Baltic Sea Environment Proceedings No. 136

HELCOM core indicators

Final report of the HELCOM CORESET project

Helsinki Commission

Baltic Marine Environment Protection Commission

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The objective of the final report is to give background to the development of the set of HELCOM core indicators, make an overview of the proposed core indicators and discuss the proposed set of core indicators in relation to anthropogenic pressures, environmental policy and monitoring programmes.

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Acknowledged persons contributing to this report and the core indicators are listed on page 71.

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Content

Executive summary

HELCOM core indicators form the critical set of indicators that are needed to regularly assess the status of the Baltic Sea marine environment against targets that reflect good environmental status. The need for a Baltic Sea-wide, coherent assessment of the state of the marine environment triggered HELCOM to launch the CORESET project (2010-2013), which was given a clear objective to develop the core indicators for biodiversity and hazardous substances, and set up a web-based follow-up system for the state of the marine environment. The CORESET project was set under the supervision of the HELCOM Monitoring and Assessment Group (MONAS), but a separate steering group (HELCOM JAB) took the role of more concrete supervision. The work of HELCOM CORESET was divided between two expert groups: one for biodiversity and another for hazardous substances, which met in regular workshops and also worked intersessionally. Altogether, some 140 experts from the Contracting Parties and Observer organizations participated in the CORESET work.

The selection of core indicators was a process guided by predefined HELCOM principles for core indicators. The principles defined that the core indicators will be monitored by all Contracting Parties; cover the entire convention area; reflect or directly measure anthropogenic pressures; be scientifically sound; be quantitative; have targets for good environmental status (GES); enable assessments under the HELCOM Baltic Sea Action Plan (BSAP) and the EU Marine Strategy Framework Directive (MSFD); be regularly updated with new data; and be publicly available. In addition to the principles, both expert groups developed selection criteria for the screening of candidate indicators and had to consider carefully the ecological objectives of the BSAP and qualitative descriptors and associated criteria of the MSFD. The development of biodiversity core indicators closely followed the principles of core indicators; it also required consideration of the Baltic Sea ecosystem and its trophic structure, functional groups, keystone species and predominant habitats. The selection of hazardous substances core indicators was based on persistence, bioaccumulation and toxicity of substances that showed high or increasing levels in the marine environment, and were recognized by international policies; it also considered indicators for effects of contaminants in organisms.

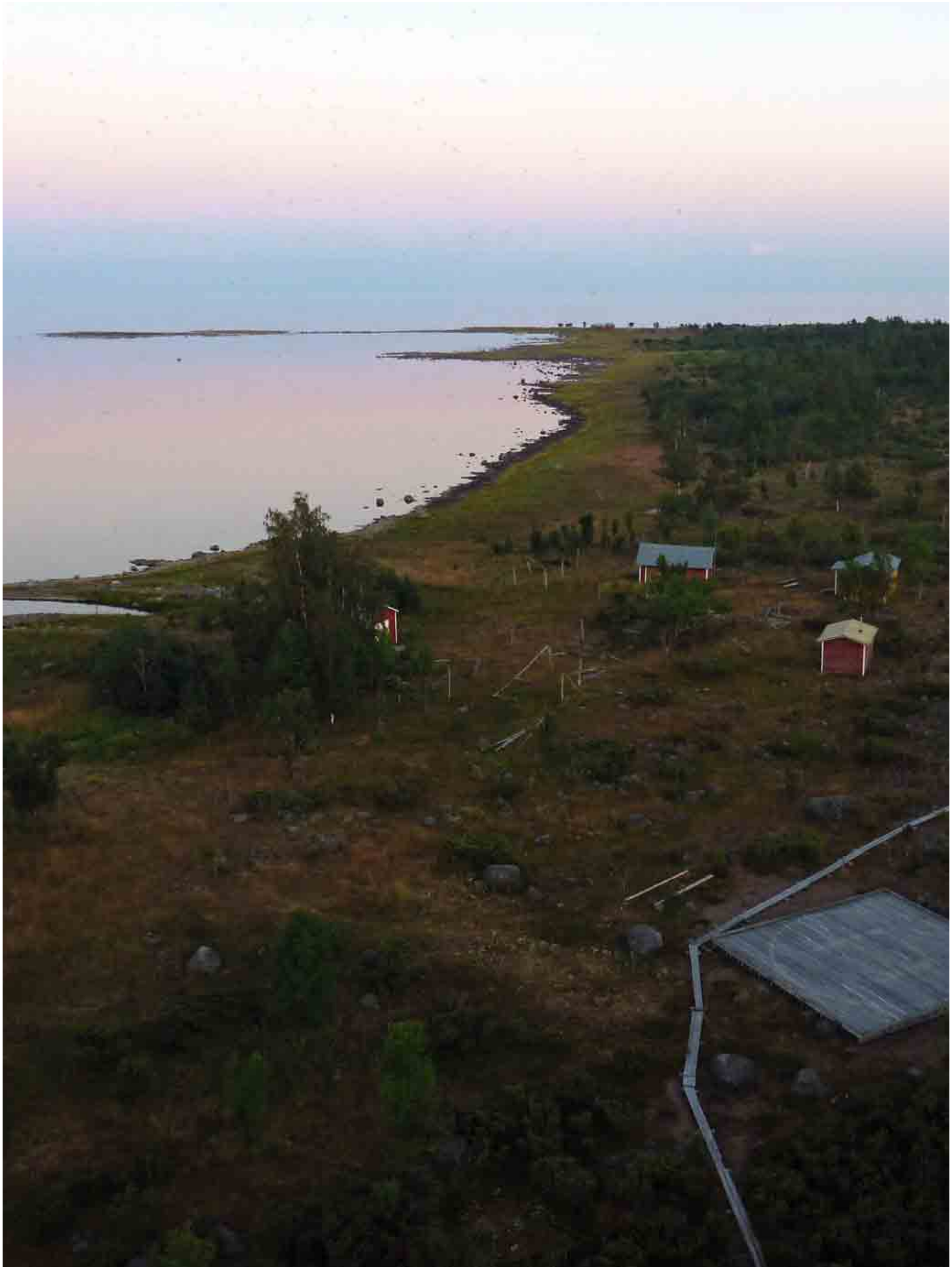
The CORESET project proposed 20 core indicators for biodiversity and 13 for hazardous substances and their biological effects. The indicators cover the Baltic Sea marine ecosystem, the main contaminants in it and address all the HELCOM ecological objectives and the MSFD qualitative descriptors for biodiversity, non-indigenous species, food web, sea-floor integrity and contaminants in the environment and seafood.

The largest gaps in the proposed set of core indicators were identified among the indicators for benthic communities and habitats, phytoplankton and pharmaceutical substances. It was concluded that the lack of HELCOM expert cooperation is the obvious reason for the lagging of the development of the benthic indicator, whereas the development of a phytoplankton indicator turned out to be time-consuming and scientifically challenging in the dynamic Baltic Sea environment. The project, however, proposed five core indicators for benthic species, communities and habitats, whereas no phytoplankton indicator was proposed at this stage. An indicator for pharmaceuticals was also proposed, including diclofenac and estrogens; however, its geographical applicability was not tested due to the lack of monitoring data.

HELCOM MONAS reviewed the proposed core indicators and recommended 17 core indicators for biodiversity and nine for hazardous substances to HELCOM's Heads of Delegation (HOD). HELCOM MONAS considered seven indicators as 'pre-core indicators' and noted the need to develop additional core indicators for phytoplankton and benthic biotopes, and requested experts to further develop them by 2015. Moreover, all the environmental targets (GES boundaries) were provisionally approved - they can be provisionally used in assessment reports but they require further development and should be reconsidered by 2015. The final decision of the HELCOM core indicators will be made by HELCOM HOD in June 2013.

The HELCOM core indicators will form the backbone of the coordinated monitoring programme in the Baltic Sea. While HELCOM is revising its monitoring and assessment strategy and the coordinated monitoring programme, the role of the CORESET project was to support the process. To this end, the core indicators include technical information of the current monitoring as well as methods for sampling and analyses, and recommendations for spatial and temporal aspects of monitoring. The envisioned continuation of the process through the CORESET II project will strengthen the expert cooperation, improve the coherence of monitoring and assessments, and fine-tune the remaining gaps in the proposed core indicators.

1 Introduction to the HELCOM core indicators



1.1 Environmental policy drivers behind the HELCOM core indicators

In the Baltic Sea Action Plan (BSAP), the Contracting Parties to the Helsinki Convention agreed to periodically evaluate whether the targets of the Action Plan have been met by using indicator-based assessments (HELCOM 2007 a). The vision of the BSAP – a healthy Baltic Sea – was built on both ecological and management objectives, leaning on a structured and coherent approach for environmental assessments. Three years after the adoption of the BSAP, the HELCOM Moscow Ministerial Meeting of May 2010 reconfirmed HELCOM's assignment related to environmental assessments:

"this work shall continue to be based on the following common principles:…a common understanding of the good environmental status of the Baltic Sea that we want to achieve by 2021, based on the agreed visions, goals and ecological objectives, and jointly constructed quantitative targets and associated indicators as initiated with the HELCOM Baltic Sea Action Plan"; and

"as practical implementation of the above principles WE DECIDE that core set indicators with quantitative targets shall be developed for each of the segments of the HELCOM Baltic Sea action Plan, while ensuring that the indicators can also be used for the other international monitoring and reporting requirements inter alia the EU Marine Strategy Framework Directive, and that a full indicator-based follow-up system for the implementation of the HELCOM Baltic Sea Action Plan be further developed and placed on the website by 2013" (Moscow Ministerial Declaration).

The EU Marine Strategy Framework Directive (MSFD, Anon. 2008 a) – adopted one year after the BSAP – reiterated the need for the protection, sustainable management and restoration of the Baltic and other European seas. The directive *inter alia* specified assessment requirements, listed predominant pressures on marine ecosystems and widened the assessment requirement to include socio-economic analysis. It also defined qualitative descriptors for the good environmental status (GES) of the marine environment. The MSFD stipulates that GES 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.*" According to the directive, the determination of good environmental status and the establishment of environmental targets should be developed "*in a coherent and coordinated manner in the framework of the requirement of regional cooperation*" (Anon. 2010, see also MSFD, Article 6).

HELCOM began to develop core indicators to enable the follow-up of the effectiveness of the Baltic Sea Action Plan and to measure the progress towards good environmental status of the Baltic Sea, including coastal and transitional waters. Core indicators form the critical set of indicators which are needed to regularly assess the status of the Baltic Sea marine environment against a definition of Good Environmental Status (GES) and targets set to achieve GES.

The objective of the core indicators is based on the HELCOM Baltic Sea Action Plan, where the vision of a healthy Baltic Sea is divided into four strategic goals, each of which is further divided into ecological objectives (**Figure 1**). The full indicator-based follow-up system is due to be placed on the HELCOM website by 2013.

The aim of the core indicators is to allow the assessment of the current status and tracking the progress towards achieving GES. The core indicators are designed to measure the distance from the current environmental status of the Baltic Sea to GES and the HELCOM ecological objectives, goals and vision. Compatibility of the HELCOM ecological objectives, goals and vision and the MSFD qualitative descriptors and criteria is discussed in the interim report of the project (HELCOM 2012 a).

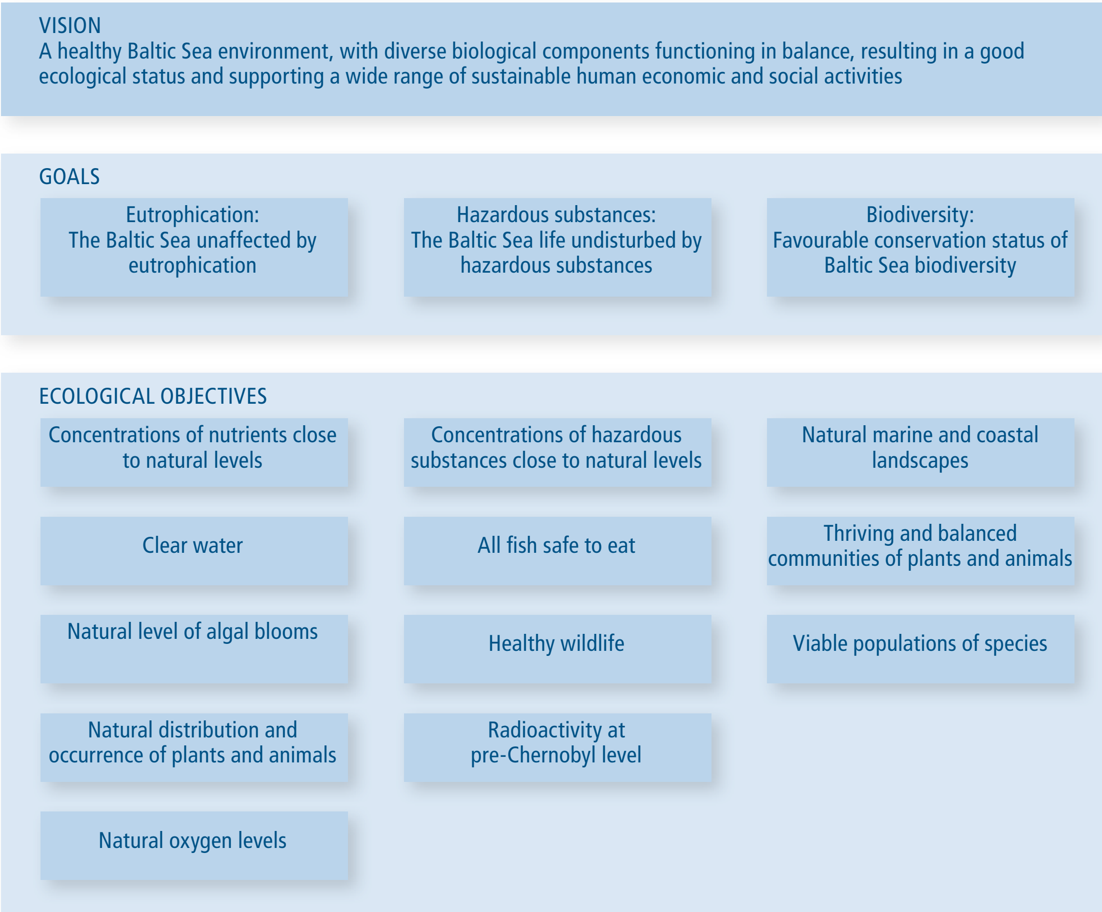


Figure 1. HELCOM's vision for a healthy Baltic Sea. The vision is divided into four goals, subdivided into ecological objectives. Each ecological objective is measured by core indicators. The vision, ecological objectives and core indicators measure the state of the Baltic marine environment. Moreover, behind each core indicator there are indicators for the underlying pressure(s) ensuring a closer link to human activities. The strategic goal and management objectives under the maritime segment are not included in this figure. See HELCOM 2009 a, b, 2010 a, b, c for more details).

Figure 2. A comparison of the HELCOM vision, strategic goals and ecological objectives, and the MSFD qualitative descriptors and associated criteria.

The HELCOM strategic goals and the ecological objectives are to a certain extent comparable with the qualitative descriptors and the associated criteria of the EU MSFD (**Figure 2, Tables 1-2**). There are 11 MSFD descriptors, covering biodiversity, fish stocks, food webs, eutrophication, hazardous substances, marine litter and underwater noise (**Table 1**). Compared to the BSAP, the MSFD GES descriptors cover a wider definition of good environmental status than the BSAP ecological objectives. As the BSAP segments, particularly biodiversity, and the associated ecological objectives have only been loosely defined, there is no critical difference between the two approaches. The CORESET project only focused on developing core indicators for biodiversity and hazardous substances, and cooperated with the HELCOM group developing eutrophication core indicators. The MSFD descriptors included in the project were: 1, 2, 4, 6, 8 and 9 (**Table 1**). The HELCOM

Table 1. Qualitative descriptors of good environmental status according to the EU Marine Strategy Framework Directive (Annex I).	
1	**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.
2	**Non-indigenous species** introduced by human activities are at levels that do not adversely alter the ecosystems.
3	Populations of all **commercially exploited fish and shellfish** are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
4	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.
5	**Human-induced eutrophication** is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.
6	**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.
7	Permanent alteration of **hydrographical conditions** does not adversely affect marine ecosystems.
8	**Concentrations of contaminants** are at levels not giving rise to pollution effects.
9	Contaminants in fish and other **seafood for human consumption** do not exceed levels established by European Union legislation or other relevant standards.
10	Properties and quantities of **marine litter** do not cause harm to the coastal and marine environment.
11	Introduction of **energy, including underwater noise**, is at levels that do not adversely affect the marine environment.

Table 2. Criteria for good environmental status, associated to MSFD descriptors. Key words in parentheses indicate the suggested aspects for measuring the criteria (EC/2010/477).	
1	1.1 Species distribution (range, pattern, covered area)
	1.2 Population size (abundance, biomass)
	1.3 Population condition (demography, genetic structure)
	1.4 Habitat distribution (range, pattern)
	1.5 Habitat extent (area, volume)
	1.6 Habitat condition (condition of typical species or communities, relative abundance and/or biomass, physical, hydrological and chemical conditions)
	1.7. Ecosystem structure (relative proportions)
2	2.1 Abundance and state characterisation of non-indigenous species, in particular invasive species (trends in abundance, temporal occurrence)
	2.2 Environmental impact of invasive non-indigenous species (ratio between NIS and native, impacts of NIS).
3	3.1 Level of pressure of the fishing activity (fishing mortality, catch-biomass ratio)
	3.2 Reproductive capacity of the stock (spawning stock biomass, biomass indices)
4	4.1 Productivity of key species or trophic groups (productivity)
	4.2 Proportion of selected species at the top of food webs (large fish)
	4.3 Abundance/ distribution of key trophic groups and species
5	5.1 Nutrient levels
	5.2 Direct effects of nutrient enrichment
	5.3 Indirect effects of nutrient enrichment
6	6.1 Physical damage, having regard to substrate characteristics (areal extent of biogenic substrate, extent of impacted seabed)
	6.2 Condition of the benthic community (presence of sensitive and tolerant species, multimetric indices, population size structure)
7	7.1 Spatial characterisation of permanent alterations (extent of area)
	7.2 Impact of permanent hydrographical changes (extent, functions)
8	8.1 Concentrations of contaminants
	8.2 Effects of contaminants (chronic and acute pollution effects)
9	9.1 Levels, number and frequency of contaminants (levels, frequency)
10	10.1 Characteristics of litter in the marine and coastal environment (trends in amounts)
	10.2. Impacts of litter on marine life (trend in ingested litter)
11	11.1 Distribution in time and place of loud, low and mid frequency impulsive sounds (impact days)
	11.2 Continuous low frequency sound (trends in days)

core indicators for descriptor 5 were developed by eutrophication experts directly under HELCOM MONAS and the core indicators for commercially exploited stocks of fish and shellfish (descriptor 3) were developed by ICES. The core indicator work for marine litter and underwater noise (descriptors 10 and 11) was postponed until European development in the respective technical subgroups has progressed further. The CORESET project manager took part in the work of the subgroups.

1.2 HELCOM indicator development before the core indicators

HELCOM had not developed a coherent system of indicators to measure progress towards the ecological objectives, the strategic goals and the vision until the CORESET project, even though some of the indicators have long been used in the region. Background documentation for the BSAP included indicators and thematic reports for each of the four segments. Although these 'BSAP indicators' were to some extent already in use, many were only proposals for further development and there was no systematic differentiation between pressure indicators, state indicators and response indicators (see **Chapter 2**). While the BSAP indicators were not endorsed by HELCOM, they formed a good basis to develop the core indicators.

The strategic goal for biodiversity had the most extensive list of proposed BSAP indicators (HELCOM 2007 b). The indicators did not include quantitative GES boundaries; rather, they were developed on the basis of qualitative targets of BSAP. **Annex 1** lists the indicators as well as the underlying qualitative targets under each of the three ecological objectives of the biodiversity goal.

The strategic goal of eutrophication was divided in the Baltic Sea Action Plan into five ecological objectives; in the BSAP background documentation, an indicator was suggested to each of the ecological objectives (HELCOM 2007 c). The BSAP indicators are almost identical to those proposed as core indicators (cf. **Chapter 5** and **Annex 1**).

The HELCOM ecological objective 'Concentrations close to natural levels' was targeted to eleven substances of 'specific concern' (HELCOM 2007 d) (**Table 3**). Three kinds of target levels were defined for these substances:

– The primary target is a decreasing trend in concentration (concerns all substances).
– The intermediate target levels are relevant at least for certain substances. EU maximum levels in fish muscle (referring to human health) are used as intermediate target levels for mercury, cadmium as well as dioxins, furans and dioxin-like PCBs.
– The ultimate target level is to reach near background concentrations for naturally occurring substances (mercury, cadmium as well as dioxins and furans, dioxin-like PCBs) and to reach close to zero concentrations for man-made synthetic substances (TBT and PFOS). The ultimate target levels reflect undisturbed conditions, i.e. reference conditions.

The ecological objective 'All fish safe to eat' aims to ensure safe seafood for humans. As a pragmatic approach, the EU maximum levels of mercury,

Table 3. **Hazardous substances of the Baltic Sea Action Plan to follow the reaching of the ecological objectives under the strategic goal of hazardous substances (HELCOM 2007 d).**
Dioxins (PCDD), furans (PCDF) & dioxin-like polychlorinated biphenyls
Tributyltin compounds (TBT) and triphenyltin compounds (TPhT)
Pentabromodiphenyl ether (pentaBDE), octabromodiphenyl ether (octaBDE) and decabromodiphenyl ether (decaBDE)
Perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA)
Hexabromocyclododecane (HBCDD)
Nonylphenols (NP) and nonylphenol ethoxylates (NPE)
Octylphenols (OP) and octylphenol ethoxylates (OPE)
Short-chain chlorinated paraffins (SCCP or chloroalkanes, C_{10-13}) and medium-chain chlorinated paraffins (MCCP or chloroalkanes, C_{14-17})
Endosulfan
Mercury (Hg)
Cadmium (Cd)

cadmium as well as dioxins and dioxin-like PCBs in muscle meat of fish are used as intermediate target levels for fish in the Baltic Sea.

The ecological objective ‘Healthy wildlife’ encompasses indicators for fish-feeding predators as well as fish. The following indicators were suggested:
– Productivity of white-tailed eagles (number of successfully reproducing pairs and brood size).
– Health of seal and harbour porpoise (pregnancy rate, fecundity rate, occurrence of uterine pathology , occurrence of intestinal ulcers).
– Fish disease index.

