Sufficiency of existing measures for migratory fish in the Baltic Sea

ACTION

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Species and biotopes

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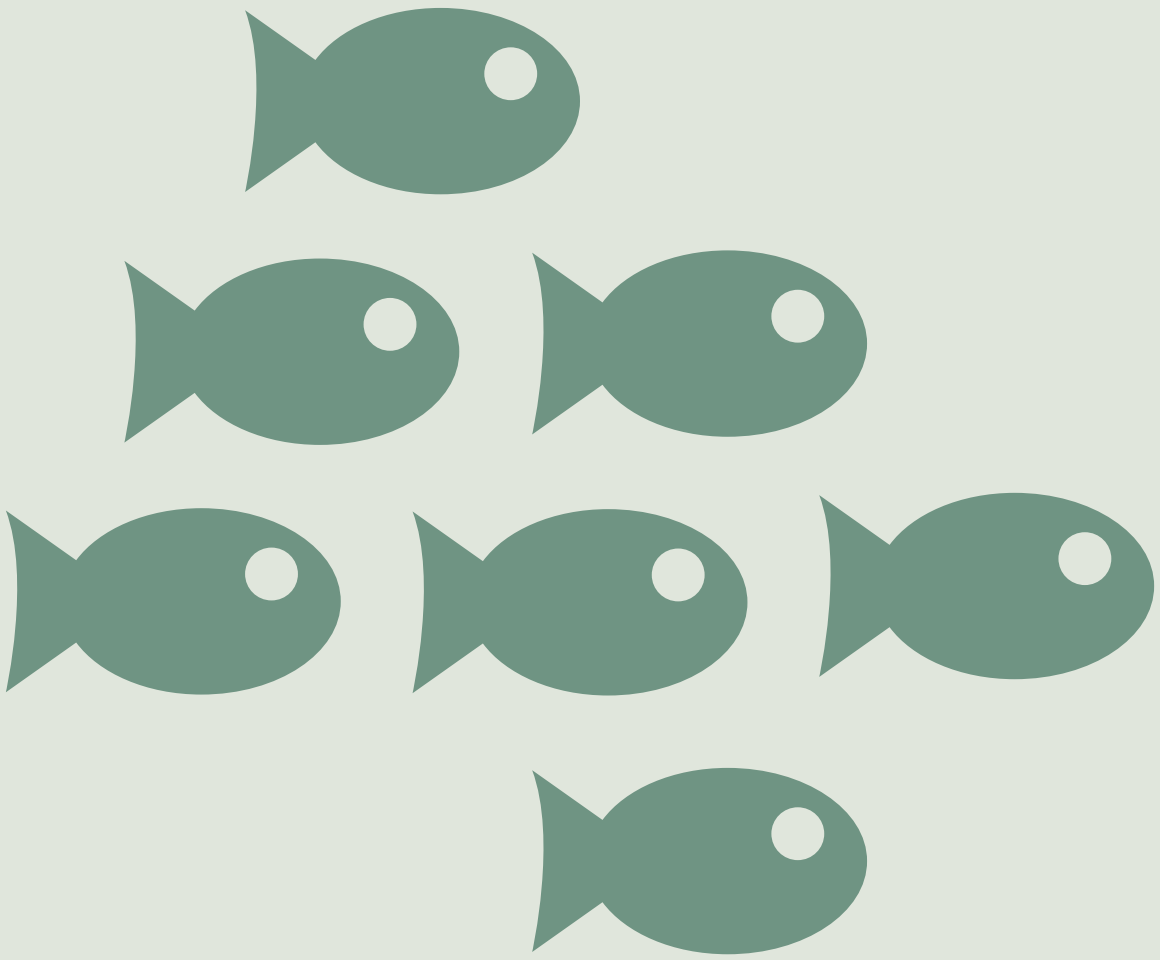

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Sufficiency of existing measures for migratory fish in the Baltic Sea

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Summary of main results

The SOM analysis for migratory fish has compared the projected pressure reductions from existing measures to the required pressure reductions to achieve GES or specific state improvements for salmon, sea trout and eel.

The results suggest that existing measures would not be sufficient in achieving GES or significant state improvements for sea trout or eel. The results on the sufficiency of measures to achieve GES for salmon have been excluded due to lack of data on the effectiveness of measure types.

The main pressure affecting migratory fish is the extraction of fish (includes prey depletion). Other important pressures are river, lake, or land habitat loss/degradation, species disturbance: obstructions and collisions, and effects of eutrophication. There is a variation in the significance of pressures across species and areas.

Seasonal and spatial closures, as well as measures to reduce recreational and commercial fishing, appear among the most effective measure types to reduce targeted extraction and bycatch of migratory fish from fish and shellfish harvesting. The estimates on the effectiveness of measure types are rather uncertain.

The contribution of activities to pressures was not assessed, as all pressures are created by a single activity or are not dependent on activities but affect pressures or state directly.

The overall certainty of the assessment for migratory fish could be characterized as low. Experts from six coastal countries contributed to the effectiveness of measures and pressure-state assessment. The total number of experts contributing to the surveys is high for both the effectiveness of measures and pressure-state part, but some individual elements have a low amount of data. Additionally, the linear nature of riverine habitat is poorly represented in the SOM analysis which increases uncertainty of e.g. the effects of dam removal/fish passage installation and overall coverage of pressures important to migratory fish is low (Tables 6.1 and 6.2).

Introduction

Report background

The sufficiency of measures (SOM) analysis assesses improvements in environmental state and reduction of pressures that can be achieved with existing measures in the Baltic Sea region, and whether these are sufficient to achieve good environmental status (GES). The analysis involves estimating the state of the marine environment in 2030, based on a starting point of 2016 (i.e. the latest HELCOM status assessment), and given measures in existing policies, their implementation status, and the projected development of human activities over time. The evaluation can be carried out compared to relevant and agreed HELCOM threshold values for GES, where available.

The main aim of the SOM analysis is to support the update of the HELCOM Baltic Sea Action Plan (BSAP) by identifying potential gaps in achieving environmental objectives with existing measures for the Baltic Sea. In addition, the analysis can indicate both thematically and spatially where new measures are likely needed.

The same overall approach has been applied across all topics included in the SOM analysis to ensure comparability and coherence of the results, while considering topic-specific aspects and making necessary adjustments. The main components of the analysis include assessing the contribution of activities to pressures, the effect of existing measures on pressures, the effect of development of human activities on pressures, and the effect of changes in pressure on environmental state. The SOM approach, model and data collection are described in detail in the methodology report.

The methodology for the SOM analysis is designed to accommodate the broad array of topics relevant in the HELCOM region and to enable a region-level analysis. It balances between state-of-the-art knowledge, availability of data, and advice taken onboard from various HELCOM meetings and bodies.

The data used in the SOM analysis have been collected using expert elicitation and by reviewing existing literature, model outputs and other data sources. Data availability varies substantially across topics and data components, which is reflected in the presentation of the methods and results in this report.

The SOM analysis presents the first attempt to quantify the effects of existing measures and policies on the environment and achieving policy objectives for various environmental topics in HELCOM and the Baltic Sea area. It is aimed at assessing the overall sufficiency of existing measures at the Baltic Sea level. The results are based mainly on expert elicitation, and thus they should be utilized appropriately. Due to the pioneering nature of the approach and variable data quality and availability in the SOM analysis, the findings do not provide conclusive answers on the need for new measures, but indicate likely gaps, and should thus also be reviewed in relation to the results of other assessments.

This topic report describes the analyses carried out and the results for the SOM analysis on migratory fish, providing detailed topic-specific information. First, it presents background information and describes the data and methods for addressing the topic in the SOM assessment, including relevant assumptions and challenges. Second, it presents and

discusses the findings for each result component. Third, it provides discussion on the impacts of alternative assumptions and data, evaluates the quality and confidence of the analysis, and provides implications and future perspectives. The annexes contain detailed information on the data components, topic structure and expert surveys for the analysis, as well as supplementary results.

Similar topic reports have been prepared for all nine topics covered in the SOM analysis. In addition, the results are summarized in the main report and the full methodology is described in the methodology report.

Topic background[1]

Salmon (*Salmo salar*) is present in 58 rivers around the Baltic Sea (27 wild, 14 mixed, and 17 reared[2]). In addition, several potential salmon rivers exist, often with ongoing reintroduction programmes and/or occasional natural reproduction. Apart from natural smolt production, a substantial amount of salmon smolts are released in order to compensate the loss of natural production due to damming of rivers for the hydropower production. Because of a precise homing behaviour, each river has its own population that is genetically distinct.

The fisheries on Baltic salmon take place by the commercial open sea long line fisheries and coastal trap net fisheries, as well as recreational trolling in open sea and rod fishing in rivers. The fisheries exploit salmon at different life stages, starting with the offshore fisheries, followed by the coastal, and ending with the river fisheries. In 2019, commercial sea fisheries accounted for 51% of the total catch of Baltic salmon, recreational sea fisheries for 16%, and river fisheries for 33%.

The current status of stocks shows a large variation, with a clear tendency for healthier river stocks in the northern Gulf of Bothnia, whereas stocks in the south-eastern Baltic Sea are in a particularly poor state. Besides the effects of fisheries, local factors (poor water quality, disease, migration obstacles, etc.) are presumed to cause a weak status for salmon in certain rivers and areas (ICES 2020b).

Sea trout (*Salmo trutta*) reproduce in 625 rivers in the Baltic Sea area (ICES 2020b). In addition, several potential sea trout rivers exist, in part of which reintroduction programmes takes place (removal of migration obstacles, improvement of spawning and rearing habitats and support releases) and occasional natural reproduction occurs. In addition to natural reproduction, substantial amounts of sea trout smolts and parr are released in order to compensate the loss of natural reproduction due to damming of rivers and brooks for the

[1] Partially adapted from ICES (2020a)

[2] ICES divides current Baltic salmon rivers into four main categories:

1. Wild salmon rivers are defined as self-sustainable, with no or limited releases of reared fish.
2. Mixed rivers have some wild production but are subject to considerable stocking.
3. Reared rivers currently cannot hold self-sustaining river stocks (e.g. because of physical barriers) and are entirely dependent on stocking.
4. Potential rivers are not currently holding a self-sustainable stock but could hold one in the future. Not counted here.

hydropower production and other water usage. Populations are genetically distinct by areas and by rivers. Feeding migration in the sea has a short range compared to e.g. salmon.

The fisheries on Baltic sea trout take place by commercial and recreational fisheries mainly in the coastal areas and only to a minor extent in the open sea. In rivers mainly recreational fishing occurs. In 2019, the total catch was 477 tonnes, of which commercial catch accounted for 33% and recreational catch 67%. Catch estimates for recreational fisheries are, in general, uncertain. They are defective or estimates are frequently missing from some countries.

Current status of sea trout stocks shows a large variation between areas. Healthier stocks are in the southwestern and western Baltic and in the Gulf of Finland and even in the southern Gulf of Bothnia, whereas in northern Gulf of Bothnia river stocks are mainly in poor state. Besides the effects of fisheries, local factors (poor water quality, disease, migration obstacles, etc.) are presumed to cause a weak status for sea trout in certain rivers and areas (ICES 2020b). Various fishing restrictions (temporal and spatial closures, gear restrictions, ban to land wild sea trout) have been implemented in order to improve the status of stocks.

European eel (*Anguilla anguilla*) utilises during its continental phase the water bodies exiting to the Baltic Sea and the coastal areas for feeding. When eel enters from ocean to the Baltic Sea most of them have reached the yellow eel stage. Apart from the collapsed natural recruitment substantial amounts of glass eel and yellow eel has been released mainly to the inland waters but also to the coastal areas and lagoons. Releases to the inland waters are aimed to substitute the loss of wild eel that does not have access there due to the migration barriers (hydropower dams, etc.). In the coastal areas and lagoons releases are carried out to compensate the low natural recruitment. Releases, however, have decreased in the last few years. In the Baltic Sea area eel mature typically at an age of 5-25 years (can exceed 50 years) and start migration back towards ocean for spawning.

Fishing of eel is restricted by the temporal and areal closures in most of the Baltic Sea countries. The remaining fisheries take place mainly at the coastal areas in the southern Baltic Sea by fykenets (mature silver eel) and partly also in the freshwater areas (yellow eel). The status of European eel is critically endangered. Apart from the anthropogenic impacts in the feeding areas (physical barriers, habitat destruction and degradation) and migration routes (fishing) also the changes in the ocean environment and the climate change are considered to be factors for the decreasing trend of recruitment observed since 1980s. ICES advices that all anthropogenic impacts, including recreational and commercial fishing on eels, should be reduced to as close to zero as possible in order to conserve this species.

Description of migratory fish in the SOM assessment

Migratory fish are included in the SOM analysis as 3 state components: *Abundance of salmon spawners and smolt, Abundance of sea trout parr,* and *Abundance of eel* (Figure 1). These components reflect the structure of MSFD criteria D1C3 [3], European Council Regulation No 1100/2007 establishing measures for the recovery of the stock of European eel, and the HELCOM indicators "Abundance of salmon spawners and smolt" and "Abundance of sea trout spawners and parr". Each state component is assessed using a different metric or approach with salmon and eel having thresholds corresponding to GES or other environmental target and sea trout being assessed against specific state improvements.

Salmon is assessed using the evaluation of potential smolt production capacity (PSPC) in each Baltic Sea salmon river by the International Council for the Exploration of the Sea Assessment Working Group on Baltic Salmon and Trout (ICES WGBAST) (ICES 2019k). The PSPCs are aggregated by ICES evaluation area to generate an assessment at the sub-basin level (Figure 2). This methodology is based on that used in the HELCOM indicator "Abundance of salmon spawners and smolt" (HELCOM 2018a).

The assessment of eel uses the evaluation of current and potential silver eel biomass escaping to the sea via the ICES Workshop for the Review of Eel Management Plan Progress Reports and national reporting under Article 9 of the Eel Regulation 1100/2007 (ICES 2019l). To avoid the domination of the assessment by high productivity areas in good status (DE Schlei/Trave and DE Warnow/Peene), the data have been aggregated to the Baltic Sea scale by averaging the ratios of current to potential escapement by management unit rather than by summing these estimates to create a single Baltic wide escapement ratio.

While baseline data exists for sea trout and is used to assess sea trout population condition by e.g. ICES (ICES 2019k), the data is not easily summarized to a level appropriate to the SOM analysis and covers less than half of the recognized trout streams. Instead of using a threshold value assessment method, sea trout are evaluated on the basis of improvement from current conditions in 5 sub-divisions of the Baltic Sea (Figure 3). Table 1 presents the structure and base states of the SOM migratory fish assessment.

[3] Marine Strategy Framework Directive criteria D1C3 – The population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures.

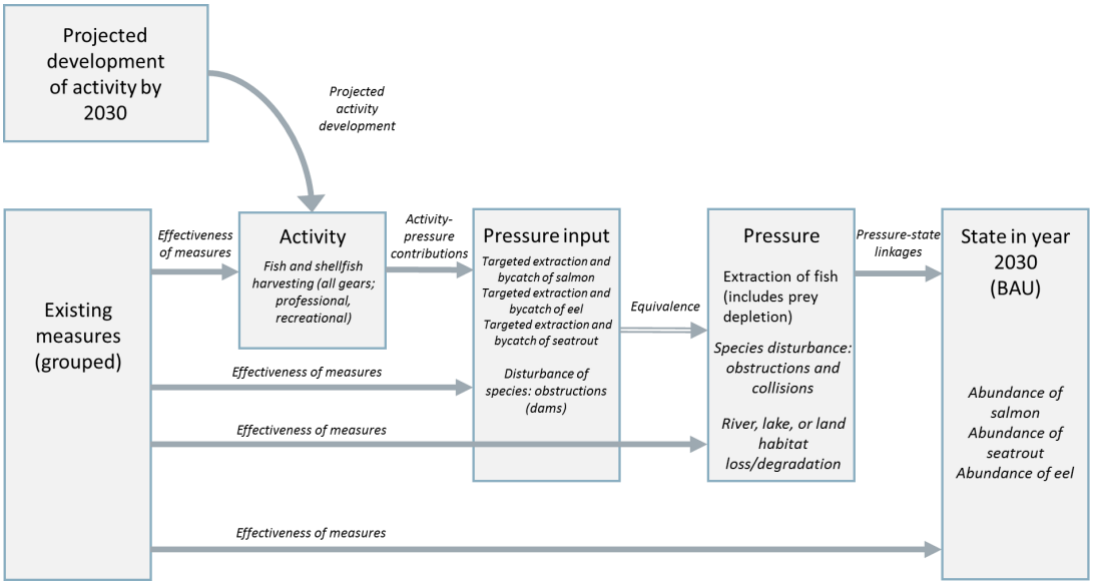

Figure 1. Schematic of the SOM model for migratory fish. While migratory fish can be influenced by any pressure in the model, they are only present in the model as a state component and therefore do not influence any other model component.

Table 1. Structure and base states of the SOM migratory fish assessments. The table presents each migratory fish assessment and the type of assessment made. For GES-based assessments, the base state and GES threshold value are presented. Improvement-based assessments do not have a base state and show not applicable (NA) in the relevant columns.

Species	Assessment area	Assessment type	Base state	GES threshold value
Salmon	Assessment unit 1-2	GES	0.99	0.75
Salmon	Assessment unit 3	GES	0.85	0.75
Salmon	Assessment unit 4	GES	0.72	0.75
Salmon	Assessment unit 5	GES	0.185	0.75
Salmon	Assessment unit 6	GES	0.19	0.75
Sea trout	Gulf of Bothnia	% improvement	NA	NA
Sea trout	Gulf of Finland	% improvement	NA	NA
Sea trout	Western Baltic	% improvement	NA	NA
Sea trout	Eastern Baltic	% improvement	NA	NA
Sea trout	Southern Baltic	% improvement	NA	NA
Eel	Whole Baltic	GES*	0.22	0.4*

*Eel uses an environmental target based on European Council Regulation No 1100/2007. There is no HELCOM indicator or GES threshold value for eel.

Fish specific pressures

For the fish specific pressures, pressure input and pressure are equivalent and only the term pressure is used further in the report (see Figure 1). Several assessed pressures are exclusive to fish, including *targeted extraction and bycatch of fish* for coastal fish, cod, flatfish, pelagic fish, salmon, sea trout and eel, as well as *disturbance of species: obstructions (dams)*. The targeted extraction pressures do not correspond to a HELCOM indicator but are assessed by ICES for many commercial species (ICES 2019a-j). Additionally, MSFD criteria D3C1[4] and to a limited extent D1C1[5] apply in combination to these pressures. The pressure *disturbance of species: obstructions (dams)* does not correspond to a HELCOM indicator but is a quality element of ecological status for rivers under the Water Framework Directive (River continuity). These pressures all originate from either a single activity (*targeted extraction and bycatch* is only caused by fishing) or are not connected to a SOM activity (*disturbance of species: obstructions (dams))*. None of these pressures are assessed against a GES threshold in the SOM analysis.

[4] Marine Strategy Framework Directive D3C1 – Primary: The Fishing mortality rate of populations of commercially-exploited species is at or below levels which can produce the maximum sustainable yield (MSY). Appropriate scientific bodies shall be consulted in accordance with Article 26 of Regulation (EU) No 1380/2013.
[5] Marine Strategy Framework Directive D1C1 – The mortality rate per species from incidental by-catch is below levels which threaten the species, such that its longterm viability is ensured.

