22-24 and from 1 July to 31 August in subareas 25-32. According to the Multiannual Plan, three permanent areas have been designated, within which during the period from May 1 to October 31 it is prohibited to fish with all active gears. These areas were designated to protect the spawning grounds of cod.

As technical measures for the conservation of cod stocks, 120 mm mesh size opening for top window codend BACOMA and T90 trawls are allowed for catches (Council Regulation (WE) No 1226/2009 of 20 November 2009 determining the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks applicable in the Baltic Sea in 2010 (O.J. EU L 330, 16/12/2009, page 1, as amended) The mesh size has been valid since 1 January 2010 for cod caught in subareas 22-24 and in subareas 25-32 from 1 March 2010. In the group of passive fishing gears fixed nets are used (dimension 110 mm mesh) and hooks (unregulated size) Effective since 1 January 2015, the protective dimension for cod is 35 cm across the Baltic Sea (Commission Delegated Regulation (EU) No 1396/2014 of 20 October 2014 establishing a plan in the field of discards in the Baltic Sea (O.J. EU L 370 of 30/12/2014, page 40); Regulation of the Minister of Agriculture and Rural Development of 6 July 2015 on the dimensions and protective periods of marine organisms caught in recreational fishing and detailed methods and conditions for recreational fishing (Journal of Laws of 2018 item 24, as amended). Pursuant to the regulation of the Minister of Agriculture and Rural Development of 6 July 2015, from 1 January 2015, the ban on discards of Baltic cod began to apply, which entails the necessity of bringing undersized cod (BMS - below minimum size) to the port (landing obligation) and their unloading. However, pursuant to Article 15 of Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013, on the Common Fisheries Policy, the discarding of Baltic cod has been in force since 1 January 2015, with the need to import all cod catches, including undersized fish (BMS - below minimum size) into the port (landing obligation) and their unloading and deduction from available fishing quotas. It should be noted, however, that the entry into force of the landing obligation was not preceded by the EC work on the appropriate amendment of the provisions on technical measures for fishing in the Baltic Sea and ensuring that fishing ports and fishing units are properly adapted to the landing obligation (from EFMiR). This caused that in the Baltic Sea region all countries had problems with the proper implementation of the landing obligation, which translated into low reporting of fish below the protection dimension. It can therefore be concluded that the landing obligation did not affect the exploitation of cod in the first 2 years of the landing obligation.

Catches of Baltic cods in Poland increased in the years 2011-2012 to 148,24 tonnes, then decreased to 11,879 tonnes in 2014. In 2015, they increased to 13636 tonnes, and in 2016 they again decreased to the lowest value (10,377 tonnes) in the 2011-2016 period (Table 4.3.5). In general, however, in the years 2011-2016 the decreasing trend of Baltic cod catches dominated. The main reason for the decline in cod catches is the poor condition of cod (decreasing body mass), which caused a reduction in the price of the first sale of this fish species. As a result, the available cod limit is also used only in 50-60%. In addition, a comparison of the results of vessels specializing in cod fisheries clearly shows a deterioration in the fishing efficiency of this species in 2011-2014. The most important gears used for cod fishing are bottom trawls and nets. The share of trawling in the years 2011-2015 has been systematically growing in the range from 57% to 72.5%, and in 2016 it slightly decreased to 71.6%. The share of net fishing, accounting for nearly 50% in the first half of the 1990s, is decreasing year by year. The same trend continued in 2011-2015 (down from 31% to 23.9%), and only in 2016 they increased to 24.7%. Also demersal longlines are used for cod fishing. In 2000-2006, a steady increase in the share of cod hook fishing was observed (up to 18.4%). The increase in this catch was mainly at the expense of reducing the size of net catches. However, in the described period 2011-2016 there was a systematic decrease in the share of this labor-intensive fishing tool, from 9.9% to just 2.9%.

Catches of Baltic cods in Poland come mainly from the Eastern Baltic Sea stock, mainly in ICES subareas 25-26. The share of cod catches from these subareas in 2011-2016 ranged from 92.8% in 2014 to 95.9% in 2011. Other cod catches take place in 24 ICES subareas, where the stock of Western Baltic cod mainly exists.

Table 4.3.5. Catches of Baltic cod in Poland in 2011-2016 (in tonnes).

| Year | 2011 | | | 2012 | | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ICES subarea | | | | | | | | | |
| Fishing gear | 24 | 25 | 26 | 24 | 25 | 26 | 24 | 25 | 26 | |
| demersal longlines | 19.5 | 819.0 | 335.8 | 29.4 | 478.7 | 245.9 | 18.1 | 393.6 | 40.2 | |
| pelagic longlines | | | | | | | | | | |
| set-nets | 228.5 | 2 660.4 | 806.3 | 402.8 | 3 073.3 | 903.7 | 369.1 | 2 351.5 | 748.0 | |
| demersal trawl | 237.6 | 2 989.8 | 3 557.0 | 384.6 | 4 979.4 | 4 213.3 | 332.0 | 4 162.2 | 4 091.4 | |
| pelagic trawl | 1.2 | 166.0 | 14.2 | 0.8 | 98.9 | 13.4 | 0.0 | 7.7 | 109.3 | |
| Total | 486.8 | 6 635.2 | 4 713.4 | 817.7 | 8 630.3 | 5 376.2 | 719.1 | 6 915.1 | 4 989.0 | |
| Year | 2014 | | | 2015 | | | 2016 | | | |
| | ICES subarea | | | | | | | | | |
| Fishing gear | 24 | 25 | 26 | 24 | 25 | 26 | 24 | 25 | 26 | 28 |
| demersal longlines | 33.0 | 382.3 | 90.4 | 12.7 | 338.2 | 66.1 | 4.9 | 275.4 | 26.0 | |
| pelagic longlines | 0.3 | 0.2 | | | 3.8 | 0.0 | | 15.5 | | |
| set-nets | 368.8 | 2 272.9 | 625.5 | 310.2 | 2 567.3 | 381.4 | 222.7 | 2 134.1 | 211.0 | |
| demersal trawl | 449.6 | 4 607.2 | 3 026.8 | 432.1 | 5 163.1 | 4 290.7 | 456.4 | 3 115.1 | 3 859.8 | |
| pelagic trawl | 0.1 | 17.5 | 4.4 | 0.2 | 37.0 | 33.6 | 2.1 | 29.2 | 22.7 | 2.3 |
| Total | 851.8 | 7 280.0 | 3 747.1 | 755.2 | 8 109.4 | 4 771.8 | 686.0 | 5 569.3 | 4 119.4 | 2.3 |

| Fishing gear | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| demersal longlines | 1 174.3 | 754.0 | 451.9 | 505.7 | 417.0 | 306.2 |
| pelagic longlines | | | | 0.5 | 3.8 | 15.5 |
| set-nets | 3 695.2 | 4 379.8 | 3 468.6 | 3 267.2 | 3 258.8 | 2 567.7 |
| demersal trawl | 6 784.4 | 9 577.2 | 8 585.5 | 8 083.6 | 9 885.9 | 7 431.3 |
| pelagic trawl | 181.4 | 113.1 | 117.0 | 22.0 | 70.8 | 56.2 |
| Total | 11 835.4 | 14 824.2 | 12 623.1 | 11 879.0 | 13 636.4 | 10 377.0 |

The highest cod catches are obtained in ICES subarea 25, from where in 2011-2016 more than half (from 53.6% to 61.3% share) of Polish catch came from. Higher catches in this ICES subarea result mainly from the creation of efficient pre-spawning and spawning concentrations in the Bornholm Basin region. The Bornholm Deep Region is the only effective spawning ground for Eastern Baltic cod in the Eastern Baltic. The share of cod catches from ICES Subarea 26 did not exceed 40% in 2011-2016, and the share of ICES Subarea 24 was small and ranged from 4.1% to a maximum of 7.2%.

Due to serious difficulties in determining the age of cod and significant, difficult to quantify, changes in biological parameters of the stock, ICES did not deliver an approved, analytical assessment of eastern Baltic cod stocks. However, the stock status and dynamics of the stock as well as the size of the fishing mortality can be roughly determined on the basis of research results (Fig. 4.3.7). They indicate a strongly declining trend of the stock biomass and a relatively small increase in the fishing mortality rate in 2011-2017.

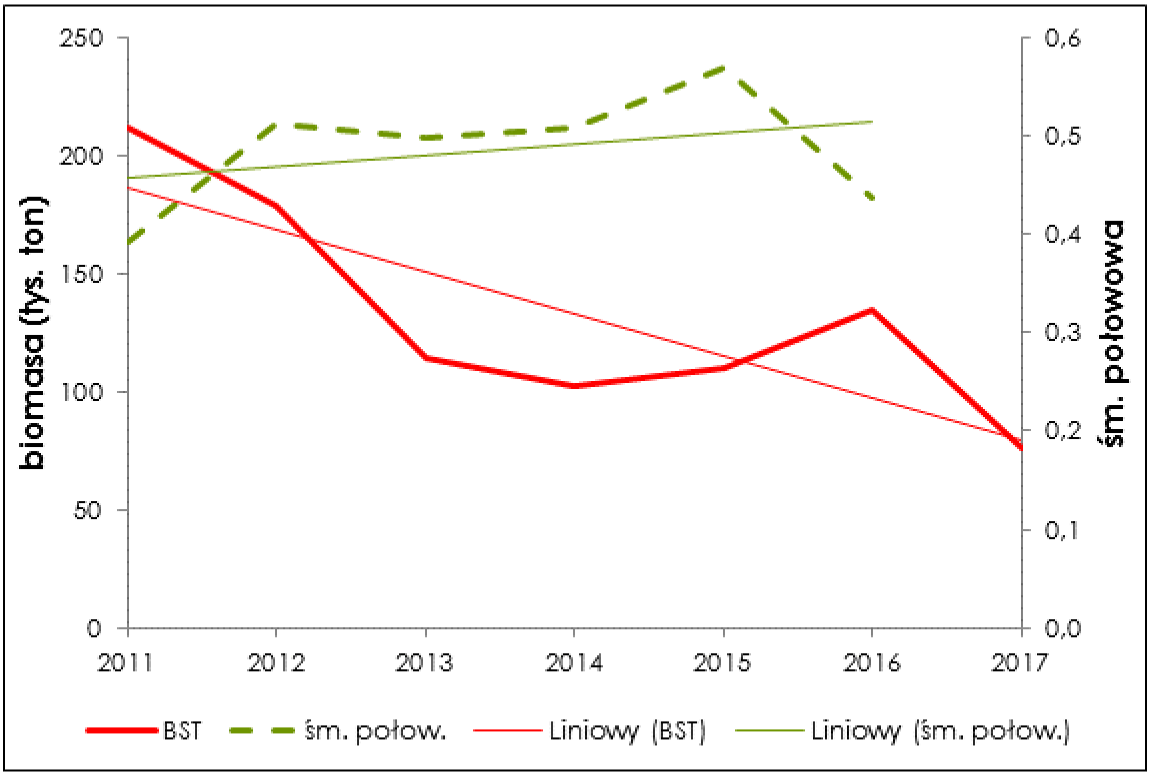



Fig. 4.3.7. Indicators of biomass size and fishing mortality of the Eastern Baltic cod in 2011-2017.

Cods from ICES subareas 25-26 belong to one stock of eastern Baltic cods characterized by the same biological parameters and growth rates, and in the ICES subarea 24 there are both western Baltic cod (different from the Eastern Baltic stock in terms of biological parameters) and eastern Baltic cods. Thus, in this study, the results of biological analyzes were presented jointly for subareas 25-26 and separately for cod from ICES subarea 24. The presentation of research results includes the division into fishing gears, which mainly due to their different selective properties catch cods differing in terms of length, weight and by-catch of undersized specimens.

The curves of the length distribution of cod in catches in Fig. 4.3.8 clearly show that in the subsequent years 2011-2016 increasingly smaller specimens were collected. This trend was found mainly for trawles of the Eastern Baltic cod stock (ICES subareas 25-26) but also of the West Baltic cod stock (24 ICES subareas). The average length of cod in trawls in ICES subareas 25-26 decreased in 2011-2015 by 4.6 cm (from 42.9 cm 38.3 cm). A slight increase in the average length was recorded in 2016 (up to 39.8 cm). In trawls, in the 24 ICES subarea, in 2011-2016, there was an uninterrupted and even greater drop in the average length of cod than in ICES subareas 25-26, by 5.6 cm (from 42.1 cm to 36.5 cm). A corresponding, strongly accentuated trend of changes in the length of cod was observed for longline fishing in ICES subareas 25-26. The average length of cod was decreasing throughout the 2011-2016 period (from 44.1 cm to 39.2 cm). On the other hand, as regards net fishing, there were no similar large changes in the length of cod although they also occurred, but to a lesser extent. The average length of cod caught in ICES subareas 25-26 in 2011-2016 decreased by 1.9 cm (from 44.2 cm to 42.3 cm). However, in net fishing in the 24 ICES subarea, the average length of cod remained at a similar level in 2011-2016, oscillating around the value of 44 cm and no significant changes in the value of this parameter were found. The above-mentioned changes in cod length in catches result mainly from the selectivity of exploitation method, which results mainly in catch of larger individuals. A less noticeable decreasing trend in changes in the average length of cod caught in net is mainly due to the more favorable selective properties of this fishing gear. This is also evidenced by the average length of cod, which in the case of trawls is 2-3 cm lower than for nets. In addition, in the case of nets, by-catch of flatfish, which often co-exist in cod catches, has a slight effect on reducing selective properties of fishing gear, and by-catch of flatfish in trawls at certain periods is very important since it causes closing of mesh of trawl bags. In Fig. 4.3.8 the distribution of the length of cod from ICES subarea 24 caught with longlines is not presented due to the small catches from this tool and the resulting difficulties in obtaining research samples.

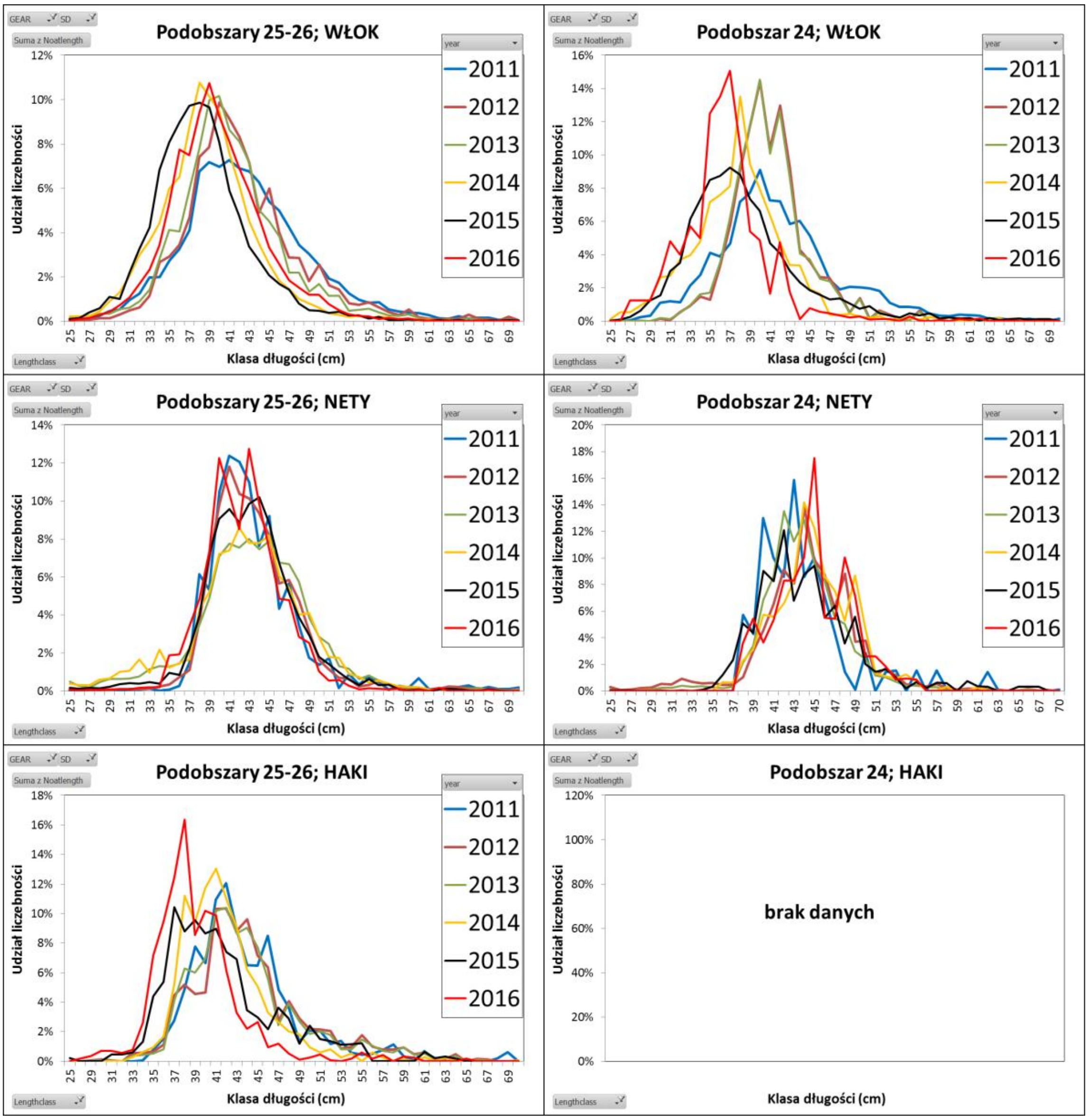



Fig. 4.3.8. Length distributions of Baltic cods caught with trawls, nets and longlines in 2011-2016.

In catches of Baltic cod in Poland with trawls, nets and longlines in ICES subareas 25-26 in years 2011-2014, the 3-year-old fish clearly dominated (

Fig. 4.3.9). The share of this age group ranged from 38.6% to 57% in the abundance. The share of 5 year old and older cods in trawles decreased slightly (from 10% to 7%) in 2011-2014. In contrast, in net and longline fishing the share of these age groups in 2011-2014 systematically increased (from 5% to 13% and from 11% to 15% respectively). In the years 2015-2016, in all fishing gear the dominance of the 4th age groups in catches was recorded, while in the case of trawling and net fishing, the share of cod of older age groups (5 and more) was higher. In trawling and net fishing, this share increased from 17% to 35% and from 20% to 34% respectively. The above changes in the age structure of the exploited stock are the result of changes in recruitment and decline in the cod growth rate recorded in the catch of all countries and observed in cod since about 2010. Cods of the same length caught in recent years are characterized by a higher age (are older) than it was observed before 2010. The decrease in the growth rate results mainly from the increased density of the stock in a small area and the occurrence of the intra-species phenomenon of competition for food. A similar phenomenon, but to a lesser extent, is also observed in the case of cod from the ICES subarea 24 (Fig. 4.3.10).

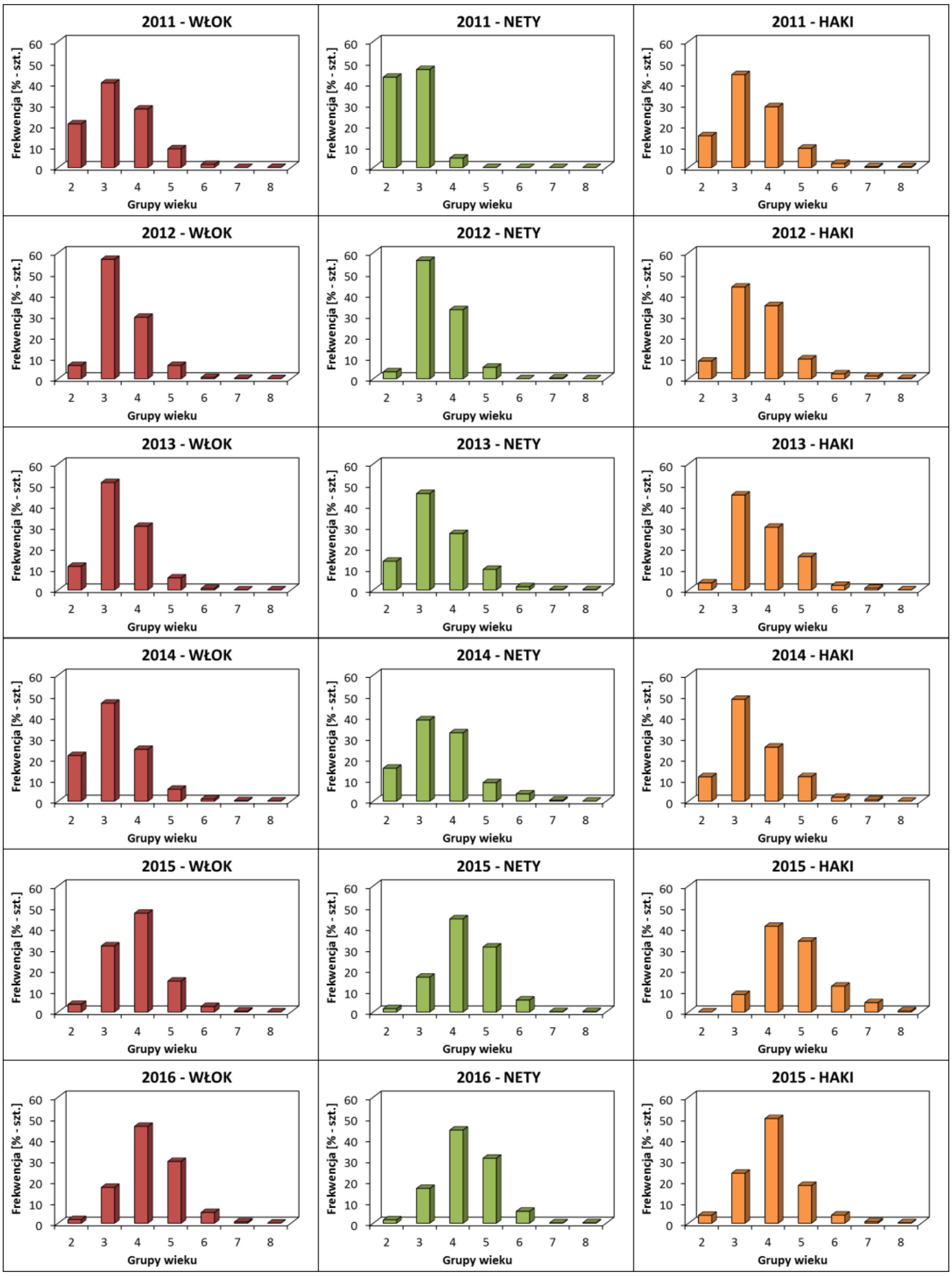



Fig. 4.3.9. Age distribution of Baltic cods caught with trawls, nets and longlines in ICES 25-26 subareas in 2011-2016.

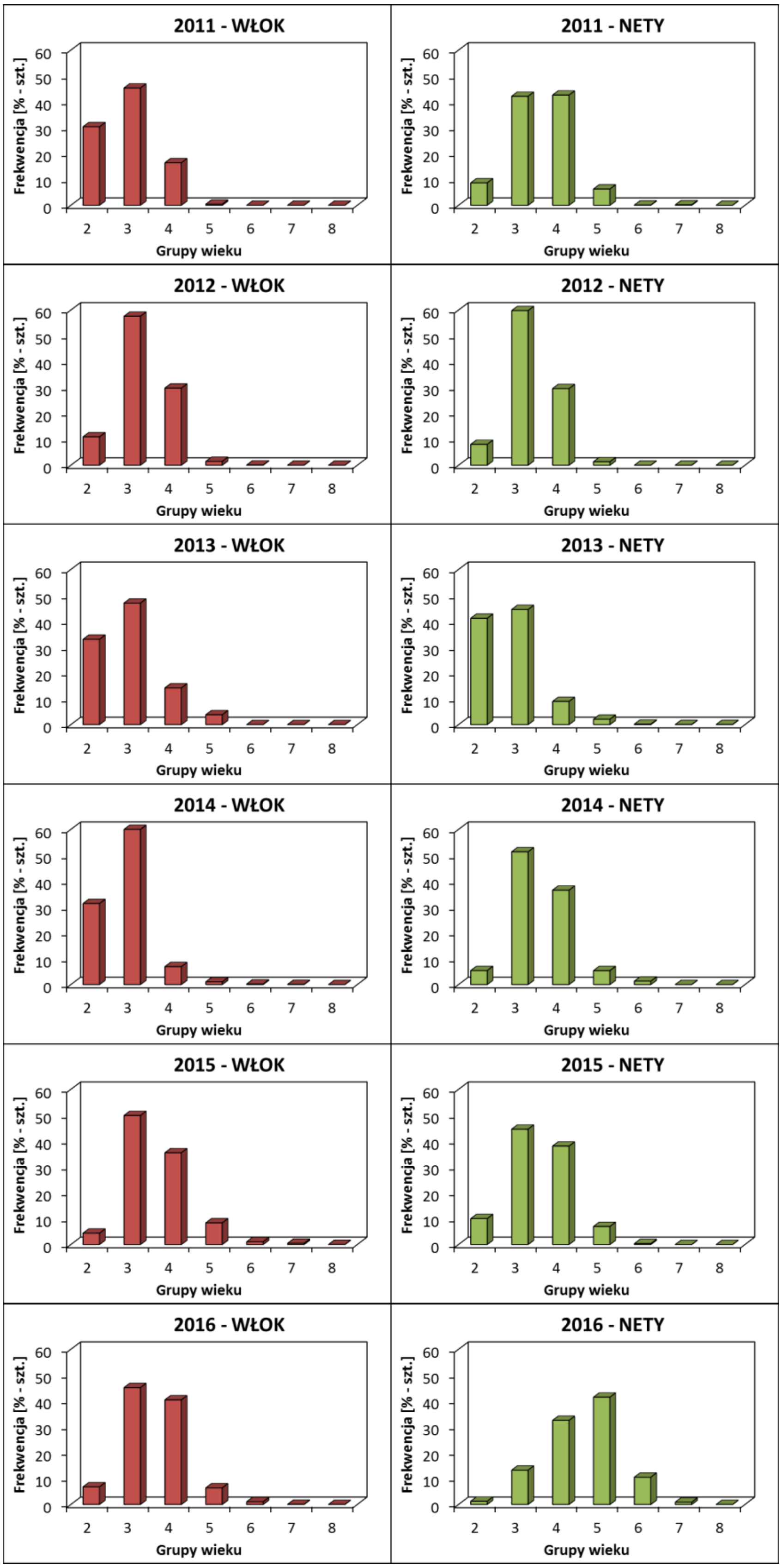



Fig. 4.3.10. Age distribution of Baltic cods caught with trawls and nets in ICES 24 subarea in 2011-2016.

However, changes in the growth rate of the Baltic cod are clearly visible on the basis of trends in average length of cod in age groups (Fig. 4.3.11). The decrease in the value of this parameter is evident in the catches of cod from all fishing gears and in analyzed subareas. The average length of cod in catches was systematically decreasing in 2011-2014, and the biggest differences compared to 2011 were recorded in 2014-2015. The biggest differences concern the average length in trawl and longline fishing. The average length of cod in trawls in ICES subareas 25-26 in 2016 for age groups 2 to 6 was lower from 6 to 18 cm in comparison with 2011, with the highest differences observed in older age groups. In the same ranking, in trawl catch in 24 subarea, these differences ranged from 4 cm to 16 cm. In longline fishing in ICES subareas 25-26, the average length of cod in age groups was in 2016 from 5 cm to 14 cm lower than in 2011. In contrast, in net fishing in ICES subareas 25-26, the average length of cod in 2016 was lower by 2 cm to 15 cm than compared to 2012 (data for 2011 do not include all age groups, hence the comparison was made in 2012)

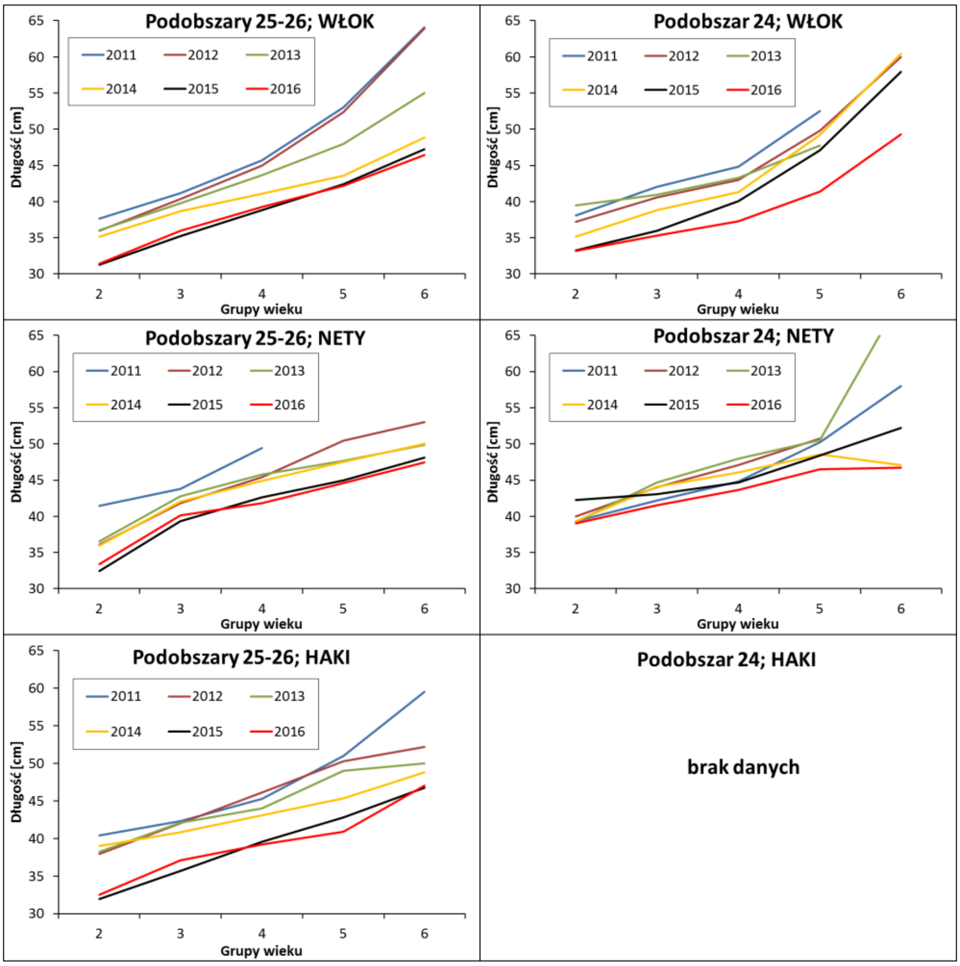



Fig. 4.3.11. The average length of Baltic cod in the age groups in 2011-2016 caught with trawls, nets and longlines.

Another important parameter characterizing the biological condition of Baltic cod is the average weight of cod in age groups. Changes in the value of this parameter in 2011-2016 are illustrated in Fig. 4.3.12. Similarly as in the case of changes in mean length in age groups, also in the case of average biomass, there was a systematic decrease in subsequent years. The lowest values of this parameter were recorded in 2015-2016. The biggest differences in average biomass cods occurred in the case of trawls and longlines. In trawls in ICES subareas 25-26 and ICES subarea 24, the average weight in 2016 was 200-600 grams lower, depending on the age group, compared to 2011. The largest differences concerned the oldest age groups. However, in the case of longline fishing in ICES subareas 25-26, the average weight in 2016 was lower by 280-1100 g than in 2011. The lowest decrease in the average weight in age groups was found in the case of net fishing. The average cod biomass in ICES subareas 25-26 in 2016 compared to 2011 was lower by 190-380 g (only age groups 2-4 were compared, since older fish did not occur in reasearch catches). Differences between the average biomass of cod in subareas in 25-26 in 2016 and in 2011 ranged from 150 to 1100 g. Decrease in average cod biomass observed in 2011- 2016 is an additional argument allowing to justify the low use of the cod fishing limit and low purchase prices for this species, as discussed in this report in the part concerning the Baltic cod catches. The decrease of cod biomass associated with the phenomenon of intra-species competition reduces the interest of fisheries in the catches of this species of fish.

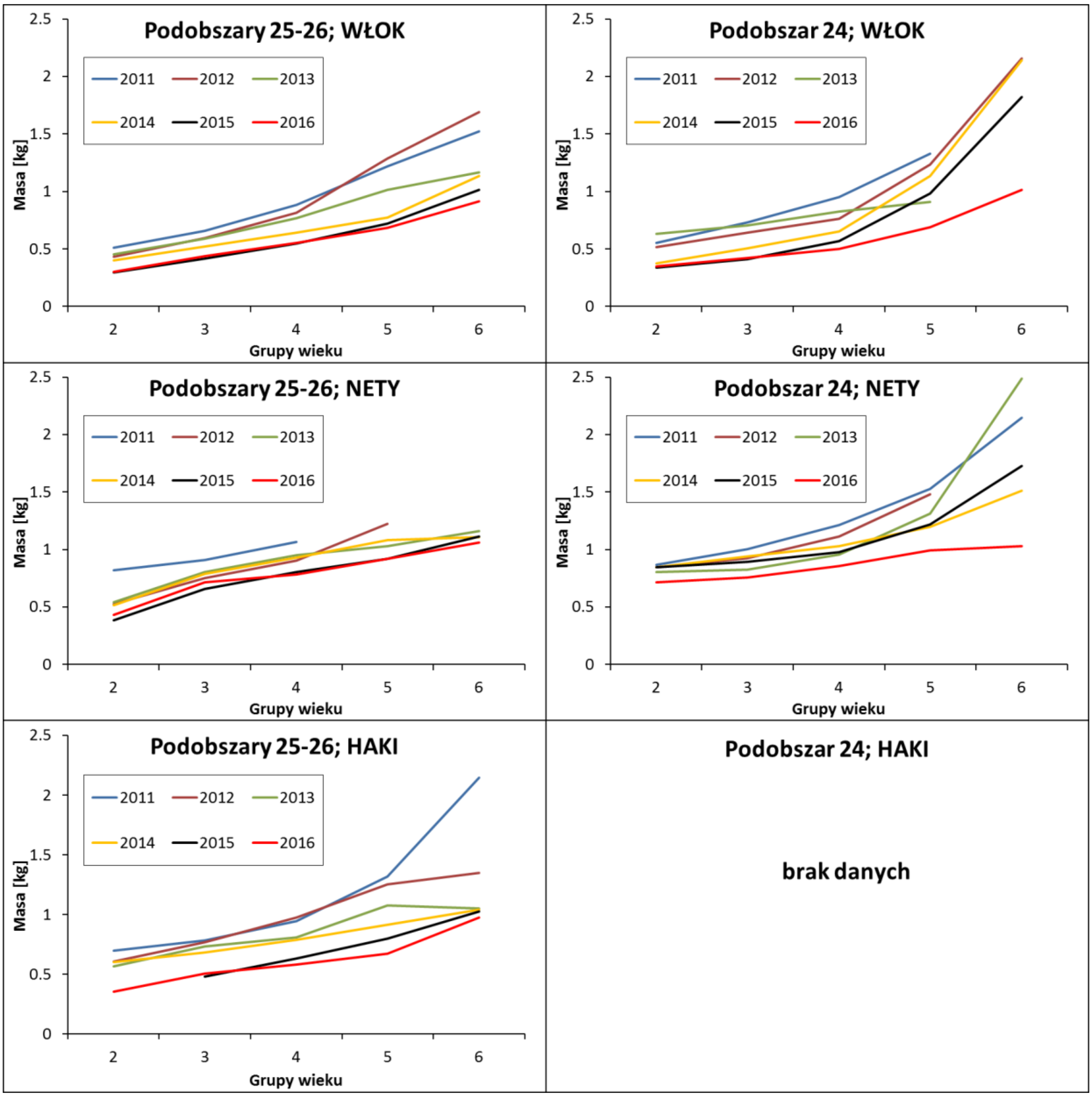



Fig. 4.3.12. The average biomass of Baltic cod in the age groups in 2011-2016 caught with trawls, nets and longlines.

Analyzing the curves of weight changes of Baltic cod in length classes originating from trawling, nets and longline samples, it was found that the highest mass values were obtained in net fishing (Fig. 4.3.13). Lower masses were obtained in the case of longlines and by far the lowest in trawling. The cod masses in individual length classes were in trawls in 2016 by 61.3-128 g (4.4% to 23.1%) lower than in fishing nets. The above test results indicate more favorable selective properties that are characteristic of nets. This is confirmed by the fact that in catches in the same length class, cods with a larger mass are retained than in the longlines and trawls (Fig. 4.3.13).

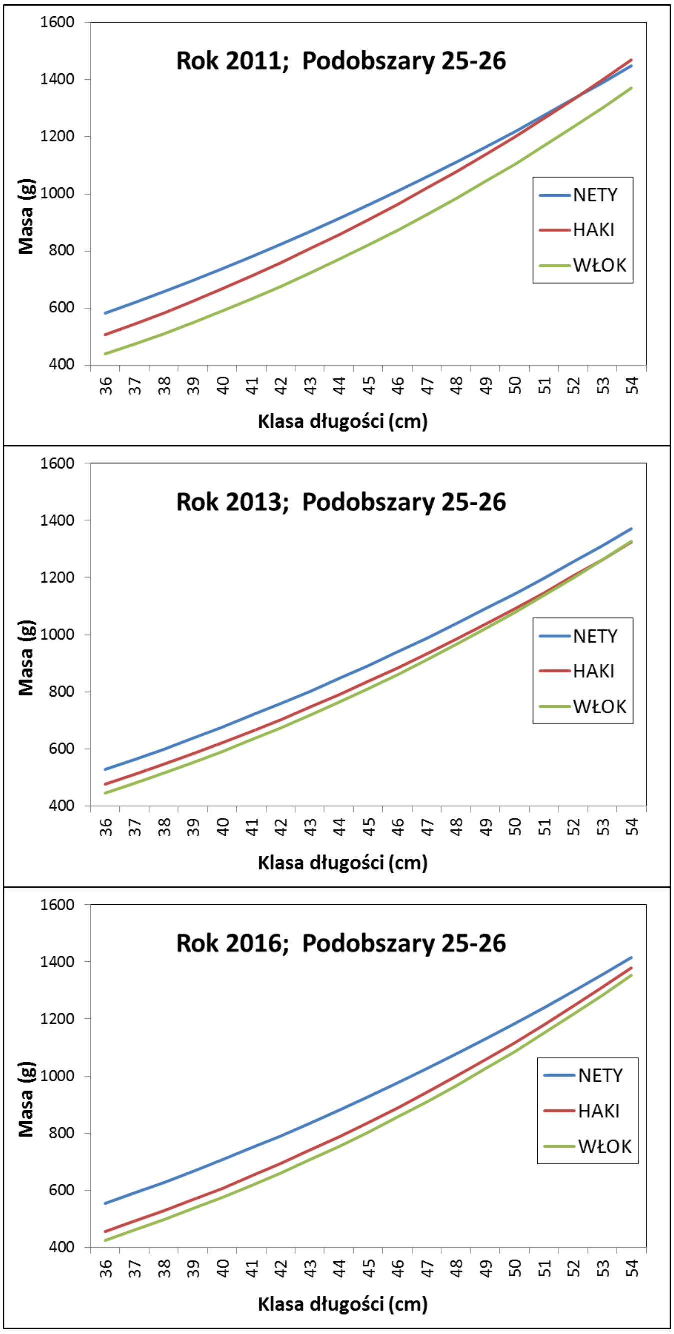



Fig. 4.3.13. The curves of changes in the biomass o Baltic cod in length classes in 2011, 2013 and 2016 caught with trawls, nets and longlines.

When analyzing the share of undersized cod in catches, one should bear in mind that the protective dimension in the period 2011-2016 has changed. In the years 2011-2014 this dimension was 38 cm, and from 2015 it was reduced to 35 cm. Therefore, the share of undersized cods in this study was analyzed as two separate dataseries for two different periods of the protective dimension. Irrespective of the ICES subarea and the year of research, a clearly lower share of by-catch of undersized cod in the net fishery was found. This share in the ICES subarea 26 fluctuated in the years 2011-2014 from 2.3% to 9.5% (Fig. 4.3.14). However, in the years 2015-2016, the share of undersized cod in net fishing was very low (about 1%), which was significantly contributed to the reduction of the protective dimension. The share of undersized cod in ICES subarea 26 in trawls in the years 2011-2014 was much higher than the catch in nets and ranged from 17.8% to 44.6%. Similarly as in net fishing, in the trawls in 2015-2016, the share of undersized cods decreased (to approx. 10%). In the ICES subarea 25, in 2011-2014, a increasing share of undersized cods was observed, both in terms of trawling and net fishing (respectively, from 15% to 36% and from 3% to 16%). In 2015-2016, this share was significantly lower in both fishing gears. In general, the higher share of undersized cod in ICES subarea 25 than in ICES subarea 26 results from the existence of smaller cod in 25 ICES subarea (where there is an effective spawning ground for cod and after spawning of young cod grow in the shallower waters zone of this subarea) and coexistence of flounder in cod catch especially during spawning of flounder in the area of the Bornholm Deep, which reduces the selectivity, mainly trawls. In the 24 ICES subarea, the share of by-catch of undersized cod increased in the years 2011-2014 from 22% to 44%. In 2015, it decreased to 23%. The share of by-catch of undersized cod in net catches in 24 ICES subarea remained at a similar level, oscillating around 6%.

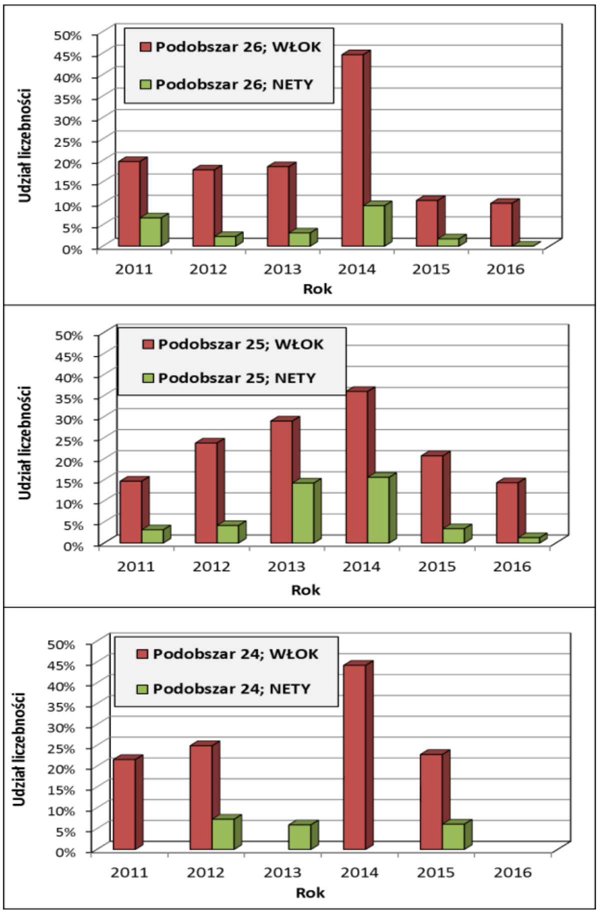
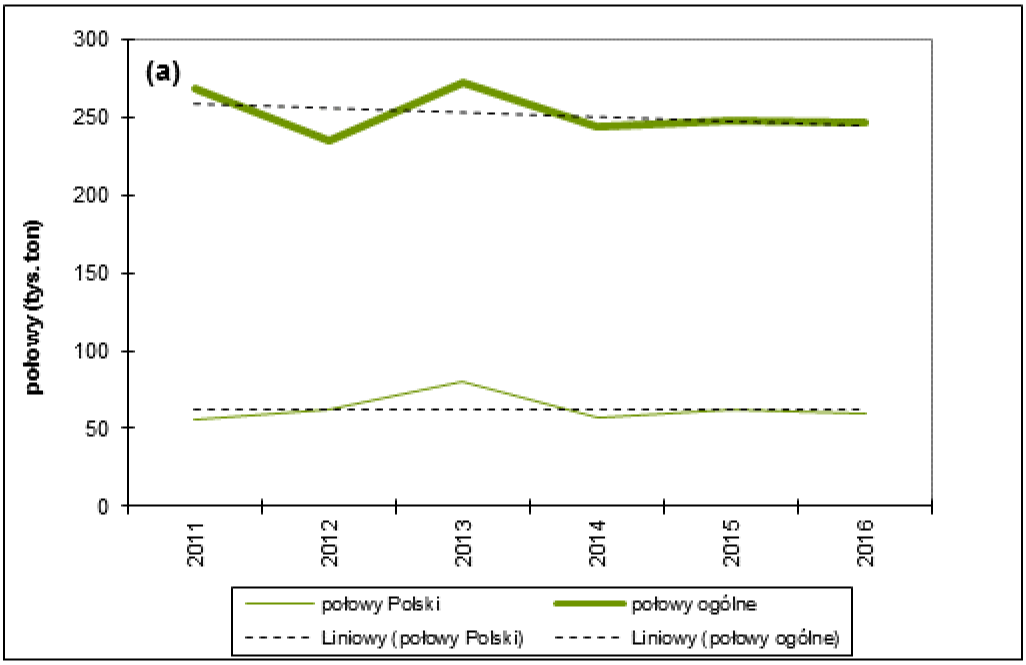



Fig. 4.3.14. The share of undersized Baltic cod in the years 2011-2016 caught by trawls and nets (*the minimum landing size for cod by 2014 was 38 cm, and from 2015 this dimension is 35 cm*).

### Exploitation of European sprat

Baltic Sprat *Sprattus sprattus balticus* (Schneider, 1904) is a subspecies of European sprat *Sprattus sprattus* (Linnaeus, 1758), which is considered to be a group of small fish commonly found, usually in large shoals, in moderately warm, pelagic sea waters. It inhabits the waters from the southern Kattegat and the Danish Straits to the eastern part of the Gulf of Finland. Determinants limiting the spread of sprats in the Baltic Sea are the salinity of the upper water layers in the spawning period - the minimum required is 6 PSU and the limit water temperature at wintering grounds is 1.5°C. Adult sprats are found mainly in the open sea, where they are reproducingx, foraging and wintering. Groupings of young sprats usually occur together with young herrings, most often in the coastal fisheries of the southern Baltic, in brackish waters, near the estuaries of large rivers. In these areas, young herring fish find shelter and feeding grounds. Areas and depth zones preferred by sprat determine the location of fishing cutters specialized in their catches.In the years 2011-2016 Poland with landing of sprats (without by-catch of herring) fluctuating from 55.3 to 79.7 thousand tonnes dominated among the Baltic States in the exploitation of this species (Fig.

4.3.15a and Fig. 4.3.16). In the aforementioned years of international landings of sprats fluctuated in the range of 230.89-272,39 thousand tonnes, and Poland's share in these catches changed from 21 to 29% (Fig. 4.3.16). In 2011-2016, the value of annual Polish sprat landings ranged from 44.2 to 93.1 million PLN. In 2016, the Polish fleet caught 60.1 thousand tonnes of this fish (with by-catches of herring) worth PLN 56.4 million, which in comparison to 2015 means a decrease by 6% in terms of weight and an increase of 3% in relation to the value determined by the purchase price of the raw material. In 2011-2016, sprats dominated in terms of mass in Polish fish landings from the Baltic Sea; their share fluctuated from 43.3% (in 2016) to 60.4% (in 2013). On the other hand, the share of sprats in the value of total Polish commercial fish landings, due to the relatively low purchase price compared to, for example, Baltic cod, salmonid or herring was smaller than the share of mass and changed from 24.1% (2011) to 39, 0% (2013). The sprat spawning biomass of the Baltic sprat (ICES subareas 22-32) in the period 2011-2015 fluctuated around 800,000 tonnes (Fig. 4.3.15b), and in 2016-2017 it increased to 1,200-1300,000 tonnes, as a result of supplying the stock with a very large generation from 2014. Against the background of these resource changes, Polish and international landings (in 2014-2016) of sprats were quite stable. The pressure of international fishing on sprat resources in the Baltic Sea, expressed by the fishing mortality rate at age 3-5 (F (3-5)), decreased in 2013-2016 from 0.39 to 0.22, i.e. by 43% (Fig. 4.3.15). In the previous three years, the average annual value of this indicator fluctuated to a relatively small extent, i.e. from 0.32 to 0,34.



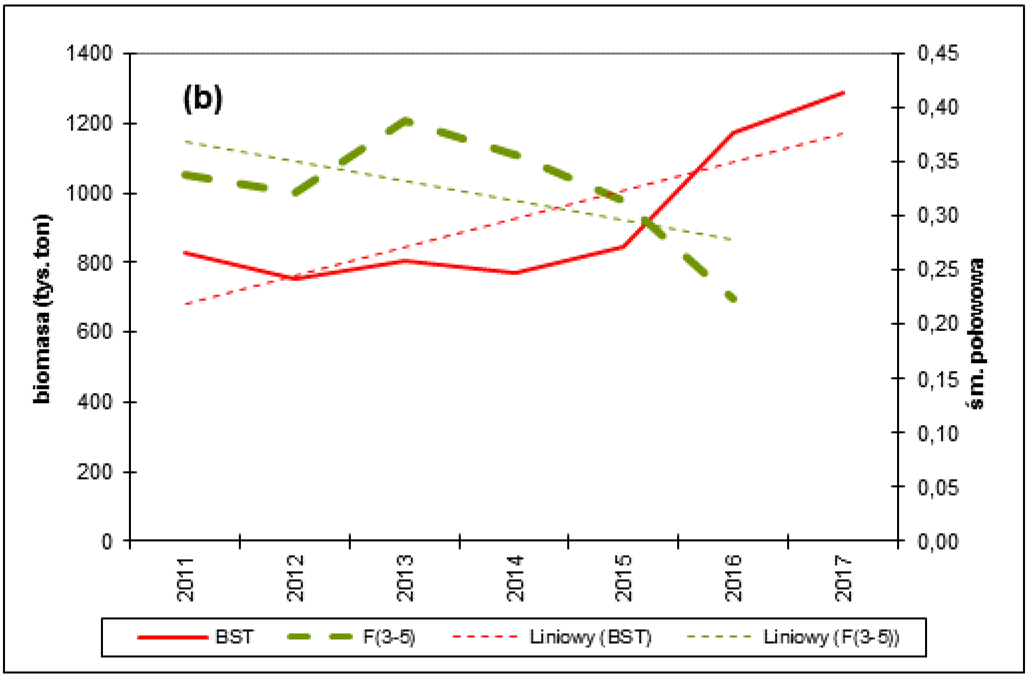



Fig. 4.3.15 (a) International and Polish landings of Baltic sprat and (b) spawning stock biomass and fishing mortality at age 3-5 in 2011-2016/2017 (based on ICES 2017).

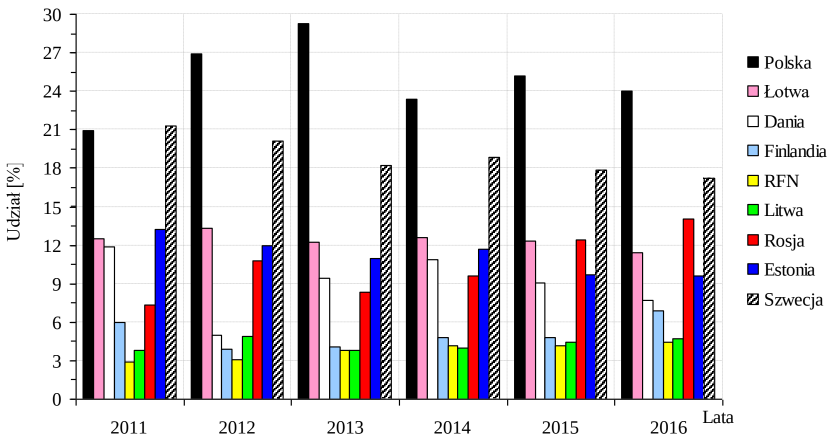



Fig. 4.3.16. Changes in the relative share of individual countries in the annual catches of the Baltic sprat in 2011-2016.

The increase in recent years of interest in sprat fishing in Poland resulted from the perturbation in cod fishery, i.e. the decline in the biological condition of fish and the share of large fractions - older individuals as well as insufficient annual catch quotas. In addition, at the same time, there has been an increase in purchase prices for sprat, on an absorptive market, and their relatively large catch quotas, also granted to small vessels. Another factor of lesser magnitude affecting the stabilization of the level of annual commercial landingss of Baltic sprat was the discharge order (discard ban) in force from 1st January 2015, pursuant to Commission Delegated Regulation (EU) No 1396/2014 of 20 October 2014 establishing a discard plan in the Baltic Sea. As a consequence of the above regulation, both young undersized fish and adult sprat, for which catches were directed along with by-catches of fish from other species, should be brought to the landing port after being caught.

Based on the ICES opinion the annuall limits of international sprat catches in the Baltic Sea TACc are set. As the basis for this limit - one of the measures regulating the exploitation of sprat resources, the principle of maximum sustainable catch (MSY) and biomass dynamics and a forecast of its size were adopted. Council Regulation (EU) No 1088/2012 of 20 November 2012 fixing fishing opportunities for 2013 for certain fish stocks and groups of fish stocks in the Baltic Sea (OJ L 323 of 22.11.2010 , page 2) a reservation is made that at least 92% of landings deducted from the sprat quota must be a target species. Annex II to Regulation No 2187/2005 states that in individual catches directed at sprat on board fish may not contain more than 3% of cod by-catch and 45% by-catch of herring per live weight shall be allowed. The description of fishing opportunities for a given year in relation to fish stocks in the Baltic Sea is included in the annual Council Regulation (EU), for 2016 it is Council Regulation (EU) 2015/2072 of 17 November 2015 determining fishing opportunities for 2016 for certain fish stocks and groups of fish stocks in the Baltic Sea and amending Regulations (EU) No 1221/2014 and (EU) 2015/104 (O.J. L 302 of 19.11.2015, p. 1, with later changes).

The use of the Polish Baltic sprat catch quota (currently monitored by the Fisheries Monitoring Center in Gdynia) was quite high in the last six years, although it showed significant fluctuations from year to year, for example in 2011 it was 66% (quota of 83,7 thousand tonnes), in 2013 - 109% (73.4 thousand tonnes) and in 2016 - 97% (61.4 thousand tonnes). In 2013, due to the accelerated use of the national annual quota for sprat, the catch in June-July was reduced to 0.1% per year - a prohibition of targeted catches of sprat in ICES subareas 22-32 by fishing vessel owners of Polish affiliation was introduced. Later, a ban was imposed on all fish catches of the abovementioned species by the end of 2013 (ordinance of the Minister of Agriculture and Rural Development of 22 May 2013 on the prohibition of fishing for sprat in subareas 22-32 of the Baltic Sea (Journal of Laws item 593) and the Regulation of the Minister of Agriculture and Rural Development of 9 July 2013 on the prohibition of fishing for sprat in subareas 22-32 of the Baltic Sea (Journal of Laws, item 806) One of the indirect but important reasons for the under-utilization of the annual sprat quota in 2014 and 2015 was introduction in 2014 of a new system for the distribution of this quota, i.e. granted individually for long-distance fishing vessels, including seagoing boats that did not previously receive this quota.

In 2011-2016, the total number of Polish vessels catching sprat increased from 85 to 133, with a greater involvement of small vessels, which resulted in structural fragmentation of catches and, consequently, increased fleet pressure on the resources of these fish in the Baltic. However, large-vessel (stern cutters and larger side boards) still dominated in sprat catches - over 25 m in length (in 2016 - 37 vessels) and then from segments 18.5-20.49 m (27 vessels), 20.5- 25.49 m (24 vessels), 12.0-16.66 m (18 vessels) and 15.0-18.48 m (13 vessels). In 2011-2016 cutters from the length group of 25.5-30.49 m caught during the year from 29410 to 44207 tonnes of sprats (Fig. 4.3.17), which constitutes on average 54.6% of the sum of nominal landings of these fish in the past six years. years. The second and third place in terms of the weight of annual catches of sprats was taken by cutters from the 20.5-25,49 m and >30,5 m segments which average share in 2011-2016 was respectively 20.0 and 13.9%. It should be noted that in 2011-2016 the interest in commercial catches of sprats by shipowners of medium-sized fishing vessels, i.e. 18.5-20.49 m long, has clearly increased (Fig. 4.3.17). At that time, the average share of sprats in the value of Polish landings of all Baltic fish, from the above-mentioned cutter segment increased from 7 to 39%, with a simultaneous decrease in the share of cod from 64 to 38%. The very small proportion (1.9 and 0.02%) of small vessels (12.0-14.99 m and <11.99 m in length) in annual catches of sprat caused emotions in the environment of fishing shipowners due to the amounts marketability (years 2014 and 2015), although the interest in commercial fishing has historically not been noticeable. As part of the amendment to the Act on Maritime Fisheries in Poland, in early 2017, a ban on the exchange of fishing quotas between shipowners was announced.

In the years 2011-2016, 22.0 to 45.7 thousand tonnes/year of sprat for consumption (for canning, smoking, other processed products) were caught and from 13.9 to 34.1 thousand tonnes for industrial purposes (for the production of fishmeal, fish oil and various components of animal feed). Sprats were also used as a bait in predacious fish catch. In the aforementioned six-year share increased from 39.7 to 71.3% of sprat landings intended for consumption purposes, and the share of landings for industrial purposes decreased from 60.3 to 28.7%.

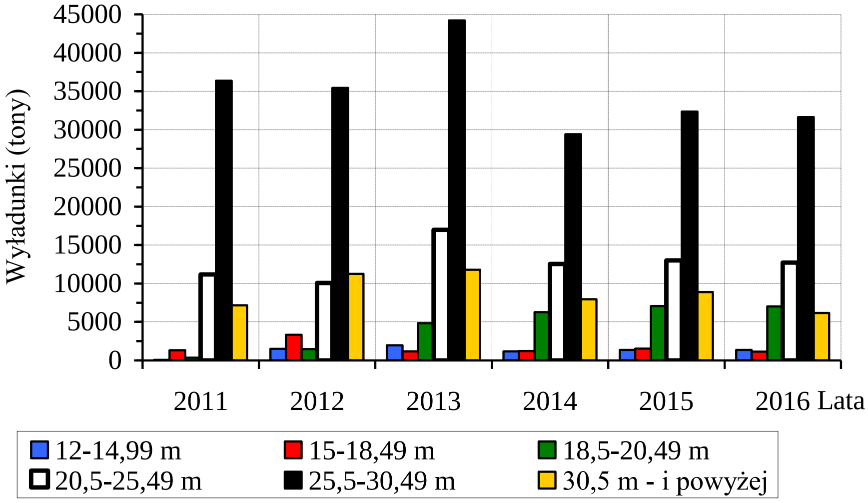



Fig. 4.3.17. Distribution of annual (2011-2016) Polish langdings of sprat by length groups of fishing vessels.

ICES statistical subareas 26, 25 and 24 including the Gdańsk, Bornholm and Arkona basins, due to the geographic location close to the Polish fishing fleet, are priority sprat fisheries, although for example in 2013 and 2015 the catches were taken from the Stockholm fishery in the north to the Rügen fishery on the south-western Baltic (Fig. 4.3.3). In 2011-2016 from the first two abovementioned basins came from 48.1 to 68.6% and from 17.2 to 42.0%, respectively, of annual landings. In 2016, an average of 54.5; 36.4; 7.9; 0.7 and 0.5% of weight of landings of sprats for consumption (42526,6 tonnes) came from 26, 25, 24, 27 and 28 of ICES subarea respectively. The distribution of the Polish sprat "fishmeal" catches in 2016 (17949,2 tonnes) differed from the above described and 51.8; 35.3; 7.7; 3.1 and 2.0% came from ICES 25, 26, 28, 29 and 24 respectively.

In the Polish part of the Baltic Sea there are no fixed sprat protection areas as well as no fixed periods completely closed for this fishery. The form of temporal regulation of sprat catches in Poland is the regulation of the Minister of Maritime Economy and Inland Navigation of 16th September 2016 on the dimensions and protective periods of marine organisms and detailed conditions for commercial fishing (Journal of Laws, item 1494, as amended) that targeted catches of sprat shall be carried out from 11th September to 9th June.

The first half-year, especially the season from February to May, was in 2011-2016 the main period of sprat exploitation by Polish fisheries, although catches of these fish were carried out each month in the above-mentioned period (except for 2013; Fig. 4.3.18). For example, from February to May 2015, 75% of annual landings of sprat were caught, in the summer - 3%, and in the fourth quarter - 13%. In the years 2011-2013, there was a time shift in April-May of the main season of commercial fishing for sprats, when the maximum landings were achieved per year. In the following years (2014-2016) the fishery was concentrated mainly in March-April, when 47.0 to 48.3% of these fish were caught.

For commercial Baltic sprat fishing, in Poland mainly small-net trawls and pelagic pair trawls are used, sporadically and to a small extent, bottom trawls. For example, in 2016, the share of trawls and pelagic pair trawls in the weight of sprats caught by Polish fishermen was on average 94.2 and 4.6%, while the share of trawls and bottom tugs amounted to 0.7 and 0.6%, respectively. In the previous year, the average share of trawls and pelagic pair trawls in sprat catches was 92.5 and 5.8%, respectively, and the share of trawls and bottom pair trawls successively, 0.9 and 0.9%. In 2015, the share of Polish fishing vessels fishing with sprat trawls and pelagic pair trawl (total) was on average 80,4; 99.9; 98.4; 100,0 and 100,0% respectively, in 24, 25, 26, 27 and 28 of the ICES subarea.

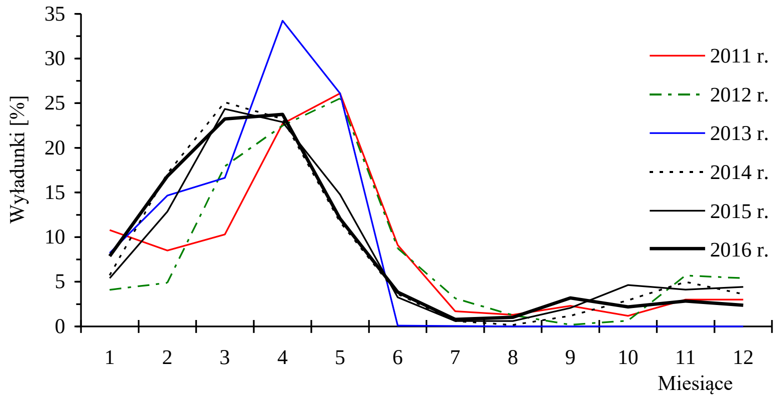



Fig. 4.3.18. Distribution of monthly Polish landings of sprat in 2011-2016; on the basis of the data of the Department of Fisheries Economics MIR-PIB and CMR in Gdynia.

The mesh size (clearance) in the sprat trawl sacks, during targeted fishing, according to the older Polish fishing regulations (the ordinance of the Minister of Agriculture and Rural Development of 16 July 2002 on the detailed conditions for performing sea fishing (Journal of Laws, item 1038) should be at least 16 mm. Minimum mesh size in the trawl for targeted species - Baltic Sprat, in accordance with Council Regulation (EC) No 2187/2005 in ICES subareas 22-27 is ≥16 mm. Annex III to Council Regulation (EC) No 2187/2005 states that ICES subareas 22-27, when fishing for the target species - Baltic sprat, the minimum mesh size in gill nets, entangling nets and trammel nets is≥ 32 mm. This fishing regulation is not practiced, as most of the fishing is done with trawls. According to the classification of fishing gears used by the European Union, the code (métier) - SPF_16-31_0_0 was adopted for the Baltic sprat, which means the acceptable mesh size in the bag from 16 to 31 mm. Sprat, as an endangered species (by-catch), is also found in pelagic trawls, herring tusks and herring trawls, where the mesh size in the bag is 32-104 mm.

In the samples from 2011-2016, the range of sprat lengths caught in the Bornholm and Gdańsk Basins ranged from 6.5 to 16.5 cm, with the proportion of individuals from the smallest and largest length classes being insignificant, usually below 0.2% (Fig. 4.3.19). Almost all curves representing the quarterly distribution (2011-2016) of the length of sprats caught in the abovementioned basins were bimodal - with a smaller extreme of frequency attendance in the group of young individuals, termed "undersized" (<10.0 cm long) and with a higher maximum share - in the adult fish group. Exceptionally, the curves reflecting the distribution of sprat lengths caught in the second quarter, in some years and lagoons had an unimodal shape, e.g. in 2015 in the Bornholm Basin the extreme frequency of abundance fell on classes 12.0-13.0 cm, which indicates that samples from this quarter came mainly from fish spawning areas of adult fish. It should be added that the curves representing the distribution of sprat lengths caught in the first and second quarter of 2015 in the Gdańsk Basin were two-peaked and in terms of numbers young fish from 8.0-9.0 cm predominated, derived from the very fertile generation of 2014. In the same period, contrary to the above, the sprat length distributions representing samples from the Bornholm Basin were monomodal, with a maximum attendance in the 12.0-13.0 cm class. The above data indicate a significant size diversification in relation to the areas of the Baltic Sea.

In Poland, the protective dimension of the Baltic sprat does not apply, while a minimum commercial dimension of 10.0 cm total length has been established, which does not mean an absolute ban on fishing and landings of smaller fish, referred to by the colloquial term "undersize", "pin".

In the 2011-2016 samples, there were sprats from age groups 0 ÷ 10 +, i.e. from generations from 2016 to 2006 (Fig. 4.3.20). The basis for Polish, annual (2011-2016) sprat catches was usually one or two very fertile generations, for example from 2008, 2011 and 2014 and 2-3 medium-fertile generations. Presence in sprat catches from the abovementioned very fertile vintages were clearly marked for the next 3-4 years, although their numbers decreased due to the pressure of fishing on the stocks. For example, in 2011, the highest number of sprat in catches made in ICES subareas 25, 26, 27, 28 and 29 was recorded for 2008 fish (in the 3rd age group), where it was: 51.4; 40.3; 52.3; 51.7 and 51.4%. On the other hand, in 2015 and 2016 the highest number of sprat in catches was noted for 2014 fish (respectively in the 1st and 2nd age group), where, for example, in the 26 ICES subarea, the share was respectively, 48.0 and 46, 8%. The annual age structure of commercial sprat landings in 2011-2016 varied, mainly due to the participation of fish from the youngest generations, complementing the exploited stock. For example, the percentage share of sprats from one age group in Polish annual commercial catches in 26 ICES subareas, successively in the years 2011-2016 was 19.8 (generation from 2010); 16.0 (generation from 2011); 20.4 (generation from 2012); 22.5 (generation from 2013); 48.0 (generation from 2014) and 9.8 (generation from 2015). In recent years, from the fourth quarter of 2014 to the fourth quarter of 2016, in each of the ICES quarters and subareas, the most numerous were sprats belonging to the highly fertile year 2014 (Fig. 4.3.20).

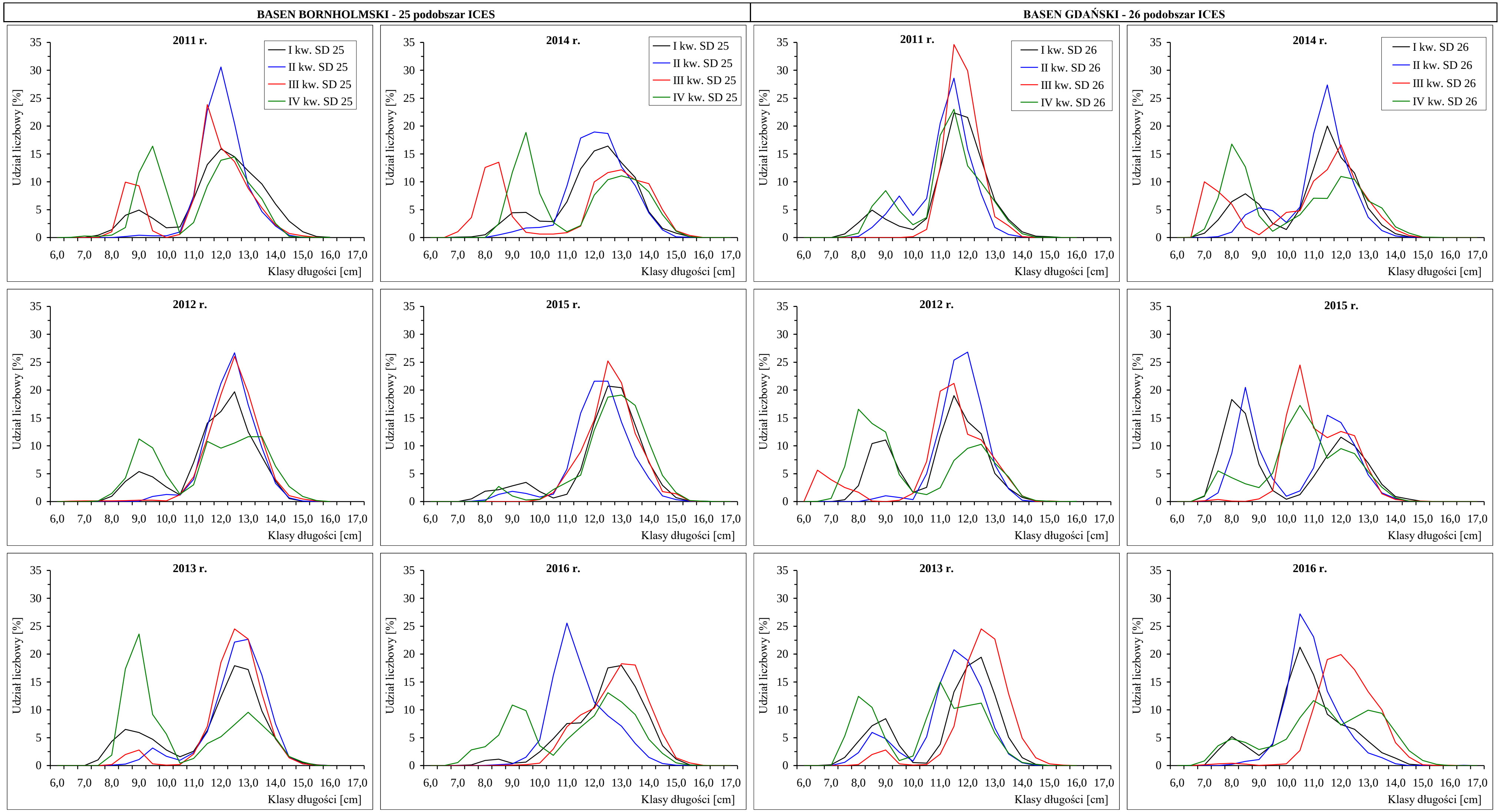



Fig. 4.3.19. Quarter distribution of sprat length in 2011-2016, based on Polish samples from Bornholm Basin and Gdańsk Basin; note: the diagrams representing data from the second half of 2013 are based only on samples from Polish research catches from "Baltica" research vessel, since commercial fishing was blocked due to the exceed of the annual catch limit.

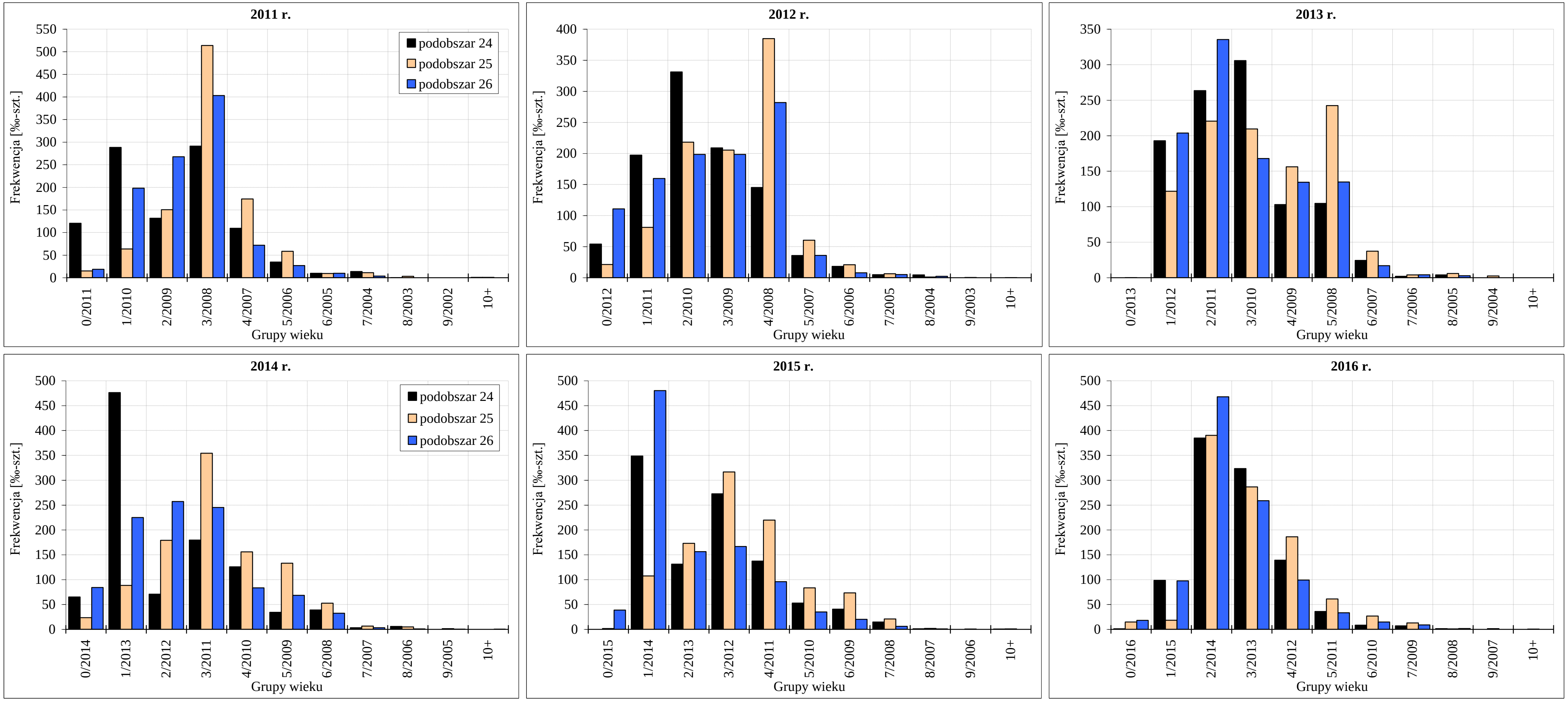



Fig. 4.3.20. Average annual distribution of sprat age, weighted by the number of Polish commercial landings in 2011-2016, in subareas 24, 25 and 26 of the ICES (the diagrams representing data from the second half of 2013 are based only on samples from Polish research catches from "Baltica" research vessel, since commercial fishing was blocked due to the exceed of the annual catch limit)

In Polish sprat catches, for many years, locally and sometimes periodically significant by-catch of juveniles of this species and of young herrings has been recorded. Young sprats prefer depths ≤20 m to 50 m, while they are very sporadically found in the zone of the deepest, open waters of the Baltic Sea. The numerical proportion of young sprat gradually decreased from 87 to 3%, adequately to the increase in depth, in the range of 20-100 m. The coexistence of young sprats and herring, in terms of quantity, is determined mainly by the number of fish from recruiters of generations.

By-catches of undersized (<10.0 cm) sprat by 2015 have often been eliminated from landings by using mechanical graders, selecting fish caught by two major size groups. The "undersize" sprat in landings intended for consumption in previous years (until January 2015) was usually subject to rejection (discards) or was sold as a component for the production of animal feed. The admixture of young sprats and herring in landings of sprat for consumer purposes is unfavorable both from the technological and biological point of view, as it increases the workload (additional sorting) and production costs and increases the mortality of recruiting generations of herring fish. Confirmation of the difference in the size of by-catch of young sprats depending on the location of the fishery and years may be summarized below the average data from the first quarters of 2009-2016 and fisheries (percentage share in numbers):

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|
| Gulf of Gdańsk (coastal fisheries) | 66 | 17 | 24 | 29 | 28 | 60 | 66 | 24 |
| Bornholm-S fishery (open sea) | 23 | 4 | 31 | 9 | 3 | 16 | 6 | 1 |

The fraction of undersized sprats in the first quarter of 2009-2015 was dominated by: the fertile generation of 2008, the medium-fertile generation of 2009, the fertile generations of 2010 and 2011, the medium-fertile generations of 2012 and 2013, the very numerical generation of 2014 and the small generation of 2015. In the first quarter of 2015, when the share of sprat from the numerous year 2014 was clearly noticeable, a large by-catch of undersized fish was noted both in the Gulf of Gdańsk and in the Gdańsk Deep, in the fisheries of Gotland (southern part) and Władysławowo; in each of the above regions, the mass share was over 22%. In the same period, the by-catch of the mass of this sprat fraction in the area of Rynna Słupska, Ławica Środkowa, Kolobrzeg-Darłowskie, Bornholm-S and Bornholm-N fisheries amounted to 1.2; 8.4; 2.0; 2.0 and 4.3%. In the first and second quarters of 2013 and 2015, the average values of the aforementioned parameter in the samples from the south-eastern Baltic fisheries than from the south-west fisheries. In the third quarter of 2013 and 2015, bycatch, the size of sprat was usually close to or equal to zero. Exceptionally, in the summer of 2013, the average share of the weight of young sprats (from generations in 2012 and 2013) in the Kolobrzeg-Darłowo fishery was 33.6% (one sample) and in the Gulf of Gdańsk - 9.8% (four samples). In the fourth quarter, the share of the sundersize increased again, roughly to the level from the first and second quarters, and in 2013 in the ustecko-łebskie fishery it was as much as 73.4% -mass (three samples), in the Gulf of Gdańsk - 25.0% (five samples), and in the Kolobrzeg-Darłowo fishery area 21.2% (10 samples).

Another example illustrating the periodic changes in the average weight share of undersized sprats are the data set out in Table 4.3.6. For example, in the first quarter, the share of undersized sprats in the Gdańsk Basin ranged from 5.0% (2011) to 24.4% (2015). In 2011 and 2015, there were also significant differences in the number of sprats from the youngest generation, recruiting to the target stock, which for the 2010 year (in 2011) amounted to 62.4 billion and for 2014 (in 2015) - 196.2 billion individuals (ICES- WGBFAS 2017). The data presented in Table 4.3.1 also indicate the seasonal variation in the proportion of young sprat mass, which, for example, in the samples from the Gdańsk Basin, in the quarters I-IV 2015 was successively: 24.4; 22.9; 1.6 and 9.7%, which proves that in the winter season and at the beginning of spring, this share reached its maximum and in the summer the minimum. This fact is due to natural causes - sprats from last year's generation grow rather quickly in terms of length and weight, gain commercial dimension. Sprats from this year's generation, in autumn, migrate to shallow and medium-deep coastal waters, most often in naturally sheltered basins, neighboring estuaries of large rivers, where they form large aggregations. Quite a large proportion of the youngest sprats, due to their short length, are not stopped in pelagic trawling bags or suspended by gill covers with net material and are mechanically damaged.

Table 4.3.6. Average quarterly share in weight of undersized sprats (<10.0 cm in length) in Polish samples from subsequent quarters of 2011-2016, by the Gdańsk Basin and Bornholm Basin.

| | Share (%) of the undersized sprat in the biomass of samples by quarter | | | |
|---|---|---|---|---|
| | I | II | III | IV |
| Years | Gdańsk Basin | | | |
| 2011 | 5.0 | 7.6 | 0.0 | 9.4 |
| 2012 | 13.7 | 0.8 | 3.3 | 26.4 |
| 2013 | 9.6 | 6.5 | 4.2 | 14.9 |
| 2014 | 10.7 | 7.2 | 10.6 | 18.2 |
| 2015 | 24.4 | 22.9 | 1.6 | 9.7 |
| 2016 | 7.8 | 4.0 | 0.4 | 7.6 |
| | Bornholm Basin | | | |
| 2011 | 5.1 | 0.3 | 9.0 | 14.9 |
| 2012 | 5.7 | 0.5 | 0.4 | 11.6 |
| 2013 | 7.9 | 1.9 | 2.0 | 27.3 |
| 2014 | 4.6 | 1.4 | 12.8 | 15.7 |
| 2015 | 3.5 | 1.9 | 0.0 | 1.3 |
| 2016 | 1.0 | 1.0 | 0.1 | 14.9 |

Within the EU, in 1996, the minimum weight category for commercial landings of Baltic sprat was set at 4 g/individual and the number of fish in 1 kg should be ≤250. With reference to the Polish part of the Baltic Sea, the above mentioned weight category is underestimated. Established in Poland in 2003, market standards - size categories of fish, with respect to sprat amounting to ≤125 individual/kg (≤8,0 g/indiv.); the ordinance of the Minister of Agriculture and Rural Development of 25 April 2003 on the list of fishery products and market standards for these products (Journal of Laws, item 686) are slightly inflated in relation to MIR-PIB data and do not fully correspond with a minimum commercial length of these fish (10.0 cm) determined according to previous (1992) Polish standards. The Baltic sprat size standards quoted above do not, according to Polish and EU standards, imply the stability of the average weight of fish in years and seasons. According to own research, in the first quarters the average weight of sprats from the 10.0 cm long class changed in 2011-2015 respectively from 5.6 to 6.8 g/individual (Bornholm Basin) and from 5.9 to 7,2 g/individual (Gdańsk Basin).

The fishing pressure on the Baltic sprat resources applies to both adults and young fish - not subject to special protective provisions. Sprat, as one of the mass-exploited species of fish in the Baltic Sea, in comparison with, for example, cod or salmon, falls under the smallest scope of provisions regulating fishing exploitation and protection of these fish resources.

**Exploitation of herring**

Herring, the Baltic subspecies (*Clupea harengus membras*) is one of the most important among economically exploited fish species. Its participation in Polish fisheries in the Baltic in the last (2011-2016) years usually oscillated around 30% of total mass. Polish fishermen use active gears such as trawls, both pelagic and bottom, to catch herring. This type of gears is used throughout the year. In the spring season (herring spawning period), passive gears are used to catch this species: set gillnets and trap-gear (seine nets, including Danish) in sea fisheries, and fyke nets at the Vistula Lagoon and Szczecin Lagoon. The basic protective procedure aimed at protecting young fish (sexually immature) of the described species in the Baltic Sea from being caught is introducing a minimum mesh size of 32 mm (clearance) for ICES subareas 22-27 and 16 mm for ICES Subareas 28-32. In this respect, there are current regulations regarding the conditions of fishing in EU Member States in the Baltic Sea and in the Belt and the Sound, contained in Regulation No. 2187/2005 and the Act of 19 December 2014 on sea fishery (Journal of Laws of 2018 item 514, as amended), along with the regulations on the dimensions and periods of protection of marine organisms and the detailed conditions for performing fishing at sea. In the case of herring no protection periods were introduced and no protection areas were defined so far. EU regulations also do not provide for a minimum size for landings. Usually (historically) in Polish fisheries, the size of 16 cm and above is assumed for commercial fish of this species. The exploitation of herring from the end of the twentieth century (late 70's) is subject to the principles of sustainable management of its resources. Herring is a species which catch is limited, and the current control (Fisheries Monitoring Center in Gdynia) is subject to the use of the fishing quota allocated to Polish fisheries (TAC). If it is depleted, a total ban on fishing is introduced. This case took place in 2011 and concerned the southern and central Baltic stocks from November 15 to the end of the year. This regulation was implemented by the regulation of the Minister of Agriculture and Rural Development of November 10, 2011 on the prohibition of fishing for herring in subareas 25-27, 28.2, 29 and 32 of the Baltic Sea (Journal of Laws, item 1433). Subsequent such cases took place in 2012 and 2013, when the herring catch was prohibited, from 30th October and 4th September, respectively. Similar regulations apply to catches and the method of lading of unsorted herring for industrial (fodder) purposes. These catches may be landed only in the indicated ports, where the program of random landings control for fodder is in place. An unfavorable phenomenon in the light of species protection (including catches targeting herring) was the problem of by-catches of mainly undersized fish of the caught species and other limited or protected species. From 1st January 2015, an obligation for all EU Member States to land all catches with regard to fishing for species subject to catch limits, including herring has been introduced (Commission Delegated Regulation (EU) No 1396/2014, 20/20/2014). , taking into account the guidelines contained in Regulation No. 1380/2013).

Polish fishery exploits herring belonging to two stocks (ICES management units): the western Baltic Sea stock, inhabiting subareas 20-24 and the Central Baltic Sea stock, inhabiting subregions 25-29 and 32 (excluding the Gulf of Riga). The status of stocks of herring and their dynamics (both stocks) are assessed on the basis of mathematical models, calibrated using acoustic assessments of the size of the stock biomass. ICES proposes TAC based on the principle of MSY (Maximum sustainable yield) and biomass dynamics and its size forecasts Fig. 4.3.21 and Fig. 4.3.22 present spawning stock biomass and fishing mortality (F) at the age 3-6 of the above-mentioned herring stocks in 2011-2016/2017.

The biomass status of the central Baltic spawning stock until 2014 had an increasing trend, reaching 1104 thousand tonnes, and in 2015-2016 there was a slight decrease in this parameter, but it was clearly above the average value from 1973-2016 (958 thousand tonnes). The level of exploitation of herring from this stock, expressed as fishing mortality rate after 2013, had an increasing trend, reaching 0.20, but it was still lower than the average value for the years 1973-2016, amounting to 0.23. In the case of herring stocks the spawning stock biomass in the discussed years was at a relatively low level - well below the long-term average of 144 thousand tonnes. Until 2014, the value of this parameter had a slight upward trend, reaching 104 thousand tonnes, after which a decrease to 97 thousand tonnes was noted in 2016. The value of fishing mortality coefficient in the discussed period fluctuated in the range of 0.29-0.35, in order to reach in 2016 the highest value - 0.41. However, these values were lower than the average for the years 1991-2016, amounting to 0.48.

