Report on gaps in monitoring programs

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CENTRAL BALTIC INTERREG IV A PROGRAMME 2007–2013

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Report on gaps in monitoring programs

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Introduction

The purpose of this report is to map the gaps in the current monitoring programs as well as the actions necessary to render the monitoring schemes compliant with the requirements of the Marine Strategy Framework Directive (MSFD) in the GES-REG project area, i.e. the Gulf of Finland, the northern Baltic Proper and the Gulf of Riga. The report is based on the outcomes of group discussions at the monitoring workshop of the GES-REG project, held in Tallinn, Estonia, on 11-12 September 2013 and subsequent comments from the GES-REG partners and other national experts.

The evaluation here is divided into 6 thematic groups: hydrography, pelagic environment, benthic environment, vertebrates, contaminants, and marine litter. Monitoring issues in regard of underwater noise and non-indigenous species is tackled in the separate reports of pilot studies.

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1. Hydrography – gaps in the monitoring of hydrographical variability and changes

This section relates to the following MSFD descriptors (Commission Decision 2010/477/EU):

- Descriptor 5: *Human-induced eutrophication is minimized, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters*,
- Descriptor 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;* and
- Descriptor 7: *Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems*.

1.1 Natural basin-wide scale hydrographical variability and changes

In order to produce information for the interpretation of assessment results relating to other descriptors (see Table 1 of Annex III in the MSFD; Characteristics – Physical and chemical features), hydrographical conditions and changes in these characteristics have to be monitored on a basin-wide scale. This is not achieved regarding all parameters.

The annual and seasonal sea surface temperature regime and ice cover as well as spatial and temporal distribution of salinity are comprehensively monitored, but improvements are needed regarding data availability. Model results, both operational and reconstructed, should be made easily available via HELCOM, BOOS or other portal.

The topography and bathymetry of the Baltic Sea seabed is well charted, except in coastal areas which are shallow and where changes occur.

In situ current velocity data is not available (except in the south-western Baltic Sea). Current velocity should be monitored in important areas such as straits, deep channels, and areas subject to coastal jets; research is needed to define monitoring network for currents. Current velocity model results, both operational and reconstructed, should be made easily available via HELCOM, BOOS or other portal.

There are not enough wave measurements from the eastern part of the open Baltic Sea and the Gulf of Riga; particularly coastal and shallow areas as well as banks should be monitored for wave exposure. Wave buoys are needed in the eastern part of the open Baltic Sea and the Gulf of Riga; research is needed regarding wave effects in coastal areas, shallow areas, and banks. Wave exposure model results, both operational and reconstructed, should be made easily available via HELCOM, BOOS or other portal.

Residence time model results, both operational and reconstructed, should be made easily available via HELCOM, BOOS or other portal.

In situ monitoring of turbidity is performed effectively using ferrybox platforms, but the network of ferrybox platforms needs to be extended to cover also the Gulf of Riga.

Total organic carbon (TOC) has not been included in past monitoring programs at all and needs to be added to the palette of parameters. The sampling of nutrients (DIN, TN, DIP, TP) and oxygen has a fairly good spatial and temporal coverage, but the ferrybox monitoring network needs to be extended to cover the Gulf of Riga. Ideally, nutrients could be analyzed *in situ*; however, *in situ* nutrient analyzers require research and development before they can be applied in the Baltic Sea. For the monitoring of the winter pool of nutrients a research vessel with a proper ice class is a requisite. Near sea-bed oxygen should be measured with higher resolution at fixed stations; there are only a few measurement points for high-resolution data.

In order to measure marine acidification, pH and pCO2 profiles are required. The monitoring of pH is spatiotemporally appropriate, but pCO2 measurements need to be made part of the routine ferrybox palette and the network of ferrybox platforms needs to be extended to cover the Gulf of Riga.