Methods and data

The section below includes an overview of any topic-specific methodologies. A full description of the general approach, methods and data collection for the SOM analysis is available in this document. Note that the detailed results are presented for the most likely development of human activities and using the expert data on effectiveness of measures.

Effectiveness of measures and pressure-state linkages

Measure types (Annex 3) and structural relationships between the measure types and activities and pressures (Annex 7) were designed by the HELCOM Workshop on the analyses of Sufficiency of Measures (SOM) for Fish (SOM-FISH WS 1-2019) and the SOM Migratory fish Topic Team in collaboration with HELCOM ACTION WP6. The measure types were informed by the existing measures list (Annex 4), but were also designed to acknowledge the full breadth of potential measures.

For migratory fish, the effectiveness of measures survey structure comprised 35 unique measure types covering one activity and three direct to pressure or state relationships. The same measure type may be listed under multiple activities and pressures. Altogether this resulted in 53 assessments of measure type effectiveness across the topic. The exact list of measure types, and their grouping by activities and pressures is shown in Annex 7. The effectiveness of measures survey itself is included as Annex 8.

Effectiveness of the measure types and links between the pressures and state components were determined using online expert surveys implemented in December 2019 – February 2020 with follow-up surveys conducted in the spring 2020. The expert pool consisted of the HELCOM Group on Ecosystem-based Sustainable Fisheries, HELCOM Task Force on Migratory Fish Species, HELCOM Project for Baltic-wide assessment of coastal fish communities in support of an ecosystem-based management, participants of the HELCOM Workshop on the analysis of sufficiency of measures for fish and nationally nominated experts. Additionally, the project received survey responses from experts not on the original invitation list; these responses were also included in the analysis. The full description of the methodology and data collection is available as part of the SOM methodology report.

Pressure reductions and state improvements

The reductions in pressures are calculated using the data on effectiveness of measure types, links between existing measures and measure types, and projected development of human activities. They account for the joint impacts across the measure types, as well as the spatial area where the pressures can be reduced to avoid overestimating the pressure reductions. Pressure reductions can be positive (pressure is reduced), negative (pressure is increased) or zero (no change in pressure), depending on the combined effect of existing measures and changes in the extent of human activities. When the reduction in pressures from existing measures is larger than the increase from changes in human activities, pressures are reduced.

The calculation of sufficiency of measures takes into account all the components of the SOM analysis for fish: the effectiveness of measure types in reducing pressures, links between existing measures and measure types, projected pressure reductions from existing measures, development of human activities, significance of pressures to state components and pressure reductions required to achieve GES/environmental target/state improvements. The analysis assumes that all existing measures are fully implemented and that there are no time lags between the input of pressures and environmental state.

Topic specific model structure, assumptions and challenges

The basic spatial structure of the SOM analysis revolves around the 17 HELCOM scale 2 sub-basins. For migratory fish, the idea of these sub-basins was extended to include the rivers which terminate in each respective basin. While this approach seems adequate for many aspects of the SOM approach, some concerns exist for the application of the approach to effectiveness of measures and existing measures in the riverine context. The issue is further discussed in the section Lessons learned.

Overview of data

The SOM analysis for fish evaluates the sufficiency of measures in achieving GES, environmental target or state improvements, considering the effects of existing measures and future development of human activities.

Table 2 shows the origin and spatial resolution for the data components in the SOM analysis for migratory fish. Activity-pressure contributions have not been assessed, as all fish-specific pressures are created by a single activity (fishing) or are not dependent on activities but affect pressures or state directly (longitudinal connectivity of rivers). Information on existing measures comes from literature reviews and Contracting Parties, and development of human activities is based on existing literature, data and projections.

Estimates of the effectiveness of measures were collected both via expert surveys and a literature review for all topics included in the SOM analysis. The aim of the literature review was to compile information from scientific articles and reports providing estimates on the effects of measures in reducing pressure inputs that could be used in the SOM analysis, either by including the estimates in the SOM model or by providing comparison points. The literature review was conducted by topic, with the information collected into structured excel files (see the methodology document, Annex 5 and Annex 6 for more information). For all fish topics, 248 effectiveness estimates from 76 studies were compiled. Out of these, 4 estimates from 3 studies could be included in the model for migratory fish. Scenarios for the development of human activities were based on existing information and projections for the Baltic Sea region, and pressure-state links were evaluated with expert elicitation.

The spatial resolution (level of detail) differs across the data components of the SOM analysis (Table 2). All areas are based on the 17 HELCOM scale 2 sub-basins and the assessment area ranges from the single Baltic Sea to individual sub-basins. The activity-pressure contributions were not necessary for this topic as all fish specific pressures are created by a single activity (fishing) or are not activity dependent (longitudinal connectivity of rivers). The effectiveness

of measure types in reducing pressures and the effect of development of human activities are assessed at the scale of the entire Baltic Sea. The spatial resolution for the pressure-state linkages varies across state components, from large sub-sections of the Baltic Sea to individual sub-basins. The definition of the state component may already include a geographic element, for example, the population of the species in a specific part of the Baltic Sea. Maps of the spatial coverage of salmon and seatrout are presented in Figures 2-3. Eel is assessed at the whole Baltic Sea scale.

Table 2. Data for fish (more information on data collection is available in the methodology document)

Data component	Origin of data	Spatial resolution
Activity-pressure contributions	NA	NA
Existing measures	Literature review, Contracting Parties	17 sub-basins
Effectiveness of measures	Expert evaluation	Whole Baltic Sea
Development of human activities	Literature review, existing data and projections	Whole Baltic Sea
Pressure-state links	Expert evaluation	Various (Figures 2-3)

NA = not applicable

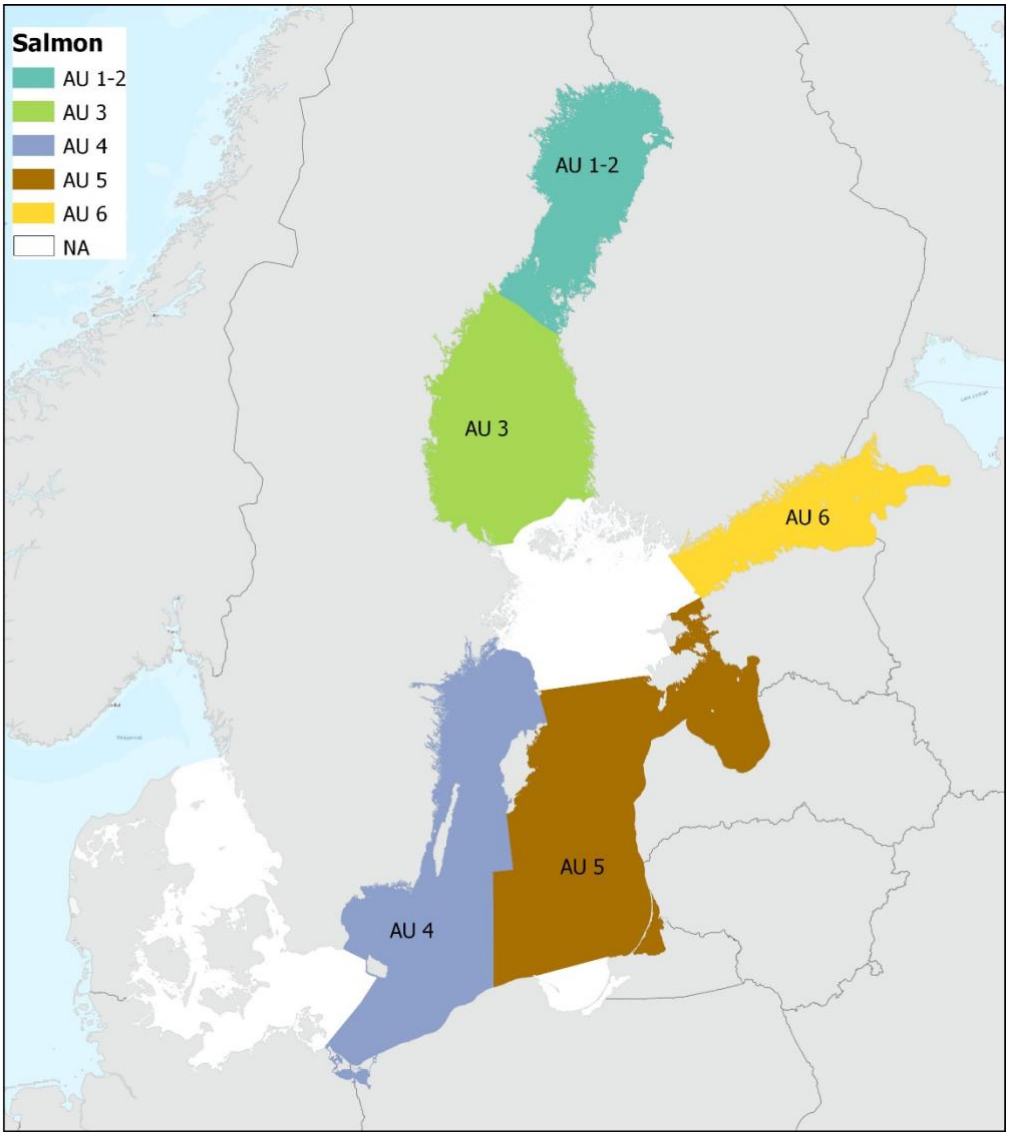

Figure 2. Spatial division of the Baltic Sea used in the state assessment of *Salmon*. Assessment is based on observed vs potential reproductive capacity of the rivers in each assessment unit (AU). The assessment units are adopted from ICES assessments.

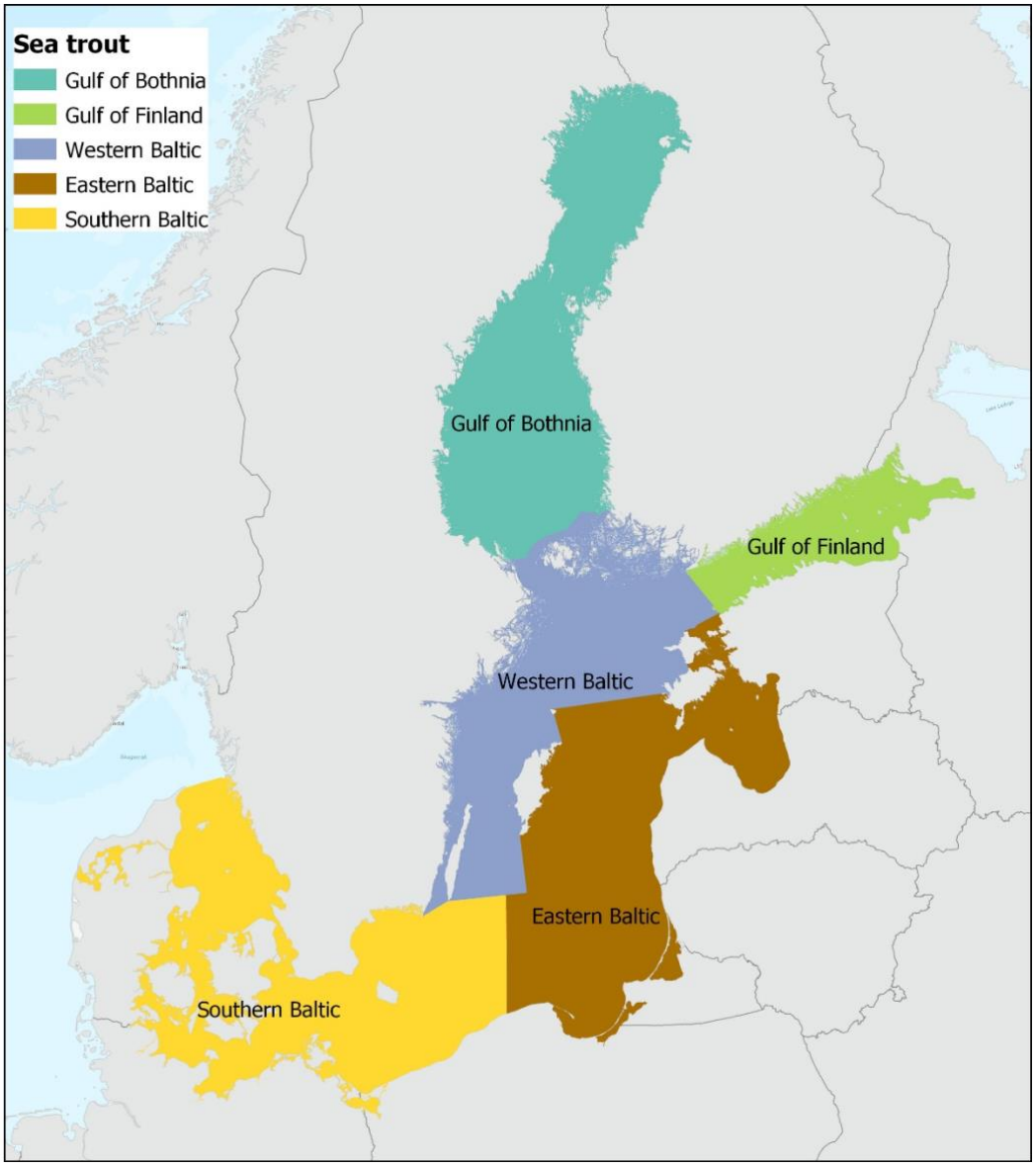

Figure 3. Spatial division of the Baltic Sea used in the state assessment of *Sea trout*.

Development of human activities

In addition to existing measures, changes in the extent of human activities may affect pressures over time. Four scenarios for future changes in human activities were developed: 1) no change, 2) low change, 3) moderate (most likely) change, and 4) high change. These alternative scenarios aim to capture uncertainties and variation in the future development of human activities. The results of the SOM analysis were estimated for each of the four scenarios to assess how the alternative assumptions on the development of human activities affect the findings. Detailed results are presented for the most likely development scenario, and implications of using the other scenarios on the results are reviewed in the discussion section.

The scenarios specify a percent change in each activity in 2016-2030 based on existing information and projections from the Baltic Sea region (for details and references, see the methodology report). Change scenarios were made only for predominant activities in the Baltic Sea region, including agriculture, forestry, waste waters, (commercial) fish and shellfish harvesting, aquaculture, renewable energy production, tourism and leisure activities, transport shipping and transport infrastructure. Other activities are assumed to stay unchanged. This means that only 9 of the 31 standard SOM activities have change scenarios in the SOM analysis. This results in varying influence of these scenarios on the results across topics, pressures and state components, depending on the significance of the activities to the pressure inputs relevant to the topic.

Development scenarios have been made for fish and shellfish harvesting, which is the single activity that contributes to the targeted extraction and bycatch of migratory fish. However, in the most likely scenario, fishing is assumed to stay constant until 2030. The alternative low and high scenarios project a decrease and increase of 10% by 2030, respectively. Note that these development scenarios do not cover changes in the direct pressure to fish habitats or disturbance of species by obstructions (dams). More information on the development scenarios and source materials is given in section 9 of the methodology report.

The current situation with COVID-19 and its possible implications to the development of human activities is not reflected in the scenarios, as there is no information on the long-term effects it may have on the economy or activities. The current situation poses a challenge for choosing the most likely scenarios for the development of human activities, which has been done based on currently available information.

Results and interpretation

Background

The SOM results are presented in the format of percent shares or probabilities. The main finding of the analysis is the probability to achieve GES/environmental target or specific state improvements/pressure input reductions, taking into consideration the effects of existing measures and changes in the activities on pressure inputs. The contribution of activities to pressure inputs, the effect of measures on pressure inputs, and the significance of pressures to state components are presented as percent values (e.g. how many percent would the measure reduce the pressure input). Results are presented mainly in tables, which show the most likely (expected) values and standard deviations. Standard deviation is a way of showing the variation in the values. When it is high, values are spread over a wider range, and when it is low, values are closer to the most likely value. Figures and graphs presenting distributions are included in the annexes. They show the same results as the tables but allow either more detailed information or alternative visualisation of the results.

For the data that are based on expert surveys, the confidence rating gives the most common answer to experts' assessment of the confidence in their own survey responses on a low-moderate-high scale. More detailed information on how each result has been calculated is presented in a separate document.

This document presents the detailed results based on the expert-based data (survey responses). Literature data on the effectiveness of measures has been collected and included in an alternative model estimation. The impacts of using the literature data are evaluated in the discussion section. In the detailed results, the projected development of human activities is based on the most likely future development until 2030 (for details, see the methodology document), and the impacts of alternative scenarios on human activities are examined in the discussion section.

Format of presentation

The format the results are reported in different ways (not presented, qualitative/semi-quantitative, quantitative) depending on the type of result and the number of participating experts. Further, for all results utilizing other SOM results as input data, reporting is done at the most conservative standard used in the input data. In practice this means that if one input data point is reported as 'insufficient data', all results using that data point will also be reported as 'insufficient data'; similarly for qualitative/semi-quantitative data points. However, note that this standard is only applied in the case of data points actively used to calculate another result. For example, many measure types are hypothetical or otherwise not implemented in the Baltic Sea and therefore do not factor into results on projected pressure input reductions from existing measures. Insufficient data for such measure types does not affect reporting other results that rely on data for effectiveness of measure types. Results that do not meet the data standards described here and in greater detail below are marked with 'insufficient data' in the report.

For results concerning required pressure reductions and significance of pressures to state components, results with 2 or fewer respondents are not reported; results with 3 to 4 respondents will be either not reported, or qualitatively/semi-quantitatively reported based on feedback from the SOM topic teams or other HELCOM expert body; results with 5 or more respondents are reported quantitatively. This standard allows flexibility for reporting on assessments that are of spatially limited areas and therefore have fewer experts available to survey, while also being somewhat conservative in reporting fully quantitative results. For migratory fish, topic experts recommended presentation of fully quantitative results for results with 3 to 4 respondents. However, topic experts emphasized that used of the probability distributions in Annex 10 and 11 is highly recommended in such cases.

For expert-based effectiveness of measures results, measure types with 5 or more respondents are reported quantitatively and those with 4 or fewer respondents are listed as having insufficient data.

For migratory fish, results on the sufficiency of measures in achieving GES for salmon have been excluded for all assessment units, due to the lack of data to project the pressure reductions from existing measures. There is insufficient data on the effectiveness of many measure types, as less than 5 experts have contributed to the estimates. The other results components for salmon are presented, and results for eel and sea trout are presented for all elements. No activity-pressure expert data for migratory fish have been collected, because all fish-specific pressures are created by a single activity or are not dependent on activities but affect pressures or state directly.

Coverage of pressures in the SOM analysis

The SOM analysis has only been able to account for a portion of all pressures that affect the state components, and the effect of several significant pressures have not been included due to not being able to quantify the link between the pressure inputs, pressures and state components in the analysis. This means that the effect of reductions in these excluded pressures on the state components is not included in the total pressure reductions, and the projected total pressure reductions and probability to achieve GES or environmental target are underestimated. The share of pressures covered in the analysis has been calculated based on the significance of pressures to the state component in question. The share varies across topics and state components from low (around 20%) to high (more than 80%) (Tables 6.1-6.2).