The indicators to follow up the ecological objective ‘Radioactivity at pre-Chernobyl levels’ comprise:
– Concentration of cesium-137 (Cs-137)in herring muscle as an indicator for the whole Baltic Sea and in plaice and flounder muscle for the Southern Baltic Sea (southwards from Gotland). The primary target is a decreasing concentration trend and the ultimate target level is to reach pre-Chernobyl level which is 2.5 Bq/kg wet weight for herring muscle and 2.9 Bq/kg wet weight for plaice and flounder muscle.
– Concentration of Cs-137 in seawater for the whole Baltic Sea with the primary target of decreasing concentration trend and an ultimate target level to reach the pre-Chernobyl level of 14.6 Bq/m^3.
– Concentration of Cs-137 in sediment for the whole Baltic Sea with with the primary target of decreasing concentration trend an ultimate target level to reach the pre-Chernobyl level of 1,640 Bq/m^2.

1.3 Marine indicator development outside the Baltic Sea

The development of HELCOM core indicators has followed similar processes in other sea regions and good experience from other sea regions has been used throughout the CORESET process. This section presents indicators and related objectives in the North-East Atlantic, the Mediterranean, the Black Sea and the United States.

North-East Atlantic

Indicator development under the OSPAR Commission has aimed to fulfil the requirements of the MSFD in the North-East Atlantic. The proposal to the OSPAR common set indicators currently contains 39 biodiversity indicators (OSPAR 2013). The OSPAR common set indicators are presented in **Annex 2**. The indicators were built on a set of selection criteria, using the already-existing Ecological Quality Objectives (EcoQO) as far as possible. The system of EcoQOs covers all major features of the North Sea ecosystem: mammals, seabirds, fish, benthic and planktonic communities and eutrophication (OSPAR 2009 a) (**Table 4**). In addition to the system of EcoQOs, OSPAR has developed Environment Assessment Criteria (EAC) and Background Assessment Criteria (BAC) for the assessment of the status of hazardous substances (OSPAR 2009 b). The substances assessed in the OSPAR Quality Status report (OSPAR 2010) and its background report (OSPAR 2009 b) are listed in **Table 5**.

Table 4. Ecological Quality Objectives of the OSPAR Commission (OSPAR 2009 a).	
Commercial fish species	Maintain the spawning stock biomass above precautionary reference points for commercial fish stocks agreed by the competent authority for fisheries management.
Marine mammals	Seal Population Trends (a) There should be no decline in harbour seal population size within any of the eleven sub-units of the North Sea.
	(b) There should be no decline in pup production of grey seals within any of the nine sub-units of the North Sea.
	Annual bycatch of harbour porpoises should be reduced to below 1.7% of the best population estimate.
Seabirds	Changes in breeding seabird abundance should be within target levels for 75% of species monitored in any of the OSPAR regions or their sub-divisions. [a]
	The proportion of oiled common guillemots should be 10% or less of the total found dead or dying in all areas of the North Sea.
	There should be less than 10% of northern fulmars (*Fulmarus glacialis*) having more than 0.1 g plastic particles in the stomach in samples of 50 to 100 beach-washed fulmars found from each of the four to five areas of the North Sea over a period of at least five years.
	Concentrations of mercury in the eggs of Common Tern (*Sterna hirundo*) and Eurasian Oystercatcher (*Haematopus ostralegus*) breeding adjacent to the eight industrialised estuaries should not exceed concentrations in eggs of the same species breeding in similar habitats in south-western Norway and in the Moray Firth.
	Concentrations of organochlorines in the eggs of Common Tern (*Sterna hirundo*) and Eurasian Oystercatcher (*Haematopus ostralegus*) breeding adjacent to the eight industrialised estuaries should not exceed the set values.
Fish communities	At least 30% of fish (by weight) should be greater than 40 cm in length.
Benthic communities	(a) The average level of imposex (development of male characteristics by females) in female dog whelks should be consistent with the specified levels.
	(b) There should be no kills in benthic animal species as a result of oxygen deficiency and/or toxic phytoplankton species.
Plankton community	(a) Maximum and mean phytoplankton chlorophyll a concentrations during the growing season should remain below the specified limits.
	(b) Area-specific phytoplankton species that are indicators of eutrophication should remain below the specified limits.
Eutrophication	All parts of the North Sea should have the status of non-problem areas with regard to eutrophication by 2010.
	Winter concentrations of dissolved inorganic nitrogen and phosphate should remain below the specified limits.
	Maximum and mean phytoplankton chlorophyll a concentrations during the growing season should remain below the specific limits.
	Area-specific phytoplankton species that are indicators of eutrophication should remain below the specific limits
	Oxygen concentration should remain above the specified limits.

a) The EcoQO for breeding seabirds was not published in OSPAR (2009 a) report but in the report of the ICES WGSE (ICES 2011).

Table 5. OSPAR hazardous substances assessed in the 2010 Quality Status Report (OSPAR 2009 b, 2010).
Metals: Cadmium, Lead, Mercury (Chemicals for Priority Action), Nickel, Copper, Zinc, Chromium and Arsenic.
Tributyltin (TBT) in sediments (**Chemical for Priority Action)** and TBT-specific biological effects.
Polycyclic aromatic hydrocarbons (PAHs) (**Chemicals for Priority Action); Focus on** fluoranthene, benzo[a]pyrene, benzo[ghi]perylene, phenanthrene and anthracene.
Polychlorinated biphenyls (PCBs) (Chemicals for Priority Action). Focus on CB153 and CB118.
Lindane (γ-hexachlorocyclohexane) (**Chemical for Priority Action**).
CYP1A (EROD) activity.

Mediterranean Sea

The Barcelona Convention has a vision of ‘A healthy Mediterranean with marine and coastal ecosystems that are productive and biologically diverse for the benefit of present and future generations’ and three strategic goals:

- To protect, allow recovery and, where practicable, restore the structure and function of marine and coastal ecosystems thus also protecting biodiversity, in order to achieve and maintain good ecological status and allow for their sustainable use.
- To reduce pollution in the marine and coastal environment so as to minimize impacts on and risks to human and/or ecosystem health and/or uses of the sea and the coasts.
- To prevent, reduce and manage the vulnerability of the sea and the coasts to risks induced by human activities and natural events (UNEP MAP 2012 a).

The Contracting Parties to the Barcelona Convention decided that the UNEP Mediterranean Action Programme (MAP) should gradually implement the ecosystem approach in the Mediterranean. The report by UNEP/MAP gave a plan for an integrated ecosystem assessment with Ecological Objectives, Operational Objectives and Indicators (UNEP MAP 2012 b). The eleven Ecological Objectives are almost one to one with the EU MSFD qualitative descriptors with the exception of having the objective '*The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved'* and only one objective for contamination. Similarly, the operational objectives and indicators closely follow the criteria and methodological standards of the EC (Anon. 2010).

Black Sea

The Black Sea Strategic Action Plan (BS SAP) identified four Ecological Quality Objectives (EcoQO) (**Table 6**), which were also divided into some sub-objectives. In order to reach the objectives, the BS SAP listed 64 management targets (Black Sea Commission 2009). Annex 4 of the BS SAP lists *process indicators* to follow up the implementation of the action plan; *stress reduction indicators* to measure the decrease of human pressures; and *environmental state indicators* to measure the state of the environment.

The BS SAP associates stress reduction indicators with the EcoQOs, but gives a separate list of nine environmental state indicators. These are:

1. Measurable improvements in trophic status.
2. Improved (measurable) ecological or biological indices.
3. Improved recruitment classes of targeted fish species/diversity/keystone species.
4. Increase in the availability of fishing resources.
5. Changes in local community income/social conditions as a result of improvements in environmental conditions.
6. Stakeholder awareness raised and involvement documented.
7. The reduction of pollutant concentrations in coastal areas and port zone (heavy metals, persistent organic compounds concentrations, etc.).
8. Relevant coastal habitats rehabilitated.
9. Reduced number of threatened species.

Table 6. Ecological Quality Objectives and sub-objectives of the Black Sea Strategic Action Plan and the associated stress reduction indicators.

Ecological Quality Objectives	Stress reduction indicators
EcoQO 1: Preserve commercial marine living resources. **EcoQO 1a: Sustainable use of commercial fish stocks and other marine living resources.** **EcoQO 1b: Restore/rehabilitate stocks of commercial marine living resources.**	Closed fishing seasons established. Number and area of no-fishing areas developed. Ban on unsustainable fishing practices in place.
EcoQO 2: Conservation of Black Sea Biodiversity and Habitats. **EcoQO 2a: Reduce the risk of extinction of threatened species.** **EcoQO 2b: Conserve coastal and marine habitats and landscapes.** **EcoQO 2c: Reduce and manage human mediated species introductions.**	Number and total area of Protected Areas. Surface area of buffer zones. Number of EA/EIA/SEA procedures used. Number and area of illegal dumping sites cleaned-up. Number of new projects to install solid waste handling facilities.
EcoQO 3: Reduce eutrophication.	Lists of WWTWs (municipal and industrial) for upgrading with financing. % of P-free detergents sold in BS countries. Prosecution numbers of dischargers failing standards. Investments in agricultural facilities to reduce N/P pollution. Funds available for economic incentives in agriculture. Area of land under modified farming practices. Number of (and investment in) farm demonstration projects.
EcoQO 4: Ensure Good Water Quality for Human Health, Recreational Use and Aquatic Biota. **EcoQO 4a: Reduce pollutants originating from land based sources, including atmospheric emissions.** **EcoQO 4b: Reduce pollutants originating from shipping activities and offshore installations.**	Number of permits / licences granted and inspections undertaken. % increases in state budget for pollution prevention. Number of installations using BAT. Number of permits for dredging disposal. Increases in treatment of ship-generated wastes. Investments in ship waste handling facilities. Harmonised cost recovery / fee system in place for ship-generated waste.

United States

The US National Oceanic and Atmospheric Administration (NOAA) has adopted a vision 'Healthy ecosystems, communities, and economies that are resilient in the face of change'. The NOAA's ocean-related goals are for 'Healthy Ocean' and 'Resilient Coastal Communities and Economies'. The NOAA objectives under the goals have associated targets, which give qualitative definitions for the follow-up of each objective. **Table 9** gives the NOAA goals, objectives and targets.

The NOAA targets have a lot of emphasis in economic growth, increased information and improved practices. The environmental targets focus on habitats, water quality, threatened species and fish stocks. A fundamental difference between NOAA and the European objectives is the lack of objectives for predominant species and food web features in the NOAA system (**Table 7**).

The US Coastal Condition Report is a multi-agency effort by using nationally consistent monitoring

Table 7. NOAA goals, objectives and targets for marine ecosystems (http://www.ppi.noaa.gov/goals/). Note that the goals, objectives and targets that are not related to state, pressures or impacts on the environment are not shown.

Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems. *Long-term goal:* Healthy oceans.	
Objectives	**Targets**
Improved understanding of ecosystems to inform resource management decisions.	*(only targets for information needs)*
Recovered and healthy marine and coastal species.	Stabilized or increased abundance of species that are depleted, threatened or endangered.
	Decreased bycatch of protected species.
	Increased number of protected species with improving status.
Healthy habitats that sustain resilient and thriving marine resources and communities.	Increased protection and restoration of habitats to enhance vital ecosystem services.
	Habitat conservation targets and evaluation protocols set to focus and improve habitat protection and restoration actions in priority areas.
	Essential fish habitat designations that encompass key habitats as informed by habitat assessments.
	Increased use of partnerships, scientifically sound conservation measures, coastal and marine spatial planning, and regional ecosystem conservation approaches to protect and restore priority habitats.
	Climate change impacts addressed in conservation actions to promote long-term habitat resilience and adaptation.
Sustainable fisheries and safe seafood for healthy populations and vibrant communities.	Improving trends in stocks categorised as overfished shown in increases in abundance.
	Reduced numbers of stocks subject to overfishing.
	Increased allowable catch levels as fish stocks reach rebuilt status.
	Decreased bycatch of target and non-target species.
Coastal and Great Lakes communities that are environmentally and economically sustainable. *Long-term goal:* Resilient Coastal Communities and Economies.	
Resilient coastal communities that can adapt to the impacts of hazards and climate change.	An increase in the percentage of U.S. coastal States and territories demonstrating annual improvements in resilience to coastal and climate hazards.
	Healthy natural habitats, biodiversity, and ecosystem services support local coastal economies and communities.
Comprehensive ocean and coastal planning and management.	Key coastal, marine, and Great Lakes areas acquired or designated for long-term conservation and managed to maintain critical ecosystem function and support coastal economies.
Safe, efficient and environmentally sound marine transportation.	Reduced maritime incidents in U.S. waters through timely and accurate navigational information.
	Increased preparedness and response to maritime incidents and emergencies.
Improved coastal water quality supporting human health and coastal ecosystem services.	Reduced impacts to human health and ecosystem services due to degraded water quality.
	Accelerated recovery and restoration of coastal resources and revitalization of coastal communities through improved water quality.
Safe, environmentally sound Arctic access and resource management.	Reduced risk and impact of maritime incidents on the Arctic environment.

surveys and a range of various indices covering issues from contamination and eutrophication to the state of lower trophic levels and fish stocks (US EPA 2012 a). The indices used in the assessment are shown in **Table 8**. The same indices are also used in the US National Estuary Programme (US EPA 2006); a specific indicator development report presents a process to identify, test and select the indicators (US EPA 2008).

Table 8. Indicators used in the Coastal Condition Report of the US EPA (2012 a).
Water Quality Index: DIN, DIP, Chl a, water clarity, dissolved O_2.
Sediment Quality Index: Toxicity with a 10-day toxicity test by the amphipod *Ampelisca abdita*; Metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc); PAH (acenaphthene, acenapthylene, anthracene, fluorene, 2-methyl naphthalene, naphthalene, phenanthrene, benz(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, pyrene, low-molecular-weight polycyclic aromatic hydrocarbon (PAH), high-molecular-weight PAH, total PAHs); DDT, DDE, total PCBs.
Benthic Index (community diversity, presence/absence of pollution-tolerant species and pollution-sensitive species.
Coastal Habitat Index: Average of the mean long-term decadal wetland loss rate and present decadal wetland loss rate.
Fish Tissue Contaminants Index: Metals (arsenic, cadmium, mercury, selenium); Organic compounds (chlordane, DDT, dieldrin, endosulfan, endrin, heptachlor epoxide, hexachlorobenzene, lindane, mirex, toxaphene, PAH (benzo(a)pyrene), PCB).
Dissolved Inorganic Nitrogen (DIN), Dissolved Inorganic Phosphorus (DIP), Chlorophyll *a*.
Water Clarity.
Dissolved Oxygen.
Sediment Contaminants.
Sediment Total Organic Carbon (TOC).
Benthic Diversity (in lieu of benthic index).
Large Marine Ecosystem Fishery stocks (landings/ catch, fishing mortality rate, yields, overfishing/overfished, degree of utilization).

2 The HELCOM approach to developing core indicators

2.1 Criteria of the HELCOM core indicators

The concept of core indicators implies that the monitoring data and assessment results are comparable across the region and over time, and that the commonly agreed set of indicators can be used in the whole Baltic Sea area. This requirement implicates that the indicators must be based on common principles. A further need for common principles arises from HELCOM's general aim to harmonise assessment procedures for the whole Baltic Sea region and from the EU legislation. This requires coherence, coordination and cooperation within the Baltic Sea and between regional sea conventions when developing targets and associated indicators, and when assessing the status of the marine environment.

The common principles for HELCOM core indicators and their quantitative targets are outlined in **Tables 9 and 10.** These principles were endorsed by HELCOM HOD 35/2011 and published in the interim report of the CORESET project (HELCOM 2012 a).

Table 9. Common principles for HELCOM core indicators, recalling the HELCOM Monitoring and Assessment Strategy, as well as the HELCOM Data and Information Strategy.

1	Compiled and updated by the Contracting Parties.
2	Science-based: Each indicator describes a scientifically sound phenomenon.
3	Link to anthropogenic pressures: Status indicators should be linked to anthropogenic pressures and indirectly reflect them, where appropriate; additional pressure indicators are also used and directly reflect anthropogenic pressures and are tightly linked to human activities.
4	Policy response: The indicator measures part of or fully an ecological objective and/or a descriptor of good environmental status.
5	Suitability with assessment tools: The indicator can be used with the assessment tools but the assessment tools will be open for modifications as necessary.
6	Suitability with BSAP/MSFD, making best use of the synergies with other Directives and according to the HELCOM Monitoring and Assessment Strategy: The indicator reflects a component contained in the HELCOM system of the vision, goals and ecological objectives and/or MSFD descriptor.
7	Qualitative or quantitative with a textual background report: Indicators, either qualitative or quantitative, are numeric, based on measurements or observations and validated models; they must also have a quantitative target level reflecting the lowest boundary of good environmental status. They also contain a textual background report with interpretation of the indicator results. The report should be published on the HELCOM website and ultimately should take the form of the three-layered indicator report (cf. preliminary core eutrophication indicator reports) with the main page containing a status map and the main message aimed at decision makers; the second page containing trend information, e.g. for different sub-basins; and the third page containing technical background information and information on the confidence of the assessment.
8	Baltic Sea wide: The HELCOM indicators should cover the whole sea area.
9	Commonly agreed: The finalised indicators and their interpretation are commonly agreed among the HELCOM Contracting Parties and HELCOM MONAS is the HELCOM body that should approve the publication of the core indicator reports on the HELCOM web page.
10	Frequently monitored and updated: Data underlying the indicators are collected within the HELCOM coordinated monitoring (HELCOM COMBINE, MORS-PRO, PLC) and the indicator reports will be updated preferably annually or at intervals suitable for the measured factor.
11	Harmonised methodology: Data in an indicator will be collected using harmonised monitoring, quality assured analytical methods, as well as harmonised assessment tools according to the relevant HELCOM guidelines or EU standards, such as methodological standards or guidelines for GES under the MSFD to be delivered by the EC and other relevant international standards.
12	Confidence evaluation: The indicator and the data must be assessed using common criteria and this confidence evaluation is to be included in the indicator report.

Table 10. Common principles for quantitative or qualitative targets of core indicators. The target here refers to the boundary of good environmental status (GES).

1	Targets need to be developed for each indicator separately.
2	Purpose of the status targets: The target reflects the boundary between GES and sub-GES. The boundary can be based on a specific score (cf. ecological quality ratio, EQS, *sensu* WFD and also used in HEAT and BEAT) that can be derived through the use of an ‘Acceptable deviation’ from a ‘Reference condition’.
3	Purpose of the pressure targets: The targets reflecting anthropogenic pressures should guide the progress towards achieving good environmental status.
4	Science-based: A target level should be based on best available scientific knowledge. In the absence of data and/or modelling results, expert judgment based on common criteria should be involved to support the target setting.
5	Spatial variability: Target levels can vary among sub-basins or among sites depending on natural conditions.
6	Confidence of the targets must be evaluated by common criteria and included in the general confidence evaluation of the indicator report.

2.2 Relationships between state, impact and pressure indicators

There is a growing need to understand the causality of human impacts on the marine environment. Therefore, the development of environmental indicators has focused, not only to depict changes in the environmental status, but also on anthropogenic pressures and societal responses.

Environmental indicators have often been categorised by the so-called DPSIR framework (overview by Kristensen 2004), where economic and social policies act as *Drivers* to the ecosystem; *Pressures* express these drivers in more detail; Environmental *State* is observed; *Impacts* are the implications of the altered state; and *Responses* are society actions to remediate the impacts. While the framework seems simple to use, in practice the differences between the components are complex and their role is always dependent on the context of the assessment. For example, nutrient concentrations can be regarded as status indicators for water quality and as pressure indicators for wildlife whereas impacts can be found on the ecosystem or society level, making the identification of real drivers a challenge for managers.

The simpler PSR (pressure-state-response) model implies that human activities exert pressures on the environment, which can induce changes in the state of the environment that societies respond to with environmental and economic policies (OECD 1993).

The HELCOM core indicators have been developed on the basis of the PSR framework. In practice, the work has concentrated on pressures and state. As the HELCOM principles for core indicators required a close connection between the state of the ecosystem and the anthropogenic pressures on it, the state core indicators can, in many cases, be also regarded as impact indicators (according to the terminology of the MSFD). The distinction between the two depends on the strength of the connection between the state and the pressure(s) and can be arbitrary to distinguish.

The principles for core indicators require the development of indicators that measure anthropogenic pressures directly (**Table 11**). The CORESET work with pressure indicators aimed at indicators that have close connection to human activities. Examples of good pressure indicators are annual inputs of nutrients to the Baltic Sea, fishing pressure on a specific stock and noise from shipping traffic. Indicators for concentrations of hazardous substances or nutrients in the marine environment or other eutrophication indicators may describe a pressure to the ecosystem; however, as they are a step farther from human activities, they are not recommended to be considered as HELCOM pressure indicators.

2.3 The process of developing the HELCOM core indicators

The selection of the set of core indicators for biodiversity and hazardous substances in the HELCOM CORESET project was initiated by HELCOM Heads of Delegation; coordinated by the Secretariat; steered by the Joint Advisory Board of the HELCOM TARGREV and CORESET Projects (HELCOM JAB); and carried out by experts working on different indicators. The HELCOM Biodiversity and Nature Conservation Group (HABITAT) and the Monitoring and Assessment Group (MONAS) reviewed the outcomes while the new HELCOM Group for the Implementation of the Ecosystem Approach (GEAR) took over the steering role of HELCOM JAB.

The work in the CORESET project was divided between two expert groups: biodiversity (BD) and hazardous substances (HS). The task of the hazardous substances group did not require the group to split into smaller teams; however, for the biodiversity group, further grouping was necessary due to the wide scope of the issue. The biodiversity group decided that the development of indicators should be carried out by six teams who focused on:

i. Mammals
ii. Birds
iii. Fish
iv. Pelagic habitats (including associated communities)
v. Seabed habitats (including associated communities)
vi. Non-indigenous species

The *ad hoc* expert group for marine mammals (HELCOM SEAL EG) specifically reviewed the mammal work. Members of the HELCOM phytoplankton expert group (PEG), the zooplankton expert group (ZEN QAI) and the project for the coastal fish assessments (HELCOM FISH-PRO) participated in the respective working teams. Experts working with the ballast water issues in HELCOM MARITIME participated in the group working on non-indigenous species. The ICES Study Group for Ecosystem Health (SGEH) and the BONUS project BEAST contributed to the development of the indicators for the biological effects of hazardous substances. Coordination with the eutrophication experts developing the core indicators under HELCOM MONAS was assured by regular information exchange between the two processes.

