**POLICY BRIEF June 2021**

# Adapt herring fisheries to scientific uncertainty

**The scientific assessments of the fish stocks in the Baltic Sea are characterized by great uncertainty. In the last five years, the size of the Central Baltic herring stock has been greatly overestimated - which has probably contributed to excessive catch quotas. It is time to introduce a larger buffer for the scientific uncertainty in management and quota decisions.**

Every autumn, EU fisheries ministers negotiate the next year's total allowable catches (TACs) for commercial fishing in the Baltic Sea. They are aided in this exercise by scientific advice from the International Council for the Exploration of the Sea (ICES) on how large catches can be allowed to achieve maximum sustainable yield (MSY). However, scientific stock estimates are fraught with uncertainties.
Estimates of how stocks and fishing mortality have developed over time can vary greatly from year to year. These uncertainties are not clearly explained in the advice, which increases the risk of overfishing. A larger precautionary buffer is needed in TAC decisions for Baltic fisheries to compensate for the uncertainty.
For stocks that show clear signs of depletion, such as the Central Baltic herring, the TAC should be set to 50 percent below the estimated MSY level ($F_{MSY}$).
TACs for other commercial stocks should be set at the lowest MSY level ($F_{lower}$) and in the longer term at 50 percent below $F_{MSY}$. This would provide catch quotas in better harmony with both scientific and ecological realities - and reduce the risk of further depletion of the Baltic fish stocks.

## The uncertainty made visible

ICES' annually recommended TACs for commercial stocks in the Baltic Sea are based on preliminary estimates of how the stocks have evolved over time. Some of the most important parameters are:

- Spawning stock biomass (SSB) – the amount of sexually mature fish
- Fishing mortality (F) – the amount of fish killed by fisheries
- Recruitment (R) – the amount of new fish added to the stock each year.

In the scientific advice, comparisons are also made with estimates from previous years – and it is in these camparisons that the scientific uncertainty becomes particularly visible. For example, when it comes to sprat[1], the western spring spawning herring[2] and the western cod stock[3], there are significant differences between different years' estimates.

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[1] ICES Advice on fishing opportunities, catch, and effort for sprat (Sprattus sprattus) in subdivisions 22–32 (Baltic Sea), 28 May 2021
https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/spr.27.22-32.pdf
[2] ICES Advice on fishing opportunities, catch, and effort for herring (Clupea harengus) in subdivisions 20–24, spring spawners (Skagerrak, Kattegat, and western Baltic), 28 May 2021
https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/her.27.20-24.pdf
[3] ICES Advice on fishing opportunities, catch, and effort for cod (Gadus morhua) in subdivisions 22–24, western Baltic stock (western Baltic Sea)
https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/cod.27.22-24.pdf

The most significant differences can be seen in the compared estimates of the Central Baltic herring stock.
According to ICES' latest stock assessment[4] and TAC advice[5] the size of the stock has been greatly overestimated for many years. At the same time, fishing pressure has been underestimated, and exceeded the limit value for sustainable fishing ($F_{MSY}$). This difference is also reflected in comparisons between older and newer stock assessment models.[6]

