BALTIC FISHERIES ASSESSMENT WORKING GROUP (WGBFAS)

October 2023: Report updated with the addition of Annex 10 (Additional catch scenarios for sole in subdivisions 20–24)

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Contents

i Executive summary

The main ToR of WGBFAS is to assess the status and produce a draft advice on fishing opportunities for 2024 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 22–24 (western Baltic; 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)
- Brill in SDs 22-32 (Baltic Sea; stock status advice for years 2024, 2025 and 2026)
- Dab in SDs 22-32(Baltic Sea; stock status advice for years 2024, 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 one exception. The assessment for cod in SDs22-24 (western Baltic) was downgraded from category 1 to category 3 due to unreliable F estimates. However, trends in SSB are still considered reliable and are used as basis for the advice. The WG was not requested to produce advice for four flounder stocks in the Baltic Sea (flounder in SD22-23, flounder in SDs 24-25, flounder in SDs 26+28, and flounder in SDs 27, 29-32) and turbot 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, considers and comments on the ecosystem and fisheries overviews, 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 and reviews the recently published work on ecosystem effects on fish populations in the Baltic Sea. 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.

ii Expert group information

Expert group name	Baltic Fisheries Assessment Working Group (WGBFAS)
Expert group cycle	Annual
Year cycle started	2023
Reporting year in cycle	1/1
Chair	Kristiina Hommik, Estonia
Meeting venue(s) and dates	5 April 2023, by correspondence (data preparation)
	18-25 April 2023, ICES headquarter, Copenhagen (24) and by correspondence (6)

1 Introduction

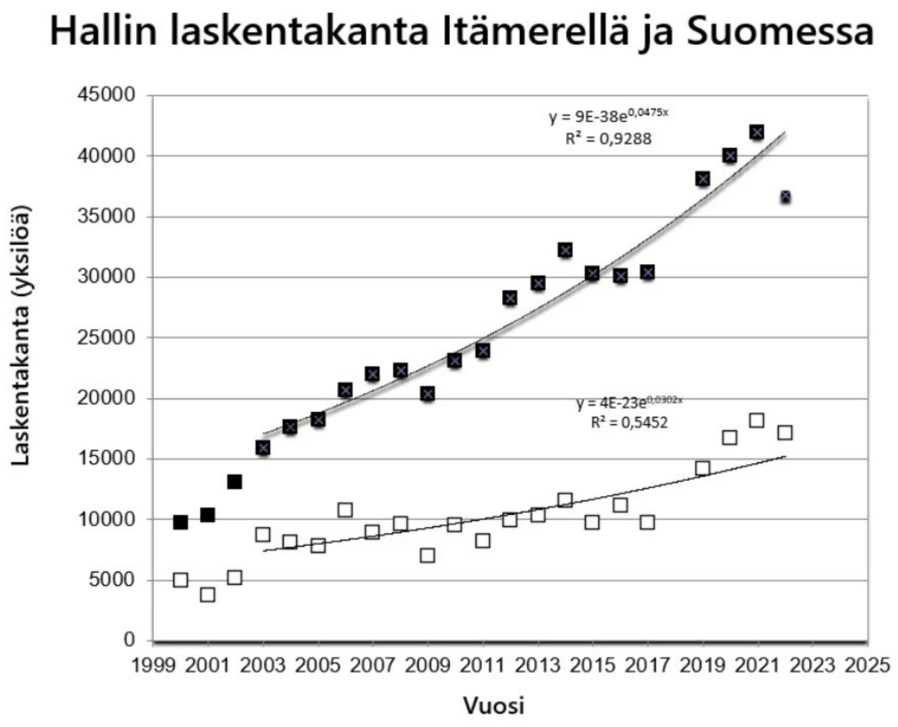
1.1 ICES code of conduct

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 Consider and comment on Ecosystem and Fisheries Overviews where available

Fisheries Overview

- Page 4, Russia: "turbot, and salmon, goby, and others non-commercial species occur". *Perhaps good to specify that 'goby' is round goby, as this may not be clear for readers from outside Baltic Sea.*
- page 5: Listing same species twice (in red). *The principal species targeted in the commercial fisheries are cod, herring, and sprat, which together constitute about 95% of the total catch. The fisheries for cod in the Baltic Sea use mainly demersal trawls and gillnets, while herring and sprat are mainly caught by pelagic trawls. Other target fish species having local economic importance are salmon, plaice, flounder, dab, brill,* ***turbot****, pikeperch, pike, perch, vendace, whitefish,* ***turbot****, eel, and sea trout.*
- similarly, page 9: *The principal species targeted in the commercial fishery are cod, herring, and sprat, which together constitute about 95% of the total catch. Other target fish species with local economic importance are salmon, plaice, dab, brill,* ***turbot****, flounder, pikeperch, pike, perch, vendace, whitefish,* ***turbot****, eel, and sea trout.*
- page 22: In 2022, almost 37 000 grey seals were seen in counts from flight (the correct expression in English?) in the Baltic Sea. All specimens in the Baltic Sea grey seal population were not seen, thus their real number is higher. So far, there are no clear signs of the number levelling off. These figures are from Mervi Kunnasranta, Luke, Finland. https://www.luke.fi/fi/seurannat/merihyljelaskennat-ja-hyljekannan-rakenteen-seuranta/harmaahyljekanta-2022 (regularly updated, but available only in Finnish)



Laskennoissa nähdyt hallit koko Itämerellä (mustat neliöt) ja Suomessa (neliöt).

Figure 1.1. The observed specimens of grey seals in the counts in the whole Baltic Sea (black squares) and in the Finnish areas (white squares).

A fresh article for reference, written in English: Sköld 2023: https://www.diva-portal.org/smash/get/diva2:1733910/FULLTEXT01.pdf

In the estimates, the numbers of ringed seals are based on sampling. The result has varied a lot in 2013–2021 because of ice conditions in April. E.g. the estimated number in 2020 was 14 600 specimens, but in 2021 11 500 specimens (https://www.luke.fi/fi/seurannat/merihyljelaskennat-ja-hyljekannan-rakenteen-seuranta/merihyljekantojen-2021-tulokset).

Ecosystem Overview

- page 17, grey seal abundance: see above.

1.3 Review progress on benchmark processes of relevance to the Expert Group

Gulf of Riga herring (her.27.28), Central Baltic herring (her.27.25-2932), and Baltic sprat (spr.27.22-32) were benchmarked early 2023 (ICES, 2023).

End of 2023 beginning of 2024 there is going to be WKMSYSPiCT workshop to develop MSY advice using SPiCT. Currently there are three candidate stocks from WGBFAS to participate in that workshop. These stocks are Baltic Sea turbot (tur.27.22-32), Belt Sea and Sound flounder (fle.27.2223) and East of Gotland and Gulf of Gdansk flounder (bzq.27.2628), Candidates for a benchmark in 2023/2024 are the plaice stocks in Baltic Sea (ple.27.21-23 and ple.27.24.32). This benchmark process will take place after the survivability roadmap workshop.

An issue list is available for each stock with research needs and prioritization (see section 1.5). Issue lists will be continually updated, and benchmarks called for when a likely research outcome could validate a benchmark.

1.4 Prepare the data calls for the next year update assessment

The WGBFAS section of the data call was reviewed, and the following sentence was added: "If biological data is not derived from sampling (e.g. mean weight at length is not estimated by length, or is derived with a length-weight relation that is not updated, etc.), please state this in the field "Info stock coordinator". It was also decided that the surveys, from which quarter one data of the assessment year is used in assessment, should be listed by stock in Annex 1 of the data call.

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

The WG recognizes that the core of appropriate stock assessment and fisheries management lies in understanding the productivity of marine ecosystems. Ecosystems productivity will change in response to many factors, including human pressures, and the impacts of climate change on marine ecosystems. It is the role of WGBFAS to handle these knowledge needs with scientific and innovative solutions. Furthermore, there is a widespread agreement about the need to move towards an ecosystem approach to fisheries management that takes into account intra- and interspecific interactions. The move requires an increase in the quantity and quality of data for use in new advanced stock assessment methods. The changing ecological situation in the Baltic Sea urges the need for combining knowledge of ecosystem processes with single species assessments. Several ICES ecosystem working groups exists, which provide regular updates on selected environmental and lower trophic level indicators, including those related to fish recruitment, and regional descriptions of ecosystem changes (ICES WGIAB 2012, 2014). However, recent ICES initiatives to bring together ecosystem and stock assessment scientists in seeking solutions to the Eastern Baltic cod assessment and management revealed that there is 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 mismatch between what is available from science and what is needed for stock assessment and management advice.

Below is 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*

  Important indicator of the ecosystem health and also possibly for information of 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 demands alternative models.

Below in a table all stocks and their coordinators and assessors are listed. The stocks are linked to their most recent issue lists which are available online. Select relevant stock code from the drop down menu at https://stockdatabase.ices.dk/Manage/rollingissues.aspx .

Fish Stock codes	Stock category	Stock Coordinator	Assessment Coordinator
bll.27.22-32	3	Stefan Neuenfeldt	Stefan Neuenfeldt
dab.27.22-32	3	Sven Stötera	Sven Stötera
tur.27.22-32	3	Sven Stötera	Sven Stötera
cod.27.21	3	Francesca Vitale	Johan Lövgren
cod.27.22-24	3	Uwe Krumme	Marie Storr-Paulsen
cod.27.24-32	1	Sofia Carlshamre	Margit Eero
sol.27.20-24	1	Jesper Boje	Jesper Boje
ple.27.21-23	1	Elliot Brown	Elliot Brown
ple.27.24-32	2	Sven Stötera	Sven Stötera
fle.27.2223	3	Sven Stötera	Sven Stötera
bzq.27.2425	3	Zuzanna Mirny	Zuzanna Mirny
bzq.27.2628	3	Didzis Ustups	Didzis Ustups
bwp.27.2729-32	3	Kristiina Hommik	Kristiina Hommik

her.27.25-2932	1	Szymon Smolinski	Mikaela Bergenius Nord
her.27.28	1	Ivars Putnis	Kristiina Hommik
her.27.3031	1	Jukka Pönni	David Gilljam
spr.27.22-32	1	Olavi Kaljuste	Jan Horbowy

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

1.6.1 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. There is, however, a request to also include Baltic stocks especially concerning the zero-catch advice both for Western Baltic and Eastern Baltic cod. To start the process of including Baltic Sea into Mixed Fisheries, some participant will be involved in 2023 Mixed Fisheries meeting.

1.6.2 Working group on the Baltic International Fish Surveys (WGBIFS)

BIAS

BIAS database was updated with the survey results from 2022. The national BIAS 2022 data were also uploaded into the ICES database for acoustic trawl surveys. The Baltic International Acoustic Survey (BIAS) in September-October 2022 was completed almost according to the plan. However, there is no data available from the Russian EEZ. Finnish research vessel did not get permission to cover 2 rectangles in Swedish coastal waters in SD 30. 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 2022 was demonstrated in consecutive graphs. In September-October 2022, the highest concentrations of herring (age 1+) were detected in the eastern and northeastern part of the Baltic Proper. At the same time, the geographical distribution of age 0 herring abundance was limited mainly to the northern part of the Baltic proper. Total abundance of age 0 herring was 3rd highest in the survey time series. Sprat (age 1+) dense shoals were mostly distributed in the eastern and northeastern part of the Baltic Proper. Total abundance of age 0 sprat was relatively low. Highest abundances of age 0 sprat were recorded in the northern part of the Baltic Proper. Both sprat and herring BIAS abundance indices showed a decrease compared to the previous year. Cod was concentrated mostly in the south-western part of Baltic Proper and in Gdansk Bay. Herring abundance in SD 30 was somewhat lower than in 2021.

WGBIFS recommended:

- The updated and corrected BIAS index series can be used in the assessment of the herring (CBH) and sprat stocks in the Baltic Sea with the restriction that the years 1993, 1995 and 1997 are excluded from the index series.
- The 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 BIAS index series calculated by the StoX can be used in assessment of the Gulf of Bothnia herring stock size. The abundance of age-groups 1 and 2 should be handled with caution due to possible over- or underestimation.

BASS

BASS database was updated with the survey results from 2022. The national BASS 2022 data were also uploaded into the ICES database for acoustic trawl surveys. The Baltic Acoustic Spring Survey (BASS) in May 2022 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. Also, two rectangles in Estonian EEZ were not covered by Latvia as it was planned during the previous WGBIFS meeting. In the May survey, the highest concentrations of sprat were distributed in the middle part of the Baltic Proper. BASS sprat abundance index showed a slight increase compared to the previous year.

WGBIFS recommended:

The 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 2022. The national GRAHS 2022 data was also uploaded into the ICES database for acoustic trawl surveys. The Gulf of Riga Acoustic Herring Survey (GRAHS) in July-August 2022 was completed according to the plan. The highest concentrations of herring were distributed in the northern part of the Gulf of Riga (in Estonian waters). The herring abundance index showed a decrease compared to the previous year.

WGBIFS recommended:

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

BITS

During the 4th quarter 2022, the level of realized valid hauls represented 99.4 % of the total planned stations. During the 1st quarter 2023, the survey realization was at the same level as the year before, i.e., 98%. The number of realized valid hauls is above the mean historical level. However, there is no data available from the Russian EEZ. The geographical distribution of cod, flounder, plaice, dab, turbot, and brill during the BITS surveys was demonstrated in consecutive graphs.

WGBIFS recommended:

The data obtained and uploaded to DATRAS for both the 4th quarter 2022 and the 1st quarter 2023 BITS can be used for calculating survey indices for the relevant cod and flatfish stocks.

1.6.3 Working group of integrated assessment of the Baltic Sea (WGIAB)

For the three years terms 2022-2024 WGIAB has as term of reference b) to develop ecosystem knowledge to support the progression of ecosystem-based fisheries advice. This ToR will investigate potential ecosystem indicators for advancing ecosystem-based fisheries advice in the Baltic Sea. The ToR is inspired by, and aims to contribute to, recent initiative within e.g., WKEBFAB and WKBALTIC, building also on the work of other ICES EGs as relevant.

1.6.4 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. The EG presented an update of the multispecies SMS keyrun model for the Baltic Sea including its review by the working group, and the review of three modelling frameworks for the Georges Bank marine ecosystem. The Baltic Sea keyrun provided updated estimates of cod predation mortality for the Baltic Sea sprat and central Baltic herring stocks made accessible for WGBFAS. The model integrates fishery and survey data on the two clupeids and makes extensive use of the cod stomach data (i.e., 64 000 stomachs are used as input to the model). Estimations of predation mortality are consistent with previous estimates and suitable for inclusion in the stock assessment of the two clupeid stocks. Predation remains low on all ages for both herring and sprat as a result of the low cod stock size.

1.7 Methods used by the working group

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

a) Cod in the SDs 24—32
b) Sole in Division 3.a + SDs 22—24
c) Plaice in SDs 21—23
d) Plaice in SDs 24—32
e) Herring in SDs 25—29 and 32, excluding SD 28.1
f) Herring in SD 28.1 (Gulf of Riga)
g) Herring in SDs 30—31
h) 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, downgraded from category 1 to category 3
c) Flounder in SDs 22–23
d) Flounder in SDs 24–25
e) Flounder in SDs 26 and 28
f) Flounder in SDs 27, 29–32
g) Brill in SDs 22–32
h) Dab in SDs 22–32
i) 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 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 four flounder stocks and turbot, but update assessments were conducted and included in the report.

1.8 Stock annex

A table containing links to the stock annexes covered by WGBFAS is found in Annex 5 of this report.

1.9 Ecosystem impacts on commercial fish vital parameters

WGBFAS recognizes the importance of considering ecosystem effects on fish population dynamics. To this end, the sections below reviews recently published knowledge and research highlights on commercial fish vital parameters reproduction, natural mortality and growth, as well as changes in spatial distributions and trends in the fish community e.g. due to alien species or temperature increase.

1.9.1 Reproduction and recruitment

As a continuation of ICES WKEBFAB, ecosystem and environmental variables were investigated that may support environmentally/ecosystem-driven Harvest Control Rules and the ICES advice on fishing opportunities using the F_{eco} approach.

Focus here is on developing a scaling factor to tune the long-term Fmsy, and account for short-to medium-term ecosystem-driven variability in productivity in the ICES advice on fishing opportunities for pelagic stocks (Central Baltic Herring stock – ICES SD 25-29 ex GOR; Baltic Sprat ICES SD 22-32).

SSB and R1 for the CBH time series could be represented by several simple GAM models with significant predictors ($p < 0.05$) explaining between 80-12% of the variability for SSB and between 65-13% for the recruitment.

Using the entire time series (1975-2022), the best GAM (Tab. 1) indicated that for no lagged and one-year lag SSB, the most important factors are:

- Salinity (Sea Surface Salinity at the Gotland basin in the summer, salinity at 60m depth at the Gotland basin in the summer),
- Temperature (Temperature at 90 and 100 m depth in Gotland and Bornholm basins in the summer), and
- Zooplankton biomass (*Acartia* sp and *Pseudocalanus* sp in spring).

SSB of Eastern Baltic Cod was used, and it is one of the most critical factors as well, but since predation mortality is included in the estimation of CBH SSB, it was excluded from the analysis.

Including Fishing mortality as a co-variable model suggesting:

- Salinity (Sea Surface Salinity at the Gotland basin in the summer or salinity at 60m depth at the Gotland basin in the summer) as the most influential factor.

- Salinity and biomass of *Acartia* in spring are also suggested from one variable GAM explained by itself 67 and 64% of the variability of CBH SSB (Table 1.1).

Table 1.1. Best GAM(M) for CBH SSB

Dependent Variable		Var1		Var2	AIC	DevExpl	Rsqadj	GCV
SSB_CBH	=	S_GB_60_Sum	+	T100_GB	9.6	79%	0.78	0.07
SSB_CBH	=	Acartia_Spr	+	SSS_GB_Sum	16.9	77%	0.75	0.08
SSB_CBH	=	Pseudo_Spr	+	S_GB_60_Sum	17.9	75%	0.74	0.08
SSB_CBH	=	F_CBH	+	SSS_GB_Sum	12.0	79%	0.78	0.07
SSB_CBH	=	F_CBH	+	S_GB_60_Sum	19.6	74%	0.73	0.08
SSB_CBH	=	SSS_GB_Sum			31.6	67%	0.66	0.11
SSB_CBH	=	Acartia_Spr			36.0	64%	0.62	0.12

Using a one-year time lag between SSB and explanatory variables, GAMs suggest the same variables as the most influential.

Recruitment of CBH for the period 1975-2022 (lagged and no lagged by one year) was explained best (between 42-57%) by the models combining: biomass of *Pseudocalanus*, Oxygen concentration (Oxygen concentration at Bornholm Basin at 90m depth in summer), Salinity (Sea surface salinity at Bornholm Basin in summer, salinity at 60m depth at Gotland Basin in Summer.

Models using only one variable explain between 28-51% of deviation, where the best are Sea surface salinity at Bornholm Basin in summer, *Pseudocalanus* biomass in spring and *Acartia* biomass in spring (Table 1.2).

Table 1.2. Best GAM(M) for CBH Recruitment

Target		Var1		Var2	AIC	DevExpl	Rsqadj	GCV
R1_CBH	=	Pseudo_Sum	+	SSS_BB_Sum	38.90	57%	0.54	0.13
R1_CBH	=	SSS_BB_Sum	+	O2_BB_90_win	40.43	56%	0.53	0.13
R1_CBH	=	Pseudo_Sum	+	S_GB_60_Sum	41.89	53%	0.50	0.13
R1_CBH	=	Pseudo_Sum	+	O2_BB_90_win	42.48	55%	0.51	0.14

Target		Var1		Var2	AIC	DevExpl	Rsqadj	GCV
R1_CBH	=	Pseudo_Sum			50.80	43%	0.40	0.16
R1_CBH	=	SSS_BB_Sum			51.21	42%	0.40	0.16
One Year Lag								
R1_CBH_lag1	=	Pseudo_Spr	+	SSS_BB_Sum	37.92	57%	0.55	0.13
R1_CBH_lag1	=	SSS_BB_Sum			43.52	51%	0.49	0.14
R1_CBH_lag1	=	Acartia_Spr			54.53	38%	0.35	0.18
R1_CBH_lag1	=	Pseudo_Spr			60.92	28%	0.25	0.21

SSB and R1 for the Baltic Sprat whole time series (1975-2022) could be represented by a number of simple GAM models with significant predictors ($p < 0.05$) explaining between 80-12% of the variability for SSB and between 72-14% for the recruitment.

The best GAM (Tab. 3) indicated that for no lagged and one-year lag SSB, the most important factors are:

- biomass of zooplankton (*Acartia* sp and *Pseudocalanus* sp in spring),
- Salinity (Sea Surface Salinity at the Bornholm basin in the summer, salinity at 90m depth at the Bornholm basin in the summer)

The temperature at 60 m depth in Gotland and Bornholm basins in the summer does not appear as an influential predictor (itself or in combination with others), explaining only 33% of deviance.

Including Fishing mortality as a co-variable, models suggests biomass of zooplankton (*Acartia* and *Pseudocalanus*) as the most influential factor. The models also include sea surface salinity at Bornholm basin in summer and DIN winter concentration.

Biomass of *Acartia* in spring, *Pseudocalanus* in spring and Summer and Sea surface Salinity are also suggested as the most influential based on one variable GAMs explained by itself 58, 47 and 44% respectively (Table 1.3).

SSB of Eastern Baltic Cod was used. It is one of the most critical factors, but since predation mortality is included in the estimation of sprat SSB, it was excluded from the analysis.

Table 1.3. Best GAM(M) for sprat SSB

Target		Var1		Var2	AIC	DevExpl	Rsqadj	GCV
SSB_SPR	=	Acartia_Spr	+	S90_BB_sum	30.25	65%	0.62	0.11
SSB_SPR	=	Acartia_Spr	+	Pseudo_Spr	34.18	61%	0.58	0.12
SSB_SPR	=	Acartia_Spr	+	SSS_BB_Sum	34.92	59%	0.57	0.12

Target		Var1		Var2	AIC	DevExpl	Rsqadj	GCV
SSB_SPR_lag1	=	Acartia_Spr	+	Pseudo_Spr	21.49	71%	0.69	0.09
SSB_SPR_lag1	=	Acartia_Spr	+	DIN_BB_10_win	23.41	70%	0.67	0.09
SSB_SPR_lag1	=	Acartia_Spr	+	S90_BB_sum	26.83	68%	0.65	0.10
SSB_SPR	=	F_SPR	+	Pseudo_Spr	49.86	45%	0.42	0.16
SSB_SPR	=	F_SPR	+	DIN_BB_90_win	57.74	33%	0.30	0.19
SSB_SPR	=	F_SPR	+	DIN_GB_10_win	58.23	35%	0.31	0.19
SSB_SPR_lag1	=	F_SPR	+	Acartia_Spr	37.63	58%	0.55	0.13
SSB_SPR_lag1	=	F_SPR	+	Pseudo_Spr	48.40	47%	0.44	0.16
SSB_SPR_lag1	=	F_SPR	+	SSS_BB_Sum	50.52	45%	0.41	0.17
SSB_SPR	=	Acartia_Spr			44.48	49%	0.47	0.14
SSB_SPR	=	Pseudo_Spr			51.06	42%	0.39	0.16
SSB_SPR	=	Pseudo_Sum			63.42	24%	0.21	0.21
SSB_SPR_lag1	=	Acartia_Spr			35.79	58%	0.56	0.12
SSB_SPR_lag1	=	Pseudo_Spr			46.95	47%	0.44	0.15
SSB_SPR_lag1	=	SSS_BB_Sum			48.73	44%	0.42	0.16
SSB_SPR_lag1	=	Pseudo_Sum			56.18	35%	0.32	0.19
SSB_SPR_lag1	=	T_BB_60_Sum			56.41	33%	0.31	0.19

Preliminary results suggest that using one-year time lag between SSB and explanatory variables for GAMs proposes the same variables as the most influential (Table 1.3).

Recruitment of Baltic Sprat for the period 1975-2022 (lagged by one year) was explained best (between 9-58%, Table 1.4) by the models combining:

- Salinity (Salinity at 60 m depth at Gotland Basin in Summer with Temperature at 60m depth at Gotland Basin in summer),
- and Sea surface temperature at Bornholm Basin in summer with salinity at 60m depth at Gotland Basin in Summer.

One model with two variables was tested with Total phosphorus concentrations and deep-water oxygen at Gotland basin, giving good results in terms of diagnostic. However, does not explain recruitment variability best and its challenging to find direct ecological explanations

Models using only one variable explain between 15-30% of deviation, where the best predictors are:

- salinity at 60 m depth in Bornholm Basin in summer,
- Sea surface temperature at Bornholm/ basins in summer,
- Chlorophyll a concentration at Bornholm basin in summer

Table 1.1. Best GAM model for Sprat recruitment (only R1 with lag one year included).

Target		Var1		Var2	AIC	DevExpl	Rsqadj	GCV
R1_SPR_lag1	=	PTOT_BB_90_sum	+	O2_220_GB_sum	47.72	35%	0.24	0.48
R1_SPR_lag1	=	S_BB_60_Sum	+	T_GB_60_Sum	73.32	47%	0.44	0.27
R1_SPR_lag1	=	SST_BB_SUM	+	S_BB_60_Sum	74.71	48%	0.43	0.28
R1_SPR_lag1	=	SST_GB_Sum	+	S_BB_60_Sum	75.53	46%	0.42	0.28
One variable GAM								
SSB_SPR_lag1	=	S_BB_60_Sum	+		84.95	30%	0.26	0.34
SSB_SPR_lag1	=	SST_BB_SUM	+		86.50	27%	0.24	0.35
SSB_SPR_lag1	=	Chla_BBspr	+		90.17	19%	0.17	0.38
SSB_SPR_lag1	=	T_GB_60_Sum	+		92.06	15%	0.13	0.40

Table 1.2. Selected environmental/ecosystem variables to test with the Feco approach

Central Baltic Herring	Baltic Sprat
S_GB_60_Sum	*Acartia_Spr*
Acartia_Spr	Chla_BBspr
T100_GB	DIN_BB_10_win
SSS_GB_Sum	O2_220_GB_sum
Pseudo_Spr	Pseudo_Spr
SSS_GB_Sum	Pseudo_Sum
Pseudo_Sum	PTOT_BB_90_sum
SSS_BB_Sum	S_BB_60_Sum
O2_BB_90_win	S90_BB_sum
	SSS_BB_Sum
	SST_BB_SUM
	SST_GB_Sum
	T_BB_60_Sum

Based on these preliminary analyses, we propose the environmental/ecosystem variables suite in tab. 5 to test with the Feco approach for Central Baltic Herring and Baltic Sprat stocks.

Additionally, a synthesis article identified the drivers maintaining low recruitment levels of Wester Baltic Spring Spawning Herring (Moyano *et al.*, 2022). This study highlighted the main driver being habitat compression of the spawning beds (due to eutrophication and coastal modification mainly) and warming, which indirectly leads to changes in spawning phenology, prey abundance and predation pressure. Furthermore, they conclude that changes in coastal fish assemblages (namely the increase in stickleback abundance and the invasion of the round goby) may increase predation pressure on the eggs, following the reduction in pressure from avian predators. This effect of Stickleback over-abundance has also recently been documented in Olin *et al*. (2022).

With spawning/egg habitat availability reduced, there is a higher probability of egg crowding which has been found to be detrimental to development and survival in Finke *et al.* (2022).

1.9.2 Natural mortality rates

Possible mortality induced by liver work infestation in Cod is reviewed under the growth & condition section.

1.9.3 Growth and condition

Using the parasite–host system between the parasitic nematode *Contracaecum osculatum* and the Eastern Baltic cod *Gadus morhua*, Ryberg *et al*. (2020) shed new light on how parasite load may relate to the physiological condition of a transport host. The Eastern Baltic cod is in distress, with declining nutritional conditions, disappearance of the larger fish, high natural mortality and no signs of recovery of the population. During the latest decade, high infection levels with *C. osculatum* have been observed in fish in the central and southern parts of the Baltic Sea. We investigated the aerobic performance, nutritional condition, organ masses, and plasma and proximate body composition of wild naturally infected *G. morhua* in relation to infection density with *C. osculatum*. Fish with high infection densities of *C. osculatum* had (i) decreased nutritional condition, (ii) depressed energy turnover as evidenced by reduced standard metabolic rate, (iii) reduction in the digestive organ masses, and alongside (iv) changes in the plasma, body and liver composition, and fish energy source. The significantly reduced albumin to globulin ratio in highly infected *G. morhua* suggests that the fish suffer from a chronic liver disease. Furthermore, fish with high infection loads had the lowest Fulton's condition factor. Yet, it remains unknown whether our results steam from a direct effect of *C. osculatum*, or because *G. morhua* in an already compromised nutritional state are more susceptible towards the parasite. Nevertheless, impairment of the physiological condition can lead to reduced swimming performance, compromising foraging success while augmenting the risk of predation, potentially leading to an increase in the natural mortality of the host. We hence argue that fish–parasite interactions must not be neglected when implementing and refining strategies to rebuild deteriorating populations.

At present, Eastern Baltic cod (*Gadus morhua*) in the southern Baltic Sea grows slowly, shows low condition factor and is heavily infected by the larvae of liver worms (*Contracaecum* spp.). It is hypothesized, that either the heavy infection by liver worms, lack of suitable food due to lack of oxygen in the deep bottoms of the Baltic Sea or both together cause severe problems for cod. The final host of the liver worm is grey seal (*Halichoerus grypus*), and this parasite is carried to cod via prey, smaller pelagic fish. Raitaniemi & Leskelä, A. (2022) report that there is a small-scale cod fishery in the Finnish waters in the Sea of Åland, where cod are large sized and in good condition. Grey seals are abundant in these waters. In this study, the occurrence of *Contracaecum* larvae in the livers of cod in the Sea of Åland and the food of the cod in the year 2021 was examined and presented together with the results from the year 2020. The size of measured cod in 2021 varied from 40 to 105 cm. Similarly, as in 2020, the number of *Contracaecum osculatum* larvae on liver surface correlated with cod length, but the number of larvae per liver weight did not. The condition factor of the cod was still very high (1.14). More importantly and similarly as in the previous year, the condition of the cod was associated neither with the number of *Contracaecum* larvae on the liver surface nor the number of larvae per liver weight. The most common food items of cod were *Saduria* and clupeid fish. The samples from both years support the conclusion that when there is enough food for the cod, the association of *Contracaecum osculatum* infection and the condition or growth of cod are small or even insignificant.

When these effects of parasite infection are incorporated into a bioenergetics model, the impact at the population can be estimated, as was done in Ryberg *et al*. (2023). High rates of infection across the population (as is seen in some areas of the Baltic, can cause significant decreases in growth and reduced reproductive output. Changes in these two dynamic rates ultimately lead to a large reduction in fisheries productivity. Furthermore, high-levels of infestation per individual can lead to mortality.

Numerous studies from the Baltic Sea have demonstrated an ongoing thiamine deficiency in several animal classes, both invertebrates and vertebrates. The thiamine status of the eastern Baltic cod was investigated by Engelhardt et al. (2020) to determine if thiamine deficiency might be a factor in ongoing population declines. Thiamine concentrations were determined by chemical analyses of thiamine, thiamine monophosphate and thiamine diphosphate (combined SumT) in the liver using high performance liquid chromatography. Biochemical analyses measured the activity of the thiamine diphosphate-dependent enzyme transketolase to determine the proportion of apoenzymes in both liver and brain tissue. These biochemical analyses showed that 77% of the cod were thiamine deficient in the liver, of which 13% had a severe thiamine deficiency (*i.e*. 25% transketolase enzymes lacked thiamine diphosphate). The brain tissue of 77% of the cod showed thiamine deficiency, of which 64% showed severe thiamine deficiency. The thiamine deficiency biomarkers were investigated to find correlations to different biological parameters, such as length, weight, otolith weight, age (annuli counting) and different organ weights. The results suggested that thiamine deficiency increased with age. The SumT concentration ranged between 2.4–24 nmol/g in the liver, where the specimens with heavier otoliths had lower values of SumT ($P = 0.0031$). Of the cod sampled, only 2% of the specimens had a Fulton's condition factor indicating a healthy specimen, and 49% had a condition factor below 0.8, indicating poor health status. These results, showing a severe thiamine deficiency in eastern Baltic cod from the only known area where spawning presently occurs for this species, are of grave concern.

The western Baltic Sea cod (WBC) stock is at historically low levels, mainly attributed to high fishing pressure and low recruitment. Stable stock assessment metrics suggested recovery potential, given appropriate fisheries management measures. However, changing environmental conditions violate stability assumptions, may negatively affect WBC, and challenge the resource management. Receveur *et al.* (2022) explored 42 years of changes in WBC biological parameters. WBC body condition gradually decreased over the last decades for juveniles and adults, with a rapid decrease in recent years when a single cohort dominated the overfished stock. The hepatosomatic index and the muscle weight decreased by 50% and 10% in the last 10 years, respectively, suggesting severely decreasing energy reserves and productivity. The changes in energy reserves were associated with changes in environmental conditions (increase in bottom water temperature, expansion of hypoxic areas during late summer/autumn), and changes in diet composition (less herring). A key bottleneck is the warming and longer-lasting summer period when WBC, trapped between warmed shallow waters and hypoxic deeper waters, have to mobilize energy reserves to account for reduced feeding opportunities and thermal stress. Our results suggest that stock recovery is unlikely to happen by fisheries management alone if environmental trajectories remain unchanged.

The intensified expansion of the Baltic Sea's hypoxic zone has been proposed as one reason for the current poor status of cod (*Gadus morhua*) in the Baltic Sea, with repercussions throughout the food web and on ecosystem services. Orio *et al*. (2022) examined the links between increased hypoxic areas and the decline in maximum length of Baltic cod, a demographic proxy for services generation. We analysed the effect of different predictors on maximum length of Baltic cod during 1978–2014 using a generalized additive model. The extent of minimally suitable areas for cod (oxygen concentration ≥ 1 ml l−1) is the most important predictor of decreased cod maximum length. We also show, with simulations, the potential for Baltic cod to increase its maximum length if hypoxic areal extent is reduced to levels comparable to the beginning of the 1990s. We discuss our findings in relation to ecosystem services affected by the decrease of cod maximum length.

1.9.4 Migrations and spatial distributions

Knowledge of the movement patterns and area utilisation of commercially important fish stocks is critical to management. The Eastern Baltic cod *Gadus morhua*, one of the most commercially and ecologically important stocks in the Baltic Sea, is currently one of the most severely impacted fish stocks in Europe. During the last 2 decades, this stock has experienced drastic decreases in population size, distributional range, individual growth and body condition, all of which may have affected the movements between different areas of the Baltic Sea. Mion *et al*. (2022) investigated the seasonal movement patterns of Eastern Baltic cod by re-analysing historical tagging data collected by the countries surrounding the Baltic Sea (1955-1988) and compared historical patterns with contemporary data from a recent international tagging experiment (2016-2019). Our re-analyses of historical data showed the presence of different movement behaviours, i.e. resident or seasonally migratory, with larger distances moved by cod released in the northern and central Baltic areas compared to cod released in the southern Baltic areas. Furthermore, trends from the recent tagging experiment indicate a persistent resident strategy in the southern Baltic area. These findings present additional information on general movement patterns and area utilisation of Eastern Baltic cod that could inform future management actions and aid stock recovery.

1.9.5 Changes in the fish community

The Baltic herring (*Clupea harengus* membras L.) is traditionally one of the main targets of pelagic fisheries in the Baltic Sea, taken mostly in mixed fishery with sprat. The annual total landings amounted around 258 000 t on average for the most recent 20 years. The international management of the Baltic herring stocks rely on the Total Allowable Catch (TAC) agreements and on a few technical measures (gear restrictions in certain areas, closed areas and periods for fishery) as the operational management tools. There are three major agreed management units of herring in the Baltic: Central Baltic herring, Herring in the Gulf of Bothnia and Gulf of Riga herring. Despite of decades–long efforts in applying of regulatory measures, the fate of the stocks has been different: The Central Baltic herring has shown two major declines during its management history while the two other stocks have shown broadly opposite trends. Raid and Sepp (2022) discuss the possible reasons for the different outcome of management like compliance of fishery with the scientific advice and changes on pelagic communities of the Baltic, focusing on the dynamics in mean weight of herring as another factor potentially effecting on management success across the area.

With projected climate change impacting both sea temperatures and a range of climatically determined marine environment conditions, mechanistic hydro-biogeochemical models can provide forecasts of the marine environment. These forecasts can be coupled with knowledge of fish physiology and ecology to understand potential changes in assemblage structure. This is especially pertinent in enclosed seas, such as the Baltic, where latitudinal shifts are limited by bathymetry. Lindmark *et al* (2022) use this approach to show that under the severe climate scenario

(RCP 8.5), direct and indirect effects result in opposing outcomes when considered as cumulative or independent. Considering only the cumulative outcomes, Lindmark *et al.* (2022) predict an increase of size-at-age for cod, sprat and herring of the south-central Baltic, especially at younger ages. However, these increased early-life growth rates are countered by a decrease in adult carrying capacity, likely leading to an overall decrease in fisheries productivity.

1.10 Stock Overviews

1.10.1 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 2022, reported landings were 19 t. The SSB has decreased to historical low levels in 2020. SSB in 2023 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.

1.10.2 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 2022 to about 2/3 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 very low year classes ever since. The 2023 spawning stock biomass was estimated to be below MSY $B_{trigger}$ and the lowest in the time series. The newest incoming year class is estimated above average but has only been seen in the Q4 survey in 2022 and in Q1 survey 2023 is therefore highly uncertain.

1.10.3 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) is presently close to the lowest level observed since the 1950s. Fishing mortality of the stock is presently at lowest level in the time series 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.

1.10.4 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 300-400 t in recent years. Sole has mainly been caught in a mixed fishery as a valuable by-catch; in the trawl fishery for *Nephrops* and in a gillnet fishery for cod and plaice. The closed area in Kattegat to protect spawning cod also restrict trawl fisheries for sole. The spawning stock biomass has since 2013 increased and is in 2023 predicted to be below MSY $B_{trigger}$ but above B_{lim}. Fishing mortality has decreased continuously since the mid-1990s and has remained below F_{MSY} since 2009. The recent 4 years of recruitment is low and record low for the year 2021. This along with a decreasing weight at age have caused a decrease in catch advice for 2024 and this will likely continue into 2025.

1.10.5 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 ~27% in 2022 as many small fish are entering the fishery from a few years of high recruitment. This combined with the increasing landings from this area is empirical proof of a targeted plaice fishery in area 22. The SSB in the plaice stock has increased in the period from 2009 to 2021, 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. The 2019, 2020, and 2021-year classes are extraordinarily large, breaking records from year to year. The 2019 cohort has entered the fishery and the 2020 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.

1.10.6 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 7 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.

1.10.7 Flounder in 22–23

The stock size indicator from surveys has increased steadily since 2005 about four-fold but was decreasing since 2016. However, the average stock size indicator (biomass-index) in the last three years (2020–2022) has been steadily increasing again, with the Survey in Q4 showing higher abundances than Q1. 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. Discards in the most recent years have been historically low at <10% of the total catch. The results of Length Based Indicator (LBI) showed a sustainable exploitation pattern, as fishing pressure on the stock is below F_{MSY} proxy.

1.10.8 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. The results of LBI showed a sustainable exploitation pattern, as fishing pressure on the stock is below F_{MSY} proxy.

1.10.9 Flounder in 26 and 28

Flounder is taken as by-catch in demersal fisheries and, to a minor extent, in a directed fishery. The main countries landing flounder from subdivisions 26 and 28 are Russia, Latvia, Poland, and Lithuania. Estimates of Russian landings were obtained from Atlantvniro home page and builds a major part of landings (around 60%) for this flounder stock. Landings in both subdivisions are dominated by active gears, taking in 80-85% of total landings. Landings in 2021 were the lowest in time series due to low activity in demersal trawling due to the ban of the direct cod fishery. Discards were considered to be substantial and determined mainly by market capacity. However, due to low sampling coverage, it was not possible to estimate discard for the last two years. The stock showed a decreasing trend from the beginning of the century although the estimated indices in last the years fluctuated without any trend. The results of LBI show that fishing pressure on the stock is below F_{MSY} proxy.

1.10.10 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. In Estonia, discards are not allowed. 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 above the F_{MSY} proxy.

1.10.11 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 bycatch 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%. The stock size indicator from surveys has increased steadily since 2001 nearly threefold. The survey index varies at around ~100 kg/hour since 2010 in SD 22– 24 and remains stable since then.

1.10.12 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 (95% of the catches in 1985–2016). Yearly landings within the Baltic Sea have varied between 27 and 105 tonnes during the last ten years. The eastern border of its occurrence is not clearly described. Additional information has 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. The stock size indicator from surveys was the highest in 2011 and varied around 0.6 individuals on average hour-1 larger or equal to 20 cm between 2012 and 2020 in SD 22– 24.

1.10.13 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 from BITS survey has been changed to a biomass index in 2022 and is stable since 2002. A large year class has been detected in 2019, resulting in record-high discard rates in the fishery in 2020 and 2021. The cohort signal was covered by a very low sampling coverage in the most recent year, but low discard rates suggest that this cohort has entered the landed fraction of the fisheries.

1.10.14 Herring in subdivisions 25–29 & 32 excl. 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 in 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. The latest stronger year classes were recorded for the years 2007, 2011, and 2014. The year class 2019, for which estimates were uncertain in the previous years, was estimated to be 10% above average (when comparing the recruitment in the recent period since 1988). Spawning-stock biomass (SSB) has fluctuated around B_{lim} since 1995 and has been below B_{lim} for the last four years since. 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.

1.10.15 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 147 000 t in 2022. The year class abundance of this stock is significantly influenced by hydro- meteorological conditions (by the severity of winter, in particular). Mild winters in 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.

1.10.16 Herring in subdivisions 30 and 31

The spawning stock of Gulf of Bothnia herring diminished from early 1960s to a relatively low level in the beginning of the 1970's until the beginning of 1980s, from which it started to increase and peaked in 1994. From there it decreased again until early 2000s and levelled down until a small peak in (2010), after which the spawning stock has again showed a decreasing trend, and in 2021-2022 is estimated to be below $B_{trigger}$. Recruitment has been on average higher since the higher biomass period starting from the late 1980s, 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 possible dying especially in larger herring. Further, 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, fishing mortality has in general decreased, however 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 had decreased from the levels that were found before 2020.

1.10.17 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%. 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 of 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 and 2022 y-c are poor (the 2021 y-c is one of the poorest). Under the F_{MSY} catches the stock is predicted to be at a level slightly below one million t in 2025.

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 2021-2022. 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.

1.11 Feedback on the WGBFAS overview of the RCG ISSG on catch, sampling and effort overviews

In 2020, WGBFAS made a request/recommendation towards the Regional Coordination Group for the Baltic (RCG Baltic) to access and use some of the RDB fisheries overviews that the RCG Baltic is producing for their annual work. The request was picked up and evaluated during the RCG technical meeting in 2021 it was agreed to use the request as a test case for RCG/ICES WG collaborations. In consultation with the RDBES team, ICES data center and the National correspondents, WGBFAS will be supplied with a data product package each year by the RCG subgroup “ISSG on catch, sampling and effort overviews”. The provision of such RDB data products is a pilot study on future collaborations between RCG groups and ICES WGs to test and evaluate how RDB data can be requested, provided and where agreements and exemptions of data policies have to be made. RCG Baltic will evaluate the responses and feedback from WGBFAS during their technical meeting in June 2023.

The data product package comprised of the four Baltic Sea TAC species (i.e. herring, sprat, cod and plaice), each with an identical set of maps, figures and overviews, generated with the most recent RDB data (2022 data) and thus are considered preliminary. The data products can be used in the report or for internal working group discussions to get a better understanding of e.g. fishing intensities, sampling coverage and the importance of different gear types.

WGBFAS is exempted from the RCG and ICES data policy and therefore can use any combination of the figures and maps provided by the RCG Baltic group in their reports; reference and a data disclaimer have to be given however.

Larger changes in the data products need permission by the National correspondents, but smaller changes (such as different scaling, color codes or variable names) can be done intersessional.

Several of the graphs (e.g. annual landings by species and by stock per rectangle; Total landings number of trips sampled for lengths/ages; Annual fishing effort) will be used in the report and have proven very helpful in discussions during the groups meeting in April 2023. WGBFAS will also inquire the possibility to use some of the graphs in the Fisheries overview section (which is managed by WKFOG and thus needs their approval).

The group appreciates the support by the ISSG and requests the provision of a similar document for Baltic Sea flounder and its stocks.

WGBFAS made several suggestions on how to improve the maps and figures:

Landing and effort maps:

- Map titles and labels need improvement and better description
- For herring and sprat: Monthly (instead of quarterly) overviews for landings and effort
- For herring and sprat: Landings: pie-chart per rectangle showing mixing of SPR and HER

Metier overview:

- Should be by species/stock

Sampling intensity and location maps (*large interest to use after correction by WGBFAS*)

- Map titles and labels need improvement and better description
- Adding Management area (or Subdiv borders) to the maps
- Sampling intensity needs to be shown by species or stock (bubbles are now identical between the documents and stocks)
- Instead of GPS coordinate bubbles, aggregate by rectangle?
    - Or combine landings and sample bubbles to a unit sampled/landings or effort (to lose one of the variables and make the maps easier to read, esp. the quarterly maps)

Gear sampling overview (*highly appreciated by WGBFAS*)

- Spell out the gear names for report reader to understand
- Sort gears by importance or landings?
- similar to sampling maps: maybe combine variable to a sampling cpue and reduce variables displayed (only color code for landings vs. sampled)

2 Cod in the Baltic and the 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.

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 has to 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 actually 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.

Four countries reported zero BMS landings for 2022 and four countries reported very small amounts (1 t or less). BMS landings were provided separately from discards by Sweden. Denmark and Poland included BMS landings in the discard estimate in the data submission and provided separate information on BMS only as "official landings". In order 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, similar to 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 2022 are shown in Table 2.1.2a. The total provided EU landings in SD 25-32 in 2022 summed up to 197 t, whereof more than 99% were above MCRS and only 2 t were BMS landings (Tables 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, no landings for Russia were officially reported to ICES. The information on Russian landings in 2022, used in the assessment, was based on the information available on *http://atlant.vniro.ru* (900 t). This 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 (Figures 2.1.1 and 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 2022 are estimated to 48 tonnes (4% of total landings of the stock). Thus, the total landings from the stock in 2022, used in this assessment were 1146 t.

2.1.1.2 Unallocated landings

For 2022, similar to 2010–2021, quantitative information on unreported landings was not available and the Working Group was not in a position to quantify them. Unallocated landings have been a significant problem during 1993–1996 and 2000–2007 when the unreported landings have been considered to be 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 2022. The discard amounts in 2022 are therefore very uncertain, even though believed to be rather limited considering the low fishing effort in the demersal fishery. Only 16% 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 33% 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 2022, in subdivision 25-32, were estimated to 20 t (not including any BMS landings), which constituted 9 % 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 2022. 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 2022 was length class 30-34 cm (43% in numbers) followed by length classes 25-29 cm and 35-37cm (30% and 16%, 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 15 tons of estimated discards of eastern Baltic stock in SD 24 in 2022 (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 similar 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 2022 was 38-44 cm (42% in numbers), followed by 35-37 cm (22%) and 30-34 cm (10%) (Table 2.1.5). Table 2.1.6 gives the estimated mean weight per length class and gear in the landings and discards 2022.

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. A comparison of length distributions of EU and Russian landings in former years shows some notable differences, especially for Passive gears (Figure 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 (Figure 2.1.3). Therefore, length distributions on Russian landings in 2022 were set equal to those in 2021.

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 2022. 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 2022 especially for discards. Numbers and mean weight at length were only provided for 18% of the total EU landings (>MCRS) in weight and for 24% 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 2017-2022. However, the resulting overall length distribution of EU catch in 2022 is similar to that in earlier years.

No biological information was available for Russian landings in 2022.

Length distributions for 2022 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 2013–2022 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 (Figure 2.1.4). Relatively high cpue values are recorded also in SD 24 that 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 (Figure 2.1.4). In BITS survey in Q1 2023 a relatively higher amounts on <35 cm cod were found in the Eastern Baltic cod distribution area (Figure 2.1.5). Some increase in the abundance of smaller cod was detected also in Q4 2022 survey. There is a stronger 2022 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 in a given year and quarter, raised with total length distribution in respective BITS survey, to represent population average (Figure 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 (Figure 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 2022 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 (Figure 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 2021 Q4 were the lowest since 2000, with some increase apparent in most recent surveys in 2023 Q1 and 2022 Q4 (Figure 2.1.8a). This increase in relative biomass in most recent surveys is visible for length groups <35 cm, not for larger individuals (Figure 2.1.8b). As described in the section for stock distribution, at least part of this increase is probably due to expansion of the stronger 2022 years class of western Baltic cod into the area. 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 around 40 cm in recent years (Figure 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 2022 than in 2021 (Figure 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 (Figure 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 2022 for EU were compiled from national data provided in IC. The assumed Russian catch in 2022 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 2023 Q1, the last data year in the Stock Synthesis model is set to 2023. This implies that catches for 2023 need to be assumed. The catch in 2023 was set to 2195 tonnes (sum of EU TAC at 595 t plus available information on Russian quota on *http://atlant.vniro.ru*, at 1600 t).

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 (Figure 2.1.11). The landings that have not been specified in IC whether active or passive were all allocated to Active. 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 (1991-2022) and Q4 (1998-2022) were included. The average length at age in the individual fish data from BITS, used as basis for ALK, are presented in Figure 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	1991-2023	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	1993-2022	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	1986-2022	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	1987-2022	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 and 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 and 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 2021, 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 time 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 2022, 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).

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 break-points 0.5, 1.5, 5.5 and 15.5 were used. Natural mortality from 2000 to 2022 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 time 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.

2.1.5.2 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.

2.1.5.3 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 (Figure 2.1.13). At the same time, growth has declined since around the year 2000 (Figure 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 Figure 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 (Figure 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 (Figure 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 Q4 in 2022 and in Q1 in 2023, 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 (Figure 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 2019-2022 was at the lowest level observed since the 1950s, with a slight increase estimated for 2023 (Figure 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 2022 (estimated at 0.015) (Figure 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 (Figure 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 taking into account 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 (Figure 2.1.22).

SPICT estimates that the biomass of the eastern Baltic cod is below Bmsy trigger proxy since 2018 (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 Short-term forecast and management options

The short-term projections were done with Stock Synthesis, using stochastic forecast with multivariate log-normal approximation (MVLN) (Walter and Winker, 2019; Winker *et al*., 2019), that makes it possible to also include the associated probability/risk of the SSB to be below B_{lim} and

$B_{trigger}$ for each year of forecast. The forecast settings in terms of F and recruitment are shown in the table below. The growth and natural mortality were kept at values estimated for 2022. For maturity and weight at length, the values for the latest time-block were used.

Variable	Value	Notes
Fages 4–6 (2023)	0.025	F based on catch constraint.
SSB (2023)	76 903	Stock Synthesis assessment estimate
R_{age0} (2022-2024)	1 995 510	Average of 2017-2021
Total catch (2023)	2195	EU TAC 595 tonnes + 1600 tonnes based on available information on Russian quota on *http://atlant.vniro.ru*

Even at no fishing, the SSB is estimated to remain below B_{lim} in 2025, with very high probability (Table 2.1.14).

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 B_{lim} is not fixed, but it is adjusted on an annual basis, to correspond to the most updated assessment.

WGBFAS (2023) estimated the B_{lim} to be at 108 942 t (SSB in 2012 in the present assessment).

B_{lim} at 108 942 t corresponds to B_{pa} at 122 114 t ($B_{lim} \times \exp(1.645 \times \sigma)$, where σ=0.07).

2.1.9 Quality of the assessment

Sampling of EU landings and discards is poor in last years, due to a combination of COVID-19 disruption and low catches. The EU discard estimate for 2022 is based on only 2 trips from one country. Low quotas may also have caused misreporting of landings.

Major part of the catches of this stock are taken by Russia, but no information on Russian catches for 2022 was officially reported to ICES. Russian catch amount for 2022 included in the assessment was based on approximate information available on *http://atlant.vniro.ru;* but no information on length composition of these catches was available to ICES and length structure was set equal to 2021. However, the perception of the stock status and present advice are considered robust to uncertainties in catch data in recent years.

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.

2.1.10 Comparison with previous assessment

The assessment is consistent with the last years' assessment.

2.1.11 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
1966	37070		26	10589	12831			56007		22525	38270				177318
1967	39105		27	21027	12941			56003		23363	42980				195446
1968	44109		70	24478	16833			63245		24008	43610				216353
1969	44061		58	25979	17432			60749		22301	41580				212160
1970	42392		70	18099	19444			68440		17756	32250				198451
1971	46831		53	10977	16248			54151		15670	20910				164840
1972	34072		76	4055	3203			57093		15194	30140				143833
1973	35455		95	6034	14973			49790		16734	20083				143164
1974	32028		160	2517	11831			48650		14498	38131				147815
1975	39043		298	8700	11968			69318		16033	49289				194649
1976	47412		287	3970	13733			70466		18388	49047				203303
1977	44400		310	7519	19120			47702		16061	29680				164792
1978	30266		1437	2260	4270			64113		14463	37200				154009
1979	34350		2938	1403	9777			79754		20593	75034	3850			227699
1980	49704		5962	1826	11750			123486		29291	124350	1250			347619
1981	68521		5681	1277	7021			120901		37730	87746	2765			331642
1982	71151		8126	753	13800			92541		38475	86906	4300			316052
1983	84406		8927	1424	15894			76474		46710	92248	6065			332148
1984	90089		9358	1793	30483			93429		59685	100761	6354			391952
1985	83527		7224	1215	26275			63260		49565	78127	5890			315083
1986	81521		5633	181	19520			43236		45723	52148	4596			252558
1987	68881		3007	218	14560			32667		42978	39203	5567			207081
1988	60436		2904	2	14078			33351		48964	28137	6915			194787
1989	57240		2254	3	12844			36855		50740	14722	4520			179178
1990	47394		1731		4691			32028		50683	13461	3558			153546

Year	Denmark	Estonia	Finland	German Dem.Rep.**	Germany Fed. Rep.	Latvia	Lithuania	Poland	Russia	Sweden	USSR	Faroe Islands^	Norway	Unallocated***	Total
1991	39792	1810	1711		6564	2627	1865	25748	3299	36490		2611			122517
1992	18025	1368	485		2793	1250	1266	13314	1793	13995		593			54882
1993	8000	70	225		1042	1333	605	8909	892	10099		558		18978	50711
1994	9901	952	594		3056	2831	1887	14335	1257	21264		779		44000	100856
1995	16895	1049	1729		5496	6638	4513	25000	1612	24723		777	293	18993	107718
1996	17549	1338	3089		7340	8709	5524	34855	3306	30669		706	289	10815	124189
1997	9776	1414	1536		5215	6187	4601	31396	2803	25072		600			88600
1998	7818	1188	1026		1270	7765	4176	25155	4599	14431					67428
1999	12170	1052	1456		2215	6889	4371	25920	5202	13720					72995
2000	9715	604	1648		1508	6196	5165	21194	4231	15910				23118	89289
2001	9580	765	1526		2159	6252	3137	21346	5032	17854				23677	91328
2002	7831	37	1526		1445	4796	3137	15106	3793	12507				17562	67740
2003	7655	591	1092		1354	3493	2767	15374	3707	11297				22147	69477
2004	7394	1192	859		2659	4835	2041	14582	3410	12043				19563	68578
2005	7270	833	278		2339	3513	2988	11669	3411	7740				14991	55032
2006	9766	616	427		2025	3980	3200	14290	3719	9672				17836	65531
2007	7280	877	615		1529	3996	2486	8599	3383	9660				12418	50843
2008	7374	841	670		2341	3990	2835	8721	3888	8901				2673	42234
2009	8295	623			3665	4588	2789	10625	4482	10182				3189	48438
2010	10739	796	826		3908	5001	3140	11433	4264	10169					50276
2011	10842	1180	958		3054	4916	3017	11348	5022	10031					50368
2012	12102	686	1405		2432	4269	2261	14007	3954	10109					51225
2013	6052	249	399		541	2441	1744	11760	2870	5299					31355
2014	6035	166	350		676	1999	1088	11026	3444	4125					28909
2015	9526	183	388		1477	2873	1845	12896	3845	4438					37471
2016	6756	2	57		918	2656	1637	9583	3392	3995					28996

Year	Denmark	Estonia	Finland	German Dem.Rep.**	Germany Fed. Rep.	Latvia	Lithuania	Poland	Russia	Sweden	USSR	Faroe Islands^	Norway	Unallocated***	Total
2017	6109	1	191		337	2058	1712	6468	4124	4316					25317
2018	2668	1	53		231	1237	684	5687	3376	1862					15800
2019	1051	2	85		281	251	111	3180	2701	665					8326
2020	20	2	24		12	76	11	376	1778	11					2310
2021	15	2	35		20	11	2	66	1225	8					1383
2022	33	1	30		5	15	2	100	900^^	9					1095

*** 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*

Table 2.1.2a. Cod in SD 25-32. Landings (tons) of EU countries by fleet, country and subdivision in 2022 (BMS excluded).

Subdivision		25	26	27	28	29	30	31	32	Total 25-32
Fleet	Country									
Active	Denmark	32	0	0		0	0			32
	Estonia									
	Finland									
	Germany	5								5
	Latvia		0		0					0
	Lithuania		0		1					1
	Poland	90	1							91
	Sweden	0	1	0	0		0	0		1
Total Active gears		128	2	0	1	0	0	0	0	131
Passive	Denmark	1	0	0		0	0			1
	Estonia				0	0			1	1
	Finland					30	0		0	30
	Latvia		8		6					15
	Lithuania		1							1
	Poland	9	0							9
	Sweden	2	0	1	0	5	0			8
Total Passive gears		12	9	1	7	35	0	0	1	64
Total All gears		140	11	1	8	35	0	0	1	195

Table 2.1.2b. Cod in SD 25-32. Total landings (tons) by country in 2022, 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	33	0.57
Estonia	1	0
Finland	30	0
Germany	5	1
Latvia	15	0
Lithuania	2	0
Poland	100	0.23
Russia	900*	
Sweden	9	0.66
Total	195	2.4

Russian landings for 2022 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://atlant.vniro.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) were 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		
	Unallocated*	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

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
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
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

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
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
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

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
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

***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***

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

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

Length class	Wanted catch	Unwanted catch	Total
<20		0	0
20-24		8	8
25-29		25	25
30-34	6	36	42
35-37	75	14	88
38-44	166	1	167
45-49	34		34
≥50	29		29
	309	84	393

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 2022.

Fleet	Length class (cm)	Wanted catch	Unwanted catch
Active	<20		57
	20-24		110
	25-29		198
	30-34	366	307
	35-37	432	406
	38-44	564	441
	45-49	902	
	≥50	1381	
Passive	<20		57
	20-24		110
	25-29		198
	30-34	368	307
	35-37	460	406
	38-44	517	441
	45-49	910	
	≥50	1421	

Table 2.1.7 Cod in SD 25-32. Indicator values for LeCren's condition index, L_{50} (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	L_{50}	L_{95}
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
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		37

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- 2022	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- 2022	5 – 120 cm	
Maturity ogives	Size at 50%maturity(L50) and slope	1946-2022		Yes (1998-2022, time blocks)
Growth	Von Bertalanffy growth parameters	1946-1990		No
Age length keys	Age length keys from BITS Q1 and Q4	1991-2022	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	1975-2023		
Length composition of survey catch	Length composition of BITS Q1 and Q4	1991-2023		
Commercial CPUE indices	Commercial CPUE 1-3	1948-1989		
SSB index	SSB index from egg production method	1986-2022		
Larval index	Larval abundance	1987-2022		

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			

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
Ln (recruitment deviations): 1946-2021	76				
Recruitment autocorrelation		0			
<u>Growth</u>					
L_{inf} (cm) (1946-1990)		125.27			
L_{inf} (cm) (1991-2022)	32	Estimated using random walk annual deviations	(40-150)	no prior	122-48
k (1946-1990)		0.10			
k (1991-2022)	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			
<u>Weight (kg) at length (cm)</u>					
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, 2021-2022)		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, 8.46E-06			
b (1991-1993, 1994- 1996, 1997-1999, 2000 -2002, 2003-2005, 2006-2008, 2009-2011,2012-2014, 2015-2017,2018-2020,2021-2022)		3.1353, 3.0636, 3.1062 3.0992, 3.0972, 3.0637 3.0831, 3.0406, 3.0087,3.0588,3.0228			
<u>Maturity</u>					
Length (cm) at 50% mature (1946-1990)		38			
Slope of the length at maturity ogive		-0.23			
Length (cm) at 50% mature (1991-1997, 1998-2000, 2001-2007, 2008-2014, 2015-2022)		38, 36, 31, 26, 21			
<u>Initial fishing mortality</u>					

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
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					
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

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
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 2.1.10. Eastern Baltic cod in SDs 24-32. Catch-at-age, estimated from Stock Synthesis.

Year	a1	a2	a3	a4	a5	a6	a7	a8+
1946	834	8281	14398	5901	3096	1591	656	773
1947	593	17482	28147	14809	3839	1792	893	792
1948	1036	11277	51396	23949	7697	1744	783	724
1949	1218	16093	27658	36907	10434	2913	633	537
1950	1289	19816	41911	21344	17378	4277	1146	452
1951	1015	20447	49910	30938	9536	6731	1588	580
1952	938	18099	56388	39677	14763	3931	2655	835
1953	788	10657	33230	30769	13066	4199	1069	926

Year	a1	a2	a3	a4	a5	a6	a7	a8+
1954	1254	13312	28906	27415	15861	5941	1843	858
1955	1086	17636	30873	20575	12162	6188	2234	995
1956	832	21354	54927	28656	11810	6128	3005	1535
1957	890	16236	63172	46228	14342	5081	2518	1820
1958	1189	11735	33501	37455	16045	4228	1422	1182
1959	1049	19256	29960	24965	16658	6130	1541	927
1960	1526	20768	57520	24856	11970	6751	2356	924
1961	1087	18448	39238	29840	7198	2864	1516	713
1962	1131	16935	44296	26309	11567	2357	889	673
1963	1320	18837	43023	31184	10664	3954	764	492
1964	1514	15282	34907	22744	9562	2762	970	300
1965	1824	22980	37295	24940	9811	3570	988	444
1966	2447	44226	84093	37763	14849	4999	1736	678
1967	2318	37590	101742	50933	12594	4074	1287	601
1968	2268	38380	92296	65980	18293	3735	1135	509
1969	1791	35166	88920	56765	22386	5108	978	416
1970	1874	27279	80064	54044	19086	6203	1328	351
1971	2098	25842	57629	46166	17446	5106	1560	409
1972	2455	28950	55960	34944	16045	5091	1408	527
1973	2522	32774	61734	34014	12423	4846	1461	540
1974	1274	32152	66721	36707	12188	3848	1437	579
1975	1151	21088	84890	52552	17901	5227	1592	816
1976	1360	16319	52286	65026	25106	7524	2119	956
1977	2469	19434	36884	34743	26842	9134	2644	1059
1978	2181	39508	45009	25299	15172	10505	3473	1384
1979	1279	34529	107503	41104	15361	8376	5656	2576
1980	2962	27125	108639	106043	26298	8854	4689	4534
1981	2415	40974	64267	85043	53698	11877	3866	3958
1982	1738	41065	103058	48148	39917	22285	4761	3083

Year	a1	a2	a3	a4	a5	a6	a7	a8+
1983	1015	27305	105197	81238	23924	17602	9505	3291
1984	1061	20617	87915	103720	50387	13094	9296	6625
1985	1249	19355	57298	67734	47129	19639	4878	5784
1986	1888	21476	53762	44882	31107	18439	7322	3876
1987	1270	35097	60774	40090	18905	10969	6158	3634
1988	854	22423	92385	41065	14990	5855	3201	2769
1989	835	14277	56174	60634	14999	4543	1670	1651
1990	793	16812	39072	40142	24179	4953	1409	999
1991	1181	11438	41703	25963	14367	6981	1328	622
1992	1102	11304	16188	15197	5036	2227	998	267
1993	528	12138	22203	9095	4978	1395	581	320
1994	565	12149	44857	30112	7652	3615	962	603
1995	852	11390	29959	32407	13895	3004	1336	559
1996	651	13741	33702	29344	20265	7706	1573	961
1997	1278	8723	31205	22409	10857	6206	2206	694
1998	1578	16753	20604	20275	7675	2903	1509	674
1999	1366	17291	42319	17266	8698	2466	821	580
2000	1103	21843	50117	34341	6813	2395	577	300
2001	1438	15165	50339	32643	11516	1656	489	162
2002	727	14954	27807	25574	8826	2364	293	104
2003	881	9117	36456	22184	11301	3087	738	115
2004	1669	10850	23329	29398	9923	3851	928	238
2005	1396	19197	23464	15423	10397	2669	895	250
2006	1039	12320	44858	21907	8535	4510	1029	411
2007	804	8849	25655	30933	8834	2652	1225	361
2008	754	8643	22898	19399	12818	2845	749	415
2009	812	9401	25528	23400	10860	5479	1077	410
2010	699	9039	23475	23202	12869	4583	2038	521
2011	794	7636	24944	23274	14215	6302	1981	1044

Year	a1	a2	a3	a4	a5	a6	a7	a8+
2012	1496	9544	24884	29452	16074	7648	2989	1328
2013	1198	9083	18203	17816	11795	4683	1900	977
2014	882	11070	25456	18842	10172	4825	1601	894
2015	735	7798	28253	25655	10843	4192	1642	754
2016	353	4698	14273	21049	11596	3638	1183	607
2017	625	3026	11135	13249	12064	5125	1393	629
2018	425	3918	5999	8953	6542	4616	1726	633
2019	125	1783	5886	3892	3572	2008	1250	601
2020	99	356	1250	1506	596	418	209	188
2021	57	452	466	749	621	205	135	131
2022	24	265	605	286	319	222	69	90

Table 2.1.11. Eastern Baltic cod in SDs 24-32. Spawning stock biomass (SSB, at the spawning time, tonnes), recruitment at age 0 (thousands) and fishing mortality (F_{bar} for ages 4-6). "High" and "low" values correspond to 90% confidence intervals.

Year	Recruitment			SSB			Fishing mortality		
	Recruitment	High	Low	SSB	High	Low	F (ages 4–6)	High	Low
1946	2157560	2422866	1921305	62861	69686	56037	0.39	0.43	0.36
1947	3136690	3457235	2845865	82786	90557	75014	0.51	0.55	0.47
1948	3713080	4066547	3390337	106429	115450	97408	0.58	0.62	0.53
1949	3803740	4161055	3477108	115173	125445	104901	0.56	0.60	0.51
1950	2974050	3290974	2687646	121151	131733	110569	0.58	0.63	0.54
1951	2376540	2664963	2119332	133125	143850	122400	0.59	0.63	0.55
1952	2728350	3043327	2445972	136569	147568	125570	0.66	0.71	0.61
1953	3962710	4335777	3621743	142489	154386	130592	0.48	0.52	0.45
1954	3847460	4203539	3521544	136804	149170	124438	0.52	0.56	0.48
1955	2343500	2615973	2099407	138087	150149	126025	0.49	0.52	0.45
1956	1943960	2185441	1729161	142610	153203	132017	0.61	0.64	0.57
1957	2978440	3264655	2717318	133830	142875	124785	0.74	0.78	0.70
1958	2476480	2738377	2239631	118619	127013	110225	0.64	0.68	0.60

Year	Recruitment			SSB			Fishing mortality		
	Recruitment	High	Low	SSB	High	Low	F (ages 4–6)	High	Low
1959	2755550	3028742	2507000	100056	107403	92709	0.69	0.74	0.65
1960	2525810	2798497	2279694	84590	91119	78061	0.91	0.97	0.84
1961	2618360	2913623	2353019	83824	90430	77217	0.73	0.78	0.68
1962	2827080	3156290	2532208	86508	93389	79627	0.73	0.78	0.68
1963	4426120	4852107	4037532	84970	92399	77541	0.78	0.84	0.72
1964	5646340	6144322	5188718	93140	101725	84555	0.60	0.64	0.55
1965	4943680	5421744	4507770	108468	117911	99025	0.58	0.62	0.53
1966	4783560	5247211	4360878	118741	128365	109117	0.88	0.95	0.80
1967	4359420	4798361	3960632	137163	146270	128056	0.84	0.90	0.79
1968	3400160	3787811	3052182	142177	151349	133005	0.88	0.93	0.83
1969	3546330	3952555	3181855	138226	147586	128866	0.88	0.93	0.82
1970	4409670	4893512	3973668	129559	139352	119766	0.87	0.93	0.81
1971	5856810	6438650	5327549	120588	131179	109997	0.79	0.85	0.73
1972	7241140	7900269	6637003	121452	133093	109811	0.72	0.78	0.66
1973	4535980	5084989	4046246	143028	156304	129752	0.63	0.68	0.57
1974	3816880	4340016	3356802	195401	211076	179726	0.49	0.53	0.46
1975	5488120	6158129	4891009	245200	263514	226886	0.50	0.54	0.47
1976	11886200	12907206	10945960	245620	267007	224233	0.49	0.53	0.46
1977	9660150	10624473	8783353	252350	276826	227874	0.41	0.44	0.37
1978	5718920	6483555	5044462	310759	337642	283876	0.34	0.36	0.31
1979	9521780	10433551	8689687	407244	435715	378773	0.37	0.40	0.35
1980	9619740	10478906	8831017	457303	487872	426734	0.47	0.50	0.45
1981	6335980	6998331	5736316	421705	452978	390432	0.48	0.51	0.45
1982	3930780	4392957	3517228	446399	475792	417006	0.46	0.49	0.43
1983	3374780	3733083	3050867	443801	468249	419353	0.46	0.49	0.44
1984	3540350	3837036	3266605	377474	396345	358603	0.61	0.63	0.58
1985	5332350	5633183	5047583	282790	297252	268328	0.65	0.67	0.62
1986	3238240	3465102	3026231	195258	207551	182965	0.72	0.76	0.68

Year	Recruitment			SSB			Fishing mortality		
	Recruitment	High	Low	SSB	High	Low	F (ages 4–6)	High	Low
1987	2021330	2186068	1869006	149671	156727	142615	0.79	0.80	0.77
1988	2040210	2191231	1899598	142483	148475	136491	0.80	0.83	0.77
1989	1493640	1623372	1374276	119505	124752	114258	0.81	0.83	0.78
1990	2987350	3200214	2788645	90070	94969	85171	0.93	0.97	0.89
1991	3548030	3778593	3331535	57472	61076	53868	1.05	1.09	1.01
1992	2395660	2579387	2225019	60987	67363	54610	0.56	0.61	0.51
1993	2016780	2177435	1867979	103145	113560	92730	0.35	0.38	0.32
1994	1970220	2123979	1827592	120533	131131	109935	0.54	0.58	0.50
1995	1464130	1602058	1338077	132252	141934	122570	0.55	0.58	0.52
1996	2742310	2973413	2529169	93871	101070	86671	0.85	0.90	0.80
1997	2790870	3044321	2558520	63303	68874	57732	0.91	0.97	0.85
1998	2867140	3129496	2626778	56050	61077	51023	0.88	0.95	0.81
1999	2227150	2479269	2000669	51971	56765	47178	0.95	1.03	0.87
2000	2905690	3164505	2668043	61608	66459	56757	1.03	1.11	0.96
2001	1910600	2106427	1732978	75403	80864	69942	1.01	1.08	0.94
2002	2343260	2558213	2146369	85029	90854	79205	0.72	0.78	0.67
2003	4042790	4354986	3752975	86704	92496	80912	0.74	0.79	0.68
2004	3176490	3472345	2905843	75587	81325	69850	0.75	0.81	0.70
2005	3953130	4328912	3609969	94283	100771	87794	0.59	0.63	0.55
2006	4184580	4598525	3807897	94986	101884	88088	0.65	0.70	0.61
2007	3957610	4377921	3577652	93791	101238	86344	0.52	0.57	0.48
2008	4147550	4601826	3738118	134284	144215	124353	0.39	0.43	0.36
2009	3543400	3983912	3151596	148363	159291	137435	0.37	0.40	0.34
2010	3781720	4267297	3351397	152917	164139	141695	0.35	0.38	0.32
2011	5134910	5754168	4582296	136020	146338	125702	0.39	0.42	0.36
2012	5235180	5872463	4667055	108942	117826	100058	0.53	0.58	0.49
2013	3245730	3713170	2837135	102055	110489	93621	0.40	0.43	0.36
2014	2602870	2989679	2266107	111502	120560	102444	0.39	0.42	0.35

Year	Recruitment			SSB			Fishing mortality		
	Recruitment	High	Low	SSB	High	Low	F (ages 4–6)	High	Low
2015	1757580	2059576	1499866	132347	142776	121918	0.38	0.41	0.35
2016	2756890	3131984	2426718	113740	122663	104817	0.30	0.32	0.27
2017	2165040	2498899	1875785	85337	92176	78498	0.31	0.33	0.28
2018	1279890	1547520	1058544	73682	79793	67571	0.27	0.29	0.24
2019	2586840	3026429	2211102	68094	73877	62311	0.160	0.174	0.145
2020	2344850	2876491	1911468	64835	70177	59493	0.039	0.042	0.036
2021	1600960	2425174	1056862	69026	74860	63193	0.024	0.026	0.022
2022	1995510*			76713	83877	69549	0.0147	0.0161	0.0133
2023	1995510*			76903	85680	68125			

***average of 2017-2021**

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
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

Year	a1	a2	a3	a4	a5	a6	a7	a8
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
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

Year	a1	a2	a3	a4	a5	a6	a7	a8
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
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

Year	a1	a2	a3	a4	a5	a6	a7	a8
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

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

Year	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
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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
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
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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
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
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

Table 2.1.14. Eastern Baltic cod in SDs 24-32. Catch scenarios.

Basis	Total catch (2024)	F (2024)	SSB* (2024)	SSB* (2025)	Probability of SSB (2024) >B_{Lim} (%)	% SSB change	Catch change**
F = 0	0	0	76534	77319	< 0.01	1.0	-100
F = 0.05	4373	0.050	75317	74671	< 0.01	-0.9	270
F = F (2022)	1299	0.015	76004	76458	< 0.01	0.6	10
Catch =TAC (2023)	2195	0.026	75824	75971	< 0.01	0.2	86
Catch =0.75 x TAC (2023)	1646	0.019	75925	76360	< 0.01	0.6	39

*SSB at the spawning time

**Catch in 2024 compared to catch in 2022 (1181 tonnes).

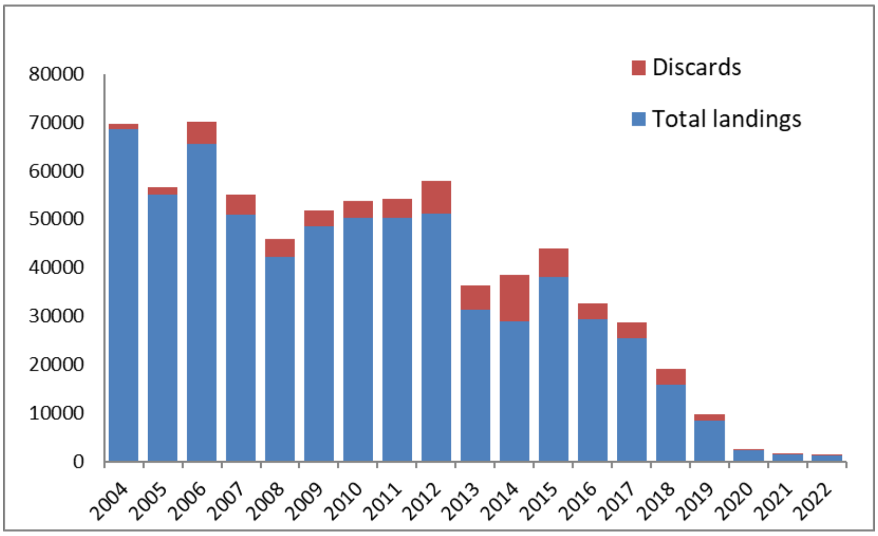


Figure 2.1.1. Eastern Baltic cod in SDs 24-32. Total landings (incl. unallocated for years before 2010) and estimated EU discards in management area of SDs 25-32.

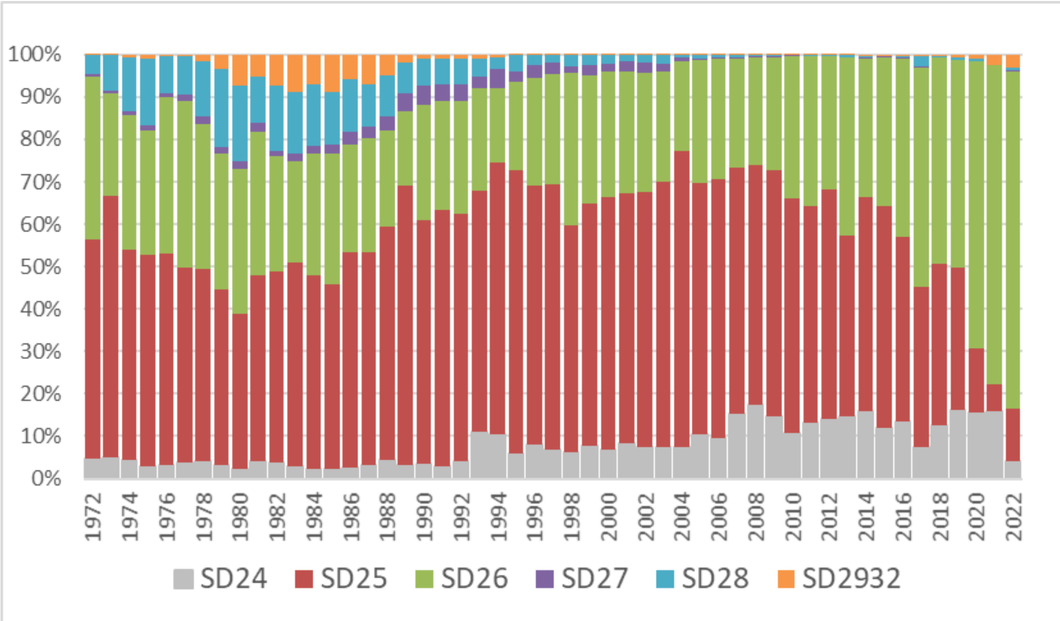


Figure 2.1.2. Eastern Baltic cod in SDs 24-32. Relative distribution of landings of the eastern Baltic cod stock by SD.

