HELCOM
Baltic Marine Environment Protection Commission

BLUES

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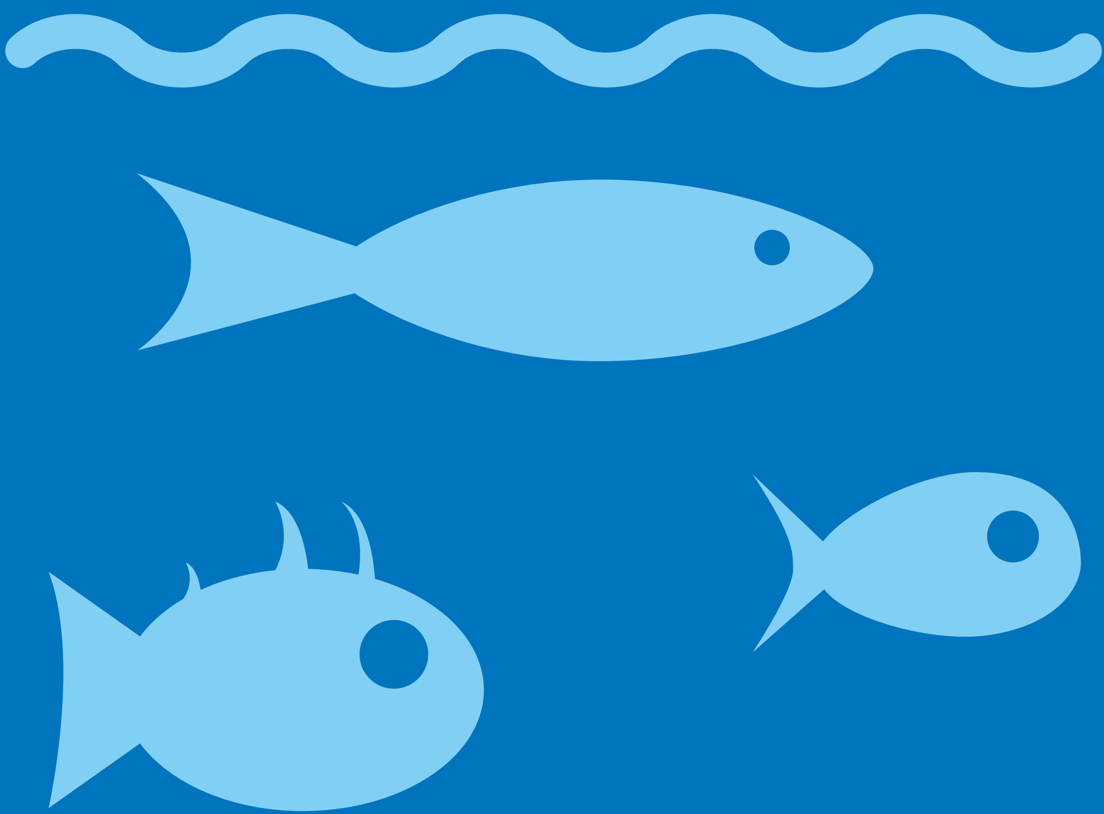
A2.2 Non-commercial fish: Key species, key groups and size of coastal fish

Main report

Activity 2- Biodiversity

2023



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HELCOM BLUES project website
Baltic Sea Action Plan 2021 (BSAP)
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Contibutors: Elisabeth Bolund, Jens Olsson, Örjan Östman, Owen Rowe, Jana Wolf

Contibutors Annex1: The HELCOM FISH PRO III expert network on coastal fish: Elisabeth Bolund, Jens Olsson, Lena Bergström, Örjan Östman, Noora Mustamäki, Rahmat Naddafi, Mikko Olin, Antti Lappalainen, Linda Sundström, Lauri Saks, Roland Svirgsden, Laura Briekmane, Linas Lozys, Justas Dainys, Adam Lejk, Łukasz Dziemian, Elliot John Brown
HELCOM Secretariat: Jannica Haldin, Owen Rowe

Contibutors Annex2: The HELCOM FISH PRO III expert network on coastal fish: Elisabeth Bolund, Jens Olsson, Lena Bergström, Örjan Östman, Noora Mustamäki, Rahmat Naddafi, Mikko Olin, Antti Lappalainen, Linda Sundström, Lauri Saks, Roland Svirgsden, Laura Briekmane, Linas Lozys, Justas Dainys, Adam Lejk, Łukasz Dziemian, Elliot John Brown
HELCOM Secretariat: Jannica Haldin, Owen Rowe

Contibutors Annex3: The HELCOM FISH PRO III expert network on coastal fish:
Elisabeth Bolund, Jens Olsson, Lena Bergström, Örjan Östman, Noora Mustamäki, Rahmat Naddafi, Mikko Olin and Antti Lappalainen, Linda Sundström, Lauri Saks, Roland Svirgsden, Laura Briekmane, Linas Lozys, Justas Dainys, Adam Lejk, Łukasz Dziemian, Elliot John Brown
HELCOM Secretariat: Jannica Haldin, Owen Rowe, Jana Wolf

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Layout: Laura Ramos Tirado

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Official address
Katajanokanlaituri 6B, 00160 Helsinki, Finland

Name and title of the Project Coordinator
Jana Wolf, Project Coordinator

Name and title of the project manager
Jannica Haldin, Deputy Executive Secretary

Name of partners in the project and abbreviations used
Center for Environmental Policy (AAPC)
Kiel Institute for the World Economy (IfW)
Latvian Institute of Aquatic Ecology (LIAE/LHEI)
Natural Resources Institute Finland (LUKE)
Swedish University of Agricultural Sciences (SLU)
Swedish Meteorological and Hydrological Institute (SMHI)
Stockholm University (SU)
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University of Veterinary Medicine Hannover (TiHo)
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Activity 2.2 – Non-commercial fish

Summary

This task of the HELCOM BLUES project has focused on developing tools for assessing status for fish species and communities that are recognized as "data-limited".
This includes coastal fish species as perch, pikeperch, whitefish, pike, and cyprinids, but also species in offshore areas lacking data for analytical stock assessment models, mainly flat fish species such as flounder, brill, dab, turbot, but also three-spined stickleback. The work has resulted in an improved method (the ASCETS-methodology) for status assessment based on abundance of coastal, as well as offshore, fish species to address change in stock status over time (A2.2. Annex 1 and 2). We have in addition developed a size-based indicator with associated threshold values for assessing the status of the size distribution of coastal fish key species (perch), available as A2.2 Annex 3. Finally, we have improved the spatial coverage, and included more species in the status assessments of coastal fish in the HELCOM region.

Task 2.2.1 Improved assessment approach for coastal fish

a) Abundance of key coastal fish species

The quantitative threshold values developed for coastal fish, are based on location-specific reference conditions where time series covering more than 15 years are available (ten or more years potential reference period + five or more years assessment period). In areas where shorter time series are available (<15 years), a trend-based approach is used.
Overall, this evaluation included between one and five key species per monitoring location and assessment unit. Good status for perch was achieved in 24 of 31 monitoring locations, and for flounder in 8 of 26 locations. An additional two monitoring locations were evaluated for flounder abundance, but time-series remained too short in these locations to do a full status evaluation. For the remaining species considerably fewer locations were evaluated and yielded the following results: 2 of 7 locations achieved good status for pike, 6 of 9 for pikeperch, 5 of 11 for whitefish, and 10 of 14 for eelpout. When comparing the two best represented key species, perch and flounder, good status is generally more often reached in areas in the northern and eastern parts of the Baltic Sea where perch is the key species. In the western and southern areas of the Baltic Sea where flounder is the key species, the status is more often not good. For pike, pikeperch, whitefish, and eelpout, the more limited data does indicate that the status for pike and whitefish tend to be poor in the majority of locations, while pikeperch and eelpout both achieve good status in two thirds or more of monitoring locations. Integration of the results of all key species over HELCOM assessment units using the One-Out-All-Out principle showed that good status is achieved in 6 of 22 evaluated units.

Good status is only achieved in the Bothnian Bay, the Finnish side of the Bothnia Sea, and along the coasts of Estonia, and Latvia. In all, this indicates an overall poor status of coastal fish key species in the Baltic Sea. The full indicator report is available as A2.2 Annex 1.

Please note that some of the species, originally planned to be included as non-commercial offshore species, were during the developmental work during HOLAS 3, recommended by IC STATE & CONSERVATION 1-2022 for inclusion for the list of commercial fish species. TThe one exception to this is the stickleback for which it was decided that achieved progress should be presented separately as an information box in the HOLAS 3 thematic assessment report for biodiversity as it was not included in the agreed list of commercial species.

b) Abundance of coastal fish key functional groups

This core indicator evaluates the abundance of selected functional groups of coastal fish in the Baltic Sea. As a rule, good status is achieved when the abundance of cyprinids or mesopredators (i.e. mid trophic-level fish) is within an acceptable range for the specific coastal area. The status of functional groups of coastal fish in the Baltic Sea has been evaluated by assessing the status of cyprinids and mesopredators during the period 2016-2020. Overall good status is achieved in 20 of the 32 monitored locations, but integration of the results of all key species over HELCOM assessment units using the One-Out-All-Out principle, showed that good status achieved in only 4 of the 14 evaluated assessment units. In the majority of the monitoring locations (24 locations) cyprinids is evaluated, and in 13 of these the threshold is met. For mesopredators the status appears to be better as the threshold is met in 7 of the in total 9 locations evaluated. Note that in one Swedish location (Kvädöfjärden), both cyprinids and mesopredators are evaluated, and neither meets the threshold, and in two Swedish areas included, the time-series is too short to allow for an evaluation of status. In the locations classified as not good, the abundance of cyprinids and mesopredators was too high in all but 2 two of the 12 locations. Generally, good status is not achieved in more central parts of the Baltic Sea including the Swedish part of the Quark, Åland Sea, Northern Baltic Proper and Western Gotland Basin, in more southern Finnish coastal waters (Archipelago Sea and Gulf of Finland), and in Estonian and Latvian coastal waters. Note that functional groups are not evaluated in the Finnish coastal areas of the Bothnian Bay and Bothnian Sea due to lack of data. The full indicator report is available as A2.2 Annex 2.

Task 2.2.2 Development of a size-based assessment for the same species and communities

This indicator evaluates the size distribution of typical key species of fish, such as perch, flounder, and pikeperch in the coastal areas of the Baltic Sea, to assess environmental status. As a rule, good status is achieved when the size of large fish (size at L90) is above a set gear- and species-specific threshold value. The current evaluation assesses status during the period 2016-2020 for which HELCOM scale 3 is used.

Good status is achieved in 14 out of the total 28 evaluated monitoring locations for perch. Status was not evaluated in relation to a threshold for flounder and pikeperch, but flounder showed stable L90-values over time in 11 out of the in total 12 evaluated monitoring locations, with one area showing an increasing trend over time. Pikeperch showed stable

values over time in 2 out of 3 evaluated monitoring locations, with one area showing an increasing trend over time. Integration of the results for perch over HELCOM assessment units using the One-Out-All-Out principle, showed that good status is achieved in only 4 out of 15 evaluated units. Good status is achieved in the Finnish coastal waters of the Quark, in the Bothnian Sea, and in the Estonian coastal waters of the Gulf of Riga.
This newly developed indicator is operational in the coastal waters of most countries bordering the Baltic Sea, except Denmark, Germany, and Russia. For the time being, it is not applicable in some areas where coastal fish monitoring data are scarce and further studies as well as time series are needed to yield a reliable assessment of these areas. In the future, in line with increasing knowledge, the indicator might undergo further development, specifically thresholds for determining good environmental status may be developed for flounder, pikeperch, and other key species in the coastal area.
The full indicator report is available as A2.2 Annex 3.

Key messages

Our results have the following **scientific** key messages*:*
1) Improved methodology for analysing structural change in time-series including uncertainty,
2) Improved understanding of the spatial and temporal dynamics in coastal fish species and offshore data-limited stocks, including uncertainties in assessments,
3) Improved understanding of spatial and temporal variation in size structure of fish in the Baltic Sea, and effects of human pressures (Östman et al. in review; Bolund et al. in prep), with methodological sampling variation taken into account.

Our results suggest the following key messages for **policy makers***:*
1) Improved and extended status assessment (species and areas) for coastal fish,
2) Assessment of changes in state of offshore data-limited stocks lacking ICES analytical reference points,
3) Management targets for size structure for a coastal key fish species, and trends over time in the size structure of data-limited offshore species.

Use of results so far and in future

Overall, our results have contributed towards a more holistic and quantitative assessment of fish in the Baltic Sea. More specifically, the outcomes of this task have directly been used in the three indicator reports for coastal fish in HOLAS 3: *Abundance of key coastal fish species*, *Abundance of coastal fish key functional groups* and *Size structure of coastal fish* (A2.2 Annex 1-3). Furthermore, the results have been used for the HOLAS 3 thematic assessment report for biodiversity, for the sections on fish and food webs.
Results also address the Baltic Sea Action Plan (BSAP). The results feed into several goals of the plan of "Baltic Sea ecosystem is healthy and resilient" and the ecological objective "viable populations of all native species", as well as the management objective "reduce or prevent human pressures that lead to imbalance in the food web". BSAP actions B15; B33

and B35 were addressed, by developing indicators, and supporting filling of gaps to enable a holistic assessment for fish, and for all relevant ecosystem components and pressures.
MSFD: The results will be part of the reporting on D1C2, D1C3, D1C6, D3C3 and D4C2; art. 8 Guidance and they will be available for national reporting of the MSFD.
The achieved progress and results of the work under HELCOM BLUES A2.2 have also supported the following outputs, available as scientific manuscripts:

- *Östman et al.* (in review) *Size-based indicators of coastal fish – useful tools for assessments of ecological status in the Baltic Sea?*
- *Bolund et al.* (in prep) *An approach for deriving threshold values of the size distribution for data-limited coastal fish species in the Baltic Sea.*

Baltic Marine Environment Protection Commission

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A2.2 Annex 1
Coastal fish key species indicator report

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2023

HELCOM

Coastal fish key species

INDICATOR TYPE: State
INDICATOR CATEGORY: Core
BSAP SEGMENT: Biodiversity
MSFD CRITERIA: D1C2

Abundance of key coastal fish species

Table of contents

1 Key message

This core indicator evaluates the abundance of typical key species of fish, such as perch, flounder, pike, pikeperch, whitefish, and eelpout, to assess environmental status in coastal areas of the Baltic Sea. As a rule, good status is achieved when the abundance is above a set site- and species-specific threshold value.

The current evaluation assesses status during the period 2016-2020 (Figure 1).

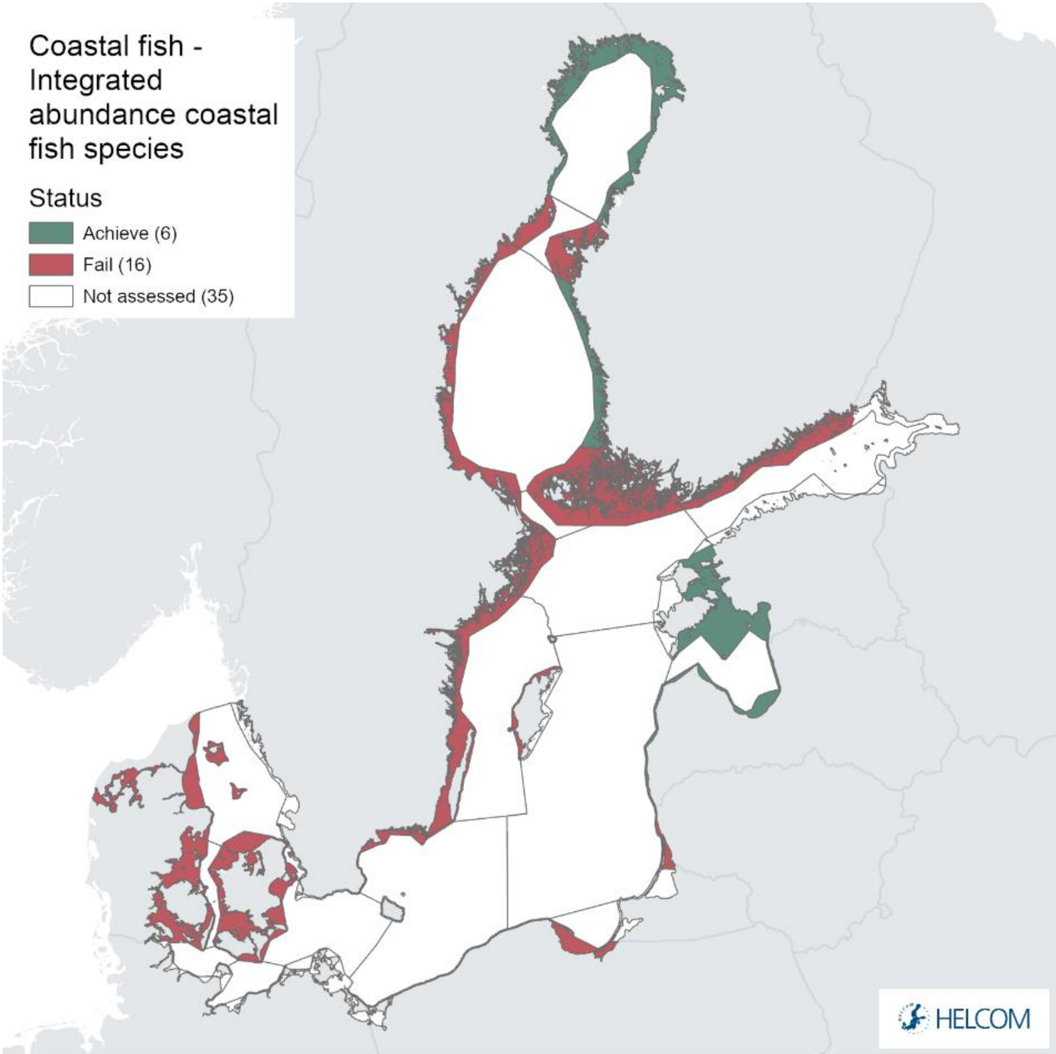

Figure 1. Status evaluation results based on the evaluation of the indicator 'abundance of key coastal fish species'. The evaluation is carried out using Scale 3 HELCOM assessment units (defined in the [HELCOM Monitoring and Assessment Strategy Annex 4]). **See 'data chapter' for interactive maps and data at the HELCOM Map and Data Service.**

Overall, this evaluation included between one and five key species per monitoring location and assessment unit. Good status for perch was achieved in 24 of 31 monitoring locations, and for flounder in 8 of 26 locations. An additional two monitoring locations were evaluated for flounder abundance, but time-series remained too short in these locations to do a full status evaluation. For the remaining species considerably fewer locations were evaluated, and yielded the following results: 2 of 7 locations achieved good status for pike, 6 of 9 for pikeperch, 5 of 11 for whitefish, and 10 of 14 for eelpout. When comparing the two best represented key species, perch and flounder, good status is generally more often reached in areas in the northern and eastern parts of the Baltic Sea where perch is the key species. In the western and southern areas of the Baltic Sea where flounder is the key species, the status is more often not good. For pike, pikeperch, whitefish, and eelpout, the more limited data does indicate that the status for pike and whitefish tend to be poor in the majority of locations, while pikeperch and eelpout both achieve good status in two thirds or more of monitoring locations. Integration of the results of all key species over HELCOM assessment units using the One-Out-All-Out principle showed that good status is achieved in 6 of 22 evaluated units. Good status is only achieved in the Bothnian Bay, the Finnish side of the Bothnia Sea, and along the coasts of Estonia, and Latvia. In all, this indicates an overall poor status of coastal fish key species in the Baltic Sea.

The level of confidence in the evaluation differs between coastal areas and regions as a result of differences in monitoring methodology, as well as lower temporal and spatial coverage of monitoring in some countries. The methodological confidence is high in all monitoring locations while the confidence in the accuracy of the evaluation is consistently high in only three assessment units. The confidence in the temporal coverage is high in all assessment units except for in six, where the individual monitoring locations have data missing during one or more years (in Sweden, Poland, Denmark and Finland), and the confidence in spatial representability is highest in the Finnish, Lithuanian, Polish, and Danish areas, but poorer in the other countries. The integrated confidence considering all four categories varies between high and intermediate depending on assessment unit, and is high in the majority of evaluated assessment units.

The indicator is operational in the coastal waters of most countries bordering the Baltic Sea. For the time being, it is not applicable in some areas where coastal fish monitoring data are scarce and further studies as well as time series are needed to yield a reliable evaluation of these areas. In the future, in line with increasing knowledge, the indicator might undergo further development.

1.1 Citation

The data and resulting data products (e.g. tables, figures and maps) available on the indicator web page can be used freely given that it is used appropriately and the source is cited. The indicator should be cited as follows:

HELCOM (2023) Abundance of coastal fish key species**.** HELCOM core indicator report. Online. [Date Viewed], [Web link].

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2 Relevance of the indicator

Coastal fish communities are of high ecological and socio-economic importance in the Baltic Sea, both for ecosystem functioning and for recreational and small-scale coastal commercial fishery activities. As such, the state of coastal fish communities generally reflects the ecological state in the coastal ecosystems.

Changes in the long-term development of the abundance of key coastal fish species mainly reflects effects of changes in the level of human exploitation (fishing and habitat degradation), natural predation pressure, increased water temperature and altered hydrographical conditions, and eutrophication in coastal areas.

2.1 Ecological relevance

Coastal fish, especially piscivorous species, are recognized as being important components of coastal food webs and ecosystem functioning (Eriksson *et al.* 2009; Baden *et al.* 2012; Olsson *et al.* 2012; Östman *et al.* 2016; Olsson 2019). Moreover, since many coastal fish species are rather local in their appearance (Saulamo & Neuman 2005; Laikre *et al.* 2005; Olsson *et al.* 2011; Östman *et al.* 2017a), the temporal development of coastal fish communities might reflect the general environmental state in the monitoring locations (Bergström *et al.* 2016b; Östman *et al.* 2017b).

Piscivorous fish species in coastal ecosystems generally have a structuring role in the ecosystem, mainly via top-down control on lower trophic levels (reviewed in Olsson 2019). Viable populations of key coastal fish species are generally considered to reflect an environmental status with few eutrophication symptoms and balanced food webs (Eriksson *et al.* 2011; Baden *et al.* 2012; Östman *et al.* 2016; Eklöf *et al.* 2020). Key coastal fish species are generally piscivores and/or benthivores species.

2.2 Policy relevance

The core indicator is relevant to the following specific 2021 Baltic Sea Action Plan actions:

- B15: Develop and coordinate monitoring and assessment methods, where ecologically relevant, for specified representative coastal fish species, populations and communities, by 2023. Based on these assessment methods, to regularly assess the state of the coastal fish community through selected coastal fish species and groups, including threatened species, by at latest 2023. Based on the results of the assessment, develop and implement management measures with the ambition to maintain or improve the status of coastal fish species, including migratory species by 2027. Cross-reference to actions in other segments.

- B35: By 2024 operationalize a set of indicators for the assessment of fish population health, including size and age distribution, where applicable, and, by 2029, for any remaining relevant species.

The core indicator also addresses the following qualitative descriptors of the MSFD for determining good environmental status:

An overview is provided in Table 1.

Table 1. Policy relevance of this specific HELCOM indicator.

	Baltic Sea Action Plan (BSAP)	**Marine Strategy Framework Directive (MSFD)**
Fundamental link	Segment: Biodiversity Goal: “Baltic Sea ecosystem is healthy and resilient” • Ecological objective: “Viable populations of all native species”. • Management objective: “Human induced mortality, including hunting, fishing, and incidental bycatch, does not threaten the viability of marine life”.	Descriptor 1 Species groups of birds, mammals, reptiles, fish and cephalopods. Species of birds, mammals, reptiles and non-commercially-exploited species of fish and cephalopods, which are at risk from incidental by-catch in the region or subregion. • Criteria 2 The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured. • Feature – Coastal fish. • Element of the feature assessed – Coastal fish species.
Complementary link	Segment: Hazardous substances Goal: “Baltic Sea unaffected by hazardous substances and litter” • Ecological objective: “Marine life is healthy”. • Ecological objective: “All sea food is safe to eat”.	Descriptor 3 Populations of all commercially-exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock. Commercially-exploited fish and shellfish. • Criteria 2 The Spawning Stock Biomass of populations of commercially-exploited species are above biomass levels capable of producing maximum sustainable yield. • Feature – Commercially-exploited fish and shellfish. • Element of the feature assessed – Commercially-exploited fish and shellfish species.
Other relevant legislation:	• In some Contracting Parties of HELCOM, potentially also EU Habitats Directive and EU Common Fisheries Policy. • UN Sustainable Development Goal 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development) is most clearly relevant, though SDG 12 (Ensure sustainable consumption and production patterns) and 13 (Take urgent action to combat climate change and its impacts) also have relevance.	

Descriptor 1: 'Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions'

Descriptor 3: 'Populations of commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock'

and the following criteria of the Commission Decision:

- Criterion D1C3 (population demographic characteristics of the species),
- Criterion D3C3 (the age and size distribution of individuals in the population).

In some Contracting Parties the indicator also has potential relevance for implementation of the EU Habitats Directive.

The indicator supports the UN Sustainable Development Goal 14: Conserve and sustainably use the oceans, sea and marine resources for sustainable development.

2.3 Relevance for other assessments

The status of biodiversity is assessed using several core indicators. Each indicator focuses on one important aspect of the complex issue. In addition to providing an indicator-based assessment of the abundance of key coastal fish species, this indicator also contributes to the overall biodiversity assessment along with the other biodiversity core indicators.

3 Threshold values

Good Status is achieved when key species abundance is above a specified threshold value. The quantitative threshold values for coastal fish are based on location-specific reference conditions where time series covering more than 15 years are available (ten or more years potential reference period + five or more years assessment period). In areas where shorter time series are available (<15 years), a trend-based approach is used. The specific approach used in the various monitoring locations is presented in the Results section.

A reference period needs to be defined for determining the threshold value. The period used to define the reference needs to cover at least ten years in order to extend over more than twice the generation time of the typical species represented in the indicator and thus cater for natural variation in the indicator value, due for example to strong and weak year classes. For the period used to determine the reference to be relevant, it must also be carefully selected to reflect time periods with stable environmental conditions, as stated within the MSFD (European Commission 2008). Substantial turnovers in ecosystem structure in the Baltic Sea were apparent in the late 1980s, leading to shifts in the baseline state (Möllmann *et al.* 2009), and for coastal fish communities, substantial shifts in community structure have been demonstrated in the late 1980s and early/mid 1990s (Olsson *et al.* 2012; Bergström *et al.* 2016a). In some areas, there have also been minor shifts in fish community structure later. To account for this, the ASCETS method (Östman *et al.* 2020) is applied on time-series with more than 15 years of data. This method offers a refined approach to infer structural changes in indicator values over time and establish threshold values for the state during a reference period based on the observed variation in indicator values.

Estimates of the relative abundance and/or biomass of key coastal fish species are used to evaluate whether the threshold value is achieved or not. These estimates are derived from fishery independent monitoring, citizen science and/or commercial catch statistics. Since there are strong environmental gradients in the Baltic Sea and coastal fish communities and stocks are typically local in their appearance and respond mainly to area specific environmental conditions, the evaluations for coastal key fish species are carried out on a relatively local scale.

The assessment period applied when using the ASCETS methods should cover at least five years to cater for natural variability. Good status is evaluated based on the deviation of the median value of the indicator during the assessment period in relation to the threshold value (Figures 2 and 3).

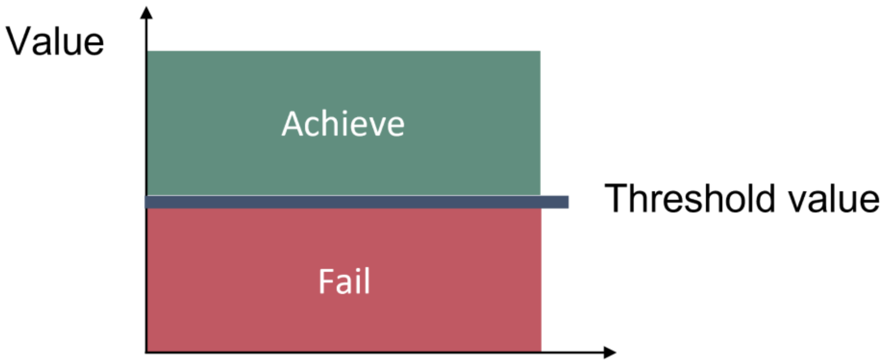


Figure 2: Acceptable deviation from baseline is used to define the threshold value between good status and not good status.

When using the trend-based approach, environmental status is evaluated based on the direction of the linear trend towards good status, over the time period 2014-2020 (Figure 3).

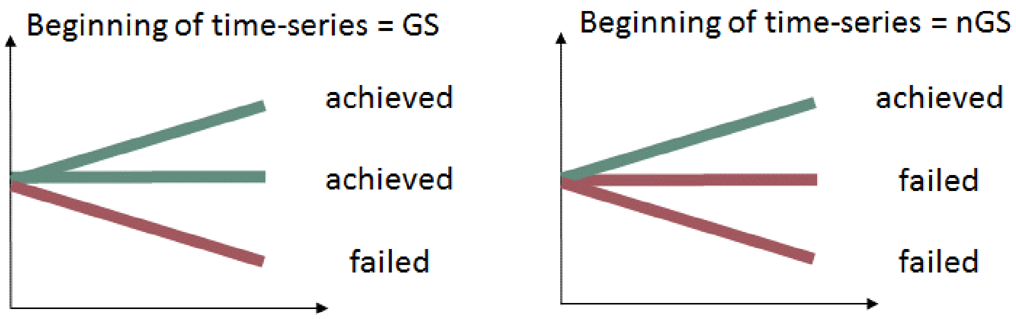


Figure 3: Application of the trend-based approach for evaluating environmental status where the status is defined based on the direction of the trend of the indicator compared to the desired direction of the indicator over time. GS = good status, nGS = not good status. See description in the assessment protocol.

Typical species considered in the context of this indicator are perch (*Perca fluviatilis*), flounder (European flounder, *Platichthys flesus,* and Baltic flounder, *Platichthys solemdali*), pike (*Esox lucius*), pikeperch (*Sander lucioperca*), whitefish (*Coregonus maraena*) and eelpout (*Zoarces viviparous*), depending on the location, coastal area and sub-basin. Perch, pike, pikeperch, and whitefish are generally the key species in coastal fish communities in the less saline eastern and northern Baltic Sea (Sweden, Finland, Estonia, and Latvia), and in more sheltered coastal areas in Lithuania, Poland and Germany. In the more exposed coastal parts of the central Baltic Sea and in its western parts, the abundance of perch is generally lower and flounder and eelpout is used as key species. Perch and flounder are considered in most assessment units, but where data is available pike, pikeperch, whitefish, and eelpout are used as complementary species in the evaluation.

3.1 Setting the threshold value(s)

To determine the status of the indicator, the ASCETS method first derives a bootstrapped distribution of median values from a time series of observed indicator values during a reference period. Specific threshold values for changes in indicator state is set, and for key species, these are based on the 5th and 98th percentile values of the bootstrapped distribution. In this way, the derived boundaries of this interval can function as threshold values for a change in state per assessment unit of each species. Second, the bootstrapped median indicator value during the assessment period is evaluated in relation to the threshold values derived from the reference period depending on how much of the bootstrapped median distribution from the assessment period that falls below, within, or above the 5th and 98th percentiles.

If the requirements for defining quantitative baseline conditions are not met (e.g. short time series), then a trend-based evaluation should be used. All available data starting from year 2014 is included in trend analyses. In the trend-based approach, good status is defined based on the direction of the trend at $p<0.1$ of the indicator compared to the desired direction of the indicator over time.

4 Results and discussion

The results of the indicator evaluation that underlie the key message map and information are provided below.

4.1 Status evaluation

The current evaluation of environmental status using coastal fish covers the assessment period from 2016 to 2020. The evaluation is based on time series data of varying length depending on the temporal coverage of data collection in each monitoring location. Time series thus start between the years 1998 and 2015 (Table 2) and depending on the time series coverage, either the 'ASCETS approach' or a 'trend-based evaluation' is used. Evaluation was carried out for 24 of the in total 42 ‘scale 3 assessment units’ and time-series data up to and including the year 2020 were available for all 24 of these units (Figure 4). Due to short time-series in two of the Swedish assessment units, an evaluation against a quantitative threshold was not possible here, and a status evaluation was hence only carried out for in total 22 assessment units. For more information on assessment units, see the Assessment protocol.

Overall, this evaluation included one to five key species per monitoring location. Good status for perch was achieved in 24 of 31 monitoring locations, and for flounder in 8 of 26 locations. An additional two monitoring locations were evaluated for flounder abundance, but time-series remained too short in these locations to do a full status evaluation. For the remaining species, considerably fewer locations were evaluated and yielded the following results: 2 of 7 locations achieved good status for pike, 6 of 9 for pikeperch, 5 of 11 for whitefish, and 10 of 14 for eelpout. Adding up all species-monitoring location combinations, totalling 98 status evaluations, 43 achieved good status. When comparing the two best represented key species, perch and flounder, good status is generally more often reached in areas in the northern and eastern parts of the Baltic Sea where perch is the key species. In the western and southern areas of the Baltic Sea where flounder is the key species, the status is more often not good. For pike, pikeperch, whitefish, and eelpout, the more limited data does indicate that the status for pike and whitefish tend to be poor in the majority of locations, while pikeperch and eelpout both achieve good status in two thirds or more of monitoring locations.

When considering the integrated status across species in all 55 monitoring locations, in more than half of them (32 locations), one or more species do not reach the threshold for good status. Within some assessment units there are discrepancies in status across species and monitoring locations, likely reflecting differences in the local appearance of coastal fish communities. When summarising over HELCOM assessment units, good status is achieved in 6 out of 22 evaluated units, indicating an overall poor environmental status of key coastal fish species in the Baltic Sea. Good status is only achieved in the Bothnian Bay, the Finnish side of the Bothnia Sea, and along the coasts of Estonia, and Latvia.

Table 2. Status evaluation outcome per monitoring location and assessment unit for the assessment period 2016-2020. GS = good status, nGS = not good status. The status for each assessment unit is derived using the One-Out-All-Out principle across species and monitoring locations.

Coastal area name (assessment unit)	Sub-basin	Country	Coastal area name (assessment unit)	Coastal area code	Monitoring area/data set	Time period assessed	key species	Monitoring method	Assessment method	Status reference period	Threshold value	Current value	Status monitoring location	Status assessment unit
Bothnian Bay Finnish Coastal waters	Bothnian Bay	Finland	Bothnian Bay Finnish Coastal waters	1	Finnish ICES SD 31	1998-2020	Perch	Commercial statistics	ASCETS	GS	0.082	0.2	GS	GS
Bothnian Bay Swedish Coastal waters	Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Råneå	2002-2020	Perch	Fisheries independent data	ASCETS	GS	17.59	25.78	GS	
Bothnian Bay Swedish Coastal waters	Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Råneå	2002-2020	Pike	Fisheries independent data	ASCETS	GS	0.045	0.089	GS	
Bothnian Bay Swedish Coastal waters	Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Råneå	2002-2020	Whitefish	Fisheries independent data	ASCETS	GS	0.014	0.089	GS	
Bothnian Bay Swedish Coastal waters	Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Kinnbäcksfjärden	2004-2020	Perch	Fisheries independent data	ASCETS	GS	6.81	7.02	GS	
Bothnian Bay Swedish Coastal waters	Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Kinnbäcksfjärden	2004-2020	Whitefish	Fisheries independent data	ASCETS	GS	3.61	4.38	GS	GS
The Quark Finnish Coastal waters	The Quark	Finland	The Quark Finnish Coastal waters	3	Finnish ICES rect 23	1998-2020	Perch	Commercial statistics	ASCETS	GS	0.13	0.4	GS	
The Quark Finnish Coastal waters	The Quark	Finland	The Quark Finnish Coastal waters	3	Finnish ICES rect 28	1998-2020	Perch	Commercial statistics	ASCETS	GS	0.192	0.19	nGS	nGS
The Quark Swedish Coastal waters	The Quark	Sweden	The Quark Swedish Coastal waters	4	Holmön	2002-2020	Perch	Fisheries independent data	ASCETS	GS	18.64	11.4	nGS	
The Quark Swedish Coastal waters	The Quark	Sweden	The Quark Swedish Coastal waters	4	Holmön	2002-2020	Whitefish	Fisheries independent data	ASCETS	nGS	1.27	1.97	GS	
The Quark Swedish Coastal waters	The Quark	Sweden	The Quark Swedish Coastal waters	4	Norrbyn	2002-2020	Perch	Fisheries independent data	ASCETS	nGS	19.78	5.4	nGS	
The Quark Swedish Coastal waters	The Quark	Sweden	The Quark Swedish Coastal waters	4	Norrbyn	2002-2020	Whitefish	Fisheries independent data	ASCETS	GS	1.66	2.7	GS	nGS
Bothnian Sea Finnish Coastal waters	Bothnian Sea	Finland	Bothnian Sea Finnish Coastal waters	5	Finnish ICES SD 30	1998-2020	Perch	Commercial statistics	ASCETS	GS	0.19	0.28	GS	
Bothnian Sea Finnish Coastal waters	Bothnian Sea	Finland	Bothnian Sea Finnish Coastal waters	5	Finnish ICES SD 30	1998-2020	Pikeperch	Commercial statistics	ASCETS	GS	0.11	0.12	GS	GS
Bothnian Sea Swedish Coastal waters	Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Gaviksfjärden	2004-2020	Perch	Fisheries independent data	ASCETS	GS	5.87	7.4	GS	
Bothnian Sea Swedish Coastal waters	Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Gaviksfjärden	2004-2020	Whitefish	Fisheries independent data	ASCETS	nGS	1.5	1.3	nGS	
Bothnian Sea Swedish Coastal waters	Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Långvindsfjärden	2002-2020	Perch	Fisheries independent data	ASCETS	GS	13.9	14.18	GS	
Bothnian Sea Swedish Coastal waters	Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Forsmark	2002-2020	Perch	Fisheries independent data	ASCETS	GS	14.7	20.7	GS	
Bothnian Sea Swedish Coastal waters	Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Forsmark	2002-2020	Pikeperch	Fisheries independent data	ASCETS	nGS	1.5	0.044	nGS	
Bothnian Sea Swedish Coastal waters	Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Forsmark	2002-2020	Whitefish	Fisheries independent data	ASCETS	nGS	0.11	0	nGS	nGS
Åland Sea Finnish Coastal waters	Åland Sea	Finland	Åland Sea Finnish Coastal waters	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Åland Sea Swedish Coastal waters	Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Galtfjärden	2002-2020	Perch	Fisheries independent data	ASCETS	GS	6.95	8.87	GS	
Åland Sea Swedish Coastal waters	Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Galtfjärden	2002-2020	Pikeperch	Fisheries independent data	ASCETS	nGS	5.87	2.87	nGS	
Åland Sea Swedish Coastal waters	Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Galtfjärden	2002-2020	Whitefish	Fisheries independent data	ASCETS	nGS	0.48	0.23	nGS	
Åland Sea Swedish Coastal waters	Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Lagnö	2002-2020	Perch	Fisheries independent data	ASCETS	GS	15.78	25.72	GS	
Åland Sea Swedish Coastal waters	Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Lagnö	2002-2020	Pike	Fisheries independent data	ASCETS	nGS	0.14	0	nGS	
Åland Sea Swedish Coastal waters	Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Lagnö	2002-2020	Whitefish	Fisheries independent data	ASCETS	nGS	1.11	0.54	nGS	nGS
Archipelago Sea Coastal waters	Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finbo	2002-2020	Perch	Fisheries independent data	ASCETS	GS	23.1	27.3	GS	
Archipelago Sea Coastal waters	Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finbo	2002-2020	Pike	Fisheries independent data	ASCETS	GS	0.02	0.11	GS	
Archipelago Sea Coastal waters	Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finbo	2002-2020	Pikeperch	Fisheries independent data	ASCETS	GS	0.29	0.47	GS	
Archipelago Sea Coastal waters	Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Kumlinge	2002-2020	Perch	Fisheries independent data	ASCETS	GS	20.9	37.9	GS	
Archipelago Sea Coastal waters	Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Kumlinge	2002-2020	Whitefish	Fisheries independent data	ASCETS	nGS	0.46	0.13	nGS	
Archipelago Sea Coastal waters	Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finnish ICES SD 29	1998-2020	Perch	Commercial statistics	ASCETS	GS	0.22	0.45	GS	
Archipelago Sea Coastal waters	Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finnish ICES SD 29	1998-2020	Pikeperch	Commercial statistics	ASCETS	GS	0.25	0.31	GS	nGS
Northern Baltic Proper Finnish Coastal waters	Northern Baltic Sea	Finland	Northern Baltic Proper Finnish Coastal waters	10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Northern Baltic Proper Swedish Coastal waters	Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Vaxholm: Askrikefjärden	2016-2020	Perch	Fisheries independent data	Trend	GS	Slope p >0.1 (+)	P slope = 0.37	GS	
Northern Baltic Proper Swedish Coastal waters	Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Vaxholm: Askrikefjärden	2016-2020	Pikeperch	Fisheries independent data	Trend	GS	Slope p >0.1 (+)	P slope = 0.67	GS	
Northern Baltic Proper Swedish Coastal waters	Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Askö	2005-2020	Perch	Fisheries independent data	ASCETS	GS	16.6	5.85	nGS	
Northern Baltic Proper Swedish Coastal waters	Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Askö	2005-2020	Pike	Fisheries independent data	ASCETS	nGS	0.17	0	nGS	
Northern Baltic Proper Swedish Coastal waters	Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Askö	2005-2020	Whitefish	Fisheries independent data	ASCETS	nGS	0.62	0.625	GS	
Northern Baltic Proper Swedish Coastal waters	Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Muskö	1992-2020	Flounder	Fisheries independent data	ASCETS	GS	6.65	2.75	nGS	nGS
Northern Baltic Proper Estonian Coastal waters	Northern Baltic Sea	Estonia	Northern Baltic Proper Estonian Coastal waters	12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Finland Finnish Coastal waters	Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Brunskär	2002-2020	Perch	Fisheries independent data	ASCETS	GS	2.8	3.4	GS	
Gulf of Finland Finnish Coastal waters	Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Tvärminne	2005-2020	Perch	Fisheries independent data	ASCETS	GS	1.26	1.16	nGS	
Gulf of Finland Finnish Coastal waters	Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Helsinki	2005-2020	Perch	Fisheries independent data	ASCETS	nGS	1.38	1.62	GS	
Gulf of Finland Finnish Coastal waters	Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Finnish ICES SD 32	1998-2020	Perch	Commercial statistics	ASCETS	GS	0.09	0.11	GS	
Gulf of Finland Finnish Coastal waters	Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Finnish ICES SD 32	1998-2020	Pikeperch	Commercial statistics	ASCETS	GS	0.23	0.25	GS	nGS
Gulf of Finland Estonian Coastal waters	Gulf of Finland	Estonia	Gulf of Finland Estonian Coastal waters	14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Finland Russian Coastal waters	Gulf of Finland	Russia	Gulf of Finland Russian Coastal waters	15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Riga Estonian Coastal waters	Gulf of Riga	Estonia	Gulf of Riga Estonian Coastal waters	16	Hiiumaa	1991-2020	Perch	Fisheries independent data	ASCETS	nGS	30.46	33.5	GS	GS
Gulf of Riga Latvian Coastal waters	Gulf of Riga	Latvia	Gulf of Riga Latvian Coastal waters	17	Daugavgriva	2016-2020	Perch	Fisheries independent data	Trend	GS	Slope p >0.1 (+)	P slope = 0.18	GS	
Gulf of Riga Latvian Coastal waters	Gulf of Riga	Latvia	Gulf of Riga Latvian Coastal waters	17	Daugavgriva	2016-2020	Pikeperch	Fisheries independent data	Trend		Slope p >0.1 (+)	P slope = 0.58		GS
Western Gotland Basin Swedish Coastal waters	Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, summer	2002-2020	Perch	Fisheries independent data	ASCETS	nGS	18.47	11.75	nGS	
Western Gotland Basin Swedish Coastal waters	Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, summer	2002-2020	Pike	Fisheries independent data	ASCETS	nGS	0.23	0	nGS	
Western Gotland Basin Swedish Coastal waters	Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, summer	2002-2022	Pikeperch	Fisheries independent data	ASCETS	nGS	0.48	1.82	GS	
Western Gotland Basin Swedish Coastal waters	Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, autumn	1998-2020	Flounder	Fisheries independent data	ASCETS	nGS	16.68	2.25	nGS	
Western Gotland Basin Swedish Coastal waters	Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, autumn	1998-2020	Whitefish	Fisheries independent data	ASCETS	nGS	2.53	0.25	nGS	
Western Gotland Basin Swedish Coastal waters	Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Vinö	2007-2020	Perch	Fisheries independent data	ASCETS	nGS	57.67	36.81	nGS	
Western Gotland Basin Swedish Coastal waters	Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Vinö	2007-2020	Pike	Fisheries independent data	ASCETS	nGS	0.0063	0	nGS	nGS
Eastern Gotland Basin Estonian Coastal waters	Eastern Gotland Basin	Estonia	Eastern Gotland Basin Estonian Coastal waters	19	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Eastern Gotland Basin Latvian Coastal waters	Eastern Gotland Basin	Latvia	Eastern Gotland Basin Latvian Coastal waters	20	Jurkalne	2016-2020	Flounder	Fisheries independent data	Trend	GS	Slope p >0.1 (+)	P slope = 0.48	GS	GS
Eastern Gotland Basin Lithuanian Coastal waters	Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Mon/But	1998-2020	Flounder	Fisheries independent data	ASCETS	GS	4.11	57	GS	
Eastern Gotland Basin Lithuanian Coastal waters	Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Šventoji	2000-2020	Flounder	Fisheries independent data	ASCETS	GS	1.64	2.67	GS	
Eastern Gotland Basin Lithuanian Coastal waters	Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Karklė	2000-2020	Flounder	Fisheries independent data	Trend	GS	Slope p >0.1 (+)	P slope = 0.52	GS	
Eastern Gotland Basin Lithuanian Coastal waters	Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Smiltynė	2000-2020	Flounder	Fisheries independent data	ASCETS	GS	2.45	6.87	GS	
Eastern Gotland Basin Lithuanian Coastal waters	Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Curonian lagoon	1998-2020	Perch	Fisheries independent data	ASCETS	GS	20.13	53	GS	
Eastern Gotland Basin Lithuanian Coastal waters	Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	22	Curonian lagoon	1998-2020	Pikeperch	Fisheries independent data	ASCETS	GS	1.33	0.9	nGS	nGS
Eastern Gotland Basin Swedish Coastal waters	Eastern Gotland Basin	Sweden	Eastern Gotland Basin Swedish Coastal waters	22	Herrvik	2018-2020	Flounder	Fisheries independent data	Trend		Slope p >0.1 (+)	P slope = 0.88		NA
Eastern Gotland Basin Russian Coastal waters	Eastern Gotland Basin	Russian	Eastern Gotland Basin Russian Coastal waters	23	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Eastern Gotland Basin Polish Coastal waters	Eastern Gotland Basin	Poland	Eastern Gotland Basin Polish Coastal waters	24	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gdansk Basin Russian Coastal waters	Gdansk Basin	Russia	Gdansk Basin Russian Coastal waters	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gdansk Basin Polish Coastal waters	Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zatoka Pucka Zewnętrzna	2011-2020	Perch	Fisheries independent data	Trend	GS	Slope p >0.1 (+)	P slope = 0.96	GS	
Gdansk Basin Polish Coastal waters	Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zatoka Pucka Zewnętrzna	2011-2020	Flounder	Fisheries independent data	Trend	GS	Slope p >0.1 (+)	P slope = 0.54	GS	
Gdansk Basin Polish Coastal waters	Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Pucki	2011-2020	Perch	Fisheries independent data	Trend	GS	Slope p >0.1 (+)	P slope = 0.94	GS	
Gdansk Basin Polish Coastal waters	Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Pucki	2011-2020	Flounder	Fisheries independent data	Trend	nGS	Slope p >0.1 (+)	P slope = 0.13	nGS	
Gdansk Basin Polish Coastal waters	Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Wiślany	2011-2020	Perch	Fisheries independent data	Trend	GS	Slope p >0.1 (+)	P slope = 0.8	GS	GS
Bornholm Basin Swedish Coastal waters	Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Torhamn	2002-2020	Perch	Fisheries independent data	ASCETS	GS	11.97	21.75	GS	
Bornholm Basin Swedish Coastal waters	Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Torhamn	2002-2020	Pike	Fisheries independent data	ASCETS	nGS	0.62	0.05	nGS	
Bornholm Basin Swedish Coastal waters	Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Hanöbukten	2015-2020	Flounder	Fisheries independent data	Trend	nGS	Slope p >0.1 (+)	P slope = 0.14	nGS	nGS
Bornholm Basin Polish Coastal waters	Bornholm Basin	Poland	Bornholm Basin Polish Coastal waters	28	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bornholm Basin Danish Coastal waters	Bornholm Basin	Denmark	Bornholm Basin Danish Coastal waters	29	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bornholm Basin German Coastal waters	Bornholm Basin	Germany	Bornholm Basin German Coastal waters	30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arkona Basin Swedish Coastal waters	Arkona Basin	Sweden	Arkona Basin Swedish Coastal waters	31	Stavstendsudde	2018-2020	Flounder	Fisheries independent data	Trend		Slope p >0.1 (+)	P slope = 0.42		NA
Arkona Basin Danish Coastal waters	Arkona Basin	Denmark	Arkona Basin Danish Coastal waters	32	Præstø Fiord	2005-2020	Flounder	Citizen Science	ASCETS	nGS	2.72	0.86	nGS	
Arkona Basin Danish Coastal waters	Arkona Basin	Denmark	Arkona Basin Danish Coastal waters	32	Præstø Fiord	2005-2020	Eelpout	Citizen Science	ASCETS	GS	0.22	0.48	GS	nGS
Arkona Basin German Coastal waters	Arkona Basin	Germany	Arkona Basin German Coastal waters	33	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mecklenburg Bight German Coastal waters	Mecklenburg Bight	Germany	Mecklenburg Bight German Coastal waters	34	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mecklenburg Bight Danish Coastal waters	Mecklenburg Bight	Denmark	Mecklenburg Bight Danish Coastal waters	35	Area south of Zealand	2003-2020	Flounder	Citizen Science	Trend	GS	Slope p >0.1 (+)	P slope = 0.58	GS	
Mecklenburg Bight Danish Coastal waters	Mecklenburg Bight	Denmark	Mecklenburg Bight Danish Coastal waters	35	Fehmarn Belt	2002-2020	Flounder	Citizen Science	Trend	nGS	Slope p >0.1 (+)	P slope = 0.46	nGS	
Mecklenburg Bight Danish Coastal waters	Mecklenburg Bight	Denmark	Mecklenburg Bight Danish Coastal waters	35	Fehmarn Belt	2002-2020	Eelpout	Citizen Science	Trend	GS	3.2	4.7	GS	nGS
Kiel Bight Danish Coastal waters	Kiel Bight	Denmark	Kiel Bight Danish Coastal waters	36	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kiel Bight German Coastal waters	Kiel Bight	Germany	Kiel Bight German Coastal waters	37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	The Great Belt	2003-2020	Flounder	Citizen Science	ASCETS	nGS	3.34	1.97	nGS	
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	The Great Belt	2003-2020	Eelpout	Citizen Science	ASCETS	GS	0.6	0.76	GS	
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	Southern Little Belt and the archipelago	2002-2020	Flounder	Citizen Science	ASCETS	nGS	2.28	1.38	nGS	
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	Odense Fiord	2002-2020	Flounder	Citizen Science	ASCETS	nGS	4.75	2.68	nGS	
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	Odense Fiord	2002-2020	Eelpout	Citizen Science	ASCETS	GS	0.3	0.35	GS	
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	Sejerø Bay	2002-2020	Flounder	Citizen Science	ASCETS	nGS	5.02	3.64	nGS	
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	Sejerø Bay	2002-2020	Eelpout	Citizen Science	Trend	GS	Slope p >0.1 (+)	P slope = 0.08	nGS	
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	Århus Bay	2002-2020	Flounder	Citizen Science	ASCETS	nGS	2.39	1.08	nGS	
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	Århus Bay	2002-2020	Eelpout	Citizen Science	ASCETS	GS	2.08	1.71	nGS	
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	Vejle Fjord	2002-2020	Flounder	Citizen Science	ASCETS	nGS	1.37	0.33	nGS	
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	Vejle Fjord	2002-2020	Eelpout	Citizen Science	ASCETS	GS	0.74	1.72	GS	
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	Fyn archipelago	2002-2020	Flounder	Citizen Science	ASCETS	nGS	7.84	2.01	nGS	
Belts Danish Coastal waters	Belt Sea	Denmark	Belts Danish Coastal waters	38	Fyn archipelago	2002-2020	Eelpout	Citizen Science	ASCETS	GS	2.9	2.74	nGS	nGS
The Sound Swedish Coastal waters	The Sound	Sweden	The Sound Swedish Coastal waters	39	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
The Sound Danish Coastal waters	The Sound	Denmark	The Sound Danish Coastal waters	40	The sound	2002-2020	Flounder	Citizen Science	ASCETS	nGS	3.84	1.23	nGS	
The Sound Danish Coastal waters	The Sound	Denmark	The Sound Danish Coastal waters	40	The sound	2002-2020	Eelpout	Citizen Science	ASCETS	GS	0.042	2.15	GS	nGS
Kattegat Swedish Coastal waters, including Limfjorden	Kattegat	Sweden	Kattegat Swedish Coastal waters, including Limfjorden	41	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kattegat Danish Coastal waters, including Limfjorden	Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Islefjord and Roskilde fjord	2003-2020	Flounder	Citizen Science	ASCETS	GS	1.6	4.51	GS	
Kattegat Danish Coastal waters, including Limfjorden	Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Islefjord and Roskilde fjord	2003-2020	Eelpout	Citizen Science	ASCETS	GS	1.11	3.28	GS	
Kattegat Danish Coastal waters, including Limfjorden	Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Northern Limfjord	2002-2020	Flounder	Citizen Science	ASCETS	nGS	0.3	0.49	nGS	
Kattegat Danish Coastal waters, including Limfjorden	Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Northern Limfjord	2002-2020	Eelpout	Citizen Science	ASCETS	GS	0.92	0.94	GS	
Kattegat Danish Coastal waters, including Limfjorden	Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Skive Fiord and Lovns Broad	2002-2020	Flounder	Citizen Science	ASCETS	nGS	1.34	0.29	nGS	
Kattegat Danish Coastal waters, including Limfjorden	Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Skive Fiord and Lovns Broad	2002-2020	Eelpout	Citizen Science	ASCETS	nGS	4.06	0	GS	
Kattegat Danish Coastal waters, including Limfjorden	Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Aalborg Bay and Laesö	2004-2020	Flounder	Citizen Science	ASCETS	nGS	2.44	1.96	nGS	
Kattegat Danish Coastal waters, including Limfjorden	Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Aalborg Bay and Laesö	2004-2020	Eelpout	Citizen Science	ASCETS	GS	1.69	1.32	nGS	
Kattegat Danish Coastal waters, including Limfjorden	Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Mariager and Horserns Fjords	2002-2020	Flounder	Citizen Science	ASCETS	nGS	1.07	0.51	nGS	
Kattegat Danish Coastal waters, including Limfjorden	Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Mariager and Horserns Fjords	2002-2020	Eelpout	Citizen Science	ASCETS	GS	2.73	0.12	GS	nGS

In the northernmost parts of the Baltic Sea (i.e. the Bothnian Bay and The Quark), the status is generally good in the Bothnian Bay across all assessment units, locations and species (perch, whitefish, and pike). In the Quark neither of the two assessment units meets the threshold due to non-good status for perch in one of the Finnish and both Swedish monitoring locations. The abundance of whitefish is only evaluated in Sweden and show good status in both monitoring locations considered.