Furthermore, it is uncertain whether the spatial coverage of monitoring for high-resolution vertical distribution of most physicochemical parameters is sufficient for the purposes of the MSFD. Research is needed to determine the appropriate spatial monitoring network for observing the annual and seasonal temperature, nutrient, oxygen and pCO2 regimes, the spatial and temporal distribution of salinity, mixing characteristics, upwelling and stratification. Application of new technologies like fixed autonomous buoys, floating buoys (Argo floats) and gliders is advisable; the methodology needs to be agreed upon internationally and the responsibilities divided.

1.2 Anthropogenic hydrographical changes

Hydrographical changes due to new infrastructures have to be assessed and monitored via environmental impact assessments and compliance monitoring (as defined in water permits) and MSFD requirements have to be taken into account (see Table 2 of Annex III in the MSFD; Pressures and impacts –, Physical loss, physical damage, interference with hydrological processes). Monitoring of hydrographical changes is however not always conducted, and/or data is lacking in quality and availability. In some cases information exists but has not been compiled, therefore basin-wide assessments are difficult to perform. To facilitate basin-wide assessments, data on hydrographical changes due to new infrastructures should be incorporated into accessible data bases such as national monitoring data bases.

Whereas pressure data regarding the amounts of dredged and disposed bottom material and the amounts of harmful substances in the sediments are collected to a register and reported to HELCOM, environmental monitoring data connected to these activities are not collected (e.g. concentration of harmful substances in dredged soils; alterations in siltation; extent of impacted area etc). Data on other activities or constructions and their impact is not collected at all, nor is abrasion (e.g. impact on the seabed of commercial fishing, boating, anchoring) monitored. It is recommended to collect all data (at least meta-data) on anthropogenic pressures and impacts listed in Annex III Table 2 of the MSFD, i.e. *physical loss* [smothering (e.g. by man-made structures, disposal of dredge spoil); sealing (e.g. by permanent constructions)], *physical damage* [changes in siltation (e.g. by outfalls, increased run-off, dredging/disposal of dredge spoil); abrasion (e.g. impact on the seabed of commercial fishing, boating, anchoring); selective extraction (e.g. exploration and exploitation of living and non-living resources on seabed and subsoil)], *interference with hydrological processes* [significant changes in thermal regime (e.g. by outfalls from power stations); significant changes in salinity regime (e.g. by constructions impeding water movements, water abstraction)]. A GIS-based information system should be developed. The development of a HELCOM recommendation and GIS system would be feasible through a HELCOM project.

1.3 Summary of gaps in the monitoring of Baltic Sea hydrography

Major gaps in monitoring:

- *in situ* current velocities
- wave exposure
- total organic carbon
- near sea-bed oxygen
- pCO2
- high-resolution vertical distribution of most physicochemical parameters

Actions required to improve monitoring, feasible with available methods and knowhow:

- extension of the ferrybox platform network to cover the Gulf of Riga
- incorporation pCO2 (and, if possible, TOC) analyzes into the ferrybox monitoring system
- application of new technologies such as fixed autonomous buoys, floating buoys (Argo floats) and gliders
- making information regarding temperature, ice cover, salinity, current velocity, wave exposure, residence time easily accessible: model results, both operational and reconstructed, to be made easily available via HELCOM, BOOS or other portal
- incorporation of data on hydrographical changes due to new infrastructures into accessible data bases (e.g. incorporation of compliance monitoring data into the national monitoring data bases)
- collection of all data (at least meta-data) on anthropogenic pressures and impacts listed in Annex III Table 2 of the MSFD

Research required to facilitate MSFD compliant monitoring of the Baltic Sea ecosystem:

- mapping the topography and bathymetry of coastal areas
- identification of the optimal spatiotemporal coverage of monitoring network for currents
- identification of the optimal spatiotemporal coverage of high-resolution vertical profiles of physicochemical parameters and identification of sensor platforms most suitable for the purpose in the shallow, heavily trafficked Baltic Sea
- research on the effects of wave exposure on coastal and shallow areas and banks
- research and development of *in situ* nutrient analyzers with the aim to incorporate these into the ferrybox monitoring system
- development of models for simulation / reconstruction of stratification, currents, bottom layer transport and oxygen, biogeochemistry
- development of remote sensing algorithms
- research on abrasion, e.g. the impact of commercial fishing on the seabed, and development of monitoring methods for this purpose.