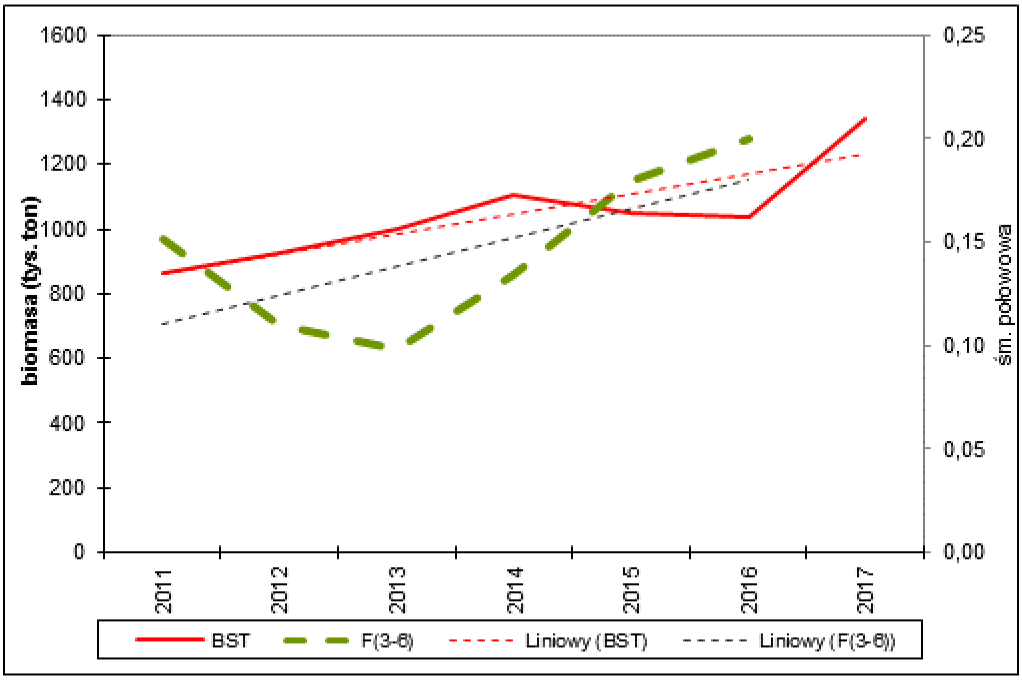



Fig. 4.3.21. Spawning stock biomass (BST) and fishing mortality of herring in age groups 3-6 (F (3-6)) from the central Baltic sea (subareas 25-29 + 32) in 2011-2016 / 2917 (according to ICES 2017).

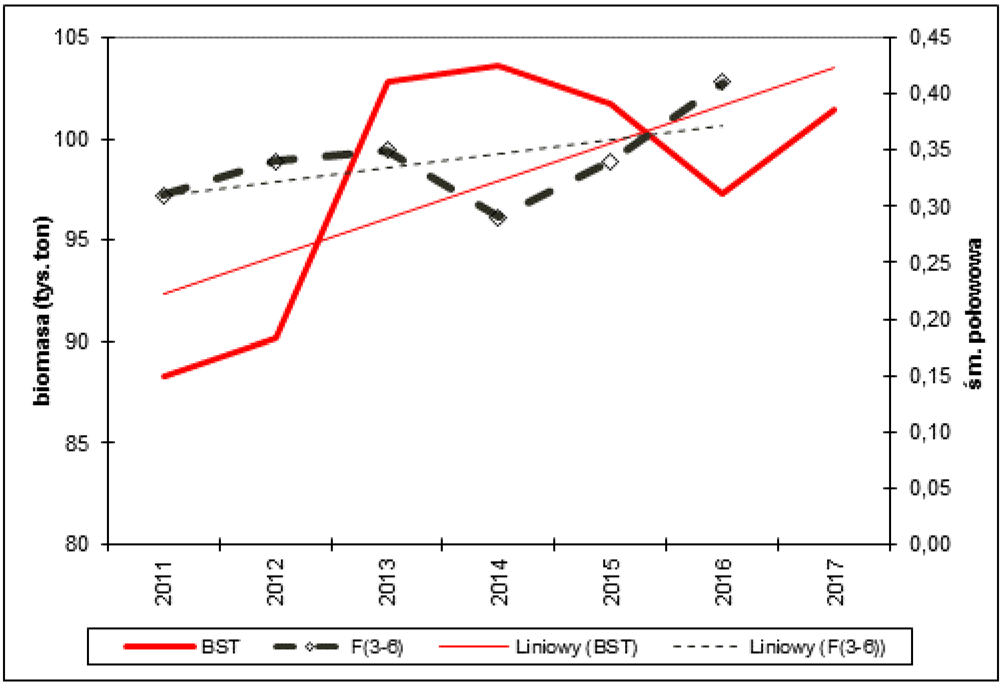



Fig. 4.3.22. Spawning stock biomass (BST) and fishing mortality of herring in age groups 3-6 (F (3-6)) from the West Baltic stock (subareas 20-22) in 2011-2016/2017 (according to ICES 2017).

Generally Polish fisheries (landings) of herring in 2011-2016, including the estimated by-catches of this species in sprat landings, initially followed a decreasing trend, and after 2013 were characterized by an increasing trend, in line with the increasing fishing quotas (TAC) granted to Polish fisheries (Table 4.3.7).

Table 4.3.7. Polish catches of herring in statistical subareas, destination and types of gears in 2011-2016 [t and %]

| Podobszar | Przeznaczenie | Typy narzędzi | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Średnio | % | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | konsumpcyjne | ciągnione (trały) | 1270,8 | 1546,5 | 2255,0 | 1760,7 | 1502,7 | 2125,8 | 1743,6 | 68,8 | |
| | | pułapkowe | 227,4 | 340,0 | 390,9 | 301,7 | 393,7 | 431,6 | 347,6 | 13,7 | |
| | | skrzelowe | 247,7 | 346,5 | 425,2 | 318,7 | 330,3 | 280,6 | 324,8 | 12,8 | |
| | | Suma | 1745,9 | 2233 | 3071,1 | 2381,1 | 2226,7 | 2838,0 | 2416,0 | 95,4 | |
| | przemysłowe | ciągnione (trały) | 44,6 | 127,7 | 37,1 | | 414,8 | 79,4 | 117,3 | 4,6 | |
| | Razem podobszar 24 | | 1790,5 | 2360,7 | 3108,2 | 2381,1 | 2641,5 | 2917,4 | 2533,2 | 100,0 | 7,7 |
| 25 | konsumpcyjne | ciągnione (trały) | 17623,2 | 13476,8 | 13618,8 | 15120,2 | 16398,1 | 19627,2 | 15977,4 | 85,0 | |
| | | pułapkowe | 117,6 | 18,2 | 22,4 | 32,6 | 65,4 | 14,1 | 45,1 | 0,2 | |
| | | skrzelowe | 241,5 | 550,4 | 591,9 | 1016,7 | 1084,4 | 806,8 | 715,3 | 3,8 | |
| | | Suma | 17982,5 | 14045,4 | 14233,1 | 16169,5 | 17547,9 | 20448,1 | 16737,8 | 89,0 | |
| | przemysłowe | ciągnione (trały) | 1225,8 | 2872,2 | 502,7 | 325,6 | 2868,2 | 2227,4 | 1670,3 | 8,9 | |
| | przyłów ze szprota* | ciągnione (trały) | 143,7 | | 343,1 | 870,3 | 991,0 | | 391,4 | 2,1 | |
| | Razem podobszar 25 | | 19352,0 | 16917,6 | 15078,9 | 17365,4 | 21407,1 | 22675,5 | 18799,4 | 100,0 | 57,1 |
| 26 (morze) | konsumpcyjne | ciągnione (trały) | 3637,4 | 1178,8 | 2423,0 | 6587,4 | 11820,5 | 14088,7 | 6622,6 | 60,3 | |
| | | pułapkowe | 2,0 | 9,5 | 254,0 | 436,7 | 53,4 | 9,6 | 127,5 | 1,2 | |
| | | skrzelowe | 83,6 | 92,3 | 171,1 | 159,9 | 176,6 | 62,8 | 124,4 | 1,1 | |
| | | Suma | 3723,0 | 1280,6 | 2848,1 | 7184,0 | 12050,5 | 14161,1 | 6874,6 | 62,6 | |
| | przemysłowe | ciągnione (trały) | 2079,9 | 4181,9 | 643,1 | 18,9 | 1446,7 | 381,5 | 1458,7 | 13,3 | |
| | przyłów ze szprota* | ciągnione (trały) | 365,2 | 589,2 | 267,2 | 574,5 | 955,0 | 305,6 | 509,5 | 4,6 | |
| | Razem morze | | 6168,1 | 6051,7 | 3758,4 | 7777,4 | 14452,2 | 14848,2 | 8842,7 | 80,5 | |
| (Zalew Wiślany) | konsumpcyjne | pułapkowe | 1799,1 | 2095,3 | 1351,3 | 1895,8 | 2893,6 | 2486,8 | 2087,0 | 19,0 | |
| | | skrzelowe | 13,4 | 68,6 | 97,6 | 28,7 | 50,7 | 43,4 | 50,4 | 0,5 | |
| | Razem Zalew Wiślany | | 1812,5 | 2163,9 | 1448,9 | 1924,5 | 2944,3 | 2530,2 | 2137,4 | 19,5 | |
| | Razem podobszar 26 | | 7980,6 | 8215,6 | 5207,3 | 9701,9 | 17396,5 | 17378,4 | 10980,1 | 100,0 | 33,4 |
| 27 | konsumpcyjne | ciągnione (trały) | | | 40,8 | 15,0 | 0,5 | 154,0 | 35,1 | 52,6 | |
| | przemysłowe | ciągnione (trały) | 52,6 | 27,5 | 102,7 | | | 7,0 | 31,6 | 47,4 | |
| | Razem podobszar 27 | | 52,6 | 27,5 | 143,5 | 15,0 | 0,5 | 161,0 | 66,7 | 100,0 | 0,2 |
| 28.2 | konsumpcyjne | ciągnione (trały) | 29,0 | 26,9 | 593,4 | 219,5 | 132,3 | 20,8 | 170,3 | 43,8 | |
| | przemysłowe | ciągnione (trały) | 566,7 | 3,5 | 4,0 | 29,8 | 38,8 | 670,0 | 218,8 | 56,2 | |
| | Razem podobszar 28.2 | | 595,7 | 30,4 | 597,4 | 249,3 | 171,1 | 690,8 | 389,1 | 100,0 | 1,2 |
| 29 | konsumpcyjne | ciągnione (trały) | 14,0 | 2,2 | | | 41,8 | 54,0 | 18,7 | 12,4 | |
| | przemysłowe | ciągnione (trały) | 604,2 | 24,4 | 124,8 | | | 40,0 | 132,2 | 87,6 | |
| | Razem podobszar 29 | | 618,2 | 26,6 | 124,8 | | 41,8 | 94,0 | 150,9 | 100,0 | 0,5 |
| OGÓŁEM | | | 30389,6 | 27578,4 | 24260,1 | 29712,7 | 41658,5 | 43917,1 | 32919,4 | | 100,0 |
| | konsumpcyjne | ciągnione (trały) | 22574,4 | 16231,2 | 18931,0 | 23702,8 | 29895,9 | 36070,5 | 24567,6 | | 74,6 |
| | | pułapkowe | 2146,1 | 2463,0 | 2018,6 | 2666,8 | 3406,1 | 2942,1 | 2607,1 | | 7,9 |
| | | skrzelowe | 586,2 | 1057,8 | 1285,8 | 1524 | 1642 | 1193,6 | 1214,9 | | 3,7 |
| | | Suma | 25306,7 | 19752,0 | 22235,4 | 27893,6 | 34944,0 | 40206,2 | 28389,7 | | 86,2 |
| | przemysłowe | ciągnione (trały) | 4573,8 | 7237,15 | 1414,4 | 374,3 | 4768,5 | 3405,3 | 3628,9 | | 11,0 |
| | przyłów ze szprota* | ciągnione (trały) | 508,9 | 589,2 | 610,3 | 1444,8 | 1946,0 | 305,6 | 900,8 | | 2,7 |

* Przyłów śledzia z wyładunków szprota został oszacowany poza oficjalną statystyką połowową, wygenerowaną z dzienników statkowych przez CMR i zawiera dane tylko z podobszarów, gdzie było próbkowanie.

Considering the dynamics of Polish herring catches, according to the years and months, two seasons can be distinguished: spring, with the peak of catches usually in March or April and summer and autumn, with peak of catches usually from August to October (Fig. 4.3.23). On average, in the discussed period, the Polish fishing fleet caught 32919 tonnes of herring, and in 2016 the catch reached 43917 tonnes. The average share of catches according to their purpose was: 86.2% for consumption purposes, 11.0% for industrial (fodder) purposes, and approx. 2.7% consisted the herring by-catch in sprat landings. The estimate of by-catches of herring in tatal landings of sprats in the discussed years was incomplete due to the lack of sampling in all quarters and statistical subareas. The main mass of herring landings was obtained from subarea 25 - an average of 57.1% and successively: 33.4% from subarea 26 (including the Vistula Lagoon), 7.7% from subarea 24, 1.2% from subarea 28.2, 0.5 % from subarea 29 and 0.2% from subarea 27. Most of the herrings were caught with active trawl gear (trawls, pelagic pair trawls), because on average constituing as much as 88.3% of the total weight. The trap gears (seine nets, fyke nets) had an average of 7.9%, and the remaining around 3.7% of the catch weight was obtained with gillnets (set-gillnets). The degree of implementation of fishing quotas of herring granted to the Polish fishing fleet is presented in the table below:

Total TAC [t] set for Poland and its implementation [%]:

| | | |
|---|---|---|
| 2011 | 29930 t | 99.83% |
| 2012 | 22256 t | 121.26%* |
| 2013 | 25825 t | 91.58% |
| 2014 | 30655 t | 92.21% |
| 2015 | 45625 t** | 83.37% |
| 2016 | 53556 t*** | 81.43% |

* catch limit for herring has been exceeded and

a ban on fishing was in force on 30/10/2012

** after exchanges with other countries

*** after the MGMiŻŚ granted an additional compensatory quota

The increase in TAC in 2016 in relation to 2015 adopted by the EU Council of Ministers

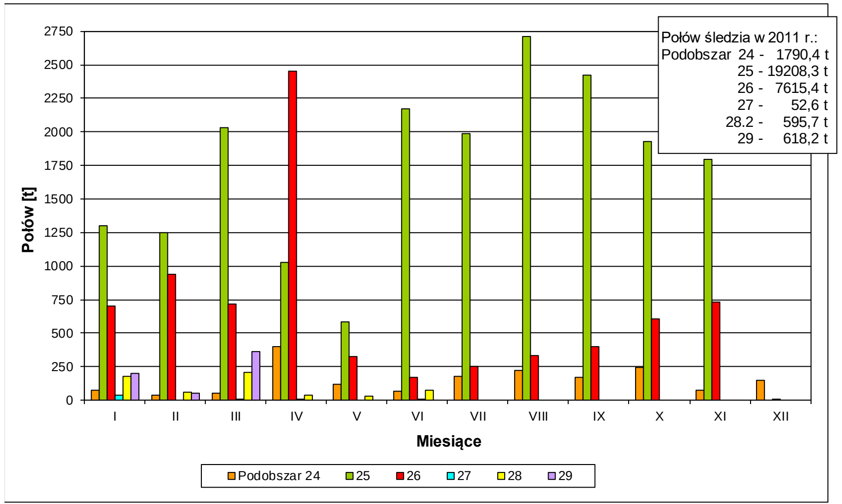
| | |
|---|---|
| *stock 22-24* | *18,20%* |
| *stock 25-29 i 32* | *8,60%* |

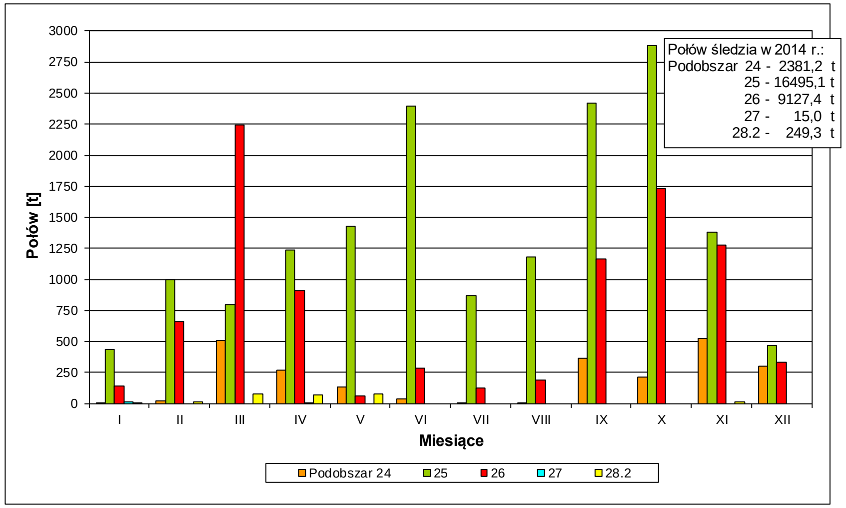
Fig. 4.3.24 shows the distribution of the length of herring caught in the fishery panel providing the largest mass of landings, i.e. in catches from cutters for consumption purposes using towed gear (trawls, pair trwals) according to statistical subareas 24-26 and individual 2011-2016 quarters in 2016. The most beneficial in terms of the technological distribution of length in fishing cutters in the discussed years was characterized by herring caught in the first and second quarter (especially in subareas 24 and 25), when in coastal fisheries pre-spawning and spawning concentrations of fish belonging to the local spring spawning population were exploited. These herrings are characterized by a relatively high rate of growth, especially a part of the population taking feeding trips to the Danish straits and the North Sea and returning in the spring to the traditional spawning grounds of the Polish coasts of the Baltic Sea. In the winter-spring period of the discussed years (2011-2016) in catches from fishing cutters for consumption purposes using towed gear (trawls, pair trwals), predominated herrings in total length classes of: in Subarea 24 - 19-24 cm, and in Subareas 25 and 26 ( without the Vistula Lagoon) - 18-22 cm. In the second half of the discussed years, half of consumer catches was conducted mainly in open fishery, where the fishing target were mainly faraging fish in mixed-population concentrations, with a large admixture of slowly growing immigrants from the northern regions of the Baltic Sea. In Arkona Basin (Subarea 24) and in the Bornholm Basin (Subarea 25), the largest frequency of herrings caught in the above-mentioned half the year fell on classes of length 17-22 cm, and in the Gdańsk Basin (Subarea 26) - 16-21 cm. Mostly in the first and fourth quarters there were more numerous by-catches of undersized herring, as in the case of Subarea 24 (years 2013 and 2014) and Subarea 26 (2012 and 2016). The frequency peaks of these fish fell on 12-15cm length classes and did not reach 10% of the total number of species.

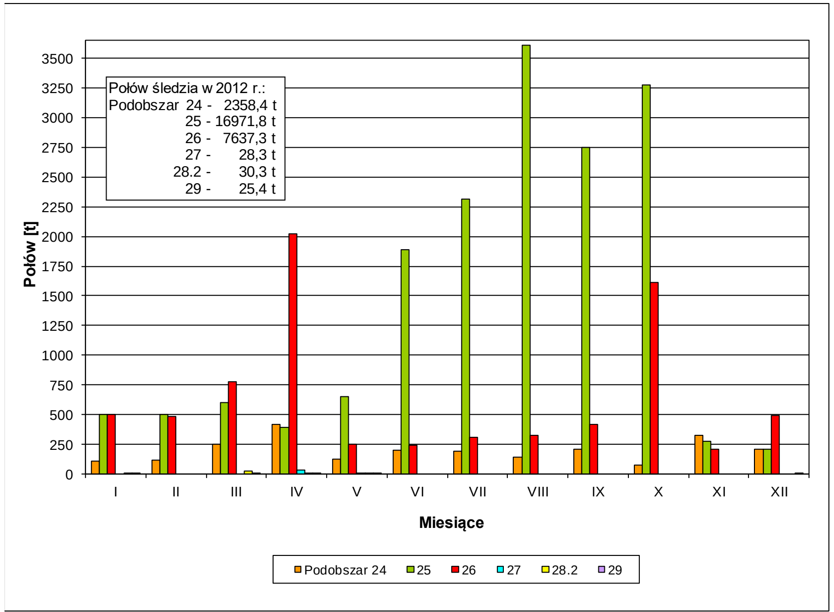
The total for 24-26 subbasins yearly population structure and age composition of Polish herring landings for consumption in the 2011-2016 period is shown in Fig. 4.3.25. In all the years discussed, the catch (landings) was dominated by the dominance of the spring population of the northern Baltic coast (so-called "Swedish" herring). Its share in the total number of species ranged from 54.1% in 2014 to 71.0 and 71.2% in 2016 and 2013 respectively. The herrings of the local spring population of the southern Baltic reached the maximum share in 2014 - 38.0% and minimal in 2016 - 21.1%, with a decreasing trend in the last two years. The share of autumn herrings was still marginal after the 60s of the last century were abundant for this population. In the spring population of the northern coast in 2007, the 2007 generation dominated for the next 3 years (2011-2013), already as 4-year-olds, predominantly in 2011 and still numerous after reaching the age of 8 in 2015. More than average generations belonged to fish born in 2011 and 2012, which as 4-year-olds dominated in years, respectively 2015 and 2016. The exceptionally fertile generation of these herrings from 2014 should dominate the population of population in 2017 catches, after its full recruitment to the stock. The age composition of catches shows that the stocks of this herring population are in good condition, fed by successive fertile fish generations and will further decide on the size of Polish catches (mainly in the second half of the year) for the coming years. Among the local population of spring herrings of the southern Baltic, in the years discussed, young fish from age groups 2-4 dominated. Older fish, over 5 age groups, were marginal. Due to poor recruitment, herring population in these years experienced a decline in the number of resources. Herring juveniles of this population were also a discard element that was formed during sorting on fishing boats targeted at this species. A pilot study of this issue carried out by MIR-PIB in 2012 showed that the average size of herring discards amounted to only 0.09% of the total weight of the catch (in individual surveyed fishing hauls in the range of 0-3.3%). In recent years, however, this is a problem disappearing in the Polish fishery oriented on herring, due to the provisions on the obligation to unload the entire catch, effective from 1 January 2015, which applies to all species of fish which catches are limited.

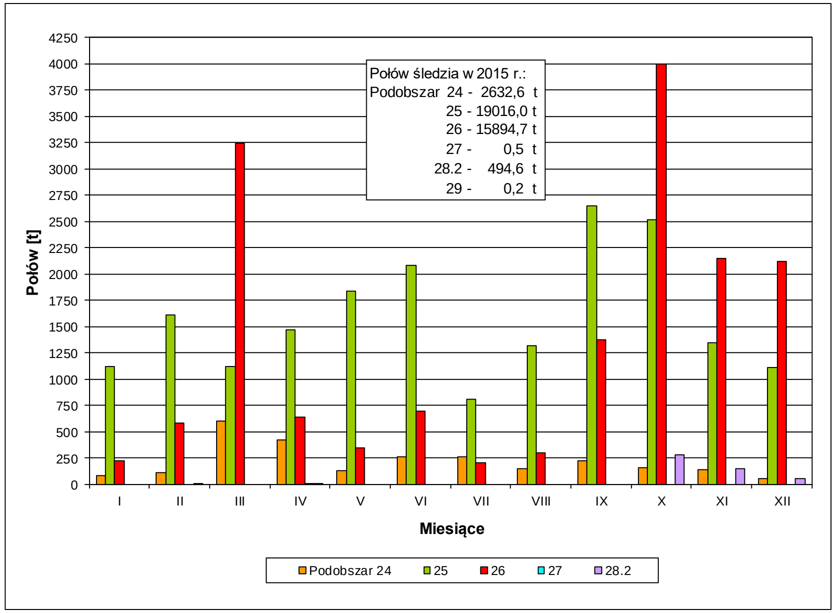
In 2011-2016, mixed (herring+sprat) catches were also sampled for industrial purposes (feed). Length distributions of herring from these catches by subareas, years and quarters are shown in Fig. 4.3.26. Since in fodder fishing of herrings trawl with a minimum mesh clearance of 16 mm (in directed herring fishing the minimum clearance for the Southern Baltic is 32 mm) is used, the greater number of herring below the so-called commercial dimension (fish under 16 cm in length) was caught. This took place mainly in Subarea 26 in the first and second quarters of 2011, 2013, 2015 and 2016, when the fishing for fodder was conducted on coastal fishery, where, in concentrations with sprat, undersized (immature sex) so-called "little herrings" were more numerous. The frequency peaks of these fish were between 12-13 cm in length. In the Subarea, 25 by-catch of "little herrings" was clearly lower. In subareas 28.2 and 29, where herring is characterized by a clearly lower growth rate than in the southern Baltic (subareas 25 and 26), modal ranges of length of herring caught correspond to classes of length 14-17 cm.

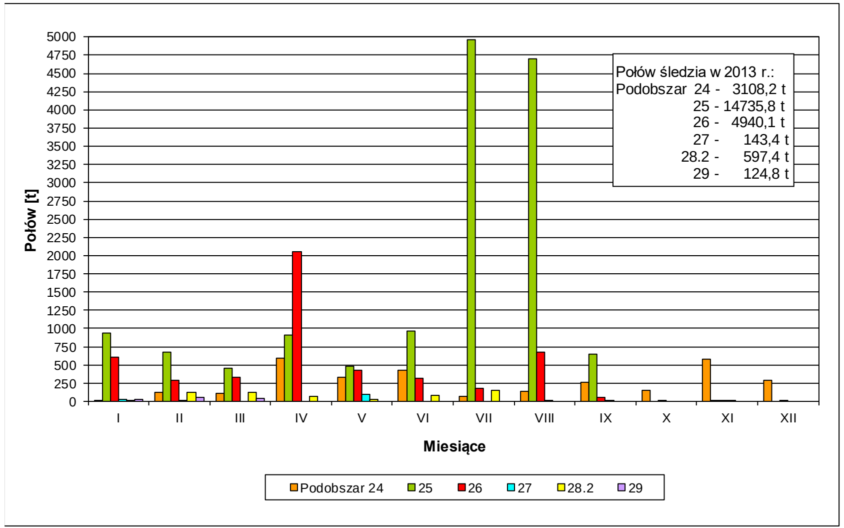
The population and age composition of herring landings for industrial purposes in the discussed years is presented in Fig. 4.3.27. Similarly to catches targeted on consumption, also in industrial catches the population of spring herrings of the northern coasts prevailed. Its quantitative participation in individual years fluctuated in the range from 46.3 in 2013 to 76.1% in 2016. In general, groups of 4-8, i.e. the vintage representing the adult part of the stock, were mostly represented. In particular, the 2007 generation of this population was numerously represented in catches in all the years discussed. By-catch of juvenile fish of this population was not large, except for 2012, when the share of 1-year-olds amounted to approximately 7.5% of the total abundance of species. The composition of the local population of spring herring was dominated mainly fish by the youngest age groups from 0 to 3, and juvenile herrings from 0 and 1 age group were clearly dominant in 2011, 2013 and 2015. More than in catches for consumption, the share of herring in the autumn population was due to the fact that most of the catches of mixed herring fish for fodder were carried out in the winter and spring season, when the herrings of the spring population were concentrating and spawning grounds located in coastal waters. In part, therefore, they were beyond the reach of the fodder fishery.


Połów śledzia w 2011 r.:
Podobszar 24 - 1790,4 t
25 - 19208,3 t
26 - 7615,4 t
27 - 52,6 t
28.2 - 595,7 t
29 - 618,2 t
Połów [t]
I II III IV V VI VII VIII IX X XI XII
Miesiące
Podobszar 24 25 26 27 28 29


Połów śledzia w 2014 r.:
Podobszar 24 - 2381,2 t
25 - 16495,1 t
26 - 9127,4 t
27 - 15,0 t
28.2 - 249,3 t
Połów [t]
I II III IV V VI VII VIII IX X XI XII
Miesiące
Podobszar 24 25 26 27 28.2


Połów śledzia w 2012 r.:
Podobszar 24 - 2358,4 t
25 - 16971,8 t
26 - 7637,3 t
27 - 28,3 t
28.2 - 30,3 t
29 - 25,4 t
Połów [t]
I II III IV V VI VII VIII IX X XI XII
Miesiące
Podobszar 24 25 26 27 28.2 29


Połów śledzia w 2015 r.:
Podobszar 24 - 2632,6 t
25 - 19016,0 t
26 - 15894,7 t
27 - 0,5 t
28.2 - 494,6 t
29 - 0,2 t
Połów [t]
I II III IV V VI VII VIII IX X XI XII
Miesiące
Podobszar 24 25 26 27 28.2



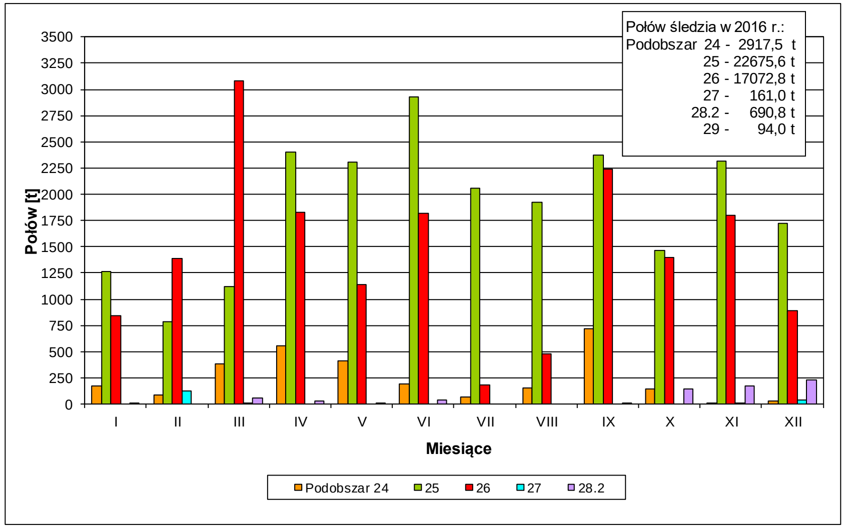
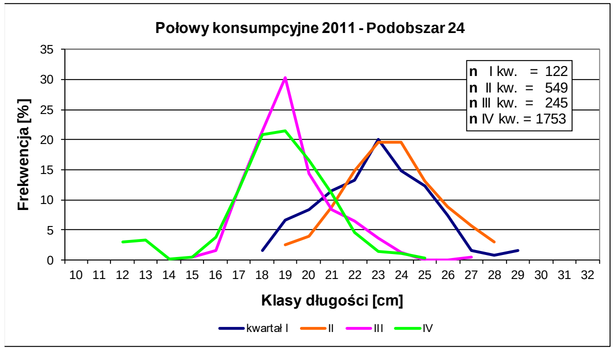
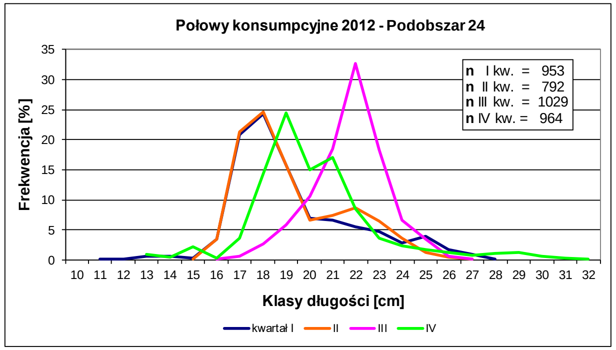
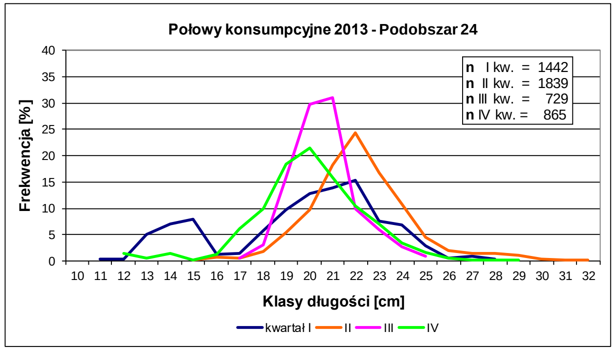
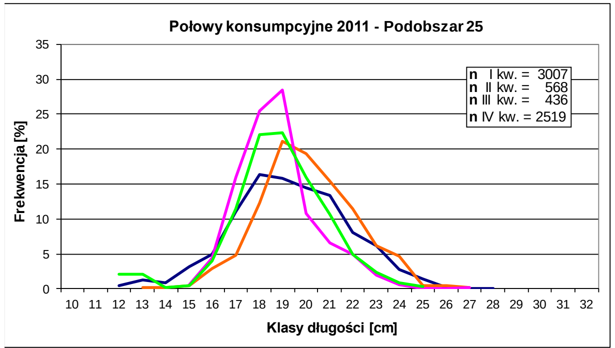



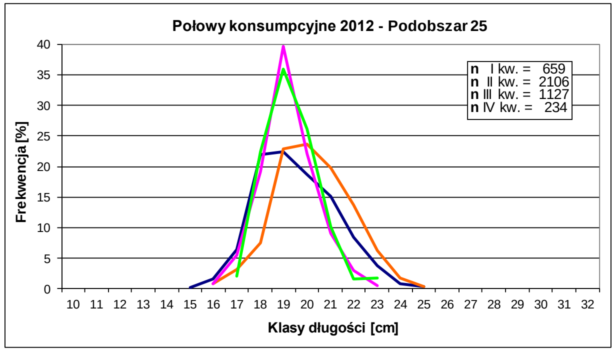

Fig. 4.3.23. The dynamics of Polish herring catch by statistical subareas and months in 2011-2016.

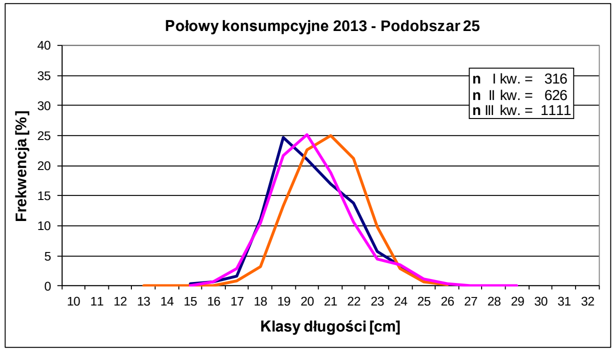


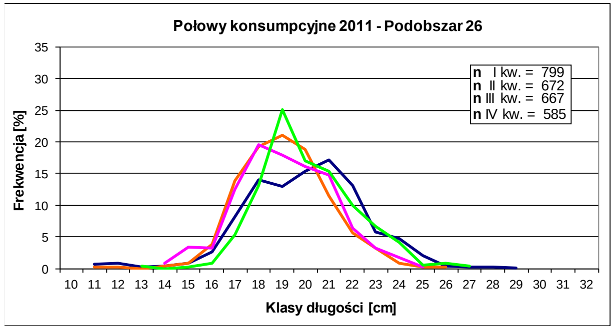



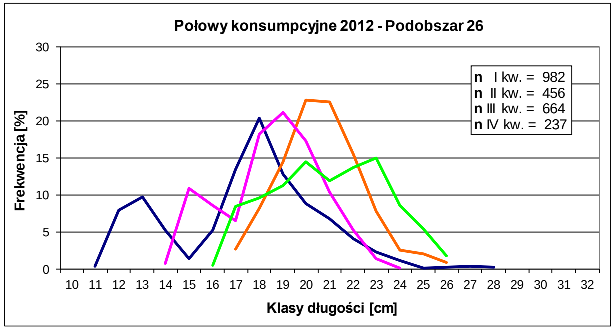



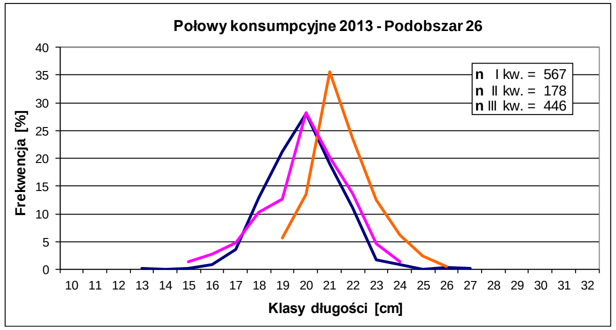

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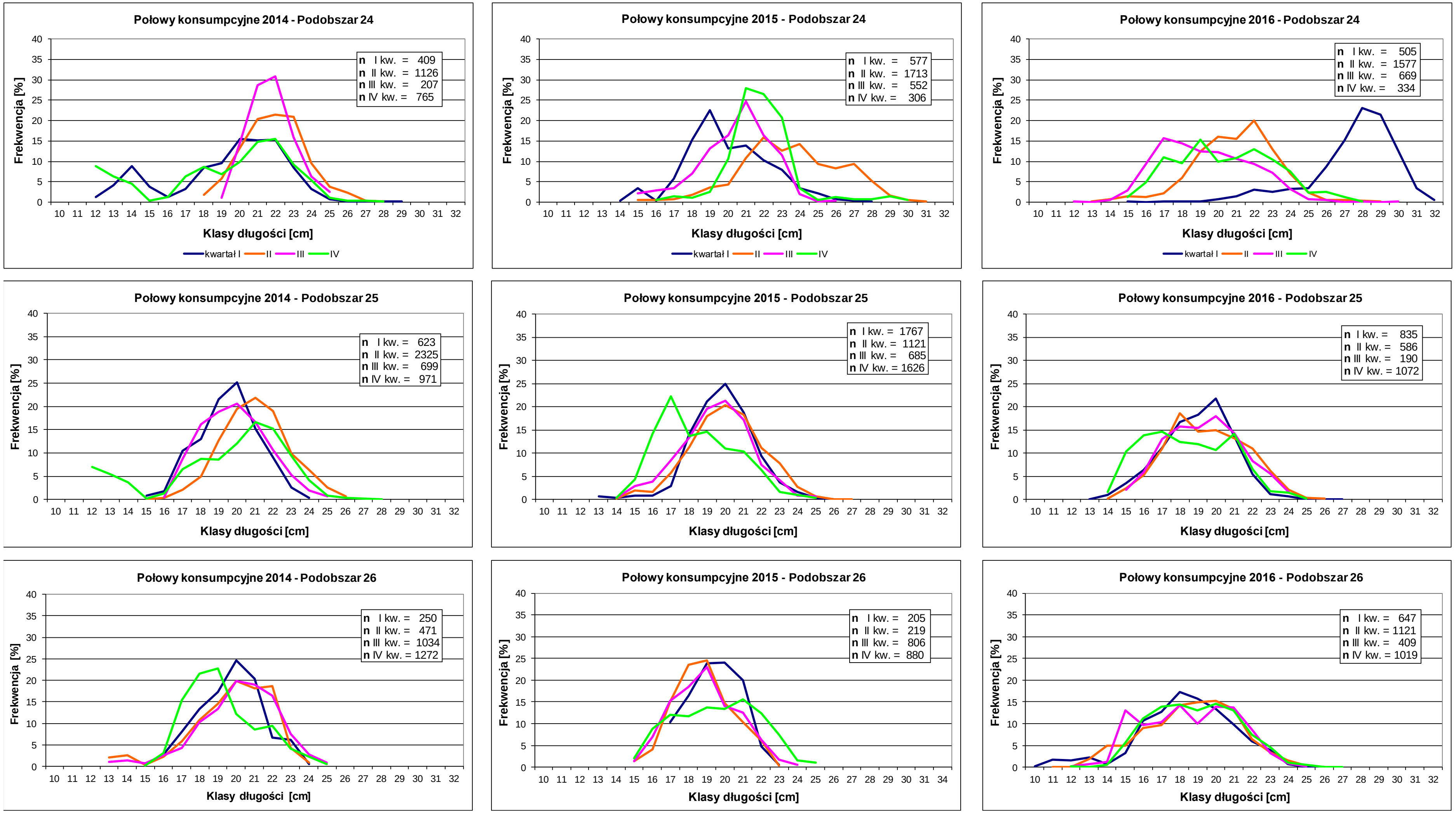



Fig. 4.3.24. Length distributions of herring caught with towed gear (trawls) for consumption purposes in statistical subareas 24-26 according to ICES in 2011-2016 [in% of abundance].

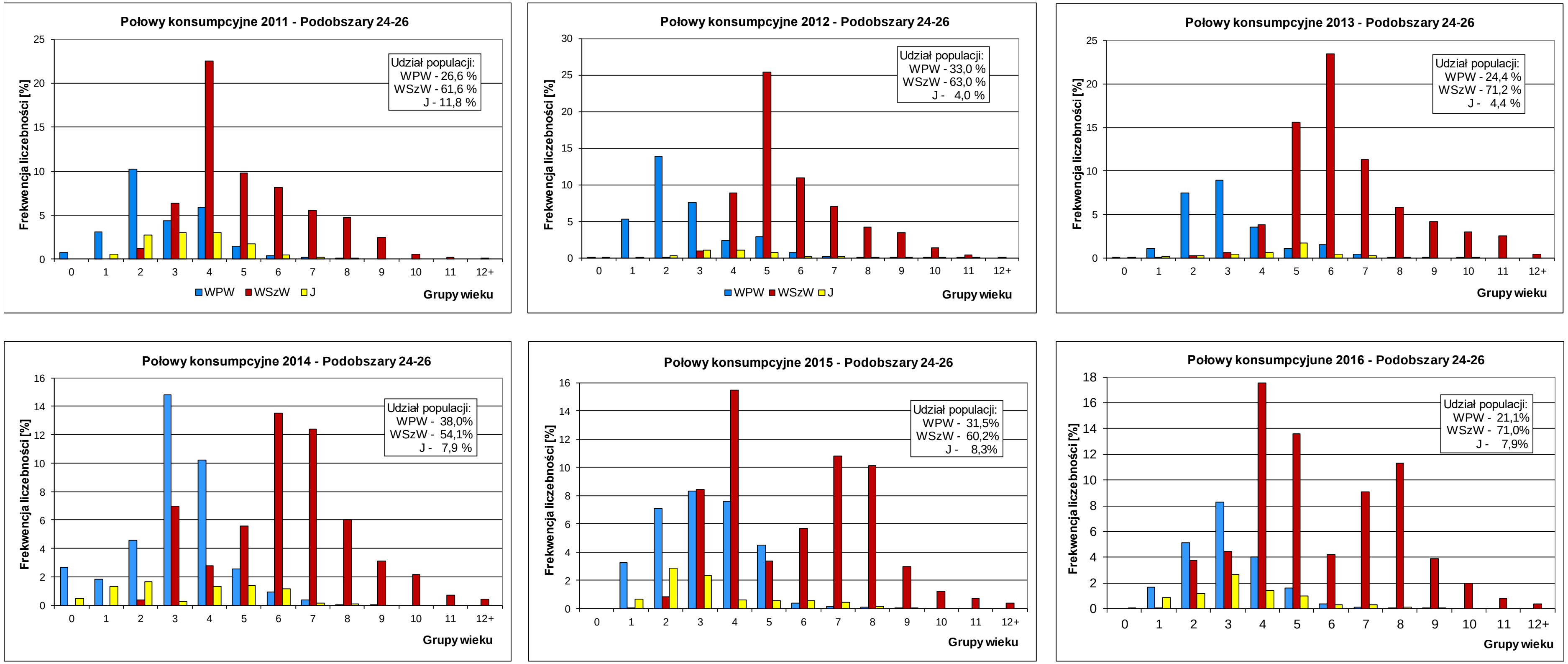



Fig. 4.3.25. The population and age structure of Polish herring landings in 2011-2016 [in % of abundance] (*populations: WPW - spring of the southern coast of the Baltic Sea, WSzW - spring of the northern Baltic coast, mainly Sweden, J - autumn*)

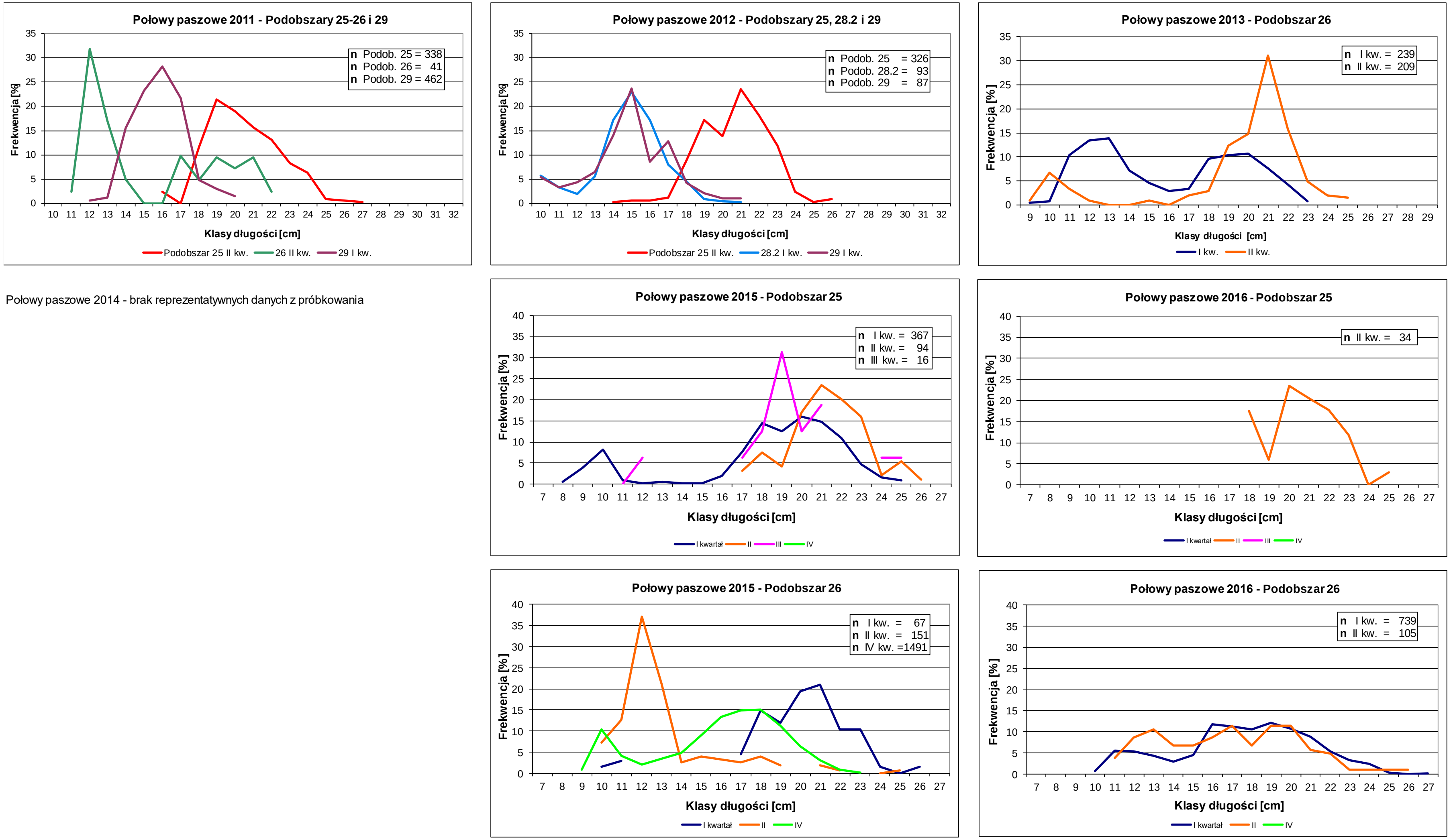



Fig. 4.3.26. Length distribution of herring from catches with towed gear (trawls) for industrial purposes (feed) in statistical subareas 25-29 according to ICES in 2011-2016 [in % of abundance].

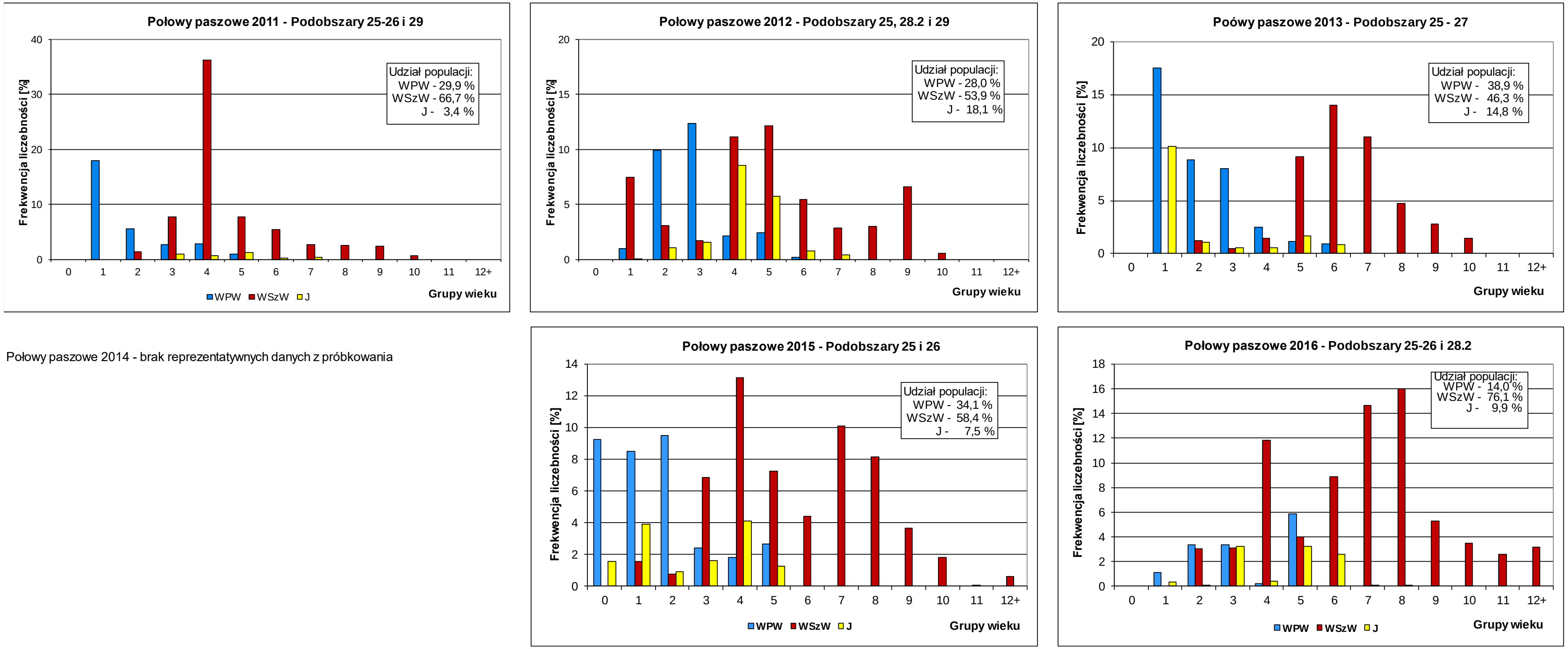



Fig. 4.3.27. The population and age structure of Polish landings of herring for industrial (feed) purposes in subareas 25-29 according to ICES in 2011-2016 [in % of abundance]. (*populations: WPW - spring of the southern coast of the Baltic Sea, WSzW - spring of the northern coast of the Baltic Sea, mainly Sweden, J - autumn*)

**Exploitation of flatfish (flounder, turbot, plaice)**

To catch flatfish in POM the bottom trawls and fixed nets are mainly used. The fishing gear authorized for fishing for Baltic fish (subareas 22-32) are set out in Annex II and Annex III to Regulation No 2187/2005. Pursuant to Regulation 2187/2005, it is allowed to fish flatfish:

1) Trawls, Danish seines and similar geara of a mesh size ≥ 90 mm (with a minimum percentage of target species 90%) and ≥ 105 mm (with a minimum percentage of target species 100%). Gear with mesh size ≥ 105 mm a top window codend BACOMA or a T90 codend and T90 extension must be used, mesh size and the specification set out in Appendices I and II. The use of a beam trawl is not allowed.
2) Gillnets, entangling nets and trammel nets of a mesh size: ≥ 110 mm and < 156 mm (with a minimum percentage of target species 90%) i ≥ 157 mm (with a minimum percentage of target species 100%).

Annex IV to Regulation 2187/2005 sets out the minimum landing size of fish, which for Flounder caught in subareas 24-25 and Subarea 26 is 23 cm and 21 cm, for Turbot 3 0 cm, and for Plaice 2 - 5 cm.

In addition, the ordinance No. 2 of the District Sea Fisheries Inspector in Szczecin of 17 November 2016 sets protective dimensions in commercial fisheries on internal sea waters and on Dąbie Lake (Journal of Laws of West Pomeranian Voivodeship, item 4486). In the case of flatfish, the following were designated: 25 cm for flounder, plaice and dab and 30 cm for turbot. In addition, protective dimensions in recreational fisheries were specified in the regulation of the Minister of Maritime Economy and Inland Navigation of 16 September 2016 on the dimensions and protection periods of marine organisms and detailed conditions for commercial fishing (Journal of Laws, item 1494, as amended) and for flatfish are: 23 cm for flounder, 25 cm for plaice and dab and 30 cm for turbot.

The protection period for flounder is valid only in subarea 26 from February 15 to May 15, and for Turbot in subareas 25 and 26 from June 1 to July 31 (Regulation (EU) No 1237/2010 of the European Parliament and of the Council of 15 December 2010 amending Council Regulation (EC) No 2187/2005 as regards the prohibition of highgrading and restrictions on fishing for flounder and turbot in the Baltic Sea, the Belts and the Sound (O.J. EU L 348 of 31/10/2010 , page 34).

<u>Description of fisheries and fisheries management - breakdown into stocks (according to ICES WGBFAS working group)</u>

Based on the type of roe in the Baltic, two main reproductive populations of the flounder are distinguished. Individuals spawning in deep water bodies have developed pelagic roe, which is characterized by inertial buoyancy and can develop in water with a minimum salinity of 11-12 PSU. Therefore, the range of occurrence of fish from this population is limited mainly to the waters of the South-West Baltic. The flounder spawning in shallow waters, with a higher specific weight, develops at the bottom in the salinity range of 5-7 PSU. The range of this population reaches the southern part of the Gulf of Bothnia and the Gulf of Finland.

Four stocks of flounder were distinguished in the Baltic Sea. Three of them were distinguished within the deepwater population: the Great and Small Belt and the Sund covering flounders from subareas 22 and 23 (fle.27.2223), the South-West Baltic from subareas 24-25 (fle.27.2425) and the East-Gotland stock and Gulf of Gdańsk from subareas 26 and 28 (fle.27.2628) - Fig. 3.1. The share of flounder from deep water stocks in Baltic landings is 80-90%. The fourth stock covers flounders from the shallow-water population, to which stocks belong from sub-areas 27 and 29-32 (fle.27.27,29-32).

The largest share in the landings of the Baltic flounder comes from Poland, which in the last six years has landed on average 62% of total landings. Two stocks operate within POM: fle.27.2425 fle.27.2628. From the above stocks, an average of 69% and 24% of landings of the Baltic flounder are reported, of which Poland landings an average of 80% and 39%.

The biomass indicator, determined on the basis of the performance of research catches BITS from the first and fourth quarters, is valid for the assessment of fish stocks larger than 20 cm.

Additionally, since 2017, the index based on the $L_{mean}/L_{F=M}$ distribution is calculated as the approximation of $F_{MSY}$ (fishing mortality at the maximum sustainable yield), which is the ratio between the average fish length in catch and the expected average length in the catch (higher than the average length of fish spawning for the first time) when fishing mortality (F) equals natural mortality (M). ICES proposes the maximum catch based on the precautionary principle, analyzing the trend of the biomass index and the value of the indicator based on the length distribution. Work on the use of analytical models to evaluate flounder resources is ongoing.

Plaice is caught mainly in subarea 22, and Denmark has the largest share in landings of this species. The next important fishing area is subarea 24, where mainly Denmark and Germany fish. In the Baltic Sea two plaice stocks can be distinguished: ple.27.2123 in Kattegat, the Great and Small Belt and the Sund (subareas 21-23); ple.27.2432 in other parts of the Baltic (subareas 24-32). Poland catches the 27.2432 stock, and its landings represent on average 17% of total landings from the abovementioned stock.

The assessment of the plaice stocks occurring in SD 24-32 and the maximum catch based on the precautionary principle proposed by ICES is determined on the basis of trends in the spawning stock biomass (SSB) and relative fishing mortality. To determine these values, an analytical model based on the age structure - SAM is used. This model has been used for this stock since 2015 and is currently in the testing phase, therefore SSB and F results can not be presented as absolute values.

Turbot occurs mainly in the southern and western parts of the Baltic Sea, hence the majority of landings of this fish come from subareas 22-26. Turbot was effectively caught in set-nets only in the early 90s, which was associated with the greater interest of fishermen in this species. Since 1990, turbot began to be sorted out from Polish catches targeting flounders due to its high price. In the last six years, Polish landings of turbot were on average 22% of landings of this species throughout the Baltic Sea.

In the case of the stock occurring in SD 22-32, ICES proposes a maximum landing based on the precautionary principle, analyzing the size index, determined on the basis of the research capacity of BITS research flights from the first and fourth quarters, valid for fish larger than 20 cm. Information on the discards size is unknown.

Biomass and catches in recent years

ICES does not have an approved analytical assessment of the flounder biomass. However, its dynamics can be roughly estimated on the basis of research results. Poland exploits a stock of subareas 24-25 and a stock of subareas 26+28. The dynamics of resources in both stocks is different - the stock in subareas 24-25 shows a strong growing trend of biomass (in 2011-2016 biomass increased almost three times), and in the stock of subareas 26+28, biomass decreases (in 2011-2016 it decreased by about 60%) (Fig. 4.3.28a).

In the case of turbot, the relative biomass values obtained from research catches do not show a clear trend. Due to the rare occurrence of turbot in research catches, estimates of the dynamics of the stock on this basis are uncertain. The relative values of biomass and fishing mortality of plaice are presented in Fig. 4.3.28b. The spawning stock biomass shows a clear upward trend, while fishing mortality - a slight decreasing trend.

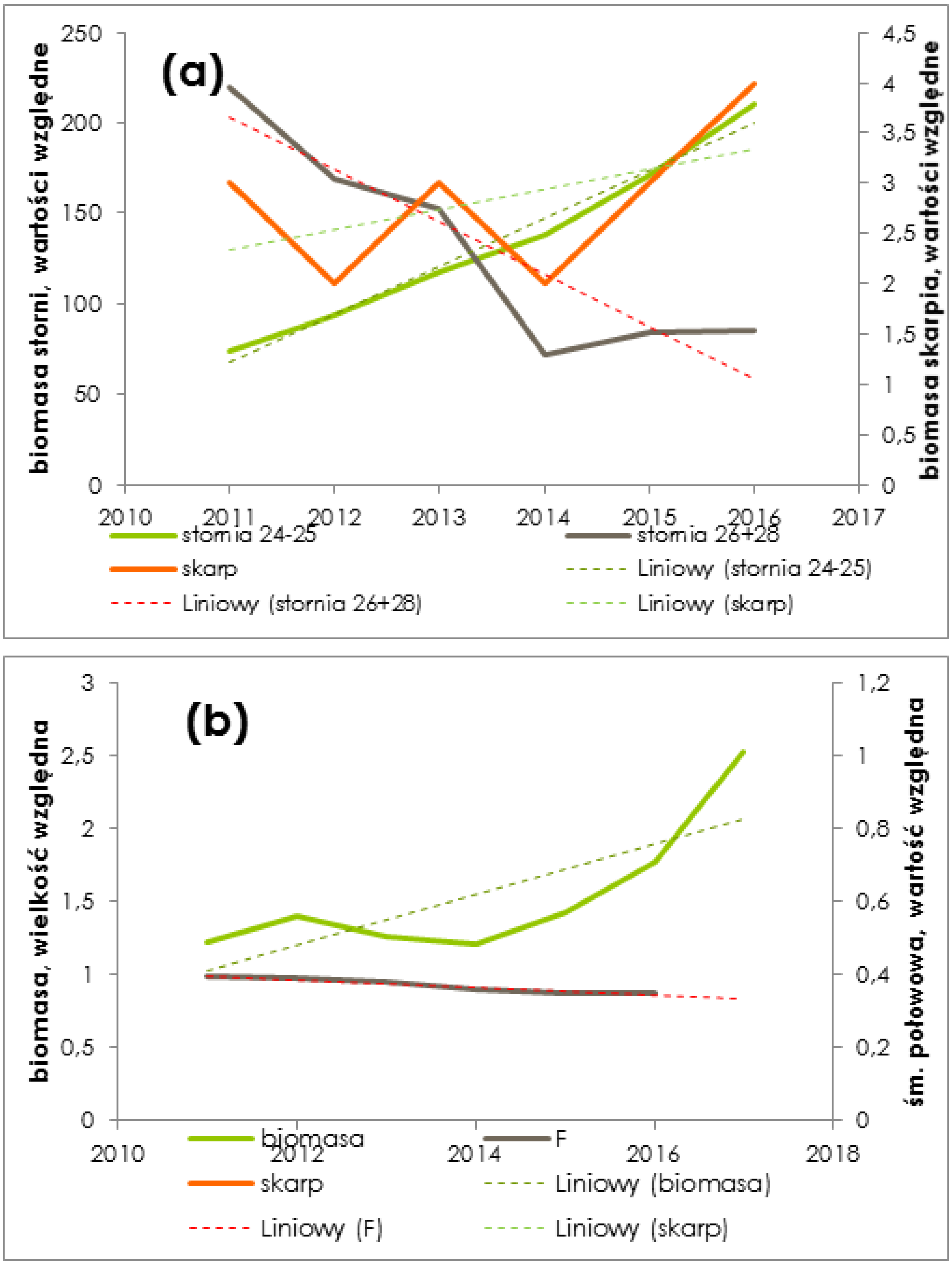



Fig. 4.3.28. (a) Index of the biomass size of the flounder in subareas 24-25 and subareas 26 + 28 and Turnip based on the results of research cruises. (b) Indicator of biomass size and fishing mortality (F) of plaice in subareas 24-32, relative values.

Mainly bottom trawls and set gillnets are used to catch flounders in POM, the share of which in the landings is respectively 99% of active and passive gears.

The largest share in the landings of the Baltic flounder comes from Poland, which in the last six years has landed on average 62% of total landings. Two exploited stocks within POM are: fl.27.2425 fl.27.2628.

Since 2011, landings of flounder in POM gradually increased. After a drop in 2015 where they reached 9902 tonnes, in 2016 they reached the highest value in recent years (14 571 tonnes) which is almost twice as much as in 2011. This was due to the increase in landings from active gears in subarea 25, which account for the largest share in landings in POM (53% on average).

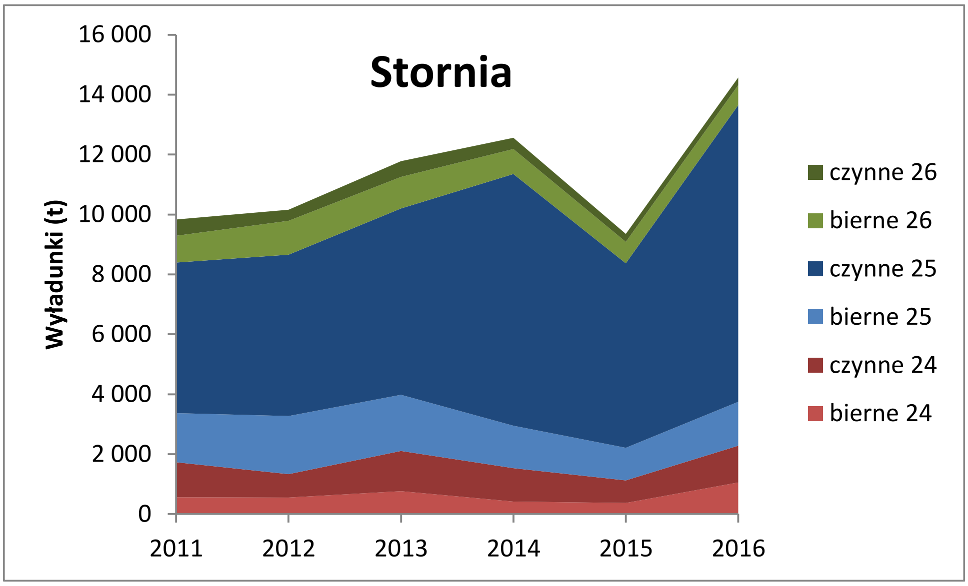



Fig. 4.3.29. Polish landings [t] of flounder by fishing gear (active - mainly bottom trawls and passive - mainly set gillnets) and ICES subareas (24, 25, 26)

Polish plaice landings have been increasing since 2013 (Fig. 4.3.30). In 2013, a total of 50 tonnes were landed, and in 2016 it was three times as large. The plaice was landed mainly in subareas 24 and 25 where 95% of Polish landings originated. In the subarea 25, the landings from active gear types is accounted for the largest share constituting on average 48% of total plaice landings. In turn, landings from subarea 26 came almost exclusively from passive gear types.

The increase in landings to a small extent may be related to the increase in plaice prices, which could lead to a more accurate sorting of this species from catches targeting demersal species.

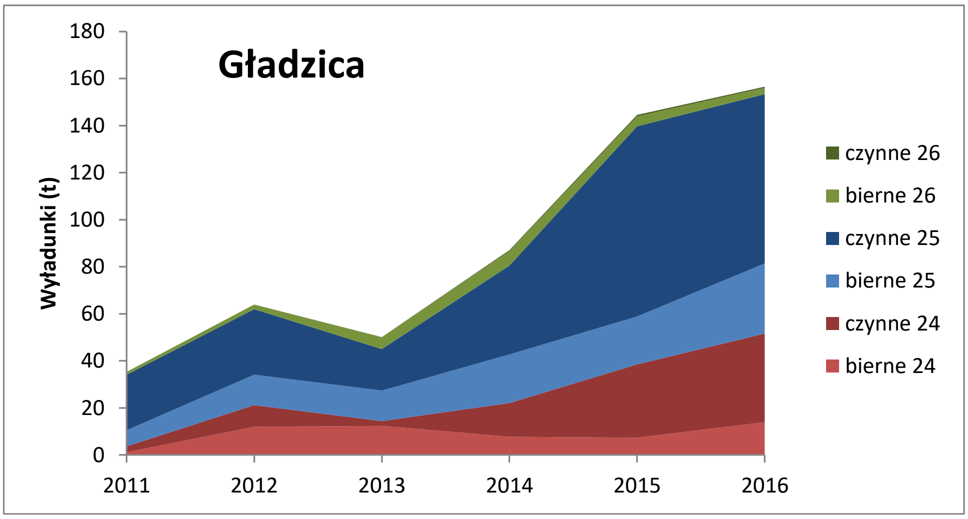



Fig. 4.3.30. Polish landings (t) of plaice in 2011-2016 by ICES subareas and by fishing gear

In the last two years, the landings of turbot began to increase, but it still remained at a level lower than the average from 2011-2013 (Fig. 4.3.31). In 2011-2016, Turbot in all POM subareas occurred mainly in landings from passive gear types. Landings from active gears constituted on average between 1% in subarea 26 to 4% in subarea 25. The largest share of Turbot was in landings from set gillnets , in subarea 25 (54% on average annual landings).

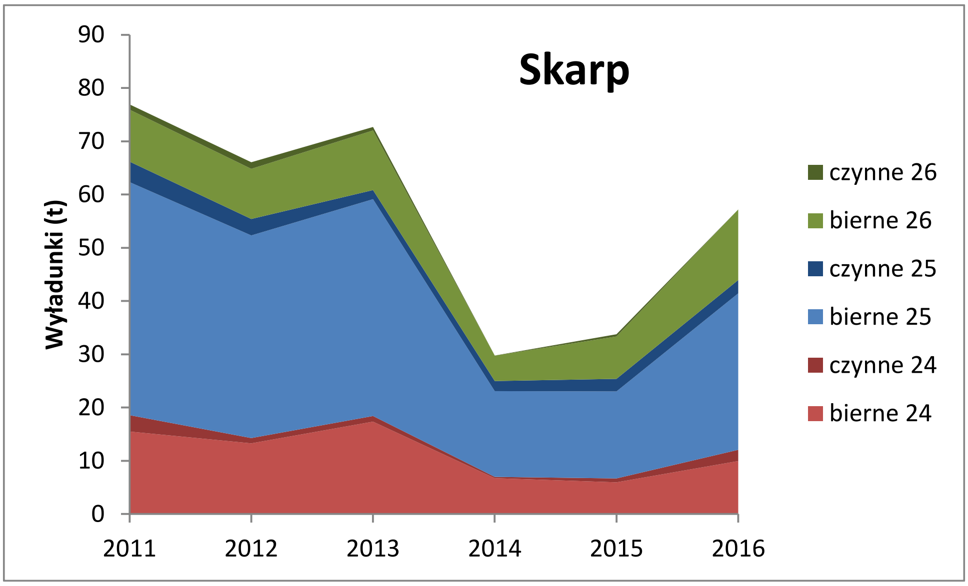



Fig. 4.3.31. Polish landings (t) of turbot in 2011-2016 by ICES subareas and by fishing gear

Length structure of the flounder in catches from POM

Since flounders from ICES subareas 24-25 belong to one southwestern stock (fle.27.2425) characterized by the same biological parameters and growth rate, and in ICES subarea 26 there are fish from a separate stock (fle.27.2628), differing from the south-west in terms of biological parameters, in this study the results of biological analyzes were presented jointly for subareas 24-25 and separately for flounders from the ICES subarea 26.

The total length distribution (*L.t.*) and the age structure of the flounder in landings and discards from 2011-2016 period are broken down into fishing gear type and ICES subareas, taking into account different stocks.

In the considered period, the scope of *L.t.* of flounder in landings and discards from passive gear in subareas 24-26 were in the range of 11-49 cm and 8-43 cm, and from active gears in the range of 15-45 cm and 5-47 cm, respectively (Fig. 4.3.32a-d i Fig. 4.3.32a-d)**.** The length distribution curves for landings depanding on gears and stocks did not change significantly over time. In most cases, they were single-peak distributions with frequency peaks falling on classes of 25-29 cm (Fig. 4.3.32a-d). In landings from passive gears in subareas 24-25, an increase in the average length of fish over the last three years can be seen (Fig. 4.3.32a). In turn, in the case of active gears, the distribution of length in particular years was similar, only in 2016 more large fish appeared in landings (Fig. 4.3.32c). The most diverse length distributions were recorded in landings from active gears in subarea 26 (Fig. 4.3.32d). The largest flounders were caught here in 2013 and 2015, and the smallest in 2014. In the case of fishing with passive gears in this subarea, the distribution of length in 2014 was most distinguished, in which the peak of attendance was shifted towards smaller length classes (Fig. 4.3.32b).

The average lengths in individual years, stocks and gears ranged from 26.5 to 32.0 cm. The largest ones were obtained in landings from passive gears in subareas 24-25 in 2011 and 2012.

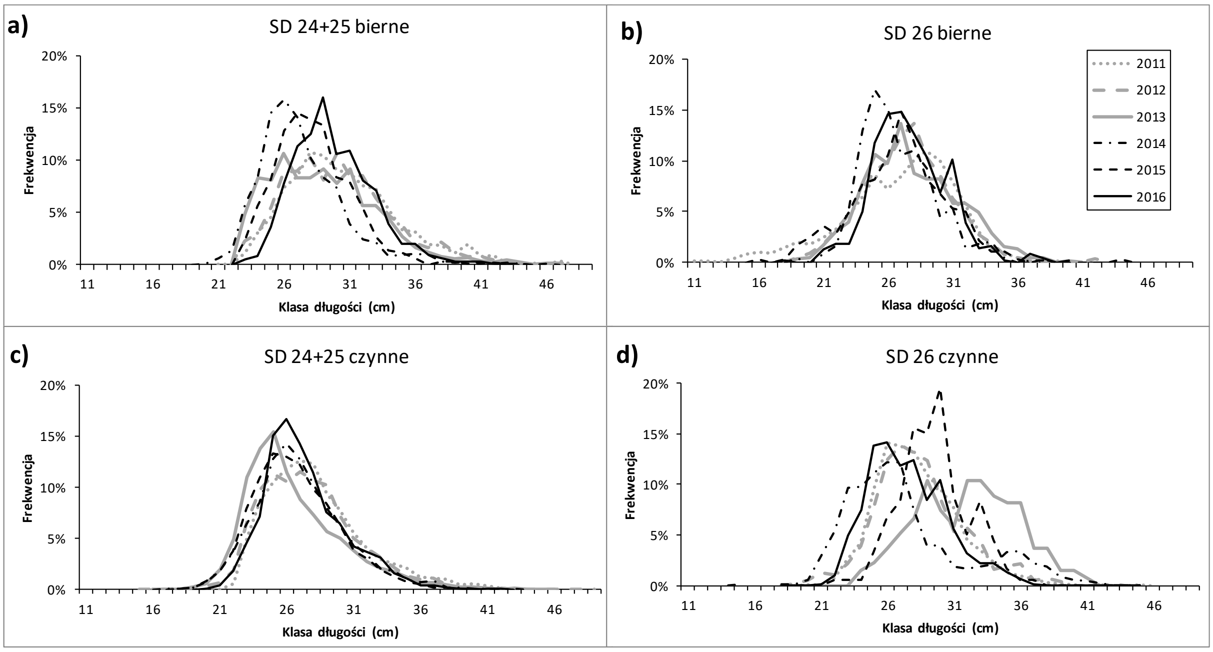



Fig. 4.3.32 Length distribution in Polish landings of flounder, taking into account the types of fishing gear in ICES subareas in 2011-2016 (as presented in figures a-d respectively)

Length structures from discards looked a bit different than from landings. Length distributions in subsequent years differed from each other, and most of them were multi-peaked (Fig. 4.3.33a-d). The smallest fish were rejected in 2011 from active fishing gear. Then in subareas 24-25 the peak of frequency for active gears was 15 cm (Fig. 4.3.33c), and in subarea 26 for passive gears at 16 and 18 cm (Fig. 4.3.33b). In comparison, the largest flounders in the dicards occurred in the active gears in subarea 26 in 2014, when the peak of length frequency was 30 cm (Fig. 4.3.33d).

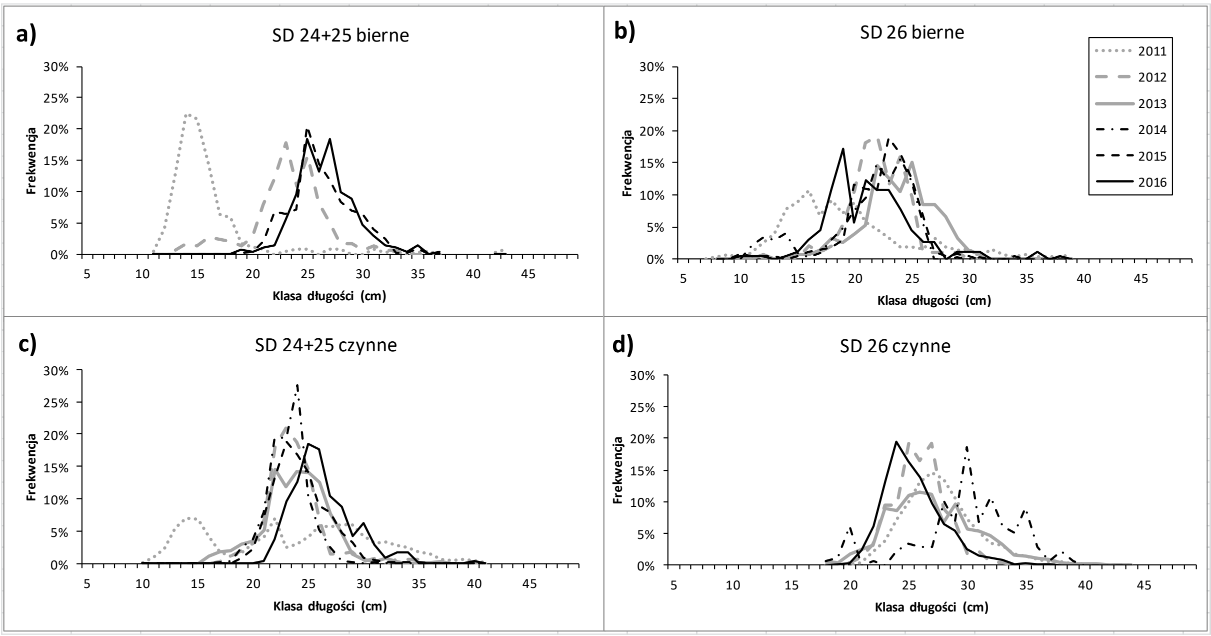



Fig. 4.3.33. Length distribution in Polish discards of flounder, taking into account the types of fishing gear in ICES subareas in 2011-2016 (as presented in figures a-d respectively)

The share of undersized flounder in catches (both in landings and discards) over recent years did not show clear trends (Fig. 4.3.34 - Fig. 4.3.35). In landings, the highest percentage (8.6%) of undersized fish was observed for passive gear in subarea 26, in 2011. (Fig. 4.3.34). In the last six years on average the most undersized fish (4.4%) were landed from active fishing in subareas 24-25.

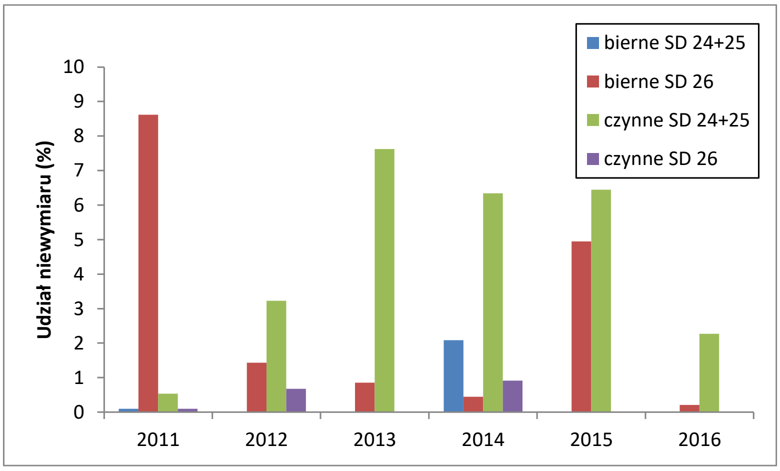



Fig. 4.3.34. Share of undersized flounders in Polish landings from various types of fishing gear in ICES sub-areas in 2011-2016

The share of undersized flounders in the discards was different (Fig. 4.3.35). Their largest percentage (91.9%) was caught using passive gear in subareas 24-25 in 2011. A high percentage of undersized flounders from subareas 24 came from by-catch samples (catches targeting perch and bream). In the remaining years, the by-catch of undersized fish caught with these gears was not so significant and did not exceed 24%. The highest mean share (32.8%) of undersized fish in discards was observed for the passive gears in subarea 26, slightly smaller (28.3%) were obtained for active gears in subareas 24-25.

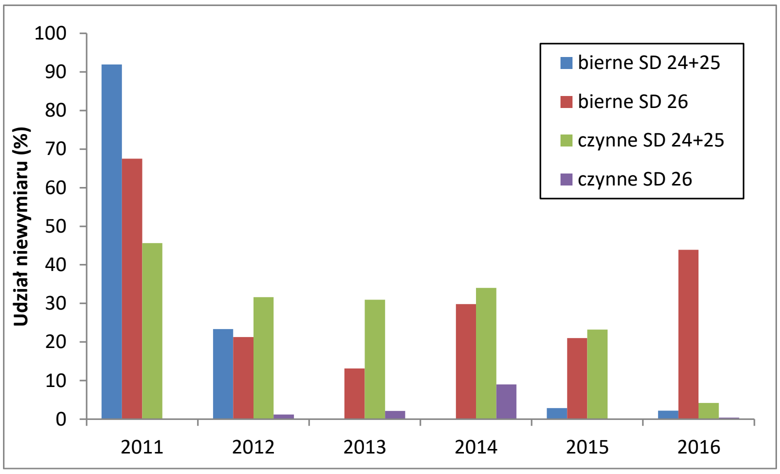



Fig. 4.3.35. Share of undersized flounders in Polish discards from various types of fishing gear in ICES sub-areas in 2011-2016

The age structure of flounder caught in POM

The age structure of flounder landings from 2011-2016, broken down into stocks and fishing gears, is shown in Fig. 4.3.36 a-d. In landings from recent years, the largest share of the 3rd and 4th age groups was observed. Only in the landings from active gears in subareas 24-25 the 4th and 5th age group dominated. With passive gears, fish from the 2nd to the 17th century were caught, and active gears from 1 to 16. Due to the small number of individuals above 9th age group, individuals from this group and older in Fig. 4.3.36 a-d were presented together.

In landings from passive gears (and to a lesser extent from active ones) from subareas 24-25, an abundant generation could be observed - in three subsequent years (2014-2016) the stock was dominated by the fertile generation born in 2011. In 2014, the largest share had 3 age group, in 2015 - 4, and in 2016 - 5 (Fig. 4.3.36a). These generations are also visible in the appropriate length distribution, where attendance peaks from three consecutive years move towards larger lengths (Fig. 4.3.32a).

In subareas 24-25 in landings from both types of gears, only in 2016 the dominant age group was group 5 (Fig. 4.3.36a i Fig. 4.3.36c), thus the oldest among the dominant groups. The reflection of this system can also be seen in the distribution of length, in which the longest fish in 2016 have the largest share (Fig. 4.3.32a).

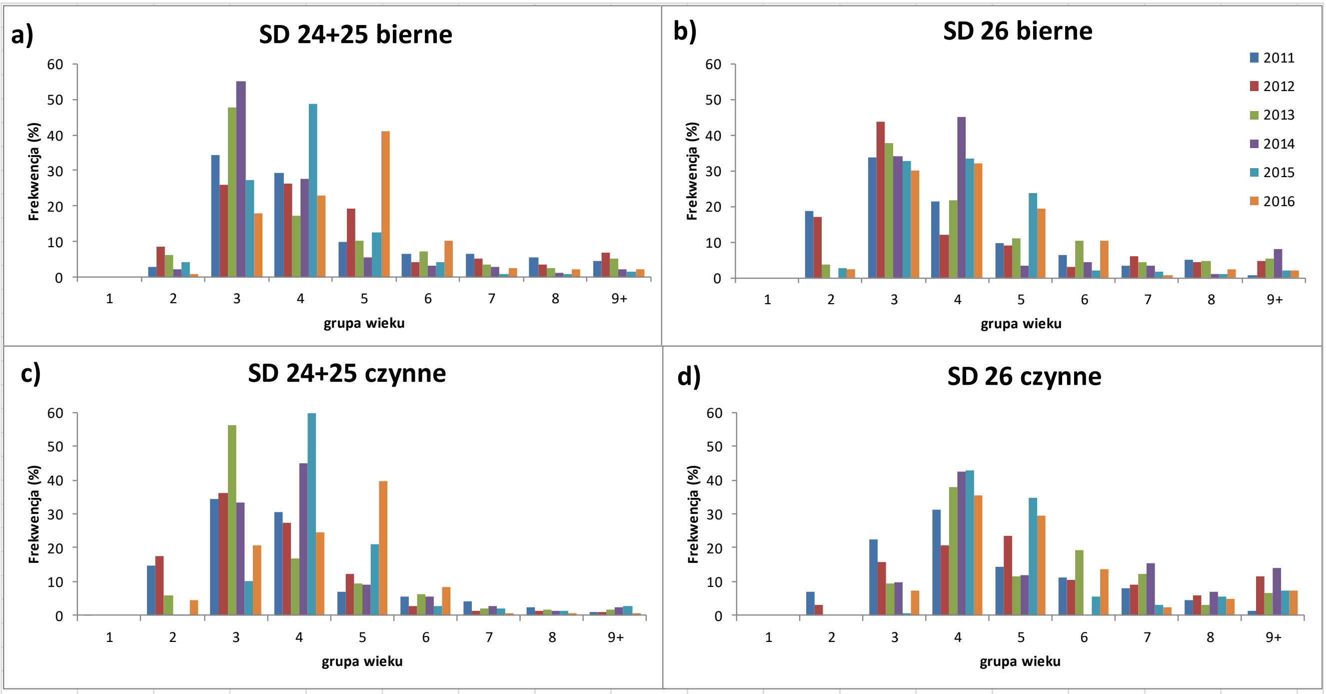



Fig. 4.3.36. Age distribution in Polish landings of flounder, taking into account the types of fishing gear in ICES subareas in 2011-2016 (as presented in figures a-d respectively).

## Salmonidae exploitation

The exploitation of salmonids in POM includes two basic species: salmon (*Salmo salar* L.) and sea trout (*Salmo trutta m. trutta* L.). In the open sea, mainly salmon and trout are caught, and in the coastal zone - mainly trout. In both cases, as by-catch, the rainbow trout (*Oncorhynchus mykiss* Rich) may occur - "escapees" from aquaculture.

Both the exploitation of salmon and trout resources is largely dependent on the level of replenishment through restocking by the Baltic States.

In Polish salmon fisheries in the years 2011-2016, the share of specimens of natural origin ("wild"), constituted from 11 to 17%, without a specified trend.

In the case of sea trout, there are no similar data on the share of fish from natural in the catch, and intensive restocking of Polish rivers (1-1.5 million smolts per year), restocking by other Baltic countries and the lack of strong natural populations in Polish rivers causes the Polish trout fishing to be practically independent of natural reproduction, and even based on fish restocking.

Both species can be caught with the same equipment. Until 2007, the main fishing gears used in salmon fishery in POM waters were driftnets and drifting longlines. From 01.2008, a ban on driftnets was introduced (Council Regulation (EC) No 812/2004 of 26 April 2004 laying down measures on incidental catches of cetaceans in fisheries and amending Regulations (EC) No. 88/98 (Official Journal EC L 150, 30/04/2004, p.12, as amended - Journal of Laws of the EU, Polish Special Edition, item 4, Vol. 7, p. 91), Regulation No. 2187/2005) and from that moment in POM salmonid fishing is mainly performed with anchored gillnets and longlines, however, these fish may also be caught as by-catch in trap gears (e.g. fyke nets, pound nets) or towed (trawls, pelagic pair trawls, Danish seines). In recent years, recreational fishing for salmon and sea trout, mainly using troll lines (trolling), has been developing significantly.

In POM for salmonids in 2011-2016, the following protective provisions established by Council Regulation No 2187/2005 were in force:

- protective landing size (minimum) of salmon 60 cm, Sea trout in subareas 24 and 25 -40 cm, and in subarea 26 - 50 cm.

- minimum mesh size in gillnets: mesh size = 80 mm and #> 157 mm (except for the Puck Bay, where the mesh width is 70 mm - OIRM Management No. 1 in Gdynia as of 28.05.2012) and the width of the hook 19 mm.

- a ban on fishing from 1 June to 15 September outside the 4-mile coastal strip, with the possibility of by-catch in this period in trap gear type.

In addition, in POM there is a ban on fishing for salmon and sea trout from 15 September to 15 November in a 4-mile internal waters zone excluding waters in OIRM management in Gdynia (Ordinance of the Minister of Maritime Economy and Inland Waterway Transport of September 16, 2016 on dimensions and periods of protection of marine organisms and detailed conditions of sea fishing (Journal of Laws, item 1494)).

In internal waters managed by OIRM in Szczecin, it is forbidden to catch salmon and sea trout in the period September 25 - November 15.

Around the mouths of a number of Pomeranian rivers and the Vistula the Vistula Lagoon, protective areas were established by individual District Sea Fisheries Inspectors to allow the salmon and trout to enter these rivers for spawning.

