BALTIC FISHERIES ASSESSMENT WORKING GROUP (WGBFAS)

September 2024: Updates to Section 4.4 (Herring in Subdivisions 30 and 31) and WD3 added.

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i Executive summary

Required summary structure:

The main ToR of WGBFAS is to assess the status and produce a draft advice on fishing opportunities for 2025 for the following stocks:

- Sole in Division 3.a, SDs 20–24 (Skagerrak and Kattegat, western Baltic Sea; catch advice)
- Cod in Kattegat SD 21 (catch advice)
- Cod in SDs 24–32 (eastern Baltic; catch advice)
- Herring in SDs 25–27, 28.2, 29 and 32 (central Baltic Sea; catch advice)
- Herring in SD 28.1 (Gulf of Riga; catch advice)
- Herring in SDs 30-31 (Gulf of Bothnia; catch advice)
- Sprat in SDs 22–32 (Baltic Sea; catch advice)
- Plaice in SDs 21–23 (Kattegat, Belt Seas, and the Sound; catch advice)
- Plaice in SDs 24–32 (Baltic Sea, excluding the Sound and Belt Seas; catch advice)
- Turbot in SDs 22-32 (Baltic Sea; stock status advice for years 2025 and 2026)
- Flounder in SDs 22-32 (Baltic Sea; stock status advice for years 2025 and 2026)
- Flounder in SDs 24+25 (Baltic Sea; stock status advice for years 2025 and 2026)
- Flounder in SDs 26+28 (Baltic Sea; stock status advice for years 2025 and 2026)
- Flounder in SDs 27, 29-32 (Baltic Sea; stock status advice for years 2025 and 2026)

The working group fulfilled the ToRs in assessing the stock status and produced draft advice, including, where relevant, forecasts for fishing opportunities for all stocks with two exceptions. The assessment for cod in SDs24-32 (eastern Baltic) was downgraded from category 1 to category 3 due to limited input data and inconsistencies in model estimates. However, trends in SSB and F are still considered reliable and are used as basis for the advice. The advice for Gulf of Bothnia herring is postponed as the biological reference points for this stock are in need of revision. Work concerning the reanalysing of biological reference points will happen outside the working group meeting dates and will be reviewed in autumn. The WG was not requested to produce advice for dab and brill stocks in the Baltic Sea (brill in SDs 22-32, dab in SDs 22-32). For these stocks, however, data were compiled and updated, and update assessments were conducted. In the introductory chapter of this report the WG, in agreement with the other ToRs, reviews the progress on benchmark processes, identifies the data needed for next year's data call with some suggestions for improvements in the data call, and summarizes general and stock-specific research needs. The introduction further summarizes the work of other WGs relevant to WGBFAS, and the assessment methods used. Finally, the introduction presents a brief overview of each stock., The analytical models used for the stock assessments were SAM, Stock Synthesis (SS) and SPiCT. For most flatfish (data limited stocks), CPUE trends from bottom-trawl surveys were used in the assessment.

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ii Expert group information

Expert group name	Baltic Fisheries Assessment Working Group (WGBFAS)
Expert group cycle	Annual
Year cycle started	2024
Reporting year in cycle	1/1
Chair(s)	Kristiina Hommik, Estonia
Meeting venue(s) and dates	10.-11. April, 2024, online Teams meeting (data preparation)
	16.-23. April, 2024, ICES headquarter, Copenhagen (30 participants)

1 Introduction

1.1 ICES code of conduct

The ICES code of conduct and the importance of identifying, reporting, and dealing with any potential conflict of interest were discussed at the start of the meeting. No conflict of interest was declared.

1.2 Review progress on benchmarks processes of relevance of the Expert Group

Several flatfish stocks within the working group was benchmarked in 2023 and early 2024. For remaining 2024 and for 2025/2026 Eastern Baltic cod, sole in 20-24, Flounder in 24-25, and two plaice stocks (21-23 and 24-32 at forthcoming scheduled WKBPLAICE in autumn 2024) are the stocks considered for benchmark processes. The main issues to be solved under these coming benchmarks are given below in the table.

An issue list is available for each stock with research needs and prioritization. Issue lists will be continually updated, and benchmarks called for when a likely research outcome could validate a benchmark.

Stock	Year for benchmark	Benchmark type	Issues	Present/aimed category
ple.27.21-23	2024	Full BM	Improve model parametrization and consider input data. Stock ID Update reference points.	1/1
ple.27.24-32	2024	Full BM	Establish an Age-based analytical assessment (SAM); presently biomass model. Stock ID	2/1
sol.27.20-24	2025	review	include index from extended survey area since 2016 Establish Stock weight at age; survey inf. Establish Maturity at age; landing sample inf. Further consider stock ID; connectivity to NS stock and implementation into assessment	1/1

cod.27.24-32	2025/2026	Review	SPiCT model considerations Examining assumptions on parameter input for model settings for the following: recruitment selectivity in fishery recent growth recent mortality	3/1
Bzq.27.24-25	2024/2025/2026	Full BM	new survey index SPiCT implementation	3/2
Her.27.30-31	2024	review	Reference points re-estimation	1/1

1.3 Prepare the data call for the next year update assessment

It was agreed upon that current specifications for the WGBFAS data call are up to date. However, one specification was found missing which concerned the exact data format for the maturity data on central Baltic herring stock. A description of the exact data format for the maturity data will be added to the Annex 1 of the data call.

1.4 Identify research needs of relevance for the work of the Expert Group

The WG recognizes that several ICES ecosystem working groups exist, which provide regular updates on selected environmental and lower trophic level indicators, including those related to fish recruitment, and regional descriptions of ecosystem changes (e.g., ICES WGIAB 2012, 2014). However, recent ICES initiatives to bring together ecosystem and stock assessment scientists in seeking solutions to the assessment and management revealed that there is a lack of up-to-date ecosystem process understanding, essential for stock assessment and management advice. This could possibly also affect other stocks but currently, there is also a challenge related to a mismatch between what is available from science and what is needed for stock assessment and management advice.

Below is a list of the most important parameters needed for a reliable stock assessment. All parameters are dependent on the understanding of current ecosystem processes:

- *Reliable recruitment estimates*
  Important for the development of the stock and for the forecast,
- *Reliable growth estimates*
  Important for stock development and health of the stock,
- *Accurate age determination*
  Vital for age base stock assessment models,
  Needed to accurately determine growth,
- *Catchability in the fishery*
  Shift in catchability will affect our perception of the stock development,

- *Quality assured survey indices*
  Will affect our perception of the stock,

- *Ecosystem-dependent estimates of natural mortality*
  Will affect our perception of the stock,

- *Accurate discard information*
  Accurate catch numbers and weight are central for stock assessment and are also important for the evaluation of the landing obligation,

- *Spatial distribution and migration between management areas*
  Integrated ecosystem knowledge is important to determine ecosystem advice,

- *Nutritional condition development*
  An important indicator of the ecosystem health and also possibly for information on infections,

- *Development of alternative stock assessment models that can include new information*
  The present variable ecological situation in the Baltic Sea and the need to integrate ecosystem factors in traditional assessment models demand alternative models.

The present variable ecological situation in the Baltic Sea and the need to integrate ecosystem factors in traditional assessment models demand alternative models.

This list of general issues is not exhaustive and does not include the specifics of particular stocks assessed by the WG. The summary of stocks linked to their most recent issue lists are available online at https://stockdatabase.ices.dk/Manage/rollingissues.aspx.

1.5 Review of the main results of Working Groups of interest to WGBFAS

Working Group on the Baltic International Fish Surveys (WGBIFS)

The presentation of WGBIFS 2023 was composed from two parts focused on the:

- Baltic acoustic-trawl surveys (BIAS, BASS, GRAHS) in 2023, and
- BITS surveys in 2023-Q4 and 2024-Q1.

BIAS

BIAS database was updated with the survey results from 2023. The national BIAS 2023 data were also uploaded into the ICES database for acoustic trawl surveys. It was pointed out that GRAHS data for 1999-2004 are still missing in the ICES database for acoustic-trawl surveys. The Baltic International Acoustic Survey (BIAS) in September-October 2023 was completed almost according to the plan. However, there is no data available from the Russian EEZ. The geographical distribution of herring and sprat abundance at age 1+ and age 0, and cod in the Baltic Sea, calculated per the ICES rectangles in 2023 was demonstrated in consecutive graphs. In September-October 2023, the highest concentrations of herring (age 1+) were detected in the northeastern part of the Baltic Proper and in the Gulf of Finland. The geographical distribution of age 0 herring abundance was limited mainly to the southwestern and northeastern part of the Baltic proper, and to the Gulf of Finland. Total abundance of age 0 herring was well below the average level of

the survey time series. Sprat (age 1+) dense shoals were mostly distributed in the Gulf of Finland. Total abundance of age 0 sprat was very low. Highest abundances of age 0 sprat were recorded in the eastern part of the Baltic Proper. Central Baltic herring and Gulf of Bothnia herring BIAS abundance indices more than doubled compared to the previous year. Sprat BIAS abundance index decreased somewhat compared to the previous year. Cod was concentrated mostly in the south-western part of Baltic Proper.

WGBIFS recommended:

- The updated BIAS index series (including data from SD 32) can be used in the assessment of the herring (CBH) and sprat stocks in the Baltic Sea with the restriction that the years 1999, 2001-2005 and 2008 are excluded from the index series.
- The updated BIAS index series calculated by the StoX can be used in assessment of the Gulf of Bothnia herring stock size.

BASS

BASS database was updated with the survey results from 2023. The national BASS 2023 data were also uploaded into the ICES database for acoustic trawl surveys. The Baltic Acoustic Spring Survey (BASS) in May 2023 was completed almost according to the plan. However, there is no data available from the Russian EEZ. Additionally, two rectangles in Lithuanian waters were not covered due to Lithuanian issues with the vessel. In the May survey, sprat was distributed quite equally all over the Baltic proper. Somewhat higher concentrations of sprat were distributed in the southern part of the Baltic Proper. BASS sprat abundance index showed a slight decrease compared to the previous year.

WGBIFS recommended:

The updated BASS index series can be used in the assessment of sprat stock in the Baltic Sea with restriction that the year 2016 is excluded from the dataset.

GRAHS

GRAHS database was updated with the survey results from 2023. The national GRAHS 2023 data were also uploaded into the ICES database for acoustic trawl surveys. The Gulf of Riga Acoustic Herring Survey (GRAHS) in July-August 2023 was completed according to the plan. The highest concentrations of herring were distributed in the northwestern part of the Gulf of Riga (in Estonian waters). Herring abundance index showed a slight decrease compared to the previous year.

WGBIFS recommended:

The updated GRAHS index series calculated by Latvia can be used in the assessment of Gulf of Riga herring stock.

BITS

During the 4th quarter 2023, the level of realized valid hauls represented 97 % of the total planned stations. During the 1st quarter 2024, the survey realization was at the same level as the year before, i.e. 97%. The number of realized valid hauls is above the mean historical level. However, there is no data available from the Russian EEZ. Graphs demonstrating the geographical

distribution of cod, flounder, plaice, dab, turbot and brill during the BITS surveys were provided to the respective stock coordinators and assessors.

WGBIFS recommended:

The data obtained and uploaded to DATRAS for both the 4th quarter 2023 and the 1st quarter 2024 BITS are used for calculating survey indices for the relevant cod and flatfish stocks.

Working Group on Multispecies Assessment Methods (WGSAM)

The Working Group on Multispecies Assessment Methods (WGSAM) aims to advance the operational use of knowledge on predator-prey interactions for advice on fisheries and ecosystem management. Key runs of multispecies and ecosystem models provided by WGSAM are integral to this mission. They serve as a robust component of ecosystem science that seamlessly integrates into the ICES advice. In 2023 WGSAM met 9-13 October and the main focus of the meeting was updating the North Sea SMS key-run.

Working Group of Integrated Assessment of Baltic Sea (WGIAB)

The Working Group of Integrated Assessment of Baltic Sea is meeting from 6-10. May, 2024. The three main topics which are addressed in the meeting are: Integrated analysis on a subbasin level (will results in a manuscript); overlooking the Baltic Sea ecosystem overview; Bayesian Networks.

Working Group of Mixed Fisheries (WGMIXFISH)

WGMIXFISH in its current setting mainly been working with the North Sea stocks. However, since 2019, the Kattegat cod has been included as a result of the zero-catch advice for the stock. The main purpose of the group is to identify the effect of different utilisation for the species present in the mixed fishery. The forecast from the individual assessments of the species is used in order to model the outcome on each individual species if on the species caught in the mix fish fishery is fully utilised.

The result is series of different scenarios for different utilisation of the individual quotas for the potential different exploitation pattern in the mix fishery. The result also provides an overview for managers to identify choke species.

So far, the only species present from the Baltic working group is the Kattegat cod. In 2023 the first steps were made to start the process of developing mixed fishery scenarios for the Baltic Sea. However, it should be noted that progress in developing these models is dependent on the transition from InterCatch to RDBES database. Currently countries are submitting data for Baltic using relatively high-level métier codes (i.e. “active”, “passive”) rather than level 6 métier codes which are needed for the analysis. Transitioning from InterCatch to RDBES guarantees the necessary resolution for the data which is needed to conduct the analysis. Meanwhile, further analysis on mixed fisheries fleets to best reflect the technical interactions in the region will be conducted using the RDBES data.

Workshop on the calculation and evaluation of new reference points for category 1-2 stocks (WKNEWREF)

The goal of WKNEWREF is to put the theory into practice calculating reference points following the recommendations of WKREF1 and WKREF2. The involvement of stock assessors is crucial for the working group to succeed. The list of the 27 stocks that contributed to the working group is shown in Table 1. Some participants worked in more than one stock.

Table 1. List of stock that contributed to WKNEWREF.

	Stock		
1	ank.27.78abd	15	hke.27.8c9a
2	cod.21.1.osc	16	mac.27.nea
3	cod.21.1a-c	17	mon.27.78abd
4	cod.21.1d-f	18	pil.27.8c9a
5	cod.27.46a7d20.NW	19	ple.27.420
6	cod.27.46a7d20.SO	20	ple.27.5b
7	cod.27.46a7d20.V	21	pok.27.1-2
8	cod.27.7e-k	22	reb.27.1-2
9	ghl.27.1-2	23	sol.27.20-24
10	had.27.5b	24	sol.27.7d
11	had.27.7b-k	25	sol.27.7fg
12	her.27.28	26	whg.27.47d
13	her.27.3031	27	whg.27.7b-ce-k
14	hke.27.3a46-8abd		

A generic R code was developed before the meeting to facilitate the work of the participants and to work with a standard same code. The code followed the TAF approach which will contribute and promote the framework and allow for direct integration in TAF of the stock specific analysis. The analysis was focused on the calculation of the reference points used currently on the ICES reference points framework to provide catch advice, namely, B_{lim}, $MSYB_{trigger}$, F_{msy} and F_{pa}, using the current definition and the WKREF1-2 proposals. Several analyses were conducted to analyse the suitability of alternative definitions for each of the reference points. The work was not finished during the meeting and is still ongoing.

Workshop on guidelines and methods for the evaluation of rebuilding plans (WKREBUILD2)

A first workshop on guidelines and methods for the design and evaluation of rebuilding plans for category 1-2 stocks, WKREBUILD, took place in 2020. WKREBUILD generated a guidance on best practices for evaluation of rebuilding plans against potential criteria of acceptability. However, it did not propose specific rebuilding plans or harvest control rules (HCRs). Instead, the workshop re-commended that a follow-up workshop be organized for testing the guidelines with actual test cases, with the aim of defining more specific criteria and guidelines. Thus, the main objective of WKREBUILD2 was to propose performance indicators and thresholds for the implementation and acceptability of rebuilding plans and a framework for the integration of rebuilding advice rules within the ICES advice framework.

To facilitate the evaluation of rebuilding plans a simulation tool was developed. The tool is based on FLR libraries and the application to specific cases is facilitated through a template consistent with TAF (Transparent Assessment Framework) and ensures an easy integration of the analysis into the ICES TAF system. The tool was tested in three specific case studies, Celtic Sea Whiting, Western Horse Mackerel and Western Baltic Herring. The application to the case studies served to validate the tool and to provide the science base to propose operational performance thresholds and criteria for the evaluation and implementation of rebuilding strategies in ICES.

WKREBUILD2 proposes to use BPA as the entry point to the rebuilding phase and MSY Btrigger as the exit point. Once a stock is estimated to be below BPA in the last assessment year, stock specific rebuilding strategies should be tested by means of simulations, preferably using the WKREBUILD2 simulation tool as the performance of HCRs are dependent on depletion rate and life history. The harvest control rule that fulfils the rebuilding criteria could then be selected to

provide headline catch advice. Two criteria to be simultaneously fulfilled are proposed for the selection of the HCR: 1) the time of recovery (i.e., time to rebuild the stock) should not exceed twice the time required to recover the stock in the absence of fishing; 2) cumulative catches are maximised over a common rebuilding period. A stock is considered to be rebuilt when it has been above MSY Btrigger for at least three consecutive years.

Future work should be focused on defining suitable MSY Btrigger reference points that are linked to a target biomass level as for example BMSY and not to BPA, replacing the three consecutive year criteria by a time criteria based on the biological characteristics of the stock as for example generation time or time to sexual maturity, revising the proposed guidelines based on the implementation of rebuilding strategies in practice and considering augmenting the rebuilding criteria with indicators of the demographic structure of the stock. The acceptable time to recovery (twice the time needed in the absence of fishing) could be shortened and the maximum cumulative catch criteria could be replaced according to management objectives agreed by relevant management parties. Recommendations for the improvement and further development of the simulation tool were made and they are already being implemented.

Workshop on establishing a roadmap for possible conservation measures for herring in the Baltic (WKHERBAL)

The Workshop on establishing a roadmap for possible conservation measures for Herring in the Baltic (WKHERBAL) was established in response to a special request from DGMARE. The potential drivers of the observed changes in age and size structure and condition of central Baltic and Gulf of Bothnia herring (*Clupea harengus*) stocks were discussed.

The timing of the observed declines was notably different between the two stocks with the decline in Central Baltic herring starting in the mid-1980s and lasting over a decade to the late 1990s. Whereas the decline in the Gulf of Bothnia started around 1990 and continued until the mid-2000s. Both stocks also show a similar sudden decline in weight-at-age in 2021 followed by a recovery in 2022. The reasons for these changes are likely to be multifactorial and while several possible causes have been suggested the relative contribution of these has not been established. WKHERBAL identified several actions in the short and long-term to further investigate the potential drivers of the observed changes in age and size structure and condition. These actions can be further elaborated and supported through dedicated scoping and resourcing to transform them into an operational roadmap to address the six evidence needs identified in the request. To implement the proposed actions, effective and sustained cooperation between all relevant Baltic Sea countries is needed.

Special request answer: https://ices-library.figshare.com/articles/report/EU_request_to_establish_a_roadmap_for_possible_conservation_measures_for_central_Baltic_and_Gulf_of_Bothnia_herring/25435741

WKHERBAL report: https://ices-library.figshare.com/articles/report/Workshop_on_establishing_a_roadmap_for_possible_sonservation_measures_for_herring_in_the_Baltic_WKHERBAL_/25310959

1.6 Methods used by the Working Group

Full analytical assessments with subsequent short-term forecasts were conducted for the following stocks:

a) Sole in Division 3.a + SDs 22—24
b) Plaice in SDs 21—23
c) Plaice in SDs 24—32
d) Herring in SDs 25—29 and 32, excluding SD 28.1

e) Herring in SD 28.1 (Gulf of Riga)
f) Herring in SDs 30—31, without STF
g) Sprat in SDs 22—32

Trend-based assessment were carried out for the following stocks:
a) Cod in the Kattegat
b) Cod in SDs 22 – 24
c) Cod in the SDs 24—32, downgraded from category 1 to category 3
d) Flounder in SDs 22–23
e) Flounder in SDs 24–25
f) Flounder in SDs 26 and 28
g) Flounder in SDs 27, 29–32
h) Brill in SDs 22–32
i) Dab in SDs 22–32
j) Turbot in SDs 22–32

The stochastic state-space model (SAM) (Nielsen, ICES 2008) was used for assessment of cod in Kattegat, cod in SDs 22-24, plaice in SDs 21–23, sole SDs 20–24, herring in SD 28.1 (Gulf of Riga) and sprat in SDs 22-32. Details on model configuration, including all input data and the results can be viewed at www.stockassessment.org. The assessments of cod in SDs 24-32, herring in SDs 30-31 and herring in SDs 25 – 29 and 32, excluding SD28.1 were conducted using the Stock Synthesis (SS) model (Methot and Wetzel, 2013). The assessment for plaice in SDs 24-32, flounder in SDs 22-23, flounder in SDs 26 and 28, and dab in SDs 22-32 was conducted using the stochastic surplus production model in continuous time (SPiCT; Pedersen and Berg, 2016), and the relative values of the assessment are used. The results of analyses are presented in corresponding sections of stocks. No advice was requested for brill and dab, but update assessments were conducted and included in the report.

1.7 Stock Overviews

In WGBFAS, a total of 3 cod stocks, 3 herring stocks, 1 sprat stock and 10 flatfish stocks are considered. The main objective of the WG in 2024 was to assess the status and produce a draft advice, when relevant, for the following stocks:

- Sole in Division 3.a, SDs 20–24 (catch advice)
- Cod in Kattegat SD 21 (catch advice)
- Cod in SDs 22–24 (no new advice in 2024)
- Cod in SDs 24–32 (catch advice)
- Herring in SDs 25–27, 28.2, 29 and 32 (catch advice)
- Herring in SD 28.1 (Gulf of Riga) (catch advice)
- Herring in SDs 30-31 (Gulf of Bothnia) (catch advice)
- Sprat in SDs 22–32 (catch advice)
- Plaice in SDs 21–23 (catch advice)
- Plaice in SDs 24–32 (catch advice)
- Flounder in SDs 22-23 (stock status advice)
- Flounder in SDs 24–25 (stock status advice)
- Flounder in SDs 26+28 (stock status advice)
- Flounder in SDs 27+29–32 (stock status advice)
- Brill in SDs 22–32 (no new advice in 2024)
- Dab in SDs 22–32 (no new advice in 2024)
- Turbot in SDs 22-32 (stock status advice)

1.7.1 Cod in Kattegat

The reported catches of cod in Kattegat have declined from more than 15 000 tonnes in the 1970s and 10 000 tonnes in the late 1990s. In 2023, reported landings were 22 t. The SSB has decreased to historical low levels in 2020. SSB in 2024 is still at a very low level. The mortality has increased from historical low levels since 2014 to historically high mortality levels. The recruitment in the Kattegat area the later year is reflecting recruitment events outside the Kattegat.

1.7.2 Cod in subdivisions 22–24 (Western Baltic cod)

The cod stock in the Western Baltic has historically been much smaller than the neighbouring Eastern Baltic stock, from which it is biologically distinct. It is adapted to the relatively shallow waters of the Western Baltic Sea and has sustained a very high level of fishing mortality for many years. In SD 24 there is a mixing between the eastern and western Baltic cod stock, which is considered in the present assessment. Recreational fishery for this stock is a rather large and amounts in 2023 to about 40% of the total catches. Recruitment is variable and the stock is highly dependent upon the strength of incoming year classes. The last relative strong yeas class is the 2016 year-class with moderate year classes in 2022 and 2023, however there is a pattern where the recruitment is getting downscaled the following years, indicating unknown mortality from age 2. The 2024 spawning stock biomass was estimated to be below $B_{trigger}$ (21 876 t) and is the lowest in the time series. The harvest rate is historic low.

1.7.3 Cod in subdivisions 25–32 (Eastern Baltic cod)

The Eastern Baltic cod stock is biologically distinct from the adjacent Western Baltic (subdivisions 22–24) stock although there is mixing of the two stocks in SD 24 that is taken into account in present assessment. The biomass increased in the end of the 1970s to the historically highest level during 1982–1983 and thereafter declined to lower levels. The pronounced decline in size at maturation over time implies that the exploitable stock size is not consistently represented by SSB, especially in recent years. The SSB in recent years includes small cod that were not part of SSB in earlier years. The biomass of commercial sized cod (>= 35 cm) and fishing mortality is presently close to the lowest level observed since the 1950s. Recruitment has generally a declining trend since 2012, with some year-to year variations. The last relatively strong year-classes were formed in 2011-2012. The poor status of the Eastern Baltic cod is largely driven by biological changes in the stock during the last decades, including poor nutritional condition, reduced growth and a high natural mortality.

1.7.4 Sole in Subdivisions 20-24

The landings of sole in SD20–24 reached a maximum of 1400 t in 1993 and have since then decreased to around 200 t in 2023. Sole has mainly been caught in a mixed fishery as a valuable bycatch; in the trawl fishery for *Nephrops,* cod and plaice, and in a gillnet fishery for cod and plaice. The protection of spawning cod has restricted trawl fisheries for sole and most likely resulted in the recent landing reductions. The spawning stock biomass has since 2008 been between MSY $B_{trigger}$ and B_{lim}. Fishing mortality has decreased continuously since the mid-1990s and is now record low below F_{MSY}. Recruitment have been record low since 2020. An assumption of continued low recruitment (avg 2021-2023) are causing a decrease in catch advice for 2025 and this will likely continue into future years with the low productivity in the stock.

1.7.5 Plaice in 21–23

Plaice is caught all year round, with the majority of catches coming from active gears in winter and spring. Survey indices show variation in CPUE latitudinally in quarters 1, 3, and 4. Subdivision 22 plaice are traditionally taken in mixed fisheries together with cod but with the loss of fishing opportunities for cod, they are now taken in a directed fishery for plaice itself. In Subdivision 21 plaice is almost exclusively a bycatch in the combined *Nephrops*–sole fishery. Discard rates in area 22 decreased from ~50% to ~13% over the last decade but with an increase up to ~45% in 2023 as many small fish are entering the fishery from continued high recruitment sine the 2019 year-class. The SSB in the plaice stock has increased in the period from 2009 to 2023, supporting increased landings with decreasing fishing pressure. In recent years, landings have decreased, probably due to a decrease in landings coming from a targeted cod fishery which has collapsed. The initial increase in SSB appears to be driven by periodically large pulses of recruitment. Year on year, the 2019, through to 2023 year-classes have been extraordinarily large, breaking records from year to year. The 2019 cohort has entered the fisher, and the 2021 cohort should enter the fishery in 2023. However, due to the large cohorts, there appears to be a decrease in growth rate, probably from density dependent competition. This is evident in a reduced size at age, which may lead to an increase in Below Minimum Size (BMS) landings and discards. Discard information is considered reliable since 2001 and BMS landings are included in discards for all countries since 2020.

1.7.6 Plaice in 24–32

Plaice is mainly caught in the area of Arkona and Bornholm basin (subdivisions 24 and 25). ICES Subdivision 24 is the main fishing area with Poland, Denmark and Germany being the main fishing countries. Subdivision 25 is the second most important fishing area. Denmark, Sweden and Poland are the main fishing countries there. Minor catches occur in the rest of the Eastern Baltic. The stock size indicator from surveys has increased steadily since the early 2000s about five-fold since the start of the survey time series in 2001. Strong year classes have been detected in 2019 and 2020, assumed to enter fisheries in 20023. However, low sampling coverage covered the signal of these cohorts in the most recent year. Since 2022, a surplus production model (SPiCT) is used as basis for the advice. The average stock size indicator (biomass index) in the last two years increased, but on a lower level than expected, mainly due to the fact that the index only takes fish >20cm TL in account, whereas a major part of the stock was below that size limit. In 2014 discard data was for the first time included in the advice of the stock. Discard was estimated to be relatively high for this stock – close to 45% in 2014 and about 26% in 2019 with an increase to >60% in the last two years due to the two strong year classes entering the fisheries (in the discarded fraction). The discard ratio dropped in the most recent year as many of these fish are >25cm and thus entering into the landed fraction of the catch. Since 2017, plaice is under a landing obligation, resulting in an additional landing of 9 tons of "unwanted catch" (BMS landings) in the most recent year.

Flounder in the Baltic

In January 2014 the flounder stocks in the Baltic were benchmarked. As a result, four different stocks of flounder were identified (WKBALFLAT, ICES 2014). Based on new genetic analysis, the currently described two sympatric populations (pelagic spawning European flounder *Platichthys flesus* and demersal spawning Baltic flounder *Platichthys solemdali*) are considered to be two different species. Flounder (*Platichthys flesus* and *solemdali*) are the most widely distributed among all flatfish species in the Baltic Sea.

1.7.7 Flounder in 22–23

ICES Subdivision 22 is the main fishing area for this stock with Denmark and Germany being the main fishing countries. Subdivision 23 is only of minor importance (around 10% of the total landings of the stock). Discards of flounder are known to be high with ratios around 30–50% of the total catch of vessels using active gears. Passive fishing gears have lower discards, varying between 10 to 20% of the total catch. Depending on market-prices and quota of target-species (e.g. cod), discards vary between quarter and years. The discarded fraction can cover all length-classes and rise up to 100% of a catch. Landings and discards in the most recent years have been historically low due to limited fishing opportunities.

Since 2024, a surplus production model (SPiCT) is used as basis for the advice and to examine the stock status. In the latest year, fishing pressure on the stock is below F_{MSY}, and spawning-stock size is above MSY $B_{trigger}$ and B_{lim}. The stock size indicator was changed to a model-based approach to calculate an exploitable biomass index (Berg et al. 2013). The new index calculation also accounts for a substantial decreasing trend in the condition of flounder since the mid 90-ties by using annual length-weight relationships instead of a fixed one.

1.7.8 Flounder in 24–25

This stock is the largest flounder stock in the Baltic. Landings in SD 25 are substantially higher than in SD 24. The main fishing nations in SD 24 are Poland and Germany and in SD 25 is Poland. The majority of landings are taken by Poland. The discard ratio in both subdivisions varies between countries, gear types, and quarters. Despite the high variability in discard ratios, discard estimates since 2014 have been used in the advice because discards reporting was improving. However, between 2020 and 2022 discards reporting decreased. The biomass index from surveys has been increasing until 2016, then it was showing a decrease until 2018 and remained stable in the following years with a slight increase since 2022. The results of LBI showed a sustainable exploitation pattern, as fishing pressure on the stock is below F_{MSY} proxy.

1.7.9 Flounder in 26 and 28

Flounder is commonly caught as by-catch in demersal fisheries and is also targeted to a lesser extent. The main countries landing flounder from subdivisions 26 and 28 are Russia, Latvia, Poland, and Lithuania. Although estimated Russian landings were not officially reported to ICES, they were obtained from public sources. In the previous year, the landings in both subdivisions were evenly divided between active and passive fishing gears for EU landings, while there was no information available from Russia. In 2023, the landings were still at a low level compared to the long-term average, due to the direct cod fishery ban. Discards were expected to be significant, mainly determined by market capacity, but due to low sampling coverage, it was impossible to estimate discards for the last three years.

Since 2024, a surplus production model (SPiCT) has been used as the basis for advice and to examine the stock status. In the latest year, fishing pressure on the stock was below FMSY, and the spawning-stock size was above MSY Btrigger and Blim. The stock size indicator was changed to a model-based approach to calculate an exploitable biomass index (Berg et al. 2013). The new index calculation also takes into account a substantial decreasing trend in the condition of flounder since the mid-1990s by using annual length-weight relationships instead of a fixed one.

1.7.10 Flounder in 27, 29–32

Flounder is mainly taken in a directed fishery, and some extent as bycatch in demersal fisheries. Major part of the landings are taken in subdivisions 29 and 32, the role of subdivision 29 has been increasing year by year. The main landing country is Estonia (>80%), followed by Sweden and Finland. Landings mainly originate from passive gears such as gillnets (>90% of landings). Discard patterns are unknown. Flounder in the northern Baltic Sea is also caught to a great extent in recreational fishery; estimates from surveys collated by ICES (2014d) suggest recreational landings of around 30% of the total landings.

The ICES BITS survey does not cover the Northern Baltic area and the surveys conducted are local surveys close to the coast. The survey indices are very variable between years and no uniform trend is evident between the surveys. The total stock size indicator value seems to show a slight increasing trend from 2012 onwards, however seem to be decreasing since 2018. It's important to note, that the trend is largely thrived by one survey in SD29 (Küdema survey, Estonia). The results of LBI show that fishing pressure on the stock is at/below the F_{MSY} proxy.

1.7.11 Dab in 22–32

Dab (*Limanda limanda*) is distributed mainly in the western part of the Baltic Sea. The eastern border of its occurrence is not clearly identified. Survey data suggest that the Baltic dab is part of the larger dab stock in Kattegat, whose distribution is ranging into the western Baltic Sea. The main dab landings are taken by Denmark (subdivisions 22 and 24) and Germany (mainly in Subdivision 22). The landings of dab are mostly bycatches of the directed cod fishery but also from flatfish directed fisheries. Due to the decline of cod-directed fisheries and decreasing fishing opportunities, landings have dropped to the ever-lowest value since 1970. Discards are substantial for this stock and estimated to be close to 50% but are decreasing in recent years to about 30-40%.

Since 2024, a surplus production model (SPiCT) is used as basis for the advice and to examine the stock status. In the latest year, fishing pressure on the stock is below F_{MSY}, and spawning-stock size is above MSY $B_{trigger}$ and B_{lim}. The stock size indicator was changed to a model-based approach to calculate an exploitable biomass index (Berg et al. 2013). The new index calculation also accounts for a substantial decreasing trend in the condition of dab since the mid 90-ties by using annual length-weight relationships instead of a fixed one.

1.7.12 Brill in 22–32

Brill is distributed mainly in the western part of the Baltic Sea and the Kattegat and Brill fishery is dominated by Denmark in SD 22 (on average 67% of the catches in 2014–2023). Annual landings within the Baltic Sea have varied between 27 and 65 tonnes during the last ten years. The eastern border of its occurrence is not clearly described. Survey information have been available based on the international coordinated Baltic International Trawl Survey (BITS) since 2001 where standard gear were applied and common survey design were used to estimate the stock abundance. The stock size indicator from surveys was the highest in 2019 and was on average 0.7 individuals >= 20 cm for an 1-hour haul between 2014 and 2023 in SD 22– 24.

1.7.13 Turbot in 22–32

Turbot is a coastal piscivorous species commonly occurring from Skagerrak up to the Sea of Åland. Turbot spawns in shallow waters (10–40 m, 10–15 m in central Baltic) and the metamorphosing post larvae migrate close to shore to shallow water (down to one meter depth). Turbot

fishery is concentrated on the westerly parts of the Baltic Sea (SD 22– 26) with the highest landings occurring in SD 22, followed by SD's 24-25 and fishery data of turbot were available from almost all national fisheries. For turbot the genetic data show no structure within the Baltic Sea (Nielsen et al., 2004, Florin and Höglund, 2007), although the former discovered a difference between Baltic Sea and Kattegat with a hybrid zone in SD 22. Spatial distributions of turbot based on BITS survey data suggest that the turbot stock SD 22–32 is probably related with turbot in SD 21. The stock size indicator was changed to a model-based approach to calculate an exploitable biomass index (Berg et al. 2013) in 2024. Both survey data and commercial catches indicate that the stock development varies between the eastern and western Baltic Sea. Opposing spatial signals in the survey index (increasing biomass and high numbers of small turbot in the western subdivisions and decreasing numbers and a lack of smaller turbot in the eastern subdivisions) are resulting in a uniform and non-responsive index. A large year class has been detected in 2019, resulting in record-high discard rates in the fishery in 2020 and 2021, which have entered into the landed fraction of fisheries in 2024.

1.7.14 Herring in subdivisions 25–29 & 32 excluding Gulf of Riga (Central Baltic herring)

This stock, which is the largest herring stock assessed by the WG, comprises several autumn and spring spawning components, some of which have been shown to be genetically distinct. Herring in different subdivisions differ in, among other things, growth, and sexual maturity but to what extent this difference is reflecting genetic differences are not yet determined. This stock complex experienced a high biomass level in the early 1970s but has declined since then and is presently on a low level. The proportion of the various spawning components has varied in both landings and stock. The southern components, in which individuals are growing to a relatively larger size, have declined and during the last years the more northerly components, composed of smaller individuals, are dominating in the landings. Spawning-stock biomass (SSB) has fluctuated around B_{lim} since 1995 and was in the start of 2024 just above B_{lim}. The relatively large year class of 2022 is currently propagated through the stock leading to increased fishing opportunities. The reported landings taken within the pelagic trawl fisheries may be uncertain as it is mostly caught in mixed fisheries together with sprat. Fishing mortality has been above F_{MSY} since 2015, then to decrease to below F_{MSY} in 2022 and 2023.

1.7.15 Gulf of Riga herring

The stock is classified to have a full reproduction capacity. The spawning stock biomass of the Gulf of Riga herring has been rather stable at the level of 40 000–60 000 t in the 1970s and 1980s. The SSB started to increase in the late 1980s, reaching the record high level of 110 000 t in 1994. Since then, the SSB has been fluctuating in the range of 73 000–127000 t and increasing to 136 638 t in 2023. The year class abundance of this stock is significantly influenced by hydrometeorological conditions (by the severity of winter, in particular). Mild winters since the second half of 1990s have supported the formation of a series of rich year-classes and increase of SSB. Historically, the sprat only occasionally occurred in the Gulf, and therefore there has not been mixed pelagic fishery in the Gulf of Riga. However, in 2020s, more intensive sprat invasion into the Gulf from the Baltic proper can be observed.

1.7.16 Herring in subdivisions 30 and 31

The spawning stock of Gulf of Bothnia herring diminished from early 1960's to a relatively low level in the beginning of the 1970's until the beginning of 1980's, from which it started to increase

and peaked in 1994. From there it decreased again until early 2000's and levelled down until a small peak in (2010), after which the spawning stock has again showed a decreasing trend, and in 2021-2022 was estimated to be below $B_{trigger}$. Recruitment has been on average higher since the higher biomass period starting from the late 1980's, and in addition, favorable environmental conditions have contributed to the production of especially abundant year classes in some years. The most abundant year classes have hatched in very warm summers like 2002, 2006, 2011, and 2014. The decrease of SSB, which started in 2020 and continued in 2021 and 2022, is presumed to be largely a consequence of a change in the food chain, which caused a remarkable decrease in weight at age, deteriorated body condition and even starving and dying especially among the larger herring. Furthermore, the overall decrease in SSB after the peak in 1994 corresponds to an overall increase in fishing mortality during the same period up until 2016. After 2016, while fishing mortality has in general decreased, the SSB has not increased. During the winter of 2022 and 2023, the condition of even the largest herring specimens recovered to long term levels of the 2010's, but the proportion of larger herring size groups have decreased drastically from the levels that were found before 2020. The recent advice has been based on the current F_{MSY}, and even though the TAC is not fully taken and F has been below F_{MSY}, the general SSB trend is negative - although it has now levelled to $B_{trigger}$ according to the 2024 assessment. The general impression of the working group and the 2023 Baltic ADG is that the GoB herring reference points should be renewed, which has already been under construction since WKNEWREF in early 2024. This renewal, however, cannot be done during the 2024 WGBFAS meeting and consequently no advice can be given within the normal timeframe. The 2024 advice will be given later this year according to a plan to come up with new reference points.

1.7.17 Sprat in subdivisions 22–32

The spawning stock biomass of sprat has been low in the first half of the 1980s, when cod biomass was high. At the beginning of the 1990s, the stock started to increase rapidly and in 1996–1997 it reached the maximum observed SSB of 1.7 million t. The stock size increased due to the combination of strong recruitments and declining natural mortality which was the effect of a quickly decreasing cod biomass. The increase in stock size was followed by a large increase in catches (which reached a record high level of over half a million tonnes in 1997) and a decline in weight-at-age of about 40%. Density dependent growth was demonstrated for the stock. High catches in the following years and five successive below-average year-classes (2009-2013) led to a stock decline which resulted in a SSB below 800 000 t. in 2014-2015. Stock biomass fluctuates; strong year-classes (1994, 2003, 2008, 2014) are followed by 4-5 weaker ones. The y-c 2019 and 2020 are above average, while the 2021 - 2023 year-classes are poor (the 2023 y-c is one of the poorest). This leads to stock decline, but SSB is still above MSY $B_{trigger}$. If such poor recruitment continues, the declining trend in SSB will continue.

The spawning stock biomass has been above precautionary levels for over 30 years, while the fishing mortality has been slightly above present F_{MSY} in 2021-2023. During the recent two decades, the stock distribution has been changing with a tendency to an increased density in the north-eastern Baltic, especially in autumn.

1.8 Comparison of InterCatch and RDBES database

Comparison of Intercatch and RDBES databases

During this year's meeting, uploaded landing and effort data from the databases Intercatch and RDBES were compared for several stocks. Differences have been communicated to data submitters to investigate the origin of these differences. Effort data were only available for demersal species and not available for pelagic species and sole in Intercatch. As differences in the other

stocks were present, special care should be given to correctly update effort data of pelagic species and sole to the RDBES.

For landings data, the main problems can be summarized as follows:

1) Rounding issues: Data are uploaded in tonnes to Intercatch and kg in RDBES. Furthermore, numbers should only be rounded at the very end of the script to avoid transporting rounding issues in the analysis.
2) As the RDBES has a higher resolution (rectangle level), landings were in a few cases assigned to the wrong subdivision when fishing was conducted very close to the border.
3) In 2022, when data were resubmitted to the RDBES database, values were not overwritten but added causing double as high landing data. These have been communicated to the ICES data centre and were corrected subsequently.
4) In some cases the data in RDBES differ from the uploaded data. This has also been communicated to the ICES data centre.
5) In some cases (DK) adjustments to the landed amounts (box weights) are made while creating InterCatch data, but the same procedures are not possible (yet) for RDBES data.
6) For the Central Baltic herring and the Gulf of Riga herring, differences in landings in SD 28.1 and SD 28.2 between the two investigated databases occur in Latvia and Estonia. This is caused by the allocations of herring catches in SD 28.1 and 28.2 into particular stocks.
7) Unlike InterCatch, the RBES data is updated every year. Because the data uploaded to the Intercatch are preliminary, there can be differences between those two databases in the previous years.

For effort data the main problems can be summarized as follows:

1) Effort data in InterCatch, are often reported by fleet segments, and often only for the fleets with the potential to catch the given species, so direct comparison is difficult, without first aligning the fleets, to which no comprehensive code list could be found.
2) Effort days at sea, can be calculated in different ways, and data providers need to ensure that the input for the two databases is calculated similarly.

This exercise helped to make data submitters aware of the possible error sources so that these can be corrected and avoided in the future.

Figure 1: Comparison of landings uploaded to Intercatch (red) and RDBES (blue) for sprat for the year 2023 on country ad subdivision level.

1.9 Scientific Presentations

1.9.1 Trophic lengthening triggered by filamentous, N_2-fixing cyanobacteria disrupts pelagic but not benthic food webs in the Baltic Sea

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Summary:

The Eastern Baltic cod stock shows no signs of recovery despite years of historically low fishing pressure, suggesting that adverse environmental conditions play a major role in stock dynamics. Possible explanations for the poor state of the stock are numerous, but only based on correlational evidence (e.g. liver infection by cod worms, hypoxia, thamine deficiency, lack of small pelagics). The results of a recent publication (DOI: 10.1002/ece3.11048) were presented that describe trophic level changes in the Baltic food web that can cause a severe decline in the productivity of the pelagic system. The point of departure is that following the 2nd law of thermodynamics, at every trophic transfer 90% of the energy is lost as heat. If a new trophic level is added in a food chain, the biomass of higher trophic levels decreases massively.

Eutrophication, increased temperatures and stratification can lead to massive, filamentous, N2-fixing cyanobacterial (FNC) blooms in coastal ecosystems with largely unresolved consequences for the mass and energy supply in food webs. Mesozooplankton adapt to not top-down controlled FNC blooms by switching diets from phytoplankton to microzooplankton, resulting in a directly quantifiable increase in its trophic position (TP) from 2.0 to as high as 3.0. If this process in mesozooplankton, we call trophic lengthening, was transferred to higher trophic levels of a food web, a loss of energy could result in massive declines of fish biomass. We used compound-specific nitrogen stable isotope data of amino acids (CSIA) to estimate and compare the nitrogen (N) sources and TPs of cod and flounder from FNC bloom influence areas (central Baltic Sea) and areas without it (western Baltic Sea). We tested if FNC-triggered trophic lengthening in mesozooplankton is carried over to fish.

The TP of cod from the western Baltic (4.1 ± 0.5), feeding mainly on decapods, was equal to reference values. Only cod from the central Baltic, mainly feeding on zooplanktivorous pelagics, had a significantly higher TP (4.6 ± 0.4), indicating a strong carry-over effect trophic lengthening from mesozooplankton. In contrast, the TP of molluscivorous flounder, associated with the benthic food web, was unaffected by trophic lengthening and quite similar reference values of 3.2 ± 0.2 in both areas. This suggests that FNC blooms lead to a large loss of energy in zooplanktivorous but not in molluscivorous mesopredators. If FNC blooms continue to trigger the detour of energy at the base of the pelagic food web due to a massive heterotrophic microbial system, the TP of cod will not return to lower TP values and the fish stock does not recover. Trophic lengthening may also have consequences for the productivity of Baltic sprat and herring stocks. These processes are not unique to the Baltic Sea but have been detected elsewhere (e.g. doi.org/10.1038/s41467-023-42966-0). Monitoring the TP of key species can identify fundamental changes in ecosystems and provide information for resource management.

1.9.2 Trapped by heat and hypoxia: poor prospects for Western Baltic cod in the Belt Sea

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Summary:
The poor status of the Western Baltic cod stock raised concerns about the usefulness of the estimated natural mortality and fishing mortality (M), which seems severely overestimated despite massively reduced fishing pressure. Continuous oceanographic data (seafloor temperature, oxygen, salinity) were recorded at 12 positions covering a typical slope area from shallow to deeper waters (5-25 m) for 2 years, supplemented by regular CTD casts in the southern Mecklenburg Bay (ICES subdivision). Mapping of environmental changes over time combined with physiological thresholds of Atlantic cod (*Gadus morhua*) were used to assess the spatio-temporal windows in habitat suitability of cod. Water temperatures >15°C down to around 15 m water depth occurred from July to October. Oxygen saturations <60% from the deeper basin up to around 15 m water depth occurred from June to November. Hence, during summer cod are trapped between a heated surface layer and hypoxic bottom water. This likely resulted in habitat exclusion or extreme habitat compression of cod during one third of the year (July-October). Use of inferior habitats in summer likely coincide with adverse metabolic conditions, poor food supply and increased exposure of cod to predators. Moreover, wind-induced rapid upwelling of hypoxic waters in early autumn may lead to local fish kills, largely invisible, difficult to quantify and presently unaccounted in M. This type of data is crucial to properly understand reasons for poor environmental conditions and poor status of affected demersal fish stocks. A publication is in preparation.

1.9.3 Cormorant-induced mortality in Western Baltic Cod

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Summary:
The cod stock in the western Baltic Sea is in a historically poor state. The stock has fewer adults than at any time since the 1980s and the production of young cod has been far below the long-term average since 2017. Despite a sharp reduction in fishing effort, there is no sign of a recovery in the cod stock. It is likely that non-fishing factors such as warming, eutrophication, habitat loss and an increase in natural mortality will play an important role in the further development. In this context, the predation of cod by cormorants is also of particular interest, but poorly quantified.

The results of a recently completed study revealed that cormorants at a roosting site on Lake Dassow near the Bay of Lübeck had an unexpectedly high proportion of juvenile cod in their diet, highlighting the potential role of natural mortality in the poor state of the western Baltic cod stock. The monthly diet of cormorants at this site consisted of 25 % to 96 % cod (based on estimated biomass), with predation mainly on zero, one- and two-year-old cod between 12 and 43 cm.

However, these results were from only one site and the temporal variability was very high. Other studies along the coast of Mecklenburg-Western Pomerania also showed high local fluctuations in the biomass proportions of cod, between 0 and 46 %. It is therefore still unclear to what extent the results the study at Lake Dassow are representative for other locations and years. To conduct a more reliable assessment of the possible influence of cormorant predation on the dynamics, status and development prospects of the western Baltic cod stock and other fish species in the region, the project KOMODO started in the end of 2023. KOMODO will focus on the following main issues:

1. Quantification of cormorant predation on selected stretches of the Baltic Sea coast with a particular focus on cod,
2. Comparison of conventional and novel genetically based methods to quantify fish predation from cormorant food pellet analyses, and
3. Assessment of the potential impact of natural mortality by cormorants on the population dynamics of cod in the western Baltic Sea.

It is cooperation between the Potsdam Institute of Inland Fisheries (coordination; expertise in cormorant pellet analysis, inland fisheries), Thünen Institute of Baltic Sea Fisheries (expertise in cod, Baltic Sea fisheries, age determination, population dynamics), Frauenhofer IZI-BB (expertise in genetics, molecular biology, automation) and ornithologists in Germany and Denmark. KOMODO is funded by the state of Schleswig-Holstein and lasts until summer 2027. Further details can be found at https://www.thuenen.de/komodo.

1.9.4 GenDC - Improving stock assessment and sustainable management of marine fisheries through integrated genetic data collection.

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Summary:
For many fish stocks, the stock assessments are calculated for defined management areas. However, many fish stocks do not adhere to these boundaries and mix, which leads to uncertainties in the stock assessments. The project GenDC, funded by EMFAF Fisheries Scientific Advice, aims at better determining the mixing between adjacent cod stocks through genetics. The applicant and coordinator of GenDC is Marie Storr-Paulsen (DTU). The collection of cod tissue samples extends from the western North Sea to the Kattegat and the eastern Baltic Sea. The samples will be taken during the standard trawl surveys (IBTS, BITS. Within GenDC, standardized sampling protocols and procedures for the integration of genetic data into stock assessments and existing databases will be developed (Lead: Thünen). The samples will be analyzed (Lead: DTU) and the results will be included in ICES stock assessments (Lead: SLU). The project will start in May 2024 and last for 2 years.

2 Cod in the Baltic and Kattegat

2.1 Cod in Subdivisions 24-32 (eastern stock)

2.1.1 The fishery

A description of eastern Baltic fisheries development is presented in the. Stock Annex (ICES 2024 b).

The advice for eastern Baltic cod was downgraded from a category 1 assessment to a category 3 assessment due to problems with model settings related to recruitment.

2.1.1.1 Landings

Due to the poor state of the stock, all fishing targeting cod has been prohibited in EU from the third quarter of 2019 onwards. Bycatch of cod has still been allowed in pelagic fisheries and demersal fisheries targeting other species than cod.

From 2015, there is a landing obligation in place for cod in the Baltic Sea. Thus, there is no minimum landing size, but a minimum conservation reference size (MCRS) of 35 cm is in force, which is a change from earlier years minimum landings size (MLS) of 38 cm. Cod below MCRS cannot be sold for human consumption and must be landed as a separate fraction of the catch. The landed cod below MCRS is here referred to as 'BMS landings' (BMS=Below Minimum Size).

There were two different options for submission of BMS landings data to InterCatch:

1) Landings, discards and BMS landings were submitted separately.

2) BMS landings were included in the discard estimate and were only reported as "Official landings" to InterCatch (The "Official landings" field is merely informative and is not included in the catch estimate when data are extracted). This option could be used if the design of the discard sampling does not allow discards and BMS to be separated in the discard estimation, for example when an observer effect on the discard pattern is suspected. In this case the estimate provided as discards is an estimate of "unwanted catch" and includes all cod that was not landed for human consumption.

Regardless of how BMS landings were provided in IC, the statistics on BMS landings presented in this report are derived from logbook data (or other official data sources) and not estimated from sampling.

Three countries reported zero BMS landings for 2023 and two countries reported very small amounts (under 2 t). BMS landings were provided separately from discards by Sweden and Latvia. Denmark and Poland included BMS landings in the discard estimate in the data submission and provided separate information on BMS only as "official landings". To quantify the different catch categories in such case, BMS landings of cod reported only as "official landings" are included in the BMS landings and subtracted from the discard estimates in this report. However, this could not be done for number of fish by length, and therefore tables showing length distribution by catch category show BMS landings and discards together as "unwanted catch".

For years before 2017, official BMS landings are not possible to show separately, due to inconsistencies in data reporting and submission in different countries. The available information indicates that BMS landings were a very small fraction of total landings, like later years.

National landings of cod from the eastern Baltic management area (Subdivisions 25–32) by year are given in Table 2.1.1 as provided by the Working Group members. Landings by country, fleet

and subdivision in 2023 are shown in Table 2.1.2a. The total provided EU landings in SD 25-32 in 2023 summed up to 191 t, whereof more than 99% were above MCRS and only 2 t were BMS landings (Table 2.1.2b, 2.1.3).

The vast majority of the Eastern Baltic cod landings in 2020-2021 were taken by Russia, as the closure of targeted cod fisheries applies only to EU countries (Table 2.1.1). For 2022 and 2023, no landings for Russia were officially reported to ICES. The information on Russian landings in 2022 was based on the information available on *http://atlant.vniro.ru* (900 t) and in 2023 *https://fish.gov.ru* (799 t). Both years catch amount was assumed to have the same distribution between Quarters and Fleets as the Russian landings reported for 2021.

Part of the landings of Eastern Baltic cod stock are taken in SD 24, i.e. the management area of Western Baltic cod (Fig. 2.1.1, 2.1.2). The total landings in SD 24 are divided between the two stocks using stock identification information derived from otolith shape analyses combined with genetics (ICES WKBALTCOD2 2019). The landings of Eastern cod taken in SD 24 in 2023 are estimated to 18 tons (2% of total landings of the stock). Thus, the total landings from the stock in 2023, used in this assessment were 1008 t.

2.1.1.2 Unallocated landings

For 2023, like 2010–2022, quantitative information on unreported landings was not available and the Working Group was not able to quantify them. Unallocated landings have been a significant problem during 1993–1996 and 2000–2007 when the unreported landings have been up to 35–40%. The decrease of unreported landings after this period is related to a decreasing fishing fleet due to EU vessel scrapping program and improvement of fishing control, and misreporting has been considered a minor problem. However, since 2019, there are concerns that the substantially reduced quota may have resulted in misreporting of landings, and discards above the level accounted for in this assessment, may occur.

2.1.1.3 Discards

Due to a very low fishing effort in the demersal fleet, very few discard samples were achieved in 2023. The discard amounts in 2023 are therefore very uncertain, even though believed to be rather limited considering the low fishing effort in the demersal fishery. Only 10% of the EU landings were covered by a discard estimate, all from active gears. No discards were reported for passive gears, and consequently no discards could be estimated for those. The EU landings from passive gears constituted 35% of the total landings and the discards are believed to be small. However, even though the demersal fishery has declined drastically, it would be important to investigate the extent of discarding of cod in the demersal fishery for flatfishes that is still carried out by a few countries.

The EU discards in 2023, in subdivision 25-32, were estimated to 12 tonnes (not including any BMS landings), which constituted 6 % of the total catch by EU countries in weight. All discard estimates shown in this report refer to EU countries.

The poor sampling levels affect both the length distribution of discards, as well as the discard amount. The length distribution of cod discards was estimated from very few samples in 2023. Table 2.1.4 shows the number of length samples by catch category and fleet in later years.

Since some countries provided discards and BMS landings together as one estimate in terms of number of fish at length (see section 2.1.1.1 for further information on how BMS data/discards were submitted), it was not possible to show length distributions for BMS landings and discards separately. Therefore, length distributions can only be separated by wanted (landings above MCRS) and unwanted (BMS + discards) catch.

The most abundant length class of the unwanted catch in 2023 was length class 30-34 cm (47% in numbers) followed by length classes 25-29 cm and 35-37cm (26% and 15%, respectively) (Table 2.1.5).

The total discards in tons estimated for SD 24 were divided between eastern and western Baltic cod using the same stock splitting information as for landings, which resulted in 45 tons of estimated discards of eastern Baltic stock in SD 24 in 2023 (Table 2.1.3).

2.1.1.4 Effort and CPUE data

No data on commercial CPUEs was presented at WGBFAS. The effort data from EU STECF FDI (2021) shows a continuous steep decline in kw-days for demersal trawls since 2013 in the central Baltic Sea. The effort in the demersal gillnet fishery shows a less steep decline, but since the ban of the targeted cod fishery in 2019 the effort for all demersal gears is on a very low level. No STECF FDI data for 2022 was available at the time of the WGBFAS meeting, but the effort submitted to WGBFAS (days at sea by active/passive demersal gears) showed similarly low levels as in 2021.

2.1.2 Biological information for catch

2.1.2.1 Catch in numbers and length composition of the catch

The EU catch numbers for SDs 25-32 were derived from compilation of biological information submitted to InterCatch. The most abundant length class in the total EU catch in 2023 was 35-37 cm (34% in numbers), followed by 30-34 cm and 38-44 cm (each 29%) (Table 2.1.5). Table 2.1.6 gives the estimated mean weight per length class and gear in the landings and discards 2023.

Catch numbers at length of the fraction of the Eastern Baltic cod stock distributed in SD 24 were derived by upscaling the numbers at length estimated for SD 25 by the fraction of catch originating from SD 24, separately for landings and discards.

No length information was available for Russian landings in 2022 or 2023. A comparison of length distributions of EU and Russian landings in former years shows some notable differences, especially for Passive gears (Fig. 2.1.3). Furthermore, differences between Russian and EU catch compositions are to be expected, due to different fisheries regulations. On the other hand, there are no substantial inter-annual differences in Russian (or EU) length compositions, within the period of most recent years (Fig. 2.1.3). Due to continued lack of data on Russian landings in 2023 the length distributions were set equal to EU landings to reflect up to date biological information.

2.1.2.2 Quality of biological information from catch

Numbers and mean weight at length were requested from commercial catches for the data year 2023. All EU countries biological data was estimated nationally before being uploaded and further processed in InterCatch. However, the difficulties to collect samples from commercial fisheries, caused by the very low fishing effort in the demersal fishery, led to very low sampling levels again in 2023 especially for landings. Numbers and mean weight at length were only provided for 3% of the total EU landings (>MCRS) in weight and for 17% of the estimated discards. No samples were reported for BMS landings. Table 2.1.4 shows the decrease in the number of samples by catch category and fleet from 2017-2023. The resulting overall length distribution of EU catch in 2023 is similar to earlier years, however, it is noticeably impacted by low sampling.

No biological information was available for Russian landings in 2022 and 2023. Length distributions for these years (2022 and 2023) should therefore be considered more uncertain.

As in previous years since 2013, the input data for SDs 25-32 for EU countries were prepared solely using InterCatch. The use of only one reporting format (in this case InterCatch) provides a transparent way to record how the input data for assessment have been calculated. However,

due to the large methodological differences in the data reporting and preparation, some inconsistencies could be expected between the data compiled in 2013–2023 and the data compiled in previous years.

2.1.3 Fishery independent information on stock status

Stock distribution

Data from BITS surveys indicate that within the management area of ICES SDs 25-32, cod is mainly distributed in SDs 25 and 26 (Fig. 2.1.4). Relatively high cpue values are recorded also in SD 24 which is a mixing area for eastern and western Baltic cod; in the easternmost areas of SD 24 most of the cod are of eastern origin. The cpue values further north-east (SD 27-28) are generally very low (Fig. 2.1.4). In BITS survey in Q1 2024 a relatively higher amounts on <35 cm cod were found in the Eastern Baltic cod distribution area . Some increase in the abundance of smaller cod was detected also in Q4 2023 survey. There is a relatively strong 2023 year-class of cod apparent in the western Baltic Sea (SDs 24 and 22). While the increase in cod abundance of several length groups <35 cm in the eastern Baltic Sea at the same time cannot be due to one incoming year-class. Thus, there are doubts that at least part of the <35cm cod seem in the eastern Baltic Sea in Q1 2023 BITS originate from the western Baltic stock.

Nutritional condition

Le Cren's condition index is provided as an index for stock health. The index is calculated as follows: As a first step, total length (L) and whole weight (W) data for a given quarter were pooled across years to estimate the parameters *a* and *b* of the length–weight relationship:

$$W = a * L^b$$

Subsequently, for each individual fish *i*, Le Cren's condition index *K* was calculated as the ratio between its weight and the predicted weight of the fish at a given length from the length-weight relationship (Le Cren 1951):

$$Le\ Cren\ K_i = \frac{W_i}{a * L_i^b}$$

The Le Cren condition index presented in this report is average for sampled individuals each year and quarter, raised with total length distribution in respective BITS survey, to represent population average (Fig. 2.1.6).

Fulton's K condition index by length is calculated for comparison. The trends in Fulton's K and Le Cren condition indices are generally similar, showing that nutritional condition of the eastern Baltic cod has substantially declined since the 1990s. Le Cren K in Q1 shows some improvement from 2015 to 2020s. In Q4, condition has remained at a relatively stable low level since around 2010. Condition is generally worse in Q4 compared to Q1 (Fig. 2.1.6).

Growth and natural mortality

The growth of the Eastern Baltic cod is expected to have declined since the 1990s, due to a reduced size at maturation, poor condition of cod, hypoxia, and parasite infestation (ICES WKBEBCA 2017, WKIDEBCA 2018). The same factors have presumably contributed to an increase in natural mortality. Recent changes in growth and natural mortality are estimated in stock assessment model (see section 2.1.5).

Maturity

Size at maturation has substantially declined in the period from the 1990s to 2000s. The L50 (50% percent mature) has been estimated at around 35-40cm (males and females combined) in the early 1990s and has declined to around 20cm since the late 2000s (Table 2.1.7). The exact estimates

of L50 in latest years are associated with relatively larger uncertainties, due to a combination of cod maturating at a very small size, and very few individuals below 20 cm are caught in BITS surveys. Thus, data are not available for all length-classes on the slope from zero to a high proportion mature, making the exact L50 estimates from glm analyses shaky and dependent on few individuals. For this reason, the variations in L50 estimates in 2020-2022 (Table 2.1.7) do not seem to represent true variations in L50 but are more due to measurement errors. Maturity ogives (proportion mature at length) shows similar pattern in recent years, suggesting that L50 has remained constant low (around 20 cm) in recent years.

Recruitment

Larval abundance from ichthyoplankton surveys in 2023 was at a similar relatively low level as for 2019-2020, and much lower compared to 2011-2012 or 2016-2017, which were the years with highest larval abundances in the last decade (Fig. 2.1.7).

Relative biomass trends and size distribution from surveys

Time series of cod cpue show a decline in biomass in both Q1 and Q4, especially since around 2015. The relative biomasses in surveys in 2022 Q1 and 2018 Q4 were the lowest since 2000, with some increase apparent in most recent surveys in 2022 Q4 and a decline in 2023 Q1 (Fig. 2.1.8a). This increase in relative biomass in most recent surveys is visible for length groups <25 cm, not for larger individuals (Fig. 2.1.8b). The length corresponding to 95th percentile of length distribution (L95 indicator) of Eastern Baltic cod in Q1 BITS survey has declined from 60-65 cm in the early 1990s to be below 40 cm in recent years (Fig. 2.1.8b; Table 2.1.7).

The SSB index based on egg abundance data from ichthyoplankton surveys and annual egg production method (Köster *et al.* 2020) shows a similar low SSB in 2023 as in 2022 and 2021 (Fig. 2.1.9).

2.1.4 Input data for stock assessment

Overview of the times series included in stock assessment with Stock Synthesis model is provided in Table 2.1.8.

2.1.4.1 Catch data

The time series of catch data used in stock assessment starts in 1946 (Fig. 2.1.10). Total catch biomass is divided between Active (trawls) and Passive (mainly gill-nets) fleets from 1987 onwards. The catches of both fleets are divided to quarters. The fleet and quarter specific data for 2023 for EU were compiled from national data provided in IC. The assumed Russian catch in 2023 was divided to quarters and fleets based on information from 2021. For documentation of catch data used in the entire time series, see ICES WKBALTCOD2 2019. The catches used in the assessment include the fraction of Eastern Baltic cod catches taken in SD24.

To be able to use the survey information from 2024 Q1, the last data year in the Stock Synthesis model is set to 2024. This implies that catches for 2024 need to be assumed. The catch in 2024 was set to 1065 tonnes (catch in 2023).

2.1.4.2 Age and length composition of catch

Age compositions of catches are included in the model for 1946-2006 (effectively until 1999 as the age composition of catches for 2000-2006 is set to not contribute to the model likelihood and are treated as "ghost fleet" by Stock Synthesis). No new information on age composition of commercial catch was included in this years' assessment.

Length compositions of commercial catch are included from 2000 onwards (Fig. 2.1.11). The landings that have not been specified in IC whether active or passive were all allocated to the Active fleet. The length compositions used in Stock Synthesis are by quarter and fleet (Active, Passive).

2.1.4.3 Conditional age at length (age-length key)

Age length keys are used in Stock Synthesis model from 1991 onwards to inform the estimated deviations in Von Bertalanffy growth parameters. The ALKs used are based on age readings from BITS surveys, available in DATRAS. Both ALKs from Q1 (1991-2023) and Q4 (1998-2023) were included. The average length at age in the individual fish data from BITS, used as basis for ALK, are presented in Fig. 2.1.12.

2.1.4.4 Tuning indices

List of the indices used in the Stock Synthesis assessment is provided in the table below.

Fleet name	Years	Description
#BITSQ1	1991-2024	Baltic International Bottom Trawl Survey, Q1 (G2916), data for SD 25-32, including the area east of 13 degrees latitude in SD 24. Modelled indices of total abundance.
#BITSQ4	1993-2023	Baltic International Bottom Trawl Survey, Q4 (G8863), data for SD 25-32, including the area east of 13 degrees latitude in SD 24. Modelled indices of total abundance.
#TrawlSurvey1	1975-1992	CPUE (kg*h–1) by German RV Solea in SD 25 (Thurow and Weber, 1992)
#TrawlSurvey2	1978-1990	CPUE (g/hour) from bottom trawl surveys by the Swedish Board of Fisheries and Baltic Fisheries Research institute (BaltNIIRH), SDs 25–28, yearly average. The index refers to total cpue in biomass of all length groups caught in the survey (Orio *et al.*, 2017).
#CommCpue1	1948-1956	Commercial CPUE (kg/h) of former USSR , February–June (Dementjeva, 1959)
#CommCpue2	1957-1964	Commercial CPUE (kg/h) of former USSR in Gdansk area, February-June (Birjukov, 1970)
#CommCpue3	1954-1989	Commercial CPUE (kg/day) of USSR (Latvian republic), SDs 26-28, annual average (Lablaika *et al.* 1991)
#SSBEggProd	1986-2023	SSB indices based on annual egg production method (Köster *et al.* 2020). Used in SS model to represent spawning stock biomass trends (survey type 30 in SS). Data from ichthyoplankton surveys.
#Larvae	1987-2023	Abundance of larvae during peak spawning, used in SS as pre-recruit survey (survey type 32). Data from ichthyoplankton surveys.

2.1.5 Stock Assessment: Stock Synthesis

2.1.5.1 Model configuration and assumptions

The assessment of the Eastern Baltic cod (SD24-32) was conducted using the Stock Synthesis (SS) model (Methot & Wetzel 2013). The assessment was conducted using the 3.30 version of the Stock Synthesis software under the windows platform. The Stock Synthesis model of Eastern Baltic cod is a one area quarterly model where the population is comprised of 15+ age-classes with both sexes combined. The model is a length-based model where the numbers at length in the fisheries and survey data are converted into ages using the Von Bertalanffy growth curve. The last age-class (i.e. 15+) represents a "plus group" in which mortality and other characteristics are assumed to be constant. Fishing mortality was modelled using the hybrid method that the harvest rate

using the Pope's approximation then converts it to an approximation of the corresponding F (Methot & Wetzel 2013).

Spawning stock and recruitment

Spawning stock biomass is estimated for spawning time (month 5 is used as an average for the entire time period). Sex ratio is set to 50% females and males. Recruitment was derived from a Beverton and Holt (BH) stock recruitment relationship (SRR) and variation in recruitment was estimated as deviations from the SRR. Main recruitment deviations were estimated for 1950 to 2022, representing the period for which age and length compositions are available. Recruitment deviates were assumed to have a standard deviation (σR which corresponds to the stochastic recruitment process error) of 0.6. The model assumes a level of steepness (h) of 0.99 for the SRR, assuming that recruitment is mainly environmentally driven in EBC. Settlement time for recruitment is set to month 8 as an average for the entire period.

Growth

Growth parameters were fixed for the period 1946-1990, at the values estimated using historical tagging data. The tagging estimates covered the period 1955-1970 (L_{inf} = 125.27, k= 0.10). Deviations in both L_{inf} and k were estimated between 1991 and 2023, when age-length keys (ALKs) were available from BITS surveys. Numbers of fish in ALK are used as sample size for each year. The variance in length-at-age was fixed for older fish and estimated for younger individuals (Table 2.1.9).

The parameters a and b in length-weight relationships are estimated from Q1 BITS survey, pooled for SD 25-32. The parameters were estimated for each year, after which the data were averaged by blocks of several years, to capture main trends in length-weight relationship. These externally estimated parameters were used as inputs in the model (Table 2.1.9).

2.1.5.2 Natural mortality

Natural mortality is assumed to be age dependent and was estimated using methods described in Then *et al.*, (2015) and Lorenzen (1996) for the historical period (1946-1999). Historical natural mortality was assumed to be equal to the average of the two methods (*tmax* and *growth*) scaled using Lorenzen (1996). In Stock Synthesis, age breakpoints 0.5, 1.5, 5.5 and 15.5 were used. Natural mortality from 2000 to 2023 for-age break 5.5. was estimated within the model as annual deviations from the historical values. For the other age-breaks, M is kept constant for the entire time series (Table 2.1.9).

Maturity

The input for maturity is L_{50} (length at 50% mature) and the slope of the maturity ogive curve. These are estimated outside of the stock assessment model from BITS Q1 data, for females and males combined. L_{50} of Eastern Baltic cod has substantially declined over time, which is captured by using time blocks in the assessment model (Table 2.1.9). For the slope, a constant value (0.23) is used for the entire period.

Selectivity

Fishery selectivity is assumed to be length-specific and time-invariant. For both the trawlers (i.e. active gears) and the gillnetters (i.e. passive gears) selectivity was estimated assuming a logistic function that constrains the older age classes to be fully selected ("flat top"). A logistic selectivity was also used for BITS surveys (both quarter 1 and quarter 4). Selectivity of historical Trawlsurveys 1 and 2 was assumed to mirror selectivity of BITS Q1 survey, while selectivity for historical commercial CPUE1, 2 and 3 was assumed to mirror selectivity of the active gears.

2.1.5.3 Uncertainty measures

The CV of catch was set to 0.05 for all years. No meaningful information is available on the annual sample size associated with age or length distribution data for commercial catches. Therefore, the same value (100) is applied for each quarter and fleet in all years.

The average CV of the BITS survey indices was assumed to be equal to 0.11 while the yearly deviation of the coefficient of variation of the BITS survey indices was estimated as part of the modelling of the survey indices outside of the stock assessment model. Numbers of hauls in BITS in each year were used as input for sample size associated with BITS length distribution data.

For the remaining surveys and CPUE indices, the CV was estimated internally in the model, except for the larval index, for which the CV was set to 0.3.

The data weighting method used for the size-composition data followed the advice of Francis (2011) (Method TA1.8). For weighting the conditional age-at-length data we used the Francis-B approach described in Punt (2017). The Hessian matrix computed at the mode of the posterior distribution was used to obtain estimates of the covariance matrix, which was used in combination with the Delta method to compute approximate confidence intervals for parameters of interest.

2.1.5.4 Stock assessment results

From the year 2000 onwards, age composition data of the commercial catch are not available, thus the length compositions are used within the assessment model, to derive the estimated catch at age. These estimated values for catch at age from the Stock Synthesis model are presented in Table 2.1.10.

The settings and estimated parameters by the model are presented in Table 2.1.9. Natural mortality is estimated to have substantially increased and is estimated considerably higher than fishing mortality in later years (Fig. 2.1.13). At the same time, growth has declined since around the year 2000 (Fig. 2.1.14), which is in line with the available biological knowledge on the stock (WKBALTCOD2 2019). The estimated time invariant selectivity is shown in Fig. 2.1.15.

Model fits and residuals for length compositions show a pattern of underestimating the peak in length distribution and slightly overestimating the proportion of the larger cod (Fig. 2.1.16, 2.1.17), however the residuals are generally small. For most fleets, there is a reasonable overall fit to the length and age composition data. Overall, the model reasonably fit to the trends in the CPUE indices (Fig. 2.1.18), besides the BITS surveys indices for 2008-2011, which were always underestimated in the model, and the most recent increases in BITS abundances in Q1 in 2024, which are not picked up by the assessment model. However, as the increased cod abundance in most recent BITS is likely at least partly due to expansion of the stronger 2022 year-class of western Baltic cod into the area, this can explain poor fit to these data in the assessment of the eastern Baltic cod.

The retrospectives of the model were reasonable (Figure 2.1.19). The estimated Hurtado-Ferro (2014) variant of the Mohn´s index was 0.15 for SSB and -0.18 for F (estimated from retrospective analyses for 5 years). Retrospective bias was relatively large for recruitment at age 0. However, this is expected as it takes about 2-3 years of data for a year class to be determined with high precision as shown by the squid plot of retrospectives of recruitment deviations (Figure 2.1.19).

The spawning stock biomass is estimated to have declined since 2015, with a small increase in 2022-2023 (Fig. 2.1.20, Table 2.1.11). The development of the stock size is not entirely represented by the spawning stock biomass in recent years, due to a large decline in size at maturation. The SSB is presently largely consisting of small individuals that were not part of the spawning stock in earlier years. The biomass of commercial sized cod (>35 cm) in 2019-2023 was almost at the

lowest level observed since the 1950s, with a slight increase estimated for 2023 (Fig. 2.1.21). Fishing mortality has declined over the last years and dropped further in 2020 to a historic low level where it has remained also in 2023 (estimated at 0.017) (Fig. 2.1.20). The large drop in fishing mortality is due to the closure of targeted fisheries for the eastern Baltic cod within EU since mid-2019. Recruitment has generally a declining trend since 2012, with some year-to year variations (Fig. 2.1.20, Table 2.1.11).

The stock numbers and fishing mortalities at age are given in Tables 2.1.12 and 2.1.13.

2.1.6 Exploratory stock assessment with SPICT

At last benchmark (WKBALTCOD2 2019), is was decided to maintain SPICT as an exploratory model for the eastern Baltic cod in WGBFAS, while Stock Synthesis is used as the basis for fisheries management advice.

SPICT stands for a stochastic surplus production model in continuous time (Pedersen and Berg, 2017). A specific version of SPICT is applied for Eastern Baltic cod, to allow considering a change in surplus production over time.

SPICT operates internally with absolute values, but produces output, including the uncertainties also in relative terms (F/FMSY and B/BMSY), because the relative estimates are considerably more certain compared to the absolute ones. This is because the same parameters are included in both numerator and denominator of the relative values, which reduces the uncertainty in the relative estimates. The relative values for F/FMSY and B/BMSY are reasonably well estimated in the model for Eastern Baltic cod, and the model passes most of the evaluation criteria in diagnostics (Fig. 2.1.22).

SPICT estimates that the biomass of the eastern Baltic cod is below Bmsy trigger proxy since 2015 (Figure 2.1.23). Fishing mortality, as well as FMSY Proxy are estimated very low, as the estimated FMSY in the model is declining as well, along with reduced productivity of the stock. SPICT results are in line with Stock Synthesis, confirming poor status of the eastern Baltic cod stock.

2.1.7 Management options

The assessment was downscaled from a category 1 assessment to a category 3 assessment indicative of trends. Even at no fishing, the SSB is estimated to remain below Blim in 2025, with very high probability (Table 2.1.20).

2.1.8 Reference points

WKBALTCOD2 (2019) concluded that B_{lim} should presently not be set lower than the SSB in 2012 that was still able to produce a strong year-class, while much of the adverse developments affecting the quality of the SSB (small size at maturation, poor condition, small size of the individuals) had already taken place (see WKBALTCOD2 2019 for further background). WGBFAS has concluded it to be appropriate that the exact value for Blim is not fixed, but it is adjusted on an annual basis, to correspond to the most updated assessment.

The assessment was downscaled from a category 1 assessment to a category 3 assessment indicative of trends. Biomass reference points are considered in relative terms.

WGBFAS (2024) estimated the Blim to be 0.63 (SSB in 2012 in the present assessment, in relative terms to time-series average).

B_{pa} ($B_{lim} \times \exp(1.645 \times \sigma)$, where σ=0.07) corresponds to 0.71.

2.1.9 Quality of the assessment

A major part of the catches of this stock (79%) are taken by the Russian Federation. No biological information on these catches is available to ICES for 2022 and 2023. The Russian Federation catch amount for 2022 and 2023 included in the assessment was based on publicly available information, but no information on length composition of these catches was available to ICES. Sampling of EU landings and discards has been poor in the last years due to a combination of low catches and COVID-19 disruption. The EU discard estimate for 2023 is based on five trips from two countries and for landings on three trips from two countries. Biological information from EU countries was applied to Russian Federation landings data.

It is recognized that age readings for the Eastern Baltic cod are uncertain, especially for later years, while age imprecision is not explicitly accounted for in the stock assessment model. Age length keys up to the present are applied to estimate the yearly values and thus the trend in Von Bertalanffy growth parameters within Stock Synthesis, which are thereafter used within the model to derive catch at age from catch at length information.

WKBALTCOD2 (2019) investigated the effects of uncertain age information on the assessment results and concluded that the ALKs presently used provide a reasonable proxy for informing growth for stock assessment purposes. This is considered a temporary solution, as an alternative method for estimating growth based on otolith microchemistry is being developed. The exact values for Von Bertalanffy growth parameters estimated within Stock Synthesis for later years are associated with uncertainties due to imprecise age information. This is affecting also the estimated natural mortality values, as growth and M are confounded. However, the results of stock assessment in terms of stock status were found to be robust to these uncertainties. See WKBALTCOD2 (2019) for further details.

Insufficient sampling, non-reliable catch information and uncertainties in modelled estimates of biological parameters are affecting the quality of the present assessment. The high recruitment estimates in the latter part of the time series are considered not reliable while trends in SSB and F are consistent with previous assessments (see 2.1.10).

2.1.10 Comparison with previous assessment

The initial assessment was consistent with the last years' assessment. However, it gave the impression that recruitment had increased compared previous assessments but without affecting SSB or F (Figure 2.1.24). The main problems are related to that assumption about 0-year growth, recruitment mortality and recruitment deviation. The 0-year growth has increased in recent years, and the natural mortality has decreased. At the same time, the surveys indicate an increase in recruitment the latest years. This, in combination with model assumptions regarding recruitment deviation was set zero, makes the model assume that there are more recruits than assumed previously forces the number of recruits to increase in later years (Figure 2.1.25, also shown by the squid plot of retrospectives of recruitment deviations Figure 2.1.19). As stated above, the retrospective patterns was not obvious in SSB and F(4-6) as most of these problems are related to recruitment, which makes us trust the trends in these two variables. However, due to these problems it was decided to downgrade the assessment from a category 1 to a category 3 assessment. The problems with the model assumptions are possible to fix but will have effects on reference values and hence, would require a future benchmark which is also an argument for downgrading it to a category 3 assessment.

Management considerations

At the presently low productivity, the stock is estimated not to recover above B_{lim} in medium-term even at no fishing. Furthermore, fishing at any level will target the remaining few

commercial sized (>=35cm) cod, and by that further deteriorate the stock structure and reduce its reproductive potential.

The poor status of the Eastern Baltic cod is largely driven by biological changes in the stock during the last decades. Growth, condition (weight at length) and size at maturation have substantially declined. These developments indicate that the stock is distressed and is expected to have reduced reproductive potential. Natural mortality has increased and is estimated to be considerably higher than the fishing mortality in recent years. Population size structure has continuously deteriorated during the last years.

The low growth, poor condition and high natural mortality of cod are related to changes in the ecosystem, which include: i) Poor oxygen conditions that can affect cod directly via altering metabolism and via shortage of benthic prey, and additionally affect the survival of offspring. ii) Low availability of fish prey in the main distribution area of cod, as sprat and herring are more northerly distributed with little overlap with cod, especially in autumn. (iii) High infestation with parasites, which is related to increased abundance of grey seals. The relative impact of these drivers for the cod stock is unclear.

Table 2.1.1 Cod SDs 25-32. Landings (tons) by country (excluding BMS).

Year	Denmark	Estonia	Finland	German Dem.Rep.**	Germany Fed. Rep.	Latvia	Lithuania	Poland	Russia	Sweden	USSR	Faroe Islands^	Norway	Unallocated***	Total
196	3707		26	1058	1283			56007		2252	38270				17731
196	3910		27	2102	1294			56003		2336	42980				19544
196	4410		70	2447	1683			63245		2400	43610				21635
196	4406		58	2597	1743			60749		2230	41580				21216
197	4239		70	1809	1944			68440		1775	32250				19845
197	4683		53	1097	1624			54151		1567	20910				16484
197	3407		76	4055	3203			57093		1519	30140				14383
197	3545		95	6034	1497			49790		1673	20083				14316
197	3202		160	2517	1183			48650		1449	38131				14781
197	3904		298	8700	1196			69318		1603	49289				19464
197	4741		287	3970	1373			70466		1838	49047				20330
197	4440		310	7519	1912			47702		1606	29680				16479
197	3026		143	2260	4270			64113		1446	37200				15400
197	3435		293	1403	9777			79754		2059	75034	385			22769
198	4970		596	1826	1175			12348		2929	12435	125			34761
198	6852		568	1277	7021			12090		3773	87746	276			33164
198	7115		812	753	1380			92541		3847	86906	430			31605
198	8440		892	1424	1589			76474		4671	92248	606			33214
198	9008		935	1793	3048			93429		5968	10076	635			39195
198	8352		722	1215	2627			63260		4956	78127	589			31508
198	8152		563	181	1952			43236		4572	52148	459			25255
198	6888		300	218	1456			32667		4297	39203	556			20708
198	6043		290	2	1407			33351		4896	28137	691			19478
198	5724		225	3	1284			36855		5074	14722	452			17917
199	4739		173		4691			32028		5068	13461	355			15354
199	3979	181	171		6564	262	186	25748	3299	3649		261			12251

199	1802	136	485	2793	125	126	13314	1793	1399	593			54882
199	8000	70	225	1042	133	605	8909	892	1009	558		1897	50711
199	9901	952	594	3056	283	188	14335	1257	2126	779		4400	10085
199	1689	104	172	5496	663	451	25000	1612	2472	777	293	1899	10771
199	1754	133	308	7340	870	552	34855	3306	3066	706	289	1081	12418
199	9776	141	153	5215	618	460	31396	2803	2507	600			88600
199	7818	118	102	1270	776	417	25155	4599	1443				67428
199	1217	105	145	2215	688	437	25920	5202	1372				72995
200	9715	604	164	1508	619	516	21194	4231	1591			2311	89289
200	9580	765	152	2159	625	313	21346	5032	1785			2367	91328
200	7831	37	152	1445	479	313	15106	3793	1250			1756	67740
200	7655	591	109	1354	349	276	15374	3707	1129			2214	69477
200	7394	119	859	2659	483	204	14582	3410	1204			1956	68578
200	7270	833	278	2339	351	298	11669	3411	7740			1499	55032
200	9766	616	427	2025	398	320	14290	3719	9672			1783	65531
200	7280	877	615	1529	399	248	8599	3383	9660			1241	50843
200	7374	841	670	2341	399	283	8721	3888	8901			2673	42234
200	8295	623		3665	458	278	10625	4482	1018			3189	48438
201	1073	796	826	3908	500	314	11433	4264	1016				50276
201	1084	118	958	3054	491	301	11348	5022	1003				50368
201	1210	686	140	2432	426	226	14007	3954	1010				51225
201	6052	249	399	541	244	174	11760	2870	5299				31355
201	6035	166	350	676	199	108	11026	3444	4125				28909
201	9526	183	388	1477	287	184	12896	3845	4438				37471
201	6756	2	57	918	265	163	9583	3392	3995				28996
201	6109	1	191	337	205	171	6468	4124	4316				25317
201	2668	1	53	231	123	684	5687	3376	1862				15800
201	1051	2	85	281	251	111	3180	2701	665				8326
202	20	2	24	12	76	11	376	1778	11				2310
202	15	2	35	20	11	2	66	1225	8				1383
202	33	1	30	5	15	2	100	900^^	9				1095
202	15	1	26	5	18	2	114	799^^^	9				990

* Provisional data.
** Includes landings from October to December 1990 of Fed.Rep.Germany.
*** Working group estimates. No information available for years prior to 1993.
^ Landings for 1997 were not officially reported – estimated by ICES.
^^ Data not officially reported, approximate landings were obtained from http://atlant.vniro.ru
^^^ Data not officially reported, approximate landings were obtained from http://fish.gov.ru

Table 2.1.2a. Cod in SD 25-32. Landings (tons) of EU countries by fleet, country and subdivision in 2023 (BMS excluded).

Subdivision		25	26	27	28	29	30	31	32	Total 25-32
Fleet	Country									
Active	Denmark	14								14
	Estonia									0
	Finland						0			0

	Germany	3	2							5
	Latvia				0					0
	Lithuania		0		0					0
	Poland	92	10							102
	Sweden	0	0	0	0	0	0			1
Total Active gears		110	12	0	0	0	0	0	0	122
Passive	Denmark	0								0
	Estonia				0	0			1	1
	Finland					26			0	26
	Latvia		6		12					18
	Lithuania		2							2
	Poland	10	2							12
	Sweden	2		1	0	4				7
Total Passive gears		13	9	1	12	31	0	0	1	67
Total All gears		122	22	1	13	31	0	0	1	189

Table 2.1.2b. Cod in SD 25-32. Total landings (tons) by country in 2023, in SDs 25-32, separated between landings for human consumption (above MCRS) and the reported BMS landings.

Country	Landings for human consumption (t)	BMS landings (t)
Denmark	15	0
Estonia	1	0
Finland	26	0
Germany	5	0
Latvia	18	0.10
Lithuania	2	0
Poland	114	0
Russia	799*	
Sweden	8	1.69
Total	189	1.8

*Russian landings for 2023 were not officially reported to ICES. The estimate shown in the table and used in stock assessment is based on the approximate information available on *http://fish.gov.ru*

Table 2.1.3. Eastern Baltic cod stock in Subdivisions 25–32 and Subdivision 24. History of ICES estimates of landings, discards, and catch by area. Landings below minimum conservation reference size (BMS) was only possible to separate from 2017 onwards. Weights in tonnes.

Year	Eastern Baltic cod stock in SD 25-32						Eastern Baltic cod stock in Subdivision 24			Eastern Baltic cod stock in Subdivisions 24+25–32		
	Un allocated*	Landings AMS	Landings BMS	Total landings	Discards	Catch	Total landings	Discards	Catch	Total landings	Discards	Total catch
1966				177318	8735	186053	6624		6624	183942	8735	192677
1967				195446	11733	207179	6899		6899	202345	11733	214078
1968				216353	9700	226053	8614		8614	224967	9700	234667
1969				212160	10654	222814	5980		5980	218140	10654	228794
1970				198451	7625	206076	5720		5720	204171	7625	211796
1971				164840	5426	170266	6586		6586	171426	5426	176852
1972				143833	8490	152323	7307		7307	151140	8490	159630
1973				143164	7491	150655	7320		7320	150484	7491	157975
1974				147815	7933	155748	6923		6923	154738	7933	162671
1975				194649	9576	204225	5676		5676	200325	9576	209901
1976				203303	4341	207644	6972		6972	210275	4341	214616
1977				164792	2978	167770	6643		6643	171435	2978	174413
1978				154009	9875	163884	6553		6553	160562	9875	170437
1979				227699	14576	242275	7745		7745	235444	14576	250020
1980				347619	8544	356163	7721		7721	355340	8544	363884
1981				331642	6185	337827	13759		13759	345401	6185	351586
1982				316052	11548	327600	12239		12239	328291	11548	339839

Year	Eastern Baltic cod stock in SD 25-32						Eastern Baltic cod stock in Subdivision 24			Eastern Baltic cod stock in Subdivisions 24+25–32		
	Unallocated*	Landings AMS	Landings BMS	Total landings	Discards	Catch	Total landings	Discards	Catch	Total landings	Discards	Total catch
1983				332148	10998	343146	9853		9853	342001	10998	352999
1984				391952	8521	400473	8709		8709	400661	8521	409182
1985				315083	8199	323282	6971		6971	322054	8199	330253
1986				252558	3848	256406	6604		6604	259162	3848	263010
1987				207081	9340	216421	6874		6874	213955	9340	223295
1988				194787	7253	202040	8487		8487	203274	7253	210527
1989				179178	3462	182640	5721		5721	184899	3462	188361
1990				153546	4187	157733	5543		5543	159089	4187	163276
1991				122517	2741	125258	3762		3762	126279	2741	129020
1992				54882	1904	56786	2324		2324	57206	1904	59110
1993	18978			50711	1558	52269	3885		3885	54596	1558	56154
1994	44000			100856	1956	102812	6551	621	7172	107407	2577	109984
1995	18993			107718	1872	109590	5585	668	6253	113303	2540	115843
1996	10815			124189	1443	125632	10040	1116	11156	134229	2559	136788
1997**				88600	3462	92062	6547	641	7189	95147	4103	99251
1998				67428	2299	69727	4582	631	5213	72010	2930	74940
1999				72995	1838	74833	6221	599	6820	79216	2437	81653
2000	23118			89289	6019	95308	6316	1209	7525	95605	7228	102833
2001	23677			91328	2891	94219	7794	389	8183	99122	3280	102402
2002	17562			67740	1462	69202	5060	562	5622	72800	2024	74824

Year	Eastern Baltic cod stock in SD 25-32						Eastern Baltic cod stock in Subdivision 24			Eastern Baltic cod stock in Subdivisions 24+25–32		
	Un allocated*	Landings AMS	Landings BMS	Total landings	Discards	Catch	Total landings	Discards	Catch	Total landings	Discards	Total catch
2003	22147			69477	2024	71501	5729	862	6592	75206	2886	78093
2004	19563			68578	1201	69779	5309	188	5497	73887	1389	75276
2005	14991			55032	1670	56702	6064	1729	7793	61096	3399	64495
2006	17836			65531	4644	70175	6767	144	6911	72298	4788	77086
2007	12418			50843	4146	54989	8792	875	9667	59635	5021	64656
2008	2673			42234	3746	45980	8811	787	9598	51045	4533	55578
2009	3189			48438	3328	51766	8284	464	8747	56722	3792	60513
2010				50276	3543	53819	6049	533	6581	56325	4076	60400
2011				50368	3850	54218	7545	482	8027	57913	4332	62245
2012				51225	6795	58020	8469	536	9004	59694	7331	67024
2013				31355	5020	36375	5359	1243	6602	36714	6263	42977
2014				28909	9627	38536	5455	1298	6753	34364	10925	45289
2015				38079	5970	44049	5029	930	5959	43108	6900	50008
2016				29313	3279	32591	4541	306	4847	33854	3585	37438
2017		25317	179	25496	3238	28734	2004	227	2231	27500	3465	30965
2018		15800	108	15907	3103	19010	2295	300	2595	18202	3403	21605
2019		8326	57	8383	1337	9720	1598	621	2219	9980	1958	11938
2020		2310	8	2319	101	2420	429	50	479	2748	152	2899
2021		1383	4	1387	85	1472	264	28	291	1651	113	1764
2022^		1095	2	1097	20.5	1118	48	14.5	63	1146	35	1181
2023^^		988	2	990	12	1002	18	45	63	1008	57	1065

***ICES estimates. No information available for years prior to 1993 or after 2009.**

****For 1997 landings were not officially reported – estimated by ICES**

^ Landings for Russia were not officially reported- approximate landings were obtained from *http://atlant.vniro.ru*

^^Landings for Russia were not officially reported- approximate landings were obtained from *http://fish.gov.ru*

Table 2.1.4 Cod SDs 25-32. Number of length samples reported to InterCatch by year, fleet and catch category 2017-2023. For 2022-2023, no sampling information for Russian catches was available to ICES.

Catch category	Fleet	2017	2018	2019	2020	2021	2022	2023
Landings	Active	239	263	147	76	49	2	1
	Passive	71	72	35	21	33	5	2
Discards	Active	127	114	51	6	4	2	5
	Passive	16	37	16	0	0	0	0
BMS landings	Active	83	91	38	0	0	0	0
	Passive	19	36	15	0	0	0	0

Table 2.1.5. Cod in SD 25-32. Numbers (in thousands) of cod by length-groups in EU landings for wanted (human consumption landings) and unwanted catch (includes both BMS landings and estimated discards) in SDs 25-32 in 2023.

Length class	Wanted catch	Unwanted catch	Total
<20		1	1
20-24		4	4
25-29		14	14
30-34	110	26	135
35-37	155	8	163
38-44	138	1	139
45-49	18		18
>=50			
	421	54	474

Table 2.1.6 Cod in SD 25-32.Mean weight (g) by length class in wanted (human consumption landings) and unwanted catch (includes both BMS landings and estimated discards), in 2023.

Fleet	Length class (cm)	Wanted catch	Unwanted catch
Active	<20		45
	20-24		91
	25-29		170
	30-34		285
	35-37	460	399
	38-44	593	475
	45-49	863	
	>=50		

Passive	<20		45
	20-24		91
	25-29		169
	30-34	262	284
	35-37	421	399
	38-44	560	475
	45-49	639	
	>=50		

Table 2.1.7 Cod in SD 25-32. Indicator values for LeCren's condition index, L50 (size at which half of the stock is mature) and L95 (length corresponding to 95th percentile of the length distribution). Based on BITS Q1 survey.

Year	LeCren K	L50	L95
1991	1.17	39	68
1992	1.12	33	64
1993	1.11	37	47
1994	1.10	33	53
1995	1.10	38	57
1996	1.07	39	59
1997	1.09	40	59
1998	1.06	37	54
1999	1.02	35	50
2000	1.04	34	45
2001	1.06	32	46
2002	1.02	31	47
2003	1.01	32	47
2004	1.02	31	47
2005	1.00	31	44
2006	0.99	28	46
2007	1.00	29	45
2008	0.99	27	45
2009	0.95	26	50
2010	0.96	27	52
2011	0.96	27	47
2012	0.96	27	45
2013	0.95	25	40
2014	0.95	27	39
2015	0.97	22	41

Year	LeCren K	L50	L95
2016	0.97	21	43
2017	1.00	21	43
2018	0.97	21	42
2019	1.00	21	39
2020	1.01	20	41
2021	0.98	16	41
2022	0.99	19	39
2023	0.99	18	37
2024	0.96		35

Table 2.1.8. Eastern Baltic cod in SDs 24-32. Input data for Stock Synthesis model.

Type	Name	Year range	Range	Time variant
Catches	Catch in tonnes split into Active/Passive and quarters	1946-2023	0 - 15+	
Age compositions of catch	Catch in numbers per age class , by fleets, by Q	1946-2006	0 - 12+	
Length compositions of catch	Catch in numbers per length class of the fleets, by Q,	2000-2023	5 – 120 cm	
Maturity ogives	Size at 50%maturity(L50) and slope	1946-2023		Yes (1998-2022, time blocks)
Growth	Von Bertalanffy growth parameters	1946-1990		No
Age length keys	Age length keys from BITS Q1 and Q4	1991-2023	0 – 12+	Yes
Natural mortality	Natural mortality by age class	1946-1999	0 - 15+	No
Trawl survey indices	CPUE from BITS Q1, Q4, and two historical trawl surveys	1975-2024		
Length composition of survey catch	Length composition of BITS Q1 and Q4	1991-2024		
Commercial CPUE indices	Commercial CPUE 1-3	1948-1989		
SSB index	SSB index from egg production method	1986-2023		
Larval index	Larval abundance	1987-2023		

Table 2.1.9. Eastern Baltic cod in SDs 24-32. Settings and estimated parameters. The columns show: number of estimated parameters, the initial values (from which the numerical optimization is started), the intervals allowed for the parameters, the priors used, and the value estimated by maximum likelihood. Parameters in bold are set and not estimated by the model.

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
Natural mortality (age classes 0.5, 1.5, 5.5, 15.5)		1.243, 0.857, 0.361, 0.215			
M (2000-2022) of age class 5.5	23	Estimated using random walk annual deviations	(0.1,2.0)	no prior	0.35-0.79
Stock and recruitment					
Ln(R_0)	1	14.8	(13,16)	no prior	15.2
Steepness (h)		0.99			
Recruitment variability (σ_R)		0.60			
Ln (recruitment deviations): 1946-2021	76				
Recruitment autocorrelation		0			
Growth					
L_{inf} (cm) (1946-1990)		125.27			
L_{inf} (cm) (1991-2023)	32	Estimated using random walk annual deviations	(40-150)	no prior	122-48
k (1946-1990)		0.10			
k (1991-2023)	32	Estimated using random walk annual deviations	(0.07-0.45)	no prior	0.10-0.27
L at minimum age (0.5 years) t_0		12			
CV of young individuals	1	0.290	(0.05-0.8)	no prior	0.26
CV of old individuals		0.05			
Weight (kg) at length (cm)					
a (1946-1990)		6.58e-06			
b (1946-1990)		3.1353			
a (1991-1993, 1994- 1996, 1997- 1999, 2000 -2002, 2003-2005, 2006-2008, 2009-2011, 2012-2014, 2015-2017, 2018-2020, 2021-2023)		6.58E-06, 8.05E-06, 6.81E-06, 6.78E-06 6.76E-06, 7.47E-06 6.70E-06, 7.73E-06, 8.78E-06,7.56E-06, 8.40E-06			

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
b (1991-1993, 1994- 1996, 1997- 1999, 2000 -2002, 2003-2005, 2006-2008, 2009-2011,2012-2014, 2015-2017,2018-2020,2021-2023)		3.1353, 3.0636, 3.1062 3.0992, 3.0972, 3.0637 3.0831, 3.0406, 3.0087,3.0588,2.9321			
Maturity					
Length (cm) at 50% mature (1946-1990)		35			
Slope of the length at maturity ogive		-0.43			
Length (cm) at 50% mature (1991-1997, 1998-2000, 2001-2007, 2008-2014, 2015-2023)		38, 36, 31, 26, 20			
Initial fishing mortality					
Active gears		0.60			
Selectivity (logistic)					
Active gears					
Time-invariant length based logistic selectivity	2	35; 12.68	(20,45; 0.01,50)	no prior	(39; 8.6)
Passive gears					
Time-invariant length based logistic selectivity	2	35; 10	(20,65; -12,15)	no prior	(41.9; 9.0)
BITS Q1 survey					
Time-invariant length based logistic selectivity	2	25,10	(15,50; -12,15)	no prior	(27;9.4)
BITS Q4 survey					
Time-invariant length based logistic selectivity	2	25,10	(15,50; -12,15)	no prior	(27.9; 10)
Commercial CPUE 1-3		Mirror active fleet			
Trawl surveys 1-2		Mirror BITS Q1			
Catchability					
BITSQ1					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation		0.001			
BITSQ4					

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation		0.001			
Trawl survey 1					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.30
Trawl survey 2					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.02
Commercial CPUE 1					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.09
Commercial CPUE 2					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.06
Commercial CPUE 3					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.32
SSBEggProd					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,1.2)	no prior	0.43
Larvae index					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation		0.3			

Table 2.1.11. Eastern Baltic cod in SDs 24-32. Assessment summary. Weights are in tonnes; recruitment, fishing mortality, and SSB are relative to the average of the time-series.

Year	Relative Recruitment	Relative SSB	Landings*	Discards	Relative Fishing Mortality (ages 4-6)
1946	0.47	0.54	40985		0.58
1947	0.67	0.73	71831		0.75
1948	0.79	0.87	107104		0.90
1949	0.82	0.91	112735		0.89
1950	0.65	0.96	124509		0.93
1951	0.52	1.04	137815		0.95
1952	0.59	1.04	161103		1.09
1953	0.85	1.04	118132		0.81
1954	0.83	0.99	123947		0.88
1955	0.51	1.02	114415		0.81
1956	0.42	1.07	151985		1.01
1957	0.64	0.98	181366		1.27
1958	0.53	0.84	136301		1.11
1959	0.59	0.73	126033		1.18
1960	0.55	0.64	145408		1.52
1961	0.56	0.64	112034		1.23
1962	0.59	0.66	115553		1.22
1963	0.91	0.65	123047		1.30
1964	1.17	0.71	97788		0.99
1965	1.04	0.84	109809		0.95
1966	1.01	0.95	183942	8735	1.43
1967	0.94	1.06	202345	11733	1.41
1968	0.75	1.08	224967	9700	1.48
1969	0.76	1.05	218140	10654	1.48
1970	0.95	0.98	204171	7625	1.46
1971	1.26	0.92	171426	5426	1.31
1972	1.58	0.96	151140	8490	1.17
1973	1.01	1.16	150484	7491	1.00

Year	Relative Recruitment	Relative SSB	Landings*	Discards	Relative Fishing Mortality (ages 4-6)
1974	0.86	1.57	154738	7933	0.79
1975	1.20	1.86	200325	9576	0.83
1976	2.6	1.80	210275	4341	0.83
1977	2.1	1.85	171435	2978	0.67
1978	1.28	2.4	160562	9875	0.54
1979	2.1	3.1	235444	14576	0.62
1980	2.1	3.3	355340	8544	0.81
1981	1.45	3.0	345401	6185	0.81
1982	0.92	3.3	328291	11548	0.77
1983	0.80	3.2	342001	10998	0.78
1984	0.82	2.7	400661	8521	1.03
1985	1.16	2.0	322054	8199	1.08
1986	0.71	1.47	259162	3848	1.16
1987	0.46	1.24	213955	9340	1.20
1988	0.48	1.19	203274	7253	1.22
1989	0.36	0.97	184899	3462	1.25
1990	0.85	0.75	159089	4187	1.40
1991	1.03	0.50	126279	2741	1.59
1992	0.72	0.46	57206	1904	0.92
1993	0.61	0.66	54596	1558	0.65
1994	0.62	0.70	107407	2577	1.04
1995	0.50	0.74	113303	2540	1.05
1996	0.93	0.52	134229	2559	1.63
1997	0.92	0.32	95147	4103	1.91
1998	0.91	0.26	72010	2930	2.1
1999	0.75	0.23	79216	2437	2.3
2000	0.93	0.28	95605	7228	2.2
2001	0.64	0.39	99122	3280	1.91
2002	0.83	0.48	72800	2024	1.25

Year	Relative Recruitment	Relative SSB	Landings*	Discards	Relative Fishing Mortality (ages 4-6)
2003	1.47	0.49	75206	2886	1.26
2004	1.15	0.43	73887	1389	1.31
2005	1.50	0.52	61096	3399	1.10
2006	1.63	0.51	72298	4788	1.23
2007	1.53	0.52	59635	5021	0.92
2008	1.70	0.79	51045	4533	0.65
2009	1.37	0.86	56722	3792	0.61
2010	1.57	0.87	56325	4076	0.58
2011	2.0	0.76	57913	4332	0.64
2012	2.0	0.64	59694	7331	0.83
2013	1.25	0.62	36714	6263	0.58
2014	0.99	0.66	34364	10925	0.56
2015	0.64	0.77	43108	6900	0.56
2016	0.90	0.65	33854	3585	0.44
2017	0.76	0.46	27500	3465	0.46
2018	0.45	0.38	18202	3403	0.41
2019	0.91	0.34	9980	1958	0.25
2020	1.06	0.31	2748	152	0.064
2021	1.61	0.33	1651	113	0.041
2022	0.96	0.35	1146	35	0.027
2023	0.95**	0.45	1008	57	0.044
2024	0.95**				

*average of 2018-2022

Table 2.1.12. Eastern Baltic cod in SDs 24-32. Stock numbers at age (thousands; in the beginning of the year).

Year	a1	a2	a3	a4	a5	a6	a7	a8
1946	2294900	453146	124897	26189	10637	4888	1948	2246
1947	1278510	746402	192689	52823	10726	4502	2172	1889
1948	1858720	415738	314817	77711	19699	4023	1751	1590
1949	2200270	604268	174198	123164	27427	6895	1452	1209

Year	a1	a2	a3	a4	a5	a6	a7	a8
1950	2253990	715309	253336	68567	44078	9782	2541	984
1951	1762340	732746	299403	98682	24027	15296	3497	1258
1952	1408270	572911	306604	116396	34441	8294	5436	1684
1953	1616740	457711	238172	115560	38380	11069	2727	2325
1954	2348190	525679	192924	96679	43924	14790	4441	2033
1955	2279890	763427	220803	76961	35576	16248	5674	2486
1956	1388690	741326	321951	89667	29235	13691	6508	3274
1957	1151930	451420	309689	124258	30895	9932	4782	3405
1958	1764930	374302	186218	112471	38271	9112	2973	2431
1959	1467490	573615	155599	70521	37549	12515	3055	1807
1960	1632850	476902	237625	57698	22584	11637	3955	1528
1961	1496720	530378	194252	80509	15547	5614	2887	1338
1962	1551560	486395	219381	71027	24997	4623	1695	1263
1963	1675250	504215	201165	80211	22058	7437	1396	886
1964	2622790	544334	207618	71941	23902	6228	2121	644
1965	3345860	852631	227723	80551	24996	8202	2199	972
1966	2929490	1087780	357459	89108	28395	8730	2951	1137
1967	2834590	951792	445811	123439	24671	7278	2237	1030
1968	2583260	920990	390744	155797	35025	6530	1932	854
1969	2014830	839206	376539	134232	42925	8942	1667	700
1970	2101450	654523	342899	129233	36975	10963	2284	595
1971	2613030	682652	267466	118116	35919	9560	2840	734
1972	3470560	849015	280815	95306	34994	10072	2706	998
1973	4290890	1127900	351631	103237	29874	10529	3079	1121
1974	2687890	1394890	471258	134948	35036	9936	3591	1424
1975	2261770	873996	588373	191128	50994	13375	3942	1990
1976	3252100	735373	367839	237033	71569	19273	5252	2332
1977	7043410	1057630	310985	149582	89569	27270	7626	3002
1978	5724340	2290930	449881	131082	60701	37421	11942	4674

Year	a1	a2	a3	a4	a5	a6	a7	a8
1979	3388870	1861670	974473	193576	56062	27268	17785	7962
1980	5642340	1102180	790817	413486	80394	24236	12421	11807
1981	5700380	1834440	463180	319918	157966	31351	9874	9927
1982	3754530	1853820	775338	188820	122093	61103	12624	8020
1983	2329270	1220850	782780	318038	73230	48272	25215	8571
1984	1999800	757474	515719	320302	122924	28861	19862	13944
1985	2097910	650195	317648	200358	110626	41699	10047	11725
1986	3159800	681987	271395	121018	66950	36049	13901	7239
1987	1918890	1027210	284217	100962	38214	20199	11022	6410
1988	1197780	623710	426186	102979	30204	10740	5708	4865
1989	1208970	389274	257810	152774	30397	8368	2990	2909
1990	885090	392947	160818	91934	44842	8380	2319	1618
1991	1770210	287522	160312	54431	24443	10870	2013	929
1992	2102460	575420	118296	53240	13329	5215	2247	590
1993	1419600	683549	243807	48066	19460	4755	1895	1020
1994	1195090	461706	290501	106090	20607	8628	2207	1356
1995	1167500	388589	193684	115256	39119	7495	3207	1313
1996	867602	379337	161261	74964	41225	14165	2796	1677
1997	1625010	281909	155806	56737	21251	10871	3742	1154
1998	1653780	527974	116795	55344	15721	5223	2613	1144
1999	1698980	537064	217914	42770	15962	3988	1274	883
2000	1319740	552028	222826	80054	12162	3765	870	442
2001	1721830	428769	225957	76638	20938	2659	751	243
2002	1132170	559427	176882	78031	20103	4684	551	190
2003	1388550	367976	233642	68262	25354	6008	1362	206
2004	2395630	451304	153940	89856	22132	7376	1681	419
2005	1882290	778531	188891	59355	28634	6260	1965	529
2006	2342500	611567	324026	74936	20953	9438	2016	774
2007	2479660	761759	257292	127040	25244	6331	2697	758

Year	a1	a2	a3	a4	a5	a6	a7	a8
2008	2345170	806609	324510	106978	46631	8519	2038	1065
2009	2457730	762835	342972	138977	42472	17453	3112	1105
2010	2099720	799413	322481	144048	54916	15834	6323	1502
2011	2240940	682948	337377	133865	56085	20429	5721	2787
2012	3042800	728861	287574	138057	49727	19382	6782	2754
2013	3102200	989337	305069	113953	46797	14493	5140	2378
2014	1923320	1008910	416181	125409	42224	15445	4397	2178
2015	1542380	625410	422260	169001	46022	13797	4608	1851
2016	1041490	501516	260617	168641	61030	14891	4090	1811
2017	1633650	338757	209745	105412	62928	21042	4843	1870
2018	1282940	531306	141491	84297	38607	21080	6639	2067
2019	758424	417300	222279	57600	31649	13299	6866	2799
2020	1532890	246796	175523	92898	23102	12079	4933	3658
2021	1389500	498892	104165	75175	39871	9931	5277	4057
2022	948687	452247	210730	44773	32540	17380	4423	4549
2023	1182490	308786	191143	90833	19497	14320	7838	4495
2024	324197	578012	403746	110332	38884	7645	5206	2549

Table 2.1.13. Eastern Baltic cod in SDs 24-32. Fishing mortality at age.

Year/Ages	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1946	0.00	0.03	0.16	0.32	0.41	0.45	0.47	0.47	0.48	0.48	0.48	0.48	0.48	0.48
1947	0.00	0.04	0.21	0.41	0.53	0.59	0.61	0.61	0.62	0.62	0.62	0.62	0.62	0.62
1948	0.00	0.04	0.24	0.47	0.60	0.66	0.68	0.69	0.69	0.70	0.70	0.70	0.70	0.70
1949	0.00	0.04	0.24	0.45	0.58	0.64	0.66	0.67	0.67	0.67	0.67	0.67	0.67	0.68
1950	0.00	0.04	0.25	0.48	0.61	0.67	0.69	0.70	0.70	0.70	0.70	0.70	0.70	0.71
1951	0.00	0.04	0.25	0.48	0.61	0.68	0.70	0.71	0.71	0.71	0.71	0.71	0.71	0.72
1952	0.00	0.05	0.28	0.54	0.69	0.75	0.78	0.79	0.79	0.79	0.79	0.79	0.79	0.80
1953	0.00	0.04	0.20	0.39	0.50	0.55	0.57	0.58	0.58	0.58	0.58	0.58	0.58	0.59
1954	0.00	0.04	0.22	0.43	0.55	0.60	0.62	0.63	0.63	0.63	0.63	0.63	0.63	0.64
1955	0.00	0.04	0.20	0.40	0.51	0.56	0.58	0.58	0.58	0.59	0.59	0.59	0.59	0.59

Year/Ages	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1956	0.00	0.05	0.26	0.49	0.63	0.69	0.72	0.73	0.73	0.73	0.73	0.73	0.73	0.74
1957	0.00	0.06	0.32	0.60	0.77	0.85	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.90
1958	0.00	0.05	0.27	0.52	0.67	0.73	0.76	0.77	0.77	0.77	0.77	0.77	0.77	0.78
1959	0.00	0.05	0.30	0.57	0.72	0.79	0.82	0.83	0.83	0.83	0.83	0.83	0.83	0.84
1960	0.00	0.07	0.39	0.74	0.94	1.03	1.07	1.08	1.09	1.09	1.09	1.09	1.09	1.09
1961	0.00	0.06	0.31	0.60	0.76	0.84	0.87	0.88	0.88	0.88	0.88	0.88	0.88	0.89
1962	0.00	0.06	0.31	0.60	0.76	0.84	0.87	0.88	0.88	0.88	0.88	0.88	0.88	0.89
1963	0.00	0.06	0.33	0.64	0.82	0.90	0.93	0.94	0.94	0.94	0.94	0.94	0.94	0.95
1964	0.00	0.05	0.25	0.48	0.62	0.68	0.71	0.71	0.72	0.72	0.72	0.72	0.72	0.72
1965	0.00	0.04	0.24	0.47	0.60	0.66	0.69	0.70	0.70	0.70	0.70	0.70	0.70	0.70
1966	0.00	0.07	0.37	0.71	0.91	1.00	1.04	1.05	1.05	1.06	1.06	1.06	1.06	1.06
1967	0.00	0.06	0.35	0.69	0.88	0.97	1.00	1.01	1.02	1.02	1.02	1.02	1.02	1.02
1968	0.00	0.07	0.37	0.72	0.92	1.01	1.04	1.05	1.06	1.06	1.06	1.06	1.06	1.06
1969	0.00	0.07	0.37	0.72	0.92	1.01	1.04	1.05	1.06	1.06	1.06	1.06	1.06	1.06
1970	0.00	0.07	0.37	0.71	0.90	0.99	1.03	1.04	1.04	1.04	1.04	1.04	1.04	1.05
1971	0.00	0.06	0.34	0.64	0.82	0.90	0.93	0.95	0.95	0.95	0.95	0.95	0.95	0.96
1972	0.00	0.06	0.30	0.59	0.75	0.83	0.86	0.87	0.87	0.87	0.87	0.87	0.87	0.88
1973	0.00	0.05	0.26	0.51	0.65	0.72	0.74	0.75	0.75	0.75	0.75	0.75	0.75	0.76
1974	0.00	0.04	0.21	0.40	0.51	0.57	0.59	0.59	0.59	0.60	0.60	0.60	0.60	0.60
1975	0.00	0.04	0.21	0.41	0.52	0.58	0.60	0.60	0.61	0.61	0.61	0.61	0.61	0.61
1976	0.00	0.03	0.20	0.40	0.52	0.57	0.59	0.60	0.60	0.60	0.60	0.60	0.60	0.61
1977	0.00	0.03	0.17	0.33	0.42	0.47	0.48	0.49	0.49	0.49	0.49	0.49	0.49	0.50
1978	0.00	0.03	0.15	0.28	0.35	0.38	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.41
1979	0.00	0.03	0.16	0.31	0.39	0.43	0.44	0.45	0.45	0.45	0.45	0.45	0.45	0.46
1980	0.00	0.04	0.21	0.39	0.49	0.54	0.56	0.56	0.57	0.57	0.57	0.57	0.57	0.57
1981	0.00	0.03	0.20	0.39	0.50	0.55	0.57	0.58	0.58	0.58	0.58	0.58	0.58	0.59
1982	0.00	0.04	0.19	0.37	0.48	0.53	0.54	0.55	0.55	0.55	0.55	0.55	0.55	0.56
1983	0.00	0.04	0.20	0.38	0.48	0.53	0.55	0.55	0.56	0.56	0.56	0.56	0.56	0.56
1984	0.00	0.04	0.25	0.49	0.63	0.70	0.72	0.73	0.73	0.73	0.73	0.73	0.73	0.74

Year/Ages	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1985	0.00	0.05	0.27	0.52	0.67	0.74	0.77	0.78	0.78	0.78	0.78	0.78	0.78	0.79
1986	0.00	0.05	0.29	0.58	0.75	0.83	0.86	0.87	0.87	0.87	0.87	0.87	0.87	0.88
1987	0.00	0.05	0.32	0.63	0.82	0.90	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.96
1988	0.00	0.06	0.33	0.65	0.83	0.92	0.95	0.97	0.97	0.97	0.97	0.97	0.97	0.97
1989	0.00	0.06	0.33	0.65	0.84	0.92	0.96	0.97	0.97	0.97	0.97	0.97	0.97	0.98
1990	0.00	0.07	0.39	0.75	0.97	1.07	1.11	1.12	1.13	1.13	1.13	1.13	1.13	1.13
1991	0.00	0.06	0.41	0.83	1.10	1.22	1.27	1.28	1.29	1.29	1.29	1.29	1.29	1.30
1992	0.00	0.03	0.20	0.43	0.58	0.65	0.68	0.69	0.70	0.70	0.70	0.70	0.70	0.70
1993	0.00	0.03	0.14	0.27	0.36	0.41	0.43	0.43	0.44	0.44	0.44	0.44	0.44	0.44
1994	0.00	0.04	0.23	0.42	0.56	0.63	0.66	0.67	0.67	0.68	0.68	0.68	0.68	0.68
1995	0.00	0.05	0.25	0.46	0.57	0.63	0.65	0.66	0.67	0.67	0.67	0.67	0.67	0.67
1996	0.00	0.06	0.35	0.69	0.88	0.97	1.01	1.03	1.04	1.04	1.04	1.04	1.04	1.04
1997	0.00	0.05	0.34	0.71	0.95	1.07	1.11	1.13	1.14	1.14	1.14	1.14	1.14	1.15
1998	0.00	0.06	0.31	0.67	0.92	1.05	1.10	1.12	1.13	1.13	1.13	1.13	1.13	1.14
1999	0.00	0.05	0.30	0.68	1.00	1.16	1.24	1.27	1.28	1.28	1.28	1.28	1.28	1.29
2000	0.00	0.07	0.37	0.77	1.07	1.26	1.34	1.38	1.39	1.39	1.39	1.40	1.40	1.40
2001	0.00	0.06	0.37	0.77	1.05	1.22	1.31	1.34	1.36	1.36	1.36	1.36	1.36	1.37
2002	0.00	0.05	0.25	0.55	0.75	0.87	0.93	0.96	0.97	0.98	0.98	0.98	0.98	0.99
2003	0.00	0.04	0.25	0.54	0.77	0.90	0.96	0.99	1.00	1.01	1.01	1.01	1.01	1.02
2004	0.00	0.04	0.24	0.55	0.78	0.93	1.00	1.04	1.05	1.06	1.06	1.06	1.06	1.07
2005	0.00	0.05	0.21	0.44	0.61	0.72	0.78	0.80	0.82	0.82	0.82	0.82	0.82	0.83
2006	0.00	0.03	0.21	0.47	0.68	0.81	0.89	0.92	0.94	0.95	0.95	0.95	0.95	0.96
2007	0.00	0.02	0.14	0.36	0.54	0.66	0.73	0.77	0.79	0.80	0.80	0.80	0.80	0.81
2008	0.00	0.02	0.10	0.27	0.41	0.51	0.56	0.59	0.61	0.62	0.62	0.62	0.62	0.64
2009	0.00	0.02	0.11	0.25	0.39	0.48	0.53	0.56	0.58	0.59	0.59	0.59	0.59	0.61
2010	0.00	0.02	0.11	0.24	0.36	0.45	0.50	0.53	0.55	0.56	0.56	0.56	0.56	0.59
2011	0.00	0.02	0.12	0.27	0.41	0.50	0.57	0.61	0.63	0.64	0.65	0.65	0.65	0.68
2012	0.00	0.02	0.14	0.35	0.55	0.70	0.80	0.86	0.91	0.93	0.94	0.95	0.95	0.97
2013	0.00	0.02	0.09	0.24	0.41	0.54	0.63	0.69	0.73	0.75	0.77	0.78	0.78	0.80

Year/Ages	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2014	0.00	0.02	0.10	0.24	0.40	0.53	0.63	0.70	0.74	0.78	0.79	0.81	0.81	0.84
2015	0.00	0.02	0.11	0.24	0.39	0.51	0.61	0.69	0.74	0.77	0.79	0.81	0.82	0.85
2016	0.00	0.02	0.09	0.19	0.30	0.40	0.47	0.54	0.58	0.61	0.63	0.65	0.66	0.69
2017	0.00	0.02	0.08	0.20	0.31	0.41	0.48	0.55	0.60	0.64	0.66	0.68	0.70	0.74
2018	0.00	0.01	0.07	0.17	0.27	0.36	0.43	0.49	0.54	0.57	0.61	0.64	0.65	0.69
2019	0.00	0.01	0.04	0.10	0.16	0.22	0.27	0.30	0.33	0.36	0.38	0.40	0.42	0.46
2020	0.00	0.00	0.01	0.03	0.04	0.05	0.06	0.07	0.08	0.08	0.09	0.09	0.10	0.13
2021	0.00	0.00	0.01	0.02	0.02	0.03	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.09
2022	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.07
2023	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.4	0.04	0.04	0.04

Figure 2.1.2 Eastern Baltic cod in SDs 24-32. Relative distribution of landings of the eastern Baltic cod stock by SD.

Figure 2.1.3. Eastern Baltic cod in SDs 24-32. Length distributions of EU commercial landings in later years, by Active and Passive fleets.

Gadus morhua 2023 Q1 less than 25cm
Catch in numbers per hour of hauling
0
2000
4000
6000
Latitude
Longitude

Gadus morhua 2023 Q1 25-45 cm
Catch in numbers per hour of hauling
2000
4000
6000
8000
Latitude
Longitude

Gadus morhua 2023 Q1 greater than 45 cm
Catch in numbers per hour of hauling
200
400
600
800
Latitude
Longitude

Gadus morhua 2023 Q4 less than 25cm
Catch in numbers per hour of hauling
0
2000
4000
6000
Latitude
Longitude

Gadus morhua 2023 Q4 25-45 cm
Catch in numbers per hour of hauling
2000
4000
6000
Latitude
Longitude

Gadus morhua 2023 Q4 greater than 45 cm
Catch in numbers per hour of hauling
10
20
30
40
50
60
Latitude
Longitude

Figure 2.1.4. Eastern Baltic cod in SDs 24-32. Distribution of cod from latest BITS surveys in Q1 (2023), Q4 (2023) and Q1 (2024) by 3 size-groups (<25cm, 25-40cm and >45cm cod). The scale is comparable between surveys within a size group, but not between size-groups.

Figure 2.1.5. Eastern Baltic cod in SDs 24-32. Length distributions in latest BITS surveys in SD 24 and in SDs 25-32, based on DATRAS data products.

Figure 2.1.6. Eastern Baltic cod in SDs 24-32. Le Cren's condition index (all lengths combined) in Q1 and Q4 (upper panels). Fulton's K condition index of cod by length groups (<25cm, 25-30cm, 30-40cm, 40-60cm) (lower panels. Data are from BITS surveys in SDs 25-32.

