# EU request to report on the implementation of the Baltic Sea Multiannual Plan

## Advice summary

The Baltic Sea ecosystem is undergoing a fundamental change and is not in equlibrium state. This has major consequences for fisheries and ecosystem management.

1. The fisheries impact the Baltic Sea ecosystem. The most important impacts are the direct removal of predators and prey with indirect effects on the foodweb, abrasion of the seabed, disturbance of associated benthic communities, and bycatch of sensitive species. Quantification of the effects of those impacts, in respect to both fisheries and environental management objectives, has yet to be carried out.

2. The factors affecting the fish stocks include abiotic factors (e.g. temperature, salinity, oxygen), changes in spatial distribution of fish stocks in response to the abiotic factors, and biotic factors (e.g. species' interactions, parasite infection, invasive species). The main consequences of these factors are changes in:

    a. productivity of herring and sprat due to change in temperature;
    b. productivity and distribution of eastern Baltic cod caused by a change in oxygen content;
    c. the foodweb functioning due to invasive species;
    d. predator–prey spatial overlap.

The relative contribution of these individual environmental impacts to the overall mortality rates are currently not available.

## Request

*The reformed CFP relies for its implementation notably on sea-basin related multiannual plans. The first such plan was adopted for the Baltic Sea in July 2016 via Regulation (EU) 2016/1139. The implementation started with the fishing opportunities for 2017. The Plan provides that by 21st July 2019 the Commission has to report to the European Parliament and the Council on the results and impact of the plan's implementation on the relevant stocks and fisheries, in particular as regards the achievement of the Plan's objectives. These objectives are:*

- *contribute to the achievement of the objectives of the CFP;*
- *aim to ensure that the populations of living marine biological resources are at sustainable levels;*
- *contribute to the elimination of discards by avoiding and reducing unwanted catches and by implementing the landing obligation for the relevant species;*
- *implement an ecosystem-based approach so as to minimise negative effects of fishing activities on the environment.*

*A lot of information is available, notably in the yearly stock and ecosystem advice from ICES and in reports from STEFC, and DG MARE will consult BaltFish and the Baltic Sea Advisory Council on various aspects. Nevertheless, the Commission would in addition need advice from ICES on some specific aspects.*

*In order to support the Commission in the preparation of the report, ICES is requested to give advice on the following questions:*

1) *What are the effects of fisheries on the ecosystem in the Baltic?*
2) *What factors other than fisheries are affecting the stocks? To the extent it is possible to provide (elements of) a reply, what is their (relative) contribution to the overall mortality rate?*

## Elaboration on the advice

**What are the effects of fisheries on the ecosystem in the Baltic?**

Description of the fisheries – cod, sprat, herring, flatfish, salmonids, and eel

The Baltic Sea is a shallow, semi-enclosed, brackish sea, characterized by vertical stratification of the water column. Salty, well-oxygenated water from the North Sea occasionally enters the Baltic Sea through the Belt Seas and propagates into the deeper areas, while freshwater flows exit at the surface. Stratification limits the oxygen from reaching the deeper waters and, hence, the oxygen content of the bottom water depends on surface oxygen consumption and the inflows of North Sea water. Due to these hydrological characteristics, the basin has a limited diversity of fish species, dominated by marine species in the southwestern areas and a combination of marine and freshwater species in the northeastern areas. Fisheries in the Baltic Sea are focused on a few major species, with 99% of landings in 2017 consisting of herring (*Clupea harengus*), sprat (*Sprattus sprattus*), cod (*Gadus morhua*), and flounder (*Platichthys flesus*).

Fishing vessels from nine nations operate in the Baltic Sea, with the highest number of large vessels (>12 m) coming from Sweden, Denmark, and Poland. Bottom trawls are the main gear used in Baltic demersal fisheries while mid-water trawls are the main gear in the pelagic fisheries. Demersal fishing effort has substantially declined since 2004. Most of the pelagic catch is used for industrial purposes. Set gillnets are widely used in the Baltic Sea, both in offshore and coastal fisheries exploiting a large variety of species. The coastal fisheries consist of thousands of small vessels mostly conducting day trips. Apart from set nets, other static gear such as traps and longlines are also used. Drifting gillnets have been banned in the Baltic Sea since 2008.

Recreational fisheries take place in all parts of the Baltic Sea, using a variety of gears that includes rod and line, longline, gillnets, traps, and spear-fishing. Recreational fisheries catch the same species as the commercial fisheries, but also several other species. For most of the stocks, recreational catches are not evaluated or included in the stock assessments. However, for salmon (*Salmo salar*) and western Baltic cod recreational catches are significant and are included in the ICES assessments of the stocks.