2. Contaminants – gaps in the monitoring of contaminants

This section relates to the following MSFD descriptors (Commission Decision 2010/477/EU):

- Descriptor 8: *Concentrations of contaminants are at levels not giving rise to pollution effects,* and
- Descriptor 9: *Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards*.

Presently, in most countries not all Environmental Quality Standards (EQS) Directive (2008/105/EC) substances are monitored, and new EQS Directive (2013/39/EC) substances are not yet monitored (almost) anywhere. In effect, in most Baltic Sea countries monitoring is not operational and a common and coherent monitoring program for the purposes of implementing the Water Framework Directive, MSFD and food safety regulations (e.g. Commission Regulation No 1881/2006), is not established in Baltic Sea coastal areas. Both the MSFD and the WFD contain elements which need to be jointly considered for coherence and efficiency.

Difficulties arise due to a lack of background values (especially for metals), lack of geographical source information for seafood, the use of a variety of different methodologies (e.g. sample preparation), and the concept of *High Limit of Quantification*, which results in lost information of low concentrations, which are needed in trend analyses and risk assessments.

Quality assurance / Quality control (QA/QC) in (marine) monitoring is hampered by proficiency testing schemes and reference materials not being available for all substances and matrices, as well as disparate sampling and analytical methods.

2.1 Selection of contaminant substances for monitoring

New EQS Directive substances should be incorporated into monitoring of substances in biota. The WFD list of priority substances (2008/105/EC + 2013/39/EC) and contaminants in foodstuffs (EC Regulation 1881/2006) should be used to produce a minimum list of contaminants. The significance of each substance should be assessed (it means, exclusion of the substances needs to be justified, e.g. there are no contaminant sources for the particular substance or the substance occurs in very low concentrations

only, etc.). Additional contaminants of relevance beyond WFD waters, marine region/sub-region/local specific substances (similar to WFD river basin specific pollutants) should be identified and the HELCOM Baltic Sea Action Plan list of substances (11 substances) should be re-checked. Next, a final list of contaminants for which GES criteria must be established should be compiled, and biological effect indicators should be selected.

2.2 Setting of quantitative MSFD GES criteria for contaminants

The best matrix or matrices for monitoring and assessment in the marine environment (water, sediment and/or biota, including trophic level) should be identified and justified – more than one matrix may be useful. The Environmental Quality Standards (EQS) for Priority Substances under the WFD should be used for GES, if available; if such are not available, use other thresholds similar to QS of WFD data sheets.

2.3 Designing the contaminant monitoring programme

An integrated WFD/MSFD monitoring programme on selected contaminants and effects should be designed by utilizing WFD and HELCOM experience as much as possible. Depending on the needs (assessment of trends in concentrations and pressure; GES assessment; investigative monitoring) different types of monitoring should be implemented. Synergies on biota sampling and analysis between MSFD/WFD and seafood legislation approaches should be identified and created. Finally, synergies to facilitate pressure monitoring (rivers, large cities WWTPs, atmospheric deposition) should be created.

2.3.1 Short cores – cost effective monitoring of contaminants in sediments

Sediment and biota are important matrices for the monitoring of substances with significant potential for accumulation. In order to assess long-term impacts of anthropogenic activity and trends, Member States should take measures, subject to Article 3(3) of the EQS Directive, with the aim of ensuring that existing levels of contamination in biota and sediment will not significantly increase:

- To assess long-term changes in natural conditions and to assess the long term changes resulting from widespread anthropogenic activity.
- To assess compliance with the "no deterioration objective" (concentrations of substances are below detection limits, declining or stable and there is no obvious risk of increase) of the WFD.
- To monitor the progressive reduction in the contamination of priority substances (PS) and phasing out of Priority Hazardous Substances (PHS)