Figure 2.1.7. Eastern Baltic cod in SDs 24-32. Abundance of larvae in the main spawning area during peak spawning time.

Fig. 2.1.8a. Eastern Baltic cod in SDs 24-32. Relative total biomass index (CPUE), estimated from Q1 and Q4 BITS surveys.

Fig. 2.1.8b. Eastern Baltic cod in SDs 24-32. Left panel: Relative biomass index (CPUE), by length-groups, estimated from Q1 and Q4 BITS surveys combined. Right panel: Length corresponding to 95% percentile of length distribution (L95), in BITS Q1 survey.

Figure 2.1.9. Eastern Baltic cod in SDs 24-32. Relative index of spawning stock biomass, calculated from egg production method. Data are from ichthyoplankton surveys.

Figure 2.1.10. Eastern Baltic cod in SDs 24-32. Time series of total catch used in the assessment, by fleets (upper panel). Share of Active and Passive gears in total catch in later years (lower panel).

Active

Passive

Figure 2.1.11. Eastern Baltic cod in SDs 24-32. Length compositions of commercial catches in recent years, by quarter, and Fleets.

2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022

Figure 2.1.12. Eastern Baltic cod in SDs 24-32. Mean length at age (LAA) based on average annual ALKs of all countries included in DATRAS, for BITS Q1 (upper panels) and BITS Q4 (lower panels) (individual sample data only, not raised to the population).

Figure 2.1.13. Eastern Baltic cod in SDs 24-32. Change in natural mortality for age-break 5.5, estimated in Stock Synthesis model (left panel). Fishing mortality (F) and natural mortality (M) for ages 4-6 (right panel).

Figure 2.1.14. Eastern Baltic cod in SDs 24-32. Estimated change in von Bertalanffy growth parameters Linf (left panel) and K (right panel) from Stock Synthesis model.

Figure 2.1.15. Eastern Baltic cod in SDs 24-32. Selectivity of different fleets.

Figure 2.1.16. Eastern Baltic cod in SDs 24-32. Fits to age (upper panels) and length (lower panels) composition data, aggregated across years.

Figure 2.1.17. Eastern Baltic cod in SDs 24-32. Residuals of fits to length composition data for different fleets.

A

B

C

D

Figure 2.1.18. Eastern Baltic cod in SDs 24-32. Model fits to different tuning indices. A- BITSQ1; B-BITSQ4; C-SSBEggProd; D- Larvae.

Figure 2.1.21. Eastern Baltic cod in SDs 24-32. Biomass of commercial sized cod (>=35 cm in length) (upper panel), compared to SSB in later years (lower panel).

Figure 2.1.22. Eastern Baltic cod in SDs 24-32. Diagnostics of SPICT model.

Figure 2.1.23. Eastern Baltic cod in SDs 24-32. Results of SPICT model.

Figure 2.1. 24. Eastern Baltic cod in SDs 24-32. Comparison of SSB, F and R between assessment results from WGBFAS 2024 and 2023 (in relative terms).

Figure 2.1.25. Model output of the 2024 assessment showing the recruitment deviation because of model settings based on the Benchmark in 2019.

2.2 Cod in Subdivision 21 (Kattegat)

2.2.1 The fishery

A general description of Kattegat cod fishery is presented in the Stock Annex (ICES 2017b).

2.2.1.1 Recent changes in fisheries regulations

The TAC is mainly regulating the fishing of Kattegat cod since the effort limitation was stopped in 2016. The effort system was introduced in the first cod recovery plan (EC No. 423/2004). Effort was limited by allowed number of fishing days for individual fishing vessels. In 2009, following the introduction of the new cod management plan (EC No. 1342/2008) for the North Sea (incl. Kattegat), a new effort system was introduced. In this system each Member State was given kW days for different gear groups. It was then the MS responsibility to distribute the kW days among fishing vessels. MS could apply for derogation from the kW days system if the catches in a certain part of the fleet was shown to consist of less than 1.5% cod (article 11(2) (b)) or avoid cuts (or part of cuts) if they introduce highly selective gear and cod avoidance plans (article 13). Sweden has used this derogation from the kW day system for the part of the fishery using sorting grids. This fishery constituted since 2010 more than half of the Swedish effort. Denmark introduced in 2010 a cod recovery plan covering their entire Kattegat fishery. As a part of this plan, since 2011 it is mandatory in Danish fisheries to use a SELTRA trawl with at least 180 mm panel.

In 2009, as a part of the attempts to rebuild of the cod stock in Kattegat, Denmark and Sweden introduced protected areas on historically important spawning grounds in South-East Kattegat. The protected zone consists of three different areas in which the fisheries are either completely forbidden or limited to certain selective gears (Swedish grid and Danish SELTRA 300 trawl) during all or different periods of the year. Since 2012 the cod quota in Kattegat was considered to be

a by-catch-quota (mainly of the *Nephrops* fishery) where the landings of cod should constitute of 50 % of the total landings.

In 2017 the cod in Kattegat came under the landing obligation. This has however not affected the discard rate of undersized cod which still remains at high levels.

The main fishery mortality for Kattegat cod is as bycatch in the *Nephrops* fishery. The decrease in minimal landings size in *Nephrops* enforced in 2015 (from 40 mm to 32 mm carapace width) might have an effect on the exploitation pattern for *Nephrops* (new areas exploited, new temporal trends in the fishery pattern) etc. These potential changes will most certainly also affect the Kattegat cod stock development.

2.2.1.2 Landings

National landings of cod from Kattegat management area (Subdivision 21) by year and country are given in Table 2.2.1 and Figure 2.2.1, as provided by the Working Group members.

Agreed TACs and reported landings have been significantly reduced since 2000 to the present historical low level. The reported landings of cod in the Kattegat in 2023 were 22 tons, among the lowest of the time series (Table 2.2.1 and Figure 2.2.1)

2.2.1.3 Discards

Both Sweden and Denmark implemented the TAC regulation through a ration-period system until 2007. The ration sizes were reduced substantially since 2000—2001 and the rations in the Kattegat were lower than those in adjacent areas, giving incentives for misreporting of catches by area (Hovgård, 2006), which could potentially have biased landings statistics for these years. In spite of that there has been a discard ban of Kattegat cod since 2017, there is no BMS landing reported so far.

Discard estimates were available from Sweden for 1997—2023 and from Denmark for 2000—2023. The estimated discard numbers by age and total discards in tons are presented in Figure 2.2.2 and in Table 2.2.2. The sampling levels are shown in Tables 2.2.3 and 2.2.4a,b.

In 2023, the estimated discards formed about 50 % of the catch weight and this proportion of discards in the catches has largely increased in the last year compared to the previous years (Figure 2.2.1). In numbers, the available data indicates that close to 95 % of the cod caught in the Kattegat is discarded. Similarly to previous years, discarding in 2023 has mostly affected ages 1-2, with a larger proportion of age 1 caught compared to last year

2.2.1.4 Unallocated removals

Unreported catches have historically been considered to be an issue for this stock, estimated as part of unallocated removals within the assessment model. The last benchmark (WKBALT 2017) concluded the catch data to be of reasonable quality from 2011 onwards. Major issues identified at WKBALT (2017) that could explain the unallocated removals estimated in the model include inflow of recruits from the North Sea cod and their return migration when they become mature, as well as possibly increased natural mortality due to seal predation.

2.2.2 Biological composition of the catches

2.2.2.1 Age composition

Historical total catches in numbers by age and year are given in Table 2.2.6.

2.2.2.2 Quality of the biological data

Both Danish and Swedish sampling data were available from the commercial fishery in 2023. Danish and Swedish commercial sample sizes are shown in Table 2.2.3. and Table 2.2.4. Landings were allocated to age groups using the Danish and Swedish age information as shown in Table 2.2.5. The catch numbers followed the same procedure as the landings, and catch in numbers by age is presented in Table 2.2.6)

2.2.2.3 Mean weight at age

Historical mean weight at age in the catches, provided by Sweden and Denmark, is given in Table 2.2.7 for all years included in the assessment (1997-2023).

Mean weight at age in the stock is based on the IBTS 1st quarter survey for age-groups 1—3. Due to low number of cod in the survey, the weights in the stock in recent years are based on a running mean of 3 years. The weight of ages 4—6+ were set equal to the mean weights in the landings.

The historical time series of mean weight at age in the stock is given in Table 2.2.8.

2.2.2.4 Maturity at age

The historical time series of maturity based on visual inspections used in the assessment is presented in Table 2.2.9. The estimates are based on the IBTS 1st quarter survey. Due to low number of cod in the survey, the maturities in recent years are based on a running mean of 3 years.

2.2.2.5 Natural mortality

A constant natural mortality of 0.2 was assumed for all ages for the entire time series.

2.2.3 Assessment

2.2.3.1 Survey data

The CPUE-values used were from the IBTS 1st and 3rd quarter surveys, from the BITS in the 1st quarter (Danish R/V Havfisken) and from the Cod survey 4th quarter. The internal consistency of surveys (numbers at age plotted against numbers at age+1 of the same cohort in the following year) are shown in Figure 2.2.3a–d. The survey indices available for the Working Group are presented in Table 2.2.10.

The tuning series available for assessment:

Fleet	Details
BITS-1Q	Danish survey, 1st quarter, R/V Havfisken (age 1-3) (1997-2024)
IBTS-3Q	International Bottom Trawl Survey, 3rd quarter, Kattegat (age 1-4) (1997-2023)
IBTS-1Q	International Bottom Trawl Survey, 1st quarter, Kattegat; (Ages 1-6) (1997-2024)
CODS-4Q	Cod survey, 4th Quarter, Kattegat, (ages 1-6). (2008-2023)

2.2.3.2 Assessment using state-space model (SAM)

A stochastic state-space model (SAM) (Nielsen, 2008, 2009) was used for assessment of cod in the Kattegat. The model allows estimation of possible bias (positive or negative) in the data on

removals from the stock in specific years. Settings of the model were used as specified in the Stock Annex (ICES 2017b).

The assessment run and the software internal code are available at https:/www.stockassessment.org,

The two updated assessment runs were performed as follows.

Catch (landings and discards) from 1997—2023 with estimating total removals from 2003—2023 within the model based on survey information. (codkat2024_wgbfas on https:/www.stockassessment.org)

Catch (landings and discards) from 1997—2023 without estimating total removals (codkat2024_wgbfas on https:/www.stockassessment.org).

Unallocated removals were estimated separately for the years 2003—2023, but common for all age-groups within a year. The scaling factors estimated for 2005—2023 were significant for all the years in the SAM run with landings and total removals estimated. In contrast to the 2023 WGBFAS run, the new run comprises scaling factors for groups of three years instead of scaling factors per year.

Estimates of recruitment, SSB and mortality (Z-0.2) with confidence intervals from the two runs with 1-yr and 3-yr scaling factors are presented in Figures 2.2.7—2.2.9 and Table 2.2.11. The total removals were estimated several folds higher than reported landings, and are not explainable by the estimated discard data only (Figure 2.2.10).

All information about the residuals and results from the SAM run is shown in Fig 2.2.11.

2.2.3.3 Harvest rate

The harvets rate for Kattegat cod in 2023 was 23% (25% in 2022). The temporal developmetn of the harvest rate is shown in Fig 2.2.12. Since 2014 harvest rate is around 20% after a shaor decrease between 2001 and 2014.

2.2.3.4 Conclusions on recruitment trends

The absolute values of recruitment estimated from the assessment analyses are considered uncertain, mainly due to mixing with North Sea cod and possibly also with cod from the Western Baltic Sea. Additionally, discards are associated with uncertainties, at least for part of the time series.

The absolute values of recruitment estimated from the assessment analyses are considered uncertain, mainly due to mixing with North Sea cod and possibly also with cod from the Western Baltic Sea. Additionally, discards are associated with uncertainties, at least for part of the time series. The latest (after 2009) recruitment events in the Kattegat are driven solely of high recruitment events in the surrounding areas.

2.2.3.5 Conclusions on trends in SSB and fishing mortality

The assessment is indicative of trends only and shows that spawning stock biomass (SSB) has decreased from historical high levels in 1997. The SSB level is at historical low level still in 2023.

The increase in SSB trend in 2013-2015 was solely due to the strong year classes of 2011 and 2012. The decrease in SSB since 2015 continues due the lack of stronger incoming year classes.

The mortality decreased from 2008 to historically low levels 2014. However, the mortality is again increasing, approaching the high mortality levels found before 2008. For Kattegat cod, the exact level of fishing mortality can still not be reliably estimated.

2.2.4 Short term forecast and management options

No short-term forecast was produced in this year's assessment.

2.2.5 Medium-term predictions

No medium-term predictions were performed.

2.2.6 Reference points

Reference points are not defined or updated for this stock. See Stock Annex (ICES 2017b) for further explanation).

2.2.7 Quality of the assessment

Indices from four different surveys that provide information on cod in the Kattegat were used in the assessment. All available survey indices are relatively noisy, however contain information that is to a certain extent consistent between years in single surveys and agrees on the same level with the estimates from other surveys. In 2003—2023, the survey data indicates significantly higher total removals from the stock than can be explained by the reported catch data.

WKBALT 2017 concluded that the unallocated removals can largely be explained by mixing with North Sea cod and potentially increased natural mortality. Also, uncertainties in catch numbers at least for some years in the time series likely contribute to this mismatch.

Therefore, the current level of fishing mortality cannot be reliably estimated and is in the range of 0.9-1.8 in the SPALY runs. The exact estimates of SSB are considered uncertain, however all available information consistently indicates that SSB is at historically low levels in 2021, around 217 tonnes, and it is still low in 2023 (292 tonnes).

2.2.8 Comparison with previous assessment

The assessment was performed using state-space assessment model (SAM) as last year. The results from this year's assessment can be found in Table 2.2.11.

2.2.9 Technical minutes

There were no major comments on last year's assessment.

2.2.10 Management considerations

Management measures taken so far have not been sufficient to ensure the recovery of this stock.

There is no targeted cod fishery in Kattegat presently and cod is mainly taken as bycatch in the Norway lobster fishery. This implies that the mortality of the stock is strongly correlated with the uptake of the Norway lobster quota and the effort directed to the Norway lobster fishery.

The fishing effort regulation is no longer present since 2016 and the TAC of Norway lobster has increased substantially in the last years.
The removal of the effort system has led to a reduction in the uptake of selective gears in the Norway lobster fishery which itself has increased the mortality of Kattegat cod. The unregulated

effort and the increased Norway lobster quota may dramatically increase the fishing mortality of the Kattegat cod.

Furthermore, the substantial decrease in the fishing opportunities of the eastern Baltic cod fishery will potentially also lead to an increase in fishing pressure when fishing capacity is moved from the eastern Baltic cod fishery to the Norway lobster fishery in the Kattegat. The movement of capacity could increase the fishing mortality of the Kattegat cod

There are fishing gears developed that keep the bycatch levels of cod to an absolute minimum in the fishery for Norway lobster and flatfish (plaice, sole).

The Swedish sorting grid has a bycatch of less than 1.5 % of cod in the Norway lobster fishery, which is well documented (Valentinsson and Ulmestrand 2006) and has been extensively used in former years. However, the removal of the effort system reduced the incentives to use this gear.
In addition, there are gears available that successfully reduce cod bycatches from flatfish catches (Andersson and Lövgren 2018, Stepputtis *et al.*, 2020). These gears are however not in use presently. Obligatory use of devices that reduce cod bycatch appear to be a necessary requirement for recovery of the cod stock in the Kattegat when the current fishing patterns on *Nephrops* and flatfish fisheries are not changed.

2.2.11 Future plans

The issues identified at WKBALT (2017) that could explain the unallocated removals estimated in SAM include inflow of recruits from the North Sea and their return migration when they become mature. WKBALT 2017 suggested intersessional work to be continued looking into possibilities to take migration more explicitly into account in the SAM model, to be able to separate fishing mortality from migration. A modified version of SAM model was presented at WGBFAS 2017, incorporating proportions of juvenile North Sea and Kattegat cod, estimated in the model, and assuming return migration to take place when the fish become mature (WD by Vinther, M. WGBFAS 2017).

WGBFAS concluded that data on the proportions of juvenile cod in the Kattegat originating from the North Sea are needed, to be incorporated in the model, or used to validate the values estimated in the model. The first step would be to analyze historical samples to determine stock origin for individuals at age 1, for the last 10 years (200 individuals per year). These data could then be included in the new version on SAM model, to account for the North Sea component in the Kattegat.

Genetic samples from the whole size range of cod are currently collected and samples back in time analyzed that are needed to split the different cohorts between North Sea and Kattegat cod, to assess the developments in Kattegat stock alone. This could subsequently be done using the traditional SAM or possibly other models (e.g SS3).

2.2.12 MSY Proxies

During the assessment in 2017 two different approaches of proxy reference points were explored.

The reference points were evaluated by the proxy reference group in 2017. They concluded:

1) *"The EG concluded that the proxies for MSY estimated using both LBI and SPiCT were unreliable. The EG notes that, should the problem with stock mixing be resolved, the SPiCT model would likely be useful in determining proxy reference points. The RG does not have sufficient*

information to comment on the conditions of the stock based on the given information and proxy reference points. Discussions of model sensitivity to changes in parameterization would have been beneficial.

2) *The RG suggests, in the future, the suite of methods for establishing proxy reference points be reviewed and, for each method, the strengths and weaknesses of the method for the stock being considered should be discussed to justify why each method was accepted or rejected.*

Following the ICES procedures, WGBFAS 20223 explored the option to provide the advice for 2023 using the ICES framework for category 3 stocks (ICES, 2022, ICES, 2023).

Following this through for Kattegat cod leads to the following conclusions:

1. There is no accepted SPiCT assessment for Kattegat cod (ICES, 2017).
2. Indices of abundance, commercial catch length data, and an estimate of the von Bertalanffy K parameter are all available.
3. For Kattegat cod, K=0.180yr−1 and Linf=104.87 cm

Hence, following the decision tree (Figure 2 in ICES, 2022) provided in the ICES technical guidance, the ***rfb* rule** (method 2.1) was explored to provide advice, given that $K \leq 0.2yr-1$.

Being based on the last year advice catches (Ay=0) the advised catches would obviously still have been 0.
However, WGBFAS 2023 rejected the assessment based on WKLIFE empirical rule as the WG deemed that the length distributions showed that there is a mixing of different stocks and should not be trusted. This is the same reason why the SpiCt analysis was rejected in WGBFAS 2017.

2.2.13 Evaluation of surveys duplication in Kattegat

The Expert Working Group EWG 19-05 met in 2019 to evaluate research surveys of marine fish resources and propose surveys to be included on the list of mandatory surveys, as a revision of the EU Multiannual Programme for data collection (EU MAP).

The EWG 19-05 proposed a series of actions to be carried out by ICES and one of them relates to potential survey duplications in the Kattegat-Skagerrak area; Scientific, Technical and Economic Committee for Fisheries (STECF) noted that the following surveys did not fully satisfy the criterion for 'no survey duplication': BITS_Q1, CODS_Q4, IBTS_Q1, IBTS_Q3.

The stocks associated with these possibly duplicate surveys are all in the Skagerrak and Kattegat region, which has complex geography that may require a number of smaller surveys to achieve adequate coverage of the stock. STECF suggested that the results of this evaluation be discussed by ICES and evaluated in future benchmarks for that region.

Those surveys, flagged as needing further expert evaluation, are associated with Cod in the Kattegat, being the main source of tuning indices on which the assessment of this stock is based on.

Due to the issues of mixing of different cod stocks in Kattegat the current assessment is only used as indicative of trends. Therefore, it is not possible at this stage to evaluate the issue of duplication of surveys in the Kattegat until the stock identification issue will be solved in the next benchmark.

2.2.14 Reporting deviations from stock annex caused by missing information from Covid-19 disruption.

1. Stock: Cod.27.21

2. Missing or deteriorated survey data: None

3. Missing or deteriorated catch data: None

4. Missing or deteriorated commercial *LPUE*/*CPUE* data: None

5. Missing or deteriorated biological data: None

6. Brief description of methods explored to remedy the challenge: None

7. Suggested solution to the challenge, including reason for this selecting this solution: -

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out?

No changes have been done to the assessment since the impact of the decreased quality of the catches has been deemed to be minor for the assessment and the advice of cod27.21.

Figure. 2.2.1. Cod in the Kattegat. Estimates of discards (Denmark and Sweden combined) compared to reported landings, in weight (upper panel) and in numbers (lower panel).

Figure. 2.2.2. Cod in the Kattegat. Estimates of discards in numbers by age in the upper panel and landings in numbers by age in the lower panel (Sweden and Denmark combined).

2024

2023

Figure 2.2.3a. Cod in Kattegat. IBTS 1st quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 1997-2024. Upper plot 2024 and lower plot 2023.

Lower right panels show the Coefficient of Determination (r^2)

Lower right panels show the Coefficient of Determination (r^2)

2023

2022

Figure 2.2.3 b. Cod in Kattegat. IBTS 3rd quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 1997-2022. Individual points are given by year-class. Upper plot 2023 and lower plot 2022.

2024

2023

Figure 2.2.3c. Cod in Kattegat. Havfisken 1st quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 1997-2023. Upper plot 2024, lower 2023.

2023

2022

Figure 2.2.3d . Cod in Kattegat. Cod Survey 4th quarter numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2008-2022. Individual points are given by year-class. Upper plot 2022, lower plot 2021.

Fig 2.2.4. Stock numbers at age for the period 1997-2024 from SAM output

Figure 2.2.5 Cod in the Kattegat. Trends in recruitment index (Age 1) from different surveys.

Figure 2.2.6. Length distributions from the Cod survey 2008-2023.

Fig 2.2.8 SSB. SAM run with yearly scaling (light green) and Sam run with 3-yrs scaling (darker line, both with 95 % confidence intervals.

Fig 2.2.8 Unallocated mortality (Z-0.2) SAM run with annual scaling (light green lines) and Sam run with 3-year scaling, both with 95 % confidence intervals)

Fig 2.2.9 Recruitment. Upper panel: SAM run without scaling (grey lines) and Sam run with scaling (black line with brown 95 % confidence interval). Lower panel: SAM run with 3-year scaling from 2024.

Year	Old	New
2003	1.48	1.512
2004	1.11	
2005	2.83	
2006	2.67	1.922
2007	1.96	
2008	3.27	
2009	3.46	2.299
2010	2.76	
2011	2.64	
2012	4.41	4.031
2013	5.2	
2014	6.63	
2015	7.42	4.829
2016	8.61	
2017	5.45	
2018	5.92	4.441
2019	5.18	
2020	6.24	
2021	8.28	5..244
2022	6.12	
2023	--	

Fig 2.2.10 Catch multiplier. The scaling factor by year from the SAM run with annual scaling and the new SAM run with 3 years scaling.

Fig 2.2.11 Residuals. a) SPALY with new 3-year scaling. The figures show normalized residuals for the current run. Blue circles indicate positive residuals (larger than predicted) and filled red circles indicate negative residuals (lower than predicted).

Fig. 2.2.12 Harvest rate. Catches here include landings and discards.

Table 2.2.1 Cod in the Kattegat. Landings (in tonnes) 1971-2022.

Year	Kattegat			Total
	Denmark	Sweden	Germany[1]	
1971	11748	3962	22	15732
1972	13451	3957	34	17442
1973	14913	3850	74	18837
1974	17043	4717	120	21880
1975	11749	3642	94	15485
1976	12986	3242	47	16275
1977	16668	3400	51	20119
1978	10293	2893	204	13390
1979	11045	3763	22	14830
1980	9265	4206	38	13509
1981	10693	4380	284	15337
1982	9320	3087	58	12465
1983	9149	3625	54	12828
1984	7590	4091	205	11886
1985	9052	3640	14	12706
1986	6930	2054	112	9096
1987	9396	2006	89	11491
1988	4054	1359	114	5527
1989	7056	1483	51	8590
1990	4715	1186	35	5936
1991	4664	2006	104	6834
1992	3406	2771	94	6271
1993	4464	2549	157	7170
1994	3968	2836	98	7802 [2]
1995	3789	2704	71	8164 [3]
1996	4028	2334	64	6126 [4]
1997	6099	3303	58	9460 [5]
1998	4207	2509	38	6835
1999	4029	2540	39	6608
2000	3285	1568	45	4897
2001	2752	1191	16	3960
2002	1726	744	3	2470
2003	1441	603 [7]	1	2045
2004	827	575	1	1403
2005	608	336	10	1070 [6]
2006	540	315	21	876
2007	390	247	7	645
2008	296	152	1	449
2009	134	62	0.3	197
2010	117	38	0.3	155
2011	102	42	1.4	145
2012	63	31	0.0	94
2013	60	32	0.0	92
2014	75	32	0.0	108
2015	68	38	0.0	106
2016	185	114	0.0	299

2017	208	85	0.0	294
2018	175	37	0.0	212
2019	66	17	1.0	83
2020	26	11	0.1	36
2021	19	4	0.8	24
2022	15	3	0.9	19
2023	18.1	3.2	0.3	22

[1] Landings statistics incompletely split on the Kattegat and Skagerrak.

[2] Including 900 t reported in Skagerrak.

[3] Including 1.600 t misreported by area.

[4] Excluding 300 t taken in Sub-divisions 22–24.

[5] Including 1.700t reported in Sub-division 23.

[6] Including 116 t reported as pollack

[7] the catch reported to the EU exceeds the catch reported to the WG (shown in the table) by 40%

Table 2.2.2 Cod in the Kattegat. Estimates of discard in numbers (in thousands) by ages and total weight in tonnes. The estimation of total discards is not entirely consistent between the years

Denmark						
Year	a1	a2	a3	a4	a5	a6
1997						
1998						
1999						
2000	880	1634	22	3	0	0
2001	1365	386	3	0	0	0
2002	2509	1226	290	0	0	0
2003	114	876	40	0	0	0
2004	2562	352	58	0	0	0
2005	616	1285	0	0	0	0
2006	614	752	203	0	0	0
2007	135	1098	259	20	0	0
2008	20	99	57	4	1	0
2009	210	41	2	0	0	0
2010	367	224	14	0	0	0
2011	559	354	22	0	0	0
2012	707	161	10	0	0	0
2013	517	322	8	3	0	0
2014	431	621	22	4	2	0
2015	120	86	82	19	7	0
2016	9	40	17	33	13	4
2017	819	99	32	1	3	1
2018	22	180	3	4	1	2
2019	85	26	19	0	0	0
2020	282	69	1	1	0	0
2021	37	78	6	0	0	0
2022	150	0	2	1	0	0
2023	307	44	1	0	0	0

Sweden						
Year	a1	a2	a3	a4	a5	a6
1997	567	678	212	13	0	0.0
1998	684	641	157	8	0	0.0
1999	579	663	177	10	0	0.0
2000	922	876	153	19	2	0.0
2001	745	720	142	17	2	0.0
2002	667	419	93	12	1	0.0
2003	514	715	49	3	1	0.2
2004	982	583	533	2	2	0.3
2005	237	464	6	5	0	0.0
2006	784	448	182	7	3	0.3
2007	534	278	32	12	0	0.1
2008	148	48	10	0.1	0	0.0
2009	179	14	0.1	0.1	0	0.0
2010	63	58	0	0	0	0
2011	71	51	9	0	0	0
2012	180	54	5	0	0	0
2013	550	190	21	1	2	0
2014	79	174	20	1	2	0
2015	119	57	58	24	4	4
2016	7	43	11	5	3	1
2017	270	16	1	0	0	0
2018	5	46	3	0	0	0
2019	26	14	1	0	0	0
2020	67	40	2	0	0	0
2021	8	17	1	0	0	0
2022	184	0	0	0	0	0
2023	152	16	1	0	0	0

DK and SWE discard numbers combined							Total discards in tonnes
Year	a1	a2	a3	a4	a5	a6	
1997	1398	2102	478	26	0.4	0.1	881
1998	1369	1454	284	23	0.3	0.0	664
1999	1158	1964	314	18	0.5	0.0	764
2000	1802	2510	175	22	1.9	0.0	653
2001	2110	1105	146	17	1.7	0.0	657
2002	3176	1645	383	12	1.3	0.0	820
2003	628	1591	89	3	0.9	0.2	616
2004	3544	934	591	2	2.1	0.3	1086
2005	853	1749	6	5	0.0	0.0	624
2006	1398	1200	386	7	2.6	0.3	862
2007	668	1377	291	32	0.5	0.1	624
2008	168	147	67	4	1	0	156
2009	389	55	2	0	0	0	67
2010	430	282	14	0	0	0	170
2011	631	405	31	0	0	0	211
2012	887	215	15	0	0	0	157
2013	1067	512	29	4	2	0	355
2014	510	795	42	5	4	0	348
2015	239	143	140	43	11	4	481
2016	16	83	28	38	16	5	222
2017	1089	115	33	1	3	1	258
2018	27	226	6	4	1	2	72
2019	111	40	20	0	0	0	40
2020	349	109	4	1	0	0	61
2021	44	96	7	0	0	0	26
2022	334	0	2	1	0	0	36
2023	459	60	1	0	0	0	50

Table 2.2.3. Cod in the Kattegat. Numbers of hauls (Sweden) and observer trips (Denmark, usually 1 hauls per trip) in discard sampling by years and countries

Year/Country	Sweden	Denmark	Total
1997	45		45
1998	50		50
1999	55		55
2000	63	52	115
2001	40	68	108
2002	63	43	106
2003	38	30	68
2004	26	47	73
2005	48	33	81
2006	66	22	88
2007	72	10	82
2008	50	24	74
2009	49	38	87
2010	58	34	92
2011	48	43	91
2012	41	48	89
2013	44	58	102
2014	39	55	94
2015	40	46	86
2016	40	37	77
2017	51	61	112
2018	41	51	92
2019	75	61	136
2020	27	45	72
2021	29	55	84
2022	41	61	102
2023	41	34	75

Table 2.2.4 a. Cod in the Kattegat. Sampling level of Danish landings, 2023

	n. of harbour days	n. of cod	n. of cod	n. of cod
Quarter		**aged**	**weighed**	**measured**
1	3	135	135	135
2	2	49	49	49
3	4	67	67	67
4	6	221	221	221
Total	15	472	472	472

Table 2.2.4 b **Cod in the Kattegat. Sampling level of Swedish landings, 2023**

	n. of hauls	n. of cod	n. of cod	n. of cod
Quarter		**aged**	**weighed**	**measured**
1	2	6	6	6
2	12	50	50	50
3	10	68	68	68
4	14	74	74	74
Total	38	198	198	198

Table 2.2.5. Cod in the Kattegat. Landings numbers and mean weight at age by quarter and country for 202

Sub-div **21**

Year	**2023**	**Quarter**	**1**			
Country	Denmark		Sweden		Grand Total	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*1000	weight (g)	*1000	weight (g)	*1000	weight (g)
1						
2	2.533585	645.3694	0.031	752.7	2.56	650.15
3	1.036262	1389.725	0.118	1861.174	1.15	1469.48
4	1.126985	2717.152	0.211	1974.91	1.34	2695.42
5	0.150335	4308.104	0.034	4024.8	0.18	4308.10
6						
7	0.059154	2306.07			0.06	2306.07
8						
9						
10						
SOP (t)	6.92			0.80	7.90	
Landings (t)	6.49			0.80	7.29	

Sub-div **21**

Year	**2023**	**Quarter**	**2**			
Country	**Denmark**		**Sweden**		**Grand Total**	
Age	**Numbers**	**Mean**	**Numbers**	**Mean**	**Numbers**	**Mean**
	***1000**	**weight (g)**	**.**	**weight (g)**	***1000**	**weight (g)**
1	0.082016	320.58			0.08	320.58
2	2.621182	361.205	0.031	752.7	2.65	365.78
3	0.783865	1322.711	0.154	2000.247	0.94	1433.96
4	0.538061	1970.413	0.114	2298.761	0.65	2027.82
5	0.146639	3086.928	0.016	4024.8	0.16	3179.19
6						
7			0.015	1872	0.02	1872.00

8						
9						
10						
SOP (t)	**3.52**			**0.69**	**4.18**	
Landings (t)	**3.50**			**0.69**	**4.19**	

Sub-div **21**

Year	**2023**	**Quarter**	**3**			
Country	**Denmark**		**Sweden**		**Grand Total**	
Age	**Numbers**	**Mean**	**Numbers**	**Mean**	**Numbers**	**Mean**
	*1000	weight (g)	*1000	weight (g)	*1000	weight (g)
1	0.691728	309.7486			0.69	309.75
2	1.047575	640.8702	0.062	1062.291	1.11	664.42
3	0.4841	1315.343	0.09	2085.215	0.57	1436.03
4	0.222568	2257.471	0.04	2802.02	0.26	2340.43
5	0.046036	4811.918	0.04	3622.102	0.09	4258.75
6			0.003	2714.4	0.00	2714.40
7	0.021725	2310.75	0.003	4270.5	0.02	2548.54
8						
9						
10						
SOP (t)	2.30			0.53	2.83	
Landings (t)	2.20			0.50	2.70	

Sub-div **21**

Year	**2023**	**Quarter**	**4**			
Country	**Denmark**		**Sweden**		**Grand Total**	
Age	**Numbers**	**Mean**	**Numbers**	**Mean**	**Numbers**	**Mean**
	***1000**	**weight (g)**	***1000**	**weight (g)**	***1000**	**weight (g)**
1	3.116211	407.4732	0.023	637.65	3.14	409.16
2	2.562153	1244.707	0.149	1187.767	2.71	1241.58

3	0.554307	1771.307	0.315	2202.765	0.87	1927.65
4	0.338188	2650.42	0.117	2844.832	0.46	2700.39
5	0.087136	4897.646	0.042	3832.867	0.13	4551.34
6			0.009	2714.4	0.01	2714.40
7	0.045142	2310.75	0.009	4270.5	0.05	2636.52
8						
9						
10						
SOP (t)	6.87			1.44	8.31	
Landings (t)	6.00			1.20	7.20	

Table 2.2.6 Cod in the Kattegat. Catches (Landings +Discards) in numbers (in thousands) by year and age. In the assessment the plus-group is defined as 6+

Year	Age					
	1	2	3	4	5	6
1997	1456	2540	5137	891	222	88
1998	1499	3587	1595	1908	283	76
1999	1201	3859	3972	455	409	77
2000	1819	3942	2346	1027	125	103
2001	2166	2012	2034	703	187	45
2002	3190	2161	1062	391	85	40
2003	628	2441	650	184	65	16
2004	3547	1077	1195	206	65	39
2005	854	2169	121	167	21	12
2006	1406	1305	796	36	33	9
2007	668	1446	383	190	16	26
2008	175	191	136	40	33	7
2009	400	92	30	22	9	4
2010	433	361	33	8	4	2
2011	631	445	84	6	2	1
2012	889	231	30	13	2	0
2013	1068	533	49	12	3	1
2014	510	804	66	20	6	0
2015	239	144	167	56	15	6
2016	16	95	68	75	38	13
2017	1090	119	68	28	30	14
2018	28	240	12	23	19	25
2019	114	46	46	5	7	3
2020	352	117	5	7	0	1
2021	47	103	12	1	2	0
2022	196	36	7	2	0	1
2023	463	70	5	3	1	0

Table 2.2.7 Cod in the Kattegat. Weight at age (kg) in the catches by year and age.

In the assessment the plus-group is defined as 6+

Year	Age							
	1	2	3	4	5	6	7	8+
1971	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1972	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1973	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1974	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1975	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1976	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1977	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1978	0.699	0.880	1.170	1.690	2.860	4.120	5.180	6.900
1979	0.708	0.868	1.086	1.890	2.215	3.382	7.314	6.101
1980	0.691	0.893	0.951	1.440	2.478	3.157	3.526	6.903
1981	0.604	0.799	1.123	1.432	2.076	3.532	4.420	4.644
1982	0.600	0.784	1.233	1.391	2.078	2.911	3.698	6.480
1983	0.595	0.752	1.129	1.943	3.348	3.141	5.301	6.325
1984	0.711	0.745	1.133	1.687	2.798	3.022	5.273	7.442
1985	0.606	0.839	0.986	1.614	2.575	4.090	6.847	7.133
1986	0.671	0.705	1.253	1.955	2.956	4.038	7.100	7.290
1987	0.483	0.716	1.118	1.972	2.868	4.200	5.185	8.288
1988	0.541	0.784	1.099	1.792	2.880	4.283	5.852	7.073
1989	0.621	0.921	1.269	2.296	3.856	5.733	5.166	6.527
1990	0.618	0.973	1.584	2.323	3.288	5.383	6.412	10.337
1991	0.578	0.861	1.533	2.986	4.548	4.179	9.127	12.055
1992	0.610	0.707	1.291	2.662	4.048	5.888	7.067	7.895
1993	0.567	0.862	1.583	2.321	4.970	7.566	9.391	8.705
1994	0.549	0.783	1.276	2.652	3.526	7.279	9.793	10.130
1995	0.598	0.799	1.121	1.947	2.404	3.537	9.973	10.708
1996	0.469	0.669	1.088	1.771	2.638	3.773	4.677	7.871
1997	0.450	0.621	0.959	1.950	2.806	3.877	5.756	7.213

Year	Age							
	1	2	3	4	5	6	7	8+
1998	0.623	0.697	0.853	1.680	2.497	4.317	6.669	8.948
1999	0.496	0.624	0.911	1.616	2.588	4.665	5.376	8.040
2000	0.487	0.611	0.868	1.332	2.779	3.944	5.069	9.020
2001	0.466	0.646	0.901	1.585	2.597	4.693	7.117	7.691
2002	0.546	0.711	1.120	2.052	3.539	4.814	6.915	7.833
2003	0.550	0.700	1.370	2.460	3.750	5.920	7.840	10.890
2004	0.570	0.700	1.010	1.630	2.700	3.920	6.180	9.420
2005	0.428	0.854	1.623	2.343	3.584	5.442	6.439	8.307
2006	0.480	0.880	1.519	3.130	3.995	4.222	5.264	6.713
2007	0.48	0.802	1.482	2.275	3.344	3.829	1.802	7.897
2008	0.574	1.075	1.837	3.210	4.097	4.437	5.552	5.827
2009	0.717	0.976	1.493	2.651	4.069	4.693	4.870	5.792
2010	0.412	0.879	1.910	3.081	4.038	3.592	4.252	6.404
2011	0.444	0.915	1.498	2.695	3.372	4.997	4.059	7.569
2012	0.545	1.191	1.769	3.174	4.004	5.224	4.305	6.921
2013	0.488	0.888	1.702	2.545	3.726	3.310	5.100	NA
2014	0.434	1.007	1.907	2.523	3.938	5.431	NA	NA
2015	0.434	1.343	1.879	2.597	3.726	3.777	NA	NA
2016	0.434	1.267	2.472	2.534	2.793	3.665	NA	NA
2017	0.434	0.915	1.996	2.942	3.453	3.921	NA	NA
2018	0.434	0.249	0.783	2.511	3.265	3.766	NA	NA
2019	0.434	0.348	1.047	2.019	2.537	3.078	NA	NA
2020	0.113	0.255	1.034	2.39	3.18	2.888	NA	NA
2021	0.165	0.251	0.821	2.851	2.888	2.788	NA	NA
2022	0.126	0.243	1.413	2.942	2.466	3.744	NA	NA
2023	0.087	0.217	1.122	2.108	3.884	2.441	NA	NA

Table 2.2.8. Cod in the Kattegat. Weight at age (kg) in the stock by year and age.

In the assessment the plus-group is defined as 6+

Year	Age							
	1	2	3	4	5	6	7	8+
1971	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1972	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1973	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1974	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1975	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1976	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1977	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1978	0.059	0.355	1.006	1.69	2.86	4.12	5.18	6.9
1979	0.059	0.35	0.934	1.89	2.215	3.382	7.314	6.101
1980	0.058	0.361	0.817	1.44	2.478	3.157	3.526	6.903
1981	0.051	0.323	0.965	1.432	2.076	3.532	4.42	4.644
1982	0.05	0.317	1.06	1.391	2.078	2.911	3.698	6.48
1983	0.05	0.304	0.971	1.943	3.348	3.141	5.301	6.325
1984	0.06	0.301	0.974	1.687	2.798	3.022	5.273	7.442
1985	0.051	0.339	0.848	1.614	2.575	4.09	6.847	7.133
1986	0.056	0.285	1.077	1.955	2.956	4.038	7.1	7.29
1987	0.041	0.289	0.961	1.972	2.868	4.2	5.185	8.288
1988	0.045	0.317	0.945	1.792	2.88	4.283	5.852	7.073
1989	0.052	0.372	1.091	2.296	3.856	5.733	5.166	6.527
1990	0.052	0.393	1.362	2.323	3.288	5.383	6.412	10.337
1991	0.06	0.415	1.799	2.986	4.548	4.179	9.127	12.055
1992	0.052	0.34	1.191	2.662	4.048	5.888	7.067	7.895
1993	0.056	0.353	1.086	2.321	4.97	7.566	9.391	8.705
1994	0.035	0.269	1.225	2.652	3.526	7.279	9.793	10.13
1995	0.032	0.148	1.31	1.947	2.404	3.537	9.973	10.708
1996	0.027	0.22	0.496	1.771	2.638	3.773	4.677	7.871
1997	0.034	0.179	0.743	1.95	2.806	3.877	5.756	7.213

Year	Age							
	1	2	3	4	5	6	7	8+
1998	0.049	0.213	0.442	1.68	2.497	4.317	6.669	8.948
1999	0.046	0.207	0.625	1.616	2.588	4.665	5.376	8.04
2000	0.046	0.176	0.624	1.332	2.779	3.944	5.069	9.02
2001	0.065	0.269	0.72	1.585	2.597	4.693	7.117	7.691
2002	0.045	0.29	1.334	2.052	3.539	4.814	6.915	7.833
2003	0.066	0.224	1.054	2.46	3.75	5.923	7.835	10.891
2004	0.052	0.407	1.007	1.63	2.7	3.916	6.181	9.423
2005	0.058	0.349	1.187	2.343	3.584	5.442	6.439	8.307
2006	0.064	0.280	1.083	3.130	3.995	4.222	5.264	6.713
2007	0.058	0.289	1.060	2.275	3.344	3.829	1.802	7.897
2008	0.045	0.335	1.010	3.210	4.097	4.437	5.552	5.827
2009	0.053	0.300	1.069	2.651	4.069	4.693	4.870	5.792
2010	0.052	0.285	1.171	3.081	4.038	3.592	4.252	6.404
2011	0.051	0.269	0.905	2.695	3.372	4.997	4.059	7.569
2012	0.044	0.251	0.923	3.174	4.004	5.224	4.305	6.921
2013	0.041	0.247	0.911	3.173	4.004	5.224	5.1	NA
2014	0.041	0.255	1.043	2.545	3.726	3.31	NA	NA
2015	0.049	0.285	1.05	2.541	3.869	5.431	NA	NA
2016	0.055	0.311	1.036	2.023	3.385	2.873	NA	NA
2017	0.045	0.338	1.041	2.448	2.72	3.665	NA	NA
2018	0.037	0.275	0.993	2.91	3.353	3.858	NA	NA
2019	0.038	0.232	1.103	2.511	3.265	3.766	NA	NA
2020	0.039	0.23	1.101	2.02	2.537	3.078	NA	NA
2021	0.039	0.277	1.157	2.39	3.18	2.888	NA	NA
2022	0.037	0.283	1.073	2.851	2.888	2.788	NA	NA
2023	0.038	0.307	1.285	2.942	2.466	3.744	NA	NA
2024	0.039	0.205	1.268	2.108	3.884	2.441	NA	NA

Table 2.2.9. Cod in the Kattegat. Proportion mature at age (combined sex).

Year	Age							
	1	2	3	4	5	6	7	8+
1971	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1972	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1973	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1974	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1975	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1976	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1977	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1978	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1979	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1980	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1981	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1982	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1983	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1984	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1985	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1986	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1987	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1988	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1989	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1990	0.02	0.61	0.62	0.99	0.93	1.00	1.00	1.00
1991	0.02	0.62	0.64	0.88	1.00	1.00	1.00	1.00
1992	0.07	0.51	0.99	1.00	1.00	1.00	1.00	1.00
1993	0.03	0.49	0.73	0.95	0.87	1.00	1.00	1.00
1994	0.01	0.60	0.96	1.00	1.00	1.00	1.00	1.00
1995	0.00	0.12	0.97	1.00	1.00	1.00	1.00	1.00
1996	0.00	0.29	0.57	0.95	1.00	1.00	1.00	1.00
1997	0.00	0.19	0.90	1.00	1.00	1.00	1.00	1.00
1998	0.00	0.38	0.65	1.00	1.00	1.00	1.00	1.00

Year	Age							
	1	2	3	4	5	6	7	8+
1999	0.02	0.58	0.87	1.00	1.00	1.00	1.00	1.00
2000	0.02	0.42	0.92	1.00	1.00	1.00	1.00	1.00
2001	0.02	0.44	0.91	1.00	1.00	1.00	1.00	1.00
2002	0.00	0.57	0.92	0.99	1.00	1.00	1.00	1.00
2003	0.00	0.54	1.00	1.00	1.00	1.00	1.00	1.00
2004	0.00	0.74	0.86	1.00	1.00	1.00	1.00	1.00
2005	0.01	0.53	0.83	0.92	1.00	1.00	1.00	1.00
2006	0.00	0.59	0.81	1.00	1.00	1.00	1.00	1.00
2007	0.00	0.60	0.89	0.93	1.00	1.00	1.00	1.00
2008	0.00	0.35	1.00	1.00	1.00	1.00	1.00	1.00
2009	0.00	0.54	0.90	0.95	1.00	1.00	1.00	1.00
2010	0.00	0.48	0.94	1.00	1.00	1.00	1.00	1.00
2011	0.00	0.60	0.90	1.00	1.00	1.00	1.00	1.00
2012	0.00	0.63	0.86	0.95	1.00	1.00	1.00	1.00
2013	0.00	0.49	0.87	0.92	1.00	1.00	1.00	1.00
2014	0.00	0.37	0.46	0.91	1.00	1.00	1.00	1.00
2015	0.01	0.364	0.591	0.83	1.00	1.00	1.00	1.00
2016	0.01	0.51	0.57	0.84	1.00	1.00	1.00	1.00
2017	0.01	0.59	0.72	0.82	1.00	1.00	1.00	1.00
2018	0.00	0.516	0.774	0.851	1.00	1.00	1.00	1.00
2019	0.00	0.49	0.85	0.94	1.00	1.00	1.00	1.00
2020	0.02	0.5	0.84	1.00	1.00	1.00	1.00	1.00
2021	0.02	0.59	0.98	1.00	1.00	1.00	1.00	1.00
2022	0.02	0.59	0.98	1.00	1.00	1.00	1.00	1.00
2023	0.03	0.70	1.00	1.00	1.00	1.00	1.00	1.00
2024	0.02	0.68	1.00	1.00	1.00	1.00	1.00	1.00