From 1 January 2015, the EU ban on salmon discards applies to commercial fishing all over the Baltic Sea (Regulation No. 1380/2013). In the recreational and recreational fishing in POM, 2 salmon and 2 trouts are allowed to be caught daily (ordinance of the Minister of Agriculture and Rural Development of 6 July 2015 on the dimensions and protective periods of marine organisms caught in recreational fishing and detailed methods and conditions of exercise recreational fishing.

Supplementary protection measures in marine internal waters in the area of Gulf of Gdańsk are provisions regarding the number of fishing gears deployed and the minimum distances between them (Order No. 1 of the District Sea Fisheries Inspector in Gdynia of 1 June 2010 on the dimensions and protection periods of marine organisms and detailed methods of marine fishing in the internal sea waters in the area of Gulf of Gdańsk and the ordinance of the Minister of Agriculture and Rural

Development of 4 March 2008 on the dimensions and protective periods of marine organisms and detailed conditions for performing marine fishing).

The exploitation of salmon stocks in the Baltic Sea is managed by the EC on the basis of ICES advice and since 1990 the total allowable catch (TAC) has been set annually, under which Poland receives the quota (in individuals) to be caught. This amount, in turn, is divided by the minister responsible for fisheries into individual quotas per fishin unit. In various years different divisions were used, e.g. in 2011, individual amounts ranged from 23 to 70 individuals per fishing unit, and in 2013 from 5 to 362 individuals per fishing unit. The size of the national amount decreased from 15 723 individuals in 2011 to 6 030 individuals in 2016, hence the decline in salmon catch.

Baltic Sea trout resources are managed at the level of Member States and are not limited since many stocks belong to local communities and so far there are no EU regulations governing the management of resources (quotas) as those existing for salmon.

In the years 2011-2016, Polish catches of salmon amounted to around 6,200 - 3,100 individuals per year (Fig. 4.3.37) and could have been greater, as the total quota was not used every year. The catch trend has a slightly decreasing trend, mainly due to declining fishing quotas. Catches of sea trout amounted annually to around 29,000 - 51,000 individuals. The trout's catch trend is more declining.

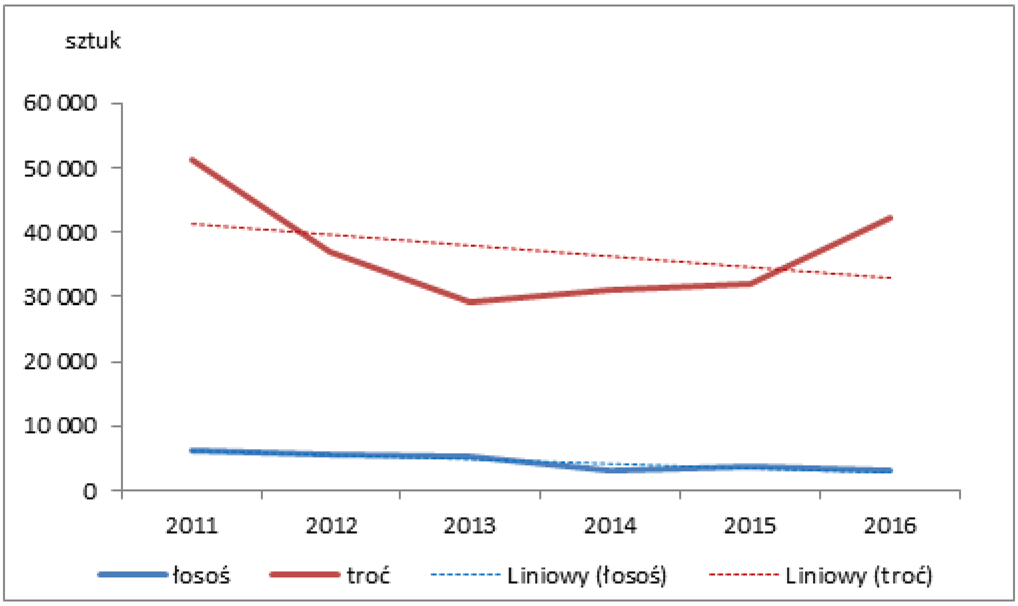



Fig. 4.3.37. Catches (pcs.) of salmon and sea trout in POM in 2011-2016

Salmon catches were mainly carried out in the open sea in subarea 26, constituing approximately 50-70% of total salmon catch and in subarea 25 (27-56% of catch), whereas from subarea 24 only up to 0.5% of total salmon catch (Fig. 4.3.38). The best season for salmon catches in the open sea are months: I-III and XI-XII. Salmon catches were mainly performed with longlines (60-90%) and gill nets (9-38%), as well as other (about 1%). In the last three years, the trend of catches with gillnets (GN) increased, and the trend of drifting longlines (LLD) decreased (Fig. 4.3.39).

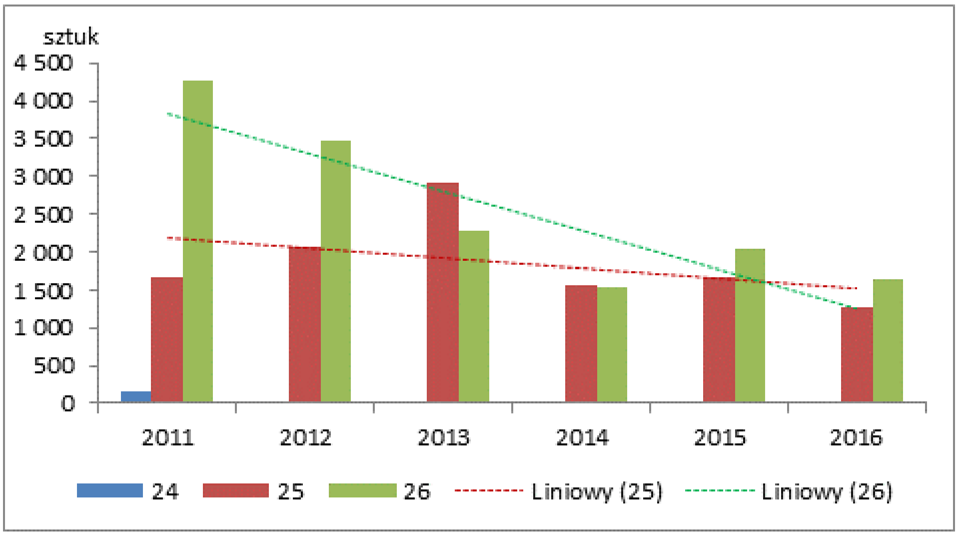



Fig. 4.3.38. Catches (pcs.) of salmon in POM in 2011-2016 in ICES subareas

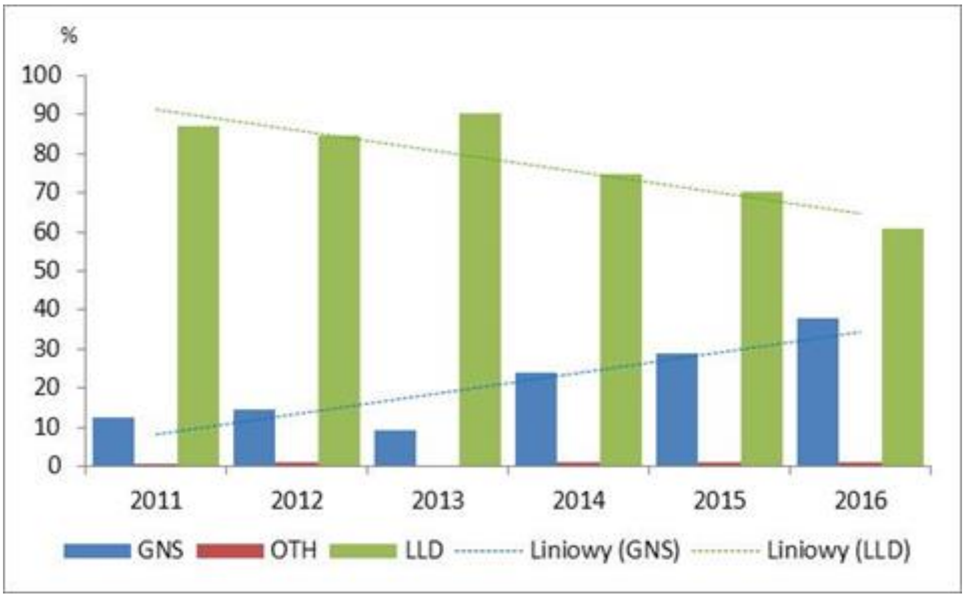



Fig. 4.3.39. Catches (%) of salmon in POM in 2011-2016 by fishing gear

Trouts are caught in about 30% by vessels under 12m in length (boats), operating in coastal waters and using anchored driftnets and trap gears. The rest of catch comes from larger units (fishing boats) outside the coastal zone. From 55 to 80% of the sea trout catch came from subareas 26, from 14-41% from subareas 25, and 1-7% from subareas 24 (Fig. 4.3.40). The best season for salmon catches in the open sea are months I-III and XI-XII. In the case of sea trout (Fig. 4.3.41), unlike in the case of salmon, an increasing trend of catches for gillnets (GNS), and a declining trend for drifting longlines (LLD) was observed.

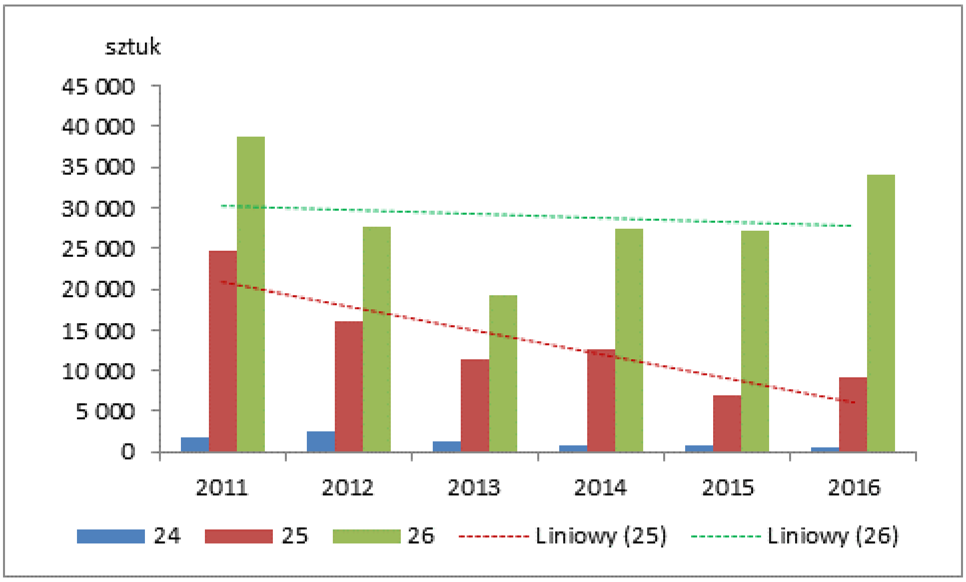



Fig. 4.3.40. Catches (pcs.) of sea trout in POM in 2011-2016 in ICES subareas

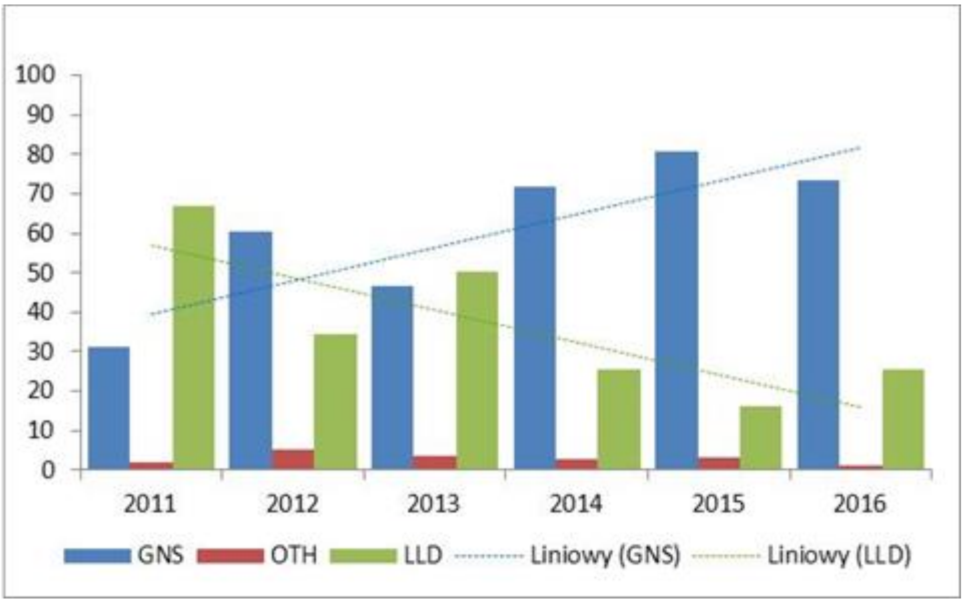



Fig. 4.3.41. Catches of sea trout in POM in 2011-2016 by fishing gear

The length of caught salmon ranged from 60 to 114 cm (Fig. 4.3.42). In 2011-2015, the modal lengths (most common values) were similar and ranged from 70 to 75 cm, i.e. the trend of modal length was stable. Only in 2016 the modal length rose to 80 cm. The share of undersized fish (below 60 cm) in 2011-2016 accounted for about 2-6% of the number of examined fish, with a declining trend (Fig. 4.3.43).

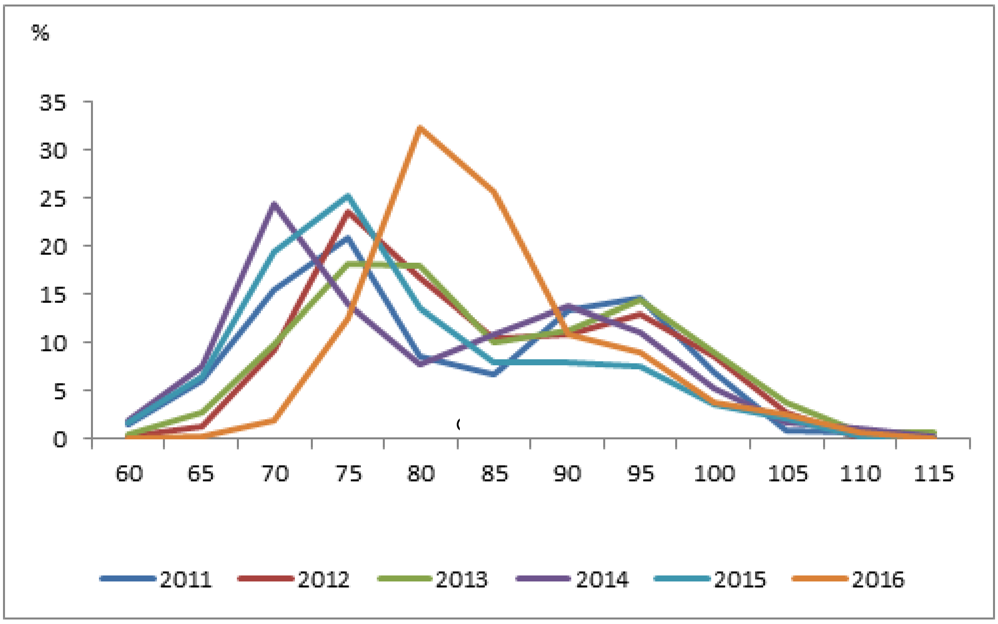



Fig. 4.3.42. Lenght distribution of salmon caught in POM in 2011-2016

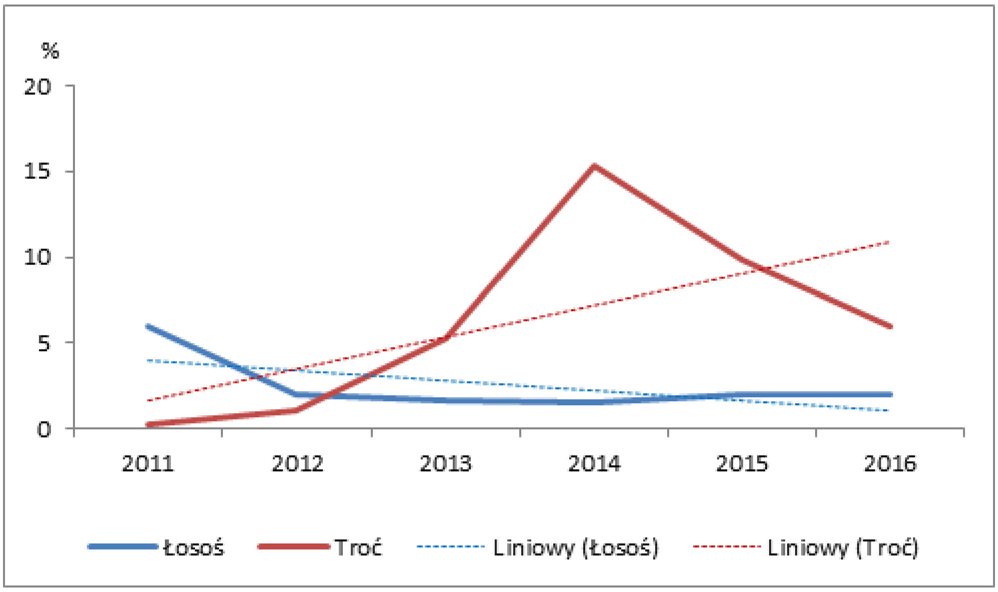



Fig. 4.3.43. Share of undersized fish in catch of salmon and sea trout in POM in 2011-2016

In terms of age, salmon was aged 1+ to 6+, with the most frequent modal 2+ and 3+, representing 35 to 60% of the share in catches. Only in 2014, the modal age group was 1+. The trend of modal share was stable, except for 2016, where the modal (about 45%) were fish of the 3+ age group (Table 4.3.8). A larger share of older and larger fish may indicate declining fishing pressure and/or a slight improvement in the status of salmon stock.

Table 4.3.8. Share (%) of salmon age groups in catch in POM in 2011-2016.

| Size group | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| 0+ | 0 | 1.3 | 0.5 | 0.0 | 1.3 | 0 |
| 1+ | 33.2 | 23.9 | 31.1 | 55.1 | 11.1 | 2.8 |
| 2+ | 50.9 | 56.8 | 59.3 | 35.2 | 47.2 | 39.7 |
| 3+ | 13.9 | 16.6 | 7.2 | 7.9 | 26.6 | 44.5 |
| 4+ | 1.9 | 1.3 | 1.9 | 1.8 | 9.6 | 10.8 |
| 5+ | 0.0 | 0.0 | 0 |  | 3.7 | 2.3 |
| 6+ | 0.0 | 0.0 | 0 | 0.0 | 0.5 | 0 |
|  |  |  |  |  |  |  |
|  | *modal age* |  |  |  |  |  |

In 2011-2016, the length of sea trout caught ranged from 50 to 105 cm (Fig. 4.3.44), and the modal length was virtually the same and ranged from 60 to 65 cm, i.e. the modal trend was stable.

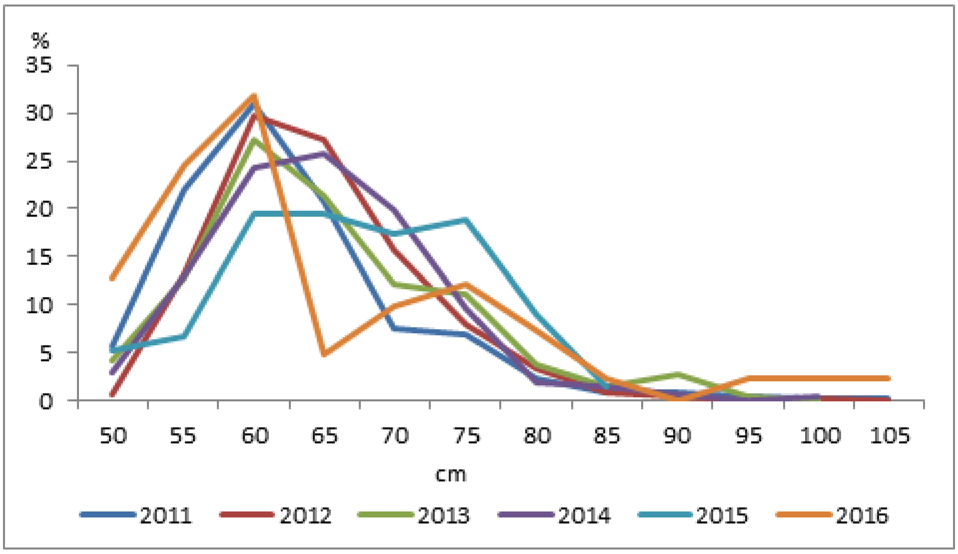



Fig. 4.3.44. Lenght distribution of sea trout caught in POM in 2011-2016

In terms of age, trouts aged 0+ to 5+ constitued catches, with a modal age group 1+. The exploitation was based mainly on young fish, feeding in the sea for one year - modal 1+, representing 55 to 90% of the share in catch. The share of undersized fish (below 50 cm) in 2011-2016 accounted for approx. 0.35.3% of the number of fish caught, with an increasing trend (Fig. 4.3.43). A larger share of fish under 50 cm may have resulted from accidental catches of juveniles - smolts (15-35 cm), especially in spring, coastal herring catches from driftnets. The trend of the share of modal age groups was stable - in all years the 1+ group was modal (Table 4.3.9). The dominant share of fish in the age group 1+ indicates very strong fishing pressure on this species. Among the age group 1+, in individual years from 1-12% of the fish were individuals below the protective dimension (50 cm), slow growing.

Table 4.3.9. Share (%) of sea trout age groups in catch in POM in 2011-2016.

| Age group | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| 0+ | 1 | 1 | 3.1 | 15.7 | 3.8 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1+ | 85 | 90 | 75.9 | 73 | 55.6 | 60.6 |
| 2+ | 13 | 7 | 19.7 | 10.7 | 30.1 | 12.1 |
| 3+ | 1 | 1 | 1.3 | 0.6 | 10.5 | 15.2 |
| 4+ | 0 | 1 | 0 | 0 | 0.0 | 9.1 |
| 5+ | 0 | 0 | 0 | 0 | 0.0 | 3.0 |
| | *modal age* | | | | | |

An increasing problem in the fishery of salmonids is the interaction with seals, destroying salmon and sea trout already in fishing gear. Data reported by fishermen directly to the MIR-PIB as part of the damage register kept by the MIR-PIB, as well as data from fishing reports (CMR) collected by MIR-PIB in 2011-2016, indicate progressive and significant losses of salmon and sea trout. In 2012, 375 salmonids were demaged, in 2015 the destruction of 7559 salmonids, and in 2016 in official fishing reports (CMR), 721 salmon and 846 sea trout were damaged. Particular losses are recorded in subarea 26 (Fig. 4.3.45), where a large seal population exists in the area of the estuary of the Vistula river, operating in many squares of this region.

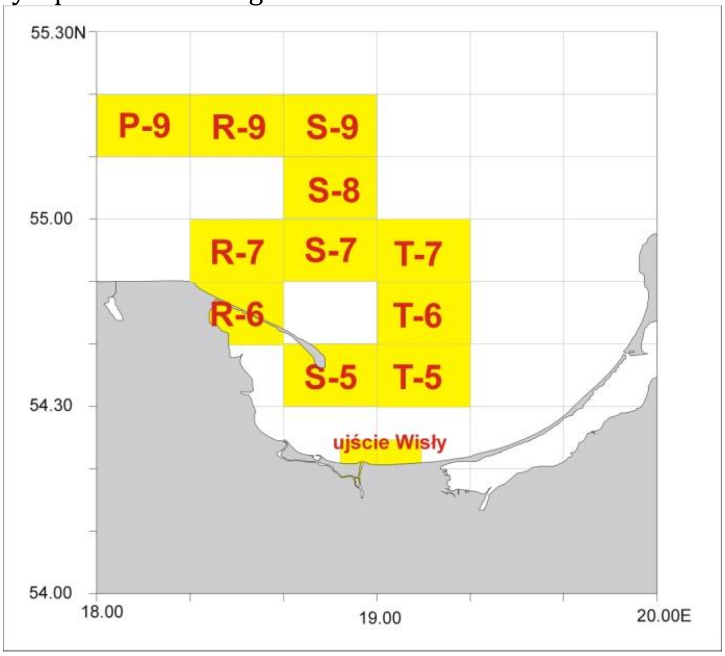



Fig. 4.3.45. Fishing squares in subarea 26 of POM, where mainly the destruction of salmonids by seals is recorded

**Exploitation of the European eel**

In accordance with Council Regulation (EC) No. 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel (O.J. L 248 of 22.09.2007, p. 17), EU Member States in which places of natural occurrence of eel have been defined are obliged to draw up management plans leading to the implementation of the objectives enshrined in this regulation. The Eel Management Plan in Poland (PGZWP) was officially approved on January 6, 2010 by relevant EU bodies. It assumes the achievement of a free eel escapement to the sea of at least 40% of escapement that would have existed if no anthropogenic influences had impacted the stock. According to the adopted document, the intended goal is to be achieved by the implementation of measures including, first of all, increasing the current restocking, unblocking the fish migration routes, and reducing the fishing mortality of eels, both from fishing and angling, at 25%. Implementation of the plan's provisions resulted in changes in the regulations on conducting fisheries in marine waters. On April 27, 2010, a protection period was introduced (June 15 - July 15) and a new unified protection dimension in the Polish territorial waters of the Baltic Sea (50 cm) - Regulation of the Minister of Agriculture and Rural Development of April 27, 2010 amending the regulation on dimensions and protective periods of marine organisms and specific conditions for the performance of sea fishing. (Journal of Laws No. 71, item 460). A little later (2011), the ordinance of April 12, 2011 amending the ordinance on the detailed manner and conditions of fishing for sports and recreational purposes and models of sport fishing permits (Journal of Laws item 490) appeared on a detailed way. and fishing conditions for sports and leisure purposes and models for sport fishing permits, introducing a catch limit of 2 eels per day. An additional form of protection for preying individuals (yellow) was the introduction of obligation in 2013 to use in the fishing gears codend of the mesh greater than or equal to 20 mm and sieves with holes allowing escape from the trap of specimens smaller than the protective dimension.

In 2016, the protective period for eel in marine waters was changed - it is covering the period from December 1 to March 31. Changes to the protection period were introduced in the OIRM Order No. 1 in Gdynia of June 20, 2016, Ordinance No. 2 OIRM in Szczecin of 22 November 2016, and the Regulation of the Minister of Maritime Economy and Inland Navigation of 16 September 2016 on dimensions and protective periods marine organisms and detailed conditions for commercial fishing.

Eel targeted fishing was developed mainly in three sub-basins of today's POM: on Szczecin Lagoon together with the coastal areas of Pomeranian Bay, in Puck Bay together with the coastal zone of the Gulf of Gdańsk from Hel to the estuary of the Vistula river and the Vistula Lagoon. The eel is caught mainly using various types of trap gears. Their structure varies depending on the area - Fyke nets (The Vistula Lagoon ,Puck Bay, Szczecin Lagoon), one-sided fyke nets (Puck Bay, Szczecin Lagoon) or “alhama” traps (Dąbie Lake) are used. A small percentage of fish are also caught using bottom hooks, mainly in the summer months during intensive feeding (Puck Bay), and in places where the setting of trap gears would be problematic due to large waving (Central Coast). Due to the low level of recruitment of natural fry of eels to Polish waters, the size of catches of adult eels forms depends on artificial restocking.

As part of the implementation of the Eel Resource Management Plan in Poland in 2011-2016, the POM zone was restocked with European eel fry. In these years, a total of 5,440,072 of stewed fry weighing on average from 2 to 10 grams were released (Table 4.3.10)

Table 4.3.10. Place and size of restocking with European eel (pcs) in 2011-2016

| Year | Szczecin Lagoon | Vistula Lagoon | Puck Bay | Total |
|---|---|---|---|---|
| 2011 | 545 000 | 343 000 | 247 000 | 1 135 000 |
| 2012 | | | | 0 |
| 2013 | 842 180 | 961 822 | 208 890 | 2 012 892 |
| 2014 | 842 180 | | | 842 180 |
| 2015 | | 1 250 000 | 200 000 | 1 450 000 |
| 2016 | | | | 0 |
| Total | 2 229 360 | 2 554 822 | 655 890 | 5 440 072 |

Restocking has the greatest impact on the results of catches, which increased from an average of 37.7 tonnes in 2011-2014 to an average of 50 tonnes in 2015-2016 (Table 4.3.1).

The size of 50 cm fish living in the POM zone reach at the age of 4 after restocking. In the years 2015-2016, 791 eel were measured. The distribution of length in 2015 and 2016 was similar to the peak length of between 50 and 60 cm.

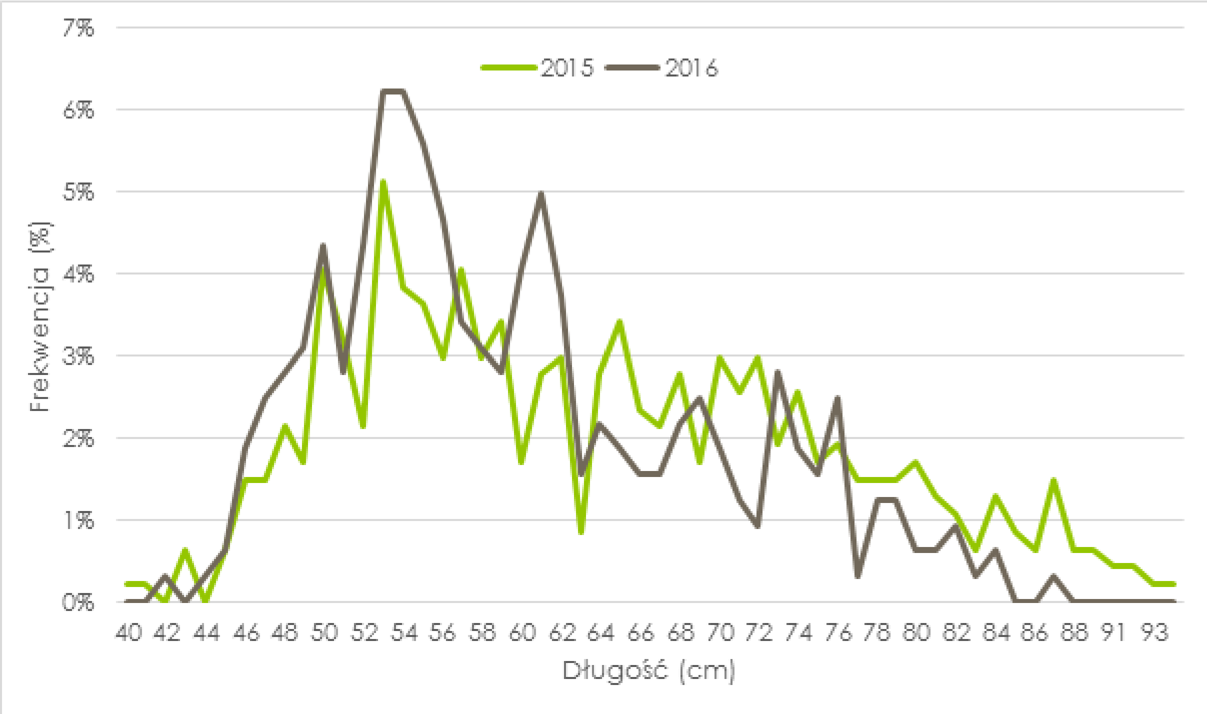



Fig. 4.3.46. Lenght frequency of eels caught in 2015 and 2016 in Szczecin Lagoon and Vistula Lagoon.

In the coming years, a further increase in the share of eels above 50 cm from stocking in 2011 and 2013 is expected. Age data from 2015 and 2016 indicate that the protective dimension of eels is achieved already at the age of 4 and 5 years. A significant share of these age classes is shown in Fig. 4.3. and Fig. 4.3.47. In 2016, the share of fish in the 4th and 5th age group reached over 50% at the Szczecin Lagoon and over 60% at the Vistula Lagoon.

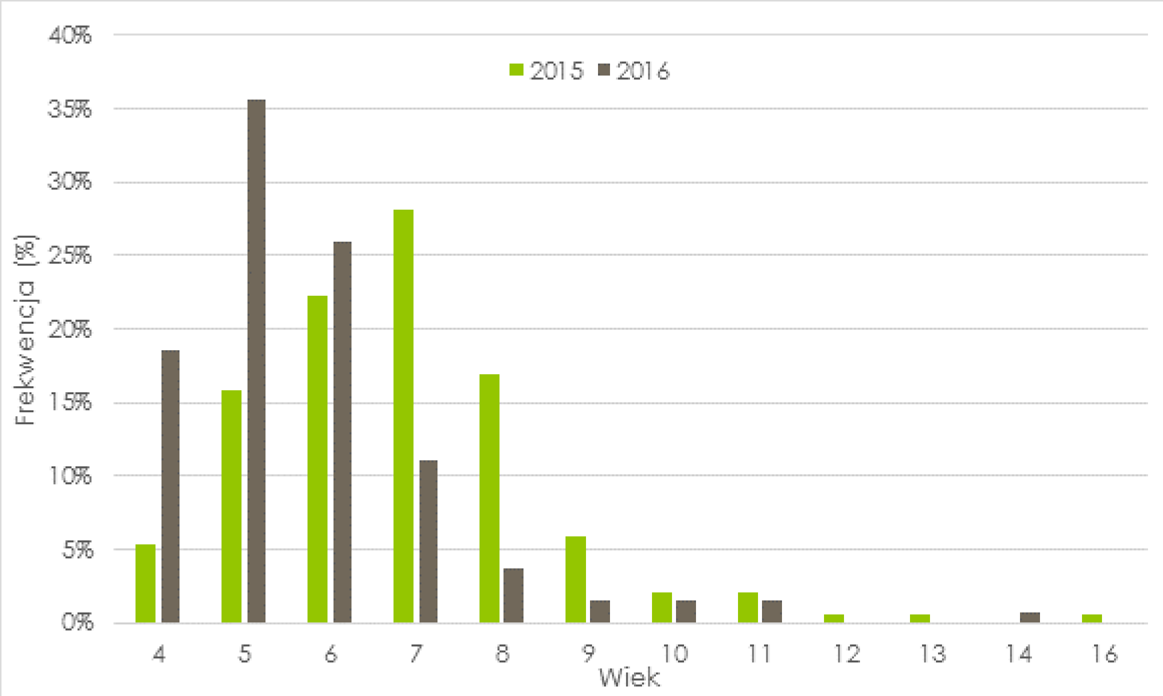



Fig. 4.3.47 Age distribution frequency of eels caught in 2015 and 2016 in Szczecin Lagoon.

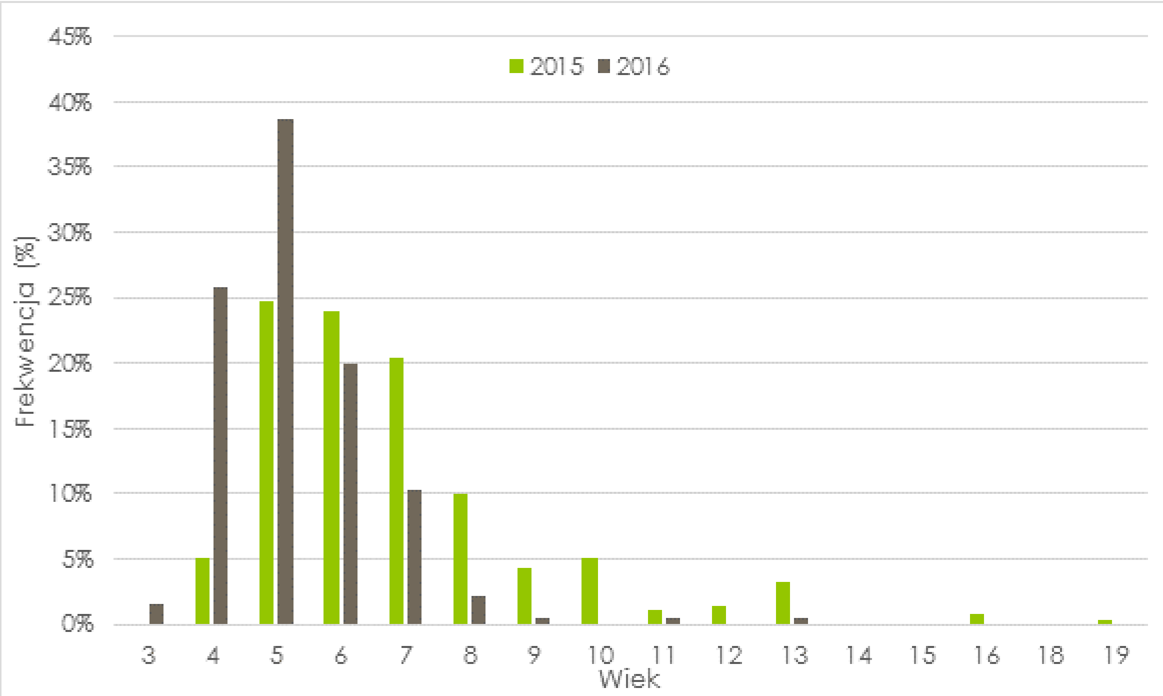



Fig. 4.3.47. Age distribution frequency of eels caught in 2015 i 2016 in Vistula Lagoon.

***Fishing exploitation at Szczecin Lagoon***

## Characteristics of Szczecin Lagoon

Szczecin Lagoon is a part of the Oder estuary and is connected with the Baltic Sea by three straits, ie Piana, Świna and Dziwna. River water runoff to the Baltic Sea is 78% by Świna, 14% by Dziwna and 8% by Piana. These straits form the so-called a return delta through which the mixing of river and sea waters takes place.

The Szczecin Lagoon is divided into the Zalew Wielki with an area of 410 km2, constituting the Polish territory and the Small Lagoon with an area of 277 km2, lying on the German waters. A water track from Świnoujście to Szczecin with an average depth of 10 m was build in the Great Lagoon.

The natural, maximum depth of the Great Lagoon is 8.5 m, and the average depth is 3.8 m. The extent of the Szczecin Lagoon and the its coast structure results in the winds blowing on this basin cousing waving with high dynamics. This waving, as well as the "backwater" of sea waters characteristic for this basin and the necessity of regular deepening of the fairway, result in a relatively large mixing of the lagoon waters and bringing all kinds of pollution to the sea. According to the WFD, the status of the Lagoon waters was described as "moderate". Excessive development of phytoplankton (mainly cyanobacteria and diatoms) and suspended organic matter is effectively eliminated by the activity of biofilters, i.e. the zebra mussel Dreissena polymorpha. The numerous representation of macrozoobenthos in which the larvae of insects and molluscs predominate causes the Szczecin Lagoon to be one of the richest fisheries in which approximately 50 fish species can be found. Comparing the largest Polish estuaries and lagoons, i.e. the Szczecin Lagoon, the Vistula Lagoon, the Puck Bay and Gardno Lake, Szczecin Lagoon is characterized by the highest efficiency of industrial fishing.

## Fishing effort in 2011-2016

According to OIRM Szczecin data, in 2004 in Szczecin Lagoon and adjacent waters (Dąbie Lake, Kamieński Lagoon), 158 fishing boats were engaged in fishing, deploying 2422 fyke nets and 5385 gillnets. In 2009, registered fishing boats were 105, which deployed 3575 gillnets and 1841 fyke nets, in 2010 there were 98 boats with special fishing licenses for the exploitation of 3390 gillnets and 1824 fyke nets. Regulation No. 2 of the Regional Sea Fisheries Inspector in Szczecin of 17 November 2016 on the dimensions, protection periods of marine organisms, areas excluded from fishing and detailed conditions for commercial fishing on sea internal waters and on Lake Dąbie, in § 9 para. 1 states that on the basis of the historical base from 2010, the following fishing gears are allowed on the waters of the Szczecin Lagoon and adjacent waters:

- fyke nets - 1824 indiv.;
- alhama nets – 184 indiv.;,
- one wing fyke net- 873 indiv.;
- gillnets– 3332 indiv.;
- trammel nets – 79 indiv.;
- przywłoki – 7 indiv.;
- seines – 5 indiv.;
- longlines 59.399 hooks.

In 2016, the number of fishing vessels holding "Special fishing permits" was 110 boats.

In order to determine trends in fishing effort, we present below a list of the number of boats, fyke nets and gillnets in 2004 (the year of Poland's accession to the EU), in 2010 - the end of the fishing vessels scrapping process and in 2016.

Table 4.3.11. Data according to OIRM Szczecin.

| Year | number of boats | % | number of gillnets | % | number of fyke nets | % |
|---|---|---|---|---|---|---|
| 2004 | 158 | 100.0 | 5385 | 100.0 | 2422 | 100.0 |
| 2010 | 98 | 62.0 | 3332 | 62.0 | 1824 | 75.3 |
| 2016 | 110 | 69.7 | 3332 | 62.0 | 1824 | 75.3 |

As can be seen from the statement, the number of gillnets in the period 2004-2010 was reduced in proportion to the number of fishing vessels withdrawn from service, and in 2016, despite the increased number of boats - remained at the level of 2010. The reduction in the number of fyke nets was not directly proportional to the reduction of fishing vessels, but also the number of fyke nets has not increased despite the increase in the number of boats. The quantities of other fishing gear were reduced in proportion to the number of boats in 2004-2010/2016.

**Fishing regulations**

Legal acts defining the principles of fishing in the waters of Szczecin Lagoon up to 2015 are:

I. The Act of 19 February 2004 on Fisheries (Journal of Laws, item 574, as amended) specifying, inter alia, maritime fisheries administration authorities and their competences. According to art. 50 of this Act - the maritime fisheries administration bodies are:

1) minister competent for fisheries (currently Minister of GMiŻŚ),

2) district sea fisheries inspectors - as non-combined administration bodies.

According to art. 5 6 of this Act, supervision over compliance with fisheries regulations is exercised by the district sea fisheries inspectors through the marine fisheries inspectors called "inspectors". Inspectors in the performance of their activities cooperate with the agencies of the Trade Quality Inspection of Agricultural and Food Products, Customs Inspection, Veterinary Inspection, Police, State Fisheries Guard, Border Guard and local maritime administration bodies. In chapter 2 pt. "Execution of fisheries" This act also specifies the conditions that must be met by the ship owner wishing to fish in the territory of the Republic of Poland i.e.:

- each vessel authorized to fish must have a Polish nationality,
- each fishing vessel must be entered in the 'register of fishing vessels' and then obtain an individual identification number and a fishery mark,
- each fishing vessel must have a "fishing license" and a "special fishing permit" which the Minister of RiRW issues for the Polish EEZ and "Special fishing permits" for fishing in Polish internal marine waters are issued by territorial District Naval Inspectors.

II. Regulations of Regional Maritime Fisheries Inspectorates. According to art. 32 of the Act of 19 February 2004 on Fisheries the competent district maritime fisheries inspector, after consulting the research and development unit or a university designated by the minister responsible for fisheries, socio-professional organizations of fishermen and the competent voivode, specifies in the form of Ordinance:

1) permanent protective areas or protective areas for a definite periods along with detailed fishing conditions;
2) protection dimensions and periods of marine organisms in internal marine waters;
3) detailed method of fishing in internal marine waters, including:
   a) type and quantity of fishing gear and their construction;
   b) order of fishing and marking of fishing gear;
   c) the way fishermen occupy their spots;
4) with a view to the protection and rational use of living marine resources.

In the context of this statutory delegation, the Regional Sea Fisheries Inspectorate in Szczecin has published the following ordinances:

1) ordinance No. 1 of the District Sea Fisheries Inspector in Szczecin of May 25, 2011 regarding the determination of protective dimensions and protection periods of marine organisms (Journal of Laws of West Pomeranian Voivodeship No. 68, item 1210) on Polish

maritime internal waters to the west from the meridian of 15 ° 23'14''E. This ordinance defines the protective dimensions for 24 species of fish found in catches in the waters of Szczecin Lagoon - among others: the protective dimension of the bream is 40 cm in length, perch - 17 cm, roach - 17 cm, Common whitefish - 40cm, pike - 45cm, eel - 50cm and sets protective periods for the following species of fish: pike - from March 1 to May 5, zander - in 4 to 6 weeks between April 5 and May 25, Common whitefish - August 20 October to December 15, salmon and sea trout - from September 25 to November 15, the wels catfish - from May 1 to June 15, Acipenser oxyrinchus (sturgeon) - from January 1 to December 31, eel - from June 15 to July 15;

2) ordinance No. 1/2008 of 15 April 2008 on the detailed manner of performing marine fishing in internal marine waters (Official Journal of West Pomeranian Voivodeship No. 44 item 941) allowing the following quantities of fishing gear to be used: fyke nets - 1883 pcs , alhama net 184 pcs, eel fyke nets 940 pcs, gillnets 3591 pcs, trammel nets 105 pcs, przywłoki 7 pcs, towed seines 5 pcs, longlines 67 thousand hooks and determines the water areas for fishing by towed seines;
3) ordinance No. 3 of the Regional Sea Fisheries Inspector in Szczecin of October 20, 2004 on protective areas and detailed conditions of fishing in those areas (Official Journal of the West Pomeranian Voivodeship No. 82, item 1436, as amended), in which fixed protection circuits (6 areas) and protective areas for a specified period (from 1 III to 5 V - 27 water areas, from 10 IV to 31 V - 10 water areas, from 5 V to 5 VI - 23 water areas, from 1 X- to 30 XI - 1 area, from 10 XI to 15 XII - 6 areas, from 1 XII- to 28 II - 4 areas);
4) ordinance No. 4 of the Regional Sea Fisheries Inspector in Szczecin of October 20, 2004 on the detailed manner of performing sea fishing in internal marine waters (Journal of Laws of the West Pomeranian Voivodeship No. 82, item 1437) regulating, among others:
    1) number of fishing gear deployed from one fishing vessel (boat),
    2) admissible length of the gillnets -50m, tremmel nets-100m,
    3) permissible length of sets (fyke nets up to 900m, gillnets and d tremmel nets up to 500m),
    4) size of the mesh side of the net in particular types of fishing gear - including the obligation to use selective sieves in eel fyke nets (Fig. 4.3.48).
    5) the size of the side of the meshes in the nets of different types of fishing gear variates, for example the perch-roach gillnets- the permissible dimension of the side of the mesh is 30 mm, others 50mm, eel fyke nets, alhama nets and eel fyke nets-14 mm.
    6) periods of prohibition on fishing with certain types of fishing gear (e.g. from November 15 to February 28, fishing with fyke nets is prohibited).

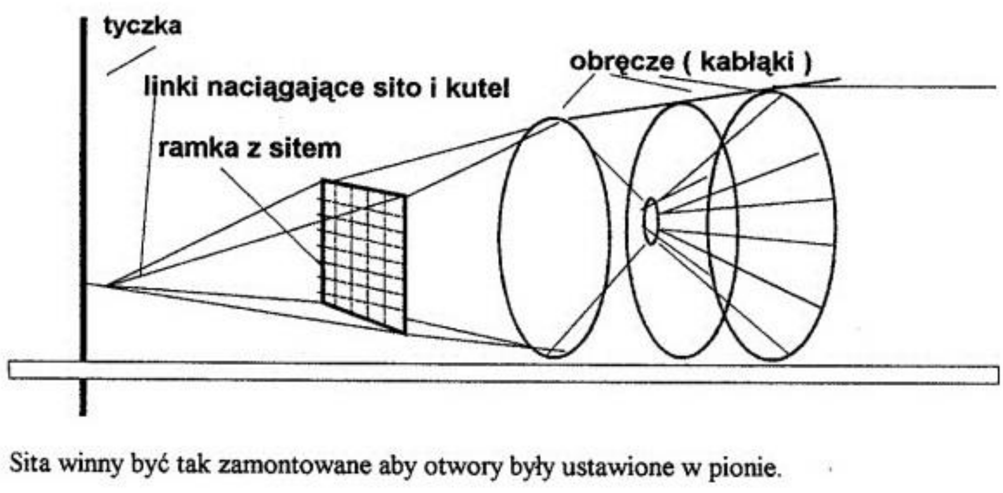



Fig. 4.3.48. The method of fixing selective sieves in fyke nets.

Catches in Polish territorial waters as well as other areas of the Polish EEZ are also regulated by Regulation (EC) No. 2178/2005.

On 17 February 2015, the Act of 19 December 2014 on sea fishing was published, which defines the principles of performing marine fishing as well as the tasks and properties of administrative bodies, and in particular regulates the principles of commercial fishing, non-commercial fishing and recreational fishing. The executive act to this act is the regulation of the Minister of Maritime Economy and Inland Navigation of 16 September 2016 on the dimensions and protective periods of marine organisms and detailed conditions for commercial fishing. On the basis of Article 11 of the Act of 19 December 2014 on sea fishing, OIRM in Szczecin issues the ordinance No. 1 of 28 January 2016 on the detailed method of dividing the herring fishing quota on Szczecin Lagoon, Kamieński Lagoon and Dąbie Lake, and order No. 2 from on November 17, 2016 on the dimensions, protective periods of marine organisms, areas excluded from fishing and detailed conditions for fishing in the internal sea waters and on Dąbie Lake. The provisions referred to here have been introduced in place of legal acts in force until 2015. According to the Ordinance of the OIRM in Szczecin No. 2, the protective dimensions for the following fish species are:

1) Bream - 40 cm,
2) Perch - 17 cm,
3) Roach - 17 cm,
4) Pike perch - 45 cm,
5) Eel - 50 cm,
6) Common whitefish - 40 cm.

**Catches and fishery resources of Szczecin Lagoon.**

Table 4.3.12. Catches of selected fish species on Szczecin Lagoon

| Year | Total catches (in tonnes) | including: | | | | | |
|---|---|---|---|---|---|---|---|
| | | Eel | Pike perch | Perch | Roach* | Bream | Lavaret |
| 2011 | 1 598.0 | 26.5 | 26.8 | 445.7 | 521.9 | 529.0 | 14.0 |
| 2012 | 1 717.4 | 18.3 | 151.8 | 569.5 | 498.8 | 422.7 | 15.0 |
| 2013 | 2 189.6 | 25.0 | 187.2 | 567.2 | 860.7 | 470.9 | 31.6 |
| 2014 | 2 204.0 | 19.0 | 134.8 | 800.9 | 679.2 | 370.6 | 9.6 |
| 2015 | 2 125.2 | 15.0 | 124.7 | 597.2 | 662.4 | 623.0 | 19.3 |
| 2016 | 2 122.3 | 21.6 | 67.1 | 691.8 | 568.7 | 625.7 | 24.7 |

* also including : white bream, zope, asp (*Source: statistic data OIRM Szczecin*)

The biggest importance for the income of fishermen in the Polish part of the Szczecin Lagoon is fishing for percidae (pike perch and perch). For example, in 2014, catches of these fish accounted for as much as 72% of the value of total catch with a share in catches of 42.5%. Correspondingly, catches of cyprinids (roach, bream, spit, asp) are about 20% of the value (47.7% of the share in catches) and the catch of eel - about 7% (share in the catch of 0.9%). (*Own calculations based on the prices of the Private limited Company. "Rybak" Stepnica and fishing statistics OIRM Szczecin for 2014*).

**Structure of catches of fish species of fundamental economic importance in 2011-2016 in fyke nets and gillnets:**

Starting from 2011, the MIR-PIB Research Station in Świnoujście participates in the implementation of the Multi-Annual Fisheries Data Collection Scheme, covering the area of the Szczecin Lagoon. In this way, data on individual measurements of commercial species (perch, pike perch, roach, bream) coming from catches carried out with fyke nets (with a mesh size ø32mm at the end of bag), perch-roach fike nets (with a mesh size of ø60mm) and pike perch fyke nets (with a mesh size of ø110-120mm) was collected.

In order to assess the trends in biomass of particular species, the results of historical research were used, because the period 2011-2016 is too short to conclude from the fishing results alone about the population variation of individual species.

## Pike perch

In the years 2011-2016, 2,320 pike perch caught with fyke nets, perch-roach gillnets and pike perch gillnets (with a mesh size of ø110-120mm) were exemined. The characteristics of pike perch collected during the research are summarized in Table 4.3.13. The total distribution of pike perch lengths caught using the above-mentioned fishing equipment is shown in Fig. 4.3.49.

Table 4.3.13. Characteristics of pike perch collected in research at the Szczecin Lagoon in 2011-2016

| Type of fishing gear | Number examined of fish | Length range (cm) | Dominant length classes (cm) | Average lenght | Dominating age groups |
|---|---|---|---|---|---|
| Fyke nets | 986 | 9 ÷ 78 | 10 ÷ 14 (31.2%) | 29.7 | 0+ |
| perch-roach gillnets | 297 | 10 ÷ 40 | 29 ÷ 35 (58.6%) | 25.7 | 1+ |
| pike perch gillnets | 1 037 | 18 ÷ 82 | 44 ÷ 51 (60.2%) | 50.0 | 3+ |
| Total | 2 320 | | | | |

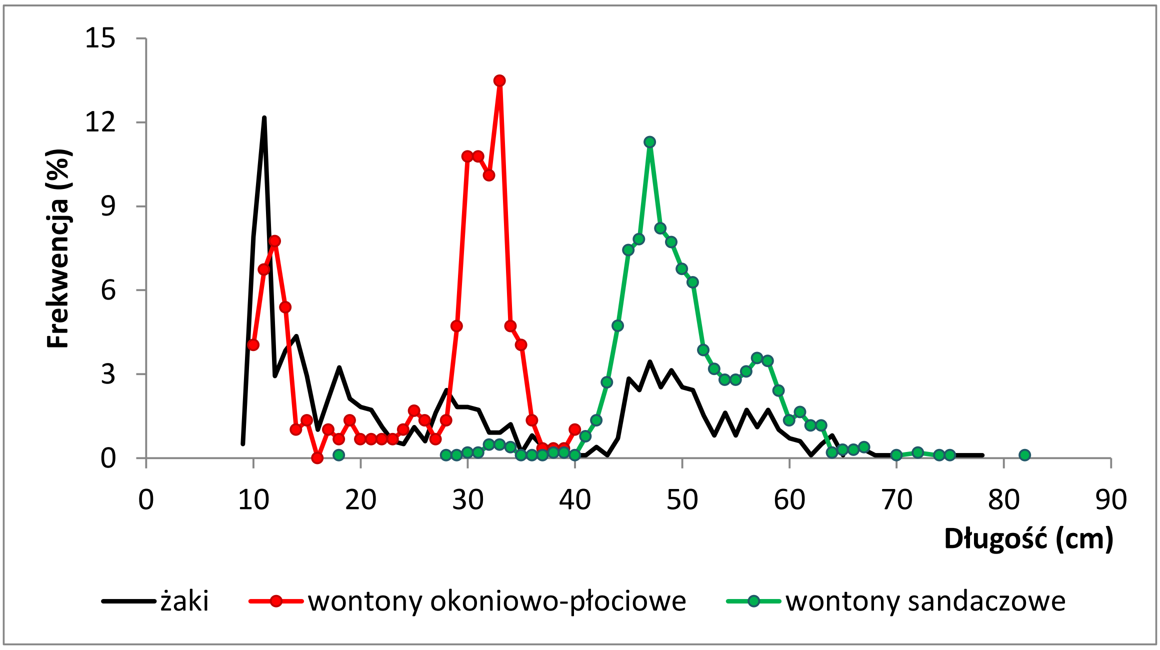



Fig. 4.3.49. Total distribution of lenghs of pike perch collected during research at the Szczecin Lagoon in 2011-2016. Colours: black – fyke nets, red – perch-roach gillnets, green – pike perch gillnets.

The total distribution of pike perch lengths varied depending on the fishing gear (Table 4.3.13; Fig. 4.3.49) indicating a fairly stable condition of the pike perch stock. In fyke nets juvenile pike perch were most numerous, which were discarde by fishermen from catch. At the same time, as much as 33.4% of pike perch caught with this equipment reached the size (45cm) size allowed to catch. In the perch-roach gillnets, undersized pike perch dominated (29-35cm), but their total attendance, in relation to all examined individuals of this species, was 12.8%. In the pike perch gillnets, the share of allowed fish (45 cm) was 87.6%

The estimation of the biomass of pike perch from Szczecin Lagoon was carried out quite a long time ago. Wengrzyn (1980) estimated it using the Beverton and Holt equations and the Gulland model for the years 1973-1980. In 1992 it was estimated by Adamski et al. (Table 4.3.14). These data indicate that the pike perch biomass, despite various regulations in the above-mentioned years, aimed at its protection, has been systematically decreasing.

Starting from the size of pikeperch catches in 2011-2016 (tab. 4.3.14) it is possible to estimate the average annual biomass of this species at a maximum of 300 tonnes. At the same time, very high variability in annual catches of this species has been noticed - for example, 2011- 33.0 tonnes, 2013 - 188.3 tonnes.

Table 4.3.14. The biomass of Pike perch according to research

| Year | Biomass (t) |
|---|---|
| *Wengrzyn, 1980* | |
| 1973 | 1 194.7 |
| 1974 | 1 101.5 |
| 1975 | 977.4 |
| 1976 | 808.7 |
| 1977 | 658.6 |
| 1978 | 566.5 |
| 1979 | 611.2 |
| 1980 | 489.9 |
| *Adamski i in. (1992)* | |
| 1988 | 535.3 |
| 1989 | 551.3 |
| 1990 | 500.5 |
| 1991 | 473.8 |

With such a large fluctuation of pike perch cetches, it is difficult to estimate its biomass, because the stock is very unstable. Analyzing catch trends for pike perch from the Szczecin Lagoon, it should rather be expected that its size in the next years will oscillate between 60 and 100 tonnes per year, and the determining factor will be supplementing the stock with a younger generations.

**Perch**

In the years 2011-2016, 8,544 perches were caught with the use of fyke nets, perch-roach gillnets and pike perch gillnets. The characteristics of perch collected during the research are summarized in Table 4.3.15. Distributions of the length of perch caught using the above-mentioned fishing gear are presented in Fig. 4.3.50.

Table 4.3.15. Characteristics of perch collected in research on the Szczecin Lagoon in 2011-2016

| Type of fishing gear | Number examined of fish | Length range (cm) | Dominant length classes (cm) | Average lenght | Dominating age groups |
|---|---|---|---|---|---|
| Fyke nets | 5 217 | 7 ÷ 38 | 15 ÷ 20 (87.0%) | 17.9 | 1-2+ |
| perch-roach gillnets | 2 224 | 12 ÷ 32 | 18 ÷ 23 (78.0%) | 20.1 | 1+ |
| pike perch gillnets | 1 103 | 13 ÷ 42 | 27 ÷ 33 (62.6%) | 28.1 | 2+ |
| Total | 8 544 | | | | |

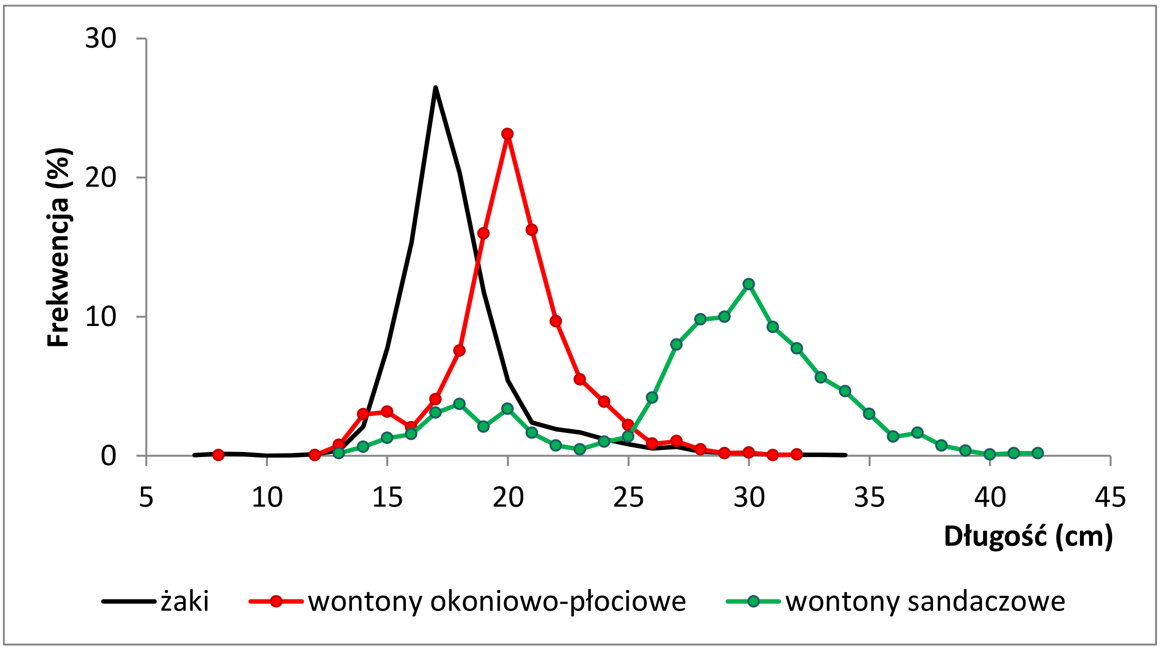



Fig. 4.3.50. Total distribution of lenghs of perch collected during research at the Szczecin Lagoon in 2011-2016. Colours: black – fyke nets, red – perch-roach gillnets, green – pike perch gillnets.

Perch length distributions observed in catches using three types of fishing gear, abundance of catches indicate their high stability.

Perch research to assess its biomass was done recently in the early 1990s. The results of these research are presented in Table 4.3.16.

Table 4.3.16. Abundance (in thousands of individuals) and biomass of perch from the Szczecin Lagoon estimated by Sawczuk (1991) and Adamski et al. (1992)

| Year | *Sawczuk (1991)* | | *Adamski i in., (1992)* |
|---|---|---|---|
| | abundance (thousand indiv.) | biomass (tonnes) | biomass (tonnes) |
| 1982 | 16 925.3 | 1 999.4 | - |
| 1983 | 16 089.5 | 1 874.1 | - |
| 1984 | 13 684.4 | 1 614.7 | - |
| 1985 | 14 600.4 | 1 474.9 | - |
| 1986 | 18 452.6 | 1 716.8 | - |
| 1987 | 21 509.4 | 1 907.5 | - |
| 1988 | 20 271.8 | 1 939.7 | 1 939.7 |
| 1989 | 17 183.0 | 1 706.1 | 1 706.1 |
| 1990 | 9 578.9 | 1 310.5 | 1 914.9 |
| 1991 | - | - | 1 896.9 |

Despite the very intensive exploitation of this species by both commercial fishermen, anglers and poachers - the state of the perch of Szczecin Lagoon is not disturbed, and its biomass in 2011-2016 can be estimated at about 1,800 tonnes, while half of this species in the next years will remain at the level of 550-600 tonnes.

### Bream

In the years 2011-2016, 3,334 breams were caught with fyke nets, perch-roach gillnets  and pike perch gillnets. The characteristics of breams collected during the research are summarized in Table 4.3.17, and the length distributions using the above-mentioned fishing gear are shown in Fig. 4.3.51.

Table 4.3.17. Characteristics of bream collected in research on the Szczecin Lagoon in 2011-2016

| Type of fishing gear | Number examined of fish | Length range (cm) | Dominant length classes (cm) | Average lenght | Dominating age groups |
|---|---|---|---|---|---|
| Fyke nets | 3 071 | 10 ÷ 63 | 16 ÷ 20; 51 ÷ 56 (50.3%) | 35.3 | 10+ |
| perch-roach gillnets | 177 | 16 ÷ 25 | 18 ÷ 20 (71.2%) | 19.6 | 2+ |
| pike perch gillnets | 86 | 20 ÷ 64 | 28 ÷ 31; 33 ÷ 35 (36.0%) | 42.5 | 10+ |
| Total | 3 334 | | | | |

The highest number of fish tested was recorded in catches with fyke nets, which are the main fishing gear used for bream fishing. Although fyke nets are a low-selectivity gear, as many as 49.9% of breams caught were over 40 cm long, and a older fish dominated in catch (age 10+). The number of breams observed in the catches carried out by the perch-roach gillnets and pike perch gillnets was negligible (177 and 86 individuals respectively). Breams caught with pike perch gillnets were not eligible for landing, as their size did not exceed the protective dimension; Among the breams observed in pike perch gillnets catches, 57.0% of the specimens were over 40 cm long.

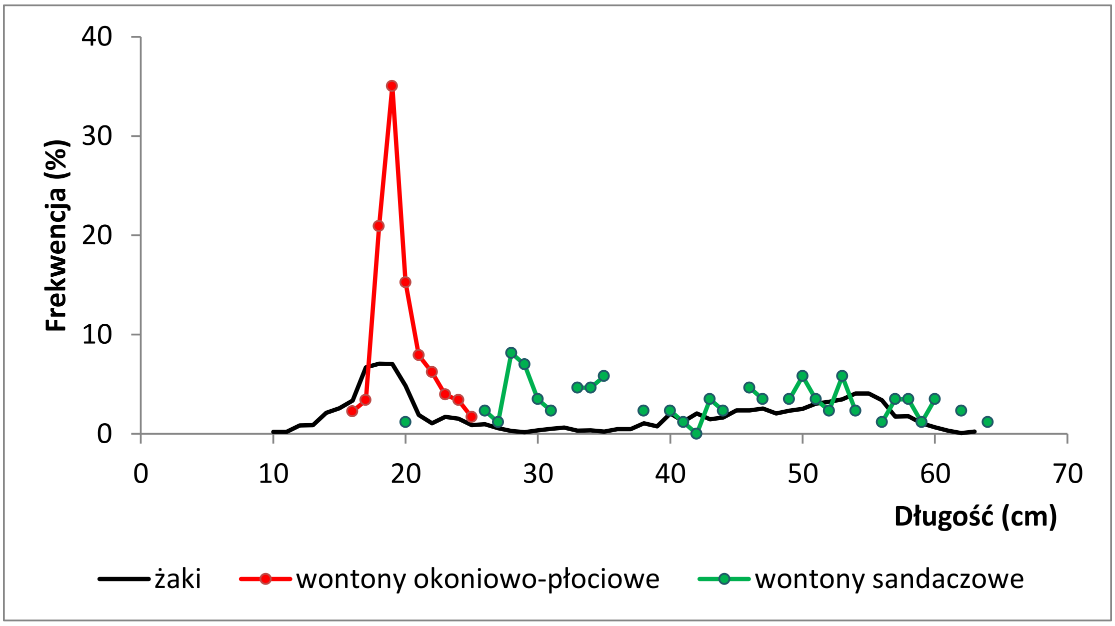



Fig. 4.3.51. Total distribution of lenghs of breams collected during research at the Szczecin Lagoon in 2011-2016. Colours: black – fyke nets, red – perch-roach gillnets, green – pike perch gillnets.

The research of bream in terms of the assessment of the state of resources was carried out in 1971-1979 (Kaczewiak, 1995), and therefore relatively long ago. When using the Gulland-Fox exponential model, the maximum allowable catch at the level of 1 070 tonnes was determined, and the rational for the stock was approximately 800 tonnes (Table 4.3.18).

Since 2005, catches below 800 tonnes per year were observed, which may indicate a decline in the population of this species in the waters of the Szczecin Lagoon. However, the migration of an adult bream from the Lagoon to the Pomeranian Bay is confirmed - especially in the periods of low abundance of Chironomidae larvae in the benthos of the Lagoon. At present, the bream biomass of the "industrial" stock is estimated at 2,000 tonnes with an acceptable catch of 500-600 tonnes per year in the following years. Nevertheless, it should be assumed that fishing for bream in the waters of the Szczecin Lagoon in the following years should be at the level of 500-600 tonnes per year.

Table 4.3.18. Abundance and estimated bream biomass in the Szczecin Lagoon in the years 1974-1979 (Kaczewiak, 1995).

| Year | Catches (in tonnes) | Stock* | |
|---|---|---|---|
| | | Abundance | Biomass (in tonnes) |
| 1971 | 806.3 | 2 891 300 | 2 481.4 |
| 1972 | 992.2 | 1 870 200 | 1 752.5 |
| 1973 | 822.5 | 2 517 800 | 2 245.8 |
| 1974 | 775.2 | 2 725 800 | 2 385.1 |
| 1975 | 677.6 | 2 728 400 | 2 409.2 |
| 1976 | 623.2 | 1 780 500 | 1 647.0 |
| 1977 | 554.1 | 1 700 400 | 1 573.0 |
| 1978 | 522.1 | 1 723 700 | 1 542.7 |
| 1979 | 534.5 | 1 824 200 | 1 827.8 |

* Data refer to six-year-old and older fish

### Common roach

In the years 2011-2016, 4,811 roaches caught with the use of fyke nets, perch-roach gillnets and pike perch gillnets. The characteristics of fish of this species are presented in Table 4.3.19, and the length distributions using the aforementioned fishing gear are presented in Fig. 4.3.52.

Table 4.3.19. Characteristics of the roach collected in research on the Szczecin Lagoon in 2011-2016

| Type of fishing gear | Number examined of fish | Length range (cm) | Dominant length classes (cm) | Average lenght | Dominating age groups |
|---|---|---|---|---|---|
| Fyke nets | 3 331 | 10 ÷ 35 | 17 ÷ 20 (66.8%) | 19.4 | 2-4 |
| perch-roach gillnets | 1 454 | 16 ÷ 34 | 19 ÷ 22 (74.1%) | 21.1 | 2-4+ |
| pike perch gillnets | 26 | 20 ÷ 37 | 30 ÷ 32 (50.0%) | 31.1 | 3+ |
| Total | 4 811 | | | | |

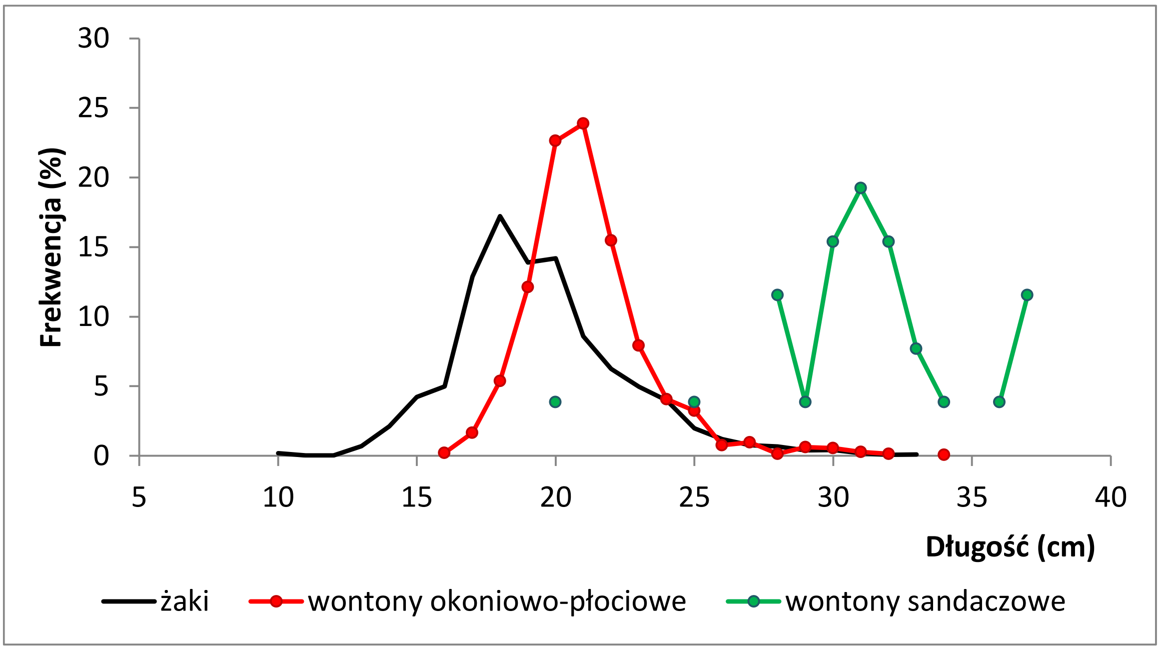



Fig. 4.3.52. Total distribution of lengh of roach collected during research at the Szczecin Lagoon in 2011-2016. Colours: black – fyke nets, red – perch-roach gillnets, green – pike perch gillnets.

In the years 2011-2016, the roach catches in the Szczecin Lagoon was mainly carried out with the use of fyke nets and perch-roach gillnets. Length distributions of the roach caught with these gears were fairly similar (Fig. 4.3.52), with slightly smaller individuals (mean length 19.4 cm) in fyke nets than in the perch-roach gillnets (average length 21.1 cm).

Similarly to pike perch, perch and bream, also the assessment of the roach biomass was made quite a long time ago (Table 4.3.20). On the basis of the exponential Gulland-Fox equation, the acceptable catch of roach at the Szczecin Lagoon was estimated at 2,328 tonnes.

Table 4.3.20. Abundance and estimated roach biomass in the Szczecin Lagoon in 1974-1979 (Grygiel & Wengrzyn, 1980)

| Year | Abundance (in thous.) | Biomass (in tonnes) |
|---|---|---|
| 1974 | 24 300 | 3 149 |
| 1975 | 56 900 | 5 622 |
| 1976 | 31 400 | 4 113 |
| 1977 | 25 900 | 3 636 |
| 1978 | 33 800 | 4 701 |
| 1979 | 29 500 | 3 534 |

Analyzing catches of the roach it should be added that in the summer season there is often a lack of demand for this fish, hence fishermen often give up their catch. Therefore, the size of catch does not reflect the actual state of biomass. Currently, it is assumed at 2500-3000 tonnes. In the years 2011-2016, the roach catches were on average of 582 t/year. It should be assumed that in the following years these catches should remain at the level of 500-600 tonnes per year.

**Common whitefish**

In the study entitled "Ochrona siei wędrownej (*Coregonus laveratus laveratus* ,L.1758) w Polsce" authors (Kuźmiński et al., 2008) state: "The unfavorable anthropogenic and environmental factors caused *Coregonus lavaretus* to be placed on the so-called "Red list of Polish ichthyofauna" as a species threatened with extinction ". In this situation, the Sea Fisheries Institute in Gdynia in cooperation with the Institute of Inland Fisheries in Olsztyn and the University of Gdańsk made a decision to actively protect the species of migratory Common whitefish by constructing a spawning stock in trout basins at the spawning establishment of salmonids in Rutki in order to conduct a restitution action in the Puck Bay and support the disappearing population of the Common whitefish in the Szczecin Lagoon and Pomeranian Bay (Research Project Order KBN No. Z022 / S3 / 9401) As a consequence in the years 1992-1994 on the Płocińka shoal near Karmocice, the spawners entering from Baltic were caught from which sexual products were obtained, while eggs were transported to ZHRŁ in Rutki. From this material, spawning stock has been created for reproduction purposes. In the history of catches carried out on Szczecin Lagoon, Common whitefish was and still is one of the most important economically caught species of fish (Table 4.3.4). In the years 1927-1939 throughout Szczecin Lagoon, 796 to 3200 kg of Common whitefish were caught annually (Pęczalska 1962). In the years 1954-1957, 643 to 1016 kg of Common whitefish were caught in the German part of the Szczecin Lagoon. On the other hand, in the Polish part of Szczecin Lagoon in the years 1956-1958 the estimated catch was about 2-3 tonnes per year (no previous data). Unfortunately, the eighties brought about the breakdown of ecological balance. Therefore, in the years 1993-1997, due to the small catch of the Common whitefish, it was listed as catches of "other species of fish", which resulted in the lack of official fish data on this species. Only in 1998 3.6 tonnes of Common whitefish catch was recorded in Szczecin Lagoon and 2.1 tonnes in the Pomeranian Bay, which was undoubtedly the result of restocking in 1995 and 1996. In the following years, as a result of the increased restocking, the common whitefish catches also gradually increased to reach in 2003 the size of 17.4 tonnes in the Szczecin Lagoon and 1.4 tonnes in the Pomeranian Bay This is the highest recorded level of catch in history (excluding current German catches), exceeding the level of approx. 12 tonnes from the early 1970. Only in 1971 in Szczecin Lagoon, 13.5 tonnes of Common whitefish was caught, i.e. 100 kg more than in 2001.

In the years 1995 -2002, 7,350 thousand fry from ZHRŁ Rutka were released to the Szczecin Lagoon. In the years 2005-2007, restocking was carried out by PZW Wrocław and PZW Szczecin, releasing 1 612, 25 thousand fry to the Oder river and Szczecin Lagoon. The restocking is also carried out by Germany. In 2014, to the waters of J. Dąbie, the company Modehpolmo Sp. z o.o. Szczecin has allowed 350,000 pieces of fry coming from Bellowo Hatchery. The Common whitefish is an example of successful restitution of this species to the area of the Szczecin Lagoon and the Pomeranian Bay.

**The effect of restocking of Common whitefish on catches of this species.**

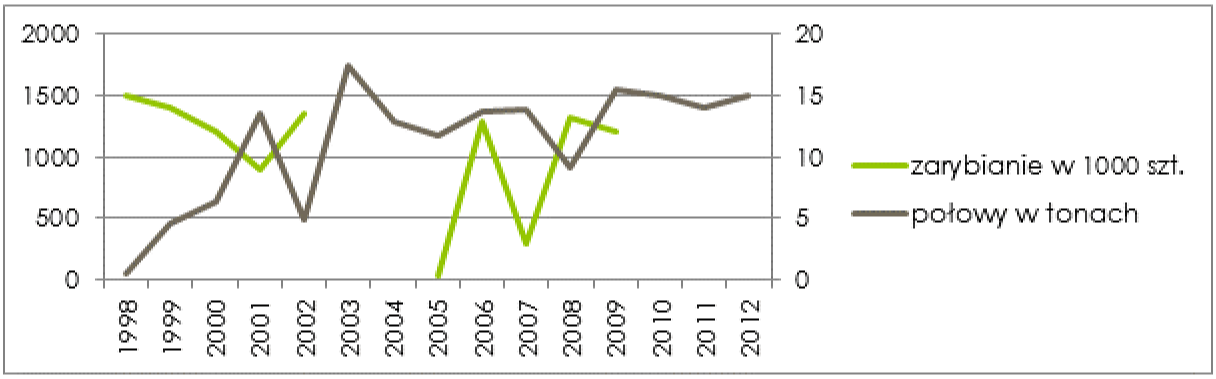



Fig. 4.3.53. In the Polish part of the Szczecin Lagoon. Restocking – green colour, catches – grey.

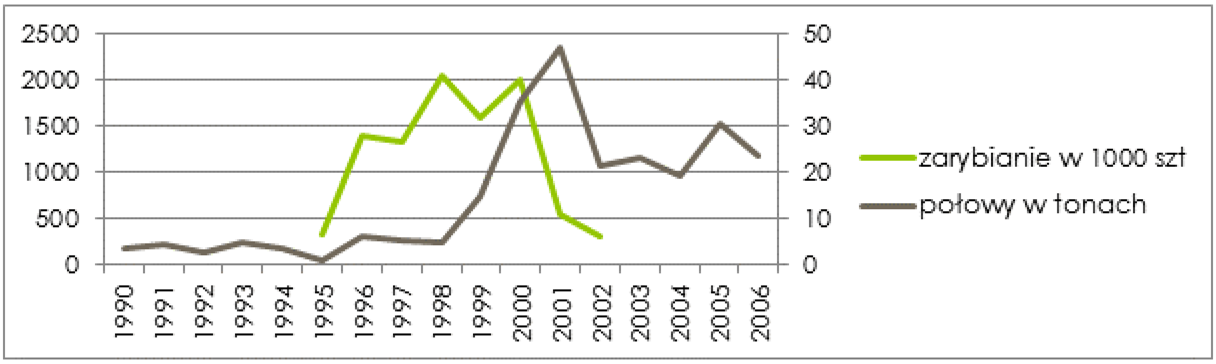



Fig. 4.3.54. In the German part of the Szczecin Lagoon and neighboring areas Peenestrom i Achterwasser. Restocking – green colour, catches – grey.

Based on the reported catches in 2011-2016 Common whitefish biomass, periodically occupying waters of the Szczecin Lagoon, can be estimated at 40-50 tonnes. The size of the catch of the whitefish at the present time depends on the size of stocks caught in the waters of the Szczecin Lagoon (Fig. 4.3.53 and Fig. 4.3.54). In the following years, this trend will not change.

*Fishing exploitation on the Vistula Lagoon*

The Vistula Lagoon is part of a larger sea basin, known before 1945 as Frische Haff or Frische Bucht. After the Second World War, the waters of this basin were divided into the Polish part (the Vistula Lagoon) and the Russian part (the Kaliningrad Lagoon). Lagoon: Vistula and Kaliningrad constitute one waterbody through which the boundary between Poland and Russia runs, and from the moment of Poland's accession to the EU - between Russia and the EU.

In hydrological terms, this is an internal waterbody covering a total of 838 $km^2$ (328 $km^2$ in Poland) waters connected to the Baltic Sea by a narrow Pilawa Strait and cut off from the Gulf of Gdańsk by the Vistula Spit (Fig. 1). The lagoon is relatively shallow and suplied wit fresh water from rivers: Nogat (a branch of the Vistula river), Pasłęka and Pregoła, and its waters are inhabited by many species of fish, both marine and freshwater.

Currently, fishing activity in the waters of the Vistula Lagoon is regulated by the Act of 19 December 2014 on marine fishing (Journal of Laws of 2018, item 514, as amended). According to art. 48 of this Act, the minister responsible for fisheries determines, by regulation, the total quota for marine organisms, for species of marine organisms not covered by European Union legislation, for a given calendar year, if the renewal of resources and biological balance of the species of marine organisms to be covered with this fishing quota is at risk, bearing in mind the need to ensure the biological balance and the sustainability of the stocks of a given species. This means that the minister responsible for fisheries only in the case of biological imbalance can issue a regulation setting the quota for the bream and pike perch to be caught on this waterbody. In Polish legislation, the entry into force of the new Act of 19 December 2014 on marine fishing (Journal of Laws of 2015, item 222), in the fishing season in 2016, affected changes in management and thus in the fishing in the waters of the Vistula Lagoon.

Firstly, the Ordinance No. 1 of Regional Sea Fisheries Inspector in Gdynia of December 29, 2015 on the detailed method of allocating fishing quotas at the Vistula Lagoon in 2016 (Journal of Laws of the Pomeranian Voivodeship, item 4541), in which with binding legislation, catch limits for bream and pike perch were not included, as was the case in previous years of the Program implementation (2011-2015).

Secondly, the Ordinance No. 1 of the District Sea Fisheries Inspector in Gdynia of June 20, 2016 on the dimensions, protection periods of marine organisms, areas excluded from fishing and detailed conditions for commercial fishing on the Vistula Lagoon (Dz. Pomeranian Province, item 2244). The above-mentioned ordinance introduced changes in relation to the existing regulations (Order No. 2 of the Regional Sea Fisheries Inspector in Gdynia of 26 August 2004 on the protection of fisheries, order in fishing and marking of fishing equipment on the Vistula Lagoon. The most important issues are:

1. change of the pike perch protective period; currently in force from April 20 to May 20 (previously: from April 20 to June 10);
2. increase of the mesh size for the perch-roach set gillnets from 72 mm to 80 mm;
3. reduction of the mesh size for pike perch-bream set gillnets from 120 mm to 100 mm;
4. permission to use perch-roach set gillnets from May 20 to April 20 (previously: from September 1 to April 20);
5. extending the catch with the perch-roach set gillnets from the coastal zone 800m west of Tolkmicko-Krynica Morska line to the entire width of Lagoon and from Frombork-Piaski line towards the west;
6. extension of the spawning grounds of Kadyny and Różaniec, due to the high pressure of anglers.

Approved fishing gears are: fyke nets, one wing fyke nets, seine nets, gillnets, gillnets, longlines and shore seines. The smallest dimensions of the mesh size of net are established as fallows:

| Fishing gear | Mesh size (mm) | | |
|---|---|---|---|
| | in the wing | in the transition part | in a snare |
| Fyke nets and one wing fyke nets* | 36 | | 30 |
| Herring seine nets | 30 | 32 | 30 |
| Set gillnets for catching bream and pike perch | 100 | - | - |

*fyke nets after 1 May must be equipped with a prescribed selective sieve

| Fishing gear | Mesh size (mm) |
|---|---|
| Set gillnets for catching roach, perch, Crucian carp and tenches | 72 or 80 – depending on the structure specified in w part 3* |
| Herring gillnets | 48-56 |

* The construction of a gillnets used for catching roach, perch, crucian carps and tenches shall meet the following requirements:
a) when 72 mm mesh size is used - the maximum depth of the gillnets is 25 meshes and may have 20 meshes per 50 cm of the fishing gear,
b) when using a mesh size of 80 mm - the maximum depth of the wonton is 25 meshes and may have 18 eyelets per 50 cm of the fishing gear,

The total number of fishing gear used simultaneously on the Vistula Lagoon and specified in special fishing permits may not exceed the number of:

1) entangling gears (GNS) – 6000 items;
2) trap gears (FPO) - 2000 items;
3) Longlines (LLS) 184000 hooks.

The following protective fish dimensions have been established:

1) Salmon (*Salmo salar*) – 60 cm;
2) Sea trout (*Salmo trutta*) – 50 cm;
3) vimba bream (*Vimba vimba*) - 30 cm;
4) common bream (*Abramis brama*) - 35 cm;
5) pike perch (*Sander lucioperca*) - 46 cm;
6) pike (*Esox lucius*) - 45 cm;
7) eel (*Anguilla anguilla*) - 50 cm;
8) carp (*Cyprinus carpio*) - 30 cm;
9) crucian carp (*Carassius carassius*) - 20 cm;
10) tench (*Tinca tinca*) – 28 cm.

Protective periods have been established for the following fish species:

1) pike perch - from 2 April to 2 May;
2) eel - from 1 December to 31 March;
3) bream - from April 20 to June 10;
4) pike - from 1 March to 30 April;
5) Atlantic sturgeon - from 1 January to 31 December;
6) river lamprey - from 1 January to 31 December;
7) twait shad - from 1 January to 31 December.

In addition, the Ordinance No. 1 Regional Sea Fisheries Inspector establishes a series of permanent protection circuits and protective circuits for a definite period for the group flow of, pike perch, bream and sea trout, and also introduces the order to use protective screens in the period from May 1 to December 31.