To this end, sediments are suitable for revealing past recent history of contaminants, whereas biota is the proper matrix to follow up the current development of contamination. Both have a time-integrating and a "smoothing" tendency, which is a cost-effective aspect. The concept is based on short sediment core sampling (ca. 10 to 30 cm), checking the recent history of especially priority hazardous substances with high affinity to particle phase such as HCHs, HCB, HCBD, Hg, PAHs, PBDE and TBT. The method is well applicable to many of the new substances such as PCDD/F + dl-PCB, HBCDD, PFOS and heptachlor/-epoxide, for which there is now EQS in biota. The concept works only for certain types of environments such as lake deeps with a relatively well known sedimentation rate and little influence of water currents. The technique is also applicable to sheltered coastal locations in the Baltic Sea.

2.4 Summary of gaps in the monitoring of Baltic Sea contaminants

Major gaps in monitoring:

- EQS Directive (2008/105/EC) and new EQS Directive (2013/39/EC) substances are inadequately monitored
- a common and coherent monitoring programme does not exist
- proficiency testing schemes and reference materials are not available for all substances and matrices

Actions required to improve monitoring, feasible with available methods and knowhow:

- compilation of a list of contaminants for which GES criteria must be established
- identification of the best matrix or matrices for monitoring and assessment in the marine environment (water, sediment and/or biota, including trophic level)
- harmonization of sampling, preparation, and analysis methodologies
- selection of biological effect indicators, e.g. HELCOM core indicators as a starting point
- design integrated WFD/MSFD monitoring programme on contaminants and their effects
- identify and create synergies with other monitoring sub-programmes
- make available geographical source information for seafood

Research required to facilitate MSFD compliant monitoring of the Baltic Sea ecosystem:

- further research on indicators, especially on biological effects
- research on pharmaceuticals in the marine environment
- research on background levels (especially for metals; PAHs, PCDD/F, brominates maybe also)
- research on combined effects of substances (more ecotoxicity and biomarker methods with GES boundaries)
- modeling of bioaccumulation (within the food web, depending on the food web structure; e.g. using stable isotopes methods)

3. Litter – gaps in the monitoring of litter

This section relates to the following MSFD descriptor (Commission Decision 2010/477/EU):

- Descriptor 10: *Properties and quantities of marine litter do not cause harm to the coastal and marine environment.*

It covers only microlitter while macrolitter monitoring and assessment requirements, gaps and recommendations are highlighted in a separate pilot study report

In the Baltic Sea and elsewhere, research into aquatic microlitter has only recently been initiated. At present, there is no microlitter monitoring in Finland, Estonia, Latvia, or Sweden. Concerning the macrolitter, Finland, Sweden, Estonia and Latvia have participated in the MARLIN project on beach litter monitoring.

3.1 Designing the microlitter monitoring programme

Based on the experiences gained in the Baltic Sea region so far, it is recommended that two different samplers should be used in combination for microlitter sampling. For larger fractions of microlitter a specially designed sampling net (Manta trawl, mesh size 300/330 µm) should be used, whereas a submersible pump system should be used to collect smaller fractions of microlitter onto a 100 µm mesh filter. Monitoring using Manta trawl can be carried out during the ordinary monitoring cruises when travelling from one monitoring station to another. Monitoring should be focused on coastal areas where the abundance of microlitter is higher than in the open sea areas. In parallel with this initial and exploratory monitoring, research should be undertaken to test the sampling and analysis options for small microlitter fractions, especially fibers, and to gain insights into the effects of microlitter in the food webs. After a certain intensive test period (of a few years), the monitoring scheme should be modified according to increased knowledge, e.g. regarding about hot spot areas, the optimal sampling network, and the optimal sampling frequency and seasonal timing of sampling. Monitoring results from a sub-region (e.g. Gulf of Finland) should be pooled together to better understand the distribution pattern and variability.