Are existing measures sufficient for achieving good status?

For eel, the SOM analysis evaluates whether existing measures are sufficient in achieving the environmental target set by European Council Regulation No 1100/2007 by comparing the state improvement from existing measures to the state improvement required to achieve that environmental target. Eel populations were assessed by ICES (2019a) to be outside safe biological limits. For sea trout, the analysis assesses the sufficiency of measures in achieving specific state improvements (10%, 25% and 50% improvement in the abundance of parr). In the latest HOLAS assessment period (2011-2016), none of the sea trout assessment areas used in the SOM analysis were in a good state based on the one-out-all-

out approach. However, populations were generally in good status in the Gulf of Riga, western and south-western Baltic and not in good status in the south-eastern and northern Baltic.

Overall, the results indicate that the probability to achieve GES/environmental target or state improvements for migratory fish with existing measures is often very low or low (Table 3). Reductions in total pressures are close to zero for eel and 5-20% for sea trout. The probability to achieve its environmental target for eel is close to zero. For sea trout, probability of a 10% state improvement in the Gulf of Finland is low to moderate, and close to zero in all other sub-areas. Results for salmon are not presented due to insufficient data.

In the case of migratory fish, the SOM analysis has been able to account for 25-55% of the pressures linked to the state components (pressures highlighted in white in Table 6). This percentage reflects the share of pressures that 1) have a quantifiable link to the fish state components and 2) have measures types that affect them in the SOM analysis. It has been calculated based on the significance of pressures affecting migratory fish (Table 6), and represents the maximum pressure reduction that could be achieved if the pressures linked to migratory fish species in the SOM analysis were eliminated. The effects of several significant pressures are not included in this total, such as river, lake, or land habitat loss/degradation, effects of eutrophication, and human-induced food web imbalance (pressures highlighted in grey in Table 6). Although some of these pressures are expected to decrease based on the results of the SOM analysis, the analysis is not able to estimate how this would affect the state of migratory fish. Thus, the total pressure reductions and probability to achieve GES/environmental target/state improvements are underestimated.

The results are presented as the probability of achieving GES/environmental target/state improvements with the projected total pressure reduction by fish species and sub-area. Table 3 shows the expected total pressure reductions from existing measures, the probability to achieve GES/environmental target or a specific state improvement with such a pressure reduction, and the maximum pressure reduction that could be achieved with the fully quantified pressures in the SOM analysis. Total pressure reductions are calculated based on the reduction in the pressures affecting migratory fish (Table 8), significance of different pressures to migratory fish (Table 6), and spatial weighting to account for the target area of existing measures. The format of the results depends on whether an established HELCOM GES threshold or other environmental target exists for the state component (species and geographic area) in question. Results with 2 or fewer responding experts are not shown due to insufficient data.

For *eel*, the expected total pressure reduction from existing measures in the Baltic Sea is close to zero, and the findings suggest that the probability to achieve its environmental target is close to zero. The findings for *sea trout* suggest that the expected pressure reductions range from 5 to 20%, which results in a very low probability to achieve state improvements in all sub-areas except the Gulf of Finland, where the probability to achieve a 10% improvement in the abundance of sea trout is 0-40%. Results on total pressure reductions and probability to achieve state improvements for *salmon* are not presented due to insufficient data.

Table 4 presents the total pressure reduction required to reach GES/environmental target or a specific state improvement for each fish species by sub-area, based on the expert responses. The required pressure reduction to achieve GES for salmon ranges between 40%

and 60%, depending on the assessment unit. For eel, the required pressure reduction to achieve its environmental target is estimated to be around 60%. For sea trout, pressure reductions of 20-50% are required to achieve 10% state improvements, depending on the sub-area. There is some uncertainty about the required pressure reductions, particularly for eel, but the certainty of the estimates is most often high. The certainty is partly explained by group responses, which reduces the standard deviations. Expert's confidence in their own responses to the question on total pressure reduction required is low-high for salmon, moderate for eel and low or moderate for sea trout.

Distributions of expert responses on the required pressure reductions to achieve GES/environmental target/state improvements are included in Annex 10. The figures indicate that experts have differing opinions about the pressure reductions required and that there is substantial uncertainty about the required pressure reductions (multiple peaks, wide distributions). Thus, these graphs provide further evidence that there is considerable uncertainty about the link between pressure reductions and achieving improvements in state.

One potential source of the differing opinions could be variation in river stocks within an assessment area. In other words, improvement may have been observed for some/most of stocks in the assessment unit in the last 8 years under the realised fishing pressure but not for others. Some experts may interpret that evidence as an indication that further reduction in fishing pressure will not improve the status of certain stocks (because of e.g. poor water quality in river habitat), while other experts may consider the evidence in a more general manner and may give more weight to the positive development observed in the stronger rivers and give less weight to the weaker ones.

Table 3. Sufficiency of measures in achieving GES/environmental targets or specific state improvements for migratory fish. The table presents the expected values and the 10-90 percentile in brackets, which shows the range in which 80% of the observations fall in. When a GES threshold or environmental target exists, the result shows the probability to achieve GES/the environmental target with expected pressure reduction. When there is no GES threshold or environmental target, the table shows the probability to achieve specific state improvement (10%, 25% and 50%) with expected pressure reduction.

State	**Assessment area**	**Total pressure reduction (%)** [10 percentile – 90 percentile]	**Probability to achieve GES/environmental targets (%) with expected pressure reduction** [10 percentile – 90 percentile]	**Probability (%) to achieve specific state improvement with expected pressure reduction** [10 percentile – 90 percentile]			**Maximum possible pressure reduction due to model coverage (%)**
				10% state improvement	**25% state improvement**	**50% state improvement**	
Salmon AU	AU 1-2	Insufficient data					
	AU 3	Insufficient data					
	AU 4	Insufficient data					
	AU 5	Insufficient data					
	AU 6	Insufficient data					
Eel	Baltic Sea	2 [1-3]	0 [0-0]				26
Sea trout	Gulf of Bothnia	7 [4-10]		0 [0-0]	0 [0-0]	0 [0-0.0]	45
	Gulf of Finland	15 [9-20]		18 [0-42]	1 [0-4]	0 [0-0]	56
	Western Baltic	6 [4-10]		0 [0-2]	0 [0-0]	0 [0-0]	41
	Eastern Baltic	9 [6-12]		0 [0-7]	0 [0-0]	0 [0-0]	46
	Southern Baltic	6 [4-8]		0 [0-0]	0 [0-0]	0 [0-0]	24

Data used: expert estimates of effectiveness of measure types, information on existing measures, expert estimates of significance of pressures to state components, expert estimates of required pressure reductions to achieve GES/state improvements, literature and projections on development of human activities

Table 4. Total pressure reduction required to reach GES/environmental target (salmon/eel) or specific state improvements (sea trout) for migratory species. Standard deviation is given in parentheses. Confidence depicts the most common rating of expert's confidence in their own responses to the question on total pressure reduction required to reach GES/environmental target/specific state improvements.

State	**Salmon, assessment units 1-2**	**Salmon, assessment unit 3**	**Salmon, assessment unit 4**
Most likely pressure reduction required (%)	41 (14) ○●●	48 (7) ●●●	62 (18) ●●●
Confidence	Low	Low	Low
Number of experts	7	7	9
State	**Salmon, assessment unit 5**	**Salmon, assessment unit 6**	
Most likely pressure reduction required (%)	63 (9) ●●●	59 (17) ●●●	
Confidence	High	Moderate	
Number of experts	4	4	
State	**Eel - Entire Baltic Sea**		
Most likely pressure reduction required (%)	60 (22) ○●●		
Confidence	Moderate		
Number of experts	10		
State	**Sea trout, Gulf of Bothnia**		
	10% state improvement	**25% state improvement**	**50% state improvement**
Most likely pressure reduction required (%)	48 (10) ●●●	51 (5) ●●●	59 (0) ●●●
Confidence	Moderate	Moderate	Moderate
Number of experts	6	6	6
State	**Sea trout, Gulf of Finland**		
	10% state improvement	**25% state improvement**	**50% state improvement**
Most likely pressure reduction required (%)	19 (3) ●●●	32 (7) ●●●	56 (4) ●●●
Confidence	Moderate	Moderate	Moderate
Number of experts	3	3	3
State	**Sea trout, Western Baltic**		
	10% state improvement	**25% state improvement**	**50% state improvement**
Most likely pressure reduction required (%)	47 (12) ●●●	50 (9) ●●●	52 (4) ●●●
Confidence	Low	Low	Low
Number of experts	6	6	6
State	**Sea trout, Eastern Baltic**		
	10% state improvement	**25% state improvement**	**50% state improvement**

Most likely pressure reduction required (%)	30 (15) ○●●	32 (7) ●●●	47 (2) ●●●
Confidence	Low	Low	Low
Number of experts	3	3	3
State	**Sea trout, Southern Baltic**		
	10% state improvement	**25% state improvement**	**50% state improvement**
Most likely pressure reduction required (%)	43 (12) ●●●	45 (6) ●●●	58 (3) ●●●
Confidence	Low	Low	Low
Number of experts	8	8	8

Colour scale for the percent reduction in pressures required to reach GES/environmental target in percent (based on the expected value): 0-10%, 10-20%, 20-40%, 40-60%, 60-100%
Categories for the certainty of the reduction required estimate (based on the relative size of the standard deviation to the expected value): low: ○○●, moderate: ○●●, high: ●●●
Data used: expert estimates of required pressure reductions to achieve GES/state improvements

What are the time lags between pressure and state?

Information on time lags between pressures and state of migratory fish was collected from experts, who evaluated how long it would take to achieve GES/environmental target assuming sufficient measures were implemented. Table 5 shows the distribution and average of the answers for migratory fish.

The longest time lags between pressure reductions and state are projected for eel, on average as long as 50 years. Time lags for salmon and sea trout are shorter, ranging on average from 5 to 20 years.

Main reported factors contributing to the time lag for eel were long generation times. For salmon and sea trout, life span and life cycle dynamics were stated to contribute to time lags the most often. In addition, ecosystem and food web recovery times were occasionally mentioned for sea trout, while experts named several reasons for salmon, such as lack of remaining wild populations, eutrophication, and food web re-establishment.

Table 5. Time lags in achieving GES/environmental target/state improvements with sufficient measures for migratory fish. The values in the row 'Number of experts' includes experts with excluded responses.

Time lag	Salmon					Sea trout					Eel
	AU 1-2	AU 3	AU 4	AU 5	AU 6	Gulf of Bothnia	Gulf of Finland	Western Baltic	Eastern Baltic	Southern Baltic	Entire Baltic Sea
0 years (no time lag)	0	0	0	0	0	0	0	0	0	0	0
0-5 years	1	1	0	0	1	0	0	0	0	2	0
6-10 years	6	6	6	0	3	6	3	6	3	7	0
11-25 years	0	0	3	4	0	0	0	0	0	1	4
26-50 years	0	0	0	0	0	0	0	0	0	0	6
51-100 years	0	0	0	0	0	0	0	0	0	0	0
More than 100 years	0	0	0	0	0	0	0	0	0	0	1
Excluded	0	0	0	0	0	0	0	0	0	0	0
Average	6.8	6.8	10.8	17.5	6.3	7.5	7.5	7.5	7.5	7.5	40.8
SD	1.8	1.8	4.7	0.0	2.2	0.0	0.0	0.0	0.0	3.9	37.6
Confidence	High	High	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Number of experts	7	7	9	4	4	6	3	6	3	10	11

Data used: expert estimates of time lags

What are the pressures contributing to the state components?

Tables 6.1 and 6.2 show the significance of pressures affecting migratory fish (salmon, eel, sea trout). They enable comparison across species/species groups and geographic areas. Overall, 13 different pressures are found to be significant to migratory fish, and the most significant pressures are the *extraction of fish* and *river, lake, or land habitat loss/degradation*, followed by *species disturbance: obstructions and collisions* and *effects of eutrophication*.

Experts' confidence in their own responses to the significance of pressures question was moderate or high.

Table 6.1. Significance of pressures (%) affecting salmon

State / Pressure	Salmon				
	AU 1-2	**AU 3**	**AU 4**	**AU 5**	**AU 6**
Extraction of fish (includes prey depletion)	27	29	22	20	30
Species disturbance or displacement by human presence	6				
Species disturbance: obstructions and collisions	11	11	4	11	17
Physical loss of marine habitats			4	5	
Effects of eutrophication	4	4	12	11	6
River, lake, or land habitat loss/degradation	32	33	30	27	34
Organohalogen pollution (e.g. PFOS, PCBs, PBDEs, dioxins)	6	7			
Effects of pressures occurring outside the Baltic Sea region (migratory species only)			3	3	
Change in hydrologic conditions	6	9	17	15	8
Human-induced food web imbalance	6	7	8	9	6
Confidence	High	High	High	High	High - Moderate
Number of experts	7	7	9	4	4

Colour scale for the significance of the pressure to the state variable (based on the expected value):
0-10%, 10-20%, 20-40%, 40-60%, 60-100%
Pressures for which we cannot quantify the link between the pressure input, pressure and state in the SOM analysis are highlighted in grey, e.g. we cannot link reductions in nutrient inputs to reductions in the effects of eutrophication and further to abundance of fish.
Data used: expert estimates of significance of pressures to state components

Table 6.2. Significance of pressures (%) affecting eel and sea trout

State / Pressure	Eel	Sea trout				
	Baltic Sea	**Gulf of Bothnia**	**Gulf of Finland**	**Western Baltic**	**Eastern Baltic**	**Southern Baltic**
Extraction of fish (includes prey depletion)	14	30	32	26	28	17
Species disturbance or displacement by human presence						10
Species disturbance: obstructions and collisions	9	16	24	15	10	3
Physical disturbance of marine habitats	1					

Physical loss of marine habitats	2				8	4
Effects of eutrophication	3	19	9	21	8	17
River, lake, or land habitat loss/degradation	23	32	35	29	26	31
Hydrocarbon pollution	1					
Organohalogen pollution (e.g. PFOS, PCBs, PBDEs, dioxins)	7					
Heavy metal pollution	6					
Effects of pressures occurring outside the Baltic Sea region (migratory species only)	30				5	3
Change in hydrologic conditions					15	13
Human-induced food web imbalance	4	3		9		1
Confidence	Moderate	High	Moderate	Moderate	Moderate	Moderate
Number of experts	11	6	3	6	3	9

Colour scale for the significance of the pressure to the state variable (based on the expected value):
0-10%, 10-20%, 20-40%, 40-60%, 60-100%
Pressures for which we cannot quantify the link between the pressure input, pressure and state in the SOM analysis are highlighted in grey, e.g. we cannot link reductions in nutrient inputs to reductions in the effects of eutrophication and further to abundance of fish.
Data used: expert estimates of significance of pressures to state components

What are the state components most affected by fishing?

The data from the pressure-state expert surveys for hazardous substances, benthic habitats, birds, fish and mammals allow for identifying the state components most affected by the pressures related to fishing. These five expert surveys provide expert views on the significance of various pressures to the state components in the SOM analysis. The most affected state components are identified based on the percent contribution of different pressures to the state component. First, the average percent significance of pressures has been calculated by state component, and then the pressures having the highest averages have been identified. This approach will overemphasize pressures important to geographically smaller assessment areas and may impact the rankings, as no corrections to account for the sizes of the assessment areas have been applied. The ranking simply lists those state components in the SOM analysis most affected by the specific pressure.

Table 7 shows the state components most affected by the extraction of fish and bycatch in fishing gears. State components most affected by bycatch in fishing gears are bird species and harbour porpoise. The extraction of fish most impacts some species of commercial and coastal fish.

Table 7. Top five state components most affected by pressures related to fishing. Listing is based on Baltic-wide averages of the significance of pressures to state components presented in each respective topic report. Average number of expert responses for the state component is given in parenthesis (total response count for the state component divided by the number of geographic areas for the state component).

Pressure	1st most affected state component	2nd most affected state component	3rd most affected state component	4th most affected state component	5th most affected state component
Extraction of fish, includes prey depletion	Plaice (6.0)	Flounder (4.3)	Herring (7.8)	Sprat (16.0)	Perch and other coastal piscivores (4.8)
Bycatch in fishing gears, for birds and mammals only; excludes ghost nets	Red-throated diver (6.0)	Long-tailed duck (7.0)	Harbour porpoise (3.0)	Great cormorant (9.0)	

Less than five most affected state components are presented in cases where there is insufficient data for some state component(s) affected by the pressure, i.e. there are not enough expert responses to the significance of pressures to the state component in the survey (e.g. some mammals species). This corresponds to the criteria for the format of presentation.
Data used: expert estimates of significance of pressures to state components for all topics

What are the reductions in pressures from existing measures?

Table 8 shows the effects of existing measures in reducing the pressures on migratory fish at the scale of the Baltic Sea in 2016-2030, considering the changes in the extent of human activities. They are calculated using the data on effectiveness of measure types, links between existing measures and measure types, and projected development of human activities. Projected reductions are presented as the weighted average of each assessment unit for each listed taxonomic grouping.

As the effectiveness of measures data are at the Baltic Sea level, the total pressure reductions are presented as an average for the entire Baltic Sea.

The *targeted extraction and bycatch of sea trout* is projected to be reduced to a moderate extent at the Baltic Sea scale. The certainty of the estimate is evaluated as high. No changes in the *targeted extraction and bycatch of eel* are projected. For *disturbance of species: obstructions (dams)*, low reductions are projected for all species. The certainty of the estimates is moderate.

The projected pressure reduction in targeted extraction and bycatch is based only on the estimated effects of existing measures, as fish and shellfish harvesting is projected to stay constant until 2030 in the most likely development scenario for human activities.

Further details on the effectiveness of different measure types can be found in Table 9.

Table 8. Projected pressure reductions (%) from existing measures on migratory fish in 2016-2030. The table depicts the most likely/expected values of total pressure reductions and gives standard deviation in parenthesis. Projected reductions are presented as the weighted average of each assessment unit for each listed taxonomic grouping.

Pressure	**Targeted extraction and bycatch**			**Disturbance of species: obstructions (dams)**		
Area	**Salmon**	**Sea trout**	**Eel**	**Salmon**	**Sea trout**	**Eel**
Baltic Sea	Insufficient data	24 (7) ●●●	1 (1) ○○●	7 (3) ○●●	9 (3) ○●●	8 (3) ○●●

Colour scale for the pressure reductions in percent (based on the expected value):
0-10%, 10-20%, 20-40%, 40-60%, 60-100%
Categories for the certainty of the pressure reductions (based on the relative size of the standard deviation to the expected value): low: ○○●, moderate: ○●●, high: ●●●
Data used: expert estimates of effectiveness of measure types, information on existing measures

How effective are measure types in reducing pressures?

This section presents the percent effectiveness of measure types in reducing the *targeted extraction and bycatch of fish*, *direct pressure to fish habitats*, *disturbance of migratory species: obstructions (dams),* and measure types *directly affecting fish abundance*. The estimates are presented per activity when relevant, i.e. they portray the percent reduction in the pressure from the activity in question, and not in the total pressure across all activities. Information on the reductions over all activities contributing to the pressure is given in the section on the impacts of measure types. Data on the effectiveness of measure types originate from expert surveys and are at the Baltic Sea scale.