**Spawning stock biomass grossly overestimated**

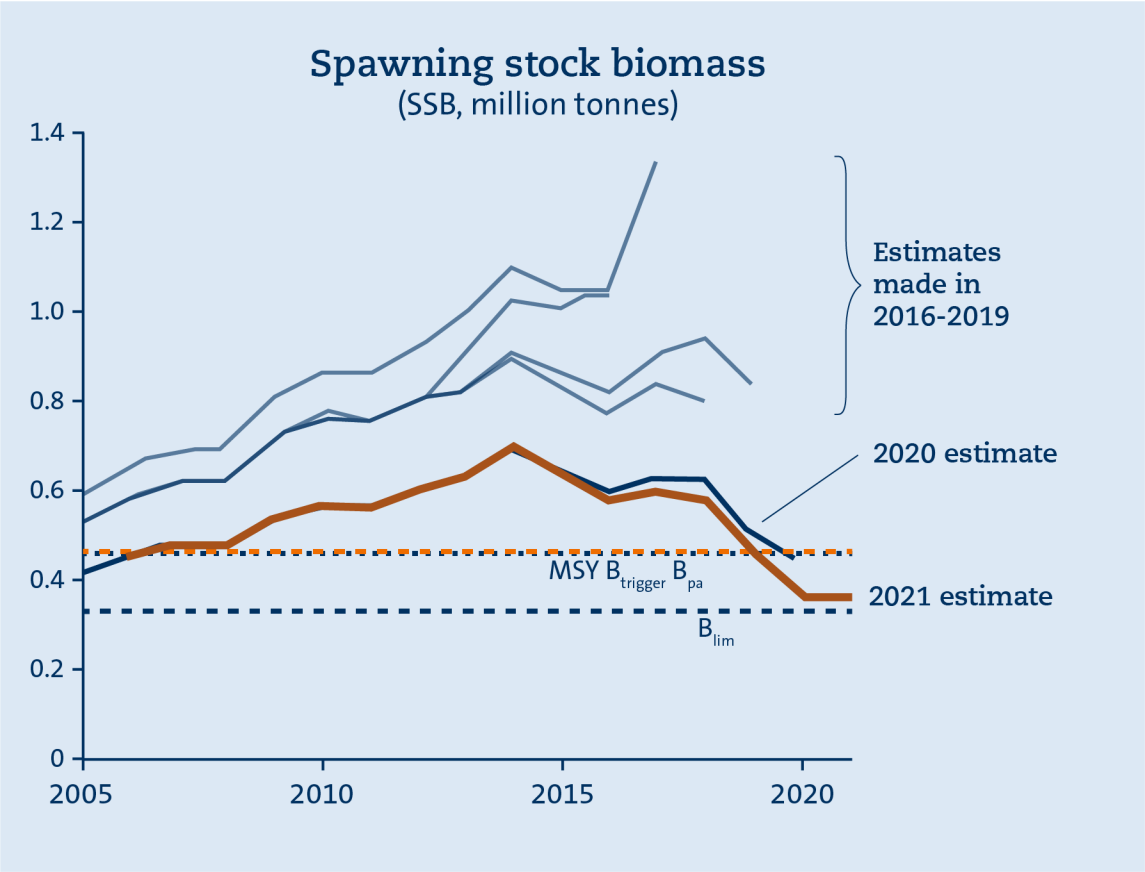


*Figure 1. Comparison of the five annual estimates of the spawning stock biomass (in tonnes) of the Central Baltic herring stock, made between 2016 and 2020. Note that MSY $B_{trigger}$ and $B_{pa}$ are at the same level. Source: ICES*

According to the stock estimate made in 2016 (the shortest curve in the graph above), the situation looked very good for the Central Baltic herring. ICES models showed that the spawning stock biomass (SSB) had grown from around 500,000 tonnes to just over one million tonnes since 2015. The following year, the SSB was estimated at just over 1.3 million tonnes. But from then on the data and the scientific models improved, which gradually gave an more bleak picture of the development.

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[4] ICES Inter-benchmark on Baltic sprat (*sprattus sprattus*) and herring (*clupea harengus*), Volume 2 / Issue 34, 2020. http://doi.org/10.17895/ices.pub.5971

[5] ICES Advice on fishing opportunities, catch, and effort for herring (Clupea harengus) in subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea), 28 May, 2021
https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/her.27.25-2932.pdf

[6] Baltic Fisheries Assessment Working Group (WGBFAS) Volume 3, Issue 53, s 287-288 (ICES, 2021)
https://www.ices.dk/sites/pub/Publication%20Reports/Forms/DispForm.aspx?ID=37633