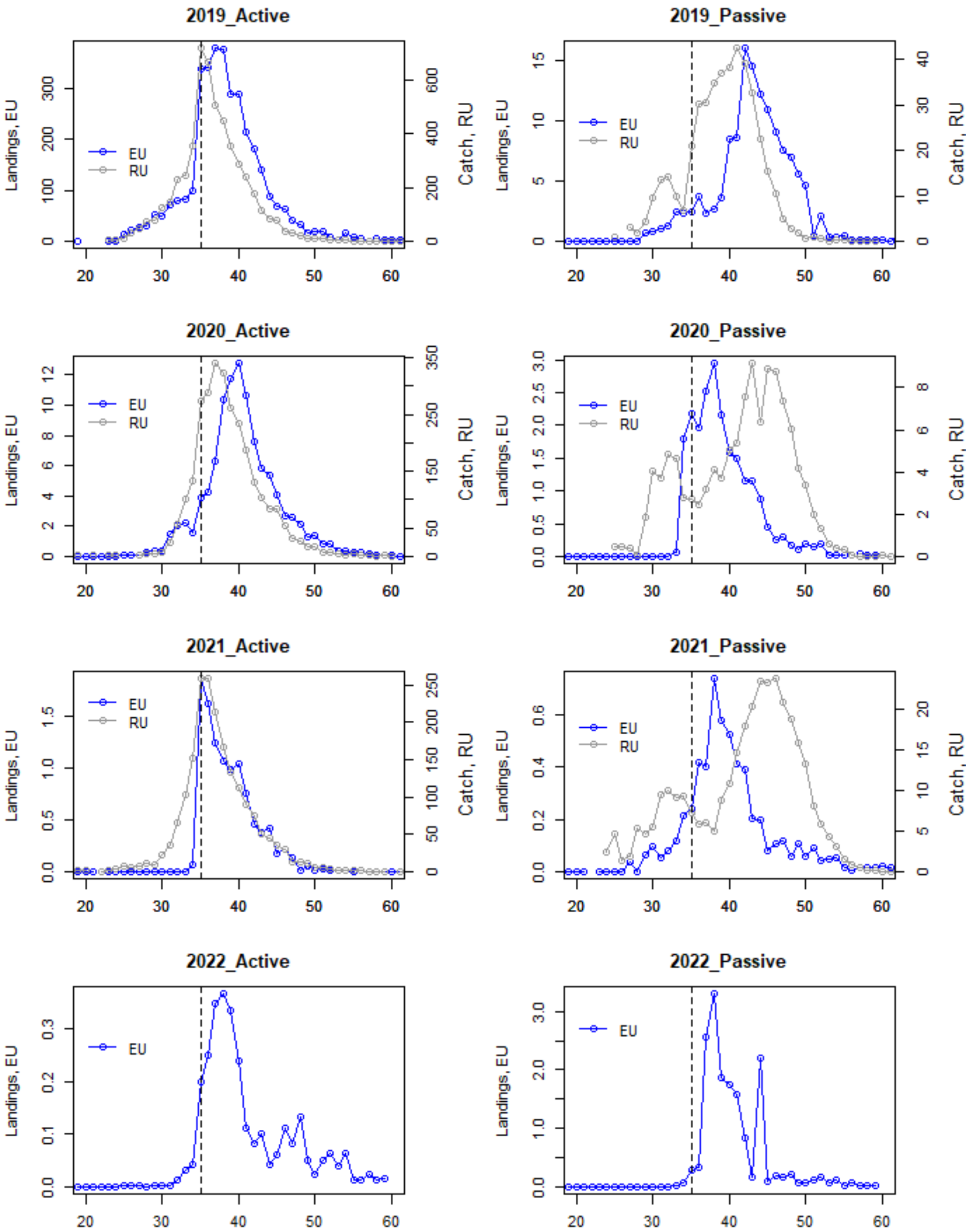


Figure 2.1.3. Eastern Baltic cod in SDs 24-32. Length distributions of EU and Russian commercial landings in later years, by Active and Passive fleets.

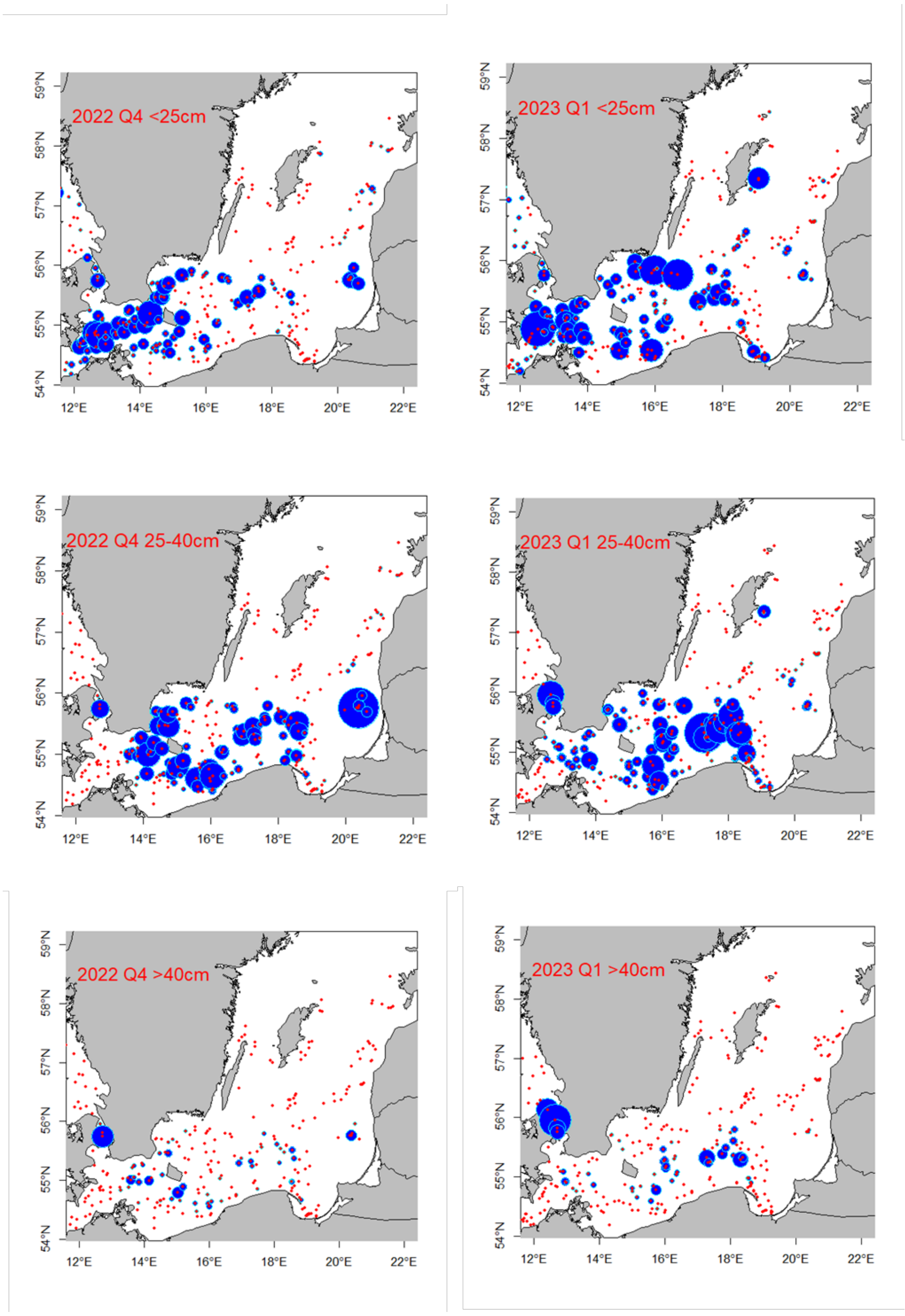
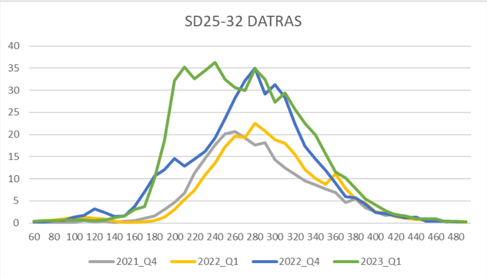
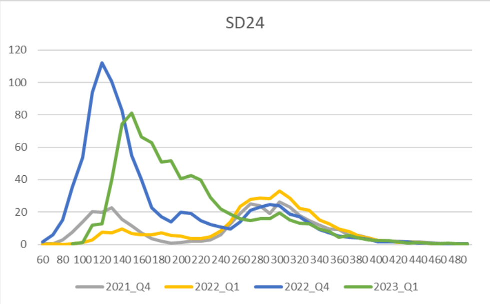


Figure 2.1.4. Eastern Baltic cod in SDs 24-32. Distribution of cod from latest BITS surveys in Q1 (2023) and Q4 (2022) by 3 size-groups (<25 cm, 25-40 cm and >40 cm cod). The scale is comparable between surveys within a size group, but not between size-groups.


SD25-32 DATRAS
40
35
30
25
20
15
10
5
0
60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480
2021_Q4
2022_Q1
2022_Q4
2023_Q1


SD24
120
100
80
60
40
20
0
60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480
2021_Q4
2022_Q1
2022_Q4
2023_Q1

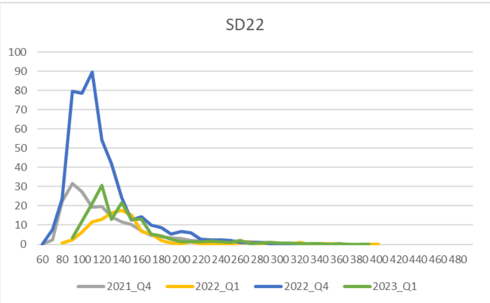

SD22
100
90
80
70
60
50
40
30
20
10
0
60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480
2021_Q4
2022_Q1
2022_Q4
2023_Q1

Figure 2.1.5. Eastern Baltic cod in SDs 24-32. Length distributions in latest BITS surveys in SDs 22 and 24 and in SDs 25-32, based on DATRAS data products.

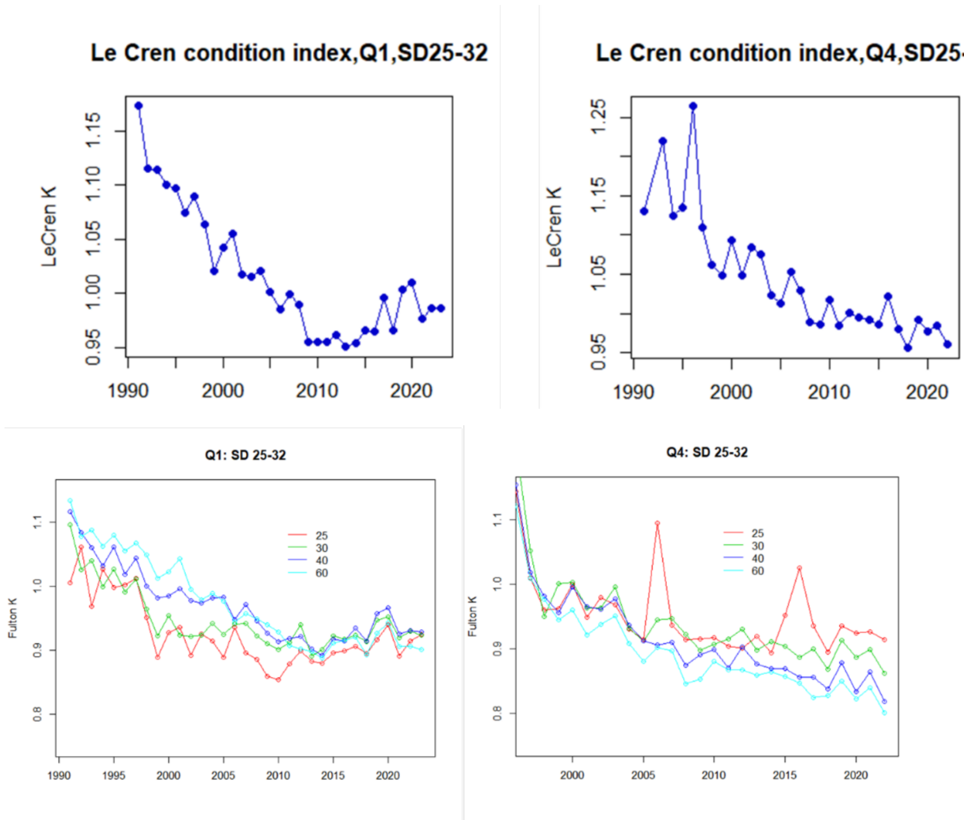


Figure 2.1.6. Eastern Baltic cod in SDs 24-32. Le Cren's condition index (all lengths combined) in Q1 and Q4 (upper panels). Fulton's K condition index of cod by length groups (<25 cm, 25-30 cm, 30-40 cm, 40-60 cm) (lower panels. Data are from BITS surveys in SDs 25-32.

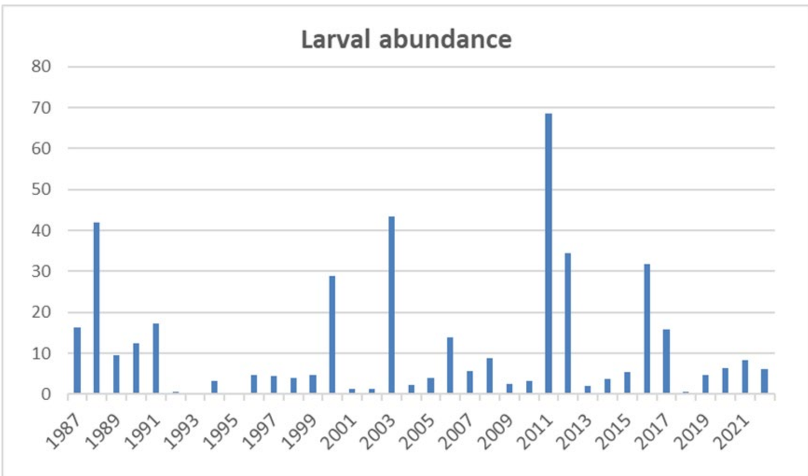


Figure 2.1.7. Eastern Baltic cod in SDs 24-32. Abundance of larvae in the main spawning area during peak spawning time.

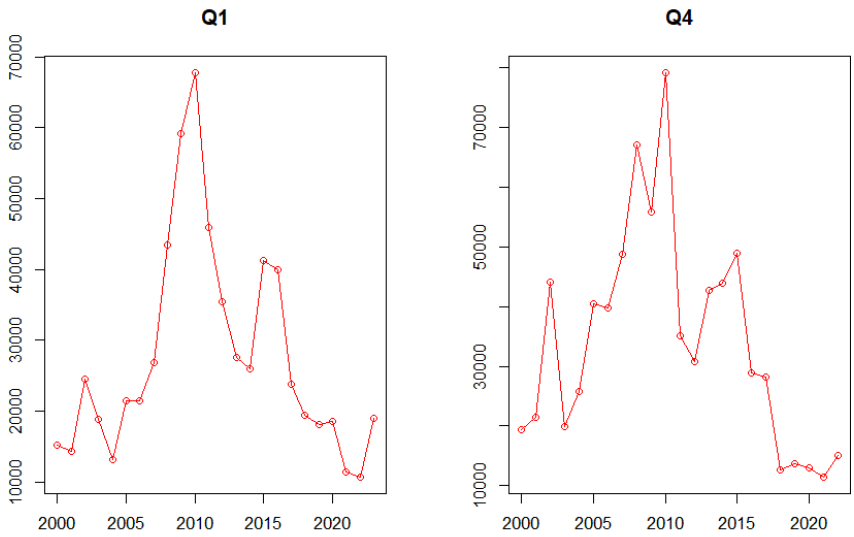


Figure 2.1.8a. Eastern Baltic cod in SDs 24-32. Relative total biomass index (CPUE), estimated from Q1 and Q4 BITS surveys.

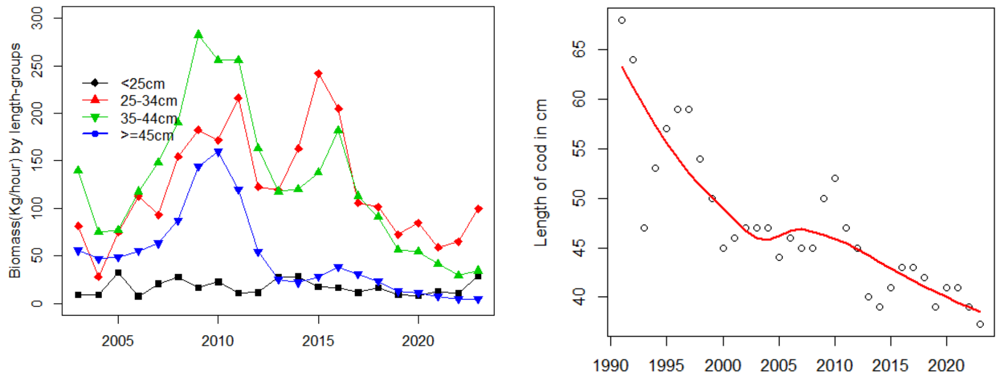


Figure 2.1.8b. Eastern Baltic cod in SDs 24-32. Left panel: Relative biomass index (CPUE), by length-groups, estimated from Q1 and Q4 BITS surveys combined. Right panel: Length corresponding to 95% percentile of length distribution (L95), in BITS Q1 survey.

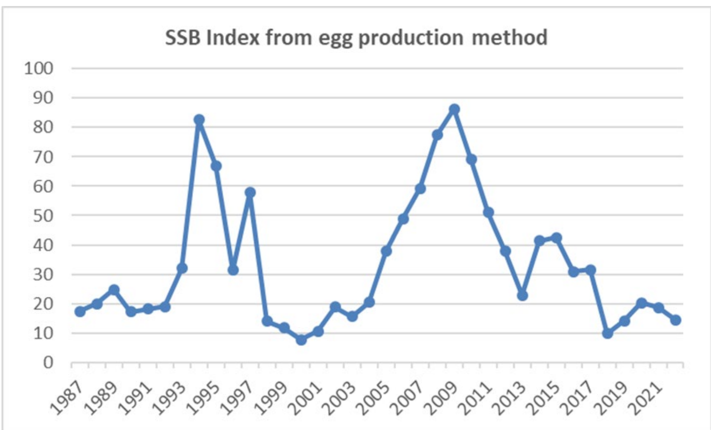


Figure 2.1.9. Eastern Baltic cod in SDs 24-32. Relative index of spawning stock biomass, calculated from egg production method. Data are from ichthyoplankton surveys.

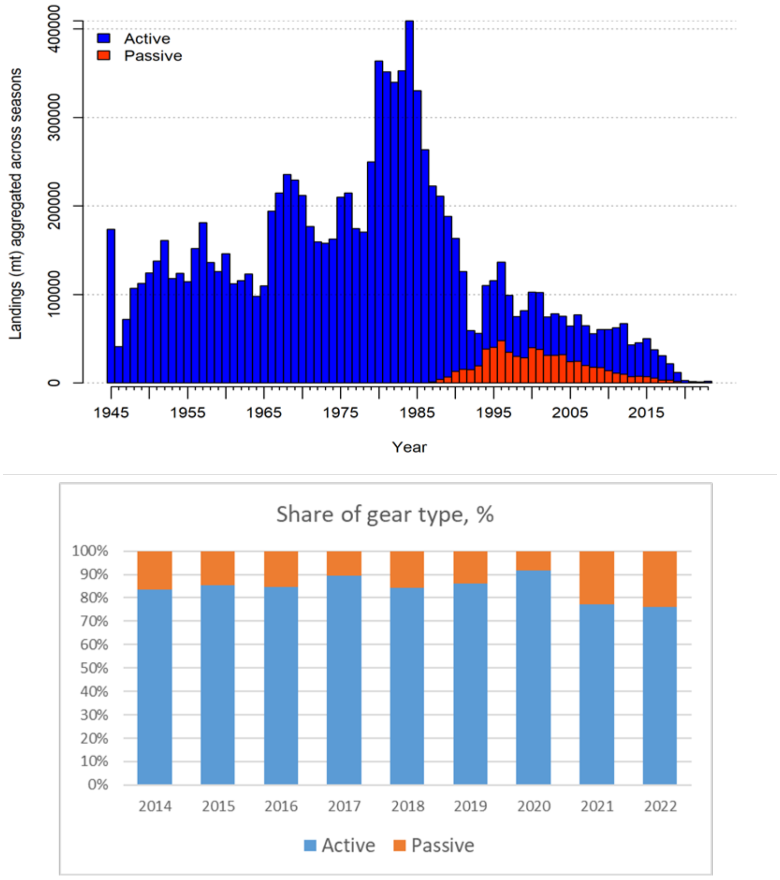
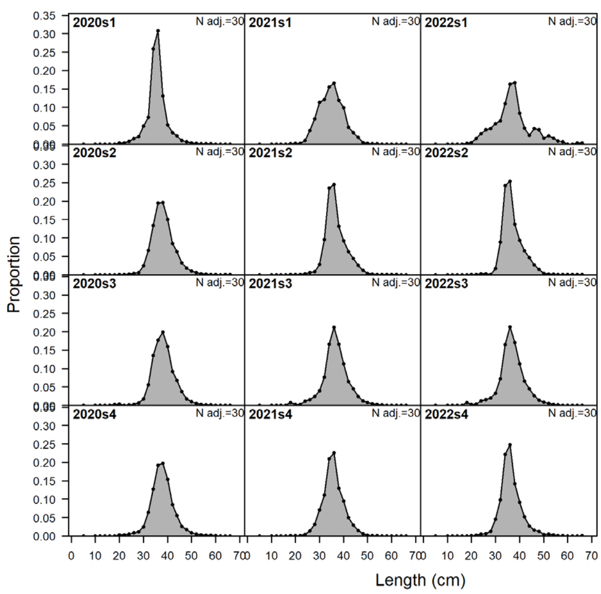


Figure 2.1.10. Eastern Baltic cod in SDs 24-32. Time-series of total catch used in the assessment, by fleets (upper panel). Share of Active and Passive gears in total catch in later years (lower panel).

Active



Passive

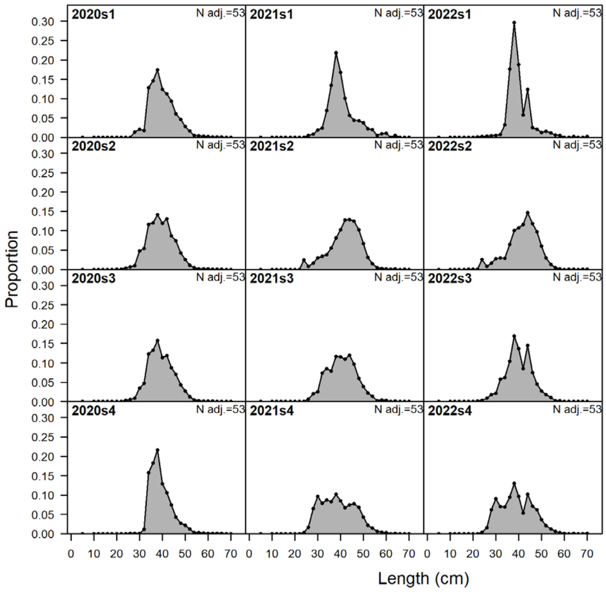

2020s1
N adj.=53
2021s1
N adj.=53
2022s1
N adj.=53
2020s2
2021s2
2022s2
2020s3
2021s3
2022s3
2020s4
2021s4
2022s4
Proportion
Length (cm)

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

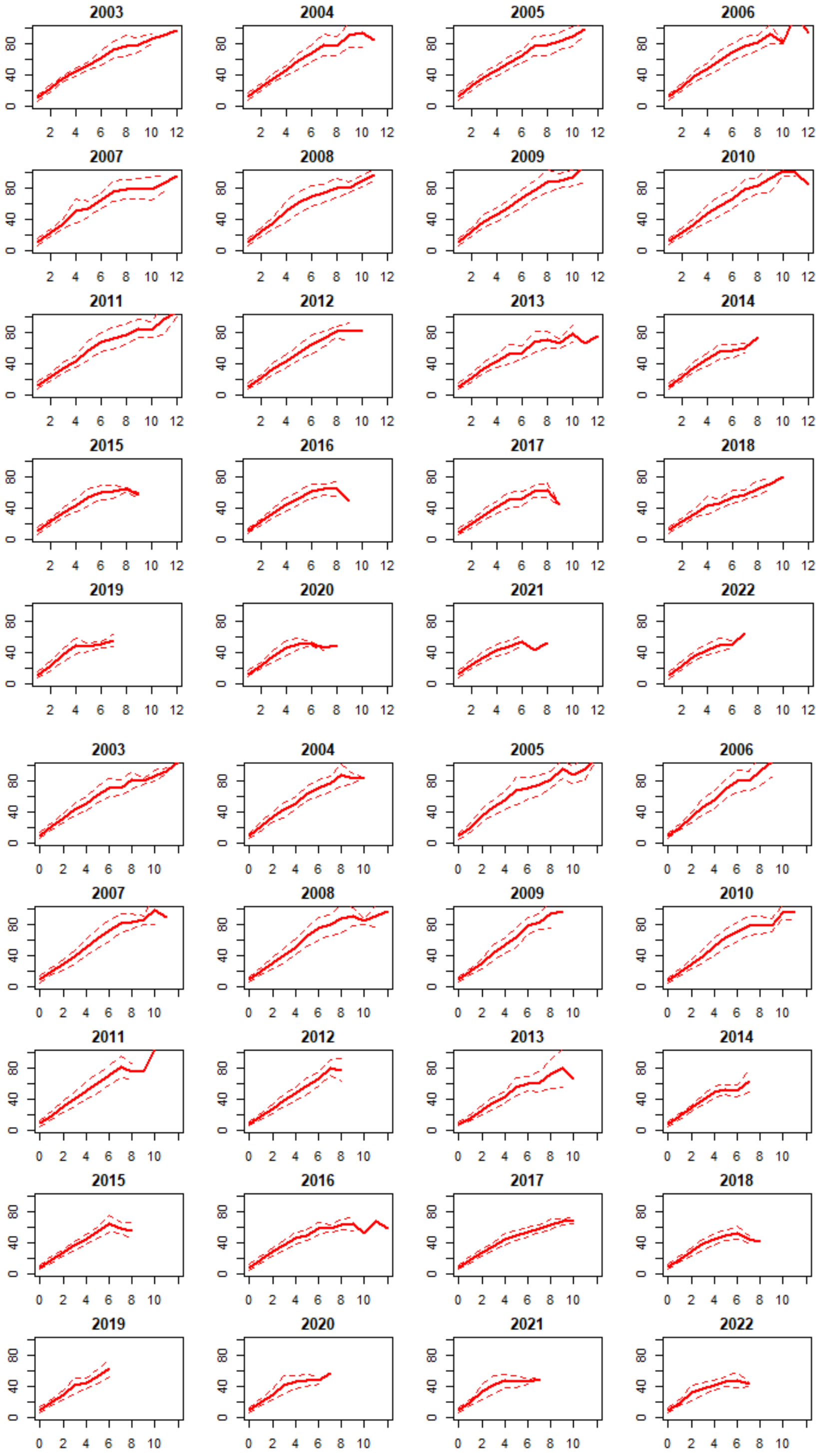


Figure 2.1.12. Eastern Baltic cod in SDs 24-32. Mean length at age (LAA) based on average annual ALKs of all countries included in DATRAS, for BITS Q1 (upper panels) and BITS Q4 (lower panels) (individual sample data only, not raised to the population).

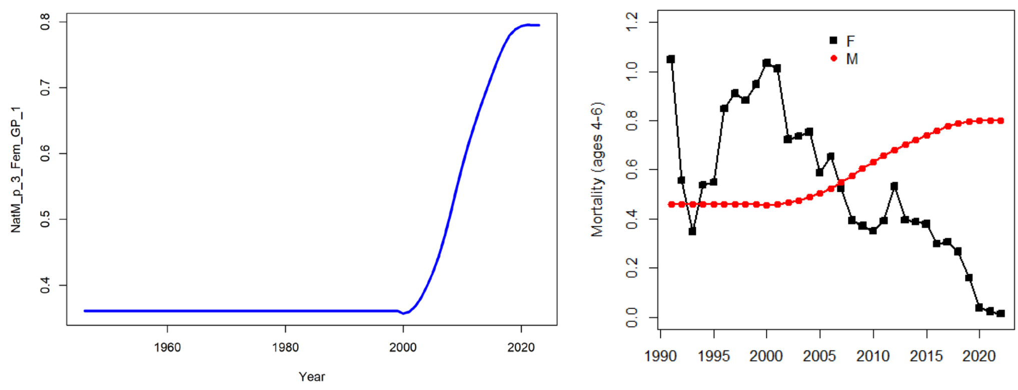


Figure 2.1.13. Eastern Baltic cod in SDs 24-32. Change in natural mortality for age-break 5.5, estimated in Stock Synthesis model (left panel). Fishing mortality (F) and natural mortality (M) for ages 4-6 (right panel).

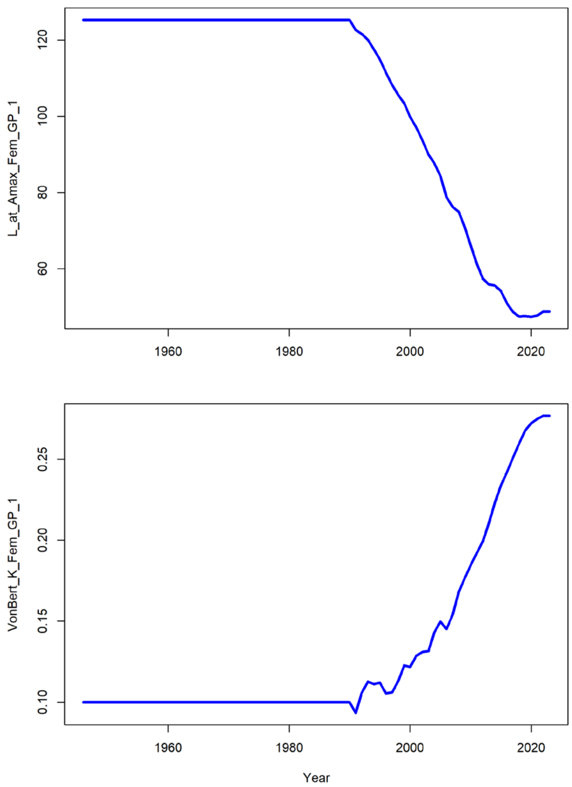


Figure 2.1.14. Eastern Baltic cod in SDs 24-32. Estimated change in von Bertalanffy growth parameters L_{inf} (left panel) and K (right panel) from Stock Synthesis model.

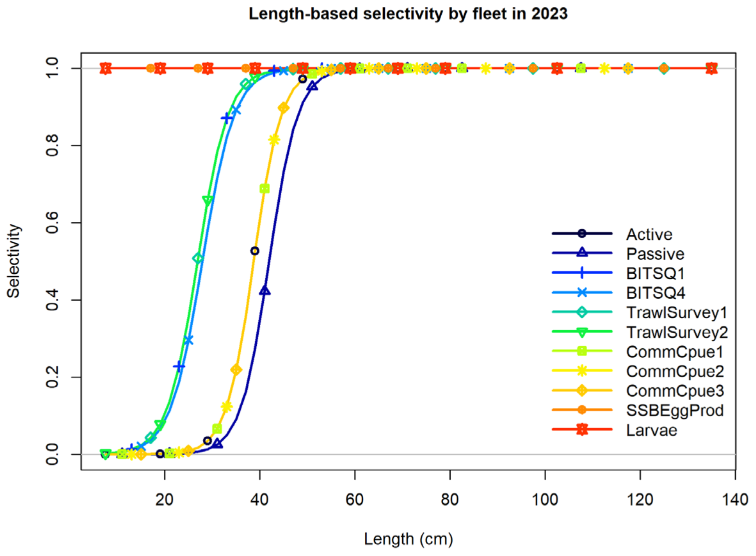
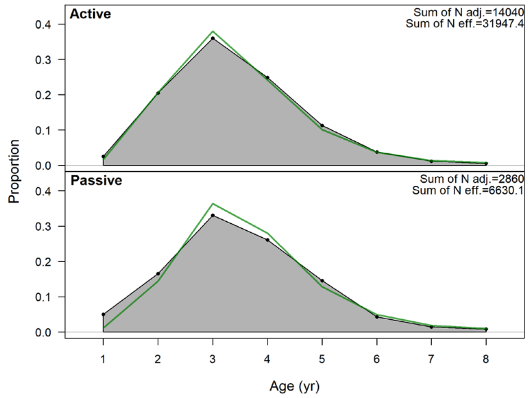


Figure 2.1.15. Eastern Baltic cod in SDs 24-32. Selectivity of different fleets.



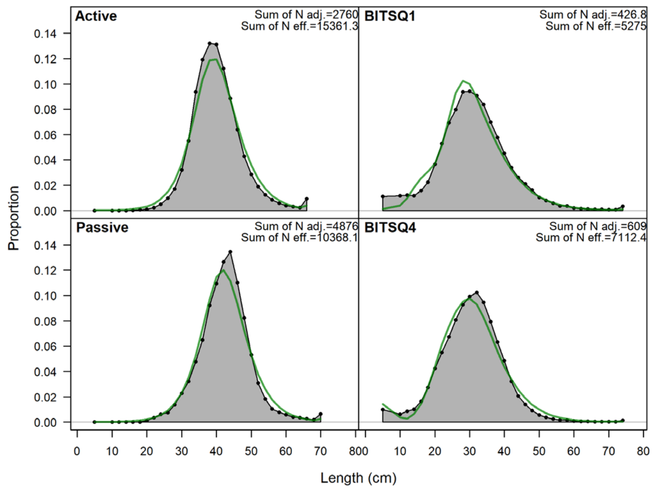


Figure 2.1.16. Eastern Baltic cod in SDs 24-32. Fits to age (upper panels) and length (lower panels) composition data, aggregated across years.

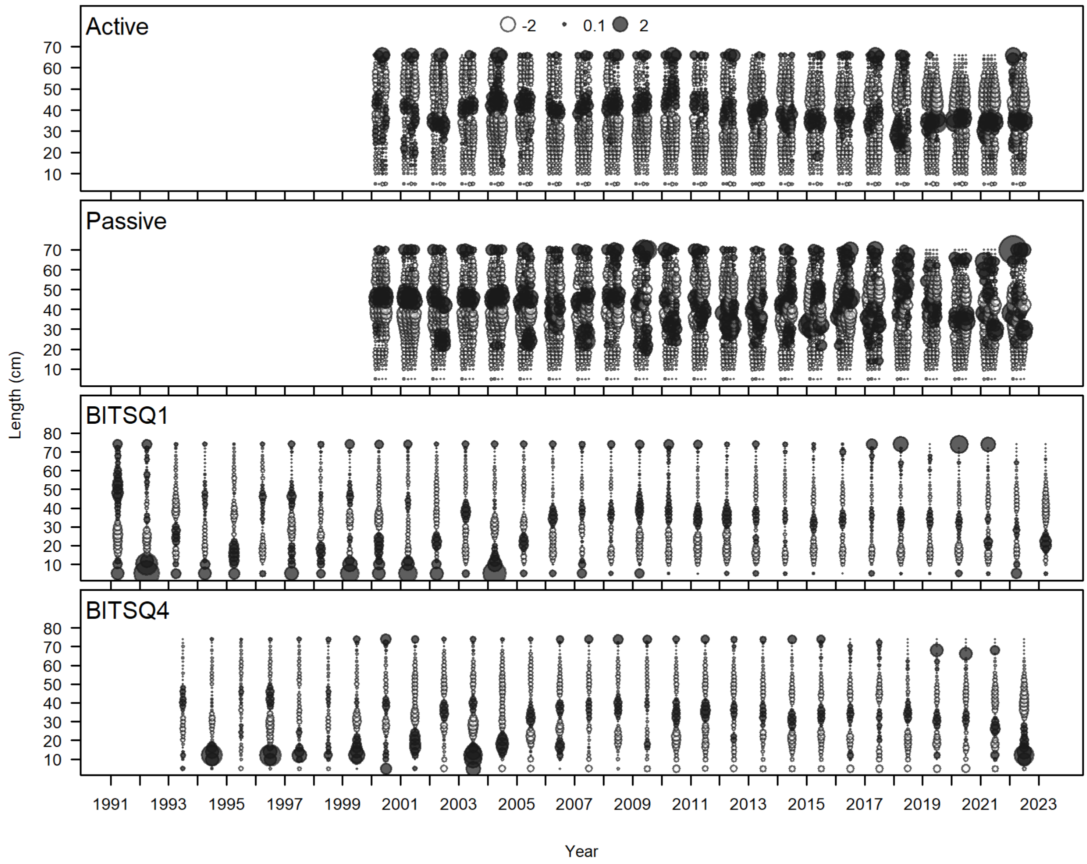


Figure 2.1.17. Eastern Baltic cod in SDs 24-32. Residuals of fits to length composition data for different fleets.

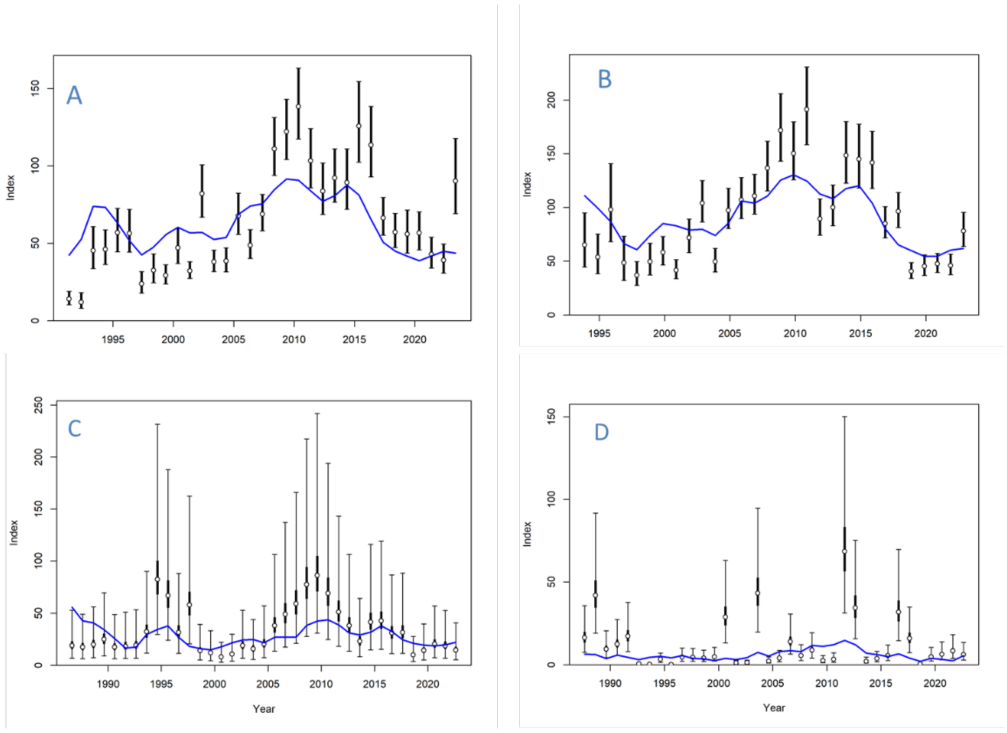


Figure 2.1.18. Eastern Baltic cod in SDs 24-32. Model fits to different tuning indices. A- BITSQ1; B-BITSQ4; C- SSBEggProd; D- Larvae.

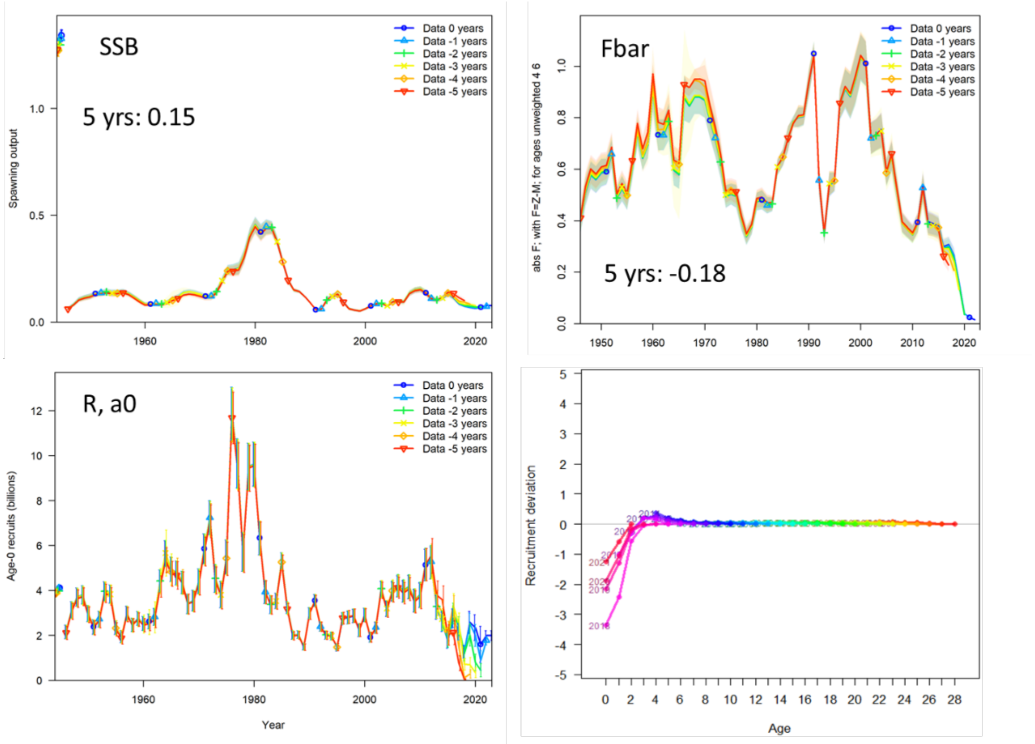


Figure 2.1.19. Eastern Baltic cod in SDs 24-32. Retrospective analyses, including Mohn's Rho values for SSB and F_{bar} estimated for 5 years.

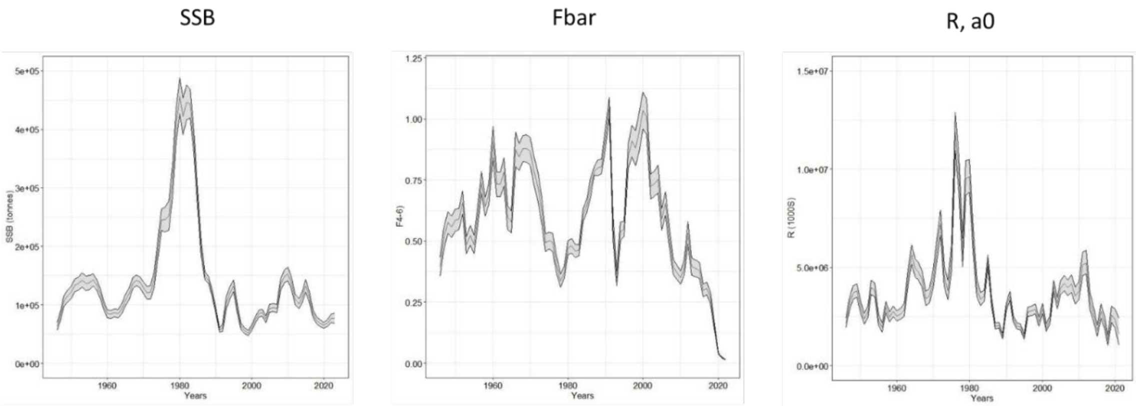


Figure 2.1.20. Eastern Baltic cod in SDs 24-32. Spawning stock biomass, fishing mortality (average of ages 4-6) and recruitment (age 0).

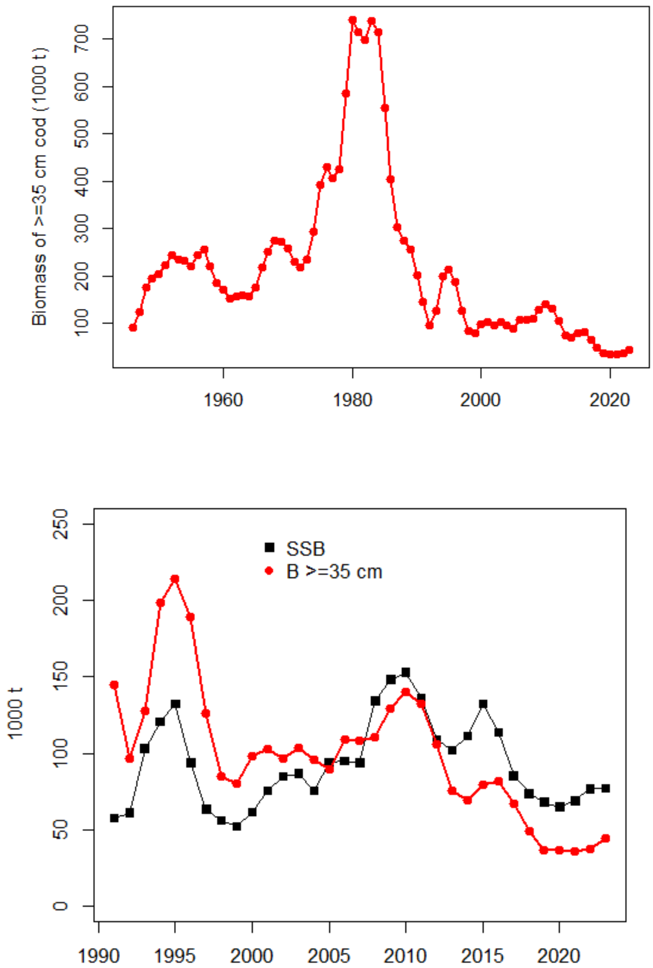


Figure 2.1.21. Eastern Baltic cod in SDs 24-32. Biomass of commercial sized cod (≥35 cm in length) (upper panel), compared to SSB in later years (lower panel).

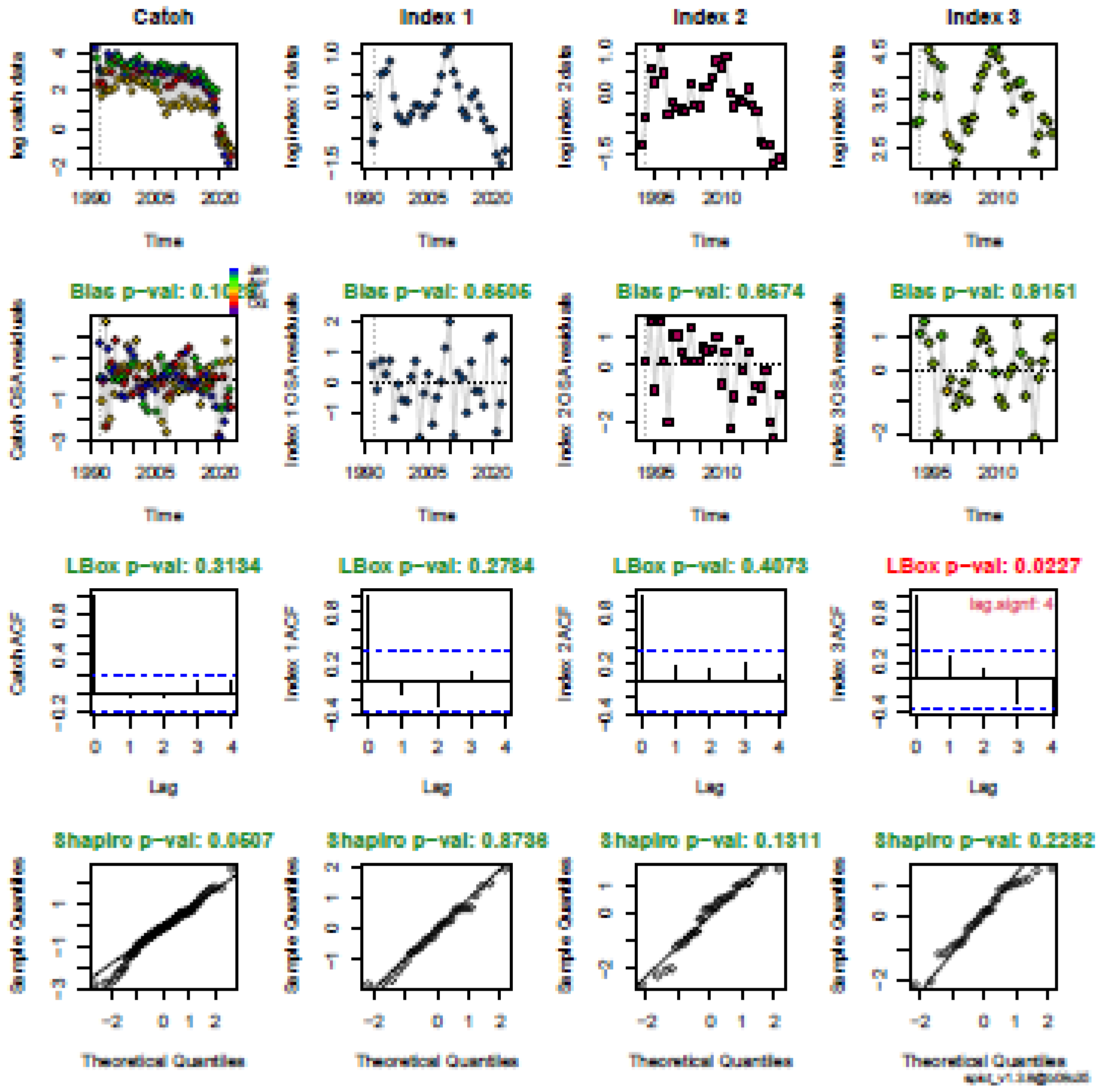


Figure 2.1.22. Eastern Baltic cod in SDs 24-32. Diagnostics of SPICT model.

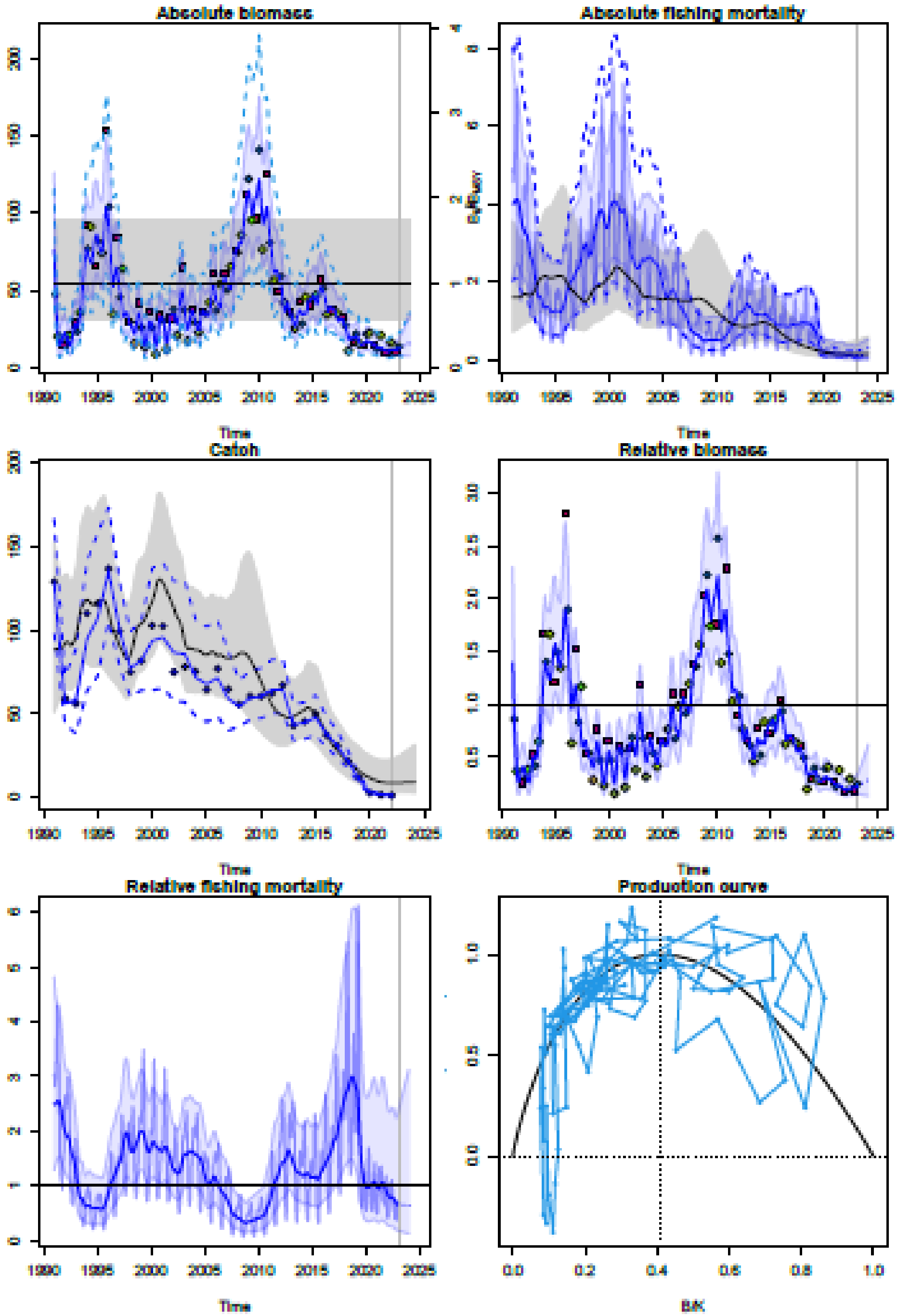


Figure 2.1.23. Eastern Baltic cod in SDs 24-32. Results of SPICT model.

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.

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 2022 were 19 tonnes, 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—2022 and from Denmark for 2000—2022. 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 2022, the estimated discards formed about 49% 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 2022 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 2022. 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 (1997-2022).

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 RV 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, RV Havfisken (age 1-3) (1997-2023)
IBTS-3Q	International Bottom Trawl Survey, 3rd quarter, Kattegat (age 1-4) (1997-2022)
IBTS-1Q	International Bottom Trawl Survey, 1st quarter, Kattegat; (Ages 1-6) (1997-2023)
CODS-4Q	Cod survey, 4th Quarter, Kattegat, (ages 1-6). (2008-2022)

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.

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—2022 with estimating total removals from 2003—2022 within the model based on survey information. (SPALY _Scaling; codkat2023 on https:/www.stockassessment.org)

Catch (landings and discards) from 1997—2022 without estimating total removals (SPALY_No Scaling; codkat2023 on stockassessment.org)

Unallocated removals were estimated separately for the years 2003—2022, but common for all age-groups within a year. The scaling factors estimated for 2005—2022 were significant for all the years in the SAM run with landings and total removals estimated.

Estimates of recruitment, SSB and mortality (Z-0.2) with confidence intervals from the two runs with and without total removals estimated are presented in figures 2.2.7—2.2.9 and tables 2.2.11—2.2.12. 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 two SAM runs are shown in Figure 2.2.11.

2.2.3.3 Exploration of the WKLIFE X DLS approach

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

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 L_{inf} = 104.87 cm
4. 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 $K \leq 0.2yr{-}1$.

The *rfb* formula contains different factors to determine the catch in the advice year:

$$A_{y+1} = A_y \times r \times f \times b \times m$$

where the advised catch (A) for next year y+1 is based on the most recent year's advised catch Ay adjusted by the components in table 3 provided in the ICES technical guidance. According to the guidelines if the most recent realized catch (catch in 2022 = 55 tonnes) is very different from the latest advice (advice for 2022 = 0 tonnes), or if no previous catch advice exists, it is suggested to consider replacing Ay with the most recent realised catch (Cy−1). These two options were deemed not applicable for Kattegat cod, so it was decided to use the advised catches Ay for 2022.

Concerning the other terms in the formula, ***r*** is the biomass ratio from a biomass index, ***f*** is the fishing pressure proxy from catch length data, ***b*** is a biomass safeguard and ***m*** a precautionary multiplier, i.e. 0.95 in method 2.1.

The Length frequency distributions (LFDs) were calculated using commercial catches from DK and SWE for the period 2014-2022 downloaded from InterCatch and plotted annually (Figure 2.2.12a) and for the last five years (2018-2022) pooled together ((Figure 2.2.12b). Also, Lc (length at first capture) was calculated on an annual basis (Table 2.2.13). and as an average for the last five years (Lc = 19 cm).

The components of the *rfb* formula, summarised in Table 2.2.14, were estimated using the R package available on GitHub: https://github.com/shfischer/cat3advice as follows:

- ***r*** is the rate of change in the biomass index (I), based on the average of the two most recent years of data (2020-2021) relative to the average of the three years prior to the most recent two (2017-2019), and termed the "2-over-3" rule. In this case, using the CODS Q4 biomass (Table index available for the period 2008-2022, r=0.95.
- The reference length follows the concepts of Beverton and Holt (1957) and is calculated as derived by Jardim, Azevedo, and Brites (2015) as LF = M = 0.75Lc + 0.25L∞ where LF = M is the MSY reference length, Lc the length at first capture, and L∞ the von Bertalanffy asymptotic length. This simple equation assumes that fishing at F = M can be used as a proxy for MSY. The indicator ratio f is the fishing pressure proxy from catch length data relative to MSY Proxy (Lmean/LF=M). Results show that f2022= 0.64. The exploitation status is above FMSY proxy when the indicator ratio value is lower than 1 (Figure 2.2.13)
- b=mi{1,$IyItrigger$/}. The value used for $Itrigger$ is 1.4*$Iloss$, where $Iloss$ is the lowest observed biomass index value (I2018=0.91), thus $Itrigger$=1.27 and consequently b=2.99. Being b=mi{1,$IyItrigger$/} then it is appropriate to set ***b*=1.0**.

- m is a multiplier intended to avoid biomass declining below $Blim$. In this situation the WKLIFE decision tree recommends for method 2.1 that $\boldsymbol{m}$=**0**.9**5**.

A discard rate in % can be provided to the argument discard_rate and this means the advice is provided for the catch and landings.

Using the estimates above in the rfb formula the advice, as shown in Table 2.2.14, is:

$$Ay{+}1=0\times0.95\times 0.64\times1.0 \text{ x } 0.95=0\ \boldsymbol{t}.$$

Being based on the last year advice catches (Ay=0) the advised catches would obviously still be 0.

If the rfb rule (method 2.1) is applied the advice becomes biennial (i.e. the catch advice is set for two years).

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.

2.2.3.4 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 (North sea and Western Baltic cod(Figure 2.2.5 and Figure 2.2.10).

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 the 1997. There were some signs of a recovery in the 2015 but the SSB level are at historical low level again in 2022.

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. The runs that estimated total removals show estimated mortality (Z-0.2) in the interval of 0.42 to 1.73. In contrast, the run without estimating total removals in the interval of 0.37 to 1.69. (Tables 2.2.11—2.2.12, Figure 2.2.8).

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 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—2022, 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 0.8-2.4 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 2022 (341 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 tables 2.2.11 and 2.2.12.

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.

2.2.10.1 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.

A longer-term step would be to gather genetic samples from the whole size range of cod, and also analyze the samples back in time that would be needed to split the different cohorts between North Sea and Kattegat cod, to assess the developments in Kattegat stock alone. This could be done using the traditional SAM or possibly other models (e.g. SS3).

2.2.10.2 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.*

Although the Reference group suggested future elaboration on the proxy reference points during the assessment 2018, no further elaboration has been performed yet.

2.2.11 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.

2.2.12 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**

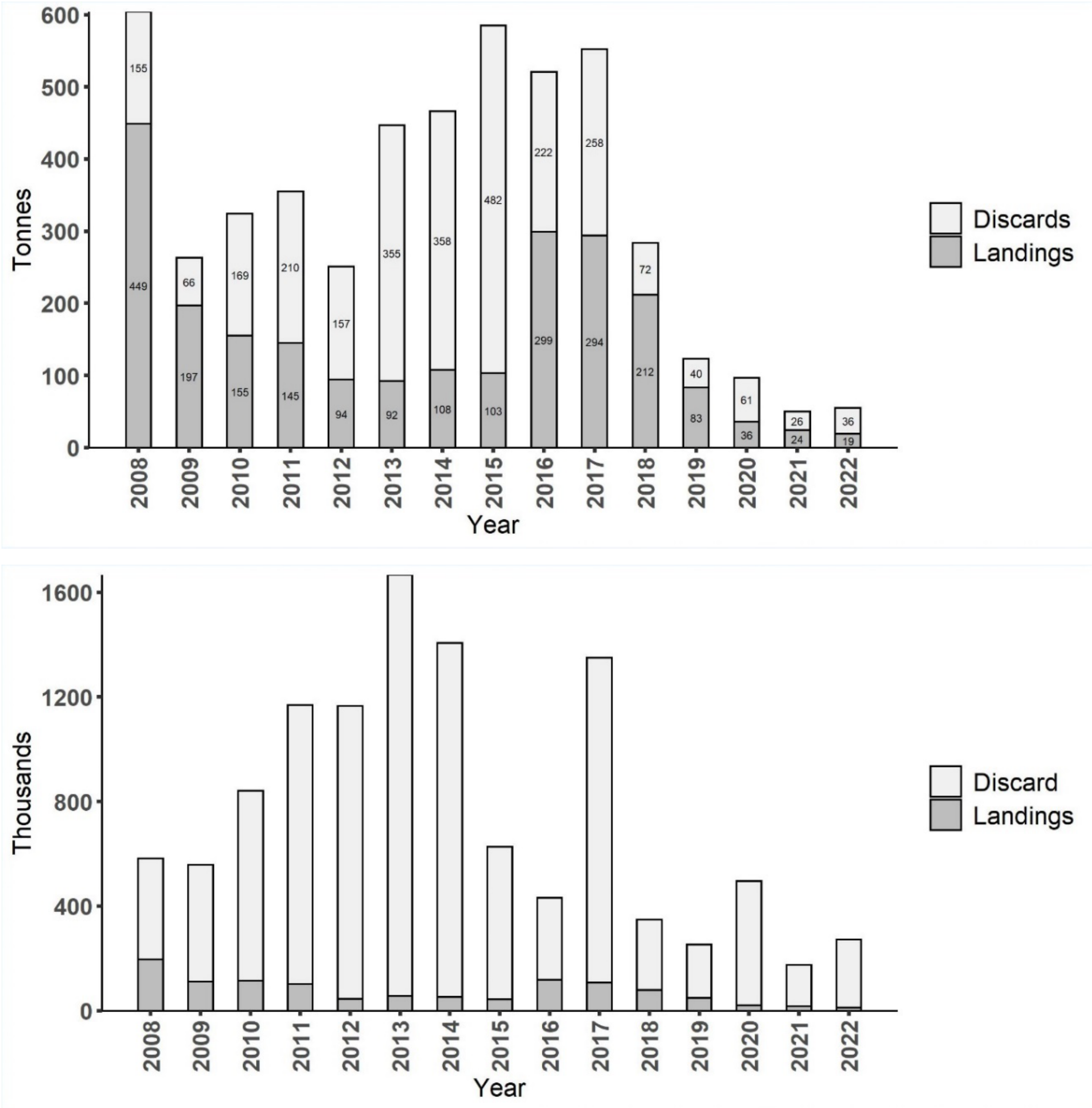


Figure 2.2.1. Cod in the Kattegat. Estimates of discards (Denmark and Sweden combined) compared to reported landings, in weight (upper panel) and in numbers (lower panel).

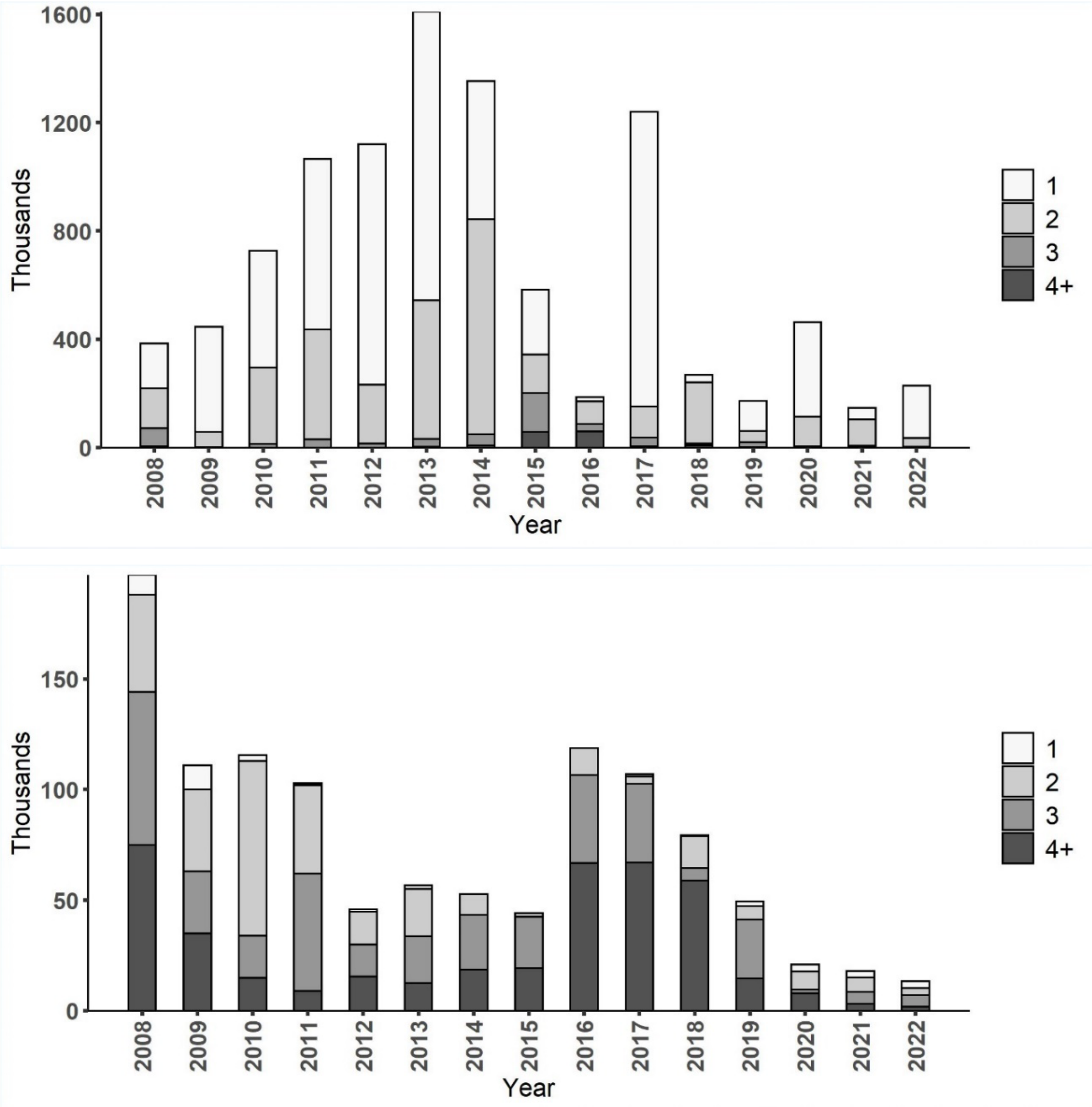
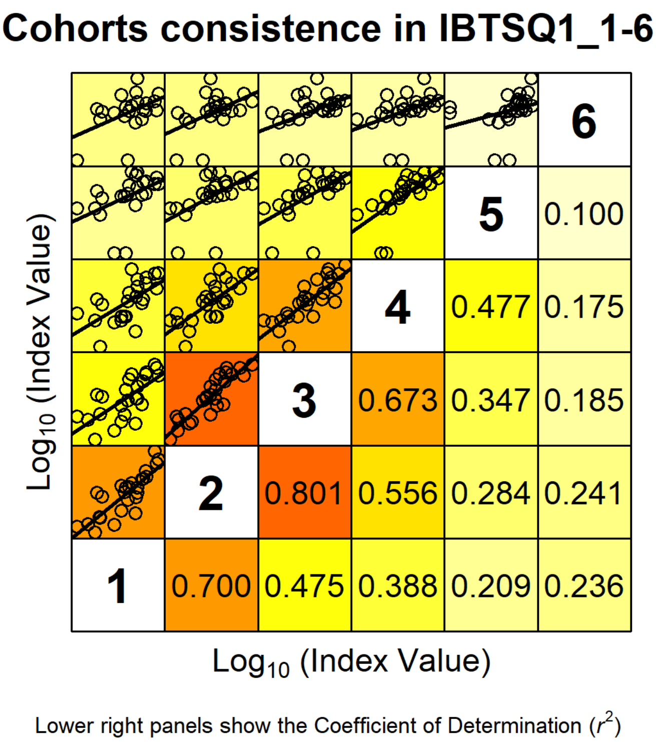


Figure. 2.2.2. Cod in the Kattegat. Estimates of discards in numbers by age in the upper panel and landings in numbers by age in the lower panel (Sweden and Denmark combined).



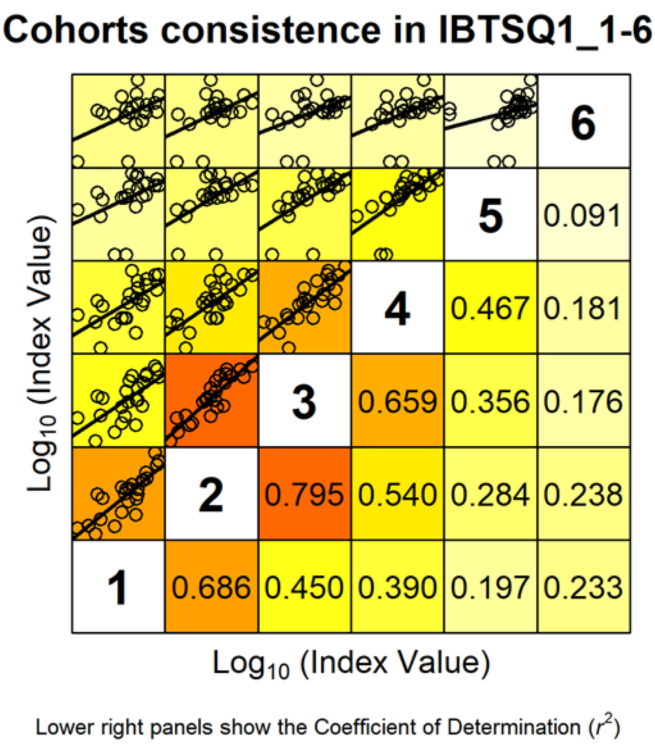
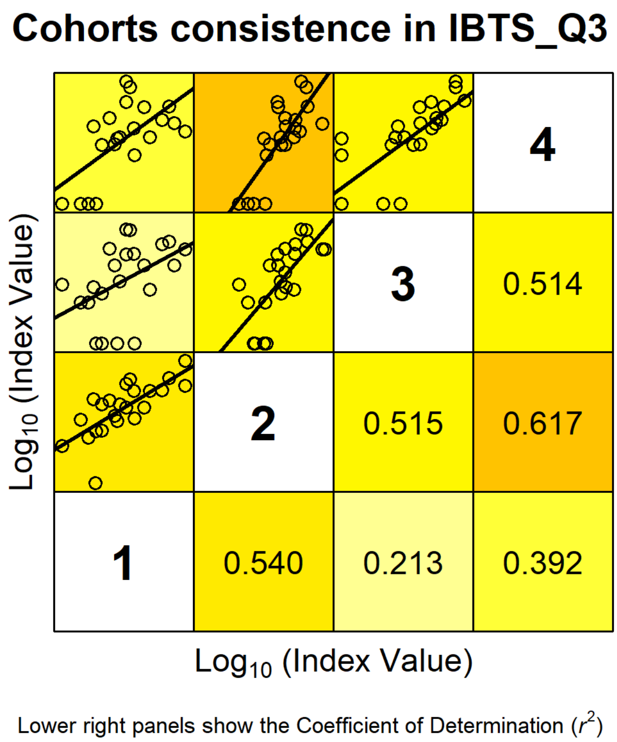


Figure 2.2.3a. Cod in Kattegat. IBTS 1st quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 1997-2023. Upper plot 2023 and lower plot 2022.



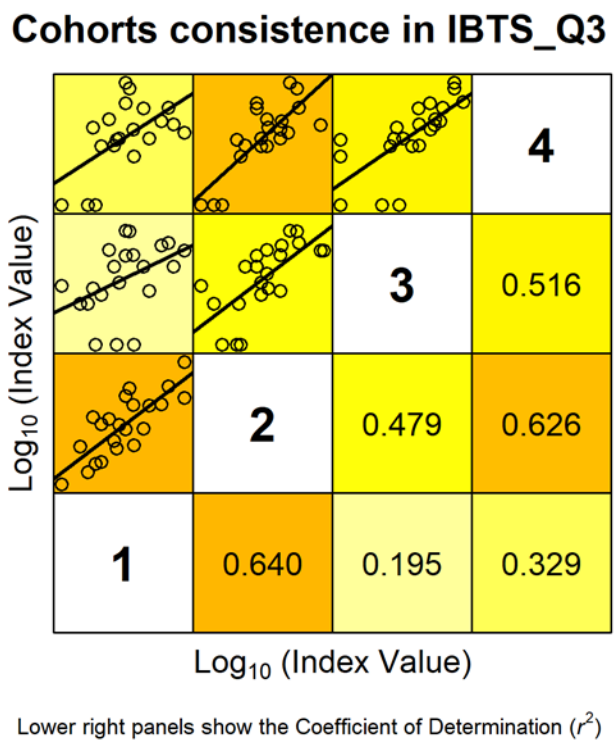
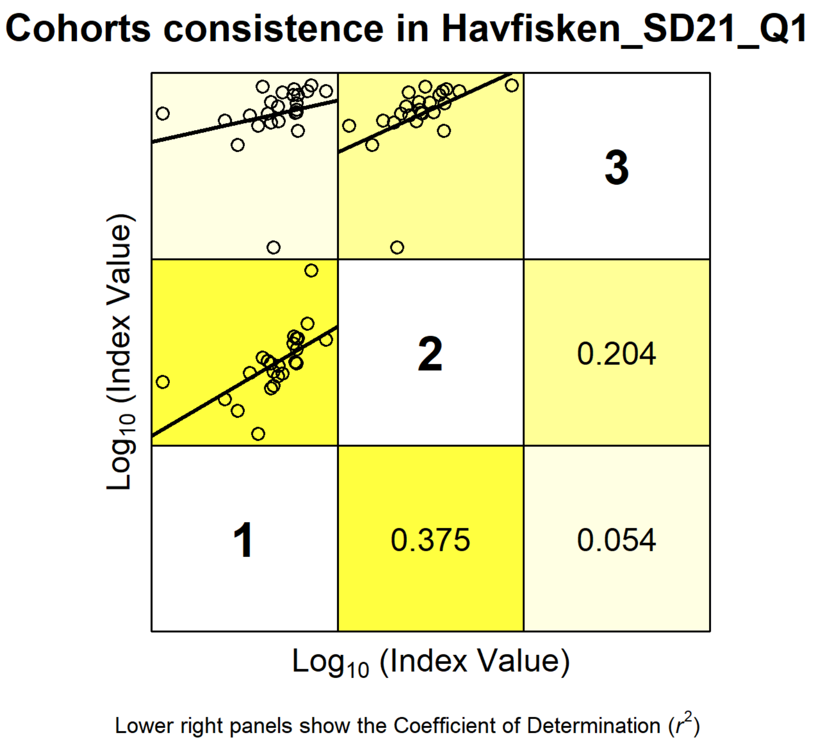


Figure 2.2.3 b. Cod in Kattegat. IBTS 3rd quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 1997-2022. Individual points are given by year-class. Upper plot 2022 and lower plot 2021.



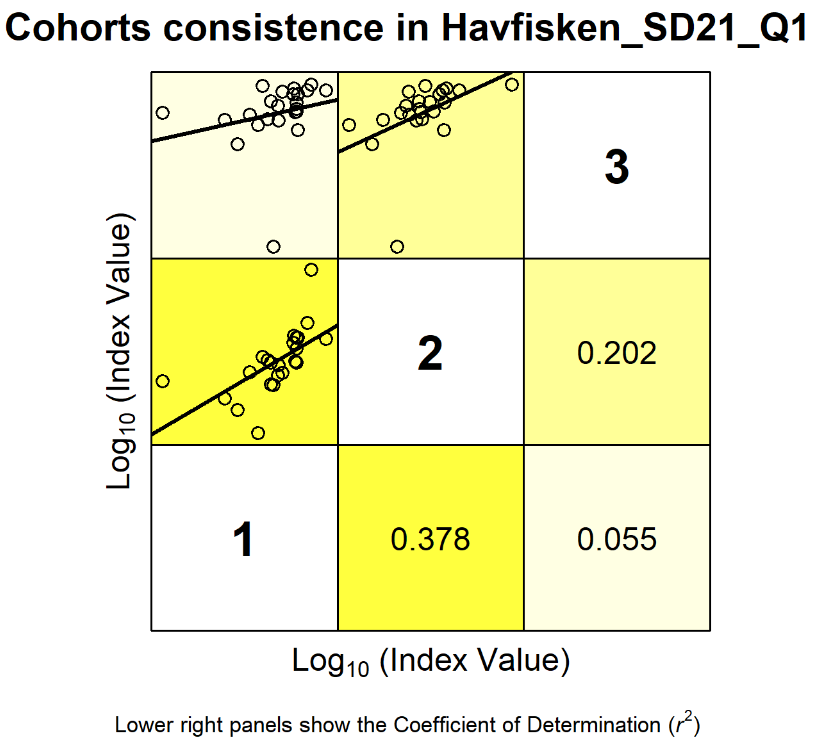
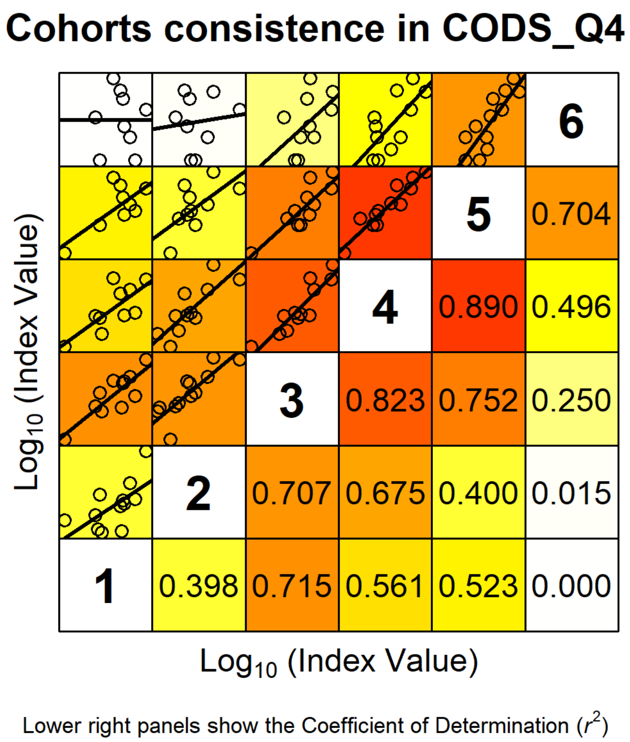


Figure 2.2.3c. Cod in Kattegat. Havfisken 1st quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 1997-2023. Upper plot 2023, lower plot 2022.



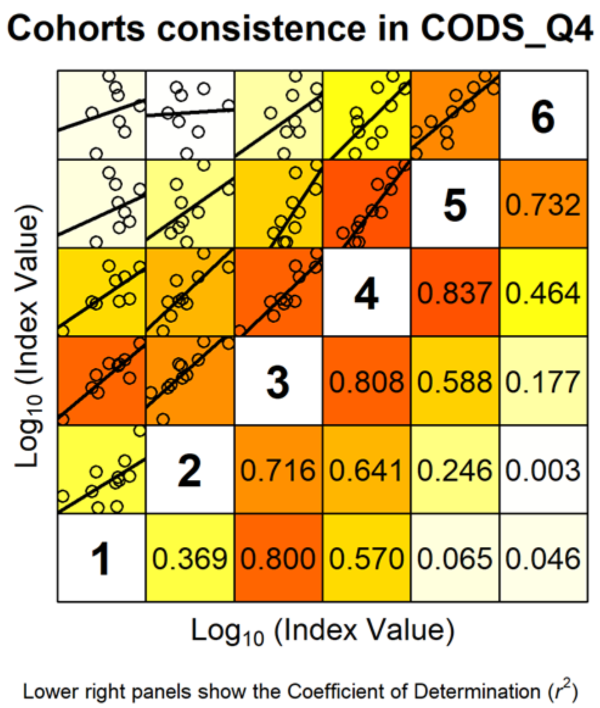


Figure 2.2.3d . Cod in Kattegat. Cod Survey 4th quarter numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2008-2022. Individual points are given by year-class. Upper plot 2022, lower plot 2021.