The effectiveness estimates can be compared across measure types to assess, on average, how effective they are in relation to each other in reducing the pressure from the specific activities, or across activities to assess which measure type could be the most effective for each activity. Results with 4 or fewer responding experts are excluded due to insufficient data.

Seasonal and spatial closures, as well as measures to reduce recreational and commercial fishing, appear among the most effective measure types to reduce *targeted extraction and bycatch of migratory fish* from *fish and shellfish harvesting* (Table 9.1). There is insufficient data on the effectiveness of several measure types for salmon.

Some measure types affect pressures or state directly rather than through activities. The effectiveness of measure types that reduce *direct pressure to riverine fish habitats* are presented in Table 9.2 and *disturbance of species: obstructions (dams)* in Table 9.3. Dam removals are evaluated to have the highest effectiveness to reduce both pressures. Effectiveness estimates for *direct pressure to fish habitats* are provided as a separate piece of additional information, and not included further in the SOM analysis (of pressure reductions and sufficiency of measures).

The effectiveness of *fish stocking programs to support existing populations* is presented in Table 9.4. These affect directly the state of migratory fish and are assessed to have moderate effectiveness for eel, salmon and sea trout. It is worth noting that it affects state directly and

thus a lower effectiveness estimate could have a larger overall impact compared to measure types affecting state through activities and pressures.

Overall, there is considerable uncertainty about the effectiveness of most measure types based on the standard deviations. The certainty of the estimates varies from low to high. Confidence of the estimates is most often high.

Table 9.1. Effectiveness of measure types (%) in reducing the *targeted extraction and bycatch of fish* from fish and shellfish harvesting (all gears, professional and recreational) for migratory fish (salmon, sea trout and eel). The effectiveness of a measure type is the percent reduction in the pressure resulting from a specific activity. The table depicts the expected values of effectiveness, and standard deviation is given in parenthesis. Estimates are presented by species. If the measure type has corresponding existing measure(s) that cover less than all the assessed species, the species with existing measures are listed in the column 'Has corresponding existing measures in the SOM analysis'.

Measure type ID	Species Measure type	Salmon	Sea trout	Eel	Has corresponding existing measures in the SOM analysis (Yes/No)
103	Technical measures to reduce catches of unwanted species	32 (15) ○●●	Insufficient data	23 (20) ○○●	No
104	Technical measures to reduce catches of unwanted sizes of fish	19 (14) ○○●	21 (15) ○○●	23 (19) ○○●	No
106	Measures to reduce recreational fishing (e.g. licenses)	Insufficient data	42 (11) ●●●	36 (21) ○●●	No
117	Measures to reduce inshore commercial fishing capacity	19 (27) ○○●	Not assessed	Not assessed	No
118	Measures to reduce offshore commercial fishing capacity	Insufficient data	Not assessed	Not assessed	No
107	Measures to reduce commercial fishing capacity	Not assessed	23 (22) ○○●	52 (23) ○●●	No
108	Catches of commercial fish in line with targets for MSY	Not assessed	33 (18) ○●●	24 (20) ○○●	No
109	Bag limits (e.g. daily/seasonal) in recreational fisheries	18 (21) ○○●	27 (22) ○○●	25 (20) ○○●	Yes (Salmon)
110	Ensure compliance with existing regulations (commercial and/or recreational)	36 (13) ○●●	Not assessed	Not assessed	No
111	Promotion of sustainable fisheries (commercial and/or recreational)	Insufficient data	31 (11) ○●●	31 (28) ○○●	Yes
112	CFP multi-annual plan	28 (10) ○●●	Not assessed	Not assessed	Yes
113	Inshore/river seasonal closures (commercial and/or recreational)	47 (8) ●●●	Not assessed	Not assessed	No
114	Offshore seasonal closures	49 (4) ●●●	Not assessed	Not assessed	No
121	Seasonal closures (commercial and/or recreational)	Not assessed	50 (16) ○●●	69 (17) ●●●	No
115	Inshore/river spatial closures (commercial and/or recreational)	Insufficient data	Not assessed	Not assessed	Yes
116	Offshore spatial closures	Insufficient data	Not assessed	Not assessed	No

Measure type ID	Species Measure type	Salmon	Sea trout	Eel	Has corresponding existing measures in the SOM analysis (Yes/No)
122	Spatial closures (commercial and/or recreational)	Not assessed	50 (17) ○●●	66 (17) ●●●	No
125	Inspection campaigns to reduce illegal fishing	Not assessed	36 (18) ○●●	41 (21) ○●●	No
141	Unspecified MPA fisheries restrictions	Insufficient data	27 (11) ○●●	18 (17) ○○●	Yes
119	Offshore catches of commercial fish in line with targets for MSY	27 (11) ○●●	Not assessed	Not assessed	No
120	Inshore catches of commercial fish in line with targets for MSY	28 (10) ○●●	Not assessed	Not assessed	No
123	National species management plans	Insufficient data	25 (12) ○●●	47 (31) ○○●	Yes (Salmon; Sea trout)
142	EU salmon discard plan	Insufficient data	Not assessed	Not assessed	Yes
	Confidence	High	High - Moderate	Moderate	
	Number of experts	5-6	5-7	5-9	

Colour scale for the effectiveness of a measure type in percent (based on the expected value):
0-10%, 10-20%, 20-40%, 40-60%, 60-100%
Categories for the certainty of the effectiveness estimate (based on the relative size of the standard deviation to the expected value): low: ○○●, moderate: ○●●, high: ●●●
Data used: expert estimates of effectiveness of measure types

Table 9.2. Effectiveness of measure types (%) in reducing *direct pressure to riverine fish habitats*. These measure types are included as additional information only and are not included in the calculation of pressure reductions and sufficiency of measures to reach GES/state improvements. They estimate the direct pressure reduction to loss of fish habitat rather than a reduction in pressure from any specific activity. The effectiveness of a measure type is the percent reduction in the pressure. The table depicts the expected values of effectiveness, and standard deviation is given in parenthesis.

Measure type ID	Direct pressure to fish habitats Measure type	Riverine fish habitat	Has corresponding existing measures in the SOM analysis (Yes/No)
126	Dam removal	75 (17) ●●●	Effectiveness values are not used in the SOM assessment and are advisory only
133	River and riparian habitat restoration/rehabilitation (excluding dam removal)	50 (29) ○●●	
134	Ensure minimum ecological flow	55 (18) ○●●	
134	Liming	32 (20) ○○●	
136	Actions to reduce/prevent input of nutrients and/or silt into water bodies	44 (23) ○●●	
	Confidence	High	
	Number of experts	13-15	

Colour scale for the effectiveness of a measure type in percent (based on the expected value):
0-10%, 10-20%, 20-40%, 40-60%, 60-100%
Categories for the certainty of the effectiveness estimate (based on the relative size of the standard deviation to the expected value): low: ○○●, moderate: ○●●, high: ●●●
Data used: expert estimates of effectiveness of measure types

Table 9.3. Effectiveness of measure types (%) in reducing the *disturbance of migratory species* (salmon, sea trout, eel). Obstructions caused by dams are not linked to any specific human activity due to unclear correlations with e.g. hydropower production and km of obstructed river. Therefore, the measure types reduce the pressure directly and not through activities. The effectiveness of a measure type is the percent reduction in the pressure. The table depicts the expected values of effectiveness, and standard deviation is given in parenthesis.

Measure type ID	Disturbance of species: obstructions (dams) Measure type	Salmon	Sea trout	Eel	Has corresponding existing measures in the SOM analysis (Yes/No)
126	Dam removal	73 (23) ○●●	72 (23) ○●●	72 (23) ○●●	Yes
127-129	Application of the best available solution for fish passage on existing obstructions	39 (29) ○○●	40 (29) ○○●	39 (30) ○○●	Yes
	Confidence	High	High	High	
	Number of experts	12-13	12	12-13	

Colour scale for the effectiveness of a measure type in percent (based on the expected value):
0-10%, 10-20%, 20-40%, 40-60%, 60-100%
Categories for the certainty of the effectiveness estimate (based on the relative size of the standard deviation to the expected value): low: ○○●, moderate: ○●●, high: ●●●
Data used: expert estimates of effectiveness of measure types

Table 9.4. Effectiveness of measure types (%) directly affecting fish abundance. The measure types improve the state directly and not through activities or pressures. The effectiveness of a measure type is the percent improvements in state. The table depicts the expected values of effectiveness, and standard deviation is given in parenthesis.

Measure type ID	Direct to fish abundance Measure type	Eel	Salmon and sea trout	Has corresponding existing measures in the SOM analysis (Yes/No)
138	Fish stocking programs to support existing populations	34 (31) ○○●	Not assessed	No
137	Fish stocking programs to support existing populations or reintroduce functionally extinct populations	Not assessed	41 (19) ○●●	No
	Confidence	High	High	
	Number of experts	17	9	

Colour scale for the effectiveness of a measure type in percent (based on the expected value):
0-10%, 10-20%, 20-40%, 40-60%, 60-100%
Categories for the certainty of the effectiveness estimate (based on the relative size of the standard deviation to the expected value): low: ○○●, moderate: ○●●, high: ●●●
Data used: expert estimates of effectiveness of measure types

Which activities contribute to pressures?

The activity-pressure contributions were not estimated for fish, as all fish specific pressures are created by a single activity (fishing) or are not dependent on activities but affect pressures or state directly (longitudinal connectivity of rivers).

What are the impacts of measure types?

The impacts of measure types show the impact of measure types on reducing the targeted extraction and bycatch of migratory fish, direct pressure to riverine fish habitats and disturbance of species: obstructions (dams) (Tables 11.1-11.2). They include the effectiveness of measure types and the contribution of activities to pressure. Thus, the impact shows how much the measure type reduces the pressure across all activities contributing to the pressure and give indications on which measures could be the most relevant in addressing specific pressures.

In the case of migratory fish, the effectiveness and impacts of measure types are the same, as the pressures originate from a single activity, or measure types affect pressures directly. The most impactful measures to reduce the targeted extraction and bycatch of migratory fish are those related to spatial and seasonal closures, as well as measures to reduce recreational and commercial fishing. Dam removal is the most impactful measure types to reduce direct pressure to riverine fish habitats and disturbance of species by obstructions.

What are the impacts of existing measures?

This section presents information about existing measures affecting the targeted extraction and bycatch of migratory fish and disturbance of species: obstructions (dams). In the SOM analysis, existing measures are those measures in current policy frameworks (e.g. BSAP, EU MSFD, EU WFD, EU Biodiversity Strategy 2020) that affect pressures and environmental state within the time frame of the analysis (2016-2030). This includes measures that have been implemented, are partially implemented or are planned to be implemented by 2030. Measures which have already been fully implemented and have fully affected pressures and environmental state by 2016 have been excluded, as no further improvement of status is expected during in 2016-2030. Information about existing measures was compiled through a literature review and from Contracting Parties.

The impact is the percent reduction in a specific pressure from implementing the measure in the relevant spatial area. It has been calculated based on the effectiveness of the measure, proxied by the effectiveness of the measure type it corresponds to, and the contribution of activities to the pressure in question. Similar to the impact of a measure type, the impact of an existing measure indicates how much the measure reduces the pressure across all activities contributing to the pressure.

Tables 11.1 and 11.2 present the impacts of existing measures in reducing the targeted extraction and bycatch and the disturbance of species: obstructions (dams) for migratory fish. The impacts are presented both for the Baltic Sea scale and for the area affected by the existing measure. In addition, information on the share of the Baltic Sea area affected by the

existing measure is included. Both the effectiveness of the measure and the spatial area affected are relevant for the impact at the Baltic Sea scale. Some existing measures may have high impact in the affected area, but their impact at the Baltic Sea scale is low because they only affect a small area, while some measures may have a relatively low impact in the affected area but affect a large share of the Baltic Sea.

There are five existing measures affecting the targeted extraction and bycatch of eel, ten affecting salmon and six affecting sea trout in the SOM analysis (Table 11.1). Impacts are low at the Baltic Sea scale for eel due to the limited application area of measures, although measures may have moderate impacts in the area affected. For salmon, *HELCOM salmon management plans* and *salmon discard plan* are the most impactful at the scale of the Baltic Sea, as they affect almost the entire sea area. For sea trout, *HELCOM sea trout management plans* have the highest impacts at the Baltic Sea scale. Many of the other measures for salmon and sea trout have moderate impacts in the area affected, but not at the scale of the Baltic Sea as they apply to limited areas.

The number of existing measures in reducing the disturbance of species: obstructions (dams) in the SOM analysis is three for eel and salmon and four for sea trout (Table 11.2). Impacts at the Baltic Sea scale are low due do small affected areas, but the measures have high impacts in the area affected. This applies particularly to *salmon river improvement*, which is the most impactful measure in the area affected for ell, salmon and sea trout.

Table 11.1. Impacts of existing measures in reducing the targeted extraction and bycatch of migratory fish. Impact is the percent reduction in a specific pressure from implementing the measure. Standard deviations are given in parenthesis. Note that values less than 0.5 have been rounded to zero. Measure name and description correspond to those used in Annex 4 for referencing purposes. In rare cases, the name and description may not be representative of the existing measure due to the free text reporting format used during existing measures data collection.

Species	Measure name	Description	Activities	Countries	Measure type	Impact at the Baltic Sea scale (%)	Impact in the area affected (%)	Affected area of the total Baltic Sea (%)
Eel	Continue to raise public awareness of sustainable, ecosystem-compatible fisheries (UZ4-01, M411)	Further anchoring of the topic "sustainable eco-system-appropriate fishing" in public awareness	Fishing	DE	Promotion of sustainable fisheries (commercial and/or recreational)	1 (1)	30 (28)	4
Eel	BALDE-M919-other	Fisheries management measures in Natura 2000 sites in the EEZ	Fishing	DE	Unspecified MPA fisheries restrictions	0 (0)	17 (16)	0
Eel	BALDE-M412-UZ4-02	Fisheries measures	Fishing	DE	Promotion of sustainable fisheries (commercial and/or recreational)	0 (0)	29 (28)	0
Eel	BALDE-M412-UZ4-02	Fisheries measures	Fishing	DE	Unspecified MPA fisheries restrictions	0 (0)	18 (17)	0
Eel	Fisheries measures (M412-UZ4-02)	o Fisheries management measures in Natura 2000 sites. Germany will develop 'common advices' for necessary fisheries restrictions in these areas, which will be developed with the federal states, stakeholders from the fisheries industry and NGOs involved in fisheries management o MSFD targets considered when developing the federal fisheries policies	Fishing	DE	Unspecified MPA fisheries restrictions	0 (0)	18 (16)	0

Species	Measure name	Description	Activities	Countries	Measure type	Impact at the Baltic Sea scale (%)	Impact in the area affected (%)	Affected area of the total Baltic Sea (%)
Salmon	Salmon management plans - HELCOM	Competent authorities to take immediate action for development of long-term management plans for commercially exploited fish stocks so that they are within safe biological limits and reach agreed targets, such as maximum sustainable yield, improve their distribution and size/age range (salmon)	Fishing	EU countries	CFP multi-annual plan	26 (6)	28 (7)	94
Salmon	Salmon discard plan	Article 3 Survivability exemption 1. By way of derogation from Article 15(1) of Regulation (EU) No 1380/2013, the landing obligation shall not apply to salmon caught with trap-nets, creels/pots, fyke-nets and pound nets. 2. Salmon caught without an available quota or below the minimum conservation reference size in the circumstances referred to in paragraph 1 shall be released back into the sea. [This regulation] shall apply from 1 January 2018 until 31 December 2020.	Fishing	EU countries	EU salmon discard plan	23 (8)	24 (9)	94
Salmon	Salmon management plans - HELCOM	Competent authorities to take immediate action for development of long-term management plans for commercially exploited fish stocks so that they are within safe biological limits and reach agreed targets, such as maximum sustainable yield, improve their distribution and size/age range (salmon)	Fishing	FI	National species management plans	5 (2)	27 (8)	20

Species	Measure name	Description	Activities	Countries	Measure type	Impact at the Baltic Sea scale (%)	Impact in the area affected (%)	Affected area of the total Baltic Sea (%)
Salmon	HELCOM conserve 10 salmon rivers	Actively conserve at least ten wild salmon river populations	Fishing	FI	Bag limits (e.g. daily/seasonal) in recreational fisheries	3 (4)	18 (20)	20
Salmon	Continue to raise public awareness of sustainable, ecosystem-compatible fisheries (UZ4-01, M411)	Further anchoring of the topic "sustainable eco-system-appropriate fishing" in public awareness	Fishing	DE	Promotion of sustainable fisheries (commercial and/or recreational)	1 (0)	31 (7)	4
Salmon	Salmon and sea trout protection	6. To prioritise the restoration of habitats of rivers that hold original salmon and sea trout populations that reproduce at a level of less than 50 % of PSPC and to apply a set of strict fishing rules for the management of river fisheries when the targeted salmon or sea trout populations reproduce at a level of less than 20 % of PSPC (cf. Annex 1).	Fishing	EE	Inshore/river spatial closures (commercial and/or recreational)	0 (0)	0 (0)	0
Salmon	BALDE-M919-other	Fisheries management measures in Natura 2000 sites in the EEZ	Fishing	DE	Unspecified MPA fisheries restrictions	0 (0)	28 (11)	0
Salmon	BALDE-M412-UZ4-02	Fisheries measures	Fishing	DE	Promotion of sustainable fisheries (commercial and/or recreational)	0 (0)	32 (7)	0
Salmon	BALDE-M412-UZ4-02	Fisheries measures	Fishing	DE	Unspecified MPA fisheries restrictions	0 (0)	28 (11)	0

Species	Measure name	Description	Activities	Countries	Measure type	Impact at the Baltic Sea scale (%)	Impact in the area affected (%)	Affected area of the total Baltic Sea (%)
Salmon	Fisheries measures (M412-UZ4-02)	o Fisheries management measures in Natura 2000 sites. Germany will develop 'common advices' for necessary fisheries restrictions in these areas, which will be developed with the federal states, stakeholders from the fisheries industry and NGOs involved in fisheries management o MSFD targets considered when developing the federal fisheries policies	Fishing	DE	Unspecified MPA fisheries restrictions	0 (0)	28 (11)	0
Sea trout	Salmon and sea trout protection	6. To prioritise the restoration of habitats of rivers that hold original salmon and sea trout populations that reproduce at a level of less than 50 % of PSPC and to apply a set of strict fishing rules for the management of river fisheries when the targeted salmon or sea trout populations reproduce at a level of less than 20 % of PSPC (cf. Annex 1).	Fishing	EE	Inshore/river spatial closures (commercial and/or recreational)	0 (0)	0 (0)	0
Sea trout	Sea trout management plans - HELCOM	Competent authorities to take immediate action for development of long-term management plans for commercially exploited fish species (sea trout) so that they are within safe biological limits	Fishing	All countries	National species management plans	25 (8)	25 (8)	100
Sea trout	Continue to raise public awareness of sustainable, ecosystem-compatible fisheries (UZ4-01, M411)	Further anchoring of the topic "sustainable eco-system-appropriate fishing" in public awareness	Fishing	DE	Promotion of sustainable fisheries (commercial and/or recreational)	1 (0)	32 (11)	4

Species	Measure name	Description	Activities	Countries	Measure type	Impact at the Baltic Sea scale (%)	Impact in the area affected (%)	Affected area of the total Baltic Sea (%)
Sea trout	BALDE-M919-other	Fisheries management measures in Natura 2000 sites in the EEZ	Fishing	DE	Unspecified MPA fisheries restrictions	0 (0)	27 (11)	0
Sea trout	BALDE-M412-UZ4-02	Fisheries measures	Fishing	DE	Promotion of sustainable fisheries (commercial and/or recreational)	0 (0)	32 (11)	0
Sea trout	BALDE-M412-UZ4-02	Fisheries measures	Fishing	DE	Unspecified MPA fisheries restrictions	0 (0)	27 (10)	0
Sea trout	Fisheries measures (M412-UZ4-02)	o Fisheries management measures in Natura 2000 sites. Germany will develop 'common advices' for necessary fisheries restrictions in these areas, which will be developed with the federal states, stakeholders from the fisheries industry and NGOs involved in fisheries management o MSFD targets considered when developing the federal fisheries policies	Fishing	DE	Unspecified MPA fisheries restrictions	0 (0)	26 (11)	0

Data used: information about existing measures and their spatial scale, expert estimates of effectiveness of measures types
Full activity names:

- Fish and shellfish harvesting (all gears, professional, recreational)

Table 11.2. Impacts of existing measures in reducing the disturbance of species: obstructions (dams). Impact is the percent reduction in a specific pressure from implementing the measure. Standard deviations are given in parenthesis. Note that values less than 0.5 have been rounded to zero. Measure name and description correspond to those used in Annex 4 for referencing purposes. In rare cases, the name and description may not be representative of the existing measure due to the free text reporting format used during existing measures data collection.