The estimate from 2021[7] shows that the SSB has never been close to 1.3 million tonnes in the last 30 years. At most, it has been just over 700,000 tonnes (2014), and then dropped to the current level of just under 500,000 tonnes.
For several years, the EU's fisheries ministers thus received scientific advice which said that there was significantly more fishable herring than there actually was. They determined TACs accordingly. In 2017, for instance, on the basis of the SSB estimate of 1.3 million tonnes, the TAC for 2018 was set at 244,365 tonnes in accordance with the MSY target. But in reality, the SSB was probably only half as large, about 600,000 tonnes, which should have led to a much lower TAC (about 130,000 tonnes).

**A decade of overfishing**

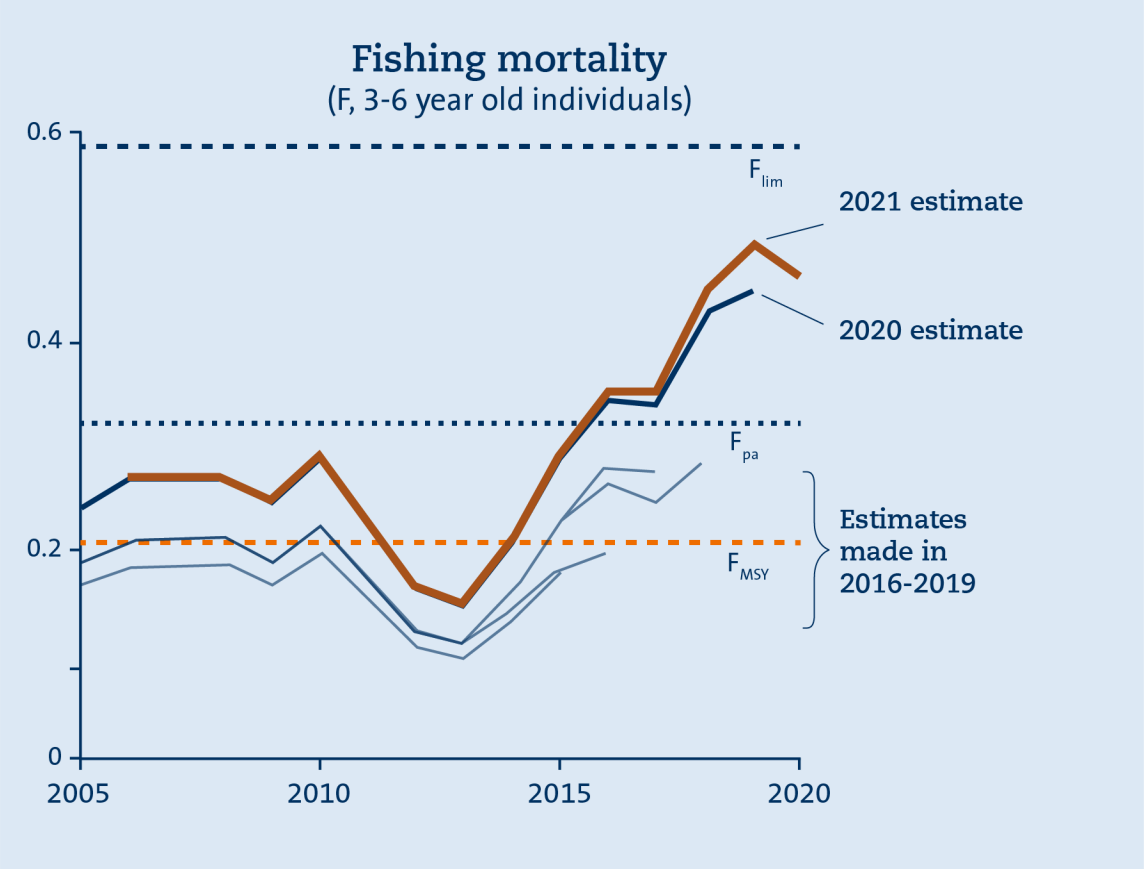


*Figure 2. Comparison of the annual estimates of fishing mortality for the Central Baltic herring stock, made between 2016 and 2021. The latest estimate from 2021 (red curve) shows that the stock has been overfished (over $F_{MSY}$) for most of the last 15 years. Source: ICES*