Since the early 1950s, landings of herring and sprat from the pelagic fisheries have dominated the total landings of fish from the Baltic Sea, peaking at more than 1.2 million tonnes in the mid-1970s. A decrease in sprat abundance, followed by a decline in cod in the late 1980s, led to a marked decline in total landings. Pelagic landings increased in the early and mid-1990s, reflecting an increase in sprat abundance during this period. The four herring stocks in the Baltic Sea have developed differently: the central Baltic herring stock, the biggest of these, declined between the early 1970s and the early 2000s and has increased since; the second largest, herring in the Bothnian Sea, peaked in the mid-1990s; the western Baltic herring stock has declined since 1990; and the Gulf of Riga herring is the smallest stock, showing no clear trend in biomass since the early 1990s. Since 2003, total Baltic Sea landings have remained fairly stable.

Landings of demersal (mostly cod) and benthic species (flatfishes) peaked in the early 1980s at more than 400 000 tonnes annually. They have declined since and have been below 100 000 tonnes since 2002. In 2017, landings of these species have been around 50 000 tonnes, where 30 000 tonnes are demersal and 20 000 tonnes are benthic species.

There has been a decline of the total nominal salmon catches in the Baltic Sea, starting at 5636 tonnes in 1990 and decreasing to 900 tonnes in 2010. Since then, catches increased somewhat again in 2011–2014. In the last three years, the total nominal catch has again decreased, and in 2017, it was 761 tonnes, the lowest value recorded so far. The highest total nominal catches of sea trout (*Salmo trutta*), above 1300 tonnes, were taken in the early and late 1990s. Since 2001 they have been decreasing to the level of 700–800 tonnes in recent years, and even 506 tonnes in 2017. Sea trout is an important target species in some recreational fisheries, but their removals are not accurately determined.

Yellow and silver European eel (*Anguilla anguilla*) landings are not always reported separately, so the two are combined in the assessment. The European total landings of yellow and silver eels decreased from 18 000–20 000 tonnes in the 1950s to 2000–3000 tonnes since 2009 (2224 tonnes in 2017). Most yellow and silver eel landings come from fresh, transitional, and coastal waters. No separate reliable statistics are available for eel catches from the Baltic Sea, but it is thought that they have been constantly declining and are currently at a historically low level.

Discards

Discards for pelagic species in the Baltic Sea are negligible, as both sprat and herring are target species and other bycatch (e.g. of sticklebacks, Gasterosteidae) is also landed in fisheries for industrial purposes. The discard rates are minor for static coastal gears and even lower for pelagic trawls. The mean discard rates of flatfish species are estimated to be around 25% and around 15% for other demersal fish since 2013. A discard ban for cod, herring, sprat, and salmon in the Baltic has been in place since 2015, and since 2017 for plaice (Pleuronectes platessa) as well. Officially reported discards have been reduced close to zero. Despite the landing obligation, discards are still occurring, based on on-board sampling by most countries and on reports from the fisheries. The total discards for the eastern Baltic cod, for example, in 2018, in subdivisions 25–32, were estimated at 3103 tonnes which constituted 16% of the total catch in weight. The reported percentage of below minimum size (BMS) fish was 0.7% in 2018. This was an increase in the discard rate of 11% in 2017, and the highest discard rate since the introduction of the landing obligation. ICES considers this a minimum estimate. 91% of the estimated discards in weight was caught by active gears. Mortality due to discarding cannot be quantified, but has to be considered substantial.

Release rates for species targeted by recreational fisheries are available for cod and salmonids and are high but vary between years and countries (between 25% and >60%). Post-release mortality estimates are available for some species, but further studies are needed.

Mixed fisheries and technical interactions

Most fishing gears catch more than one species at the same time, so “technical interactions” occur between stocks when multiple species are captured in the same gear during fishing operations.

The Baltic herring fisheries often catch also sprat, and vice versa, with high spatial variability. Cod fisheries often capture flatfish and occasionally take whiting. Fisheries targeting flatfish frequently have bycatches of cod with high spatial variability.

Cod and flounder account for the highest landings of demersal and benthic species in the Baltic Sea. The majority of the landings are made with demersal trawls, but there are also significant landings with gillnets.