Cooperation in the field of fish economy was defined in the agreement between the Government of the Republic of Poland and the Government of the Russian Federation of July 5, 1995. Pursuant to this agreement, the Polish-Russian Mixed Commission for fisheries management was set up with the purpose of, among others, proper management of resources on the Vistula Lagoon, including mutual exchange of information on the characteristics of exploited stocks of bream and pike perch and joint determination of catch limits for these species . In 2011-2015, the catch limit for the Polish side was set at 100 tonnes of pike perch and 160 tonnes of bream. The contract does not include herring which catches in Vistula Lagoon are not limited by Poland and eel, which was a dozen years ago the main source of income for fishermen in lagoon. As a result of arrangements made at the meeting of the 15th Mixed Commission in Kaliningrad (17-18 November 2015) in 2016, the fishing quota for the Polish side was set at: 100 tonnes of pike perch and 160 tonnes of bream. The Polish side, however, announced that as a result of the entry into force of the Act of 19 December 2014 on marine fishing, in accordance with Article 48 of this Act, the minister responsible for fisheries only in case of biological imbalance can issue a relevant regulation fixing the amount of the bream and pike perch to be coaught on this basin. Bearing in mind that both parties acknowledged at the meeting of the 15th Mixed Commission that the state of bream and pike perch stocks is not threatened, the fixed fishing quotas for bream and pike perch did not oblige the Minister competent for fisheries to issue a relevant regulation. Catches of these fish species were to be regulated by fishing effort and not by fishing quotas. After the entry into force of the Act of 19 December 2014 on marine fishing in 2015, the minister responsible for fisheries for species not quoted at EU level may only establish catch quotas if the state of resources is at risk. Due to the fact that the state of the bream and pike perch resources was not in danger, the minister competent for fisheries had no legal basis to issue relevant regulations. It was established that fishing for these fish species will be regulated by fishing effort rather than catch quotas. Every year, research is conducted on the state of resources of these fish and the state of their resources is monitored on an ongoing basis.

The most important species obtained in the course of fishing activity in the waters of the Vistula Lagoon are herring, pike perch, bream, eel, perch and roach. Catches of herring are carried out in the spring period and last for a relatively short time, from three to five spring weeks (so-called "herring harvests"), nevertheless hering dominate the total biomass of catches of fish obtained in this water body. Their weight participation in catches in 2011-2016 ranged from 74.6% (2016) to 86.3% (2012), and on average - 81.1% of the total weight of fish caught.

The research of the National Marine Fisheries Research Institute in 2011-2016, in addition to herring, which was the subject of research under the Multiannual Fisheries Data Collection Plan, was focused on bream and pike perch, i.e. species covered by the Agreement between Poland and Russia.

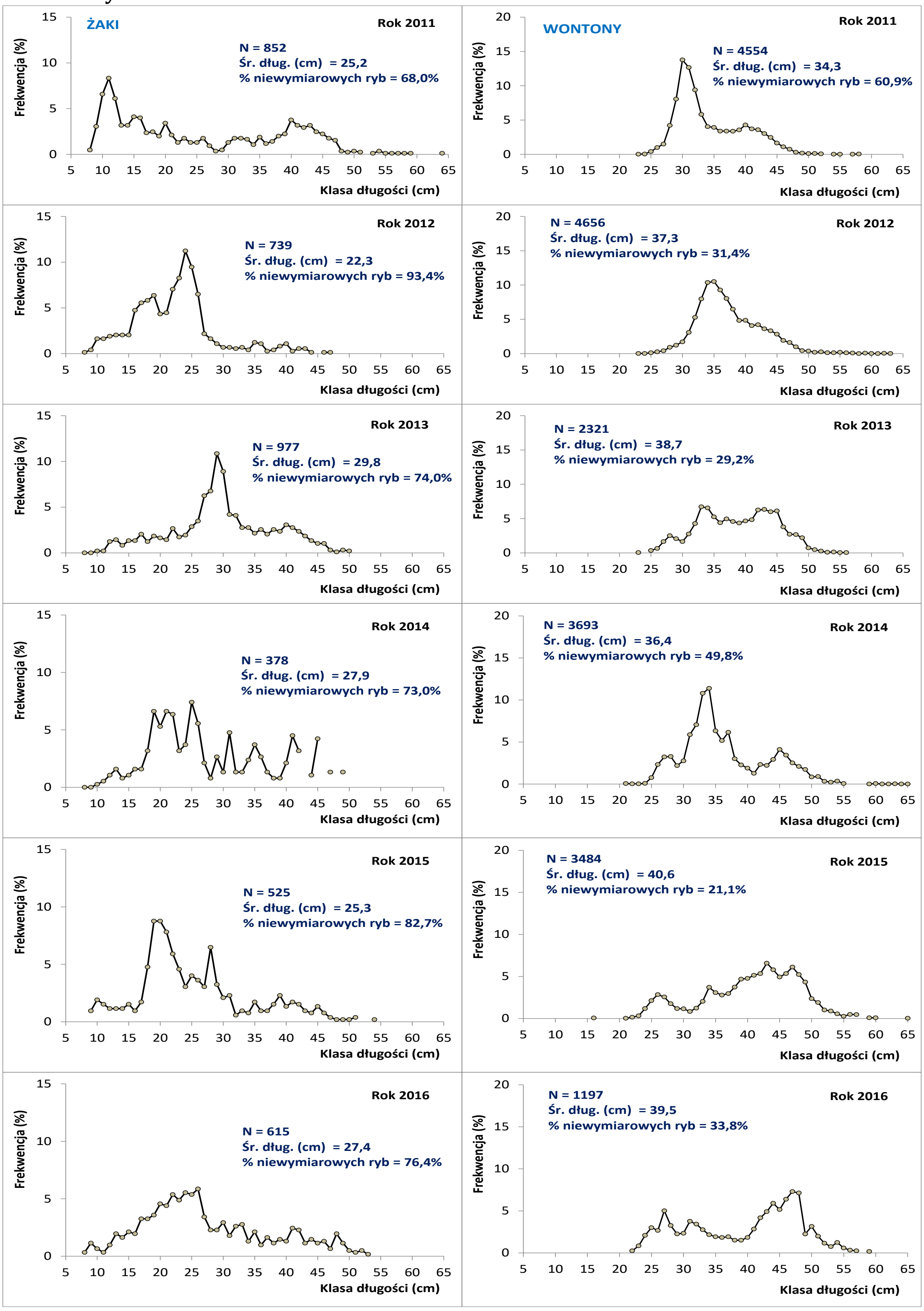
**In the years 2011-2016, the lenght distribution of breams caught with fyke nets and set gillnets varied. In fyke nets, individuals from 8 cm to 64 cm in length were recorded ( Fig. 4.3.55). The average length of breams observed in the above-mentioned years ranged from 22.3 cm to 29.8 cm, and the share of undersized fish in research catches ranged from 68.0% to 93.2%. In gillnets, which were the main gear used for catching breams, the average length of breams observed in the above-mentioned years ranged from 34.3 cm to 40.6 cm, while the share of undersized fish in research catches ranged from 21.1% to 60.9% (**
Fig. 4.3.55).

Similarly to the length distributions, also the age structures of breams caught with fyke nets and gillnets varied (Fig. 4.3.56). In fyke nets, individuals aged from 0 to 12 years were observed, and the average age of breams ranged from 2.3 to 3.7 years. From the summary of the grouped age classes of breams caught with the use of fyke nets (Fig. 4.3.57) it turned out that in the subsequent years of research, the fish frequency at the age of 0-2 and 3-5 years changed quite clearly, nevertheless their total amount (age: 0 -5) was close to the frequency of undersized fish observed in length distributions. It resulted from the fact that bream living in the waters of the Vistula Lagoon reaches the length of 35 cm between 4 and 6 years of age. At the same time, over the years 2011-2016 there was a high variation in the frequency of older fish (over 5 years old), which translated into a large variation in the average age of bream in catches carried out with the use of fyke nets.

In the gillnets, the average age of caught breams ranged from 5.0 to 6.4 years and the age ranged from 1 to 18 years (Fig. 4.3.56). The increase in the average age of breams caught in the years 2013-2016 resulted from the annualy growing share of older fish, over 5 years of age (Fig. 4.3.58).

The analysis of the bream catch trend in 2011-2016 was hindered by two factors, namely:

limiting the catches of this species in the period 2011-15 and changing the management of the fisheries economy in this basin in 2016[9].




[9] *Ordinance No. 1 of the District Sea Fisheries Inspector in Gdynia of June 21, 2016 on the dimensions, protective periods of marine organisms, areas excluded from fishing and detailed conditions for commercial fishing on the Vistula Lagoon (Official Journal of the Pomeranian Voivodeship, item 2244*)

Fig. 4.3.55. Length distributions of breams caught by fyke nets and set gillnets in 2011-2016 in the waters of the Vistula Lagoon.

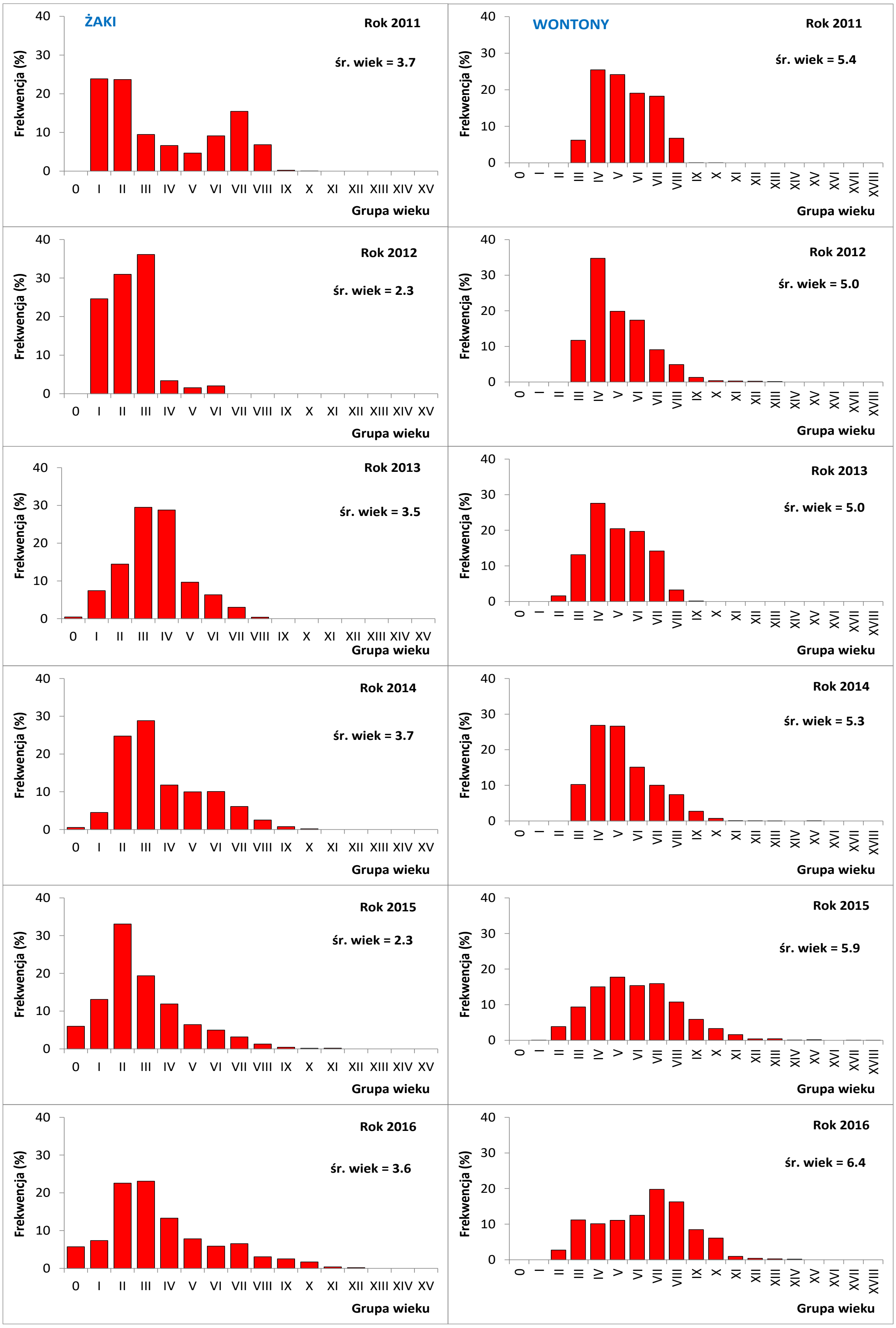



Fig. 4.3.56. The age structure of breams caught by fyke nets and set gillnets in 2011-2016 in the waters of the Vistula Lagoon.

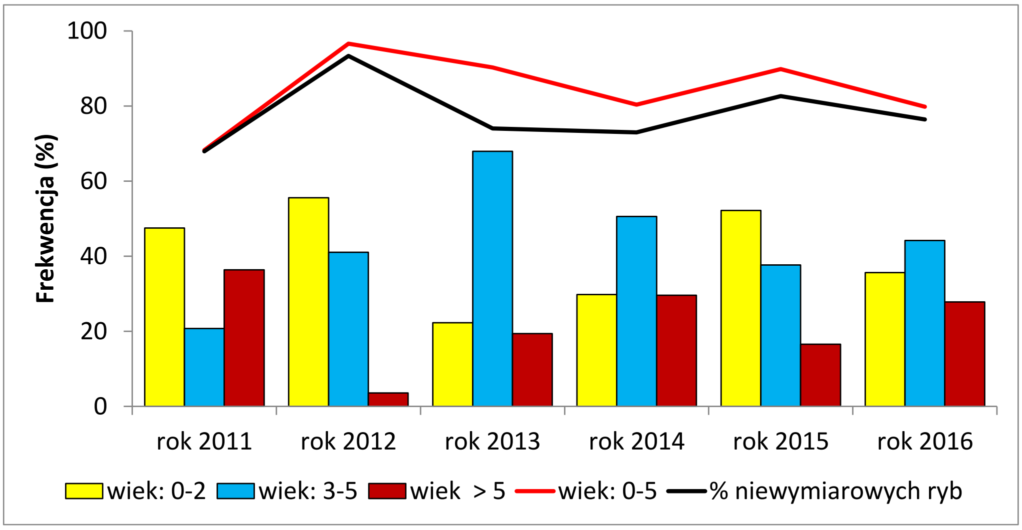



Fig. 4.3.57. The grouped age structure of breams caught by fyke nets in the years 2011-2016 on the waters of the Vistula Lagoon.

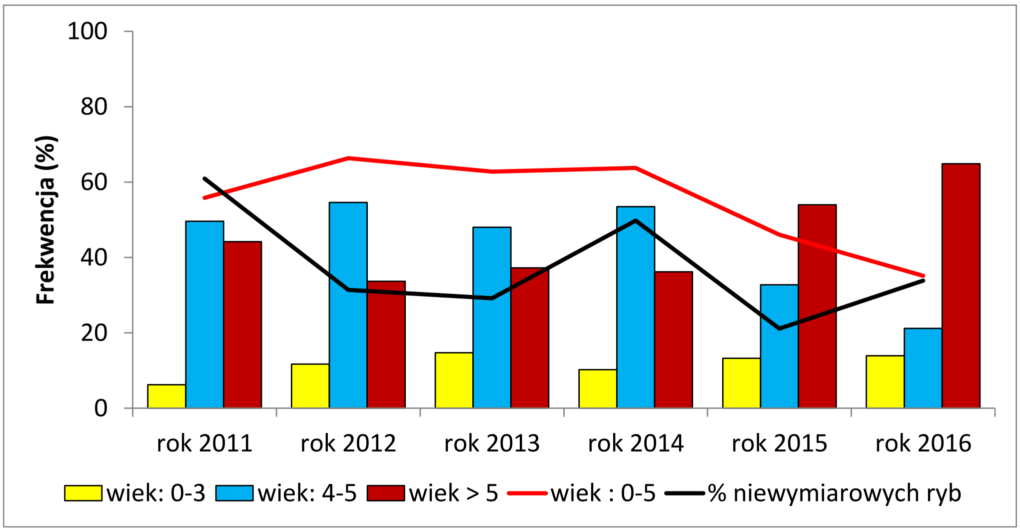



Fig. 4.3.58. The grouped age structure of breams caught by set gillnets of 2011-2016 in the waters of the Vistula Lagoon.

When analyzing the trend of bream catches in 2011-2016, it should be recalled that the assessment of the state of fish stocks of this species showed that the average exploitation intensity of the bream was similar (although slightly higher) to the intensity corresponding to sustainable exploitation in 2011-2015. The results of the calculations suggested a decrease in the stock replenishment, which (if confirmed in further studies) may contribute to the decline of resources in the near future[10].

[10] Trella, K., J. Horbowy. 2016. Assessment of the state of fish stocks, with particular emphasis on the population of bream and pike perch in the Vistula Lagoon in 2016. Report prepared for the Ministry of Maritime Economy and Inland Navigation.

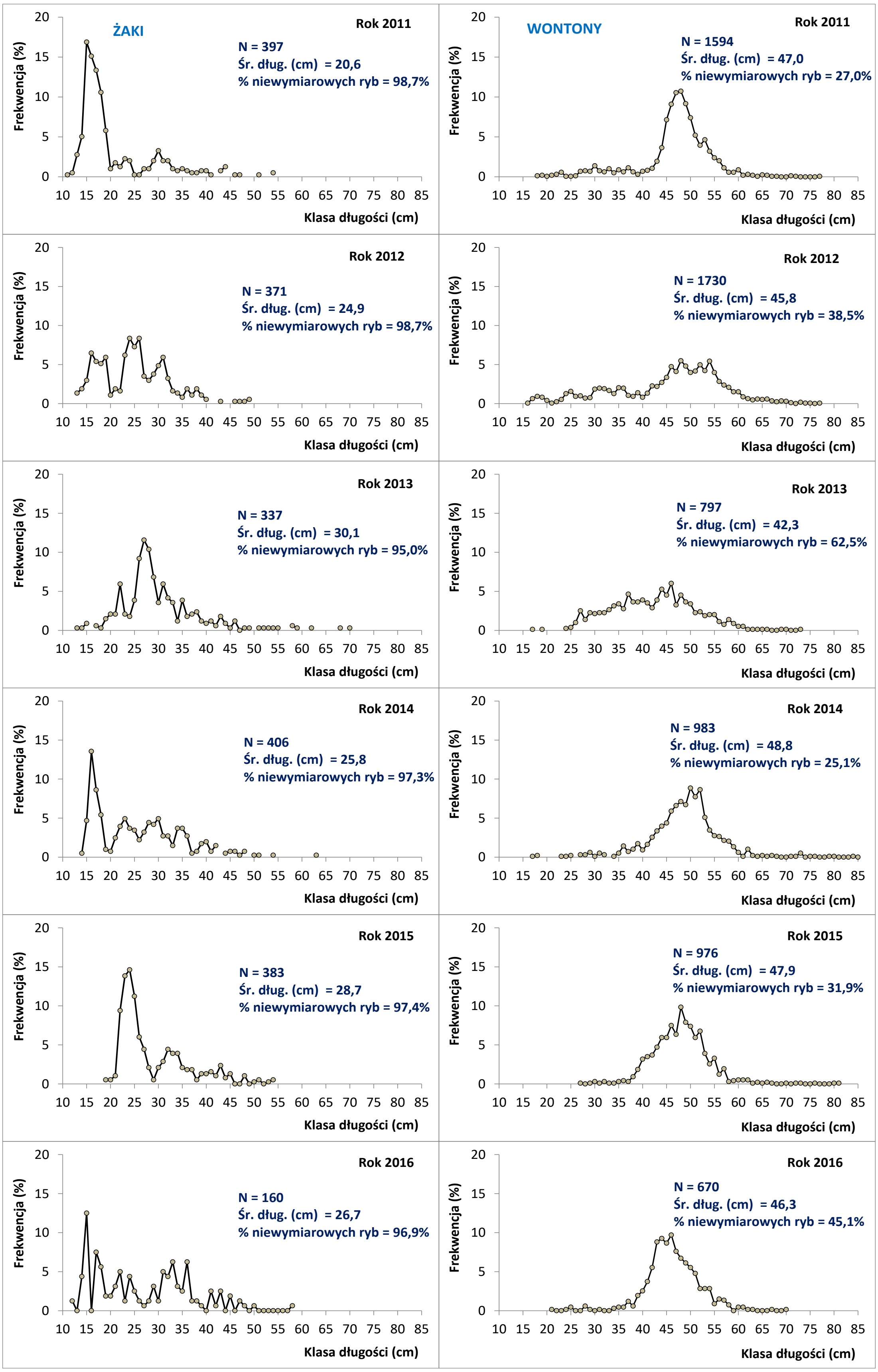



Fig. 4.3.59. Length distribution of pike perch caught by fyke nets and set gillnets in 2011-2016 in the waters of the Vistula Lagoon.

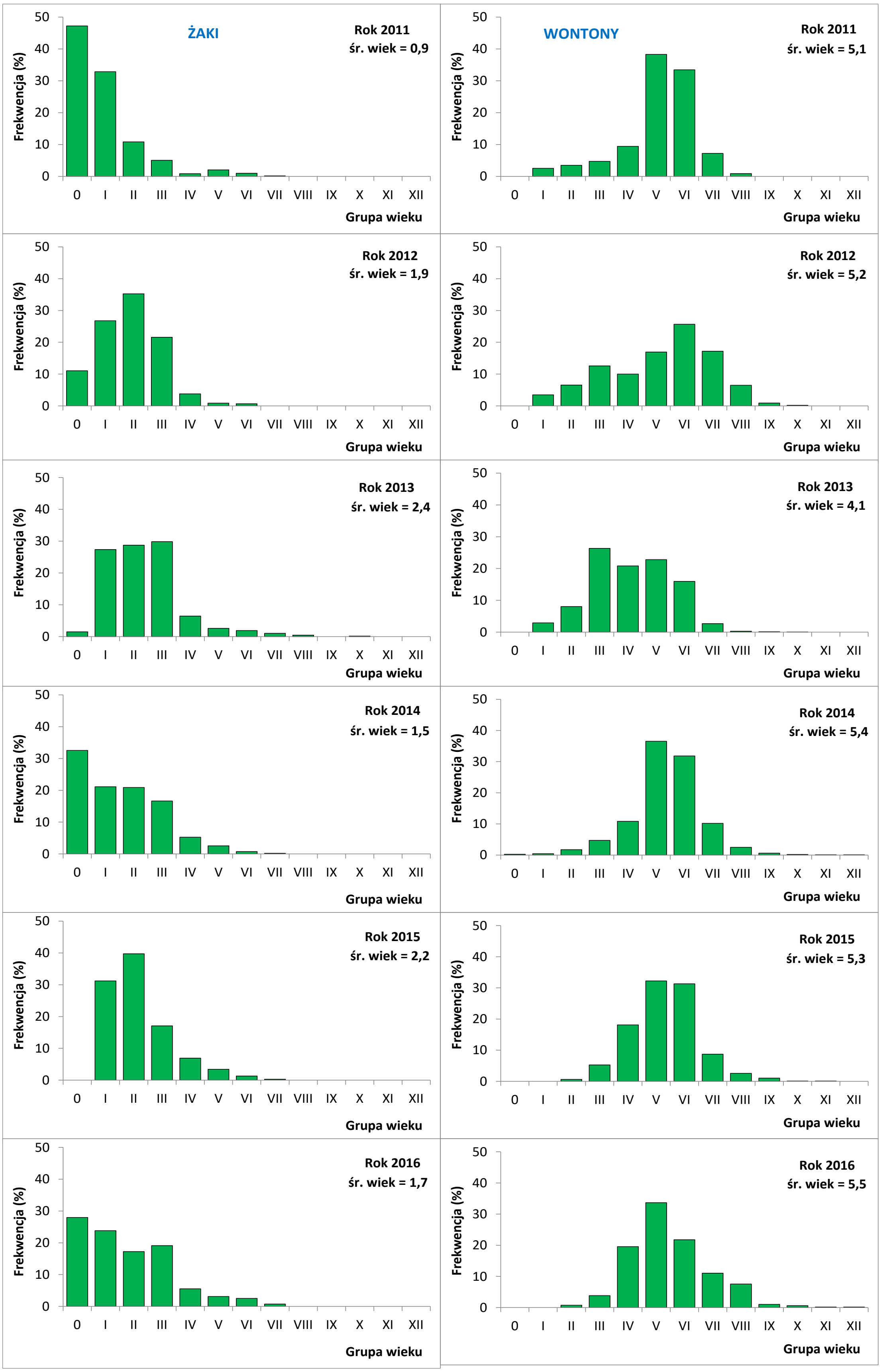



Fig. 4.3.60. Age structure of pike perch caught by fyke nets and set gillnets in 2011-2016 in the waters of the Vistula Lagoon.

In pike perch catches with fyke nets and set gillnets in 2011-2016, the length distributions varied. In fyke nets, individuals with lengths from 11 cm to 70 cm have been recorded (Fig. 4.3.59). The average length of pike perch observed in the above-mentioned years ranged from 20.6 cm to 30.1 cm, while the share of undersized fish in research catches ranged from 95.0% to 98.7%. In the set gillnets, which, like in the case of the bream, were the main gear for acquiring pike perch, the average length of observed fish in 2011-2016 ranged from 43.3 cm to 48.8 cm, while the share of undersized fish in research catches ranged from 27 , 0% to 62.5% (Fig. 4.3.59).

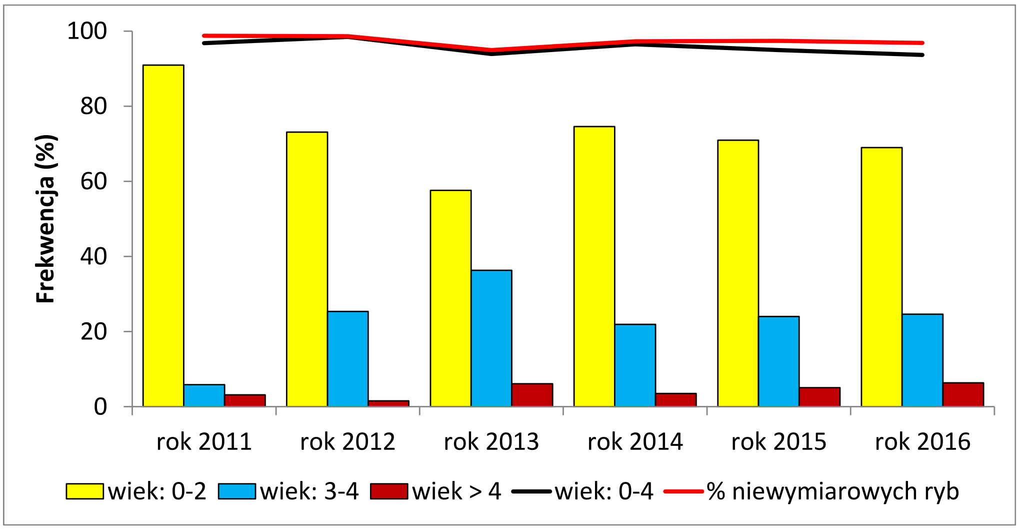



Fig. 4.3.61. Grouped age structure of pike perch caught by fyke nets in 2011-2016 on the waters of the Vistula Lagoon.

The diversity of length distribution of pike perch observed in the years 2011-2016 corresponded to the diversity of the age structure. In fyke nets, individuals aged from 0 to 10 years were observed, and the average age of pike perch caught varied from 0.9 to 2.4 years (Fig. 4.3.60). The summary of the grouped age classes of pike perch caught with the use of fyke nets (Fig. 4.3.61) explained the high proportion of undersized fish in catches and their average age. The visualized data showed that the proportion of undersized individuals was identical to the corresponding percentage of pike perch aged 0 to 4 years old. These observations confirmed the earlier results of the study, which indicated that the pike perch achieved a length of 46 cm between 4 and 5 years of age[11].

In gillnets, the average age of pike perch caught varied from 4.1 to 5.5 years and the age range was from 0 to 12 years (Fig. 4.3.60). In the years 2014-2016, the average age stabilized at 5.3-5.5 years, however, at the same time an increase in the share of undersized fish (less than 46 cm in length) was noted.

[11] Kosior, M., T. Wandzel, T. 2001. Comparison of fecundity of pikeperch (*Stizostedion lucioperca* (L.)) in three lagoons in the southern Baltic Sea. *Bulletin of the Sea Fisheries Institute* 154: 3–27.

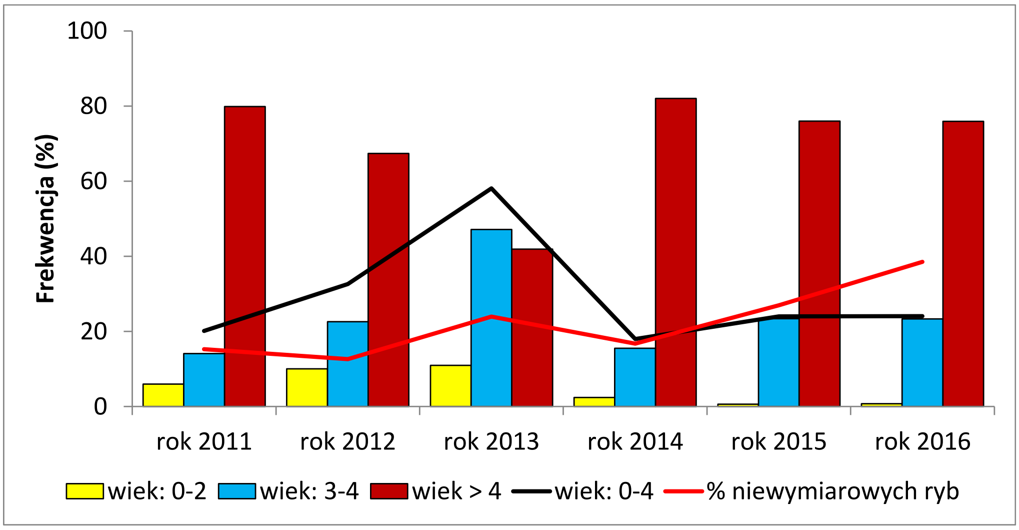



Fig. 4.3.62. The grouped age structure of pike perch caught by set gillnets in 2011-2016 in the waters of the Vistula Lagoon.

Similarly to breams, the analysis of the trend of fishing for pike perch caught in the Vistula Lagoon over the years 2011-2016 was hindered by the same factors, namely the limitation of catches of this species fish in the period 2011-15 and a change in the way of managing the economy fishing on this basin in 2016[12]. Nevertheless, the assessment of the pike perch resources in 2016 was less optimistic than for bream. The average exploitation intensity of pike perch was in the period 2006-2010 high, in 2011-2015 it decreased slightly, but it is still too high in relation to approximate reference points[13]. The results of the research carried out in 2016 indicated a possible reduction in the replenishment of pike perch stocks. They are subject to the assessment of the pike perch resources, which will be completed only in 2017. As a result of the change in the way fish resources are managed on the Vistula Lagoon, resulting in (similarly as in the case of a bream), a large increase in zander catches in 2016, it can be expected that in subsequent years the zander catch may be reduced, while the bream catches may remain at the same level, nevertheless the younger, meaning smaller individuals may dominate.

The diversity of the share of undersized breams and zander in the subsequent years of research in set gillnets catches is primarily due to the fact that the same type of fishing gear is used for catching both species, although both species differ significantly in anatomical structure. As a result in set gillnets of a mesh size of 120mm more individuals of allowable size of are caught, which is accompanied by a relatively large number undersized bream. In the set gillnets with larger meshes (e.g. with 160 mm clearance), the proportion of undersized breams is much smaller and practically no zander are caugh. In smaller meshes (with a mesh size of 120mm) the proportion of undersized zanders increases, while the share of undersized breams decreases sinc the fish “bounce of” the pike perch. The second factor that makes the share of undersized fish of both species change annually, is the fertility of younger generations (in the case of pike perch 3-4 year old, and in the case of bream 4-5 years old), which sizes are not much lower than the protective dimension (e.g. zander of lengths from 42 cm to 45 cm, or breams from 31 cm to 34 cm in length).

12 Ordinance No. 1 of the District Sea Fisheries Inspector in Gdynia of June 21, 2016 on the dimensions, protection periods of marine organisms, areas excluded from fishing and detailed conditions for commercial fishing on the Vistula Lagoon (Dz.U. Woj. Pomorskiego, Gdańsk, 21 June 2016 r., Poz. 2244)

13 Trella, K., J. Horbowy. 2016. Assessment of the state of fish stocks, with particular emphasis on the population of bream and zander in the Vistula Lagoon in 2016. Report prepared for the Ministry of Maritime Economy and Inland Navigation.

***Fishing exploitation on the Puck Bay***

The Puck Bay occupies the western part of the Gulf of Gdańsk. The southern border, according to different authors, runs from the Hel Peninsula to Kępa Redłowska or to the Przylądek Orłowski (Majewski, 1990), and according to Słomianki (1974) it reaches Kamienna Góra in Gdynia. Due to the morphometry, the Puck Bay can be divided into two parts: shallow - inner Puck Bay and deepwater - the outer Puck Bay. The boundary separating these two basins is the shallows running from Kuźnica towards Cypel Rewski called "Rybitwia Mielizna or Ryf Mew"(Fig. 4.3.63). The outer Puck Bay is characterized by the lack of varied bottom sculpture, however, the varied slopes occure in the area. The bottom of the Bay decreases gently from the land line and Rybitwia Shallow towards the Gulf of Gdańsk to a depth exceeding 50 meters. Larger slopes are located on the side of the Hel Peninsula. This basin is classified to brackish waters.

The inner Puck Bay has an average depth of just over 3 meters. The deepest natural place is Jama Kuźnicka - over 9 m, Jama Chałupska - 4 m. Both depressions are located near the Hel Peninsula, and Jama Rzucewska with a depth of nearly 6 m in the area of Rzucewo. Additionally, as a result of the silting work, artificial depressions of depths of 6 to 9 meters were created along the Hel Peninsula, mainly in the area of Chałupy and in the outer waters of the Puck Bay near Jastarnia. It was aimed at using the extracted sand to protect the peninsula from breakage and connecting with the open waters of the Baltic Sea. Two rivers flow into the internal waters of the Puck Bay: Reda near Rewa and Płutnica near Puck, and two watercourses - Gizdepka near Osłonina and Potok Błądzikowski near the area of the Cypel Rzucewski. The inner Puck Bay is included in the estuarine lagoons. The bottom of the Puck Bay is mostly sandy, especially along the Hel Peninsula, sometimes gravelly (larger granulation), and in some places, mainly in sections of estuaries, natural and artificial depressions can be covered with mud. During severe winters the area of the Puck Bay is sometimes covered with ice. Exceptionally, the period of freezing may last from November to April. The hydrological conditions in this part of the Bay are influenced by the point source phenomena, the rivers and watercourses escaping into its waters, but mainly the hydrological conditions depend on the design of winds and currents. The water exchange takes place through Głębinka ("Depka") - a trim between the Cypel Rewski, and Ryf Mew and the isthmus near Kuźnica.

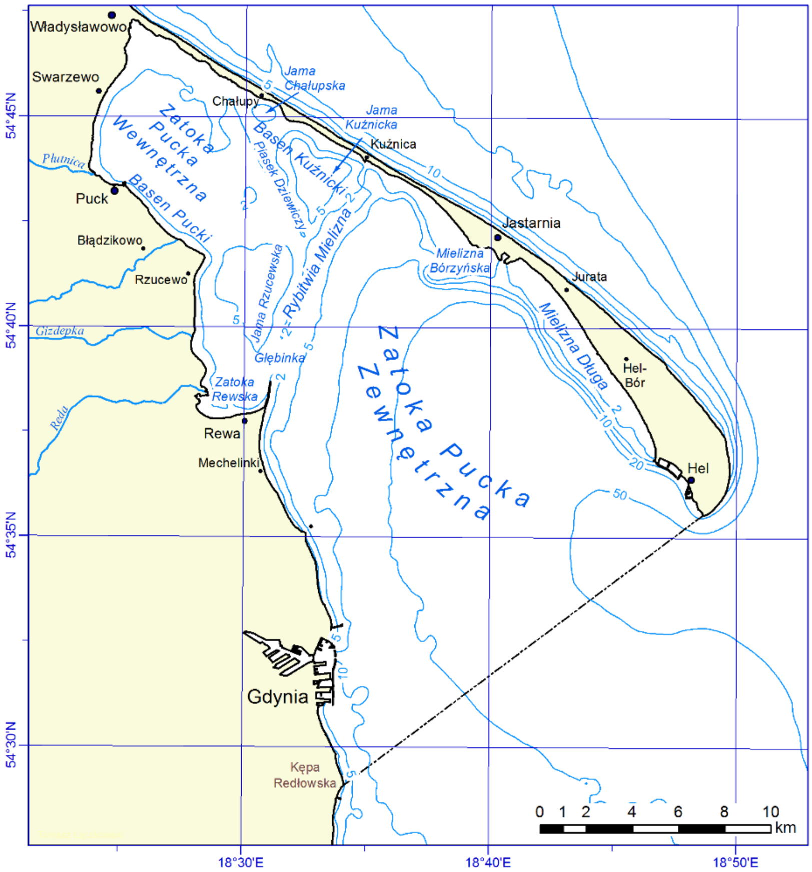



Fig. 4.3.63. Map of the Puck Bay

### Fisheries in the Puck Bay

At present, there are 9 fishing bases and 3 ports - fishing harbors on the Puck Bay. The character of these fishery bases and havens can be divided into four groups. The division criterion is the size of the vessel, which determines the range of fishing and the fishing gear used: passive or active. The first group are cutters from the port of Jastarnia, who are trawling or using set nets, entangling nets outside the area of the Bay of Puck. In Gdynia - the second fishing port there are currently no cutter registered, but one fishing boat is registered. This port is characterized by high potential in terms of the offered place and cutter registration possibilities. The second group are the coastal fishermen who use boats to deploy the entangling nets or hook gear in the waters of the Gulf of Gdańsk and the Outer Puck Bay and in the open sea on the Hel Peninsula. This group includes mainly fishermen from bases in Hel, Jastarnia, partly from Kuźnica and single boats from bases in Chałupy, Swarzewo, Puck, Rewa, Władysławowo, Mechelinki, Obłuże and Oksywie. The third group are coastal fishermen who periodically catch both in the inner Puck Bay area and use fish resources from the area of the outer part of the Puck Bay. This group includes fishermen from the Kuźnica port and bases in Rewa, Mechelinki and Chałupy. The fourth group are fishermen who fish only on the internal Puck Bay. This group includes some fishermen from Chałupy, Władysławowo, Swarzewo and Puck. Classification of fishermen from fishing bases for individual groups is based on obtaining information directly from them - or in the absence of such knowledge on the arbitrary resolution of the issue of membership and reports of fishermen from their fishing activities to the CMR database.

Due to the fact that the present state of resources and fishing pressure on basic fish species have been discussed in separate chapters, the main focus in this chapter will concern resources and fishing pressure on species not discussed earlier, but important for the fisheries of the Puck Bay as well as the its entire ecosystem. Commenting on the data included in Table 4.3.21 there is a dramatic decline in cod fishing on the Puck Bay from nearly 212 tonnes in 2012 to nearly 27 tonnes in 2016. Eel catches increased from almost 1,400 kg in 2011 to more than 6,700 kg in 2016, which is the result of restocking carried out in recent years. Flounder catches were stable and over the last 6 years exceeded 100 tonnes. Catches of salmonids were also maintained at a similar level - mainly due to the annual restocking with trout and salmon smolt. The share of rainbow trout caught decreased due to the ban on introducing this species to the natural environment as a foreign species for the ichthyofauna of Poland.

Table 4.3.21. Catches on the Puck Bay in 2011-16 according to the data of the Fisheries Monitoring Center (CMR).

| Nr. | Species / group | Unit | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|
| 1 | *Cod* | *kg* | 162 067 | 214 749 | 185 134 | 144 652 | 86 210 | 26 820 |
| 2 | *Flounder* | *kg* | 121 610 | 139 746 | 158 410 | 135 669 | 141 793 | 118 399 |
| 3 | *European plaice* | *kg* | 135 | 645 | 3 107 | 2 701 | 1 051 | 657 |
| 4 | *Turbot* | *kg* | 1 427 | 405 | 338 | 85 | 1 291 | 2 051 |
| 5 | *Herring* | *kg* | 11 833 | 18 343 | 13 492 | 39 564 | 38 164 | 13 404 |
| 6 | *European sprat* | *kg* | 0 | 0 | 90 | 310 | 60 | 270 |
| 7 | *Eel* | *kg* | 1 379 | 1 072 | 2 552 | 4 378 | 5 981 | 6 711 |
| 8 | *Viviparous eelpout* | *kg* | 0 | 105 | 40 | 39 | 76 | 393 |
| 9 | *Bream* | *kg* | 0 | 47 | 13 | 22 | 177 | 64 |
| 10 | *Crucian carp* | *kg* | 0 | 176 | 78 | 0 | 18 | 36 |
| 11 | *Perch* | *kg* | 4 729 | 22 145 | 33 702 | 28 236 | 12 721 | 37 571 |
| 12 | *Pike* | *kg* | 401 | 638 | 4 697 | 1 611 | 431 | 168 |
| 13 | *Zander* | *kg* | 65 | 207 | 312 | 346 | 398 | 181 |
| 14 | *Roach* | *kg* | 0 | 357 | 43 | 36 | 22 | 708 |
| 15 | *Common whitefish* | *kg* | 471 | 602 | 164 | 681 | 663 | 600 |
| 16 | *Vimba bream* | *kg* | 0 | 0 | 0 | 15 | 3 | 2 |
| 17 | *Garfish* | *kg* | 14 761 | 20 333 | 25 588 | 11 920 | 42 817 | 44 519 |
| 18 | *Atlantic mackerel* | *kg* | 0 | 3 | 0 | 0 | 0 | 0 |
| 19 | *Gobiidae* | *kg* | 0 | 0 | 0 | 10 | 38 | 178 |
| 20 | *Other sea fish* | *kg* | 1 874 | 4 | 0 | 52 | 38 | 18 |
| 21 | *Atlantic salmon* | *kg* | 2 682 | 1 103 | 1 146 | 545 | 1 534 | 1 780 |
| | | *szt.* | 885 | 242 | 349 | 102 | 325 | 343 |
| 22 | *Rainbow trout* | *kg* | 213 | 619 | 153 | 57 | 112 | 27 |
| | | *szt.* | 75 | 233 | 51 | 21 | 44 | 11 |
| 23 | *Sea trout* | *kg* | 8 979 | 15 186 | 14 873 | 12 996 | 17 818 | 27 092 |
| | | *szt.* | 3 552 | 5 309 | 4 721 | 4 462 | 5 311 | 6 535 |

**Status of selected fish species stocks**

**Perch**

Catches of this species on the Puck Bay oscillated from approximately 5 tonnes in 2011 to over 37 tonnes in 2016. On average, over 23 tonnes of fish were caught annually in the last 6 years. The protective size of the perch has not changed and is 17 cm. The relevant regulations and ordinances are quoted later in this report. No protection period has been introduced. Perches are caught on the Puck Bay, mainly using the perch nets with a mesh size no smaller than 30 mm. Occasionally fish of this species, in form of by-catch, are recorded in other trap gears (set gillnets) as well as in trap-like gears such as fyke nets or one wing fyke nets, or set longlines. The age structure of perches occurring in catches or research catches in 2011-16 is shown in Fig. 4.3.64. The perch age structure from 2015 and 2016 presented in this figure was obtained on the basis of research catches carried out in the Puck Bay. Data from 2011-2014 came from commercial and research catches.

The basis of catch is perch from age groups from 3 to 6 years old. In various years, spawning efficiency varied. Perch as a long-lived fish for now is relatively resistant to fishing pressure, despite the fact that the protective dimension is only 17 cm and in this case protects more males than females. The sexual maturity curves presented below for perch from the Puck Bay (Fig. 4.3.65) confirm this fact.

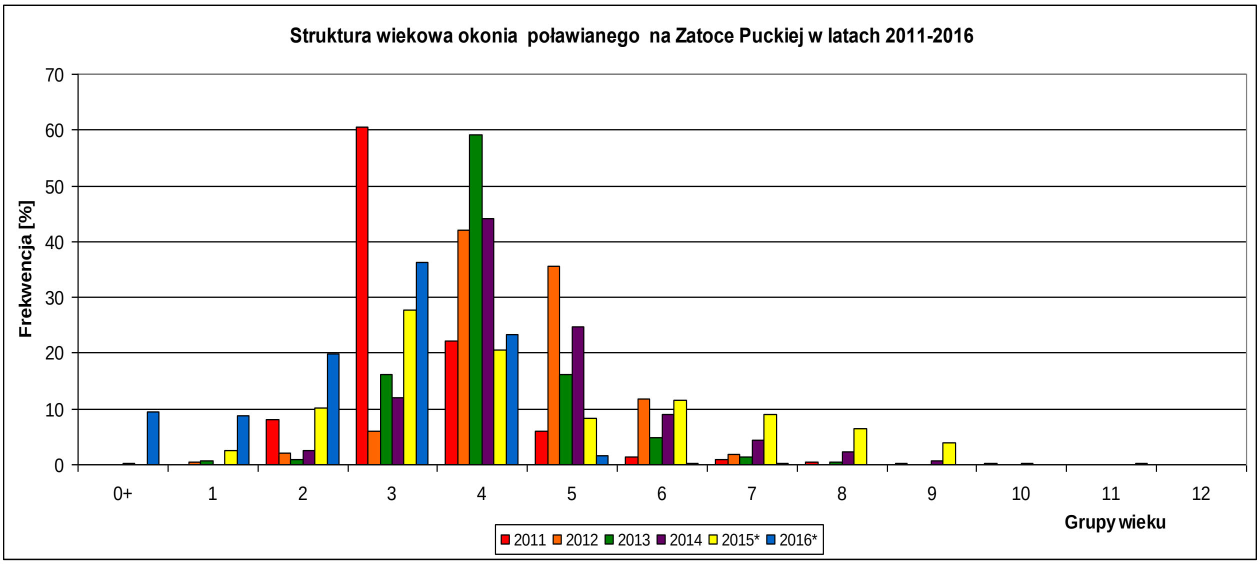



Fig. 4.3.64. Age structure of perch caught in the Puck Bay in 2011-2016

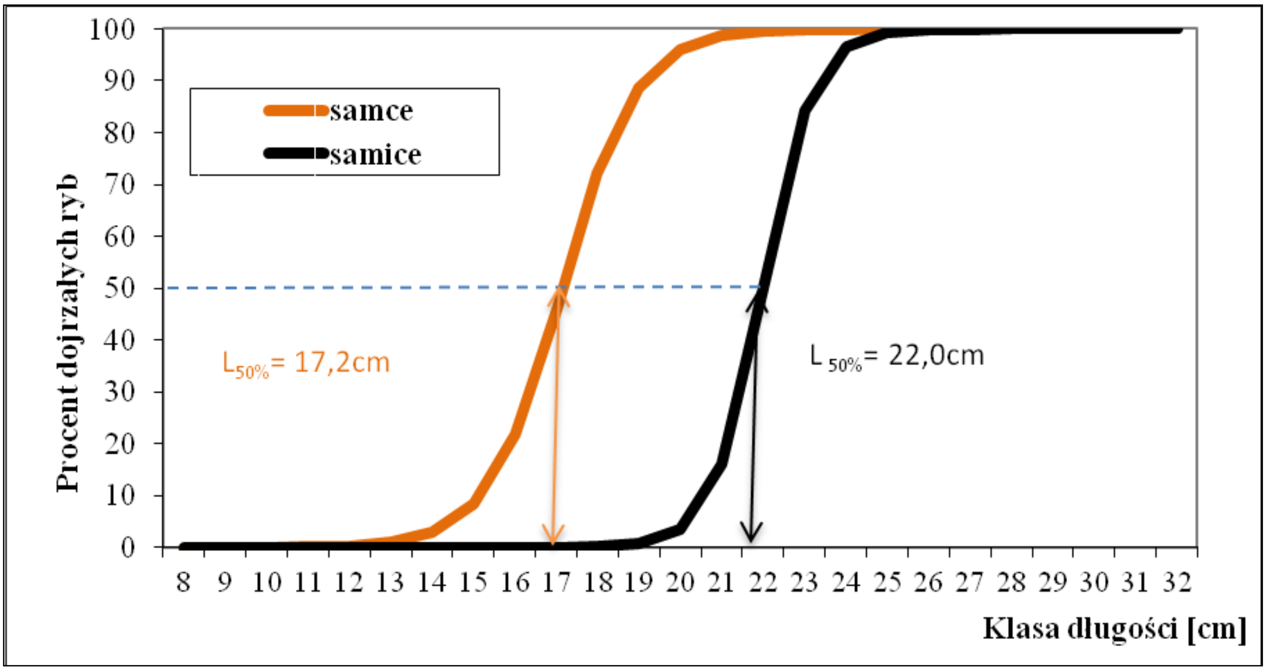



Fig. 4.3.65. Statistics of maturity of perch caught in the Puck Bay in 2011-2014.

Optimistic for this species is the fact that nearly 10% of the research catches consisted of group 0+ in 2016, despite the highest documented catches in the analyzed six-year period. Perch, in addition to being an important species for the fishermen catch in the Puck Bay, is also a very important predatory fish in the Bay ecosystem. Fish of this species largely limit the population of Gasterosteidae fish (e.g., three-spined stickleback, ninespine stickleback) and round goby. This is confirmed by studies on the composition of the perch's diet.

### Garfish

Garfish in the waters of the Puck Bay is usualy caught from the second half of April to the end of June. This species comes to the area in order to spawn. In 2011-16, the smallest catch was recorded in 2014 - 12 tonnes, and the highest in 2016 - 44.5 tonnes. On average over 26.5 tonnes per year were caught in the discussed period. On the Puck Bay there is no protective dimension nor period for this species. Fig. 4.3.66 presents the age structure of garfish caught in the Puck Bay in the years 2011-15.

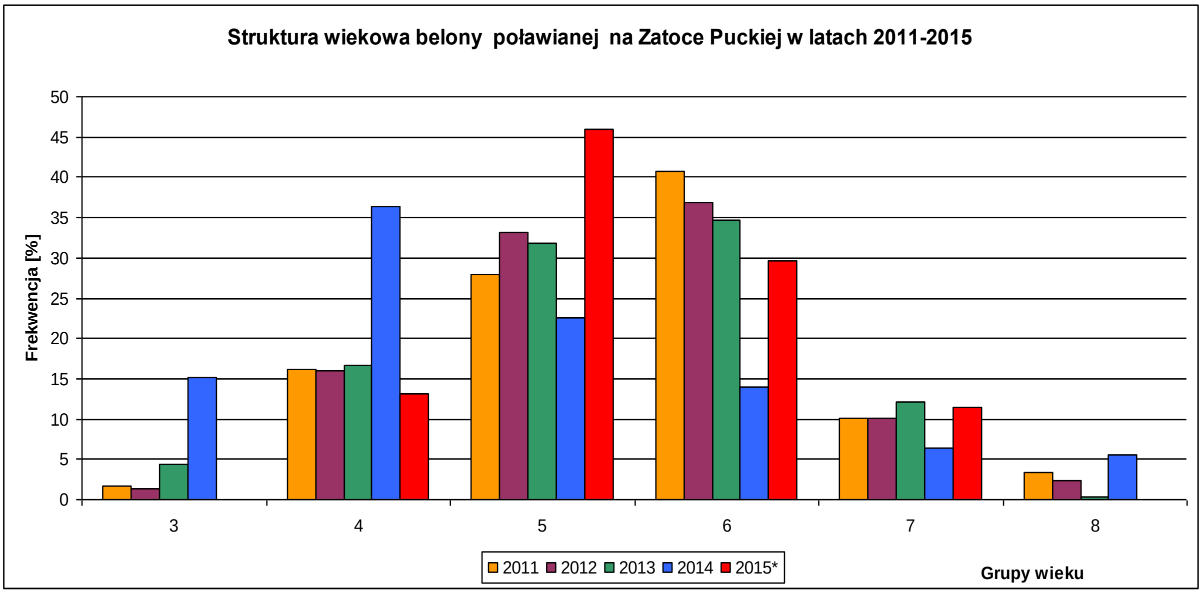



Fig. 4.3.66. Age structure of garfish caught in the Puck Bay in 2011-2015

* data only from research

The fish recorded in catches were from 3 to 8 years old. Garfish in the age range from 4 to 6 years dominate in catch. Juveniles, group 0+, after hatching from spawn, live in the waters of the Puck Bay until September, and then leave the waters of the Bay to return at the age of 3 in order to spawn. For the time being, the stocks of this species are stable and despite the lack of protection (protective dimension, protective period), catches have remained stable in recent years above 10 tonnes per year.

### Pike

The pike was an important ingredient in fishermen catches from the Puck Bay. The best catches of this species were recorded in the years 1965 - 1972. From 1965, when 23 tonnes of pike were caught, their catches were gradually growing, up to the value of over 45 tonnes in 1972. From this year, landings were successively decreasing. Even in 1981, 2.3 tonnes were recorded, and in 1987 only 0.3 tonnes. In the 1990s, several-kilogram catches of this species were reported. Literature data describe a pike from the Puck Bay as a separate population characterized by a fast growth rate. Unfortunately, this population can be regarded as extinct, because the number of individuals required to restore the population is too small. The closest related population of this species was breeding in the Reda river. Unfortunately, genetic research has shown that the condition of this population is at the stage of inbreeding, which means that pike from this population are very closely related to each other. This situation caused that spawners from Wisła and Motława were used to restore the pike population. Since 2007, the restocking of the Puck Bay with pike fry has begun and continued every year. In 2010-2015, 1.3 million fryies were released to the Puck Bay waters. Previous experience from the 90s associated with restocking of the Puck Bay waters with hatched specimens with dimensions of 3-4 cm did not give the expected result. Therefore, in restocking from 2008, it was decided to allow the fry in the Bay's waters with dimensions above 9 cm.

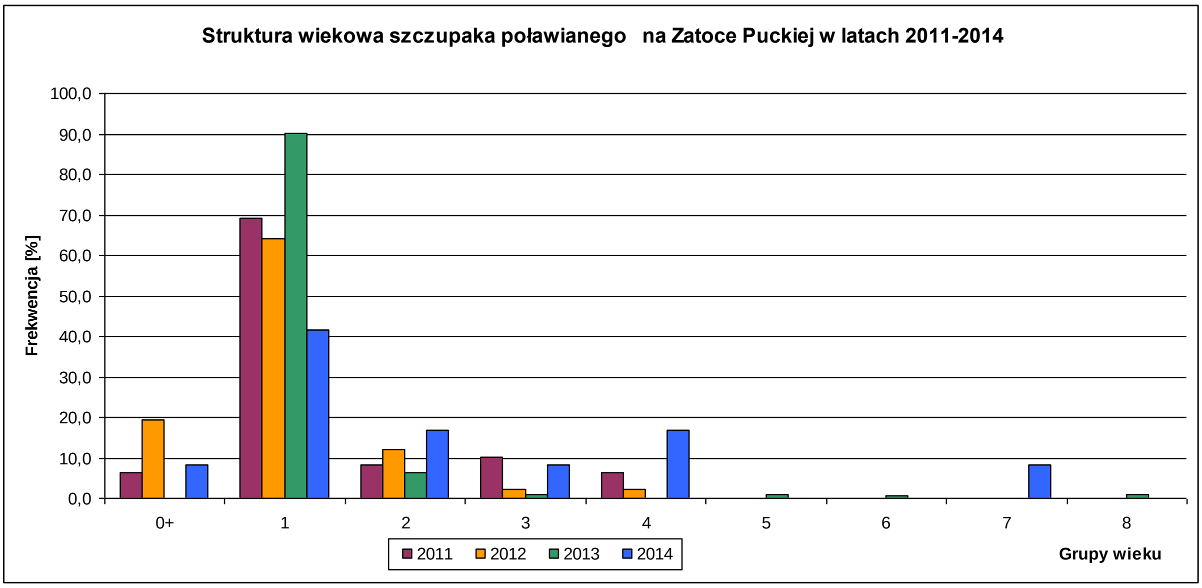



Fig. 4.3.67. Age structure of pike caught in the Puck Bay in 2011-2014.

The catch of pike in the years 2011 - 16 from the Puck Bay ranged from 168 kg in 2016 to 4697 kg in 2013. The average annual catch of this species in the analyzed period was 1324 kg. An analysis of the size of catches and the age structure from 2011-16 shows a clear correlation between restocking and catches. The catches of this species at the level of nearly 5 tonnes in 2013 were just a result of restocking. As part of the "Zostera" program, one of the elements was the introduction and support of the ichthyofauna of the Puck Bay with a predator who constantly lived in its waters, which would limit the populations of Gasterosteidae fish and round goby, despite the considerable restocking effort the stable population could not be reproduced. The reason for this is the lack of spawning areas for pike. Unfortunately, for proper embryo development, fish of this species have to spawn in freshwater, not brackish waters (Puck Bay with salinity at the level of 6-7 PSU does not provide sufficient conditions). The historical breeding sites on the Puck Bay were the Płutnica river, which after carrying out modernization and drainage works, and especially the construction of a pumping station on this watercourse in the 1970s, lost permeability in accessing the pike from the Puck Bay to spawning grounds. After introducing a significant number of pike to the Bay and observation of its growth rate (pike in July 7-8 cm long reached the size of 35 to 42 cm at the end of October), it can be concluded that at this stage one of the most important activities is development and construction of a fish pass that allows spawners to reach flooded meadows above the pumping station. In 2015, during March and April, control catches were carried out using a power generator. As a result of these catches, it was found that Płutnica was visited by pike spawners, which sought for a suitable breeding site. During the control catch, from a few to above dozen specimens of this species were collected, measuring up to 20 to 80 cm - fish with pre-breeding and spawning gonads stages. Therefore, it is necessary to as soon as possible develop and conduct such activities jointly with the local government and PZW, the district of Gdańsk, which would lead to designation of spawning grounds, construction of a fish pass and supervision of potential spawning grounds for this species (Skóra K., 1993). The lack of such activities will cause that this species will disappear from the waters of the Puck Bay or its maintenance in the Bay will be associated with costly restocking. The protective dimension for this species in the Puck Bay is 45 cm. The protection period from March 1 to April 30 was in force in 2010-2015 and in 2016, although the protection period was postulated from January 1 to May 15. In this case, considering the extension of the protection period, it was taken into account that the fish of this species are the most northern population in Poland and during the long wintertime the spawning period may shift to May. In Swedish waters, pike spawning takes place in June and July. In conclusion, this species in the Puck Bay can be of great importance both for fisheries and the ecosystem as a constantly inhabiting predator. Without the support of restocking or creating places for natural reproduction in the area of the estuary meadows of the Płutnica river, its existence in these waters is endangered. Sooner or later, larger individuals will be caught, and without the fry there is no chance for permanent existence of this species in the waters of the Bay.

### Common whitefish

The migrating Common whitefish in the waters of the Puck Bay was a separate population, and its role and significance as well as unusual sensitivity to external conditions was noticed already in the interwar period. At that time the species was supported by restocking. After the war, good catches of this species in the Puck Bay waters were recorded until the early 1970s, when they amounted from 3 to 12 tonnes per year. In the 1980s and early 1990s, the species was not recorded in catches. At the beginning of the 1990s, it was decided to restock the Puck Bay with this species - spawners came from the Pomeranian Bay. In 2011-16, fishermen declared that 164 to 681 kg of fish of this species were caught. The average annual catch from 2011-16 was over 530 kg per year.

It reaches sexual maturity at the age of 3-9 years, and usually at the age of 4. The protection dimension for common whitefish was introduced in the previous Ordinance No. 1 of the District Sea Fisheries Inspector in Gdynia of June 1, 2010 on the dimensions and protective periods of marine organisms and detailed methods of marine fishing in internal sea waters in the Gulf of Gdańsk region at 40 cm and in the regulation of the Minister of Maritime Economy and Inland Navigation from 16 September 2016 on the dimensions and protective periods of marine organisms and detailed conditions for commercial fishing.

This dimension allows the species to spawn in a minimal manner. At this point, one should explain the sensitivity of this species to external conditions.

The spawning season usually takes place from mid-November to mid-December, but the spawning in the Puck Bay is observed already in October, which is exploited by fishermen and 90% of the catch biomass comes from this period. The roe is usually laid on a sandy or gravelly stony ground. The incubation period is quite long. Hatching usually occurs at the end of March and at the beginning of April, and this is the most critical moment for the existence of this species. If meteorological-hydrological conditions, and especially trophic conditions are appropriate and hatching encounters sufficient amounts of zooplankton, then the survival rate of the fry is high. The opposite situation occurs in the absence of zooplankton, then only a small number of individuals who managed to gain food survive. That is why it is so important to support this population with restocking. In addition, the above-mentioned ordinance of the Minister of Maritime Economy and Inland Navigation of 16 September 2016 on the dimensions and protection periods of marine organisms and detailed conditions for commercial fishing has introduced a protective period for this species from January 1 to January 31 and December 1 to December 31, and therefore it allows the spawners to be protected only during the spawning season - beginning of December. The common whitefish is not protected on the Puck Bay during a spawning raid, that is, from October to November.

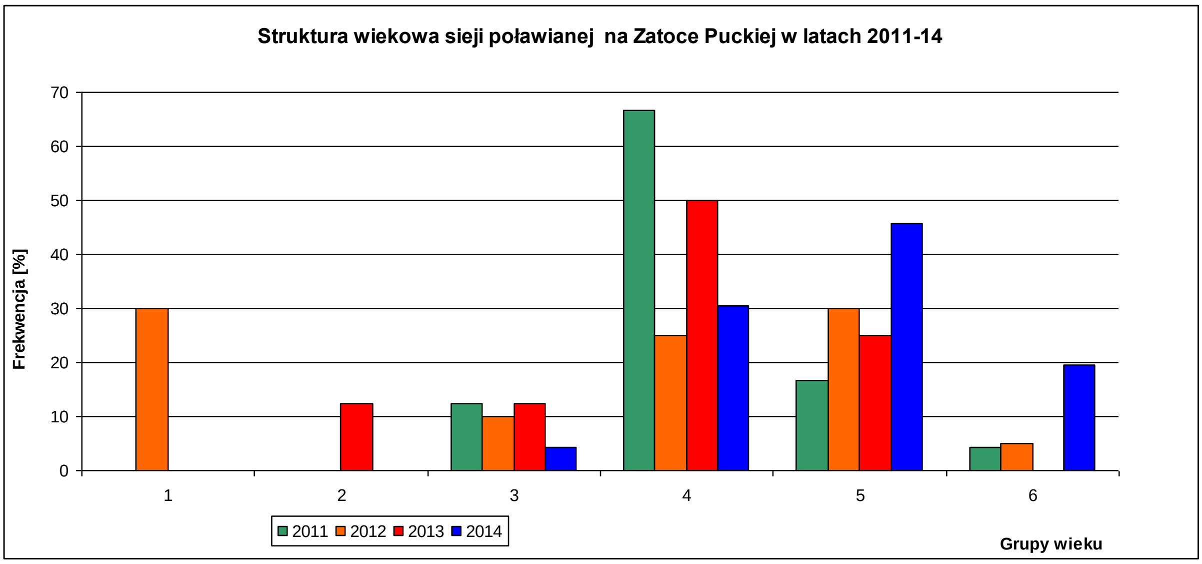



Fig. 4.3.68. The age structure of common whitefish in the years 2010-14 - data from fishermen's catches and research catches.

The basis for the exploitation of the stock from the Puck Bay are fish aged 4 and 5. The state of the stock depends on the size and frequency of restocking with this species of Puck Bay waters. The minister responsible for fisheries is responsible for restocking.

### Roach

Roach in the 1960s and 1970s played a very important role in the Puck Bay fishery. In the 1970s, on average, over 140 tonnes were caught. The largest catches of the roach were recorded in 1979 - almost 200 tonnes. In the 1990s, the catches of this species fell to 1.2 tonnes initially, and at the end of the 1990s no roach was found in the fishery. In 2011-16, fishermen from the Puck Bay declared that 36 kg of roach in landings. The observations conducted as part of the Zostera program confirm that the amount of fish of this is decreasing in the Puck Bay. It is not a target species, it is very often re-released into the waters of the Bay.

Roach reaches sexual maturity at the age of 3, sometimes 4 years, usually males mature faster than females.

An earlier ordinance of the Minister of Maritime Economy and Inland Navigation of 16 September 2016 on the dimensions and protection periods of marine organisms and detailed conditions for commercial fishing (Dz. U. z 2015, poz. 1015) specifying the protective dimension in internal waters in the area of the Puck Bay at the level of 20 cm "under normal conditions" (no competition from the round goby) should secure this species wellbeing. However, the situation in the Puck Bay has undergone some changes. In the 1970-1980, the bay underwent strong eutrophication - this was used by Cyprinid fish, which in the eutrophicated waters met growth supporting conditions. An example of this is the roach and its dynamic growth of biomass and catches in these years. In 1990, in the Hel area, the first specimens of round goby were recorded (Skóra K.E. 1992, Skóra K. E., Stolarski J. 1993, Skóra K.E. 1993.). This alien species for the ichthyofauna of the Puck Bay, due to its breeding strategy, a wider spectrum of adaptation possibilities, with simultaneously similar food preferences, began to displace the roach from the Puck Bay.

In 2014, the waters of the Puck Bay were restocked with 1,2 million. pieces of roach fry with dimensions from 2.5 to 3.5 cm. The above-mentioned arguments tend to increase the protection of this species. It was proposed to increase the protective dimension from 20 to 30 cm. With this length, the fish will reach 8 years, i.e. they will be able to spawn at least 4 to 5 times. In addition, their fertility will increase each year. The guarantee of limiting the size of the roach will be additionally pike, which was restocked in the waters of the Puck Bay in 2010-2014. The Ordinance of the Minister of Maritime

Economy and Inland Navigation from 16 September 2016 on the dimensions and protective periods of marine organisms as well as detailed conditions for commercial fishing established however a protective dimension for this species on 20 cm.

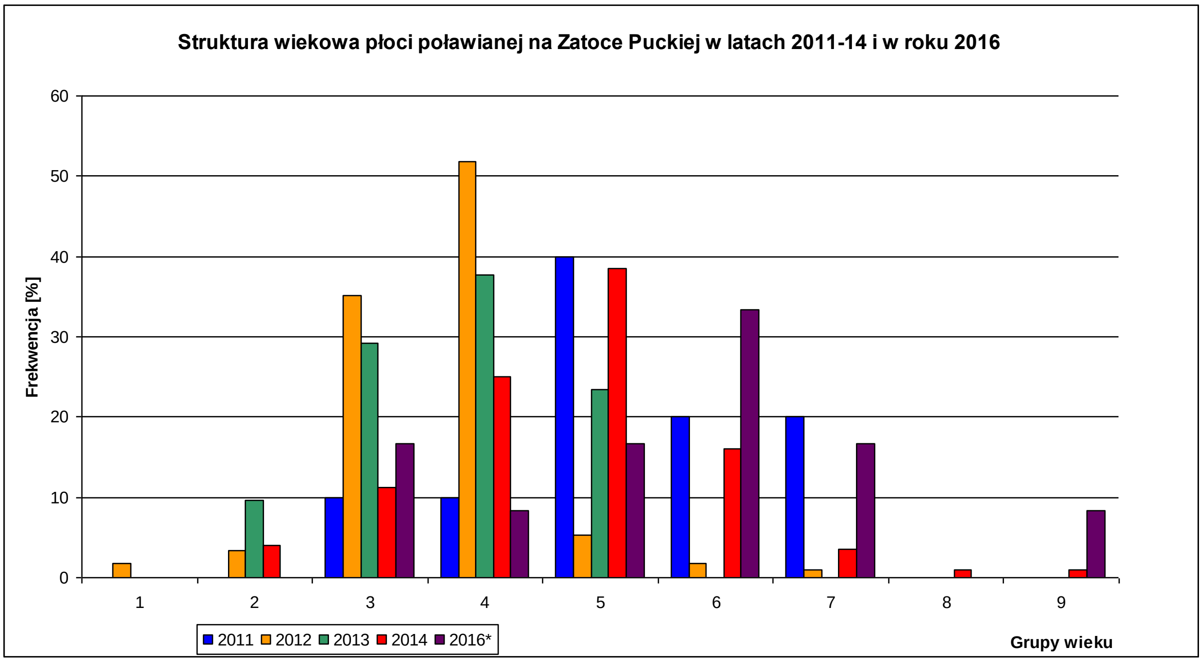



Fig. 4.3.69. The age structure of the roach caught in the Puck Bay in 2011-2014 and in 2016.

The breeding period usually takes place between April and May, when the water temperature reaches 10-11°C. Since in the previous years there was no protection period introduced for this species in interior waters of the Puck Bay, it was proposed to introduce it for the period from March 1 to May 15 or May 30. However, this requirement was not included in the above-mentioned Regulation. For the roach, therefore, there is no protection period.

**Protected species and protected areas of the Puck Bay.**

Table 4.3.22 presents the list of protected species that occured or have been found in the Puck Bay and the extent of fishery impact on them. The impact of fishery on protected species is minimal, only accidental catches of twait shad in the outer part and sturgeon originating from restocking were recorded. Other species due to their size were not recorded in catches.

Table 4.3.22. List of protected species recorded on the Puck Bay and the impact of fishery.

| Species | | constant | living periodically | occasionall | The nature of occurrence | The impact of fishing on the species |
|---|---|---|---|---|---|---|
| Polish name | Latin name | | | | | |
| Aloza | *Alosa alosa* | | | X | dying | no |
| Babka czarna | *Gobius nigier* | X | | | rare | no |
| Babka czarnoplama | *Coryphopterus flavescens* | X | | | very rare | no |
| Babka mała | *Pomatoschistus minutus* | X | | | frequently occurring | no |

| Species | | constant | living periodically | occasionall | The nature of occurrence | The impact of fishing on the species |
|---|---|---|---|---|---|---|
| Polish name | Latin name | | | | | |
| Babka piaskowa | *Pomatoschistus microps* | X | | | numerous locally | no |
| Dennik | *Liparis liparis* | | | X | very rare | no |
| Iglicznia | *Syngnathus typhle* | X | | | numerous | no |
| Jesiotr ostronosy | *Acipenser oxyrinchus* | | | X | rare from stocking | little |
| Kur rogacz | *Troglopsis quadricornis* | | | X | rare | no |
| Parposz | *Alosa fallax* | | X | | rare | sporadically caught on the outer Puck Bay |
| Pocierniec | *Spinachia spinachia* | | | X | very rare | found on the outer Puck Bay |
| Wężynka | *Nerophis ophidion* | X | | | frequent | no |

In the area of the Puck Bay, there are two Natura 2000 areas. The first, the Puck Bay is the PLB 22005 bird area, the second is the Puck Bay and the Hel Peninsula, the PLH 220032 habitat area. In addition, the Nadmorski Park Krajobrazowy is located in this area. In the area of the Puck Bay there is also a reserve "Beka" with an area of 355,60 ha located in the land part of the Puck district in the municipalities of Puck and Kosakowo and in the maritime area of the internal marine waters of the Gulf of Gdańsk.

The reserve includes halophilous meadows (salty), Molinia meadows and sedge marshes as well as reed beds and dune formations. The area of the reserve is the habitat for many rare birds, including the dunlin, Eurasian bittern, greylag goose, common shelduck, red-breasted merganser, three species of harrier, grey heron crane, etc. This place is also a winter refuge for Eurasian coot, tufted duck, mallard, common goldeneye and swans. In the vicinity of Władysławowo there is a nature reserve "Salty Meadows" with valuable species of protected plants such as: brookweed, sea plantain, Blysmus rufus or centuria and Centaurium littorale. The area of the reserve is a place where many species of waterfowl can be found, such as: Eurasian coot, mute swans, various species of ducks or charadriiformes birds, among others, dunlin, common snipe or wood sandpiper

In the areas of the "Beka" reserve, by the Ordinance No. 1 of the District Sea Fisheries Inspector in Gdynia of June 1, 2010 on the dimensions and periods of protection of marine organisms and detailed methods of sea fishing in the internal sea waters in the Gulf of Gdańsk region, a permanent fishing protective circuit was introduced, additionally, there was a periodic fishing protective circuit in the region of the Płutnica River mouth from April 20 to June 20. In the current regulations (the ordinance of the Minister of Maritime Economy and Inland Navigation from 16 September 2016 on the dimensions and protection periods of marine organisms and detailed conditions for commercial fishing), protective circuits in these regions have not been taken into account..

***A summary on the selective extraction of animal species including incidental catches of non-target species, including those caused by commercial and recreational fishing;***

**By-catch of non-commercial and protected species**

The update of initial assessment of marine waters was based on data from observations of catches made by inspectors located on fishing vessels operating at sea. The largest amount of information came from the database of the Multiannual Fisheries Collection Program (WPZDR); only a small percentage came from the implementation of other programs performed by MIR-PIB, from the sea fishery monitoring by observers performing their tasks on fishing vessels. The term "non-commercial species" used in the text means species of fish which are not the target of the catch, but can be treated equaly to the target species - they are then landed and reach the market. In addition, it should be noted that the revenues generated from their sale do not constitute a significant part in inflows to the budget of fishing enterprises and individual fishermen.

A different situation occurs in the case of sand lance caught intentionally in POM (lesser sand eel- *Ammodytes tobianus* and great sand eel- *Hyperoplus lanceolatus*) - half of the fishing fleet has been focused on these species in recent years. This situation is the result of increased demand for raw materials used for the production of fodder intended for aquaculture. For the purpose of this study, data from observations of catches at sea carried out by observers on behalf of MR-PIB were used. In total, in the years 2011-2016 observations were carried out during 550 flights. The vast majority of data - 540 observed cruises - was obtained in connection with the implementation of WPZDR (Multi-annual Fisheries Data Collection Program; Table 4.3.23). In only 10 cases, the information came from cruises performed during implementation of other research programs.

Table 4.3.23. Number of research cruises observed under WPZDR in 2011-2016.

| ICES subarea or Lagoon/Year | ICES 24, 25, 26 (excl. lagoons) | Szczecin Lagoon | Vistula Lagoon |
|---|---|---|---|
| 2011 | 66 | 14 | 14 |
| 2012 | 52 | 14 | 14 |
| 2013 | 59 | 10 | 10 |
| 2014 | 66 | 14 | 13 |
| 2015 | 75 | 14 | 14 |
| 2016 | 65 | 14 | 12 |
| Total | 383 | 80 | 77 |

WPZDR guidelines define the number of observations at sea necessary to enable the characterization of catches from fishing vessels operating under the Polish flag. In addition, the program assumptions define in detail the areas, fishing gear, type and size of fishing vessels and determine the frequency and number of samples for a given species subject to exploitation. Every time the research of caught fish (constituting the main mass of landings) on board fishing vessels, the scientific research team is obliged to record other sea organisms caught occasionally, therefore the WPZDR indications allow to sketch the basic by-catch characteristics of non-commercial and protected species.

From the data obtained, it can be clearly stated that the largest number of non-commercial fish was recorded in both lagoons (Vistula and Szczecin); in both cases this is related to the location of the fishing gears deployed. Due to the prevailing conditions within both lagoons (partly sheltered coast, short distance from the home port) it is possible to deploy on shallow fishing grounds fishing gear specific to the lagoons conditions. It is within the shallow habitats of transitional waters, because of the favorable conditions for spawning and living, where the young individuals of non-commercial fish are found.

Table 4.3.24. The number of individual fish species in the catch in the years 2011-2016 based on observations of catches conducted under WPZDR and other MIR-PIB research programs (550 cruises).

| Species | ICES 24 | ICES 25 | ICES 26 | Szczecin Lagoon | Vistula Lagoon |
|---|---|---|---|---|---|
| Protected species | | | | | |
| Broadnosed pipefish | 0 | 0 | 1 | 0 | 0 |
| Twait shad | 0 | 3 | 8 | 0 | 0 |
| 'Non-commercial' species (no demand) | | | | | |
| Shorthorn sculpin | 94 | 166 | 4 | 0 | 0 |
| Lumpsucker | 51 | 125 | 239 | 0 | 0 |
| Three-spined stickleback | 0 | 3 | 45 | 0 | 0 |
| 'Rarely commercial' species (occasionally individual fish are retained) | | | | | |
| Ruffe | 0 | 0 | 0 | 1737 | 385 |
| Ide | 0 | 0 | 0 | 33 | 5 |
| Chub | 0 | 0 | 0 | 24 | 1 |
| Common bleak | 0 | 0 | 0 | 6 | 113 |
| Viviparous eelpout | 16 | 2 | 0 | 0 | 0 |
| Species "sometimes commercial" (depending on the size of the catch, the size of the individuals and demand the fish are retained) | | | | | |
| Round goby | 0 | 2 | 42 | 976 | 407 |
| Garfish | 5 | 32 | 1 | 62 | 0 |
| Asp | 0 | 0 | 0 | 39 | 7 |
| Vimba | 0 | 0 | 0 | 180 | 66 |
| Whiting | 606 | 116 | 0 | 0 | 0 |
| Sichel (Vistula Lagoon ) | 0 | 0 | 0 | 0 | 891 |
| Smelt | 4 | 1 | 11 | 65 | 125 |
| Fourbeard rockling | 5 | 4 | 0 | 0 | 0 |
| White bream | 0 | 0 | 0 | 190 | 773 |
| 'Commercial' species (undersized individuals are rejected - in accordance with applicable regulations or customary commercial dimension) | | | | | |
| Mackerel | 22 | 129 | 4 | 0 | 0 |
| Common carp | 0 | 0 | 0 | 0 | 2 |
| Burbot | 0 | 0 | 0 | 112 | 34 |
| Haddock | 3 | 1 | 0 | 0 | 0 |
| European whitefish | 4 | 1 | 53 | 184 | 0 |
| Common sole | 2 | 0 | 0 | 0 | 0 |

The number of taxa found in the lagoon and sea environment (Table 4.3.24) was similar (14 and 17 species respectively). However, clear difference in the species composition of ichthyofauna in both environments can be noticed: in the case of lagoon, cyprinidae and pericidae fish predominate; the remaining waters are dominated by marine taxons.

Of all the non-commercial fish species, only four (round goby, garfish, smelt, common whitefish) were found in both lagoon and sea.

On both lagoons, the most commonly caught non-commercial species are the ruffe and the round goby. There are fewer numbers of white bream, vimba, smelt and burbot. Only within Szczecin Lagoon, a common whitefish was recorded, while the occurrence of a sabrefish in the catch was limited to the waters of Vistula Lagoon.

The species most often caught on the sea were: whiting, lumpsucker, shorthorn sculpin and mackerel. Clearly more frequent occurrence of whiting, shorthorn sculpin and mackerel within ICES subareas 24 and 25 than in ICES 26. The lumpsucker was evenly distributed in the scale of the three ICES subareas mentioned above.

In the catch in the years 2011-2016, two protected species were found: in subareas 25 and 26 of the ICES, there were 11 twait shads and one individual of the broadnosed pipefish (ICES sub-region 26, Puck Bay).

The sichels found in fishing gear were not protected, as according to the regulations of the Minister of the Environment of 16 December 2016 on animal species protection (Journal of Laws of 2016, item 2183), individuals from the Vistula Lagoon population were not are protected.

***Cod recreational fishing at sea***

The new law act on sea fisheries of 19 December 2014 (Journal of Laws of 2015, item 222), which entered into force on 4 March 2015, specifies the principles of performance of marine fishing. Recreational fishing, consisting part of the use of resources, has also been subject to the regulation of the new law. The most important change regarding angling was to divide people involved in marine fishing into two groups. The first are ship owners and organizers of fishing competitions. For this group, recreational fishing is allowed on the basis of a permit issued by a regional inspector of marine fishing. The issued permits are registered. The second group are persons (anglers), for whom the obligation to hold a permit for recreational fishing has been abolished, and fishing for these persons is allowed on the basis of a proof of payment. In particular, the Regulation of the Minister of Agriculture and Rural Development of 6 July 2015 on the dimensions and protective periods of marine organisms caught in recreational fishing and detailed methods and conditions for recreational fishing determines the admissible number of cod which can be caught. According to the provisions of this regulation, the amount of cod that can be caught and kept by a single person in one day is no more than 14 individuals. Meanwhile, ship-owners of vessels carrying anglers and fishing contest organizers can perform unlimited cod catches, but ship-owners and competition organizers must draw up a report on catches from anglers, including the number of individuals caught. Cod fishing is not limited due to the protection periods that apply to commercial fishing. However, the cod conservation dimension of 35 cm for commercial fishing also applies to cod recreational fishing. Certain limitation is the method of fishing for cod, which, in accordance with the provisions of the above-mentioned ordinance of the Minister of Agriculture and Rural Development of 6 July 2015 on the dimensions and protective periods of marine organisms caught in recreational fishing and detailed methods and conditions for recreational fishing allows fishing for cod from a ship or other vessel, where the termination of line with an artificial bait with attached, in aflexible manner, hook of not more than 3 blades spaced out and in such a way that they do not exceed the perimeter of the circle with a diameter of 30 mm or did not exceed the width of the bait, or the leader ended with a hook of one blade, the opening of which does not exceed 20 mm, with attached artificial bait. There is no EU regulation regarding recreational fishing for cod.

Recreational fishing cruises are organized from the following Polish coast ports: Hel, Jastarnia, Władysławowo, Łeba, Ustka, Darłowo, Kołobrzeg, Mrzeżyno (Fig. 4.3.70).

Based on the registration of outgoing recreational vessels carried out at the Masters offices of the aforementioned ports, the annual number of fishing trips for 2011-2016 was summarized (Fig. 4.3.71).

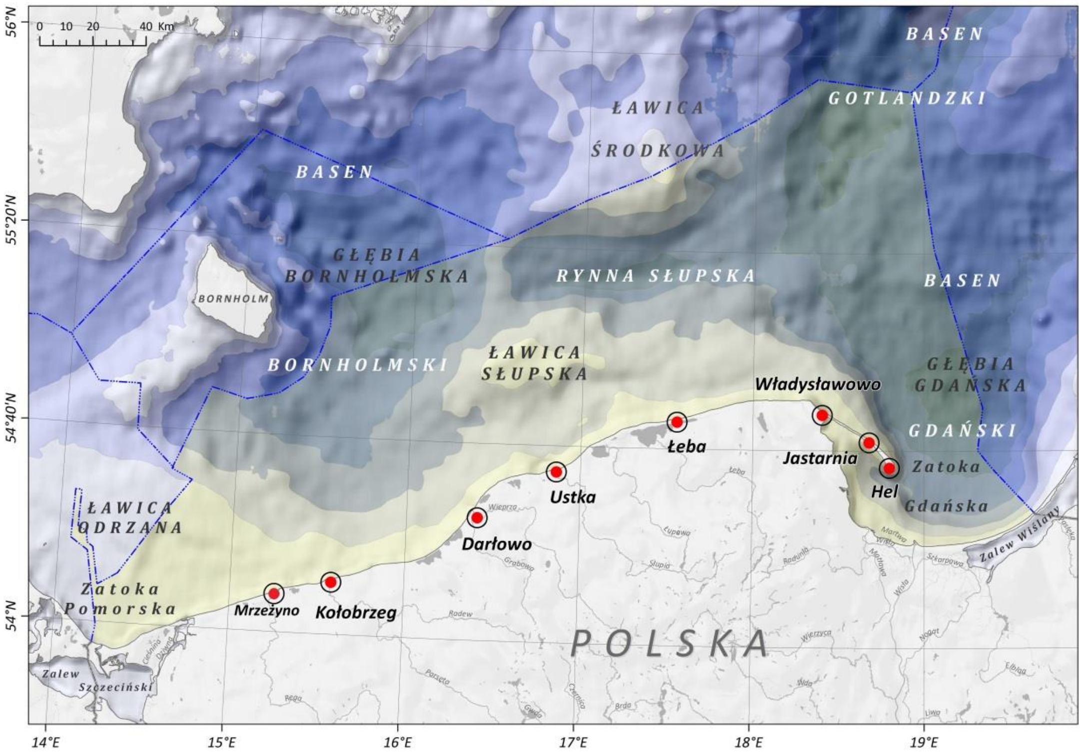



Fig. 4.3.70. Ports from which recreational cod fishing trips are organized (*a map compiled by Lena Szymanek, MIR-PIB*).

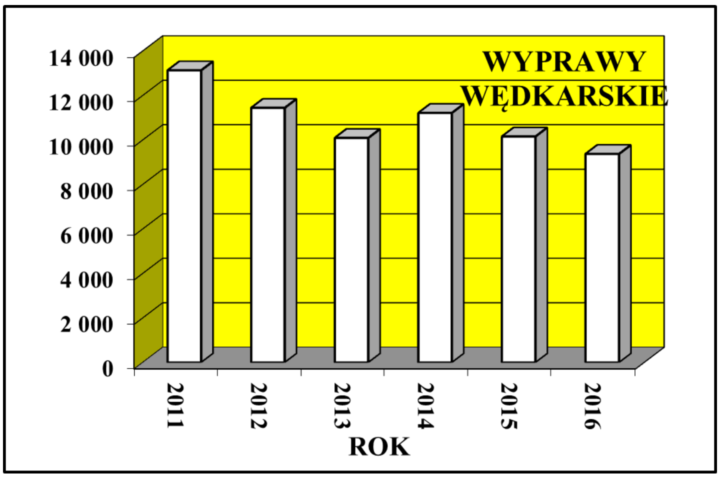



Fig. 4.3.71. Number of recreational cruises recorded by Harbor Master's Office

In 2011-2013, the total number of recreational cruises decreased. The reduction was significant as the number of trips in 2013 was 23% lower than in 2011. However, in 2014 there was an increase of 11% compared to 2013. In 2015 and 2016, the number of recreational expeditions decreased.

Therefore, in the years 2011-2016 there was a decreasing trend in the number of cruises (a reduction of 28.6% in the aforementioned period).

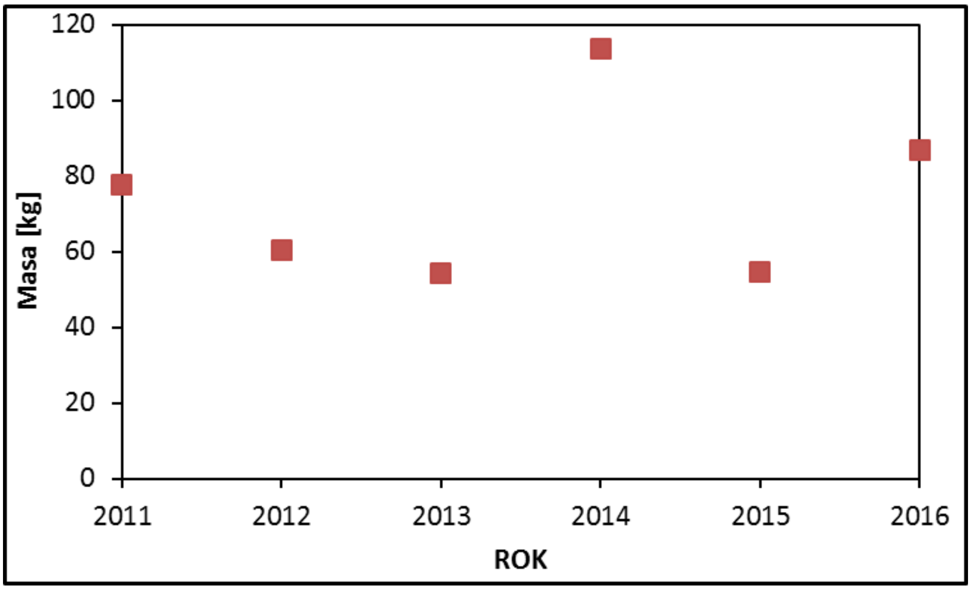



Fig. 4.3.72. The average annual weight of cod obtained in a fishing expedition in 2011-2016 on the basis of the participation of MIR-PIB employees on cruises (on-board observer trips).