Whereas the overall status is good for the Finnish parts of the Bothnian Sea where both perch and pikeperch are considered, the status is considerably lower along the Swedish parts of the Bothnian Sea and Åland Sea, and in the Finnish Archipelago Sea. Perch abundance is above the threshold for good status in all five monitoring locations considered in the Swedish parts of the Bothnian Sea and Åland Sea, whereas the abundance pikeperch, pike, and whitefish are below the threshold leading to an overall poor status in the two assessment units. The overall poor status in the Archipelago Sea is attributable to low abundances of whitefish in one of the locations (Kumlinge), whereas the abundances of perch, pike and pikeperch are all above the threshold for good status in the in total three locations considered.

In the central parts of the Baltic Sea (Northern Baltic Proper, Gulf of Finland, Gulf of Riga and Western Gotland Basin), there are differences in the status across the monitoring locations and assessment units. In the more northern regions (Finnish parts of the Gulf of Finland and Swedish parts of Northern Baltic Proper) the overall status is poor as a result of poor status for perch in one (Tvärminne) of four considered locations in the Finnish parts of the Gulf of Finland. The abundance of perch and pikeperch in the remaining locations of this assessment unit meets the threshold. In the Swedish parts Northern Baltic Proper, the overall poor status is due to poor status of perch, pike and flounder in two of the monitoring locations considered, whereas the status of whitefish is good as is the status of both perch and pikeperch in one location. In the Gulf of Riga, the status is good in both Estonian and Latvian coastal areas where only perch is considered, but in the Western Gotland basin where perch, pike, pikeperch, flounder and whitefish are considered the overall status is poor. This is the result of poor status of all species except for pikeperch that is considered in only one of the two locations included in the evaluation.

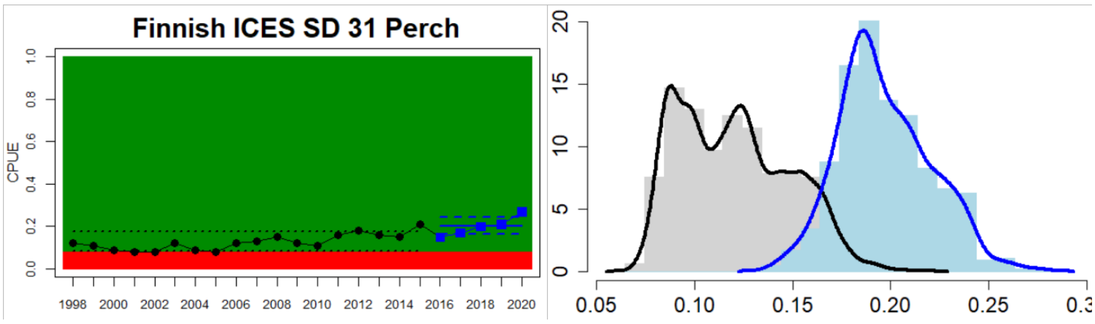
In the Eastern Gotland Basin, data is available for Latvia and Lithuania. In Latvia the assessment unit meets the threshold for good status, and only flounder is considered as key species, whereas in Lithuania the overall status for the assessment unit is poor due poor status of pikeperch in the Curonian Lagoon. For the other four monitoring locations where flounder is considered the key species, the abundances meet the threshold for good status.

In the Bornholm, Gdansk and Arkona Basins there is data from two Swedish, three Polish, and one Danish location. Species that are considered are perch (Sweden and Poland), flounder (Sweden, Poland and Denmark), pike (Sweden), and eelpout (Denmark). The overall status is poor in the Swedish parts of the Bornholm Basin as a result of poor status for pike and flounder, but not for perch. The overall status is poor in the Polish parts of the Gdansk basin because, while both perch and flounder meet the threshold for good status in most areas considered, flounder does not meet the threshold in one area. Finally, the overall status is poor in the Danish parts of the Arkona basin as a result of poor status for flounder, but good for eelpout.

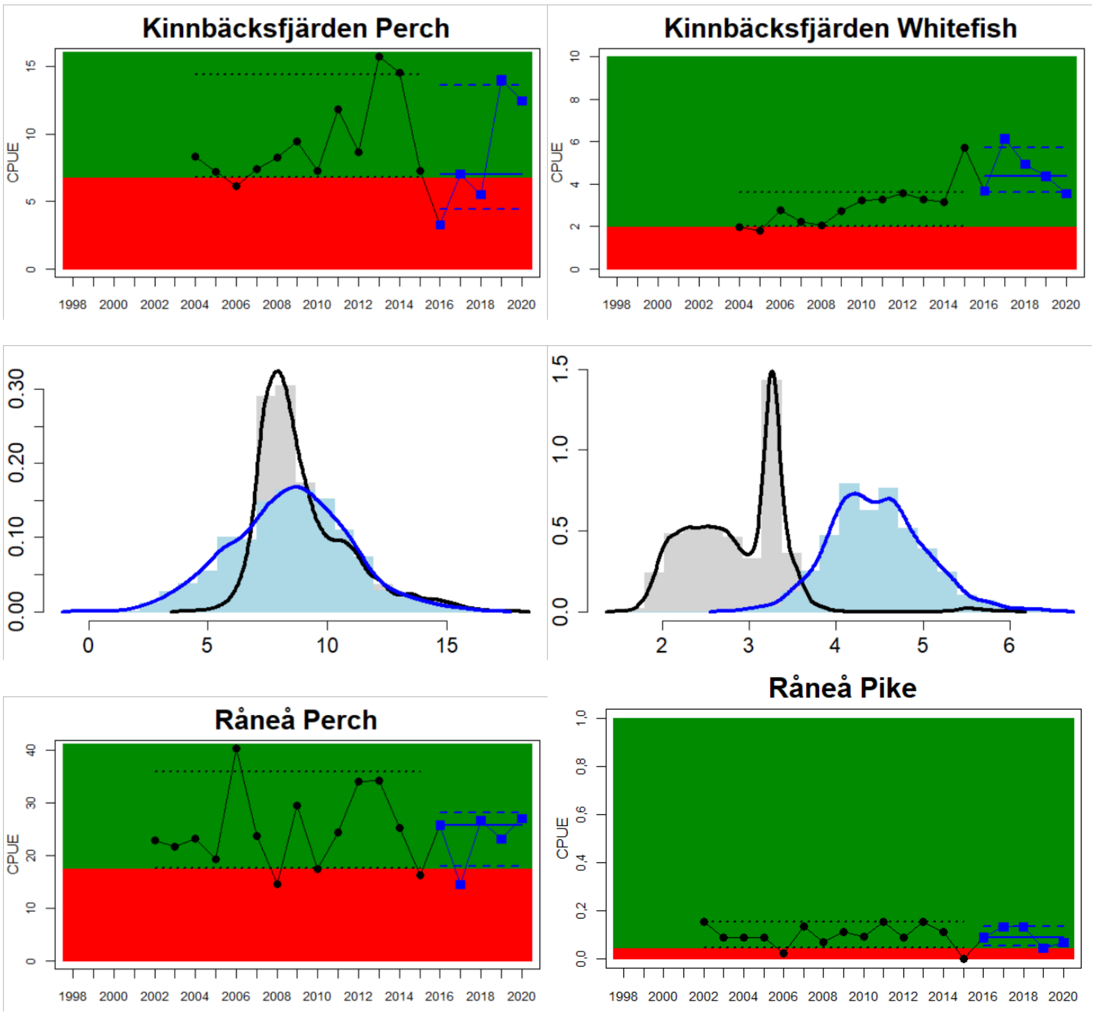
In the most western parts of the Baltic Sea, only Danish monitoring locations are considered. The overall status is poor in all four assessment units, as a result of overall poor status in 14 of the 17 monitoring locations considered. The three monitoring locations that achieved good overall status were found in Danish waters of Kattegat, the Mecklenburg Bight and Belts Sea. In general eelpout have a better status (good status in 10 out of 14 monitoring locations), compared to flounder (good status in 2 out of 14 monitoring locations)

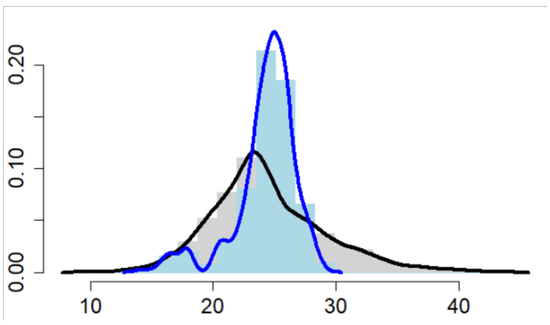
Bothnian Bay

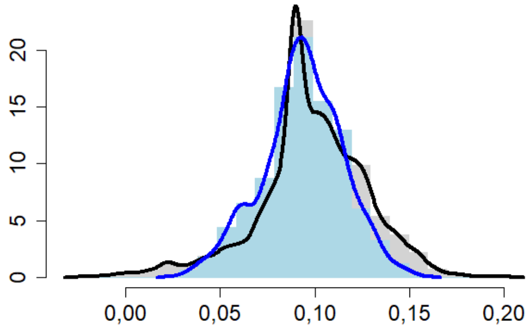
Finland

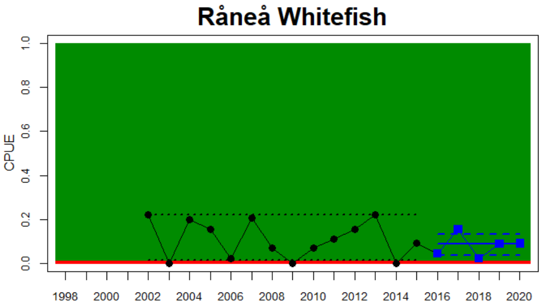


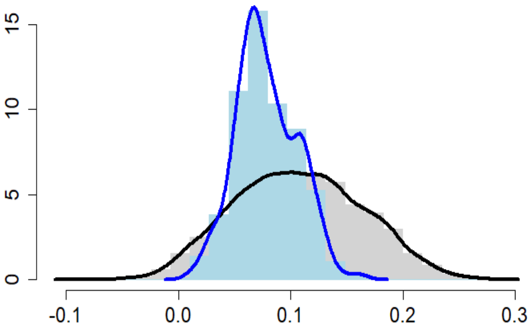
Sweden





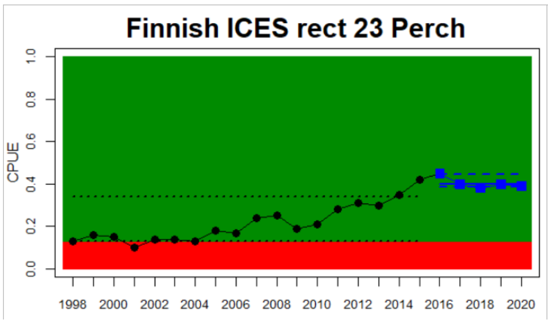


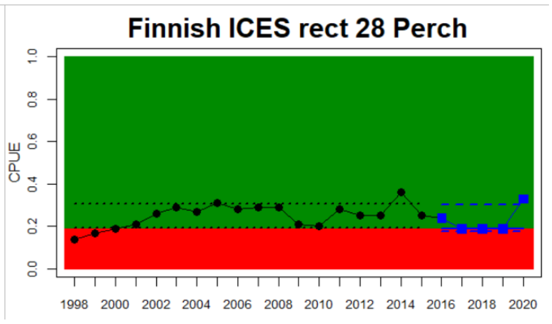


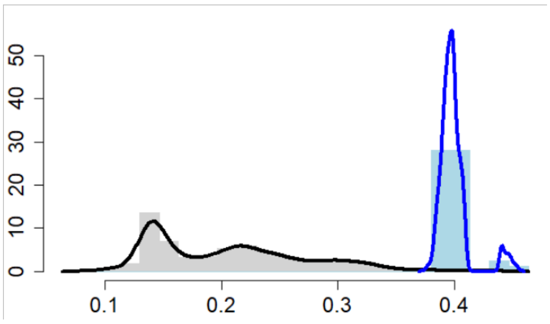


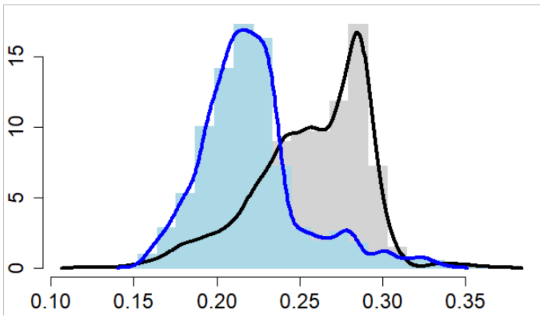
The Quark

Finland

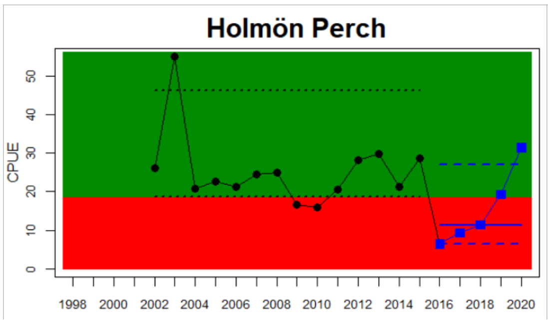


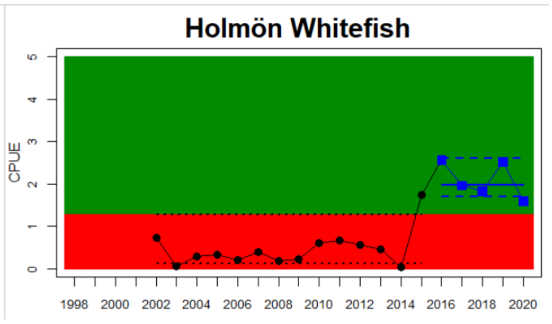






Sweden


Holmön Perch
CPUE


Holmön Whitefish
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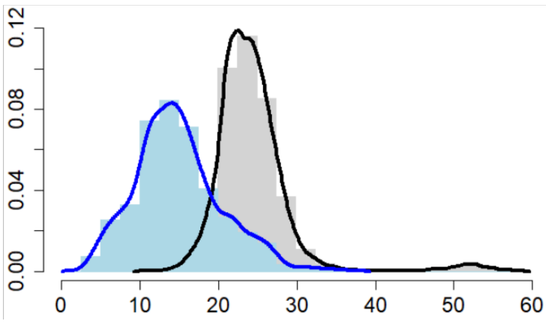

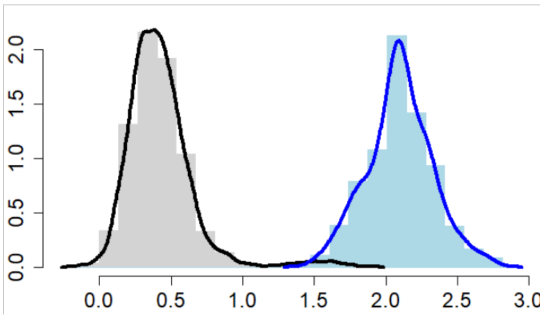

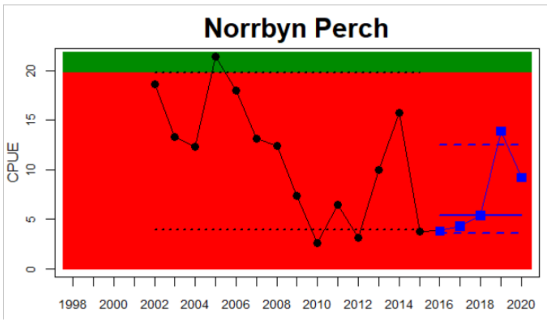
Norrbyn Perch
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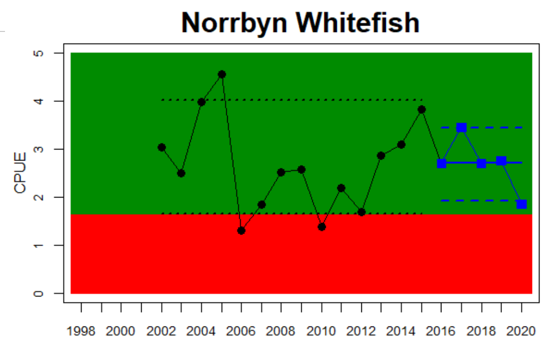
Norrbyn Whitefish
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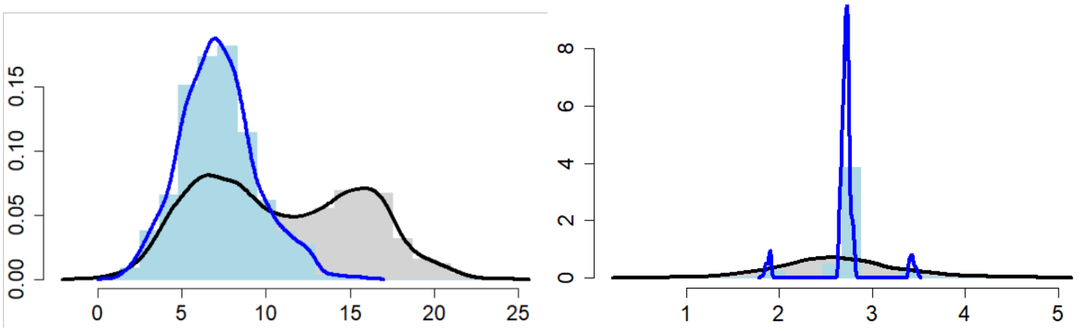
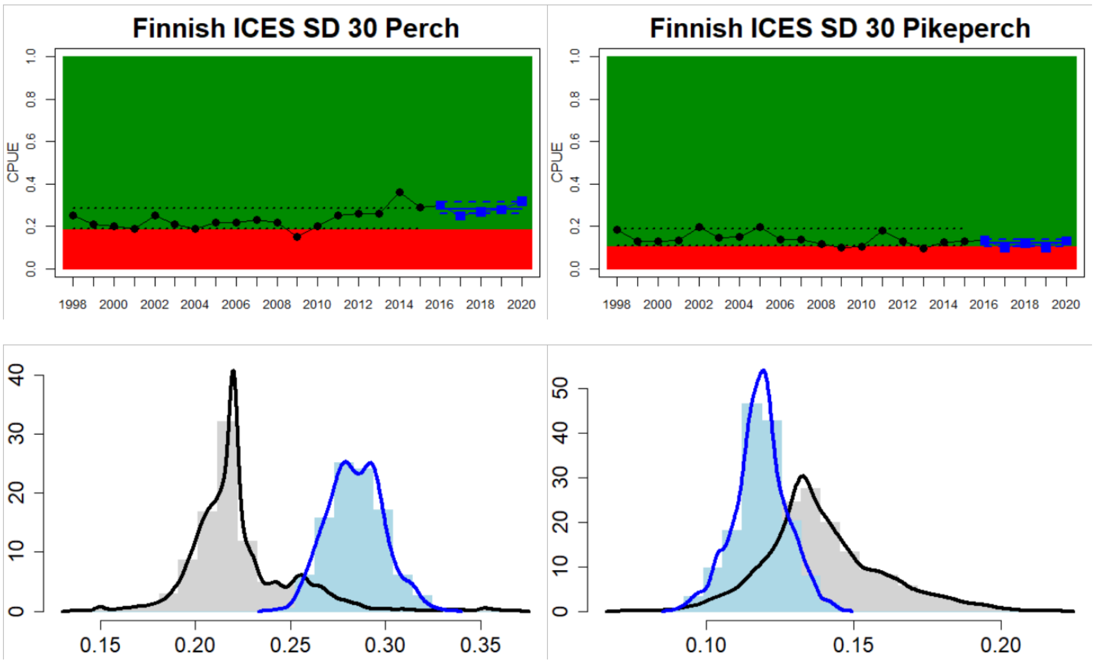
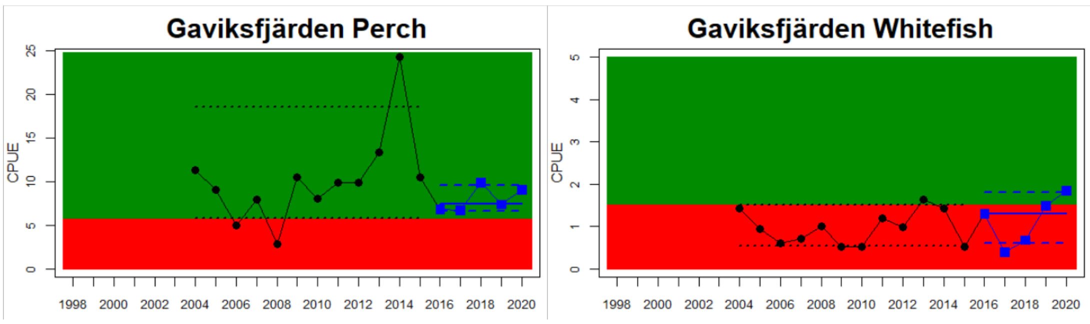


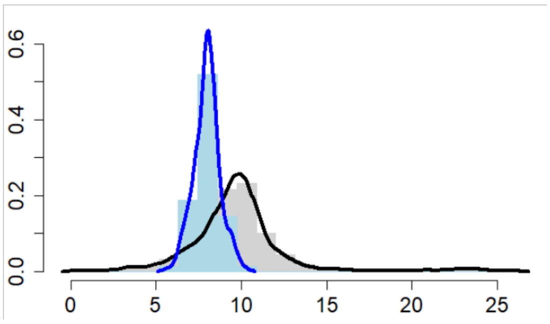
Bothnian Sea

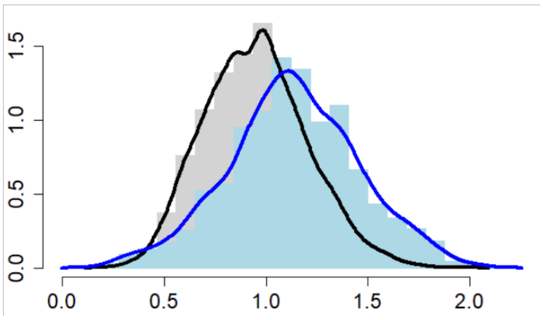
Finland

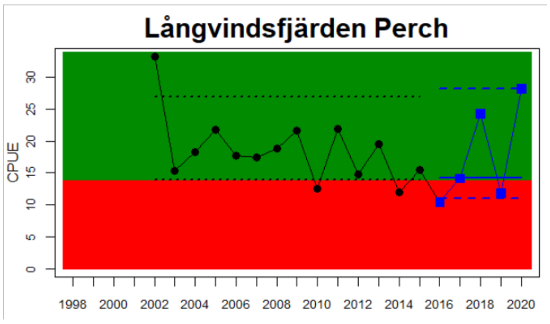


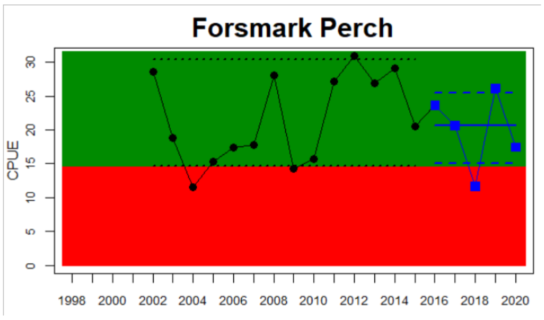
Sweden








Långvindsfjärden Perch
CPUE


Forsmark Perch
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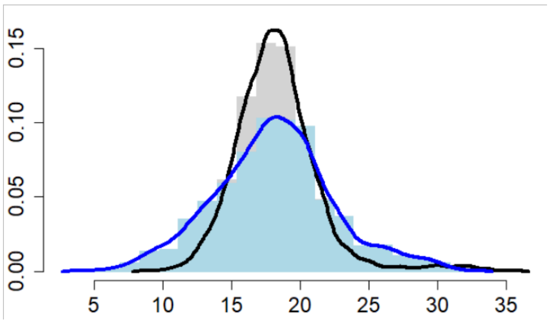

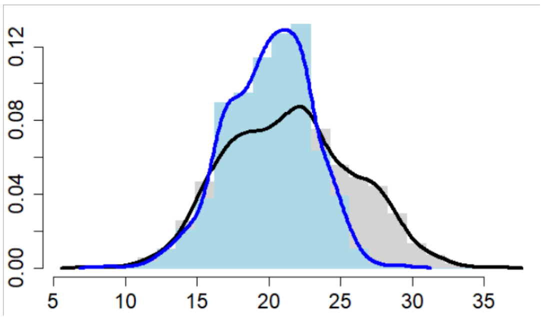

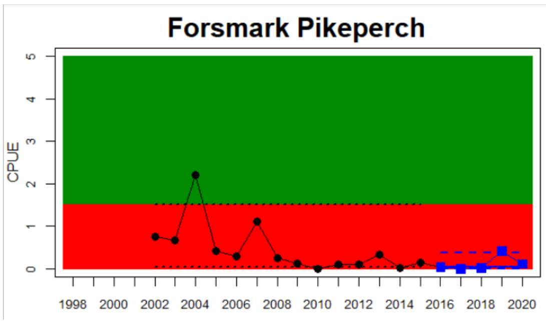
Forsmark Pikeperch
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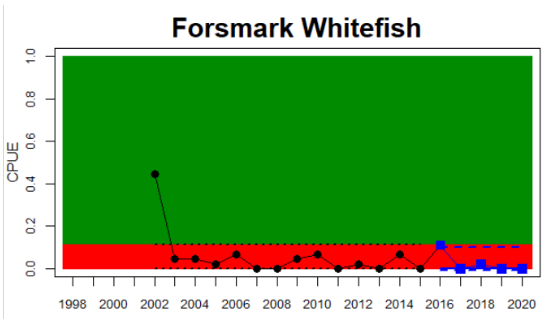
Forsmark Whitefish
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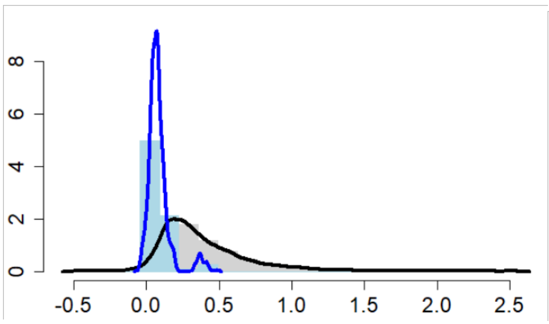
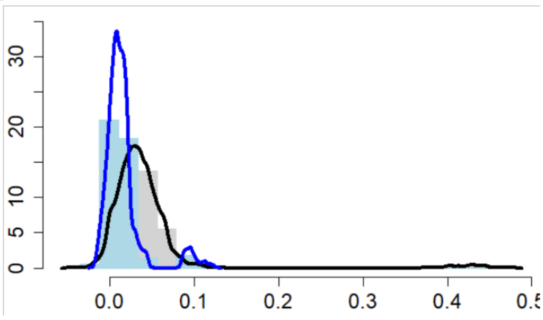
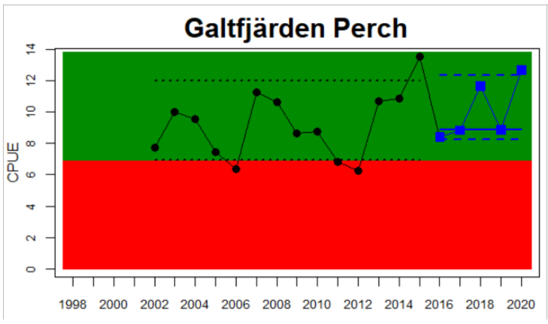
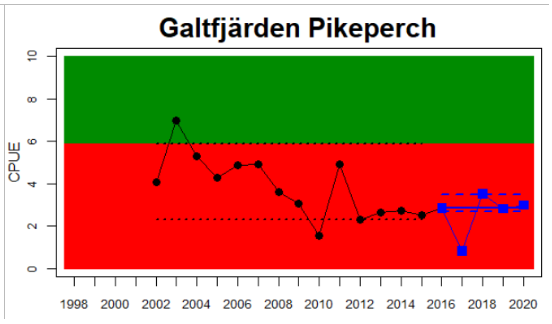


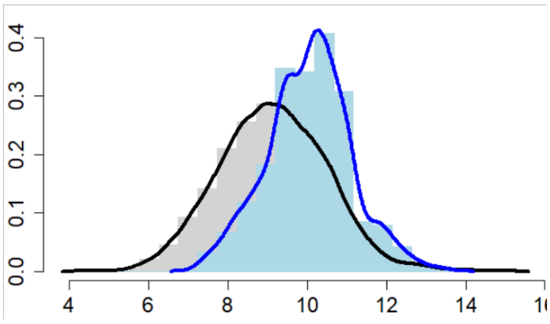


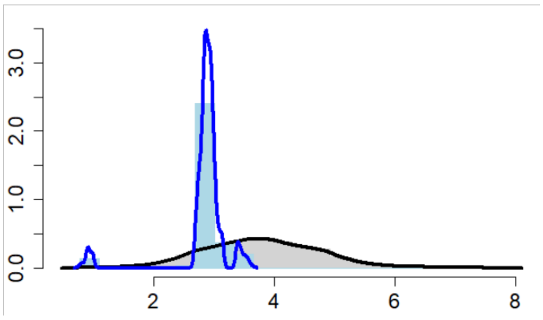
Åland Sea

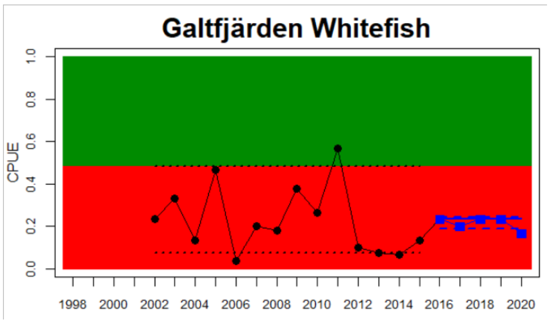
Sweden

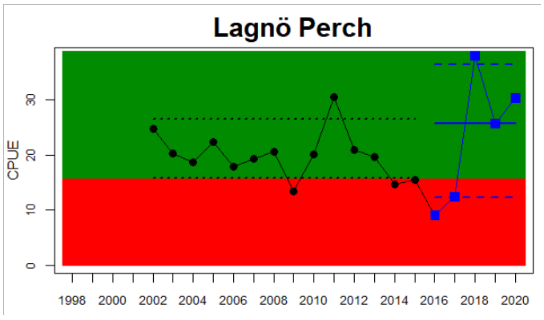


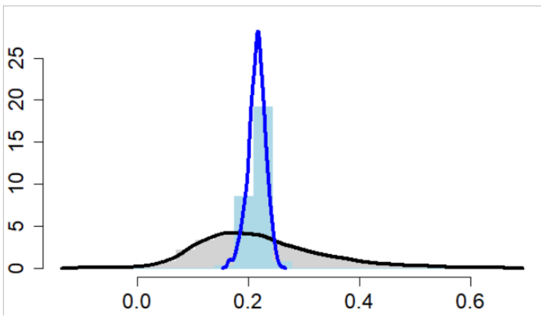


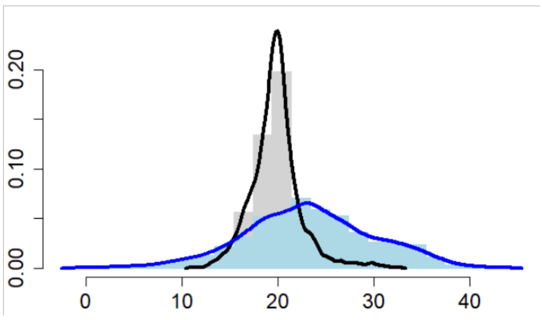


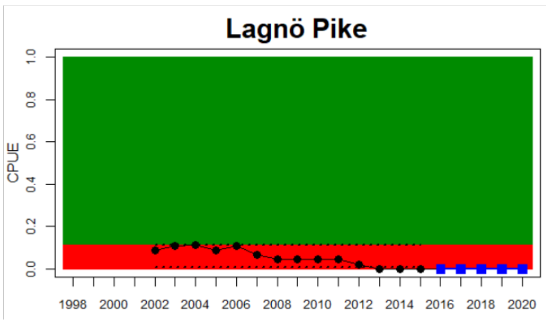


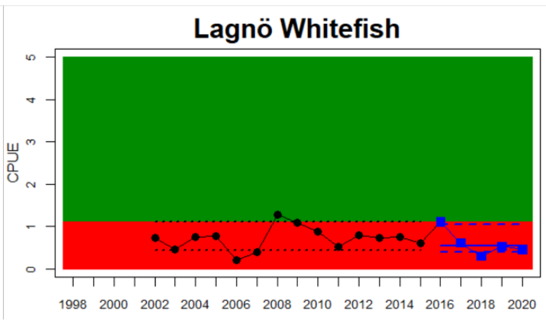


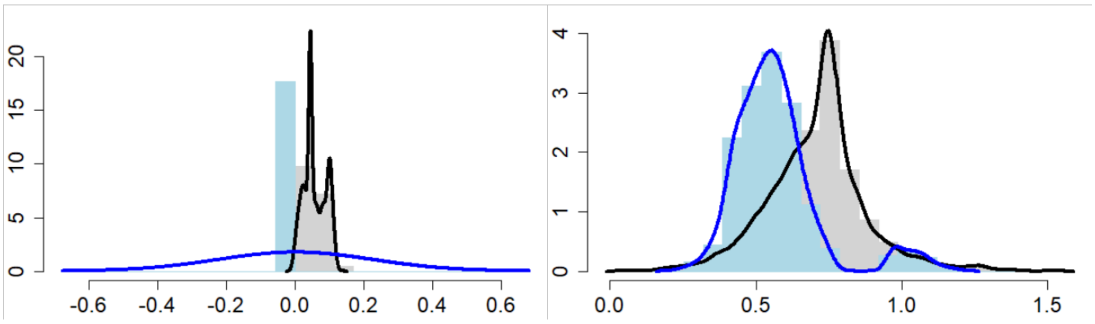






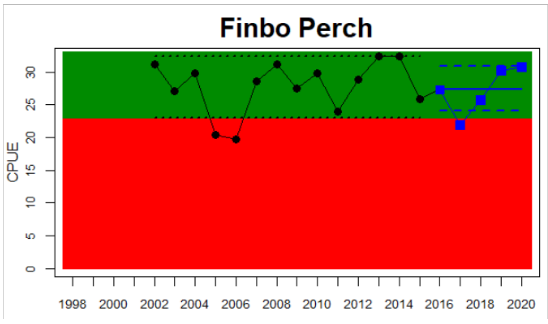


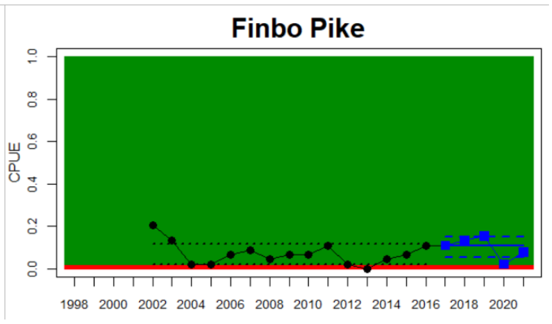


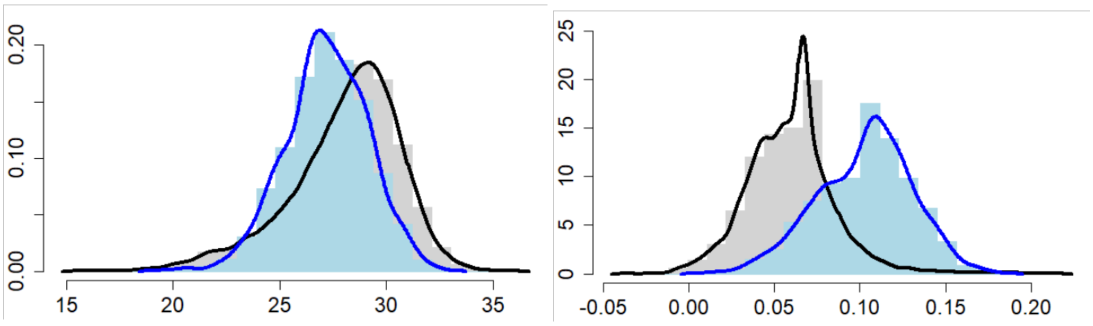


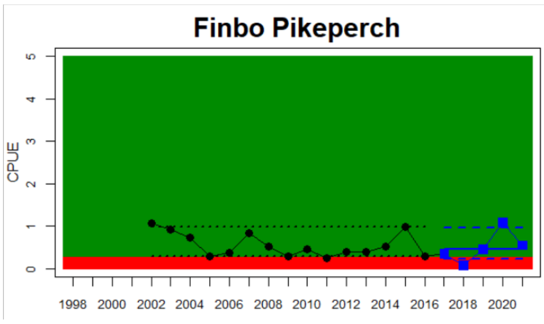
Archipelago Sea

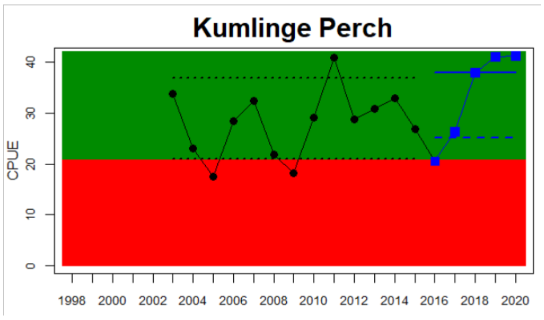
Finland

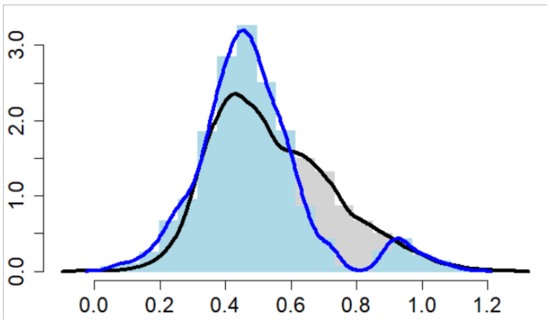


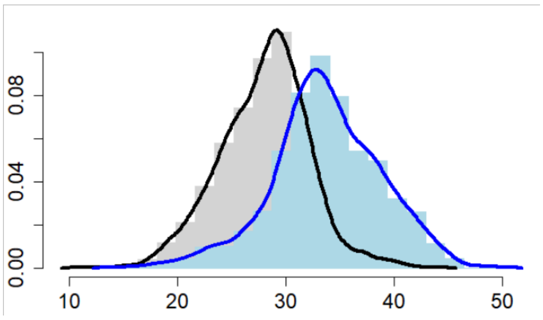


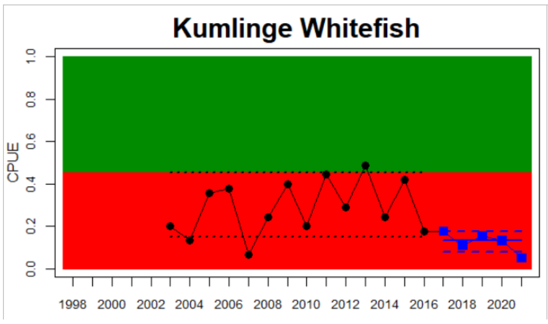


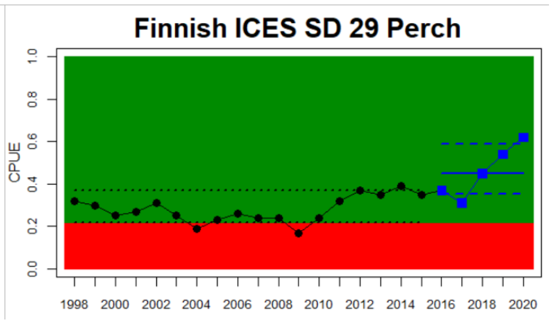









Kumlinge Whitefish
CPUE


Finnish ICES SD 29 Perch
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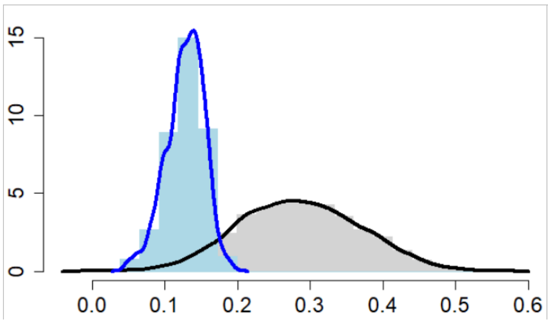

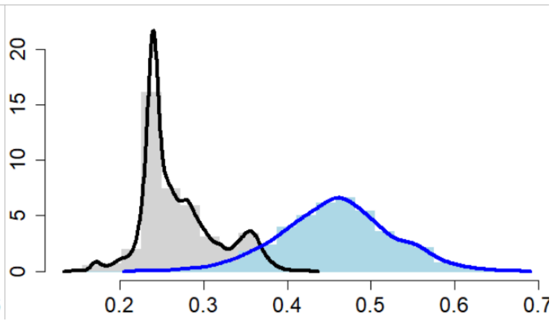

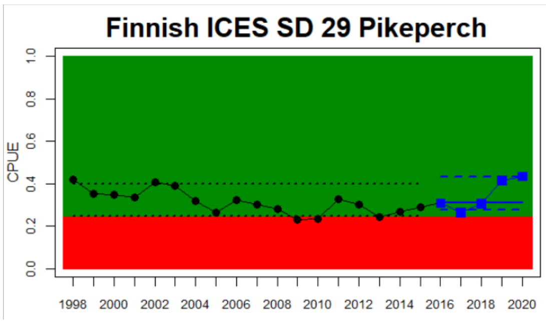
Finnish ICES SD 29 Pikeperch
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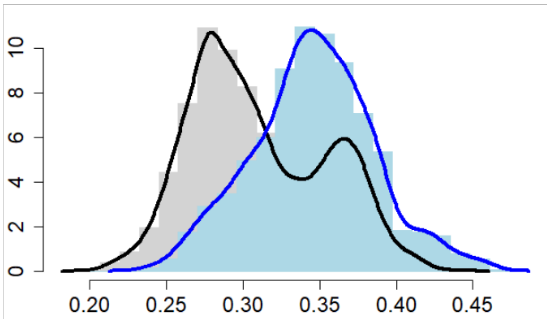
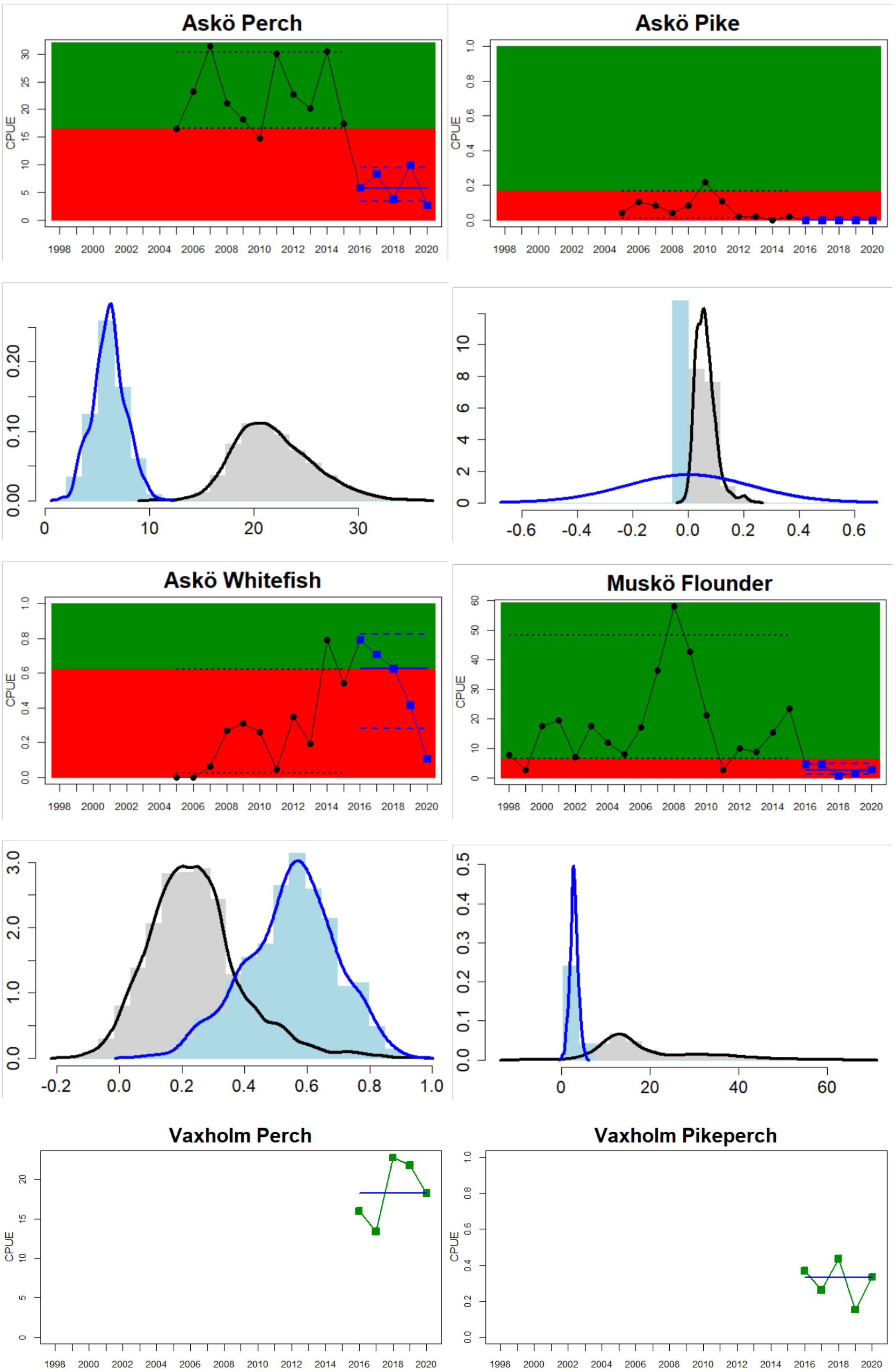