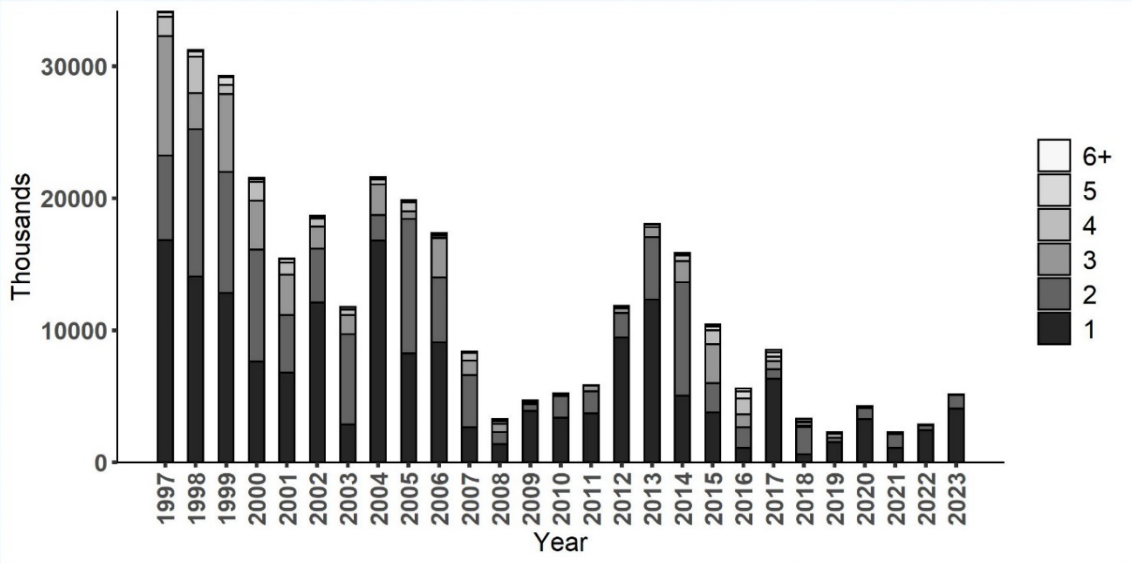


Figure 2.2.4. Cod in Kattegat. Stock numbers at age for the period 1997-2023 from SAM output

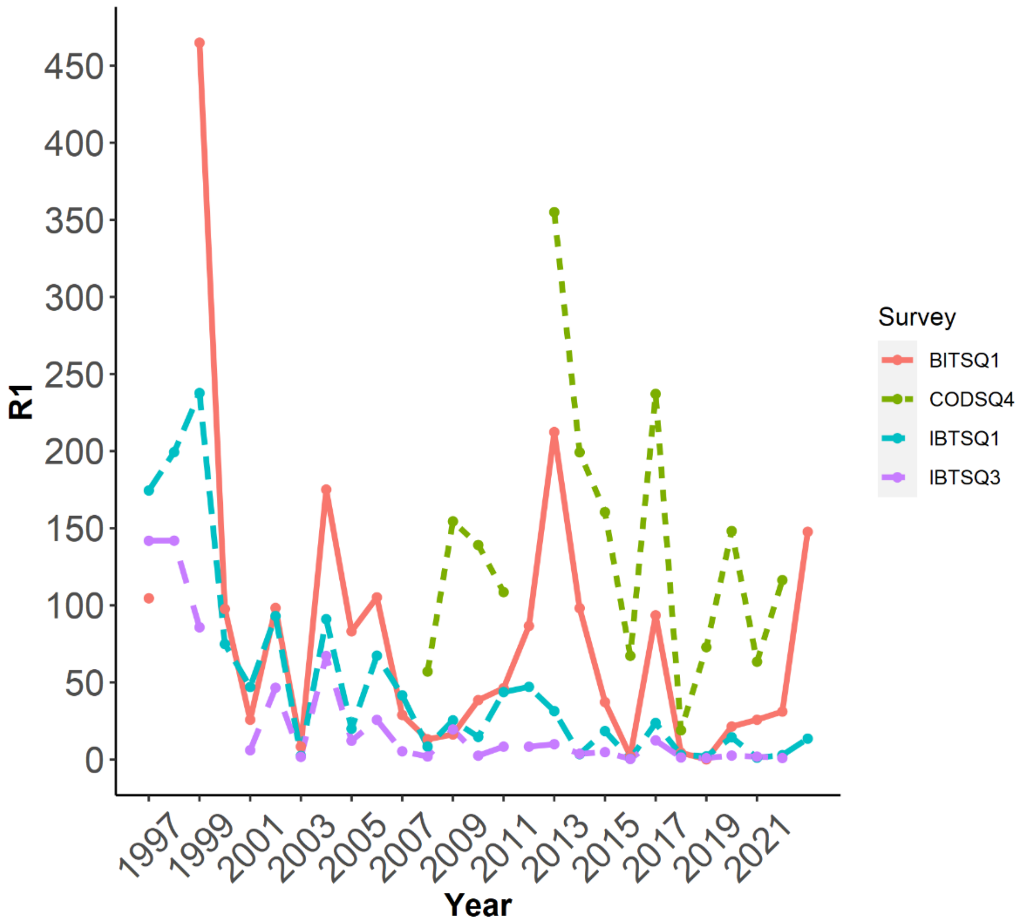


Figure 2.2.5. Cod in the Kattegat. Trends in recruitment index (Age 1) from different surveys.

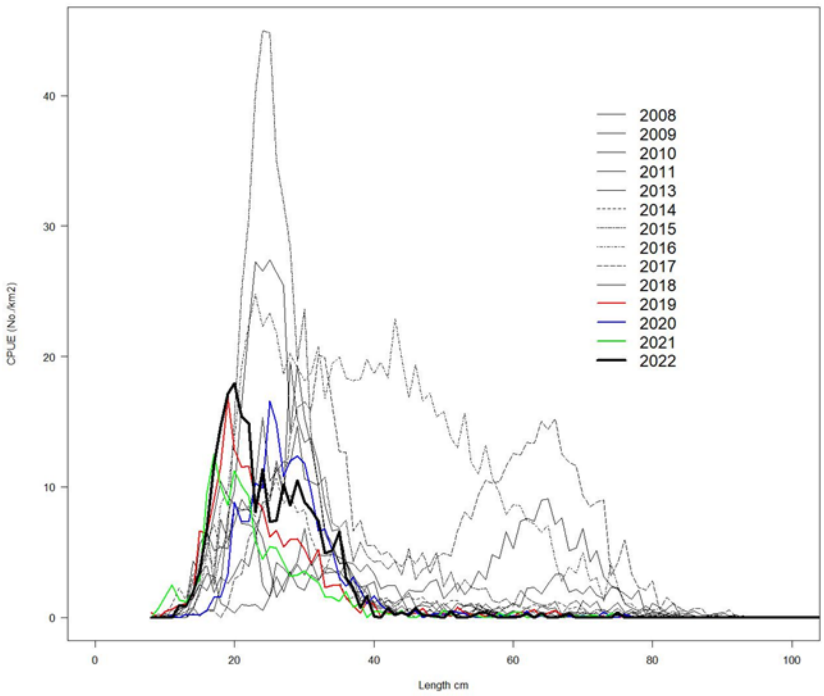


Figure 2.2.6. Cod in Kattegat. Length distributions from the Cod survey 2008-2022.

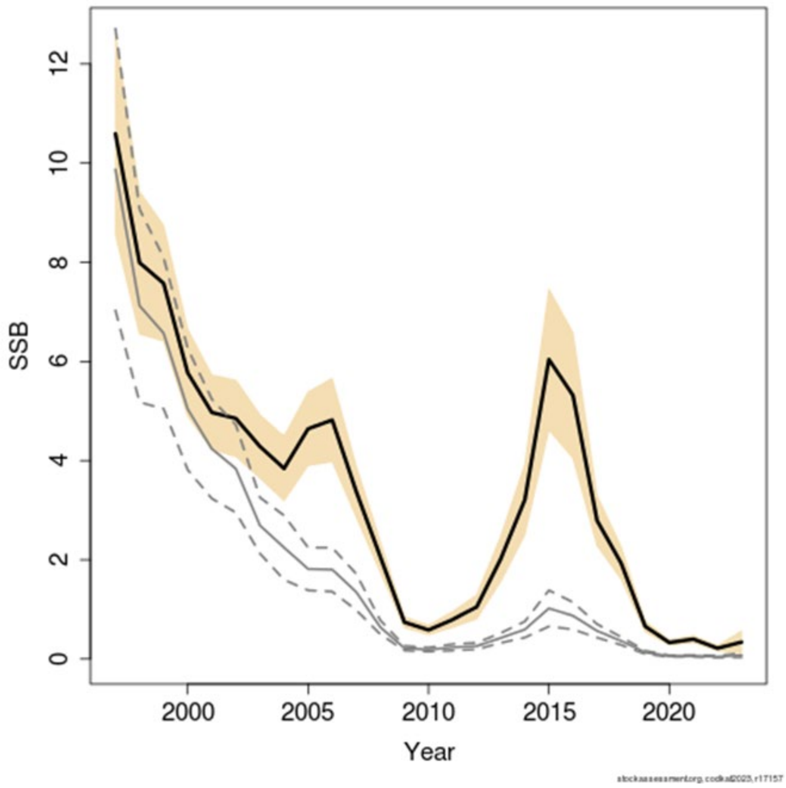


Figure 2.2.7. Cod in Kattegat. SSB in tonnes. SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95% confidence interval).

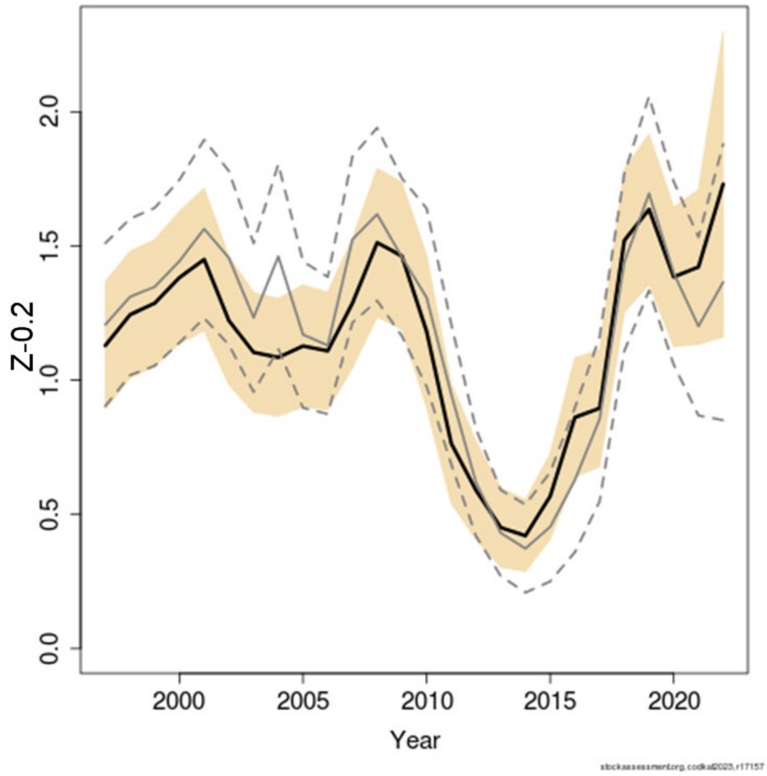


Figure 2.2.8. Cod in Kattegat. Unallocated mortality (Z-0.2) SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95 % confidence interval).

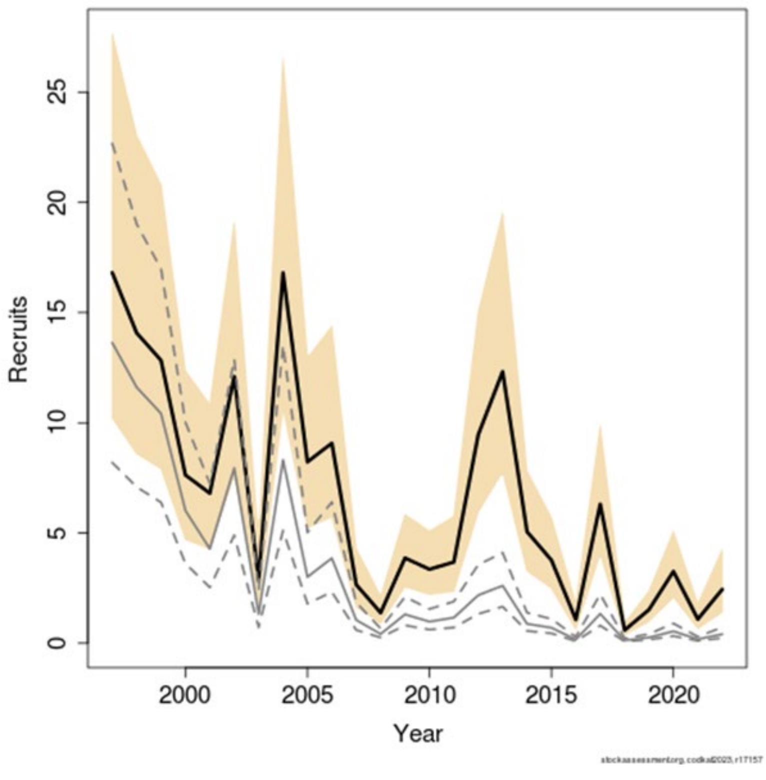
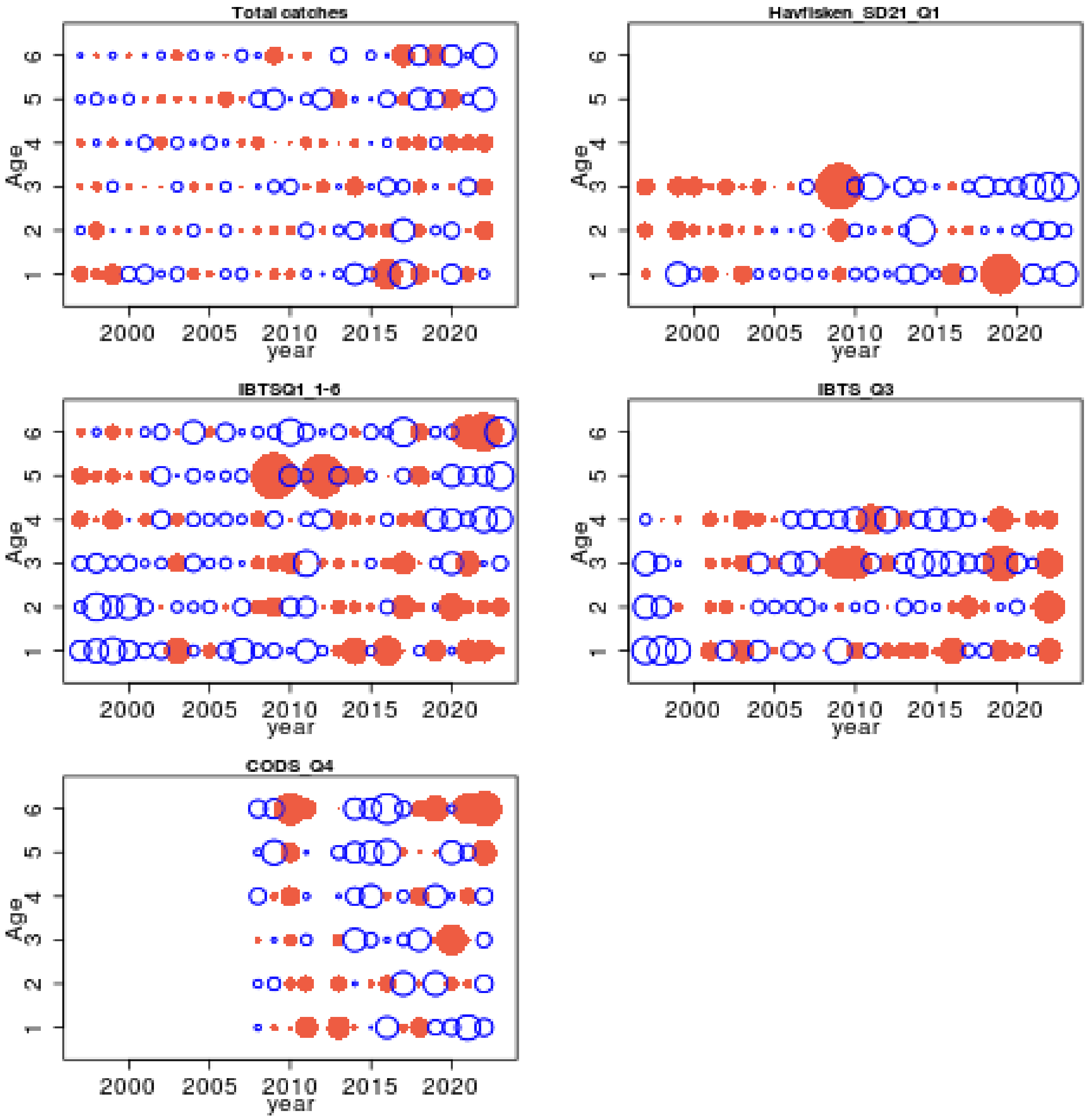


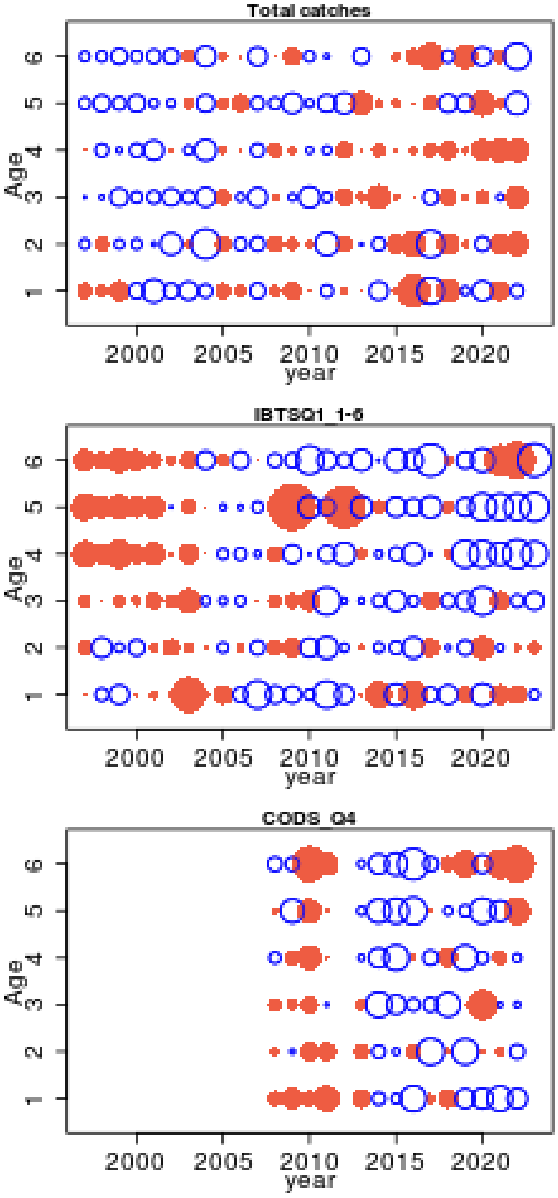
Figure 2.2.9. Cod in Kattegat. Recruitment in millions. SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95 % confidence interval).

Year	Catch multiplier
2003	1.48
2004	1.11
2005	2.83
2006	2.67
2007	1.96
2008	3.27
2009	3.46
2010	2.76
2011	2.64
2012	4.41
2013	5.2
2014	6.63
2015	7.42
2016	8.61
2017	5.45
2018	5.92
2019	5.18
2020	6.24
2021	8.28
2022	6.12

Figure 2.2.10. Cod in Kattegat. Catch multiplier. The scaling factor by year from the SAM run with scaling.

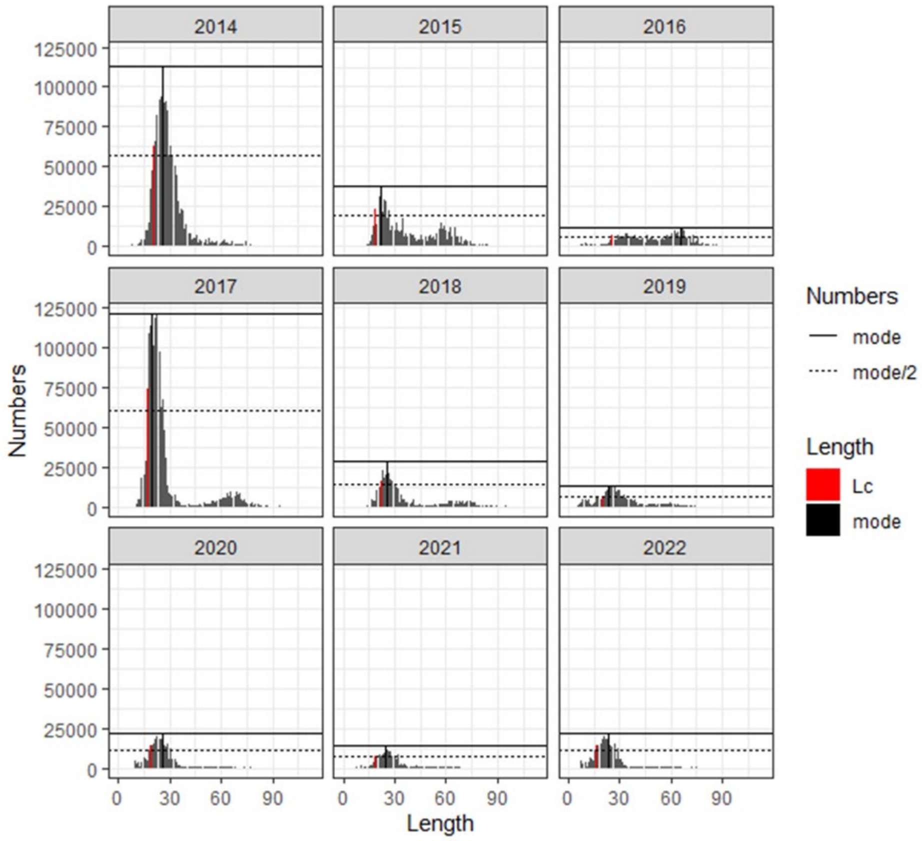

Total catches
Havfisken_SD21_Q1
IBTSQ1_1-6
IBTS_Q3
CODS_Q4
Age
year
2000
2005
2010
2015
2020
1
2
3
4
5
6

a)

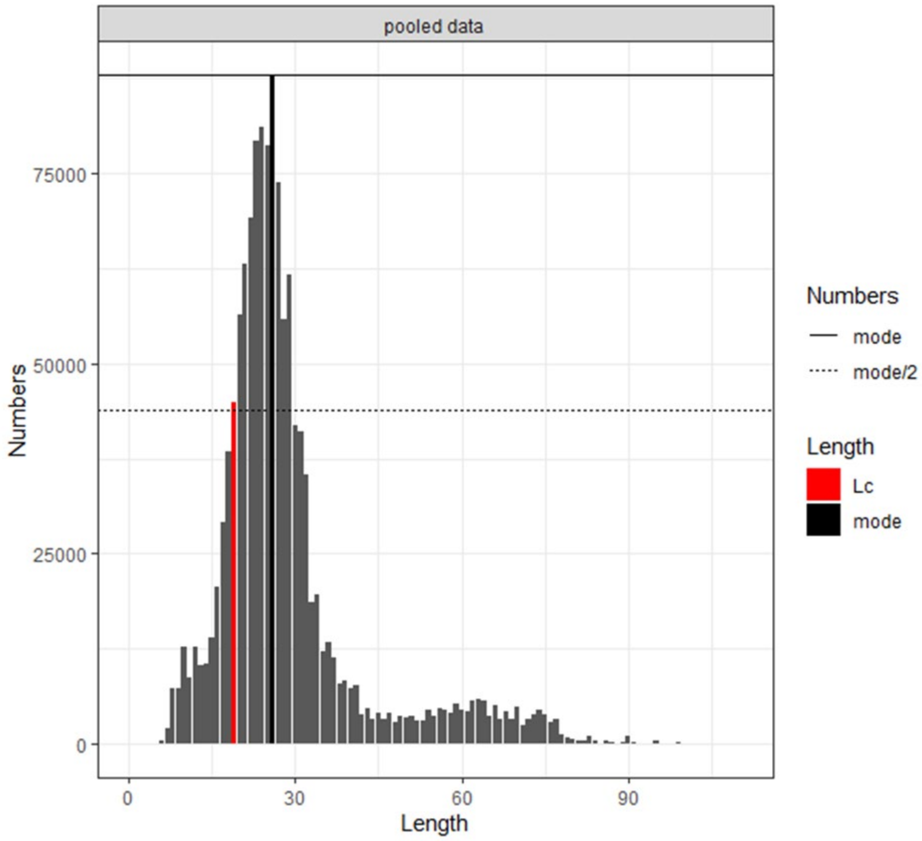


b)

Figure 2.2.11. Cod in Kattegat. Residuals. a) SAM run with scaling b) SAM run without 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).



a)



b)

Figure 2.2.12. Length frequency distribution and Lc (Length at first capture) based on Swedish and Danish commercial catches a) for the period 2014-2022 and b) for the last five years (2018-2022) pooled together.

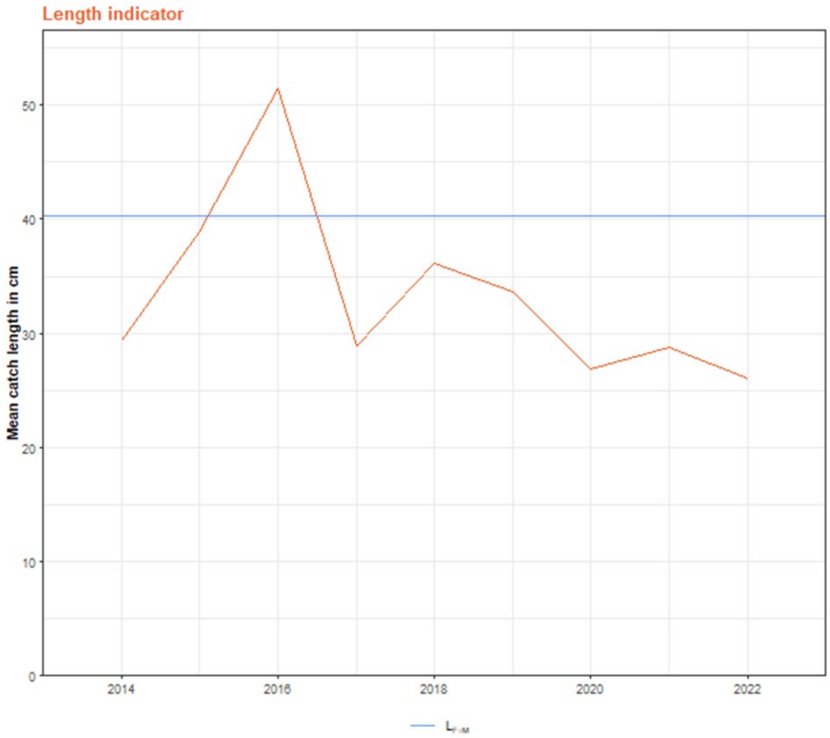


Figure 2.2.13. Indicator ratio (Lmean/LF=M).

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

[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

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

DK and SWE discard numbers combined Year	a1	a2	a3	a4	a5	a6	Total discard in tons
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

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

Table 2.2.4 a Cod in the Kattegat. Sampling level of Danish landings, 2022

Quarter	n. of harbour days	n. of cod aged	n. of cod weighed	n. of cod measured
1	4	120	120	120
2	22	11	11	11
3	5	26	26	26
4	6	235	235	235
Total	37	392	392	392

Table 2.2.4 b Cod in the Kattegat. Sampling level of Swedish landings, 2022

Quarter	n. of hauls	n. of cod aged	n. of cod weighed	n. of cod measured
1	8	54	54	54
2	6	32	34	34
3	4	40	40	40
4	0	0	0	0
Total	18	126	128	128

Table 2.2.5. Cod in the Kattegat. Landings numbers and mean weight-at-age by quarter and country for 2022.

Subdivision 21
Year 2022 – Quarter 1

Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1						
2	0.401937	529.4421	0.154	1345.5	0.56	755.50
3	1.921409	1466.369	0.269	1930.5	2.19	1523.37
4	0.484894	3109.649	0.15	2558.4	0.63	2979.41
5	0.132503	1961.358	0.009	3872.7	0.14	2082.92
6	0.38448	3590.381			0.38	3590.38
7						
8	0.046547	4153.5			0.05	4153.50
9						
10						
SOP (t)	6.37			1.15	7.52	
Landings (t)	6.16			0.82	6.98	

Subdivision 21
Year 2022 – Quarter 2

Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1						
2	0.189502	683.415	0.065	1450.8	0.25	879.41
3	0.576255	1698.33	0.138	2155.14	0.71	1786.59
4	0.004054	4905.81	0.048	3263.078	0.05	3391.03
5						
6	0.118227	2642.532			0.12	2642.53
7						
8						
9						
10						
SOP (t)	1.44			0.55	1.99	
Landings (t)	1.43			0.45	1.88	

Subdivision 21
Year 2022 – Quarter 3

Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1	0.313797	694.3353			0.31	694.34
2	0.169447	1517.603	0.056	1450.8	0.23	1501.01
3	0.472936	2435.325	0.147	2129.4	0.62	2362.78
4	0.03285	3032.64	0.069	2357.077	0.10	2574.97
5						
6	0.021999	5577.39			0.02	5577.39
7						
8						
9						
10						
SOP (t)	1.85			0.56	2.41	

Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
Landings (t)	1.73			0.50	2.23	

Subdivision 21
Year 2022 – Quarter 4

Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1	2.730635	420.5561			2.73	420.56
2	1.709741	965.5865	0.184	1254.398	1.89	993.65
3	1.040536	2130.323	0.348	1830.291	1.39	2055.13
4	0.068143	2651.185	0.054	2132.002	0.12	2421.65
5						
6	0.173607	3251.765			0.17	3251.76
7						
8						
9						
10						
SOP (t)	5.76			0.98	6.74	
Landings (t)	5.60			0.77	6.37	

Subdivision 21
Year 2022 – Quarter all

Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1	3.044432	694.3353			3.04	694.34
2	2.470628	1517.603	0.459	1450.8	2.93	1507.14
3	4.011136	2435.325	0.902	2155.14	4.91	2383.89
4	0.589942	4905.81	0.321	3263.078	0.91	4326.94
5	0.132503	1961.358	0.009	3872.7	0.14	2082.92
6	0.698313	5577.39			0.70	5577.39
7						
8	0.046547	4153.5			0.05	4153.50

Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
9						
10						
SOP (t)	22.87			3.69	26.57	
Landings (t)	14.90			2.50	17.40	

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+

	Age					
Year	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

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+

	Age							
Year	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
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

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+

	Age							
Year	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
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

Table 2.2.9 **Cod in the Kattegat.** Proportion mature at age (combined sex).
In the assessment the plus-group is defined as 6+

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
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

Table 2.2.10. Tuning data for the Kattegat cod assessment 2022.

Tuning Data; Cod in the Kattegat (part of Division IIIa)_14/04/23
104
Havfisken_SD21_Q1
1997 2023
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

IBTSQ1_1-6
1997 2023
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
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

IBTS_Q3
1997 2022
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

CODS_Q4

2008	2022					
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

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	Recruits	Low	High	TSB	Low	High	SSB	Low	High	Z-0.2	Low	High
1997	16808	10218	27649	12768	10685	15257	10592	8741	12835	1.129	0.916	1.393
1998	14074	8598	23038	10577	9010	12416	7992	6674	9570	1.244	1.029	1.504
1999	12831	7917	20793	9428	8099	10974	7575	6495	8834	1.287	1.072	1.546
2000	7628	4711	12352	7165	6196	8284	5773	4959	6720	1.383	1.157	1.652
2001	6803	4276	10824	6260	5423	7226	4972	4271	5789	1.45	1.207	1.741
2002	12098	7678	19063	6096	5255	7072	4853	4141	5688	1.222	1.005	1.486
2003	2868	1796	4582	5177	4473	5992	4285	3690	4976	1.104	0.902	1.351
2004	16801	10657	26488	5244	4452	6177	3841	3244	4549	1.085	0.887	1.328
2005	8226	5232	12931	7035	5949	8319	4643	3958	5447	1.128	0.922	1.38
2006	9074	5728	14374	6581	5564	7785	4820	4050	5737	1.109	0.911	1.351
2007	2658	1642	4304	4205	3627	4876	3375	2897	3932	1.287	1.067	1.554
2008	1384	903	2121	2316	2011	2666	2058	1769	2394	1.513	1.26	1.816
2009	3868	2564	5836	1046	899	1216	741	638	861	1.463	1.213	1.765
2010	3357	2213	5092	1015	847	1216	585	495	690	1.182	0.931	1.502
2011	3684	2359	5754	1203	992	1458	794	650	971	0.764	0.571	1.023
2012	9453	5952	15015	1702	1370	2115	1049	833	1321	0.59	0.432	0.805
2013	12321	7775	19526	3252	2632	4018	2019	1610	2531	0.451	0.325	0.626
2014	5060	3279	7808	5795	4692	7157	3211	2573	4006	0.421	0.307	0.578
2015	3772	2499	5692	8362	6685	10460	6041	4775	7642	0.568	0.429	0.751
2016	1074	638	1808	6455	5170	8060	5315	4188	6745	0.862	0.666	1.115
2017	6309	4047	9837	3494	2953	4134	2791	2328	3346	0.896	0.702	1.143
2018	595	384	921	2343	2010	2731	1932	1630	2289	1.521	1.276	1.812
2019	1527	986	2365	812	692	952	657	557	774	1.637	1.38	1.942
2020	3258	2088	5085	560	469	670	332	281	392	1.385	1.148	1.671
2021	1092	668	1786	563	468	677	401	336	479	1.422	1.161	1.741
2022	2443	1406	4246	329	254	427	217	170	277	1.731	1.246	2.405
2023	4077	1049	15848	582	301	1126	341	177	656	1.644	1.004	2.693

Table 2.2.12 summary run SPALY without scaling

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

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	Z-0.2	Low	High
1997	13628	8193	22668	11776	9022	15370	9871	7403	13163	1.207	0.939	1.552
1998	11609	7087	19016	9397	7474	11814	7125	5421	9363	1.311	1.049	1.637
1999	10418	6392	16980	8123	6524	10113	6570	5211	8284	1.348	1.084	1.677
2000	6017	3612	10022	6203	4964	7751	5039	3953	6424	1.444	1.17	1.781
2001	4284	2534	7244	5227	4210	6489	4239	3347	5368	1.564	1.264	1.934
2002	7947	4902	12882	4687	3786	5801	3836	3048	4830	1.456	1.166	1.818
2003	1324	727	2410	3223	2626	3957	2692	2182	3320	1.233	0.985	1.544
2004	8315	5116	13513	2975	2296	3856	2246	1683	2998	1.461	1.155	1.849
2005	3005	1795	5029	2748	2141	3528	1816	1432	2302	1.17	0.927	1.477
2006	3861	2328	6402	2478	1967	3121	1803	1410	2305	1.13	0.901	1.416
2007	1054	601	1850	1688	1296	2197	1350	1030	1770	1.524	1.244	1.868
2008	420	262	674	725	592	887	640	514	797	1.619	1.326	1.975
2009	1311	816	2106	318	262	386	219	177	271	1.459	1.193	1.784
2010	982	620	1554	328	263	410	190	154	234	1.309	1.015	1.686
2011	1164	715	1894	359	279	460	236	180	309	0.947	0.719	1.247
2012	2178	1332	3563	416	331	522	260	202	336	0.619	0.449	0.854
2013	2614	1664	4105	680	549	841	425	336	537	0.431	0.297	0.625
2014	883	562	1388	1050	809	1364	595	453	782	0.373	0.24	0.579
2015	707	452	1105	1407	1009	1961	1022	715	1459	0.454	0.29	0.71
2016	167	96	292	1056	796	1401	871	636	1192	0.628	0.41	0.964
2017	1339	806	2225	703	566	874	567	446	721	0.855	0.598	1.223
2018	135	84	217	451	364	559	364	292	454	1.439	1.144	1.811
2019	263	165	420	164	129	207	134	104	172	1.696	1.371	2.098
2020	546	331	902	96	77	119	58	45	76	1.399	1.096	1.785
2021	184	113	300	89	67	120	62	48	82	1.201	0.911	1.584
2022	412	234	722	67	49	91	47	33	67	1.365	0.937	1.99
2023	918	260	3247	129	74	225	77	44	134	1.301	0.745	2.273

Table 2.2.13. Input values for the application of rbf method.

year	Lc	Linf	LFeM	Lmean	f=Lmean/LF=M	Index	Catch	C/I ratio
2014	21	104.87	41.97	29.99	0.71	142.23	466.00	3.28
2015	19	104.87	40.47	38.91	0.96	97.66	585.00	5.99
2016	26	104.87	45.72	52.54	1.15	18.78	521.00	27.74
2017	17	104.87	38.97	27.28	0.70	12.37	552.00	44.62
2018	22	104.87	42.72	37.54	0.88	0.91	284.00	311.44
2019	20	104.87	41.22	33.96	0.82	1.58	123.00	77.77
2020	19	104.87	40.47	26.90	0.66	5.11	97.00	18.99
2021	19	104.87	40.47	28.71	0.71	0.97	50.00	51.60
2022	17	104.87	38.97	24.94	0.64	3.82	55.00	14.39

Table 2.2.14. Advice based on rfb rule

Previous catch advice Ay (advised catch for 2022)		0 tonnes
Stock biomass trend		
Index A (2021,2022)		2.40 kg/hr
Index B (2018,2019,2020)		2.53 kg/hr
r: stock biomass trend (index ratio A/B)		0.95
Fishing pressure proxy		
Mean catch length (Lmean = L2022)		26 cm
MSY proxy length (LF=M)		40 cm
f: Fishing pressure proxy relative to MSY proxy (L2022/LF=M)	0.64	
Biomass safeguard		
Last index value (I2022)		3.8 kg/hr
Index trigger value (Itrigger = Iloss x 1.4)		1.27 kg/hr
b: index relative to trigger value, min{I2022/Itrigger, 1}		2.99 -> 1.00
Precautionary multiplier to maintain biomass above Blim with 95% probability		
m: multiplier (generic multiplier based on life history)		0.95
RFB calculation (r*f*b*m)		0.00 tonnes
Stability clause (+20%/-30% compared to Ay, only applied if b=1)	Not applied	
Catch advice for 2023 and 2024 (Ay * r * f * b * m)		0 tonnes
Discard rate		65 %
Projected landings corresponding to advice		**0 tonnes**
% advice change		%

2.3 Western Baltic cod (update assessment)

Note that this assessment was updated at ADGBS in May 2023. See Annex 8 for details.

The western Baltic cod stock assessment has been downgraded from a category 1 assessment to a category 3 assessment where SSB and recruitment are only trusted for the 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 fisher-ies 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 in-creased 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). How-ever, 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 uncer-tainties 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 ground fish 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. There is a trawling ban in place in subdivision SD 23 (the Sound) 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 2022, however, Poland contributed the major part of the landings (from SD24). Time series of total cod landings by country and SD in the management area of SD 22–24 are given in Table 2.3.1. Since 2017 landing numbers include the BMS fraction, which was around 1 t in 2022 in the western Baltic management area. Normally trawlers have been responsible for the main landings of cod in the western Baltic but since 2021 the gillnetters are accounting for a large part (in 2022: 41%). Landings by SD, passive and active gear in 2022 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 2022 was 137 (including BMS) t, which corresponds to 10% of last year's level (1329 t) and a quota utilization of 28% (489 t), being the historically lowest quota utilization. In the last 10 years slightly more than half of the total western Baltic area landings have been fished in SD 24, in 2019 -2021 this changed and was lesser, due to a management regulation installed since mid-2019 (see below), where a directed cod fishery in SD 24 was prohibited (Figure 2.3.1 and Table 2.3.11). However, in 2022 the pattern was again close to the historic pattern with 41% of the total catches in SD 24 although the total level was much lower.

In the Western Baltic cod stock assessment recreational fishing is also included in the stock assessment, as this fraction in several years has been a large part of the total catch (~30%). However, in 2022 due to the very low commercial catches the recreational fraction increased to 68% of the total catch, although the actual level of recreational catches was estimated to be historic low (288 t) (Figure 2.3.2).

As the Western and Eastern Baltic cod stock mix in SD 24, a splitting factor (based on genetics and otolith shape analysis) has been 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 in 2020, 2021 and 2022 the spawning closure was reintroduced given the decreased stock size. 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 2022 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 (1 February to 31 March) (Table 2.3.11). In 2022 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 Figure 2.3.4.

2.3.1.2 Discards

Denmark, Germany and Sweden uploaded their discard data to InterCatch for SD 22–24 from 2022. There was 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 2022 was estimated to have increased compared to previous years and was estimated at 9% in 2022 (discard/total fishery). If only looking at the commercial catches, the discard rate was 23%. 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 2022 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 2022 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. Due to the decreased commercial catches, the relative contribution of the recreational fisheries to the total catches increased from close to 30% to be 68% in 2022. 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 2022 were estimated to be 288 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. The majority of cod landings in 2022 originated from Poland in SD24 and no discard samples were available.

Since 2015, 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), discards and recreational catches, were estimated to be 403 t in 2022 (19% of last years´ catches). Landings and discards of eastern Baltic cod in SD 24 is estimated to be 63 t and are shown in Table 2.3.6. By management area, the total catch is estimated to be 466 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 2022 (i.e. the allocation overview) applied in InterCatch is given for landings and discards in Table 2.3.4.

The last 3 years Covid-19 pandemic has together with the decreased fishing in the western Baltic area decreased the sampling level. In 2022 both the landing levels for cod and the sampling level for cod dropped to historic low levels so that the uncertainty can be considered relatively high (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 2022 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.

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.

The numbers-at-age per stratum in the catch data suggest that all countries consistently identified the strong 2016 cohort and the weak following year classes in their age readings.

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 2022, 34 % 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 2022 landings by ICES square in SD 24.

Mixing proportions from a German historic survey were used to calculate a splitting proportion on the historic part of the time series (1985-1995). For more details on the mixing proportions please refer to WKBALTCOD2 (2019).

2.3.2.2 Catch in numbers

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.

In 2022 the large 2016-year class amounting to 16% of the total catch in numbers as age 6 (Figure 2.3.6, Table 2.3.15). In the recreational fishery, the contribution of age-6 cod was below 1%, so the influence of the 2016-year class to the total catch has decreased considerably (Table 2.3.12 and table 2.3.14). There are indications that the new 2022-year class is relatively strong, however more data points will be needed before this can be confirmed.

2.3.2.3 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 along with the progress of the 2016 cohort (Receveur et al. 2022).

2.3.2.4 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 and WKBALTCOD2 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 1998-2021 (Table 2.3.20).

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.

2.3.2.5 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.

In 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 Figures 2.3.9, 2.3.10 and 2.3.11.

Funk et al. (2020) showed that 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)	2001–2022	age 0–4+
BITS, Q1, SD22–24W (12–13 degrees)	2001–2023	age 1–4+
FEJUCS, SD22	2011-2022	age 0

2.3.3.1 Recruitment estimates

A strong year class was estimated in 2016 but the four following year classes (i.e. the 2017, 2018, 2019 and 2020) year classes were estimated very weak and among the lowest in the time-series. The 2022 is estimated to be 50% above average although with wide confidence intervals (Figure 2.3.19). The last large year class (2016) was downgraded with nearly 50%, in the next assessments and the recruitment is therefore considered uncertain at this point.

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 cat. 3 assessment 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

Covid-19 pandemic. In this year´s assessment the same settings were used, with the same argument.

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 0.16 and –0.11, respectively), and 0.19 for the recruitment. (Figure 2.3.18).

The summaries for SSB, Recruitment and F from the final run are shown in Figure 2.3.19 with last years´ assessment in the same plot and Table 2.3.23. Stock number and fishing mortalities are presented in Tables 2.3.24 and 2.3.25, respectively.

The input data, settings and final run are visible in www.stockassessment.org, the stock is coded "WBCod23".

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.

The SSB development and recruitment estimate from stock assessment is considered less affected, though the estimates for fishing mortality may include sources other than mortality caused by fishing only. Therefore, the majority of the working group suggested to present the SSB and recruitment as relative values only and not to use the fishing mortality from the model. Instead, fishing effort in the western Baltic area was investigated with data from the FDI data base, VMS effort from the Danish fishery and harvest rate (figures 2.3.19 and 2.3.20). All these alternative data sources showed a strong decrease in the fishing effort in later years, which is not reflected in the F pattern from the present model.

2.3.6 Reference points

In 2016, a Baltic multiannual management plan has been introduced with F ranges (0.15–0.26 and 0.26–0.45) depending on the SSB in the intermediate year+1 compared to the MSY B-trigger level. These values were updated at the inter-benchmark in 2021 to 0.17 (lower), 0.26 (F_{MSY}) and 0.44 (Higher).

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.

F_{lim} and F_{pa} were estimated using EqSim with the same settings and dataset as used for the F_{MSY} calculation, however, calculated without trigger and Fcv=0, F_{phi}=0. This estimation gave a F_{lim} at 1.23 and an F_{pa} = $F_{p0.5}$=at 0.689.

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 2022, 68% 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 therefore it is not directly comparable to last years´ assessment.

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. As the size and fate of the 2022-year class is still very uncertain, given that only a few, data points are available (Q4 survey in fall 2022 and Q1 survey in 2023, pound net survey), the working group recommends zero catches to protect this single incoming year class.

In 2022 the recreational fishery was fishing was 68% 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).

Table 2.3.1 Cod in SD 22-24. Total landings (tons) of COD in the ICES Sub-divisions 22, 23, 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		137

[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: 2022
Gear: Active and passive gear combined

Country/Subdivision	22	23	24	22-24
Denmark	31	13	24	68
Germany	12	0	8	20
Sweden	0	8	1	9
Poland	0	0	39	39
Total	43	21	72	136

Year: 2022
Gear: Active gear

Country/Subdivision	22	23	24	22-24
Denmark	10	2	22	33
Germany	3	0	5	8
Sweden	0	0	0	0
Poland	0	0	38.4	38
Total	13	2	65	80

Year: 2022
Gear: Passive gear

Country/Subdivision	22	23	24	22-24
Denmark	21	11	2	34
Germany	8	0	3	12
Sweden	0	8	1	9
Poland	0	0	0.2	0
Total	30	19	7	56

Table 2.3.3a. Cod 22–23. Unsampled landing strata and allocated sampled strata in 2022

DE_27.3.c.22_Active_3_L,DE_27.3.c.22_Active_2_L,X

DE_27.3.c.22_Active_3_L,DK_27.3.c.22_Active_2_L,X

DE_27.3.c.22_Active_3_L,DK_27.3.c.22_Active_4_L,X

DE_27.3.c.22_Active_4_L,DE_27.3.c.22_Active_2_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_4_L,X

DE_27.3.c.22_Gillnets set_2_L,DE_27.3.c.22_Gillnets set_1_L,X

DE_27.3.c.22_Gillnets set_2_L,DK_27.3.c.22_Gillnets set_1_L,X

DE_27.3.c.22_Gillnets set_2_L,DK_27.3.c.22_Gillnets set_2_L,X

DK_27.3.b.23_Active_1_L,DE_27.3.c.22_Active_1_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_2_L,DE_27.3.c.22_Active_1_L,X

DK_27.3.b.23_Active_2_L,DE_27.3.c.22_Active_2_L,X

DK_27.3.b.23_Active_2_L,DK_27.3.c.22_Active_1_L,X

DK_27.3.b.23_Active_2_L,DK_27.3.c.22_Active_2_L,X

DK_27.3.b.23_Active_3_L,DE_27.3.c.22_Active_2_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_4_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_1_L,DE_27.3.c.22_Gillnets set_1_L,X

DK_27.3.b.23_Gillnets set_1_L,DK_27.3.c.22_Gillnets set_1_L,X

DK_27.3.b.23_Gillnets set_1_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_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_4_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_4_L,X

DK_27.3.c.22_Active_3_L,DK_27.3.c.22_Active_4_L,X

DK_27.3.c.22_Gillnets set_3_L,DE_27.3.c.22_Gillnets set_3_L,X

DK_27.3.c.22_Gillnets set_3_L,DE_27.3.c.22_Gillnets set_4_L,X

DK_27.3.c.22_Gillnets set_3_L,DK_27.3.c.22_Gillnets set_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_3_Active_D,DE_27.3.c.22_1_Active_D,X

DE_27.3.c.22_3_Active_D,DE_27.3.c.22_2_Active_D,X

DE_27.3.c.22_3_Active_D,DE_27.3.c.22_4_Active_D,X

DE_27.3.c.22_3_Gillnets set_D,DK_27.3.b.23_3_Gillnets set_D,X

DE_27.3.c.22_3_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X

DK_27.3.b.23_1_Active_D,DE_27.3.c.22_1_Active_D,X

DK_27.3.b.23_1_Active_D,DE_27.3.c.22_2_Active_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,DK_27.3.c.22_2_Gillnets set_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_3_Active_D,DE_27.3.c.22_2_Active_D,X

DK_27.3.b.23_3_Active_D,DE_27.3.c.22_4_Active_D,X

DK_27.3.b.23_4_Active_D,DE_27.3.c.22_4_Active_D,X

DK_27.3.c.22_1_Active_D,DE_27.3.c.22_1_Active_D,X

DK_27.3.c.22_1_Active_D,DE_27.3.c.22_2_Active_D,X

DK_27.3.c.22_1_Active_D,DE_27.3.c.22_4_Active_D,X

DK_27.3.c.22_1_Gillnets set_D,DE_27.3.c.22_1_Gillnets set_D,X

DK_27.3.c.22_1_Gillnets set_D,DE_27.3.c.22_2_Gillnets set_D,X

DK_27.3.c.22_1_Gillnets set_D,DK_27.3.c.22_2_Gillnets set_D,X

DK_27.3.c.22_2_Active_D,DE_27.3.c.22_1_Active_D,X

DK_27.3.c.22_2_Active_D,DE_27.3.c.22_2_Active_D,X

DK_27.3.c.22_2_Active_D,DE_27.3.c.22_4_Active_D,X

DK_27.3.c.22_3_Active_D,DE_27.3.c.22_2_Active_D,X

DK_27.3.c.22_3_Active_D,DE_27.3.c.22_4_Active_D,X

DK_27.3.c.22_3_Gillnets set_D,DK_27.3.b.23_3_Gillnets set_D,X

DK_27.3.c.22_3_Gillnets set_D,DK_27.3.b.23_4_Gillnets set_D,X

DK_27.3.c.22_4_Active_D,DE_27.3.c.22_1_Active_D,X

DK_27.3.c.22_4_Active_D,DE_27.3.c.22_2_Active_D,X

DK_27.3.c.22_4_Active_D,DE_27.3.c.22_4_Active_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,DK_27.3.b.23_4_Gillnets set_D,X

DK_27.3.c.22_4_Gillnets set_D,DK_27.3.c.22_2_Gillnets set_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 2021 (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											
TAC 44%		Gillnets set		4			3		1	2	10	31	**42%**
	Landings *2	Active	9	5		5					19		
		Gillnets set	9	5		5		2			2		
Germany	Discards *1	Active	1	1		1					3		
TAC 21%		Gillnets set	1	1		2					4		
	Landings *1	Active	2	1							3	14	**19%**
		Gillnets set	1		2	1					4		
Sweden	BMS *3	Gillnets set					4	4	3	4			
TAC 16%	Discards *2	Gillnets set					4	4	3	4	15	29	**39%**
	Landings *2	Gillnets set					3	4	3	4	14		
			14	12	2	9	10	10	7	10	74		

*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											
TAC 44%		Gillnets set		12			3		15	32	62	271	**43%**
	Landings	Active	118	43		24					185		
		Gillnets set	118	43		24		24			24		
Germany	Discards	Active	3	1		2					6		
TAC 21%		Gillnets set	12	2		13					27		
	Landings	Active	8	1							9	81	**13%**
		Gillnets set	6		31	2					39		
Sweden	BMS	Passive					28	29	44	32			
TAC 16%	Discards	Passive					28	29	44	32	133	276	**44%**
	Landings	Passive					9	61	52	21	143		
Total			147	59	31	41	40	114	111	85	628		

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											
TAC 44%		Gillnets set		12			3		13	17	45	253	**44%**
	Landings	Active	117	43		24					184		
		Gillnets set	117	43		24		24			24		
Germany	Discards	Active	3	1		2					6		
TAC 21%		Gillnets set	12	2							14		
	Landings	Active	4	1							5	42	**7%**
		Gillnets set	6		9	2					17		
Sweden	BMS	Passive					28	29	44	32			
TAC 16%	Discards	Passive					28	29	44	32	133	276	**48%**
	Landings	Passive					9	61	52	21	143		
Total			142	59	9	28	40	114	109	70	571		

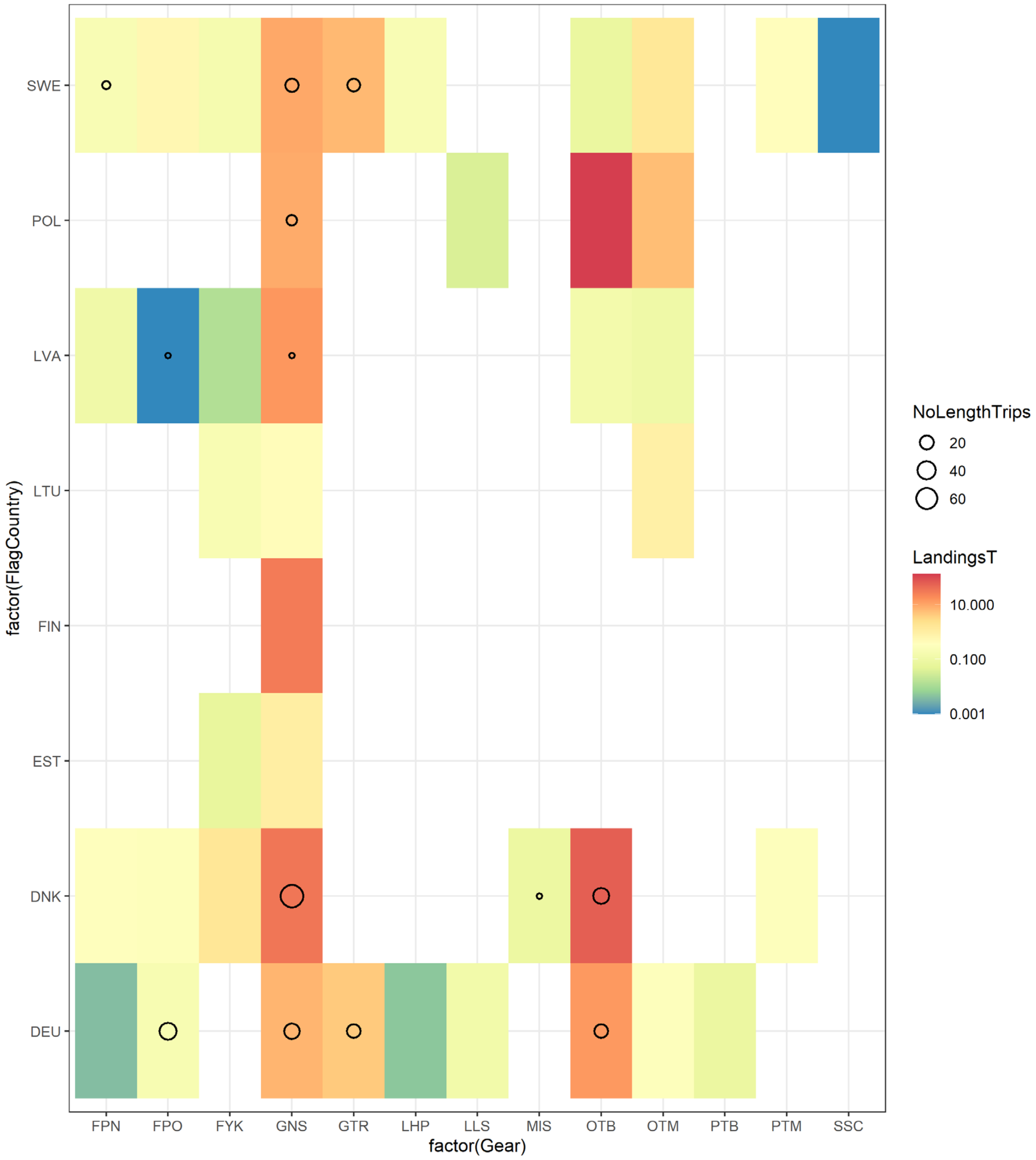


Figure 2.3.4b. Western Baltic cod. Total landings and number of trips sampled with cod, by gear and country.

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	<1	1	0.1	0.3	2
Active gears	7	10	13	5	34
Grand Total	7	11	13	5	36

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 2017-2022 includes BMS.

Year	WB cod stock					EB cod stock					EB+WB cod stock		
	Landings	Discards	Recreational catch	% discard	% of comm. catch in SD 24	Landings in SD 24	Discards in SD24	Landings in SD 25-32	Discards in SD 25-32	% of catch in SD 24	Catch in SD 22-24	% commercial catch of west cod	stock Comm. catch in SD 24
1985	33188		2075		0.29	6971		315083	8199	2	42234	0.83	0.71
1986	20088		2078		0.36	6604		252558	3848	3	28770	0.75	0.93
1987	21692		2081		0.37	6874		207081	9340	3	30647	0.76	0.86
1988	20672		2082		0.47	8487		194787	7253	4	31241	0.71	0.87
1989	12795		2083		0.49	5721		179178	3462	3	20599	0.69	0.92
1990	12237		2085		0.49	5543		153546	4187	3	19865	0.69	0.92
1991	12931		2087		0.32	3762		122517	2741	3	18780	0.77	0.92
1992	15672		2420		0.19	2324		54882	1904	4	20416	0.87	0.76
1993	11815		2752		0.27	3885		50711	1558	7	18452	0.75	1.20
1994	16642	1614	3088	0.09	0.41	6551	621	100856	1956	7	28516	0.72	0.97
1995	28310	3016	3417	0.10	0.29	5585	668	107718	1872	5	40996	0.83	0.68
1996	38505	6868	3419	0.15	0.32	10040	1116	124189	1443	8	59948	0.80	0.77
1997	37077	3981	3420	0.10	0.33	6547	641	88600	3462	7	51666	0.85	0.53
1998	29634	5575	3410	0.16	0.37	4582	631	67428	2299	7	43833	0.87	0.40
1999	35934	4378	3416	0.11	0.32	6221	599	72995	1838	8	50549	0.86	0.52
2000	31132	3738	3432	0.11	0.32	6316	1209	89289	6019	7	45827	0.82	0.68
2001	27781	2449	3427	0.08	0.36	7794	389	91328	2891	8	41840	0.79	0.75
2002	20410	1395	3437	0.06	0.31	5060	562	67740	1462	8	30864	0.80	0.84
2003	17205	3473	3448	0.17	0.34	5729	862	69477	2024	8	30718	0.76	0.95
2004	17686	2189	3445	0.11	0.27	5309	188	68578	1201	7	28817	0.78	1.04
2005	18493	3265	3771	0.15	0.42	6064	1729	55032	1670	12	33322	0.74	0.86
2006	18503	1686	2923	0.08	0.27	6767	144	65531	4644	9	30024	0.74	1.28
2007	17384	1325	2782	0.07	0.35	8792	875	50843	4146	15	31158	0.66	1.46
2008	11302	336	3039	0.03	0.31	8811	787	42234	3746	17	24274	0.55	2.66
2009	7313	351	2648	0.05	0.42	8284	464	48438	3328	14	19060	0.47	2.75
2010	8007	838	3367	0.09	0.36	6049	533	50276	3543	11	18793	0.57	2.08
2011	9107	299	2595	0.03	0.24	7545	482	50368	3850	13	20029	0.54	3.59
2012	8622	370	3661	0.04	0.31	8469	536	51225	6795	13	21657	0.50	3.28
2013	7697	1007	3106	0.12	0.29	5359	1243	31355	5020	15	18413	0.57	2.62
2014	8083	837	4044	0.09	0.33	5455	1298	28909	9627	15	19716	0.57	2.30
2015	8390	432	4568	0.05	0.29	5029	930	38079	5970	12	19348	0.60	2.35
2016	6122	143	3505	0.02	0.31	4541	306	29313	3279	13	14617	0.56	2.53
2017	3861	180	1315	0.04	0.20	2058	227	25496	3238	7	7642	0.64	2.86
2018	3555	157	1600	0.04	0.21	2295	300	15907	3103	12	7907	0.59	3.38
2019	6103	655	2573	0.10	0.26	1598	621	8383	1337	19	11550	0.75	1.27
2020	2900	152	1311	0.05	0.10	429	50	2319	101	17	4842	0.864	1.62
2021	1065	51	968	0.05	0.10	262	29	1387	85	17	2375	0.793	2.68
2022	88	27	288	0.23	0.27	48	15	1387	85	4	466	0.647	1.99
3 avr.					0.16								2.09

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:	2022		Gear:	Trawl, gillnet and longlines combined		
Year:	**2022**	**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						
2	0.5	856	0.1	851	1	853
3	1	2383	1	2081	2	2254
4	1	3512	0.3	2919	1	3216
5	0.1	4087	0.02	3931	0.1	4009
6	1	6117	0.1	4485	1	5301
7	0.03	2492	0.02	2831	0.1	2696
8						
9						
SOP [t]	14		2		16	
Landings (t)	13		2		15	
Year:	**2022**	**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						
2	1	1662	0.3	747	1	1319
3	1	2387	2	1927	3	2190
4	1	3539	1	2419	1	3059
5	0.003	3435	0.05	4181	0.1	3932
6	0.7	4683	1.0	3613	2	4224
7	0.003	2492	0.05	2967	0.05	2809
8						
9						
SOP [t]	10		9		19	
Landings (t)	10		8		18	
Year:	**2022**	**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	0.5	572	0.01	576	0.5	573
2	4	1591	3	963	7	1321
3	0.4	3461	1	1875	2	2668
4	0.0005	3455	0.1	2341	0.1	2620
5			0.1	2106	0.1	2106
6	0.0005	4546	0.02	4546	0.02	4546
7						
8						
9						
SOP [t]	4		5		10	
Landings (t)	4		5		9	

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	

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

CATON	SD 22	SD23	SD24
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	SD 22	SD23	SD24
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
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

year	Area 1 _ W	Area 2_ E	Present WBC in landings for SD 24
2012	52	19	23
2013	53	23	28
2014	51	25	31
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

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	distance from coast	Special rules/exemptions	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		Vessel <12m can fish shallower than 20 water depth	2017/1970 27. Oct. 2017	5 cod/day 3 cod/day (1/2-31/3)	<20 m
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	<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	<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				<20 m
2022	22-23	15.01.-31.03. 2,5 months		1) vessels <12 m that fish with gillnets, entangling nets or trammel nets, with bottom set lines, longlines within 4 nm, drifting lines, handlines and jigging equipment or similar passive gear, in areas shallower than 20 m 2) vessels fishing with dredges for bivalve molluscs, in areas shallower than 20 m	2021/1888 29. Oct. 2021	0 cod / day from 15.01.-31.03. During the rest of the year: 1 cod / day	<20 m

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

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
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

age	a1	a2	a3	a4	a5	a6	a7+
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

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
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

age	a1	a2	a3	a4	a5	a6	a7+
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
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

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
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

age	a1	a2	a3	a4	a5	a6	a7+
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

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

age	a1	a2	a3	a4	a5	a6	a7+
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
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

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

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

age	a1	a2	a3	a4	a5	a6	a7+
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
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

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

age	a0	a1	a2	a3	a4	a5	a6	a7+
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
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

age	a0	a1	a2	a3	a4	a5	a6	a7+
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

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+
1998-2022	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+
1985-2022	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	11275	131805	16608	904
1997	12096	2958	13418	668
1998	25946	8903	585	665
1999	7383	15726	2688	339
2000	11002	7044	6780	1221
2001	4325	5967	1245	778
2002	10842	3674	1883	294
2003	910	5220	588	220
2004	9287	1943	2364	153
2005	6358	39034	1638	881
2006	9613	7225	8673	359
2007	1793	10870	2866	1763
2008	71	1224	1302	716
2009	6526	822	1077	533

BITS Q1	a1	a2	a3	a4
2010	2358	12310	468	263
2011	9030	9052	15408	133
2012	1618	3788	1807	1218
2013	6213	3383	2504	455
2014	3754	5265	710	307
2015	2533	5711	2219	230
2016	41	889	634	698
2017	8613	354	1242	701
2018	477	23392	410	1031
2019	507	1501	10539	358
2020	1209	977	385	2531
2021	3713	2611	435	328
2022	2774	1471	411	98
2023	7469	1798	375	134

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

BITS Q4	a0	a1	a2	a3	a4
1999	10953	5725	2530	157	20
2000	3639	3039	746	124	33
2001	22644	2198	956	139	73
2002	2700	6782	788	288	31
2003	23988	3627	1581	96	39
2004	4840	8166	815	275	29
2005	4186	1860	1361	103	68
2006	2379	2804	313	665	86
2007	461	302	175	174	245
2008	19735	43	55	73	76
2009	2841	1836	56	91	28
2010	10350	747	506	26	19

BITS Q4	a0	a1	a2	a3	a4
2011	3541	1386	113	159	14
2012	15372	1246	337	74	50
2013	7105	3159	178	72	35
2014	5752	1451	689	113	61
2015	445	706	289	278	60
2016	32442	138	101	40	105
2017	284	6274	101	158	52
2018	1030	287	749	18	58
2019	3469	277	12	105	28
2020	4386	675	25	12	135
2021	9694	949	60	7	47
2022	27260	2288	73	17	10

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

FEJUCS	a0
2011	20.7
2012	0.0
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

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	48092	25386	91105	35473	27106	46424	1.166	1.01	1.347	48408	37872	61876
1986	131297	70758	243632	24782	19976	30744	1.156	1.016	1.316	39065	31445	48532
1987	44101	24179	80437	26207	20389	33685	1.142	1.012	1.288	39307	30130	51280
1988	19585	10625	36101	27702	20910	36700	1.136	1.012	1.276	35910	27494	46900
1989	22500	12328	41066	19737	15369	25346	1.136	1.016	1.271	25611	20304	32305
1990	35320	19340	64501	13516	11014	16587	1.154	1.037	1.286	19654	16201	23844
1991	59479	32616	108468	11772	9569	14483	1.177	1.058	1.309	20672	16654	25659
1992	118858	64871	217776	13929	10951	17719	1.19	1.069	1.325	26602	20537	34457
1993	43136	23561	78974	22601	16993	30059	1.184	1.066	1.315	36062	27311	47616
1994	96561	52814	176546	32485	24402	43245	1.173	1.058	1.301	48612	37752	62596
1995	158477	87067	288454	36392	28766	46040	1.184	1.066	1.314	57389	45669	72116
1996	42814	23779	77086	47222	37042	60201	1.173	1.058	1.301	67675	53262	85988
1997	132826	77982	226242	49798	37347	66399	1.178	1.062	1.307	69854	53973	90408
1998	212124	125355	358954	37035	29488	46515	1.184	1.067	1.315	66030	52353	83279
1999	73390	45501	118371	40902	32650	51238	1.206	1.079	1.348	59965	47795	75233
2000	74772	47353	118068	38564	30436	48863	1.202	1.073	1.347	52341	42051	65149
2001	48265	30313	76849	35192	28769	43049	1.195	1.065	1.34	49305	40548	59953
2002	103291	65057	163993	31837	25801	39284	1.171	1.046	1.309	45125	36957	55098
2003	29881	18618	47959	28952	23618	35490	1.136	1.02	1.266	42563	34600	52359
2004	115523	72611	183794	28490	22584	35939	1.108	0.996	1.233	43508	35137	53875
2005	32465	20553	51283	33190	26663	41315	1.069	0.961	1.19	47852	38207	59931
2006	36745	23187	58232	31957	25082	40716	1.022	0.911	1.148	40661	32256	51256
2007	11109	6864	17978	29032	23334	36122	1.008	0.897	1.132	36780	29796	45401
2008	4024	2150	7533	20140	16632	24388	1.013	0.907	1.131	25033	20791	30142
2009	46467	28637	75398	14404	11915	17413	1.015	0.911	1.131	19711	16456	23611
2010	15976	10088	25301	13850	11206	17118	1.015	0.911	1.132	20656	16530	25813
2011	24449	15326	39001	14540	11183	18903	1.001	0.897	1.117	19385	15187	24743
2012	18661	11853	29379	15534	12417	19433	0.989	0.885	1.105	20929	17023	25731
2013	46992	29681	74399	12732	10475	15477	0.999	0.893	1.117	18495	15375	22248

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(3-5)	Low	High	TSB	Low	High
2014	26995	17091	42637	16169	13289	19674	0.982	0.875	1.102	22479	18430	27417
2015	16027	10141	25328	17286	13996	21349	0.971	0.861	1.095	22621	18411	27795
2016	3012	1821	4981	12746	10164	15985	0.968	0.853	1.099	16772	13533	20786
2017	54779	33179	90441	9311	7491	11574	0.961	0.838	1.101	13087	10617	16133
2018	2104	1295	3419	10438	8152	13365	0.956	0.823	1.11	14792	11366	19251
2019	3265	1967	5418	12261	8984	16735	0.953	0.809	1.124	14857	10931	20194
2020	7539	4402	12913	8351	5522	12630	0.949	0.794	1.135	10342	6986	15311
2021	10799	6080	19183	4360	2921	6506	0.941	0.775	1.142	6172	4360	8737
2022	22912	11828	44383	3561	2439	5198	0.93	0.753	1.149	6420	4371	9431
2023	79688	30865	205743	5279	3266	8533				11442	6082	21524

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

Year Age	Age 0	age 1	age 2	age 3	age 4	age 5	age 6	age 7
1985	467206	48092	24391	21969	4214	1128	364	209
1986	166710	131297	22100	8739	4844	838	289	142
1987	76324	44101	66845	7981	2015	969	208	111
1988	85370	19585	21723	22897	2035	454	252	92
1989	132467	22500	8340	8445	5308	497	126	93
1990	223219	35320	11350	3392	2244	1267	150	69
1991	413939	59479	18351	4287	801	491	336	70
1992	173694	118858	29005	6502	981	150	119	101
1993	355958	43136	58672	11399	1494	197	25	50
1994	549772	96561	21661	26806	3535	288	33	17
1995	176949	158477	54496	9084	8409	1119	76	9
1996	482947	42814	101704	24399	2169	2296	247	12
1997	742269	132826	14363	46972	5158	587	518	78
1998	285450	212124	60961	5983	9803	1199	160	142
1999	257490	73390	96256	22442	1750	1937	301	92
2000	160345	74772	33023	32565	5672	359	422	85
2001	354554	48265	40949	11970	7638	1396	85	120

Year Age	Age 0	age 1	age 2	age 3	age 4	age 5	age 6	age 7
2002	107122	103291	26331	15548	2674	1543	366	40
2003	385997	29881	57924	9508	3041	567	351	100
2004	119227	115523	14802	22826	2549	609	158	119
2005	118507	32465	68225	5855	5852	602	137	70
2006	41270	36745	17168	29452	1849	1409	145	40
2007	15491	11109	18988	7993	8013	708	414	52
2008	166894	4024	6969	7326	2674	1785	258	151
2009	61016	46467	4086	4324	2266	803	380	113
2010	97486	15976	29055	2759	1596	629	203	110
2011	72824	24449	8444	15164	1425	461	127	68
2012	175534	18661	12752	4641	4805	659	131	38
2013	103676	46992	9659	6517	1642	1285	230	60
2014	63813	26995	24277	4506	2172	386	307	63
2015	13436	16027	12995	10725	1418	541	91	101
2016	199463	3012	8429	4652	3327	400	127	53
2017	8017	54779	1722	4079	1394	725	97	47
2018	13077	2104	26136	750	1344	341	149	36
2019	30744	3265	941	13142	299	357	73	38
2020	42996	7539	1510	469	5121	83	74	25
2021	89965	10799	3420	694	142	1417	19	22
2022	288186	22912	4491	1522	232	39	307	9
2023		79688	10525	2039	593	71	10	82

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

Year Age	age 1	age 2	age 3	age 4	age 5-7
1985	0.097	0.55	1.109	1.272	1.118
1986	0.096	0.547	1.098	1.261	1.109
1987	0.095	0.543	1.085	1.242	1.097
1988	0.095	0.532	1.08	1.23	1.099
1989	0.093	0.523	1.073	1.229	1.105
1990	0.092	0.519	1.076	1.243	1.145
1991	0.09	0.514	1.071	1.252	1.208
1992	0.089	0.502	1.058	1.241	1.271
1993	0.087	0.49	1.04	1.219	1.293
1994	0.086	0.485	1.046	1.18	1.294
1995	0.085	0.48	1.072	1.176	1.304
1996	0.085	0.477	1.093	1.184	1.242
1997	0.084	0.478	1.097	1.212	1.226
1998	0.081	0.486	1.09	1.246	1.217
1999	0.078	0.49	1.101	1.269	1.247
2000	0.075	0.491	1.107	1.266	1.234
2001	0.073	0.488	1.088	1.265	1.231
2002	0.07	0.48	1.057	1.247	1.207
2003	0.068	0.466	1.012	1.217	1.181
2004	0.066	0.452	0.964	1.176	1.184
2005	0.064	0.442	0.914	1.123	1.171
2006	0.062	0.434	0.879	1.064	1.124
2007	0.061	0.428	0.849	1.054	1.12
2008	0.059	0.415	0.829	1.041	1.168
2009	0.058	0.406	0.804	1.043	1.198
2010	0.058	0.39	0.787	1.043	1.216
2011	0.057	0.378	0.775	1.036	1.193
2012	0.057	0.369	0.771	1.043	1.153
2013	0.057	0.365	0.77	1.043	1.184

Year Age	age 1	age 2	age 3	age 4	age 5-7
2014	0.057	0.359	0.766	1.021	1.161
2015	0.057	0.352	0.761	0.996	1.157
2016	0.057	0.343	0.756	0.983	1.165
2017	0.057	0.332	0.738	0.965	1.179
2018	0.057	0.318	0.729	0.948	1.19
2019	0.058	0.311	0.733	0.942	1.185
2020	0.058	0.312	0.731	0.935	1.181
2021	0.057	0.312	0.729	0.93	1.164
2022	0.057	0.311	0.724	0.923	1.143
2023					

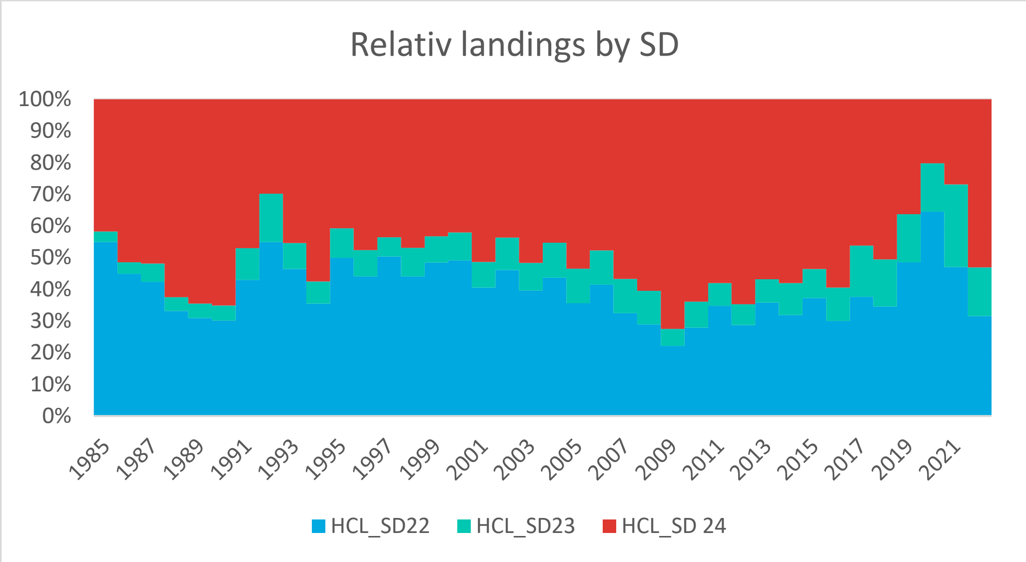


Figure 2.3.1. Western Baltic cod. Relative landings by SD (tonnes) for the western Baltic management area (both east and west cod included). HCL: human consumption landings.

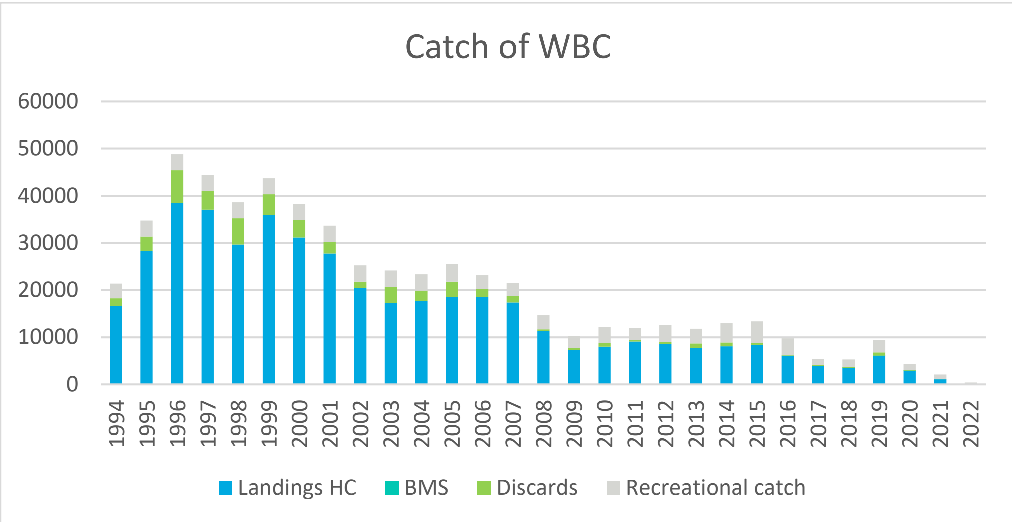


Figure 2.3.2. Western Baltic cod. Commercial landings, discard and recreational catch (tonnes) of the WBC stock.

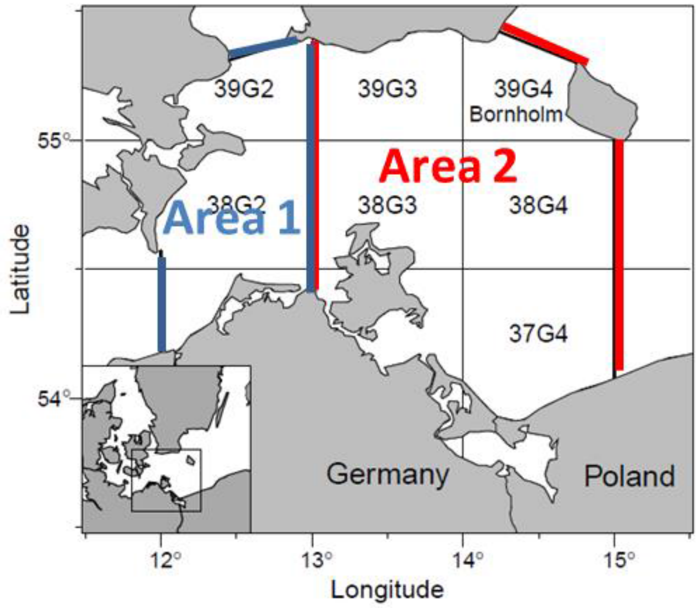


Figure 2.3.3. Western Baltic cod. Subareas (Area 1 and Area 2 within SD 24) for which different keys for splitting between eastern and western Baltic cod catches in SD 24 were applied.