3.2 Summary of gaps in the monitoring of Baltic Sea litter

Major gaps in monitoring:

- microlitter is not monitored at all

Actions required to improve monitoring, feasible with available methods and knowhow:

- implementation of initial and exploratory microlitter monitoring, which is to be revised after test period
- establishment of an expert network between countries to exchange information on survey results (techniques for sampling, laboratory analyses of samples etc)
- arrangement of joint microlitter surveys, sharing of survey data

Research required to facilitate MSFD compliant monitoring of the Baltic Sea ecosystem:

- research on possible indicators on microlitter
- testing of the sampling and analysis options for small microlitter fractions, especially fibers
- research into the effects of microlitter on the food webs

4. The pelagic habitat – gaps in the monitoring of variability and changes in the pelagial

This section relates to the following MSFD descriptors (Commission Decision 2010/477/EU):

- Descriptor 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 climate conditions*,
- Descriptor 2: *Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem*
- Descriptor 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*, and
- Descriptor 5: *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*

The pelagic ecosystem is highly dynamic and its components display great heterogeneity in space and time. In order to obtain a detailed understanding of such an environment, spatially and temporally frequent sampling during a prolonged period of time is necessary. This chapter represents the opinion of experts only from Finland, Estonia and Latvia, because Sweden will evaluate their pelagic monitoring at a later stage.

4.1 Phytoplankton species composition, biomass and chlorophyll a

In Finland, the spatial and temporal resolution of phytoplankton species composition monitoring is at present not sufficient to fulfill the needs of the MSFD. Estonia collects and analyses ca 300 samples per year, which is adequate for the purposes of the MSFD. Temporal resolution in monitoring of phytoplankton in Latvian waters is in most areas insufficient.

In open sea areas, phytoplankton sampling can effectively be performed by utilizing the ferrybox platform network. Hence the challenge in meeting the MSFD requirements lies not in the performing of sampling, rather, the resources presently allocated to phytoplankton monitoring in Finland do not allow the analyzing of the requisite number of samples. Although supplementary phytoplankton monitoring methods (such as satellite instruments and pigment analysis) are under development, there are at

present no alternative methods to the labour-intensive and special expertise requiring quantitative phytoplankton species composition analyses. Modelling and statistical analysis should be utilized to optimize the sampling station network.

Chlorophyll *a* (chl *a*) varies rapidly both vertically and horizontally, wherefore a once-a-month sampling interval (as the best temporal resolution obtained by using research vessels) is too scarce. Automatic sampling with higher temporal and spatial resolution is possible using ferrybox platforms, but the network of ferrybox platforms needs to be extended to cover also the Gulf of Riga. A greater number of automatic profiling buoys should be employed to follow the vertical distribution of phytoplankton and hence chlorophyll *a*. A greater number of automatic profiling buoys should be employed. In Estonia, buoys have been operational since 2009, in Finland the method is undergoing testing and development, in Latvia plans exist to develop and test such approach in the future. Traditional chl *a* sampling and analysis are however still necessary to perform, since chl *a* results are needed to validate the fluorescence results provide by the buoys. A proper combination of buoys and e.g. once-a-month sampling is suggested as an approach to meet both temporal resolution and quality assurance requirements.

4.2 Zooplankton

In Finland, the spatial and temporal resolution of zooplankton species composition monitoring is at present not sufficient to fulfill the needs of the MSFD. The data is lacking in both temporal and spatial resolution, since the open sea stations are sampled only once per year and coastal waters are not sampled at all. Estonia collects zooplankton data several times per year from the same stations as phytoplankton but mostly in the coastal waters, which is adequate for the purposes of the MSFD. Open sea monitoring for zooplankton is mostly performed twice a year.

4.3 Microzooplankton and picoplankton

Microzooplankton and picoplankton constitute important components of the pelagic food web. They are significant recyclers of organic matter and nutrients, and microzooplankton are important food for mesozooplankton. They are furthermore indicative of the state of the system, i.e. whether it is leaning toward autotrophy or heterotrophy. At times the phytoplankton community biomass can be dominated

by picoplankton; on these occasions routine phytoplankton analysis, which covers the larger-sized nano- and microphytoplankton, gives an underestimation of the primary producer biomass and an inaccurate picture of the phytoplankton community composition. At present microzooplankton and picoplankton are not monitored in Finland, Estonia, Latvia or Sweden. Microzooplankton and picoplankton should be added to the monitoring palettes. The subsamples for microzooplankton and picoplankton should be taken from the same water samples as the subsamples for phytoplankton analysis.