Table 11 gives a summary of the HELCOM CORESET meetings and meetings of its advisory groups (JAB, MONAS and GEAR). The interim report of the project (HELCOM 2012 a) describes the work of the expert groups and the selection of the indicator in more detail.

Table 11. Meetings of the HELCOM CORESET project.

Time and place	Meeting
20-21 September 2010, Stockholm	HELCOM JAB 1/2010
20-21 October 2010, Hamburg	HELCOM CORESET HS 1/2010
3-4 November 2010, Helsinki	HELCOM CORESET BD 1/2010
2-3 February 2011, Helsinki	HELCOM CORESET HS 2/2011
16-18 February 2011, Gothenburg	HELCOM CORESET BD 2/2011
21-22 March 2011, Berlin	HELCOM JAB 2/2011
31 May – 1 June 2011, Klaipeda	HELCOM CORESET HS 3/2011
15-17 June 2011, Riga	HELCOM CORESET BD 3/2011
27-28 June 2011, Warsaw	HELCOM JAB 3/2011
12-13 September 2011, Copenhagen	HELCOM CORESET BD 4/2011
20-21 September 2011, Tallinn	HELCOM SEAL EG 5/2011
4 October 2011, Vilnius	HELCOM JAB 4/2011
4-6 October 2011, Vilnius	HELCOM MONAS 15/2011
15-16 November 2011, Helsinki	HELCOM JAB 5/2011
15-16 December 2011, Gothenburg	HELCOM CORESET TOOLS 1/2011
11-12 January 2012, Stockholm	HELCOM CORESET HS 4/2012
31 January – 1 February 2012, Helsinki	HELCOM CORESET waterbird team meeting
6 February 2012, Hamburg	HELCOM CORESET porpoise team meeting
14-15 February 2012, Gothenburg	HELCOM JAB 6/2012
16 February 2012, Helsinki	HELCOM CORESET fish team meeting
28 February 2012, Helsinki	HELCOM CORESET zooplankton team meeting
15 March 2012, Helsinki	HELCOM CORESET benthos team meeting
27-28 March 2012, Helsinki	HELCOM CORESET BD 5/2012
28-29 May 2012, Bonn	HELCOM GEAR 1/2012
11-12 September 2012, St. Petersburg	HELCOM SEAL EG 6/2012
25-28 September 2012, Gothenburg	HELCOM MONAS 17/2012
22-24 October 2012, Gothenburg	HELCOM GEAR 2/2012
10-11 December 2012, Kalø	HELCOM CORESET waterbird team meeting
29-31 January 2013, Warnemünde	HELCOM CORESET benthos team meeting
11-12 February 2013, Roskilde	HELCOM CORESET HS 5/2013
26-27 February 2013, Helsinki	HELCOM CORESET BD 6/2013
22-25 April 2013, Rønne	HELCOM MONAS 18/2013

The biodiversity expert group had several major issues to clarify in the selection process:

– What are the key species and key trophic groups in the Baltic ecosystem?
– How can species to functional groups be categorised?
– How can anthropogenic pressures be linked to species, groups of species or parameters?
– What approach should be selected to determine a quantitative boundary for GES?
– How can several candidate indicators be filtered to a limited set of core indicators?

As a result of the process, the expert group categorised several candidate indicators into core indicators - the rest were either left aside or specifically recommended as supplementary indicators. As a side product of the CORESET project, five supplementary indicators on non-indigenous species (NIS) were published as Baltic Sea Environment Fact Sheets in www.helcom.fi. The core indicators for biodiversity and their effects are described in Chapter 3.

The hazardous substances expert group faced the challenge of making reliable selection criteria for the indicators as there are hundreds of potential substances known to have adverse effects on the environment. The selection criteria for the hazardous substances core indicators were:

– alarming / increasing levels of the substance in the Baltic;
– PBT properties (persistence, bioaccumulation, toxicity);
– management status (banned, regulated, not banned);
– policy relevance (existing priority lists);
– the availability of targets for GES; and
– the availability of monitoring data (not a strict criterion for the selection).

The hazardous substances expert group was able to benefit from the European and US process of setting ecotoxicological thresholds for marine biota, water and sediment, which made the determination of the GES boundary easier than in the biodiversity group. The core indicators for hazardous substances and their effects are described in Chapter 4.

The CORESET project did not develop eutrophication core indicators because this process was already started by eutrophication experts under HELCOM MONAS (the CORE EUTRO process). Chapter 5 summarises the progress made with the eutrophication core indicators.

2.3 Towards an operational follow-up system of the state of the Baltic Sea

The ultimate objective of the HELCOM core indicator work is to produce a system for following-up the effectiveness of the implementation of the Baltic Sea Action Plan. The work directly benefits the implementation of the Marine Strategy Framework Directive of the EU Member States in the region and the revision of the joint monitoring programmes. Spin-offs of this work improve awareness of the pressures, impacts and state of the Baltic Sea environment.

In order to be effective, the core indicators need to be *operational*. This means that:

- required sampling through a monitoring programme has been set up;
- quality control of the data has been organised;
- an expert group has taken responsibility for the data analysis;
- …, interpretation of the analysis results and
- … visualization of the indicator; and
- data flow from monitoring programmes to the assessment product has been automated as far as convenient.

The revision of the HELCOM Monitoring and Assessment Strategy was scheduled by the Moscow Ministerial Declaration (2010); the development of operational core indicators is an integral part of this strategy. In practice, a regular update of a core indicator and the maintenance of high quality assessment products require an expert group to take responsibility over core indicators and the entire cycle presented in **Figure 3**.

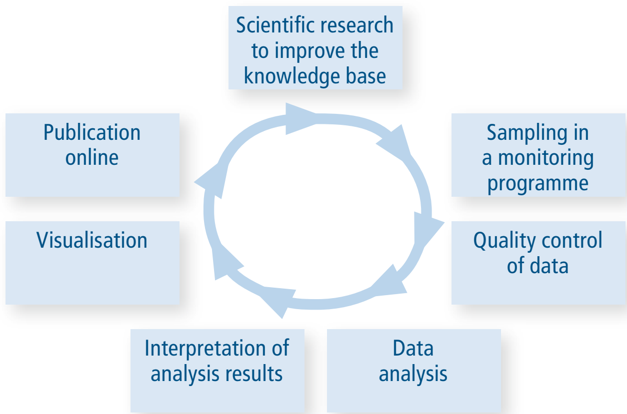
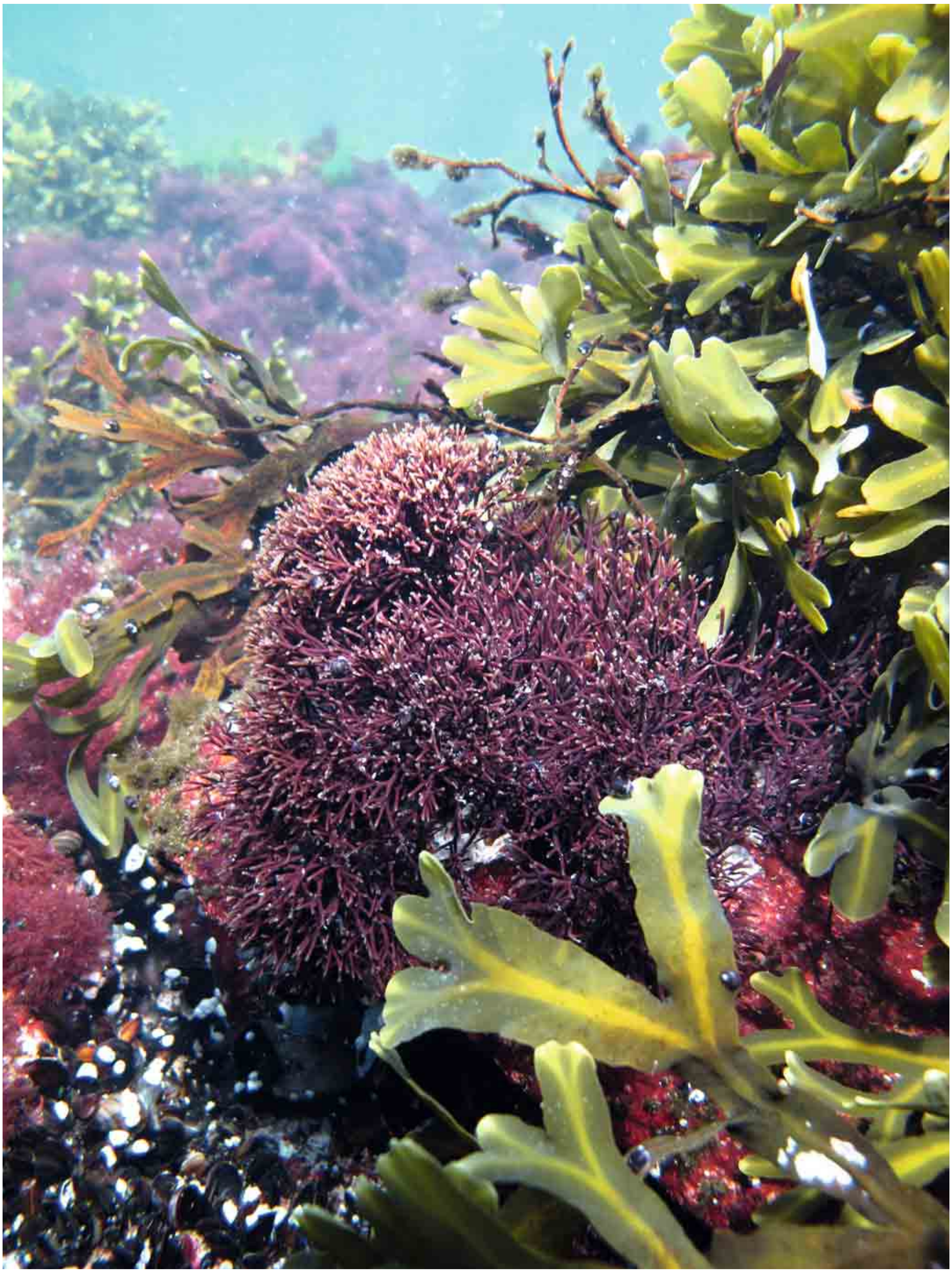


Figure 3. Cycle of an operational core indicator. See text for further insight.

3 The set of biodiversity core indicators for the Baltic Sea



3.1 Biodiversity indicators cover the Baltic marine ecosystem

From the outset of the CORESET project, the development of biodiversity core indicators concentrated on species that are common and play a significant role in the Baltic Sea food web or the ecosystem in general. The same approach was applied to habitat indicators which were to follow predominant habitats or communities. In some cases, it was more reasonable to identify a functional group (e.g. cyprinid fish) or a trophic group (e.g. mesopredators) than a species representing the group (e.g. roach). By definition, the purpose of the core indicators is not to fully cover the Baltic ecosystem but to represent the main features.

The Baltic Sea ecosystem comprises a fairly simple food web with a handful of keystone species. Following the advice of the EU MSFD Task Group 1 for the development of criteria and methodological standards (Cochrane et al. 2010), the indicators were divided to mammals, birds, fish, benthic habitats and communities as well as pelagic habitats and communities (**Tables 12** and **13**). The benthic habitats were divided by depth zones and according to substrate types, whereas pelagic habitats are estuarine, coastal and offshore waters. The habitat grouping was made on a coarse level and it should be aligned with the new HELCOM biotope classification in future work (HELCOM 2013). The divisions differed from Cochrane et al. (2010) as certain adjustments to the conditions of the Baltic Sea such as shallowness, brackish water, lack of certain fauna (e.g. cephalopods) and the proximity of coast was required.

Although the above-mentioned functional groups and the predominant habitats formed the basis of the development of core indicators, some indicators required further recognition of keystone species and those functional groups that have a keystone role in representing the ecosystem or a process or a phenomenon within it. These more detailed lists of these species and taxa were given in the interim report of the CORESET project (HELCOM 2012 a).

In total, 20 biodiversity core indicators were developed and proposed. The core indicators cover reasonably well, and in a balanced way, the different species groups (**Table 14**, **Figure 4 A**). There are four indicators for mammals, five for birds (one shared with mammals), five for fish and five for benthic habitats and communities. The pelagic or planktonic features have a weaker representation – with only one zooplankton indicator. The ICES-generated indicators for the commercially exploited fish stocks (cod, sprat and herring) largely represent the pelagic community and, hence, the pelagic core indicators can be assessed in a better balance in the Baltic Sea. Moreover, the proportion of large pelagic fish was included as a component in the 'large fish indicator' (cf. **Table 14**). There is no indicator proposed for phytoplankton.

The core indicator for the non-indigenous species (NIS) represents non-native biodiversity in the Baltic Sea. The indicator was agreed to cover all marine NIS and follow the number of new species per assessment unit. However, to interpret the indicator – impacts, distribution and abundance of the species – it was agreed to develop supplementary indicators, which were published as Baltic Sea environment fact sheets (formerly known as indicator fact sheets).

In addition to the core indicators, the HELCOM assessment products also account for other indicators which support the core indicators by giving more detailed information on natural processes or being indicators of a narrower geographic extent. The Baltic Sea Environment Fact Sheets (BSEFS) are expert-maintained and regularly updated online publications that provide up-to-date information on species abundance, distribution and temporal trends, intensities of algal blooms as well as occurrences of non-indigenous species, among others. In addition, EFSs give basic hydrographical, chemical and physical information of the Baltic Sea. They are published on the HELCOM web site (www.helcom.fi).

The biggest gaps in this first set of core indicators are the lack of indicators for phytoplankton and for hard-bottom and macrophyte communities. Moreover, the proposal had only a couple of pressure indicators (see **Chapter 3.5**).

Development of the phytoplankton core indicator proved to be a difficult task; at least three candidate indicators were tested during the project's lifetime in addition to previous studies (Jaanus et al. 2009, Uusitalo et al. 2013). The challenge with the phytoplankton indicator was not its functionality, for example in responding to pressures or showing a change in species composition, but in applying it over wider geographical area. The environmental gradients in the Baltic Sea seem to affect the responsiveness of the phytoplankton communities, making it difficult to find similar indicator responses from northern and southern sub-basins (Wasmund & Siegel 2008, Jaanus et al. 2011). The latest research on the changes in dinoflagellate and diatom species composition, however, seems to promise some developments in this field in the near future (Hällfors 2013).

The lack of an operational core indicator for hard-bottom communities is a big gap both in the north – where that is a predominant substrate type – and in the south, where hard-bottom areas are often protected under the EU Habitats Directive (Anon. 1992). Although the proposed core indicators include an indicator for macroalgae and blue mussels, these are considered underdeveloped at present and thus more work is needed to operationalize them. Similar responses of hard-bottom communities to higher nutrient availability or organic content have been shown throughout the Baltic Sea in several studies (e.g. Lotze et al. 2000, 2001, Berger et al. 2003, Bergström et al. 2003, Korpinen et al. 2007, 2010). For example, the macrophyte species composition in vegetated shallow areas is as sensitive to changes along a eutrophication gradient as the fauna in the macroalgal zones (Selig et al. 2007, Rosqvist 2010). Blue mussel is a keystone species in many benthic biotopes and the main food source of demersal fish and diving waterbirds in the offshore waters.

3.2 How ready are the biodiversity core indicators?

The degree of completion varies among the 20 biodiversity indicators. Ready core indicators will have the GES boundary in place and data available - the ultimate aim is that the indicators are updated regularly. Regular core indicator reports will be guaranteed by sampling through a monitoring programme, quality control, regular data flow, data analysis, assessment and visualisation (**Figure 3**). Currently, this degree of completion can be credited only to core indicators that have been processed by expert groups over several years (e.g. ICES WG Baltic Salmon and Sea trout). The marine mammal (abundance) indicator (authored by HELCOM SEAL EG), the zooplankton indicator (authored by the HELCOM ZEN QAI) and the coastal fish indicators (authored by HELCOM FISH-PRO) are also close to being operational.

The widest gaps in the operationalization can be found in the core indicators for benthic habitats and communities. In practice, this is only due to the lack of coordination between experts. The challenge of HELCOM groups is to bring this sector into closer cooperation and integrate the monitoring of these parameters in a more concrete way to the new monitoring strategy. The newly developed HELCOM underwater biotope classification system promises some support to this process (HELCOM 2013).

A practical solution for many of the gaps, presented in **Table 14**, would be to set up expert groups to take care of the entire monitoring and assessment cycle (cf**. Figure 3**).

3.3 Biodiversity core indicators in relation to other indicator work

The proposed set of biodiversity core indicators is a highly filtered subset of several potential indicators considered by the CORESET project.

The biodiversity core indicators were developed in close connection to the OSPAR COBAM process in the NE Atlantic and benefiting of the previous HELCOM work. The indicators related to the ecological objectives – the so-called BSAP indicators (**Chapter 1.2** and **Annex 1**) – were partly included in the set of core indicators. The ecological objective for the seascapes had five proposed BSAP indicators (four of them related to marine protected areas); the one following the proportion of biotopes in GES is now included in the set of core indicators. The ecological objective for the communities had four proposed BSAP indicators, of which the one following the number of new non-indigenous species was also selected as a core indicator. The ecological objective for the populations had ten proposed BSAP indicators, of which five were selected as core indicators. In addition, the indicator following the state of the cod stocks is being maintained by ICES and will be included to the follow-up system of the state of the Baltic Sea marine environment. The follow-up system will focus solely on the new set of core indicators, while the old BSAP indicators can be used as a basis for the development of new core indicators.

The OSPAR EcoQOs closely resemble the HELCOM core indicators (**Table 4**). The biodiversity core indicators include all the EcoQOs of **Table 4**, except that of the ingested marine litter. The targets of the indicators may, however, differ between the two sea regions. Moreover, the proposed OSPAR common set indicators (OSPAR 2013) are very similar to the proposed HELCOM core indicators (see **Annex 2** for comparison). The OSPAR common set indicators are more specific, i.e. thematically narrower, whereas in the HELCOM core indicators the same information is embedded as supporting information (e.g. species distribution is given in association with abundance). The main difference between the two approaches is that the HELCOM core indicators do not provide GES boundaries for these supporting parameters. A more thorough comparison of the two sets can be made, however, only after formal adoption of the indicators by the two commissions.

The biodiversity core indicators differ considerably from the indicators used by NOAA and US EPA (see **Chapter 1.3**). The NOAA indicators focus on responses and the only similarity is found with the indicator for bycaught protected species. The US EPA indicators for the Coastal Condition Report have their main focus in water and sediment quality and the contamination of fish. The benthic community diversity is the only direct similarity with the core indicators.

Various indicators from scientific publications, national work or HELCOM projects were also considered to the set of core indicators. Their further testing was limited mainly by the lack of data and experience (e.g. some macroalgae indicators, impacts of noise on mammals); unclear linkage to anthropogenic pressures (e.g. zooplankton diversity); difficulty in finding a proper monitoring method (e.g. fish trophic index); or too dynamic a response to environmental conditions (e.g. phytoplankton indicators). The CORESET interim report (HELCOM 2012 a) describes some of the candidate indicators listed during the process.

A)

B)

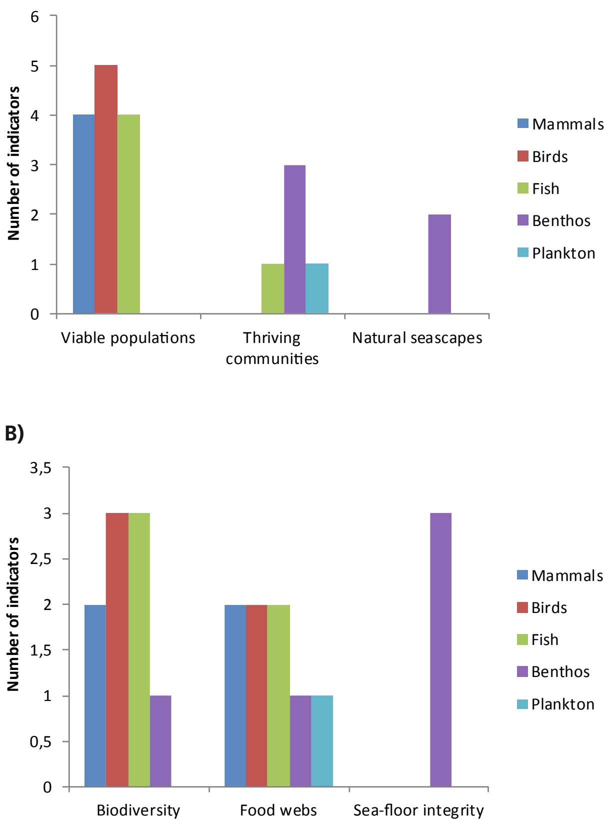


Figure 4. Summary of ecosystem components represented in the core indicators (A) among the ecological objectives and (B) MSFD qualitative descriptors. See the full names of the ecological objectives and qualitative descriptors in Figure 1 and Table 1.

Table 12. **Division of mobile species to functional groups and species groups. The groups were used as the basis for indicator development.**

Species groups	Functional groups
Birds	Coastal pelagic fish feeder Offshore pelagic fish feeder Subtidal offshore benthic feeder Subtidal coastal benthic feeder Subtidal coastal herbivorous feeder Intertidal benthic feeding birds Coastal top predators
Mammals	Toothed whales Seals
Fish	Pelagic fish Demersal fish Elasmobranchs Coastal fish Anadromous/catadromous fish

Table 13. **Division of habitats to predominant habitat types in the CORESET project. Note that the habitat types differ from the HELCOM underwater biotope and habitat classification, which was only finalised after this CORESET work (HELCOM 2013).**

Habitat group	Predominant habitat type
Seabed habitat	Baltic hydrolittoral rock and other hard substrata Baltic hydrolittoral sediment [a] Baltic infralittoral rock and other hard substrata Baltic infralittoral sediment [a] Baltic circalittoral rock and other hard substrata Baltic circalittoral sediment [a] Baltic deep sea rock and other hard substrata Baltic deep sea sediment [a]
Pelagic (water column) habitat	Estuarine water Coastal water Offshore water
Ice-associated marine habitats	

[a)] The soft sediment can be further divided into sands and muds, for example.