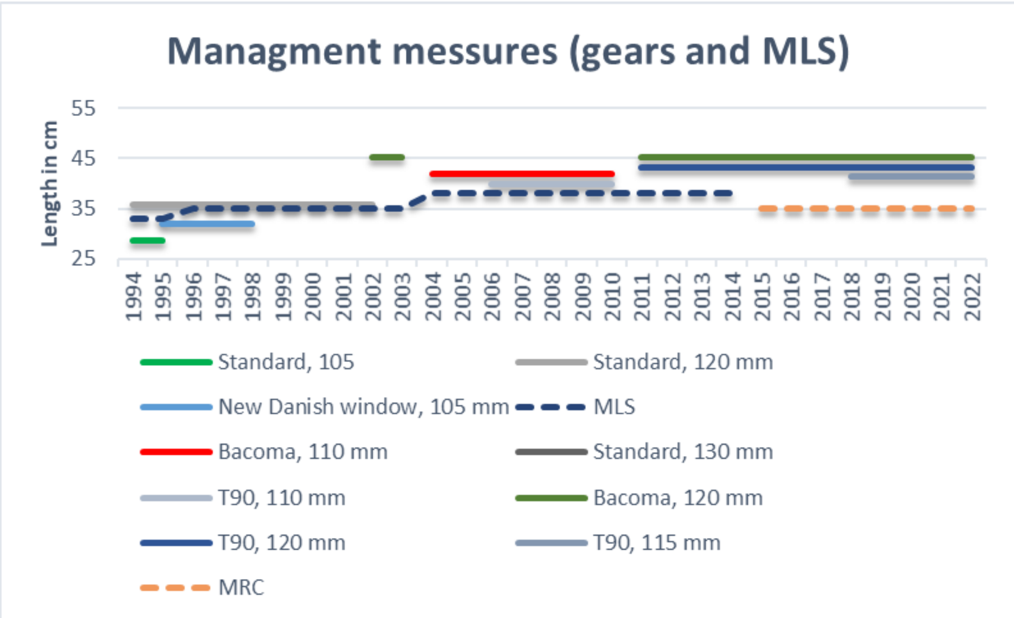


Figure 2.3.4. Western Baltic cod. Management measures for gear and minimum landing size, since 1994.

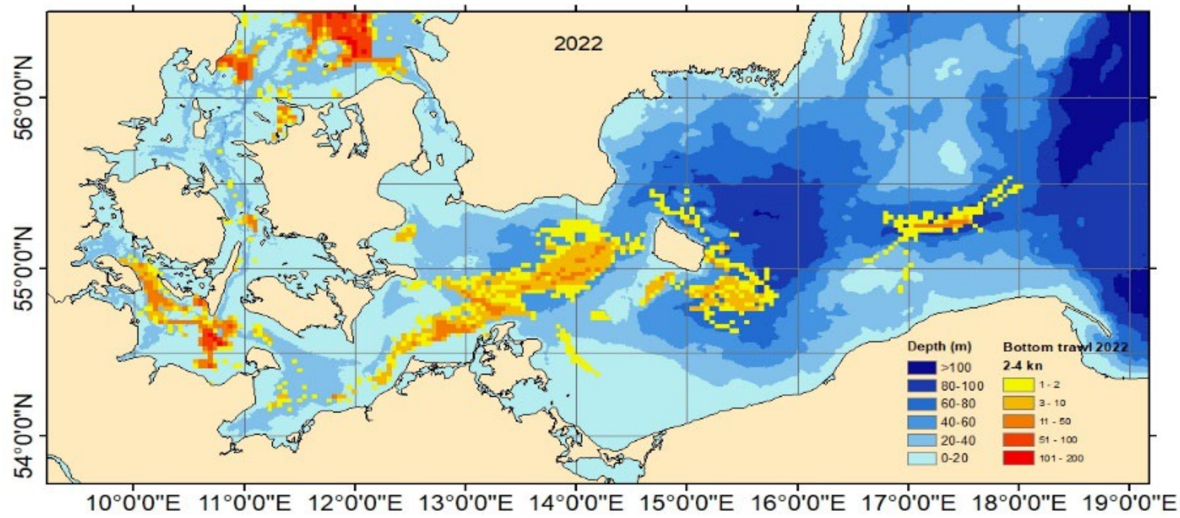


Figure 2.3.5. Danish VMS data from 2022 from OTB.

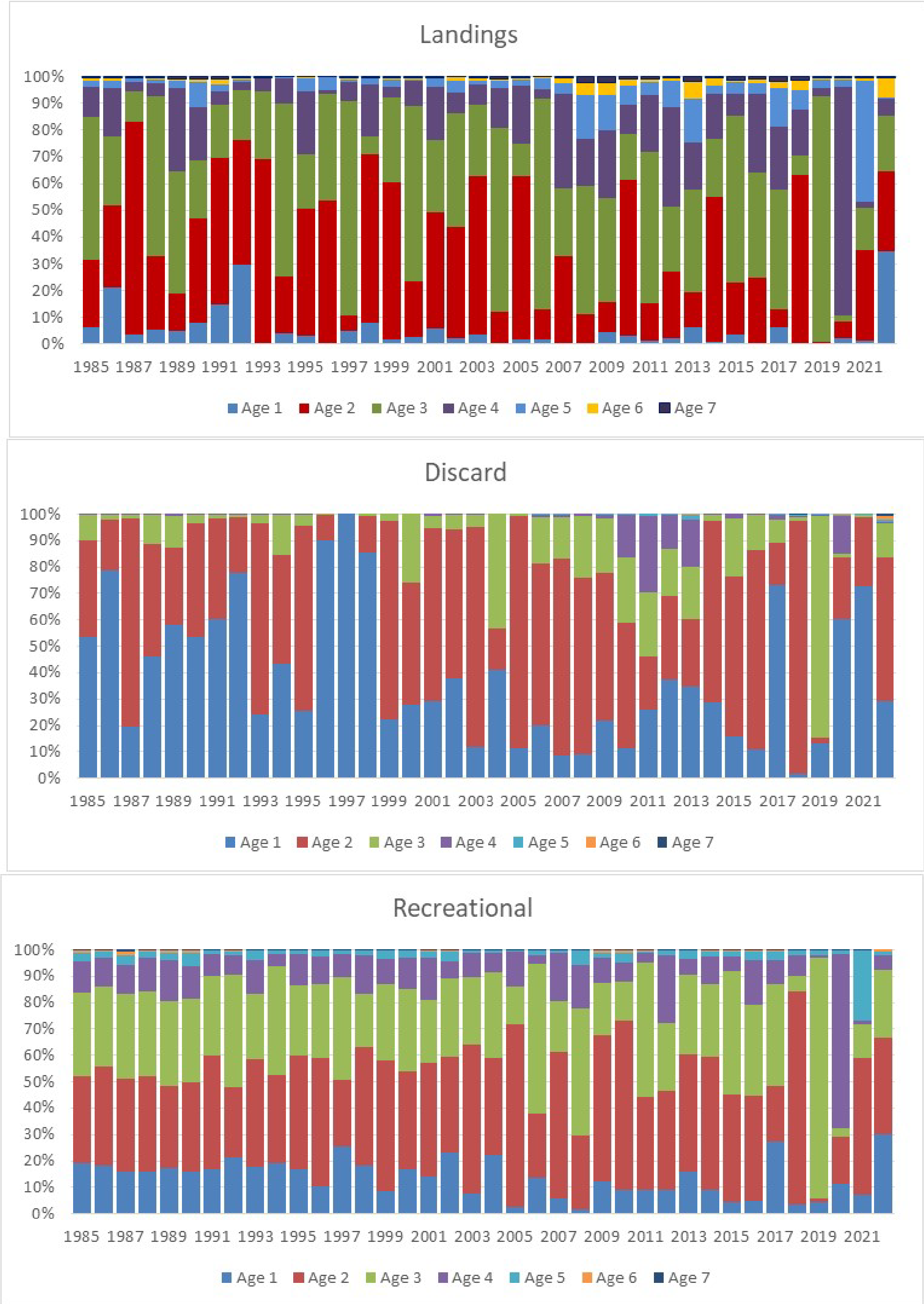


Figure 2.3.6. Western Baltic cod. Number at age distribution of cod in commercial landings, discards and recreational catch (relative proportions).

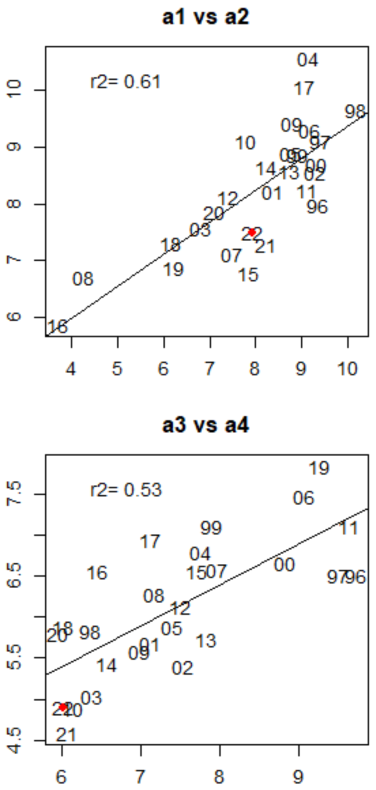


Figure 2.3.7a. Western Baltic cod. CPUE at age i vs numbers at age i +1 in the following year, in BITS Q1 survey. Red dots highlight the information from the latest year.

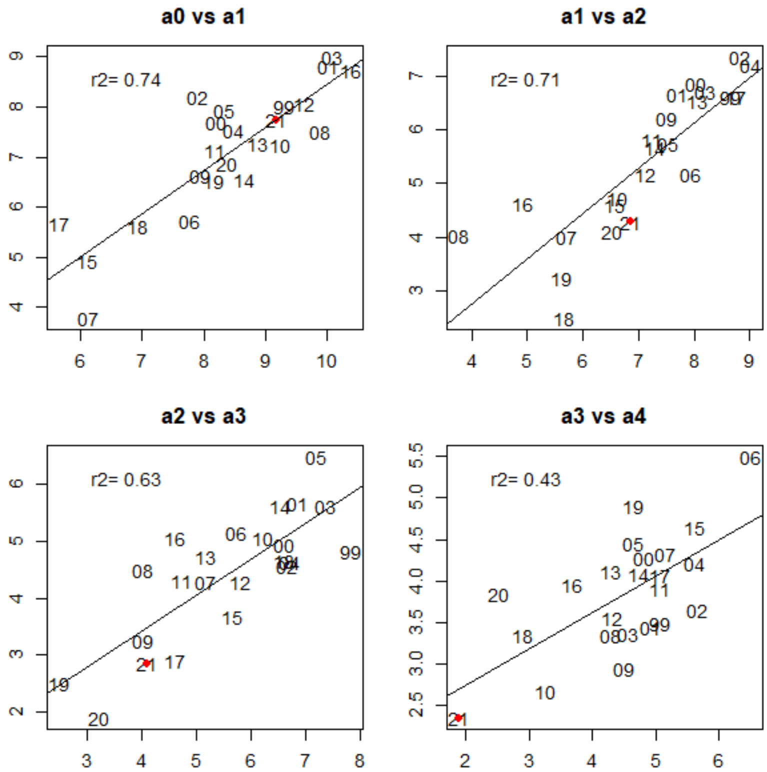


Figure 2.3.7b. Western Baltic cod. Western Baltic cod. CPUE at age i vs numbers at age i +1 in the following year, in BITS Q4 survey. Red dots highlight the information from the latest year.

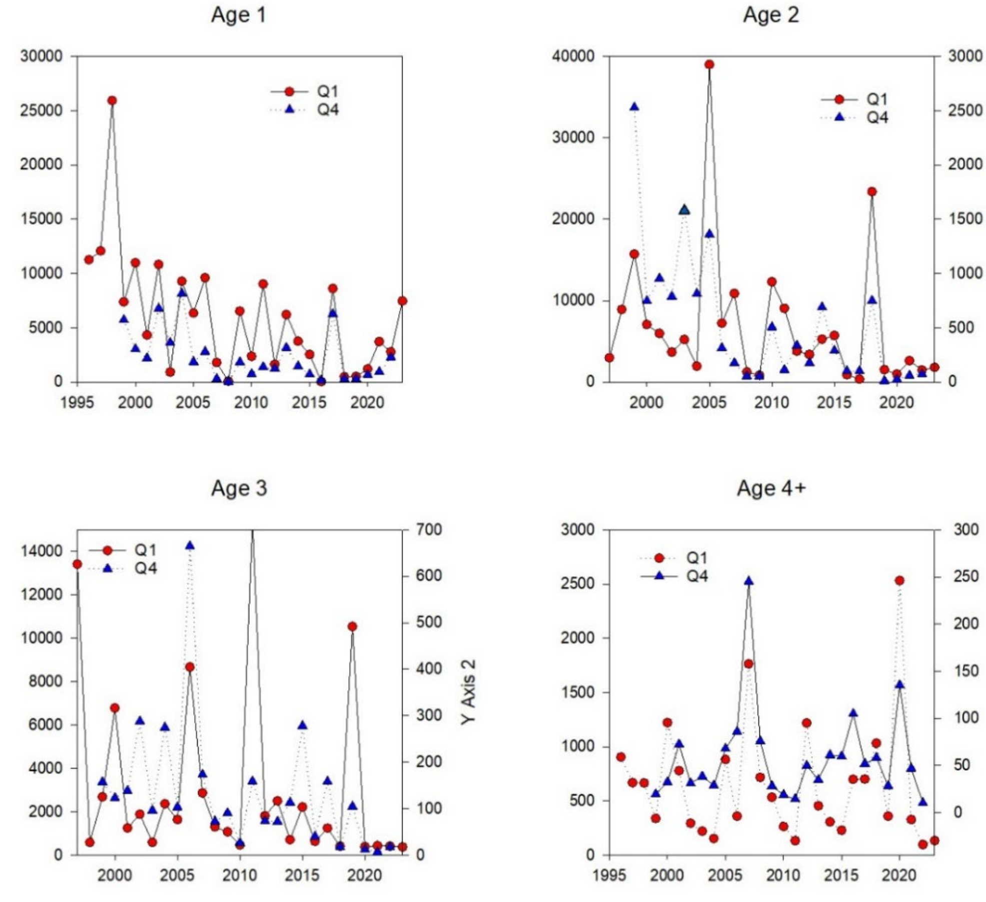


Figure 2.3.8. Western Baltic cod. Time-series of BITS Q1 and BITS Q4 in numbers by age groups.

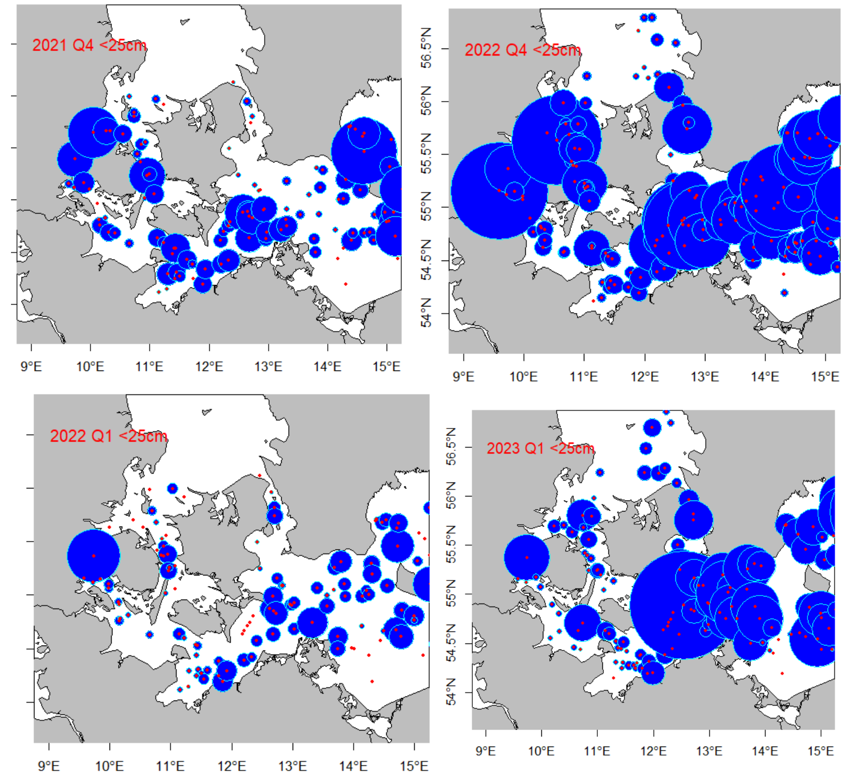


Figure 2.3.9. Western Baltic cod. Distribution of cod<25 cm from BITS Q4 2021 to BITS Q1 2023.

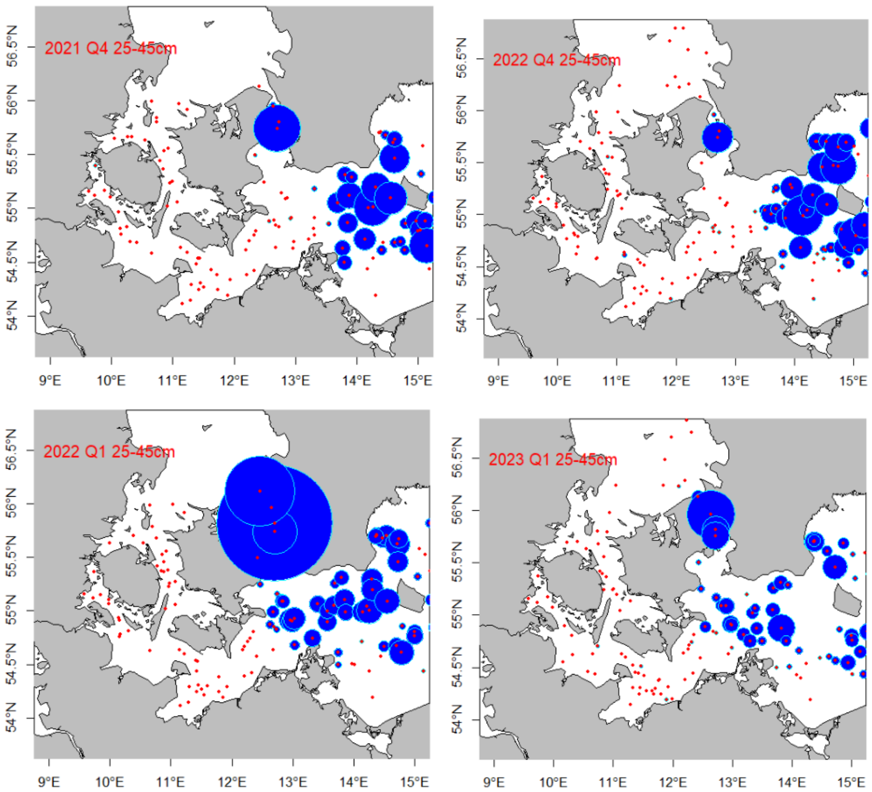


Figure 2.3.10. Western Baltic cod. Distribution of cod 25-45 cm from BITS Q4 2021 to BITS Q1 2023.

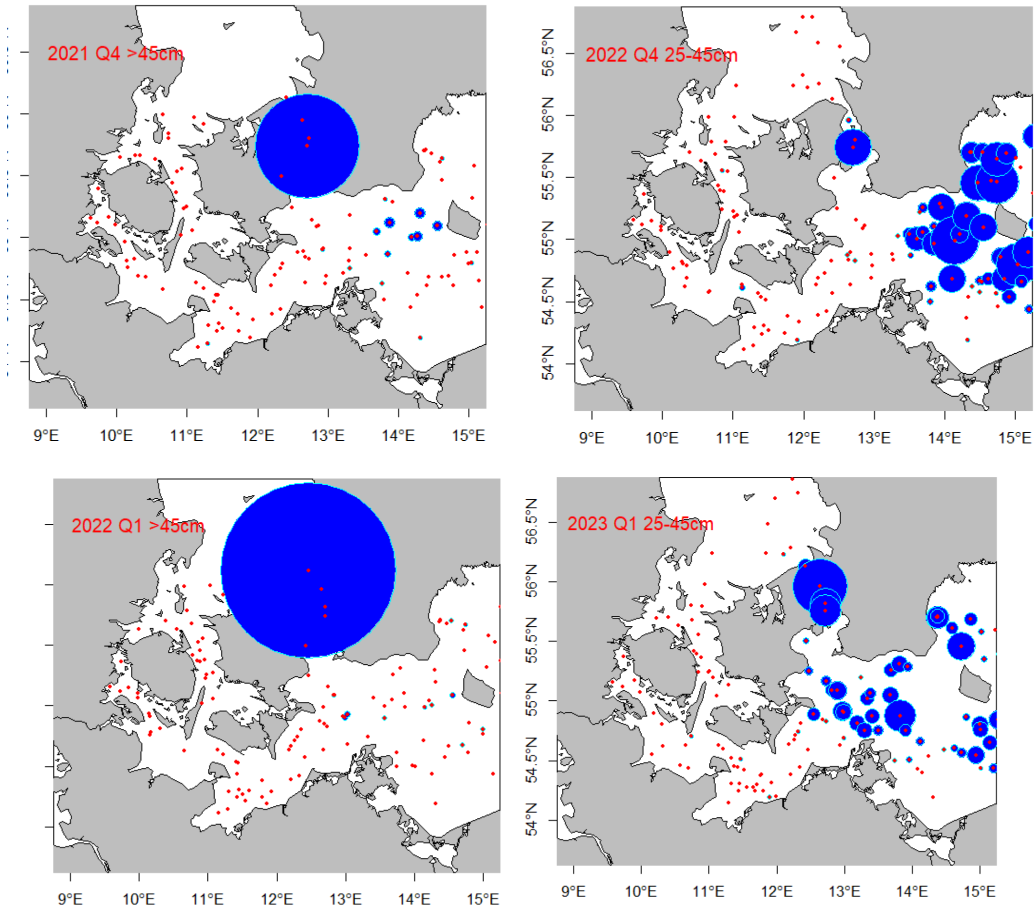


Figure 2.3.11. Western Baltic cod. Distribution of cod 25-45 cm from BITS Q4 2021 to BITS Q1 2023.

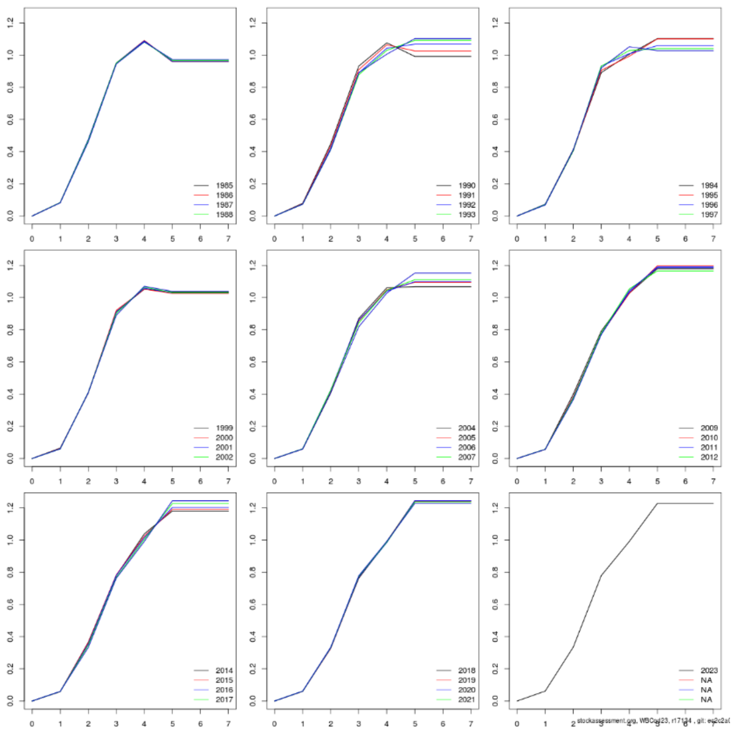


Figure 2.3.12. Western Baltic cod. Selection pattern

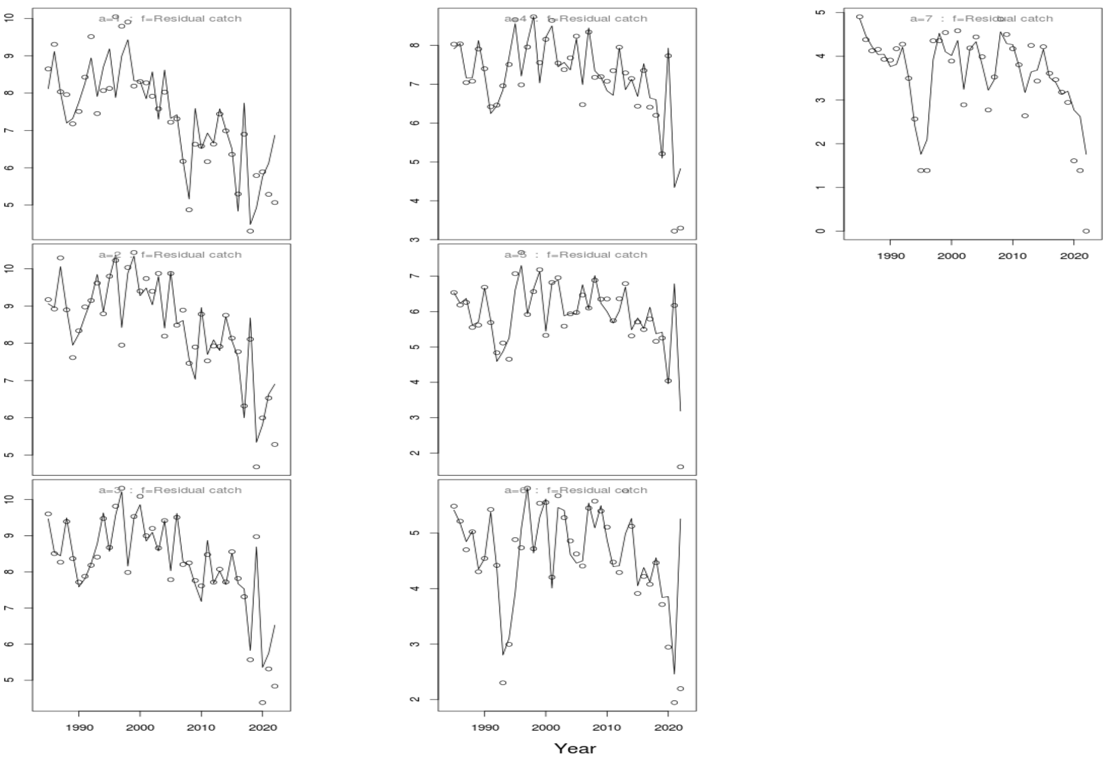


Figure 2.3.13. Western Baltic cod. Model fitting to catch data (line is model and cycles are data points.

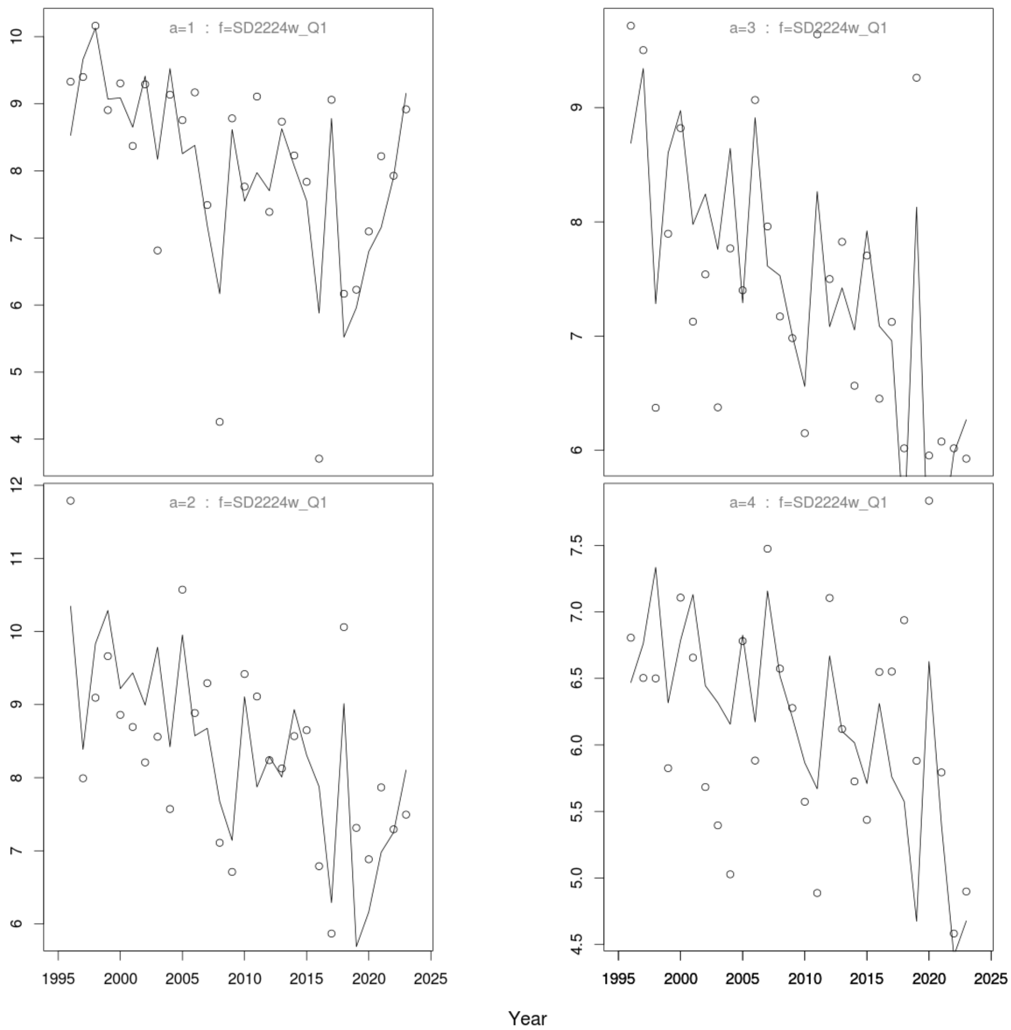


Figure 2.3.14. Western Baltic cod. Model fitting to Q1 survey data (line is model and cycles are data points.

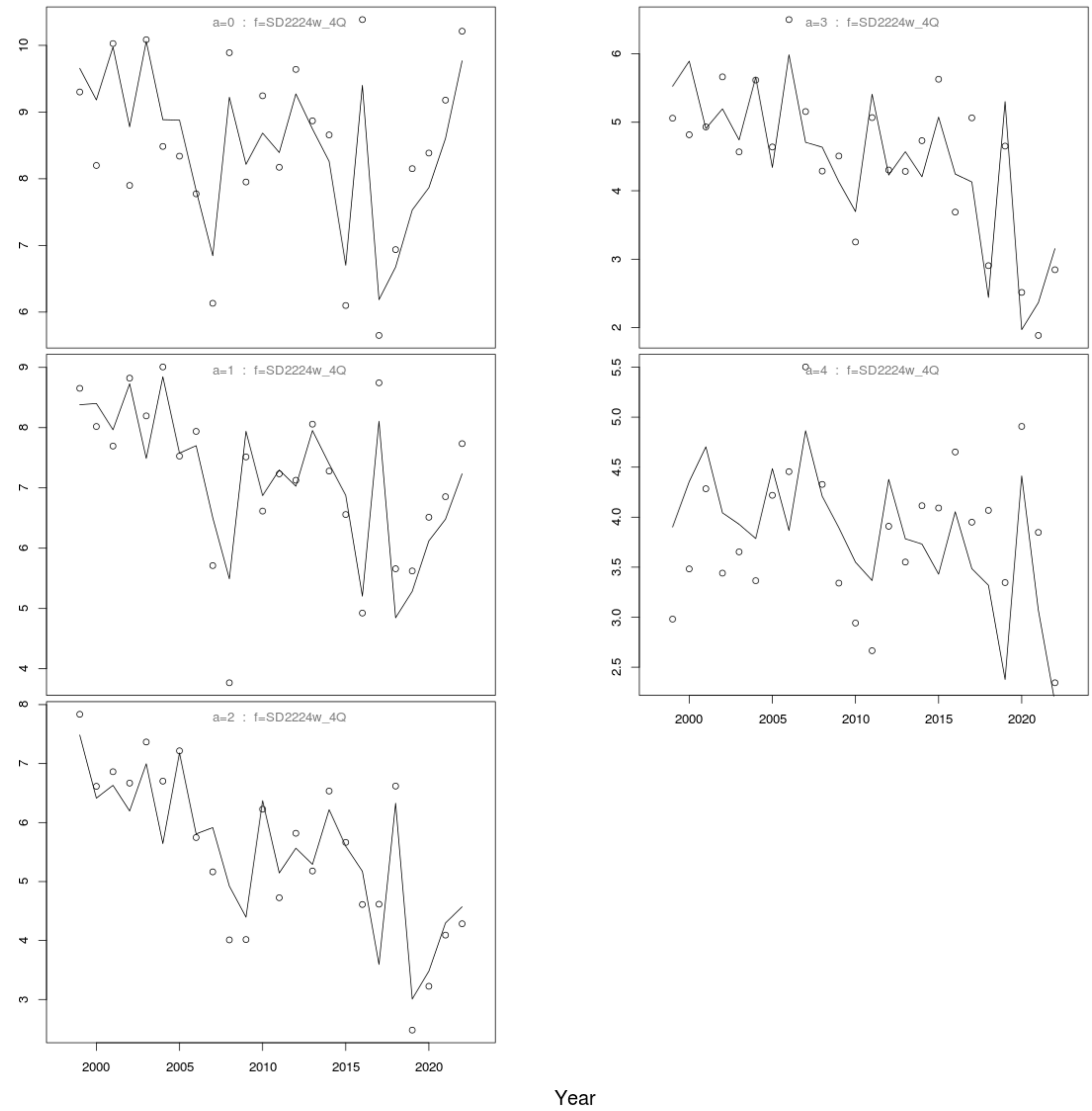


Figure 2.3.15. Western Baltic cod. Model fitting to Q4 survey data (line is model and cycles are data points)

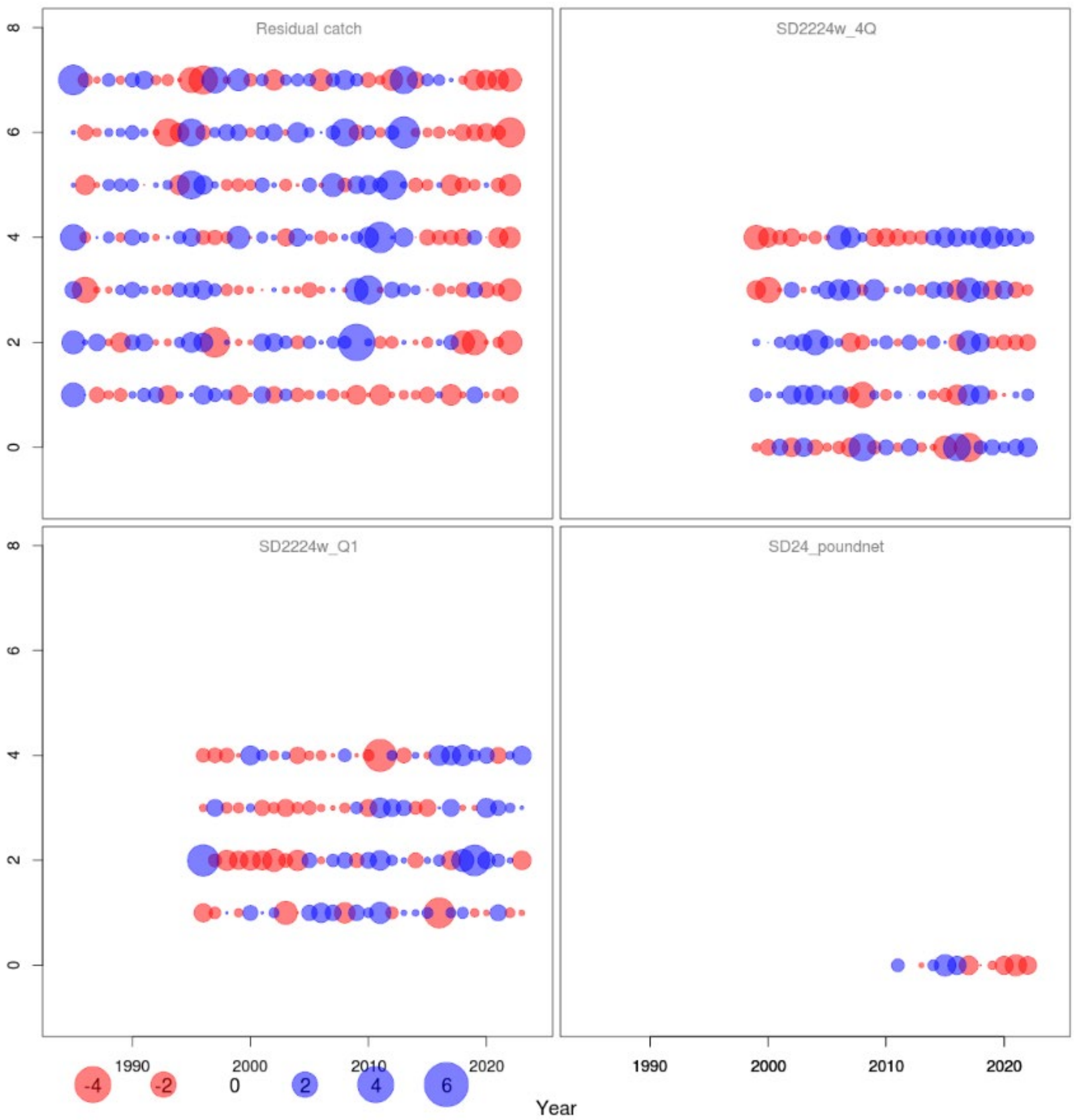


Figure 2.3.16. Western Baltic cod. Residuals in catch data and surveys.

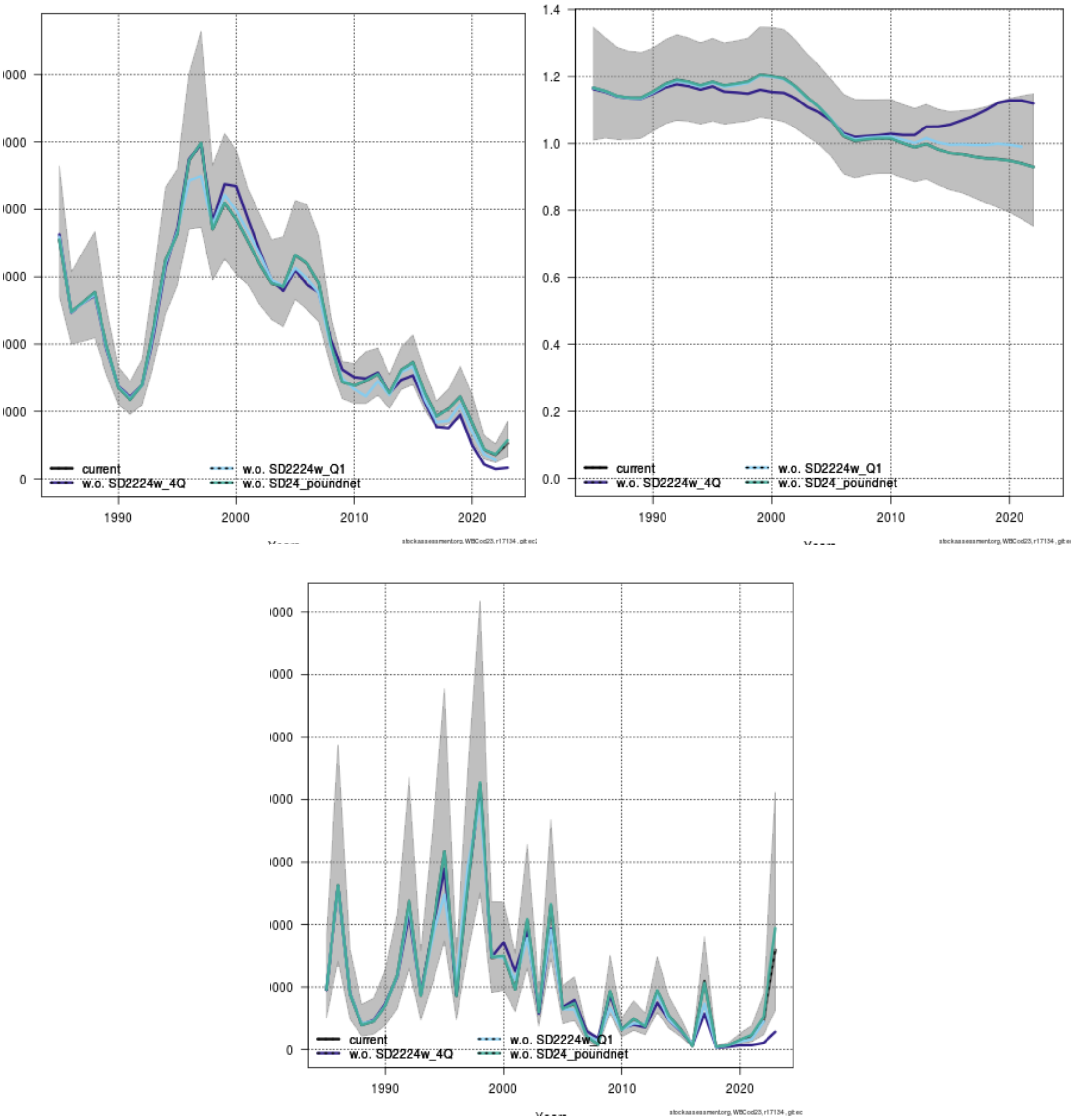


Figure 2.3.17. Western Baltic cod. Leave one out

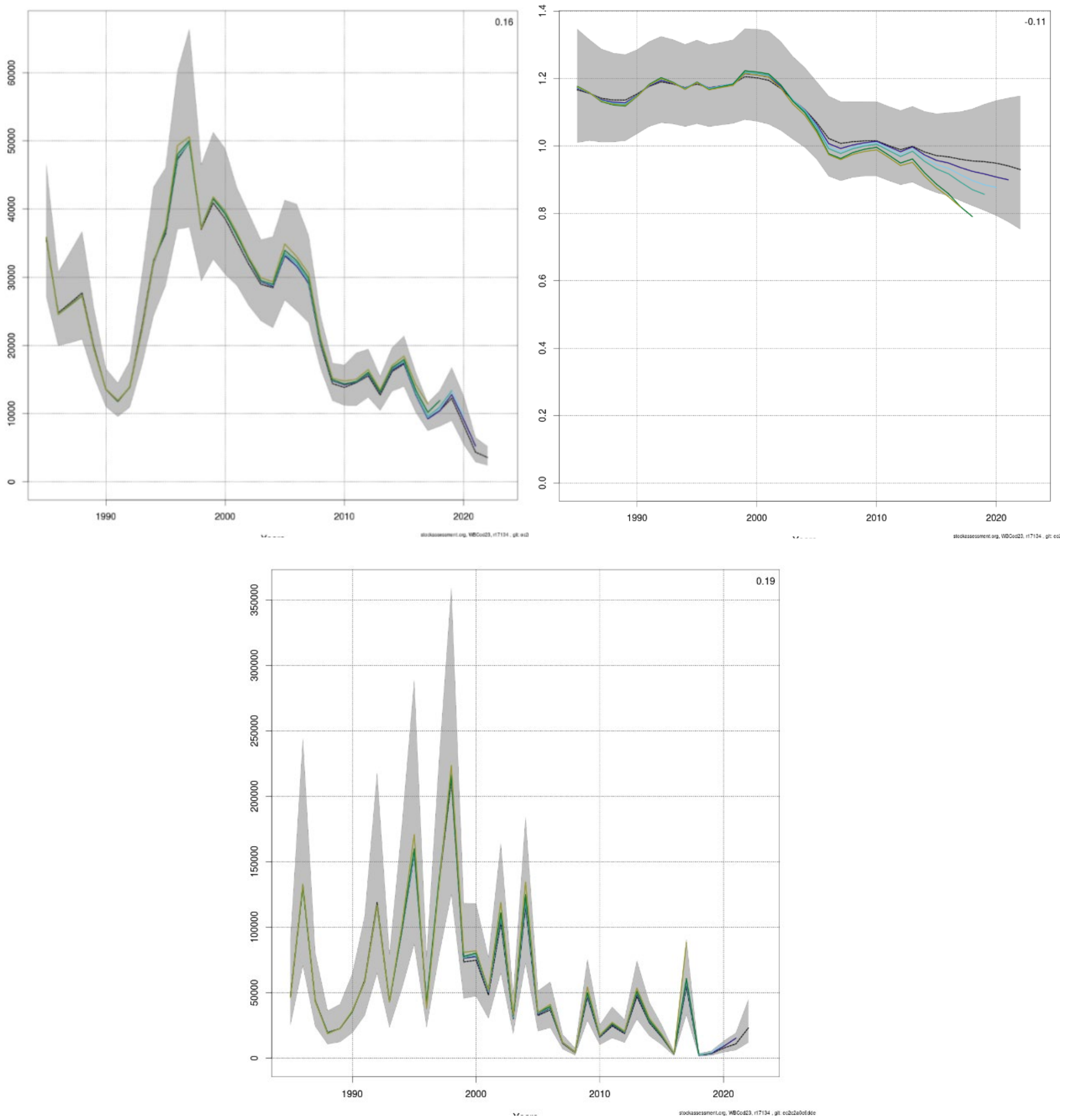


Figure 2.3.18. Western Baltic cod. Retrospective pattern in SSB, F and R. Mohn's Rho is indicated in the figures.

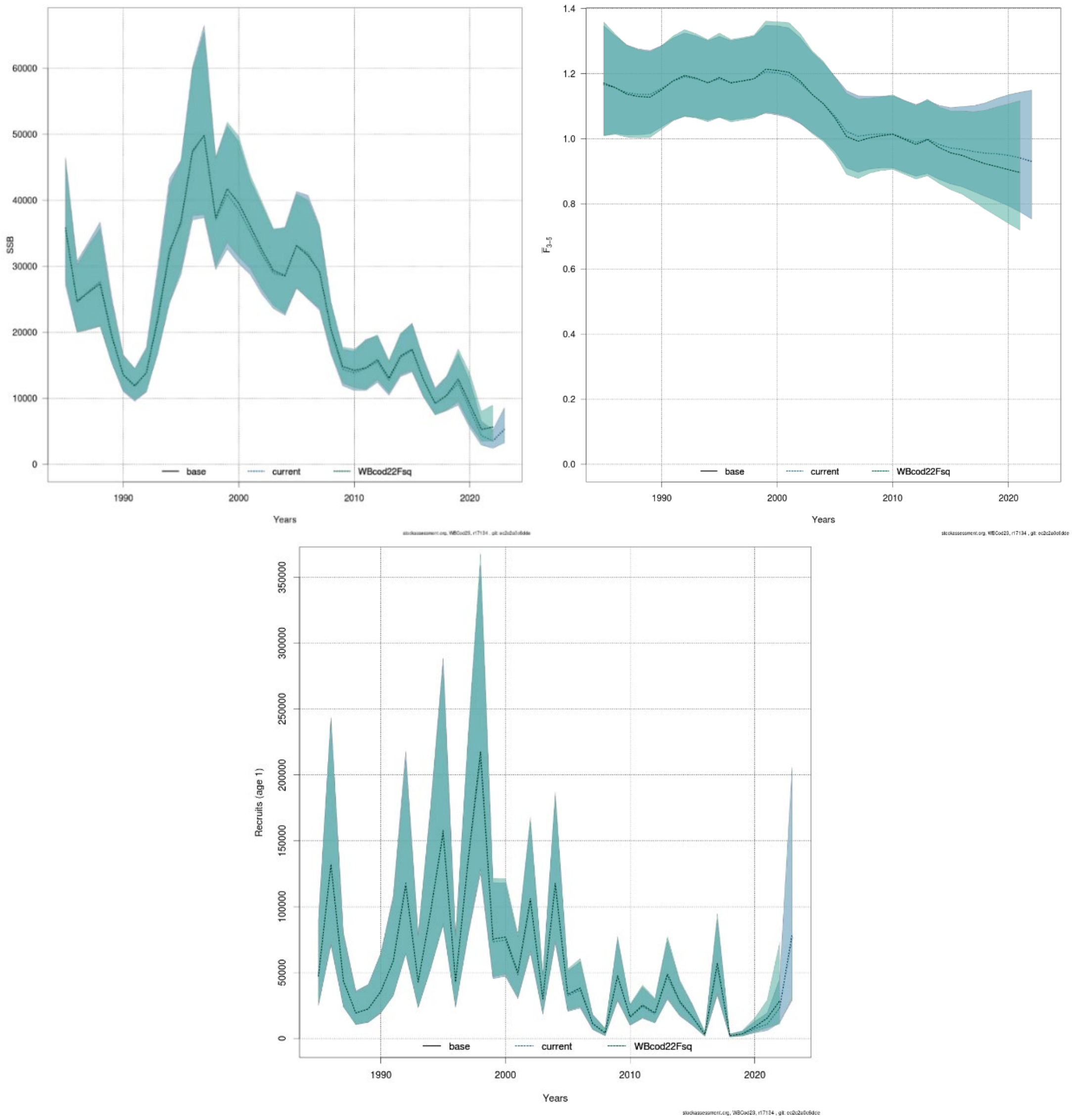


Figure 2.3.19. Western Baltic cod. Final assessment with SSB, F and R (age 1). Last years´ assessment indicated in green colours.

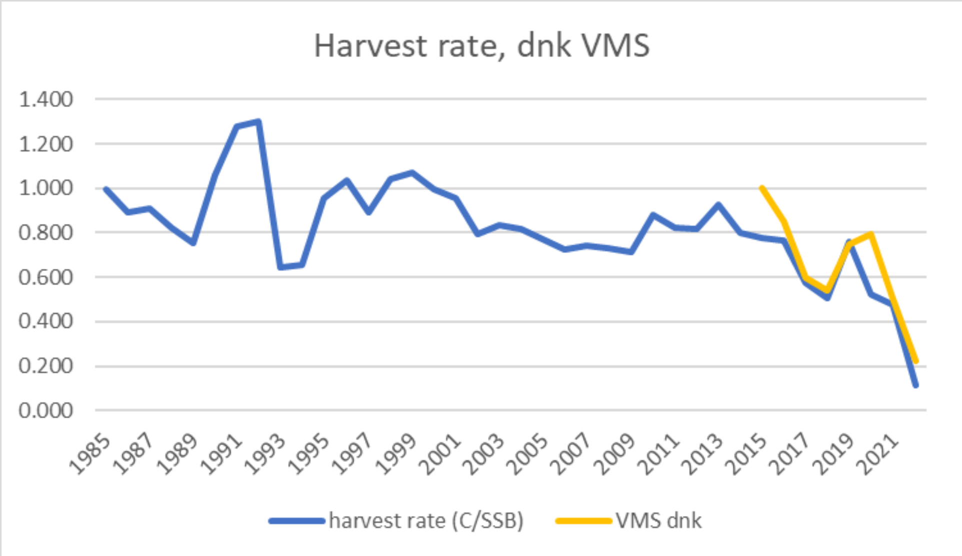
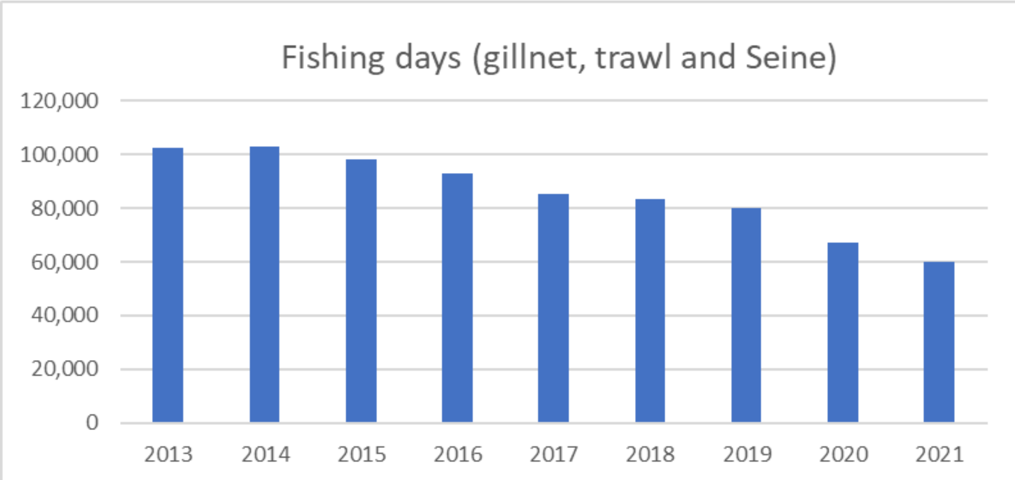


Figure 2.3.20. Western Baltic cod. Harvest rate (total catch/SSB) and pings from the Danish (dnk) VMS data from all vessels fishing demersal (gillnetters, seines, trawlers)



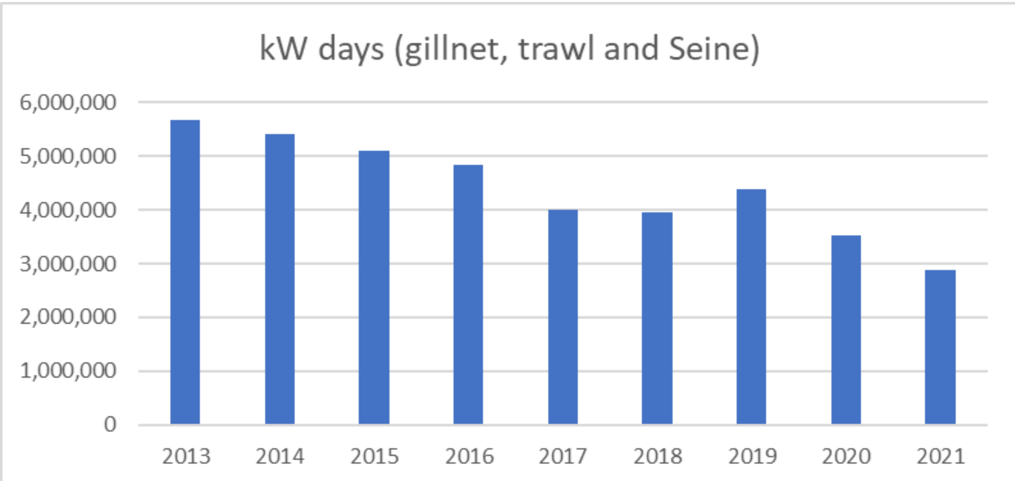


Figure 2.3.21. Western Baltic cod. Effort from the FDI database showing the annual international effort from 2013 to 2021 in fishing days (upper) and kWdays (lower) in SD area 22-24.

3 Flounder in the Baltic

3.1 Introduction

3.1.1 Stock identification

Previously it was believed that in the Baltic Sea European flounder has two distinctively different ecotypes (sometimes also considered as two sympatric flounder populations) – the pelagic and demersal spawners. In 2018 Momigliano *et al*. (2018) revealed that these two ecotypes are in fact two different species - European flounder *Platichthys flesus* (pelagic spawners) and Baltic flounder *Platichthys solemdali* (demersal spawners).

There are significant disparities between two sympatric flounder populations (since 2018 considered as two separate species) in the Baltic Sea, the flounder with pelagic, and demersal eggs. They differ in their spawning habitat, egg characteristics (Nissling *et al.*, 2002; Nissling and Dahlman, 2010), and genetics (Florin and Höglund, 2008; Hemmer-Hansen *et al.*, 2007a), although they utilize the same nursery grounds and feeding grounds in summer - autumn (Nissling and Dahlman, 2010).

Baltic flounder produce small and heavy eggs which develop at the bottom of shallow banks and coastal areas in the northern part of the Baltic Proper. They were established as a one stock/assessment unit comprised of SDs 27, and 29–32, but they also inhabit SD28 (Nissling and Dahlman, 2010).

European flounder are distributed in the southern and the deeper eastern part of the Baltic Sea and spawn at 70–130 m depth. The activation of their spermatozoa and fertilization occurs at an average of 10–13 psu, whereas an average salinity required to obtain neutral egg buoyancy is 13.9–26.1 psu (Nissling *et al.*, 2002).

There are also differences within the European flounder, which led to the designation of three stocks/assessment units at the DCWKBALFLAT: SD 22 and 23; SD 24 and 25; SD 26 and 28 (ICES, 2014). There is evidence of a differentiation between SD 22 and 23 from SD 24 and 25 based on egg buoyancy (Nissling *et al.*, 2002), length at maturity, and to some extent genetics (Hemmer-Hansen *et al.*, 2007b). Even though there is no physical connection between SD 22 and SD23, flounder in these areas are assumed to be connected through the western part of SD 24.

Flounder in SD 24 and 25 are also different from flounder in SD 26 and 28 based on separate spawning areas, and tagging data indicate no dispersal between these areas (Cieglewicz, 1963; Otterlind, 1967; Vitinsh, 1976). Trends in survey CPUE are inconclusive and the extent of exchange of early life stages between the areas is unknown. Therefore, the distinction between these two stocks should be further examined, e.g. whether a more consistent assessment with lower uncertainty would be obtained in merging these two units. For the time being, it was decided to assume two separate stocks.

In BONUS INSPIRE project (Ojaveer *et al.*, 2017) genetic samples of flounder during spawning time were collected to determine the proportions of the two flounder ecotypes (European vs Baltic) in subdivisions. An estimate of the proportion of pelagic ecotype per SD was calculated (Table 3.1). It revealed that the current management unit of SD26 & 28 is problematic since approximately half of the flounders in the unit are of each species, furthermore the proportion differs between SD 26 and 28 such that 28 is dominated by Baltic flounder while SD 26 is dominated by the European flounder. Considering the new findings that the two ecotypes are in fact different species, meaning that the assessment unit SD26+28 consist of two flounder species, complicates the matter even more.

Currently these two flounder species can be separated only through genetic analysis, therefore at current times there is no easy and inexpensive way to separate these species in commercial catches nor in BITS survey trawl. Therefore, in current state it is acknowledged that there are two different flounder species in the Baltic, and in all of the management units (except SDs 22 and 23) there is a mix of these two species, however no separation is attempted during the assessment process.

Table 3.1. Proportion of flounder with pelagic eggs (European flounder) per SD.

Subdivision	Proportion
32	8%
28	24%
26	98%
25	76%
24	97%

3.1.2 WKBALFLAT – Benchmark

In January 2014 the flounder stocks in the Baltic were benchmarked. As a result, four different stocks of flounder were identified (WKBALFLAT 2014). Flounder (*Platichthys* spp) is the most widely distributed among all flatfish species in the Baltic Sea.

3.1.3 Discard

During WKBALFLAT the quality of the estimations of discards were questioned. The main problem was very high flounder discards variability, which exceed the landings or sometimes are even 100% of the catch. Within InterCatch, it is not possible to raise discard data properly, when discard data are available for particular stratum and there is no landing of flounder assigned, then the discard is estimated as zero (see introduction section on IC for further comments).

Because the discard ratio in both subdivisions is significantly different between countries, fleets, vessels and even individual hauls of the same vessel and trip, a common discard ratio cannot be applied. Discarding practices are, in fact, controlled by factors such as market price and cod catches.

According to the call for data submission for ICES WGBFAS, new method for estimated the discards was recommended and should be applied to all flounder stocks, here the main issue was that the discard should be raised by total landings or effort and not by the landings of flounders:

$$\text{Discard Rate}_{\text{Time,SD,fleet segment,Species}} = \frac{\sum \text{Weight of discard}_{\text{Trip,Haul,Time,SD,Fleet segment,Species}}}{\sum \text{Weight of landing}_{\text{Trip,Haul,Time,SD,Fleet segment}}}$$

$$\text{Discard (ton)}_{\text{Time,SD,Fleet segment,Species}} = \text{Landings (ton)}_{\text{Time,SD,fleet segment}} \times \text{Discard Rate}_{\text{Time,SD,fleet segment,Species}}$$

WKBALFLAT recommended, that the quantitative assessment cannot be provided until discards recalculation by using better approach, which avoid the underestimation of discards.

3.1.4 Tuning fleet

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 performed twice a year, in 1st and 4th quarter.

For the northern Baltic Sea flounder the surveys used were 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 and from Sweden two surveys were available as well.

3.1.5 Effort

Time-series from 2009–2022 was available from ICES WGBFAS data call where countries submitted flatfish effort data by fishing fleet and subdivision. Effort data were asked to report as days at sea. However, different calculation methods were used by countries. Some countries reported all of fishing days when flounder were landed, some countries reported number of fishing days were significant amount of flounder were landed, while some countries reported fishing days for whole demersal fleet. It was discussed than in the future more specific description about methodology should be given.

Standardisation and weighting factor was applied for submitted effort data to calculate a common effort index for whole population. First, every country data was standardised using proportion for given year from the national average. Standardised effort data were weighted by demersal fish landings for every country and year and final effort for whole population was calculated summing all countries efforts.

3.1.6 Biological data

Because of the major age determination problems in flounder, WGBFAS decided in 2006 that age data from whole otoliths shall not be used for assessment (ICES, 2006; see also Gardmark, *et al.*, 2007; ICES, 2007a).

3.1.7 Survival rate

Survival rate for the discarded flounder is unknown. However, the relatively wide range of survival rates was obtained from several studies conducted in the Baltic Sea (see WKBALFLAT 2014, WD 2.1). During WKBALFLAT the precautionary level of survival rate was assumed as 50% in I and IV quarter and 10% in II and III quarter (ICES, 2014b).

3.1.8 Reference points

The stock status was evaluated by calculating length-based indicators applying the LBI method developed by WKLIFE V (ICES, 2015). Where available, commercial landings were used to estimate length distribution and average weight by length groups The alternative was to use survey length distribution data. Biological parameters: L_∞ and L_{mat} were calculated using survey data from DATRAS with the exception of the Northern flounder stock. For estimating L_∞ data from Q1 and Q4 were taken unsorted by sex. In the case of L_{mat} data were derived from only from Q1 and females, as distinguishing between mature and immature fish were possible only for this time of the year.

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

3.2.1 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 3.2.1. The trend and the amount of the landings from this flatfish stock are shown in Figure 3.2.1.

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 3.2.2). 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.

3.2.2 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 2022 were at about 322 tonnes (Table 3.2.2) and the lowest observed landings since the beginning of the timeline (1973).

3.2.2.1 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.

3.2.2.2 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 3.2.3a); only a few biological samples are available (Figure 3.2.3b). 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 ratio 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 2022 are estimated to be around 51 tonnes, which would result in a discard ratio of 14% of the total catch, which is the second-lowest discard value since the start of the timeline, where on average about 26% of the total catch was discarded.

3.2.3 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 (1^{st} and 4^{th} 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. Effort and biomass-index are calculated from the catches. The BITS-Index is calculated as:

Average number of flounder ≥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 length-class (Figure 3.2.4).

In 2012, one haul in the Q4 survey was excluded from the calculations in SD 23 as it was clearly an outlier, providing values ten times higher than in all other years in this area.

3.2.4 Assessment

The flounder stock in SD 22–23 is categorized as a data-limited-stock (DLS). Especially sampling data from the beginning of the time-period (2000–2006) are considered as very poor with a low sampling coverage in time and space. More than half of the strata (landings and discards) from that period had to be filled with borrowed data (extrapolated length-distributions and mean weights per length-class). Any analytical assessment using this data-matrix can only be used as an exploratory assessment, but not for reasonable advice.

The update on the stock status is based on the data-limited approach of ICES. The "advice based on landings" has been changed to "advice based on catch" in 2016 and was based on estimated discards of the respective last three years. The intermediate stock status update for 2021 was also a catch advice. The mean biomass index the recent year has increased and indicates an increasing biomassin the stock. The length-based indicators are suggesting a good status of the stock.. Length-based indicators are used to assess the stock status in terms of over-exploitation of immatures and/or large individuals following the guidelines provided by WKLIFE V (2015). The 3-year average (2019–2021) absolute value of $L_{F=M}$ was used as a F_{MSY} Proxy.

3.2.5 Reference points

The stock status was evaluated by calculating length-based indicators applying the LBI method developed by WKLIFE V (2015). CANUM and WECA of commercial catches from 2014–2022 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

- L_{inf}: average of 2002–2018, both quarter and sexes → L_{inf} = 44.3 cm
- L_{mat}: average of 2002–2018, quarter 1, only females → L_{mat} = 20.5 cm

The results were compared to standard length-based reference values to estimate the status of the stock (Table 3.2.4).

The results of LBI show that the stock status of fle.27.2223 is above possible reference points, for most of the variables (Table 3.2.5). $L_{max5\%}$ increased well above the lower limit of 0.80 in 2022, some truncation in the length distribution in the catches might take place. Compared to last year's data, similar amounts of mega spawners occur, P_{mega} accounts for 31% of the catch and is therefore above the optimum of >0.3. Catch is close to the theoretical length of L_{opt} and L_{mean} is stable over time and close to 1, indicating fishing close to the optimal yield. Exploitation consistent with F_{MSY} proxy (LF = M) (Figure 3.2.3).

Table 3.2.1. 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	
	22	23	22	22	22	23
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

Table 3.2.2. 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
2000	2556	41	2597

Year	Total by SD		Total
	22	23	SD 22-23
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

Table 3.2.3fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

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 Lopt + 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	$L_{opt} = \frac{3}{3+\frac{M}{k}} \times L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{maxy}	Length class with maximum biomass in catch	$L_{opt} = \frac{3}{3+\frac{M}{k}} \times L_{inf}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals > Lc	LF=M = $(0.75L_c+0.25L_{inf})$	L_{mean} / LF=M	≥ 1	MSY

Table 3.2.4. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Indicator status for the most recent three years.

	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} / $L_{F=M}$
2020	1.24	1.34	0.91	0.36	1.04	1.31
2021	1.24	1.34	0.92	0.31	1.03	1.43
2022	1.29	1.34	0.91	0.34	1.08	1.03

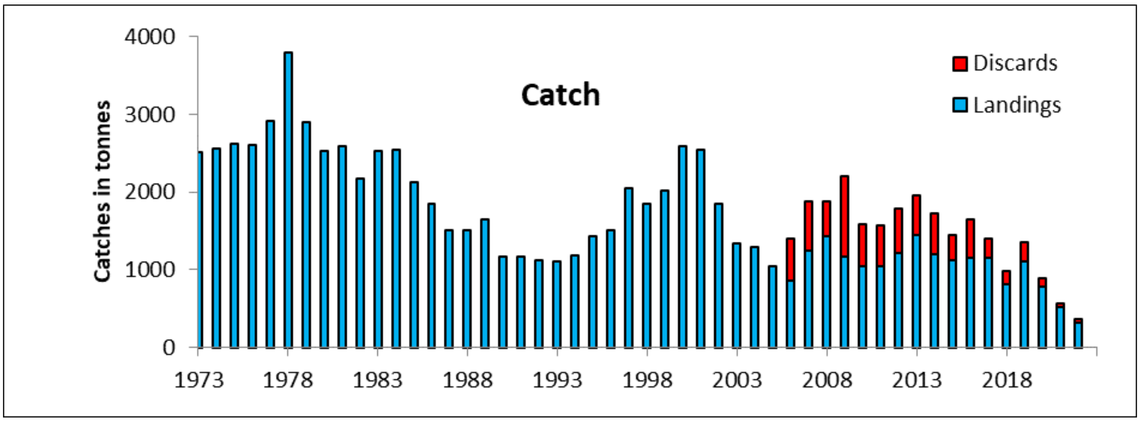


Figure 3.2.1. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings of flounder in tonnes for subdivisions SD 22–23 (Western Baltic Sea). ICES discard estimates are included from 2006 onwards.

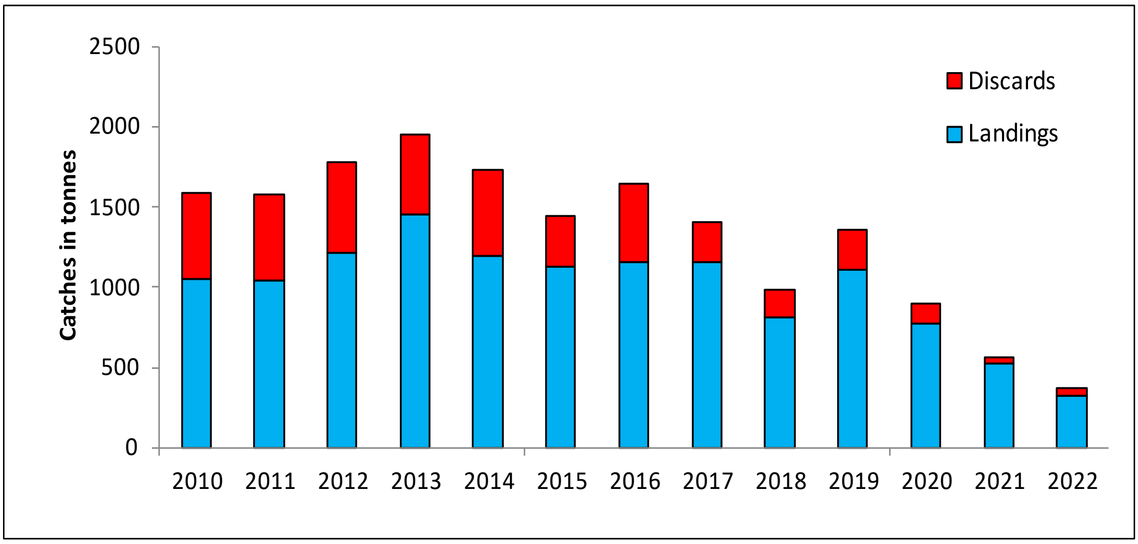


Figure 3.2.2. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings and calculated discards (in tonnes) of flounder for subdivisions SD 22–23 (Western Baltic Sea).

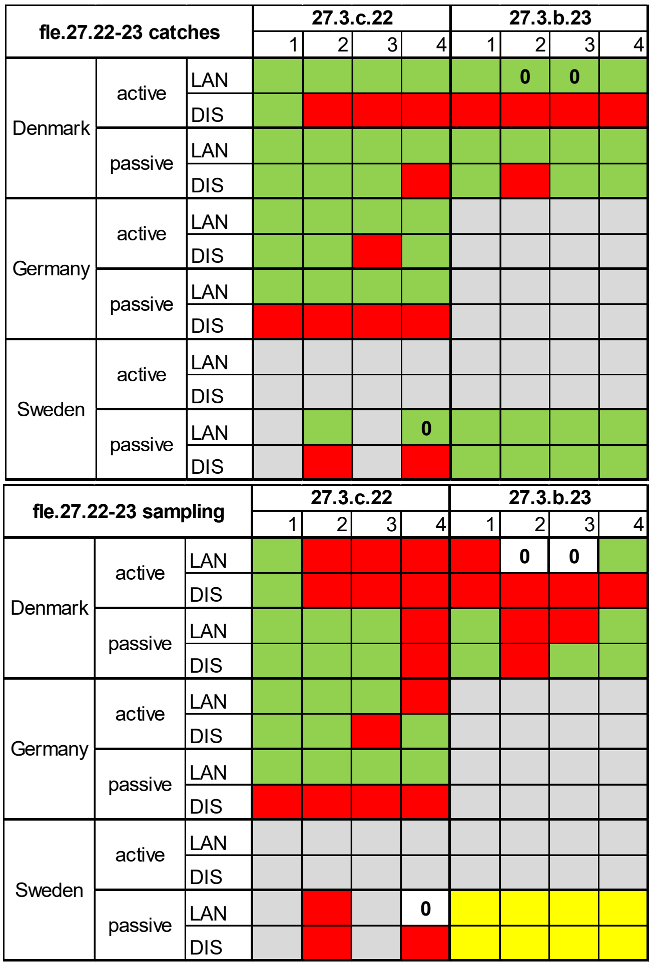


Figure 3.2.3. **fle.27.22-23. Sampling coverage and quality**
3.2.3.a: top plot: provided official landings and discard estimates (green) of member states, including reported zeroes and non-provided strata (red).
3.2.3.b: bottom plot: provided biological samples per stratum (green) and non-sampled strata (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)

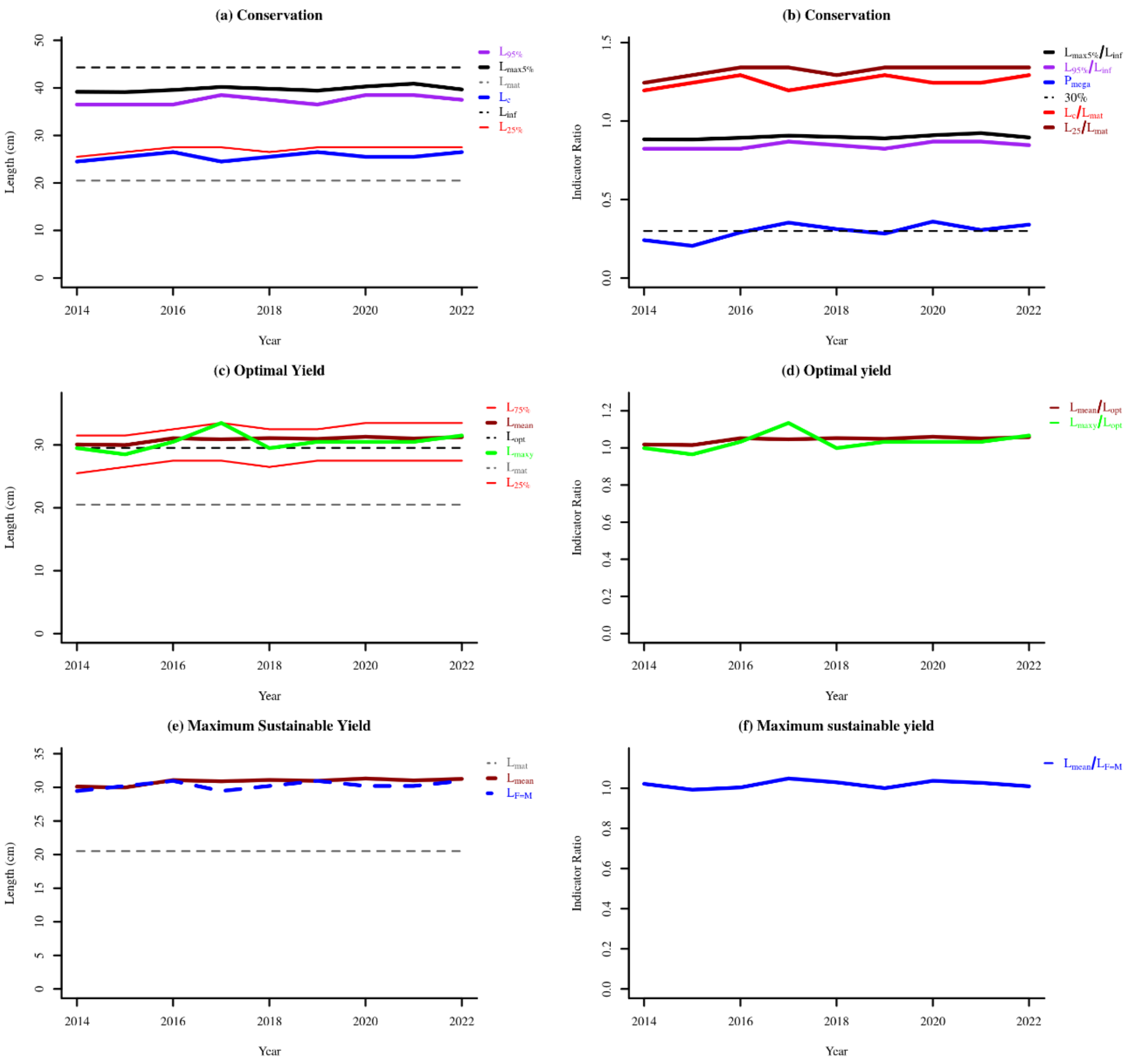


Figure 3.2.4. fle.27.2223. LBI indicator trends

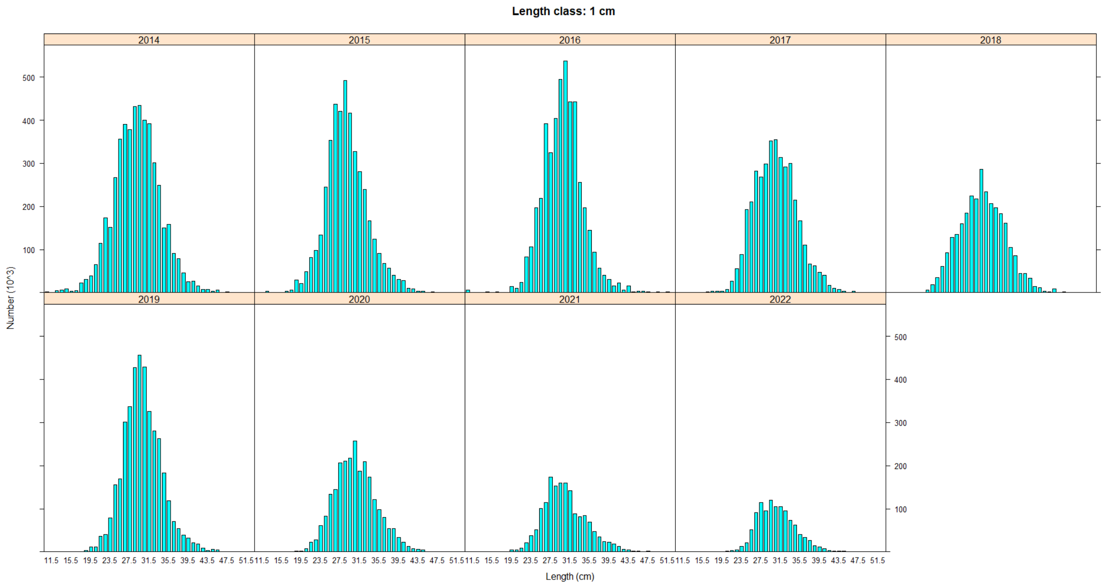


Figure 3.2.5. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Catch in numbers per length class in Subdivision 22 and 23 (Belts and Sound). All countries and fleets were combined.

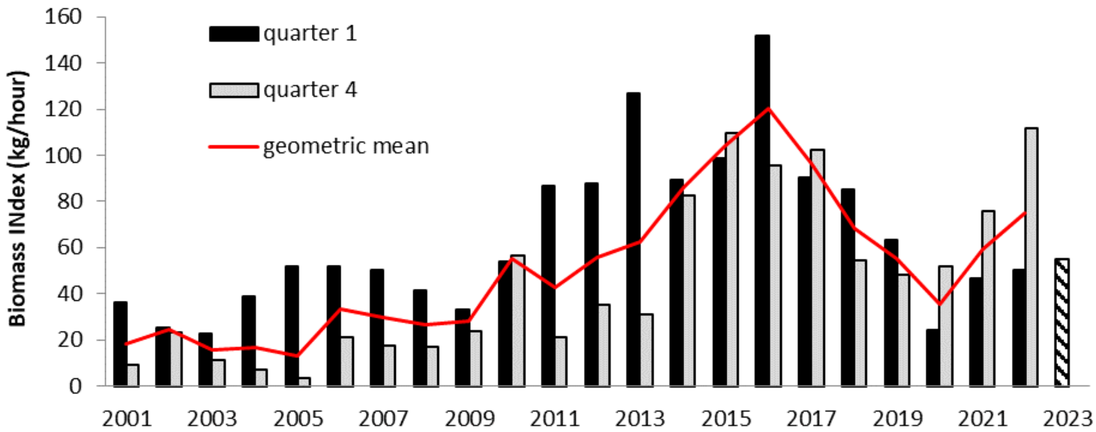


Figure 3.2.6. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Survey-biomass-index (BITS).

3.3 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.

3.3.1 The Fishery

3.3.1.1 Landings

Landings from SD 25 are substantially higher than in SD 24 (Figure 3.3.1). The majority of landings in both SDs is taken by Poland. The other fishing nations which take significant landings are Germany and Denmark (Figure 3.3.2, Table 3.3.1a).

Similarly, as in 2020, in 2021 abnormally high flounder bycatch from pelagic trawlers (OTM) was reported by Poland. It decreased in 2022, but remained still significant. It was substantially lower in the SD24 comparing to the SD25. There are no direct and reliable observations on this procedure, because of lack of observers onboard due to COVID-19 restrictions (in 2020 and 2021), and in 2022 due to high refusal rate of taking observers onboard. However, these data seem to be unreliable and need further analysis and verification. Significant part of this bycatch is assumed to be misreported sprat.