Effects of fisheries: selective extraction, bycatch, abrasion of seabed and impact on benthos, trophic cascades

Size-selective fishing may disrupt fish population dynamic stability and lower natural productivity might amplify the effects of selective fishing. It was shown that the eastern and western Baltic cod have gone toward more truncated size structures between 1991 and 2016, in particular for the eastern Baltic cod, whereas the Öresund cod show no trend.

Studies conducted between 1980 and 2005 indicated that at least 76 000 birds, mostly sea ducks, were killed annually in Baltic Sea gillnets. This number may have declined in more recent years, probably due to the decline in sea duck populations. Birds that actively pursue their prey underwater were more susceptible than those that graze on the benthos. For three bird species (greater scaup (*Aythya marila*), common guillemot (*Uria aalge*) and long-tailed duck (*Clangula hyemalis*)), gillnet bycatch could pose threat.

The only cetacean species to occur regularly in the Baltic Sea is the harbour porpoise (*Phocoena phocoena)*. The Baltic Sea subpopulation has declined during the past 50–100 years. With a most recent estimation of around 500 individuals (95% confidence interval: 80–1091), this subpopulation is listed as critically endangered. The more westerly Belt Sea subpopulation has a much higher abundance, estimated at around 40 000 individuals. Dead harbour porpoises exhibiting evidence of gillnet entanglements are found and reported regularly, so it is likely that bycatch in gillnets is adversely affecting this species, specifically the critically endangered Baltic Sea subpopulation.

Disturbance of seabed habitats due to physical abrasion from mobile bottom-contacting fishing gears occurs mostly in the southern parts of the Baltic Sea. This is mainly abrasion from otter trawls targeting demersal and benthic fish. Abrasion may affect the surface (top 2 cm of sediments) or the subsurface (> 2 cm). As only a very few studies are available to examine the impact of fishing-related abrasion on benthic communities in the Baltic Sea, the impact cannot be quantified. As well, information on thresholds of environmental impact is also currently lacking.

Abandoned, lost, or otherwise discarded fishing gear (ALDFG) are an unsolved and “silent” problem. Such gear may continuously catch fish, birds, and marine mammals for a long time. It was estimated that 0.1% of nets are lost annually in the Swedish Baltic Sea gillnet fishery. The impact on the environment is not quantified. However, there is information that fishing pressure exerted by lost static nets could range from 20% of its usual net capacity after three months, down to a maximum of 6% after two years.

Fisheries have a large impact on the upper trophic levels of the Baltic ecosystems. In the eastern Baltic, this impact has been shown to cascade down the foodweb, affecting indirectly the lower trophic levels. For example, the reduction of the eastern Baltic cod stock in the late 1980s has favored the increased biomass of its main fish prey, the zooplanktivorous sprat, and in turn the decrease in the summer biomass of zooplankton in the Baltic proper. This has provoked a decline in the body condition and growth of both sprat and herring. There is further indication that this trophic cascade could also have facilitated the observed increase in phytoplankton biomass and therefore worsened the eutrophication symptoms.

**Which factors other than fisheries are affecting the stocks?**

Abiotic factors

A particular feature of the Baltic Sea since the mid-1990s has been a drastic increase in the extent of anoxic and hypoxic areas, likely due to almost lack of strong water inflows from the North Sea (only two major inflows to the Baltic Sea have been recorded since the late 1980s) and potentially increased biological oxygen consumption on seafloor. Reduced oxygen conditions can affect adult cod directly by altering metabolism and indirectly by limiting the availability of benthic organisms as prey. Increasing average temperature and decreasing average salinity in the Baltic surface waters are influenced by large-scale atmospheric processes. These drivers are documented to influence the dynamics of biomass and recruitment of the eastern Baltic cod, sprat, and herring. For the eastern Baltic cod it has been shown that the fraction of the total eggs produced that survive until the larval stage depend on the volume of water with salinity >11 and oxygen >2 ml $l^{-1}$ (also known as the reproductive volume). Years characterized by a strong larval drift towards coastal areas correspond to a relatively low recruitment of sprat, while strong recruitment is formed during the years of larval retention within the deep basins. Sprat recruitment is also strongly linked to sea surface temperature in summer. For western Baltic herring, an increase in temperature has been identified as major trigger for a decrease in productivity of the stock. There seems to be a phenology shift that causes an earlier occurrence of herring larvae on the spawning grounds compared to the early 1990s. At the time of occurrence, however, their main prey (copepod larvae) is not fully available. The effect of this divergence between larvae and prey occurrence is reduced recruitment of the stock, and consequently a much lower availability of adult fish to the fishery. In addition to the main commercially exploited fish, probably more species are impacted. There is no quantified population dynamics impact available.

