Final project summary report:
Actions to evaluate and identify effective measures to reach GES in the Baltic Sea marine region (HELCOM ACTION)

Contents

Summary of achievements under the ACTION project

The ACTION project was designed to support HELCOM Contracting Parties that are also EU Member States in updating and implementing their MSFD Programme of Measures and to contribute to the update of the HELCOM Baltic Sea Action Plan (BSAP) by 2021. The project focussed on six major topic areas (work packages) and was guided by a project implementation and policy-project interface work package (WP7). The following themes and technical developments were addressed as separate work packages:

- By-catch – Work package 1:
  Identifying high-risk areas for by-catch of mammals and birds, evaluating technical measures to reduce by-catch of harbour porpoise, estimating the effect and cost of these mitigation measures.
- Impacts on the seabed – Work package 2:
  Evaluating restoration measures in coastal areas and impacts of spatial regulation of offshore fisheries, including effects on benthic communities and costs of measures.
- Marine protected areas (MPAs) – Work package 3:
  Developing a method to assess management effectiveness of MPAs, assessing how MPAs contribute to achieving GES in the Baltic Sea.
- Input of nutrients – Work package 4:
  Analysing sources and trends of nutrient input and compatibility of nutrient reduction targets under different policies, evaluating the combined effect of existing measures.
- Conditions that influence GES – Work package 5:
  Analysing the conditions of the Baltic Sea that influence achievement of GES, including climate change.
- Sufficiency of measures – Work package 6:
  Developing business-as-usual (BAU) scenarios for selected topics to identify potential gaps in measures to achieve GES, estimating cost-effectiveness of tentative new measures.

The work initially planned in the project was expanded further to provide the strongest input possible to the Baltic Sea Action Plan update process and rather than addressing only selected topics for the assessment of the sufficiency of measures this analysis was extended to cover as many as possible topics of relevance to the Baltic Sea. The methodology developed also accommodates the varying data quality/availability for the topics and allowed an assessment to be carried out that may range from qualitative through to quantitative. As a result, business-as-usual (BAU) scenarios (i.e. the sufficiency of existing measures) were developed for 11 separate topics, as well as summarised in an overview report, the detailing of a methodology and guide for interpreting the results. Using the 2018 State of the Baltic Sea report (HOLAS II) as the baseline, the gap(s) to Good Environmental Status (GES),

and thus the sufficiency of existing measures was assessed, indicating where new measures may need to be targeted to achieve improvements.

In addition to contributing to the above described work related to the sufficiency of measures (i.e. work package 6), each work package also carried out developments within their own specific topic. Work package 1 has developed methodologies and sub-regional assessments of bycatch risk, work package 2 has reviewed the current knowledge available on pressures and impacts on the seafloor as well as addresses spatial fisheries measures and coastal restoration, work package 3 has developed and tested a methodology for assessing the management effectiveness of Marine Protected Areas (MPAs), work package 4 has reviewed available data, evaluated nutrient inputs from point sources, and reviewed comparability issues between the HELCOM Baltic Sea Action Plan nutrient input targets and those applied under relevant other policies, and work package 5 has reviewed the application of exceptions under the Marine Strategy Framework Directive (MSFD) by HELCOM Contracting Parties that are also EU Member States further reviewing possible scientific basis and best practices behind the use of these in the future.

A brief summary of the work carried out and major findings is provided in this summary report (under section 'Tasks executed and results achieved under the ACTION project') and greater details are available through the 25 project reports and 6 workshop outcomes developed during the process. The deliverables and reports are listed in tables within this report (under section 'Products and deliverables resulting from each work package or task, and status of completion') and the full reports are also provided. A brief summary of the impact of the work is also provided in this report (under section 'Impact of results and relevance for Contracting Parties and authorities') where items of relevance, such as the contribution to national, international and regional porcesses (e.g. the updat eof the BSAP) is discussed.

Tasks executed and results achieved under the ACTION project

The achievements of the ACTION project across the whole project period are summarised in this section. Summaries are provided per work package (WP), including information on interaction with relevant HELCOM or external groups. Information related to project deliverables and the reports that address the identified deliverables is covered in tables in the subsequent section.

WP1 By-catch

Work package 1 applied various methodologies, each adapted to the availability or specificities of the underlying data, to develop bycatch risk maps for selected species. In addition, the cost of implementation measures (pingers) and the potential effectiveness of these measures is reviewed based on approaches trialed in Sweden. A single report covers all the relevant deliverables and includes an extensive compilation of relevant data and sources.

Presentation of this work package (as either documents or oral presentations) has taken place at the following HELCOM Meetings: SOM Platform 1-2019 and 2-2019, GEAR 20-2019, State and Conservation 10-2019 and 11-2019, FISH 10-2019, and EG MAMA 13-2019. The partners involved in this work package were also active participants, including leading sub-sections, in the Joint OSPAR-HELCOM Incidental by-catch workshop. The final report will be shared with the next meeting of HELCOM EG MAMA, with relevant HELCOM Working Groups and relevant OSPAR groups during 2021.

The following key findings are reported in the work package 1 report 'Bycatch in Baltic Sea commercial fisheries: High-risk areas and evaluation of measures to reduce bycatch':

- Significant levels of bycatch estimated for mammals and birds in all assessed areas
- Different methodologies applied to accommodate data specificities when producing risk maps
- Larger bycatch estimates than previous studies likely due to inclusion of fishing effort of smaller vessels (smaller vessels being a large component of the Baltic fleets)
- Total bycatch mortality estimates likely underestimated in certain regions due to missing effort from other countries active in those regions
- First costing of large scale pinger application in the Baltic Sea

- Need for further data and reporting improvements for improved bycatch assessment (actual and risk maps)

WP 1.1 Identification of high-risk areas

Bycatch is a significant anthropogenic pressure on marine mammals (and birds) where impacts, for example from gillnet fisheries, has been well documented. However, due to limited monitoring and limited data availability for certain critical parameters (including some key parameters or activities exerting the pressure) the possibility to carry out a status assessment related to bycatch has so far been limited. In light of such limitations, the need to apply alternative assessment approaches is critical to support management decision making and thus WP1.1 has focused efforts on developing risk mapping approaches that are adaptable the underlying data.

Since data on bycatch are often limited (e.g., actual rates) and the alternative data needed, for example on fishing effort and species distribution, exists in different formats and scales (as well as differences and differing availabilities between countries), a significant amount of data harmonization was required. However, subsequently, all methodologies applied intercepted the available fisheries effort data with knowledge on the distribution of species, focusing on those species (or groups) commonly accidentally caught in fishing gear. The one exception to this was the application of electronic monitoring data (EM, application of video footage from a reference fleet) where work was carried out to analyze bycatch rates data based on video images from a reference fleet. Overall, risk mapping was carried out based on modeling, logbook data and EM analysis, the latter approach further developing advanced methodologies and potentially providing an opportunity in the future to help ground-truth other risk mapping assessment approaches.

Baltic Sea species commonly reported in bycatch data were focused on in the studies carried out and the following species (or groups of species) were addressed: harbour porpoise, seals, seaducks, and the great cormorant. Where available, data from ICES squares 20-28 (corresponding to HELCOM assessment areas: Kattegat, Belt Seas, Sound, Kiel Bay, Bay of Mecklenburg, Arkona Basin, Bornholm Basin, Eastern Gotland Basin and Western Gotland Basin)) were utilized in the studies.

The example provided below, in Swedish waters (Figure 1), provides an example of how risk mapping offers the opportunity to highlight zones of expected high bycatch risk, by combining the relevant information on the fishing activities taking place and the species distribution. In addition, other relevant aspects such as seasonality can be addressed, as well as factors such as the potential impact of a measure/action. Such approaches are thus valuable in supporting planning and management actions to minimize bycatch.

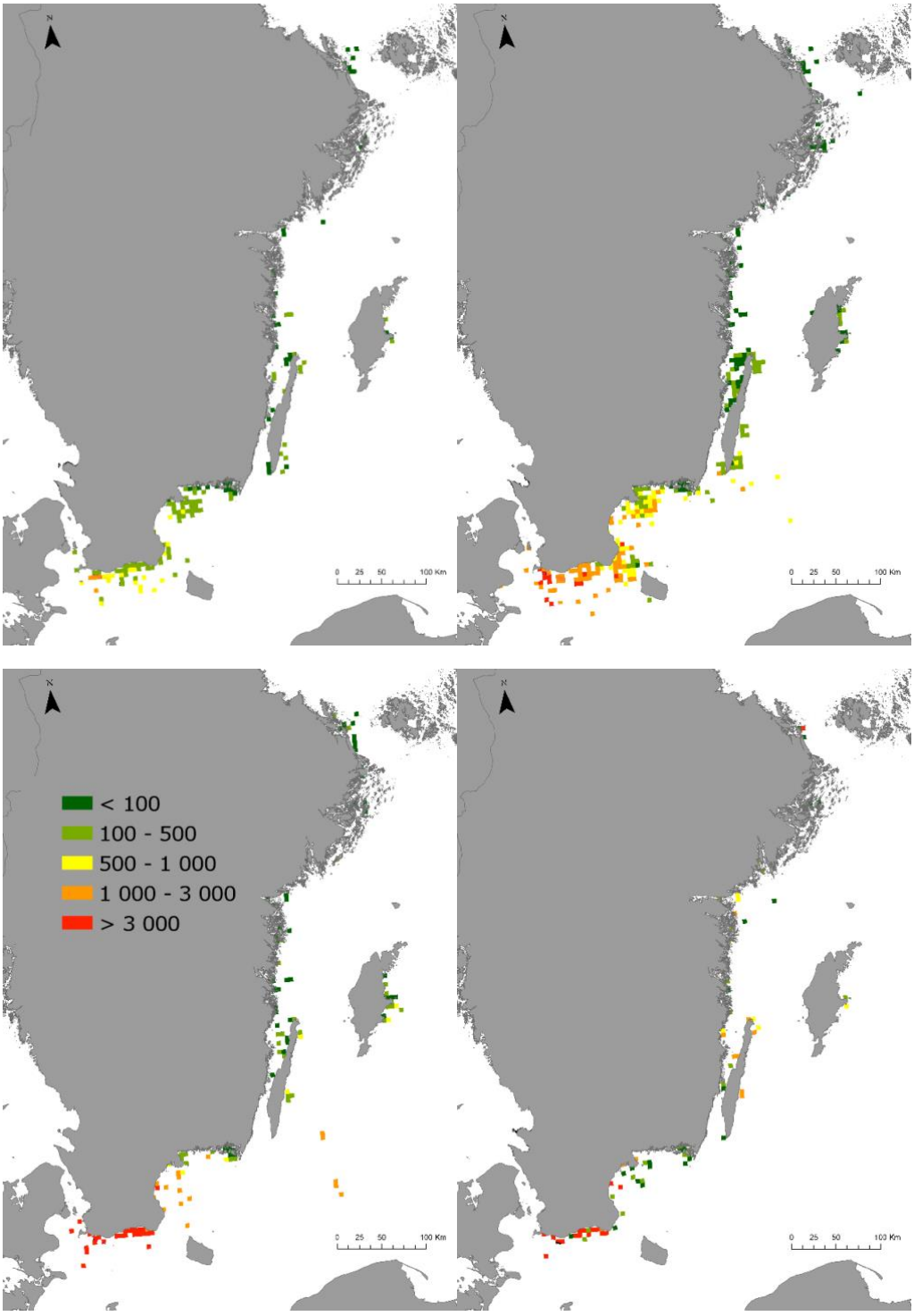

Figure 1: Relative bycatch risk for harbour porpoise, estimated as the probability of harbour porpoise detection during May 2011-April 2013 (data from Carlén et al. (2018)) multiplied by gillnet fishing effort reported to the Swedish Agency for Marine and Water Management for 2019. Top left: Feb-Apr 2019; top right: May-July 2019; lower left: Aug-Oct 2019 (gillnet effort data after implementation of cod fishing ban); lower right: Jan 2019 (gillnet effort data before the cod fishing ban) and Nov-Dec 2019 (gillnet effort data after the cod fishing ban).