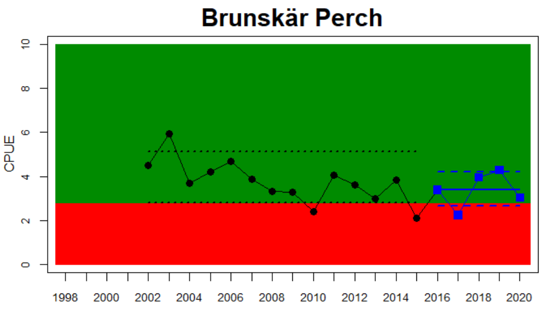
Northern Baltic Sea

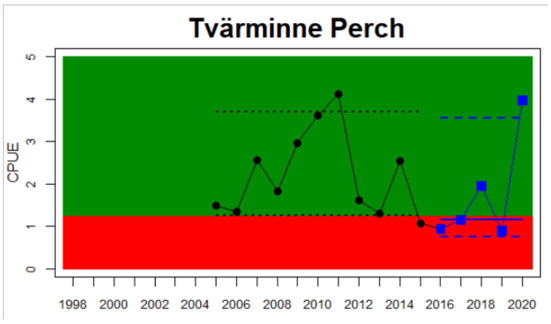
Sweden

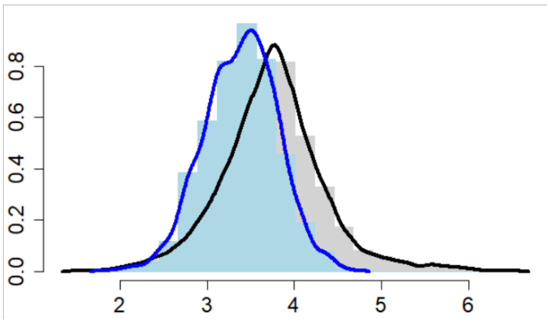


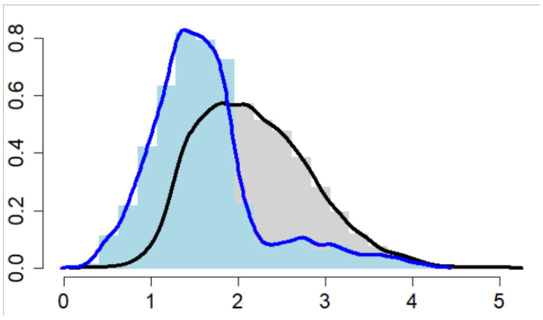
Gulf of Finland

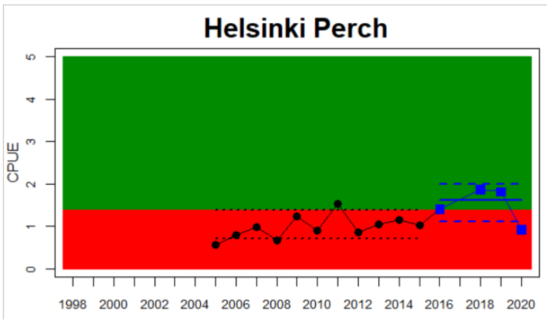
Finland

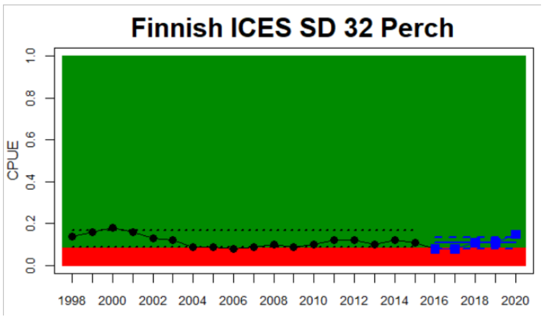


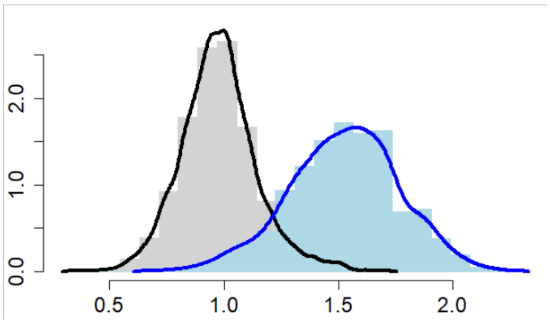


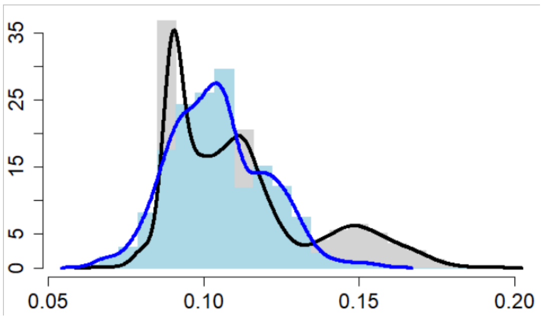


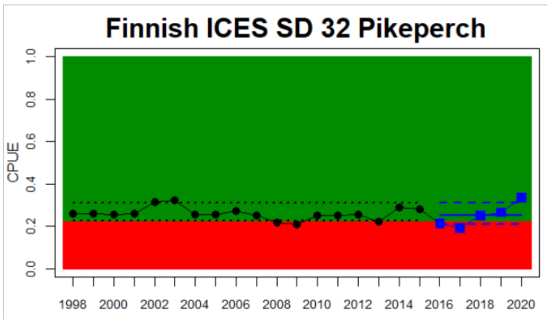


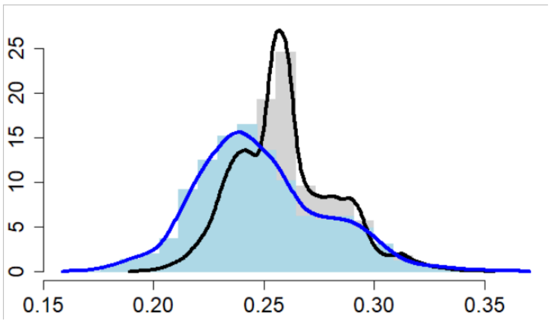






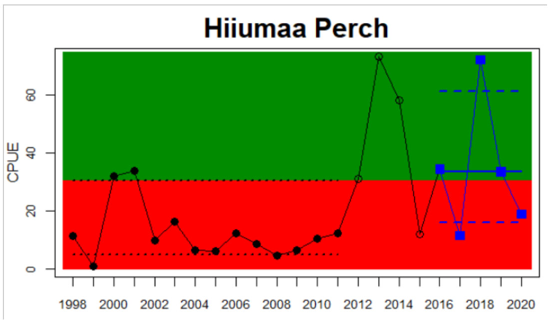


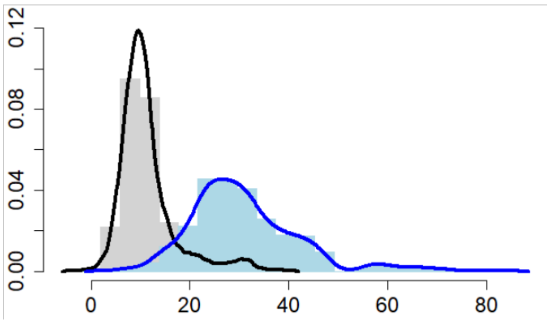




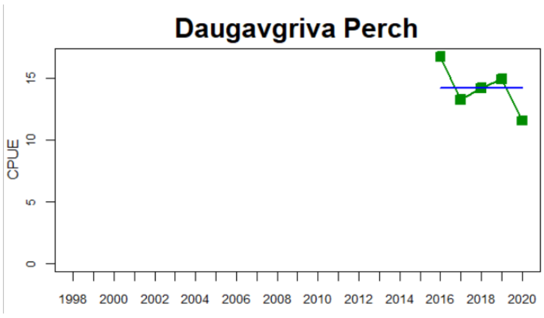
Gulf of Riga

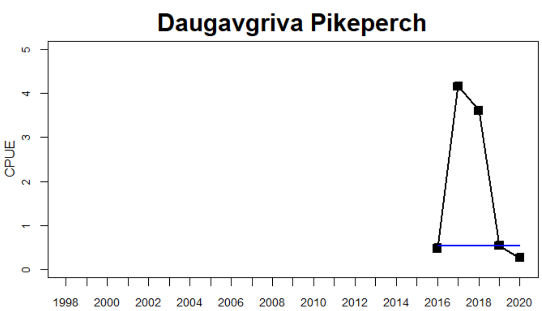
Estonia





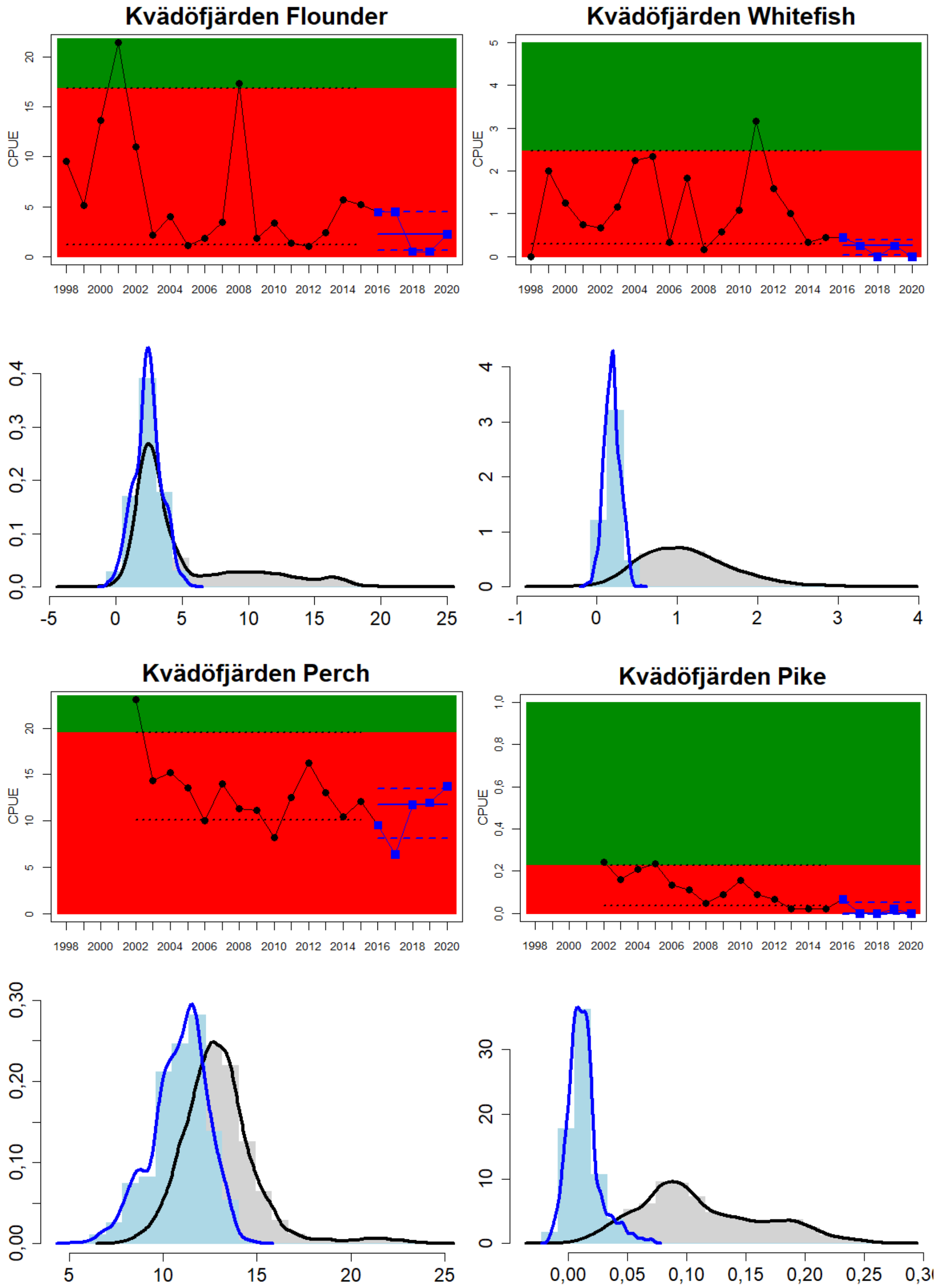
Latvia

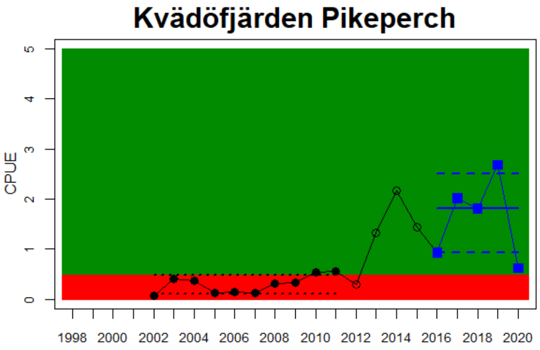


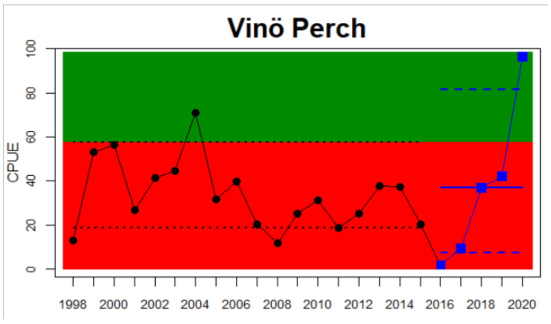


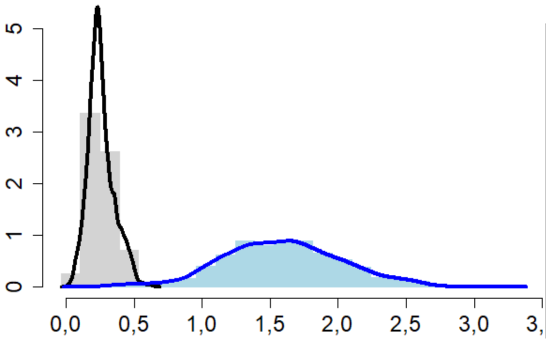
Western Gotland Basin

Sweden




Kvädöfjärden Pikeperch
CPUE
0 1 2 3 4 5
1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020


Vinö Perch
CPUE
0 20 40 60 80 100
1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020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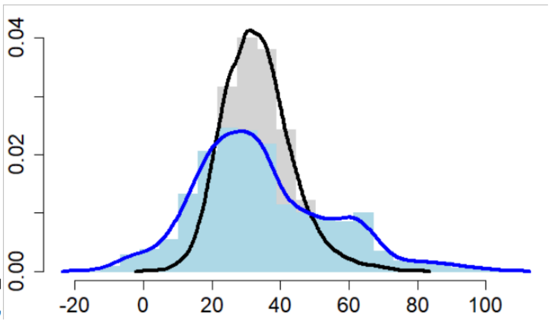
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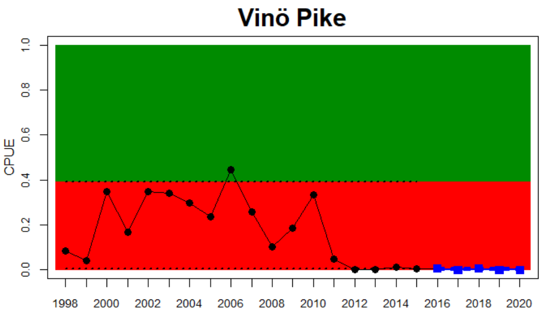
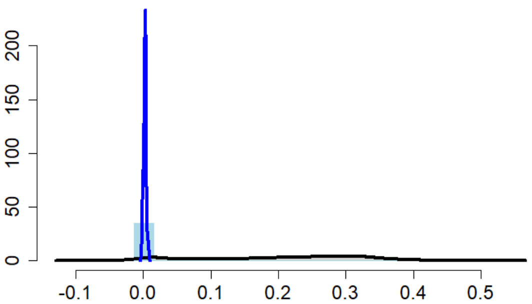

Vinö Pike
CPUE
0.0 0.2 0.4 0.6 0.8 1.0
1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020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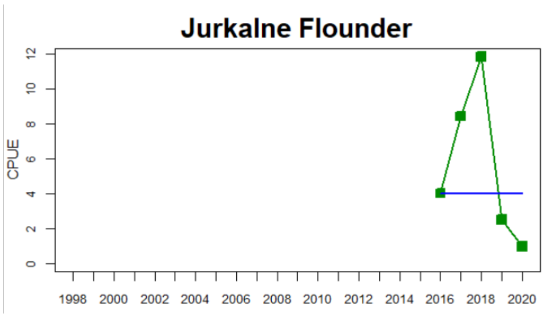
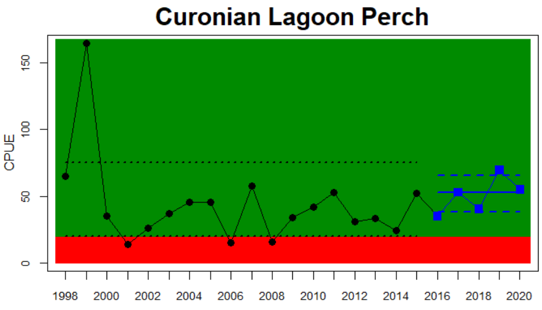
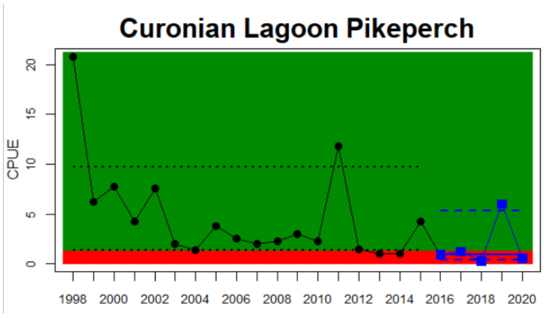
Eastern Gotland Basin

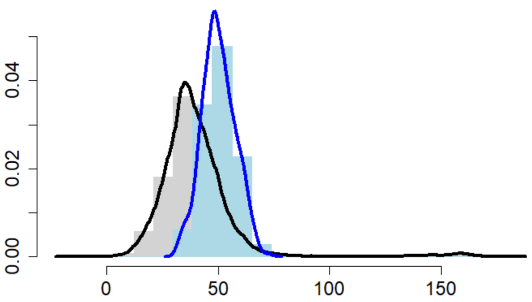
Latvia

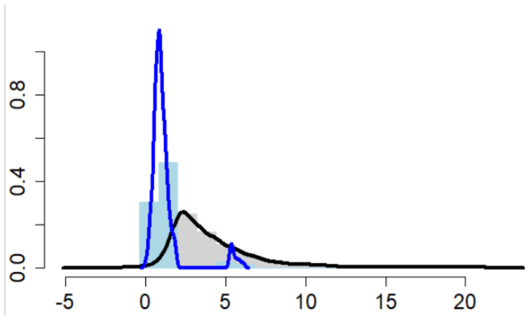


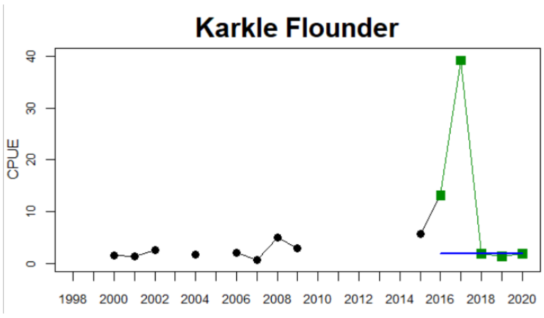
Lithuania

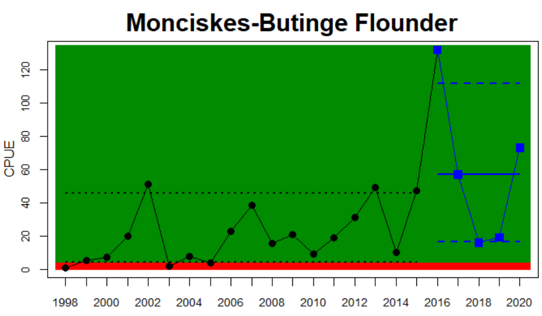











Monciskes-Butinge Flounder
CPUE
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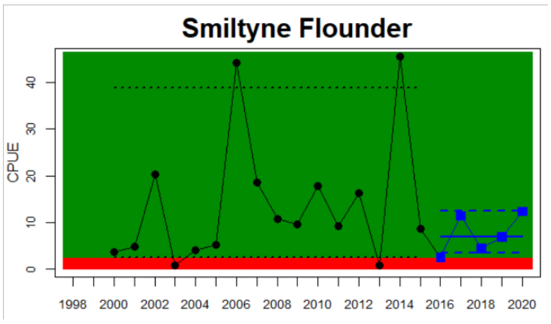
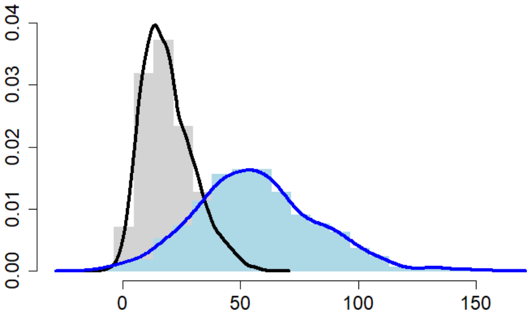
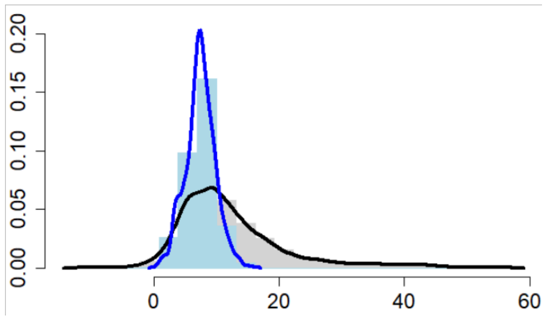
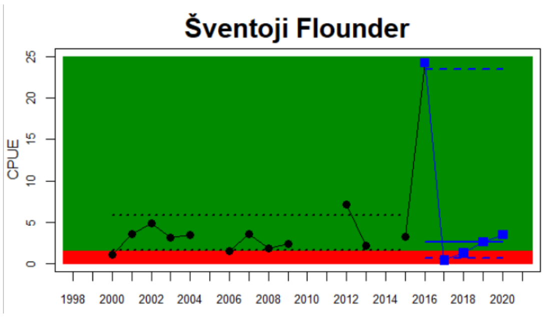
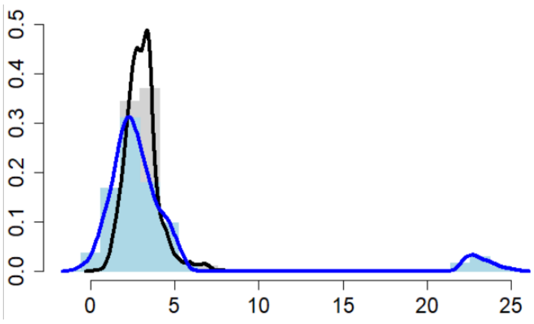
1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020


Smiltyne Flounder
CPUE
0 10 20 30 40
1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020

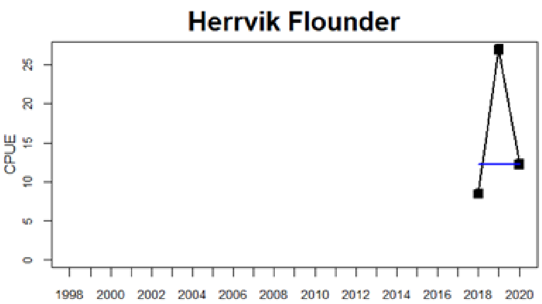

0.00 0.01 0.02 0.03 0.04
0 50 100 150


0.00 0.05 0.10 0.15 0.20
0 20 40 60


Šventoji Flounder
CPUE
0 5 10 15 20 25
1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020

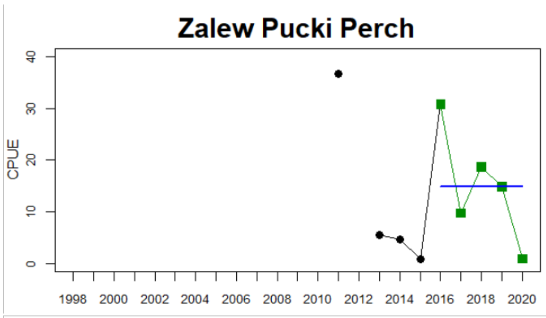

0.0 0.1 0.2 0.3 0.4 0.5
0 5 10 15 20 25

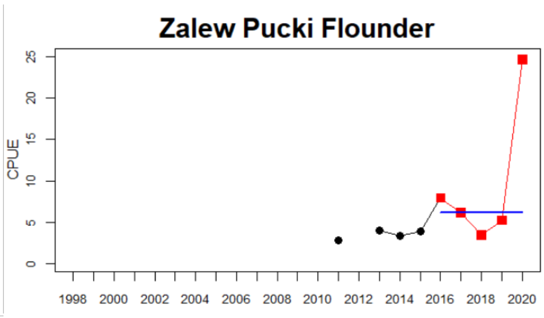
Sweden

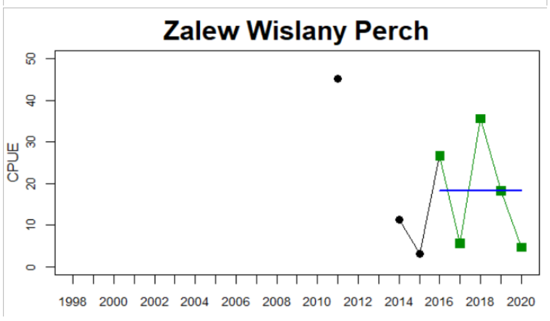

Herrvik Flounder
CPUE
0 5 10 15 20 25
1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020