Spatial distribution

Fish distribution has changed considerably during the past decades. The eastern Baltic cod, in parallel with the decrease in its stock size, has contracted its distribution to the southern areas since the mid-1980s. The sprat stock on the other hand, increased mostly in the northern areas of the Baltic Proper, which has been interpreted as a spatial predation release effect.

As a consequence of the spatial relocation of the sprat stock to more northern areas, the growth of sprat decreased mostly in the eastern areas, indicating a spatial density-dependent effect. The current low spatial overlap between predator (cod) and prey (sprat), at least in some seasons, implies changes in the strength of the predator–prey relationship from the 1970s–1980s.

Large changes in the depth distribution of cod and flounder have occurred in the Baltic Proper during the last four decades. From the late 1980s the mean depth of both adult cod and flounder distributions has decreased while that of juvenile cod increased, and furthermore the depth ranges have contracted, probably due to a combination of hypoxia in deep waters and increased risk of predation in shallower waters. The net effect of these changes is that adult cod, juvenile cod, and flounder overlap more, which may increase the intra - and interspecific interactions.

Evidence highlighting the importance of coastal shallow waters as major nursery and feeding grounds for immature cod, and to some extent mature individuals, has increased in recent years. Standardized Baltic International Trawl Surveys (BITS) cover mostly deeper waters (>15 m water depth) and thus possibly underestimate the abundance of species inhabiting coastal areas.

Species interactions, including parasites

In the Baltic Proper, multispecies analyses indicate that trade-offs exist between fishing on cod or herring and sprat. Increased fishing pressure on cod may increase the risk of a low cod stock size, thereby reducing cod predation on sprat and herring and allowing higher survival in these two prey species. Increased fishing pressure on herring and sprat may have a negative impact on the condition and growth of cod (by reducing the forage available for cod) and result in lower cod yields. The magnitude of the interaction between the species depends on the spatial and temporal overlap among the three stocks. Currently, the eastern Baltic cod stock is at such a low level that its impact on herring and sprat mortality rates can be considered to be very low. On the other hand, decreasing fishing pressure on sprat might not necessarily improve cod condition and recruitment, because at the moment the main bottleneck for cod growth is the absence of benthic food. Cod might not reach the condition necessary to forage on sprat.

In the last two decades the two cod stocks have decreased, while the flounder and plaice stocks in the Baltic have increased. The increase in flounder might at least partially have happened due to the release from cod predation. As flounder is currently not included in the multispecies models for the Baltic Sea, no estimates of predation mortality rates or interspecific competition for food are available.

The thiamine deficiency syndrome M74 is a reproductive disorder, which causes mortality among yolk-sac fry of Baltic salmon. The development of M74 is caused by a deficiency of thiamine in the salmon eggs that, in turn, is suggested to be coupled to an abundant, but unbalanced fish diet with too low a concentration of thiamine in relation to fat and energy content. The intake of thiamine for Baltic salmon in relation to energy and fat remains lowest when feeding on young clupeids, especially young sprat. Although a large sprat stock may have a positive impact on salmon growth, it may increase M74 and thereby mortality of Baltic salmon fry.

Three seal species occur regularly in the Baltic Sea: grey seal (*Halichoerus grypus*), harbour seal (*Phoca vitulina*), and ringed seal (*Phoca hispida*). While grey seals are present throughout the Baltic Sea and are in a good status in most parts of the distribution area, the latter is not the case for the other two seal species. The grey seal population grew rapidly between 2000 and 2016, before levelling off at above 30 000 individuals. Herring, sprat, cod, flounder and salmonids may have high occurrence in the diet of seals and consumption by seals has been estimated to be significant in some areas of the Baltic Sea. In the Bothnian Bay, the annual ringed seal consumption on herring had been estimated in 2008 to be higher than the catches from the Swedish and Finnish fishery. Also, seal consumption in 2004 was estimated to be comparable with catches of salmonids in the Baltic Sea. Considering the increasing population of grey seals in the last decade, the effects of seals on fish stocks are likely to have also increased, altough no estimations have been recently available.

Studies have also shown that bird (mainly cormorants) predation can locally affect fish populations, including flatfish, but their effects on the fish stocks is not yet quantified.