Table 14. **HELCOM core indicators for biodiversity. The level of readiness by the end of the CORESET project has been indicated.**

Species / habitat group	Core indicator	Level of readiness
Marine mammals	Population growth rates, abundance and distribution of marine mammals.	Seals: almost operational, lacking only a coordinated database; harbour porpoise: lacking coordination of monitoring.
	Pregnancy rates of marine mammals.	Ready for grey seal. Insufficient data for some species [a].
	Nutritional status of seals.	Ready for grey seal. Insufficient data for some species [a].
	Number of drowned mammals and waterbirds in fishing gears.	Not ready. Lack of monitoring [b].
Birds	White-tailed eagle productivity.	Almost operational, insufficient geographic data [a].
	Abundance of waterbirds in the wintering season.	Semi-ready, only coastal data; lack of offshore coordination.
	Abundance of waterbirds in the breeding season.	Semi-ready, lack of coordination.
	Number of waterbirds being oiled annually.	Semi- ready. Gaps in coverage [b].
Fish	Abundance of key fish species.	Semi-ready. GES boundaries only trend-based.
	Abundance of key functional fish groups.	Semi-ready. GES boundaries only trend-based.
	Proportion of large fish in the community.	Demersal fish: semi-ready (Lack of coordination). Pelagic fish: not ready.
	Abundance of sea trout spawners and parr.	Operational.
	Abundance of salmon spawners and smolt.	Operational.
Plankton	Zooplankton mean size and total abundance.	Ready. Lacking only a coordinated database.
Benthic habitats and communities	State of the soft-bottom macrofauna communities.	Semi-ready. Lack of offshore index.
	Lower depth distribution limit of macrophyte species.	Semi-ready. Lack of coordination, gaps in geographic coverage.
	Population structure of long-lived macrozoobenthic species.	Not ready. Need for monitoring manual and data.
	Cumulative impact on benthic habitats	Semi-ready. Need for improved spatial data.
	Extent, distribution and condition of benthic biotopes.	Semi-ready. Waiting for biotope assessments.
Non-indigenous species	Trends in arrival of new non-indigenous species.	Ready.

[a)] Data covers only some countries and/or not all species.
[b)] Limited monitoring exists in the region.

3.4 Biodiversity core indicators mirror anthropogenic pressures

An overarching theme in the development of core indicators was linking them to anthropogenic pressures. This is one of the cornerstones in indicator development (Rice & Rochet 2005). During the project, experts carried out two separate exercises to agree on the main pressures: first on functional groups and predominant habitats and then on the proposed core indicators. This linkage is especially important for managers who prioritise restrictions, bans, preventive actions or restoration plans. All the HELCOM biodiversity core indicators have this pressure linkage; however, its strength varies and in some cases several pressures were identified behind the observed response. A summary of the results is given in **Figure 5** and the matrices are presented in **Annex 3. Chapter 3.5** discusses the pressure indicators in more detail.

The main categories of anthropogenic pressures in the Baltic Sea are only few: fishing and hunting, inputs of nutrients and organic matter, inputs of hazardous substances and habitat damage/loss. The damage or loss of habitats can be further divided into constructions and installations on offshore and coastal areas, dredging and the consequent disposal of dredged matter, and the extraction of sand and gravel from the seabed. The HELCOM Initial Holistic Assessment showed that the most impacting, widespread, frequent and intensive pressures in the Baltic Sea are inputs of nutrients and organic matter, fishing and inputs of hazardous substances (HELCOM 2010 a). The assessment, however, made a particular note that the significance of pressures is highly scale dependent. For example, inputs of nutrients and organic matter from fish farms is a minor pollution source in the scale of the entire sea area whereas on a local scale it is a major pollution source that may predominate the ecosystem functioning. Similarly, while dredging may affect only a coastal bay, its impact overrides any other pressure by far on this scale. Although climate change is a global pressure and affects the entire Baltic Sea ecosystem, it is not discussed further in this report since it is not a regionally manageable pressure.

In the development of core indicators, one of the objectives was to address all the anthropogenic pressures in the region (**Table 15**). Eutrophication - a dominating phenomenon in the region - was seen to affect most of the indicators, particularly on the lower trophic levels. The higher trophic levels, however, were seen to respond, in general, more to fishing, hunting, noise and physical loss of habitats. Contamination mainly affects the top predators and breeding birds, which are impacted by predatory non-indigenous species (American mink). The abrasive impacts of demersal trawling were considered to have a high impact on benthic habitats and communities, causing habitat damage. The habitat loss caused by installations, construction works, dredging and the disposal of dredged matter showed similar linkages to the core indicators as the habitat damage (**Table 15**).

The results of the CORESET pressure-impact matrices are compatible with the results of the HELCOM Holistic Assessment (HELCOM 2010 c). Both approaches estimate the greatest pressures and highest impacts on a range of species groups and predominant habitats; in both cases, fishing, contamination and eutrophication were estimated to be of highest importance in general. In the CORESET work, more ecosystem features, i.e. functional groups and predominant habitats, were estimated than in the previous work, enabling more a specific evaluation of pressures and impacts. It is no wonder, therefore, that the two results differ to some extent.

In the Northeast Atlantic, the OSPAR Commission has deployed a similar pressure-impact matrix (OSPAR 2009 c) where MSFD pressures and various ecosystem components are linked by expert evaluations to the OSPAR sub-regions. Region II is the closest to the Baltic Sea, encompassing the Greater North Sea. Within this area, the removal of species (i.e. target and non-target fishing/hunting) and climate change were estimated to be the highest pressures for marine mammals, seabirds and fish; several weaker pressures were also identified. Habitat loss and damage as well as climate change and non-indigenous species were estimated to be the main pressures for benthic habitats. A striking difference between the CORESET and OSPAR matrices is that salinity and temperature were not considered to be relevant pressures for the North Sea ecosystem, whereas in the Baltic Sea – likely due to the strong gradients in these parameters – both of the parameters received moderate ranking from experts.

Another recent pressure-impact study was made within the MOPODECO project (Skov et al. 2012), which concentrated on benthic habitats (*sensu* EU Habitats Directive) and habitat-forming species. A great achievement of the MOPODECO project was to link the MSFD pressures to human activities and the human activities directly to the habitats and species. The project concentrated on pressure-impact links in reefs and sandbanks. According to the results, the reefs suffer from physical disturbances (causing siltation, turbidity, burial, abrasion

Table 15. Summary of the linkages between core indicators and anthropogenic pressures. An estimate of the magnitude of the impact is shown by colour (red = high, orange = moderate, yellow = weak). Note that the pressure descriptions are simplified and differ from Figure 5.

Taxon	*Core indicator*	*Pressure*	*Pressure*	*Pressure*
Mammals	Population growth rates, abundance and distribution of marine mammals	Fishing (bycatch, prey species)	Contamination	Noise
	Pregnancy rates of marine mammals	Contamination	Fishing (prey species)	Noise
	Nutritional status of seals	Fishing (prey species)	Noise	Nutrients, contamination
Mammals/birds	Number of drowned mammals and waterbirds in fishing gears	Fishing		
Birds	White-tailed eagle productivity	Contamination	Fishing (prey species)	
	Abundance of waterbirds in the wintering season	Fishing (bycatch)	Contamination (oil)	Habitat loss/damage
	Abundance of waterbirds in the breeding season	Fishing (bycatch)	Contamination (oil), NIS	Habitat loss/ damage, non-indigenous species
	Number of waterbirds being oiled annually	Contamination (oil)		
Fish	Abundance of key fish species	Fishing	Nutrients, loss of habitats	Temperature and salinity
	Abundance of fish key functional groups	Fishing	Nutrients, loss of habitats	Temperature and salinity
	Proportion of large fish in the community	Fishing	Nutrients	
	Abundance of sea trout spawners and parr	Fishing		
	Abundance of salmon spawners and smolt	Fishing		
Zoo-plankton	Zooplankton mean size and total abundance	Fishing, NIS	Nutrients	Temperature and salinity
Benthic habitats and communities	State of the soft-bottom macrofauna communities	Nutrients	Habitat loss/damage	Salinity
	Lower depth distribution limit of macrophyte species	Nutrients	Habitat loss/damage	Temperature
	Population structure of long-lived macrozoobenthic species	Habitat loss/damage	Nutrients	Temperature and salinity
	Cumulative impact on benthic habitats	Habitat loss/damage	Nutrients	Temperature and salinity
	Extent, distribution and condition of benthic biotopes	Habitat loss/damage	Nutrients	Temperature and salinity

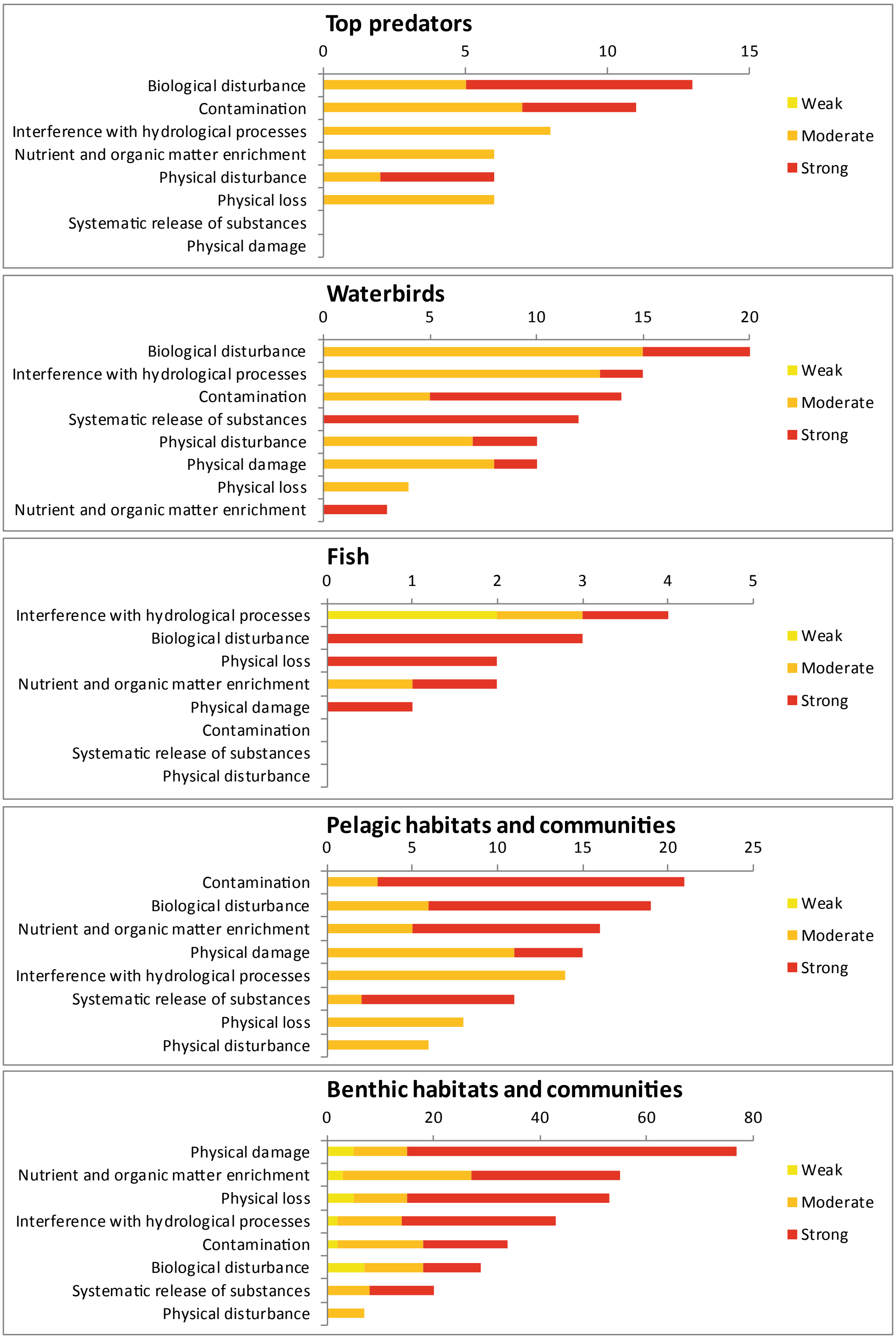


Figure 5. **A summary of the main anthropogenic pressures affecting functional groups (grouped into mammals, birds and fish) and predominant habitats and communities (grouped into pelagic and benthic). The pressures are categorised according to the EU MSFD, Annex III, Table 2. The impact scores (horizontal axis) are sums of estimated impacts on the population distribution, size and condition of the functional groups of Tables 12 and 13. Note that the scales between the graphs are not comparable. Note that in most of the graphs, the weak effects were omitted in order to focus on prioritised impacts. See Annex 3 for more information.**

and the extraction of sea-floor material), climate change (mainly salinity change, increased turbidity and siltation) and increased nutrient levels. The human activities behind the physical pressures were identified mainly as dredging, dumping dredged material, constructions, bottom trawling, gravel extraction, boating and algal/mussel harvesting. Nutrient enrichment, on the other hand, was estimated to originate from 35 different activities; for climate change, the project did not differentiate the human activities. The sandbanks were estimated to be impacted mainly by nutrient enrichment and physical pressures: the former leading to increased sedimentation, turbidity and epiphyte biomass; and the latter causing increased sedimentation, wave action, turbidity, burial and the extraction of seafloor material.

An evaluation of anthropogenic pressures on Baltic waterbirds was made in the recent SOWBAS project (Skov et al. 2011). The project suggested that fishery bycatch, oil pollution and habitat loss are significant pressures for Baltic waterbirds. These results are directly comparable with the CORESET results, where the same pressures were considered as the greatest threats to the waterbirds (**Figure 5**).

Impacts of different fishing gears on harbour porpoise, seals, waterbirds and benthic habitats and communities were estimated in the HELCOM BALTFIMPA project (HELCOM 2013 b). The preliminary results indicate that demersal seine nets, demersal trawls and mussel dredges were considered to be the most destructive on benthic habitats; trammel nets and various gillnets were estimated as the most destructive on mammals and birds; and longlines on diving birds.

According to the recent summary of the reporting under the EU Water Framework Directive (WFD) (ETC/ICM 2012), 'pollution from diffuse sources' was considered to be the main pressure for coastal water bodies (78% of the coastal water bodies in the Baltic Sea), particularly in Finland, Germany and Sweden (92-100%). Point-source pollution was typically reported to affect less than 50% of the water bodies. Nutrient enrichment to coastal waters was reported as the major pollution pressure (75% of the Baltic Sea coastal water bodies), whereas organic matter was reported in fewer water bodies (17% in the Baltic Sea). Only Sweden reported contamination as a significant pressure (41% of water bodies). Hydromorphological pressures (dredging, physical barriers, land reclamation, altered flow, etc.) were reported by Estonia (50% of the coastal water bodies), Finland (7%) and Germany (5%), while altered habitats – a result of these pressures – were reported from Finland and Germany only (7 and 5%, respectively).

The reporting of the ecological status of the coastal waters in the Baltic Sea under the EU WFD resembled that of the HELCOM assessments of eutrophication and biodiversity (HELCOM 2009 a, b, ETC/ICM 2012). The southern and southwestern water bodies were in poorer status than those affects in the north. The coastal waters of Denmark, Latvia, Lithuania and Poland were classified entirely as less than good status and in Estonia (30%), Sweden (22%), Finland (17%) and Germany (2%) only a small proportion of the coastal water bodies were considered in good or high status. All the transitional water bodies were in less than good status.

3.5 Development of pressure core indicators for biodiversity

The first set of core indicators – presented in this report – focuses on assessing the state of the marine environment with state core indicators. There are only three core indicators in this report – proportion of oiled birds, number of bycaught birds and mammals, and cumulative impacts on the seabed – that can be considered as pressure indicators. In addition, the core indicator for inputs of nitrogen and phosphorus to the sea follows the reaching of the nutrient reduction targets; however, this was developed outside the HELCOM CORESET project and is reported elsewhere.

Drowning in fishing gears is a politically topical and ecologically significant pressure on marine mammals and waterbirds. While globally this has been estimated among the top pressures on marine biodiversity (Tasker et al. 2000, Tuck et al. 2001, Zydelis et al. 2009, 2013), in the Baltic Sea where biodiversity is lower, estimates of its significance are not yet conclusive. Several recent studies, however, show that the pressure has clear adverse effects on the two populations of harbour porpoise (Herr et al. 2009, ASCOBANS 2012) and some populations of waterbirds (Bellebaum et al. 2012). There are also big knowledge gaps of its impacts, for instance on the threatened and declining subpopulations of ringed seals, and hence, the core indicator and its associated monitoring are considered important steps in the fulfilling of the ecological objective 'Viable populations of species'.

Oiling of waterbirds is a continuous pressure despite declining oil observations in the region (Larsson & Tyden 2005, Larsen et al. 2007). The core indicator following the number and proportion of oiled waterbirds in the Baltic Sea is actually not a direct pressure indicator, but presents the impact of oil. However, it may be a more accurate indicator for the oil problem than visual observations, and can also be used to track down the causalities behind observed changes in abundances of marine waterbirds. The CORESET project considered the monitoring of the oiled waterbirds significant. Oil-generated mortality of waterbirds can occur already with very small amounts of oil, which may be overlooked by surveillance flights. The core indicator is related to the ecological objective 'Viable populations of species' and the management objective 'No illegal pollution'.

The anthropogenic pressures impacting the sea floor have increased since various underwater construction projects have increased on top of the demersal fishing activities, which have ploughed the sea floor already for decades. The core indicator for the cumulative impacts of anthropogenic

pressures on the sea floor was adapted from the Baltic Sea Pressure Index (HELCOM 2010 c, Korpinen et al. 2012) to pressures particularly affecting benthic habitats.

Chapter 3.4 already described how the biodiversity core indicators reflect anthropogenic pressures; it was also noted that for some indicators this linkage is stronger than for others, and in those cases the indicator can be used to estimate the amount of a single pressure affecting the species. This is particularly the case for the pregnancy rate indicator for marine mammals, which directly reflects the impacts of persistent organic pollutants (POP), and for the brood size of the white-tailed eagle, which is mainly affected by the same pressure.

3.6 Biodiversity indicators meet the assessment needs

The three HELCOM ecological objectives under the biodiversity segment of the Baltic Sea Action Plan (BSAP) are the key requirements for the biodiversity core indicators from the perspective of the BSAP. In addition to these, there are other HELCOM ecological objectives or management objectives that touch the biodiversity core indicators. **Table 16** gives an overview of how the core indicators potentially address various HELCOM objectives. The comparison shows that the three biodiversity ecological objectives are covered by the core indicators, and that the indicators also address one eutrophication objective, one hazardous substances objective and three management objectives under the maritime segment.

The biodiversity core indicators were also developed to align with the MSFD qualitative descriptors (Anon. 2008 a) and the associated criteria (Anon. 2010). **Figure 4 b** and **Table 17** show that the biodiversity indicators potentially cover descriptors 1, 2, 4, 5, 6 and 8 (see **Chapter 1.1**). However, there are some gaps on the criterion level: the criteria for ecosystem structure (1.7) and the impacts of non-indigenous species (2.2) do not have a core indicator. As regards the former, the project was not able to suggest any reliable indicator. The impacts of NIS, however, can be assessed by the biopollution level index, which is a simple tool to aggregate impact information from various sources (Zaiko et al. 2010). To bridge this gap, HELCOM has published a Baltic-wide environment fact sheet 'Biopollution level index' in 2012.

As the MSFD descriptors 5 (eutrophication) and 8 (contaminants) are not actually descriptors for biodiversity core indicators, the potential linkages between them and the biodiversity core indicators were not the primary intention of the CORESET project. Nonetheless, there are two potential core indicators for the former and three for the latter (**Table 17**).

Table 16. Summary of how the HELCOM core indicators can potentially address the HELCOM ecological objectives for biodiversity and some additional ecological and management objectives. See the list of ecological objectives and management objectives in Figure 1 and at www.helcom.fi.

HELCOM core indicator	Viable populations of species	Thriving and balanced communities of plants and animals	Natural landscapes and seascapes	Natural distribution and occurrence of plants and animals	Healthy wildlife	No illegal pollution	Safe maritime traffic without accidental pollution	No introductions of alien species
Population growth rates, abundance and distribution of marine mammals	■							
Pregnancy rates of marine mammals	■				■			
Nutritional status of seals	■				■			
Number of drowned mammals and waterbirds in fishing gears	■							
White-tailed eagle productivity	■							
Abundance of waterbirds in the wintering season	■							
Abundance of waterbirds in the breeding season	■							
Number of waterbirds being oiled annually						■	■	
Abundance of key fish species	■	■						
Abundance of fish key functional groups		■		■				
Proportion of large fish in the community		■						
Abundance of sea trout spawners and parr	■							
Abundance of salmon spawners and smolt	■							
Zooplankton mean size and total abundance		■						
State of the soft-bottom macrofauna communities		■		■				
Lower depth distribution limit of macrophyte species		■		■				
Population structure of long-lived macrozoobenthic species		■						
Cumulative impact on benthic habitats			■					
Extent, distribution and condition of benthic biotopes			■					
Trends in arrival of new non-indigenous species								■

Table 17. Summary of how the HELCOM core indicators can potentially address the EU MSFD qualitative descriptors for good environmental status and their associated criteria. See the list of descriptors and criteria in **Table 1. Annex 4** presents a comparison against the indicators of the EC Decision 477/2010/EC.