4.4 Summary of gaps in the monitoring of Baltic Sea pelagic habitat

Major gaps in monitoring:

- insufficient spatiotemporal resolution of phytoplankton monitoring in some areas
- insufficient spatiotemporal resolution of zooplankton monitoring in some areas
- microzooplankton and picoplankton are not monitored at all

Actions required to improve monitoring, feasible with available methods and knowhow:

- optimization of pelagic sampling station network using statistical tools and modelling
- increasing the utilization of the ferrybox platform network for phytoplankton and chlorophyll *a* sampling
- increasing employment of automatic profiling buoys for chl *a* fluorescence analysis
- initiating microzooplankton and picoplankton monitoring

Research required to facilitate MSFD compliant monitoring of the Baltic Sea ecosystem:

- development of supplementary phytoplankton monitoring methods such as satellite instruments (and adequate algorithms) and pigment analysis
- research and development of Baltic-wide and regional indicators
- research into the applicability of genetic bar-coding in pelagic monitoring

5. The benthic habitat – gaps in the monitoring of variability and changes in the benthos

This section relates to the following MSFD descriptors (Commission Decision 2010/477/EU):

- Descriptor 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 climate conditions*,
- Descriptor 2: *Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem*¸
- Descriptor 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*,
- Descriptor 5: *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*, and
- Descriptor 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*.

In Finland, comprehensive offshore benthic monitoring is performed, but whether or not e.g. its spatial resolution is sufficient in fulfilling the requirements of the MSFD (all descriptors and their criteria) has not been fully assessed. In Finnish coastal areas the soft bottom macrobenthos monitoring network is fairly extensive but some spatial gaps have been identified on the west coast. Sand-bottom monitoring is practically non-existent. Hard-bottom monitoring exists (WFD, Fucoid monitoring) but this is not sufficient for the purposes of the MSFD.

Data on the amounts of dredged and disposed bottom material and the amounts of harmful substances in the sediments are collected to a register and reported to HELCOM. Also other pressures affecting the seafloor, such as smothering by e.g. cables and pipelines, the amount of potential siltating material, the amount of abrasion and the amount of exploitation of the seabed and subsoil, need to be monitored.

In Estonia, the spatial and temporal resolution of offshore benthic monitoring is at present not sufficient to fulfill the needs of the MSFD. In coastal areas the monitoring is more comprehensive because of WFD monitoring but there are some deficiencies regarding the taxonomical resolution of collected data. Pressures and impacts are not monitored in Estonian waters.

In Sweden benthic monitoring in the Baltic consists of monitoring of benthic invertebrates in clusters in the coastal areas (20 stations) and offshore areas (10 stations). There exists monitoring programme for macrophyte depth distribution in coastal areas (diving transects, blue mussels included). Monitoring in the offshore areas is not sufficient. Offshore banks have been surveyed twice in the 00-ties.

The benthic inventory/monitoring methods are similar (some differences in sieve size and grabbers). Reporting of distribution and extent of habitats listed in the Habitats Directive are based on modelling and expert judgement mainly, so monitoring is not sufficient.

In Latvia the benthic monitoring is divided into two parts - according to soft and hard bottom habitats. The monitoring of soft bottom habitats is made once per year (May). Multimetric macrozoobenthos indicator is applied.

Hard bottom monitoring is foreseen for future. The mapping of hard bottom habitats is video based and then the samples are collected. August is most common timing for hard bottom sampling. The indicator for hard bottom zoobenthos is under development.

The depth distribution of phytobenthos is used to characterize the benthos habitats. National inventories have been carried out and therefore the methods are similar to those of Finland, Estonia and Sweden. The link with impacts and pressures is not yet addressed.