WP 1.2 Evaluation of measures to reduce by-catch of harbour porpoises

The application of 'pingers' to reduce bycatch has been documented to be successful and studies have also explored the most effective spacing and application of these tools. This mitigation method can be particularly effective in reducing the bycatch of harbour porpoise (e.g., in gillnet fisheries), a species already under significant pressure in the Baltic Sea region. In this task, a costing estimate was carried out to evaluate the cost of implementing pingers in relevant fisheries for the Swedish logbook data covering ICES squares 21, 22, 23 and 24 (corresponding to HELCOM assessment areas: Kattegat, Belt Seas, and Sound). The cost of such an application is summarized on Table 1, below. Follow up and enforcement of such a measure was however not included in the below scenario and if pingers were to be implemented and regulated in fisheries, additional costs for enforcement, administration, and legal process to address violations of the measure would likely be relevant.

Table 1: Example from Sweden ICES subdivisions 21, 22, 23, 24. Costs are in Euro and cover a five-year period assuming that pingers are functional over this time period.

Number of active boats	**97**
Mean meter of net used	5,580 – 9,189
Number of pingers per fishermen	28 - 46
Costs for pingers (every 5 years)	135,800 – 223,100
Additional costs (bat detector)	7,275
Costs for data collection/education/controls (Yearly cost of €300 000)	150,000
Cost per fisherman	3,021 – 3,921
Total cost for implementing pingers voluntary (Euro)	**293,075 – 380,375**

WP2 Impacts on the seabed

Work package 2 consisted of three separate sections that summarized the current knowledge on the topic from the region, produced an evaluation and description of coastal restoration measures for the region, and developed a methodology and testing of potential spatial fisheries management measures. Three separate reports cover the deliverables in the work package and two successful workshops were also held, the outcomes of which are available through the links in the table below.

The report (and project) has been presented at various HELCOM meetings (and input from the Contracting Parties is being incorporated into the final version). The work has been presented at the following meetings: HELCOM ACTION WS2.1-2019, HELCOM ACTION WS2.2-2020, SOM Platform 1-2019 and 2-2019, FISH 10-2019, PRESSURE 11-2019, State and Conservation 11-2019 and 12-2020, and EN BENTHIC 3-2019. The final reports will also be shared with the next meeting of HELCOM EN

BENTHIC, with relevant HELCOM Working Groups and relevant OSPAR groups during 2021.

The following key findings are reported in the work package 2 reports; 'Impacts on seabed: 'Approaches for assessment as step towards successful measures', 'Reducing fisheries impacts on the seafloor: a bio-economic evaluation of policy strategies for improving sustainability in the Baltic Sea', and 'Restoration measures for coastal habitats in the Baltic Sea: cost-efficiency and areas of highest significance and need'.

- Most extensive pressures, having highest potential impact, include physical disturbance to seabed, eutrophication and hazardous substances.
- Critical to better understand the activities and pressures plus their corresponding sensitivities and thus impact to further develop stronger assessments. Understanding will also help develop appropriate mitigation approaches.
- Spatial fisheries management, based on the current modelling approaches and available information appear to indicate minimal improvements in status (compared to comparative studies in the Kattegat, North Sea side).
- A viable model for the implementation (and further development) of spatial fisheries management is available.
- A large number of coastal restoration measures are available and viable in the Baltic Sea, though effective placement is important, and impacts may be on local scales, at least initially.

WP 2.1 Identification of major pressures in Baltic Sea sub-basins

The status of seabed habitats is a pertinent topic that was identified in HELCOM (and within the EU) as a priority area requiring further development to support assessment, and thus the subsequent implementation of suitable measures. A significant amount of work has taken place on the topic in the Baltic Sea region, such as in previous HELCOM projects co-financed by the EU (e.g. BalticBOOST, TAPAS, SPICE), as well as other recent relevant work such as the ICES Guidance developed via WKBEDPRES1, WKBEDLOSS, WKBEDPRES2 and the establishment of the EU Technical Group on Seabed habitats (TG Seabed). The report produced under this task summarizes the previous work to provide an overview of current knowledge on the topic, as well as highlighting gaps in knowledge on the topic of benthic habitats and seafloor integrity. The report focusses on key pressures known to be relevant in the region and explores the sensitivity of the seafloor habitats to those pressures as well as the significance of them. The summarised information will support future work, in particular the development and application of assessments that can subsequently inform the implementation of measures.

WP 2.2 Identification of effective measures to reduce impacts on the seafloor

Two major tasks were carried out under this section of the project. Both tasks addressed measures to reduce pressures on the seafloor but from significantly different angles: restoration or degraded habitats or coastal areas, and the redistribution of fisheries activities to minimise impact on the seafloor.

Coastal restoration measures

The report provides and introduction to the logic or restoration and identifies key aspects that need to be considered when planning the appropriate restoration measures. These key aspects aim to ensure that restoration measures are well planned, suitable for the specific region (sub-region), and in doing so should ensure the greatest possibility for a successful outcome. For example, key issues might include ensuring that activities resulting in a pressure that degrades the environment are understood and managed/eliminated or that appropriate follow up of the restoration measure implemented is carried out (e.g. to monitor and evaluate success). The report also addresses an expert based evaluation of feasibility/effectiveness of the measures proposed.

To support the process of selecting appropriate restoration measures 17 relevant approaches are reviewed in detail, as listed below. For each of these the following factors are addressed: Drivers/activities causing pressure, pressures, resulting state changes, the practical restoration measure, examples of where such measures have been applied, the expected outcomes of such measures, evidence and references to support/evaluate the effectiveness of the measure, ecosystem service and human benefits (including target groups in society), any time lags expected between restoration and change in status, and the costs of implementation. The following restoration approaches are reviewed in detail:

- Restoration of eelgrass, *Zostera marina*
- Restoration of soft bottom macrophytes (other than eelgrass)
- Restoration of brown macroalgae, mainly *Fucus vesiculosus*
- Restoration of blue mussel reefs
- Restoration of stony reefs in areas where these have previously been lost
- Restoration of soft bottoms naturally free of vegetation
- Restoration of coastal wetlands and fladas/lagoons
- Strengthening piscivorous fish to rehabilitate coastal ecosystem function
- Reducing nutrient loading by farming and harvesting blue mussels
- Rehabilitation of hypoxic areas by oxygen pumping
- Reducing internal phosphorus loads by metal binding
- Investigative and trial biomanipulation by removing cyprinids and sticklebacks as a method for rehabilitating coastal ecosystems

- Rehabilitation of anoxic, nutrient rich or polluted sediments by removal or coverage
- Establishment of artificial reefs
- Protection of habitats
- Follow-up and knowledge sharing

The report also provides some key conclusions such as: coastal restoration measures are often local in scale, but may have broader impacts (e.g. production of predatory fish), active restoration may work better in sheltered areas, facilitation of passive recovery may be a better option in open areas, protection to allow passive recovery may be more effective and cost effective in cases, several restoration measures closely situated may increase benefits, geographical specificities need to be considered, green infrastructure and connectivity should be a key consideration when restoring habitat, and generally preventing damage is more effective and cost-effective than restoration.

Spatial fisheries management

Spatial regulation of fisheries effort can be achieved via measures such as bans or closures. The current approach tested in this task explored the impact of displacing fisheries effort and reducing the number of trips. The approach employed in the model developed (DISPLACE) examined the possibility to displace fishing effort (i.e. maintaining the same overall effort) from peripheral fishing areas and thus concentrate the effort in areas already more heavily visited. The model assessed the potential benefit that can be achieved, in terms of reducing impacts on the status of the seafloor and habitats, by this displacement of fisheries pressure and also applied an economic assessment of the applied scenarios (built for example on the economic impact of longer journey time to trawl sites).

The model developed and the software for this is freely available for download (https://displace-project.org/blog/download/) and the dataset related to this project is also available (https://github.com/frabas/DISPLACE_input_BalticSea).

A number of scenarios were tested in the ACTION project, including: spatially restricted areas on the periphery of fishing grounds, applied per Exclusive Economic Zone (EEZ) as spatially restricted areas on the periphery of fishing grounds, applied per type of habitat (EUNIS EMODNet habitat Level 6) as spatially restricted areas in the core of fishing grounds, fewer trips, restriction on nets, and restriction on nets and restriction on bottom-contacting gear. The latter two scenarios were applied in particular to carry out an exploratory assessment in cooperation with work package 1 and assess the impact related to bycatch. An example of the spatial restriction of areas by the displacement of fisheries effort from peripheral areas (red) to be concentrated in spatially smaller allowed (open) areas (green) is given below (Figure 2).