On the basis of the participation of MIR-PIB employees in cruises on fishing vessels, the average weight of cod catch per recreational expedition was obtained (Fig. 4.3.72). From these data, it appears that the amount of cod catch in 2011-2016 remained relatively similar (from 54 kg to 87 kg). The exception was 2014, when this it reached 113.5 kg. Therefore, there was no evidence of a strongly marked trend in changes in the value of this parameter.

Both the data on the number of recreational trips and the results of recreational fishing for cod in the sea were used to estimate the annual amount of cod catches obtained by anglers coming from Polish ports. The adopted method calculates the average weight of cod obtained in the expedition in a given quarter of the year, because the cod fishing results (and the average weight of cod caught) are different due to the season (quarters used). The average weight of the catch calculated this way was multiplied by the number of fishing trips registered by Masters office of the port in a given quarter, because the fishing activity of cod expressed by the number of cruises is very different between individual quarters. The summing of quarterly catches in individual years gave the annual recreational catches presented ina Fig. 4.3.73.

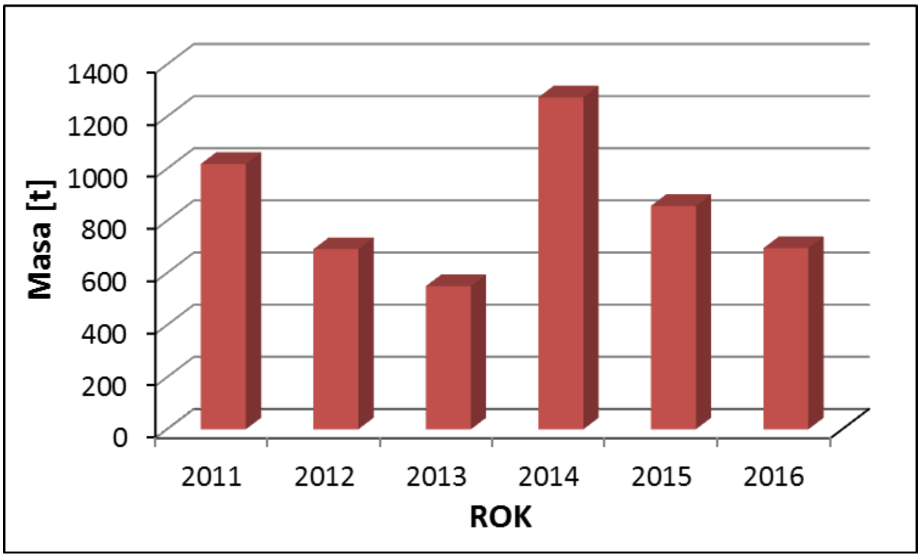



Fig. 4.3.73. The size of the estimated Polish recreational catches (tonnes) of cod in 2011-2016.

Fishing in 2011-2016 can be divided into two periods characterized by a declining fishing trend. The first concerned the years 2011-2013 and the second period 2014-2016. The year 2014 is significantly different from other years, which results from the increase in the number of fishing trips recorded this year (Fig. 4.3.71) and obtaining the highest average fishing capacity per flight in 2011-2016 (Fig. 4.3.72). These two factors contributed to the highest catch in 2014. Changes in the estimated annual amount of recreational fishing, however, were characterized by a slightly decreasing trend in 2011-2016.

**Information on the results of by-catch of mammals and waterbirds in fishing nets of fishing vessels flying the Polish flag**

The Marine Fisheries Institute - PIB, as part of an annual monitoring program for incidental catches of cetaceans in POM, conducted parallel observations of by-catch of other marine mammals (seals) and birds. Detailed information on the results of the program was reported after the end of the annual monitoring cycle in the form of a "Report on the implementation of the Monitoring Program of Accidental By-catch of Cetaceans in ...". Until 2014, the said monitoring program (hereinafter referred to as "the Program") was a separate work financed by the Ministry of Agriculture, and from 2015 it was included in the of the Fishing Data Collection National Program, financed by the EC and Poland. Still, the main goal of the Program is the monitoring of fishing on cutters with a length equal to or exceeding 15m, fishing using bottom set gillnets (GNS) with a mesh size of more than 80 mm and pelagic trawls for accidental catches of cetaceans in POM. This activity resulted from Poland's commitment to implement the provisions of Council Regulation (WE) No. 812/2004 of 26 April 2004 laying down measures concerning incidental catches of cetaceans in fisheries and amending Regulation (WE) No. 88/98. In the event of time, technical or formal difficulties related to the possibility of monitoring the size of planned fishing effort for the cutter segment >15 m, in some years also by-catch monitoring from boats in the coastal zone, mainly in the Puck Bay was performed.

During the 11 years of the implementation of the Programme (since 2006), no cetacean by-catch, specifically the Baltic porpoise, has been reported. During the period covered by this study, i.e. 2011-2016, with one exception there was no bird and seal mortality observed in trawls. The only case of catching a bird during trawling (herring gull) took place on 5/6/2012, however, due to the incidental nature of this incident, it was not included in the further part of the study. The phenomenon of mortality of birds and mammals (seals) was observed only from bottom set gillnets (GNS) and it occurred to a very small extent, both in open and coastal waters. Table 4.3.25 presents a summary of the fishing effort monitored for by-catch of birds and marine mammals during the implementation of the Monitoring Program of Accidental By-catch of Cetaceans.

Table 4.3.25 The number of by-caught birds and seals in relation to the size of the monitored fishing effort of the GNS segment in the years 2011-2016, broken down into boats and units > 15 m and ICES squares.

| Year | Period of conducted by-catch observations | Lenght class (m) | ICES ICES subarea | Observation time (days) | Total length of monitored, deployed nets (km) | Monitored GNS fishing effort (NMD) | By-catch of birds (number)* | By-catch of seals (number)* |
|---|---|---|---|---|---|---|---|---|
| 2011 | 3.05-27.05 | >15 | 25 | 109.59 | 204.15 | 258 600.80 | 4 | 0 |
| 2011 | 13.04-8.11 | łódki | 26 | 35.71 | 30.01 | 31 464.17 | 2 | 0 |
| 2012 | 29.06-9.07 | >15 | 24 | 80.46 | 213.60 | 206 150.00 | 0 | 0 |
| 2012 | 14.05-24.06 | >15 | 25 | 117.02 | 260.32 | 461 145.00 | 2 | 0 |
| 2012 | 29.05-16.06 | >15 | 26 | 25.17 | 92.06 | 115 825.00 | 0 | 0 |
| 2012 | 23.03-19.10 | łódki | 26 | 16.17 | 14.36 | 14 927.00 | 4 | 0 |
| 2013 | 18-20.07 | >15 | 24 | 9.42 | 30.00 | 57 500.00 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2013 | 19.05-13.12 | >15 | 25 | 86.05 | 408.80 | 607 425.00 | 0 | 3 |
| 2013 | 15.04-8.11 | łódki | 26 | 74.75 | 24.02 | 28 328.33 | 1 | 0 |
| 2014 | 21.05-31.10 | >15 | 25 | 200.64 | 589.20 | 684 522.60 | 0 | 0 |
| 2014 | 9.09-16.10 | łódki | 26 | 116.35 | 32.40 | 26 816.67 | 0 | 0 |
| 2015 | 27.10-23.11 | >15 | 25 | 32.04 | 152.90 | 168 139.60 | 0 | 0 |
| 2016 | 2.04-26.10 | >15 | 25 | 54.33 | 276.30 | 334 147.90 | 2 | 1 |

*) applies to the total number of dead and live animals found in nets

A detailed list of all species of animals found during the monitored catches with set gillnets (GNS) is presented in Table 4.3.26.

Table 4.3.26. Detailed list of animals by-caught during monitored catches by set gillnets (GNS) in POM, in 2011-2016, by year, fleet segments and ICES statistical areas.

| Species by-caught | Dead individual | Living individual | Date | Time | Latitude. N | Longitude E | Fishing square | ICES area | gear code | Mesh size (mm) | gear length (m) | Duration of catch (h) | Fishing segment | Vessel length(m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Velvet scoter (*Melanitta fusca*) | 0 | 1 | 05.05.2011 | 19:05:00 | 55.18 | 17.09 | M-9 | 25 | GNS | 160 | 400 | 14,3 | >15 | 17 |
| Thick-billed murre (*Uria lomvia*) | 1 | 0 | 05.05.2011 | 19:15:00 | 55.18 | 17.11 | M-9 | 25 | GNS | 160 | 400 | 13,4 | >15 | 17 |
| Red-throated diver (*Gavia stellata*) | 0 | 1 | 05.05.2011 | 19:36:00 | 55.18 | 17.15 | M-9 | 25 | GNS | 160 | 400 | 11,5 | >15 | 17 |
| Razorbill (*Alca torda*) | 0 | 1 | 08.05.2011 | 19:19:00 | 55.17 | 17.14 | M-9 | 25 | GNS | 160 | 800 | 11,6 | >15 | 17 |
| Thick-billed murre (*Uria lomvia*) | 2 | 0 | 21.04.2011 | 06:30:00 | 54.41 | 18.36 | R-6 | 26 | GNS | 140 | 2100 | 24 | łódki | 6 |
| Thick-billed murre (*Uria lomvia*) | 1 | 0 | 30.05.2012 | 13:20:00 | 54.58 | 16.45 | L-7 | 25 | GNS | 240 | 7800 | 110 | >15 | 17 |
| Thick-billed murre (*Uria lomvia*) | 1 | 0 | 30.05.2012 | 16:30:00 | 54.59 | 16.50 | L-7 | 25 | GNS | 240 | 3600 | 115 | >15 | 17 |
| Thick-billed murre (*Uria lomvia*) | 0 | 1 | 23.03.2012 | 06:30:00 | 54.37 | 18.39 | R-5 | 26 | GNS | 160 | 840 | 48 | łódki | 7 |
| Unidentified | 3 | 0 | 13.04.2012 | 06:00:00 | 54.38 | 18.39 | R-5 | 26 | GNS | 160 | 840 | 24 | łódki | 7 |
| Grey seal (*Halichoerus grypus*) | 1 | 0 | 19.05.2013 | 14:00:00 | 55.03 | 16.56 | L-8 | 25 | GNS | 220 | 2500 | 74 | >15 | 17 |
| Grey seal (*Halichoerus grypus*) | 1 | 0 | 31.05.2013 | 20:00:00 | 55.01 | 17.00 | M-8 | 25 | GNS | 220 | 5000 | 120 | >15 | 17 |
| Grey seal *Halichoerus grypus*) | 1 | 0 | 01.06.2013 | 20:00:00 | 55.02 | 16.50 | L-8 | 25 | GNS | 220 | 5000 | 120 | >15 | 17 |
| Tufted duck (*Aythya fuligula*) | 1 | 0 | 22.10.2013 | 05:00:00 | 54.38 | 18.32 | R-5 | 26 | GNS | 110 | 800 | 13 | łódki | 8 |
| Grey seal (*Halichoerus grypus*) | 1 | 0 | 20.05.2016 | 14:40:00 | 54.52 | 16.23 | K-7 | 25 | GNS | 240 | 18000 | 126 | >15 | 17 |
| Black-throated loon (*Gavia arctica*) | 2 | 0 | 27.10.2016 | 10:00:00 | 55.45 | 17.16 | M-6 | 25 | GNS | 110 | 2500 | 18 | >15 | 17 |

Considering the total size of the fishing effort monitored, which in the generally used effort units, i.e. 1000 NMD (1000 m of fixed nets per day of catch) amounted to 3000, a small share of by-catch species was found. This is due to the fact that the monitored fishing effort on GNS nets in coastal areas where the largest concentration of wintering seabirds is observed, including in the Puck Bay, where observations were carried out (Area 26, fishing squares R5 and R6) amounted to less than 3.4% of the total GNS effort monitored in the years 2011-2016 in POM.

Moreover, observations carried out did not include the winter period. Therefore it should be stated that the presented specification does not present appropriate material on the basis of which the scale of the problem of incidental by-catch of birds in set gillnets exploited by Polish fisheries can be determined. The by-catch of seals in the Baltic Sea is estimated at 8%, and in the northern Baltic Sea the estimated number of seals in the by-catch amounts to 2,180 to 2,380 individuals (Vanhatalo J. et al., 2014).

***Fishery pressure on the seafloor - fishing effort of bottom gears***

The only type of fishing gear operating in POM affecting the structure and integrity of the seafloor are bottom otter trawls (OTB) and bottom pair trawls (PTB). For the purposes of this study, data on catches of Polish fishing vessels in the years 1995-2016, in the possession of MIR-PIB and the Fisheries Monitoring Center (CMR) in Gdynia, were used.

For the parameter describing the fishing effort, the number of days a vessel has spent fishing was used. The fishing days taken into account omitted the time spent at departing and returning from the fishery - not the full cruise time was considered here, but only the days reported as those in which the catches were made, i.e. the time when the gears could actually affect the seabed.

The calculations were made for statistical units of area such as Baltic fishing squares (resolution: X : 0.33(3)°, Y: 0.166(6)°; the area of the full square varies depending on the location from 389 to 404 $km^2$).

Changes of fishing effort for particular years are presented in Fig. 4.3.74 - Fig. 4.3.76.

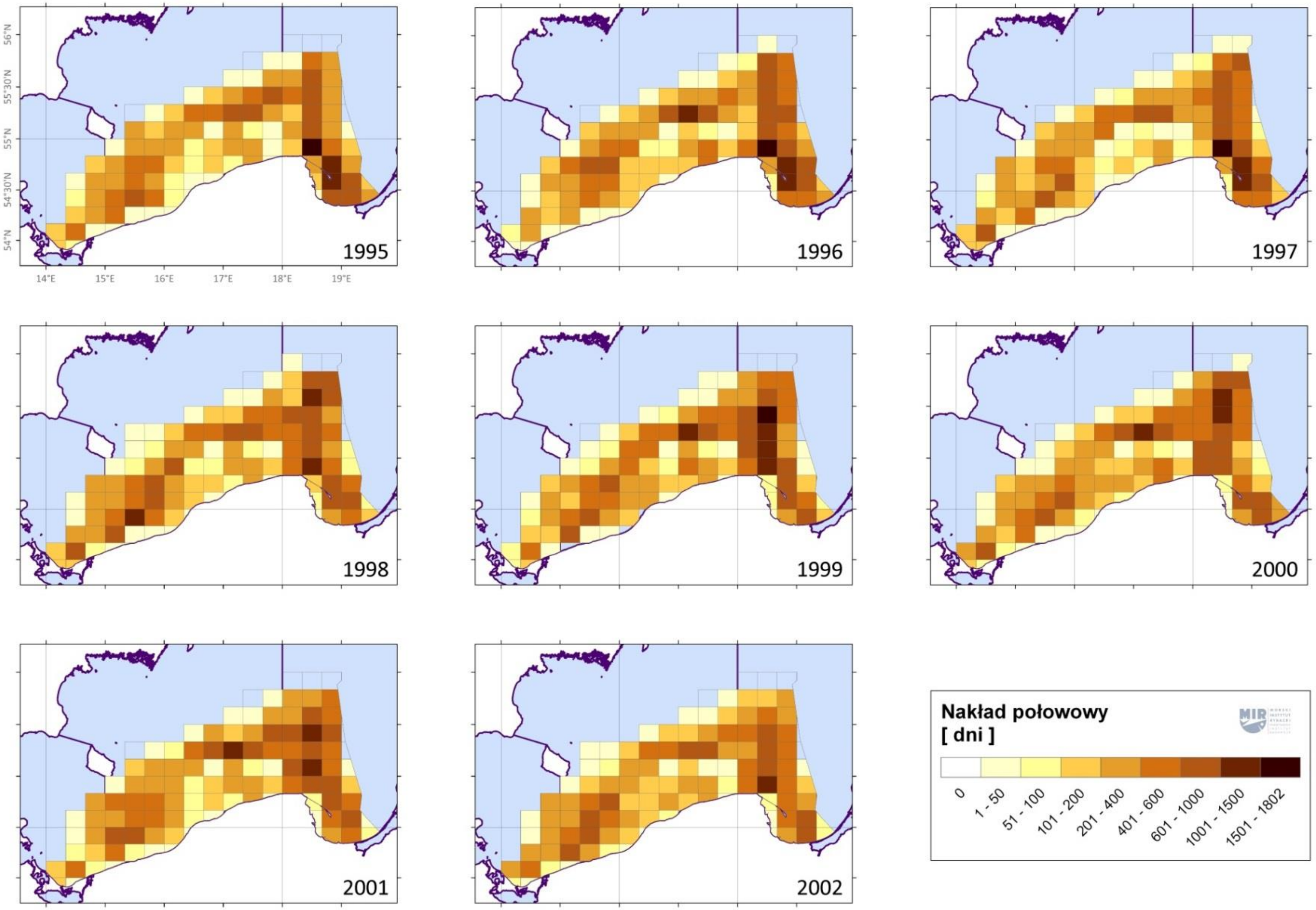



Fig. 4.3.74. Fishing effort with fishing gears affecting the bottom, in 1995-2002

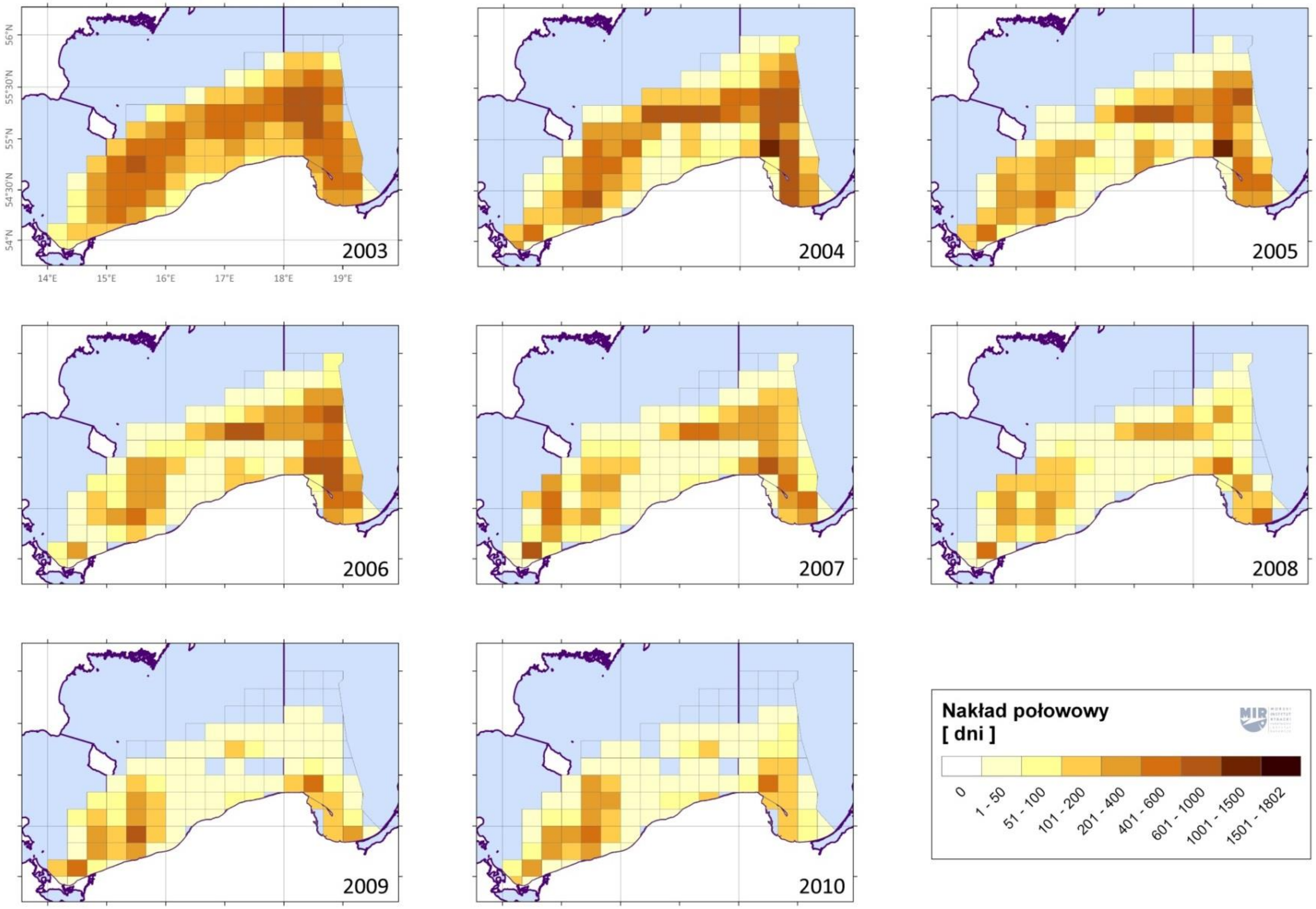



Fig. 4.3.75. Fishing effort with fishing gears affecting the bottom, in 2003-2010

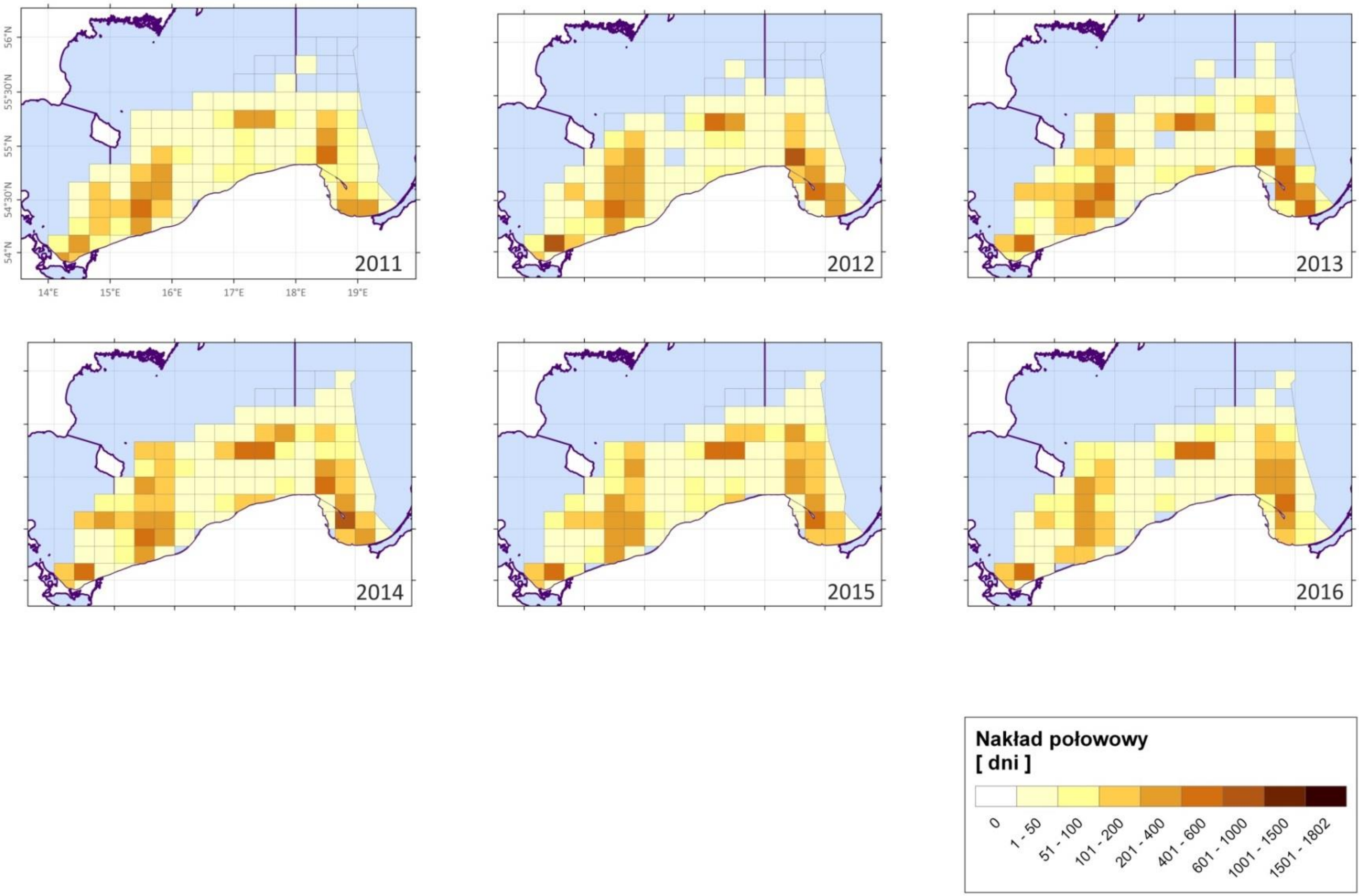



Fig. 4.3.76. Fishing effort with fishing gears affecting the bottom, in 2011-2016

The presented maps show both significant spatial diversification of the estimated effort as well as a general decrease in the intensity of use of both analyzed fishing gears. The reasons for the decreasing trend are most likely due in part to the reduction of the fleet (after joining the EU), as well as the introduction of new management measures, such as the so-called three-field system (2009-2011), and regress in cod fishing (caused by poor fish condition). In recent years, the fishing effort have remained at a similar level, with the maximum in the area of Rynna Słupska, the Gdańsk Basin (especially around Hel) and the southern part of the Bornholm Basin and the Kołobrzeg fishery.

The total fishing effort in the analyzed period is shown in Fig. 4.3.77. It allows to identify areas potentially exposed to pressure resulting from the use of the discussed bottom gears.

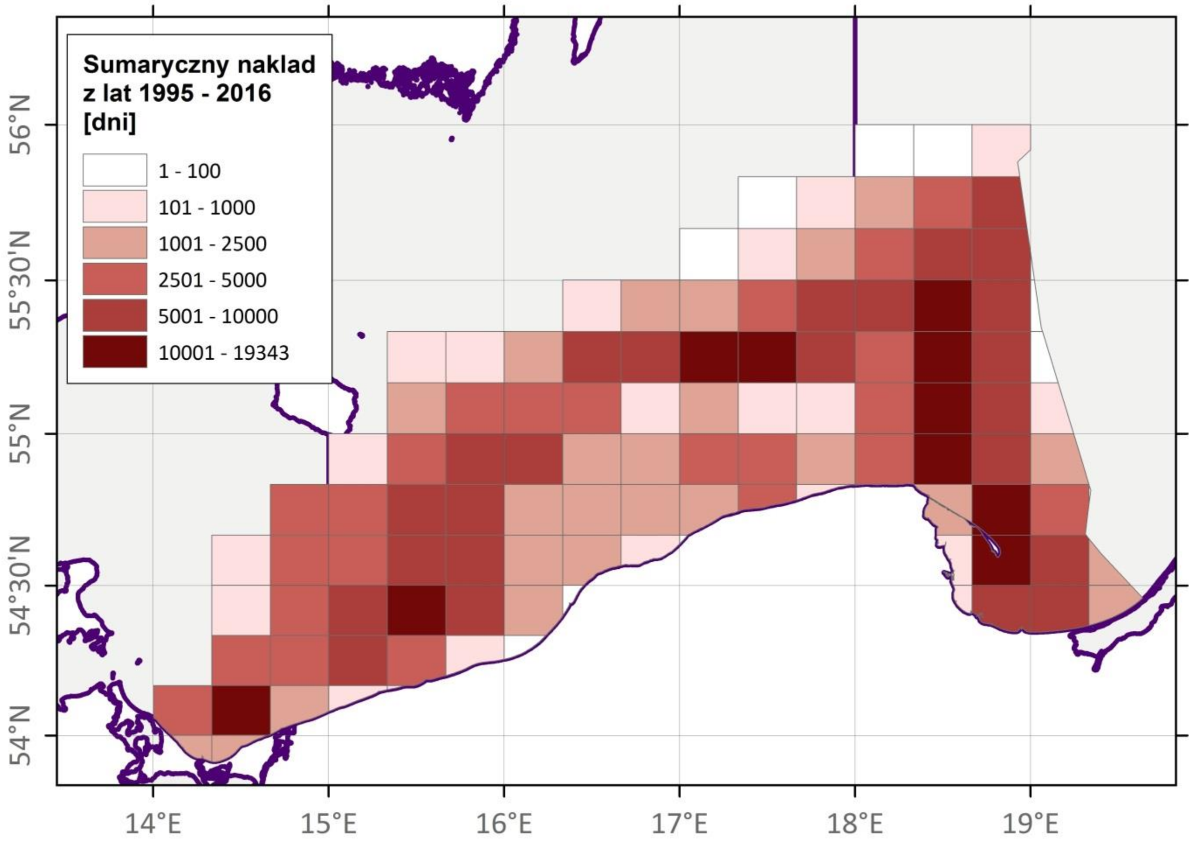



Fig. 4.3.77. Total effort from 1995-2016

Fig. 4.3.78 shows a summary of changes in the size of the average fishing effort in the years 1995-2016. There is a clear reduction in the fishing effort by 2011 and a slight increase in subsequent years, but definitely below the level before Poland's accession to the EU (1995-2004) and before the implementation of so-called three-field system (2005-2008).

A possible attempt to determine the significance of fishing pressure must take into account not only corresponding data from countries fishing in South Baltic, but also the fact of high resistance to such pressure of benthic communities inhabiting the sandy bottom in this region (results of the COST-IMPACT project co-financed from the 5th Program The EU Framework did not show any significant impact of trawling on macrozoobenthos and meiobenthos communities in the Gulf of Gdańsk region). In addition, both analyzed gears: bottom otter trawls (OTB) and bottom pair trawls (PTB) are generally considered to be much less dangerous for the structure of seafloor and the organisms inhabiting than for dredges and beam trawls (TBB), in practice not used in Polish waters.

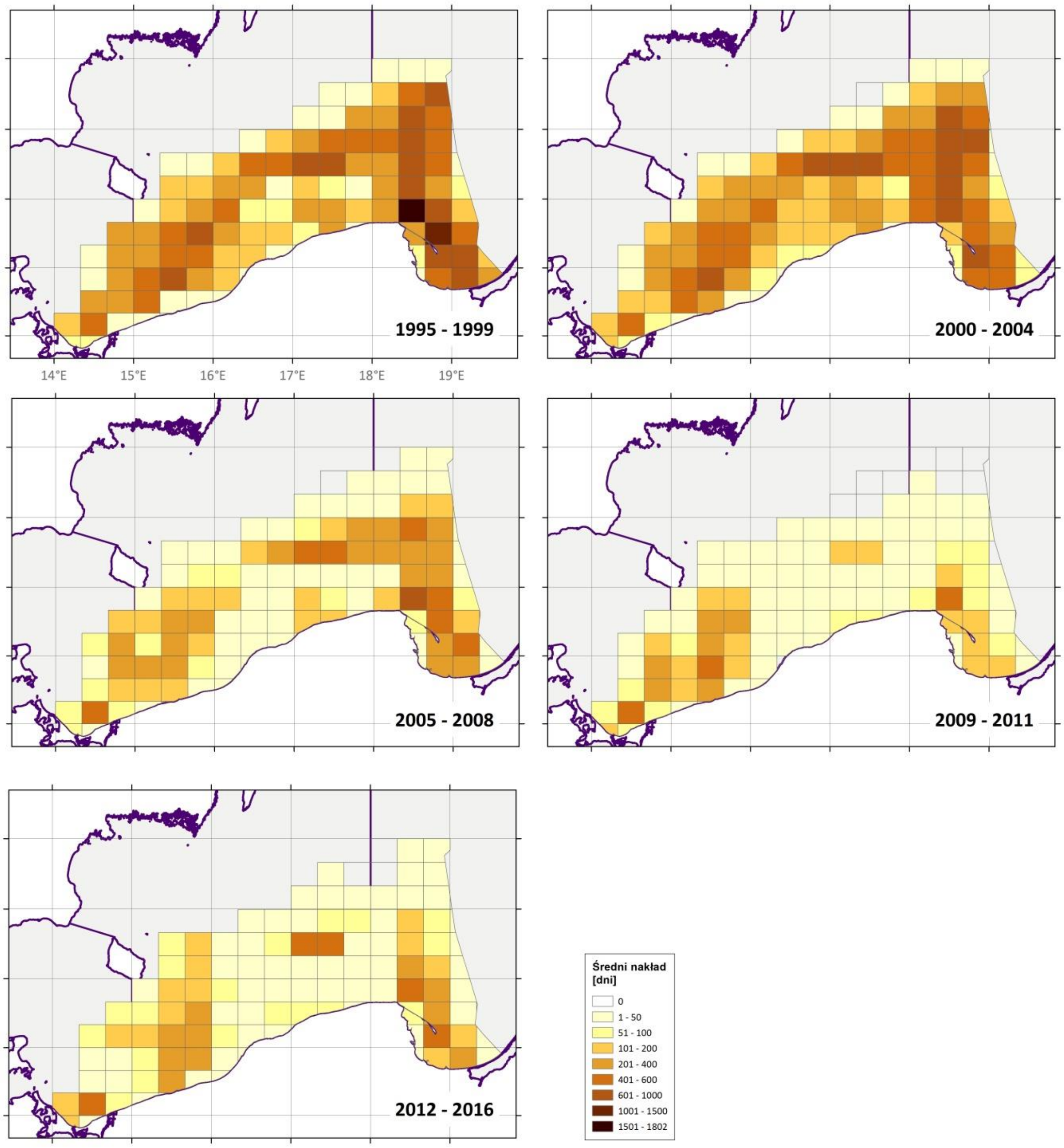



Fig. 4.3.78. Change in the average fishing effort in the years 1995-2016.

# 5. Socio-economic analysis of the use of marine waters and the cost of degradation of marine environment (in accordance with Article 8 of the Act 1 the letter c MSFD)

## 5.1. Analysis of available materials, adopted methodological assumptions

***Terminological issues***

The term "maritime economy" is used by GUS for selected departments, sub-departments of sections according to PKD. This set, analyzed below, is not completely compatible with the scope of analysis. For simplification, this aggregate will be referred to as the 'marine economy area'. For the purpose of distinguishing the strict GUS terminology the concepts from the Polish Classification of Activities of 2007 (PKD) - "section", "department" from the analysis areas called sectors were distinguished.

The concept of disadvantages associated with the degradation of the Baltic Sea is closely related to the concept of benefits gained when water status is restored. Therefore, these concepts can be used interchangeably - they refer to the same numerical values. The disadvantages occur until the state, does not reach the level described as good, and as a result of its achievement it will be possible to talk about the benefits of improvement.

The official definition of Baltic communes includes both municipalities located on the Baltic Sea and those with a minimum of 50% of the area located within 10 km of the coastline. In practice, municipalities located directly at the sea were used for research related to the existence of bathing areas. These collectivities were each time described in the calculations.

In Poland, three voivodships have access to the sea. In practice, data from two voivodeships Pomeranian and West Pomeranian were used to perform calculations regarding tourism and recreation. Coastal communes of Warmia and Mazury voivodship are responsible for 1.7% of the Baltic coastal tourism turnout, and GUS does not disclose any detailed disaggregations in these units.

In the report, in the part concerning maritime economy, the notions of "working" and "employed" appear. Employees are people employed on the basis of an employment relationship or a business relationship. The concept of working people is wider; they are people who work to earn their wages (in the form of remuneration for work) or income. Therefore, they are not only employed, but also employers and self-employed, people performing home work, agents and co-op members.[14]

The measure of disadvantage of low quality of the environment (e.g. the Baltic Sea) is the tendency to incur expenditures to improve the quality of this environment. This tendency is measured in financial units (PLN, €) per person. Depending on the designed research, it refers to one-off payment or cyclical - annual payment. In short, this tendency is marked as WTP (willingness to pay).

***Compatibility of sections by PKD and sectors of analysis***

The main source of data describing maritime economy is GUS. In connection with the above, such data are given in disaggregation according to the Polish Classification of Activities of 2007 (PKD), developed on the basis of NACE. The mentioned aggregation is not completely compatible with the sectors of this analysis. For ordering of the terminology, the areas of activity classified by GUS for "maritime economy" were cited, and then the manner of assigning the NACE sections to the analysis sectors was shown.

Table 5.1.1. Comparison of business areas classified as "maritime economy" according to GUS and areas of analysis

| Section by PKD | Activities from a given section qualified for "maritime economy" | Assignment to analysis areas |
|---|---|---|
| Section A. Agriculture, | Fisheries in sea waters | Fisheries/sea fishing |

[14] http://stat.gov.pl/metainformacje/slownik-pojec/pojecia-stosowane-w-statystyce-publicznej/lista.html

| Section by PKD | Activities from a given section qualified for "maritime economy" | Assignment to analysis areas |
|---|---|---|
| forestry, fishing | | |
| Section B. Mining and quarrying | Not taken into account (oil and gas mining) from the seabed | Extraction industry/maritime mining industry |
| Section C. Industrial processing | Manufacture of ships and floating structures, cruise and sport boats, repair and maintenance of ships and boats, processing and preserving of fish, crustaceans and molluscs | Shipyards / shipbuilding |
| Section D. Production and supply of electricity, gas | Not taken into account (windmills off shore) | Others - offshore wind energy /renewable energy - wind farms |
| Section G. Wholesale and retail trade | Wholesale trade of other food: fish, crustaceans and molluscs, retail sale in specialized stores | Fisheries/sea fishing |
| Section H. Transport and storage | Sea and coastal transport, cargo and passenger transport, reloading and warehousing of goods in ports, service activity supporting sea transport, | Shipping and sea ports |
| Section I. Activities related to accommodation and catering services | | Tourism and Recreation |
| Section L. Activities related to real estate services | Not included (Section 55 Accommodation) | Seaports |
| Section M. Professional, scientific and technical activities | Management of seaports | Ommited * |
| Section N. Administrative activities | Research | Ommited * |
| Section O. Public administration and national defense | Rental and leasing of water transport means | Shipping * |
| Section P. Education | Maritime Authorities. Not taken into account - national defense | Ommited * |

* omitted in sectoral analyzes, taken into account when analyzing the whole aggregate "maritime economy"
Source: Own study

The comparison of GUS disaggregations to sectors required in the analysis reveals several problem:

1) difficulty in disaggregating shipping and ports - these categories are given together;
2) in the study of GUS, the wind energy was omitted from natural causes - the first farm will be built in Poland (more precisely in the Polish exclusive economic zone) in 2021 the fastes;
3) The GUS for "maritime economy" does not include: oil and gas extraction from the seabed of the Baltic Sea, extraction of non-energy resources from the seabed, tourism and recreation on the Baltic Sea, military sector.

Based on the above observations, it should be noted that certain statistical categories, given in total for the aggregate of the whole "maritime economy" do not fully cover the scope of the given analysis.

## 5.3. Characteristics of the research area

In the light of art. 8 MSFD, for each Marine Region or Sub-Region, Member States shall prepare an initial assessment of their marine waters that takes into account existing data and includes, inter alia, economic and social analysis of their use and analysis of the costs of degradation of marine environment.

Therefore, the environmental maritime economy and its implementation is a duty resulting not only from legal (national and international) or political conditions, but it is a real obligation that determines the further development of the Baltic Sea Region. Spatial, ecosystem, political and legal determinants make the environmental maritime economy become the basic foundation for the development of this region. Coordinated by numerous instruments of EU and international law. The main legal instrument, at EU level, on the basis of which Member States take the necessary measures to achieve or maintain a good ecological status of the marine environment is - mentioned in the introduction - the MSFD. Its aim is to establish a framework of actions and common objectives for the protection and preservation of the marine environment up to 2020, i.e. protecting and maintaining the marine environment, preventing its degradation or, where feasible, restoring marine ecosystems in areas where they have been adversely affected, and preventing and gradually eliminating pollution of the marine environment, to exclude its significant impact on: marine biological diversity, marine ecosystems, human health and legal forms of use of marine environmant, or a significant threat to them. The directive sets out common principles on the basis of which Member States are to develop their own strategies to achieve good environmental status (GES) for the marine waters for which they are responsible. In Poland, such a strategy was, adopted on December 2, 2016 by the Council of Ministers, KPOWM. KPOWM is a strategic document for water management, which defines an optimal set of measures necessary to achieve good environmental status of marine waters. Within the framework of KPOWM, 55 new educational, legal, administrative, economic and control measures were proposed, which are addressed both to users of sea waters and inland waters. The time horizon of KPOWM covers the years 2016-2020, but due to natural processes, economic or social considerations, it is not assumed that environmental targets will be achieved before 2027. The document has been forwarded to the EC, which has 6 months to assess it.

In order to ensure that the second cycle of implementation of marine strategies of individual Member States, will additionally contribute to the MSFD objectives and bring more consistent determination of good environmental status, in the report of the first phase of implementation, the EC recommended that at EU level, EC services and EU Member States should cooperate in order to review, strengthen and refine the Commission Decision of 1 September 2010 on the criteria and methodological standards for good environmental status of marine waters (O.J. L 232, 02/09/2010, p. 14) to 2015. The purpose of this cooperation was to provide a more clear, simple, concise and comparable set of characteristics and methodological standards for good environmental status, while reviewing Annex III to MSFD and, if necessary, revising it, as well as developing specific guidelines to ensure a more coherent and uniform approach to assessments in the next implementation cycle. As a result of these activities, Commission Directive 2017/845 was published in May 2017. For the purpose of directing the process of assessing the use of marine waters in accordance with Article 8 sec. 1. c MSFD, and assessment of the effects of human activity in accordance with art. 8 sec. 1. b MSFD, the table Anthropogenic pressures, uses and human activities in or affecting the marine environment' has been extended to include an exemplary list of use and human activities to ensure consistency of assessments across marine regions and sub-regions.

One of the elements of the MSFD implementation process is socio-economic analysis, which is a gear supporting the stage of identification of the dominant pressures and impact of human activity on the state of marine waters. This analysis should be based on current data. In the light of the guidelines Working Group on Economic and Social Assessment Economic and Social Analysis for the Initial Assessment for the Marine Strategy Framework Directive: A Guidance Document, developed by the working group for socio-economic assessment established by the EC, in defining the sectors that use, or affect marine waters, one can include:

1) aquaculture and mariculture;
2) shipbuilding and transport;
3) coast defense and flood protection;
4) military defense;
5) fisheries;
6) tourism;
7) mining (gravel, sand);
8) oil and gas extraction;
9) cables (for example, propulsion systems, telecommunications, pipelines/gas pipelines);
10) renewable energy (e.g. wind farms);
11) storage (e.g. $CO_2$);
12) water intake;
13) water transport;
14) use of sea water for wastewater disposal (agriculture, industry, households, etc.);
15) infrastructure (e.g. ports, marinas, etc.).

The indicators that may be relevant for the assessment of the above mentioned sectors are:

1) added value;
2) the value of intermediate consumption;
3) income/revenue/remuneration of employees;
4) employment.

Of course, there are other direct activities that are not included in the above-mentioned sectors, that include:

1) bathing sites;
2) sport fishing;
3) diving;
4) other recreational activities in the areas of transitional, coastal and marine waters,
5) education and research related to marine areas.

The above actions are important for the well-being of people, but their value is not easy to estimate. Potential indicators relevant for value assessment, not reflected in market values are:

1) expressing economic and social preferences, through public consultations, press information, etc.;
2) market prices for complementary products (e.g. fishing licenses/cards, diving equipment);
3) the value of recreation;
4) different research results (e.g. from surveys, readiness to pay tests).

An attempt to identify the above applications contributes to a more holistic view of the benefits of marine waters.

In theory, there are different approaches to the analysis of socio-economic use of marine waters, including analysis of the use of marine waters based on a sectoral approach, i.e. Marine Water Accounting Approach and, in the case of non-market value estimates, ecosystem provisions/services - Ecosystem Services Approach. By means of the analysis of the use of marine waters, an attempt was made to collect regionally comparable data on the economic significance of the use of the Baltic Sea waters and to combine them with the assessment of pressures and impacts. Pressures and impacts of anthropogenic origin are described, for example, with the help of economic indicators. Analysis of the use of marine waters should describe the dependence of a given sector on the condition of the marine environment. Using the Marine Water Accounting approach, it is advisable to consider seasonal variability in the use of the given area of interest. Use and human activities that have/could have a significant impact on the marine environment are contained in the revised Annex III to the MSFD. In addition, in analyzes beyond the sectors that exert significant pressure on the marine environment, it is recommended to take into account those that achieve significant benefits from the use of marine waters or depend on the condition of the Baltic Sea environment. It is also worth determining both the direct and indirect benefits that society achieves from the use of marine waters. Economic estimates may include the following indicatorsi:

1) production volume;
2) intermediate consumption (as purchase prices);
3) gross value added (as market prices);
4) wages/remuneration;
5) labor/number of employees.

The amended Annex III to MSFD, in the part which is particularly important for this work, lists the following exemplary anthropogenic pressures and human activities relating to marine waters:

Table 5.3.1 Uses and human activities in the marine environment or affecting the marine environment

| Uses and human activities in or affecting the marine environment with particular relevance for points (b) and (c) of Article 8(1) | |
|---|---|
| Theme | Activity |
| Physical restructuring of rivers, coastline or seabed (water management) | Land claim<br>Canalisation and other watercourse modifications<br>Coastal defence and flood protection*<br>Offshore structures (other than for oil/gas/renewables)* |
| | Restructuring of seabed morphology, including dredging and depositing of materials* |
| Extraction of non-living resources | Extraction of minerals (rock, metal ores, gravel, sand, shell)* |
| | Extraction of oil and gas, including infrastructure* |
| | Extraction of salt* |
| | Extraction of water* |
| Production of energy | Renewable energy generation (wind, wave and tidal power), including infrastructure* |
| | Non-renewable energy generation |
| | Transmission of electricity and communications (cables)* |
| Extraction of living resources | Fish and shellfish harvesting (professional, recreational)* |
| | Fish and shellfish processing* |
| | Marine plant harvesting* |
| | Hunting and collecting for other purposes* |
| Cultivation of living resources | Aquaculture — marine, including infrastructure* |
| | Aquaculture — freshwater |
| | Agriculture |
| | Forestry |
| Transport | Transport infrastructure* |
| | Transport — shipping* |
| | Transport — air* |
| | Transport — land* |
| Urban and industrial | Urban uses |

| | |
|---|---|
| uses | Industrial uses |
| | Waste treatment and disposal* |
| Tourism and leisure | Tourism and leisure infrastructure* |
| | Tourism and leisure activities* |
| Security/defence | Military operations (subject to Article 2(2)) |
| Education and research | Research, survey and educational activities* |

*activities relevant for Article 8 (1) (c) of the MSFD Source: Annex III to MSFD amended

Ecosystem Services Approach should be used when estimating non-market values such as biodiversity or water quality. It should be taken into account that the benefits of one ecosystem service may be related to other ecosystem services and thus the impact on one benefit may reduce the benefit of another. Benefits may be complementary but may also rule each other out. The identification of ecosystem services should be carried out in such a way as to refer to the characteristics (descriptors) of the environment contained in Annex I to MSFD. When assessing the impact of ecosystem services on human well-being, it is advisable to focus on its benefits. The analysis of the costs of degradation, if possible, should be carried out for each descriptor or group of descriptors separately.

In Poland, at present, the following human sectors can be identified that have/can have a significant impact on the marine environment or their functioning depends on the condition of the Baltic Sea:

1) shipping;
2) seaports;
3) shipbuilding;
4) sea fishing;
5) tourism and recreation;
6) offshore industry;
7) other, i.e.: renewable energy - wind farms; sea wreck tourism; military activity; research, analysis and educational activities.

In addition, with regard to the possible impact of agriculture and the municipal sector on the condition of the Baltic Sea waters (e.g. through the discharge of pollutants to these waters and the possible impact on the eutrophication process), above. sectors are described in Chapter 5.2. The pressures listed in Annex III to MSFD have been described in detail and analyzed in chapters of the update of Initial Assessment of the State of the Marine Waters regarding the analysis of the dominant pressures and impacts, including anthropogenic, on the marine waters of the Polish zone of the Baltic Sea.

## 5.5. Identification and description of sea use

***Shipping***

The term "sea transport" can include all transport activities of goods and people by sea, including sea tourism. The term also includes the port service of marine transport and activities related to the provision of maritime safety and maritime security.

The increase in activity in the maritime transport sector, both freight and passenger, in the Baltic Sea has been observed since the end of the twentieth century and is currently considered one of the most intense in the world. Two main shipping routes of the southern Baltic run through the area of Polish marine waters: the open-sea and the coastal route.

The investments carried out or planned for implementation are of great importance for shipping. The most important include the deepening of the Świnoujście-Szczecin fairway to the technical depth of 12.5 m. This is one of the basic investments, connected both with the development of the port in Szczecin, development of the entire region, and increasing the competitiveness of this sector. The technical depth of the 68 km fairway connecting Świnoujście with Szczecin, at almost the entire length, is 10.5 m, which allows for safe navigation of ships with a draft of 9.15 m. However, the Baltic standard in the depth of basins in sea ports or container terminals is currently15-16m.[15]

Another investment that will have a real impact on the number of vessels in POM and the increase in transhipments in ports is the "Modernization of the curtain breakwater system in the Northern Port of Gdańsk ". This investment consists on the expansion of the system of breakwaters guaranteeing the protection of the eastern side of the North Port.

Another important investment, which is mainly important for the defense and security of the state, and is being prepared for implementation by MGMiŻŚ, is the construction of a waterway connecting the Vistula Lagoon with the Gulf of Gdańsk (a cross-cut through the Vistula Spit). The investment will allow for direct access of Naval and Border Guard units from the sea to the ports of the Vistula Lagoon, in particular the port of Elbląg. As a result, this investment will contribute to the improvement of the security of the external borders of Poland and the EU. Its purpose is also to enable social and economic growth through free and year-round access of sea-going vessels to the port of Elbląg. Currently, the passage from the Vistula Lagoon to the Baltic Sea runs through the Szkarpawa River or through the Russian Pilawa Strait. The lack of free connection of the basin with the Baltic Sea is a basic factor limiting the possibility of development of communes neighboring directly or indirectly with the Vistula Lagoon. For the implementation of the program "The construction of a waterway connecting the Vistula Lagoon with the gulf of Gdańsk" (a Nowy Świat variant) funds in the amount of PLN 880 million were allocated. It is assumed that the channel will be 1.1 km long and 5 m deep, a water gate with a length of 200 m will be built next to the channel, as well as a stand for units that will wait to enter the lock. All issues related to the impact on the environment, including the impact on the NATURA 2000 areas, will be resolved as part of the decision on the environmental conditions of the investment implementation, which guarantees the implementation of the project in a manner consistent with the requirements of environmental protection.

The following tables summarize the most important statistics available on shipping:

Table 5.5.1 Maritime transport fleet (as of 31 XII of individual years)

| YEAR | vessels flyingPolish flag | | | vessels flyingforeign flag | | |
|---|---|---|---|---|---|---|
| | number of ships | Deadweight (DWT) in thous. tonnes | total gross tonnage (GT) in thous. | number of ships | Deadweight (DWT) in thous. tonnes | total gross tonnage (GT) in thous. |
| 2011 | 15 | 26.4 | 21.2 | 93 | 2904.6 | 2018.0 |
| 2012 | 15 | 28.3 | 21.4 | 95 | 3016.5 | 2105.4 |
| 2013 | 22 | 37.9 | 29.1 | 88 | 2998.2 | 2055.2 |
| 2014 | 23 | 41.2 | 31.7 | 81 | 2679.7 | 1862.3 |

[15] http://www.port.szczecin.pl/pl/spolka/strategia-i-rozw%C3%B3j/rozw%C3%B3j/125m-dla-szczecina/

| | | | | | | |
|---|---|---|---|---|---|---|
| 2015 | 25 | 40.2 | 31.3 | 77 | 2474.4 | 1747.0 |
| 2016 | 22 | 35.0 | 26.2 | 74 | 2350.2 | 1671.7 |

Source: Own elaboration based on "Statistical Yearbook of Maritime Economy 2015. GUS", table 5.2 "Statistical Yearbook of Maritime Economy 2016, GUS", table 5.2, "Statistical Yearbook of Maritime Economy 2017. GUS". Table 5.2 and "Maritime economy in Poland in 2011, GUS, Szczecin, 2017" table 1.

Table 5.5.2 Status and changes in the maritime transport fleet on Polish ownership and co-ownership

| YEAR | Increase | | | Decrease | | | Status on 31 XII of particular years | | |
|---|---|---|---|---|---|---|---|---|---|
| | number of ships | Deadweight (DWT) in thous. tonnes | total gross tonnage (GT) in thous. | number of ships | Deadweight (DWT) in thous. tonnes | total gross tonnage (GT) in thous. | number of ships | Deadweight (DWT) in thous. tonnes | total gross tonnage (GT) in thous. |
| 2011 | 8 | 223.0 | 147.6 | 21 | 233.5 | 218.9 | 108 | 2931.0 | 2039.2 |
| 2012 | 18 | 375.0 | 263.6 | 16 | 261.2 | 176.0 | 110 | 3044.8 | 2126.8 |
| 2013 | 14 | 345.1 | 184.2 | 15 | 354.0 | 227.2 | 110 | 3036.1 | 2084.4 |
| 2014 | 2 | 4.2 | 3.7 | 8 | 319.3 | 194.0 | 104 | 2721.0 | 1894.0 |
| 2015 | 5 | 4.2 | 3.0 | 7 | 210.6 | 145.8 | 102 | 2514.7 | 1778.3 |
| 2016 | 6 | 146.9 | 103.0 | 12 | 276.4 | 183.4 | 96 | 2385.1 | 1697.9 |

Source: Own elaboration based on "Statistical Yearbook of Maritime Economy 2015. GUS", "Statistical Yearbook of Maritime Economy 2017. GUS". Tables 5.1. and Maritime Economy in Poland in 2016, GUS, 2017a.

Table 5.5.3 Status and changes in the coastal transport fleet on Polish ownership and co-ownership

| ROK | Increase | | | Decrease | | | Status on 31 XII of particular years | | |
|---|---|---|---|---|---|---|---|---|---|
| | number of ships | Deadweight (DWT) in thous. tonnes | total gross tonnage (GT) in thous. | number of ships | Deadweight (DWT) in thous. tonnes | total gross tonnage (GT) in thous. | number of ships | Deadweight (DWT) in thous. tonnes | total gross tonnage (GT) in thous. |
| 2011 | bd | bd | bd | bd | bd | bd | 27 | 1.132 | 5.285 |
| 2012 | 6 | 0.096 | 0.380 | 5 | 0.057 | 0.246 | 28 | 1.171 | 5.419 |
| 2013 | 8 | 7.371 | 4.151 | 3 | 0.146 | 0.829 | 33 | 8.396 | 8.741 |
| 2014 | | – | – | 7 | 6.237 | 3. 381 | 26 | 2.159 | 5.360 |
| 2015 | – | 0.039 | – | 2 | 0.065 | 0.120 | 24 | 2.133 | 5.240 |
| 2016 | 15 | 10.372 | 5.374 | – | – | 0.060 | 39 | 12.505 | 10.554 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, Table 5.13, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012, Table 5.16 and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013 -2016, Table 5.16.

At the end of 2016, the marine and coastal transport fleet consisted of 135 vessels, owned or co-owned by Polish shipowners and operators. A large part of the marine fleet was flying the foreign flag. The systematic decline in the number of vessels forming the maritime transport fleet is clearly noticeable. In 2016, 11% of less vessels were flying than in 2011. The reason for this may be the re-registration and relocation of Polish shipping companies, as well as the increased scrapping of worn-out ships or the bankruptcy of enterprises.

Table 5.5.4 Transport of cargo by maritime transport fleet (in thousands of tonnes), by type of navigation and ranges of sailing

| YEAR | TOTAL | vessels flying Polish flag | vessels flying foreign flag | regular shipping | | | irregular shipping | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | total | ocean range | Baltic range | total | ocean range | Baltic range | European range |
| 2011 | 7737.5 | 205.1 | 7532.4 | 5994.4 | 570.0 | 5424.3 | 1743.1 | 431.6 | 487.6 | 823.9 |
| 2012 | 7475.9 | 148.9 | 7327.0 | 6081.9 | 613.2 | 5468.7 | 1394.0 | 104.3 | 148.9 | 1140.8 |
| 2013 | 6965.4 | 249.3 | 6716.1 | 6191.3 | 594.3 | 5597.0 | 774.1 | 32.4 | 129.3 | 612.4 |
| 2014 | 6780.5 | 355.1 | 6425.4 | 5941.4 | 632.7 | 5308.7 | 839.1 | 57.0 | 139.1 | 643.1 |
| 2015 | 6963.2 | 501.5 | 6461.7 | 6212.5 | 598.0 | 5614.5 | 750.6 | 44.2 | 242.5 | 464.0 |
| 2016 | 7248.2 | 648.0 | 6600.2 | 6595.6 | 407.2 | 6188.4 | 652.6 | 4.6 | 279.7 | 368.3 |

Source: Own study based on the "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, table 5.6, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012, table 5.9 and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013 -2016, table 5.9.

Data regarding sea transport includes cargo and passenger transport performed on international flyights, completed in the reporting year, own ships and leased ships flying the Polish and foreign flags, shipowners or operators of Polish nationality. Data on the sea and coastal transport fleet concern ships with Polish ownership and co-ownership regardless of the flag being lifted.

Data on the transport fleet concern marine and coastal vessels, excluding training, scientific and research vessels, fishing vessels, tug boats, pushers, state service units, Navy and Border Guard. Regular transport services include transport made with ships operating according to a pre-determined and announced travel schedule on a predetermined route and calling at the ports specified in the travel schedule. The basic form of transport in sea transport is regular and irregular, also known as linear and tramp shipping.

Regular shipping includes cruises that last from the start of loading at the starting port, until the end of unloading in the same port and ferry transport. Irregular flyights include cruises from the moment of loading in port A and lasts until the unloading is completed in port B.

For shipments made in non-scheduled sailing, freight included cargo ships of non-scheduled shipping, i.e.: ships operating without a declared travel schedule and managed in accordance with current transport needs. Short sea shipping includes transport in the Baltic and European range, while long-range shipping includes ocean transport. For transport in the Baltic area, the transport includes cruises made on routes covering the ports of the Baltic Sea up to the line Kristiansand (Norway) - Skagen (Denmark). From 2011, transport of cargo by marine fleet within the European scope is carried out exclusively by tramp shipping. Both short-haul and short-haul transport are dominant in both regular and irregular shipping.

Transport of cargo carried out by vessels of the maritime transport fleet amounted to 7248.2 thousand tonnes in 2016 and were higher by 4.1% compared to 2015, but lower by 6.3% compared to 2011.

***Sea ports***

Seaports are an important element of the transport network of cargo and passengers. Ports also fulfill basic socio-economic functions, which include the following: industrial, commercial, transport, tourism and services for the Baltic fisheries.

In the light of the 2020 Strategy for Responsible Development (with a view to 2030), the economic role of seaports in the Baltic Sea basin is gradually increasing. The ports of primary importance for the national economy, according to the Act of 20 December 1996 on ports and marinas, include the largest Polish ports, ie Gdańsk, Gdynia, Szczecin and Świnoujście. These ports have the greatest importance in terms of the size of transshipments, therefore they are described in detail in the further part of this chapter. Ports playing a smaller role are Kołobrzeg, Darłowo, Elbląg and Police, their significance in terms of participation in transshipments is not large, however, they play an important role in activazing the areas on which they are located.

Table 5.5.5 Technical data of seaports of basic importance for the national economy

| SPECIFICATION | Gdańsk | Gdynia | Szczecin | Świnoujście |
|---|---|---|---|---|
| The maximum length of ships calling | 425 | 340 | 215 | 270 |
| Maximum overall width of ships calling | no data | no data | 31 | 42 |
| Maximum draft of ships calling | 15 | 13 | 9.2 | 13.5 |
| Port fairway | | | | |
| bottom width | 350 | 150 | no data | 240 |
| minimum depth | 17 | 14.1 | 14.3-12.5 | 14.5 |

Source: "Maritime economy in Poland in 2015-2016. GUS, Szczecin "tabl. 2 [11]

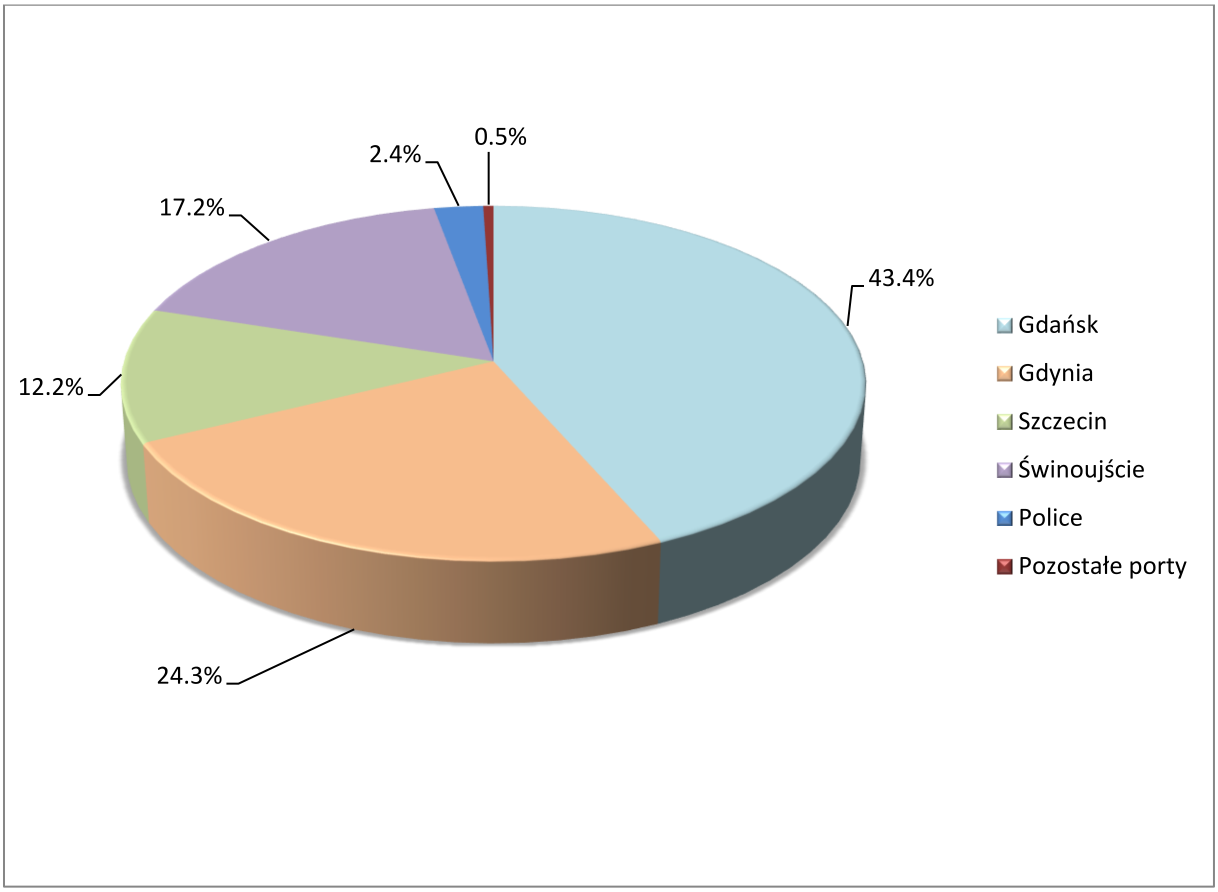
Table 5.5.6 Cargo turnover at sea ports (in thousands of tonnes)

| category | year | total | unloading | loading | international maritime trade | | | domestic maritime trade | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total | unloading | loading | Total | unloading | loading |
| total | 2011 | 57738.2 | 33573.5 | 24164.7 | 56609.3 | 32663.5 | 23945.8 | 1128.8 | 910.0 | 218.9 |
| | 2012 | 58825.2 | 34543.7 | 24281.5 | 57727.6 | 33745.3 | 23982.2 | 1097.6 | 798.4 | 299.3 |
| | 2013 | 64282.5 | 34991.0 | 29291.5 | 62995.2 | 34264.2 | 28731 | 1287.3 | 726.8 | 560.5 |
| | 2014 | 68744.0 | 38973.2 | 29770.8 | 68018.1 | 38526.4 | 29491.6 | 726.0 | 446.7 | 279.2 |
| | 2015 | 69529.5 | 39833.6 | 29695.9 | 68460.2 | 39202.5 | 29257.7 | 1069.3 | 631.1 | 438.2 |
| | 2016 | 72926.2 | 40954.2 | 31972 | 70776.3 | 39773.9 | 31002.4 | 2149.9 | 1180.3 | 969.6 |
| coal and coke | 2011 | 8002.6 | 4004.3 | 3998.3 | 8002.6 | 4004.3 | 3998.3 | – | – | – |
| | 2012 | 8476.4 | 4257.4 | 4219.1 | 8178.5 | 4098.1 | 4080.4 | 297.9 | 159.2 | 138.7 |
| | 2013 | 11905.8 | 4136.4 | 7769.4 | 11217.3 | 3792.2 | 7425.1 | 688.5 | 344.2 | 344.2 |
| | 2014 | 9831.8 | 4788.6 | 5043.3 | 9831.8 | 4788.6 | 5043.3 | – | – | – |
| | 2015 | 8138.8 | 3428.2 | 4710.6 | 8138.8 | 3428.2 | 4710.6 | – | – | – |
| | 2016 | 8856.3 | 4162.7 | 4693.6 | 8856.3 | 4162.7 | 4693.6 | – | – | – |
| ore and scrap | 2011 | 912.9 | 619.3 | 293.6 | 912.8 | 619.3 | 293.6 | 0.1 | 0.1 | – |
| | 2012 | 1038.9 | 794.1 | 244.8 | 1038.8 | 794.0 | 244.8 | 0.1 | 0.1 | – |
| | 2013 | 3036.6 | 2848.3 | 188.3 | 3036.6 | 2848.3 | 188.3 | – | – | – |
| | 2014 | 2375.4 | 2091.0 | 284.3 | 2375.4 | 2091.0 | 284.3 | – | – | – |
| | 2015 | 2401.1 | 2211.1 | 190.0 | 2399.5 | 2209.5 | 190.0 | 1.6 | 1.6 | – |
| | 2016 | 2204.5 | 1936.1 | 268.4 | 2204.4 | 1936.0 | 268.4 | 0.1 | 0.1 | – |
| Petroleum | 2011 | 7695.9 | 3702.1 | 3993.7 | 7572.6 | 3582.2 | 3990.5 | 123.2 | 120.0 | 3.2 |
| | 2012 | 7564.6 | 6739.5 | 825.1 | 7382.4 | 6558.2 | 824.2 | 182.2 | 181.3 | 0.9 |
| | 2013 | 8194.6 | 8050.0 | 144.6 | 8033.8 | 7889.3 | 144.6 | 160.8 | 160.8 | – |
| | 2014 | 9133.5 | 8640.1 | 493.3 | 8978.4 | 8485.1 | 493.3 | 155.1 | 155.1 | – |
| | 2015 | 10957.3 | 10405.1 | 552.3 | 10781.1 | 10230.2 | 550.9 | 176.3 | 174.9 | 1.4 |
| | 2016 | 9986.5 | 8357.7 | 1628.9 | 9770.1 | 8142.6 | 1627.5 | 216.4 | 215.0 | 1.4 |

| category | year | total | unloading | loading | international maritime trade | | | domestic maritime trade | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total | unloading | loading | Total | unloading | loading |
| oil products | 2011 | 5040.2 | 1636.1 | 3404.1 | 4715.0 | 1508.6 | 3206.4 | 325.2 | 127.5 | 197.8 |
| | 2012 | 4757.7 | 674.7 | 4083.0 | 4536.5 | 570.1 | 3966.4 | 221.2 | 104.6 | 116.6 |
| | 2013 | 4544.5 | 401.5 | 4143.0 | 4329.7 | 294.1 | 4035.6 | 214.8 | 107.4 | 107.4 |
| | 2014 | 4977.1 | 641.2 | 4335.9 | 4707.4 | 507.9 | 4199.5 | 269.7 | 133.3 | 136.4 |
| | 2015 | 5736.5 | 939.8 | 4796.8 | 5154.0 | 651.3 | 4502.7 | 582.5 | 288.5 | 294.0 |
| | 2016 | 6775.5 | 2163.6 | 4611.9 | 5253.7 | 1412.8 | 3840.8 | 1521.9 | 750.7 | 771.1 |
| liquid gas | 2011 | 137.6 | 133.4 | 4.2 | 137.6 | 133.4 | 4.2 | 0 | 0 | – |
| | 2012 | 93 | 71.7 | 21.2 | 93.0 | 71.7 | 21.2 | – | – | – |
| | 2013 | 117.3 | 85.2 | 32.1 | 117.3 | 85.2 | 32.1 | – | – | – |
| | 2014 | 181.9 | 180.3 | 1.7 | 181.9 | 180.3 | 1.7 | – | – | – |
| | 2015 | 237.7 | 237.7 | – | 237.7 | 237.7 | – | – | – | – |
| | 2016 | 1010.7 | 978.1 | 32.6 | 1005.2 | 972.6 | 32.6 | 5.5 | 5.5 | – |
| agricultural products | 2011 | 1057.9 | 757.6 | 300.3 | 1008.2 | 708.0 | 300.3 | 49.7 | 49.7 | – |
| | 2012 | 4074.5 | 2043.9 | 2030.7 | 4027.2 | 2007.3 | 2019.9 | 47.4 | 36.6 | 10.8 |
| | 2013 | 5359.7 | 2188.3 | 3171.4 | 5254.5 | 2135.8 | 3118.7 | 105.2 | 52.5 | 52.7 |
| | 2014 | 6820.8 | 2628.9 | 4191.9 | 6604.8 | 2522.2 | 4082.6 | 216.0 | 106.7 | 109.3 |
| | 2015 | 7198.8 | 2511.5 | 4687.3 | 6957.5 | 2396.0 | 4561.5 | 241.2 | 115.5 | 125.8 |
| | 2016 | 7889.1 | 2972 | 4917.2 | 7530.1 | 2781.0 | 4749.1 | 359 | 190.9 | 168.1 |
| containers | 2011 | 4560.0 | 2330.1 | 2229.9 | 4559.7 | 2329.8 | 2229.9 | 0.3 | 0.3 | 0.1 |
| | 2012 | 10781.4 | 5392.1 | 5389.4 | 10772.6 | 5392.1 | 5380.5 | 8.9 | – | 8.9 |
| | 2013 | 13060.4 | 6552.0 | 6508.4 | 13022.7 | 6533.9 | 6488.8 | 37.7 | 18.1 | 19.6 |
| | 2014 | 15448 | 8142.8 | 7305.2 | 15447.3 | 8142.6 | 7304.7 | 0.8 | 0.2 | 0.6 |
| | 2015 | 13576.4 | 7038.9 | 6537.5 | 13557.1 | 7026.2 | 6530.9 | 19.3 | 12.7 | 6.6 |
| | 2016 | 14840.8 | 7484.7 | 7356.1 | 14820.1 | 7474.4 | 7345.7 | 20.7 | 10.4 | 10.3 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, Table 4.2, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012. table 4.2. and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013-2016, Table 4.2.

Structure of cargo turnover in 2016 (by sea ports)




Source: Own study based on: "Maritime economy in Poland in 2015-2016. GUS, Szczecin "Chart 9 [16]

Fig. 5.5.1 Structure of cargo turnover in 2016 (by sea ports)

Over 90% of cargo traffic was performed in Polish seaports of primary importance for the national economy. According to the available data, 2016 cargo turnover in seaports amounted to 72.9 million tonnes i.e. much more than in 2011, when it was at the level of approx. 57.7 million tonnes. Good transhipment results are the result of, inter alia, many infrastructural investments carried out by ports and the developing logistic base enabling the handling of an increasing number of goods transshipped and stored in and outside port areas. Polish ports have a chance for further development due to the growth dynamics of transshipments in recent years and their development plans. Nevertheless, it is worth noting that although the transshipment offer of Polish ports is similar to the standards in the Baltic Sea region, the number of cargoes is much smaller than in the case of German, Danish or Swedish ports and not much higher than the one for Latvian or Lithuanian ports[16]. That is why Polish ports still need to improve their access from the sea (deepening and maintaining approaching waterways) and land (connection to land transport network).

On the Polish coast, including lagoons, there are 29 smaller seaports and 49 marinas. They occupy an important place both in local politics, shaped at the level of the commune (as an element of local development potential), and also constitute an element of the country's development potential. Regional and local ports are, by definition, components of local infrastructure that provide opportunities to take advantage of the opportunities offered by the location at the coast, which is why their functions are adapted to existing forms of use of the sea. Regional and local ports are becoming increasingly important infrastructure points for coastal

[16] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_r_mago_nm&lang=en

communes, also for generating jobs and income. In some cases these ports, formerly fishing, become ports serving tourism and recreation functions - from sailing and tourist sailing to sport fishing. In addition, regional and local ports in connection with the implementation of investment or ownership transformation processes envisage adjustments of their territorial boundaries, which results in the need to expand port areas. The regional ports include:

- ✓ Darłowo

  It is considered that already in the 10th century there was a commercial-port center in Darłowo. Currently, the sea port in Darłowo is a commercial and fishing harbor located at the Wieprza River mouth and covering, almost three kilometer long sector entering the Baltic Sea. It is an open port of the Baltic Sea. It consists of two parts. The first, located in the immediate vicinity of the sea, with breakwaters, port entrance, an outport, a fishing basin and a bridge. The second part of the port is located approximately 2.3 km from the port entrance in the immediate vicinity of the city of Darłowo with a port turnstile, industrial basin and the Wieprza riverbed. Both parts of the port are connected by a 2.5 km port channel with a navigable depth of 5.5 m. The maximum ship parameters for the Darłowo port are: length 90 m, the ship's draft for fresh water with average water state in the port is 4.20 m (increased deepening at designated quays). Darłowo port in a limited scope performs all typical economic functions consisting of: trans-shipment of goods in domestic and foreign trade; purchase, storage, processing and sale of marine fish; repairs, maintenance of hulls and marine engines; providing services for moored vessels with full service support at scheduled stops between cruises; accepting and providing services for sport and recreation vessels. The current trans-shipment potential of the Darłowo port is not fully used.[17]

- ✓ Elbląg

  The Port of Elbląg is the largest Polish port of the Vistula Lagoon. It is located on the Elbląg River, 6 km from its mouth entering the Vistula Lagoon, which is connected with the Gulf of Gdańsk by the inland river Szkarpawa and through the Strait of Baltiysk. The Port of Elbląg is a regional port operating Vistula Lagoon and Baltic coastal and passenger-tourist shipping. Annually, over 30,000 passangers are transported through Elbląg. It is one of the few Polish seaports with international cargo turnover. The conditions for the functioning of the port in Elbląg will definitely improve with the implementation of the government investment in the construction of a waterway connecting the Vistula Lagoon with the Gulf of Gdańsk. It will provide a free access to the port from the sea will, which will positively affect the security of the state and increase the possibilities of using the port of Elbląg for socio-economic needs.[18]

- ✓ Hel

  The port in Hel is sheltered from the Gulf of Gdańsk with two breakwaters simultaneously performing the function of wharfs: the Western Breakwater with a length of 615 m and the South Breakwater with a length of 180 m. Inside the port there are wharfs, piers and basins: 240 m long unloading wharf; 146 m long werehouse wharf; Repair Quay with a length of 128 m; 100 m long Fishing Jetty, length of the mooring wall is 200 m; Kashubian pier with a length of 92 m, length of the mooring wall 184 m; Inner jetty of 135 m, length of mooring wall 270 m; Marina (where floating piers for sport vessels were installed); Indoor and Outdoor Basin. In addition, the Port has electricity and water consumption points, a tank for receiving oily water; crane for lifting vessels up to 5 tonnes; video monitoring system; marina with sanitary facilities for yachts; Border Guard, Portman's Office, Sea Fisheries Inspectorate. Hel is one of the seaports in which the SAR Service Rescue Station is located. In the summer season, the port offers passenger and water scooters cruises on the Port, as well as water trams between Hel and Tricity. It should be emphasized that the Port of Hel is one of the best seaports in Poland in terms of the size of fish unloading. [19]

[17]based on http://www.port.darlowo.pl/pl/
[18]based on http://www.port.elblag.pl/page/show/2/dane-ogolne?lang=pl
[19]based on http://www.hel.info.pl/

- ✓ Kołobrzeg

Kołobrzeg port provides fishing, passenger-tourist, yacht and commercial services. The port consists of a commercial, yacht, fishing and passenger port. The geographical location of the port and its infrastructure potential make it possible to prosper in many branches of the economy. The yacht port has full infrastructure for yachts, and yacht service operates in the hall located in the marina. In the marina there are bathrooms, a laundry room with a drying room and many green areas. The Solna Island, where the marina is located, is a place which in the summer season is filled with sailors from around the world as well as tourists visiting Kolobrzeg. In the marina, further investments are being made to increase the number of mooring sites and improve the infrastructure. The Fishing Port enables mooring of cutters, fishing vessels and fishing and tourism boats. Several passenger ships are permanently moored in the passenger port, where one of them serves passengers on the international route Kołobrzeg - Bornholm. In the port there is also a breakwater - a place for over half a million pedestrians a year. The Port of Kołobrzeg is one of the best seaports in Poland in terms of the size of fish unloading. In the case of cargo traffic, it should be noted that the volume of cargo handled is stable (nearly 150,000 tonnes in 2016). Bulk cargo predominate before the so-called other LCL. These include: pellets, wood, aggregates, fertilizers. The port also handles liquid bulk cargo.[20]

- ✓ Łeba

The port in Łeba is located on the mouth section of the Łeba River and is a fishing and tourist port. It has an extensive yacht harbor and fishing quays. In the summer season many cruise ships are based in the port, which offer short cruises on the sea. In the sea port of Łeba there is a Marine Rescue Station Service of the SAR and Masters Office of the port of Łeba. The maximum parameters for ships entering the Port of Łeba must not exceed: total length 65 m, width 15.0 m, draft 3.0 m for fresh water at medium water level. [21]

- ✓ Police

Seaport Police is a sea and river port on the Oder River in Police at the Szczecin-Świnoujście seaway. This port is a fifth port in Poland in terms of cargo volume transhipment. About 1.8 million tonnes of cargo are handled annually. The Police port has four transshipment terminals for bulk such as phosphorites, apatites, potassium salt, fertilizers, ilmenite ores, ammonia, and sulfuric acid. Azoty Zakłady Chemiczne "POLICE" S.A. Group is the only national company in the chemical industry with specialized port facilities in the immediate vicinity of the company. [22]

- ✓ Stepnica

The port is located on the eastern shore of the Stepnica Bay, i.e. the part of Roztoka Odrzańska, which is the bay of Szczecin Lagoon. The maximum overall length of vessels capable of calling at the port is 115 m, and the maximum overall width is 13.5 m provided that ships of more than 75 m overall length can only be navigated at daytime for visibility over 2 Mm, wind force up to 4 B at the free opposite quay. In the port there is the harbour boatswain’s office of the Stepnica Port. Within the borders of Stepnica port, two functional areas can be distinguished: the Railway Basin, where bulk cargo transshipments can take place and the Fisherman's Basin, where there are mooring sites for fishing boats and several yachts. In the Railway Basin there are two northern and southern quays with three separate transshipment stations.[23]

- ✓ Ustka

The Ustka harbor is located on the Baltic Sea at the mouth of the Słupia River. The port began to be important for Polish shipping after its reconstruction in the early

[20]based on http://www.zpm.portkolobrzeg.pl/
[21]based on http://port.leba.eu/pl/home
[22]based on http://www.portpolice.pl/
[23]based on https://www.stepnica.pl/

nineteenth century. Then, the east breakwater was rebuilt, the right bank of Słupia was rebuilt and reinforced, the breakwater was extended to 76 meters and the eastern shore of Słupia was repaired. In the 1970s, there were plans to create a large shipyard in Ustka, which forced the construction of a large port. The first plans for the necessary earthworks were made, but they were never carried out on a larger scale. Currently, the port mainly serves fishing and tourist vessels and sport units. In addition, it offers cruises on the sea, including a seasonal ferry connection to the Danish island of Bornholm. It is worth noting that the Port of Ustka is one of the leading seaports in Poland in the category of the size of the registered fishing fleet and the unloading of fish.[24]

- ✓ Władysławowo

The port in Władysławowo, which is situated above at open sea, is one of the most important fishing ports in the Baltic Sea due to the amount of fish unloaded, the number of fishing vessels and equipment being serviced. This port is a typical fishing port with a marina and passenger harbor. In the port, from May to October, the calling and mooring units can supply fuel, provisions and water, and make necessary repairs and renovations. In the summer months the vessels from the passenger port depart for a cruise on the Baltic Sea. On the other hand, the western breakwater of the port plays the role of a pier and is a place of walks for tourists and for fishing. It also has a small reloading function for goods in domestic traffic. The size of vessels entering the Władysławowo port can not exceed 70 m in length and 4 m in draft.[25]

In the group of regional ports, those located in Elbląg, Kołobrzeg, Police and Ustka are considered as the leading ones. They should be regarded as important parts of the country's transport system and sought to be integrated as soon as possible due to the high quality of road and rail infrastructure. It is pointed out that these ports should be developed to be included in the TEN-T network. These ports have very large supralocal significance for socio-economic activation.

Local harbors in Poland are: Dziwnów, Dźwirzyno, Frombork, Jastarnia, Kamień Pomorski, Karsibór, Kąty Rybackie, Krynica Morska, Lubin, Mrzeżyno, Nowa Pasłęka, Nowe Warpno, Przytór, Puck, Rowy, Sierosław, Tolkmicko, Trzebież, Wapnica, Wolin.

[24]based on http://ustkaport.pl/
[25]based on http://www.wladyslawowo.info.pl/atrakcje/2/port_wladyslawowo

Table 5.5.7 Length of quays (in meters) in seaports in 2016

| PORT | TOTAL | Including usable | Wharfs with a depth of more than 10.9 m (out of a total number) | Transhipment dockside (from total number) | |
|---|---|---|---|---|---|
| | | | | TOTAL | Including usable |
| Gdańsk | 30 079 | 20 434 | 5 546 | 10 200 | 9 301 |
| Gdynia | 14 329 | 13 393 | 3 901 | 10 844 | 10 844 |
| Szczecin | 20 153 | 15 049 | – | 11 719 | 10 826 |
| Świnoujście | 8 025 | 7 924 | 1 781 | 6 818 | 6 768 |
| Police | 1 000 | 1 000 | – | 1 000 | 1 000 |
| Darłowo | 5 734 | 5 734 | – | 452 | 452 |
| Dziwnów | 1 536 | 1 432 | – | 232 | 232 |
| Elbląg | 4 001 | 4 001 | – | 2 555 | 2 555 |
| Kołobrzeg | 3 123 | 3 070 | – | 719 | 719 |
| Nowe Warpno | 193 | 193 | – | – | – |
| Stepnica | 500 | 500 | – | 452 | 452 |
| Trzebież | 747 | 747 | – | – | – |
| Ustka | 2 881 | 2 256 | – | 873 | 873 |
| Władysławowo | 2 167 | 2 167 | – | 349 | 349 |
| TOTAL | 94 468 | 77 900 | 11 228 | 46 213 | 44 371 |

Source: "Statistical Yearbook of Maritime Economy 2017. GUS", table 4.1

Table 5.5.8 International passenger traffic in seaports

| Port | year | passangers total | Arrivals | Departures |
|---|---|---|---|---|
| Total | 2011 | 1 581 885 | 780 027 | 801 858 |
| | 2012 | 1 612 538 | 802 702 | 809 836 |
| | 2013 | 1 596 763 | 787 070 | 809 693 |
| | 2014 | 1 753 577 | 875 519 | 878 058 |
| | 2015 | 1 851 298 | 919 666 | 931 632 |
| | 2016 | 1 933 480 | 962 509 | 970 971 |
| Ports of fundamental importance for the national economy | | | | |
| Gdańsk | 2011 | 148 330 | 73 427 | 74 903 |
| | 2012 | 146 721 | 73 313 | 73 408 |
| | 2013 | 125 764 | 61 943 | 63 821 |
| | 2014 | 121 228 | 60 026 | 61 202 |
| | 2015 | 107 976 | 52 840 | 55 136 |
| | 2016 | 103 588 | 51 657 | 51 931 |
| Gdynia | 2011 | 484 910 | 241 334 | 243 576 |
| | 2012 | 505 029 | 255 524 | 249 505 |
| | 2013 | 514 838 | 256 487 | 258 351 |
| | 2014 | 571 745 | 289 753 | 281 992 |
| | 2015 | 604 250 | 301 365 | 302 885 |
| | 2016 | 612 718 | 306 408 | 306 310 |
| Szczecin and Świnoujście | 2011 | 865 139 | 423 903 | 441 236 |
| | 2012 | 881 649 | 435 022 | 446 627 |
| | 2013 | 866 573 | 423 919 | 442 654 |
| | 2014 | 970 217 | 481 041 | 489 176 |
| | 2015 | 1 047 636 | 520 205 | 527 431 |
| | 2016 | 1 117 187 | 554 025 | 563 162 |

Source: Own study based on the "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, table 4.11, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012. Table 4.11 and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013-2016, Table 4.11

In 2016, approximately 1,933,500 passengers started or finished their journey at Polish seaports, i.e. by 4.4% more than in 2015 and by 22.2% more than in 2011. International passenger traffic in relation to Polish seaports is almost entirely concentrated on European reach. In 2016, passengers arriving or departing from Polish seaports began or ended their travels primarily in Sweden and Germany.