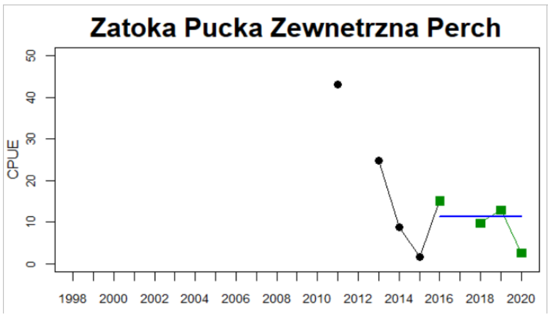
Gdansk Basin

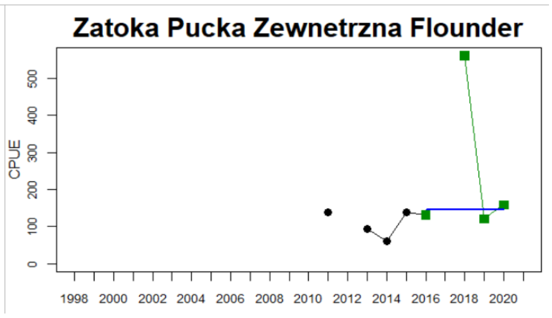
Poland





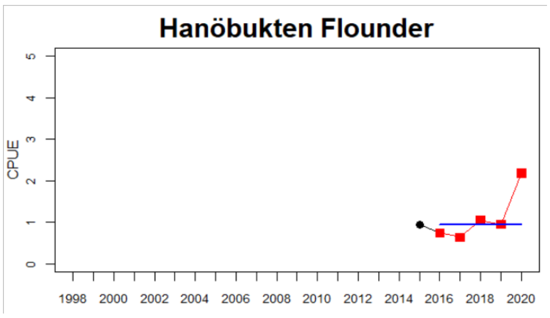


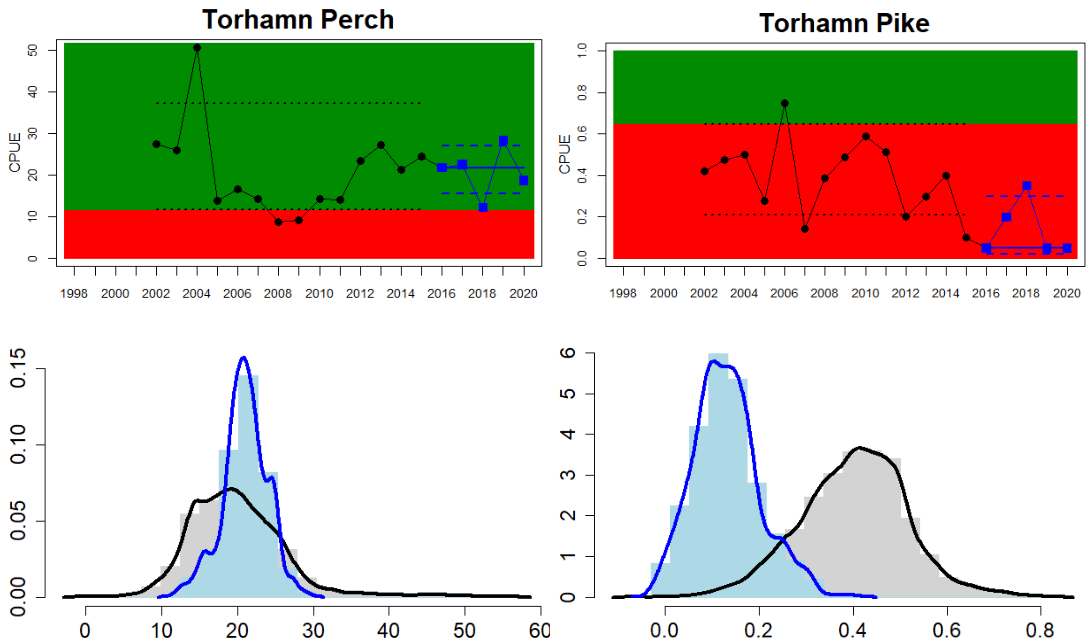




Bornholm Basin

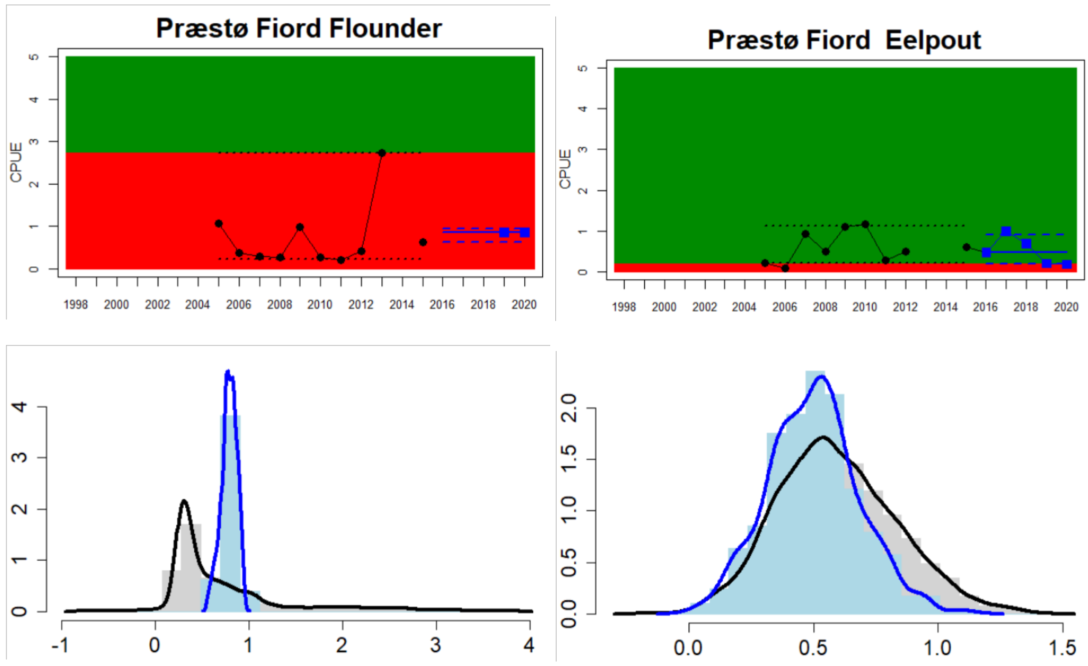
Sweden



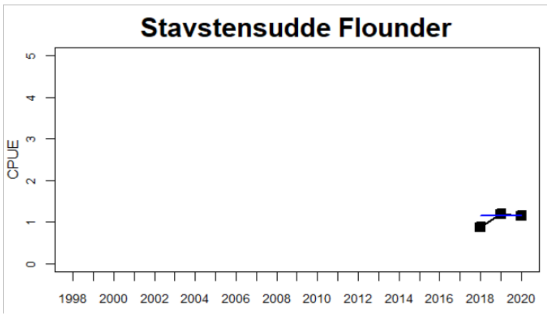


Arkona Basin

Denmark

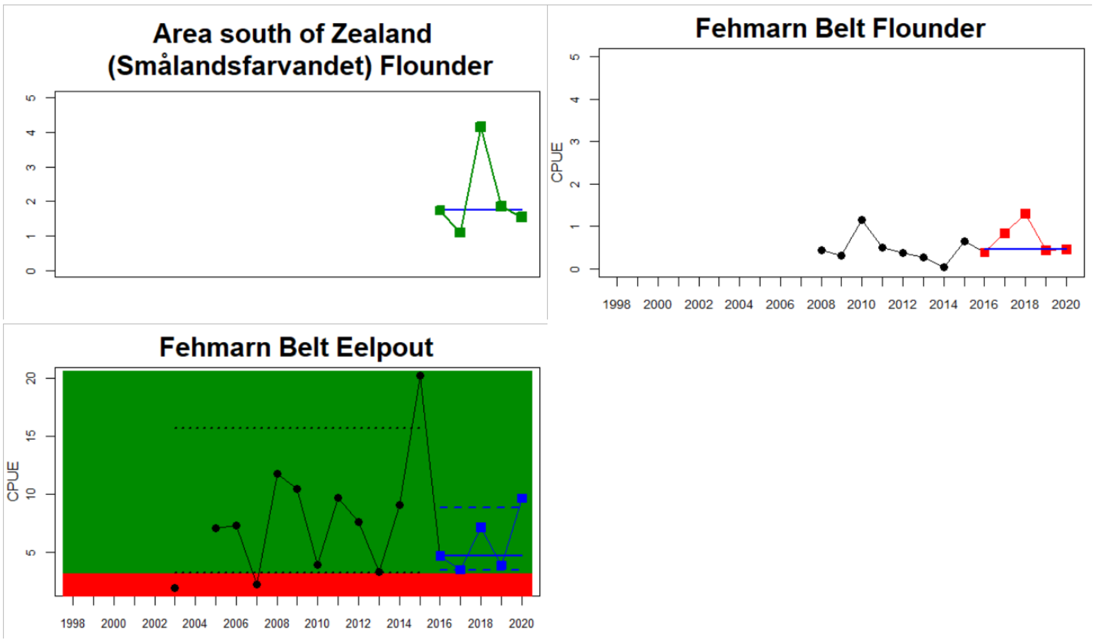


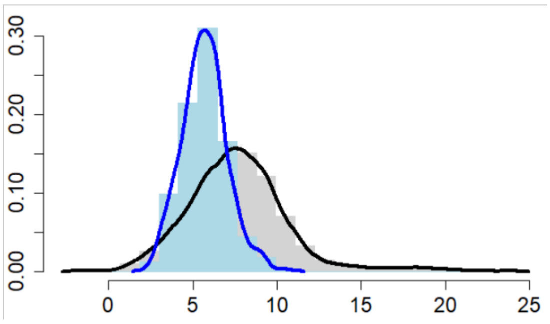
Sweden



Mecklenburg Bight

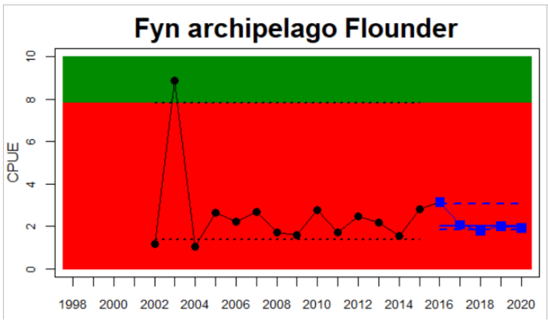
Denmark

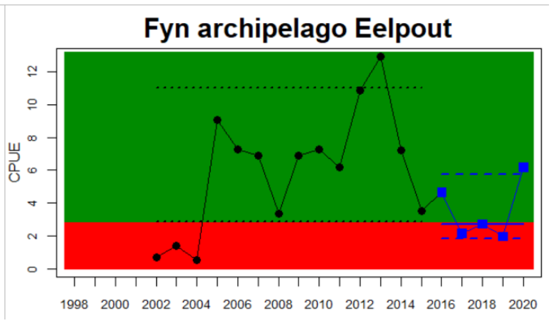


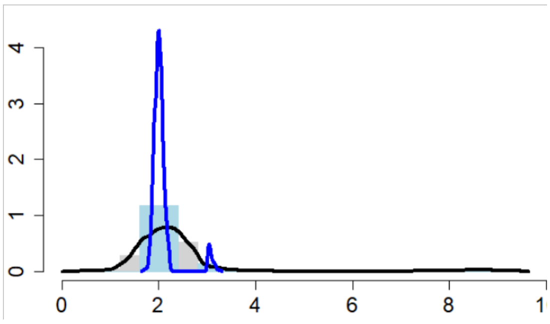


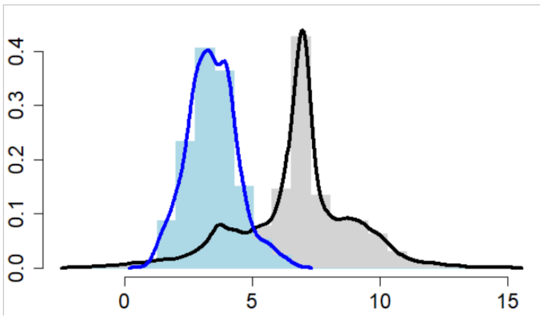
Belt Sea

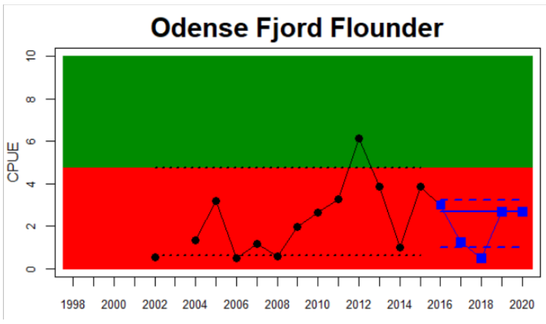
Denmark

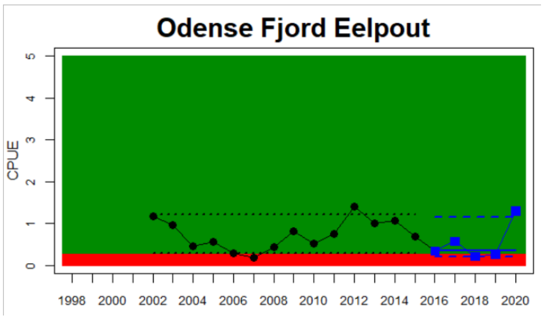


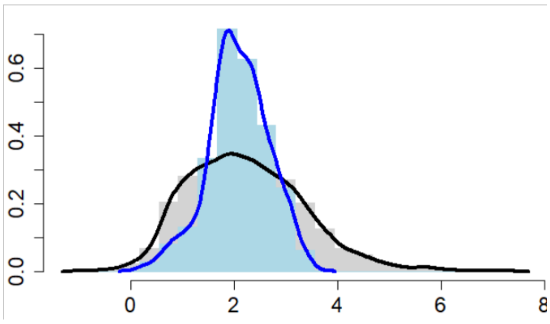


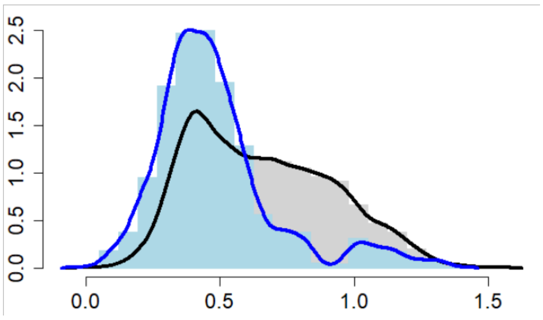


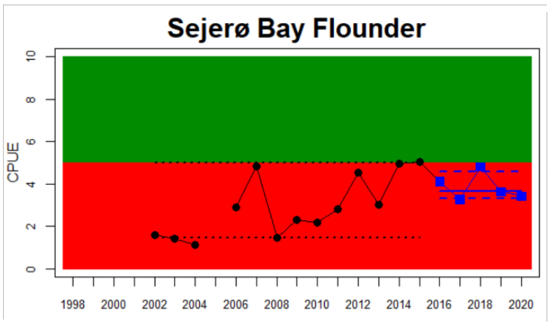


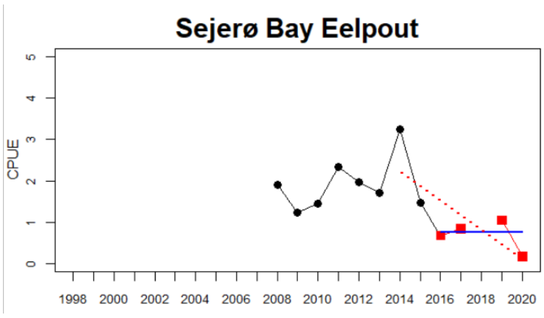


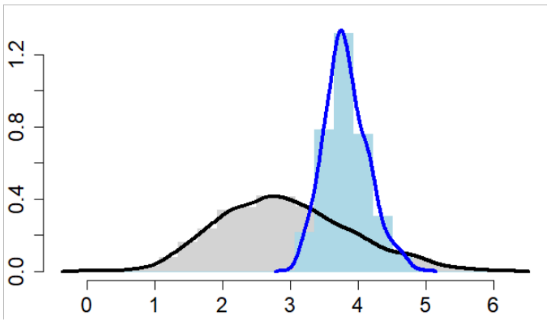


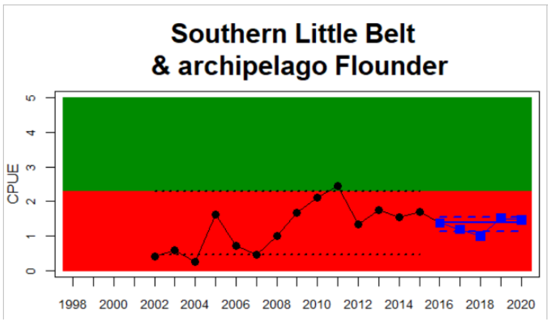


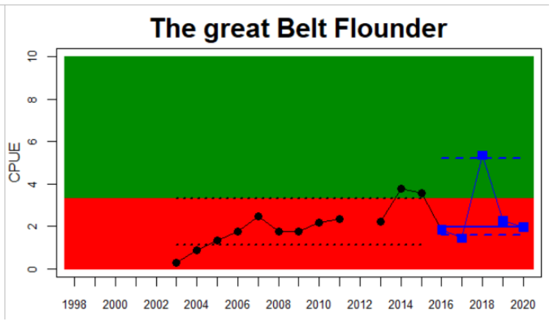


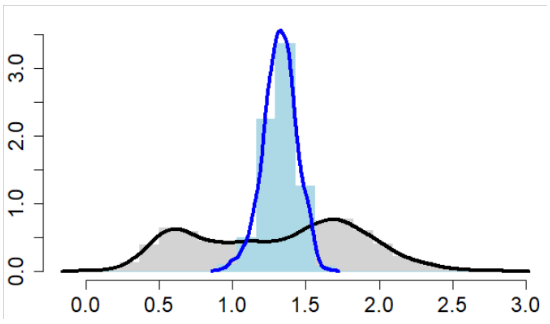


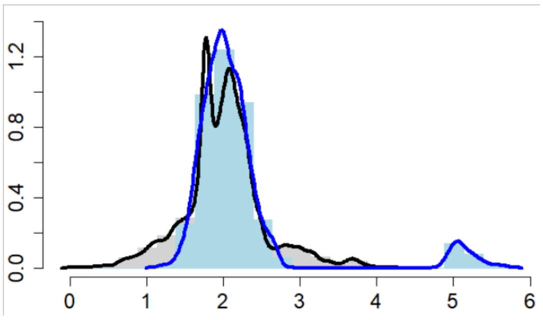


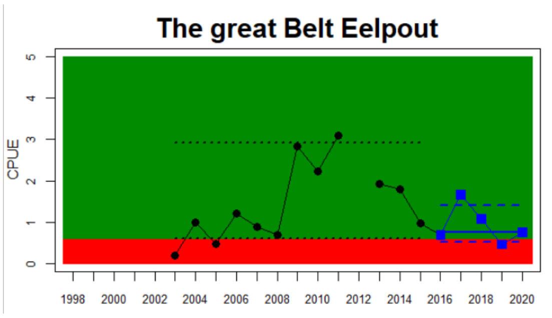


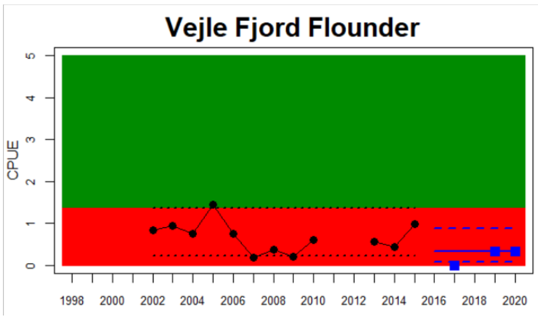

Southern Little Belt
& archipelago Flounder
CPUE

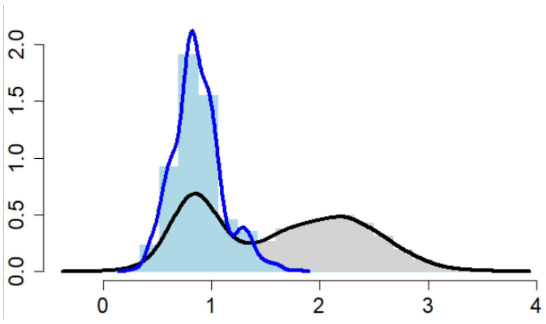

The great Belt Flounder
CPUE

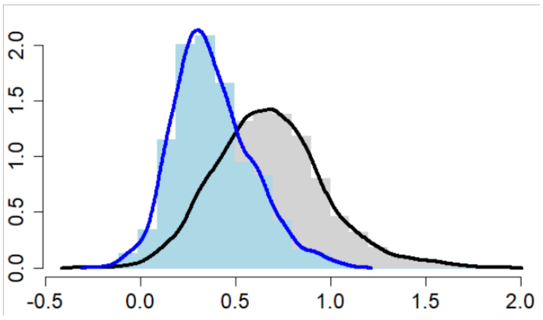


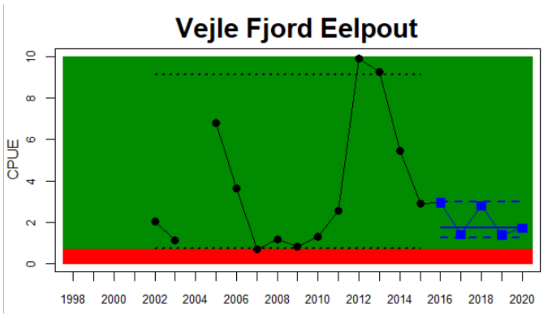


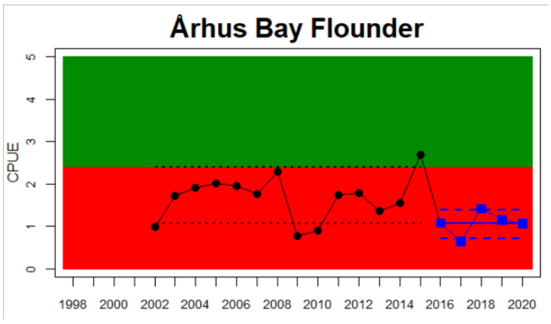

The great Belt Eelpout
CPUE

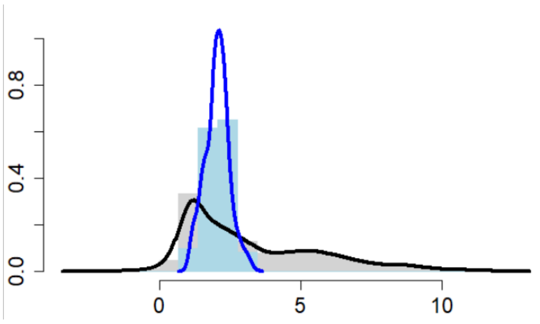

Vejle Fjord Flounder
CPUE

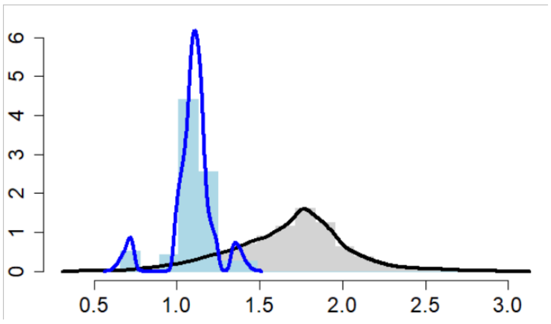


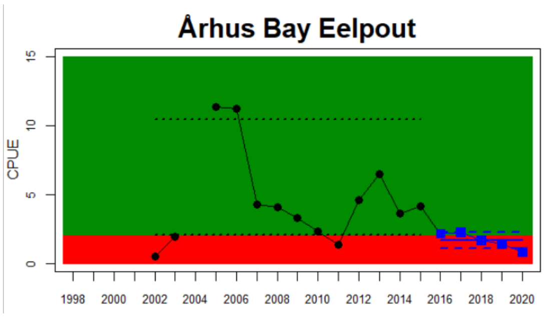


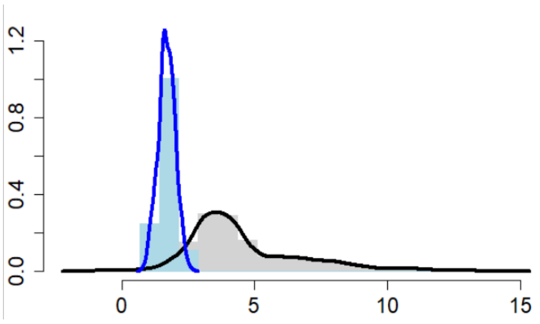






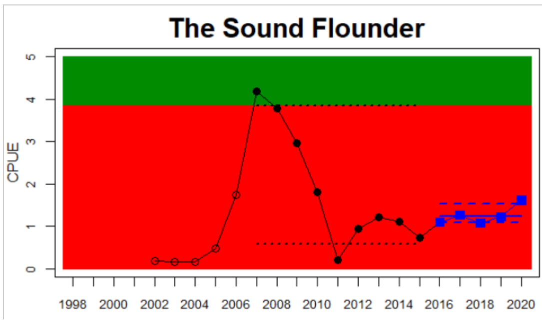


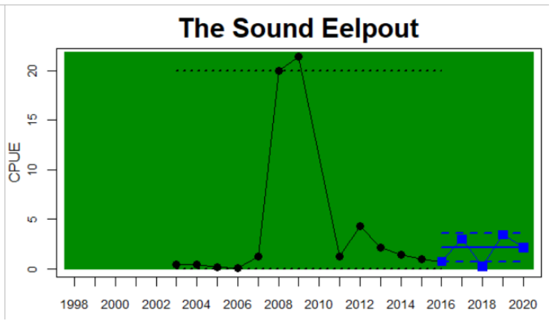


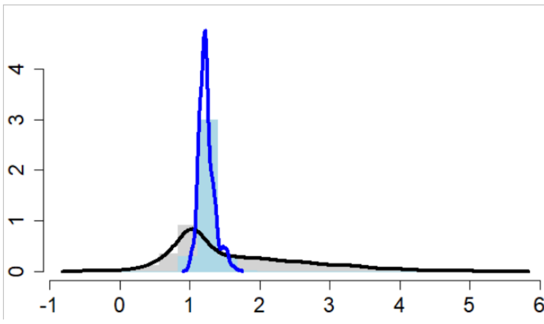


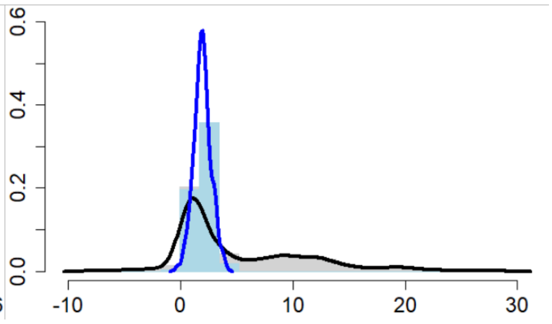
The Sound

Denmark



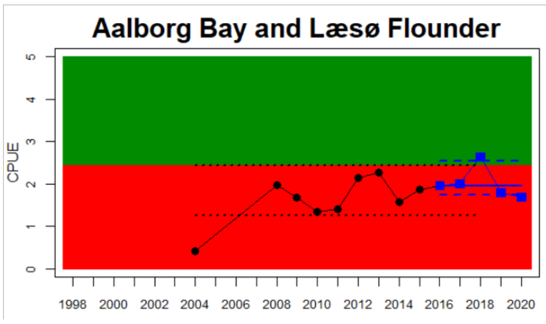


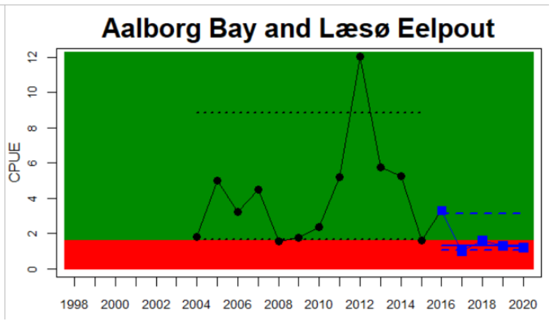


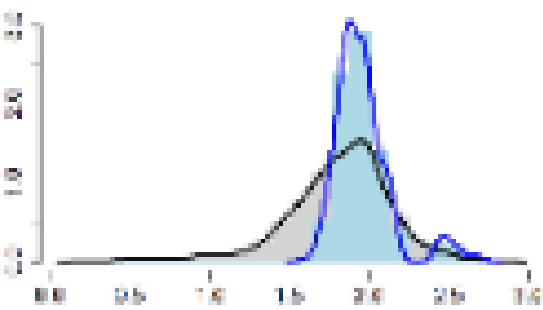


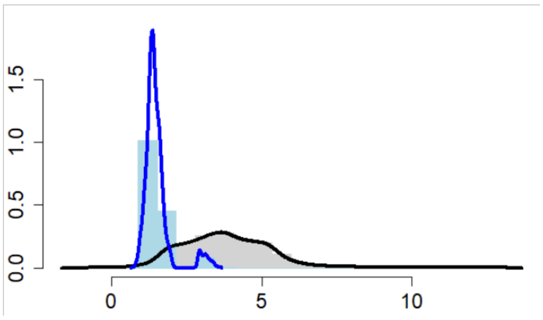
Kattegat

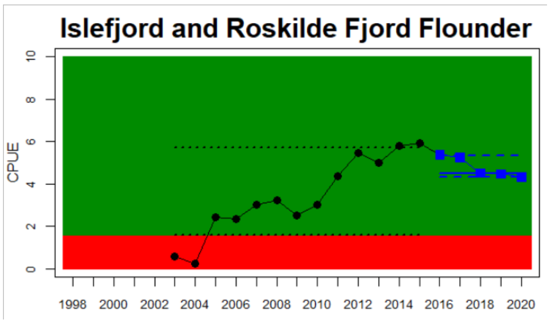
Denmark

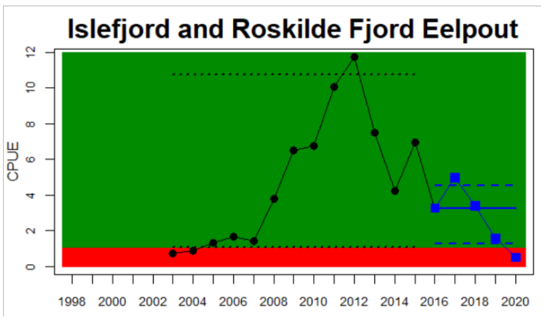


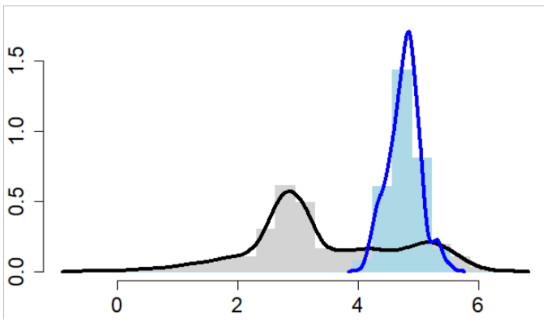


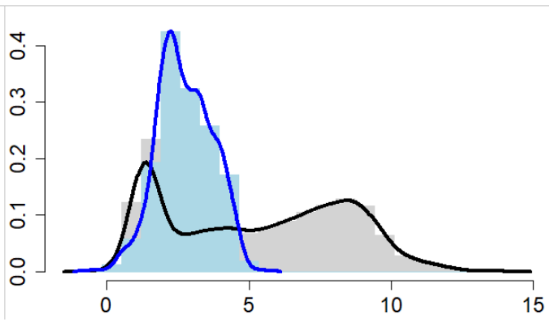


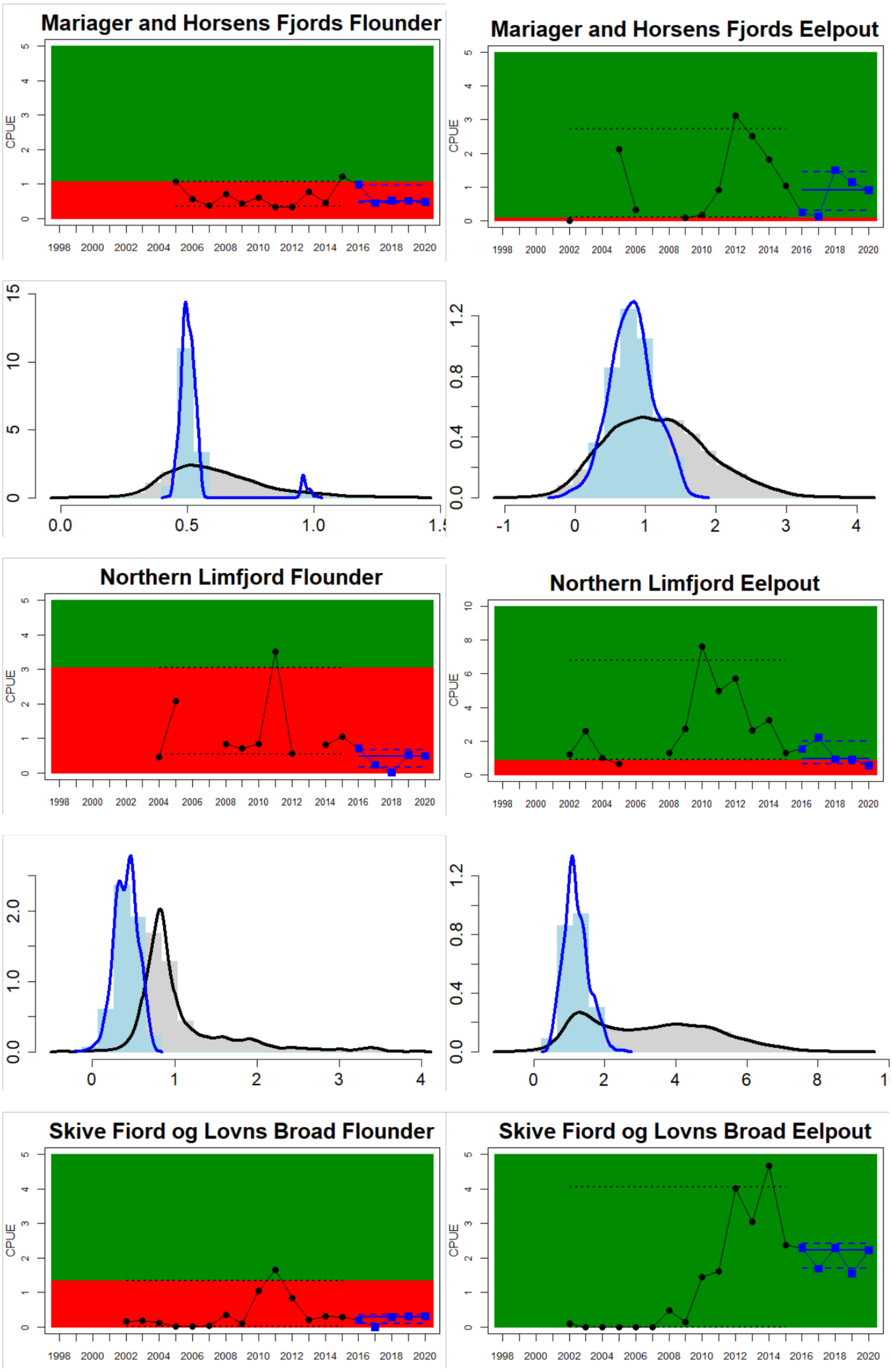











Mariager and Horsens Fjords Flounder
Mariager and Horsens Fjords Eelpout
CPUE
Northern Limfjord Flounder
Northern Limfjord Eelpout
CPUE
Skive Fiord og Lovns Broad Flounder
Skive Fiord og Lovns Broad Eelpout
CPUE
1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020

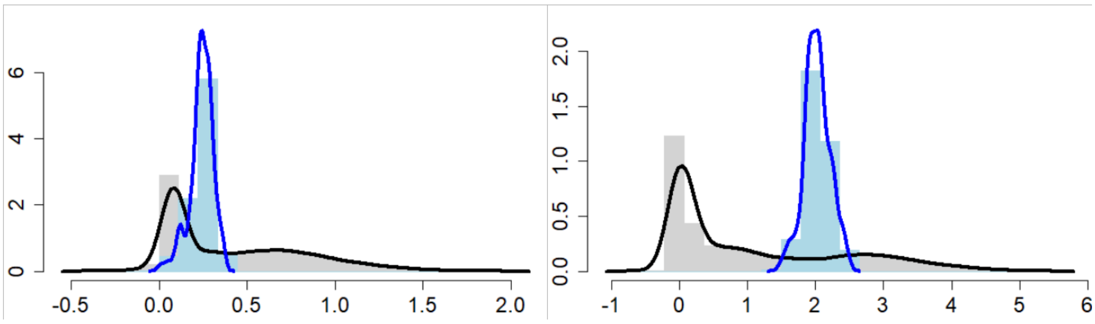


Figure 4. Status evaluation displayed per sub-basin for each monitoring location. In locations where the ASCETS approach is applied, threshold values are displayed by black dotted lines between fields in green (good status) and red (not good status), with the colour of the fields determined by the status during the reference period. The evaluation of good status/not good status is performed for the assessment period compared to the reference period by comparing the location of the median during the assessment period (full blue line) with the location of the respective threshold line. The 95th percentile intervals associated with the median during the assessment period are displayed in hatched blue lines. Below each ASCETS graph, a small graph shows the smoothed bootstrapped medians of the indicator values from the reference period (bars in grey with a black line) and the assessment period (bars in blue with a blue line). For assessment units where the available data only allowed for a trend-based evaluation, green squares denote a good status evaluation outcome during the assessment period whereas red squares denote a not good status assessment outcome. The hatched trend-line indicates a significant positive (green) and negative (red) trend at $p < 0.1$ during 2014-2020 for the times-series in each location.

4.2 Trends

Overall, the status of coastal fish in the Baltic Sea has deteriorated between this and the HOLAS II, conducted in 2018 including data until 2016 (Table 3). However, the decreased overall status partly reflects the inclusion of additional key species in the current evaluation, namely pike, pikeperch, whitefish, and eelpout, and applying a stricter integrating approach across monitoring locations (majority rule in HOLAS II vs One-Out-All-Out principle in the current evaluation). Pike and whitefish do not achieve good status in the majority of the monitoring locations. Thus, only 6 out of 22 HELCOM assessment units achieve good status in the current evaluation, compared to 13 out of 21 assessment units achieving good status in HOLAS II. Focussing on the comparable key species perch and flounder, differences between this and the previous evaluation are only minor. The status of perch has decreased in 2 and increased in 1 out of 23 comparable monitoring locations, and the status of flounder has decreased in 1 out of 14 comparable monitoring locations since 2018. When the status is integrated over HELCOM assessment units, the status of perch has increased in the Gulf of Riga, decreased in the Finnish Quark, while in the Swedish Northern Baltic proper, the status of both perch and flounder have decreased. The integrated status remains unchanged in the remaining 17 assessment units when considering perch and flounder only.

Table 3. Overview of trends between current and previous evaluation in year 2018 (HOLAS II, including data until 2016). For each HELCOM assessment unit, it is noted whether the integrated status using the BEAT tool achieves of fails to achieve the threshold value. The current integrated status is compared to the pervious status with regards to any distinct increasing or decreasing trend. In case of changed integrated status, the outcome is briefly described focusing on the relevant changes compared to the previous evaluation.

HELCOM Assessment unit name (and ID)	**Threshold value: achieved/failed**	**Distinct trend between current and previous evaluation (HOLAS II).**	**Comparison of outcomes**
Archipelago Sea Coastal waters	failed	decrease	All location-species combinations besides whitefish and Kumlinge have GS. Due to inclusion of whitefish in Kumlinge the combined status decreased
Arkona Basin Danish Coastal waters	failed	no change	
Belts Danish Coastal waters	failed	no change	
Bornholm Basin Swedish Coastal waters	failed	NA	Not included in HOLAS II
Bothnian Bay Finnish Coastal waters	achieved	no change	
Bothnian Bay Swedish Coastal waters	achieved	no change	
Bothnian Sea Finnish Coastal waters	achieved	no change	
Bothnian Sea Swedish Coastal waters	failed	decrease	All comparable location-species combinations have GS. Due to inclusion of whitefish in Gaviksfjärden and pikeperch and whitefish in Forsmark the combined status decreased
Eastern Gotland Basin Latvian Coastal waters	achieved	no change	
Eastern Gotland Basin Lithuanian Coastal waters	failed	decrease	All comparable location-species combinations have GS. Due to inclusion of pikeperch in Curonian Lagoon the combined status has decreased
Gdansk Basin Polish Coastal waters	failed	NA	Not included in HOLAS II

Gulf of Finland Finnish Coastal waters	failed	decrease	Inclusion of 3 new monitoring locations, the status is decreased due to nGS of perch in Tvärminne
Gulf of Riga Estonian Coastal waters	achieved	increase	Only one evaluation. Status of perch in Hiummaa has increased
Gulf of Riga Latvian Coastal waters	achieved	no change	
Kattegat Danish Coastal waters, including Limfjorden	failed	no change	
Mecklenburg Bight Danish Coastal waters	failed	no change	
Northern Baltic Proper Swedish Coastal waters	failed	decrease	Both comparable location-species combinations have decreased. In addition, pike in Askö has nGS.
The Quark Finnish Coastal waters	failed	decrease	The status of perch in ICES SD rect 28 has decreased
The Quark Swedish Coastal waters	failed	no change	
The Sound Danish Coastal waters	failed	no change	
Western Gotland Basin Swedish Coastal waters	failed	no change	
Åland Sea Swedish Coastal waters	failed	decrease	Due to inclusion of pike and whitefish in Lagnö the combined status has decreased

4.3 Discussion text

In conclusion, the overall environmental status of coastal fish in the Baltic Sea is poor, when summarising the results across the six key species and the 22 HELCOM assessment units that allows an evaluation of status against a threshold. Good status is achieved in 6 out of 22 evaluated units. There were often pronounced differences in environmental status between different key species in the same monitoring location, indicating that the inclusion of the additional key species pike, pikeperch, whitefish, and eelpout, allows a more nuanced picture of the status of coastal fish in the Baltic Sea, compared to previous evaluations. Adding up all species-monitoring location combinations, totalling 98 status evaluations, 43 achieved good status. Overall, good status was achieved in the majority of the monitoring locations for perch, pikeperch, and eelpout, while the majority of the monitoring locations showed not good status for flounder, pike, and whitefish. When comparing the two best represented key species, perch and flounder, good status is generally more often reached in areas in the northern and eastern parts of the Baltic Sea where perch is the key species. In the western and southern areas of the Baltic Sea where flounder is the key species, the status is more often not good.

5 Confidence

In general, the confidence varies across assessment units, countries and monitoring programmes since, for example, the number of years for which coastal fish monitoring has been carried out varies between locations, as does the spatial coverage of monitoring within assessment units, and thus the confidence in the actual evaluation (Table 4). Generally, the confidence of the evaluation is higher in locations where monitoring started before 1999 and where data is available for all years during the assessment period (2016-2020), where there is good spatial coverage of monitoring, and where the monitoring is fisheries independent and targeting the focal species of the evaluation.

The confidence scoring followed the principles as outlined in the HELCOM integrated biodiversity assessment. Confidence was scored using four criteria with three different levels (1= high, 0.5 = intermediate, and 0 = low). The criteria used were:

Confidence in the accuracy of the estimate (ConfA). In the ASCETS approach, confidence in the evaluation is determined by the C(S) value. C(S) varies between 0 and 1, with values <0.1 representing high confidence of changed status and values >0.9 high confidence of unchanged status (Level 1). Values of 0.1-0.3 represent medium confidence in changed status and 0.7-0.9 medium confidence in unchanged status (Level 0.5). Values of 0.3-0.5 represent low confidence of changed status and 0.5-0.7 low confidence in unchanged status (Level 0). In the trend-based approach, confidence in the evaluation is determined by the p-value of the linear regression, with p-values <0.05 representing high confidence in a trend, p<0.1 medium confidence in a trend, p 0.10-0.20 low confidence in no trend, p 0.21-0.49 medium confidence in no trend, and p 0.5-1.0 high confidence in no trend.

Confidence in the temporal coverage of evaluation (ConfT). Level 1 = data for all years during 2016-2020, 0.5 = one or two years of data missing during 2016-2020, and 0 = three or more years of data missing during 2016-2020.

Confidence in spatial representability of the evaluation (ConfS). Level = 1 full coverage/several monitoring locations per assessment unit given its size, 0.5 = two or more monitoring locations per assessment unit, and 0 = one monitoring location per assessment unit.

Methodological confidence (ConfM). For coastal fish all assessment units reach level 1 since all monitoring programs included in the evaluation are described in the coastal fish monitoring guidelines .

Table 4. Confidence in the status evaluation according to the criteria developed within HELCOM for the integrated biodiversity assessment.

Sub-basin	Country	Coastal area name (assessment unit)	Coastal area code	Monitoring area/data set	Time period assessed	key species	Monitoring method	ConfA	ConfT	ConfS	ConfM
Bothnian Bay	Finland	Bothnian Bay Finnish Coastal waters	1	Finnish ICES SD 31	1998-2020	Perch	Commercial statistics	0.5	1	1	1
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Råneå	2002-2020	Perch	Fisheries independent data	1	1	0.5	1
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Råneå	2002-2020	Pike	Fisheries independent data	1	1	0.5	1
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Råneå	2002-2020	Whitefish	Fisheries independent data	1	1	0.5	1
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Kinnbäcksfjärden	2004-2020	Perch	Fisheries independent data	0.5	1	0.5	1
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Kinnbäcksfjärden	2004-2020	Whitefish	Fisheries independent data	1	1	0.5	1
The Quark	Finland	The Quark Finnish Coastal waters	3	Finnish ICES rect 23	1998-2020	Perch	Commercial statistics	1	1	1	1
The Quark	Finland	The Quark Finnish Coastal waters	3	Finnish ICES rect 28	1998-2020	Perch	Commercial statistics	0.5	1	1	1
The Quark	Sweden	The Quark Swedish Coastal waters	4	Holmön	2002-2020	Perch	Fisheries independent data	0.5	1	0.5	1
The Quark	Sweden	The Quark Swedish Coastal waters	4	Holmön	2002-2020	Whitefish	Fisheries independent data	1	1	0.5	1
The Quark	Sweden	The Quark Swedish Coastal waters	4	Norrbyn	2002-2020	Perch	Fisheries independent data	1	1	0.5	1
The Quark	Sweden	The Quark Swedish Coastal waters	4	Norrbyn	2002-2020	Whitefish	Fisheries independent data	1	1	0.5	1
Bothnian Sea	Finland	Bothnian Sea Finnish Coastal waters	5	Finnish ICES SD 30	1998-2020	Perch	Commercial statistics	0	1	1	1
Bothnian Sea	Finland	Bothnian Sea Finnish Coastal waters	5	Finnish ICES SD 30	1998-2020	Pikeperch	Commercial statistics	0.5	1	1	1
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Gaviksfjärden	2004-2020	Perch	Fisheries independent data	1	1	0.5	1
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Gaviksfjärden	2004-2020	Whitefish	Fisheries independent data	0.5	1	0.5	1
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Långvindsfjärden	2002-2020	Perch	Fisheries independent data	0.5	1	0.5	1
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Forsmark	2002-2020	Perch	Fisheries independent data	1	1	0.5	1
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Forsmark	2002-2020	Pikeperch	Fisheries independent data	0	1	0.5	1
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Forsmark	2002-2020	Whitefish	Fisheries independent data	0.5	1	0.5	1
Åland Sea	Finland	Åland Sea Finnish Coastal waters	7	NA	NA	NA	NA	NA	NA	NA	NA
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Galtfjärden	2002-2020	Perch	Fisheries independent data	1	1	0.5	1
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Galtfjärden	2002-2020	Pikeperch	Fisheries independent data	1	1	0.5	1
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Galtfjärden	2002-2020	Whitefish	Fisheries independent data	1	1	0.5	1
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Lagnö	2002-2020	Perch	Fisheries independent data	0	1	0	1
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Lagnö	2002-2020	Pike	Fisheries independent data	1	1	0	1
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Lagnö	2002-2020	Whitefish	Fisheries independent data	0.5	1	0	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finbo	2002-2020	Perch	Fisheries independent data	1	1	1	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finbo	2002-2020	Pike	Fisheries independent data	0.5	1	1	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finbo	2002-2020	Pikeperch	Fisheries independent data	0.5	1	1	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Kumlinge	2002-2020	Perch	Fisheries independent data	0.5	1	1	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Kumlinge	2002-2020	Whitefish	Fisheries independent data	0.5	1	1	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finnish ICES SD 29	1998-2020	Perch	Commercial statistics	1	1	1	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finnish ICES SD 29	1998-2020	Pikeperch	Commercial statistics	1	1	1	1
Northern Baltic Sea	Finland	Northern Baltic Proper Finnish Coastal waters	10	NA	NA	NA	NA	NA	NA	NA	NA
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Vaxholm: Askrikefjärden	2016-2020	Perch	Fisheries independent data	0.5	1	0.5	1
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Vaxholm: Askrikefjärden	2016-2020	Pikeperch	Fisheries independent data	1	1	0.5	1
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Askö	2005-2020	Perch	Fisheries independent data	1	1	0.5	1
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Askö	2005-2020	Pike	Fisheries independent data	1	1	0.5	1
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Askö	2005-2020	Whitefish	Fisheries independent data	0	1	0.5	1
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Muskö	1992-2020	Flounder	Fisheries independent data	1	1	0.5	1
Northern Baltic Sea	Estonia	Northern Baltic Proper Estonian Coastal waters	12	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Brunskär	2002-2020	Perch	Fisheries independent data	1	1	1	1
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Tvärminne	2005-2020	Perch	Fisheries independent data	0	1	1	1
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Helsinki	2005-2020	Perch	Fisheries independent data	0.5	0.5	1	1
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Finnish ICES SD 32	1998-2020	Perch	Commercial statistics	0.5	1	1	1
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Finnish ICES SD 32	1998-2020	Pikeperch	Commercial statistics	0.5	1	1	1
Gulf of Finland	Estonia	Gulf of Finland Estonian Coastal waters	14	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Finland	Russia	Gulf of Finland Russian Coastal waters	15	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Riga	Estonia	Gulf of Riga Estonian Coastal waters	16	Hiiumaa	1991-2020	Perch	Fisheries independent data	0	1	0	1
Gulf of Riga	Latvia	Gulf of Riga Latvian Coastal waters	17	Daugavgriva	2016-2020	Perch	Fisheries independent data	0	1	0	1
Gulf of Riga	Latvia	Gulf of Riga Latvian Coastal waters	17	Daugavgriva	2016-2020	Pikeperch	Fisheries independent data	0.5	1	0	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, summer	2002-2020	Perch	Fisheries independent data	0.5	1	0.5	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, summer	2002-2020	Pike	Fisheries independent data	1	1	0.5	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, summer	2002-2022	Pikeperch	Fisheries independent data	1	1	0.5	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, autumn	1998-2020	Flounder	Fisheries independent data	0.5	1	0.5	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, autumn	1998-2020	Whitefish	Fisheries independent data	0.5	1	0.5	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Vinö	2007-2020	Perch	Fisheries independent data	0	1	0.5	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Vinö	2007-2020	Pike	Fisheries independent data	0	1	0.5	1
Eastern Gotland Basin	Estonia	Eastern Gotland Basin Estonian Coastal waters	19	NA	NA	NA	NA	NA	NA	NA	NA
Eastern Gotland Basin	Latvia	Eastern Gotland Basin Latvian Coastal waters	20	Jurkalne	2016-2020	Flounder	Fisheries independent data	0.5	1	0	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Mon/But	1998-2020	Flounder	Fisheries independent data	0	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Šventoji	2000-2020	Flounder	Fisheries independent data	0.5	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Karklė	2000-2020	Flounder	Fisheries independent data	1	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Smiltynė	2000-2020	Flounder	Fisheries independent data	1	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Curonian lagoon	1998-2020	Perch	Fisheries independent data	1	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	22	Curonian lagoon	1998-2020	Pikeperch	Fisheries independent data	0.5	1	1	1
Eastern Gotland Basin	Sweden	Eastern Gotland Basin Swedish Coastal waters	22	Herrvik	2018-2020	Flounder	Fisheries independent data	1	0.5	0	1
Eastern Gotland Basin	Russian	Eastern Gotland Basin Russian Coastal waters	23	NA	NA	NA	NA	NA	NA	NA	NA
Eastern Gotland Basin	Poland	Eastern Gotland Basin Polish Coastal waters	24	NA	NA	NA	NA	NA	NA	NA	NA
Gdansk Basin	Russia	Gdansk Basin Russian Coastal waters	25	NA	NA	NA	NA	NA	NA	NA	NA
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zatoka Pucka Zewnętrzna	2011-2020	Perch	Fisheries independent data	1	0.5	1	1
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zatoka Pucka Zewnętrzna	2011-2020	Flounder	Fisheries independent data	1	0.5	1	1
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Pucki	2011-2020	Perch	Fisheries independent data	1	1	1	1
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Pucki	2011-2020	Flounder	Fisheries independent data	0	1	1	1
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Wiślany	2011-2020	Perch	Fisheries independent data	1	1	1	1
Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Torhamn	2000-2020	Perch	Fisheries independent data	1	1	0.5	1
Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Torhamn	2000-2020	Pike	Fisheries independent data	0.5	1	0.5	1
Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Hanöbukten	2015-2020	Flounder	Fisheries independent data	0	1	0.5	1
Bornholm Basin	Poland	Bornholm Basin Polish Coastal waters	28	NA	NA	NA	NA	NA	NA	NA	NA
Bornholm Basin	Denmark	Bornholm Basin Danish Coastal waters	29	NA	NA	NA	NA	NA	NA	NA	NA
Bornholm Basin	Germany	Bornholm Basin German Coastal waters	30	NA	NA	NA	NA	NA	NA	NA	NA
Arkona Basin	Sweden	Arkona Basin Swedish Coastal waters	31	Stavstendsudde	2018-2020	Flounder	Fisheries independent data	0.5	0.5	0	1
Arkona Basin	Denmark	Arkona Basin Danish Coastal waters	32	Præstø Fiord	2005-2020	Flounder	Citizen Science	1	0	0	1
Arkona Basin	Denmark	Arkona Basin Danish Coastal waters	32	Præstø Fiord	2005-2020	Eelpout	Citizen Science	1	1	0	1
Arkona Basin	Germany	Arkona Basin German Coastal waters	33	NA	NA	NA	NA	NA	NA	NA	NA
Mecklenburg Bight	Germany	Mecklenburg Bight German Coastal waters	34	NA	NA	NA	NA	NA	NA	NA	NA
Mecklenburg Bight	Denmark	Mecklenburg Bight Danish Coastal waters	35	Area south of Zealand	2003-2020	Flounder	Citizen Science	1	1	0.5	1
Mecklenburg Bight	Denmark	Mecklenburg Bight Danish Coastal waters	35	Fehmarn Belt	2002-2020	Flounder	Citizen Science	0.5	1	0.5	1
Mecklenburg Bight	Denmark	Mecklenburg Bight Danish Coastal waters	35	Fehmarn Belt	2002-2020	Eelpout	Citizen Science	1	1	0.5	1
Kiel Bight	Denmark	Kiel Bight Danish Coastal waters	36	NA	NA	NA	NA	NA	NA	NA	NA
Kiel Bight	Germany	Kiel Bight German Coastal waters	37	NA	NA	NA	NA	NA	NA	NA	NA
Belt Sea	Denmark	Belts Danish Coastal waters	38	The Great Belt	2003-2020	Flounder	Citizen Science	1	1	1	1
Belt Sea	Denmark	Belts Danish Coastal waters	38	The Great Belt	2003-2020	Eelpout	Citizen Science	0.5	1	1	1
Belt Sea	Denmark	Belts Danish Coastal waters	38	Southern Little Belt and the archipelago	2002-2020	Flounder	Citizen Science	1	1	1	1
Belt Sea	Denmark	Belts Danish Coastal waters	38	Odense Fiord	2002-2020	Flounder	Citizen Science	1	1	1	1
Belt Sea	Denmark	Belts Danish Coastal waters	38	Odense Fiord	2002-2020	Eelpout	Citizen Science	0.5	1	1	1
Belt Sea	Denmark	Belts Danish Coastal waters	38	Sejerø Bay	2002-2020	Flounder	Citizen Science	1	1	1	1
Belt Sea	Denmark	Belts Danish Coastal waters	38	Sejerø Bay	2002-2020	Eelpout	Citizen Science	0.5	0.5	1	1
Belt Sea	Denmark	Belts Danish Coastal waters	38	Århus Bay	2002-2020	Flounder	Citizen Science	0	1	1	1
Belt Sea	Denmark	Belts Danish Coastal waters	38	Århus Bay	2002-2020	Eelpout	Citizen Science	0.5	1	1	1
Belt Sea	Denmark	Belts Danish Coastal waters	38	Vejle Fjord	2002-2020	Flounder	Citizen Science	0.5	0.5	1	1
Belt Sea	Denmark	Belts Danish Coastal waters	38	Vejle Fjord	2002-2020	Eelpout	Citizen Science	1	1	1	1
Belt Sea	Denmark	Belts Danish Coastal waters	38	Fyn archipelago	2002-2020	Flounder	Citizen Science	1	1	1	1
Belt Sea	Denmark	Belts Danish Coastal waters	38	Fyn archipelago	2002-2020	Eelpout	Citizen Science	0	1	1	1
The Sound	Sweden	The Sound Swedish Coastal waters	39	NA	NA	NA	NA	NA	NA	NA	NA
The Sound	Denmark	The Sound Danish Coastal waters	40	The sound	2002-2020	Flounder	Citizen Science	1	1	0	1
The Sound	Denmark	The Sound Danish Coastal waters	40	The sound	2002-2020	Eelpout	Citizen Science	1	1	0	1
Kattegat	Sweden	Kattegat Swedish Coastal waters, including Limfjorden	41	NA	NA	NA	NA	NA	NA	NA	NA
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Islefjord and Roskilde fjord	2003-2020	Flounder	Citizen Science	1	1	1	1
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Islefjord and Roskilde fjord	2003-2020	Eelpout	Citizen Science	1	1	1	1
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Northern Limfjord	2002-2020	Flounder	Citizen Science	0.5	1	1	1
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Northern Limfjord	2002-2020	Eelpout	Citizen Science	0.5	1	1	1
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Skive Fiord and Lovns Broad	2002-2020	Flounder	Citizen Science	1	1	1	1
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Skive Fiord and Lovns Broad	2002-2020	Eelpout	Citizen Science	1	1	1	1
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Aalborg Bay and Laesö	2004-2020	Flounder	Citizen Science	1	1	1	1
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Aalborg Bay and Laesö	2004-2020	Eelpout	Citizen Science	0.5	1	1	1
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Mariager and Horserns Fjords	2002-2020	Flounder	Citizen Science	1	1	1	1
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	Mariager and Horserns Fjords	2002-2020	Eelpout	Citizen Science	1	1	1	1

The level of confidence in the evaluation differs between coastal areas and regions as a result of differences in monitoring methodology, as well as lower temporal and spatial coverage of monitoring in some countries. The methodological confidence is high in all monitoring locations and the confidence in the accuracy of the evaluation is high in only three assessment units. The confidence in the temporal coverage is high in all assessment units except for in six, where the individual monitoring locations have data missing for one or more years (in Finland, Denmark, Poland and Sweden), and the confidence in spatial representability is highest in the Finnish, Lithuanian, Polish, and Danish areas, but poorer in other countries. The integrated confidence considering all four categories varies between high and intermediate depending on assessment unit and is high in the majority of evaluated assessment units (Figure 5). Intermediate confidence of the evaluation is only found along the Swedish Bothnian Sea coast, Gulf of Riga, the Eastern Gotland Basin Latvian coast, the Bornholm Basin Swedish coast, Danish coast of the Arkona Basin, and the Danish coastal waters of The Sound. In all these assessment units, the spatial representability of monitoring is relatively low.

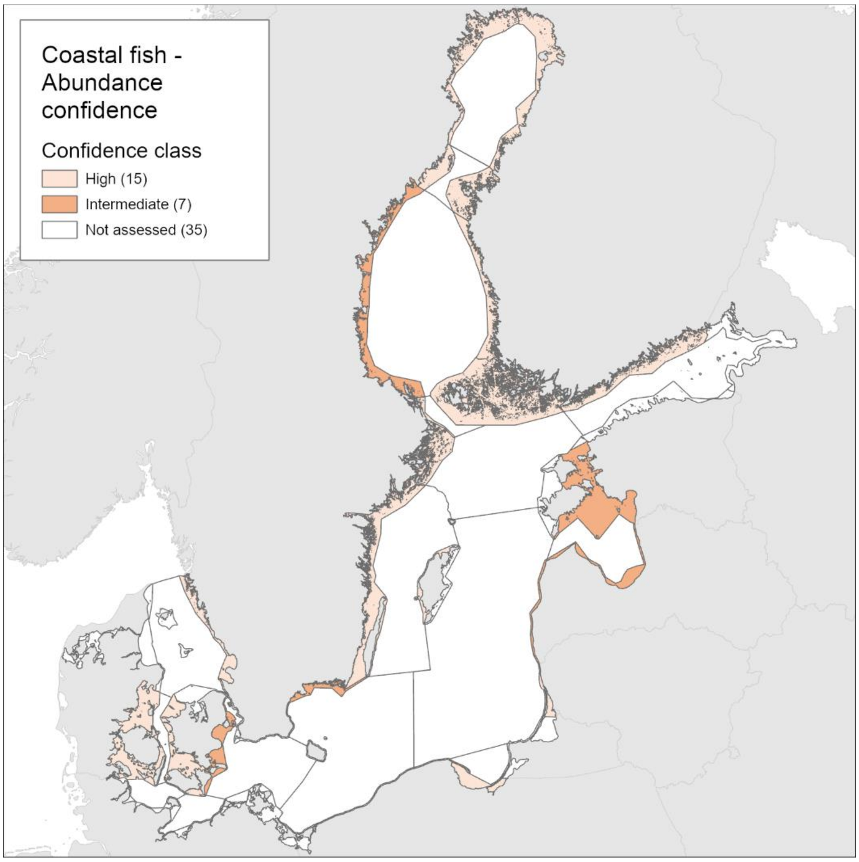


Figure 5. Maps of confidence of the current evaluation. See Table 4 for details.

The confidence concept as developed for the purposes of the integrated biodiversity assessment is not fully applicable to coastal fish as further evaluation of the precision in data and the congruence in status across monitoring locations within assessment units would provide additional needed information.

The state of key coastal fish species in the Baltic Sea is influenced by multiple pressures, including climate, eutrophication, fishing mortality and exploitation of essential habitats, but also by natural processes such as food web interactions and predation from apex predators.

The effect of eutrophication on the state of coastal fish species is also of importance (Bergström *et al.* 2016b; Olsson 2019) and might increase with higher latitudes (Östman *et al.* 2017b).

The abundance of key species of coastal fish (such as perch, flounder, pike, pikeperch, whitefish and eelpout) is influenced by recruitment success and mortality rates, which in turn might be influenced by ecosystem changes, interactions within the coastal ecosystem and abiotic perturbations. An increased abundance of perch and pike may, for example be governed by increasing water temperatures, moderate eutrophication, availability of recruitment habitats, low fishing pressure, and low predation pressure from apex predators (Berggren *et al.* 2022; Böhling *et al.* 1991; Edgren 2005; Bergström *et al.* 2007, 2016b, 2019, 2022; Linlokken *et al.* 2008; HELCOM 2012, 2018, 2021; Olsson *et al.* 2012; Olsson 2019, Östman *et al.* 2012, 2017b; Veneranta *et al.* 2020). As for the majority of coastal species, exploitation of recruitment areas has a negative impact on the development of perch populations (Sundblad *et al.* 2014; Sundblad & Bergström 2014). Changes in the long-term development of the abundance of perch and pike could hence reflect effects of increased water temperature and eutrophication in coastal areas and/or changes in the level of exploitation or predation pressure.

The abundance of pikeperch is influenced by similar factors but is in contrast to a larger extent favoured by increased levels of eutrophication (Bergström *et al.* 2013) and fishing (Lappalainen *et al.* 2016; Bergström *et al.* 2019). Whitefish is a species that is disfavoured by more nutrient rich waters, deteriorating quality of nursery habitats, and elevated water temperatures with decreasing periods of ice-coverage during winter (Veneranta *et al.* 2013a,b). The influence of predation by seals and fishing on the abundance of whitefish is also a concern (Hansson *et al.* 2017; Berkström *et al.* 2021).

The abundance of flounder is favoured by somewhat increasing water temperatures, moderate eutrophication, and low fishing pressure (Olsson *et al.* 2012; Florin *et al.* 2013). Increased presence of ephemeral macroalgae due to eutrophication reduces the suitability of nursery habitats (Carl *et al.* 2008) and increases in the level of predation from avian predators negatively affect the abundance of juvenile flounder with unfavourable consequences to recruitment (Nielsen *et al.* 2008). Changes in the long-term abundance of flounder thus may reflect effects of eutrophication and/or changes in the level of predation pressure and fishing mortality in coastal areas. Recent studies have also suggested an impact of the invasive species round goby on the abundance of flounder (Ustups *et al.* 2016).

Less information on the factors driving changes in population abundance of eelpout are available, but the role of hazardous substances (Bergek *et al.* 2012), natural predation (Hansson *et al.* 2017) and increasing water temperatures (Mustamäki *et al.* 2020) are recognisable. Eelpout is in contrast to the other key species considered here, not a target for any form of fishing in the Baltic Sea (Hansson *et al.* 2017).

Natural interactions such as predation pressure from apex predators, foremost cormorants (*Phalacrocorax carbo*) and grey seal (*Halichoerus grypus*), could at least locally impact the state of coastal fish communities (Vetemaa *et al.* 2010; Östman *et al.* 2012; Mustamäki *et al.* 2014; Hansson *et al.* 2017; Veneranta *et al.* 2020; Bergström *et al.* 2022). In some areas the outtake of coastal fish by cormorants exceeds, or is of a similar magnitude, to that of the commercial and recreational fisheries (Östman *et al.* 2013). However, the natural mortality from other sources such as predatory fish can be higher than the mortality caused by cormorants in some areas (Heikinheimo *et al.* 2016). The effects of predation by apex predators might hence vary between coastal areas (see for example Heikinheimo and Lehtonen 2016; Lehikoinen *et al.* 2017).

Table 5. Brief summary of relevant pressures and activities with relevance to the indicator.

	General	**MSFD Annex III, Table 2a**
Strong link	Several pressures, both natural and human, acting in concert affect the state of coastal key fish species. These include climate, eutrophication, fishing, and exploitation and loss of essential habitats. To date, no analyses on the relative importance of these variables have been conducted.	Biological - Extraction of, or mortality/injury to, wild species (e.g. selective extraction of species, including incidental non-target catches) - Disturbance of species (e.g. where they breed, rest and feed) due to human presence Physical - Physical disturbance to seabed (temporary or reversible) - Changes to hydrological conditions Substances, litter and energy - Inputs of nutrients – diffuse sources, point sources, atmospheric deposition
Weak link	There might also be effects of hazardous substances and non-indigenous species on the state of key coastal fish species	Substances, litter and energy - Input of other substances (e.g. synthetic substances, non-synthetic substances, radionuclides) Biological *- Input or spread of non-indigenous species*

7 Climate change and other factors

Climate change generally has a large effect on the species considered here (Möllmann *et al.* 2009; Olsson *et al.* 2012; Östman *et al.* 2017b; Olsson 2019, HELCOM 2021) as have alterations in the food web (Eriksson *et al.* 2009; 2011; Östman *et al.* 2016; Bergström *et al.* 2022; Olin *et al.* 2022). Stressors related to human activities, mainly exploitation of essential habitats (Sundblad *et al.* 2014; Sundblad & Bergström 2014; Kraufvelin *et al.* 2018) and fishing (Edgren 2005; Bergström *et al.* 2007, 2022; Fenberg *et al.* 2012; Florin *et al.* 2013; Berkström *et al.* 2021) also impact the state of coastal fish species. For obligate coastal species such as perch, pike, whitefish, and pikeperch, the outtake comes from both the recreational and small-scale commercial fisheries sector, with the recreational sector dominating in some countries (HELCOM 2015), whereas cod and flounder are exploited both in the offshore and coastal commercial fishery. In some areas of the Baltic Sea, flounder and cod are also targeted by recreational fisheries.

The topic of climate change and its specific interaction with this indicator is also addressed in further detail under Chapter 6 as it is a major driver of change.

8 Conclusions

8.1 Future work or improvements needed

Due to the presence of natural environmental gradients across the Baltic Sea and the rather local appearance of coastal fish communities (and hence their different structures and responses to environmental change), the spatial coverage of monitoring should be improved in some areas in order to enhance the confidence of the evaluation outcome. When designating new potential monitoring programmes, it should be considered that the levels of direct human impact on the coastal fish communities in many of the existing monitoring locations are low, and future locations should include also more heavily affected areas.

Moreover, the current monitoring in the northern and eastern parts of the Baltic Sea is designed to target coastal fish species that prefer higher water temperatures and that dominate coastal areas during warmer parts of the year, typically those with a freshwater origin such as perch. Monitoring of species like whitefish, herring, flounder and cod that dominate coastal fish communities in more exposed parts of the coast and during colder parts of the year are, however, rather poorly represented. Increased monitoring of these species and components should be considered in the future establishment of coastal fish monitoring programmes.

In addition, as a multitude of factors with natural environmental gradients in the Baltic Sea potentially impact coastal fish communities and species, the magnitude of importance of different factors in different coastal areas should be understood. A more mechanistic understanding of how pressures impact upon coastal fish in local contexts will enable managers to take relevant measures to halt declining trends of coastal fish species in some coastal areas. More specifically, the role of fishing (both commercial and recreational) and natural predation needs further investigation.

9 Methodology

This indicator uses two different approaches for evaluating whether good status is achieved. The approach used depends on the data used for the evaluation. If certain criteria are met, the ASCTES approach is used (Östman *et al.* 2020). If not, then the trend-based approach is used.

The methodology and basis of the indicator evaluation is provided below.

9.1 Scale of assessment

Due to the local appearance of typical coastal fish populations, status assessments of coastal fish communities are representative for rather small geographical scales. In this evaluation the HELCOM assessment unit scale 3 'Open sub-basin and coastal waters' has been applied. The indicator is not evaluated for the open sea sub-basins since the species in focus are coastal.

Evaluations were carried out for 24 of the 42 assessment units and data up to 2020 was available for all assessment units. The number of units evaluated are currently restricted by the availability of monitoring programs.

For the integration of status across species and monitoring locations within assessment units, the One-Out-All-Out principle is applied (Dierschke *et al.* 2021).

The assessment units are defined in the Annex 4 of the HELCOM Monitoring and Assessment Strategy.

9.2 Methodology applied

ASCETS approach

Coastal fish datasets must meet certain criteria in order to be able to apply an evaluation of good status using the ASCETS approach:

1. The time period used to determine the reference period should cover a minimum number of years that is twice the generation time of the species most influential in the indicator assessment. This is to ensure that the influences of strong year classes are taken into account. For coastal fish, this is typically about ten years. In this evaluation, the time period used to determine the reference period against which good status is evaluated spans the years 1998-2015, with varying numbers of years depending on data availability for each time series.
2. Before evaluating good status, it should be decided whether or not the reference period reflects good status. If a previous status evaluation exists from HOLAS II, the reference period is assigned the same status as the assessment period in HOLAS II (2011-2016). If a previous status evaluation does not exist, this can is done by using data dating back earlier than the start of the period used to determine the reference period, using additional information, or by expert judgment. For example, if data from time periods preceding the period used for

determining the reference period have much higher indicator values, the reference might represent not good status (in case of an indicator where higher values are indicative of a good environmental state) or good status (in case of an indicator where higher values are indicative of an undesirable state).

The ASCETS method (Östman *et al.* 2020) offers a refined approach to infer structural changes in indicator values over time and establish threshold values for the state during a reference period based on the observed variation in indicator values. ASCETS also gives estimates on the confidence of an apparent change in state of indicator values between a reference period and an assessment period. Thus, by applying ASCETS to time series data, it is possible to derive threshold values for addressing structural changes in indicator values over time and a developed evaluation of the confidence of the derived current indicator state relative to previous indicator values. To determine the status of the indicator, the ASCETS method first derives a bootstrapped distribution of median values from a time series of observed indicator values during a reference period. Specific threshold values for changes in indicator state is set based on the Xth and XXth percentile values of the bootstrapped distribution. For key species, the percentiles are 5 and 98 percent, representing the confidence interval of median indicator values. In this way, the derived boundaries of the confidence interval can function as threshold values for a change in state per assessment unit of each species. Because ASCETS bootstraps median indicator values during the reference period it is possible that one or several observed indicator values during the reference period will fall outside of the 95% confidence interval, because the bootstrapping reduces the influence of what may be large sampling errors. Second, the bootstrapped median indicator value during the assessment period is evaluated in relation to the threshold values derived from the reference period depending on how much of the bootstrapped median distribution from the assessment period that falls below, within, or above the Xth and XXth percentiles. (see Figure 2 and decision tree in Figure 6):

1. In situations where the reference conditions represent good status, the median of the years in the assessment period should be above the 5th percentile of the median distribution of the dataset used to determine the baseline in order to reflect good status.
2. In situations where the baseline conditions represent not good status, the median of the years in the assessment period should be above the 98th percentile of the median distribution of the dataset used to determine the baseline in order to reflect good status.

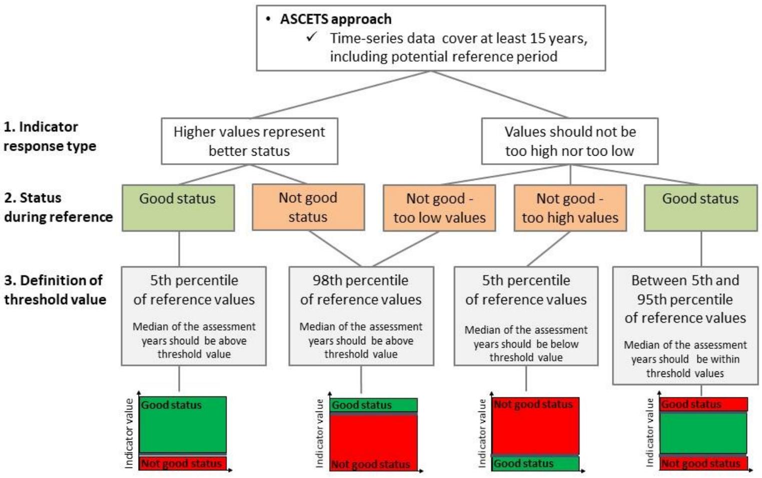
Trend-based approach

If the requirements for defining quantitative baseline conditions are not met (e.g. short time series), then a trend-based evaluation should be used. All available data starting form year 2014 is included in trend analyses.

In the trend-based approach, good status is defined based on the direction of the trend of the indicator compared to the desired direction of the indicator over time (Figure 3). When the first years of the time series evaluated represent good status, the trend of the indicator over time should not be negative in order to represent good status. If the first years of the time series evaluated represent not good status, the trend in the indicator should be positive in order to represent good status. The level of significance for these trends should be $p < 0.1$.

Decision tree for evaluation using coastal fish community structure

The assessment protocol is found in figure 6.