HELCOM core indicator	1.1/1.2	1.3	1.4/1.5	1.6	1.7	2.1	2.2	4.1	4.2	4.3	5.3	6.1	6.2	8.2
Population growth rates, abundance and distribution of marine mammals	X									X				
Pregnancy rates of marine mammals		X						X						X
Nutritional status of seals		X								X				
Number of drowned mammals and waterbirds in fishing gears	X									X				
White-tailed eagle productivity		X						X						X
Abundance of waterbirds in the wintering season	X								X					
Abundance of waterbirds in the breeding season	X								X					
Number of waterbirds being oiled annually	X								X					X
Abundance of key fish species	X									X				
Abundance of key functional fish groups									X					
Proportion of large fish in the community		X		X					X				X	
Abundance of sea trout spawners and parr	X							X		X				
Abundance of salmon spawners and smolt	X							X		X				
Zooplankton mean size and total abundance				X					X					
State of the soft-bottom macrofauna communities				X							X		X	
Lower depth distribution limit of macrophyte species			X							X	X	X		
Population structure of long-lived macrozoobenthic species				X									X	
Cumulative impact on benthic habitats			X									X		
Extent, distribution and condition of benthic biotopes			X	X								X		
Trends in arrival of new non-indigenous species						X								

3.7 How the boundaries for GES have been set

The central objectives of the BSAP and MSFD are to **achieve** or **maintain** 'good environmental status' (GES). In the BSAP, the qualitative descriptions of GES have been communicated through the HELCOM vision, strategic goals and ecological objectives, whereas in the MSFD these are given by the qualitative descriptors and the associated criteria (Anon. 2010). Both the instruments give two status classes: GES and the status below GES (sub-GES). Thus, in the CORESET project, a single boundary for GES has been suggested for each indicator, if possible. The GES boundary in this report is equivalent to the *environmental target* of the MSFD.

As indicated above, the BSAP or MSFD do not define whether a binomial or a more detailed classification should be used, while the EU WFD (Anon. 2000) uses a five-level classification to describe a more detailed status of ecological status in coastal, transitional and inland waters: the acceptable state is described as 'high' or 'good' and the unacceptable classes as 'moderate', 'poor' or 'bad' (**Figure 6)**. The HELCOM thematic assessments have used a similar five-class system. The WFD uses a two-class system (good chemical status achieved / not achieved) for the chemical status in waters up to 12 nautical miles from the baseline. As it was not yet clear at the end of the CORESET project what stand HELCOM will take as regards status classes, the project concentrated on one boundary; however, it did not restrict the expert teams in developing other boundaries.

Since the MSFD and WFD overlap in coastal waters, it is important that the interpretation of 'good status' is in agreement between the two directives. The CORESET project has discussed and noted that this is not always the case: the WFD defines good status as only 'slightly' deviating from type-specific conditions and communities (2000/60/EC, Annex V, Table 1.2), while the MSFD definition of GES is linked to the concepts 'ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions' as well as to 'sustainable use' of the marine resources. For the time being, however, the project has taken a pragmatic approach and decided that for those indicators that have previously been used in the

MSFD	GES		Sub-GES		
WFD	High	Good	Moderate	Poor	Bad
HD	Favourable		Unfavourable-Inadequate		Unfavourable-Bad

Figure 6. Status classification in the Marine Strategy Directive (MSFD); the Water Framework Directive (WFD); and the Habitats Directive (HD) and their possible relationship. Note that the MSFD uses the concept 'Good Environmental Status'; the WFD 'Good Ecological Status'; and the HD 'Favourable conservation status'. Current HELCOM assessment tools use an approach similar to that of the WFD for good ecological status.

implementation of the WFD and are now also proposed to be used as core indicators, the GES boundary should be aligned with the good/moderate boundary defined in the WFD. Thus, the range covered by bad, poor and moderate is tentatively considered as representing sub-GES, while the lower range limit of good status is considered to reflect the boundary between GES and sub-GES. Likewise, the GES boundary could tentatively be compared to the boundary favourable-unfavourable conservation status used in the Habitats Directive (**Figure 6**).

The interim report of the CORESET project has presented six approaches for setting up GES boundaries for core indicators (HELCOM 2012 a). The six approaches rely partly on the rationale of the EU WFD, where a *reference level* is set and an *acceptable deviation* defines the boundary for GES. In this report, a GES boundary is redefined so that it can be set directly to a certain level, which is considered representative for the indicator. Moreover, this report also presents a seventh approach for setting a GES boundary: an indicator's relation to other taxa and environmental conditions. This approach was used in the zooplankton indicator, where time periods of good herring growth and acceptable levels of chlorophyll a were used as boundary criteria for GES. **Table 18** presents the approaches and summarises that have been used in the HELCOM core indicators to date.

Core indicators do not only provide information of the GES/sub-GES status but also on the direction of change, i.e. whether the state is moving towards or away from GES. Therefore each core indicator report aims at presenting temporal development of the assessed parameters with the aim to have statistical testing for trends.

Table 18. Approaches to set up boundaries for good environmental status and the use of them in the core indicators. An asterisk means that more than one approach was used for the indicator.

GES approach	Use in core indicators
Based on an acceptable deviation from a reference condition	White-tailed eagle productivity; Pregnancy rate of marine mammals; Nutritional status of seals; State of soft-bottom macrofauna communities; Lower depth distribution limit of macrophyte species; Extent, distribution and condition of benthic biotopes*.
Based on an acceptable deviation from a fixed reference point/period	Cumulative impact on benthic habitats; Trends in arrival of new non-indigenous species.
Based on an acceptable deviation from a potential state	Population growth rate, abundance and distribution of marine mammals*;
Based on the knowledge of physiological or population-related limitations	Population growth rate, abundance and distribution of marine mammals*; Proportion of large fish in the community; Abundance of salmon spawners and smolts; Abundance of sea trout spawners and parr.
Based on temporal trends	Number of drowned mammals and waterbirds in fishing gears; Number of waterbirds being oiled annually; Abundance of waterbirds in the wintering season*; Abundance of waterbirds in the breeding season*^; Abundance of key fish species; Abundance of key fish functional groups; Extent, distribution and condition of benthic biotopes*.
Adverse effects on the condition of an organism	
Relations other taxa and environmental conditions	Zooplankton mean size and total abundance.

3.8 Are the biodiversity GES boundaries in line with each other?

The HELCOM strategic goal for biodiversity is to have a favourable conservation status of Baltic Sea biodiversity. Together with other strategic goals, the BSAP aims at good environmental status. This means that the GES boundaries of the underlying core indicators need to be in line with each other in order to have comparable assessment results and a reliable holistic assessment of GES.

A decline of one species may be accompanied by an increase of another, resulting in a mismatch in the interpretation of GES, as known from the fish stock assessments for years (ICES 2012). To avoid such a situation where ecological interactions like competition or predation are in a decisive role in reaching GES, the HELCOM core indicators were not developed for tightly coupled species or trophic levels, e.g. cod and sprat stocks. However, since the core indicators represent all the trophic levels of the Baltic Sea ecosystem, from primary producers to top predators, GES conflicts between the indicators are still expected. For example, the increased abundance of White-tailed eagle has affected the abundance of some breeding waterbird populations (e.g. Common Eider, Caspian Tern) and the increasing grey seal population affects the coastal fish stocks negatively. **Figure 7** presents in a simplified form trophic relationships of species or functional groups used in the core indicators.

Another potential source of conflict between GES boundaries is the linkage of a species group to environmental conditions like nutrient concentrations or water transparency. It has not been thoroughly tested whether the eutrophication GES boundaries and those of the eutrophication-affected core indicators match; this should, however, be done when the core indicators become more established and it is time to refine their GES boundaries. For example, two core indicators linked to the eutrophication status are the state of macrozoobenthic communities (negatively affected) and breeding waterbirds (positively affected). It is expected that the reduction of eutrophication will decrease the abundance of breeding waterbirds.

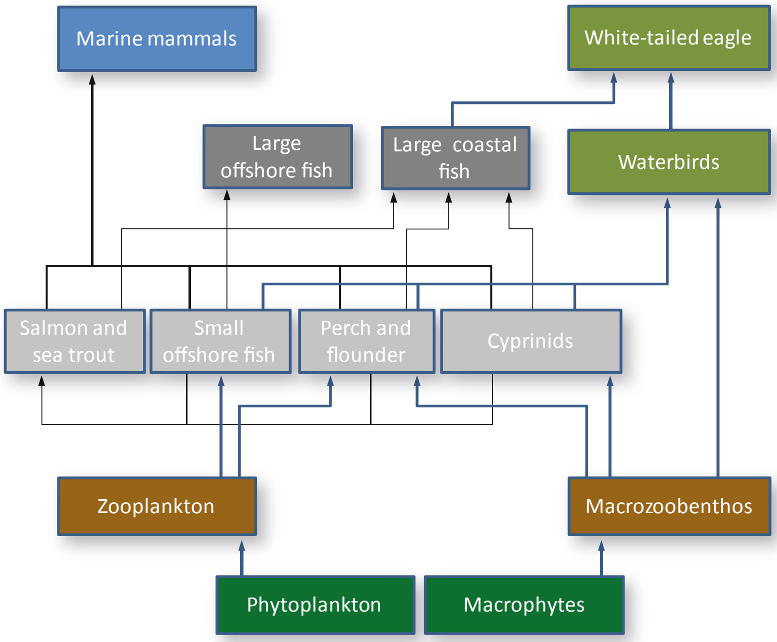


Figure 7. A simple food web of the species and functional groups (from a bottom-up view) used in the core indicators.

More detailed investigation of GES conflicts could be continued in the CORESET II project. It is likely, however, that definitions of quantitative relations of the core indicators require use of food web modelling and therefore closer cooperation with such groups could be encouraged.

The GES boundaries need regular updating as the science they are based on advances and new understanding of the target conditions is achieved. Setting definite thresholds for species abundance is a difficult task and sometimes not a reasonable target to aim at, as population sizes fluctuate with climatic factors and interactions with other species. However, as population sizes can be indicative of anthropogenic changes, the indicators can also be assessed by temporal trends. The time series graphs show changes over longer periods and how the status approaches a desired direction (GES). At the moment, some core indicators do not have static GES boundaries but rely solely on temporal trends. These indicators can inform whether the GES is approached without giving exact understanding of the effort needed to achieve it.

Several core indicators are affected by climate change. The predicted changes in ice cover, hydrography (temperature, salinity), air temperature and chemical conditions (e.g. pH) will affect the distribution and abundance of species, thus raising the need to revise the GES boundaries.

4 The set of core indicators for hazardous substances and their effects

4.1 Core indicators for hazardous substances

The CORESET expert group for hazardous substances developed 13 core indicators. Nine of these indicators measure concentrations of the substances listed in **Table 19**. The substances consist of organic contaminants as well as metals and a radioactive isotope. TBT and PAH substance indicators also include effect aspects - imposex and PAH metabolites - which give a wider picture of the contamination status. In addition to substance indicators, there are also four indicators measuring the effects of contaminants (**Table 20**).

Table 19. The substances included in the set of HELCOM core indicators for hazardous substances. The table also shows which substances can be used to assess the EU MSFD qualitative descriptors 8 (contaminants in environment) and 9 (contaminants in seafood).

Substances	Descriptor 8	Descriptor 9
Polybrominated biphenyl ethers (PBDE): BDE-28, 47, 99, 100, 153 and 154	■	
Hexabromocyclododacene (HBCD)	■	
Perfluorooctane sulphonate (PFOS)	■	
Polychlorinated biphenyls (PCB) and dioxins and furans: CB-28, 52, 101, 118, 138, 153 and 180; WHO-TEQ of dioxins, furans +dl-PCBs	■	■
Polyaromatic hydrocarbons and their metabolites: US EPA 16 PAHs / selected metabolites.	■	■
Metals (lead, cadmium and mercury)	■	■
Radioactive substances: Caesium-137 in fish and surface waters	■	■
Tributyltin (TBT) and imposex	■	
Pharmaceuticals: Diclofenac, EE2 (+E1, E2, E3 + in vitro yeast essay)	■	

According to the HELCOM BSAP (HELCOM 2007 a) and the EC Decision 477/2010/EU (Anon. 2010), the contamination of seafood by hazardous substances can be addressed by following the concentrations of contaminants in fish or other seafood against existing safety limits (e.g. Anon. 2006, 2008 b). The indicators for food safety are the same as for the environment (**Table 19**), with the exception that not all substances currently have a GES boundary and therefore they cannot be used in quantitative assessments.

The HELCOM ecological objectives for the hazardous substances segment of the BSAP cover concentrations of hazardous substances, their effects, radioactivity and safe seafood. With the current core indicators, all the four ecological objectives can be addressed (**Figure 1**). In addition, some of the 'bioeffect indicators' can also, potentially, cover other objectives that reflect the condition of individuals or populations.

MSFD descriptors 8 (contaminants in environment) and 9 (contaminants in seafood) are the main policy objectives of the MSFD for this set of core indicators. The associated criteria of descriptor 8 describe the concentrations (8.1) and effects (8.2) of the contaminants, whereas there is only a single criterion for descriptor 9, which describes concentrations of hazardous substances against EU food safety legislation. The HELCOM core indicators presented in **Tables 19** and **20** cover these criteria sufficiently. In criterion 8.2, there is also a specific aspect of oil pollution, which was not included in the set of core indicators from the hazardous substances expert group. However, the biodiversity expert group developed an indicator for oiled waterbirds – addressing the effects of oil in the water. HELCOM MARITIME is regularly following the number of oil spills with aerial surveillance flights. The information of the number of oil spills is included in the oiled bird indicator as supplemen-

Table 20. Proposed core indicators for the biological effects of hazardous substances and a summary on how all hazardous substances core indicators can potentially address the HELCOM ecological objectives, the EU MSFD qualitative descriptors for good environmental status and their associated criteria. See the list of ecological objectives, descriptors and criteria in Chapter 1.

Proposed core indicator	Viable Populations of species	Concentrations of hazardous substances close to natural levels	Healthy wildlife	Radioactivity at pre-Chernobyl level	Fish safe to eat	MSFD criterion 1.3	MSFD criterion 4.1	MSFD criterion 8.1	MSFD criterion 8.2	MSFD criterion 9.1
PAH metabolites		■	■			■		■	■	
Tributyltin (TBT) and imposex	■	■	■			■		■	■	■
Eelpout and amphipod embryo malformations	■		■			■	■		■	
Lysosomal Membrane Stability – a toxic stress indicator			■			■			■	
Fish diseases – a fish stress indicator			■			■			■	
Micronuclei test – a genotoxicity indicator			■			■			■	
9 HS concentration indicators		■		■	■			■		■

tary information, which is also published annually as a Baltic Sea Environment Fact Sheet.

The background report to the hazardous substances segment of the BSAP (HELCOM 2007 c) proposed indicators in order to follow the progress towards reaching the four ecological objectives. The current set of core indicators reflects the proposed indicators in many cases. Seven of the eleven 'substances of specific concern' (BSAP substances) were selected as the core indicators. The core indicators for safe seafood follow the same food safety regulations as in HELCOM (2007 c). The indicators measuring the health state of wildlife and radioactivity were all included in the set of core indicators.

The substances in the HELCOM core indicators are mostly the same as in the OSPAR Quality Status Report (**Table 5**). The HELCOM core indicators do not include zinc, nickel, copper, chromium, arsenic and lindane, whereas the OSPAR system does not include as many halogenated pollutants (PFOS, PBDE, HBCD). Additional differences are among the bioeffect indicators; the EROD activity indicator was not included in the set of core indicators.

4.2 Hazardous substances core indicators address the main pollution problems

The HELCOM thematic assessment of hazardous substances (HELCOM 2010 a) dedicated a chapter for the sources of pollution in the Baltic Sea and how it has caused the current contamination status. Although many of the sources were historical – from old paper and pulp mills, old mines or other industry – and not a current pollution source, the current status is partly caused by current pollution. Point source pollution is the easiest to manage with hundreds in the Baltic Sea, although nearly all the hot spots have been eliminated after years of international cooperation (HELCOM 1990, 2010 a). In addition, municipal wastewater treatments plants – though only conducts of pollution – leak high amounts of some contaminants and can be managed in similar ways as a point source. While not all of today's pollution is from point sources, pollutants do in fact trickle from diffuse sources such as household combustion, the vaporisation of contaminants, or from waste dumps and storm waters from urban or industrial areas.

The chemical status of the surface waters, as reported by the EU Member States under the Water Framework Directive, was also analysed by ETC/ICM (2012). Four of the HELCOM Contracting Parties – Estonia, Finland, Latvia and Lithuania – reported that all their coastal waters are in good chemical status - Germany reported almost as high a proportion (98%). In striking contrast, Sweden reported 100% poor status in rivers, lakes, transitional waters and coastal waters due to high mercury contamination. Sweden was the only country that assessed the concentration of mercury solely from fish muscle - a more reliable matrix with which to measure mercury contamination than water. Poland did not report the chemical status.

The substances causing poor chemical status in transitional waters were mainly mercury (Sweden); 'other substances – aggregated' (Germany); TBT (Sweden, Lithuania); and DEHP (Lithuania). In the coastal waters, the decisive substances were mercury (Denmark, Sweden); 'other substances – aggregated' (Germany); and Nickel, TBT, fluoranthene, other PAH, hexachlorobenzene and PBDE (Sweden). Only the above-mentioned Baltic Sea countries had specified the substances.

The HELCOM thematic assessment of hazardous substances (HELCOM 2010 a) showed a result that differs from the WFD reporting as regards most of the countries. According to the HELCOM integrated assessment, the coastal waters were almost entirely in 'less than good status'. There are three possible reasons for the differences in the assessment results:

1. The HELCOM assessment focused on large sea areas and not on coastal water bodies.
2. The TWFD assessment relied only on Priority Substances, many of which are problematic only in freshwater systems and did not include, for example, PCBs, dioxins, DDTs and PFOS, which were recognised as the decisive substances in most of the HELCOM assessment sites.
3. The WFD assessments were based on water samples, which are not suitable for most of the hazardous substances that are hydrophobic.

Table 21 lists the main pathways of the core indicator substances to the environment.

Table 21. Major pathways of the core indicator substances to the Baltic Sea. For details, see HELCOM 2009 c and 2010 a.	
Polybrominated biphenyl ethers (PBDE)	Present: leakage from products (e.g. furniture, electrical products, mattresses) via rivers, atmosphere or wastewater treatment plants.
Hexabromocyclododacene (HBCD)	Present: leakage from products (e.g. insulation, electrical products and textiles) via rivers, atmosphere or wastewater treatment plants.
Perfluorooctane sulphonate (PFOS)	Present: leakage from products (metal plating, impregnation of textiles and papers, cleaning products) via rivers or wastewater treatment plants.
PCBs and dioxins and furans	Present: combustion (dioxins), leakage from products and isolation (PCBs). *Past: paper and pulp mills.*
PAHs / selected metabolites	Present: household and industrial combustion, land traffic, shipping, oil drilling, leaks of petroleum products.
Cadmium	Present: metallurgic industry, batteries, plastic production, fertilizers and storm waters via coastal point sources, rivers, wastewater treatment plants or atmospheric deposition, high concentrations in harbours. *Past: mines and metal industry, e.g. galvanic plants.*
Lead	Present: storm waters via rivers, wastewater treatment plants or atmospheric deposition, high concentrations in harbours. *Past: leaded gasoline, bullets, metal industry, e.g. galvanic plants.*
Mercury	Present: household products (e.g. lamps), dental mercury, industrial processes via rivers, wastewater treatment plants or atmospheric deposition. *Past: industry.*
Caesium-137	*Past: Chernobyl accident.*
Tributyltin (TBT)	Present: Intermediate product in industrial processes, various household products, biocide in imported goods, storm waters. *Past: anti-fouling paints especially in harbour areas.*
Diclofenac	Present: wastewaters from households and animal farms.
Estrogens	Present: household wastewater.

4.3 Hazardous substances outside the set of core indicators

The set of hazardous substances selected as core indicators is a tiny fraction of all anthropogenic substances present in the marine environment. Although the selected substances are considered representative in terms of their PBT properties and known concentrations in the Baltic Sea, environmental monitoring should cover other substances as well.

DDT and its degradation products - DDE and DDD - are widely known for their adverse impacts on higher trophic levels and for being successfully banned in several countries. Despite the ban, DDE is one of the main contaminants found in Baltic fish. Other organochlorine substances, such as hexachlorocyclohexanes (HCHs, e.g. lindane) and hexachlorobenzene (HCB), have been used as pesticides and have adverse impacts on aquatic organisms. However, the levels of HCHs and HCB do not frequently exceed the Environmental Quality Standards in the Baltic marine environment. Although DDTs, HCHs and HCB were not proposed as core indicators, monitoring their levels in the Baltic Sea should be continued with regular assessments recommended. This may be relatively easy to achieve as their chemical analysis can be done together with the analysis of PCBs - a core indicator.

The group of hazardous substances not included in the core set are alkylphenols. Nonylphenols and octylphenols are the two alkylphenol substances included in the HELCOM BSAP list (**Table 3**). They are used in several industrial processes as emulsifiers and in detergents and cosmetic products. The HELCOM thematic assessment found high concentrations of them in marine sediments (HELCOM 2010 a). The CORESET project recommended that close watch be kept on the substance and could be reconsidered as a core indicator in the near future.

The metal core indicator only includes cadmium, lead and mercury, whereas copper and zinc have high and increasing concentrations in some Baltic

Sea sub-basins (see Baltic Sea Environment Fact Sheet 2012 http://www.helcom.fi/BSAP_assessment/ifs/ifs2012/en_GB/cover/). CORESET recommends that copper and zinc are regularly screened in the Baltic Sea and frequently monitored in those areas where concentrations are increasing.

4.4 Linkages between the core indicators for hazardous substances and biodiversity

A cornerstone in the development of core indicators was to link the indicators to anthropogenic pressures. It is therefore obvious that some of the biodiversity core indicators also reflect the effects of contamination.

The biodiversity core indicators with direct linkage to contamination effects are the ones related to the productivity of animals (productivity of White-tailed eagle and pregnancy rate of marine mammals), whereas the condition of macrozoobenthic communities is only partially related to contamination (reflecting also other pressures).

Three of the core indicators for biological effects of hazardous substances have a potential value as indirect indicators for the biological state of populations: imposex of gastropods (causing lower population productivity), fish disease index (reflecting condition of fish) and the number of malformed embryos in eelpout and amphipods (causing lower population productivity).

4.5 How the GES has been set for hazardous substances and their impacts

Good environmental status of the hazardous substances core indicators is defined by various threshold levels which reflect ecotoxicological tipping points. The main thresholds are the EU Environmental Quality Standards and the OSPAR Environmental Assessment Criteria; however, food safety limits and levels derived by scientific expert cooperation have also been applied. This Chapter first describes different contaminant targets and then the GES boundaries that have been used for the HELCOM hazardous substances core indicators.

4.5.1 What are the Environmental Quality Standards?

The methodological framework used in deriving the Environmental Quality Standards (EQS) is described by Lepper (2005). The Environmental Quality Standards Directive (Anon. 2008 b) presents EQSs for substances that were identified in the EU Water Framework Directive as priority substances. The EQSs aim to show good chemical status of European inland waters and coastal and transitional waters up to 12 nm seawards from the coastline. Their objective is to protect pelagic and benthic freshwater, marine ecosystems and humans from the adverse impacts of chemical contaminants (regarding human protection, this must not be mixed with food safety legislation).