Fishing mortality (F) indicates the proportion of a stock that is killed by fishing. As long as the fishery does not kill more fish than the stock can produce from year to year (taking account of natural mortality), the fishery is considered to be sustainably managed. If the fishing exceeds the fishing mortality consistent with achieving the maximum sustainable yield ($F_{MSY}$), it is classified as overfishing. Maintaining fishing pressure at or below $F_{MSY}$ is one

[7] ICES Advice on fishing opportunities, catch, and effort for herring (Clupea harengus) in subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea), 28 May, 2021
https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/her.27.25-2932.pdf

of the criteria for assessing whether a commercially fished stock has "good environmental status", according to the EU Marine Strategy Framework Directive (MSFD).[8]
ICES' latest assessment of the Central Baltic herring (2021) shows that the stock has been overfished every year since 2005, with the exception of 2012 and 2013. However, this did not appear in the scientific advice until 2020. For example, in 2016, ICES assessed that the stock had been fished sustainably between 2005 and 2015. That year's TAC negotiations assumed that this was the case – but in reality, the stock had been overfished for a decade.

As recently as 2019, the scientific assessment concluded that fishing mortality for 2018 was just above $F_{MSY}$, and the herring fishery could still be classified as a reasonably sustainable. But according to later estimates, fishing mortality had already reached far beyond the limit for $F_{MSY}$ (just over 0.2) and was significantly above the precautionary level $F_{pa}$ (around 0.5). In 2020, therefore, fishing mortality was actually more than twice as high as it should have been according to MSY.