Although the above bycatch data are still reported by fishermen they have not been reported to the Inter Catch database due to its uncertain species composition. This year an approach how to deal with those data was proposed. The bycatch value for each subdivision would be split using the proportion in species composition from pelagic trawler trips where a significant flounder bycatch occurred. Then the splitted values would be uploaded to the Inter Catch as an additional data for the respective stocks. That approach would be applied both for current and historic bycatch data.

The OTM bycatches from both SD’s were included in figures and tables. However, they were excluded from the discard ratio estimation and the assessment because information on the length structure of this bycatch is lacking.

Flounder landings in both SD’s were mainly taken with active gears. Including bycatch from pelagic trawlers, around 87% of total landings were taken by those gears in 2022 (Figure 3.3.3). If we consider only demersal landings, then the contribution for active gears dropped to 85% of total landings.

In 2022 landings amounted to 8125 tonnes (959 and 7166 tonnes for SD 24 and SD 25, respectively). After excluding OTM bycatch, the landings in 2022 were 6919 tonnes (943 and 5976 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 (not including pelagic OTM bycatch) reached 7766 tonnes in 2022 (Figure 3.3.4).

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

3.3.1.2 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 3.3.2). 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 estimations in 2022 were available for only 21% of the strata with landings and were even lower than compared to last year (26%). A decrease in the sampling of discards in 2020 and 2021 was caused by COVID-19 related restrictions and in 2022 the reason for that was a high refusal rate of at sea sampling, which in some countries prevented observers from sampling onboard. Due to the poor availability of discard information, discards estimated in 2020 - 2022 are less reliable than in previous years.

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 2022 the discards proportion in the catches was similar in all main fishing countries and didn't exceed 13% (Table 3.3.1b; Figure 3.3.5). 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 2022 for both SDs was 0,07, with discard equal to 847 tonnes.

3.3.1.3 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:

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

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

The effort in 2022 was close to the one in 2020 and 2021, and the lowest in the time series (Figure 3.3.6).

3.3.2 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 3.3.3). 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 and in 2022 was even worse than in 2020 and 2021. 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. Flounder discard in SD 24 was sampled by Germany and Denmark but no samples from SD 25 were available.

3.3.3 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 3.3.4).

3.3.4 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 3.3.7) 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 (Figure 3.3.7).

3.3.5 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 2014–2022 were used to estimate CANUM (Figure 3.3.8). 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 3.3.5). The results of LBI (Table 3.3.6) 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 (2020 – 2022) was equal to 26.0 cm and L_{mean} - 28.0 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 3.3.9).

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.

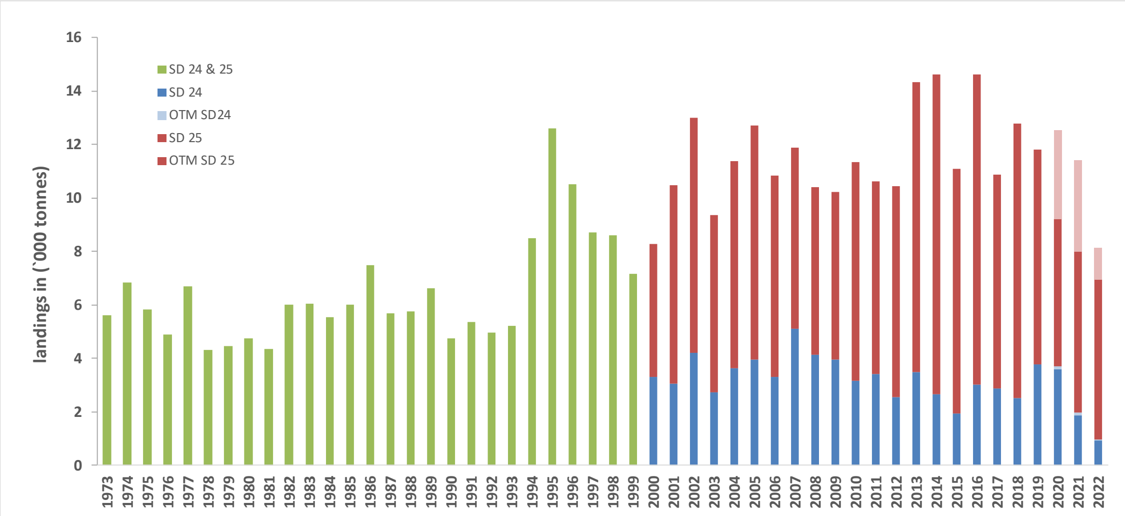


Figure 3.3.1. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Landings in thousand tonnes; bycatch from pelagic trawlers included between 2020 - 2022 (light blue and red colour);

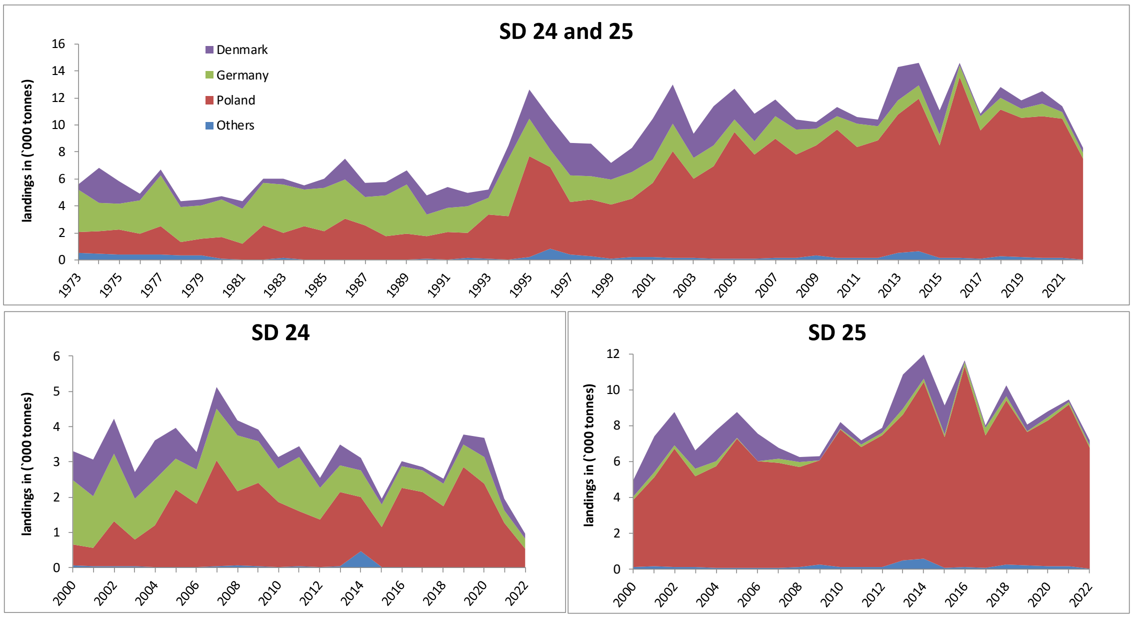


Figure 3.3.2. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Landings by country in thousand tonnes; bycatch from pelagic trawlers included in 2020, 2021 and 2022 Polish landings (for merged SD 24–25 – upper plot and separately for SD 24 and SD 25 – lower plots)

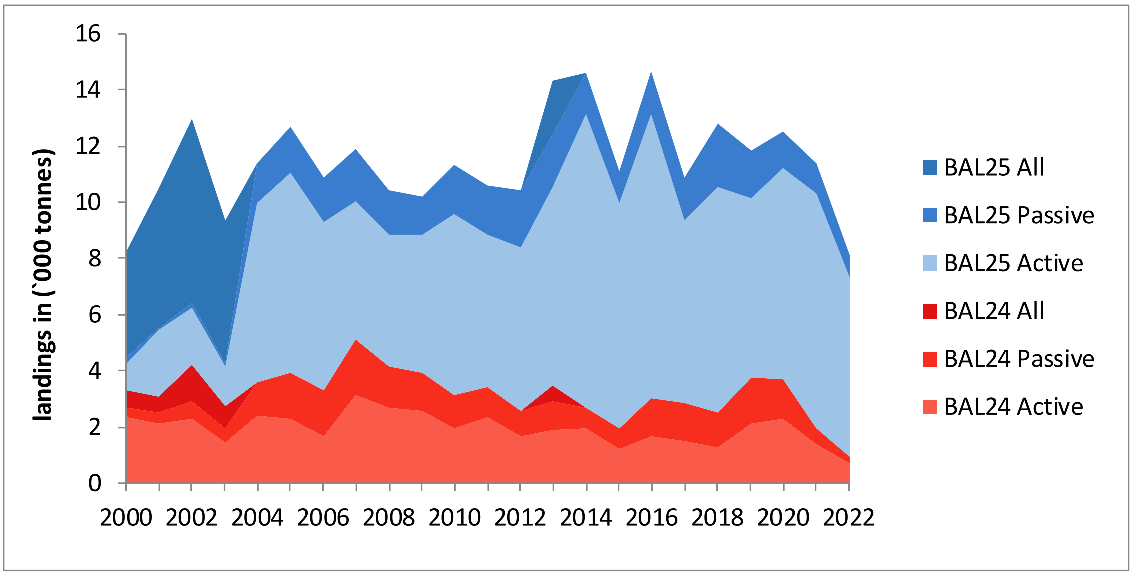


Figure 3.3.3. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Landings by fleet type in thousand tonnes (SD 24 - reddish colors, SD 25 – bluish); bycatch from pelagic trawlers included in 2020, 2021 and 2022 active gears

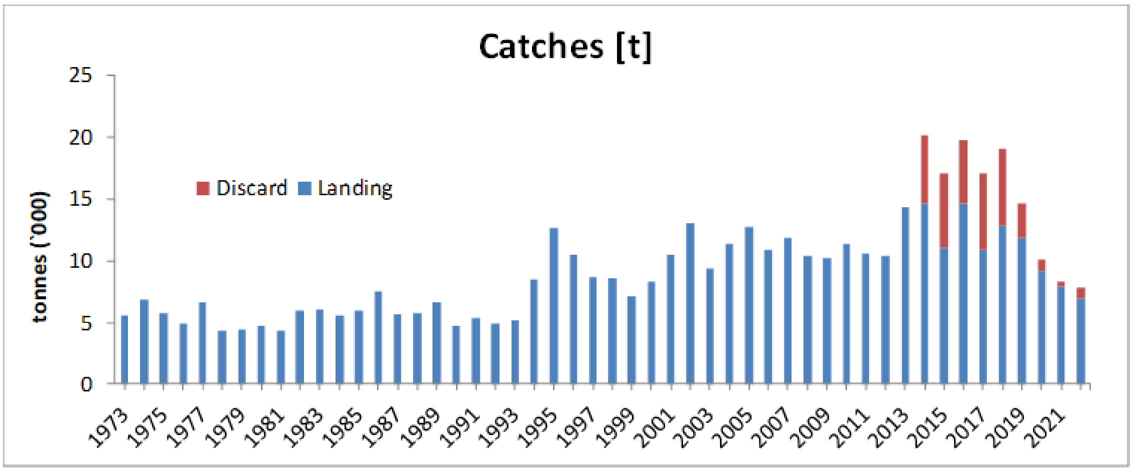


Figure 3.3.4. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Catches (ICES estimates) in subdivisions 24–25. Discard data have only been included since 2014.

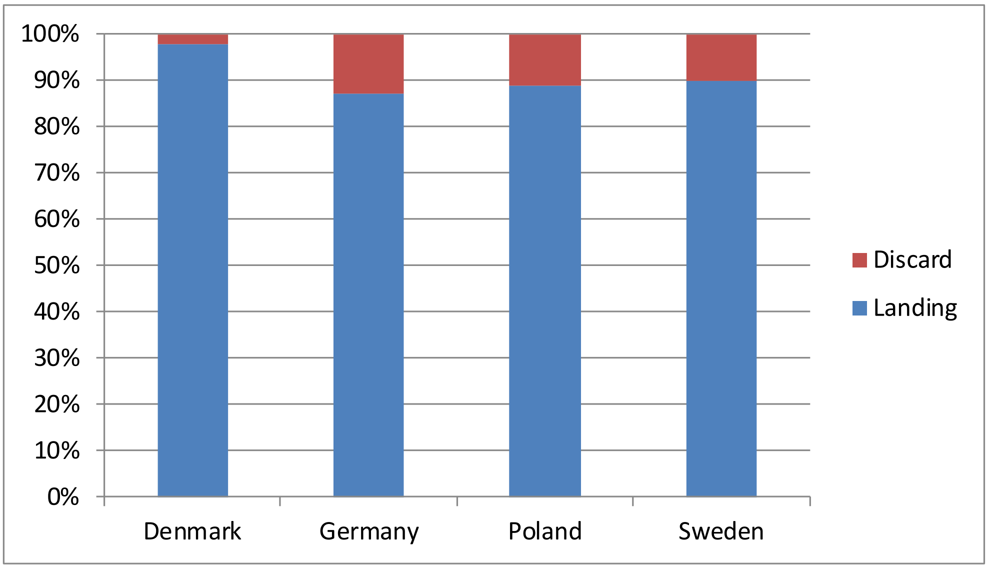


Figure 3.3.5. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Discard and landing proportion in 2021 catches in main fishing countries

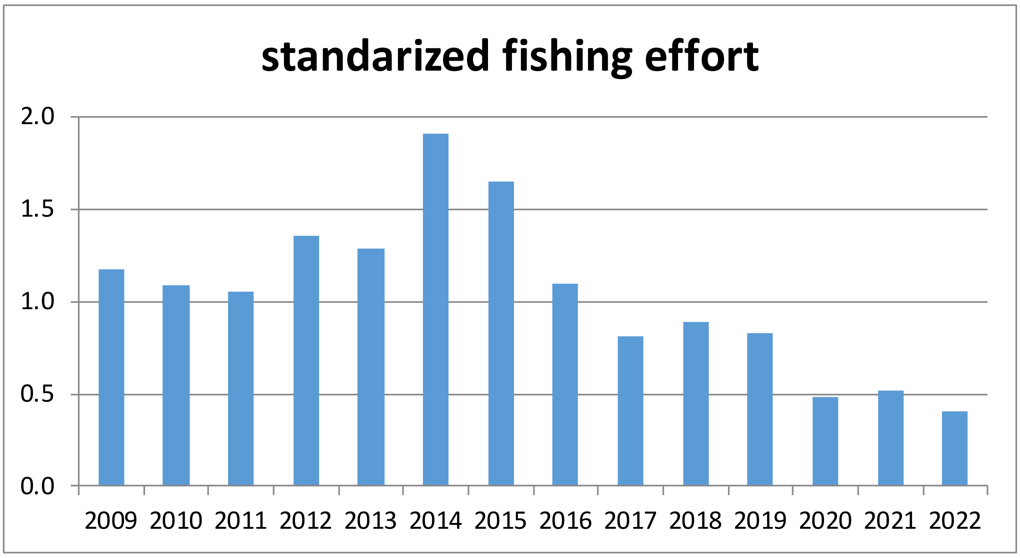


Figure 3.3.6. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Standardized fishing effort (standardized within each country and weighted by the national flounder or demersal fish landings from SD 24–25)

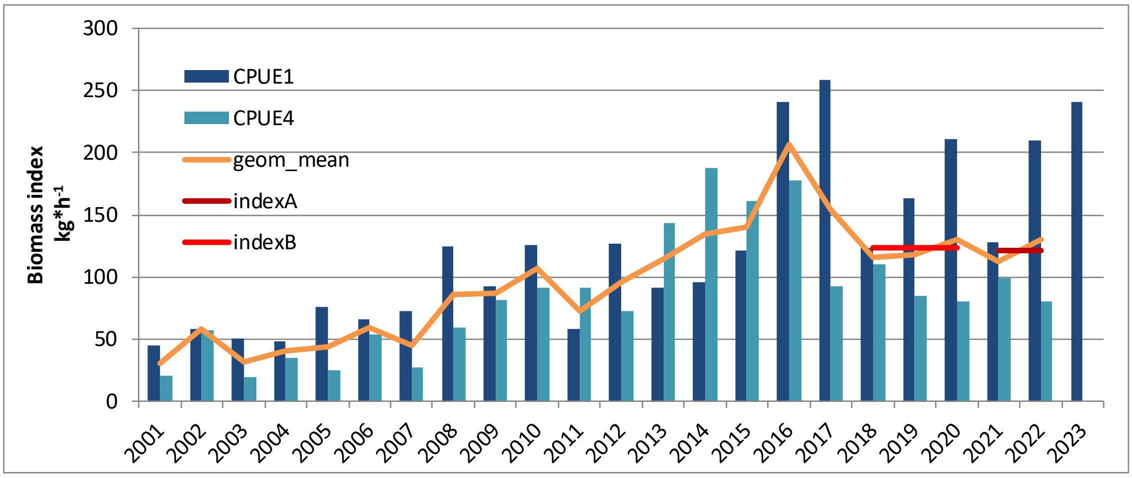


Figure 3.3.7. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Survey-biomass-index (BITS) for Q1 and Q4 from 2001-2022; Q1 2023 and geometric mean (line); Stock trends from Baltic International Trawl Survey (BITS)

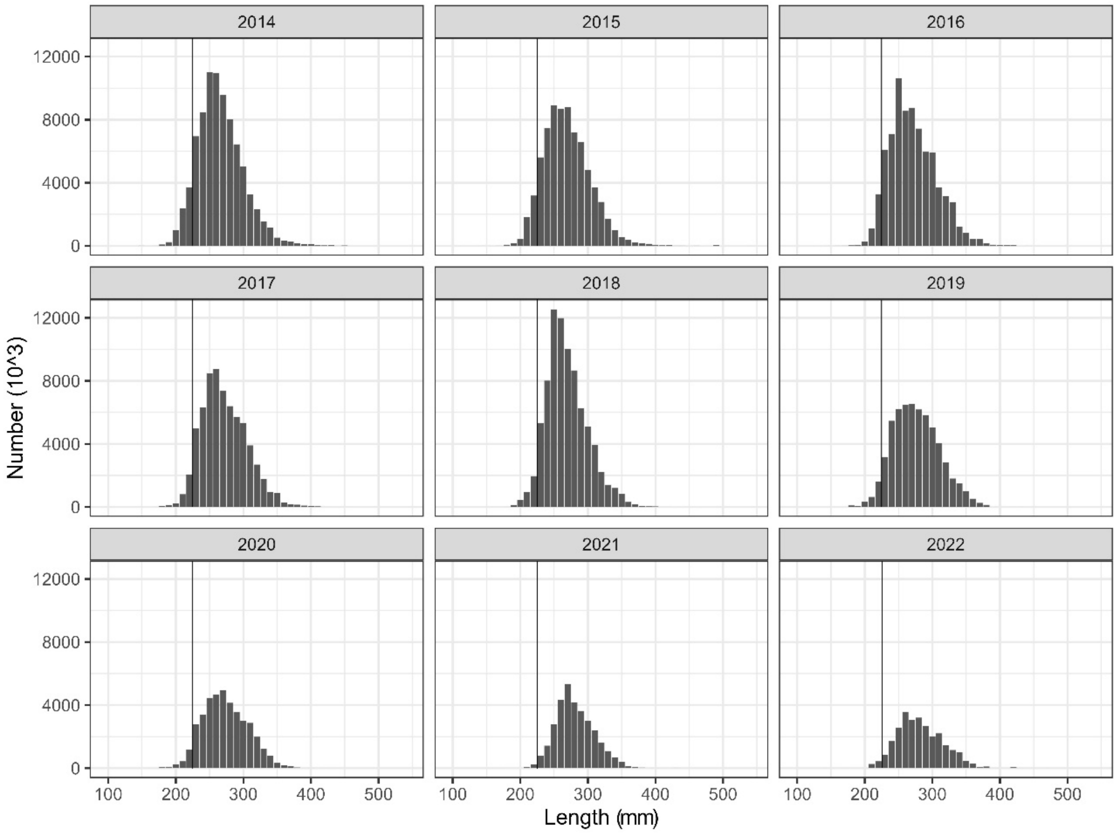


Figure 3.3.8. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Catch in numbers (CANUM) per length classes; black vertical lines at length 230 mm indicates minimum landing size.

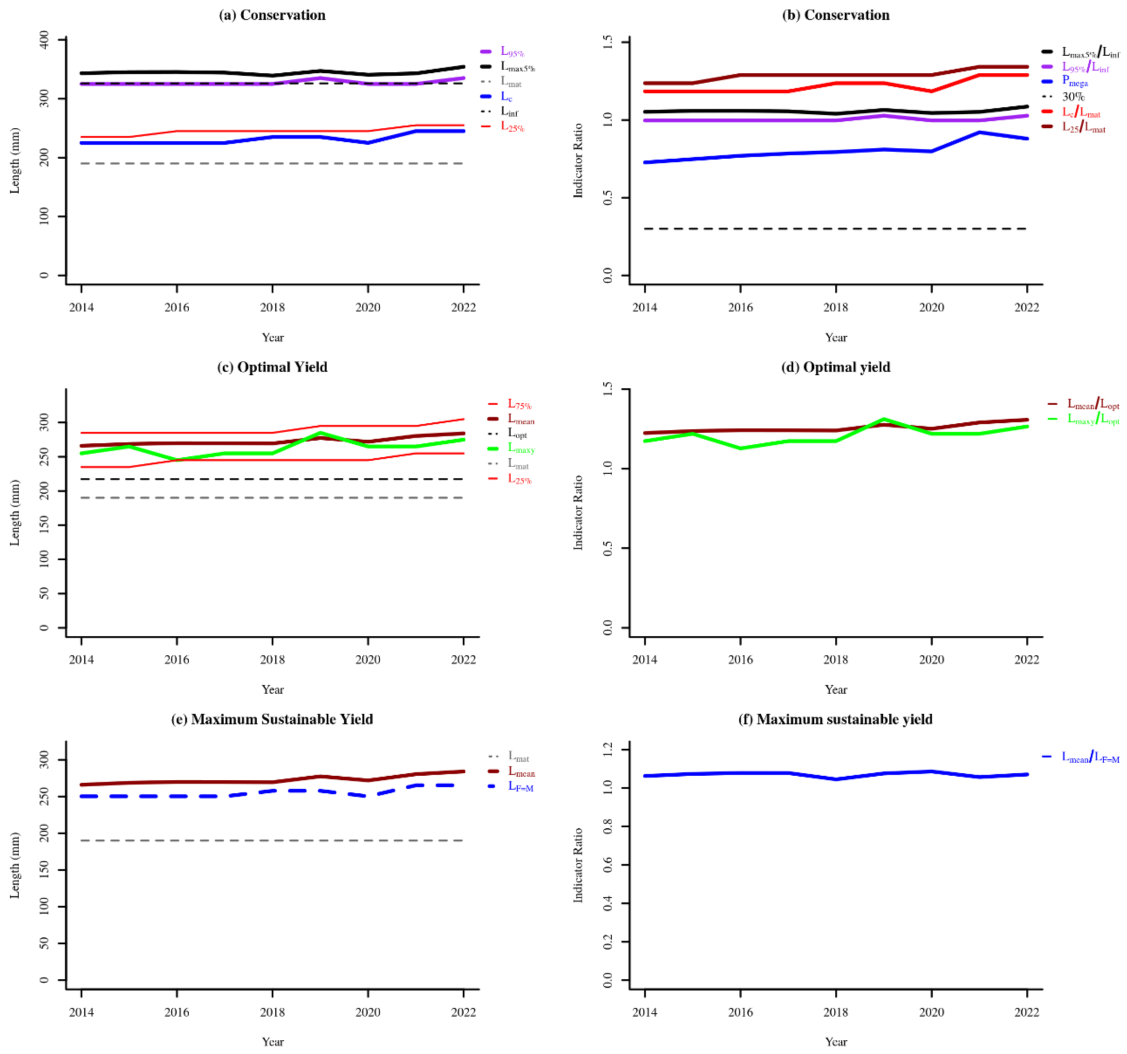


Figure 3.3.9. Flounder (Platichthys spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); LBI indicators trends

Table 3.3.1a. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Total landings (tonnes) 1973–2022 by Subdivision and country

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	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
1987			1007									2107									2530			43	5687

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
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
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

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
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
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

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
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

*** Landings does not include bycatch from Polish pelagic trawlers.**

Table 3.3.1b. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Estimated discards (tonnes) 2014–2022 by subdivision and country. Zero values indicate discards under 0.5 tonnes.

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
2014	1402	2450	3852				0	0	0	171	15	185	2	35	37		7	7	29	128	157	187	1117	1303	5542
2015	1186	3900	5086				0	0	0	199	35	234	0	0	0		1	1	80	307	387	98	157	255	5965
2016	664	2880	3544				2	0	2	298	63	360		9	9		0	0	235	391	625	386	216	602	5143
2017	467	3915	4382				0	1	1	121	177	298		6	6				144	767	911	390	212	602	6201
2018	286	4242	4528				0	0	0	80	180	260		13	13		0	0	110	1065	1175	54	288	342	6318
2019	143	733	876					4	4	118	42	160		4	4		1	1	351	1118	1496	101	226	328	2842
2020	37	12	49					0	0	130	28	158		2	2				267	510	776	4	3	6	992
2021	61		61							37	19	56							125	134	259	0	0	1	377
2022	8	1	10							45	20	65							68	701	769	0	4	4	847

Table 3.3.2. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Discard allocation scheme for 2022; green cells – reported estimated discard, grey cells – allocated discard.

24		2022				
fleet	quarter	Denmark	Germany	Latvia	Poland	Sweden
Active	1				DE_A_1_24	
	2	DK_A_1_24			DE_A_1_24	
	3	DK_A_4_24			DE_A_3_24	
	4				DE_A_4_24	
Passive	1	DE_P_1_24			DE_P_1_24	DE_P_1_24
	2	DE_P_1_24	DE_P_1_24		DE_P_1_24	DE_P_1_24
	3	DE_P_3_24			DE_P_3_24	DE_P_3_24
	4	DE_P_4_24			DE_P_4_24	DE_P_4_24
25		2022				
fleet	quarter	Denmark	Germany	Latvia	Poland	Sweden
Active	1		DE_A_1_24		DE_A_1_24	DE_A_1_24
	2	DK_A_1_25			DE_A_1_24	DE_A_1_24
	3				DE_A_3_24	DE_A_3_24
	4	DK_A_4_24			DE_A_4_24	DE_A_4_24
Passive	1	DE_P_1_24			DE_P_1_24	DE_P_1_24
	2	DE_P_1_24			DE_P_1_24	DE_P_1_24
	3	DE_P_3_24			DE_P_3_24	DE_P_3_24
	4	DE_P_4_24			DE_P_4_24	DE_P_4_24

Table 3.3.3. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); The coverage of sampled landings and discards in 2022 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	144	2	220
Germany		283	17	4455
Poland		513	4	394
Sweden		2	0	0
Denmark	Discards estimates	8	2	142
Germany		45	9	827
Poland		68	0	0
Sweden		0.1	0	0
	Total	1064	34	6038

Area: 27.3.d.25

Country	Catch category	CATON	No. of length samples in numbers	No. Measured in numbers
Denmark	Landings	247	2	253
Germany		151	0	0
Latvia		12	0	0
Poland		5536	20	2044
Sweden		30	0	0
Denmark	Discards estimates	1	0	0
Germany		20	0	0
Latvia		0	0	0
Poland		701	0	0
Sweden		4	0	0
	Total	6702	22	2297

Table 3.3.4. 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

	SD 24		SD 25	
	Q1	Q4	Q1	Q4
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
average	50	46	95	75

Table 3.3.5. 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 3.3.6. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Indicator status for the most recent three years; L_{inf} and L_{mat} calculated using both sexes;

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} / $L_{F=M}$
2020	1.18	1.29	1.04	0.80	1.25	1.09
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

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

ICES SD 26 and 28 were defined as a new assessment unit for flounder at a Benchmark Workshop on Baltic Flatfish Stocks (WKBALFLAT; ICES. 2014) in 2014.

Taking into account contrasting reproductive flounder behaviors in the Baltic Sea: offshore spawning of pelagic eggs and coastal spawning of demersal eggs, Momigliano et al. (2018) 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 *Platichthys flesus* and the coastal spawning - newly described species *Platichthys solemdali*, was estimated to be approximately 45 and 55%, respectively (Florin et al. unpublished data). It is not possible at this stage to separate the proportion of this species in either stock assessment or fisheries.

3.4.1 Fishery

The main fishing countries in Subdivision 26 are Russia, Latvia, Poland, and Lithuania while in Subdivision 28 – Latvia (Table 3.4.1). In the previous years, the Polish fishery was mainly a gillnet fishery targeting flounder along the coast, whereas the Latvian, Russian, and Lithuanian landings were mainly in a bottom trawl mix-fishery.

3.4.1.1 Landings

Landings by countries and subdivisions are presented in Table 3.4.1.

The total landings in SD 26 and 28 combined continued to decrease in 2022 and were 1589 tonnes, the lowest in this century. A decrease in landings was observed since 2014 (Figures 3.4.1. and 3.4.2.), and only in Russia significant increase of landings were observed in 2021 followed by a decrease in 2022. The highest landings in 2022 were recorded in Russia (1000 tonnes), Latvia (279 tonnes), and Poland (244 tonnes). The major part of the landings in EU were realised with active fishing gears (318 tonnes or 54%). There is information about landings by fishing gear from Russia in 2022, while total landings were obtained from Atlantvniro homepage.

A major part of the landings was taken in Subdivision 26 (82%). Russia has the highest landings in Subdivision 26 – 77% or 1000 tonnes, while Poland landings in 2022 were well below long-term average – 244 tonnes. In EU, 69% of landings were realized with passive gears.

The total landings in Subdivision 28 amounted to about 293 tonnes, which was lower than the long-term average. The highest landings in Subdivision 28 were observed in 2015-2016 after that gradual decrease could be observed. The major part of landings was realized by Latvian fishermen (247 tonnes). Most landings in EU were realized using active gears (77 %).

Flounder fishery in 2022 continues to be heavily affected due to cod fishing restriction.

3.4.1.2 Unallocated removals

There is no information about unallocated removals for this stock.

3.4.1.3 Discards

The first discard estimates were calculated in WKBALFLAT in the InterCatch database in 2014. It was found that raising procedure in InterCatch for such by-catch species as flounder gives underestimated and imprecise discard estimates. Therefore, WK decided that discard raising should be performed outside of InterCatch.

No discard estimation was available for flounder in subdivisions 26 and 28 in 2022. In Russia and Estonia discarding of flounder is forbidden, while from other countries (e.g. Latvia, Poland) only one discard sample (collected in the harbour) was available – with a discard rate of 22%. Applying this rate to countries where discarding is allowed – the total discard rate would be 5.8%. The expert group decided that available discard information is not enough to estimate a total discard rate for the stock (Figure 3.4.3).

3.4.1.4 Effort and CPUE data

Time series from 2009–2022 were available from ICES WGBFAS data call where countries were asked to submit flatfish effort data by fishing fleet and subdivision. It should be mentioned that different calculation methods were used by countries to estimate a fishing effort. Some countries reported all of the fishing days when flounder were landed; some countries reported the number of fishing days where a significant amount of flounder were landed, while some countries reported fishing days for the whole demersal fleet. Due to new cod fishery restrictions last two years demersal trawling was heavily influenced in SD 26 and especially in SD 28, where flounder were fished as bycatch in cod fishery.

Standardisation and weighting factor were applied for submitted effort data to calculate a common effort index for the stock. First, every country's data were standardised using proportion for a given year from the national average. Standardised effort data were weighted by cod and flounder landings in subdivisions 26 and 28 for every country and year and final effort for stock was calculated summing all countries efforts.

According to new effort estimates a sharp overall decrease (with some increase in 2020) was observed in general and in most of countries (Figure 3.4.4). In all EU countries, due to cod fishery restriction, flounder fishery effort has significantly decreased (Figure 3.4.5). No effort data were available from Russia therefore estimates from 2021 were applied in the calculations Effort data from last two years should be analysed with precautionary, while different factors influenced demersal trawling. EU countries reduced cod TAC and therefore also flounder as bycatch fishery was restricted. No restriction in Russian cod fishery was observed, therefore no major influence to flounder fishery.

The highest landings per unit effort in 2022 were registered in Russia (Figure 3.4.6) which indicated a target flounder fishery. Flounder landings per day at sea in other countries were less than 100 kg which indicated that flounder is typically bycatch in the fishery.

3.4.2 Biological information

3.4.2.1 Catch in numbers

In total 13428 flounder were measured from the landings ((72 samples) Table 3.4.3). Lengths measurements from Russia (53 samples with 10 705 length measurements) were used from 2021 reported data. 81% of landings were covered with length information (including Russian data from 2021) or 49% from EU countries using data reported from 2022. Most length measurements were from Russia and were taken from 2021 data (53 samples, 10 705 flounder). Data from 2022 was available from Lithuania (8 samples, 1456 flounder), Latvia (3 samples, 826 flounder) and Poland (3 samples, 195 flounder). Total of 6 length samples (152 flounder) from discard was available from Estonia and Poland for the expert group. Data from Estonia (5 samples) should be interpreted cautiously, while length measurements were reported in IC with 0 kg CANUM.

3.4.3 Fishery independent information

Catch per unit of effort (kg per hour) from the BITS Survey in the 4th quarter was used to calculate an index representing flounder abundance by weight, as the stock is defined as a Data limited stock by ICES. Data were compiled from the ICES DATRAS output format "*CPUE_per_length_per_haul*" where the database provides CPUE by length in numbers. Weight-at-length was estimated as an average weight-at-length for data from 1991–2013, and subdivisions 26+28. Next, to such data weight-length relationships of the form w=a L^b were fitted, were: a = 0.0158 and b = 2.90. Next, biomass for fish longer than 20 cm were summed to get the total biomass index by quarters. All fish with length <20 cm were excluded from the calculations, as flounder nurseries are located in shallow coastal areas and are not covered in BITS surveys. Data from the 4th quarter only was used while in this time of the season, both flounder species are mixing in the survey area.

Historical BITS data (1991-1998) were updated in DATRAS database, therefore survey estimates differ from previous years. Historical data were not used in the Advice.

Assessment

No analytical assessment can be presented for this stock. Therefore, detailed management options cannot be presented. ICES is in the process of compiling existing data and testing assessment models.

The ICES framework for category 3 stocks was applied. The Baltic International Trawl Survey (BITS, G8863 – Q4) was used as the index of stock development.

The stock showed a decreasing trend from the beginning of the century although the estimated indices in last years are fluctuating without any trend (Figure 3.4.7, Table 3.4.4). For this stock scientific advice on stock status is provided for 2023.

3.4.4 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 2014–2022 were used to estimate CANUM and WECA (Figure 3.4.8, 3.4.9). Whereas the biological parameters: L_{inf} and L_{mat} were calculated using survey data from DATRAS.

For estimating L_{inf} data from 2014–2019 from Q4, and for both sexes were taken. Only age data determined by recommended ageing technique was included in the analyses, as a result for Subdivision 26 data from Poland, Lithuania, and Latvia while for Subdivision 28 – data from Latvia and Estonia were used. Age data with inadequate ageing technique (whole otoliths) were excluded from calculations. Preliminary analysis indicated different growth rate in subdivisions 26 and 28 therefore expert group decided to calculate separate L_{inf} for each subdivision and later calculate one weighted L_{inf} where landings of flounder by subdivisions were used as a weighting factor. For Subdivision 25 L_{inf} was 32.46 cm, while for Subdivision 28 – 28.38 cm. Landing proportion between subdivisions in the last five years is 65% (for Subdivision 26) and 35 % (for Subdivision 28). As a final weighted L_{inf} was calculated 31.04 cm. Data from BITS Q4 only were used. In Q1 flounder is close to spawning time and both flounder species are separated at this time of the year. In BITS Q1 surveys mainly European flounder (or pelagic flounder) are represented. In Q4 both species is mixing, therefore those data better represent all flounder in subdivisions 26 and 28.

In the case of L_{mat} data for females were derived from 2014–2019 (also Q4; the reason for this is described in the previous paragraph). Like for L_{inf}, the same approach was used to calculate weighted L_{mat}, L_{mat} for Subdivision 26 was 18.8 cm, for Subdivision 28 – 15.3 cm, while the weighted average for the stock – 17.6 cm.

Accepted biological parameters mentioned above are as follows:

L_{inf} = 31.04 mm
L_{mat} = 17.6 mm
The results were compared to standard length-based reference values to estimate the status of the stock (Table 3.4.5).

The results of LBI (Table 3.2.5, Figures 3.4.10 and 3.4.11) show that the stock status of fle.27.2628 is above possible reference points (Table 3.4.6). $L_{max5\%}$ is well above the lower limit of 0.80 (*i.e.* 1.04 in 2021), some truncation in the length distribution in the catches might take place. Catch is close to the theoretical length of L_{opt} and L_{mean} is stable over time and close to 1, indicating fishing close to the optimal yield. Exploitation is consistent with F_{MSY} proxy ($L_{F=M}$).

Table 3.4.1. 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		
	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	0			0		0
Finland	1	0	1			0
Germany	1		1			0
Poland	236		236	244		244
Sweden	3	8	11	2	12	15
Estonia		26	26		28	28
Latvia	20	348	369	31	247	279
Lithuania	14	8	22	18	6	24
Russia	1245		1,245	1000		1,000
Total	1520	391	1911	1296	293	1,589

Table 3.4.2. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Discards were not estimated for 2022.

Country	Landings	Discards	Catch	Discard ratio
Estonia	28.2	NA	NA	NA
Germany	0	NA	NA	NA
Latvia	278.6	NA	NA	NA
Lithuania	23.9	NA	NA	NA
Poland	244.0	NA	NA	NA
Sweden	14.6	NA	NA	NA
Russia*	1000.0	NA	NA	NA
Finland	0	NA	NA	NA
Total	1589.3	NA	NA	NA

***Data from http://atlant.vniro.ru/**

Table 3.4.3. 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	5	246	5	246
	Latvia	3	826	3	255
	Lithuania	8	1456	0	0
	Poland	3	195	2	98
	Russia*	53	10705	53	820
Landing total		72	13428	63	1419
Discard	Estonia**	5	26	5	26
	Poland	1	126	1	57
Discard total		6	152	6	83
Total		78	13580	69	1502

*** Data from 2021**

**** Discard data from nonreported discards**

Table 3.4.4. 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	4th quarter	Combined index
1991	15.7		15.7
1992	51.1		51.1
1993	80.4	48.4	62.4
1994	60.5	30.2	42.8
1995	102.3	68.3	83.6
1996	71.8	30.2	46.5
1997	143.7	80.9	107.9
1998	96.4	67.9	80.9
1999	102.3	73.7	86.8
2000	189.5	65.3	111.2
2001	279.9	437	349.8
2002	238.2	317	274.6
2003	157.0	144	150.1
2004	145.7	367	231.2
2005	128.7	295	194.9
2006	119.7	151	134.5
2007	239.4	224	231.4
2008	330.1	199	256.2
2009	267.9	146	198.1
2010	242.2	196	218.1
2011	230.4	210	219.9
2012	211.7	134	168.5
2013	133.7	176	153.3
2014	82.7	96	89.0
2015	102.4	69	83.9
2016	132.6	52	82.7
2017	128.7	106	116.6
2018	87.9	73	79.9

Year	**1st quarter**	**4th quarter**	**Combined index**
2019	203.9	119.3	156.0
2020	120.4	69.2	91.3
2021	205.6	68.2	118.4
2022	55.5	121.8	82.3
2023	165.7		

Table 3.4.5. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). 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 3.4.6. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Indicator status for the last seven years.

Year	Conservation				Optimizing Yield	MSY
	Lc / Lmat	L25% / Lmat	Lmax 5 / Linf	Pmega	Lmean / Lopt	Lmean / LF = M
2014	1.34	1.34	1.01	0.85	1.28	1.05
2015	1.34	1.39	1.15	0.89	1.34	1.09
2016	1.34	1.39	1.08	0.87	1.31	1.07
2017	1.16	1.22	0.99	0.58	1.17	1.04
2018	1.22	1.28	1.08	0.71	1.24	1.07
2019	1.28	1.28	1.06	0.74	1.26	1.06
2020	1.22	1.28	1.05	0.68	1.25	1.08
2021	1.16	1.22	1.04	0.64	1.22	1.09
2022	1.11	1.16	1.03	0.47	1.16	1.07

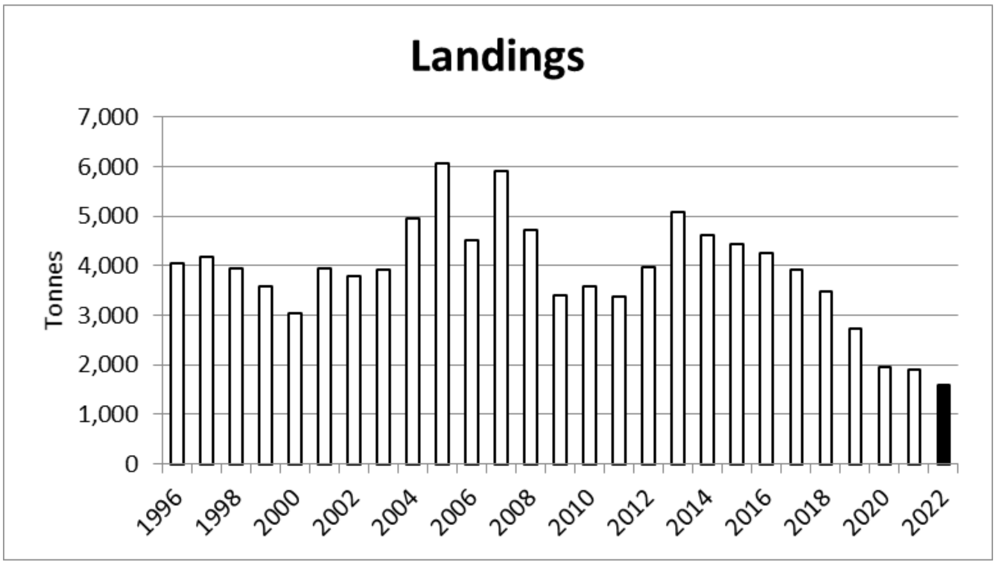


Figure 3.4.1. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder in subdivisions 26 and 28.

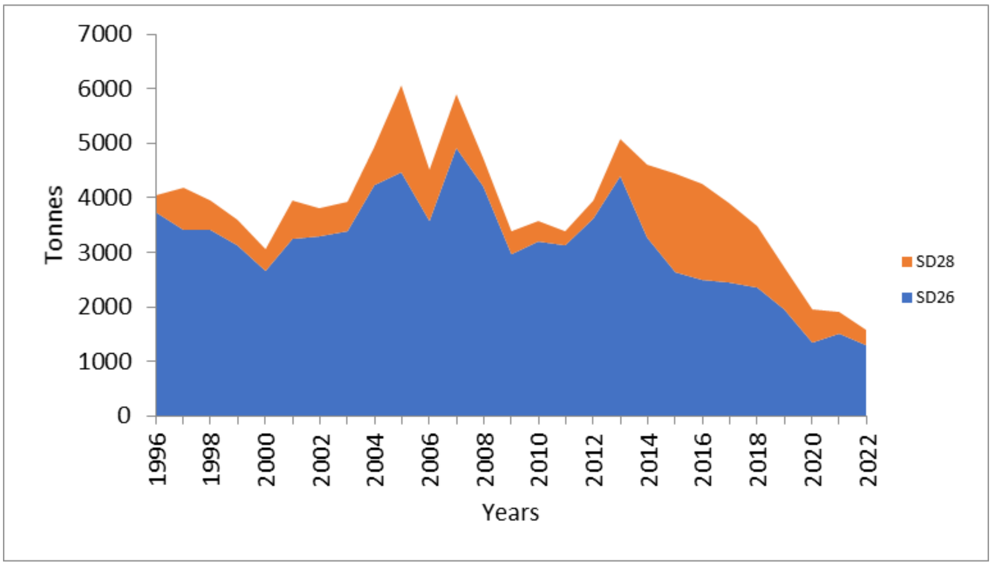


Figure 3.4.2. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder by subdivisions.

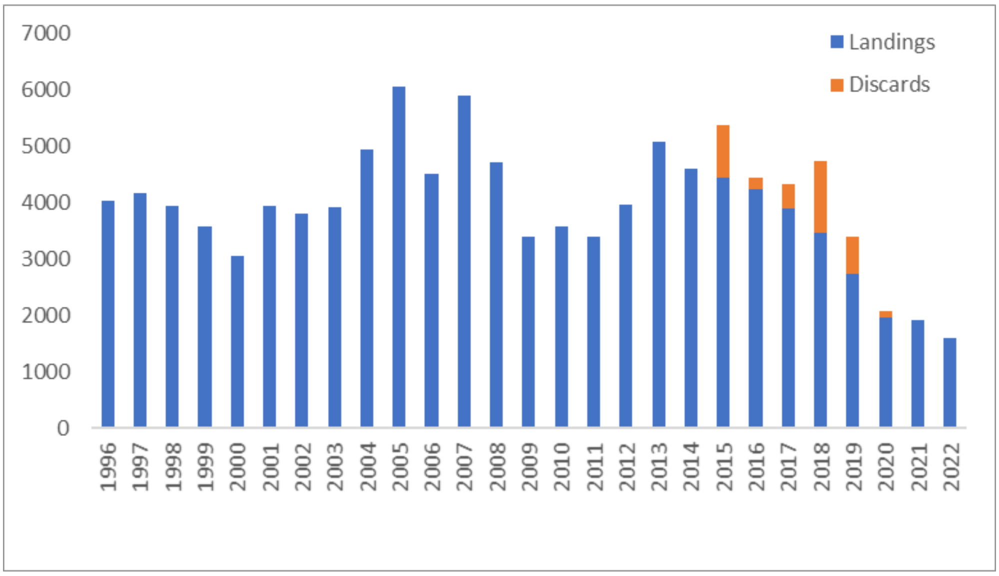


Figure 3.4.3. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES catch of flounder in subdivisions 26 and 28. Discards in 2021-2022 were not estimated.

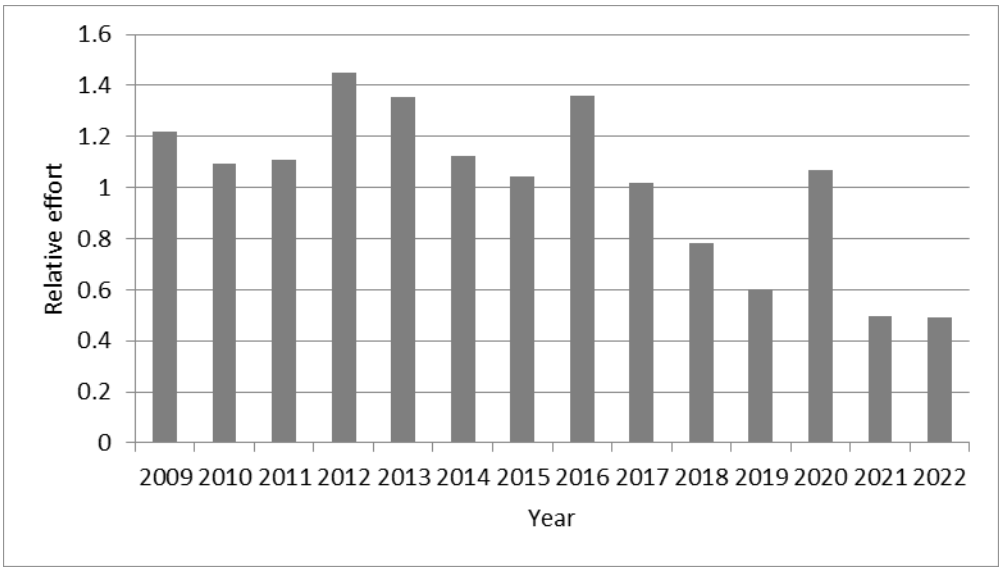


Figure 3.4.4. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Effort data (days-at-sea) of flounder in subdivisions 26 and 28 (days-at-sea).

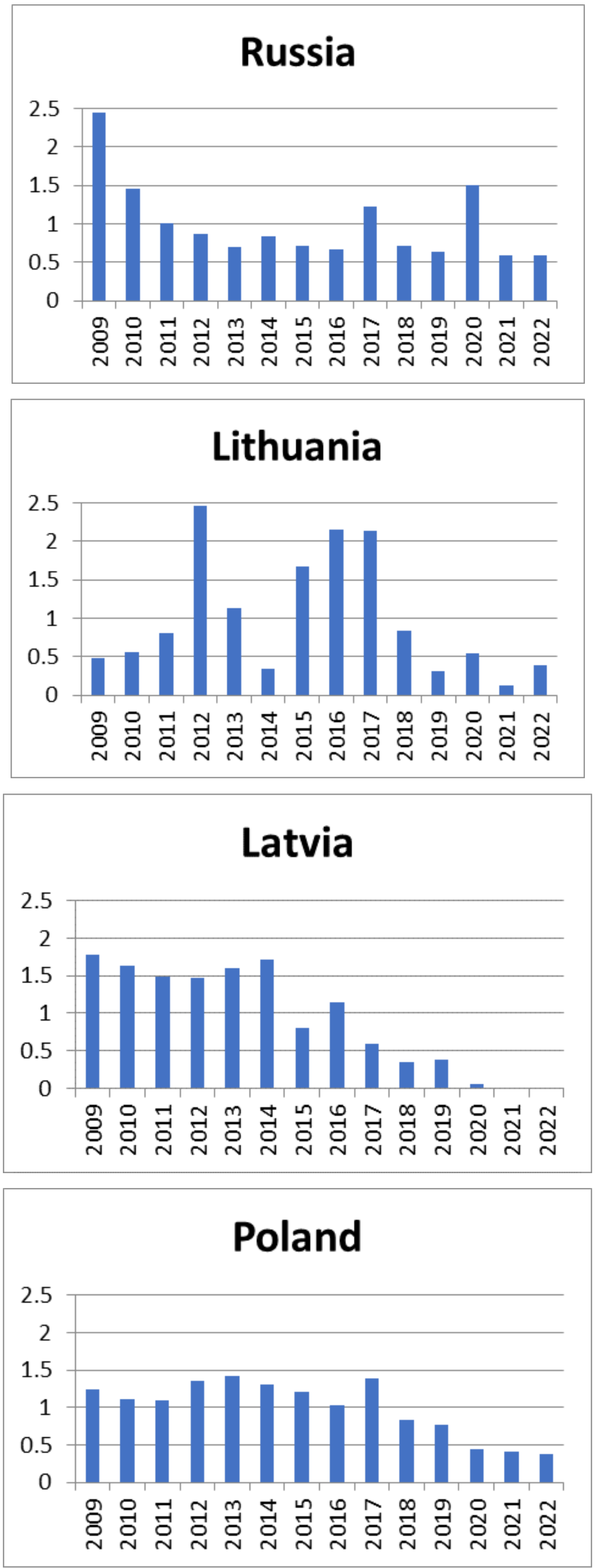


Figure 3.4.5. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Effort data of flounder in subdivisions 26 and 28 by main fishing countries (days-at-sea).

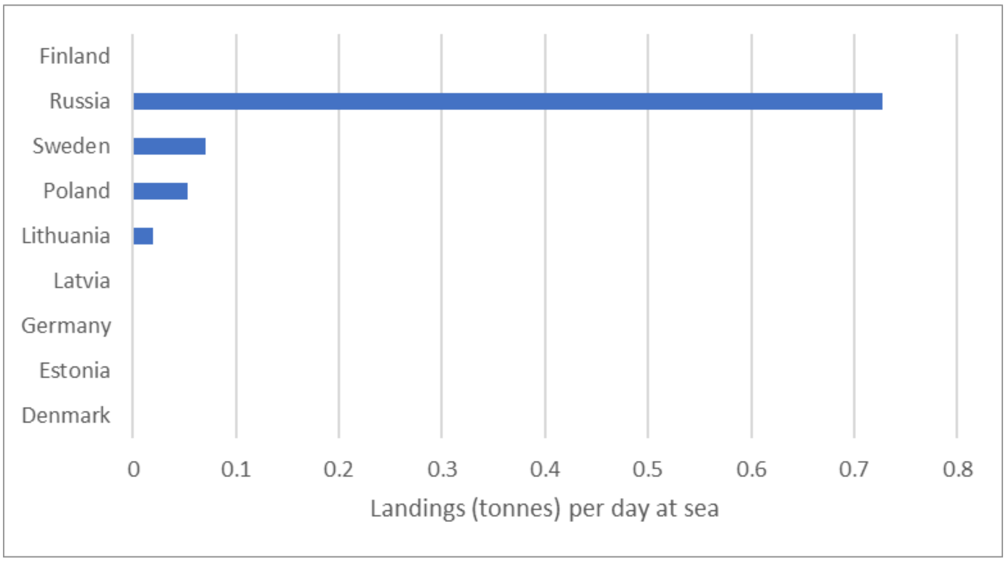


Figure 3.4.6. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Landings of flounder in tones per days-at-sea by country in subdivisions 26 and 28.

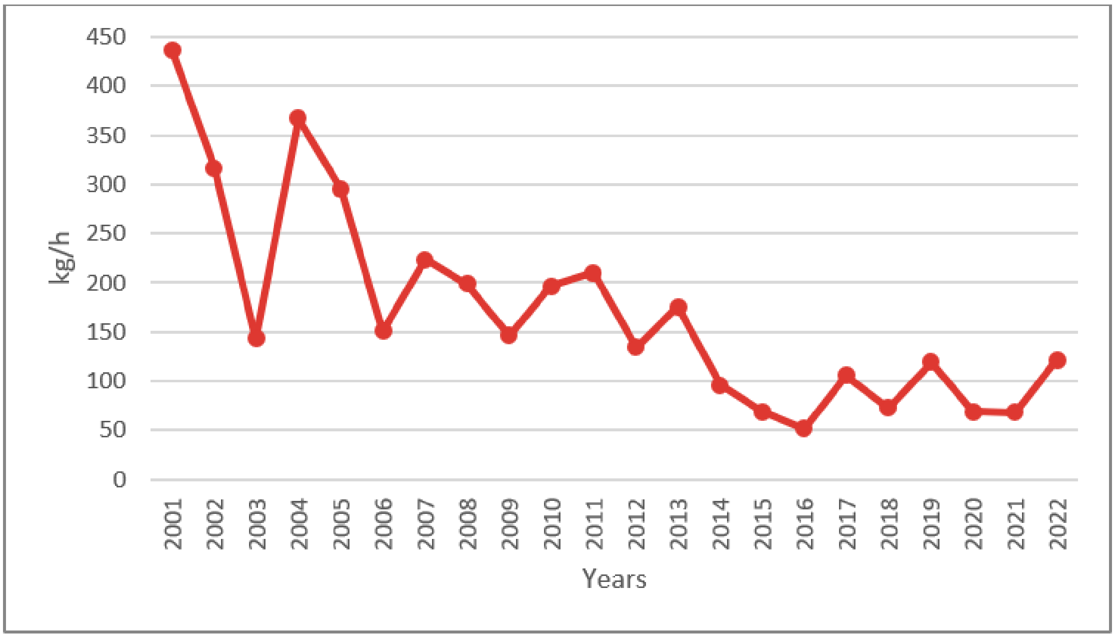


Figure 3.4.7. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch per unit of effort (kg per hour) from BITS Survey in 4th Quarter. Subdivisions 26 and 28.

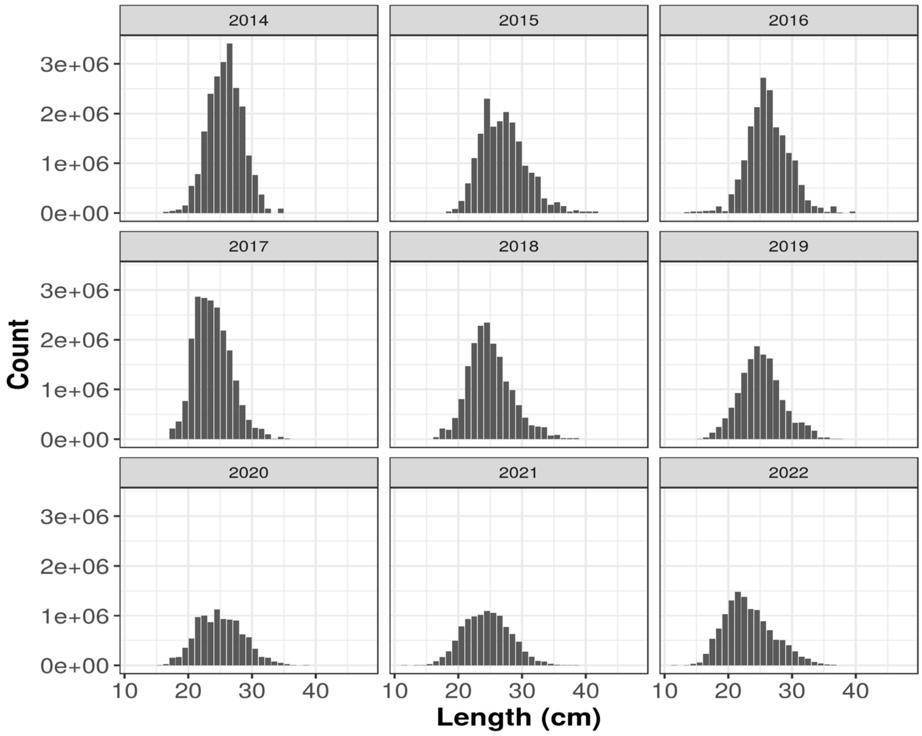


Figure 3.4.8. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch in numbers (CANUM) per length classes.

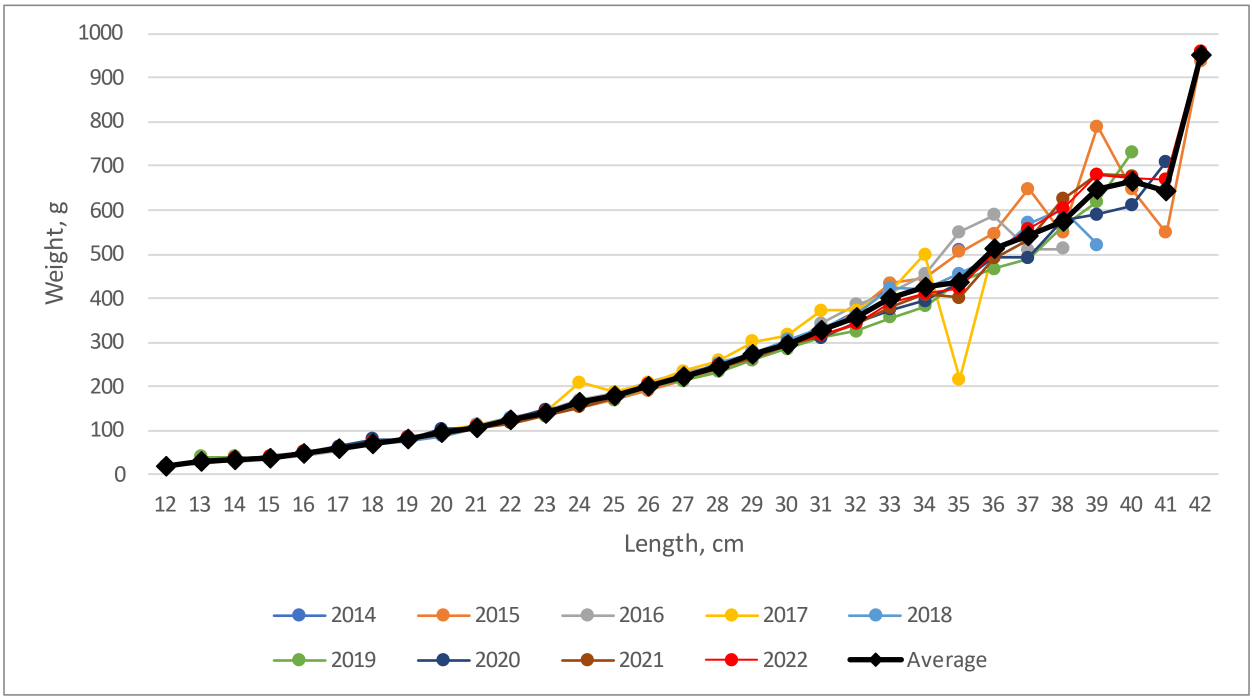


Figure 3.4.9. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Average weight (WECA) per length classes.

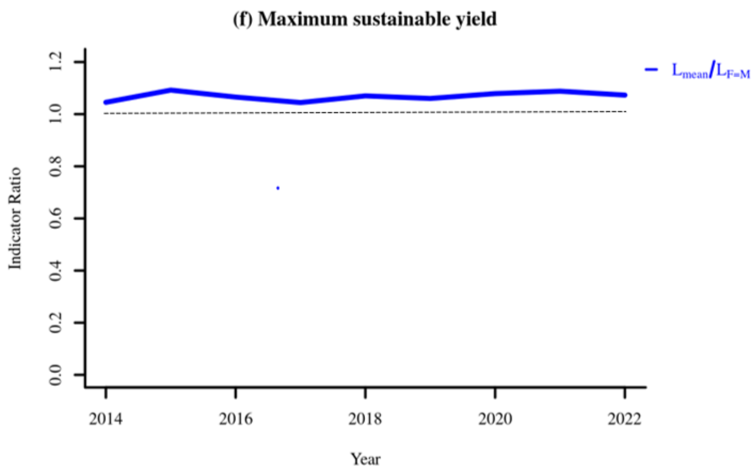


Figure 3.4.10. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Index ratio L_{mean}/LF=M from the length-based indicator method (LBI; ICES. 2015) used for the evaluation of the exploitation status. The exploitation status is below the F_{MSY} proxy when the index ratio value is higher than 1.

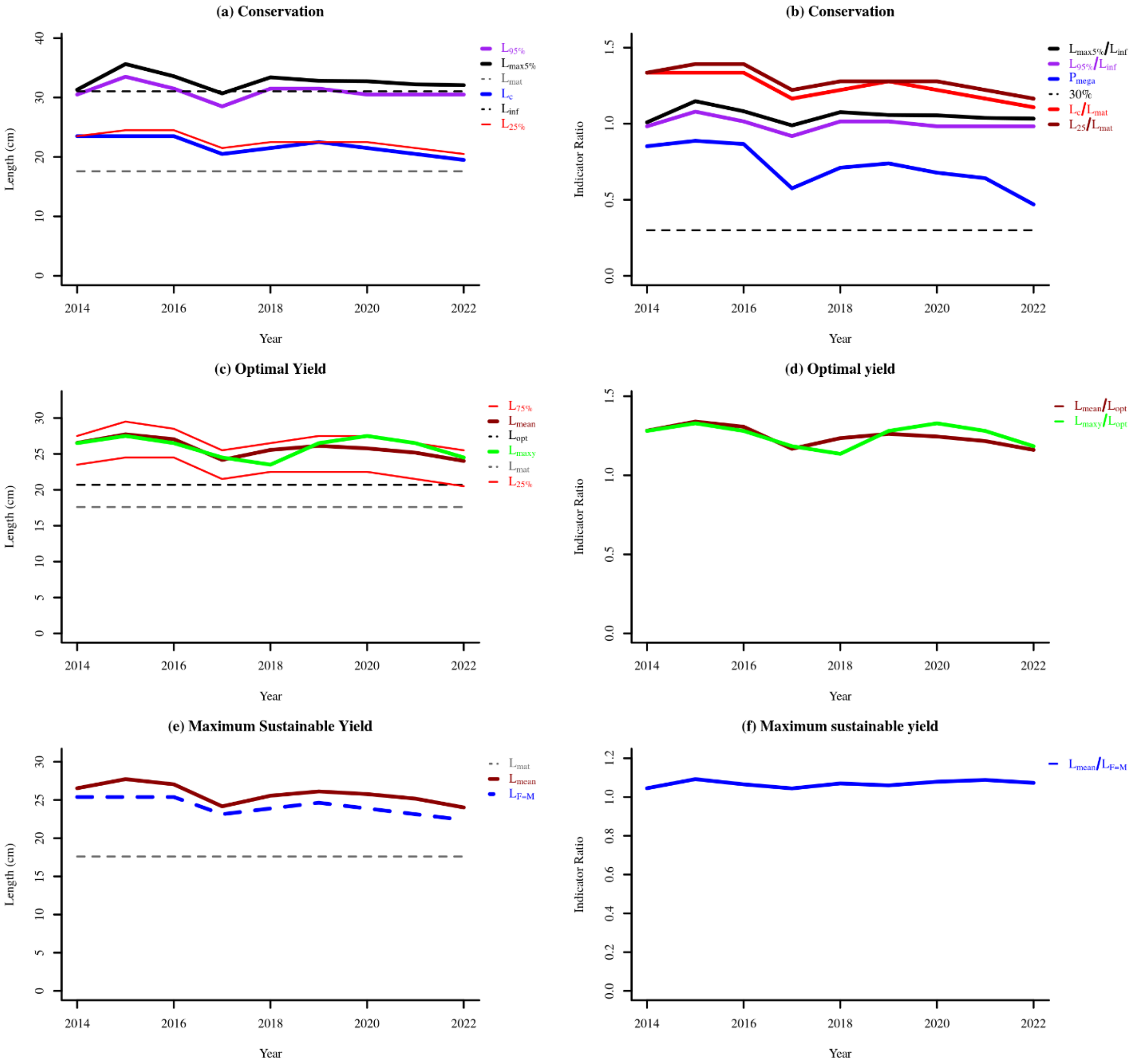


Figure 3.4.11. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Length based indicator trends.

3.5 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.

3.5.1 Fishery

3.5.1.1 Landings

In subdivisions 27 and 29-32 flounder is caught mainly in the SDs 29 and 32 (Figure 3.5.1). The majority (>95% 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 1980s but have been decreasing form end of 1980's, reaching level below 150 tonnes since 2017. In 2022 the landings were the lowest of the timeseries, only 93 tonnes. Estonia is the major fishing nation, standing for more than 80% of the catches followed by Sweden with a share of 10-15% and the rest is taken by Finland and in some years also Poland (Table 3.5.1). 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.

3.5.1.2 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.

3.5.1.3 Recreational fishery

In the northern Baltic Sea, the importance of recreational fishery is substantial. Recreational catches are estimated by Estonia and Finland (Table 3.5.2), 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 three 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.

3.5.1.4 Effort

The exploitation status of the stock is unknown, since effort data from the most important fishery, passive gears, is lacking from the dominating fishing nation Estonia (Table 3.5.3). 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.

3.5.2 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).

3.5.2.1 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 gillnet catches is show in Figure 3.5.2.

3.5.2.2 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 3.5.3).

3.5.3 Fishery independent data

Fishery independent data is gathered form 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 3.5.4).

3.5.4 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 3.5.4). 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.

3.5.5 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.

3.5.5.1 Data

3.5.5.1.1 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 3.5.2).

3.5.5.1.2 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 3.5.5 and the fit is shown in Figure 3.5.5.

Biological parameters needed for the length-based indicators calculations are shown in Table 3.5.6. 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:

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

3.5.5.2 Results

Based on the L_{mean} indicator Baltic flounder stock has been overfished for the last five years (Table 3.5.7). However, 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 3.5.7).

Table 3.5.1. 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
2008		189	11		49		249

Year	Denmark	Estonia*	Finland	Poland	Sweden	USSR	Total
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

*** 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 3.5.2. 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		
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

	Finland				Estonia	
	SD32	SD29	SD30	SD31	SD32	SD29
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	7	4	0	7.9	6.5

*** Finland catch statistic for 2022 was not out for the WG meeting, same values as 2020 and 2021 was used**

Table 3.5.3. 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

Table 3.5.4. 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		
Survey	Muuga-Q4	Kudema-Q4	Kvädöfjärden-Q4[1)]	Muskö-Q4[1)]	Combined for SD27[2)]	Combined[3)]
	(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
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

SD	32	29	27			
Survey	Muuga-Q4	Kudema-Q4	Kvädöfjärden-Q4[1)]	Muskö-Q4[1)]	Combined for SD27[2)]	Combined[3)]
	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	kg gear-night-1)
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

1) Biomass prior to 2009 is estimated from numbers and length distribution

2) Arithmetic mean

3) Weighted mean with the respective SDs landings.

Table 3.5.5. 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 3.5.6 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	Commercial gillnet catch	2017-present	
L_{inf}	Küdema survey (2000-2011)	31.88cm	females only
K		0.22year^{-1}	
L_{mat}	2011 survey in Hiiumaa (Q2)	16.8 cm	females only
L_{mat95}		20.89 cm	
M/K		1.34	

Table 3.5.7. Baltic flounder SD27, 29-32 (Northern Baltic Sea). Length-based indicators analysis results.

	Conservation	Optimising Yield	MSY		
Year	**Lc/Lmat**	**Lmean/Lopt**	**Lmean/Lf=m**	**Lmean**	**Lf=m**
Ref	**>1**	**~1(>0.9)**	**≥1**	**cm**	**cm**
2017	1.28	1.01	0.99	24.06	24.32
2018	1.28	1.01	0.99	24.06	24.32
2019	1.28	1.00	0.99	24.01	24.32
2020	1.28	1.02	0.98	24.40	24.32
2021	1.34	0.96	0.92	23.00	25.05
2022	1.22	0.98	0.99	23.41	23.59

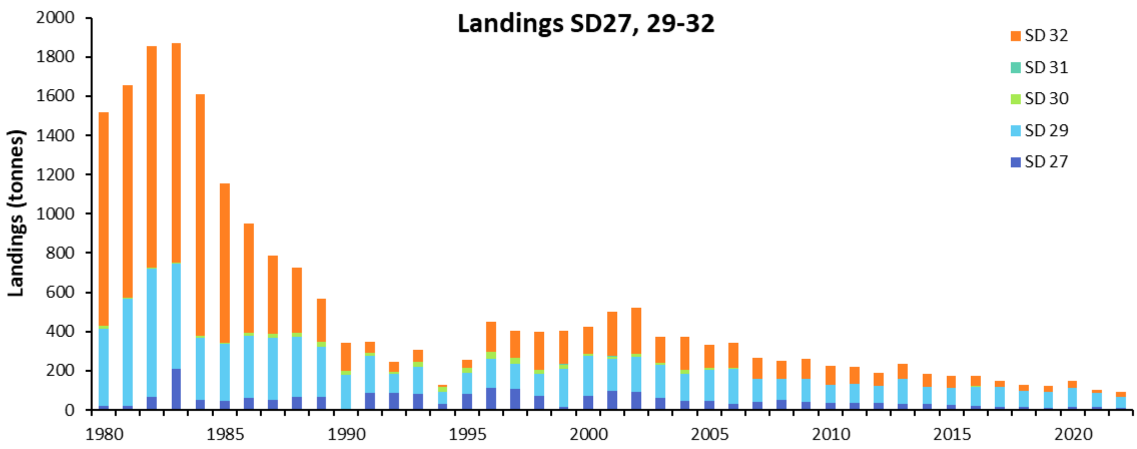


Figure 3.5.1. Baltic flounder SD27, 29-32 (Northern Baltic Sea). Landings (tonnes) in subdivisions (SDs) 27 and 29-32 from 1980-2022.

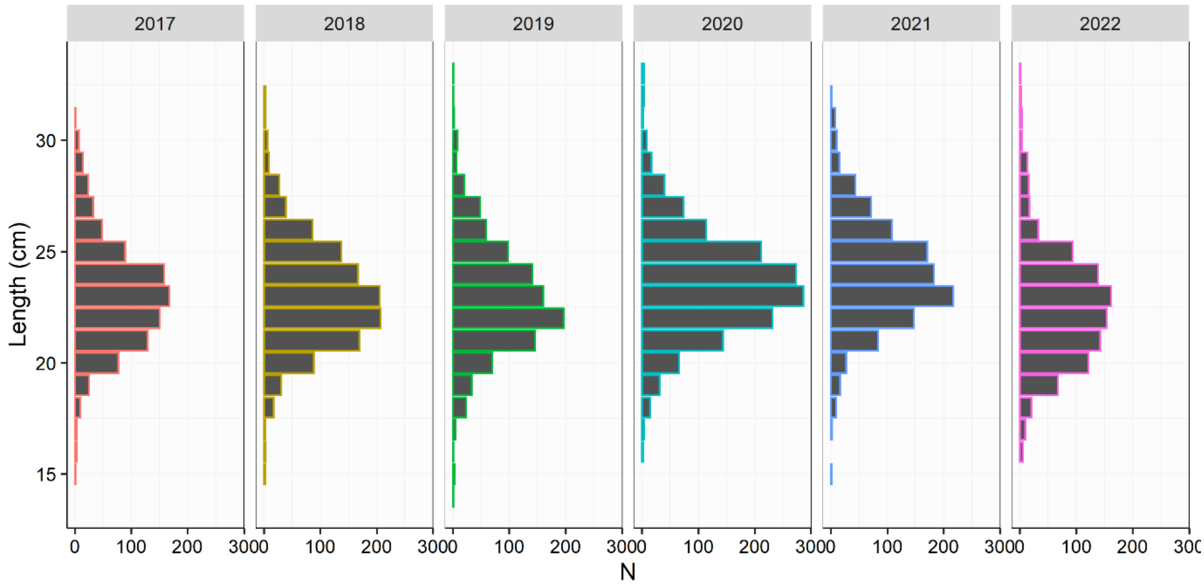


Figure 3.5.2. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Length frequency distribution from commercial gillnets (2017-2022).

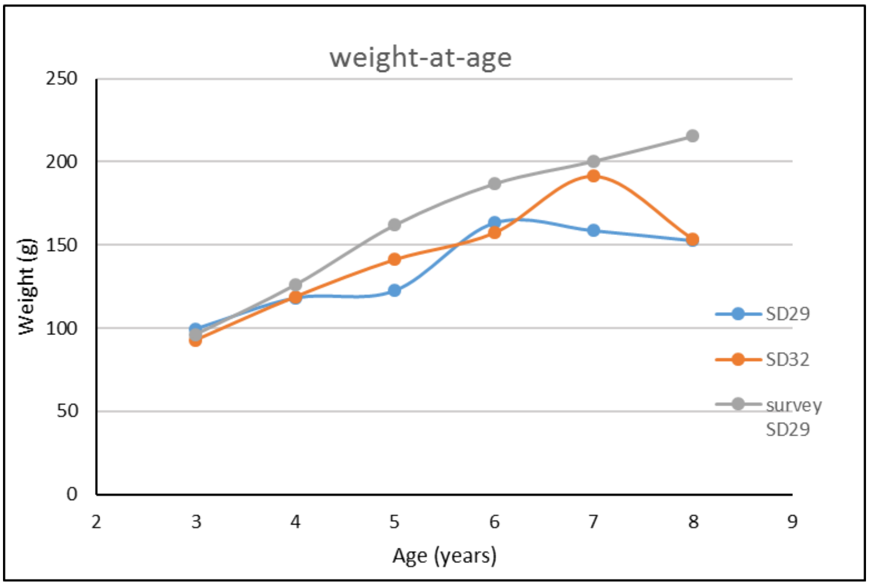


Figure 3.5.3. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Mean weights per age for Estonian commercial trap net landings (2011-2016) per Subdivision (Q3+4) and for survey in SD29 (2000-2012).

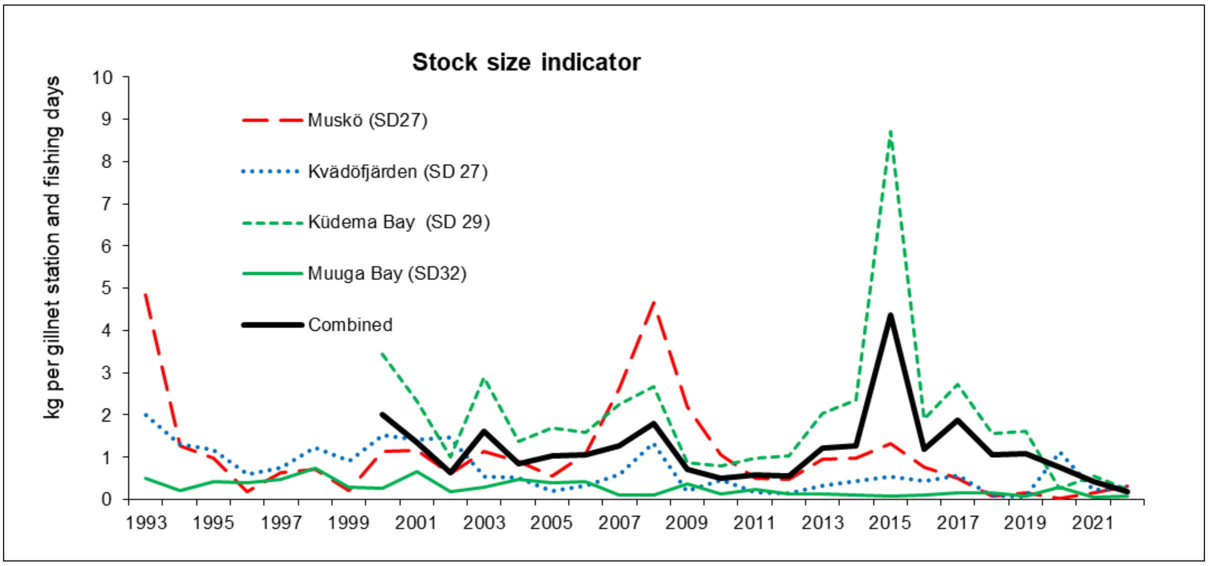


Figure 3.5.4. Baltic flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Biomass indices of Muuga Bay (SD 32) (solid green line), Küdema Bay (SD 29) (dashed green line), Muskö (SD 27) (red dash line), Kvädöfjärden (SD 27) (dotted blue line) surveys and combined index (kg per gillnet station and fishing days).

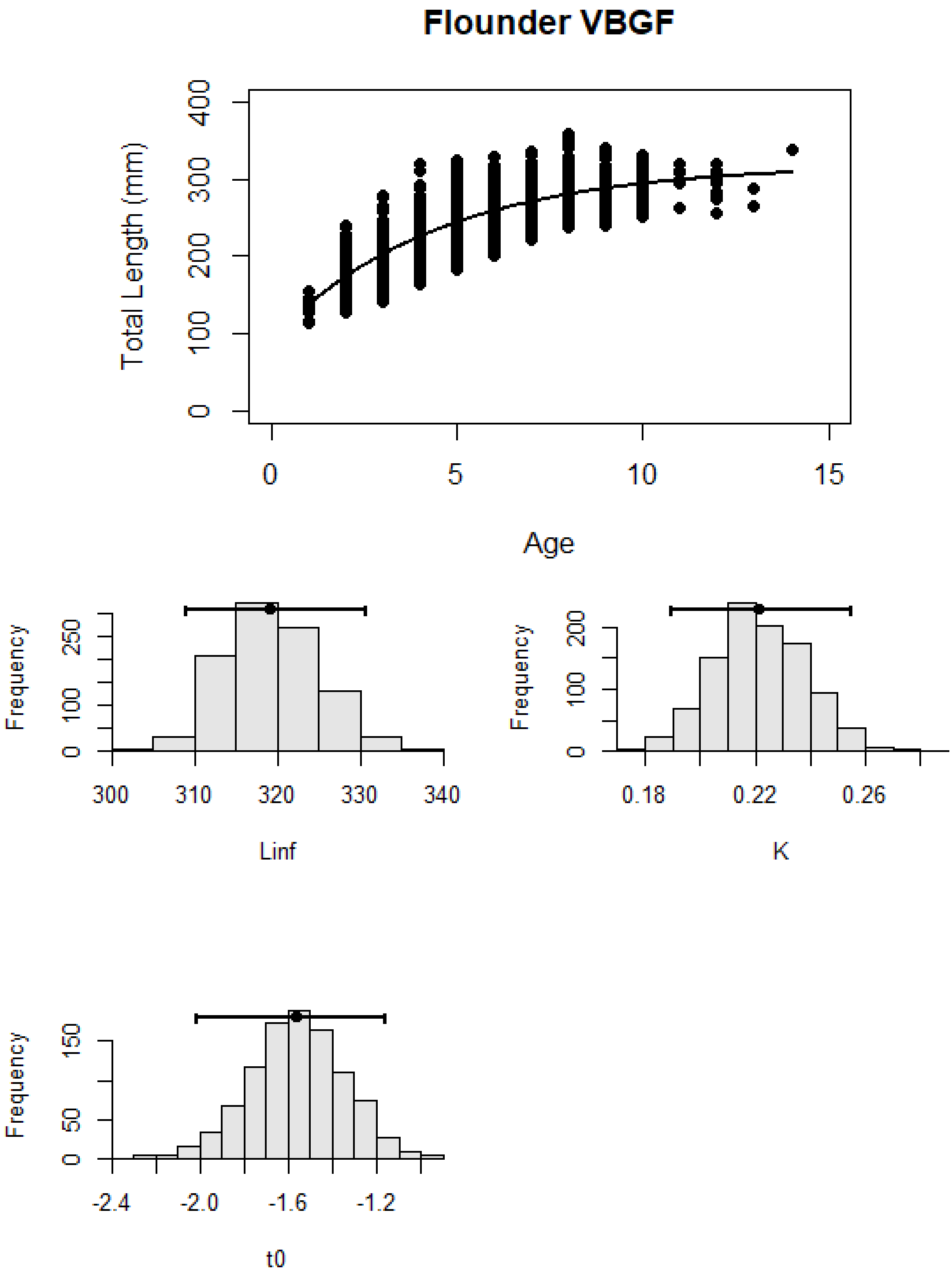


Figure 3.5.5. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Von Bertalanffy growth curve fit (upper) and corresponding parameter estimate distributions (lower).