The directive defined EQS only for surface water and only hexachlorobenzene, hexachlorobutadiene and mercury had thresholds for biota. The secondary target with the priority substances is to ensure that their concentrations do not significantly increase in the water, sediment or biota. The revision of the directive, however, took place in 2012 where 16 new Priority Substances were added, seven EQSs were changed and several biota-based EQSs presented.

The assessment framework has been based on deriving EQS values for water (protection of the pelagic community), sediments (protection of the benthic community), and biota (protection of predators against secondary poisoning). Additionally, for human health related protection objectives, EQSs were derived for biota (fishery products; protection of humans against adverse effects upon consumption of fishery products), and water intended for drinking. The lowest of these values was set as the overall EQS.

4.5.2 What are the OSPAR Assessment Criteria?

Environmental Assessment Criteria (EAC) are concentrations of contaminants in monitoring matrices, normally sediment or biota, below which unintended or unacceptable biological responses, or unintended or unacceptable levels of such responses, are unlikely to occur even in the most sensitive species (OSPAR 2009 b). The derivation of EACs follows the same principles as EQSs.

A Background Concentration (BC) is defined as the concentration of a contaminant at a 'pristine' or 'remote' site based on contemporary or historical data. The BC for a man-made substance is therefore zero. As historical samples are not generally available for biota, background concentrations have generally been estimated from modern data from areas distant from the sources of contaminants. Background Assessment Criteria (BAC) are derived mathematically from BCs to enable a robust analysis of the monitoring data in relation to the objective that concentrations should be 'near background'. See OSPAR (2009 b, 2010) and Law et al. (2010) for details.

The OSPAR Quality Status Report 2010 used EACs as the primary threshold in the assessment of hazardous substances (OSPAR 2009 b, 2010). There were, however, cases when EACs were lower than the BACs, for instance in the case of lead, cadmium, mercury and PCBs in biota and/or sediment. In such cases, the OSPAR Quality Status Report 2010 used BACs, EU Food Safety Limits (Anon. 2006) or Effect Range – Low thresholds of the US EPA. The assessment approaches used in the OSPAR Quality Status Report 2010 are presented and discussed in detail in Law et al. (2010).

4.5.3 Effect Range – Low thresholds of the NOAA and US EPA

The Effect Range – Low (ERL) threshold is defined as the lower tenth percentile of the data set of concentrations in sediments, which were associated with biological effects (Long & Morgan 1990, Long et al. 1998). ERL thresholds are sediment quality guidelines that were developed for the US National and Atmospheric Administration (NOAA) for screening metals and organic contaminants (NOAA 1999); the US EPA also uses it for sediment contamination studies and for assessing the potential harm of sediments to benthic organisms (US EPA 2011, 2012 b). Adverse effects on organisms are rarely observed when concentrations fall below the ERL value; the ERL, therefore, has some parallels with the philosophy underlying the OSPAR EACs and WFD EQSs. As the ways in which the criteria are derived are very different, precise equivalence should not be expected.

4.5.4 GES boundaries for the HELCOM core indicators

All the proposed core indicators have targets that show the boundary for good environmental status (GES). In contrast to the recent HELCOM integrated assessment, the status of the hazardous substances core indicators was decided to be presented in three status classes: good, moderate and bad. 'Good' environmental status and 'moderate' status are determined by the so-called GES boundary or GES threshold, while 'bad' represents a condition of particularly high concentration or adverse impacts.

The GES boundaries were primarily selected among the EU EQSs. The EQSs selected for the core indicators are included in the proposed revision by the EC[5]. EQSs were not available for all the core indicators as they mainly include substances that are sampled from biota (e.g. invertebrates, fish, bird eggs and mammals) and all needed EQSs are not yet biota based.

In addition to EQSs, the GES boundaries of the core indicators also apply the OSPAR Environmental Assessment Criteria (EAC) that were used in the OSPAR Quality Status Report (QSR) 2010 and ensure that no chronic effects occur below that level. According to OSPAR (2009 b), the EACs and

5 The proposal: http://ec.europa.eu/environment/water/water-dangersub/pdf/com_2011_876.pdf

EQSs have very much in common; accordingly, the CORESET project and the preceding HELCOM HOLAS project used both of the approaches in a similar way. For PAHs in sediment, the core indicators also used the Effect Range – Low thresholds.

Following the example of the OSPAR QSR 2010 (OSPAR 2009 b, 2010), the metal core indicators used the OSPAR Background Assessment Criteria (BAC) as the GES boundary and the EU food safety limits (Anon. 2006) for the boundary of 'bad' status (discussed by Law et al. 2010). It was decided that the Food Safety Limit of the European Union (EU/1881/2006) would be the threshold concentration to indicate 'bad status' in mussels and fish and the ERL threshold (see OSPAR 2009 b) in sediment. Moreover, as the EU food safety limits are meant only for fish meat (i.e. muscle samples), it was decided for the liver concentrations of lead and cadmium, which are higher than the muscle concentrations, to follow the food safety limits of bivalves. This selection of thresholds is artificial and not based on as clear a scientific basis as the use of EACs and EQSs; however, it can nevertheless give an indication of the status and it follows the same approach as in the North Sea (discussed by Law et al. 2010).

The polyaromatic hydrocarbons (PAH) were another exception, when EACs or EQSs were not available for GES boundaries in sediment. The core indicators follow the OSPAR example (2009 b, 2010) and use the ERL thresholds for sediment assessments. However, there were no criteria available for chrysene or indeno(1,2,3-cd)pyrene, which were assessed against BACs and temporal trends.

The GES boundary for the core indicator of polychlorinated biphenyls (PCB) in biota is not scientifically adequate since it suffers from the same problem as metals in biota and PAHs in sediments: EACs were lower than BACs and thus not applicable. As a solution, the OSPAR QSR 2010 used an alternative method to calculate so-called passive EAC for biota, which is a potential bioavailability of PCBs in the sediment pore water and is in line with the sediment EACs (OSPAR 2009 b). However, compared to BACs and food safety limits of dioxin-like PCBs, this passive EAC is very high and the CORESET expert group doubted its use as indicative for Good Environmental Status. As an intermediate solution, the core indicator uses the passive EAC as the GES boundary, but withholds the decision on how to classify PCBs in the Baltic.

For the core indicators of biological effects of hazardous substances, the ICES working groups are developing thresholds for GES. In the CORESET project, the thresholds (i.e. the GES boundaries) were mainly developed by the BONUS BEAST project in association with ICES SGEH; for the imposex indicator, however, the project used the GES boundaries adopted by OSPAR (2010). Law et al. (2010) present some of the ICES thresholds in the TG8 report.

4.5.5 GES boundaries for sea food

The HELCOM ecological objective 'Fish safe to eat' and MSFD qualitative descriptor 9 requires an assessment of food safety with regard to fish and shellfish in European seas. GES can be measured through three complementary routes: (1) using the legally binding food safety limits of the EU Food Safety Directive (Anon. 2006, 2011); (2) using the specific Quality Standards calculated for human consumption of fish meat (Anon. 2012); or (3) estimating a threshold from the daily allowed amount of specific substances by using standard human weight, size of portion, frequency of eating seafood and safety factors (Baars et al. 2001, TGD 2003, EFSA 2004, Lepper 2005).

The CORESET expert group decided, as a first step, to only use the food safety limits of the directive and refrain from deciding, as yet, on the use of the specific Quality Standards of the EU Priority Substances. The expert group also discussed whether the 'seafood indicators' can be separate from the 'environmental indicators' or should the seafood limit act as the 'moderate-poor boundary' for the core indicators. As this decision may become more topical only when HELCOM initiates the process of an integrated assessment of hazardous substances (cf. HELCOM 2010 a), a recommendation has yet to be made.

4.6 Hazardous substances core indicators address European and global policies

The substances and biological effects selected as the HELCOM core indicators reflect the European and global environmental policies. One of the criteria for the selection of the core indicators was that the substances or the biological effects should be 'listed' by HELCOM, Stockholm Convention, OSPAR or the EU Priority Substance Directive. As the directive was under revision during the project period, the proposed Priority Substances were also considered in the selection process.

HELCOM has identified eleven so-called BSAP substances, of which six were selected as core indicators (**Table 22**) with the nonyl- and octylphenols considered as potential core indicators. All of the substances, except for Cesium-137, are listed by the OSPAR Commission as substances of Priority Action or Possible Concern and all the substances, except for Cesium-137, are listed as Priority Substances by the European Union.

Two of the core indicator substances are listed by the Stockholm Convention on its Annex A (elimination), one on its Annex B (restriction) and one in Annex C (unintentional production). For Annex A substances, parties must take measures to **eliminate** the production and use of the chemicals; under Annex B, the parties must take measures to **restrict** the production and use of the chemicals; and under the Annex C, the parties must take measures to reduce the unintentional releases of the substances with the goal of continuing minimisation and, where feasible, ultimate elimination.

The biological effects indicators were summarised in the Task Group 8 report (Law et al. 2010). **Table 23** presents the biological effect indicators and how they have been included in the OSPAR Joint Assessment and Monitoring Programme (JAMP) or OSPAR Coordinated Environmental Monitoring Programme (CEMP); how they have been recommended by the ICES WGBEC (working group for biological effects of contaminants); and what quality control is available.

Table 22. Listing of the substances of the proposed core indicators on various priority lists. Key: A, B and C under the Stockholm Convention refer to the annexes of the convention; PA and PC under the OSPAR Commission stand for the 'Priority Action' and 'Possible Concern'.

Proposed core indicators	BSAP	EU PS	Stockholm	OSPAR
Polybrominated biphenyl ethers	X	X	A	PA
Hexabromocyclododacene	X	X	[proposed]	PA
Perfluorooctane sulphonate	X	X	B	PA
Polychlorinated biphenyls and dioxins and furans		X	A, C	PA
Polyaromatic hydrocarbons and their metabolites		X		PA, PC
Metals	X (Cd, Hg)	X		PA
Radioactive substances	X			
Tributyltin compounds / imposex index	X	X		PA
Pharmaceuticals		X		PC

Table 23. Status of biological effects indicators on the OSPAR and ICES lists. Source: Law et al. (2010).

Core indicator	OSPAR JAMP	OSPAR CEMP	WGBEC	Quality Control
Lysosomal Membrane Stability	Yes (fish), No (mussels)	Suitable (fish), No (mussels)	Yes	Yes
Micronucleus test				
Imposex	Yes	Mandatory	Yes	Yes
Malformed eelpout embryos	Yes	Suitable	Yes	Yes
Malformed amphipod embryos				
Fish diseases	Yes	Suitable, voluntary	Yes	Yes
PAH metabolites	Yes	Suitable	Yes	Yes

5 Eutrophication core indicators

5.1 The assessment needs for eutrophication core indicators

Eutrophication is one of the four thematic segments of the HELCOM Baltic Sea Action Plan (BSAP) with the strategic goal of having a Baltic Sea unaffected by eutrophication. The HELCOM goal for eutrophication is broken down into five ecological objectives defining the desired state in terms of water clarity, nutrients, oxygen, algal blooms and marine fauna and flora.

The EU Marine Strategy Framework Directive (MSFD) requires that "human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters" (descriptor 5). There are three criteria to assess eutrophication under descriptor 5: (1) nutrient levels; (2) direct effects of nutrient enrichment; and (3) indirect effects of nutrient enrichment.

According to the MSFD, the assessment of eutrophication in marine waters needs to take into account the assessment for coastal and transitional waters under the EU Water Framework Directive (WFD) in a way that ensures comparability, while taking into consideration the information and knowledge gathered and the approaches developed in the framework of regional sea conventions.

The HELCOM thematic assessment of eutrophication was the first indicator-based assessment in the Baltic Sea (HELCOM 2009 a). The experience from the assessment process produced a demonstration set of core indicators, which were introduced at the Moscow Ministerial Meeting in 2010 and published as core indicator reports on the HELCOM web site. The work to operationalize the eutrophication core indicators, including harmonising the targets for good environmental status (GES), was continued under the supervision of MONAS in the CORE EUTRO process, which also cooperated tightly with the HELCOM TARGREV project ('Review of the ecological targets for eutrophication of the HELCOM BSAP') to strengthen the science basis of the eutrophication core indicators.

The HELCOM CORESET project cooperated with the development process of eutrophication core indicators and, as some of the biodiversity core indicators can also be used for assessments of eutrophication status, the progress in CORE EUTRO is summarised in this report.

5.2 Eutrophication core indicators

The HELCOM eutrophication core indicators have been selected on the basis of the HELCOM ecological objectives and the MSFD criteria for eutrophication. The two policies can be addressed by the same set of core indicators: concentrations of nutrients and chlorophyll a, Secchi depth (water transparency) and oxygen concentrations. In addition to this, eutrophication assessments should also

Table 24. HELCOM eutrophication core indicators from the CORE EUTRO process. The table indicates which HELCOM ecological objectives and MSFD criteria of descriptor 5 the core indicators can potentially address. Two biodiversity core indicators responding to eutrophication and used in the HELCOM eutrophication assessment (HELCOM 2009 a) have been added in parentheses.

Core indicator	Clear water	Concentrations of nutrients close to natural levels	Natural level of algal blooms	Natural oxygen levels	Natural distribution and occurrence of plants and animals	D5.1 Nutrient levels	D5.2 Direct effects	D5.3 Indirect effects
Water transparency (Secchi depth)	x						x	
Concentration of dissolved inorganic nitrogen		x				x		
Concentration of dissolved inorganic phosphorus		x				x		
Concentration of chlorophyll a			x				x	
Oxygen concentration				x				x
(State of soft-bottom macro-zoobenthos)					x			
(Lower depth distribution limit of macrophytes)					x			x

include indicators for benthic and pelagic fauna and flora, particularly focusing on shifts in species composition and from sensitive to tolerant species.

On the basis of the experience from the HELCOM integrated eutrophication assessment and the above-mentioned assessment needs, the CORE EUTRO process has suggested five core indicators for eutrophication (**Table 24**).

The five eutrophication core indicators cover four of the five HELCOM ecological objectives and all three MSFD criteria of the qualitative descriptor 5. The recent thematic assessment of eutrophication in the Baltic Sea also utilised the indicators for benthic fauna and flora, namely the multimetric faunal indices and the macrophyte depth distribution, which have a strong response to eutrophication and can also be used to assess the ecological objective for plant and animal distribution and occurrence (**Table 24**, HELCOM 2009 a).

These two indicators have been developed in the CORESET project and are presented in Chapter 3.

5.3 GES boundaries of the eutrophication core indicators

The indicator targets were based on work mainly carried out in the TARGREV project (HELCOM 2013 c), also taking advantage of the work done during the EUTRO PRO project while producing the HELCOM thematic assessment of eutrophication (HELCOM 2009 a). In the TARGREV project, the objective was to revise the scientific basis underlying the ecological targets for eutrophication, placing much emphasis on providing a strengthened data and information basis on which to set the quantitative targets. The final targets were set in the CORE EUTRO group through an expert evaluation process and accepted by the HELCOM Heads of Delegations 39/2013.

6 Monitoring of the state and changes in the Baltic ecosystem

6.1 Spatial and temporal assessment needs of the core indicators

HELCOM core indicators will be the main instruments in the assessments of the state of the marine environment in the Baltic Sea. For this reason, the Contracting Parties have agreed that the core indicators will be included as mandatory parameters to the coordinated monitoring programme. There are some exceptions to this general rule since not all core indicators can be monitored in all areas of the Baltic Sea; these exceptions are specifically mentioned in the core indicator reports.

Spatial coverage and temporal frequency of the monitoring are always trade-offs in the current resource-limited reality. Therefore, the monitoring of the HELCOM core indicators is recommended to be set up to support the required assessment products. The BSAP and MSFD assessments primarily focus on the *general state of the marine environment* and lead to closer details only in cases where special risks are suspected. Therefore, the monitoring of core indicators should focus on:

– areas outside the range of point-source polluters,
– representative areas (predominant habitats, common species, etc.), and
– reliable temporal change (to follow up effectiveness of management measures).

Temporal scales of the core indicators should therefore be adjusted according to parameter-wise variation and statistical power analyses, which can reveal the needed length of time series for detecting temporal changes. Even for those core indicators where the GES boundary is not dependent on temporal trends, statistically tested temporal changes provide essential information on the direction of the state of the environment.

As the core indicators were developed to support future integrated assessments, their spatial assessment scales were thoroughly planned. In order to comprise the various assessment needs, the assessment units of the core indicators form a nested system, where the assessments of coastal waters are enabled on the level of WFD water bodies and offshore waters on the level of HELCOM sub-basins (outside coastal waters). Coastal water bodies can also be aggregated to larger units (coastal waters of a sub-basin) and the assessment can also be made on the level of sub-basins only (not separating coastal and offshore waters). The highest hierarchical level of the assessment units is the entire Baltic Sea area.

From a scientific perspective, administrative assessment units are often arbitrary and therefore some flexibility was allowed in combining the sub-basins in order to get larger assessment units, for example for waterbirds. The core indicators for salmon, sea trout and 'large fish' have been traditionally developed for different assessment systems; the salmonid indicators for spawning rivers and the offshore fish for ICES sub-divisions. The ICES sub-divisions, however, closely resemble the HELCOM sub-basins and thus using these in parallel is unlikely to cause misinterpretation of the state of the fish community. The assessment units of the two salmonid indicators should be re-considered in the near future.

6.2 The overview of current monitoring

Each draft core indicator report includes an estimate of the state of the current monitoring and a recommendation if the monitoring requires improvement. The descriptions also include a suggestion for assessment units, i.e. the scale for the assessment results, and areas not relevant for the indicator. In this chapter, a summary of the current monitoring is presented.

Marine mammals. The population growth indicator was considered well monitored for all the seal species, except the southern populations of ringed seal; the monitoring of harbour porpoise was also considered as a significant gap.

As the indicators for pregnancy rate and nutritional status are based on dead animals, their monitoring depends on unwanted bycatch or hunted animals. There is enough material to assess the indicators for the grey seal and the Bothnian Bay ringed seal; the health condition of the other species will be assessed only after accumulating more material. The only recommendation was that improved cooperation between institutes could accumulate the indicator data more efficiently and improve geographical data coverage.

The indicator for drowning in fishing gears was considered poorly monitored for all species; some options for monitoring were suggested.

Waterbirds. The abundance of wintering waterbirds is well monitored in coastal waters; however, the lack of coherent offshore monitoring does not allow state assessments of Long-tailed Duck and Common Scoter, which are significant parts of the Baltic food web during the winter. The expert group suggested coordinated offshore aerial surveys and proposed further investigation of the potential to use annual migration statistics for indicator purposes.

The abundance of breeding birds is well monitored in the Baltic Sea. The expert group noted that the indicator is rather slowly-responding to prevailing pressures and suggested that reproductive success could be monitored for selected species by the same effort.

The proportion of oiled waterbirds is monitored in a few places in the Baltic Sea; it was noted that additional monitoring could improve the understanding of the severity of the oil spill pressure and the decline of offshore species. The expert group noted that visual inspections of plumage would give a reliable measure of the proportion of oiled Long-tailed Ducks.

Although the indicator for drowning in fishing gears was considered to be poorly monitored for waterbirds, existing project data gives a rather accurate overview of the situation. The expert group suggested several options for monitoring and emphasised the need to relate the data to fishing efforts.

Fish. Coastal fish monitoring was considered adequate in the Baltic Sea. Monitoring the pelagic and demersal communities (proportion of large fish) is also well-covered by coordinated trawl surveys under ICES. The monitoring of salmon reproductive success covers the main rivers. A similar monitoring of sea trout only covers part of the sea trout rivers. Both salmonid indicators are coordinated by the ICES WGBAST.

Benthic fauna and flora. The monitoring of soft-sediment fauna covers the Baltic Sea area adequately. The indicator can be reliably assessed, but differences in grab types and sieve sizes limit the comparability of the results. The indicator for the size-frequency distribution of bivalves can also be used on hard-bottoms and thus offers a possibility for the assessment of blue mussel biotopes. Assessing the size frequency of bivalves would require additional analyses on top of the current monitoring as well as new monitoring of blue mussel biotopes in several areas of the Baltic Sea. Blue mussel monitoring was suggested to be monitored together with the macroalgae.

The monitoring of macrophytes differs among the Baltic Sea countries. Some monitoring strategies aim at spatial coverage (mainly to fulfil requirements of the EU WFD) while the expert group also suggested that monitoring long-term changes in 'references areas' should be considered. There seems to be a gap in the monitoring in the northern sub-basins.

The extent, distribution and condition of benthic biotopes are not monitored by common metrics in the Baltic Sea. The HELCOM RED LIST project has proposed a biotope classification and assessment criteria that are based on criteria by IUCN (Keith et al. 2013). The current biotope assessment process in the RED LIST project will give a status for the Baltic Sea scale, whereas an assessment for the Baltic Sea would benefit the sub-basin scale assessment results.

'Impacts on benthic habitats' is an indicator that compiles spatial pressure information from the Baltic Sea and overlays it with habitat maps. The indicator does not require monitoring in the traditional sense, but depends on accurate habitat maps and data of pressures. Although both data are available, it was noted that the accuracy could be improved in order to target management actions more reliably.

Pelagic fauna and flora. HELCOM CORESET proposed only one pelagic indicator: zooplankton mean size and total abundance. This indicator is adequately monitored in the Baltic Sea.

Non-indigenous species (NIS). Monitoring of new observations of NIS is based on two kinds of data: side-products of all biological monitoring (incl. scientific studies) and targeted NIS monitoring in selected sites (e.g. ports). An established network of port monitoring should be enough to enable assessments of this indicator.

6.3 The role of project-based data in the HELCOM core indicators

Almost all of the proposed core indicators have been assessed by some data during the project period. Data in the assessments have been collected from both national monitoring programmes as well as from various projects and scientific studies. As one of the principles for the core indicators is that national monitoring is established, it is expected that the indicators shift from project data to national monitoring data with HELCOM as the coordinator.

The greatest influence of project data is in the indicators requiring spatially-wide data sets like the assessment of benthic biotopes and the impacts on benthic habitats. Another indicator based on project data is the bycatch of birds and mammals. This is almost solely based on short-term projects, although data from the European Fisheries Data Collection Framework could be improved to better support this indicator. In some areas, the project data cover long time periods.