5.1 Summary of gaps in the monitoring of the Baltic Sea benthic habitat

Major gaps in monitoring:

- sand-bottom and hard-bottom monitoring practically non-existent in some areas
- pressures affecting the seafloor not monitored
- monitoring of distribution and extent of habitats is almost fully absent

Actions required to improve monitoring, feasible with available methods and knowhow:

- setting up a joint framework for the monitoring of benthic biota, as well as the pressures and impacts on the biota, based on an analysis of the required efficiency (by power analysis) and of the optimal sampling methods and station network
- agreement on common indicators (within ongoing international projects and HELCOM)
- agreement on common monitoring methods for assessing the quality of habitats
- harmonization of methods (e.g. zoobenthos samplers) where possible, and development of methods for converting results into a common reporting format
- agreement on common reporting formats
- sharing of infrastructure and efforts (particularly regarding monitoring of offshore or deeper stations)
- sharing of data-sets (e.g. pressure data, ecological data), to facilitate common sub-regional reporting
- agreement on whether and how to use the HELCOM HUB biotope classification system in the joint monitoring

Research required to facilitate MSFD compliant monitoring of the Baltic Sea ecosystem:

- research into the real (quantified) impact of human activities on habitats and species, including cumulative impacts and the distance (distance gradient and temporal aspects) at which specific human activities affect habitats, populations and species
- research on how to monitor and assess responses of the benthic community to pressures and protection measures, and whether to include this research as a part of the benthic monitoring or perform it as basic research.
- research into the applicability of genetic bar-coding in benthic monitoring
- research and development of Baltic-wide and regional indicators (e.g. food web indicators)
- research into automated detection and analysis related to benthic monitoring (e.g. detection of supporting parameters, automated/semi-automated pre-classification of underwater drop-video images and benthic community composition samples)

6. Vertebrates – gaps in the monitoring of vertebrates

This section relates to the following MSFD descriptors (Commission Decision 2010/477/EU):

- Descriptor 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 climate conditions*,
- Descriptor 2: *Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem*,
- Descriptor 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*,
- Descriptor 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*,
- Descriptor 5: *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 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*,
- Descriptor 9: *Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards*.

Birds monitoring is existing in all countries as part of the biodiversity monitoring. However it is not coordinated between the countries. Indicators are under development. Those may vary between the countries. Regional coordination would be beneficial both in regard of cost-efficiency and comparability of assessment results. An expert group could be created.

Coordination in the coastal fish monitoring: it is coordinated for perch and flounder (HELCOM FISH-PRO); however, not coordinated for white fish and pikeperch.

Examples of the of autonomous methods, e.g. salmon spawners are counted by automatic methods (Lidar) in the river mouths for some rivers; remote-tracked seals to monitor their distribution areas and preferable habitats; hydrophones are used to listen to marine mammals – SAMBAH project could give an advice.

The abundance of grey-seals and ringed seals is monitored annually, but by-catch monitoring of young specimens should be considered (extra mortality by fishing gears; only minimum estimates are available).

6.1 Summary of gaps in the monitoring of Baltic Sea vertebrates

Major gaps in monitoring:

- monitoring of birds uncoordinated and insufficient
- lack of coordination (i.e. utilization of different methods) in coastal fish monitoring
- monitoring of large fish insufficient in some areas
- monitoring of birds feeding on herring and sprat is non-existing or insufficient
- monitoring of American mink abundances in insufficient in some areas (relevant for archipelago areas)

Actions required to improve monitoring, feasible with available methods and knowhow:

- establishment of expert networks for different topics (as it exists for seals), e.g. birds
- coordination of indicator development and assessment effort
- harmonization is needed in monitoring and assessment of those fish species that are outside the ICES stock assessments
- increase co-operation between HELCOM and ICES (fish) assessments

Research required to facilitate MSFD compliant monitoring of the Baltic Sea ecosystem:

- research into food web linkages and processes (e.g. the importance of stickleback and garfish in the food web, the effects of commercial fisheries on food webs and vice versa)
- research into the effects of climate change on the higher trophic levels of the food web
- research and development of Baltic-wide and regional indicators
- maximum sustainable yield of salmon and sea trout
- research into the carrying capacity of the system regarding e.g. seal and fish stocks

Conclusions and recommendations

This report covers the following topics and/or monitoring sub-programmes: Hydrography, Pelagic habitats, benthic environment, vertebrates, contaminants, and marine litter.