Table 5.5.9 Ships entering seaports

| PORT | YEAR | Total | | | With load included | | |
|---|---|---|---|---|---|---|---|
| | | Numer of vessels | net capacity (NT) | Gross capacity (GT) | Numer of vessels | net capacity (NT) | Gross capacity (GT) |
| Total | 2011 | 18 864 | 71 905.3 | 169 583.3 | 15 271 | 61 481.1 | 147 544.9 |
| | 2012 | 18 416 | 73 720.2 | 171 670.3 | 14 419 | 61 565.0 | 147 418.2 |
| | 2013 | 17 816 | 76 076.1 | 172 794.0 | 13 378 | 62 794.6 | 146 475.7 |
| | 2014 | 17 384 | 84 315.5 | 190 664.6 | 13 022 | 70 440.1 | 163 498.1 |
| | 2015 | 18 169 | 83 909.2 | 194 332.4 | 13 918 | 70 181.6 | 166 805.9 |
| | 2016 | 18 928 | 89 061.6 | 205 810.3 | 14 471 | 74 350.7 | 176 548.2 |
| Ports of fundamental importance for the national economy | | | | | | | |
| Gdańsk | 2011 | 3 252 | 16 971.8 | 36 651.0 | 2 158 | 12 064.8 | 26 717.5 |
| | 2012 | 3 127 | 17 832.8 | 39 029.9 | 1 974 | 12 868.4 | 28 798.1 |
| | 2013 | 2 948 | 17 989.1 | 38 407.8 | 1 753 | 12 582.9 | 27 277.5 |
| | 2014 | 2 869 | 19 059.3 | 40 684.0 | 1 742 | 13 997.7 | 30 023.4 |
| | 2015 | 3 106 | 20 904.1 | 45 190.6 | 1 889 | 15 392.0 | 33 683.9 |
| | 2016 | 3 274 | 23 403.4 | 48 978.5 | 2 040 | 17 570.2 | 36 977.6 |
| Gdynia | 2011 | 3 864 | 26 391.2 | 59 442.5 | 3 177 | 23 537.6 | 52 856.1 |
| | 2012 | 3 578 | 26 917.6 | 58 149.1 | 2 741 | 22 731.7 | 50 325.4 |
| | 2013 | 3 618 | 26 437.7 | 55 118.2 | 2 709 | 22 201.1 | 47 087.0 |
| | 2014 | 3 754 | 28 690.8 | 59 756.6 | 2 879 | 23 822.1 | 51 027.5 |
| | 2015 | 3 678 | 26 852.5 | 56 360.8 | 2 854 | 22 289.6 | 47 900.5 |
| | 2016 | 3 956 | 27 959.3 | 59 804.7 | 3 038 | 23 112.2 | 50 465.6 |
| Szczecin and Świnoujście | 2011 | 7 988 | 27 041.7 | 70 234.6 | 6 508 | 24 665.0 | 65 293.9 |
| | 2012 | 7 940 | 27 544.9 | 71 372.9 | 6 293 | 24 818.6 | 65 755.9 |
| | 2013 | 7 785 | 30 352.5 | 76 528.6 | 6 097 | 27 175.2 | 70 250.2 |
| | 2014 | 7 698 | 35 133.1 | 87 322.0 | 5 992 | 31 639.3 | 80 379.1 |
| | 2015 | 8 177 | 34 711.0 | 89 651.3 | 6 359 | 31 400.0 | 82 782.1 |
| | 2016 | 8 487 | 36 366.3 | 94 035.0 | 6 502 | 32 570.4 | 86 605.6 |

Source: Own study based on the "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, table 4.13, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012. Table 4.13 and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013-2016, Table 4.13.

Of the total number of ships that entered Polish ports in 2016, the most came to ports in Świnoujście and Gdynia (over 50%).

***Port in Gdańsk***

Located in the central part of the southern coast of the Baltic Sea - the Port of Gdańsk - is an important international communication hub. The Port of Gdańsk is an important link of the Trans-European Transport Network TEN-T. The port operates within the corridor of the TEN-T core network "Baltic-Adriatic", connecting north and south of Europe.

The largest port in Poland consists of an internal port located along the Martwa Wisła and Port Channel, which can accept ships with a maximum draft of 10.2 m and a length of 225 m and an external port having direct access to the Gulf of Gdańsk, where the largest ships that sail on the Baltic Sea (with a maximum draft of 15m) can call. In addition, in the outer port there is a modern deepwater container terminal DCT Gdańsk.[26]

The Port of Gdańsk is a universal port that has a transshipment capacity of 3 million TEU (DCT terminal) and is at the forefront of container reloading leaders in the Baltic. It ranks first among Polish ports and second among all Baltic ports after St.Petersburg.[27]

Table 5.5.10 Transshipments at the port of Gdańsk by commodity groups (in thousands of tonnes)

| | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
|---|---|---|---|---|---|---|
| Total | 25 305.48 | 26 898.14 | 30 259.29 | 32 277.56 | 35 913.64 | 37 288.97 |
| Coal and coke | 1 789.26 | 1 923.79 | 4 589.25 | 3 322.36 | 4 487.90 | 5 080.91 |
| ore | 11.10 | 16.20 | 12.42 | 5.20 | 84.94 | 202.39 |
| Other mass | 5 000.65 | 4 311.52 | 2 637.96 | 3 607.91 | 3 500.05 | 3 500.05 |
| Grain | 816.12 | 1 017.61 | 1 479.44 | 1 629.21 | 1 455.34 | 1 147.95 |
| Wood | 0.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| break bulk cargo | 7 299.69 | 8 888.02 | 10 513.94 | 11 229.72 | 11 814.19 | 14 549.12 |
| Liquid fuels | 10 387.87 | 10 741.00 | 11 026.28 | 12 483.16 | 14 710.48 | 12 808.55 |
| Intermodal containers | 6 100.51 | 7 629.91 | 9 745.26 | 10 366.11 | 10 706.30 | 13 398.46 |
| TEU containers | 68 5643 | 928 905 | 1 177 623 | 1 212 054 | 1 091 202 | 1 299 373 |

Source: Own study based on the "Report on the implementation of the Polish maritime policy in 2011", Annex I to the "Report on the implementation of the Polish maritime policy in 2015", Annex I to "Report on the implementation of the Polish maritime policy in 2016" and data on the port website.

Total transshipments in 2016 amounted to almost 37.3 million tonnes (including own weight of loaded cargo units), i.e. nearly 4% more than in 2015. Thus, 2016 was the best in the history of the Port of Gdańsk in terms of transshipped goods and at the same time was a record for the Polish maritime economy. 2016 was also the fifth in a row when the Port of Gdańsk strengthened its second position on the Baltic Sea in terms of container turnover. The largest group of goods in 2016 was general cargo and liquid fuels. Container turnover reached a level of about 1.3 million TEU in 2016, which meant that the fifth succesive year, the Port of Gdańsk was ranked second among the largest container ports in the Baltic Sea. The port has two terminals for container reloading. One at the Szczecińskie Nabrzeże in the internal port of GTK, and the other, located in the outer port - DCT. In January 2015, the construction of the new DCT wharf was started to double the annual transshipment capacity to the level of 3 million TEU. The construction was completed in October 2016, thanks to which the terminal became the largest container terminal in the Baltic Sea in terms of its technical parameters. The DCT terminal is adapted to service the largest vessels that enter the Baltic Sea - Baltimax type vessels. The terminals at the Port of Gdańsk provide integrated terminal services and depot holders and support feeder and short-range lines. The Port of Gdańsk also serves ro-ro units within the Free Customs Area. In addition, the Westerplatte Ferry Terminal located on the east side of the Port

[26] based on https://www.portgdansk.pl/o-porcie/lokalizacja
[27] based on https://www.portgdansk.pl

Channel has mooring sites equipped with ro-ro ramps and spacious storage and maneuvering yards. Ro-ro ramp is also located in the Ferry Base of Polish Baltic Shipping S.A., offering permanent ferry connections with Sweden, as well as on the DCT container terminal. The dry bulk cargo terminal consists of an import terminal on Rudowy Pier and an export terminal located on Węglowy Pier. In the external port, coal is transshipped at the bulk cargo terminal and in the internal port on Basen Górniczy. In the outer port there are two modern terminals in which transhipment of liquid fuels and liquid gas takes place. The Naftoport liquid fuel handling base operates in the northern port of Gdańsk, which in a crisis situation has the capacity to receive up to 60 million tonnes of oil per year (the Gdańsk-Płock pipeline has a throughput of 30 million tonnes per year). The fuel and base oil is reloaded at the Obronców Poczty Polskiej quay in the internal port. In addition, on the same wharf, there is a terminal adapted to handle sulfur. Transshipment operations are carried out in an environment friendly closed system. In addition, the handling potential of terminals at the Port of Gdańsk ensures countrie's energy security. The bulk cargo in the inner port is reloaded at the Oliwskie, Wislana, Szczecinskie, Przemysłowy, Rudowy, Węglowy, Obrońców Westerplatte quays and on the quays of the Free Customs Area. In the inner port there is also a modern base for transshipping citrus fruits. In addition, the port has a phosphor transshipment base located at the Nabrzeże Chemików, and together with Nabrzeże Przemysłowe, it is a place for handling loads such as: fertilizers, liquid chemical products, minerals and quayssses. In addition, port is used to transfer sharps, aggregates, iron ore, fertilizers, malt, rye, wheat and barley. At Bytomskie Nabrzeże, where the malt processing plant is located, medical and technical gases are also transhipped. The port also has a scrap service base. In addition, at the Port of Gdańsk, veterinary border control of products of animal origin according to EU standards is possible.

Due to the landscape and pressence of monuments, many passenger vessels also call the Port of Gdańsk. The ferry service is operated by the Polish Baltic Shipping Ferry Base and the Westerplatte Ferry Terminal. Cruise ships are moored at Westerplatte. They are also serviced on the walking promenade of captain Ziółkowski.

It should also be emphasized that in the area administered by ZMPG S.A., in 2011-2016, in line with the strategic directions of port development included in the "Port Development Strategy for Gdańsk until 2027", investments were made to increase the port's transhipment potential and strengthen the role of the distribution port at Baltic Sea. In 2015, the first stage of construction of the Oil Terminal of the PERN S.A. Capital Group was completed. In 2016, a tunnel under the Martwa Wisła was opened, which made it possible to shorten the time and reduce the transport costs to and from the Port of Gdańsk.

One of the last investments in the Port of Gdańsk is implemented by OT Logistics S.A. construction of the largest transshipment terminal for agricultural goods on the southern Baltic Sea. The investment in Gdańsk will consist of the construction of a handling and storage terminal, adapted and used to service ships and their cargo in port traffic, cargo handling in land transfer and storage. In this way, the company plans to gain as much as 50% share in transshipment of grains in the Baltic Sea. In 2017 and 2018 it is planned that the terminal will reach the throughput capacity of 2.7 million tonnes per year, while in 2019 and 2020 this capacity will be doubled.[28]

[28]based on https://www.portgdansk.pl/

***Port in Gdynia***

The Port in Gdynia is a modern universal port. Specializes in servicing general cargo, carried in containers and in ro-ro system, based on a well-developed network of multimodal connections with facilities, regular short-sea shipping lines and ferry connections. It is an important element of the TEN-T core network corridor "Baltic-Adriatic". Handling of containerized cargo at the Port of Gdynia takes place at two modern container terminals located in the Port of West: Baltic Container Terminal Sp. z o.o. (BCT) and Gdynia Container Terminal S.A. (GCT). The port is equipped with modern transshipment equipment and freight terminals. OT Port Gdynia Sp. z o.o. specializes in handling general cargo[29]

Table 5.5.11 Transshipments at the port of Gdynia by commodity groups (in thousands of tonnes)

| SPECIFICATION | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| Total | 15 911.4 | 15 809.5 | 17 658.6 | 19 408.3 | 18 197.8 | 19 536.3 |
| Coal and coke | 1 399.8 | 2 050.3 | 2 639.9 | 2 060.7 | 1 386.4 | 1 485.8 |
| ore | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.3 |
| Other mass | 2 714.9 | 1 794.5 | 1 630.7 | 1 476.7 | 1 356.2 | 1 100.9 |
| Grain | 1 598.9 | 1 782.1 | 2 178.0 | 2 902.0 | 3 711.1 | 4 090.5 |
| Wood | 45.1 | 50.3 | 95.0 | 46.3 | 63.1 | 62.9 |
| break bulk cargo | 9 562.2 | 9 919.7 | 11 053.2 | 12 693.1 | 11 279.1 | 11 465.5 |
| Liquid fuels | 590.5 | 212.6 | 61.8 | 229.5 | 401.9 | 1 324.4 |
| TEU containers | 616 441 | 676 349 | 729 607 | 849 123 | 684 796 | 642 195 |

Own study based on the "Report on the implementation of the Polish maritime policy in 20151", Annex I to the "Report on the implementation of the Polish maritime policy in 2015", Annex I to "Report on the implementation of the Polish maritime policy in 2016" and data on the port website.

Transshipments at the port of Gdynia in 2016 amounted to 19,536.3 thousand tonnes (taking into account the own mass of loaded cargo units). This means that it was a record year in terms of transshipment (the previous record result was in 2014).

In annual comparison, in 2016, there was an increase in transshipments in the group of coal and coke, ore, grain, general cargo, and above all liquid fuels in relation to the previous year. Over threefold increase in transshipments of liquid fuels is associated with changes in the fuel market, such as increased demand for diesel fuel and new legal regulations (sealing of the tax system). The factor conducive to the increase in the transshipment of fuels is the qualitative change at the Port of Gdynia consisting in the reconstruction of the Liquid Fuel Overloads Station (including the assembly of a new filler) completed in 2014.[30]

The Port of Gdynia Authority (ZMPG-a S.A.) in accordance with the port development strategy increased the handling capacity of ro-ro cargoes. The implemented investments in the area of enlargement of storage areas and storage areas increased the transshipment potential of the port. In 2016-2018, the management of the Port of Gdynia intends to spend PLN 605.5 million on investments in the expansion and modernization of infrastructure. The reconstruction of the Indian and Helskie wharfs (PLN 220 million), deepening of the approach fairway and internal lagoons (PLN 336 million), construction of the ferry terminal (PLN 155 million) and reconstruction of railway access to the western part of the port (PLN 60.7 million) are planned.

An investment of strategic importance for maintaining the competitiveness of the port of Gdynia will be deepening the approach fairway and inner basins, where it is planned to build a new turntable no. 2 with a diameter of 480 m in the area of Basin IX, widening and deepening the approach fairway to the ordinate - 17 m, deepening the internal waters to the ordinate - 16 m in the port channel and - 15,5 m at the quays.[31]

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[29] based on http://www.port.gdynia.pl/pl/

[30] based on „Raportu z realizacji polityki morskiej RP w 2016 r."

[31] based on http://www.port.gdynia.pl/pl/

***Ports of Szczecin and Swinoujscie***

Ports in Szczecin and Świnoujście form one of the largest port complexes in the Baltic Sea region, and, like Gdańsk and Gdynia, are included in the TEN-T core network constituting important links of the "Baltic-Adriatic" corridor. They are located on the shortest road connecting Scandinavia with Central and Southern Europe, and are located on the shortest sea route connecting Estonia, Finland, Lithuania, Latvia and Russia with Western Europe. Ports in Szczecin and Świnoujście are the nearest seaports for the western and south-western part of Poland, which brings together the most important industrial areas of the country, such as Upper Silesia, the area of Wrocław and Poznań. They are also characterized by proximity to the region of eastern Germany, especially the Berlin region. In addition, for many years, both ports have been important transit ports for the Czech Republic and Slovakia. The Szczecin-Świnoujście port complex is well-connected to the mainland with national and European facilities (west and the center of the continent). Via the A11 and A20 motorways on the German side, the port complex is well connected with many western economic centers, and through national road No. 3 (E-65, ultimately the S3 express road) with the south of Poland, the Czech Republic and Slovakia and other countries of central and southern Europe. Both ports also have convenient railway connections - through the Oder's main road they connect to the industrial centers of central and southern Europe (lines CE-59 and E-59). Access to the European inland navigation system is guaranteed by the Oder - Havel channel (German: Oder-Havel-Kanal). The Szczecin and Świnoujście ports have river connections with the national back-up via the Oder Waterway (E30).

The port in Świnoujście is located directly by the sea, which allows it to provide high-efficiency ferry connections and accept ships with a draft of up to 13.5 m and a up to 270 m in length. One of the main elements of this port is a terminal serving dry bulk (coal - in export and in import) as well as imported ore for Polish, Czech and Slovakian smelters. The ferry terminal in Świnoujście is the largest in Poland and one of the most modern in the Baltic. It is equipped with five stands for servicing passenger-car and car ferries on the Poland-Scandinaivia route. Thanks to the appropriate layout of tracks, maneuvering and storage yards, the terminal can be adapted for transshipment of intermodal transport units. In Świnoujście, a terminal for transshipping agri-food products with a total capacity of over 50,000 tonnes has also been created. In both Świnoujście and Szczecin, it is possible to reload and store various liquid cargoes: petroleum products, methanol, ethanol, vegetable oils, fertilizers, tar and pitch. The connection of ports with railway, road and inland water infrastructure creates an excellent point for reloading liquid products in the relation between ships - tanks - rail tankers, road tankers, or barges.

The port in Szczecin is 68 km away from the sea, which may be its asset, as it creates a chance to reach importers and exporters of goods inland in a cost effective way. The crossing by a waterway from the road in Świnoujście to Szczecin takes about 4 hours. The port can accept ships with a draft of up to 9.15 m and a length of 215 m. It is a universal port serving both general cargo and bulk cargo. Containers, metallurgical products, oversized loads, paper, and cellulose are transshipped and stored at the port. It also supports dry bulk cargoes - such as coal, coke, aggregates, grain, fertilizers and liquid cargoes. This port is the largest reloading center of granite blocks in Poland. In order to increase the transshipment capacity of the port in Szczecin, it is necessary to deepen the fairway, which is also forced with trends in the world fleet - on the shipping market more larger ships carrying more goods occur. This means that their basic parameters, including immersion, are constantly increasing. A large investment will be implemented in the form of modernization of the Świnoujście-Szczecin fairway, which will cost about PLN 1.38 billion, of which EU funding is PLN 1.18 billion. As part of the investment, the fairway will be deepened to 12.5 meters, as well as bank slopes and fortifications will be constructed and reconstructed, the work will also include leveling the bottom in the Świnoujście zone, and turntables will be deepened and expanded. The deepening of the fairway will significantly improve the handling capacity of the port of Szczecin, as it will enable the admission of vessels with a larger draft. It should be emphasized that the investments related to the planned modernization are already carried out by the Maritime Office in Szczecin through the reconstruction of the Piastowski Canal.[32]

Table 5.5.12 Transshipments in Szczecin and Świnoujście Seaports S.A. by commodity groups (in thousands of tonnes)

| SPECIFICATION | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| Total | 21 354.1 | 21 266.7 | 22 750.0 | 23 401.4 | 23 174.4 | 24 113.0 |
| Coal and coke | 5 422.1 | 4 257.4 | 4 529.4 | 4 601.8 | 3 119.8 | 2 930.9 |
| ore | 464.9 | 720.8 | 2 654.7 | 1 880.4 | 1 851.9 | 1 557.1 |
| Other mass | 3 670.0 | 4 040.4 | 2 887.6 | 3 250.0 | 3 451.0 | 2 919.5 |
| Grain | 1 081.8 | 1 394.4 | 1 648.6 | 1 644.3 | 1 743.9 | 2 046.8 |
| Wood | 23.1 | 25.2 | 16.8 | 17.4 | 14.3 | 7.2 |
| break bulk cargo | 9 290.7 | 9 425.5 | 9 392.2 | 10 337.2 | 11 254.6 | 12 349.3 |
| Liquid fuels | 1 401.5 | 1 403.0 | 1 620.8 | 1 670.3 | 1 738.9 | 2 302.2 |
| containers | bd | 532.4 | 587.3 | 665.0 | 675.0 | 673.6 |
| TEU containers | 55 098.0 | 52 179 | 62 307 | 78 439 | 87 784 | 90 869 |

Source: Own study based on the "Report on the implementation of the Polish maritime policy in 2011", Annex I to the "Report on the implementation of the Polish maritime policy in 2015", Annex I to "Report on the implementation of the Polish maritime policy in 2016" and data on the port website.

In 2016, transshipments in the port complex of Szczecin-Świnoujście amounted to 24,113,000 tonnes (taking into account the own mass of transshiped cargo units). It should be noted that this is the next highest level of transshipment recorded by the Port of Szczecin and Świnoujście Seaports Authority (ZMPSiŚ S.A.) after the best, starting from 1980, result from 2014. In 2016, there was an increase in transshipments in the group of grain, general cargo, and liquid fuels in relation to the previous year. The port has recorded record-breaking transshipment of containers in the amount 90 869 TEU.

Last years were a period of important investments for the Port of Szczecin-Świnoujście - in 2015, LNG terminal of. President Lech Kaczyński in Świnoujście was opened, and a grain elevator "Ewa" in Szczecin, was leased to the Danish company Copenhagen Merchants Holding A/Sna for 30 years. The new LNG terminal will provide about 5 billion $m^3$ of gas annually, which corresponds to around one third of Poland's natural gas demand. With the expansion of the LNG terminal in Świnoujście, the construction of a Baltic Pipe gas pipeline was planned to allow the gas extracted on the North Sea shelf belonging to Norway to be imported. It is estimated that after launching the elevator, "Ewa" transshipments in the port of Szczecin will increase by approx. 350-375 thousand tonnes per year. In subsequent years, this increase should be even greater.[33]

32 based on http://www.port.szczecin.pl/pl/

33 based on http://www.port.szczecin.pl/pl/

### *Shipbuilding*

The Polish shipbuilding industry is developing very dynamically. It is the second in Europe and the fifth in the world. Private companies are in an increasingly better condition, have an ever-growing portfolio of orders and successfully compete with giants from Scandinavian countries. In Poland, there are production and repair shipyards with various production potential.

The current economic situation in the world has a very large impact on the condition of the shipbuilding industry. This can be seen, inter alia, in the transfer of production to cheaper countries. This was also the case for European shipyards that lost their competition with East Asian shipyards by producing standard ships. The global ship market in recent years has been characterized by inheritance factors. Prices for new ships have decreased, and the number of new orders has also dropped. This resulted in a reduction in the global order portfolio for ships, in the structure of which bulk carriers, tankers and offshore vessels dominated. The year 2016 brought the lowest values since the 80s of the twentieth century for the shipyards around the world, and in 2016, orders were placed at a value of about 75% less than in 2015. The strongest decreases related to the container industry with a capacity of over 8,000. TEU (over 95% fewer orders than in 2015), LNG gas carriers (79% less), bulk carriers (87% less) and tankers (75% less). The market condition can be illustrated by The ClarkSea Index, informing about the earnings of shipowners providing transport services at global maritime market. At the beginning of 2016, operators of tankers, bulk carriers, container ships and gas carriers earned on the carriage on average about 14 thousand dollars a day, reaching at the end of this year $ 9,042 a day.

The shipbuilding industry is potentially one of the most innovative branches of the Polish economy, which is characterized by advanced design knowledge, high standards of Health and safety and environmental protection, as well as modern technology.

Polish shipyards, apart from fully equipped units, also build partially equipped ship hulls for European shipyards (mainly Scandinavian, German and Dutch). Shipbuilding also began to specialize in the construction of blocks and sections of hull, which are exported to Germany, Norway, France and the USA.[34]

Table 5.5.13 Portfolio of orders for fully equipped ships (as of 31 XII of individual years)

| **YEAR** | | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
|---|---|---|---|---|---|---|---|
| Number of ships | | 22 | 22 | 19 | 19 | 19 | 21 |
| Total Gross Capacity (GT) in thous. | | 77.9 | 89.3 | 57.1 | 76.2 | 83.3 | 81.7 |
| Completed gross register capacity (CGT) in thous. | | 146.9 | 166.5 | 96.2 | 127.6 | 129.0 | 140.2 |
| Container ships and semi-container ships | Number of vessels | – | – | 5 | 5 | 4 | 3 |
| | total gross capacity (GT) in thous. | – | – | 19.1 | 19.1 | 17.9 | 16.9 |
| cargo ship | Number of vessels | 1 | – | – | – | – | 2 |
| | total gross capacity (GT) in thous. | 2.8 | – | – | – | – | 13.2 |
| chemical tanker | Number of vessels | – | – | 1 | – | – | – |
| | total gross capacity (GT) in thous. | – | – | 4.2 | – | – | – |
| gas carrier | Number of vessels | – | 1 | 1 | – | – | – |
| | total gross capacity (GT) in thous. | – | 7.5 | 7.5 | – | – | – |

[34] Report on the implementation of the Polish maritime policy in 2016.

| YEAR | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| ferry | Number of vessels | 4 | 4 | 1 | 5 | 6 | 6 |
| | total gross capacity (GT) in thous. | 22.8 | 20.4 | 5.7 | 34.1 | 35.1 | 25.6 |
| passenger ship | Number of vessels | – | – | – | – | – | 1 |
| | total gross capacity (GT) in thous. | – | – | – | – | – | 0.4 |
| fishing vessel | Number of vessels | 4 | 4 | 3 | – | – | 3 |
| | total gross capacity (GT) in thous. | 14.9 | 6.1 | 0.4 | – | – | 7.6 |
| non-cargo ships | Number of vessels | 13 | 13 | 8 | 9 | 9 | 6 |
| | total gross capacity (GT) in thous. | 37.5 | 55.3 | 20.2 | 23 | 30.3 | 18 |

Source: Own study based on the "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, tables7.3 and 7.4, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012. tables 7.3 and 7.4 and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013-2016, tables 7.3 and 7.4

Table 5.5.14 Production of fully equipped ships by types

| YEAR | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| Number of ships | | 14 | 15 | 12 | 8 | 7 | 12 |
| Total Gross Capacity (GT) in thous. | | 71.9 | 84.8 | 34.7 | 25.6 | 18.9 | 38.9 |
| Completed gross register capacity (CGT) in thous. | | 93.9 | 133.7 | 68.7 | 47.1 | 33.6 | 68.0 |
| Bulk carriers | Number of vessels | – | – | – | – | – | 1 |
| | total gross capacity (GT) in thous. | – | – | – | – | – | 1.9 |
| Container ships and semi-container ships | Number of vessels | 1 | – | – | – | – | – |
| | total gross capacity (GT) in thous. | 35.9 | – | – | – | – | – |
| cargo ship | Number of vessels | 2 | 1 | – | – | 2 | 2 |
| | total gross capacity (GT) in thous. | 5.4 | 2.8 | – | – | 6 | 2.4 |
| gas carrier | Number of vessels | – | – | – | 1 | – | – |
| | total gross capacity (GT) in thous. | – | – | – | 7.5 | – | – |
| ferry | Number of vessels | 7 | 4 | 2 | 1 | 1 | – |
| | total gross capacity (GT) in thous. | 20.3 | 22.8 | 8.0 | 5.7 | 5.5 | – |
| passenger ship | Number of vessels | – | – | – | – | – | 1 |
| | total gross capacity (GT) in thous. | – | – | – | – | – | 0.1 |
| fishing vessel | Number of vessels | 3 | 1 | – | 1 | 1 | 1 |
| | total gross capacity (GT) in thous. | 7.4 | 2.8 | – | 0.4 | 0.4 | 0.5 |
| non-cargo ships | Number of vessels | 1 | 9 | 10 | 5 | 3 | 7 |
| | total gross capacity (GT) in thous. | 3.0 | 56.6 | 26.7 | 12.0 | 7.0 | 33.9 |

Source: Own study based on the "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, tables 7.1 and 7.2, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012. tables 7.1 and 7.2 and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013-2016, tables 7.1 and 7.2

In 2016, the order book for Polish shipyards amounted to 21 fully equipped vessels, and the 12 fully equipped vessels were produced. Poor inflow of new orders to Polish shipyards has recently been the result of the collapse of the offshore market. The order book size shown above in 2016 includes both orders received during 2016 and earlier. According to the ship and shipbuilding database of IHS Sea-Web, Polish shipyards throughout the 2016 have won orders for four small, fully equipped vessels with a total tonnage of approx. 5,400 GT. The following are selected units built in 2015 and 2016 by Polish shipyards:

- ✓ marine mining supplier - Ship, which purpose will be to transport cargo necessary for drilling wells and operation of oil rigs. It is a multi-purpose vessel designed for operating drilling and mining oil rigs equipped with an electric-diesel drive, enabling economical operation in a wide load range, with a significant reduction in fuel consumption (lower emission of harmful substances into the atmosphere;
- ✓ PSV vessel built for the Norwegian shipowner - the second ship in this series. These were the first gas supply vessels built at Remontowa Holding SA;
- ✓ a three-masted frigate for the Algerian Navy and the Maritime Academy - a unit which shape is similar to the Dar Młodzieży, and one of its masts functions as a chimney, resulting in less exhaust gas discharge through the lateral exhausts;
- ✓ a three-masted training ship for the Vietnamese Navy (built at the Marine Project Shipyard in Gdańsk);
- ✓ offshore ship for a Canadian shipowner - a ship designed to monitor and control the state of ice cover, correcting the course of moving icebergs in the region of Labrador and Newfoundland (protection of offshore mining installations against possible collision with a "wandering" iceberg);
- ✓ passenger - car gas ferry for a Canadian shipowner - a modern ferry in its class propelled by azimuth thruster with electric drive, where the source of energy are dual-fuel generator sets powered with conventional diesel oil or LNG gas;
- ✓ Kormoran ship for the Polish Navy - a ship designed to search for and combat marine mines;
- ✓ "Oceanograf." - scientific and research catamaran intended for conducting interdisciplinary research on the Baltic Sea. It was built by the Nauta shipyard for the University of Gdańsk. Modern devices have been installed on the unit that enable conducting bathymetric, chemical, geological and seabed research;
- ✓ residential module on the oil rig - in 2016 Energomontaż-Północ Gdynia completed the construction of a residential module weighing 1140 tonnes on the Maersk Guardian oil rig. The construction was the largest commission of the company as part of the unit's modernization. The oil rig was to start working in the Danish part of the North Sea. Maersk Guardian is a Jack-up oil rig, 90 m long and 84.4 m wide. It is adapted to work in areas where the water depth is 107 m;
- ✓ specialized, multi-purpose AHTS type ship built by order of a Canadian shipowner - the first such ship built by Remontowa Shipbuilding S.A. with the possibility of deployment in difficult Arctic conditions of the North Atlantic. The ship is already carrying out its tasks around mining oil rigs in the region of Labrador and Newfoundland;
- ✓ cable ship built for the Norwegian shipowner by Remontowa Holding S.A. - one of the most technologically advanced vessels in the history of the Polish shipbuilding industry. This unit was entirely developed in Gdańsk, starting from the development of a working project, through the construction of a hull with an innovative shape, up to the equipment with state-of-the-art navigation systems (including an extensive dynamic positioning system DP2, diesel-electric drive, and a system for laying submarine cable connections).

Important activities undertaken in previous years, i.e. from 2015, resulted in wide cooperation between business (shipbuilding and yacht industry) and scientific and research departments. The aim of these activities was to develop innovative solutions that could be implemented in practice and implemented by the industry.[35]

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35 Report on the implementation of the Polish Maritime Policy in 2015, Warsaw 2016 and Report on the implementation of the Polish Maritime Policy in 2016, Warsaw 2017

**Energomontaż– Gdynia Północ Corporate Group**

Energomontaż - Gdynia Północ Corporate Group consists of the following entities: Energomontaż- Gdynia Północ Ltd. and Energop Ltd.

Energomontaż-Gdynia Północ S.A. is a leading Polish manufacturer of highly specialized, fully equipped steel structures for the offshore sector, conventional, renewable and nuclear energy, chemical and petrochemical industry as well as the shipbuilding industry. In addition, the company also rebuilds specialized units servicing offshore wind farms and offshore mining industry. It has the power to weld all types of steel structures (including pressure and vacuum structures, cranes, bridges and both marine and ship structures). In 2015, Energomontaż – Gdynia Północ S.A. among others cooperated in the implementation of the steel structure of the M3 production module for the Petrobaltic oil rig. In addition, in August 2016 Energomontaż-Gdynia Północ S.A. completed the construction of a residential module, called Maersk Guardian, weighing 1140 tonnes on a Jack-up oil rig, 90 m long and 84.4 m wide. This oil rig is adapted to work in areas where the water depth is 107 m. The construction was the largest, as part of the modernization of the unit, order of the company.[36]

**Morska Stocznia Remontowa Gryfia S.A.**

Morska Stocznia Remontowa Gryfia S.A. was created as a result of the merge of two West Pomeranian plants. The production plants are located in Szczecin and Świnoujście. The yard offers services in the field of renovation, reconstruction and construction of new units. Performs emergency repairs and ship class reviews. For over 15 years, it has also been a producer of offshore steel structures. In 2015, the shipyard obtained a license to operate in the field of trade of goods and technology for military or police purposes. In 2016, the company completed 198 ship repair orders, including 4 ferries for the largest Polish shipowners, i.e. Polsteam and Euroafrica. At the end of 2016, the shipyard concluded a contract with Polsteam for the renovation of 12 bulk ships in 2017 for approximately USD 7.5 million. In the offshore segment, Morska Stocznia Remontowa Gryfia S.A. has completed the construction of three steel containers designed for the Norwegian company Nyhamna Expansion. In the shipyard, a dock repair of the ORP Toruń ship was made, offers were submitted in two tender proceedings under PMT - SUPPLY and HOLOWNIK projects (in consortium with Nauta Shiprepair Yard). In addition, in 2016, the Morska Stocznia Remontowa Gryfia S.A. and Nauta Shiprepair Yard signed a letter of intent regarding the construction of a ro-pax ferry for the Polish Baltic Shipping Company. On 23 June 2016, on the slipway Wulkan Nowy in Szczecin Industrial Park, the keel for the construction of a passenger-car ferry (Ro-Pax) was established, which will be constructed in Szczecin for Polferries. The ferry will be 202.4 m long and 30.8 m wide. It will reach a speed of 18 knots at a design draft of 6.3 m. The new unit will accommodate a crew of 75 people and 400 passengers on board. Thanks to the solutions applied, it will be a modern unit that meets high environmental standards. Ro-Pax will be equipped with a diesel-electric drive, and the main fuel used by the ferry will be liquid natural gas (LNG). The ferry will be adapted for bunkering with the use of the LNG terminal in Świnoujście infrastructure and the Ystad port. In 2016, the yard also obtained an industrial safety certificate.[37]

**Remontowa Holding S.A.**

Remontowa Holding S.A. is the largest shipbuilding capital group in Poland. It is a leader in the industrial sector in the region, which manages 25 companies from the shipping and offshore industry, including two shipyards. It specializes in the construction of modern ecological passenger-car ferries as well as technologically advanced vessels from the offshore industry and ships. In addition, it operates on the market of renovations and reconstructions of both ships and oil rigs. The Group's leaders are two shipyards, i.e. Remontowa Shipbuilding S.A. and Gdańska Stocznia "Remontowa" S.A. The latter specializes in the renovation and reconstruction

[36] http://epgsa.com/epgpl/

[37] http://www.msrgryfia.pl/

of passenger ferries, oil rigs, and is currently implementing more and more contracts for the installation of scrubbers (scrubber for flue gas desulfurization). The variety of products and specialized services provides comprehensive solutions for the entire shipping industry. Remontowa Holding S.A. is also one of the largest employers in Pomerania. In the companies of the Remontowa Holding SA group. innovative, most advanced projects and products in the European maritime industry are created. The group's revenues in 2016 amounted to approximately PLN 2.1 billion, of which over 80% were export revenues (20 entities employing approx. 8 thousand employees). In 2016, the construction of 6 fully equipped vessels was completed as part of the group and work continued on a further 7 units.[38]

**The Crist S.A. shipyard**

The Crist S.A. shipyard has been active on the shipbuilding, steel constructions and ship repairs market for years. Economic changes and the development of renewable technologies - such as hydropower and wind energy - have also created opportunities for operation in new markets. Currently, Cristal Shipyard S.A. participates in the implementation of projects in the field of specialized offshore structures, maritime transport and units for the exploitation of marine resources. It builds prototypes and highly innovative vessels, including Jack-up Innovation vessels and VIDAR Jack-up vessels to service offshore wind farms. In 2016, the heavy-lift Jack-Up "Zourite" technical barge was produced at the shipyard, and on May 18, 2017, the seventh eco-friendly innovative ferry P310 "Electra" with hybrid drive for Finnish Finferries left the shipyard.[39]

**Stocznia Gdańsk S.A.**

Gdańsk Shipyard S.A. is known worldwide as a ship manufacturer. Currently, it mainly builds partially equipped hulls at the request of other shipyards as well as steel constructions and wind blowers. In 2016, the following investments were completed: the opening of a new conservation and painting line and a new technological line allowing to double the current production capacity of wind turbine towers, as well as start the production of wind towers for the offshore market. In addition, in 2016, GSG Towers, part of the Gdańsk Shipyard Group, signed a contract with BladtIndustries for the construction of three halves of transformer stations serving the world's largest offshore wind farm "Hornsea". Each of the parts manufactured in Gdańsk will weigh 536 tonnes. The final customer is Dong Energy, a Danish energy company with 100% shares in a unique farm off the coast of Great Britain.[40]

**Naval Shipyard S.A.**

The Naval Shipyard S.A. in liquidation bankruptcy (used abbreviated name: SMW S.A. in liquidation bankruptcy) is the oldest existing shipyard in Poland. Its main purpose is to meet the state's defense needs in the areas of repairs, reconstructions, modernization, maintenance of Naval vessels, commercial, fishing, technical and special fleets. It performs in full range repairs of submarines, specializes in the construction of civilian and special vessels, as well as the production of specialized equipment, products, subassemblies and spare parts. In addition, it provides repair, docking, design, cooperative, transport, forwarding, warehouse and diagnostic services. It operates both on the territory of the Republic of Poland and abroad. It also has a license to export weapons. In May 2017, an initial agreement was signed for the purchase, in liquidation bankruptcy, of the Naval Shipyard in Gdynia. The only bidder in the tender was the Polska Grupa Zbrojeniowa Navy Shipyard.[41]

38 http://www.remontowaholding.pl/

39 http://www.crist.com.pl/

40 http://www.gdanskshipyard.pl/pl/

41 http://www.navship.pl/

### Stocznia Remontowa Nauta S.A.

Stocznia Remontowa Nauta S.A. shipyard occupies an area of about 19.7 ha, including current facilities near the center of Gdynia and the newly acquired area of the former Gdynia Shipyard. It has one 380-meter dry dock and four floating docks with a capacity of 1,200 to 12,000 tonnes and wharfs with a length of 2,900 meters for staging units. Stocznia Remontowa Nauta S.A is fully equipped to perform the most advanced ship repairs and conversions as well as the production of new ships and ship constructions. It deals with repairs and reconstructions of vessels, both civilian and military, as well as other services related to the maritime industry. The company also operates in the construction of new vessels.

In 2016, on order from among others EifraShips AS, Coral Line, Ostranios Transport, V Ships UK, Bernhard Schulte and JSC Murmansk, the shipyard refurbished 111 civilian ships, carried out renovation works on two ships and two Frigate missiles. There are renovations of four other special units under construction. Together with the MSR Gryfia shipyard, Stocznia Remontowa Nauta S.A started a tender for the repairs of two Gardno trawlers and two transport and mine ships. The shipyard plans to participate in the Polish Naval Technical Modernization Program (implementation of projects by MIECZNIK and CZAPLA, SUPPLY and HOLOWNIK).[42]

Table 5.5.15 Ship repairs and order book for repairs

| SPECIFICATION | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| Ship repairs carried out | | | | | | |
| Number of renovations | 624 | 617 | 532 | 599 | 610 | 537 |
| Value in million euros | 286.0 | 227.5 | 232.8 | 276.4 | 311.8 | 237.5 |
| Order book for repairs | | | | | | |
| Number of renovations | 278 | 202 | 97 | 68 | 39 | 86 |
| Value in million euros | 90.9 | 103.2 | 102.3 | 159.2 | 118.2 | 114.2 |

Source: Own study based on the "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, tables 7.5 and 7.6, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012. Tables 7.5 and 7.6 and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013-2016, Tables 7.5 and 7.6

In 2016, 537 vessels were repaired in Polish shipyards. This is a decrease by more than 16% in relation to the number of repairs made in 2011. The value of units renovated in 2016 amounted to 237.5 million.

The order book for repairs for 2016 amounted to 86 vessels, it was more than a two-fold increase compared to 2015, but a three-fold decrease compared to 2011.

### Yacht production industry

The yacht sector (production of yachts, equipment, services) in Poland is about 0.15% of the total value of Polish export. For the yacht sector, export account for 90% of its production. Due to the very important role for the balanced regional development of Poland, the number of jobs created and the export potential, the yacht industry has become one of the Polish export specialties. It consists of about 900 enterprises in Poland and employs 35 thousand people. Polish yacht shipyards produce more than a dozen thousand vessels each year, both motorboats and sailing boats.

The real curiosity of the Polish yacht industry is the ability to build virtually any yacht, regardless of the material, size and technology. Wooden yachts are produced in accordance with the centuries-old boatbuilding tradition, but also yachts made of aluminum, steel and carbon fiber, a polyester resin with glass fiber. The offer of Polish producers of sailing yachts is very wide. It consists of several dozen models with a length from 3 to over 30 m. They are intended mainly for coastal and inland navigation. There are also constructions that allow for deep sea boat trips below 8 m in length or a cruise around the world on a yacht not exceeding 9 m. The

[42] http://www.nauta.pl/index.php?shiprepair-yard

leading Polish yacht shipyards include: DelphiaYachts (Olecko), Galeon (Straszyn), SunreefYachts (Gdańsk), Balt-Yacht (Żarnowo k/Augustowa), Ostróda Yacht, S-Yachts (Ślepsk), Mazurskie Przedsiębiorstwo Produkcyjno-Budowlane JW Ślepsk (Augustów). Polish shipyards produce yachts not only under their own brands, but also on orders from foreign shipyards, including the world's largest Brunswick company.[43]

Table 5.5.16 Production of other vessels (data refer to business entities in which the number of employees exceeds 9 people)

| | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| Shipping, recreational or sporting boats | Manufactured production | 626 pcs. | 538 pcs. | 591 pcs. | 630 pcs. | 699 pcs. | 1177 pcs. |
| | Sold production | 627 pcs. | 539 pcs. | 593 pcs. | 630 pcs. | 699 pcs. | 1176 pcs. |
| | | 184,2 ml zł | 186,8 mln zł | 256 mln zł | 212,9 mln zł | 232,6 mln zł | 282 mln zł |
| Recreational and sporting motorboats | Manufactured production | 410 pcs. | 411 pcs. | 589 pcs. | 999 pcs. | 1087 pcs. | 1235 pcs. |
| | Sold production | 383 pcs. | 406 pcs. | 562 pcs. | 997 pcs. | 1062 pcs. | 1284 pcs. |
| | | 27,8 mln zł | 22,2 mln zł | 39,9 mln zł | 60,5 mln zł | 72,2 mln zł | 88,3 mln zł |

Source: Own study based on the "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, table 7.7, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012. Table 7.7 and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013-2016, table 7.7

The production of other vessels in 2016 amounted to 1,177 open sea, recreational or sporting yachts and 1235 open sea motor or recreational motor boats. This represents an increase of 88% and 200% respectively compared to the production results in 2011.

In order to rebuild the Polish shipbuilding industry, MGMiŻŚ in cooperation with the shipbuilding industry prepared a law Act of 6 July 2016 on the activation of the shipbuilding industry and complementary industries (Journal of Laws of 2018, item 387, as amended). The Act introduces instruments supporting the shipbuilding industry, including the most-desired changes in VAT tax, and considerably extends the possibility of applying VAT of 0% on production, import, parts and equipment for a broadly defined catalog of sea vessels in accordance with Council Directive 2006/112/EC of 28 November 2006 on the common system of value added tax (O.J. EU L 347 of 11.12.2006, page 1, as amended) and executive acts. The condition for using the 0% rate is the use of a given unit for navigation on the open sea and for transport of passengers or for commercial, industrial or fishing purposes, as well as for rescue and assistance at sea and for offshore fishing. It is estimated that the implementation of the Act will result in the development of shipbuilding in Poland, the development of research and development centers developing innovative types of ships, increase in employment and the maintenance of qualified employees and ensuring competitive rules for the Polish shipbuilding industry and complementary production on international markets.[44]

43 [43]http://polishyachts.eu/przemysl-jachtowy-w-polsce/

44 Report on the implementation of the maritime policy of the Republic of Poland in 2016, Warsaw 2017

***Sea fishing***

The state of natural resources of the Baltic Sea, compared to other marine areas, is poor, which is caused primarily by hydrological conditions, mainly salinity. Living natural resources of the Baltic Sea are primarily fish.

Fishermen use a twofold way of naming the fishery located in POM. The first is based on the division of marine waters into statistical subareas of the International Council for the Exploration of the Sea (ICES). Polish fishing grounds are located in subareas 24, 25 and 26 (west, central and east coast region). Subarea 24 covers the area of the west coast, west of the meridian 15° East longitude (west of Niechorze); Subarea ICES 25 covers the area of the central coast, between meridians 15° and 18° East (between Niechorze and Białogóra), while ICES subarea 26 covers the east coast region, east of the meridian 18° East Longitude (east of Białogóra). The second method is based on the use of a fishing squere grids, which is used in radio communication and logbooks. The grid is made of conventional squares with a area equal to 10x11.5 nautical miles determined by parallels every 10 minutes and meridians every 20 minutes.[45]

Polish sea fishing is divided into two basic sectors: Baltic fishing, which is definitely the largest part of the Polish fishing fleet and ocean fishing. The Baltic fleet includes cutters and motor and self-proppeled fishing boats operating in the Baltic Sea and internal marine waters, while the basic species caught by Polish fishermen in the Baltic Sea are: cod, salmon, herring, sprat, sea trout and flounders, local fish such as: garfish , viviparous eelpout, rock gunnel, vendace , common whitefish and smelt also have a small local importance. The main species caught by Polish ocean fleet include: Atlantic horse mackerel, cod, saithe, sardine, black scabbardfish, European hake, mackerel. Particularly important for Polish fishermen are cod catches, which are subject to many limitations resulting, among others from the recovery plan for this species (limiting the increase in catch limits, protective periods and restrictions in the use of certain fishing gear). The pelagic catches (sprat and herring) influence the income of Polish fishermen to a large extent. Sea trouts and flounders are also willingly caught and equally valuable from economical perspective. Crucial to the functioning of the Polish ocean fleet are the fishing opportunities resulting from EU fisheries agreements with the countries of West Africa: Morocco and Mauritania. The chances for the development of the Polish ocean fleet depend on obtaining fishing opportunities in new fisheries, based on new EU fisheries agreements with third countries[46]

Table 5.5.17 Fishing fleet by ownership sectors and types of vessels (as of 31 XII of individual years)

| SPECIFICATION | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| TOTAL | vessels | 790 | 798 | 838 | 873 | 875 | 843 |
| | total gross capacity (GT) in thous. | 33.4 | 33.4 | 33.9 | 34.1 | 34.3 | 34.9 |
| | power in thous. kW | 82.9 | 81.9 | 81.4 | 81.5 | 81.5 | 83.2 |

[45] http://www.portrega.pl

[46] Annual report on measures to achieve a balance between fishing capacity and size allowable fishing for the period from 1 January to 31 December 2016, Report for the EC and Report on the implementation of the maritime policy of the Republic of Poland in 2016, Warsaw 2017

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ownership sector | | | | | | | |
| public sector | vessels | 5 | 5 | 5 | 5 | 5 | 5 |
| | total gross capacity (GT) in thous. | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| | power in thous. kW | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| private sector | vessels | 785 | 793 | 833 | 868 | 870 | 838 |
| | total gross capacity (GT) in thous. | 32.6 | 32.6 | 33.1 | 33.3 | 33.5 | 34.1 |
| | power in thous. kW | 80.8 | 79.8 | 79.3 | 79.4 | 79.4 | 81.1 |
| Vessel type | | | | | | | |
| Deep-sea trawlers | vessels | 3 | 3 | 3 | 3 | 3 | 4 |
| | total gross capacity (GT) in thous. | 17.4 | 17.4 | 17.3 | 17.3 | 17.3 | 18.7 |
| | power in thous. kW | 15.2 | 15.2 | 14.6 | 14.6 | 14.6 | 20 |
| Fishing boats | vessels | 143 | 140 | 139 | 139 | 139 | 126 |
| | total gross capacity (GT) in thous. | 11.6 | 11.6 | 12.2 | 12.3 | 12.5 | 12.1 |
| | power in thous. kW | 37 | 36.2 | 36.2 | 36.2 | 36.2 | 34.3 |
| Motor fishing boats | vessels | 617 | 618 | 634 | 655 | 657 | 639 |
| | total gross capacity (GT) in thous. | 4.3 | 4.3 | 4.4 | 4.4 | 4.4 | 4 |
| | power in thous. kW | 30.6 | 30.5 | 30.6 | 30.7 | 30.7 | 28.8 |
| Rowing fishing boats | vessels | 27 | 37 | 62 | 76 | 76 | 74 |

Source: Own study based on the "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, Table 8.1, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012. Table 8.1 and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013-2016, Table 8.1

At the end of 2016, the Polish Baltic fleet consisted of 839 fishing vessels (including vessels fishing on the Vistula Lagoon and Szczecin Lagoon), while the ocean fleet consisted of 4 vessels that fished only in waters outside the Baltic Sea and outside Polish marine internal waters.

Table 5.5.18 Catches by selected species (in tonnes)

| SPECIFICATION | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| TOTAL | 179 914 | 179 703 | 195 482 | 170 516 | 187 037 | 198 877 |
| Deep sea fishing | 69 147 | 59 129 | 61 399 | 52 052 | 52 312 | 59 979 |
| Baltic fishing | 110 767 | 120 575 | 134 083 | 11 8464 | 134 725 | 138 898 |
| Diadromous fish | no data | no data | 254 | 200 | 231 | 317 |
| Freshwater fish | no data | no data | 3 125 | 3 082 | 2 869 | 3 174 |
| Marine fish | 174 514 | 177 071 | 192 103 | 16 7234 | 183 937 | 195 385 |
| selected fish species | | | | | | |
| saithes | 584 | _ | 2 | 2 | 1 154 | 528 |
| cods | 15 631 | 18 552 | 19 104 | 18 244 | 18 486 | 15 562 |
| salmons | bd | 35 | 33 | 18 | 23 | 21 |
| mackerels | 5 998 | 3 651 | 7 595 | 5 662 | 3 915 | 9 242 |
| hakes | 55 | 362 | 58 | 1 060 | 1 270 | 647 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Atlantic horse mackerels | 20 608 | 34 534 | 27 758 | 34 951 | 39 701 | 39 201 |
| Flounders | 10 008 | 11 028 | 12 031 | 12 795 | 9 644 | 15 299 |
| Sardines and European anchovies | 33 171 | 13 522 | 17 408 | 2 995 | 705 | 2 695 |
| European sprats | 56 490 | 63 119 | 80 988 | 58 575 | 64 175 | 60 057 |
| herrings | 29 881 | 27 114 | 23 581 | 28 137 | 39 712 | 44 056 |

Source: Own study based on the "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, tables 8.6 and 8.7, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012. tables 8.6 and 8.7, "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013-2016, Tables 8.6 and 8.7, "Maritime Economy in Poland in 2012-2014. GUS, Szczecin "tabl. 5 [33] and "Maritime Economy in Poland in 2015-2016. GUS, Szczecin "tabl. 4 [34]

Catches of fish and marine invertebrates amounted to 198.9 thousand tonnes in 2016 and were higher by 10.5% compared to the catches achieved in 2011. Baltic catches reached the level of 138.9 thousand tonnes, while the ocean catches, nearly 60,000 tonnes of fish. Sprats dominated in the species structure. Catches of this fish amounted to over 60,000 tonnes, which accounted for 1/3 of the total catch. The second most-favored species was herring, which accounted for 22% of the total catches in 2016.

The management of living marine resources falls within the competence of the EU. EU Member States collectively use marine ecosystems, and the activities of one fleet have a direct impact on future fishing opportunities of other fleets exploiting the same fish stocks and the same ecosystems. Among other things, for these reasons, the Common Fisheries Policy has introduced a landing obligation for individual species of fish, meaning that all fish independent of their size, such as cod, herring, sprat and salmon caught in the Baltic Sea must be reported and landed and deducted from the fishing quota.

In 2016, the proposal for a Regulation of the European Parliament and of the Council establishing a multiannual plan for cod, herring and sprat stocks in the Baltic Sea and the fisheries exploiting those stocks, amending Council Regulation (WE) No 2187/2005 and repealing Council Regulation (WE) No. 1098/2007. From July 21, 2016, Poland applies the provisions of Regulation (EU) 2016/1139 of the European Parliament and of the Council of 6 July 2016 establishing a multiannual plan for the stocks of cod, herring and sprat in the Baltic Sea and the fisheries exploiting those stocks, amending Council Regulation (EC) No 2187/2005 and repealing Council Regulation (EC) No 1098/2007 as regards the management of cod, herring, sprat and flounders stocks, bearing in mind the sustainable exploitation of stocks and the stable size of fishing permits.

In addition, in the light of the regulations in force, the minister responsible for fisheries is obliged to conduct restocking in order to maintain and restore fish stocks in maritime areas of the Republic of Poland. The restocking results from the need to maintain species of diadromous fish valuable to Polish fisheries, such as, sea trout and salmon. Fish restocked as part of the task "Restocking of Polish sea areas" includes the Vistula and the Oder basins, Pomeranian rivers and marine waters. Fish restocking is made in batches so that the quantity and range of released fish can be controlled on a daily basis.[47]

The following tables present data on catches and the use of quotas in 2011-2016.

[47]„ Report on the implementation of the maritime policy of the Republic of Poland in 2016", Warsaw 2017

Table 5.5.19 . Total catches and quota consumption in 2011

| Gatunek organizmu morskiego | Dorsz [1] (t) | | Łosoś (szt.) | Szprot (t) | Gładzica (t) | Śledź (t) | | Stornia (t) | Troć wędrowna (szt.) | Pozostałe gatunki (t) |
|---|---|---|---|---|---|---|---|---|---|---|
| Obszar | 22-24 [2] | 25-32 [2] | 22-31 | 22-32 | 22-32 | 22-24 | 25–27, 28.2, 29 i 32 | 22-32 | 22-32 | 22-33 |
| Ogólna kwota połowowa | 1496 | 13945 | 15723 | 83680 | 456 | 2067 | 27863 | - | - | - |
| | 15441 | | | | | | | | | |
| Przedział długości statków rybackich | | | | | | | | | | |
| pon. 8 m | 3,60 | 561,88 | 1121 | 0,74 | 0,39 | 0,00 | 667,62 | 687,39 | 7790 | 702,59 |
| 8 - 11,99 | 205,35 | 3456,46 | 1465 | 0,77 | 8,87 | 502,20 | 1618,11 | 2406,97 | 10243 | 1676,46 |
| 12 - 14,99 | 145,45 | 2168,07 | 434 | 65,33 | 16,76 | 44,66 | 587,12 | 4049,15 | 5317 | 71,80 |
| 15 - 18,49 | 103,73 | 2292,54 | 2710 | 1285,63 | 7,37 | 27,10 | 708,59 | 1098,50 | 25731 | 38,27 |
| 18,5 - 20,49 | 22,60 | 540,36 | 289 | 426,37 | 1,03 | 16,65 | 470,65 | 308,66 | 702 | 4,36 |
| 20,5 - 25,49 | 4,59 | 1850,61 | 87 | 11182,88 | 1,02 | 0 | 1583,11 | 1026,34 | 1437 | 1,41 |
| 25,5 - i pow. | 2,39 | 501,32 | 0 | 43527,92 | 0,00 | 1199,78 | 22454,99 | 147,55 | 0 | 7,31 |
| *Połowy w podziale na stada* | *487,72* | *11371,23* | | | | | | | | |
| *Wykorzystanie kwoty w podziale na stada (%)* | *32,60* | *81,54* | | | | | | | | |
| **Połowy łącznie:** | **11858,95** | | **6106** | **56489,62** | **35,42** | **1790,38** | **28090,19** | **9724,56** | **51220** | **2502,20** |
| ***Wykorzystanie kwoty (%)*** | ***77*** | | ***39*** | ***68*** | ***8*** | ***87*** | ***101*** | **-** | **-** | **-** |

[1] In accordance with COMMISSION REGULATION (EC) No 635/2008 of 3 July 2008 adapting the cod fishing quotas to be allocated to Poland in the Baltic Sea (Subdivisions 25-32, EC Waters) from 2008 to 2011 pursuant to Council Regulation (EC) No 338/2008 (O.J. L 176 of 04.07.2008, page 8) - the cod quota has been reduced by 2400 tonnes.
[2] Fishing quotas after international exchanges.

Source: Data provided by the Fisheries Department of MGMiŻŚ. Data comes from monthly reports and pages from fishing logbooks completed by fishing vessel owners. ERS - Ministry of Agriculture and Rural Development. State of ERS on ERS Status on 11/02/2013 (for 2012)

Table 5.5.20. Total catches and quota consumption in 2012

| Gatunek organizmu morskiego | Dorsz (t) | | Łosoś (szt.) | Szprot (t) | Gładzica (t) | Śledź (t) | | | Stornia (t) | Troć wędrowna (szt.) | Pozostałe gatunki (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Obszar | 22-24 [1] | 25-32 [1] | 22-31 | 22-32 | 22-32 [1] | 22-24 | 25–27, 28.2, 29 i 32 | Zalew Wiślany | 22-32 | 22-32 | 22-32 |
| Ogólna kwota połowowa | 1337 | 20534 | 7704 | 66128 | 390 | 2719 | 18037 | 1500 | - | - | - |
| | 21871 | | | | | | 19537 | | | | |
| Przedział długości statków rybackich | | | | | | | | | | | |
| pon. 8 m | 0,00 | 519,34 | 247 | 0,00 | 2,24 | 3,80 | 295,71 | 412,88 | 858,31 | 11177 | 809,12 |
| 8 - 9,99 m | 21,33 | 798,01 | 418 | 0,00 | 2,74 | 274,31 | 307,72 | 1522,83 | 803,76 | 8054 | 1566,10 |
| 10 - 11,99 m | 261,01 | 2229,29 | 798 | 13,35 | 13,52 | 429,85 | 217,48 | 93,41 | 2443,20 | 6920 | 308,77 |
| 12 - 14,99 m | 250,02 | 3170,81 | 137 | 1515,52 | 21,76 | 63,37 | 307,41 | | 3358,94 | 170 | 1802,85 |
| 15 - 18,49 m | 227,39 | 3183,74 | 3455 | 3338,46 | 14,38 | 26,91 | 538,70 | | 1355,17 | 9150 | 333,88 |
| 18,5 - 20,49 m | 53,51 | 1085,93 | 745 | 1471,44 | 3,51 | 14,77 | 321,44 | | 537,13 | 1233 | 1,77 |
| 20,5 - 25,49 m | 1,93 | 2315,41 | 0 | 10084,34 | 5,68 | 6,80 | 2166,72 | | 671,39 | 198 | 289,90 |
| 25,5 - 30,49 m | 0,84 | 712,42 | 0 | 35443,11 | 0,00 | 1362,59 | 16003,01 | | 60,50 | 0 | 24,49 |
| 30,5 - i pow. | 0,00 | 4,96 | 0 | 11248,98 | 0,00 | 176,00 | 2566,60 | | 0,00 | 0 | 0,00 |
| *Połowy w podziale na obszary* | *816,01* | *14019,91* | | | | | *22724,80* | *2029,12* | | | |
| *Wykorzystanie kwoty w podziale na obszary (%)* | *61,03%* | *68%* | | | | | *126%* | *135%* | | | |
| **Połowy łącznie:** | **14835,93** | | **5800** | **63115,19** | **63,81** | **2358,40** | **24753,92** | | **10088,40** | **36902** | **5136,87** |
| ***Wykorzystanie kwoty (%)*** | ***68%*** | | ***75%*** | ***95%*** | ***16%*** | ***87%*** | ***127%*** | | **-** | **-** | **-** |

[1] Fishing quotas after international exchanges.

Source: Data provided by the Fisheries Department of MGMiŻŚ. Data comes from monthly reports and pages from fishing logbooks completed by fishing vessel owners. ERS - Ministry of Agriculture and Rural Development. State of ERS on ERS Status on 11/02/2013 (for 2012).

Table 5.5.21 Total catches and quota consumption in 2013.

| Gatunek organizmu morskiego | Dorsz (t) | | Łosoś (szt.) | Szprot (t) | Gładzica (t) | Śledź (t) | | | Stornia (t) | Troć wędrowna (szt.) | Pozostałe gatunki (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Obszar | 22-24 (1)(5) | 25-32 (1)(2) | 22-31 (4) | 22-32 (1) | 22-32 (1) | 22-24 | 25–27, 28.2, 29 i 32 (3) | Zalew Wiślany | 22-32 | 22-32 | 22-32 |
| Ogólna kwota połowowa | 1328 | 19438,4 | 5061 | 76680 | 411 | 3357 | 18835 | 1726 | - | - | - |
| | 20766,4 | | | | | | 20561 | | | | |
| Przedział długości statków rybackich | | | | | | | | | | | |
| pon. 8 m | 0,00 | 423,11 | 169 | 0,09 | 5,43 | 4,70 | 265,87 | 427,62 | 833,51 | 7958 | 1001,88 |
| 8 - 9,99 m | 46,22 | 677,34 | 625 | 4,95 | 1,89 | 332,71 | 270,50 | 1196,31 | 887,92 | 6408 | 2019,56 |
| 10 - 11,99 m | 304,55 | 2055,07 | 635 | 17,54 | 14,76 | 523,10 | 399,10 | 56,60 | 2477,06 | 6238 | 250,94 |
| 12 - 14,99 m | 182,23 | 2563,07 | 190 | 1974,54 | 9,89 | 76,81 | 614,08 | | 4595,51 | 307 | 1526,03 |
| 15 - 18,49 m | 89,82 | 2222,62 | 2727 | 1170,90 | 15,30 | 40,33 | 559,50 | | 1446,49 | 7340 | 41,75 |
| 18,5 - 20,49 m | 75,34 | 1385,54 | 928 | 4851,78 | 1,67 | 11,45 | 776,50 | | 852,17 | 1392 | 62,96 |
| 20,5 - 25,49 m | 0,20 | 1893,98 | 3 | 16987,93 | 1,08 | 23,03 | 1640,88 | | 612,86 | 4 | 0,71 |
| 25,5 - 30,49 m | 8,30 | 571,20 | 0 | 44206,70 | 0,22 | 1802,75 | 12693,77 | | 161,18 | 0 | 23,70 |
| 30,5 - i pow. | 0,00 | 6,10 | 0 | 11773,30 | 0,00 | 291,60 | 1573,93 | | 0,63 | 0 | 0,00 |
| *Połowy w podziale na obszary* | *706,66* | *11798,04* | | | | | *18794,13* | *1680,53* | | | |
| *Wykorzystanie kwoty w podziale na obszary (%)* | *53,21%* | *61%* | | | | | *99,8%* | *97%* | | | |
| **Połowy łącznie:** | **12504,70** | | **5277** | **80987,74** | **50,23** | **3106,46** | **20474,67** | | **11867,33** | **29647** | **4927,53** |
| ***Wykorzystanie kwoty (%)*** | ***60%*** | | ***104%*** | ***105,62%*** | ***12%*** | ***93%*** | ***99,6%*** | | **-** | **-** | **-** |

(1) Fishing quotas after international exchanges.
(2) In accordance with Commission Implementing Regulation (EU) No 323/2013 of 9 April 2013 adding to the 2013 fishing quotas certain quantities withheld in the year 2012 pursuant to Article 4(2) of Council Regulation (EC) No 847/96 - the cod quota for Poland has been increased by 2053,4 tonnes.
(3) In accordance with Commission Implementing Regulation (EU) No 770/2013 of 8 August 2013 operating deductions from fishing quotas available for certain stocks in 2013 on account of overfishing in the previous years - the herring fishing quota for Poland, decreased by 1907,02 tonnes.
(4) In accordance with Commission Regulation (EU) No 1223/2013 of 29 November 2013 providing for deduction from salmon fishing quota allocated to Poland in 2013 and subsequent years in ICES subdivisions 22-31 on account of overfishing in 2012r. - salmon fishing quota for Poland, decreased by 1776 pcs.
(5) In accordance with Commission Implementing Regulation (EU) No 1402/2013 of 19 December 2013 operating deductions from fishing quotas available for certain stocks in 2013 on account of overfishing of other stocks in the previous year and amending Implementing Regulation (EU) 770/2013 as regards amounts to be deducted in future years, the quota for cod, in subareas 22-24 of the Baltic Sea, has been reduced by 13 tonnes.

Source: Data provided by the Fisheries Department of MGMiŻŚ. Data comes from monthly reports and pages from fishing logbooks completed by fishing vessel owners. ERS - Ministry of Agriculture and Rural Development. State of ERS on 12/03/2014 (for 2013).

Table 5.5.22 Total catches and quota consumption in 2014.

| Gatunek organizmu morskiego | Dorsz (t) | | Łosoś (szt.) | Szprot (t) | Gładzica (t) | Śledź (t) | | | Stornia (t) | Troć wędrowna (szt.) | Pozostałe gatunki (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Obszar | 22-24 (1) | 25-32 (1)(2) | 22-31 (4) | 22-32 (1)(3) | 22-32 (1) | 22-24 | 25–27, 28.2, 29 i 32 | Zalew Wiślany | 22-32 | 22-32 | 22-32 |
| Ogólna kwota połowowa | 1090 | 20484 | 6484 | 62053 | 311 | 2570 | 25928 | 2157 | - | - | - |
| | 21574 | | | | | | 28085 | | | | |
| Przedział długości statków rybackich | | | | | | | | | | | |
| pon. 8 m | 0,00 | 405,22 | 153 | 1,83 | 5,39 | 3,25 | 381,30 | 563,12 | 628,12 | 10667 | 1135,42 |
| 8 - 9,99 m | 36,29 | 687,13 | 524 | 1,09 | 4,43 | 229,32 | 673,36 | 1340,46 | 486,03 | 7283 | 1949,97 |
| 10 - 11,99 m | 286,15 | 1940,56 | 420 | 16,33 | 25,05 | 419,77 | 711,45 | 20,68 | 2071,66 | 7314 | 194,33 |
| 12 - 14,99 m | 324,68 | 2538,45 | 247 | 1181,33 | 35,48 | 87,95 | 338,00 | | 5432,29 | 204 | 2455,19 |
| 15 - 18,49 m | 104,44 | 1982,33 | 1524 | 1202,00 | 8,47 | 30,28 | 462,78 | | 1910,44 | 4878 | 88,36 |
| 18,5 - 20,49 m | 85,06 | 1352,31 | 149 | 6282,20 | 4,99 | 10,03 | 1512,31 | | 883,68 | 560 | 664,94 |
| 20,5 - 25,49 m | 8,01 | 1725,87 | 91 | 12543,19 | 1,32 | 0,00 | 3710,07 | | 915,19 | 15 | 0,58 |
| 25,5 - 30,49 m | 3,12 | 415,26 | 0 | 29422,74 | 2,19 | 1502,85 | 14146,12 | | 305,14 | 0 | 473,31 |
| 30,5 - i pow. | 0,58 | 8,21 | 0 | 7937,47 | 0,92 | 30,38 | 1963,44 | | 1,41 | 0 | 22,26 |
| *Połowy w podziale na obszary* | *848,34* | *11055,35* | | | | | *23898,82* | *1924,25* | | | |
| *Wykorzystanie kwoty w podziale na obszary (%)* | *77,83%* | *54%* | | | | | *92,2%* | *89%* | | | |
| **Połowy łącznie:** | **11903,70** | | **3108** | **58588,18** | **88,24** | **2313,83** | **25823,07** | | **12633,96** | **30921** | **6984,36** |
| ***Wykorzystanie kwoty (%)*** | ***55%*** | | ***48%*** | ***94%*** | ***28%*** | ***90%*** | ***92%*** | | **-** | **-** | **-** |

(1) Fishing quotas after international exchanges.
(2) In accordance with Commission Implementing Regulation (EU) No 520/2014 of 16 May 2014 adding to the 2014 fishing quotas certain quantities withheld in the year 2013 pursuant to Article 4(2) of Council Regulation (EC) No 847/96 - the cod quota, for Poland, was increased by 1943.84 tonnes.

(3) In accordance with Commission Implementing Regulation (EU) No 871/2014 of 11 August 2014 operating deductions from fishing quotas available for certain stocks in 2014 on account of overfishing in the previous years - the sprat catch quota, for Poland, was reduced by 5,215 tonnes.
(4) In accordance with Commission Implementing Regulation (EU) No 871/2014 of 11 August 2014 operating deductions from fishing quotas available for certain stocks in 2014 on account of overfishing in the previous years - the quota for salmon, for Poland, has been reduced 216 pieces.
Source: Data provided by the Fisheries Department of MGMiŻŚ. Data comes from monthly reports and pages from fishing logbooks completed by fishing vessel owners. ERS - Ministry of Agriculture and Rural Development. State of ERS on 16/02/2015 (for 2014).

Table 5.5.23 Total catches and quota consumption in 2015 r.

| Gatunek organizmu morskiego | Dorsz (t) | | Łosoś (szt.) | Szprot (t) | Gładzica (t) | Śledź (t) | | | Stornia (t) | Troć wędrowna (szt.) | Pozostałe gatunki (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Obszar | 22-24 (1) | 25-32 (1)(2) | 22-31 | 22-32 (3) | 22-32 (1) | 22-24(1) | 25–27, 28.2, 29 i 32 (4) | Zalew Wiślany | 22-32 | 22-32 | 22-32 |
| Ogólna kwota połowowa | 1257 | 16801 | 6030 | 66171 | 311 | 2641 | 39857 | 3128 | - | - | - |
| | 18058 | | | | | | 42985 | | | | |
| Przedział długości statków rybackich | | | | | | | | | | | |
| pon. 8 m | 0,00 | 344,65 | 228 | 0,58 | 4,88 | 5,26 | 207,92 | 933,72 | 547,87 | 9330 | 1181,63 |
| 8 - 9,99 m | 29,53 | 545,50 | 465 | 0,00 | 4,57 | 295,35 | 524,57 | 1919,15 | 461,33 | 7508 | 1736,22 |
| 10 - 11,99 m | 275,01 | 2026,08 | 473 | 4,69 | 22,43 | 414,34 | 619,20 | 91,49 | 1615,97 | 9634 | 255,82 |
| 12 - 14,99 m | 260,31 | 2921,40 | 137 | 1345,17 | 83,70 | 64,58 | 655,46 | | 4197,75 | 105 | 3285,89 |
| 15 - 18,49 m | 88,10 | 2313,48 | 1751 | 1534,32 | 10,75 | 39,33 | 454,79 | | 1102,92 | 4420 | 64,93 |
| 18,5 - 20,49 m | 76,40 | 1778,19 | 614 | 7071,56 | 11,38 | 33,55 | 2671,06 | | 831,68 | 1047 | 306,43 |
| 20,5 - 25,49 m | 0,00 | 2369,07 | 64 | 13007,12 | 0,24 | 6,25 | 5025,37 | | 462,37 | 22 | 0,21 |
| 25,5 - 30,49 m | 15,34 | 544,98 | 13 | 32340,83 | 1,47 | 1748,80 | 20497,62 | | 165,78 | 0 | 633,83 |
| 30,5 - i pow. | 0,00 | 28,81 | 0 | 8868,50 | 2,62 | 34,01 | 3472,79 | | 54,93 | 0 | 11,54 |
| *Połowy w podziale na obszary* | *744,69* | *12872,16* | | | | | *34128,78* | *2944,36* | | | |
| *Wykorzystanie kwoty w podziale na obszary (%)* | *59,24%* | *76,61%* | | | | | *85,63%* | *94,14%* | | | |
| **Połowy łącznie:** | **13616,85** | | **3745** | **64172,77** | **142,04** | **2641,47** | **37073,14** | | **9440,60** | **32066** | **7476,50** |
| ***Wykorzystanie kwoty (%)*** | ***75,40%*** | | ***62,11%*** | ***96,98%*** | ***45,67%*** | ***100,02%*** | ***86,25%*** | | - | - | - |

(1) Fishing quotas after international exchanges.
(2) In accordance with Commission Implementing Regulation (EU) 2015/1170 of 16 July 2015 adding to the 2015 fishing quotas certain quantities withheld in the year 2014 pursuant to Article 4(2) of Council Regulation (EC) No 847/96 - - the cod quota for Poland, increased by 2048,384 t.
(3) In accordance with Council Regulation (EU) No 1221/2014 of 10 November 2014 fixing for 2015 the fishing opportunities for certain fish stocks and groups of fish stocks applicable in the Baltic Sea and amending Regulations (EU) No 43/2014 and (EU) No 1180/2013 - the sprat catch quota increased by 3,464,820 tonnes.
(4) In accordance with Council Regulation (EU) No 1221/2014 of 10 November 2014 fixing for 2015 the fishing opportunities for certain fish stocks and groups of fish stocks applicable in the Baltic Sea and amending Regulations (EU) No 43/2014 and (EU) No 1180/2013 - the herring quota increased by 2,261,930 t.
Source: Data provided by the Fisheries Department of MGMiŻŚ. Data comes from monthly reports and pages from fishing logbooks completed by fishing vessel owners. ERS - Ministry of Agriculture and Rural Development. State of ERS on February 15, 2016 (for 2015).

Table 5.5.24 Total catches and quota consumption in 2016 r.

| Gatunek organizmu morskiego | Dorsz (t) | | Łosoś (szt.) | Szprot (t) | Gładzica (t) | Śledź (t) | | | Stornia (t) | Troć wędrowna (szt.) | Pozostałe gatunki (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Obszar | 22-24 (1) | 25-32 (1) | 22-31 | 22-32 (2) | 22-32 (1) | 22-24 (1) | 25–27, 28.2, 29 i 32 (3) | Zalew Wiślany | 22-32 | 22-32 | 22-32 |
| Ogólna kwota połowowa | 1186 | 12076 | 6030 | 61342 | 355 | 3088 | 46321 | 3396 | - | - | - |
| | 13262 | | | | | | 49717 | | | | |
| Przedział długości statków rybackich | | | | | | | | | | | |
| pon. 8 m | 0,06 | 273,29 | 225 | 0,34 | 5,02 | 1,94 | 85,74 | 980,17 | 598,91 | 9405 | 1191,64 |
| 8 - 9,99 m | 15,27 | 423,03 | 503 | 1,02 | 4,51 | 332,33 | 322,31 | 1517,96 | 652,98 | 7646 | 1997,99 |
| 10 - 11,99 m | 230,57 | 1427,46 | 850 | 5,96 | 31,27 | 403,28 | 523,17 | 34,54 | 2487,73 | 13054 | 257,35 |
| 12 - 14,99 m | 259,47 | 2066,62 | 139 | 1346,63 | 65,40 | 250,65 | 844,78 | | 5400,91 | 1331 | 4007,79 |
| 15 - 18,49 m | 91,51 | 1868,10 | 1490 | 1141,81 | 18,08 | 37,53 | 650,75 | | 1707,19 | 9698 | 43,76 |
| 18,5 - 20,49 m | 97,88 | 1251,13 | 527 | 7028,92 | 17,05 | 53,68 | 3323,82 | | 1359,59 | 1211 | 795,72 |
| 20,5 - 25,49 m | 0,00 | 1825,30 | 19 | 12715,45 | 3,27 | 0,50 | 7813,13 | | 774,06 | 53 | 51,45 |
| 25,5 - 30,49 m | 7,08 | 483,48 | 16 | 31640,63 | 6,41 | 1729,32 | 20866,96 | | 1756,08 | 0 | 635,98 |
| 30,5 - i pow. | 1,55 | 13,15 | 0 | 6176,34 | 6,20 | 35,15 | 4248,10 | | 322,47 | 0 | 23,15 |
| *Połowy w podziale na obszary* | *703,39* | *9631,56* | | | | | *38678,76* | *2532,67* | | | |
| *Wykorzystanie kwoty w podziale na obszary (%)* | *59,31%* | *79,76%* | | | | | *83,50%* | *74,57%* | | | |
| **Połowy łącznie:** | **10334,95** | | **3769** | **60057,10** | **157,21** | **2844,38** | **41211,43** | | **15059,92** | **42398** | **9004,83** |
| ***Wykorzystanie kwoty (%)*** | ***77,93%*** | | ***62,50%*** | ***97,91%*** | ***44,28%*** | ***92,12%*** | ***82,89%*** | | - | - | - |

1. (1) Fishing quotas after international exchanges.

(2) Zgodnie z Council Regulation (EU) 2015/2072 of 17 November 2015 fixing for 2016 the fishing opportunities for certain fish stocks and groups of fish stocks applicable in the Baltic Sea and amending Regulations (EU) No 1221/2014 and (EU) 2015/104 - the sprat fishing quota increased by 1 998.048 tonnes.
(3) Zgodnie Council Regulation (EU) 2015/2072 of 17 November 2015 fixing for 2016 the fishing opportunities for certain fish stocks and groups of fish stocks applicable in the Baltic Sea and amending Regulations (EU) No 1221/2014 and (EU) 2015/104 - catch amount of herring increased by 5,911,786 t.
Source: Data provided by the Fisheries Department of MGMiŻŚ. Data comes from monthly reports and pages from fishing logbooks completed by fishing vessel owners. ERS - MGMiŻŚ. State of ERS on 03/04/2017 (for 2016).

**Processing of fish and shellfish**

Fish are an important component of human food. Their meat contains: 63-78% water, 15-20% protein, 1-30% fat, approx. 0.1% saccharides, selenium, iodine, fluorine and magnesium, B vitamins, and some fish also contain vitamins A and D.

Poland has a modern and highly-efficient fish industry. In order to increase its efficiency, fish are imported and then exported in form of prepared products. Fish are processed into consumer products, intended primarily for the domestic market and for export. The main recipients of Polish seafood and fish products are EU countries[48]

The fish industry is considered one of the fastest growing branches of the food sector in Poland. Despite the fact that Poland is not a record holder in fishing and fish farming, it is becoming an increasingly important producer of fish products. Polish fish processing industry is one of the best in Europe and has great prospects for development, especially on the absorbing European market. Three species of fish predominate in Polish fish processing industry: herring used for canning, marinades and smoking; sprat and mackerel for smoking and canning. [49]

***Maritime and coastal tourism***

Tourism is an important domain of the Polish economy, and the tourism industry is one of the key elements of the development of coastal regions. Seaside stay is the most common purpose of long-term holiday trips in Poland. According to the Institute of Tourism forecasts, domestic traffic will increase in the coming years, both in the area of short-term arrivals and long-term visits.

Activation in the field of tourism contributes to economic growth, improvement of infrastructure, reduction of unemployment, as well as intensification of international contacts, especially with the countries of the Baltic Sea region.

Maritime tourism is a tourist activity based on specific resources of the sea. There are usually two main forms of tourism related to the sea. These are:

1) maritime tourism - activity on the open sea, on cruise ships (cruisers), passenger liners, yachts (ocean sailing - tourism) or ferries. Examples of activities related to maritime tourism are: pleasure cruises, sea fishing, diving in the sea, sailing, water paragliding, sport sailing.
2) coastal tourism - all forms of activities undertaken in the coastal area, i.e. white navigation (on coastal vessels), sailing, windsurfing, kitesurfing, ice sailing, canoeing, diving, fishing, etc.

Another criterion that can differentiate tourism is the form of activity. It is possible to distinguish qualified tourism, i.e. all water sports and leisure tourism, which includes, among others, sea baths, passenger cruises, etc.

The advantages of coastal areas in Poland are both large port centers and smaller, local ports and harbors located in towns of key tourist importance (e.g. Gdańsk, Gdynia, Hel, Jastarnia, Łeba, Ustka, and Świnoujście). In Poland, due to the 560 km coastline and its historical and cultural heritage, coastal tourism is developing rapidly. Its characteristic descriptor is seasonality, as it takes place within approx. 60-90 days a year. The reason for this are weather and climatic conditions. Sea space is used primarily for activities such as sailing, windsurfing, kitesurfing, wreck diving and recreational fishing. Other forms of tourism that use the sea space are: underwater tourism (artificial coral reefs), paragliding (behind a motorboat or from cliffs),

[48] „Ryby i ich przetwórstwo w Polsce na początku XXI wieku", Kapusta F. 2011
[49] „Przetwórstwo ryb w Polsce – szanse i zagrożenia", Bykowski P., 2010

canoeing (usually in closed water bodies), or fishing (from fishing boat and from the shore). In Poland, the ferry industry is also developing due to the variety of recreational cruises.

The development of tourism is of great importance for local coastal governments in which tourism is developed. In coastal towns, numerous hotels, guesthouses, private lodgings, campsites, etc. are created. The tourist accommodation base mainly focuses on the areas of municipalities that have a maritime border, i.e. they are located directly on the Baltic Sea or over 50% of the commune's area is in the distance not more than 10 km from the sea. These include municipalities located in the following voivoodships: Pomeranian, Warmian-Masurian and West Pomeranian. EUROSTAT also considers coastal communes: Słupsk, Główczyce, Gniewin, Pruszcz Gdański, Cedry Wielkie, Koszalin and Sianów. In the statistics of the European Union, Szczecin is not considered as a seaside region, however, in GUS statistics, it is taken into account due to its location at marine internal waters and close linkage with the sea.

It should also be emphasized that the GUS in the study of tourist accommodation establishments identifies the following types of facilities examined by the institution: a hotel, motel, guest house, other hotel facilities (e.g. hotel facility, motel or guesthouse, which has not been assigned a category), a hostel, youth hostel, school and youth hostel, excursion house, holiday resort, training and holiday center, camp center, creative work house, tourist house complex, hostel, camping, campsite, spa facility, guest room (private accommodation), agro tourism lodging, other unclassified facilities (facilities that, when not fully used in accordance with their purpose or in part, function as an accommodation facility for tourists, including dormitories, student houses, recreation and sports centers, etc.). The data on the number of facilities and beds presented in the tables below cover all facilities open on July 31 and facilities closed on that day, but open on other days of the month under review. The maximum number of rooms has been adopted for them. Intermission breaks, due to renovation, disinfection, etc. are not included in the calculation of the number of days of activity of the facilities.[50]

Table 5.5.25 Tourist spots and accommodation in coastal areas

| Specification | | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|
| coastal areas | tourist spots | 2 227 | 2 277 | 2 303 | 2 427 |
| | accommodations | 184 437 | 187 722 | 190 271 | 202 716 |
| Pomeranian Voivodeship | tourist spots | 1 102 | 1 122 | 1 171 | 1 253 |
| | accommodations | 73 661 | 75 945 | 79 908 | 88 045 |
| Warmian-Masurian Voivodeship | tourist spots | 27 | 29 | 27 | 30 |
| | accommodations | 1 702 | 1 871 | 1 678 | 1 888 |
| West Pomeranian Voivodeship | tourist spots | 1 098 | 1 126 | 1 105 | 1 144 |
| | accommodations | 109 074 | 109 906 | 108 685 | 112 783 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2014. GUS" for 2013, table 11.1, "Statistical Yearbook of Maritime Economy 2015. CSGUSO" for 2014, table 11.1, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2015 ,. Table 11.1 and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2016, table 11.1. No statistical data for previous years.

Accommodation base in coastal area is constantly growing. In 2016, 2 427 accommodation facilities with nearly 203,000 beds were available in the Pomeranian, Warmian-Masurian and West Pomeranian Voivodeships. This is an increase of 9% compared to 2013.

Table 5.5.26 Tourists using tourist accommodation facilities have coastal areas (in thousands)

| Specification | | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|
| coastal areas | tourists | 3 165.8 | 3 834.0 | 4 141.9 | 4 513.0 |

[50] „Statistical Yearbook of Maritime Economy 2017". GUS, Warsaw, 2017

| | | | | | |
|---|---|---|---|---|---|
| | including foreigners | 728.7 | 931.3 | 982.8 | 1 090.6 |
| Pomeranian Voivodeship | tourists | 1 590.3 | 1 767.1 | 1 965.1 | 2 145.4 |
| | including foreigners | 348.4 | 395.5 | 417.7 | 467.4 |
| Warmian-Masurian Voivodeship | tourists | 74.1 | 80.4 | 84.6 | 103.5 |
| | including foreigners | 22.2 | 23.2 | 21.7 | 23.3 |
| West Pomeranian Voivodeship | tourists | 1 501.4 | 1 986.5 | 2 092.1 | 2 264.2 |
| | including foreigners | 358.1 | 512.6 | 543.5 | 600.0 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2014. GUS" for 2013, table 11.2, "Statistical Yearbook of Maritime Economy 2015. GUS" for 2014, table 11.1, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2015 ,. Table 11.1 and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2016, table 11.1. No statistical data for previous years.

The number of tourists visiting coastal regions increases year by year. This applies to both domestic and foreign tourists. In 2016, over 4.5 million tourists benefited from tourist accommodation facilities, i.e. 42% more than in 2013. Foreign tourists accounted for 24.2% of tourists using seaside accommodation facilities in 2016. According to the data published in the study by GUS "Maritime economy in Poland in 2015-2016" the largest group of foreign tourists in 2016 came from Germany (612.6 thousand), then from Norway (90 thousand), Sweden (64.7 thousand) and from Great Britain (40.1 thousand).

Table 5.5.27 Passenger traffic in ports of primary importance for the national economy (in thousands)

| Specification | | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|
| POLAND | total | 2201.1 | 2224.1 | 2421.3 | 2601.7 |
| | ferries | 1413.6 | 1482.3 | 1679.7 | 1749.0 |
| | passenger ships | 773.4 | 635.7 | 739.5 | 850.3 |
| Gdańsk | total | 212.6 | 188.3 | 200.1 | 228.4 |
| | ferries | 125.6 | 121.0 | 107.7 | 103.5 |
| | passenger ships | 86.9 | 67.1 | 92.1 | 124.8 |
| Gdynia | total | 608.4 | 662.5 | 709.2 | 733.4 |
| | ferries | 499.4 | 566.8 | 599.4 | 607.1 |
| | passenger ships | 98.4 | 94.4 | 108.9 | 125.0 |
| Szczecin | total | 23.0 | 1.5 | 1.3 | 0.9 |
| | ferries | – | – | – | – |
| | passenger ships | 22.9 | 1.5 | 1.2 | 0.8 |
| Świnoujście | total | 888.6 | 970.6 | 1047.1 | 1116.6 |
| | ferries | 788.7 | 794.5 | 972.5 | 1038.3 |
| | passenger ships | 99.9 | 72.5 | 74.5 | 78.2 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2014. GUS" for 2013, table 11.8, "Statistical Yearbook of Maritime Economy 2015. GUS" for 2014, table 11.7, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2015 ,. Table 11.7 and "Statistical Yearbook of Maritime Economy 2017" GUS "for 2016, table 11.7. No statistical data for previous years.