Species	Measure name	Description	Activities	Countries	Measure type	Impact at the Baltic Sea scale (%)	Impact in the area affected (%)	Affected area of the total Baltic Sea (%)
Eel	Salmon river improvement	a) to undertake all necessary measures feasible to improve the environmental conditions in present and potential salmon rivers to facilitate future natural reproduction of salmon. Such measures can be improvement of water quality and quantity, restoration of rearing habitats, removal of man-made mechanical obstacles or by other measures facilitating salmon migration;	Direct to pressure	EE	Dam removal	6 (2)	72 (23)	8
Eel	Salmon and sea trout recovery	1. To take urgent measures for the recovery of the original salmon and sea trout populations that reproduce at a level of less than 50 % of the potential smolt production capacity (PSPC). The list of original salmon populations that based on recent smolt production data reproduce at a level of less than 50 % of PSPC are listed in Annex 1.	Direct to pressure	PL	Application of the best available solution for fish passage on existing obstructions (eel)	2 (1)	41 (30)	5
Eel	Salmon river improvement	a) to undertake all necessary measures feasible to improve the environmental conditions in present and potential salmon rivers to facilitate future natural reproduction of salmon. Such measures can be improvement of water quality and quantity, restoration of rearing habitats, removal of man-made mechanical obstacles or by other measures facilitating salmon migration;	Direct to pressure	LT	Application of the best available solution for fish passage on existing obstructions (eel)	1 (0)	40 (30)	2

Species	Measure name	Description	Activities	Countries	Measure type	Impact at the Baltic Sea scale (%)	Impact in the area affected (%)	Affected area of the total Baltic Sea (%)
Salmon	Salmon river improvement	a) to undertake all necessary measures feasible to improve the environmental conditions in present and potential salmon rivers to facilitate future natural reproduction of salmon. Such measures can be improvement of water quality and quantity, restoration of rearing habitats, removal of man-made mechanical obstacles or by other measures facilitating salmon migration;	Direct to pressure	EE	Dam removal	6 (2)	72 (23)	8
Salmon	River restoration plans	Develop restoration plans (including restoration of spawning sites and migration routes) in suitable rivers to reinstate migratory fish species	Direct to pressure	FI	Application of the best available solution for fish passage on existing obstructions (salmon)	1 (1)	39 (29)	2
Salmon	Salmon river improvement	a) to undertake all necessary measures feasible to improve the environmental conditions in present and potential salmon rivers to facilitate future natural reproduction of salmon. Such measures can be improvement of water quality and quantity, restoration of rearing habitats, removal of man-made mechanical obstacles or by other measures facilitating salmon migration;	Direct to pressure	LT	Application of the best available solution for fish passage on existing obstructions (salmon)	1 (0)	36 (29)	2
Sea trout	Salmon river improvement	a) to undertake all necessary measures feasible to improve the environmental conditions in present and potential salmon rivers to facilitate future natural reproduction of salmon. Such measures can be improvement of water quality and quantity, restoration of rearing habitats, removal of man-made mechanical obstacles or by other measures facilitating salmon migration;	Direct to pressure	SE	Dam removal	6 (2)	72 (23)	8

Species	Measure name	Description	Activities	Countries	Measure type	Impact at the Baltic Sea scale (%)	Impact in the area affected (%)	Affected area of the total Baltic Sea (%)
Sea trout	Salmon and sea trout recovery	1. To take urgent measures for the recovery of the original salmon and sea trout populations that reproduce at a level of less than 50 % of the potential smolt production capacity (PSPC). The list of original salmon populations that based on recent smolt production data reproduce at a level of less than 50 % of PSPC are listed in Annex 1.	Direct to pressure	PL	Application of the best available solution for fish passage on existing obstructions (seatrout)	2 (1)	41 (29)	5
Sea trout	River restoration plans	Develop restoration plans (including restoration of spawning sites and migration routes) in suitable rivers to reinstate migratory fish species	Direct to pressure	FI	Application of the best available solution for fish passage on existing obstructions (seatrout)	1 (1)	41 (30)	2
Sea trout	Salmon river improvement	a) to undertake all necessary measures feasible to improve the environmental conditions in present and potential salmon rivers to facilitate future natural reproduction of salmon. Such measures can be improvement of water quality and quantity, restoration of rearing habitats, removal of man-made mechanical obstacles or by other measures facilitating salmon migration;	Direct to pressure	LT	Application of the best available solution for fish passage on existing obstructions (seatrout)	1 (0)	40 (29)	2

Data used: information about existing measures and their spatial scale, expert estimates of effectiveness of measures types

Background of respondents

For the effectiveness of measures survey for fish (common for coastal, commercial and migratory fish), altogether 24 survey responses with 37 contributing experts were received. Six of the answers were group responses with two to eight contributing experts. The migratory fish portion of the effectiveness of measure survey had altogether 13 survey responses and 23 contributing experts (with three group responses from two to eight experts each). For the pressure-state survey for migratory fish, 15 responses from 23 experts were received. Three group responses were received for the pressure-state survey for migratory fish, with two to five contributing experts, depending on the sub-topic.

The number of experts contributing to the migratory fish surveys is shown in Table 10, with the sub-topic division and geographic area presented in Table 11.

More detailed information about the background of the experts participating in the effectiveness of measures and the pressure-state surveys is available. Experts stated most often fish research and fisheries as their respective field, followed by aquatic sciences, marine ecology, migration of fish and MSFD/WFD. For both surveys, more than half of the experts had 10-20 or over 20 years of experience (Table 12). Experts represented research institutions, NGOs, or ministries.

Table 10. Number of experts contributing to the fish surveys for migratory fish

Survey	DE	DK	EE	FI	LT	LV	PL	RU	SE	Total
Effectiveness of measures (all fish groups)	5	5	3	6	2	-	3	-	13	37
Effectiveness of measures (migratory fish)	4	-	2	3	1	-	1	-	12	23
Pressure-state linkages (migratory fish)	6	-	3	2	1	-	2	-	9	23

Table 11. Number of responses to the fish surveys

Survey	Sub-topic	Geographic area	Response count
Effectiveness of measures		Whole Baltic	36
Pressure-state (migratory fish)	Salmon in assessment units 1-2		7
	Salmon in assessment unit 3		7
	Salmon in assessment unit 4		9
	Salmon in assessment unit 5		4
	Salmon in assessment unit 6		4
	Sea trout - Gulf of Bothnia		6
	Sea trout - Gulf of Finland		3
	Sea trout - Western Baltic		7
	Sea trout - Eastern Baltic		3
	Sea trout - Southern Baltic		10
	Eel - Entire Baltic Sea		11

Table 12. Years of experience in the field for the fish surveys

	Effectiveness of measures		Pressure-state (migratory fish)	
Years of experience	**Number of experts**	**Share of experts**	**Number of experts**	**Share of experts**
0-2 years	1	3 %	3	13 %
3-5 years	3	8 %	0	0 %
5-10 years	10	27 %	8	35 %
10-20 years	10	27 %	7	30 %
over 20 years	13	35 %	5	22 %

Discussion

Impact of alternative scenarios for development of human activities

The detailed results are presented for the most likely development scenario for the extent of human activities in 2016-2030. In addition, three other development scenarios were estimated: no change, low change and high change scenarios. These scenarios cover 9 out of the 31 activities in the SOM analysis. The extent of other activities is assumed to remain constant in all scenarios.

As activities contribute to pressures, their assumed change over time affects the pressure reductions and probability to achieve state improvements. The impact depends on what extent the activities contributing to the specific pressure are covered in the change scenarios. For migratory fish, the activity that contributes to the targeted extraction and bycatch of fish is fish and shellfish harvesting, and it is covered in the change scenarios. In the most likely scenario, no changes in the extent of fishing are projected until 2030. The alternative low and high scenarios project a decrease and increase of 10% by 2030, respectively.

Overall, the impact of alternative development scenarios on projected pressure reductions is not very significant for migratory fish, as the projected changes in fish and shellfish harvesting by 2030 are relatively small in both the low and high scenarios. Decrease in fish and shellfish harvesting results in somewhat larger pressure reductions, while increase leads to smaller pressure reductions (±6%). Effects on the total pressure reductions and the probability to achieve the environmental target/state improvements for eel and sea trout are negligible.

Impact of using literature data on effectiveness of measures

In addition to survey data from experts, literature data on the effectiveness of measures has been compiled. The literature data points have been used in a similar way as the expert survey responses, and when it has been available, it has been used to replace the expert estimates of the effectiveness of the measure type. However, literature estimates are not available for all measure types. Thus, it is not possible to implement the model estimation and provide the results relying entirely on the literature data on effectiveness of measure types. Thus, the model including the literature estimates is a combination of literature and expert data on effectiveness of measure types. The origin of other data components is not affected.

For migratory fish, only 4 estimates from 3 studies could be included in the SOM model. The projected pressure reductions from existing measures are not affected by the inclusion of literature data, as few of the implemented measure types have literature data. Thus, the results on total pressure reductions or sufficiency of measures to achieve GES/environmental target or specific state improvements do not change.

Evaluation of quality and confidence

The SOM analysis for migratory fish has been able to assess the sufficiency of existing measures to achieve GES/environmental target for some species and sub-areas, but not all of them, as no GES thresholds were available. Additionally, some results for salmon have been left out due to too few data points, including total pressure reductions and sufficiency of measures for achieving state improvements.

The overall certainty of the assessment for migratory fish could be characterized as low. Experts from six coastal countries contributed to the effectiveness of measures and pressure-state assessment. The total number of experts contributing to the surveys is high for both the effectiveness of measures and pressure-state part, but some individual elements suffer from a low amount of data. Additionally, the linear nature of riverine habitat is poorly represented in the SOM analysis which increases uncertainty of e.g. the effects of dam removal/fish passage installation and overall coverage of pressures important to migratory fish is low (Tables 6.1 and 6.2). The results on the sufficiency of measures to achieve GES for salmon have been excluded due to lack of data on the effectiveness of measure types. Further, the results on the effectiveness of measure types are rather uncertain. As the effects of some important pressures to the state of migratory fish have not been estimated within the analysis, the pressure reductions and probability to achieve GES/environmental target/state improvements are likely underestimated.

Quality and precision could potentially be improved with the collection of additional expert responses, particularly for salmon, but significant changes to the assessment structure are recommended before further work is conducted on the topic of migratory fish (see section Lessons learned).

For the individual results, certainty ranges from low to high for the effectiveness of measures types, and from moderate to high for the projected reductions in pressures. Group responses to the pressure-state expert survey have resulted in a lower variation in the data for the required pressure reductions to achieve state improvements, and thus its certainty is somewhat difficult to evaluate. These uncertainties should be kept in mind, in particular when examining the numeric estimates.

The most common confidence level experts reported for their own evaluations is moderate or high for the effectiveness of measures and significance of pressures to state components. For the estimates of required pressure reductions, it is low-high for salmon, moderate for eel, and low or moderate for sea trout.

There were some technical challenges that affected the survey implementation. Firstly, there was a problem in the survey software for the effectiveness of measure types survey that resulted in losing some responses. The original responses became often unusable, as it was not possible to identify which items had been skipped on purpose and which were lost data. This issue was addressed by sending follow-up invitations for experts to review and, when needed, complement their original saved response. Not all experts participated in the review and those responses had to be deleted from the final sample, thus the final numbers presented above represent only those with completed and reviewed responses. Secondly, the simultaneous assessment of effectiveness of a measure type and certainty of that effectiveness proved in some cases difficult, as it required placing non-quantitative dots in a coordinate system to generate quantitative estimates. The dots were translated into

effectiveness and certainty values between 0 and 100. Some experts would have preferred that the quantitative estimates would have been visible and could have been transparently influenced.

When interpreting the results, the assumptions and generalizations that were made when collecting the input data and defining and using the data on measure type effectiveness and pressure-state linkages need to be taken into account. The input data are based mainly on expert elicitations rather than existing models and data, and reflect substantial uncertainty. For more information on the SOM methodology, data collection and assumptions, see this document. Additionally, Annexes 10 and 11 are valuable resources for interpreting the effectiveness of measures and required pressure reductions. The probability distributions more fully capture the uncertainty of these estimates and therefore provide a more complete perspective.

Reflection on measure types

Much credit should go to the participants of the HELCOM Workshop on the analyses of Sufficiency of Measures (SOM) for Fish (SOM-FISH WS 1-2019) for their contributions to the formation of the measure types for fish. The fishing measures types are a model for intra-topic consistency and overall clarity. Some modest species-specific adaptations were made for measure types related to salmon fisheries, but these have not raised any concerns. Like all topics, review of these measure types should be conducted before they are applied in any future analysis.

The measure types on direct pressure to riverine fish habitats and fish stocking are a separate issue that suffers from the unique challenges related to the linear nature of river habitats (discussed below in Lessons learned) and the focused view of the SOM assessment on a single metric, abundance of migratory fish. The effectiveness of measure types that affect riverine fish habitats directly have no effect on the outcome of the SOM analysis, as these measure types are only advisory. The evaluation of the measure type on fish stocking is perhaps hampered by the focus on abundance of specific age-groups rather than population health. Stocking is not a purely positive activity, but the abundance of the stocked species clearly increases. Further, the amount of increase is related to the size of the stocking effort and may be better represented through a purely mathematical assessment of the size of the stocking effort compared to the size of the existing population. Further development of measure types that are highly dependent on the magnitude of the action undertaken is required.

When it comes to fishing closures, ICES salmon assessments show that some stocks don't recover even under a zero-fishing scenario. However, despite being an unlikely option to become implemented, the total closure of fishing could be included as a measure type in a future SOM analysis. ICES has advised similar action for e.g. eels (ICES, 2018).

Lessons learned

Numerous effectiveness of measures data from the literature were originally generated for the fish topics (coastal, commercial, migratory fish). However, structural conflicts with the

existing measure types did not allow for their inclusion in the model. In the future, the structural relationships of several of the fish measure types, particularly those related to MPAs and other spatial/temporal closures, will need to be changed from the standard measure type affecting state via activities and pressures to a measure type affecting state directly. It is also possible that enough literature data exists to comfortably rely solely on those data points and in this case the creation of a new measure type would be sufficient. In either case, the change will significantly increase the utilization of literature data on effectiveness of measures. More broadly, a similar assessment should be undertaken for all the SOM topics.

Spatially explicit inland measures are a challenge for the SOM analysis. These would include contaminated site clean-ups, landfill upgrades, dam removals, and other riverine habitat restoration measures. For most of the SOM analysis, these measure types form just a small part of the existing measures in each topic. However, for migratory fish, these measure types are a key component of the suite of existing measures used to improve the condition of migratory fish stocks. In such cases, it is critical to know additional site-specific details to accurately estimate the measure effectiveness of a particular existing measure. For instance, while we have estimates on the effectiveness of installing a fish passage on an existing dam, the pressure created from river obstructions is not evenly distributed throughout a river and much less a sub-basin. Due to the linear nature of river habitats at this scale, it matters very much where in the river the dam is situated, the status of other up- and down-stream dams, the amount of suitable habitat behind each damn, etc. This greatly increases the spatial data required for a thorough assessment of migratory fish species. Such an effort is currently not feasible. In the future, adapting the SOM analysis to migratory fish will require profound collaboration with topic experts, access to fairly extensive riverine habitat maps, and adaptations to the SOM approach to allow for the incorporation of such spatially explicit data. Such work will require a dedicated project and is not recommended as a priority improvement at this time.

Use of results, implications and future perspectives

The results of this exercise emphasize the importance of reduction of anthropogenic impacts in the inland water areas (removal of migration barriers, reduction of nutrient load and silting caused by peat mining, restoration of spawning and rearing habitats, etc). This aspect could be highlighted and further explored in future work.

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ICES (2019h). Plaice (Pleuronectes platessa) in subdivisions 21–23 (Kattegat, Belt Seas, and the Sound). ICES Advice on fishing opportunities, catch, and effort. Baltic Sea Ecoregion: 29 May 2019. https://doi.org/10.17895/ices.advice.4751

ICES (2019i). Plaice (Pleuronectes platessa) in subdivisions 24–32 (Baltic Sea, excluding the Sound and Belt Seas). ICES Advice on fishing opportunities, catch, and effort. Baltic Sea Ecoregion Version 2: 26 July 2019. https://doi.org/10.17895/ices.advice.4752

ICES (2019j). Sprat (Sprattus sprattus) in subdivisions 22–32 (Baltic Sea). ICES Advice on fishing opportunities, catch, and effort. Baltic Sea Ecoregion: 29 May 2019. https://doi.org/10.17895/ices.advice.4754

ICES (2019k). Baltic Salmon and Trout Assessment Working Group (WGBAST). ICES Scientific Reports. 1:23. 312 pp. http://doi.org/10.17895/ices.pub.4979

ICES (2019l). Report of the Workshop for the Review of Eel Management Plan Progress Reports (WKEMP), 17–19 July and 13–16 November 2018, Copenhagen, Denmark. ICES CM 2018/ACOM:46. 100 pp.