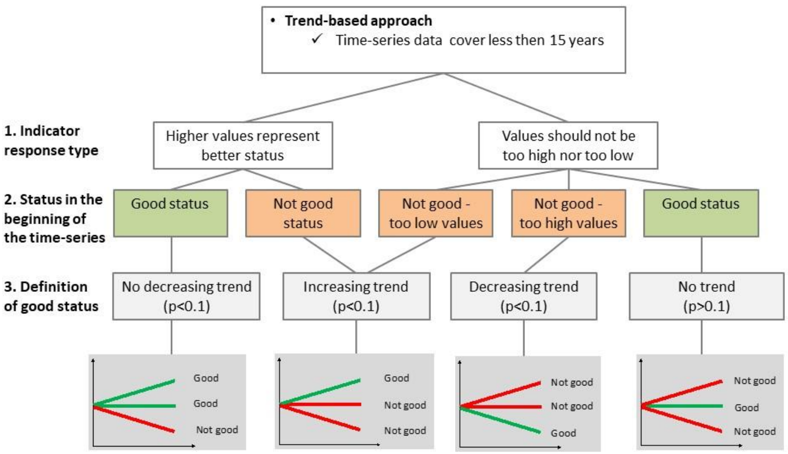


Figure 6. Decision tree for assessment using coastal fish community structure. The ASCETS approach (top figure) and trendbased approach (bottom figure) are presented.

Data analyses

The data used for the assessments are derived from fishery independent monitoring, citizen science and/or commercial catch statistics.

Fishery independent monitoring

The analyses are based on catch per unit effort (CPUE) data from annual averages of all sampling stations in each area. Individuals smaller than 12 cm (Nordic Coastal multimesh nets) or 14 cm (other net types) were excluded from the evaluation in order to only include species and size-groups suited for quantitative sampling by the method. Abundance is calculated as the number of individuals of the species included in the indicator per unit effort (CPUE).

Commercial catch data

Analyses were based on CPUE data in the form of kg/gillnet day, and each data point represents total annual CPUE per area. The gillnets used have mesh sizes between 36-60 mm (bar length) and hence target a somewhat different aspect of the fish community in the area. In addition, fishing is not performed at fixed stations nor with a constant effort across years. As a result, the estimates from the gillnet monitoring programmes and commercial catch data are not directly comparable, and only relative changes across data sources should be compared.

Citizen science

As for the other surveys, analyses were based on CPUE data (number of fish per effort) from monofilament gill nets or fyke nets. Voluntary recreational fishermen undertake fishing during the period April to November. For comparability only data from August was used in the current evaluation. The fishermen fish at fixed stations and during the first half of each month throughout the season. This mediates the comparability of the data with fisheries independent monitoring programs using gill nets or fyke nets.

9.3 Monitoring and reporting requirements

Monitoring methodology

The HELCOM common monitoring on coastal fish is described on a general level in the HELCOM Monitoring Manual in the sub-programme: Coastal fish.

The HELCOM common monitoring on coastal fish is described in guidelines that were adopted in 2014 and updated in 2019.

Current monitoring

The monitoring activities relevant to the indicator that are currently carried out by HELCOM Contracting Parties are described in the HELCOM Monitoring Manual in the Monitoring Concepts table as well as in the guidelines for coastal fish monitoring.

Sub-programme: Coastal fish

Monitoring Concepts table

Coastal fish monitoring is rather widespread in the Baltic Sea, and at present covers 32 of the total 42 'scale 3 HELCOM assessment units'. Coastal areas that lack coastal fish monitoring includes Russia and Germany (in total 7 assessment units) where there is no current and official monitoring program for coastal fish, two assessment units in Finland (Åland Sea Finnish coastal waters and Northern Baltic Proper Finnish coastal waters) and one in Denmark (Kiel Bight Danish coastal waters). The current monitoring where information on Key species can be extracted to date is less extensive, covering 24 assessment units.

The current monitoring of coastal fish in the Baltic Sea represents a minimum level of effort and serves as a first step for evaluating the status of coastal fish communities.

The current monitoring likely yields insights into major and large-scale changes in coastal fish communities in the Baltic Sea, but unique and departing responses are possible in some areas.

In Estonia and Latvia, coastal fish monitoring is carried out at several locations, but the evaluation has only been made for one location in Estonia and two in Latvia. In Denmark, no data is available to support the cyprinids/mesopredators, and the Finnish commercial catch data is not applicable for assessing status of non-targeted fish species. In Germany, there is no coordinated monitoring program for coastal fish, but a project aiming to establish such a program was initiated in 2020 in the coastal areas of Schleswig-Holstein.

10 Data

The data and resulting data products (e.g. tables, figures and maps) available on the indicator web page can be used freely given that it is used appropriately and the source is cited.

Result: Abundance of key coastal fish species

Data: Abundance of key coastal fish species – point and polygon

Data are typically collected annually in August by national and regional monitoring programmes. Catch per unit effort from commercial catch statistics in Finland represent total annual catches and citizen science data from Denmark a larger selection of months. See HELCOM (2019) for details. For future updates of this evaluation, data should be collected in each location on an annual basis.

A few time series of coastal fish began in the 1970s (Olsson *et al.* 2012), whereas others were started in the 1980s and the mid-1990s (HELCOM 2019). In Finland and Sweden, a new coastal fish monitoring programme with a higher spatial resolution was established in the early 2000s, and in Poland and Denmark monitoring data and citizen science data is typically available from the mid 2010s. For more information, see HELCOM 2019.

The raw data on which this evaluation is based, are stored in national databases. Each country has its own routines for quality assurance of the stored data. From 2017, each country calculates indicator values for their monitoring locations from the raw data from fish monitoring. The indicator data and values are then during the first half of the year uploaded to the HELCOM database for coastal fish core indicators, COOL (http://www.helcom.fi/baltic-sea-trends/data-maps/biodiversity/) as hosted by the HELCOM secretariat. Indicator data for status evaluations are extracted from the COOL database, and the evaluation undertaken by the lead country (Sweden) according to the assessment protocol outlined in this report.

Data sources

Coastal fish monitoring is coordinated within the HELCOM FISH PRO III expert network. The network compiles data from fisheries independent monitoring in Finland, Estonia, Latvia, Lithuania, Poland, Germany, Denmark and Sweden. Coastal fish communities in the Baltic Sea areas of Russia are to some extent monitored as well. In Germany, there is no coordinated monitoring program for coastal fish, but a project aiming to establish such a program was initiated in 2020 in the coastal areas of Schleswig-Holstein. In Denmark, there is no coastal fish monitoring programme and the data provided relies on voluntary catch registration by recreational fishermen through the "key-fishermen" project, which has no long-term secured funding (initiated in 2005). Due to lack of geographical coverage, the state of coastal fish communities in Finland is monitored using estimates of catch per unit effort (CPUE) from the small-scaled coastal commercial fishery. There are some additional monitoring locations (see HELCOM 2019), which were not included in this evaluation due to lack of funding in some countries for carrying out status evaluations.

The institutes responsible for sampling are: Natural Resources Institute Finland (Luke) (Finland), Provincial Government of Åland Islands (Finland), Estonian Marine Institute (Estonia), University of Tartu (Estonia), Institute of Food Safety, Animal Health and Environment "BIOR" (Latvia), Nature Research Center (Lithuania), Klaipeda University (Lithuania), National Marine Fisheries Research Institute, Gdynia (Poland), National Institute of Aquatic Resources, Technical University of Denmark (Denmark), Department of Aquatic Resources, Swedish University of Agricultural Sciences (Sweden).

11 Contributors

The HELCOM FISH PRO III expert network on coastal fish:

Jens Olsson, Elisabeth Bolund, Lena Bergström, Örjan Östman, Noora Mustamäki and Rahmat Naddafi, Department of Aquatic Resources, Swedish University of Agricultural Sciences, Sweden

Mikko Olin and Antti Lappalainen, Natural Resources Institute Finland (Luke), Finland

Linda Sundström, Provincial Government of Åland Islands, Finland

Lauri Saks and Roland Svirgsden, Estonian Marine Institute, University of Tartu, Estonia

Laura Briekmane, Institute of Food Safety, Animal Health and Environment "BIOR", Latvia

Linas Lozys and Justas Dainys, Nature Research Center, Vilnius, Lithuania

Adam Lejk and Łukasz Dziemian, National Marine Fisheries Research Institute, Gdynia, Poland

Elliot John Brown, National Institute of Aquatic Resources, Technical University of Denmark, Denmark

HELCOM Secretariat: Jannica Haldin, Owen Rowe

12 Archive

This version of the HELCOM core indicator report was published in April 2023:

The current version of this indicator (including as a PDF) can be found on the HELCOM indicator web page.

Earlier versions of the core indicator report include:

Abundance of key coastal fish species HELCOM core indicator 2018 (pdf)

HOLAS II component - Core indicator report – web-based version July 2017 (pdf)

Core indicator report – web-based version October 2015 (pdf)

Extended core indicator report – outcome of CORESET II project (2015) (pdf)

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Baltic Marine Environment
Protection Commission

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A2.2 Annex 2
Coastal fish key groups indicator report

For bibliographic purposes this document should be cited as: HELCOM (2023) Abundance of coastal fish key functional groups. HELCOM core indicator report.

2023

HELCOM

Coastal fish key groups

INDICATOR TYPE: State
INDICATOR CATEGORY: Core
BSAP SEGMENT: Biodiversity
MSFD CRITERIA: D4C2

Abundance of coastal fish key functional groups

Table of contents

1 Key message

This core indicator evaluates the abundance of selected functional groups of coastal fish in the Baltic Sea. As a rule, good status is achieved when the abundance of cyprinids or mesopredators (i.e. mid trophic-level fish) is within an acceptable range for the specific coastal area. The status of functional groups of coastal fish in the Baltic Sea has been evaluated by assessing the status of cyprinids and mesopredators during the period 2016-2020 (Figures 1 and 2).

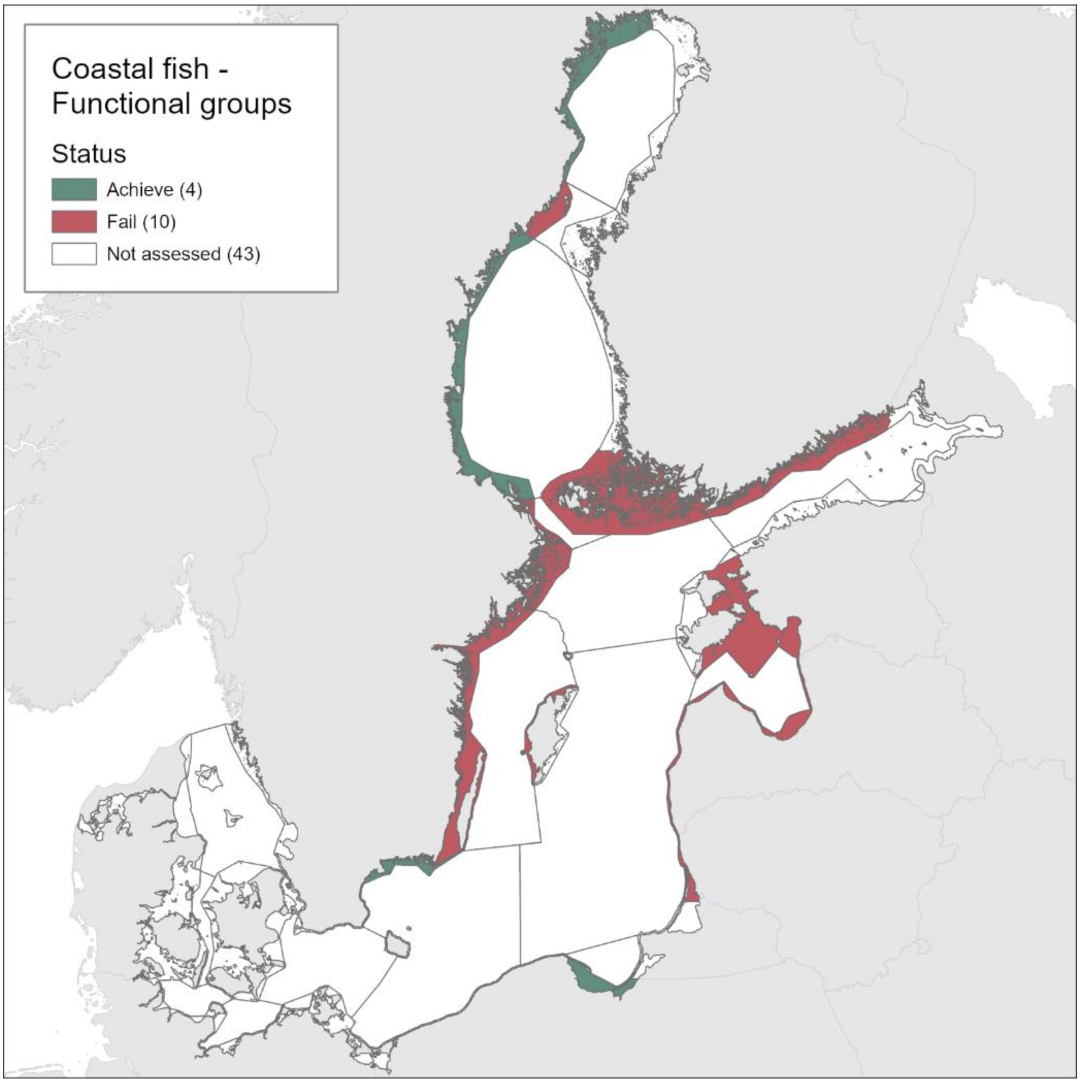
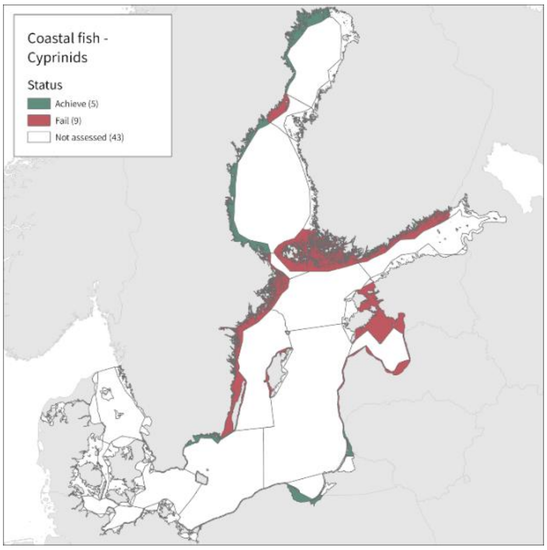


Figure 1. Status evaluation results based on the evaluation of the indicator 'abundance of coastal fish key functional groups' - integrated results of the two functional groups, cyprinids and mesopredators (see Figure 2 for separate). The evaluation is carried out using Scale 3 HELCOM assessment units (defined in the HELCOM Monitoring and Assessment Strategy Annex 4). **See 'data chapter' for interactive maps and data at the HELCOM Map and Data Service.**

For cyprinids/mesopredators, good status is achieved in 20 of the 32 monitored locations, but integration of the results of all key species over HELCOM assessment units using the One-Out-All-Out principle, showed that good status achieved in only 4 of the 14 evaluated assessment units. In the majority of the monitoring locations (24 locations) cyprinids is evaluated, and in 13 of these the threshold is met. For mesopredators the status appears to be better as the threshold is met in 7 of the in total 9 locations evaluated. Note that in one Swedish location (Kvädöfjärden), both cyprinids and mesopredators are evaluated, and neither meets the threshold, and in two Swedish areas included, the time-series is too short to allow for an evaluation of status.

In the locations classified as not good, the abundance of cyprinids and mesopredators was too high in all but two of the 12 locations (i.e. Hiiumaa in Estonia, and Jurkalne in Latvia).



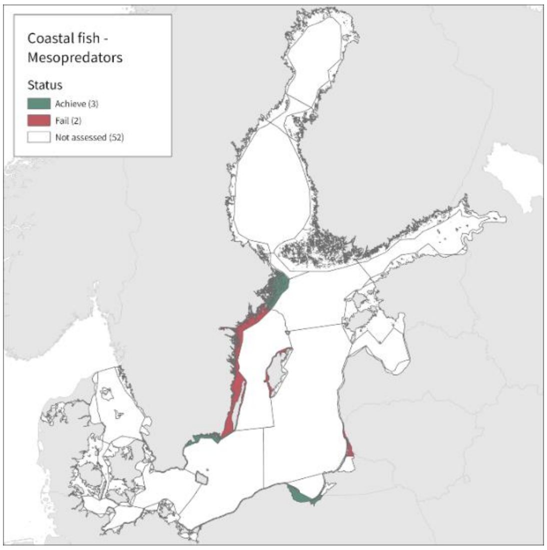


Figure 2. Status evaluation results based on the evaluation of the indicator 'abundance of coastal fish key functional groups' – results shown separately for the two functional groups cyprinids to the left and mesopredators to the right. The evaluation is carried out using Scale 3 HELCOM assessment units (defined in the [HELCOM Monitoring and Assessment Strategy Annex 4](#)). **See 'data chapter' for interactive maps and data at the HELCOM Map and Data Service.**

Generally, good status is not achieved in more central parts of the Baltic Sea including the Swedish part of the Quark, Åland Sea, Northern Baltic Proper and Western Gotland Basin, in more southern Finnish coastal waters (Archipelago Sea and Gulf of Finland), and in Estonian and Latvian coastal waters. Note that functional groups are not evaluated in the Finnish coastal areas of the Bothnian Bay and Bothnian Sea due to lack of data.

The level of confidence in the evaluation differs between areas and regions due to differences in monitoring methodology as well due to lower temporal and spatial coverage of monitoring in some countries, the latter generally relating to resource availability. The methodological confidence is high in all areas, and the confidence in the accuracy of the evaluation is high in the majority of the assessment units. The confidence in the temporal coverage is high in all areas except for Latvian and Lithuanian coastal areas, and the confidence in spatial representability is moderate to high in all assessment units evaluated besides those in Estonia and Latvia. The overall integrated confidence evaluation considering all four categories is high in five assessment units and intermediate in the remaining nine units, with no clear spatial pattern.

The indicator is operational in the coastal waters of most countries bordering the Baltic Sea. For the time being, it is not applicable in some areas where coastal fish monitoring data are scarce, or where the group meso-predators overlaps heavily with the species reported under the indicator "Abundance of coastal fish key species" and further studies as well as time series are needed to yield a reliable evaluation. In the future, in line with increasing knowledge, the indicator might undergo further development.

1.1 Citation

The data and resulting data products (e.g. tables, figures and maps) available on the indicator web page can be used freely given that it is used appropriately and the source is cited. The indicator should be cited as follows:

HELCOM (2023) Abundance of coastal fish key functional groups**.** HELCOM core indicator report. Online. [Date Viewed], [Web link].

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2 Relevance of the indicator

The state of coastal fish communities reflects the ecological state of coastal ecosystems, and in some areas where cyprinids and mesopredators are targeted, the effects of mainly small-scale coastal commercial fisheries. Changes in the long-term development of the abundance of coastal fish functional groups reflects the effects of increased water temperature and eutrophication in coastal areas, and/or changes in the level of human exploitation (mainly habitat degradation), natural predation pressure, and in some areas fishing.

2.1 Ecological relevance

Coastal fish are recognized as being important components of coastal food webs and ecosystem functioning and high abundances of cyprinids and mesopredatory fish are generally indicative of poorer environmental conditions in the coastal ecosystem (Eriksson *et al.* 2009; Baden *et al.* 2012; Bergström *et al.* 2016b, 2019; Östman *et al.* 2016). High abundances of cyprinids and mesopredators might reflect lack of top-down regulation, elevated eutrophication and increased water temperatures. In Sweden and Finland, a fishery targeting cyprinids has developed during recent years (Lappalainen *et al.* 2019; Dahlin *et al.* 2021), and resulting effects on targeted populations might hence be seen in the future.

Moreover, since many coastal fish species are rather local in their appearance (Saulamo & Neuman 2005; Laikre *et al.* 2005; Olsson *et al.* 2011; Östman *et al.* 2017a), the temporal development of coastal fish communities might reflect the general environmental state in the monitoring locations (Bergström *et al.* 2016b, 2019; Östman *et al.* 2017b).

2.2 Policy relevance

The core indicator on abundance of coastal fish functional groups addresses the Baltic Sea Action Plan's (BSAP 2021). Biodiversity and nature conservation segment's ecological objectives 'Natural distribution and occurrence of plants and animals' and 'Thriving and balanced communities of plants and animals'.

The core indicator is relevant to the following specific BSAP actions:

- 'to develop long-term plans for, protecting, monitoring and sustainably managing coastal fish species, including the most threatened and/or declining, including anadromous ones (according to the HELCOM Red list of threatened and declining species of lampreys and fishes of the Baltic Sea, BSEP No. 109), by 2012' and
- 'develop a suite of indicators with region-specific reference values and targets for coastal fish as well as tools for evaluation and sustainable management of coastal fish by 2012'.

The core indicator also addresses the following qualitative descriptors of the MSFD for determining good environmental status:

Descriptor 4: 'All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity'.

and the following criteria of the Commission Decision:

- Criterion D4C2 (Trophic guilds, balance of total guild abundance).

In some Contracting Parties the indicator also has potential relevance for implementation of the EU Habitats Directive.

A summary is provided in Table 1.

Table 1. Policy relevance

	Baltic Sea Action Plan (BSAP)	Marine Strategy Framework Directive (MSFD)
Fundamental link	Segment: Biodiversity Goal: "Baltic Sea ecosystem is healthy and resilient" • Ecological objective: "Functional, healthy and resilient food webs". • Management objective: "Reduce or prevent human pressures that lead to imbalance in the food web".	Descriptor 4 Ecosystems, including food webs - Trophic guilds of an ecosystem • Criteria 2 The balance of total abundance between the trophic guilds is not adversely affected due to anthropogenic pressures. • Feature – Coastal ecosystems. • Element of the feature assessed – Coastal fish species.
Complementary link	Segment: Biodiversity Goal: "Baltic Sea ecosystem is healthy and resilient" • Ecological objective: "Viable populations of all native species". • Management objective: "Human induced mortality, including hunting, fishing, and incidental bycatch, does not threaten the viability of marine life".	
Other relevant legislation:	In some Contracting Parties of HELCOM - potentially also EU Habitats Directive. UN Sustainable Development Goal 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development) is most clearly relevant, though SDG 12 (Ensure sustainable consumption and production patterns) and 13 (Take urgent action to combat climate change and its impacts) also have relevance.	

2.3 Relevance for other assessments

The status of biodiversity is assessed using several core indicators. Each indicator focuses on one important aspect of the complex issue. In addition to providing an indicator-based evaluation of the abundance of selected functional groups of coastal fish, this indicator also contributes to the overall biodiversity assessment along with the other biodiversity core indicators.

3 Threshold values

Good status is achieved when the abundance of cyprinids/mesopredators is within an acceptable range. The quantitative threshold values for coastal fish are based on location-specific reference conditions where time series covering more than 15 years are available (ten or more years reference period + five or more years assessment period). In areas where shorter time series (i.e. less than 15 years) are available, a trend-based approach is used.

A reference period needs to be defined for determining the threshold value. The period used to define the reference needs to cover at least ten years in order to extend over more than twice the generation time of the typical species represented in the indicator and thus cater for natural variation in the indicator value, due for example to strong and weak year classes. For the period used to determine the reference to be relevant, it must also be carefully selected to reflect time periods with stable environmental conditions, as stated within the MSFD (European Commission 2008). Substantial turnovers in ecosystem structure in the Baltic Sea were apparent in the late 1980s, leading to shifts in the baseline state (Möllmann *et al.* 2009), and for coastal fish communities, substantial shifts in community structure have been demonstrated in the late 1980s and early/mid 1990s (Olsson *et al.* 2012; Bergström *et al.* 2016a). In some areas, there have also been minor shifts in fish community structure later. To account for this, the ASCETS method (Östman *et al.* 2020) is applied on time-series with more than 15 years of data. This method offers a refined approach to infer structural changes in indicator values over time and establish threshold values for the state during a reference period based on the observed variation in indicator values.

Estimates of the relative abundance and/or biomass are used to determine whether coastal fish key functional groups in the Baltic Sea achieve good status or not. These estimates are derived from fishery independent monitoring. Since there are strong environmental gradients in the Baltic Sea and coastal fish communities, stocks are typically local in their appearance and respond mainly to area-specific environmental conditions. The evaluations for coastal fish key functional groups are thus carried out on a relatively local scale.

The assessment period applied when using the ASCETS method should cover at least five years to cater for natural variability. Good status is evaluated based on the deviation of the median value of the indicator during the assessment period in relation to the threshold value (Figure 3).

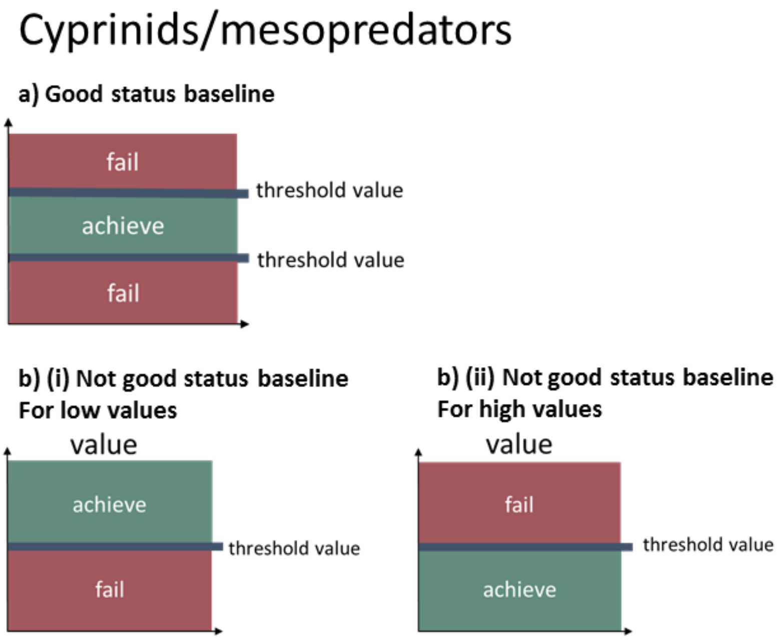


Figure 3. Determination of acceptable range from baseline.

When using the trend-based approach, environmental status is evaluated based on the direction of the trend towards good status, over the time period 2014-2020 (Figure 4).

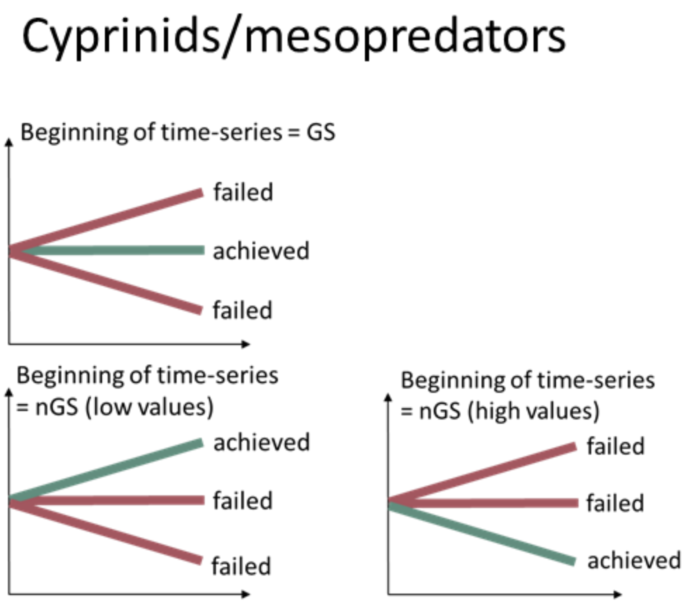


Figure 4. Application of the trend-based approach for evaluating environmental. The status is defined based on the direction of the trend of the indicator compared to the desired direction of the indicator over time. GS = good status, nGS = not good status.

The functional groups used in this indicator are members of the cyprinid family. In areas where cyprinids do not exist naturally, mesopredatory fish species are used e.g. any mid-trophic level species that are not piscivorous. The composition of cyprinid and mesopredator species differ along the coast. The most abundant species in the Cyprinid family (*Cyprinidae*) in the less saline eastern and northern parts of the Baltic Sea are for example roach (*Rutilus rutilus*) and bream (*Abramis sp.*), whereas mesopredatory fish are representative of the more exposed coastal parts of the central Baltic Sea and in its more saline western region.

Table 2. Species included in the two functional groups cyprinids and mesopredators in the different countries for which the indicator is currently applicable. Presence is indicated according to the following; X: Occurs in monitoring in representative numbers, X*: Occurs in monitoring in representative numbers, but no identification of the different species is possible, x: Occurs in monitoring but in low and non-representative numbers, blank: Not applicable in the country. Countries: FI: Finland, EE: Estonia, LV: Latvia, LT: Lithuania, PL: Poland, SE: Sweden.

Cyprinids	**FI**	**EE**	**LV**	**LT**	**PL**	**SE**
Roach (*R. Rutilus*)	X	X	X	X	X	X
Rudd (*S. Erythtrophthalmus*)	X	X	X	x	x	X
Bleak (*A. Alburnus*)	X	X	X	X	x	X
Common bream (*A. Brama*)	X	x	X	X	X	X
White bream (*A. Bjoerkna*)	X	X	X	X	X	X
Zope (*A. Ballerus*)					x	
Wimba bream (V. *vimba*)	X	X	X	X	x	x
Ide (*L. Idus*)	X	X	X	x	x	x
Dace (*L. Leusicus*)		x	X	x		x
Crucian carp (*C. Carassius*)	x	X	X	x	X	x
Gibel carp (*C. Gibelio*)		X				
Tench (*T. Tinca*)	x	x		x	x	x
Minnow (*P. Phoxinus*)		x				x
Gudgeon (*G. Gobio*)		X				
Chub (*S. cephalus*)		x			x	
Sichel (*P. cultratus*)	x	x			x	
Mesopredators	**FI**	**EE**	**LV**	**LT**	**PL**	**SE**
All cyprinid fish (see above)	X	X	X	X	X	X
Flounder (*P. Flesus)*	X*	X*	X*	X*	X	X*
Baltic flounder (*P. Solemdali*)	X*	X*	X*	X*		X*
Ruffe (*G. Cernuus*)	X	X	X	X	x	X
Eel (*A. Anguilla*)		x			x	X
Herring (*C. Harengus*)	X	X	X	X	x	X
Sprat (*S. Sprattus*)	X	x	X	X	x	x
Smelt (*O. Eperlanus*)	X	X	X	X	x	x
Plaice (*P. Platessa*)					x	x
Common dab (*L. Limanda*)						
Common sole (*S. Solea*)						x
Whitefish (*C. Maraena*)	X	X	X	X	x	X
Eelpout (*Z. Viviparous*)	X	X	X	x	x	X
Vendace (*C. Albula)*	x	x				X
Labrids (*L. Berggylta, L. Mixtus, C. Exoletus, S. Melops, C. Rupestris*)						X
Sculpins (*C. Poecilopus, T. Quadricornis, T. Bubalis, A. Cataphractus, M. Scorpius*)	X	X	X	X	x	X
Gobies (*G. Niger, N. Melanostomus)*	X	X	X	X	X	X
Sticklebacks (*G. Aculeatus, P. Pungiutus*)	X	x	X	x	x	X
Rocklings (*C. Mustela, E. Cimbrius*)						x
Pipefishes (*E. Aequoreus, S. Acus, S. Rostellatus, S. Tyhple*)	X	x	x	x	x	x
Garfish (*B. Belone*)		x		x	x	
Lumpfish (*C. Lumpus*)		x		x		x
Lesser sand-eel (*A. Marinus*)					x	
Small sandeel (*A. tobianus*)	x	x	X	x	x	x
Great sandeel (*H. lanceolatus*)	x	x	X	x	x	x

3.1 Setting the threshold value(s)

To determine the status of the indicator, the ASCETS method first derives a bootstrapped distribution of median values from a time series of observed indicator values during a reference period. Specific threshold values for changes in indicator state is set, and for key species, these are based on the 5th and 98th percentile values of the bootstrapped distribution. In this way, the derived boundaries of this interval can function as threshold values for a change in state per assessment unit of each species. Second, the bootstrapped median indicator value during the assessment period is evaluated in relation to the threshold values derived from the reference period depending on how much of the bootstrapped median distribution from the assessment period that falls below, within, or above the 5th and 98th percentiles.

If the requirements for defining quantitative baseline conditions are not met (e.g. short time-series), then a trend-based evaluation should be used. All available data starting from year 2014 is included in trend analyses. In the trend-based approach, good status is defined based on the direction of the trend at $p<0.1$ of the indicator compared to the desired direction of the indicator over time.

4 Results and discussion

The results of the indicator evaluation that underlie the key message map and information are provided below.

4.1 Status evaluation

The current evaluation of coastal fish environmental status covers the period 2016-2020. The evaluation is based on time-series data of varying length depending on the temporal coverage of data collection in each monitoring location. Time series thus start between the years 1998 and 2015 (Table 2) and depending on the time-series coverage, either the 'ASCETS approach' or a 'trend-based evaluation' is used. Evaluations were carried out for 14 of the in total 42 scale 3 assessment units and time series data up to and including the year 2020 were available for all 14 of these units.

The environmental status of cyprinids and mesopredator abundance is generally not good. Good status is achieved in 63 % of the evaluated monitoring locations (20 out of in total 32 locations), but only 4 out of 14 assessment units achieve good status (see Table 3). In the locations classified as not good, the abundance of cyprinids and mesopredators was too high in all but two (Hiiumaa, Estonia, and Jurkalne, Latvia) of the 12 locations.

In the majority of the monitoring locations (24 locations) cyprinids is evaluated, and in 13 of these the threshold is met. For mesopredators the status appears to be better as the threshold is met in 7 of the in total 9 locations evaluated. Note that in one Swedish location (Kvädöfjärden), both cyprinids and mesopredators are evaluated, and neither meets the threshold, and in two Swedish areas included, the time-series is too short to allow for an evaluation of status.

There are some geographical patterns in the status of the cyprinids/mesopredators, and good status is generally not achieved in more central parts of the Baltic Sea including the Swedish part of the Quark, Åland Sea, Northern Baltic Proper and Western Gotland Basin, in more southern Finnish coastal waters (Archipelago Sea and Gulf of Finland), and in Estonian and Latvian coastal waters.

Evaluations of the indicator were only carried out for cyprinids/mesopredators in the central and northern parts of the Baltic Sea since monitoring to support the indicator is currently lacking in Germany and Denmark, and in the Northern parts of Finland (Bothnian Bay and Bothnian Sea). Coastal fish monitoring is not available in Russia.

Table 3. Cyprinid/mesopredators evaluation results for the assessment period 2016-2021. GS = good status, nGS = not good status.

Sub-basin	Country	Coastal area name (assessment unit)	Coastal area code	Monitoring area/data set	Time period assessed	Identity of indicator	Monitoring method	Assessment method	Ref. period status	Threshold value(s)	Current value	Status monitoring location	Status assessment unit
Bothnian Bay	Finland	Bothnian Bay Finnish Coastal waters	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Kinnbäcksfjärden	2004-2020	Cyprinids	Fisheries independent data	ASCETS	GS	0.013;0.19	0.14	GS	
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Råneå	2002-2020	Cyprinids	Fisheries independent data	ASCETS	GS	18.15;35.7	26.25	GS	GS
The Quark	Finland	The Quark Finnish Coastal waters	3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
The Quark	Sweden	The Quark Swedish Coastal waters	4	Holmön	2002-2020	Cyprinids	Fisheries independent data	ASCETS	nGS	4.66;13.9	12.74	nGS	
The Quark	Sweden	The Quark Swedish Coastal waters	4	Norrbyn	2002-2020	Cyprinids	Fisheries independent data	ASCETS	nGS	4.54;10	12.69	nGS	nGS
Bothnian Sea	Finland	Bothnian Sea Finnish Coastal waters	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Forsmark	2002-2020	Cyprinids	Fisheries independent data	ASCETS	GS	4.36;9.27	8.3	GS	
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Gaviksfjärden	2004-2020	Cyprinids	Fisheries independent data	ASCETS	GS	9.27;17.85	15.2	GS	
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Långvindsfjärden	2002-2020	Cyprinids	Fisheries independent data	ASCETS	GS	4.59;14.87	13.36	GS	GS
Åland Sea	Finland	Åland Sea Finnish Coastal waters	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Galtfjärden	2002-2020	Cyprinids	Fisheries independent data	ASCETS	GS	14.36;21.31	20.97	GS	
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Lagnö	2002-2020	Cyprinids	Fisheries independent data	ASCETS	nGS	34.5;10.67	14.7	nGS	nGS
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finbo	2002-2021	Cyprinids	Fisheries independent data	ASCETS	nGS	12.1;22.7	22.1	nGS	
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Kumlinge	2002-2021	Cyprinids	Fisheries independent data	ASCETS	nGS	3.07;7.28	5.23	nGS	nGS
Northern Baltic Sea	Finland	Northern Baltic Proper Finnish Coastal waters	10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Askö	2005-2020	Cyprinids	Fisheries independent data	ASCETS	GS	1.86;22.3	10.5	GS	
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Muskö	1992-2020	Mesopredators	Fisheries independent data	ASCETS	GS	12;51.41	16.75	GS	
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Vaxholm: Askrikefjärden	2016-2020	Cyprinids	Fisheries independent data	Trend	nGS	Slope p >0.1 (-)	P slope = 0.46	nGS	nGS
Northern Baltic Sea	Estonia	Northern Baltic Proper Estonian Coastal waters	12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Brunskär	2002-2020	Cyprinids	Fisheries independent data	ASCETS	GS	0.07;0.8	0.32	GS	
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Helsinki	2005-2020	Cyprinids	Fisheries independent data	ASCETS	nGS	1.79;3.34	2.71	nGS	
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Tvärminne	2005-2020	Cyprinids	Fisheries independent data	ASCETS	GS	1.48;3.7	2.46	GS	nGS
Gulf of Finland	Estonia	Gulf of Finland Estonian Coastal waters	14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Finland	Russia	Gulf of Finland Russian Coastal waters	15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Riga	Estonia	Gulf of Riga Estonian Coastal waters	16	Hiiumaa	1991-2020	Cyprinids	Fisheries independent data	ASCETS	nGS	2.66;10.48	1.06	nGS	nGS
Gulf of Riga	Latvia	Gulf of Riga Latvian Coastal waters	17	Daugavgriva	2016-2020	Cyprinids	Fisheries independent data	Trend	nGS	Slope p >0.1 (-)	P slope = 0.17	nGS	nGS
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden	1998-2020	Mesopredators	Fisheries independent data	ASCETS	nGS	12.01;65.4	19.44	nGS	
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden	2002-2020	Cyprinids	Fisheries independent data	ASCETS	GS	10.88;18.2	20.18	nGS	
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Vinö	2007-2020	Cyprinids	Fisheries independent data	ASCETS	GS	24.9;86.28	65.42	GS	nGS
Eastern Gotland Basin	Estonia	Eastern Gotland Basin Estonian Coastal waters	19	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Eastern Gotland Basin	Latvia	Eastern Gotland Basin Latvian Coastal waters	20	Jurkalne	2016-2020	Cyprinids	Fisheries independent data	Trend	nGS	Slope p >0.1 (+)	P slope = 0.03	nGS	nGS
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Curonian lagoon	1998-2020	Cyprinids	Fisheries independent data	ASCETS	GS	141.3;308.7	175	GS	
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Karklė	2000-2020	Mesopredators	Fisheries independent data	Trend	GS	Slope p >0.1	P slope = 0.91	GS	
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Mon/But	1998-2020	Mesopredators	Fisheries independent data	ASCETS	GS	43;104.3	133	nGS	
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Smiltynė	2000-2020	Mesopredators	Fisheries independent data	ASCETS	GS	8.99;43	39.8	GS	
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Šventoji	2000-2020	Mesopredators	Fisheries independent data	ASCETS	GS	4.1;34.3	20.1	GS	nGS
Eastern Gotland Basin	Sweden	Eastern Gotland Basin Swedish Coastal waters	22	Herrvik	2018-2020	Mesopredators	Fisheries independent data	Trend			P slope = 0.2		NA
Eastern Gotland Basin	Russian	Eastern Gotland Basin Russian Coastal waters	23	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Eastern Gotland Basin	Poland	Eastern Gotland Basin Polish Coastal waters	24	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gdansk Basin	Russia	Gdansk Basin Russian Coastal waters	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Pucki	2011-2020	Mesopredators	Fisheries independent data	Trend	GES	Slope p >0.1	P slope = 0.62	GS	
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Wiślany	2011-2020	Cyprinids	Fisheries independent data	Trend	GES	Slope p >0.1	P slope = 0.69	GS	
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zatoka Pucka Zewnętrzna	2011-2020	Mesopredators	Fisheries independent data	Trend	GES	Slope p >0.1	P slope = 0.94	GS	GS
Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Hanöbukten	2015-2020	Mesopredators	Fisheries independent data	Trend	GS	Slope p >0.1	P slope = 0.2	GS	
Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Torhamn	2002-2020	Cyprinids	Fisheries independent data	ASCETS	GS	10.5;17.95	16.4	GS	GS
Bornholm Basin	Poland	Bornholm Basin Polish Coastal waters	28	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bornholm Basin	Denmark	Bornholm Basin Danish Coastal waters	29	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bornholm Basin	Germany	Bornholm Basin German Coastal waters	30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arkona Basin	Sweden	Arkona Basin Swedish Coastal waters	31	Stavstendsudde	2018-2020	Mesopredators	Fisheries independent data	Trend			P slope = 0.62		NA
Arkona Basin	Denmark	Arkona Basin Danish Coastal waters	32	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arkona Basin	Germany	Arkona Basin German Coastal waters	33	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mecklenburg Bight	Germany	Mecklenburg Bight German Coastal waters	34	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mecklenburg Bight	Denmark	Mecklenburg Bight Danish Coastal waters	35	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kiel Bight	Denmark	Kiel Bight Danish Coastal waters	36	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kiel Bight	Germany	Kiel Bight German Coastal waters	37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Belt Sea	Denmark	Belts Danish Coastal waters	38	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
The Sound	Sweden	The Sound Swedish Coastal waters	39	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
The Sound	Denmark	The Sound Danish Coastal waters	40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kattegat	Sweden	Kattegat Swedish Coastal waters, including Limfjorden	41	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

In the northernmost parts of the Baltic Sea, data is only available for Sweden. The status is generally good in the Bothnian Bay, but poor in the Quark (Table 3 and Figure 5). In the Quark the abundance of cyprinids is high and increasing in both locations evaluated, whereas in the two Swedish Bothnian Bay locations abundances are stable and meet the threshold for good status.

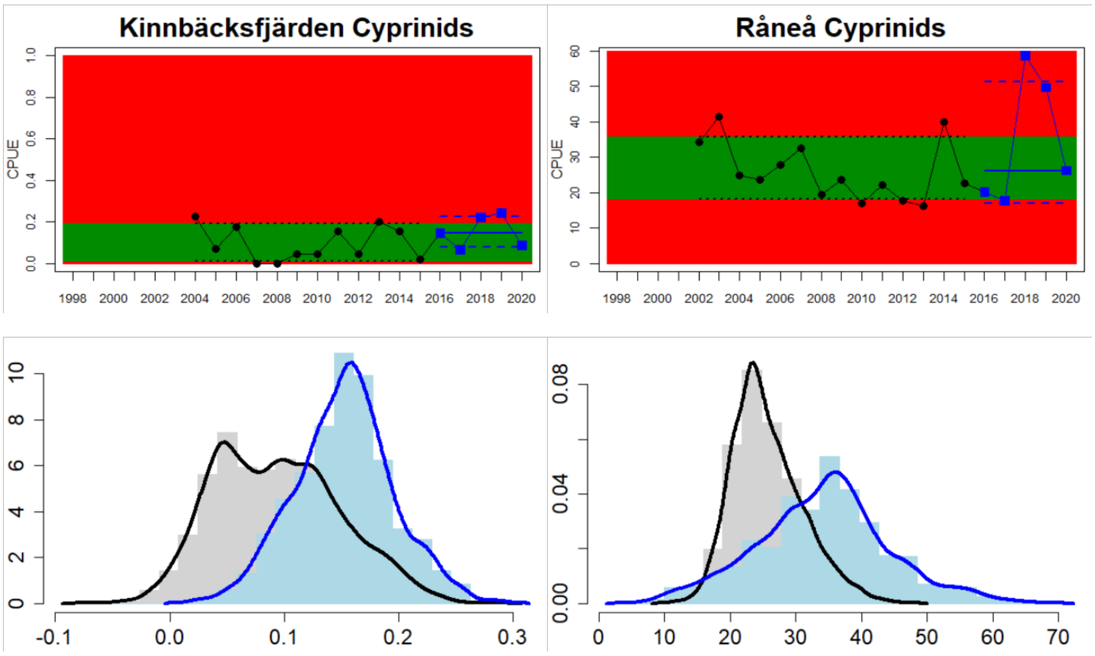
In the Swedish areas of the Bothnian Sea and Åland Sea, the relative abundance of cyprinids is generally stable and acceptable (indicating good status), except for one location (Lagnö, Åland Sea) where the abundance is increasing indicating a poor status. By contrast, the status is not good due too high or increasing abundances of cyprinids along the Finnish coast of the Archipelago Sea (see Figure 5).

In the central parts of the Baltic Sea (Northern Baltic Sea, Gulf of Finland, Gulf of Riga and Gotland Basin) the status is good in all but two Swedish locations (Vaxholm and Kvädöfjärden) and all but one Finnish location (Helsinki). Along the Estonian and Latvian coasts, the status is not good in all three locations, as a result of too low abundances of cyprinids in two locations and too high abundance in one location. In the four Lithuanian locations the status appears to be good in all but one location (Monciskes and Butinge) where the abundances of mesopredators is too high during recent years.

In the five southernmost locations in Sweden and Poland, the evaluation of cyprinids and mesopredators indicates good status in all locations.