In the hazardous substances indicators, project data is used in substances that have not been yet included in monitoring programmes, but due to recent listing as Priority Substances, they have been identified as important parts of monitoring. The indicators now being solely based on project data are the estrogens, diclofenac and micronuclei tests.

6.4 The need to adjust the manuals of the coordinated monitoring

The development of HELCOM core indicators and the revision of the HELCOM monitoring and assessment strategy include a step where the monitoring manuals will be revised. The CORESET project began to identify some basic needs for the proposed core indicators, such as assessment units, sampled parameters and differences in national monitoring methods. **Tables 25** and **26** summarise some basic information on the need to revise the monitoring manuals.

Biodiversity. Biological variables have been largely missing from the HELCOM COMBINE manual; however, ICES manuals have covered many fish parameters; Wetlands International has coordinated a manual on wintering waterbirds; HELCOM SEAL EG has taken care of harmonised monitoring

Table 25. Identified needs to revise monitoring manuals of the biodiversity core indicators. The 'Manuals' column refers to existing manuals; 'Timing' refers to the potential needs to revise the monitoring time; 'Spatial coverage' refers to the potential needs to revise the monitoring network; and 'Sample details' refers to the potential needs to revise other details associated with sampling and analyses.

Proposed core indicator	Manuals	Timing	Spatial coverage	Sample details
Population growth rates, abundance and distribution of marine mammals	No	seals: OK, porpoise: not established	seals: OK, porpoise: not established	Ringed seal + porpoise need a decision
Pregnancy rates of marine mammals	No	To be decided	seals: OK, porpoise not established	
Nutritional status of seals	No	OK	OK	OK
Number of drowned mammals and waterbirds in fishing gears	No	To be decided	To be decided	To be decided
White-tailed eagle productivity	No	OK	OK	Brood size not counted everywhere
Abundance of waterbirds in the wintering season	Yes	To be decided	To be decided	Count method not agreed
Abundance of waterbirds in the breeding season	No	OK	OK	Count method varies
Number of waterbirds being oiled annually	No	To be decided	To be decided	Count method varies
Abundance of key fish species	Yes	OK	OK	Nets vary
Abundance of fish key functional groups	Yes	OK	OK	Nets vary
Proportion of large fish in the community	Yes	OK	OK	OK
Abundance of sea trout spawners and parr	Yes	OK	To be decided	Model missing
Abundance of salmon spawners and smolt	Yes	OK	OK	Adult counters are few
Zooplankton mean size and total abundance	Yes	To be decided	OK	Size measurement varies
State of the soft-bottom macrofauna communities	Yes	To be decided	To be decided	Sieve sizes and grab types vary
Lower depth distribution limit of macrophyte species	Yes	OK	To be decided	Methods vary
Population structure of long-lived macrozoobenthic species	No	To be decided	To be decided	To be decided
Cumulative impact on benthic habitats	No	Not relevant	OK	To be decided
Extent, distribution and condition of benthic biotopes	No	Not relevant	OK	Biotope maps vary
Trends in arrival of new non-indigenous species	No	Not relevant	To be decided	

Table 26. Identified needs to revise the monitoring manuals of the hazardous substances core indicators.

Proposed core indicators	Manuals	Species	Tissue	Sample details	Stations
21. Polybrominated biphenyl ethers	Yes	New spp.	To be decided	To be decided	To be decided
22. Hexabromocyclododacene	No	New spp.	To be decided	To be decided	To be decided
24. Perfluorooctane sulphonate	No	New spp.	To be decided	To be decided	To be decided
25. Polychlorinated biphenyls and dioxins and furans	PCBs: Yes Dioxins: No	PCBs: OK	PCB: OK	PCB: OK	PCB: OK
26. Polyaromatic hydrocarbons and their metabolites	Yes	New spp.	To be decided	To be decided	To be decided
27. Metals	Yes	OK	OK	OK	OK
28. Radioactive substances	Yes	OK	OK	OK	OK
29. Tributyltin compounds / imposex index	Yes	New spp.	To be decided	To be decided	To be decided
30. Pharmaceuticals	No	To be decided	To be decided	To be decided	To be decided
31. Lysosomal membrane stability (LMS)	Yes	To be decided	To be decided	To be decided	To be decided
32. Fish diseases	Yes	To be decided	To be decided	To be decided	To be decided
33. Micronuclei test	Yes	To be decided	To be decided	To be decided	To be decided
34. Amphipod and eelpout reproductive success	Yes	To be decided	To be decided	To be decided	To be decided

methods for seals; and there are several national manuals of different indicators under the EU WFD. Although official cooperation in sampling has been missing, expert networks have coordinated many monitoring efforts by comparable sampling methods (e.g. White-tailed eagle, the breeding and bycatch of waterbirds, and the abundance of seals). However, even common manuals have not always prevented non-compatible sampling as is the case with benthic fauna where different sieve sizes and grab types have resulted in great differences in data sets, even within countries.

Hazardous substances. The short overview of the needed revision in the coordinated monitoring programme shows that six of the 13 indicators are (at least somehow) included in the COMBINE manual; seven substances or effect indicators need to be included in the manual. In addition, the national monitoring strategies have changed and there is a need to consider adding and removing species from the manual, changing sampled tissue, sharpening the details of the sample and agreeing on an effective placement of the monitoring stations.

6.5. Steps towards a coordinated monitoring of core indicators.

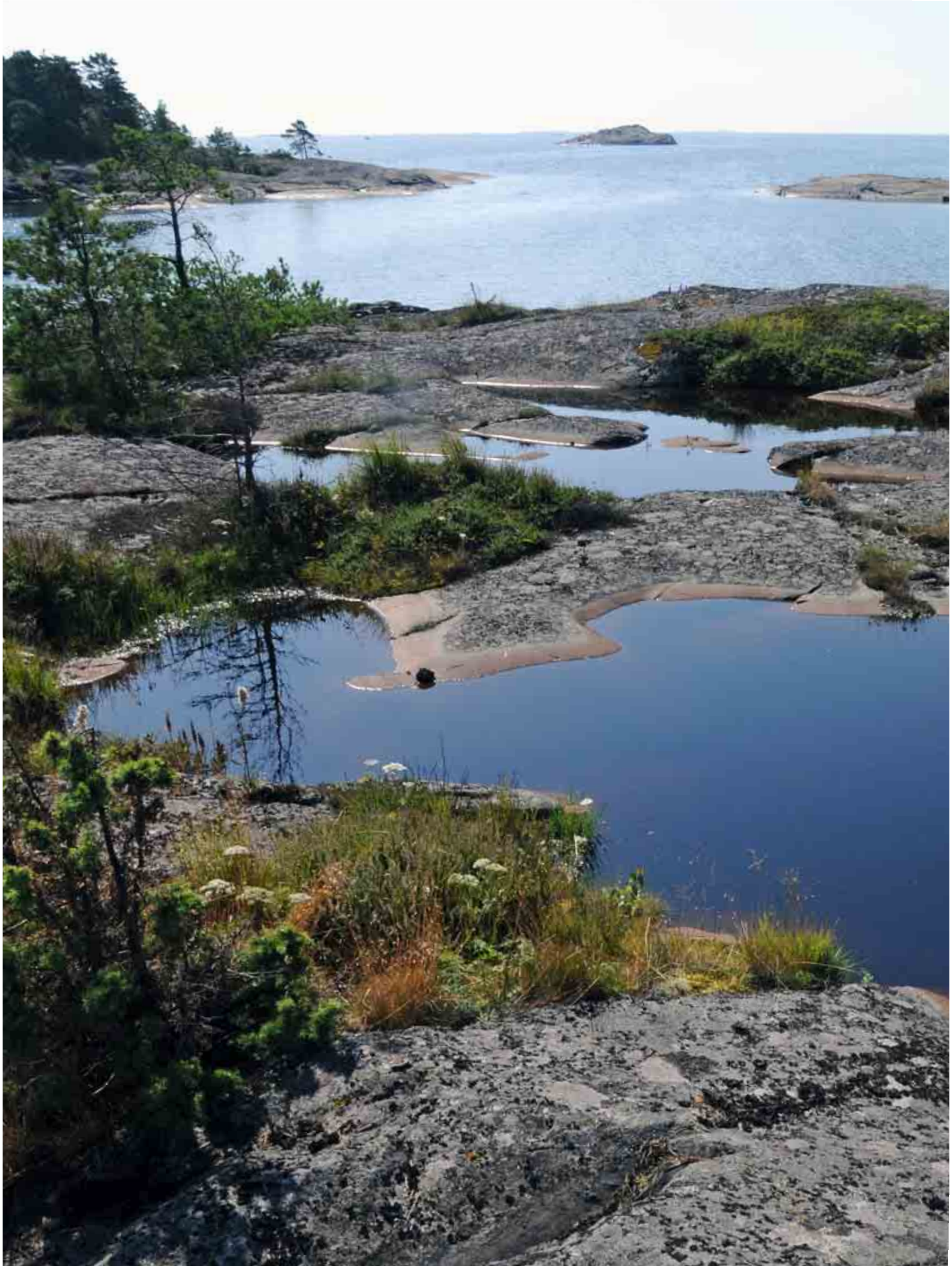
After adopting the core indicators for a coordinated monitoring and assessment of the Baltic Sea, HELCOM Heads of Delegations endorsed the revised Monitoring and Assessment Strategy in June 2013 and the implementation of the Strategy will start immediately. An important step of the implementation will be to review HELCOM's current monitoring programmes, an activity that is scheduled to be ready by 2014.

Revising the monitoring manuals is tedious work, which requires thorough understanding of the hands-on work with the samples and analyses as well as national monitoring strategies and confounding factors of the parameters. It is therefore suggested that HELCOM establishes temporary groups of thematic expertise to revise the manuals of the respective core indicators and other monitored parameters. The expert groups are most urgently needed for waterbirds, macrophytes and macrozoobenthos.

It has also been suggested that the development of the monitoring for harbour porpoise may require additional harbour porpoise expertise in the HELCOM SEAL group if coordinated harbour porpoise monitoring will be established in the sea area.

Integrating the monitoring activities with the ongoing fish surveys – coordinated by ICES – may provide additional synergies, especially with the hazardous substances monitoring (from fish).

7 Key messages and perspectives



The HELCOM CORESET project delivered a proposal for HELCOM core indicators for biodiversity and hazardous substances. The proposed core indicators:

– cover different trophic levels in the Baltic food web;
– reflect the assessment needs from the Baltic Sea Action Plan (ecological objectives), the EU Marine Strategy Framework Directive (qualitative descriptors and associated criteria) and the EU Habitats Directive;
– reflect the main anthropogenic pressures in the Baltic Sea marine environment; and
– can be used to assess good environmental status of the marine environment.

Although most of proposed core indicators can be considered as ready for use, some require considerable development while several of them should accumulate more experience before functioning optimally. The immediate steps in this development relate to the advancement of common monitoring methods. Agreements on the assessment principles (e.g. assessment units, GES boundaries) should also be made, if they are not yet already in place.

The biggest gaps that require further development and operationalization among the biodiversity core indicators were in benthic fauna, flora and biotopes as well as in the lack of an indicator for phytoplankton and ecosystem structure. In the groups of hazardous substances indicators, pharmaceutical substances were seen as the least ready for operational use.

The proposed set of core indicators includes only three indicators for the follow-up of the anthropogenic pressures. The gap is partly filled by the ICES indicators for fishing mortality of commercially exploited stocks and the nutrient input indicator by the HELCOM LOAD group; however, there are still gaps in shipping-generated pressures and coastal habitat damage/loss.

The proposal for core indicators was submitted to the HELCOM Monitoring and Assessment Group (MONAS) in April 2013. HELCOM MONAS recommended 17 core indicators for biodiversity and eight for hazardous substances to the HELCOM Heads of Delegation for approval (**Table 27**). Three biodiversity and five hazardous substances indicators were considered as 'pre-core indicators', which are to be further developed and resubmitted by 2015 for further evaluation. In addition, HELCOM MONAS recommended that an additional core indicator should be developed for the extent and distribution of benthic biotopes by 2015. HELCOM MONAS agreed that the boundaries for good environmental status (GES), which were proposed by the CORESET project, can be provisionally used in HELCOM

Table 27. All HELCOM core indicators and pre-core indicators.

Core indicators for biodiversity and food webs	**Core indicators for hazardous substances and their ffects**
Population growth rates, abundance and distribution of marine mammals	Polybrominated biphenyl ethers (PBDE)
Pregnancy rates of marine mammals	Hexabromocyclododacene (HBCD)
Nutritional status of seals	Perfluorooctane sulphonate (PFOS)
Number of drowned mammals and waterbirds in fishing gears	Polychlorinated biphenyls (PCB) and dioxins and furans
Abundance of waterbirds in the wintering season	Polyaromatic hydrocarbons and their metabolites
Abundance of waterbirds in the breeding season	Metals (lead, cadmium and mercury)
White-tailed eagle productivity	Radioactive substances: Caesium-137
Abundance of key fish species	Tributyltin (TBT) and imposex
Abundance of fish key functional groups	
Proportion of large fish in the community	
Abundance of sea trout spawners and parr	
Abundance of salmon spawners and smolt	
Zooplankton mean size and total abundance	
State of the soft-bottom macrofauna communities	
Population structure of long-lived macrozoobenthic species	
Red-listed benthic biotopes	
Trends in arrival of new non-indigenous species	
Pre-core indicators for biodiversity and food webs	**Pre-core indicators for hazardous substances and their effects**
Number of waterbirds being oiled annually	Pharmaceuticals: Diclofenac & estrogens
Lower depth distribution limit of macrophyte species	Lysosomal Membrane Stability – a toxic stress indicator
Cumulative impact on benthic habitats	Fish diseases– a fish stress indicator
Extent and distribution of benthic biotopes	Micronuclei test– a genotoxicity indicator
	Reproductive disorders: Malformed eelpout and amphipod embryos

assessments; however, these should be revisited by 2015 before HELCOM starts preparing for the next assessments of the state of the Baltic Sea environment.

The core indicator reports will become publically available on the HELCOM web site, where the set of core indicators enables a follow up system for the state of the marine environment. Together with the HELCOM eutrophication core indicators, the ICES MSY indicators for commercially exploited fish stocks and the indicators for underwater noise and marine litter, the core indicator system will form the quantitative tool for the upcoming assessments of the marine environment.

Further development of the core indicators and pre-core indicators will be carried out in the CORESET II project (2013-2015). As regards the more developed core indicators, the emphasis will be in the operationalization by further improving expert networking and the setting up of routines in data flow and assessment work. With the less-developed core indicators and the pre-core indicators, the CORESET II project will focus on knowledge gaps, laying down scientific basis for the indicators and finding solutions for the diverse methods in the monitoring and assessments of benthic fauna, flora and biotopes. As some core indicators still lack data due to missing monitoring activities and all the GES boundaries require more thorough consideration, the CORESET II project and the respective authors of the core indicators will continue to develop those core indicators towards the next assessment round.

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Glossary

CORE INDICATOR. An indicator that is science-based and reflects a component contained in the HELCOM system of the vision, goals and ecological objectives and/or an MSFD descriptor. The core indicators for status are linked to anthropogenic pressures and reflect them directly or indirectly. An indicator measures in part of or in full an ecological objective and/or a descriptor of good environmental status, and provides a measure of the distance to the target/GES. Whenever ecologically relevant, an indicator is Baltic-wide and the area of applicability is expressed on the indicator report. The ultimate aim is that the set of core indicators will be measured by all Contracting Parties with coordinated monitoring according to the HELCOM Monitoring and Assessment Strategy. Core indicators are presented as core indicator reports on the HELCOM web page. They will also be used for integrated thematic and holistic assessments. The ultimate aim is that those Contracting Parties that are also EU Member States will use the core indicators for the MSFD implementation.

pre-CORE INDICATOR. An indicator that that has been identified as necessary by the Contracting Parties for the BSAP/MSFD purposes, and on which there is a common understanding at the general level, but where the content of the indicator is still underdeveloped and for which there is no coordinated monitoring. A pre-core indicator will be further developed by means such as testing, validation, development of coordinated monitoring as well as methods by HELCOM experts; for example, under the HELCOM CORESET II project during 2013-2015 with the aim that it will be developed into a fully-fledged core indicator proposal by 2015 and considered for inclusion into the core set by HELCOM HOD in 2015. HELCOM MONAS will identify the relevant expert groups for each pre-core indicator (e.g. the HAZAS Expert Group for hazardous substances). Meanwhile, each Contracting Party should aim to monitor the parameters relevant for the pre-core indicators, but with the understanding that some of the pre-core indicators can be based on compilations of data from sources other than monitoring data.

SUPPORTING PARAMETERS are any parameters that assist in the interpretation of indicator results, but do not measure distance to a target such as the GES for example. They are monitored in a coordinated monitoring programme. Supporting parameter information complements core indicator information. Such information includes the commonly agreed HELCOM Baltic Sea Environment Fact Sheets.

CANDIDATE INDICATOR. A candidate indicator is an issue that is being developed into a core indicator proposal. Candidate indicators include indicators on which there is not yet a common understanding on the concept, but there is a need, in general, for the theme to be addressed by a core indicator that has been identified. Candidate indicators were listed in the CORESET interim report (BSEP 129); other candidate indicators should also be addressed based on a gap analysis carried out against the BSAP/MSFD. The candidate indicator list should be a living document. Indicators, such as litter, noise and phytoplankton, should have a primary position on the candidate list. Candidate indicators should be developed into core indicator proposals in work to be carried out by HELCOM expert teams and under the HELCOM CORESET II project in 2013-2015. At the end of 2015, HELCOM HOD should consider the core indicator proposals for inclusion into the set of core indicators.

SUPPLEMENTARY INDICATOR. A supplementary indicator is an indicator applied in a sub-regional basis agreed among the countries of the sub-region. The reasons for the application of an indicator as a supplementary indicator - by contrast to a core indicator - are other than ecological reasons, such as resource limitations. A supplementary indicator measures a distance to the target/GES. Calibration of GES boundaries between the countries should ensure the applicability of these supplementary indicators also in common HELCOM integrated assessments. Proposals for supplementary indicators should be considered and further discussed within CORESET II.

Annex 1.

Table A1. Suggested HELCOM indicators to follow the ecological objectives under the strategic goal of biodiversity (HELCOM 2007 b).	
Targets	**Indicators**
Natural marine and coastal landscapes	
By 2010, to have an ecologically coherent and well-managed network of coastal and offshore BSPAs, Natura 2000 areas and Emerald sites in the Baltic Sea. By 2012, to have common broad-scale spatial planning principles for protecting the marine environment and reconciling various interests concerning the sustainable use of coastal and offshore areas, including the Coastal Strip as defined in HELCOM Rec. 15/1. By 2021, to ensure that 'natural' and near natural marine landscapes are adequately protected, and the degraded areas will be restored.	Designated BSPAs, Natura 2000 and Emerald site areas as a percentage of total sub-region areas. Percentage of important migration and wintering areas for birds within the Baltic Sea area that are covered by the BSPAs, Natura 2000 and Emerald sites. Number of BSPAs protecting threatened and/or declining species (for each species separately). Percentage of endangered and threatened habitats/biotopes' surface covered by the BSPAs in comparison to their distribution in the Baltic Sea Percentage of marine and coastal landscapes in good ecological and favourable conservation status.
Thriving and balanced communities of plants and animals	
By 2021, all elements of the marine food webs, to the extent that they are known, occur at natural and robust abundance and diversity. By 2021, that the spatial distribution, abundance and quality of the characteristic habitat forming species, specific for each Baltic Sea sub-region, extends close to its natural range.	Percentage of all potentially suitable substrates covered by characteristic and healthy habitat forming species, such as bladder wrack, eelgrass, blue mussel and stoneworts Marine Trophic Index in the Baltic Sea.
By 2010, to halt the degradation of threatened and/or declining marine biotopes/habitats in the Baltic Sea, and by 2021 to ensure that threatened and/or declining marine biotopes/habitats in the Baltic Sea have largely recovered.	Trends in the abundance and distribution of rare, threatened and/or declining marine and coastal biotopes/habitats included in the HELCOM lists of threatened and/or declining species and habitats of the Baltic Sea area.
To prevent adverse alternations of the ecosystem by minimising, to the extent possible, new introductions of non-indigenous species.	Trends in the numbers of detections of non-indigenous aquatic organisms introduced into the Baltic Sea.
Viable populations of species	
By 2015, improved conservation status of species included in the HELCOM lists of threatened and/or declining species and habitats of the Baltic Sea area with the final target to reach and ensure favourable conservation status of all species. By 2021, populations of all commercially exploited fish species are within safe biological limits, reach Maximum Sustainable Yield, are distributed through their natural range, and contain full size/age range. By 2015, achieve viable Baltic cod populations in its natural distribution area in the Baltic proper. By 2015, to have the re-introduction programme for Baltic sturgeon in place, and - as a long term goal, after their successful reintroduction has been attained - to have best natural reproduction and populations within safe genetic limits in each potential river.	Trends in the number of threatened and/or declining species. Abundance, trends and distribution of Baltic seal species compared to the safe biological limit (limit reference level) as defined by HELCOM HABITAT. Abundance trends and distribution of Baltic harbour porpoise. Number of rivers with viable populations of Baltic sturgeon. Spawning stock biomass of western Baltic cod and eastern Baltic cod compared to the precautionary level (Bpa) as advised by ICES and/or defined by EC management plans. Trends in the age class structure and also fork length of the upper decile (largest 10% or as specified through scientific consultation) of indicator fish species caught in scientific surveys (including multiple trophic levels, such as cod, sprat, herring).
By 2015, discards of fish are close to zero (<1%). By 2015, bycatch for harbour porpoise1 seals, water birds and non-target fish species has been significantly reduced with the aim to reach bycatch rates close to zero.	Trends in the numbers of discards and bycatch of fish, marine mammals and water birds. Number of entangled and drowned marine mammals and water birds.
By 2015, as the short-term goal, to reach production of wild salmon at least 80% or 50% for some very weak salmon river populations, of the best estimate of potential production, and within safe genetic limits, based on an inventory and classification of Baltic salmon rivers.	Number of salmon rivers with viable stocks. Trend of salmon smolt production in wild salmon rivers.