**Overestimated recruitment**

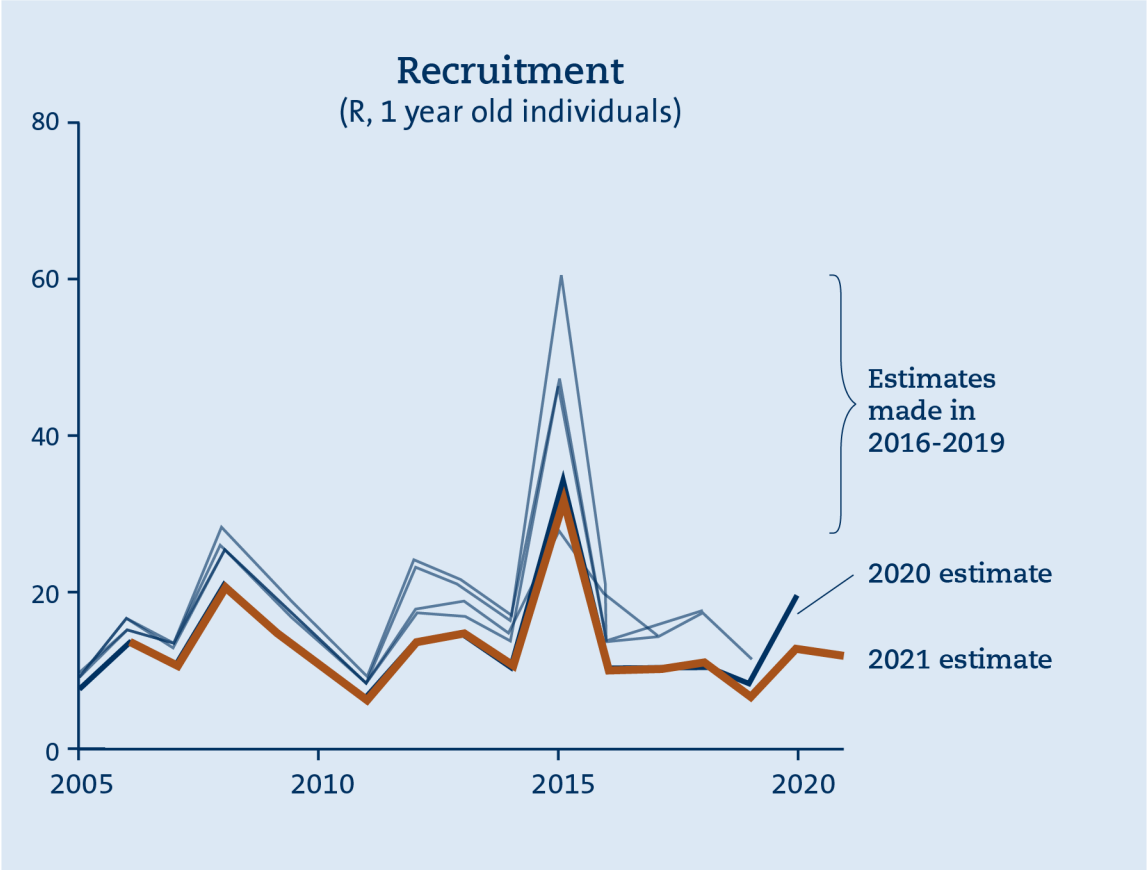


*Figure 3. Annual estimates of recruitment in the central herring stock, made between 2016 and 2020. The latest estimate (blue line) shows that recruitment has been greatly overestimated for several years. Source: ICES*

The recruitment in the Central Baltic herring stock soared in 2015, and created a record-breaking year class of herring. At that point, ICES estimated that the stock would have over

[8] https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm

25 billion new individuals. In 2017, recruitment for 2015 was significantly adjusted upwards, to 61 billion individuals. The conclusion was that a huge amount of herring would reach fishable size in 2018.
According to the latest ICES assessment (2021), however recruitment in 2015 was in fact just over 30 billion individuals – that is, half as large as was thought in 2017. This miscalculation probably had a major impact on TAC decisions.

### Uncertain forecasts

The annual ICES stock assessments and TAC advice are based on extensive scientific work and advanced modeling. Data are obtained from research, environmental monitoring, sampling and the catches reported by the fisheries.
Perhaps the most important reason why stock estimates and assessments can vary so greatly from year to year is that the process in itself consists of a large number of different factors – none of which is constant. Everything, from climate change and other environmental conditions to species development and interaction, is constantly changing. The methods for calculating stock size and catches also change over time.

### Uncertain data from the fishermen

Misreporting of catches is another important source of uncertainty. It has been shown that large-scale pelagic trawling vessels in many cases catch more sprat and less herring than indicated in their catch reports.[9] This is a well-known and presumably extensive problem, about which the administration currently has little knowledge. Correct catch data from the fisheries are a central part of the researchers' stock analyzes and estimates, and incorrect reporting can therefore lead to grossly incorrect estimates.

### Sub-populations and lack of knowledge

The goal in today's MSY-based fisheries management is to fish exactly at level where the stocks give the highest yield in biomass, with the smallest possible margin. At the same time, fishing must be sustainable. This places unreasonably high demands on data and precise stock estimates – especially in a complex and changing marine ecosystem such as the Baltic Sea.
For the Central Baltic herring, the requirements are particularly high since it has been shown that the stock in fact consists of several sub-populations and local spawning stocks with different reproduction, growth and mortality rates.[10] At present, the fisheries administration does not take this into account, as the state of knowledge about the herring stock structure is considered insufficient.
At the same time, a larger proportion of the Swedish large-scale pelagic herring fisheries has moved closer to the east coast[11]. Thus, there is a great risk that local sub-populations will be depleted or even disappear due to an excessively high fishing pressure, and that the catch may be very large locally in the areas where large-scale fishing is conducted.