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Tuning Data; Cod in the Kattegat (part of Division IIIa)_14/04/23
        104
Havfisken_SD21_Q1
1997    2024
1       1       0       0.25
1       3
                1       104.5521        24.10579        16.37002
                1       -9              -9              -9
                1       464.8633        25.74058        8.849066
                1       97.61678        44.32915        5.524313
                1       25.78995        30.09901        11.12194
                1       98.273          16.65293        3.154042
                1       8.341221        47.24216        5.778205
                1       175.0556        11.18347        5.333216
                1       83.14981        86.67933        2.545501
                1       105.1494        38.4633         10.83763
                1       28.87485        46.52737        8.60812
                1       13.09734        6.648042        1.012895
                1       16.21239        0.908864        0.001
                1       38.50059        21.42233        1.388749
                1       46.24852        15.00446        14.26268
                1       86.61548        10.8254         1.844459
                1       212.3437        51.34188        10.25782
                1       98.15682        781.2383        12.33839
                1       37.23411        16.90285        15.66501
                1       2.231747        9.862954        3.595991
                1       93.50864        3.781223        4.307714
                1       4.370284        17.71467        1.90121
                1       0.083652        2.379284        2.978978
                1       21.37097        7.788465        0.443476
                1       25.77316        18.64659        2.920182
                1       29.44751        5.892575        2.921923
                1       147.6604        11.92258        1.70136
                1       36.14408        65.37739        2.378572
IBTSQ1_1-6
1997    2024
1       1       0       0.25
1       6
                1       174.4673        54.17918        108.874         6.3358          1.379162        1.052075
                1       199.3658        470.6493        47.07079        24.61658        2.672512        1.320837
                1       237.6786        167.7995        62.98428        2.257075        3.113862        0.583337
                1       74.84901        233.6876        47.39008        14.02511        1.3133          1.159887
                1       47.05208        46.05903        24.37296        5.275775        1.692212        0.747912
                1       93.04713        21.15468        15.40363        14.68903        3.2729          1.065962
                1       2.342425        52.46283        3.545637        2.61305         1.69975         0.375
                1       91.01563        14.12248        32.84681        6.007112        2.050562        2.64905
                1       19.99001        86.9476         5.060875        10.69735        1.2             0.3875
                1       67.31363        21.88264        27.46999        2.661387        2.247375        0.9875
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1 41.60551 41.93674 7.399237 7.522862 0.766212 0.827775
1 8.391675 2.4089 2.224437 0.858337 0.583337 0.416662
1 25.38333 0.925 0.441675 2.041675 0.001 0.333337
1 14.63573 22.46011 0.241662 0.333337 0.529162 0.541662
1 43.72658 24.42604 17.48698 0.6 0.177087 0.125
1 47.11146 9.586875 2.019437 4.055562 0.001 0.083337
1 31.39375 14.16423 3.6191 0.877075 1.4125 0.275
1 3.451525 30.88956 9.951462 3.132475 0.4625 0.333337
1 18.44983 10.18948 27.39344 9.53065 4.195962 2.151037
1 0.522925 14.55145 4.311475 18.67959 5.759175 3.000337
1 23.69166 0.8 0.9375 1.923612 6.200687 15.4382
1 2.993487 7.596475 0.809862 0.846037 0.379162 0.625
1 2.0238 1.708825 3.111112 1.065975 0.444437 0.3125
1 14.40613 0.480375 0.97865 2.338212 0.121875 0.181875
1 1.191487 2.9848 0.116212 0.125 0.583337 0.001
1 2.8408 0.955975 0.50875 0.666662 0.0625 0.001
1 13.5375 1.812637 0.622075 0.669437 0.125 0.125
1 4.402862 8.689225 0.672087 0.24305 0.083337 0.027775
IBTS_Q3
1997 2023
1 1 0.75 0.83
1 4
1 141.86 32.69 14.63 0.78
1 141.92 38.42 1.57 0.92
1 85.73 6.18 1.64 0.2
1 -9 -9 -9 -9
1 6.025 2.109 0.458 0.117
1 46.53 1.566 0.268 0.21
1 1.701 4.499 0.133 0.05
1 67.119 2.282 2.432 0.083
1 12.166 10.937 0.083 0.256
1 25.694 4.263 2.977 0.167
1 5.326 4.222 1.153 0.617
1 1.942 0.467 0.067 0.15
1 19.492 0.217 0.001 0.083
1 2.504 1.279 0.001 0.075
1 8.348 1.594 0.45 0.001
1 8.335 1.248 0.05 0.583
1 9.955 6.993 1.086 0.05
1 3.717 9.976 7.543 0.816
1 4.755 2.104 7.362 3.23
1 0.376 0.692 1.666 2.225
1 12.383 0.075 0.467 0.294
1 1.326 0.555 0.099 0.051
1 0.902 0.14 0.001 0.001
1 2.558 0.509 0.025 0.025
1 1.836 0.235 0.025 0.001
1 0.955 0.005 0.001 0.001
```

1	5.147	0.118	0.126	0.023		
CODS_Q4						
2008	2023					
1	1	0.83	0.92			
1	6					
1	57.1	24.2	9.1	5.8	2.8	1
1	154.4	20.7	2.7	1.7	2	0.8
1	139.1	39	2	0.4	0.2	0.03
1	108.5	30.7	16.2	1.4	0.4	0.1
1	-9	-9	-9	-9	-9	-9
1	355	109.7	21	9.7	3.7	0.7
1	199.2	346.5	164	37.6	13.6	4.5
1	160.4	85	143.8	119.2	31.6	10.4
1	67.2	34.3	29.6	32.9	58.2	33.9
1	237.1	49.9	19.9	13.4	9.5	9.3
1	19	41.3	7	1.5	1.8	1.5
1	72.8	16.4	5.3	1.2	0.6	0.1
1	148.2	9.5	0.1	1.9	0.2	0.3
1	63.4	10.2	1.3	0.1	0.9	0.01
1	116.3	10.9	1.8	0.3	0.01	0.01
1	511.3	23.5	3.1	0.4	0.2	0.1

Table 2.2.11. Summary run SPALY with scaling

Table 1. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), and mortality (Z-0.2).

Year	R(age 1)	Low	High	SSB	Low	High	Z-0.2	Low	High	TSB	Low	High
1997	17206	10826	27344	10542	8208	13539	1.151	0.92	1.44	12689	10082	15972
1998	13485	8432	21565	7812	6196	9848	1.261	1.037	1.533	10454	8583	12734
1999	12748	8065	20151	7383	6086	8957	1.301	1.075	1.573	9193	7640	11062
2000	7220	4540	11482	5643	4631	6877	1.39	1.154	1.674	7004	5828	8417
2001	6238	3905	9963	4902	4001	6006	1.439	1.178	1.757	6161	5093	7454
2002	11949	7185	19873	4920	3855	6278	1.225	0.961	1.562	6129	4834	7771
2003	2710	1517	4842	4277	2937	6228	1.137	0.927	1.395	5173	3563	7512
2004	13857	7986	24042	3753	2449	5750	1.375	1.109	1.706	4981	3304	7509
2005	6122	3452	10858	3204	2143	4791	1.037	0.792	1.358	4896	3268	7336
2006	7342	3996	13491	3555	2270	5569	1.069	0.87	1.315	4873	3134	7577
2007	1890	997	3582	2719	1704	4338	1.468	1.203	1.792	3384	2130	5376
2008	985	571	1700	1352	886	2062	1.47	1.161	1.86	1533	1015	2315
2009	3120	1816	5359	528	346	806	1.337	1.102	1.622	767	511	1153
2010	2697	1564	4651	485	321	735	1.127	0.884	1.437	845	558	1279
2011	3277	1848	5810	672	444	1017	0.78	0.585	1.04	1017	678	1525

Year	R(age 1)	Low	High	SSB	Low	High	Z-0.2	Low	High	TSB	Low	High
2012	7688	4244	13927	925	603	1417	0.612	0.451	0.831	1471	965	2243
2013	9445	5355	16660	1590	1045	2421	0.453	0.32	0.644	2534	1669	3847
2014	3448	1984	5993	2241	1479	3393	0.399	0.279	0.57	3981	2624	6039
2015	2669	1549	4600	4032	2556	6361	0.529	0.402	0.695	5584	3562	8753
2016	782	426	1437	3521	2241	5530	0.734	0.562	0.96	4299	2765	6683
2017	4685	2639	8317	2339	1527	3584	0.954	0.734	1.24	2871	1891	4358
2018	495	278	883	1471	949	2282	1.496	1.253	1.787	1811	1176	2790
2019	1105	613	1990	543	345	854	1.715	1.434	2.051	664	425	1038
2020	2186	1203	3971	246	158	383	1.359	1.083	1.704	397	259	611
2021	813	441	1498	281	176	448	1.172	0.947	1.449	399	249	638
2022	1578	848	2936	217	135	349	1.264	1.001	1.596	296	185	472
2023	6168	3105	12251	292	182	467	1.129	0.802	1.59	574	350	942
2024	1751	479	6395	592	309	1135	1.122	0.656	1.919	837	435	1609

2.3 Western Baltic cod (update assessment)

The western Baltic cod stock assessment was downgraded in 2023 from a category 1 assessment to a category 3 assessment where SSB and recruitment are only trusted for trends. The reason for this downgrading is the very uncertain fishing mortality estimated in the assessment model. Such a pattern suggests that processes other than those captured by the available data on fisheries catches and assumed natural mortality are influencing the SSB of the western Baltic cod stock. The sources for the presumed additional mortality are presently unclear but could involve increased natural mortality (e.g. due to increased predation, decreased condition linked to heat stress and hypoxia in summer (Receveur *et al.* 2022), changes in distribution towards the eastern Baltic, unreported catches or local/regional fish kills due to upwelling of hypoxic waters). However, the effects and order of magnitude associated with these different potential drivers can presently not be quantified and are therefore difficult to account for in the assessment. Further, due to the presently very low landings of cod, the sampling level is low and adds to the uncertainties in the assessment.

2.3.1 The Fishery

The commercial fishery targeting cod has changed very much in latest years: from being the main targeted species in the groundfish fishery it has become a bycatch species in the flatfish fishery. Further, there has been a change in the traditional main fishing grounds and peak fishing time due to closed seasons and areas (Table 2.3.11). In subdivision SD 23 (the Sound) there is a trawling ban in place since 1932 (except for a small area in the north called Kilen); and therefore, commercial cod catches in SD 23 come mainly from gillnetters. Since the second half of 2019 a large area of SD 24 has been closed for a directed cod fishery to protect the cod stocks.

Overall catches were predominantly Danish, German and Swedish. In 2023, however, landings were historically low and Denmark, Germany and Poland (only fishing in SD24) contributed the major part of the landings. Time series of total cod landings by country and SD in the management area of SD 22–24 is given in Table 2.3.1. Since 2017 landing numbers include the BMS fraction, which was around 1 t in 2023 in the western Baltic management area. Normally trawlers have been responsible for the main landings of cod in the western Baltic but since 2021 passive gears are accounting for a large part (in 2023: 52%). Landings by SD, passive and active gear in 2023 are given in Table 2.3.2 (both include eastern Baltic cod landings in SD 24).

The total commercial human consumption landings in the management area (including the eastern Baltic stock component) in 2023 was 89 t (including BMS), which corresponds to a quota utilization of 18% (489 t), being the historically lowest quota utilization. The contribution to landings by subdivision is given in Figure 2.3.1.

In the Western Baltic cod stock assessment recreational fishing is included in the stock assessment, as this fraction has been a large part of the total catch (~30%). However, in 2023 due to the very low commercial catches the recreational fraction increased to 41% of the total catch, although the actual level of recreational catches was estimated to be historic low (111 t) (Figure 2.3.2). Despite the discard rate in 2023 was one of the highest observed in many years (32%), the discard amount is still low (87t). The increased discard could be caused by a change fishing pattern towards smaller mesh sizes in trawlers targeting flatfish in SD22 and a high proportion of small cod in the catches of SD24.

As the Western and Eastern Baltic cod stock mix in SD 24, a splitting factor (based on genetics and otolith shape analysis) is applied to the commercial cod landings in SD 24 to include only those fish belonging to the WB cod stock (Table 2.3.10). A weighted average of the proportions

of WB cod in SD 24 in the two sub-areas was applied (Area 1 and Area 2 in Figure 2.3.3, to account for known spatial differences in stock mixing within SD 24). The weightings for each year represent relative proportions of commercial cod landings taken in areas 1 and 2.

2.3.1.1 Regulation

Since 01.01.2015, the EU landing obligation is in place in the Baltic, obliging the fisheries to land the entire catch of cod. There is a "minimum conservation reference size" of ≥ 35 cm, i.e. cod below this size cannot be sold for human consumption but has to be landed whole (Figure 2.3.4).

In 2019, there was no spawning closure in place in the western Baltic (SD 22–24) unlike in previous years, but since 2020 a spawning closure is in place again (Table 2.3.11). Further, in June 2019, the European Commission issued an immediate measure to protect the cod stock of the eastern Baltic Sea (EU 2019/1248). It also prohibited to carry out a directed fishery for cod in SD 24, with special regulations for active and passive gear fisheries (Table 2.3.11). The Danish fishing pattern in 2023 can be seen by VMS plots in Figure 2.3.5.

In the recreational fishery bag limits have been in place since a few years, and in 2020 and 2021 the regulation was 5 cod per day and only 2 cod per day during the main spawning time (1st Feb. to 31st Mar.) (Table 2.3.11). In 2022 and 2023 the bag limit has been limited to 0 cod during the spawning closure and 1 cod per angler and day in the rest of the year. Details about the regulations can be found in Table 2.3.11 and Fig. 2.3.4.

2.3.1.2 Discards

Denmark, Germany and Sweden uploaded their discard data to InterCatch for SD 22–24 from 2023. There was again no discard data from Poland. Besides the sample level shown in Table 2.3.4, observer trips have been conducted in SD 24, however due to the mixing of the Eastern and Western Baltic cod stock in this area, otoliths are presently only used for stock ID and not for age reading.

The discard rate in 2023 was estimated to have increased compared to previous years and was estimated at 32% in 2023 (discard/total fishery). Discards in numbers per gear segment and quarter can be found in Table 2.3.5.

The discard weights at age for SD 22 and SD 23 for 2023 were included in the catch-at-age weights, and were also applied for the discard estimates in SD 24 (see section 2.3.2.3).

2.3.1.3 Recreational catches

At the benchmark 2019 (WKBALTCOD2 2019), recreational catches from Sweden and Denmark were included in the assessment, German recreational data have been available since 2013 (WKBALTCOD 2015). The recreational catch included in the assessment has been just below 3000 t for a longer time period but has been decreasing since 2017 due to the introduction of a bag limit and reduced resource availability. In 2023 the sampling level of the recreational fishery was very low in SD 23 and gap filling was necessary. As the age distribution in the commercial gillnet fishery in SD 23 was very similar to the recreational age distribution in recent years, the ratio from the commercial fishery was used to extrapolate the biological data of the recreational catches from SD23 in 2022. In recent years Sweden has not been able to provide catch data from their recreational fishery. Due to the decreased commercial catches, the relative contribution of the recreational fisheries to the total catches increased from close to 30% to be 41% in 2023. The recreational catches are mainly taken by private and charter boats and to a small degree by land-based fishing methods. The recreational catches in 2023 were estimated to be 111 t, the lowest in the time series.

The relative amount of recreational catches by age included in the assessment compared to commercial landings and discards is shown in Figure 2.3.2 and Table 2.3.6. All recreational cod caught in SD 22–24 is assumed to be WB cod (WKBALTCOD2, 2019).

2.3.1.4 Unallocated removals

Low quotas may have caused misreporting of landings by the commercial fisheries. However, reliable estimates of potentially unallocated removals are not available for any fleet segment.

From 2015-2020, Germany included cod discard estimates from the German pelagic trawl fishery targeting herring in SD24 (PTB_SPF). This sampling was stopped in 2021 when the processing plant stopped processing catches from the Baltic Sea.

2.3.1.5 Total catch

Total catches of the Western Baltic cod stock (SD 22–24), including commercial landings (and since 2017 including reported BMS and logbook registered discards), discards and recreational catches, were estimated to be 268 t in 2023 (33% lower than last years´ catches). Landings and discards of eastern Baltic cod in SD 24 is estimated to be 63 t in 2023 and are shown in Table 2.3.6. By management area, the total catch is estimated to be 331 t in the western Baltic Sea.

2.3.1.6 Data quality

Denmark, Germany and Sweden provided quarterly landings, LANUM and WELA by gear type (active, gillnets set, longlines set) for SD 22–23 (Table 2.3.2, Table 2.3.7).

All commercial data were successfully uploaded to and processed in InterCatch. There was no national filling of empty strata prior to upload to InterCatch so that bias due to undocumented national extrapolations could be reduced. The list of unsampled strata and their allocated sampled strata in 2023 (i.e. the allocation overview) applied in InterCatch is given for landings and discards in Table 2.3.3a and b.

The Covid-19 pandemic and the decreased fishing in the western Baltic area has decreased the sampling level. In 2023 both the landing levels for cod and the sampling level for cod dropped to historic low levels so that the uncertainty in the catch data has likely increased (Table 2.3.4).

In Sweden, on passive gear trips both landings and discards are sampled. Germany samples catches (i.e. both landings and discards) via at-sea observers and purchased samples from commercial vessels. The German catch sampling program samples length distributions of catches and uses a knife-edge approach to separate the catch into landings and discards (i.e. presently 35 cm). Denmark samples landings via harbour-sampling with harbour trips being the primary sampling unit and discard via at-sea observer sampling with a random selection of all active vessels above 10 m. Sampling levels of commercial catch in 2023 are given in Table 2.3.4.

The Danish port sampling scheme (where commercial size sorting categories are sampled) result in national raising of passive and active gear landings strata with the same data sets. Both Denmark and Sweden are sampling boxes as the secondary sampling unit. In Denmark this is presently done under the assumption that the age and length distribution within a box do not depend on the gear that caught the fish. Information on the number of boxes per size sorting category and strata would be very important to assess the quality of the data submitted to the assessment. However, presently size sorting category data cannot be hold within InterCatch. If these data were to be assessed in the future, the data would have to be provided outside InterCatch, e.g. in the RDBES which should be able to contain this information.

Poland reported that the introduction of a probability-based sampling scheme unfortunately resulted zero at-sea samples and zero observer trips in 2022 and 2023.

The different sampling units (number of harbour days, number of trips) render between-country comparisons difficult. Possible effects of the differences between national sampling levels on data quality of the international data set have not been assessed.

Sampling data from recreational fisheries by SD and nation are shown in Tables 2.3.8 and 2.3.9.

2.3.2 Biological data

2.3.2.1 Proportion of WB cod in SD 22–24

During the benchmark the time series of estimated mixing proportions of eastern and western Baltic cod within SD 24 was updated (WKBALTCOD2 2019). The proportions of eastern and western cod in SD 24 are estimated separately for 2 sub-areas, marked as Area 1 (Darss sill and entrance of SD 23) and Area 2 (Arkona basin, Rönnebank, Oderbank) in Figure 2.3.3.

In 2023, 49 % of cod in SD 24 was found to be WB based on otolith shape analysis and genetics (Table 2.3.10). The split is conducted on the cod genetics and otoliths sampled from the commercial Danish and German trawl fisheries in SD 24. The split is weighted with landings from Germany, Denmark, Sweden and Poland based on 2023 landings by ICES square in SD 24. In 2023 very few cod were available for sub area 1.

Mixing proportions from a German historic survey were used to calculate a splitting proportion on the historic part of the time series (1985-1995).

Time series of the western Baltic stock commercial landings, discards, recreational catch and total catch in numbers-at-age are shown in Tables 2.3.12, 2.3.13, 2.3.14 and 2.3.15, respectively. Given the aging issues with EB cod that have a major contribution in SD 24, age composition information is only used from SD 22–23 (WKBALTCOD, 2015). Commercial catch at age for the entire western Baltic cod stock (i.e. including western Baltic cod in SD 24) were obtained by upscaling the catch at age in SD 22 by the catch of WB cod taken in SD 24 compared to SD 22. Catch at age in SD 23 was subsequently added to obtain the catch at age of the WB cod stock for SD 22–24.

2.3.2.2 Mean weight at age

Mean weight at age in commercial landings, discards and in total catch is shown in Tables 2.3.16, 2.3.17 and 2.3.18, respectively. This is based on data from SD 22–23. The mean weight at age in total catch is estimated as a weighted average of mean weights at age in commercial landings, discards and recreational catch, weighted by the respective catch numbers.

Weight-at-age in the stock for ages 1–3 is obtained from the BITS Q1 survey data for SD 22–23. For age 4-7 weight-at-age in the stock is derived from the commercial catches (Table 2.3.19). The Fulton condition factor of cod in SD 22 and SD 24 has continuously decreased in the last decades, with a massive drop in recent years (Receveur *et al.* 2022).

2.3.2.3 Maturity ogive

The maturity ogive estimations are based on data from BITS Q1 surveys in SD 22–23 (Table 2.3.20) and represent spawning probability. See Stock Annex (ICES 2021B) and WKBALTCOD2 (ICES, 2019) for details. At the inter-benchmark the maturity was changed from a moving average over 5 years to a fixed value based on a mean from the time period 1998-2023 (Table 2.3.20). However, annual maturity is still calculated and this indicates increased maturity in younger year classes over time (Fig 2.3.6)

Spawning stock biomass is calculated at the start of the year, i.e. the proportion of fishing and natural mortality before spawning is assumed to be zero for all years and ages.

2.3.2.4 Natural mortality

At the inter-benchmark in June 2021 it was decided to use the Then growth method as it was based on stock-specific data derived from a contemporary mark-recapture study in SD 22 (McQueen *et al.*, 2019). Further, the estimates were similar to other cod stocks (e.g. cod in Division 6.a (west of Scotland)), although lower than the natural mortality used in the North Sea cod assessment. (Table 2.3.21).

Life history estimates used for the calculation of the natural mortality for western Baltic cod.

Life history parameters	Value	Source
k (combined sex)	0.11	McQueen *et al.*, 2019
Linf (combined sex)	154.56	McQueen *et al.*, 2019
to (combined sex)	-0.13	McQueen *et al.*, 2019
Max age (combined sex, tmax)	25	based on cod in general
a	0.00000792	BITS Q1 & Q4
b	3.0563	BITS Q1 & Q4

2.3.3 Fishery independent information

In the western Baltic Sea two vessels are contributing to the BITS survey quarter 1 and quarter 4 used in the assessment, the German "Solea" and the Danish "Havfisken". Both vessels are part of the international coordinated BITS (Baltic international trawl survey).

In addition, a survey of juvenile cod (age 0) abundances from commercial pound nets (Fehmarn Juvenile Cod Survey - FEJUCS) was included in the assessment in the benchmark (WKBALTCOD2 2019).

BITS Q1 and Q4

The tuning series used in the assessment are BITS Q1, BITS Q4 and a pound net survey. The years and age-groups included in the assessment are shown in the table below and the time series of CPUE indices in Table 2.3.22. Internal consistency of BITS Q1 and Q4 series is presented in Figure 2.3.7a-b and the time series in Figure 2.3.8.

At the inter-benchmark the model calculating the survey index was slightly changed and the new settings are:

- Delta-Lognormal GAM model with time-invariant spatial effect,
- no ship effects (except for the externally estimated conversion for "Havfisken"),
- last age group: 4+,
- only using data collected with the TVS gear in years actually used in the assessment.

The CPUE by age from the BITS tuning series are shown in Figure 2.3.8 and table 2.3.22 The area included in the indices is SD 22–23 and the western part of SD 24 (longitude 12° to 13° which corresponds to Area 1 in Fig. 2.3.3). Presently the area covering the eastern part of the SD 24 (longitude 13° to 15°) is not included in the index due to the uncertainties related to stock mixing

in this area. The abundances of cod in three different size groups (<25, 25-45 and >45 cm TL) caught in the survey can been seen in Figure 2.3.9, 2.3.10 and 2.3.11.

Funk *et al.* (2020) showed that commercial-sized cod in SD22 use areas deeper than 15m from late December until March and again from July until August; shallower areas were favoured during the rest of the year. When cod tend to use shallower habitats in the fourth quarter, the trawl survey catchability is probably much lower (underestimation of true abundances) than in the first quarter when cod is aggregated at the spawning grounds. This effect could be problematic for the Q4 survey if the distribution is not constant in time, but differs in a non-systematic way with regards to age groups, sex or fish condition between quarters or years. In the last couple of years, the internal consistency plot for the Q4 BITS has decreased for older age groups. Changed behaviour could be caused by a delayed cooling of the sea surface in fall giving cod forage opportunities in shallow-water habitats for a longer time period before seeking to the deeper areas where the survey is conducted. Also, increased areas with oxygen-depletion at the bottom could have changed the stock distribution encountered during the Q4 survey in recent years.

FLEET	YEAR RANGE	AGE RANGE
BITS, Q4, SD22–24W (12–13 degrees)	2001–2023	age 0–4+
BITS, Q1, SD22–24W (12–13 degrees)	2001–2024	age 1–4+
FEJUCS, SD22	2011-2023	age 0

2.3.3.1 Recruitment estimates

A strong year class was estimated in 2016 but since then only weak year classes have been recorded.

2.3.4 Assessment

A stochastic state-space model (SAM) is used for assessment of cod in the western Baltic Sea. However, due to the large uncertainties, especially in F, the WG decided to downscale the assessment to a Category 3 assessment in 2023 and only trust in the relative trends.

The configuration of the model used in the assessment is specified in the Stock Annex.

In the inter-benchmark a setting was used to downscale the reliability in the commercial data (to 1/10), mainly due to reduced sampling levels that are linked to very low landing levels and the Covid-19 pandemic. In this year´s assessment the same settings were used, with the same argument. The catchability seems to be stable over time (Figure 2.3.12).

The residuals indicate that there is a mismatch between catch and survey data (a pattern of negative residuals for the later years in the catch matrix and positive residuals for the older age groups mainly in the Q4 survey (Figure 2.3.16). This is also evident in the leaving-out-one plots where one tuning series at a time is excluded (Figure 2.3.17).

The model did not fit very well to catch data; especially for the older ages were the model estimated more older fish than were seen from the observed catch data (figure 2.3.13). The model fit to the survey data was better (figure 2.3.14 and 2.3.15).

The retrospective pattern (Mohn's Rho) for SSB and F was at 0.28 and –0.12, respectively), and 0.71 for the recruitment. (Figure 2.3.18), much higher values than recorded last year.

The summaries for SSB, Recruitment and F from the final run are shown in Figure 2.3.19 and Table 2.3.23. Stock number and fishing mortalities are presented in Tables 2.3.24 and 2.3.25, respectively. Further, harvest rate has been estimated as F is considered unreliable for this stock (Table 2.3.26)

The input data, settings and final run are visible in www.stockassessment.org, the stock is coded "WBCod2024".

2.3.5 Short-term forecast and management options

Forecast is not provided for this stock, due to inconsistencies between previously forecasted and subsequently observed stock development.

In previous years´ forecasts, the expected catch in the interim year predicted a substantial reduction in fishing mortality, and a corresponding increase in SSB. However, although the assumptions made on catches in the interim year have turned out to be reasonable, the fishing mortality estimated from the assessment has remained high, and SSB subsequently considerably lower than was predicted. Such a pattern suggests that processes other than those captured by the available data on fisheries catches and assumed natural mortality are influencing the SSB of the western Baltic cod stock. The sources for the presumed additional mortality are presently unclear but could involve increased natural mortality (due to increased predation, decreased condition linked to heat stress and hypoxia in summer (Receveur *et al.* 2022), changes in distribution towards the eastern Baltic, unreported catches or local/regional fish kills due to upwelling of hypoxic waters). However, the effects and order of magnitude associated with these drivers are presently not possible to quantify and are therefore difficult to account for in the forecast.

2.3.6 Reference points

Biomass reference points are B_{lim}= 15067t and B_{pa} at 32 492 t (IBPWEB 2021). B_{pa} is considered to correspond to B_{MSY} trigger.

Since 2023 the reference points in the advice for the western Baltic cod has been given as relative terms as the assessment (see figure 2.3.19).

2.3.7 Quality of assessment

The western Baltic cod stock assessment has been downgraded from a category 1 assessment to a category 3 assessment where SSB and recruitment is only trusted for trends. The reason for this downgrading is the very uncertain fishing mortality estimated in the assessment model. Such a pattern suggests that processes other than those captured by the available data on fisheries catches and assumed natural mortality are influencing the SSB of the western Baltic cod stock. The sources for assumed additional mortality are presently unclear but could involve increased natural mortality or unreported catches. However, the effects associated with these drivers are presently not possible to quantify and there are no times series of these potential drivers so that it is difficult to account for it in the assessment.

Furthermore, the low sampling level (a combination between the Covid-19 pandemic and a low level of landings) gives conflicting information from the surveys and the catch matrix. In 2023, 41% of the total catch is estimated to come from the recreational fishery and this data is considered more uncertain due to the lack of logbooks and catch reporting.

Mixing of the eastern and western Baltic cod stocks is also a major issue in SD 24. The stock mixing within SD 24 is variable spatially and possibly between seasons and age-groups of cod. This introduces uncertainty to the stock separation keys presently applied in the assessment, however the total landings in this area have decreased significantly in recent years. Moreover, mixing may occur beyond the SD 24 boundaries (in the eastern Baltic area) which is presently not accounted for.

2.3.8 Comparison with previous assessment

The assessment this year is shown in relative terms and the recruitment has been down scaled compared to last year, for this reason the SSB is downscaled as well. The downscaling of recruitment has been observed in this assessment several times before. The recruits are observed in the survey and in the fishery as age group 0, 1 and sometimes age 2, but then disappearing at a higher rate than would be expected from the model. It is presently unknown if this is due to an increased natural mortality, migration or increased discard rate.

2.3.9 Management considerations

The stock is presently at a historic low level and even if the incoming year class (2022) is estimated larger compared to the 2017-2021 year-classes, the stock is still very low. The size of the 2022 year-class has been downscaled compared to last year's assessment. In 2023 the recreational fishery was fishing 41% of the total catch.

Table 2.3.1. Cod in management area of SD 22–24. Total landings (tonnes) and discard of cod in the ICES subdivisions 22, 23, 24 (includes eastern Baltic cod landings in SD 24).

	Denmark			Finland	German Dem.Rep.[1]	Germany, FRG		Estonia		Lithuania	Latvia	Poland	Sweden			Total				
	22	23	22+24	24	22+24	22	22+24	22	24	24	24	24	22	23	22+24	22	23	24	Unalloc.	Grand total
1965			19457		9705		13350								2182	27867		17007		44874
1966			20500		8393		11448								2110	27864		14587		42451
1967			19181		10007		12884								1996	28875		15193		44068
1968			22593		12360		14815								2113	32911		18970		51881
1969			20602		7519		12717								1413	29082		13169		42251
1970			20085		7996		14589								1289	31363		12596		43959
1971			23715		8007		13482								1419	32119		14504		46623
1972			25645		9665		12313								1277	32808		16092		48900
1973			30595		8374		13733								1655	38237		16120		54357
1974			25782		8459		10393								1937	31326		15245		46571
1975			23481		6042		12912								1932	31867		12500		44367
1976		712	29446		4582		12893								1800	33368	712	15353		49433
1977		1166	27939		3448		11686							550	1516	29510	1716	15079		46305
1978		1177	19168		7085		10852							600	1730	24232	1777	14603		40612
1979		2029	23325		7594		9598							700	1800	26027	2729	16290		45046
1980		2425	23400		5580		6657							1300	2610	22881	3725	15366		41972
1981		1473	22654		11659		11260							900	5700	26340	2373	24933		53646
1982		1638	19138		10615		8060							140	7933	20971	1778	24775		47524
1983		1257	21961		9097		9260							120	6910	24478	1377	22750		48605
1984		1703	21909		8093		11548							228	6014	27058	1931	20506		49495
1985		1076	23024		5378		5523							263	4895	22063	1339	16757		40159
1986		748	16195		2998		2902							227	3622	11975	975	13742		26692
1987		1503	13460		4896		4256							137	4314	12105	1640	14821		28566
1988		1121	13185		4632		4217							155	5849	9680	1276	18203		29159
1989		636	8059		2144		2498							192	4987	5738	828	11950		18516
1990		722	8584		1629		3054							120	3671	5361	842	11577		17780
1991		1431	9383				2879							232	2768	7184	1663	7846		16693
1992		2449	9946				3656							290	1655	9887	2739	5370		17996
1993		1001	8666				4084							274	1675	7296	1275	7129	5528	21228
1994		1073	13831				4023							555	3711	8229	1628	13336	7502	30695
1995		2547	18762	132			9196				15			611	2632	16936	3158	13801		33895
1996		2999	27946	50			12018		50		32			1032	4418	21417	4031	23097	2300	50845
1997		1886	28887	11			9269		6			263		777	2525	21966	2663	18995		43624
1998		2467	19192	13			9722		8		13	623		607	1571	15093	3074	16049		34216
1999		2839	23074	116			13224		10		25	660		682	1525	20409	3521	18225		42155
2000		2451	19876	171			11572		5		84	926		698	2564	18934	3149	16264		38347
2001		2124	17446	191			10579		40		46	646		693	2479	14976	2817	16451		34244
2002		2055	11657	191			7322				71	782		354	1727	11968	2409	9781		24158
2003		1373	13275	59			6775				124	568		551	1899	9573	1925	13127		24624
2004		1927	11386				4651				221	538		393	1727	9091	2320	9430	13	20854
2005		1902	9867	2			7002	72	67		476	1093		720	835	8729	2621	10686	9	22045
2006		1899	9761	242			7516		91		586	801			1855	9979	1914	10858		22751
2007		2169	8975	220			6802		69		273	2371		534	2322	7840	2713	13183		23736
2008		1612	8582	159			5489		134		30	1361		525	2189	5687	2139	12256		20082
2009		567	7871	259			4020		194		23	529		269	1817	3451	839	11259		15549
2010		689	6849	203			4250			9	159	319		490	1151	3925	1179	9016		14120
2011		783	7799	149			4521				24	487		414	2153	5493	1198	9641		16332
2012		733	8381	260			4522		3		11	818		390	1955	4896	1123	11053		17072
2013		580	6566	50			3237				128	708		380	1317	4675	960	7333		12968
2014	2206	795	6804	7		2109	3243				39	854	1	565	1231	4316	1361	7862		13538
2015	2781	738	6623	28		2213	2915				7	755		493	1858	4994	1232	7193		13418
2016	1576	675	4881	29		1617	2390					657	1	448	1550	3193	1123	6313		10629
2017	1167	506	2352			1029	1281					926		435	352	2196	941	2714		5852
2018	1010	475	2235	0.5		1005	1373					886		395	462	2014	870	2942		5826
2019	2074	608	3194			1653	1992					991	2	559	334	3728	1167	2783		7679
2020	1456	177	1791			691	936					74	1	331	17	2147	508	671		3326
2021	469	127	574			155	43					200	1	218	9	624	345	357		1326
2022	31	13	55			12	20					39		8	1	43	21	72		136
2023	29	9	33			10	17					26		4	0	40	12	36		88

[1] Includes landings from Oct.-Dec. 1990 of Fed.Rep.Germany.

Table 2.3.2. **Cod in management area of SD 22–24. Total landings (t) by Sub-division (includes Eastern Baltic cod in SD 24) sorted by column "22–24".**

Year	**2023**	**Active and passive gear combined**		
Sub-div.	**22**	**23**	**24**	**22-24**
Country				
Denmark	29	9	3	42
Germany	10	0	7	17
Sweden	0	0	26	26
Poland	0	4	0	4
Finland	0	0	0	0
Latvia	0	0	0	0
Estonia	0	0	0	0
Lithuania	0	0	0	0
Russia	0	0	0	0
Total	40	12	36	88

Year	**2023**	**Gear: Active gear**		
Sub-div.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	8	0	3	10
Germany	3	0	3	6
Sweden	0	0	0	0
Poland	0	0	26	26
Finland	0	0	0	0
Estonia	0	0	0	0
Lithuania	0	0	0	0
Russia	0	0	0	0
Latvia	0	0	0	0
Total	11	0	32	43

Year	2023	Gear: Passive gear		
Sub-div.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	22	9	1	31
Germany	7	0	3	10
Sweden	0	0	0	0
Poland	0	4	0.3	4
Latvia	0	0	0	0
Estonia	0	0	0	0
Finland	0	0	0	0
Lithuania	0	0	0	0
Russia	0	0	0	0
Total	29	12	5	46

Table 2.3.3a. Cod 22–23. Unsampled landing strata and allocated sampled strata in 2023

DE_27.3.c.22_Active_1_L,DK_27.3.b.23_Active_2_L,X
DE_27.3.c.22_Active_1_L,DK_27.3.c.22_Active_1_L,X
DE_27.3.c.22_Active_1_L,DK_27.3.c.22_Active_2_L,X
DE_27.3.c.22_Active_1_L,DK_27.3.c.22_Active_3_L,X
DE_27.3.c.22_Active_1_L,DK_27.3.c.22_Active_4_L,X
DE_27.3.c.22_Active_2_L,DK_27.3.b.23_Active_2_L,X
DE_27.3.c.22_Active_2_L,DK_27.3.c.22_Active_1_L,X
DE_27.3.c.22_Active_2_L,DK_27.3.c.22_Active_2_L,X
DE_27.3.c.22_Active_2_L,DK_27.3.c.22_Active_3_L,X
DE_27.3.c.22_Active_2_L,DK_27.3.c.22_Active_4_L,X
DE_27.3.c.22_Active_4_L,DK_27.3.b.23_Active_2_L,X
DE_27.3.c.22_Active_4_L,DK_27.3.c.22_Active_1_L,X
DE_27.3.c.22_Active_4_L,DK_27.3.c.22_Active_2_L,X
DE_27.3.c.22_Active_4_L,DK_27.3.c.22_Active_3_L,X
DE_27.3.c.22_Active_4_L,DK_27.3.c.22_Active_4_L,X
DE_27.3.c.22_Gillnets set_4_L,DE_27.3.c.22_Gillnets set_1_L,X
DE_27.3.c.22_Gillnets set_4_L,DE_27.3.c.22_Gillnets set_2_L,X
DE_27.3.c.22_Gillnets set_4_L,DE_27.3.c.22_Gillnets set_3_L,X
DE_27.3.c.22_Gillnets set_4_L,DK_27.3.b.23_Gillnets set_1_L,X
DE_27.3.c.22_Gillnets set_4_L,DK_27.3.b.23_Gillnets set_2_L,X
DE_27.3.c.22_Gillnets set_4_L,DK_27.3.c.22_Gillnets set_1_L,X
DE_27.3.c.22_Gillnets set_4_L,DK_27.3.c.22_Gillnets set_2_L,X
DE_27.3.c.22_Gillnets set_4_L,DK_27.3.c.22_Gillnets set_3_L,X
DE_27.3.c.22_Gillnets set_4_L,DK_27.3.c.22_Gillnets set_4_L,X
DE_27.3.c.22_Gillnets set_4_L,SE_27.3.b.23_Passive_1_L,X

DE_27.3.c.22_Gillnets set_4_L,SE_27.3.b.23_Passive_2_L,X
DE_27.3.c.22_Gillnets set_4_L,SE_27.3.b.23_Passive_3_L,X
DE_27.3.c.22_Gillnets set_4_L,SE_27.3.b.23_Passive_4_L,X
DK_27.3.b.23_Active_1_L,DK_27.3.b.23_Active_2_L,X
DK_27.3.b.23_Active_1_L,DK_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_1_L,DK_27.3.c.22_Active_2_L,X
DK_27.3.b.23_Active_1_L,DK_27.3.c.22_Active_3_L,X
DK_27.3.b.23_Active_1_L,DK_27.3.c.22_Active_4_L,X
DK_27.3.b.23_Active_3_L,DK_27.3.b.23_Active_2_L,X
DK_27.3.b.23_Active_3_L,DK_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_3_L,DK_27.3.c.22_Active_2_L,X
DK_27.3.b.23_Active_3_L,DK_27.3.c.22_Active_3_L,X
DK_27.3.b.23_Active_3_L,DK_27.3.c.22_Active_4_L,X
DK_27.3.b.23_Active_4_L,DK_27.3.b.23_Active_2_L,X
DK_27.3.b.23_Active_4_L,DK_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_4_L,DK_27.3.c.22_Active_2_L,X
DK_27.3.b.23_Active_4_L,DK_27.3.c.22_Active_3_L,X
DK_27.3.b.23_Active_4_L,DK_27.3.c.22_Active_4_L,X
DK_27.3.b.23_Gillnets set_3_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Gillnets set_3_L,DE_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Gillnets set_3_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Gillnets set_3_L,DK_27.3.b.23_Gillnets set_1_L,X
DK_27.3.b.23_Gillnets set_3_L,DK_27.3.b.23_Gillnets set_2_L,X
DK_27.3.b.23_Gillnets set_3_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Gillnets set_3_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Gillnets set_3_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Gillnets set_3_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.b.23_Gillnets set_3_L,SE_27.3.b.23_Passive_1_L,X
DK_27.3.b.23_Gillnets set_3_L,SE_27.3.b.23_Passive_2_L,X
DK_27.3.b.23_Gillnets set_3_L,SE_27.3.b.23_Passive_3_L,X
DK_27.3.b.23_Gillnets set_3_L,SE_27.3.b.23_Passive_4_L,X
DK_27.3.b.23_Gillnets set_4_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Gillnets set_4_L,DE_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Gillnets set_4_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Gillnets set_4_L,DK_27.3.b.23_Gillnets set_1_L,X
DK_27.3.b.23_Gillnets set_4_L,DK_27.3.b.23_Gillnets set_2_L,X
DK_27.3.b.23_Gillnets set_4_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Gillnets set_4_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Gillnets set_4_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Gillnets set_4_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.b.23_Gillnets set_4_L,SE_27.3.b.23_Passive_1_L,X
DK_27.3.b.23_Gillnets set_4_L,SE_27.3.b.23_Passive_2_L,X
DK_27.3.b.23_Gillnets set_4_L,SE_27.3.b.23_Passive_3_L,X
DK_27.3.b.23_Gillnets set_4_L,SE_27.3.b.23_Passive_4_L,X

Table 2.3.3b. Unsampled discard strata and allocated sampled strata for Western Baltic cod in 2022 (SD22-23).
DE_27.3.c.22_1_Active_D,DK_27.3.c.22_1_Active_D,X
DE_27.3.c.22_1_Active_D,DK_27.3.c.22_4_Active_D,X
DE_27.3.c.22_2_Active_D,DK_27.3.c.22_1_Active_D,X
DE_27.3.c.22_2_Active_D,DK_27.3.c.22_4_Active_D,X

DE_27.3.c.22_4_Active_D,DK_27.3.c.22_1_Active_D,X
DE_27.3.c.22_4_Active_D,DK_27.3.c.22_4_Active_D,X
DK_27.3.b.23_1_Gillnets set_D,DE_27.3.c.22_1_Gillnets set_D,X
DK_27.3.b.23_1_Gillnets set_D,DE_27.3.c.22_2_Gillnets set_D,X
DK_27.3.b.23_1_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
DK_27.3.b.23_1_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DK_27.3.b.23_1_Gillnets set_D,DK_27.3.c.22_1_Gillnets set_D,X
DK_27.3.b.23_1_Gillnets set_D,DK_27.3.c.22_3_Gillnets set_D,X
DK_27.3.b.23_1_Gillnets set_D,SE_27.3.b.23_1_Passive_D,X
DK_27.3.b.23_1_Gillnets set_D,SE_27.3.b.23_2_Passive_D,X
DK_27.3.b.23_1_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X
DK_27.3.b.23_1_Gillnets set_D,SE_27.3.b.23_4_Passive_D,X
DK_27.3.b.23_2_Active_D,DK_27.3.c.22_1_Active_D,X
DK_27.3.b.23_2_Active_D,DK_27.3.c.22_4_Active_D,X
DK_27.3.b.23_2_Gillnets set_D,DE_27.3.c.22_1_Gillnets set_D,X
DK_27.3.b.23_2_Gillnets set_D,DE_27.3.c.22_2_Gillnets set_D,X
DK_27.3.b.23_2_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
DK_27.3.b.23_2_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DK_27.3.b.23_2_Gillnets set_D,DK_27.3.c.22_1_Gillnets set_D,X
DK_27.3.b.23_2_Gillnets set_D,DK_27.3.c.22_3_Gillnets set_D,X
DK_27.3.b.23_2_Gillnets set_D,SE_27.3.b.23_1_Passive_D,X
DK_27.3.b.23_2_Gillnets set_D,SE_27.3.b.23_2_Passive_D,X
DK_27.3.b.23_2_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X
DK_27.3.b.23_2_Gillnets set_D,SE_27.3.b.23_4_Passive_D,X
DK_27.3.b.23_3_Gillnets set_D,DE_27.3.c.22_1_Gillnets set_D,X
DK_27.3.b.23_3_Gillnets set_D,DE_27.3.c.22_2_Gillnets set_D,X
DK_27.3.b.23_3_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
DK_27.3.b.23_3_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DK_27.3.b.23_3_Gillnets set_D,DK_27.3.c.22_1_Gillnets set_D,X
DK_27.3.b.23_3_Gillnets set_D,DK_27.3.c.22_3_Gillnets set_D,X
DK_27.3.b.23_3_Gillnets set_D,SE_27.3.b.23_1_Passive_D,X
DK_27.3.b.23_3_Gillnets set_D,SE_27.3.b.23_2_Passive_D,X
DK_27.3.b.23_3_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X
DK_27.3.b.23_3_Gillnets set_D,SE_27.3.b.23_4_Passive_D,X
DK_27.3.b.23_4_Active_D,DK_27.3.c.22_1_Active_D,X
DK_27.3.b.23_4_Active_D,DK_27.3.c.22_4_Active_D,X
DK_27.3.b.23_4_Gillnets set_D,DE_27.3.c.22_1_Gillnets set_D,X
DK_27.3.b.23_4_Gillnets set_D,DE_27.3.c.22_2_Gillnets set_D,X
DK_27.3.b.23_4_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
DK_27.3.b.23_4_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DK_27.3.b.23_4_Gillnets set_D,DK_27.3.c.22_1_Gillnets set_D,X
DK_27.3.b.23_4_Gillnets set_D,DK_27.3.c.22_3_Gillnets set_D,X
DK_27.3.b.23_4_Gillnets set_D,SE_27.3.b.23_1_Passive_D,X
DK_27.3.b.23_4_Gillnets set_D,SE_27.3.b.23_2_Passive_D,X
DK_27.3.b.23_4_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X
DK_27.3.b.23_4_Gillnets set_D,SE_27.3.b.23_4_Passive_D,X
DK_27.3.c.22_2_Active_D,DK_27.3.c.22_1_Active_D,X
DK_27.3.c.22_2_Active_D,DK_27.3.c.22_4_Active_D,X
DK_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_1_Gillnets set_D,X
DK_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_2_Gillnets set_D,X
DK_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X

DK_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DK_27.3.c.22_2_Gillnets set_D,DK_27.3.c.22_1_Gillnets set_D,X
DK_27.3.c.22_2_Gillnets set_D,DK_27.3.c.22_3_Gillnets set_D,X
DK_27.3.c.22_2_Gillnets set_D,SE_27.3.b.23_1_Passive_D,X
DK_27.3.c.22_2_Gillnets set_D,SE_27.3.b.23_2_Passive_D,X
DK_27.3.c.22_2_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X
DK_27.3.c.22_2_Gillnets set_D,SE_27.3.b.23_4_Passive_D,X
DK_27.3.c.22_3_Active_D,DK_27.3.c.22_1_Active_D,X
DK_27.3.c.22_3_Active_D,DK_27.3.c.22_4_Active_D,X
DK_27.3.c.22_4_Gillnets set_D,DE_27.3.c.22_1_Gillnets set_D,X
DK_27.3.c.22_4_Gillnets set_D,DE_27.3.c.22_2_Gillnets set_D,X
DK_27.3.c.22_4_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
DK_27.3.c.22_4_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DK_27.3.c.22_4_Gillnets set_D,DK_27.3.c.22_1_Gillnets set_D,X
DK_27.3.c.22_4_Gillnets set_D,DK_27.3.c.22_3_Gillnets set_D,X
DK_27.3.c.22_4_Gillnets set_D,SE_27.3.b.23_1_Passive_D,X
DK_27.3.c.22_4_Gillnets set_D,SE_27.3.b.23_2_Passive_D,X
DK_27.3.c.22_4_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X
DK_27.3.c.22_4_Gillnets set_D,SE_27.3.b.23_4_Passive_D,X

Table 2.3.4. Cod in subdivisions 22–23 only. Overview of the number of samples (number of trips, harbor visits or number of boxes), number of length measurements and number of otoliths available per stratum in 2023 (upper, middle and lower table, respectively). Colour codes indicate sampling coverage (see legend below). Also SD 24 has otolith and length samples.

SD2223		Area	27,3,c,22				27,3,b,23						
Number of samples			Season				Season				Total	Country sum	%
Country	Catch Category	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards *1	Active	4			2					6		
TAC 44%		Gillnets set	5		3						8	55	**52%**
	Landings *2	Active											
		Gillnets set	12	9	10	7	1	2			41		
Germany	Discards *1	Active											
TAC 21%		Gillnets set	4	2	2	4					12		
	Landings *1	Active										21	**20%**
		Gillnets set	6	1	2						9		
Sweden	Discards *2	Gillnets set					5	4	5	3	17	29	**28%**
TAC 16%	Landings *2	Gillnets set					4	3	3	2	12		
			31	12	17	13	10	9	8	5	105		

*1: number of sampled trips; *2: harbor days; *3: Below Minimum Size (BMS) sampled in harbor

SD2223		Area	27,3,c,22				27,3,b,23						
Number of length measurements			Season				Season				Total	Country sum	%
Country	Catch Category	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards	Active	10			31					41		
TAC 44%		Gillnets set	12		13						25	534	**61%**
	Landings	Active											
		Gillnets set	161	88	84	71	26	38			468		
Germany	Discards	Active											
TAC 21%		Gillnets set	8	7	45	21					81		
	Landings	Active										119	**14%**
		Gillnets set	25	7	6						38		
Sweden	Discards	Passive					26	22	82	24	154	220	**25%**
TAC 16%	Landings	Passive					15	10	33	8	66		
Total			216	102	148	123	67	70	115	32	873		

SD2223		Area	27,3,c,22				27,3,b,23						
Number of otoliths age-read			Season				Season				Total	Country sum	%
Country	Catch Category	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards	Active	10			19					29		
TAC 44%		Gillnets set	8		13						21	518	**66%**
	Landings	Active											
		Gillnets set	161	88	84	71	26	38			468		
Germany	Discards	Active											
TAC 21%		Gillnets set	2	4	23	1					30		
	Landings	Active										42	**5%**
		Gillnets set	3	7	2						12		
Sweden	Discards	Passive					26	22	82	24	154	220	**28%**
TAC 16%	Landings	Passive					15	10	33	8	66		
Total			184	99	122	91	67	70	115	32	780		

SD2223		Area	27,3,c,22				27,3,b,23						
Reported Landings 2023 (tons)			Season				Season				Total	Country sum	%
Country		Fleets	1	2	3	4	1	2	3	4			
Denmark	Landings	Active	5	2	0.01	1		0.1		0.01	8	38	**74%**
TAC 44%		Gillnets set	9	5	4	4	2	3	3	1	30		
Germany	Landings	Active	1	0.2		2					3	10	**20%**
TAC 21%		Gillnets set	2	1	1	3					7		
Sweden	Landings	Passive					2	1	1	0.3	4	4	**7%**
TAC 16%													
	Landings		16	8	5	11	4	3	4	1	52		

TAC: total allowable catches for SD22-24

	sampled stratum
	duplicated sampled size. DK: landings of active and passive
	not sampled but Landings or Discards

Table 2.3.5. **Cod 22–23. 2022. Discard (Number * 1000) by quarter and gear type for management area.**

Sum of DISCARD	Quarter				Grand Total
Gear type	1	2	3	4	
Passive gears	2	0	0.2	47	49
Active gears	6	4	21	61	92
Grand Total	**8**	**5**	**21**	**108**	**141**

Table 2.3.6. **Western Baltic cod. Catches in the WB management area (SD 22–24) for WB and EB stocks (in tonnes). Recreational catch (Germany, Denmark and Sweden). Landings in 2017-2023 includes BMS.**

Year	WB cod stock					EB cod stock			Managment area 22-24				
	Landings*	Discards	Recreational catch	% discard	% of comm. catch in SD 24	Landings in SD 24	Discards in SD24	% of catch in SD 24	Total landings	Discards	Recreatio nal catch	total catch	EBC/ WBC stock commercial catch in SD 24
1985	33188		2075		0.29	6971		2	40159		2075	42234	0.71
1986	20088		2078		0.36	6604		3	26692		2078	28770	0.93
1987	21692		2081		0.37	6874		3	28566		2081	30647	0.86
1988	20672		2082		0.47	8487		4	29159		2082	31241	0.87
1989	12795		2083		0.49	5721		3	18516		2083	20599	0.92
1990	12237		2085		0.49	5543		3	17780		2085	19865	0.92
1991	12931		2087		0.32	3762		3	16693		2087	18780	0.92
1992	15672		2420		0.19	2324		4	17996		2420	20416	0.76
1993	11815		2752		0.27	3885		7	15700		2752	18452	1.20
1994	16642	1614	3088	0.09	0.41	6551	621	7	23193	2235	3088	28516	0.97
1995	28310	3016	3417	0.10	0.29	5585	668	5	33895	3684	3417	40996	0.68
1996	38505	6868	3419	0.15	0.32	10040	1116	8	48545	7984	3419	59948	0.77
1997	37077	3981	3420	0.10	0.33	6547	641	7	43624	4623	3420	51666	0.53
1998	29634	5575	3410	0.16	0.37	4582	631	7	34216	6206	3410	43833	0.40
1999	35934	4378	3416	0.11	0.32	6221	599	8	42155	4978	3416	50549	0.52
2000	31132	3738	3432	0.11	0.32	6316	1209	7	37448	4947	3432	45827	0.68
2001	27781	2449	3427	0.08	0.36	7794	389	8	35574	2838	3427	41840	0.75
2002	20410	1395	3437	0.06	0.31	5060	562	8	25470	1957	3437	30864	0.84
2003	17205	3473	3448	0.17	0.34	5729	862	8	22934	4336	3448	30718	0.95
2004	17686	2189	3445	0.11	0.27	5309	188	7	22995	2377	3445	28817	1.04
2005	18493	3265	3771	0.15	0.42	6064	1729	12	24557	4994	3771	33322	0.86
2006	18503	1686	2923	0.08	0.27	6767	144	9	25270	1831	2923	30024	1.28
2007	17384	1325	2782	0.07	0.35	8792	875	15	26176	2200	2782	31158	1.46
2008	11302	336	3039	0.03	0.31	8811	787	17	20112	1123	3039	24274	2.66
2009	7313	351	2648	0.05	0.42	8284	464	14	15597	815	2648	19060	2.75
2010	8007	838	3367	0.09	0.36	6049	533	11	14055	1371	3367	18793	2.08
2011	9107	299	2595	0.03	0.24	7545	482	13	16652	781	2595	20029	3.59
2012	8622	370	3661	0.04	0.31	8469	536	13	17091	905	3661	21657	3.28
2013	7697	1007	3106	0.12	0.29	5359	1243	15	13056	2250	3106	18413	2.62
2014	8083	837	4044	0.09	0.33	5455	1298	15	13538	2135	4044	19716	2.30
2015	8390	432	4568	0.05	0.29	5029	930	12	13419	1361	4568	19348	2.35
2016	6122	143	3505	0.02	0.31	4541	306	13	10663	449	3505	14617	2.53
2017	3861	180	1315	0.04	0.20	2058	227	7	5920	407	1315	7642	2.86
2018	3555	157	1600	0.04	0.21	2295	300	12	5850	458	1600	7907	3.38
2019	6103	655	2573	0.097	0.26	1598	621	19	7701	1276	2573	11550	1.27
2020	2900	152	1311	0.050	0.10	429	50	17	3329	202	1311	4842	1.62
2021	1065	51	968	0.046	0.10	262	29	17	1327	80	968	2375	2.67
2022	88	27	288	0.234	0.29	48	15	4	136	42	288	466	1.90
2023	71	87	111	0.551	0.47	18	45	100	89	132	111	331	0.86
3 avr.													

*including BMS

Table 2.3.7. **Cod in SD 22–23. Numbers at age (LANUM) and mean weight at age (WELA) in commercial landings for Sub-division 22 and 23 by quarter and gear in 2022.**

Year: 2023		**Gear: Trawl, gillnet and longlines combined**				
Year:	**2023**	**Quarter:**	**1**			
Sub-div.	**Sub-div. 22**		**Sub-div. 23**		**Sub-div. 22-23**	
Age	**Numbers**	**Mean**	**Numbers**	**Mean**	**Numbers**	**Mean**
	*10-3	weight [g]	*10-3	weight [g]	*10-3	weights [g]
1	0	666	0.03	666	0.03	666
2	0.2	738	0.4	607	1	651
3	0.9	1635	2	2136	3	1921
4	1.0	2267	2	3002	3	2687
5	0.3	3082	1	4008	1	3611
6	0.04	3560	0.04	5882	0.1	4721
7	0	6466	0.3	6417	0.3	6429
8						
9	0	6903	0.1	6903	0.1	6903
SOP [t]	16		4		20	
Landings (t)	16		4		20	

Year: 2023		**Quarter: 2**				
Sub-div,	**Sub-div. 22**		**Sub-div. 23**		**Sub-div. 22-23**	
Age	**Numbers**	**Mean**	**Numbers**	**Mean**	**Numbers**	**Mean**
	***10-3**	**weight [g]**	***10-3**	**weight [g]**	***10-3**	**weights [g]**
1			0.01	666	0.01	666
2	0.2	910	1	877	1	891
3	1	1449	2	2095	3	1818
4	1	1921	1	3410	1	2665
5	0.1	2280	0.3	4530	0.5	3565
6			0.001	5710	0.001	5710

7		0.2	6556	0.2	6556
8					
9		0.001	6903	0.001	6903
SOP [t]	8	4		12	
Landings (t)	8	3		12	

continued

Table 2.3.7. **Cod in SD 22–23. Numbers at age (LANUM) and mean weight at age (WELA) in commercial landings by Sub-division, quarter and gear in 2022. 2/2**

Year:	**2022**	**Quarter:**	**4**			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	weight [g]	*10-3	weight [g]	*10-3	weights [g]
1	12	545	0.4	570	13	552
2	2	2133	3	1458	4	1844
3	2	3480	1	2566	3	3088
4	0.1	3455			0.1	3455
5						
6	0.09	4546			0.09	4546
7						
8						
9						
SOP [t]	17		6		22	
Landings (t)	16		6		21	

Year:	**2022**	**Quarter:**	**All**			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	weight [g]	*10-3	weight [g]	*10-3	weights [g]
1	13	555	0.5	572	13	560
2	7	1611	6	1005	13	1351
3	5	2892	4	2112	9	2546
4	1	3511	1	2560	3	3036
5	0.1	3924	0.2	3481	0.3	3642
6	2	5131	1	4120	3	4688
7	0.03	2492	0.1	2886	0.1	2738
8						
9						
SOP [t]	45		22		67	
Landings (t)	43		21		64	

Year: 2023		**Quarter: 3**				
Sub-div.	**Sub-div. 22**		**Sub-div. 23**		**Sub-div. 22-23**	
Age	**Numbers**	**Mean**	**Numbers**	**Mean**	**Numbers**	**Mean**
	***10-3**	**weight [g]**	***10-3**	**weight [g]**	***10-3**	**weights [g]**
1	0.05	672	0.1	718	0.1	695
2	1	850	1	719	2	785
3	1	2036	1	1403	2	1719

4	0.4	2792	0.5	2253	1	2577
5	0.1	4260	0.4	850	0.5	3123
6	0.01	5156			0.01	5156
7	0.03	6466			0.03	6466
8						
9	0.005	6903			0.005	6903
SOP [t]	5		4		9	
Landings (t)	5		4		9	

Year: 2023		Quarter: 4				
Sub-div.	**Sub-div. 22**		**Sub-div. 23**		**Sub-div. 22-23**	
Age	**Numbers**	**Mean**	**Numbers**	**Mean**	**Numbers**	**Mean**
	***10-3**	**weight [g]**	***10-3**	**weight [g]**	***10-3**	**weights [g]**
1	0.02	739	0.6	638	1	682
2	0.2	863	1	1152	2	1028
3	0.2	2060	2	3049	2	2625
4	0.1	2792	0.7	4611	1	3832
5	0.02	4260	0.08	4260	0.1	4260
6	0.003	5156	0.1	5433	0.1	5341
7	0.01	6466	0.1	6466	0.1	6466
8						
9	0.001	6903	0.01	6903	0.01	6903
SOP [t]	11		1		12	
Landings (t)	11		1		12	

Year: 2023		Quarter: All				
Sub-div.	**Sub-div. 22**		**Sub-div. 23**		**Sub-div. 22-23**	
Age	**Numbers**	**Mean**	**Numbers**	**Mean**	**Numbers**	**Mean**
	***10-3**	**weight [g]**	***10-3**	**weight [g]**	***10-3**	**weights [g]**
1	0.1	705	1	665	1	682
2	1	850	4	847	6	848
3	3	1795	6	2222	9	2032
4	2	2443	4	3476	6	2980
5	0.5	3313	2	3956	2	3650
6	0.1	4624	0.2	5601	0.2	5150
7	0.03	6466	1	6482	1	6476
8						
9	0.01	6903	0.1	6903	0.1	6903

SOP [t]	40	13	53
Landings (t)	40	12	52

Table 2.3.8. Western Baltic Cod. Overview of the recreational total catch data (tons) used in stock assessment

	SD 22	SD23	SD24
CATON			
DK	1985-2008: Catch per year is calculated as the mean catch per year for the period 2009-2018, which is then weighted for each year with the number of Danish citizens being 18 – 65 years old.	Same as in SD 22	Same as in SD 22
	2009-2018: Statistics Denmark recall survey with adjusted estimates using correction factor from REKREA on-site studies on tour boats and private boats in SD23 in 2016-2018.	2009-2018: Statistics Denmark recall survey with adjusted estimates using correction factor from REKREA on-site studies on tour boats and private boats in 2016-2018.	Same as in SD 22
DE	1980-2004: reconstruction of the time-series is based on the average catch from 2009-2015. To account for the historic development (former GDR) catches in Mecklenburg-Western Pomerania were set to 20% from 1980-1991 with an annual linear increase by 20% between 1991-1995		Same as in SD 22
	2005-2014: Annual catch is calculated on the basis of a mail-diary study (effort) corrected with annual license sales and using CPUE data from an annual on-site intercept survey.		Same as in SD 22
	2015-2017: Annual catch is calculated on the basis of a national telephone-diary study (effort) corrected with annual license sales and using CPUE data from an annual on-site intercept survey.		Same as in SD 22
SE		1985-2010: Catch per year was calculated as the mean catch per year for the period 2011-2018	No estimate for 1985-2016.
		2011-2018: Tour boat census 2011-2018 and marina sampling of private boats 2017-2018	2017-2018; Marina sampling of private boats

Table 2.3.9. Western Baltic Cod. Overview of the recreational biological catch data (length, weight and age) used in stock assessment

Length			
DK	Same as for German data	From on-site studies 2012, 2013, 2016, 2017 and 2018 used in combination with Danish and Swedish data. An average of the time series was used to estimate the historic data (1985-2012)	Same as German data
DE	1980-2004: pooled length distribution from 2005-2017 on-site measurement from national survey onboard tour boats, private boats (sea-based), and from self-sampling during fishing competitions (land-based)		Same as in SD 22
	2005-2017: annual values from on-site measurement from national survey onboard tour boats, private boats (sea-based) and from self-sampling during fishing competitions (land-based)		Same as in SD 22
SE		Same as for Danish data	
Age/weight			
DK	Same as for German data	Data from both Danish and Swedish recreational surveys, commercial landings and BITS survey. Data lacking from 1985 – 1990 and 2001-2003. Age length key based on mean values of the years 1991-1994 applied to the years 1985-1990. Mean age length key based on mean values of the years 1997-2000 and 2004-2008 applied to the years 2001-2003. Face value from 2016-2017.	Same as for German data
SE		Same as for Danish data.	
DE	1980-2002: matching the recreational catch length distribution (total numbers-at-length) with ALK from BITS data for each year.		Same as in SD 22
	2002-2017: matching the recreational length distribution (total numbers-at-length) with ALK from German commercial sampling data for each year.		Same as in SD 22

Table 2.3.10. Western Baltic cod. Percentage of western cod in Area 1 (W: western part of SD 24, 12– 13 degrees longitude) and Area 2 (E: eastern part of SD 24, from 13 -15 degrees longitude); and weighted average of those percentages applied to extract the WB cod landings in SD 24.

Year	**Area 1 _ W**	**Area 2_ E**	**Present WBC in landings for SD 24**
1985	65	56	58

Year	Area 1 _ W	Area 2_ E	Present WBC in landings for SD 24
1986	65	46	52
1987	65	50	54
1988	65	50	53
1989	65	50	52
1990	65	50	52
1991	65	50	52
1992	65	54	57
1993	65	41	46
1994	65	47	51
1995	65	57	60
1996	66	49	57
1997	69	60	66
1998	72	71	71
1999	72	60	66
2000	71	49	60
2001	65	48	57
2002	63	45	54
2003	62	43	52
2004	61	40	49
2005	63	50	54
2006	54	35	44
2007	54	35	41
2008	46	20	27
2009	52	23	27
2010	57	26	33
2011	51	15	22
2012	52	19	23
2013	53	23	28
2014	51	25	31

Year	Area 1 _ W	Area 2_ E	Present WBC in landings for SD 24
2015	50	25	30
2016	58	23	28
2017	62	20	27
2018	51	20	23
2019	41	48	43
2020	93	35	36
2021	88	28	27
2022	95	35	34
2023	100	52	49

Table 2.3.11. Western Baltic cod. Management regulations effecting the western Baltic cod stock in relations area closures and bag limits in the recreational fishery.

Year	Area (SD)	Time period	restricted distance from coast	Regulation	Baglimits (recreational fishery)	restricted depth
2016	22-24	15.02.-31.03. 1.5 months		2015/2072 17. Nov. 2015	No bag limit	
2017	22-24	01.02.-31.03. 2 months		2016/1903 28. Oct. 2016	5 cod/day 3 cod/day (1/2-31/3)	
2018	22-24	01.02.-31.03. 2 months		2017/1970 27. Oct. 2017	5 cod/day 3 cod/day (1/2-31/3)	
2019	22-24	No clouser		2018/1628 30. Oct. 2018	7 cod/day	
2020	22-23	01.02.-31.03. 2 months		2019/1838 30. Oct. 2019	5 cod / day in time period 01.02-31.03 2 cod / day	not deeper 20 m
	24	entire year 12 months	not further than 6 nm		5 cod / day in time period 01.02-31.03 2 cod / day	not deeper 20 m
2021	22-23	01.02.-31.03. 2 months		2020/1579 29. Oct. 2020	5 cod / day in time period 01.02-31.03 2 cod / day	
	24	entire year 12 months	not further than 6 nm			not deeper than 20 m
2022 2023	22-23	15.01-31.03., 2.5 month	1) vessel< 12 m that fish with passive gears in areas shallower that 20 m 2) vessels fishing with dredges for mussels in areas shallower than 20 m	2021/1888 29 0ct. 2021; 2022/2090 31.10.2022	0 cod / day from 15.01-31.03. During the rest of the year: 1 cod / day	<20 m
	24	15.05.-15.08.	vessels <12 m fishing with passive gears; 4 nautical miles measured from the baselines in areas shallower than 20 m		0 cod / day from 15.01-31.03. During the rest of the year: 1 cod / day, within 6 nautical miles measured from the baselines	

Table 2.3.12. **Western Baltic cod. Landings (in numbers (000)) by year and age for the western Baltic cod stock.**

Age	a1	a2	a3	a4	a5	a6	a7+
1985	1569	6360	13467	2795	628	220	126
1986	3394	4885	4093	2838	439	169	77
1987	923	21491	3093	901	448	81	52
1988	948	5110	10932	912	205	141	62
1989	363	1068	3506	2368	210	58	47
1990	580	2739	1527	1376	689	80	43
1991	1415	5238	1917	441	266	221	65
1992	4021	6361	2492	472	94	73	71
1993	2	10171	3718	727	79	5	33
1994	669	3741	11158	1685	61	14	12
1995	676	10765	4638	5317	1141	123	3
1996	96	23597	17390	721	2068	108	2
1997	1831	2000	28844	2563	322	325	77
1998	2413	18597	2129	5721	654	105	76
1999	661	23558	12559	1602	1219	245	92
2000	813	6484	20538	3078	127	245	47
2001	1503	11121	7013	5111	841	49	95
2002	450	8615	8716	1659	923	269	18
2003	647	10092	4525	1303	230	190	65
2004	65	1519	8842	1923	340	123	84
2005	293	9153	1810	3256	374	99	53
2006	260	1575	11186	527	586	79	15
2007	58	3372	2657	3697	419	223	34
2008	20	597	2585	942	867	256	127
2009	179	453	1540	1007	521	189	83
2010	196	3503	1064	634	448	139	56
2011	70	848	3377	1268	285	81	40
2012	112	1300	1264	1919	523	60	14

Age	a1	a2	a3	a4	a5	a6	a7+
2013	286	597	1719	802	734	311	68
2014	42	2657	1077	819	138	145	24
2015	172	943	3018	376	227	34	61
2016	1	876	1371	1028	140	55	34
2017	116	130	854	448	277	53	30
2018	0	1265	144	341	143	80	23
2019	6	28	4226	148	142	35	16
2020	38	101	36	1373	38	14	4
2021	8	184	84	13	245	5	3
2022	20	17	12	4	0	4	0
2023	1	7	12	7	3	0	1

Table 2.3.13. Western Baltic cod. Discard (in numbers (000)) by year and age for the for the western Baltic cod stock.

Age	a1	a2	a3	a4	a5	a6	a7+
1985	3721	2575	667	14	0	0	0
1986	7215	1774	182	13	0	0	0
1987	1837	7305	129	4	0	0	0
1988	1583	1458	382	3	0	0	0
1989	581	292	117	8	0	0	0
1990	906	731	50	5	0	0	0
1991	2803	1772	79	2	0	0	0
1992	9048	2444	117	2	0	0	0
1993	1290	3826	171	3	0	0	0
1994	1962	1873	684	11	0	0	0
1995	2139	5819	307	36	0	0	0
1996	22617	2408	10	0	0	0	0
1997	15207	0	0	0	0	0	0
1998	17005	2708	121	0	0	0	0
1999	2662	9002	302	0	0	0	0

Age	a1	a2	a3	a4	a5	a6	a7+
2000	2679	4390	2486	0	0	0	0
2001	1982	4463	306	48	0	0	0
2002	1510	2243	217	16	0	0	0
2003	1065	7587	414	13	0	0	0
2004	2240	864	2371	0	0	0	0
2005	968	7640	44	0	0	0	0
2006	872	2633	763	43	2	0	0
2007	277	2466	504	39	5	0	0
2008	72	543	193	4	0	0	0
2009	197	499	185	13	0	0	0
2010	225	942	490	313	7	0	0
2011	188	144	177	206	6	0	0
2012	366	310	176	124	3	0	0
2013	903	666	500	469	52	0	0
2014	667	1592	48	7	0	0	0
2015	220	829	303	23	0	0	0
2016	40	282	50	1	0	0	0
2017	451	99	54	12	1	0	0
2018	10	563	7	3	3	0	0
2019	213	38	1345	10	1	0	0
2020	173	68	4	40	1	1	0
2021	124	44	2	0	0	0	0
2022	16	29	7	0	0	1	0
2023	151	127	83	6	0	0	0

Table 2.3.14. **Western Baltic cod. Recreational catch (in numbers (000)) by year and age for the western Baltic cod stock. Data from Germany, Denmark and Sweden.**

Age	a1	a2	a3	a4	a5	a6	a7+
1985	413	703	681	260	64	21	9
1986	400	830	669	244	46	14	3

Age	a1	a2	a3	a4	a5	a6	a7+
1987	333	736	672	238	76	30	10
1988	335	752	673	269	52	11	2
1989	367	671	682	334	65	16	5
1990	337	708	665	251	114	14	7
1991	351	902	640	171	29	5	1
1992	486	600	968	166	32	10	1
1993	432	1011	599	321	87	5	1
1994	561	970	1197	126	45	6	1
1995	566	1463	900	415	39	8	1
1996	347	1637	928	359	78	7	2
1997	857	836	1291	290	50	9	1
1998	609	1522	685	500	55	7	2
1999	278	1583	928	308	101	9	2
2000	573	1250	1043	405	79	13	2
2001	445	1382	773	505	77	19	4
2002	780	1199	983	214	128	21	1
2003	243	1785	822	280	37	6	1
2004	758	1230	1106	236	39	6	1
2005	107	2671	549	517	20	3	1
2006	366	638	1520	78	55	3	0
2007	145	1427	492	465	21	10	1
2008	39	603	1040	361	112	8	1
2009	381	1744	619	312	52	31	7
2010	299	2076	472	236	121	26	9
2011	218	869	1247	81	21	7	4
2012	284	1160	799	793	56	13	0
2013	517	1465	985	196	103	7	2
2014	376	2079	1125	442	65	24	7
2015	184	1651	1882	223	74	16	7

Age	a1	a2	a3	a4	a5	a6	a7+
2016	159	1223	1061	531	103	13	3
2017	425	324	591	145	49	6	2
2018	64	1498	110	148	28	7	1
2019	109	41	2325	25	48	6	2
2020	151	233	40	863	17	4	1
2021	66	457	117	12	234	2	1
2022	123	151	107	23	4	4	0
2023	136	81	27	9	2	0	0

Table 2.3.15. Western Baltic cod. Total catch in numbers ('000) at age (incl. Landing, discards, recreational catch) for the western Baltic cod stock.

Age	a1	a2	a3	a4	a5	a6	a7+
1985	5703	9638	14816	3069	691	241	135
1986	11008	7489	4944	3095	486	184	80
1987	3092	29531	3893	1143	524	110	62
1988	2866	7320	11987	1184	258	152	64
1989	1311	2031	4305	2711	275	74	51
1990	1823	4178	2242	1633	803	94	50
1991	4569	7913	2636	614	296	227	65
1992	13556	9405	3577	640	126	83	72
1993	1724	15008	4488	1052	166	10	33
1994	3193	6584	13038	1821	105	20	13
1995	3381	18047	5845	5768	1180	132	4
1996	23060	27642	18328	1079	2146	114	4
1997	17895	2836	30135	2853	372	333	78
1998	20027	22827	2935	6221	710	112	78
1999	3601	34143	13789	1910	1319	254	94
2000	4065	12123	24066	3484	206	258	49
2001	3929	16966	8091	5664	918	67	98
2002	2741	12056	9916	1888	1051	291	18

Age	a1	a2	a3	a4	a5	a6	a7+
2003	1955	19464	5761	1596	267	196	66
2004	3062	3613	12318	2158	379	129	85
2005	1368	19465	2403	3773	393	102	54
2006	1498	4846	13469	648	644	82	16
2007	480	7265	3653	4201	446	233	34
2008	131	1743	3818	1307	979	264	128
2009	758	2697	2344	1332	573	221	90
2010	720	6521	2025	1182	577	165	65
2011	476	1861	4801	1554	312	88	45
2012	761	2770	2238	2836	581	73	14
2013	1705	2729	3204	1467	890	318	70
2014	1085	6328	2250	1268	203	168	31
2015	577	3423	5202	622	301	50	68
2016	200	2380	2482	1559	243	68	37
2017	991	554	1498	606	327	59	32
2018	74	3326	262	492	174	87	24
2019	328	108	7896	183	191	41	19
2020	362	402	80	2276	57	19	5
2021	198	685	203	25	480	7	4
2022	159	197	126	27	5	9	1
2023	288	215	122	23	5	0	1

Table 2.3.16. Western Baltic cod. Mean weight at age in commercial landings.

Age	a1	a2	a3	a4	a5	a6	a7+
1985	0.456	0.744	1.159	2.113	3.605	5.768	8.812
1986	0.457	0.747	1.160	2.102	3.578	5.714	8.131
1987	0.462	0.756	1.162	2.075	3.512	5.581	8.128
1988	0.461	0.756	1.162	2.077	3.516	5.590	8.191
1989	0.462	0.757	1.162	2.071	3.502	5.561	7.982
1990	0.463	0.759	1.163	2.065	3.487	5.532	8.181
1991	0.468	0.770	1.165	2.033	3.409	5.374	7.508
1992	0.471	0.776	1.167	2.015	3.366	5.287	7.379
1993	0.464	0.762	1.163	2.057	3.468	5.492	7.627
1994	0.445	0.834	1.367	2.378	4.491	6.436	5.045
1995	0.398	0.792	1.215	2.112	3.643	6.064	10.446
1996	0.442	0.685	1.086	2.091	2.879	5.544	8.371
1997	0.503	0.753	0.993	1.685	2.195	4.043	6.407
1998	0.524	0.737	1.155	1.915	2.960	3.940	6.444
1999	0.528	0.666	1.133	1.405	3.141	3.920	4.978
2000	0.509	0.707	0.957	1.655	3.479	5.174	7.303
2001	0.519	0.688	1.082	1.756	3.181	5.090	7.026
2002	0.512	0.716	1.124	1.701	3.386	4.079	6.586
2003	0.593	0.810	1.092	2.002	3.679	5.162	7.224
2004	0.517	0.776	1.008	1.487	3.376	4.179	6.132
2005	0.599	0.738	1.270	2.207	3.362	4.875	6.874
2006	0.217	0.625	1.086	2.485	3.674	4.205	5.725
2007	0.412	0.862	1.186	2.093	3.185	4.747	6.423
2008	0.437	0.906	1.347	2.187	3.234	4.352	6.953
2009	0.768	0.702	1.158	1.794	3.120	4.979	4.986
2010	0.807	0.944	1.111	1.805	2.924	3.384	4.305
2011	0.955	1.212	1.292	1.382	1.905	2.551	2.117
2012	0.902	0.976	1.189	2.000	2.610	2.506	3.504

Age	a1	a2	a3	a4	a5	a6	a7+
2013	0.832	1.035	1.288	1.843	2.517	3.301	3.534
2014	0.859	0.988	1.467	2.793	3.857	5.577	5.453
2015	0.625	0.807	1.585	2.601	4.759	4.507	6.926
2016	0.710	1.027	1.239	2.488	3.273	4.947	6.306
2017	0.796	1.059	1.423	2.265	3.650	4.274	5.478
2018	0.550	1.015	1.870	2.702	3.674	4.937	6.050
2019	0.588	0.816	1.202	2.598	3.271	4.033	6.386
2020	0.631	1.019	1.640	1.852	3.319	4.283	6.897
2021	0.524	1.042	1.591	1.874	2.823	3.248	4.736
2022	0.446	1.272	2.362	2.777	3.075	4.313	3.156
2023	0.644	0.865	2.156	3.027	2.604	4.891	6.543

Table. 2.3.17. Western Baltic cod. Mean weight-at-age in discards.

age	a1	a2	a3	a4	a5
1985-2014	0.262	0.391	0.531	0.469	0.469
2015	0.155	0.333	0.363	0.352	0.352
2016	0.297	0.371	0.487	0.962	0.962
2017	0.221	0.405	0.649	0.789	0.789
2018	0.239	0.268	0.719	1.336	1.336
2019	0.249	0.321	0.436	0.650	1.861
2020	0.282	0.488	1.279	1.576	2.505
2021	0.279	0.353	0.458	0.905	0.356
2022	0.218	0.382	1.290	2.600	1.625
2023	0.211	0.234	0.398	0.570	1.000

Table 2.3.18. **Western Baltic cod. Mean weight-at-age in catch (combined for commercial landings, discards, recreational catch).**

Age	a1	a2	a3	a4	a5	a6	a7+
1985	0.313	0.648	1.127	2.078	3.500	5.562	8.491
1986	0.319	0.662	1.138	2.070	3.475	5.516	7.991
1987	0.321	0.666	1.124	1.989	3.308	4.852	7.423
1988	0.328	0.683	1.139	2.004	3.324	5.410	8.100
1989	0.303	0.703	1.125	2.012	3.237	5.067	7.661
1990	0.326	0.699	1.117	2.001	3.270	5.166	7.593
1991	0.326	0.687	1.170	2.013	3.369	5.343	7.491
1992	0.333	0.683	1.143	2.017	3.340	5.097	7.365
1993	0.340	0.678	1.154	1.947	2.749	4.659	7.589
1994	0.328	0.699	1.318	2.384	3.897	5.782	5.147
1995	0.291	0.665	1.174	2.091	3.634	5.928	9.171
1996	0.261	0.664	1.096	1.985	2.872	5.451	6.462
1997	0.294	0.761	1.005	1.702	2.302	4.036	6.400
1998	0.294	0.705	1.139	1.907	2.935	3.952	6.418
1999	0.308	0.601	1.128	1.472	3.085	3.901	4.975
2000	0.314	0.600	0.927	1.669	3.059	5.070	7.206
2001	0.371	0.620	1.083	1.741	3.131	4.260	6.900
2002	0.339	0.672	1.127	1.726	3.281	3.942	6.588
2003	0.373	0.647	1.101	1.977	3.654	5.135	7.218
2004	0.287	0.710	0.948	1.547	3.359	4.176	6.128
2005	0.325	0.607	1.268	2.133	3.348	4.877	6.868
2006	0.305	0.526	1.072	2.318	3.556	4.211	5.729
2007	0.357	0.693	1.108	2.038	3.146	4.687	6.439
2008	0.413	0.802	1.308	2.081	3.135	4.324	6.926
2009	0.422	0.471	1.165	1.847	3.119	4.683	4.798
2010	0.516	0.804	1.043	1.545	2.789	3.347	4.628
2011	0.429	0.965	1.247	1.306	1.949	2.594	2.361
2012	0.410	0.820	1.183	1.864	2.670	2.559	3.555

Age	a1	a2	a3	a4	a5	a6	a7+
2013	0.385	0.744	1.152	1.395	2.333	3.288	3.513
2014	0.332	0.759	1.308	2.409	3.305	5.143	4.681
2015	0.338	0.666	1.424	2.370	4.285	3.838	6.535
2016	0.483	0.835	1.202	2.218	2.814	4.490	6.149
2017	0.280	0.713	1.257	2.097	3.429	4.118	5.434
2018	0.145	0.759	1.679	2.390	3.441	4.790	5.961
2019	0.262	0.567	1.010	2.383	3.158	3.927	6.034
2020	0.353	0.693	1.277	1.593	2.736	3.946	6.558
2021	0.313	0.935	1.295	1.863	2.179	3.075	4.130
2022	0.296	0.719	1.505	2.623	3.509	4.140	4.274
2023	0.190	0.369	0.703	1.739	2.210	4.172	5.352

Table 2.3.19. Western Baltic cod. Mean weight-at-age in stock (in kg).

age	a0	a1	a2	a3	a4	a5	a6	a7+
1985	0.005	0.063	0.301	0.874	2.078	3.500	5.562	8.491
1986	0.005	0.063	0.301	0.874	2.070	3.475	5.516	7.991
1987	0.005	0.063	0.301	0.874	1.989	3.308	4.852	7.423
1988	0.005	0.063	0.301	0.874	2.004	3.324	5.410	8.100
1989	0.005	0.063	0.301	0.874	2.012	3.237	5.067	7.661
1990	0.005	0.063	0.301	0.874	2.001	3.270	5.166	7.593
1991	0.005	0.063	0.301	0.874	2.013	3.369	5.343	7.491
1992	0.005	0.063	0.301	0.874	2.017	3.340	5.097	7.365
1993	0.005	0.063	0.301	0.874	1.947	2.749	4.659	7.589
1994	0.005	0.063	0.301	0.874	2.384	3.897	5.782	5.147
1995	0.005	0.063	0.301	0.874	2.091	3.634	5.928	9.171
1996	0.005	0.057	0.259	0.990	1.985	2.872	5.451	6.462
1997	0.005	0.050	0.327	0.896	1.702	2.302	4.036	6.400
1998	0.005	0.081	0.316	0.735	1.907	2.935	3.952	6.418
1999	0.005	0.042	0.285	0.801	1.472	3.085	3.901	4.975

age	a0	a1	a2	a3	a4	a5	a6	a7+
2000	0.005	0.059	0.234	0.801	1.669	3.059	5.070	7.206
2001	0.005	0.043	0.388	0.895	1.741	3.131	4.260	6.900
2002	0.005	0.043	0.433	1.117	1.726	3.281	3.942	6.588
2003	0.005	0.054	0.321	1.032	1.977	3.654	5.135	7.218
2004	0.005	0.067	0.536	0.870	1.547	3.359	4.176	6.128
2005	0.005	0.051	0.350	1.038	2.133	3.348	4.877	6.868
2006	0.005	0.043	0.310	0.795	2.318	3.556	4.211	5.729
2007	0.005	0.073	0.411	0.908	2.038	3.146	4.687	6.439
2008	0.005	0.043	0.465	1.019	2.081	3.135	4.324	6.926
2009	0.005	0.051	0.559	1.327	1.847	3.119	4.683	4.798
2010	0.005	0.066	0.369	1.082	1.545	2.789	3.347	4.628
2011	0.005	0.045	0.360	0.767	1.306	1.949	2.594	2.361
2012	0.005	0.050	0.301	0.882	1.864	2.670	2.559	3.555
2013	0.005	0.049	0.391	0.866	1.395	2.333	3.288	3.513
2014	0.005	0.039	0.345	0.965	2.409	3.305	5.143	4.681
2015	0.005	0.057	0.415	0.891	2.370	4.285	3.838	6.535
2016	0.005	0.045	0.357	0.695	2.218	2.814	4.490	6.149
2017	0.005	0.043	0.241	1.033	2.097	3.429	4.118	5.434
2018	0.005	0.074	0.327	0.948	2.390	3.441	4.790	5.961
2019	0.005	0.050	0.487	0.892	2.383	3.158	3.927	6.034
2020	0.005	0.046	0.324	0.958	1.593	2.736	3.946	6.558
2021	0.005	0.048	0.309	0.933	1.863	2.179	3.075	4.130
2022	0.005	0.024	0.322	0.608	2.623	3.509	4.140	4.274
2023	0.005	0.030	0.256	0.649	1.739	2.210	4.172	5.352

Table 2.3.20. Western Baltic cod. Proportion mature at age (spawning probability) as a fixed value.

age	a1	a2	a3	a4	a5	a6	a7+
1998-2023	0.06	0.60	0.84	0.86	0.90	0.94	1.00

Table 2.3.21. Western Baltic cod. Natural mortality at age.

age	a0	a1	a2	a3	a4	a5	a6	a7+
1985-2023	1.318	0.598	0.411	0.324	0.274	0.241	0.218	0.201

Table 2.3.22. Western Baltic cod. Tuning fleets BITS Q4, Q1 and pound net survey FEJUCS.

BITS Q1	a1	a2	a3	a4
1996	11195	130019	16313	909
1997	12461	3012	13456	673
1998	26625	8973	592	670
1999	7629	16009	2689	340
2000	11463	7128	6787	1226
2001	4370	6193	1264	783
2002	11166	3778	1897	294
2003	957	5340	589	221
2004	9397	1986	2361	153
2005	6461	39716	1642	883
2006	9724	7324	8679	361
2007	1819	11137	2872	1766
2008	65	1263	1306	719
2009	6588	859	1089	534
2010	2384	12555	469	264
2011	9159	9072	15320	133
2012	1625	3848	1804	1223
2013	6214	3441	2496	455
2014	3765	5320	716	308
2015	2560	5856	2226	230
2016	37	955	625	696

BITS Q1	a1	a2	a3	a4
2017	8623	353	1241	706
2018	485	24120	414	1036
2019	491	1539	10568	347
2020	1141	970	385	2495
2021	3713	2570	439	338
2022	2749	1521	416	99
2023	7440	1849	378	126
2024	3220	1928	175	52

Table 2.3.22. Western Baltic cod. Tuning fleets BITS Q4 and Q1. (Continued)

BITS Q4	a0	a1	a2	a3	a4
1999	11221	5630	2399	164	21
2000	3756	3006	713	128	34
2001	23209	2177	944	144	78
2002	2673	6648	805	296	33
2003	24140	3586	1524	102	42
2004	4886	8080	747	272	20
2005	4290	1851	1267	110	74
2006	2455	2758	299	685	93
2007	463	294	179	181	267
2008	20035	42	53	75	83
2009	2906	1836	52	94	32
2010	10564	729	465	27	20
2011	3643	1373	103	152	17
2012	15634	1240	298	55	53
2013	7113	3116	171	73	36
2014	5833	1443	654	115	65
2015	455	707	260	259	59
2016	32666	133	98	40	114

BITS Q4	a0	a1	a2	a3	a4
2017	294	5981	110	155	56
2018	1063	284	763	18	61
2019	3506	282	15	107	35
2020	4318	644	24	13	147
2021	9684	920	61	7	51
2022	27621	2268	70	18	11
2023	10406	2214	83	11	6

Table 2.3.22. Western Baltic cod. Tuning fleets. Pound net survey (FEJUCS).

FEJUCS	a0
2011	20.7
2012	NA
2013	16.8
2014	25.5
2015	14.3
2016	169.8
2017	0.3
2018	2.2
2019	4.6
2020	2.1
2021	2.4
2022	11.4
2023	1.2

Table 2.3.23. Western Baltic cod. Output from SAM with recruitment (age 1), SSB (t.), and F (Fbar 3-5)

Year	R (age 1)	Low	High	SSB	Low	High	Fbar(3-5)	Low	High	TSB	Low	High
1985	49263	25526	95075	35418	26708	46969	1.164	1.011	1.341	48373	37404	62560
1986	130365	69275	245326	24886	19859	31184	1.157	1.017	1.315	39172	31281	49052
1987	44489	24122	82055	26275	20241	34108	1.145	1.016	1.291	39413	29905	51943
1988	20407	10922	38129	27817	20732	37324	1.142	1.018	1.28	36110	27326	47719

Year	R (age 1)	Low	High	SSB	Low	High	Fbar(3-5)	Low	High	TSB	Low	High
1989	22569	12229	41650	19838	15275	25764	1.142	1.022	1.276	25750	20203	32819
1990	35090	19009	64773	13538	10928	16771	1.157	1.04	1.287	19677	16089	24067
1991	59942	32523	110476	11755	9473	14587	1.175	1.058	1.306	20644	16501	25828
1992	118980	64223	220425	13957	10857	17941	1.186	1.067	1.319	26672	20412	34851
1993	43282	23362	80187	22678	16861	30501	1.182	1.065	1.311	36124	27059	48226
1994	94129	50836	174291	32490	24092	43815	1.174	1.06	1.3	48354	37122	62984
1995	153089	82906	282685	36116	28256	46163	1.182	1.066	1.31	56760	44781	71943
1996	45345	24528	83830	46991	36494	60508	1.174	1.06	1.3	67518	52641	86600
1997	133298	76968	230853	50201	37216	67716	1.178	1.064	1.305	70223	53677	91869
1998	205804	120026	352884	37021	29196	46942	1.183	1.067	1.313	65477	51545	83176
1999	70815	43307	115795	40344	31949	50945	1.199	1.073	1.34	58990	46652	74591
2000	72773	45214	117130	37937	29696	48466	1.196	1.068	1.338	51440	41001	64538
2001	47910	29552	77671	34808	28230	42919	1.188	1.06	1.331	48639	39685	59614
2002	96514	59592	156313	31636	25435	39350	1.167	1.044	1.303	44589	36239	54863
2003	29895	18330	48757	28360	22968	35017	1.137	1.023	1.265	41518	33505	51447
2004	108471	66707	176383	28000	22011	35620	1.112	1.001	1.234	42472	34020	53024
2005	31648	19642	50991	32737	26079	41094	1.076	0.969	1.195	47108	37298	59498
2006	35120	21780	56632	31923	24832	41039	1.035	0.925	1.159	40532	31864	51558
2007	10684	6450	17700	28924	23023	36338	1.02	0.911	1.143	36579	29357	45576
2008	3961	2065	7595	19951	16341	24357	1.022	0.917	1.14	24676	20321	29964
2009	42278	25422	70311	14213	11668	17313	1.023	0.919	1.138	19258	15959	23239
2010	15252	9437	24649	13462	10809	16767	1.021	0.918	1.137	19998	15869	25201
2011	22439	13804	36476	14360	10910	18901	1.009	0.905	1.125	19041	14738	24599
2012	17946	11179	28809	15067	11922	19041	0.999	0.894	1.115	20208	16283	25080
2013	43830	27188	70658	12430	10143	15232	1.005	0.9	1.123	17932	14801	21726
2014	25494	15869	40958	15816	12902	19388	0.992	0.885	1.112	21898	17825	26900
2015	15127	9394	24357	16916	13592	21051	0.984	0.874	1.108	22087	17842	27341
2016	2984	1759	5063	12603	9946	15970	0.982	0.867	1.113	16401	13101	20533
2017	48338	28747	81282	9259	7380	11616	0.979	0.856	1.119	12769	10278	15863

Year	R (age 1)	Low	High	SSB	Low	High	Fbar(3-5)	Low	High	TSB	Low	High
2018	2104	1275	3472	10170	7887	13115	0.978	0.846	1.132	14354	10956	18806
2019	3095	1829	5238	11807	8584	16241	0.981	0.837	1.15	14288	10429	19575
2020	6329	3618	11072	7750	5066	11855	0.983	0.827	1.169	9532	6354	14301
2021	8133	4508	14672	3750	2476	5679	0.982	0.815	1.183	5131	3567	7379
2022	12775	6799	24003	2641	1815	3844	0.975	0.798	1.192	4274	3035	6018
2023	34291	17001	69163	2383	1615	3515	0.97	0.783	1.201	4657	3107	6982
2024	33853	12005	95459	5213	2976	9133				9150	5038	16621

Table 2.3.24. Western Baltic cod. Estimated stock numbers by age.

Estimated stock numbers at age.								
Year Age	0	1	2	3	4	5	6	7
1985	458813	49263	24421	21912	4204	1128	364	208
1986	168753	130365	22421	8787	4853	841	288	141
1987	80056	44489	66655	8085	2026	974	208	110
1988	86114	20407	21850	22990	2051	455	251	91
1989	131928	22569	8528	8495	5329	499	126	92
1990	224789	35090	11362	3428	2246	1268	149	68
1991	408091	59942	18273	4292	803	491	335	69
1992	176923	118980	29170	6501	979	151	119	101
1993	346339	43282	58801	11473	1491	196	25	50
1994	525102	94129	21673	26825	3534	288	34	17
1995	190257	153089	53841	9060	8365	1105	76	9
1996	482134	45345	101444	24285	2163	2258	247	13
1997	710388	133298	14609	47507	5141	581	515	78
1998	278039	205804	60703	6020	9844	1192	159	142
1999	250229	70815	94071	22230	1746	1931	299	91
2000	163073	72773	32129	31897	5641	359	422	85
2001	325368	47910	40467	11770	7567	1391	85	120
2002	109769	96514	25972	15526	2651	1533	364	40

2003	352906	29895	55983	9276	3041	565	350	100
2004	117035	108471	14720	22496	2430	602	157	118
2005	113099	31648	66755	5861	5805	586	135	70
2006	39558	35120	16949	29530	1850	1399	143	40
2007	15751	10684	18566	7985	8042	702	409	51
2008	144752	3961	6774	7227	2670	1783	253	148
2009	58631	42278	3951	4282	2232	795	380	112
2010	87470	15252	28048	2666	1563	618	202	110
2011	70342	22439	8080	15157	1362	451	126	68
2012	159097	17946	12087	4432	4719	639	129	38
2013	96739	43830	9369	6395	1579	1268	223	58
2014	58749	25494	23392	4434	2138	380	304	61
2015	13722	15127	12548	10491	1395	537	90	99
2016	164160	2984	8186	4523	3330	397	125	51
2017	8271	48338	1696	4062	1381	731	95	46
2018	12285	2104	24877	736	1348	339	148	35
2019	25564	3095	957	12559	294	359	71	37
2020	32726	6329	1404	478	4712	81	72	23
2021	53691	8133	2842	620	144	1199	17	20
2022	137018	12775	3180	1162	191	39	213	8
2023	118747	34291	4712	1211	379	51	9	44
2024		33853	15917	1902	441	115	12	13

Table 2.3.25. Western Baltic cod. Estimated fishing mortality by age.

	Estimated fishing mortality at age.				
Year Age	**age 1**	**age 2**	**age 3**	**age 4**	**age 5-7**
1985	0.096	0.541	1.103	1.266	1.123
1986	0.095	0.539	1.095	1.257	1.117
1987	0.095	0.535	1.085	1.243	1.108
1988	0.094	0.527	1.081	1.233	1.111

1989	0.093	0.519	1.075	1.232	1.118
1990	0.091	0.516	1.077	1.242	1.152
1991	0.09	0.511	1.072	1.25	1.204
1992	0.089	0.501	1.062	1.241	1.256
1993	0.087	0.492	1.047	1.223	1.275
1994	0.086	0.487	1.051	1.192	1.278
1995	0.085	0.483	1.071	1.189	1.286
1996	0.086	0.48	1.087	1.196	1.239
1997	0.084	0.48	1.09	1.219	1.226
1998	0.082	0.487	1.083	1.246	1.22
1999	0.079	0.49	1.09	1.265	1.243
2000	0.077	0.489	1.092	1.262	1.233
2001	0.075	0.486	1.073	1.26	1.229
2002	0.072	0.479	1.045	1.244	1.21
2003	0.07	0.467	1.006	1.218	1.188
2004	0.068	0.455	0.963	1.182	1.19
2005	0.066	0.446	0.919	1.133	1.177
2006	0.065	0.439	0.887	1.081	1.138
2007	0.063	0.433	0.859	1.068	1.134
2008	0.062	0.422	0.841	1.054	1.172
2009	0.061	0.414	0.819	1.053	1.196
2010	0.06	0.4	0.803	1.049	1.212
2011	0.06	0.39	0.793	1.04	1.194
2012	0.06	0.382	0.788	1.043	1.165
2013	0.06	0.377	0.785	1.041	1.191
2014	0.06	0.372	0.78	1.021	1.175
2015	0.06	0.366	0.776	1	1.177
2016	0.06	0.358	0.772	0.988	1.187
2017	0.06	0.348	0.758	0.973	1.206
2018	0.06	0.337	0.753	0.959	1.223

2019	0.061	0.332	0.759	0.955	1.229
2020	0.06	0.334	0.759	0.951	1.239
2021	0.06	0.335	0.762	0.947	1.237
2022	0.06	0.335	0.76	0.942	1.224
2023	0.06	0.335	0.76	0.937	1.213

Table 2.3.26. Western Baltic cod. Estimated harvest rate.

Year	harvest rate (C/SSB)
1985	1.301
1986	1.110
1987	1.166
1988	1.088
1989	0.968
1990	1.300
1991	1.570
1992	1.652
1993	0.857
1994	0.875
1995	1.208
1996	1.317
1997	1.191
1998	1.310
1999	1.339
2000	1.258
2001	1.170
2002	0.978
2003	1.022
2004	1.033
2005	0.957
2006	0.922
2007	0.921
2008	0.882
2009	0.866
2010	1.090
2011	1.073
2012	1.019

Year	harvest rate (C/SSB)
2013	1.128
2014	0.975
2015	0.957
2016	0.961
2017	0.714
2018	0.651
2019	1.037
2020	0.790
2021	0.713
2022	0.165
2023	0.082

Figure 2.3.1. Western Baltic cod. Relative landings by SD (tonnes) for the western Baltic management area (both east and west cod included). HCL: human consumption landings.

Figure 2.3.2. **Western Baltic cod. Commercial landings, discard and recreational catch (tonnes) of the WBC stock.**

Figure 2.3.3. **Western Baltic cod. Subareas (Area 1 and Area 2 within SD 24) for which different keys for splitting between eastern and western Baltic cod catches in SD 24 were applied.**

Figure 2.3.4. **Western Baltic cod. Management measures for gear and minimum landing size, since 1994.**

Figure 2.3.5. Western Baltic cod. Danish VMS data from 2023 from OTB.

Figure 2.3.6. Western Baltic cod. Maturity as a 5 year moving average, which was used in former assessment.

i

Figure 2.3.7a. **Western Baltic cod. CPUE at age i vs numbers at age i +1 in the following year, in BITS Q1 survey. Red dots highlight the information from the latest year.**

Figure 2.3.7b. **Western Baltic cod. Western Baltic cod. CPUE at age i vs numbers at age i +1 in the following year, in BITS Q4 survey. Red dots highlight the information from the latest year.**

Figure 2.3.8. **Western Baltic cod. Time series of BITS Q1 and BITS Q4 in numbers by age groups.**

Figure 2.3.9. Western Baltic cod. Distribution of cod<25 cm from BITS Q4 2023 to BITS Q1 2024. Green dots have minimum 1 cod, red dots are zero catch for that size group.

Figure 2.3.10. **Western Baltic cod. Distribution of cod 25-45 cm from BITS Q4 2023 and BITS Q1 2024. Green dots have minimum 1 cod, red dots are zero catch for that size group.**

Figure 2.3.11. **Western Baltic cod. Distribution of cod >45 cm from BITS Q4 2023 to BITS Q1 2024. Green dots have minimum 1 cod, red dots are zero catch for that size group.**

Figure 2.3.12. Western Baltic cod. Selection pattern

Figure 2.3.13. Western Baltic cod. Model fitting to catch data (line is model and cycles are data points.

Figure 2.3.14. Western Baltic cod. Model fitting to Q1 survey data (line is model and cycles are data points.

Figure 2.3.15. Western Baltic cod. Model fitting to Q4 survey data (line is model and cycles are data points.

Figure 2.3.16. **Western Baltic cod. Residuals in catch data and surveys.**

Figure 2.3.17. **Western Baltic cod. Leave one out SSB and F**

Figure 2.3.18. **Western Baltic cod. Retrospective pattern in SSB, F and R. Mohn's Rho is indicated in the figures.**

Figure 2.3.19. **Western Baltic cod. Final assessment with SSB, harvest rate and R (age 1).**

3 Flounder in the Baltic

3.1 Flounder in subdivisions 22 and 23 (Belts and Sound)

3.1.1 The fishery

The landing data of flounder in the Western Baltic (fle.27.22-23) according to ICES subdivisions and countries are presented in Table 3.1.1. The trend and the amount of the landings from this flatfish stock are shown in Figure 3.1.1.

Flounder is mainly caught in the area of the Belt Sea (SD 22). The Sound (SD 23) is of minor importance for the contribution to the total landings (Table 3.12). Denmark, Germany, and Sweden are the only fishing countries in both areas.

Flounder are caught mostly by trawlers and gillnetters. The minimum landing size is 23 cm. Active gears provided about 30% of the landings in SD22, whereas passive gears have been increasing their share in the landed fraction to about 70% in the last year. In SD 23, passive gears provide around >95% of total flounder landings (for the Swedish fleet 98–100%) in this area. Flounder used to be fished as a bycatch-species in cod targeting fisheries (i.e. mostly trawlers) and in a mixed flatfish fishery (i.e. mostly gillnetters). However, fisheries are shifting towards a plaice- and mixed flatfish directed fishery since 2020.

3.1.2 Landings

The highest total landings of flounder in subdivisions 22 and 23 were observed at the end of the seventies (3790 t in 1978). Landings decreased in the period between 1989 and 1993. Since 1993 the landings increased again and reached a moderate maximum in 2000 (2597 t). After 2000 the landings decreased to 866 t in 2006. Landings slightly increased since 2006 and vary between 1400 and 1000 tonnes since then. Landings in 2023 were at about 252 tonnes (Table 3.1.2) and the lowest observed landings since the beginning of the timeline (1911). The timeline has been extended from 1973 back to 1911 at the benchmark in 2024 (WKMSYSPICT3, ICES 2024a), using landings from the ICES catch statistics database (https://www.ices.dk/data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx).

3.1.2.1 Unallocated removals

Unallocated removals might take place but are considered minor, as there is no TAC on this stock, and are not reported from the respective countries. The recreational fishery on flounder takes place, but removals are considered to be minor and not taken into account in the catches.

3.1.2.2 Discards

Discards of flounder are known to vary greatly with ratios around 20–50% of the total catch of vessels using active gears (e.g. trawling). Passive fishing gears have lower discards, varying between 10 to 20% of the total catch. Depending on market prices, quality and quota of target species (e.g. cod), discards vary between hauls, trips, vessels, areas, quarters and years. The discarded fraction can cover all length-classes and rise up to 100% of a catch.

Denmark is not sampling discard data from the passive gear segment because amounts are considered minor; empty strata are extrapolated with sampling data from other countries. The quality of the discard data increased in recent years, as the national data submitters conducted more estimation. In strata without landings, no discard information was extrapolated.

Subdivision 22 (the Belt) shows a relatively good sampling coverage that allows reasonable discard estimations at least for the last four years. Subdivision 23 (Sound) is sampled less (Figure 3.1.3a); only a few biological samples are available (Figure 3.1.3b). However, discard estimations provided by national data submitters are given in many strata. Sampling intensity has increased steadily in the last years; therefore, less discard ratios were borrowed. Before 2006, sampling intensity was too low to give a reasonable estimation, especially in the passive segment, where almost no data were available. The discards in 2023 are estimated to be around 58 tonnes, which would result in a discard ratio of 19% of the total catch, which is on a similar level as the late 2010s.

The change towards flatfish-directed fisheries in both active and passive gears resulted in higher discards due to smaller mesh sizes (90mm flatfish gears instead of 105+mm cod-directed gears). The decreasing condition in Baltic Sea flatfishes (see 3.1.7.2) is lso affecting flounder in SDs 22 and 23, resulting in flounder above the MCRS being discarded more often than before.

3.1.3 Fishery independent information

The "Baltic International Trawl Survey" (BITS) is covering the area of the flounder stock in SD 22–23. The survey is conducted twice a year (1st and 4th quarter) by the member states having a fishery in this area. Survey design and gear is standardized.

The calculation of the survey index changed from a biomass index to a delta GAM model-based approach after the benchmark in 2024 (see 3.1.4) This was done to account for reduced spatial coverage in earlier years (before 2000), Before 2000, the BITS survey was not standardized, different survey gears were used, and spatial coverage was incomplete. The model-based approach accounts for different catchability between gears, unsampled areas, and quantifies the increased index uncertainty due to these issues.
The new index calculation also accounts for a substantial decreasing trend in the condition of flounder since the mid 90-ties by using annual length-weight relationships instead of a fixed one. The improved index from the delta GAM model-based approach is similar to the trends of the previously used biomass index, slightly increasing compared to the previous year and after a larger decrease in the mid-2010s (Figure 3.1.6).

3.1.4 Assessment

This stock was benchmarked in 2024 (ICES, 2024a). The assessment category changed from category 3 to category 2. The stock assessment method was changed from Length-based-Indicators (LBI) to a surplus production model (SPiCT), using a model-based approach to calculate an exploitable biomass index (Berg *et al*. 2013).

3.1.4.1 Surplus production model (SPiCT) and reference points

The stochastic production model in continuous time (SPiCT) was applied to the flounder stock fle.27.22-23. Input data were commercial landings from 1973 to 2023 and the improved BITS biomass index Q1 and Q4 from the delta GAM model survey index (Table 3.1.3) from 1991 to 2023. Sensitivity runs performed during the benchmark suggested that choosing the catch time series starting in 1973 results in the most reliable model results. The long catch time series between (1911+) displayed a steady decline in biomass and increasing fishing mortality until the late 1990s. The model was not able to reflect the period of the highest catches in the late 1960s to 1980s and is therefore not considered as a viable option. Trimming the time series to 1973 resulted in a slightly higher starting point for the estimation of the absolute and relative biomass and fishing mortality, especially in the 1980s. The short catch time series (1991+, in parallel with the biomass index time series) estimates a lower biomass and higher fishing mortality than the previous

models. This is caused by the exclusion of the higher catches reported between the 1960s and 1980s and thus missing valuable information of the catch history to accurately estimate the stock status. Of the three model runs, the medium catch time series (starting 1973) reflects the fishing pattern and its expected influence on biomass and fishing mortality most accurate and used for further sensitivity examinations.

No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios F/F_{MSY} and B/B_{MSY} are used to estimate stock status relative to the MSY reference points and are used in the catch advice and catch scenarios. A short-term forecast was conducted assuming F_{sq}.

The results of the assessment are stating a good status (Figure 3.1.4) of the stock, where F is below F_{MSY} and B above $B_{trigger}$ (Figure 3.1.5) and thus confirming the results of the previously conducted LBI and the stock trend of the BITS. Retrospective analysis of the SPiCT data series indicating a consistent pattern in catches and survey indices (Figure 3.1.6, Figure 3.1.7).

The remaining uncertainty might be attributed to inconsistency between landings and index time-series and missing contrast in the landings time-series.

Despite the remaining variance, the model states a good stock condition in recent years and well within F_{MSY} and B_{MSY}. Following the ICES approach, a proxy for MSY $B_{trigger}$ can be calculated as 0.5 x B_{MSY}.

3.1.4.2 Technical criteria for accepting a SPiCT assessment

When determining harvest limits using output from SPiCT, the application depends on appropriate model performance. An accepted assessment using SPiCT would ideally fulfil all of the following points:

- Model converged;
- All parameter uncertainties could be estimated and finite;
- No violation of model assumptions such as bias, auto-correlation of OSA residuals, and normality. This means that p-values are not significant ($p > 0.05$);
- Consistent trend in the retrospective analysis. There should not be a tendency to consistently under- or overestimate relative fishing mortality and biomass in successive assessments, in particular if the retrospective estimates are outside the confidence intervals of the base run;
- Non-influential starting values – the results should be the same for all starting values;
- Model parameter estimates and variance parameters should be meaningful. This means that the parameter of the production curve (*n*) should not be very skewed away from the symmetrical curve (B_{MSY}/K should be between 10% and 90%) and the variance parameters (sdb, sdc, sdi, sdf) should not be unrealistically low. In these cases, a prior on the unrealistic parameter could be considered.

The flounder dataset and results of the SpiCT were tested for all the above criteria. All technical criteria were fulfilled.

3.1.5 Biological reference points (Precautionary approach)

F_{MSY}, B_{MSY} and the yield at MSY are all directly estimated in the model. It should be noted that these will vary when new survey and catch information is added. B_{pa} and B_{lim} are defined as 50%B_{MSY} and 30%B_{MSY} respectively. F_{lim} is defined as 1.7 F_{MSY} and is the F that drives the stock to B_{lim} assuming B_{lim}=30%B_{MSY}. The derivation is given below:

$P=rB(1-B/K)$

The surplus productivity associated with B_{lim} is:

$P_{lim}=rB_{lim}(1-B_{lim}/K)$

The corresponding F is:

$Flim=rB_{lim}(1-Blim/K)/B_{lim} = r(1-B_{lim}/K)$

$Blim=0.3B_{MSY} = 0.3K/2$ $Flim = r(1-0.3K/(2K)) = r(1-0.3/2) =0.85r$

$F_{MSY}=r/2$, *let x denote the proportionality between F_{MSY} and Flim*

$xF_{MSY}=F_{lim}$

$x(r/2)=0.85r$

$x=2*0.85$

$x=1.7$

3.1.6 Management considerations

To improve the assessment and hence the quality of the advice, more discard estimations are required by national data submitters. Additionally, more flexible tools need to be developed for InterCatch, allowing the allocation of discards also to strata with no landings attached (discard only) and extrapolation across years (to allow reasonable borrowing in years without sufficient estimations). Data handling, such as allocation and hole filling should take place in the database to allow comprehension of the methods used.

3.1.7 Stock identity

Distribution maps from scientific surveys strongly suggest that there is no spatio-temporal separation between flounder in Kattegat and the Western Baltic (Belt Seas and the Sound) and that flounder in the Kattegat have negligible links to flounder in the North Sea (Annex 5 WD2). The Danish Straits are highly dynamic connecting channels between the southern Kattegat and Kiel and Mecklenburg Bight south of Denmark that make a stock separation between SDs 22-23 and SD21 highly unlikely. No distinct differences were found in biological life history parameters (i.e. maturity and growth) between flounder from SD21 and SDs 22-23. Additionally, genetic studies confirm that all flounder found in Kattegat and the Western Baltic are in fact European flounder *Platichthys flesus*, whereas the Baltic flounder *P. solemdali* only occurs further east. Thus, a stock comprising flounder from the management areas SD 21-23 would realistically reflect the flounder population around the Danish archipelago.

The working groups recommends to investigate the stock boundaries of flounder in the Western Baltic and Kattegat. Similar analyses already resulted in the inclusion of Kattegat to the Western Baltic plaice stock (ple.27.21-23) and of Kattegat and Skagerrak to the Baltic sole stock (sol.27.20-24), making a similar scenario for other flatfishes very likely.

3.1.7.1 Stock condition

Flounder in the Western Baltic are experiencing changing environmental condition. A combination of decreasing inhabitable areas, foraging grounds and food availability due to oxygen depletion in deeper basins, higher water temperatures and increasing stock biomass resulted in drastically decreasing fish condition since 2015 (Figure 3.1.8). While the condition of juvenile flounder is less drastic, adult flounder are increasingly unmarketable for the commercial fisheries due to their bad condition.

ICES advises that for European flounder in the western Baltic Sea, management should be considered within the context of a degraded ecosystem, resulting from cumulative anthropogenic pressures and climate change. Habitat restoration efforts with a focus on improving bottom oxygen content are recommended (direct effects on mortality and indirect effects on individual condition). National data submitter should be careful when extrapolating weight-at-length-data and should preferably use length-weight-coefficients of the same year to account for the decreasing condition.

Table 3.11. **fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings (tonnes) by country and subdivision.**

Year/SD	Denmark		Germ. Dem. Rep.	Germany, FRG	Sweden	
	22	**23**	**22**	**22**	**22**	**23**
1970						
1971						
1972						
1973	1983		181	349		
1974	2097		165	304		
1975	1992		163	469		
1976	2038		174	392		
1977	1974		555	393		
1978	2965		348	477		
1979	2451		189	259		
1980	2185		138	212		
1981	1964		271	351		
1982	1563	104	263	248		
1983	1714	115	280	418		
1984	1733	85	349	371		
1985	1561	130	236	199		
1986	1525	65	127	125		
1987	1208	122	71	114		
1988	1162	125	92	133		
1989	1321	83	126	122		
1990	941		52	183		
1991	925			246		
1992	713	185		227		
1993	649	194		235		26
1994	882	181		44		84
1995	859	231		286		58
1996	1041	227		189	2	58

Year/SD	Denmark	Germ. Dem. Rep.	Germany, FRG	Sweden
1997	1356		655	42
1998	1372		411	61
1999	1473		510	37
2000	1896		660	41
2001	2030		458	52
2002	1490		317	42
2003	1063		241	33
2004	952		315	31
2005	725	184	94	38
2006	620	182	34	30
2007	585	233	406	26
2008	554	199	627	47
2009	505	113	521	37
2010	557	91	376	29
2011	441	78	497	0.2 28
2012	530	98	569	22
2013	639	83	713	19
2014	513	68	589	0 23
2015	361	73	679	0 16
2016	436	63	641	15
2017	508	61	575	0 13
2018	406	59	330	0 15
2019	572	59	473	0 10
2020	377	36	350	0 12
2021	218	31	263	0 14
2022	105	17	188	0 13
2023	87	18	135	0 13

Table 3.12. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings (tonnes) by subdivision

Year	Total by SD		Total
	22	23	SD 22-23
1973	2513	0	2513
1974	2566	0	2566
1975	2624	0	2624
1976	2604	0	2604
1977	2922	0	2922
1978	3790	0	3790
1979	2899	0	2899
1980	2535	0	2535
1981	2586	0	2586
1982	2074	104	2178
1983	2412	115	2527
1984	2453	85	2538
1985	1996	130	2126
1986	1777	65	1842
1987	1393	122	1515
1988	1387	125	1512
1989	1569	83	1652
1990	1176	0	1176
1991	1171	0	1171
1992	940	185	1125
1993	884	220	1104
1994	926	265	1191
1995	1145	289	1434
1996	1232	285	1517
1997	2011	42	2053
1998	1783	61	1844
1999	1983	37	2020

Year	Total by SD		Total
	22	23	SD 22-23
2000	2556	41	2597
2001	2488	52	2540
2002	1807	42	1849
2003	1304	33	1337
2004	1267	31	1298
2005	819	222	1041
2006	654	212	866
2007	991	259	1250
2008	1181	246	1427
2009	1026	150	1176
2010	933	120	1053
2011	938	106	1044
2012	1099	120	1219
2013	1352	102	1454
2014	1103	91	1193
2015	1040	90	1130
2016	1077	78	1155
2017	1083	74	1158
2018	736	73	809
2019	1045	69	1114
2020	727	48	775
2021	480	45	526
2022	293	30	323
2023	221	31	252

Table 3.1.3 Flounder in subdivisions 22 and 23 (Belts and Sounds). Overview of SPiCT data and prior settings.

Setting/Data	Values/Source
Catch time series	Historical landings 1973-2011 InterCatch landings data 2012–2023
BITS biomass Index quarter 1, "Bergdex"	1991-2023, ≥ 20 cm
BITS biomass Index quarter 4, "Bergdex"	1991-2023, ≥ 20 cm
SPiCT settings	
- Standard deviation on the indices (observation) (sdi)	Log(sdi1)~N(log(index_CV),0.3^2) Log(sdi2)~N(log(index_CV), 0.3^2)
- Standard deviation on the indices (observation) (stdevfacI)	indexQ1_CV/mean(indexQ1_CV), indexQ4_CV /mean(indexQ4_CV)
- Standard deviation on the catch (observation) (stdevfacC)	For 2022 stdevfacC = 2;
- Biomass process noise (logsdb)	Log(0.15)-0.5*0.5^2, 0.5
- Catch observation error (logsdc)	Log(0.1)-0.5*0.5^2, 0.5
- Uncertainty ratio of index (observation) to biomass process (alpha)	Deactivated
- Uncertainty ratio of catch (observation) to fishing mortality process (beta)	Deactivated
- Shape parameter (n)	Schaefer model, Log(n)~N(log(2),0.001)
- Intrinsic growth rate (r)	Log(r)~N(log(0.56), 0.2)
- Initial depletion (bkfrac)	None (default)
- Discretion time step (dteuler)	1/16 year (default)

Figure 3.1.1. **fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings of flounder in tonnes for subdivisions SD 22–23 (Western Baltic Sea). ICES discard estimates are included from 2006 onwards.**

Figure 3.1.2. **fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings and calculated discards (in tonnes) of flounder for subdivisions SD 22–23 (Western Baltic Sea).**

Figure 3.1.3. fle.27.22-23. Sampling coverage and quality

3.1.3.a: left plot: provided official landings and discard estimates (green) of member states, including reported zeroes and non-provided strata (red).

3.1.3.b: right plot: provided biological samples per stratum (green) and non-sampled strata (red). Yellow fields indicate dismissed biological samples (either due to low sample sizes or non-updated length-weight-coefficients were used by the member state to impute missing weight data)

Figure 3.1.4. fle.27.2223. Overview of the SPiCT assessment results

Figure 3.1.5. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Relative stock development plots of the SPiCT assessment and relative reference points.

Figure 3.1.6. **fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Survey-biomass-index (BITS) from 1991, based on a GAM model approach (after Berg *et al.* 2017, ICES 2024a). Data from the assessment year (2024 Q1) are preliminary and not used in the assessment.**

Figure 3.1.7 **fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Retrospective analysis of the assessment**

Figure 3.1.8 fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Condition factor development of flounder in the Belt Sea (SD22), from Krumme *et al.* (in prep.)

3.2 Flounder in subdivisions 24 and 25

ICES SD 24 and 25 were defined as an assessment unit for flounder at a Benchmark Workshop on Baltic Flatfish Stocks (WKBALFLAT; ICES, 2014) in 2014.

Considering contrasting reproductive flounder behaviors in the Baltic Sea, i.e., offshore spawning of pelagic eggs and coastal spawning of demersal eggs, Momigliano *et al.* (2018) genetically distinguished two flounder species in the Baltic Sea. Both of them are present in the management area. According to survey data from 2014 and 2015, the share of offshore spawning European flounder *Platichthys flesus* and the coastal spawning - newly described species, the Baltic flounder *Platichthys solemdali*, was estimated to be approximately 85 and 15%, respectively (Ojaveer *et al.*, 2017). It is not possible at this stage to separate the proportion of the species in either stock assessment or fisheries.

3.2.1 The Fishery

3.2.1.1 Landings

Landings from SD 25 are substantially higher than in SD 24 (Figure 3.2.1). The majority of landings in both SD's is taken by Poland. The other fishing nations which take significant landings are Germany and Denmark (Figure 3.2.2, Table 3.2.1a).

Flounder landings in both SD's were mainly taken with active gears. Around 84% of total landings were taken by those gears in 2023 (Figure 3.2.3).

In 2023 landings amounted to 5 360 tonnes (1 369 and 3 990 tonnes for SD 24 and SD 25, respectively). Since 2014 the discard has been estimated according to the methodology suggested during WKBALFLAT (ICES, 2014). The total catch for flounder in SD 24–25 reached 5894 tonnes in 2023 (Figure 3.2.4).

Recreational fishery is known to take place, but it is difficult to quantify. However, those catches are negligible in comparison to commercial landings.

In recent years pelagic trawlers in Subdivisions 24, 25, and 26 have reported landings of flounder in the catch (over 3000 tonnes in 2020-2021 with a decline to ca 500 tonnes in 2023). These catches are suspected to be misreported sprat and herring but have so far not been included in the flounder, central Baltic herring, or Baltic sprat assessments. This year the first attempt to validate those catches has been made. The bycatch value was splitted using the proportion in species composition from pelagic trawler trips where a significant flounder bycatch occurred. However, the threshold value assumed as a reliable flounder catch used in those calculations (set to 0,5 t) was questioned. Analyses to validate these landings will be continued, and will likely result in the assignment of these catches to either sprat, herring, and flounder

3.2.1.2 Discards

During WKBALFLAT (ICES, 2014) the quality of the estimated discards was questioned and a new method for discards estimation was recommended. For strata with no discard estimates available, the discard rate was borrowed from other strata according allocation schemes considering differences in discard patterns between subdivisions, countries, gear types and quarters (Table 3.2.2). Then the discard rate was raised by demersal landings. Such discard estimations have been performed since 2014. The discard ratio in both SDs varies between countries, gear types, and quarters and in addition, discarding practices are influenced by factors such as market price, quality of the fish and cod catches. Discard sampling in 2023 has improved and discard ratio was estimated for 32% of the strata with landings (compared to 21% last year).

Before 2020, the highest discards in SDs 24 and 25 could be assigned to Sweden and Denmark. Germany and Poland had moderate discards. However, between 2020 and 2023 the discard proportion in the catches was similar in all main fishing countries and didn't exceed 15% (Table 3.2.1b; Figure 3.2.5). This was likely related to the cod fishery closure in SD 24 and 25. As a result, less flounder was discarded by countries catching flounder as a bycatch in cod fishery (e.g. by Denmark, Sweden).

Mean discard rate for 2023 for both SDs was 0,12, with discard equal to 535 tonnes.

3.2.1.3 Effort data

Effort data for the demersal fleet back to 2009 are available for all countries. As countries have not used the same approach for reporting effort data, the effort was standardized within each country and weighted by the national flounder or demersal fish (cod and flounder) landings from SD's 24–25.

Standardized effort (SE) by average effort by country (*se*) was calculated from equation:

$$se = \frac{f_c}{avg\ f_c}$$

where: f_c – effort by country c

Standardized effort by total flounder or demersal landings (SE) in year (y) by country (c) was calculated from equation:

$$\mathrm{SE} = \sum \left(L_{\mathrm{y,c}} \cdot se_{y,\mathrm{c}}\right) \div \sum L_{y,\mathrm{c}}$$

$L_{y,c}$ – landings by country and year

The effort in 2023 was one of the lowest in time series and close to the ones between 2020 and 2022 (Figure 3.2.6).

3.2.2 Biological information

The number of sampled flounder in SD 24 was slightly higher than in SD 25, even though the landings in SD 25 were much higher (Table 3.2.3). Most of the samples were analyzed by Germany in SD 24 and by Poland in SD 25.

Sampling coverage of discards differs between years and subdivisions. That was due to COVID-19 related restrictions (2020-2021) followed by high refusal rate of taking observers in 2022, which in some countries prevented observers from sampling onboard. However, in 2023 it has significantly improved. Flounder discard in SD 24 was sampled by Germany and in SD 25 by Denmark, Germany and Poland.

3.2.3 Fishery independent information

Since 2001 the Baltic International Trawl Survey (BITS) has been carried out using a new (stratified random) design and a new standard gear (TV3). BITS surveys are conducted twice a year, in the 1st and 4th quarter. BITS surveys in SD 24 are performed by Germany, Sweden, Denmark and in SD 25 by Poland, Denmark Sweden and Germany. The number of stations is higher in SD 25 compared to SD 24 (Table 3.2.4).

3.2.4 Assessment

The flounder stock in SD 24–25 belongs to category 3.2.0: Stocks for which survey-based assessments indicate trends (ICES DLS approach, ICES, 2012).

The stock trend is estimated using the Biomass Index from BITS-Q1 (G2916) and BITS-Q4 (G8863) surveys. The index is calculated by length-classes for the fish larger or equal to 20 cm total length and covers the period from 2001 onwards.

Both BITS-Q1 and BITS-Q4 surveys (Figure 3.2.7) are aggregated into one annual index value for a given year (using geometric mean between quarters). The Biomass-Index is calculated for each year. The advice used to be based on a comparison of the average from two most recent index values with the three preceding values. However, since 2019 ICES has not been requested to provide advice on fishing opportunities for this stock, only updated stock status is required.

Stock trends from Baltic International Trawl Survey (BITS) for SD 24 and 25 have been increasing until 2016, then they were showing a decrease until 2018. In recent years they have been fluctuating at the level higher than in the 2000s with an increase in 2022 and 2023 (Figure 3.2.7).

3.2.5 Reference points

The stock status was evaluated by calculating length-based indicators applying the LBI method developed by WKLIFE V (ICES, 2015). Commercial landings from InterCatch from 2014–2023 were used to estimate CANUM (Figure 3.2.8). The biological parameters L_{inf} and L_{mat} were calculated using BITS survey data from DATRAS. For estimating L_{inf}, data for both sexes and both quarters (Q1 and Q4) of 2012–2021 were used. In the case of L_{mat}, data for females were derived from 2001–2021, only from Q1, as distinguishing between mature and immature fish was possible only for this time of the year. Biological parameters mentioned above are as follows:

L_{inf} = 326 mm

L_{mat} = 190 mm

The above biological parameters are slightly different when compared to the ones from previous years (L_{inf} = 329 mm and L_{mat} = 220 mm). This was due to the changes made in the DATRAS database. Slight difference in L_{inf} was caused by errors in age records – some flounder with no age readings were assigned to age 0 instead of -9. Conversion of maturity scales from national scales to ICES M6 or SMSF in 2021 was the reason for change in L_{mat}.

The results were compared to standard length-based reference values to estimate the status of the stock (Table 3.2.5). The results of LBI (Table 3.2.6) showed a sustainable exploitation pattern, as the stock status of bzq.27.2425 was above possible reference points.

Average $L_{F=M}$ for the three most recent years (2021–2023) was equal to 26.5 cm and L_{mean} - 28.2 cm. The overall catch is close to the theoretical length of optimal yield. The mean length is stable across the time-series and is close to the MSY proxy of $L_{F=M}$ (Figure 3.2.9).

The overall perception from the length-based indicators analysis is that the stock is fished sustainably at levels close to optimum yield and with exploitation at the MSY level.

Figure 3.2.1. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Landings in thousand tonnes

Figure 3.2.2. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Landings by country in thousand tonnes (for merged SD 24–25 – upper plot and separately for SD 24 and SD 25 – lower plots)

Figure 3.2.3. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Landings by fleet type in thousand tonnes (SD 24 - reddish colors, SD 25 – bluish)

Figure 3.2.4. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Catches (ICES estimates) in subdivisions 24–25. Discard data have only been included since 2014.

Figure 3.2.5. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Discard and landing proportion in 2023 catches in main fishing countries

Figure 3.2.6. Flounder (Platichthys spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Standardized fishing effort (standardized within each country and weighted by the national flounder or demersal fish landings from SD 24–25)

Figure 3.2.7. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Survey-biomass-index (BITS) for Q1 and Q4 from 2001-2023; Q1 2024 and geometric mean (line); Stock trends from Baltic International Trawl Survey (BITS)

Figure 3.2.8. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Catch in numbers (CANUM) per length classes; black vertical lines at length 230 mm indicates minimum landing size.

Figure 3.2.9. **Flounder (Platichthys spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); LBI indicators trends**

Table 3.2.1a. Flounder (Platichthys spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Total landings (tonnes) 1973–2023 by Subdivision and country

Year	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
	SD 24	SD 25	SD24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24–25
1973			386									3144									1580			502	5612
1974			2578									2139									1635			470	6822
1975			1678									1876									1871			400	5825
1976			482									2459									1549			400	4890
1977			389									3808									2071			416	6684
1978			415									2573									996			346	4330
1979			405									2512									1230			315	4462
1980			286									2776									1613			62	4737
1981			548									2596									1151			51	4346
1982			257									3203									2484			55	5999
1983			450									3573									1828			180	6031
1984			306									2720									2471			45	5542
1985			649									3257									2063			40	6009
1986			1558									2848									3030			51	7487

Year	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
	SD 24	SD 25	SD24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24–25
1987			1007									2107									2530			43	5687
1988			990									2986									1728			58	5762
1989			1062									3618									1896			56	6632
1990			1389									1632									1617			120	4758
1991			1497									1814									2008			55	5374
1992			975									1972									1877			129	4953
1993			635									1230									3276			90	5231
1994			1016									4262									3177			38	8493
1995			2110			8						2825									7437			214	12594
1996			2306						1			1322									6069			819	10517
1997			2452			15			1			1982									3877			370	8697
1998			2393			10			2			1729			2						4215			236	8587
1999			1206			8						1825									4015			111	7165
2000	825	923	1748				14	4	18	1809	171	1979							605	3765	4370	49	123	172	8288
2001	1026	1976	3002				9	68	77	1468	299	1766							531	4962	5493	30	95	125	10464

Year	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
	SD 24	SD 25	SD24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24–25
2002	995	1877	2872				5	34	39	1910	154	2064							1288	6577	7865	30	111	141	12982
2003	750	1052	1802				2	7	8	1165	389	1553							758	5087	5845	45	106	152	9360
2004	1114	1753	2866							1307	275	1582	1	6	7				1177	5633	6810	19	86	105	11370
2005	853	1445	2298				1	2	3	881	43	924	2		2				2194	7192	9386	26	58	84	12696
2006	513	1518	2031				2	3	5	973	7	979		11	11				1782	5959	7741	23	61	84	10852
2007	620	623	1243				2	8	10	1455	215	1670	8	7	15		11	11	3016	5840	8856	27	59	86	11891
2008	422	313	736							1601	238	1840		74	74		4	4	2094	5569	7663	29	66	95	10410
2009	325	199	524				41		41	1175	29	1204		155	155		31	31	2378	5802	8180	27	65	92	10227
2010	333	368	701		16	16	13	2	16	953	31	983		31	31		19	19	1833	7665	9498	21	64	85	11348
2011	310	226	536		20	20	3	2	5	1529	147	1676		39	39		15	15	1567	6666	8233	26	60	86	10610
2012	290	250	540		19	19	20	17	36	904	151	1055		8	8		24	24	1331	7325	8657	23	67	90	10430
2013	572	1889	2460		10	10	1	9	10	771	332	1103	4	76	80		54	54	2104	8118	10222	35	344	379	14318
2014	349	1324	1673		83	83				751	212	963	3	288	291		74	74	1537	9821	11358	22	146	168	14610
2015	169	1614	1783		39	39	1	4	4	635	181	815	2	6	8		7	7	1122	7247	8370	24	40	64	11090
2016	135	84	219				2		2	630	246	876		81	81		9	9	2238	11157	13395	16	41	56	14637

Year	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
	SD 24	SD 25	SD24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24–25
2017	97	112	209				1		1	619	423	1042		2	2		2	2	2143	7383	9525	5	68	73	10855
2018	133	623	756							650	243	893		119	119		61	61	1740	9123	10863	6	90	96	12788
2019	276	350	626					44	44	650	38	687		36	36		16	16	2480	7459	10300	6	100	106	11815
2020*	559	362	921					1	1	758	162	920		90	90				2 277	4 834	7 111	6	63	69	9 112
2021	332	121	453							347	147	494		67	67				1 195	5 598	6 793	4	99	103	7 910
2022	144	247	391							283	151	434		12	12				513	5536	6048	2	30	32	6919
2023	61	187	247							246	229	475							1 060	3 558	4 619	3	16	19	5 360

Table 3.2.2. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Discard allocation scheme for 2023; green cells – reported estimated discard, grey cells – allocated discard.

24		2023			
fleet	quarter	Denmark	Germany	Poland	Sweden
Active	1	DE_A_1_24		DE_A_1_24	
	2	DE_A_1_24	DE_A_1_24	DE_A_1_24	
	3	DE_A_3_24		PL_A_4_24	
	4	DE_A_4_24			
Passive	1	DK_P_2_24	DE_P_2_24	PL_P_2_24	DK_P_2_24
	2				DE_P_2_24
	3	DE_P_3_24		PL_P_4_24	DE_P_3_24
	4	DE_P_4_24			DE_P_4_24

25		2023			
fleet	quarter	Denmark	Germany	Poland	Sweden
Active	1			DE_A_1_25	
	2			DE_A_1_25	
	3			PL_A_4_24	
	4			PL_A_4_24	
Passive	1	PL_P_1_25			PL_P_1_25
	2	PL_P_2_25			PL_P_2_25
	3	PL_P_3_25			PL_P_3_25
	4				PL_P_4_25

Table 3.2.3. Flounder (*Platichthys spp.*) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); The coverage of sampled landings and discards in 2023 in subdivisions 24 and 25.

Area: 27.3.d.24

Country	Catch category	CATON	No. of length samples in numbers	No. Measured in numbers
Denmark	Landings	61	1	53
Germany		246	15	5058
Poland		1060	6	662
Sweden		3	0	0
Denmark	Discards estimates	17	0	0
Germany		63	9	831
Poland		143	0	0
Sweden		2	0	0
	Total	1594	31	6604

Area: 27.3.d.25

Country	Catch category	CATON	No. of length samples in numbers	No. Measured in numbers
Denmark	Landings	187	4	436
Germany		229	1	645
Poland		3558	17	1828
Sweden		16	0	0
Denmark	Discards estimates	4	4	277
Germany		21	1	99
Poland		285	8	111
Sweden		0,4	0	0
	Total	4301	35	3396

Table 3.2.4. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Number of BITS-stations in SD 24 and SD 25.

	SD 24		SD 25	
	Q1	Q4	Q1	Q4
2001	66	40	96	52
2002	55	46	57	75
2003	48	46	97	61
2004	50	47	112	63
2005	43	46	113	81
2006	43	44	95	72
2007	45	41	88	81
2008	35	47	97	62
2009	45	53	104	81
2010	50	31	80	77
2011	44	50	105	77
2012	52	47	102	74
2013	54	38	102	75
2014	52	49	97	73
2015	50	38	97	73
2016	53	47	85	81
2017	55	51	102	96
2018	56	43	107	99
2019	39	50	110	87
2020	57	51	94	73
2021	49	49	78	69
2022	49	53	63	71
2023	45	68	74	93
average	49	47	94	76

Table 3.2.5. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Description of the selected LBI

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
$L_{max5\%}$	Mean length of largest 5%	L_{inf}	$L_{max5\%}$ / L_{inf}	> 0.8	Conservation (large individuals)
$L_{95\%}$	95th percentile		$L_{95\%}$ / L_{inf}		
P_{mega}	Proportion of individuals above L_{opt} + 10%	0.3–0.4	P_{mega}	> 0.3	
$L_{25\%}$	25th percentile of length distribution	L_{mat}	$L_{25\%}$ / L_{mat}	> 1	Conservation (immatures)
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c/L_{mat}	> 1	
L_{mean}	Mean length of individuals > Lc	$L_{opt} = \frac{3}{3+M/k} \times \mathbf{L_{inf}}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{maxy}	Length class with maximum biomass in catch	$L_{opt} = \frac{3}{3+M/k} \times \mathbf{L_{inf}}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals > L_c	LF=M = ($0.75L_c$+$0.25L_{inf}$)	L_{mean} / LF=M	≥ 1	MSY

Table 3.2.6. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Indicator status for the most recent three years; L_{mat} and L_{inf} calculated using females and both sexes, respectively;

L_{inf} = 32.6 cm and L_{mat} = 19.0 cm

	Conservation				Optimizing Yield	MSY
Year	L_c / L_{mat}	$L_{25\%}$ / L_{mat}	$L_{max\ 5}$ / L_{inf}	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
2021	1.29	1.34	1.05	0.92	1.29	1.06
2022	1.29	1.34	1.09	0.88	1.31	1.07
2023	1.29	1.34	1.05	0.88	1.29	1.06

3.3 Flounder in subdivisions 26–28 (Eastern Gotland and Gulf of Gdansk)

In 2014, a new assessment unit for flounder was defined as ICES SD 26 and 28 during the Baltic Flatfish Stocks Benchmark Workshop (WKBALFLAT; ICES. 2014). This flounder stock was benchmarked again in 2024, during WKSPICT3. A study conducted by Momigliano *et al.* (2018) considered the contrasting reproductive behaviours of flounder in the Baltic Sea - offshore spawning of pelagic eggs and coastal spawning of demersal eggs - and distinguished two flounder species in the region. Both of these species are present in the management area. The survey data from 2014 and 2015 indicated that the offshore spawning species, *Platichthys flesus*, accounted for around 45% of the flounder population, while the newly discovered species, *Platichthys solemdali*, which spawns along the coast, accounted for approximately 55% of the population

(Florin et al. unpublished data). At present, it is not possible to differentiate between the two species in either stock assessment or fisheries.

3.3.1 Fishery

The primary countries engaged in fishing within Subdivision 26 are Russia, Latvia, Poland, and Lithuania, while in Subdivision 28, it is mostly Latvia (as per Table 3.3.1). In previous years, the Polish fishery was primarily focused on gillnet fishing for flounder along the coast. On the other hand, Latvian, Russian, and Lithuanian landings were mainly a mix-fishery using bottom trawls.

3.3.1.1 Landings

Table 3.3.1 presents the landings by countries and subdivisions. In 2023, the total landings in Subdivisions 26 and 28 combined were 1910 tonnes, which was similar to the 2020 figures. After the targeted cod fisheries in the EU were closed, the landings decreased and stabilized around 2000 tonnes. This is 2-3 times lower than at the start of the century, as seen in Figures 3.3.1 and 3.3.2. Russia had the highest landings in 2023 at 1331 tonnes, followed by Latvia at 240 tonnes and Poland at 228 tonnes. The majority of the landings in the EU were made using passive fishing gears (319 tonnes or 55 %). Information about Russian landings was not reported to ICES, and it was obtained from public sources (fish.gov.ru).

Most of the landings (84%) were taken in Subdivision 26, with Russia having the highest landings at 83% or 1331 tonnes. On the other hand, Poland's landings were well below the long-term average at 228 tonnes. In the EU in Subdivision 26, 93% of the landings were made using passive gears.

In Subdivision 28, the total landings were approximately 313 tonnes, lower than the long-term average. The highest landings in Subdivision 28 were observed in 2015-2016, after which a gradual decrease was observed. Latvian fishermen accounted for the majority of the landings at 225 tonnes. In the EU in Subdivision 28, the majority of the landings were made using active gears (78%). In 2023, the flounder fishery in EU countries continued to be heavily affected due to cod fishing restrictions.

3.3.1.2 Unallocated removals

There is no information about unallocated removals for this stock.

3.3.1.3 Discards

In 2014, the first discard estimates were calculated in WKBALFLAT, which is a part of the InterCatch database. It was discovered that the discard raising procedure in InterCatch for by-catch species such as flounder gave underestimated and imprecise discard estimates. As a result, WK decided that discard raising should be done outside of InterCatch.

In 2023, there was no discard estimation available for flounder in subdivisions 26 and 28. Russia and Estonia forbid discarding of flounder, while other countries like Latvia and Poland had only limited samples available, which covered only passive fishing gears (Q1-4.2%, Q2-4.1%, Q3-5.5%, Q4-1.0%).

Applying those rates to countries where discarding is allowed – the total discard rate would be 1.2 %. The expert group decided that available discard information is insufficient to estimate the stock's total discard rate (Figure 3.3.3., Table 3.3.2.).

3.3.1.4 Effort and CPUE data

European Union countries provided effort data as requested in data call, but Russia did not provide any effort data for the past two years. As a result, around 70% of landings did not have effort information available. The time series from 2009-2022 were not updated, and effort calculations were not conducted in 2023.

3.3.1.5 Biological information

A total of 2,503 flounder were measured from 39 samples of landings, as shown in Table 3.3.3. However, length measurements from Russia were not reported after 2022. Only 17% of landings had length information, or 58% if EU country's landings were taken into account. Specifically, data from 2023 was available from Poland (22 samples, 1,126 flounder), Lithuania (11 samples, 1,224 flounder), Latvia (samples number NA, flounder number NA), and Estonia (6 samples, 153 flounder). For the expert group, a total of 11 length samples (156 flounder) from discard were available from Estonia and Poland. However, data from Estonia (2 samples) should be interpreted cautiously because the length measurements were reported in IC with 0 kg CANUM.

3.3.1.6 Fishery independent information

Survey indices of exploitable stock biomass (20 cm+) are calculated using the methodology similar to what is described in Berg and Kristensen (2014), that is a Delta-Lognormal model which consists of a binomial presence/absence model and a lognormal model for strictly positive responses. Once the parameters in the model are estimated, a standardized survey index is obtained by predicting and adding up the abundances in a fine meshed grid of points that is the same in all years. This can be thought of as performing a virtual experiment where the experimental conditions such as the haul positions, gear type etc. are the same in each year.

The observed exploitable stock biomass is calculated from observed numbers-at-length and a length-weight model with time-varying coefficients (because there have been some significant changes in the LW relationship over time for flounder).

The model has the following formula (in R syntax) for both the presence/absence and the positive part.

Year*Quarter + s(sqrt(Depth),k=5,bs='ds',m=c(1,0),by=Quarter) + Gear + s(Ship,bs='re') + s(lon,lat,bs='ds',m=c(1,0.5),k=80,by=Quarter) + s(lon,lat,bs='ds',m=c(1,0.5),by=YearQ,k=6,id=1) + offset(log(HaulDur))

where "YearQ" is a factor for each combination of year and quarter.

In this formulation there are independent parameters estimated for each combination of year and quarter (no smoothing across time which would violate the assumption of independent errors in SPiCT).

The different survey gears in the BITS data are accounted for by the Gear effect in the model. All BITS data (Q1 and Q4) and IBTS Q1 data from ICES subareas 21-32 are used to fit the model. This was done in order to get as much data and spatio-temporal overlap between the different gear types as possible to reliably estimate conversion factors. The robustness of the model estimates before the gear was standardized (year 2000) was checked by leaving one of the gear types out and re-estimating the model (Figure 3.3.4). The model estimates were robust (within the confidence bounds for the base run).

Preliminary analysis of flounder condition factors indicated changes over the whole time series (Figure 3.3.5.). After some increase in the beginning of 1990ies. Starting from 1995, a gradual decrease of flounder condition factors in both quarters was observed; therefore, in the index calculation, the length of the weight relationship was used annually.

Figure 3.3.6 and Table 3.3.4. presents new estimates of BITS survey indices with CV, calculated in WKBMSYSPICT3 and WGBFAS. Compared to the old index used in the advice, the last ten years have shown similar trends, while at the beginning of the time series, indices show different developments of the stock (Figure 3.3.7.)

3.3.2 Assessment

The surplus production model in continuous time (SPiCT, Pedersen and Berg 2017) is used for the assessment of the stock. The input data for the stock were 1) landings series from 1977-2023 with the first part of the time series from the historical official landings and the most recent part (2012-2023) from ICES InterCatch landings; 2) 2 survey indices from BITS surveys: one for 1st quarter from 1991-2024, one for 4th quarter from 1991-2023. The survey time series were trimmed to include only flounder equal to or larger than 20 cm to obtain a better proxy for the exploitable biomass, which is a prerequisite for a production model.

The model settings and *priors* are set in accord to the WKBSMYSPiCT3 analysis (Table 3.3.5.).

The output of the assessment model is shown in Figure 3.3.8. and Table 3.3.6. Convergence was obtained. The absolute biomass fluctuated around 20,000 tonnes last year, with some lower estimates in the previous century. Absolute fishing mortality gradually decreased and, in recent years, has been at its lowest level. An increased trend of catches was observed from the 1980s, reaching its peak around 2005. After that, a sharp decrease in catches and fishing mortality was observed, mainly due to restrictions in cod fishery, where flounder is caught as a by-catch. The phase plot shows that the development of biomass and fishing mortality has been sustainable in the second part of the time series. The production curve (fitted to Schaefer model) was considered as realistic.

3.3.3 Model diagnostics

Process residuals and one-step-ahead residuals show no violation of model assumptions (Figure 3.3.9. and 3.3.10.). All p-values are above 0.05. A hindcast analysis was carried out to check the ability of the SPiCT model to predict the index by removing a data point and keeping the catch information (Figure 3.3.11). The MASE predictor was calculated for both indices below 1 (0.613 and 0.837), which is considered good and slightly better than produced in the benchmark. To evaluate the robustness of the model fit to the introduction of new data, a retrospective analysis using 5 peels was performed (Figure 3.3.12.). Although confidence intervals are large for the absolute biomass and absolute fishing mortality, there is no consistent pattern comparing the different peels. No consistent over- or underestimation of relative fishing mortality and biomass is present, which is supported by the Mohn's rho values (-0.033 and 0.027).

3.3.3.1 Reference points

The table below summarises all known reference points for flounder in subdivisions 26 and 28 and their technical basis.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	$0.5 \times B_{MSY}$ = $0.25 \times K^*$	Relative value. B_{MSY} is estimated directly from the assessment model and changes when the assessment is updated.
	F_{MSY}	$r/2^*$	Relative value. F_{MSY} is estimated directly from the assessment model and changes when the assessment is updated.

Precautionary approach	B_{lim}	$0.3 \times B_{MSY}$*	Relative value (equilibrium yield at this biomass is 50% of MSY).
	B_{pa}	Not defined	
	F_{lim}	$1.7 \times F_{MSY}$	Relative value (the F that drives the stock to B_{lim})*
	F	Not defined	

Table 3.3.1. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Total ICES landings (tonnes) by Subdivision and country.

Country	1996			1997			1998			1999			2000		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark			0	10		10			0			0	8	0	9
Finland			0			0			0			0	0		0
Germany	10	9	19	12	4	16	2		2			0			0
Poland	2 556		2 556	1 730		1 730	1 370		1 370	1 435		1 435	721		721
Sweden	48	31	79	31	370	401	18	117	135	47		47	0	27	28
Estonia		44	44		101	101		146	146		92	92		65	65
Latvia	74	215	289	78	284	362	88	274	362	140	365	505	113	302	415
Lithuania	316		316	554		554	737		737	547		547	575		575
Russia	740		740	1 001		1 001	1 188		1 188	964		964	1 236	0	1 236
Total	**3 744**	**299**	**4 043**	**3 416**	**759**	**4 175**	**3 403**	**537**	**3 940**	**3 133**	**457**	**3 590**	**2 654**	**395**	**3 049**

Country	2001			2002			2003			2004			2005		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	1	14	15	42	0	42	1		1	1		1	0		0
Finland			0	0		0	0		0			0	0		0
Germany			0			0			0			0			0
Poland	548		548	626		626	648		648	1 955		1 955	1 743		1 743
Sweden	3	179	182	4	48	52		17	17		18	18	0	124	124
Estonia		100	100		91	91		122	122		89	89		133	133
Latvia	201	412	613	221	375	596	281	392	673	169	600	769	383	1 333	1 716
Lithuania	1 127		1 127	1 077		1 077	1 066		1 066	834		834	949		949
Russia	1 355		1 355	1 314		1 314	1 402		1 402	1 277		1 277	1 393		1 393
Total	**3 235**	**706**	**3 941**	**3 284**	**514**	**3 798**	**3 399**	**531**	**3 929**	**4 236**	**707**	**4 943**	**4 468**	**1 590**	**6 058**

Country	2006			2007			2008			2009			2010		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	4		4	2		2			0			0	0		0
Finland	0	0	0	1	0	2			0			0			0
Germany			0			0			0			0			0
Poland	1 675		1 675	1 829		1 829	1 451		1 451	1 472		1 472	1 727		1 727
Sweden	1	20	22	1	18	20	0	18	19	0	17	17	0	15	15
Estonia		83	83		92	92		91	91		77	77	0	93	93
Latvia	317	838	1 155	166	877	1 043	203	374	577	52	312	364	25	225	250
Lithuania	355		355	268		268	601	27	629	472	27	499	407	55	462
Russia	1 231		1 231	2 650		2 650	1 960		1 960	969		969	1 030		1 030
Total	**3 583**	**941**	**4 524**	**4 917**	**987**	**5 905**	**4 216**	**512**	**4 727**	**2 964**	**433**	**3 398**	**3 189**	**388**	**3 577**

Country	2011			2012			2013			2014			2015		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	1		1	0		0	22		22	0.872	0	1	0	0	0
Finland	1		1	10		10	8		8	0.459	0	0	0	0	0
Germany			0			0	0		0			0			
Poland	1 437		1 437	1 501		1 501	1 578	3	1 581	1209.7379	0	1 210	981	0	981
Sweden	1	20	20	2	13	14	21	24	45	0.271	0	0	0	17	18
Estonia	15	74	89	11	70	81	24	52	76	25.457	53.771	79	2	53	55
Latvia	114	166	280	378	244	622	780	619	1 399	298.9	1278.9	1 578	281	1 744	2 025
Lithuania	418	0	418	640	12	651	947	1	949	698.075	0	698	258	0	258
Russia	1 139		1 139	1 079		1 079	1 010		1 010	1047.097	0	1 047	1 106	0	1 106
Total	**3 127**	**260**	**3 387**	**3 620**	**339**	**3 959**	**4 391**	**698**	**5 089**	**3 281**	**1 333**	**4 614**	**2 628**	**1 815**	**4 443**

Country	2016			2017			2018			2019			2020		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	0	0	0			0	8		8	1	0	1			0
Finland			0			0			0	11	0	11			0
Germany	1	0	1			0			0	2	0	2		0	0
Poland	912	0	912	701		701	473		473	565	0	565	273		273
Sweden	3	14	16	2	10	12	4	16	20	1	18	19	1	18	19
Estonia	0	52	52		59	59		60	60	0	43	43		46	46
Latvia	161	1683	1 843	190	1386	1 576	171	1036	1 207	38	715	753	227	553	780
Lithuania	295	0	295	255		255	214		214	20	0	20	74	3	77
Russia	1133	0	1 133	1304		1 304	1493		1 493	1325	0	1325	770		770
Total	**2503**	**1748**	**4 252**	**2452**	**1455**	**3 907**	**2363**	**1112**	**3 475**	**1963**	**776**	**2740**	**1345**	**620**	**1965**

Country	2021			2022			2023		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	0			0		0			0
Finland	1	0	1			0		0	0
Germany	1		1			0	1		1
Poland	236		236	244		244	228		228
Sweden	3	8	11	2	12	14	3	8	12
Estonia		26	26		28	28		67	67
Latvia	20	348	369	31	247	278	15	225	240
Lithuania	14	8	22	18	6	24	19	12	31
Russia	1245		1 245	1131		1 131	1331		1 331
Total	**1520**	**391**	**1911**	**1426**	**293**	**1 719**	**1597**	**313**	**1 910**

Table 3.3.2. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Discards were not estimated for 2023.

Country	Landings	Discards	Catch	Discard ratio
Estonia	67	NA	NA	NA
Germany	1	NA	NA	NA
Latvia	240	NA	NA	NA
Lithuania	31	NA	NA	NA
Poland	228	NA	NA	NA
Sweden	12	NA	NA	NA
Russia*	1331	NA	NA	NA
Finland	1	NA	NA	NA
Total	1910	NA	NA	NA

***Data from https://fish.gov.ru/**

Table 3.3.3. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Number of length measurements of flounder catch in Subdivisions 26 and 28.

Catch Cat.	Country	Number of samples	Length measurements	Number of samples	Age measurements
Landing	Estonia	6	153	6	153
	Latvia	NA	NA	NA	NA
	Lithuania	11	1224	0	0
	Poland	22	1126	12	548
Landing total		39	2503	18	701
	Estonia*	2	6	2	6
	Poland	9	150	0	0
Discard total		11	156	2	6
Total		50	2659	20	707

*** Discard data from nonreported discards**

Table 3.3.4. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch per unit of effort (kg per hour) from BITS Survey in 1st and 4th Quarters. Subdivision 26 and 28.

Year	1st quarter	1st quarter CV	4th quarter	4th quarter CV
1991	36.7	0.208	140.5	0.520
1992	36.0	0.199	54.2	1.009

Year	1st quarter	1st quarter CV	4th quarter	4th quarter CV
1993	48.9	0.211	195.3	0.464
1994	46.1	0.185	173.5	0.544
1995	69.4	0.190	328.8	0.439
1996	71.5	0.185	111.4	0.569
1997	86.1	0.207	136.3	0.255
1998	56.1	0.210	81.6	0.377
1999	104.6	0.160	70.3	0.262
2000	137.6	0.183	121.7	0.229
2001	123.5	0.140	206.0	0.235
2002	126.0	0.162	252.7	0.212
2003	101.8	0.124	41.3	0.208
2004	57.5	0.148	58.8	0.227
2005	52.3	0.125	112.0	0.170
2006	60.0	0.154	62.1	0.211
2007	104.3	0.139	249.3	0.200
2008	144.8	0.147	357.8	0.186
2009	184.3	0.153	119.4	0.206
2010	162.6	0.130	260.2	0.180
2011	98.1	0.164	132.9	0.199
2012	94.6	0.183	123.4	0.207
2013	87.9	0.132	93.5	0.185
2014	48.7	0.156	57.8	0.188
2015	70.1	0.156	97.2	0.197
2016	67.8	0.128	85.2	0.164
2017	79.8	0.129	113.9	0.171
2018	53.2	0.136	60.8	0.177
2019	112.1	0.144	107.1	0.175
2020	71.1	0.149	60.4	0.171
2021	71.2	0.136	55.2	0.184

Year	1st quarter	1st quarter CV	4th quarter	4th quarter CV
2022	31.9	0.137	90.9	0.189
2023	100.9	0.154	61.0	0.164
2024	63.9	0.145		

Table 3.3.5. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Assessment settings and priors for the final SPiCT model

Setting/Data	Values/Source
Catch time series	Historical landings 1977-2011
	InterCatch landings data 2012–2023
Survey index Q1	1991-2023, ≥ 20 cm
Survey index Q4	1991-2022, ≥ 20 cm
Spict settings	
Standard deviation on the indices (sdi)	Log(sdi1)~N(log(index_CV),0.5^2)
	Log(sdi2)~N(log(index_CV), 0.5^2)
Uncertainty ratio of catch (observation) index to biomass process (alpha)	Deactivated
Uncertainty ratio of catch (observation) index to fishing mortality process (beta)	Deactivated
Shape parameter (n)	Schaefer model, Log(n)~N(log(2),0.5)
Intrinsic growth rate (r)	FishBase prior, Log(r)~N(log(0.56),0.5)
Biomass process noise (sdb)	Log(0.15)-0.5*0.5^2, 0.5
Catch observation error (sdc)	Log(0.1)-0.5*0.5^2, 0.5

Table 3.3.6. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Summary of assessment

Year	Relative exploitable biomass			Landings	Discards	Relative fishing pressure		
	Low	B/B_{MSY}	High			Low	F/F_{MSY}	High
1977	0.20	0.45	1.02	3 380		0.96	1.76	3.23

Year	Relative exploitable biomass			Landings	Discards	Relative fishing pressure		
	Low	B/B_{MSY}	High			Low	F/F_{MSY}	High
1978	0.20	0.44	1.00	3 684		1.05	1.88	3.34
1979	0.18	0.42	0.96	3 188		1.03	1.96	3.75
1980	0.15	0.36	0.87	2 452		0.85	1.74	3.58
1981	0.15	0.35	0.85	2 535		0.75	1.62	3.48
1982	0.15	0.36	0.90	2 499		0.72	1.67	3.85
1983	0.13	0.33	0.86	1 717		0.57	1.41	3.52
1984	0.13	0.33	0.83	1 648		0.46	1.15	2.85
1985	0.16	0.37	0.87	1 771		0.44	1.06	2.54
1986	0.20	0.44	0.97	2 400		0.47	1.08	2.48
1987	0.25	0.54	1.15	3 276		0.56	1.28	2.96
1988	0.25	0.54	1.16	2 326		0.48	1.19	2.92
1989	0.26	0.55	1.14	2 400		0.40	1.02	2.55
1990	0.27	0.55	1.10	1 741		0.33	0.83	2.11
1991	0.34	0.63	1.16	2 772		0.32	0.79	1.94
1992	0.45	0.80	1.44	3 165		0.37	0.92	2.28
1993	0.45	0.82	1.47	2 160		0.29	0.73	1.89
1994	0.48	0.85	1.52	2 055		0.21	0.56	1.45
1995	0.57	0.99	1.73	2 386		0.20	0.51	1.30
1996	0.73	1.25	2.14	4 043		0.24	0.59	1.48
1997	0.84	1.44	2.48	4 175		0.28	0.69	1.73
1998	0.84	1.44	2.46	3 940		0.26	0.65	1.65
1999	0.88	1.50	2.58	3 590		0.23	0.59	1.50
2000	0.89	1.53	2.62	3 049		0.19	0.49	1.26
2001	0.98	1.68	2.86	3 941		0.19	0.48	1.23
2002	1.01	1.73	2.97	3 798		0.21	0.53	1.35
2003	0.92	1.54	2.58	3 929		0.23	0.59	1.49
2004	0.77	1.27	2.09	4 943		0.32	0.78	1.94
2005	0.77	1.27	2.12	6 058		0.42	1.03	2.52

Year	Relative exploitable biomass			Landings	Discards	Relative fishing pressure		
	Low	B/B_{MSY}	High			Low	F/F_{MSY}	High
2006	0.78	1.31	2.19	4 524		0.37	0.91	2.26
2007	0.94	1.56	2.59	5 905		0.31	0.75	1.85
2008	1.20	2.05	3.52	4 727		0.25	0.62	1.56
2009	1.21	2.12	3.69	3 398		0.17	0.44	1.13
2010	1.17	2.01	3.44	3 577		0.15	0.40	1.02
2011	1.11	1.87	3.17	3 387		0.17	0.44	1.11
2012	0.97	1.61	2.69	3 959		0.21	0.52	1.31
2013	0.91	1.51	2.51	5 089		0.29	0.72	1.78
2014	0.76	1.28	2.16	4 614		0.35	0.89	2.23
2015	0.68	1.16	1.97	4 443	944	0.35	0.89	2.27
2016	0.69	1.18	2.01	4 251	191	0.34	0.86	2.20
2017	0.69	1.19	2.05	3 908	418	0.31	0.80	2.06
2018	0.68	1.17	2.03	3 478	1259	0.28	0.74	1.92
2019	0.67	1.17	2.07	2 740	650	0.23	0.62	1.63
2020	0.62	1.09	1.92	1 965	101	0.18	0.49	1.31
2021	0.57	0.99	1.72	1 911	NA	0.17	0.45	1.20
2022	0.53	0.91	1.56	1 719*	NA	0.17	0.45	1.16
2023	0.60	1.04	1.79	1 910*	NA	0.16	0.42	1.08
2024	0.64	1.09	1.86					

Russian Federation landings were not officially report to ICES.

Figure 3.3.1. **Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder in subdivisions 26 and 28.**

Figure 3.3.2. **Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder by subdivisions.**

Figure 3.3.3. **Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES catch of flounder in subdivisions 26 and 28. Discards in 2021-2022 were not estimated.**

Figure 3.3.4. **Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Leave-one-gear-out sensitivity runs.**

Figure 3.3.5. **Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Flounder in subdivisions 26 and 28. Condition factor, an example of 26 cm length group in BITS Quarter 1 and Quarter 4 series in 1990 – 2023.**

Figure 3.3.6. **Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). BITS survey indices in first and fourth quarters**

Figure 3.3.7. **Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Comparison of BITS indices calculated in WGBFAS and WKSPICT3 (and used in assessment)**

Fitting spict

Figure 3.3.8. **Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Final SPiCT model output.**

Figure 3.3.9. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Final assessment one-step-ahead residuals for observations.

Figure 3.3.10. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Final assessment model process residuals.

Figure 3.3.11. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Final assessment hindcast analysis with MASE predictor.