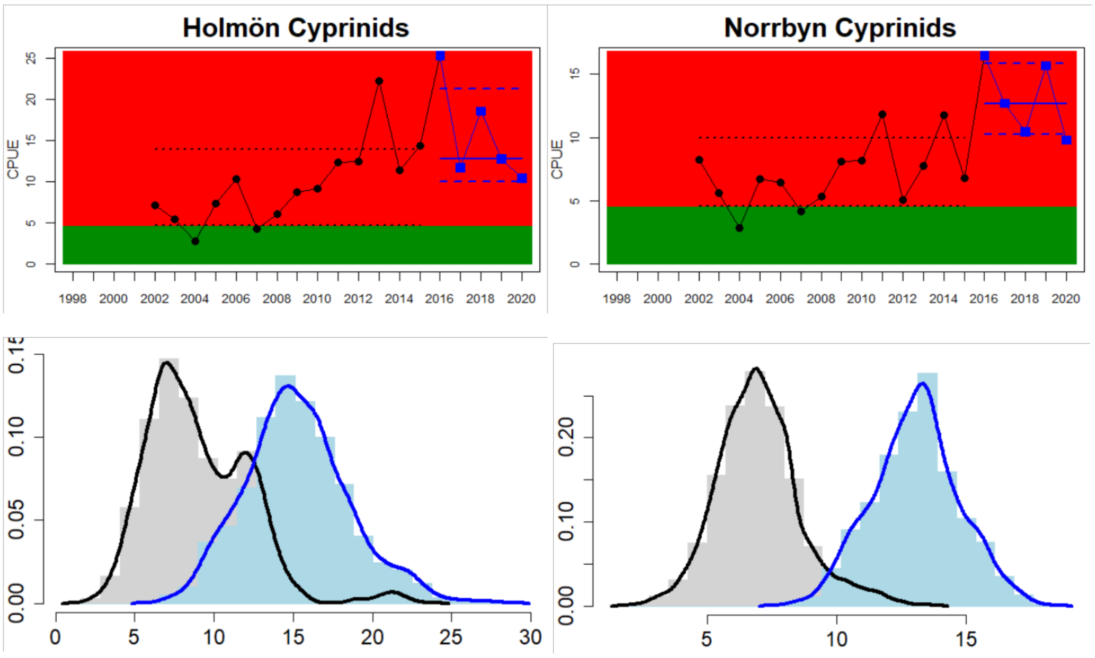
Bothnian Bay

Sweden



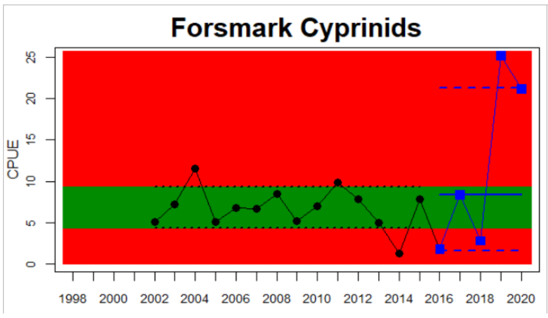
The Quark

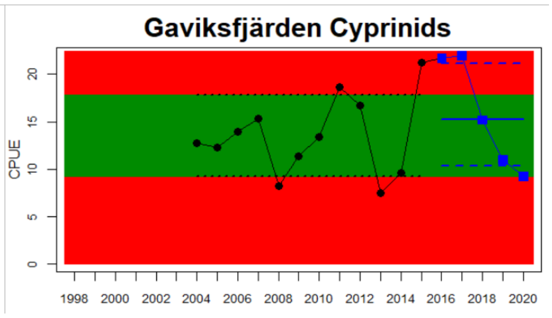
Sweden

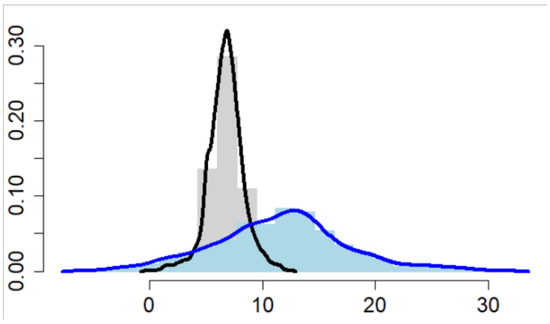


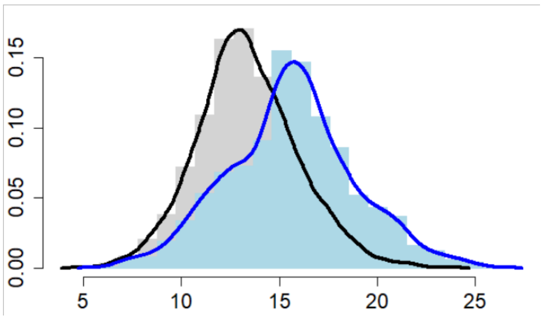
Bothnian Sea

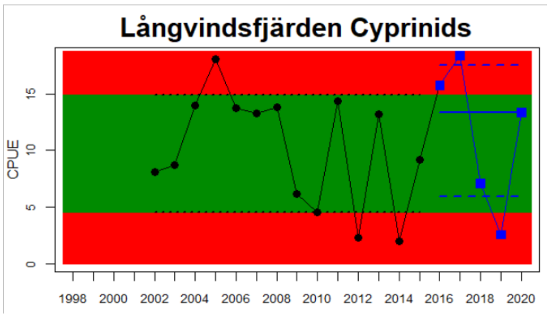
Sweden

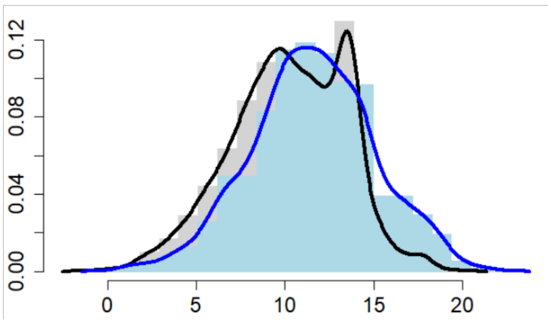






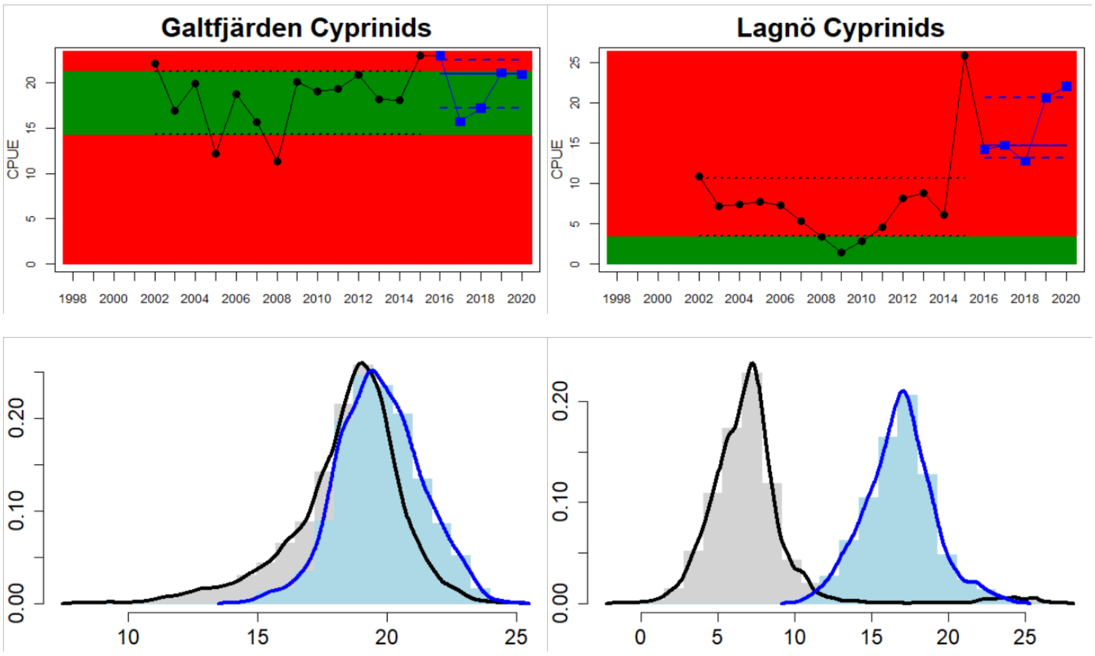






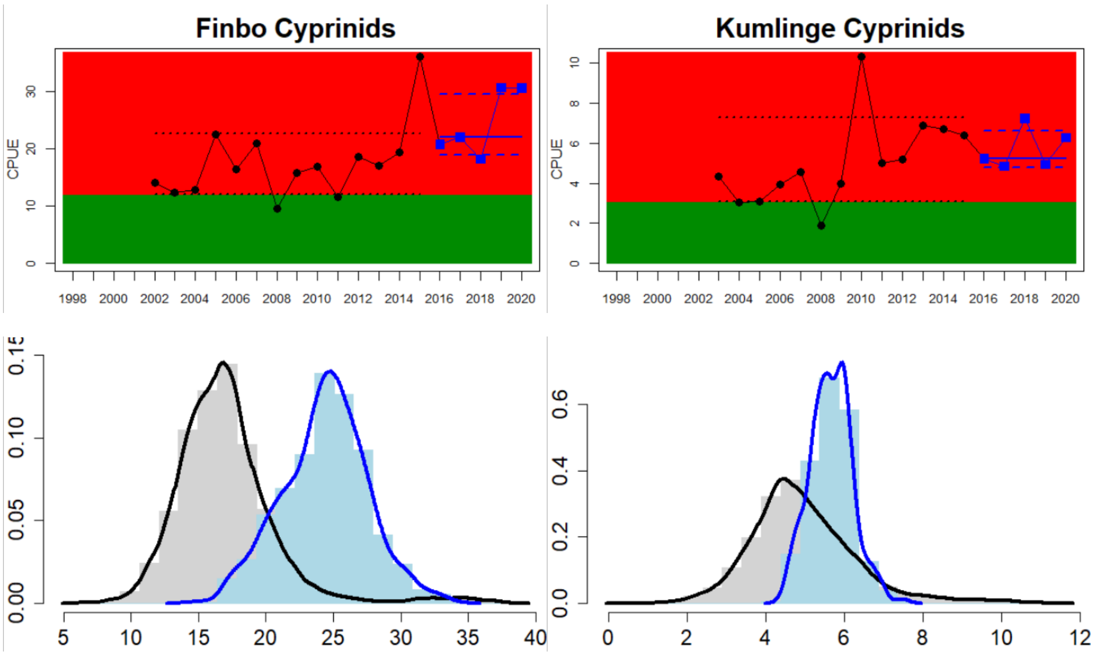
Åland Sea

Sweden



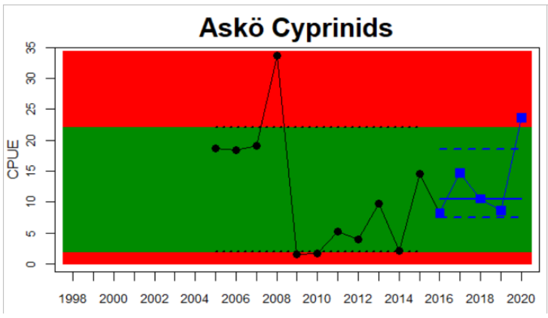
Archipelago Sea

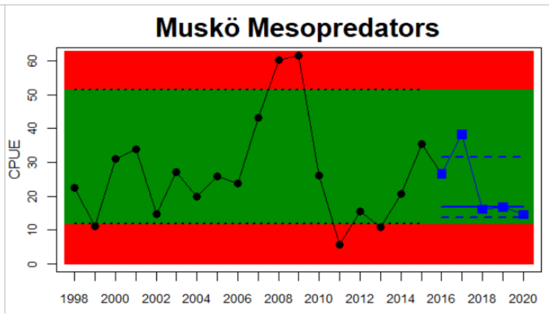
Finland

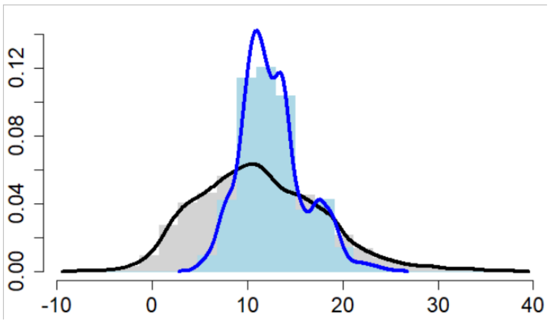


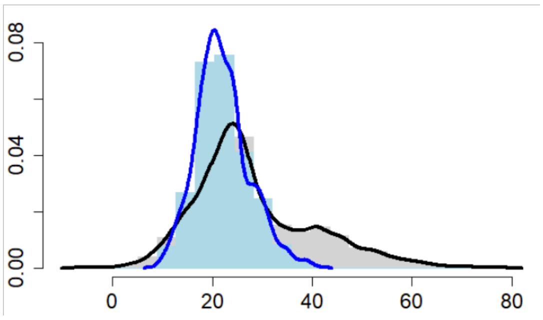
Northern Baltic Sea

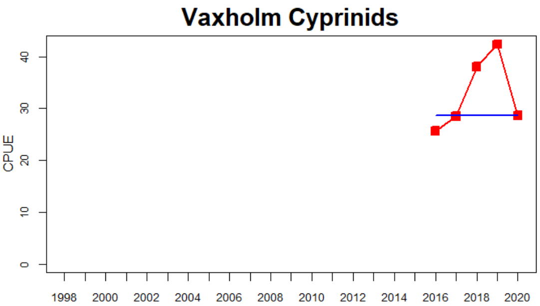
Sweden





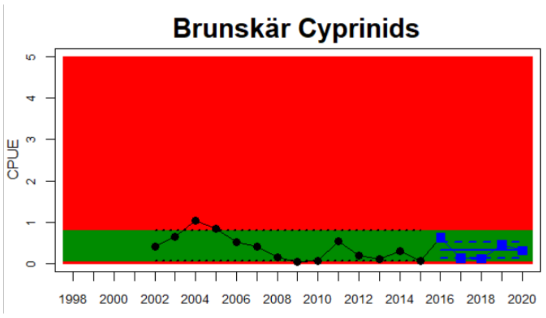


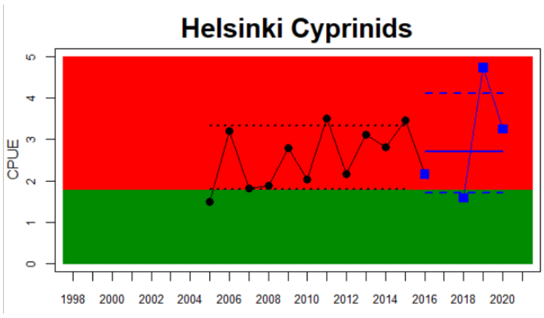


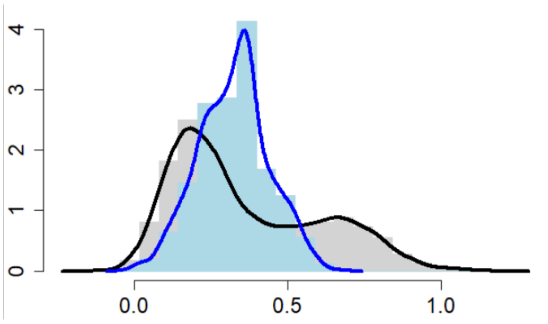


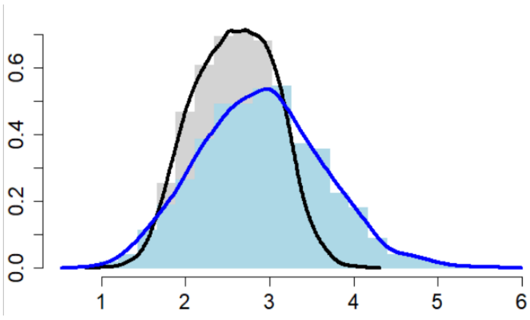
Gulf of Finland

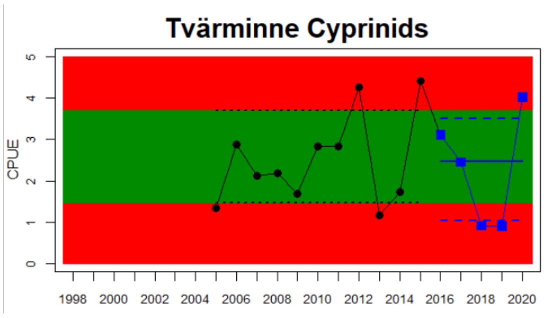
Finland

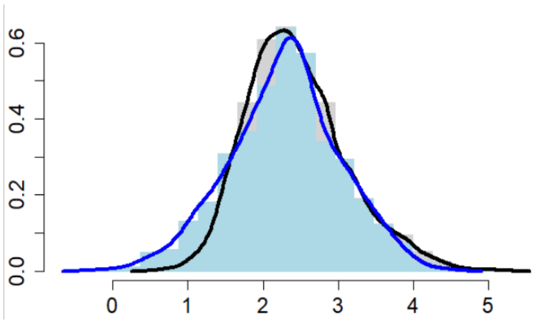






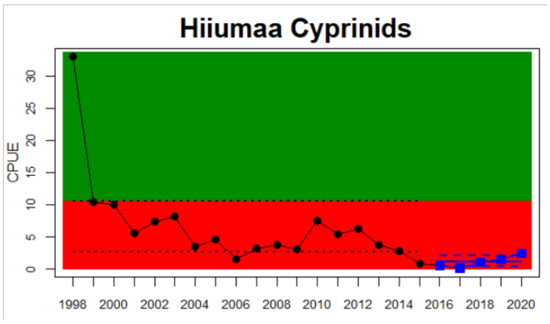


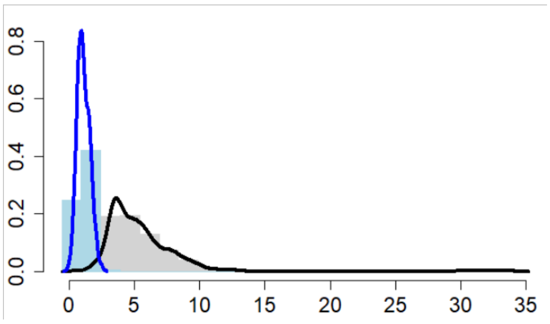




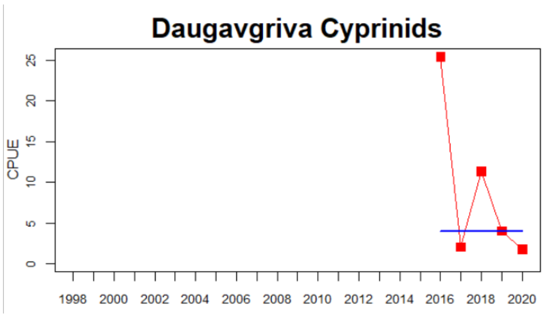
Gulf of Riga

Estonia



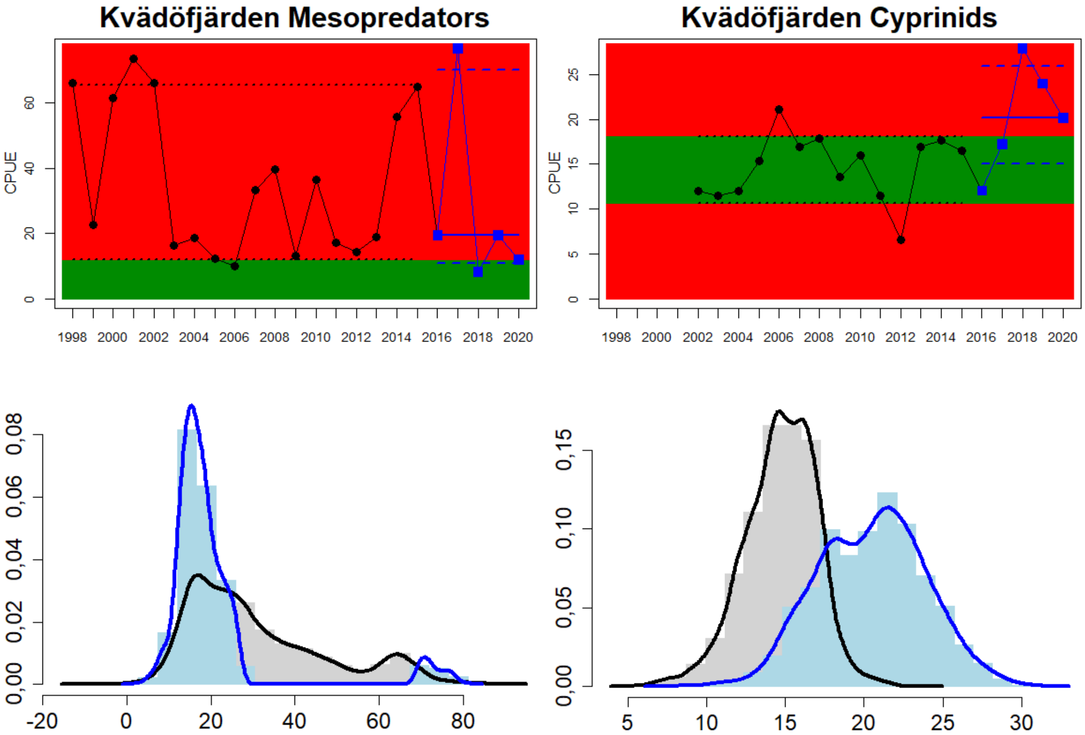


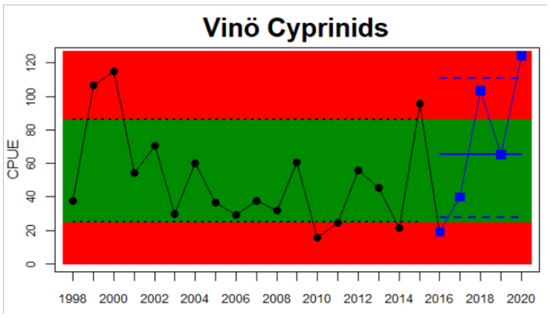
Latvia

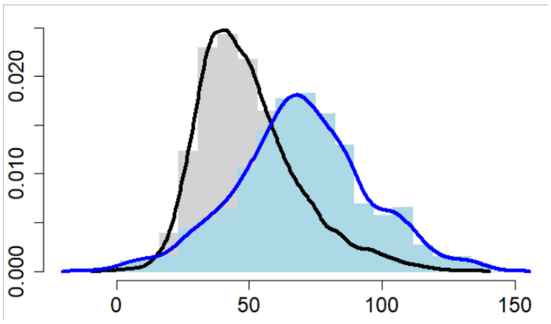


Western Gotland Basin

Sweden

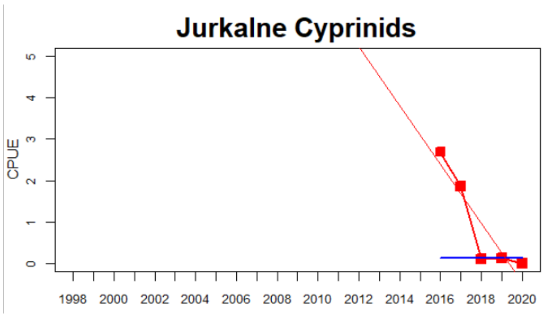




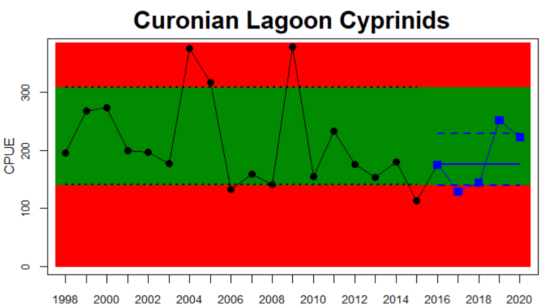


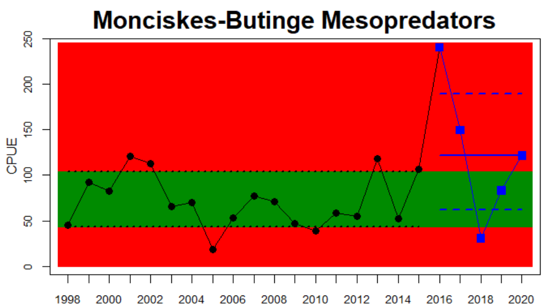
Eastern Gotland Basin

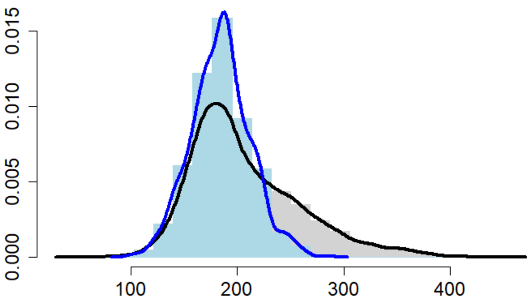
Latvia

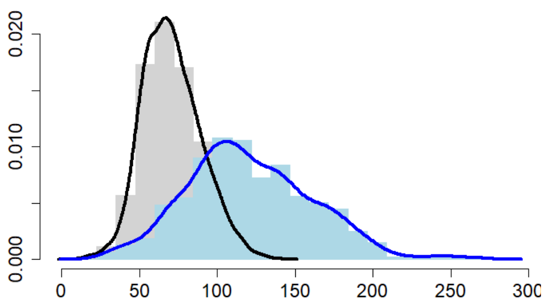


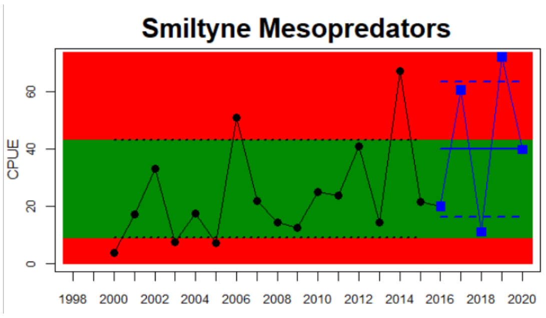
Lithuania










Smiltyne Mesopredators
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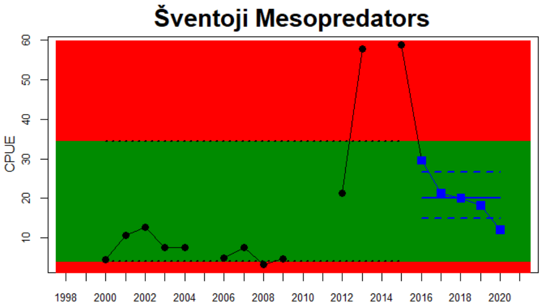
Šventoji Mesopredators
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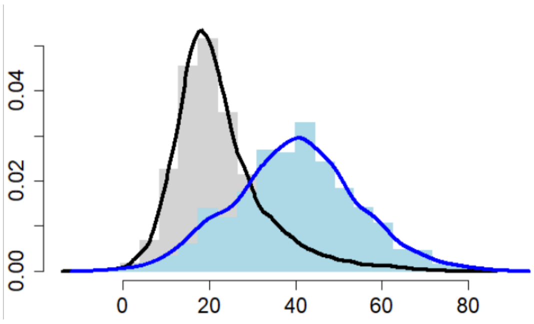
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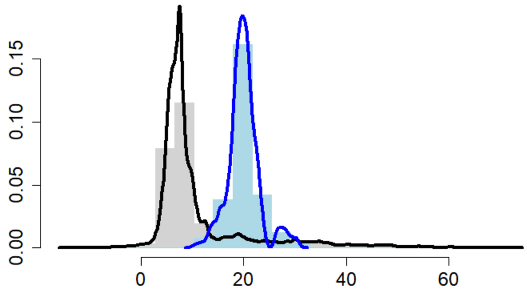
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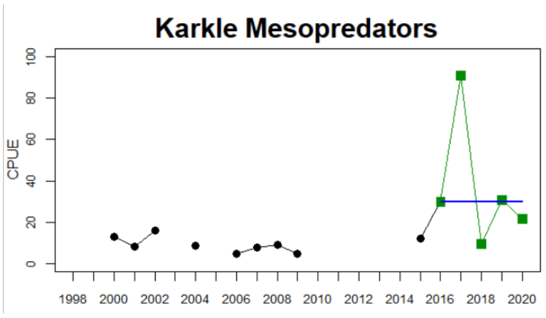
Karkle Mesopredators
CPUE
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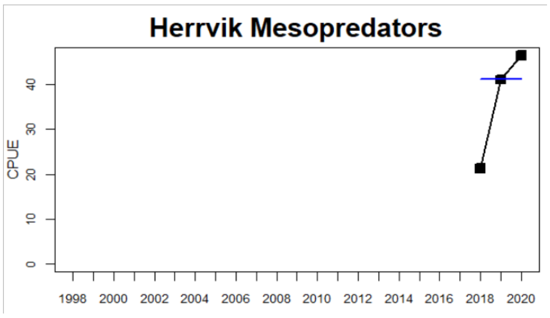
Sweden


Herrvik Mesopredators
CPUE
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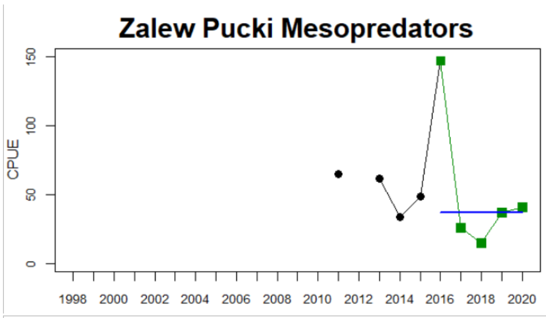
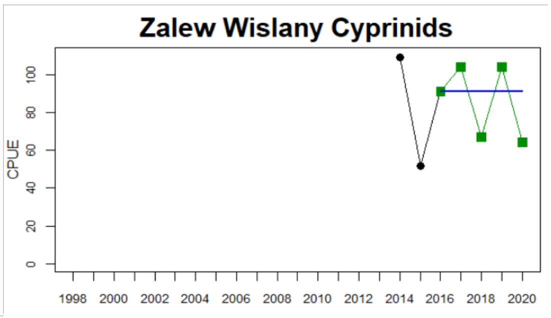
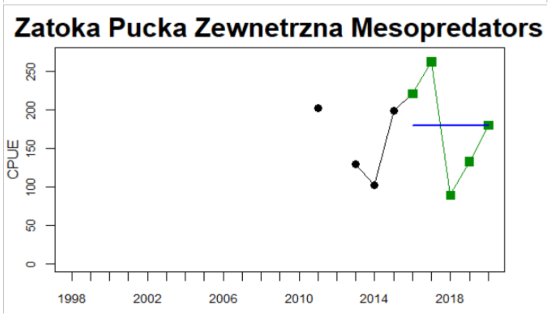
Gdansk Basin

Poland

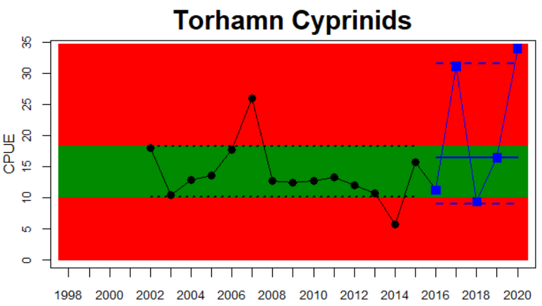


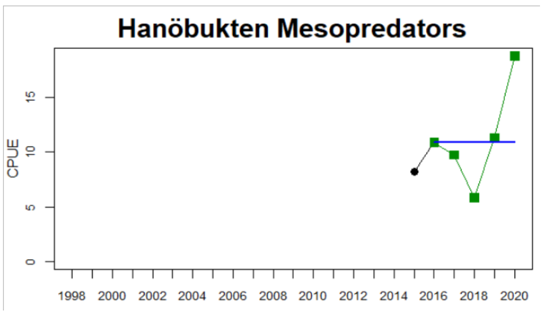


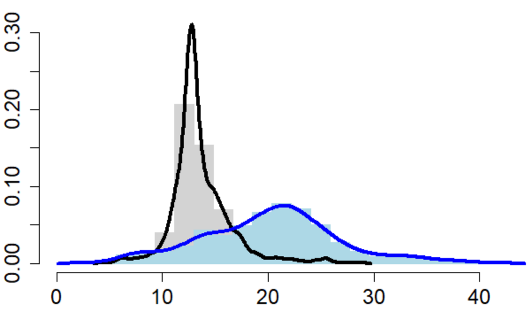


Bornholm Basin

Sweden







Arkona Basin

Sweden

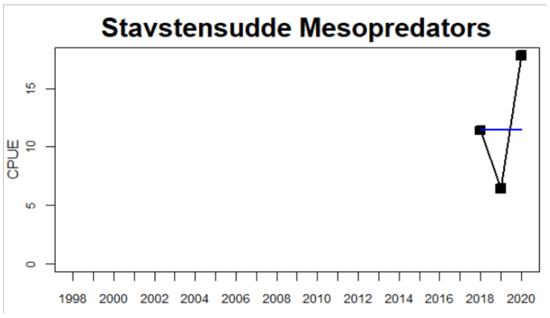


Figure 5. Cyprinid/mesopredator evaluation outcome. All evaluations are displayed per sub-basin and country for each monitoring location. In locations where the ASCETS approach is applied, threshold values are displayed by black dotted lines between fields in green (good status) and red (not good status), with the colour of the fields determined by the status during the reference period. The evaluation of good status/not good status is performed for the assessment period compared to the reference period by comparing the location of the median during the assessment period (full blue line) with the location of the respective threshold line. The 95th percentile intervals associated with the median displayed in hatched blue lines. Below each ASCETS graph, a small graph shows the smoothed bootstrapped medians of the indicator values from the reference period (bars in grey with a black line) and the assessment period (bars in blue with a blue line). For assessment units where the available data only allowed for a trend-based evaluation, green squares denote a good status evaluation outcome during the assessment period whereas red squares denote a not good status evaluation outcome. The hatched trend-line indicates a significant positive (green) and negative (red) trend at $p < 0.1$ during 2014-2020 for the times-series in each location.

4.2 Trends

There is a tendency for a slight decrease in the status of coastal fish in the Baltic Sea when considering cyprinids and mesopredators between this evaluation and HOLAS 2, conducted in 2018 including data until 2016 (Table 3). In three of the assessment units also considered in HOLAS 2, the status has decreased, and in the remaining ten assessment units there is no change over time in status. However, the decreased overall status partly reflects the inclusion of additional areas and functional groups (mesopredators) in some assessment units and areas (see comments in Table 3). The use of a stricter integrating approach across monitoring locations (majority rule in HOLAS 2 vs One-Out-All-Out principle in the current evaluation), might also contribute to the pattern observed.

Table 4. Overview of trends between current and previous evaluation in year 2018 (HOLAS 2, including data until 2016). For each HELCOM assessment unit, it is noted whether the integrated status using the BEAT tool achieves of fails to achieve the threshold value. The current integrated status is compared to the pervious status with regards to any distinct increasing or decreasing trend. In case of changed integrated status, the outcome is briefly described focusing on the relevant changes compared to the previous evaluation.

HELCOM Assessment unit name	Threshold value: achieved/failed	Distinct trend between current and previous evaluation	Description of outcomes
Archipelago Sea Coastal waters	failed	no change	
Bornholm Basin Swedish Coastal waters	achieved	no change	
Bothnian Bay Finnish Coastal waters	NA	NA	Included in HOLAS 2, but not in HOLAS III
Bothnian Bay Swedish Coastal waters	achieved	no change	
Bothnian Sea Finnish Coastal waters	NA	NA	Included in HOLAS 2, but not in HOLAS III
Bothnian Sea Swedish Coastal waters	achieved	no change	
Eastern Gotland Basin Latvian Coastal waters	failed	no change	
Eastern Gotland Basin Lithuanian Coastal waters	failed	decrease	Inclusion of 3 new monitoring locations, all with GS, but status is decreased due to nGS in Mon/But
Gulf of Finland Finnish Coastal waters	failed	no change	
Gdansk Basin Polish Coastal waters	achieved	NA	Not included in HOLAS 2
Gulf of Riga Estonian Coastal waters	failed	no change	
Gulf of Riga Latvian Coastal waters	failed	no change	
Northern Baltic Proper Swedish Coastal waters	failed	decrease	Inclusion of two new monitoring locations, status has decreased due to inclusion of Vaxholm
The Quark Finnish Coastal waters	NA	NA	Included in HOLAS 2, but not in HOLAS III
The Quark Swedish Coastal waters	failed	no change	
Western Gotland Basin Swedish Coastal waters	failed	decrease	Due to inclusion of mesopredators in Kvädöfjärden, status has decreased
Åland Sea Swedish Coastal waters	failed	no change	

4.3 Discussion text

The overall environmental status of coastal fish in the Baltic Sea is poor. When summarising the results across cyprinids and mesopredators good status is only achieved in 4 out of the 14 assessment units analysed. 32 monitoring locations are considered in total, and among these, good status is achieved in 20 locations only. In the locations classified as not good, the abundance of cyprinids and mesopredators was too high in all but two (Hiiumaa, Estonia, and Jurkalne, Latvia) of the 12 locations.

There are some geographical patterns in the status of the cyprinids/mesopredators. Good status is only achieved along the Swedish coasts of the Bothnian Bay and Bothnian Sea, as well as along the southernmost Swedish coast (Bornholm Basin) and Polish coastal areas (Gdansk Basin).

5 Confidence

In general, the confidence varies between assessment units, countries and monitoring programmes since, for example, the number of years for which coastal fish monitoring has been carried out varies between locations, as does the spatial coverage of monitoring within assessment units. Generally, the confidence of the evaluation is higher in locations where monitoring started before 1999 and where data is available for all years during the assessment period (2016-2020) and where there is good spatial coverage of monitoring.

The confidence scoring followed the principles as outlined in the HELCOM integrated biodiversity assessment. Confidence was scored using four criteria with three different levels (1 = high, 0.5 = intermediate, and 0 = low). The criteria used were:

Confidence in the accuracy of the estimate (ConfA). In the ASCETS approach, confidence in the evaluation is determined by the C(S) value. C(S) varies between 0 and 1, with values <0.1 representing high confidence of changed status and values >0.9 high confidence of unchanged status (Level 1). Values of 0.1-0.3 represent medium confidence in changed status and 0.7-0.9 medium confidence in unchanged status (Level 0.5). Values of 0.3-0.5 represent low confidence of changed status and 0.5-0.7 low confidence in unchanged status (Level 0). In the trend-based approach, confidence in the evaluation is determined by the p-value of the linear regression, with p-values <0.05 representing high confidence in a trend, p<0.1 medium confidence in a trend, p 0.10-0.20 low confidence in no trend, p 0.21-0.49 medium confidence in no trend, and p 0.5-1.0 high confidence in no trend.

Confidence in the temporal coverage of evaluation (ConfT). Level 1 = data for all years during 2016-2020, 0.5 = data missing for one or two years during 2016-2020, and 0 = data missing for three or more years during 2016-2020.

Confidence in spatial representability of the evaluation (ConfS). Level 1 = full coverage/several monitoring locations per assessment unit given its size, 0.5 = two or more monitoring locations per assessment unit, and 0 = one monitoring location per assessment unit.

Methodological confidence (ConfM). For coastal fish all assessment units reach level 1 since all monitoring programs included in the evaluation are described in the coastal fish monitoring guidelines.

Table 5. Confidence in the status evaluation of the cyprinids/mesopredators indicator according to the criteria developed within HELCOM for the integrated biodiversity assessment.

Sub-basin	Country	Coastal area name (assessment unit)	Coastal area code	Monitoring area/data set	Time period assessed	Identity of indicator	Monitoring method	Assessment method	ConfA	ConfT	ConfS	ConfM
Bothnian Bay	Finland	Bothnian Bay Finnish Coastal waters	1	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Kinnbäcksfjärden	2004-2020	Cyprinids	Fisheries independent data	ASCETS	0.5	1	0.5	1
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Råneå	2002-2020	Cyprinids	Fisheries independent data	ASCETS	0	1	0.5	1
The Quark	Finland	The Quark Finnish Coastal waters	3	NA	NA	NA	NA	NA	NA	NA	NA	NA
The Quark	Sweden	The Quark Swedish Coastal waters	4	Holmön	2002-2020	Cyprinids	Fisheries independent data	ASCETS	0	1	0.5	1
The Quark	Sweden	The Quark Swedish Coastal waters	4	Norrbyn	2002-2020	Cyprinids	Fisheries independent data	ASCETS	1	1	0.5	1
Bothnian Sea	Finland	Bothnian Sea Finnish Coastal waters	5	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Forsmark	2002-2020	Cyprinids	Fisheries independent data	ASCETS	0.5	1	0.5	1
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Gaviksfjärden	2004-2020	Cyprinids	Fisheries independent data	ASCETS	0.5	1	0.5	1
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Långvindsfjärden	2002-2020	Cyprinids	Fisheries independent data	ASCETS	0.5	1	0.5	1
Åland Sea	Finland	Åland Sea Finnish Coastal waters	7	NA	NA	NA	NA	NA	NA	NA	NA	NA
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Galtfjärden	2002-2020	Cyprinids	Fisheries independent data	ASCETS	0.5	1	0.5	1
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Lagnö	2002-2020	Cyprinids	Fisheries independent data	ASCETS	1	1	0.5	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finbo	2002-2021	Cyprinids	Fisheries independent data	ASCETS	0.5	1	0.5	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Kumlinge	2002-2021	Cyprinids	Fisheries independent data	ASCETS	1	1	0.5	1
Northern Baltic Sea	Finland	Northern Baltic Proper Finnish Coastal waters	10	NA	NA	NA	NA	NA	NA	NA	NA	NA
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Askö	2005-2020	Cyprinids	Fisheries independent data	ASCETS	1	1	0.5	1
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Muskö	1992-2020	Mesopredators	Fisheries independent data	ASCETS	1	1	0.5	1
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Vaxholm: Askrikefjärden	2016-2020	Cyprinids	Fisheries independent data	Trend	0.5	1	0.5	1
Northern Baltic Sea	Estonia	Northern Baltic Proper Estonian Coastal waters	12	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Brunskär	2002-2020	Cyprinids	Fisheries independent data	ASCETS	1	1	1	1
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Helsinki	2005-2020	Cyprinids	Fisheries independent data	ASCETS	0	0.5	1	1
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Tvärminne	2005-2020	Cyprinids	Fisheries independent data	ASCETS	0.5	1	1	1
Gulf of Finland	Estonia	Gulf of Finland Estonian Coastal waters	14	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Finland	Russia	Gulf of Finland Russian Coastal waters	15	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Riga	Estonia	Gulf of Riga Estonian Coastal waters	16	Hiiumaa	1991-2020	Cyprinids	Fisheries independent data	ASCETS	1	1	0	1
Gulf of Riga	Latvia	Gulf of Riga Latvian Coastal waters	17	Daugavgriva	2016-2020	Cyprinids	Fisheries independent data	Trend	0	1	0	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden	1998-2020	Mesopredators	Fisheries independent data	ASCETS	0.5	1	0.5	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden	2002-2020	Cyprinids	Fisheries independent data	ASCETS	0.5	1	0.5	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Vinö	2007-2020	Cyprinids	Fisheries independent data	ASCETS	0.5	1	0.5	1
Eastern Gotland Basin	Estonia	Eastern Gotland Basin Estonian Coastal waters	19	NA	NA	NA	NA	NA	NA	NA	NA	NA
Eastern Gotland Basin	Latvia	Eastern Gotland Basin Latvian Coastal waters	20	Jurkalne	2016-2020	Cyprinids	Fisheries independent data	Trend	1	1	0	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Curonian lagoon	1998-2020	Cyprinids	Fisheries independent data	ASCETS	1	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Karklė	2000-2020	Mesopredators	Fisheries independent data	Trend	1	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Mon/But	1998-2020	Mesopredators	Fisheries independent data	ASCETS	0	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Smiltynė	2000-2020	Mesopredators	Fisheries independent data	ASCETS	0	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Šventoji	2000-2020	Mesopredators	Fisheries independent data	ASCETS	1	1	1	1
Eastern Gotland Basin	Sweden	Eastern Gotland Basin Swedish Coastal waters	22	Herrvik	2018-2020	Mesopredators	Fisheries independent data	Trend	0.5	0.5	0	1
Eastern Gotland Basin	Russian	Eastern Gotland Basin Russian Coastal waters	23	NA	NA	NA	NA	NA	NA	NA	NA	NA
Eastern Gotland Basin	Poland	Eastern Gotland Basin Polish Coastal waters	24	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gdansk Basin	Russia	Gdansk Basin Russian Coastal waters	25	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Pucki	2011-2020	Mesopredators	Fisheries independent data	Trend	1	1	1	1
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Wiślany	2011-2020	Cyprinids	Fisheries independent data	Trend	1	1	1	1
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zatoka Pucka Zewnętrzna	2011-2020	Mesopredators	Fisheries independent data	Trend	1	0.5	1	1
Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Hanöbukten	2015-2020	Mesopredators	Fisheries independent data	Trend	0	1	0.5	1
Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Torhamn	2000-2020	Cyprinids	Fisheries independent data	ASCETS	0.5	1	0.5	1
Bornholm Basin	Poland	Bornholm Basin Polish Coastal waters	28	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bornholm Basin	Denmark	Bornholm Basin Danish Coastal waters	29	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bornholm Basin	Germany	Bornholm Basin German Coastal waters	30	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arkona Basin	Sweden	Arkona Basin Swedish Coastal waters	31	Stavstendsudde	2018-2020	Mesopredators	Fisheries independent data	Trend	1	0.5	0	1
Arkona Basin	Denmark	Arkona Basin Danish Coastal waters	32	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arkona Basin	Germany	Arkona Basin German Coastal waters	33	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mecklenburg Bight	Germany	Mecklenburg Bight German Coastal waters	34	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mecklenburg Bight	Denmark	Mecklenburg Bight Danish Coastal waters	35	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kiel Bight	Denmark	Kiel Bight Danish Coastal waters	36	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kiel Bight	Germany	Kiel Bight German Coastal waters	37	NA	NA	NA	NA	NA	NA	NA	NA	NA
Belt Sea	Denmark	Belts Danish Coastal waters	38	NA	NA	NA	NA	NA	NA	NA	NA	NA
The Sound	Sweden	The Sound Swedish Coastal waters	39	NA	NA	NA	NA	NA	NA	NA	NA	NA
The Sound	Denmark	The Sound Danish Coastal waters	40	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kattegat	Sweden	Kattegat Swedish Coastal waters, including Limfjorden	41	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	NA	NA	NA	NA	NA	NA	NA	NA	NA

The confidence in the accuracy of the evaluation (ConfA) is high in 14, medium in 11, and low in 7 of the in total 32 monitoring locations considered. In the locations scoring low for ConfA, there is either short time-series or substantial interannual variation in the indicator value during the assessment period leading to a lower confidence in the evaluation of status. The confidence in the temporal coverage (ConfT) is high in all areas except for the locations of Helsinki (Gulf of Finland, Finland) and Zatoka Pucka Zewnętrzna (Gulf of Gdansk, Poland) due to missing data in one or more of the years in the assessment period. The confidence in spatial representability (ConfS) is only high along the Lithuanian and Polish coasts and low along the southern Swedish coast (Arkona basin) and in Latvian and Estonian coastal waters. In all other areas, ConfS is scored as being intermediate. The methodological confidence (ConfM) is high an all locations evaluated. The integrated confidence considering all four categories varies between high (five assessment units) and intermediate (nine assessment units), but with no clear spatial pattern (Figure 6).

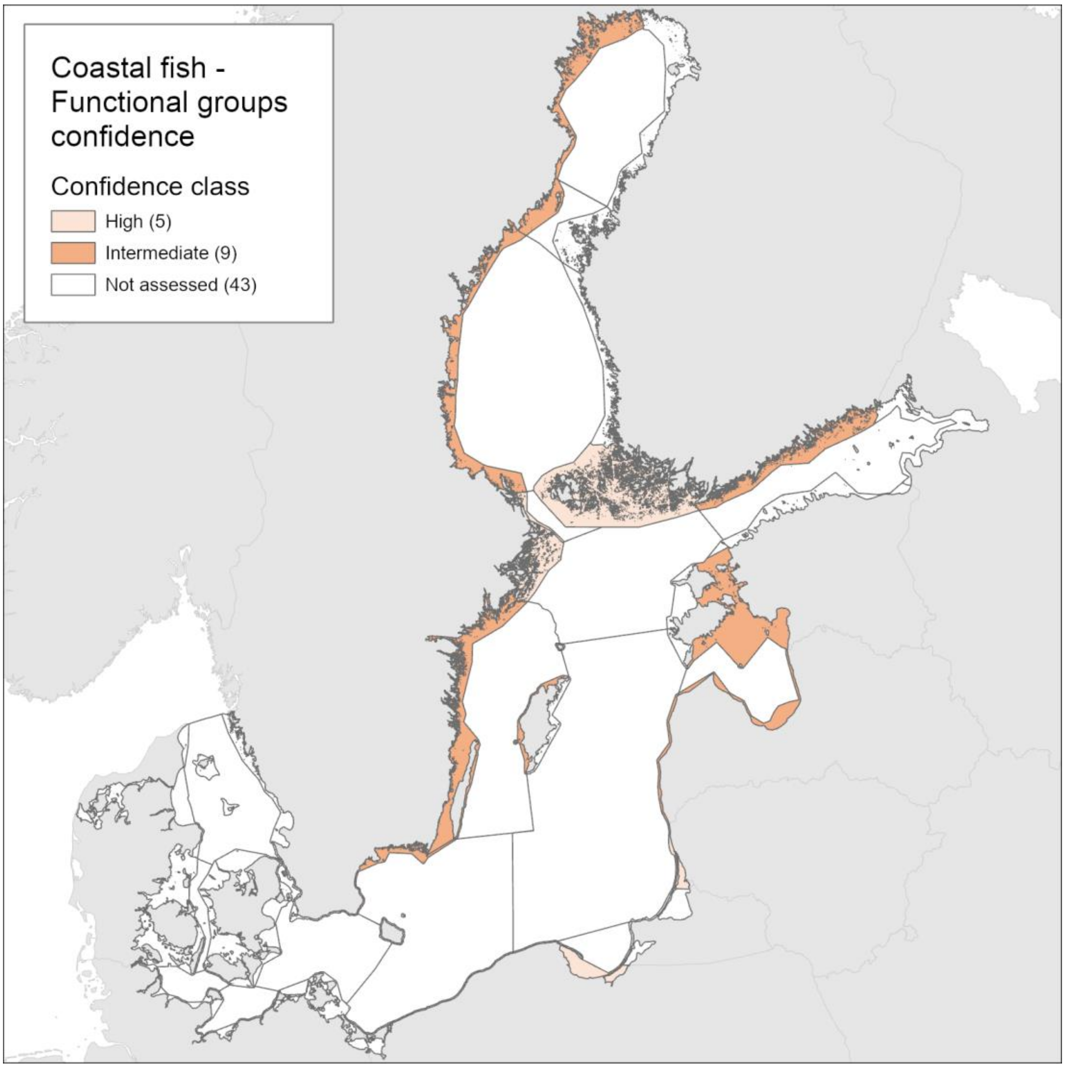


Figure 6. Map of confidence of the current evaluation of the cyprinids/mesopredators indicator. See Table 5 for details.

The confidence concept as developed for the HELCOM integrated biodiversity assessment is not fully applicable to coastal fish as further evaluation of the precision in data and the congruence in status across monitoring locations within assessment units would provide additional information that is needed.

6 Drivers, Activities, and Pressures

The state of key functional groups of coastal fish in the Baltic Sea is influenced by multiple pressures, including climate, eutrophication, exploitation of essential habitats, and in a few areas fishing mortality. Natural processes such as food web interactions and predation from apex predators are also of importance.

The functional groups considered in this indicator are generally heavily affected by the impacts of a changing climate (Olsson *et al.* 2012; Bergström *et al.* 2016b, 2019; Östman *et al.* 2017b) (cf. Chapter 7), including alterations in the food web (Eriksson *et al.* 2009; 2011; Östman *et al.* 2016), the impact of increased water temperature and, for cyprinids in particular, also lowered salinity (Härmä *et al.* 2008; Östman *et al.* 2017b).

Among pressures related to human activities, exploitation of essential habitats (Sundblad *et al.* 2014; Sundblad & Bergström 2014; Kraufvelin *et al.* 2018) impact cyprinids/mesdopredators throughout the Baltic, whereas fishing generally affects mainly cyprinids locally in Sweden and Finland (Lappalainen *et al.* 2019; Dahlin *et al.* 2021), and to some extent in the Baltic States and Polish coasts.

The effect of eutrophication on the state of coastal fish communities do mainly affect cyprinids (Härmä *et al.* 2008; Bergström *et al.* 2016b, 2019), and might increase with higher latitude (Östman *et al.* 2017b).

Cyprinids and mesopredatory fish species typically represent lower trophic levels in being planktivores and benthivores. As such, these groups of species are both impacted by bottom-up mechanisms such as eutrophication (Härmä *et al.* 2008; Östman *et al.* 2016) as well as by top-down regulation by piscivorous fish species (Eriksson *et al.* 2011; Baden *et al.* 2012; Casini *et al.* 2012; Östman *et al.* 2016) and apex predators (Östman *et al.* 2012; Hansson *et al.* 2018). Hence, high abundances of cyprinids and mesopredators often characterize ecosystems in an undesirable environmental state.

Natural interactions such as predation pressure from apex predators, foremost cormorants (*Phalacrocorax carbo*), could at least locally impact the state of coastal fish communities (Vetemaa *et al.* 2010; Östman *et al.* 2012; Hansson *et al.* 2018). In some areas the outtake of coastal fish by cormorants exceeds, or is of a similar magnitude, to that of the commercial and recreational fisheries (Östman *et al.* 2013; Hansson *et al.* 2018). The state of groups of mesopredatory fish species such as wrasses, sticklebacks and gobies, and potentially also cyprinids, could be affected by the food web structure in coastal areas and neighbouring ecosystems (Eriksson *et al.* 2011; Baden *et al.* 2012; Casini *et al.* 2012). Especially decreased predation pressure from declining stocks of piscivorous fish species might favour the increase in abundance of mesopredatory fish species (Östman *et al.* 2016). On the other hand, the mesopredators are an important part of the diet of cormorants, which may locally compensate the lack of predatory fish.

Table 6. Brief summary of relevant pressures and activities with relevance to the indicator.

	General	MSFD Annex III, Table 2a
Strong link	Several pressures, both natural and human, acting in concert affect the state of key functional groups of coastal fish. These include climate, eutrophication, fishing, and exploitation and loss of essential habitats. To date, no analyses on the relative importance of these variables have been conducted.	Biological *Extraction of, or mortality/injury to, wild species* (e.g. selective extraction of species, including incidental non-target catches) Physical *Physical disturbance to seabed* (e.g. abrasion and selective extraction) *Physical loss* (e.g.sealing) *Changes to hydrological processes* (e.g. significant changes in thermal and/or salinity regime) Substances *Inputs of nutrients* (e.g. inputs of fertilisers and other nitrogen and phosphorus-rich substances)
Weak link	There might also be effects of hazardous substances and non-indigenous species on the state of coastal fish key functional groups	Substances *Input of other substances (*e.g. synthetic substances, non-synthetic substances, radionuclides*)* Biological *Input or spread of non-indigenous species*

7 Climate change and other factors

The functional groups considered in this indicator are generally heavily affected by the impacts of a changing climate (Olsson *et al.* 2012; Bergström *et al.* 2016b, 2019; Östman *et al.* 2017b), including alterations in the food web (Eriksson *et al.* 2009; 2011; Östman *et al.* 2016), the impact of increased water temperature and, for cyprinids in particular, also lowered salinity (Härmä *et al.* 2008; Östman *et al.* 2017b) (cf. section 6 of this report).