4 Herring in the Baltic Sea

4.1 Introduction

4.1.1 Pelagic Stocks in the Baltic: Herring and Sprat

Descriptions of the fisheries for pelagic species and other species are found in Section 1.4 Fisheries Overview.

The distribution of reported landings by statistical rectangle of herring and sprat in 2022 are shown in Figure 4.1.1.

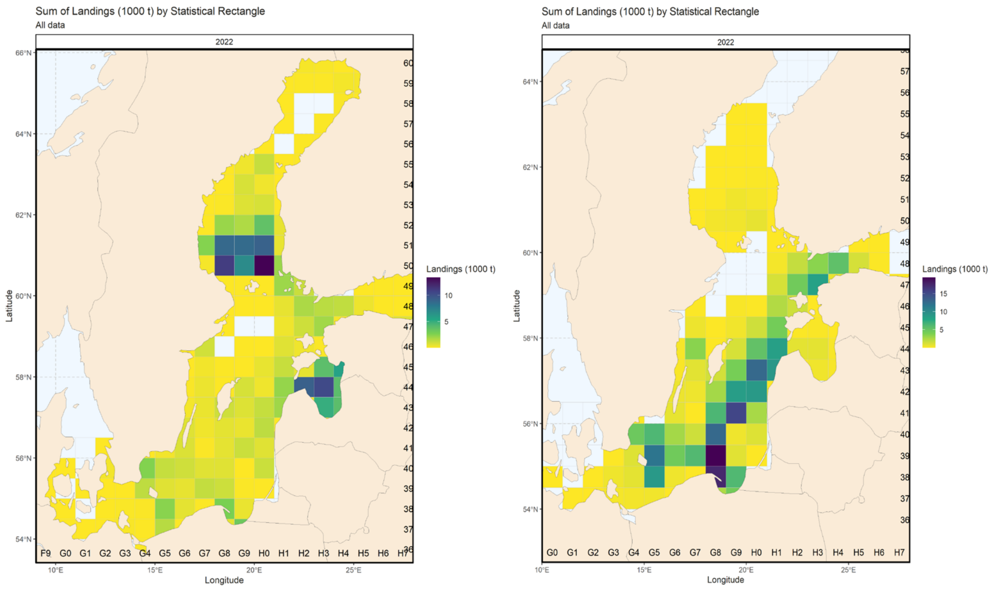


Figure 4.1.1 Sum of landings (1000t) by statistical rectangle for herring (left) and sprat (right). 0.07% and 1.88% of landings for herring and sprat, respectively, reported for the missing statistical rectangle.

The distribution by subdivision of reported landings of herring and sprat in 2022 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 2022 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 reasonable 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 2022, 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 ISSG Small Pelagic Fisheries Baltic. The effects of central Baltic herring and sprat misreporting on 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 4.1.2.

Management 2022 and 2023 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 2022		ICES Advice for 2023 (Basis)	TAC 2023
	in relation to SSB2021 MSY & PA & MP	in relation to F2020 MSY & PA & MP	(t)	(t)
SPRAT				
SD 22-32	Above trigger & Full reproductivity& Above	Above & Harvested sustainably & Within range	183 749–317 905 (MAP applied)	*269200
HERRING				
SD 25–29&32 (excl. GOR)	Below trigger & Increased risk & Below	Above & Increased risk & Above ranges	70 130–95 643 (MAP applied)	*100239
SD 28.1 (Gulf of Riga)	Above trigger & Full reproductivity & Above	Below & Harvested sustainably& Within the ranges	33 519–50 079 (MAP applied)	37868
SD 30–31 (Bothnian Sea)	Below trigger & Increased risk & Below	Above & Harvested sustainably& Within the ranges	80 047–103 059 (MAP applied)	80074

***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	53.9	109.9	49.0%
2001	63.7	105.8	60.2%
2002	52.7	106.2	49.6%
2003	40.3	78.3	51.5%
2004	41.7	76.8	54.3%
2005	43.7	88.4	49.4%
2006	41.9	90.5	46.3%
2007	40.5	69.0	58.7%
2008	43.1	68.5	62.9%
2009	31.0	67.3	46.1%
2010	17.9	42.2	42.4%
2011	15.8	27.8	57.0%
2012	21.1	38.7	54.5%
2013	25.5	43.8	58.2%
2014	18.3	37.4	48.9%
2015	22.1	37.5	58.9%
2016	25.1	51.3	48.9%
2017	26.5	46.3	57.2%
2018	19.0	41.1	46.2%
2019	9.8	25.4	38.6%
2020	4.0	22.1	18.1%
2021	1.6	14.9	10.7%
2022	0.6	6.2	10.2%
Mean	28.7	56.3	46.8%

***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	175.6	2.6%
2001	2.9	148.4	2.0%
2002	3.5	129.2	2.7%
2003	4.3	113.6	3.8%
2004	3.3	93.0	3.5%
2005	2.3	91.6	2.5%
2006	3.2	110.4	2.9%
2007	1.5	116.0	1.3%
2008	6.1	126.2	4.8%
2009	4.9	134.1	3.7%
2010	5.2	136.7	3.8%
2011	5.5	116.8	4.7%
2012	3.8	101.0	3.8%
2013	4.1	101.0	4.1%
2014	4.5	132.7	3.4%
2015	5.0	174.4	2.8%
2016	4.3	192.1	2.2%
2017	3.9	202.5	1.9%
2018	4.2	244.4	1.7%
2019	3.6	204.4	1.8%
2020	1.3	177.1	0.7%
2021	2.1	129.0	1.6%
2022	2.6	83.4	3.1%
Mean	3.8	140.6	2.8%

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	34.7	5.5%
2001	1.2	38.8	3.1%
2002	0.4	39.7	1.0%
2003	0.4	40.8	1.0%
2004	0.2	39.1	0.5%
2005	0.5	32.2	1.6%
2006	0.4	31.2	1.3%
2007	0.1	33.7	0.3%
2008	0.1	31.1	0.3%
2009	0.1	32.6	0.3%
2010	0.4	30.2	1.3%
2011	0.1	29.7	0.3%
2012	0.2	28.1	0.7%
2013	0.3	26.5	1.1%
2014	0.2	26.3	0.8%
2015	0.3	32.9	0.9%
2016	0.3	30.9	1.0%
2017	0.2	28.1	0.7%
2018	0.5	*25.7	1.9%
2019	1.2	28.9	4.2%
2020	1.2	33.2	3.6%
2021	0.8	35.8	2.2%
2022	0.8	43.0	1.9%
Mean	0.5	33.1	1.5%

***corrected at WGBFAS 2020**

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 2022 by subdivision and quarter.

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
SD 25	Landings ('000t)	35.3545	14.3738	5.2977	10.3399	65.3669
	Herring (%)	7.91%	14.19%	73.65%	61.66%	23.12%
	Sprat (%)	92.09%	85.81%	26.35%	38.34%	76.88%
SD26	Landings ('000t)	105.1054	31.3391	4.3476	18.2779	159.069
	Herring (%)	11.34%	17.03%	66.47%	33.08%	16.47%
	Sprat (%)	88.66%	82.97%	33.53%	66.92%	83.53%
SD 27	Landings ('000t)	6.579	2.3897	0.0058	0.3092	9.2827
	Herring (%)	32.62%	32.22%	86.21%	96.05%	34.66%
	Sprat (%)	67.38%	67.78%	13.79%	3.95%	65.34%
SD28.1 and SD28.2	Landings ('000t)	57.5671	22.5655	12.2198	39.1038	131.4572
	Herring (%)	30.81%	61.94%	51.37%	47.26%	42.96%
	Sprat (%)	69.19%	38.06%	48.63%	52.74%	57.04%
SD29	Landings ('000t)	7.6295	1.7334	0.9068	10.266	20.5358
	Herring (%)	43.84%	86.77%	22.83%	30.89%	40.06%
	Sprat (%)	56.16%	13.23%	77.17%	69.11%	59.94%
SD30	Landings ('000t)	28.9042	38.18	1.5223	11.515	80.1224
	Herring (%)	97.34%	98.24%	99.39%	91.43%	96.96%
	Sprat (%)	2.66%	1.76%	0.61%	8.57%	3.04%
SD31	Landings ('000t)	0	0.432	0.14	0.355	0.928
	Herring (%)		100.00%	100.00%	100.00%	100.00%

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
	Sprat (%)		0.00%	0.00%	0.00%	0.00%
SD32	Landings ('000t)	12.7586	5.2063	3.6712	16.0402	37.6762
	Herring (%)	48.74%	74.91%	23.29%	38.58%	45.55%
	Sprat (%)	51.26%	25.09%	76.71%	61.42%	54.45%
Total	Landings ('000t)	253.8983	116.2198	28.1112	106.207	504.4382
	Herring (%)	28.48%	56.33%	56.17%	48.44%	40.64%
	Sprat (%)	71.52%	43.67%	43.83%	51.56%	59.36%

Table 4.1.2. Proportion of herring in landings 2022.

COUNTRY	QUARTER	SUBDIVISION							
		25	26	27	28.1&28.2	29	30	31	32
DEN	1	0.11	0.03	0.41	0.03		0.95		
	2						0.93		
	3								
	4		0.02		0.16	0.11			
EST	1				0.78	0.20			0.24
	2				1.00	0.41			0.51
	3				0.49	0.29			0.08
	4				0.58	0.14			0.15
FIN	1					0.69	0.97		0.42
	2					1.00	0.98	1	0.98
	3				0.18	0.22	0.99	1	0.34
	4				0.37	0.52	0.90	1	0.25
GER	1	0.03	0.01	0.01	0.02				
	2		0.01	0.11	0.01				
	3								
	4	0.12			0.07	0.07			
LAT	1	0.02	0.01		0.41				
	2	0.02	0.04		0.48				

COUNTRY	QUARTER	SUBDIVISION							
	3		0.12		0.54				
	4		0.17		0.56				
LIT	1		0.17		0.04	0.09			0.17
	2		0.12		0.00	0.16			0.22
	3		1.00		0.10	0.11			0.00
	4		0.93		0.21	0.09			0.04
POL	1	0.05	0.12		0.00				
	2	0.10	0.11		0.00				
	3	0.71	0.48		0.00				
	4	0.53	0.33		0.00				
RUS	1		0.19						0.94
	2		0.22						0.94
	3		0.89						0.00
	4		0.33						0.87
SWE	1		0.08	0.34	0.14	0.15	0.99		
	2		0.09	0.32	0.35	1.00	0.99	1	
	3			0.87	0.62	1.00	1.00	1	
	4			0.96	0.38	0.47	1.00	1	
Total	1	0.08	0.11	0.33	0.31	0.44	0.97		0.49
	2	0.14	0.17	0.32	0.62	0.87	0.98	1	0.75
	3	0.74	0.66	0.87	0.51	0.23	0.99	1	0.23
	4	0.62	0.33	0.96	0.47	0.31	0.91	1	0.39
Acoust.stock	4	0.62	0.61	0.48	0.42*	0.39	0.94		0.37

*** Only SD 28.2**

Table 4.1.3. Herring in subdivisions 25–32. Samples of commercial catches by quarter and subdivision for 2022 available to the Working Group.

	Quarter	Landings in tonnes	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 25	1	2797	36	1265	631
	2	2039	14	2201	538
	3	3902	5	250	248
	4	6376	13	953	647
	Total	15115	68	4669	2064
	Quarter	Landings in tonnes	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 26	1	11924	33	3069	1021
	2	5338	14	2687	769
	3	2890	1	230	83
	4	6046	11	2296	598
	Total	26197	59	8282	2471
	Quarter	Landings in tonnes	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 27	1	2146	7	350	349
	2	770	7	302	302
	3	5	0	0	0
	4	297	0	0	0
	Total	3217	14	652	651
	Quarter	Landings in tonnes	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 28.2 (includes landings of Central Baltic herring from the Gulf of Riga)	1	3496	34	2461	1674
	2	2319	50	6068	4780
	3	1062	13	2300	1145
	4	6618	35	4226	2317
	Total	13495	132	15055	9916

	Quarter	Landings in tonnes	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 28.1 (Gulf of Riga herring)	1	14238	23	3180	2393
	2	11658	48	5742	4806
	3	5215	9	2090	957
	4	11864	19	3775	2091
	Total	42976	99	14787	10247
	Quarter	**Landings in tonnes**	**Number of samples**	**Number of fish meas.**	**Number of fish aged**
Subdivision 29	1	3345	12	449	845
	2	1504	20	5045	1664
	3	207	4	258	1150
	4	3171	14	485	1694
	Total	8227	50	6237	5353
	Quarter	**Landings in tonnes**	**Number of samples**	**Number of fish meas.**	**Number of fish aged**
Subdivision 30	1	28136	16	5485	637
	2	37508	31	11082	789
	3	1513	4	1270	248*
	4	10528	10	3823	166
	Total	77686	61	21660	1840
	Quarter	**Landings in tonnes**	**Number of samples**	**Number of fish meas.**	**Number of fish aged**
Subdivisoon 31	1	0	0	0	0
	2	432	12	3564	392
	3	140	6	1274	60
	4	355	5	750	32
	Total	928	23	5588	484

	Quarter	Landings in tonnes	Number of samples	Number of fish meas.	Number of fish aged
Subdivisoon 32	1	6218	11	976	976
	2	3900	23	3971	1739
	3	855	5	290	1205
	4	6188	9	612	612
	Total	17161	48	5849	4532
	Quarter	Landings in tonnes	Number of samples	Number of fish meas.	Number of fish aged
Subdivisions 25-32	1	72300	172	17235	8526
	2	65468	219	40662	15779
	3	15789	47	7962	5096
	4	51443	116	16920	8157
	Total	205002	554	82779	37558

*In addition, 2588 age readings from BIAS 2022 were included in SD 30 Q3 age-length keys

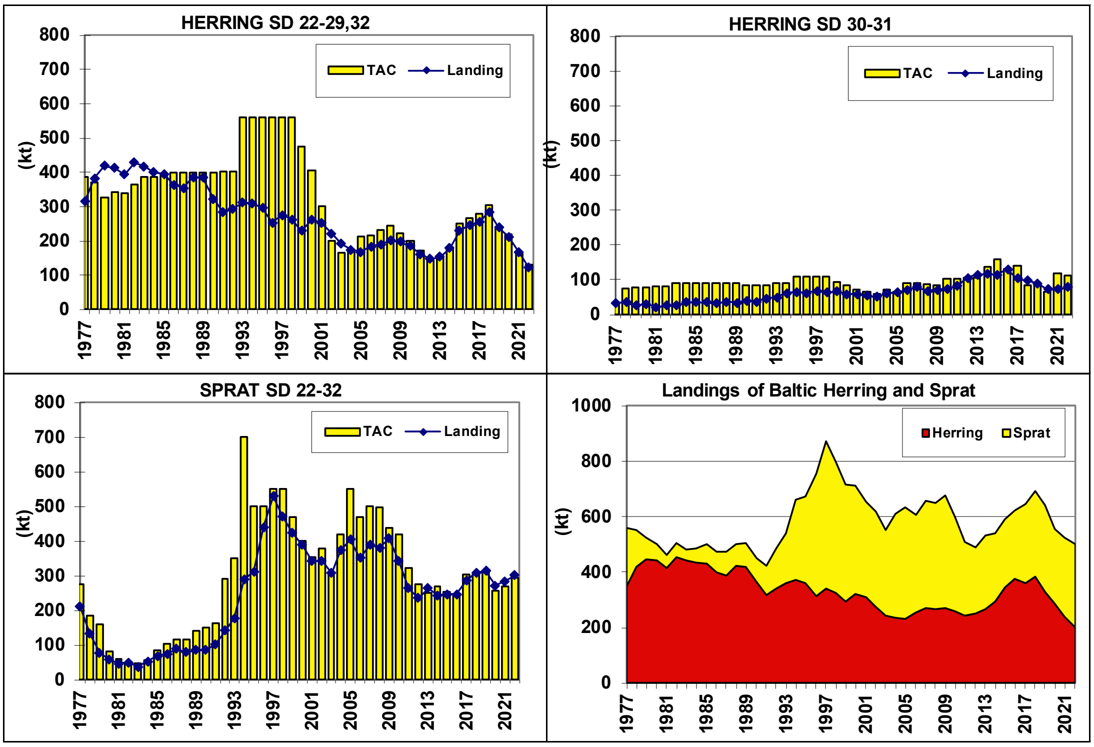


Figure 4.1.2. Reported landings of herring and sprat and agreed TACs in the Baltic Sea. (since 2007 TACs for herring and sprat: EC quota + Russian TAC).

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 2023a) 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 catches for 2022 was officially reported to ICES. Russian catch for 2022 included in the assessment was based on approximate information available at http://atlant.vniro.ru. Catches in 2022 amounted to 83 411 t, which is 35 % lower than last year. Catches decreased for most of the countries: Denmark (-69%), Estonia (-39%), Finland (-48%), Germany (-60%), Lithuania (-60%), Poland (-33%), and Sweden (-53%). The largest part of the catches in 2022 was taken by Russia (estimated catch equals 30% of the total CBH catch), followed by Poland (21%) 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 2022 the spatial distribution of catches was as follows: 31% in SD 26, 21% in SD 32, 18% in SD 25, 16% in SD 28.2, 10% in SD 29, and 4% in SD27. For landings of herring in the Central Baltic management area 2022 per statistical rectangle see the top figure in Figure 4.2.1

4.2.1.2 Discards

Only Finland reported logbook registered discards of 11.5 t (~0.01% of total catch) in 2022. 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 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 2023 most countries provided the age composition of their major catches (caught in their waters by quarter and subdivision). However, no information on Russian catches for 2022 was officially reported to ICES. Russian catch amount for 2022 included in the assessment was based on approximate information available at http://atlant.vniro.ru; 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 42% of the total catches in 2022 (the Russian catches constitute 30% of the total catches in this year).

The compilation of 2022 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 84% in 2021 and 85% in 2022 of the catches in numbers respectively (Figure 4.2.1). The strong year class of 2019 is 3 years old in 2022 and is still contributing to the fishery with 34% 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 catches, catch numbers-at-age and mean weight-at-age by subdivision, whereas Table 4.2.4 shows catch numbers-at-age and mean weight-at-age by subdivision and by quarter.

4.2.2.2 Mean weights-at-age

The mean weights-at-age were compiled by subdivision and quarter for 2022 (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%, bringing these values close to the 2012-2021 average.

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 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.

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 (L_{inf}, k and t_0) 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 Subdivisions 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 was assumed equal to M in 2021. Figure 4.2.5 and Table 4.2.7. show M at age 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 2022 is given in Table 4.2.2. In 2022, sampling was most frequent in SD 28.2. The number of samples in 2022 was comparable to 2021, 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 westernmost 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 Figure 4.2.5 and Table 4.2.7

The model input starts with catch data from year 1903 and age-composition data from 1974 (Figure 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 (ICES, 2023a and stock annex (Annex 5)).

In preparation of the update assessment some minor corrections were made to the benchmark model. First, the sample numbers for the age distributions were not correct and the correct numbers were therefore entered. Second, there was a small mistake (on the third decimal point) in the natural mortality assumed for the historical period (1903-1973) in Run1. Third, the standard errors (SE) of the bias index needed to be corrected (these had erroneously not been updated with the latest estimates during the benchmark) and the extra standard error of the index was removed. The extra standard error was removed as the SE now is estimated externally and entered in the model and the extra SE is not needed. This became apparent as the new sample numbers for the age distributions were corrected (with higher values) and the model including the extra SE put unproportioned weight to the catch data. So, the extra SE was removed to align the weight of the information from the catch age distributions (the new sample numbers) with the information from the survey. The difference in the results of Run 1 in the ensemble from the benchmark before and after these revisions was negligible (Figure 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/SSB_{target} and F/F_{target}) 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 (Figure 4.2.8) and to the catch and survey age compositions (Figure 4.2.9) are acceptable. Pearson residuals for the three models are presented in Figure 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 4.2.10and Figs. 4.2.11 - 4.2.14. The abundances and age frequency distributions passed the ordinary Runs test for all three models (Figure 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% (Figure 4.2.12), indicating a random pattern of the survey's residuals and the age frequency distributions (Winker *et al.*, 2019). The retrospective analyses worsened for the models since the benchmark, i.e. with one year more of data (Figure 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 outside the bounds for all three models (0.34, 0.36 and 0.27 for model 1, 2 and 3, respectively). Forecast Mohn's rho F values were also outside the bounds for two of the models (-0.16 and - 0.19 for model 1 and 2, respectively), indicating a worsened predictive power of these models since the benchmark. 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. Both the mean age predictions of the commercial and survey data, and the predictions of the survey index scored better relative to the naïve model (Figure 4.2.14).

4.2.4.3 Historical stock trend

The resulting stock trajectories for the three models used in the ensemble are shown Figure 4.2.15 and the weighted-median value of the three runs in Figure 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 B_{lim} in the latest years. SSB has been below B_{MSY} 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 F_{MSY} in a few years, increased again to 2018, then to decrease to below F_{MSY} in 2022 (F/F_{MSY} = 0.91) .
- State of the juveniles (Recr): Large year classes were observed in the 1980s. With the exception of the 2014-year class, recruitment has been 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. In this year's assessment the 2022-year class is estimated from the Beverton and Holt stock recruitment function with autocorrelation and is thus close to the long-term average recruitment.

A Kobe plot for the ensemble model is presented in Figure 4.2.17. The Kobe plot considers the time-series of pressure (F/F_{target}) on the y-axis and the state of the stock's biomass (SSB/SSB_{target}) on the x-axis. The reference point is $B_{30\%}$. The orange area indicates healthy stock sizes that are about to be depleted by overfishing. The red area indicates ongoing overfishing and that the stock is too small to produce maximum sustainable yields. The yellow area indicates that the biomass is too small/still recovering and that a reduction in fishing pressure is needed. The green area is the target area for management, indicating sustainable fishing pressure and a healthy stock size capable of producing high yields close to the chosen reference points (MSY or proxies).

The stock trajectory began in 1903 in the downright quadrant (i.e. green quadrant of the Kobe plot), when the biomass was higher compared to the reference points. In the period 1960–2000, the F level increased which resulted in a progressive erosion of the stock size, moving the stock trajectory towards the up-left quadrant (i.e. red quadrant of the Kobe plot). Following this, F has been fluctuating above and below the F reference point, but remained below the SSB reference point since then.

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 100 239 tonnes (EU share (70 822 tonnes) + Russian quota (27 000 tonnes taken from *http://atlant.vniro.ru*) + central Baltic herring stock caught in Gulf of Riga (3211 tonnes [mean 2017–2021]) − Gulf of Riga herring stock caught in central Baltic Sea (794 tonnes [mean 2017–2021]) was used as catch in the in the intermediate year 2023 since the total TAC in 2022 was more than fully exploited (109%). As the short-term forecasts show that SSB is below $B_{trigger}$, F_{upper} is removed from the F ranges in the multiannual plan, and F_{MSY} and Flower is reduced by adding the multiplier SSB2024/$B_{trigger}$ ($F_{MSY} = F_{MSY} * SSB_{2024}/B_{trigger}$). This results in herring catches in the central Baltic in 2024 between 41 706 tonnes and 52 549 tonnes (Table 4.2.11). The resulting catches at the adjusted F_{MSY} in 2024 (52 549 tonnes) is a decrease by 45% relative to the catches at MSY in 2022.

Note that no EU MAP scenario will keep the stock above $B_{trigger}$ in 2024, and the probability of being below B_{lim} is between 31% and 29%. Even a zero catch (in 2024 will not bring the stock above B_{lim} in 2025 with 95% probability. As the EU MAP states that "*Fishing opportunities shall in any event be fixed in such a way as to ensure that there is less than a 5% probability of the spawning stock biomass falling below B_{lim}*", F = 0 should be considered as basis for the advice (Table 4.2.11, catch scenario "EU MAP: P(SSB_{2025} < B_{lim}) > 5 % ~ F = 0").

The decreased catch advice is mainly due to the use of the new benchmark reference points. Both the F and SSB reference points have increased relative to similar fishing mortality levels and stock status. In particular the increase in MSY $B_{trigger}$ resulted in a, relative to last year, large reduction of F when multiplied with the SSB/$MSY_{Btrigger}$ ratio.

Comparison with previous forecast – section asked for by ACOM

The entire ensemble with the three runs are available in the Spin the Data folder – CBH folder

A multi-panel plot comparing Rec, F and SSB from last year and this year's (Model 1) assessments can be found in Figure 4.2.18. The difference between the two assessments (albeit only model 1 from the ensemble) is small.

Figure 4.2.18 shows weight-at-age assumed for 2022 in last year's (2022) forecast compared to weight at age in 2022 estimated from data and used in this year's assessment. The differences are small.

The forecast assumptions for this year's assessment compared to last year's assessment were:

	Year*	Current assessment (2023)	Previous assessment (2022)
Assumed recruitment	2022	18711032 (0-year olds)	9597000 (1-year olds)
	2023	18544632 (0-year olds)	12085820 (1-year olds)
Catch	2022	83411	83505
F	2022	0.23	0.2

***'2022' = Intermediate year in the previous assessment; '2023' = advice year in the previous assessment**

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 (in Annex).

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 was officially reported to ICES. Russian catch amount for 2022 included in the assessment was based on approximate information available in http://atlant.vniro.ru/ (5 April 2023); but no biological information on 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 was 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), makes 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.

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 B_{MSY} trigger since 1985 and has been below B_{lim} since 2020.

Fishing mortality (F_{3-6}) has been above F_{MSY} since 2015 but is in 2022 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 strong recruitment since 2014, resulting in a low number of older ages.

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), makes 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.

Note that no EU MAP scenario will keep the stock above $B_{trigger}$ in 2024, and the probability of being below B_{lim} is between 31 % and 29 %. Even a zero catch (in 2024 will not bring the stock above B_{lim} in 2025 with 95% probability. As the EU MAP states that "*Fishing opportunities shall in any event be fixed in such a way as to ensure that there is less than a 5% probability of the spawning stock biomass falling below B_{lim}*", F = 0 should be considered as basis for the advice (Table 4.2.11, catch scenario "EU MAP: P(SSB_{2025} < B_{lim}) > 5 % ~ F = 0").

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 year's assessment. M in 2022 was assumed to be the same as 2022, 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
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	***24.9	14.6	83.4

*** Preliminary**

**** In 1977–1990 sum of catches for Estonia, Latvia, Lithuania and Russia**

***** Estimated catch.**

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2022 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	706	15	149	149
		2				
		3				
		4				
		Total	706	15	149	149
	Germany	1	33	0	0	0
		2				
		3				
		4	8	0	0	0
		Total	41	0	0	0
	Poland	1	989	10	996	364
		2	1 225	8	1 967	305
		3	2 688	0	0	0
		4	4 161	2	424	122
		Total	9 063	20	3 387	791
	Sweden	1	1 067	11	120	118
		2	809	6	234	233
		3	1 214	5	250	248
		4	2 206	11	529	525
		Total	5 296	33	1 133	1 124
	Latvia	1	2	0	0	0
		2	5	0	0	0
		3				
		4				
		Total	8	0	0	0
	Total	1	2 797	36	1 265	631
		2	2 039	14	2 201	538
		3	3 902	5	250	248
		4	6 376	13	953	647
		Total	15 115	68	4 669	2 064

(cont').
Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2022 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	296	6	7	7
		2				
		3				
		4	3	0	0	0
		Total	299	6	7	7
	Germany	1	127	0	0	0
		2	4	0	0	0
		3				
		4				
		Total	131	0	0	0
	Latvia	1	14	0	0	0
		2	16	0	0	0
		3	29	0	0	0
		4	79	0	0	0
		Total	138	0	0	0
	Lithuania	1	566	8	1 625	609
		2	178	5	1 420	398
		3	2	1	230	83
		4	248	2	347	144
		Total	994	16	3 622	1 234
	Poland	1	3 837	19	1 437	405
		2	1 073	9	1 267	371
		3	936	0	0	0
		4	2 845	9	1 949	454
		Total	8 691	37	4 653	1 230
	Russia	1	5 141	0	0	0
		2	4 017	0	0	0
		3	1 922	0	0	0
		4	2 870	0	0	0
		Total	13 950	0	0	0
	Sweden	1	1 944	0	0	0
		2	50	0	0	0
		3				
		4				
		Total	1 994	0	0	0
	Total	1	11 924	33	3 069	1 021
		2	5 338	14	2 687	769
		3	2 890	1	230	83
		4	6 046	11	2 296	598
		Total	26 197	59	8 282	2 471

(cont').
Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2022 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	469	0	0	0
		2				
		3				
		4				
		Total	469	0	0	0
	Germany	1	4	0	0	0
		2	1	0	0	0
		3				
		4				
		Total	5	0	0	0
	Sweden	1	1 672	7	350	349
		2	769	7	302	302
		3	5	0	0	0
		4	297	0	0	0
		Total	2 744	14	652	651
	Total	1	2 146	7	350	349
		2	770	7	302	302
		3	5	0	0	0
		4	297	0	0	0
		Total	3 217	14	652	651

(cont').
Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2022 available to the Working Group.
4/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Subdivision 28.2 (includes landings of Central Baltic Herring from Gulf of Riga)	Denmark	1	236	3	7	7
		2				
		3				
		4	272	0	0	0
		Total	508	3	7	7
	Estonia	1	210	12	449	449
		2	1 185	6	551	551
		3	105	4	258	258
		4	464	11	389	389
		Total	1 965	33	1 647	1 647
	Finland	1				
		2				
		3	100	0	0	0
		4	1 831	0	0	0
		Total	1 931	0	0	0
	Germany	1	38	0	0	0
		2	1	0	0	0
		3				
		4	24	0	0	0
		Total	64	0	0	0
	Latvia	1	578	9	1 933	1 146
		2	789	40	5 350	4 065
		3	601	9	2 042	887
		4	2 066	10	3 152	1 262
		Total	4 034	68	12 477	7 360
	Lithuania	1	145	0	0	0
		2	5	0	0	0
		3	22	0	0	0
		4	440	1	85	69
		Total	612	1	85	69
	Sweden	1	2 288	10	72	72
		2	338	4	167	164
		3	234	0	0	0
		4	1 522	13	600	597
		Total	4 382	27	839	833
	Total	1	3 496	34	2 461	1 674
		2	2 319	50	6 068	4 780
		3	1 062	13	2 300	1 145
		4	6 618	35	4 226	2 317
		Total	13 495	132	15 055	9 916

(cont').

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2022 available to the Working Group.

5/6

Subdivision 29	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
	Denmark	1				
		2				
		3				
		4	74	0	0	0
		Total	74	0	0	0
	Estonia	1	720	12	449	449
		2	119	5	443	443
		3	31	4	258	258
		4	596	11	389	389
		Total	1 466	32	1 539	1 539
	Finland	1	2 587	0	0	396
		2	1 325	15	4 602	1 221
		3	170	0	0	892
		4	2 375	0	0	1 210
		Total	6 456	15	4 602	3 719
	Germany	1				
		2				
		3				
		4	10	0	0	0
		Total	10	0	0	0
	Lithuania	1	6	0	0	0
		2	12	0	0	0
		3	2	0	0	0
		4	57	0	0	0
		Total	78	0	0	0
	Sweden	1	31	0	0	0
		2	49	0	0	0
		3	4	0	0	0
		4	59	3	96	95
		Total	143	3	96	95
	Total	1	3 345	12	449	845
		2	1 504	20	5 045	1 664
		3	207	4	258	1 150
		4	3 171	14	485	1 694
		Total	8 227	50	6 237	5 353

(cont').
Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2022 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	1 612	11	976	976
		2	1 187	14	1 061	1 061
		3	117	5	290	290
		4	1 328	9	612	612
		Total	4 244	39	2 939	2 939
	Finland	1	675	0	0	0
		2	5	9	2 910	678
		3	738	0	0	915
		4	471	0	0	0
		Total	1 889	9	2 910	1 593
	Lithuania	1	53	0	0	0
		2	6	0	0	0
		3	0	0	0	0
		4	9	0	0	0
		Total	68	0	0	0
	Russia	1	3 877	0	0	0
		2	2 702	0	0	0
		3				
		4	4 380	0	0	0
		Total	10 959	0	0	0
	Total	1	6 218	11	976	976
		2	3 900	23	3 971	1 739
		3	855	5	290	1 205
		4	6 188	9	612	612
		Total	17 161	48	5 849	4 532
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	**29 925**	**133**	**8 570**	**5 496**
		2	**15 870**	**128**	**20 274**	**9 792**
		3	**8 921**	**28**	**3 328**	**3 831**
		4	**28 695**	**82**	**8 572**	**5 868**
		Total	**83 411**	**371**	**40 744**	**24 987**

Table 4.2.3. Herring in SD 25–29, 32 (excl. GoR).

Catch by country and SD and mean weight by SD in 2022.

CATCH (1000 T) BY COUNTRY AND SD							
Country	**Total**	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
Denmark	2.056	0.706	0.299	0.469	0.508	0.074	0.000
Estonia	7.675	0.000	0.000	0.000	1.965	1.466	4.244
Finland	10.276	0.000	0.000	0.000	1.931	6.456	1.889
Germany	0.250	0.041	0.131	0.005	0.064	0.010	0.000
Latvia*	4.180	0.008	0.138	0.000	4.034	0.000	0.000
Lithuania	1.753	0.000	0.994	0.000	0.612	0.078	0.068
Poland	17.754	9.063	8.691	0.000	0.000	0.000	0.000
Russia	24.909	0.000	13.950	0.000	0.000	0.000	10.959
Sweden	14.559	5.296	1.994	2.744	4.382	0.143	0.000
Total	**83.411**	**15.115**	**26.197**	**3.217**	**13.495**	**8.227**	**17.161**

*Catches in SD 28.2 include 1464 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	166686	1060	1218	2478	37246	38985	85699
1	304041	43499	96096	7816	27197	104557	24876
2	325459	31741	32681	7950	36392	100605	116090
3	962324	94363	207091	50970	144774	128162	336965
4	442297	54732	103244	19355	88313	33215	143438
5	374080	52355	118650	20805	69292	34243	78735
6	179266	22889	44510	11426	43293	23679	33468
7	135027	20271	44810	10349	24767	9445	25384
8	111541	13298	45536	3507	19557	7113	22530
9	5664	1648	1517	121	538	250	1591
10+	6081	1209	1439	248	1451	521	1213
Total N	**3012466**	**337066**	**696792**	**135024**	**492821**	**480775**	**869989**
CATON	**83.411**	**15.115**	**26.197**	**3.217**	**13.495**	**8.227**	**17.161**
Mean weight (g)							
AGE	**Mean**	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
0	5.8	16.0	18.6	6.1	7.2	5.4	5.0
1	15.8	33.4	18.6	10.7	19.3	6.6	10.1
2	20.8	44.1	33.9	16.7	23.0	14.7	15.5
3	27.4	41.7	39.0	22.3	26.5	21.6	19.7
4	31.0	47.4	37.3	24.8	29.7	24.4	23.3
5	36.0	49.8	42.6	27.7	32.6	29.3	25.0
6	35.7	48.2	43.5	28.2	34.1	28.5	26.5
7	38.4	51.5	46.1	29.5	33.3	30.4	25.9
8	47.2	57.6	49.4	42.6	39.6	40.1	46.4
9	49.4	57.9	61.4	60.1	33.9	31.4	36.3
10+	57.4	85.3	75.3	66.3	43.0	33.8	33.8

Table 4.2.4. Herring in SD 25–29, 32 (excl. GoR). Catch in number-at-age (millions) per SD and quarter in 2022. 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	167.450	5.898	71.298	2.528	3.937	77.635	6.155
2	109.982	5.609	19.802	2.528	2.343	51.098	28.603
3	382.125	24.983	97.145	37.361	32.788	46.864	142.983
4	142.108	11.908	51.184	12.869	16.847	14.960	34.340
5	168.883	17.677	59.755	15.396	23.130	19.685	33.239
6	79.869	10.334	10.109	7.826	21.226	11.692	18.682
7	68.640	5.725	27.674	7.570	10.464	4.969	12.238
8	52.529	4.902	18.412	1.771	12.049	2.432	12.964
9	1.585	0.035	0.907	0.000	0.000	0.104	0.539
10+	1.613	0.040	0.427	0.000	0.293	0.313	0.539
Total N	1174.785	87.113	356.712	87.848	123.076	229.752	290.283
CATON	29.925	2.797	11.924	2.146	3.496	3.345	6.218
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	26.367	3.810	2.880	4.183	0.553	9.689	5.252
2	70.772	2.941	5.779	3.392	5.016	12.378	41.266
3	217.167	10.188	49.810	10.277	29.282	38.804	78.807
4	102.806	7.055	18.831	4.523	16.348	5.313	50.735
5	78.323	8.321	24.518	4.403	16.862	5.801	18.418
6	44.388	3.697	18.003	2.942	7.698	5.170	6.879
7	32.878	6.263	8.079	2.482	7.546	1.622	6.885
8	27.958	4.213	12.283	1.581	4.071	1.848	3.961
9	1.088	0.534	0.078	0.110	0.366	0.000	0.000
10+	2.023	0.210	0.071	0.230	0.858	0.000	0.654
Total N	603.769	47.231	140.334	34.123	88.600	80.623	212.857
CATON	15.870	2.039	5.338	0.770	2.319	1.504	3.900
Quarter:	**3**						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	6.939	0.000	0.322	0.015	5.343	0.560	0.700
1	31.910	17.127	6.183	0.033	7.110	0.685	0.773
2	27.595	9.254	2.434	0.039	8.165	1.523	6.180
3	70.587	16.773	20.591	0.081	15.305	3.762	14.074
4	44.112	17.127	10.667	0.024	5.297	0.920	10.077
5	32.147	11.986	11.490	0.015	1.942	1.306	5.408
6	13.127	5.141	6.159	0.003	1.051	0.000	0.773
7	7.687	3.438	3.219	0.003	0.524	0.000	0.504
8	10.477	2.731	5.197	0.008	0.453	1.046	1.042
9	1.264	1.028	0.151	0.000	0.064	0.000	0.020
10+	0.717	0.353	0.261	0.000	0.083	0.000	0.020
Total N	246.562	84.959	66.672	0.220	45.338	9.802	39.570
CATON	8.921	3.902	2.890	0.005	1.062	0.207	0.855
Quarter:	**4**						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	159.747	1.060	0.897	2.463	31.904	38.425	84.999
1	78.313	16.664	15.735	1.073	15.597	16.548	12.696
2	117.109	13.937	4.666	1.992	20.868	35.605	40.041
3	292.445	42.419	39.544	3.251	67.398	38.733	101.100
4	153.271	18.641	22.562	1.939	49.820	12.023	48.286
5	94.728	14.371	22.887	0.991	27.358	7.451	21.670
6	41.882	3.718	10.239	0.655	13.318	6.818	7.135
7	25.822	4.844	5.838	0.295	6.233	2.853	5.758
8	20.577	1.452	9.644	0.147	2.984	1.787	4.563
9	1.728	0.050	0.381	0.010	0.108	0.145	1.032
10+	1.728	0.606	0.679	0.017	0.217	0.208	0.000
Total N	987.350	117.762	133.073	12.832	235.806	160.597	327.279
CATON	28.695	6.376	6.046	0.297	6.618	3.171	6.188

continued

Table 4.2.4. Herring in SD 25–29, 32 (excl. GoR). Mean weight-at-age per SD and quarter in 2022. 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	9.5	18.7	13.8	15.6	5.1	5.1	5.4
2	16.8	23.8	33.0	17.0	17.5	12.2	12.5
3	24.3	27.1	35.8	22.1	23.4	19.7	18.3
4	29.0	29.9	35.1	24.2	26.8	23.3	25.0
5	32.7	36.7	41.5	27.1	29.8	24.4	24.2
6	32.1	36.7	44.2	27.8	33.0	28.5	26.2
7	36.6	42.2	45.9	29.1	32.1	27.6	25.3
8	47.3	49.2	48.8	39.7	39.5	37.5	54.6
9	50.9	177.0	60.5	NA	NA	31.0	30.4
10+	48.1	64.0	71.8	NA	49.5	36.1	34.4
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	9.6	23.4	15.9	5.7	8.8	5.8	6.4
2	14.9	34.4	21.8	13.0	14.7	13.0	13.3
3	24.1	42.4	36.9	21.2	22.1	18.3	17.7
4	26.2	44.8	35.0	24.8	26.7	23.0	20.6
5	33.0	47.7	40.3	26.8	29.0	27.3	23.5
6	34.1	47.0	39.2	28.3	31.7	28.6	23.3
7	35.0	43.7	43.1	30.0	31.3	34.1	23.5
8	42.8	49.4	47.9	46.1	34.3	49.9	24.4
9	56.8	68.3	62.5	63.0	37.0	NA	NA
10+	45.9	63.1	86.9	69.1	41.8	NA	33.0
Quarter:	**3**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	6.4	NA	18.8	6.0	6.0	6.0	3.9
1	32.0	39.5	31.5	18.5	17.9	14.4	13.8
2	32.3	49.6	42.0	23.3	22.6	18.8	18.7
3	35.1	47.1	44.3	25.4	26.5	21.2	20.7
4	36.9	45.5	40.6	29.7	30.4	24.5	22.8
5	41.4	48.5	44.9	32.6	34.5	25.0	24.5
6	42.5	42.5	46.5	35.7	33.1	NA	24.1
7	46.1	47.4	48.6	43.8	43.8	NA	23.4
8	49.3	60.4	50.7	45.4	35.5	29.2	39.0
9	49.3	48.9	63.0	23.3	23.3	NA	49.0
10+	67.6	62.8	76.5	NA	64.9	NA	46.1
Quarter:	**4**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	5.7	16.0	18.5	6.1	7.4	5.4	5.0
1	24.7	34.7	36.1	18.5	23.9	13.5	13.6
2	25.3	50.7	48.0	22.5	25.8	18.9	19.3
3	32.0	48.0	46.8	27.8	29.9	27.2	23.0
4	34.3	61.1	42.5	29.0	31.7	26.3	25.0
5	42.5	68.1	46.5	41.2	37.1	44.5	27.7
6	41.9	89.4	48.6	32.5	37.1	28.2	30.7
7	45.3	75.4	50.3	35.7	36.9	33.1	30.5
8	52.0	104.4	51.5	39.6	48.3	39.7	44.0
9	43.3	47.6	62.8	30.2	29.8	31.7	39.1
10+	75.3	107.4	75.9	30.3	30.3	30.3	NA

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 0**	**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		304041	325459	962324	442297	374080	179266	135027	123286

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	0.0158	0.0208	0.0274	0.0310	0.0360	0.0357	0.0384	0.0478

Table 4.2.7.a. Herring in SD 25–29, 32 (excl. GoR). 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*	0.1537	0.2729	0.2011	0.1816	0.1702	0.1615	0.1557	0.1509	0.1460

1974–2021 based on the latest SMS run provided during BWKBALTPEL 2023

***2023 assumed as the 2018-2022 mean**

Table 4.2.7.b. Herring in SD 25–29, 32 (excl. GoR). 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*	0.1954	0.3538	0.2921	0.2753	0.2654	0.2578	0.2533	0.2497	0.2460

1974–2022 based on the latest SMS run provided during BWKBALTPEL 2023

***2023 assumed as the 2018-2022 mean**

Table 4.2.7.c. Herring in SD 25–29, 32 (excl. GoR). 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

1974–2022 based on the latest SMS run provided during BWKBALTPEL 2023

***2023 assumed as 2018-2022 mean**

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	0.2558	0.7199	0.9162	0.9730	0.9885	0.9955	0.9987	0.9998	0.9999

1974–2022 based on the latest analysis provided during BWKBALTPEL 2023

***2023 assumed as 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

The new tuning index provided by the WGBIFS (ICES, 2023a) includes ICES 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				
	Positive	Covergence	Run test and RMSE					Retrospective analysis				Hindcasting (MASE)				
Run name	Hessian		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	Not Passed	Passed	Not Passed	Passed	Passed	Passed	Passed	0.83
Run2	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Not Passed	Not Passed	Passed	Not Passed	Passed	Passed	Passed	Passed	0.75
Run3	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Not Passed	Passed	Passed	Passed	Passed	Passed	Passed	0.92

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	Fishing pressure relative to F_{MSY}		
	Age 0	5%	95%	SSB	5%	95%	Catch	Ages 3–6	5%	95%
	thousands			tonnes			tonnes			
1904	28604267	23106943	45647978	2.89	2.26	4.31	20104	0.022	0.0119	0.033
1905	28598611	23141908	45827352	2.90	2.26	4.33	33402	0.037	0.020	0.055
1906	28571695	23141169	45811759	2.89	2.26	4.31	37064	0.041	0.022	0.061
1907	28562536	23219781	45475406	2.87	2.25	4.29	53899	0.060	0.032	0.089
1908	28592225	23110844	45593169	2.86	2.23	4.26	60539	0.068	0.037	0.101
1909	28573666	23085745	45635689	2.83	2.22	4.23	50956	0.058	0.031	0.086
1910	28503533	23140167	45580626	2.81	2.20	4.23	46499	0.053	0.028	0.079
1911	28537855	23132119	45568631	2.81	2.19	4.22	39896	0.046	0.024	0.068
1912	28515899	23063484	45598619	2.81	2.19	4.20	35571	0.041	0.022	0.060
1913	28503700	23144251	45516983	2.81	2.19	4.20	41262	0.047	0.025	0.070
1914	28519751	23088861	45429398	2.81	2.19	4.20	33908	0.039	0.021	0.058
1915	28545756	23091214	45573144	2.80	2.19	4.21	34578	0.039	0.021	0.059
1916	28584431	23136846	45556634	2.81	2.19	4.20	41322	0.047	0.025	0.070
1917	28558763	23137241	45468706	2.80	2.19	4.19	48588	0.056	0.030	0.083
1918	28524308	23113798	45692677	2.80	2.18	4.20	47308	0.054	0.029	0.081
1919	28547012	23103057	45446154	2.79	2.18	4.20	43540	0.050	0.027	0.075
1920	28456264	23105710	45472003	2.79	2.17	4.20	41328	0.048	0.025	0.071
1921	28507105	23084999	45624705	2.78	2.17	4.17	40591	0.047	0.025	0.070
1922	28542839	23059369	45555836	2.79	2.17	4.20	39800	0.046	0.024	0.068
1923	28498103	23097415	45597726	2.79	2.17	4.19	41661	0.048	0.026	0.072
1924	28489789	23088324	45582077	2.79	2.17	4.19	42003	0.048	0.026	0.072
1925	28528949	23118357	45476074	2.79	2.17	4.19	39424	0.045	0.024	0.068
1926	28562908	23111364	45727590	2.79	2.18	4.19	40365	0.046	0.025	0.069
1927	28512417	23048331	45496640	2.79	2.17	4.18	41909	0.048	0.026	0.072
1928	28476280	23091266	45688144	2.79	2.17	4.17	43907	0.051	0.027	0.076
1929	28511100	23030539	45565934	2.78	2.17	4.21	47677	0.055	0.029	0.083

Year	Recruitment			SSB relative to MSY $B_{trigger}$*			Total	Fishing pressure relative to F_{MSY}		
	Age 0	5%	95%	SSB	5%	95%	Catch	Ages 3–6	5%	95%
	thousands			tonnes			tonnes			
1930	28556081	23119326	45492776	2.77	2.17	4.17	47093	0.055	0.029	0.082
1931	28492581	23109065	45330718	2.77	2.16	4.18	42068	0.049	0.026	0.072
1932	28499213	23061508	45638313	2.77	2.16	4.19	47373	0.055	0.029	0.082
1933	28509530	23092481	45396431	2.77	2.16	4.17	51086	0.059	0.031	0.089
1934	28441703	23056477	45600444	2.76	2.16	4.17	56079	0.065	0.034	0.097
1935	28434775	23019878	45558585	2.76	2.14	4.17	60507	0.071	0.037	0.106
1936	28510488	23074407	45672742	2.74	2.14	4.14	67497	0.080	0.042	0.119
1937	28411603	23011072	45407671	2.73	2.12	4.12	64562	0.077	0.040	0.114
1938	28408607	22986206	45434785	2.71	2.11	4.10	64712	0.077	0.041	0.116
1939	28444923	23014945	45166831	2.70	2.11	4.09	48609	0.058	0.031	0.087
1940	28432506	23030940	45210945	2.71	2.11	4.09	42721	0.051	0.027	0.076
1941	28433478	23030756	45165622	2.72	2.11	4.11	57754	0.069	0.036	0.103
1942	28434724	23055673	45353611	2.71	2.11	4.10	68085	0.081	0.043	0.122
1943	28422095	23005115	45245640	2.69	2.10	4.11	75808	0.091	0.047	0.136
1944	28427736	22991426	45112344	2.68	2.09	4.06	60906	0.073	0.039	0.110
1945	28403702	22963197	45306802	2.67	2.08	4.06	62807	0.076	0.040	0.114
1946	28446828	22955430	45162787	2.67	2.08	4.06	46604	0.056	0.029	0.085
1947	28455685	22977815	45226512	2.68	2.08	4.09	38913	0.047	0.024	0.070
1948	28438288	23015594	45434447	2.70	2.10	4.10	41791	0.050	0.026	0.075
1949	28402829	23015578	45387515	2.71	2.11	4.11	62362	0.075	0.039	0.11
1950	28427616	23023116	45294392	2.69	2.10	4.10	66595	0.080	0.042	0.12
1951	28474830	23017846	45250808	2.69	2.09	4.06	56712	0.068	0.036	0.10
1952	28410513	22975516	45443237	2.69	2.09	4.09	52949	0.064	0.033	0.10
1953	28418759	23060311	45200699	2.69	2.10	4.08	86728	0.10	0.055	0.16
1954	28338662	22953668	45255696	2.66	2.08	4.05	83947	0.10	0.054	0.15
1955	28347134	22985813	45132481	2.65	2.05	4.03	184885	0.23	0.12	0.35
1956	28312778	22885471	44988781	2.55	1.98	3.91	180244	0.23	0.12	0.36

Year	Recruitment			SSB relative to MSY $B_{trigger}$*			Total	Fishing pressure relative to F_{MSY}		
	Age 0	5%	95%	SSB	5%	95%	Catch	Ages 3–6	5%	95%
	thousands			tonnes			tonnes			
1957	28231657	22767408	44699845	2.46	1.90	3.80	152126	0.20	0.10	0.31
1958	28108923	22731232	44722811	2.42	1.85	3.74	165452	0.23	0.12	0.35
1959	28055816	22673064	44468467	2.36	1.82	3.70	168709	0.24	0.12	0.37
1960	28019785	22665224	44332482	2.31	1.77	3.63	154894	0.23	0.11	0.35
1961	27968141	22653566	44409002	2.27	1.75	3.60	162346	0.24	0.12	0.37
1962	27914513	22632259	44153319	2.24	1.72	3.56	162767	0.24	0.12	0.38
1963	27867434	22556199	44048668	2.21	1.69	3.53	205899	0.32	0.16	0.49
1964	27818124	22473675	44080003	2.14	1.64	3.45	181712	0.29	0.14	0.45
1965	27712463	22416744	43589251	2.11	1.60	3.41	194208	0.31	0.15	0.49
1966	18625725	9074727	40770609	2.06	1.57	3.38	216123	0.36	0.17	0.57
1967	22325971	11048324	48609640	1.99	1.51	3.27	269141	0.48	0.22	0.76
1968	18286801	9719920	35966928	1.85	1.40	3.06	323765	0.63	0.29	0.98
1969	18154277	10647828	31429605	1.64	1.25	2.78	269536	0.58	0.27	0.90
1970	35184510	24750208	52371798	1.49	1.15	2.54	288626	0.69	0.33	1.05
1971	22477928	15738804	33182866	1.34	1.03	2.30	305211	0.81	0.40	1.21
1972	31375767	23849288	43481920	1.28	0.97	2.23	268832	0.77	0.38	1.12
1973	31288810	23853819	42757115	1.25	0.94	2.17	376787	1.18	0.58	1.68
1974	26423215	19775790	36706072	1.15	0.86	2.00	368652	1.30	0.64	1.86
1975	44219717	34671530	59374288	1.15	0.85	1.99	354851	1.30	0.64	1.89
1976	27907780	21155029	38201703	1.05	0.77	1.83	305420	1.20	0.59	1.76
1977	40149580	29600688	52889347	1.19	0.85	2.06	301952	1.06	0.53	1.58
1978	34263135	24013104	46911041	1.27	0.91	2.18	278966	0.94	0.47	1.42
1979	64016248	46685631	83580233	1.29	0.92	2.20	278182	0.96	0.49	1.46
1980	88476138	66316277	110012786	1.18	0.84	1.99	270282	0.98	0.49	1.48
1981	64533241	47834448	83668921	1.11	0.79	1.88	293615	1.08	0.54	1.60
1982	43460852	32247152	58260263	1.16	0.84	2.00	273134	1.01	0.50	1.49
1983	54945098	42199644	72330587	1.18	0.86	2.03	307601	1.22	0.60	1.77

Year	Recruitment			SSB relative to MSY $B_{trigger}$*			Total	Fishing pressure relative to F_{MSY}		
	Age 0	5%	95%	SSB	5%	95%	Catch	Ages 3–6	5%	95%
	thousands			tonnes			tonnes			
1984	39468751	30959722	53144474	1.02	0.76	1.78	277926	1.23	0.59	1.76
1985	15185333	11217469	21659336	0.99	0.74	1.73	275760	1.29	0.62	1.85
1986	37055976	29726061	49698835	0.86	0.65	1.51	240516	1.25	0.60	1.77
1987	11099407	8035085	16072517	0.84	0.64	1.47	255498	1.38	0.66	1.94
1988	18574883	14626325	26385983	0.89	0.67	1.56	262558	1.45	0.69	2.04
1989	19954671	16048058	29087479	0.80	0.62	1.42	276066	1.69	0.79	2.36
1990	12166855	9304249	18317242	0.65	0.49	1.17	227617	1.67	0.78	2.34
1991	18289199	14540344	27210024	0.64	0.49	1.18	197610	1.51	0.70	2.12
1992	16260620	12348600	24218123	0.59	0.45	1.07	190258	1.42	0.67	2.03
1993	12554010	9186150	18937906	0.61	0.46	1.09	212101	1.61	0.76	2.31
1994	17748613	13803611	26529386	0.64	0.48	1.14	218116	1.62	0.76	2.33
1995	15421515	12119648	23281828	0.53	0.40	0.94	187409	1.67	0.78	2.37
1996	7926350	5891571	12410528	0.45	0.34	0.80	161148	1.60	0.75	2.28
1997	14228926	11304039	22234740	0.43	0.32	0.77	159056	1.71	0.79	2.44
1998	6388314	4584772	10660377	0.42	0.31	0.75	184140	2.10	0.97	3.05
1999	20475594	15532198	33230264	0.36	0.26	0.66	145717	1.86	0.85	2.78
2000	11226759	8174589	19358619	0.39	0.27	0.73	174301	2.18	0.95	3.32
2001	12599455	9208477	21960613	0.36	0.25	0.70	137080	1.89	0.80	2.92
2002	27869672	20894866	46766395	0.35	0.24	0.71	128344	1.70	0.70	2.65
2003	13518238	9913351	23133243	0.37	0.26	0.78	112118	1.32	0.54	2.08
2004	8801829	6311547	15236998	0.38	0.26	0.80	95151	1.04	0.42	1.65
2005	17777588	13180450	28974099	0.43	0.29	0.88	91094	0.93	0.39	1.48
2006	13788774	10115298	22732986	0.47	0.32	0.93	113536	1.07	0.45	1.69
2007	30396758	22696418	47668762	0.48	0.33	0.95	115790	0.99	0.42	1.56
2008	18967581	13879880	30248509	0.47	0.33	0.93	126363	1.08	0.47	1.70
2009	15542150	11340902	25085740	0.56	0.38	1.10	135659	1.19	0.51	1.86
2010	8567558	6091638	14426745	0.52	0.36	1.01	137189	1.20	0.52	1.88

Year	Recruitment			SSB relative to MSY $B_{trigger}$*			Total	Fishing pressure relative to F_{MSY}		
	Age 0	5%	95%	SSB	5%	95%	Catch	Ages 3–6	5%	95%
	thousands			tonnes			tonnes			
2011	22906474	17284978	36671337	0.48	0.33	0.95	118563	1.11	0.47	1.71
2012	20988774	15930346	33405842	0.48	0.34	0.94	101526	0.81	0.35	1.25
2013	13879268	10385539	22206107	0.55	0.39	1.07	100484	0.77	0.33	1.16
2014	50982828	40696516	77162569	0.60	0.43	1.15	134482	1.00	0.45	1.51
2015	12101986	9291211	19549898	0.55	0.40	1.04	174945	1.35	0.61	2.03
2016	14026097	11099004	22594426	0.58	0.42	1.08	190641	1.59	0.71	2.39
2017	14188278	11384676	23055729	0.62	0.45	1.16	199428	1.53	0.68	2.29
2018	7751012	5927039	12998488	0.60	0.44	1.12	240738	2.00	0.88	2.99
2019	17735135	13821757	29667794	0.51	0.37	0.98	200956	1.85	0.81	2.78
2020	7263307	5093283	12717947	0.41	0.29	0.80	174521	1.91	0.83	2.88
2021	6653760	4186745	12014436	0.37	0.25	0.73	128961	1.69	0.73	2.61
2022	18711032	14370833	27005779	0.40	0.27	0.80	83411**	0.91	0.40	1.44
2023	18544632	14101051	26420268	0.39	0.26	0.76				

*** 1 January.**

**** Landings of Russia were not officially reported to ICES, the estimate of information on Russian landings available on http://atlant.vniro.ru/**

Table 4.2.11. Herring in subdivisions 25–29 and 32, excluding the Gulf of Riga. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2024)	Fishing mortality F_{2024}/F_{MSY}	Stock Size B_{2025}/MSY $B_{trigger}$	% Probability of SSB (2025) < Blim ^	Probability of SSB (2025) < MSY $B_{trigger}$(%) ^	% SSB change*	% Advice change **
EU MAP ^^: F = F_{MSY} × SSB_{2024}/MSY $B_{trigger}$	52549	0.46	0.60	31	92	29	-45
EU MAP ^^: F = MAP range F_{lower} × SSB_{2024}/MSY $B_{trigger}$	41706	0.36	0.61	29	91	31	-41
EU MAP^^^: P(SSB_{2025} < B_{lim}) > 5 % ~ F = 0	0	0.00	0.64	22	88	39	-100
F_{MSY}	108434	1.0	0.55	40	95	19	13
F_{lower}	82577	0.75	0.57	35	94	24	18
F_{upper}	126785	1.21	0.54	43	96	15	33
EU MAP ^^: F = MAP range F_{upper} × SSB_{2024}/MSY $B_{trigger}$	62558	0.56	0.59	33	93	27	-35
F = F_{pa} × SSB_{2024}/MSY $B_{trigger}$	62558	0.56	0.59	33	93	27	-35
SSB (2025) = B_{lim}	166822	1.66	0.50	49	98	-0.54	74
SSB (2025) = B_{pa} ##							
SSB (2025) = MSY $B_{trigger}$ ##							
SSB (2025) = SSB (2024)	208527	2.20	0.47	56	99	-1.6#	118
F = F_{2023}	116775	1.103	0.55	40	96	15	22

*** SSB 2025 relative to SSB 2024.** Advice values for 2024 relative to the corresponding 2023 values (EU MAP advice of 95 643 [F_{MSY}], 95 643 [F_{upper}] and 70 130 [F_{lower}] tonnes, respectively; other values are relative to 95 643 tonnes).**

^ The probability of SSB being below SSB reference points in 2025. This probability relates to the short-term probability of SSB < B_{lim} and MSY $B_{trigger}$ and is not comparable to the long-term probability of SSB < B_{lim} and MSY $B_{trigger}$ tested in simulations when estimating fishing mortality reference points.

^^ MAP multiannual plan (EU, 2016, 2019).^^^ Following the EU MAP plan when the probability of SSB (2025) < B_{lim} is greater than 5 %.

 # Based on stochastic forecasts, using the F with two decimals to get close to the biomass target.

The B_{pa}, and MSY $B_{trigger}$ options were left blank because B_{pa}, and MSY $B_{trigger}$ cannot be achieved in 2025 even with zero catch in 2024.

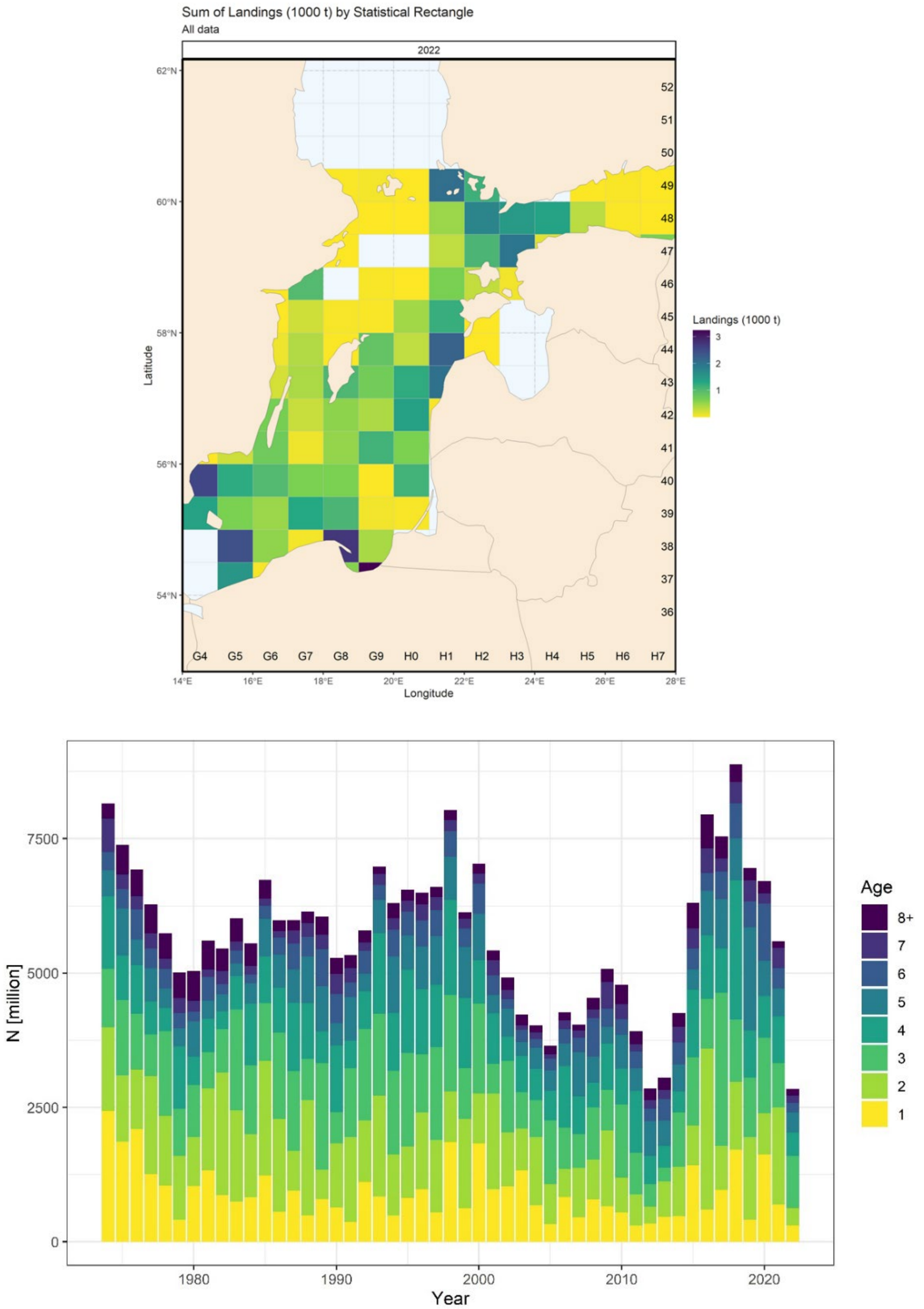


Figure 4.2.1. Herring in SD 25–29, 32 (excl. GoR). Top figure: Sum of Landings (1000 t) by Statistical Rectangle. All data. 0.21% of Landings (1000 t) - reported for missing Statistical Rectangle.Bottom figure: Proportions of age groups (numbers) in the total catch (CANUM).

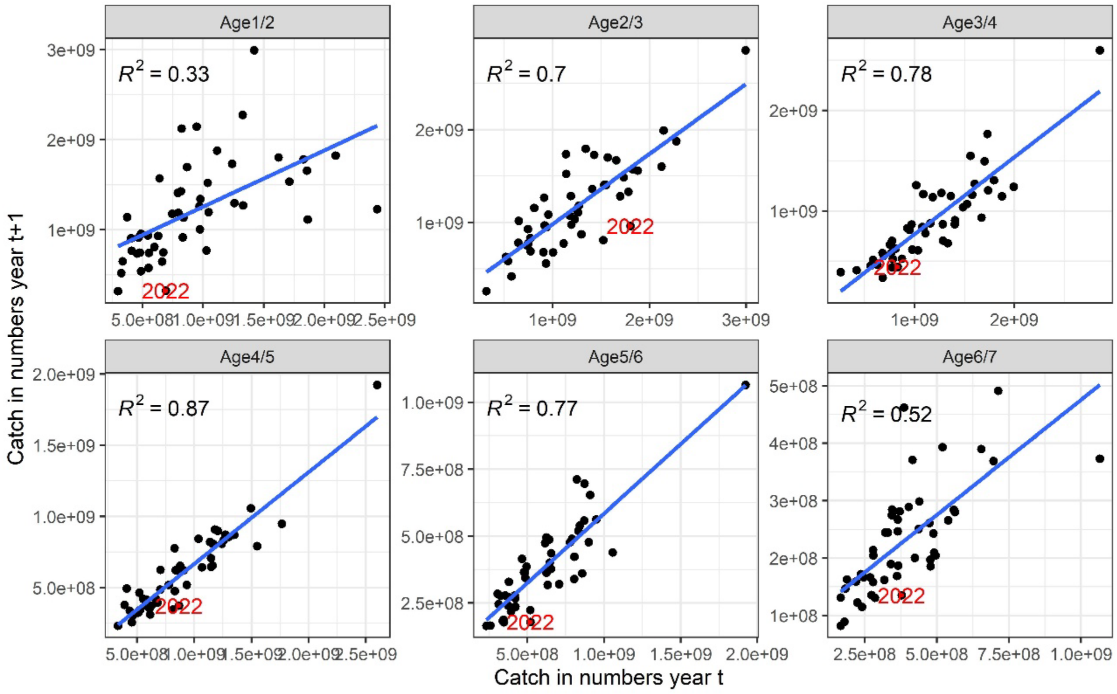


Figure 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Catch in numbers (thousands) at age vs. numbers-at-age +1 of the same cohort in the following year in the period 1974–2022.

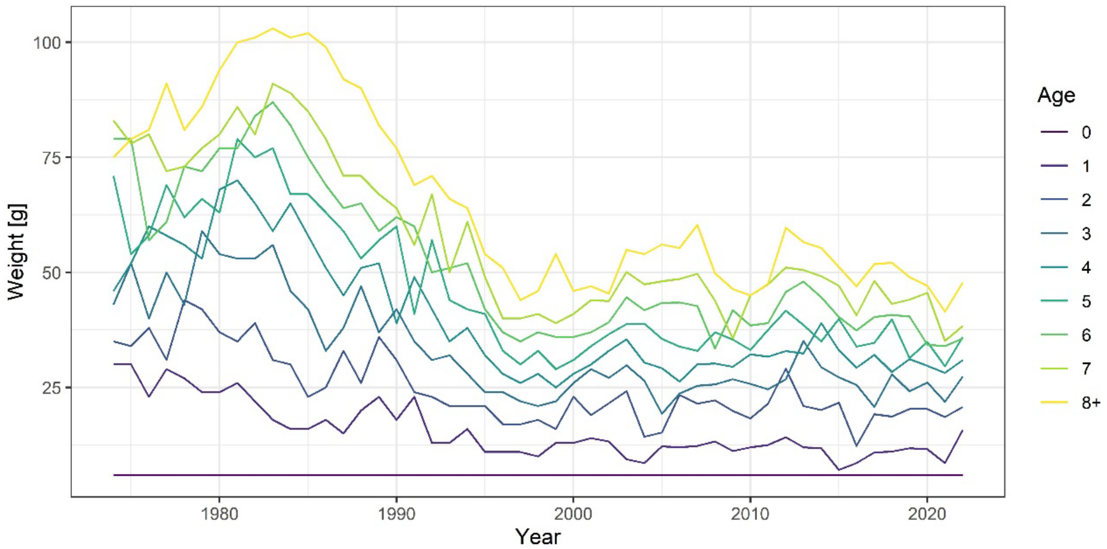


Figure 4.2.3. Herring in SD 25–29, 32 (excl. GoR).
Trends in the mean weights at age (g) in the catch (WECA).

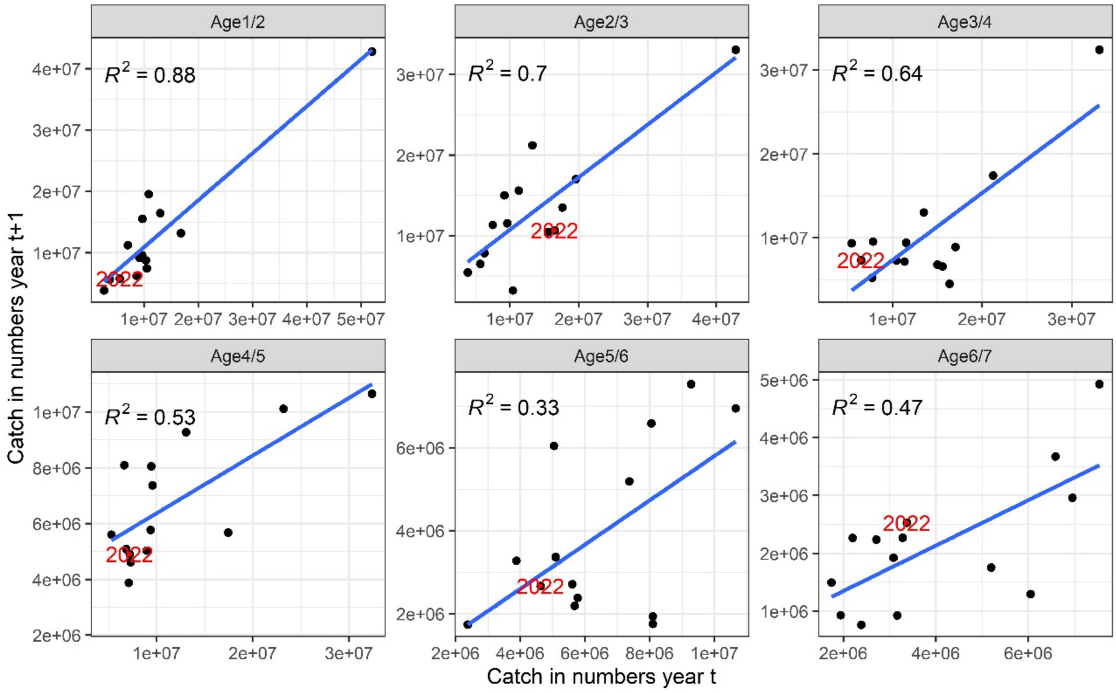


Figure 4.2.4 Herring in SD 25–29, 32 (excl. GoR). Acoustic survey numbers-at-age vs. numbers-at-age +1 of the same cohort in the following year (index values presented in Table 4.2.11 are used).

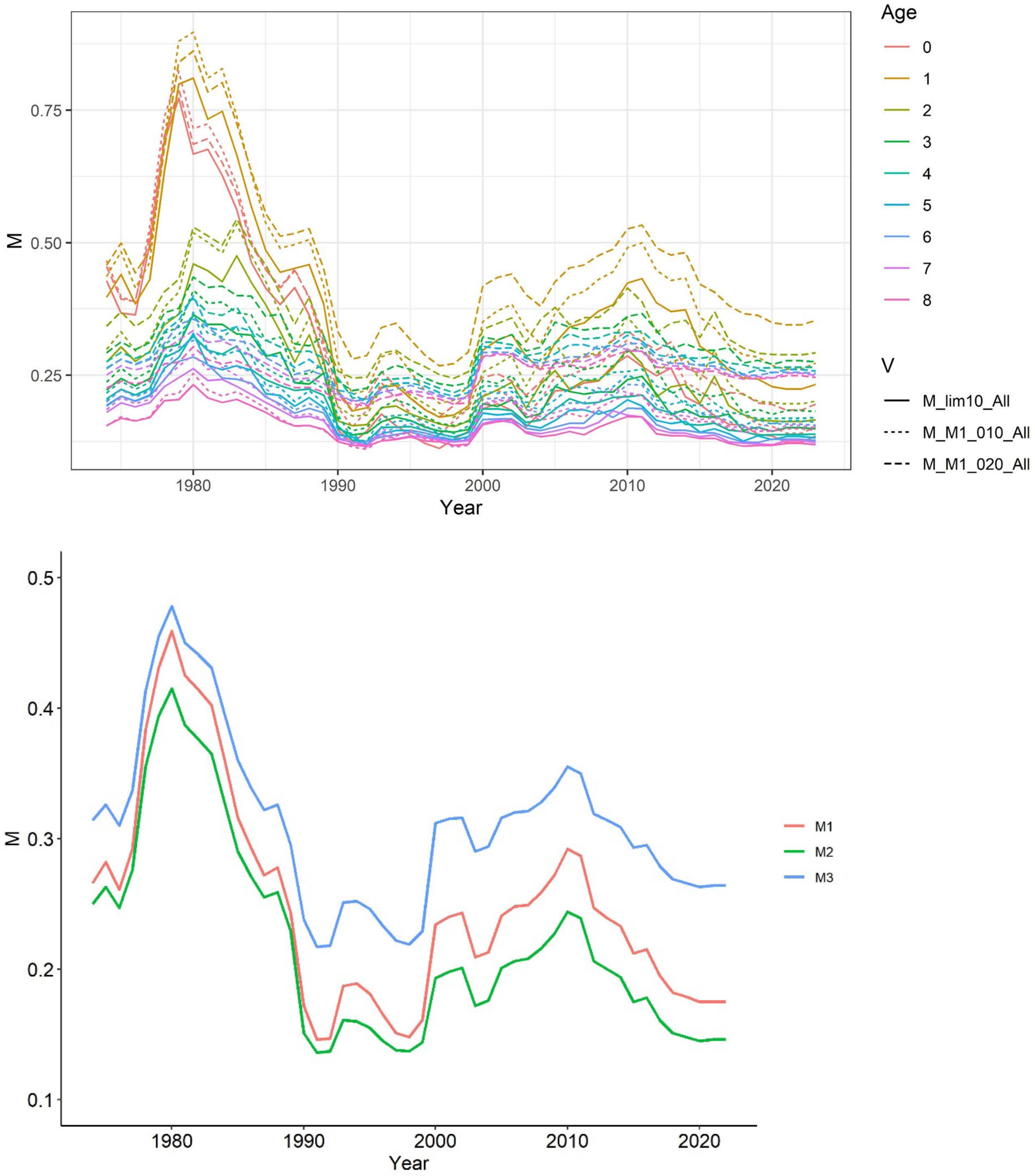


Figure 4.2.5 Herring in SD 25–29, 32 (excl. GoR). The Natural mortality-at-age estimates used in the ensemble, i.e. for Model 1 (M1_010_All), 2 (M1_020_All) and 3 (M_lim10_all) (top). Mean natural mortality for each of the models (bottom) Min 2022 was assumed to be = 2021.