```
      FFmsy       BBmsy
-0.03338333  0.02703758
```

Figure 3.3.12. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Final assessment retrospective analysis.

3.4 Flounder in Subdivision 27, 29-32 (Northern flounder)

Based on the decision by Benchmark Workshop on Baltic Flatfish Stocks (WKBALFLAT; 26—28 Nov 2013; 27—31 Jan 2014) flounder with demersal eggs inhabiting mainly the Northern Baltic Proper (SD 27, 29—32) is treated as a separate flounder stock. In the rest of the Baltic Sea flounder with pelagic eggs dominate.

Flounder with demersal eggs spawn in the shallow water down to salinities of 5—7 psu. This means that, flounder in the SDs 31 and 32 are at the border of its distribution area. Eggs are demersal, small (diameter < 1 mm) and relatively heavy. There are probably local spatially distinctive populations in the different coastal areas, and the migration between these areas is limited. Flounder with demersal eggs inhabit also the Central Baltic Sea; however, it is not possible to separate the landings of the two spawning types and in SD 28 presumably pelagic spawning type dominates. Therefore, SD 28 is not included in this stock.

3.4.1 Fishery

3.4.1.1 Landings

In subdivisions 27 and 29-32 flounder is caught mainly in the SDs 29 and 32 (Figure 3.4.1). The majority (>98% in three latest years) of the catches are taken with passive gears, mostly gillnets.

Yearly total landings were above 1000 tonnes in the beginning of 1980's but have been decreasing form end of 1980's, reaching level below 150 tonnes since 2017. The landings are showing a decreasing trend and were only 82 tonnes in 2023. Estonia is the major fishing nation, standing for more than 85% of the catches followed by Sweden with a share of 6-15% and the rest is taken by Finland and in some years also Poland (Table 3.4.1). Estonia fishes in subdivision 29 and 32, and the importance of SD29 has increased in time. Finland fishes mainly in subdivision 32 and 29. Sweden main catches come from subdivision 27 but low level of catches are also maintained in SD29.

3.4.1.2 Discards

Discards probably take place, the extent depending on market price, but the amount is unknown. In the major fishing country, Estonia, discard is not allowed. Survival rate of flounder in discards is unknown for passive gears but can probably be high under certain conditions. In Sweden no discard sampling is made for this stock. Swedish discard rate is calculated using estimates from SD 25 and scaled up to total landings of demersal fish species in the fished strata (passive gear per quarter and SD). Swedish discard can be almost up to the same level as landings. Since 2020 no discard estimates from SD25 are available, there no discard numbers for Sweden could be calculated. Reported discard in Finland is low, discard rate of <5% is estimated for this stock.

3.4.1.3 Recreational fishery

In the northern Baltic Sea, the importance of recreational fishery is substantial. Recreational catches are estimated by Estonia and Finland (Table 3.4.2), however these estimates do not represent whole recreational catches for the stock and therefore not included to the total amount of catches.

The Finnish recreational flounder catches are estimated by mail survey every second year. The main gear used in Finland for recreational fishery for flounder is gill net, in some years there is also a small contribution from other hand-hauled gears (jig, hook and line, fishing rod). Finland recreational flounder catches can be two to three times larger than the commercial catches. There has been significant decrease in the catches since early 2000s, same is seen in commercial catches.

The Estonian recreational catch estimates represent the gill net, and hook and line catches. There is another part of the flounder recreational catches (caught with jig or different types of fishing rods), however the exact amount of these catches is unknow. Estonian recreational flounder catches have been rather stable, however have been decreasing for the past years, same as with commercial catches. On average, Estonian recreational catches with gill nets and hook and line are equivalent to 20-40% of the commercial catches.

In Sweden flounder is not distinguished from the rest of flatfishes, which complicates the catch estimates for recreational fishery. Although the species composition is unknown the majority of this is ought to be flounder. Rough calculations have shown that recreational fishery catches for Sweden can be three times higher as commercial landings.

3.4.1.4 Effort

The exploitation status of the stock is unknown, since effort data from the most important fishery, passive gears, was unavailable s from the dominating fishing nation Estonia. In addition, there is no data on effort for the recreational fishery which could roughly constitute up to 30% of the commercial landings. However, some improvement has been made, and starting from 2019 Estonia is able to provide the effort data on the passive gear (Table 3.4.3).

3.4.2 Biological information

Age data are considered to be applicable only when the ageing was conducted using method breaking and burning of otoliths as recommended by ICES WKARFLO (2007; 2008) and ICES WKFLABA (2010).

3.4.2.1 Catch in numbers

Age information from commercial catches is very limited. Catch in numbers-at-age (CANUM) and mean weight-at-age are available from Estonian commercial trap nets between 2011-2020 in SD29 and 32. Age data is not sampled in commercial landings in Finland, for Sweden age data exists only for the years 2009-2010.

Currently Estonian commercial age data from trap-nets is not used in the assessment, as the main catches come from gillnets, and the selectivity of these two gears differ. Since 2017, Estonia has been sampling gillnet catches from SD29 and 32, however there is no age data available currently. The length distribution of sampled gill net catches is shown in Figure 3.4.2.

3.4.2.2 Mean weights-at-age

Mean weights per age were available only for Estonia commercial trap net landings (2010-2016). The weight per age strongly fluctuates. The high fluctuation of weights per age could be the product of small sample size, especially for older ages. Mean weights per age are also available for survey in SD29 (2000-2012). The survey weight data seems to be more stable compared to commercial data (Figure 3.4.3).

3.4.3 Fishery independent data

Fishery independent data is gathered from four national gillnet surveys since the BITS survey was deemed inappropriate for this stock (not covering shallow areas, not covering Northern Baltic Sea). From Estonia two surveys were available, one in Muuga bay near Tallinn (mesh size 40—60 mm bar length) in SD 32 ongoing since since 1993, and one in Küdema bay in SD 29 since 2000 (mesh size 21.5, 30, 38, 50 and 60 mm bar length). In Muuga the survey is done weekly from May to October while in Küdema six fixed stations are fished during six nights in October/November in depths 14—20 m. Data was restricted to October for the Muuga survey index.

From Sweden two surveys were available using the same gear as in Küdema and the same time of year September/October in two areas in the southern and the northern part of SD 27, Kvädöfjärden (data from 1989) and Muskö (data from 1992) respectively. In Kvädöfjärden six fixed stations are fished during six nights at 15—20 m depth while in Muskö eight fixed stations are fished during six nights at 16—18 m depth. In 2018 Sweden modified their survey protocol and are fishing only during one night instead of six (ref). It was shown that the change of fishing one night instead of six nights does not have a statistically significant effect on the survey's CPUE.

Cpue in biomass (kg per fishing station and fishing day) was used as biomass index for all four surveys. The arithmetic mean of the two surveys in SD 27 was combined with the biomass indices in 29 and 32. The stock size indicator could be calculated from year 2000 and onwards. For this the indices from these SD-s were combined using the total commercial landings of flounder per SD as a weighting factor (Table 3.4.4).

3.4.4 Assessment

Assessment method of category 3 for stocks for which survey-based assessments indicate trends (ICES DLS approach, ICES, 2012) was used. Since 2019 ICES has been requested to provide advice on stock status but has not been requested to provide advice on fishing opportunities for this stock.

Stock trends are calculated based on national gillnet surveys: two surveys in SD 27, one survey in SD 29 and one survey in SD 32 (Figure 3.4.4). Extremely high cpue value for Küdema bay in 2015 is probably not representative, although consistent increase in all survey biomasses (except Muuga bay) is evident for years before 2015. The stock size indicator value seems to show slight increasing trend from 2012 onwards but has been decreasing 2018 onwards.

3.4.5 MSY proxy reference points

In 2017 MSY proxy reference points were calculated for this stock using two different methods, length-based indicators, and length-based spawning potential ratio (LB-SPR; Hordyk *et al*., 2015). After external review it was decided that most appropriate approach for providing MSY proxy reference points is using the length-based indicators.

Data

3.4.5.1 Length-frequency data

Up to 2021 the LBI analysis was done using the Küdema survey data, as no representative commercial gillnet length data was available. Since 2017 Estonia has been collecting samples from the commercial gillnetters. Since 2022 the length-based indicators have been re-calculated using the commercial gillnet length-frequency data (Figure 3.4.2).

3.4.5.2 Life-history information

When the MSY reference points were first calculated in 2017, the asymptotic size (L_∞) for Baltic flounder was calculated using the commercial age data from the trapnet fishery.

In 2022 the length-based indicators were re-calculated using the commercial gillnet data. The ICES Technical Guidelines (ICES, 2018) suggest L_∞ should generally be higher than L_{max}, as when L_∞ is being underestimated, the resulting LBIs may give the impression that a stock is in a better state than it actually is. Comparing the LFD from commercial gillnets and also from Küdema survey, it was seen that previously estimated that L_∞ (27.45 cm) was below L_{max}. This itself can't be considered unusual as the previously calculated L_∞ is the average asymptotic size and hence it is expected that there are also fish above that length. However, this is problematic for the length-based methods which assume that there is no growth variability. Therefore, in 2022 the L_∞ for Baltic flounder was revised.

Von Bertalanffy growth curve was constructed using Küdema survey data from 2000-2011 and including only female fish as this species exhibits dimorphic growth. The analysis was conducted in R (R Core Team, 2021) using the package "*FSA*" (Ogle et al., 2021) to find reasonable starting values for the parameters in specific parameterisation of the von Bertalanffy growth function, and the data was fitted using the non-linear least square function ("nlstools" package (Baty et al., 2015)). The estimated von Bertalanffy growth parameters are in Table 3.4.5 and the fit is shown in Figure 3.4.5.

Biological parameters needed for the length-based indicators calculations are shown in Table 3.4.6. L_c is length class where 50% of individuals are vulnerable to, and retained by, the gear. L_c is determined as the length at half of the maximum frequency in the ascending part of the curve.

The mean length of catch indicator (L_{mean}) is calculated as the mean length of catch of fish ≥ L_c. The corresponding reference point $L_{F=M}$ is calculated using formula:

$$L_{F=\gamma M;K=\theta M} = \frac{\theta L_\infty + L_c(\gamma + 1)}{\theta + \gamma + 1}$$

where γ=1 and θ=0.745 (corresponding to M/k=1.34).

L_{opt} is calculated:

$$L_{opt} = L_\infty \left(\frac{3}{3 + {}^{M}/_{K}} \right)$$

3.4.5.3 Results

Based on the L_{mean} indicator Baltic flounder stock has been overfished with the exception of 2023 year (Table 3.4.7). Based on the L_{opt} indicator fish seem to be harvested at or close to optimal size, and immature fish are not targeted in the fishery ($L_c \geq L_{mat}$; Table 3.4.7).

Table 3.4.1. Baltic flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Total landings (tonnes) by country.

Year	Denmark	Estonia*	Finland	Poland	Sweden	USSR	Total
1980			53		52	1414	1519
1981			78		55	1523	1656
1982			50		68	1736	1854
1983			38		221	1611	1870
1984			43		55	1512	1610
1985			37		49	1071	1157
1986			52		63	837	952
1987	1		58		53	676	788
1988			69		71	588	728
1989			69		69	428	566
1990			58			285	343
1991		186	75		88		349
1992		93	63		89		245
1993		141	83		83		307
1994	9	7	79		43		138
1995	1	87	89		81		258
1996		244	92		114		450
1997		221	80		105		406
1998		166	71		70		307
1999	1	314	76		15		406
2000	1	292	56		73		422
2001	10	355	50		88		503
2002		392	35		95		523
2003	1	284	31		57		373
2004		294	34		45		374
2005		258	23		49		331
2006		294	17		33		344
2007		214	9		40		263

Year	Denmark	Estonia*	Finland	Poland	Sweden	USSR	Total
2008		189	11		49		249
2009		210	10		41		262
2010		180	10		36		227
2011		177	9		35		220
2012		147	5	3**	36		191
2013		198	5	0	31		234
2014		150	4	0	29		183
2015		145	4	0	26		176
2016		148	3		22		173
2017		128	4		18		150
2018		109	4		14		127
2019		106	3		12		121
2020		130	4		15		149
2021		108	1		15		124
2022		80	2		11		93
2023		74	3		5		82

*** Data Corrected for Estonia 2000-2004, 2007-2012 with figures from Estonian Ministry of Environment, older data includes recreational fishery**

**** Poland 2012 corrected**

Zero values equal to landings under 0.5 tonnes

Table 3.4.2. Baltic flounder SD27, 29-32 (Northern Baltic Sea). Recreational gillnet fishery catch estimates for Estonia and Finland, in tonnes.

	Finland				Estonia	
	SD32	SD29	SD30	SD31	SD32	SD29
2000	156	187	30	1		
2002	14	78	63	0		
2004	12	64	3	0		
2006	25	48	2	0		
2008	6	27	7	0		
2010	1	9	0	1		

	Finland				Estonia	
2012	13	24	1	0	16.6	15.0
2013	13	24	1	0	19.6	16.9
2014	1	9	1	0	16.6	15.0
2015	1	9	1	0	28.0	15.7
2016	6	5	0	0	20.0	15.0
2017	6	5	0	0	13.1	12.9
2018	1	4	0	0	14.8	13.7
2019	1	4	0	0	13.2	11.2
2020	1	7	4	0	9.0	8.3
2021	1	7	4	0	6.3	5.5
2022	1	6	0	0	7.9	6.5
2023*	1	6	0	0	7.2	5.4

* Estimated by mail survey every second year; assumed same as in 2022.

Table 3.4.3. Baltic flounder SD27, 29-32 (Northern Baltic Sea). Fishing effort (days at sea) per country and gear type (passive/active).

	SWE Active	SWE Passive	EE Active	EE Passive	FI Passive
2009	4	3029	46		9030.8
2010	11	2265	22		10067.6
2011	6	2250	3		8290.0
2012	4	2119	14		6120.0
2013	8	2037	77		5510.4
2014	3	2004	56		4466.7
2015	16	2177	50		2814.0
2016	19	1985	72		3028.0
2017	6	1394	59		2826.0
2018	20	1232	5		2234.0
2019	25	1106	2	18741	2696.0
2020	19	683	2	19412	1641.0
2021	59	729	1	22392	865.0
2022	78	456	1	16684	1138

2023	7	376	7	11955	853

Table 3.4.4. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Biomass index for the surveys (kg per number of gillnet stations times number of fishing days) Muuga Bay (SD 32), Küdema Bay (SD 29), Muskö (SD 27), and Kvädöfjärden (SD 27) and combined index.

SD	32	29	27			Combined[3)]
Survey	Muuga-Q4	Kudema-Q4	Kvädöfjärden-Q4[1)]	Muskö-Q4[1)]	Combined for SD27[2)]	
	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	kg gear-night-1)
1989			1.21			
1990			1.79			
1991			0.57			
1992			1.97	5.20	3.58	
1993	0.49		1.99	4.84	3.42	
1994	0.20		1.29	1.26	1.28	
1995	0.43		1.18	0.97	1.07	
1996	0.40		0.60	0.18	0.39	
1997	0.47		0.74	0.64	0.69	
1998	0.73		1.24	0.71	0.97	
1999	0.28		0.90	0.20	0.55	
2000	0.25	3.45	1.51	1.12	1.32	2.01
2001	0.65	2.32	1.42	1.17	1.29	1.34
2002	0.172	1.01	1.46	0.60	1.03	0.63
2003	0.30	2.89	0.54	1.14	0.84	1.60
2004	0.47	1.37	0.51	0.89	0.70	0.86
2005	0.39	1.70	0.20	0.55	0.37	1.03
2006	0.42	1.57	0.32	1.09	0.70	1.04
2007	0.096	2.24	0.60	2.61	1.60	1.27
2008	0.108	2.68	1.33	4.67	3.00	1.80
2009	0.36	0.86	0.20	2.19	1.19	0.71
2010	0.136	0.79	0.45	1.04	0.75	0.50

SD	32	29	27			Combined[3)]
Survey	Muuga-Q4	Kudema-Q4	Kvädöfjärden-Q4[1)]	Muskö-Q4[1)]	Combined for SD27[2)]	
	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	kg gear-night-1)
2011	0.24	0.97	0.163	0.50	0.33	0.59
2012	0.126	1.03	0.136	0.48	0.31	0.56
2013	0.128	2.03	0.32	0.95	0.63	1.22
2014	0.090	2.35	0.43	0.98	0.70	1.26
2015	0.070	8.70	0.53	1.32	0.92	4.36
2016	0.111	1.90	0.43	0.76	0.60	1.18
2017	0.164	2.72	0.57	0.50	0.54	1.88
2018	0.151	1.57	0.088	0.08	0.083	1.04
2019	0.071	1.60	0.075	0.147	0.111	1.07
2020	0.032	1.11	0.26	0.30	0.28	0.76
2021	0.046	0.54	0.22	0.149	0.183	0.43
2022	0.085	0.23	0.26	0.31	0.28	0.19
2023	0.28	0.33	0.28	0.04	0.16	0.30

[1)] **Biomass prior to 2009 is estimated from numbers and length distribution**

[2)] **Arithmetic mean**

[3)] **Weighted mean with the respective SDs landings.**

Table 3.4.5. Baltic flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Estimated mean von Bertalanffy growth parameters. Values inside square brackets are the 95% confidence intervals (CI).

PARAMETER	ESTIMATE
L_∞	31.88 [30.84; 33.14]
K	0.22 [0.19; 0.26]
t_0	-1.55 [-2.03; -1.16]

Table 3.4.6 Baltic flounder SD27, 29-32 (Northern Baltic Sea). Input parameters for the length-based indicators analysis (LBI).

Data type	Source	Years/Value	Notes
Length frequency distribution	Commerical gillnet catch	2017-present	

Linf	Küdema survey (2000-2011)	31.88 cm	females only
K		0.22 year^{-1}	
Lmat	2011 survey in Hiiumaa (Q2)	16.8 cm	females only
Lmat95		20.89 cm	
M/K		1.34	

Table 3.4.7. Baltic flounder SD27, 29-32 (Northern Baltic Sea). Length-based indicators analysis results.

	Conservation	Optimaizing Yield	MSY		
Year	Lc/Lmat	Lmean/Lopt	Lmean/Lf=m	Lmean	Lf=m
Ref	>1	~1(>0.9)	≥1	cm	cm
2017	1.28	1.09	0.99	24.06	24.32
2018	1.28	1.09	0.99	24.06	24.32
2019	1.28	1.09	0.99	24.01	24.32
2020	1.28	1.11	0.98	24.40	24.32
2021	1.34	1.04	0.92	23.00	25.05
2022	1.22	1.06	0.99	23.41	23.59
2023	1.22	1.08	1.01	23.76	23.59

Figure 3.4.1. Baltic flounder SD27, 29-32 (Northern Baltic Sea). Landings (tonnes) in subdivisions (SDs) 27 and 29-32 from 1980-2023.

Figure 3.4.2. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Length frequency distribution of sampled commercial gillnets (2017-2023).

Figure 3.4.3. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Mean weights per age for Estonian commercial trap net landings (2011-2016) per Subdivision (Q3+4) and for survey in SD29 (2000-2012).

Figure 3.4.4. Baltic flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Biomass indices of Muuga Bay (SD 32) (solid green line), Küdema Bay (SD 29) (dashed green line), Muskö (SD 27) (red dash line), Kvädöfjärden (SD 27) (dotted blue line) surveys and combined index (kg per gillnet station and fishing days).

Figure 3.4.5. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Von Bertalanffy growth curve fit (upper) and corresponding parameter estimate distributions (lower).

4 Herring in the Baltic sea

Introduction

4.1.1 Pelagic Stocks in the Baltic: Herring and Sprat

The distribution by subdivision of reported landings of herring and sprat in 2023 is given in Table 4.1.1.

In Table 4.1.2 the proportion of herring in landings is given by country, subdivision and quarter for 2023 together with the proportion of herring in the acoustic survey in the fourth quarter. It is tacitly assumed that the acoustic survey would yield a reasonably good picture of the spatial distribution of the pelagic stocks. Consequently, some resemblance to the distribution of landings of the two species could be expected.

Table 4.1.3 shows the total reported landings of herring by quarter for 2023, along with the number of samples, the number of fishes measured and the number of fishes aged.

4.1.1.1 Mixed pelagic fishery and its impact on herring

Pelagic stocks in the Baltic Proper (subdivisions 25–29, 32) are mainly taken in pelagic trawl fisheries, of which the majority take herring and sprat simultaneously. According to the national data submitters, the mixing of pelagic species in the landings is variably taken care of before submitting input data.

Potential needs for corrections of national catch data of Baltic sprat and central Baltic herring were analysed by the 8 member states of the RCG ISSG Small Pelagic Fisheries Baltic. The effects of central Baltic herring and sprat misreporting on the assessment of both stocks were analysed in the framework of the WKBALTPEL and showed a greater sensitivity of spawning stock biomass estimates than of fishing mortality estimates to misreporting.

4.1.2 Fisheries Management

4.1.2.1 Management units

Sprat is managed in the Baltic Sea by two quotas: one EC and one Russian quota.

Herring has in former time been managed by three TAC's:

- SD 22–29S and 32 (excl. Gulf of Riga),
- Gulf of Riga (SD 28.1),
- SD 29N, 30, 31.

The units were changed in 2005 to be:

- SD 22–24,
- SD 25–27, 28.2, 29 and 32 (EC and Russian quotas),
- Gulf of Riga (SD 28.1),
- SD 30, 31.

The historical development of agreed TACs and reported landings for these management units are illustrated in Figure 4.1.1.

4.1.2.2 Management 2023 and 2024 herring – sprat

The stock status, recommendations from ICES and the TAC decided are presented for the pelagic stocks. The stock status is expressed in relation to the MSY and precautionary reference levels.

Stock	Stock status ACOM 2023		ICES Advice for 2024 (Basis)	TAC 2024
	in relation to SSB_{2023} MSY & PA & MP	in relation to F_{2023} MSY & PA & MP	(t)	(t)
SPRAT				
SD 22-32	Above trigger & Full reproductivity& Above	Above & Harvested sustainably & Within range	191075 – 247704 (MAP applied)	*245200
HERRING				
SD 25–29&32 (excl. GOR)	Below trigger & Increased risk & Below	Below & Harvested sustainably & Within range	41706 – 52549 (MAP applied)	*67368
SD 28.1 (Gulf of Riga)	Above trigger & Full reproductivity & Above	Below & Harvested sustainably& Within the ranges	27696 – 41370 (MAP applied)	37959
SD 30–31 (Bothnian Sea)	Below trigger & Increased risk & Below	Below & Harvested sustainably& Within the ranges	48824 – 63049 (MAP applied)	55000

***EC + Russian quotas**

4.1.3 Catch options by management unit for herring

The herring assessed in SD 25–29 (excluding 28.1) and 32 is also caught in the Gulf of Riga; likewise, the Gulf herring assessed in the Gulf of Riga is caught in SD 28 outside the Gulf. These allocations may be based on proportions of landed amounts in the areas.

Proportion of the Western Baltic Spring Spawning Herring (WBSSH) stock (her.27.20-24) caught in SD 22–24.

Year	WBSSH** caught in SD 22–24 (1000 tonnes)*	Total catches of the WBSSH stock (1000 tonnes)*	% of WBSSH caught in SD 22–24
2000	54.0	118.0	45.76%
2001	64.0	112.0	57.14%
2002	53.0	107.0	49.53%
2003	40.0	78.0	51.28%
2004	42.0	77.0	54.55%
2005	44.0	89.0	49.44%

Year	WBSSH** caught in SD 22–24 (1000 tonnes)*	Total catches of the WBSSH stock (1000 tonnes)*	% of WBSSH caught in SD 22–24
2006	42.0	89.0	47.19%
2007	40.0	69.0	57.97%
2008	44.0	69.0	63.77%
2009	31.0	67.0	46.27%
2010	18.0	43.0	41.86%
2011	16.0	28.3	56.54%
2012	21.0	38.0	55.26%
2013	26.0	43.5	59.77%
2014	18.0	37.0	48.65%
2015	22.0	37.0	59.46%
2016	25.0	51.0	49.02%
2017	26.5	46.3	57.21%
2018	19.0	41.1	46.26%
2019	9.8	25.4	38.67%
2020	4.0	22.1	17.92%
2021	1.6	14.2	11.29%
2022	0.6	6.3	10.21%
2023	0.7	3.3	21.63%
Mean	27.6	54.6	45.7%

***Finnish data not included.**
**** In SD 22–26 the herring stocks are known to be mixed, but the degree of this mixing is not yet quantified.**

Proportion of Central Baltic herring (CBH) stock (her.27.25-2932) caught in the Gulf of Riga (SD 28.1).

Year	CBH caught in Gulf of Riga (SD 28.1) (1000 tonnes)	Total catches of the CBH stock (SD 25–27, 28.2,29 &32) (1000 tonnes)	% of CBH caught in Gulfof Riga (SD 28.1)
2000	4.6	173.7	2.6%
2001	2.9	138.8	2.1%
2002	3.5	128.3	2.7%
2003	4.3	112.4	3.8%
2004	3.3	95.2	3.5%

Year	CBH caught in Gulf of Riga (SD 28.1) (1000 tonnes)	Total catches of the CBH stock (SD 25–27, 28.2,29 &32) (1000 tonnes)	% of CBH caught in Gulfof Riga (SD 28.1)
2005	2.3	91.1	2.5%
2006	3.2	113.4	2.8%
2007	1.5	115.8	1.3%
2008	6.1	126.4	4.8%
2009	4.9	135.6	3.6%
2010	5.2	137.2	3.8%
2011	5.5	118.6	4.6%
2012	3.8	101.5	3.7%
2013	4.1	100.5	4.1%
2014	4.5	134.5	3.4%
2015	5.0	174.9	2.8%
2016	4.3	190.6	2.3%
2017	3.9	199.4	2.0%
2018	4.2	240.7	1.7%
2019	3.6	201.0	1.8%
2020	1.3	174.5	0.7%
2021	3.1	129.0	2.4%
2022	2.6	83.8	3.1%
2023	5.7	98.7	5.8%
Mean	3.9	138.2	3.0%

Proportion of the Gulf of Riga herring (GORH) stock (her.27.28) caught outside the Gulf of Riga in SD 28.2 (only Latvian catches).

Year	GORH caught outside Gulf of Riga in SD 28.2 (1000 tonnes)	Total stock GORH catches (1000 tonnes)	% GORH caught outside Gulf of Riga in SD 28.2
2000	1.9	34.1	5.6%
2001	1.2	38.8	3.0%
2002	0.4	39.7	1.0%
2003	0.4	40.8	0.9%
2004	0.2	39.1	0.5%

Year	GORH caught outside Gulf of Riga in SD 28.2 (1000 tonnes)	Total stock GORH catches (1000 tonnes)	% GORH caught outside Gulf of Riga in SD 28.2
2005	0.5	32.2	1.6%
2006	0.4	31.2	1.3%
2007	0.1	33.7	0.4%
2008	0.1	31.1	0.5%
2009	0.1	32.6	0.3%
2010	0.4	30.2	1.4%
2011	0.1	29.6	0.3%
2012	0.2	28.1	0.6%
2013	0.3	26.5	1.0%
2014	0.2	26.3	0.6%
2015	0.3	32.9	1.0%
2016	0.3	30.9	0.9%
2017	0.2	28.1	0.8%
2018	0.5	25.7	2.1%
2019	1.2	28.9	4.1%
2020	1.2	33.2	3.7%
2021	0.8	35.8	2.2%
2022	0.8	41.1	1.9%
2023	0.3	42.8	0.8%
Mean	0.5	33.1	1.5%

The two tables above are used for the calculation of the fishing quotas in the Central Baltic Sea (SD 25–27, 28.2, 29 and 32) and in the Gulf of Riga (SD 28.1).

4.1.4 Assessment units for herring stocks

The herring in the Central Baltic Sea is assessed as two units:

- Herring in SD 25–27, 28.2, 29 and 32
- Gulf of Riga herring (SD 28.1)

The herring in the Gulf of Bothnia are assessed as one stock. It includes two subdivisions:

- Herring in SD 30
- Herring in SD 31

The herring in SW Baltic (SD 22–24) is assessed together with the spring spawners in Kattegat and Skagerrak (Division 3.a) within the ICES Herring Assessment Working Group for the Area South of 62° N (HAWG).

Table 4.1.1 Pelagic landings ('000 t) and species composition (%) in 2023 by subdivision and quarter.

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
SD 25	Landings ('000 t)	24.91	16.75	5.01	8.25	**54.92**
	Herring (%)	16.83	17.38	86.00	71.66	**31.55**
	Sprat (%)	83.17	82.62	14.00	28.34	**68.45**
SD 26	Landings ('000 t)	84.93	31.66	5.09	16.42	**138.10**
	Herring (%)	15.13	16.04	65.66	29.48	**18.91**
	Sprat (%)	84.87	83.96	34.34	70.52	**81.09**
SD 27	Landings ('000 t)	16.11	2.57	0.00	0.18	**18.86**
	Herring (%)	31.22	31.65	45.65	98.02	**31.91**
	Sprat (%)	68.78	68.35	54.35	1.98	**68.09**
SD 28*	Landings ('000 t)	27.49	8.96	5.18	24.01	**65.64**
	Herring (%)	11.68	7.97	23.20	15.67	**13.55**
	Sprat (%)	88.32	92.03	76.80	84.33	**86.45**
SD 29	Landings ('000 t)	19.59	1.03	0.32	11.39	**32.32**
	Herring (%)	31.09	96.99	24.47	23.17	**30.34**
	Sprat (%)	68.91	3.01	75.53	76.83	**69.66**
SD 30	Landings ('000 t)	28.77	26.63	1.88	10.85	**68.13**
	Herring (%)	96.92	97.61	99.46	94.79	**96.92**
	Sprat (%)	3.08	2.39	0.54	5.21	**3.08**
SD 31	Landings ('000 t)	0.00	0.37	0.15	0.22	**0.74**
	Herring (%)	0.00	100.00	100.00	100.00	**100.00**
	Sprat (%)	0.00	0.00	0.00	0.00	**0.00**
SD 32	Landings ('000 t)	10.94	4.43	4.77	14.08	**34.22**
	Herring (%)	41.19	60.09	26.60	37.76	**40.19**
	Sprat (%)	58.81	39.91	73.40	62.24	**59.81**
Total	Landings ('000 t)	**212.73**	**92.40**	**22.39**	**85.40**	**412.92**
	Herring (%)	**29.97**	**42.79**	**54.55**	**38.82**	**36.00**
	Sprat (%)	**70.03**	**57.21**	**45.45**	**61.18**	**64.00**

*** Gulf of Riga included**

Table 4.1.2 Proportion of herring in landings 2023.

COUNTRY	QUARTER	SUBDIVISION							
		25	26	27	28*	29	30	31	32
DEN	1	0.22	0.09	0.37	0.00	0.19			
	2	0.03							
	3								
	4				0.00				
EST*	1				0.00	0.29			0.30
	2				0.04	1.00			0.52
	3				1.00	1.00			0.17
	4				0.00	0.17			0.19
FIN	1					0.70	0.96		0.45
	2					0.97	0.98	1.00	0.84
	3				0.00	0.24	1.00	1.00	0.39
	4				0.00	0.37	0.94	1.00	0.36
GER	1	0.05	0.02		0.00	0.03			
	2	0.04		0.05	0.00				
	3								
	4	0.00			0.00	0.15			
LAT*	1		0.03		0.00				
	2		0.03		0.00				
	3		1.00		0.00				
	4		1.00		0.00				
LIT	1		0.05		0.03	0.11			0.16
	2		0.04		0.18				
	3		0.14		0.39	0.25			0.10
	4		0.98		0.20	0.13			0.32
POL	1	0.12	0.14		0.25				
	2	0.15	0.11		0.63				
	3	0.82	0.50		0.88				
	4	0.69	0.31		0.18				
RUS	1		0.25						0.95
	2		0.20						0.84
	3		0.85						
	4		0.28						0.89
SWE	1	0.25	0.17	0.30	0.22	0.11	0.99		
	2	0.43		0.33	0.39	1.00	0.97	1.00	
	3	0.97		0.46	0.82	1.00	0.98	1.00	
	4	0.84	0.95	0.98	0.32	1.00	1.00	1.00	
Total	1	0.17	0.15	0.31	0.10	0.36	0.97		0.51
	2	0.17	0.16	0.32	0.08	0.98	0.98	1.00	0.70
	3	0.86	0.66	0.46	0.11	0.27	0.99	1.00	0.31
	4	0.72	0.29	0.98	0.08	0.28	0.95	1.00	0.44
Acoust. Stock**	4	0.62	0.75	0.67	0.52**	0.86	0.96		0.43

* Gulf of Riga included

** Gulf of Riga excluded

Table 4.1.3. Herring in subdivisions 25–32. Samples of commercial catches by quarter and subdivision for 2023 available to the Working Group.

	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 25	1	4 191	32	1 381	865
	2	2 912	24	2 994	1 136
	3	4 308	7	830	339
	4	5 915	19	2 956	1 253
	Total	17 326	82	8 161	3 593
	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 26	1	12 847	34	2 739	1 228
	2	5 078	9	1 761	687
	3	3 343	13	3 073	693
	4	4 840	17	6 834	1 216
	Total	26 108	73	14 407	3 824
	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 27	1	5 029	11	600	600
	2	814	10	507	505
	3	1	0	0	0
	4	173	4	200	200
	Total	6 017	25	1 307	1 305
	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 28*	1	21 890	43	4 650	3 319
	2	17 857	54	6 213	5 191
	3	6 528	14	2 683	1 356
	4	14 305	30	3 462	2 123
	Total	60 580	141	17 008	11 989
	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 29	1	6 091	11	2 919	245
	2	999	8	1 861	94
	3	77	3	34	0
	4	2 638	25	3 097	671
	Total	9 805	47	7 911	1 010
	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 30	1	27 881	10	3 096	429
	2	25 995	31	9 537	688
	3	1 870	7	2 463	391
	4	10 287	17	5 991	276
	Total	66 032	65	21 087	1 784
Subdivisi	Quarter	Landings	Number of	Number of	Number of

		in tons	samples	fish meas.	fish aged
	1	0	0	0	0
	2	367	10	3192	325
	3	147	7	1433	84
	4	222	7	1258	56
	Total	737	24	5 883	465
Subdivision 32	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
	1	4 508	2	678	40
	2	2 662	5	1 634	80
	3	1 268	4	907	74
	4	5 315	2	678	40
	Total	13 752	13	3 897	234
25-32 Subdivisions	**Quarter**	**Landings in tons**	**Number of samples**	**Number of fish meas.**	**Number of fish aged**
	1	**82 437**	**143**	**16 063**	**6 726**
	2	**56 684**	**151**	**27 699**	**8 706**
	3	**17 542**	**55**	**11 423**	**2 937**
	4	**43 694**	**121**	**24 476**	**5 835**
	Total	**200 357**	**470**	**79 661**	**24 204**

* Gulf of Riga included

Figure 4.1.1. Reported landings of herring and sprat and agreed TACs in the Baltic Sea. (since 2007 TACs for herring and sprat: EC quota + Russian TAC).

4.2 Herring in subdivisions 25-27, 28.2, 29 and 32

4.2.1 The Fishery

4.2.1.1 Landings

Three sources of information on the catch statistics have been combined in the assessment of the Central Baltic Herring. For the period 1903-1949 ICES historical landings (version: 28-10-2014), for the period 1950-1973 historical nominal catches (version 26-06-2019), and for the period 1974-onwards data that has been updated annually by ICES WGBFAS and revised during the last benchmark process (ICES 2023d) have been used in the stock assessment.

The total reported catches by country (detailed data available from 1977), including the fraction of the Central Baltic Herring, caught in the Gulf of Riga (SD 28.1, see Section 4.1.3), are given in Table 4.2.1. No information on Russian Federation catches for 2022 and 2023 was officially reported to ICES. In 2023, the Russian Federation catch in 2022 included in the assessment was estimated based on information available at the AtlantNIRO website (http://www.vniro.ru/). In 2024, the Russian Federation catch for 2022 was corrected due to a new source of data where the information about total catch was available (<http://fish.gov.ru> accessed 10th April 2024). No additional estimates were needed unlike in 2023. This same source was used to obtain the Russian Federation catches in 2023. Catches in 2023 amounted to 98 696 t, which is 18 % higher than last year. Catches increased for most of the countries: Denmark (153%), Estonia (46%), Finland (33%), Germany (130%), Latvia (36%) and Poland (12%). The largest part of the catches in 2023 was taken by Russia (catch equals 25% of the total CBH catch), followed by Poland (20%) and Sweden (17%).

Catches by country and subdivision are presented in tables 4.2.2–4.2.3 (incl. Central Baltic Herring caught in SD 28.1, see Section 4.1.3). In 2023 the spatial distribution of catches was as follows: 26% in SD 26, 20% in SD 32, 18% in SD 28.2, 18% in SD 25, 12% in SD 29, and 6% in SD27.

4.2.1.2 Discards

Only Finland reported logbook registered discards of 0.03 t (less than 0.01% of total catch) in 2023. No discards have been reported before 2016. Discarding at sea is regarded to be negligible.

4.2.1.3 Unallocated removals

The species misreporting of herring and sprat in the Baltic has been discussed for many years (ICES 2022). The RCG ISSG consequently made an attempt to provide the last benchmark of the stock with a corrected time series of catch data for which species misreporting had been corrected (ICES, 2023a). It was concluded that the issue of misreporting could not be addressed adequately by all the countries in time for the benchmark and that the issue needs to be postponed. The working document in the last benchmark report (ICES, 2023a) outlines the approach taken by countries so far to analyse if there are errors in the time series of catch data due to inadequate reporting of species and/or other reasons and if the countries foresee that alternative time series of catch should be provided. Denmark and Sweden provided alternative time series of catches, of which the time series of catches from Denmark was included in the benchmark assessment.

4.2.1.4 Effort and CPUE data

Data on commercial effort and CPUE were not used in the assessment.

4.2.2 Biological information

4.2.2.1 Catch in numbers

Data on the catch in numbers is available from 1974. In 2024 most countries provided the age composition of their major catches (caught in their waters by quarter and subdivision). However, no information on Russian Federation catches for 2022 and 2023 was officially reported to ICES. Russian Federation catch amount for 2022 and 2023 included in the assessment was based on information available at http://fish.gov.ru (accessed 10th April 2024); but no information on the age composition of these catches was available to ICES. In total, the catches for which age composition was missing represented about 32% of the total catches in 2023 (the Russian catches constitute 25% of the total catches in this year).

The compilation of 2023 national data was done by subdivision and quarter, but not by fishery (Table 4.2.4). The non-sampled catches were assumed to have the same age composition as those sampled in the same subdivision and quarter.

Herring of age groups 1–5 made up 85% in 2022 and 83% in 2023 of the catches in numbers respectively (Figure 4.2.1). The strong year class of 2019 is 4 years old in 2023 and is still contributing to the fishery with 29% of the catches in numbers. The internal consistency of the catch-at-age in numbers was checked by plotting catch-at-age against the catch of the same cohort at age 1 year younger (Figure 4.2.2). The results (R^2) are similar to the last year. Table 4.2.3 gives catch in numbers per country, catch numbers-at-age and mean weight-at-age by subdivision in 2023, whereas Table 4.2.4 shows catch numbers-at-age and mean weight-at-age by subdivision and by quarter in 2023. Table 4.2.4 shows catch in numbers at age per year from 1974 to 2023.

4.2.2.2 Mean weights-at-age

The mean weights-at-age were compiled by subdivision and quarter for 2023 (Table 4.2.4) and then combined to give the mean weight-at-age for the whole catch. Weight-at-age data are only available from 1974 and onwards, and was for 1903-1973 assumed the same as 1973. The marked

decrease in mean weights at age that started in the early 1980s ceased around the mid-1990s and remains at this low level. When a particularly strong year class occurs, like 2002, 2007, and 2014, or 2019, there may be density-dependent effects (Figure 4.2.3). The increased sprat stock size has most likely also contributed to the low herring weight-at-age during the past 25 years. A considerable increase in the mean weight at age in catch was observed in 2022 when compared to 2021. The mean weight at age 1 increased by 84%, while the mean weight at age in the older fish increased by 5-25%. Mean weight at age in 2023 only slightly increased compared to 2022, due to an increased weight at age for 2, 4, 6 and 7 year olds, by 32, 7, 14 and 6% respectively.

The marked geographical differences in growth patterns are shown in Table 4.2.4. The mean weight is higher in subdivisions 25 and 26 than in the more northern subdivisions. As a consequence, the observed variation in average weight (total catches in tonnes/total numbers) could be not only due to a real decrease in growth but also where the larger proportion of herring is caught. As in the years before, the mean weight in the catch was also used as the mean weight in the stock. Weight-at-age in the catch and in the stock generally shows a high correlation for herring (ICES, 2023a).

4.2.2.3 Maturity at age

According to evidence of a spatial-temporal trend in the maturation of herring stock, new analyses on maturity ogive were conducted on the proportion of mature data from 1984 to 2021 using a generalized linear mixed model (ICES, 2023a). Based on observations, and in line with previous analyses (ICES, 2013a), maturity ogive was produced based only on the spring spawning part of the stock. Maturity ogives to be used in the stock assessment were produced as predictions by area and year from the best model. Since the current stock assessment configuration did not allow results to be used by area, predictions were averaged over the total area using spatial distribution by BIAS survey to obtain the final matrix of the percentage of mature by age and by year (Table 4.2.8). Maturity data are only available from 1984 and onwards, and was for 1974-1983 assumed the same as 1984. As maturity data were not available by country and area for 2022 and 2023, maturity in 2022 was assumed to be the average of maturity in 2019-2021 and in 2023 equal to 2022.

4.2.2.4 Natural mortality

The natural mortality (M) used varied between years and ages as an effect of cod predation and the life history of the species. Specifically, length-at-age data from 1984 to 2021 has been used to derive VB parameters (Linf , k and t0) to be used as input parameters to derive the proxy of M1 to be used in SMS (ICES, 2023a). Since length-at-age data reveals a decreasing trend all along the time series, the VB equation parameters per year were used as input value in the Barefoot Ecologist's Toolbox to produce a time-varying natural mortality vector. A significant breakpoint in the natural mortality time series was detected in 2000 so the mean value calculated before and after the breakpoint (M before 2000: 0.28, M after 2000: 0.38) have been used to re-scale the assumed annual M1 in the SMS model (scenarios for "likely" M1 presented in working documents of ICES, 2023a).

The key run uses the SMS model (Lewy and Vinther, 2004) which is a stock assessment model including biological interactions estimated from a parameterised size-dependent food selection function. The model is formulated and fitted to observations of total catches, survey cpue and stomach contents for the Eastern Baltic Sea (ICES Sub-divisions 25-32, excluding the Gulf of Riga). Parameters are estimated by maximum likelihood and the variance/covariance matrix is obtained from the Hessian matrix.

In the present SMS analysis, cod is a predator, and herring and sprat are preys. The population dynamics of cod were estimated outside the model by ICES WGBFAS, whereas key runs before 2019 estimated cod stock size and cod cannibalism within the SMS. The SMS model starts in 1974.

Substantial changes of input data were part of the 2019 key run, but the 2022 key run (including data from 1974-2021) is mainly an addition of stock assessment data of the last three years and a small correction of the food ration calculation. The 2022 estimated predation mortalities (M2) are largely consistent with the M2 values from the previous key run in 2019. As described in the benchmark report (ICES 2023a) three plausible scenarios of M at age, one for each of the three models included in the ensemble. These were for model 1: M1_010 (average annual M1 = 0.1, Quarterly M1(1974-1999)=0.08/4 and M1(2000-2021)=0.12/4), model 2: M1_020_average annual M1 = 0.2, Quarterly M1(1974-1999)=0.17/4 and M1(2000-2021)=0.23/4 and lim_10 (10% quantile of the parameter a and b for cod food consumptions (ICES 2023a). M for 2022 and 2023 were assumed equal to M in 2021 and will be updated when results from a new key run are available. Fig 4.2.5 and Table 4.2.7.show M at age 1974-2022 for the different models and the average runs and the average M for each of the models. M at age before 1974 was assumed to be equal to M at age in 1974 for each of the three models in the ensemble.

4.2.2.5 Quality of catch and biological information

The level and frequency of herring sampling in subdivisions 25–29 and 32 (excl. GoR) in the Baltic for 2023 is given in Table 4.2.2. In 2023, sampling was most frequent in SD 28.2. The number of samples in 2023 was comparable to 2022, except SDs 26 and 32 for which Russian data were lacking causing a significant decrease in the number of samples.

Mixing of different herring stocks and stock components occurs in the Baltic Sea. The central Baltic herring is known to be dominated by a northern and a southern component. A recent workshop (ICES, 2018) showed how the latter shares numerous characteristics with the adjacent western Baltic herring stock. Its growth and otolith shape are more similar to those of herring of western origin than to fish from the northern component. Based on only growth, a high proportion of fast-growing herring is found in SD25 and especially in the western most rectangles but it remains unclear if those fish are part of the southern component of the central Baltic or if they are the results of extensive mixing with the western Baltic herring. Analyses suggest a progressive genetic differentiation along the entire southern Baltic coasts from SD24 to SD26 rather than a clear-cut division between different assessment units. Thus, separating the Central Baltic herring stock from the western Baltic spring spawning herring stock is problematic. The stock discrimination between the Central Baltic herring and the Gulf of Riga herring is less problematic as these two stocks are more clearly distinguishable based on the body and otolith morphometrics and other biological features.

4.2.3 Fishery independent information

The stock abundance estimates from the Baltic International Acoustic October Survey (BIAS) were available to tune the stock assessment model (years 2000, 2006, 2007, 2009-2022, ages 1–8+). The tuning index covers the area of SD 25–27, 28.2,29, and 32. The BIAS index for ages 1–8+ is given in Table 4.2.9. The consistency of the survey data at age was checked by plotting survey numbers at each given age against the numbers of the same year class at age + 1 (Figure 4.2.4).

4.2.4 Assessment

4.2.4.1 Stock synthesis model

The stock assessment was benchmarked in February 2023 (ICES, 2023a). At the benchmark, it was decided that an age-based Stock Synthesis (SS3) statistical framework (ICES, 2023a, and references therein) should replace the XSA model. The new SS3 model is used to assess the status of the stock and form a basis for advice. Based on the importance of considering both structural

and parameter uncertainty, an ensemble approach was selected as the best solution by the benchmark. This is because an ensemble can theoretically represent all plausible "states of nature" of the stock under analysis, based on selected main sources of uncertainty, which in this case was identified in natural mortality (M). The final model grid for the ensemble included three alternative values for M as shown in Fig 4.2.5 and Table 4.2.7.

The model input starts with catch data from year 1903 and age-composition data from 1974 (Fig. 4.2.6), and the initial population age structure was assumed to be in an exploited state, so that the initial catches was assumed to be the average of last three years (1903–1905) in the time-series. Fishing mortality was modelled using hybrid F method (Methot & Wetzel, 2013). Option 5 was selected for the F report basis; this option represents a recent addition to SS3 and corresponds to the fishing mortality requested by the ICES framework (i.e. simple unweighted average of the F of the age classes chosen to represent the F_{bar} (age 3–6)). Further details on model settings can be found in the benchmark report and stock annex (ICES, 2023d and ICES, 2023e).

In preparation of the update assessment, some updates were made to the 2022 Russian catch data (section 4.2.1.1). The difference in the results of Run 1 in the ensemble from last year's assessment (old Russian data) and from Run 1 including the updated data was negligible (Fig. 4.2.7).

4.2.4.2 Model diagnostics and fit

Residual patterns, the fit of the model to the index and the catches as well as several diagnostics tests were run for all three models in the ensemble, The model diagnostics used were convergency (which includes checking of parameters at the bounds, final gradient and inversion of the Hessian matrix for uncertainty estimation), runs test and RMSE, retrospective analysis, and hindcasting cross-validation (ICES 2023a). The diagnostic scores from each of the test for each of the models is subsequently used to assign weights to the models (Maunder *et al.*, 2020). This weighting factor is then used as a scaling factor for the number of simulations used by the delta-Multivariate log-Normal estimator (delta-MVLN; Walter and Winker 2019; Winker *et al.* 2019) to stitching together the joint posterior distributions of the target-derived quantities (e.g. SSB/SSBtarget and F/Ftarget) from the three plausible models. In other words, the final outputs from the ensemble model are based on the weighted-median value of the three runs.

The model diagnostics of the three runs for this update assessment compared to the diagnostics from the benchmark did not indicate any issues with the model fit. The fits of the models to the survey abundances (Fig. 4.2.8) and to the catch and survey age compositions (Fig. 4.2.9) are acceptable. Pearson residuals for the three models are presented in Fig. 4.2.10 and do not reveal any unacceptable patterns. A summary of the results from the Runs test, the retrospective tests and the MASE for each of the models are provided in Table 4.2.10 and Figs. 4.2.11 - 4.2.14. The abundances and age frequency distributions passed the ordinary Runs test for all three models (Fig. 4.2.11). The RMSE runs test indicated that the fit of the survey index was good for all three models as no residuals were larger than 1 and the root-mean square error (RMSE) was less than 30% (Fig. 4.2.12), indicating a random pattern of the survey's residuals and the age frequency distributions (Winker *et al.*, 2019). The retrospectives improved since the assessment last year (Fig. 4.2.13). The estimated Hurtado-Ferro *et al.* (2014) Mohn's rho indices were outside the bounds for SSB (0.22) for model 1 using 5-year peels. Forecast Mohn's rho SSB values were now inside the bounds for all three models (0.09, 0.10 and 0.05 for model 1, 2 and 3, respectively). Forecast Mohn's rho F values did also improve since last year's assessment and were now inside the bounds for all models (-0.07, -0.08 and - 0.04 for model 1, 2 and 3, respectively), indicating a improved predictive power of these models since last year. Prediction skill was also evaluated using the mean absolute scaled error (MASE) score, which builds on the principle of evaluating the prediction skill of a model relative to a naïve baseline prediction (Carvalho *et al.*, 2021). A MASE score > 1 indicates that the average model is worse than a random walk, whereas a score of e.g. 0.5 indicates that the forecasts were twice as accurate as the naïve prediction. The mean

age predictions of the commercial data and the predictions of the survey index scored better relative to the naïve model, while the survey mean ages scored worse than the naïve model and did not pass the test (Fig. 4.2.14).

4.2.4.3 Historical stock trend

The resulting stock trajectories for the three models used in the ensemble are shown Fig. 4.2.15 and the weighted-median value of the three runs in Fig. 4.2.16. The final weighting factor used to stich the three models together in the ensemble procedure is shown in Table 4.2.10.

The main trends from the ensemble are:

- State of the adult biomass (SBB): Total spawning biomass of Central Baltic herring has declined from the beginning of the 1960s to a minimum in the beginning 2000s, thereafter it has slightly recovered but it declined again to below Blim for the years 2020 to 2023. SSB is estimated to be above Blim in 2024. SSB has been below Bmsy trigger since 1985.

- State of exploitation (F): Fishing mortality is defined as the average F of age classes 3 to 6. F increased in the beginning of 1960s to reach a peak in year 2018. F then decreased to be below Fmsy in a few years, increased again to 2018, then to decrease to below Fmsy in 2022 (F/Fmsy = 0.91). F/Fmsy in 2023 was 0.85.

- State of the juveniles (Recr): Large year classes were observed in the 1980s. With the exception of the 2014 and 2022-year classes, recruitment has been relatively low in the last decade. The historical decrease in SSB is believed to be partly caused by a shift in the fishing area from SD 25 and 26 to SD 28.2 and 29 where the average mean weight is lower. Holmgren *et al.* 2012 showed that with the current growth rate and continuous low cod abundance, the herring stock will not reach an equilibrium state until 2030. During the last years, the relative proportion of catches from SD 25 and SD 26 have varied, and since the mean weight-at-age also varies, being higher in SD 25 than in SD 26, the estimation of SSB will consequently be affected.

A major cause for decreasing trends in stock development is the drastic decrease in mean weight (size) at-age during the period of assessment (Figure 4.2.3). One of the reasons is that slow-growing herring, emanating from the north-eastern parts of the Baltic, has been dominating the catches over the recent years. These fish are also caught - outside the spawning time - in other parts of the Baltic, thereby decreasing the overall mean weights. However, mean weight decreased in all the areas of the Baltic Sea, likely indicating a real change in growth rate. Simultaneously, a decrease in body condition for herring was also observed, which was attributed to a decreased salinity (Möllmann *et al.*, 2003; Rönkkönen *et al.*, 2004; Casini *et al.*, 2010) and increased competition with large sprat stock (Cardinale and Arrhenius, 2000; Casini *et al.*, 2006; Casini *et al.*, 2010), both factors decreasing the availability of the main prey of herring, the copepod *Pseudocalanus* spp.

Recruitment-at-age 0 was high at the beginning of the 1980s, but being on a low level for some years afterwards (Figure 4.2.16). Since the mid-1980s recruitment has been variable, without a clear trend. The year class 2014 is, however, is one of the largest year classes in the time series. The strong year class 2014 has been followed by 8 years of below average recruitment, with the exception of the 2022 year class that is 8% larger than the long term average recruitment. This year class was underestimated in last year's assessment (then estimated from the Beverton and Holt stock recruitment function with autocorrelation and is thus close to the long-term average recruitment). With information on this year class from the survey and the fishery this recruitment was upscaled by 55% (Figure 4.2.17). Also SSB was upscaled this assessment by 7.6 and 28.6% for 2022 and 2023 respectively due to an upscaled 2022 year class and increased mean weight at age for 2023 (which was assumed as a 3 year average last year, Figure 4.2.18). It should be noted that the recruitment in 2023 and 2024 are uncertain (derived from the the Beverton and Holt

stock recruitment function) and this uncertainty will be propagated into the forecasted catch in 2025 and SSB in 2026.

4.2.5 Short-term forecast and management options

The short-term projections were performed following the procedures set out by the benchmark (ICES, 2023), with SS3 using the delta-multivariate log-normal (delta-MVLN) estimator (Walter and Winker, 2019; Winker *et al.*, 2019) to provide stochastic forecasts with probabilities. Recruitment in the forecast period was derived from the Beverton and Holt Stock-recruitment function with autocorrelation. For maturity, natural mortality and weight-at-age an average of the last three years was used. Selectivity is constant. The TAC constraint of 69 425 tonnes (EU share (40 368 tonnes) + Russian quota (27 000 tonnes taken from *http://atlant.vniro.ru*) + central Baltic herring stock caught in Gulf of Riga (2 959 tonnes [mean 2018–2022]) − Gulf of Riga herring stock caught in central Baltic Sea (902 tonnes [mean 2018–2022]) was used as catch in the in the intermediate year 2024 since the total TAC in 2023 was fully exploited (101 %). As the short-term forecasts show that SSB is below Btrigger, Fupper is removed from the F ranges in the multiannual plan, and FMSY and Flower is reduced by adding the multiplier SSB2025/Btrigger (FMSY = FMSY * SSB2025/Btrigger). This results in herring catches in the central Baltic in 2025 between 110 539 tonnes and 143 603 tonnes (Table 4.2.11). The resulting catches at the adjusted FMSY in 2025 (143 603 tonnes) is an increase by 173 % relative to the catches at MSY in 2023.

The increased catch advice is due to the combination of the increase in SBB and decrease in F and upscaling of SSB and recruitment (Figure 4.2.17, Table 4.2.12). As mentioned above, the recruitment in 2023 and 2024 are uncertain and this uncertainty will be propagated into the forecasted catch in 2025 and SSB in 2026, i.e. as 1 and 2 year old herring (Figure 4.2.19).

4.2.6 Reference points

At WKBBALTPEL B_{lim} was defined as 15% of B_0 (unexploited SSB at current conditions). The rest of the reference points were agreed during WGBFAS 2023 based on Management Strategy Evaluation runs.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	$B_{30\%}$	Relative value. Set at 30% of B_0*. Determined through management strategy evaluation with the objective to achieve high sustainable yields without exceeding a 5% probability of SSB falling below B_{lim} in any single year.	ICES (2023a)
	F_{MSY}	$F_{B30\%}$	Relative value. Set as the F which will achieve 30% of B_0. Determined through management strategy evaluation with the objective to achieve high sustainable yields without exceeding a 5% probability of SSB falling below B_{lim} in any single year.	ICES (2023a)
Precautionary approach	B_{lim}	0.15 x B_0	Relative value. Set at 15% of B_0.	ICES (2023a)
	B_{pa}=MSY $B_{trigger}$	$B_{30\%}$	Relative value. Set at 30% of B_0.Determined through management strategy evaluation with the objective to achieve high sustainable yields without exceeding a 5% probability of SSB falling below B_{lim} in any single year.	ICES (2023a)

	F_{pa}	$F_{B25\%}$**	F_{P05}. Relative value. Determined through management strategy evaluation. The F that leads to SSB ≥ B_{lim} with 95% probability.	ICES (2023a)
Management plan	MAP MSY $B_{trigger}$	$B_{30\%}$	MSY $B_{trigger}$	ICES (2023a)
	MAP B_{lim}	0.15 x B_0	B_{lim}	ICES (2023a)
	MAP F_{MSY}	$F_{B30\%}$	F_{MSY}	ICES (2023a)
	MAP target range F_{lower}	$F_{B40\%}$	Relative value. Determined through management strategy evaluation, consistent with the ranges which result in no more than a 5% reduction in long-term yield compared to MSY.	ICES (2023a)
	MAP target range F_{upper}	$F_{B25\%}$**	Relative value. Determined through management strategy evaluation, consistent with the ranges which result in no more than a 5% reduction in long-term yield compared to MSY. Capped to F_{P05}.	ICES (2023a)

*** B_0 is the estimated unexploited spawning biomass at current conditions (average of the last 10 years in biology)**

**** Determined from the management strategy evaluation, to be precautionary this reference point can only be used with the MSY $B_{trigger}$**

4.2.7 Quality of assessment

The assessment was benchmarked in 2023 (ICES 2023a).

No information on Russian catches for 2022 and 2023 was officially reported to ICES. Russian catch amounts for 2022 and 2023 included in the assessment were based on approximate information available in http://fish.gov.ru/ (10 April 2024); but no biological information on the composition of these catches was available to ICES.

The natural mortality was provided from multi-species models for the years 1974–2021 (ICES 2023a), M for 2022 and 2023 were set equal to 2021.

Catches of central Baltic spring-spawning herring taken in the Gulf of Riga are included in the assessment.

The Central Baltic herring stock consists of several different spawning components (Ojaveer 1981), which have been shown to be genetically distinct (Han et. al 2020, Laikre and Johannesson 2023). Differences in genetics and migration routes between spawning components, and spatial differences in growth and maturity (Popiel 1958, Ojaveer 1989, ICES 2023a), make the Central Baltic herring stock complex vulnerable to loss in genetic diversity and overall productivity. To this aim, a spatial model, which integrates the different components into a single framework, should be developed in the near future.

Likewise, important to investigate further is the mixing of Central Baltic herring (CBH) and Western Baltic spring spawning herring (WBSSH) in SDs 24–26 (see also section 4.2.2.5). Depending on the degree of mixing it could have significant impacts on our perception of both herring stocks.

ICES has been stating for several years that the pelagic fisheries take a mixture of herring and sprat and this causes uncertainties in catch levels. The extent to which species misreporting has occurred and is occurring is however not well known. Analysis of a questionnaire answered by all Baltic countries in 2012 revealed that misreporting is mainly an issue of the industrial trawl fishery targeting sprat-herring mix in nearshore waters (ICES CM 2013/ACOM:43: WD 5

Krumme, Gröhsler, see also section 4.2.2.5). Countries with major proportions of sprat catches used for industrial purposes are Sweden, Poland and Denmark. Countries with major proportions of herring catches used for industrial purposes are Finland and Sweden. An attempt was made as part of the latest benchmark (ICES 2023a) to estimate the extent of the misreporting and provide alternative catch scenarios for sensitivity testing. Although some information about the potential problem of misreporting was provided by each of the countries, no alternative time series of catch data was provided for simulation testing on impacts on the development of the stock. Significant misreporting can potentially be a large problem with regard to our perception of these stocks.

The recruitment in 2023 and 2024 are uncertain (estimated by the stock recruitment function) and this uncertainty will be propagated into the forecasted catch in 2025 and SSB in 2026, i.e. as 1 and 2 year old herring (Figure 4.2.19). The BIAS survey shows a weak recruitment of herring (0 year olds) (ICES 2023a). This estimate is however uncertain and Figure 4.2.8b presenting the retrospective patterns in estimation of recruitment deviations from the survey shows that two years of observing a cohort is necessary to estimate it with low uncertainty. The plot show no bias, but that the cohort cannot be estimated without large uncertainty until after 2 years of data. It was decided at the benchmark that the trial run including 0 year olds from the survey should be excluded from the ensemble due to the poor model diagnostics (ICES 2023d).

4.2.8 Management considerations

The stock was benchmarked in 2023, which resulted in a new assessment model with updated maturity and natural mortality estimates. In order to account for uncertainty in natural mortality it was agreed that an ensemble of three models would be used to estimate stock status and forecast. The use of an ensemble model and forecast is considered to result in a significant improvement in the quality of the assessment and advice. The perception of the status of the stock is similar to the previous assessment. The fishing mortality and biomass reference points were updated at the benchmark.

SSB has been below Bmsy trigger since 1985, was below Blim between 2020 and 2023, but is in 2024 estimated to be above Blim.

Fishing mortality ($F_{3–6}$) has been above F_{MSY} since 2015 but is in 2023 below F_{MSY}. It can be noted that several year classes above the long-term mean have contributed to the stock since 2007 (2007, 2008, 2011, 2012 and 2014), but there has been no real strong recruitment since 2014, resulting in a low number of older ages. The 2022 year class was stronger than estimated last year and therefore up scaled, but it is only 8% large than the average of the time series.

The Central Baltic herring stock consists of several different spawning components (Ojaveer 1981), which have been shown to be genetically distinct (Han et. al 2020, Laikre and Johannesson 2023. Differences in genetics and migration routes between spawning components, and spatial differences in growth and maturity (Popiel 1958, Ojaveer 1989, ICES 2023a), make the Central Baltic herring stock complex vulnerable to loss in genetic diversity and overall productivity. Thus, the advice should account for the productivity of the various stock components. To this aim, a spatial model, which integrates the different components into a single framework, should be developed in the near future.

The fluctuations of the eastern cod stock and sprat stock (see also WKREFBAS 2008/ICES CM 2008/ACOM:28) should be considered in herring management. Currently, the cod stock is concentrated in SD 25 and 26 and shows bad growth conditions probably due to lack of food. This may be related to the low abundance of herring in this area (WGBIFS 2016). New M values from WGSAM in 2022 (ICES 2023a) up to 2021 have been used in this assessment. M in 2022 and 2023

were assumed to be the same as 2021, so in this way the predation by the cod stock is taken into account in the assessment.

Table 4.2.1. Herring in SD 25–29, 32 (excl. GoR). Catches by country (1000 t) (incl. central Baltic herring caught in GoR, see Section 4.1.3).

Year	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia*	Sweden	Total
1977	11.9		33.7				57.2	112.8	48.7	264.3
1978	13.9		38.3	0.1			61.3	113.9	55.4	282.9
1979	19.4		40.4				70.4	101.0	71.3	302.5
1980	10.6		44.0				58.3	103.0	72.5	288.4
1981	14.1		42.5	1.0			51.2	93.4	72.9	275.1
1982	15.3		47.5	1.3			63.0	86.4	83.8	297.3
1983	10.5		59.1	1.0			67.1	69.1	78.6	285.4
1984	6.5		54.1				65.8	89.8	56.9	273.1
1985	7.6		54.2				72.8	95.2	42.5	272.3
1986	3.9		49.4				67.8	98.8	29.7	249.6
1987	11.0		50.4				55.5	100.9	25.4	243.2
1988	17.6		58.1				57.2	106.0	33.4	272.3
1989	7.9		50.0				51.8	105.0	55.4	270.1
1990	3.6		26.9				52.3	101.3	44.2	228.3
1991	6.7	27.0	18.1		20.7	6.5	47.1	31.9	36.5	194.6
1992	8.6	22.3	30.0		12.5	4.6	39.2	29.5	43.0	189.7
1993	11.9	25.4	32.3		9.6	3.0	41.1	21.6	66.4	211.3
1994	11.1	26.3	38.2	3.7	9.8	4.9	46.1	16.7	61.6	218.4
1995	10.7	30.7	31.4	0.0	9.3	3.6	38.7	17.0	47.2	188.6
1996	10.7	35.9	31.5	0.0	11.6	4.2	30.7	14.6	25.9	165.2
1997	8.5	42.6	23.7	0.0	10.1	3.3	26.2	12.5	44.1	171.1
1998	12.2	34.0	24.8	0.0	10.0	2.4	19.3	10.5	71.0	184.2
1999	6.0	35.4	17.9	0.0	8.3	1.3	18.1	12.7	48.9	148.5
2000	14.4	30.1	23.3	0.0	6.7	1.1	23.1	14.8	60.2	173.7
2001	4.5	27.4	26.1	0.0	5.2	1.6	28.4	15.8	29.8	138.8
2002	3.7	21.0	25.7	0.3	3.9	1.5	28.5	14.2	29.4	128.3

Year	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia*	Sweden	Total
2003	3.9	13.3	14.7	3.9	3.1	2.1	26.3	13.4	31.8	112.4
2004	2.3	10.9	14.5	4.3	2.7	1.8	22.8	6.5	29.3	95.2
2005	2.6	10.8	6.4	3.7	2.0	0.7	18.5	7.0	39.4	91.1
2006	3.3	13.4	9.6	3.2	3.0	1.2	16.8	7.6	55.3	113.4
2007	1.1	14.0	13.9	1.7	3.2	3.5	19.8	8.8	49.9	115.8
2008	1.5	21.6	19.1	3.4	3.5	1.7	13.3	8.6	53.7	126.4
2009	3.0	19.9	23.3	1.3	4.1	3.6	18.4	11.8	50.2	135.6
2010	5.9	17.9	21.6	2.2	3.9	1.5	25.0	9.1	50.0	137.2
2011	3.6	14.9	19.2	2.7	3.4	2.0	28.0	8.5	36.2	118.6
2012	2.0	11.4	18.0	0.9	2.6	1.8	25.5	13.0	26.2	101.5
2013	2.9	12.6	18.2	1.4	3.5	1.7	20.6	10.0	29.5	100.5
2014	4.5	15.3	27.9	1.7	4.9	2.1	27.3	15.9	34.9	134.5
2015	0.8	18.8	31.6	2.9	5.7	4.7	39.0	20.9	50.6	174.9
2016	2.6	20.1	28.9	4.3	8.4	5.2	41.0	24.2	56.0	190.6
2017	6.3	23.3	40.7	3.6	7.9	4.0	40.1	22.3	51.2	199.4
2018	7.7	24.3	45.4	4.0	11.2	6.6	49.3	25.4	66.9	240.7
2019	5.4	21.5	37.0	1.8	7.6	6.1	40.3	25.8	55.6	201.0
2020	6.7	17.1	31.9	0.8	5.2	5.6	35.9	26.0	45.3	174.5
2021	6.6	12.5	19.8	0.6	3.8	4.3	26.7	23.7	30.8	129.0
2022	2.1	7.7	10.3	0.3	4.2	1.8	17.8	25.3**	14.6	83.8
2023	5.2	11.2	13.7	0.6	5.7	1.5	19.9	24.5**	16.4	98.7

*** In 1977–1990 sum of catches for Estonia, Latvia, Lithuania and Russia**

**** Russian Federation landings were not officially reported to ICES**

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2023 available to the Working Group.
1/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 25	Denmark	1	1 409	13	282	282
		2	0	0	0	0
		3				
		4				
		Total	1 409	13	282	282
	Germany	1				
		2				
		3	142	0	0	0
		4	46	0	0	0
		Total	188	0	0	0
	Germany	1	56	0	0	0
		2	8	0	0	0
		3				
		4				
		Total	65	0	0	0
	Poland	1	1 353	10	756	240
		2	2 154	11	2 392	538
		3	2 793	4	680	190
		4	4 495	13	2 656	953
		Total	10 795	38	6 484	1 921
	Sweden	1	1 374	9	343	343
		2	749	13	602	598
		3	1 373	3	150	149
		4	1 374	6	300	300
		Total	4 869	31	1 395	1 390
	Total	1	4 191	32	1 381	865
		2	2 912	24	2 994	1 136
		3	4 308	7	830	339
		4	5 915	19	2 956	1 253
		Total	17 326	82	8 161	3 593

(cont').

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2023 available to the Working Group.
2/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 26	Denmark	1	1 007	1	1	1
		2				
		3				
		4				
		Total	1 007	1	1	1
	Finland	1				
		2				
		3	32	0	0	0
		4				
		Total	32	0	0	0
	Germany	1	119	0	0	0
		2				
		3				
		4				
		Total	119	0	0	0
	Latvia	1	26	0	0	0
		2	11	1	199	86
		3	0	0	0	0
		4	0	1	189	76
		Total	37	2	388	162
	Lithuania	1	106	6	1 323	662
		2	80	6	1 471	578
		3	1	2	590	189
		4	2	3	1 177	367
		Total	189	17	4 561	1 796
	Poland	1	3 802	21	1 354	504
		2	1 045	3	290	109
		3	1 419	11	2 483	504
		4	1 995	14	5 657	849
		Total	8 261	49	9 784	1 966
	Russia	1	5 060	0	0	0
		2	3 953	0	0	0
		3	1 891	0	0	0
		4	2 825	0	0	0
		Total	13 729	0	0	0
	Sweden	1	2 754	6	61	61
		2				
		3				
		4	17	0	0	0
		Total	2 771	6	61	61
	Total	1	12 873	34	2 739	1 228
		2	5 089	10	1 960	773
		3	3 343	13	3 073	693
		4	4 840	18	7 023	1 292
		Total	26 145	75	14 795	3 986

(cont').

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2023 available to the Working Group.
3/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Subdivision 27	Denmark	1	1 322	1	14	14
		2				
		3				
		4				
		Total	1 322	1	14	14
	Germany	1				
		2	5	0	0	0
		3				
		4				
		Total	5	0	0	0
	Sweden	1	3 707	10	586	586
		2	809	10	507	505
		3	1	0	0	0
		4	173	4	200	200
		Total	4 690	24	1 293	1 291
	Total	1	5 029	11	600	600
		2	814	10	507	505
		3	1	0	0	0
		4	173	4	200	200
		Total	6 017	25	1 307	1 305

(cont').

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2023 available to the Working Group.
4/6

Subdivision 28.2 (includes landings of Central Baltic Herring from Gulf of Riga)

Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Denmark	1	457	0	0	0
	2				
	3				
	4	308	2	9	9
	Total	766	2	9	9
Estonia	1	367	8	409	409
	2	2 705	4	491	491
	3	30	2	193	193
	4	210	4	91	91
	Total	3 313	18	1 184	1 184
Finland	1				
	2				
	3	711	0	0	0
	4	1 460	0	0	0
	Total	2 171	0	0	0
Germany	1	108	0	0	0
	2				
	3				
	4	209	0	0	0
	Total	317	0	0	0
Latvia	1	1 684	8	348	212
	2	998	34	870	720
	3	713	12	478	299
	4	2 231	8	593	321
	Total	5 627	62	2 289	1 552
Lithuania	1	45	0	0	0
	2	137	1	103	102
	3	120	0	0	0
	4	773	5	475	167
	Total	1 076	6	578	269
Poland	1	145	0	0	0
	2	386	0	0	0
	3	222	0	0	0
	4	111	0	0	0
	Total	864	0	0	0
Sweden	1	2 437	10	422	421
	2	174	0	0	0
	3	144	0	0	0
	4	891	0	0	0
	Total	3 646	10	422	421
Total	1	5 245	26	1 179	1 042
	2	4 400	39	1 464	1 313
	3	1 941	14	671	492
	4	6 194	19	1 168	588
	Total	17 780	98	4 482	3 435

(cont').

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2023 available to the Working Group.
5/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Subdivision 29	Denmark	1	688	0	0	0
		2				
		3				
		4				
		Total	688	0	0	0
	Estonia	1	1 388	6	243	243
		2	268	4	491	491
		3	11	2	193	193
		4	700	7	273	273
		Total	2 367	19	1 200	1 200
	Finland	1	4 833	10	2 865	191
		2	987	8	1 861	94
		3	64	3	34	0
		4	2 461	8	2 013	134
		Total	8 345	29	6 773	419
	Germany	1	13	0	0	0
		2				
		3				
		4	57	0	0	0
		Total	70	0	0	0
	Lithuania	1	120	0	0	0
		2				
		3	13	0	0	0
		4	118	17	1 084	537
		Total	250	17	1 084	537
	Sweden	1	437	1	54	54
		2	12	0	0	0
		3	0	0	0	0
		4	2	0	0	0
		Total	452	1	54	54
	Total	1	7 479	17	3 162	488
		2	1 267	12	2 352	585
		3	88	5	227	193
		4	3 338	32	3 370	944
		Total	12 172	66	9 111	2 210

(cont').

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2023 available to the Working Group.
6/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Subdivision 32	Estonia	1	2 267	16	1 455	1 455
		2	1 398	18	1 806	1 806
		3	291	4	400	400
		4	1 547	9	715	715
		Total	5 503	47	4 376	4 376
	Finland	1	684	2	678	40
		2	3	5	1 634	80
		3	1 261	4	907	74
		4	985	2	678	40
		Total	2 932	13	3 897	234
	Lithuania	1	8	0	0	0
		2				
		3	7	0	0	0
		4	19	0	0	0
		Total	34	0	0	0
	Russia	1	3 816	0	0	0
		2	2 659	0	0	0
		3				
		4	4 311	0	0	0
		Total	10 786	0	0	0
	Total	1	6 775	18	2 133	1 495
		2	4 060	23	3 440	1 886
		3	1 559	8	1 307	474
		4	6 861	11	1 393	755
		Total	19 255	60	8 273	4 610
SD 25-32 (excl. 28.1 & 30-31)	**Total**	**Quarter**	**Catches in tons**	**Number of samples**	**Number of fish meas.**	**Number of fish aged**
		1	**41 592**	**138**	**11 194**	**5 718**
		2	**18 543**	**118**	**12 717**	**6 198**

3	**11 239**	**47**	**6 108**	**2 191**
4	**27 321**	**103**	**16 110**	**5 032**
Total	**98 696**	**406**	**46 129**	**19 139**

Table 4.2.3. Herring in SD 25–29, 32 (excl. GoR). Catch by country and SD and mean weight by SD in 2023.

CATCH (1000 T) BY COUNTRY AND SD							
Country	**Total**	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
Denmark	5.192	1.409	1.007	1.322	0.766	0.688	0.000
Estonia	11.183	0.000	0.000	0.000	3.313	2.367	5.503
Finland	13.668	0.188	0.032	0.000	2.171	8.345	2.932
Germany	0.575	0.065	0.119	0.005	0.317	0.070	0.000
Latvia*	5.664	0.000	0.037	0.000	5.627	0.000	0.000
Lithuania	1.550	0.000	0.189	0.000	1.076	0.250	0.034
Poland	19.920	10.795	8.261	0.000	0.864	0.000	0.000
Russia	24.515	0.000	13.729	0.000	0.000	0.000	10.786
Sweden	16.428	4.869	2.771	4.690	3.646	0.452	0.000
Total	**98.696**	**17.326**	**26.145**	**6.017**	**17.780**	**12.172**	**19.255**

*Catches in SD 28.2 include 3174 t of CBH taken in GoR (SD 28.1)

Catch in numbers (thousands)							
AGE	Total	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
0	97173	12623	707	0	1787	27597	54459
1	635924	23485	27755	70476	89253	185823	239131
2	301137	43768	68342	49978	39885	53039	46125
3	411035	39691	34687	35967	49085	79654	171953
4	948048	96687	166895	72587	178549	157987	275343
5	407772	52342	101154	21672	84379	45030	103196
6	262460	40239	72854	13258	64786	24766	46557
7	136807	17255	40654	8318	28789	14482	27309
8	104190	12634	43033	3863	21920	10429	12311
9	60222	5221	30437	61	7849	5138	11516
10+	23790	1800	2054	0	4129	4980	10827
Total N	**3388558**	**345744**	**588571**	**276179**	**570412**	**608926**	**998726**
CATON	**98.696**	**17.326**	**26.145**	**6.017**	**17.780**	**12.172**	**19.255**
Mean weight (g)							
AGE	Mean	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
0	7.3	15.7	13.5	0.0	8.4	6.1	5.8
1	12.0	35.3	22.6	7.4	16.2	9.5	10.2
2	27.3	49.0	36.3	18.4	27.5	14.7	17.2
3	27.0	53.2	43.6	23.0	30.0	21.9	19.9
4	32.9	51.0	46.6	29.6	32.4	26.5	23.1
5	36.3	52.7	43.0	31.6	35.9	29.5	25.5
6	41.4	56.1	47.6	35.4	38.3	36.4	27.5
7	41.0	55.1	47.7	36.3	38.9	38.6	26.8
8	44.4	54.2	51.9	37.6	39.3	33.4	28.8

9	45.3	58.6	50.9	61.5	43.3	36.4	29.6
10+	46.2	84.1	95.6	60.0	41.9	38.3	35.9

CATON is given in 1000 tons

Table 4.2.4. Herring in SD 25–29, 32 (excl. GoR). Catch in number-at-age (millions) per SD and quarter in 2023. CATON in 1000 t).
1/2

Quarter:	**1**						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	330.140	6.424	16.983	67.294	27.415	120.512	91.512
2	156.293	11.465	37.054	44.686	8.936	37.211	16.940
3	177.478	7.016	14.463	28.628	5.930	55.206	66.234
4	441.237	28.651	79.246	59.008	51.945	106.499	115.887
5	208.591	17.240	64.912	18.070	27.992	36.068	44.310
6	117.057	15.955	33.609	10.210	24.069	13.886	19.328
7	68.789	6.554	23.483	7.070	11.528	9.017	11.138
8	53.209	5.848	27.346	3.400	7.972	3.658	4.984
9	28.045	1.712	15.630	0.000	2.983	2.426	5.294
10+	5.450	0.216	1.567	0.000	0.104	2.250	1.314
Total N	1586.290	101.081	314.294	238.367	168.874	386.733	376.940
CATON	41.592	4.191	12.873	5.029	5.245	7.479	6.775
Quarter:	**2**						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	38.433	0.110	2.292	0.543	4.099	0.340	31.049
2	34.944	3.786	11.682	4.598	3.879	5.752	5.247
3	86.303	5.112	6.772	5.745	9.370	9.355	49.949
4	210.738	12.937	36.359	12.164	54.053	20.291	74.935
5	84.087	9.677	10.476	3.089	25.648	4.425	30.771
6	66.678	7.953	15.802	2.727	24.380	3.912	11.905
7	26.424	3.756	4.727	1.207	8.243	2.679	5.812
8	22.003	3.127	6.432	0.423	9.968	1.183	0.871
9	16.683	2.349	9.857	0.060	2.238	0.437	1.742
10+	5.399	1.014	0.021	0.000	3.045	1.026	0.293
Total N	591.693	49.821	104.420	30.556	144.923	49.400	212.573
CATON	18.543	2.912	5.089	0.814	4.400	1.267	4.060
Quarter:	**3**						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	18.139	1.264	0.047	0.000	0.000	0.037	16.790
1	49.633	6.940	2.945	0.008	15.651	0.045	24.044
2	30.652	11.674	6.168	0.004	8.636	0.007	4.163
3	33.753	11.423	7.228	0.004	9.017	0.007	6.074
4	69.862	26.310	21.523	0.005	13.895	0.773	7.356
5	33.873	11.750	12.007	0.003	7.089	0.005	3.019
6	22.997	8.414	9.560	0.001	2.383	0.766	1.872
7	14.578	2.564	7.067	0.001	1.586	0.007	3.353
8	9.075	1.012	3.861	0.000	0.532	0.769	2.901
9	4.219	0.095	2.351	0.000	0.734	0.002	1.037
10+	8.567	0.140	0.073	0.000	0.087	0.019	8.248
Total N	295.349	81.586	72.830	0.026	59.609	2.439	78.859
CATON	11.239	4.308	3.343	0.001	1.941	0.088	1.559
Quarter:	**4**						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32

0	79.034	11.358	0.660	0.000	1.787	27.560	37.669
1	217.719	10.011	5.537	2.630	42.088	64.927	92.526
2	79.248	16.843	13.437	0.690	18.434	10.069	19.774
3	113.501	16.140	6.223	1.590	24.767	15.086	49.695
4	226.211	28.789	29.767	1.410	58.657	30.424	77.165
5	81.221	13.674	13.758	0.510	23.650	4.532	25.096
6	55.728	7.917	13.883	0.320	13.954	6.202	13.453
7	27.015	4.381	5.378	0.040	7.431	2.779	7.006
8	19.903	2.647	5.394	0.040	3.449	4.819	3.555
9	11.274	1.066	2.600	0.000	1.894	2.272	3.442
10+	4.374	0.430	0.393	0.000	0.894	1.685	0.972
Total N	915.226	113.256	97.028	7.230	197.005	170.354	330.353
CATON	27.321	5.915	4.840	0.173	6.194	3.338	6.861

continued

Table 4.2.4. Herring in SD 25–29, 32 (excl. GoR). Mean weight-at-age per SD and quarter in 2023. Mean weight (g). 2/2

Quarter:	**1**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	NA	NA	NA	NA	NA	NA	NA
1	7.1	18.0	17.2	6.9	7.9	6.2	5.7
2	21.2	37.4	31.5	18.3	23.2	12.7	12.7
3	23.1	40.3	41.7	22.8	28.6	21.1	18.6
4	30.8	38.9	43.8	30.1	33.6	26.4	22.9
5	33.5	43.4	39.4	31.7	35.3	29.1	24.4
6	39.9	49.8	44.3	35.7	40.6	39.4	25.9
7	39.4	48.4	44.2	35.5	39.7	41.0	24.9
8	44.6	48.6	49.8	37.1	43.0	36.0	25.4
9	44.0	53.7	47.8	0.0	46.5	38.8	30.7
10+	57.8	67.6	102.6	0.0	36.8	40.3	34.5
Quarter:	**2**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	NA	NA	NA	NA	NA	NA	NA
1	6.8	25.1	18.9	12.2	7.5	7.9	5.6
2	27.4	52.3	37.3	18.3	19.2	15.1	15.0
3	23.3	54.5	43.7	23.6	24.3	19.3	17.9
4	31.0	57.1	50.5	26.9	28.2	25.2	21.2
5	35.2	57.0	53.4	30.5	33.2	31.8	24.7
6	40.5	63.8	50.4	34.6	34.6	37.0	26.6
7	40.7	60.6	53.3	41.4	35.4	36.4	27.0
8	44.8	58.4	56.0	40.6	35.8	36.0	30.5
9	48.3	58.8	52.2	61.6	38.0	40.3	27.1
10+	49.2	85.5	78.2	0.0	39.5	44.9	36.5
Quarter:	**3**						

AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	6.1	13.9	14.2	0.0	0.0	6.4	5.5
1	22.3	45.4	27.2	23.4	23.4	17.1	14.3
2	39.9	53.7	39.7	30.6	30.7	22.3	20.4
3	39.6	53.0	42.8	31.9	32.4	23.6	21.1
4	43.0	51.8	44.1	36.5	35.8	30.4	23.1
5	47.4	58.4	46.7	40.1	39.4	24.2	26.5
6	49.6	57.5	49.1	45.9	44.8	33.5	29.6
7	46.0	51.4	52.3	46.1	45.3	28.8	28.9
8	45.8	57.6	56.7	54.5	51.2	35.5	29.0
9	49.7	105.0	56.8	51.3	50.9	28.1	27.6
10+	37.4	73.1	84.1	60.0	60.0	36.0	36.1
Quarter:	**4**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	7.5	15.9	13.4	0.0	8.4	6.1	5.9
1	18.0	39.6	38.5	18.3	19.7	15.7	15.2
2	34.4	52.9	47.2	23.2	29.8	21.8	21.1
3	32.0	58.6	48.8	24.5	31.6	26.4	23.3
4	35.8	59.5	51.5	29.1	34.4	27.4	25.3
5	39.7	56.6	49.0	32.8	38.5	30.5	28.3
6	42.1	59.6	51.6	31.9	39.8	29.8	30.4
7	42.4	62.5	52.1	22.0	40.3	33.1	28.6
8	42.8	60.5	54.1	46.4	38.7	30.4	33.0
9	42.2	62.0	58.9	0.0	41.7	33.2	29.7
10+	45.6	92.6	70.8	0.0	49.2	31.6	35.7

Table 4.2.5. Herring in SD 25–29, 32 (excl. GoR). SS3 input: Catch in numbers (thousands).

CANUM: Catch in numbers (Total International Catch) (Total) (Thousands)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	2436300	1553800	1090600	1347900	483100	343500	619000	285100
1975	1861800	1229200	1405600	829900	870700	364000	274800	546800
1976	2093100	1114800	1034000	907300	476800	558500	246500	494400
1977	1258500	1825900	773600	608300	621700	365300	284000	545400
1978	1044000	1298700	1575100	436800	355100	370700	186800	478300
1979	405300	1195500	873200	1159500	338900	278700	281200	478500
1980	1037000	907100	977400	524600	654900	182500	204400	550500
1981	1325500	1523500	680000	615000	343600	436300	146600	527500
1982	867000	2277000	810100	334200	312000	188100	250500	420700
1983	744300	1698700	1875700	625300	233100	245700	162500	433400
1984	822000	1177900	1282900	1145700	374300	165500	166300	421100
1985	1237800	2124100	1076100	867300	707200	240300	131000	346900
1986	552824	1733617	1601914	838843	614707	320221	114772	208901
1987	945327	745986	1484780	1271054	623710	473691	244552	199341
1988	486648	2147103	766214	1036539	872065	363754	260983	215706
1989	794526	541708	1992376	581189	842424	696525	267046	337290

1990	640611	1189807	583053	1240693	417647	538839	368952	304721
1991	372775	1571174	1285670	512528	807430	278307	265811	238120
1992	1115394	1142261	1701161	704665	324914	423360	158096	219149
1993	838183	1879241	1524614	1494588	624554	277940	200340	142115
1994	486548	1137808	1558899	1068194	1056701	495193	213649	282263
1995	817134	956260	1735550	1549018	643051	438593	204358	211230
1996	977130	1428624	1086262	1205900	791081	487673	298452	221832
1997	545954	1342320	1728425	1166963	899453	489689	242757	185000
1998	1856752	938998	1794821	1765917	805895	477518	209495	184459
1999	627929	1657990	947956	1305930	948817	339777	185681	119783
2000	1828063	932802	1669288	812699	857910	562876	189815	183613
2001	972157	1782792	558886	933541	347156	361277	280108	184412
2002	1027613	1006095	1330751	453735	518894	178489	168697	228576
2003	1329969	772503	678602	677808	257879	223884	88764	199754
2004	671773	1271605	689164	581155	393467	166094	122460	132878
2005	324497	749399	1180620	554117	376388	218528	82081	158451
2006	831563	520087	775634	1136658	420787	272459	158922	151900
2007	456636	918388	628955	701731	822101	268105	135696	111787
2008	790691	736725	970016	462256	486600	712185	166171	215981
2009	660502	1411015	754455	864815	305941	344388	491627	242074
2010	548284	647551	1362114	664075	632458	284767	284724	363672
2011	297582	577555	782534	1147746	421832	317528	130844	238870
2012	335448	318999	419256	520994	646033	235896	161717	209750
2013	468137	652626	258829	408791	465263	401709	172074	223095
2014	476375	914765	1017185	390851	494632	415256	289129	254127
2015	1419735	747319	1268349	1256442	379147	385941	371041	474811
2016	597706	2992739	927863	1179979	832280	329297	462529	624369
2017	968739	811053	2854156	827908	909598	519551	244676	405538
2018	1711852	1261365	1156675	2598270	777298	654135	392985	330275
2019	409746	1534828	1108371	876593	1923802	477036	389803	235279
2020	1621155	770021	1403244	777282	652917	1064990	196934	225170
2021	691437	1805171	831906	867236	519655	377932	373009	129976
2022	309783	332533	965167	450065	377223	178646	145213	118387
2023	635924	301137	411035	948048	407772	262460	136807	188202

Table 4.2.6. Herring in SD 25–29, 32 (excl. GoR). SS3 input: Mean weight in the catch and in the stock (Kilograms).

WECA (= WEST): Mean weight in Catch (Total International Catch) (Total) (Kilograms)

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.0060	0.0300	0.0350	0.0430	0.0460	0.0710	0.0790	0.0830	0.0750
1975	0.0060	0.0300	0.0340	0.0520	0.0520	0.0540	0.0790	0.0780	0.0790
1976	0.0060	0.0230	0.0380	0.0400	0.0600	0.0580	0.0570	0.0800	0.0810
1977	0.0060	0.0290	0.0310	0.0500	0.0580	0.0690	0.0610	0.0720	0.0910
1978	0.0060	0.0270	0.0440	0.0430	0.0560	0.0620	0.0730	0.0730	0.0810
1979	0.0060	0.0240	0.0420	0.0590	0.0530	0.0660	0.0720	0.0770	0.0860
1980	0.0060	0.0240	0.0370	0.0540	0.0680	0.0630	0.0770	0.0800	0.0940
1981	0.0060	0.0260	0.0350	0.0530	0.0700	0.0790	0.0770	0.0860	0.1000
1982	0.0060	0.0220	0.0390	0.0530	0.0650	0.0750	0.0840	0.0800	0.1010
1983	0.0060	0.0180	0.0310	0.0560	0.0590	0.0770	0.0870	0.0910	0.1030
1984	0.0060	0.0160	0.0300	0.0460	0.0650	0.0670	0.0820	0.0890	0.1010
1985	0.0060	0.0160	0.0230	0.0420	0.0580	0.0670	0.0750	0.0850	0.1020
1986	0.0060	0.0180	0.0250	0.0330	0.0510	0.0630	0.0690	0.0790	0.0990

1987	0.0060	0.0150	0.0330	0.0380	0.0450	0.0590	0.0640	0.0710	0.0920
1988	0.0060	0.0200	0.0260	0.0470	0.0510	0.0530	0.0650	0.0710	0.0900
1989	0.0060	0.0230	0.0360	0.0370	0.0520	0.0570	0.0590	0.0670	0.0820
1990	0.0060	0.0180	0.0310	0.0420	0.0390	0.0600	0.0620	0.0640	0.0770
1991	0.0060	0.0230	0.0240	0.0350	0.0490	0.0410	0.0600	0.0560	0.0690
1992	0.0060	0.0130	0.0230	0.0310	0.0420	0.0570	0.0500	0.0670	0.0710
1993	0.0060	0.0130	0.0210	0.0320	0.0350	0.0440	0.0510	0.0500	0.0660
1994	0.0060	0.0160	0.0210	0.0280	0.0380	0.0420	0.0520	0.0610	0.0640
1995	0.0060	0.0110	0.0210	0.0240	0.0320	0.0410	0.0420	0.0490	0.0540
1996	0.0060	0.0110	0.0170	0.0240	0.0280	0.0330	0.0370	0.0400	0.0510
1997	0.0060	0.0110	0.0170	0.0220	0.0260	0.0300	0.0350	0.0400	0.0440
1998	0.0060	0.0100	0.0180	0.0210	0.0280	0.0330	0.0370	0.0410	0.0460
1999	0.0060	0.0130	0.0160	0.0220	0.0250	0.0290	0.0360	0.0390	0.0540
2000	0.0060	0.0130	0.0230	0.0260	0.0280	0.0310	0.0360	0.0410	0.0460
2001	0.0060	0.0140	0.0190	0.0290	0.0300	0.0340	0.0370	0.0440	0.0470
2002	0.0060	0.0133	0.0216	0.0271	0.0330	0.0366	0.0392	0.0438	0.0454
2003	0.0060	0.0094	0.0242	0.0298	0.0355	0.0388	0.0446	0.0501	0.0549
2004	0.0060	0.0086	0.0143	0.0265	0.0304	0.0389	0.0418	0.0474	0.0540
2005	0.0060	0.0122	0.0152	0.0193	0.0292	0.0356	0.0434	0.0481	0.0561
2006	0.0060	0.0120	0.0234	0.0237	0.0263	0.0339	0.0435	0.0486	0.0553
2007	0.0060	0.0123	0.0215	0.0254	0.0300	0.0330	0.0427	0.0497	0.0603
2008	0.0060	0.0133	0.0222	0.0257	0.0302	0.0370	0.0335	0.0439	0.0498
2009	0.0060	0.0112	0.0199	0.0268	0.0295	0.0354	0.0418	0.0357	0.0464
2010	0.0060	0.0120	0.0183	0.0258	0.0322	0.0332	0.0385	0.0450	0.0450
2011	0.0060	0.0125	0.0215	0.0246	0.0317	0.0375	0.039	0.0474	0.0475
2012	0.0060	0.0142	0.0291	0.0268	0.0329	0.0417	0.0458	0.0511	0.0597
2013	0.0060	0.0120	0.0210	0.0351	0.0324	0.0386	0.0480	0.0505	0.0566
2014	0.0060	0.0118	0.0201	0.0294	0.0390	0.0350	0.0446	0.0492	0.0553
2015	0.0060	0.0071	0.0217	0.0272	0.0331	0.0399	0.0403	0.0471	0.0512
2016	0.0060	0.0086	0.0123	0.0256	0.0293	0.0339	0.0374	0.0407	0.0470
2017	0.0060	0.0109	0.0192	0.0208	0.0321	0.0347	0.0403	0.0482	0.0518
2018	0.0060	0.0111	0.0187	0.0279	0.0284	0.0398	0.0408	0.0432	0.0521
2019	0.0060	0.0118	0.0203	0.0242	0.0312	0.0314	0.0404	0.0441	0.0490
2020	0.0060	0.0116	0.0203	0.0261	0.0297	0.0349	0.0343	0.0456	0.0471
2021	0.0060	0.0086	0.0186	0.0219	0.0282	0.0296	0.0340	0.0351	0.0415
2022	0.0060	0.0153	0.0207	0.0273	0.0307	0.0361	0.0362	0.0387	0.0470
2023	0.0060	0.0120	0.0273	0.0270	0.0329	0.0363	0.0414	0.0410	0.0449

Table 4.2.7.a. Herring in SD 25–29, 32 (excl. GoR). SS3 input: Natural mortality. SMS run M_M1_010_All.

SS3 input: Natural Mortality. SMS run M_M1_010_All.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.4664	0.4362	0.2990	0.2371	0.2163	0.2020	0.1998	0.1851	0.1545
1975	0.3974	0.4832	0.3323	0.2634	0.2391	0.2238	0.2230	0.2077	0.1719
1976	0.3887	0.4147	0.2960	0.2436	0.2234	0.2103	0.2089	0.1964	0.1644
1977	0.5317	0.4636	0.3162	0.2582	0.2367	0.2224	0.2203	0.2049	0.1712
1978	0.7368	0.6947	0.3786	0.3297	0.3082	0.2847	0.2587	0.2432	0.2117
1979	0.8233	0.8801	0.4070	0.3407	0.3267	0.3122	0.3031	0.2670	0.2163
1980	0.7151	0.8971	0.5188	0.4103	0.3627	0.3684	0.3160	0.2896	0.2535
1981	0.7244	0.8104	0.5010	0.3858	0.3299	0.2962	0.2975	0.2614	0.2218
1982	0.6754	0.8285	0.4806	0.3882	0.3222	0.2869	0.2679	0.2651	0.2112
1983	0.6083	0.7382	0.5352	0.3677	0.3411	0.2967	0.2662	0.2495	0.2189
1984	0.5032	0.6306	0.4766	0.3640	0.2879	0.2867	0.2567	0.2309	0.2046
1985	0.4498	0.5369	0.4266	0.3153	0.2638	0.2313	0.2239	0.2110	0.1880
1986	0.4164	0.4894	0.3667	0.3221	0.2486	0.2263	0.2068	0.1926	0.1677
1987	0.4502	0.4966	0.2996	0.2540	0.2368	0.2005	0.1844	0.1731	0.1540
1988	0.3951	0.5061	0.3600	0.2520	0.2404	0.2213	0.1966	0.1777	0.1558
1989	0.3008	0.4186	0.2734	0.2742	0.2253	0.1974	0.1856	0.1669	0.1465
1990	0.1895	0.2755	0.1906	0.1685	0.1755	0.1485	0.1410	0.1347	0.1268
1991	0.1520	0.2140	0.1729	0.1457	0.1295	0.1401	0.1209	0.1245	0.1146
1992	0.1844	0.2223	0.1748	0.1510	0.1259	0.1170	0.1260	0.1135	0.1105
1993	0.2357	0.2849	0.2286	0.1880	0.1710	0.1523	0.1421	0.1505	0.1290
1994	0.2059	0.2937	0.2360	0.2039	0.1741	0.1631	0.1505	0.1366	0.1352
1995	0.1791	0.2565	0.2128	0.1939	0.1755	0.1643	0.1590	0.1464	0.1436
1996	0.1542	0.2211	0.1962	0.1728	0.1633	0.1552	0.1470	0.1416	0.1302
1997	0.1387	0.1972	0.1790	0.1594	0.1503	0.1408	0.1358	0.1319	0.1264
1998	0.1633	0.2028	0.1707	0.1553	0.1405	0.1322	0.1262	0.1248	0.1144
1999	0.1872	0.2303	0.1880	0.1640	0.1543	0.1419	0.1315	0.1292	0.1183
2000	0.2121	0.3511	0.2560	0.2405	0.2292	0.2203	0.2053	0.1963	0.1940
2001	0.2216	0.3715	0.2703	0.2348	0.2298	0.2160	0.2072	0.2044	0.2005
2002	0.2086	0.3840	0.2870	0.2495	0.2260	0.2193	0.2074	0.1994	0.2050
2003	0.1757	0.3369	0.2296	0.2097	0.1988	0.1924	0.1849	0.1773	0.1745
2004	0.2034	0.3089	0.2801	0.2173	0.2036	0.1854	0.1794	0.1727	0.1657
2005	0.2470	0.3663	0.3103	0.2774	0.2287	0.2036	0.1885	0.1797	0.1705
2006	0.2491	0.3996	0.2712	0.2671	0.2520	0.2263	0.1975	0.1876	0.1786
2007	0.2616	0.4073	0.2894	0.2609	0.2407	0.2278	0.1976	0.1860	0.1708
2008	0.2665	0.4306	0.2911	0.2665	0.2441	0.2178	0.2263	0.1994	0.1881
2009	0.2966	0.4452	0.3181	0.2666	0.2556	0.2281	0.2112	0.2258	0.2018
2010	0.3165	0.4907	0.3594	0.2949	0.2572	0.2510	0.2322	0.2168	0.2136
2011	0.2953	0.4998	0.3285	0.3018	0.2615	0.2372	0.2312	0.2125	0.2127
2012	0.2758	0.4479	0.2556	0.2616	0.2293	0.2033	0.1940	0.1827	0.1727
2013	0.2921	0.4290	0.2758	0.2147	0.2196	0.1954	0.1809	0.1749	0.1681
2014	0.2370	0.4337	0.2824	0.2286	0.1945	0.2012	0.1806	0.1740	0.1677
2015	0.2207	0.3599	0.2412	0.2126	0.1930	0.1771	0.1761	0.1663	0.1621
2016	0.1980	0.3393	0.2978	0.2106	0.1976	0.1849	0.1749	0.1702	0.1628
2017	0.1791	0.3071	0.2341	0.2159	0.1803	0.1726	0.1630	0.1539	0.1501
2018	0.1767	0.2885	0.2135	0.1790	0.1766	0.1548	0.1526	0.1501	0.1431
2019	0.1578	0.2846	0.2012	0.1858	0.1680	0.1665	0.1516	0.1483	0.1443
2020	0.1537	0.2683	0.1984	0.1763	0.1686	0.1578	0.1588	0.1455	0.1447
2021	0.1402	0.2616	0.1963	0.1835	0.1688	0.1642	0.1577	0.1553	0.1491
2022*	0.1402	0.2616	0.1963	0.1835	0.1688	0.1642	0.1577	0.1553	0.1491

2023*	0.1402	0.2616	0.1963	0.1835	0.1688	0.1642	0.1577	0.1553	0.1491

1974–2021 based on the latest SMS run provided during BWKBALTPEL 2023
*2022 and 2023 = 2021 (the latest SMS run)

Table 4.2.7.b. Herring in SD 25–29, 32 (excl. GoR). SS3 input: Natural mortality. SMS run M_M1_020_All.

SS3 input: Natural Mortality. SMS run M_M1_020_All.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.4552	0.4578	0.3424	0.2923	0.2754	0.2636	0.2619	0.2506	0.2259
1975	0.3939	0.4996	0.3699	0.3131	0.2932	0.2805	0.2799	0.2680	0.2391
1976	0.3891	0.4431	0.3421	0.2987	0.2821	0.2711	0.2700	0.2602	0.2340
1977	0.5149	0.4847	0.3599	0.3116	0.2937	0.2816	0.2800	0.2678	0.2400
1978	0.7007	0.6777	0.4073	0.3682	0.3506	0.3322	0.3102	0.2977	0.2716
1979	0.7892	0.8403	0.4310	0.3759	0.3654	0.3536	0.3457	0.3162	0.2750
1980	0.6859	0.8619	0.5292	0.4351	0.3948	0.3995	0.3560	0.3343	0.3040
1981	0.6961	0.7844	0.5130	0.4156	0.3683	0.3410	0.3418	0.3121	0.2794
1982	0.6512	0.8023	0.4958	0.4183	0.3631	0.3337	0.3177	0.3152	0.2714
1983	0.5927	0.7246	0.5445	0.4005	0.3784	0.3415	0.3161	0.3019	0.2770
1984	0.4971	0.6346	0.4971	0.3991	0.3342	0.3334	0.3090	0.2874	0.2655
1985	0.4491	0.5555	0.4578	0.3613	0.3165	0.2895	0.2833	0.2723	0.2533
1986	0.4147	0.5123	0.4048	0.3655	0.3036	0.2849	0.2689	0.2575	0.2370
1987	0.4476	0.5175	0.3464	0.3091	0.2946	0.2646	0.2512	0.2422	0.2264
1988	0.3974	0.5263	0.3976	0.3058	0.2957	0.2800	0.2596	0.2448	0.2271
1989	0.3118	0.4507	0.3240	0.3241	0.2826	0.2596	0.2500	0.2348	0.2188
1990	0.2151	0.3321	0.2578	0.2385	0.2443	0.2219	0.2159	0.2109	0.2046
1991	0.1819	0.2806	0.2448	0.2211	0.2076	0.2161	0.2005	0.2034	0.1953
1992	0.2109	0.2874	0.2462	0.2257	0.2051	0.1977	0.2051	0.1949	0.1924
1993	0.2567	0.3402	0.2910	0.2555	0.2410	0.2258	0.2173	0.2238	0.2064
1994	0.2303	0.3483	0.2972	0.2687	0.2435	0.2346	0.2242	0.2127	0.2115
1995	0.2072	0.3173	0.2785	0.2612	0.2453	0.2357	0.2312	0.2207	0.2183
1996	0.1857	0.2880	0.2660	0.2448	0.2363	0.2292	0.2222	0.2177	0.2081
1997	0.1713	0.2677	0.2513	0.2337	0.2256	0.2173	0.2131	0.2098	0.2054
1998	0.1932	0.2720	0.2442	0.2301	0.2173	0.2102	0.2051	0.2039	0.1954
1999	0.2133	0.2938	0.2568	0.2361	0.2277	0.2172	0.2088	0.2070	0.1982
2000	0.2459	0.4187	0.3365	0.3224	0.3128	0.3049	0.2929	0.2858	0.2840
2001	0.2530	0.4344	0.3473	0.3168	0.3122	0.3008	0.2939	0.2914	0.2885
2002	0.2395	0.4412	0.3583	0.3267	0.3076	0.3017	0.2929	0.2867	0.2906
2003	0.2125	0.4020	0.3126	0.2962	0.2871	0.2820	0.2760	0.2701	0.2678
2004	0.2372	0.3802	0.3554	0.3030	0.2917	0.2774	0.2728	0.2676	0.2622
2005	0.2736	0.4264	0.3783	0.3505	0.3106	0.2906	0.2785	0.2717	0.2646
2006	0.2753	0.4528	0.3453	0.3410	0.3282	0.3072	0.2846	0.2770	0.2701
2007	0.2844	0.4580	0.3587	0.3353	0.3184	0.3078	0.2849	0.2757	0.2643
2008	0.2890	0.4760	0.3591	0.3389	0.3207	0.2998	0.3065	0.2857	0.2769
2009	0.3158	0.4880	0.3811	0.3388	0.3299	0.3077	0.2943	0.3058	0.2872
2010	0.3335	0.5258	0.4145	0.3610	0.3310	0.3253	0.3104	0.2983	0.2960
2011	0.3139	0.5334	0.3889	0.3663	0.3335	0.3143	0.3095	0.2949	0.2953
2012	0.2975	0.4909	0.3305	0.3349	0.3093	0.2888	0.2817	0.2733	0.2656
2013	0.3126	0.4766	0.3483	0.2995	0.3026	0.2838	0.2725	0.2679	0.2628
2014	0.2643	0.4816	0.3537	0.3097	0.2832	0.2880	0.2719	0.2669	0.2621
2015	0.2532	0.4216	0.3215	0.2980	0.2820	0.2692	0.2685	0.2610	0.2577
2016	0.2340	0.4070	0.3703	0.2968	0.2859	0.2748	0.2672	0.2635	0.2578
2017	0.2172	0.3817	0.3182	0.3022	0.2727	0.2656	0.2583	0.2512	0.2483
2018	0.2155	0.3664	0.3020	0.2727	0.2700	0.2519	0.2504	0.2484	0.2430

2019	0.1980	0.3634	0.2917	0.2781	0.2632	0.2610	0.2497	0.2471	0.2440
2020	0.1950	0.3494	0.2896	0.2707	0.2640	0.2546	0.2554	0.2453	0.2447
2021	0.1841	0.3449	0.2887	0.2774	0.2650	0.2607	0.2555	0.2538	0.2491
2022*	0.1841	0.3449	0.2887	0.2774	0.2650	0.2607	0.2555	0.2538	0.2491
2023*	0.1841	0.3449	0.2887	0.2774	0.2650	0.2607	0.2555	0.2538	0.2491

1974–2021 based on the latest SMS run provided during BWKBALTPEL 2023
*2022 and 2023 = 2021 (the latest SMS run)

Table 4.2.7.c. Herring in SD 25–29, 32 (excl. GoR). SS3 input: Natural mortality. SMS run M_lim10_All.

SS3 input: Natural Mortality. SMS run M_lim10_All.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.4280	0.3972	0.2751	0.2225	0.2051	0.1934	0.1918	0.1800	0.1554
1975	0.3672	0.4402	0.3035	0.2441	0.2235	0.2108	0.2103	0.1978	0.1688
1976	0.3642	0.3846	0.2762	0.2301	0.2128	0.2018	0.2008	0.1904	0.1639
1977	0.4988	0.4306	0.2953	0.2438	0.2251	0.2128	0.2112	0.1984	0.1702
1978	0.6912	0.6342	0.3449	0.3020	0.2831	0.2634	0.2414	0.2284	0.2021
1979	0.7729	0.7994	0.3652	0.3077	0.2959	0.2837	0.2760	0.2456	0.2040
1980	0.6671	0.8107	0.4602	0.3649	0.3238	0.3288	0.2844	0.2623	0.2324
1981	0.6763	0.7332	0.4471	0.3458	0.2974	0.2691	0.2703	0.2399	0.2075
1982	0.6270	0.7478	0.4267	0.3461	0.2900	0.2603	0.2446	0.2421	0.1987
1983	0.5624	0.6654	0.4755	0.3281	0.3053	0.2679	0.2427	0.2289	0.2043
1984	0.4633	0.5686	0.4254	0.3258	0.2608	0.2597	0.2350	0.2139	0.1926
1985	0.4141	0.4860	0.3832	0.2857	0.2419	0.2151	0.2089	0.1985	0.1799
1986	0.3836	0.4443	0.3325	0.2930	0.2305	0.2119	0.1959	0.1845	0.1645
1987	0.4155	0.4518	0.2744	0.2362	0.2216	0.1917	0.1786	0.1696	0.1543
1988	0.3637	0.4588	0.3265	0.2335	0.2238	0.2077	0.1876	0.1727	0.1553
1989	0.2799	0.3845	0.2536	0.2540	0.2123	0.1889	0.1793	0.1642	0.1481
1990	0.1463	0.2211	0.1641	0.1498	0.1540	0.1374	0.1328	0.1292	0.1246
1991	0.1227	0.1831	0.1550	0.1373	0.1273	0.1336	0.1220	0.1242	0.1183
1992	0.1450	0.1888	0.1567	0.1411	0.1255	0.1200	0.1254	0.1180	0.1162
1993	0.1767	0.2272	0.1888	0.1622	0.1516	0.1401	0.1338	0.1389	0.1261
1994	0.1553	0.2312	0.1919	0.1710	0.1523	0.1457	0.1381	0.1299	0.1291
1995	0.1372	0.2066	0.1770	0.1646	0.1531	0.1462	0.1430	0.1354	0.1338
1996	0.1215	0.1849	0.1675	0.1522	0.1462	0.1411	0.1362	0.1330	0.1263
1997	0.1123	0.1708	0.1581	0.1450	0.1392	0.1333	0.1303	0.1280	0.1247
1998	0.1293	0.1753	0.1532	0.1429	0.1336	0.1284	0.1249	0.1241	0.1180
1999	0.1446	0.1922	0.1637	0.1479	0.1418	0.1342	0.1280	0.1266	0.1202
2000	0.1870	0.2972	0.2098	0.1963	0.1865	0.1788	0.1662	0.1588	0.1568
2001	0.1962	0.3165	0.2224	0.1912	0.1868	0.1753	0.1677	0.1655	0.1621
2002	0.1837	0.3267	0.2369	0.2035	0.1833	0.1777	0.1677	0.1609	0.1659
2003	0.1531	0.2859	0.1876	0.1704	0.1612	0.1559	0.1497	0.1434	0.1412
2004	0.1798	0.2605	0.2335	0.1776	0.1657	0.1505	0.1455	0.1400	0.1343
2005	0.2205	0.3109	0.2587	0.2289	0.1861	0.1649	0.1522	0.1449	0.1375
2006	0.2224	0.3414	0.2236	0.2194	0.2060	0.1838	0.1596	0.1513	0.1440
2007	0.2358	0.3487	0.2400	0.2143	0.1965	0.1850	0.1599	0.1501	0.1378
2008	0.2392	0.3709	0.2405	0.2186	0.1990	0.1768	0.1840	0.1612	0.1518
2009	0.2683	0.3829	0.2639	0.2180	0.2083	0.1850	0.1707	0.1830	0.1629
2010	0.2867	0.4241	0.2998	0.2419	0.2093	0.2038	0.1877	0.1748	0.1721
2011	0.2668	0.4325	0.2715	0.2479	0.2128	0.1921	0.1871	0.1712	0.1714
2012	0.2493	0.3866	0.2096	0.2147	0.1867	0.1648	0.1569	0.1477	0.1395
2013	0.2639	0.3702	0.2283	0.1754	0.1791	0.1588	0.1467	0.1417	0.1363
2014	0.2093	0.3734	0.2333	0.1859	0.1576	0.1632	0.1460	0.1407	0.1356

2015	0.1950	0.3048	0.1971	0.1724	0.1560	0.1430	0.1421	0.1342	0.1309
2016	0.1743	0.2870	0.2481	0.1708	0.1599	0.1492	0.1411	0.1372	0.1313
2017	0.1576	0.2602	0.1928	0.1767	0.1464	0.1399	0.1320	0.1247	0.1216
2018	0.1562	0.2450	0.1759	0.1460	0.1439	0.1259	0.1241	0.1221	0.1164
2019	0.1388	0.2429	0.1656	0.1521	0.1370	0.1357	0.1235	0.1207	0.1175
2020	0.1354	0.2287	0.1637	0.1445	0.1379	0.1288	0.1296	0.1187	0.1180
2021	0.1234	0.2239	0.1626	0.1512	0.1384	0.1344	0.1290	0.1271	0.1218
2022*	0.1234	0.2239	0.1626	0.1512	0.1384	0.1344	0.1290	0.1271	0.1218
2023*	0.1354	0.2329	0.1661	0.1490	0.1391	0.1318	0.1270	0.1231	0.1191

1974–2021 based on the latest SMS run provided during BWKBALTPEL 2023
*2022 and 2023 = 2021 (the latest SMS run)

Table 4.2.8. Herring in SD 25–29, 32 (excl. GoR). SS3 input: Proportion mature at year start.

MATPROP: Proportion of Mature at Year Start (Total international Catch) (Total)

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
1974	0.0000	0.0954	0.5829	0.9372	0.9941	0.9995	0.9999	1.0000	1.0000	1.0000
1975	0.0000	0.0954	0.5829	0.9372	0.9941	0.9995	0.9999	1.0000	1.0000	1.0000
1976	0.0000	0.0954	0.5829	0.9372	0.9941	0.9995	0.9999	1.0000	1.0000	1.0000
1977	0.0000	0.0954	0.5829	0.9372	0.9941	0.9995	0.9999	1.0000	1.0000	1.0000
1978	0.0000	0.0954	0.5829	0.9372	0.9941	0.9995	0.9999	1.0000	1.0000	1.0000
1979	0.0000	0.0954	0.5829	0.9372	0.9941	0.9995	0.9999	1.0000	1.0000	1.0000
1980	0.0000	0.0954	0.5829	0.9372	0.9941	0.9995	0.9999	1.0000	1.0000	1.0000
1981	0.0000	0.0954	0.5829	0.9372	0.9941	0.9995	0.9999	1.0000	1.0000	1.0000
1982	0.0000	0.0954	0.5829	0.9372	0.9941	0.9995	0.9999	1.0000	1.0000	1.0000
1983	0.0000	0.0954	0.5829	0.9372	0.9941	0.9995	0.9999	1.0000	1.0000	1.0000
1984	0.0000	0.0954	0.5829	0.9372	0.9941	0.9995	0.9999	1.0000	1.0000	1.0000
1985	0.0000	0.2538	0.6851	0.9191	0.9829	0.9965	0.9993	0.9998	1.0000	1.0000
1986	0.0000	0.1630	0.6447	0.9326	0.9905	0.9987	0.9998	1.0000	1.0000	1.0000
1987	0.0000	0.2029	0.6639	0.9212	0.9848	0.9972	0.9995	0.9999	1.0000	1.0000
1988	0.0000	0.4301	0.7555	0.9099	0.9687	0.9894	0.9964	0.9988	0.9996	0.9999
1989	0.0000	0.4613	0.7539	0.8986	0.9613	0.9859	0.9950	0.9982	0.9994	0.9998
1990	0.0000	0.3208	0.7211	0.9190	0.9790	0.9947	0.9986	0.9996	0.9999	1.0000
1991	0.0000	0.5707	0.7628	0.8607	0.9185	0.9532	0.9734	0.9848	0.9913	0.9949
1992	0.0000	0.1505	0.6649	0.9506	0.9948	0.9995	0.9999	1.0000	1.0000	1.0000
1993	0.0000	0.1931	0.6769	0.9381	0.9905	0.9985	0.9998	1.0000	1.0000	1.0000
1994	0.0000	0.3990	0.7175	0.8822	0.9542	0.9829	0.9937	0.9977	0.9992	0.9997
1995	0.0000	0.3577	0.7006	0.8844	0.9580	0.9848	0.9944	0.9979	0.9992	0.9997
1996	0.0000	0.2616	0.6593	0.8876	0.9691	0.9921	0.9980	0.9995	0.9999	1.0000
1997	0.0000	0.1982	0.6702	0.9318	0.9890	0.9983	0.9997	1.0000	1.0000	1.0000
1998	0.0000	0.2804	0.6794	0.9091	0.9782	0.9950	0.9989	0.9997	0.9999	1.0000
1999	0.0000	0.2745	0.6462	0.9180	0.9819	0.9965	0.9993	0.9999	1.0000	1.0000
2000	0.0000	0.1474	0.7682	0.9456	0.9931	0.9986	0.9996	1.0000	1.0000	1.0000
2001	0.0000	0.2209	0.6378	0.9148	0.9800	0.9961	0.9992	0.9998	1.0000	1.0000
2002	0.0000	0.0987	0.6375	0.9337	0.9919	0.9992	0.9999	1.0000	1.0000	1.0000
2003	0.0000	0.0987	0.6375	0.9337	0.9919	0.9992	0.9999	1.0000	1.0000	1.0000
2004	0.0000	0.1236	0.5725	0.9191	0.9888	0.9985	0.9998	1.0000	1.0000	1.0000
2005	0.0000	0.2138	0.6437	0.9286	0.9903	0.9957	0.9990	0.9998	1.0000	1.0000
2006	0.0000	0.1441	0.6583	0.9390	0.9898	0.9987	0.9997	0.9999	1.0000	1.0000
2007	0.0000	0.1725	0.6522	0.9073	0.9816	0.9975	0.9994	0.9999	1.0000	1.0000
2008	0.0000	0.1352	0.6081	0.9246	0.9871	0.9966	0.9993	0.9998	1.0000	1.0000
2009	0.0000	0.3137	0.7413	0.9014	0.9737	0.9905	0.9964	0.9990	0.9992	0.9997
2010	0.0000	0.1931	0.6311	0.9038	0.9746	0.9924	0.9980	0.9991	0.9998	0.9999

2011	0.0000	0.3383	0.5906	0.8653	0.9633	0.9895	0.9962	0.9986	0.9996	0.9999
2012	0.0000	0.1178	0.5766	0.9183	0.9897	0.9988	0.9998	1.0000	1.0000	1.0000
2013	0.0000	0.2341	0.7197	0.9513	0.9910	0.9960	0.9983	0.9989	0.9993	0.9997
2014	0.0000	0.2310	0.8025	0.9497	0.9902	0.9967	0.9991	0.9998	1.0000	1.0000
2015	0.0000	0.1332	0.6052	0.9088	0.9851	0.9975	0.9995	0.9999	1.0000	1.0000
2016	0.0000	0.3234	0.7113	0.9242	0.9548	0.9829	0.9946	0.9976	0.9990	0.9996
2017	0.0000	0.3659	0.8015	0.9110	0.9495	0.9527	0.9657	0.9756	0.9812	0.9851
2018	0.0000	0.2229	0.7563	0.9547	0.9835	0.9973	0.9992	0.9998	0.9999	1.0000
2019	0.0000	0.3818	0.7824	0.9533	0.9815	0.9922	0.9971	0.9989	0.9996	0.9998
2020	0.0000	0.1455	0.7004	0.9403	0.9870	0.9953	0.9989	0.9998	1.0000	1.0000
2021	0.0000	0.3346	0.7239	0.8829	0.9569	0.9808	0.9917	0.9975	0.9997	0.9999
2022	0.0000	0.2873	0.7355	0.9255	0.9751	0.9895	0.9959	0.9987	0.9998	0.9999
2023*	0.0000	0.2873	0.7355	0.9255	0.9751	0.9895	0.9959	0.9987	0.9998	0.9999

1974–2022 based on the latest analysis provided during BWKBALTPEL 2023
*2023 assumed as the 2020-2022 mean

Table 4.2.9. Herring in SD 25–29, 32 (excl. GoR). SS3 input: Tuning Fleet/International Acoustic Survey.

Fleet:
International Acoustic Survey (Millions)

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2000	0	36325	6175	13326	8230	8309	4622	3610	2460
2001									
2002									
2003									
2004									
2005									
2006	0	10308	10385	16353	23178	8094	3161	1719	1234
2007	0	7507	8773	3208	4522	10112	1760	925	843
2008									
2009	0	9623	17587	7738	7083	2377	3080	2878	652
2010	0	8600	9595	13496	5273	3879	1738	1924	1827
2011	0	2633	6274	11532	13037	5606	3278	1495	2357
2012	0	16761	3839	7847	9425	9275	2711	2271	2115
2013	0	10835	13216	5464	9559	8053	7532	2239	3620
2014	0	6994	19549	21194	9356	7370	6584	4929	3885
2015	0	51982	11236	17027	17420	5774	5192	3678	4352
2016	0	9117	42808	15590	8932	5681	2384	1756	1756
2017	0	9687	9173	33042	6607	5037	2195	764	1574
2018	0	10512	15556	15017	32380	8093	6045	2268	1311
2019	0	3669	7463	10455	6825	10655	1937	1294	803
2020	0	12953	5642	11333	7287	5091	6948	929	1283
2021	0	5525	16464	6519	7179	4625	3369	2960	1068
2022	0	3116	5773	10675	7366	4909	2668	2529	1574
2023	0	35738	5245	10733	14907	8675	4084	1955	2968

The tuning index includes subdivisions 25-27, 28.2, 29, and 32

Table 4.2.10. Herring in subdivisions (SDs) 25-29, 32 excluding the Gulf of Riga (Central Baltic Sea). Summary table of the diagnostics used in the weighting procedure. Green refers to a "Passed" score.

			Goodness of the fit					Consistency				Prediction skills				
			Run test and RMSE					Retrospective analysis				Hindcasting (MASE)				
Run name	Positive Hessian	Covergence	Survey	Age1	Age2	Survey	Ages	Retro_SSB	Forecast_SSB	Retro_F	Forecast_F	Survey	Age1	Age2	Joint	Weight
Run1	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Not Passed	Passed	0.93
Run2	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	1.00
Run3	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Not Passed	Passed	0.93

Table 4.2.11. Herring in SD 25–29, 32 (excl. GoR). Output from SS3: Stock Summary.

Year	Recruitment			SSB relative to MSY $B_{trigger}$*			Total Catch	Fishing pressure relative to F_{MSY}		
	Age 0	5%	95%	SSB	5%	95%		Ages 3–6	5%	95%
1966	19261477	9208348	42909122	2.04	1.53	3.33	216123	0.34	0.162	0.55
1967	23031976	11175144	50081525	1.97	1.48	3.24	269141	0.45	0.21	0.73
1968	18573905	9709100	36484245	1.82	1.37	3.01	323765	0.59	0.28	0.96
1969	18414624	10690909	32235823	1.62	1.22	2.73	269536	0.55	0.26	0.88
1970	35498294	24668104	52619772	1.47	1.12	2.49	288626	0.65	0.31	1.02
1971	22746612	15642298	33701941	1.32	1	2.26	305211	0.78	0.38	1.19
1972	31784297	23709591	43668659	1.26	0.95	2.19	268832	0.75	0.37	1.10
1973	31883858	23962802	43280133	1.23	0.92	2.14	376787	1.15	0.56	1.66
1974	26933878	19852766	36985445	1.14	0.84	1.97	368652	1.27	0.61	1.84
1975	44995701	34630260	59773862	1.13	0.82	1.96	354851	1.28	0.61	1.87
1976	28448644	21061045	38447806	1.03	0.75	1.8	305420	1.17	0.56	1.75
1977	40746012	29737645	53249682	1.17	0.83	2.02	301952	1.04	0.50	1.57
1978	34715725	24119669	47506807	1.26	0.88	2.14	278966	0.92	0.45	1.41
1979	65090894	46684825	84233003	1.28	0.89	2.16	278182	0.94	0.46	1.44
1980	89604808	66432927	110588329	1.16	0.81	1.96	270282	0.96	0.47	1.47
1981	65589173	47991139	84295704	1.1	0.77	1.86	293615	1.05	0.51	1.59
1982	44311754	32314411	58693645	1.15	0.82	1.97	273134	0.98	0.48	1.47
1983	55923790	42275156	72952906	1.17	0.84	2	307601	1.19	0.57	1.75
1984	40260376	31027439	53477780	1.01	0.74	1.76	277926	1.19	0.57	1.75
1985	15486368	11214010	21947917	0.98	0.72	1.71	275760	1.26	0.60	1.82
1986	37738930	29819186	50093524	0.85	0.64	1.49	240516	1.22	0.57	1.75
1987	11269636	8008384	16373947	0.83	0.62	1.46	255498	1.34	0.63	1.92
1988	18960041	14674756	26606450	0.88	0.66	1.54	262558	1.41	0.66	2.0
1989	20357444	16021277	29319985	0.79	0.6	1.41	276066	1.64	0.76	2.3
1990	12437760	9325621	18547833	0.64	0.48	1.16	227617	1.62	0.74	2.3
1991	18761027	14574988	27420769	0.64	0.48	1.16	197610	1.47	0.67	2.1
1992	16692134	12431860	24450593	0.58	0.43	1.05	190258	1.39	0.64	2.0

Year	Recruitment			SSB relative to MSY $B_{trigger}$*			Total Catch	Fishing pressure relative to F_{MSY}		
	Age 0	5%	95%	SSB	5%	95%		Ages 3–6	5%	95%
1993	12883096	9260830	19196764	0.61	0.45	1.08	212101	1.57	0.73	2.3
1994	18132721	13869207	26723878	0.63	0.46	1.12	218116	1.58	0.73	2.3
1995	15778543	12171742	23487449	0.52	0.39	0.93	187409	1.62	0.75	2.3
1996	8144193	5926631	12588660	0.45	0.33	0.8	161148	1.55	0.71	2.2
1997	14559199	11328601	22384699	0.42	0.32	0.76	159056	1.65	0.76	2.4
1998	6633220	4620599	10846853	0.41	0.31	0.74	184140	2.0	0.92	3.0
1999	20876174	15480120	33371084	0.36	0.26	0.65	145717	1.81	0.80	2.7
2000	11561944	8180231	19657361	0.38	0.27	0.73	174301	2.1	0.90	3.3
2001	13032541	9249787	22280198	0.35	0.24	0.7	137080	1.84	0.76	2.9
2002	28620431	20999230	47205824	0.35	0.24	0.71	128344	1.65	0.66	2.6
2003	13983902	9972974	23599721	0.37	0.25	0.78	112118	1.29	0.51	2.1
2004	9114402	6349416	15428692	0.38	0.26	0.79	95151	1.01	0.40	1.62
2005	18280547	13205968	29340001	0.43	0.29	0.87	91094	0.91	0.37	1.46
2006	14160611	10051029	22851606	0.46	0.31	0.93	113536	1.03	0.42	1.66
2007	31184634	22833708	48222980	0.48	0.32	0.95	115790	0.96	0.40	1.53
2008	19468052	13934629	30603377	0.47	0.32	0.93	126363	1.05	0.44	1.67
2009	16025832	11391931	25415146	0.56	0.37	1.09	135659	1.15	0.48	1.82
2010	8867588	6098912	14641861	0.52	0.35	1.01	137189	1.16	0.48	1.84
2011	23531923	17368299	37134013	0.48	0.33	0.94	118563	1.07	0.44	1.68
2012	21503301	15928417	33841063	0.47	0.33	0.94	101526	0.78	0.33	1.22
2013	14297754	10407545	22685413	0.54	0.38	1.07	100484	0.74	0.32	1.14
2014	51899849	40815216	78034154	0.6	0.42	1.15	134482	0.97	0.42	1.48
2015	12528108	9403641	19993865	0.55	0.39	1.03	174945	1.30	0.57	1.98
2016	14310779	11129206	22919582	0.58	0.41	1.08	190641	1.53	0.67	2.3
2017	14715995	11596814	23871804	0.62	0.44	1.17	199428	1.47	0.64	2.2
2018	8614520	6491583	14360464	0.6	0.43	1.13	240738	1.90	0.82	2.9
2019	19054115	14726608	31694263	0.52	0.37	0.99	200956	1.75	0.75	2.7
2020	7930762	5594781	13656349	0.42	0.3	0.82	174521	1.78	0.75	2.7

Year	Recruitment			SSB relative to MSY $B_{trigger}$*			Total Catch	Fishing pressure relative to F_{MSY}		
	Age 0	5%	95%	SSB	5%	95%		Ages 3–6	5%	95%
2021	6387027	4117065	11200810	0.38	0.26	0.77	128961	1.54	0.65	2.4
2022	29003801	19066104	49015406	0.42	0.28	0.85	83821**	0.82	0.35	1.31
2023	21339782	10974870	42057066	0.49	0.32	0.97	98696**	0.85	0.40	1.36
2024	20938212	8914745	49246849	0.62	0.39	1.19				

* 1 January.

** Russian Federation landings were not officially reported to ICES.

Table 4.2.11. Herring in subdivisions 25–29 and 32, excluding the Gulf of Riga. Annual catch scenarios. All weights are in tonnes.

Variable	Value	Notes
F_{2024}/F_{MSY}	0.48	Relative value. Based on a catch of 69 425 tonnes for 2024
SSB_{2025}/MSY $B_{trigger}$	0.73	Relative value, short-term forecast
$R_{age\ 0}$ (2023)	14.9	Geometric mean (1987-2022); billions
$R_{age\ 0}$ (2024)	20.8	Beverton and Holt stock–recruitment function with autocorrelation; billions
$R_{age\ 0}$ (2025)	21.7	Beverton and Holt stock–recruitment function with autocorrelation; billions
Total catch (2024)	69 425	Catch constraint in 2024: EU share (40 368 tonnes) + Russian Federation quota (27 000 tonnes) + central Baltic herring stock caught in Gulf of Riga (2 959 tonnes [mean 2018–2022]) − Gulf of Riga herring stock caught in central Baltic Sea (902 tonnes [mean 2018–2022]); tonnes

Basis	Total catch (2025)	Fishing mortality F_{2025}/F_{MSY}	SSB_{2026}/MSY $B_{trigger}$	% probability of SSB(2026) < B_{lim}*	Probability of SSB (2026) < MSY $B_{trigger}$(%)*	% SSB change**	% advice change ***
ICES advice basis							
EU MAP^: F = F_{MSY} × SSB_{2025}/MSY $B_{trigger}$	125344	0.73	0.85	4.9	65	16	139
EU MAP^: F = MAP range F_{lower} × SSB_{2025}/MSY $B_{trigger}$	95340	0.54	0.87	3.4	62	19	129
Other scenarios							
F = 0	0	0.00	0.95	0.9	55	30	-100
F_{MSY}	167388	1	0.81	7.4	68	11	219
F_{lower}	128305	0.75	0.85	5.1	65	16	144
F_{upper}	198182	1.21	0.79	9.8	70	8.2	277
EU MAP^: F = MAP range F_{upper} × SSB_{2025}/MSY $B_{trigger}$	148932	0.88	0.83	6.3	66	14	138
SSB (2026) = B_{lim}^^	542828	4.48	0.51	0.48	0.905	-30	933
SSB (2026) = B_{pa}^^^^							
SSB (2026) = MSY $B_{trigger}$^^^^							
SSB (2026) = SSB (2025)	276349	1.79	0.73	17.0	75	0	426
F = F_{2024}	84879	0.48	0.88	2.99	62	21	62
p(SSB(2026)<Blim)=5%	127318	0.74	0.85	5.0	65	16	142

*** The probability of SSB being below SSB reference points in 2026. This probability relates to the short-term probability of SSB < Blim and MSY Btrigger and is not comparable to the long-term probability of SSB < Blim and MSY Btrigger tested in simulations when estimating fishing mortality reference points.**

**** SSB 2026 relative to SSB 2025.**

***** Advice values for 2025 relative to the corresponding values for 2024 (EU MAP advice of 52 549 [FMSY], 41 706 [Flower] tonnes, and 62 558 [Fupper] respectively, all other values relative to 52 549).**

^ MAP multiannual plan (EU, 2016, 2019, 2020).

For the Blim option only a scenario for which Blim could be achieved by 1.03% is presented. This is because at the high F level required to achieve Blim in 2026 the model did not converge.

^^^^ The Bpa and MSY Btrigger options were left blank because Bpa and MSY Btrigger cannot be achieved in 2026, even with zero catch in 2025.

Table 4.2.12. Herring in subdivisions 25–29 and 32, excluding the Gulf of Riga. Comparison of assumptions made in the forecast for the intermediate year last and the assessment and forecast this year.

	Year	Current assessment and forecast (2024)	Previous forecast intermediate year (2023)
Assumed recruitment	2023	14913162**	18544632*
	2024	20751785*	18544632*
Catch	2023	98696	100 239
F/FMSY	2023	0.85	1.13

'2023' = Intermediate year in the previous assessment; '2024' = advice year in the previous assessment.

***Estimated from the stock recruitment relationship.**

**** Estimated from the geometric mean from model estimates of 0 year olds for the years 1987-2022.**

Figure 4.2.1. Herring in SD 25–29, 32 (excl. GoR). Proportions of age groups (numbers) in the total catch (CANUM).

Figure 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Catch in numbers (thousands) at age vs. numbers-at-age +1 of the same cohort in the following year in the period 1974–2023.

Figure 4.2.3. Herring in SD 25–29, 32 (excl. GoR).
Trends in the mean weights at age (g) in the catch (WECA).

Figure 4.2.4 Herring in SD 25–29, 32 (excl. GoR). Acoustic survey numbers-at-age vs. numbers-at-age +1 of the same cohort in the following year (index values presented in Table 4.2.11 are used).

Figure 4.2.5 Herring in SD 25–29, 32 (excl. GoR). The Natural mortality at age estimates used in the ensemble, i.e. for Model 1 (M1_010_All), 2 (M1_020_All) and 3 (M_lim10_all) (top). Mean natural mortality for each of the models (bottom) M in 2022 and 2023were assumed to be = 2021. (2023 is not included in the figure.)

Figure 4.2.6 Herring in SD 25–29, 32 (excl. GoR). Overview of data included in each of the models of the ensemble.

Figure 4.2.7 Herring in SD 25–29, 32 (excl. GoR). Model (Run) 1 in the ensemble from the 2023 assessment before and after the updates of the Russian Federation catch data for 2022.

Model 1

Model 2

Model 3

Figure 4.2.8a. Herring in SD 25–29, 32 (excl. GoR). The fit of the model to the survey index abundances for the three models in the ensemble.

Figure 4.2.8b. Herring in SD 25–29, 32 (excl. GoR). BIAS Survey retrospective patterns in the estimation of recruitment deviations.

Model 1

Model 2

Model 3

Figure 4.2.9 Herring in SD 25–29, 32 (excl. GoR). The fit of the models (green line) to the age compositions for the fleet (catch) and the survey data, aggregated across time.

Model 1

Model 2

Model 3

Figure 4.2.10 Herring in SD 25–29, 32 (excl. GoR). Pearson residuals for commercial (catch) and the survey data. Filled and open bubbles denote positive and negative residuals respectively.

Figure 4.2.11 Herring in SD 25–29, 32 (excl. GoR). Residuals from Runs test analyses for the age distributions of the commercial fleet and survey, and the fit to the survey index, for all three models.

Model 1

Model 2

Model 3

Figure 4.2.12 Herring in SD 25–29, 32 (excl. GoR). Residuals from the RMSE test for the age distributions of the commercial fleet and survey, and the fit to the survey index, for all three models.

Model 1

Model 2

Model 3

Figure 4.2.13 Herring in SD 25–29, 32 (excl. GoR). Retrospective analyses for each of the three models. Spawning-stock biomass (SSB, left) and fishing mortality (F, right), showing 5 years peels with 95% confidence bands for the reference year 2024 (SSB) and 2023 (F).

Model 1

Model 2

Model 3

Figure 4.2.14. Herring in SD 25–29, 32 (excl. GoR). Model prediction (for model 1, 2 and 3 respectively) skill evaluated using the mean absolute scaled error (MASE) score, for mean age commercial (upper left) and survey (upper right), and survey index (lower) model fits (coloured lines), compared to one-year-ahead forecasts (black dashed lines). Large dots connected by dashed white lines show the observed values.

Figure 4.2.15. Herring in SD 25–29, 32 (excl. GoR). Comparison of stock assessment results, SSB, F and Recr with 95% confidence intervals, across the 3 runs included in the ensemble. Trajectory of the stock and fishing mortality is compared

to the reference points B30% and Blim which is set as 15% of B_0 (top fig-ures). Dashed line is the Btrg and continuous line is Blim.

Figure 4.2.16. Herring in SD 25–29, 32 (excl. GoR). Stock assessment results of the final ensemble. Weighted-median value of SSB, F and Recr with 95% confidence intervals from delta-MVLN. Trajectory of the stock and fishing mortality is compared to the reference points B30% and Blim which is set as 15% of B0 (top figures). Dashed line is the Btrg and continuous line is Blim.

Figure 4.2.17. Herring in SD 25–29, 32 (excl. GoR).). Stock assessment results of the final ensemble compared to the assessment last year (2023).

Figure 4.2.18. Herring in SD 25–29, 32 (excl. GoR). Mean weight at age in the stock (and catch) in 2023 for 2023 compared with the assumption for 2023 in last year's assessment for 2023 (intermediate year).

Figure 4.2.19. Herring in SD 25–29, 32 (excl. GoR). Biomass at age, and % biomass at age in the forecasted catch for 2025.

GULF OF RIGA HERRING

4.3 Gulf of Riga herring (Subdivision 28.1)

The stock was benchmarked in 2023 (ICES, 2023) and below are listed main changes concerning the assessment input data and model:

- Age 0 was included into the catch matrix; updated catch-at-age in numbers and weight-at-age
- Previously two tuning series (commercial trap-net tuning fleet and hydroacoustic tuning fleet) were used, while in benchmark it was decided to exclude the commercial trap-net tuning series. Therefore, now only one tuning fleet is included in the assessment – the hydroacoustic tuning fleet.
- Time varying maturity ogive starting from 1995.
- Change of assessment model from XSA to SAM (Berg and Nielsen, 2014)
- Change in F_{bar}. New $F_{bar}=F_{2\text{-}6}$
- Reference points were updated

More details can be found in the WKBBPALTBEL report (ICES, 2023).

Gulf of Riga herring is a separate population of the Baltic herring (*Clupea harengus*) that is met in the Gulf of Riga (ICES Subdivision 28.1). It is a slow-growing herring with one of the lowest length and weight-at-age in the Baltic and thus differing considerably from the neighbouring herring stock in the Baltic Proper (Subdivisions 25–28.2, 29 and 32) (ICES, 2001; Kornilovs, 1994). The distinct differences in otolith structure serve as a basis for discrimination of Baltic herring populations (ICES, 2005, Ojaveer *et al.* 1981, Raid *et al.* 2005). Therefore the population belonging of individuals is assigned during the age reading process. The Gulf of Riga herring does not perform significant migrations into the Baltic Proper; only minor part of the older herring leaves temporarily the gulf after spawning season in summer –autumn period and returns afterwards to the gulf. There is an evidence, that the migrating fishes mainly stay close to the Irbe Strait region in Subdivision 28.2 and do not perform longer trips. The extent of this migration depends on the stock size and the feeding conditions in the Gulf of Riga. In 1970s and 1980s when the stock was on a low level the amount of migrating fishes was considered negligible. Since the beginning of 1990s when the stock size increased also the number of migrating fishes increased and the catches of the Gulf of Riga herring outside the Gulf of Riga in Subdivision 28.2 are considered in the assessments.

4.3.1 The Fishery

Herring fishery in the Gulf of Riga is performed by Estonia and Latvia, using both trawls and trap-nets. Herring catches in the Gulf of Riga include the local Gulf of Riga herring and the Central Baltic herring, entering the Gulf of Riga for spawning. Discrimination between the two stocks is based on the different otolith structure due to different feeding conditions and growth of herring in the Gulf of Riga and the Baltic Proper (ICES, 2005). The Latvian fleet also takes Gulf of Riga herring outside the Gulf of Riga in Subdivision 28.2. In 2023 these catches were estimated as 325 t, while the last five years average catches of the gulf herring outside the Gulf of Riga were 861 t. These catches are included in the total Gulf of Riga herring catches (Table 4.3.1b).

4.3.1.1 Catch trends in the area and in the stock

The catches have shown a sharp increase in the 1990s after being at a record low level during the 1980s. After the considerable decrease of catches in 1998 as a result of the decline in market conditions, the total catches of herring in the Gulf of Riga have gradually increased till 44 703 t in 2003. In 2005 the total herring landings decreased to 34 025 t and since then have been following the changes in TAC which is usually almost fully utilised. In 2023 the total catches of herring in the Gulf of Riga were 48 206 t (106% of TAC_{2023}). (Table 4.3.1a).

The catches from the Gulf of Riga herring stock showed similar pattern as the total caches of herring in the Gulf of Riga. They were the highest in the beginning of 2000s and then gradually decreased. Since 2019 the catches of the Gulf of Riga herring stock gradually increased and were 42 800 t in 2023 (Table 4.3.1b).

The landings of Central Baltic herring in the Gulf of Riga were 5731 t in 2023, increasing twice compared to the value of 2022 (Table 4.3.1b). The average catch of Central Baltic herring in the last five years was 3263 t.

The trap-net catches of Gulf of Riga herring were 6897 t, 18% more than in 2022. The trap-net catches comprised 16% of the total catches of the Gulf of Riga herring in 2023.

4.3.1.2 Unallocated landings

According to the information (interviews) on the level of misreporting in the commercial fishery, since 1993 till 2010 unallocated landings were added to the official landings. Latvian catches represented to the Working Group were taken to be 25% higher in 1993 and 1994, 20% higher in 1995-1999, 15% higher in 2000-2007, and 10% for years 2009-2010. In recent years it was stated that the level of misreporting is gradually decreasing due to scrapping of the fishing vessels. Thus, in Latvia the trawl fishing fleet is currently almost three times smaller than it used to be, and, therefore it is considered that the fishing capacities now are more or less balanced with the fishing possibilities and no unallocated landings have been assumed since 2011. The level of misreporting in Estonian herring fishery has been estimated to be low and therefore the official catch figures have been used in the assessment.

4.3.1.3 Discards

The discards of herring in the Gulf of Riga are assumed to be negligible and have not been recorded by observers working on the fishing vessels.

4.3.1.4 Effort and CPUE data

The number of trap-nets used in herring fishery increased up to 2001 and slightly decreased since then, however in 2005 the decrease was more substantial especially in the Estonian coastal fishery. Since then, the number of licenses for trap-nets have been fairly constant for both countries.

Prior to the 2000s the trawl fishery in the Gulf of Riga was permanently performed by approximately 70 Latvian and 5–10 Estonian vessels with 150–300 HP engines. Since then, the Latvian trawl fleet has gradually decreased due to scrapping. There were 25 active Latvian vessels operating in the Gulf of Riga in 2023.

The number of Estonian trawl vessels operating in the Gulf of Riga in 2023 was 13.

A number of protection measures have been implemented by the authorities in management of the Gulf of Riga herring fishery. The maximum number and engine power of trawl vessels operating in the Gulf of Riga are limited. Additionally, the summer ban (from mid- June to September) in the Estonian part of the gulf and the 30-day ban for trawl fishery during the main spawning migrations of herring in both Latvia (12 May - 10 June) and Estonia (25 April - 25 May) are implemented in the Gulf of Riga. No historical time-series of CPUE data are available.

4.3.2 Biological composition of the catch

4.3.2.1 Age composition

The quarterly catches of Gulf of Riga herring from Estonian and Latvian trawl and trap-net fishery were compiled to get the annual catch in numbers (Table 4.3.2, Figure 4.3.1 and 4.3.2). The available catch-at-age data are for ages 0–8+. In SAM ages 0–8+ and in tuning fleet ages 1–8+ are used.

4.3.2.2 Quality of catch and biological data

The sampling of biological data from commercial trawl and trap-net catches was performed by Estonia and Latvia on a monthly basis (from trap-nets on a weekly basis). The sampling intensity of both countries is described in Table 4.3.3. The sample number per 1000 t of catch in the Gulf of Riga was 1.8 in Estonia and 2.3 in Latvia (2.1 in total) in 2023. The check of consistency of catch-at-age data is shown in Figure 4.3.3.

4.3.2.3 Mean weight-at-age

The annual mean weights by age groups used for assessment were compiled from quarterly data collected from the trap-net and trawl fishery of Estonia and Latvia (Table 4.3.4, Figure 4.3.4.). The mean weights-at-age in the stock were assumed to be equal to the mean weights in catches because it was not possible to obtain the historical mean weight-at-age at the spawning time. Moreover, since the gears used in the herring fishery are not selective, the weights in the catch should correspond to the weights in the stock.

A decreasing trend in mean weight-at-age of Gulf of Riga herring was observed since the mid–1980s. Since 1998 the mean weight-at-age has started to increase and in 2000 was at the level of the beginning of the 1990s but was still considerably lower than in the 1980s. Since 2000 the mean weight-at-age was fluctuating without clear trend probably depending on feeding conditions in the specific year. Thus, the most unfavourable feeding conditions in 2003 resulted in a decrease of mean weight-at-age for most of the age groups. Since 2012 mean weight-at-age slightly fluctuated and showed a decreased trend for older age groups. After the decrease in 2021, over 10% increase in mean weight-at-age was observed, in 2022 in most of the age groups. In 2023, mean weight-at-age continued to increase in most of the age groups, except age 1, where a 19% decrease was observed, likely due to higher catch of age 1 herring in the first half of the year i.e. before the intensive individual growth occurring in the 2nd half-year (Figure 4.3.4).

4.3.2.4 Maturity at age

A new approach to maturity at age was implemented starting from the 2023 assessment on the basis of maturity data from the commercial landings of Estonia and Latvia from January to April. The maturity was modelled as a binomial GLM with a logit link $logit(M)$=log$(M$ / 1−$M)$. Raw

maturity estimates were smoothed fitting a generalised additive model (GAM) separately for each age group. The method was applied for the time period since 1995, while the historical data was applied for the rest of the time series (Table 4.3.5, Figure 4.3.5).

4.3.2.5 Natural mortality

Since the cod stock has remained at a low level in the Gulf of Riga, the natural mortality (0.2) used in the previous years was applied. Constant natural mortality M = 0.20 was used for all the years except for the period 1979–1983 when a value of M = 0.25 was used due to presence of cod in the Gulf of Riga.

4.3.3 Tuning Fleets

One scientific tuning fleet, the Estonian-Latvian hydro-acoustic survey in the Gulf of Riga (GRAHS), is used in the assessment. GRAHS survey is carried out in the end of July-beginning of August since 1999 Ages 1-8+ are considered in the assessment. The tuning data are presented in the Table 4.3.6 and Figure 4.3.6. The check of internal consistency of tuning data is shown in Figure 4.3.7.

The overall acoustic estimate of herring abundance (ages 1+) was 18% lower than in 2022. However, the decrease of biomass estimate was less expressed (-12%) due to increase in mean weights in most of the age groups.

4.3.4 Assessment

4.3.4.1 Assessment

The assessment was performed with the state-space assessment model SAM (Nielsen and Berg, 2014). The assessment is publicly available in www.stockassessment.org under the name "GoR_wgbfas2024".

A full description of the SAM method, inputs and settings are given in the Stock Annex.

The stock summary is given in Figure 4.3.8. Compared to last year's assessment, the spawning stock biomass was downscaled and fishing mortality upscaled (Figure 4.3.8). This results from the downscaling of younger ages in the acoustics by the model (Figure 4.3.9) which in turn leads to downscaling of stock numbers at age for ages 0-3 for recent years (Figure 4.3.10).

The acoustic survey index has been showing decreasing trend both in numbers and biomass for past years, however the SSB estimate is still high, and all time high in 2023. This is related to the fact that there has been two very strong year-classes (2019 and 2022) and above average year-classes between. However, the acoustic survey index is not showin as strong signal for the 2022 year-class as is present from the catch.

The one-observation-ahead (Figure 4.3.11) and process error (Figure 4.3.12) residuals are relatively small, although slightly larger residuals can be seen at the beginning of the time-series, these are similar to those seen at the benchmark.

Results of SAM retrospective analysis for Gulf of Riga herring are summarized in Figure 4.2.13. When comparing 2024 assessment with 2023 assessment then SSB is downscaled and F upscaled. While when comparing assessments from years 2021-2022, the estimates are more consistent. However, in last year's assessment there was an overall downscaling in SSB and upscaling of F, which is also reflected in the high Mohn's Rho values for SSB and F (13% and -11%, respectively). The retrospective runs still fall inside the pointwise 95% confidence intervals of the full time-series assessment, and are within the -15% – 20% limits specified by WKFORBIAS (ICES, 2020).

Fishing mortality estimates from final SAM assessment are presented in Table 4.3.7, the stock numbers in Table 4.3.8, and the assessment summary in Table 4.3.9.

4.3.4.2 Historical stock trends

The main stock parameters (Table 4.3.9, Figure 4.3.8) show that the spawning stock biomass of the Gulf of Riga herring has been rather stable at the level of 40 000–50 000 t in the 1970s and 1980s. The SSB started to increase in the late 1980s, peaking at 111 830 tonnes in 1994. The increase of SSB was connected with the regime shift which started in 1989 and manifested itself as a row of mild winters that was very favourable for the reproduction of Gulf of Riga herring. After mild winters the abundance of zooplankton in spring is usually higher thus ensuring better feeding conditions for herring larvae and evidently higher survival of them. Beginning with 1989, most of the year-classes were abundant or above the long-term average and only in few years when the winters were severe (1996, 2003, 2006, 2010, 2013) the recruitment was poor. Afterwards due to rather high fishing mortality SSB decreased and was fluctuating at the level below 100 000 t. In 2005–2006 SSB decreased to the level of 70 - 75 000 tonnes that is below the long-term average, and increased since then. After appearance of very rich year classes in 2011 and 2012 the SSB reached 110 070 t in 2014 but has decreased since then. In 2017-2022 the SSB increased again, reaching 136 638 t in 2023 that is historically highest. The mean fishing mortality in age groups 2–6 has been rather high in 1970s and 1980s fluctuating between 0.31 and 0.66. It has decreased below 0.24 in 1990 and fluctuated between 0.24-0.36 till 1996. Afterwards the fishing mortality increased above 0.4 that was regarded as F_{pa} then. Since 2008 the fishing mortality has decreased below 0.4. In 2017-2023 the fishing mortality was in the range of 0.23-0.29. The estimate for 2023 was 0.28 that is at the F_{msy} (0.28).

4.3.4.3 Recruitment estimates

With the inclusion of age 0 into the catch matrix, the recruitment starts now at age 0, compared to previously (before the benchmark) used age 1. Below is an overview of previous procedures on recruitment (age 1) estimation.

Till 2011 the values of mean water temperature of 0−20 m water layer and the biomass of *Eurytemora affinis* in May (factors which significantly influence the year class strength of Gulf of Riga herring, ICES 1995/J:10) were regressed to the 1-group from the XSA using the RCT3 program. It was considered that year-class strength of the Gulf of Riga herring was strongly influenced by the severity of winter, which determines the water temperature, and abundance of zooplankton in spring. The higher water temperature in spring favours a longer spawning period and more even distribution of herring spawning activity. After mild winters the abundance of zooplankton is higher thus ensuring better conditions for the feeding of herring larvae. However, it was found in the previous years that RCT3 poorly predicts the rich year classes. In 2011 the analysis of factors determining year-class strength was performed and a paper at ICES Annual science conference in Gdansk was presented (Putnis *et al.,* 2011). Two additional significant relationships were found for the herring year-class strength. It was shown that since 2000 the year-class strength strongly depends on the feeding conditions during the feeding season of the adult (1+) herring. The feeding conditions were characterised as the average Fulton's condition factor for ages 2–5. In 2012 RCT3 analysis was done for the prediction of recruitment using the biomass of *Eurytemora affinis* in May and average Fulton's condition factor. However, this estimate was not accepted due to high variation ratio. Therefore, since 2012 the geometric mean of year classes over the period from 1989 corresponding to period of improved reproduction conditions and prevalence of mild winters were used as input for recruitment (age 1) in short-term forecast..

The last year recruitment (age 0) estimate is uncertain, as this is based on only information on the catches. The abundance of age 0 in the catches is not only dependent on the year-class strength but is also influenced by other factors, such as growth and fishery behaviour. Growth

is one of the main factors which defines how early in the year the age 0 fish will enter into the fishery. In addition, fishing activity might not be divided equally throughout the year, and this is dependent on the fishing opportunities, weather, etc. Meaning that, lower fishing activity at the end of year could also influence the abundance of age 0 in the catches.

The uncertainty around age 0 estimate is clearly seen from the retrospective figure (Figure 4.3.13). For example, known strong year-classes of 2017 and 2019 were underestimated by the model when basing the estimation only on information from catches, but year-class of 2022 was overestimated. Additional information from next year (age 1 estimate from catch and survey) improves the recruitment estimate as more information on cohort strength becomes available.

Due to the uncertainty around the age 0 estimate in the final year, for the forecast process, the final year recruitment estimate is substituted with a median recruitment estimate from time-period 1989 to data year -1.

4.3.5 Short-term forecast and management options

The short-term forecast is a stochastic forecast conducted in SAM. The inputs to the short-term forecast are presented in Table 4.3.10.

Initial stock size: The initial stock sizes are simulated from a estimated distribution at the start of the intermediate year (including covariance). Final year recruitment value is assumed median recruitment estimate from time-period 1989 to data year -1.

Natural mortality: equal to 0.2 for all ages.

Maturity, weights-at-age and exploitation pattern: Both maturity and weights-at-age estimates used in the forecast are set equal to the mean of final 3 data years (2021-2023).

Fishing mortality: TAC constraint. TAC for 2024 is 35 902 tonnes.

4.3.6 Reference points

The biological reference points for the Gulf of Riga herring were re-estimated at WKBBALTPEL meeting in 2023 (ICES, 2023) using EqSim following the acceptance of the benchmark assessment. The EqSim settings and assumptions are detailed in the WKBBALTPEL report (ICES, 2023). The calculation are based on full time-series.

For Gulf of Riga herring there is no clear stock-recruitment relationship, and fitting Beverton-Holt and smooth hockey-stick SRR produced a straight line. Therefore, it was decided to follow a similar approach as last time when reference points were calculated (ICES, 2015). B_{pa} was defined separately from B_{lim}, and used as the fixed breakpoint in segmented regression. B_{pa} was calculated as average SSB based on SBB-recruitment pairs where SSB ≤ median SSB and recruitment ≥ median recruitment. B_{pa} was set to 72907 tonnes, and B_{lim} was calculated as $B_{pa}/1.4$. B_{lim} was set at a value of 52076 tonnes. And EqSim analysis run without assessment or advice error or the advice rule, and with a segmented regression with a breakpoint fixed at B_{lim}, gave the value of 0.49 for F_{lim} (the F that, on average, leads to B_{lim}).

To estimate the unconstrained F_{MSY}, the EqSim was run without the advice rule (i.e. no MSY $B_{trigger}$), with assessment and advice error using the values $(F_{cv}, F_{phi}) = (0.25, 0.30)$ as suggested by WKMSYREF3 (ICES, 2015), and with a segmented regression with a breakpoint fixed at B_{pa}. The resulting unconstrained F_{MSY} obtained (median MSY for lanF) was $F_{MSY} = 0.28$.

To ensure consistency between the precautionary and the MSY frameworks, F_{MSY} is not allowed to be above $F_{p.05}$; therefore, if the initial F_{MSY} value is above $F_{p.05}$, F_{MSY} is reduced to $F_{p.05}$. $F_{p.05}$ was

calculated by running EqSim with assessment/advice error, with advice rule, and with a segmented regression with breaking point fixed at B_{pa} to ensure that the long-term risk of SSB<B_{lim} of any F used does not exceed 5% when applying the advice rule. $F_{p.05}$ was estimated to be 0.353. Therefore, as explained above, F_{pa} = $F_{p.05}$ = 0.353. The F_{MSY} ranges are, F_{lower}= 021, and F_{upper}=0.33.

MSY $B_{trigger}$ was set equal to B_{pa}, as even though the stock has been fished below F_{MSY} (0.28) for the last 5 years, the 5th percentile of B_{MSY}>B_{pa}, and according to ICES technical guidelines this will lead to setting MSY $B_{trigger}$ = B_{pa}.

The reference points in full from these analysis, and with comparison to previous reference points are given below:

Reference point	New value	Values from 2015 WK
$F_{MSYlower}$	0.21	0.24*
F_{MSY}	0.28	0.32*
$F_{MSYupper}$	0.33	0.38*
MSY $B_{trigger}$	72907	60000
B_{pa}	72907	57000
B_{lim}	52076	40800*
F_{pa}	0.35	0.38*
F_{lim}	0.49	0.88*
$F_{p.05}$	0.35	0.38*
$F_{MSY_unconstr}$	0.28	0.32*

* F_{bar} = F_{3-7}

4.3.7 Quality of assessment

The catches are estimated on the basis of the national official landing statistics of Latvia and Estonia. The stock is well sampled and the number of measured and aged fish has been historically high (Table 4.3.3). Since 1993 the total landings of Latvia were increased according to information on misreporting. There was no information on unallocated catches of herring since 2011. Due to scrapping of fishing vessels the fishing fleet in the Gulf of Riga has been considerably reduced and the fishing capacity could be in balance with the fishing possibilities. The joint Estonian-Latvian hydro-acoustic survey (GRAHS), started in 1999 to obtain tuning data, which were implemented for the first time in 2004 assessment. The Mohn's Rho index (average for last 5 years) for fishing mortality an SSB is -11%, 13% respectively.

4.3.8 Change in advice

The change in advice (9.3%) is due to above average year-class of 2022 resulting in increasing SSB.

A comparison of the numbers at age of the current (WGBFAS 2024) and the previous (WGBFAS 2024) forecast are shown in Figure 4.3.15. The numbers at age in 2022 and 2023 for age classes 0-4 have been revised downwards in current assessment compared to assessment and assumptions made in the intermediate year of the forecast at WGBFAS 2023. The exception is 2022 year-class

which is estimated to be above average recruitment and therefore was underestimated in last year's assessment with the median value assumption.

Comparison of stock weights-at-age used in the forecst years (Figure 4.3.16) shows that the difference is small. The realised stock weights-at-age for 2023 were higher compared to forecasted in WGBFAS 2023. The assumed stock weights-at-age for 2024 are higher than assumed last year due to the higher weights in 2023.

The comparison of the assumed SSB, F_{2-6}, total catch and recruitment is shown in Figure 4.3.17.

4.3.9 Management considerations

There are no explicit management objectives for this stock. The International Baltic Sea Fisheries Commission (IBSFC) started to treat Gulf of Riga herring as a separate management unit in 2004 and a separate TAC for the Gulf of Riga was established. Since then the TAC is divided into catch quotas of Estonia and Latvia. Thus, the danger of overshooting the ICES advice for the Gulf of Riga herring, that was present when this stock was managed together with herring stock in the Central Baltic, has been eased. It should be that some amount of Central Baltic herring stock component is taken in the Gulf of Riga (Subdivision 28.1) and some amount of Gulf of Riga herring is taken in Subdivision 28.2. This is considered when setting TAC for the Gulf of Riga herring and herring in Sub-divisions 25–27, 28.2, 29, 32.
The TAC proposed for the Gulf of Riga area is based on the advised catch for the Gulf of Riga herring stock, plus the assumed catch of herring from the central Baltic stock taken in the Gulf of Riga, minus the assumed catch of the Gulf of Riga herring taken outside the Gulf of Riga. The values of the two latter are given by the average over the last five years.

1. Central Baltic herring assumed to be taken in the Gulf of Riga in 2025 (Subdivision 28.1) is 3263 tonnes (average 2019–2023);
2. Gulf of Riga herring assumed to be taken in Subdivision 28.2 in 2025 is 861 tonnes (average 2019–2023).

As an example, following ICES MSY approach (here identical to the MAP F_{MSY}), catches from the Gulf of Riga herring stock in 2025 should be no more than 39 233 tonnes. The corresponding TAC in the Gulf of Riga management area for 2025 would be calculated as: 39 233 tonnes – 861 tonnes + 3263 tonnes = 41 635 tonnes.