8 Conclusions

8.1 Future work or improvements needed

Due to the presence of natural environmental gradients across the Baltic Sea, and the rather local appearance of coastal fish communities (and hence their differing structures and responses to environmental change), the spatial coverage of monitoring should be improved in some areas in order to enhance the confidence of the evaluation outcome. When designating new potential monitoring programmes, it should be considered that the levels of direct human impact on the coastal fish communities in many of the existing monitoring areas are low, and future locations should also include more heavily affected areas.

In addition, as a multitude of factors with natural environmental gradients in the Baltic Sea potentially impact coastal fish communities and species, the magnitude of importance of different factors in different coastal areas should be understood. A more mechanistic understanding of how pressures impact upon coastal fish in local contexts will enable managers to take relevant measures to halt declining trends of coastal fish species in some coastal areas.. More specifically, the role of fishing (both commercial and recreational) and natural predation needs further investigation.

9 Methodology

This indicator uses two different approaches for evaluating whether Good Status is achieved. The approach used depends on the availability of data. If certain criteria are met, the ASCETS method is used (Östman *et al.* 2020). If not, the trend-based approach is used.

The methodology and basis of the indicator evaluation is provided below.

9.1 Scale of assessment

Due to the local appearance of typical coastal fish populations, status evaluations of coastal fish communities are representative of rather small geographical scales, however, there is scope to further interrogate the citizen science monitoring data to try and develop a mesopredator index independent of the abundances of flounder and eelpout, which are currently used in the "Abundance of coastal fish species" indicator. In this evaluation the HELCOM assessment unit scale 3 'Open sub-basin and coastal waters' has been applied. The indicator is not evaluated for the open sea sub-basins since the species in focus are coastal.

Evaluations for both indicators were carried out for 16 coastal HELCOM assessment units, but in two Swedish units the time-series was too short to allow for an evaluation against a quantitative threshold value. The number of units evaluated is currently restricted by the availability of monitoring data.

For the integration of status across species and monitoring locations within assessment units, the One-Out-All-Out principle is applied (Dierschke *et al.* 2021).

The assessment units are defined in the HELCOM Monitoring and Assessment Strategy Annex 4.

9.2 Methodology applied

ASCETS approach

Coastal fish datasets must meet certain criteria in order to be able to apply an evaluation of good status using the ASCETS approach:

1. The time period used to determine the reference period should cover a minimum number of years that is twice the generation time of the species most influential in the indicator evaluation. This is to ensure that the influences of strong year classes are taken into account. For coastal fish, this is typically about ten years. In this evaluation, the time period used to determine the reference period against which good status is evaluated spans the years 1998 to 2015, with varying numbers of years depending on data availability for each time series.
2. Before evaluating good status, it should be decided whether or not the reference period reflects good status. If a previous status evaluation exists from HOLAS 2, the reference period is assigned the same status as the assessment period in HOLAS 2 (2011-2016). If a previous status evaluation does not exist, this can is

done by using data dating back earlier than the start of the period used to determine the reference period, using additional information, or by expert judgment. For example, if data from time periods preceding the period used for determining the reference period have much higher indicator values, the reference might represent not good status (in case of an indicator where higher values are indicative of a good environmental state) or good status (in case of an indicator where higher values are indicative of an undesirable state).

The ASCETS method (Östman *et al.* 2020) offers a refined approach to infer structural changes in indicator values over time and establish threshold values for the state during a reference period based on the observed variation in indicator values. ASCETS also gives estimates on the confidence of an apparent change in state of indicator values between a reference period and an assessment period. Thus, by applying ASCETS to time series data, it is possible to derive threshold values for addressing structural changes in indicator values over time and a developed evaluation of the confidence of the derived current indicator state relative to previous indicator values. To determine the status of the indicator, the ASCETS method first derives a bootstrapped distribution of median values from a time series of observed indicator values during a reference period. Specific threshold values for changes in indicator state is set based on the Xth and XXth percentile values of the bootstrapped distribution. For functional groups, the percentiles are 5 and 95/98 percent (depending on the status of the reference period, see below), representing the confidence interval of median indicator values. In this way, the derived boundaries of the confidence interval can function as threshold values for a change in state per assessment unit of each species. Because ASCETS bootstraps median indicator values during the reference period it is possible that one or several observed indicator values during the reference period will fall outside of the 95% confidence interval, because the bootstrapping reduces the influence of what may be large sampling errors. Second, the bootstrapped median indicator value during the assessment period is evaluated in relation to the threshold values derived from the reference period depending on how much of the bootstrapped median distribution from the assessment period that falls below, within, or above the Xth and XXth percentiles (cf. Figure 3 and decision tree in Figure 7):

1. In situations where the baseline state reflects good status, the median of the years in the assessment period should be above the 5th percentile and below the 95th percentile to reflect good status.

2. In situations where the baseline state reflects not good status, in order to reflect good status, the median of the years in the assessment period should be above the 98th percentile if the baseline status is indicative of too low abundances, and below the 5th percentile if the baseline status is indicative of too high abundances.

Trend-based approach

If the requirements for defining quantitative baseline conditions are not met (e.g. short time series), then a trend-based evaluation should be used. All available data starting from year 2014 is included in trend analyses.

In the trend based approach, good status is defined based on the direction of the trend compared to the desired direction of the indicator over time (cf. Figure 4). Where the first years in the evaluated time series represent good status, the trend of the indicator over time should not exhibit any direction in order to reflect good status. If, on the other hand, the first years of the evaluated time series represent not good status, the trend should be in the desired direction to reflect good status. The significance level for these trends should be p <0.1.

Decision tree for evaluation using coastal fish community structure

The assessment protocol is found in figure 7.

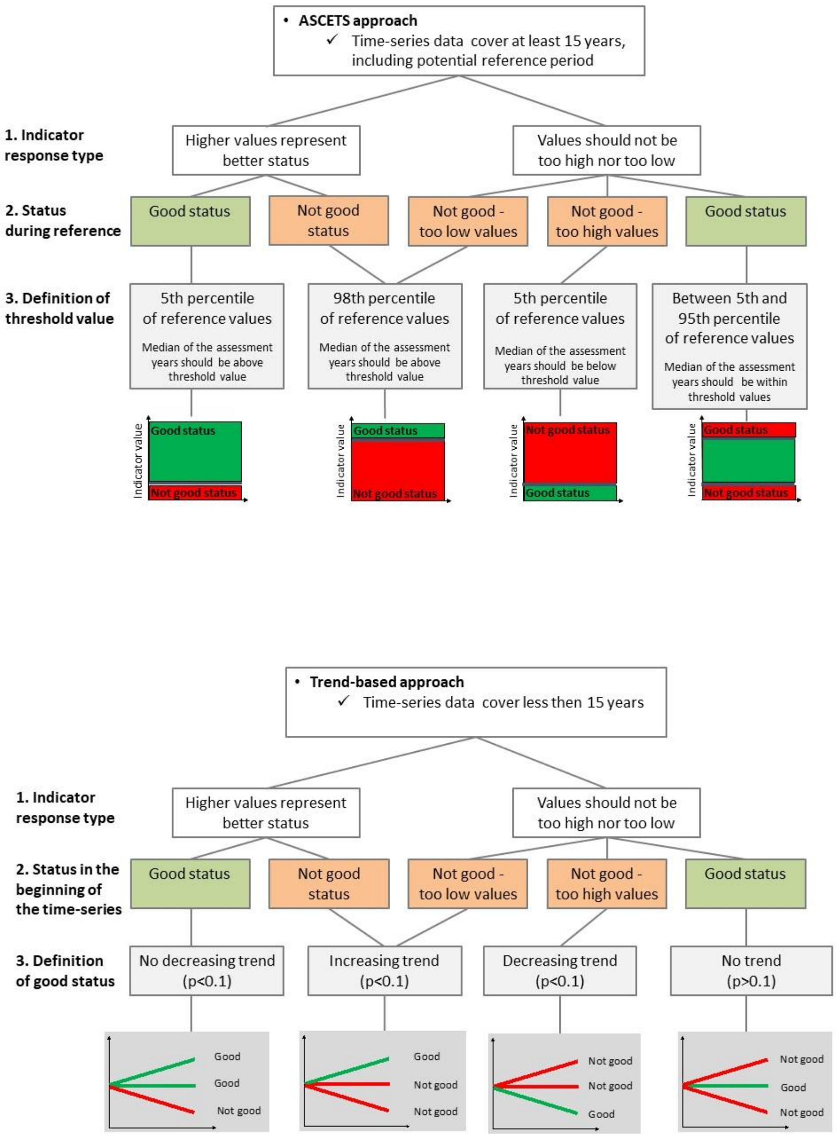


Figure 7. Decision tree for status evaluation using coastal fish community structure. ASCETS approach (top figure) and the trendbased approach (bottom figure) are presented.

Data analyses

The data used for the evaluations are derived from fishery independent monitoring. The analyses are based on catch per unit effort (CPUE) data from annual averages of all sampling stations in each area. Individuals smaller than 12 cm (Nordic Coastal multimesh nets) or 14 cm (other net types) were excluded from the evaluation in order to only include species and size-groups suited for quantitative sampling by the method. Abundance is calculated as the number of individuals of the species included in the indicator per unit effort (CPUE).

9.3 Monitoring and reporting requirements

Monitoring methodology

The HELCOM common monitoring on coastal fish is described on a general level in the HELCOM Monitoring Manual in the sub-programme: Coastal fish.

The HELCOM common monitoring on coastal fish is described in guidelines that were adopted in 2014 and updated in 2019.

Current monitoring

The monitoring activities relevant to the indicator that are currently carried out by HELCOM Contracting Parties are described in the HELCOM Monitoring Manual in the Monitoring Concepts table as well as in the guidelines for coastal fish monitoring.

Sub-programme: Coastal fish

Monitoring Concepts table

Coastal fish monitoring is rather widespread in the Baltic Sea, and at present covers 32 of the in total 42 'scale 3 HELCOM assessment units'. Coastal areas that lack coastal fish monitoring includes Russia and Germany (in total 7 assessment units) where there is no current and official monitoring program for coastal fish, two assessment units in Finland (Åland Sea Finnish coastal waters and Northern Baltic Proper Finnish coastal waters) and one in Denmark (Kiel Bight Danish coastal waters). The current monitoring where information cyprinds/mesopredators can be extracted to date is less extensive, covering 14 assessment units.

The current monitoring of coastal fish in the Baltic Sea represents a minimum level of effort and serves as a first step for evaluating the status of coastal fish communities.

The current monitoring likely yields insights into major and large-scale changes in coastal fish communities in the Baltic Sea, but unique and departing responses are possible in some areas.

In Estonia and Latvia, coastal fish monitoring is carried out at several locations, but the evaluation has only been made for one location in Estonia and two in Latvia. In Denmark, no data is available to support the cyprinids/mesopredators, and the Finnish commercial catch data is not applicable for assessing status of non-targeted fish species. In Germany, there is no coordinated monitoring program for coastal fish, but a project aiming to establish such a program was initiated in 2020 in the coastal areas of Schleswig-Holstein.

10 Data

The data and resulting data products (e.g. tables, figures and maps) available on the indicator web page can be used freely given that it is used appropriately and the source is cited.

Result: Abundance of coastal fish key functional groups – integrated result

Result: Abundance of coastal fish key functional groups – cyprinids

Result: Abundance of coastal fish key functional groups – mesopredators

Data: Abundance of coastal fish key functional groups

Data are typically collected annually in August by national and regional monitoring programmes (cf. HELCOM (2019) for details). For future updates of this evaluation, data should be collected in each location on an annual basis.

A few time series of coastal fish began in the 1970s (Olsson *et al.* 2012), whereas others were started in the 1980s and the mid-1990s (HELCOM 2019). In Finland and Sweden, a new coastal fish monitoring programme with a higher spatial resolution was established in the early 2000s, and in Poland monitoring data is typically available from the mid 2010s. For more information, see HELCOM 2019.

The raw data on which this evaluation is based, are stored in national databases. Each country has its own routines for quality assurance of the stored data. From 2017, each country calculates indicator values for their monitoring locations from the raw data from fish monitoring. The indicator data and values are then during the first half of the year uploaded to the HELCOM database for coastal fish core indicators, COOL as hosted by the HELCOM secretariat. Indicator data for status evaluations are extracted from the COOL database, and the evaluation undertaken by the lead country (Sweden) according to the assessment protocol outlined in this report.

Data source

Coastal fish monitoring is coordinated within the HELCOM FISH-PRO III expert network. The network compiles data from various sources of data for coastal fish in Finland, Estonia, Latvia, Lithuania, Poland, Germany, Denmark and Sweden (HELCOM 2019). In Germany, there is no coordinated monitoring program for coastal fish, but a project aiming to establish such a program was initiated in 2020 in the coastal areas of Schleswig-Holstein.

The institutes responsible for sampling are: Natural Resources Institute Finland (Luke) (Finland), Provincial Government of Åland Islands (Finland), Estonian Marine Institute (Estonia), University of Tartu (Estonia), Institute of Food Safety, Animal Health and Environment "BIOR" (Latvia), Nature Research Center (Lithuania), Klaipeda University

(Lithuania), National Marine Fisheries Research Institute, Gdynia (Poland), Association Fish and Environment Mecklenburg-Vorpommern e.V. (Germany), University of Rostock (Germany), National Institute of Aquatic Resources, Technical University of Denmark (Denmark), Department of Aquatic Resources, Swedish University of Agricultural Sciences (Sweden).

11 Contributors

The HELCOM FISH PRO III expert network on coastal fish:

Jens Olsson, Elisabeth Bolund, Lena Bergström, Örjan Östman, Noora Mustamäki and Rahmat Naddafi, Department of Aquatic Resources, Swedish University of Agricultural Sciences, Sweden

Mikko Olin and Antti Lappalainen, Natural Resources Institute Finland (Luke), Finland

Linda Sundström, Provincial Government of Åland Islands, Finland

Lauri Saks and Roland Svirgsden, Estonian Marine Institute, University of Tartu, Estonia

Laura Briekmane, Institute of Food Safety, Animal Health and Environment "BIOR", Latvia

Linas Lozys and Justas Dainys,Nature Research Center, Vilnius, Lithuania

Adam Lejk and Łukasz Dziemian, National Marine Fisheries Research Institute, Gdynia, Poland

Elliot John Brown, National Institute of Aquatic Resources, Technical University of Denmark, Denmark

HELCOM Secretariat: Jannica Haldin, Owen Rowe.

12 Archive

This version of the HELCOM core indicator report was published in April 2023:

The current version of this indicator (including as a PDF) can be found on the HELCOM indicator web page.

Earlier versions of the core indicator report include:

Abundance of coastal fish key functional groups HELCOM core indicator 2018 (pdf)

HOLAS 2 component - Core indicator report – web-based version July 2017 (pdf)

Core indicator report – web-based version October 2015 (pdf)

Extended core indicator report – outcome of CORESET II project (pdf) (2015)2013 Indicator report (pdf)

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Baltic Marine Environment
Protection Commission

BLUES

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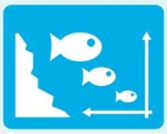
A2.2 Annex 3
Coastal fish size indicator report

For bibliographic purposes this document should be cited as: HELCOM (2023). Size structure of coastal fish (Coastal fish size). HELCOM core indicator report.

2023

HELCOM

Coastal fish size



INDICATOR TYPE: State
INDICATOR CATEGORY: Core
BSAP SEGMENT: Biodiversity
MSFD CRITERIA: D1C3

Size structure of coastal fish

Table of Content

1 Key message

This core indicator evaluates the size distribution of typical key species of fish, such as perch, flounder, and pikeperch in the coastal areas of the Baltic Sea, to assess environmental status. As a rule, good status is achieved when the size of large fish (size at L90) is above a set gear- and species-specific threshold value.

The current evaluation assesses status during the period 2016-2020 (Figure 1).

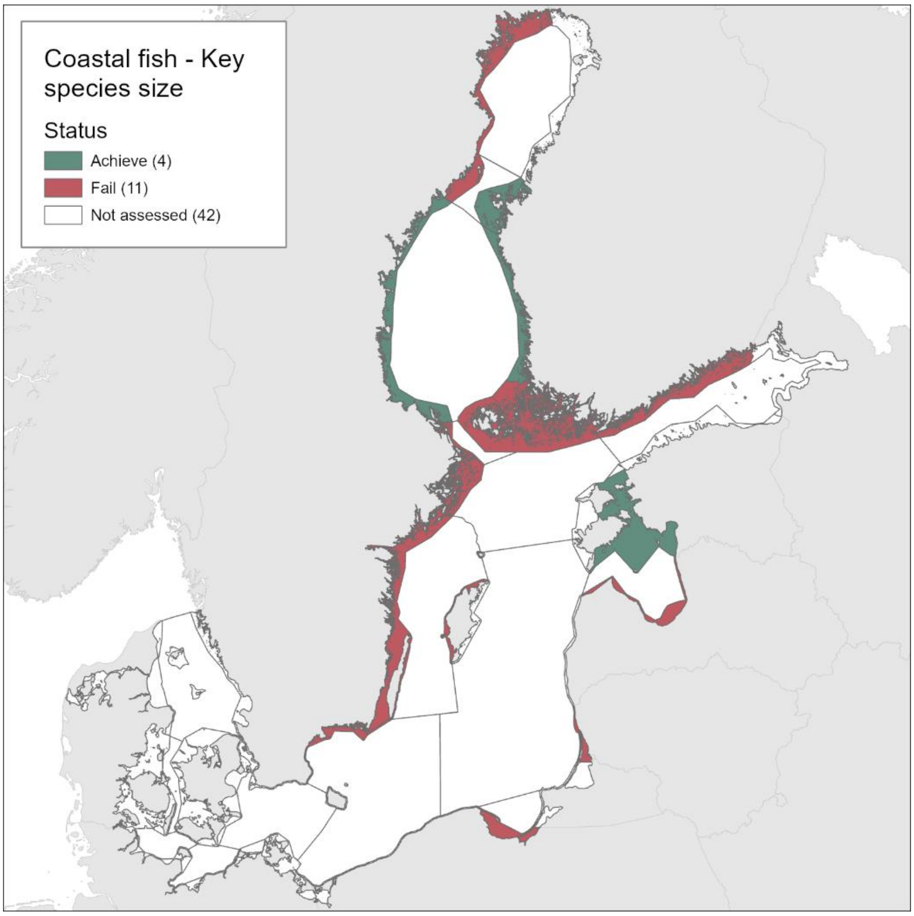


Figure 1. Status evaluation results based on the indicator 'Size structure of coastal fish'. The evaluation is carried out using Scale 3 HELCOM assessment units (defined in the HELCOM Monitoring and Assessment Strategy Annex 4). **See 'data chapter' for interactive maps and data at the HELCOM Map and Data Service.**

Good status is achieved in 14 out of the total 28 evaluated monitoring locations for perch. Status was not evaluated in relation to a threshold for flounder and pikeperch, but flounder showed stable L90-values over time in 11 out of the in total 12 evaluated monitoring locations, with one area showing an increasing trend over time. Pikeperch showed stable values over time in 2 out of 3 evaluated monitoring locations, with one area showing an increasing trend over time. Integration of the results for perch over HELCOM assessment units using the One-Out-All-Out principle, showed that good status is achieved in only 4 out of 15 evaluated units. Good status is achieved in the Finnish coastal waters of the Quark, in the Bothnian Sea, and in the Estonian coastal waters of the Gulf of Riga.

The indicator is operational in the coastal waters of most countries bordering the Baltic Sea, except Denmark, Germany, and Russia. For the time being, it is not applicable in some areas where coastal fish monitoring data are scarce and further studies as well as time series are needed to yield a reliable evaluation of these areas. In the future, in line with increasing knowledge, the indicator might undergo further development, specifically thresholds for determining good environmental status may be developed for flounder, pikeperch, and other key species in the coastal area.

1.1 Citation

The data and resulting data products (e.g. tables, figures and maps) available on the indicator web page can be used freely given that it is used appropriately and the source is cited. The indicator should be cited as follows:

HELCOM (2023). Size structure of coastal fish (Coastal fish size). HELCOM core indicator report. Online. [Date Viewed], [Web link].

ISSN 2343-2543.

2 Relevance of the indicator

Coastal fish communities are of high ecological and socio-economic importance in the Baltic Sea, both for ecosystem functioning and for recreational and small-scale coastal commercial fishery activities. As such, the state of coastal fish communities generally reflects the ecological state in the coastal ecosystems.

Changes in the long-term development of the size structure of coastal fish species mainly reflects effects of changes in the level of human exploitation (fishing), natural predation pressure, eutrophication, and growth rates which in turn are influenced by temperature and food web structure.

2.1 Ecological relevance

Coastal fish, especially piscivorous species, are recognized as being important components of coastal food webs and ecosystem functioning (Eriksson *et al.* 2009; Baden *et al.* 2012; Olsson *et al.* 2012; Östman *et al.* 2016; Olsson 2019). Moreover, since many coastal fish species are rather local (Saulamo & Neuman 2005; Laikre *et al.* 2005; Olsson *et al.* 2011; Östman *et al.* 2017a), the temporal development of coastal fish communities might reflect the general environmental state in the monitoring locations (Bergström *et al.* 2016b; Östman *et al.* 2017b).

Large piscivores in coastal ecosystems, such as perch and pikeperch, generally have a structuring role in the ecosystem, mainly via top-down control on lower trophic levels (reviewed in Olsson 2019). Also, viable populations of key coastal fish species are generally considered to reflect an environmental status with few eutrophication symptoms and balanced food webs (Eriksson *et al.* 2011; Baden *et al.* 2012; Östman *et al.* 2016; Eklöf *et al.* 2020). In perch, the size distribution tends to decrease with increasing levels of eutrophication along the coast (Östman *et al.* in prep).

Large individuals of a population often contribute disproportionally to reproduction and are thus highly important for the sustainability of fish populations (Birkeland & Dayton 2005, Olin *et al.* 2012). Large piscivores such as perch and pikeperch, are targeted by both the small-scale coastal commercial fishery and by recreational fishing (Olsson *et al.* 2015; Bergström *et al.* 2016b), and the share of large perch in a population is affected by the fishing pressure in an area (Bergström *et al.* 2016a, Östman *et al.* in prep). In general, fishing can have a stronger effect on fish size structure than changes in temperature (Blanchard *et al.* 2005). Thus, the size distribution of a population gives an indication both regarding the fishing pressure in the area as well as the state of the coastal ecosystem.

2.2 Policy relevance

The core indicator is relevant to the following specific 2021 Baltic Sea Action Plan actions:

- B15: Develop and coordinate monitoring and assessment methods, where ecologically relevant, for specified representative coastal fish species, populations and communities, by 2023. Based on these assessment methods, to regularly assess the state of the coastal fish community through selected coastal fish species and groups, including threatened species, by at latest 2023. Based on the results of the assessment, develop and implement management measures with the ambition to maintain or improve the status of coastal fish species, including migratory species by 2027. Cross-reference to actions in other segments.

- B35: By 2024 operationalize a set of indicators for the assessment of fish population health, including size and age distribution, where applicable, and, by 2029, for any remaining relevant species.

The core indicator also addresses the following qualitative descriptors of the MSFD for determining good environmental status:

Descriptor 1: 'Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions'

Descriptor 3: 'Populations of commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock'

and the following criteria of the Commission Decision:

- Criterion D1C3 (population demographic characteristics of the species),
- Criterion D3C3 (the age and size distribution of individuals in the population).

In some Contracting Parties the indicator also has potential relevance for implementation of the EU Habitats Directive.

The indicator supports the UN Sustainable Development Goal 14: Conserve and sustainably use the oceans, sea and marine resources for sustainable development.

An overview is provided in Table 1.

Table 1. Policy relevance of this specific HELCOM indicator.

	Baltic Sea Action Plan (BSAP)	**Marine Strategy Framework Directive (MSFD)**
Fundamental link	Segment: Biodiversity Goal: “Baltic Sea ecosystem is healthy and resilient” • Ecological objectives: “Viable populations of all native species “, “Natural distribution, occurrence and quality of habitats and associated communities”, “Functional, healthy and resilient food webs”. • Management objective: “Minimize disturbance of species, their	Descriptor 1 'Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions' • Criterion 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. • Feature – Species groups.

<table>
<tr><td></td><td>habitats and migration routes from human activities”; “Effective and coordinated conservation plans and measures for threatened species, habitats, biotopes, and biotope complexes”.</td><td>Element of the feature assessed – Coastal fish species.
Descriptor 3 'Populations of commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock'
Criterion D3C3: the age and size distribution of individuals in the population.
Feature – Species groups.
Element of the feature assessed – Coastal fish species.</td></tr>
<tr><td>Complementary link</td><td>Segment: Eutrophication

Goal: “Baltic Sea unaffected by eutrophication”
Ecological objective: “Natural distribution and occurrence of plants and animals”.
Management objective: “Minimize inputs of nutrients from human activities”.
Segment: Sea-based activities

Goal: “Environmentally sustainable sea-based activities”
Ecological objective: “No or minimal disturbance to biodiversity and the ecosystem”,
Management objective:, “Minimize the input of nutrients, hazardous substances and litter from sea-based activities”, “Ensure sustainable use of the marine resources”.</td><td>Descriptor 1 'Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions'
Criterion D1C2: 2 The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured.
Feature – Species groups.
Element of the feature assessed – Coastal fish species.
Descriptor 4 Ecosystems, including food webs
Criterion D4C4: Productivity of the trophic guild is not adversely affected due to anthropogenic pressures.
Feature – Coastal ecosystems.
Element of the feature assessed – Trophic guilds.</td></tr>
<tr><td>Other relevant legislation:</td><td colspan="2">EU Birds Directive (migrating species Article 4 (2); barnacle goose, pied avocet, Mediterranean gull, Caspian tern, sandwich tern, common tern, Arctic tern, little tern listed in Annex I)

Birds Directive Article 12 report, parameter "Population trend"; Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA);

UN Sustainable Development Goal 14.</td></tr>
</table>

2.3 Relevance for other assessments

The status of biodiversity is assessed using several core indicators. Each indicator focuses on one important aspect of the complex issue. In addition to providing an indicator-based evaluation of the size structure of key coastal fish species, this indicator also contributes to the overall biodiversity assessment along with the other biodiversity core indicators. The results on perch are utilised in the integrated assessments via the BEAT tool.

3 Threshold values

Good Status is achieved when key species size distribution (in this case represented by the indicator L90) is above a specified threshold value (Figure 2). The threshold approach is implemented for perch. For flounder and pikeperch, trends over time for L90 are visualised.

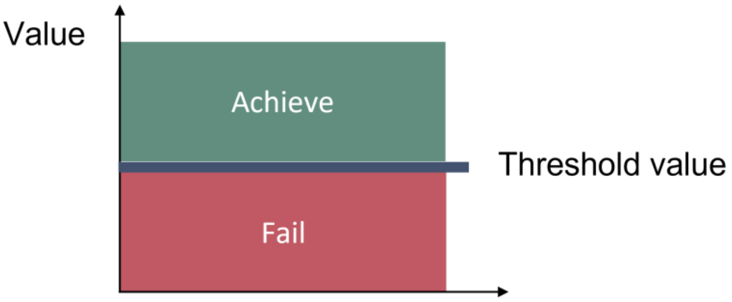


Figure 2: Schematic representation of the threshold value applied in the 'coastal fish size distribution core indicator.

The 90th percentile of the size distribution (L90) is used as an indicator of the size structure of large fish in the stock. Before calculating L90, a lower cut-off of 15 cm is applied to lower the influence on the indicator value from yearly fluctuations in recruitment. For perch, the fish in each monitoring location are evaluated in relation to a gear-specific threshold of 25 cm for Nordic multimesh nets and fyke nets, and 23 cm for net series. The median of the L90-values during the assessment period is evaluated in relation to this threshold to determine whether the stock is in good status or not. Perch is evaluated along the coasts of the central and northern parts of the Baltic Sea down to its more southern and western areas. Flounder and pikeperch are not evaluated in relation to a threshold, and therefore no quantitative status evaluation is made. Changes in L90 over time in flounder and pikeperch are instead evaluated according to a trend-based approach, with a linear regression for year 2014-2020 and the significance threshold set to $p<0.1$. Flounder is evaluated in the southern and central parts of the Baltic Sea and pikeperch is assess in Finnish waters.

3.1 Setting the threshold value(s)

Gear specific threshold values for good status are implemented for perch. The thresholds were arrived at by analysing data on perch size distributions from 33 monitoring locations throughout the Baltic Sea coasts, using time series data of varying length from each location, ending at the year 2020 and with the longest time series starting in 1978 (Bolund *et al.* in prep). The data was composed of annual survey data from Sweden, Estonia, Latvia, Lithuania, and Poland, and a combination of annual monitoring data and commercially collected data from Finland that fulfilled minimum data criteria (namely, a minimum of 50 measured individuals per year per location, and a minimum of six years of data from each location). After accounting for the effects of gears, seasons, regions, and time on L90 in a linear mixed-effects model framework, the mean L90 value was set as the threshold (Bolund *et al.* in prep). There was relatively low amount of variation in L90 across regions and seasons, and also over time, but significant differences in the size distribution due to gears used necessitated gear-specific thresholds of 23 cm for net series and 25 cm for Nordic multimesh nets and fyke nets. The data used to map size structure of perch likely reflects a situation where the populations are not overfished (i.e. we see no strong negative trends over time), but still exploited at a level that the size structure is impacted.

It is challenging setting a regional threshold value for L90 in flounder. This is because of substantial differences in L90 among regions, gears, seasons and ecotypes, and often there is a combination of these factors in different areas (Bolund *et al.* in prep). Therefore, trends over time in L90 for flounder are addressed in the different monitoring areas during the past 12 years (i.e. two MSFD management cycles). For pikeperch, data from commercial fisheries in Finland provide sample sizes that allow estimation of L90 and evaluation of trends over time. The limited data on pikeperch however does not allow a formal analysis of threshold values.

4 Results and discussion

4.1 Status evaluation

The current evaluation of environmental status using coastal fish covers the period 2016-2020. The evaluation is based on time-series data of varying length depending on the temporal coverage of data collection in each monitoring location. Time-series starts between the years 1998 and 2018 (Table 2). Evaluations of status in relation to a threshold for L90 in perch were carried out for 15 of the in total 42 HELCOM scale 3 assessment units, and time-series data up to and including the year 2020 were available for all 15 of these units. Evaluations of trends in size distribution over time were carried out in flounder for 12 and for pikeperch three of the scale 3 assessment units. As data on flounder is unique for two assessment units (Eastern Gotland Basin Latvian Coastal waters and Eastern Gotland Basin Swedish Coastal waters), in total 17 assessment units were considered for the size structure of coastal key fish species. For more information on assessment units, see HELCOM Monitoring and Assessment Strategy Annex 4 .

Good status is achieved for L90 in perch in half of the monitoring locations (14 out of 28 locations, Figure 3), indicating a moderate overall environmental status. There is substantial variation in L90 on small geographical scales. More northern parts of the Baltic Sea do, however, tend to have a better status, but a couple of monitoring locations in the Bothnian Bay and the Quark do not meet the threshold values whereas a few locations in the southern parts of the Baltic Sea meet the threshold. This substantial spatial variation in the status across coastal areas suggests that the role of local (for example fishing) more than regional (for example eutrophication and climate) factors are of importance for explaining the observed variation in the status of the indicator. When summarising over HELCOM assessment units, good status is achieved in only 4 out of 15 evaluated units, indicating an overall poor environmental status regarding perch size distribution in the Baltic Sea when aggregated on larger spatial scales. The indicator L90 meets the threshold value only in the Bothnian Sea (both Sweden and Finland), the Quark in Finland, and in the Gulf of Riga in Estonia.

Status was not evaluated in relation to a threshold for flounder and pikeperch. Flounder showed substantial variation between monitoring locations in L90, with values between 23 and 31, indicating regional differences in the size distribution of flounder. However, L90-values were stable over time in 11 out of the in total 12 evaluated monitoring locations, with one area showing an increasing trend over time (Karklė, Lithuania). Similarly, pikeperch showed stable values over time in 2 out of 3 evaluated monitoring locations, with the third area showing an increasing trend over time (Finnish ICES SD 32). Thus, the more limited data on flounder and pikeperch suggests that the proportion of large fish in general tends to be rather stable over time.

Table 2. Status evaluation outcome per monitoring location and assessment unit for the assessment period 2016-2020. GS = good status, nGS = not good status. The current value is shown for perch. For flounder and pikeperch, the current value with accompanying direction of trend is shown (+: increasing, s: stable, -: decreasing).

Sub-basin	Country	Coastal area name (assessment unit)	Coastal area code	Monitoring area	Time period assesed	L90 key species	Monitoring method	Assessment method	Threhold value	Current value (trend)	status, monitoring location	Status, assessment unit
Bothnian Bay	Finland	Bothnian Bay Finnish Coastal waters	1	NA	NA	NA	Commercial statistics	NA	NA	NA	NA	NA
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Råneå	2002-2020	Perch	Fisheries independent data	THV	25	28	GS	
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Kinnbäcksfjärden	2004-2020	Perch	Fisheries independent data	THV	25	23	nGS	nGS
The Quark	Finland	The Quark Finnish Coastal waters	3	Finnish ICES rect 23	2017-2019	Perch	Commercial statistics	THV	25	29	GS	GS
The Quark	Sweden	The Quark Swedish Coastal waters	4	Holmön	2002-2020	Perch	Fisheries independent data	THV	25	27	GS	
The Quark	Sweden	The Quark Swedish Coastal waters	4	Norrbyn	2002-2020	Perch	Fisheries independent data	THV	25	23	nGS	nGS
Bothnian Sea	Finland	Bothnian Sea Finnish Coastal waters	5	Finnish ICES SD 30	2010-2020	Perch	Commercial statistics	THV	25	29	GS	GS
Bothnian Sea	Finland	Bothnian Sea Finnish Coastal waters	5	Finnish ICES SD 30	2010-2020	Pikeperch	Commercial statistics	Trend	NA	42(s)	NA	NA
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Gaviksfjärden	2004-2020	Perch	Fisheries independent data	THV	25	26	GS	
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Långvindsfjärden	2002-2020	Perch	Fisheries independent data	THV	25	27	GS	
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Forsmark	2002-2020	Perch	Fisheries independent data	THV	25	26	GS	GS
Åland Sea	Finland	Åland Sea Finnish Coastal waters	7	NA	NA	NA	NA	NA	NA	NA	NA	NA
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Galtfjärden	2002-2020	Perch	Fisheries independent data	THV	25	23	nGS	
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Lagnö	2002-2020	Perch	Fisheries independent data	THV	25	23	nGS	nGS
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finbo	2002-2020	Perch	Fisheries independent data	THV	25	28	GS	
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Kumlinge	2003-2020	Perch	Fisheries independent data	THV	25	24	nGS	
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finnish ICES SD 29	2010-2020	Perch	Commercial statistics	THV	25	30	GS	nGS
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finnish ICES SD 29	2010-2020	Pikeperch	Commercial statistics	Trend	NA	43(s)	NA	NA
Northern Baltic Sea	Finland	Northern Baltic Proper Finnish Coastal waters	10	NA	NA	NA	NA	NA	NA	NA	NA	
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Vaxholm: Askrikefjärden	2016-2020	Perch	Fisheries independent data	THV	25	28.5	GS	
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Askö	2005-2020	Perch	Fisheries independent data	THV	25	23	nGS	nGS
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Muskö	1992-2020	Flounder	Fisheries independent data	Trend	NA	23.5(s)	NA	NA
Northern Baltic Sea	Estonia	Northern Baltic Proper Estonian Coastal waters	12	NA	NA	NA	NA	NA	NA	NA	NA	
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Brunskär	2002-2020	Perch	Fisheries independent data	THV	25	21	nGS	
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Tvärminne	2005-2020	Perch	Fisheries independent data	THV	25	22	nGS	
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Helsinki	2005-2020	Perch	Fisheries independent data	THV	25	26	GS	nGS
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Finnish ICES SD 32	2010-2020	Pikeperch	Commercial statistics	Trend	NA	50(+)	NA	NA
Gulf of Finland	Estonia	Gulf of Finland Estonian Coastal waters	14	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Finland	Russia	Gulf of Finland Russian Coastal waters	15	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Riga	Estonia	Gulf of Riga Estonian Coastal waters	16	Hiiumaa	1998-2020	Perch	Fisheries independent data	THV	23	24	GS	GS
Gulf of Riga	Latvia	Gulf of Riga Latvian Coastal waters	17	Daugavgriva	2016-2020	Perch	Fisheries independent data	THV	25	20	nGS	nGS
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, summer	2002-2020	Perch	Fisheries independent data	THV	25	27	GS	
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, autumn	1989-2020	Flounder	Fisheries independent data	Trend	NA	27.5(s)	NA	NA
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Vinö	2007-2020	Perch	Fisheries independent data	THV	23	22	nGS	nGS
Eastern Gotland Basin	Estonia	Eastern Gotland Basin Estonian Coastal waters	19	NA	NA	NA	NA	NA	NA	NA	NA	NA
Eastern Gotland Basin	Latvia	Eastern Gotland Basin Latvian Coastal waters	20	Jurkalne	2016-2020	Flounder	Fisheries independent data	Trend	NA	29(s)	NA	NA
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Mon/But	1998-2020	Flounder	Fisheries independent data	Trend	NA	26(s)	NA	NA
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Šventoji	2006-2020	Flounder	Fisheries independent data	Trend	NA	30(s)	NA	NA
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Karklė	2006-2020	Flounder	Fisheries independent data	Trend	NA	31.2(+)	NA	NA
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Smiltynė	2006-2020	Flounder	Fisheries independent data	Trend	NA	31(s)	NA	NA
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Curonian lagoon	1998-2020	Perch	Fisheries independent data	THV	23	22	nGS	nGS
Eastern Gotland Basin	Sweden	Eastern Gotland Basin Swedish Coastal waters	22	Herrvik	2018-2020	Flounder	Fisheries independent data	Trend	NA	28(s)	NA	NA
Eastern Gotland Basin	Russian	Eastern Gotland Basin Russian Coastal waters	23	NA	NA	NA	NA	NA	NA	NA	NA	NA
Eastern Gotland Basin	Poland	Eastern Gotland Basin Polish Coastal waters	24	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gdansk Basin	Russia	Gdansk Basin Russian Coastal waters	25	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zatoka Pucka Zewnętrzna	2014-2020	Perch	Fisheries independent data	THV	25	22	nGS	
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zatoka Pucka Zewnętrzna	2014-2020	Flounder	Fisheries independent data	Trend	NA	24(s)	NA	NA
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Pucki	2014-2020	Perch	Fisheries independent data	THV	25	22	nGS	
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Pucki	2014-2020	Flounder	Fisheries independent data	Trend	NA	29(s)	NA	NA
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Wiślany	2014-2020	Perch	Fisheries independent data	THV	25	26	GS	nGS
Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Torhamn	2002-2020	Perch	Fisheries independent data	THV	25	24	nGS	nGS
Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Hanöbukten	2015-2020	Flounder	Fisheries independent data	Trend	NA	30(s)	NA	NA
Bornholm Basin	Poland	Bornholm Basin Polish Coastal waters	28	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bornholm Basin	Denmark	Bornholm Basin Danish Coastal waters	29	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bornholm Basin	Germany	Bornholm Basin German Coastal waters	30	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arkona Basin	Sweden	Arkona Basin Swedish Coastal waters	31	Stavstendsudde	2018-2020	Flounder	Fisheries independent data	Trend	NA	31(s)	NA	NA
Arkona Basin	Denmark	Arkona Basin Danish Coastal waters	32	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arkona Basin	Germany	Arkona Basin German Coastal waters	33	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mecklenburg Bight	Germany	Mecklenburg Bight German Coastal waters	34	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mecklenburg Bight	Denmark	Mecklenburg Bight Danish Coastal waters	35	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kiel Bight	Denmark	Kiel Bight Danish Coastal waters	36	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kiel Bight	Germany	Kiel Bight German Coastal waters	37	NA	NA	NA	NA	NA	NA	NA	NA	NA
Belt Sea	Denmark	Belts Danish Coastal waters	38	NA	NA	NA	NA	NA	NA	NA	NA	NA
The Sound	Sweden	The Sound Swedish Coastal waters	39	NA	NA	NA	NA	NA	NA	NA	NA	NA
The Sound	Denmark	The Sound Danish Coastal waters	40	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kattegat	Sweden	Kattegat Swedish Coastal waters, including Limfjorden	41	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	NA	NA	NA	NA	NA	NA	NA	NA	NA

In the Bothnian Bay, L90 was only evaluated for perch in Sweden. The status was good in one of the monitoring locations (Råneå) and poor in the other location evaluated (Kinnbäcksfjärden). In the Quark, the indicator is applied in both Swedish and Finnish coastal waters. The status was good in one Finnish and one Swedish monitoring location, but poor in the second Swedish monitoring location (Norrbyn). The overall status of coastal fish size distribution in the Swedish parts of the Bothnian Bay and the Quark is therefore poor, and good in the Finnish parts of the Quark.

In the Bothnian Sea, Åland Sea and Archipelago Sea, L90 is evaluated for perch in Sweden, and perch and pikeperch in Finland. The status was good in all four (Finnish and Swedish) evaluated monitoring locations in the Bothnian Sea, poor in both Swedish locations in the Åland Sea, and poor in one (perch in Kumlinge) of the three Finnish locations in the Archipelago Sea. This results in an overall good status in the Bothnian Sea, but poor status in Åland Sea and Archipelago Sea.

In the Northern Baltic Sea perch and flounder are included in the evaluation, and no evaluation is undertaken in Finland. The status of L90 perch is poor in one of the locations

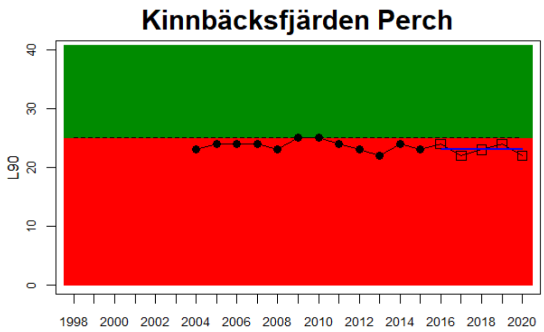
(Askö) and L90 flounder is stable in the monitoring location of Muskö, rendering an overall poor status of the assessment unit. In the Gulf of Finland, data is only available for Finnish coastal waters with three locations having data for perch and one for pikeperch. For perch the status is good in all but one (Helsinki) locations yielding an overall poor status of the assessment unit.

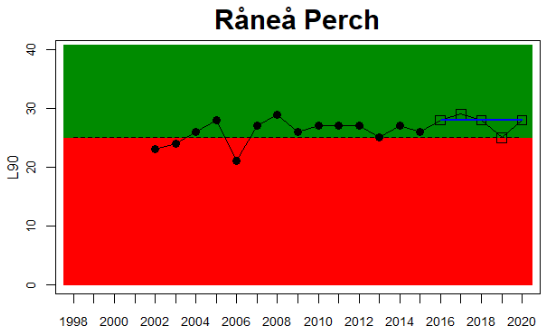
In the Gulf of Riga and Western Gotland Basin, perch and flounder (only in Sweden) is evaluated. There are differences in status across locations with about half the monitoring locations in each region showing good status. Besides for the Estonian waters, the One-Out-All-Out principle thus results in an overall poor status of coastal fish size distribution in these parts of the Baltic Sea.

In the more southern parts of the Baltic Sea, the Eastern Gotland Basin, Gdansk Basin, and the Bornholm Basin, both perch and flounder are included in the evaluation. The status is consistently poor for perch in all but one monitoring location (Zalew Wiślany, Poland), yielding an overall poor status in these assessment units.