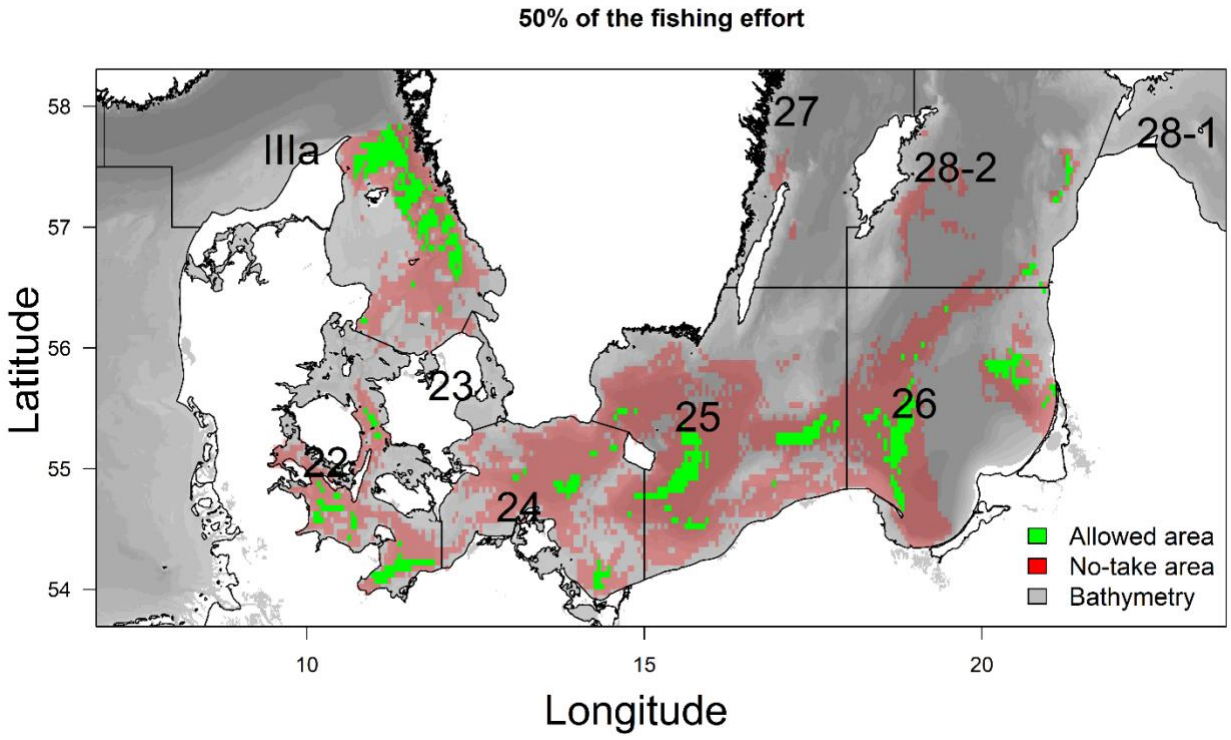

Figure 2. Corresponding surface area closed for bottom-contact gears when historical fishing spatial effort allocation is being cut starting from the peripheral cells towards the core cells of fishing grounds. The relationship is curved because the fishing tends to be patchily distributedly distributed by concentrating on some specific grounds, also showing that low effort occurred over a very large marine surface area (1% of the effort explored ca. 20000 km^2 of marine space). The allowed areas (in green) and no-take areas (in red) for bottom-contacting gears corresponding to a cut of 30% or 50% in fishing effort starting from the peripheral fishing ground cells. In this illustration, the cut has been applied per Exclusive Economic Zone (EEZ) separately. Grey levels give the bathymetry extracted from gebco.net. The text labels correspond to the International Council for the Exploration of the Seas (ICES) for Baltic subdivision area naming (www.ices.dk).

The tested scenarios indicate that restricting fishing does not always translate into a direct reduction on impact on benthic habitats and that while displacement in fishing effort can support improvement in benthic habitat status (or prevention of degradation) it is not always comparable across all regions and certain specificities may drive the outcome. For example, the conditions, species composition and pressures occurring in the Kattegat respond positively (i.e. show improved benthic status) as an outcome of the model simulations, whereas such improvements in the central Baltic Sea region are not seen. Furthermore, the minimal improvements detected in the central Baltic Sea assessment were also generally tied with marked losses in the economic analyses carried out. This effect is at least in part attributed to the fact that that the largest improvement in the model is detected in long-lived benthic species, many of which are not currently detected in the central Baltic Sea assessment.

WP3 Marine protected areas (MPAs)

Work package 3 developed a methodology to assess the management effectiveness of the Baltic Sea Marine Protected Area (MPA) network and applied this based on a questionnaire directed to HELCOM Contracting Parties and targeting 200 MPAs. A single report covers all the relevant deliverables and a regional workshop on the topic was also successfully executed, the links to which are provided in the table below.

The work has been presented and discussed at the following meetings: SOM Platform 1-2019 and 2-2019, State and Conservation 10-2019 and 11-2019, 12-2020, the expert workshop "Assessment of MPA management effectiveness" (19 – 21.11.2019, Vilm, Germany) and two-day dedicated workshop "MPA network effectiveness" As part of the process a questionnaire was distributed to all HELCOM Contracting Parties to cover the 200 selected MPAs, via the national State and Conservation Contacts. The final report will be shared with relevant HELCOM Working Groups and relevant OSPAR groups during 2021.

The following key findings are reported in the work package 3 report 'Methodology, test case and recommendations for assessing the management effectiveness of the Baltic Sea Marine Protected Area (MPA) network':

- Three quarters of human activities are relevant to more than half of the MPAs assessed.
- Most of the assessed human activities were addressed by other management instruments, not the specific MPA management plans.
- Management of the activities is generally high in a large percentage of the MPAs, however management of fishery activities differ substantially among habitats and part of human activities (e.g. shipping, fishery by bottom contacting gears) are managed to a different degree in different countries.
- Higher number of unmanaged or partly managed human activities is observed in MPAs with terrestrial component.
- Fishery with towed bottom contacting gear (in specific sub-region) have specific management plans that differ from general approach.
- Human activities based on infrastructure are better managed compared to more spatially diffuse human impacts, even if the two could be considered directly associated (e.g. transport infrastructure and shipping).
- The applied approach provides important insights into the possibility to assess management effectiveness of the Baltic Sea MPA network.
- Improvements to the approach to hone the process and improve the spatial coverage would facilitate even stronger findings and unpick more subtle trends or results.

A methodology to assess the management effectiveness of the Baltic Sea MPA network was developed following the approach developed by the IUCN-WCPA (International Union for Conservation of Nature-World Commission on Protected Areas). A schematic of the methodology is provided below in Figure 3.

Figure 3. Schematic visualisation of the concept of methodology in this study in a context of management effectiveness assessment framework described by Hockings et al. (2006). The smaller peripheral circles outline the four main questions identified as the basis of this MPA management effectiveness assessment. The overall approach is based on the approach developed by the IUCN-WCPA (International Union for Conservation of Nature -World Commission on Protected Areas)

To apply the methodology, a series of test cases were developed and these focussed on a selection of conservation features (species or habitats) and a core set of relevant MPAs to facilitate the analysis. The priority selection criteria included the need for them to be NATURA 2000 sites, which are also HELCOM sites. However, other factors such as distribution, including latitudinal/longitudinal gradients factors and amongst all HELCOM Contracting Parties were also considered. In total 200 MPAs were selected. The selection of conservation features included all Habitat Directive Annex I marine habitat types: Sandbanks (1110), Estuaries (1130), Mudflats and sandflats

(1140), Coastal lagoons (1150), Large shallow inlets and bays (1160), Reefs (1170), Submarine structures made by leaking gases (1180). In addition, species listed under the categories “Endangered” or “Critically endangered” in the HELCOM Red List assessment (HELCOM, 2013) or included in the Annexes of the Bird Directive or Habitat Directive were included.

The test case results are based on the responses related to 68 individual MPAs and cover 4 countries. Of these, 65 MPAs were assessed in a context of habitat types and 64 MPAs were analysed considering pre-defined species. Some habitat types (Sandbanks, Reefs, Coastal lagoons and Large shallow inlets and bays) were covered by the majority (38-42) of analysed MPAs and 20% of analysed MPAs represented only one habitat type only, while more than half (53%) covered from 2 to 4 habitat types and quarter of MPAs had 5 habitat types within their territory.

The test case results indicate that although a large number of human activities (thus pressures) are relevant for an extensive number of the assessed MPAs then these activities are generally well managed across the studied MPAs. However, it was found that the majority of activities were managed by other instruments and not directly addressed by the MPA management plans themselves (possibly due to the activities being widespread and also addressed by broader regional or international agreements). It was also noted that MPAs that have a larger terrestrial component also generally have a larger diversity of management categories yet, though a smaller number of activities are relevant in purely marine MPAs the activities are often more highly managed. Overall, the applied approach provides important insights into the possibility to assess management effectiveness of the Baltic Sea MPA network, though improvements in the future can be made to increase spatial coverage as this will help clarify sub-regional specificities and further unpick key trends. To support this, a number of recommendations, including submissions directly made to the Baltic Sea Action Plan update (BSAP UP) process, are also provided to facilitate further developments and improved implementation in the future.

WP4 Input of nutrients

Work package 4 carried out work on test cases to follow up on existing measures and understand the sufficiency to meet obligations under the Baltic Sea Action Plan (BSAP), examined inputs of nutrients from point sources and the potential to reduce them, reviewed the compatibility of BSAP and other relevant policy initiatives (e.g. the Water Framework Directive, WFD), and provided information to assess the potential nutrient load reductions from existing measures. The latter component is not reflected in an independent report (see table below) as information, data and discussion from this task were provided directly to work package 6 and the information is summarized in the Sufficiency of Measures Topic Report on the input of nutrients. In addition, two workshops (BSAP and MSFD measures to abate

eutrophication and incorporation of River Basin Management Authorities to support reducing potential inputs) were successfully held and these supported further developments within the project itself and also contributed input to the Baltic Sea Action Plan update process. The documentation and outcomes of these workshops are available via links in the tables below.

The work has been presented and discussed at the following meetings: SOM Platform 1-2019 and 2-2019, HELCOM RBMA WS1-2019, HELCOM ACTION WS4.2-2020, PRESSURE 11-2019, 12-2020, and 13-2020. The work has also been presented at the 2021 Baltic Sea Days Day Round Table: River Basin Management plans and BSAP targets. Effectiveness and Sufficiency of measures to reduce nutrient loads and achieve BSAP targets. The final report will be shared with relevant HELCOM Working Groups and relevant OSPAR groups during 2021.