4.3.10 Gulf of Riga herring fisheries management

The herring fishery in the Gulf of Riga is based on TAC distribution between two countries: Estonia and Latvia. National quotas are distributed between trawl fishery in open areas of the Gulf of Riga and the stationary coastal net fishery. As the national management of herring fishery have differences between the countries, this is shown by countries separately.

Year	Country	Coastal fishery			Trawl fishery
		Number of allowed fishing gears in the specialized herring fishery	Total limit	Regulations	Closures
2023	Latvia	In total 115 pound-nets and 610	No less than 15% of the Latvian quota. 4 % of the total	The total herring coastal limit in the Gulf of Riga is distributed by three coastal areas (Eastern, Southern and Western). When	12th May - 10th June

		herring gill-nets.	coastal limit is allocated to the gillnet fishery.	the area limit is reached, the fishery is ceased in a given area. In a situation, when there are indications that the total limit in the area will not be taken, it is possible to allocate part of this limit to the area where it has been already reached.	
2023	Esto-nia	In total 155 herring pound-nets	Total EST quota in the Gulf of Riga is divided between trawl and coastal fishery according to historical share of the com-panies/fishers involved. Cur-rently 40% for coastal fishery and 60% for trawls. The quota for coastal fishers is divided between Saaremaa Island (9%) and Pärnu county 93% (Pärnu area and Kihnu Island).	The total herring quota for coastal fishery within area is distributed between fishing companies/fishers according to their historical share (90%). The rest 10% is distributed between companies/fishers through open auctions.	April 20- May, 22 , 31 days, can be shifted depending on ice conditions in winter; Addi-tional closure in certain rectan-gles from 1st April to 20 May. "Unofficial" (not established by the authori-ties) closure for trawl fishery 15th June -15th September.

Table 4.3.1a Total catches of herring in the Gulf of Riga by nation (official + unallocated landings). All weights are in tonnes.

Year	Estonia	Latvia	Unallocated landings	Total
1991	7420	13481	-	20901
1992	9742	14204	-	23946
1993	9537	13554	3446	26537
1994	9636	14050	3512	27198
1995	16008	17016	3401	36425
1996	11788	17362	3473	32623
1997	15819	21116	4223	41158
1998	11313	16125	3225	30663
1999	10245	20511	3077	33833
2000	12514	21624	3244	37382
2001	14311	22775	3416	40502
2002	16962	22441	3366	42769
2003	19647	21780	3267	44694
2004	18218	20903	3136	42257
2005	11212	19788	2968	33969
2006	11925	19186	2878	33989
2007	12764	19425	2914	35103
2008	15877	19290	1929	37096
2009	17167	18308	1831	37306
2010	15422	17751	1775	34949
2011	14721	20303	-	35024
2012	13789	17944	-	31733
2013	11898	18462	-	30360
2014	10561	20065	-	30626
2015	16501	21002	-	37503
2016	15814	19078	-	34892
2017	13772	17948	-	31720
2018	12521	16904	-	29425

Year	Estonia	Latvia	Unallocated landings	Total
2019	13320	17961	-	31281
2020	12231	21019	-	33249
2021	16099	22011	-	38110
2022	18810	24166	-	42976
2023	20726	27480	-	48206

Table 4.3.1b Herring caught in the Gulf of Riga and Gulf of Riga herring catches in central Baltic. All weights are in tonnes.

Year	Catches in the Gulf of Riga			Gulf of Riga herring catches	
	Gulf of Riga herring	Central Baltic herring	Total	In the Central Baltic	Total
1977	24186	2400	26586	-	24186
1978	16728	6300	23028	-	16728
1979	17142	4700	21842	-	17142
1980	14998	5700	20698	-	14998
1981	16769	5900	22669	-	16769
1982	12777	4700	17477	-	12777
1983	15541	4800	20341	-	15541
1984	15843	3800	19643	-	15843
1985	15575	4600	20175	-	15575
1986	16927	1300	18227	-	16927
1987	12884	4800	17684	-	12884
1988	16791	3000	19791	-	16791
1989	16783	5900	22683	-	16783
1990	14931	6000	20931	-	14931
1991	14791	6100	20891	-	14791
1992	20400	3500	23946	1300	21700
1993	21500	4300	25800	1200	22700
1994	22200	5000	27200	2100	24300
1995	30256	6100	36356	2400	32656
1996	28284	4400	32684	4300	32584

Year	Catches in the Gulf of Riga			Gulf of Riga herring catches	
	Gulf of Riga herring	Central Baltic herring	Total	In the Central Baltic	Total
1997	36943	4300	41243	2900	39843
1998	26643	4100	30743	2800	29443
1999	29503	4300	33803	1900	31403
2000	32169	4600	36769	1900	34069
2001	37632	2870	40502	1153	38785
2002	39301	3468	42769	400	39701
2003	40444	4250	44694	359	40803
2004	38923	3334	42257	193	39116
2005	31715	2254	33969	510	32225
2006	30834	3154	33989	398	31232
2007	33617	1486	35103	125	33742
2008	30993	6103	37096	144	31137
2009	32441	4865	37306	112	32553
2010	29743	5206	34949	432	30175
2011	29553	5472	35024	85	29638
2012	27949	3784	31733	166	28115
2013	26258	4103	30360	254	26511
2014	26091	4535	30626	162	26253
2015	32535	4968	37503	316	32851
2016	30576	4315	34892	289	30865
2017	27824	3896	31720	234	28058
2018	25217	4208	29425	530	25747
2019	27721	3560	31281	1200	28922
2020	31986	1264	33249	1229	33215
2021	34984	3126	38110	775	35758
2022	40340	2636	42976	777	41117
2023	42475	5731	48206	325	42800

Table 4.3.3. Sampling of herring landings in the Gulf of Riga in 2023.

Country	Quarter	Landings	Samples	Measured	Aged
Estonia	I	7385	14	1297	1297
	II	10097	12	932	932
	III	484	2	200	200
	IV	2760	9	847	847
	Total	**20726**	**37**	**3276**	**3276**
Latvia	I	10387	9	2160	1013
	II	6486	37	4725	3815
	III	4279	9	2003	870
	IV	6327	8	1629	830
	Total	27480	63	10517	6528
Total	**I**	**17772**	**23**	**3457**	**2310**
	II	16583	49	5657	4747
	III	4763	11	2203	1070
	IV	9088	17	2476	1677
Grand total	**Total**	**48206**	**100**	**13793**	**9804**

Table 4.3.2 Gulf of Riga herring. Catch in numbers 1977-2023 in thousands.

Year	0	1	2	3	4	5	6	7	8+
1977	800	69500	885100	141400	109700	35300	15700	16000	600
1978	7600	112000	97300	403900	39200	35900	9300	3200	5700
1979	15400	76700	176500	103800	342500	22100	19300	6800	5500
1980	18500	101000	125900	99600	55400	133100	10500	8600	2500
1981	10700	62500	172500	112000	83000	51400	71700	7400	3500
1982	1400	80000	96000	116900	68800	43000	29900	24500	3300
1983	3100	49700	225300	138300	77700	38900	23300	15500	9600
1984	1900	44000	152100	255100	96300	56700	32500	14700	11900
1985	4400	23200	283900	203900	121700	31800	23700	8000	6100
1986	1000	9200	106700	246900	110600	66500	19600	8000	5800
1987	1000	70000	49000	110000	205000	75000	32000	5000	2000
1988	1400	6000	197700	112700	112400	144600	38700	27800	5900
1989	15100	61100	47400	492700	143000	76300	53900	6500	5400
1990	12500	88100	83100	67100	263500	66800	27600	14600	4100
1991	18500	119500	234000	94500	40800	180500	40500	35400	40800
1992	12100	150300	339100	369300	91300	33200	157400	19000	47600
1993	8600	192200	381400	298100	224400	66800	19000	78800	26900
1994	11760	164230	288440	368870	263500	192700	46080	9410	56150
1995	18100	232400	316900	363000	426900	277200	170900	39300	51500
1996	31700	428800	450100	281400	247600	291000	183800	105600	57000
1997	31700	204200	930700	559700	345400	242800	186700	90600	61100
1998	19600	239360	282060	505410	274890	172470	114020	90230	67650
1999	31400	361890	446500	157050	316480	157200	83650	60670	81050
2000	49700	259030	552300	359430	123730	258070	83980	35120	53370
2001	38700	819480	461570	378160	261040	81170	120980	56040	70710
2002	29057	304160	1182680	360540	202120	118950	36310	48060	44940
2003	5930	591660	396178	922839	231178	107441	70509	19995	58637
2004	50863	166756	1342017	306214	505774	129160	64392	33204	73423

Year	0	1	2	3	4	5	6	7	8+
2005	44630	384871	205390	833206	213430	171555	55243	27450	28925
2006	70251	787870	600122	113606	467376	100900	70418	16470	20007
2007	28897	305069	1145972	441269	83886	305940	59687	33710	24165
2008	40183	583363	341051	703895	165817	22389	119082	13798	26776
2009	55660	274301	765448	200530	494726	107356	20478	100014	28994
2010	48129	469192	407892	515483	109991	275715	55632	7764	75734
2011	48443	88964	327256	391007	278589	170847	128611	31572	63420
2012	76397	458920	123970	276010	196090	245430	39330	90650	33980
2013	17708	435220	596630	95600	143650	86850	128500	21350	57920
2014	50932	76960	553760	443440	68530	115750	62060	80660	58830
2015	108856	277380	141080	575230	394950	68160	82500	63190	117450
2016	36183	467310	287890	110350	427240	291430	43770	50850	94760
2017	61159	291780	449000	219830	59410	251400	183300	24030	94910
2018	29515	357867	295664	329437	150533	46463	149032	88866	36412
2019	64518	174379	629505	255381	267814	117162	48007	116436	60657
2020	41046	623754	285022	512507	192367	158621	85216	23743	109093
2021	136985	314882	794199	268629	384044	148641	123598	49741	70121
2022	393019	340257	369797	699700	294019	222375	89077	36256	47090
2023	9384	1011031	369883	248755	432233	169836	129861	38607	58110

Table 4.3.4. Gulf of Riga herring. Weights (kg) in catch and stock in 1977-2023.

Year	0	1	2	3	4	5	6	7	8+
1977	0.0029	0.0132	0.0160	0.0227	0.0269	0.0295	0.0312	0.0294	0.0508
1978	0.0053	0.0098	0.0177	0.0219	0.0273	0.0311	0.0304	0.0381	0.0504
1979	0.0063	0.0122	0.0162	0.0234	0.0276	0.0298	0.0340	0.0368	0.0360
1980	0.0071	0.0145	0.0201	0.0241	0.0321	0.0393	0.0456	0.0533	0.0711
1981	0.0076	0.0121	0.0216	0.0288	0.0334	0.0390	0.0439	0.0499	0.0595
1982	0.0054	0.0141	0.0214	0.0287	0.0357	0.0372	0.0451	0.0503	0.0684
1983	0.0057	0.0138	0.0193	0.0276	0.0379	0.0416	0.0509	0.0610	0.0913
1984	0.0054	0.0100	0.0150	0.0215	0.0281	0.0343	0.0391	0.0491	0.0559

Year	0	1	2	3	4	5	6	7	8+
1985	0.0060	0.0129	0.0172	0.0208	0.0278	0.0358	0.0487	0.0531	0.0665
1986	0.0060	0.0126	0.0198	0.0256	0.0314	0.0402	0.0462	0.0639	0.0709
1987	0.0060	0.0101	0.0154	0.0197	0.0263	0.0303	0.0379	0.0431	0.0905
1988	0.0066	0.0117	0.0186	0.0210	0.0273	0.0368	0.0434	0.0586	0.0750
1989	0.0067	0.0120	0.0148	0.0166	0.0196	0.0230	0.0315	0.0382	0.0364
1990	0.0114	0.0146	0.0178	0.0198	0.0269	0.0306	0.0331	0.0522	0.0554
1991	0.0069	0.0119	0.0154	0.0178	0.0199	0.0214	0.0225	0.0269	0.0336
1992	0.0063	0.0112	0.0136	0.0177	0.0215	0.0236	0.0250	0.0264	0.0359
1993	0.0064	0.0125	0.0136	0.0161	0.0201	0.0247	0.0263	0.0275	0.0352
1994	0.0041	0.0112	0.0146	0.0162	0.0188	0.0215	0.0252	0.0263	0.0300
1995	0.0054	0.0104	0.0136	0.0164	0.0179	0.0209	0.0229	0.0263	0.0291
1996	0.0039	0.0105	0.0125	0.0157	0.0177	0.0189	0.0215	0.0235	0.0280
1997	0.0049	0.0097	0.0124	0.0149	0.0178	0.0191	0.0196	0.0212	0.0242
1998	0.0066	0.0101	0.0133	0.0169	0.0182	0.0203	0.0213	0.0225	0.0240
1999	0.0049	0.0131	0.0155	0.0189	0.0221	0.0231	0.0245	0.0265	0.0289
2000	0.0063	0.0125	0.0165	0.0201	0.0229	0.0254	0.0264	0.0282	0.0296
2001	0.0052	0.0102	0.0160	0.0205	0.0230	0.0245	0.0277	0.0283	0.0307
2002	0.0050	0.0100	0.0153	0.0193	0.0236	0.0250	0.0271	0.0280	0.0309
2003	0.0047	0.0076	0.0153	0.0199	0.0223	0.0248	0.0263	0.0268	0.0276
2004	0.0044	0.0086	0.0101	0.0165	0.0210	0.0242	0.0268	0.0271	0.0331
2005	0.0052	0.0120	0.0139	0.0158	0.0193	0.0241	0.0254	0.0287	0.0308
2006	0.0054	0.0086	0.0132	0.0178	0.0191	0.0228	0.0266	0.0275	0.0296
2007	0.0056	0.0089	0.0117	0.0154	0.0202	0.0196	0.0237	0.0271	0.0278
2008	0.0054	0.0098	0.0149	0.0173	0.0205	0.0239	0.0233	0.0285	0.0327
2009	0.0058	0.0092	0.0140	0.0176	0.0191	0.0218	0.0207	0.0244	0.0294
2010	0.0045	0.0091	0.0138	0.0169	0.0194	0.0209	0.0237	0.0231	0.0260
2011	0.0045	0.0123	0.0159	0.0184	0.0215	0.0238	0.0254	0.0257	0.0288
2012	0.0055	0.0094	0.0159	0.0203	0.0232	0.0258	0.0277	0.0299	0.0334
2013	0.0058	0.0097	0.0146	0.0197	0.0227	0.0257	0.0282	0.0295	0.0319

Year	0	1	2	3	4	5	6	7	8+
2014	0.0056	0.0098	0.0138	0.0176	0.0216	0.0236	0.0253	0.0271	0.0302
2015	0.0058	0.0089	0.0150	0.0182	0.0211	0.0230	0.0252	0.0272	0.0295
2016	0.0060	0.0086	0.0152	0.0181	0.0204	0.0223	0.0239	0.0260	0.0283
2017	0.0051	0.0087	0.0147	0.0185	0.0209	0.0225	0.0241	0.0248	0.0276
2018	0.0065	0.0097	0.0153	0.0191	0.0216	0.0230	0.0245	0.0256	0.0284
2019	0.0059	0.0087	0.0136	0.0181	0.0207	0.0232	0.0237	0.0248	0.0262
2020	0.0060	0.0090	0.0154	0.0189	0.0212	0.0231	0.0250	0.0247	0.0260
2021	0.0054	0.0086	0.0138	0.0178	0.0196	0.0215	0.0231	0.0247	0.0253
2022	0.0055	0.0107	0.0153	0.0190	0.0219	0.0238	0.0255	0.0279	0.0282
2023	0.0080	0.0087	0.0168	0.0210	0.0247	0.0278	0.0300	0.0314	0.0344

Table 4.3.5. Gulf of Riga herring. Maturity ogive, GAM smoothed values for 1995-2023, fixed values for 1997-1994.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8+
1977	0	0	0.93	0.98	0.98	1	1	1	1
1978	0	0	0.93	0.98	0.98	1	1	1	1
1979	0	0	0.93	0.98	0.98	1	1	1	1
1980	0	0	0.93	0.98	0.98	1	1	1	1
1981	0	0	0.93	0.98	0.98	1	1	1	1
1982	0	0	0.93	0.98	0.98	1	1	1	1
1983	0	0	0.93	0.98	0.98	1	1	1	1
1984	0	0	0.93	0.98	0.98	1	1	1	1
1985	0	0	0.93	0.98	0.98	1	1	1	1
1986	0	0	0.93	0.98	0.98	1	1	1	1
1987	0	0	0.93	0.98	0.98	1	1	1	1
1988	0	0	0.93	0.98	0.98	1	1	1	1
1989	0	0	0.93	0.98	0.98	1	1	1	1
1990	0	0	0.93	0.98	0.98	1	1	1	1
1991	0	0	0.93	0.98	0.98	1	1	1	1
1992	0	0	0.93	0.98	0.98	1	1	1	1

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8+
1993	0	0	0.93	0.98	0.98	1	1	1	1
1994	0	0	0.93	0.98	0.98	1	1	1	1
1995	0	0.25	0.71	0.94	0.99	1	1	1	1
1996	0	0.25	0.70	0.94	0.99	1	1	1	1
1997	0	0.25	0.70	0.94	0.99	1	1	1	1
1998	0	0.25	0.69	0.94	0.99	1	1	1	1
1999	0	0.25	0.69	0.93	0.99	1	1	1	1
2000	0	0.24	0.69	0.93	0.99	1	1	1	1
2001	0	0.24	0.68	0.93	0.99	1	1	1	1
2002	0	0.24	0.68	0.93	0.98	1	1	1	1
2003	0	0.24	0.67	0.92	0.98	1	1	1	1
2004	0	0.24	0.67	0.92	0.98	1	1	1	1
2005	0	0.24	0.66	0.92	0.98	1	1	1	1
2006	0	0.24	0.66	0.91	0.98	1	1	1	1
2007	0	0.24	0.65	0.91	0.98	1	1	1	1
2008	0	0.24	0.64	0.91	0.98	1	1	1	1
2009	0	0.25	0.64	0.91	0.98	1	1	1	1
2010	0	0.25	0.64	0.90	0.97	1	1	1	1
2011	0	0.25	0.63	0.90	0.97	1	1	1	1
2012	0	0.25	0.63	0.90	0.97	1	1	1	1
2013	0	0.25	0.62	0.89	0.97	1	1	1	1
2014	0	0.26	0.62	0.89	0.97	1	1	1	1
2015	0	0.26	0.62	0.89	0.97	1	1	1	1
2016	0	0.27	0.62	0.88	0.96	1	1	1	1
2017	0	0.27	0.61	0.88	0.96	1	1	1	1
2018	0	0.27	0.61	0.88	0.96	1	1	1	1
2019	0	0.27	0.61	0.87	0.96	1	1	1	1
2020	0	0.28	0.60	0.87	0.96	1	1	1	1
2021	0	0.28	0.60	0.87	0.96	1	1	1	1

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8+
2022	0	0.28	0.60	0.87	0.96	1	1	1	1
2023	0	0.28	0.59	0.86	0.96	1	1	1	1

Table 4.3.6. Gulf of Riga herring. Tuning fleet: hydro-acoustics survey.

Year	Effort	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8+
1999	1	5292	4363	1343	1165	457	319	208	98
2000	1	4486	4012	1791	609	682	336	151	243
2001	1	7567	2004	1447	767	206	296	56	173
2002	1	3998	5994	1068	526	221	87	165	128
2003	1	12441	1621	2251	411	263	269	46	193
2004	1	3177	10694	675	1352	218	195	94	137
2005	1	8190	1564	4532	337	691	92	75	83
2006	1	12082	1986	213	937	112	223	36	49
2007	1	1478	3662	1265	143	968	116	103	39
2008	1	9231	2109	4398	816	134	353	6	23
2009	1	6422	4703	870	1713	284	28	223	44
2010	1	5077	2311	1730	244	593	107	12	50
2011	1	3162	5289	2503	2949	597	865	163	162
2012	1	5957	758	1537	774	1035	374	308	193
2013	1	9435	5552	592	1240	479	827	187	427
2014	1	1109	3832	2237	276	570	443	466	370
2015	1	3221	539	1899	1110	255	346	181	325
2016	1	4542	1081	504	1375	690	152	113	103
2017	1	3231	3442	874	402	1632	982	137	752
2018	1	11216	4529	3607	776	338	1439	755	381
2019	1	4912	7007	2237	1335	475	228	681	265
2020	1	9947	2637	3571	1189	985	344	186	805
2021	1	6171	4885	990	2085	793	670	257	405
2022	1	5247	1842	2259	1022	734	298	102	131
2023	1	4647	947	740	1188	752	641	205	379

Table 4.3.7. Gulf of Riga herring. SAM output: Fishing mortality at age.

Year	0	1	2	3	4	5	6	7	8+	F_{bar} (2-6)
1977	0.005	0.131	0.368	0.590	0.700	0.736	0.917	0.844	0.844	0.662
1978	0.005	0.105	0.280	0.411	0.491	0.567	0.618	0.641	0.641	0.473
1979	0.005	0.105	0.283	0.412	0.509	0.589	0.736	1.034	1.034	0.506
1980	0.004	0.088	0.248	0.352	0.419	0.518	0.605	0.819	0.819	0.428
1981	0.004	0.076	0.246	0.385	0.465	0.552	0.703	0.894	0.894	0.470
1982	0.003	0.050	0.205	0.358	0.443	0.527	0.647	0.777	0.777	0.436
1983	0.002	0.041	0.204	0.394	0.488	0.554	0.693	0.780	0.780	0.466
1984	0.002	0.031	0.190	0.423	0.581	0.655	0.974	1.132	1.132	0.565
1985	0.002	0.025	0.165	0.364	0.494	0.583	0.835	0.905	0.905	0.488
1986	0.001	0.017	0.121	0.278	0.412	0.528	0.743	0.917	0.917	0.417
1987	0.001	0.019	0.106	0.236	0.348	0.451	0.491	0.445	0.445	0.326
1988	0.001	0.019	0.102	0.239	0.362	0.475	0.601	0.650	0.650	0.356
1989	0.003	0.041	0.139	0.282	0.364	0.409	0.370	0.264	0.264	0.313
1990	0.003	0.034	0.117	0.223	0.273	0.328	0.254	0.156	0.156	0.239
1991	0.003	0.038	0.121	0.215	0.276	0.361	0.395	0.391	0.391	0.274
1992	0.003	0.047	0.137	0.224	0.279	0.367	0.420	0.434	0.434	0.285

Year	0	1	2	3	4	5	6	7	8+	F_{bar} (2-6)
1993	0.004	0.058	0.143	0.207	0.252	0.340	0.370	0.367	0.367	0.263
1994	0.004	0.062	0.150	0.207	0.252	0.339	0.357	0.348	0.348	0.261
1995	0.005	0.081	0.187	0.255	0.317	0.406	0.475	0.517	0.517	0.328
1996	0.007	0.101	0.221	0.282	0.344	0.434	0.523	0.626	0.626	0.361
1997	0.009	0.137	0.293	0.369	0.432	0.485	0.540	0.585	0.585	0.424
1998	0.008	0.116	0.272	0.334	0.398	0.461	0.480	0.518	0.518	0.389
1999	0.008	0.129	0.281	0.330	0.390	0.456	0.461	0.487	0.487	0.383
2000	0.009	0.133	0.301	0.362	0.417	0.465	0.434	0.389	0.389	0.396
2001	0.010	0.157	0.341	0.425	0.493	0.516	0.522	0.533	0.533	0.459
2002	0.010	0.147	0.337	0.428	0.485	0.492	0.464	0.400	0.400	0.441
2003	0.009	0.126	0.329	0.446	0.530	0.525	0.533	0.474	0.474	0.472
2004	0.011	0.159	0.364	0.490	0.601	0.588	0.669	0.701	0.701	0.543
2005	0.011	0.146	0.340	0.439	0.545	0.543	0.613	0.560	0.560	0.496
2006	0.012	0.144	0.318	0.399	0.463	0.482	0.498	0.415	0.415	0.432
2007	0.014	0.170	0.334	0.426	0.494	0.496	0.578	0.490	0.490	0.466
2008	0.012	0.135	0.271	0.324	0.352	0.386	0.384	0.371	0.371	0.343
2009	0.012	0.123	0.249	0.309	0.341	0.402	0.438	0.448	0.448	0.348

Year	0	1	2	3	4	5	6	7	8+	F_{bar} (2-6)
2010	0.014	0.138	0.239	0.291	0.299	0.374	0.373	0.403	0.403	0.315
2011	0.012	0.106	0.208	0.277	0.289	0.373	0.356	0.439	0.439	0.301
2012	0.013	0.105	0.198	0.252	0.264	0.325	0.286	0.328	0.328	0.265
2013	0.012	0.095	0.180	0.219	0.224	0.280	0.245	0.247	0.247	0.230
2014	0.012	0.094	0.176	0.214	0.228	0.282	0.262	0.282	0.282	0.232
2015	0.016	0.130	0.213	0.256	0.279	0.323	0.351	0.415	0.415	0.284
2016	0.015	0.128	0.211	0.254	0.278	0.320	0.364	0.409	0.409	0.285
2017	0.014	0.111	0.192	0.232	0.253	0.296	0.351	0.412	0.412	0.265
2018	0.012	0.086	0.169	0.206	0.234	0.267	0.286	0.288	0.288	0.232
2019	0.012	0.091	0.179	0.219	0.259	0.288	0.330	0.300	0.300	0.255
2020	0.015	0.113	0.195	0.232	0.271	0.295	0.347	0.307	0.307	0.268
2021	0.017	0.133	0.216	0.253	0.297	0.311	0.368	0.310	0.310	0.289
2022	0.019	0.152	0.235	0.272	0.307	0.300	0.308	0.215	0.215	0.284
2023	0.020	0.172	0.244	0.273	0.310	0.299	0.298	0.212	0.212	0.285

Table 4.3.8. Gulf of Riga herring. SAM output: Stock numbers at age (start of year) (10^3)

Year	0	1	2	3	4	5	6	7	8+
1977	1265679	666955	2832308	299149	230909	66913	26086	32659	1148
1978	1142958	1082133	498277	1504515	124200	92248	24724	8105	12408
1979	1618721	913328	773254	346794	831439	61057	42547	11018	8950
1980	1295507	1244804	646570	429558	202036	363266	27451	16064	5282
1981	2270552	959648	839163	397266	241155	124775	156050	12604	7079
1982	1699068	1776734	659908	466724	214168	118414	64199	55240	6450
1983	2347844	1337353	1293443	429576	241969	108560	54974	28500	21349
1984	1350905	1875179	991327	777919	217410	115019	51077	22369	18373
1985	968603	1104789	1675571	676143	385428	90637	45424	15580	11024
1986	3690334	747393	913688	1156576	369095	191368	41070	14959	9212
1987	588119	3316930	639870	638255	728163	195267	96212	15933	7221
1988	1600507	452519	2574921	556725	423144	414986	90904	52184	12559
1989	3642702	1326384	396656	1998744	412246	253571	207191	35773	26352
1990	4346891	2976676	916005	305648	1222003	235634	146586	120652	36433
1991	4722724	3537308	2390130	622699	193097	757619	130922	103916	121940
1992	4165855	3832474	2781987	1821287	419471	118418	470361	66505	131518
1993	3479271	3406393	3096125	1926908	1174863	267859	66281	264275	101683
1994	4095537	2843072	2476924	2252202	1318196	764034	166019	36612	209218
1995	5632054	3352223	2122460	1726690	1572027	870111	466322	100293	143287
1996	2304751	4740419	2566175	1431365	1066498	929113	479253	239730	123830
1997	3252890	1795299	3543633	1736218	949016	653009	496202	230576	156544
1998	3648046	2637983	1244411	2024680	932928	501053	335349	240474	179501
1999	3039185	2998901	2031847	734007	1135400	491717	253957	175644	206980
2000	7072971	2402093	2198867	1259961	423872	660227	257076	127533	192194
2001	2963017	5948848	1776672	1254638	715068	222831	342627	132822	184896
2002	7306079	2301522	4395715	1074184	630042	345348	108133	167494	152076
2003	1508536	6327917	1507843	2602282	573800	310014	178147	55536	181632
2004	3982765	1185319	5031302	841288	1297701	275671	155048	79660	130856

Year	0	1	2	3	4	5	6	7	8+
2005	7923963	3223798	758597	2936216	448799	531376	122165	67605	80274
2006	2662656	6728099	2287210	390584	1602041	230709	231910	52894	67555
2007	5848258	2033799	4783635	1351732	203168	904626	117770	110261	65838
2008	3711312	4942160	1427205	2925519	650695	95452	483719	47101	92395
2009	4114900	2971116	3617561	868434	1774391	362034	53944	303133	82110
2010	1449192	3386028	2179400	2343264	527532	1003316	194206	27597	225653
2011	5896897	1091407	2203111	1433767	1448372	384319	541828	106842	156518
2012	6261625	4927290	778698	1429771	823645	945816	202615	321572	139605
2013	1308907	5213385	3791448	527482	870634	464052	587566	119304	281385
2014	3006139	1005981	3963805	2586790	361417	542561	300249	366652	259500
2015	5188673	2419844	773114	2823925	1695955	257042	319870	193757	380206
2016	3576532	4216612	1622604	548031	1840716	1072808	153389	178518	305956
2017	5970858	2856008	3022229	1075440	346144	1152396	646565	82546	275080
2018	3089930	4953920	2120939	1994822	710853	237998	718998	364444	177591
2019	7144557	2435084	3932702	1469344	1237398	482246	166843	464763	295046
2020	3608013	5977654	1886355	2690171	944462	731812	306837	100174	445752
2021	3684751	2882221	4365574	1374427	1700233	604640	426653	185518	308009
2022	7870914	2863830	1931847	2890573	1074325	968371	369241	220588	283101
2023	1775021	6436368	1902012	1225889	1749459	697393	579247	218877	335206

Table 4.3.9. Gulf of Riga herring. SAM output: Summary. Numbers in thousand and biomass in tonnes. High and Low refer to 95% confidence intervals.

Year	Recruitment (Age 0)			Stock size			Catches	F (2-6)		
	R	High	Low	SSB*	High	Low		F	High	Low
1977	1265679	1771263	904408	52816	62695	44494	24186	0.66	0.76	0.58
1978	1142958	1585579	823897	43719	50995	37481	16728	0.47	0.54	0.42
1979	1618721	2268069	1155281	40862	46384	35998	17142	0.51	0.57	0.45
1980	1295507	1823509	920390	40402	45240	36081	14998	0.43	0.49	0.38
1981	2270552	3181847	1620256	43346	48495	38743	16769	0.47	0.53	0.42
1982	1699068	2379954	1212979	39498	44195	35299	12777	0.44	0.49	0.39
1983	2347844	3332265	1654242	48959	55452	43226	15541	0.47	0.53	0.41
1984	1350905	1915788	952582	39869	45160	35197	15843	0.56	0.64	0.49
1985	968603	1398683	670767	52899	60835	45998	15575	0.49	0.56	0.42
1986	3690334	5329088	2555514	62408	71651	54358	16927	0.42	0.49	0.36
1987	588119	839428	412047	46748	53700	40696	12884	0.33	0.38	0.28
1988	1600507	2267519	1129703	83083	97035	71137	16791	0.36	0.43	0.30
1989	3642702	5146087	2578518	55361	64271	47686	16783	0.31	0.37	0.26
1990	4346891	6124242	3085355	67835	78311	58761	14931	0.24	0.28	0.20
1991	4722724	6648064	3354980	68948	79855	59532	14791	0.27	0.32	0.23
1992	4165855	5841952	2970643	88873	102280	77222	21700	0.29	0.33	0.24
1993	3479271	4862426	2489565	103102	118412	89772	22700	0.26	0.31	0.22
1994	4095537	5698552	2943453	111830	127120	98378	24300	0.26	0.30	0.22
1995	5632054	7816471	4058102	109104	121856	97686	32656	0.33	0.38	0.29
1996	2304751	3204086	1657845	101817	113078	91677	32584	0.36	0.41	0.31
1997	3252890	4484548	2359500	96782	108163	86598	39843	0.42	0.49	0.37
1998	3648046	4957135	2684664	85288	95190	76417	29443	0.39	0.45	0.34
1999	3039185	4121398	2241144	85454	95066	76813	31403	0.38	0.44	0.33
2000	7072971	9595314	5213682	86154	95777	77497	34069	0.40	0.45	0.35
2001	2963017	4041940	2172093	85763	94976	77444	38785	0.46	0.52	0.40
2002	7306079	10066485	5302625	92425	103701	82375	39701	0.44	0.50	0.39
2003	1508536	2064922	1102066	92398	103458	82521	40803	0.47	0.54	0.42

Year	Recruitment (Age 0)			Stock size			Catches	F (2-6)		
	R	High	Low	SSB*	High	Low		F	High	Low
2004	3982765	5408167	2933049	79634	89017	71240	39116	0.54	0.62	0.48
2005	7923963	10819020	5803593	75828	85466	67277	32225	0.50	0.57	0.43
2006	2662656	3644699	1945219	74392	83588	66208	31232	0.43	0.50	0.38
2007	5848258	7980675	4285618	77412	87677	68348	33742	0.47	0.54	0.40
2008	3711312	5069966	2716751	90672	103098	79743	31137	0.34	0.40	0.30
2009	4114900	5637474	3003543	92668	105173	81650	32553	0.35	0.40	0.30
2010	1449192	2001014	1049546	92624	105303	81471	30175	0.32	0.37	0.27
2011	5896897	8106615	4289509	97366	111275	85195	29638	0.30	0.35	0.26
2012	6261625	8626659	4544975	96725	110790	84446	28115	0.26	0.31	0.22
2013	1308907	1802815	950312	105602	121081	92102	26511	0.23	0.27	0.194
2014	3006139	4128594	2188849	110682	127537	96054	26253	0.23	0.27	0.197
2015	5188673	7160595	3759789	109811	127069	94897	32851	0.28	0.34	0.24
2016	3576532	4963965	2576888	98553	114563	84781	30865	0.29	0.34	0.24
2017	5970858	8349312	4269949	97990	115170	83373	28058	0.26	0.32	0.22
2018	3089930	4348829	2195457	106943	127237	89886	25747	0.23	0.28	0.190
2019	7144557	10168551	5019859	108283	130548	89815	28922	0.26	0.32	0.21
2020	3608013	5283825	2463699	120694	148327	98208	33215	0.27	0.34	0.21
2021	3684751	5710419	2377652	117333	148892	92463	35758	0.29	0.38	0.22
2022	7870914	13803646	4488038	127561	170441	95469	41117	0.28	0.39	0.21
2023	3684751**	7870914**	1308907**	136638	196506	95009	42800	0.28	0.42	0.193
2024	3711312**	7870914**	1308907**	131262***	208663***	81960***				

*** At spawning time.**

**** Median recruitment, resampled from 1989–2022.**

***** Predicted.**

Table 4.3.10. Gulf of Riga herring. Short-term forecast input.

2024								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
0	3711312		0.000			0.00627	0.02	0.00627
1	3047431	0.2	0.276	0.2	0.3	0.00935	0.15	0.00935
2	4410244	0.2	0.595	0.2	0.3	0.01530	0.21	0.01530
3	1222338	0.2	0.866	0.2	0.3	0.01924	0.24	0.01924
4	765690	0.2	0.960	0.2	0.3	0.02208	0.27	0.02208
5	1051624	0.2	1.000	0.2	0.3	0.02437	0.26	0.02437
6	420919	0.2	1.000	0.2	0.3	0.02620	0.25	0.02620
7	354373	0.2	1.000	0.2	0.3	0.02800	0.19	0.02800
8+	374309	0.2	1.000	0.2	0.3	0.02930	0.19	0.02930

2025								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
0	3711312		0.000			0.00627	0.02	0.00627
1	3149891	0.2	0.276	0.2	0.3	0.00935	0.15	0.00935
2	2188151	0.2	0.595	0.2	0.3	0.01530	0.21	0.01530
3	2887067	0.2	0.866	0.2	0.3	0.01924	0.24	0.01924
4	791388	0.2	0.960	0.2	0.3	0.02208	0.27	0.02208
5	479043	0.2	1.000	0.2	0.3	0.02437	0.26	0.02437
6	660201	0.2	1.000	0.2	0.3	0.02620	0.25	0.02620
7	263119	0.2	1.000	0.2	0.3	0.02800	0.18	0.02800
8+	490519	0.2	1.000	0.2	0.3	0.02930	0.18	0.02930

2026								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
0	3982765		0.000			0.00627	0.02	0.00627
1	3134103	0.2	0.276	0.2	0.3	0.00935	0.17	0.00935
2	2207419	0.2	0.595	0.2	0.3	0.01530	0.24	0.01530
3	1420696	0.2	0.866	0.2	0.3	0.01924	0.26	0.01924

4	1859953	0.2	0.960	0.2	0.3	0.02208	0.30	0.02208
5	488448	0.2	1.000	0.2	0.3	0.02437	0.29	0.02437
6	300898	0.2	1.000	0.2	0.3	0.02620	0.28	0.02620
7	414832	0.2	1.000	0.2	0.3	0.02800	0.20	0.02800
8+	514404	0.2	1.000	0.2	0.3	0.02930	0.20	0.02930

Input units are thousand and kg
M= natural mortality
Mat=maturity ogive
PF=proportion of F before spawning
PM=proportion of M before spawning
SWt=weight in stock (kg)
Sel=exploitation pattern
CWt=weight in catch (kg)

Table 4.3.11. Gulf of Riga herring. Short-term results as used in ICES advice.

Basis	Total catch (2025)	F (2025)	SSB (2025)	SSB (2026)	% SSB change **	% Advice change ***	Probability SSB < Blim in 2026 (%)^^^
ICES advice basis							
EU MAP*: F_{MSY}	39233	0.28	133844	128161	-4.2	9.3	0.4
EU MAP*: MAP range F_{lower}	30394	0.21	135620	137695	1.53	9.7^	0.2
EU MAP*: MAP range F_{upper}	45235	0.33	132678	121900	-8.1	9.3^^	0.7
Other scenarios							
F = 0	0	0	140655	171863	22	-100	0
F = F_{pa}	47593	0.35	132193	119479	-9.6	33	0.8
F = F_{lim}	62780	0.49	128805	103729	-19	75	3.3
SSB (2025) = SSB (2026)	32720	0.228	135193	135193	0	-8.9	0.2
SSB (2026) = B_{lim}	118298	1.232	111994	52076	-54	230	50
SSB (2026) = B_{pa} = MSY $B_{trigger}$	94540	0.854	120182	72906	-39	163	23
F = F_{2024}	35529	0.25	134609	131298	-2.5	-1.0	0.4

*** MAP (EU, 2016, 2019, 2020).**

**** SSB 2026 relative to SSB 2025.**

***** Total catch in 2025 relative to ICES advice for 2024 (35 902 tonnes for the Gulf of Riga herring stock).**

^ ICES advice for F_{lower} for 2025 relative to ICES advice for EU MAP range F_{lower} for 2024 (27 696 tonnes).

^^ ICES advice for F_{upper} for 2025 relative to ICES advice for EU MAP range F_{upper} for 2024 (41 370 tonnes).

^^^ The probability of SSB being below B_{lim} in 2026. This probability relates to the short-term probability of SSB < B_{lim} and is not comparable to the long-term probability of SSB < B_{lim} tested in simulations when estimating fishing mortality reference points.

Figure 4.3.1. Gulf of Riga herring. Relative catch at age in numbers (left) and biomass (right) in 1977-2023.

Figure 4.3.2. Gulf of Riga herring. Catch proportion at age.

Figure 4.3.3. Gulf of Riga herring. Internal consistency in catch-at-age. Latest year is shown in red.

Figure 4.3.4. Gulf of Riga herring. Mean weight at age in the catches.

Figure 4.3.5. Gulf of Riga herring. Maturity ogive. Points are GLM estimates and lines shows the GAM smoothed values.

Figure 4.3.6. Gulf of Riga herring. Proportion of ages in hydro-acoustics tuning fleet.

Figure 4.3.7. Gulf of Riga herring. Internal consistency in hydro-acoustics tuning fleet. Latest year is shown in red.

Figure 4.3.8. Gulf of Riga herring. Stock summary. This year's assessment comparison (green line) with last year's assessment (black dotted line).

Figure 4.3.9. Gulf of Riga herring. SAM acoustic survey estimates at age from this year's assessment (blue) compared to last year's assessment (red). Dots are observations.

Figure 4.3.10. Gulf of Riga herring. SAM stock numbers at age estimates from this year's assessment (blue) compared to last year's assessment (red).

Figure 4.3.11. Gulf of Riga herring. One-observation-ahead residuals for catch and survey.

Figure 4.3.12. Gulf of Riga herring. Process error (logN, logF) residuals.

Figure 4.3.13. Gulf of Riga herring. Retrospective analysis (5 years).

Figure 4.3.14. Gulf of Riga herring. Short term prediction. Age composition of catches and SSB.

Figure 4.3.15. Gulf of Riga. Compare numbers-at-age in the forecast.

Figure 4.3.16. Gulf of Riga herring. Compare stock weights-at-age used in forecast.

Figure 4.3.17. Gulf of Riga herring. Compare forecast assumptions for SSB, F, R and total catch.

4.4 Herring in Subdivisions 30 and 31 (Gulf of Bothnia)

4.4.1 The Fishery

The three main fleets operating in Baltic herring fisheries in the Gulf of Bothnia are:

- Pelagic trawling (single and pair trawling)
- Demersal trawling
- Trapnet fisheries (spawning fishery)

In the Finnish trawl fishery, the same trawls are often used in the pelagic trawling near the surface and in deeper mid-water. In 2023, 93% of the Finnish catches were fished with trawls, 7% with trapnets and 0.05% with gillnets. In 2023, 98,3% of the Swedish catches came from trawls, 1,6% from gillnets and 0.04% from other fishing gears.

4.4.1.1 Landings

The total catch in the Gulf of Bothnia decreased by 11787 tonnes (15%) from 78614 tonnes in 2022 to 66827 tonnes in 2023 (Figure 4.4.1), of which 83% (55635 tonnes) was Finnish catch and 17% (11192 tonnes) Swedish catch (Table 4.4.1). The Finnish catch decreased by 7% (4 155 tonnes) and the Swedish catch by 34% (5716 tonnes) compared to 2022.

4.4.1.2 Unallocated removals

No unallocated removals were reported.

4.4.1.3 Discards

Discarding rates in the fisheries are small. Logbook reported discards sum up to 009% (59 tonnes) of total catches and those have been taken into account in the assessment. One reason for discarding is connected with the catch amounts related to the market's demand. In gillnet and trapnet fisheries, all the fish damaged by seal (grey or ringed) predation are typically discarded. In autumn, herring is also sometimes appearing as unwanted bycatch in the vendace and whitefish fisheries. Most of the Swedish discards are reported in the herring fishery with gillnets. In Sweden, however, the previously made interviews for fishermen indicated that estimations of the discard rate was about 10% for the entire year.

However, the reported discards have historically constituted at most up to 1% of the total GoB herring catches and old discards are therefore regarded as negligible.

4.4.1.4 Effort and CPUE data

One commercial tuning series is used in the assessment, a trapnet cpue time series from Bothnian Sea 1990–2006, with ages 3-9. In the trapnet fisheries the number of trapnets set is used as effort (Figure 4.4.2). Throughout the 1980s the number of set trap nets decreased drastically, in 1991 the amount of set nets had declined by 80% in comparison to 1980. Since then, the amount remained more or less stable.

The trapnet-tuning fleet was renewed in 2013 according to recommendations from WKPELA 2012 (see also IBP her-30 report). It consisted of gapless catch and effort timeseries, combined from three areas within the Finnish coast of Bothnian Sea (Finnish rectangles 23, 42 and 47) (Figure 4.4.3). Since 2015, however, the area 23 did not have a qualified trapnet fishery anymore, i.e. catch and effort were 0. The time series was further shortened from originally 1990–2014 to 1990–2006, due to a declining effort trend).

4.4.2 Biological information

4.4.2.1 Catch in numbers

During the WKCluB benchmark-meeting in 2021 the age- matrix was expanded from age 10+ to 15+ due to the SS3-model's requirements (Figure 4.4.4). Finnish catch at age data from the Bothnian Sea were available for all years and have been applied on Swedish catches, excluding the years: 1987, 1989–1991, 1993 and 2000–2015. During mentioned years the Swedish catches were mostly allocated according to Swedish catch sampling. For the calculations of catch in numbers in 2023 Finnish and Swedish unsampled catches were mostly allocated in InterCatch according to the Finnish sampling and mostly from respective fisheries and year-quarters. Finnish and Swedish sampled catches are shown in Table 4.4.2. The most common age-group in catches (both in numbers and in terms of biomass) during 2023 was age-group 4. In the recent years the number of fish has declined in most age groups, especially in the older age groups (7-15+). The total catch at age in numbers is also shown in Table 4.4.3. The internal consistency of the age estimates is shown in Figure 4.4.5.

4.4.2.2 Mean weight at age

The average weight at age has decreased for all ages since about the end of 1990's (Table 4.4.4 and Figure 4.4.6), but stabilized in the 2000's. During recent years weights at age were quite stable for all age-groups, however, in 2021 the mean weights decreased considerably in all age-groups except age 1 and 14. In 2022 the situation improved in many age-groups and the improvement continued in 2023 in all ages except the 15+ group.

4.4.2.3 Maturity at age

Constant maturity ogives have been used for the period 1980–1982. Since 1983 the proportion of mature individuals at age have been annually updated from the samples taken before spawning time. Updated maturity ogives since 1980 are shown in Table 4.4.5 and Figure 4.4.7. The annual maturation variation in age-group 2 is usually quite large. The sensitivity of the variability in maturity ogives from year to year was evaluated during the benchmark working group in 2012 and it was concluded to continue the annual updates of maturity ogives (ICES 2012).

4.4.2.4 Quality of catch and biological information

From Finnish commercial catches, 77 length samples and 67 age samples were taken during 2023, and 12 length samples and 8 age samples from the Swedish fisheries. In total, during 2023, 26970 herrings were length-measured and 2249 were aged (Table 4.4.2).

In the BIAS trawl samples, mean Fulton's condition ($K = W/L^3$) has gradually increased since 2015 in small herring with total length of 10–12 cm, whereas in length groups 13–15 cm condition has been relatively stable. In larger herring, i.e. length groups 16–20 cm, the earlier stable condition decreased from 0.62–0.64 in 2019 to 0.47–0.53 in 2021, but had increased to 0.57–0.59 in 2023 (Figure 4.4.10). According to samples from commercial fishery, the condition continued to improve throughout 2023. The condition of larger herring size groups in 2021 was the lowest observed in 1973–2022 (however, old values of condition are from age groups, not length groups). Weight at age decreased from 2019 in almost all age groups, more in old than young herring, and increased again in 2023 (Figure 4.4.6).

The practical starving of larger herring may have been caused by several co-occurring phenomena: large crustaceans that are typical food for herring, amphipods, have not been abundant in recent decades (Henrik Nygård, pers.comm.), and mysids that were commonly seen in herring surveys in the 2010s and foraged by the herring, were seen rarely in the survey of 2021. Mysids were still not abundant in 2022 among the catch nor in the stomachs of large herring. In 2023,

mysids were more commonly seen among the catch and typical prey in the stomachs of larger herring. These observations suggest a recovery in the food resources of herring.

4.4.3 Fishery independent information

A joint Finnish - Swedish –hydroacoustic survey has been annually conducted in late September – early October in the Bothnian Sea. Vessels used during the periods: 2007-2010: Swedish RV Argos and continued in 2011-2012 with Danish RV Dana, during: 2013-2016 with Finnish RV Aranda, in late October 2017 with RV Dana and in 2018-2023 with RV Aranda. This survey is coordinated by ICES within the frame of Baltic International Acoustic Surveys (BIAS, ICES Code A1588). The survey covers most of the SD 30 area, excluding only the shallow areas (mostly < 40 metres) mainly along the Finnish coast and SD 31, which has not been surveyed. The survey generally tracks all age groups well, except for the ages 0, 1 and 2 (Figure 4.4.8). The survey is providing yearly estimates of abundance (Table 4.4.6). In the 2017 benchmark the age-group 1 was included in the survey-index after a conclusion that it had similar consistency within the age-matrix (Figure 4.4.9) as the other age groups (ICES 2017).

In 2012 the survey was not performed according to standard coverage (60 nmi per 1000 nmi^2 = statistical rectangle), instead only half of it and with 50% less control trawl hauls (normally 2 per rectangle) due to the withdrawal of the Swedish half of the total funds to the survey. In 2015 a part of the Bothnian Sea was not covered due to breakdown of the research vessel, but the acoustic index was accepted by WGBIFS to be used in assessment (ICES 2016). In 2016-2020 the survey coverage was good. In 2021, 2022 and 2023 Swedish authorities denied the use of acoustic equipment in two rectangles close to Swedish coast, which diminished the overall coverage. Acoustic surveys have shown to be essential for the assessment of this stock, and therefore they should be continued with the required effort-level.

4.4.4 Assessment

4.4.4.1 SS3

After the benchmark (WKCluB) in 2021, the assessment for the Gulf of Bothnia herring (SD 3031) was upgraded from category 5 to category 1. In the benchmark a new model, Stock Synthesis (SS3 v. 3.30, Method & Wetzel, 2013), was evaluated and taken into use for the assessment of Gulf of Bothnia Herring SD 30-31 in order to minimize the previously observed retrospective pattern. A mistake in the survey input data in the 2019 assessment was detected and found to be the cause to the earlier high Mohn's rho values. In the 2024 assessment, SS3 was updated to version 3.30.22.1.

The model input starts with catch data from year 1963 and age-composition data from 1980 (Fig. 4.3.11), and the initial population age structure was assumed to be in an exploited state, so that the initial catches was assumed to be the average of last three years (1963–1965) in the time-series. Fishing mortality was modelled using hybrid F method (Methot & Wetzel, 2013). Option 5 was selected for the F report basis; this option represents a recent addition to SS3 and corresponds to the fishing mortality requested by the ICES framework (i.e. simple unweighted average of the F of the age classes chosen to represent the F_{bar} (age 3–7)). Further details on model settings can be found in the benchmark report (ICES, 2019).

The assessment is using two tuning indexes, 2007-2021 acoustic time series with ages 1-15+ from Bothnian sea (Table 4.4.6 & Figure 4.4.8) and 1990-2006 time series of age groups 3-9 from Trapnet catches in Bothnian sea (Figures 4.3.2 & 4.3.3).

The spawning stock of Gulf of Bothnia herring diminished from early 1960's to a relatively low level in the beginning of the 1970's until the beginning of 1980's, from which it started to increase and peaked in 1994 (Fig. 4.3.12, Table 4.4.7). From there it decreased again until early 2000's and levelled down until a small peak in 2010, after which the spawning stock has again showed a decreasing trend. SSB in 2023-2024 is estimated to be below 540 000 ton, which together with the low levels in the early 1970s is the lowest SSB in the time-series. Compared to the 2023 year's assessment, estimated SSB has been upgraded for the years 2019-2023. This change in SSB compared to last year's assessment is likely to be related to the upward revision of recruitment and stock numbers back in time, primarily driven by the high survey index in 2023 revealing relatively large numbers of age 1-3 year olds in 2023 (Fig. 4.3.18, Table 4.4.8). Recruitment has been on average higher since the higher biomass period starting from the late 1980's, compared to the period before the biomass peak (Fig. 4.3.12, Table 4.4.7), but recruitment in 2021 was notably low. Recruitment in 2022-2023 seems to have recovered, however recruitment estimates from these years have high uncertainties. (Fig. 4.3.12, Table 4.4.7). Fishing mortality has historically been at a low level ($F < 0.1$) and started to increase in the early 2000s, peaked in 2016 ($F_{2016} = 0.260$), decreased until 2020 ($F_{2020} = 0.164$), then increased again in 2021-2022, and decreased in the last year of the assessment ($F_{2023} = 0.160$) (Fig. 4.3.12, Table 4.4.7).

The fit of the model is good with age compositions well reconstructed (Fig. 4.3.13-14). Pearson residuals are within the range [-2.2 2.2] without any particularly worrying patterns (Fig. 4.3.13). Note that a positive residual pattern by cohort for acoustics, and a residual pattern with negative residuals in the historical part followed by positive residuals in recent years for older ages, changing from negative to positive around year 2000, was pointed out and discussed in the benchmark (ICES, 2021). These patterns are still seen in the latest analyses after adding the 2023 data (Fig. 4.3.12). A non-random pattern of residuals may indicate that some heteroscedasticity is present, or there is some leftover serial correlation in sampling/observation error or model misspecification. We used the Runs test (RMSE and ordinary Runs test) to evaluate the residuals of surveys and age frequency distributions (e.g. SEDAR 40, 2015; Winker et al., 2018), presented in Fig. 4.3.15 A-B. The ordinary Runs test was passed for both acoustic and trapnet surveys residuals and also for all age frequency distributions with the exception of the trapnet (Figure 4.4.15 A). The RMSE runs test indicated that the fit of the CPUE index was good because no residuals were larger than 1 and the root-mean square error (RMSE) was less than 30% (Fig. 4.3.15 B), indicating a random pattern of the survey's residuals and the age frequency distributions (Winker *et al*., 2018).

A retrospective analysis was conducted for the last five years of the assessment time horizon, to evaluate whether there were any strong changes in model results (Fig. 4.3.16). Retrospective pattern bias increased compared to the 2023 year's assessment, but the estimated Hurtado-Ferro et al. (2014) 5-year peel Mohn's rho indices (SSB = -0.08; F = 0.06) were still inside the bounds of recommended values. Forecast Mohn's rho values were -0.15 and 0.10 for SSB and F respectively.

Prediction skill was evaluated using the mean absolute scaled error (MASE) score, which builds on the principle of evaluating the prediction skill of a model relative to a naïve baseline prediction (Carvalho *et al*., 2021). A MASE score > 1 indicates that the average model is worse than a random walk, whereas a score of e.g. 0.5 indicates that the forecasts were twice as accurate as the naïve prediction. Both the mean age predictions of the commercial (0.54) and survey data (0.67), and the predictions of the tuning index (0.90) scored better relative to the naïve model (Fig. 4.3.17).

4.4.4.2 Short-term forecast and management options

Note that this section was updated in September 2024

No short-term projections were performed during spring 2024, as reference points for the Gulf of Bothnia herring were pending revision.

Reference points were revised in spring -summer 2024 (see WD3 in Annex 5) and a short-term forecast was run.

The short-term projections are conducted either with Stock Synthesis using MCMC or the delta-Multivariate log-Normal' (delta-MVLN) estimator (Walter and Winker, 2019; Winker et al., 2019). MVLN infers within-model uncertainty from maximum likelihood estimates (MLEs), standard errors (SEs) and the correlation of the untransformed quantities and it has demonstrated to be able to mimic the MCMC fairly closely.

Recruitment in the forecast period is set to the average of the last ten years for which recruitment deviations are estimated in the Stock Synthesis model. For maturity and weight-at-age an average of the last three years is used. Constant selectivity is used. Probabilistic forecasts were used.

Fishing mortality in the intermediate year was estimated consistent with TAC in 2024 (55000 tonnes).

Short term forecast results with TAC constraint are shown in Table 4.4.9.

4.4.4.3 Reference points

Note that this section was updated in September 2024.

The GoB herring SSB has been on a generally decreasing trend since the middle of the 1990s and is now estimated to be at $B_{trigger}$, even though fishing mortality (F) is estimated to be well below the accepted F_{msy} until 2023 (0.271). Considering the development of SSB and F, WGBFAS raised the concern that F_{msy} is set too high, and it was consequently decided during the WGBFAS 2024 meeting that the current reference points for Gulf of Bothnia herring should be reinvestigated. This concern was also raised at last year's ADG meeting, and the stock was added to the list of stocks to be analysed during WKNEWREF. WKNEWREF was however not finished in time for WGBFAS.

Reference points were updated during the spring-summer of 2024 and a working document describing the process and results is available in Annex XX (to be added reference toAnnex XX to WGBFAS 2024 report:A proposal for new reference points for the Gulf of Bothnia herring).

4.4.4.4 Quality of the assessment

Note that this section was updated in September 2024.

The tuning is based on acoustic surveys in the Bothnian Sea since 2007 and commercial trapnet data from the Bothnian Sea herring stock assessments from the years 1990–2006. Trapnet data from later years have not been included in the assessment, because the effort decreased a lot in later years, and they are considered to be too unreliable. Yet the trapnet tuning indices are statistically sound and they are anchoring the model to the past.

Due to an error, which was found in the time-series, the acoustic indices were examined thoroughly and recalculated with ICES StoX-program in 2020 and the assessment was benchmarked early 2021.

The acoustic survey time-series is still relatively short. Thus, it is expected that extending the acoustic survey time-series will improve the quality of the assessment. Further, ongoing work to include the effects of e.g. temperature on the abundance on young herring in the index will improve the assessment further.

The current assessment's diagnostic scores (residual tests, retrospective analyses and prediction skill evaluation) are within the range of accepted values. The assessment shows a small increase in SSB between 2023 and 2024. This increase is partly due to increased weight-at-age in 2023 compared with the years 2021 and 2022, and an upward revision of the number of age 1-3 fish.

4.4.4.5 Management considerations

Note that this section was updated in September 2024.

This stock is the resource basis for the herring TAC set for Management Unit III including subdivisions 30 and 31. The current assessment unit in the two subdivisions was previously assessed as two herring stocks, which were merged at the benchmark workshop in 2017 (ICES 2017).

Spawning stock biomass has an overall decreasing trend since 1994, corresponding to the increasing fishing mortality starting in the beginning in the 1990s and the low level of mean weight at age for the last 20 years (Fig. 4.3.6).

An important factor contributing to the fluctuations of SSB is the variation in the weight at age of the spawners. In recent years, estimated weight at age was most likely affected by the scarcity (in 2021) then reappearance (after 2022) of important prey, possibly Mysidae and/or Pseudocalanus sp., which underlines the need for improved information on the food web related to herring (ICES 2024c).

The mean proportion of numbers and biomass of age 5+ individuals of the stock have for the last 8 years been significantly lower compared to the mean of the previous years of the time-series (ICES 2024c). Without a management measure put in place to increase the proportion of older and larger individuals in the stock, this may result in continued low catch rates for larger herring.

The Gulf of Bothnia herring stock consists of several different spawning components which have been shown to be genetically distinct (Han et al., 2020). It is very likely that the Gulf of Bothnia herring stock is vulnerable to loss in genetic diversity. Further research on the stock structure is needed (ICES 2023b).

Table 4.4.1. Herring in SD 30-31. Catches by country.

Year	Finland	Sweden	Denmark	Total
1980	27657	2152		29809
1981	19616	1910		21526
1982	24099	2400		26499
1983	23115	3093		26208
1984	31550	2995		34545
1985	32830	2602		35432
1986	32742	2837		35579
1987	30403	2225		32628
1988	32979	3439		36418
1989	29458	3628		33086
1990	36418	2762		39180
1991	30019	3400		33419
1992	42510	4100		46610
1993	45352	3962		49314
1994	59055	2931		61986
1995	62704	2843		65547
1996	59452	1851		61303
1997	67727	2081		69808
1998	59473	3001		62474
1999	64392	2110		66502
2000	57365	1487		58852
2001	55742	2064		57806
2002	49847	4122		53969
2003	49787	3857		53644
2004	56067	5356		61423
2005	60222	2689		62911
2006	69646	1672		71318
2007	75108	3570		78678
2008	64065	3849		67914
2009	67047	4201		71248
2010	70658	1932		72590
2011	78348	3502		81850
2012	99454	6553		106007
2013	103421	10975		114396
2014	102416	12950		115366
2015	100784	14158		114942
2016	107803	22226		130029
2017	93558	10800		104358
2018	80870	16496		97366
2019	73243	15664		88907
2020	60545	12412		72956
2021	56924	14999		71924
2022	59790	16908	1916	78614
2023	55635	11192		66827

Table 4.4.2. Herring in SD 30-31. Sampling by country.

ICES Sub Division	Country	Quarter	Number of length samples	Number of fish measured	Number of age samples	Number of fish aged
30	Finland	1	10	3096	10	429
		2	26	7032	23	462
		3	4	1213	4	123
		4	15	4295	14	276
Total			55	15636	51	1290
31	Finland	1	0	0	0	0
		2	8	2189	7	147
		3	7	1433	5	84
		4	7	1258	4	56
Total			22	4880	16	287
30	Sweden	1	0	0	0	0
		2	5	2505	3	226
		3	3	1250	3	268
		4	2	1696	0	0
Total			10	5451	6	494
31	Sweden	1	0	0	0	0
		2	2	1003	2	178
		3	0	0	0	0
		4	0	0	0	0
Total			2	1003	2	178
Total			89	26970	75	2249

Table 4.4.3. Herring in SD 30-31. Catch at age in numbers..

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1980	124930	112920	61920	66620	262270	90230	96830	57120	21975	30323	5895	2811	1183	247	286
1981	27570	124000	59130	48010	57110	136920	54220	40650	22597	11658	13766	2519	795	1474	322
1982	26810	107840	270020	60380	49410	73080	114910	32730	32040	11800	7946	7603	1062	232	636
1983	102120	191340	104320	178520	23900	32000	48610	86810	21824	19309	9494	3865	1078	350	90
1984	142210	291180	209560	109520	132580	25450	25350	35000	57350	16341	18625	6698	1858	2977	410
1985	95150	373640	319790	144620	50160	88430	17750	15850	18317	40024	9750	8678	4106	1398	1406
1986	19100	406380	354920	217790	100740	47350	56500	9160	11426	17052	19772	5067	4659	1316	3128
1987	49170	77260	232130	254920	143520	69250	43370	21590	10706	11158	11786	8275	1000	1565	1280
1988	16480	226490	86310	203000	213910	122760	52930	26270	15435	10315	9527	6402	4451	1191	1119
1989	99380	79740	181120	70520	127840	133340	71910	28950	14631	8078	5861	5109	1719	2117	1157
1990	199890	511580	63700	131380	47270	99210	114320	47820	17975	16514	5758	3026	2325	1822	3729
1991	44190	224870	341910	48990	92540	58850	71890	46920	27505	10661	7624	4912	1813	1578	2707
1992	89540	232470	463390	358030	67780	81820	74790	55710	28937	14405	6138	6295	4256	1466	733
1993	222810	391710	211390	348550	317940	53970	62080	40350	25885	12762	7927	3603	628	954	1411
1994	84500	404060	361710	221140	347250	311050	48400	78140	34470	20947	10128	3331	906	525	323
1995	109660	249730	515960	325460	230160	287240	205880	41230	61001	19404	19283	4994	2791	2140	819
1996	109490	519790	247930	337900	258500	165210	203360	129180	18462	21710	8082	8768	1266	516	2865
1997	141310	407600	490200	274540	317290	230680	187540	150140	91849	13440	22691	6617	3811	1860	623
1998	296540	259230	337110	363200	238600	180210	160460	67120	53018	90747	34401	34744	16180	6027	3392
1999	147710	694270	312710	373660	278140	163180	216350	79080	57399	78561	27613	16886	10011	5538	1523
2000	289776	211673	433968	326427	200555	209571	118562	76728	62365	105656	46388	45821	27266	13185	11348
2001	266243	450302	203894	460811	167923	140134	139361	92518	68976	40305	103933	27796	18453	13735	10904
2002	308482	270574	404072	159300	216521	101917	58483	90625	82209	38414	41400	38165	29161	30350	19603
2003	305396	425299	267888	246267	177145	185773	67146	57477	49827	48923	49420	31533	25123	28618	27325
2004	104393	1021965	490316	243896	200519	143971	136323	65848	59707	39436	34104	25166	25094	25338	16658
2005	172165	238898	1189611	337559	182116	161536	87738	95355	76075	48573	35780	26610	16502	23875	12096
2006	176592	292909	132105	1061307	379704	161606	94974	128742	90335	57131	87244	24995	31028	18760	11643
2007	552847	660118	357542	168654	1017283	275806	92438	127731	87818	43966	51214	28743	19447	22977	13137
2008	266434	873384	327757	318645	218789	404664	186749	126807	94630	57204	51571	23608	17948	9705	16501
2009	268319	446210	586402	414737	128103	131399	355613	143488	82792	56912	33126	35109	18479	13428	21903
2010	297532	820306	481726	418950	286816	105453	82757	234997	86170	75015	19577	27325	21106	13041	16423
2011	251376	634214	569108	374424	369070	174016	92440	81609	247597	95550	82767	41832	22936	15236	49513
2012	512943	429102	696213	573553	364869	348220	183169	148802	82567	242740	120868	52298	48163	21863	25420
2013	486237	894795	530634	396023	567340	299623	294588	182312	95551	105273	109550	60420	50663	20657	48283
2014	434458	701891	753506	267860	427997	284267	225170	212795	118943	71664	65706	76491	63442	46905	61302
2015	1378190	913322	725069	450623	325361	247165	222505	150439	112138	55306	26751	47904	91521	21057	45589
2016	821289	1663093	811016	466569	337671	225412	268940	147995	125977	92024	44509	34376	31239	70054	90905
2017	742230	859392	1172496	435129	294949	133535	101620	128330	87524	58511	56329	62840	24453	23704	71325
2018	380824	1153984	573476	737474	299807	184310	104430	100232	60145	62283	29064	56602	24736	14416	53408
2019	460671	610074	792040	410444	459170	216637	134556	108043	44082	42040	24349	22425	25410	5233	39223
2020	460473	673491	444079	371701	238534	328573	130323	52863	51067	21263	30618	26237	9398	13312	14796
2021	331770	982264	626256	297293	296916	225031	173386	74886	63698	36557	27501	16293	18579	12198	27063
2022	260703	872768	1125949	532031	249440	192177	154974	87349	54125	21669	15464	16448	8477	6618	2702
2023	502325	431750	588854	625252	364229	189099	59145	48024	42762	26159	10886	5253	2033	3888	7125

Table 4.4.4. Herring in SD 30-31. Weight at age in the catch (g)

	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12	AGE 13	AGE 14	AGE 15+
1980	11	20,6	25,7	32,3	35,4	37,5	40,1	45	50,3	55,7	58,2	57,1	77,4	61,5	93
1981	12,4	20,3	27,2	33,9	40,6	41,9	46	48,5	54,2	58,8	68,4	68,3	64,8	109,8	74,5
1982	10,1	18,8	27,8	38	39,1	43,3	44,7	50,3	52,1	59,5	60,8	67,4	79,5	72,5	84,2
1983	12	21,1	32	38	43,9	50,3	52,2	56,1	62,9	62,6	69,5	81,2	92,4	103,3	106,3
1984	13,1	22,2	32,1	40	44,5	51	58,3	60,5	59,2	63,1	66,8	81,8	73,9	72,2	115
1985	10	20,4	30	38,2	42,1	46,5	51,9	56,3	57,6	59,5	63,5	71,7	75,5	71,3	80,4
1986	11,8	18,3	27,2	34,9	39,8	44,6	48,4	50,4	59,4	57,7	62,7	63,4	68,2	81,4	63,3
1987	10,1	22	28,5	34,8	41,7	46,3	51,3	56,9	60,2	61,1	66,4	67,2	66,4	74,1	90
1988	11,3	20,5	31,9	36,9	42,1	47,9	53,9	61,1	62	69,6	71,6	78,4	77	83,5	90,4
1989	12,4	23,6	33,3	41,6	46,5	51,7	55,6	60,7	67,2	64,5	71	75,7	80,8	81,7	116,7
1990	9,8	19,4	32,2	38,8	45,2	50,7	57	60,1	68,5	71,5	75,2	93,4	85	78,8	94,4
1991	12,2	21,5	27,6	35,5	41	48	52,5	55	58,6	63,8	67,4	70,6	72,1	79,7	79,9
1992	12,1	20	27,2	30,4	39,8	43,6	49,9	53,8	58	64,8	63,8	71,5	64,8	87	72
1993	10,9	19,3	27,4	31,1	34	43,9	50,3	54,7	59,6	63,5	66,5	70,8	78,8	93	95,2
1994	11,7	21	27,5	32,6	35,7	39,5	49,3	55,7	62	69	73,6	69,9	76,5	45,5	84,5
1995	9,2	19	27,1	30,4	35,2	38,6	43,1	52,2	61,6	67,9	76,4	94	87,3	104	102,3
1996	10,8	17	25,7	31,7	34,4	39,7	44	49,4	57,8	64,3	68,7	75,8	70	98	87
1997	9,4	15,7	23,1	29,2	33,9	37	42,7	47,2	54,4	63,7	69	71,1	90,6	86	92
1998	7,8	13,5	20,8	27,9	34,2	40,7	44,4	55,6	58,1	66,6	81,5	82,6	111,6	96,8	110,1
1999	7,9	13,4	20,7	26,4	32,9	41,4	46	53,5	57,3	62,6	73,7	79,3	86	103,3	120,6
2000	7,7	14,3	20,1	25	29,3	34,4	38,8	41,1	46,2	56,3	55,3	65,4	70,9	68,7	78,2
2001	8,6	15,4	22,1	26,7	28,9	32,6	39,5	42,1	47,1	47,5	57,6	61,6	61,9	68,2	77,6
2002	8,1	15,8	22,5	26,9	30,6	35	38,7	43,9	47,7	54	58,2	58	66,4	74,7	88,1
2003	7,7	16,1	23,3	26,7	30,5	34,5	40,1	42	49,2	56,7	61	61,9	61,6	71,2	85,2
2004	6,7	13,8	20,4	25,9	30	37,1	38,9	43,3	49	53	59,6	59,3	64	72,7	62,9
2005	7,5	13	19,5	24,8	29,5	31,8	38,6	38,8	42,6	44,6	47,5	50,4	44,5	56,5	55,3
2006	8,2	15	19,4	23,1	26,7	32,6	35	38	39,9	43,3	43	44,8	50,6	54,4	50,9
2007	7,4	14,8	21	24,8	27,1	31,1	35,5	39,2	42,6	44	48	49,6	52,2	51,6	63,6
2008	9	14,7	21	23,3	28,2	28,5	33,4	37,6	40,4	45,7	53,5	47,4	53,8	61,8	51,4
2009	9,9	15,8	20,6	23,9	30,2	31,1	34,7	37,4	41,1	44,1	51,9	50,8	56,7	56,3	56,1
2010	8,2	16,5	22,5	25,9	28,8	34,9	33,4	39,4	44	43,1	50,2	58	54,9	55,1	67,3
2011	8,9	16	23	26,8	29,3	32,7	36,3	38,8	42,1	42,7	48	49,5	50,4	59,8	52,8
2012	9,2	16,5	23,8	27,4	30,3	35,9	38,7	40,8	45,8	48,6	50,3	52,6	56,7	57,1	68,2
2013	12,8	20,4	25,1	28,6	32,2	35,2	36,8	38,5	43,8	46,1	46,3	47,4	51,5	53,4	57,2
2014	9,6	18,2	25,9	29,2	32,6	40,3	42,9	45,5	47,6	49,4	48,6	59,8	55,5	59	70,4
2015	13,4	19,3	24,9	29,4	31,7	36,6	39,4	43	44,4	47,1	52,2	50,8	55,4	52,5	54,4
2016	12,1	17,4	22,7	28,3	31,9	34,8	38,2	44,9	48,4	51,6	53,1	53,9	64,5	66	61,5
2017	10,4	17,6	23,2	27,3	31,9	38,1	39	42,4	48,1	53,4	55,7	54,6	59	61,5	66,6
2018	10,2	17,5	24,4	27,8	32,1	36,5	36,7	40,9	46,5	50,3	61,1	49,1	57,7	64,5	62
2019	9,7	16,53	24,05	29,55	32,27	33,75	39,42	42,56	46,93	50,88	51,27	53,36	55,74	63,74	64,34
2020	7,02	16,97	24,16	29,68	33,6	35,93	39,41	46,77	48,39	51,35	56,93	60,33	58,35	47,52	67,68
2021	7,47	15,58	21,05	25,07	28,17	31,97	33,65	35,63	41,06	42,68	44,73	49,24	50,85	49,65	55,06
2022	7,54	14,92	21,04	24,51	28,89	32,44	33,99	37,34	39,31	43,87	45,52	45,58	53,95	46,73	56,20
2023	8,12	16,39	22,2	24,43	30,99	35,39	40,45	43,38	41,3	43,95	57,38	51,94	55,87	62,27	54,4

Table 4.4.5. Herring in SD 30-31. Maturity ogive.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1980	0,00	0,31	0,92	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1981	0,00	0,31	0,93	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1982	0,00	0,29	0,93	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1983	0,00	0,21	0,92	0,98	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1984	0,00	0,23	0,93	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1985	0,00	0,20	0,92	0,99	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1986	0,00	0,28	0,91	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1987	0,00	0,32	0,89	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1988	0,00	0,10	0,85	0,96	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1989	0,00	0,23	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1990	0,00	0,59	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1991	0,00	0,59	0,94	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1992	0,00	0,50	0,90	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1993	0,00	0,44	0,82	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1994	0,00	0,63	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1995	0,00	0,35	0,91	0,95	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1996	0,00	0,66	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1997	0,00	0,32	0,84	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1998	0,03	0,33	0,72	0,96	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
1999	0,01	0,38	0,88	0,99	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2000	0,11	0,65	0,93	0,98	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2001	0,01	0,61	0,97	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2002	0,03	0,58	0,96	0,97	0,99	0,96	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2003	0,00	0,56	0,94	0,97	0,96	1,00	1,00	0,89	0,89	1,00	1,00	1,00	1,00	1,00	1,00
2004	0,02	0,34	0,91	0,97	1,00	1,00	1,00	1,00	1,00	0,96	1,00	1,00	1,00	1,00	1,00
2005	0,02	0,28	0,86	0,96	0,94	0,97	1,00	1,00	1,00	0,96	1,00	1,00	1,00	1,00	1,00
2006	0,02	0,37	0,92	0,91	1,00	0,94	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2007	0,02	0,56	0,87	1,00	0,96	1,00	1,00	0,90	1,00	0,97	1,00	1,00	1,00	1,00	1,00
2008	0,00	0,50	0,91	1,00	0,93	1,00	1,00	1,00	1,00	0,94	1,00	1,00	1,00	1,00	1,00
2009	0,00	0,51	0,91	0,95	0,95	0,91	0,97	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2010	0,05	0,87	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2011	0,01	0,46	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,97	1,00	1,00	1,00	1,00	1,00
2012	0,01	0,75	0,97	0,98	1,00	1,00	0,94	1,00	1,00	0,99	1,00	1,00	1,00	1,00	1,00
2013	0,11	0,78	0,98	1,00	1,00	1,00	1,00	1,00	1,00	0,98	1,00	1,00	1,00	1,00	1,00
2014	0,16	0,71	1,00	1,00	1,00	1,00	0,94	0,95	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2015	0,13	0,80	0,98	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2016	0,05	0,72	0,90	1,00	1,00	1,00	1,00	1,00	1,00	0,92	1,00	1,00	1,00	1,00	1,00
2017	0,11	0,76	0,98	0,99	1,00	1,00	1,00	1,00	1,00	0,98	1,00	1,00	1,00	1,00	1,00
2018	0,16	0,88	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,98	1,00	1,00	1,00	1,00	1,00
2019	0,08	0,83	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,94
2020	0,06	0,89	0,93	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
2021	0,04	0,80	0,99	1,00	1,00	1,00	1,00	1,00	0,95	1,00	0,93	1,00	1,00	1,00	0,86
2022	0,02	0,84	1,00	0,97	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,86	1,00
2023	0,05	0,86	1,00	1,00	0,99	0,97	0,95	1,00	0,99	1,00	1,00	1,00	1,00	1,00	0,50

Table 4.4.6. Herring in SD 30-31. Area corrected numbers (millions) of herring per age group in the ICES sub-division 30 (StoX calculated).

Year	Sub_Div	AREA CORR FACTOR	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6	AGE7	AGE8	AGE9	AGE10	AGE11	AGE12	AGE13	AGE14	AGE15+
2007	30	1,04	480,40	6345,61	5227,99	1901,71	1492,27	5449,22	1419,72	786,50	535,52	489,52	322,08	252,68	139,30	145,30	75,48	259,64
2008	30	1,21	1068,55	3073,50	5105,44	3477,91	1648,52	1706,72	3284,77	1234,75	986,89	630,05	395,85	291,87	173,18	154,89	145,21	146,65
2009	30	1,06	819,06	4666,78	5074,25	5358,37	2490,87	1258,73	1458,45	3524,67	1209,81	543,92	574,98	316,43	336,01	172,35	151,53	221,08
2010	30	1,06	711,72	4465,15	7188,86	3611,37	3424,11	1669,25	1054,62	930,72	2144,53	505,08	519,27	260,81	184,36	127,94	71,61	173,46
2011	30	1,06	2503,80	4412,33	6285,06	7406,36	2942,45	3127,49	1360,08	586,81	496,84	1948,75	378,50	288,02	202,27	163,54	133,47	148,69
2012	30	1,08	1398,38	11389,23	3905,43	3271,23	2901,73	1695,40	1626,90	962,03	382,20	504,23	817,27	344,29	139,53	104,02	103,32	178,00
2013	30	1,08	5567,47	1848,61	3888,51	1502,95	1717,38	1596,95	711,15	883,81	408,30	171,76	260,07	477,48	188,40	92,18	48,60	103,62
2014	30	1,08	11844,93	4838,71	2637,37	2193,45	1011,92	686,86	553,53	625,98	321,69	180,11	102,13	203,54	236,61	52,02	49,78	81,47
2015	30	1,22	3446,24	8863,22	3461,94	1911,51	1333,77	762,51	763,78	458,48	471,71	284,45	156,45	120,54	175,58	129,42	109,03	64,95
2016	30	1,08	1501,59	2002,62	6118,35	2778,41	1544,22	955,79	499,11	539,92	437,61	275,51	263,31	137,78	137,53	222,73	173,18	170,87
2017	30	1,08	1287,28	7731,92	5064,92	8105,15	2443,61	1594,55	926,94	449,38	426,42	368,23	294,34	237,85	62,36	82,12	147,90	206,59
2018	30	1,08	6173,92	2882,08	3937,18	2086,75	3158,16	868,86	766,89	412,26	261,83	275,07	244,55	136,55	161,28	68,44	47,78	189,75
2019	30	1,08	2797,62	3537,66	3682,27	3780,16	1834,00	2332,59	838,28	491,74	440,29	260,56	148,11	125,13	50,06	83,51	47,43	93,77
2020	30	1,08	5444,46	9016,27	8361,15	3422,06	2986,58	1992,91	1299,36	482,91	318,55	240,97	91,79	91,43	78,84	45,61	18,37	85,90
2021	30	1,16	2731,60	2201,53	5200,29	3045,64	1448,84	962,80	811,49	298,54	198,80	181,31	79,19	69,35	49,18	31,50	33,45	74,92
2022	30	1,16	1393,14	1161,51	2538,82	4671,57	2266,39	960,86	655,43	323,38	185,23	176,61	73,43	62,11	34,23	29,69	7,28	26,96
2023	30	1,16	2053,61	7413,52	4865,10	6375,51	5807,38	3218,38	1557,09	554,93	476,21	172,71	56,01	65,95	47,95	56,96	40,35	22,69

Table 4.4.7. Herring in subdivisions 30 and 31. Assessment summary. Weights are in tonnes. Recruitment in thousands.

Year	Recruitment			SSB			Total	F		
	Low Recruitment	Midpoint Recruitment	High Recruitment	Low SSB	Mid-point	High SSB	Catch	Low	Mid-point	High
	thousands			tonnes			tonnes			
1963	9328554	19976600	42778823	962168	1106990	1251812	29739	0.025	0.029	0.033
1964	8690941	18296600	38518910	961246	1105090	1248934	25204	0.021	0.025	0.028
1965	8075101	16720800	34623115	939597	1081500	1223403	27541	0.024	0.028	0.032
1966	7452770	15188500	30953662	846399	997519	1148639	22164	0.021	0.024	0.028
1967	6768762	13556600	27151405	761069	915967	1070865	27772	0.028	0.033	0.038
1968	6401052	12499100	24406535	677746	831088	984430	28966	0.031	0.038	0.044
1969	6306728	11899400	22451534	593181	739009	884837	35996	0.043	0.053	0.063
1970	10659796	17934200	30172765	533980	680362	826744	32790	0.042	0.053	0.064
1971	7950762	13416500	22639650	409212	522166	635120	36347	0.060	0.076	0.093
1972	11589542	17871100	27557278	429540	558077	686614	34092	0.051	0.065	0.080
1973	16724051	23948000	34292331	454755	600965	747175	26507	0.036	0.047	0.058
1974	13443813	19183600	27373968	393515	516727	639939	26776	0.041	0.053	0.065
1975	31400508	40992600	53514843	422010	550310	678610	21811	0.031	0.041	0.050
1976	10927225	15010200	20618785	430213	560205	690197	30520	0.043	0.056	0.069
1977	6910926	9622480	13397933	466184	604645	743106	33634	0.043	0.056	0.070
1978	6927488	9445590	12879007	527345	685479	843613	34873	0.043	0.057	0.071
1979	19286338	24521500	31177716	479148	628639	778130	26109	0.035	0.046	0.057
1980	10503616	13811300	18160604	417916	551565	685214	29809	0.043	0.057	0.071
1981	16293870	20860700	26707517	425526	563297	701068	21526	0.030	0.039	0.048
1982	27250705	33987900	42390732	443032	582431	721830	26499	0.037	0.049	0.061
1983	36045135	44303000	54452724	484282	636751	789220	26208	0.031	0.041	0.051
1984	29875662	36828000	45398210	537725	697835	857945	34545	0.036	0.048	0.059
1985	11966773	15492800	20057775	598336	766108	933880	35432	0.035	0.045	0.056

Year	Recruitment			SSB			Total	F		
	Low Re-cruitment	Midpoint Re-cruitment	High Re-cruitment	Low SSB	Mid-point	High SSB	Catch	Low	Mid-point	High
	thousands			tonnes			tonnes			
1986	24832405	30624400	37767340	681160	860133	1039106	35579	0.034	0.044	0.054
1987	11320675	14745400	19206170	757670	952938	1148206	32628	0.029	0.037	0.045
1988	53083762	63383600	75681914	735125	925631	1116137	36418	0.031	0.039	0.048
1989	48246056	57866300	69404817	848700	1056950	1265200	33086	0.026	0.033	0.039
1990	26334858	32375700	39802226	971919	1188440	1404961	39180	0.030	0.037	0.044
1991	30845639	37572200	45765633	1096625	1323980	1551335	33419	0.024	0.029	0.034
1992	33167938	40005900	48253588	1068487	1286160	1503833	46610	0.033	0.041	0.048
1993	20308055	25244300	31380389	1028015	1237720	1447425	49314	0.035	0.043	0.050
1994	26655492	32476000	39567477	1138781	1363620	1588459	61986	0.044	0.053	0.062
1995	21007154	25991400	32158229	1001351	1206410	1411469	65547	0.049	0.059	0.070
1996	18254955	22842200	28582164	988445	1188490	1388535	61303	0.049	0.060	0.070
1997	34842462	41935600	50472740	823480	996407	1169334	69808	0.062	0.076	0.089
1998	19155020	24300700	30828682	780202	952651	1125100	62474	0.057	0.070	0.082
1999	29538100	36225400	44426676	761668	929037	1096406	66502	0.063	0.077	0.091
2000	23429495	29297500	36635170	713321	862596	1011871	58852	0.066	0.080	0.095
2001	36512359	44302500	53754716	701046	845412	989778	57806	0.065	0.079	0.093
2002	76134759	88455700	102770548	708462	853908	999354	53969	0.059	0.072	0.085
2003	15317115	20003000	26122413	722727	865183	1007639	53644	0.055	0.067	0.078
2004	16413064	21214600	27420794	765240	906733	1048226	61423	0.059	0.071	0.082
2005	23494539	29056700	35935661	782776	917702	1052628	62911	0.064	0.076	0.089
2006	34154770	40779100	48688222	699926	820345	940764	71318	0.081	0.095	0.110
2007	24163679	29579500	36209173	683180	798769	914358	78678	0.092	0.109	0.126
2008	33118150	39542400	47212824	651109	759534	867959	67914	0.085	0.099	0.114
2009	26947001	32637400	39529441	649282	752855	856428	71248	0.089	0.104	0.119

Year	Recruitment			SSB			Total	F		
	Low Recruitment	Midpoint Recruitment	High Recruitment	Low SSB	Mid-point	High SSB	Catch	Low	Mid-point	High
	thousands			tonnes			tonnes			
2010	17744769	22329500	28098792	787931	902399	1016867	72590	0.089	0.103	0.118
2011	25001253	30358600	36863937	698840	801535	904230	81850	0.103	0.120	0.137
2012	18734489	23208100	28749965	707168	810412	913656	106007	0.138	0.161	0.184
2013	21742812	26635500	32629167	706906	807020	907134	114396	0.158	0.185	0.21
2014	38365600	45291600	53467926	647631	746681	845731	115366	0.169	0.200	0.23
2015	20436003	25291500	31300639	610244	704477	798710	114942	0.182	0.22	0.25
2016	24813995	30570100	37661450	566933	659804	752675	130029	0.21	0.26	0.30
2017	16651616	21338200	27343820	544507	643673	742839	104358	0.177	0.22	0.26
2018	22983443	29323600	37412737	544191	651895	759599	97366	0.170	0.21	0.25
2019	30793412	39558200	50817726	472342	580202	688062	88907	0.159	0.20	0.25
2020	18289671	24932900	33989103	470339	591753	713167	72956	0.126	0.164	0.20
2021	10872739	16361400	24620788	440563	564985	689407	71924	0.129	0.171	0.21
2022	22668483	35660500	56098649	414119	548671	683223	78614	0.140	0.192	0.25
2023	9464408	23897600	60341366	377960	526061	674162	66827	0.111	0.160	0.21
2024		33863400		368100	539609	711118				

Table 4.4.8. Ratio of N@age in 2023 and 2024 year's assessments (numbers estimated in current assessment / numbers estimated or assumed in previous assessment). Ratio < 1 (orange gradient) denotes a downgrade in the current (2024) year's assessment. Ratio > 1 (green gradient) denotes an upgrade in the current (2024) year's assessment.

	Age																				
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
2020	1.18	1.10	1.10	1.09	1.03	1.04	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
2021	1.22	1.18	1.11	1.11	1.10	1.04	1.05	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
2022	1.55	1.22	1.18	1.12	1.12	1.11	1.05	1.06	1.06	1.06	1.06	1.05	1.05	1.06	1.06	1.06	1.06	1.05	1.05	1.06	1.06
2023	0.75	1.55	1.22	1.20	1.14	1.15	1.14	1.08	1.09	1.08	1.09	1.09	1.08	1.08	1.08	1.08	1.09	1.08	1.08	1.08	1.09

Table 4.4.9. Herring in subdivisions 30 and 31. Annual catch scenarios. All weights are in tonnes.

Basis	**Total catch (2025)**	**F (2025)**	**SSB (2026)**	**% SSB change***	**% TAC change ****	**% Advice change*****	**Probability SSB < B_{lim} in 2026 (%)^**
ICES advice basis							
EU MAP^^: $F_{MSY} \times SSB(2025)/B_{trigger}$	74 515	0.190	532 003	-0.3	36	18	4.8
EU MAP^^: MAP range $F_{lower} \times SSB(2025)/B_{trigger}$	66 446	0.168	539 660	1.2	21	36	4.1
Other scenarios							
F = 0	0	0.000	602 872	13	-100	-100	1.0
F_{MSY}	84 586	0.218	522 454	-2.1	54	34	6.1
F_{lower}	75 605	0.193	530 970	-0.5	38	20	4.9
$F_{pa} = F_{MSY\ upper}$	84 586	0.218	522 454	-2.1	54	34	6.1
$F_{upper} \times SSB(2025)/B_{trigger}$	74 515	0.190	532 003	-0.3	36	18	4.8
SSB (2026) = B_{lim}	225 320	0.690	389 921#	-27	310	257	50.0
SSB (2026) = B_{pa}	90 593	0.235	516 760#	-3.1	65	44	6.9
SSB (2026) = MSY $B_{trigger}$##							
SSB (2026) = SSB (2025)	73 058	0.186	533 385#	0.0	33	16	4.7
$F = F_{2024}$	56 654	0.142	548 957	2.9	3	-10	3.4
P(SSB (2026) < B_{lim}) = 5 %	75 605	0.193	530 970	-0.5	38	20	5.0

* **SSB 2026 relative to SSB 2025.**

** **Catch in 2025 relative to the TAC in 2024 (55 000 tonnes).**

*** **Advice values for 2025 relative to the corresponding 2024 values (EU MAP advice of 63 049 [F_{MSY}] and 48 824 [F_{lower}] tonnes, respectively; other values are relative to 63 049 tonnes).**

~ Advice values for 2025 relative to the 2024 value corresponding to $F_{MSY\ upper}$.

^ The probability of SSB being below Blim in 2026. This probability relates to the short-term probability of SSB < B_{lim} and is not comparable to the long-term probability of SSB < B_{lim} tested in simulations when estimating fishing mortality reference points.

^^ MAP multiannual plan (EU, 2016, 2019, 2020).

Based on stochastic forecasts, using the F with three decimals to get close to the biomass target.

The MSY $B_{trigger}$ option was left blank because MSY $B_{trigger}$ cannot be achieved in 2026, even with zero catch in 2025.

Figure 4.4.1. Herring in SD 30-31. International catches by Subdivision

Figure 4.4.2. Herring in SD 30-31. Trapnet catch (kg) and effort (number of traps) in three different areas used to calculate the trap net tuning index.

Figure 4.4.3. Herring in SD 30-31. The areas (statistical rectagles) where the trapnets are situated. .

Figure 4.4.4. Herring in SD 30-31. Numbers at age.

Figure 4.4.5. Herring in SD 30-31. Consistency in catch at age data.

Figure 4.4.6. Herring in SD 30-31. Mean weight at age.

Figure 4.4.7. Herring in SD 30-31. Maturity at age.

Figure 4.4.8. Herring in SD 30-31. Autumn (BIAS) tuning fleet index (abundance per age group and years 2007-2023) for herring in SD 30.

Figure 4.4.9. Herring in SD 30-31. Consistency of acoustic age matrix.

Figure 4.4.10. Herring in SD 30-31. Fulton's condition of herring in the Bothnian Sea at different length groups.

Figure 4.4.11. Herring in SD's 30 and 31. Model input data.

Figure 4.4.12. Herring in SD's 30 and 31. Stock summary. Estimated spawning-stock biomass (SSB), recruitment (R) and fishing pressure (F). R, F, and SSB show confidence intervals (90%) in the plot. The assumed recruitment for 2024 is shaded in a lighter colour. Note that this Figure was updated in September 2024 and reference points were added.

Figure 4.4.13. Herring in SD's 30 and 31. Pearson residuals for commercial (upper), acoustic (middle) and trapnet (lower) data, in 1980-2023. Residuals are within the range [-2.2 2.2]. Filled and open bubbles denote positive and negative residuals respectively.

Figure 4.4.14. Herring in SD's 30 and 31. Age-composition fit of model (green line) with commercial (upper left), acoustic (upper right) and trapnet (lower) data, aggregated across time.

A

B

Figure 4.4.15. Herring in SD's 30 and 31. Residuals from Runs test analyses for the age distributions and the fit to the acoustic and trapnet survey indices (A) and from the RMSE test analyses for the age distributions and the fit to the acoustic and trapnet survey indices (B).

Figure 4.4.16. Herring in SD's 30 and 31. Retrospective analyses for spawning-stock biomass (upper) and fishing mortality (lower), showing 5 years peels with 95% confidence bands for the reference year 2024. Left column shows the full time-series whereas the right column shows the last 18 years.

Figure 4.4.17. Herring in SD's 30 and 31. Model prediction skill evaluated using the mean absolute scaled error (MASE) score, for mean age commercial (upper left; 0.54) and survey (upper right; 0.67), and survey index (lower; 0.90) model fits (coloured lines), compared to one-year-ahead forecasts (black dashed lines). Large dots connected by dashed white lines show the observed values.

Figure 4.4.18. Herring in subdivisions 30 and 31. Historical assessment results (final-year recruitment estimates included). The stock was benchmarked in 2021 and upgraded to category 1. Only assessment results following the benchmark are shown.

5 Plaice

Introduction

5.1.1 Biology

5.1.1.1 Assessment units for plaice stocks

Plaice within inner Danish waters and the Baltic consist of two stocks. One stock (ple.27.21–23) is defined by the Subdivision 21 (Kattegat), Subdivision 23 (the Sound) and Subdivision 22 (Belt area and western part of the Baltic Sea). The other stock (ple.27.24–32) is defined by the area south of Subdivision 22 and eastward into the remainder of the Baltic Sea. The separation between Subdivisions 22, 23 and 24, 25 is questionable, given the stocks' development appear to track each other. Each stock is assessed individually; ple.27.21–23 is a category 1 stock and ple.27.24–32 is a category 2 stock. This does not align with the management of the stocks where SD21 is managed under North Sea TACs while the TAC for the remaining SD22-32 are combined.

5.2 Plaice in subdivisions 27.21–23 (Kattegat, the Sound and Western Baltic)

This stock identity is a result of the recommendation made by the benchmark workshop WKPLE in February 2015 (ICES, 2015) and later by the Stock Identification Method Working Group (SIMWG) in June 2015, which confirmed the revised stock structure for the plaice stocks in the North Sea, Skagerrak, Kattegat and the Baltic Sea recommendation made by ICES WKPESTO (2012). Plaice in Skagerrak is now included in the North Sea stock. Kattegat and subdivisions 22 and 23 are merged into one stock and Subdivision 24–32 is regarded as one separate stock. The 21-23 stock was, as a consequence of the benchmark in February 2015 upgraded to category 1 (full analytical age-based assessment). A review and modification of the procedure behind this assessment was made in 2019.

The SAM state-based model was used and subsequently selected as the method for the assessment.

5.2.1 The fishery

5.2.1.1 Regulations in place

Minimum Landing Size in SD 21 is 27 cm (Regulation 2019/1241).

Minimum Landing Size in SD 22 and SD 23 is 25 cm (Regulation 2019/1241).

The closed season for spawning females in SD 22 and SD 23 from 15/1 to 30/4, which was introduced in the mid-sixties has been abandoned since 2017.

In the Sound (SD 23) trawling is only allowed in the northern-most part. Additionally, this area was also included in the closed areas to protect spawning cod in Kattegat, so trawling is forbidden in February and March were the cod is on spawning migration.

In SD 22 the BACOMA exit window is implemented. This is a square mesh window inserted in the top panel of the cod-end. The mesh size in the exit panel was increased to from 110 to 120 mm in 2010, and reduced to 115 in 2018 [Commission Delegated Regulation (EU) 2018/47].

In Kattegat the plaice fishery was very much connected to the cod fishery and as part of the Danish cod recovery plan introduced in 2011 it is mandatory in Danish fisheries to use a SELTRA trawl with 180 mm panel during the first three quarters of a year. In 2009, as part of the attempts to rebuild of the cod stock in Kattegat, Denmark and Sweden, introduced protected areas on historically important spawning grounds in South East Kattegat. The protected zone consists of three different areas in which the fisheries are either completely forbidden or limited to certain selective gears during all or different periods of the year. As the cod fishery in the Kattegat has collapsed, the majority of plaice caught in active gears in SD21 now come as bycatch from the *Nephrops* fishery.

From 1 January 2017 the EU landing obligation was introduced in SD 22 and 23. In the Kattegat, the landing obligation applies as part of the discards plan for the North Sea. In 2018, (Commission Delegated Regulation (EU) 2018/45 of 20 October 2017), plaice was subjected to the landing obligation in TR1 (trawls and seines ≥100 mm), BT1 (Beam trawls ≥120 mm), hooks and lines and trawls 32-69 mm. For the period 2019-2023 the landing obligation is fully in force, but the following exemptions apply in the Kattegat (Commission Delegated Regulation (EU) 2018/2035 of 18 October 2018):

- A survivability exemption applies to plaice caught with nets (GNS, GTR, GTN, GEN), with Danish seines; with bottom trawls (OTB, PTB) with a mesh size of at least 120 mm when targeting flatfish or roundfish in winter months (from 1 November to 30 April).
- a combined *de minimis* quantity of common sole, haddock, whiting, cod, plaice, saithe, herring, Norway pout, greater silver smelt and blue whiting below minimum conservation reference size (MCRS), which shall not exceed 5% of the total annual catches of Norway lobster, common sole, haddock, whiting, cod, saithe, plaice, Northern prawn, hake, Norway pout, greater silver smelt, herring and blue whiting;

This has implications for management since 2017, but because of the insignificant amount of the landings below minimum size (BMS) so far (18 tonnes in 2023), the impact cannot be detected.

5.2.1.2 Landings

The annual landings are available since 1970 (SD 22) and 1972 (SD 21) and are given by subdivision and country separately in Table 5.2.1 and Figures 5.2.1 and 5.2.2. The landings by country and for each subdivision is given in Figure 5.2.3.

5.2.1.3 Unallocated removals

No significant misreporting is believed to take place.

5.2.1.4 Discards

Discard data are only available back to 2002. SAM can handle if minor gaps exist the data series but cannot handle long periods of missing data. As discard information are only available back to 2002, the discard time-series is extended three years back to 1999 (based on average discards from 2002–2004) in order to provide a time-series sufficiently long for the assessment. The discard estimates are processed in InterCatch and consistent throughout the whole time-series (2002–2023). The practice of utilizing the artificially extended time-series should be reviewed at the next benchmark.

Discard and landings (2023) by gear type and quarter are given in Table 5.2.2. Discards by gear type and area and quarter are given in Figure 5.2.4a.

After raising, the discard ratio across the whole stock was ~45% in 2023, totalling 1144 tonnes. This continues a four year trend of increasing discard rate since 2019 (from ~20%), to a point where the discard rates are again above the median of the available time series (Figure 5.2.4b).

In 2023, the discards ratio was estimated as 73% in Kattegat (SD 21), 35% in SD 22 and 24% in SD 23 (Figure 5.2.4c).

5.2.1.5 Effort and CPUE data

Effort data from Sweden and Denmark only is available in InterCatch back to 2013. Data from Germany is available from 2002 and on although the units are not consistent throughout the series.

5.2.2 Biological information

5.2.2.1 Age composition

Since 2004, Denmark and Sweden have put a significant amount of effort into increasing the quality of age reading for plaice in Kattegat through a series of workshops and otolith exchanges between age readers. During the WGBFAS in 2015 it was demonstrated that significant inconsistencies occur between readers particularly from Denmark, and circulation of otoliths between the three countries were initiated. The results of the exercise were available in March 2016. The results show varying levels of accuracy and precision depending on reader expertise, method applied and sample origin, but there were no consistent patterns where one method always produced better results compared to the other. Results of Swedish inter-calibration studies in 2017 and 2018 showed that most uncertainty (differences between readers) appear for ages 4-5. Germany is continuing to investigate methods for SW Baltic plaice but so far there is no solution proposed to solve the age-reading discrepancies. In the period 2020-2021, Denmark participated in a North Sea/Skagerrak plaice otolith exchange programme which has increased uniformity for age-reading methodology for this stock. In 2023, an otolith exchange was organised by Denmark, based on otoliths from SD23, with Sweden, Germany and Poland participating. Otoliths from different sizes fish, were read according to three methods (whole, sectioned, sectioned & stained). Results show similar levels of dissimilarity as from the 2016 otolith exchange, However, it was determined that the staining step did not provide significant improvements in reading consistency and did require more expertise and more involved processes to be operationalised, and therefore, this method was discounted as a solution to the uncertainties coming from age reading. Furthermore, a systematic difference was determined between the German reading of sectioned otoliths and the Danish reading of sectioned and whole otoliths. This error seems to be derived from the interpretation of the first summer translucent ring as "phantom" ring, or the first annual ring. The results from the intercalibration will be investigated for use in the assessment model (errors around ages) at the benchmark to be held in 2024. A further workshop on establishing standard methodologies for reading plaice otoliths is being considered by Denmark and other participants

Catch-at-age data were raised using ICES InterCatch database. Age-distribution information was available for most strata (Table 5.2.3), summing up to 95% of the total landings, and 89% of the discards.

The proportion of landed fish by age are presented in Table 5.2.4a and the relative age distributions in the landing and discard by year are presented in figures 5.2.5a and 5.2.5b, respectively.

Total catch numbers are presented in Table 5.2.4h. The proportion of older fish, age 5 and above, has decreased in recent years as record breaking strong year classes have been occurring since 2019.

5.2.2.2 Mean weight-at-age

Weight-at-age in catch is presented in Table 5.2.4c (landings), Table 5.2.4e (discards) and Table 5.2.4g (catch). Mean weight at age in catch over the entire time-series and for 2021 is presented in Figure 5.2.6.

Mean weight in stock is obtained from Combined 1 quarter surveys and according to the stock annex, is used as an average from 1999–current year. The procedure for calculating this average was updated in 2019 (the same procedure as used for Western Baltic cod). It was observed that stock mean weight at age has been steadily declining since 1999. This is probably due to some combination of density dependence (as stock size and recruitment both continue to reach record high observations, year-on-year since 2020) and environmental constraints (deep water hypoxia and shallow water temperatures). This change in mean stock weight at age can have significant effects on the estimated stock biomass, and therefore, in 2023, WGBFAS decided to change the stock weight at age procedure for the years 2020 onward. The period 1999-2019 still uses the average of that period because the assumption of stable mean weight at age holds true and this maintains the alignment of the majority of the assessment period with the stock annex procedure. However, for the years 2020 onwards, the annual values taken from the Q1 survey are applied for each year independently. This allows the assessment model to better estimate recent changes in stock biomass and allows these changes in the stock to occur gradually, as they do in the data (as opposed to using a new recent three year average). These new stock weights at age are presented in Table 5.2.4f and Figure 5.2.7.

5.2.2.3 Natural mortality

Natural mortality is assumed constant for all years and is set at 0.1 for all ages except age 1, which is set to 0.2 (Table 5.2.4d). Recent downscaling of the estimated SSB in each subsequent assessment year may be due to unaccounted for mortality occurring at young ages. Record high recruitment has been seen consistently, year on year, across both survey indices making the model assume large increases in SSB. However not all of these fish appear to make it to larger ages, and when they do, they are getting lower weights-at-age, in each subsequent year. A combination of density dependence and degraded habitat for fish age 1-3 may be increasing mortality for fish as they move from juvenile to adult habitats. Further research into the validity of this hypothesis and the potential mechanisms driving any increased natural mortality are warranted.

5.2.2.4 Maturity-at-age

The annual maturity ogives was revised for the ICES WKPLE in 2015 and is based on the average from 2002–2023 from information from the Combined 1q survey Table 5.2.4b.

5.2.2.5 Quality of catch and biological data

The sampling of the commercial catches is relatively good except for Subdivision 23 where low numbers of samples are taken by Denmark and very few by Sweden (Table 5.2.3). The low sampling for area 23 should be considered in the context of the relatively limited catches from that subdivision.

It is acknowledged that the variability of growth as well as inconsistency in age readings are important sources of uncertainty in the catch matrix. But this supports the use of a statistical assessment model that can account for some uncertainties in the catch-at-age data.

Historically, the internal consistency of the catch matrix is not very high, and it was difficult to follow large year-classes over time, however, with recent, consistently large recruitment, cohorts seem more coherent from Age 2 onwards (Figure 5.2.8).

5.2.3 Fishery independent information

Only scientific tuning fleets are used. Two tuning series are produced (Table 5.2.4i). These two series are constructed by the combination of 1st quarter NS-IBTS and the 1st quarter BITS on the one hand, and the combination of 3rd quarter NS-IBTS and 4th quarter BITS on the other hand. The surveys are combined using a GAM approach (Berg *et al.*, 2013) considering the uneven

distributions of the two surveys. The following effects are considered using a Delta-Gamma distribution (zeroes and positive catches are modelled separately) to estimate the indices. Explanatory variables included in the model are year, spatial position, depth, gear, time of the day and haul duration. Estimation of the gear effect is possible due to some spatio-temporal overlap of sampling between BITS and NSIBTS, which use different gears. The survey index is derived by letting the model predict the catch rates by year in an ideal experimental design, i.e. in a spatial grid covering the stock area using the same gear, at the same time of day etc. Variation in catch rates caused by changes in the sampling are filtered out in this process and the influence of single hauls with large catches are also reduced.
Very few plaice aged 0 (4th quarter) are caught during the surveys and these are removed from the analysis.

The BITS Q4 survey catches for all age groups were very low in 2019. This decrease in the tuning indices (especially for ages 2-4) was investigated in the raw data and checked with national survey operators, who determined that the reported low survey catches in 2019 were real observations, not erroneous. A potential explanation considered at the time was the presence of abnormally low oxygen conditions in the basins where the majority of survey hauls take place (2019 compared to 2018 and 2017) (Velasco, 2019; 2018; and 2017). Plaice may have been excluded from these areas and hence the population not properly surveyed. A project that ran from 2020 to 2023 (*HypCatch*: Brown *et al*, 2023), investigated including bottom water oxygen concentration as an explanatory variable in the index model, to account for impacts on plaice catchability in the survey. Results showed that, for plaice, oxygen at the levels currently observed in the western Baltic Sea had little to no effect on catchability in the survey. This finding has no bearing on the physiological or population dynamic impacts of hypoxia on plaice. From 2020 onwards, the Q3/4 indices for plaice have been calculated without the 2019 data and that year's indices are considered missing in the assessment (i.e. set to "-9).

A major change was introduced during WGBFAS 2019, in an attempt to reduce the large retrospective patterns observed with the previous model setup. Age 6 are now included in the survey tuning indices. As in the catches, age 6 fish have been increasingly observed in both surveys after 2012 (Figure 5.2.9), and its consistency with other ages is rather good (figures 5.2.10, 5.2.11, and 5.2.12).

Another change in the survey data was introduced in 2019. In 2019, it was determined, that at the time when WGBFAS meets, the age-readings for the most recent Q1 survey are usually completed by Sweden and Germany, but not by Denmark. These age readings represent more than half of the total age readings for the combined survey. As a consequence, the in-year Q1 survey index is highly uncertain, with strong deviations between the index calculated in one year and the same index calculated the following year when all age readings have been uploaded to DATRAS (see 2019 WGBFAS report).

It was decided in WGBFAS 2019 to remove that point from the time-series, until procedures are changed in Denmark and plaice otoliths are read before the Working Group. As such the assessment in 2024 followed this method and only survey data until 2023 have been included in this assessment (although the data from 2024 Q1 are presented in the graphical results). At the conclusion of the WGBFAS meeting in 2020, Denmark stated that they can now reliably provide age reading of Q1 survey samples before the WGBFAS meeting, therefore, the decision to exclude the Q1 survey data from the year of assessment should be revisited in the next benchmark (following the recommendation that this should happen after 3 years of data being provided on time).

5.2.4 Assessment

The stock is a Category 1 (Full annual age based analytical assessment). The State based Assessment Model (SAM) is used. In addition to the changes to the data introduced to the model, that were made in the 2019 assessment review, one further change was made in the model setup. The fishing mortality of ages 6-7+ were decoupled from age 5. This change, along with the other data changes, has been carried forward into all subsequent assessments.

The SPALY assessment had only minor deviations from last year, but performed well. This is observed in retrospective patterns, with a Mohn's rho estimate of 2% for the SSB and 5% for F (Figure 5.2.14).

This SPALY run in SAM is named: ple.27.21-23_WGBFAS_2024_SPALY_v1. The assessment is available at "stockassessment.org" and is visible for everybody.

While the SPALY assessment fit well, the stock size estimates for 2022, from the 2024 assessment model were lower than the 2023 assessment. This downscaling cannot be attributed to changes in the recalculated stock indices. A possible reason for over estimations of stock-size, may be due to unexplained natural mortality that is higher than assumed under the current assessment protocol, especially for younger age groups, but not limited to them (see section 5.2.2 on "Biological information").

5.2.4.1 Recruitment estimates

Estimates of recruitment have drastically increased year on year to unseen levels for all year classes since 2019. Age 1 recruitment estimates for all subsequent years are the absolute highest seen for this stock (~120, ~153, 249, and ~356 million individuals, respectively). While not utilized in the assessment, the Q1 2024 surveys indicate that this trend has continued, extraordinarily large recruitment appears to be true (Figure 5.2.11) and is corroborated by continued high recruitment in the neighbouring ple.27.24-32 stock (pers. Comms. Ple.27.24-32 stock assessor).

5.2.4.2 Historical stock trends

The stock is in good condition, and remains above MSY $B_{trigger}$ since 2014. The results show that an increase in biomass that began ~2010, has continued from a lowest estimated SSB at 3.7 kt in 2009, to the highest of the time series in 2023, at ~18.5 kt. Historically, population growth was boosted by sporadically large recruitment pulses, however, since 2020, we can see a stock-recruitment relationship that resembles a more typical, theorised relationship between SSB and Recruitment. Large stock size appears to be supporting a sustained high level of recruitment with a curve starting to indicate that the stock may be experiencing density dependent recruitment (Figure 5.2.16). This draws into question the relevance of using a resampled median recruitment value from the time series in the forecasts. This recruitment assumption should be addressed in the upcoming benchmark.

As a large portion of the fishery for this stock is either as bycatch (in *Nephrops* or [previously] cod fisheries) or as part of a mixed demersal fishery, the increase in SSB has led to a decrease in F, albeit coupled to increased landings and periods of decreased discard rates.

5.2.5 Short-term forecast and management options

The procedures for the short-term forecast were changed slightly in 2019, and the stock annex was updated accordingly.

Since the Q1 survey in the intermediate year is currently not utilised, the forecasts use most recent data year as the base year and project for four years (base year, intermediate/assessment year, advice year, forecast year, respectively). Intermediate year (2024) assumption for fishing

pressure is is status quo (F=0. 119 for 2024, = F_{2023}). Recruitment for 2024, 2025, and 2026 is a median, resampled from the entire time-series. This approach, specified in the stock annex, looks to have been a sensible approach in the past, however, in recent years, we see that these estimates are well below the actual observed recruitment that we see starting to track with SSB (Figure 5.2.16).

While weight-at-age, catch at age and maturity are described as an average over the last three years in the stock annex, this was changed to equal the most recent data year (2022) in the 2023 assessment, and was retained in the 2024 assessment. This change was made according to a decision taken by WGBFAS as a whole, the purpose of which is to reflect the recent changes in stock weight-at-age (Figure 5.2.7).

As described above, this stock is doing well with continued extraordinary recruitment and stock size since 2019/2020. The large recruitment pulses observed in 2020 and 2021 were expected to enter the fishery fully from 2023. While these cohorts track well in survey indices, due to large discard rates from a non-target fishery and decreasing fish condition, they are not so well tracked in catches. The continued large recruitment contribute to the increase in advice. Furthermore, advice for this stock changed from a decrease (2020 advice) which was due to a change in the basis of the advice (precautionary to MSY approach) to increasing advised catches since 2021, as the stock continues to develop.

5.2.6 Reference points

Reference points were reviewed, together with assessment changes, in 2019. The 2024 assessment uses these same reference point values which are available in Table 5.2.8. One exception is the value of F_{pa}, which was changed to equal $F_{p=0.05}$ in 2020, following the ACOM decision to make the basis for F_{pa} to be the F that leads to SSB $\geq B_{lim}$ with 95% probability. In 2020, this was set to the $F_{p=0.05}$ estimated without the advice rule of $B_{trigger}$ (0.68) and this was corrected in 2021 to match the value of $F_{p=0.05}$ estimated with the advice rule (0.809). As the basis for the advice for this stock over this period was the MSY approach and the SSB and F were far from either value of F_{pa}, this oversight had no effect on the advice provided in 2020.

5.2.7 Quality of assessment

The quality of the assessment is acceptable in 2024 but comes with revisions to the SSB and F over the past five years, relative to the past assessments. This is due to a combination of changes in the fishery associated with a switch to a directed fishery in SD22 (where the majority of catches are fished), extraordinarily good year classes coming through, and particularly the changes made to the use of annual (decreasing) stock weights at age for the years since 2020. Furthermore, the reduction in estimates of SSB has started to be a pattern in subsequent year-on-year assessment comparisons, indicating that the assessment model is overestimating SSB in the assessment year. The best explanation for this repeated over-estimation is unaccounted natural mortality, where large numbers of recruits are not surviving to contribute to the SSB as the mode anticipates. Assumptions of natural mortality and model configurations that can estimate natural mortality, should be investigated during the upcoming benchmark to try and account for this change in natural mortality, and thus ameliorate the SSB overestimation issues.

While the 2024 assessment revises some of the absolute views of the stock, the assessment continues the same relative trends and remains in a strong state. The increase in SSB observed in recent history, continues and appears to be entering a virtuous cycle, whereby it is producing very high recruitment that in-turn supports a growing SSB, Fishing mortality remains below F_{MSY}. The retrospective analyses of this assessment are good.

5.2.8 Management issues

The management areas for plaice in the Baltic Sea (i.e. Subdivision 21 and subdivisions 22–32) are different from the stock areas (i.e. SDs 21–23 and 24–32). The following shows an option for calculating TAC by management area based on the catch distribution observed in 2023. This procedure was adopted in 2016 and has been in use since then.

The catch ratio between SD 21 and SDs 22–23 in 2023 was used to calculate a split of the advised catches for 2025, and a similar calculation was done for the landings only. The advised catch for the stock in SDs 24–32 (Section 5.3.16) was added to the calculated catch for SDs 22–23 to obtain plaice catches by management area that would be consistent with the ICES advice for the two stocks. This results in catches of no more than 5,286 tonnes in SD 21 and 20,079 tonnes in SDs 22–32 (Table 5.2.9).

Table 5.2.1. Plaice in SD 27.21–23. Official landings (t) by Subdivision and country. 1970–2022.

	21			22			23		Total
Year	Denmark	Germany	Sweden	Denmark	Germany	Sweden	Denmark	Sweden	
1970				3757	202				3959
1971				3435	160				3595
1972	15504	77	348	2726	154				18809
1973	10021	48	231	2399	165				12864
1974	11401	52	255	3440	202				15350
1975	10158	39	296	2814	313				13620
1976	9487	32	177	3328	313				13337
1977	11611	32	300	3452	353				15748
1978	12685	100	312	3848	379				17324
1979	9721	38	333	3554	205				13851
1980	5582	40	313	2216	89				8240
1981	3803	42	256	1193	80				5374
1982	2717	19	238	716	45				3735
1983	3280	36	334	901	42				4593
1984	3252	31	388	803	30				4504
1985	2979	4	403	648	94				4128
1986	2470	2	202	570	59				3303
1987	2846	3	307	414	18				3588
1988	1820	0	210	234	10				2274
1989	1609	0	135	167	7				1918

	21			22			23		Total
Year	Denmark	Germany	Sweden	Denmark	Germany	Sweden	Denmark	Sweden	
1990	1830	2	202	236	9				2279
1991	1737	19	265	328	15				2364
1992	2068	101	208	316	11				2704
1993	1294	0	175	171	16			2	1658
1994	1547	0	227	355	1			6	2130
1995	1254	0	133	601	75		64	12	2127
1996	2337	0	205	859	43	1	81	13	3526
1997	2198	25	255	902	51			13	3431
1998	1786	10	185	642	213			13	2836
1999	1510	20	161	1456	244	1		13	3392
2000	1644	10	184	1932	140			26	3910
2001	2069		260	1627	58			39	4014
2002	1806	26	198	1759	46			42	3835
2003	2037	6	253	1024	35	0		26	3355
2004	1395	77	137	911	60			35	2580
2005	1104	47	100	908	51		145	35	2355
2006	1355	20	175	600	46		166	39	2362
2007	1198	10	172	894	63		193	69	2531
2008	866	6	136	750	92	0	116	45	1966
2009	570	5	84	633	194	0	139	42	1626
2010	428	3	66	748	221	0	57	17	1524
2011	328	0	40	851	310		46	11	1575
2012	196	0	30	1189	365	7	54	12	1841
2013	232	0	60	1253	319	0	14	76	1955
2014	343	1	68	1097	320	0	57	45	1931
2015	807	0	87	1103	560	0	26	103	2687
2016	984	1	121	1108	680	0	107	20	3020
2017	703	1	97	1424	939	0	70	13	3247

	21			22			23		Total
Year	Denmark	Germany	Sweden	Denmark	Germany	Sweden	Denmark	Sweden	
2018	482	1	51	1708	1080	0	111	13	3474
2019	332	4	28	2342	1504	0	102	24	4334
2020	264	2	17	2201	824	0	87	14	3409
2021	197	5	13	1081	753	0	63	15	2162
2022	140	10	11	650	591	0	47	11	1461
2023	162	3	14	550	619	0	40	8	1396

Table 5.2.2. Catches from ple.27.21-23 in 2023 by catch category, by fleet and over quarters (tonnes).

Subdivision	CatchCategory	Fleet	Q1	Q2	Q3	Q4
27.3.a.21	Discards	Active	82	82	194	126
27.3.a.21	Discards	Passive	1	1	3	1
27.3.a.21	Landings	Active	42	21	44	45
27.3.a.21	Landings	Passive	3	7	12	6
27.3.b.23	Discards	Active	NA	1	NA	1
27.3.b.23	Discards	Passive	4	7	1	1
27.3.b.23	Landings	Active	0	0	0	0
27.3.b.23	Landings	Passive	13	14	15	5
27.3.c.22	Discards	Active	327	129	14	154
27.3.c.22	Discards	Passive	3	3	6	2
27.3.c.22	Landings	Active	152	172	27	251
27.3.c.22	Landings	Passive	237	173	101	58

Table 5.2.3. Plaice in SD 27.21–23. Sampling effort 2023 by country, gear type and area.

Subdivision	Catch Category	Country	Fleet	Catch (tonnes)	Length Samples	Lengths Measured	Age Samples	Ages Read
27.3.a.21	Discards	Denmark	Active	388.544	39	3072	39	551
27.3.a.21	Discards	Denmark	Passive	3.525	0	0	0	0
27.3.a.21	Discards	Germany	Active	7.554	0	0	0	0
27.3.a.21	Discards	Germany	Passive	0.348	0	0	0	0
27.3.a.21	Discards	Sweden	Active	88.018	27	2496	30	1121
27.3.a.21	Discards	Sweden	Passive	2.235	3	163	15	671
27.3.a.21	Landings	Denmark	Active	136.852	17	3050	17	616
27.3.a.21	Landings	Denmark	Passive	25.286	17	3050	17	616
27.3.a.21	Landings	Germany	Active	1.771	0	0	0	0
27.3.a.21	Landings	Germany	Passive	1.436	0	0	0	0
27.3.a.21	Landings	Sweden	Active	12.279	0	0	0	0
27.3.a.21	Landings	Sweden	Passive	1.592	0	0	0	0
27.3.b.23	Discards	Denmark	Active	1.584	0	0	0	0
27.3.b.23	Discards	Denmark	Passive	9.726	4	208	4	37

Subdivision	Catch Category	Country	Fleet	Catch (tonnes)	Length Samples	Lengths Measured	Age Samples	Ages Read
27.3.b.23	Discards	Sweden	Passive	3.987	0	0	0	0
27.3.b.23	Landings	Denmark	Active	0.506	0	0	0	0
27.3.b.23	Landings	Denmark	Passive	39.614	0	0	0	0
27.3.b.23	Landings	Sweden	Passive	7.744	0	0	0	0
27.3.c.22	Discards	Denmark	Active	265.661	6	609	6	86
27.3.c.22	Discards	Denmark	Passive	7.596	10	210	10	54
27.3.c.22	Discards	Germany	Active	358.402	4	2703	4	406
27.3.c.22	Discards	Germany	Passive	7.077	15	113	15	45
27.3.c.22	Landings	Denmark	Active	303.055	45	9032	45	1706
27.3.c.22	Landings	Denmark	Passive	247.115	45	9032	45	1706
27.3.c.22	Landings	Germany	Active	298.019	4	1372	4	536
27.3.c.22	Landings	Germany	Passive	321.134	21	9744	21	1289
27.3.a.21	Discards	Denmark	Active	388.544	39	3072	39	551
27.3.a.21	Discards	Denmark	Passive	3.525	0	0	0	0

Table 5.2.4a. Plaice in SD 27.21–23. Landing fraction.

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1999	0	0.24	0.3	0.59	0.8	0.55	0.64	0.89	0.98	0.99
2000	0.14	0.23	0.48	0.49	0.78	0.85	0.81	0.94	0.97	0.97
2001	0.02	0.44	0.51	0.41	0.64	0.83	0.85	0.93	0.99	0.98
2002	0.09	0.09	0.38	0.34	0.47	0.42	0.62	1	0.78	0.91
2003	0.06	0.24	0.5	0.67	0.74	0.67	0.59	1	1	1
2004	0.05	0.29	0.52	0.67	0.75	0.92	1	0.99	1	1
2005	0.12	0.34	0.76	0.82	0.73	0.72	0.75	0.49	0.38	0.68
2006	0	0.18	0.37	0.56	0.9	0.77	0.79	0.96	1	1
2007	0.02	0.37	0.44	0.68	0.8	0.67	0.55	0.57	0.78	0.98
2008	0	0.07	0.53	0.78	0.87	0.95	0.97	0.88	0.93	0.98
2009	0.07	0.15	0.35	0.61	0.53	0.32	0.37	0.15	1	0.37
2010	0.08	0.14	0.45	0.63	0.71	0.91	0.97	0.97	0.98	0.99
2011	0.07	0.15	0.28	0.42	0.56	0.55	0.73	0.73	0.86	0.98

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
2012	0.02	0.23	0.46	0.63	0.82	0.96	0.99	0.93	1	0.83
2013	0.01	0.16	0.47	0.59	0.57	0.85	0.88	0.82	1	0.87
2014	0	0.2	0.42	0.42	0.49	0.55	0.56	0.54	0.68	0.83
2015	0	0.2	0.5	0.58	0.74	0.85	0.93	0.88	0.84	0.82
2016	0.02	0.23	0.49	0.61	0.62	0.73	0.86	0.94	0.9	1
2017	0.005	0.207	0.543	0.792	0.806	0.942	0.921	0.893	0.833	0.941
2018	0.01	0.245	0.414	0.656	0.856	0.971	0.885	0.99	0.959	0.97
2019	0	0.175	0.573	0.741	0.888	0.847	0.926	0.992	0.996	0.983
2020	0.03	0.11	0.51	0.81	0.78	0.93	0.96	0.98	0.92	0.94
2021	0.1	0.132	0.277	0.614	0.731	0.776	0.889	0.994	0.973	0.994
2022	0.012	0.098	0.285	0.571	0.815	0.915	0.971	0.955	0.973	0.905
2023	0	0.04	0.13	0.37	0.75	0.92	0.94913	2023	0	0.04

Table 5.2.4b. Plaice in SD 27.21–23. Maturity ogive (corrected methodology since 1999)

	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10
Mean (2002-2023)	0.22	0.55	0.73	0.81	0.9	0.94	0.96	0.97	0.97	0.94

Table 5.2.4c. Plaice in SD 27.21–23. Landings mean weight (kg)

Year	1	2	3	4	5	6	7	8	9	10+
1999	0.22	0.283	0.291	0.329	0.374	0.371	0.412	0.862	0.569	1.274
2000	0.22	0.276	0.289	0.309	0.334	0.447	0.569	0.648	1.016	1.221
2001	0.227	0.264	0.271	0.304	0.323	0.397	0.457	0.596	0.851	1.19
2002	0.239	0.261	0.279	0.265	0.317	0.363	0.432	0.424	0.533	0.523
2003	0.272	0.275	0.283	0.308	0.3	0.474	0.468	0.498	0.548	0.746
2004	0.257	0.242	0.266	0.302	0.324	0.373	0.426	0.618	0.478	1.195
2005	0.202	0.256	0.27	0.308	0.326	0.319	0.35	0.411	0.598	1.451
2006	0.166	0.243	0.294	0.313	0.335	0.316	0.344	0.451	0.53	0.884
2007	0.238	0.236	0.273	0.323	0.455	0.482	0.515	0.54	0.398	0.773
2008	0.225	0.225	0.256	0.303	0.376	0.442	0.499	0.558	0.481	0.529
2009	0.212	0.24	0.28	0.316	0.43	0.577	0.621	0.877	0.644	1.152
2010	0.227	0.292	0.292	0.31	0.379	0.403	0.399	0.372	0.369	0.421

Year	1	2	3	4	5	6	7	8	9	10+
2011	0.237	0.308	0.322	0.343	0.34	0.427	0.481	0.462	0.446	0.441
2012	0.265	0.3	0.335	0.393	0.404	0.462	0.426	0.466	0.565	0.546
2013	0.241	0.301	0.317	0.39	0.489	0.565	0.574	0.562	0.648	0.807
2014	0.241	0.27	0.308	0.341	0.408	0.433	0.509	0.682	1.106	0.78
2015	0.241	0.274	0.303	0.327	0.374	0.441	0.536	0.782	0.792	0.868
2016	0.213	0.295	0.298	0.346	0.376	0.415	0.534	0.518	0.753	0.649
2017	0.126	0.254	0.307	0.333	0.383	0.438	0.458	0.598	0.615	0.771
2018	0.211	0.254	0.295	0.3	0.36	0.422	0.504	0.477	0.568	0.553
2019	0.183	0.248	0.27	0.296	0.361	0.378	0.448	0.528	0.479	0.701
2020	0.173	0.228	0.258	0.306	0.329	0.384	0.45	0.471	0.68	0.575
2021	0.189	0.233	0.235	0.274	0.322	0.363	0.426	0.501	0.557	0.635
2022	0.209	0.246	0.252	0.311	0.353	0.409	0.469	0.576	0.603	0.637
2023	0.322	0.243	0.223	0.242	0.278	0.317	0.4330076	2023	0.322	0.243

Table 5.2.4d. Plaice in SD 27.21–23. Natural mortality.

	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10
All years	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table 5.2.4e. Plaice in SD 27.21–23. Discard mean weight (kg)

Year	1	2	3	4	5	6	7	8	9	10+
1999	0.081	0.12	0.156	0.208	0.288	0.242	0.289	0.436	0.622	1.154
2000	0.081	0.12	0.156	0.208	0.288	0.242	0.289	0.436	0.622	1.154
2001	0.081	0.12	0.156	0.208	0.288	0.242	0.289	0.436	0.622	1.154
2002	0.082	0.104	0.124	0.171	0.193	0.353	0.321	0.519	0.189	0.913
2003	0.081	0.12	0.149	0.165	0.138	0.11	0.136	0.436	0.622	1.154
2004	0.089	0.127	0.175	0.297	0.249	0.159	0.294	0.168	0.622	1.154
2005	0.091	0.141	0.177	0.224	0.3	0.394	0.535	0.724	1.054	1.394
2006	0.061	0.11	0.154	0.183	0.561	0.192	0.159	0.331	0.622	1.154
2007	0.044	0.088	0.132	0.176	0.323	0.437	0.636	0.824	1.052	1.732
2008	0.102	0.136	0.157	0.287	0.365	0.388	0.111	0.104	0.126	0.132
2009	0.086	0.118	0.139	0.194	0.168	0.139	0.148	0.161	0.622	0.21

Year	1	2	3	4	5	6	7	8	9	10+
2010	0.095	0.121	0.13	0.159	0.187	0.353	0.513	0.452	0.955	0.185
2011	0.066	0.113	0.206	0.233	0.213	0.167	0.276	0.274	0.333	0.217
2012	0.07	0.131	0.244	0.32	0.298	0.183	0.181	0.643	0.178	0.586
2013	0.074	0.106	0.206	0.332	0.39	0.207	0.295	0.242	0.411	0.789
2014	0.087	0.13	0.171	0.279	0.339	0.335	0.424	0.405	1.14	0.465
2015	0.077	0.1	0.144	0.16	0.212	0.235	0.321	0.2	0.13	0.321
2016	0.07	0.107	0.14	0.175	0.275	0.376	0.281	0.182	0.246	0.305
2017	0.072	0.118	0.157	0.206	0.301	0.382	0.333	0.49	0.579	0.46
2018	0.075	0.116	0.142	0.215	0.257	0.175	0.463	0.204	0.152	0.215
2019	0.065	0.102	0.126	0.135	0.156	0.136	0.167	0.354	0.17	0.35
2020	0.068	0.105	0.193	0.276	0.294	0.375	0.45	0.468	0.643	0.573
2021	0.055	0.081	0.103	0.116	0.137	0.1	0.096	0.385	0.211	0.469
2022	0.054	0.069	0.101	0.125	0.143	0.176	0.21	0.38	0.519	0.265
2023	0.059	0.066	0.073	0.096	0.118	0.13	0.2877437	2023	0.059	0.066

Table 5.2.4f. Plaice in SD 27.21–23. Mean weight (kg) in stock by age used in 2024 assessment.

	1	2	3	4	5	6	7	8	9	10+
Mean(1999-2019)	0.037	0.077	0.133	0.201	0.257	0.310	0.414	0.435	0.426	0.492
2020	0.018	0.048	0.127	0.183	0.242	0.241	0.263	0.339	0.325	0.447
2021	0.018	0.047	0.078	0.162	0.186	0.234	0.246	0.326	0.383	0.260
2022	0.019	0.041	0.086	0.109	0.151	0.161	0.252	0.212	0.229	0.297
2023	0.018	0.040	0.070	0.102	0.139	0.180	0.204	0.272	0.400	0.397

Table 5.2.4g. Plaice in SD 27.21–23. Mean weight (kg) in catch by age.

Year	1	2	3	4	5	6	7	8	9	10+
1999	0.081	0.159	0.196	0.280	0.356	0.313	0.368	0.806	0.563	1.263
2000	0.101	0.156	0.220	0.258	0.324	0.416	0.515	0.631	0.994	1.199
2001	0.084	0.184	0.215	0.248	0.311	0.371	0.432	0.578	0.843	1.172
2002	0.097	0.117	0.182	0.202	0.252	0.357	0.390	0.424	0.458	0.559
2003	0.092	0.157	0.216	0.261	0.258	0.355	0.331	0.498	0.548	0.746
2004	0.097	0.161	0.222	0.300	0.305	0.355	0.426	0.613	0.478	1.195

Year	1	2	3	4	5	6	7	8	9	10+
2005	0.104	0.180	0.248	0.293	0.319	0.340	0.397	0.570	0.881	1.432
2006	0.061	0.133	0.205	0.255	0.358	0.287	0.306	0.447	0.530	0.884
2007	0.047	0.143	0.195	0.276	0.429	0.467	0.569	0.661	0.540	0.794
2008	0.102	0.142	0.210	0.299	0.375	0.439	0.489	0.502	0.455	0.520
2009	0.096	0.137	0.189	0.268	0.306	0.280	0.322	0.267	0.644	0.556
2010	0.105	0.158	0.240	0.259	0.325	0.396	0.403	0.374	0.381	0.419
2011	0.077	0.141	0.239	0.280	0.284	0.311	0.425	0.411	0.430	0.437
2012	0.074	0.169	0.286	0.366	0.384	0.452	0.423	0.478	0.564	0.553
2013	0.076	0.138	0.259	0.366	0.446	0.511	0.540	0.503	0.647	0.804
2014	0.087	0.159	0.229	0.305	0.373	0.388	0.471	0.556	1.117	0.727
2015	0.077	0.135	0.223	0.256	0.332	0.410	0.521	0.715	0.689	0.768
2016	0.074	0.150	0.218	0.280	0.338	0.404	0.498	0.498	0.701	0.648
2017	0.073	0.146	0.238	0.307	0.367	0.435	0.448	0.586	0.609	0.753
2018	0.076	0.150	0.205	0.271	0.345	0.415	0.499	0.475	0.551	0.543
2019	0.065	0.128	0.208	0.255	0.338	0.341	0.427	0.526	0.478	0.695
2020	0.068	0.105	0.193	0.276	0.294	0.375	0.450	0.468	0.643	0.573
2021	0.087	0.101	0.140	0.213	0.272	0.304	0.389	0.501	0.547	0.635
2022	0.057	0.083	0.142	0.197	0.280	0.338	0.403	0.465	0.574	0.571
2023	0.059	0.072	0.092	0.150	0.238	0.303	0.356	0.437	0.544	0.589

Table 5.2.4h. Plaice in SD 27.21–23. Total catches (CANUM).

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1999	1377659	7286520	7123406	6540780	2427443	355338	167828	60681	39013	89466
2000	1610659	7179902	9714540	5232865	2256294	1057577	316913	112681	24920	39940
2001	1405659	9931207	10245755	4543348	1356553	940961	409406	92047	50314	48320
2002	4435651	8578400	20441469	12680459	1269575	292505	129360	58473	8181	5161
2003	946442	12394512	4692894	6070359	3079534	399508	101550	31089	8697	4837
2004	1015923	2702712	6024522	3791879	2375641	916596	171059	3396	1358	2795
2005	774005	7254148	3086708	2166619	991902	776303	330360	56681	3068	16163
2006	321609	4580833	9969825	2896298	1208044	867801	611949	105917	13137	11880

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
2007	267054	3636564	7725502	3650027	1054350	522184	97803	83092	26152	22273
2008	2147170	7356643	4817249	2517528	973474	379320	154559	41156	67899	105171
2009	681346	5923506	4454970	2925220	1266692	463083	66854	146568	516	10243
2010	1007663	6382103	4475417	1781851	574649	207700	128380	106640	74233	35767
2011	2681908	6570857	5962611	1686722	679439	490565	257862	141363	74256	70418
2012	990000	3978884	4597271	2014708	477022	150657	106988	70967	56634	67134
2013	1778988	5835653	4700512	2424381	785435	203019	81130	34499	30040	32541
2014	446667	3373311	5047504	4184430	1521451	530256	116942	40482	5390	19456
2015	268363	3195165	4417121	3785213	2402626	747101	352195	61537	15351	5859
2016	1258096	4309152	6803758	3340644	2161240	1063172	294669	152507	56218	54383
2017	1298124	2985733	4028499	3913709	1721828	1028901	623925	218615	132563	82287
2018	665693	6292779	4775073	3661795	2587740	1151678	557017	189004	104599	138207
2019	302677	2950727	10360430	4532742	1998352	1247147	578394	262947	194713	140809
2020	2619018	3801778	5455340	6047568	1755936	780805	334362	219039	93177	139420
2021	778511	6044065	2912124	2796783	2638133	853073	441930	177339	93928	162123
2022	1270871	3042265	5431104	2139918	1049015	626216	245013	121875	67165	93256

Table 5.2.4i. Plaice in SD 27.21–23. Survey indices NS-IBTS and BITS combined.

1st quarter

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1992	0	2362.846	10091.4998	7351.8269	1141.1884	29.0644
1993	417.671	4374.1907	4263.7874	2418.3682	770.7019	194.1303
1994	97.9782	8038.4476	6865.0801	1753.583	633.39	98.495
1995	337.737	2987.3578	8950.956	2703.0775	465.724	267.4453
1996	0	9876.041	6576.7886	2439.5532	813.775	206.325
1997	6.9117	2970.7787	5422.0498	1450.5924	491.7181	46.6969
1998	470.8421	3776.9416	4986.9279	3455.6277	1174.6454	396.5003
1999	1554.1383	12391.5007	6068.9149	1585.4708	822.6172	67.7182
2000	3928.7552	31807.964	14493.3469	2392.0105	746.5912	416.0301

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
2001	1167.4272	17127.7743	18393.9769	4295.3487	588.1275	241.245
2002	1894.5305	4865.4541	13539.8642	7143.7912	1454.9223	347.3288
2003	1770.6135	20216.4402	9362.3508	10502.3771	5433.1826	733.2937
2004	1260.5501	7697.3418	16337.1337	7317.5228	4679.9669	2859.3047
2005	1605.5565	17103.6935	15372.8402	8353.0898	2916.7335	2514.2282
2006	382.2786	10542.3226	24211.1283	9363.2965	3491.7201	751.0243
2007	1441.1086	9343.5166	17062.3132	12755.9161	3169.4665	1342.4434
2008	1827.0593	6543.7907	8884.1303	4699.3721	1564.9221	504.8321
2009	763.2812	5552.456	9863.105	4642.5068	1659.5246	616.0882
2010	4125.8056	10326.3172	12939.9941	6505.0925	2561.5674	602.4174
2011	1443.9075	15001.0287	12160.1238	5846.5886	2938.0887	1183.1389
2012	2674.0806	11274.6876	13074.7905	5455.963	1391.9303	507.6828
2013	577.305	8207.453	20660.059	10471.6915	6205.0168	1448.2642
2014	278.5612	9098.7562	17034.9288	15311.4364	6970.7311	2403.381
2015	549.1481	10706.2764	16085.8729	12437.5783	7695.1154	3759.4207
2016	1289.2371	15874.1902	22867.4636	14950.4198	7138.3126	3425.8731
2017	4206.0209	16081.3558	22786.3857	10048.5472	5307.2758	2419.6492
2018	3707.3434	21360.9638	19311.9054	10510.4663	5821.7533	1887.8064
2019	607.2468	18718.9321	25761.867	10229.6677	3121.7933	2076.693
2020	7550.6566	8172.5744	13618.6574	14258.59	5715.3452	1720.3078
2021	11480.3316	77577.3806	26626.9196	10766.6493	7107.2156	3480.5513
2022	20892.3142	145546.0984	76617.2944	17430.8828	9033.2663	4460.3568
2023	37590.2415	206441.7344	147830.1513	62315.567	19331.9171	4469.6113

3rd and 4th quarter (2019 set to "missing" with "-9")

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1999	28513.84	20841.42	3863.94	390.38	472.35	93.22
2000	11737.50	23596.24	8476.32	109.37	75.41	122.21
2001	4338.38	14849.17	6938.51	1452.47	162.46	203.90
2002	10182.31	5741.75	7262.43	4487.09	917.99	160.05

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
2003	4476.31	15921.66	4573.20	3298.79	1677.74	272.37
2004	8465.10	9202.71	15600.17	3811.75	2398.61	1678.51
2005	7945.86	11889.18	3439.77	1707.99	490.02	579.74
2006	7519.52	11178.53	10601.89	2111.84	986.40	595.47
2007	5806.40	11211.46	4786.62	2814.08	742.20	353.02
2008	2557.54	11653.02	10036.69	3481.15	984.11	217.16
2009	4691.24	10573.02	11496.43	2122.09	426.53	228.74
2010	4865.64	7097.57	4721.31	3941.26	1172.54	597.86
2011	11555.22	12764.76	7961.18	2814.67	606.02	276.59
2012	11973.38	13317.51	10075.12	4985.79	1208.13	312.70
2013	5243.25	11850.18	11879.98	5051.83	2345.46	906.88
2014	10560.34	12060.62	11288.73	5778.49	3003.49	816.06
2015	6028.12	15253.62	13662.22	9725.81	4681.33	1073.10
2016	12436.50	14355.34	10983.76	4768.25	2400.71	1224.52
2017	25661.34	12319.25	7429.33	4285.78	1784.05	1196.47
2018	16215.51	21359.62	9052.26	3466.09	1123.42	1078.03
2019						
2020	52253.51	16243.27	8563.14	5857.98	1424.00	682.33
2021	84861.63	52697.10	16204.56	5147.02	4000.70	1411.55
2022	96432.08	71824.88	46907.28	12778.19	2366.93	1663.57
2023	127941.38	86004.93	56922.96	29334.72	5329.90	2169.24

Table 5.2.5 Plaice in SD 27.21–23. SAM results from the final assessment (SPALY_v1). Estimated recruitment (000s), spawning stock biomass (SSB in tonnes), and average fishing mortality for ages 3 to 5 (F_{3-5}). High and low refers to 95% confidence intervals.

	Recruitment (Age1)			SSB (tonnes)			Fbar(3-5)		
Year	**Low**	**Median**	**High**	**Low**	**Median**	**High**	**Low**	**Median**	**High**
1999	34936	48555	67483	4043	4933	6018	0.831	1.064	1.361
2000	33056	45385	62313	4526	5444	6547	0.915	1.136	1.411
2001	18266	25220	34823	5113	6179	7467	0.823	1.011	1.244
2002	30578	43627	62244	5411	6584	8011	0.784	0.968	1.195
2003	16498	22734	31326	4847	5767	6862	0.636	0.794	0.991
2004	21047	28826	39480	4394	5195	6143	0.552	0.704	0.897
2005	17939	24605	33748	4092	4814	5663	0.528	0.684	0.885
2006	10637	15044	21276	4190	4998	5962	0.629	0.797	1.009
2007	13223	18217	25097	3625	4309	5122	0.594	0.763	0.979
2008	17356	24371	34222	3385	4014	4759	0.652	0.823	1.038
2009	14909	20407	27932	3161	3761	4475	0.596	0.76	0.969
2010	23756	32852	45431	3129	3702	4381	0.478	0.63	0.832
2011	24577	33766	46389	3633	4317	5131	0.529	0.706	0.944
2012	25978	36100	50166	3994	4788	5742	0.322	0.445	0.614
2013	20489	28251	38953	5033	6040	7248	0.297	0.408	0.562
2014	14408	20367	28791	5864	7046	8466	0.288	0.392	0.535
2015	13973	19568	27404	6331	7588	9095	0.309	0.416	0.561
2016	20750	28664	39595	6468	7713	9197	0.399	0.526	0.694
2017	34970	49527	70143	6301	7530	8998	0.394	0.516	0.675
2018	28657	41065	58846	6692	7999	9562	0.417	0.545	0.712
2019	16859	24607	35918	7052	8550	10366	0.408	0.54	0.715
2020	81259	120430	178484	6137	7462	9074	0.358	0.485	0.658
2021	104710	152947	223404	6320	7836	9714	0.209	0.293	0.412
2022	163044	249297	381181	8881	11324	14438	0.109	0.159	0.232
2023	208673	355775	606576	14022	18567	24585	0.078	0.118	0.178
2024	15044*	28826*	355777*						

*** Median resampled from the entire time-series of recruitment.**

Table 5.2.6. Plaice in SD 27.21–23. Estimated fishing mortality (F) at-age.

Year Age	1	2	3	4	5	6	7
1999	0.044	0.344	0.783	1.262	1.146	1.037	1.037
2000	0.049	0.372	0.826	1.338	1.246	1.168	1.168
2001	0.05	0.373	0.76	1.164	1.111	1.083	1.083
2002	0.057	0.418	0.789	1.096	1.018	0.981	0.981
2003	0.047	0.351	0.653	0.894	0.835	0.806	0.806
2004	0.039	0.299	0.575	0.79	0.747	0.713	0.713
2005	0.036	0.283	0.551	0.762	0.738	0.703	0.703
2006	0.039	0.314	0.634	0.884	0.873	0.826	0.826
2007	0.038	0.309	0.615	0.846	0.828	0.751	0.751
2008	0.049	0.373	0.688	0.903	0.877	0.771	0.771
2009	0.048	0.361	0.65	0.828	0.803	0.684	0.684
2010	0.044	0.32	0.561	0.683	0.648	0.546	0.546
2011	0.051	0.359	0.625	0.759	0.736	0.622	0.622
2012	0.034	0.23	0.398	0.476	0.46	0.387	0.387
2013	0.032	0.214	0.37	0.438	0.416	0.342	0.342
2014	0.026	0.185	0.342	0.423	0.412	0.336	0.336
2015	0.024	0.178	0.349	0.448	0.451	0.369	0.369
2016	0.029	0.214	0.435	0.567	0.576	0.468	0.468
2017	0.025	0.188	0.405	0.555	0.586	0.489	0.489
2018	0.022	0.177	0.408	0.588	0.639	0.544	0.544
2019	0.019	0.16	0.391	0.582	0.646	0.562	0.562
2020	0.017	0.139	0.348	0.524	0.584	0.514	0.514
2021	0.009	0.076	0.198	0.313	0.369	0.34	0.34
2022	0.005	0.041	0.106	0.169	0.203	0.194	0.194
2023	0.004	0.03	0.078	0.124	0.151	0.148	0.148

Table 5.2.7. Plaice in SD 27.21–23. Estimated stock numbers at age (thousands).

Year / Age	1	2	3	4	5	6	7
1999	48555	31235	11193	5476	3226	333	954
2000	45385	40292	18719	4369	1610	976	480
2001	25220	37174	26626	7411	1195	526	481
2002	43627	17895	25285	13928	2187	408	315
2003	22734	30961	10842	10845	4963	720	249
2004	28826	15910	16485	5890	4160	2127	384
2005	24605	24209	10507	6848	2252	1768	1045
2006	15044	19769	17267	5796	2828	993	1209
2007	18217	13881	12744	7603	2077	1039	768
2008	24371	15774	10780	6042	2511	767	752
2009	20407	16809	10847	5200	2037	898	616
2010	32852	16128	9951	4820	2051	767	739
2011	33766	25302	11832	4717	1893	937	845
2012	36100	24315	15141	6279	1831	695	841
2013	28251	26055	18976	8693	3549	991	840
2014	20367	23364	18335	12030	5045	1947	1036
2015	19568	20059	16770	11567	6696	2802	1764
2016	28664	19471	16122	10323	5988	3415	2512
2017	49527	21351	14608	9429	4996	2804	3176
2018	41065	35499	16499	8594	5119	2403	3118
2019	24607	29994	26056	10550	4055	2510	2848
2020	120430	21480	18777	15038	5384	1882	2664
2021	152947	86239	18857	10675	7345	2893	2553
2022	249297	123114	61039	14983	6611	4125	3424
2023	355775	196943	99651	46733	12122	4525	5559

Table 5.2.8. Plaice in SD 27.21–23. Reference points for 2024, retained from 2019 review and with F_{pa} updated to the correct F_p=0.05.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	4 730	= B_{pa}
	F_{MSY}	0.31	Equilibrium scenarios stochastic recruitment.
	$F_{MSY(upper)}$	0.59	
	$F_{MSY(lower)}$	0.18	
Precautionary approach	B_{lim}	3 635	B_{loss} (lowest observed biomass=Biomass in 2009)
	B_{pa}	4 730	$B_{lim} \times e^{1.645\sigma}$, $\sigma = 0.16$
	F_{lim}	1.00	Equilibrium scenarios prob(SSB< B_{lim})< 50% with stochastic recruitment.
	F_{pa}	0.809	Fpa = Fp=0.05 (with Btrigger)

Table 5.2.9. Plaice in SD 27.21–32. Potential allocation of catches by management area.

Basis		Catch 2023	Landings 2023	ICES stock advice 2025 (catch)
Stock area-based	SDs 21-23	2541	1396	20062
	SDs 24-32	783	498	5303
Total advised catch, 2025 (SDs 21-32)				25365
Management area-based	SD 21	669	179	
	SDs 22-23	1871	1217	
	SDs 22-32	2654	1715	

	Calculation	Result
Share of SD 21 of the total catch in SDs 21–23 in 2023	= 669 / 2541	0.263
	(catch in 2023 SD 21 / catch in2023SDs 21–23)	
Catch in 2025 for SD 21	= 20062 * 0.263	5286
	(ICES stock advice in 2025 (catch) for SDs 21–23 × share)	
Catch in 2025 for SD 22-32	= 25365 - 5286	20079
	(total advised catch in 2025 SDs 21–32 minus catch SD 21)	
Share of SD 21 of the total landings in SDs 21–23 in 2023	= 179 / 1396	0.128
	(landings in 2023 SD 21 / landings in 2023 SDs 21–23	

Figure 5.2.1. Plaice in SD 27.21–23. Landings by subdivision by year.

Figure 5.2.2. Plaice in SD 27.21–23. Landings (t) by country by year.

Figure 5.2.3. Plaice in SD 27.21–23. Landings (t) by country by year across areas. Advised TAC for SD 21 shown as a purple line.

Figure 5.2.4a. Plaice in SD 27.21–23. Catches (t) in 2021 by gear type, area, quarter and catch category. Note varying y-axis values by area.

Figure 5.2.4b. Plaice in SD 27.21–23. Discard ratio over time, orange line is the median of the time series.

Figure 5.2.4c. Plaice in SD 27.21–23. Catch components over time by Subdivision. Note varying y-axes by subdivision.

Figure 5.2.5a. Plaice in SD 27.21–23. Age composition for landings over time.

Figure 5.2.5b. Plaice in SD 27.21–23. Age composition for discards over time.

Figure 5.2.6. Plaice in SD 27.21–23. Mean weight (kg) at-age in catch.

Figure 5.2.7. Plaice in SD 27.21–23. Mean weight (kg) at-age in stock. Blue line with ribbon is the mean of the whole time series, used in the SPALY assessment according to the stock annex. Green line with ribbon is the mean applied to the period 1999:2019 in the assessment, similar to the stock annex. The remaining lines without ribbons show the annual values which are applied for all years after 2019 in the assessment, as a deviation from the stock annex.

Figure 5.2.8. Plaice in SD 27.21–23. Cohort tracking of the catch-at-age matrix

Figure 5.2.9. Plaice in SD 27.21–23. Catch-at-age over time.

Figure 5.2.10. Plaice in SD 27.21-23. Survey indices over time (re-calculated within assessment year with all available data). Top: Q1 combined indices (note 2023 data not used in calculation of indices for the 2023 assessment. Bottom: Q3-4 combined indices (note 2019 data not used in calculation of indices for the 2023 assessment).

Figure 5.2.11. Plaice in SD 27.21-23. Cohort-tracking through survey indices by age. Bubble size relative to within year index by age recalculated from total data series available at time of assessment in 2023. Top: Combined Q1 survey indices (note 2023 data not used in assessment). Bottom: Combined Q3-4 survey indices (note 2019 excluded from calculation of all indices according to decision in 2019 assessment).

Figure 5.2.12. Plaice in SD 27.21–23. Internal consistency of the two survey indices. Top: Q1 survey. Bottom: Q3-4 survey.

25000
20000
15000
10000
5000
0
SSB
se
current
ple.27.21-23_WGBFAS_202
2000
2005
2010
2015
2020
Years
stockassessment.org, ple.27.21-23_WGBFAS_2024_SPALY_v1, r18032 , git: e38ae2b498f0

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
$\overline{F}_{3-5}$
se
current
ple.27.21-23_WGBFAS_202
2000
2005
2010
2015
2020
Years
stockassessment.org, ple.27.21-23_WGBFAS_2024_SPALY_v1, r18032 , git: e38ae2b498f0

Recruits (age 1)
0e+00
1e+05
2e+05
3e+05
4e+05
5e+05
6e+05
se
current
ple.27.21-23_WGBFAS_202
2000
2005
2010
2015
2020
Years
stockassessment.org, ple.27.21-23_WGBFAS_2024_SPALY_v1, r18032 , git: e38ae2b498f0

Figure 5.2.13. Plaice in SD 27.21–23. SPALY (green) and Alternative (purple) SAM runs. Last year's assessment is shown in blue while this year's assessment is in green.

Rho 2%
SSB
15000
10000
5000
Rho 5%
F_{3-5}
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Catch
8000
6000
4000
2000
0
w.o. Plaice21-23IBTS+BITS-;calculated2024-04-1516:17:45
w.o. Plaice21-
Years
2000
2005
2010
2015
2020
Rho -7%
Recruits (age 1)
3e+05
2e+05
1e+05
0e+00
Years

Figure 5.2.15. Plaice in SD 27.21–23. Alternative SAM Residuals by Fleet, Age and Year. The top panel represent catches, the middle the combined Q1 survey indices and the bottom the combined Q3-Q4 survey indices.

Figure 5.2.16. Stock recruitment relationship for plaice in SD 27.21–23 based on the SPALY SAM Run.

5.3 Plaice in subdivisions 24–32

5.3.1 The Fishery

There are no management objectives for the stock. The management areas do not match the assessment areas. The TAC for the combined stock ple.27.22-32 was 9050 and 11 313 tonnes in 2022 and 2023, respectively. The analytical assessment of ple.27.21-23 indicated an increase in recruitment which was considered when combining the results with ple.27.24-32, where a similar signal occurred.

5.3.1.1 Technical Conservation Measures

Plaice in the eastern Baltic Sea is mainly caught in the area of Arkona and Bornholm basin (SD 24 and SD 25). ICES Subdivision 24 is the main fishing area with Denmark and Germany being the main fishing countries. Subdivision 25 is the second most important fishing area. Denmark, Sweden and Poland are the main fishing countries there. Minor catches occur in Gdansk basin

(SD 26). Marginal catches of plaice in other SD are found occasionally in some years, but were usually lower than 1 ton/year (Figure 5.3.1).

Plaice are caught by trawlers and gillnetters mostly. The minimum landing size is 25 cm in 2022, active gears provide most of the landings in SD 24 (ca. 90%) and SD 25 (ca. 62%) while passive gears provided most of the landings in SD 26 (ca. 80%); passive gears provided on average 16% of total plaice landings in 2023.

5.3.1.2 Landings

The catch and landings data of plaice in the Eastern Baltic (ple.27.24-32) according to ICES subdivisions and countries are presented in tables 5.3.1 and 5.3.2. Only Denmark, Poland and Germany are landing plaice in larger quantitiy. Minor landings occur from Sweden and Finland (traded quota from Sweden) The trend and the amount of the landings of this flatfish per country is shown in Figure 5.3.2.

The highest total landings of plaice in SDs 24 to 32 were observed at the end of the 1970s (4530 t in 1979) and the lowest around the period between 1990 and 1994 (80 t in 1993). Since 1995 the landings increased again and reached a moderate temporal maximum in 2003 (1281 t) and again in 2009 (1226 t). After 2009 the landings are decreasing to 748 t in 2011, slightly increased in 2012 to around 848 tonnes and decreased to 427 tonnes in 2015. Landings (wanted catch) in 2018 and 2019 were about 160 tonnes and almost three times higher than in previous years. Recent landings in 2023 increased slightly to about 498 tonnes and is the second-lowest since the mid 1990s. Since 2017, a landing obligation is in place, resulting in an additional 9.2 tonnes of "BMS landings" (i.e. landings of plaice below the minimum conservation reference size of 25 cm) in 2023, which accounted for 1.8% of the total catch.

5.3.1.3 Unallocated removals

Unallocated removals might take place but are considered minor and are not reported from the respective countries. Recreational fishery on plaice might take place with unknown removals, but is also considered to be of minor influence.

5.3.1.4 Discards

Although a landings obligation is in place since 2017, discards in the commercial fisheries remain to be high and seems to vary greatly between countries. For example, the trawl-fishery targeting cod in SD 26 may even have a 100% discard rate of plaice throughout the year. Only a few occasional landings from trawl-fisheries took place in SD 26. Countries without a TAC for plaice are assumed to have 100% discard. Several countries without a TAC are regularly reporting their estimated discards to be included into the stock assessment and for stock status updates. The discards in 2016 were exceptional high and estimated to be around 1050 tonnes, which would result in a discard ratio of 67% of the total catch.

However, the available data on discards are incomplete for all subdivisions. Provided discard estimates from national sampling programs were exceptionally low in the current year. National discard estimations were missing in almost all strata, especially where fishing effort has been reduced due to historically low cod quota and fishing closures. Only Germany provided a good coverage of estimates. One estimate was provided by Poland and Denmark in 2023, respectively (Figure 5.3.2a).

Sampling coverage, esp. in the passive-gear segment had been improving for several years now, but decreased in 2020 and 2021 due to covid-19 restrictions for e.g. observer trips, entry to harbor facilities and auction halls and was exceptionally bad for the current year, where most national institutes failed to send obersers onboard on fishing vessels (Figure 5.3.2.b). Discards in the most

recent year (2023) were around 284 tonnes (i.e. 36% of the total catch), which is higher than in the previous year.

The change towards flatfish-directed fisheries in both active and passive gears resulted in higher discards due to smaller mesh sizes (90mm flatfish gears instead of 105+mm cod-directed gears). High discards were recorded at 23-24cm total length, just below the minimum conservation reference size (MCRS). The decreasing condition in Baltic Sea flatfishes (see 5.3.6.2 and Figure 5.3.13) is also strongly affecting plaice, resulting in dab above the MCRS being discarded more often than before.

5.3.2 Biological composition of the catch

5.3.2.1 Sampling coverage

All major fishing gears are covered by biological sampling, with sampling effort adjusted to fishing activity (i.e. more prominent fishing gears are covered by a higher number of samples, Figure 5.3.3). However, only Germany was able to provide biological sampling data in landings and discards in 2023. Denmark provided two samples from the active fisheries, covering the active fishery in Q1 in SD25 of the catch. Other member states have not been able to sample harbors or vessels for plaice (Figure 5.3.2b). The overvall lack in samples results in increased uncertainty in the data.

5.3.2.2 Length composition

Plaice in the Baltic Sea (ple.27.21–23 and ple.27.24–32) are both experiencing extraordinarily high recruitment pulses from the 2019 and 2020 year classes, confirmed from both surveys and commercial catches (Figure 5.3.4). The length distribution indicates that these cohorts entered fisheries in 2021 and are fully covered by fisheries in 2023. The average length in the catches decreased strongly in 2022 and 2023 (33.5 and 27cm, respectively, Table 5.3.3), indicating that these cohorts are now indeed present in the unwanted catch fraction of the commercial fisheries. The switch to smaller meshsizes in the commercial fishery to target flatfishes and decreasing condition of plaice is also contributing to increasing discards.

Table 5.3.3: average length-at-catch ($\bar{L}$) in commercial fisheries of ple.27.24-32 of the last five years, all gears and areas combined.

Year	2019	2020	2021	2022	2023
$\bar{L}$	43.18	41.16	33.50	26.98	23.52

In 2023, the average length-at-catch in the landing fraction was about 23.5 cm, whereas the average length-at-catch in the discard fraction was about 175 cm.

5.3.2.3 Age composition

Age class 3 is most abundant in the landing fraction of plaice and accounts for 22% of the catch fraction. In the most recent year (2023) ages classes 3 to 6 each covered around 20% of the catch fraction, contributing a total of 86% to the landings.

In the discard fraction, age class 4, originating from the strong 2019 cohort, is the most abundant, accounting for 60% of the catch fraction. Age class 3, originating from the strong 2020 cohort, accounted for 20% of the catch fraction. Only around 5% of discarded plaice were above age class 6 (Figure 5.3.5). Age reading errors are known to occur in when reading plaice otoliths. National labs often differ in the interpretation of the first settlement ring, especially when average length and weight are similar between ages (Figure 5.3.6.) and do not give an indication of the real

age.However, as preparation of the benchmark in 2024, national labs are currently using age-validated otoliths to check and correct the age readings.

5.3.2.4 Mean weight-at-age

Recent years show a decrease in the average weight for almost all age classes (Figure 5.3.5). The age classes above 7 are usually not very well sampled, causing some fluctuations in the average weight. The most recent year displays a large drop of around 25% in stock weights in almost all age-/length classes compared to previous stock weights. This effect has been visible for three years in the western plaice stock, ple.27.21-23, but has not been seen as prominently in ple.27.24-32. This is mostly due to a lower sampling coverage, but also due to some member states method of calculating weight-at-length and weight-at-age, where averaged survey length-weight-coefficients have been used to calculate stock weights. These values have not been updated each year and thus missing the development in stock weight. The decrease in weight-at-length continues in 2023, mainly caused by bad condition on plaice (Figure 5.3.5, Figure 5.3.13). The exact reason for the decrease in stock weight is unknown, but it might be density-related, along with other environmental effects influencing plaice food availability.

5.3.2.5 Natural mortality

No further information or studies on natural mortality are available. The average natural mortality for age classes 1 and 2 is set at 0.2, age classes 3+ are set at 0.1 as a default.

5.3.2.6 Maturity-at-age