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[9] SR Kaliber: *Många rapporterar fel fiskmängder* (sept 2019) https://sverigesradio.se/artikel/7298246
[10] Fan Han et al: *Ecological adaptation in Atlantic herring is associated with large shifts in allele frequencies at hundreds of loci (eLife, 2020)* https://elifesciences.org/articles/61076
[11] Policy brief: *Minska det kustnära trålfisket för att skydda Östersjösillen* (Östersjöcentrum 2021) https://balticeye.org/sv/policy-briefs/minska-det-kustnara-tralfisket-for-att-skydda-ostersjosillen/

## Other uncertainties

EU fisheries policy mandates an ecosystem-based management that applies the precautionary approach and contributes to achieving good environmental status for the sea. Today's management does not live up to these requirments. With its one-sided focus on achieving the MSY goals of maximum yield, management takes far too little account of other important factors, such as:

- the consequences of offshore fishing for coastal and archipelago fisheries
- the important role of herring in the ecosystem, both offshore and in coastal areas
- the role of herring as food for other commercially fished species.

## Buffer for uncertainty in TAC decisions

Scientific uncertainty calls for more caution, not less. Therefore, managment should introduce a buffer for uncertainty in the TAC decision process as soon as possible. This means that TACs should be incrementally set at 50 percent below Fmsy for all commercial stocks in the Baltic Sea. It is not possible to prove that 50 percent has a better effect than, for example, 40 or 60 percent. But the target must be set somewhere. Scientific modeling[12] shows that catch levels of about half of Fmsy can reduce the risk of overfishing and provide greater returns in the longer term.

For stocks that show clear signs of depletion, the 50 percent buffer should be introduced immediately. This applies, for example, to herring in the central Baltic Sea, where there is currently an obvious risk of subpopulations and local spawning stocks being wiped out. In addition, large herring are missing along the Swedish east coast, which indicates that the fishing pressure is too high.
For stocks that develop particularly negatively, fishing should be stopped completely until the stock has recovered.[13]

## Use $F_{lower}$

In the long term, a buffer of 50 percent below $F_{MSY}$ should also be introduced for other fish stocks in the Baltic Sea – not least for sprat, as the fishing for sprat and herring is a mixed fishery. Until then, management should use the safety margin that is already in place in ICES recommendations, and consistently set TACs for other stocks on $F_{lower}$, which is the lowest level of fishing mortality within the $F_{MSY}$ framework.

## Reduced risk for overfishing

The introduction of a 50 percent buffer in TAC decisions could be a powerful management tool to deal with the inevitable uncertainties associated with fisheries management, scientific advice and ecosystem change. At the same time, the risks of overfishing due to lack of knowledge would be radically reduced. In the longer run, it would probably provide not only more sustainable fish stocks but also more profitable fishing.

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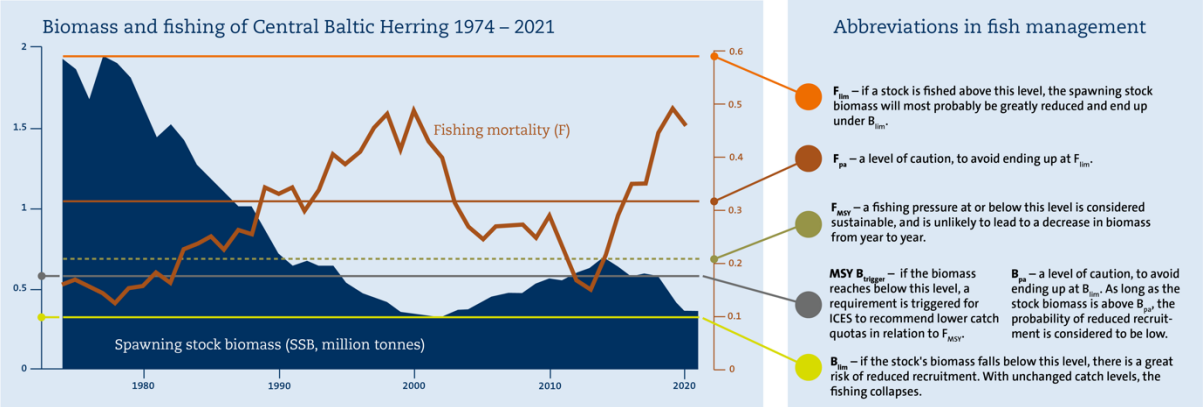
[12] Mildenberget, Tobias K. et al*: Implementing the precautionary approach into fisheries management: Making the case for probability-based harvest control rules* (bioRxiv, 2020)
https://www.biorxiv.org/content/10.1101/2020.11.06.369785v1.abstract