The following key findings are reported in the work package 4 reports: 'Approaches and their potential to reduce nutrient loads in the Baltic Sea region', 'Input of nutrients: potential to reduce input from point sources', and 'Compatibility of targets under different marine policies - Sufficiency of the EU WFD targets for individual rivers basins to achieve the BSAP goals':

- Inputs of nutrients from municipal waste water treatment plants (WWTPs) have decreased in recent times, however there remains high potential for further reductions.
- As much as 10% of the BSAP reduction targets could be achieved if all WWTPs followed HELCOM recommendation 28E/5 fully.
- Data was reviewed, updated and improved in the HELCOM Pollution Load Compilation (PLC) as a result of the analysis carried out.
- Data harmonization needs and limitations were also identified, as well as recommendations on possible improvements for future iterations of PLC (e.g. inclusion of supporting parameters such as measures applied in an area).
- Discrepancies between Water Framework Directive (WFD) targets in coastal areas and Baltic Sea Action Plan (BSAP) targets were identified in certain areas, i.e. where for example WFD targets are not sufficient to achieve the BSAP aims (e.g. in the Baltic Proper or Gulf of Finland).
- Where discrepancies occurred they were generally larger for phosphorus.
- Recommendations were made on how to improve and harmonise these policy initiatives.

WP 4.1 Following up existing measures

The data in the HELCOM Pollution Load Compilation (PLC) database were reviewed and updated where possible to enable the best assessment to be carried out. This process also identified clear gaps or issues with the available data (influencing the

uncertainly of confidence in the results) and highlighted possible areas for future improvement in data reporting and harmonization. While the specific application of test cases to identify existing measures having the strongest effects (e.g. at the level of each area/river) was not possible to carry out in full, some general trends were possible to extract from the data as well as a series of recommendations on how to build towards being able to achieve such a level of assessment in the future. For example, it is possible to detect clear reductions in loads between 2000 and 2018 (example for total phosphorus, circa 60% reduction, provided in Figure 4), however the share of load is not significantly changed and despite improvements in municipal wastewater treatment there appears clear potential for further reductions. In the future, supported, for example, by a more complete data set, harmonization across the models used to derive the PLC data (e.g. addressing standardizes components of the nutrient cycle chain), and a collation of higher resolution river basin specific measures would facilitate a significantly improved analysis.

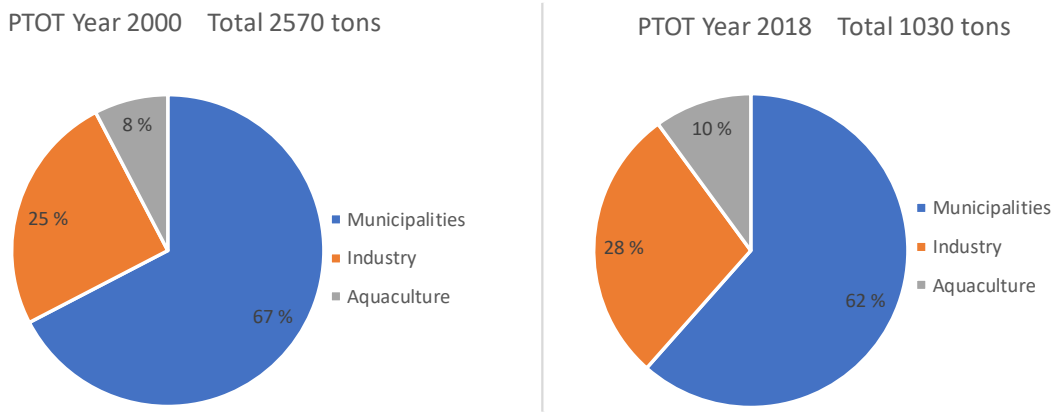

Figure 4. Direct point source PTOT loads by sources in 2000 (left) and 2018 (right).

The potential to reduce inputs from point sources is further addressed in the report 'Input of nutrients: potential to reduce input from point sources' (which after review by the HELCOM PRESSURE Working Group this report has also been published as a HELCOM report). This report indicates that despite clear improvements and reductions of inputs from municipal waste water treatment plants (MWWTPs) there remains strong potential for further reductions to be achieved. For example, if all MWWTPs achieved the targets set out via the HELCOM recommendation 28E/5 it could be possible for a circa 10% reduction towards the BSAP reduction targets.

WP 4.2 Compatibility of targets under different marine policies

The main aim was to compare the EU Water Framework Directive (WFD, 2000/60/EC) targets and the HELCOM Baltic Sea Action Plan (HELCOM BSAP, https://helcom.fi/baltic-sea-action-plan/, and as revised under the 2013 HELOCM Ministerial Meeting) nutrient load reduction targets. For that, the following analyses were conducted:

1. The nutrient loads per country and sub-basin which reflect the loads if rivers would be in good ecological status according to the WFD (GES loads) were estimated and the results were compared with the maximum allowable inputs (MAI and NIC);
2. The nutrient concentrations in rivers/freshwater discharge to achieve HELCOM reduction targets were calculated and the results were compared with the nutrient concentrations corresponding to the boundary of good/moderate classes.

Data used for the analysis was obtained from the HELCOM countries and PLC database (available for HELCOM PRESSURE 12-2020). WFD related classification schemes in rivers were received from the countries, data on freshwater discharge and nutrient loads for the period 1995-2017 from the PLC database. All initial data, including runoff estimates from the unmonitored coastal areas, were reported to the PLC database by the HELCOM countries.

The results indicate that in general, the sum of riverine GES loads of nitrogen to the Baltic Sea sub-basins from the surrounding countries are close or lower than required by the Baltic Sea Action Plan expressed as MAI and NIC. The Baltic Sea sub-basins, where the total TN GES load is higher than the MAI and NIC values, are the Baltic Proper, the Gulf of Riga, and the Bothnian Bay. The comparison was not possible for the Gulf of Finland. The largest discrepancy between the TN GES load and targets is in the Baltic Proper. The riverine GES loads of phosphorus to the Baltic Sea sub-basins from the surrounding countries are higher than the BSAP targets except for the Bothnian Sea, the Danish Straits and the Kattegat. Like the nitrogen load, the largest discrepancy between the TP GES load and the BSAP targets is in the Baltic Proper. At the same time, most of the rivers entering the Baltic Sea have good ecological status with average nutrient concentrations less than the set good/moderate boundary for total nutrients. Thus, the real loads are lower than the estimated GES loads.

The comparison of estimated maximum allowable nutrient concentrations in the freshwater discharge from the HELCOM countries to the Baltic Sea sub-basins with the defined boundaries between the good and moderate ecological status in rivers revealed a similar pattern. Maximum allowable nutrient concentrations are lower than the G/M boundary concentrations for both nitrogen and phosphorus in the Gulf of Riga, the Baltic Proper and the Bay of Bothnia. The targets disagree for phosphorus also in the Gulf of Finland. Furthermore, the maximum allowable concentrations of

TP are more than twice as low as the G/M boundary concentrations for all evaluated countries in the Baltic Proper and the Gulf of Finland. The analysis also shows that the maximum allowable concentrations of nutrients to achieve the BSAP targets vary considerably between the Baltic sub-basins and between the countries contributing to the nutrient load into the same sub-basin.

The main conclusions and recommendations are:

- WFD based good status in rivers is often not enough to achieve BSAP targets (especially for the phosphorus load) – the countries see the level corresponding to good status differently from the HELCOM load reduction targets.
- Take steps towards harmonized WFD classification schemes for nutrient concentrations in rivers and/or methodology to define nutrient input ceilings for coastal water bodies.
- Promote co-operation between the countries to analyse nutrient concentrations for reference conditions in different types of rivers.
- Conduct further analyses to estimate the proportion of anthropogenic and natural loads in the riverine input of nutrients.
- Consider nutrient concentrations for reference conditions and the proportion of anthropogenic and natural background loads when re-calculating nutrient input ceilings per country and Baltic Sea sub-basin.

All these steps would harmonize the targets set based on different policies and follow the HELCOM polluter-pays principle better. At the same time, the present analysis results do not question the overall HELCOM nutrient reduction targets. In order to achieve good environmental status of the Baltic Sea, joint efforts are needed to reduce the nutrient loads as agreed in BSAP.

WP 4.3 Potential nutrient load reductions through existing measures

An independent deliverable/report was not prepared for this task (as agreed with the project officer) due to the complete overlap in terms of substance and output with work carried out in cooperation between members of work package 4 and work package 6 (i.e. Sufficiency of existing measures). Discussion, data (e.g. source apportionment evaluations and expert-based gap filling questionnaire related to agriculture) and guidance were provided by work package 4 members to support the assessment of the sufficiency of existing measures to reduce the inputs of nutrients to the Baltic Sea and the methodologies employed, underlying data utilised and results of the analyses are available via the work package 6 report ‘Sufficiency of existing measures for the input of nutrients into the Baltic Sea’.

WP 4.4 Sharing experiences of Cycle 1 MSFD Programmes of Measures

This task was addressed as a workshop (HELCOM ACTION WS4.2-2020) and the outcome is available at the meeting site. The outcomes of this workshop also clearly identify a list of eight issues and actions considered relevant for HELCOM and the Contracting Parties for their future work.

WP5 Conditions that influence GES

Work package 5 collated information related to exceptions reported by HELCOM Contracting Parties that are also EU Member States for not achieving Good Environmental Status (GES) under the Marine Strategy Framework Directive (MSFD) in the previous reporting cycle. A review was carried out to explore commonalities in the exceptions reported and the commonalities in justifications utilised for reporting those exceptions. In addition, an approach to define 'best practices' in the application of exceptions in the future was drafted to support countries in applying such justifications in the most scientifically justifiable manner possible. To support countries in such processes, a scientific review of selected topics of significance where such justifications may be required was carried out, each detailing reasons and scenarios that may influence the achievement of GES (e.g. natural recovery lags, or changes in climatic and environmental conditions).

The work has been presented and discussed at the following meetings: SOM Platform 1-2019 and 2-2019, State and Conservation 11-2019, GEAR 21-2019 (and significant intersessional work with the associated HELCOM Correspondence Group on the Marine Strategy Framework Directive, CG MSFD), and PRESSURE 11-2019, and 13-2020. The final report will be shared with relevant HELCOM Working Groups and relevant OSPAR groups during 2021.

The following key findings are reported in the work package 5 reports: 'Conditions that influence Good Environmental Status (GES) in the Baltic Sea' and 'Analysis of total nitrogen in the Baltic Sea and implications for time lag in achieving good environmental status (GES)':

- Limited commonality was observed in the reporting of exceptions under the MSFD by HELCOM Contracting Parties that are also EU Member States.
- The highest number of countries indicated the exceptions of not achieving GES regarding D5 – eutrophication and D8 – contaminants. Also, the GES Descriptors related to species and habitats, as D1 – biodiversity, D2 – non-indigenous species, D3 – commercial fish, D4 – food webs, and D6 – seabed integrity, were reported.