In terms of the number of passengers visiting Poland by sea, the largest traffic in 2016 was observed in the port of Świnoujście. In comparison to 2013, the number of passengers arriving to this port increased by 25.6%. The second port most frequently visited by passengers was the port of Gdynia (733 409 people).

The international passenger movement of relations with Polish seaports almost entirely concentrates on European reach. In 2016, passengers departing or arriving at Polish seaports mainly started or finished their trip in Sweden at the port of Ystad.[51]

When describing tourism and recreation, it is necessary to indicate tasks related to public health protection implemented by the State Sanitary Inspection. These include activities in the field of:

1) sanitary supervision of vessels calling at subordinate ports and preparations for issuing ShipSanitation Control Exemption Certificate/Ship Sanitation Control;
2) sanitary supervision of ports, harbors, vessels, passenger traffic;
3) supervision of disinfection, desinfestation and deratization procedures performed on the premises of port facilities and on ships;
4) performance of duties resulting from international health regulations and international conventions ratified by Poland, including the implementation of protective vaccinations required in international traffic;
5) control, prevention and surveillance of infectious diseases intrduced with marine traffic, conducting interviews and epidemiological investigations;
6) cooperation in organizing and directing the sanitary action in the emergency of mass threat states and emergency states in the territorial waters;
7) supervising the sanitary condition of public facilities with particular emphasis on seaports, sea border crossings and sea and inland waterway harbors;
8) supervision over the quality of water intended for human consumption in means of marine transport;
9) participation in the admission for use of marine vessels;
10) agreeing or reviewing the design documentation in terms of hygiene and health requirements for the construction and change in the use of marine vessels.

Local governments achieve goals in the field of development of maritime and seaside tourism by creating favorable conditions for recreation and places of safe bathing for tourists and people relaxing along the entire coast. Such places are the bath sites designated each year by resolutions of the municipal council. The organizers of bathing areas, self-government bodies, organs of the State Sanitary Inspection, are responsible for protecting the society against the potential occurrence of both accidental and long-term contaminants that may affect water quality and bathing conditions. Quality of bathing water in terms of parameters resulting from Directive 2006/7 / WE of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160 / WE (O.J. L 64/04/04) .2006, p. 37, as amended), is assessed by the State Sanitary Inspection. The conducted water quality tests include microbiological parameters that prove faecal contamination of water, i.e. Escherichia coli and enterococcus, and which cause a health risk for bathing people. In addition, during the bathing season, a visual assessment of water is carried out with particular reference to the production of macroalgae or marine phytoplankton, cyanobacteria blooms and the presence of other solid contaminants that may have a negative impact on the health of people.

Every year, in order to ensure the active dissemination of up-to-date information concerning the quality of bathing water and available bathing infrastructure, GIS in accordance with the provisions of Article 347 para. 3 of the Water Law Act runs the bathing service. It

[51] „Maritime economy in Poland in 2015-2016", GUS, Warsaw-Szczecin, 2017

contains information on the quality of water, in municipal councils approved by resolutions, bathing areas along with spatial visualization of the above data. The bathing service (http: //sk.gis.gov.pl/) functions as an application that allows fast and multilateral exchange of information on the quality of bathing water during the bathing season. It contains the following information: address of the bathing establishment, indication of the proper sanitary and epidemiological station supervising a given bathing site, data on the organizer, bathing infrastructure, the current assessment of water quality performed by the State District Sanitary Inspector to determine its suitability for bathing. The bathing service also contains the category "Programs and distinctions" according to the commonly accepted definition, for example Blue Flag. The second category is "Infrastructure", which includes information on wheter the bathing site provides, among others: designated swimming zone, designated beach zone for recreation and sport, platform, access to water outlet with sewage disposal, adaptation for the disabled people, trash can, toilet, shower. The third category is "Safety", which includes information on whether there is a mast with the WOPR flag in the bathing area, a special place for bathing for children, a ban on introducing pets, a lifeguard, bathing rules, regulations. The new bathing service was welcomed mainly by people planning a trip to the Baltic Sea in summer. It has an impact on the development of tourism in towns that have bathing sites. It also contributes to improving the health safety of bathers or sports and recreation.

The bathing service is popular between people planning a summer trip to the Baltic Sea and it has undoubtedly an impact on the development of tourism in the towns that have bathing sites, as well as contributing to the health safety of people using bathing sites.[52]

***Marine mining industry***

The geological surveys conducted in the Polish zone of the Baltic Sea so far have shown the existence of oil deposit and natural gas fields, construction aggregates and amber. Four areas have been documented with significant resources of gravel and coarse sands. According to the Polish Geological Institute, these are the Słupsk Bank, Middle South Bank, Koszalińska Bay and Oder Bank. Potentially there are also shale gas resources estimated only jointly for sea and land areas. There are no estimates for marine areas only. Oil production from the Baltic Sea currently accounts for only about 2% of Poland's annual demand. Two documented oil deposits located on the Baltic shelf account for approx. 20% of national resources. In many fields, crude oil occurs with natural gas. In addition, it is estimated that iron and manganese concretions occur at the bottom of the Baltic Sea, the resources of which constitute approx. 100 million tonnes.

**Petroleum**

Documented oil deposits on the Baltic shelf account for approx. 20% of national resources. In many areas, crude oil occurs jointly with natural gas. Further growth of natural gas and oil production in POM should be expected. The strategy of LOTOS "Petrobaltic" assumes the allocation of 52% of the Investment Program funds for exploration of crude oil, the majority of which (73%) in the Baltic Sea basin. In September 2015, production from the second deposit - B8 was launched. There is another, the second co-gas transmission pipeline under construction that will connect the oil rig on the B8 field with the heat and power plant Energobaltic Sp. z o.o. in Władysławowo. In 2020, the company's own output will reach the level of 5 million tonnes of oil. There will be new production centers along with security zones, which will be closed for shipping and fishing. It will be connected with land by submarine installations, which will cause restrictions in the use of the bottom resources. On Gaz Południe license, reconnaissance works are at an advanced stage. If the deposit is documented, mining operations may potentialy begin within 10 years. The remaining concession areas are at the initial stages of exploration and recognition or preparation for exploration. In these cases, the time horizon of potential mining is 20-30 years. The total area of exploration and appraisal concessions is over 8.5 thousand km$^2$. Considering the potential extraction from the areas on which exploration is currently underway,

[52] Report on the implementation of the maritime policy of the Republic of Poland in 2016, Warsaw 2017

it is necessary to assume that the functions of laying and maintaining underwater pipelines in these areas will be accepted.[53]

**Natural gas**

In the Polish Exclusive Economic Zone, 4 good quality natural gas fields (70-95% of methane) were identified. Prospects for the discovery of new gas deposits are estimated at around 100 billion $m^3$. Natural gas occurs alone in the B4 and B6 fields and together with crude oil in the B3 and B8 fields. It is estimated that natural gas resources on the Baltic shelf account for 4% of national resources. Currently, licenses for exploration and production of natural gas from the bottom of the Baltic Sea are held by LOTOS Petrobaltic S.A. and BalticGas Sp. z o.o.

**Aggregates**

The deposits of raw material for the production of natural aggregates occur mainly in the waterside and coastal zones, within the banks and shore embankments. These are mainly raw material deposits for the production of gravel aggregates. In the case of deposits of natural aggregates, such as sands and gravels lying at a depth of up to 100 m, exploitation is economically viable, as evidenced by numerous examples of European countries carrying out this kind of mining activity.

In the area of the Baltic Sea, three gravel-sand aggregate deposits with a resources of 147.983 thousand tonnes have been documented on the total area of the fields amounting to 70.8 $km^2$. They include:

1) Middle South Bank - the deposit is divided into 9 fields with an area of 0.5 to 16.9 $km^2$ (a total of approx. 26 $km^2$), with an average thickness of the layer of 0.9 m (maximum> 5 m);
2) Słupsk Bank - the deposit constitutes 8 isolated fields of sand-gravel sediments deposited on a sandy substrate or in the western part on washed-up till clay. The area of fields is from 0.9 to 10.5 $km^2$ (altogether approx. 21.45 $km^2$), with an average thickness of layer of approx. 0.91 m (maximum> 2 m);
3) Koszalin Bay - the deposit is located within the Koszalin Bay, at the level from Dąbki to Jarosławiec, in the sea zone from 10 to 25 m deep and includes 17 fields in the form of isolated layers of sand and gravel deposits on a sandy substrate and on boulder clay.

The exploitation of solid raw materials from the seabed does not require the construction of permanent marine constructions, the extraction takes place from ships and is carried out only in a sub-surface manner.

The exploitation of solid raw materials from the seabed is associated with: loosening, mining, transport and unloading of raw materials. Loosening means reducing the cohesion of the rock bed. Mining is separating a portion of material from the undisturbed soil. In some cases, these processes may occur simultaneously, e.g. when mining with excavators, where the shovel (scraper, scoop bucket, grab) loosens and mines the material. Mechanical strength (cutting, shearing, bending), hydraulic energy, rock crushing (mechanical), vibrations as well as explosives can be used for loosening. Similar processes are used for mining (mechanical, hydraulic, gravity, centrifugal forces). However, the most difficult task is transporting (mechanical or hydraulic) material to the surface. Suction excavators fitted with scraper baskets are best suited for use in marine environment. Such units can exploit deposits at a depth of over 100 meters and can take up to 40,000 tonnes of load at a time. For the exploitation of deep-sea deposits, the following methods are usually used: Continuous Line Buckets CLB, Hydraulic Pumping or Air Lift Pumping. For the exploitation of shallow water resources, it is possible to use suction excavators with a Cutter Suction Dredgers CSD, Suction Dredgers SD, Trailing Hopper Suction Dredgers THSD and Bucked Dredgers BD. The unloading of aggregate takes place through the use of special unloading machines, or through the excavator itself. Excavators

[53] http://www.lotos.pl/322/p,174,n,4566/grupa_kapitalowa/centrum_prasowe/aktualnosci/lotos_2017-22_stabilizacja_i_bezpieczny_rozwoj

are sometimes equipped with a hydraulic unloading system allowing direct delivery of material to the pipeline on the wharf. In the case of suction and multiwell excavators, material is transported by water or underwater pipelines, barges, screes, or floating conveyor belts (mainly in closed waters).

In the case of exploitation of the seabed, impacts can be divided into the impact on the biological and physical domains of the natural environment. Interference with the biological domain is related to the distribution of sediment deposits on the seafloor, as a result of which release of any contaminants contained in the sediment may occur. In this situation, the quality of the water decreases, which may result in an impact on the fauna and flora. The impact of extraction of aggregates from the sea on the environment is also associated with lowering of the seafloor. The scope and extent of the adverse impact on the biological communities, which consists in the degradation of the biological area of exploitation, depends on the type of organisms living in the impact area, the type of sediment or the season of the year. Physical impact on the environment is associated primarily with the disruption of the coastal life cycle (movement of waves, tides, etc.) and may lead to an accelerated erosion of the coastline. In a situation when the planned exploitation concerns an sensitive environment, then the operation process must be monitored and adapted to environmental conditions, which necessitates the selection of the appropriate thickness and length of the treated layers and in the case of suction and milling dredgers, mining units height, head speed, power and pump pressure etc.[54]

**Baltic amber**

Baltic amber occurs mainly along the southern shores of the Baltic Sea. Amber heaps in the shallow and coastal belts of the Baltic are of character Pleistocene and Holocene accumulations in post-glacial coastal areas and do not show regularity in distribution, concentration and quality.

In Poland, Baltic amber occurs in the following fields:

- ✓ in the vicinity of the Gulf of Gdańsk, the Vistula Spit, at the base of the Hel Peninsula;
- ✓ in post-glacial sediments, including so-called incidental inclusions (e.g. the former amber mine in Możdżanów near Słupsk);
- ✓ near Lubartów;
- ✓ in Kurpie.

***Municipal sector***

The municipal sector, through the volume of pollutants discharged into the Baltic Sea, affects its condition and assossiated ecosystems. In Poland, for many years, the number of people using the water supply and sewage system and sewage treatment has been increasing, and the volume of discharged loads is gradually decreasing.

Table 5.5.28 Length of sewerage system in thous. km (status on 31 December each year)

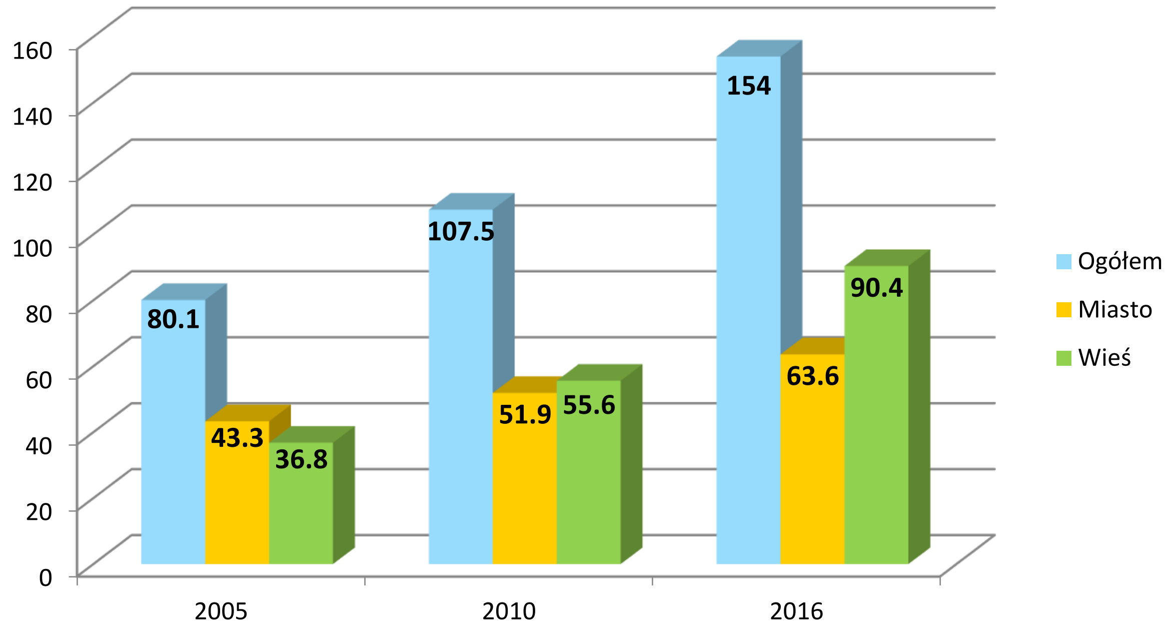
| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| sewerage system | 117,7 | 125,6 | 132,9 | 142,9 | 149,7 | 154,0 |

Source: Own study based on "Municipal infrastructure in 2016", GUS, 2017

In the light of data from GUS published in the "Municipal infrastructure in 2016" in the period 2005-2016, the length of the sewerage system increased by 92.2%. In 2011, the length of the sewerage system was nearly 118 thousand km, while in 2016, 155,000 km. Sewerage system growth was greater in rural areas than in cities.

[54] Kawalec P., Kozioł W., Machniak Ł., *Eksploatacja kruszyw naturalnych ze złóż dna morskiego i jej oddziaływanie na środowisko.* Katedra Górnictwa Odkrywkowego, Wydział Górnictwa i Geoinżynierii AGH Kraków
Kozioł W., Ciepliński A., Goleniewska J., Machniak Ł., *Eksploatacja kruszyw z obszarów morskich w Polsce i Unii Europejskiej.* Górnictwo i Geoinżynieria, Rok 35, Zeszyt 4/1., 2011

Compared with 2015, the length of the sewerage system in rural areas in 2016 increased by over 2.8 thousand km, while in the same period, in cities above1.5 thousand km of sewerage system was build.[55] The above data is of particular importance in the context of achieving environmental targets, and above all for Descriptor D5 eutrophication.




Data source: Municipal infrastructure in 2016, GUS, Warsaw 2017

Fig. 5.5.2. The length of the active sewerage system for the spaces of 2005, 2010, 2016 (in thousand km). Colours: blue – total, yellow – city, green – countryside.

With the development of water supply and sewage infrastructure, in the last eleven years the number of people using the abovementioned system has also increased. There is a noticeable decrease in the amount of water consumed per 1 inhabitant. Increased water saving by households is the result of changes in water prices and widespread metering of water consumption. In addition, the decrease in water consumption is caused by the reduction of water losses from the system as a result of the modernization of existing system. In the light of the report of GUS, "Municipal infrastructure in 2016" the percentage of people using the sewerage system in the period 2005-2016 increased from 59.2% to 70.2%. In cities 90% of the population used system, and 40.3% in rural areas. In the case of areas with insufficiently developed sewerage infrastructure, home sewage systems are still being used. Household sewage treatment plants, or septic tanks (cesspools) are still, and probably will be, a cheaper alternative to the construction of a sewage system that drains sewage to a sewage treatment plant. In Poland, in 2016, there were 2,333,000 such devices, of which about 91% were septic tanks. For several years, a systematic decrease in the number of septic tanks has been observed, while the number of household sewage treatment plants is increasing. The number of septic tanks decreased from about 2,359 thousand in 2011 to 2 117 thousand in 2016, while the number of household sewage treatment plants increased from around 103 thousand in 2011 to about 217,000 in 2016, almost 86% of household litter disposal facilities were located in rural areas (about 85% of all septic tanks and about 92% of the total number of household sewage treatment plants).

Liquid litter, in areas not connected to the collective sewage system, was collected from owners of septic tanks and delivered to sewage treatment plants or catchment stations.[56]

[55] Municipal infrastructure in 2016, GUS, 2017,

[56] Municipal infrastructure in 2016, GUS, 2017

The source of water pollution may also be the lack of proper collection and treatment systems for domestic wastewater. At the beginning of the 21st century, only 11.5% of residents used the sewage system in the countryside, and in 2005, every fifth person had access to the system, and according to the latest GUS data in 2016, as much as 40.3% of the rural population was connected to the sewage system.[57]

The implementation of Council Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment (O.J. WE L 135, 30/05/1991, p. 40, as amended - Journal of the EU, Polish Special Edition, Chapter 15, Volume 2, page 26), so-called "wastewater" directive is of major importance for the improvement of the state of the Baltic Sea. The basic instrument for implementing the provisions of the abovementioned directive is KPOŚK. The purpose of KPOŚK is to reduce discharges of insufficiently treated wastewater. The result of this limitation may be the protection of the aquatic environment, including the waters of the Baltic Sea. The goal of KPOŚK will be achieved by implementing the investments included, assuming that it will be subject to periodic updates. The KPOŚK update for 2017 contains a list of agglomerations of the size measured by the equivalent number of inhabitants for RLM larger than 2000 and planned investments concerning their equipment in collective sewage systems in 2016 - 2021 and concerns 1585 agglomerations with a total of 39 million RLM, in which 1769 municipal wastewater treatment plants are located. The agglomerations were divided into three priorities according to the importance of the investment and the urgency of providing funds. In addition, the so-called agglomerations outside the priority, which do not qualify for the population covered by the sewage directive, but which plan to undertake investment activities that bring them closer to meeting the requirements were also included. The investment intentions presented by the agglomerations show that 112 new sewage treatment plants are planned to be built as part of KPOŚK update carried out in 2017. It is also planned to build 14 185,9 km of a new sewerage system and to modernize 3 406.6 km of the system. After the completion of all RLM investments using the sewage system, it will cover 97.2% of all RLM. The planned costs of the above projects amount to PLN 27.01 billion. In agglomerations included in KPOŚK, as expected, nearly 100% level of RLM service should be achieved using the sewage system, assuming that remaining inhabitants of the agglomeration will use other sewage treatment systems. This means that the entire load pollution generated in the agglomeration should be supplied to a treatment plant servicing the agglomeration or removed in other sewage treatment systems, providing the same level of environmental protection.[58]

***Agriculture***

Agriculture is an important sector of the Polish economy. This is confirmed mainly in the structure of land use and the structure of employment of the population. The total area of Poland is mainly used for agricultural purposes (51.7%), and forest and arboreous areas constitute a large share (29.6%). Agricultural land consists of arable land (75%), permanent pasture (20%), orchards (2%) and other lands (3%). By farming on over half of the total area of the country, agriculture determines the main functions and directions of land use and shapes natural environment and landscape. The purity of water, air and soil and the diversity of plant and animal species depend largely on the agricultural economy. Thanks to the preservation of traditional forms of extensive farming, local varieties of arable crops and local livestock breeds have survived. Gross value added to the economy by this sector is on average around 3.5% of PKB (Gross domestic product). This sector is a source of livelihood for a large part of the Polish population. The structure of land use in individual provinces depends on the quality of soils, their suitability, the type of water in the soil and the terrain. The area of agricultural land is 46.5% the total area of the country and is about 14 545.27 thousand ha, and the area of agricultural land maintained in good agricultural culture is approx. 14,398.21 thousand ha. On the other hand, permanent grasslands account for 10% and long-term crops for 1.3% of area of

[57] „Municipal infrastructure in 2011", GUS. Warsaw, 2012 and "Municipal infrastructure in 2016", GUS, Warsaw, 2017

[58] http://www.kzgw.gov.pl/index.php/pl/materialy-informacyjne/programy/krajowy-program-oczyszczania-sciekow-komunalnych

Poland. In Poland, the number of farms in June 2016 was 1,411 million, of which as much as 97% (about 1,407 million) are individual farms. In the total number of farms, 54% are farms operating on the area of 1 to 5 ha of agricultural land. Large farms with an area of 5 to 50 ha of agricultural land - account for 44% of all farms, while the largest, over 50-hectare, constitute only 2%[59]

Modern agriculture often uses "industrial" methods for production, on one hand it brings greater economic benefits than traditional agriculture, on the other, there is a number of various threats. Therefore, EU agricultural policy provides for the development of the so-called sustainable agriculture, focused on the use of land resources that does not destroy their natural sources, but allows to meet the basic needs of subsequent generations of producers and consumers. Therefore, we call sustainable farming the effective production of safe, high-quality food in a way that protects, or even improves the natural environment, social and economic conditions of the farmer's existence and employees on the farm as well as local communities. Sustainable agriculture has therefore, to promote a sustainable management system, which consists in the rational use of natural resources, which allows for reducing the negative impact of agriculture on the environment and prevents the loss of organic matter in the soil.

The basic principles of sustainable agriculture are:

1) care for soil which is the main mean of production for farmers, i.e. preventing erosion regular soil analysis, improving its productivity;
2) application of fertilization, in accordance with the plan developed for a given farm
3) compliance with the principles of integrated agricultural production;
4) supporting local social initiatives;
5) developing of competences, sharing of knowledge and experience with others
6) compliance with the basic principles of health and safety at the farm;
7) understanding and care for the farm financial accounts.

In addition to the development of sustainable agriculture in Poland, it is also necessary to point out the great popularity of organic farming, which is defined as a management system with sustainable crop and animal production. Organic production combines environmentally friendly management practices, supports a high degree of biodiversity, uses natural processes and ensures proper animal welfare. It is a system that positively influences the natural environment, which contributes to achieving broadly understood agri-environmental benefits. Currently, the share of organic area in Poland is about 4% of the total area of farms in the country. According to the available data as part of EUROSTAT, in 2012 Poland was ranked 3rd in the EU in terms of the number of organic farms. The area used in accordance with the regulations on organic farming in 2013 amounted to nearly 675 thousand ha. This means a 2% increase in relation to 2012. In 2013, the number of organic farms was 26,598, of which the largest number of organic farms was in Warmian-Masurian Voivodeship (4,235), West Pomeranian Voivodeship (3640) and Podlaskie Voivodeship (3407). The requirements of both sustainable and ecological agriculture focus on the rational use of both fertilizers and plant protection products.[60]

Particular importance in the context of the implementation of environmental targets, and above all for the Descriptor C5 eutrophication have compounds of nitrogen and phosphorus getting into the waters. Agricultural compounds that can enter water are nitrates and phosphates. One of sources of emissions of these compounds may be the use of fertilizers. In the situation when fertilizers are not taken up by plants, nitrogen (ammonium and nitrate) and phosphates enter the surface waters (and then into the Baltic Sea). Part of the ammonium nitrogen is released into the atmosphere or partially undergoes nitrification to form nitrate nitrogen, which can be washed out of the soil profile into groundwater and then transported to surface waters. The scale of use of mineral or natural fertilizers decreased slightly or remained stable. On a national scale, the balance of gross nitrogen balance in the years 2012-2014 amounted to approximately 47.6 kgN/ha. Consumption of mineral fertilizers in the 2014/2015

[59] „Characteristics of agricultural holdings in 2016", GUS, Warsaw, 2017

[60] www.minrol.gov.pl

marketing year in the pure component per 1 ha agricultural land amounted to 123.2 kg and was 7.3% lower than in the previous marketing year, of which 69.0 kg of nitrogen fertilizers were used (by 8.6% less than last year), phosphorus - 20.9 kg (by 10.7% less) and potassium 33.3 kg (2.3% less). Manure consumption in the marketing year 2015/2016 reached 49.9 million tonnes, which in terms of pure component (NPK) gave the value of over 42 kgNPK/ha of agricultural land in good culture.

In addition to the level of fertilization and yield, one of the most important factors determining the nature of plant production is the sow stucture. It determines not only the production and economic effects, but also significantly affects the quality status of the water and soil environment. The crop production in Poland is dominated by grains, the area of which currently amounts to approx. 7,512 thousand ha, which constitutes approx. 72% of the total sown area. The potato and sugar beet cultivation area is also decreasing, which in 2015 was respectively 300,000 ha and 180 thousand ha. The reduction in the area of potato cultivation is associated with changes in the animal nutrition system.

Over the past 20 years, significant and multi-directional changes have occurred in animal production in Poland. Fluctuations in the number of livestock and livestock production are observed. The pace of these changes is different in individual provinces. After Poland's accession to the EU, the number of cows increased mainly in the voivodeships with the largest stock of cattle, while the pig population significantly fell in all voivodeships outside Wielkopolskie Voivodeship. Rearing or breeding livestock may be another source of environmental pollution. The feeds used to farm animals include nitrogen and phosphorus compounds. Since these compounds, are not completely used by animals they become part of natural fertilizers. The use of nitrogen and phosphorus from feed (and therefore the amount of nutrients excreted in manure) in animal production is influenced by many factors resulting from the composition of the fed feed dose. Nitrogen is excreted to a greater extent in the feces when the food dose contains too much of the protein in general relative to the animals needs or when the protein has a low biological value. The reduction in the share of total protein and the addition of synthetic exogenous amino acids (in particular, limiting amino acids) is crucial in reducing the amount of nitrogen excreted. The amount of protein in the diet must be adapted to the needs of animals in a given phase of the production cycle, so as not to overfeed them with proteins that will not be used. An inappropriate way of feeding animals can therefore adversely increase the emission of nitrogen and phosphorus compounds to the environment. It is therefore necessary to provide animals with a balanced food dose that complies with the nutritional norm. A more and more widely used method of reducing the amount of phosphorus excreted by monogastric animals is the addition of exogenous (not emitted by organisms) phytases.

Harmful substances from agriculture that can reach the water and then the Baltic Sea are also chloroorganic pesticides or polycyclic aromatic hydrocarbons. According to GUS data, the consumption of plant protection products in 2015 amounted to 24 thousand tonnes. However, increasing the consumption of pesticides does not mean an increase of negative impacts on the environment. Increasing legal requirements force the withdrawal of the most dangerous substances from the market (e.g. chloroorganic pesticides), eliminating the use of persistent or hardly biodegradable, carcinogenic substances, for substances that are degraded quickly in the environment, causing their activity to be limited. to a specific time and area in which it was applied.[61]

Table 5.5.29 The outflow of organic and biogenic substances by rivers to the Baltic Sea by voivodships

| SPECIFICATION | $BZT_5$ | Total nitrogen | nitrates | organic nitrogen | Total phosphorus | phosphates |
|---|---|---|---|---|---|---|
| | in thousand tonnes/year | | | | | |

[61] „Środki produkcji w rolnictwie w roku gospodarczym 2014/2015", GUS, Warszawa, 2016 oraz „Środki produkcji w rolnictwie w roku gospodarczym 2015/2016", GUS, Warszawa, 2017

| SPECIFICATION | | $BZT_5$ | Total nitrogen | nitrates | organic nitrogen | Total phosphorus | phosphates |
|---|---|---|---|---|---|---|---|
| | | in thousand tonnes/year | | | | | |
| TOTAL | 2011 | 170.4 | 191.8 | 112.6 | 70.4 | 10.4 | 3.8 |
| | 2012 | 109.8 | 103.4 | 51.8 | 45.4 | 6.7 | 3.2 |
| | 2013 | 149.3 | 170.3 | 100.7 | 62.9 | 10.5 | 3.4 |
| | 2014 | 108.0 | 112.8 | 64.7 | 44.5 | 10.8 | 3.5 |
| | 2015 | 88.2 | 76.6 | 47.1 | 27.0 | 4.8 | 1.6 |
| Pomeranian Voivodeship | 2011 | no data | no data | no data | no data | no data | no data |
| | 2012 | 57.4 | 49.9 | 24.4 | 23.4 | 4.0 | 2.6 |
| | 2013 | 89.5 | 99.0 | 54.5 | 40.2 | 6.2 | 2.5 |
| | 2014 | 65.0 | 67.2 | 36.8 | 28.1 | 8.1 | 2.9 |
| | 2015 | 55.3 | 42.7 | 26.6 | 14.2 | 2.9 | 1.1 |
| Warmian-Masurian Voivodeship | 2011 | no data | no data | no data | no data | no data | no data |
| | 2012 | 1.3 | 1.5 | 0.5 | 0.9 | 0.1 | 0 |
| | 2013 | 1.4 | 1.3 | 0.5 | 0.5 | 0.1 | 0 |
| | 2014 | 0.8 | 0.9 | 0.3 | 0.5 | 0.1 | 0 |
| | 2015 | 0.7 | 1.3 | 0.5 | 1.3 | 0.1 | 0 |
| West Pomeranian Voivodeship | 2011 | no data | no data | no data | no data | no data | no data |
| | 2012 | 51.1 | 52.0 | 26.9 | 21.1 | 2.6 | 0.6 |
| | 2013 | 58.5 | 70.2 | 45.6 | 22.2 | 4.3 | 0.9 |
| | 2014 | 42.2 | 44.6 | 27.5 | 15.9 | 2.6 | 0.6 |
| | 2015 | 32.3 | 32.6 | 20.0 | 11.5 | 1.8 | 0.4 |

Source: Own elaboration based on "Statistical Yearbook of Maritime Economy 2015. GUS" table 10.3, "Statistical Yearbook of Maritime Economy 2016. GUS" table 10.3 and "Statistical Yearbook of Maritime Economy 2017. GUS" table 10.3

Table 5.5.30 Consumption of mineral fertilizers (calculated as pure component)

| Year | total | nitrogen | phosphate | potassium |
|---|---|---|---|---|
| 2010/11 | 1 683.8 | 928.2 | 363.6 | 392.0 |
| 2011/12 | 1 625.6 | 938.1 | 330.4 | 357.1 |
| 2012/13 | 1 679.2 | 1 015.6 | 326.4 | 337.2 |
| 2013/14 | 1 691.9 | 952.6 | 304.0 | 435.3 |
| 2014/15 | 1 553.8 | 861.3 | 267.7 | 424.8 |
| 2015/16 | 1 688.0 | 917.4 | 295.5 | 475.0 |

Source: Own study based on "Agricultural production means in the 2015/2016 marketing year", Table 8, GUS, Warsaw, 2017

### *Renewable energy - wind farms*

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (O.J. L 307, 140, 05.06.2009, page 16, as amended) and the climate and energy package assumptions until 2020, a 20% share of renewable energy in the total energy production of a given country and a 20% reduction in carbon dioxide emissions should be provided. It is possible to partially obtain this energy from marine areas, e.g. by using wind, wave, marine current or osmosis energy. In POM, in accordance with the Act of March 21, 1991 on the maritime areas of the Republic of Poland and maritime administration, wind farms may be located only in the area of the exclusive economic zone. Offshore wind energy is one of the fastest growing forms of energy in the world. Offshore wind farms can be one of the elements in the implementation of the EU energy and climate policy. In addition, the development of this sector leads to the creation of new jobs. In the project Concept of Spatial Development of the Country until 2033, as part of the strategic objective of effective use of the Polish maritime space, the operational objective was formulated: using the potential of marine areas for production of renewable energy and strengthening the energy security of the country. Among the instruments to achieve this goal, the creation of an infrastructure development program transmission and defining stable systems to support the production of renewable energy in the maritime space were mentioned. At present, Poland does not have offshore wind farms.

The ratio of installed power in wind farms in Poland in 2016 to total energy consumption was at the level of 3.6% and placed Poland in the 9th position in the EU. According to the data of the Energy Regulatory Office, in 2016 in Poland there were 1,193 installations using wind energy, with a total capacity of 5 807,416 MW.

Table 5.5.31 Installed capacity [MW], as at 31/12/2016.

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| wind installations | 1616.4 | 2496.7 | 3389.5 | 3833.8 | 4582.0 | 5807.4 |

Source: Own study based on the data of the Energy Regulatory Office (URE)

The report prepared by Ernst & Young in cooperation with the Polish Wind Energy Association[62] analyzes three scenarios for the development of offshore wind energy. Assuming the rapid development scenario, by 2025, Poland may install 6 GW of generated power in offshore wind farms, which may account for over 10% of the electricity demand in Poland. In practice, assuming the installation of approx. 5 MW of generated power per km$^2$, this means occupying approx. 1,200 km$^2$ of sea surface. By increasing the size of turbines, the amount of installed capacity may increase to a level that could make Poland the largest electricity producer in the Baltic. Poland has favorable conditions for the location of offshore wind farms due to the occurrence of winds with an average speed of approx. 9 m/s at a height of 80 m, approx. 9.25 m/s at a height of 100 m and 9.5 m/s at an altitude of 125 m. At altitude of 100 m, the average wind speed is often above 9-9.5 m/s, the number of windy hours per year reaches 7,000, and the energy production efficiency can reach over 40%. Some of restrictive factors may include: the use of sea space for other purposes, type of ground, performing geological and engineering analyzes at the stage of preparing a construction project, slope of the bottom and occurrence of some extremely unfavorable deposits, long distance from the shore and the depth increasing the costs of farm service and investment in energy transmission. This situation makes it necessary to use more expensive technological solutions. The share of wind energy in the domestic electricity production according to GUS is presented in Table 5.5.32.

Table 5.5.32 The share of wind energy in the domestic production of electricity

| Year | Wind energy production [GWh] | Total electricity production in Poland [GWh] |
|---|---|---|
| 2011 | 3 204.5 | 163 153 |
| 2012 | 4 746.6 | 159 853 |
| 2013 | 6 003.8 | 162 501 |
| 2014 | 7 675.6 | 156 567 |
| 2015 | 10 858.4 | 161 772 |
| 2016 | 12 587.6 | 162 626 |

Source: Prepared on the basis of data included in the publication: "Energy from renewable sources in 2015, GUS, Warsaw 2016, Annex 2," Energy from renewable sources in 2016, GUS, Warsaw 2017, Annex No. 2 and Reports on the President's Activities ERO for the years 2011-2016.

### *Marine wreck tourism*

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[62] Report „Morska energetyka wiatrowa – analiza korzyści dla polskiej gospodarki oraz uwarunkowań rozwoju." Warszawa 2013

The history of research on Baltic wrecks is abundand in extremely interesting finds. It is estimated that there are several hundred wrecks from the period of World War I and II in the Baltic Sea.

According to estimates made before the Second World War, up to 2,000 wrecks can be found on the section from Szczecin to the Vistula Spit. Due to low salinity and low temperatures, the waters of the Baltic Sea provide conditions conducive to the preservation of organic materials, especially wood, which in most seas is destroyed by *Toredo navalis*. Due to the described conditions, the Baltic Sea wrecks with insignificantly damaged hulls can be encountered. The Polish Baltic coast is also abundand in wrecks, which to a greater extent than in other places in the Baltic Sea are more exposed to destruction because the flat, sandy bottom allows for trawling for fish which is destructive for wooden structures. Nevertheless, discovered objects provide very valuable information. There are 65 registered underwater positions in Poland and non of the positions is protected. The main diving centers are located in Hel, Jastarnia and Kuźnica. They offer trips to discover the wrecks around Gdańsk. In addition, on the central coast, deep sea diving trips are offered in ports of Łeba, Darłowo and Kołobrzeg. Due to the increasing popularity of diving, despite the difficulties resulting from natural conditions and legal restrictions, activities related to diving and wreck tourism are expanding. Wreck tourism encourages the creation of complex, specialized tourist sites, engaging both vessels, bases located in ports, and port services (food, accommodation).

In Poland, the legal act regulating diving on shipwrecks is the Act of March 21, 1991 on Marine Areas of the Republic of Poland and Maritime Administration (Journal of Laws of 2017, item 2205). It imposes on the organizers of diving expeditions the requirement to obtain the permission of the director of the relevant maritime office to search for shipwrecks. The permit must be consulted with the Border Guard and the Voivodeship Conservator, and the vessel carrying the participants must sail out and return to the Polish port. In addition, there is an obligation to transfer all items removed from the water to the appropriate maritime office. In 2006, the Director of the Maritime Office in Gdynia issued Order No 9 of 23 May 2006 on the prohibition of diving on shipwrecks of war tomb vessels (Journal of the Pomeranian Voivodeship, item 1277, Official Journal of the Warmian-Masurian Voivodeship item 1331). As a consequence, a zone was established in which all underwater activities around the wrecks of ships "Wilhelm Gustloff" and "Goya" were excluded those are a resting place of victims of great maritime disasters. In addition, in 2010, the Director of the Maritime Office in Słupsk forbade to dive within a radius of 500 m from the shipwreck "General von Steuben" (Order of the Director of the Maritime Office in Słupsk no. 1 dated 4 February 2010 on the prohibition of diving on the wreck of a ship - a war tomb). The statement of the United Nations Convention on the Law of the Sea is applied to shipwrecks that are archaeological finds, which results in a restriction of diving on objects of archaeological and historical nature.

It is estimated that for several years, the number of people interested in diving has been increasing. According to information from 2016, diving in Poland performed by about 75 thousand people, and the total number of people previously trained in all diving systems exceeds 150,000.[63]

***Military activity***

Military marine areas are established on the basis of the ordinance of the Minister of National Defense of 3 April 2014 on restricted zones for shipping and fishing in the maritime areas of the Republic of Poland (Journal of Laws, item 482).

In the f the Baltic Sea, there are designated zones for military activities. In places where periodic military exercises are carried out, a temporary ban on recreational sailing, mooring, fishing, anchoring and diving is introduced. Military activities are conducted in areas with potentially designated protected areas and shipping routes where fishing, tourist and

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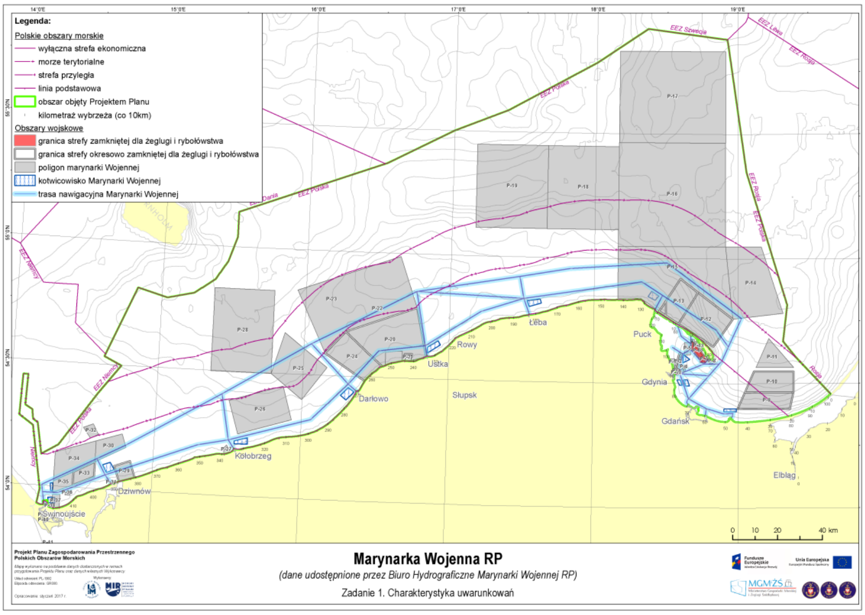
[63]http://www.nurkopedia.pl/index.php/Historia_nurkowania_w_Polsce

recreational activities can be performed, pipelines and power cables as well as wind farms could be installed. Plans to establish new polygons may be in conflict with nature protection[64].

The naval forces of the Republic of Poland, including the Polish Navy together with the hydrographic service, marine special operation units, the Sea Border Guard Department, local maritime administration bodies, the Maritime Search and Rescue Service, Customs Service, Water Police, and other entities having competences in the area of maritime safety, constitute the total strength and resources available to conduct maritime policy in Poland. Their scope and impact on the Baltic Sea ecosystem depends on the socio-economic situation of the country.

The following maps, providad by MGMiŻŚ (prepared as part of the "Project of urban development plan POM"), present:

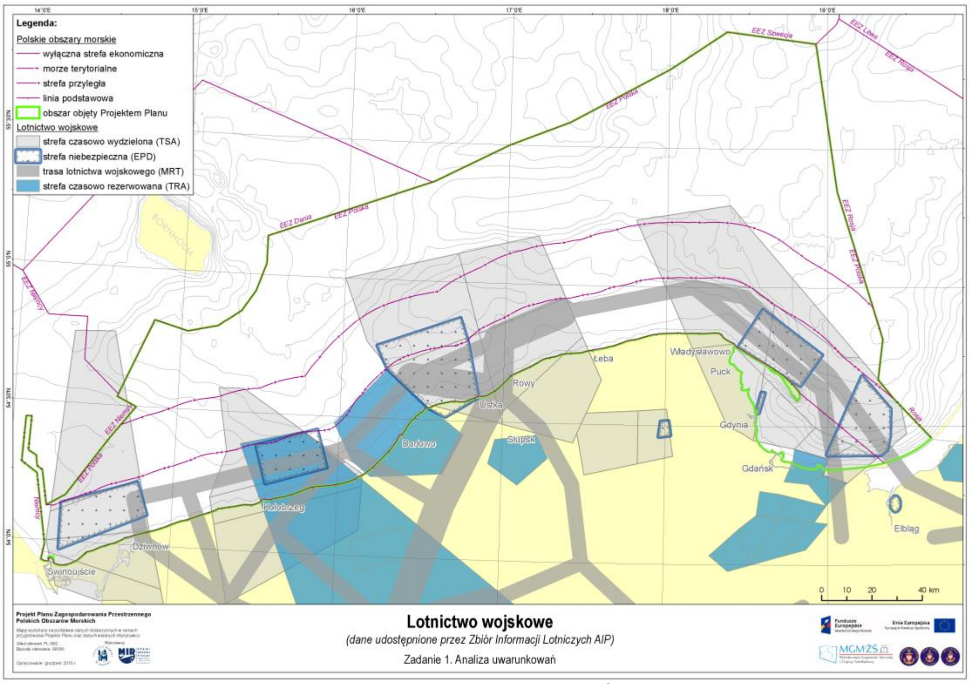
1) Polish Navy;
2) Polish Air Force;
3) civilian airport zones with minimum altitudes.




Source: data provided by the Department of Maritime Economy MGMiŻŚ

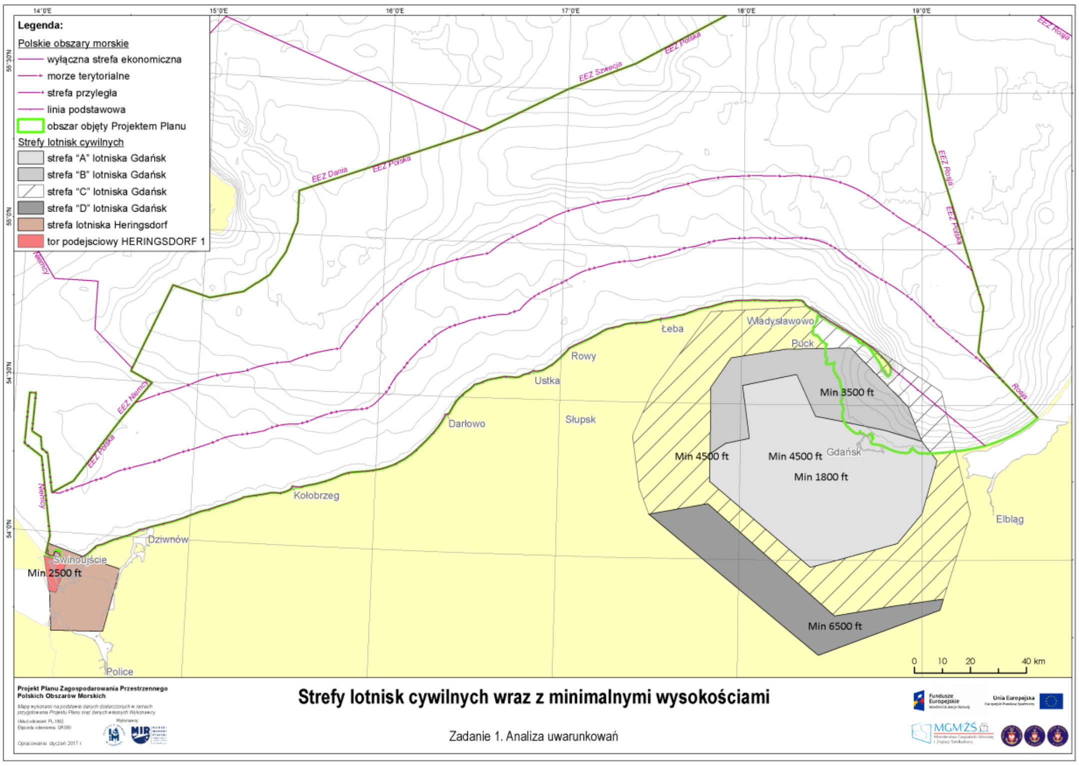
Fig.5.5.3 The Polish Navy

64 Przyszłość Morza Bałtyckiego – tendencje rozwojowe. Program WWF na rzecz ochrony Ekoregionu Bałtyku; Raport WWF 2011




Source: data provided by the Department of Maritime Economy MGMiŻŚ

Fig.5.5.4. Polish Air Force




Source: data provided by the Department of Maritime Economy MGMiŻŚ

Fig.5.5.5. Civil airport zones with minimum altitudes

***Scientific research, analysis and educational activities***

In accordance with applicable regulations, scientific units implementing activities for the maritime policy of the Republic of Poland are classified as fallows:

1) scientific institutes of the Polish Academy of Sciences - art. 42 of the Act of 30 April 2010 on the Polish Academy of Sciences (Journal of Laws of 2018 item 1475, as amended) - Institute of Oceanology, Polish Academy of Sciences in Sopot;
2) research institutes - art. 1 point 1 of the Act of 30 April 2010 on Research Institutes (Journal of Laws of 2018 item 736, as amended) - Maritime Institute in Gdańsk, Sea Fisheries Institute in Gdynia;
3) other scientific units referred to in art. 2 points 9 lit. f of the Act of 30 April 2010 on the rules for financing science (Journal of Laws of 2018, item 87)

Scientific research, analysis and educational activities related to the Baltic Sea in Poland are mainly carried out by the following centers:

1) Institute of Oceanology of the Polish Academy of Sciences, which conducts basic research on the marine environment, in particular on the phenomena and processes occurring. These studies concern primarily the role of the ocean in shaping the climate and the effects of climate change in European seas, natural and anthropogenic variability of the Baltic Sea environment, present ecosystem changes at shores of the shelf seas and genetic and physiological mechanisms of the functioning of marine organisms, including the application of marine biotechnology achievements;
2) Maritime Institute in Gdańsk, which conducts scientific research and development related mainly to sea basins and the coastal zone, mainly concerning sea shore protection systems, spatial planning, marine area research for the possibility of offshore wind farm construction, development of transport corridors as well as research on marine habitat and the sustainable use of marine resources;
3) National Marine Fisheries Research Institute, the oldest marine research facility in Poland, which aim is to provide independent, objective and current knowledge based on scientific research and development works that support economically sustainable and environmentally friendly development of sea fishing;
4) Polish Geological Institute, which basic research topic concerns the geological structure and raw material forecast of POM, preparation of geological maps of the basins bottom, research and monitoring of coastal erosion processes determined by geological structure, creation and management of marine and geophysical geological data. PIG-PIB activity also concerns international issues in the field of geology and raw materials of the ocean floor;
5) Institute of Meteorology and Water Management – National Research Institute - Maritime Branch in Gdynia, where the basic tasks of the Department of Oceanography and Atmosphere and Hydrosphere Monitoring of this institute, carried out as part of oceanographic activities in 2016, consisted of systematic registration of parameters of the marine environment and providing current and forecasted information on the condition of the marine environment of the southern Baltic;
6) Gdynia Maritime University, which educates highly qualified specialists in accordance with the strategy for the development of higher education in Poland, as well as assumptions of the maritime policy of the Republic of Poland;
7) Maritime University of Szczecin, where faculties and specializations relevant to the maritime economy of the country are conducted at particular faculties;
8) University of Gdańsk - is a leading Polish university conducting interdisciplinary research related to the Baltic Sea and educating the staff necessary to implement the maritime policy of the country;
9) Hel Marine Station of Institute of Oceanography in the Faculty of Oceanography and Geography at the University of Gdańsk (SMIOUG) is the only facility of this type in Poland. It supports the research needs of the entire scientific environment of the country and provides a field basis for all research groups working in this region (academic teams

of various universities, industry institutes and the Polish Academy of Sciences). Creation of the Marine Station was guided mainly by research needs that arose from the anthropogenic process of degradation of the natural environment of the Gulfs: Gdańsk and Puck, and the coastal sea zone. The location of the facility in the central point of the Gulf of Gdańsk creates opportunities for conducting research within the open sea and its coastal zone. It allows to track regional physico-chemical, biological and geological processes in the zone of contact of water with the bottom, land and atmosphere and phenomena occurring in the sea. The Marine Station in Hel is particularly suitable for undertaking research on the functioning and protection of the Baltic Sea life under multilateral research obligations (including international ones). It complements research possibilities of institutes, studies of reactions of fauna and flora to changing hydrological conditions (studies on the impact of pollution on their health condition, growth and reproductive ability). The existence of such a system, which is currently the only one in the southern and eastern Baltic, allows for the long-term storing of living research material for various research purposes. In 1994, the Marine Station in Hel was incorporated into the European Marine Network - Biological Research Stations (MARS - Network). It is also a didactic facility;

10) Gdańsk University of Technology, where scientific and research works are carried out, as well as research and expertise commissioned by the marine and defense sector are conducted;
11) Polish Naval Academy, which has experience and research capabilities to carry out work that primarily fits in the main areas of defense technology. Research carried out by the Academy are designed to serve the shaping of scientific specialties in conjunction with the plans for the development of Polish Navy and the process of technical modernization of ships, munitions and equipment;
12) University of Szczecin, which educates personnel for maritime economy enterprises, including entities related to the operation of maritime transport (port, shipping, agency enterprises, international logistic operators and many others);
13) West Pomeranian University of Technology in Szczecin, where in the academic year 2015/2016 the first recruitment for the new field of study "Refrigeration and Air Conditioning" was carried out, in which, apart from knowledge of basic, technical and engineering subjects, the graduate receives detailed knowledge and skills in the field of construction refrigeration and air conditioning equipment and installations, their design and operation, including: land and port refrigerators, chambers of various purpose, containers and cars - cold stores, air-conditioned objects, heat pumps. The general goal of education is to acquire the ability to design or select cooling devices for various purposes, heat pumps and air conditioning systems, knowledge of their construction and knowledge of the operation of land and sea objects, with particular emphasis on energy efficiency, renewable energy and environmental protection.
14) Polish Register of Shipping, which purpose is to help ensure technical safety of ships. It is implemented primarily by developing safety standards, and then supervising their implementation during construction and its maintenance during the ship's operation. Additional research is carried out on issues related to the safety of ship's structure. In the Polish Register of Ships, a group of inspectors and scientists systematically deals with solving scientific and research problems, creates gears for conducting necessary analyzes and simulations of ship's behavior, its construction and equipment in conditions affecting the safety of the vessel.

Apart from the above Research centers scientific projects are also implemented by non-governmental organizations and international organizations operating in the Baltic Sea region or interested in the protection of the Baltic Sea environment.

The Baltic Sea is both environmental and economic wealth. It requires compliance with the principles of sustainable use and international cooperation, which allows to develop solutions that affect the entire region, are not only of national or local character. In this situation, activities, including research, development and planning projects, as well as investments should be carried out. Taking into consideration the above mentioned conditions, Poland participates in projects related to the Baltic Sea area, implemented mainly under HELCOM or the EU Strategy for the Baltic Sea Region. It is also worth pointing out that at the meeting of the Monitoring Committee of the Interreg Baltic Sea Program 2014-2020, which was held in Helsinki in May 2017, 39 regular (in the areas of: innovation, transport and natural resources) and 25 seed money projects were approved, which concern and cover issues related to the Baltic Sea area. Approx. 65 Polish beneficiaries are involved in approved projects. A detailed list of projects is available on the website: https://www.interreg-baltic.eu/fileadmin/user_upload/News/2017_all_news/2017.05_all/Interreg_BSR_2nd_call_projects_approved.pdf. In the second recruitment (priorities 1-3) 212 project ideas were submitted, after the first stage there were 75 projects left in the recruitment (of which 71 decided to submit a full design application). From this group, the Monitoring Committee chose 39 projects which will receive co-financing (important: some projects will have to meet additional requirements before signing the contract).

The following are some of the projects implemented in 2016 for the Baltic Sea:

1) MARELITT Baltic - Reducing the impact of marine litter in the form of derelict fishing gear (DFG) on the Baltic Sea environment - implemented by WWF;
2) MARELITT - carried out by WWF and the Maritime University of Szczecin;
3) MARELITT Baltic - Reducing the impact of marine litter in the form of derelict fishing gear (DFG) on the Baltic Sea environment - implemented by the Institute of Logistics and Warehousing;
4) Mediation of integrated activities for sustainable ecosystem services in a changing climate - MIRACLE - implemented by POMInnO Sp. z o.o .;
5) Cross-border development and transfer of innovative and sustainable aquaculture technologies in the South Baltic area - implemented by the University of Gdańsk;
6) Mitigation of the Consequences of Accidents in the Ports of the Baltic Sea Region - implemented by the Polish Safety and Reliability Association;
7) ELMAR Seed - Promotion of the production and use of boats and electric ships in the South Baltic area - implemented by the Gdańsk University of Technology
8) Development of the power grid for the needs of offshore wind energy - implemented by the Maritime Institute in Gdańsk;
9) Economic preventive measures regarding hazards in coastal areas - implemented by the Maritime Institute in Gdańsk;
10) Sustainable shipping and environment in the Baltic Sea Region - SHEBA - implemented by the Maritime Institute in Gdańsk;
11) The initiation of blue mussel farming in the Baltic Sea (BBG) - carried out by the Maritime Institute in Gdańsk;
12) Green Cruise Port - Sustainable development of cruise ship call points - implemented by the Maritime Institute in Gdańsk;
13) Inventory of resources of countries from the Baltic Sea region that can be used in submarine rescue - implemented by the Polish Naval Academy;
14) Support for the decision-making process concerning the handling of munition sunk on the bottom of the Baltic Sea - carried out by the Maritime Institute in Gdańsk;
15) Soils2Sea - Reduction of pollution loads from agricultural sources entering the Baltic Sea through underground and surface waters - carried out by the AGH University of Science and Technology;
16) Environmental impact of low-emission shipping: measurements and modeling strategies - implemented by the Maritime University of Szczecin;
17) Use of coastal radars for environmental monitoring purposes - HARDCORE - implemented by the Institute of Meteorology and Water Management – National Research Institute (IMGW-PIB);
18) Biodiversity changes - causes, consequences and implications for management - BIO-C3 - implemented by the National Marine Fisheries Research Institute;

19) The impact of environmental conditions on the growth rate of the early development stages of cod (*Gadus morhua* L.) in the South Baltic Sea - implemented by the National Marine Fisheries Research Institute;
20) Safety and quality of marine food in the aspect of zoonoses and toxicological threats: risk assessment, monitoring and counteraction - implemented by the National Marine Fisheries Research Institute;
21) Reliable and autonomous system for monitoring the technical condition of marine structures (RAMMS) - implemented by The Szewalski Institute of Fluid-Flow Machinery Polish Academy of Sciences;
22) Baltic Prosperity - applications combining natural sciences and economics - BalticAPP - implemented by the University of Warsaw;
23) Development and production of cost-effective sensors, consistent with current EU policy requirements, ready for use in existing marine observation systems - implemented by the Institute of Oceanology of the Polish Academy of Sciences;
24) New operational initiatives for the European integration of the fleet of research vessels - carried out by the Institute of Oceanology of the Polish Academy of Sciences.

## 5.6. Analysis of the use of marine waters (Marine Water Accounting Approach)

***Description of economic benefits for sectors using marine waters***

Analysis of the use of marine waters attempts to collect regionally comparable data on the economic significance of the use of the Baltic Sea waters and to combine them with the assessment of pressures and impacts. Antropogenic pressures and impacts can be described using economic indicators that show their economic importance.

The Marine Water Accounting sector approach should be based on available statistical data and include recognition and, if possible, identification of economic benefits from economic sectors using marine waters in terms of, inter alia, the size of production, revenues, financial result, value added, the number of employees and their remuneration, etc. The guidelines of the Working Group on Socioeconomic Assessment established by the EC[65] recommend the inclusion of economic data based on the following indicators:

1) production volume;
2) intermediate consumption (at purchase prices);
3) gross value added (at market prices);
4) wages/remuneration;
5) labor/number of employees.

Existing economic indicators, for 2011-2016, published by the national statistics, are presented in the following tables. Basic data on entities of the national economy were presented, which main activity is classified as maritime economy. The basic activity was determined using such information as: value added, sales revenues, employment, and basic activities as envisaged in the statute. Entities of the national economy are legal entities, i.e. corporations, organizational units without legal personality, and natural persons conducting economic activity.

Marine economy entities are mainly located in the coastal voivodeships: Pomeranian, Warmian-Masurian and West Pomeranian. The largest number of maritime economy entities is located in the Pomorskie Voivodeship (52.7%).[66]

Table 5.6.1 Revenues from the overall activity of "maritime economy" against the background of the domestic economy

| | units | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| Revenues in the national economy | mln zł | 2 889 319.5 | 2 986 196.3 | 3 008 086.3 | 3 084 787.5 | 3 161 366.4 | 3 267 258.7 |
| Revenues in the "maritime economy" | | 24 894.2 | 27 325.7 | 29 216.1 | 32 660.5 | 34 354.5 | 43 314.2 |
| Revenues in the "maritime economy" as a percentage of total income | % | 0.86% | 0.91% | 0.97% | 1.06% | 1.08% | 1.33% |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS " for 2011, Table II, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012, Table II, "Statistical Yearbook of Maritime Economy 2017. GUS " for 2013 -2016, table II

The list of revenues from total activity of sectors using marine waters is included in the tables below.

65 Working Group on Economic and Social Assessment Economic and Social Analysis for the Initial Assessment for the Marine Strategy Framework Directive: A Guidance Document. European Commision, Brussels 2010

66 „Maritime economy in Poland in 2015-2016", GUS, Szczecin, 2017

Table 5.6.2 Revenues from total activity for the analyzed sectors (millions PLN)

| SPECIFICATION | | maritime transport | sea ports | shipbuilding industry | marine fisheries | maritime mining industry | tourism |
|---|---|---|---|---|---|---|---|
| Revenues from total activity | 2011 | 4 029.9 | 2 042.2 | 8 294.3 | 30.1 | no data | no data |
| | 2012 | 4 601.6 | 2 147.3 | 9 177.5 | 187.4 | no data | no data |
| | 2013 | 4 683.1 | 2 634.9 | 9 313.6 | 76.2 | no data | no data |
| | 2014 | 5 548.3 | 2 904.3 | 9 886.8 | 259.3 | no data | no data |
| | 2015 | 5 349.9 | 2 978.7 | 10 688.9 | 86.3 | no data | no data |
| | 2016 | 6 627.8 | 7 821.3 | 10 724.0 | 123.7 | no data | 225.6 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS " for 2011, Table 3.1, "Statistical Yearbook of Maritime Economy 2016. GUS " for 2012, Table 3.1, "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013 -2016, table 3.1

Table 5.6.3 Revenue from total activity in maritime economy subjects (millions PLN)

| SPECIFICATION | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| TOTAL | 24 894.2 | 27 325.7 | 29 216.1 | 32 660.5 | 34 354.5 | 43 314.2 |
| Transhipment, storage and storage of goods in seaports | 1 496.1 | 1 640.6 | 2 120.2 | 2 319.9 | 2 401.8 | 7 208.6 |
| Other activity supporting maritime transport | 680.4 | 748.7 | 722.3 | 849.4 | 912.7 | 1 163.6 |
| Activities of maritime transport agencies | 2 403.7 | 2 702.7 | 2 886.2 | 3 332.1 | 3 400.5 | 4 171.8 |
| Management of seaports | 546.1 | 506.7 | 514.7 | 584.4 | 576.9 | 612.7 |
| Sea and coastal water transport | 945.8 | 1 150.2 | 1 074.6 | 1 366.8 | 1 036.7 | 1 292.4 |
| Production and repair of ships and boats | 8 294.3 | 9 177.5 | 9 313.6 | 9 886.8 | 10 688.9 | 10 724.0 |
| Fisheries in sea waters | 30.1 | 187.4 | 76.2 | 259.3 | 86.3 | 123.7 |
| Processing and preserving of fish and fishery products | 7 122.4 | 7 674.8 | 8 686.6 | 9 337.0 | 10 045.5 | 12 258.1 |
| Wholesale and retail sale of fish, crustaceans and mollusca | 1 681.0 | 1 718.1 | 2 109.2 | 2 354.0 | 2 206.7 | 2 808.4 |
| Research and development and maritime education | 1 46.5 | 184.9 | 188 | 212.1 | 233.1 | 172.5 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS " for 2011, Table 3.1, "Statistical Yearbook of Maritime Economy 2016. GUS " for 2012, Table 3.1, "Statistical Yearbook of Maritime Economy 2017. GUS " for 2013 -2016, table 3.1

It is impossible to set clear geographical boundaries for the occurrence of economic entities using marine water in their activities, therefore, the data for agriculture is not available in the list above. The head office of the entity may be located outside the place of business.

From 2016, GUS presents economic data for maritime economy entities conducting tourist activity and these are included in other types of activity.

Large entities with a stable market position are important for the maritime economy. Investments in infrastructure and diversification of serviced cargo result in the growth of the rank of Polish seaports on the international arena, while the possibility of feeder service improves their competitiveness. Baltic fisheries are usually based on small family fishing enterprises.[67]

The lack of data on revenues from the offshore oil industry results from various reasons. GUS does not qualify such activity for the maritime economy and does not conduct such reporting. The production of hydrocarbons is handled by Lotos Petrobaltic belonging to the Lotos S.A. capital group. The latter in its financial statements does not provide data for individual companies. Obtaining information about Lotos Petrobaltic also does not solve the problem, as it has subsidiaries involved in exploration and production of hydrocarbons outside the country, both in sea and land areas. The information on LOTOS Petrobaltic's revenue is therefore increased by the activity of the subsidiary companies. The extracted crude oil from the Baltic Sea is processed and sold at the refinery of the Capital Group. Hence, in the face of such vertical integration it is difficult to separate the expected category. The concept of total activity for the Lotos Capital Group is a completely different concept which has little to do with maritime economy, since Baltic oil is only a few percent of oil processed by the refineries of the Capital Group.

**Wages/remuneration**

Salaries include cash payments and the value of benefits in kind or their equivalents due to employees for work. The components of remuneration are: personal wages, payments for participation in profit and balance surplus in cooperatives, additional annual wages and salaries for employees of budgetary sphere entities, impersonal wages, agency and commission wages and fees. Data on remuneration were presented in gross terms, i.e. including advances for personal income tax and including pension, disability and sickness insurance contributions paid by insured employees.

The amounts presented in the table below are not reported by GUS in disaggregation into sections, so there is no way to connect them to the analysis sectors. In addition, the visible amounts do not include hydrocarbon production (remuneration at Petrobaltic is covered by the secrecy clause), and above all, there is no information on employment related to accommodation.

[67] „Maritime economy in Poland in 2015-2016", GUS, Szczecin, 2017

Table 5.6.4 Maritime economy in coastal voivodships

| voivodship | Pomeranian Voivodeship | | | | | | Warmian-Masurian Voivodeship | | | | | | West Pomeranian Voivodeship | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| Entities of maritime economy | 5 807 | 6 404 | 6 398 | 6 565 | 7 594 | 9 186 | 230 | 262 | 348 | 388 | 471 | 694 | 2 783 | 2 919 | 3 022 | 3 079 | 3 453 | 4 205 |
| % share in the total number of entities in the voivodship | 2.2 | 2.4 | 2.4 | 2.4 | 2.7 | 3.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.6 | 1.3 | 1.3 | 1.4 | 1.4 | 1.6 | 1.9 |
| Working in maritime economy in thous. | 38.8 | 40.8 | 41.7 | 45.7 | 47.2 | 51 | 1.8 | 1.8 | 1.9 | 2.1 | 2.4 | 3.1 | 22.5 | 23.2 | 24.6 | 22.7 | 23.7 | 25.4 |
| % share in the total number of employees in the voivodship | 5.2 | 5.9 | 5.9 | 5.9 | 5.9 | 6.1 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 | 0.7 | 4.4 | 4.9 | 5.2 | 4.4 | 4.5 | 4.7 |
| Average monthly gross wages and salaries in the maritime economy in PLN | 4 322.0 | 4 505.0 | 4 659.3 | 4 875.9 | 5 048.5 | 5 140.0 | 3 268.5 | 3 365.2 | 3 354.5 | 3 510.0 | 3 721.5 | 3 733.3 | 3 780.6 | 3 846.8 | 3 938.1 | 4 160.6 | 4 384.3 | 4 571.2 |
| Capital expenditures on maritime economy in PLN million | 782.8 | 1005.2 | 1057.8 | 1561.5 | 1892 | 1340.1 | 28.7 | 18.2 | 35.2 | 16.4 | 12 | 17.3 | 616.3 | 918.3 | 658 | 1635.7 | 594.7 | 197.5 |
| % share in total investment expenditure in the voivodship | 5.6 | 6.8 | 7.7 | 10.3 | 11.3 | 8.4 | 0.4 | 0.2 | 0.6 | 0.2 | 0.1 | 0.2 | 7 | 9.3 | 6.1 | 15.6 | 5.4 | 2.4 |
| Gross value of fixed assets in the maritime economy in PLN million | 10 108.4 | 10 812.0 | 11 403.8 | 12 639.5 | 13 998.5 | 15 749.2 | 196.5 | 211 | 243.7 | 241.7 | 256.1 | 288.6 | 4 473.3 | 4 343.1 | 4 250.8 | 5 226.9 | 5 923.4 | 4 661.7 |
| % share in the value of gross fixed capital formation | 6.6 | 6.6 | 6.6 | 6.9 | 7.1 | 7.5 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 3.9 | 3.5 | 3.3 | 3.7 | 3.9 | 3 |
| Share of% of the voivodship in: | | | | | | | | | | | | | | | | | | |
| cargo turnover in seaports | 63.2 | 63.9 | 65.9 | 66.5 | 67.7 | 67.6 | 0 | 0.3 | 0.4 | 0.5 | 0.3 | 0.2 | 36.6 | 35.8 | 33.6 | 33 | 32 | 32.2 |
| sea transport | 8.2 | 8.9 | 10.7 | 13.4 | 14.5 | 11.3 | _ | _ | _ | _ | _ | _ | 89.1 | 89.5 | 87.8 | 84.8 | 83.2 | 86.4 |
| sea fish catches | 73.9 | 69.3 | 70.9 | 72.5 | 71.8 | 72.1 | 1.1 | 1 | 0.8 | 1.6 | 1.4 | 1.1 | 25 | 29.7 | 28.3 | 25.9 | 26.9 | 26.8 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS " for 2011, Table III, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012, Table III, "Statistical Yearbook of Maritime Economy 2017. GUS " for 2013 -2016, table III

Table 5.6.5 Gross wages and salaries in „maritime economy" (mln PLN)

| SPECIFICATION | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| Total | 3 327.4 | 3 454.2 | 3 601.1 | 3 889.4 | 4 077.3 | 4 945.6 |
| Personal salaries | 3 080.3 | 3 176.3 | 3 318.6 | 3 600.8 | 3 792.0 | 4 371.2 |
| Payments for participation in profit and balance surplus in cooperatives | 8.4 | 4.1 | 7.0 | 5.6 | 6.1 | 5.9 |
| Impersonal salaries | 216.1 | 252.6 | 255.1 | 261.2 | 257.8 | 543.2 |
| Additional annual salaries | 8.1 | 7.9 | 8.1 | 8.2 | 8.3 | 9.1 |
| Remuneration | 14.5 | 13.3 | 12.3 | 13.6 | 12.7 | 16.2 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS " for 2011, table 1.13, "Statistical Yearbook of Maritime Economy 2016. GUS " for 2012, table 1.13, "Statistical Yearbook of Maritime Economy 2017. GUS " for 2013 -2016, table 1.13

Table 5.6.6 Average monthly gross wages and salaries in the analyzed sectors in PLN (data refer to business entities in which the number of employees exceeds 9 persons)

| SPECIFICATION | | maritime transport | sea ports | shipbuilding industry | marine fisheries | maritime mining industry | tourism |
|---|---|---|---|---|---|---|---|
| The average monthly gross wage | 2011 | 5 493.1 | 4 491.9 | 4 448.6 | 2 805.4 | no data | no data |
| | 2012 | 5 657.6 | 4 593.3 | 4 590.6 | 3 441.4 | no data | no data |
| | 2013 | 5 804.3 | 4 752.9 | 4 789.0 | 3 369.0 | no data | no data |
| | 2014 | 5 936.7 | 4 914.1 | 5 070.0 | 3 708.4 | no data | no data |
| | 2015 | 6 120.6 | 5 049.2 | 5 440.5 | 2 950.7 | no data | no data |
| | 2016 | 6 267.4 | 5 476.5 | 5 397.4 | 3 265.0 | no data | 2 982.5 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS " for 2011, table 1.14, "Statistical Yearbook of Maritime Economy 2016. GUS " for 2012, table 1.14, "Statistical Yearbook of Maritime Economy 2017. GUS " for 2013 -2016, table 1.14

Table 5.6.7 Average monthly gross wages and salaries in maritime economy entities (data refer to business entities in which the number of employees exceeds 9 persons)

| **SPECIFICATION** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
|---|---|---|---|---|---|---|
| TOTAL | 4 019.7 | 4 175.0 | 4 301.7 | 4 510.9 | 4 673.2 | 4 801.9 |
| Pomeranian Voivodeship | no data | 4 505.0 | 4 659.3 | 4 875.9 | 5 048.5 | 5 140.0 |
| Warmian-Masurian Voivodeship | no data | 3 365.2 | 3 354.6 | 3 510.0 | 3 721.5 | 3 733.3 |
| West Pomeranian Voivodeship | no data | 3 846.9 | 3 938.1 | 4 160.6 | 4 384.3 | 4 571.2 |
| Transhipment, storage and storage of goods in seaports | 3 974.4 | 3 926.0 | 4 075.0 | 4 184.8 | 4 247.1 | 4 620.1 |
| Other activity supporting maritime transport | 5 418.7 | 5 532.4 | 5 293.1 | 5 407.2 | 5 731.9 | 6 212.4 |
| Activities of maritime transport agencies | 4 862.5 | 5 482.9 | 5 529.4 | 5 502.1 | 5 641.7 | 5 771.0 |
| Management of seaports | 5 009.3 | 5 260.6 | 5 430.8 | 5 643.5 | 5 851.2 | 6 332.8 |
| Sea and coastal water transport | 6 198.2 | 5 957.3 | 6 590.4 | 6 900.9 | 6 988.2 | 6 818.6 |
| Production and repair of ships and boats | 4 448.6 | 4 590.6 | 4 789.0 | 5 070.0 | 5 440.5 | 5 397.4 |
| Fisheries in sea waters | 2 805.4 | 3 441.4 | 3 369.0 | 3 708.4 | 2 950.7 | 3 265.0 |
| Processing and preserving of fish and fishery products | 2 490.8 | 2 680.2 | 2 762.2 | 2 998.0 | 3 099.6 | 3 342.0 |

| SPECIFICATION | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| Wholesale and retail sale of fish, crustaceans and molluscs | 2 764.4 | 2 833.5 | 2 976.0 | 2 953.5 | 3 040.2 | 3 353.5 |
| Research and development and maritime education | 4 747.0 | 4 812.7 | 5 061.8 | 5 452.1 | 5 730.5 | 5 771.2 |
| Offshore offices | 3 875.5 | 3 888.4 | 3 930.3 | 3 985.0 | 4 053.7 | 4 288.1 |
| Other activities | 5 490.1 | 5 875.0 | 6 193.3 | 6 016.5 | 5 636.2 | 5 462.8 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, table 1.14, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012, table 1.14, "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013 - 2016, table 1.14, "Maritime economy in Poland in 2012-2014, GUS " table 3 and "Maritime economy in Poland in 2015-2016, GUS" table 3

### Working and employment

Employees are employed on the basis of an employment contract for a definite period (including seasonall and odd employees) and indefinite, full-time and part-time employees, employees on private farms in agriculture and teachers in a state of rest or on health leave. The concept of working people is wider. It is referred to as people performing work that brings them earnings (in the form of remuneration for work) or income. Therefore, they are not only employed, but also employers and self-employed, people performing home work, agents, and members of the cooperative.

Table 5.6.8 Employees in the analyzed sectors (data refer to business entities in which the number of employees exceeds 9 people)

| SPECIFICATION | | maritime transport | sea ports | shipbuilding industry | marine fisheries | maritime mining industry | sea and coastal tourism |
|---|---|---|---|---|---|---|---|
| Employees | 2011 | 9 364 | 9 217 | 29 582 | 2 947 | 393 | bd |
| | 2012 | 9 962 | 8 866 | 30 693 | 2 794 | 389 | bd |
| | 2013 | 9 343 | 8 884 | 31 508 | 2 770 | 385 | bd |
| | 2014 | 9 680 | 9 213 | 32 343 | 2 507 | 432 | bd |
| | 2015 | 10 393 | 9 372 | 29 912 | 2 779 | 395 | bd |
| | 2016 | 12 846 | 10 142 | 32 610 | 3 314 | 378 | 1 177 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, Table 1.2, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012, Table 1.2, "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013 -2016, table 1.2 and Management Board reports on the operations of the LOTOS Group from 2011-2016

Table 5.6.9 Employees in the sectors of maritime economy.

| SPECIFICATION | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| TOTAL | 84 939 | 88 051 | 90 348 | 94 394 | 97 688 | 108 199 |
| Transhipment, storage and storage of goods in seaports | 8 300 | 7 989 | 7 989 | 8 323 | 8 481 | 9 243 |
| Other activity supporting maritime transport | 2 170 | 2 261 | 2 310 | 2 268 | 2 813 | 3 059 |
| Activities of maritime transport agencies | 4 544 | 4 863 | 4 325 | 4 609 | 5 227 | 7 093 |
| Management of seaports | 917 | 877 | 895 | 890 | 891 | 899 |
| Sea and coastal water transport | 2 650 | 2 838 | 2 708 | 2 803 | 2 353 | 2 694 |
| Production and repair of ships and boats | 29 582 | 30 693 | 31 508 | 32 343 | 29 912 | 32 610 |
| Fisheries in sea waters | 2 947 | 2 794 | 2 770 | 2 507 | 2 779 | 3 314 |
| Processing and preserving of fish and fishery products | 17 711 | 18 224 | 19 549 | 20 208 | 20 136 | 21 055 |
| Wholesale and retail sale of fish, crustaceans and molluscs | 5 820 | 5 994 | 6 780 | 7 460 | 7 427 | 8 925 |
| Research and development and maritime education | 3 430 | 4 160 | 4 178 | 4 335 | 4 360 | 4 356 |
| Offshore offices | 1 553 | 1 565 | 1 544 | 1 543 | 1 524 | 1 516 |
| Other activities | 5 315 | 5 793 | 5 792 | 7 105 | 11 785 | 13 435 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS " for 2011, Table 1.2, "Statistical Yearbook of Maritime Economy 2016. GUS " for 2012, Table 1.2, "Statistical Yearbook of Maritime Economy 2017. GUS " for 2013 - 2016, table 1.2

### Finance of maritime economy entities

Financial results of maritime economy entities were presented in adjusting to the applicable accounting regulations. Data on the finances of maritime economy enterprises include business entities keeping accounting books in which the number of employees exceeds 9 persons.

Table 5.6.10 Financial results in the analysed sectors

| Year | maritime transport | | | seaports | | | Shipbuilding industry | | | marine fisheries | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | accounting profit | gross profit | gross loss | accounting profit | gross profit | gross loss | accounting profit | gross profit | gross loss | accounting profit | gross profit | gross loss |
| 2011 | 80.0 | 181.0 | 101.0 | 148.6 | 201.4 | 52.8 | 526.2 | 602.8 | 76.7 | -19.2 | 1.9 | 21.1 |
| 2012 | 251.1 | 266.6 | 15.6 | 207.3 | 264.1 | 56.8 | 473.0 | 624.5 | 151.5 | 34.1 | 34.1 | – |
| 2013 | 213.1 | 253.0 | 39.9 | 315.7 | 326.8 | 11.1 | 626.5 | 744.8 | 118.3 | 1.9 | 27.5 | 25.6 |
| 2014 | 324.4 | 346.5 | 22.0 | 343.2 | 351.7 | 8.4 | 621.7 | 745.9 | 124.1 | 21.6 | 30.1 | 8.5 |
| 2015 | 353.5 | 356.9 | 3.4 | 386.8 | 401.4 | 14.6 | 650.7 | 674.5 | 23.8 | 26.1 | 32.2 | 6.1 |
| 2016 | 484.9 | 513.0 | 28.1 | 389.0 | 411.1 | 22.1 | 362.6 | 442.2 | 79.6 | 36.0 | 36.1 | 0.1 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS " for 2011, Table 3.3, "Statistical Yearbook of Maritime Economy 2016. GUS " for 2012, Table 3.3, "Statistical Yearbook of Maritime Economy 2017. GUS " for 2013 -2016, table 3.3

***Identification and an attempt to quantify the pressure generated by the sectors studied***

In Poland, KOBiZE is responsible for estimation of emissions to air, pursuant to the Act on the management of greenhouse gas emissions and other substances. The implementation of the tasks of KOBiZE takes place in the IOŚ-PIB organizational structure, and the supervision over this center is exercised by the Minister of the Environment. KOBiZE was appointed to fulfill obligations, resulting from from EU directives and from participation in the greenhouse gas emission allowance trading scheme.

KOBiZE runs a national database where data on greenhouse gas emissions and other substances are collected. This database is a constantly improved gear that offers unique information about emission sources along with the location and operating parameters of individual installations. It allows to obtain accurate information based on real data provided by entities as part of annual reporting. KOBiZE also performs tasks related to preparing projections of greenhouse gas emissions, defining methods for estimation of the volume of emissions and emission factors, and analysis of the distribution of emission allowances among EU ETS participants.

Due to international and national obligations in the field of reporting, an important aspect of KOBiZE's work is to carry out an annual, national inventory of emissions of greenhouse gas and other substances. In KOBiZE, analyzes and reports, as well as summaries of data on emissions for use by government, self-government and interested entities are also prepared.

Currently, the inventory of pollutant emissions into the air is being prepared for the needs of national statistics, EU requirements and commitments to international organizations within the framework of:

1) the EU, Eurostat and the European Environment Agency;
2) The United Nations Convention on the Transboundary Transport of Air Pollutants at Long Distances; (LRTAP), EKG ONZ and the European EMEP programme.

Inventory of emissions on a national scale includes the following pollutants and their groups:

1) sulfur dioxide, nitrogen oxides, ammonia, carbon monoxide;
2) suspended dust;
3) heavy metals, non-methane volatile organic compounds;
4) persistent organic pollutants (including dioxins and furans, polychlorinated biphenyls, hexachlorobenzene, benzo (a) pyrene and three other polycyclic aromatic hydrocarbons).

The procedure for implementing the national emission inventory covers the following tasks:

1) development of sets of emission factors for each category and sub-category;
2) development of a set of data on activities of emission sources;
3) performing calculations and preparing tables of results for individual categories and aggregate tables in the format specified by EKG ONZ/EMEP.

The development of sets of emission factors for each emission category and subcategory has been made by:

1) selection of emission factors from domestic data sources;
2) selection of emission factors from EMEP/CORINAIR sources and other published sources in the absence of national data.

Bearing in mind the scope of competence of KOBIZE, as well as the need to harmonize the methodologies, models used, data and results of forecasts/impacts of individual sectors/activities on the environment, including the marine environment, it is necessary to include potential needs for estimating the impact generated by identified economic sectors using marine waters for example, $CO_2$ emissions to analyzes performed by KOBIZE.

Based on the available data, such as the current analyzes prepared by KOBIZE reported to the EC, it can be indicated, for example, that in 2013 and 2014 emissions according to sources in the layout of the latest classification Nomenclature for Reporting 2014, used in reporting to the LRTAP and EU Conventions were as follows:

Table 5.6.11 Emission volumes in accordance with the latest Nomenclature for Reporting 2014 classification for sea transport

| National navigation (shipping) – kod 1A3dii | | | | | | |
|---|---|---|---|---|---|---|
| Years/substance | NOx emission in [Gg] | CO emission in [Gg] | NMLZO emission in [Gg] | Heavy metal emission: Cu in [Mg] | Emission of heavy metals: Ni in [Mg] | Emission of heavy metals: Zn in [Mg] |
| 2013 | 0.213 | 0.095 | 0.049 | 0.003 | 0.003 | 0.004 |
| 2014 | 0.268 | 0.129 | 0.062 | 0.004 | 0.005 | 0.005 |

Source: Own study based on data published by KOBIZE

The report from which the above information was obtained is available on the website: http://www.kobize.pl/uploads/materialy/materialy_do_pobrania/krajowa_inwentaryzacja_emisji/Bilans_emisji_-_raport_podstawowy_2014.pdf.

For example, in previous reports sent to the EC, the following issues were estimated: emission for 080402 Shipping, diesel. Data for 2004 and 2005 are as follows:

Table 5.6.12 Emission estimation for activity 080402 in 2004 and 2005

| 080402 Shipping, diesel, heating oil - code 1A3dii | | | |
|---|---|---|---|
| Year/substance | Emission $SO_2$ [Gg] | Emission $NO_x$ [Gg] | Emission NMLZO [Gg] |
| 2004 | 0.14 | 0.72 | 0.16 |
| 2005 | 0.09 | 0.05 | 0.16 |

Source: Own study based on data published by KOBIZE

The report from which the above information was obtained is available on the following website: http://ec.europa.eu/environment/air/pdf/nat_prog/poland_pl.pdf.

It is estimated that shipping in the Baltic Sea contributes to 9% of nitric oxide emissions and 5% of total nitrogen emissions to this basin.

In addition, on 1 July 2015 Regulation (EU) 2015/757 of the European Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC (Journal of Laws UE L 123 of 19.05.2015, p. 55, as amended) antered the force, according to which the mechanism of monitoring, reporting and verification of $CO_2$ emissions from maritime transport will include $CO_2$ emissions from ships with a gross tonnage of more than 5,000 GT, making voyages from the last port of calling to the port under the jurisdiction of an EU Member State and calling from the port of under the jurisdiction of an EU Member State to the next port of and within the port of calling under the jurisdiction of a Member State. According to art. 2. This mechanism does not cover the following types of vessels: warships, warships of auxiliary fleet, fishing vessels or vessels for fish processing, wooden vessels of simple construction, non-mechanical ships, government vessels used for non-commercial purposes. In Poland, the authority responsible for administering the monitoring, reporting and verification system for $CO_2$ emissions from international maritime transport is the Polish Register of Shipping S.A. (www.prs.pl). Polish Register of Shipping S.A. will perform the role of a verifier, performing tasks consisting of:

1) checking monitoring plans;
2) verifying of annual reports on $CO_2$ emissions;
3) participating in contacts with owners and operators of ships flying the Polish flag;
4) issuing the required documents of compliance.

In terms of emissions of pollutants discharged into marine waters, such estimates are made, for example, for nutrients as part of the HELCOM work [68] (PLC project). Currently, the

[68] http://www.helcom.fi/baltic-sea-trends/pollution-load-compilations

next, seventh, PLC update is planned. The aim of the project will be to make a balance of pollutant loads coming from rivers and from areas of direct runoff to the Baltic Sea. The task will be to assess the size of discharges of pollutants originating from point and area sources discharged by rivers from the area of Poland and from the areas of direct runoff to the Baltic Sea. As part of the seventh PLC update for Poland, it is planned to calculate the loads to the Baltic Sea from the following sources:

1) dispersed (agriculture, atmospheric deposition on inland surface water, dispersed residential buildings, forest areas, permanent wasteland and areas with a similar natural habitat, rainwater discharges);
2) point (municipal sewage treatment plants, industrial point sources of pollution, fish breeding centers);
3) cross-border (loads of pollutants flowing to Poland, as well as departing abroad).

The main task foreseen in the work program for the implementation of the seventh PLC update is to divide the total nitrogen and total phosphorus load discharged into the Baltic Sea due to its source. In addition, the PLC analyzes the impact of selected hazardous substances on the condition of the Baltic Sea.

In the context of emissions to waters from the municipal sector or agriculture, in view of the Descriptor D5 eutrophication, the significance of the volume of nitrogen and phosphorus discharges to the waters of the Baltic Sea is significant. A summary of available GUS data in this is included in Table 5.5.29.

In summary, based on the current work and analyzes, there is a lack of comprehensive and consistent data on the quantitative impact of, the described in Chapter 3, economic sectors using marine waters.