The maturity ogive was taken from the BITS from SD22 and SD24 (since they are more reliable and consistent than SD24+, see WKPLE 2015 report). Both quarters from the period 2002 to 2018 were combined and an average maturity-at-age was calculated:

Age	1	2	3	4	5	6	7	8	9	10
Maturity	0.18	0.51	0.70	0.85	0.94	0.97	0.97	0.99	0.98	0.99

5.3.3 Fishery independent information

The "Baltic International Trawl Survey (BITS)" is covering the area of the plaice stock in SD24–32. The survey is conducted twice a year (1st and 4th quarter) by the member-states having a fishery in this area. Survey-design and gear is standardized. Due to a change in trawling gear in 2000, only first and fourth quarter BITS since 2001 are considered. The CPUE is calculated from the catches. The BITS-Index is calculated as a biomass index (for the SPiCT assessment) and as an age index (for the exploratory SAM model):

Biomass index: Average number of plaice ≥20 cm weighted by the area of each depth stratum which all together covers the area covered by the stock. These are multiplied with the average weight of the respective length-class. The length-weight-coefficients are regularly checked and updated to account for changes in stock weights.

Age index: Average number of plaice ≥20 cm per age, weighted by the area of each depth stratum which all together covers the area covered by the stock. (Figure 5.3.8).

The preliminary 2024 Q1 survey shows a highly increased number of smaller plaice (age 1) and higher amounts of age 0, which are usually not covered by the BITS trawls. As the index only takes plaice >20cm into account, the effect of the large amount of small plaice is not fully covered by the survey index.

The biomass index (as used for the SPiCT) shows the effect more prominently but is also not fully accounting the huge amount of incoming smaller fish (Figure 5.3.7). A length-based index or young fish survey index would be more appropriate to display and account for smaller plaice.

5.3.4 Assessment

Following an independent review, plaice is assessed as a category 2 stock using SPiCT as basis for the assessment and advice (ICES, 2022).

Before the benchmark in 2015, trends in the stock were evaluated by survey-indices only. From 2016 to 2021, an exploratory SAM assessment was conducted and relative SSB trends were used to give catch advice. From 2018, SPiCT and LBI were additionally conducted to assess MSY reference points according to category 3 (DLS) stocks.

5.3.4.1 Surplus production model (SPiCT)

The stochastic production model in continuous time (SPiCT) was applied to the plaice stock ple.27.24–32. Input data were commercial catch (landings and discards) from 2002 to 2023 and the BITS biomass index Q1 and Q4. No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios F/F_{MSY} and B/B_{MSY} are used to estimate stock status relative to the MSY reference points and are used in the catch advice and catch scenarios. A short-term forecast was conducted assuming F_{sq}.

The results of the assessment are stating a good status (Figure 5.3.8 and Figure 5.3.9) of the stock, where F is below F_{MSY} and B above $B_{trigger}$ (Figure 5.3.11) and thus confirming the results of the previously conducted SAM assessment and the stock trend of the BITS. Retrospective analysis of the SPiCT dats series indicating a consistent pattern in catches and survey inidices (Figure 5.3.10).

The remaining uncertainty might be attributed to inconsistency between catch and index time-series and missing contrast in the catch time-series.

Despite the remaining variance, the model states a good stock condition in recent years and well within F_{MSY} and B_{MSY}. Following the ICES approach, a proxy for MSY $B_{trigger}$ can be calculated as 0.5 x B_{MSY}.

5.3.4.2 Technical criteria for accepting a SPiCT assessment

When determining harvest limits using output from SPiCT, the application depends on appropriate model performance. An accepted assessment using SPiCT would ideally fulfil all of the following points:

- Model converged;
- All parameter uncertainties could be estimated and finite;
- No violation of model assumptions such as bias, auto-correlation of OSA residuals, and normality. This means that p-values are not significant ($p > 0.05$);
- Consistent trend in the retrospective analysis. There should not be a tendency to consistently under- or overestimate relative fishing mortality and biomass in successive assessments, in particular if the retrospective estimates are outside the confidence intervals of the base run;
- Non-influential starting values – the results should be the same for all starting values;
- Model parameter estimates and variance parameters should be meaningful. This means that the parameter of the production curve (n) should not be very skewed away from the symmetrical curve (B_{MSY}/K should be between 10% and 90%) and the

variance parameters (sdb, sdc, sdi, sdf) should not be unrealistically low. In these cases, a prior on the unrealistic parameter could be considered.

The plaice dataset and results of the SpiCT were tested for all the above criteria. All technical criteria were fulfilled.

The final run in SPiCT is named: ple.27.2432_ SPiCT_2024

5.3.4.3 Historical stock trends

Since 2022, plaice is assessed as a category 2 stock, using SPiCT. Additionally, an exploratory SAM is conducted to gain further insights of the stock dynamics that are not or only partially covered by SPiCT (e.g. recruitment trends). The comparison of trends between SPiCT and SAM also allows to check for concistency and reliability of the models. Both models have been used for several years and display a very good agreement in trends and stock development.

The stock annex has also been updated accordingly to the change to a category 2 stock in 2022 and explains the used parameters and settings in more details. It also contains information on the previously used assessment methods.

5.3.5 Recruitment estimates

No recruitment estimates are given for the stock.

5.3.6 Short-term forecast and management options

Projections are performed based on SPiCT estimates. Input data to short term prediction are provided in Tables 5.3.4 and 5.3.54.

If the TAC is assumed unlikely to be caugh in the intermediate year, the status quo F of the latest observation year is used for the intermediate year. The Fsq assumption results in a theoretical catch for the intermediate year and is then used as starting point for the short-term-prediction and management evaluation of the following year.

The basis for Fsq is the most recent F scaled to the intermediate year.

If the total catch in the intermediate year is assumed to exceed the TAC, the F of the intermediate year will be assumed by using a TAC constraint on the latest observation year.

TAC was not utilized in 2023, total catches were about 13% of the TAC. Therefore, the TAC of 4 549t for 2023 (as provided by EC) is assumed unlikely to be caught and status quo F is used as option to reach catch for the intermediate year (2024). An F_{sq} ($F = F_{2023}$) assumption leads to a catch of 800 t in 2024 (compared to a catch of 783 t in 2023). The basis for F_{sq} (F_{2022}) is the most recent F scaled to the intermediate year (= 0.114). Assumptions for the intermediate year are provided in Table 5.3.5.

Table 5.3.5: Values in the forecast and the interim year.

Variable	Value	Notes
F2024/FMSY	0.114	Status quo F: Fsq (equal to F2023)
B20254/BMSY	1.90	Short term forcast (STF) under status quo Fishing at Fsq from short-term forecast
Catch (20243)	800	STF of catch under status quo F; in tonnesFishing at Fsq from short-term forecast; in tonnes

Discard rate (2024)	36.3%	Discard rate of 2023; percentage by weight of the total catch
Projected landings (20243)	510	Marketable landings assuming 2023 discard rate; in tonnes
Projected discards (20243)	291	Based on 2022 2023 discard rate; in tonnes

Given the F_{sq} assumption, SSB in the beginning of 2024 is estimated at around 27 400 t (or B_{2022}/B_{MSY} at 1.66; Table 5.3.6, Table 5.3.7) and well above the MSY $B_{trigger}$ (ca. 12 000 t or B/B_{MSY} at 1). Therefore, the advice for 2025 will be based on the MSY approach ("ices rule"). With these assumptions, the forecast predicts that advised fishing in 2025 will lead to a total yield of 5 303 t. At this level of exploitation, spawning stock biomass is estimated at around 28 900 t in 2025.

Catch in 2025 in predicted to be dominated by the relatively large 2019 and 2020-year classes of age 4 and 5 (age 6 to 7 in 2025) plaice that are dominating the discards and accounts for >36% of catches in 2023. However, given the lower growth rates and decreased condition registered in the 2023 samples, the strong year class of 2020 might still dominate the discard fraction of the catch and not be fully included in the landing fraction in 2025 (Figure 5.3.11). Following the MSY approach, the adviced catch will be 5 303 tonnes, resulting in a change in biomass of about -13% (Table 5.3.8).

Table 5.3.8: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2025)	Projected landings (2025)*	Projected discards (2025)**	Fishing mortality F_{2025}/F_{MSY}	Stock size B_{2026}/B_{MSY}	% biomass change^	% advice change^^
ICES advice basis							
MSY approach (35th percentile of predicted catch distribution under $F = F_{MSY}$)	5 303	3 377	1 926	0.81	1.66	-13	+18
Other scenarios							
F_{MSY}	6 429	4 094	2 335	1	1.59	-16	+43
F_{2024}	798	509	290	0.114	1.90	0	-82
F = 0	0	0	0	0	1.94	+2	-100

*** Marketable landings assuming 2022 discard rate.**

**** Including BMS landings (EU stocks), assuming 2022 discard rate.**

^ Biomass 2025 relative to biomass 2024.

^^ Advice value for 2024 relative to the advice value for 2023 (4 549 tonnes).

5.3.7 Biological reference points (Precautionary approach)

F_{MSY}, B_{MSY} and the yield at MSY are all directly estimated in the model. It should be noted that these will vary when new survey and catch information is added. B_{pa} and B_{lim} are defined as 50%B_{MSY} and 30%B_{MSY} respectively. Flim is defined as 1.7 F_{MSY} and is the F that drives the stock to B_{lim} assuming B_{lim}=30%B_{MSY}. The derivation is given below:

$P=rB(1-B/K)$

The surplus productivity associated with B_{lim} is:

$P_{lim}=rB_{lim}(1-B_{lim}/K)$

The corresponding F is:

$Flim=rB_{lim}(1-Blim/K)/B_{lim} = r(1-B_{lim}/K)$

$Blim=0.3B_{MSY} = 0.3K/2\ Flim = r(1-0.3K/(2K)) = r(1-0.3/2) =0.85r$

$F_{MSY}=r/2$, *let x denote the proportionality between F_{MSY} and Flim*

$xF_{MSY}=F_{lim}$

$x(r/2)=0.85r$

$x=2*0.85$

$x=1.7$

5.3.8 MSY evaluations

Proxy reference points (F_{MSY} and $B_{trigger}$) were explored for the stock since 2018. A biomass dynamic model (SPiCT-Stochastic Production model in Continuous Time) was used to explore these reference points. This analysis was updated again by WGBFAS 2023 using the SPiCT r package (Pedersen and Berg, 2016). The summary plots are shown in Figure 5.3.8 and 5.3.9, retrospective patterns are shown in Figure 5.3.10. The stochastic reference point estimates are shown below (Table 5.3.9). These are not significantly different to the results obtained by WGBFAS last year.

Table 5.3.9: stochastic reference point estimate

	estimate	cilow	ciupp	log.est
B_{MSYs}	15565.06	7785.85	31116.82	9.65
F_{MSYs}	0.247	0.170	0.359	-1.398
MSYs	3846.26	2500.85	5915.48	8.25

5.3.9 Quality of assessment and forecast

The quality of reported landings and estimated discard data has improved steadily since 2012 and the biological sampling is considered adequate for the conducted assessments and used to give advice (Figure 5.3.11). However, sampling coverage in 2023 has again been very low, with only one member state providing sufficient data, although plaice samples are a manadtroy part of national sampling schemes, given tis status as a TAC species. One member state failed again to provide sampling data, although they are responsible for one third of commercial catches. Age reading needs to be validated and cross-reading between member states, as differences in age reading are known to occur. Other biological parameters such as mean weights and length distributions have also been revised when changing the assessment method from the exploratory SAM to SPiCT, they should, however, undergo an extended review and evaluation, e.g. as part of an inter-benchmark process or a data-compilation during the benchmark.

The stock is categorized as a Category 2 stock, using production models for advice. Stock Trend analysis was previously based on the results of the SAM assessment. Even though the SAM

assessment is "indicative of trends only", the assessment shows surprisingly robustness despite the relatively short time series available and is in accordance with the results of the SPiCT assessment in 2023. The conducted SPiCT also confirms stock trends of earlier years. This is expressed in the retrospective analysis which is acceptable (Figure 5.3.10).

5.3.10 Comparison with previous assessment

Compared to the catch advice given in 2023, no major differences in stock indicators were found when applying SPiCT. Both, the trend of the stock and the respective catch advice are similar to each other and continue stock trends seen since upgrading the stock in 2015 (using stock trends from SAM to give advice) and again since 2022 (using SPiCT to give advice).

5.3.11 Management considerations

5.3.11.1 Sampling quality

To improve the assessment and hence the quality of the advice, more discard estimations are required by national data submitters. Additionally, more flexible tools need to be developed for InterCatch, allowing the allocation of discards also to strata with no landings attached (discard only) and extrapolation across years (to allow reasonable borrowing in years without sufficient estimations). Data handling, such as allocation and hole filling should take place in the database to allow comprehension of the methods used.

The sampling of biological data needs further enhancement, esp. in SD 25, where the number of age readings and length measurements is in no relation to the landings. The discarded fraction needs a better sampling coverage. Although all landing countries are obliged to submit biological data, almost no information was uploaded by the member states, except Germany and partially Denmark. To improve the quality of the assessment, this is however mandatory.

The conducted SPiCT assessment relies strongly on survey data and catches; adding a tuning fleet using commercial effort might be beneficial to improve the quality of the ouput. Adding time series before 2002, both survey and commercial data, might further improve the assessment. Reference points and priors of the model needs to be explored and tested further.

To improve the exploratory SAM, natural mortality values should be verified, the index values of BITS should be verified as well to minimize residuals.

BMS landings should be sampled additionally to the ongoing discard-sampling to allow reasonable data extrapolation for this part of the catch.

The stock is going to be benchmarked in 2024 and the above mentioned points will be added to the respective issue list.

5.3.11.2 Stock condition

Plaice in the Baltic Sea are experiencing changing environmental condition. A combination of decreasing inhabitable areas, foraging grounds and food availability due to oxygen depletion in deeper basins, higher water temperatures and increasing stock biomass resulted in drastically decreasing fish condition since 2015 (Figure 5.3.13). While the condition of juvenile plaice is less drastic, adult plaice are increasingly unmarketable for the commercial fisheries due to their bad condition.

Considering the condition of plaice, stock management should be considered within the context of a degraded ecosystem, resulting from cumulative anthropogenic pressures and climate change. Habitat restoration efforts with a focus on improving bottom oxygen content are recommended (direct effects on mortality and indirect effects on individual condition). National data

submitter should be careful when extrapolating weight-at-length-data and should preferably use length-weight-coefficients of the same year to account for the decreasing condition.

Table 5.3.1. ple.27.24–32. Plaice in the Baltic Sea. Total landings (tonnes) by ICES Subdivision and country.

Year/SD	Denmark			Germ. Dem. Rep*	Germany, FRG		Poland		Sweden**						Finland		
Area	24(+25)	25	26+27	24	24(+25)	25	25(+24)	26	24	25	26	27	28	29	24	25	26
1970	494				16				149								
1971	314				2				107								
1972	290				2				78								
1973	203			44	1		174	30	75								
1974	126			10	2		114	86	60								
1975	184			67	1		158	142	45								
1976	178			82	3		164	76	44								
1977	221			36	2		265	26	41								
1978	681			1198	3		633	290	32								
1979	2027			1604	7		555	224	113								
1980	1652			303	5		383	53	113								
1981	937			52	31		239	27	118								
1982	393			25	6		43	64	40	6		7	1				
1983	297			12	14		64	12	133	20		24	2				
1984	166			2	8		106		23	3		4	1				
1985	771			593	40		119	49	25	4		5	1				
1986	1019			372	7		171	59	48	7		9	1				
1987	794			142	16		188	5	68	10		12	1				
1988	323			16	1		9	1	49	7		9	1				
1989	149			5			10		34	5		6	1				
1990	100			1	1		6		50								
1991	112				9		2	1	5	2		2					
1992	74				4		6		3	1		1					
1993	66				6		4		4								
1994	159						43	4	4	7							

Year/SD	Denmark			Germ. Dem. Rep*	Germany, FRG		Poland		Sweden**						Finland		
Area	24(+25)	25	26+27	24	24(+25)	25	25(+24)	26	24	25	26	27	28	29	24	25	26
1995	343				91		233	2	13	10	1						
1996	263				77		183	5	28	23	10	1					
1997	201				56		308	3	7	8		1					
1998	278				41		101	14	6	17		1					
1999	183				46		145	1	5	10							
2000	161				37		408	3	9	12							
2001	173				43		549	3	9	13							
2002***	153	159	0		137	7	429	3	10	15							
2003	326	299	2		68	25	480	10	16	51		0	0				
2004	167	239			50	13	292	8	6	37							
2005	164	241			90	17	511	11	16	28		0	0				
2006	82	632			173	11	52	3	17	41			0				
2007	408	490	0		151	12			41	61		0	0				
2008	450	339			150	10	29	0	45	69			0				
2009	581	359	0		96	21	42	0	43	79		0					
2010	345	295	1		66	13	93	8	22	61	1	0					
2011	291	233			109	6	37	1	33	36	0	0			1	0	0
2012	477	148	0		86	4	62	2	23	43	1	0			2	1	0
2013	382	196	0		46	1	45	5	29	33	0	0			1		
2014	231	118	0		57	<1	80	7	21	19	<1	<1	0	0	<1		
2015	145	69	0		44	1	140	5	12	12	0	0	0	0	0		
2016	187	60	1		93	2	151	3	15	10	<1	<1	0	0	0	0	0
2017	124	68	<1		143	1.4	293	3	6	12	<1	0	0	0	0	0	0
2018	435	158	2		353	3	667	1	13	11	0	0	<1	0	0	0	0
2019	611	51	0		331	0	728	1	13	6	0	<1	<1	0			
2020	462	11			232	2	311	3	1	4	0	<1	0	0	0	0	0
2021	272	5	0		198	2	286	4	<1	<1	0	<1	0	0	0	0	0
2022	153	5	0		143	0	152	4	1	<1	0	0	0	0	0	0	0

Year/SD	Denmark			Germ. Dem. Rep*	Germany, FRG		Poland		Sweden**						Finland		
Area	24(+25)	25	26+27	24	24(+25)	25	25(+24)	26	24	25	26	27	28	29	24	25	26
2023	166	3	0		164	0	160	2	1	1	0	0	0	0	0	0	0

***From October to December 1990 landings from Fed. Rep. of Germany are included.**

****For the years 1970–1981 and 1990 the Swedish landings of subdivisions 25–28 are included in Subdivision 24.**

*****From 2002 and onwards Danish and German, FRG landings in SW Baltic were separated into subdivisions 24 and 25.**

Table 5.3.2. **ple.27.24–32. Landings (tonnes), BMS landings (tonnes) and discard (tonnes) in 2023 by Subdivision, catch category, country and quarter.**

Area	Country	CatchCategory	1	2	3	4	Total*
27.3.d.24	**Denmark**	Landings	49.05	42.66	57.04	17.50	166.24
		Discards	97.24	14.86	17.97	11.75	141.83
		BMS landing	1.34	0.65	0.57	2.42	4.98
	Germany	Landings	1.65	2.37	138.72	20.37	163.11
		Discards	1.23	0.12	41.40	19.01	61.76
		BMS landing	0.11		3.04	0.58	3.74
	Poland	Landings	4.50	20.11	55.28	9.10	88.99
		Discards	9.05	3.25	16.75	6.14	35.18
		BMS landing	0.00	0.14	0.44	0.02	0.61
	Sweden	Landings	0.00	0.14	0.44	0.02	0.61
		Discards	0.00	0.00	0.00	0.00	0.00
		BMS landing					
27.3.d.25	**Denmark**	Landings	2.90	0.00	0.00	0.00	2.90
		Discards	2.21				2.21
		BMS landing	1.26				1.26
	Germany	Landings	1.26				1.26
		Discards	2.13				2.13
		BMS landing					
	Poland	Landings	11.91	27.95	19.82	11.48	71.16
		Discards	23.42	7.69	5.32	2.92	39.34
	Sweden	Landings	0.01	0.18	0.83	0.06	1.07
		Discards	0.00	0.01	0.08	0.05	0.14
		BMS landing					
27.3.d.26	**Denmark**	BMS landing	0.00	0.00	0.00	0.00	0.00
	Germany	Landings	0.48				0.48
		Discards	0.96				0.96
	Lithuania	Landings	0.00	0.00	0.00	0.00	0.00
	Poland	Landings	0.00	0.05	1.63	0.69	2.37
		Discards		0.02	0.15	0.64	0.82
	Sweden	Landings		0.02	0.15	0.64	0.82
		BMS landing	0.00	0.00	0.00	0.00	0.00
27.3.d.27	**Denmark**	BMS landing	0.00	0.00	0.00	0.00	0.00
	Sweden	Landings	0.00	0.00	0.00	0.00	0.00
		BMS landing		0.00	0.00	0.00	0.00
27.3.d.28	**Lithuania**	Landings	0.00	0.00	0.00	0.00	0.00
	Sweden	Landings		0.00	0.00	0.00	0.00
		BMS landing		0.00	0.00	0.00	0.00
27.3.d.29	**Denmark**	BMS landing	0.00	0.00	0.00	0.00	0.00
	Sweden	Landings		0.00	0.00	0.00	0.00
		BMS landing		0.00			0.00
27.3.d.30	**Denmark**	BMS landing				0.00	0.00
	Sweden	Landings				0.00	0.00
27.3.d.31	**Sweden**	Landings	0.00	0.00	0.00	0.00	0.00
		BMS landing	0.00	0.00	0.00	0.00	0.00

***BMS landings are included in the discards and need to be substracted from the total sum**

Table 5.3.6. ple.27.24-32. Overview of SPiCT result values on catch and survey data 2002–2023.

Deterministic reference points (Drp)					
	Bmsyd	15565.060	7785.851	31116.820	9.653
	Fmsyd	0.247	0.170	0.359	-1.398
	MSYd	3846.261	2500.848	5915.484	8.255
	Bmsyd	15565.060	7785.851	31116.820	9.653
Stochastic reference points (Srp)					
		estimate	**cilow**	**ciupp**	**log.est**
	Bmsys	15195.150	7634.943	30241.540	9.629
	Fmsys	0.243	0.166	0.354	-1.416
	MSYs	3686.033	2417.258	5620.765	8.212
States	**w**	**0.95**	**CI**	**(inp$msytype:**	**s)**
		estimate	**cilow**	**ciupp**	**log.est**
	B_2023.94	29017.370	14291.540	58916.530	10.276
	F_2023.94	0.028	0.012	0.066	-3.589
	B_2023.94/Bmsy	1.910	1.439	2.535	0.647
	F_2023.94/Fmsy	0.114	0.056	0.230	-2.173
Predictions	**w**	**0.950**	**CI**	**(inp$msytype:**	**s)**
	B_2026.00	28896.930	13755.670	60704.650	10.271
	F_2026.00	0.028	0.007	0.115	-3.589
	B_2026.00/Bmsy	1.902	1.433	2.524	0.643
	F_2026.00/Fmsy	0.114	0.030	0.428	-2.173
	Catch_2025.00	798.576	274.638	2322.054	6.683
	E(B_inf)	28201.710	NA	NA	10.247

Table 5.3.7 **Plaice in subdivisions 24–32.** Assessment summary. Weights are in tonnes. High and low refers to 95% confidence intervals.

Year	B/B_{MSY}			Landings*	Discards	F/F_{MSY}		
	Low	Relative SSB	High			Low	Ages 2–5	High
2002	0.163	0.243	0.360	915	353	0.684	1.331	2.591
2003	0.182	0.261	0.375	1 281	271	0.951	1.628	2.786
2004	0.157	0.229	0.333	1 081	214	0.944	1.658	2.913
2005	0.172	0.253	0.371	1 081	166	0.718	1.261	2.214
2006	0.237	0.338	0.482	1 012	818	0.670	1.163	2.016
2007	0.292	0.423	0.613	1 167	491	0.606	1.097	1.985
2008	0.345	0.505	0.738	1 102	294	0.433	0.799	1.474
2009	0.419	0.620	0.918	1 226	418	0.358	0.672	1.263
2010	0.471	0.689	1.008	903	998	0.384	0.724	1.364
2011	0.489	0.713	1.041	748	1 377	0.414	0.780	1.471
2012	0.519	0.761	1.116	848	917	0.367	0.696	1.317
2013	0.552	0.812	1.196	738	781	0.290	0.556	1.066
2014	0.586	0.871	1.295	534	481	0.197	0.376	0.719
2015	0.690	1.017	1.501	427	220	0.105	0.211	0.425
2016	0.871	1.250	1.794	521	1 058	0.121	0.224	0.413
2017	1.000	1.411	1.991	650	408	0.132	0.242	0.445
2018	1.152	1.601	2.226	1 644	711	0.145	0.267	0.494
2019	1.229	1.713	2.389	1 741	617	0.193	0.378	0.742
2020	1.231	1.705	2.363	1 024	223	0.142	0.265	0.493
2021	1.231	1.686	2.309	767	550	0.111	0.207	0.385
2022	1.266	1.717	2.329	458	150	0.073	0.134	0.249
2023	1.352	1.805	2.409	498 284		0.055	0.104	0.194

*** Below minimum size (BMS) landings are included since 2017.**

Figure 5.3.1. **ple.27.24-32. Historical landings per country (in tonnes).**

Figure 5.3.4. **ple.27.24-32. Catch in numbers per age class and catch category in Subdivision 24 and 25. All countries and fleets were combined.**

Figure 5.3.3. **Sampling coverage and quality of ple.27.24-32.**

5.3.3.a: Upper plot: provided official landings and discard estimates (green) of member states, including reported zeroes and non-provided strata (red).

5.3.3.b: Lower plot: provided biological samples per stratum (green) and non-sampled strata (red). Yellow fields indicate dismissed biological samples (either due to low sample sizes or non-updated length-weight-coefficients were used by the member state to impute missing weight data)

Figure 5.3.2. Sampling coverage and quality of ple.27.24-32.

5.3.2.a: Upper plot: provided official landings and discard estimates (green) of member states, including reported zeroes and non-provided strata (red).

5.3.2.b: Lower plot: provided biological samples per stratum (green) and non-sampled strata (red). Yellow fields indicate dismissed biological samples (either due to low sample sizes or non-updated length-weight-coefficients were used by the member state to impute missing weight data)

Figure 5.3.3 **ple.27.24-32. Main fishing gear by member state (colored squares, x and y axis) and respective sampling coverage (number of trips with length sampling conducted, bubble size according to number of trips sampled). (RCG Baltic, 2023)**

Figure 5.3.4. **ple.27.24-32. Numbers-at-age in commercial fisheries catch fractions**

Figure 5.3.5. ple.27.24-32. Average weight-at-age for the age classes 1 to 10 in subdivisions 24 and 25. All countries and fleets were combined. Shown for the latest year of the assessment and the five years before.

Figure 5.3.6 ple.27.24-32. Number-at-age index of the BITS Survey Q1 and Q4 for 2023

Figure 5.3.7. **ple.27.24-32. Average biomass index from Q1 and Q4 BITS from SD24-SD26 (no plaice catches in SD27+). 2024 data (Q1) are preliminary.**

Figure 5.3.8. **ple.27.24-32. Overview of the results of the surplus production model (SPiCT) on catch and survey data 2002–2023.**

Figure 5.3.9. **ple.27.24-32. Overview of the results of the surplus production model (SPiCT) on catch and survey data 2002–2023. Absolute and relative B and F and their respective estimated reference points.**

Figure 5.3.10. **ple.27.24-32. Overview of the retrospective analysis of the surplus production model (SPiCT) on catch and survey data–2023**

Figure 5.3.11: ple.27.24-32. Stock assessment graphs, relative F and SSB

Figure 5.3.12. ple.27.24-32. Results from the exploratory SAM assessment: a) total SSB, b) F (age2–5,) and c) recruitment

Figure 5.3.13 Plaice in subdivisions 24 to 32. Condition factor development of plaice in the Belt Sea (SD22, upper figure) and Arkona Sea (SD24, lower figure), from Stötera *et al.* (in prep.)

6 Sole in Subdivisions 20-24 (Skagerrak, Kattegat, the Belts and Western Baltic)

6.1.1 The Fishery

Sole is economically an important species in in the Danish fisheries. For both Kattegat and Skagerrak the major part of the sole catches is taken in the mixed species trawl fishery, using mesh sizes 90–105 mm and with gillnets using mesh sizes of 90–120 mm. The landings share of active and passive gears has in previous years been approx. 55/45, respectively, however in recent year the proportions are nearly equal. Minimum legal landing size is 24.5 cm.

There is seasonality in sole fishery with both gill net and trawl. The low season for trawl is from May to September (Figure 6.2), where the gillnet fishery dominates. During this season, about 80% of the gillnet catches are sole. Additional information of the sole fishery is provided in the Stock Annex.

6.1.1.1 Landings

The officially reported landings by area, gear and country for 2023 are given in Table 6.1. Total landings amounted to 211 t (30% decrease from 2022) where Denmark took 87% of the total landings. Kattegat has traditionally been the most important area, but in recent years the proportion between the three areas, Skagerrak, Kattegat and the Belts/western Baltic have been less in favour of Kattegat with only 22% of total landings in 2023.

Historical catches, including the working group corrections, are provided in Figure 6.1 and Table 6.2. The fishery peaked in the mid-1990s at 1656 t and since then landings have decreased to now around 200-300 t. Figure 6.2 provide the Danish catches cumulated by month since 1998 including preliminary 1st quarter catches of 2024, indicating seasonal trends in the fishery.

6.1.1.2 Discards

Danish discard sampling at sea is carried out within EU programmes that began in 1995 in both Kattegat and Skagerrak. Results indicate that the amount of sole discarded was very limited in years after 2005 when the fishery was not restricted by quotas (*i.e.*, discard levels are believed to be only a few percent when measured relative to the sole landings). Discards in 2023 amounts to a record low of 0.6% of the catches by weight based on sampling from trawlers and gillnetters (Table 6.3). The average of the recent 5 years is 2.8% discard (used in advice to add up to total catches).

Since the discards overall are considered insignificant and relatively constant over the entire time series and in addition incomplete in coverage, these data are not included in present assessment but added only in the advice.

6.1.1.3 Effort and CPUE Data

Presently private logbook data time series from selected Danish trawlers and gillnetters are kept from the past to calibrate the assessment: trawl cpue's from 1987–2008 and gillnet cpue's from 1994–2007 (Table 6.5).

6.1.2 Biological composition of the catch

6.1.2.1 Catch in numbers

Sampling of age structure of the catch was available only for the Danish fishery (Table 6.4). Overall the sampling has slowly improved from the past (724 specimens from the landings). In 2023 a gap in samplings are evident in 3rd quarter with no samplings in any of the areas. The age structure of the Danish catch was applied to the total international catch (Table 6.6) since no other age information was available.

The age composition of the catch has mainly been composed of 3–5-year-olds since the beginning of the 1990s but in recent two decades, older fish have a higher proportion of the catch (Table 6.6 and Figure 6.6).

6.1.2.2 Mean weight-at-age

Data for mean weight-at-age in the catches were derived using the same sample allocation as used in the computation of catch-at-age. The mean weight-at-age in the catch is shown in Table 6.7 and Figure 6.7. In general, weight-at-age data are highly variable between years, and this variability is not assumed to be connected to biological events but rather reflect the scattered sampling, ageing problems and/or sex differentiated growth. In 2023 mean weights of most age groups increased.

6.1.2.3 Maturity at-age

Due to insufficient biological information on maturity, the present assessment uses a fixed maturity ogive as in all assessments since 1996 (knife-edge maturity-at-age 3).

6.1.2.4 Natural mortality

The natural mortality is unknown and was assumed to be 0.1 per year for all ages and years.

6.1.2.5 Quality of catch and biological data

Denmark provided statistics on catch sampling for the Kattegat, Skagerrak and the Belts/western Baltic (Table 6.4). Sampling improved from 2022 and all subdivisions were sampled in 2023. The small and scattered catches in the fishery for sole mainly caught as by-catch requires a huge effort in port sampling and many port trips for samplings are therefore in vein. The improved sampling effort in recent years seem to have a positive effect on the assessment quality in reducing retrospective patterns in stock and fishery development. The restrictions for fishery for cod have also limited the bycatch fishery for sole and thus the sampling.

6.1.3 Fishery independent information

Since 2004 a survey conducted cooperatively by DTU Aqua and Danish fishermen was designed with fixed haul positions chosen by both scientists and fishermen. The survey takes place in November-December and covers the central part of the stock (Figures 6.4.1 and 6.5). The survey was not conducted in in 2012–13. Since 2016 the survey has gradually been expanded to cover more areas in Skagerrak and also in the Belts and western Baltic. Figure 6.5 show the progressive expansion of the survey since 2015. The stations in the extended area are so far not included in the survey biomass index calculation, but awaits a longer time series. A forthcoming benchmark will address this issues. The CPUE distribution in the survey area in 2022 and 2023 are provided in Figure 6.4.1.

Based on 61 successful hauls in 2023, age disaggregated indices from the survey are used for the analytical assessment (Table 6.5). The index is estimated by a GAM model that takes into account spatial diversity of growth (see stock annex). The aggregated index show a decreasing trend in

catch rates from 2018 to 2022. Further, recruitment (age 1) is still observed to be at near record low levels(Figure 6.3 and Table 6.5).

6.1.4 Assessment

Since the benchmark in 2010 (WKFLAT) the SAM model has been used to assess the stock. Final assessment in 2024 is named 'sole20_24_2024' and is visible at stockassessment.org.

6.1.4.1 Model residuals

Model residuals for the survey indices and catch in numbers are provided in Figure 6.8. No blocks of either negative or positive residuals are apparent for both survey indices and catch numbers.

6.1.4.2 Fleet sensitivity analysis

In order to examine the effect of the single fleet calibration indices on the F and SSB estimates, assessment was conducted with fleet indices left out of the analysis one at a time (Figure 6.9). The survey is virtually the only calibration to the catch matrix (the other two series ceased 2007/2008) and therefore the effect of removing the survey is expected to be visible. However, leaving out the survey index does not change perception of SSB and F markedly.

6.1.4.3 Final stock and fishery estimation and historical stock trends

Stock summary (SSB, fishing mortality and recruitment) as estimated from the assessment is provided in Figure 6.10. and in Table 6.10. The SSB remained at the 2022 level and is estimated to be at 2211 t in 2023. Fishing mortality decreased to a record low at 0.116. Estimated fishing mortalities and stock numbers by age are provided in Tables 6.8 and 6.9. Recruitment calculated at age 1 has since 2008 been low but with two relatively good year-classes in 2014 and 2017. The recent recruitment, 2022 year-class is estimated record low (Figure 6.10, Table 6.10).

6.1.4.4 Retrospective analysis

The assessment is considered robust with no observed retrospective bias (Figure 6.11. Mohns rho are in the range +-0.03 for SSB and F, and 0.09 for recruitment, thus far below any concern. The assessment consistency has most likely improved from higher sampling intensity from the fishery (see section 6.2.1).

6.1.5 Short-term forecast and management options

Input data to short term prediction are provided in Tables 6.11- 6.12.

Discards are not included in the assessment but is estimated to 0.6% in weight in 2023 (Table 6.3). The average of the discard in the recent 5 years (2.81%) is added to landings to derive advised catches for 2025.

Assumed recruitment ages 1 has previously been drawn randomly from and longer time series since 2004 that is considered a low productivity period which was assumed to be representative in the forecast period. However, the estimated continuous decrease in recruitment since 2018 (Figure 6.10 and Table 6.10) led the group to change basis for recruitment in 2024 and 2025. A short term average (randomly drawn in model) of the 3 recent years low recruitment (2021-2023) has therefore been used in the short term prediction.

As in previous years TAC was not fully utilized in 2023 and preliminary information for Danish catches in the first quarter of 2024 suggest low catches in 2024. Therefore, the TAC of 327 t for 2024 (as provided by EC) is assumed unlikely to be caught and status quo F is continued as

option to reach catch for the intermediate year (2024). An Fsq (F=F2023) assumption leads to a catch of 239 t in 2024 (compared to a catch of 211 t in 2023). The basis for Fsq (F2023) is an average of recent Fs (e.g. 3 yrs) scaled to the final year (=0.116). Assumptions for the intermediate year are provided in Table 6.11-12.

Given the Fsq assumption, SSB in the beginning of 2025 is estimated at 2256 t (Table 6.12) which is below the MSY Btrigger (2600 t). Therefore the advice for 2025 will be based on a reduced F corresponding to Fmsy*SSB2025/MSY Btrigger (eq F=0.226). With these assumptions, the forecast predicts that advised fishing in 2025 will lead to a total yield in the range 322 - 429 t. (Fmsylower – Fmsy).At this level of exploitation, spawning stock biomass is estimated 2139 t and 2038 t, respectively in 2026. Catch in 2025 is predicted to be dominated by older ages 7-9+ (Figure 6.13).

A yield-per-recruit analysis was made using long term data averages (15 years) with unscaled exploitation pattern. The yield-per-recruit curve (Figure 6.14) indicates that maximal yield per recruit is poorly estimated at $F_{4–8}$ around 0.7 and that $F_{0.1}$ is estimated to 0.18.

6.1.6 Reference points

The present reference points are as follows:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY Bt_{rigger}	2600 t	B_{pa}	ICES (2015)
	F_{MSY}	0.26	Equilibrium scenarios stochastic recruitment, short time-series 1992–2014,.	ICES (2015)
	F_{MSY} lower	0.19	F_{MSY} lower without AR from equilibrium scenarios	ICES (2015)
	F_{MSY} upper	0.26	F_{MSY} upper capped by Fp05 with AR from equilibrium scenarios	ICES (2015)
Precautionary approach	B_{lim}	1850 t	B_{loss} from 1992 (low productivity regime)	ICES (2015)
	B_{pa}	2600 t	$B_{lim} \times e\ 1.645\sigma$, $\sigma = 0.20$	ICES (2015)
	F_{lim}	0.315	Equilibrium scenarios prob(SSB< B_{lim})< 50% with stochastic recruitment	ICES (2015)
	F_{pa}	0.26	Fp05 from equilibrium scenarios w. stochastic recruitment, short time-series 1992–2014	ICES (2021)
Management plan	SSB_{MGT}	Not defined.		
	F_{MGT}	Not defined.		

6.1.7 Quality of assessment

Sampling from this relatively small and spatially dispersed fishery has been a challenge for a long time and often results in few measured fish per sample. Sampling since 2017 has improved

partially due to a reference fleet of fishing vessels (only in 2015-2016) but recently due to increased sampling effort from the Danish National Institute of Aquatic Resources, DTU Aqua.

The enhanced sampling has likely caused the assessment to improve and to reduce the annual variation in stock and fishing pressure perception as evident from the retrospective plots. Bias in the assessment measured as Mohn's rho have improved significantly and are at acceptable levels.

As maturity-at-age is not determined for the species but assumed to age 3+, the true SSB for the stock is uncertain. Present assumption is that maturity is constant over time. Any future adoption of observed maturity data might therefore change the perception of the stock history and stock-recruitment relations. Presently, the sole survey is conducted in November while the species spawns in May, so maturity data is unlikely obtained from the survey. Weight-at-age in the stock from the sole survey is a potential future data source for the assessment. A study conducted by DTU Aqua (FORFLAD project) investigated the connection between the North Sea sole stock and the sole in Subdivs. 20-24. Both genetics and otolith microchemistry suggest a seasonal mix of North Sea sole into Skagerrak, Kattegat and western Baltic with an decreasing proportion with distance from the North Sea. However, since the mix is not well quantified and that the most biomass indices used for assessment of the Subdiv 20-24 stock are from Kattegat and the Belts where proportion of North Sea sole is less, an implementation of the dynamics in the assessment model is not presently possible. Given that the Subdiv 20-24 stock is about 1/10 in size of the North Sea stock a continued assessment separation between the two stocks are considered precautionary to prevent local population depletion In order to accommodate for the mix of the North Sea stock in the 20-24 sole assessment, further work is required on defining spawning grounds for the stocks to determine and quantify drift patterns for larvae and migration patterns for adults. A genetic sampling programme should also be established to be able to quantify temporal variations in stock proportions in Subdivison. 20-24.

6.1.8 Comparison with previous assessment

This year's assessment is conducted as in previous years and in accordance with the procedure described in the stock annex. The historical performance of the assessment is provided in Figure 6.12. It is noted that the recent two projected SSBs for the assessment year 2021 and 2022 was estimated considerably lower one year later when catch data was available (Fig 6.12). One of more reasons was that the mean weight at age used to compute SSB for the assessment year (5 year average) were too optimistic when averaged over a period when weight at age are decreasing. This issue is not to be relevant this year and historically this has not been an issue since weight at age are variable without a trend.

6.1.9 Management considerations

Management of the sole fishery should take into account that particularly the trawl fishery is a *Nephrops* fishery with bycatches of cod, plaice and sole. With the restricted catch opportunities of cod in SD 21-24, combined with the landing obligation, cod is potentially being a choke species in this mixed fishery. If the mixed fishery could be un-coupled, management in the Kattegat and the Belts would be more straightforward and sustainable. Such un-coupling could be achieved by selective gears and area restrictions.

6.1.10 Issues relevant for a forthcoming benchmark

DTU Aqua finalized in 2023 a project aimed to investigate stock connectivity of sole in SDs 20-24 and the North Sea to evaluate possible mix between the two stocks. The project followed a

former project of stock structure within SD 20-24 that showed some differences in origin of Kattegat sole and Skagerrak sole. Therefore the new project wanted to explore whether Skagerrak and the North Sea populations had more common origin or mix than Skagerrak and SD 21-24. More methods (genetics, otolith microchemistry, growth, productivity) points to two identified stocks, a North Sea stock and a SD 20-24 stock, with a mix of North Sea sole into SD 20-24. However, presently it is not possible to quantify the mix and for implementation in an assessment model temporal knowledge is required on migrations/drift patterns in addition to more exact knowledge on spawning- and nursery grounds.

For a forthcoming benchmark research items that could realistic be solved are therefore:

- Inclusion of **survey data from the gradually expanded survey area** since 2015 (Skagerrak, the Belts and the western Baltic). This is required to represent entire stock distribution and to take account for an expansion of the fishery.
- **Weight in stock** is presently assumed equal to weight in catch due to lack of information. However, data from the sole survey could be utilized to establish WEST.
- **Maturity at age** is presently not known but assumed; the sole survey is late in the year (November-December) when sole is difficult to assess with respect to maturity and likelihood of spawning. An effort could be made in the sampling program from the fishery to achieve maturity data, however, establishing a few years maturity will only result in scaling of perception of the SSB development over time and requires more years to identify eventual changes in maturity at age.

Continued research on stock entities and migrations patterns with neighbouring stocks should be carried out along with effort on investigating more precise locations of spawning- and nursery grounds.

Table 6.1. Sole 20-24. Landings (t) of sole in 2023 by area, nation, quarter and gear.

Skagerrak (SD20)	Quarter				Gear		Total
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	7	30	4	30	39	32	71
Germany	0	8	0	0	0	8	8
Sweden	0	0	0	0	1	0	1
Netherlands	1	0		5	6	0	6
Norway	0	0	0	0	0	0	0
Total	9	38	4	35	46	40	86

Kattegat (SD21)	Quarter				Gear		Total
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	8	6	7	16	27	11	37
Germany	0	1	5	0	0	6	6
Sweden	0	1	1	2	2	2	4
Total	9	8	13	18	28	18	47

Belts and Baltic (SD22-24)	Quarter				Gear		Total
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	4	22	19	29	24	52	75
Germany	0	2	0	0	1	1	3
Sweden	0	0	0	0	0	1	1
Total	0	0	1	0	25	54	79

Table 6.2 Sole 20--24. Catches (tons) in the Skagerrak, Kattegat and the Belts 1952–2023. Official statistics and Expert Group corrections. For Sweden there is no information 1962–1974.

Year	Denmark			Sweden	Germany	Belgium	Netherlands	Working Group	Total
	Kattegat	Skagerrak	Belts	20-24	20-24	Skagerrak	Skagerrak	Corrections	
1952	156			51	59				266
1953	159			48	42				249
1954	177			43	34				254
1955	152			36	35				223
1956	168			30	57				255
1957	265			29	53				347
1958	226			35	56				317
1959	222			30	44				296
1960	294			24	83				401
1961	339			30	61				430
1962	356				58				414
1963	338				27				365
1964	376				45				421
1965	324				50				374
1966	312				20				332
1967	429				26				455
1968	290				16				306
1969	261				7				268
1970	158	25							183
1971	242	32			9				283
1972	327	31			12				370
1973	260	52			13				325
1974	388	39			9				436
1975	381	55		16	16		9	-9	468
1976	367	34		11	21	2	155	-155	435
1977	400	91		13	8	1	276	-276	513
1978	336	141		9	9		141	-141	495
1979	301	57		8	6	1	84	-84	373
1980	228	73		9	12	2	5	-5	324
1981	199	59		7	16	1			282
1982	147	52		4	8	1	1	-1	212
1983	180	70		11	15		31	-31	276
1984	235	76		13	13		54	-54	337
1985	275	102		19	1	+	132	-132	397
1986	456	158		26	1	2	109	-109	643
1987	564	137		19		2	70	-70	722
1988	540	138		24		4			706
1989	578	217		21	7	1			824
1990	464	128		29		2		427	1050
1991 [1]	746	216		38	+			11	1011
1992	856	372		54				12	1294
1993	1016	355		68	9			-9	1439
1994	890	296		12	4			-4	1198
1995	850	382		65	6			-6	1297
1996	784	203		57	612			-597	1059
1997	560	200		52	2				814
1998	367	145		90	3				605
1999	431	158		45	3				637
2000	399	320	13	34	11			-132 [2]	645
2001 [1]	249	286	21	25				-103 [2]	478
2002 [3]	360	177	18	15	11			281	862
2003 [3]	195	77	17	11	17			301	618
2004 [3]	249	109	40	16	18			392	824
2005 [3]	531	132	118	30	34	Norway		145	990
2006	521	114	107	38	43	9	4		836
2007	366	81	93	45	39	9	0		633
2008	361	102	113	34	35	7	3		655
2009	325	103	145	37	27	4			641
2010	273	61	125	46	26	3	3		538
2011	271	127	65	53	33	3			552
2012	154	140	28	30	0	6	0		358
2013	153	78	33	54	9	6	0		332
2014	141	104	48	36	2	3	0		335
2015	95	66	36	9	7	5	6		224
2016	164	78	56	14	17	2	16		348
2017	215	166	46	19	21	2	31		501
2018	158	140	57	16	15	0	47		434
2019	150	88	82	13	15	2	69		417
2020	136	109	85	9	24	1	60		424
2021	121	116	70	10	23	0	47		387
2022	71	79	97	8	32	1	14		302
2023	37	71	75	5	16	0	6		211

Considerable non-reporting assumed for the period 1991–1993. [2]Catches from Skagerrak were reduced by these amounts because of misreporting from the North Sea. The subtracted amount has been added to the North Sea sole

catches. Total landings for these years in IIIA has been reduced by the amount of misreporting. [3]Assuming misreporting rates at 50, 100, 100 and 20% in 2002-2005, respectively.

Table 6.3 Sole 20-24. Discard from active gears as obtained from observers.

Discard in weight (kg)												
Age												
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
1	128	490	3,128	1,156	5,913	254	230	219	348	494	56	137
2	1,326	2,392	2,492	828	2,761	2,095	476	1,415	1,236	1,421	2,333	165
3	1,782	1,872	19,126	-	1,800	9,733	2,457	1,281	3,686	786	1,119	294
4	4,032	954	1,316	1,076	3,408	1,117	568	2,465	474	1,676	6,033	726
5	680	510	1,785	981	14	1,404	1,379	1,306	973	294	7,302	174
6	928	1,232	972	264	315	692	588	518	703	615	1,193	370
7	570	1,030	1,800	-	702	315	716	155	1,093	363	3,915	195
8	248	416	1,220	296	-	603	30	441	1,105	431	1,333	12
9	572	708	232	-	172	345	143	103	2,319	350	274	0
10	393	224	-	832	1,456	379	45	182	-		-	-
11	345			118	-	169	-	211	-		-	-
Total (t)	11	10	32	6	17	17	7	8	12	6	24	2
Landings(t)	359	332	335	224	348	520	348	417	424	387	302	211
Catches	370	342	367	230	365	537	355	425	436	393	326	213

Discard %	3%	3%	9%	2%	5%	3%	2%	2%	2.7%	1.5%	7.2%	1%

Table 6.4 Sole 20-24. Sampling in 2023 from landings.

	Belts and Baltic			Skagerrak			Kattegat			Total		
Quarter	**Landings**	**Sampled catch**	**Aged**	**Landings**	**Sampled catch**	**Aged**	**Landings**	**Sampled catch**	**Aged**	**Landings**	**Sampled catch**	**Aged**
1	4,454	-	-	8,656	7,152	76	8,503	8,065	92	21,613	15,217	168
2	24,388	-	-	38,399	30,352	76	7,959	6,250	22	70,745	36,602	98
3	19,964	-	-	4,291	-	-	12,573	-	-	36,828	-	-
4	29,771	27,597	328	34,684	29,761	54	17,728	16,046	76	82,182	73,404	458
Total	78,577	27,597	328	86,030	67,265	206	46,762	30,361	190	211,368	125,223	724

Table 6.5. Sole 20-24. Tuning fleets.

Tuning Data; Sole in ICES Div IIIa

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Fisherman-DTU Aqua survey Spatial CL and reduced

2004	2022								
1	1	0.8	1						
1	9								
1	16.85963	55.63743	51.25082	32.12494	22.20887	9.310701	7.66656	4.612178	6.238217
1	12.74653	37.85718	68.41383	36.22411	18.69613	7.677196	3.251101	1.801281	1.532472
1	35.13302	39.50066	29.29465	52.55517	25.98851	14.17839	4.917416	1.613704	5.143157
1	32.54162	34.10023	24.84114	30.19984	31.44671	20.68541	12.05462	7.432666	13.05204
1	10.24085	47.07506	28.15955	15.96622	13.65289	17.6826	7.447549	6.813955	7.798046
1	16.08012	11.39743	35.48561	14.2116	15.56494	14.90989	17.29956	5.185324	7.971787
1	13.70905	16.60382	20.42419	18.38752	7.023587	10.71156	7.295555	11.99338	15.58484
1	15.01056	30.35226	18.17989	17.40126	16.09109	10.07621	9.011582	4.137883	19.45883
1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1	22.45647	17.38115	19.30901	14.36802	12.06721	9.590962	4.023162	8.365093	12.58072
1	33.96722	28.53565	16.67462	15.12215	9.693589	17.18358	6.422476	4.673582	30.38403
1	17.74836	37.94521	26.88038	14.52138	13.9044	4.172301	7.633703	4.480278	26.26042
1	10.79649	50.54734	37.52496	24.32936	7.883941	12.43821	2.319349	2.338682	22.41587
1	39.26203	18.17896	41.44222	37.89991	17.41419	6.922358	7.636913	2.474638	22.43871
1	20.82234	57.37614	11.27727	28.77581	17.33189	15.47493	2.7942	4.820038	21.64232
1	13.04238	30.49211	42.73166	7.692297	21.69692	18.85832	12.21745	1.842754	26.57574
1	6.492096	25.20489	31.06281	26.43781	6.277524	8.937632	7.711412	5.702597	13.34936
1	12.33901	13.09465	15.85756	24.33142	17.70737	4.014277	7.613162	9.649343	19.57844
1	6.934936	23.71641	15.71663	18.598073	17.610647	12.779451	3.648364	6.071612	24.994793

Private logbooks Gillnet KC + KS combined

1994	2007		
1	1	0.25	0.87
2	9		
7246	1071	8794	7892	2547	1254	268	187	60
5900	682	3284	6795	4942	1673	936	203	153
24238	4914	19748	8589	10880	6350	2872	1578	948
19939	1303	5568	8787	7036	9251	6658	4775	3280
18984	2685	3309	3816	4869	2632	3033	3443	2270
19917	10704	33215	3187	3507	2700	2176	1978	1633
23645	2336	12192	11953	1815	2285	2461	2222	2315
17755	5721	11108	9181	3953	1463	2717	812	1260
19930	17094	20860	6010	6043	6757	2384	2155	2801
13812	2029	17166	16000	4387	7051	2468	395	691
5518	547	3854	4483	2289	1391	864	523	226
9067	2827	11590	13754	5559	1832	485	455	170
9742	1495	5999	10446	8760	5434	1443	991	287
7026	1374	2638	2360	3039	1856	920	394	319

Private logbook TR KC+KS combined

1987			2008		
1			1		0.75
2			6		
712	2756	5140	5562	2667	954
876	5667	7735	5361	3432	1025
933	5097	2253	3761	2825	2126
1174	16408	10277	2753	3874	1545
1809	16085	35139	14745	4452	3878
3136	56849	46507	16304	7177	1545
4035	41739	44475	19945	11105	6685
5276	9498	55455	64125	19324	12725
4969	42026	35885	41231	29359	14705
4294	24861	38831	23489	26033	16360
4027	3927	13138	14220	10668	13279
2464	12543	3357	1117	1041	1736
2142	13031	24798	3690	4268	3927
3342	9566	16153	20370	3215	2692
2268	6292	11562	6052	6953	635
1498	29987	20538	4835	5483	3963
2093	7473	21584	14949	7199	3760
3999	20124	39887	47640	18374	8401
2463	7956	34026	29590	16011	6975
3132	11878	14708	24084	19146	12809
2730	14422	11847	4636	8756	515
1281	4393	2674	2438	2735	2130

Table 6.6. Sole 20-24. Catch in numbers (thousands) by year and age.

Numbers*10**-3

YEAR AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
2	64	786	258	391	516	863	1209	530	506	523
3	638	594	1255	857	1035	613	1300	1301	1178	1804
4	240	190	671	1018	897	847	651	928	939	1251
5	117	55	210	434	484	592	564	334	493	826
6	31	60	33	174	129	404	310	345	320	418
7	33	16	36	64	37	83	167	302	178	117
8	40	8	33	31	23	30	27	180	166	137
+gp	175	69	63	87	60	52	31	76	239	157
0 TOTALNUM	1338	1778	2559	3056	3181	3484	4259	3996	4019	5233
TONSLAND	337	397	643	722	706	824	1050	1011	1294	1439
SOPCOF %	99	100	100	100	100	100	100	95	93	100

YEAR AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
2	127	272	316	54	303	249	142	170	655	48
3	1037	622	1015	251	146	826	483	369	758	431
4	1451	1359	537	440	212	150	771	360	285	480
5	752	1226	691	365	299	228	114	354	423	280
6	444	600	440	505	267	177	130	68	472	344
7	152	385	232	360	250	165	123	84	94	197
8	45	142	148	262	218	167	135	36	85	25
+gp	59	104	203	263	292	233	306	205	464	210
0 TOTALNUM	4067	4710	3582	2500	1987	2195	2204	1646	3236	2015
TONSLAND	1198	1297	1059	814	605	638	646	476	862	619
SOPCOF %	99	98	98	100	100	100	100	99	100	100

YEAR AGE	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
2	195	231	122	293	313	554	230	138	26	48
3	602	1015	400	420	330	683	591	558	157	226
4	814	1083	857	384	354	445	458	613	284	286
5	475	583	734	583	297	285	211	246	160	194
6	257	276	505	299	489	139	132	65	111	137
7	187	117	169	135	240	92	67	28	36	62
8	86	102	67	81	179	29	83	14	54	23
+gp	171	91	116	108	202	88	103	106	192	96
0 TOTALNUM	2787	3498	2970	2303	2404	2315	1875	1768	1020	1072
TONSLAND	824	990	836	633	656	640	541	507	358	332
SOPCOF %	99	98	98	97	102	98	101	100	100	109

YEAR AGE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
2	13	37	110	137	32	163	45	63	55	15
3	66	81	273	181	131	59	325	181	72	83
4	178	95	190	347	268	309	96	202	234	71
5	109	109	175	195	201	268	228	65	176	151
6	199	89	82	186	97	93	243	126	47	98
7	105	81	38	163	144	54	120	122	120	14
8	68	18	50	120	104	83	34	92	137	38
+gp	69	93	181	301	157	235	214	224	123	140
0 TOTALNUM	807	603	1099	1630	1134	1264	1305	1075	964	610
TONSLAND	331	215	348	520	434	417	424	387	302	211
SOPCOF %	100	100	101	100	100	99	100	99	100	100

Table 6.7 Sole 20-24. Weight at age (kg) in the catch and in the stock.

Catch weights at age (kg)

YEAR AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
2	.1830	.1740	.1650	.1600	.1590	.1760	.1800	.1740	.2130	.1780
3	.2130	.2340	.2310	.1940	.1970	.2210	.2280	.2290	.2520	.2240
4	.2570	.2830	.2870	.2450	.2350	.2550	.2510	.2750	.3360	.2740
5	.2940	.2910	.2970	.2740	.2510	.2660	.3080	.2920	.4120	.3280
6	.2970	.3350	.4090	.3190	.3350	.2710	.3330	.3460	.4300	.3740
7	.2800	.2920	.2670	.3600	.3480	.3520	.4000	.3090	.4910	.4030
8	.3210	.2790	.2620	.4170	.3630	.3000	.5470	.3860	.5660	.3880
+gp	.3680	.3640	.3830	.3610	.3520	.3550	.5550	.5030	.6220	.4740
0 SOPCOFAC	.9930	.9984	.9995	1.0027	1.0032	.9964	.9970	.9508	.9304	.9980

YEAR AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
2	.1740	.1870	.1760	.1980	.1610	.1620	.1690	.1840	.1720	.1740
3	.2290	.2000	.2180	.2720	.2190	.2320	.2360	.2420	.2050	.2100
4	.2800	.2480	.2670	.2960	.3160	.3040	.3040	.2900	.2940	.2460
5	.3420	.2910	.3070	.3080	.3220	.3680	.3440	.3780	.3730	.3600
6	.3880	.3510	.3390	.3450	.3500	.3600	.3190	.3460	.3860	.3820
7	.4450	.3820	.4040	.3590	.3580	.3780	.3640	.3080	.2140	.4310
8	.4480	.4320	.4570	.3640	.3770	.3970	.3520	.3620	.2920	.2610
+gp	.3940	.3830	.6640	.3610	.3270	.3500	.3280	.2810	.2760	.3820
0 SOPCOFAC	.9931	.9767	.9826	.9983	1.0006	1.0041	1.0004	.9941	.9967	.9971

YEAR AGE	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
2	.2030	.1920	.2010	.2110	.2150	.2110	.2580	.2610	.2850	.2390
3	.2370	.2230	.2150	.2280	.2460	.2590	.2700	.2710	.2790	.2250
4	.2910	.3000	.2630	.2950	.2670	.3010	.2830	.2920	.3170	.2760

5	.3280	.3240	.3170	.3020	.2800	.3190	.3240	.2770	.3750	.3040
6	.3710	.3670	.3390	.3540	.2900	.4030	.3110	.3580	.4060	.3730
7	.4010	.3710	.3210	.3390	.2960	.4390	.3690	.4760	.4060	.3050
8	.3700	.4210	.2930	.3800	.3010	.4390	.3100	.2850	.3500	.3060
+gp	.3150	.3720	.3440	.2440	.2460	.2630	.2630	.3010	.4060	.2870
0 SOPCOFAC	.9916	.9841	.9794	.9654	1.0209	.9832	1.0103	1.0003	1.0006	1.0891

YEAR	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
AGE										
2	.2270	.2210	.2340	.2160	.2100	.2000	.1820	.1930	.1730	.1880
3	.2830	.2390	.2670	.2650	.2280	.2880	.2400	.2640	.2150	.2800
4	.3720	.2860	.2680	.2920	.3130	.2900	.2650	.3220	.2690	.2770
5	.4210	.3910	.2830	.2990	.3680	.3840	.3470	.3370	.3060	.3380
6	.4430	.4040	.3410	.3260	.3570	.4230	.3570	.3680	.4350	.3450
7	.4860	.3880	.3300	.3770	.4630	.4590	.3000	.4110	.3110	.4580
8	.4540	.5010	.5440	.3340	.4750	.3860	.4790	.4180	.3480	.4660
+gp	.4060	.4340	.4390	.3950	.5640	.3440	.4360	.4870	.4510	.4090
0 SOPCOFAC	.9976	1.0043	1.0051	1.0034	1.0007	.9949	1.0022	.9899	.9977	.9955

Table 6.8. Sole 20-24. Fishing mortality at age (age 6-9 assumed constant).

Year Age	2	3	4	5	6	7	8	9
1984	0.084	0.389	0.482	0.407	0.381	0.381	0.381	0.381
1985	0.073	0.296	0.365	0.332	0.288	0.288	0.288	0.288
1986	0.084	0.313	0.412	0.393	0.347	0.347	0.347	0.347
1987	0.101	0.336	0.452	0.461	0.455	0.455	0.455	0.455
1988	0.098	0.311	0.414	0.411	0.404	0.404	0.404	0.404
1989	0.103	0.318	0.427	0.431	0.417	0.417	0.417	0.417
1990	0.096	0.3	0.409	0.414	0.377	0.377	0.377	0.377
1991	0.098	0.306	0.424	0.443	0.484	0.484	0.484	0.484
1992	0.098	0.307	0.426	0.467	0.582	0.582	0.582	0.582
1993	0.097	0.308	0.428	0.479	0.588	0.588	0.588	0.588
1994	0.081	0.26	0.359	0.407	0.443	0.443	0.443	0.443
1995	0.088	0.289	0.385	0.44	0.482	0.482	0.482	0.482
1996	0.084	0.285	0.356	0.403	0.429	0.429	0.429	0.429
1997	0.079	0.258	0.338	0.385	0.425	0.425	0.425	0.425
1998	0.074	0.239	0.313	0.373	0.404	0.404	0.404	0.404
1999	0.068	0.225	0.294	0.343	0.368	0.368	0.368	0.368
2000	0.065	0.215	0.29	0.328	0.361	0.361	0.361	0.361
2001	0.055	0.181	0.237	0.281	0.302	0.302	0.302	0.302
2002	0.063	0.2	0.266	0.326	0.421	0.421	0.421	0.421
2003	0.055	0.169	0.245	0.299	0.386	0.386	0.386	0.386
2004	0.065	0.197	0.293	0.35	0.44	0.44	0.44	0.44
2005	0.075	0.225	0.327	0.379	0.444	0.444	0.444	0.444
2006	0.076	0.229	0.32	0.377	0.371	0.371	0.371	0.371
2007	0.077	0.235	0.317	0.35	0.302	0.302	0.302	0.302
2008	0.089	0.272	0.372	0.379	0.321	0.321	0.321	0.321
2009	0.078	0.255	0.356	0.327	0.193	0.193	0.193	0.193
2010	0.071	0.257	0.358	0.321	0.171	0.171	0.171	0.171
2011	0.054	0.205	0.311	0.257	0.127	0.127	0.127	0.127
2012	0.043	0.158	0.262	0.225	0.141	0.141	0.141	0.141

Year Age	2	3	4	5	6	7	8	9
2013	0.038	0.136	0.237	0.21	0.145	0.145	0.145	0.145
2014	0.031	0.101	0.193	0.183	0.148	0.148	0.148	0.148
2015	0.027	0.085	0.154	0.168	0.126	0.126	0.126	0.126
2016	0.034	0.1	0.188	0.207	0.17	0.17	0.17	0.17
2017	0.042	0.112	0.224	0.266	0.271	0.271	0.271	0.271
2018	0.037	0.094	0.185	0.222	0.239	0.239	0.239	0.239
2019	0.035	0.094	0.177	0.21	0.212	0.212	0.212	0.212
2020	0.035	0.102	0.175	0.211	0.214	0.214	0.214	0.214
2021	0.033	0.095	0.154	0.192	0.198	0.198	0.198	0.198
2022	0.03	0.085	0.135	0.169	0.169	0.169	0.169	0.169
2023	0.022	0.07	0.1	0.133	0.115	0.115	0.115	0.115

Table 6.9. Sole 20-24. Stock number at age from assessment.

Year Age	1	2	3	4	5	6	7	8	9
1984	6399	2599	1617	510	365	134	80	126	478
1985	5240	5972	2323	926	266	220	89	45	349
1986	4823	4656	4966	1658	598	173	144	70	264
1987	4331	4381	3883	3261	991	364	124	91	221
1988	5898	3674	3784	2693	1861	492	177	71	180
1989	7598	5383	2669	2569	1677	1157	265	102	149
1990	7537	7159	4428	1749	1578	1011	697	143	141
1991	8510	6685	5649	2870	1036	942	664	465	186
1992	6500	8181	5431	3524	1579	586	510	369	392
1993	3577	6188	6912	3636	2112	879	286	264	369
1994	3503	2960	5242	4822	2197	1210	413	140	295
1995	2277	3378	2605	3941	3133	1443	763	265	281
1996	1544	2047	2913	1853	2413	1735	853	428	373
1997	3617	1153	1441	1728	1241	1509	1116	621	543
1998	3672	3726	870	943	985	773	851	686	740
1999	3107	3418	3664	634	725	612	520	521	882

Year Age	1	2	3	4	5	6	7	8	9
2000	4414	2595	2673	2532	430	502	371	363	955
2001	5881	4033	2176	1952	1590	296	374	211	897
2002	4441	5811	3759	1552	1495	1152	225	273	838
2003	4496	3840	4383	2712	1139	1042	633	120	641
2004	2920	4358	3734	3259	1739	757	582	345	442
2005	2492	2733	4514	3327	2183	969	377	289	346
2006	3186	2366	2255	3454	2147	1408	554	228	416
2007	3418	2665	1947	1620	2191	1082	789	360	492
2008	2018	3181	1926	1414	1084	1397	649	539	591
2009	2102	1871	2659	1271	989	685	889	357	675
2010	1974	1928	1847	1771	749	661	436	668	801
2011	1752	1846	1805	1429	1147	489	461	269	1108
2012	1527	1535	1508	1379	918	813	338	369	1084
2013	1534	1352	1360	1203	1014	660	631	240	989
2014	2520	1286	1152	1007	847	773	451	526	886
2015	3208	2265	1126	1012	692	668	547	303	1238
2016	2644	2826	2101	958	928	483	454	395	1364
2017	1551	2609	2396	1712	684	779	377	332	1435
2018	3385	1172	2191	1995	1200	439	570	279	1274
2019	2510	3211	837	1796	1491	860	270	408	1257
2020	1680	2249	2654	612	1272	1148	667	181	1315
2021	1227	1489	2019	1852	426	823	805	477	1090
2022	1428	1142	1181	1673	1313	295	600	664	1143
2023	1072	1333	1056	981	1286	961	209	430	1422

Table 6.10. Sole 20-24. Stock summary from SAM.

Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), and average fishing mortality for ages 4 to 8 (F48). "Low" and "high" are lower and upper boundary of 95% confidence limits as indicated on plots.

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(4-8)	Low	High	TSB	Low	High
1984	6399	3930	10419	861	697	1065	0.407	0.307	0.539	1721	1406	2107
1985	5240	3412	8048	1122	899	1401	0.312	0.238	0.410	2476	1980	3095
1986	4823	3197	7277	2029	1622	2539	0.369	0.290	0.469	3087	2542	3748
1987	4331	2834	6619	2102	1746	2531	0.456	0.359	0.579	3063	2594	3616
1988	5898	3909	8898	2161	1821	2563	0.407	0.320	0.518	3098	2652	3620
1989	7598	5023	11492	2181	1857	2562	0.422	0.333	0.534	3585	3057	4203
1990	7537	5007	11346	2706	2302	3182	0.391	0.311	0.491	4447	3777	5236
1991	8510	5579	12982	3190	2696	3774	0.464	0.374	0.576	4863	4147	5704
1992	6500	4310	9802	4158	3539	4887	0.528	0.424	0.656	6291	5354	7392
1993	3577	2385	5366	3958	3347	4681	0.534	0.427	0.668	5274	4513	6165
1994	3503	2346	5231	4134	3540	4828	0.419	0.334	0.525	4859	4205	5615
1995	2277	1513	3425	3430	2972	3959	0.454	0.366	0.564	4198	3667	4807
1996	1544	978	2437	3247	2827	3728	0.409	0.331	0.505	3700	3243	4220
1997	3617	2384	5488	2629	2289	3019	0.400	0.323	0.495	3074	2698	3502
1998	3672	2459	5484	1881	1623	2180	0.379	0.304	0.474	2701	2340	3118
1999	3107	2064	4678	2242	1913	2627	0.348	0.280	0.433	2982	2567	3465
2000	4414	2958	6586	2285	1954	2672	0.340	0.273	0.424	2988	2583	3458
2001	5881	3895	8879	2240	1926	2605	0.285	0.226	0.359	3335	2873	3871
2002	4441	2982	6613	2588	2220	3018	0.371	0.296	0.465	3854	3295	4508
2003	4496	3039	6653	2945	2526	3433	0.340	0.268	0.432	3883	3371	4471
2004	2920	2068	4123	3185	2760	3674	0.393	0.314	0.491	4245	3699	4871
2005	2492	1752	3546	3458	2984	4006	0.408	0.325	0.510	4132	3596	4747
2006	3186	2232	4548	2939	2525	3420	0.362	0.291	0.450	3606	3125	4160
2007	3418	2405	4858	2491	2148	2889	0.314	0.249	0.397	3258	2829	3754
2008	2018	1384	2941	2060	1760	2410	0.343	0.268	0.438	2865	2461	3334
2009	2102	1479	2988	2387	2005	2841	0.253	0.195	0.326	2908	2475	3416

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(4-8)	Low	High	TSB	Low	High
2010	1974	1386	2810	2026	1697	2420	0.238	0.183	0.310	2642	2237	3121
2011	1752	1205	2547	2029	1682	2446	0.190	0.145	0.248	2615	2192	3120
2012	1527	996	2342	2238	1834	2732	0.182	0.138	0.240	2767	2292	3341
2013	1534	1015	2317	1742	1428	2126	0.177	0.135	0.232	2157	1787	2604
2014	2520	1763	3602	2217	1834	2681	0.164	0.126	0.214	2660	2225	3181
2015	3208	2211	4656	2001	1654	2420	0.140	0.106	0.184	2694	2256	3217
2016	2644	1856	3767	2209	1838	2655	0.181	0.140	0.233	3346	2809	3985
2017	1551	1032	2330	2413	2019	2883	0.261	0.201	0.339	3255	2740	3868
2018	3385	2268	5051	2838	2361	3410	0.225	0.175	0.289	3693	3089	4416
2019	2510	1753	3594	2412	2005	2901	0.204	0.158	0.264	3378	2824	4041
2020	1680	1169	2414	2511	2069	3047	0.205	0.158	0.267	3256	2713	3907
2021	1227	828	1817	2637	2173	3201	0.188	0.143	0.247	3059	2543	3680
2022	1428	947	2154	2167	1761	2666	0.162	0.122	0.216	2522	2072	3068
2023	1072	614	1875	2211	1758	2781	0.116	0.083	0.160	2558	2058	3181

Table 6.11. Sole 20-24. Input to short term prediction.

2024								
Age	N	M	Mat	PF	PM	SWt	pF	CWt
1	1227	0.1	0	0	0	0.128	0.000	0.128
2	980	0.1	0	0	0	0.186	0.022	0.186
3	1173	0.1	1	0	0	0.257	0.070	0.257
4	897	0.1	1	0	0	0.284	0.100	0.284
5	807	0.1	1	0	0	0.342	0.133	0.342
6	1049	0.1	1	0	0	0.384	0.115	0.384
7	784	0.1	1	0	0	0.381	0.115	0.381
8	168	0.1	1	0	0	0.419	0.115	0.419
9	1518	0.1	1	0	0	0.425	0.115	0.425

2025								
Age	N	M	Mat	PF	PM	SWt	pF	CWt
1	1227	0.1	0	0	0	0.128	0.000	0.128
2	1107	0.1	0	0	0	0.186	0.022	0.186
3	879	0.1	1	0	0	0.257	0.070	0.257
4	987	0.1	1	0	0	0.284	0.100	0.284
5	732	0.1	1	0	0	0.342	0.133	0.342
6	633	0.1	1	0	0	0.384	0.115	0.384
7	841	0.1	1	0	0	0.381	0.115	0.381
8	643	0.1	1	0	0	0.419	0.115	0.419
9	1368	0.1	1	0	0	0.425	0.115	0.425

2026								
Age	N	M	Mat	PF	PM	SWt	pF	CWt
1	1227	0.1	0	0	0	0.128	0.000	0.128
2	1123	0.1	0	0	0	0.186	0.022	0.186
3	971	0.1	1	0	0	0.257	0.070	0.257
4	698	0.1	1	0	0	0.284	0.100	0.284

5	763	0.1	1	0	0	0.342	0.133	0.342
6	524	0.1	1	0	0	0.384	0.115	0.384
7	471	0.1	1	0	0	0.381	0.115	0.381
8	625	0.1	1	0	0	0.419	0.115	0.419
9	1529	0.1	1	0	0	0.425	0.115	0.425

Input units are thousands and kg

Table 6.12. Sole 20-24. Basis for forecasts and catch opportunities tables for short term predictions.

Variable	Value	Notes
F ages 4–8 (2024)	0.116	Fsq (=avg F2021-23 rescaled to F2023)
SSB (2025)	2256 tonnes	When fishing at F=0.116 in 2024
Rage1 (2024-2025)	1227 thousands	Resampled from recruitment (2021-2023)
Projected landings (2024)	232 tonnes	Fishing at F=0.116 in 2024
Projected discards (2024)	7 tonnes	Mean discard rate in weight (2019-2023):2.810%.
Total catch (2024)	239 tonnes	Based on fishing at Fsq and mean discard rate

Total catch is calculated based on projected landings (fish that would be landed in the absence of the EU landing obligation) and projected discards based on recent discard rate (in weight).

Basis	Total catch (2025) *	Projected landings	Projected discard	$F_{projected\ landings}$ (4–8) (2025)	SSB (2026)	% SSB change ***	% TAC	% Advice change ^^	ProbSSB(2026) <Blim
		(2025) **	(2025) **				change ^		
ICES advice basis									
EU MAP#: $F_{MSY*SSB2025/MSY\ Btrigger}$	429	417	12	0.226	2038	-9.9	31.1	-1.7	21.6
EU MAP#: $F_{lower*SSB2025/MSY\ Btrigger}$	322	313	9	0.165	2139	-5.5	-1.6	0.0	30.6
Other options									
F = 0	0	0	0	0	2478	9.5	-100.0	-100.0	4.1
$F_{pa,\ Fmsy}$	485	472	13	0.26	1983	-12.4	48.4	11.3	36.1
MAP range Fupper	485	472	13	0.26	1983	-12.4	48.4	11.3	36.1
MAP range Flower	367	357	10	0.19	2096	-7.4	12.2	-15.8	24.5
F_{lim}	573	557	16	0.315	1892	-16.4	75.1	31.3	46.1
TAC 2023*1.2	403	392	11	0.211	2062	-8.9	23.2	-7.6	27.9

SSB (2026) = Blim	612	595	17	0.340	1850	-18.3	87.1	40.3	50.0
SSB (2026) = Bpa	scenarios not possible - zero catch provide SSB(2026)=2478 t < Bpa, MSY Btrigger								
SSB (2026) = MSY Btrigger									
SSB(2026)=SSB(2025)	209	203	6	0.104	2256	-0.3	-36.2	-52.1	14.6
P(SSB(2026)<Blim)=5%	15	15	0	0.007	2460	8.7	-95.3	-96.5	5.0
F = F_{2024}	231	225	6	0.116	2233	-1.3	-29.3	-46.9	15.5

Fig. 6.1. Sole 20-24. Landings of sole in Divs 20-24 by nation since 1952 and for TAC since 1986.

Figure 6.2. Sole 20-24. Cumulative Danish landings of sole by month. Black bold curves are 2023 and red bold curve is 2024 January to March.

Figure 6.3 . Sole 20-24. Upper: Age aggregated catch rates from Fisherman/DTU Aqua survey.Lower: age disaggregated indices from the survey.

Figure 6.4.1 Fisherman-DTU Aqua survey. Catch rate distribution of stations in 2022 and 2023

Figure 6.5. Sole 20-24. Map of sole survey station distribution in 2017 – 2023. The red boxes indicates annual expansion from the core area in Kattegat as surveyed prior to 2017. Only hauls in the core area are used for estimation of survey indices for assessment calibration.

Figure 6.6. Sole 20-24. Landing numbers at age.

Figure 6.7. Sole in 20-24. Landings weight-at-age.

Figure 6.8. Sole 20-24. Model residuals for landings and survey.

Figure 6.9. 20-24. Fleet sensitivity. Estimated SSB, and fishing mortality from runs leaving single fleets out. Recruitment (age 1) plot is not possible to provide since only the survey contains age 1 group.

Figure 6.10. Sole 20-24. Stock summary; SSB, F(4-8) and R (age 1) compared to last year's assessment.

Figure 6.11. Sole 20-24. Retrospective analyses for SSB, F, and recruitment. Confidence limits are provided for the 2023 scenario.

Figure 6.12. Sole 20-24. Historical performance of F, SSB and recruitment.

Figure 6.13. Sole 20-24. Short-term forecast for 2024-2026. Yield and SBB at age 2-9+ assuming fishery at F_{sq} in 2024-25.

Figure 6.14 Sole 20-24 Yield per recruit curve and reference point estimates (red=Fmax, green=F35%SPR and blue=F0.1)

7 Sprat in subdivisions 22–32

As in previous years, sprat in the Baltic subdivisions 22–32 was assessed as a single unit. The note on assessments by „assessment units" used up to the early 1990s (subdivisions 22–25, subdivisions 26+28, and subdivisions 27, 29–32) was provided in the Report from WGBFAS meeting in 2017 (ICES, 2017). Short information is also provided in the Quality of assessment section.

In 2023 the sprat assessment was benchmarked at WKBBALTPEL (ICES, 2023) and the present assessment of sprat has been conducted following the procedure agreed during the benchmark. The major change at the benchmark workshop was the change of the assessment model from XSA to SAM, updated predation mortality estimates obtained from the SMS model, some changes in tuning fleets and updated Danish historic sprat catches.

Tuning fleets were updated by WGBIFS and modified BIAS index was implemented at the benchmark. The BIAS index, that was based on survey data from the ICES subdivisions 22-29 before the benchmark, is now including subdivision 32 data. For the years with low or absent coverage of subdivision 32, the old BIAS index is used to fill the gaps, resulting in two BIAS time series covering different periods for sprat age 1 and older. Age 0 index time series (also including now subdivision 32) was shortened and covers the years starting from 2010.

7.1 The Fishery

7.1.1 Landings

No information on Russian catches for 2023 was officially reported to ICES. Russian catch amount for 2023 included in the assessment was based on the information available in AtlantNIRO (2023) and Federal Fisheries Agency (2024) websites.; no biological information on composition of these catches was available to ICES. In the above-mentioned websites are given the Russian catches of sprat in the first quarter 2023, from January to June, from January to September, from January to December of 2023 and from January to December in 2022. The estimated Russian 2022 total catch number was replaced with the total catch number obtained from the Russian Federal Fisheries Agency home page. The first quarter 2023 Russian catches were given as total catch for the Baltic Sea. This total catch was distributed to the ICES subdivisions based on the average Russian catch composition in 2019-2021. The catch numbers in the Russian Federal Fisheries Agency (2024) home page are given separately to the Gulf of Finland (SD 32) and Baltic Proper (SD 26). Quarter 2 Russian catches were calculated by subtracting quarter 1 catches from the 6-month catches. Quarter 3 Russian catches were calculated by subtracting 6-month catches from the 9-month catches. Quarter 4 Russian catches were calculated by subtracting 9-month catches from the 2023 total catches. Next, Russian 2023 quarterly sprat catches were uploaded to InterCatch by the sprat stock coordinator of WGBFAS. According to the data uploaded to the InterCatch, sprat catches in 2023 were 265 900 t, which is 12% less than in 2022 and 51% less than the record high value of 543 228 t in 1997. In 2023 total TAC set by the EU plus the Russian autonomous quota was 269 214, which was utilized in 99%. The largest decrease in catches was observed for Germany, Sweden and Poland (18, 18 and 17%, respectively). At the same time, the Finnish catches increased by 9% compared to 2022.

The spatial distribution (by subdivision) of sprat catches was similar to previous years. Subdivision 26 dominated the catches with a 42% share in the sprat catch. Other important areas are subdivisions 28 and 25 (21 and 14%, respectively). Landings by country and subdivision are

presented in Tables 7.1–7.2. Figure 7.1 presents the shares of catches by subdivision in 2001–2023. Table 7.3 contains landings, catch numbers, and weight-at-age by subdivision and quarter.

7.1.2 Unallocated removals

The species misreporting of herring and sprat in the Baltic has been discussed for many years (ICES 2022). The RCG ISSG consequently made an attempt to provide the last benchmark of the stock with corrected time series of catch data for which species misreporting had been corrected (ICES, 2023). It was concluded that the issue of misreporting could not be addressed adequately by all the countries in time for the benchmark and that the issue needs to be postponed. The working document in the last benchmark report (WKBBALTPEL, ICES, 2023) outlines the approach taken by countries so far to analyse if there are errors in the time series of catch data due to inadequate reporting of species and/or other reasons and if the countries foresee that alternative time series of catch should be provided. Denmark and Sweden provided alternative time series of catches, of which the new time series of catches from Denmark was included in the benchmark assessment. No new information on unallocated catches was presented to the group.

7.1.3 Discards

According to the EC Common Fisheries Policy (adopted in 2014) in 2015, the landing obligation began to cover small and large pelagic species, industrial fisheries and the main fisheries in the Baltic. Historically, discards in most countries have probably been small because the undersized and lower quality fish can be used for the production of fish meal and feeding in animal farms. In fisheries directed for human consumption, however, young fish (0 and 1 age groups) were discarded with higher rates in years when strong year classes recruit to the fishery. Recruitment to the fishery takes place in the 4th (age 0) and 1st (age 1) quarters. The amount of discarding of these age-groups was unknown. In the 2015 data call (L.27/ACB/HSL in 2015) ICES requested landings, discards, biological sample and effort data from 2014 in support of the ICES fisheries advice in 2015. Only Estonia and Germany provided the requested discard data for Baltic sprat. However, these two countries reported zero discards in years 2012–2014. For year 2015 catches, there were no discard data of Baltic sprat available. Only Finland has uploaded (logbook registered) discard data for Baltic sprat in 2016, 2017, 2018, 2020 and 2021 into the InterCatch – 563, 482, 335, 135 and 282 kg, respectively from the passive gear catches. No sprat discard data were uploaded into InterCatch for 2022 and 2023.

7.1.4 Effort and CPUE data

Only Denmark and Lithuania uploaded the fishing effort data for 2014 into the InterCatch in 2015. Russia provided in 2021 the updated data on fishing effort and CPUE for Subdivision 26 in 1995–2020 (Table 7.4). There are no updates presented since 2022. These data indicate an increase in CPUE in 1995–2004 and stable CPUE in 2005–2011, followed by a stable CPUE at a higher level in 2012–2017. In 2018-2020 the Russian effort was much higher compared to the previous years. At the same time, the CPUE has decreased again. The dynamics of this CPUE did not reflect the stock size estimates from the analytical models (previously used XSA or currently used SAM). Available effort and CPUE data are restricted to only some regions and years, and are not considered representative for the entire stock and therefore were not applied in the assessment.

7.2 Biological information

7.2.1 Age composition

All countries except Russia provided age distributions of their major catches (landed in their waters) by quarter and Subdivision (Table 7.5). Catches for which the age composition was missing represented about 21% of the total. The unsampled catches were distributed to ages according to overall age composition in a given Subdivision and quarter using "Allocation scheme" with CATON values as weighting keys in InterCatch. A large part of the sprat catches is taken as part of the fish meal fishery. In some fisheries the species composition of the catch is imprecise.

The estimated catch-at-age in numbers is presented in Tables 7.3 and 7.6 and the age composition of the catches is shown in Figure 7.2. The consistency of the catch-at-age estimates was checked in bubbles-plot (Figure 7.3). The correlation between catch at a given age and the catch of the same generation one year later is high and exceeds 0.9 in most cases.

7.2.2 Mean weight-at-age

Almost all countries presented rather extensive data on weight-at-age in the catch by quarter and subdivision. Mean weights-at-age in the catch were obtained as averages weighted by catch in numbers. The weights-at-age have decreased by about 40% in 1992–1998 (Figure 7.4). In 1999–2023 the weights have fluctuated without a clear trend. Although, the mean weights-at-age of the year-class 2003 are significantly lower compared to other year-classes in the last decade. The mean weight of the year-class 2014 is also very low; it could be a result of density dependent effects as both year-classes were very abundant. After 2014, the new year-classes have showed increased mean weight-at-age. Mean weights in the stock were assumed the same as mean weights in the catch (Table 7.7). The consistency of the weight-at-age estimates was explored and it is of a similar quality as the consistency of catch-at-age data (the correlation between mean weight at a given age and the mean weight of the same generation 1 year later is high and exceeds 0.9 in most cases).

7.2.3 Natural mortality

As in previous years, the natural mortalities used varied between years and ages as an effect of cod predation.

In 2022 new estimates of predation mortality (M2) covering 1974-2021 were available from updated SMS (WGSAM 2022), using analytical estimates of cod stock as an external variable. The M2 for 2022 and 2023 was assumed equal to the 2021 values. The estimates of M are given in Table 7.8.

7.2.4 Maturity-at-age

The maturity estimates were kept unchanged from previous years and constant throughout the time-series (Table 7.9). In 2002 the WG was provided with rather extensive maturity data by the Study Group on Herring and Sprat Maturity. These data were analysed using the GLM approach and year dependent estimates were obtained (ICES, 2002). These estimates at age 1 varied markedly from year to year and the WG felt that it was necessary to continue sampling and perform a more extensive analysis of the data. Thus, the maturities were averaged over years in the 2002 assessment. These maturities were kept the same in the assessments up to 2012.

At the benchmark workshop in 2013 (ICES, 2013) maturity estimates were obtained from several countries but only a simplified approach for their analysis was applied due to time constraints. The results did not suggest the need to change the maturity parameters used so far. Thus, maturities estimated in 2002 are still kept in the present assessment.

Proportions of M and F before spawning are shown in Tables 7.10–7.11.

7.2.5 Quality of catch and biological data

In all countries around the Baltic Sea fish catch statistics are based on log-book data. In some countries, such as Denmark and Poland, these data are supplemented by data collected in regional Marine Offices. In Denmark, Sweden, Finland, and to a lesser degree in Poland, much of the sprat catch is taken in industrial fisheries where large by-catches of other fish species (mostly herring) may occur. The species composition of these catches is not accurately known, and can create errors in annual sprat catch statistics.

The landings and sampling activity for 2023 by quarter, ICES subdivision, and country are presented in Table 7.5. These data show that generally in 2023 the sampling activity by ICES subdivision exceeded much the levels indicated in the EC regulation No. 1639/2001, i.e. at least one sample per 2000 t. of catch, 100 length measurements and 50 age readings per sample. On average number of samples, a number of length measurements, and a number of age readings was three times higher than indicated in the directive.

7.3 Fishery independent information

To tune SAM, two surveys were available: the October acoustic survey (BIAS) and the May acoustic survey (BASS). They resulted in four tuning fleets:

- fleet1: October acoustic survey (BIAS) in the years 2000-2023 (gaps in years 2001-2005 and 2008) covering the ages 1-8 and subdivisions 22-29+32,
- fleet2: October acoustic survey (BIAS) in the years 1991-2008 covering the ages 1-8 and subdivisions 22-29 (years from this fleet which overlapped with above fleet1 were excluded),
- fleet3: May survey (BASS) in the years 2001-2023 covering the ages 1-8 and subdivisions 24-26+28,
- fleet4: October (BIAS) survey covering the age 0 sprat and subdivisions 22-29+32 in 2010-2023; the age 0 series was shifted to represent the age 1 the following year.

The tuning fleets are presented in Tables 7.12–7.15. The survey indices are corrected for area coverage. However, in 2016 the May survey (BASS) only covered ca. 50% of planed areas, so the 2016 survey estimates from BASS we not used in the assessment as recommended by the WGBIFS (ICES, 2024). Due to the low area coverage also the 1993, 1995, and 1997 BIAS survey estimates we not used in the assessment as recommended by the WGBIFS (ICES, 2024).

The internal consistency of the survey at age estimates and consistency between surveys was checked on graphs (Figures 7.5-7.6). The correlation between survey index a given age and the survey index of the same generation one year later is high ranging between 0.7–0.9.

7.4 Assessment

7.4.1 SAM

The input data for the catch-at-age analysis are presented in Tables 7.6–7.15. The settings for the parameterisation of SAM were the same as specified in the benchmark assessment:

- 4 tuning fleets were used.
- Catchability depended on year-class strength at age 1 for all fleets.
- Catchability plateau was set at age 6 (ages 6-8 assume the same q).
- Recruitment was modelled as random walk.
- Covariance structure for each fleet was set as "ID" (independent).

Configuration file used for SAM assessment is shown in Table 7.16.

The distributions of residuals do not show clear patters except age 1 in both age0 acoustic (fleet4) and October acoustic in sub-divisions 22-29 (fleet2). In these fleets there is tendency for negative residuals at first years of the survey (Figure 7.7).

The leave-one-out analysis (Figure 7.8) shows low effect of excluding from tuning age 0 acoustic (fleeet4) and October acoustic in sub-divisions 22-29 (fleet2). However, fleet4 is important as it provides estimate of recruitment in intermediate year using SAM.

Retrospective analysis shows some tendency to overestimate biomass and recruitment and underestimate fishing mortality (Figure 7.9). However, in recent years assessment is very consistent and Mohn's rho values are equal to 0.02, -0.03, and 0.04 for SSB, F_{bar}, and recruitment, respectively. Quality of the assessment in terms of retrospective deviations is higher than it was in previous XSA assessments, where Mohn's rho values ranged from -0.15 to 0.15.

The summary of assessment, stock numbers and fishing mortalities at age are shown in Tables 7.17–7.19. Fish stock summary plots are presented in Figure 7.10. Present assessment with SAM is very consistent with last year assessment (Figure 7.11).

7.4.2 Recruitment estimates

The acoustic estimates on age-0 sprat in subdivisions 22–29,32 (shifted to represent age 1) were used to estimate recruitment at age 1 in intermediate year (year class 2023). This year class is estimated at 13.57 billion, which is well below average of 81.4 billion in 1991-2023.

7.4.3 Historical stock trends

In the 1990s the SSB exceeded 1 million t, being record high in 1996–1997 (about 1.7 million t). These values were several times higher than the SSB estimates of about 0.3 million tonnes in the early 1980s. Since 2000 the SSB has been generally fluctuating around about 1 million tonnes. The strong year-class of 2014 has led to a marked increase of stock biomass in 2016-2017. However, three most recent year-classes are very poor which has led to marked decline of biomass. The prediction of SSB for 2024 at spawning time (assuming TAC constraint) is 692126 tonnes, which is 22% lower than the SSB estimated for 2023.

Weight-at-age has decreased since the early 1990s, and has remained low since then. This is likely due to density-dependent effects. In 2022-2023 small increase in mean weights was observed. Acoustic surveys show that in recent years in autumn the stock has been mainly concentrated in subdivisions 27–29 and 32 (Casini *et al.*, 2011, WGBIFS, 2024).

7.5 Short-term forecast and management options

The short-term forecast was performed using forecast procedure in stockassessment package. The 2023-year class at age 1 was estimated in SAM. The 2024- and 2025-year classes were resampled from SAM estimates of the recruitment at age 1 in 1991–2023 (period of recruitment fluctuations without a clear trend). The natural mortalities, mean weights, and fishing pattern were assumed as averages of 2021–2023 values. Fishing mortality in the intermediate year was estimated consistent with TAC in 2024 (TAC defined as EU quota of 201 kt plus assumed Russian quota of 44.2 kt, in total 245.2 kt). Input data for catch prediction are presented in Table 7.20.

Prediction results with TAC constraint are shown in Table 7.21. In addition, a prediction option with F_{sq} of 0.36 in 2024 was performed; that produced catches in 2024 at 212 kt, ca 14% lower than the TAC. Since 2015 TAC has been fully utilised (except in 2017), thus the group considers TAC constraint prediction as the basis for the advice.

This year forecast at F_{MSY} shows 32% lower catches compared to last year forecast. The change in advice is mainly due to decline in stock size (the SSB in 2024 declined by 22% compared to 2023 estimate) and 23% lower estimate of 2022 y-c than estimated in SAM last year using survey data only.

Comparison of present SAM and previous SAM assessments in terms of ratios of estimated stock numbers is presented in Table 7.22. Major difference (23%) is for the estimate of 2022 y-c (age 1 in 2023 estimated in 2023 SAM basing on age 0 survey only). In present assessment the estimate of this y-c also uses catches and data from other surveys, and is more precise.

The forecast assumptions are presented in Table 7.23 and comparison of weights, selectivity's and natural mortalities used in predictions for 2024 and 2025 are shown in Figure 7.12. Differences between compared values are very small.

7.6 Reference points

During the benchmark (ICES, 2023), the BRPs were estimated using the methodology shortly described below. Three stock-recruitment models were fitted to the entire time-series data: Beverton and Holt (B&H), Ricker, and hockey-stick models. The analyses revealed that the B&H function and segmented regression (segreg) had the highest contribution to the bootstrap model averaging procedure with 45% and 42%, respectively. The Ricker function had a contribution of 13% . Due to the low weight of the Ricker function, this S-R relationship was not included in the further estimation of F_{MSY}. In the following analysis, the combination of the B&H and the segmented regression was used.

The B_{lim} (459 000 t) was estimated as the biomass that produces half of maximal (from the model) recruitment following Myers *et al.* (1994) and the previous approaches for sprat stock. That resulted in B_{pa} of 541 000 t (Blim*$e^{sigmaSSB*1.645}$; sigmaSSB = 0.1 from assessment); $B_{MSYtrigger}$ was set at B_{pa}.

The F_{MSY} simulations were conducted in Eqsim. Noise in biological parameters and fishing pattern was generated on the basis of the last ten (2012-2021) and five data years (2017-2021), respectively. Details of the procedure are presented in the benchmark report (ICES, 2023, WKBALTPEL). The F_{MSY} and the ranges were estimated at 0.34 and 0.26-0.44, respectively. However, F_{p05} was estimated at 0.35, thus $F_{MSY\text{-}upper}$ was constrained to 0.35. F_{lim} was estimated at 0.58. The changes in biological data (natural mortality, weight-at-age, and maturity) may have a large impact on estimates of the fishing mortality reference points. Both natural mortalities and weights were variable historically.

New estimates of BRPs and their basis are given below.

Reference Point	Value	Rationale
B_{lim}	459 000t	The SSB producing 50% of maximal recruitment from the Beverton and Holt S-R function.
B_{pa}	541 000t	Blim*$e^{sigmaSSB*1.645}$; sigmaSSB = 0.1
MSY $B_{trigger}$	541 000t	B_{pa}
F_{msy}	0.34	Estimated by EqSim
$F_{msyUpper}$	0.35	The F which produces 95% of the MSY landings was estimated by EqSim at 0.44. As Fp05 was estimated at 0.35, the $F_{msy\text{-}upper}$ was capped at 0.35.
$F_{msyLower}$	0.25	Estimated by EqSim as the F producing 95% of the landings at F_{msy}
F_{lim}	0.58	Estimated by EqSim as the F with 50% probability of SSB being less than B_{lim}
F_{pa}	0.35	$F_{p.05}$, F which leads to 95% probability of SSB being above B_{lim}

7.7 Quality of assessment

In the mixed fishery for herring and sprat, the reported quantities landed by each species are (could be) imprecise. These uncertainties could influence the estimates of absolute stock size and fishing mortality. The retrospective plots with SAM show moderate deviations of estimates for certain years. In the case of fishing mortality, the deviations may be to some extent caused by F_{bar} based on three values only (F-at-age 3–5), that is sensitive to bias in F-at-age, occurring especially for weak year classes neighbouring a strong year class.

The predicted SSB for the year following the prediction year is sensitive to the assumed (median of values resampled from years 1991+) year class strength. The assumed year classes contribute usually 40–50% to the predicted SSB. If a strong year class goes through the stock (e.g. 2014 y-c), this contribution is smaller, close to 40%.

The sprat in subdivisions 22–32, now being assessed as one unit, was previously considered to be composed of three stock components: sprat in subdivisions 22–25, 26+28, and 27+29–32. An analysis of the impact of merging components on stock assessment was performed during the benchmark workshop in 2013 and recently within Inspire project (2016, BONUS financial support). It showed that sum of biomass of separately assessed components is similar to biomass estimated for the whole stock.

The inputs to the assessments are catch-at-age data and age-structured stock estimates from the acoustic surveys. The survey estimates of stock numbers are internally consistent and the same applies to catch-at-age numbers. Surveys are also consistent between themselves.

7.8 Comparison with previous assessment

The comparison between the results of 2023 and 2024 SAM assessments is presented in the text table below. Both assessments are very consistent in terms of SSB and F values. The 13% difference is observed in recruitment estimate; terminal recruitment (for intermediate year) is estimated in SAM using age0 survey data only, and next year this estimate is updated in SAM using also catch numbers and other surveys.

Category	Parameter	Assessment 2023	Assessment 2024	Diff. (+/-) %
Data input	Maturity ogives	age 1 – 17%, age 2 – 93%	age 1 – 17%, age 2 – 93%	No
	Natural mortality	M in 1974–2021 estimated in updated SMS, M2022=M2021	M in 1974–2021 estimated in updated SMS, M2023 and M2022 assumed equal to M2021	No
Assessment input	Catchability dependent on year class strength	Age<2	Age<2	No
	Catchability independent on age	Age >=6	Age >=6	No
	Tuning data	International acoustic autumn International Acoustic May	International acoustic autumn International Acoustic May	No
		Acoustic on age 0 (subdiv. 22–32)	Acoustic on age 0 (subdiv. 22–32)	No
Assessment results	SSB 2022 (10^6 t)	1.127	1.127	0%
	F(3-5) 2022	0.36	0.36	0%
	Recruitment (10^9)	43.8	33.6	-13%

7.9 Management considerations

There is an EU multiannual plan for sprat in the Baltic Sea (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R1139&from=EN). In the plan, F_{MSY} ranges are defined as 0.19 – 0.26 and 0.26–0.27. During the benchmark process, the F_{MSY} and ranges were redefined as 0.26-0.34 and 0.34-0.35 (ICES, 2023, benchmark report).

As in previous years, sprat in Baltic subdivisions 22–32 was assessed as a single unit, and this procedure shows relatively good assessment quality.

The spawning stock biomass has been low in the first half of the 1980s. At the beginning of the 1990s, the stock started to increase rapidly and in 1996–1997 it reached the maximum observed spawning stock biomass of 1.7 million tonnes. The stock size increased due to the combination of strong recruitments and a decline in natural mortality (effect of low cod biomass). Next, following high catches and varying recruitment, SSB fluctuated along the average of about 1 million tonnes. Very strong year-class of 2014 has led to a marked increase in stock size, SSB reached 1.2 million tonnes in 2016–2017. After 2000 fishing mortality increased and next fluctuated, exceeding F_{MSY} in most years. Among the year classes 2009–2021, only one (2014) was strong, which contributed to the previous stock decline. The 2019-2020-year class are above average, while the 2021 and 2023 year classes are very poor.

The marked part of the sprat catches is taken in a mixed sprat-herring fishery, and the species composition of these catches is imprecise in some fishing areas/periods.

Table 7.1. Sprat landings in Subdivisions 22-32 (thousand tonnes)

Year	Denmark	Finland	Germany Dem. Rep.	Germany Fed. Rep.	Poland	Sweden	USSR	Total
1977	7.2	6.7	17.2	0.8	38.8	0.4	109.7	180.8
1978	10.8	6.1	13.7	0.8	24.7	0.8	75.5	132.4
1979	5.5	7.1	4.0	0.7	12.4	2.2	45.1	77.1
1980	4.7	6.2	0.1	0.5	12.7	2.8	31.4	58.1
1981	8.4	6.0	0.1	0.6	8.9	1.6	23.9	49.3
1982	6.7	4.5	1.0	0.6	14.2	2.8	18.9	48.7
1983	6.2	3.4	2.7	0.6	7.1	3.6	13.7	37.3
1984	3.2	2.4	2.8	0.7	9.3	8.4	25.9	52.5
1985	4.1	3.0	2.0	0.9	18.5	7.1	34.0	69.5
1986	6.0	3.2	2.5	0.5	23.7	3.5	36.5	75.8
1987	7.8	2.8	1.3	1.1	32.0	3.5	44.9	93.4
1988	4.5	3.0	1.2	0.3	22.2	7.3	44.2	82.7
1989	8.1	2.8	1.2	0.6	18.6	3.5	54.0	88.8
1990	10.1	2.7	0.5	0.8	13.3	7.5	60.0	94.9
1991	23.3	1.6		0.7	22.5	8.7	59.7*	116.5

Year	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden	Total
1992	27.9	4.1	1.8	0.6	17.4	3.3	28.3	8.1	54.2	145.7
1993	32.9	5.8	1.7	0.6	12.6	3.3	31.8	11.2	92.7	192.6
1994	69.4	9.6	1.9	0.3	20.1	2.3	41.2	17.6	135.2	297.6
1995	77.5	13.1	5.2	0.2	24.4	2.9	44.2	14.8	143.7	326.0
1996	120.4	21.1	17.4	0.2	34.2	10.2	72.4	18.2	158.2	452.3
1997	151.2	38.9	24.4	0.4	49.3	4.8	99.9	22.4	151.9	543.2
1998	101.3	32.3	25.7	4.6	44.9	4.5	55.1	20.9	191.1	480.4
1999	97.3	33.2	18.9	0.2	42.8	2.3	66.3	31.5	137.3	429.8
2000	51.9	39.4	20.2	0.0	46.2	1.7	79.2	30.4	120.6	389.6
2001	50.7	37.5	15.4	0.8	42.8	3.0	85.8	32.0	85.4	353.4
2002	43.4	41.3	17.2	1.0	47.5	2.8	81.2	32.9	77.3	344.6

Year	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden	Total
2003	33.2	29.2	9.0	18.0	41.7	2.2	84.1	28.7	63.4	309.4
2004	37.9	30.2	16.6	28.5	52.4	1.6	96.7	25.1	78.3	367.3
2005	45.6	49.8	17.9	29.0	64.7	8.6	71.4	29.7	87.8	404.4
2006	34.6	46.8	19.0	30.8	54.6	7.5	54.3	28.2	68.7	344.6
2007	35.5	51.0	24.6	30.8	60.5	20.3	58.7	24.8	80.7	386.8
2008	42.0	48.6	24.3	30.4	57.2	18.7	53.3	21.0	81.1	376.6
2009	57.0	47.3	23.1	26.3	49.5	18.8	81.9	25.2	75.3	404.4
2010	43.0	47.9	24.4	17.8	45.9	9.2	56.7	25.6	70.4	340.8
2011	31.1	35.0	15.8	11.4	33.4	9.9	55.3	19.5	56.2	267.6
2012	19.4	27.7	9.0	11.3	30.7	11.3	62.1	25.0	46.5	243.0
2013	26.1	29.8	11.1	10.3	33.3	10.4	79.7	22.6	49.7	272.9
2014	25.0	28.5	11.7	10.2	30.8	9.6	56.9	23.4	46.0	242.2
2015	22.5	24.0	12.0	10.3	30.5	11.0	62.2	30.7	44.1	247.3
2016	19.7	23.7	16.9	10.9	28.1	11.6	59.3	34.6	42.4	247.1
2017	29.9	25.3	16.1	13.6	35.7	12.5	68.4	38.7	48.3	288.5
2018	28.0	29.3	16.4	15.2	37.1	16.2	79.4	41.4	49.1	312.2
2019	34.4	29.2	16.1	14.6	38.9	16.2	82.4	40.7	45.1	317.7
2020	29.0	24.3	12.5	8.9	28.9	11.2	72.5	45.7	41.1	274.1
2021	24.8	25.6	14.8	12.0	29.1	11.4	79.2	43.4	44.8	284.9
2022**	26.2	27.3	13.5	14.9	31.4	11.9	79.8	42.2	53.8	300.8
2023	24.2	24.8	14.7	12.2	28.8	11.2	66.5	39.1	44.3	265.9

*** Sum of landings by Estonia, Latvia, Lithuania, and Russia.**

**** Russian landings were corrected according to the updated landing statistics.**

Table 7.2. Sprat landings in the Baltic Sea by country and Subdivision (thousand tonnes). 1/5

Year 2001

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	50.7	11.7	0.1	1.0	19.4	8.6	1.4	7.5	1.0	-	-	-
Estonia	37.5	-	-	-	-	-	-	6.3	16.1	-	-	15.1
Finland	15.3	-	-	-	-	-	-	-	4.5	3.2	0.001	7.6
Germany	0.8	0.02	-	0.8	-	-	-	-	-	-	-	-
Latvia	42.8	-	-	-	1.1	7	-	34.7	-	-	-	-
Lithuania	3.0	-	-	-	-	3	-	-	-	-	-	-
Poland	85.8	-	-	0.4	46.3	39.1	-	-	-	-	-	-
Russia	31.9	-	-	-	-	29.6	-	2.3	-	-	-	-
Sweden	85.3	-	-	1	2.9	4.8	27.8	30.2	18.1	-	-	0.5
Total	353.1	11.7	0.1	3.2	69.7	92.1	29.2	81.0	39.7	3.2	0.001	23.2

Year 2002

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	43.4	5.3	0.03	1.1	22.7	8.3	0.6	4.4	0.9	-	-	-
Estonia	41.3	-	-	-	-	-	-	7.7	17.0	-	-	16.6
Finland	17.2	-	-	0.8	2.3	0.004	0.1	0.001	3.7	4.8	-	5.5
Germany	1.0	0.03	-	-	0.1	0.4	0.1	0.1	0.2	-	-	-
Latvia	47.5	-	-	-	1.4	4.5	-	41.7	0.0	-	-	-
Lithuania	2.8	-	-	-	0.0	2.8	-	-	-	-	-	-
Poland	81.2	-	-	0.04	39.7	41.5	-	-	-	-	-	-
Russia	32.9	-	-	-	-	29.9	-	2.9	-	-	-	-
Sweden	77.3	-	-	3.0	13.3	5.6	27.2	19.9	8.3	-	-	-
Total	344.6	5.3	0.03	4.9	79.5	93.1	28.1	76.7	30.1	4.8	0.0	22.1

Year 2003

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	33.2	7.7	-	0.7	10.2	9.8	1.8	2.7	0.4	-	-	-
Estonia	29.2	-	-	-	-	-	-	11.1	11.6	-	-	6.5
Finland	9.0	-	-	0.03	0.4	0.04	0.2	0.1	4.6	1.5	0.001	2.0

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Germany	18.0	0.2	-	0.5	0.8	3.0	9.5	2.8	1.1	-	-	-
Latvia	41.7	-	-	-	0.8	7.8	-	33.2	-	-	-	-
Lithuania	2.2	-	-	-	-	2.2	-	-	-	-	-	-
Poland	84.1	-	-	0.03	26.7	57.4	-	-	-	-	-	-
Russia	28.7	-	-	-	0.0	27.2	-	1.4	-	-	-	-
Sweden	63.4	-	-	2.1	5.5	8.6	24.1	19.3	3.8	-	-	-
Total	309.4	7.9	0.0	3.4	44.5	115.9	35.6	70.5	21.6	1.5	0.001	8.5

Year 2004

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	37.9	13.4	0.1	5.9	12.9	0.4	0.4	3.8	1.1	-	-	-
Estonia	30.2	-	-	-	-	-	-	8.9	10.1	-	-	11.1
Finland	16.6	-	-	0.5	2.5	0.003	0.1	0.03	9.3	3.0	0.003	1.1
Germany	28.5	0.8	-	0.9	1.4	6.0	8.2	6.8	4.4	-	-	-
Latvia	52.4	-	-	-	2.3	7.5	0.2	42.4	0.0	-	-	-
Lithuania	1.6	-	-	-	-	1.6	-	-	-	-	-	-
Poland	96.7	-	-	1.4	33.6	61.6	0.04	0.02	-	-	-	-
Russia	25.1	-	-	-	-	23.9	-	1.2	-	-	-	-
Sweden	78.3	-	-	1.4	9.2	7.6	25.8	22.3	12.0	-	-	-
Total	367.3	14.2	0.1	10.1	61.9	108.7	34.7	85.5	36.9	3.0	0.003	12.2

Year 2005

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	45.6	16.2	0.1	2.1	11.6	5.4	0.2	9.8	0.2	-	-	-
Estonia	49.8	-	-	-	-	-	-	7.1	16.6	-	-	26.0
Finland	17.9	-	-	0.1	0.6	0.6	0.1	0.3	9.0	3.2	0.005	4.0
Germany	29.0	1.2	-	0.1	0.4	4.3	10.2	6.8	6.1	-	-	-
Latvia	64.7	-	-	-	1.2	7.3	0.4	55.8	-	-	-	-
Lithuania	8.6	-	-	-	-	8.6	-	-	-	-	-	-
Poland	71.4	-	-	2.0	23.5	45.6	0.2	0.1	-	-	-	-
Russia	29.7	-	-	-	-	29.7	-	-	-	-	-	0.1

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Sweden	87.8	-	-	0.7	11.1	10.3	25.1	24.5	16.2	-	-	-
Total	404.4	17.4	0.1	4.9	48.3	111.7	36.1	104.3	48.0	3.2	0.005	30.2

Year 2006

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	34.6	15.0	0.2	1.3	5.9	8.3	0.3	2.3	0.9			0.3
Estonia	46.8	-	-	-	0.1	-	0.3	5.5	19.2	-	-	21.6
Finland	19.0	-	-	0.2	0.5	1.1	1.9	2.0	6.8	3.5	0.007	3.0
Germany	30.8	1.2	-	0.01	1.3	8.2	12.0	4.6	3.4	-	-	-
Latvia	54.6	-	-	-	1.1	6.0	-	47.5	-	-	-	-
Lithuania	7.5	-	-	-	-	7.5	-	-	-	-	-	-
Poland	54.3	-	-	0.8	16.7	36.8	-	-	-	-	-	-
Russia	28.2	-	-	-	-	27.9	-	-	-	-	-	0.3
Sweden	68.7	-	-	0.7	4.6	25.3	13.7	16.6	7.6	-	-	0.2
Total	344.6	16.2	0.2	3.0	30.3	121.2	28.2	78.6	37.9	3.5	0.007	25.4

Year 2007

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	35.5	7.5	0.2	0.5	6.4	17.0	-	3.2	0.9	-	-	-
Estonia	51.0	-	-	-	2.2	0.8	0.1	4.3	15.3	-	-	28.3
Finland	24.6	-	-	0.02	1.9	4.2	0.3	2.6	4.5	7.2	0.002	3.8
Germany	30.8	0.8	-	0.46	1.8	12.2	5.8	4.8	4.9	-	-	-
Latvia	60.5	-	-	-	5.1	7.4	1.4	46.5	-	-	-	-
Lithuania	20.3	-	-	-	1.7	11.8	-	3.6	3.2	-	-	-
Poland	58.7	-	-	0.8	21.4	36.4	0.04	0.06	-	-	-	-
Russia	24.8	-	-	-	-	24.8	-	-	-	-	-	-
Sweden	80.7	-	-	1.8	10.0	30.8	11.0	14.9	11.9	0.1	-	0.2
Total	386.8	8.3	0.2	3.5	50.4	145.4	18.7	80.0	40.7	7.3	0.002	32.4

Year 2008

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	42.0	5.7	0.3	0.6	5.8	14.3	-	8.5	6.3	-	-	0.5
Estonia	48.6	-	-	-	0.3	0.02	-	5.3	15.6	-	-	27.3
Finland	24.3	-	-	-	2.1	2.1	0.2	2.3	8.6	5.2	0.0002	3.8
Germany	30.4	1.3	-	0.07	1.8	6.0	4.0	13.7	3.6	-	-	-
Latvia	57.2	-	-	-	2.1	6.3	0.2	48.6	0.005	-	-	-
Lithuania	18.7	-	-	0.01	5.5	6.0	0.7	4.6	1.8	-	-	-
Poland	53.3	-	-	3.9	25.4	23.8	0.02	0.15	-	-	-	-
Russia	21.0	-	-	-	-	21.0	-	-	-	-	-	-
Sweden	81.1	-	-	2.0	13.3	13.2	9.1	27.4	15.4	0.00005	-	0.7
Total	376.6	7.0	0.3	6.6	56.2	92.7	14.3	110.5	51.4	5.2	0.0002	32.3

Year 2009

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	57.0	3.0	0.5	0.7	8.8	15.4	0.3	19.7	8.4	-	-	0.1
Estonia	47.3	-	-	-	0.6	-	-	2.5	13.7	-	-	30.5
Finland	23.1	-	-	-	0.03	2.7	0.3	2.9	7.7	4.4	0.0001	5.2
Germany	26.3	1.4	-	0.24	1.9	3.7	6.2	9.0	4.0	-	-	-
Latvia	49.5	-	-	0.01	6.0	5.0	0.5	38.0	0.008	-	-	-
Lithuania	18.8	-	-	0.45	3.3	6.4	0.5	7.2	0.9	-	-	-
Poland	81.9	-	0.3	2.1	25.4	33.9	6.60	8.40	5.2	-	-	-
Russia	25.2	-	-	-	-	25.2	-	-	-	-	-	-
Sweden	75.3	-	-	2.4	7.9	13.5	10.5	28.2	12.6	0.0014	-	0.2
Total	404.4	4.4	0.9	5.8	53.9	105.7	24.9	115.9	52.4	4.4	0.0001	36.1

Year 2010

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	43.0	8.2	0.5	0.3	4.6	13.0	1.9	9.1	5.4	-	-	-
Estonia	47.9	-	-	-	-	-	-	2.6	16.9	-	-	28.3
Finland	24.4	-	-	-	-	1.9	0.3	5.3	6.8	3.3	0.002	6.9
Germany	17.8	1.8	-	0.05	1.3	4.7	2.8	4.5	2.7	-	-	-

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Latvia	45.9	-	-	-	5.2	5.0	-	35.7	-	-	-	-
Lithuania	9.2	-	-	-	0.03	4.6	-	4.6	-	-	-	-
Poland	56.7	-	0.02	0.1	14.3	32.8	6.1	2.9	0.6	-	-	-
Russia	25.6	-	-	-	-	25.6	-	-	-	-	-	-
Sweden	70.4	-	-	1.6	5.3	8.8	22.5	19.9	12.2	0.003	-	-
Total	340.8	10.0	0.5	2.1	30.6	96.4	33.5	84.5	44.6	3.3	0.002	35.2

Year 2011

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	31.1	6.9	0.3	0.170	2.1	3.8	0.12	9.1	8.4			0.3
Estonia	35.0				0.2	0.2	0.04	2.5	11.9			20.2
Finland	15.8					0.6	0.27	1.2	4.5	3.49		5.7
Germany	11.4	1.2		0.061	0.4	2.8	0.01	3.8	3.3			
Latvia	33.4			0.003	2.5	4.2	0.12	26.6				
Lithuania	9.9			0.021	1.8	5.8	0.05	1.7	0.6			
Poland	55.3			0.689	9.5	38.0	0.16	6.0	1.0			
Russia	19.5					19.5						
Sweden	56.2			1.190	5.9	8.9	11.02	15.4	11.9	0.08		1.8
Total	267.6	8.1	0.3	2.1	22.4	83.6	11.8	66.3	41.5	3.6	0.0	28.0

Year 2012

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	19.4	4.79	0.03	0.26	2.5	1.4	0.13	7.34	2.95	-	-	-
Estonia	27.7	-	-	-	-	-	-	2.19	10.16	-	-	15.3
Finland	9.0	-	-	-	-	-	-	-	2.34	2.45	0.02	4.1
Germany	11.3	0.92		0.06	2.0	2.2	0.09	4.10	1.93	-	-	-
Latvia	30.7	-	-	-	0.1	4.7	-	25.85	0.01	-	-	-
Lithuania	11.3	-	-	-	2.8	6.6	-	2.00	-	-	-	-
Poland	62.1	-	-	3.56	24.3	30.5	0.08	2.55	1.16	-	-	-
Russia	25.0	-	-	-	-	25.0	-	-	-	-	-	-
Sweden	46.5	-	-	0.59	7.7	2.7	5.30	19.31	10.62	0.04	-	0.3

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Total	243.0	5.7	0.03	4.5	39.4	73.0	5.6	63.3	29.2	2.5	0.02	19.8

Year 2013

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	26.1	6.97		0.29	3.42	2.1	0.7	3.7	9.0			
Estonia	29.8							1.8	11.7			16.2
Finland	11.1				0.08		0.1	0.2	4.1	2.86		3.7
Germany	10.3	0.59		0.17	1.30	2.6	0.9	1.4	3.4			
Latvia	33.3				0.12	4.2		28.6	0.4			
Lithuania	10.4				1.35	4.6		3.1	1.3			
Poland	79.7			0.96	19.13	53.4	1.6	2.6	2.1			
Russia	22.6					22.6						
Sweden	49.7			0.12	8.25	4.4	10.9	8.8	16.5	0.12		0.5
Total	272.9	7.6	0.0	1.5	33.7	93.8	14.2	50.2	48.4	3.0	0.0	20.5

Year 2014

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	25.0	0.82		1.28	6.62	4.7	0.2	5.5	5.8			0.1
Estonia	28.5				0.00	0.0		1.1	9.9			17.5
Finland	11.7						0.2	0.1	2.8	2.80	0.001	5.8
Germany	10.2	0.60		0.04	2.62	2.2	0.6	1.5	2.6			
Latvia	30.8				0.27	2.9		27.6				
Lithuania	9.6				0.65	3.5	0.0	4.5	0.9			
Poland	56.9			1.49	21.83	31.2	0.2	2.1	0.1			
Russia	23.4					23.4						
Sweden	46.0			0.04	8.27	6.4	6.3	11.0	12.8	0.25		0.9
Total	242.2	1.4	0.0	2.8	40.3	74.4	7.5	53.5	35.0	3.0	0.001	24.3

Year 2015

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	22.5	4.007		0.476	0.099	4.072	0.758	9.533	3.583			
Estonia	24.0				0.490		0.205	1.378	6.807			15.073
Finland	12.0				0.354		0.482	0.082	4.396	2.027	0.0003	4.619
Germany	10.3	0.657		0.071	2.680	0.851	0.294	4.671	1.068			
Latvia	30.5				0.527	2.716		27.067	0.182			
Lithuania	11.0				4.355	0.782		5.117	0.749			
Poland	62.2			2.715	26.122	33.004	0.001	0.387				
Russia	30.7					30.694						
Sweden	44.1			0.059	5.857	0.957	13.320	11.212	12.544	0.181		
Total	247.3	4.7	0.0	3.3	40.5	73.1	15.1	59.4	29.3	2.2	0.0003	19.7

Year 2016

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	19.1	2.317		0.313	2.551	0.842	1.326	5.497	6.818			
Estonia	23.7				0.535		0.104	4.780	4.702			13.566
Finland	16.9				0.274		0.191	0.677	7.139	5.342		3.284
Germany	10.9	0.394		0.075	1.166	2.378	0.010	4.184	2.698			
Latvia	28.1				1.390	1.789		24.922				
Lithuania	11.6				4.063	1.039	0.054	5.126	1.275			
Poland	59.3			3.703	24.620	28.475	0.313	1.587	0.560			
Russia	34.6					34.588						
Sweden	42.4			0.032	5.506	5.862	5.719	13.958	10.919	0.435		
Total	247.1	2.7	0.0	4.1	40.1	75.0	7.7	60.7	34.1	5.8	0.0	16.9

Year 2017

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	27.1	1.141		0.913	5.596	10.651	4.825	4.413	2.374			
Estonia	25.3							1.925	9.719			13.640
Finland	16.1				0.353	0.127	0.959	1.008	7.766	2.307	0.001	3.576
Germany	13.6	0.688		0.165	1.046	7.293		2.326	2.035			

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Latvia	35.7				2.372	2.195		31.175				
Lithuania	12.5				3.107	3.444	0.526	4.406	0.996			
Poland	68.4			4.196	24.900	34.587	0.743	3.406	0.598			
Russia	38.7					38.683						
Sweden	48.3			0.150	6.013	12.369	11.553	11.894	6.284	0.052		
Total	288.5	1.8	0.0	5.4	43.4	109.3	18.6	60.6	29.8	2.4	0.001	17.2

Year 2018

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	24.6	4.239		0.104	5.809	6.464	0.784	8.465	2.086			
Estonia	29.3							4.066	11.430			13.845
Finland	16.4			0.081	0.191	1.234	0.343	2.186	7.049	2.010	0.011	3.326
Germany	15.2	1.419		0.104	0.898	7.828	0.558	3.635	0.771			
Latvia	37.1				1.588	4.211		31.301				
Lithuania	16.2				3.410	8.201		4.246	0.392			
Poland	79.4			1.971	32.904	42.147		2.349	0.025			
Russia	41.4					41.374						
Sweden	49.1			0.116	6.506	9.471	5.938	19.007	7.869	0.057	0.170	
Total	312.2	5.7	0.0	2.4	51.3	120.9	7.6	75.3	29.6	2.1	0.2	17.2

Year 2019

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	30.9	0.002		0.008	12.458	7.689	3.484	6.411	4.344			
Estonia	29.2							3.949	8.386			16.843
Finland	16.1				0.550	1.265	0.046	1.424	5.713	0.875	0.040	6.223
Germany	14.6	0.396		0.088	1.998	9.596		1.180	1.388			
Latvia	38.9				1.887	4.232		32.795				
Lithuania	16.2				2.503	7.597	0.017	5.838	0.273			
Poland	82.4			2.298	37.967	40.443		1.690				
Russia	40.7					39.153						1.541
Sweden	45.1			0.005	9.925	6.159	12.520	11.881	4.533	0.041		

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Total	317.7	0.4	0.0	2.4	67.3	116.1	16.1	65.2	24.6	0.9	0.04	24.6

Year 2020

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	26.4	0.0001		0.003	17.332	1.218	0.971	4.701	4.756			
Estonia	24.3							3.751	6.605			13.915
Finland	12.5				0.184	0.048	0.050	0.686	6.440	0.743	0.019	4.328
Germany	8.9	0.001		0.018	5.049	0.373		2.225	1.264			
Latvia	28.9				0.423	2.950		25.521				
Lithuania	11.2				3.303	4.197		3.665				
Poland	72.5			2.434	35.046	33.364	0.067	1.629				
Russia	45.7					44.884						0.832
Sweden	41.1		0.004	0.005	14.035	2.129	6.451	14.582	3.858	0.008		
Total	274.1	0.001	0.004	2.5	75.4	89.2	7.5	56.8	22.9	0.8	0.02	19.1

Year 2021

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	24.8			0.002	6.584	11.748	1.809	3.328	1.282			
Estonia	25.6							2.958	7.481			15.142
Finland	14.8					1.030	0.031	0.641	5.903	1.515	0.00002	5.654
Germany	12.0	0.0005		0.004	3.829	6.374	0.219	0.636	0.896			
Latvia	29.1					2.087		27.004				
Lithuania	11.4					5.511		5.209	0.643			0.006
Poland	79.2			1.855	41.849	34.459		1.035				
Russia	43.4					42.429						0.932
Sweden	44.8		0.002	0.0001	7.879	18.764	5.425	9.140	3.449	0.145		
Total	284.9	0.0005	0.002	1.9	60.1	122.4	7.5	50.0	19.7	1.7	0.00002	21.7

Year 2022

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	26.2			0.000	5.898	10.466	0.674	8.442	0.572	0.131		
Estonia	27.3							5.494	6.680			15.112
Finland	13.5							3.573	3.967	2.151		3.796
Germany	14.9	0.0008		1.030	1.014	9.264	0.534	2.894	0.134			
Latvia	31.4				0.382	2.259		28.713				
Lithuania	11.9					4.193		6.464	0.709			0.519
Poland	79.8			0.942	34.146	42.892		1.772				
Russia*	42.2					40.958						1.214
Sweden	53.8				8.812	22.094	4.858	17.634	0.247	0.155		
Total	300.8	0.001	0.0	2.0	50.3	132.1	6.1	75.0	12.3	2.4	0.0	20.6

Year 2023

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	24.2			0.001	5.037	10.085	2.224	3.896	2.973			
Estonia	24.8							3.449	6.858			14.509
Finland	14.7				0.112	0.005		1.467	6.527	1.984		4.629
Germany	12.2	0.001		0.640	1.365	6.244	0.099	3.092	0.797			
Latvia	28.8					1.311		27.505				
Lithuania	11.2					4.011		5.281	1.778			0.144
Poland	66.5			1.005	25.605	38.696		1.216				
Russia	39.1					37.916						1.183
Sweden	44.3				5.474	13.722	10.518	10.846	3.580	0.115		
Total	265.9	0.001	0.0	1.6	37.6	112.0	12.8	56.8	22.5	2.1	0.0	20.5

* Russian landings were corrected according to the updated landing statistics.

Table 7.3. Sprat in SD 22–32. Catch in numbers and weight-at-age by quarter and Subdivision in 2023

Subdivision 22

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0				0.0	0.0				7.8
1		0.0	0.0	0.0	0.0		6.1	13.7	12.1
2		0.0	0.0	0.0	0.0		11.0	16.6	14.5
3		0.0	0.0	0.0	0.0		12.7	17.5	15.6
4		0.0	0.0	0.0	0.0		14.0	17.9	16.6
5		0.0	0.0	0.0	0.0		13.9	17.9	17.0
6		0.0	0.0	0.0	0.0		13.7	18.2	17.7
7		0.0	0.0	0.0	0.0		16.2	17.8	17.1
8		0.0	0.0	0.0	0.0		16.9	18.1	17.7
9			0.0	0.0	0.0			18.8	18.5
10			0.0		0.0			18.8	
Sum	0.0	0.0	0.0	0.0	0.1				
SOP	0.0	0.5	0.1	0.4	1.0				
Catch	0.0	0.5	0.1	0.4	1.0				

Subdivision 23

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0					0.0				
1					0.0				
2					0.0				
3					0.0				
4					0.0				
5					0.0				
6					0.0				
7					0.0				
8					0.0				

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
9					0.0				
10					0.0				
Sum	0.0	0.0	0.0	0.0	0.0				
SOP	0.0	0.0	0.0	0.0	0.0				
Catch	0.0	0.0	0.0	0.0	0.0				

Subdivision 24

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0				0.4	0.4				8.1
1	12.2	38.8	0.1	1.0	52.1	6.1	6.1	13.7	12.2
2	5.2	16.5	0.8	1.5	24.0	11.0	11.0	16.6	14.0
3	4.6	14.8	1.9	4.0	25.3	12.7	12.7	17.5	15.7
4	1.8	5.8	5.9	5.9	19.3	14.0	14.0	17.9	16.7
5	1.4	4.4	3.7	2.9	12.5	13.9	13.9	17.9	17.1
6	0.8	2.5	2.2	1.9	7.3	13.7	13.7	18.2	17.9
7	0.2	0.6	0.9	0.7	2.4	16.2	16.2	17.8	17.3
8	0.2	0.5	0.3	0.7	1.6	16.9	16.9	18.1	17.8
9			0.2	0.2	0.3			18.8	18.8
10			0.2		0.2			18.8	
Sum	26.4	83.9	16.1	19.0	145.4				
SOP	251.5	800.5	287.0	306.9	1645.9				
Catch	251.3	800.0	287.1	307.1	1645.6				

Subdivision 25

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0				2.9	2.9				7.9
1	19.9	0.9	0.3	6.7	27.8	5.9	6.2	13.7	12.2
2	102.3	54.7	1.9	10.9	169.9	10.8	10.3	16.6	14.2

	Numbers (milions)					Weight (g)			
Age	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
3	337.6	323.3	4.7	31.2	696.8	11.7	11.2	17.5	15.6
4	506.5	381.5	14.5	44.7	947.2	12.8	11.5	17.9	16.6
5	334.6	232.5	9.1	21.4	597.7	13.4	13.1	17.9	17.1
6	185.9	86.0	5.4	14.5	291.8	13.6	13.3	18.2	17.7
7	69.6	48.5	2.1	5.5	125.7	14.3	12.6	17.8	17.0
8	52.9	10.7	0.7	5.8	70.0	14.1	15.9	18.1	17.7
9	17.1	11.9	0.4	1.9	31.4	14.0	15.8	18.8	17.7
10	6.6	5.8	0.4		12.7	14.2	18.1	18.8	
Sum	1633.2	1155.7	39.4	145.6	2973.9				
SOP	20744.2	13839.9	701.4	2341.3	37626.8				
Catch	20713.8	13839.1	701.5	2339.5	37593.9				

Subdivision 26

	Numbers (milions)					Weight (g)			
Age	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
0			0.2	100.2	100.4			4.5	3.7
1	41.4	5.1	3.2	38.3	87.9	4.8	5.0	11.6	10.3
2	539.9	221.1	7.7	87.9	856.6	10.1	9.6	12.8	12.2
3	2155.7	1074.0	31.7	269.6	3531.0	10.9	9.7	13.2	12.4
4	2269.6	747.3	45.4	333.1	3395.4	11.3	10.4	14.2	12.9
5	805.4	295.0	20.2	93.4	1214.0	12.0	11.8	15.3	13.0
6	362.5	144.8	8.6	36.8	552.8	12.0	11.7	15.5	12.9
7	162.5	53.1	4.0	20.0	239.6	12.3	12.6	15.7	13.5
8	55.4	21.1	1.9	9.3	87.7	12.7	13.5	16.3	13.4
9	47.0	5.4	0.7		53.1	11.8	13.3	14.9	
10	10.7				10.7	12.4			
Sum	6450.1	2566.9	123.7	988.5	10129.1				
SOP	72199.3	26538.4	1747.6	11559.6	112045.0				
Catch	72082.8	26580.5	1748.5	11577.2	111989.0				

Subdivision 27

	Numbers (milions)					Weight (g)			
Age	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
0			0.0	0.0	0.0			2.4	3.6
1	146.5	22.2	0.0	0.0	168.7	4.5	4.5	10.3	9.7
2	123.4	24.6	0.0	0.0	148.0	8.9	8.2	11.1	10.9
3	440.8	54.5	0.0	0.1	495.5	9.4	8.9	12.0	11.4
4	313.5	63.5	0.0	0.1	377.1	9.9	9.1	12.3	12.1
5	76.5	20.9	0.0	0.0	97.4	11.0	9.7	12.8	12.5
6	46.2	6.4	0.0	0.0	52.5	11.1	9.5	13.3	12.8
7	18.2	3.5	0.0	0.0	21.8	10.6	11.5	12.7	13.0
8	16.4	2.9	0.0	0.0	19.3	12.0	10.5	13.3	13.3
9	16.4	3.9		0.0	20.3	10.7	10.3		11.8
10	10.9	2.4			13.4	13.3	8.9		
Sum	1208.8	204.8	0.1	0.3	1414.0				
SOP	11069.1	1760.8	1.0	3.5	12834.4				
Catch	11078.5	1757.3	1.0	3.5	12840.3				

Subdivision 28

	Numbers (milions)					Weight (g)			
Age	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
0			0.4	60.3	60.7			2.5	3.7
1	205.0	49.7	15.7	115.8	386.2	4.5	4.9	10.3	10.2
2	213.7	76.3	20.8	145.2	456.0	8.8	8.8	11.1	11.4
3	813.9	293.6	83.1	495.4	1686.1	9.6	9.4	12.0	11.7
4	822.7	245.7	93.0	571.3	1732.7	10.2	10.1	12.3	12.2
5	218.2	78.3	50.1	221.5	568.0	10.8	10.5	12.8	12.8
6	117.8	38.3	17.0	62.1	235.3	11.1	11.1	13.3	13.1
7	53.2	18.6	17.0	26.8	115.6	11.4	11.4	12.7	13.3
8	56.1	54.2	27.1	24.7	162.2	11.7	11.2	13.2	13.0
9	12.0	0.6		3.6	16.2	12.1	9.0		11.8

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
10	14.0				14.0	12.5			
Sum	2526.7	855.3	324.2	1726.9	5433.1				
SOP	24256.3	8228.9	3974.9	20196.3	56656.4				
Catch	24276.9	8246.4	3979.7	20248.4	56751.4				

Subdivision 29

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0			0.1	23.6	23.7			2.5	3.6
1	341.5	1.8	4.4	133.4	481.2	3.4	4.0	10.0	9.7
2	133.8	0.0	2.7	51.1	187.6	7.9	8.3	10.9	10.8
3	431.0	0.1	4.9	215.5	651.4	8.4	9.1	11.6	11.1
4	487.5	0.5	3.3	175.9	667.3	9.2	10.0	12.1	11.7
5	141.2	0.3	2.3	65.9	209.7	9.8	10.7	12.6	11.9
6	41.8	0.3	1.4	33.5	77.0	9.9	10.7	13.1	12.2
7	36.0	0.1	0.2	21.4	57.7	10.3	10.2	13.2	11.9
8	85.0	0.9	1.4	63.9	151.1	9.9	10.9	13.4	11.8
9	5.1			0.0	5.1	10.6			0.0
10	11.4				11.4	11.2			
Sum	1714.2	4.1	20.8	784.2	2523.2				
SOP	13513.7	31.0	239.4	8582.6	22366.8				
Catch	13497.1	31.1	238.2	8747.8	22514.2				

Subdivision 30

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0			0.0	0.0	0.0			3.6	3.6
1	22.4	37.7	0.1	0.0	60.2	3.6	4.0	11.0	11.0
2	8.8	0.2	0.1	5.7	14.8	7.8	8.3	11.4	10.1
3	28.3	2.7	0.2	19.7	51.0	8.4	9.1	11.7	10.6

	Numbers (milions)					Weight (g)			
Age	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
4	32.0	10.4	0.2	11.3	53.9	9.1	10.0	12.4	11.0
5	9.3	6.8	0.1	2.8	19.0	9.8	10.7	14.0	13.9
6	2.7	6.5	0.1	4.2	13.6	10.0	10.7	12.9	11.8
7	2.4	2.2	0.0	0.0	4.6	10.2	10.2	15.1	15.1
8	5.6	17.4	0.1	2.9	26.0	9.8	10.9	14.8	12.8
9	0.3		0.0	2.8	3.2	10.6		13.2	13.1
10	0.7				0.7	11.2			
Sum	112.7	84.0	0.8	49.4	246.9				
SOP	888.2	636.3	10.1	553.2	2087.8				
Catch	887.2	636.5	10.2	565.4	2099.3				

Subdivision 31

	Numbers (milions)					Weight (g)			
Age	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
0					0.0				
1					0.0				
2					0.0				
3					0.0				
4					0.0				
5					0.0				
6					0.0				
7					0.0				
8					0.0				
9					0.0				
10					0.0				
Sum	0.0	0.0	0.0	0.0	0.0				
SOP	0.0	0.0	0.0	0.0	0.0				
Catch	0.0	0.0	0.0	0.0	0.0				

Subdivision 32

	Numbers (milions)					Weight (g)			
Age	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
0			0.4	5.7	6.0			0.4	2.8
1	138.3	21.3	64.7	142.1	366.4	3.9	4.0	9.7	9.6
2	37.6	10.2	33.9	47.9	129.6	8.5	8.3	10.8	10.8
3	208.9	45.8	73.5	236.1	564.3	9.1	9.1	11.3	10.9
4	196.4	58.2	51.2	187.1	492.9	10.0	10.0	11.7	11.5
5	51.5	14.7	37.1	66.4	169.7	10.4	10.7	12.1	11.8
6	26.4	9.0	20.9	33.7	90.0	10.9	10.7	12.6	12.1
7	29.3	8.9	6.8	19.4	64.3	10.5	10.2	12.4	11.6
8	53.1	23.5	21.6	60.1	158.4	10.8	10.9	12.8	12.0
9					0.0				
10					0.0				
Sum	741.5	191.6	310.2	798.5	2041.7				
SOP	6428.2	1768.5	3497.4	8760.5	20454.7				
Catch	6436.8	1767.8	3498.5	8762.1	20465.2				

Subdivision 22-32

	Numbers (milions)					Weight (g)			
Age	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
0			1.1	193.1	194.3			2.1	3.7
1	927.3	177.6	88.5	437.3	1630.6	4.0	4.8	9.9	9.9
2	1164.7	403.6	67.9	350.2	1986.5	9.5	9.5	11.4	11.5
3	4420.9	1808.8	200.1	1271.6	7701.5	10.2	9.9	12.1	11.7
4	4630.1	1512.8	213.5	1329.4	7685.8	10.9	10.6	13.1	12.4
5	1638.0	652.9	122.7	474.5	2888.0	11.8	12.0	13.5	12.8
6	784.1	293.9	55.5	186.8	1320.2	12.0	12.0	14.0	13.1
7	371.4	135.5	31.0	93.8	631.7	12.1	12.2	13.5	12.9
8	324.6	131.2	53.1	167.4	676.3	11.6	11.9	13.2	12.4
9	97.9	21.9	1.3	8.5	129.5	12.0	14.0	16.5	13.7

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
10	54.4	8.2	0.5		63.1	12.6	15.4	18.8	
Sum	14413.4	5146.4	835.1	4512.4	24907.3				
SOP	149350.6	53604.8	10458.9	52304.3	265718.7				
Catch	149224.5	53659.1	10464.8	52551.4	265899.8				

Table 7.4. Sprat in SD 22–32. Fishing effort and CPUE data.
Russia - Subdivision 26

Year	Type of vessels			
	*)SRTM (51 m length, 1100 hp)		MRTK (27 m length, 300 hp)	
	Effort [h]	CPUE, [kg/h]	Effort [h]	CPUE, [kg/h]
1995	8907	647	8760	601
1996	12129	620	7810	953
1997	17140	470	10691	746
1998	13469	646	9986	782
1999	13898	869	15967	965
2000	14417	766	13501	1031
2001	12837	937	12912	1282
2002	11789	884	18979	1012
2003	5869	958	14128	1285
2004	2973	895	14751	1394
2005	1696	1323	21908	1115
2006	877	1362	16592	1406
2007			16032	1303
2008			14428	1306
2009			17966	1258
2010			14179	1276
2011			9373	1125
2012			13308	1877

Year	Type of vessels			
	*)SRTM (51 m length, 1100 hp)		MRTK (27 m length, 300 hp)	
	Effort [h]	CPUE, [kg/h]	Effort [h]	CPUE, [kg/h]
2013			11988	1885
2014			11724	2000
2015			15822	1940
2016			19746	1752
2017			21092	1834
2018			30046	1377
2019			32184	1209
2020			45572	1015

***) - vessels withdrawn from exploitation in 2007**

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2023 available to the Working Group. 1/8

Sub-division 22	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Germany	1				
		2	0.5	0	0	0
		3	0.1	0	0	0
		4	0.4	0	0	0
		Total	1.0	0	0	0
	Total	1	-	0	0	0
		2	0.5	0	0	0
		3	0.1	0	0	0
		4	0.4	0	0	0
		Total	1.0	0	0	0
Sub-division 23+24	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1				
		2	0.6	0	0	0
		3				
		4				
		Total	0.6	0	0	0
	Finland	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Germany	1	0.0	0	0	0
		2	640.0	3	586	158
		3	0.0	0	0	0
		4	0.3	0	0	0
		Total	640.4	3	586	158
	Latvia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Lithuania	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Poland	1	251.3	0	0	0
		2	159.4	0	0	0
		3	287.1	0	0	0
		4	306.8	0	0	0
		Total	1 004.6	0	0	0
	Sweden	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Total	1	251.3	0	0	0
		2	800.0	3	586	158
		3	287.1	0	0	0
		4	307.1	0	0	0
		Total	1 645.6	3	586	158

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2023 available to the Working Group. 2/8

Sub-division 25	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	5 020.8	14	2145	725
		2	16.5	0	0	0
		3				
		4				
		Total	5 037.3	14	2145	725
	Estonia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Finland	1				
		2				
		3	48.2	0	0	0
		4	63.4	0	0	0
		Total	111.6	0	0	0
	Germany	1	1 122.5	2	336	64
		2	222.6	0	0	0
		3				
		4	20.3	0	0	0
		Total	1 365.4	2	336	64
	Latvia	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Lithuania	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Poland	1	10 411.2	10	2124	602
		2	12 592.7	4	745	167
		3	606.7	4	308	126
		4	1 994.8	9	1690	576
		Total	25 605.4	27	4867	1471
	Sweden	1	4 159.2	10	653	652
		2	1 007.4	3	102	102
		3	46.7	0	0	0
		4	261.0	5	79	79
		Total	5 474.3	18	834	833
	Total	1	20 713.8	36	5258	2043
		2	13 839.1	7	847	269
		3	701.5	4	308	126
		4	2 339.5	14	1769	655
		Total	37 593.9	61	8182	3093

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2023 available to the Working Group. 3/8

Sub-division 26	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	10 084.6	12	1382	603
		2				
		3				
		4				
		Total	10 084.6	12	1382	603
	Estonia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Finland	1				
		2				
		3	5.4	0	0	0
		4				
		Total	5.4	0	0	0
	Germany	1	6 243.5	5	1144	166
		2				
		3				
		4				
		Total	6 243.5	5	1144	166
	Latvia	1	906.8	0	0	0
		2	403.8	1	207	103
		3	-	0	0	0
		4	-	0	0	0
		Total	1 310.6	1	207	103
	Lithuania	1	1 825.0	0	0	0
		2	2 180.8	0	0	0
		3	4.8	0	0	0
		4	0.0	0	0	0
		Total	4 010.7	0	0	0
	Poland	1	24 287.8	20	4363	1040
		2	8 592.9	3	638	158
		3	1 407.2	8	1438	303
		4	4 408.3	31	5426	734
		Total	38 696.2	62	11865	2235
	Russia	1	15 014.0	0	0	0
		2	15 403.0	0	0	0
		3	331.0	0	0	0
		4	7 168.0	0	0	0
		Total	37 916.0	0	0	0
	Sweden	1	13 721.0	9	850	830
		2				
		3				
		4	0.9	0	0	0
		Total	13 721.9	9	850	830
	Total	1	72 082.8	46	7739	2639
		2	26 580.5	4	845	261
		3	1 748.5	8	1438	303
		4	11 577.2	31	5426	734
		Total	111 989.0	89	15448	3937

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2023 available to the Working Group. 4/8

Sub-division 27	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	2 223.7	1	97	49
		2				
		3				
		4				
		Total	2 223.7	1	97	49
	Estonia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Finland	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Germany	1				
		2	99.0	1	250	39
		3				
		4				
		Total	99.0	1	250	39
	Latvia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Lithuania	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Poland	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Sweden	1	8 854.8	10	531	527
		2	1 658.3	7	399	399
		3	1.0	0	0	0
		4	3.5	0	0	0
		Total	10 517.7	17	930	926
	Total	1	11 078.5	11	628	576
		2	1 757.3	8	649	438
		3	1.0	0	0	0
		4	3.5	0	0	0
		Total	12 840.3	19	1277	1014

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2023 available to the Working Group. 5/8

Sub-division 28	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	2 267.0	1	188	50
		2				
		3				
		4	1 628.5	2	199	100
		Total	3 895.6	3	387	150
	Estonia	1	1 612.1	20	2010	1110
		2	238.5	3	77	77
		3				
		4	1 598.4	12	1550	650
		Total	3 448.9	35	3637	1837
	Finland	1				
		2				
		3	157.8	0	0	0
		4	1 309.1	0	0	0
		Total	1 466.9	0	0	0
	Germany	1	1 358.8	2	410	64
		2	197.9	0	0	0
		3				
		4	1 535.1	2	406	77
		Total	3091.8	4	816	141
	Latvia	1	8 513.0	11	2203	1080
		2	6 690.0	6	1262	602
		3	3 571.2	10	2023	941
		4	8 730.5	9	1771	878
		Total	27 504.8	36	7259	3501
	Lithuania	1	1 458.3	1	346	68
		2	615.6	2	373	127
		3	188.5	0	0	0
		4	3 018.4	5	1018	205
		Total	5 280.7	8	1737	400
	Poland	1	445.9	0	0	0
		2	231.3	0	0	0
		3	30.5	0	0	0
		4	508.6	0	0	0
		Total	1 216.3	0	0	0
	Russia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Sweden	1	8 621.8	10	462	461
		2	273.2	1	50	50
		3	31.7	0	0	0
		4	1 919.7	1	100	100
		Total	10 846.4	12	612	611
	Total	1	24 276.9	45	5619	2833
		2	8 246.4	12	1762	856
		3	3 979.7	10	2023	941
		4	20 248.4	31	5044	2010
		Total	56 751.4	98	14448	6640

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2023 available to the Working Group. 6/8

Sub-division	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
29	Denmark	1	2973.0	0	0	0
		2				
		3				
		4				
		Total	2973.0	0	0	0
	Estonia	1	3406.0	6	1065	565
		2				
		3				
		4	3451.7	8	1850	800
		Total	6857.7	14	2915	1365
	Finland	1	2091.0	7	485	0
		2	31.1	0	0	0
		3	200.3	0	0	0
		4	4204.7	7	915	0
		Total	6527.1	14	1400	0
	Germany	1	475.6	1	204	32
		2				
		3				
		4	321.8	0	0	0
		Total	797.4	1	204	32
	Latvia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Lithuania	1	971.0	0	0	0
		2				
		3	37.9	0	0	0
		4	769.5	19	3234	457
		Total	1778.4	19	3234	457
	Poland	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Sweden	1	3580.5	1	250	245
		2				
		3				
		4				
		Total	3580.5	1	250	245
	Total	1	13497.1	15	2004	842
		2	31.1	0	0	0
		3	238.2	0	0	0
		4	8747.8	34	5999	1257
		Total	22514.2	49	8003	2099

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2023 available to the Working Group. 7/8

Sub-division 30	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Finland	1	847.4	0	0	0
		2	572.8	0	0	0
		3	6.2	4	358	940
		4	557.6	0	0	0
		Total	1984.0	4	358	940
	Sweden	1	39.8	0	0	0
		2	63.7	0	0	0
		3	4.0	1	52	52
		4	7.8	0	0	0
		Total	115.2	1	52	52
	Total	1	887.2	0	0	0
		2	636.5	0	0	0
		3	10.2	5	410	992
		4	565.4	0	0	0
		Total	2099.3	5	410	992
Sub-division 31	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Finland	1				
		2				
		3				
		4				
		Total	0.00	0	0	0
	Sweden	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Total	1	0.00	0	0	0
		2	0.00	0	0	0
		3	0.00	0	0	0
		4	0.00	0	0	0
		Total	0.00	0	0	0

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2023 available to the Working Group. 8/8

Sub-division 32	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Estonia	1	5 359.4	13	3593	1170
		2	1 278.3	10	2208	1000
		3	1 434.7	4	1294	400
		4	6 436.9	9	2894	900
		Total	14 509.3	36	9989	3470
	Finland	1	847.8	2	338	0
		2	0.5	2	78	0
		3	2 004.6	4	603	0
		4	1 776.3	4	516	0
		Total	4 629.2	12	1535	0
	Lithuania	1	43.5	0	0	0
		2				
		3	59.2	0	0	0
		4	41.0	3	462	92
		Total	143.7	3	462	92
	Russia	1	186.0	0	0	0
		2	489.0	0	0	0
		3	-	0	0	0
		4	508.0	0	0	0
		Total	1 183.0	0	0	0
	Total	1	6 436.8	15	3931	1170
		2	1 767.8	12	2286	1000
		3	3 498.5	8	1897	400
		4	8 762.1	16	3872	992
		Total	20 465.2	51	11986	3562
Sub-divisions 22-32	**Total**	**Quarter**	**Landings in tons**	**Number of samples**	**Number of fish measured**	**Number of fish aged**
		1	**149 224.5**	**168**	**25179**	**10103**
		2	**53 659.1**	**46**	**6975**	**2982**
		3	**10 464.8**	**35**	**6076**	**2762**
		4	**52 551.4**	**126**	**22110**	**5648**
		Total	**265 899.8**	**375**	**60340**	**21495**

Table 7.6. Sprat in SD 22–32. Catch-in-numbers (Thousands) CANUM.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	2854471	6737206	3949321	2117657	2105650	1018440	1324081	303458
1975	764470	2473570	6911876	2905715	961674	1068797	300675	664650
1976	5158494	901249	2320331	3867218	1145842	385620	603771	464948
1977	2371000	8399000	997000	1907000	1739000	364000	140000	399000
1978	500000	3325000	4936000	480000	817000	683000	73000	189000
1979	1340000	597000	1037000	2291000	188000	150000	335000	125000
1980	369000	1476000	378000	500000	1357000	72000	67000	235000
1981	2303000	920000	405000	94000	88000	527000	13000	99000
1982	363000	2460000	425000	225000	64000	57000	231000	51000
1983	1852000	297000	531000	107000	47000	12000	18000	148000
1984	1005000	2393000	388000	447000	77000	38000	9000	83000
1985	566000	1703000	2521000	447000	271000	30000	19000	65000
1986	495000	1142000	1425000	2099000	340000	188000	16000	50000
1987	824719	417123	1397470	1940577	1910934	240322	157745	77284
1988	80472	2781435	753133	1185411	786147	784084	67060	145468
1989	2172410	299714	1831356	417533	763754	403064	411332	141589
1990	1163452	3516976	383751	1055869	208512	350478	124220	221821
1991	1178590	2990502	2753429	459469	642354	119665	180627	171595
1992	1827431	3013928	3117503	1684887	455320	318929	124085	167156
1993	1981094	6147662	3508006	2052465	955942	288729	263857	277915
1994	1111832	8417569	8424782	3632260	2267973	802704	198873	214329
1995	6646975	2441639	6928582	6921281	3510704	1983767	653955	426583
1996	8603566	28382846	4824315	6683686	3407993	1537340	707648	413308
1997	1762808	23786621	24005176	6508435	4215143	1694061	700814	286277
1998	11239592	3879485	18043738	20012554	2712477	1813759	1497524	498835
1999	2116903	20234621	5929768	10139171	8984127	1199782	698517	523633
2000	10548782	2951857	14735252	2873755	4289605	4082334	707925	761996
2001	2865053	11927743	2755652	9548800	2063127	2736043	2336628	539778
2002	6674521	5450658	10824009	3850299	4325186	1001981	883511	1345346

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2003	9401375	7135850	4823148	5086138	2405049	1910187	836146	1388223
2004	22865653	12869793	5354714	3033159	3190419	1311158	1123429	1340644
2005	2836706	30899441	11229085	2927505	1863864	841134	657541	613638
2006	10619360	3196279	20646634	6686155	1350541	600893	396354	518686
2007	13722736	11904443	3686319	13650123	3834528	619692	299402	536138
2008	6324583	15318705	6615024	2906164	5659491	2232003	295969	358718
2009	21720304	9132909	10457988	4011207	1844250	2914404	1035851	362547
2010	4359496	20441572	5100731	4027269	1178808	837906	945070	485887
2011	8389357	4157842	12126805	2620974	1402791	523667	361108	541549
2012	5491110	6052392	2881288	7442494	1316519	764583	310009	453991
2013	6277500	9586966	4494926	2395068	3855862	683709	310577	317567
2014	4879317	7569532	6456413	2358146	1449131	1393046	350105	369394
2015	17062390	4721734	5122951	3273052	1245001	659271	584741	292927
2016	2981093	18565096	3810393	2553854	1229387	509378	407220	451724
2017	3614921	6201106	16705645	3226989	1578918	682113	243671	402254
2018	6346667	6567815	6543666	12934390	1891634	616832	258340	209799
2019	6028654	10377984	5622130	5605427	7528813	785873	293900	237821
2020	6499891	5708479	6277637	3845035	2843776	3525079	343622	236476
2021	4943822	11224038	5225472	4918213	2113486	1649830	1825537	287538
2022*	1292563	9047288	10132267	4462908	2996209	1153186	876887	786800
2023	1630625	1986453	7701466	7685750	2887960	1320209	631683	868908

* CANUM was updated in accordance with the corrected (Russian) landing data.

Table 7.7. Sprat in SD 22–32. Mean weight in the catch and in the stock (g).

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	6.60	10.50	12.20	13.40	13.90	15.40	14.10	14.30
1975	6.80	11.20	12.40	13.40	14.70	14.30	15.70	13.50
1976	6.90	10.70	12.70	13.50	14.50	16.10	14.70	14.30
1977	5.40	11.00	13.40	14.00	14.40	15.90	15.90	15.80
1978	5.10	10.90	12.50	13.10	14.10	15.20	15.80	15.10

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1979	5.50	12.70	13.00	13.70	15.10	15.80	15.60	16.20
1980	7.80	11.30	14.30	14.10	14.30	16.70	15.80	16.00
1981	6.30	14.10	16.10	18.00	16.50	15.90	16.80	16.10
1982	8.80	11.70	16.00	16.20	16.70	16.40	16.30	17.30
1983	9.20	14.50	16.20	17.10	16.90	17.00	16.90	16.80
1984	9.70	11.10	14.60	15.30	15.80	16.30	16.90	17.20
1985	9.10	11.30	12.70	14.00	16.00	17.10	17.10	15.80
1986	7.90	12.10	12.90	14.00	14.80	16.10	17.00	16.70
1987	8.50	11.70	13.30	14.50	15.20	16.40	17.00	17.60
1988	5.60	10.30	12.20	14.20	15.20	15.30	16.60	17.00
1989	9.70	13.60	14.50	15.80	16.90	17.30	17.50	18.10
1990	10.40	12.60	14.90	16.00	17.50	17.70	18.40	18.10
1991	9.00	12.90	14.30	15.80	16.60	17.50	16.90	16.90
1992	8.70	12.10	14.70	15.40	17.30	17.20	18.10	18.40
1993	6.60	11.10	13.80	14.60	15.00	16.20	16.60	16.60
1994	8.00	9.80	12.10	14.00	14.50	15.20	15.50	15.90
1995	6.50	10.60	11.00	12.60	13.70	14.10	14.30	14.50
1996	4.30	7.50	10.30	11.10	12.40	12.80	12.70	12.90
1997	6.70	7.40	8.50	10.10	11.70	12.40	12.50	12.70
1998	4.60	7.60	8.30	8.90	10.40	10.60	10.80	11.80
1999	4.00	7.80	9.20	9.10	9.20	10.60	11.20	11.00
2000	6.20	10.20	10.00	10.80	11.30	11.70	12.80	13.40
2001	6.30	9.30	11.40	10.80	11.60	11.30	11.00	11.80
2002	6.90	9.70	10.20	10.90	11.10	11.10	11.50	11.70
2003	5.00	9.90	10.80	10.90	11.40	11.10	10.70	10.80
2004	4.40	7.60	10.50	11.20	11.10	11.40	11.10	11.30
2005	4.70	6.90	8.10	10.70	11.20	11.60	11.00	11.30
2006	4.90	7.80	8.20	8.90	10.80	11.20	11.10	11.40
2007	5.60	7.70	9.10	9.20	9.40	10.90	11.30	11.00

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2008	6.83	9.15	9.83	10.51	10.34	10.23	11.16	12.19
2009	4.97	9.16	10.52	10.93	11.38	10.76	10.98	11.96
2010	5.15	8.01	9.86	10.73	11.00	11.18	10.81	11.36
2011	4.00	9.07	9.59	10.65	11.44	11.43	11.41	12.41
2012	5.89	9.37	11.04	11.17	11.99	12.32	12.28	12.14
2013	5.13	9.57	11.49	12.51	12.61	12.85	12.97	12.48
2014	5.15	9.15	10.74	12.03	12.70	12.72	12.31	12.31
2015	4.17	9.53	10.96	11.74	12.57	13.17	12.52	12.18
2016	4.71	7.12	9.86	11.26	11.75	12.56	12.33	12.16
2017	5.38	7.95	8.84	10.84	11.80	11.82	11.54	10.91
2018	4.70	8.55	9.60	9.80	11.00	11.74	11.73	11.12
2019	4.94	7.84	9.43	10.22	10.33	12.10	12.19	11.94
2020	5.59	9.20	9.92	10.75	11.14	11.22	12.34	12.35
2021	5.36	8.27	9.61	10.17	10.75	11.61	11.04	11.63
2022	6.59	8.42	9.77	10.93	11.42	11.71	12.00	11.46
2023	0.0060	0.0099	0.0104	0.0112	0.0121	0.0123	0.0123	0.0121

Table 7.8. Sprat in SD 22–32. Natural Mortality.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.76	0.54	0.48	0.45	0.45	0.44	0.45	0.45
1975	0.76	0.57	0.50	0.48	0.48	0.46	0.47	0.47
1976	0.62	0.49	0.44	0.42	0.42	0.41	0.42	0.42
1977	0.82	0.57	0.49	0.46	0.46	0.45	0.46	0.46
1978	1.16	0.78	0.72	0.64	0.63	0.62	0.62	0.62
1979	1.27	0.84	0.77	0.77	0.71	0.72	0.73	0.73
1980	1.26	0.89	0.76	0.74	0.75	0.71	0.73	0.73
1981	1.13	0.72	0.68	0.64	0.64	0.67	0.62	0.62
1982	1.12	0.77	0.68	0.67	0.64	0.67	0.67	0.67
1983	0.87	0.68	0.61	0.59	0.58	0.56	0.56	0.56

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1984	0.72	0.60	0.52	0.52	0.50	0.50	0.49	0.49
1985	0.64	0.52	0.48	0.47	0.45	0.43	0.44	0.44
1986	0.65	0.49	0.46	0.43	0.42	0.41	0.41	0.41
1987	0.66	0.49	0.44	0.42	0.42	0.42	0.41	0.41
1988	0.63	0.48	0.46	0.43	0.41	0.41	0.40	0.40
1989	0.52	0.40	0.38	0.37	0.36	0.36	0.35	0.35
1990	0.37	0.31	0.30	0.30	0.29	0.29	0.29	0.29
1991	0.33	0.27	0.27	0.26	0.26	0.26	0.26	0.26
1992	0.35	0.28	0.27	0.26	0.26	0.26	0.26	0.26
1993	0.38	0.34	0.32	0.31	0.31	0.30	0.30	0.30
1994	0.38	0.33	0.32	0.31	0.30	0.30	0.30	0.30
1995	0.33	0.30	0.30	0.29	0.29	0.29	0.29	0.29
1996	0.31	0.29	0.28	0.28	0.27	0.27	0.27	0.27
1997	0.30	0.28	0.27	0.27	0.26	0.26	0.26	0.26
1998	0.31	0.29	0.28	0.28	0.27	0.27	0.27	0.27
1999	0.34	0.30	0.29	0.29	0.29	0.28	0.28	0.28
2000	0.38	0.32	0.32	0.31	0.31	0.31	0.30	0.30
2001	0.39	0.33	0.32	0.32	0.31	0.32	0.32	0.32
2002	0.41	0.34	0.34	0.33	0.33	0.33	0.33	0.33
2003	0.37	0.32	0.31	0.31	0.30	0.31	0.31	0.31
2004	0.35	0.32	0.30	0.29	0.29	0.29	0.29	0.29
2005	0.40	0.36	0.35	0.33	0.32	0.32	0.32	0.32
2006	0.43	0.38	0.37	0.36	0.34	0.34	0.34	0.34
2007	0.44	0.38	0.36	0.36	0.36	0.35	0.34	0.34
2008	0.47	0.38	0.37	0.36	0.37	0.37	0.35	0.35
2009	0.47	0.38	0.37	0.36	0.36	0.36	0.36	0.36
2010	0.50	0.43	0.40	0.39	0.39	0.38	0.39	0.39
2011	0.52	0.42	0.41	0.39	0.38	0.38	0.38	0.38
2012	0.49	0.38	0.36	0.36	0.35	0.34	0.35	0.35

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2013	0.49	0.37	0.34	0.34	0.33	0.33	0.33	0.33
2014	0.49	0.38	0.36	0.34	0.33	0.33	0.34	0.34
2015	0.40	0.33	0.31	0.31	0.30	0.30	0.30	0.30
2016	0.38	0.34	0.31	0.30	0.30	0.29	0.29	0.29
2017	0.36	0.31	0.30	0.29	0.28	0.28	0.28	0.28
2018	0.34	0.30	0.29	0.29	0.28	0.27	0.27	0.27
2019	0.34	0.30	0.28	0.28	0.28	0.27	0.27	0.27
2020	0.32	0.28	0.27	0.27	0.27	0.27	0.26	0.26
2021	0.31	0.28	0.27	0.27	0.26	0.26	0.26	0.26
2022	0.31	0.28	0.27	0.27	0.26	0.26	0.26	0.26
2023	0.31	0.28	0.27	0.27	0.26	0.26	0.26	0.26

Table 7.9. Sprat in SD 22–32. Proportion mature at spawning time.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2023	0.17	0.93	1.0	1.0	1.0	1.0	1.0	1.0

Table 7.10. Sprat in SD 22–32. Proportion of M before spawning.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2023	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table 7.11. Sprat in SD 22–32. Proportion of F before spawning.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2023	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table 7.12. Sprat in SD 22–32. Tuning Fleet/Acoustic Survey in SD 22–29,32 (fleet1)

Year	Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2000	1	72295	8611	53087	8052	16597	15982	1739	2753
2001	1	NA	NA	NA	NA	NA	NA	NA	NA
2002	1	NA	NA	NA	NA	NA	NA	NA	NA
2003	1	NA	NA	NA	NA	NA	NA	NA	NA
2004	1	NA	NA	NA	NA	NA	NA	NA	NA
2005	1	NA	NA	NA	NA	NA	NA	NA	NA
2006	1	83120	24175	147488	52014	10143	5143	2278	3491
2007	1	75613	39491	12088	40276	15871	1516	768	2379
2008	1	NA	NA	NA	NA	NA	NA	NA	NA
2009	1	134253	49826	39347	9935	9111	13065	4102	2176
2010	1	15367	88035	14904	9019	2161	2967	3707	1560
2011	1	34095	20175	68118	17115	8393	3072	1838	3188
2012	1	108251	28703	15212	43526	6640	3453	2135	4196
2013	1	38416	35889	17151	8465	15537	3171	1116	2739
2014	1	19021	33428	22062	11957	5857	9166	1771	2026
2015	1	162639	18894	22417	12790	4198	3964	3086	2164
2016	1	33849	119884	29659	11196	5441	2461	1506	1805
2017	1	48761	52739	103922	15961	7473	3698	1230	2445
2018	1	41907	24557	16383	39840	11997	3293	1434	1905
2019	1	17161	28807	15797	12692	29391	4002	1642	2404
2020	1	62659	19408	21467	9689	8402	17421	1226	1343
2021	1	100173	70693	23649	19445	7632	6306	12185	1910
2022	1	9810	38604	35439	18894	9536	4830	3394	8878
2023	1	19677	10003	42129	26657	11629	5770	2020	5031

Table 7.13. Sprat in SD 22–32. Tuning Fleet/ International Acoustic Survey in October (SD 22-29, fleet2).

Year	Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	1	46488	40299	43681	2743	8924	1851	1957	3117
1992	1	36519	26991	24051	9289	1921	2437	714	560
1993	1	NA	NA	NA	NA	NA	NA	NA	NA
1994	1	12532	44588	43274	17272	11925	5112	1029	1559
1995	1	NA	NA	NA	NA	NA	NA	NA	NA
1996	1	69994	130760	20797	23241	12778	6405	3697	1311
1997	1	NA	NA	NA	NA	NA	NA	NA	NA
1998	1	100615	21975	55422	36291	8056	4735	1623	1011
1999	1	4892	90050	15989	35717	38820	5231	3290	1738
2000	1	NA	NA	NA	NA	NA	NA	NA	NA
2001	1	12047	35687	6927	30237	4028	9606	6370	2407
2002	1	31209	14415	36763	5733	18735	2638	5037	4345
2003	1	99129	32270	24035	23198	8016	13163	4831	8536
2004	1	119497	47027	11638	7929	4876	2450	2389	3552
2005	1	7082	125148	48724	10035	5116	3011	2364	3325
2006	1	NA	NA	NA	NA	NA	NA	NA	NA
2007	1	NA	NA	NA	NA	NA	NA	NA	NA
2008	1	28805	45118	20134	5350	18820	5678	1241	1917

Table 7.14. Sprat in SD 22–32. Tuning Fleet/ International Acoustic Survey in SD 24–28 excl. 27 (fleet3)

Year	Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2001	1	8 225	35 735	12 971	37 328	5 384	4 635	4 526	600
2002	1	27 412	18 982	36 814	19 045	14 759	2 517	3 670	2 585
2003	1	26 469	16 471	8 423	15 533	5 653	7 170	1 660	3 607
2004	1	136 162	65 566	15 784	11 042	12 655	3 271	7 806	6 321
2005	1	4 359	88 830	23 557	7 258	3 517	2 781	1 830	2 243
2006	1	13 417	7 980	76 703	21 046	5 702	1 970	1 526	1 943
2007	1	51 569	28 713	6 377	36 006	7 481	1 261	533	698
2008	1	9 029	40 270	20 164	5 627	21 188	4 210	757	1 477

Year	Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2009	1	39 412	26 701	36 255	10 549	6 312	14 106	5 341	964
2010	1	9 387	58 680	15 199	15 963	5 062	1 654	5 566	1 273
2011	1	18 092	6 791	66 160	16 689	10 565	4 077	2 399	3 382
2012	1	22 700	22 080	11 274	35 541	7 515	5 025	1 367	2 158
2013	1	24 877	35 333	18 393	11 358	14 959	3 385	2 164	950
2014	1	10 145	26 907	19 857	7 458	6 098	3 810	1 217	1 058
2015	1	70752	24660	29744	18935	8081	4074	2581	1721
2016	1	NA	NA	NA	NA	NA	NA	NA	NA
2017	1	32701	36292	132939	20630	6790	2250	809	942
2018	1	27209	25642	38632	69259	7251	2086	1025	619
2019	1	15958	28778	32532	49495	30131	3384	487	647
2020	1	38096	26252	29054	19630	18377	11756	473	376
2021	1	23212	45545	20134	18028	8525	7160	5361	911
2022	1	4374	49794	41506	16150	10552	5029	3835	2857
2023	1	5497	10421	41461	27318	10838	4552	4775	1856

Table 7.15 SPRAT in SD 22-32. Tuning Fleet/Baltic International Acoustic Survey (SD 22-29 and 32, fleet4)

Year	Effort	Age 1
2010	1	14528
2011	1	53562
2012	1	49130
2013	1	34941
2014	1	25347
2015	1	182073
2016	1	43534
2017	1	32784
2018	1	126748
2019	1	19371
2020	1	122062

Year	Effort	Age 1
2021	1	111155
2022	1	12442
2023	1	21928
2024	1	4430

Table 7.16. Configuration file for sprat assessment with SAM.