- The internal load of accumulated nutrients from sediments was indicated as the main reason for not achieving GES under D5 – eutrophication. For both eutrophication and contaminants, retention of substances in the drainage area, accumulation in sediments and limited water exchange were mentioned.
- Time lags for achieving GES after the measures were implemented were commonly not estimated and reported.

WP 5 Analysis of reasons for not achieving GES

Scientific literature and recent project outcomes, including scenario simulations, were analyzed to identify gaps or delays in achieving GES due to natural conditions. The analysis focused on selected topics under GES Descriptors: D1 – Biodiversity, D5 – Eutrophication, and D8 – Contaminants. The activity also involved an evaluation of the impacts of projected climate change on the effectiveness of measures taken to improve the Baltic Sea.

For the analysis of time lags in achieving GES under D5 – Eutrophication, a nitrogen budget for the Baltic Sea was established. It shows that currently, the Baltic Sea is near balance, with a marginal decline of around 8 kt nitrogen per year from 2005 to 2018. The estimates suggest that it is not possible to reach GES by 2021 and realistically not before 2050. There are three main causes for such a long time lag: the long residence time of the Baltic Sea, the large pool of organic matter that has been built up over the decades and, most importantly, that the present nitrogen loadings are approximately 3.4 times higher than the natural background. Thus, the reason why GES is not possible in the near future is that it is unrealistic to bring down the nitrogen inputs to near the background level. The time lag will ultimately depend on how much the nitrogen loadings are reduced, but it should be measured in decades.

Under the contaminants Metals – mercury (Hg), lead (Pb), and cadmium (Cd), TBT (tributyl-tin), PFOS (PFASs), Pharmaceuticals. The review of scientific literature identified the causes of long-lasting or secondary inputs and estimated time lags of achieving GES presented in the following table (Table 2).

Table 2. Summary of natural conditions influencing GES and estimated time lag for hazardous substances.

Substances	**Natural conditions influencing achieving of GES**	**Estimated time lag**
Metals (Hg, Pb, Cd)	Soils of the catchment areas and seabed sediments are reservoirs of Hg, Cd and Pb accumulated there over a long period. Secondary inputs from the catchment could increase due to changes in land use, replacement of the natural surfaces due to urbanization, increasing intensity and duration of precipitation, storm and flooding events. Metals may be released from the sediments by physical disturbance, molecular diffusion, gas ebullition, bioturbation/bioirrigation. The flux is depending on changing conditions, such as changes in pH, dissolved oxygen or temperature.	The time lag of achieving GES after the measures are implemented is about 30 years – water residence time of the Baltic Sea is 20–30 years and the average residence time of mercury in oceanic waters is 20–30 years.
TBT	TBT has a high degradation rate in the water column, but it is low in sediments. The persistence of butyltin compounds in sediments can be enhanced by high salinity, low temperature, high water column depth, high organic matter content, and a high percentage of the fine grain-size fraction. The half-life of TBT in the deep-sea sediment has been estimated at 8±5 years for the surface oxic layer and 87±17 years for the deep anoxic layer. Periodical dredging of the port channels and shipping routes and disposal of contaminated sediments are the reasons for butyltin remobilization from sediment to the water column.	Estimates are in the range of 8-80 years.
Pharmaceuticals	Direct photolysis is the predominant removal process for diclofenac, exhibiting a half-life of 8 days. The removal rate of ibuprofen and carbamazepine in freshwater estimated at 32 days and 63 days, respectively. Due to their continuous discharge into the environment through different entry paths, pharmaceuticals are regarded as a class of pseudo-persistent contaminants.	No evidence of long time lags.
PFOS (PFASs)	Highly persistent, especially long-chain PFASs (e.g. PFOS and PFOA). Most PFAAs are not buried in sediments to a substantial degree. Runoff from background soil and atmospheric deposition of PFAAs associated with sea spray are the main sources of secondary pollution. No clear temporal trends observed for PFOS since the late 1990s; it means environmental PFOS concentrations have not yet declined as a response to reduced emissions.	Not estimated, but highly persistent.

The analysis under the Biodiversity topic focused on certain species (e.g., ringed seals and grey seals and their abundance and distributional range) and benthic habitats. Both human impacts and natural ecosystem processes that may influence the achieving of GES were indicated. Examples of the analysis results are shown in the table below (Table 3).

Table 3. Summary of natural conditions influencing GES and estimated time lag for species/habitat.

Species/habitat	Main reasons of non-GES status	Conditions influencing achieving of GES
Ringed seals	The main reasons for the decline of the ringed seal abundances in the 20th century were hunting and high concentrations of environmental pollutants. Incidental by-catch is considered as one of the risks. The ringed seals in the Bothnian Bay management unit have reached good status for population size but not for growth rate. The state of distribution of ringed seals is not good since the area of occupancy is currently more restricted compared to pristine conditions >100 years ago.	One of the reasons for the slow population growth rate is mild winters with poor ice conditions. The low growth rate of the ringed seal population in the Bothnian Bay may be the relatively low birth rate caused, at least partly, by the declining nutritional status of adult females. The area of breeding ice is a strong regulating factor for the Baltic ringed seals. The projected mean number of Baltic ringed seals in 2100 is 30730 individuals. Southern sub-populations, especially in the Gulf of Riga, are at high risk (due to ice conditions).
Grey seals	The main reasons for the decline of the grey seal abundances in the 20th century were hunting and high concentrations of environmental pollutants. Also, by-catch is considered as one of the risks. Grey seal reproduction is not in good status, and they failed to achieve the threshold value of nutritional status.	Changes in ice conditions affect the status of Baltic grey seals. Food availability and quality (e.g., herring catch size) are important for their nutritional status. The prey fish quality could have delayed effects on grey seals, and continuous food limitation can influence population size.
Benthic habitats	Demersal trawling, dredging, shipping and nutrient inputs cause the majority of impacts on benthic habitats in the Baltic Sea. Oxygen deficiency, caused by both eutrophication and certain hydrographic conditions, is a widespread threat to coastal and estuarine communities. As a result of trawling, a shift from communities dominated by relatively high biomass species towards dominance by high abundances of small-sized organisms can occur.	Recovery time post trawling depend on species dispersal potential, longevity and habitat-specific requirements. The recovery time for species with a high dispersal potential and less habitat-specific requirements is <3 years, for longer-lived species with low dispersal potential and specific habitat requirements – up to 20 years. The status improvement of deep benthic habitats is linked to the time lag of recovery from eutrophication (30-40 years). Changes in climatic conditions could have a significant impact.

The climate change effects on achieving GES regarding the above-listed Descriptors, substances, and species were analyzed by reviewing the published scientific literature results. The factors analyzed were: changes in meteorological conditions (air temperature, humidity, wind, runoff), seawater temperature and salinity, sea level, ice conditions, and stratification.

WP6 Sufficiency of measures

Work package 6 consisted of two separate components, one focused on the effectiveness and sufficiency of existing measures and the second addressing effectiveness and cost-effectiveness of potential new measures. Both approaches utilize the same underlying methodology developed within the ACTION project to carry out the sufficiency of measures component of the analyses, based on a conceptual framework that informs the analytical tool ('SOM model') and contains sufficient flexibility to apply across a broad range of topics.

The initial scope of the work in the ACTION project work package 6 was greatly expanded at an early stage of the process due to the initiation of the Baltic Sea Action Plan update (BSAP UP) process. During the process it was recognized that the developments towards an assessment of the sufficiency of measures, as taking place under the ACTION project, could better support the BSAP UP process if rather than focusing on the selected topics initially identified in the project application, a broader range of topics could be addressed. On this basis the work in the ACTION project was adapted to cover as many as possible pressure and state topic areas as possible that were relevant to the Baltic Sea region, and the two processes (ACTION and BSAP UP) subsequently worked in close cooperation. This close cooperation can be seen via the integration of the ACTION project work into the BSAP UP process (SOM overview and supporting information), the contribution to the five meetings of the 'ad hoc HELCOM Platform on sufficiency of measures' (SOM Platform), and in the broad selection of deliverables from the project.

The work under this work package has been reviewed and supported by an extensive number of HELCOM Expert and Working Groups, including expert topic teams associated with the SOM Platform. The details of these processes are reflected in the deliverables, in particular the topic specific reports. The main methodological developments, results, and overall review has, however, been carried out under the guidance of the HELCOM SOM Platform (SOM Platform 1-2019, SOM Platform 2-2019, SOM Platform 3-2020 (held cooperatively with ACTION WP6 workshop), SOM Platform 4-2020, SOM Platform 5-2020), HELCOM Working Group for the implementation of the ecosystem approach (GEAR 21-2019, GEAR 22-2020, GEAR 23-2020), the HELCOM Expert Network on economic and social analyses (EN ESA 9-2020, EN ESA 10-2020), the HELCOM Heads of Delegation (HOD 58-2020, HOD 59-2020), and the topic specific SOM workshops set up to support the BSAP UP process:

SOM Biodiversity: Marine Mammals workshop, HELCOM SOM-Birds WS 1-2019, HELCOM Workshop on the analysis of sufficiency of measures for hazardous substances, HELCOM Workshop on the analyses of Sufficiency of Measures (SOM) for Fish, HELCOM BSAP UP workshop on hazardous substances and litter for the consideration of proposed new actions, HELCOM BSAP UP workshop on eutrophication for the consideration of proposed new actions, HELCOM BSAP UP workshop on biodiversity, including extraction of species and spatial measures, for the consideration of proposed new actions, and HELCOM BSAP UP workshop on maritime activities, including underwater noise, non-indigenous species and response actions, for the consideration of proposed new actions.

The project developments have already been presented to the EU POMESA group and within OSPAR. The final reports will also be shared with the next meeting of HELCOM EN ESA, with relevant HELCOM Working Groups and with relevant OSPAR and EU groups during 2021.

The outputs are reported in the work package 6 reports. These include three main reports that summarize the work under this work package, a report that supports the interpretation of the SOM results, and additional 11 topic-specific reports on the sufficiency of existing measures that give greater details and discuss any topic specific modifications made. The three main reports are: 'Methodology for the sufficiency of measures analysis', 'Sufficiency of existing measures to achieve good status in the Baltic Sea', and 'Cost effectiveness of proposed new measures for the Baltic Sea Action Plan 2021'.