Bothnian Bay

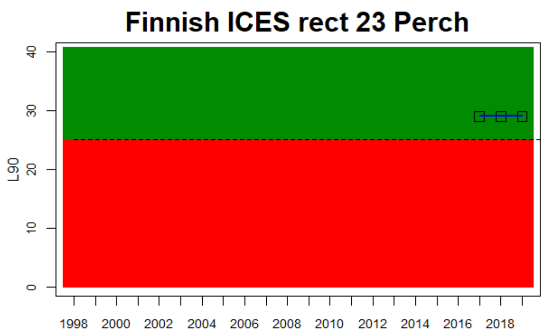
Sweden



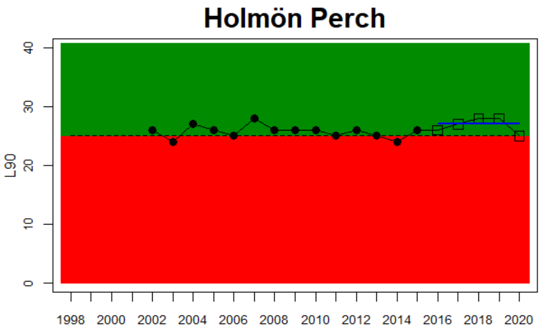


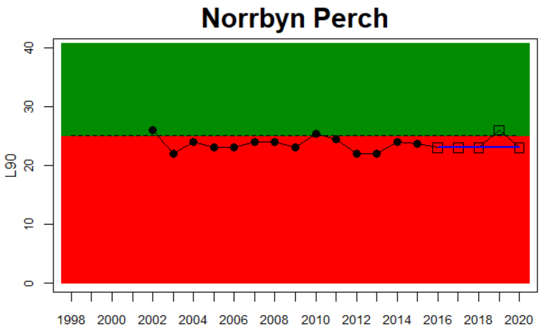
The Quark

Finland



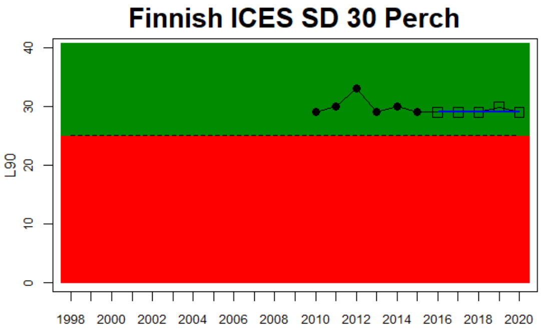
Sweden

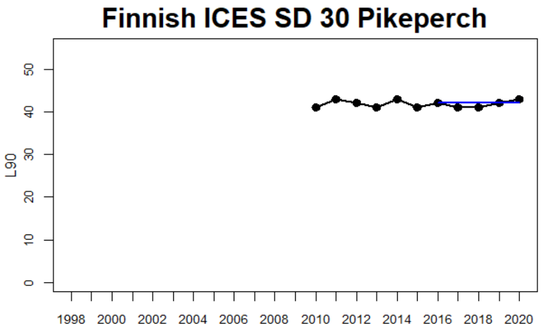




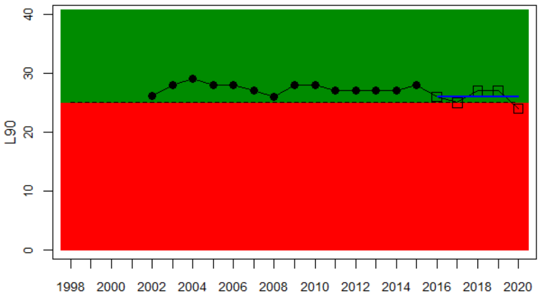
Bothnian Sea

Finland

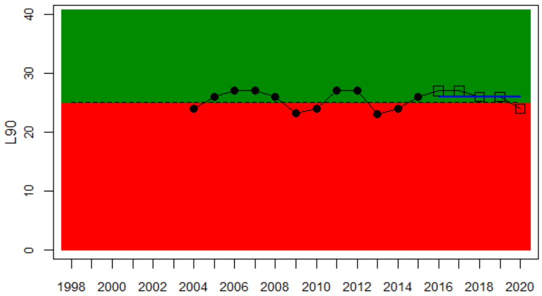




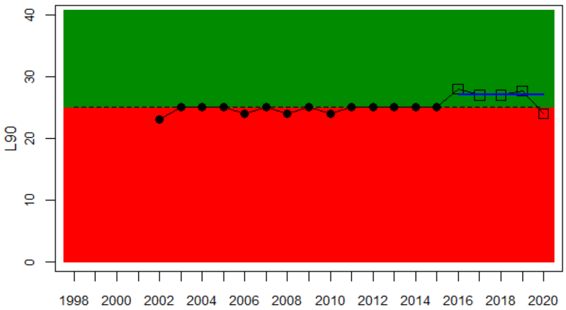
Sweden



Forsmark Perch



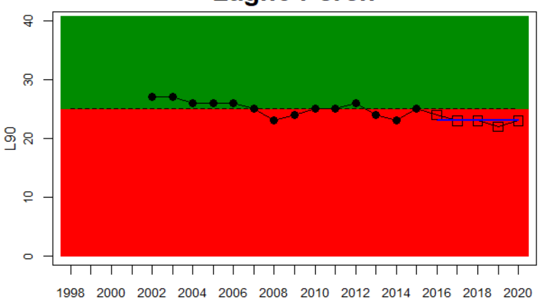
Gaviksfjärden Perch



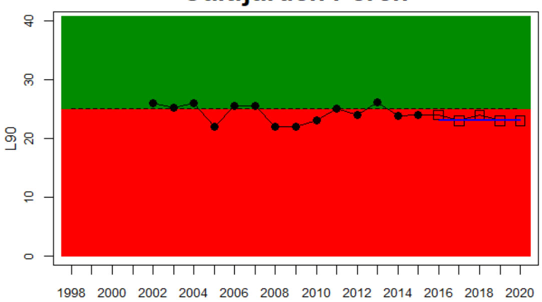
Långvindsfjärden Perch

Åland Sea

Sweden



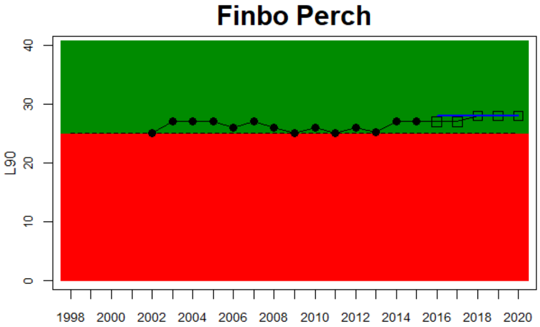
Lagnö Perch

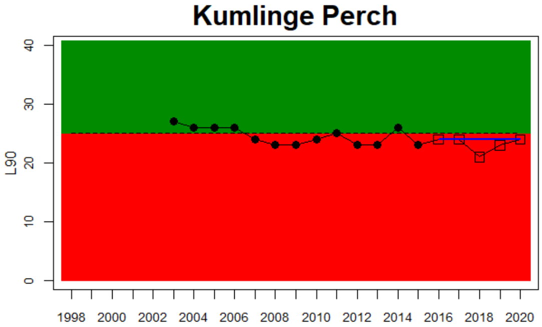


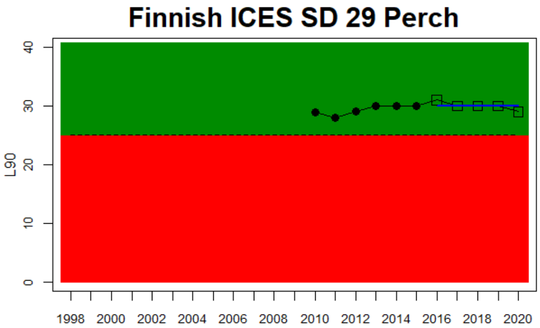
Galtfjärden Perch

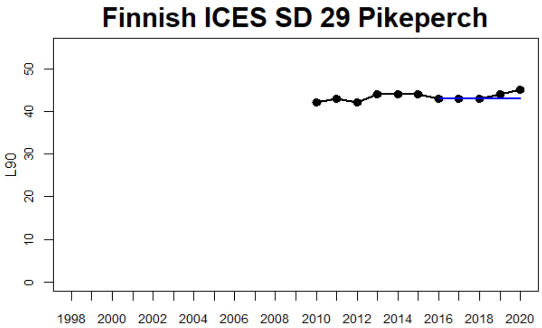
Archipelago Sea

Finland



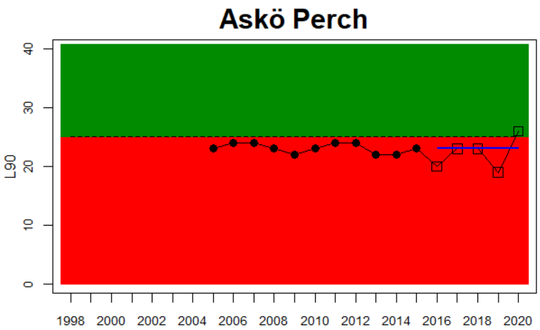


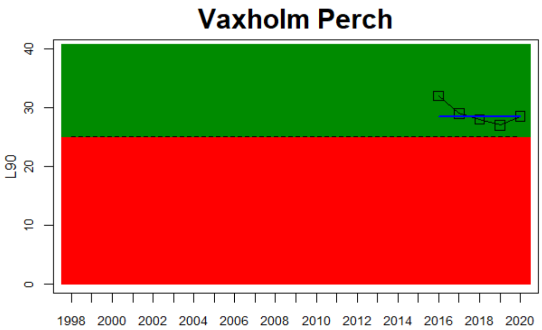


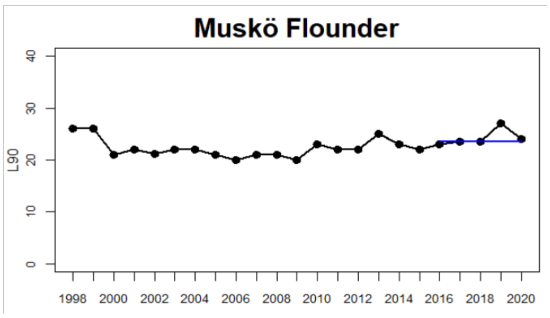


Northern Baltic Sea

Sweden

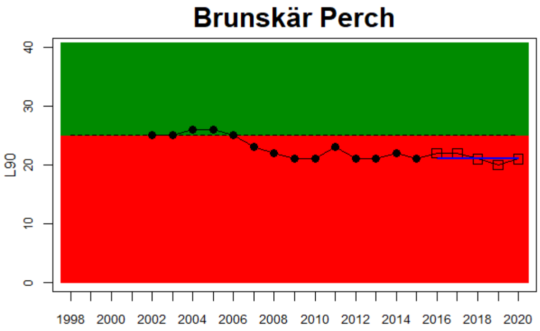


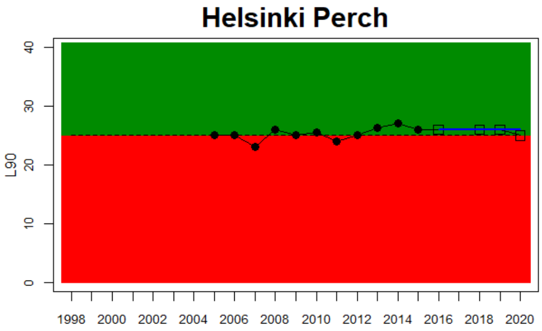


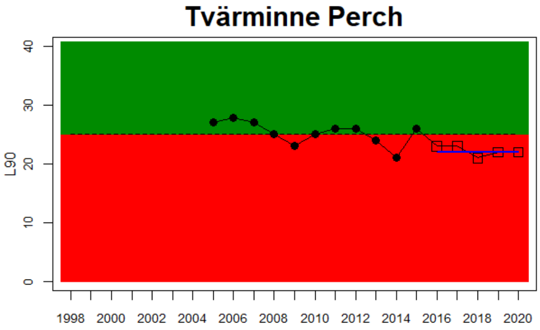


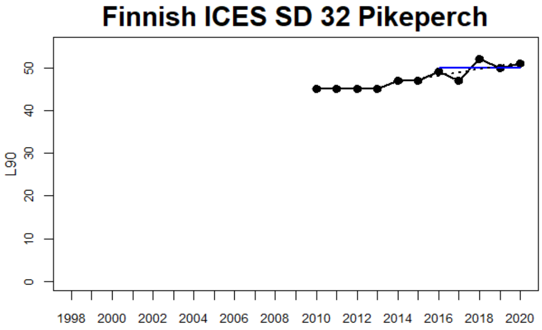
Gulf of Finland

Finland



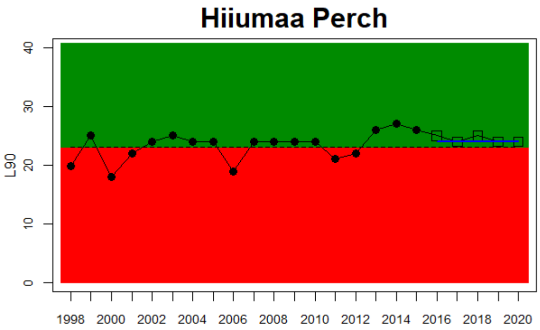




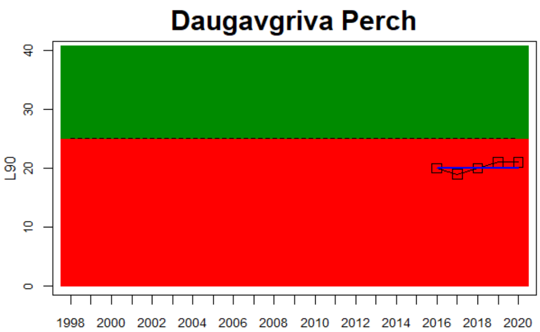


Gulf of Riga

Estonia

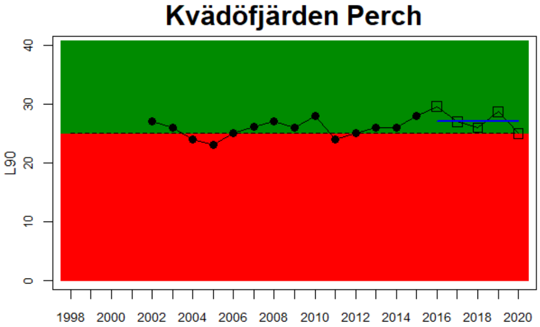


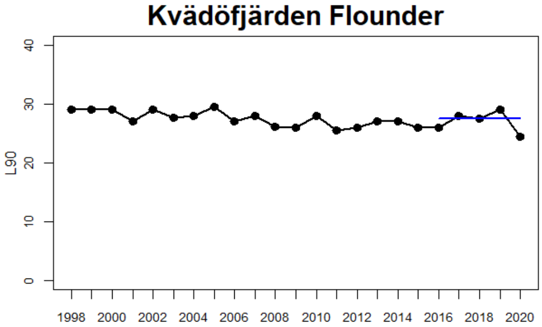
Latvia

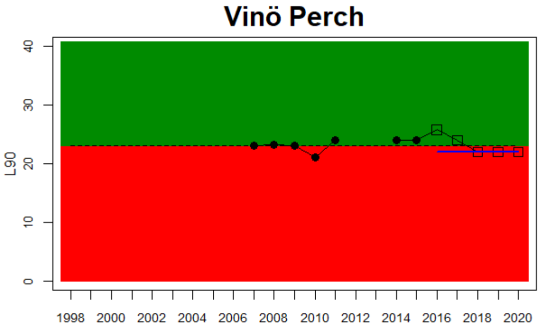


Western Gotland Basin

Sweden

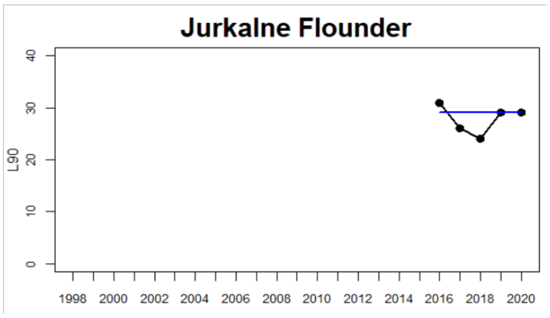




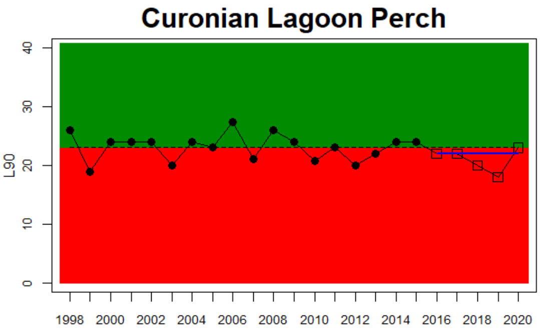


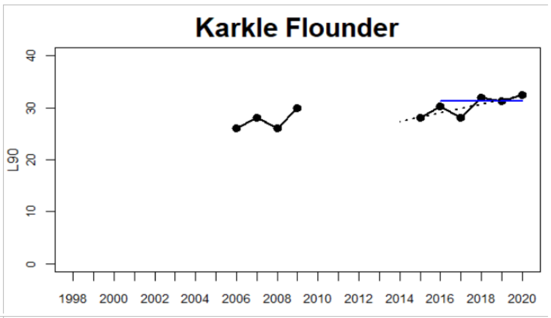
Eastern Gotland Basin

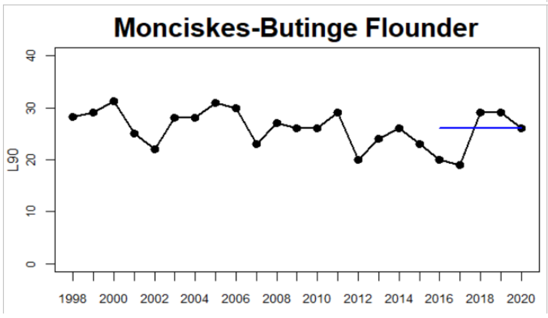
Latvia

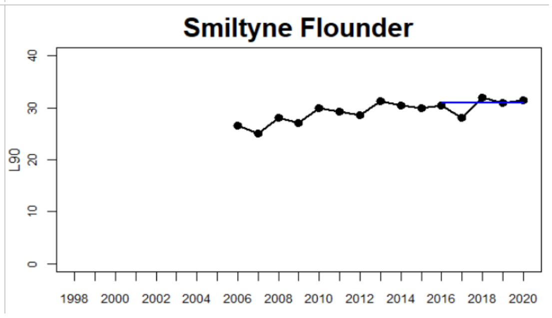


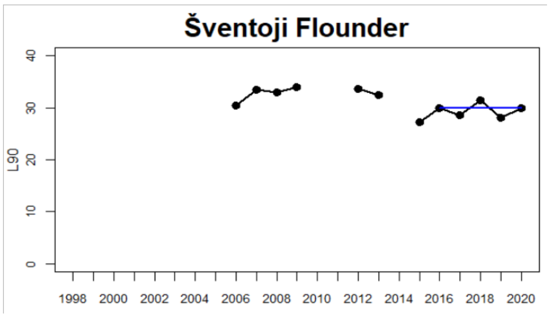
Lithuania



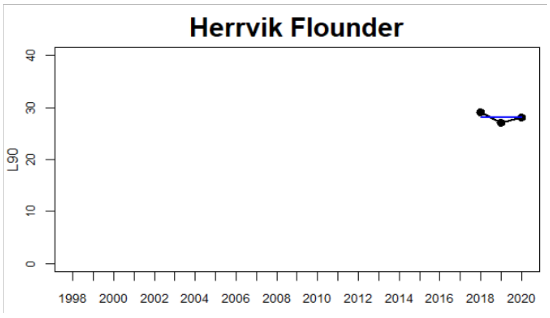






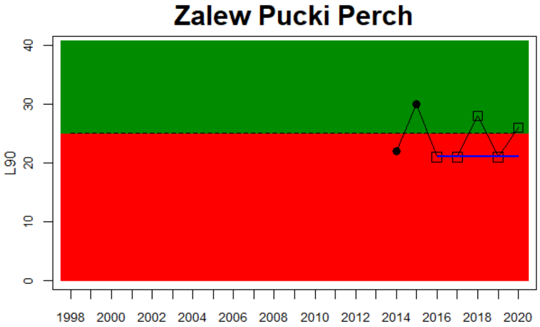


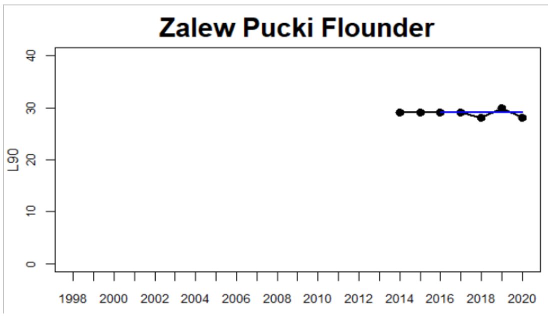
Sweden

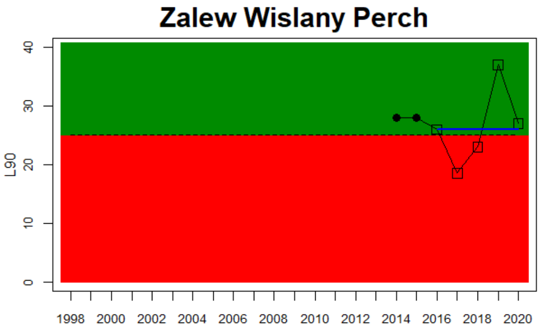


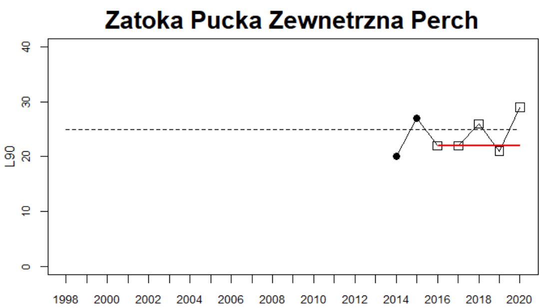
Gdansk Basin

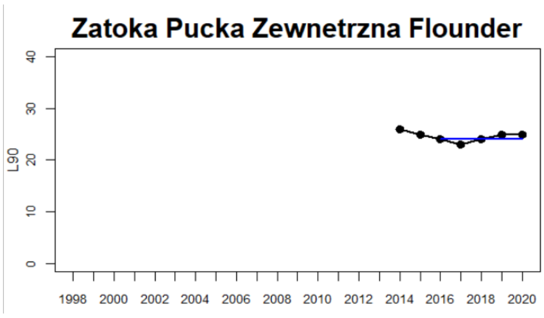
Poland





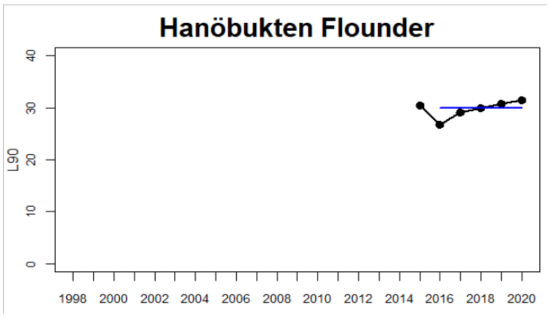


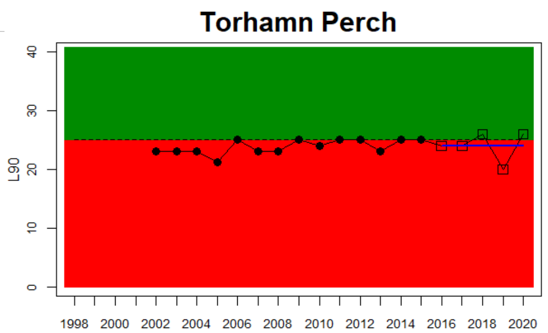




Bornholm Basin

Sweden





Arkona Basin

Sweden

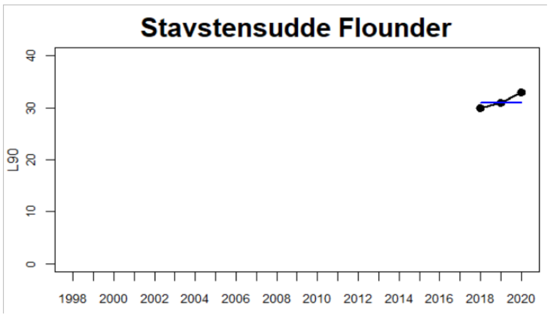


Figure 3. Status evaluations are displayed per sub-basin for each monitoring location. For perch, the gear-specific threshold value is displayed by a black dotted line between fields of green (good status) and red (not good status). The results preceding the assessment period are displayed with filled circles and the results during the assessment period with empty squares with the median displayed as a blue line. For flounder and pikeperch, trends over time are shown with the median during the assessment period marked by a blue line, and the hatched black trend-line indicates a significant positive or negative linear trend at p < 0.1 during 2014-2020 for the times-series in each location.

4.2 Trends

The size distribution of coastal fish was not included in the previous status evaluation, HOLAS II. Available data dating back to the late 1990s and early 2000s do, however, suggest that L90 in perch have been rather stable over time with no strong temporal trends (Bolund *et al.* in prep; Figure 3). L90 in flounder and pikeperch have likewise tended to remain stable over time in terms of L90 in most monitoring locations (Bolund *et al.* in prep; Figure 3). Despite that no previous evaluation has been undertaken, this lack of consistent regional trends over time indicates that there does not seem to be a general worsening of the situation regarding size distribution of key species in the Baltic Sea. However, current data only allows for an evaluation of three species with a rather limited spatial coverage. Moreover, L90 in perch did not meet the threshold for good environmental status in 11 out of 15 HELCOM assessment units (Table 3), suggesting that the environmental status in terms of L90 for perch in the Baltic Sea is consistently not good in the majority of evaluated coastal areas.

4.3 Discussion text

In conclusion, the overall environmental status of coastal fish size distribution is poor, when summarising the results over the 15 HELCOM assessment units that allow an evaluation of status against a threshold in perch. Good status is achieved in only 4 of the 15 evaluated units (Table 3). There were often pronounced differences in environmental status between different monitoring locations within the same assessment unit, indicating that local factors are important for the size structure of perch (Table 4). A poor status of the size distribution can have negative consequences for both the ecosystem functioning and for the availability of large fish for commercial and recreational fisheries. Local variation in L90 may reflect variation in fishing pressure (selectively removing large individuals), eutrophication (affecting growth rates), and predation by apex predators, but more information is needed to disentangle the relative importance of these effects. L90 does appear to be stable over time in perch, as well as in flounder and pikeperch, indicating that the size structure of key coastal fish species is not deteriorating further over time in the Baltic Sea.

Table 3. Perch size structure status integrated over HELCOM assessment units. Shown is the accumulated number of monitoring areas within each assessment unit that achieves or fails to achieve good environmental status, and the integrated status over the coastal area using the BEAT tool with the One-Out-All-Out principle, GS = good status, nGS = not good status.

HELCOM assessment unit	achieve /fail	Status, coastal area
Archipelago Sea Coastal waters	2/1	nGS
Bornholm Basin Swedish Coastal waters	0/1	nGS
Bothnian Bay Swedish Coastal waters	1/1	nGS
Bothnian Sea Finnish Coastal waters	1/0	GS
Bothnian Sea Swedish Coastal waters	3/1	GS
Eastern Gotland Basin Lithuanian Coastal waters	0/1	nGS
Gdansk Basin Polish Coastal waters	1/2	nGS
Gulf of Finland Finnish Coastal waters	1/2	nGS
Gulf of Riga Estonian Coastal waters	1/0	GS
Gulf of Riga Latvian Coastal waters	0/1	nGS
Northern Baltic Proper Swedish Coastal waters	1/1	nGS
The Quark Finnish Coastal waters	1/0	GS
The Quark Swedish Coastal waters	1/1	nGS
Western Gotland Basin Swedish Coastal waters	1/1	nGS
Åland Sea Swedish Coastal waters	0/1	nGS

5 Confidence

In general, the confidence varies across assessment units, countries and monitoring programmes since, for example, the number of years for which coastal fish monitoring has been carried out varies between locations, as does the spatial coverage of monitoring within assessment units, and thus the confidence in the actual evaluation. Generally, the confidence of the evaluation is higher in locations where data is available for the full assessment period (2016-2020), and where there is good spatial coverage of monitoring, and where the monitoring is fisheries independent and targeting the focal species of the evaluation.

The confidence scoring followed the principles as outlined in the HELCOM integrated biodiversity assessment. Confidence was scored using four criteria with three different levels (1= high, 0.5 = intermediate, and 0 = low). The criteria used were:

Confidence in the accuracy of the estimate (ConfA). Confidence in the evaluation is determined by the number of years during the assessment period that falls above or below the median. If all values fall either below or above the median, the confidence is high. If all values except one fall above/below the median, the confidence is medium, and if all values except two fall above/below, the confidence is low.

Confidence in the temporal coverage of evaluation (ConfT). Level 1 = data for all years during 2016-2020, 0.5 = one or two years of data missing during 2016-2020, and 0 = three or more years of data missing during 2016-2020.

Confidence in spatial representability of the evaluation (ConfS). Level = 1 full coverage/several monitoring locations per assessment unit given its size, 0.5 = two or more monitoring locations per assessment unit, and 0 = one monitoring location per assessment unit.

Methodological confidence (ConfM). For coastal fish all assessment units reach level 1 since all monitoring programs included in the evaluation are described in the coastal fish monitoring guidelines .

Table 4. Confidence in the status evaluation according to the criteria developed within HELCOM for the integrated biodiversity assessment.

Sub-basin	Country	Coastal area name (assessment unit)	Coastal area code	Monitoring area	Time period assesed	L90 key species	Monitoring method	Assessment method	ConfA	ConfT	ConfS	ConfM
Bothnian Bay	Finland	Bothnian Bay Finnish Coastal waters	1	NA	NA	NA	Commercial statistics	NA	NA	NA	NA	NA
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Råneå	2002-2020	Perch	Fisheries independent data	THV	0.5	1	0.5	1
Bothnian Bay	Sweden	Bothnian Bay Swedish Coastal waters	2	Kinnbäcksfjärden	2004-2020	Perch	Fisheries independent data	THV	1	1	0.5	1
The Quark	Finland	The Quark Finnish Coastal waters	3	Finnish ICES rect 23	2017-2019	Perch	Commercial statistics	THV	1	0.5	0.5	1
The Quark	Sweden	The Quark Swedish Coastal waters	4	Holmön	2002-2020	Perch	Fisheries independent data	THV	0.5	1	0.5	1
The Quark	Sweden	The Quark Swedish Coastal waters	4	Norrbyn	2002-2020	Perch	Fisheries independent data	THV	0.5	1	0.5	1
Bothnian Sea	Finland	Bothnian Sea Finnish Coastal waters	5	Finnish ICES SD 30	2010-2020	Perch	Commercial statistics	THV	1	1	1	1
Bothnian Sea	Finland	Bothnian Sea Finnish Coastal waters	5	Finnish ICES SD 30	2010-2020	Pikeperch	Commercial statistics	Trend	NA	1	1	1
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Gaviksfjärden	2004-2020	Perch	Fisheries independent data	THV	0.5	1	0.5	1
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Långvindsfjärden	2002-2020	Perch	Fisheries independent data	THV	0.5	1	0.5	1
Bothnian Sea	Sweden	Bothnian Sea Swedish Coastal waters	6	Forsmark	2002-2020	Perch	Fisheries independent data	THV	0	1	0.5	1
Åland Sea	Finland	Åland Sea Finnish Coastal waters	7	NA	NA	NA	NA	NA	NA	NA	NA	NA
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Galtfjärden	2002-2020	Perch	Fisheries independent data	THV	1	1	0.5	1
Åland Sea	Sweden	Åland Sea Swedish Coastal waters	8	Lagnö	2002-2020	Perch	Fisheries independent data	THV	1	1	0	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finbo	2002-2020	Perch	Fisheries independent data	THV	1	1	1	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Kumlinge	2003-2020	Perch	Fisheries independent data	THV	1	1	1	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finnish ICES SD 29	2010-2020	Perch	Commercial statistics	THV	1	1	1	1
Archipelago Sea	Finland	Archipelago Sea Coastal waters	9	Finnish ICES SD 29	2010-2020	Pikeperch	Commercial statistics	Trend	NA	NA	NA	NA
Northern Baltic Sea	Finland	Northern Baltic Proper Finnish Coastal waters	10	NA	NA	NA	NA	NA	NA	NA	NA	NA
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Vaxholm: Askrikefjärden	2016-2020	Perch	Fisheries independent data	THV	1	1	1	1
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Askö	2005-2020	Perch	Fisheries independent data	THV	0.5	1	1	1
Northern Baltic Sea	Sweden	Northern Baltic Proper Swedish Coastal waters	11	Muskö	1992-2020	Flounder	Fisheries independent data	Trend	NA	1	1	1
Northern Baltic Sea	Estonia	Northern Baltic Proper Estonian Coastal waters	12	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Brunskär	2002-2020	Perch	Fisheries independent data	THV	1	1	1	1
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Tvärminne	2005-2020	Perch	Fisheries independent data	THV	1	1	1	1
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Helsinki	2005-2020	Perch	Fisheries independent data	THV	0.5	0.5	1	1
Gulf of Finland	Finland	Gulf of Finland Finnish Coastal waters	13	Finnish ICES SD 32	2010-2020	Pikeperch	Commercial statistics	Trend	NA	1	1	1
Gulf of Finland	Estonia	Gulf of Finland Estonian Coastal waters	14	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Finland	Russia	Gulf of Finland Russian Coastal waters	15	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulf of Riga	Estonia	Gulf of Riga Estonian Coastal waters	16	Hiiumaa	1998-2020	Perch	Fisheries independent data	THV	1	1	0	1
Gulf of Riga	Latvia	Gulf of Riga Latvian Coastal waters	17	Daugavgriva	2016-2020	Perch	Fisheries independent data	THV	1	1	0	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, summer	2002-2020	Perch	Fisheries independent data	THV	0.5	1	0.5	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Kvädöfjärden, autumn	1989-2020	Flounder	Fisheries independent data	Trend	NA	1	0.5	1
Western Gotland Basin	Sweden	Western Gotland Basin Swedish Coastal waters	18	Vinö	2007-2020	Perch	Fisheries independent data	THV	0	1	0.5	1
Eastern Gotland Basin	Estonia	Eastern Gotland Basin Estonian Coastal waters	19	NA	NA	NA	NA	NA	NA	NA	NA	NA
Eastern Gotland Basin	Latvia	Eastern Gotland Basin Latvian Coastal waters	20	Jurkalne	2016-2020	Flounder	Fisheries independent data	Trend	NA	NA	NA	NA
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Mon/But	1998-2020	Flounder	Fisheries independent data	Trend	NA	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Šventoji	2006-2020	Flounder	Fisheries independent data	Trend	NA	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Karklė	2006-2020	Flounder	Fisheries independent data	Trend	NA	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Smiltynė	2006-2020	Flounder	Fisheries independent data	Trend	NA	1	1	1
Eastern Gotland Basin	Lithuania	Eastern Gotland Basin Lithuanian Coastal waters	21	Curonian lagoon	1998-2020	Perch	Fisheries independent data	THV	0.5	1	1	1
Eastern Gotland Basin	Sweden	Eastern Gotland Basin Swedish Coastal waters	22	Herrvik	2018-2020	Flounder	Fisheries independent data	Trend	NA	0.5	0	1
Eastern Gotland Basin	Russian	Eastern Gotland Basin Russian Coastal waters	23	NA	NA	NA	NA	NA	NA	NA	NA	NA
Eastern Gotland Basin	Poland	Eastern Gotland Basin Polish Coastal waters	24	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gdansk Basin	Russia	Gdansk Basin Russian Coastal waters	25	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zatoka Pucka Zewnętrzna	2014-2020	Perch	Fisheries independent data	THV	0	1	1	1
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zatoka Pucka Zewnętrzna	2014-2020	Flounder	Fisheries independent data	Trend	NA	1	1	1
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Pucki	2014-2020	Perch	Fisheries independent data	THV	0	1	1	1
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Pucki	2014-2020	Flounder	Fisheries independent data	Trend	NA	1	1	1
Gdansk Basin	Poland	Gdansk Basin Polish Coastal waters	26	Zalew Wiślany	2014-2020	Perch	Fisheries independent data	THV	0	1	1	1
Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Torhamn	2002-2020	Perch	Fisheries independent data	THV	0	1	0.5	1
Bornholm Basin	Sweden	Bornholm Basin Swedish Coastal waters	27	Hanöbukten	2015-2020	Flounder	Fisheries independent data	Trend	NA	1	0.5	1
Bornholm Basin	Poland	Bornholm Basin Polish Coastal waters	28	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bornholm Basin	Denmark	Bornholm Basin Danish Coastal waters	29	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bornholm Basin	Germany	Bornholm Basin German Coastal waters	30	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arkona Basin	Sweden	Arkona Basin Swedish Coastal waters	31	Stavstendsudde	2018-2020	Flounder	Fisheries independent data	Trend	NA	0.5	0	1
Arkona Basin	Denmark	Arkona Basin Danish Coastal waters	32	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arkona Basin	Germany	Arkona Basin German Coastal waters	33	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mecklenburg Bight	Germany	Mecklenburg Bight German Coastal waters	34	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mecklenburg Bight	Denmark	Mecklenburg Bight Danish Coastal waters	35	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kiel Bight	Denmark	Kiel Bight Danish Coastal waters	36	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kiel Bight	Germany	Kiel Bight German Coastal waters	37	NA	NA	NA	NA	NA	NA	NA	NA	NA
Belt Sea	Denmark	Belts Danish Coastal waters	38	NA	NA	NA	NA	NA	NA	NA	NA	NA
The Sound	Sweden	The Sound Swedish Coastal waters	39	NA	NA	NA	NA	NA	NA	NA	NA	NA
The Sound	Denmark	The Sound Danish Coastal waters	40	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kattegat	Sweden	Kattegat Swedish Coastal waters, including Limfjorden	41	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kattegat	Denmark	Kattegat Danish Coastal waters, including Limfjorden	42	NA	NA	NA	NA	NA	NA	NA	NA	NA

In general, the confidence in the accuracy of the evaluation (ConfA) is medium to high in the majority of the assessment units. Only in the Polish coastal waters and the southernmost Swedish assessment unit (Bornholm Basin) is ConfA low as a result of strong interannual variation in L90 values during the assessment period (Figure 3). The confidence in the temporal coverage (ConfT) is high in most areas except for some Finnish areas due to missing data in one or more of the years in the assessment period. The confidence in spatial representability (ConfS) is generally high in Finnish, Lithuanian, and Polish areas, but poorer in other assessment units. The integrated confidence considering all four categories varies between high (in 7 units) and intermediate (in 8 units) depending on assessment unit (Table 3 and Figure 4).

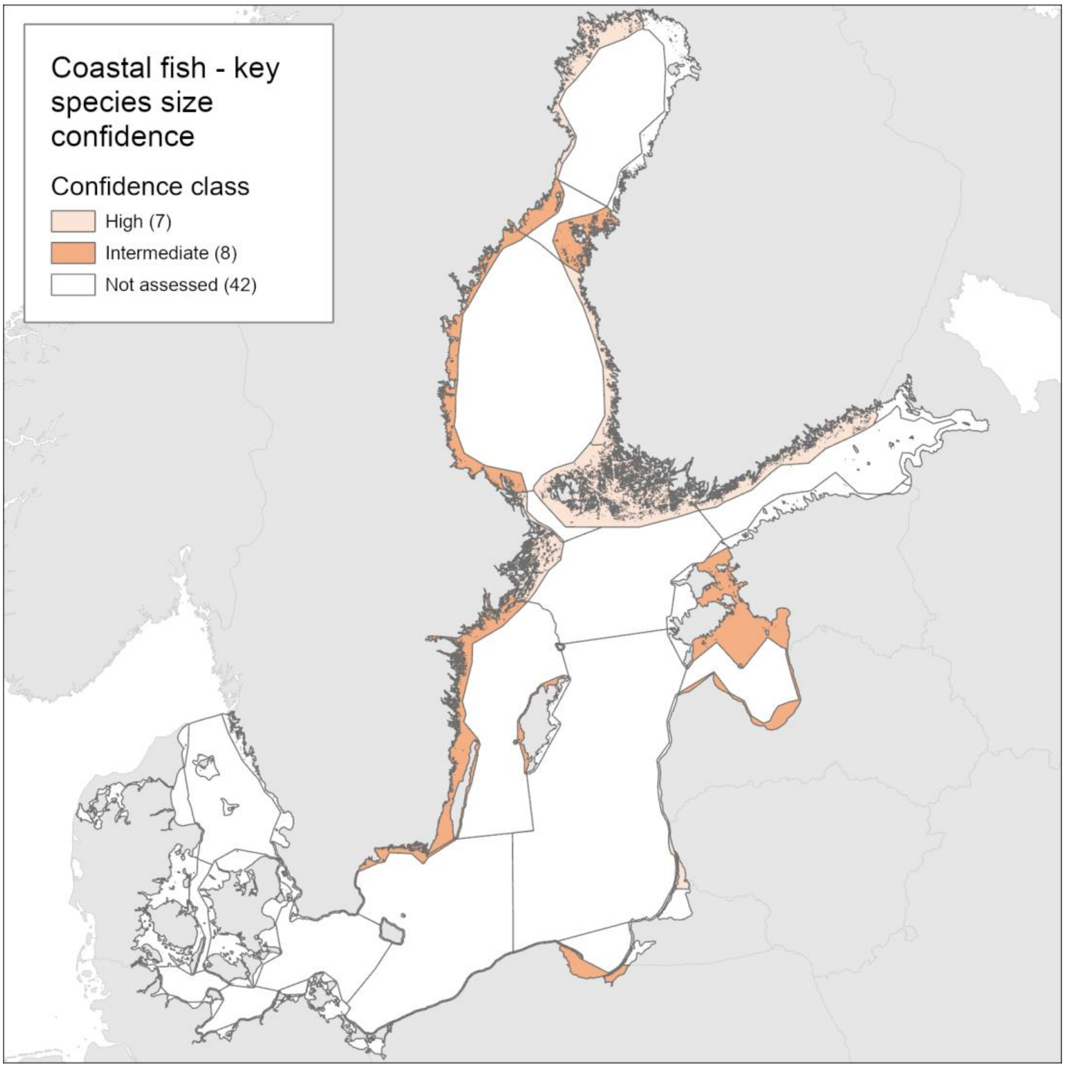


Figure 4. Maps of confidence of the current evaluation. See Table 3 for details.

The confidence concept as developed for the purposes of the integrated biodiversity assessment is not fully applicable to coastal fish as further evaluation of the precision in data and the congruence in status across monitoring locations within assessment units would provide additional needed information.

6 Drivers, Activities, and Pressures

The state of coastal fish species in the Baltic Sea is influenced by multiple pressures, including climate (cf. Chapter 7), eutrophication, fishing mortality and exploitation of essential habitats, but also by natural processes such as food web interactions and predation from apex predators (reviewed in Olsson 2019). In perch, the size distribution tends to decrease with increasing levels of eutrophication along the coast (Östman *et al.* in prep).

Large individuals of a population often contribute disproportionally to reproduction and are thus highly important for the sustainability of fish populations (Birkeland & Dayton 2005, Olin *et al.* 2012). Large coastal piscivores such as perch, pike, and pikeperch, are targeted by both the small-scale coastal commercial fishery as well as by recreational fishing (Olsson *et al.* 2015; Bergström *et al.* 2016b), with the recreational sector dominating in some countries (HELCOM 2015), whereas flounder are exploited both in the offshore and coastal commercial fishery. In some areas of the Baltic Sea, flounder is also targeted by recreational fisheries. The share of large perch in a population is affected by the fishing pressure in an area, and increases in Marine Protected Areas (Bergström *et al.* 2016a, Östman *et al.* in prep). Thus, the size distribution of a population gives an indication both regarding the fishing pressure in the area as well as the state of the coastal ecosystem.

Table 5. Brief summary of relevant pressures and activities with relevance to the indicator.

	General	**MSFD Annex III, Table 2a**
Strong link	Several pressures, both natural and human, acting in concert affect the state of coastal key fish species. These include climate, eutrophication, fishing, and exploitation and loss of essential habitats, prey depletion and habitat loss. There is also a strong link to the food web structure and the food quality, which are indirectly influenced by human activities.	Biological pressures: - disturbance of species (e.g. where they breed, rest and feed) due to human presence. - extraction of, or mortality/injury to, wild species (by commercial and recreational fishing and other activities). Physical pressures: - physical disturbance to seabed (temporary or reversible). - Changes to hydrological conditions Pressures by substances, litter and energy - input of nutrients – diffuse sources, point sources, atmospheric deposition - input of organic matter – diffuse sources and point sources.
Weak link	There might also be effects of hazardous substances and non-indigenous species on coastal fish species.	Substances, litter and energy - Input of other substances (e.g. synthetic substances, non-synthetic substances, radionuclides) Biological pressures: - - Input or spread of non-indigenous species

7 Climate change and other factors

Fish of freshwater origin dominate most Baltic coastal areas, some preferring warm (perch, cyprinids) and others cold waters (salmonids, burbot). These species often migrate back to their natal spawning ground for spawning, resulting in many local populations that adapt to local conditions. Small scale environmental variations, local fishing pressure, habitat availability, and food web interactions influence their reproduction, recruitment, growth, and mortality (HELCOM 2021).

A common response to warming in fish is increased growth rates and smaller adult sizes (Atkinson 1994). Evidence from perch does suggest that growth rate may increase as a result of warming (Mustamäki *et al.* 2020). However, adult body size can be maintained despite increased growth under warming over several generations (Huss *et al.* 2019). Higher water temperature has already improved the reproduction of many spring and summer spawners, including perch and pikeperch (Böhling *et al.* 1991, Karås & Thoresson 1992, Lehtonen & Lappalainen 1995, Karås 1996, Kjellman *et al.* 2001, Heikinheimo *et al.* 2014, Kokkonen *et al.* 2019, Pekcan-Hekim *et al.* 2011). In contrast, the reproduction of autumn-spawners, e.g., vendace and whitefish, have been disfavoured by warm winters and their distribution decreasing with less ice cover and higher winter temperatures (Candolin & Voigt 2020, Kallio-Nyberg *et al.* 2019, Veneranta *et al.* 2013, Bergenius *et al.* 2013). Species preferring warm waters have become more common relative to winter-spawning species (Veneranta *et al.* 2013). In the future earlier spawning, faster egg, and larval development, increased larval survival of spring spawning freshwater coastal fish species can be expected due to warmer water temperatures (Kjellman *et al.* 2001, Heikinheimo *et al.* 2014, Kokkonen *et al.* 2019, Pekcan-Hekim *et al.* 2011, Tamario *et al.* 2019, Härmä *et al.* 2008, Dainys *et al.* 2019). Earlier migration from nursery habitats, as a consequene of warmer water, may influence food web interactions with negative effects on piscivorous species (Kjellman *et al.* 2001, Östman *et al.* 2014). The effect of water temperature on body growth differs among species and size-classes: growth is generally expected to increase for small but not for large fish (Karås & Thoresson 1992, Candolin & Voigt 2020, Dahl *et al.* 2014, Kallio-Nyberg *et al.* 2004, Härmä *et al.* 2008, Dainys *et al.* 2019) Possible brownification of coastal waters may decrease body growth (Böhling *et al.* 1991).

8 Conclusions

8.1 Future work or improvements needed.

Due to the presence of natural environmental gradients across the Baltic Sea and the rather local appearance of coastal fish communities (and hence their different structures and responses to environmental change), the spatial coverage of monitoring should be improved in some areas in order to enhance the confidence of the evaluation outcome. When designating new potential monitoring programmes, it should be considered that the levels of direct human impact on the coastal fish communities in many of the existing monitoring locations are low, and future locations should include more heavily affected areas.

Moreover, the current monitoring in the northern and eastern parts of the Baltic Sea is designed to target coastal fish species that prefer higher water temperatures and that dominate coastal areas during warmer parts of the year, typically those with a freshwater origin such as perch. Monitoring of species like whitefish, herring, flounder and cod that dominate coastal fish communities in more exposed parts of the coast and during colder parts of the year are, however, rather poorly represented. Increased monitoring of these species and components should be considered in the future establishment of coastal fish monitoring programmes.

The current evaluation implements a threshold for L90 only for perch. A threshold for flounder could not be implemented, due to difficulties in establishing the separate influences of various confounders (such as gears, ecotypes, seasons, and regions) on the size distribution given the available somewhat limited data. Efforts towards developing thresholds for flounder, as well as for other key species, such as pikeperch, whitefish, and pike, are needed, but are dependent on data availability.

9 Methodology

This indicator is evaluated against a gear-specific threshold for perch. For flounder and pikeperch, no evaluation against a threshold is made, but trends over time in L90 are displayed.

The methodology and basis of the indicator evaluation is provided below.

9.1 Scale of assessment

Due to the local appearance of typical coastal fish populations, status evaluations of coastal fish communities are representative for rather small geographical scales. In this evaluation the HELCOM assessment unit scale 3 'Open sub-basin and coastal waters' has been applied. The indicator is not evaluated for the open sea sub-basins since the species in focus are coastal.

Evaluations against a quantitative threshold were carried out for perch in 15 of the 42 assessment units and data up to 2020 was available for all except one assessment units. The number of units evaluated are currently restricted by the availability of monitoring programs. An additional two assessment units was included when also considering flounder, but the assessment of status was not quantitative against a threshold value.

For the integration of status across species and monitoring locations within assessment units, the One-Out-All-Out principle is applied (Dierschke *et al.* 2021).

The assessment units are defined in the HELCOM Monitoring and Assessment Strategy Annex 4.

9.2 Methodology applied

Gear specific threshold values for good status are implemented for perch. The thresholds were arrived at by analysing data on perch size distributions from 33 monitoring locations throughout the Baltic Sea coasts, using time series data of varying length from each location, ending at the year 2020 and with the longest time series starting in 1978 (Bolund *et al.* in prep). The data was composed of annual survey data from Sweden, Estonia, Latvia, Lithuania, and Poland, and a combination of annual monitoring data and commercially collected data from Finland that fulfilled minimum data criteria (namely, a minimum of 50 measured individuals per year per location, and a minimum of six years of data from each location). Before calculating L90, a lower cut-off of 15 cm is applied to lower the influence of yearly fluctuations in recruitment. After accounting for the effects of gears, seasons, regions, and time on L90 in a linear mixed-effects model framework, implemented in R (R core team 2022), the mean L90 value was set as the threshold (Bolund *et al.* in prep). There was relatively low amount of variation in L90 across regions and seasons, and also over time, but significant differences in the size distribution due to gears used necessitated gear-specific thresholds of 23 cm for net series and 25 cm for Nordic multimesh nets and fyke nets. The data used to map size structure of perch likely reflects a situation where the populations are not overfished (i.e. we see no strong negative trends over time), but still exploited at a level that the size structure is impacted (i.e. L90 is higher in no-take areas and MPAs; Östman *et al.* in prep). To assess environmental status, the median value during the assessment period was evaluated in relation to the gear-specific threshold, and confidence in the status was determined by the number of years that fell above/below the threshold.

It is challenging setting a regional threshold value for L90 in flounder. This is because of substantial differences in L90 among regions, gears, seasons and ecotypes, and often there is a combination of these factors in different areas (Bolund *et al.* in prep). Therefore, trends over time in L90 for flounder are addressed in the different monitoring areas during the past 12 years (i.e. two MSFD management cycles). Linear trends are evaluated with a significance threshold set at $p<0.1$. For pikeperch, data from commercial fisheries in Finland provide sample sizes that allow estimation of L90 and evaluation of trends over time. The commercial data on pikeperch may allow the development of threshold values in future (Lappalainen *et al.* 2016).

Data analyses

The data used for the evaluations are derived from fishery independent monitoring, or commercial catch statistics.

Fishery independent monitoring

The analyses are based on annual length distribution data from all sampling stations in each area.

Commercial catch data

Analyses were based on annual length distribution data from commercial fyke nets, and hence target a somewhat different aspect of the fish community in the area compared to the fisheries independent gill-net monitoring data. In addition, fishing is not performed at fixed stations nor with a constant effort across years. As a result, the estimates from the gillnet monitoring programmes and commercial catch data are not directly comparable, and only relative changes across data sources should be compared.

9.3 Monitoring and reporting requirements

Monitoring methodology

The HELCOM common monitoring on coastal fish is described on a general level in the HELCOM Monitoring Manual in the sub-programme: Coastal fish.

The HELCOM common monitoring on coastal fish is described in guidelines that were adopted in 2014 and updated in 2019.

Current monitoring

The monitoring activities relevant to the indicator that are currently carried out by HELCOM Contracting Parties are described in the HELCOM Monitoring Manual in the Monitoring Concepts table as well as in the guidelines for coastal fish monitoring.

Sub-programme: Coastal fish

Monitoring Concepts table

Coastal fish monitoring is rather widespread in the Baltic Sea, and at present covers 32 of the total 42 'scale 3 HELCOM assessment units'. Coastal areas that lack coastal fish monitoring includes Russia and Germany (in total 7 assessment units) where there is no current and official monitoring program for coastal fish, two assessment units in Finland (Åland Sea Finnish coastal waters and Northern Baltic Proper Finnish coastal waters) and one in Denmark (Kiel Bight Danish coastal waters). The current monitoring where information on the size of Key species can be extracted is less extensive, at present covering 17 assessment units of which 15 allows for an evaluation against a threshold value. In the future, an expansion of the evaluation including data from also Denmark and additional areas in Finland, Estonia and Latvia considering also additional species is expected as data is present but not yet available for an evaluation. Furthermore, in Germany, there is no coordinated monitoring program for coastal fish, but a project aiming to establish such a program was initiated in 2020 in the coastal areas of Schleswig-Holstein.

The current monitoring of coastal fish in the Baltic Sea represents a minimum level of effort and serves as a first step for evaluating the status of coastal fish communities.

The current monitoring likely yields insights into major and large-scale changes in coastal fish communities in the Baltic Sea, but unique and departing responses are possible in some areas.

10 Data

The data and resulting data products (e.g. tables, figures and maps) available on the indicator web page can be used freely given that it is used appropriately and the source is cited.

HELCOM (2023). Size structure of coastal fish (Coastal fish size). HELCOM core indicator report. Online. [Date Viewed], [Web link]. ISSN 2343-2543.

[Result: Coastal fish size structure]

[Data: Coastal fish size structure]

Data are typically collected annually in August by national and regional monitoring programmes. Commercial catch statistics in Finland represent total annual catches. See HELCOM (2019) for details. For future updates of this evaluation, data should be collected in each location on an annual basis.

A few time series of coastal fish began in the 1970s (Olsson *et al.* 2012), whereas others were started in the 1980s and the mid-1990s (HELCOM 2019). In Finland and Sweden, a new coastal fish monitoring programme with a higher spatial resolution was established in the early 2000s, and in Poland and Denmark monitoring data and citizen science data is typically available from the mid 2010s. For more information, see HELCOM 2019.

The data used for this newly developed indicator is not yet made publicly available in the HELCOM database for coastal fish core indicators, COOL (http://www.helcom.fi/baltic-sea-trends/data-maps/biodiversity/), hosted by the HELCOM secretariat. Data will be made available in COOL in future.

Data sources

Coastal fish monitoring is coordinated within the HELCOM FISH PRO III expert network. The network compiles data from fisheries independent monitoring in Finland, Estonia, Latvia, Lithuania, Poland, Germany, Denmark and Sweden. Coastal fish communities in the Baltic Sea areas of Russia are to some extent monitored as well. In Germany, there is no coordinated monitoring program for coastal fish, but a project aiming to establish such a program was initiated in 2020 in the coastal areas of Schleswig-Holstein. In Denmark, there is no coastal fish monitoring programme and the data provided relies on voluntary catch registration by recreational fishermen through the "key-fishermen" project, which has no long-term secured funding (initiated in 2005). Due to lack of geographical coverage, the state of coastal fish communities in Finland is monitored using estimates of catch per unit effort (CPUE) from the small-scaled coastal commercial fishery. There are some additional monitoring locations (see HELCOM 2019), which were not included in this evaluation due to lack of funding in some countries for carrying out status evaluations.

The institutes responsible for sampling are: Natural Resources Institute Finland (Luke) (Finland), Provincial Government of Åland Islands (Finland), Estonian Marine Institute

(Estonia), University of Tartu (Estonia), Institute of Food Safety, Animal Health and Environment "BIOR" (Latvia), Nature Research Center (Lithuania), Klaipeda University (Lithuania), National Marine Fisheries Research Institute, Gdynia (Poland), National Institute of Aquatic Resources, Technical University of Denmark (Denmark), Department of Aquatic Resources, Swedish University of Agricultural Sciences (Sweden).

11 Contributors

The HELCOM FISH PRO III expert network on coastal fish:

Jens Olsson, Elisabeth Bolund, Lena Bergström, Örjan Östman, Noora Mustamäki and Rahmat Naddafi, Department of Aquatic Resources, Swedish University of Agricultural Sciences, Sweden

Mikko Olin and Antti Lappalainen, Natural Resources Institute Finland (Luke), Finland

Linda Sundström, Provincial Government of Åland Islands, Finland

Lauri Saks and Roland Svirgsden, Estonian Marine Institute, University of Tartu, Estonia

Laura Briekmane, Institute of Food Safety, Animal Health and Environment "BIOR", Latvia

Linas Lozys and Justas Dainys, Nature Research Center, Vilnius, Lithuania

Adam Lejk and Łukasz Dziemian, National Marine Fisheries Research Institute, Gdynia, Poland

Elliot John Brown, National Institute of Aquatic Resources, Technical University of Denmark, Denmark

HELCOM Secretariat: Jannica Haldin, Owen Rowe, Jana Wolf

12 Archive

This version of the HELCOM core indicator report was published in April 2023:

The current version of this indicator (including as a PDF) can be found on the HELCOM indicator web page.

There are no previous versions of this indicator.

13 References

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14 Other relevant resources

There are no additional resources for this current indicator evaluation.