Fishes host several parasites, with potential negative effects on their health. In the Baltic Sea, the grey seal population has increased markedly since the early 2000s. The grey seal is the main definitive host to the liver worm *Contracaecum osculatum*, a parasitic nematode to which cod is one of several intermediate hosts. Recent investigations have shown a marked increase in prevalence and abundance of infection of this parasite in livers of cod inhabiting the central Baltic Sea. Prevalence and abundance of *C. osculatum* in cod livers differ significantly between the eastern and western Baltic Sea, with the highest levels of infection occurring in the low-salinity central (eastern) Baltic areas. Highly infected fish in the east have significantly lower condition factors than their westerly, less infected conspecifics. Spatial differences in local seal abundance and seal species, salinity, and feeding ecology may explain the observed differences in *C. osculatum* infection between eastern and western Baltic cod. It is not yet clear whether a high infection rate is the cause or the effect of low cod condition.

Immature cod feed almost exclusively on benthic prey. In the last decade juvenile eastern Baltic cod have been feeding at a lower rate than previously, resulting in severe growth limitation and increased starvation-related mortality. At the population level, this results in a reduction in size-at-age and low population abundance. The low feeding levels most probably result from a decrease in benthic prey availability due to increased hypoxic areas. This food reduction is amplified by accumulation of cod of smaller size competing for the scarce benthic resources. Only the fishes with feeding levels well above average will survive, though growing slowly. These results suggest that there is a relationship between consumption rate, somatic growth, and population density. The consequences for species interactions and ecosystem functioning are strongly environmentally mediated and hence not stable under environmental change.

The invasive round goby (*Neogobius melanostomus*) has become established in all Baltic Sea sub-basins and is continuously increasing its range and abundance in the recently colonized habitats. The species has become the predominant fish species in many coastal areas and poses strong predatory pressure, essentially on epibenthic mollusks. It is suggested that the high densities of round goby at the Lithuanian coast have locally depleted previously dense blue mussel (*Mytilus edulis*) banks. In regions where round gobies have become abundant, they have become important prey items to both avian and fish predators: round goby is the main food item for cod and perch (*Perca fluviatilis*) in the Gulf of Gdansk, an increasingly important prey for perch in Estonia, and also an important prey item for great cormorant (*Phalacrocorax carbo*) and grey heron (*Ardea cinerea*), contributing locally up to 60–95% to their diets. In Lithuania round gobies were found in the diet of most piscivorous fish species, including turbot (*Scophthalmus maximus*) and even such species as shorthorn sculpin (*Myoxocephalus scorpius*). Certain piscivorous and commercially valued fish can potentially benefit from round goby.

**To the extent it is possible to provide (elements of) a reply, what is their (relative) contribution to the overall mortality rate?**

The contribution of individual factors other than fisheries currently affecting the stocks cannot be assessed quantitatively. These factors also vary largely between stocks. For eastern Baltic cod, the natural mortality has increased in the last two decades and it is estimated to be three times higher than fishing mortality in 2018. For other stocks fishing is considered to have the highest impact on stock dynamics. The underlying mechanisms are highly complex and spatially heterogeneous, and observational data as well as knowledge are lacking for key elements to develop ecological quantitative population models.

However, the contribution of individual environmental factors (biotic and abiotic) and their impact on stocks changes over time. These factors include:

- Temperature trends decoupling spawning-stock biomass from recruitment of herring and sprat;
- Oxygen trends decoupling cod recruitment for cod spawning-stock biomass;
- Invasive species changing the foodweb configurations;
- Changes in predator–prey spatial overlap.

## Basis of the advice

**Methods**

The advice is based on a literature review, including ICES expert group reports. The "Sources and references" section lists the literature consulted for the review.

## Suggestions

The concept of $F_{MSY}$ assuming long term equilibrium is not considered approppriate for the eastern Baltic cod stock presently due to the large decline in productivity in later years.

F-ranges based on static reference biomasses ignore trends in carrying capacity of the marine ecosystem. F-ranges should not be seen as a tool to incorporate the ecosystem impacts of fisheries. In dynamic ecosystems, even regular updates of (single-stock MSY) references points may not provide the optimum approach to an ecosystem management.

Effects of environmental factors on ecosystem productivity and of the fisheries on the environment are both changing over time. Different ecosystem components may be affected differently. Adaptative management approaches, linked to metrics from fish stock and ecosystem assessments are required. In this context, thresholds of impacts, which are currently lacking, would also need to be determined.

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*Recommended citation:* ICES. 2019. EU request to report on the implementation of the Baltic Sea Multiannual Plan. *In* Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sr.2019.15, https://doi.org/10.17895/ices.advice.5459