ICES (2018) European Eel (Anguilla anguilla) throughout its natural range. ICES Advice on fishing opportunities, catch, and effort. Ecoregions in the Northeast Atlantic: 7 November 2018. https://doi.org/10.17895/ices.pub.4601

SOM report series

HELCOM ACTION 2021a. Sufficiency of existing measures to achieve good status in the Baltic Sea. Available at: http://www.helcom.fi/SOM/MainSOMReport

HELCOM ACTION 2021b. Methodology for the sufficiency of measures analysis. Available at: http://www.helcom.fi/SOM/MethodologyReport

HELCOM ACTION 2021c. A practical guide to interpreting the SOM results. Available at: http://www.helcom.fi/SOM/PracticalGuide

HELCOM ACTION 2021d. Sufficiency of existing measures for benthic habitats in the Baltic Sea. Available at: http://www.helcom.fi/SOM/BenthicHabitatsReport

HELCOM ACTION 2021e. Sufficiency of existing measures for coastal fish in the Baltic Sea. Available at: http://www.helcom.fi/SOM/CoastalFishReport

HELCOM ACTION 2021f. Sufficiency of existing measures for commercial fish in the Baltic Sea. Available at: http://www.helcom.fi/SOM/CommercialFishReport

HELCOM ACTION 2021g. Sufficiency of existing measures for hazardous substances in the Baltic Sea. Available at: http://www.helcom.fi/SOM/HazardousSubstancesReport

HELCOM ACTION 2021h. Sufficiency of existing measures for input of nutrients in the Baltic Sea. Available at: http://www.helcom.fi/SOM/NutrientsReport

HELCOM ACTION 2021i. Sufficiency of existing measures for marine litter in the Baltic Sea. Available at: http://www.helcom.fi/SOM/MarineLitterReport

HELCOM ACTION 2021j. Sufficiency of existing measures for marine mammals in the Baltic Sea. Available at: http://www.helcom.fi/SOM/MarineMammalsReport

HELCOM ACTION 2021k. Sufficiency of existing measures for migratory fish in the Baltic Sea. Available at: http://www.helcom.fi/SOM/MigratoryFishReport

HELCOM ACTION 2021l. Sufficiency of existing measures for non-indigenous species in the Baltic Sea. Available at: http://www.helcom.fi/SOM/NISReport

HELCOM ACTION 2021m. Sufficiency of existing measures for underwater noise in the Baltic Sea. Available at: http://www.helcom.fi/SOM/UnderwaterNoiseReport

HELCOM ACTION 2021n. Sufficiency of existing measures for waterbirds in the Baltic Sea. Available at: http://www.helcom.fi/SOM/WaterbirdsReport

HELCOM ACTION 2021o. Sufficiency and cost-effectiveness of potential new measures to achieve good status in the Baltic Sea. Available at: http://www.helcom.fi/SOM/CostEffectivenessReport

Model code is available at: https://github.com/LiisaSaikkonen/ACTION_SOM

Annexes

Annexes 1–9 contain the expert surveys as well as information on the measure types and the literature review. They are available on the SOM Platform workspace.

Annexes 10–12 contain graphs and tables that provide additional information and perspectives on the results.

Annex 1 Activity-pressure survey

All topic specific pressures are single activity pressures, so no activity-pressure survey is available.

Annex 2 Modified activity list (if modified)

The topic uses the standard activity list, so no modified activity list is available.

Annex 3 Measure types list

PDF containing the measure types used in the assessment of the effectiveness of measures for *Migratory fish*. Document includes examples of existing measures that if implemented would be included in the corresponding measure type.

Annex 4 Linking existing measures to measure types

Excel containing the identified existing measures and their relationship to the measure types used in the SOM analysis.

Annex 5 Literature review search terms

Excel containing the search terms used during the literature review on effectiveness of measures for *Migratory fish*.

Annex 6 Literature review summary

Excel document containing the effectiveness of measures data retrieved from the literature review.

Annex 7 Topic structure

Excel containing the relationships between measure types, activities, pressures, state components, and sub-basins. Also contains information on GES thresholds.

Annex 8 Effectiveness of measures survey

PDF of the Effectiveness of measures survey for *Migratory fish*.

Annex 9 Pressure-state survey

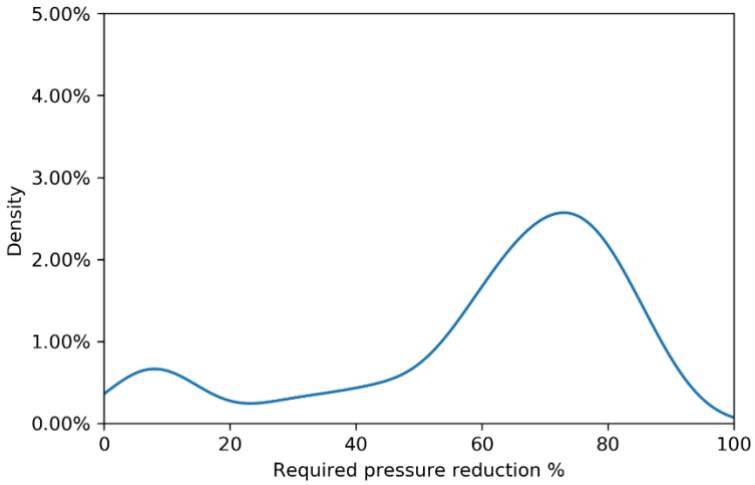
PDF of the Pressure-state survey for *Migratory fish*.

Annex 10 Supplementary results for required pressure reductions

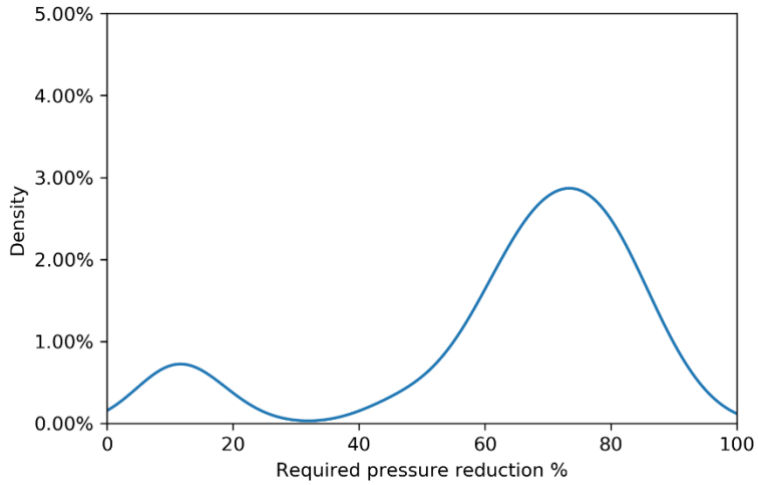
This annex presents the probability density functions of required pressure reductions to achieve GES/environmental target based on responses to the expert survey questions. The graphs show the probability distribution of the pooled expert responses on how much pressures should be reduced to achieve GES/environmental target. Pressure reduction is presented on the x-axis (0-100%) and probability on the y-axis. The probability density function presents the probability of the pressure reduction falling within a particular range of values. This probability is given by the integral of the probability density over that range—that is, it is given by the area under the density function but above the horizontal axis and between the lowest and greatest values of the range.

Salmon

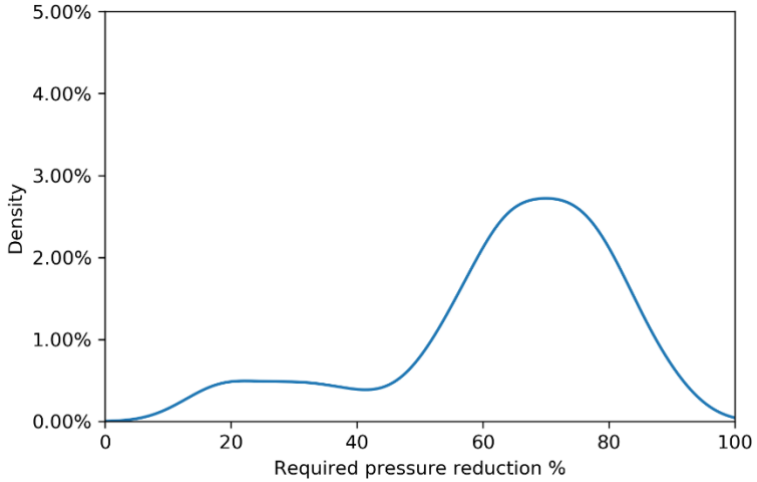
Assessment unit 1-2
(No of experts = 7, Confidence = low)



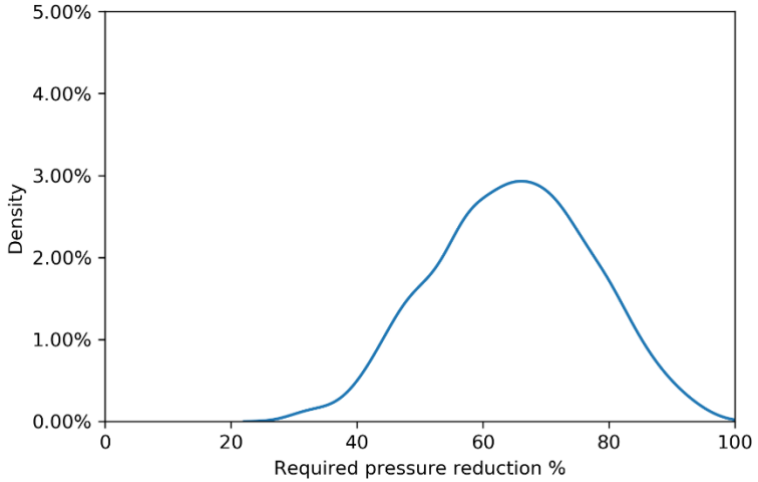
Assessment unit 3
(No of experts = 7, Confidence = low)



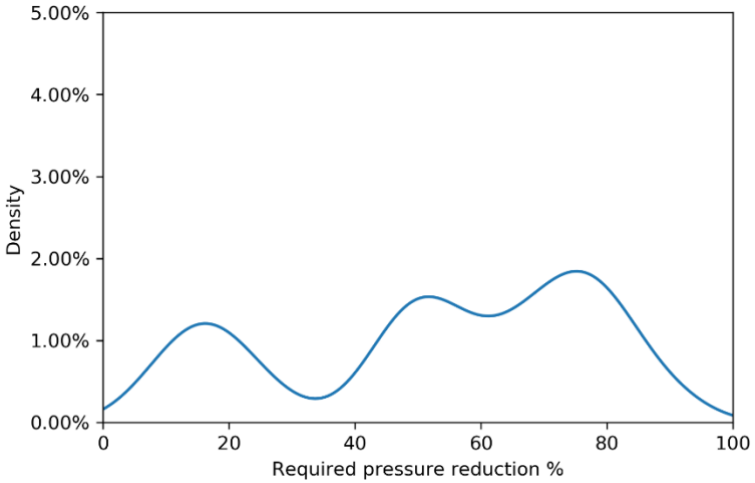
Assessment unit 4
(No of experts = 9, Confidence = low)



Assessment unit 5
(No of experts = 4, Confidence = high)



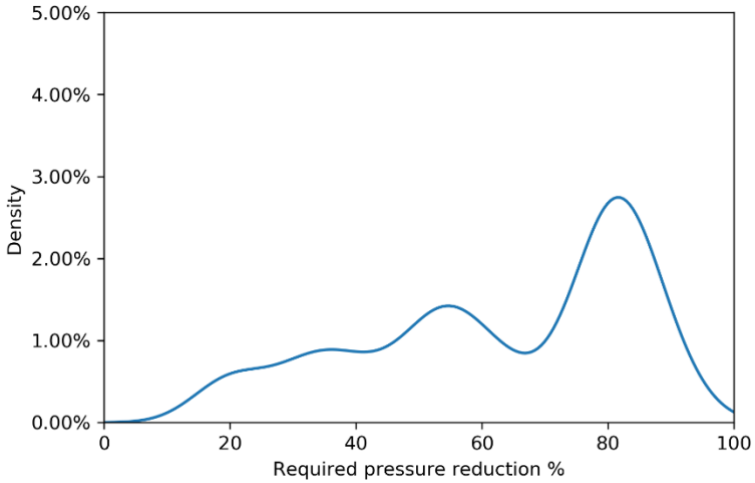
Assessment unit 6
(No of experts = 4, Confidence = moderate)

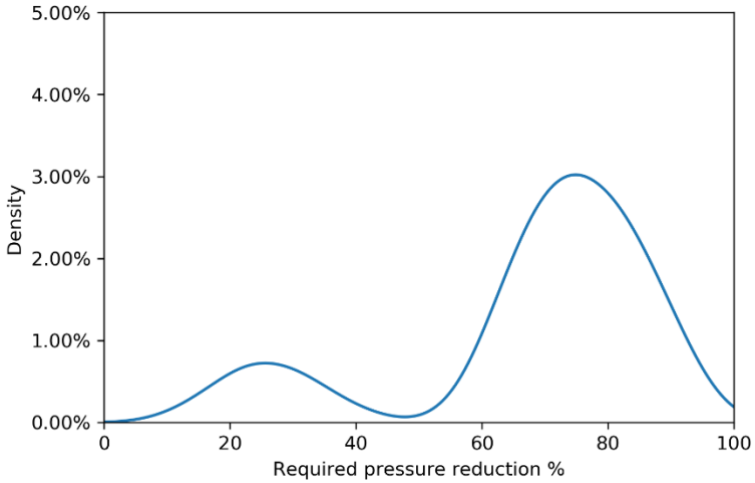
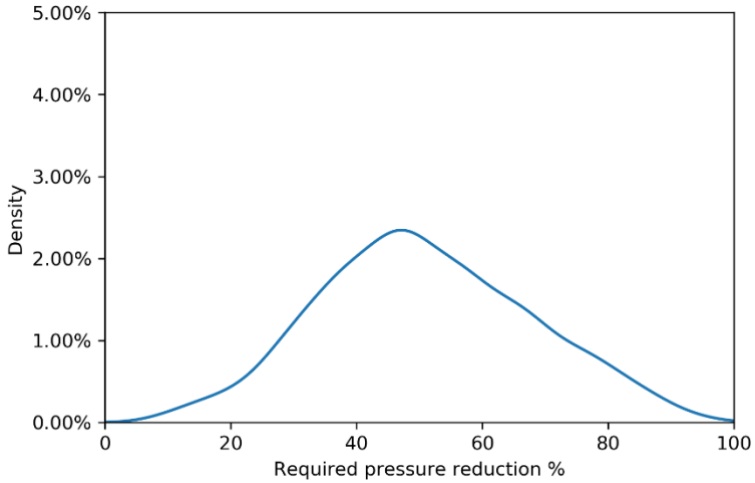
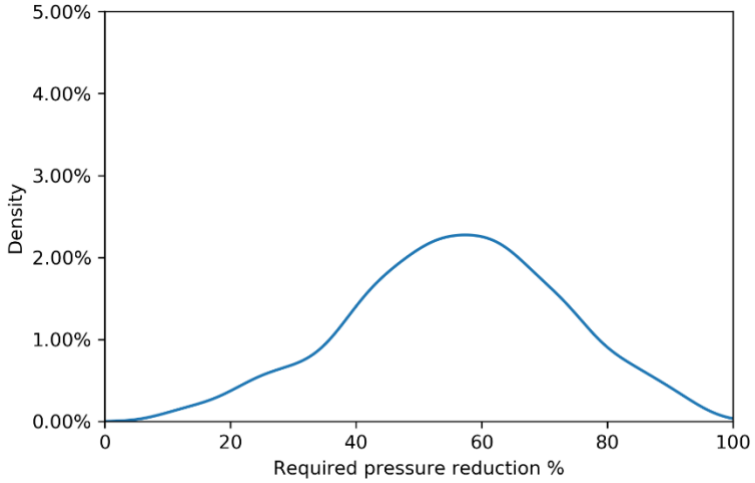
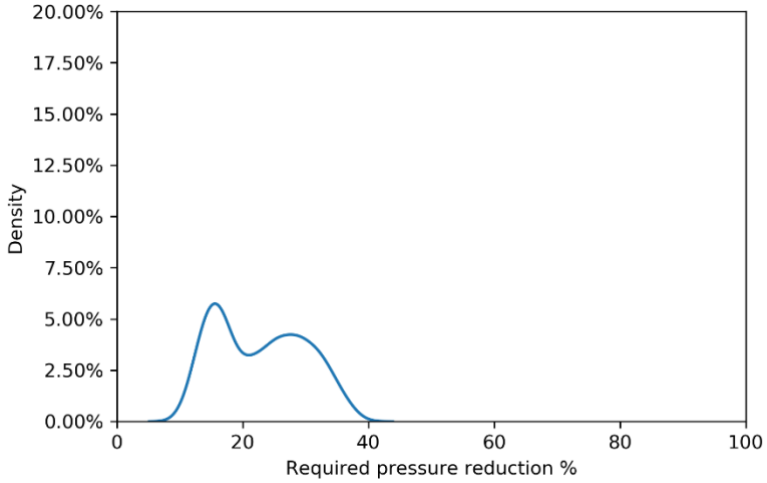


Eel

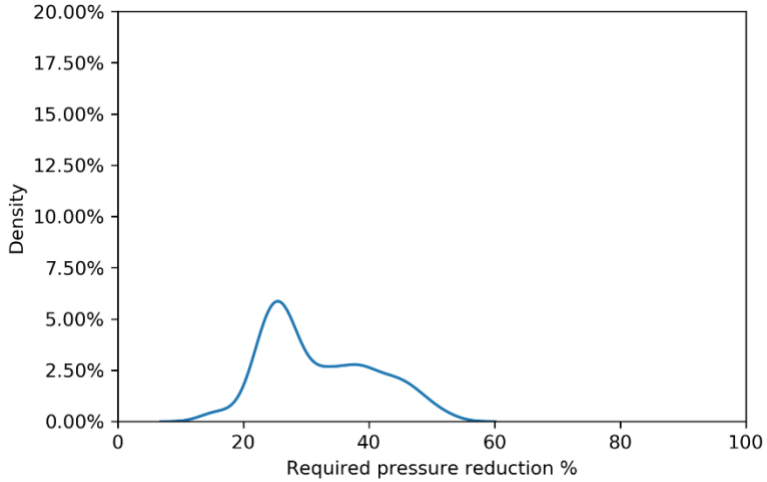
Assessment unit 1-2

(No of experts = 10, Confidence = moderate)

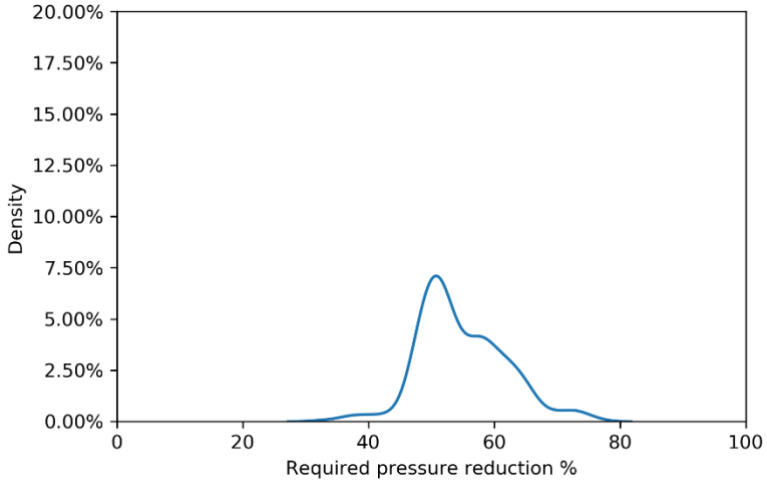


Sea trout	
Gulf of Bothnia, 10% state improvement (No of experts = 6, Confidence = moderate) 	**Gulf of Bothnia, 25% state improvement** (No of experts = 6, Confidence = moderate) 
Gulf of Bothnia, 50% state improvement (No of experts = 6, Confidence = moderate) 	**Gulf of Finland, 10% state improvement** (No of experts = 3, Confidence = moderate) 