The key findings and outputs from WP6 are:

- A conceptual and operational framework for assessing effectiveness and sufficiency of measures to achieve state improvements, flexible enough to accommodate various data availability (from expert-based evaluations through to full quantitative assessment) is described.
- The methodology is constructed around a causal framework, linking measures, activities, pressures and subsequently state; estimating the gap to achievement of good environmental status/state improvements.
- Three pressures, eutrophication, extraction of species (incl. prey depletion) and human induced food web imbalance, are identified as predominant drivers of change for the Baltic Sea ecosystem.
- In general, the results indicate that existing measures are likely not sufficient to reach GES for most of the analysed pressures/state components, which are currently not in good status.
- The results suggest that progress is being made and that existing measures are projected to lead to significant pressure reductions by 2030, if they are fully implemented.
- The proposed new measures were estimated to further reduce the pressures by 2030; the highest reductions were estimated for seabed disturbance.

- It was shown that the probabilities to reach good state (or improve the state) increased for almost all state components.
- Among the proposed new measures, the spatial protection measures were the ones addressing most of the pressures and were also considered effective if they truly regulate human activities within the areas, e.g. fisheries, boating, tourism and construction.

WP 6.1 Regional business-as-usual (BAU) scenarios

The sufficiency of existing measures and the methodology developed to carry out this work are significant advances in the field, in particular due to the range of topics addressed and the scale at which the analyses have been applied. The methodology is described in detail in the respective report (see table below) and uses 2016 (i.e. the final data year for the previous HELCOM holistic assessment period) as its baseline, exploring the change in pressures/environmental status by a future end year (2030) if all existing measures are fully implemented. The scenarios also consider potential changes in the extent of human activities (or the pressures exerted by those activities) across the period and conclude on a likelihood of the implemented measured in achieving Good Environmental Status (GES). A subsequent gap to GES could therefore be indicative of the need for more measures to be implemented to achieve GES, or in certain cases there may be relevant recovery lags that prevent GES being achieved even though sufficient measures are implemented (e.g. as addressed under work package 5). An overview of the concept is provided in Figure 5.

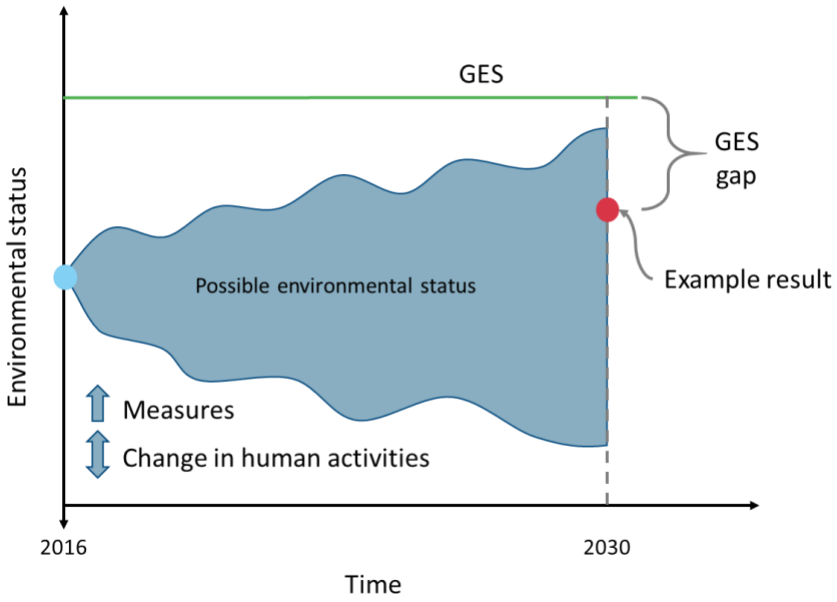

Figure 5. Conceptual illustration of the SOM analysis. The current environmental status, as determined during the Second HELCOM holistic assessment 2011-2016 (light blue circle on left), could develop in a variety of ways by 2030. The example result (red circle on right) indicates that current efforts are likely to be insufficient and a gap to GES would remain by 2030 if only the existing measures are applied.

To achieve the assessment conceptualised in Figure 5 a causal framework is required, to place the individual components in an effect chain. The framework links measures (grouped into related categories) to activities, pressures and environmental state, also addressing expected changes in the extent of human activities by 2030. This outcome represents the business as usual (BAU) evaluation, or the sufficiency of measures to achieve GES with existing measures by 2030 and thus the expected gap to GES (Figure 6).

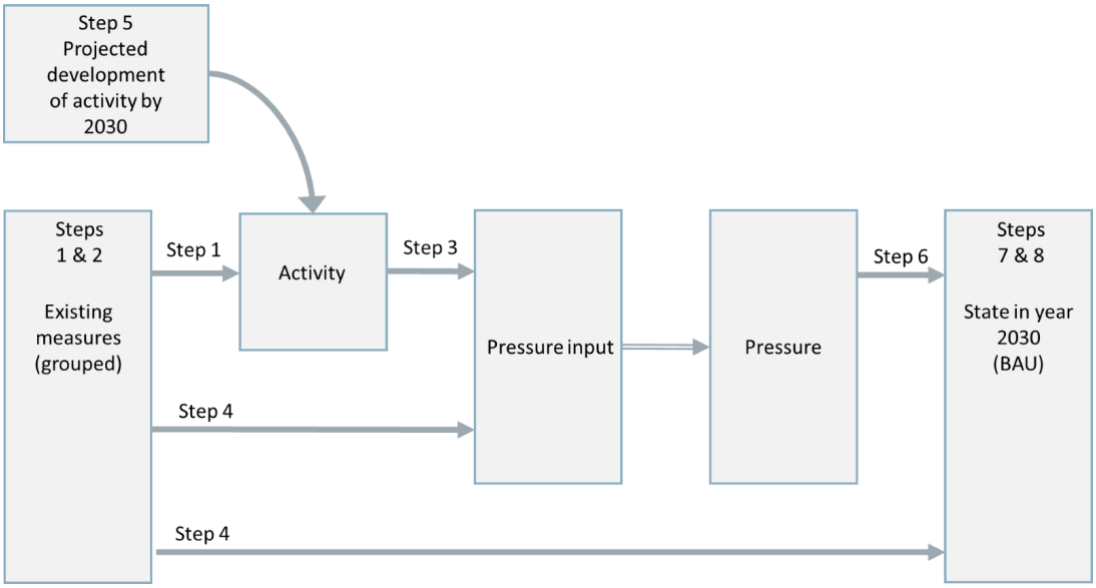

Figure 6. General schematic of the main components of the SOM analysis.

Due to the broad range of topics addressed by the ACTION project the application of the schematic above (Figure 6) requires adaptation to meet the data type and availability of each topic. For example, in certain cases the approach is exclusively carried out as qualitative assessment and based on expert evaluations (methodology and results described in detail within the reports), while for data rich topics such as eutrophication (inputs of nutrients) one or more components of the assessment could be applied in a quantitative manner. Each of the 11 topic-specific reports provide the details behind the applied methodologies, alterations from the generic schematic, the underlying data (be it expert based, model based, or data based), well as an evaluation of the confidence in the assessment carried out. These topic specific intricacies, the methodology and results (plus interpretation of them) are presented in a transparent way to support appropriate utilisation of the results and further development work.

Overall, some general conclusions can be drawn from the assessment of the sufficiency of existing measures. For example, the results indicate that existing

measures are not anticipated to be sufficient to reach GES in the time frame of the analysis (by 2030). This conclusion holds true for the majority of analysed pressures and state components which are currently not in good status. Three key pressures: eutrophication, extraction of species (incl. prey depletion) and human induced food web imbalance, were identified as predominant drivers of change for the Baltic Sea ecosystem. However, despite indications that GES in not likely to be achieved based only on existing measures, the analysis does also indicate that there remains potential for progress to be made towards GES based on the pool of existing measures and that if fully implemented they would result in significant pressure reductions by 2030.

WP 6.2 Potential new measures and their cost-effectiveness

The objective of the WP6, Task 2 was to estimate the cost-effectiveness of the proposed new measures and, hence, support the HELCOM Contracting Parties in the selection and application of relevant measures. Of the 133 new measures proposed to the update of the Baltic Sea Action Plan through the HELCOM process, 83 measures were estimated to have the potential to reduce pressures or improve ecosystem state, and they were included to the SOM analysis of new measures. These proposed new measures were further evaluated to detect overlaps and potentially regroup them.

Costs of the proposed new measures were estimated through four steps: (1) Identification of cost types, (2) cost data collection, (3) cost transfer, and (4) cost estimation of the new measures. The following cost types were included: Capital costs, operation and maintenance costs, increase in daily business/operation costs, indirect costs of implementation, other costs, opportunity costs of foregone revenues, decrease (save) in daily business/operation costs, and other cost saving. The cost data was collected from multiple sources in the Baltic Sea region and the final costs were calculated to the entire region as a range of potential costs per measure.

Effectiveness of each of the proposed new measures was estimated as a reduction of pressure(s) or direct improvement in state(s) from a wide range of literature, project reports, model outcomes, other WPs in HELCOM ACTION project and expert survey data collected under WP6.1. The work utilized the methodology and concepts developed for the assessment of the effectiveness of existing measures (WP6, Task 1) as the backbone of the assessment. The new measures were first compared by their potential to reduce each pressure and, secondly, by their total pressure reductions for each state component. A ratio of the cost and the effectiveness allowed comparison of the proposed new measures. Finally, the effectiveness of the new measures was estimated through the whole SOM model as the probability to reach good state of the ecosystem components and by comparing the model results between the existing measures and both the existing and new measures.

Overall, the regional assessment of cost-effectiveness of new measures provided insights into those measures that may be most cost effective. In addition, it suggested whether the new measures, as a set, are sufficient to reach good environmental status in the region. The overall costs of the proposed new measures were estimated as 2650 million € annually. Uncertainties around this estimate are, however, considerable due to several reasons, not least because of the dependency on the level of implementation by the Contracting Parties.

The analysis of the cost-effectiveness showed that spatial protection measures – be they for strict, general or sectoral protection – were the ones addressing most of the pressures and were also considered effective, given that the management plans allow restrictions on the key human activities. These included not only protected areas but also, e.g., maritime spatial planning and spatial restrictions of boating in sensitive areas. Regulatory measures such as fishery or boating regulations or requirements for best available technology were also estimated as effective and have low costs.

The proposed new measures will make a clear difference to the existing BSAP by reducing several key pressures of the Baltic Sea marine environment and also directly improve states of species and habitats in the area. The analysis estimated that almost all the assessed inputs of pressures would decrease as a result of the new measures.

High uncertainties were associated with the estimations of improving the state of the Baltic Sea. The analysis could not confirm that good state of the Baltic Sea could be reached with the new measures. It was, however, shown that the probabilities to reach good state (or improve the state) increased for almost all state components.