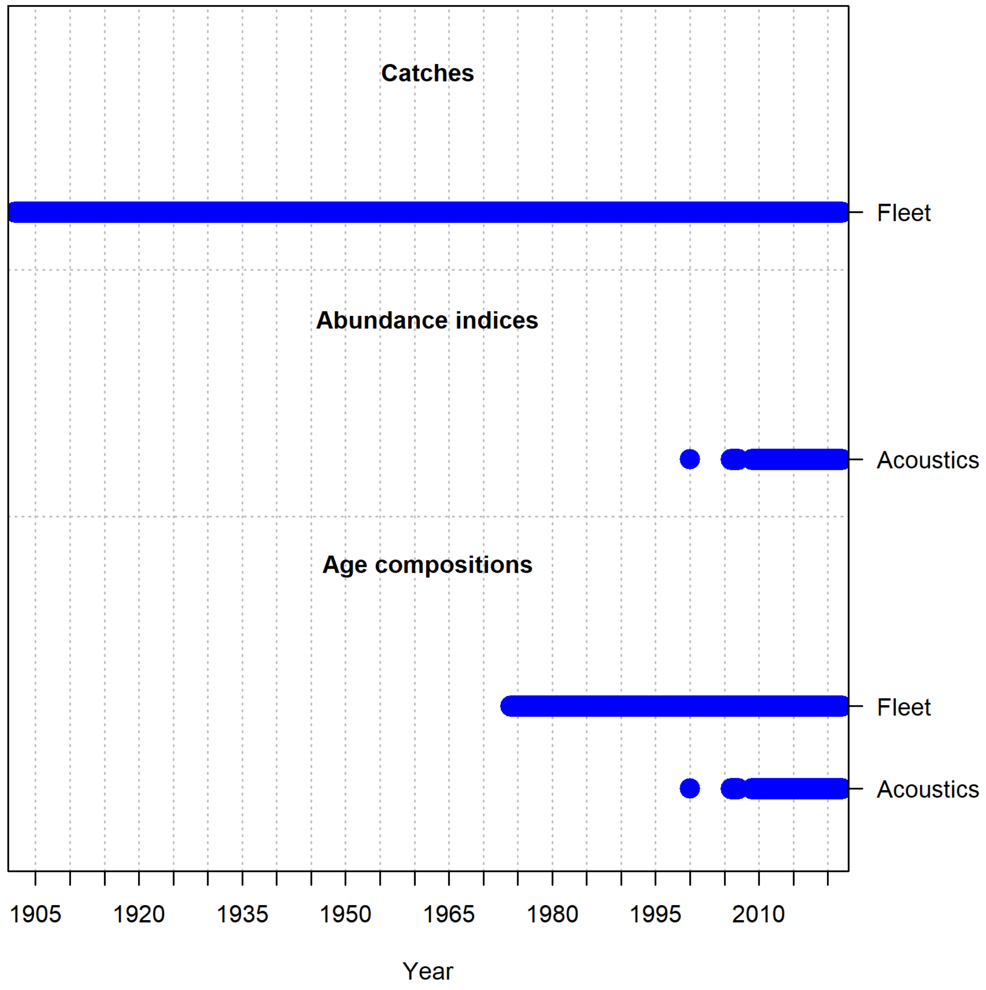


Figure 4.2.6 Herring in SD 25–29, 32 (excl. GoR). Overview of data included in each of the models of the ensemble. 1

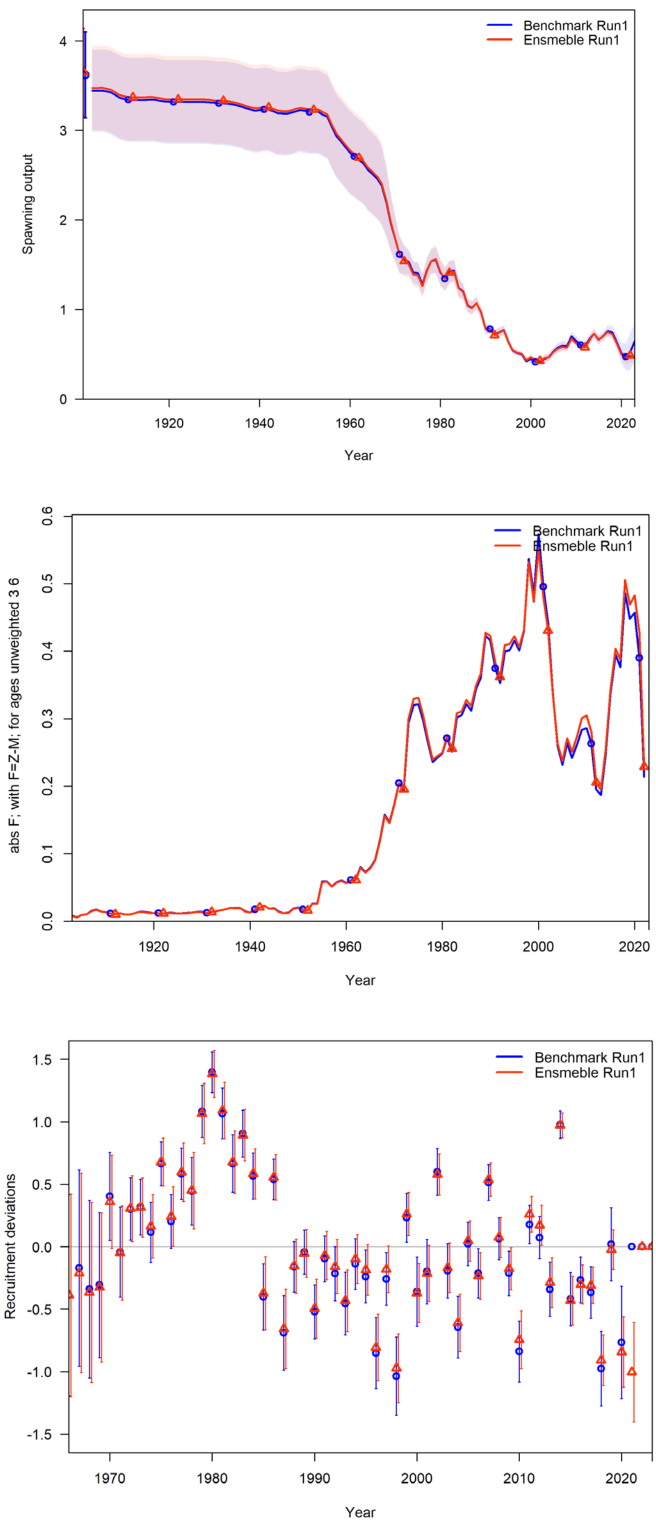
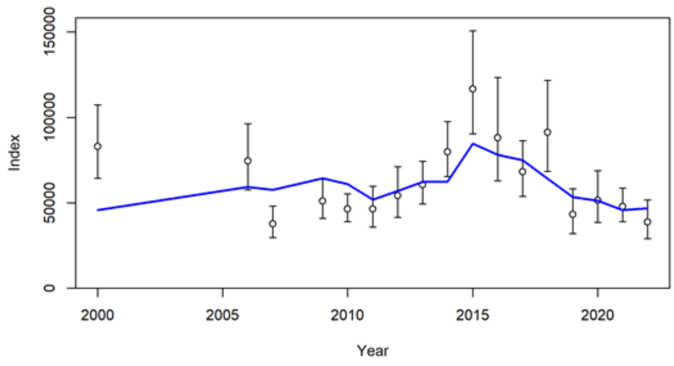
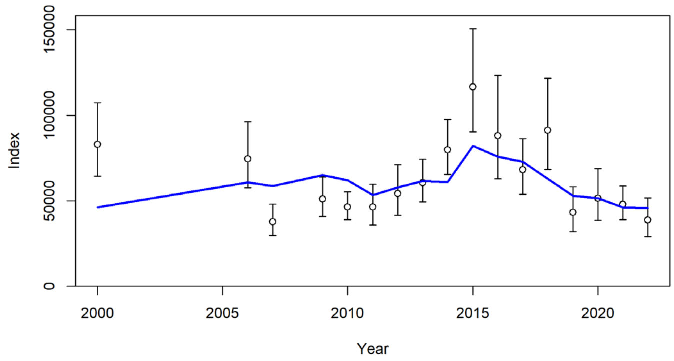


Figure 4.2.7 Herring in SD 25–29, 32 (excl. GoR). Model 1 in the ensemble from the benchmark before and after revisions. Benchmark Run1 = model 1 in the benchmark and Ensemble Run 1 = Benchmark Model 1 after revisions.

Model 1



Model 2



Model 3

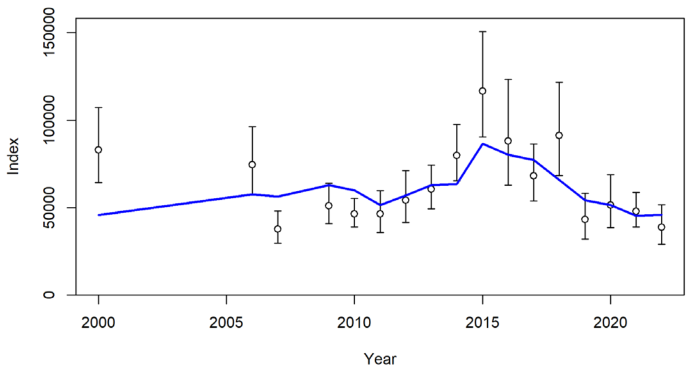
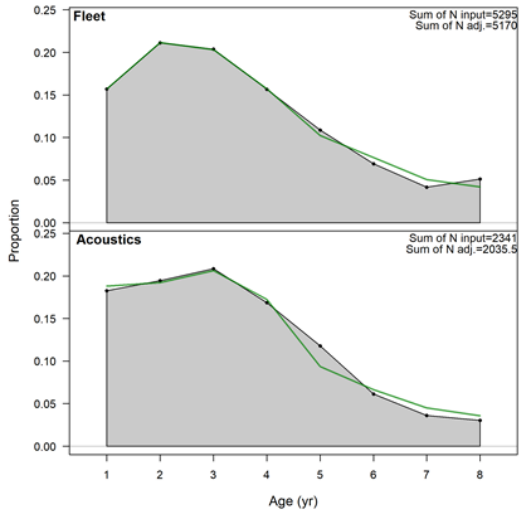
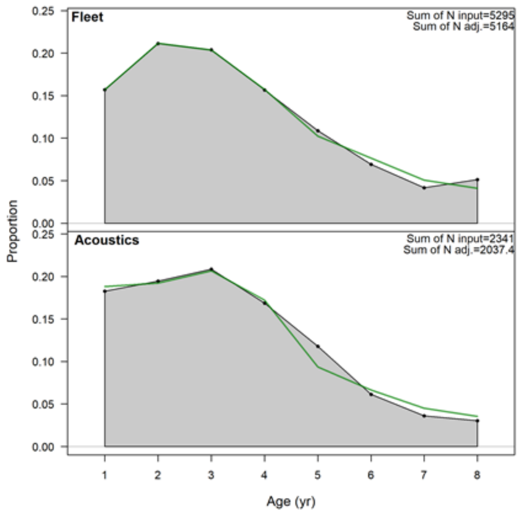


Figure 4.2.8 Herring in SD 25–29, 32 (excl. GoR). The fit of the model to the survey index abundances for the three models in the ensemble.

Model1



Model 2



Model 3

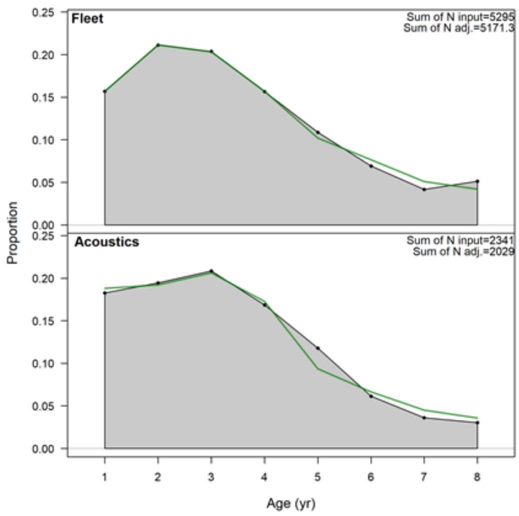
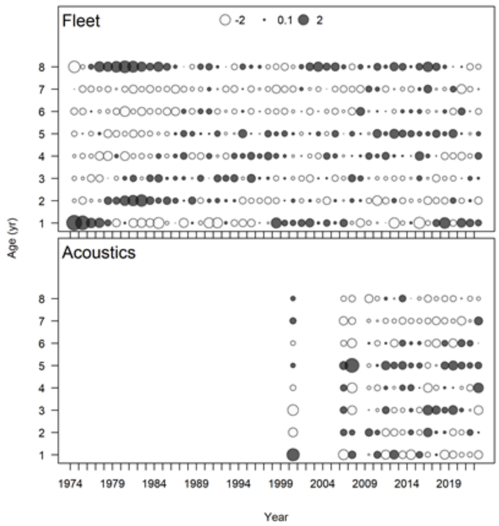
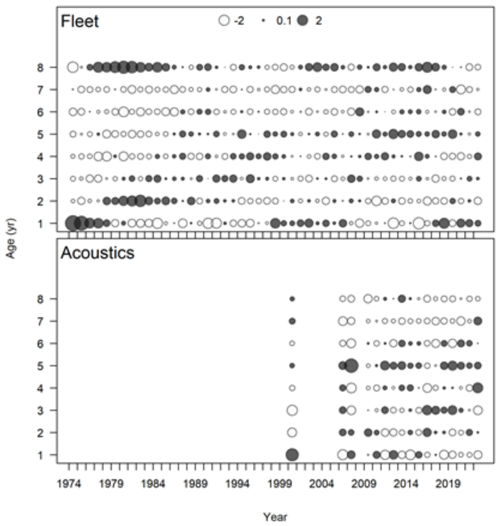


Figure 4.2.9 Herring in SD 25–29, 32 (excl. GoR). The fit of the models (green line) to the age compositions for the fleet (catch) and the survey data, aggregated across time.

Model 1



Model 2



Model 3

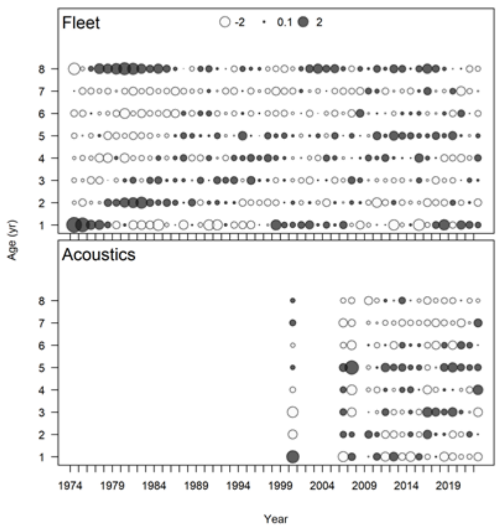
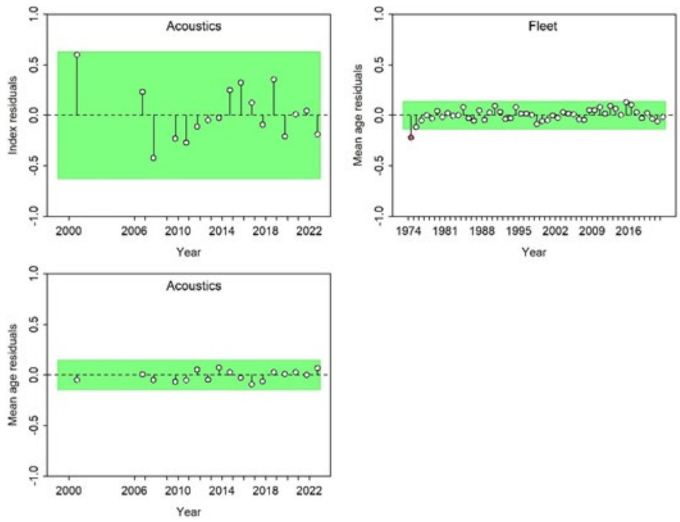
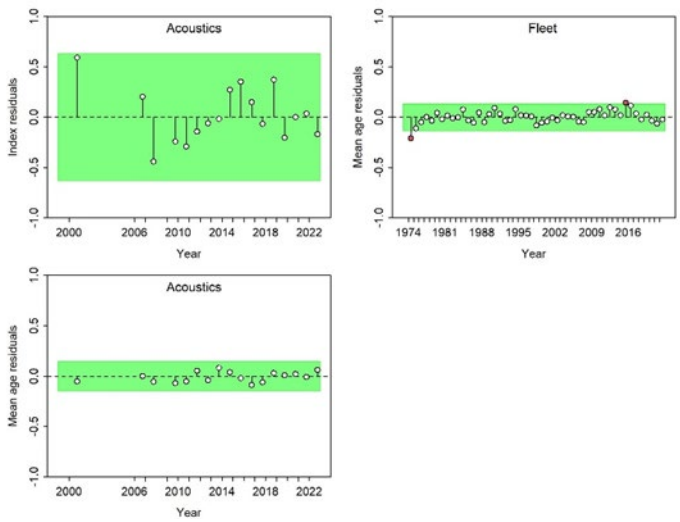


Figure 4.2.10 Herring in SD 25–29, 32 (excl. GoR). Pearson residuals for commercial (catch) and the survey data. Filled and open bubbles denote positive and negative residuals respectively.

Model 1



Model 2



Model 3

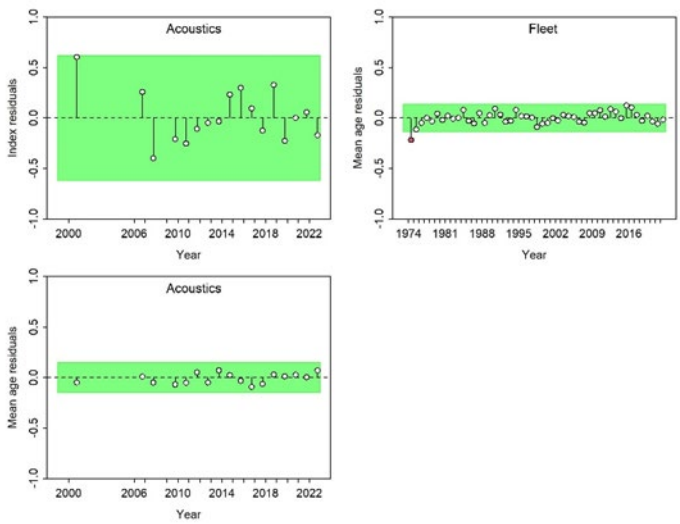
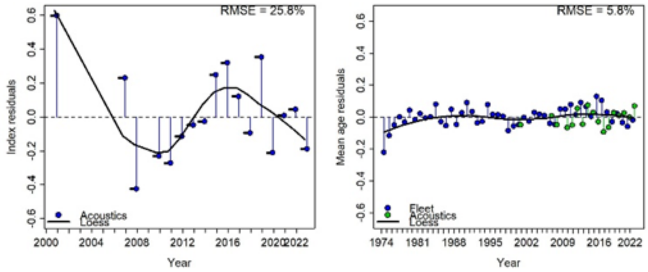
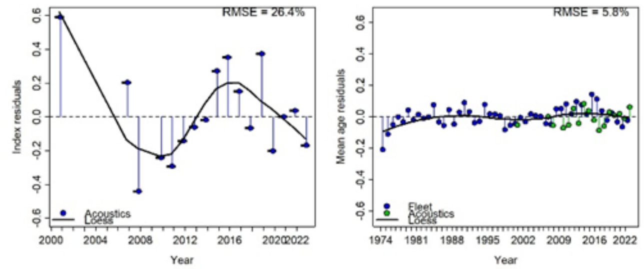


Figure 4.2.11 Herring in SD 25–29, 32 (excl. GoR). Residuals from Runs test analyses for the age distributions of the commercial fleet and survey, and the fit to the survey index, for all three models.

Model 1



Model 2



Model 3

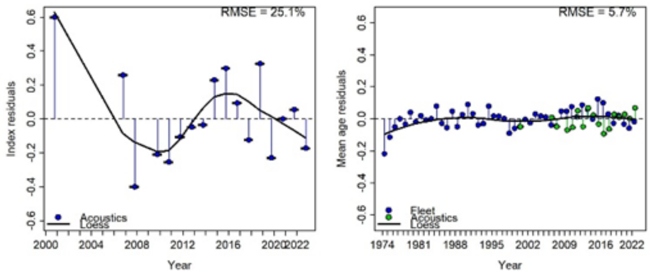
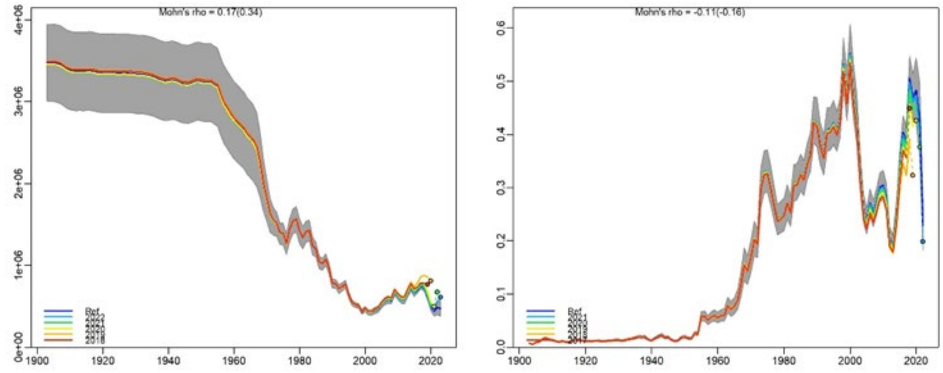
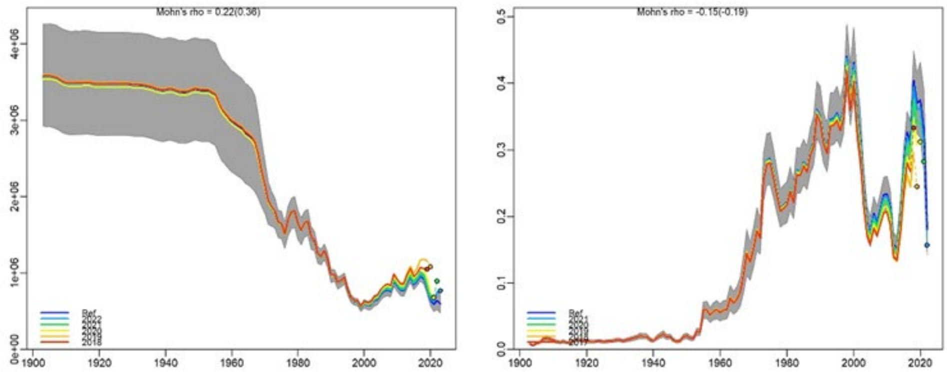


Figure 4.2.12 Herring in SD 25–29, 32 (excl. GoR). Residuals from the RMSE test for the age distributions of the commercial fleet and survey, and the fit to the survey index, for all three models.

Model 1



Model 2



Model 3

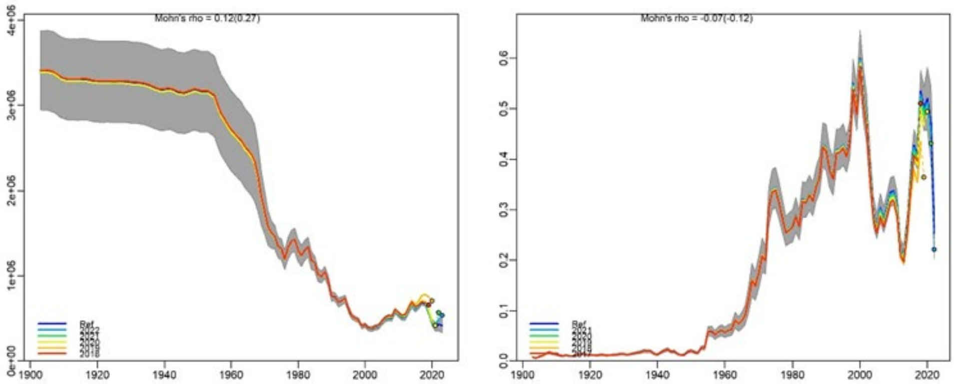
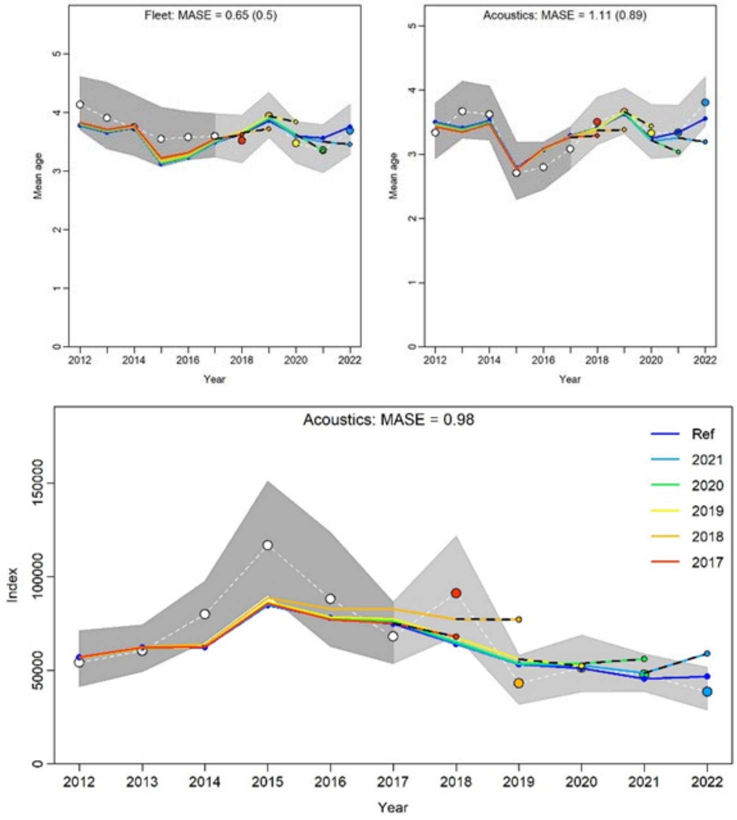
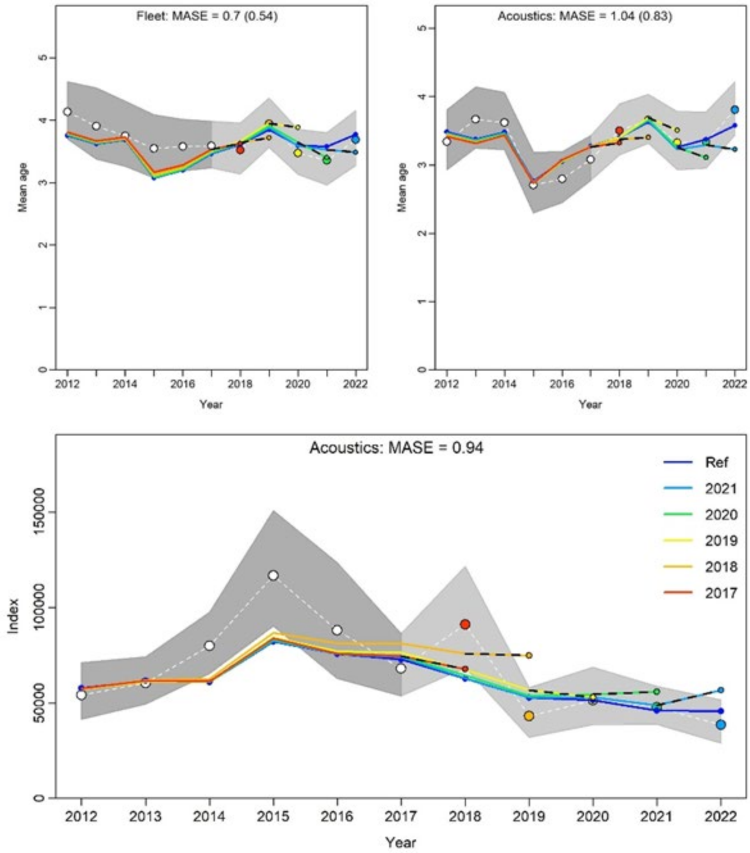


Figure 4.2.13 Herring in SD 25–29, 32 (excl. GoR). Retrospective analyses for each of the three models. Spawning-stock biomass (SSB, left) and fishing mortality (F, right), showing 5 years peels with 95% confidence bands for the reference year 2022 (SSB) and 2021 (F).

Model 1



Model 2



Model 3

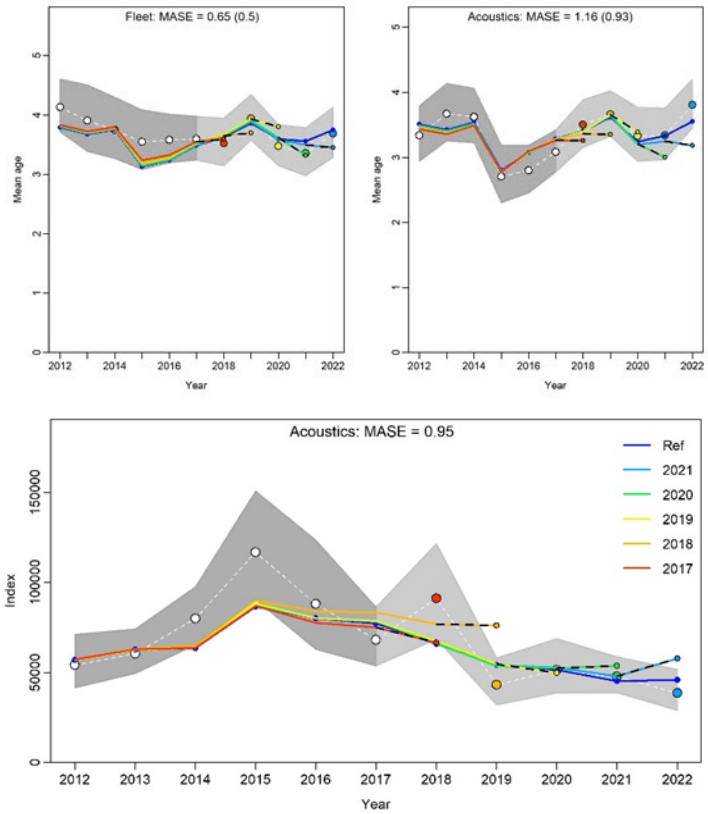


Figure 4.2.14. Herring in SD 25–29, 32 (excl. GoR). Model prediction (for model 1, 2 and 3 respectively) skill evaluated using the mean absolute scaled error (MASE) score, for mean age commercial (upper left) and survey (upper right), and survey index (lower) model fits (coloured lines), compared to one-year-ahead forecasts (black dashed lines). Large dots connected by dashed white lines show the observed values.

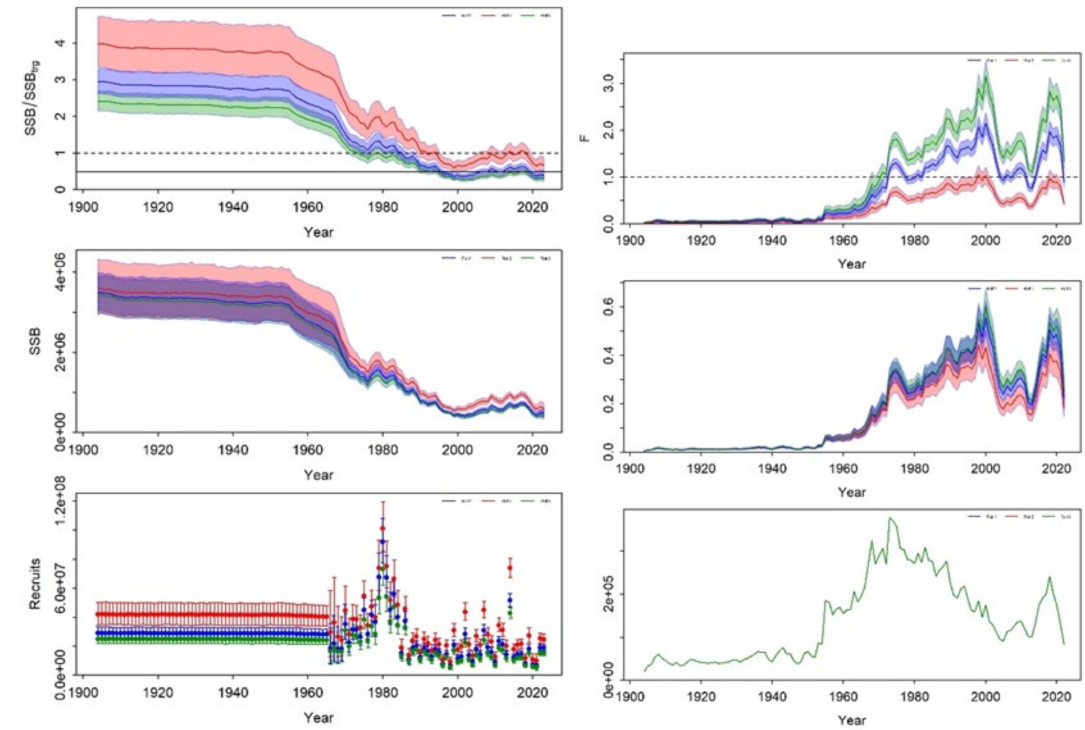


Figure 4.2.15. Herring in SD 25–29, 32 (excl. GoR). Comparison of stock assessment results, SSB, F and Recr with 95% confidence intervals, across the 3 runs included in the ensemble. Trajectory of the stock and fishing mortality is compared to the reference points B30% and B_{lim} which is set as 15% of B_0 (top figures). Dashed line is the B_{trg} and continuous line is B_{lim}.

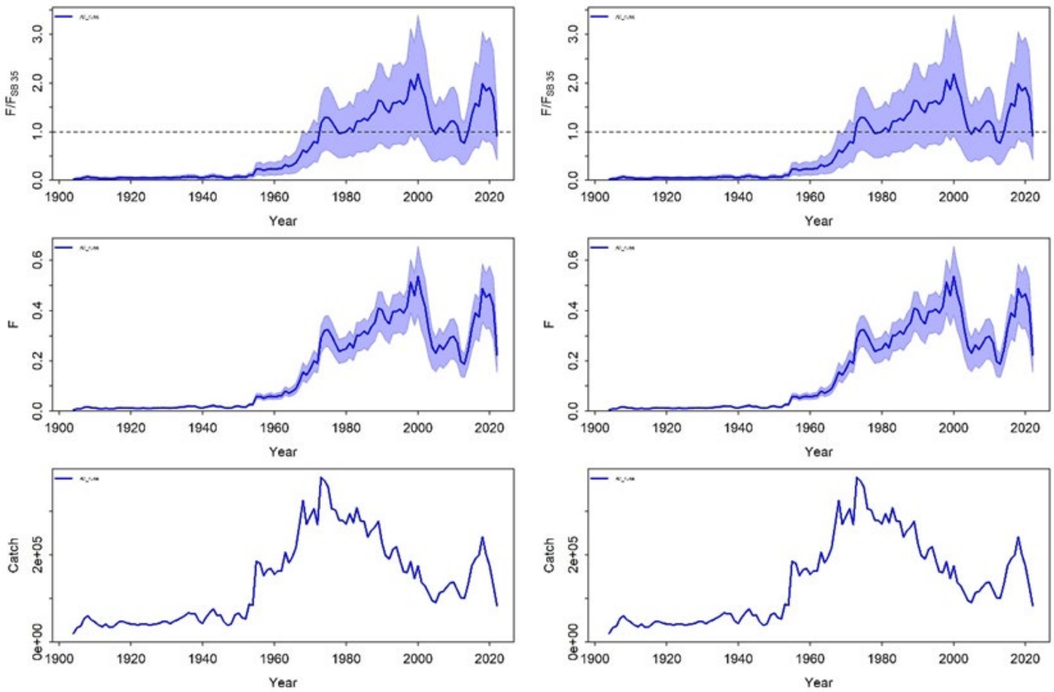


Figure 4.2.16. Herring in SD 25–29, 32 (excl. GoR). Stock assessment results of the final ensemble. Weighted-median value of SSB, F and Recr with 95% confidence intervals from delta-MVLN. Trajectory of the stock and fishing mortality is compared to the reference points B30% and B_{lim} which is set as 15% of B0 (top figures). Dashed line is the B_{trg} and continuous line is B_{lim}.

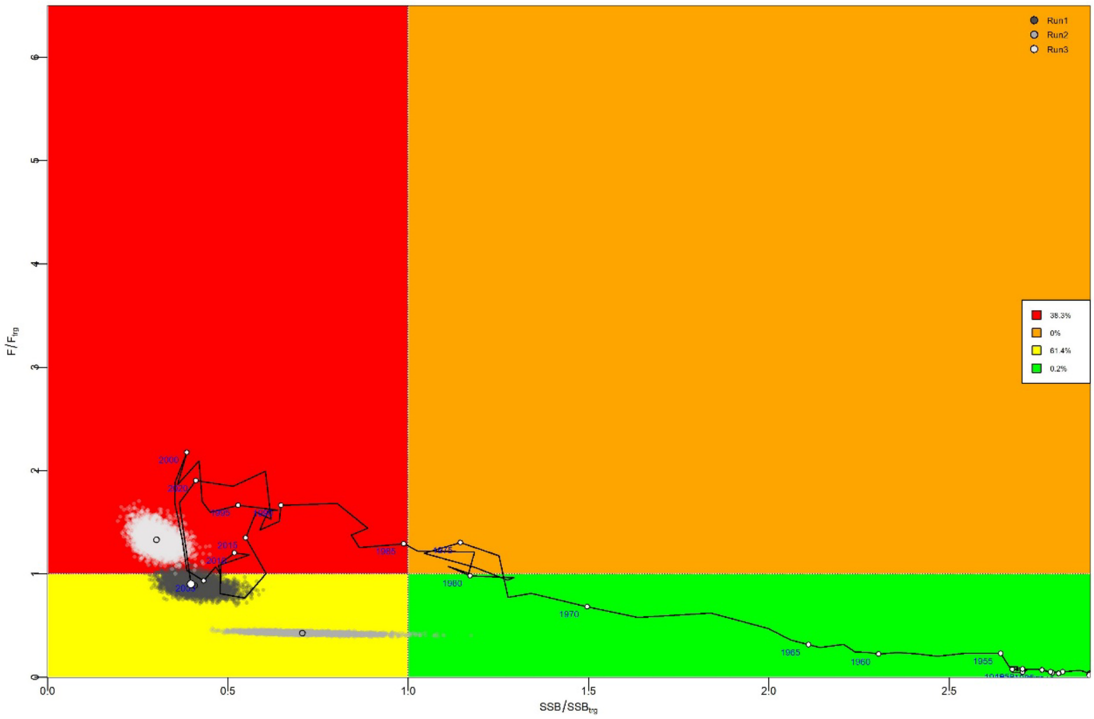


Figure 4.2.17. Herring in SD 25–29, 32 (excl. GoR). Kobe plot showing the trajectory of relative stock size (SSB/SSB_{30}) over relative exploitation (F/F_{30}) based on the final ensemble model (white dot: the weighted-median value of the 3 models). The points represent 5000 iterations from delta-MVNL of the final assessment year (2022).

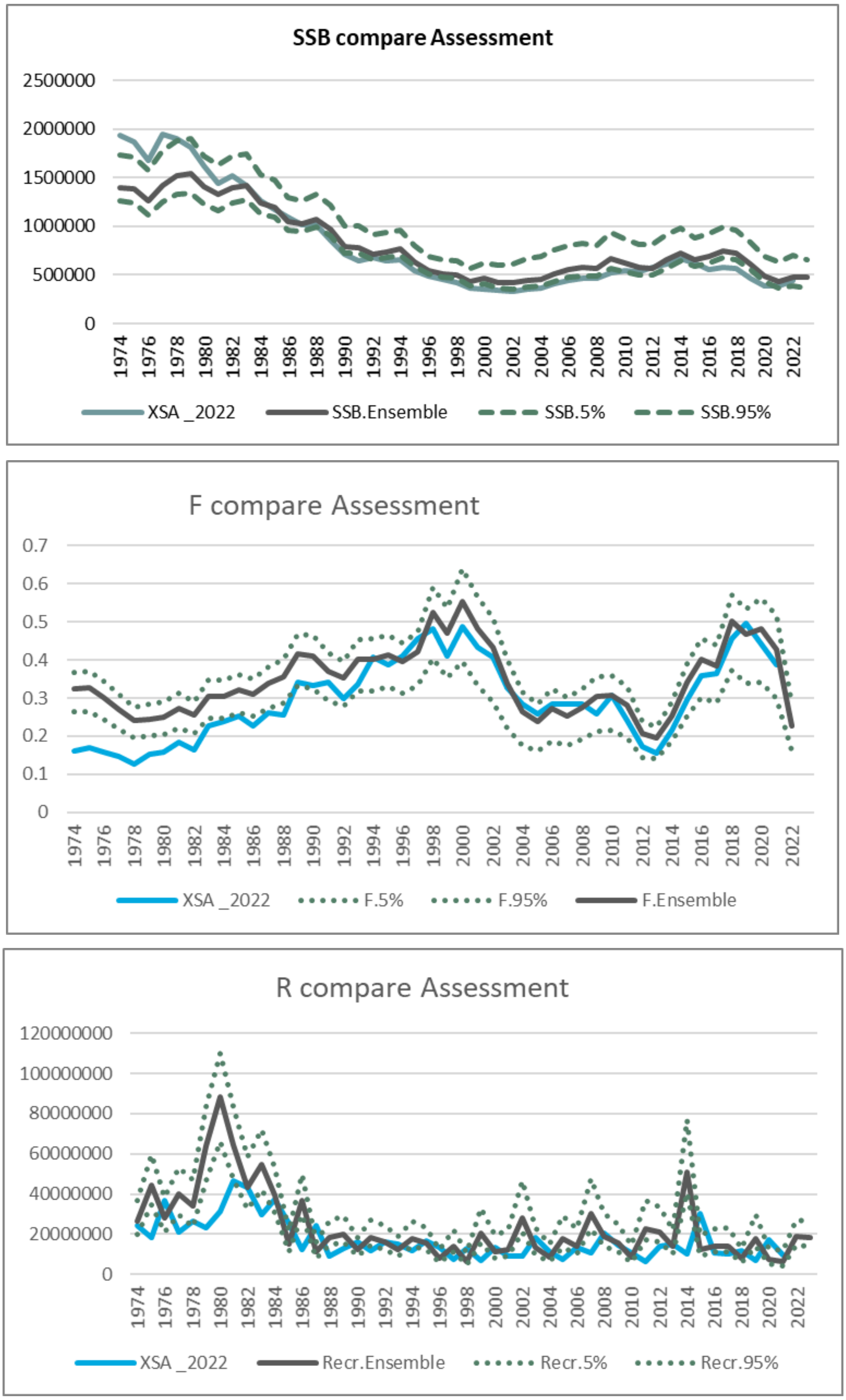


Figure 4.2.18. Herring in SD 25–29, 32 (excl. GoR). Stock assessment results of the final ensemble compared to the assessment last year (2022).

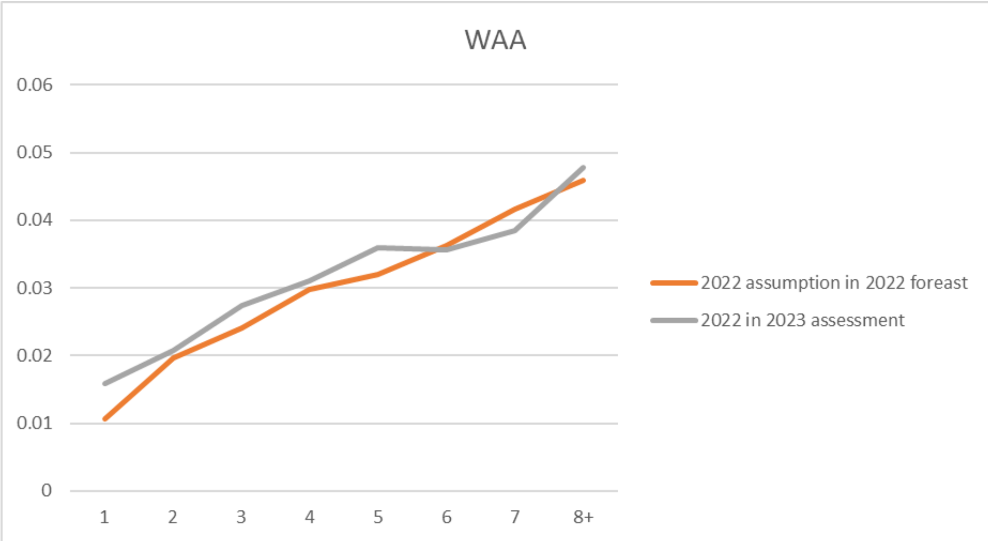


Figure 4.2.18. Herring in SD 25–29, 32 (excl. GoR). Stock assessment results of the final ensemble compared to the assessment last year (2022).

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 (Nielsen and Berg, 2014)
- Change in F_{bar}. New F_{bar}=F_{2-6}
- Reference points were updated

More details can be found in the WKBBPALTBEL report (ICES, 2023) and stock annex (Annex 5).

Gulf of Riga herring is a separate population of 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 differs 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). The population belonging is assigned during the age reading process. The Gulf of Riga herring stock does not perform significant migrations into the Baltic Proper; only minor part of the older herring leaves the gulf after spawning season in summer –autumn period but 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 2022 these catches were 777 t, while the average catches in the last five years were 902 t. These catches are included in the total Gulf of Riga herring landings (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 2022 the total catches of herring in the Gulf of Riga were 42 976 t (90% of TAC utilisation). (Table 4.3.1a).

The landings 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. In 2021 and 2022 the catches of the Gulf of Riga herring stock increased and were 35 758 t and 41 117 t respectively (Table 4.3.1b).

The landings of Central Baltic herring in the Gulf of Riga were 2636 t in 2022 (Table 4.3.1b). The average catch of Central Baltic herring in the last five years was 2959 t.

The trap-net catches of Gulf of Riga herring were 5834 t, 17% less than in 2021. The trap-net catches comprised 14 % of the total catches of Gulf of Riga herring in 2022.

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 2022.

The number of Estonian trawl vessels operating in the Gulf in 2022 was 8.

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, figures 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. In 2022 significant increase in age 0 catches were observed, which constituted around 18% of catch in numbers (Figure 4.3.1).

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 monthly basis (from trap-nets on weekly basis). The sampling intensity of both countries is described in Table 4.3.3. In 2022 the sample number per 1000 t was as follows: in Estonia 2.0 samples and in Latvia 3.1 samples (2.3 in total). 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 on 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. Besides since the gears used in the herring fishery are not selective the weight in the catch should correspond to the weight 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 and probably depended 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 (Figure 4.3.4).

4.3.2.4 Maturity at age

A new approach to maturity at age was implemented in 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 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 was taken to be the same as that used in the previous years - 0.2. Constant natural mortality M = 0.20 is used for all the years except for the period 1979–1983 when a value of M = 0.25 is 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 given in 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 abundance estimates for year 2020 and 2021 were updated in WGBFAS 2023 meeting compared to what was used in the benchmark (ICES, 2023). The changes were minor (excluding Central Baltic herring from estimates) and had no effect on the benchmarked SAM model fit.

The overall acoustic estimate of herring abundance (ages 1+) was 28% lower than in 2021. However, the decrease of biomass estimate was less expressed (-8%) due to increase in mean weights, particularly in most abundant 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_wgbfas2023_final".

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. The spawning stock biomass was downscaled and fishing mortality upscaled compared to the benchmark assessment (Figure 4.3.8). This results from the low abundance estimates by age in the acoustics, especially for older age groups. The SAM acoustic estimates were downscaled compared to the benchmark assessment (Figure 4.3.9) and in addition, this negative signal led to downscaling of stock numbers back in time (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 2022. This is related to the fact that there has been two very strong year-classes (2017 and 2019) and above average year-classes between. The two strong year-classes make up 50% of the SSB in 2021 and 2022, and will continue to contribute to the SSB next year.

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.

Figure 4.2.13 summarizes the results of SAM retrospective analysis for Gulf of Riga herring. It can be seen that there is evidence of some retrospective noise and bias for recruitment estimate. Which is expected, as the recruitment estimate is uncertain, as it relies only from information in catches. Some noise and bias is also seen for SSB and $F_{2\text{-}6}$, however all retrospective runs fall inside the pointwise 95% confidence intervals of the full time-series assessment.

Mohn's rho values (average relative bias of retrospective estimates) were calculated for SSB, F and recruitment estimates from SAM and were 8%, -9% and -1% respectively and all lie well 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 111 599 t 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 t 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 147 109 t in 2022 that is historically highest. The mean fishing mortality in age groups 2–6 has been rather high in 1970s and 1980s fluctuating between 0.32 and 0.61. It has decreased below 0.3 in 1989 and stayed on this level 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 2017-2022 the fishing mortality was in the range of 0.23-0.28. The estimate for 2022 was 0.27 that is below 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 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. 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 (2020-2022).

Fishing mortality: TAC constraint. TAC for 2023 is 44 945 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 this 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*

* $F_{bar} = F_{3\text{-}7}$

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, SSB and recruitment is -9%, 8% and -1% respectively.

4.3.8 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 2024 (Subdivision 28.1) is 2959 tonnes (average 2018–2022);
2. Gulf of Riga herring assumed to be taken in Subdivision 28.2 in 2023 is 902 tonnes (average 2018–2022).

As an example, following ICES MSY approach (here identical to the MAP F_{MSY}), catches from the Gulf of Riga herring stock in 2024 should be no more than 35 902 tonnes. The corresponding TAC in the Gulf of Riga management area for 2023 would be calculated as: 35 902 tonnes – 902 tonnes + 2959 tonnes = 37 953 tonnes.

4.3.9 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.

		Coastal fishery		Trawl fishery	
Year	**Country**	**Number of allowed fishing gears in the specialized herring fishery**	**Total limit**	**Regulations**	**Closures**
2021	Latvia	In total 117 pound-nets and 529 herring gillnets.	No less than 15% of the Latvian quota. 4 % of the total coastal limit is allocated to the gillnet fishery.	The total herring coastal limit in the Gulf of Riga is distributed by three coastal areas (Eastern, Southern and Western). When 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.	12 May - 10 June
2022	Estonia	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 companies/fishers involved. Currently 46% for coastal fishery and 54% 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.	20 April – 22 May, 31 days, can be shifted depending on ice conditions in winter; Additional closure in certain rectangles from 1 April to 20 May. “Unofficial” (not established by the authorities) closure for trawl fishery 15 June - 15 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
2019	13320	17961	-	31281
2020	12231	21019	-	33249
2021	16099	22011	-	38110
2022	18810	24166	-	42976

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
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

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
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

Table 4.3.3. Sampling of herring landings in the Gulf of Riga in 2022.

Country	Quarter	Landings	Samples	Measured	Aged
Estonia	I	8049	14	1247	1247
	II	7146	11	1038	1038
	III	176	1	100	100
	IV	3439	11	998	998
	Total	18810	37	3383	3383
Latvia	I	6189	9	1933	1146
	II	4513	37	4704	3768
	III	5039	8	1990	857
	IV	8425	8	2777	1093
	Total	24166	62	11404	6864
Total	I	14238	23	3180	2393
	II	11658	48	5742	4806
	III	5215	9	2090	957
	IV	11864	19	3775	2091
Grand total	Total	42976	99	14787	10247

Table 4.3.2 Gulf of Riga herring. Catch in numbers 1977-2022 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
2005	44630	384871	205390	833206	213430	171555	55243	27450	28925

Year	0	1	2	3	4	5	6	7	8+
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

Table 4.3.4. Gulf of Riga herring. Weights (kg) in catch and stock in 1977-2022.

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
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

Year	0	1	2	3	4	5	6	7	8+
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
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
	0.0055	0.0107	0.0153	0.0190	0.0219	0.0238	0.0255	0.0279	0.0282

Table 4.3.5. Gulf of Riga herring. Maturity ogive, GAM smoothed values for 1995-2022, 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
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	0.252651	0.706026	0.941586	0.991261	1	1	1	1
1996	0	0.250492	0.702163	0.93982	0.990499	1	1	1	1
1997	0	0.248343	0.698254	0.938031	0.989731	1	1	1	1
1998	0	0.246234	0.694291	0.93621	0.988951	1	1	1	1
1999	0	0.244269	0.690249	0.934322	0.988147	1	1	1	1
2000	0	0.242517	0.68598	0.932275	0.987292	1	1	1	1
2001	0	0.241059	0.681351	0.929987	0.986364	1	1	1	1
2002	0	0.239962	0.676276	0.927409	0.985352	1	1	1	1
2003	0	0.23923	0.670756	0.92456	0.984262	1	1	1	1
2004	0	0.238901	0.664944	0.921525	0.983117	1	1	1	1
2005	0	0.238836	0.659034	0.918439	0.981949	1	1	1	1

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8+
2006	0	0.238872	0.653083	0.91531	0.980738	1	1	1	1
2007	0	0.23913	0.647269	0.912144	0.979459	1	1	1	1
2008	0	0.239821	0.641815	0.908952	0.978092	1	1	1	1
2009	0	0.241194	0.636925	0.905724	0.976613	1	1	1	1
2010	0	0.243405	0.632732	0.902457	0.975013	1	1	1	1
2011	0	0.246594	0.629364	0.899154	0.973295	1	1	1	1
2012	0	0.250868	0.626863	0.895765	0.971449	1	1	1	1
2013	0	0.256372	0.625234	0.892212	0.969464	1	1	1	1
2014	0	0.263024	0.624325	0.888468	0.967356	1	1	1	1
2015	0	0.270566	0.623992	0.884607	0.965187	1	1	1	1
2016	0	0.278757	0.624218	0.880788	0.963055	1	1	1	1
2017	0	0.287214	0.624913	0.877182	0.961078	1	1	1	1
2018	0	0.295497	0.62581	0.873794	0.959296	1	1	1	1
2019	0	0.303384	0.62663	0.870482	0.957635	1	1	1	1
2020	0	0.310984	0.627284	0.867125	0.95601	1	1	1	1
2021	0	0.318457	0.627808	0.863688	0.954379	1	1	1	1
2022	0	0.325845	0.628243	0.860198	0.952737	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

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	0.128	0.365	0.587	0.699	0.734	0.916	0.844	0.844	0.660
1978	0.005	0.106	0.280	0.412	0.492	0.568	0.621	0.643	0.643	0.474
1979	0.005	0.105	0.282	0.411	0.508	0.588	0.735	1.034	1.034	0.505
1980	0.005	0.089	0.248	0.353	0.418	0.518	0.606	0.818	0.818	0.429
1981	0.004	0.076	0.247	0.384	0.464	0.551	0.702	0.892	0.892	0.470
1982	0.003	0.050	0.205	0.358	0.443	0.526	0.647	0.776	0.776	0.436
1983	0.002	0.041	0.204	0.395	0.489	0.554	0.693	0.780	0.780	0.467
1984	0.002	0.031	0.190	0.424	0.581	0.655	0.972	1.130	1.130	0.565
1985	0.002	0.025	0.165	0.364	0.496	0.584	0.836	0.906	0.906	0.489
1986	0.001	0.016	0.120	0.278	0.412	0.528	0.742	0.916	0.916	0.416
1987	0.001	0.019	0.105	0.235	0.348	0.450	0.491	0.443	0.443	0.326
1988	0.001	0.019	0.102	0.238	0.361	0.473	0.598	0.646	0.646	0.354
1989	0.003	0.041	0.138	0.280	0.362	0.408	0.369	0.262	0.262	0.312
1990	0.003	0.034	0.117	0.222	0.272	0.328	0.254	0.155	0.155	0.239
1991	0.003	0.038	0.121	0.214	0.276	0.360	0.395	0.390	0.390	0.273
1992	0.003	0.047	0.137	0.223	0.278	0.366	0.418	0.432	0.432	0.284
1993	0.004	0.057	0.143	0.207	0.252	0.339	0.369	0.367	0.367	0.262
1994	0.004	0.062	0.150	0.206	0.252	0.339	0.356	0.347	0.347	0.261
1995	0.005	0.081	0.187	0.254	0.316	0.405	0.473	0.517	0.517	0.327
1996	0.007	0.102	0.222	0.282	0.344	0.434	0.522	0.627	0.627	0.361
1997	0.009	0.137	0.294	0.369	0.432	0.484	0.539	0.585	0.585	0.424
1998	0.008	0.116	0.273	0.336	0.399	0.461	0.480	0.518	0.518	0.390
1999	0.009	0.130	0.282	0.331	0.392	0.456	0.462	0.487	0.487	0.385
2000	0.009	0.133	0.302	0.363	0.418	0.466	0.436	0.390	0.390	0.397
2001	0.010	0.158	0.342	0.426	0.494	0.516	0.523	0.534	0.534	0.460
2002	0.009	0.146	0.338	0.429	0.487	0.493	0.466	0.401	0.401	0.443
2003	0.009	0.125	0.330	0.447	0.531	0.525	0.534	0.475	0.475	0.473
2004	0.011	0.158	0.365	0.491	0.602	0.589	0.669	0.703	0.703	0.543
2005	0.011	0.145	0.340	0.439	0.545	0.543	0.613	0.561	0.561	0.496

Year	0	1	2	3	4	5	6	7	8+	F_{bar} (2-6)
2006	0.012	0.143	0.318	0.400	0.463	0.481	0.499	0.415	0.415	0.432
2007	0.014	0.170	0.335	0.426	0.493	0.494	0.576	0.489	0.489	0.465
2008	0.012	0.135	0.272	0.324	0.353	0.386	0.384	0.370	0.370	0.344
2009	0.013	0.122	0.250	0.309	0.341	0.402	0.436	0.445	0.445	0.348
2010	0.015	0.138	0.240	0.291	0.301	0.374	0.373	0.402	0.402	0.316
2011	0.012	0.105	0.209	0.277	0.290	0.373	0.357	0.440	0.440	0.301
2012	0.013	0.105	0.198	0.252	0.265	0.326	0.288	0.330	0.330	0.266
2013	0.012	0.095	0.180	0.219	0.225	0.281	0.247	0.249	0.249	0.231
2014	0.013	0.094	0.177	0.215	0.229	0.283	0.264	0.284	0.284	0.234
2015	0.016	0.130	0.213	0.257	0.280	0.324	0.353	0.418	0.418	0.285
2016	0.016	0.128	0.211	0.255	0.279	0.321	0.367	0.413	0.413	0.287
2017	0.014	0.111	0.192	0.235	0.255	0.298	0.356	0.418	0.418	0.267
2018	0.012	0.085	0.168	0.209	0.238	0.269	0.291	0.293	0.293	0.235
2019	0.012	0.086	0.175	0.221	0.263	0.290	0.336	0.305	0.305	0.257
2020	0.015	0.100	0.184	0.232	0.274	0.296	0.355	0.314	0.314	0.268
2021	0.016	0.103	0.191	0.245	0.295	0.309	0.377	0.318	0.318	0.283
2022	0.016	0.095	0.186	0.246	0.295	0.293	0.313	0.218	0.218	0.267

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	1252068	678634	2822924	297739	230617	66654	26012	32721	1148
1978	1145037	1071548	505910	1508086	124785	92330	24779	8126	12381
1979	1604909	915115	770274	349838	828208	61387	42573	11001	8930
1980	1296399	1232647	647053	430802	203245	363026	27526	16051	5297
1981	2259831	959928	834013	397482	241314	124401	156394	12553	7107
1982	1689710	1767262	661160	466529	214251	118608	63718	55657	6437
1983	2357254	1330823	1287181	427937	242066	108632	55077	28201	21533
1984	1358305	1882894	987950	776736	216728	114622	50911	22332	18318
1985	993913	1110354	1667450	672621	387196	90990	45457	15594	11000

Year	0	1	2	3	4	5	6	7	8+
1986	3672704	767225	915484	1155397	367890	192213	41184	15028	9163
1987	597946	3295843	651178	642540	727519	194378	96417	15994	7291
1988	1589175	460544	2579944	558603	425676	415779	91183	51967	12599
1989	3657130	1315540	399144	1997930	409463	254699	208531	36329	26517
1990	4355716	2987375	919018	304998	1225855	234425	146933	121422	37080
1991	4757088	3542920	2397963	627985	193377	762067	130929	103329	121977
1992	4158349	3859914	2786975	1821192	422097	118631	470310	67030	130950
1993	3473523	3399096	3107715	1936918	1178821	269129	66451	263886	102121
1994	4088372	2839155	2483826	2257491	1321940	765855	166104	36788	209400
1995	5576626	3347447	2126282	1731231	1570080	869990	465839	99991	143536
1996	2305649	4691584	2559032	1435537	1072342	929974	479171	239572	123441
1997	3256459	1795920	3509299	1724886	945458	653482	496580	230870	156613
1998	3617837	2641308	1244349	2017507	930658	499993	335664	240448	179398
1999	3045102	2973160	2023853	736742	1133999	491451	253847	175477	206664
2000	7025411	2407920	2180243	1254565	424409	656844	256353	127721	192222
2001	2957411	5904401	1773596	1251931	712493	222750	341769	132459	184476
2002	7412880	2296776	4359157	1068675	631122	344793	107988	167204	151901
2003	1517555	6425339	1502441	2586111	570258	310843	177394	55358	181110
2004	4030051	1193462	5057285	838364	1296945	273829	155109	79755	129556
2005	8019224	3261807	758937	2956839	444793	533994	121722	67396	80225
2006	2629534	6813836	2294054	391511	1614866	228199	233771	52835	67569
2007	5837641	2005623	4827970	1352941	203142	909784	116608	111295	65814
2008	3751301	4936222	1411526	2934826	652820	95954	486479	47232	92716
2009	4097984	3006328	3603960	864933	1772979	362662	53963	303121	82247
2010	1473651	3368360	2181571	2342225	526049	1004057	194548	27705	224757
2011	5872875	1111094	2201108	1423212	1449659	378170	542846	107176	154749
2012	6279148	4904847	785062	1431598	819305	942151	201372	320212	138882
2013	1304707	5228506	3767605	528483	872786	464846	582548	118864	279043
2014	2999332	1003283	3969615	2575211	360632	543312	299084	364090	257204

Year	0	1	2	3	4	5	6	7	8+
2015	5169700	2414109	770809	2819508	1685419	255342	319798	192277	377448
2016	3547983	4199827	1617319	546615	1832375	1063488	152130	178182	303396
2017	6068195	2833685	3012163	1066898	345909	1147036	639155	81959	271151
2018	3216865	5038235	2111469	1982179	702026	236517	712534	359102	175688
2019	7792267	2538694	3979365	1467494	1226956	475324	164079	456557	292554
2020	4444991	6524283	1957587	2725436	945100	726120	301569	98029	438197
2021	5614781	3563912	4848411	1408542	1727573	605569	421936	180791	302616
2022	13965380	4408637	2490776	3291844	1064291	993817	371191	217739	277138

Table 4.3.9. Gulf of Riga herring. SAM output: Summary. Numbers in thousand and biomass in tonnes.

Year	Recruitment			Stock size			Catches	Fishing pressure		
	Age 0	97.5%	2.5%	SSB	97.5%	2.5%		F2-6	97.5%	2.5%
1977	1252068	1741099	900394	52661	62517	44360	24186	0.66	0.76	0.57
1978	1145037	1576930	831432	43918	51185	37683	16728	0.47	0.54	0.42
1979	1604909	2234189	1152872	40819	46299	35987	17142	0.50	0.57	0.45
1980	1296399	1813954	926512	40465	45282	36161	14998	0.43	0.49	0.38
1981	2259831	3143864	1624382	43263	48357	38706	16769	0.47	0.53	0.42
1982	1689710	2349478	1215215	39521	44182	35353	12777	0.44	0.49	0.39
1983	2357254	3322822	1672268	48823	55243	43150	15541	0.47	0.53	0.41
1984	1358305	1911785	965063	39763	45001	35136	15843	0.56	0.64	0.49
1985	993913	1424249	693603	52766	60597	45947	15575	0.49	0.56	0.43
1986	3672704	5276111	2556572	62417	71569	54436	16927	0.42	0.49	0.36
1987	597946	846368	422440	46952	53881	40914	12884	0.33	0.38	0.28
1988	1589175	2233915	1130517	83298	97158	71415	16791	0.35	0.43	0.30
1989	3657130	5127336	2608489	55427	64259	47809	16783	0.31	0.37	0.26
1990	4355716	6089318	3115663	68014	78387	59013	14931	0.24	0.28	0.20
1991	4757088	6645560	3405264	69219	80041	59860	14791	0.27	0.32	0.23
1992	4158349	5787001	2988054	88986	102221	77465	21700	0.28	0.33	0.24
1993	3473523	4817828	2504315	103498	118649	90281	22700	0.26	0.31	0.22

Year	Recruitment			Stock size			Catches	Fishing pressure		
	Age 0	97.5%	2.5%	SSB	97.5%	2.5%		F2-6	97.5%	2.5%
1994	4088372	5646384	2960264	112107	127219	98791	24300	0.26	0.30	0.22
1995	5576626	7682552	4047972	109167	121743	97890	32656	0.33	0.38	0.28
1996	2305649	3184087	1669558	101788	112874	91790	32584	0.36	0.41	0.31
1997	3256459	4455384	2380160	96309	107461	86315	39843	0.42	0.48	0.37
1998	3617837	4868603	2688398	85107	94840	76372	29443	0.39	0.45	0.34
1999	3045102	4090876	2266665	85210	94643	76718	31403	0.38	0.44	0.34
2000	7025411	9445849	5225195	85723	95135	77243	34069	0.40	0.45	0.35
2001	2957411	4002687	2185102	85316	94319	77172	38785	0.46	0.52	0.40
2002	7412880	10132572	5423183	91828	102857	81981	39701	0.44	0.50	0.39
2003	1517555	2064959	1115263	91994	102869	82268	40803	0.47	0.54	0.42
2004	4030051	5428679	2991761	79559	88831	71256	39116	0.54	0.62	0.48
2005	8019224	10858398	5922416	76018	85587	67520	32225	0.50	0.57	0.43
2006	2629534	3572811	1935297	74530	83624	66425	31232	0.43	0.50	0.38
2007	5837641	7895238	4316280	77550	87707	68569	33742	0.46	0.54	0.40
2008	3751301	5079190	2770571	90538	102763	79768	31137	0.34	0.40	0.30
2009	4097984	5562628	3018982	92370	104632	81545	32553	0.35	0.40	0.30
2010	1473651	2020405	1074857	92415	104881	81431	30175	0.32	0.37	0.27
2011	5872875	8002346	4310070	97053	110742	85056	29638	0.30	0.35	0.26
2012	6279148	8577174	4596817	96460	110335	84329	28115	0.27	0.31	0.23
2013	1304707	1783164	954629	105406	120757	92007	26511	0.23	0.27	0.195
2014	2999332	4089565	2199743	110532	127409	95891	26253	0.23	0.28	0.197
2015	5169700	7096498	3766054	109481	126947	94418	32851	0.29	0.34	0.24
2016	3547983	4914325	2561529	98502	115106	84294	30865	0.29	0.34	0.24
2017	6068195	8478041	4343337	98091	116470	82612	28058	0.27	0.33	0.22
2018	3216865	4551841	2273414	107635	130114	89040	25747	0.23	0.29	0.188
2019	7792267	11324153	5361939	109524	135134	88767	28922	0.26	0.33	0.20
2020	4444991	6797948	2906458	124925	158550	98432	33215	0.27	0.35	0.20
2021	5614781	9546104	3302474	125901	167352	94717	35758	0.28	0.39	0.20

Year	Recruitment			Stock size			Catches	Fishing pressure		
	Age 0	97.5%	2.5%	SSB	97.5%	2.5%		F2-6	97.5%	2.5%
2022	13965380	49147731	3968278	145915	207564	102577	41117	0.27	0.39	0.182
2023	4097984	7792267	1304707	139870	212643	89308				

Table 4.3.10. Gulf of Riga herring. Short-term forecast input.

2023

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4097984		0.000			0.00563	0.02	0.00563
1	3250338	0.2	0.318	0.2	0.3	0.00945	0.11	0.00945
2	3265205	0.2	0.628	0.2	0.3	0.01482	0.22	0.01482
3	1695338	0.2	0.864	0.2	0.3	0.01855	0.29	0.01855
4	2112649	0.2	0.954	0.2	0.3	0.02092	0.35	0.02092
5	649764	0.2	1.000	0.2	0.3	0.02280	0.34	0.02280
6	604213	0.2	1.000	0.2	0.3	0.02453	0.36	0.02453
7	223153	0.2	1.000	0.2	0.3	0.02577	0.26	0.02577
8+	331701	0.2	1.000	0.2	0.3	0.02649	0.26	0.02649

2024

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4097984		0.000			0.00563	0.02	0.00563
1	3327830	0.2	0.318	0.2	0.3	0.00945	0.11	0.00945
2	2335479	0.2	0.628	0.2	0.3	0.01482	0.22	0.01482
3	2131586	0.2	0.864	0.2	0.3	0.01855	0.29	0.01855
4	1039860	0.2	0.954	0.2	0.3	0.02092	0.35	0.02092
5	1213532	0.2	1.000	0.2	0.3	0.02280	0.34	0.02280
6	376566	0.2	1.000	0.2	0.3	0.02453	0.36	0.02453
7	335900	0.2	1.000	0.2	0.3	0.02577	0.26	0.02577
8+	349036	0.2	1.000	0.2	0.3	0.02649	0.26	0.02649

2025

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4088372		0.000			0.00563	0.02	0.00563
1	3344838	0.2	0.318	0.2	0.3	0.00945	0.1	0.00945
2	2428572	0.2	0.628	0.2	0.3	0.01482	0.19	0.01482
3	1540573	0.2	0.864	0.2	0.3	0.01855	0.25	0.01855
4	1299722	0.2	0.954	0.2	0.3	0.02092	0.3	0.02092
5	596702	0.2	1.000	0.2	0.3	0.02280	0.3	0.02280
6	705447	0.2	1.000	0.2	0.3	0.02453	0.31	0.02453
7	210657	0.2	1.000	0.2	0.3	0.02577	0.22	0.02577
8+	438888	0.2	1.000	0.2	0.3	0.02649	0.22	0.02649

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 (2024)	F (2024)	SSB (2024)	SSB (2025)	%SSB change**	%Advice change***
ICES advice basis						
EU MAP*: F_{MSY}	35902	0.28	131236	126108	-3.9	-17
EU MAP*: F_{MSY} lower^	27696	0.21	133105	134969	1.40	-17
EU MAP*: F_{MSY} upper^^	41370	0.33	130033	120453	-7.4	-17
Other scenarios						
ICES MSY approach: F_{MSY}	35902	0.28	131236	126108	-3.9	-17
F= 0	0	0	138263	165744	20	-100
F= F_{pa}	43455	0.35	129594	118190	-8.8	0.53
F= F_{lim}	57266	0.49	126176	103935	-18	32
SSB (2025) = B_{lim}	29999	0.228	132571	132571	0	-31
SSB (2025) = B_{pa}	113815	1.357	108611	52076	-52	163
SSB (2025) = MSY $B_{trigger}$	90410	0.916	116951	72907	-38	109
SSB (2025) = SSB (2024)	90315	0.916	117661	72907	-38	109
F=F_{2023}	39756	0.315	130443	122883	-5.8	-8.0

*** MAP multiannual plan (EU, 2016).**

**** SSB 2025 relative to SSB 2024.**

***** Total catch in 2024 relative to ICES advice for 2023 (43226 tonnes for the Gulf of Riga herring stock).**

^ ICES advice for Flower for 2024 relative to ICES advice for EU MAP range Flower for 2023 (33519 tonnes).

^^ ICES advice for Fupper for 2024 relative to ICES advice for EU MAP range Fupper for 2023 (50079 tonnes).

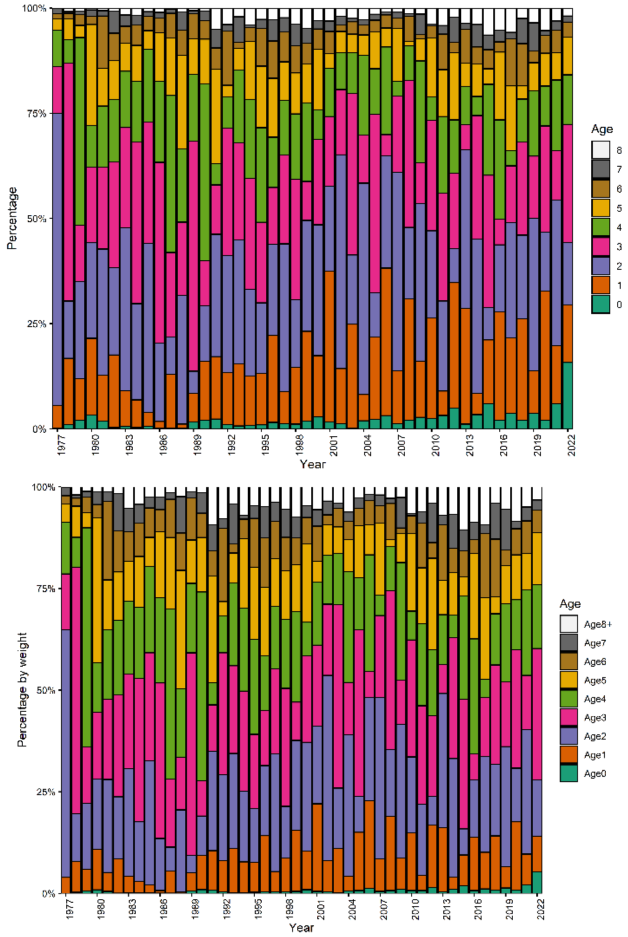


Figure 4.3.1. Gulf of Riga herring. Relative catch at age in numbers (left) and biomass (right) in 1977-2022.

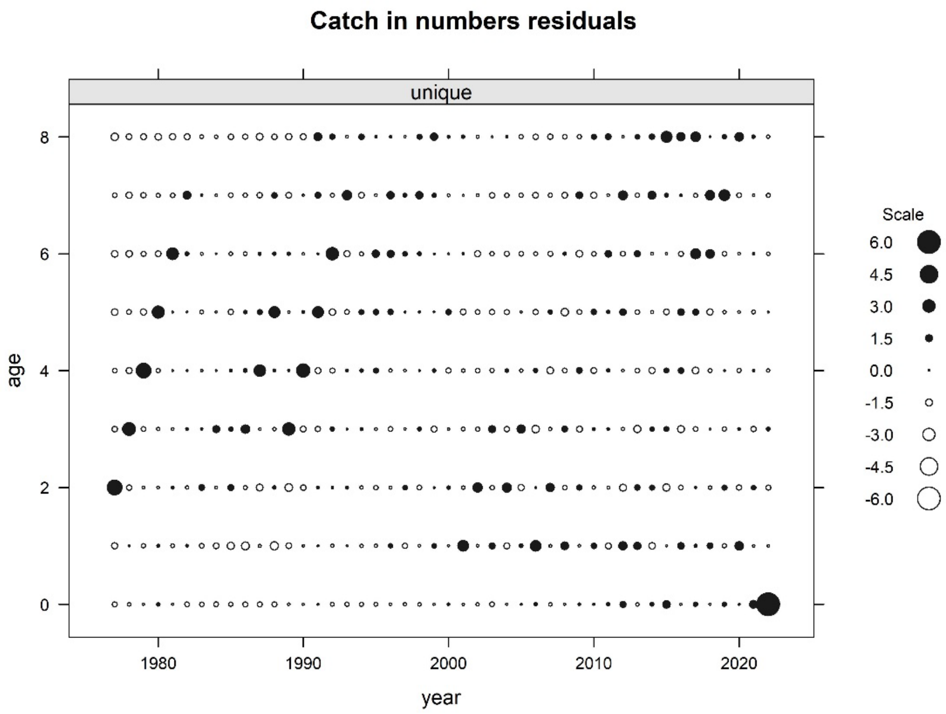


Figure 4.3.2. Gulf of Riga herring. Catch proportion at age.

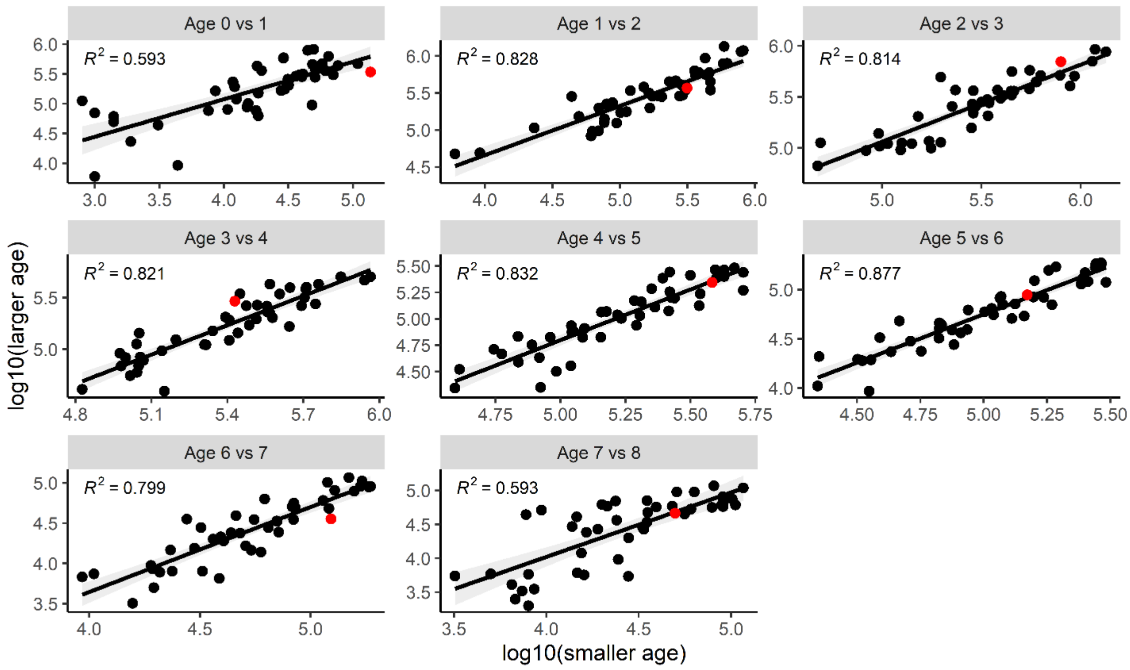


Figure 4.3.3. Gulf of Riga herring. Internal consistency in catch-at-age. Latest year is shown in red.

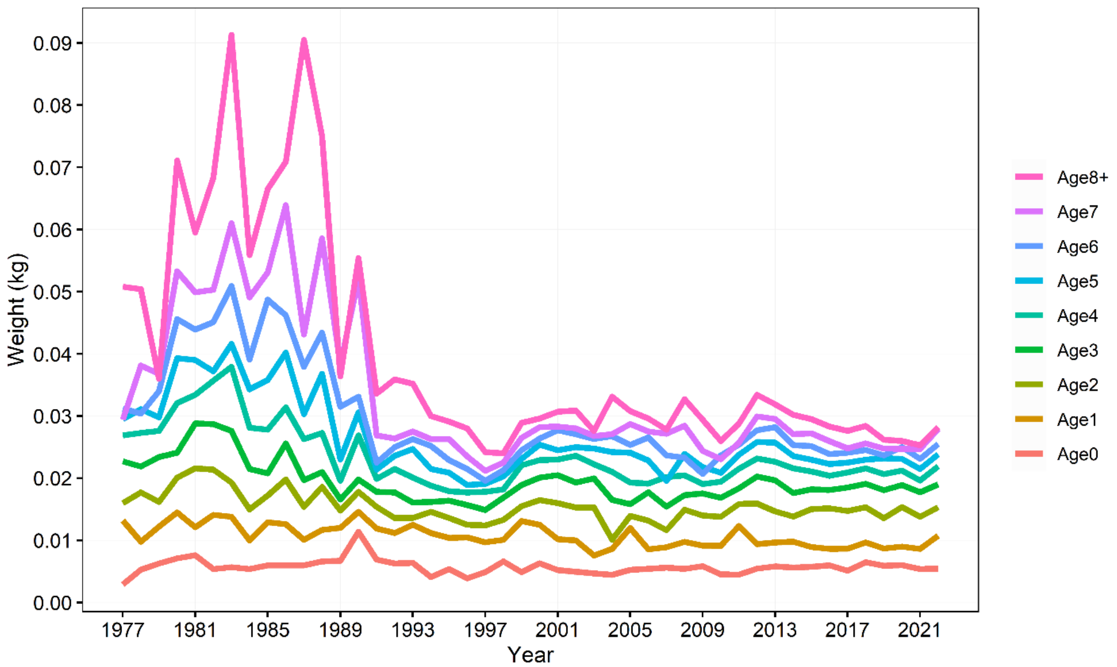


Figure 4.3.4. Gulf of Riga herring. Mean weight at age in the catches.

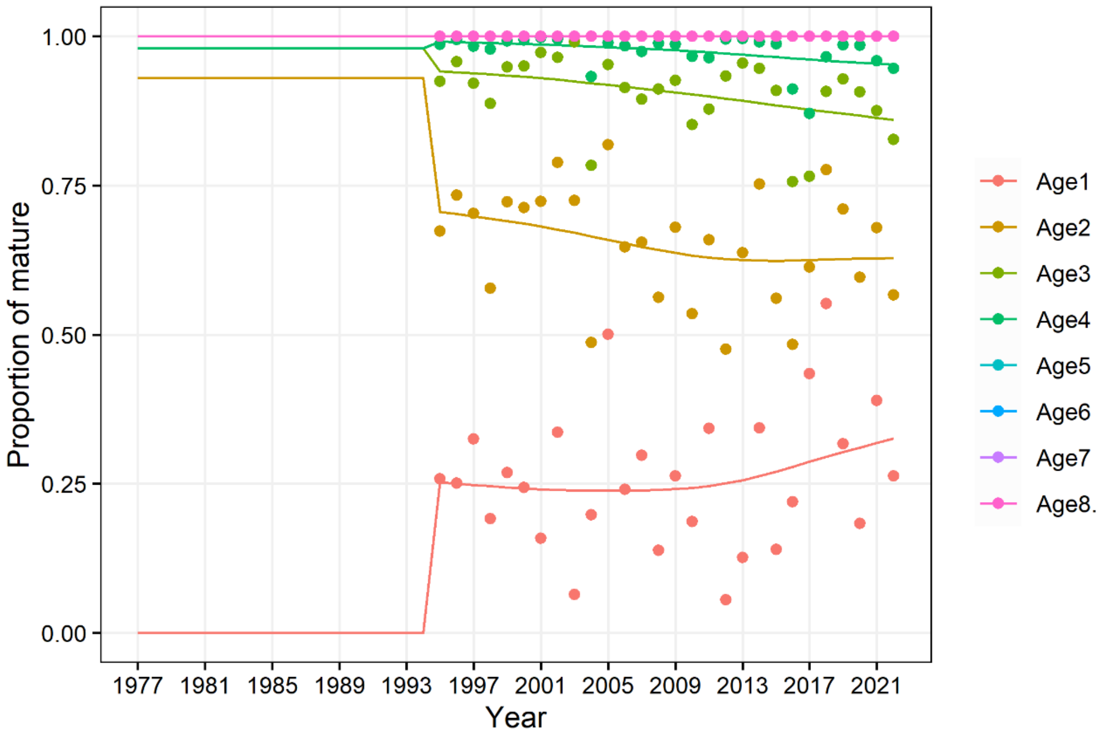


Figure 4.3.5. Gulf of Riga herring. Maturity ogive. Points are GLM estimates and lines shows the GAM smoothed values.