[13] This was done, for example, for the North Sea herring between 1977 and 1983 as a result of long-term overfishing.

## RECOMMENDATIONS

- Set the annual catch quotas (TAC) for Central Baltic herring 50 percent below the recommended MSY quota ($F_{MSY}$).
- Introduce in the longer term a similar buffer for uncertainty also for sprat and other commercially fished stocks in the Baltic Sea.
- Until the buffer for uncertainty is introduced as a rule in the TAC decision process for all commercial stocks, the TAC should be set at the lowest possible $F_{MSY}$ level, i. e. $F_{lower}$.
- Carry out a thorough investigation of the fisheries's misreporting of herring and sprat, and analyse to what extent it affects the scientific stock estimates.
- Complement today's management models with better regulation of what, when and how fishing may be conducted, where a first step would be to move the Swedish trawl boundary further out from the coastline.




*Since the 1970s, spawning stock biomass of the Central Baltic herring has decreased by almost 80 percent, from about two million tonnes (1974) to just under 500,000 tonnes (2020). The decline took off in the early 1980s at the same time as fishing pressure rose above the limit for sustainable fishing ($F_{MSY}$). When spawning stock biomass reached a bottom of 330,000 tonnes (around 2003), fishing pressure was at its highest. In the following years, fishing decreased sharply, while spawning stock biomass increased. Today, the spawning stock biomass is below sustainable levels while the fishing pressure is again too high.*

## Setting TACs with a buffer for uncertainty

For 2022, ICES recommends that the total allowable catch (TAC) for Central Baltic herring be set between 52 443 and 87 581 tonnes, and that, according to $F_{MSY}$, it should not exceed 71 939 tonnes. With the uncertainty buffer proposed in this policy brief, the TAC for Central Baltic herring would be 35 970 tonnes (71 939 x 0.5).

For herring in the Gulf of Bothnia, ICES recommends that the TAC be set between 86 729 and 111 714 tonnes, where the catch corresponding to $F_{MSY}$ is 111 345 tonnes. With a buffer against uncertainty, the TAC for herring in the Gulf of Bothnia would instead be 55 677 tonnes (111 345 x 0.5).

## ICES and MSY

The MSY concept is used to estimate the maximum sustainable yield, or the largest catch, that can be made from a fish stock while leaving enough fish to increase or maintain the stock at the theoretically most productive level.

- ICES interpretation of MSY aims at maximizing the average long-term return from a given fish stock while maintaining productive fish stocks.[14]
- ICES advice aims to *inform policies for high long-term yields while maintaining productive fish stocks in marine ecosystems that meet expected environmental standards (e.g. good environmental standards (GES) in the EU)*.[15]
- All ICES advice are in accordance with the precautionary principle, which is a necessary but not sufficient condition for MSY.[16]

Over the years, ICES has worked to develop criteria to minimize the risk of overfishing and possibly jeopardize the reproductive capacity of the stock.

[14] ICES Advice basis (2019)
https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/Introduction_to_advice_2019.pdf
[15] ICES Advice basis (2019)
https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/Introduction_to_advice_2019.pdf
[16] ICES Advice basis (2019)
https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/Introduction_to_advice_2019.pdf