Products and deliverables resulting from each work package or task, and status of completion

WP1 By-catch

WP1 has provided one report: 'Bycatch in Baltic Sea commercial fisheries: High-risk areas and evaluation of measures to reduce bycatch' and all expected deliverables identified in the application are covered in that report.

WP 1.1 Identification of high-risk areas

TASK	Partners	Reports provided and project deliverable addressed	Status
a) Data collection	**DTU** SLU HELCOM	**REPORT: Bycatch in Baltic Sea commercial fisheries: High-risk areas and evaluation of measures to reduce bycatch**	**Completed**
b) High-risk areas for by-catch	**DTU** SLU SWaM	Deliverables addressed: - High-risk maps for by-catch for mammals and birds, including underlying data and methodological description - By-catch estimates for birds and marine mammals primarily in Swedish, ~~German~~ and Danish fisheries	**Completed** It was not possible to include German data.

WP 1.2 Evaluation of measures to reduce by-catch of harbour porpoises

TASK	Partners	Reports provided and project deliverable addressed	Status
a) Evaluation of cost of measures	**DTU** SLU SWaM SYKE HELCOM	**REPORT: Bycatch in Baltic Sea commercial fisheries: High-risk areas and evaluation of measures to reduce bycatch** Deliverables addressed: - A report on the cost and effect of implementing mitigation measures to reduce by-catch of harbour porpoise	**Completed**
b) Evaluation of the effect of measures	**DTU** **SLU** SWaM SYKE HELCOM		**Completed**

WP2 Impacts on the seabed

WP2 has provided three reports and all expected deliverables identified in the application are covered in these reports

- Impacts on seabed: Approaches for assessment as step towards successful measures
- Reducing fisheries impacts on the seafloor: a bio-economic evaluation of policy strategies for improving sustainability in the Baltic Sea
- Restoration measures for coastal habitats in the Baltic Sea: cost-efficiency and areas of highest significance and need

Two regional workshops were also held and the documentation and outcomes of these events are provided via links within the table.

WP 2.1 Identification of major pressures in Baltic Sea sub-basins

TASK	Partners	Reports provided and project deliverable addressed	Status
a) Consolidation of existing results	**SYKE** DTU HELCOM SWaM	**REPORT: Impacts on seabed: Approaches for assessment as step towards successful measures** Deliverables addressed: - Summary report of the activities and pressures causing major impacts on benthic habitats in the Baltic Sea on a sub-basin scale	**Completed**
b) HELCOM ACTION Workshop 2.1	**SYKE** DTU HELCOM SWaM SLU	**HELCOM ACTION Workshop 2.1 - Impacts on the seabed: Activity-Pressure-Measures (HELCOM ACTION WS2.1-2019).** An outcome from the workshop is available here.	**Completed**

WP 2.2 Identification of effective measures to reduce impacts on the seafloor

TASK	Partners	Reports provided and project deliverable addressed	Status
a) Restoration of coastal habitats	**SLU** DTU SYKE	**REPORT: Restoration measures for coastal habitats in the Baltic Sea: cost-efficiency and areas of highest significance and need** Deliverables addressed: - Identification of cost-effective restoration measures and in which coastal areas they are of highest significance/need	**Completed**
b) Spatial fishery management measures	**DTU**	**REPORT: Reducing fisheries impacts on the seafloor: a bio-economic evaluation of policy strategies for improving sustainability in the Baltic Sea** Deliverables addressed: - A modelling platform informed by existing monitoring systems for benchmarking the effectiveness of alternative management measures and spatial plans affecting fisheries - Report on the cost and effect of mitigating or displacing the fishing pressure in the Baltic Sea including distributional effects	**Completed**
c) HELCOM ACTION Workshop 2.2	**SYKE** DTU HELCOM SWaM SLU	**HELCOM ACTION Workshop 2.2 - Existing and tentative new measures and the status of benthic species and habitats (HELCOM ACTION WS2.2-2020).** An outcome from the workshop is available here.	**Completed**

WP3 Marine protected areas (MPAs)

WP3 has provided one report: 'Methodology, test case and recommendations for assessing the management effectiveness of the Baltic Sea Marine Protected Area (MPA) network' and all expected deliverables identified in the application are covered in that report.

A regional workshop was also held and the documentation and outcomes are provided via links within the table.

WP 3 WP3 Assessment of effectiveness of MPA network

TASK	Partners	Reports provided and project deliverable addressed	Status
a) Method development	**KU** UT AU HELCOM	**REPORT: Methodology, test case and recommendations for assessing the management effectiveness of the Baltic Sea Marine Protected Area (MPA) network** Deliverables addressed: - Report on methodology for assessing management effectiveness of the Baltic Sea MPA network - Report on the assessment of effectiveness of the Baltic Sea MPA network - Recommendations for improvement of MPA network effectiveness in reaching GES	**Completed**
b) Collection of data and information	**KU** UT HELCOM		**Completed**
c) Application of method	**KU** UT AU HELCOM		**Completed**
d) HELCOM ACTION Workshop 3	**KU** **UT** AU HELCOM SYKE	HELCOM ACTION Workshop 3: MPA network effectiveness **(HELCOM ACTION WS2.2-2020).** An outcome from the workshop is available here.	**Completed**

WP4 Input of nutrients

WP4 has provided three reports and all expected deliverables identified in the application are covered in these reports, in addition to reports provided under WP6

- Approaches and their potential to reduce nutrient loads in the Baltic Sea region.
- Input of nutrients: potential to reduce input from point sources
- Compatibility of targets under different marine policies - Sufficiency of the EU WFD targets for individual rivers basins to achieve the BSAP goals

Two regional workshops were also held and the documentation and outcomes of these events are provided via links within the table.

WP 4.1 Following up existing measures

TASK	Partners	Reports provided and project deliverable addressed	Status
a) Identify test cases	**SYKE** **SwAM** **BNI** SLU TTU AU HELCOM	**REPORT: Approaches and their potential to reduce nutrient loads in the Baltic Sea region.** Deliverables addressed: - Report describing and explaining more and less successful approaches to reduce nutrient loads and the need for additional measures for achieving the BSAP objectives.	**Completed**
b) Sufficiency of current measures to meet the BSAP obligations	**SwAM** **BNI** **SLU** **TTU** **AU** HELCOM		**Completed**

TASK	Partners	Reports provided and project deliverable addressed	Status
c) Contributions from point sources	**SYKE** SLU TTU AU HELCOM	**REPORT: Input of nutrients: potential to reduce input from point sources** Deliverables addressed: - Improved quality control of point source data in the HELCOM PLC database - Report describing the variation in efficiency of nutrient treatment from point sources, discussing variability across the region and between industrial sectors and potential for improved, harmonised treatment requirements across the region	**Completed** NOTE: after review by the HELCOM PRESSURE Working Group this report has also been published as a HELCOM report: https://helcom.fi/wp-content/uploads/2020/10/Inputs-of-nutrients-potential-to-reduce-input-from-point-sources-ACTION-WP4.pdf

WP 4.2 Compatibility of targets under different marine policies

TASK	Partners	Reports provided and project deliverable addressed	Status
a) WFD targets to achieve HELCOM BSAP	**TTU** SYKE SwAM SLU AU HELCOM	**REPORT: Compatibility of targets under different marine policies - Sufficiency of the EU WFD targets for individual rivers basins to achieve the BSAP goals** Deliverables addressed: - Recommendations on ways to improve compatibility of targets under various legislative instruments	**Completed** NOTE: after review by the HELCOM PRESSURE Working Group this report has been approved for publication as a HELCOM report. This will take place in the first half of 2021.

WP 4.3 Potential nutrient load reductions through existing measures

TASK	Partners	Reports provided and project deliverable addressed	Status
a) Development and implementation of a questionnaire on Measures	**HELCOM** SYKE SwAM SLU TTU AU	Incorporated into the SOM process, see below under task c. Deliverables addressed: - Results of a questionnaire describing national commitments and collating information from regional and local authorities describing implemented, physical measures	**Completed**
b) HELCOM ACTION Workshop 4.1	**HELCOM** SYKE SwAM SLU TTU AU	**HELCOM ACTION Workshop 4.1: HELCOM Workshop with River Basin Management Authorities (RBMA WS 1-2019).** An outcome from the workshop is available here.	**Completed**
c) Assessing the possibility to meet the BSAP targets	**HELCOM** SYKE SwAM SLU TTU AU	REPORT: No separate report was prepared for this sub-task, as agreed with the project officer (email 17/11/2020), as the substance was incorporated into the WP6 report 'Sufficiency of existing measures for the input of nutrients into the Baltic Sea' Deliverables addressed: - Report describing work to date and the potential for additional measures to achieve the BSAP goals	**No deliverable/report provided, as agreed with project officer.**

WP 4.4 Sharing experiences of Cycle 1 MSFD Programmes of Measures

TASK	Partners	Reports provided and project deliverable addressed	Status
a) HELCOM ACTION Workshop 4.2	**HELCOM** SYKE SwAM SLU TTU AU	**HELCOM ACTION Workshop 4.2: BSAP and MSFD measures to abate eutrophication (HELCOM ACTION WS4.2-2020)** An outcome from the workshop is available here.	**Completed**

WP5 Conditions that influence GES

WP5 has provided two reports: 'Conditions that influence Good Environmental Status (GES) in the Baltic Sea' and 'Analysis of total nitrogen in the Baltic Sea and implications for time lag in achieving good environmental status (GES)' and all expected deliverables identified in the application are covered in the reports.

WP 5 Analysis of reasons for not achieving GES

TASK	Partners	Reports provided and project deliverable addressed	Status
a) Best practices	**TTU** AU HELCOM	**REPORTS:** – **Conditions that influence Good Environmental Status (GES) in the Baltic Sea** – **Analysis of total nitrogen in the Baltic Sea and implications for time lag in achieving good environmental status (GES)** Deliverables addressed: - Best practices for reporting of MSFD exceptions - Report on natural conditions of the Baltic Sea that influence achievement of GES - Topic-specific input to WP6 (BAU scenario development) estimating potential delay in achieving GES for different criteria and impact on measures	**Completed**
b) Review and analyses	**TTU** AU HELCOM		**Completed**
Final report	**TTU** AU HELCOM		**Completed**

WP6 Sufficiency of measures

WP6 has provided fifteen reports, fourteen under WP6.1 and one under WP6.2, and all expected deliverables identified in the application are covered in these reports. To support the update of the Baltic Sea Action Plan process, a much broader series of topics than initially identified in the project application were addressed, covering as many relevant topics as possible for the HELCOM region and not the limited selection initially identified in the application (those being eutrophication, impacts on the seabed and by-catch).