```
#
$minAge
# The minimum age class in the assessment
 1
$maxAge
# The maximum age class in the assessment
 8
$maxAgePlusGroup
# Is last age group considered a plus group for each fleet (1 yes, or 0 no).
 1 1 1 1 0
$keyLogFsta
# Coupling of the fishing mortality states (normally only first row is used).
  0  1  2  3  4  5  6  6
 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1
$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, 2 AR(1), 3 separable AR(1).
2
$keyLogFpar
# Coupling of the survey catchability parameters (normally first row is not used, as that is covered by fishing mortality).
 -1 -1 -1 -1 -1 -1 -1 -1
  0  1  2  3  4  5  5  5
  6  7  8  9  10  11  11  11
 12 13 14 15 16 17 17 17
 18 -1 -1 -1 -1 -1 -1 -1
$keyQpow
# Density dependent catchability power parameters (if any).
 -1 -1 -1 -1 -1 -1 -1 -1
 0 -1 -1 -1 -1 -1 -1 -1
 1 -1 -1 -1 -1 -1 -1 -1
 2 -1 -1 -1 -1 -1 -1 -1
 3 -1 -1 -1 -1 -1 -1 -1
$keyVarF
# Coupling of process variance parameters for log(F)-process (normally only first row is used)
  0  0  0  0  0  0  0  0
 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1
$keyVarLogN
```