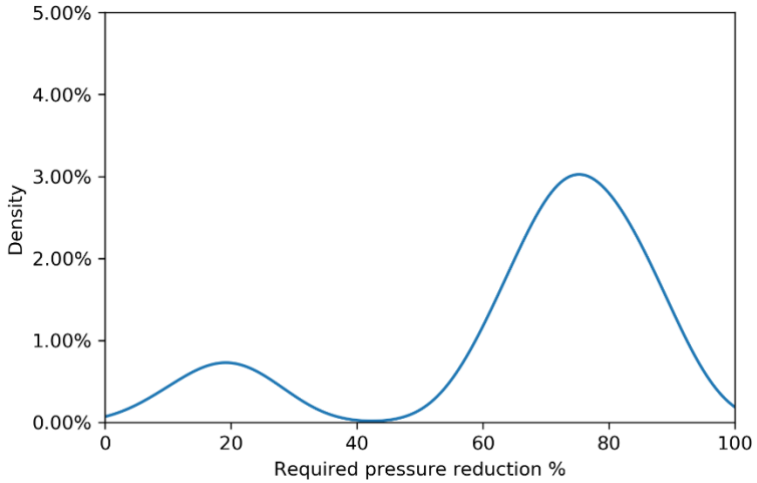
Gulf of Finland, 25% state improvement
(No of experts = 3, Confidence = moderate)



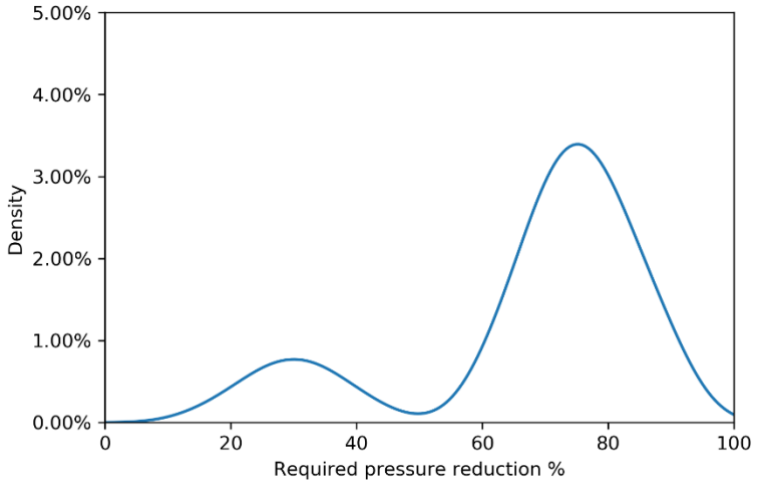
Gulf of Finland, 50% state improvement
(No of experts = 3, Confidence = moderate)



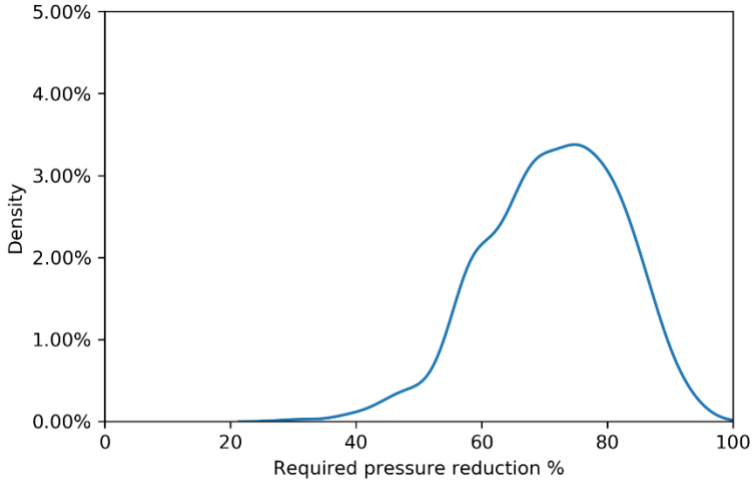
Western Baltic, 10% state improvement
(No of experts = 6, Confidence = low)



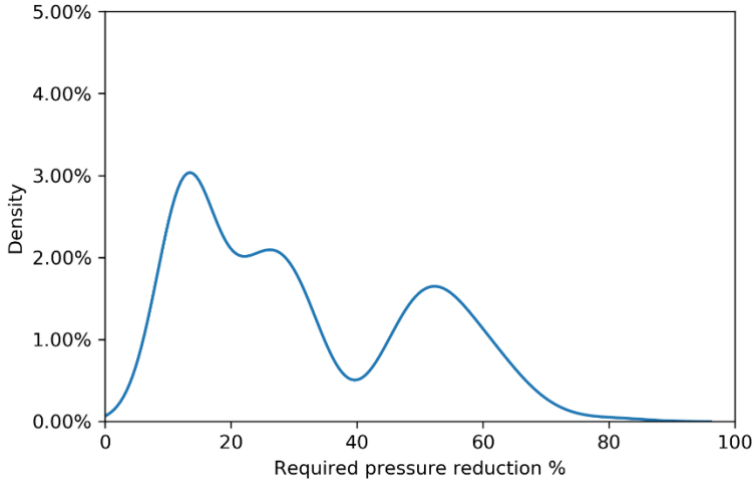
Western Baltic, 25% state improvement
(No of experts = 6, Confidence = low)



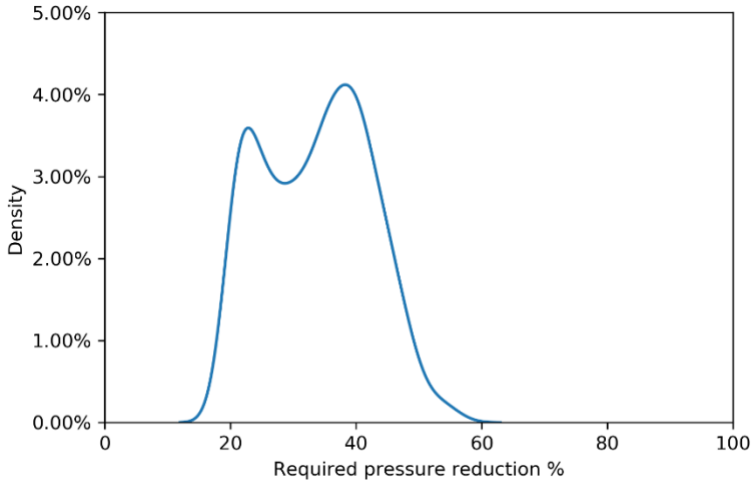
Western Baltic, 50% state improvement
(No of experts = 6, Confidence = low)



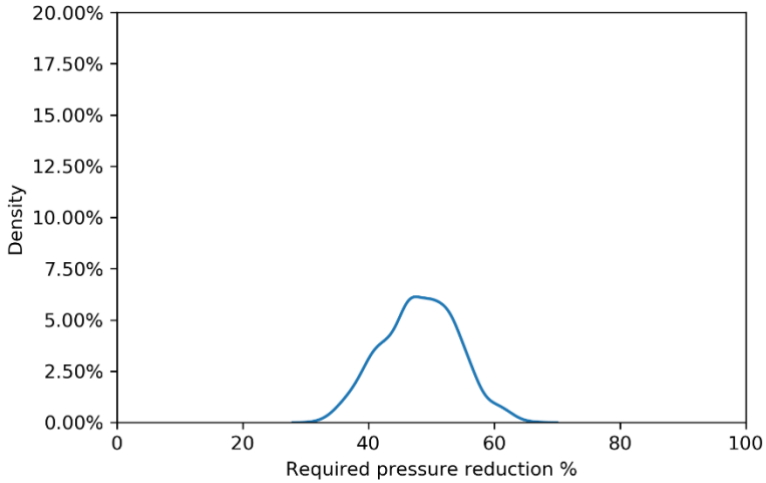
Eastern Baltic, 10% state improvement
(No of experts = 3, Confidence = low)



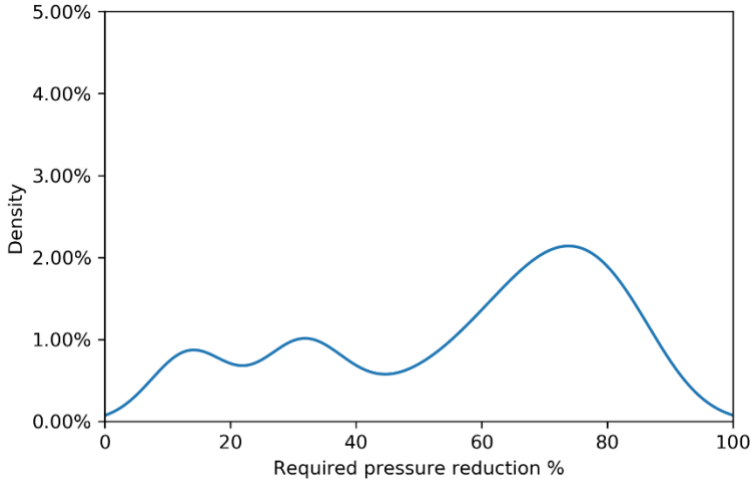
Eastern Baltic, 25% state improvement
(No of experts = 3, Confidence = low)



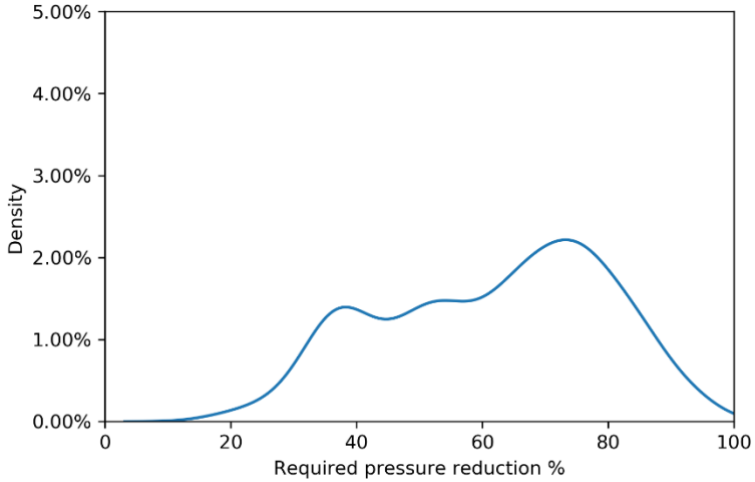
Eastern Baltic, 50% state improvement
(No of experts = 3, Confidence = low)



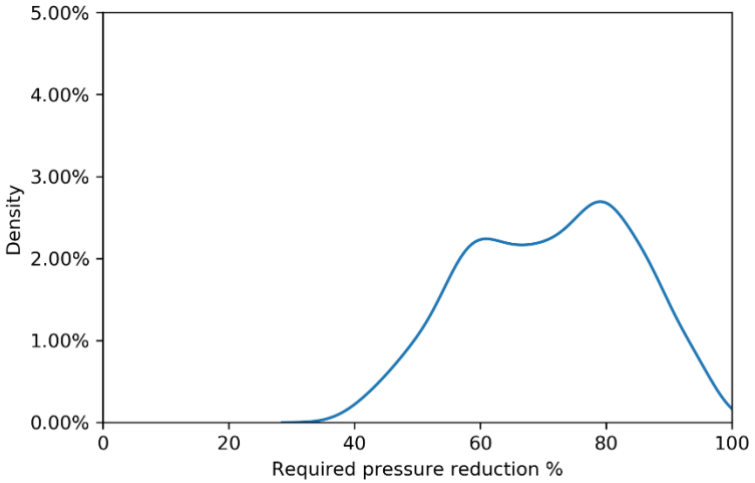
Southern Baltic, 10% state improvement
(No of experts = 8, Confidence = low)



Southern Baltic, 25% state improvement
(No of experts = 8, Confidence = low)



Southern Baltic, 50% state improvement
(No of experts = 8, Confidence = low)



Annex 11 Supplementary results for effectiveness of measures

Table A1. Distribution of the effectiveness of measure types in controlling the pressure *of targeted extraction and bycatch of salmon.* The effectiveness of a measure type is the percent reduction in a pressure resulting from a specific activity. The graphs present the probability distribution of effectiveness, based on expert responses or literature estimates. The dashed line represents the expected value. Figures showing only a dashed line and no apparent probability distribution are point estimates without variation.

Pressure:	Targeted extraction and bycatch of salmon
Activity:	Fish and shellfish harvesting (all gears; professional, recreational)
Measure type:	116: Offshore spatial closures
	114: Offshore seasonal closures
	115: Inshore/river spatial closures (commercial and/or recreational)
	113: Inshore/river seasonal closures (commercial and/or recreational)
	106: Measures to reduce recreational fishing (e.g. licenses)
	110: Ensure compliance with existing regulations (commercial and/or recreational)
	103: Technical measures to reduce catches of unwanted species
	111: Promotion of sustainable fisheries (commercial and/or recreational)
	112: CFP multi-annual plan
	141: Unspecified MPA fisheries restrictions
	120: Seasonal closures (commercial and/or recreational)
	119: Offshore catches of commercial fish in line with targets for MSY
	123: National species management plans
	142: EU salmon discard plan
	104: Technical measures to reduce catches of unwanted sizes of fish
	118: Measures to reduce offshore commercial fishing capacity
	117: Measures to reduce inshore commercial fishing capacity
	109: Bag limits (e.g. daily/seasonal) in recreational fisheries
Expert assessment:	5-6 experts, confidence = high

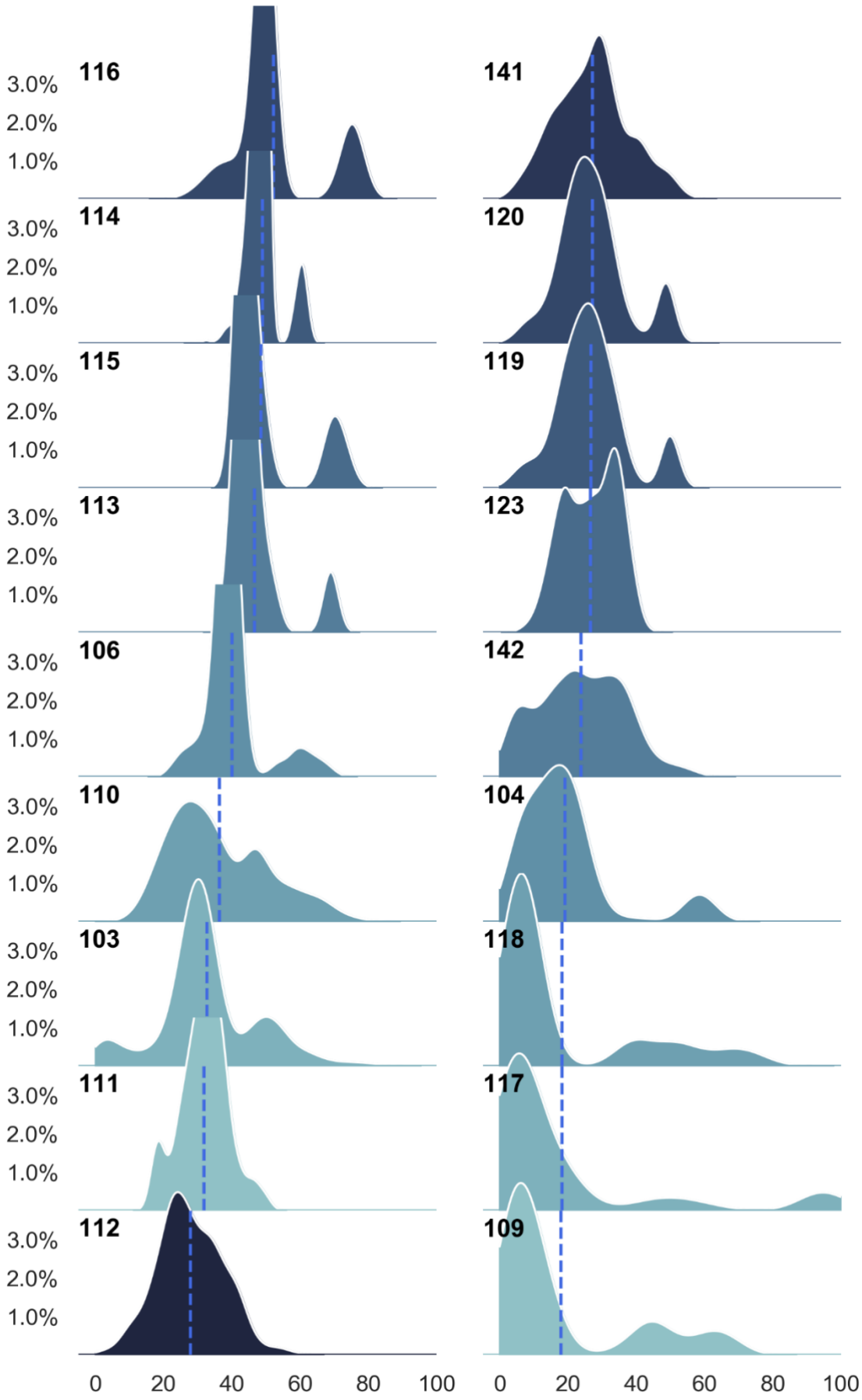

116
141
114
120
115
119
113
123
106
142
110
104
103
118
111
117
112
109
3.0%
2.0%
1.0%
0
20
40
60
80
100

Table A2. Distribution of the effectiveness of measure types in controlling the pressure *of targeted extraction and bycatch of seatrout.* The effectiveness of a measure type is the percent reduction in a pressure resulting from a specific activity. The graphs present the probability distribution of effectiveness, based on expert responses or literature estimates. The dashed line represents the expected value. Figures showing only a dashed line and no apparent probability distribution are point estimates without variation.