- Methodology for the sufficiency of measures analysis
- A practical guide to interpreting the SOM results
- Sufficiency of existing measures to achieve good status in the Baltic Sea (summary report)

- Sufficiency of existing measures for benthic habitats in the Baltic Sea
- Sufficiency of existing measures for marine mammals in the Baltic Sea
- Sufficiency of existing measures for the input of nutrients into the Baltic Sea
- Sufficiency of existing measures for non-indigenous species in the Baltic Sea
- Sufficiency of existing measures for underwater noise in the Baltic Sea
- Sufficiency of existing measures for marine litter in the Baltic Sea
- Sufficiency of existing measures for waterbirds in the Baltic Sea
- Sufficiency of existing measures for coastal fish in the Baltic Sea
- Sufficiency of existing measures for migratory fish in the Baltic Sea
- Sufficiency of existing measures for commercial fish in the Baltic Sea
- Sufficiency of existing measures for hazardous substances in the Baltic Sea

- Cost effectiveness of proposed new measures for the Baltic Sea Action Plan 2021

In addition, a regional workshop was held and the documentation and outcomes of this event are provided via links within the table.

WP 6.1 Regional business-as-usual (BAU) scenarios

TASK	Partners	Reports provided and project deliverable addressed	Status
a) Approach	**SYKE** HELCOM TTU SWaM AKTiiVS	**REPORTS:** - **Methodology for the sufficiency of measures analysis** - **A practical guide to interpreting the SOM results** Deliverables addressed: - Linkages between measures, human activities and pressures in the Baltic Sea region - Compilation of information on existing and planned measures having an impact on the Baltic Sea	**Completed**
b) Linkage framework	**SYKE** TTU HELCOM AKTiiVS		**Completed**
c) List of existing measures and their status	**HELCOM** SYKE AKTiiVS		**Completed**
d) Effectiveness of existing measures	**SYKE** HELCOM AU DTU KU SLU TTU UT Bionautit	**REPORTS:** • **Sufficiency of existing measures to achieve good status in the Baltic Sea (summary report)** • **Sufficiency of existing measures for benthic habitats in the Baltic Sea** • **Sufficiency of existing measures for marine mammals in the Baltic Sea** • **Sufficiency of existing measures for the input of nutrients into the Baltic Sea** • **Sufficiency of existing measures for non-indigenous species in the Baltic Sea**	**Completed**
e) Projections of human activities or pressures	**HELCOM** SYKE AKTiiVS		**Completed**

TASK	Partners	Reports provided and project deliverable addressed	Status
f) Gap analysis	**HELCOM** SYKE TTU DTU AKTiiVS	• **Sufficiency of existing measures for underwater noise in the Baltic Sea** • **Sufficiency of existing measures for marine litter in the Baltic Sea** • **Sufficiency of existing measures for waterbirds in the Baltic Sea** • **Sufficiency of existing measures for coastal fish in the Baltic Sea** • **Sufficiency of existing measures for migratory fish in the Baltic Sea** • **Sufficiency of existing measures for commercial fish in the Baltic Sea** • **Sufficiency of existing measures for hazardous substances in the Baltic Sea** Deliverables addressed: - Linkages between measures, human activities and pressures in the Baltic Sea region - Compilation of information on existing and planned measures having an impact on the Baltic Sea - Report with BAU scenarios and gap-analysis for achieving GES for selected topics, eutrophication, impacts on the seabed and by-catch.	**Completed**
a) HELCOM ACTION Workshop 6	**HELCOM** SYKE AU DTU KU SLU TTU UT SWaM AKTiiVS	**HELCOM ACTION Workshop 6: Third Meeting of the ad hoc HELCOM Platform on sufficiency of measures (SOM Platform 3-2020)** An outcome from the workshop is available here. To provide the highest impact and ensure the work of the ACTION project was best incorporated into ongoing HELCOM work the workshop was held in direct cooperation with the HELCOM SOM Platform.	**Completed**

WP 6.2 Potential new measures and their cost-effectiveness

TASK	Partners	Reports provided and project deliverable addressed	Status
a) Identification of potential new measures	**HELCOM** SYKE AU DTU KU SLU TTU UT	**REPORT: Cost effectiveness of proposed new measures for the Baltic Sea Action Plan 2021** Deliverables addressed: - Method description to run regional cost-effectiveness analyses over multiple pressures - Report on cost-effectiveness of potential new measures to bridge the gap to GES	**Completed**
b) Effectiveness of new measures	**SYKE** HELCOM SWaM UT DTU KU SLU AKTiiVS		**Completed**
c) Joint effects of new measures	**SYKE** HELCOM TTU SWaM		**Completed**
d) Cost estimation	**SYKE** HELCOM SWaM DTU AKTiiVS		**Completed**

TASK	Partners	Reports provided and project deliverable addressed	Status
e) Finding optimal sets of new measures	**SYKE** HELCOM AU DTU KU SLU TTU UT SWaM AKTiiVS		**Completed** This issue is addressed in the report but is limited by the availability of the data to carry out an in-depth analysis. The focus of the analysis has been on the measures identified through HELCOM processes with potential to enter the updated BSAP.

Impact of results and relevance for Contracting Parties and authorities

The ACTION project covered a broad range of topics that are somewhat separate yet also converge, for example via work carried out under WP6 and other relevant national and HELCOM processes. The experts involved in work packages 1-5 have supported work where possible under work package 6 but to enable clear presentation on the application and impact of results from the ACTION project each work package is addressed separately below.

WP1

The work related to risk mapping builds on developments that took place at the in the Joint OSPAR-HELCOM Incidental by-catch workshop. The developments carried out in ACTION have also lead to the inclusion of further work on the topic in the recently approved HELCOM BLUES project where the focus will include increasing the coverage of relevant species and also improving the spatial scale of the assessment. This work under both ACTION and BLUES will support an improved HELCOM indicator assessment by HOLAS III (the Third HELCOM Holistic Assessment) and thereby support HELCOM Contracting Parties that are also EU Member States in their MSFD reporting as well as offer support for management decision making on the topic.

In addition, the work under the ACTION project work package 1 was used to support planning and preparation on national measures in Sweden and was also utilized in an ICES workshop to address emergency measures to minimize by-catch of short-beaked common dolphins in the bay of Biscay and harbour porpoise in the Baltic Sea (WKEMBYC). The resulting report 'EU request on emergency measures to prevent bycatch of common dolphin (Delphinus delphis) and Baltic Proper harbour porpoise (Phocoena phocoena) in the Northeast Atlantic' also includes and annex (Annex 2) that lists different mitigation measures to prevent bycatch of harbour porpoise including: time-area closures, gillnet modifications, acoustic deterrence and bycatch quotas.

WP2

A major contribution of this work package too the form of 'synopses' contributed to the Baltic Sea Action Plan update (BSAP UP) process. As part of the BSAP UP process national representatives, NGOs and international projects were invited to provide short and clear suggestions for new actions or measures (synopses) that would be reviewed by relevant HELCOM Working Groups for potential inclusion in the updated

Baltic Sea Action Plan. Work under this work package supported the development of 17 proposals related to coastal restoration measures and an additional 8 more general proposals resulting from the second workshop (HELCOM ACTION WS2.2). An example of the proposals, as under discussion in the HELCOM State and Conservation Working Group, can be seen in the summary provided in document 3J-5 All.1 Rev.1 from State and Conservation 12-2020. In addition the work related to spatial measures for fisheries has already been published in a peer reviewed scientific journal (Reducing fisheries impacts on the seafloor: A bio-economic evaluation of policy strategies for improving sustainability in the Baltic Sea) and the work on coastal measures has supported decision making nationally within Sweden and is in preparation for publication as a peer reviewed article.

WP3

Work package 3 provided three synopses to the Baltic Sea Action Plan update process, addressing improved application and management of Marine Protected Areas (MPAs) in the Baltic Sea region. In addition to highlighting key management issues and knowledge gaps, the developed methodology lays the framework for further development and full application in the region. The focus on this issue has also supported the development of a core group within HELCOM that are currently actively developing an application for LIFE funding on the topic of MPAs. Thus, the work carried out in ACTION acts as the foundation for certain focus areas under discussion in that application process and, in line with other current developments (e.g. proposals related to the Convention on Biological Diversity Aichi targets), this work has clearly been very timely. The work package 3 team are currently preparing the work in the project for publication in a peer reviewed scientific journal, where the methodology, test cases carried out and key messages are to be presented.

WP4

Improved data harmonisation and quality in the HELCOM Pollution Load Compilation (PLC) database has been achieved as a result of this work, as well as identification of areas where further improvements or additions can be made (recommendations). Such improvements and additions can greatly increase the potential of the data collected. In addition, the work package has increased information sharing in the region, integrated discussion with River Basin Management Authorities, and contributed to the Baltic Sea Action Plan update process (synopsis). The discussion initiated related to harmonization between different policy initiatives to support improved status in the Baltic Sea is also anticipated to continue.

WP5

The work carried out under work package 5 aims to enable a greater harmonisation across the Baltic Sea region when HELCOM Contracting Parties that are also EU Member States report exceptions for not achieving Good Environmental Status (GES) under the Marine Strategy Framework Directive (MSFD). The report aims to consolidate best practices for the application of such exceptions and the scientific basis for them to work towards a common regional approach that places a strong scientific understanding at the centre of any justification for the failure to achieve GES. In addition to developing a framework for best practices, selected topics are also addressed in greater detail to provide a review of current knowledge, for example on lags in achieving GES for eutrophication, selected hazardous substances, or factors impaction the achievement of GES for certain biodiversity parameters.

WP6

As described above, work carried out under work package 6 has been integral to the planning and preparation towards the update of the Baltic Sea Action Plan (BSAP). The close integration of the ACTION project work, via the SOM Platform, has supported discussion and development towards new actions and measures by highlighting the areas of clear need (i.e. where existing measures do not currently offer potential to achieve good status, even if fully implemented). The methodology developed has its foundations in a causal framework, linking measures-activities-pressures-state, and provides sufficient flexibility for it to be applied both qualitatively and quantitatively. It is thus a solid starting platform for the assessment of a broad range of topics and could be adapted to sub-regional, regional or 'other-regional' application. Moreover, the clear documentation of lessons learned and uncertainties or inadequacies in the current method have in part already been acted on in the form of the recently applied and funded HELCOM BLUES project. Once appropriately annotated the SOM model (code for the assessment tool) will also be made publicly available so that further development can be continued. Finally, the work has also supported discussion and preparation towards the national update of MSFD programmes of Measures (PoMs), for example in Finland the SOM methodology developed under ACTION has been applied as part of their national process.