## 5.8. Analysis of the use of marine waters (Ecosystem Services Approach)

The term "ecosystem services" has many translations in Polish-language. Some researchers use the term of providing ecosystems, ecosystem services or landscape services, while others use these terms interchangeably. The argument for using the term "ecosystem services" is the broader content range of this concept. It contains not only services, but also goods that are obtained thanks to the functioning of the natural environment (called ecosystem goods and services = ecosystem services). In contrast to the term "services", the term " benefits " does not imply the equality of the service provider and the service recipient, which can not be mentioned in human relations with ecosystems. Ecosystem services are not the result of the operation of natural systems on the order of a man, and such a thought may suggest the use of the term "services". In an official translation of EU documents dealing with the subject of "ecosystem services", the Polish-language term "ecosystem services" has been adopted (e.g. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Our life insurance and our natural capital - EU strategy for protection biodiversity for the period up to 2020, COM (2011) 244 final, KE, Brussels 2011). In the expert opinion, the word "ecosystem services" is treated as a synonym for "ecosystem provisions".

In practice, there are several approaches to analyzing the use of marine waters. These include, among others, the Marine Water Accounting Approach and, in the case of non-market valuation, the Ecosystem Services Approach. The main difference between the above approaches are the starting point for analysis and the level of ambition, and thus the requirements for the necessary data. The Ecosystem Services Approach begins with the identification of a marine ecosystem service, in contrast to the Marine Water Accounting Approach that has its starting point in economic sectors benefiting from marine waters.

***Identification of ecosystem services in marine areas, using analyzes of state, pressures and impacts***

All ecosystems, including marine ecosystems, have been affected by human activity for centuries and are all subject to both short-term natural change and long-term evolution. The ecosystem approach is focused on the management of human activity, affecting the marine environment and its life forms. This approach recognizes that man is part of the ecosystem and strives to ensure that both factors: economic activity and the environment that supports it, are sustainable in terms of the ability to neutralize stress.

The term "ecosystem services" therefore means a set of products and ecosystem functions that are useful to people. The products include tangible goods directly used. However, useful descriptors include life suppoering functions (e.g. cleansing functions) and improving its quality (e.g. aesthetic values and cultural values). In economic terms - because the concept is derived from environmental economics - one can perceive nature as a supply side, and user, or man, as a demand side. As noted by many authors, the concept of ecosystem services (benefits) is a great gear for informing local communities and politicians about human dependence on nature and the need for sustainable development.

The resources and values of the natural environment, referred to as natural capital, are one of the foundations of the development of civilization. The reference use of these goods should therefore satisfy the needs of the present generation, taking into account the needs of the next generations. This is the foundation of sustainable development, harmonizing the natural, economic and social spheres in order to ensure a high quality of life. It is necessary in this respect to make the right decisions regarding the use of the environment at every level of management, based on the quantitative and qualitative recognition of human benefits from the functioning of natural systems. An approach based on the identification of ecosystem services should be used when estimating non-market values such as recreation and its costs. The analysis should take into account the fact that the benefits from one ecosystem service may be related to other ecosystem services and thus the effect on one benefit may reduce the benefit of another. Benefits may be complementary but may also exclude each other. Identification of ecosystem services should take into account the results of analyzes of the state of waters and pressures and their impacts, and refer to the characteristics (descriptors) of the environment contained in Annex I of the MSFD.

It is also worth noting what the authors of the publication of "Coastal eutrophication research: a new awareness" write[69], clearly emphasizing that when setting targets to restoring a good ecological status, the focus should be on securing ecosystem services, not previous environmental conditions. These authors believe that climate change, demographic change, etc. can have a fundamental impact on the functioning of ecosystems, thus creating base conditions that are completely different from the "reference values" (i.e., not disturbed by human activity). This means that a rational approach should be maintained so as not to have negative effects on the sectors and their "services". It is currently assumed that the most likely scenario is the delay in the effect of reducing the dynamics of eutrophication as a result of retention mechanisms associated with the storage of biogenic substances (in bottom sediments or biomass), as well as a change in the system's regime, entailing not only changes in physico-chemical parameters, but also the species composition of organisms inhabiting a given ecosystem.

The ecosystem approach, which requires cross-sectorial and sustainable management of human activities, and which goal is to achieve a good state of the Baltic Sea ecosystem, according to HELCOM, is the overarching principle of spatial planning for marine areas. Sustainable management means reconciling economic, social and environmental interests. Planning of maritime spatial development is an activity promoted and recommended in MSFD. It imposes on Member States the obligation to achieve good environmental status (GES) by 2020, applying the ecosystem approach and ensuring that the pressure exerted by human activities does not prevent the achievement of good environmental status, which means "the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations." The condition for drawing up appropriate analyzes and assessments is gathering and analyzing information on the natural values of a given basin in order to determine the most valuable places, but also sensitive to all kinds of human interference, while valorisation of the marine space in terms of individual elements of the environment includes both quantitative and qualitative criteria. Quantitative criteria include: abundance, biomass of species (e.g. high concentration of wintering water birds); species richness (biodiversity). Quality criteria are: scarcity of species/habitat (uniqueness); naturalness (degree of conservation of the complex/habitat in the intact state); the presence of the protected species/habitat; significance of the species/habitat for the ecological processes. For example, the main threats to ichthyofauna associated with investments at sea, sea transport and the exploitation of ichthyofauna resources are: contamination of marine waters with oil, chemicals, radioactive substances; exploitation of aggregates, oil and gas; construction of marine constructions; exploitation and development of ports; fishing; blocking the migration routes of two-environmental fish by building/silting river estuaries.

Problematic issues include measuring the value of ecosystem services. Benefits of ecosystems for management purposes are worth quantifying from the scale of an individual farm, through the municipality and region to the state and the EU. Research on the benefits of ecosystems involve the implementation of two general directions of action: biophysical, related to natural sciences, aimed at protection of nature and services provided important for human well-being, and economic related to the quantitative measurement of benefits for the needs of decision-making processes justifying interventions aimed at nature conservation.

***Identification and attempt to quantify the benefits of ecosystem services achieved using the estimation methods appropriate for market and non-market goods***

Ecosystems provide basic services to people. The impact of people on marine ecosystems should be regulated in order to prevent losses to populations and economic activities that

[69] „Coastal eutrophication research: a new awareness" Duarte, C.M., 2009. Hydrobiologia, 629: 263-269 oraz Return to Neverland: Shifting baselines affect eutrophication restoration targets. Estuar. Coast., 32: 29–36 Duarte, C.M., Conley, D.J., Carstensen, J., Sanchez-Camacho, M., 2009

depend on the good condition of the Baltic Sea. The Convention on Biological Diversity indicates that "The ecosystem approach is a strategy for the integrated management of land, sea and living resources that promotes their protection and sustainable exploitation in a fair manner".

An overview of the benefits of ecosystem services in individual analyzed sectors is presented in the table below.

Table 5.8.1 Review of hypothetical benefits of ecosystem services for the analyzed sectors

| Sector | Potential ecosystem benefits |
|---|---|
| Maritime transport | Water is used as a means of transport, quality does not affect the level of benefits, but its very existence determines the activity |
| seaports | |
| shipyard industry / shipyards | |
| agriculture | none |
| maritime mining industry | Exploited resources under the seabed |
| sea fishing | Caught species |
| tourism and sea recreation | Recreational potential, generating demand for tourism and recreation |
| military activity | none |
| Other - Offshore wind energy offshore | Potential energy resources |

Source: Own study

The assessment of benefits broken down by sector, is included in Chapter 5.4. In the current chapter, the focus will be on an attempt to evaluate tourism and recreation. The data and methodological material used in the HELCOM HOLAS II project[70] and the source document [71] which the project was based on.

**Analysis of consumer surplus related to trips to the Baltic Sea**

The consumer surplus is the difference between the amount the buyer is willing to pay for a certain amount of good and the amount that he must actually pay. It is a measure of the benefit derived from the consumption of a given quantity of good. At the first stage of the analysis, assumptions from the methodological material and the source document were used:

1. Consumer surplus resulting from a trip to the Baltic Sea (according to M. Czajkowski and Others, Table 3): 71.51 €/trip per person;
2. Assumption concerning the traveling population: age over 18 (according to M. Czajkowski and Others);
3. The number of trips to the Baltic Sea for an adult citizen (according to M. Czajkowski et al.): 1.1195 per year.
4. Data summary for calculating the benefit streams (consumer surplus) for the years 2012-2015.

Table 5.8.2 Calculation of consumer surplus flows according to the Helcom HOLAS II methodology

| Descriptor | unit | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| Total population (1) | thousands of people | 38 525.7 | 38 533.8 | 38502.4 | 38 478.6 | 38 437.2 | 38 426.8 |
| Population from 18 years old (2) | thousands of people | 31 333.7 | 31 426.7 | 31473.3 | 31 535.7 | 31 535.5 | 31 532.0 |
| Consumer surplus (3) | €/trip/person | 71.51 | | | | | |
| Statistical | trip/person/ | 1.1195 | | | | | |

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71 Czajkowski M. i inn. Valuing the commons: An international study on the recreational benefits of the Baltic Sea. Journal of Environmental Management 156 (2015) str. 209-217

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| number of trips (4) | year | | | | | | |
| Consumer surplus - domestic (5) | mln €/year | 2 508.4 | 2 515.9 | 2 519.6 | 2 524.6 | 2 524.6 | 2 524.3 |

(1),(2) according to GUS for 2016 "Demographic yearbook 2017", table 14, "Demographic yearbook 2016" table 14, for the years 2015 and 2014 "Demographic yearbook 2016", table 14, for 2013 and 2012 "Demographic yearbook 2014", table 14, for 2011 "Yearbook demographic 2012 ", table 14
(3), (4) according to Czajkowski M. et al. Valuing the commons: An international study on the Baltic Sea. Journal of Environmental Management 156 (2015) pp. 209-217 value comes from tab.3
(5 as the product of the 18+ population, the number of trips and the unit surplus
Source: Own calculations based on the data and assumptions specified in the table above.

The study of recreational benefits from a trip to the Baltic Sea was based on questionnaires carried out in 2010 in all Baltic countries. In total, 9 127 questionnaires were collected, about 100 in each country. Respondents were asked, among others, about the number of recreational trips to the Baltic Sea, which they had during the last 12 months. The statistical number of trips to the Baltic Sea by the average Polish citizen was estimated at 1.1195 per year. It was assumed that all-year-round recreational trips are related to the quality of the Baltic Sea and that the surplus of the consumer is equal to the cost of travel. Way of estimating the cost of travel. Based on the interviews, the cost of travel was estimated, and the travel distance was set at 461.2 km and the travel time was 7.93h. It was also assumed that everyone travels in cars. The valuation of travel costs consisted of the value of time devoted to travel and the so-called "kilometrowka"(the travel cost set by the Minister of Infrastructure for tax purposes). The unit rate in Poland has not been changed since 2007[72]. The cost of travel was calculated as the product of the distance and kilometer rate increased by the value of one person's time. Indicator: 71.51 €/person obtained by dividing the calculated cost (according to M. Czajkowski et al., Table 1) by the statistical household size in Poland (2.6 people), despite the fact that the number of the traveling family was higher than 3.3 according to the study. Considering that people travel to a large extent with children - the value of surveys (3.3 people) seems to be correct. Such an estimated surplus stream seems to be relatively stable over time and fluctuates around EUR 2.5 billion.

***Identification of indicators and pressures affecting ecosystem services***

The analyzed sectors of the economy have a diverse impact on the Baltic Sea environment, but it should be noted that this impact depends on the type and functioning of the sector. In addition, correlations between sectors that can intensify the negative impact on the marine environment are also important. Therefore, it is important to analyze the state of compliance or conflict between various sectors of the maritime economy, which, depending on the situation, may co-exist in the same area. In other cases, a reverse situation may arise where sectors can not occupy and use the same area due to the mutual restrictions they impose.

The table below describes those activities/sectors that are significant in Poland, exert significant pressure on the condition of the Baltic Sea waters, achieve significant benefits from the use of marine waters or their activities depend significantly on these waters. It was recognized that the sectors/activities with significant pressure on the condition of the Baltic Sea or dependent on its waters or that could affect the condition of the Baltic Sea are: sea shipping, seaports, shipbuilding, sea fishing, offshore industry, tourism and recreation, agriculture and the municipal sector.

Table 5.8.3 Human uses or sector or human activity in the marine environment affecting the environment of the Baltic Sea or which functioning depends on the condition of the Baltic Sea waters or which may affect the condition of the Baltic Sea

| Activity/sector | Does the activity/sector exert significant pressure | Is the activity/sector significantly | Can the activity/sector affect the status of |
|---|---|---|---|

[72] PLN 0.8358/km for cars over 900cc engine capacity

| | on the marine environment (Yes/No) | dependent on the status of marine waters (Yes/No) | sea waters (Yes/No |
|---|---|---|---|
| Maritime transport | Yes | Yes | Yes |
| seaports | Yes | No | Yes |
| shipyard industry/shipyards | Yes | No | Yes |
| sea fishing | Yes | Yes | Yes |
| Tourism and Recreation | Yes | Yes | Yes |
| Marine mining industry | Yes | No | Yes |
| Agriculture | Yes | No | Yes |
| Municipal sector | Yes | No | Yes |

Source: Own study based on planning documents in force in Poland.

Coastal areas and river basins that are directly related to the Baltic Sea can have an impact on the entire ecosystem. Ports and sectors of the maritime industry use sea routes and infrastructure at sea, while the coasts attract, especially in the summer season, a large number of tourists.

One of the most intensively developing sectors that uses maritime space is sea transport. Currently, shipping on the Baltic Sea is one of the most intense in the world. The implementation of freight as well as passenger transport by sea is a major threat to the balance of the Baltic ecosystem. Marine waters are polluted, among others, with such substances as: crude oil and its products, municipal and industrial sewage discharged both from land and ships into the sea, chemicals entering the sea during reloading operations or during breakdowns. The harmfulness of crude oil and its products to marine waters results from its long-lasting properties on the water surface, limiting the access of oxygen and light to the sea and thus inhibiting the biological processes.

The intensity of ship traffic is the highest on the most frequented shipping routes and in coastal zones. This involves the emission of fuel combustion compounds into the air. While ships stopover and during maneuvers, devices that emit toxic compounds to the atmosphere are most often engines of power generators and auxiliary boilers. Another source of marine pollution is ballast water, which may contain around 1.0% of oil. Another, difficult to predict threat, to the marine environment are accidents that may occur during transport. Their course is unique. Therefore, maritime transport is characterized by a high potential for danger, and the risks associated with maritime transport can be reduced by appropriate measures, however, eliminating the danger and risk of accidents at sea is impossible, therefore it is necessary to prevent and minimize their possible consequences as much as possible.

In ports, new investments can be a potential threat to the environment. A large impact on the marine environment due to the destruction of habitats results from deepening of bottom, which may also cause changes in the chemical composition of water (when dredging, harmful substances and nutrients can be released from bottom sediments and can cause blooms of cyanobacteria and adversely affect the marine ecosystem). As a result, this has an impact on other sectors, such as fishing, tourism and recreation.

The threat of air quality resulting from anthropogenic activity in ports and shipyards comes from suspended dust. The shipbuilding industry and associated companies introduce into the atmosphere a number of heavy metals, i.e. lead, arsenic, cadmium, nickel and other substances, including POPs. They are particularly dangerous because they do not decompose in the environment and accumulate in living tissues. In addition, in shipyards, while painting and varnishing, organic solvents such as xylene and toluene are also emitted into the atmosphere.

Fisheries and aquaculture exert one of the greatest, among human activities, impacts on the marine environment. This impact may increase if fishermen take control of new fisheries and species. Fishing activities are carried out on a large scale throughout the region, with the greatest fishing pressure recorded in the southern part of the Baltic Sea. Fisheries pressure throughout the Baltic Sea, including POM, is rather high and concerns not only fish caught, but also the whole marine ecosystem, including mainly non-target fish, birds and benthic invertebrates. The environmental effects of fishing depend on both fishing gear and the intensity of fishing (fishing effort). Open-sea fishing uses mainly active (bottom and pelagic trawls) and passive fishing gears (set nets, fyke nets, seines), while coastal fishing and fishing on shallow shoals mainly passive gear is used. The threat to the Baltic Sea ecosystem is overfishing, which occurs if the quantity of catches exceeds the natural reproductive capacity of fish stocks. The development of the fisheries sector depends to a large extent on the condition of fish populations, their development and, as a consequence, a healthy ecosystem, not subject to excessive exploitation. The sector should therefore be based on planning based on an ecosystem approach. Irrespective of the above, it should be pointed out that fishing is also one of the most environmentally friendly sources of animal protein in the human population victualing system.

Ecological significance of fish and marine invertebrates for human is related to the fact that their meat, in comparison to the meat of other animals, has the highest content of easily digestible protein, and consequently no other animal is able to provide so much material to build human tissues. The fishing industry still has the important advantage, compared to animals cultured on land in inland or marine waters, it does not produce litter and problems of diseases while providing food supply. With the increase of the population, the consumption of natural resources is growing.

The planning of tourism infrastructure on the coasts is a source of conflict of interest. Tourism has a significant impact on the coastal environment, often in conflict with fishing. It requires a lot of space, significant water consumption and discharge of large amounts of wastewater, thereby exerting an impact on the marine ecosystem. The pressure exerted by the tourism sector is, however, seasonal in nature, which in the Baltic region lasts during the summer months.

The extraction of sand and gravel from the Baltic Sea bottom is carried out on a small scale and takes place mainly for earthworks, road construction, beach reconstruction and construction in ports and coastal areas. Nevertheless, it should be noted that the extraction of sand and gravel from the sea affects the change of currents, sedimentation and causes local hypoxia. As a consequence, it affects marine organisms, marine vegetation and on the scope of erosion, which in turn has a negative impact on fishing, nature, tourism and recreation.

Wind energy is renewable energy source, requiring large sea areas. Knowledge about the impact of wind farms on the environment is still small, but the wind farms can potentially disrupt hydrological processes in the sea by changing currents, translocating sediments and marine organisms. The cumulative impact of wind farms (noise caused by turbines, vibrations) can negatively affect fish and other marine organisms.

Coastal regions of the Baltic Sea are the subject of development of shore infrastructure, and its greatest intensity takes place in urban areas or in their vicinity. Urban and industrial buildings, bridges, dams, coastal defence, summer houses and other types of coastal or offshore structures occupy more and more areas, which can have an intensive impact on the environment, fishing, navigation, tourism and recreation.

Areas relating directly to the marine environment are also military zones and units. They may cause environmental pressure in the form of water pollution by oil derivatives, animal disturbance and increased noise emission. However, areas of military activity are subject to mid-intensive exploitation and thus have high natural value. In densely populated areas, polygons are often the only areas on which protected zones could be designated.

From the economic point of view, hydrocarbon extraction is of the greatest importance for human activities at sea, and results from macroeconomic factors such as economic growth that increases the demand for energy fuels, or international obligations, among others reduction of $CO_2$ emissions.

In addition to the pressure exerted by offshore activities, the Baltic ecosystem may be exposed to additional pressures stemming from external sources such as communal sector, agriculture, industrial pollution or climate change. Waters of some rivers entering the Baltic Sea, may also contain nutrients contributing to eutrophication, pesticides, heavy metals, chemicals that after penetrateing into fish, shellfish, etc. pose a threat to human.

## 5.9. Analysis of the costs of degradation of marine environment

The cost of degradation of marine environmernt means a decrease in the society's benefits resulting from the deterioration of the environment. Degradation causes many negative, adverse effects that directly or indirectly affect human, and may include:

1) increasing water turbidity, more frequent occurrence of algae and oxygen deficiencies at the bottom;
2) reduction of fish stocks;
3) contamination of fish and seafood;
4) loss of marine biodiversity.

The noticeable effects of degradation are expressed in limiting the recreational use of beaches and sea, reducing the quantity and deterioration of the quality of fish and seafood, adverse impact on human health, reducing biodiversity of the ecosystem, reducing the use of present and future marine ecosystems. The degradation of the marine environment is noticable when the supply of goods and services of the Baltic Sea ecosystem is limited.

As previously indicated, the objective of protecting marine waters is to achieve good status (GES), i.e. to protect and preserve the marine environment, prevent its degradation or, where possible, restore ecosystems where they have been adversely affected; prevent and gradually eliminate pollution of the marine environment in order to exclude a significant impact on marine biodiversity, marine ecosystems, human health and legal forms of sea use, or a significant threat to them. When applying an ecosystem-based approach to manage human activities while enabling the sustainable use of marine resources and services, priority should be given to actions to achieve or maintain a good marine environment, to further protect and preserve, and to prevent further deterioration. The diversity of the conditions, problems and needs of different marine regions or subregions that make up the marine environment makes it necessary to introduce different, specific solutions. This diversity should be taken into account at all stages of preparation of marine strategies, but especially during the preparation, planning and implementation of measures aimed at achieving good environmental status of the marine environment. Thus, the cost of degradation can be expressed by changing the well-being of people resulting from the "departure" from the current or initial state of the marine environment.

According to the European working group established for the implementation of MSFD, the so-called "Working Group of Economic and Social Analyzes" has three main approaches to assess the costs of degradation:

1) Ecosystem Service Approach including:
   a) defining th good environmenta status (GES) and baseline/reference point (BAU Scenario) and differences in terms of ecosystem services;
   b) describing the consequences for the well-being of people.
2) A thematic approach that includes:
   a) identification of the causes of degradation (e.g. eutrophication);
   b) determination of current and the target status (e.g. GES, threshold values of indicators);
   c) describing the consequences for the well-being of people.
3) A cost-based approach that includes an assessment of the cost of current measures implemented to prevent the degradation of the marine environment.

The most ambitious is the ecosystem approach, followed by a thematic approach, and than by a cost-based approach. All approaches require a kind of assessment of resutlts for human well-being. The ecosystem and thematic approach include valuation of benefits lost if the condition does not improve, while the cost-based approach focuses on the costs planned to implement the measures/actions. Thus, the cost-based approach indicates what measures are necessary to improve the state of the sea. The cost-based approach can be used as an approximation to the costs of degradation, when a thematic approach or an ecosystem approach can not be applied.

## 5.10. Identification of good environmental status, that should be achieved in 2020, and reference point (BAU scenario)

***Identification of good environmental status, that should be achieved in 2020 - established environmental targets for marine waters***

The key element for achieving the MSFD targets is to obtain information on the current state of the marine environment. According to art. 8 MSFD, all contracting countries, including Poland, were obliged to carry out both an initial assessment of the state of their marine waters, as well as establish the criteria for good environmental status (Annex 1 to MSFD). In Poland, an initial assessment of the state of the marine environment was performed on the basis of which a set of environmental targets for marine waters was developed for 11 status or pressure descriptors, which are:

- ✓ D1 Biodiversity (status descriptor)

Environmental target: Reducing or maintaining anthropogenic pressure at the current level, ensuring the maintenance of natural habitats in which natural biodiversity of existing biotic elements is preserved and protection of habitats within Natura 2000 protected areas is ensured.

- ✓ D2 Non-indigenous species (status descriptor)

Environmental target: Non-indigenous species introduced as a result of human activity are at levels that do not change the ecosystem structure.

- ✓ D3 Commercially exploited fish and shellfish (state descriptor)

Environmental target: The goal is to maintain a population of commercially exploited fish and shellfish within safe biological limits corresponding to natural conditions by limiting anthropogenic pressures, i.e. establishing catch limits guaranteeing the maximum sustainable yield of the species exploited.

- ✓ D4 The food web (state descriptor)

Environmenta target: By 2020 achieving a state when the pressure exerted by man does not cause changes in the environment in which all elements of the marine food webs show a natural and stable level of abundance and diversity, to the extent known so far.

- ✓ D5 Eutrophication (pressure descriptor)

Environmental target: Baltic Sea, including Polish Baltic areas, do not show significant effects of eutrophication caused by human activity, i.e. marine environment not threatened by eutrophication.

- ✓ D6 Seafloor integrity (state descriptor)

Environmental target: The goal is to achieve the level of the seafloor integrity, ensuring the protection of the structure and functions of ecosystems, where no negative impact of human activity is observed, especially on bottom ecosystems.

- ✓ D7 Hydrographic conditions (state descriptor)

Environmental target: Minimazing activities affecting the change of hydrographic conditions guaranteeing lack of their adverse impact on marine ecosystems and taking measures to improve hydrographic conditions in areas of permenent alteration.

- ✓ D8 Hazardous substances and their effects (pressure descriptor)

Environmental target: To reduce or maintain at the current level the input of hazardous substances introduced into the marine environment from various marine and land sources, in order to achieve or maintain concentrations of hazardous substances in the biotic and abiotic elements of marine ecosystem at levels not exceeding the limit values below which the probability of occurrence of undesirable effects of hazardous substances on marine organisms is minimal and which are consistent with the recommendations of the applicable national and international legislation and which guarantee the achievement of good environmental status.

- ✓ D9 Hazardous substances in fish and seafood for human consumption (pressure descriptor)

Environmental target: To reduce or maintain at the current level the input of hazardous substances introduced into the marine environment from various marine and land sources, in order to achieve or maintain concentrations of hazardous substances in fish and seafood for human consumption at levels not exceeding the admissible values, which comply with the standards and recommendations of applicable national and international legal acts and which guarantee the achievement of good environmental status.

- ✓ D10 Marine litter (pressure descriptor)

Environmental target: Reduction of the amount of newly emerging or deposited solid litter in the marine environment, coming from various sources, to levels guaranteeing the proper functioning of the ecosystem, taking into account its natural resilience, or to completely eliminate newly emerging litter.

- ✓ D11 Underwater noise (pressure descriptor)

Environmental target: Achieving the underwater noise level that guarantees the proper functioning of marine organisms by taking measures to limit the sources and intensity of noise and by defining protection and buffer zones with a ban on noise-generating activities.

Due to the complexity of procedure for setting specific criteria to define environmental targets, for some of the above descriptors, targets have been defined in a descriptive way. In some cases indicators or specific limit values have been developed or sets of actions recommended by international organizations have been prepared, such as Oceana, WWF, The Fisheries Secretariat (FISH), Ocean Care, Coastwatch Europe, Seas At Risk, Swedish Society for Nature Conservation, Marine Conservation Society, and included in multilateral environmental agreements. Environmental targets should be quoted in accordance with the Regulation of the Minister of the Environment of 17 February 2017 on the adoption of a set of environmental objectives for marine waters (Journal of Laws, item 593).

***BAU scenario***

The BAU scenario aims to determine the expected changes in the state of the environment, the socio-economic and legal situation related to the marine environment, at a given time, in the absence of measures related to the implementation of MSFD. BAU is fundamental to determining the difference between the values characterizing a given sector before and after implementation of activities. In accordance with the guidelines "Working Group on Economic and Social Assessment Economic and Social Analysis for the Initial Assessment for the Marine Strategy Framework Directive: A Guidance Document", established at the European Commission, the analyzes should concern 2020 and, when justified, where relevant data and strategies are available, the date of later.

Since in Poland at the end of 2016, the BAU Scenario was adopted at KPOWM, taking into account the requirements of MSFD and the abovementioned guidelines, it was decided to transfer the assumptions contained mainly in the BAU published in the KPOWM to this assessment. The scenario has been updated based on reliable data for 2011-2016. The description refers to the main sectors that both exert pressure and influence particular indicators (descriptors), as well as the receivers of activities the included in KPOWM. These sectors include:

1) shipping;
2) sea ports;
3) sea fisheries;
4) tourism and recreation;

5) agriculture.

**Shipping and sea ports**

The sea transport fleet includes two main branches, i.e. freight and passenger traffic. Maritime transport generates various pressures also on the waters of the Baltic Sea. The description of the sector was made in chapter 5.3, and in this part it was extended with the issue of forecasted changes in the BAU scenario.

The quantities characterizing maritime transport are presented in two time variants: current state, i.e. 2016, and the forecasted state in 2020. According to data of GUS, in 2016, the marine transport fleet was 96 vessels with a total capacity of 2385.1 thous. tonnes. The sea transport fleet operated by shipowners and Polish operators are mainly ships for the transport of solid cargo (75). The transport fleet also includes tankers (4), ferries (7), passenger ships (3) and sea yachts (5).

**Passenger transport**

According to data of Statistics Poland (GUS), in 2016, a total of 2 601 707 passengers were transported by the sea fleet. The intensity of passenger traffic is constantly growing every year.

**Freight transport**

In 2016, the transport fleet transported 7248.2 thous. tonnes of cargo, ships flying the Polish flag - 648 thousand tonnes and 6600.2 thousand tonnes by ships flying foreign flag.

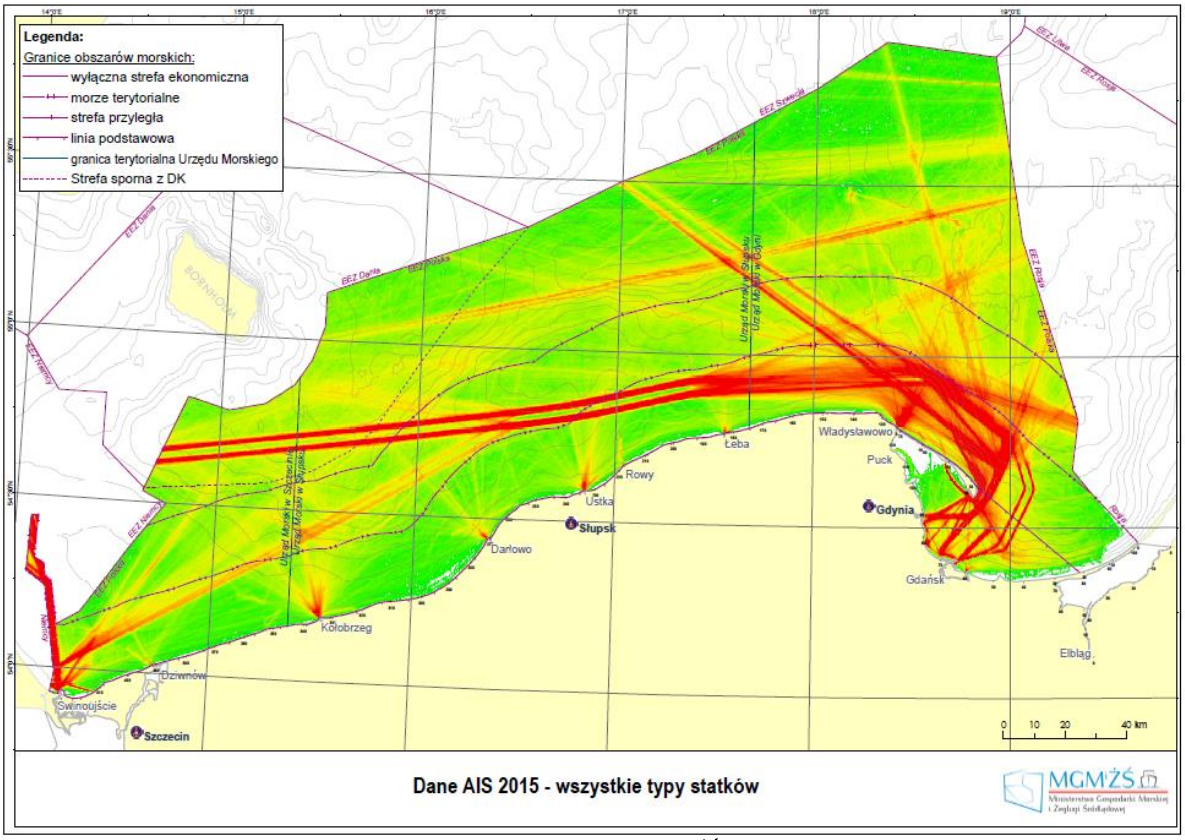
**Shipping in Polish Maritime Areas (POM)**

Information on the traffic of ships is obtained from the vessel traffic monitoring database of the AIS system. This system is installed on larger vessels, on all passenger ships, and also voluntarily on many smaller ships and yachts, in accordance with the requirements of the International Convention for the Safety of Life at Sea, 1974 (SOLAS Convention), and is a gear to support navigation systems to prevent collisions.

The main routes on which the ships navigate in POM are:

1) a route south of Bornholm leading to the Polish and Russian ports of the southern Baltic;
2) route south of the Southern Central Bank, connecting Klaipeda with the ports of the southern Baltic - mainly the ports of Świnoujście, Sassnitz and Mukram. The main users of this route are goods-railway ferries (Mukram-Klaipeda) and cargo ships;
3) route leading the movement of ships from the Pomeranian Bay and the Szczecin-Świnoujście port complex towards the Danish Straits. After leaving the fairway to Świnoujście, the ships go northwest to the port of Ystad or towards the Danish Straits;
4) route from south to north passing west of Bornholm. It connects the ports of Świnoujście and Karlshamn in Sweden. Mainly used by passenger and cargo ferries, special ships and other destinations. [73]

[73] SUZPPOM with spatial analysis, Gdańsk, 2015




Source: data provided by the Department of Maritime Economy MGMiŻŚ

Fig.5.10.1 The intensity of vessel traffic at POM in 2015.

The improvement of the competitiveness of Polish ports on the Baltic and European port services market is a priority of the Ministry of Maritime Economy and Inland Navigation. Investments in port infrastructure and port access infrastructure from the sea and land allow their development, attracting private entrepreneurs, including foreign ones, to Polish seaports. Ports are an important element of the maritime economy as well as the transport economy, and now they are also becoming an important element of tourism.

**Ports - passenger transport**

In 2016, according to GUS, in Polish seaports 1933,480 thousand people began or ended their foreign international journey. Every year, the number of passengers who finish or start their international journey in Polish seaports is growing.

**Ports - freight transport**

The cargo turnover at seaports, which means the total amount of cargo moved across ports in a given period of time, slightly decreased in 2001 compared to the previous year (by 0.2%), and then by 2004 gradually increased, showing annual average growth rate of 6.0% and reached in total 56 917.9 thousand tonnes. From 2005 to 2009 there was a systematic decrease in turnover (on average by 4.6% per year), reflecting the global economic crisis and in 2009 the cargo turnover of Polish ports was the lowest in the period 2000-2015.[74] In 2016, the cargo turnover of seaports reached level 72926.2 thous. tonnes and was the highest in the last fifteen years.

**BAU scenario**

The table below presents more detailed data and forecasts for the Port of Szczecin and Świnoujście, including sea transport and inland navigation.

[74] KPOWM - Report to the European Commission. Warsaw, 2016

Table 5.10.1 Passenger traffic forecast for 2020 and 2030

| | 2016 | 2020 | 2030 |
|---|---|---|---|
| Szczecin i Świnoujście | 1 117 500 | 1 150 000 | 1 380 000 |
| Gdańsk | 228 400 | 230 000 | 235 000 |
| Gdynia | 733 400 | 750 000 | 1 000 000 |
| Polska | 2 601 700 | 2 650 000 | 2 700 000 |

Source: MGMiŻŚ own estimates based on data received from ZMPSiŚ S.A., ZMPG S.A. and ZMPG-a S.A.

It should be noted that passenger traffic in Polish seaports is constantly growing. Small and medium-sized ports are characterized by passenger traffic in a quantity comparable to the one for Gdańsk North Port. The constant development of port infrastructure will be conducive to a further increase in passenger traffic in ports of key importance for the national economy.

Table 5.10.2 Forecast of the volume of trans-shipment turnover in thous. tonnes

| | 2016 | 2020 | 2030 |
|---|---|---|---|
| Szczecin i Świnoujście | 21 483.5 | 25 477.0 | 31 749.0 |
| Gdańsk | 31 566.2 | 54 750.1 | 99 643.7 |
| Gdynia | 17 751.1 | 23 500.0 | 38 380.0 |
| Polska | 72 926.2 | 105 000.0 | 175 000.0 |

Source: MGMiŻŚ own estimates based on data received from ZMPSiŚ S.A., ZMPG S.A. and ZMPG-a S.A.

Table 5.10.3 Transshipment forecast in the Szczecin-Świnoujście port complex by 2030 in thous. tonnes

| Load group forecast | | 2017 | 2018 | 2019 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| coal and coke | minimum | 4 087 | 4 087 | 4 087 | 4 087 | 4 646 | 5 487 |
| | maximum | 4 903 | 5 001 | 5 101 | 5 203 | 6 329 | 7 595 |
| metal ores | minimum | 1 763 | 1 710 | 1 676 | 1 659 | 1 578 | 1 499 |
| | maximum | 2 156 | 2 146 | 2 135 | 2 124 | 2 072 | 2 020 |
| oil and its products | minimum | 1 729 | 1 756 | 1 783 | 1 810 | 1 946 | 2 081 |
| | maximum | 1 872 | 1 935 | 1 998 | 2 060 | 2 374 | 2 688 |
| liquid gas | minimum | 1 500 | 1 750 | 2 000 | 2 250 | 3 500 | 4 750 |
| | maximum | 2 200 | 2 800 | 3 400 | 4 000 | 5 607 | 7 215 |
| grain and agricultural products | minimum | 1 784 | 1 820 | 1 856 | 1 894 | 2 091 | 2 297 |
| | maximum | 2 053 | 2 177 | 2 306 | 2 441 | 3 060 | 3 524 |
| other bulk cargoes | minimum | 3 187 | 3 267 | 3 349 | 3 432 | 3 884 | 4 361 |
| | maximum | 3 250 | 3 348 | 3 448 | 3 586 | 4 363 | 5 226 |
| containerized loads | minimum | 706 | 720 | 734 | 748 | 823 | 902,2 |
| | maximum | 1 157 | 1 336 | 1 531 | 1 741 | 3 077 | 4 757 |
| break bulk cargo from ferries ro-ro | minimum | 7 125 | 7 231 | 7 327 | 7 415 | 7 775 | 8 074 |
| | maximum | 8 123 | 8 387 | 8 646 | 8 861 | 9 642 | 10 397 |
| other break bulk cargo | minimum | 2 181 | 2 181 | 2 181 | 2 181 | 2 181 | 2 181 |
| | maximum | 2 361 | 2 408 | 2 456 | 2 506 | 3 018 | 3 323 |
| Total | minimum | 24 064 | 24 522 | 24 993 | 25 477 | 28 423 | 31 749 |
| | maximum | 28 075 | 29 537 | 31 020 | 32 523 | 39 541 | 46 636 |

Source: Data from ZMPSiŚ S.A.

Table 5.10.4 Transshipment forecast in the Port of Gdynia by 2030 in thous. tonnes

| | 2020 | 2027 | 2030 |
|---|---|---|---|
| Oil and its products | 1 670.0 | 2 100.0 | 2 400.0 |
| Liquefied gas | 30.0 | 400.0 | 400.0 |
| coal and coke | 1 500.0 | 1 700.0 | 2 100.0 |
| Ore and scrap | 0.0 | 0.0 | 80.0 |
| Agricultural products | 400.0 | 4 500.0 | 4 900.0 |
| Other bulk cargoes | 1 200.0 | 1 500.0 | 1 500.0 |
| Other break bulk cargoes | 600.0 | 800.0 | 800.0 |
| Containerized loads | 8 250.0 | 12 370.0 | 16 490.0 |
| Ro-ro loads | 2 420.0 | 3 220.0 | 3 330.0 |
| Total | 19660.0 | 26590.0 | 32000.0 |

Source: Data from ZMPSiŚ S.A.

Table 5.10.5 Transshipment forecast in the Port of Gdańsk until 2030 in thous. tonnes

| | 2020 | 2030 |
|---|---|---|
| Containers | 22 295.2 | 45 912.4 |
| Mass liquid | 20 205.7 | 28 364.7 |
| Mass dry | 10 054.8 | 18 640.4 |
| Others | 2 194.5 | 6 726.2 |
| Total | 54 750.1 | 99 643.8 |

Source: Data from ZMPSiŚ S.A.

Table 5.10.6 Transshipment forecast in ports of the Maritime Office in Słupsk (Kołobrzeg, Darłowo, Ustka) in thous. tonnes

| Transport type | 2020 | 2025 | 2030 |
|---|---|---|---|
| maritime cargo transport | 320.0 | 360.0 | 400.0 |

Source: Data from the Maritime Office in Słupsk

The port market in Poland has recorded a systematic increase in trans-shipment turnovers over the past years. The Port of Gdańsk has been recording record-breaking transshipments for several years. Larger transhipments show an increase in the competitiveness of Polish ports in the Baltic Sea region and better communication with the hinterland thanks to many infrastructural investments in ports. It can be assumed that, if the current growth rate of cargo traffic is maintained, total transshipment will be expected to increase to 105 million tonnes in 2020. Trends in global maritime transport indicate a steady development in the transport of cargo in containers and an increase in the size of vessels. The increase in cargo traffic will result in the need to launch new shipping connections and increase ship traffic on the Baltic Sea.

## I. Sea fishing

The national fishing fleet in 2016 consisted of 843 vessels (by 3.8% less than in 2015). In the years 2000-2002, the national fishing fleet was divided into subgroups according to the total length: trawlers - over 30 m to under 40 m; cutters - from 15 m to below 30 m; boats - less than 15 m. This division was used for the record of fishing vessels kept by district inspectors of sea fishing. At present, in accordance with the Act of 19 December 2014 on sea fishing, the fishing fleet is divided into segments by fishing areas, and in practice also the division by length of the total fishing vessel is applied.

The general fishing quotas in the Baltic Sea set for Poland by the EU Council are set out in Council Regulation (EU) 2015/2072 of 17 November 2015 fixing for 2016 the fishing opportunities for certain fish stocks and groups of fish stocks applicable in the Baltic Sea and amending Regulations (EU) No 1221/2014 and (EU) 2015/104 are subject to catch limits, which Polish fishermen do not fully use. In 2016, 725 special fishing permits were issued to ship owners in Poland authorizing them to fish in the Baltic Sea

### Restocking

Pursuant to Article 98 para. 1 of the Act of 19 December 2014 on sea fishing, maintenance and restoration of fish stocks in POM is carried out by restocking of these areas carried out by the minister responsible for fisheries. According to art. 98 para. 2 of the Act the costs of restocking of POM are incurred annually by the state budget, the part of which is administered by the minister competent for fisheries.

The purpose of restocking results from the need to maintain species of diadromous fish that are valuable to Polish fisheries, such as, for example, sea trout and salmon. In the past, these species were present in many Polish rivers and within POM. The current state of resources of at least several species of diadromous fish requires restocking to support their populations. The restocking of Polish marine areas is carried out on the basis of the restocking plan prepared by the Fish Restructuring Team appointed by the minister responsible for fisheries.

Restocking is performed as part of the task "Restocking of Polish marine areas" in the Vistula and Oder river basin districts, Pomeranian rivers and marine waters, especially with salmon and sea trout, as well as vimba bream, common whitefish and sturgeon species. The restocking is carried out in batches so that the quantity and range of released fish can be controlled on a regular basis in accordance with the restocking plan.[75]

Table 5.10.7 Financing the "Restocking of Polish sea areas" task in 2011-2016

| Year | Amount allocated for the whole task (PLN) |
|---|---|
| 2011 | 4 614 000 |
| 2012 | 5 000 000 |
| 2013 | 5 000 000 |
| 2014 | 4 852 000 |
| 2015 | 4 852 000 |
| 2016 | 5 000 000 |

Source: data was received from the Department of Fisheries of MGMiŻŚ

### Impact on port operations and on sectors of other sectors of the economy

Fisheries interact with various areas of maritime economy. Displacement by infrastructure and shipping is one of the major factors affecting fishing, as well as restrictions generated by protected areas. Fishing is at the heart of port development, especially for ports from outside the largest group.[76]

A cutter is a fishing vessel having a continuous deck, the total length of which is more than 15 m and not more than 30 m, and the main propulsion power does not exceed 611 kW. The

[75] KPOWM- Report to the European Commission. Warsaw, 2016

[76] Maritime Institute in Gdańsk, Independent Spatial Policy Studio, SUZPPOM with spatial analysis, Gdańsk, February 2015

largest number of fishing vessels based on statistical data is stationed in the ports of Władysławowo (37 in 2016), Ustka (20 in 2016) and Kołobrzeg (18 in 2016), and according to the provisions of the PO RYBY 2014-2020, almost half landings take place in the port of Kołobrzeg and Władysławowo. Detailed data regarding the boat fleet is included in the table below.

Table 5.10.8 Cutter fleet by registration ports

| SPECIFICATION | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| TOTAL | marine vessels | 143 | 140 | 139 | 139 | 139 | 126 |
| | Total Gross Capacity (GT) in thous. | 11.6 | 11.6 | 12.2 | 12.3 | 12.5 | 12.1 |
| | horsepower in thous. kW | 37 | 36.2 | 36.2 | 36.2 | 36.2 | 34.3 |
| Świnoujście | marine vessels | 3 | 3 | 3 | 3 | 3 | 3 |
| | Total Gross Capacity (GT) in thous. | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| | horsepower in thous. kW | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Dziwnów | marine vessels | 6 | 6 | 6 | 7 | 7 | 7 |
| | Total Gross Capacity (GT) in thous. | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 |
| | horsepower in thous. kW | 1.4 | 1.4 | 1.4 | 1.5 | 1.5 | 1.5 |
| Kołobrzeg | marine vessels | 18 | 18 | 17 | 17 | 17 | 18 |
| | Total Gross Capacity (GT) in thous. | 2.1 | 2.2 | 2.3 | 2.3 | 2.4 | 2.5 |
| | horsepower in thous. kW | 6 | 6 | 6 | 5.9 | 5.9 | 6.2 |
| Darłowo | marine vessels | 10 | 10 | 10 | 10 | 10 | 4 |
| | Total Gross Capacity (GT) in thous. | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.1 |
| | horsepower in thous. kW | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 0.5 |
| Ustka | marine vessels | 26 | 27 | 27 | 25 | 25 | 20 |
| | Total Gross Capacity (GT) in thous. | 1.8 | 2 | 2.1 | 1.8 | 1.8 | 1.6 |
| | horsepower in thous. kW | 5.3 | 5.7 | 5.7 | 5.2 | 5.2 | 4.4 |
| Łeba | marine vessels | 10 | 10 | 10 | 10 | 10 | 9 |
| | Total Gross Capacity (GT) in thous. | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| | horsepower in thous. kW | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.6 |
| Władysławowo | marine vessels | 39 | 36 | 36 | 38 | 38 | 37 |
| | Total Gross Capacity (GT) in thous. | 4.2 | 4 | 4.2 | 4.5 | 4.5 | 4.4 |
| | horsepower in thous. kW | 11.7 | 10.9 | 11 | 11.7 | 11.7 | 11.2 |
| Jastarnia | marine vessels | 14 | 14 | 14 | 14 | 14 | 12 |
| | Total Gross Capacity (GT) in thous. | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.5 |

| SPECIFICATION | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| | horsepower in thous. kW | 3 | 3 | 3 | 3 | 3 | 2.7 |
| Hel | marine vessels | 8 | 8 | 8 | 8 | 8 | 9 |
| | Total Gross Capacity (GT) in thous. | 1 | 1 | 1.1 | 1.2 | 1.2 | 1.3 |
| | horsepower in thous. kW | 3 | 3 | 3 | 3 | 3 | 3.4 |
| Gdańsk Górki Zachodnie | marine vessels | 4 | 4 | 4 | 4 | 4 | 4 |
| | Total Gross Capacity (GT) in thous. | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| | horsepower in thous. kW | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Gdańsk Górki Wschodnie | marine vessels | 1 | 1 | 1 | 1 | 1 | 1 |
| | Total Gross Capacity (GT) in thous. | 0 | 0 | 0 | 0 | 0 | 0 |
| | horsepower in thous. kW | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Gdańsk | marine vessels | 4 | 3 | 3 | 2 | 2 | 2 |
| | Total Gross Capacity (GT) in thous. | 0.3 | 0.3 | 0.3 | 0.2 | 0.2 | 0.2 |
| | horsepower in thous. kW | 1.1 | 0.9 | 0.9 | 0.6 | 0.6 | 0.6 |

Source: Own study based on "Statistical Yearbook of Maritime Economy 2015. GUS" for 2011, Table 8.3, "Statistical Yearbook of Maritime Economy 2016. GUS" for 2012. Table 8.3 and "Statistical Yearbook of Maritime Economy 2017. GUS" for 2013-2016, Table 8.3.

**BAU scenario**

Fisheries depend to a large extent on the condition of the environment – resources of fish stocks. The fish quotas, that take into account the size of the resources and depend on the size of fish stocks are the gear that affects the sector of fisheries. The development of fish stocks depends on the state of the environment, e.g. salinity. The variability of the environment is practically impossible to forecast. For example, in 2015, there was an inflow of saline waters into the Baltic Sea from the North Sea, which created better conditions for the development of cod and bottom ecosystems.[77] Therefore, the following trends were described which concern fisheries and which are not directly dependent on the state of the environment.

Polish fishing vessels go to the sea to catch three main fish species, namely sprat ,herring and cod. Each of these species is covered by catch limits.

Another argument for the precautionery approach for the forecasts of the fisheries sector in Poland is the lack of a state strategy for this sector. At present, the Ministry of Maritime Economy and Inland Navigation is working on the preparation of change to the PO RYBY project 2014-2020. The subject of the proposed changes is, among others relocation of funds from Priority 2 Supporting environmentally sustainable, resource-efficient, innovative, competitive, knowledge-based aquaculture - for Priority 1 Promoting environmentally sustainable, resource-efficient, innovative, competitive and knowledge-based fisheries. At present, the draft of the PO RYBY 2014-2020 has been forwarded to informal consultations with the EC.

Based on the analysis of historical data, it can be assumed that the amount of fish catches will not increase significantly. It is most probable to assume the stable catch sizes in the future. Of course, some fluctuations may occur, but they will not be significant. It should also be noted that in the years 2010-2013, most of fishing quotas were not fully utilized.[78]

[77] http://www.baltyk.pogodynka.pl/ftp/img/oc/luty_2015-MBI.pdf

[78] https://mgm.gov.pl/rybolowstwo/rybolowstwo-morskie/statystyki-polowow/

The fisheries sector is changing gradually: there is a replacement of old vessels and the purchase of new ones. In relation to the work on the implementation of PO RYBY 2014-2020, it can be expected that the number of fishing vessels will not increase significantly, but their average age will decrease. It is also possible to predict an increase in the cost effectiveness of fishing activity, however, there is a risk that in the near future (until 2020), relatively new cutters will be scrapped, so that the average age of vessels will continue to increase.[79]

A detailed discussion questioning the concept of BAU for fisheries can be found in chapter 5.7 Identification of good environmental status, that should be achieved in 2020 and in BAU scenario part of subsection III. Agriculture, pargraph: Sea fishery.

### II. Tourism and maritime recreation

Tourism is a sector that is in constant development and has been growing continuously for years. The maritime and coastal tourism sector is spatially diversified and includes leisure tourism (recreation), active and spa tourism.

The coastal communes constitute over 22% of all accommodation facilities in Poland and over 1/4 of all accommodation places in Poland. In 2011-2015, the number of tourists increased. According to GUS publication "Tourism in 2016": As of 01/01/2016, there were a total of 2,478 communes in Poland, of which 55 according to the Eurostat methodology were classified as coastal areas (coastal areas cover municipalities situated at the sea or in its vicinity). They cover the area of 7 891 km$^2$ (2.5% of Poland) and are situated at the Baltic Sea or in its vicinity. They consisted 2,299 - 22.7% of all tourist accommodation facilities. For every 100 km$^2$ there were 29 objects in this area (average for Poland is 3). Among them, 901 objects are guest rooms, and 26.2% of all places in accommodation facilities were located in seaside communes. In the light of GUS data, the overnight stay index in hotels in the period 2004-2016 has been systematically growing. Tourists increasingly choose hotels as accommodation during trips. It enabled the development of a hotel-type accommodation base and improvement of the financial situation of households. The main group using the accommodation base in the coastal areas in the summer season of 2016 were national tourists - 1,203.1 thous. persons (by 52.8 thousand more than in the previous year). Foreign tourists using accommodation in coastal areas constituted 17.5% of all foreign tourists in the accommodation base during the summer of 2016 - 260.3 thousand, i.e. by 13.0 thousand more than in the previous year. In addition, in the coastal areas, the dynamics of the number of tourists (104.7%) and overnight stays (104.5%) were higher than the rate of growth of new facilities (101.9) and beds (103.4%). The largest among seaports in terms of the number of border crossings are: Gdańsk (Nowy) Port - 31.8 thousand, (decrease by 6.2% compared to 2015), Gdynia - 31.7 thousand, (decrease by 5.8% compared to 2015), Szczecin Port - 21.1 thousand, (increase by 13.2% compared to 2015), Kołobrzeg - 18.7 thousand, (decrease by 0.3% compared to 2015). In 2016, at the maritime border (in and from Poland), 1,933,500 crosses were recorded and this was 4.4% more than in 2015. The number of crossings by Polish residents throuigh this section of the border amounted to 1 126.5 thousand, which is an increase of 3.5% compared to 2015. During the summer (in July and August) the most accommodation, among 16 voivodeships, was granted in the following: Pomeranian - 46.0%, Warmian-Masurian - 42.2% and West Pomeranian - 37.3%.[80]

The “Tourism Development Program 2020”, prepared by the Ministry of Sport and Tourism indicated that the potential of the tourism sector is underused. This is especially true for the unused accommodation base. However, there is a very slow increase in the use of hotel base from 33.7% in 2013 to 34.7% in 2014. Similarly, the use of other tourist accommodation facilities increased from 34% to 35% in 2013 and 2014.

The dynamically developing activities of tourists are certainly:

1) board sports (kitesurfing, windsurfing, Stand Up Paddle Board (SUP)),
2) sea and coastal recreation,
3) sea and coastal fishing.

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[79] Ex-ante assessment PO RYBY 2014-2020. Report, Annex to the PO RYBY 2014-2020

[80] Tourism in 2016, GUS, Warsaw, 2017

**BAU scenario**

Global trends predict further development of tourism (the average annual growth of the tourist sector in the world is 3%).[81]. Development is also foreseen in Poland, including in the coastal regions, which is conditioned by the high potential of Polish tourism (including unused accommodation) and the effect of implementing the 500+ program.

Expansion is expected in terms of the increase in the number of overnight stays with very slow increase in the use of place in accommodation facilities, as well as the growing importance of water sports, especially in the area of the Gulf of Gdańsk and the Gulf of Puck. This will reduce the disproportion in accomodation occupancy between summer and the remaining months of the year. Fishing development is also expected. The state of income of tourists is of fundamental importance in the case of angling, as it is valued as higher than the value of recreation in the form of hunting for large game.[82] Another argument is the fact that sea fishing was defined in the PO RYBY 2014-2020 as an opportunity for fishing in Poland. It results directly from the possibility of fishermen retraining and finding another source of income. It was recommended to limit the amount of funds in the Program to the action of permanent cessation of fishing activities, for diversification within the framework of fisheries and the creation of jobs in fishery areas.[83]

### III. Agriculture

Agriculture is a sector of the economy that is not included in the maritime sector but can have a significant impact on the elements of the marine environment. Agriculture, next to the municipal sector, may cause emissions of nutrients to rivers and to the Baltic Sea.

When it comes to the emission of nutrients, fertilization plays a key role. According to GUS data (Table 5.5.30), the consumption of nitrogen and phosphorus varies. The declines in 2013-2014 of the size of fertilizers used may result from the reduction of the absorption of EU funds in agriculture and the information campaign conducted by the Ministry of Agriculture and Rural Development.

**BAU scenario**

Agriculture is a sector strongly affecting the level of nutrients discharged from land areas to the Baltic Sea. No major changes are expected in the structure of farms until 2020. It is possible that the number of the smallest farms (<5 ha) will decrease in favor of larger ones, which will result in a larger average size of farms and a slightly higher number of units in larger acreage groups, but exact values are difficult to estimate.

It is expected that the amount of fertilizers used will increase compared to 2012 (consumption at the level of 76.6 kg N/ha and 24.6 kg P/ha). According to the BAU contained in the KPOWM approved in 2016, by 2020 an increase of 5% in nitrogen and phosphorus consumption is assumed, to average doses of approx. 80 kg N/ha and 26 kg P/ha in 2020. Furthermore, the trend for phosphorus may also be appropriate due to the much lower fertilizer consumption in Poland compared to EU countries. It should be emphasized, however, that the use of fertilizers alone does not indicate their impact on the status of waters. Properly used fertilizers (at the right dose and the right time) do not have to have a negative impact on the environment. The role of fertilizers is to provide plants with the right amount of nutrients. Therefore, to assess the impact of crop and animal production on water, it is necessary to review the methodologies used so far to determine the impact of this sector on the state of the environment. Bearing in mind the above and planned measures to limit the outflow of nitrates from agricultural sources to waters in connection with the publication of the Water Law Act, a

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81 Tourism development program until 2020, Warsaw, 2015

82 S. Kasiewicz, W. Rogowski, Inwestycje hybrydowe – nowe ujęcie oceny efektywności, Szkoła Główna Handlowa w Warszawie – Oficyna Wydawnicza, Warszawa 2009

83 Ex-ante assessment PO RYBY 2014-2020. Report, Annex to the PO RYBY 2014-2020

significant reduction in the impact of agriculture on the water status in the context of N and P emissions is to be expected. and thus the status of pressure Descriptor D5 eutrophication.[84]

***Description of the gaps between the scenarios***

The analysis and description of the gaps between the scenarios in this chapter was based on KPOWM. In order to eliminate the gaps in achieving the assumed environmental targets, it is necessary to implement the measures planned for the years 2016-2020 and described in detail in the KPOWM. Additional benefits for the environment will be achieved by implementing the assumptions of the next KPOŚK update and implementation in the whole country of a single program of measures aimed at limiting the pollution of waters with nitrates of agricultural origin.

Prediction of future values is subject to risk, which can be seen on the example of forecasts for maritime shipping prepared in other strategic documents. At the moment, increases forecasted for the coming years are already being achieved and the forecasts have been exceeded. Moreover, the source of uncertainty, and hence the gaps in the scenarios, comes from numerous dependencies of market sizes on the behavior of entities on a given market and indirectly outside it. Therefore, to minimize these gaps, the adopted documents, forecasts and strategies for individual sectors should be reviewed.

The gaps between the scenarios also result from the lack of data especially of long time series cause gaps in scenarios and difficulties in the preparation of projected projections of the use of marine waters in future by particular sectors.

In addition, the gaps in the scenarios result from a lack of knowledge. It is necessary to supplement information on various indicators and descriptors, which is of key importance in the analysis, which indirect goal is to achieve the environmental targets set for the Baltic Sea. In addition, there is a lack of full knowledge about the processes taking place between human activities and the marine environment.

It should also be noted that there are no tools or no access to existing tools (due to technical, financial, etc.).

[84] KPOWM - Report to the European Commission. Warsaw, 2016

***A description of the effects on human well-being expressed in monetary terms either quantitatively or qualitatively***

A review of the impact of achievement of GES on welfare in individual sectors analyzed, together with information on the availability of the methodology of valuation prepared under the Helcom HOLAS II[85] project, is presented in the table below.

Table 5.10.9 Review of the hypothetical benefits of achieving GES for the analysed sectors

| Sector | Influence of GES achievement on the change of benefits achieved by the sector | Methodology of respect developed by HELCOM / HOLAS [86] |
|---|---|---|
| shipping | None | Lack of methodology |
| seaports | None | Lack of methodology |
| shipyard industry/shipyards | None | Lack of methodology |
| agriculture | None | Lack of methodology |
| maritime mining industry | None | Lack of methodology |
| sea fishing | expected | Lack of methodology |
| tourism and sea recreation | expected | A calculation for a single year has been prepared, expected |
| military activity | None | Lack of methodology |

Source: Own study

Due to the fact that in only 2 sectors one can expect some influence from achieving GES on the stream of benefits - they will be discussed separately. Lack of methodology of valuation for the vast majority of sectors in the methodical document of the Helcom HOLAS II project should not surprise. Most sectors are simply insensitive to the quality of the Baltic. For example: the condition of shipping depends on the condition of the economy (national, world,) on the competitive environment, but not on the quality of water on which ships sail. Similarly, the situation concerns the activity of seaports, they are exposed to global climate changes - sea level changes, but these are changes of a quantitative and not qualitative nature. The shipbuilding industry reacts exactly the same, significant level changes are key, while water quality is not important. The agricultural sector was included in the list only due to the potential pressure of this sector on the Baltic Sea, but these are one-way pressures. As long as the water from the desalination station (which do not occur on the Polish Baltic coast) will not be used in agriculture, the quality of the Baltic Sea will not affect this sector. One can even risk a reverse hypothesis - a significant improvement in the quality of the Baltic - and especially the return or increase in the number of endangered species (including marine mammals such as harbor porpoises or gray seals) may lead to strengthening the protective regime of selected parts of the Baltic Sea and limiting economic activity or increasing the costs of this activity.

**Sea fishing**

With regard to the fishing sector, the concept of the BAU scenario is totally inadequate, as fishing quotas are set each year and the management of living marine resources is based on the best available scientific knowledge on the state of living marine resources. The institution preparing scientific advice for the main commercial fish stocks is the International Council for the Exploration of the Sea (ICES). It prepares an annual assessment of the state of resources based on scientific research (research cruises), in which scientific units from all countries in the region participate, as well as information provided by fishermen and the administrations of the Member States. STECF (Scientific, Technical and Economic Committee for Fisheries) is also

[85] ECONOMIC AND SOCIAL ANALYSES IN THE BALTIC SEA REGION-Supplementary Report to the First Version of the HELCOM 'State of the Baltic Sea' report 2017

[86] Draft supplementary report on ESA for HELCOM HOLAS II

involved in assessing the state of fish stocks, which prepares an annual report on the current state of fishery resources and its future potential. STECF plays an important role, assisting the European Commission in formulating policy in the field of both long-term planning and emergency closures of fishing areas, issuing a reliable and detailed scientific opinion. This committee is also responsible for consultancy in the field of economics and social issues. Annual resource assessments prepared by ICES and STECF contain a wide analysis of the state of resources used as a basis for the EC to prepare proposals for the division of TAC and quotas and long-term proposals on sustainable fisheries management in European waters. Catch quotas are set annually by an EU Council regulation specifying the catch limit for fish stocks in the Baltic Sea area. These amounts are subject to significant fluctuations year-on-year and there are is no mention on linear extrapolations or the assumption of maintaining any level from a particular year. The basis for determination of quotas is the concept of maximum sustained yield derived from the MSY stock, and in practice there are two further factors: techniques for measuring the size of existing stocks (and more specifically, changing measurement techniques) and political/sector pressure. The scale of changes in year-to-year cycles is presented in the table below.

Table 5.10.10 Overview of changes in total allowable catches (TAC) in 2016 and 2017

| Stock and ICES fishing zone; subarea | 2015 | 2016 | 2017* |
|---|---|---|---|
| Eastern cod stock 25-32 | 100% | -20 % | bz** |
| Western cod stock 22-24 | 100% | -20 % | bz** |
| Western herring stock 22-24 | 100% | 18 % | 8 % |
| Herring stock in the Gulf of Bothnia 30-31 | 100% | -24 % | 17 % |
| Herring stock in the Gulf of Riga 28.1 | 100% | -10 % | -21 % |
| Herring stock from the central basin 25-27, 28.2, 29, 32 | 100% | 9 % | 8 % |
| Sprat 22-32 | 100% | -5 % | 40 % |
| European plaice 22-32 | 100% | 18 % | 95 % |
| A salmon stock in the main basin 22-31 | 100% | bz** | 10 % |
| Stock of salmon in the Gulf of Finland 32 | 100% | bz** | -28 % |

* Commission proposal (percentage difference compared to TAC from 2016)
** bz – no change
Source: a summary of information from the KE's proposal on fishing rights in the Baltic Sea for 2017. http://europa.eu/rapid/press-release_IP-16-2849_pl.htm

For particular species, acceptable catch and more specifically their year-to-year changes, range from -24% to + 40% - it is not a stable scenario.

### Tourism and leisure

Achievement of the good status of the Baltic Sea and effects on the population, including the stream of benefits related to recreation and tourism, were the subject of dedicated research and were included in the methodological annex of the Helcom HOLAS II[87] project.

Indicators according to the Helcom HOLAS II report:

1) Number of adult Poles 18-80; 29789 thous.
2) Unit indicator WTP; 12-13 €/person

[87] ECONOMIC AND SOCIAL ANALYSES IN THE BALTIC SEA REGION-Supplementary Report to the First Version of the HELCOM 'State of the Baltic Sea' report 2017

A detailed analysis of the project [88], to which the authors of the Helcom HOLAS II report refer, enables a more detailed comparison of the following indicators (assumptions of the basic study (Ahtiainen et al.) constituing the source of estimates):

1) Benefits streams presented to respondents:
   a) Water tansparency,
   b) Cyanobacteria blooms,
   c) Condition of underwater meadows,
   d) Number of fish species,
   e) Oxygenation of deep water layers.
2) Base scenario: withholding investments on land aimed at reducing nutrients (sewage treatment plants, sewerage, agricultural sector, etc.).
3) Number of adult (15+[89]) citizens for estimates 24624 thous. (2011).
4) Average net income per capita for 2011, according to Eurostat, € according to PPP 492 according to study 495.
5) WTP income elasticity for Poland: change in income by 1% changes WTP by 0.21%.
6) Household size according to the study 3.3 according to GUS 2.6.
7) Individual annual WTP in € 2011 according to PPP 12.15 €/person
8) Annual WTP for Poland € 299.2 million 2011 according to PPP.

These data make it possible to combine streams of disadvantages resulting from the failure to achieve good status for the years 2012-2015. Due to some discrepancies in the population included in the calculations (15+ or 18+), the number of Polish citizens, in given age categories, differs. Due to the inability to decide which age range is correct, the calculations were repeated for two variants.

Table 5.10.11 Summary of annual streams of disadvantage due to failure to achieve good condition of the Baltic Sea - option 1, age 15+

| | unit | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| Total population | people | 38 533 | 38 496 | 38 479 | 38 437 | 38 433 |
| Population aged 15+ | people | 32 724.7 | 32 714 | 32 714.8 | 32 682.5 | 32 659.6 |
| WTP unit | €/person/ year | 12.24 | 12.28 | 12.37 | 12.46 | 12.65 |
| WTP total | mln €/r. | 400.6 | 401.7 | 404.7 | 407.2 | 413.1 |

Source: Own calculations based on data from Ahtainen H. et al., Benefits ... opus cit.

Table 5.10.12 List of annual streams disadvantages due to failure to achieve good condition of the Baltic Sea - option 2, age 18+

| | unit | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| Total population | people | 38 533 | 38 496 | 38 479 | 38 437 | 38 433 |
| Population aged 18+ | people | 31 425.8 | 31 467 | 31 536 | 31 535.3 | 31 572.6 |
| WTP unit | €/person/ year | 12.24 | 12.28 | 12.37 | 12.46 | 12.65 |
| WTP total | mln €/r. | 384.7 | 386.4 | 390.1 | 392.9 | 399.4 |

Source: Own calculations based on data from Ahtainen H. et al., Benefits ... opus cit.

It should be noted that the estimated streams of disadvantages in a very general way refer to the concept of "tourism and recreation."

[88] Heini Ahtiainen i inn Benefits of meeting nutrient reduction targets for the Baltic Sea – results from a contingent valuation study in the nine coastal states. W: Journal of Environmental Economics and Policy, Volume 3, 2014 - Issue 3, Pages 278-305

[89] In the primary material, the population was included from the age of 15, in the methodological appendix from 18 - referring to the primary material, without any comment related to the change.

As part of the project, an attempt was made to verify the research using a conditional valuation method using a dedicated econometric model. The previous research and recommendations of the Helcom HOLAS II project and the source projects base the valuation of the quality (improvement of the quality) of the Baltic Sea by the method of declared preferences. Using this approach, unit valuation (the disadvantage of low quality of the Baltic Sea) is built by averaging the response from a representative research group. Questions, however, concern a hypothetical situation - a virtual payment for improvment of the water status. The standard problem with such tests is their adequacy, in a situation when they actually incur expenses.

In this study an attempt was made to empirically verify the hypothesis assigning a specific value verified by the market to the quality of the Baltic Sea. The attempt consists in finding a connection between the quality of water (measured by the state of bathing sites) and the frequency of visits. Because the tourist attendance data is available at the municipal level - it was decided to investigate whether the fact of having a bathing area (where the water quality is controlled) and good condition of this bathing site affect the tourist attendance. The following hypotheses were put forward:
Hypothesis 1. The mere fact of having a bathing site (sites) significantly affects the greater tourist turnout (in the current or next year).

The basic feature of the bathing site is to ensure safety and comfort for users. The operationalization of this concept has two basic dimensions: strictly defined requirements for emergency services and systematic control of water quality. This statement, however, is a certain simplification, as further information requirements - a table with water temperature, etc. - are also to be included. It seems, however, that these are not the prerequisites of choice. Separation of these components according to users' preferences is not possible without dedicated surveys. Thus, assigning water quality control to the primary motivation of site selection is some overestimation.
Hypothesis 2. High quality of water in existing bathing places significantly affects tourist attendance (in the current or next year).

The fact of the existence of a bathing site is connected with systematic control of water quality. One should be aware of a certain unconsciousness of the average consumer (tourist). The vast majority of users comply with the standards (here the "bathing water quality") equates to the safety of use. In fact, there is no guarantee of security. The fulfillment of a given standard leads to not exceeding the specified risk margin, and not to the guarantee of safety. These nuances, however, are able to be captured by few people who have knowledge of risk management. Universal opinion is based on a strong simplification, where quality control is identified with safety.

Verification of both hypotheses requires the quantification of several concepts:

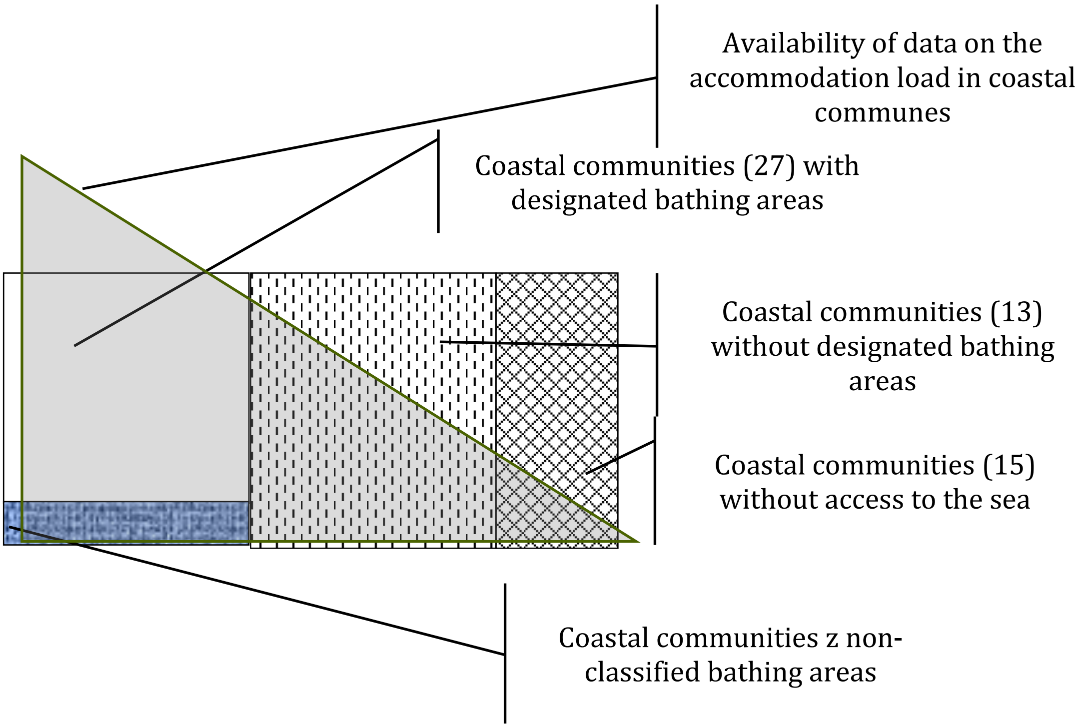
1) The concept of a coastal commune - according to the Eurostat definition, these are not only municipalities located by the sea, but also those with a minimum of 50% of the area not more than 10 km from the coast. Such requirements are met by 55 municipalities in Poland. In practice, the research will be limited to municipalities located directly by the sea. It is difficult to link the quality of a bathing area with a municipality that has no access to the sea. The necessity to use a car for traveling makes it possible to choose the neighboring commune and the bathing area with good water quality located a bit further.
2) "The fact of having a bathing site" - In practice, municipalities have from 0 to 15 bathing sites. Due to the fact that tourist attendance is counted on the entire municipality - it is necessary to average the quality of bathing sites for a given commune (arithmetic mean). In practice, the mere fact of one bathing site (where water quality is controlled) seems to be a sufficient condition. The number of bathing sites as an explanatory variable - has been omitted.
3) Bathing water quality - is marked on a 1-4 scale for the whole season. The first model treated the bathing water quality assessment as the only explanatory variable. More

extensive calculations (the second model) will also take into account the fact when the bathing site is closed during the season (due to blooms of cyanobacteria, coliforms, etc.). Such closure reduces the aggregate quality assessment.

4) Tourist attendance - is measured using the accommodation base in %. Due to the large variation in the scale of subsequent seasons, the deviation from the average value in a particular season and changes in this deviation will be measured.

**Description of the test sample**

From the initial list of 55 coastal communes, 40 with direct access to the sea are suitable for research. From this grouping, 27 communes have designated at least one bathing site on their territory, but not all of them have been examined and categorized. Information on the quality of bathing areas has been made available by the Chief Sanitary Inspector. In addition, data on occupancy of the accommodation base at the level of individual municipalities are necessary for the research. Such information is collected by GUS. However, data is not widely available to all coastal municipalities due to the statistical secrecy associated with the averaging of information from a small number of objects. In practice, information was obtained on the use of accommodation for 47 coastal communes, including 25 communes with bathing sites.




Source: Own study

Fig.5.10.2 Disaggregation of the coastal communities database

The econometric analysis of the collection described in this way has some weaknesses resulting from the low sample size. The number of coastal communes is not subject to fluctuations, and the assessment of the condition of bathing sites was characterized by a methodology that was variable in time which excludes the use of longe time series. Due to independent reasons, it was not possible to increase the number of observations. The most promising results of the estimation were obtained based on the Panel Generalized Method of Moments. The results of the calculations indicated a low degree of fit of the model, which also seems quite obvious. A huge number of variables affects the tourist turnout, for example:

1) weather;
2) terrorist threats on competitive markets (Egypt, Tunisia);
3) catastrophes in competitive markets (earthquakes, oil spills);
4) additional income shocks (500+ program).

In this context, the construction of a model for determining the impact on attendance, which has only one explanatory variable (the existence of a bathing site) can not, of course, have a high degree of fit.

Despite the reservations related to the low number of observations, it was possible to confirm the first hypothesis: **the fact of designating a bathing site in a statistically significant way affects the tourist attendance**. Details of the calculations using the generalized moment method are presented in Table 5.10.1 - Table 5.10.6. from Annex 1 to present update of initial assessment of the state of marine waters.

It can therefore be concluded that the designation of a bathing site along with the completion of all procedures, including water quality control, is important when selecting a tourist destination. Tourists attach importance to this fact. Specifying, the fact of bathing site designation - increases the turnout by 4.6% (the change described as K) compared to the value before designation. For example, with a base use rate of 20% in a municipality without bathing sites, its designation increases base load to 21%.

Analogical calculations assuming the relationship between the existence of a bathing site in the previous year and the current year's attendance also gave a statistically significant result (details of calculations are presented in Annex 1 to present update of initial assessment of the state of marine waters). This approach has some justification. People traveling to the Baltic Sea systematically relate on their experience from previous years. They are not necessarily able to find current data on these bathing sites on the bathing website, but rely on their own or heard opinions. Therefore, the model underwent a verification: tourist attendance measured by the accommodation base load is a function of the existence of a bathing site in the commune in the previous year. The value of the coefficient at the explanatory variable was slightly higher. The increase in attendance reached 5% (exactly 4.97%). More specifically, the fact of the existence/absence of a bathing site explained (in a statistically significant way) 3,5% of the change in attendance. Other factors were responsible for other changes in the turnout (weather, terrorist threats on competitive markets, catastrophes on competitive markets, etc.).

On the other hand, it was not possible to confirm the second hypothesis: **high water quality in existing bathing sites significantly affects tourist attendance (in the current or next year)**. The details of the analysis are contained in Annex 2 to present update of initial assessment of the state of marine waters.

The result of the calculations was not statistically significant. This means that it has not been possible to confirm the relationship between the quality of the bathing site and the choice of a place of rest. The interpretation of such a result should be emphasized: the lack of such a relationship has not been proved – which does not mean that the realtionship has not been found. When searching, a number of modeled methods were used - none of them led to statistically significant results. Certainly, the low sample size was the leading factor lowering the chances of obtaining a statistically significant result. On the other hand, the concept of a small number of observations refers to a purely econometric point of view. A number of observations covered 4 seasons, however, the term of turnout in a single season covers over one million Poles traveling to the Baltic Sea and spending over 6 million person-days at the seaside.

The absence of a clear cause and effect relationship between the quality of bathing areas and occupancy suggests that the results of surveys conducted using the conditional valuation method should be treated with extreme caution, where respondents answered the question about the hypothetical readiness to pay for improving the quality of the Baltic Sea. Questions addressed to the respondents were hypothetical (they asked about hypothetical readiness to pay for the improvement of water quality defined by selected physico-chemical and biological parameters, and the respondent was fully aware that in the current legal situation it is not possible to enforce the submitted declaration) and the obtained research results were confronted with the analysis of the actual behavior of consumers. Observations of the actual behavior of Poles suggest that it is difficult to find behaviors indicating the attachment of any importance to the quality of the Baltic Sea treated as a place to bathe. Ex-post examinations included 4 years where the Baltic Sea was visited by over 4 million Poles. It should be noted, however, that respondents questioned about WTP (conditional valuation method) presented more streams of benefits, including non-use benefits (biodiversity, oxygenation of deep waters). Theoretically, it is possible for these respondents to assign monetary values to non-utilitarian values (biodiversity, reduction of anaerobic zones), and not to the direct use-value that they themselves use (a good bathing site). However, this explanation seems unlikely.

Translating the results of econometric analysis into a stream of benefits requires the adoption of certain subjective assumptions. The calculated rate of increase in accommodation base load (and thus the increase in attendance) by 5% should be referred to a certain population. Because some municipalities are already equipped with bathing sites - this should not be related to the entire population of tourists visiting the coast. Taking into account only the group of a dozen or so municipalities located directly on the Baltic Sea and having no bathing sites, the increase in attendance amounts to less than 2,000 tourists/season. Specifically, the increase applies only to the July-August bathing season.

## List of literature and law acts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## Annex 1

Adopted designations:

SWBN – the status of the accommodation base occupancy

K – existence of a bathing site in the commune

K(-1) – existence of a bathing site in the commune in the previous year

JK1 - bathing site quality– annual assessment of Board of Health

JK1(-1) - bathing site quality in the previous year - annual assessment of Board of Health

JK2(-1) – bathing site quality in the previous year modified by the number of closing days (added a/62 fraction, where a is the number of days in the season when the bathing site was closed)

Many different approaches are used to assess the fit of the model to empirical data diagnostic statistics. One of the most commonly used is the coefficient of determination marked as $R^2$. It is calculated according to the formula:

$$R^2 = \frac{\sum_{t=1n} \quad (\widehat{y_t}}{} - \bar{y})^2 \sum_{t=1}^{n}(y_t - \bar{y})^2$$

Where:

$R^2$ - determination coefficient, R-squared, percentage of explained variation by the model

yt - actual value of the dependent variable (measured)

y^t - predicted value of the dependent variable (based on the regression model)

y¯ - average value of the actual dependent variable

Read more on: Wątroba J., Prosto on matching simple or linear regression analysis in practice.
https://media.statsoft.pl/_old_dnn/downloads/analiza_regresji_liniowej_w_praktyce.pdf

# Annex 2

Table 5.10.1 Dependence of existance of bathing site on tourist attendance.

| | | | | |
|---|---|---|---|---|
| Dependent Variable: SWBN | | | | |
| Method: Panel Generalized Method of Moments | | | | |
| Date: 07/04/17 Time: 10:44 | | | | |
| Sample (adjusted): 2013 2016 | | | | |
| Periodsincluded: 4 | | | | |
| Cross-sectionsincluded: 40 | | | | |
| Total panel (unbalanced) observations: 149 | | | | |
| 2SLS instrument weightingmatrix | | | | |
| Instrument specification: C K(-1) | | | | |
| | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| | | | | |
| C | 0.184301 | 0.018921 | 9.740504 | 0.0000 |
| K | 0.046833 | 0.022224 | 2.107270 | 0.0368 |
| | | | | |
| R-squared | 0.029322 | Mean dependent var | | 0.218247 |
| Adjusted R-squared | 0.022719 | S.D. dependent var | | 0.122554 |
| S.E. of regression | 0.121154 | Sum squaredresid | | 2.157715 |
| Durbin-Watson stat | 0.670066 | J-statistic | | 3.42E-29 |
| Instrument rank | 2 | | | |

Source: Own calculations

Table 5.10.2 Dependence of existance of bathing site in the previous year on tourist attendance.

| | | | | |
|---|---|---|---|---|
| Dependent Variable: SWBN | | | | |
| Method: Panel Generalized Method of Moments | | | | |
| Date: 07/04/17 Time: 10:45 | | | | |
| Sample (adjusted): 2014 2016 | | | | |
| Periodsincluded: 3 | | | | |
| Cross-sectionsincluded: 40 | | | | |
| Total panel (unbalanced) observations: 111 | | | | |
| 2SLS instrument weightingmatrix | | | | |
| Instrument specification: C K(-2) | | | | |
| | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| | | | | |
| C | 0.182541 | 0.021337 | 8.554970 | 0.0000 |
| K(-1) | 0.049669 | 0.024978 | 1.988483 | 0.0493 |
| | | | | |
| R-squared | 0.035006 | Mean dependent var | | 0.218786 |
| Adjusted R-squared | 0.026153 | S.D. dependent var | | 0.118429 |
| S.E. of regression | 0.116870 | Sum squaredresid | | 1.488781 |
| Durbin-Watson stat | 1.022866 | J-statistic | | 1.95E-28 |
| Instrument rank | 2 | | | |

Source: Own calculations

Table 5.10.3 Dependence of water quality in existing bathing areas on tourist attendance.

| | | | | |
|---|---|---|---|---|
| Dependent Variable: SWBN | | | | |
| Method: Panel Generalized Method of Moments | | | | |
| Date: 07/04/17 Time: 10:46 | | | | |
| Sample (adjusted): 2013 2016 | | | | |
| Periodsincluded: 4 | | | | |
| Cross-sectionsincluded: 24 | | | | |
| Total panel (unbalanced) observations: 89 | | | | |
| 2SLS instrument weightingmatrix | | | | |
| Instrument specification: C JK1(-1) | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 0.181924 | 0.224950 | 0.808730 | 0.4209 |
| JK1 | 0.032427 | 0.144106 | 0.225025 | 0.8225 |
| R-squared | -0.005500 | Mean dependent var | | 0.232453 |
| Adjusted R-squared | -0.017057 | S.D. dependent var | | 0.125250 |
| S.E. of regression | 0.126314 | Sum squaredresid | | 1.388101 |
| Durbin-Watson stat | 0.756341 | J-statistic | | 8.63E-26 |
| Instrument rank | 2 | | | |

Source: Own calculations

Table 5.10.4 Dependence of water quality in existing bathing areas on tourist attendance (NMK method)

| | | | | |
|---|---|---|---|---|
| Dependent Variable: SWBN | | | | |
| Method: Panel LeastSquares | | | | |
| Date: 07/04/17 Time: 10:56 | | | | |
| Sample: 2012 2016 | | | | |
| Periodsincluded: 5 | | | | |
| Cross-sectionsincluded: 27 | | | | |
| Total panel (unbalanced) observations: 120 | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 0.204067 | 0.029200 | 6.988606 | 0.0000 |
| JK1 | 0.016276 | 0.017921 | 0.908208 | 0.3656 |
| R-squared | 0.006942 | Mean dependent var | | 0.228602 |
| Adjusted R-squared | -0.001474 | S.D. dependent var | | 0.121307 |
| S.E. of regression | 0.121396 | Akaike info criterion | | -1.362985 |
| Sum squaredresid | 1.738976 | Schwarz criterion | | -1.316527 |
| Log likelihood | 83.77908 | Hannan-Quinn criter. | | -1.344118 |
| F-statistic | 0.824842 | Durbin-Watson stat | | 0.591652 |
| Prob(F-statistic) | 0.365619 | | | |

Source: Own calculations

Table 5.10.5 Dependence of water quality in existing bathing areas on tourist attendance (with delayed explanatory variable)

| | | | | |
|---|---|---|---|---|
| Dependent Variable: SWBN | | | | |
| Method: Panel Generalized Method of Moments | | | | |
| Date: 07/04/17 Time: 10:58 | | | | |
| Sample (adjusted): 2014 2016 | | | | |
| Periodsincluded: 3 | | | | |
| Cross-sectionsincluded: 23 | | | | |
| Total panel (unbalanced) observations: 67 | | | | |
| 2SLS instrument weightingmatrix | | | | |
| Instrument specification: C JK1(-2) | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 0.241772 | 0.171682 | 1.408260 | 0.1638 |
| JK1(-1) | -0.006519 | 0.104735 | -0.062243 | 0.9506 |
| R-squared | -0.003012 | Mean dependent var | | 0.231128 |
| Adjusted R-squared | -0.018443 | S.D. dependent var | | 0.122963 |
| S.E. of regression | 0.124091 | Sum squaredresid | | 1.000915 |
| Durbin-Watson stat | 1.042008 | J-statistic | | 1.86E-27 |
| Instrument rank | 2 | | | |

Source: Own calculations

Table 5.10.6 Dependence of water quality in existing bathing areas on tourist attendance (with delayed explanatory variable MNK method)

| | | | | |
|---|---|---|---|---|
| Dependent Variable: SWBN | | | | |
| Method: Panel LeastSquares | | | | |
| Date: 07/04/17 Time: 10:57 | | | | |
| Sample (adjusted): 2013 2016 | | | | |
| Periodsincluded: 4 | | | | |
| Cross-sectionsincluded: 27 | | | | |
| Total panel (unbalanced) observations: 96 | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 0.222664 | 0.032859 | 6.776434 | 0.0000 |
| JK1(-1) | 0.005294 | 0.019530 | 0.271087 | 0.7869 |
| R-squared | 0.000781 | Mean dependent var | | 0.230893 |
| Adjusted R-squared | -0.009849 | S.D. dependent var | | 0.122657 |
| S.E. of regression | 0.123260 | Akaike info criterion | | -1.328432 |
| Sum squaredresid | 1.428140 | Schwarz criterion | | -1.275008 |
| Log likelihood | 65.76472 | Hannan-Quinn criter. | | -1.306837 |
| F-statistic | 0.073488 | Durbin-Watson stat | | 0.751542 |
| Prob(F-statistic) | 0.786918 | | | |

Source: Own calculations