The following major gaps in the present monitoring programmes and action for the nearest future have been identified by the GES-REG project experts:

Hydrography

Gaps –

- the following parameters are mostly not part of the environmental monitoring: *in situ* current velocities, wave exposure, total organic carbon, pCO2
- too low sampling frequency is identified in regard of near sea-bed oxygen
- high-resolution vertical distribution of most physicochemical parameters is missing

Actions –

- extension of the ferrybox platform network to cover the Gulf of Riga
- incorporation pCO2 and TOC analyzes into the ferrybox monitoring system
- joint efforts to apply new technologies (fixed autonomous buoys, Argo floats, and gliders)
- making model results regarding temperature, ice cover, salinity, current velocity, wave exposure, residence time easily accessible
- making data on hydrographical changes due to new infrastructures commonly available
- collection of data on anthropogenic pressures and impacts listed in Annex III Table 2 of the MSFD

Contaminants

Gaps –

- EQS Directive (2008/105/EC) and new EQS Directive (2013/39/EC) substances are inadequately monitored
- a common and coherent monitoring programme does not exist
- proficiency testing schemes and reference materials are not available for all substances and matrices

Actions –

- compilation of a list of contaminants for which GES criteria must be established
- identification of the best matrix or matrices for monitoring and assessment in the marine environment (water, sediment and/or biota, including trophic level)

- harmonization of sampling, preparation, and analysis methodologies
- selection of biological effect indicators, e.g. HELCOM core indicators as a starting point
- identify and create synergies with other monitoring sub-programmes; make available geographical source information for seafood

Litter

Gaps –

- microlitter is not monitored at all

Actions –

- implementation of initial and exploratory microlitter monitoring, which is to be revised after test period
- establishment of an expert network between countries to exchange information on survey results (techniques for sampling, laboratory analyses of samples etc)
- arrangement of joint microlitter surveys, sharing of survey data

Pelagic habitats

Gaps –

- insufficient spatiotemporal resolution of phytoplankton monitoring in some areas
- insufficient spatiotemporal resolution of zooplankton monitoring in some areas
- microzooplankton and picoplankton are not monitored at all

Actions –

- optimization of pelagic sampling station network using statistical tools and modelling
- increasing the utilization of the ferrybox platform network for phytoplankton and chlorophyll *a* sampling
- increasing employment of automatic profiling buoys for chl *a* fluorescence analysis
- initiating microzooplankton and picoplankton monitoring

Benthic habitats

Gaps –

- sand-bottom and hard-bottom monitoring practically non-existent in some areas
- pressures affecting the seafloor not monitored
- monitoring of distribution and extent of habitats is almost fully absent

Actions –

- setting up a joint framework for the monitoring of benthic biota, as well as the pressures and impacts on the biota, based on an analysis of the required efficiency (by power analysis) and of the optimal sampling methods and station network
- agreement on common indicators (within ongoing international projects and HELCOM) and monitoring methods
- sharing of infrastructure, efforts and datasets
- agreement on whether and how to use the HELCOM HUB biotope classification system in the joint monitoring

Vertebrates

Gaps –

- monitoring of birds uncoordinated and insufficient
- lack of coordination (i.e. utilization of different methods) in coastal fish monitoring
- monitoring of large fish insufficient in some areas

Actions –

- establishment of expert networks for different topics (as it exists for seals), e.g. birds
- coordination of indicator development and assessment effort
- harmonizing needed in monitoring and assessment of those fish species that are outside the ICES stock assessments
- increase co-operation between HELCOM and ICES (fish) assessments