Pressure:	Targeted extraction and bycatch of seatrout
Activity:	Fish and shellfish harvesting (all gears; professional, recreational)
Measure type:	121: Seasonal closures (commercial and/or recreational)
	122: Spatial closures (commercial and/or recreational)
	106: Measures to reduce recreational fishing (e.g. licenses)
	125: Inspection campaigns to reduce illegal fishing
	108: Catches of commercial fish in line with targets for MSY
	103: Technical measures to reduce catches of unwanted species
	111: Promotion of sustainable fisheries (commercial and/or recreational)
	109: Bag limits (e.g. daily/seasonal) in recreational fisheries
	141: Unspecified MPA fisheries restrictions
	123: National species management plans
	107: Measures to reduce commercial fishing capacity
	104: Technical measures to reduce catches of unwanted sizes of fish
Expert assessment:	5-7 experts, confidence = high-moderate

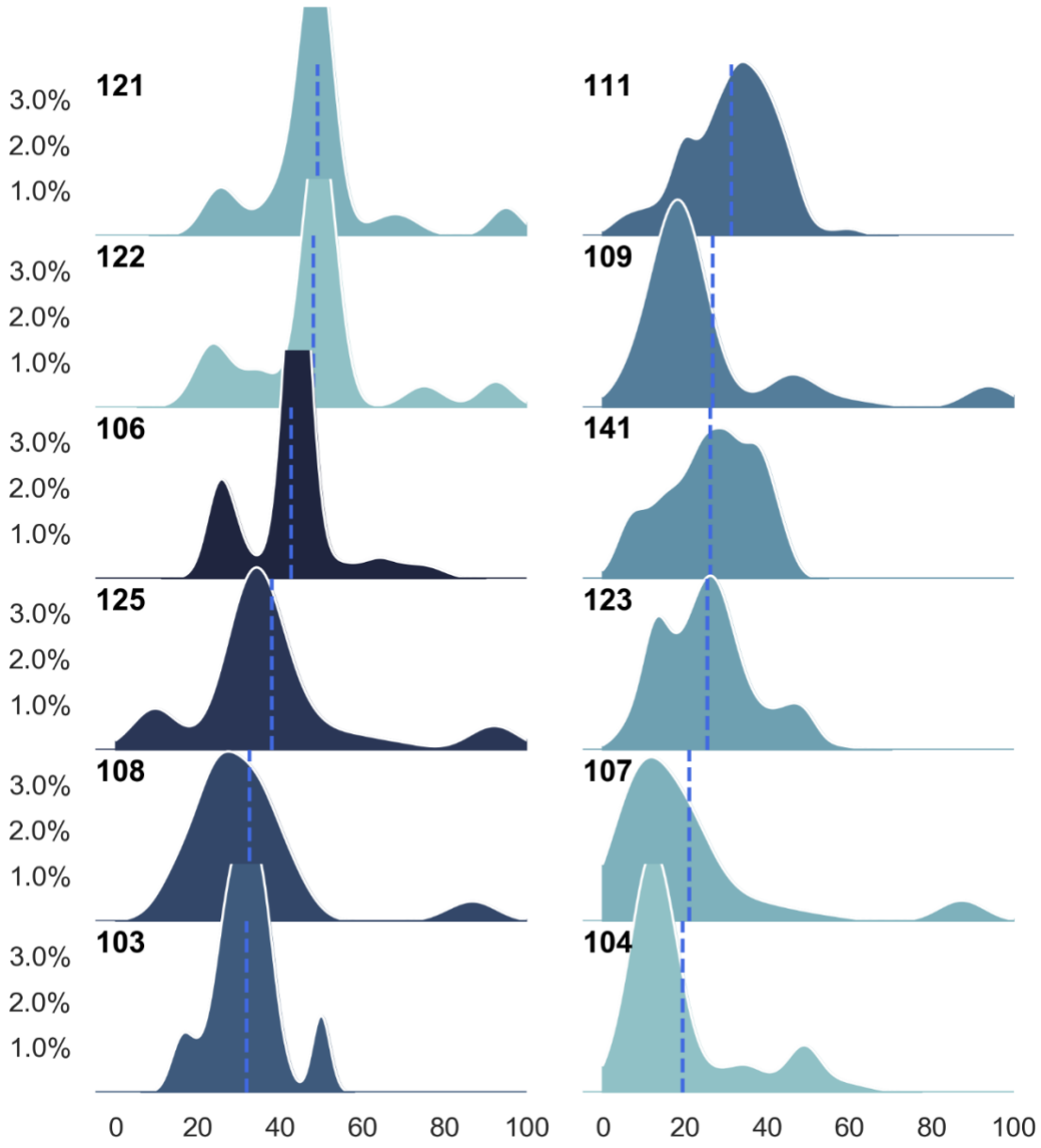

121
111
122
109
106
141
125
123
108
107
103
104
3.0%
2.0%
1.0%
0
20
40
60
80
100

Table A3. Distribution of the effectiveness of measure types in controlling the pressure *of targeted extraction and bycatch of eel.* The effectiveness of a measure type is the percent reduction in a pressure resulting from a specific activity. The graphs present the probability distribution of effectiveness, based on expert responses or literature estimates. The dashed line represents the expected value. Figures showing only a dashed line and no apparent probability distribution are point estimates without variation.

Pressure:	Targeted extraction and bycatch of eel
Activity:	Fish and shellfish harvesting (all gears; professional, recreational)
Measure type:	121: Seasonal closures (commercial and/or recreational)
	122: Spatial closures (commercial and/or recreational)
	107: Measures to reduce commercial fishing capacity
	123: National species management plans
	125: Inspection campaigns to reduce illegal fishing
	106: Measures to reduce recreational fishing (e.g. licenses)
	111: Promotion of sustainable fisheries (commercial and/or recreational)
	109: Bag limits (e.g. daily/seasonal) in recreational fisheries
	108: Catches of commercial fish in line with targets for MSY
	103: Technical measures to reduce catches of unwanted species
	104: Technical measures to reduce catches of unwanted sizes of fish
	141: Unspecified MPA fisheries restrictions
	109L: Bag limits (e.g. daily/seasonal) in recreational fisheries (literature based)
	117L: Measures to reduce inshore commercial fishing capacity (literature based)
Expert assessment:	5-9 experts, confidence = moderate

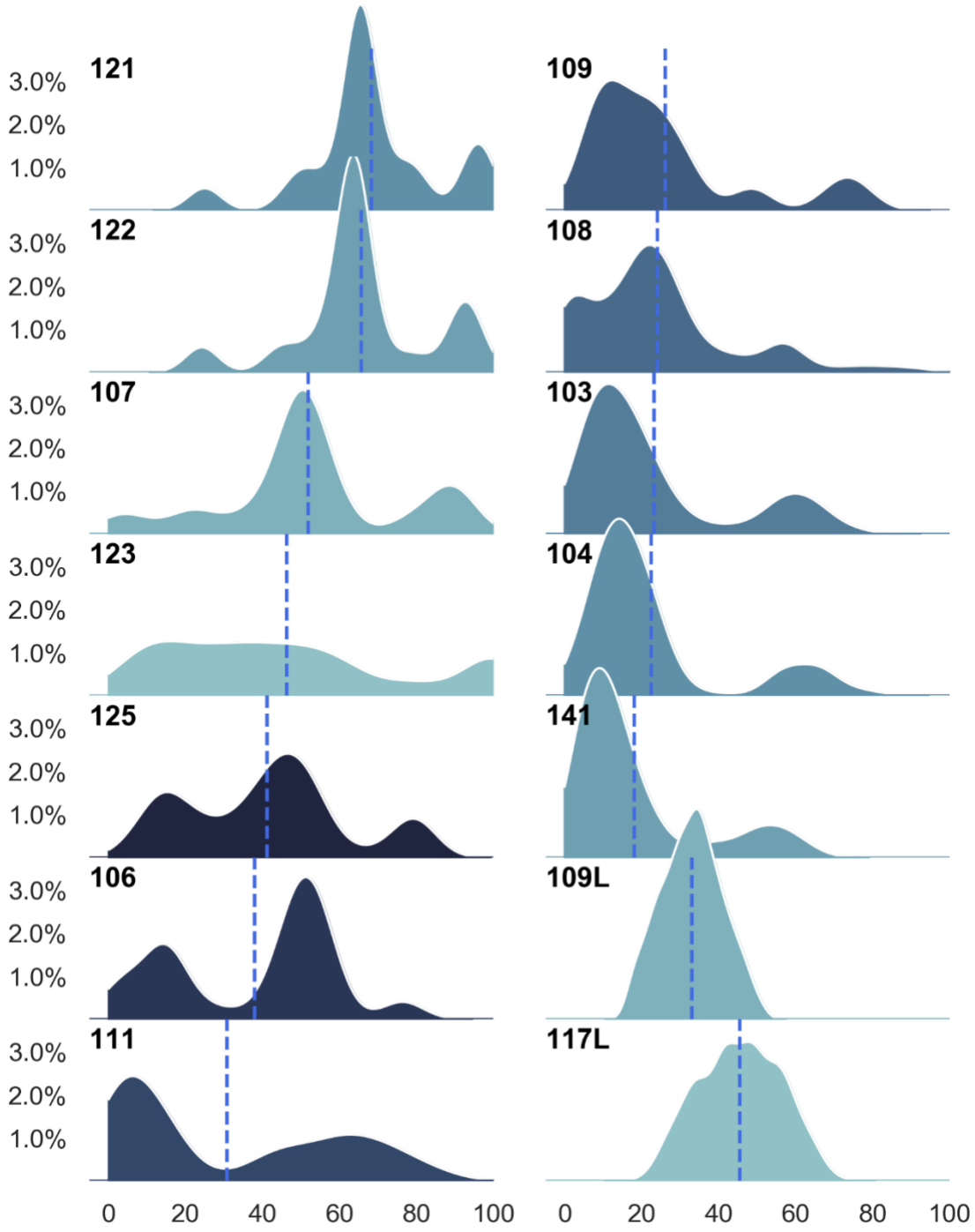

121
109
122
108
107
103
123
104
125
141
106
109L
111
117L
3.0%
2.0%
1.0%
0
20
40
60
80
100

Table A4. Distribution of the effectiveness of measure types in controlling *direct pressure to riverine fish habitat.* The effectiveness of a measure type is the percent reduction in a pressure resulting from a specific activity. The graphs present the probability distribution of effectiveness, based on expert responses or literature estimates. The dashed line represents the expected value. Figures showing only a dashed line and no apparent probability distribution are point estimates without variation.

Pressure:	Direct to pressure - riverine fish habitat
Activity:	Direct to pressure
Measure type:	126: Dam removal
	134: Ensure minimum ecological flow
	133: River and riparian habitat restoration/rehabilitation (excluding dam removal)
	136: Actions to reduce/prevent input of nutrients and/or silt into water bodies
	135: Liming
Expert assessment:	13-15 experts, confidence = high

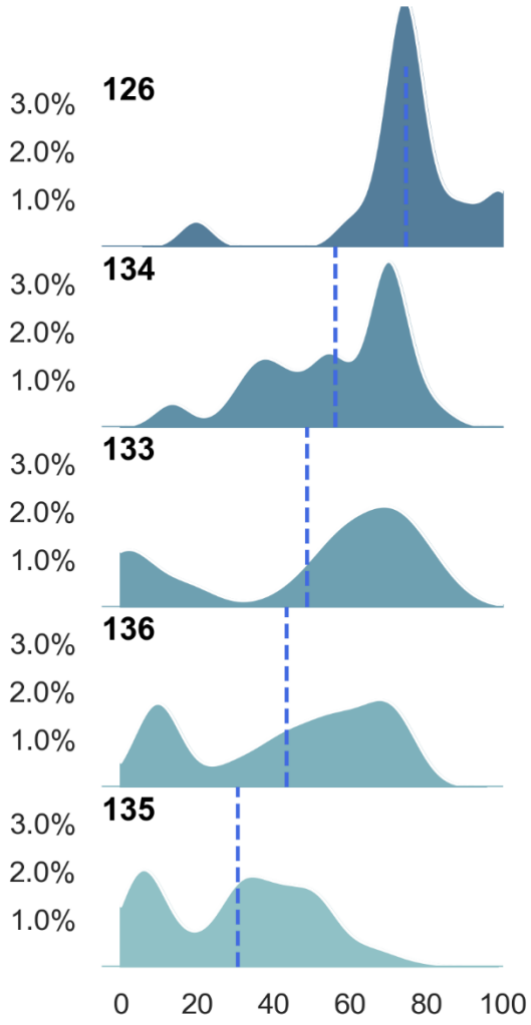


Table A5. Distribution of the effectiveness of measure types in controlling the pressure *of disturbance of Species: obstructions (dams)-Salmon.* The effectiveness of a measure type is the percent reduction in a pressure resulting from a specific activity. The graphs present the probability distribution of effectiveness, based on expert responses or literature estimates. The dashed line represents the expected value. Figures showing only a dashed line and no apparent probability distribution are point estimates without variation.

Pressure:	Disturbance of Species: obstructions (dams)-Salmon
Activity:	Direct to pressure
Measure type:	126: Dam removal
	127: Application of the best available solution for fish passage on existing obstructions (salmon)
Expert assessment:	12-13 experts, confidence = high

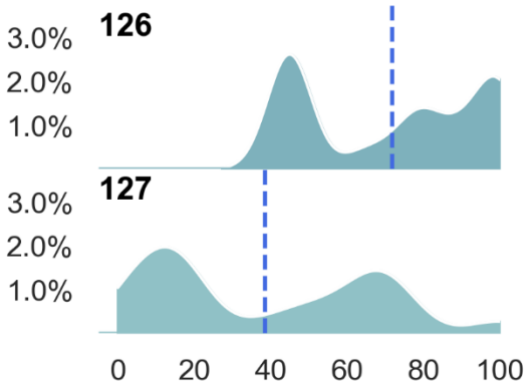


Table A6. Distribution of the effectiveness of measure types in controlling the pressure *of disturbance of Species: obstructions (dams)-Sea trout.* The effectiveness of a measure type is the percent reduction in a pressure resulting from a specific activity. The graphs present the probability distribution of effectiveness, based on expert responses or literature estimates. The dashed line represents the expected value. Figures showing only a dashed line and no apparent probability distribution are point estimates without variation.

Pressure:	Disturbance of Species: obstructions (dams)-Sea trout
Activity:	Direct to pressure
Measure type:	126: Dam removal
	128: Application of the best available solution for fish passage on existing obstructions (seatrout)
Expert assessment:	12 experts, confidence = high

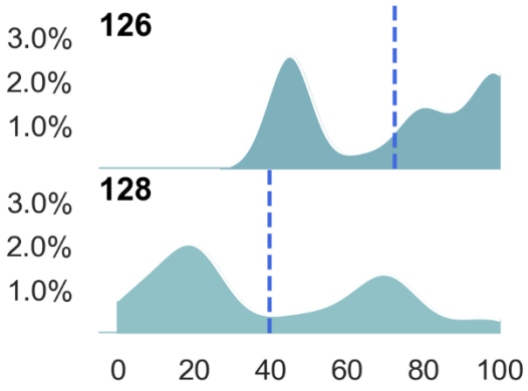
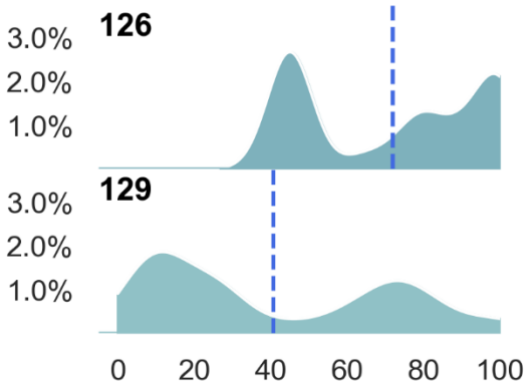


Table A7. Distribution of the effectiveness of measure types in controlling the pressure *of disturbance of Species: obstructions (dams)-Eel.* The effectiveness of a measure type is the percent reduction in a pressure resulting from a specific activity. The graphs present the probability distribution of effectiveness, based on expert responses or literature estimates. The dashed line represents the expected value. Figures showing only a dashed line and no apparent probability distribution are point estimates without variation.

Pressure:	Disturbance of Species: obstructions (dams)-Eel
Activity:	Direct to pressure
Measure type:	126: Dam removal
	129: Application of the best available solution for fish passage on existing obstructions (eel)
Expert assessment:	12-13 experts, confidence = high



Annex 12 Impacts of measure types

Table A8. Impacts of measure types (%) in reducing the targeted extraction and bycatch of migratory fish, direct pressure to riverine fish habitats and disturbance of species: obstructions (dams). The impact shows how much the measure type reduces the pressure across all activities contributing to the pressure. Estimates with less than 5 contributing experts are marked to have insufficient data.

Pressure on fish at the Baltic Sea scale	Measure type	Mean (Standard deviation)
Targeted extraction and bycatch of salmon	Offshore spatial closures	insufficient data
	Offshore seasonal closures	49 (4)
	Inshore/river spatial closures (commercial and/or recreational)	insufficient data
	Inshore/river seasonal closures (commercial and/or recreational)	47 (8)
	Measures to reduce recreational fishing (e.g. licenses)	insufficient data
	Ensure compliance with existing regulations (commercial and/or recreational)	36 (13)
	Technical measures to reduce catches of unwanted species	32 (15)
	Promotion of sustainable fisheries (commercial and/or recreational)	insufficient data
	CFP multi-annual plan	28 (10)
	Inshore catches of commercial fish in line with targets for MSY	28 (10)
	Unspecified MPA fisheries restrictions	insufficient data
	Offshore catches of commercial fish in line with targets for MSY	27 (11)
	National species management plans	insufficient data
	EU salmon discard plan	insufficient data
	Technical measures to reduce catches of unwanted sizes of fish	19 (14)
	Measures to reduce inshore commercial fishing capacity	19 (27)
	Measures to reduce offshore commercial fishing capacity	insufficient data
	Bag limits (e.g. daily/seasonal) in recreational fisheries	18 (21)
Targeted extraction and bycatch of sea trout	Seasonal closures (commercial and/or recreational)	50 (16)
	Spatial closures (commercial and/or recreational)	50 (17)
	Measures to reduce recreational fishing (e.g. licenses)	42 (11)
	Inspection campaigns to reduce illegal fishing	36 (18)
	Catches of commercial fish in line with targets for MSY	33 (18)
	Technical measures to reduce catches of unwanted species	insufficient data
	Promotion of sustainable fisheries (commercial and/or recreational)	31 (11)
	Bag limits (e.g. daily/seasonal) in recreational fisheries	27 (22)
	Unspecified MPA fisheries restrictions	27 (11)
	National species management plans	25 (11)
	Measures to reduce commercial fishing capacity	23 (22)
	Technical measures to reduce catches of unwanted sizes of fish	21 (15)
Targeted extraction and bycatch of eel	Seasonal closures (commercial and/or recreational)	69 (17)
	Spatial closures (commercial and/or recreational)	66 (17)
	Measures to reduce commercial fishing capacity	52 (23)
	National species management plans	47 (31)
	Inspection campaigns to reduce illegal fishing	41 (21)
	Measures to reduce recreational fishing (e.g. licenses)	36 (21)
	Promotion of sustainable fisheries (commercial and/or recreational)	31 (28)

Pressure on fish at the Baltic Sea scale	Measure type	Mean (Standard deviation)
	Bag limits (e.g. daily/seasonal) in recreational fisheries	25 (20)
	Catches of commercial fish in line with targets for MSY	24 (20)
	Technical measures to reduce catches of unwanted species	23 (20)
	Technical measures to reduce catches of unwanted sizes of fish	23 (19)
	Unspecified MPA fisheries restrictions	18 (17)
Direct pressure to riverine fish habitat	Dam removal	75 (17)
	Ensure minimum ecological flow	55 (18)
	River and riparian habitat restoration/rehabilitation (excluding dam removal)	50 (29)
	Actions to reduce/prevent input of nutrients and/or silt into water bodies	44 (23)
	Liming	32 (20)
Disturbance of species: obstructions (dams) - salmon	Dam removal	73 (23)
	Application of the best available solution for fish passage on existing obstructions (salmon)	39 (29)
Disturbance of species: obstructions (dams) – sea trout	Dam removal	72 (23)
	Application of the best available solution for fish passage on existing obstructions (sea trout)	40 (29)
Disturbance of species: obstructions (dams) - eel	Dam removal	72 (23)
	Application of the best available solution for fish passage on existing obstructions (eel)	39 (30)