Table A2. **Suggested HELCOM indicators to follow the ecological objectives under the strategic goal of eutrophication (HELCOM 2007 c).**

Ecological objectives	Indicators
Clear water	Summer Secchi depth
Concentrations of nutrients close to natural levels	Winter surface concentrations of nutrients
Natural level of algal blooms	Chlorophyll a concentrations
Natural distribution and occurrence of plants and animals	Depth range of submerged vegetation
Natural oxygen levels	Area and length of seasonal oxygen depletion

Annex 2.

Comparison between the HELCOM CORESET biodiversity indicators and the proposed OSPAR COBAM biodiversity indicators.

Table A3. Biodiversity indicators of OSPAR COBAM and the proposed HELCOM core indicators.

COBAM indicator	HELCOM core indicator	Comment
M-1 Distributional range and pattern of grey and harbour seal haul-outs and breeding colonies [CORE]	Population growth rates, abundance and distribution of marine mammals	
M-2 Distributional range and pattern of cetaceans species regularly present [CORE]	Population growth rates, abundance and distribution of marine mammals	Harbour porpoise distribution is not yet assessed in the HELCOM core indicator
M-3 Abundance of grey and harbour seal at haul-out sites & within breeding colonies [CORE]	Population growth rates, abundance and distribution of marine mammals	Population growth rate is not included in COBAM indicators
M-4 Abundance at the relevant temporal scale of cetacean species regularly present [CORE]	Population growth rates, abundance and distribution of marine mammals	Harbour porpoise abundance is not yet assessed in the HELCOM core indicator
M-5 Harbour seal and Grey seal pup production [CORE]	Pregnancy rates of marine mammals	Different monitoring but functionally similar indicators
M-6 Numbers of individuals within species being bycaught in relation to population [CORE]	Number of drowned mammals and waterbirds in fishing gears	
	Nutritional status of seals	
B-1 Species-specific trends in relative abundance of non-breeding and breeding marine bird species [CORE]	Abundance of waterbirds in the wintering season Abundance of waterbirds in the breeding season	
B-2 Annual breeding success of kittiwake [CORE]		Not applicable for the Baltic Sea
B-3 Breeding success/failure of marine birds [CORE]		
B-4 Non-native/invasive mammal presence on island seabird colonies [CORE]	Abundance of waterbirds in the breeding season	Breeding success is embedded in the HELCOM core indicator for a few species
B-5 Mortality of marine birds from fishing (bycatch) and aquaculture [CANDIDATE]	Number of drowned mammals and waterbirds in fishing gears	
B-6 Distributional pattern of breeding and non-breeding marine birds [CORE]		
	White-tailed eagle productivity	Not applicable for the whole OSPAR area
	Number of waterbirds being oiled annually	
FC-1 Population abundance/ biomass of a suite of selected species [CORE]	Abundance of key fish species Abundance of fish key functional groups	
FC-2 OSPAR EcoQO for proportion of large fish (LFI) [CORE]	Proportion of large fish in the community	
FC-3 Mean maximum length of demersal fish and elasmobranchs [CORE]		Not applicable for the Baltic Sea
FC-4 Bycatch rates of Chondrichthyes [CANDIDATE]		Not applicable for the Baltic Sea
FC-5 Conservation status of elasmobranch and demersal bony-fish species (IUCN) [CANDIDATE] FC-6 Proportion of mature fish in the populations of all species sampled adequately in international and national fish surveys [CANDIDATE]		Not applicable for the Baltic Sea
FC-7 Distributional range of a suite of selected species [CANDIDATE] FC- 8 Distributional pattern within range of a suite of selected species [CANDIDATE]		
	Abundance of sea trout spawners and parr	
	Abundance of salmon spawners and smolt	
FW-1 Reproductive success of marine birds in relation to food availability [CORE]		
FW-2 Production of phytoplankton [CORE]		

Table A3. Biodiversity indicators of OSPAR COBAM and the proposed HELCOM core indicators.		
COBAM indicator	**HELCOM core indicator**	**Comment**
FW-3 Size composition in fish communities (LFI) [CORE]	Proportion of large fish in the community	
FW-4 Changes in average trophic level of marine predators (cf MTI) [CORE]		
FW-5 Change of plankton functional types (life form) index Ratio between: Gelatinous zooplankton & Fish larvae; Copepods & Phytoplankton; Holoplankton & Meroplankton [CORE]		
FW-6 Biomass, species composition and spatial distribution of zooplankton [CANDIDATE]	Zooplankton mean size and total abundance	Similar monitoring but the assessment method may be different
FW-7 Fish biomass and abundance of dietary functional groups [CANDIDATE]	Abundance of fish key functional groups	
FW-8 Changes in average faunal biomass per trophic level (Biomass Trophic Spectrum) [CANDIDATE]		
FW-9 Ecological Network Analysis indicator (e.g. trophic efficiency, flow diversity) [CANDIDATE]		
BH-1 Typical species composition [CORE]		
BH-2 Multi-metric indices [CORE]	State of the soft-bottom macrofauna communities	
BH-3 Physical damage of predominant and special habitats [CORE]	Cumulative impact on benthic habitats	
BH-4 Area of habitat loss [CANDIDATE]		
BH-5 Size-frequency distribution of bivalve or other sensitive/indicator species [CANDIDATE]	Population structure of long-lived macrozoobenthic species	
	Lower depth distribution limit of macrophyte species	In the OSPAR work, this indicator is seen as linked to descriptor 5 and is not considered by COBAM
	Extent, distribution and condition of benthic biotopes	
PH-1 Changes of plankton functional types (life form) index Ratio [CORE]		
PH-2 Plankton biomass and/or abundance [CORE]		
PH-3 Changes in biodiversity index(s) [CORE]		
NIS-1 Pathways management measures [CANDIDATE]		
NIS-2 Rate of new introductions of NIS (per defined period) [CANDIDATE]	Trends in arrival of new non-indigenous species	Note that in COBAM, this indicator is considered as a candidate

Annex 3.

Links between the proposed core indicators and anthropogenic pressures.

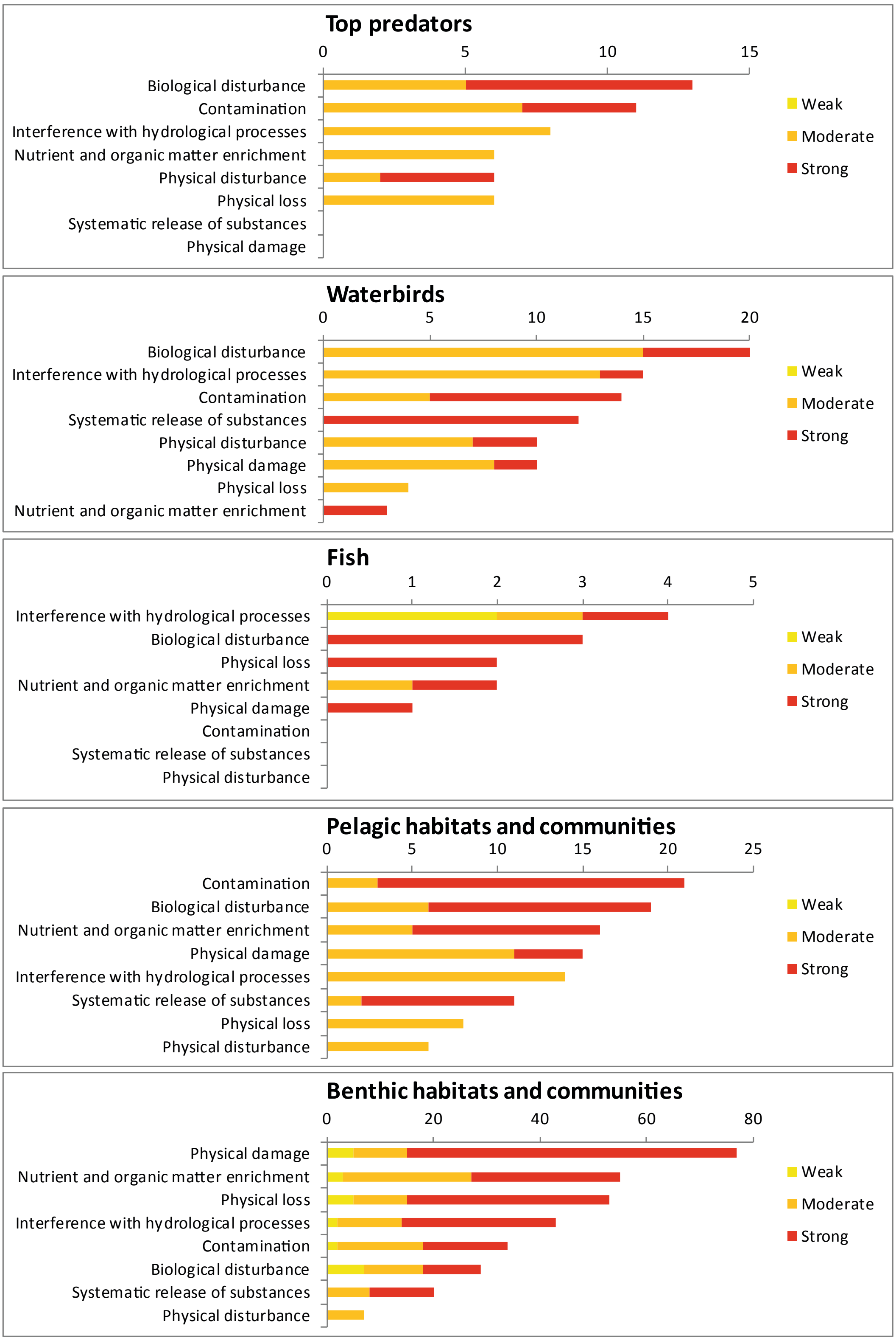

Figure A1. A summary of the main pressures linked to the core indicators with strong, moderate or weak impacts. The core indicators are categorised into top predators (seals, harbour porpoise and white-tailed eagle); waterbirds (wintering and breeding); fish; zooplankton community; and benthic habitats and communities. The impact scores (horizontal axis) are sums of estimated impacts in Table A4. Note that the scales between the graphs are not comparable.

Table A4. **Proposed core (and candidate) indicators and their linkages to anthropogenic pressures. The pressures are grouped according to the EU MSFD. Red = strong link; orange = moderate link; yellow = weak link; blue = uncertain/debatable impact. Note that the weak link has been shown only if there are few stronger links, The matrices linking functional groups and anthropogenic pressures were first presented in the interim report of the CORESET project (HELCOM 2012).**

Proposed core indicators	Physical loss: Smothering	Physical loss: Sealing	Physical damage: Changes in siltation	Physical damage: Abrasion	Physical damage: Selective extraction	Physical disturbance: (Underwater) noise	Physical disturbance: Marine litter	Interference with hydrological processes: Significant changes in thermal regime	Interference with hydrological processes: Significant changes in salinity regime	Contamination by hazardous substances: Introduction of synthetic compounds	Contamination by hazardous substances: Introduction of non-synthetic compounds	Contamination by hazardous substances: Introduction of radionuclides	Systematic and/or intentional release of substances: Introduction of other substances	Nutrient and organic matter enrichment: Inputs of fertilisers and other nitrogen and phosphorus-rich substances	Nutrient and organic matter enrichment: Inputs of organic matter	Biological disturbance: Introduction of microbial pathogens, parasites	Biological disturbance: Introduction of non-indigenous species	Biological disturbance: Selective extraction of species
1 Population growth rates of marine mammals -Abundance of marine mammal populations -Distribution of marine mammals		– / Yellow				Orange / Red				Light red	Orange			Blue	Blue			Red
2 -Pregnancy rates of marine mammals -Other condition parameters						Orange				Red / Orange	Red / Orange		Red	Blue	Blue	Red / –	Orange / –	Yellow
3 Nutritional status of marine mammals -Other condition parameters						Orange	Yellow			Yellow	Yellow		Yellow	Yellow	Yellow	Red	Yellow	Orange
4 Bycatch of mammals and seabirds																		Red
5 White-tailed eagle productivity										Red			Yellow					Yellow
6 Abundance of wintering populations of seabirds -Distribution of wintering populations of seabirds	Orange	Orange	Orange	Orange	Orange	Blue		Orange	Orange	Orange			Red					Red
7 Abundance of breeding populations of seabirds -Breeding success of waterbirds	Orange	Orange	Orange	Orange	Orange	Blue		Orange	Orange	Orange			Red			Orange	Light red	Red
8 Number of seabirds being oiled annually													Red					
9 Abundance of key fish species	Blue	Blue	Yellow	Yellow	Yellow			Orange	Orange					Orange	Orange		Yellow	Red
10 Abundance of fish key functional groups	Blue	Blue	Yellow	Yellow	Yellow			Orange	Orange					Red	Blue		Yellow	Red
11 Proportion of large fish in the community														Blue	Blue			Red
12 Abundance of sea trout spawners and parr	Blue							Yellow	Yellow				Yellow	Blue	Blue			Red
13 Abundance of salmon spawners and smolt	Blue							Yellow	Yellow				Yellow	Blue	Blue			Red
14 Trends in arrival/establishment of new non-indigenous species		Yellow						Orange	Orange					Yellow			Red	Yellow
15 Zooplankton mean size-total abundance indicator								Orange	Orange	Yellow	Yellow			Red	Orange		Red	Red
16 Phytoplankton diversity			Red				Yellow	Orange	Orange	Yellow	Yellow			Red	Red		Red	
17 Multimetric macrozoobenthic indices	Blue	Orange	Red	Red	Red			Red						Light red	Light red		Light red	Red
18 Lower depth distribution limit of macrophyte species	Red	Red	Red	Red	Red			Red	Orange	Red				Red	Red			Yellow
19 Population structure of long-lived macrozoobenthic species	Red			Red	Red			Orange	Orange					Light red	Light red		Orange	Red
20 Cumulative impact on benthic habitats	Red	Red	Red	Red	Red		Yellow	Orange	Orange					Orange	Orange			Red
21 Distribution of biotopes	Light red	Light red	Light red	Light red	Light red			Orange	Orange					Orange	Orange			

Annex 4.

Comparison of the proposed HELCOM core indicators with the indicators of the EC Decision 477/2010/EC.

This annex compares the proposed HELCOM core indicators with the indicators which are proposed in the ED Decision document 'Criteria and methodological standards for the good environmental status (GES) (2010/477/EC)'.

Table A5. Descriptor 1 Biodiversity		
Species level		
MSFD Criteria	**Proposed MSFD indicator**	**Proposed HELCOM core indicators [and Baltic Sea Environment Fact Sheets, BSEFS]**
1.1 Species distribution	Distributional range	Population growth rate, abundance and distribution of marine mammals.
	Distribution pattern	
	Area covered by the species	
1.2 Population size	Abundance	Population growth rate, abundance and distribution of marine mammals Abundance of salmon spawners and smolts Abundance of sea trout spawners and parr Abundance of waterbirds in the wintering season (each species) Abundance of waterbirds in the breeding season (each species) [BSEFS: Population development of White-tailed Eagle; Population Development of Dunlin]
	Biomass	Abundance of key fish species Abundance of fish key functional groups
1.3 Population condition	Population demographic characteristics	Pregnancy rate of marine mammals Nutritional status of seals White-tailed Eagle productivity
	Population genetic structure	
Habitat level (including associated communities)		
1.4 Habitat distribution	Distributional range	Extent, distribution and condition of benthic biotopes
	Distributional pattern	
1.5 Habitat extent	Habitat area	Extent, distribution and condition of benthic biotopes Lower depth distribution limit of macrophyte species
	Habitat volume	
1.6 Habitat condition	Condition of the typical species and communities	Population structure of long-lived macrozoobenthic species Extent, distribution and condition of benthic biotopes
	Relative abundance and/or biomass	
	Physical, hydrological and chemical conditions	
Ecosystem level		
1.7 Ecosystem structure	Ecosystem structure: Composition and relative proportions of ecosystem components	

Table A6. Descriptor 2 Non-indigenous species		
Criteria	**Proposed indicator**	**Proposed HELCOM core indicator**
2.1 Abundance and state characterisation of non-indigenous species, in particular invasive species	Trends in abundance, temporal occurrence and spatial distribution in the wild of non-indigenous species, particularly invasive non indigenous species, notably in risk areas, in relation to the main vectors and pathways of spreading of such species.	Trends in arrival of new non-indigenous species [Baltic Sea Environment Fact Sheets: Abundance and distribution of Round goby (*Neogobius melanostomus*) Abundance and distribution of the Zebra mussel (*Dreissena polymorpha*) Abundance and distribution of marenzelleria species in the Baltic Sea
2.2 Environmental impact of invasive non-indigenous species	Ratio between invasive non-indigenous species and native species in some well-studied taxonomic groups (e.g. fish, macroalgae, molluscs) that may provide a measure of change in species composition (e.g. further to the displacement of native species)	[Baltic Sea Environment Fact Sheet: Observed non-indigenous and cryptogenic species in the Baltic Sea]
	Impacts of non-indigenous invasive species at the level of species, habitats and ecosystem, where feasible	[Baltic Sea Environment Fact Sheet: Biopollution level index]

Table A7. Descriptor 4 Food webs

MSFD Criteria	Proposed MSFD indicator	Proposed HELCOM core indicators
4.1 Productivity of key species or trophic groups	Performance of key predator species (mammals, seabirds) using their production per unit biomass (productivity)	Population growth rates, abundance and distribution of marine mammals White-tailed Eagle productivity Abundance of sea trout spawners and parr Abundance of salmon spawners and smolt
4.2 Proportion of selected species at the top of food webs	Large fish (by weight)	Proportion of large fish in the community (by length)
4.3 Abundance/distribution of key trophic groups and species	Abundance trends of functionally important selected key trophic groups/species	Abundance of fish key functional groups Zooplankton mean size and total abundance

Table A8. Descriptor 5 Eutrophication

Criteria	Proposed indicator	Proposed HELCOM core indicator
5.1 Nutrient levels	Nutrients concentration in the water column	DIN concentrations DIP concentrations
	Nutrient ratios (silica, nitrogen and phosphorus), where appropriate	
5.2 Direct effect of nutrient enrichment	Chlorophyll concentration in the water column	Chlorophyll concentrations
	Water transparency related to increase in suspended algae, where relevant	Water transparency
	Abundance of opportunistic macroalgae	
	Species shifts in floristic composition (diatom: flagellate ratio, benthic/pelagic shifts)	
5.3 Indirect effects of nutrient enrichment	Abundance of perennial seaweeds and seagrasses adversely affected by decrease in water transparency	Lower depth distribution limit of macrophyte species
	Dissolved oxygen, i.e. changes due to increased organic matter decomposition and size of the area concerned	Oxygen concentrations (or oxygen debt)

Table A9. Descriptor 6 Seafloor integrity

Criteria	Proposed indicator	Proposed HELCOM core indicator
6.1 Physical damage, having regard to substrate characteristics	Type, biomass and areal extent of relevant biogenic substrate	Extent, distribution and condition of benthic biotopes
	Extent of the seabed significantly affected by human activities for the different substrate types	Cumulative impacts on benthic biotopes
6.2 Condition of the benthic community	Presence of particularly sensitive and/or tolerant species	A parameter embedded in the indicator 'State of the soft-bottom macrofauna communities'
	Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species	State of the soft-bottom macrofauna communities
	Proportion of biomass or number of individuals in the macrobenthos above some specified length/size	Population structure of long-lived macrozoobenthic species
	Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community	Population structure of long-lived macrozoobenthic species

Table A10. Descriptor 8 Concentrations of contaminants		
Criteria	**Proposed indicator**	**Proposed HELCOM core indicator**
8.1. Concentration of contaminants	Concentration of the contaminants mentioned above, measured in the relevant matrix (such as biota, sediment and water) in a way that ensures comparability with the assessments under Directive 2000/60/EC	The following substance indicators: PBDE, HBCD, PFOS, PCB+dioxins, PAHs, Metals (Cd, Pb, Hg), TBT, Cesium-137, Pharmaceuticals (diclofenac, estrogens)
8.2. Effects of contaminants	Levels of pollution effects on the ecosystem components concerned, having regard to the selected biological processes and taxonomic groups where a cause/effect relationship has been established and needs to be monitored	Imposex (embedded in TBT core indicator); PAH metabolites (embedded in PAH core indicator) Lysosomal membrane stability: a toxic stress indicator Micronuclei test: a genotoxicity indicator Fish disease index: a fish stress indicator Malformed embryos of eelpout and amphipods White-tailed eagle productivity Pregnancy rate of marine mammals
	Occurrence, origin (where possible), extent of significant acute pollution events (e.g. slicks from oil and oil products) and their impact on biota physically affected by this pollution	Number of waterbirds being oiled annually. [BSEFS: Illegal discharges of oil in the Baltic Sea]

Table A11. Descriptor 9 Contaminants in seafood		
Criteria	**Proposed indicator**	**Proposed HELCOM core indicator**
9.1. Levels, number and frequency of contaminants	Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels	CORESET proposed core indicators to assess concentrations against specific limit levels; substances are Cadmium, Lead, Mercury, dl-PCBs, dioxins, Benzo[a]Pyrene and Cesium-137
	Frequency of regulatory levels being exceeded	

Table A12. Descriptor 10 Marine litter		
Criteria	**Proposed indicator**	**Proposed HELCOM core indicator**
10.1. Characteristics of litter in the marine and coastal environment	Trends in the amount of litter washed ashore and/or deposited on coastlines, including the analysis of its composition, spatial distribution and, where possible, source	
	Trends in the amount of litter in the water column (including floating at the surface) and deposited on the sea-floor, including the analysis of its composition, spatial distribution and, where possible, source	
	Trends in the amount, distribution and, where possible, composition of micro-particles (in particular micro-plastics)	
10.2. Impacts of litter on marine life	Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis)	

Table A13. Descriptor 11 Underwater energy		
Criteria	**Proposed indicator**	**Proposed HELCOM core indicator**
11.1. Distribution in time and place of loud, low and mid frequency impulsive sounds	Proportion of days and their distribution within a calendar year over areas of a determined surface as well as their spatial distribution, in which anthropogenic sound sources exceed levels that are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re 1µPa2.s) or as peak sound pressure level (in dB re 1µPapeak) at one metre, measured over the frequency band 10 Hz to 10 kHz	
11.2. Continuous low frequency sound	Trends in the ambient noise level within the 1/3 octave bands 63 and 125 Hz (centre frequency) (re 1µPa RMS; average noise level in these octave bands over a year) measured by observation stations and/or with the use of models if appropriate	

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