```
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1 1
$keyVarObs
# Coupling of the variance parameters for the observations.
   0   0   0   0   0   0   0   0
   1   1   1   1   1   1   1   1
   2   2   2   2   2   2   2   2
  3   3   3   3   3   3   3   3
   4  -1  -1  -1  -1  -1  -1  -1
$obsCorStruct
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"
 "ID" "ID" "ID" "ID" "ID"
$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#1-2 2-3 3-4 4-5 5-6 6-7 7-8
  NA  NA  NA  NA  NA  NA  NA
  NA  NA  NA  NA  NA  NA  NA
  NA  NA  NA  NA  NA  NA  NA
NA  NA  NA  NA  NA  NA  NA
  -1  -1  -1  -1  -1  -1  -1
$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, 2 for Beverton-Holt, and 3 piece-wise constant).
 0
$noScaledYears
# Number of years where catch scaling is applied.
 0
$keyScaledYears
# A vector of the years where catch scaling is applied.

$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).

$fbarRange
# lowest and highest age included in Fbar
 3 5
$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, 2 FSB index, 3 total catch, 4 total landings and 5 TSB index).
 -1 -1 -1 -1 -1
$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "LN" "LN" "LN" "LN" "LN"
$fixVarToWeight
# If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight).
 0
$fracMixF
# The fraction of t(3) distribution used in logF increment distribution
 0
$fracMixN
# The fraction of t(3) distribution used in logN increment distribution
 0
```

$fracMixObs
A vector with same length as number of fleets, where each element is the fraction of t(3) distribution used in the distribution of that fleet
0 0 0 0 0
$constRecBreaks
Vector of break years between which recruitment is at constant level. The break year is included in the left interval. (This option is only used in combination with stock-recruitment code 3)
$predVarObsLink
Coupling of parameters used in a prediction-variance link for observations.
-1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1
NA NA NA NA NA NA NA NA

Table 7.17. Sprat in SD 22–32. Stock summary, output from SAM (SSB estimates for 2024 refer to spawning time and are estimated assuming F in 2024 the same as F in 2024, other F assumptions in 2024 may be used for short-term predictions).

	R(age1)	Low	High	SSB	Low	High	Fbar(3-5)	Low	High
1974	76290	52206	111485	1060032	783065	1434959	0.31	0.22	0.43
1975	23173	15985	33593	844228	623196	1143653	0.30	0.22	0.42
1976	148882	102659	215917	639754	471637	867798	0.30	0.21	0.42
1977	76202	52517	110568	925028	675068	1267542	0.29	0.21	0.40
1978	21400	14674	31208	695456	507486	953051	0.25	0.177	0.35
1979	60757	41587	88763	378827	274583	522645	0.23	0.160	0.32
1980	19723	13272	29310	281511	204019	388436	0.24	0.173	0.34
1981	108321	73529	159576	282509	205804	387803	0.189	0.134	0.27
1982	19663	13318	29030	345653	248666	480470	0.195	0.139	0.27
1983	125840	85619	184957	344582	251376	472347	0.127	0.091	0.178
1984	62637	43319	90570	556560	408345	758571	0.149	0.109	0.20
1985	33672	23500	48247	611848	460927	812185	0.162	0.121	0.22
1986	24484	17039	35183	547321	421512	710681	0.180	0.137	0.24
1987	45408	31942	64552	471979	368891	603876	0.23	0.174	0.30
1988	4594	3229	6535	466974	362670	601276	0.24	0.180	0.31
1989	90854	64520	127936	449128	355912	566759	0.24	0.187	0.31
1990	58008	42057	80009	746328	587635	947876	0.196	0.156	0.25
1991	64255	48425	85259	939360	767484	1149727	0.181	0.147	0.22
1992	86944	65723	115018	1004855	835406	1208673	0.20	0.167	0.25
1993	87136	63852	118909	1274480	1041627	1559386	0.22	0.179	0.27

	R(age1)	Low	High	SSB	Low	High	Fbar(3-5)	Low	High
1994	36570	27738	48214	1421597	1186447	1703354	0.27	0.23	0.33
1995	182016	133349	248443	1125830	946570	1339038	0.35	0.29	0.43
1996	165699	125755	218332	1625684	1345548	1964143	0.40	0.34	0.47
1997	31527	23436	42413	1733655	1435915	2093132	0.43	0.36	0.52
1998	163479	125854	212353	1169393	996348	1372492	0.47	0.40	0.56
1999	27754	21447	35916	1270013	1077001	1497615	0.43	0.37	0.51
2000	133176	103061	172092	1037563	891527	1207521	0.42	0.36	0.50
2001	41528	32680	52771	1040390	893799	1211024	0.42	0.36	0.50
2002	84897	67050	107494	900806	781528	1038287	0.42	0.36	0.49
2003	125378	98798	159109	847163	735179	976205	0.41	0.35	0.48
2004	258838	203042	329968	955566	820304	1113132	0.46	0.39	0.54
2005	32148	25388	40708	1338413	1121052	1597918	0.42	0.36	0.49
2006	117138	91659	149700	1047567	886402	1238035	0.37	0.31	0.44
2007	144227	113933	182576	928383	801357	1075545	0.44	0.38	0.52
2008	68935	54501	87192	1025943	879535	1196721	0.44	0.37	0.51
2009	203663	160170	258966	969576	836397	1123962	0.45	0.39	0.53
2010	46436	36690	58770	1040678	873620	1239682	0.40	0.34	0.47
2011	95120	74579	121318	866488	734447	1022268	0.32	0.27	0.39
2012	94109	73601	120330	865674	741294	1010923	0.31	0.26	0.37
2013	83686	65990	106127	893501	762366	1047192	0.35	0.30	0.42
2014	59560	46944	75566	774466	660993	907420	0.37	0.31	0.44
2015	242285	188917	310727	796356	681050	931184	0.34	0.29	0.41
2016	60238	46560	77933	1193575	982544	1449932	0.31	0.26	0.38
2017	70769	55522	90202	1194111	1002809	1421906	0.33	0.27	0.39
2018	97086	76118	123830	1016795	868617	1190252	0.36	0.30	0.42
2019	66397	51432	85717	916438	784604	1070424	0.41	0.34	0.48
2020	112670	88404	143598	892276	766354	1038888	0.37	0.31	0.45
2021	99802	77590	128372	1083527	920357	1275626	0.36	0.30	0.43
2022	24400	18362	32425	1126771	949445	1337215	0.36	0.30	0.44

	R(age1)	Low	High	SSB	Low	High	Fbar(3-5)	Low	High
2023	33631	24335	46477	890326	733090	1081286	0.36	0.29	0.44
2024	13566	5751	32002	696446	506141	958304			

Table 7.18. Sprat in SD 22–32. Output from SAM. Stock number at age (Numbers*10^-6).

	1	2	3	4	5	6	7	8
1974	76290	63852	23102	9082	9175	4263	6562	1524
1975	23173	25582	38510	12199	4105	4972	1665	3587
1976	148882	8861	13821	17256	4723	1740	2905	2405
1977	76202	76623	5683	8538	8193	1741	808	2333
1978	21400	32578	37200	2770	4115	4398	581	1424
1979	60757	6917	8922	16132	1166	1159	2544	981
1980	19723	15394	2667	2913	8111	428	479	1642
1981	108321	9601	3905	773	741	3959	120	839
1982	19663	30034	3717	1562	397	404	1952	427
1983	125840	6483	8051	1199	506	131	183	1400
1984	62637	45833	4494	3919	575	294	75	748
1985	33672	28439	26496	3360	2008	229	149	495
1986	24484	18092	14825	15032	2068	1235	115	366
1987	45408	7090	11244	9895	9012	1105	818	379
1988	4594	31043	5187	6575	4022	4008	387	741
1989	90854	3559	13543	2297	3557	1817	1952	657
1990	58008	46013	3158	6675	1181	1879	719	1225
1991	64255	41099	24437	2858	3785	755	1011	1022
1992	86944	39402	24419	10421	2179	1747	569	833
1993	87136	72105	27047	13001	5142	1355	1091	1086
1994	36570	72042	49020	17322	9232	3198	757	903
1995	182016	22070	37306	25385	10679	5520	1780	1113
1996	165699	172117	21121	22498	10762	4512	1969	1097
1997	31527	131610	98555	17592	11490	5043	1853	830
1998	163479	23693	67579	56176	7575	4709	2973	1138

	1	2	3	4	5	6	7	8
1999	27754	111815	20142	32516	27037	3560	2007	1468
2000	133176	16984	60101	9758	13785	12276	1771	1925
2001	41528	69643	11983	31279	5694	7305	6177	1453
2002	84897	29620	41445	11385	13840	3143	2984	3852
2003	125378	40448	18472	17746	6845	6417	2331	4163
2004	258838	73163	19507	9517	8073	3510	3089	3525
2005	32148	171926	44899	9680	5075	2794	1932	2131
2006	117138	20554	95824	25452	4741	2167	1395	1877
2007	144227	59429	13645	43044	11858	1840	863	1551
2008	68935	77268	25879	8696	18305	6359	916	1195
2009	203663	45118	38359	11566	5531	8997	3204	1120
2010	46436	114614	21353	14019	4037	2701	3473	1642
2011	95120	25387	62206	11384	6055	2229	1478	2331
2012	94109	41575	14855	31274	5341	3002	1254	1935
2013	83686	56011	20255	8976	13399	2579	1251	1314
2014	59560	45749	27603	8942	4927	5103	1261	1312
2015	242285	32374	24355	12358	4305	2531	2217	1176
2016	60238	147534	21438	10832	4736	1847	1379	1593
2017	70769	47816	91531	12949	5385	2307	846	1363
2018	97086	41919	30154	47533	6411	2157	957	819
2019	66397	55744	23813	18561	23595	2586	935	832
2020	112670	37772	29202	13053	9344	11525	1058	768
2021	99802	79402	25090	17353	6878	5343	6057	983
2022	24400	65039	47685	15884	9172	3825	2922	3042
2023	33631	15237	39980	27092	9069	4344	2142	2911
2024	13566	23223	9816	23652	14252	4521	2210	2602

Table 7.19.Sprat in SD 22–32. Output from SAM. Fishing mortality (F) at age.

	1	2	3	4	5	6	7	8
1974	0.050	0.154	0.245	0.337	0.349	0.328	0.279	0.279
1975	0.048	0.149	0.239	0.328	0.340	0.313	0.265	0.265
1976	0.047	0.149	0.236	0.321	0.338	0.311	0.265	0.265
1977	0.046	0.154	0.235	0.309	0.319	0.287	0.243	0.243
1978	0.042	0.143	0.208	0.266	0.273	0.240	0.203	0.203
1979	0.038	0.133	0.190	0.239	0.245	0.221	0.192	0.192
1980	0.040	0.143	0.206	0.258	0.265	0.245	0.213	0.213
1981	0.034	0.119	0.164	0.200	0.204	0.191	0.169	0.169
1982	0.033	0.114	0.162	0.207	0.216	0.203	0.181	0.181
1983	0.021	0.071	0.102	0.134	0.145	0.141	0.134	0.134
1984	0.023	0.076	0.116	0.157	0.174	0.169	0.158	0.158
1985	0.023	0.079	0.124	0.172	0.189	0.183	0.171	0.171
1986	0.024	0.084	0.136	0.191	0.214	0.207	0.192	0.192
1987	0.026	0.095	0.164	0.241	0.278	0.276	0.258	0.258
1988	0.028	0.103	0.176	0.248	0.280	0.276	0.262	0.262
1989	0.029	0.107	0.181	0.252	0.288	0.288	0.281	0.281
1990	0.025	0.090	0.150	0.206	0.234	0.234	0.235	0.235
1991	0.023	0.084	0.138	0.189	0.215	0.215	0.224	0.224
1992	0.026	0.093	0.153	0.210	0.244	0.249	0.267	0.267
1993	0.029	0.102	0.166	0.225	0.265	0.279	0.309	0.309
1994	0.038	0.129	0.209	0.283	0.328	0.340	0.370	0.370
1995	0.047	0.156	0.257	0.366	0.435	0.463	0.513	0.513
1996	0.060	0.190	0.302	0.417	0.475	0.495	0.549	0.549
1997	0.070	0.212	0.335	0.458	0.506	0.513	0.570	0.570
1998	0.082	0.232	0.368	0.496	0.551	0.571	0.650	0.650
1999	0.088	0.233	0.355	0.454	0.490	0.495	0.551	0.551
2000	0.091	0.230	0.343	0.439	0.484	0.495	0.555	0.555
2001	0.091	0.226	0.338	0.439	0.493	0.498	0.544	0.544
2002	0.097	0.234	0.345	0.437	0.476	0.460	0.488	0.488

	1	2	3	4	5	6	7	8
2003	0.098	0.228	0.337	0.426	0.475	0.455	0.479	0.479
2004	0.110	0.250	0.371	0.475	0.541	0.519	0.537	0.537
2005	0.110	0.239	0.343	0.433	0.481	0.458	0.464	0.464
2006	0.105	0.220	0.307	0.382	0.415	0.403	0.406	0.406
2007	0.125	0.266	0.370	0.464	0.493	0.488	0.487	0.487
2008	0.126	0.266	0.368	0.460	0.478	0.474	0.463	0.463
2009	0.135	0.282	0.386	0.481	0.492	0.484	0.469	0.469
2010	0.122	0.254	0.342	0.423	0.435	0.428	0.416	0.416
2011	0.103	0.213	0.280	0.341	0.351	0.344	0.335	0.335
2012	0.089	0.193	0.262	0.327	0.345	0.338	0.329	0.329
2013	0.098	0.218	0.297	0.371	0.391	0.374	0.357	0.357
2014	0.100	0.223	0.309	0.389	0.416	0.398	0.385	0.385
2015	0.084	0.193	0.274	0.357	0.390	0.376	0.367	0.367
2016	0.068	0.163	0.238	0.326	0.372	0.374	0.376	0.376
2017	0.069	0.168	0.247	0.341	0.392	0.393	0.390	0.390
2018	0.079	0.194	0.278	0.374	0.412	0.398	0.383	0.383
2019	0.092	0.226	0.322	0.430	0.466	0.444	0.425	0.425
2020	0.074	0.192	0.285	0.396	0.440	0.429	0.418	0.418
2021	0.065	0.174	0.266	0.379	0.427	0.415	0.402	0.402
2022	0.064	0.172	0.265	0.382	0.434	0.415	0.396	0.396
2023	0.060	0.164	0.256	0.376	0.433	0.418	0.402	0.402

Table 7.20. Sprat in SD 22–32. Input data for short-term prediction. Recruitment in 2025 and 2026 are resampled from SAM estimated recruitment in 1991-2023.

2024

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	13566	0.310	0.17	0.4	0.4	6.0	0.075	6.0
2	23223	0.276	0.93	0.4	0.4	8.9	0.201	8.9
3	9816	0.269	1	0.4	0.4	9.9	0.311	9.9
4	23652	0.266	1	0.4	0.4	10.8	0.449	10.8
5	14252	0.263	1	0.4	0.4	11.4	0.512	11.4

6	4521	0.258	1	0.4	0.4	11.9	0.493	11.9
7	2210	0.262	1	0.4	0.4	11.8	0.474	11.8
8	2602	0.262	1	0.4	0.4	11.7	0.474	11.7

Table 7.21. Sprat in SD 22–32. Output from short-term prediction for TAC constrained fishery in 2024 for range of F values and options.

Basis	Total catch (2025)	F_{total} (2025)	SSB (2025)	SSB (2026)	% SSB change *	% TAC change **	% advice change ***	P(SSB(2026)>Blim)
ICES advice basis								
EU MAP^^: F_{MSY}	164947	0.34	530445	750348	41	-33	-32	92
EU MAP^^: range F_{lower}	130195	0.26	544794	791738	45	-47	-32^	95
EU MAP^^: range F_{upper}	169131	0.35	528587	745651	41	-31	-32^	91
Other scenarios								
F = 0	0	0	592399	958710	62	-100	-100	100
F = F_{pa}	169131	0.35	528587	745651	41	-31	-30	91
F = F_{lim}	256291	0.58	491060	644202	31	4.5	6.1	81
SSB (2026) = B_{lim}	365841	1.20	564307	459094	-18.6	49	51	50
SSB (2026) = B_{pa}	321171	0.87	444753	541487	22	31	33	65
SSB (2026) = MSY $B_{trigger}$	321171	0.87	444753	541487	22	31	33	65
SSB (2026) = SSB (2025)	606126	2.3	288172.5	288353	0	147	151	18.3
SSB (2026) = SSB (2024)	231416	0.47	509664	692035	0	-5.6	-4.2	87
F = F_{2024}	197214	0.42	516497	711732	38	-20	-18.4	89

Table 7.22. Ratio of SAM estimates of stock numbers in 2024 and 2023 assessments (N2024/N2023) by age and year

	2019	2020	2021	2022	2023
1	1.00	0.99	0.99	0.97	0.77
2	1.00	1.00	1.00	1.00	0.88
3	1.00	1.00	1.01	1.00	0.96
4	1.00	1.00	1.00	1.02	0.98
5	1.00	0.99	0.99	0.98	1.11
6	1.00	1.00	0.99	1.01	0.92
7	1.00	1.00	0.99	0.98	1.10
8	1.00	1.00	0.99	0.97	0.91
		5-10% difference			
		10-15% diffrence			
		>15% difference			

Fig. 7.1. Sprat in Subdivisions 22-32. Share of catches by Sub-division in 2001-2023

Figure 7.2. Sprat in SD 22-32. Relative catch-at-age in numbers in 1974-2023.

Figure 7.3. Sprat in SD 22-32. CANUM consistency check.

Fig. 7.4. Sprat in SD 22-32: mean weight-at-age in the catches in 1974-2023 by ages and average of values relative to weights in 1992 (weight in the stock assumed as in the catches).

Figure 7.5a. Sprat in SD 22-32. Check for consistency in October acoustic survey (BIAS) estimates.

Figure 7.5b. Sprat in SD 22-32. Check for consistency in May acoustic survey (BASS) estimates.

Figure 7.6. Sprat in SD 22-32. Check for consistency between stock size estimates from May and October acoustic surveys.

Figure 7.7. Sprat in SD 22-32. Residuals by fleet from SAM.

Figure 7.8. Leave-one-out analysis from SAM.

Figure 7.9. Retrospective estimates of SSB, fishing mortality, and recruitment from SAM.

Figure 7.10. Summary of sprat assessment from SAM.

Figure 7.11. Comparison of 2024 SAM assessment with SAM assessment from 2023 and historical assessments with XSA (both SAM assessments are very similar, so it is difficult to see the difference on the graph).

Figure 7.12. Weights, selectivity and M at age used for predictions in advice years 2024 (2023 assessment) and 2025 (present assessment).

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8 Dab, turbot and brill in the Baltic Sea

8.1 Dab

8.1.1 Fishery

8.1.1.1 Landings

Dab (*Limanda limanda*) is distributed mainly in the western part of the Baltic Sea. The eastern border of its occurrence is not clearly identified. Total landings of dab were around 1000 t between 1970 and 1978 and fluctuated around 2000 t between 1979 and 1996 (Table 8.1.1). During the years 1994 to 1996 the total landings of dab were over-reported due to bycatch misreporting in the cod fishery. Less than 1000 t were landed in 1997 and from 1999 to 2002. Since 2003, landings fluctuate around 1200 t without a distinct trend. In 2023, landings decreased to below 169 t, the lowest amount since the beginning of the recording in the 1910s.

The largest amount of dab landings is reported by Denmark (subdivisions 22 and 24) and Germany (mainly in Subdivision 22, Figure 8.1.1). The German and Danish landings of dab are mostly bycatch of the directed cod fishery and the target of a mixed flatfish fisheries. Due to reduced fishing opportunities for cod and decreasing fishing effort, fishing pattern are evolving toward flatfish-directed fisheries.

8.1.1.2 Discards

Estimates of discards are available from Denmark and Germany since 2012 (Figure 8.1.2a), covering the main fishing areas in SD 22 and Sd 24. Occasional samples and discard estimates are taken from SD 23 and SD 25.

Discards of dab are known to vary greatly with ratios around 30–80% of the total catch of vessels using active gears (e.g. trawling). Passive fishing gears have lower discards, varying between 10 to 20% of the total catch. Depending on market prices, quality and quota of target species (e.g. cod), discards vary between hauls, trips, vessels, areas, quarters and years. The discarded fraction can cover all length-classes and rise up to 100% of a catch.

Year	Landings (t)	Discards (t)
2012	1285	1191
2013	1384	1458
2014	1269	757
2015	1268	1055
2016	1356	1007
2017	1227	905
2018	941	840
2019	1102	801
2020	1026	573

2021	793	468
2022	256	133
2023	169	393

Subdivision 22 (the Belt) shows a relatively good sampling coverage that allows reasonable discard estimations at least for the last four years. Subdivision 23 (Sound) is sampled less (Figure 8.1.2a); only a few biological samples are available (Figure 8.1.2b). However, discard estimations provided by national data submitters are given in many strata. Sampling intensity has increased steadily in the last years; therefore, less discard ratios were borrowed. Before 2012, sampling intensity was too low to give a reasonable estimation, especially in the passive segment, where almost no data were available. The discards in 2023 are estimated to be around 393 tonnes, which would result in a discard ratio of 70% of the total catch, the highest recorded discard ratio since the beginning of the estimation

The change towards flatfish-directed fisheries in both active and passive gears resulted in higher discards due to smaller mesh sizes (90mm flatfish gears instead of 105+mm cod-directed gears). High discards were recorded at 23-24cm total length, just below the minimum conservation reference size (MCRS). The decreasing condition in Baltic Sea flatfishes (see 8.1.6.2) is also strongly affecting dab, resulting in dab above the MCRS being discarded more often than before.

8.1.2 Fishery independent information

The Baltic International Trawl Survey (BITS) is covering the entire Baltic Sea and southern Kattegat and is conducted twice per year, in quarters Q1 and Q4. Both surveys are conducted using the same sampling protocols and data are publicly available at the International Survey database DATRAS, hosted by ICES (https://datras.ices.dk).

Although the Baltic Sea dab stock virtually covers the entire Baltic Sea, the focal point of its distribution is the western part of the Baltic. Only very few dabs are found east of the Arkona basin (SD 24) and almost no dab is found east of Bornholm. Thus, the index calculation is only using data from the main distribution area in SD22 and SD23 in the subareas 8, 9, and 10 (WKBALFLAT 2014).

In 2001, the survey design of BITS was changed and standardized and national research vessels changed to a standard gear to generate comparable effort and cpue data. BITS data prior to 2001 have not been standardized in DATRAS. To make these data available for the dab index calculation, DATRAS CPUE data were standardized applying the national gear conversion factors of WKBALT (2003) to the respective survey gears. The subsequent calculation of the cpue and biomass index followed the DATRAS guidelines of ICES (2013).

The stock indices, mean weight of dab >15 cm captured per hour in units of the standard gear TVL, were calculated based on the mean catch in number per hour in units of TVL and the mean weight-length relation. Recent decrease in the stock condition factor of dab resulted in a change of biomass index calculation during WKMSYSPICT3 (ICES 2024a). Previously, averaged length-weight coefficients were used to calculate the index. The new approach is using annual length-weight-coefficients of the respective survey year, resulting in a lower estimated biomass for recent years.

8.1.3 Assessment

This stock was benchmarked in 2024 (ICES, 2024a). The assessment method changed from category 3 to category 2. The stock assessment method was changed from Length-based-Indicators (LBI) to a surplus production model (SPiCT), using a model-based approach to calculate an exploitable biomass index (Berg *et al*. 2013).

8.1.3.1 Surplus production model (SPiCT) and reference points

The stochastic production model in continuous time (SPiCT) was applied to the dab stock dab.27.22-32. Input data were commercial landings from 1991 to 2023 and the improved BITS biomass index Q1 and Q4 (Table 8.1.2). No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios F/F_{MSY} and B/B_{MSY} are used to estimate stock status relative to the MSY reference points and can be used for catch advice and catch scenarios (Table 8.1.3).

The results of the assessment are stating a good status (Figure 8.1.4) of the stock, where F is below F_{MSY} and B above $B_{trigger}$ (Figure 3.2.5) and thus confirming the results of the previously conducted LBI and the stock trend of the BITS. Retrospective analysis of the SPiCT dats series indicating a consistent pattern in catches and survey indices (Figure 8.1.6, Figure 8.1.7).

The remaining uncertainty might be attributed to inconsistency between landings and index time-series and missing contrast in the landings time-series.

Despite the remaining variance, the model states a good stock condition in recent years and well within F_{MSY} and B_{MSY}. Following the ICES approach, a proxy for MSY $B_{trigger}$ can be calculated as 0.5 x B_{MSY}.

8.1.3.2 Technical criteria for accepting a SPiCT assessment

When determining harvest limits using output from SPiCT, the application depends on appropriate model performance. An accepted assessment using SPiCT would ideally fulfil all of the following points:

- Model converged;
- All parameter uncertainties could be estimated and finite;
- No violation of model assumptions such as bias, auto-correlation of OSA residuals, and normality. This means that p-values are not significant ($p > 0.05$);
- Consistent trend in the retrospective analysis. There should not be a tendency to consistently under- or overestimate relative fishing mortality and biomass in successive assessments, in particular if the retrospective estimates are outside the confidence intervals of the base run;
- Non-influential starting values – the results should be the same for all starting values;
- Model parameter estimates and variance parameters should be meaningful. This means that the parameter of the production curve (n) should not be very skewed away from the symmetrical curve (B_{MSY}/K should be between 10% and 90%) and the variance parameters (sdb, sdc, sdi, sdf) should not be unrealistically low. In these cases, a prior on the unrealistic parameter could be considered.

The dab dataset and results of the SPiCT were tested for all the above criteria. All technical criteria were fulfilled.

8.1.3.3 Biological reference points (Precautionary approach)

F_{MSY}, B_{MSY} and the yield at MSY are all directly estimated in the model. It should be noted that these will vary when new survey and catch information is added. B_{pa} and B_{lim} are defined as

50%B_{MSY} and 30%B_{MSY} respectively. F_{lim} is defined as 1.7 F_{MSY} and is the F that drives the stock to B_{lim} assuming B_{lim}=30%B_{MSY}. The derivation is given below:

$P=rB(1-B/K)$

The surplus productivity associated with B_{lim} is:

$P_{lim}=rB_{lim}(1-B_{lim}/K)$

The corresponding F is:

$Flim=rB_{lim}(1-Blim/K)/B_{lim} = r(1-B_{lim}/K)$

$Blim=0.3B_{MSY} = 0.3K/2\ Flim = r(1-0.3K/(2K)) = r(1-0.3/2) =0.85r$

$F_{MSY}=r/2$, *let x denote the proportionality between F_{MSY} and Flim*

$xF_{MSY}=F_{lim}$

$x(r/2)=0.85r$

$x=2*0.85$

$x=1.7$

8.1.4 Management considerations

To improve the assessment and hence the quality of the advice, more discard estimations are required by national data submitters. Additionally, more flexible tools need to be developed for InterCatch, allowing the allocation of discards also to strata with no landings attached (discard only) and extrapolation across years (to allow reasonable borrowing in years without sufficient estimations). Data handling, such as allocation and hole filling should take place in the database to allow comprehension of the methods used.

8.1.4.1 Stock identity

Distribution maps from scientific surveys strongly suggest that there is no spatio-temporal separation between dab in Kattegat and the Baltic Sea and that dab in the Kattegat have negligible links to dab in the North Sea (Annex WD2). The Danish Straits are highly dynamic connecting channels between the southern Kattegat and Kiel and Mecklenburg Bight south of Denmark that make a stock separation between SDs 22-23 and SD21 highly unlikely. No distinct differences were found in biological life history parameters (i.e. maturity and growth) between dab from SD21 and SDs 22-23, while dab in the North Sea displays a different growth and maturation pattern than dab in SD 21 and SD22-32.

Thus, a stock comprising dab from the management areas SD 21-32 would realistically reflect the dab population in the Baltic Sea.

The working group recommends to investigate the stock boundaries of dab in the Western Baltic and Kattegat. Similar analyses already resulted in the inclusion of Kattegat to the Western Baltic plaice stock (ple.27.21-23) and of Kattegat and Skagerrak to the Baltic sole stock (sol.27.20-24), making a similar scenario for other flatfishes very likely.

8.1.4.2 Stock condition

Dab in the Baltic Sea are experiencing changing environmental condition. A combination of decreasing inhabitable areas, foraging grounds and food availability due to oxygen depletion in deeper basins, higher water temperatures and increasing stock biomass resulted in drastically decreasing fish condition since 2015 (Figure 8.1.7). While the condition of juvenile dab is less drastic, adult dab are increasingly unmarketable for the commercial fisheries due to their bad condition.

Considering the condition of dab, stock management should be considered within the context of a degraded ecosystem, resulting from cumulative anthropogenic pressures and climate change. Habitat restoration efforts with a focus on improving bottom oxygen content are recommended (direct effects on mortality and indirect effects on individual condition). National data submitter should be careful when extrapolating weight-at-length-data and should preferably use length-weight-coefficients of the same year to account for the decreasing condition.

Table 8.1.1. Dab in the Baltic Sea: total landings (tonnes) of by Subdivision and country.

Year/SD	Denmark				Germany, Fed. Rep. (+ Germany, Dem. Rep. before 1990)				Sweden[2]					Discards	Total Catch
	22	23	24(+25)	25-28	22	24	25	26	22	23	24	25	27-30	22-32	22-32
1970	845		20		85										
1971	911		26		74										
1972	1110		30		72						23				
1973	1087		58		136						30				
1974	1178		51		136						34				
1975	1273		74		151						32				
1976	1238		60		131						27				
1977	889		32		102						25				
1978	928		51		147	18									
1979	1413		50		141	26					9				
1980	1593		21		116	25					3				
1981	1601		32		188	39					5				
1982	1863		50		228	42					6	5	15		
1983	1920		42		244	28					24	20	56		
1984	1796		65		205	49					4	3	10		
1985	1593		58		239	53					3	3	9		
1986	1655		85		221	36					1	1	2		
1987	1706		93		290	91					1	1	2		
1988	1846		75		303	92					1	1	2		
1989	1722		48		244	20					1	1	3		
1990	1743		146		266	12					8				
1991	1731		95		340	5					1				
1992	1406		81		409	6						1	5		
1993	996		155		556	10				7	1	1	1		
1994	1621		163		1190	80	45			5	1	1	0		
1995	1510	47	127	10	1185	49	3			5	1	5	1		
1996	913	37	128		991	134	13	2	3		3	4	1		
1997	728		60		413	21	2	0		5	5	10	4		
1998	569		89		280	6	2	0		7	3	3	1		
1999	664		59		339	4		0		3	1	1			
2000	612		46		212	3		0		2		1			
2001	586		72		191	5		0		4	1	2			
2002	502		31		173	5			0	4	0	0	0		
2003	559		171		494	7			0	1	<1	0	0		
2004	953		185		745	10			0	1	1	0	0		
2005	752	34	163	16	474	45	9		0	1	1	0	0		
2006	400	23	112	161	494	24	11		0	1	2	0	0		
2007	860	40	108	7	472	18			0	<1	<1	0	0		
2008	757	36	86	222	507	33			0	3	<1	1	3		
2009	521	25	97		587	32			0	2	<1	<1	3		
2010	552	18	51		398	17	2		0	1	<1	<1	0		

Year/SD	Denmark				Germany, Fed. Rep. (+ Germany, Dem. Rep. before 1990)				Sweden[2]					Discards	Total Catch
	22	23	24(+25)	25-28	22	24	25	26	22	23	24	25	27-30	22-32	22-32
2011	544	20	39		647	15			0	1	<1	1	<1		
2012	481	22	69	0	692	20	0	0	0	1	0	0	1	1191	2476
2013	445	18	69	0	834	17	0	0	0	0	0	1	1	1458	2842
2014	373	11	57	0	801	25	2	0	0	0	0	0	0	757	2026
2015	268	9	21	0	955	14	0	0	0	0	0	0	1	1055	2323
2016	268	14	21	0	1027	23	1	0	0	<1	<1	0	1	1007	2365
2017	276	9	15	0	874	50	0	0	0	<1	<1	<1	1	905	2132
2018	273	18	20	<1	560	66	0	0	0	1	<1	<1	<1	840	1781
2019	388	15	68	0	592	37	0	0	<1	2	<1	<1	<1	801	1903
2020	398	13	95	0	469	49	0	0	0	1	<1	<1	1	573	1599
2021	243	7	89	0	414	37	<1	0	0	1	0	0	2	468	1260
2022	111	6	17	0	102	18	0	0	0	1	<1	<1	1	133	389
2023	73	4	25	0	57	8	0	0	0	1	<1	<1	1	393	562

1 From October-December 1990 landings of Germany, Fed. Rep. are included.

2 For the years 1970–1981 and 1990 the catches of subdivisions 25–28 are included in Subdivision 24.

3 For the years 1970–1981 and 1990 the Swedish catches of subdivisions 25–28 are included in Subdivision 24.

5 In 1995 Danish landings of subdivisions 25–28 are included.

Table 8.1.2. Dab in Subdivisions 22-32. SPiCT settings and input data.

Setting/Data	Values/Source
Catch time series	Historical landings 1991-2011 InterCatch landings data 2012–2023
BITS biomass Index quarter 1	1991-2023, ≥ 15 cm
BITS biomass Index quarter 4	1991-2023, ≥ 15 cm

SPiCT settings		
-	Standard error on the indices (observation) (sdi)	Log(sdi1)~N(log(index_CV),0.3^2) Log(sdi2)~N(log(index_CV), 0.3^2)
-	Standard deviation on the indices (observation) (stdevfacI)	indexQ1_CV/mean(indexQ1_CV), indexQ4_CV /mean(indexQ4_CV)
-	Standard deviation on the catch (observation) (stdevfacC)	For >2021 stdevfacC = 2;
-	Biomass process noise (logsdb)	Log(0.15)-0.5*0.5^2, 0.5
-	Catch observation error (logsdc)	Log(0.1)-0.5*0.5^2, 0.5
-	Uncertainty ratio of index (observation) to biomass process (alpha)	Deactivated
-	Uncertainty ratio of catch (observation) to fishing mortality process (beta)	Deactivated
-	Shape parameter (n)	Thorson model, Log(n)~N(log(1.353),0.55)
-	Intrinsic growth rate (r)	Log(r)~N(log(0.71*0.6765), -0.5*0.5^2,0.5)
-	Initial depletion (bkfrac)	None (default)
-	Discretion time step (dteuler)	1/16 year (default)

Table 8.1.3.: Dab in subdivisions 22-32. stochastic reference point estimates

	estimate	cilow	ciupp	log.est
B_{MSYs}	7235.561	4486.387	11669.380	8.887
F_{MSYs}	0.282	0.192	0.412	-1.267
MSYs	2037.704	1718.537	2416.146	7.620
B2023.94/Bmsy	2.223	1.764	2.802	0.799
F2023.94/Fmsy	0.038	0.021	0.068	-3.270

Table 8.1.2. Dab in Subdivisions 22-32. SPiCT settings and input data.

Setting/Data	Values/Source
Catch time series	Historical landings 1991-2011 InterCatch landings data 2012–2023
BITS biomass Index quarter 1	1991-2023, ≥ 15 cm
BITS biomass Index quarter 4	1991-2023, ≥ 15 cm

SPiCT settings	
- Standard error on the indices (observation) (sdi)	Log(sdi1)~N(log(index_CV),0.3^2) Log(sdi2)~N(log(index_CV), 0.3^2)
- Standard deviation on the indices (observation) (stdevfacI)	indexQ1_CV/mean(indexQ1_CV), indexQ4_CV /mean(indexQ4_CV)
- Standard deviation on the catch (observation) (stdevfacC)	For >2021 stdevfacC = 2;
- Biomass process noise (logsdb)	Log(0.15)-0.5*0.5^2, 0.5
- Catch observation error (logsdc)	Log(0.1)-0.5*0.5^2, 0.5
- Uncertainty ratio of index (observation) to biomass process (alpha)	Deactivated
- Uncertainty ratio of catch (observation) to fishing mortality process (beta)	Deactivated
- Shape parameter (n)	Thorson model, Log(n)~N(log(1.353),0.55)
- Intrinsic growth rate (r)	Log(r)~N(log(0.71*0.6765), -0.5*0.5^2,0.5)
- Initial depletion (bkfrac)	None (default)
- Discretion time step (dteuler)	1/16 year (default)

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F2023.94/Fmsy	0.038	0.021	0.068	-3.270

Figure 8.1.1. Dab in subdivisions 22 to 32. Development of dab landings [t] from 1970 onwards by ICES subdivision (SD).

Figure 8.1.2. **Sampling coverage and quality of dab.27.22-32.**

8.1.2.a: Upper plot: provided official landings and discard estimates (green) of member states, including reported zeroes and non-provided strata (red).

8.1.2.b: Lower plot: provided biological samples per stratum (green) and non-sampled strata (red). Yellow fields indicate dismissed biological samples (either due to low sample sizes or non-updated length-weight-coefficients were used by the member state to impute missing weight data)

Figure 8.1.3. Dab in subdivisions 22 to 32. Output plot of the final SPiCT assessment.

Figure 8.1.4. Dab in subdivisions 22 to 32. Relative stock development plots of the SPiCT assessment and relative reference points.

Figure 8.1.5. Dab in subdivisions 22 to 32. Mean biomass (kg hr^{-1}) of dab with L ≥ 15 cm based of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–24.Data from the assessment year (2024 Q1) are preliminary and not used in the assessment.

Figure 8.1.6. Dab in subdivisions 22 to 32. Retrospective analysis of the assessment

Figure 8.1.7 Dab in subdivisions 22 to 32. Condition factor development of dab in the Belt Sea (SD22), from Kokubun *et al*. (in prep.)

8.2 Turbot

Turbot is a coastal piscivorous species commonly occurring from Skagerrak up to the Sea of Åland. Turbot spawns in shallow waters (10–40 m, 10–15 m in central Baltic) and the metamorphosing post larvae migrate close to shore to shallow water (down to one-meter depth).

Turbot fishery is concentrated on the westerly parts of the Baltic Sea (SD 22– 26) with the highest landings occurring in the Belt Sea (SD 22), followed by Arkona and Bornholm Sea (SD's 24-25). Historic catch data also document larger catches in the Eastern part of the Baltic Sea. However, less than 30% of catches are taken east of SD25 for almost 30 years, suggesting a local depletion of stock components or changed environmental conditions in this area. For turbot the genetic data show no structure within the Baltic Sea (Nielsen *et al.*, 2004, Florin and Höglund, 2007), although the former discovered a difference between Baltic Sea and Kattegat with a hybrid zone in SD 22. Spatial distributions of turbot based on BITS survey data suggest that the turbot stock SD 22–32 is probably related with turbot in SD 21.

8.2.1 Fishery

8.2.1.1 Landings

Turbot were mainly landed in the southern and western parts of the Baltic Proper (ICES subdivisions 22–26). The total landings of turbot increased from 42 t to 1206 t from 1965 to 1996 followed by a decrease to 525 t in 2000 and a slower decline until the minimum of 305 t in 2006 and varied between 221 t in 2012 and 394 t in 2009 with a slightly negative trend between 2007 and 2016 (Table 8.2.1, 8.2.2, Figure 8.2.1). The landings of 2001 and 2012 were slightly corrected based on the evaluation of the reported data and the calculation procedures. A successful turbot gillnet fishery started at the beginning of the 1990s in subdivisions 26 and 28. Since 1990 in all eastern Baltic countries, turbot is sorted out from the flatfish catches due to a higher market price. For example, the Polish landings of turbot increased from 33 t to 362 t from 1999 to 2003. Swedish landings are taken mainly from a gillnet fishery that reached a maximum of 283 t in 1996. Since then, Swedish landings decreased and have been under 50 t for the last five years. Presently, Denmark and Germany are the main fishing countries in the Western Baltic and landed about 97

tonnes of turbot from subdivisions 22 and 24. Poland and Sweden are the main fishing countries in the Eastern Baltic and landed about 45 tonnes from subdivisions 25–28. Total landings in 2023 were about 143 tonnes.

8.2.1.2 Discard

Estimates of discards are available from most countries from 2012 onwards. The data illustrate the high variability of the relation between landings. The mean proportion of discarded turbot in relation to total catch was 30% for the years 2012 to 2023. Discard sampling and thus the quality of discard estimates have increased in the last five years, as more countries are reporting data and the number of length measures was increasing. Reported discard estimates covered around 75% of the landed weight of turbot (Figure 8.2.2a). Discards in 2020, 2021 and 2023 were exceptionally high, about three times higher (>60%) than the average discard since the beginning of the time-series. A very strong year class entered the fisheries and an increasing amount of smaller turbot was caught, especially in trawl fisheries. Similar, a signal of above-average recruitment is apparent in the survey index. The signal could not be clearly identified in 2022 datasets, as the sampling coverage was exceptionally low, only German data from 27.3.d.24 of the passive fisheries were available (Figure 8.1.2.b). Passive gears usually catch larger turbot, thus masking the incoming strong cohort of smaller turbot in the length.

The change towards flatfish-directed fisheries in both active and passive gears resulted in higher discards due to smaller mesh sizes (90mm flatfish gears instead of 105+mm cod-directed gears).

8.2.2 Fishery independent information

The "Baltic International Trawl Survey" (BITS) is covering the area of the turbot stock in the Baltic Sea. The survey is conducted twice a year (1st and 4th quarter) by the member states having a fishery in this area. Survey design and gear is standardized.

The calculation of the survey index changed from a biomass index to a delta GAM model-based approach after the benchmark in 2024 (see 8.1.4) This was done to account for reduced spatial coverage in earlier years (before 2000), Before 2000, the BITS survey was not standardized, different survey gears were used, and spatial coverage was incomplete. The model-based approach accounts for different catchability between gears, unsampled areas, and quantifies the increased index uncertainty due to these issues (Table 8.2.2.).
The new index calculation also accounts for decreasing trends condition of flatfishes since the mid 90-ties by using annual length-weight relationships instead of a fixed one.
The improved index from the delta GAM model-based approach is similar to the trends of the previously used biomass index, where no large differences occurred in the index after the mid-1990s (Figure 8.2.3).

Although turbot is assessed as one large stock and genetic studies indicate no structure within the Baltic Sea (Florin & Höglund 2007, Nielsen *et al.*, 2004) tagging studies indicate that turbot does not perform long migrations, and both survey data and commercial catch by subarea indicate that the stock development varies between the eastern and western Baltic Sea.
Opposite spatial signals in the survey index (increasing biomass and high numbers of small turbot in the western subdivisions and decreasing numbers and a lack of smaller turbot in the eastern subdivisions) are resulting in a uniform and non-responsive index.

8.2.3 Assessment

An update advice was last given in 2021 and the stock was benchmarked in 2024 (ICES, 2024a). However, given the opposing spatial trends in the survey, the stock was kept as a Category 3 stock. Only catches and trends in the survey were used to update the stock status for the advice.

8.2.4 Management considerations

To improve the assessment and hence the quality of the advice, more discard estimations are required by national data submitters. Additionally, more flexible tools need to be developed for InterCatch, allowing the allocation of discards also to strata with no landings attached (discard only) and extrapolation across years (to allow reasonable borrowing in years without sufficient estimations). Data handling, such as allocation and hole filling should take place in the database to allow comprehension of the methods used.

8.2.4.1 Stock identity

The questions of stock structure for turbot should be revisited while considering separate management of the eastern and western Baltic and the connection with SD21. Alternative models that include the non-exploitable biomass (e.g. length-based models) should be considered also to better account for the occasional exceptionally large year classes.

Table 8.2.1. tur.27.22-32. Overviews of total landings and discards since 2012

Year	Landings (t)	Discards (t)
2012	221	139
2013	313	25
2014	253	85
2015	233	34
2016	252	100
2017	264	57
2018	370	147
2019	201	95
2020	197	374
2021	209	339
2022	134	90
2023	143	190

Table 8.2.2. Turbot in the Baltic Sea. Total landings (tonnes) by ICES Subdivision and country.

Year/SD	Denmark					Germ. Dem. Rep.[1]		German y, FRG				Poland		Sweden[2]							Latvia		Lithuania	Russia	Finland						Estonia	
	22	23	24(+25)	25	26+27	22	24	22	24	25	27	25(+24)	26	22	23	24	25	26	27	28(+29)	26	28	26	26	24	25	29	30	31	32	29	32
1965						3	39																									
1966	16		21			5	53																									
1967	14		20			7	10																									
1968	14		18			3	67																									
1969	13		13			4	57																									
1970	11		13			5	40									2																
1971	11		26			4	86									2																
1972	10		26			3	100									3																
1973	11		30			3	33					58	13			5																
1974	14		40			2	23					34	36			6																
1975	27		48			3	38	15				23	6			7																
1976	29		24				52	11				14	12			7																
1977	32		37				55	9				12	55			8																
1978	33		37			2	27	9				7	3			10																
1979	23		38			3	39	6				29	34			12																
1980	28		38				30	9				12	20			15																
1981	28		62			1	46	8				10	19			7																
1982	31		51			1	27	7				2	17			3	4		4	3												
1983	33		40			3	9	8				5	4			31	41		35	24												
1984	41		45			4	8	12				13	2			3	4		3	2												
1985	56		34			5	22	15				67	15			4	5		4	3												
1986	99		81			6	32	25				32	37			6	8		7	5												
1987	134		93			4	34	30				155	21			8	11		9	6												
1988	117		117			3	28	34				7	10			12	16		14	9												
1989	135		109			7	22	20					11			11	15		13	9												
1990	178		181			4	2	26				24	25			14																
1991	228		137					44	39			73	20			2	12		16													
1992	267		127					55	68			80	55			12	12		21	36				30								
1993	159	29	152					74	56			520	72		2	4	14		13	38				34								
1994	211	18	166					52	57	10		380	30		2	3	18	1	17	44				15								
1995	257	11	94					65	53	4		30	15		2	3	54	9	31	83	34	27	15	20								
1996	207	12	95					36	47	4	1	288	92	1	3	15	100	5	54	104	42	3	72	25								
1997	151		68					60	52	3		290	70		2	6	70	1	53	86	33	14	59	25								
1998	138		80					44	55	1		66	68		2	4	58	1	18	69	12	24	62	96								
1999	106		59					23	48			18	15		2	4	41	3	17	60	20	34	58	48								
2000	97		58					23	54			90	12		2	3	39		16	39	7	9	23	53								
2001	76		53					19	31			121	10		2	5	16		9	29	5	1	18	69								
2002	73		22	4	0			20	32	2		245	65		5	2	15		7	21	2	8	18	50								
2003	48		28	5	0			10	39	1		184	178		1	2	18		3	14	7	2	13	28								
2004	61		27	7				12	27	1		225	96		1	1	8		3	14	3	8	7	15								
2005	57	5	36	12				14	35	1		123	57		1	3	6		5	21	1	6	18	19								
2006	30	5	16	33				19	45	1		87	11		1	2	5	0	4	19	3	3	9	12								
2007	60	5	26	5	0			22	34	0		83	8		0	5	5		2	15	0	1	12	24								
2008	79	5	33	6				24	30	0		95	15		1	7	11		8	17			10	14								
2009	111	6	35	7	0			33	50	1		92	11		1	6	10	0	5	6	0	0	11	8								
2010	102	6	31	4	0			24	35	0		38	1		1	4	16	0	4	8	3	7	9	2								
2011	84	3	24	3	0			26	31	0		66	11	0	0	0	0	0	0	0	3	6	0	5	0	0	0	0	0	0	0	0
2012	43	3	16	1	0			16	27	0	0	55	11	0	0	0	0	0	0	0	5	5	14	15	0	0	0	0	0	0	0	0
2013	66	5	21	1	0			23	40	0	0	61	12	0	1	6	16	0	1	3	5	4	13	20	16	0	0	0	0	0	0	0
2014	84	5	27	1	0			35	30	0	0	25	5	0	1	3	13	0	2	4	2	5	7	6	0		0				0	
2015	84	5	22	1	0			27	19	0	0	41	8	0	0	4	9	0	1	1	0	4	4	3	0	0	0	0	0	0	0	0
2016	68	4	37	3	0			25	23	1		43	13	0	2	5	9	0	1	1	1	5	7	6	0	0	0	0	0	0	0	0
2017	76	5	18	3	0			41	33	0		55	8	0	1	2	4	0	1	1	0	1	7	7	0	0	0	0	0	0	0	0
2018	103	9	41	3	0			37	55	<0.5		72	4	<0.5	1	14	11	0	1	2	1	5	<0.5	7	0	0	<0.5	0	0	0	<0.5	<0.5
2019	53	2	25	1	0			20	26	<0.5		50	5	0	1	3	2	0	1	2	1	4	5	1			0			0	0	0
2020	57	3	26	0				28	19	<0.5		42	3	0	<0.5	3	5	0	2	2	0	2	2	0	0	0	0	0	0	0	<0.5	<0.5
2021	49	6	17	1				33	10	<0.5		66	5	0	1	6	4	0	2	3	0	2	4	<0.5	0	0	0	0	0	0	<0.5	<0.5
2022	40	3	8	<0.5	0			19	6	0	0	30	4	0	2	7	6	<0.5	2	3	0	1	3	1	0	0	0	0	0	<0.5	<0.5	<0.5
2023	40	3	6	<0.5	0			17	5	0	0	43	6	0	2	7	3	0	1	3	0	2	4	0	0	0	0	0	0	<0.5	<0.5	<0.5

continued

Table 8.2.2. Turbot in the Baltic Sea. Total landings (tonnes) by ICES Subdivision and country.

Year	Total by SD								Total
	22	23	24[3]	25	26	27	28(+29)	30-32	SD 22-32
1965	3	0	39	0	0	0	0		42
1966	21	0	74	0	0	0	0		95
1967	21	0	30	0	0	0	0		51
1968	17	0	85	0	0	0	0		102
1969	17	0	70	0	0	0	0		87
1970	16	0	55	0	0	0	0		71
1971	15	0	114	0	0	0	0		129
1972	13	0	129	0	0	0	0		142
1973	14	0	68	58	13	0	0		153
1974	16	0	69	34	36	0	0		155
1975	45	0	93	23	6	0	0		167
1976	40	0	83	14	12	0	0		149
1977	41	0	100	12	55	0	0		208
1978	44	0	74	7	3	0	0		128
1979	32	0	89	29	34	0	0		184
1980	37	0	83	12	20	0	0		152
1981	37	0	115	10	19	0	0		181
1982	39	0	81	6	17	4	3		150
1983	44	0	80	46	4	35	24		233
1984	57	0	56	17	2	3	2		137
1985	76	0	60	72	15	4	3		230
1986	130	0	119	40	37	7	5		338
1987	168	0	135	166	21	9	6		505
1988	154	0	157	23	10	14	9		367
1989	162	0	142	15	11	13	9		352
1990	208	0	197	24	25	0	0		454
1991	272	0	178	85	20	16	0		571
1992	322	0	207	92	85	21	36		763
1993	233	31	212	534	106	13	38		1167
1994	263	20	226	408	46	17	44		1024
1995	322	13	150	88	93	31	110		807
1996	244	15	157	392	236	55	107		1206
1997	211	2	126	363	188	53	100		1043
1998	182	2	139	125	239	18	93		798
1999	129	2	111	59	144	17	94		556
2000	120	2	115	129	95	16	48		525
2001	95	2	89	137	102	9	30		464
2002	93	5	56	266	135	7	29		591
2003	58	1	69	208	225	3	16		579
2004	73	1	55	241	121	3	22		516
2005	72	5	74	143	94	5	27	0	420
2006	49	6	63	126	35	4	22	0	305
2007	83	5	65	94	44	2	16	0	309
2008	103	6	70	113	39	8	17	0	356
2009	144	7	91	110	31	5	6	0	394
2010	126	7	70	58	15	4	15	0	295

2011	110	3	56	70	19	0	6	0	263
2012	59	3	44	57	44	0	5	0	221
2013	88	5	83	77	50	1	7	0	313
2014	119	5	60	39	19	2	9	0	253
2015	111	5	45	51	15	1	5	0	233
2016	94	6	64	56	28	1	7	0	255
2017	117	5	53	63	23	1	2	0	265
2018	141	10	111	87	13	1	7	0	370
2019	73	3	69	38	11	1	6	0	201
2020	86	4	62	34	5	2	5	0	197
2021	83	7	54	49	10	2	5	0	209
2022	58	4	28	30	7	2	5	0	133
2023	58	5	34	30	9	1	5	0	143

1 From October-December 1990 landings of Germany, Fed. Rep. are included

2 For the years 1970-1981 and 1990 catches of Subdivisions 25–28 are included in Subdivision 24

3 For the years 1970-1981 and 1990 Swedish catches of Subdivisions 25–28 are included in Subdivision 24

4 Preliminary data

Danish catches in 2002-2004 in SW Baltic were separated according to Subdivisions 24 and 25

In 2005 Lithuanian landings are reported for 1995 onwards

Table 8.2.3.: Turbot in the Baltic Sea. Survey exploitable biomass index for BITS Q1 (quarter 1) and BITS Q4 (quarter 4) and their respective coefficient of variation (CV; standardised to the mean) for the period 1991-2023. Different prioritization of gears and the respective standardization in the model resulted in different scaling of the Q1 and Q4 index values. Therefore, both are also given standardized to the mean for better comparison.

Year	IndexQ1	IndexQ1.CV	rel. Index Q1	Year	IndexQ4	IndexQ4.CV	rel. Index Q4
1991	192.381	0.441	0.732	1991	1563.020	0.311	0.857
1992	157.605	0.407	0.599	1992	2369.254	0.285	1.299
1993	198.749	0.377	0.756	1993	2357.205	0.228	1.292
1994	451.027	0.323	1.715	1994	1898.289	0.296	1.040
1995	1004.728	0.305	3.820	1995	3645.774	0.196	1.998
1996	411.121	0.355	1.563	1996	2140.634	0.260	1.173
1997	451.057	0.344	1.715	1997	2695.512	0.231	1.477
1998	379.223	0.365	1.442	1998	1442.217	0.272	0.790
1999	242.721	0.328	0.923	1999	1372.534	0.228	0.752
2000	152.317	0.358	0.579	2000	1270.417	0.235	0.696
2001	227.069	0.307	0.863	2001	1058.108	0.280	0.580
2002	114.143	0.338	0.434	2002	2156.368	0.191	1.182
2003	203.924	0.264	0.775	2003	1115.821	0.251	0.612
2004	114.406	0.309	0.435	2004	1917.800	0.201	1.051
2005	109.779	0.283	0.417	2005	1302.111	0.214	0.714
2006	141.570	0.283	0.538	2006	1521.710	0.214	0.834
2007	262.040	0.224	0.996	2007	2171.351	0.158	1.190
2008	309.752	0.240	1.178	2008	1213.800	0.200	0.665
2009	309.487	0.241	1.177	2009	2185.739	0.157	1.198
2010	270.901	0.252	1.030	2010	2114.622	0.164	1.159
2011	287.123	0.248	1.092	2011	2308.223	0.176	1.265
2012	178.434	0.277	0.678	2012	1906.504	0.194	1.045
2013	207.300	0.255	0.788	2013	1854.617	0.187	1.016
2014	214.724	0.266	0.816	2014	1771.500	0.187	0.971
2015	187.548	0.276	0.713	2015	1770.121	0.180	0.970
2016	333.314	0.252	1.267	2016	2441.669	0.143	1.338
2017	313.695	0.224	1.193	2017	2031.893	0.159	1.114

2018	272.492	0.239	1.036	2018	1442.601	0.199	0.791
2019	284.383	0.246	1.081	2019	1426.281	0.195	0.782
2020	224.109	0.271	0.852	2020	1956.322	0.156	1.072
2021	151.340	0.274	0.575	2021	1305.564	0.176	0.716
2022	200.299	0.256	0.762	2022	1352.849	0.179	0.741
2023	119.750	0.290	0.455	2023	1131.542	0.214	0.620
2024	129.100	0.300					

Figure 8.2.1. Turbot in the Baltic Sea. Development of turbot landings [t] from 1970 onwards by ICES subdivision (SD).

Figure 8.2.2. Sampling coverage and quality of tur.27.22-32.

8.2.2.a: Upper plot: provided official landings and discard estmiates (green) of member states, including reported zeroes and non-provided strata (red).

8.2.2.b: Lower plot: provided biological samples per stratum (green) and non-sampled strata (red). Yellow fields indicate dismissed biological samples (either due to low sample sizes or non-updated length-weight-coefficients were used by the member state to impute missing weight data)

Figure 8.2.3. Turbot in the Baltic Sea. Mean CPUE (biomass index, kg/hr.) of turbot with L ≥ 20 cm based on geometric mean of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–28, based on a GAM model approach (after Berg *et al.* 2017, ICES 2024a).

Figure 8.2.4. Turbot in subdivisions 22 to 32. Binned length frequency distributions.

To improve the assessment and hence the quality of the advice, more discard estimations are required by national data submitters. Additionally, more flexible tools need to be developed for InterCatch, allowing the allocation of discards also to strata with no landings attached (discard only) and extrapolation across years (to allow reasonable borrowing in years without sufficient estimations). Data handling, such as allocation and hole filling should take place in the database to allow comprehension of the methods used.

8.2.4.2 Stock identity

Distribution maps from scientific surveys strongly suggest that there is no spatio-temporal separation between dab in Kattegat and the Baltic Sea and that dab in the Kattegat have negligible links to dab in the North Sea (Annex 5 WD3). The Danish Straits are highly dynamic connecting channels between the southern Kattegat and Kiel and Mecklenburg Bight south of Denmark that make a stock separation between SDs 22-23 and SD21 highly unlikely. No distinct differences were found in biological life history parameters (i.e. maturity and growth) between dab from

SD21 and SDs 22-23, while dab in the North Sea displays a different growth and maturation pattern than dab in SD 21 and SD22-32.

Thus, a stock comprising dab from the management areas SD 21-32 would realistically reflect the dab population in the Baltic Sea.

The working group recommends to investigate the stock boundaries of dab in the Western Baltic and Kattegat. Similar analyses already resulted in the inclusion of Kattegat to the Western Baltic plaice stock (ple.27.21-23) and of Kattegat and Skagerrak to the Baltic sole stock (sol.27.20-24), making a similar scenario for other flatfishes very likely.

8.2.4.3 Stock condition

Dab in the Baltic Sea are experiencing changing environmental condition. A combination of decreasing inhabitable areas, foraging grounds and food availability due to oxygen depletion in deeper basins, higher water temperatures and increasing stock biomass resulted in drastically decreasing fish condition since 2015 (Figure 8.1.7). While the condition of juvenile dab is less drastic, adult dab are increasingly unmarketable for the commercial fisheries due to their bad condition.

Considering the condition of dab, stock management should be considered within the context of a degraded ecosystem, resulting from cumulative anthropogenic pressures and climate change. Habitat restoration efforts with a focus on improving bottom oxygen content are recommended (direct effects on mortality and indirect effects on individual condition). National data submitter should be careful when extrapolating weight-at-length-data and should preferably use length-weight-coefficients of the same year to account for the decreasing condition.

Table 8.1.1. Dab in the Baltic Sea: total landings (tonnes) of by Subdivision and country.

Year/SD	Denmark				Germany, Fed. Rep. (+ Germany, Dem. Rep. before 1990)				Sweden[2]					Discards	Total Catch
	22	23	24(+25)	25-28	22	24	25	26	22	23	24	25	27-30	22-32	22-32
1970	845		20		85										
1971	911		26		74										
1972	1110		30		72						23				
1973	1087		58		136						30				
1974	1178		51		136						34				
1975	1273		74		151						32				
1976	1238		60		131						27				
1977	889		32		102						25				
1978	928		51		147	18									
1979	1413		50		141	26					9				
1980	1593		21		116	25					3				
1981	1601		32		188	39					5				
1982	1863		50		228	42					6	5	15		
1983	1920		42		244	28					24	20	56		
1984	1796		65		205	49					4	3	10		
1985	1593		58		239	53					3	3	9		
1986	1655		85		221	36					1	1	2		
1987	1706		93		290	91					1	1	2		
1988	1846		75		303	92					1	1	2		
1989	1722		48		244	20					1	1	3		
1990	1743		146		266	12					8				
1991	1731		95		340	5					1				
1992	1406		81		409	6						1	5		

Year/SD	Denmark				Germany, Fed. Rep. (+ Germany, Dem. Rep. before 1990)				Sweden[2]					Discards	Total Catch
	22	23	24(+25)	25-28	22	24	25	26	22	23	24	25	27-30	22-32	22-32
1993	996		155		556	10				7	1	1	1		
1994	1621		163		1190	80	45			5	1	1	0		
1995	1510	47	127	10	1185	49	3			5	1	5	1		
1996	913	37	128		991	134	13	2	3		3	4	1		
1997	728		60		413	21	2	0		5	5	10	4		
1998	569		89		280	6	2	0		7	3	3	1		
1999	664		59		339	4		0		3	1	1			
2000	612		46		212	3		0		2		1			
2001	586		72		191	5		0		4	1	2			
2002	502		31		173	5			0	4	0	0	0		
2003	559		171		494	7			0	1	<1	0	0		
2004	953		185		745	10			0	1	1	0	0		
2005	752	34	163	16	474	45	9		0	1	1	0	0		
2006	400	23	112	161	494	24	11		0	1	2	0	0		
2007	860	40	108	7	472	18			0	<1	<1	0	0		
2008	757	36	86	222	507	33			0	3	<1	1	3		
2009	521	25	97		587	32			0	2	<1	<1	3		
2010	552	18	51		398	17	2		0	1	<1	<1	0		
2011	544	20	39		647	15			0	1	<1	1	<1		
2012	481	22	69	0	692	20	0	0	0	1	0	0	1	1191	2476
2013	445	18	69	0	834	17	0	0	0	0	0	1	1	1458	2842
2014	373	11	57	0	801	25	2	0	0	0	0	0	0	757	2026
2015	268	9	21	0	955	14	0	0	0	0	0	0	1	1055	2323
2016	268	14	21	0	1027	23	1	0	0	<1	<1	0	1	1007	2365
2017	276	9	15	0	874	50	0	0	0	<1	<1	<1	1	905	2132
2018	273	18	20	<1	560	66	0	0	0	1	<1	<1	<1	840	1781
2019	388	15	68	0	592	37	0	0	<1	2	<1	<1	<1	801	1903
2020	398	13	95	0	469	49	0	0	0	1	<1	<1	1	573	1599
2021	243	7	89	0	414	37	<1	0	0	1	0	0	2	468	1260
2022	111	6	17	0	102	18	0	0	0	1	<1	<1	1	133	389
2023	73	4	25	0	57	8	0	0	0	1	<1	<1	1	393	562

1 From October-December 1990 landings of Germany, Fed. Rep. are included.

2 For the years 1970–1981 and 1990 the catches of subdivisions 25–28 are included in Subdivision 24.

3 For the years 1970–1981 and 1990 the Swedish catches of subdivisions 25–28 are included in Subdivision 24.

5 In 1995 Danish landings of subdivisions 25–28 are included.

Table 8.1.2. Dab in Subdivisions 22-32. SPiCT settings and input data.

Setting/Data	Values/Source
Catch time series	Historical landings 1991-2011 InterCatch landings data 2012–2023
BITS biomass Index quarter 1	1991-2023, ≥ 15 cm
BITS biomass Index quarter 4	1991-2023, ≥ 15 cm

SPiCT settings

-	Standard error on the indices (observation) (sdi)	Log(sdi1)~N(log(index_CV),0.3^2) Log(sdi2)~N(log(index_CV), 0.3^2)
-	Standard deviation on the indices (observation) (stdevfacI)	indexQ1_CV/mean(indexQ1_CV), indexQ4_CV /mean(indexQ4_CV)
-	Standard deviation on the catch (observation) (stdevfacC)	For >2021 stdevfacC = 2;
-	Biomass process noise (logsdb)	Log(0.15)-0.5*0.5^2, 0.5
-	Catch observation error (logsdc)	Log(0.1)-0.5*0.5^2, 0.5
-	Uncertainty ratio of index (observation) to biomass process (alpha)	Deactivated
-	Uncertainty ratio of catch (observation) to fishing mortality process (beta)	Deactivated
-	Shape parameter (n)	Thorson model, Log(n)~N(log(1.353),0.55)
-	Intrinsic growth rate (r)	Log(r)~N(log(0.71*0.6765), -0.5*0.5^2,0.5)
-	Initial depletion (bkfrac)	None (default)
-	Discretion time step (dteuler)	1/16 year (default)

Table 8.1.3.: Dab in subdivisions 22-32. stochastic reference point estimates

	estimate	cilow	ciupp	log.est
B_{MSYs}	7235.561	4486.387	11669.380	8.887
F_{MSYs}	0.282	0.192	0.412	-1.267
MSYs	2037.704	1718.537	2416.146	7.620
B2023.94/Bmsy	2.223	1.764	2.802	0.799
F2023.94/Fmsy	0.038	0.021	0.068	-3.270

Figure 8.1.1. Dab in subdivisions 22 to 32. Development of dab landings [t] from 1970 onwards by ICES subdivision (SD).

Figure 8.1.2. **Sampling coverage and quality of dab.27.22-32.**

8.1.2.a: Upper plot: provided official landings and discard estimates (green) of member states, including reported zeroes and non-provided strata (red).

8.1.2.b: Lower plot: provided biological samples per stratum (green) and non-sampled strata (red). Yellow fields indicate dismissed biological samples (either due to low sample sizes or non-updated length-weight-coefficients were used by the member state to impute missing weight data)

Figure 8.1.3. Dab in subdivisions 22 to 32. Output plot of the final SPiCT assessment.

Figure 8.1.4. Dab in subdivisions 22 to 32. Relative stock development plots of the SPiCT assessment and relative reference points.

Figure 8.1.5. Dab in subdivisions 22 to 32. Mean biomass (kg hr^{-1}) of dab with L ≥ 15 cm based of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–24. Data from the assessment year (2024 Q1) are preliminary and not used in the assessment.

Figure 8.1.6. Dab in subdivisions 22 to 32. Retrospective analysis of the assessment

Figure 8.1.7 Dab in subdivisions 22 to 32. Condition factor development of dab in the Belt Sea (SD22), from Kokubun *et al.* (in prep.)

8.3 Brill

8.3.1 Fishery

8.3.1.1 Landings

Total landings of brill varied from 1 t to 160 t between 1975 and 2004 (Table 8.3.1, Figure 8.3.1). It can be assumed that the total landings of brill reported for 1994–1996 are overestimated due to species-misreporting in the landings of the directed cod fishery. Moderate increase of the landings was observed from 19 t in 2001 to 56 t in 2007 followed by landings of 105 t in the following year. A decreasing trend in landings has been observed from 2009 to 2014. Landings varied between 39 t and 40 t between 2015-2017 and peaked in 2020 with 65 t. Since then, landings were decreasing to 41 t in 2022 and 28 t in 2023. Landings in Subdivision 22 have constantly contributed to 75-82% of the total.

Table 8.3.1 Brill in the Baltic Sea: total landings (tonnes), discards (tonnes) and total catch (tonnes) by subdivision (SD) and country. Separate discard values are available since 2014. "0" since 2014 are true "0".

Year/SD	Denmark			Germany		Sweden		Total			Discards	Total Catch
	22	23	24-28	22	24	23	24-28	22	23	24-28	22-32	22-28
1970	4							4	0	0		4
1971	3							3	0	0		3
1972	7							7	0	0		7
1973	11		2					11	0	2		13
1974	25		1					25	0	1		26
1975	38		1	1				39	0	1		40
1976	45		1	2				47	0	1		48
1977	60		2	5				65	0	2		67
1978	37			3				40	0	0		40
1979	30							30	0	0		30
1980	26							26	0	0		26
1981	22			1				23	0	0		23
1982	19						17	19	0	17		36

1983	13						42	13	0	42		55
1984	12						3	12	0	3		15
1985	16						1	16	0	1		17
1986	15						3	15	0	3		18
1987	12						3	12	0	3		15
1988	5						1	5	0	1		6
1989	9						1	9	0	1		10
1990							1	0	0	1		1
1991	15							15	0	0		15
1992	28							28	0	0		28
1993	29	5	1					29	5	1		35
1994	57	4	1				1	57	4	2		63
1995	134	12	1			5	8	134	17	9		160
1996	56	6						56	6	0		62
1997	25					1		25	1	0		26
1998	21					1		21	1	0		22
1999	24					1		24	1	0		25
2000	27					1		27	1	0		28
2001	19							19	0	0		19
2002	25		0			1		25	1	0		27
2003	35		1			0		35	0	1		36
2004	39		1			1	0	39	1	1		41
2005	50	9	3			0	0	50	9	3		62
2006	42	9	2	3		0	0	45	9	2		56
2007	50			5		0	0	55	0	0		56
2008	81	9	3	11		1	1	92	10	3		105
2009	70	7	2	11		1	0	82	8	3		92
2010	65	4	1	10		0	0	76	5	1		82
2011	46	5	1	4		1	0	50	6	1		57
2012	24	4	0	2		1	0	26	4	0		31
2013	24	6	0	1	0	1	0	25	7	0		31
2014	19	5	<1	2	<1	1	0	21	6	1	8	36
2015	29	7	<1	3	<1	1	0	31	8	<1	2	42
2016	27	8	<1	3	<1	1	<1	30	9	<1	<1	40
2017	29	6	<1	4	<1	<1	<1	33	7	<1	9	49
2018	36	11	1	6	1	1	<1	41	11	2	3	58
2019	35	6	1	5	<1	1	<1	40	8	1	13	61
2020	43	11	2	7	1	1	<1	50	12	3	6	72
2021	34	8	1	8	<1	1	<1	42	10	2	2	55
2022	27	7	<1	5	<1	3	<1	32	9	<1	2	43
2023	16	4	1	4	<1	2	<1	20	6	2	2	30

Figure 8.3.1 Development of brill landings [t] from 1970 onwards by ICES subdivision (SD).

8.3.1.2 Discards

Less than 100 kg of brill was discarded in 2012. Discards increased to 299 kg in 2013 and further increased to 7.7 t in 2014. In the following years, discards varied between 0.5 t in 2016 and 12.5 t in 2019. Discards in 2023 decreased to 1.9 t. Most of these discards have been generated in subdivision 22 and 23.

8.3.2 Biological composition of the catch

The information available on population structure for brill is extremely limited. Only one study analysed genetic variation at allozyme loci and potential geographic differences in the whole distributional range of brill (Blanquer et al. 1992). A lack of genetic population structure within the Atlantic and only a weak differentiation between the Atlantic and the Mediterranean samples was reported (Blanquer et al. 1992). Lack of structure was suggested also at microsatellite loci within the NE Atlantic (Vandamme 2014). Therefore, further studies are needed to test whether brill represents a panmictic population or, rather genetic differentiation exists also within the Atlantic and the Mediterranean. Brill is a bycatch species in fisheries directed to other flatfish and the cod fishery in former years.

8.3.3 Fishery independent information

Stock indices (CPUE) were estimated as weighted mean catch in number per hour for brill with a length of ≥ 20 cm in the subdivisions 22-24. The CPUE values of the small TV were multiplied with a conversion factor of 1.4 (Figure 8.3.2).

The index was area corrected based on area data available at http://www.ices.dk/marine-data/data-portals/Pages/DATRAS-Docs.aspx. The CPUE data were derived from DATRAS (CPUE per length per haul per hour).

Stable index with low fluctuations were observed between 2004 and 2024. CPUE values follow in general fisheries landings.

Figure 8.3.2 Mean CPUE (no. hr^{-1}) of brill with L ≥ 20 cm.

8.3.4 Assessment

ICES has not been requested to advice on fishing opportunities for this stock

8.3.5 Management considerations

Brill is according to survey estimation at the edge of its distributional area in ICES Sub-divisions 24 to 32. It might be worth-while considering how to best combine Brill stocks assessed by ICES.

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Annex 1: List of participants

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Annex 2: Resolutions

2023/AT/FRSG08 The **Baltic Fisheries Assessment Working Group** (WGBFAS), chaired by Kristiina Hommik, Estonia, will meet on 10–11 April 2024 online and on 16–23 April 2024 at ICES HQ, Copenhagen, Denmark to:

a) Address generic ToRs for Regional and Species Working Groups.
b) Review the main result from WGMIXFISH, WGIAB, WGSAM, WGBIFS, WKBM-SYSPiCT3, WKHERBAL, WKNEWREF, and WKREBULD2, with main focus on the biological processes and interactions of key species in the Baltic Sea.

The assessments will be carried out on the basis of the stock annexes. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group on the dates to be specified in the 2024 ICES data call.

WGBFAS will report by 9 May 2024 for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group.

Annex 3: Audits

Audit of Eastern Baltic cod (cod.27.22-24)

Date: 25.04.2023

Auditors: Elliot John Brown, Joakim Hjelm

Secretariat representative: Ruth Fernandez

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

Short description of the assessment as follows :

Assessment type: Annual Update

Assessment: Accepted

Forecast: Not provided

Assessment model: SAM. Since 2023, only relative trends of SSB and recruitment are considered (Cat 3).

Consistency: As this assessment only uses relative trends, no direct comparison can be made with last year's assessment. However, the misalignment between catch data and survey data continue, which leaves the assessment in the same situation as last year.

Stock status: B < Blim. F estimates unreliable. Uncertain sources of mortality

Management plan: According to the management plan, reference points with F ranges were updated in 2021. However, due to the uncertainty in F, applying these reference values is un-warranted. The stock status is well below the calculated Blim, and therefore zero catch advice is warranted.

General comments

With very low stock size, fishing opportunities are limited. With limited fishing opportunities, comes limited commercial sampling and even limited biological sampling from surveys.

Technical comments

Conclusions

The challenges of assessing this stock are derived from the poor stock status. Stock rebuilding efforts need to be undertaken in parallel to understanding environmental causes for the stock's vulnerability. This requires further research work outside of this working group.

Audit of Dab (*Limanda limanda*) in subdivisions 22–32 (Baltic Sea)

Review of ICES Scientific Report, (WGBFAS 16-23.04-2024)

Reviewers: Tiit Raid

Expert group Chair: K. Hommik

Secretariat representative: R. Fernandez

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

ICES has not been requested to provide advice on fishing opportunities for this stock.
The assessment has been conducted according to the stock annex.
Stock has been benchmarked in 2024

For single-stock summary sheet advice

Stock **Dab (*Limanda limanda*) in subdivisions 22–32 (Baltic Sea)**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: Update assessment
2) Assessment: Accepted
3) Forecast: not presented since ICES has only been requested to provide stock status but not fishing opportunities for this stock.
4) Assessment model:
   After the 2024 benchmark, the stochastic production model in continuous time (SPiCT) was applied to the dab stock in 27.22-32. Input data were commercial catch (landings and discards) from 2002 to 2023 and the improved BITS biomass index Q1 and Q4 from the delta GAM model survey index.
   No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios F/F_{MSY} and B/B_{MSY} were used to estimate stock status relative to the MSY reference points and are used in the catch catch scenarios. A short-term forecast was conducted assuming Fsq.
   Bpa and Blim are defined as 50%BMSY and 30%BMSY respectively. Flim is defined as 1.7 FMSY and is the F that drives the stock to Blim assuming Blim=30%BMSY.
5) Consistency: Assessment results confirm the results of the previously conducted LBI assessment and the stock biomass trend indicator from the BITS results. Retrospective analysis of the SPiCT data series indicate a consistent pattern in catch-es and survey indices
6) Stock status:
   The results of the assessment are stating a good status of the stock, where F is below F_{MSY} and B above $B_{trigger}$
   Dab in the Baltic Sea are experiencing changing environmental condition. A combination of decreasing inhabitable areas, foraging grounds and food availability due to oxygen depletion in deeper basins, higher water temperatures and increasing stock

biomass resulted in drastically decreasing dab condition since 2015.

7) Management plan:
Bycatch of this species is not considered in the EU Multiannual Plan for the Baltic Sea

General comments

The report is This was a well-documented,well ordered and considered section. It was easy to follow and interpret.

Technical comments

Discard estimates are available from Denmark and Germany since 2012, covering the main fishing areas in SD 22 and Sd 24.

Discards of dab are known to vary greatly with ratios around 30–80% of the total catch of vessels using active gears.

Conclusions

The assessment has been performed correctly. Stock separation between dab in 27.2232 and dab in the Kattegat may be evaluated

(Single tables or figures can be added in the text, longer texts should be added as annexes.)

Audit of Brill (*Scophthalmus rhombus*) in subdivisions 22-32 (Baltic Sea), bll.27.22-32

Date: 23.04.2024

Format for audits (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, WGBFAS, 16 – 23.04.2024

Reviewer: Tomas Zolubas

Expert group Chair: Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General

ICES has not requested to provide advice on fishing opportunities for this stock. Information on stock status has been provided.

For single-stock summary sheet advice

Stock bll.27.22-32

Short description of the assessment as follows:

8) Assessment type: Stock status update
9) Assessment: Accepted
10) Forecast: Not presented since ICES has not been requested to provide fishing opportunities for this stock
11) Assessment model: Survey trends.
12) Consistency: NA
13) Stock status: Stable index with low fluctuations.
14) Management plan: Bycatch of this species is considered in an EU multiannual plan for Baltic Sea stocks.

General comments

The stock status update is performed according to the stock annex. Easy to follow and interpret.

Technical comments

In 2024 stock index was area corrected.

Conclusions

The assessment has been performed correctly.

Audit of Flounder in Sub-divisions 27, 29-32 (bwp.2729-32)

Format for audits (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, (WGBFAS, 2024, 16-23 April)

Reviewers: Didzis Ustups, Rebeka Tetere

Expert group Chair: Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General

- ICES has not been requested to provide advice on fishing opportunities for this stock for 2023.
- Two flounder species occur in the Baltic Sea, European flounder P. flesus and Baltic flounder P. solemdali. The predominant flounder species in this area is the Baltic flounder, however mixing occurs between these two species in the catches. The species can be identified with genetic methods or gamete physiology, but not from appearance.

For single-stock summary sheet advice

Stock: bwp.2729-32 (Baltic flounder in SD 2729-32)

Short description of the assessment as follows:

1. Assessment type: update
2. Assessment: accepted
3. Forecast: not presented
4. Assessment model: Length-based Indicators used as a proxy for exploitation.
5. Consistency: Assessment is consistent with previous assessment
6. Stock status: Fishing pressure on the stock is below the FMSY proxy. No reference points for stock size have been defined for this stock.
7. Management plan: The EU multiannual plan for the Baltic Sea (EU, 2016, 2019) applies to bycatches of this stock taken when fishing for the target stocks described in the plan.

General comments

Overall, this section was well-prepared, organized, and carefully considered. Two flounder stocks have been upgraded to Category 2, and the third one is being considered for upgrade pending a benchmark assessment. The available data suggests that the SPiCT model can most likely be applied to this stock as well.

Technical comments

No comments

Conclusions

The assessment has been performed correctly.

Audit of Flounder in Subdivisions 22 and 23

Date: 22 April 2024

Review of ICES Scientific Report, WGBFAS 16-23.04-2023

Reviewers: Nicolas Goñi, Jukka Pönni

Expert group Chair: Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General

- The stock has been upgraded from category 3 to category 2 after the benchmark done in 2024. The stock assessment is now done through a stochastic production model in continuous time (SPiCT), using a model-based approach to calculate an index of exploitable biomass (referred to as "Bergdex" in the assessment report).

For single-stock summary sheet advice

Stock: fle.27.22-23 (Flounder in SD 22-23)

Short description of the assessment as follows:

15) Assessment type: first assessment after benchmark
16) Assessment: accepted
17) Forecast: presented under the assumption of F_{sq}.
18) Assessment model: stochastic production model in continuous time (SPiCT), with the improved BITS biomass index of quarters 1 and 4 from the delta GAM model survey index
19) Data issue: none
20) Consistency: not applying
21) Stock status: according to assessment, the stock status is good, with F below F_{MSY} and B above $B_{trigger}$
22) Management plan: not applying

General comments

This was a well-documented, well ordered and considered section. Easy to follow and interpret.

Technical comments

The working group recommends extending this stock to SD 21, based on survey data, life-history parameters and genetics. This extension would make the stock similarly managed as plaice (SD 21-23 stock) and sole (SD 20-24 stock), for which the merging was based on similar analyses.

Conclusions

The assessment was performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? **YES**
- Is the assessment according to the stock annex description? **YES**
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? **NA**
- Have the data been used as specified in the stock annex? **YES**

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **NA**
- Is there any **major** reason to deviate from the standard procedure for this stock? **NO**
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **YES**

Audit for Flounder in Sub-divisions 27.24-25 (bzq.27.2425)

Review of ICES Scientific Report, (WGBFAS_ 16-23.04-2024)
Reviewers: Uwe Krumme and Tiit Raid

Expert group Chair: K. Hommik

Secretariat representative: R. Fernandez

General

This was a well-documented, well ordered and considered section.
It was easy to follow and interpret.

ICES has not been requested to provide advice on fishing opportunities for this stock.
The assessment has been conducted according to the stock annex.

Stock has been benchmarked in 2014.

For single-stock summary sheet advice

Stock Flounder in Sub-divisions 27.24-25 (bzq.27.2425)

Short description of the assessment as follows (examples in grey text):

1) Assessment type: Update assessment.
2) Assessment: Accepted
3) Forecast: Not presented since ICES has not been requested to provide fishing opportunities for this stock.
4) Assessment model: This is a category 3 stock. A length-based indicator method (LBI) using catch data from commercial samplings and abundance estimates from Baltic International Trawl Survey (BITS – Q1 (G2916) and BITS Q4 (G8863) to assess the stock status.
   F_{MSY} proxy
5) Consistency: Consistent with previous assessment
6) Stpck status: Stock exploitation status is assessed in relation to F_{MSY} proxy (relative value from LBI analysis, assuming M/K = 1.5. LF=M is based on Lc (length at 50% of modal abundance), which varies each year. Fishing pressure on the stock is below the F_{MSY} proxy.
   The stock size indicator (combined biomass index (kg h−1) of flounder ≥ 20 cm from the Baltic International Trawl Survey (BITS Q1 and Q4)), shows that stock size has decreased from historical highs since 2016 but started to increase again in 2022-2023.
7) Management plan:
   Bycatch of this species is considered in the EU Multiannual Plan for the Baltic Sea

General comments

Two flounder species are present in the management area. The proportion of European flounder (*Platichthys flesus*) and Baltic flounder (*Platichthys solemdali*) in this management area were estimated at approximately 85% and 15% respectively. However, the it is not feasible to separate the proportions of the two species in neither the stock assessment nor the fisheries.

Technical comments

Data are available as described in the stock annex. The level of length sampling from the fishery looks adequate to provide a reliable length-based indicator of flounder exploitation.

Discard information is available since 2014 and included in the assessment. Discarding seem to be decreasing since 2020 but discard values are still highly uncertain.

Since 2016 pelagic trawlers fishing in Subdivisions 24, 25, and 26 have reported landings of flounder in Poland (between 155 and 3649 tonnes). These catches are suspected to be misreported sprat and herring but have so far not been included in the flounder, central Baltic herring or Baltic sprat assessments. Analyses to validate these landings are needed in order to clarify the potential scale of misreporting.

Conclusions

The assessment has been performed correctly.

Audit for Flounder in Sub-divisions 27.26-28 (bzq.27.2628)

Review of ICES Scientific Report, (WGBFAS_ 16-23.04-2024)
Date: 07.05.2024

Reviewers: Tiit Raid, Ivars Putnis

Expert group Chair: K. Hommik

Secretariat representative: R. Fernandez

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
ICES has not been requested to provide advice on fishing opportunities for this stock for 2025 or 2026. The assessment has been conducted according to the stock annex. The stock has been benchmarked in 2024.

Stock **Flounder in Sub-divisions 27.26-28 (bzq.27.2628)**

Short description of the assessment as follows (examples in grey text):

1. Assessment type: Update assessment
2. Assessment: Accepted
3. Forecast: Not presented
4. Assessment model: After the benchmark in 2024, the stock was upgraded from Category 3 to Category 2, and the stock assessment method was changed from LBI (length-based indicator) to surplus production model (SPiCT) that uses landings in the model. Commercial landings and survey data from the Baltic International Trawl Survey BITS – Q1 [G2916], BITS–Q4 [G8863]) were used as input information. The following relative reference points are now defined for this stock: $MSYB_{trigger}$, F_{MSY}, B_{lim} and F_{lim}.
5. Consistency: Due to a change in the assessment model, the assessment is not consistent with the previous assessment.
6. Stock status: Fishing pressure on the stock is below F_{MSY}, and the spawning stock size is above MSY $B_{trigger}$ and B_{lim}.
7. Management plan: The EU multiannual plan for the Baltic Sea applies to by-catches of this stock taken when fishing for the target stocks described in the plan.

General comments
Two flounder species are present in the management area. The proportions of European flounder (*Platichthys flesus*) and Baltic flounder (*Platichthys solemdali*) in this management area were estimated at approximately 45% and 55%, respectively. However, it is not possible at this stage to separate the proportions of the two species in either the stock assessment or the fisheries.

Technical comments
Discard estimates, available from 2015 to 2020, show a strong year effect and remain uncertain. No estimates were available for 2021-2023 (partly probably due to COVID-19 restrictions and partly due to missing information from the Russian Federation). Therefore, only landing estimates are available for these years. No information on Russian Federation landings for 2022 and 2023 was officially reported to ICES.

Conclusions
The assessment has been performed correctly.

Audit of Herring (*Clupea harengus*) in subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea), her. 27.25-2932

Date: 02.05.2024

Format for audits (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, (*WGBFAS 2024 16-24 April 2024*)

Reviewers: **Olavi Kaljuste, David Gilljam**

Expert group Chair: **Kristiina Hommik**

Secretariat representative: Ruth Fernandez

Audience to write for: ADG, ACOM, benchmark groups and WGBFAS

General
The assessment has been conducted according to the stock annex as an update assessment. Some catch data (<1% of the total catches were not delivered at the time of the working group. This was deemed to have a negligible impact on the quality of the assessment. This stock has been benchmarked in 2023, which resulted in a new assessment model, updated maturity, and natural mortality estimates. To account for uncertainty in natural mortality it was agreed that an ensemble of three models would be used to estimate stock status and forecast.

For single-stock summary sheet advice
Stock **Her.27.25-2932**
Short description of the assessment as follows (examples in grey text):

1) Assessment type: **Update**
2) Assessment: **Accepted**
3) Forecast: **Accepted**
4) Assessment model: **XSA + tuning with one acoustic survey index (BIAS A1588)**
5) Consistency: **The 2022 assessment is consistent with 2021 assessment and was accepted both years.**
6) Stock status: B< MSY Btrigger and Bpa< B <Blim. since 2020, F>FMSY and Fpa<F<Flim, R is below the average recruitment of age 1 of the whole time series
7) Management plan: This stock is shared between the EU and Russia. An EU multi-annual plan (MAP) in place for stocks in the Baltic Sea includes herring (EU, 2016, 2019). The advice, based on the FMSY ranges used in the management plan, is considered precautionary. Russia does not have a management plan for this stock.

General comments:

The report was well documented, describing the stock and the assessment in an exhaustive and clear way.

Technical comments (FV)

No technical issues. The advice is appropriate.

Conclusions

(Single tables or figures can be added in the text, longer texts should be added as annexes.)

The assessment has been performed correctly

Audit of Herring (*Clupea harengus*) in Subdivision 28.1 (Gulf of Riga), her.27.28

Date: 27.04.2024

Review of ICES Scientific Report, WGBFAS 2024 16-23 April
Reviewers: Szymon Smoliński, Olavi Kaljuste

Expert group Chair: Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General

The assessment has been conducted according to the stock annex as an updated assessment. Data is available and seems correct as do the reflections of the data in the report (figures and tables).

For single-stock summary sheet advice

Stock **her.27.28 (Herring in SD 28.1 Gulf of Riga)**

Short description of the assessment as follows:

1) Assessment type: update
2) Assessment: accepted analytical (category 1)
3) Forecast: presented and accepted
4) Assessment model: state-space assessment model SAM – tuning by 1 acoustic survey index
5) Consistency: The assessment is consistent with the benchmark 2023 assessment (setup and assumptions). Compared to last year's assessment, the spawning stock biomass was downscaled and fishing mortality upscaled. This results from the downscaling of younger ages in the acoustics by the model which in turn leads to downscaling of stock numbers at age for ages 0-3 for recent years The last year's recruitment (age 0) estimate is uncertain, as this is based on only information on the catches. The abundance of age 0 in the catches is not only dependent on the year-class strength but is also influenced by other factors, such as growth and fishery behavior. For these reasons, it was decided at the WGBFAS meeting that for the forecast process, the final year recruitment estimate is substituted with a median recruitment estimate from the period 1989– 2022, as in the last year's assessment.
6) Stock status: SSB is well above MSY Btrigger, Bpa and Blim, F is below Fmsy and well below Fpa and Flim
7) Management plan: The EU multiannual plan (MAP) in place for stocks in the Baltic Sea includes herring. The advice based on the FMSY ranges used in the management plan is considered precautionary

General comments

This was a well-documented, well-ordered, and considered section. It was easy to follow and interpret.

Technical comments

The advice is appropriate.

Conclusions

The assessment has been performed correctly.

Audit of Herring in the Gulf of Bothnia (her.27.3031)

Date: 27.04.2024
Auditors: S. Haase, I. Putnis

Audience to write for: ADG, ACOM, benchmark groups and EG next year.

General

The assessment has been conducted as an update assessment following the benchmark in early 2021, where the assessment type was updated to category 1. The main features of the stock as changes in age composition, growth and maturity are well captured by the Stock Synthesis model now applied as assessment model to this stock since 2021. During WGBFAS it was decided to re-estimate reference points as these are considered as not appropriate after initiated analyses during the WKNEWREF. Advice is postponed to the end of August and the new reference points will be reviewed externally.

For single stock summary sheet advice:

1) **Assessment type:** Update assessment
2) **Assessment**: age-based analytical and fully stochastic model analytical (SS3)
3) **Forecast**:
4) **Assessment model**: Stock Synthesis (SS3) – fitted to 2 abundance indices (one acoustic survey (BIAS, A1588: 2007-2023) and one historic commercial trapnet survey (1990-2006)). Annual maturity data from Finnish commercial trawl catches before spawning; age-specific natural mortalities, constant through time. Discards are included but considered negligible. Model starts in 1963 and uses 20+ internal age-classes.
5) **Data issues:** Mean weight at age has been now at low levels for 15 years, but slightly increased in 2022 and 2023. In addition, the present low state of the body condition of larger herring has not improved.
6) **Consistency**: in early 2021 upgraded to category 1, before that category 5. The 2024 assessment is consistent with 2022 assessment and was accepted.
7) **Stock status**:
8) **Management Plan**: EU multiannual plan (MAP) is in place for stocks in the Baltic Sea (EU, 2016).

General comments:
The report was well documented, describing the SS3 assessment in a clear way.

Technical comments:
No specific comments.

Conclusions
The assessment has been performed correctly. As the reference points will be re-estimated, no advice I given at this point.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? **No**

- Is the assessment according to the stock annex description? **Yes**

- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? **Yes**

- Have the data been used as specified in the stock annex? **Yes**

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **Forecast model will be applied until the end of August. Assessment followed the stock annex.**

- Is there any **major** reason to deviate from the standard procedure for this stock? **Yes, reference points will be re-estimated as they are not considered as appropriate anymore.**

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **Advice postponed until the end of August.**

Audit of Plaice in Sub-divisions 27.21-23

Date: 26 April 2024

Review of ICES Scientific Report, WGBFAS 16-23.04-2024
Reviewers: Jan Horbowy, Stefan Neuenfeldt

Expert group Chair: Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General
Recommendations, general remarks for expert groups, etc.
Stock: ple.27.21-23 (Plaice in SD 21-23)

Short description of the assessment:

1. **Assessment type:** update
2. **Assessment**: accepted
3. **Forecast**: accepted, based on MSY, Fsq assumed in intermediate year
4. **Assessment model**: Age-based analytical assessment with SAM; for tuning two combined surveys indices have been used, both combine Baltic and NS surveys in 1st and 3rd - 4th quarter. The surveys have been combined into indexes applying GAMs.
5. **Consistency**: The 2024 assessment is quite consistent with assessments from 2023 and was accepted. Retrospective analysis indicates Mohn's rho estimate of 2% for the SSB and 5% for F
6. **Stock status**: SSB is well above all biomass reference points. Fishing mortality (F) declined below F_{MSY} in 2021 and was low in 2023. The year classes 2019 - 2022 are estimated very strong.
7. **Management Plan**: The EU Multiannual Plan for the Baltic Sea (EU, 2016) takes bycatch of this species into account.

General comments
This is a well-documented, easy to follow and interpret section.

The assessment and forecast have been conducted generally following procedure agreed at benchmark in 2015 and updated in 2019 with a few justified deviations.

Since 2019 weights in the stock have been strongly declining (density-dependent effects ?) and yearly weights were used in assessment and predictions instead of averages over 1999-2019. Such deviation from stock annex.is justified by recent dynamics in stock weights.

As in previous assessments the 2019 combined survey index from 3rd&4th quarter was excluded when fitting GAMs for indices and tuning the assessment; that was accepted by previous ADGs. These survey indices were very low in 2019 and potential explanation was abnormally low oxygen conditions in 2019, however, later project did not confirm major effect of oxygen conditions on survey catchability of plaice in the considered area.

Technical comments
No specific comments.

Conclusions
The assessment and forecast have been performed correctly.

Audit of Plaice in Subdivisions 24-32

Date: 26 April 2024
Review of ICES Scientific Report, WGBFAS 16-23.04-2024
Reviewers: Stefanie Haase, Szymon Smoliński

Expert group Chair: Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General

- Advice for the stock has changed from a precautionary approach to an MSY approach. The assessment is run in SPiCT.

For single-stock summary sheet advice
Stock: ple.27.24-32 (Plaice in SD 24-32)

Short description of the assessment as follows:

1) Assessment type: Surplus Production model, reviewed in 2022
2) Assessment: accepted
3) Forecast: presented, based on MSY
4) Assessment model: Surplus Production model in Continuous Time (SPiCT; ICES, 2022)
5) Consistency: A new assessment approach and change from category 3 to category 2 in 2022. The assessment is consistent with last year's advice.
6) Stock status: B > MSY $B_{trigger}$, F < F_{msy}
7) Management plan: The EU multiannual plan for the Baltic Sea (EU, 2016, 2019) applies to bycatches of this stock taken when fishing for the target stocks described in the plan

General comments
In general, this was a well-documented, well ordered and considered section. The stock will be undergoing a benchmark in 2024.

Technical comments
NA
Conclusions
NA

Audit of tur.27.22-32 (Turbot in SD 22-32)

Date: 23 April 2024

Review of ICES Scientific Report, WGBFAS, 16-23. 04.2024

Reviewers: Jari Raitaniemi, Tomas Zolubas

Expert group Chair: Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General

ICES has not been requested to provide advice on fishing opportunities for this stock for 2025.

For single-stock summary sheet advice: An update advice was last given in 2021.

Stock tur.27.22-32 (Turbot in SD 22-32)

Short description of the assessment as follows:

1) Assessment type: An update advice was last given in 2021, benchmarked in 2024.
2) Assessment: An update of stock status in the report
3) Forecast: not presented
4) Assessment model: Landings and survey trends, calculation of survey index with a delta GAM model-based approach
5) Consistency: An update advice was last given in 2021. After benchmark in 2024, annual length-weight relationships were used in the new GAM model instead of earlier fixed relationship. The new survey index increases slightly the trend when compared with the earlier one.
6) Stock status: The length-based indicator is stating an unsustainable stock status. This is however un an uncertain result, as the length distribution gained from the poor sampling might not reflect the actual length distribution of the stock.
7) Management plan: Bycatch of this species is considered in the EU multi-annual plan for Baltic Sea.

General comments:

Poor sampling from commercial catches causes uncertainty in the assessment.

In general, this was a well-documented, well ordered and considered section.

Technical comments:

Figure 8.2.6 missing from the report in 23 Apr.

Conclusions:

NA

Audit of sol.27.20-24 (Sole in SD 20-24)

Review of ICES Scientific Report, WGBFAS 2024, 16-23 April 2024

Reviewers: Julita Gutkowska, Zuzanna Mirny-Krystkiewicz

Expert group Chair: Kristiina Hommik

Secretariat representatives: Ruth Fernandez

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
The assessment has been conducted according to the stock annex as an update assessment.

For single-stock summary sheet advice
Stock **sol.27.20-24**

Short description of the assessment as follows:

1) **Assessment type:** update
2) **Assessment:** accepted
3) **Forecast:** accepted
4) **Assessment model:** Age-based analytical stochastic assessment (SAM) that uses landings only in the model. Discards are included in the forecast.
5) **Input data:** Commercial catches (international landings, ages and length frequencies from catch sampling), one survey index (Fishermen–DTU Aqua sole survey, 2004–2023, [G4052]), two commercial indices: (private logbooks, gillnetters (1994–2007), private logbooks trawlers (1987–2008)); fixed maturity and fixed natural mortality (0.1) for all age groups
6) **Consistency:** The assessment of recent years including the 2022 assessment has been accepted. This year's assessment is conducted as in previous years and in accordance with the procedure described in the stock annex.
7) **Stock status:** Fishing pressure on the stock is below F_{MSY} and spawning-stock size is below MSY $B_{trigger}$, and between B_{pa} and B_{lim}.
8) **Management plan:** EU multiannual plan (MAP) for stocks in the North Sea. The plan specifies conditions for setting fishing opportunities depending on stock status and making use of the F_{MSY} range for the stock. ICES considers that the F_{MSY} range for this stock used in the MAP is precaution nary.

General comments
There were some comments to the advice sheet and the report. They were forwarded to the stock assessor.

Technical comments
Conclusions
The assessment was performed correctly.

Audit of spr.27.22-32 (Sprat in SD 22-32)

Review of ICES Scientific Report, WGBFAS 16-23.04-2024
Reviewers: Nicolas Goñi, Stefan Neuenfeldt

Expert group Chair: Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General
- The stock was benchmarked in 2023 at WKBBALTPEL and is now assessed with SAM.
- Four abundance indices derived from BIAS survey are used, two of them include SD32.
- The group underlined the record low recruitment estimate for 2024, following two years of second and third lowest recruitment respectively.

For single-stock summary sheet advice

Stock: Spr.27.22-32 (sprat in SD 22 to 32)

1) Assessment type: update (second assessment after benchmark)
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SAM, since WKBBALTPEL benchmark in 2023
5) Data issues: missing catch data from Russia were completed according to the information available on the *atlantniro* webpage
6) Consistency: The assessment of recent years including the 2023 assessment have been accepted. SSB and F values from the last two assessments (done with SAM) are very similar
7) Stock status: B > B_{pa} but F still slightly > F_{pa}. The abundance of age-0 class was record low in 2023, the last good recruitment occurred in 2020.
8) Management plan: EU Baltic multiannual plan

General comments
This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments
- Predation mortality estimates (M2) were assumed equal to 2022 and 2021 values, the 2021 values being obtained from the SMS model
- Within-cohort consistency of the acoustic indices (correlations between the survey index values of a given age in year y and of the same generation in year y+1) was high
- Within-year consistency of the acoustic indices (May vs October) was good except for age 4
- The residuals are OK except for the youngest age class that displays a temporal pattern in two of the four acoustic indices
- The retrospective estimates show a pattern of slight overestimation for SSB and slight underestimation for F, but the Mohn's rho values are very good

Conclusions
The assessment was performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?

Yes

- Is the assessment according to the stock annex description?

Yes

- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?

Yes

- Have the data been used as specified in the stock annex?

Yes

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

Yes

- Is there any major reason to deviate from the standard procedure for this stock?

No

- Does the assessment give a valid basis for advice?

Yes

Annex 4: Updated stock annexes

The table below provides an overview of the WGBFAS Stock Annexes. Stock Annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the year, ecoregion, species, and acronym of the relevant ICES expert group.

Name	DOI
cod 27.24-32	ICES. 2024. Stock Annex: Cod (Gadus morhua) in Subdivisions 24–32, eastern Baltic stock. ICES Stock Annexes. 22 pp. https://doi.org/10.17895/ices.pub.25930969
dab.27.22-3	ICES. 2024. Stock Annex: Dab (*Limanda limanda*) in subdivisions 22-32 (Baltic Sea) ICES Stock Annexes. 13 pp. https://doi.org/10.17895/ices.pub.25933558
fle27.2223	ICES. 2024. Stock Annex: Flounder (Platichthys flesus) in Subdivision 22 and 23 (Belt Seas the Sound). ICES Stock Annexes 12 pp. https://doi.org/10.17895/ices.pub.25933141

Annex 5: Working Documents

WD1: Unallocated flounder landings in SubDivisions 24 and 25 in Poland sprat fishery

Unallocated flounder landings in SubDivisions 24 and 25 in Poland sprat fishery

Notes about relatively large amounts of flounder from SD2425 landed in the sprat fishery of Poland in recent years.

- Is the flounder reported by the sprat fishery really flounder? Most likely not all of them are flounder. If not, the amounts should be assigned to sprat, herring and flounder and added to the respective stocks.
- This could be as OTM metier in the herring and sprat fisheries.
- Largest "FlatSprat" landings occurred in SD 25 in second quarter.

The group agreed to request the following analyses from Poland:

1. Histogram on % weight contribution of flounder in total catch of fishing trips targeting pelagic fish (sprat and herring) since 2010 (if possible). Histograms by year and maybe quarter and subdivision (SD24, SD25)
2. Threshold to be decided based on Polish observer data from the pelagic fleet from 2010 – 2019, e.g., 95 percentiles defined based on the distribution of % weight contribution of flounder in total catch.
3. Comparison of the period 2010-2015 and 2016-2023 (period with EU rule allowing larger bycatches in pelagic fisheries) to identify a threshold of "natural" flounder bycatches in the pelagic fishery in Poland.
4. When threshold has been decided, the fake flounder needs to be divided in sprat and herring with the same proportion as reported in the same trip.
5. The rest of the flounder will be uploaded as flounder per area.
6. Deadline 15 November 2024.

WD2: Review and update of the stock definition of flounder in the Belt Seas and the Sound (fle.27.22-23) and North Sea flounder (fle.27.3a4). Sven Stötera and Holger Haslob

Survey Index Calculations for flounder in the Baltic

Survey indices of exploitable stock biomass (20 cm+) are calculated using the methodology similar to what is described in Berg and Kristensen (2014), that is a Delta-Lognormal model which consists of a binomial presence/absence model and a lognormal model for strictly positive responses. Once the parameters in the model are estimated, a standardized survey index is obtained by predicting and adding up the abundances in a fine meshed grid of points that is the same in all years. This can be thought of as performing a virtual experiment where the experimental conditions such as the haul positions, gear type etc. are exactly the same in each year.

The observed exploitable stock biomass is calculated from observed numbers-at-length and a length-weight model with time-varying coefficients (because there has been some significant changes in the LW relationship over time for flounder).

The model has the following formula (in R syntax) for both the presence/absence and the positive part.

```
Year*Quarter + s(sqrt(Depth),k=5,bs='ds',m=c(1,0),by=Quarter) + Gear +
s(Ship,bs='re')   +   s(lon,lat,bs='ds',m=c(1,0.5),k=80,by=Quarter)   +
s(lon,lat,bs='ds',m=c(1,0.5),by=YearQ,k=6,id=1) + offset(log(HaulDur))
```

where “YearQ” is a factor for each combination of year and quarter.

In this formulation there are independent parameters estimated for each combination of year and quarter (no smoothing across time which would violate the assumption of independent errors in SPiCT).

The different survey gears in the BITS data are accounted for by the Gear effect in the model. All BITS data (Q1 and Q4) and IBTS Q1 data from ICES subareas 21-23 are used to fit the model.

This was done in order to get as much data and spatio-temporal overlap between between the different gear types as possible to reliably estimate conversion factors. The robustness of the model estimates before the gear was standardized (year 2000) was checked by leaving one of the gear types out and re-estimating the model (see figure). The model estimates were robust (within the confidence bounds for the base run).

Leave-one-gear-out sensitivity runs.

References

Casper W Berg, Anders Nielsen, and Kasper Kristensen. *Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models*. Fisheries Research, 151:91–99, 2014.

Kasper Kristensen and Casper W. Berg. *Datras package for R*. https://github.com/DTUAqua/DATRAS, 2012.

WD3: A proposal for new reference points for the Gulf of Bothnia herring

David Gilljam[1], Nicolas Goñi[2], Jari Raitaniemi[2] & Massimiliano Cardinale[1]

[1] Swedish University of Agricultural Sciences, Department of Aquatic Resources (SLU Aqua)

[2] Natural Resources Institute Finland (LUKE)

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Summary

Considering the development of the Gulf of Bothnia (GoB) herring spawning biomass and fishing mortality, WGBFAS raised the concern that the current F_{MSY} is set too high, and it was decided during the WGBFAS 2024 meeting that the current reference points should be reinvestigated. In this analysis, we report the analyses performed following the WGBFAS meeting on the reference points for the GoB herring and provide proposed new values which can be used for providing catch advice in the fall of 2024. A Management Strategy Evaluation (MSE) approach was used to determine the target and trigger reference points to be used to provide advice. Two objectives must be met by the harvest control rule (HCR) selected; (1) the probability of the median long-term SSB to fall below B_{lim} in any single year should be less than 5 %, and (2), conditional on objective (1), long-term yield should be maximised. In addition, F_{target} should be lower than the current F_{MSY}, as this was the basis for the reinvestigation. The MSE showed that the HCR with a F_{target} that leads to a long-term spawning biomass that is 50% of the unexploited spawning biomass at current conditions, in combination with a biomass trigger (MSY $B_{trigger}$) where fishing is reduced at the same spawning biomass level, fulfils objectives (1) while maximising long-term yield (objective (2)). The resulting F_{MSY} (0.218) and MSY $B_{trigger}$ (613 355 tonnes) values are 20 % and 15 % lower and higher, respectively, compared to the current reference points. These new proposed reference points will result in lower catch advice because of a lower F_{MSY} and an earlier activation of reduced F advice due to a higher MSY $B_{trigger}$.

Background

Current stock status/situation

The Gulf of Bothnia (GoB; ICES SD 30-31) herring spawning stock biomass (SSB) has decreased since the middle of the 1990s. It is now estimated to be at the current MSY $B_{trigger}$ (SSB_{2024} = 539 609 tonnes, current MSY $B_{trigger}$ = 533 515 tonnes), even though fishing mortality (F) is estimated to be well below the current F_{MSY} (F_{2023} = 0.160; current F_{MSY} = 0.271) and it has been so for the entire time-series (Fig. 1, WGBFAS 2024).

Figure 1. Herring in SD's 30 and 31. Catch, estimated recruitment, fishing mortality (F) and spawning-stock biomass (SSB) with confidence intervals (90%, shaded bands. Horisontal blue lines show the current F_{MSY} and MSY $B_{trigger}$, respectively.

Considering the development of SSB and F, WGBFAS raised the concern that the current F_{MSY} is set too high, and it was consequently decided during the WGBFAS 2024 meeting that the current reference points for Gulf of Bothnia herring should be recalculated (WGBFAS 2024). This concern was

also raised at last year's ADG meeting, and the stock was added to the list of stocks to be analysed during WKNEWREF. WKNEWREF was however not finished in time for WGBFAS 2024 and the reference point analyses for GoB herring was not completed for WGBFAS.

In this analysis, we report the continued and finalised work on the reference points for the GoB herring, which can be used for providing catch advice for 2025 in the fall of 2024.

History of Gulf of Bothnia herring reference points

The main trait of the GoB herring stock dynamics is the absence of a strong relationship between spawning stock biomass and recruitment, as well as the absence of indication of past or present impaired recruitment. This generates difficulties in the estimation of the base reference point B_{lim} i.e. the spawning stock biomass under which the recruitment is impaired. Furthermore, from an oceanographic perspective, the GoB is a remote gulf to which the flow of Atlantic waters – and therefore the salinity and concentration of critical elements such as iodine – can be very variable depending on atmospheric conditions, which affects the carrying capacity of the ecosystem, and consequently the life history traits of herring.

In this context, the estimation of reference points for the GoB herring has always been challenging, in comparison with Atlantic stock displaying clear indications for the estimation of B_{lim}. This partly explains the previous changes in the estimates of B_{lim} and F_{MSY}, and their magnitude (Table 1):

Table 1. Reference points of the GoB herring in the last decade.

	Pre 2017	**2017 - 2021**	**2021-2024 (current)**
F_{MSY}	0.15	0.21	0.271
B_{lim}	not defined	202 272	376 571
B_{pa}	not defined	283 180	533 515
$B_{trigger}$	316 000	283 180	533 515

Attempts to recalculate reference points in WKNEWREF

In the framework of ICES-WKNEWREF we tried to recalculate B_{lim} using the different approaches in the scripts provided at the beginning of the workshop: segmented regression, B_{lim} as proportion of B_0, and empirical definition of B_{lim}. Additionally, due to differences in data quality and reliability between the years 1963-1973, 1974-1979 and 1980-present, three different runs were made for each approach, with the series starting in 1963, 1974 and 1980, respectively.

The results differed according to the years considered but differed more according to the method used, ranging from 38% to 195% of the B_{lim} value in use so far. Additionally, when using the function srrTMB() in the segmented regression, the breakpoint was much lower than B_{loss}, whereas when using the function eqsr_fit(), this breakpoint was much higher than B_{loss}. Also, if using a 'standard' deterministic segmented regression model (R package "segmented", setting starting values for breakpoint estimation), the breakpoint estimates displayed wide variations depending on the starting value.

Regarding F_{MSY}, the segmented regression model using the whole data series was giving a value of 0.068 i.e. 25% of the F_{MSY} in use so far. Using the empirical B_{lim}, the FMSY was estimated at 0.0305 i.e. 11.2% of current FMSY. Both estimates were implausibly low and not in line with the history of the stock.

Due to the lack of convergence or implausibility of the estimates depending on the method used, it was not possible to deliver new estimates of reference points after the WKNEWREF, and the alternative option chosen was Management Strategy Evaluation, taking the F_{MSY} in use so far as an upper limit.

Methods

Dynamic B_0, B_{loss}, B_{pa} & B_{lim}

The carrying capacity of the stock in terms of spawning stock biomass, defined here as B_0, was estimated by the stock assessment model as the unfished SSB at current conditions (Dynamic B_0, Bessel-Brown *et al*., 2022), calculated using the biology averaged over the last three years of the assessment. B_{loss}, B_{pa} and B_{lim} were estimated following ICES guidelines for a type 6 stock ("stocks with a narrow dynamic range of SSB, and no evidence that recruitment is or has been impaired"; (ICES 204b), that is, B_{loss} is set to the lowest observed SSB, $B_{pa} = B_{loss}$ and $B_{lim} = B_{pa} / \exp(1.645 * CV(SSB_{2023}))$. The estimated B_{lim} was cross-checked against B_0 to verify the corresponding level of depletion.

Management Strategy Evaluation

A Management Strategy Evaluation (MSE) was used to determine the target and trigger reference points to be used to provide advice for GoB herring.. The same methodology has been recently used to determine reference points for Northern shrimp in ICES division 3.a and 4.a East (ICES 2022a) and herring in ICES SDs 25-29, 32 excluding the Gulf of Riga (Central Baltic Sea; her.27.25-2932; ICES 2023). To this aim, we used the simulation-testing framework available in the Fisheries Library for R (FLR; Kell et al., 2007; https://flr-project.org/). The simulation framework was implemented in the FLR library `mse` (https://github.com/flr/mse) with `FLasher` (https://github.com/flr/FLasher) being used to carry out the forward projections. Reference points at equilibrium were calculated with `FLBRP` (https://github.com/flr/FLSRTMB). To facilitate customized reference point estimation and visualisation of F_{MSY} proxy (along with the true F_{MSY} estimated in a stochastic framework) (hereafter defined as F_{target}, which in this case was expressed as the F that brings the stock at a given fraction of B_0, i.e. FB%), B_{lim}, $F_{P.05}$ and $B_{trigger}$, we used the FLR package `FLRef` (https://github.com/henning-winker/FLRef).

Harvest control rules (HCRs) are kept generic and in the same form of the conventional ICES Advice Rule (ICES, 2021a), where the advice decreases from F_{target} to zero and from MSY $B_{trigger}$ to zero SSB. Variations of the tested HCRs are therefore determined by the parameters F_{target} and MSY $B_{trigger}$. The HCRs were implemented using a simulated feedback control loop between the implementation system and the operating model (OM), where the implementation system translates the assessment outcome via the HCR into the Total Allowable Catch (TAC) advice (Figure 2). The key difference to a simple stochastic risk simulation, such as EQsim, is that the simulated feedback control loop between the implementation system and the operating model allows accounting for the lag between the last year of data used in the assessment and the implementation year of TAC advice. In ICES, the implementation system of the HCR assumes that advice is given for year y+1 based on an assessment completed in year y, which is typically fitted to data up until year y-1 (ICES, 2020). Therefore, implementation of the TAC derived through HCR requires projection of the stock dynamics by way of a short-term forecast (Mildenberger et al., 2021). In contrast to a full Management Strategy Evaluation (MSE) simulation design (Punt et al., 2014), this MSE 'short-cut' approach (e.g. ICES, 2020b), omits the step of the annual updating of the estimation model (assessment) in the feedback control (Figure 2). Instead, it passes the 'true' age-structured dynamics from the OM (or with some assumed error) to the HCR implementation. The merits of a short-cut MSE approach include the incorporation of the lag effect between data, assessment, and management implementation. The limitation of the MSE short-cut approach is

that it cannot fully account for uncertainties resulting from imperfect sampling of the full age-structure (e.g. poorly sampled recruits).

Figure 2. Schematic illustrating the key processes of the short-cut approach to MSE, showing the operating model (OM) that simulates the fishery and the stock dynamics to the left and the implementation system including the short-term forecast on the right. The short-cut denotes the omission of the estimation (stock assessment) model that updates to new observations (with estimation error) in a conventional MSE implementations with full feedback control loop.

The operating models were implemented as single sex and single fleet models with an annual time step. Future projections were run over 58 years (i.e. 2024-2082) with 500 iterations, and based on the 3-years average of the most recent data years for weight-at-age, maturity-at-age . This choice was made to account for non-stationary processes in these quantities and to align the biology with the calculation of B_0 which is estimated as unexploited biomass at current conditions. The performance evaluations were based on the last 30 years of the total projection horizon (i.e. 2053-2082). For the simulation testing, stock and recruitment, steepness, sigma R and autocorrelation were set as equal to the one derived for the assessment model. The recruitment deviation is assumed to be associated with a first-order autocorrelation (AR1) process and a function of recruitment standard deviation σ and the AR1 coefficient ρ (Johnson et al., 2016) which are both estimated from the stock assessment model. Simulations included no implementation error.

In addition to the reference OM (from here on OM1; latest model accepted by WGBFAS in April 2024, using the settings described above) one alternative OM (OM2) was simulated. OM2 instead assumed a reduced productivity of the stock, with R_0 set as 80 % of R_0 from the reference model. Results from OM2 can be used to, e.g., test the sensitivity of the MSE performance to a potential reduction in recruitment of herring in the Gulf of Bothnia in the future.

Harvest control rules

The HCRs that were tested were the F_{target} that achieves a long-term SSB (B_{target}) that is 30, 35, 40, 45, 50, 51, 52, 53, 54 or 55 % of B_0, in combination with a MSY $B_{trigger}$ that is 60, 80 or 100 % of B_{target} ($F_{BX\%}.Y$, where X is the fraction of B_0 and Y is the fraction of B_{target}). In addition, the F_{target} that achieves the deterministic B_{MSY} was also tested ($F_{MSY.Y}$).

Performance Evaluation Criteria

The consistency tests were designed to identify the generic HCRs for specifying F_{target}, B_{target} and MSY $B_{trigger}$ according to stock-specific productivity that meet the following three main objectives:

1) The probability of median long-term SSB to fall below B_{lim} in any single year should be less than 5 % (Criteria 1).
2) Conditional on criteria 1, long-term yield should be maximised (Criteria 2).

Consistent with the objectives of ICES advice framework (ICES, 2024b), criteria 1 and 2 are interpreted hierarchically in that criteria 1 is the overriding objective of maintaining stock size above B_{lim} with at least 95% probability to be compliant with the ICES Precautionary Approach (PA). Conditional on criteria 1, criteria 2 is based on the ICES definition for using plausible values around Ftarget in the advice rule, which are derived so that they lead to no more than a 5% reduction of MSY obtained by fishing at F_{target} in the long term.

In addition F_{target} should be lower than the current F_{MSY}, as current F_{MSY} is deemed too high (the basis for this reinvestigation).

Results

B_0 (unfished SSB at current conditions) was estimated by the stock assessment model to be 1 226 710 tonnes. Following ICES guidelines for a type 6 stock, B_{loss} was set to 516 727 tonnes (the lowest observed SSB in the time-series) and B_{pa} was set equal to B_{loss}. B_{lim} was subsequently calculated to 389 938 tonnes (corresponding to 31.8% of B_0).

In total, 33 HCRs (10 x F_{target} and the deterministic F_{MSY}, in combination with 3 x MSY $B_{trigger}$) were evaluated (Methods).

With B_{lim} set to 389 938 tonnes, the MSE's reference operating model (OM1) shows that no harvest control rule (HCR) with a F_{target} that brings the stock to a long-term SSB less or equal to 40% of B_0 results in a F_{target} < current F_{MSY} ([0.271]; Table 2). Of the remaining HCRs, twelve cases meet the first criteria of a median probability of SSB to fall below B_{lim} lower than 5 % (in the interval of a F_{target} that leads to a SSB ranging from 50 to 55 % of B_0; Fig. 2, Table 2). Out of these twelve, the HCR F_{B501} (F_{target} = $F_{B50\%}$ and MSY $B_{trigger}$ set at 100 % of $B_{50\%}$) achieves the highest long-term yield (criteria 2, Fig. 2, Table 2). $F_{B50\%}$ equals 0.218 which corresponds to a B_{target} of 613 355 tonnes (50% of B_0). A MSY $B_{trigger}$ set at 100% of B_{target} then also equals 613 355 tonnes. The projected long-term median catch for this HCR is around 80 000 tonnes (Fig. 3). Realised long-term forward simulations of SSB, F, recruitment and catches for all HCRs is shown in Fig. 4).

Catches 5 % greater than catches at F_{target} are not precautionary, thereby limiting F_{upper} to $F_{B50\%}$. The HCR that closest matches F_{lower}, i.e. when catches are 5 % less than at F_{target}, is equal to F_{B531} (catch at F_{B531} is 0.708/0.743=0.952 times the catch at F_{B501}; Table 2), resulting in F_{lower} = 0.193 (Table 2).

F_{pa} is equal to F_{P05} which is capped at $F_{B50\%}$ as this is the F that leads to a level of SSB that is larger than B_{lim} with 95 % probability (i.e., F_{pa} = F_{P05} = $F_{B50\%}$ = 0.218).

All new reference points for the herring in the Gulf of Bothnia is summarised in Table 3.

The alternative operating model (OM2), exploring a scenario with reduced productivity of the stock (R_0 set as 80% of the R_0 used in OM1), illustrates the sensitivity of the system to, for example, a reduced future reproduction and is included in the report for comparison. In such a low productivity scenario, no HCR tested here meet performance evaluation criteria 1 (Fig. 3 in Appendix 2).

Table 2. Herring (*Clupea harengus*) in ICES Subdivisions 30 and 31 (Gulf of Bothnia). Detailed MSE performance results for the reference operating model (OM1). Harvest control rules (HCRs) are based on $F_{B\%}$ and MSY $B_{trigger}$ as fractions of B_0, where e.g. $F_{B55.6}$ equals the candidate scenario where F_{target} = $F_{B55\%}$ and MSY $B_{trigger}$ = 0.6 * $B_{55\%}$. Median columns show the probability of SSB to fall below B_{lim} in any year (P3(B<B_{lim}); criteria 1), median catches in relation to catches at the deterministic F_{MSY} (Catch/MSY; criteria 2), the average annual variation in catches (AAV), median SSB and F in relation to deterministic B_{MSY} and F_{MSY} (B/B_{MSY} and F/F_{MSY} respectively) and the probability of SSB to be above 80 % of the deterministic B_{MSY} in any year (B>80B_{MSY}). Orange cells show F_{target} >= current F_{MSY} [0.271]). Green P3(B<B_{lim}) cells show probabilities meeting criteria 1 (i.e. P < 0.05), where the scenario highlighted in bold text show the scenario meeting criteria 2 (highest median long-term catch; shaded from dark green [highest catch] to yellow [lowest catch]) conditional on criteria 1.

HCR	Btrigger	Ftarget	Median values					
			P3(B<Blim); (criteria 1)	Catch/MSY; (criteria 2)	AAV	F/Fmsy	B/Bmsy	B>80Bmsy
FB30.6	220808	0.505	0.676	0.899	0.188	0.753	1.106	0.846
FB30.8	294410	0.505	0.650	0.895	0.202	0.723	1.139	0.872
FB301	368013	0.505	0.604	0.889	0.218	0.686	1.186	0.910
FB35.6	257609	0.403	0.492	0.883	0.178	0.604	1.302	0.944
FB35.8	343479	0.403	0.456	0.880	0.191	0.581	1.332	0.964
FB351	429349	0.403	0.406	0.869	0.204	0.550	1.383	0.978
FB40.6	294410	0.326	0.312	0.854	0.168	0.490	1.490	0.992
FB40.8	392547	0.326	0.284	0.851	0.180	0.472	1.531	0.996
FB401	490684	0.326	0.244	0.840	0.194	0.447	1.579	1.000
FB45.6	331212	0.266	0.182	0.814	0.161	0.401	1.686	1.000
FB45.8	441616	0.266	0.162	0.812	0.174	0.388	1.719	1.000
FB451	552020	0.266	0.114	0.797	0.189	0.366	1.774	1.000
FB50.6	368013	0.218	0.084	0.765	0.157	0.330	1.879	1.000
FB50.8	490684	0.218	0.064	0.763	0.170	0.318	1.913	1.000
FB501	**613355**	**0.218**	**0.046**	**0.743**	**0.183**	**0.300**	**1.962**	**1.000**
FB51.6	375373	0.209	0.068	0.754	0.156	0.317	1.916	1.000
FB51.8	500498	0.209	0.056	0.752	0.170	0.306	1.950	1.000
FB511	625622	0.209	0.036	0.731	0.183	0.288	2.002	1.000

FB52.6	382734	0.201	0.056	0.743	0.157	0.305	1.953	1.000
FB52.8	510311	0.201	0.046	0.741	0.168	0.294	1.989	1.000
FB521	637889	0.201	0.032	0.718	0.183	0.277	2.041	1.000
FB53.6	390094	0.193	0.050	0.733	0.155	0.293	1.995	1.000
FB53.8	520125	0.193	0.038	0.732	0.167	0.283	2.028	1.000
FB531	650156	0.193	0.022	0.708	0.182	0.266	2.079	1.000
FB54.6	397454	0.186	0.044	0.721	0.155	0.281	2.035	1.000
FB54.8	529939	0.186	0.030	0.722	0.166	0.272	2.065	1.000
FB541	662423	0.186	0.018	0.696	0.181	0.256	2.116	1.000
FB55.6	404814	0.178	0.036	0.709	0.154	0.270	2.075	1.000
FB55.8	539752	0.178	0.028	0.708	0.165	0.261	2.102	1.000
FB551	674691	0.178	0.016	0.684	0.182	0.246	2.156	1.000
FMSY.6	186481	0.641	0.828	0.888	0.204	0.955	0.914	0.670
FMSY.8	248641	0.641	0.810	0.894	0.220	0.914	0.945	0.708
FMSY1	310801	0.641	0.772	0.891	0.240	0.861	0.993	0.754
advice	310801	0.641	0.772	0.891	0.240	0.861	0.993	0.754

Table 3. Herring (*Clupea harengus*) in ICES subdivisions 30 and31 (Gulf of Bothnia). Reference points, proposed new values and their technical basis. Weights are in tonnes. B_0 is the estimated unexploited spawning biomass at current conditions (average biological parameters for the last 3 years).

Reference point	Value	Technical basis
F_{MSY} (F_{target})	$F_{B50\%}$ = 0.218	Set as the F which will achieve 50% of B_0. Determined through MSE with the objective to achieve high sustainable yields without exceeding a 5% probability of SSB falling below B_{lim} in any single year.
F_{p05} with MSY $B_{trigger}$	$F_{B50\%}$ = 0.218	Determined through MSE. The F that leads to SSB ≥ B_{lim} with 95% probability. To be precautionary, this reference point can only be used with MSY $B_{trigger}$.
F_{pa}	$F_{B50\%}$ = 0.218	F_{p05} with MSY $B_{trigger}$
F_{lower}	$F_{B53\%}$ = 0.193	Determined through MSE, consistent with the ranges that result in no more than a 5% reduction in long-term yield compared to MSY.
F_{upper}	$F_{B50\%}$ = 0.218	Determined through MSE, consistent with the ranges that result in no more than a 5% increase in long-term yield compared to MSY. Capped to F_{p05}.
MSY $B_{trigger}$	613 355 t	Set at 50% of B_0. Determined through MSE with the objective to achieve high sustainable yields without exceeding a 5% probability of SSB falling below B_{lim} in any single year.
B_{pa}	516 727 t	B_{pa} = B_{loss} (lowest observed SSB during 1980-2023)
B_{lim}	389 938 t	B_{lim} = B_{pa} / exp(1.645 * σ), σ = CV of SSB_{2023}. 32% of B_0.

Figure 2. Herring (*Clupea harengus*) in ICES subdivision 30 and31 (Gulf of Bothnia). MSE performance for all HCRs based on $F_{B\%}$ and Btrigger as fraction of B_0, where e.g. $F_{B55.6}$ equals the HCR where Ftarget = $F_{B55\%}$ and MSY $B_{trigger}$ = 0.6 * $B_{55\%}$. Panels show the probability of SSB to fall below B_{lim} in any year (P3(B<B_{lim}); performance evaluation criteria 1), median catches in relation to catches at the deterministic F_{MSY} (Catch/MSY; performance evaluation criteria 2), the average annual variation in catches (AAV), median SSB and F in relation to deterministic B_{MSY} and F_{MSY} (B/B_{MSY} and F/F_{MSY} respectively) and the probability of SSB to be above 80 % of the deterministic B_{MSY} in any year (B>80B_{MSY}). Horizontal red dashed lines denote probabilities of 0.05 and 0.95.

Landings
200000
150000
100000
50000
0
MSY
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
2060
2065
2070
2075
2080
om1
FB30.6
FB30.8
FB301
FB35.6
FB35.8
FB351
FB40.6
FB40.8
FB401
FB45.6
FB45.8
FB451
FB50.6
FB50.8
FB501
FB55.6
FB55.8
FB551
FB51.6
FB51.8
FB511
FB52.6
FB52.8
FB521
FB53.6
FB53.8
FB531
FB54.6
FB54.8
FB541
FMSY.6
FMSY.8
FMSY1
advice

Figure 3. Herring (*Clupea harengus*) in ICES subdivision 30 and31 (Gulf of Bothnia). Long-term median catches for all HCRs based on $F_{B\%}$ and MSY $B_{trigger}$ as fraction of B_0, where e.g. $F_{B55.6}$ equals the HCR where F_{target} = $F_{B55\%}$ and MSY $B_{trigger}$ = 0.6 * $B_{55\%}$.

Figure 4. Herring (*Clupea harengus*) in ICES subdivision 30 and31 (Gulf of Bothnia). Long-term forward projections of recruitment (R), spawning stock biomass (SB), catches (C) and fishing mortality (F), for all HCRs based on $F_{B\%}$ and MSY $B_{trigger}$ as fraction of B_0, where e.g. $F_{B55.6}$ equals the HCR where F_{target} = $F_{B55\%}$ and MSY $B_{trigger}$ = 0.6 * $B_{55\%}$.

Conclusions

In this document, we report the analyses performed following the WGBFAS meeting on the reference points for the GoB herring and provide proposed new values that can be used for providing catch advice for 2025. B_{lim} was calculated following the ICES guidelines for a type 6 stock to 389 938 t (31.8% of B_0) which is 3.5% higher compared to the current B_{lim}. The MSE showed that the HCR with a F_{target} that leads to a long-term spawning biomass that is 50% of the unexploited spawning biomass at current conditions, in combination with a trigger – at which fishing is reduced – at the same spawning biomass level, fulfils objective (1) while maximising long-term yield (objective (2)). The resulting F_{target} (0.218; current F_{MSY} = 0.271) and MSY $B_{trigger}$ (613 355 t; current MSY $B_{trigger}$ = 533 515 t) values are 20 % lower and 15 % higher, respectively, compared to the current reference points.

These new proposed reference points will result in lower catch advice because of a reduced F_{target} and earlier activation of downscaled advice due to an increased MSY $B_{trigger}$ to the same biomass level as the target, compared to the current reference points. SSB in the beginning of 2024 is estimated to around 540 000 t (WGBFAS 2024), which is 73 000 t lower than the target level of 613 000 t proposed here. These new proposed reference points will help the stock in recovering to spawning biomass levels around the target biomass.

From the SSB peak in 1996 until now, SSB has generally been decreasing even though fishing mortality only once, in the year 2016 when catches peaked, has been higher than the proposed F_{target} (Fig. 1, WGBFAS 2024). However, it is important to note that the herring in the Gulf of Bothnia was exploited at very low levels compared to many other herring stocks. Up until the early 1990s, fishing mortality varied slightly around 0.05, with catches around 30 000 t (Fig. 1, WGBFAS 2024). When fishing mortality started to increase, SSB started to decrease correspondingly, basically no matter what target reference point > 0.05 that was used. SSB was also negatively affected by the decrease in weight-at-age of older age-classes during the late 1990s to around 2005 (WGBFAS 2024). SSB in the beginning of 2024 compared to in the beginning of 2023 has increased marginally (by ~10 000 t; WGBFAS 2024). According to the MSE performed here the stock will, in the long term, increase to SSB levels around the target, provided that the assumptions made in the forward projections do not change. It is therefore crucial to be observant to these assumptions in the coming years. For example, the results of the alternative operating model (OM2) shows that the results are highly sensitive to the level of productivity of the stock.

The performance evaluation criteria used here does not include any objective regarding age or size-structure. The proportion of estimated numbers and biomass of older herring in the Gulf of Bothnia herring stock has continuously decreased during the last 15 years and has for the last 8 years been significantly lower compared to historical levels (ICES 2024a). The Marine Strategy Framework Directive's (MSFD) objective of good environmental status relates both to healthy stocks in terms of sufficient biomass as well as in terms of the age and size distribution (D3). Preliminary analyses performed by SLU Aqua and reported during WKHERBAL (ICES 2024a) shows a clear effect of future exploitation levels on the age-structure of the stock and highlights that it is likely that even at the reduced F_{target} proposed here, the proportion of older fish in the stock will decrease even further (ICES 2024a). Such age-structural changes in the stock are not evaluated by the MSE used here, however it could be implemented using for example the framework developed by Griffiths et al (2024).

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Appendices

Appendix 1 – Reviewers' report

After an in deep analysis of stock-recruitment relationship and recruitment dynamics Blim was set following ICES guidelines. Using a percentage of B0 was also considered which led to a value similar to the selected Blim. The uncertainty around theoretical Fmsy was high, a flat yield per recruit curve resulted in very different (and high) Fmsy-s depending on the method. Thus, using an MSE short cut approach was considered the best way to calculate the ICES Fmsy and MSYBtrigger. A set or Fmsy and MSYBtrigger pairs were tested and among the set that fulfilled the precautionary condition, the one that resulted in higher catches at equilibrium was selected. Although the procedure did not follow the ICES guidelines the approach used is considered a better approach, especially in this case were estimation of Fmsy is problematic. Furthermore, it includes the time lag between assessment and advice, which has been proven to be a key element in the quantification of inherent risk.

All the process was very transparent, the method, results as well as the code were shared with the reviewers.

Appendix 2 – MSE for Gulf of Bothnia herring (R markdown pdf including R code)

Attached at the end of this report.

MSE for Gulf of Bothnia herring

Max Cardinale (SLU), modified from code
provided by Iago Mosqueira for WKREBUILD and WKNEWREF

22 July, 2024

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1 Gulf of Bothnina herring

GOB herring model has been developed in 2021 and reviewed by a benchmark. The latest update was run by WGBFAS in April 2024. Two different Operative Models (OMs) will be tested, a reference case (OM1; latest model accepted at WGBFAS in April 2024) and an alternative model (OM2), which assumes a reduced productivity of the stock, with R0 as XX% of the original R0 from there reference case. Reference points will be estimated separately for each OM and as an ensamble of the two OMs.

1.1 Load models created by Create FLR stock objects for MSE.R file and attributes (created by MSE_reference points_estimation_best case.R file

Load libraries

```
library(mse)
library(FLRef)
library(FLBRP)
library(progressr)
# handlers(global=TRUE)
library(doFuture)
library(r4ss)
library(ss3diags)
library(ss3om)
library(icesTAF)
library(parallel)
library(mseviz)
library(dplyr)
# devtools::install_github('mebrooks/stockrecruit/StockRecruitSET',
# build_opts = c('--no-resave-data', '--no-manual'))
```

Get the libraries specifications

```
sessionInfo()
   R version 4.2.3 (2023-03-15 ucrt)
   Platform: x86_64-w64-mingw32/x64 (64-bit)
   Running under: Windows 10 x64 (build 22631)

   Matrix products: default

   locale:
   [1] LC_COLLATE=English_United Kingdom.utf8
   [2] LC_CTYPE=English_United Kingdom.utf8
   [3] LC_MONETARY=English_United Kingdom.utf8
   [4] LC_NUMERIC=C
   [5] LC_TIME=English_United Kingdom.utf8

   attached base packages:
   [1] parallel  stats     graphics  grDevices utils     datasets  methods
   [8] base

   other attached packages:
    [1] dplyr_1.1.4          mseviz_0.2.6.9008    patchwork_1.2.0
    [4] icesTAF_4.2.0        ss3om_0.5.2.9005     ss3diags_1.10.2
    [7] r4ss_1.49.2          FLRef_1.10.4         FLSRTMB_1.1.4.9014
   [10] mse_2.2.3.9252       progressr_0.14.0     data.table_1.15.4
```

```
 [13] doFuture_1.0.1       future_1.33.2        foreach_1.5.2
 [16] FLBRP_2.5.9.9022     FLasher_0.7.1.9221   FLFishery_0.3.8.9009
 [19] ggplotFL_2.7.0.9133  ggplot2_3.5.1        FLCore_2.6.19.9105
 [22] iterators_1.0.14     lattice_0.20-45      knitr_1.48

loaded via a namespace (and not attached):
  [1] jsonlite_1.8.8      viridisLite_0.4.2   stats4_4.2.3
  [4] yaml_2.3.9          ggrepel_0.9.5       globals_0.16.3
  [7] pillar_1.9.0        glue_1.7.0          TAF_4.2.0
 [10] digest_0.6.36       colorspace_2.1-0    cowplot_1.1.3
 [13] htmltools_0.5.8.1   Matrix_1.6-5        pkgconfig_2.0.3
 [16] listenv_0.9.1       purrr_1.0.2         xtable_1.8-4
 [19] corpcor_1.6.10      scales_1.3.0        svglite_2.1.3
 [22] tibble_3.2.1        generics_0.1.3      withr_3.0.0
 [25] furrr_0.3.1         TMB_1.9.14          cli_3.6.2
 [28] magrittr_2.0.3      evaluate_0.24.0     data.tree_1.1.0
 [31] fansi_1.0.6         parallelly_1.37.1   MASS_7.3-58.2
 [34] xml2_1.3.6          tools_4.2.3         gh_1.4.1
 [37] formatR_1.14        lifecycle_1.0.4     stringr_1.5.1
 [40] munsell_0.5.1       kableExtra_1.4.0    compiler_4.2.3
 [43] systemfonts_1.1.0   tinytex_0.51        rlang_1.1.3
 [46] grid_4.2.3          rstudioapi_0.16.0   rmarkdown_2.27
 [49] gtable_0.3.5        codetools_0.2-19    roxygen2_7.3.2
 [52] R6_2.5.1            gridExtra_2.3       fastmap_1.2.0
 [55] future.apply_1.11.2 utf8_1.2.4          stringi_1.8.4
 [58] Rcpp_1.0.12         vctrs_0.6.5         tidyselect_1.2.1
 [61] xfun_0.45           coda_0.19-4.1
```

Define folder with R data files and other additional parameters

```
setwd("~/Max/Commitees/ICES/WGBFAS/2024/GBH")

plan(multisession, workers = 9)

its <- 500
fy <- 2082
iy <- 2024

basecase <- mget(load("Reference_run.rda"))
R0reduced <- mget(load("Reference_run_R0_reduced.rda"))
load("GOB_herring_attributes.rda")
```

1.2 OMs conditioning, defining FLStocks, FLSRs and SS3 refpts

```
stks <- FLStocks(REF = basecase$stk, RED = R0reduced$stk)
srrs <- FLSRs(REF = basecase$srr, RED = R0reduced$srr)
srps <- list(REF = basecase$rps, RED = R0reduced$rps)
```

Define functions

```
getabSR <- function(stk, srr) {
    ab(fmle(as.FLSR(stk, model = "bevholtSV"), fixed = list(s = params(srr)$s,
        v = params(srr)$v, spr0 = params(srr)$v/params(srr)$R0)))
```

```
}

getBRPs <- function(stk, srr) {
    # COERCE FLSR as bevholt(a,b)
    nsr <- getabSR(stk, srr)

    # FIT brps
    brp <- brp(FLBRP(stk, sr = nsr))

    # EXTRACT brefpts
    brps <- remap(refpts(brp), R0 = c("virgin", "rec"), MSY = c("msy",
        "yield"))

    return(brps)
}
```

1.2.1 This part is only to hack Blim up to line 160

Load the stock object in FLR

```
stk_single <- readFLSss3(dir = "~/Max/Commitees/ICES/WGBFAS/2024/GBH/Reference_run",
    wtatage = TRUE)
```

Load the SS model and parameters

```
out <- SS_output(dir = "~/Max/Commitees/ICES/WGBFAS/2024/GBH/Reference_run",
    covar = T, printstats = FALSE)
R0 <- exp(out$parameters$Value[out$parameters$Label == "SR_LN(R0)"])
s <- out$parameters$Value[out$parameters$Label == "SR_BH_steep"]
sigmaR <- out$parameters$Value[out$parameters$Label == "SR_sigmaR"]
rho <- out$parameters$Value[out$parameters$Label == "SR_autocorr"]
B0 <- out$derived_quants$Value[out$derived_quants$Label == "SSB_unfished"]
SSBcv <- out$derived_quants$StdDev[out$derived_quants$Label ==
    "SSB_2023"]/out$derived_quants$Value[out$derived_quants$Label ==
    "SSB_2023"]
Fcv <- out$derived_quants$StdDev[out$derived_quants$Label ==
    "F_2023"]/out$derived_quants$Value[out$derived_quants$Label ==
    "F_2023"]
BMSYss <- out$derived_quants$Value[out$derived_quants$Label ==
    "SSB_MSY"]
FMSYss <- out$derived_quants$Value[out$derived_quants$Label ==
    "annF_MSY"]
MSYss <- out$derived_quants$Value[out$derived_quants$Label ==
    "Dead_Catch_MSY"]
TB0ss <- out$derived_quants$Value[out$derived_quants$Label ==
    "Totbio_unfished"]
```

Coerce FLSR as bevholt(a,b) from SS

```
nsr <- ab(fmle(as.FLSR(stk, model = "bevholtSV"), fixed = list(s = s,
    v = B0, spr0 = B0/R0)))
     Nelder-Mead direct search function minimizer
   function value for initial parameters = -27.508534
     Scaled convergence tolerance is 4.09909e-07
   Stepsize computed as 0.100000
```

```
   Exiting from Nelder Mead minimizer
       1 function evaluations used
```

Fit brps as single stock to hack Blim for the oms list. Blim set as 32% of B0

```
brp_single <- brp(FLBRP(stk, sr = nsr))
brps_single <- remap(refpts(brp_single), R0 = c("virgin", "rec"),
    MSY = c("msy", "yield"))
brps_single$Blim <- B0 * 0.31787
```

2 Get Brps and add Blim to refpts

```
brps <- lapply(srps, rbind, Blim = brps_single$Blim)
```

3 Change rpts for the for the reduced R0 model and fix the units

```
brps$RED[1] <- brpred[5]
brps$RED[2] <- brpred[4]
brps$RED[4] <- brpred[2]
brps$RED[5] <- brpred[1]
brps$RED[6] <- brpred[7]

brps["RED"]$RED@units <- brps["REF"]$REF@units
```

3.1 Coerce SRRs to ab bevholt

```
nsrs <- Map(function(x, y) getabSR(x, y), x = stks, y = srrs)
     Nelder-Mead direct search function minimizer
   function value for initial parameters = -27.686585
     Scaled convergence tolerance is 4.12562e-07
   Stepsize computed as 0.100000
   Exiting from Nelder Mead minimizer
       1 function evaluations used
     Nelder-Mead direct search function minimizer
   function value for initial parameters = -31.613710
     Scaled convergence tolerance is 4.71081e-07
   Stepsize computed as 0.100000
   Exiting from Nelder Mead minimizer
       1 function evaluations used
```

3.2 Create FLoms

```
oms <- Map(function(x, y, z) FLom(stock = x, sr = y, refpts = z),
    x = stks, y = srrs, z = brps)
```

3.3 Extend to the future

```
oms <- lapply(oms, function(x) propagate(fwdWindow(x, end = fy),
    its))
```

3.4 Add SR deviances, same across OMs, and add those to OMs

```
devs <- rlnormar1(its, sdlog = sigmaR, rho = rho, years = seq(2023,
    fy))

oms <- lapply(oms, function(x) {
    deviances(x) <- devs
    return(x)
})
```

3.5 F and SSB deviances for shortcut and STF

```
sdevs <- shortcut_devs(oms[[1]], Fcv = Fcv, Fphi = 0.423, SSBcv = SSBcv)
```

4 MP setup

4.1 Setup standard ICES advice rule

```
arule <- mpCtrl(list(

  # (est)imation method: shortcut.sa + SSB deviances
  est = mseCtrl(method=shortcut.sa,
    args=list(SSBdevs=sdevs$SSB)),

  # hcr: hockeystick (fbar ~ ssb | lim, trigger, target, min)
  hcr = mseCtrl(method=hockeystick.hcr,
    args=list(lim=0, trigger=trigger, target=target,
    min=0, metric="ssb", output="fbar")),

  # (i)mplementation (sys)tem: tac.is (C ~ F) + F deviances
  # rec as GM ignoring last 2 years
  isys = mseCtrl(method=tac.is,
    args=list(recyrs=-2, fmin=0, Fdevs=sdevs$F))
  ))
```

Plotting the HCR

```
setwd("~/Max/Commitees/ICES/WGBFAS/2024/GBH")
plot_hockeystick.hcr(arule$hcr, labels = c(trigger = "Btrigger",
    target = "Ftarget")) + xlab("SSB (t)") + ylab(expression(bar(F))) +
    ggtitle("HCR")
```

Figure 1: Harvest control rule used in the MSE

```
mseargs <- list(iy = iy - 1, fy = fy, data_lag = 1, management_lag = 1,
    frq = 1)
```

Get candidate values for Btrigger & Ftarget creating combinations of based on fraction of B0 (FBx ~ Bx * c(0.30, 0.45, 0.05)) and adding FMSY ~ BMSY * c(0.6, 0.8, 1)

```
frps <- Map(function(x, y) {
    lapply(seq(30, 55, by = 5), function(i) {
        Fbrp(computeFbrp(x, sr = y, proxy = "bx", x = i, blim = 0.31787))
    })
}, x = stks, y = nsrs)
   Computing Fsb30 with Btgt = Bsb30

     Blim = 0.31787B0
   Computing Fsb35 with Btgt = Bsb35

     Blim = 0.31787B0
   Computing Fsb40 with Btgt = Bsb40

     Blim = 0.31787B0
   Computing Fsb45 with Btgt = Bsb45

     Blim = 0.31787B0
   Computing Fsb50 with Btgt = Bsb50

     Blim = 0.31787B0
   Computing Fsb55 with Btgt = Bsb55

     Blim = 0.31787B0
   Computing Fsb30 with Btgt = Bsb30

     Blim = 0.31787B0
   Computing Fsb35 with Btgt = Bsb35

     Blim = 0.31787B0
   Computing Fsb40 with Btgt = Bsb40

     Blim = 0.31787B0
   Computing Fsb45 with Btgt = Bsb45

     Blim = 0.31787B0
   Computing Fsb50 with Btgt = Bsb50

     Blim = 0.31787B0
   Computing Fsb55 with Btgt = Bsb55

     Blim = 0.31787B0

opts <- Map(function(x, y) {
    res <- list(target = rep(unlist(lapply(x, "[", 1)), each = 3),
        trigger = unlist(lapply(seq(0.3, 0.55, by = 0.05), function(i) (c(refpts(y)$SB0) *
            i) * c(0.6, 0.8, 1))))
    res$target <- c(res$target, rep(c(refpts(y)$FMSY), 3))
```

```
    res$trigger <- c(res$trigger, c(refpts(y)$SBMSY) * c(0.6,
        0.8, 1))
    return(res)
}, x = frps, y = oms)

nms <- c(paste0(rep(paste0("FB", seq(30, 55, by = 5)), each = 3),
    rep(c(".6", ".8", "1"), 6)), c("FMSY.6", "FMSY.8", "FMSY1"))
```

Run for all options on 'hcr' control element for all OMs and ICES advice. To be done on a cluster pc

```
system.time(plans <- Map(function(x, y) {

    runs <- mps(x, ctrl = arule, args = mseargs, hcr = y, names = nms)

    runs$advice <- advice <- mp(x, ctrl = arule, args = mseargs)

    return(runs)

}, x = oms, y = opts))
```

Save the MSE results

```
save(oms, plans, file = "plans.rda", compress = "xz")
```

4.2 Compute MSE performances

Define performances metrics

```
metrics <- list(SB = ssb, F = fbar, C = landings, TC = catch,
    Rec = rec)

stats <- list(medianFmsy = list(~yearMedians(F/FMSY), name = "F/Fmsy",
    desc = "Median annual F/Fmsy"), medianBmsy = list(~yearMedians(SB/SBMSY),
    name = "B/Bmsy", desc = "Median annual B/Bmsy"), medianCmsy = list(~yearMedians(C/MSY),
    name = "Catch/MSY", desc = "Median Catch/MSY over years"),
    aavC = list(~yearMedians(iav(C)), name = "AAV", desc = "Median annual variation in catches"),
    riskBlim = list(~apply(iterMeans((SB/Blim) < 1), 1, max),
        name = "P3(B<Blim)", desc = "Probability that SSB < Blim"),
    risk10SB0 = list(~apply(iterMeans((SB/(SB0 * 0.1)) < 1),
        1, mean), name = "P(B<SB0.10)", desc = "Probability that SSB < 10% SB0"),
    P80BMSY = list(~apply(iterMeans((SB/(SBMSY * 0.8)) > 1),
        1, max), name = "B>80Bmsy", desc = "Probability that SSB > 80% x Bmsy"),
    medianSBMSY = list(~yearMedians(SB/SBMSY), name = "SSB/SSB[MSY]",
        desc = "Median annual SSB/SSBmsy"), medianFMSY = list(~yearMedians(F/FMSY),
        name = "F/F[MSY]", desc = "Median annual F/FMSY"))
```

Compute performances, add HCR parameters Btrigger and Ftarget and define long time horizon for evaluation

```
plans_perf <- lapply(plans, function(x) {

    res <- performance(x, statistics = stats, years = list(all = 2024:fy,
        long = 2053:fy))

    hps <- rbindlist(lapply(x, function(i) args(control(i)$hcr)[c("trigger",
        "target")]), idcol = "mp")
```

```
    performance(x) <- merge(res, hps, by = "mp")

    return(x)
})
```

Create MSE performance table

```
perf <- rbindlist(lapply(plans_perf, performance), idcol = "om")
write.csv(perf, file = "msePerf_data.csv")
```

Save performances objects

```
save(oms, plans, plans_perf, file = "plans_oms_new.rda", compress = "xz")
```

Load performances objects derived from a run made on a 16 cores cluster computer on Linux

```
load("~/Max/Commitees/ICES/WGBFAS/2024/GBH/MSE/plans_oms_new.rda")
```

5 MSE Performance plots and tables

```
ncol = length(unique(perf$mp)) # n colors
perfom1 = perf[perf$om=="REF",]
pbp = plotBPs(perfom1[perfom1$year=="long",],
statistics=c("medianFmsy","medianBmsy","medianCmsy", "aavC", "riskBlim", "P80BMSY"),
size=3, target = c(medianFmsy=1,medianBmsy=1, medianCmsy=1),
limit= c(riskBlim=0.05,P80BMSY=0.95),
yminmax = c(0.05, 0.95))+theme_bw()+
facet_wrap(~name,scales = "free_y",ncol=2)+
ggtitle(paste0("Performance: Long"))+
ylab("Performance statistics")+
scale_fill_manual(values=ss3col(ncol))+ # USE FLRef::ss3col
theme(axis.text.x=element_blank())+xlab("Candidates")
pbp
```

```
ncol = length(unique(perf$mp)) # n colors
perfom2 = perf[perf$om=="RED",]
pbp = plotBPs(perfom2[perfom2$year=="long",],
statistics=c("medianFmsy","medianBmsy","medianCmsy", "aavC", "riskBlim", "P80BMSY"),
size=3, target = c(medianFmsy=1,medianBmsy=1, medianCmsy=1),
limit= c(riskBlim=0.05,P80BMSY=0.95),
yminmax = c(0.05, 0.95))+theme_bw()+
facet_wrap(~name,scales = "free_y",ncol=2)+
ggtitle(paste0("Performance: Long"))+
ylab("Performance statistics")+
scale_fill_manual(values=ss3col(ncol))+ # USE FLRef::ss3col
theme(axis.text.x=element_blank())+xlab("Candidates")
pbp
```

```
ncol = length(unique(perf$mp)) # n colors
pbp = plotBPs(perf[perf$year=="long",],statistics=c("medianFmsy","medianBmsy","medianCmsy", "aavC", "ri
              target = c(medianFmsy=1,medianBmsy=1, medianCmsy=1),
              limit= c(riskBlim=0.05,P80BMSY=0.95),
              yminmax = c(0.05, 0.95))+theme_bw()+
  facet_wrap(~name,scales = "free_y",ncol=2)+
```

Figure 2: Herring (Clupea harengus) in subdivisions 30 and 31 (Gulf of Bothnia). MSE performance plot for OM1

Figure 3: Herring (Clupea harengus) in subdivisions 30 and 31 (Gulf of Bothnia). MSE performance plot for OM2

```
  ggtitle(paste0("Performance: Long"))+
  ylab("Performance statistics")+
  scale_fill_manual(values=ss3col(ncol))+ # USE FLRef::ss3col
  theme(axis.text.x=element_blank())+xlab("Candidates")
pbp
```

Figure 4: Herring (Clupea harengus) in subdivisions 30 and 31 (Gulf of Bothnia). MSE performance plot, ensemble

5.1 MSE Table

```
perf_table <- perf %>%                                  # Specify data frame
  group_by(om, name, mp, year, trigger, target) %>%     # Specify group indicator
  summarise_at(vars(data),                              # Specify column
               list(Median = median),na.rm = TRUE)      # Specify function

write.csv(perf_table,file="msePerf_table.csv")
```

5.2 MSE kobe plot

```
kbcex =function(){theme(plot.title = element_text(size=10),
                        legend.key.size = unit(0.3, 'cm'), #change legend key size
                        legend.key.height = unit(0.4, 'cm'), #change legend key height
                        legend.key.width = unit(0.4, 'cm'), #change legend key width
                        legend.text = element_text(size=10)) #change legend text font size
}
kobeMPs(perf,y="medianFmsy", x="medianBmsy", SBlim=NULL, Ftarget = 1)+
  ylab(expression(F/F[MSY]))+xlab(expression(B/B[MSY]))+ylim(0,2.5)+kbcex()+theme()
   Scale for y is already present.
   Adding another scale for y, which will replace the existing scale.
```

Figure 5: Herring (Clupea harengus) in subdivisions 30 and 31 (Gulf of Bothnia). MSE kobe plot, ensemble

5.3 Trajectories plot for each OM

```
plot(oms[[1]], plans[[1]])
```

Figure 6: Herring (Clupea harengus) in subdivisions 30 and 31 (Gulf of Bothnia). Trajectories plot for OM1

```
plot(oms[[2]], plans[[2]])
```

Figure 7: Herring (Clupea harengus) in subdivisions 30 and 31 (Gulf of Bothnia). Trajectories plot for OM2

5.4 Plotting single trajectories and medians for each OMs

```
rp = oms$REF@refpts
om1 = window(FLStockR(oms[[1]]@stock), end = 2023)
om1@refpts = FLPar(Fmsy = rp["FMSY"], Bmsy = rp["SBMSY"], Blim = rp["Blim"],
    MSY = rp["MSY"])
stks1 = FLStocks(lapply(plans[[1]], function(x) {
    out = FLStockR(x@om@stock)
    out@refpts = om1@refpts
    out
}))

res1 = FLStocks(c(FLStocks(om1), stks1))
names(res1)[1] = "om1"

# Medians
med1 = FLStocks(lapply(res1, function(x) {
    iterMedians(x)
}))
```

```
rp = oms$RED@refpts
om2 = window(FLStockR(oms[[2]]@stock), end = 2023)
om2@refpts = FLPar(Fmsy = rp["FMSY"], Bmsy = rp["SBMSY"], Blim = rp["Blim"],
    MSY = rp["MSY"])
stks2 = FLStocks(lapply(plans[[2]], function(x) {
    out = FLStockR(x@om@stock)
    out@refpts = om1@refpts
    out
}))

res2 = FLStocks(c(FLStocks(om2), stks2))
names(res2)[1] = "om2"

# Medians
med2 = FLStocks(lapply(res2, function(x) {
    iterMedians(x)
}))
```

```
plotAdvice(med1) + geom_line(linewidth = 0.8) + scale_color_manual(values = c("black",
    sscol(length(stks1)))) + scale_x_continuous(breaks = seq(1960,
    fy, 5)) + theme(axis.text.x = element_text(size = 8, angle = 90)) +
    guides(col = guide_legend(ncol = 1))
```

Figure 8: Herring (Clupea harengus) in subdivisions 30 and 31 (Gulf of Bothnia). Trajectories plot for OM1 medians

```
plotAdvice(med2) + geom_line(linewidth = 0.8) + scale_color_manual(values = c("black",
    sscol(length(stks2)))) + scale_x_continuous(breaks = seq(1960,
    fy, 5)) + theme(axis.text.x = element_text(size = 8, angle = 90)) +
    guides(col = guide_legend(ncol = 1))
```

Figure 9: Herring (Clupea harengus) in subdivisions 30 and 31 (Gulf of Bothnia). Trajectories plot for OM2 medians

```
plotAdvice(res1) + scale_color_manual(values = c("black", sscol(length(stks1)))) +
    scale_fill_manual(values = c("black", sscol(length(stks1)))) +
    scale_x_continuous(breaks = seq(1960, fy, 5)) + theme(axis.text.x = element_text(size = 8,
    angle = 90)) + guides(col = guide_legend(ncol = 1))
```

```
plotAdvice(res2) + scale_color_manual(values = c("black", sscol(length(stks2)))) +
    scale_fill_manual(values = c("black", sscol(length(stks2)))) +
    scale_x_continuous(breaks = seq(1960, fy, 5)) + theme(axis.text.x = element_text(size = 8,
    angle = 90)) + guides(col = guide_legend(ncol = 1))
```

Figure 10: Herring (Clupea harengus) in subdivisions 30 and 31 (Gulf of Bothnia). Trajectories plot for OM1, all

Figure 11: Herring (Clupea harengus) in subdivisions 30 and 31 (Gulf of Bothnia). Trajectories plot for OM2, all

5.5 Select best HCR target and trigger combination

```
perfCsv <- read.csv("msePerf_table.csv")
OM <- c("REF", "RED")
OM <- c("REF")

p05 <- subset(perfCsv, om %in% OM & (name == "P3(B<Blim)" & Median <
    0.05))
catchP05 <- subset(perfCsv, om %in% OM & (name == "Catch/MSY" &
    mp %in% p05$mp))
bestCase <- subset(catchP05, Median == max(Median))
bestCase <- bestCase %>%
    select(mp, trigger, target)
bestCase$target <- round(bestCase$target, 3)
names(bestCase)[1] <- "MP"
names(bestCase)[2] <- "Btrigger"
names(bestCase)[3] <- "Ftarget"

knitr::kable(bestCase, "pipe", align = "lc", caption = "Summary of estimated reference points for refer
```

Table 1: Summary of estimated reference points for reference case model of Gulf of Bothnian herring

	MP	Btrigger	Ftarget
846	FB501	613355	0.218

6 Estimate Blim with different methods as the minimum SSB level that resulted in a recruitment higher that the median and fractions of B0

```
library(StockRecruitSET)
   Loading required package: TMB
   Loading required package: RcppEigen
   Loading required package: bbmle
   Loading required package: stats4

   Attaching package: 'bbmle'
   The following object is masked from 'package:dplyr':

       slice

flsr <- as.FLSR(stk_single)
S <- an(ssb(flsr))
R <- an(rec(flsr))

Bpaemp <- calcBlim(S, R, quant = 0.5, type = 1, nmin = 1, AIC = TRUE)
Blim_emp = round(Bpaemp/(exp(1.645 * SSBcv)), 0)
Blim_emp_defCV = round(Bpaemp/(exp(1.645 * 0.2)), 0)
Blim24 <- round(B0 * 0.24, 0)
Blim30 <- round(B0 * 0.3, 0)
```

```
### Bloss calculations
Bloss = min(ssb(stk_single))
BpaBloss = Bloss
BlimBloss = BpaBloss/(exp(1.645 * SSBcv))


Bpaemp
   [1] 548671
Blim_emp
   [1] 414043
Blim_emp_defCV
   [1] 394847
Blim24
   [1] 294410
Blim30
   [1] 368013
Bloss
   [1] 516727.1
BpaBloss
   [1] 516727.1
BlimBloss
   [1] 389937.5
```

bestCase %>% select(name, mp, year)