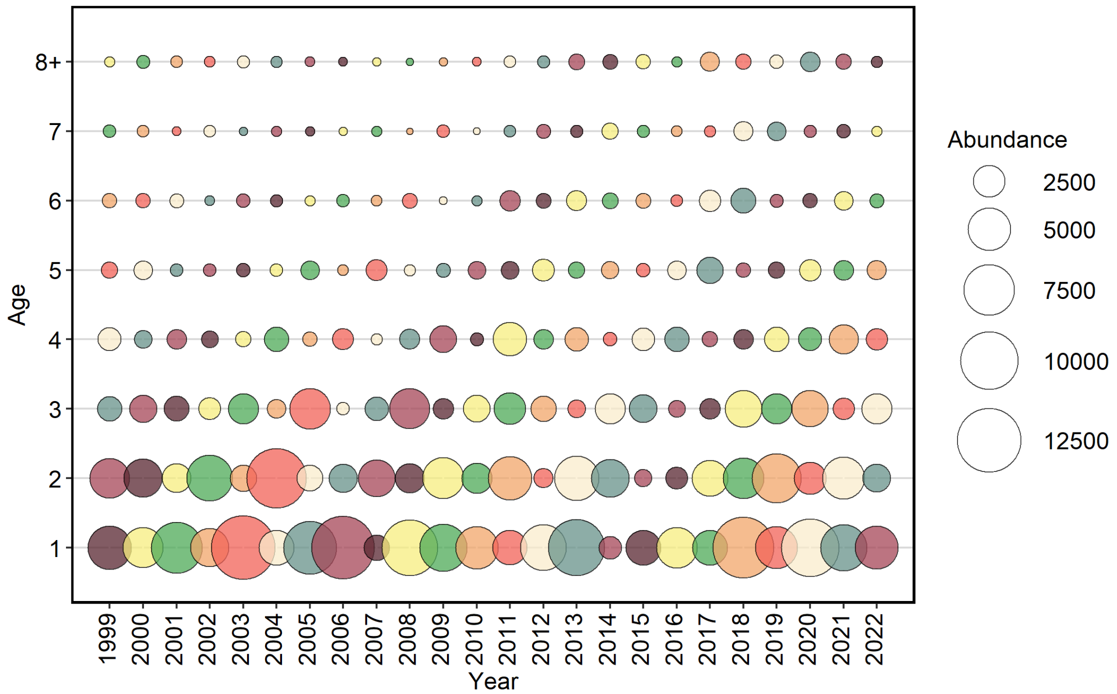


Figure 4.3.6. Gulf of Riga herring. Proportion of ages in hydro-acoustics tuning fleet.

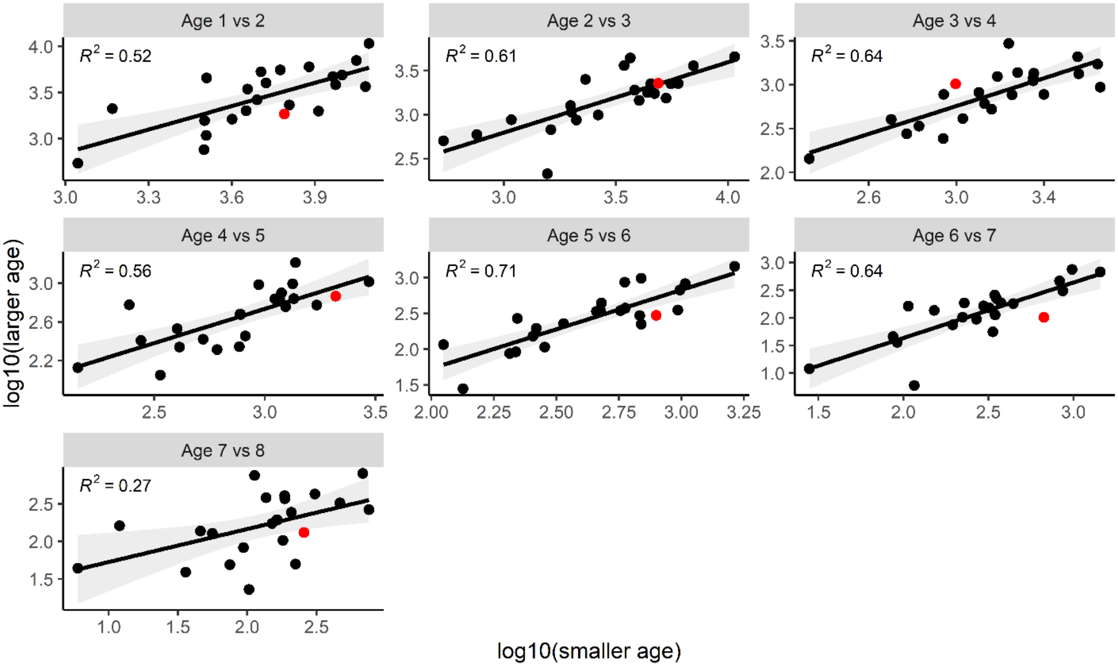


Figure 4.3.7. Gulf of Riga herring. Internal consistency in hydro-acoustics tuning fleet. Latest year is shown in red.

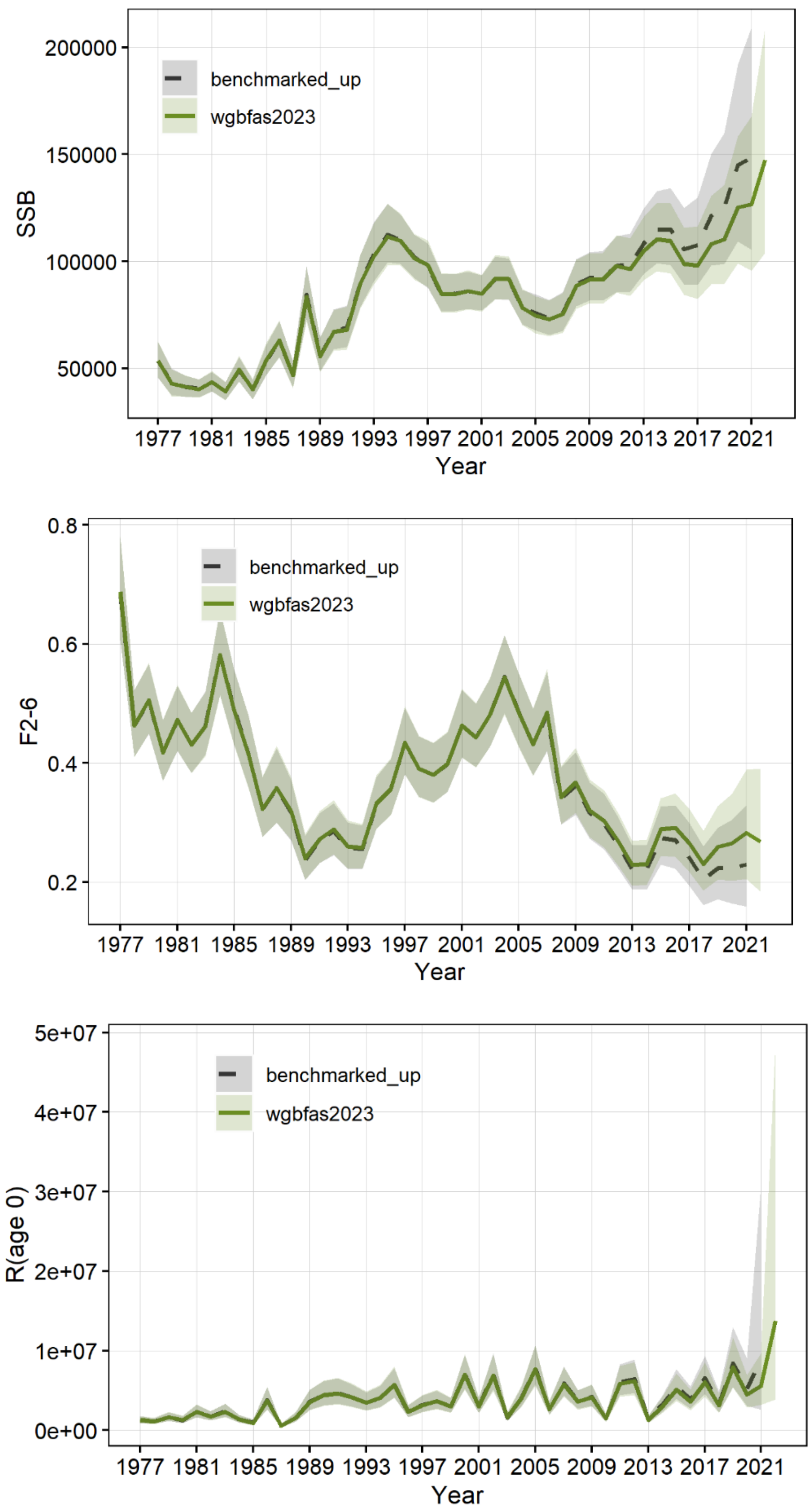


Figure 4.3.8. Gulf of Riga herring. Stock summary. This year's assessment comparison (green line) with benchmarked assessment (black dotted line).

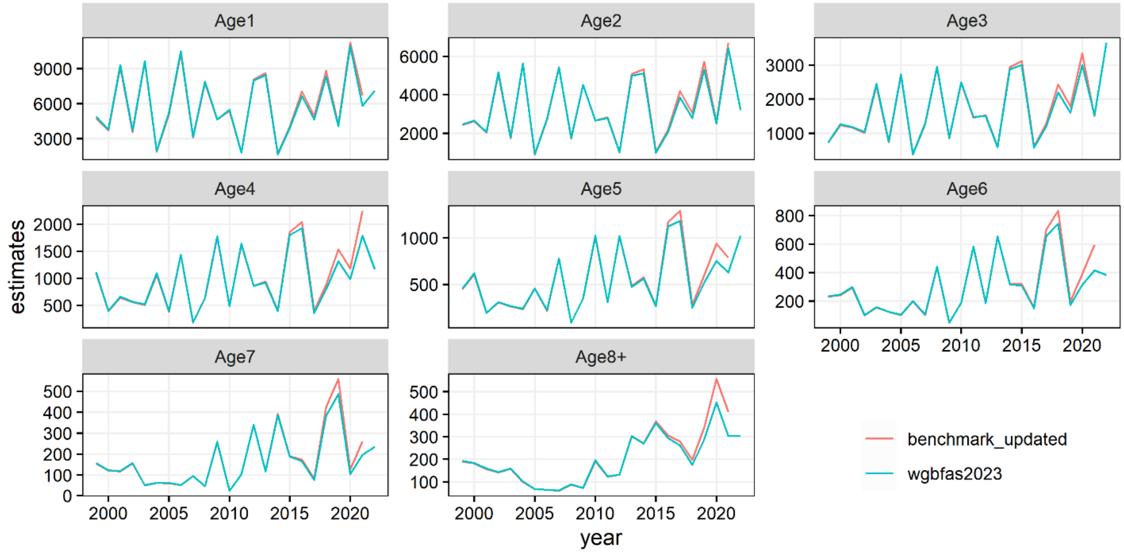


Figure 4.3.9. Gulf of Riga herring. SAM acoustic survey estimates at age from this year's assessment (blue) compared to benchmark assessment (red).

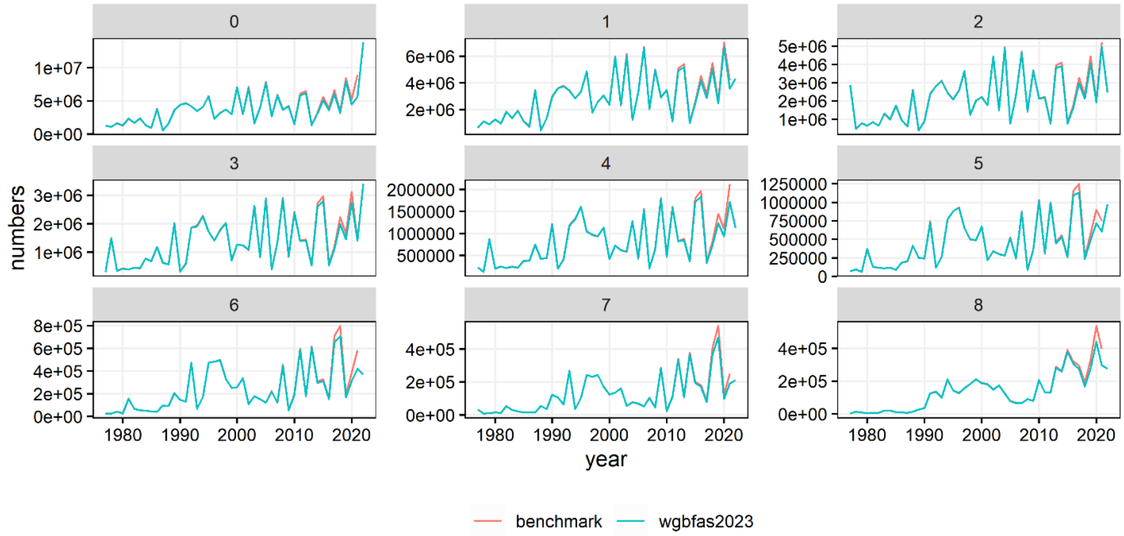


Figure 4.3.10. Gulf of Riga herring. SAM stock numbers at age estimates from this year's assessment (blue) compared to benchmark assessment (red).

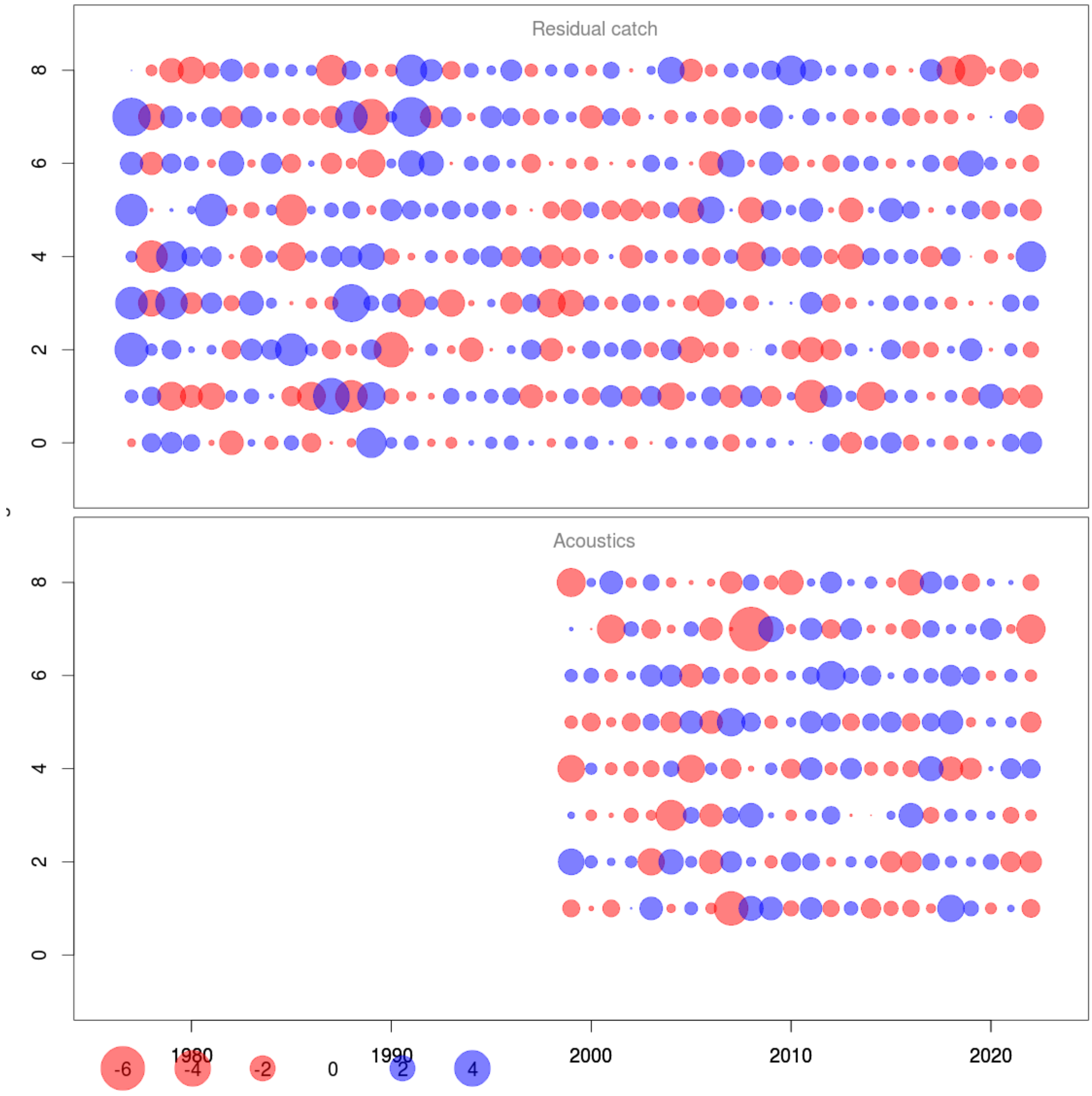


Figure 4.3.11. Gulf of Riga herring. One-observation-ahead residuals for catch and survey.

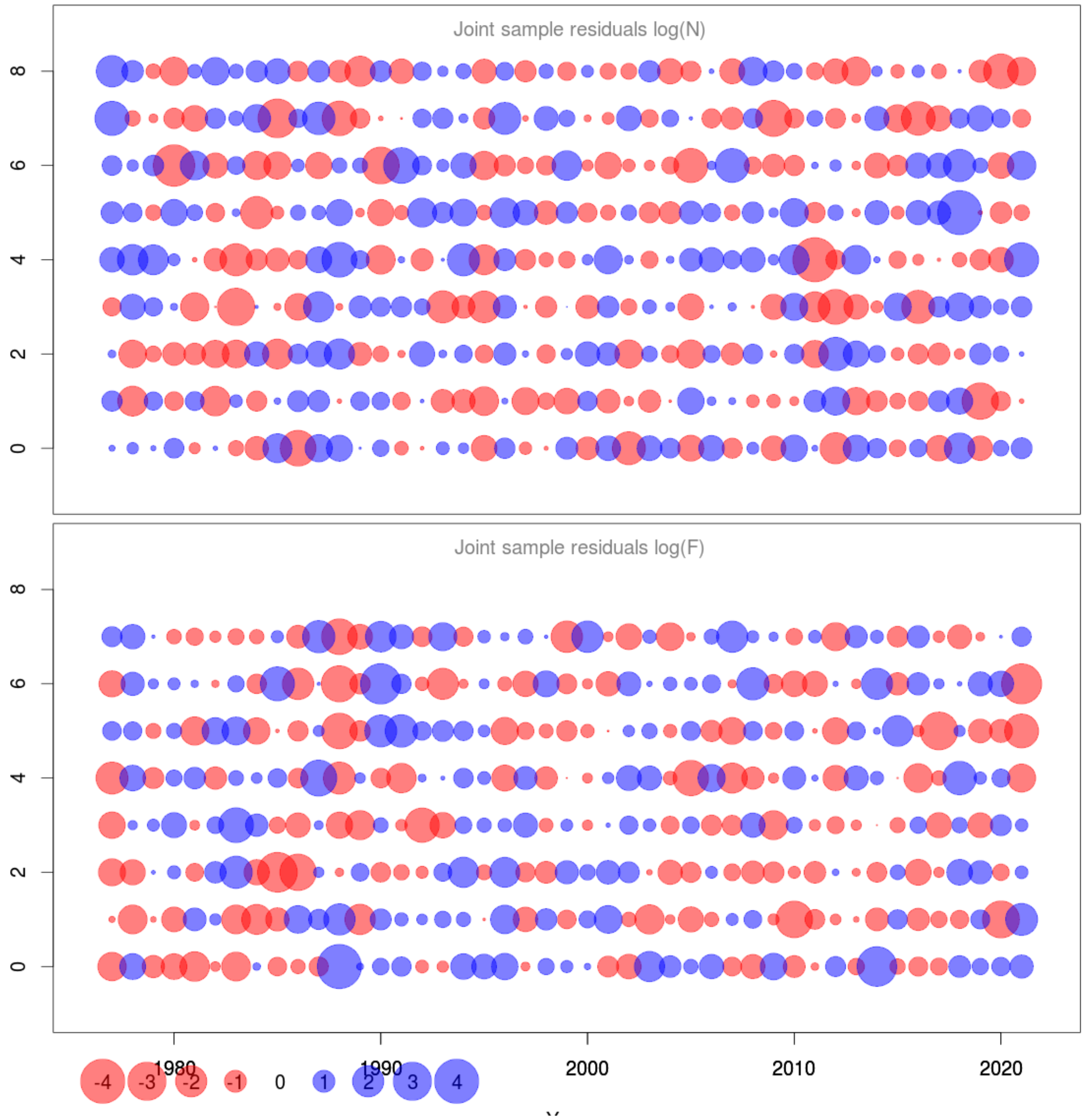


Figure 4.3.12. Gulf of Riga herring. Process error (logN, logF) residuals.

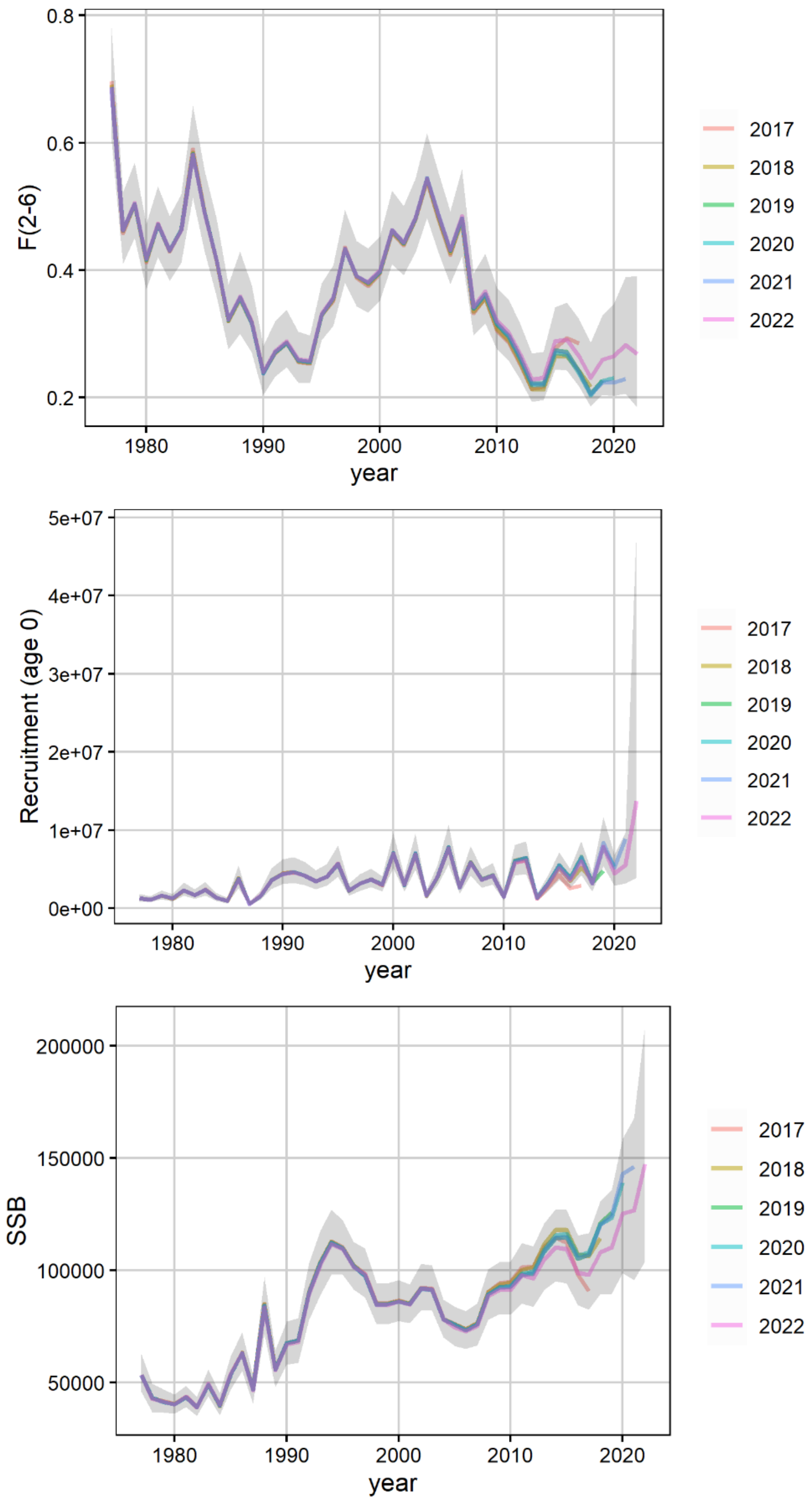


Figure 4.3.13. Gulf of Riga herring. Retrospective analysis (5 years).

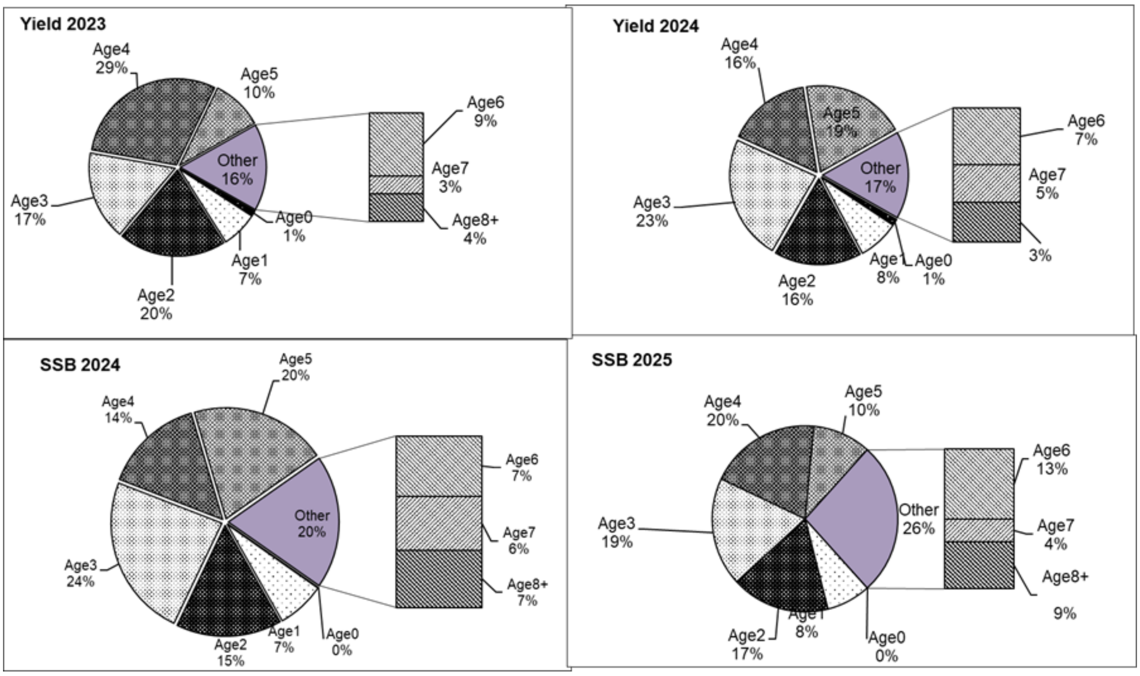


Figure 4.3.14. Gulf of Riga herring. Short term prediction. Age composition of catches and SSB.

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 2022, 96% of the Finnish catches were fished with trawls, 4% with trapnets and 0.05% with gillnets. In 2022, 99% of the Swedish catches came from trawls, 1% from gillnets and 0.03% from other fishing gears.

4.4.1.1 Landings

The total catch in the Gulf of Bothnia increased by 6691 tonnes (9%) from 71 924 tonnes in 2021 to 78 614 tonnes in 2022 (Figure 4.3.1), of which 76% (59 790 tonnes) was Finnish catch, 22% (16 908 tonnes) Swedish catch and 2% was Danish catch (Table 4.4.1). The Finnish catch increased by 5% (2866 tonnes) and the Swedish catch by 22% (1909 tonnes) compared to 2021. In 2022, 1916 tonnes were fished in Gulf of Bothnia under Danish flag for the first time.

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 0.11% (87 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 times series, 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 2022 Finnish and Swedish unsampled catches were mostly allocated in InterCatch according to the Finnish sampling and mostly from respective fisheries. Finnish, Swedish and Danish 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 2022 was age-group 3. In the recent years the number of fish has declined in most age groups, especially in the older age groups (10-15+). 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 1990s (Table 4.4.4 and Figure 4.4.6), but stabilized in the 2000s. 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 except in age-groups 2, 4, 9, 12 and 14.

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). During the meeting, a mistake was discovered in the 2022 calculations which were fixed. A maturity expert checked the method but some other maturity data issues were discovered from the database, which needs checking and consequently the whole data series derived from that database needs reviewing before the 2024 assessment.

4.4.2.4 Quality of catch and biological information

From Finnish commercial catches, 71 length samples and 64 age samples were taken during 2022, and 12 length samples and 7 age samples from the Swedish fisheries and 1 length and age sample from the Danish catches. In total, during 2022, 27 248 herrings were length-measured and 2 324 were aged (Table 4.4.2). The COVID pandemic did not influence the catch-sampling in any country in 2022

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 0.51–0.58 in 2022 (Figure 4.4.10). According to samples from commercial fishery, the condition continued to improve in the winter of 2022–2023. As low condition as that of 2021 in larger herring size groups has not been observed during the period of 1973–2022 (however, old values of condition are from age groups, not length groups). Weight at age has decreased from 2019 in almost all age groups, more in old than young herring (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 some years ago and foraged by the herring were seen rarely in the survey of 2021, and they were not abundant in 2022, either. Improved herring condition in the winter of 2022–2023 suggests 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 2018-2022 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 and 2022 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.

The model input starts with catch data from year 1963 and age-composition data from 1980 (Figure 4.4.11), 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 4.4.2 and 4.4.3).

The spawning stock of Gulf of Bothnia herring diminished from early 1960’s to a relatively low level in the beginning of the 1970s until the beginning of 1980s, from which it started to increase and peaked in 1994 (Figure 4.4.12, Table 4.4.7). From there it decreased again until early 2000s and levelled down until a small peak in 2010, after which the spawning stock has again showed a decreasing trend. In 2021 and 2022, SSB is estimated to be below $B_{trigger}$ for the first time since the 1970s. This decrease in 2021-2022 SSB is likely to be related to the downward revision of recruitment and stock numbers in 2021-2022 (Figure 4.4.16, Table 4.4.12), and the low weight-at-age of the larger herring in particular (Figure 4.4.6). Recruitment has been on average higher since the higher biomass period starting from the late 1980s, compared to the period before the biomass peak (Figure 4.4.12, Table 4.4.7), but the last three years (2020-2021) has been lower compared to the average of the last 10 years (Figure 4.4.12, 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 ($F_{2016} = 0.26$), decreased until 2020 ($F_{2020} = 0.173$) and then increased again for the last two years of the assessment ($F_{2022} = 0.22$) (Figure 4.4.12, Table 4.4.7).

The fit of the model is good with age compositions well reconstructed (Figure 4.4.13-14). Pearson residuals are within the range [-2.2 2.2] without any particularly worrying patterns (Figure 4.4.13). 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 2022 data (Figure 4.4.12). 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 Figure 4.4.15 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% (Figure 4.4.15 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 (Figure 4.4.16). Retrospective patterns improved compared to the 2022 year’s assessment. The estimated Hurtado-Ferro et al. (2014) Mohn’s rho indices were still inside the bounds of recommended values for SSB (-0.01) and F (0.04), using 5-year peels. Forecast Mohn’s rho values were -0.03 and 0.03 for SSB and F respectively, indicating good predictive power of the model.

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. Both the mean age predictions of the commercial (0.52) and survey data (0.71), and the predictions of the tuning index (0.68) scored better relative to the naïve model (Figure 4.4.17).

4.4.4.2 Short-term forecast and management options

The short-term projections were performed following the same procedures as set out by the benchmark (ICES, 2021), with SS3 using the delta-multivariate log-normal (delta-MVLN) estimator (Walter and Winker, 2019; Winker *et al.*, 2019) to provide stochastic forecasts. Recruitment in the forecast period is set to the average of the last ten years for which recruitment deviations are estimated in the SS3 model. For maturity and weight-at-age an average of the last three years is used. Constant selectivity was used. Probabilistic forecasts were used.

The assumed fishing mortality for 2023 was based on catching the full 2023 TAC (80 074 tonnes; F_{2023}=0.25; Table 4.4.8). As the short-term forecasts show that SSB is below $B_{trigger}$, F_{upper} is removed from the the F ranges in the multiannual plan, and F_{MSY} and F_{lower} is reduced by adding the multiplier $SSB_{2024}/B_{trigger}$ ($F_{MSY} = F_{MSY} * SSB_{2024}/B_{trigger} = 0.208$, $F_{lower} = F_{lower} * SSB_{2024}/B_{trigger} = 0.158$). This results in herring catches in the Gulf of Bothnia in 2024 between 48 824 tonnes and 63 049 tonnes (Table 4.4.9). The resulting catches at the adjusted F_{MSY} in 2024 (63 049 tonnes) is a decrease by 39% relative to the catches at MSY in 2022.

Note that no EU MAP scenario will keep the stock above $B_{trigger}$ in 2024, and the probability of being below B_{lim} is between 26 % and 21 %. Even a zero catch (in 2024 will not bring the stock above B_{lim} in 2025 with 95% probability. As the EU MAP states that "*Fishing opportunities shall in any event be fixed in such a way as to ensure that there is less than a 5% probability of the spawning stock biomass falling below B_{lim}*", F = 0 should be considered as basis for the advice (Table 4.4.9, catch scenario "EU MAP: P($SSB_{2025} < B_{lim}$) > 5 % ~ F = 0").

The decreased catch advice is an effect of the continued decrease in SSB, likely to be related to the downward revision of recruitment and stock numbers in 2021-2022 (Figure 4.4.16, Table 4.4.12), and the low weight-at-age (Figure 4.4.6) of the larger herring in particular. The reasons for the decline in weight-at-age are not fully understood. Further, body condition of larger herring was record low in 2021. This in combination with lower proportion of older herring in the stock will likely result in remaining low catch rates for larger herring.

4.4.4.3 Reference points

Reference points for the GoB herring stock were calculated in the 2021 WKCluB benchmark (ICES, 2021) with upper and lower ranges. However, they were updated at the advice Drafting Group ADGBS in 2021 (see WGBFAS 2021 report, annex 7 for more details).

4.4.4.4 Quality of the assessment

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 (and shows a slight improvement compared to the assessment performed in 2022).

4.4.4.5 Management considerations

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 (Figure 4.4.6). The further decrease in SSB in 2021-2023, to levels below $B_{trigger}$, is likely to be related to the downward revision of recruitment and stock numbers in 2021-2022 (Figure 4.4.16, Table 4.4.12), and the low weight-at-age (Figure 4.4.6) of the larger herring in particular. Further, body condition of larger herring was record low in 2021 (Figure 4.4.10). This in combination with lower proportion of older herring in the stock will likely result in remaining low catch rates for larger herring.

Note that no EU MAP scenario will keep the stock above $B_{trigger}$ in 2024, and the probability of being below B_{lim} in 2024 is between 26 % and 21 %. Even a zero catch (in 2024 will not bring the stock above B_{lim} in 2025 with 95% probability. As the EU MAP states that "*Fishing opportunities shall in any event be fixed in such a way as to ensure that there is less than a 5 % probability of the spawning stock biomass falling below B_{lim}*", F = 0 should be considered as basis for the advice (Table 4.4.9, catch scenario "EU MAP: $P(SSB_{2025} < B_{lim}) > 5$ % ~ F = 0").

Table 4.4.1 Herring in GOB (SD's 30 and 31) catches

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	2 689		62 911
2006	69646	1 672		71 318
2007	75108	3 570		78 678
2008	64065	3 849		67 914

Year	Finland	Sweden	Denmark	Total
2009	67047	4 201		71 248
2010	70658	1 932		72 590
2011	78348	3 502		81 850
2012	99454	6 553		106 007
2013	103421	10 975		114 396
2014	102416	12 950		115 366
2015	100784	14 158		114 942
2016	107803	22 226		130 029
2017	93558	10 800		104 358
2018	80870	16 496		97 366
2019	73243	15664		88 907
2020	60518	12412		72 956
2021	56924	14999		71 924
2022	59790	16908	1916	78 614

Table 4.3.2. Herring in GoB. Sampling in 2022.

Country and SD	Season	Catches	No of Length Samples	No of Length Measured	No of Age Samples	No of Age Readings
Denmark 30	1	648				
	2	1268	1	210	1	55
	3					
	4					
Total		1916	1	210	1	55
Finland 30	1	19369	15	4733	15	637
	2	30031	24	7311	24	488
	3	1275	2	601	2	29
	4	8529	9	2763	9	166
Total		59205	50	15408	50	1320
Finland 31	1					
	2	398	10	2776	8	204
	3	60	6	1274	4	60
	4	127	5	750	2	32
Total		585	21	4800	14	296
Sweden 30	1	8119	1	752		
	2	6209	6	3561	3	246
	3	238	2	669	2	219
	4	1999	1	1060		
Total		16566	10	6042	5	465
Sweden 31	1					
	2	34	2	788	2	188
	3	80				
	4	228				
Total		342	2	788	2	188
Grand Total		**78614**	**84**	**27248**	**72**	**2324**

In addition, 2588 age readings from BIAS 2022 were included in SD 30 Q3 age-length relationships for ALKs.

Table 4.4.3. Herring in GoB. 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

Table 4.4.4. Herring in GoB. Weight at age in catches (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	21	26	32	35	38	40	45	50	56	58	57	77	62	93
1981	12	20	27	34	41	42	46	49	54	59	68	68	65	110	75
1982	10	19	28	35	39	43	45	50	52	60	61	67	80	73	84
1983	12	21	32	38	44	50	52	56	63	63	70	81	92	103	106
1984	13	22	32	40	45	51	58	61	59	63	67	82	74	72	115
1985	10	20	30	38	42	47	52	56	58	60	64	72	76	71	80
1986	12	18	27	35	40	45	48	50	59	58	63	63	68	81	63
1987	10	22	29	35	42	46	51	57	60	61	66	67	66	74	90
1988	11	21	32	37	42	48	54	61	62	70	72	78	77	84	90
1989	12	24	33	42	47	52	56	61	67	65	71	76	81	82	117
1990	10	19	32	39	45	51	57	60	69	72	75	93	85	79	94
1991	12	22	28	36	41	48	53	55	59	64	67	71	72	80	80
1992	12	20	27	30	40	44	50	54	58	65	64	72	65	87	72
1993	11	19	27	31	34	44	50	55	60	64	67	71	79	93	95
1994	12	21	28	33	36	40	49	56	62	69	74	70	77	46	85
1995	9	19	27	30	35	39	43	52	62	68	76	94	87	104	102
1996	11	17	26	32	34	40	44	49	58	64	69	76	70	98	87
1997	9	16	23	29	34	37	43	47	54	64	69	71	91	86	92
1998	8	14	21	28	34	41	44	56	58	67	82	83	112	97	110
1999	8	13	21	26	33	41	46	54	57	63	74	79	86	103	121
2000	8	14	20	25	29	34	39	41	46	56	55	65	71	69	78
2001	9	15	22	27	29	33	40	42	47	48	58	62	62	68	78
2002	8	16	23	27	31	35	39	44	48	54	58	58	66	75	88
2003	8	16	23	27	31	35	40	42	49	57	61	62	62	71	85
2004	7	14	20	26	30	37	39	43	49	53	60	59	64	73	63
2005	8	13	20	25	30	32	39	39	43	45	48	50	45	57	55
2006	8	15	19	23	27	33	35	38	40	43	43	45	51	54	51
2007	7	15	21	25	27	31	36	39	43	44	48	50	52	52	64
2008	9	15	21	23	28	29	33	38	40	46	54	47	54	62	51
2009	10	16	21	24	30	31	35	37	41	44	52	51	57	56	56
2010	8	17	23	26	29	35	33	39	44	43	50	58	55	55	67
2011	9	16	23	27	29	33	36	39	42	43	48	50	50	60	53
2012	9	17	24	27	30	36	39	41	46	49	50	53	57	57	68
2013	13	20	25	29	32	35	37	39	44	46	46	47	52	53	57
2014	10	18	26	29	33	40	43	46	48	49	49	60	56	59	70
2015	13	19	25	29	32	37	39	43	44	47	52	51	55	53	54
2016	12	17	23	28	32	35	38	45	48	52	53	54	65	66	62
2017	10	18	23	27	32	38	39	42	48	53	56	55	59	62	67
2018	10	18	24	28	32	37	37	41	47	50	61	49	58	65	62
2019	10	17	24	30	32	34	39	43	47	51	51	53	56	64	64
2020	7	17	24	30	34	36	39	47	48	51	57	60	58	48	68
2021	7	16	21	25	28	32	34	36	41	43	45	49	51	50	55
2022	8	15	21	25	29	32	34	37	39	44	46	46	54	47	56

Table 4.4.5. Herring in Gulf of Bothnia. 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	0,86	1,00	1,00	1,00	0,86	1,00

Table 4.4.6. Area corrected numbers (millions) of herring per age groups in the ICES Subdivision 30 (StoX calculated).

ANNUS	Sub_Div	CORR_F/	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6	AGE7	AGE8	AGE9	AGE10	AGE11	AGE12	AGE13	AGE14	AGE15+
2007	30	1,04	480	6346	5228	1902	1492	5449	1420	786	536	490	322	253	139	145	75	260
2008	30	1,21	1069	3074	5105	3478	1649	1707	3285	1235	987	630	396	292	173	155	145	147
2009	30	1,06	819	4667	5074	5358	2491	1259	1458	3525	1210	544	575	316	336	172	152	221
2010	30	1,06	712	4465	7189	3611	3424	1669	1055	931	2145	505	519	261	184	128	72	173
2011	30	1,06	2504	4412	6285	7406	2942	3127	1360	587	497	1949	379	288	202	164	133	149
2012	30	1,08	1398	11389	3905	3271	2902	1695	1627	962	382	504	817	344	140	104	103	178
2013	30	1,08	5567	1849	3889	1503	1717	1597	711	884	408	172	260	477	188	92	49	104
2014	30	1,08	11845	4839	2637	2193	1012	687	554	626	322	180	102	204	237	52	50	81
2015	30	1,22	3446	8863	3462	1912	1334	763	764	458	472	284	156	121	176	129	109	65
2016	30	1,08	1502	2003	6118	2778	1544	956	499	540	438	276	263	138	138	223	173	171
2017	30	1,08	1287	7732	5065	8105	2444	1595	927	449	426	368	294	238	62	82	148	207
2018	30	1,08	6174	2882	3937	2087	3158	869	767	412	262	275	245	137	161	68	48	190
2019	30	1,08	2798	3538	3682	3780	1834	2333	838	492	440	261	148	125	50	84	47	94
2020	30	1,08	5444	9016	8361	3422	2987	1993	1299	483	319	241	92	91	79	46	18	86
2021	30	1,16	2732	2202	5200	3046	1449	963	811	299	199	181	79	69	49	32	33	75
2022	30	1,16	1393	1162	2539	4672	2266	961	655	323	185	177	73	62	34	30	7	27

Table 4.4.7. Herring in subdivisions 30 and 31. Assessment summary. Weights are in tonnes. Recruitment in thousands.

Year	Recruitment			SSB*			Total	F		
	Age 0	90%	10%	SSB	90%	10%	Catch	Ages 3–7	90%	10%
	thousands			Tonnes			tonnes			
1963	19 616 800	42 059 415	9 149 410	1 078 880	1 222 510	935 250	29 739	0.030	0.033	0.026
1964	17 989 500	37 922 600	8 533 753	1 077 000	1 219 645	934 355	25 204	0.025	0.029	0.022
1965	16 462 800	34 138 415	7 938 968	1 054 110	1 194 719	913 501	27 541	0.029	0.033	0.025
1966	14 970 400	30 557 775	7 334 070	972 410	1 121 704	823 116	22 164	0.025	0.028	0.021
1967	13 376 900	26 836 671	6 667 796	893 246	1 046 052	740 440	27 772	0.034	0.039	0.028
1968	12 345 300	24 146 737	6 311 678	810 699	961 885	659 513	28 966	0.039	0.046	0.032
1969	11 766 800	22 236 721	6 226 529	721 149	864 906	577 392	35 996	0.054	0.065	0.044
1970	17 800 300	29 967 415	10 573 174	664 206	808 490	519 922	32 790	0.054	0.065	0.043
1971	13 292 500	22 451 926	7 869 728	509 359	620 724	397 994	36 347	0.078	0.095	0.062
1972	17 745 600	27 367 541	11 506 562	544 925	671 643	418 207	34 092	0.067	0.082	0.052
1973	23 798 800	34 068 311	16 624 918	588 004	732 183	443 825	26 507	0.048	0.059	0.036
1974	19 048 000	27 175 178	13 351 387	506 516	628 057	384 975	26 776	0.054	0.067	0.041
1975	40 792 900	53 226 655	31 263 672	540 496	667 065	413 927	21 811	0.041	0.051	0.032
1976	14 912 500	20 481 794	10 857 577	551 671	679 973	423 369	30 520	0.057	0.070	0.043
1977	9 553 010	13 301 142	6 861 065	596 622	733 356	459 888	33 634	0.057	0.070	0.043
1978	9 371 230	12 776 964	6 873 303	677 463	833 775	521 151	34 873	0.058	0.072	0.044
1979	24 351 600	30 955 042	19 156 828	621 574	769 410	473 738	26 109	0.047	0.058	0.035
1980	13 712 700	18 029 373	10 429 544	545 482	677 692	413 272	29 809	0.058	0.072	0.044
1981	20 726 200	26 531 440	16 191 182	557 253	693 590	420 916	21 526	0.039	0.049	0.030
1982	33 792 900	42 139 158	27 099 737	576 378	714 364	438 392	26 499	0.049	0.061	0.037

Year	Recruitment Age 0	90%	10%	SSB* SSB	90%	10%	Total Catch	F Ages 3–7	90%	10%
	thousands			Tonnes			tonnes			
1983	44 077 000	54 163 623	35 868 759	630 308	781 284	479 332	26 208	0.042	0.052	0.032
1984	36 644 900	45 164 290	29 732 532	691 335	849 962	532 708	34 545	0.048	0.059	0.037
1985	15 408 000	19 946 786	11 901 991	759 621	925 929	593 313	35 432	0.046	0.056	0.035
1986	30 480 100	37 583 462	24 719 290	853 620	1 031 139	676 101	35 579	0.045	0.054	0.035
1987	14 678 000	19 118 211	11 269 030	945 861	1 139 566	752 156	32 628	0.038	0.046	0.030
1988	63 161 600	75 403 350	52 907 300	918 734	1 107 728	729 740	36 418	0.040	0.048	0.032
1989	57 661 700	69 148 323	48 083 185	1 049 510	1 256 157	842 863	33 086	0.033	0.039	0.026
1990	32 257 700	39 652 267	26 242 112	1 181 130	1 396 113	966 147	39 180	0.037	0.044	0.030
1991	37 430 100	45 586 107	30 733 319	1 316 830	1 542 700	1 090 960	33 419	0.029	0.034	0.024
1992	39 868 500	48 079 997	33 059 430	1 279 510	1 495 813	1 063 207	46 610	0.041	0.048	0.034
1993	25 154 300	31 265 439	20 237 644	1 231 370	1 439 777	1 022 963	49 314	0.043	0.051	0.035
1994	32 375 500	39 439 937	26 576 437	1 357 030	1 580 536	1 133 524	61 986	0.053	0.062	0.044
1995	25 902 900	32 046 042	20 937 382	1 200 390	1 404 230	996 550	65 547	0.060	0.070	0.049
1996	22 763 300	28 481 797	18 192 947	1 182 760	1 381 655	983 865	61 303	0.060	0.070	0.050
1997	41 814 700	50 320 996	34 746 314	991 481	1 163 428	819 534	69 808	0.076	0.089	0.063
1998	24 220 400	30 727 028	19 091 588	947 730	1 119 202	776 258	62 474	0.070	0.082	0.057
1999	36 126 600	44 303 961	29 458 567	924 282	1 090 720	757 844	66 502	0.078	0.092	0.064
2000	29 205 100	36 521 824	23 354 197	858 384	1 006 849	709 919	58 852	0.080	0.095	0.066
2001	44 189 700	53 622 940	36 415 937	841 419	985 044	697 794	57 806	0.079	0.094	0.065
2002	88 439 800	102 774 343	76 104 580	849 923	994 658	705 188	53 969	0.072	0.085	0.059
2003	20 025 600	26 161 783	15 328 644	861 359	1 003 190	719 528	53 644	0.067	0.079	0.055
2004	21 279 400	27 519 899	16 454 016	903 300	1 044 289	762 311	61 423	0.071	0.083	0.059
2005	29 104 000	36 018 507	23 516 877	915 083	1 049 731	780 435	62 911	0.077	0.089	0.064
2006	40 678 400	48 608 997	34 041 686	818 430	938 706	698 154	71 318	0.096	0.111	0.081
2007	29 460 100	36 089 987	24 048 152	797 435	913 032	681 838	78 678	0.109	0.126	0.093
2008	39 421 200	47 103 914	32 991 547	758 237	866 779	649 695	67 914	0.099	0.114	0.085
2009	32 542 200	39 442 242	26 849 254	751 256	855 080	647 432	71 248	0.104	0.119	0.089
2010	22 273 700	28 048 233	17 688 020	900 023	1 015 048	784 998	72 590	0.103	0.118	0.089

	Recruitment			SSB*			Total	F		
Year	Age 0	90%	10%	SSB	90%	10%	Catch	Ages 3–7	90%	10%
	thousands			Tonnes			tonnes			
2011	30 251 400	36 772 462	24 886 754	799 206	902 547	695 865	81 850	0.120	0.137	0.103
2012	22 969 500	28 508 140	18 506 922	807 850	911 965	703 735	106 007	0.161	0.185	0.138
2013	26 278 100	32 290 605	21 385 123	803 968	905 329	702 607	114 396	0.185	0.210	0.158
2014	44 750 500	53 104 475	37 710 706	742 618	843 157	642 079	115 366	0.200	0.230	0.169
2015	24 727 600	30 835 799	19 829 361	698 528	794 816	602 240	114 942	0.220	0.250	0.183
2016	30 094 500	37 495 464	24 154 360	652 592	748 297	556 887	130 029	0.260	0.310	0.210
2017	19 752 100	25 821 686	15 109 217	633 744	736 985	530 503	104 358	0.220	0.260	0.178
2018	26 683 900	35 048 236	20 315 731	638 711	752 351	525 071	97 366	0.220	0.260	0.171
2019	35 812 600	47 791 009	26 836 477	561 006	675 077	446 935	88 907	0.210	0.260	0.161
2020	21 175 600	30 774 802	14 570 558	559 409	688 079	430 739	72 956	0.173	0.220	0.129
2021	13 416 100	23 562 344	7 638 957	522 158	654 338	389 978	71 924	0.186	0.240	0.133
2022	23 010 100	58 172 225	9 101 675	492 750	634 359	351 141	78 614	0.220	0.280	0.146
2023	26 570 110**			449 913	600 729	299 097				

Table 4.4.8 Herring in subdivisions 30 and 31. The basis made for the interim year 2023 and in the forecast for 2024.

Variable	Value	Notes
$F_{ages\ 3–7}$ (2023)	0.25	Based on a catch of 80074 tonnes in 2023 (agreed TAC).
SSB (2024)	410 006	Short term forecast; tonnes
$R_{age\ 0}$ (2023–2025)	26 570	Average of recruitment (2013–2022); millions
Total catch (2023)	80 074	STF using TAC; tonnes

Table 4.4.9 Herring in subdivisions 30 and 31. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2024)	F (2024)	SSB (2025)	% SSB change *	% TAC change**	% Advice change ***	Probability SSB < B_{lim} in 2025^
ICES advice basis							
EU MAP^^: F_{MSY} * SSB(2024)/$B_{trigger}$	63 049	0.208	430 423	5	-21	-39	0.26
EU MAP^^: MAP range F_{lower} * SSB(2024)/$B_{trigger}$	48 824	0.158	444 084	8.3	-39	-39	0.21
EU MAP^^^: P(SSB_{2025} < B_{lim}) > 5 % ~ F = 0	0	0	491 083	20	-100	-100	0.09
Other scenarios							
F_{MSY}	80 198	0.271	413 976	1	0.2	-22	0.32
F_{lower}	62 491	0.206	430 958	5.1	-22	-39	0.25
F_{pa} = $F_{MSY\ upper}$	80 463	0.272	413 722	0.9	0.5	-22	0.32
F_{lim}	135 034	0.496	361 570	-12	69	32	0.58
F_{upper} * SSB (2024)/$B_{trigger}$	63 328	0.209	430 155	4.9	-21	-39	0.26
SSB (2025) = B_{lim}	119 217	0.427	376 655#	-8.1	49	16	0.5
SSB (2025) = B_{pa}##							
SSB (2025) = MSY $B_{trigger}$##							
SSB (2025) = SSB (2024)	84 420	0.287	409 930#	0	5.4	-18	0.34
F = F_{2023}	74 845	0.251	419 108	2.2	-6.5	-27	0.29

*** SSB 2025 relative to SSB 2024.**

**** Catch in 2024 relative to the TAC in 2023 (80074 tonnes).**

***** Advice values for 2024 relative to the corresponding 2023 values (EU MAP advice of 102 719 [F_{MSY}], 103 059 [F_{upper}] and 80 074 [F_{lower}] tonnes, respectively; other values are relative to 102 719 tonnes).**

^ The probability of SSB being below B_{lim} in 2025. 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).

^^^ Following the EU MAP plan when the probability of SSB (2025) < B_{lim} is greater than 5 %.

 # Based on stochastic forecasts, using the F with three decimals to get close to the biomass target.

The B_{pa}, and MSY $B_{trigger}$ options were left blank because B_{pa}, and MSY $B_{trigger}$ cannot be achieved in 2025 even with zero catch in 2024.

Table 4.4.10. Ratio of N@age in 2022 and 2023 year's assessments (numbers estimated in current assessment / numbers estimated in previous assessment). Ratio < 1 (red gradient) denotes a downgrade in the current (2023) 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+**
2019	1.01	0.99	0.97	0.96	0.97	0.95	0.96	0.96	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2020	1.02	1.01	0.98	0.97	0.95	0.96	0.95	0.95	0.95	0.94	0.94	0.94	0.94	0.94	0.94	0.93	0.93	0.93	0.93	0.93	0.93
2021	0.57	1.02	1.01	0.98	0.96	0.94	0.96	0.94	0.95	0.94	0.94	0.94	0.93	0.93	0.93	0.93	0.93	0.92	0.92	0.93	0.92
2022	0.67	0.57	1.02	1.01	0.97	0.96	0.94	0.95	0.93	0.94	0.93	0.93	0.93	0.93	0.93	0.93	0.92	0.92	0.92	0.92	0.92

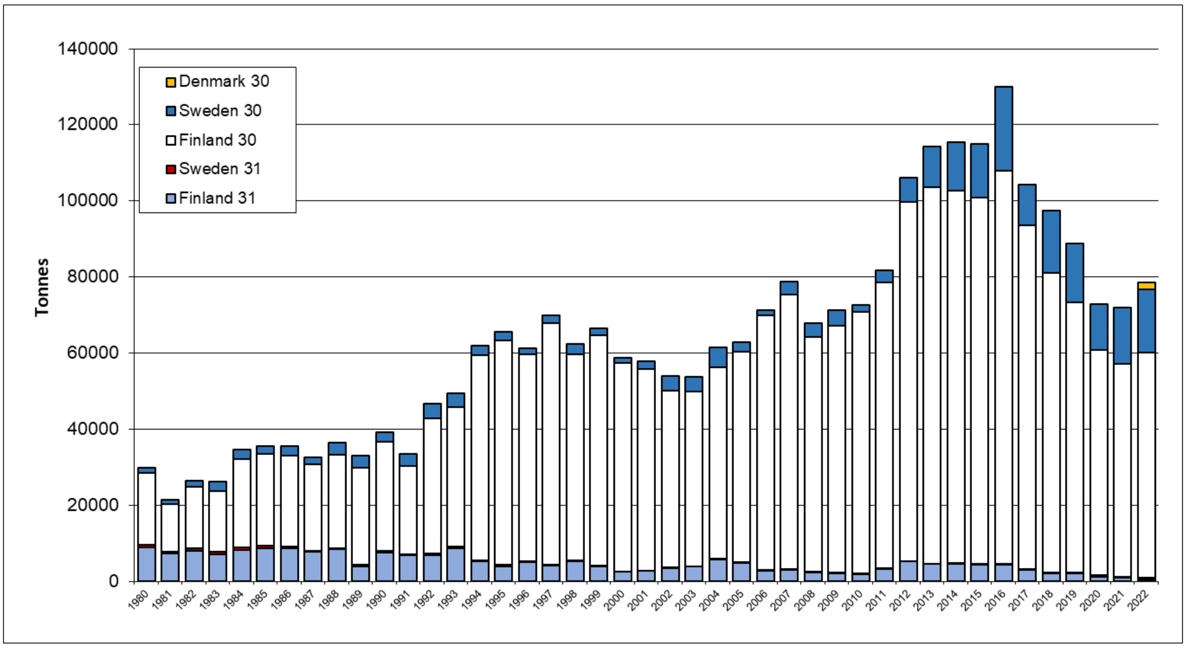


Figure 4.4.1 Herring in SD's 30 and 31. Catches (tonnes) by country

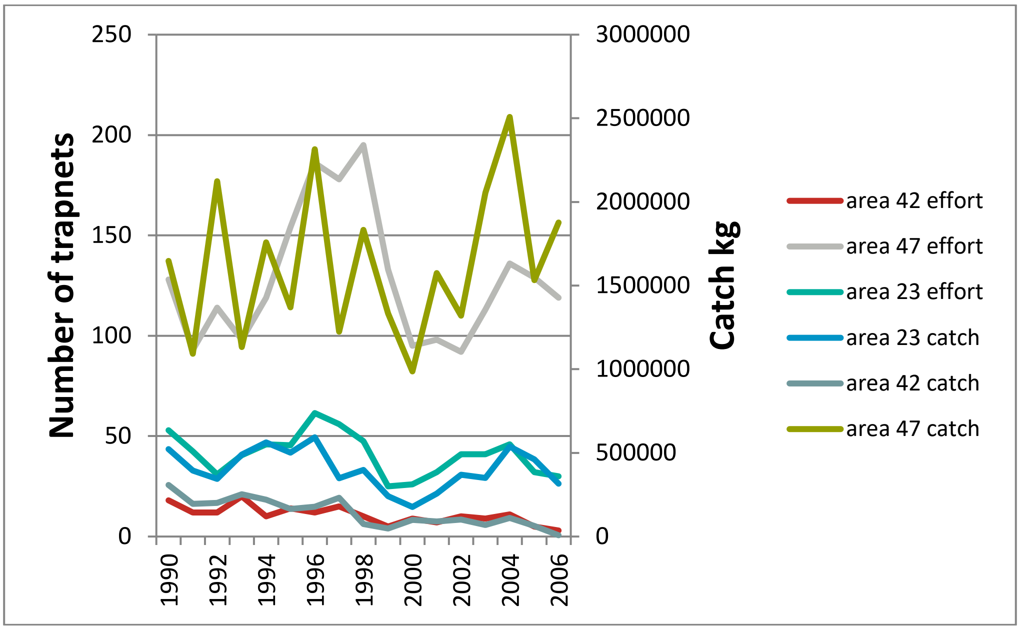


Figure 4.4.2. Herring in SD's 30 and 31. Trapnets catch (kg) and effort (number of traps) in three different areas used to calculate the trap net tuning index..

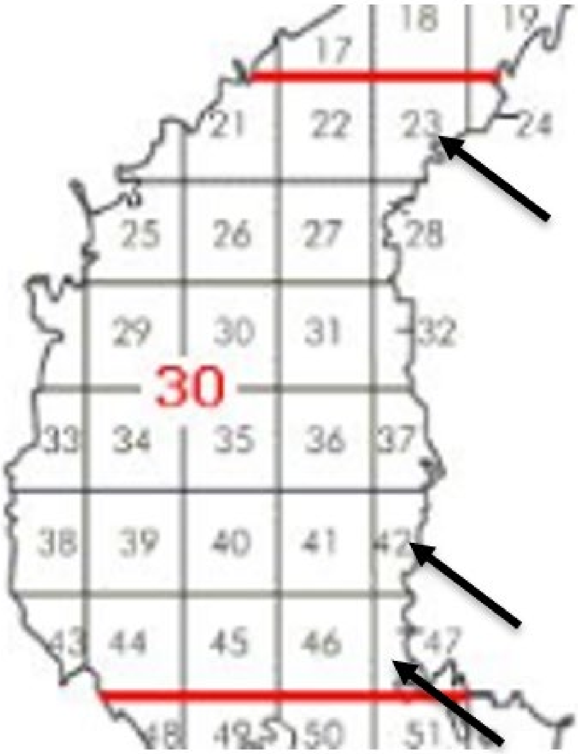


Figure 4.4.3. Herring in SD's 30 and 31. The areas (statistical rectangles) where the Trapnets were situated.

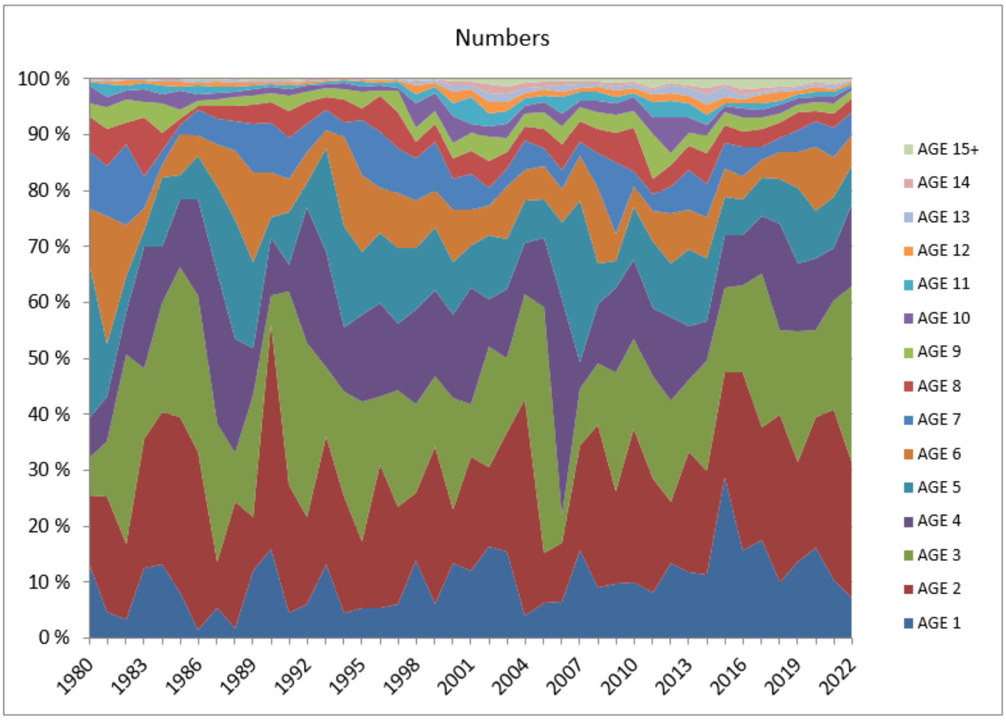


Figure 4.4.4. Herring in SD's 30 and 31. Shares of age-groups in catches (Canum)

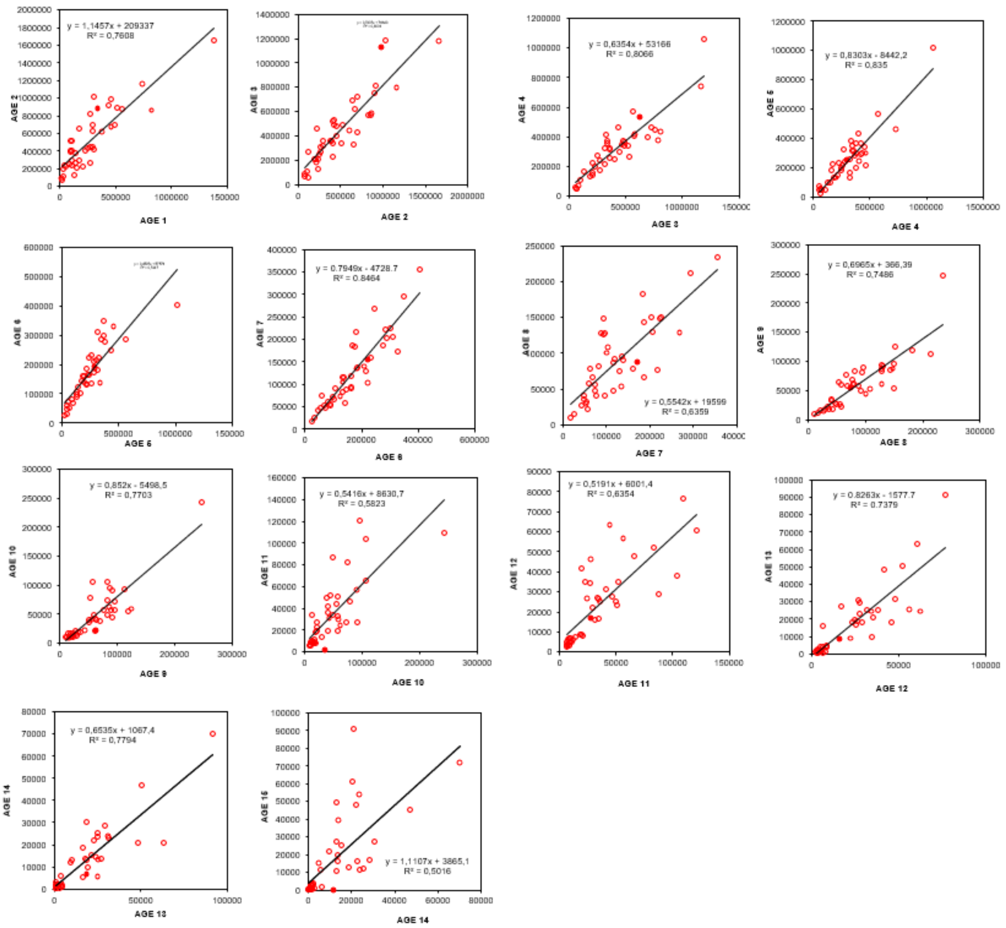


Figure 4.4.5. Herring in SD's 30 and 31. Consistency in catch at age data.

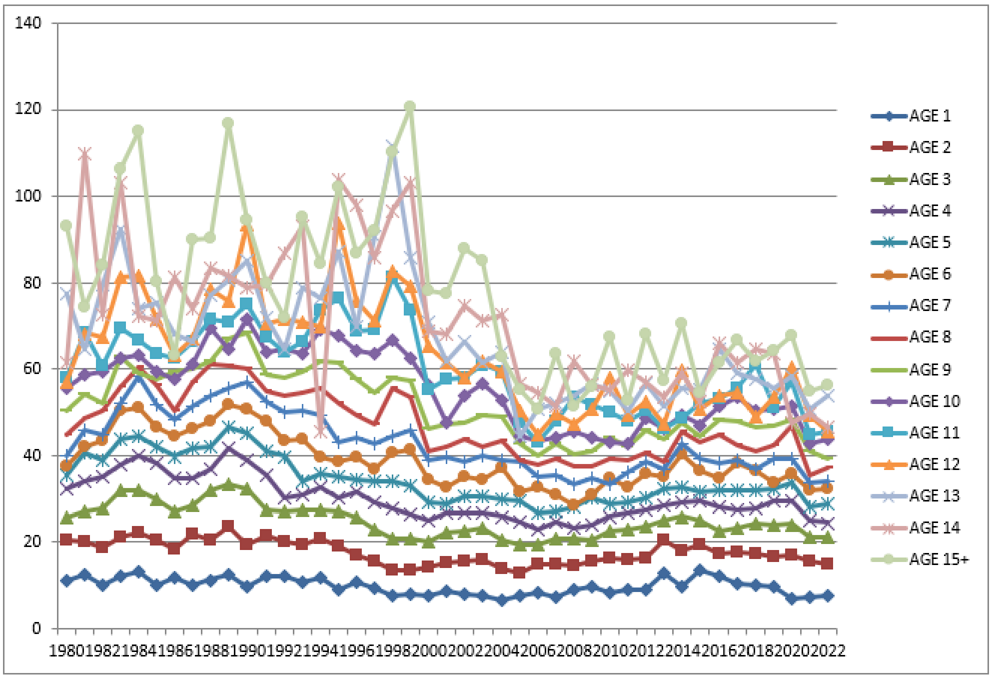


Figure 4.4.6. Herring in SD's 30 and 31. Mean weights at age in catches

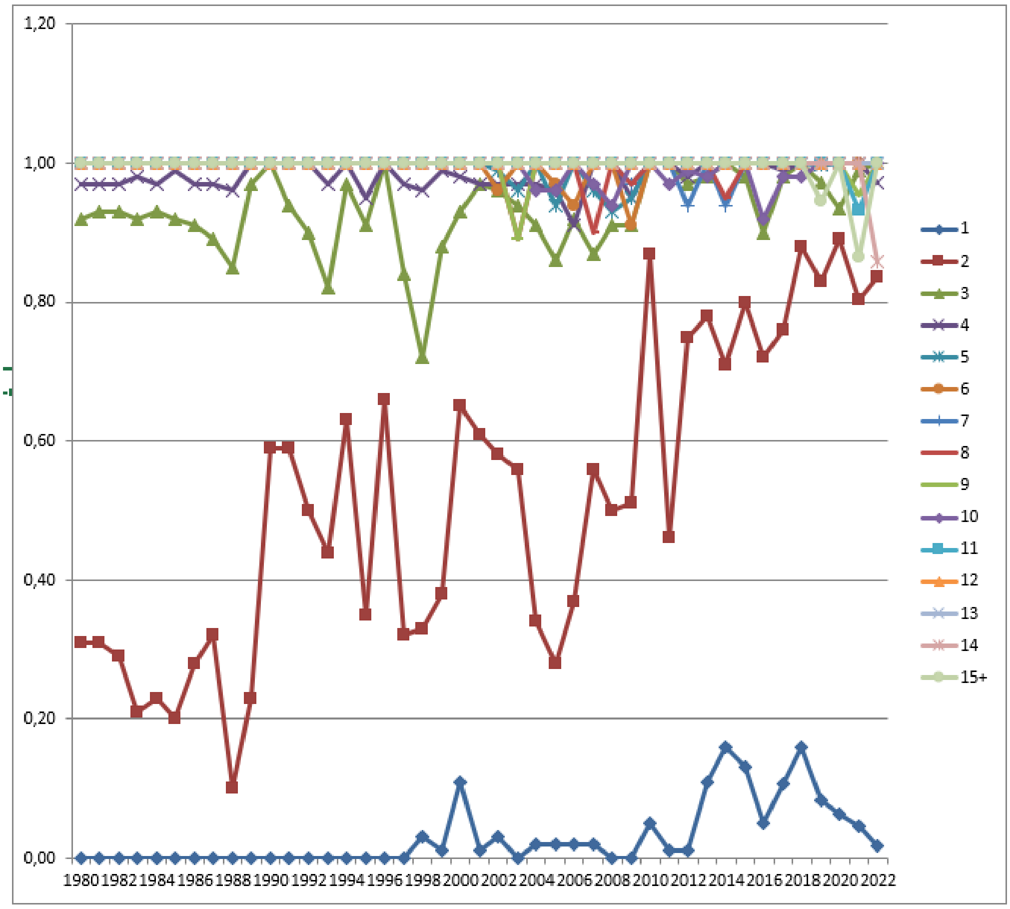


Figure 4.4.7. Herring in SD's 30 and 31. Maturity at age

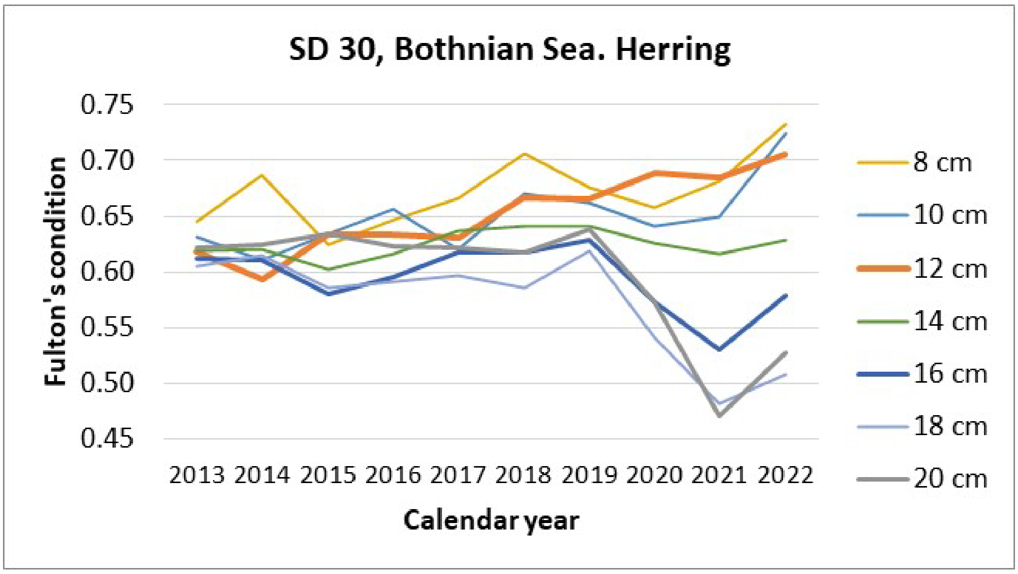


Figure 4.4.10. Herring in SD's 30 and 31. Fulton's condition (K = W/L³) of herring in different length classes (total length) in BIAS surveys in 2013–2022.

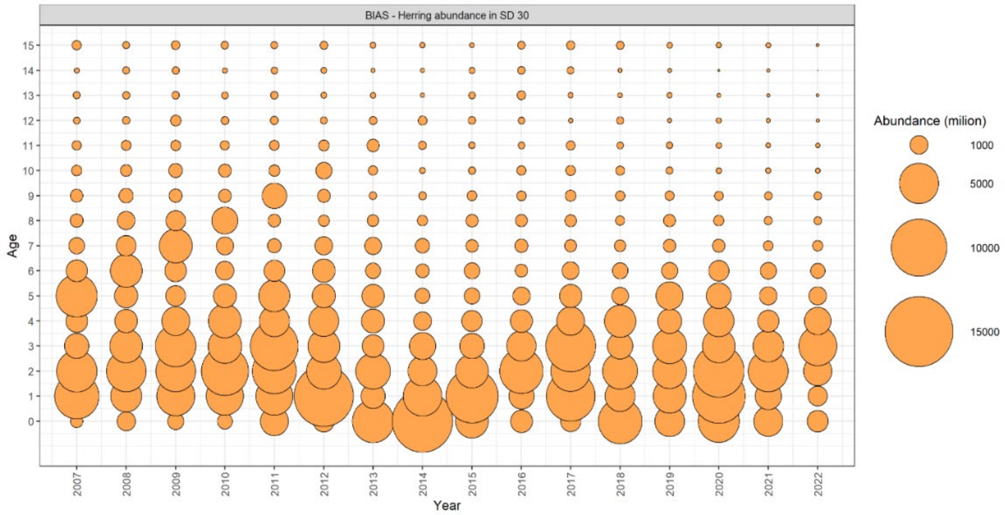


Figure 4.4.8. Herring in SDs 30 and 31. Year class strength in acoustic estimates in ages 0-15+

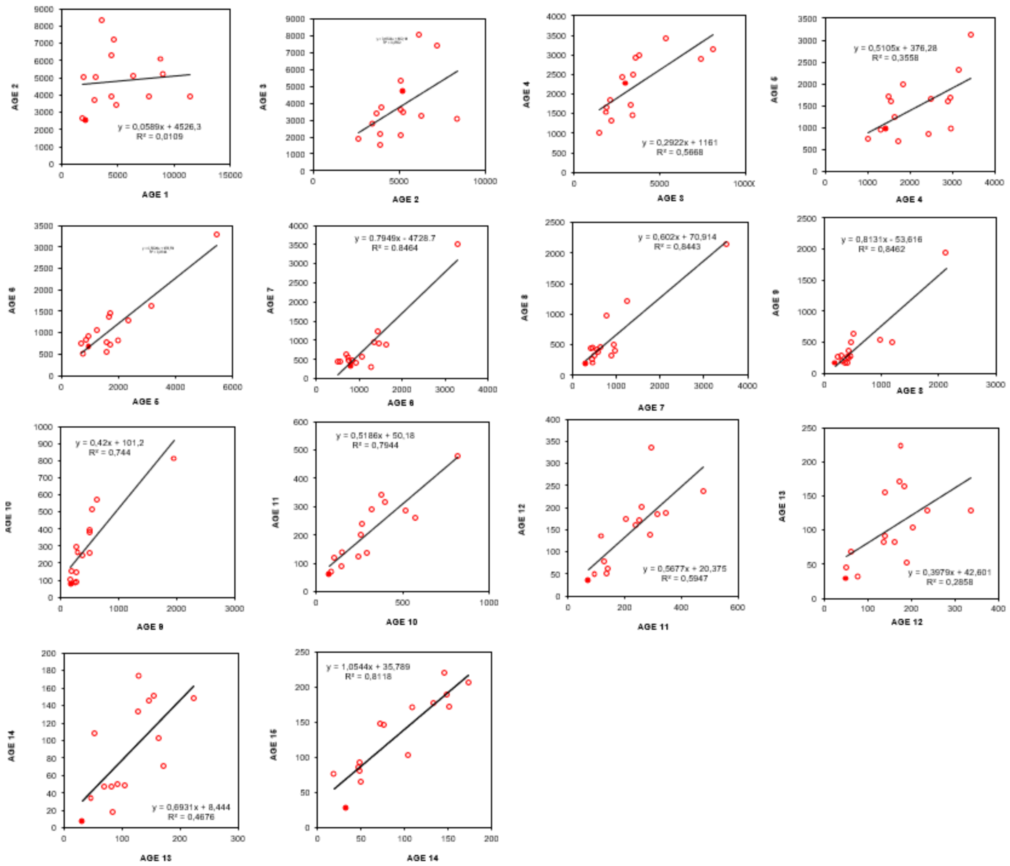


Figure 4.4.9. Herring in SD 30 and 31. Internal consistency in the acoustic age matrix.

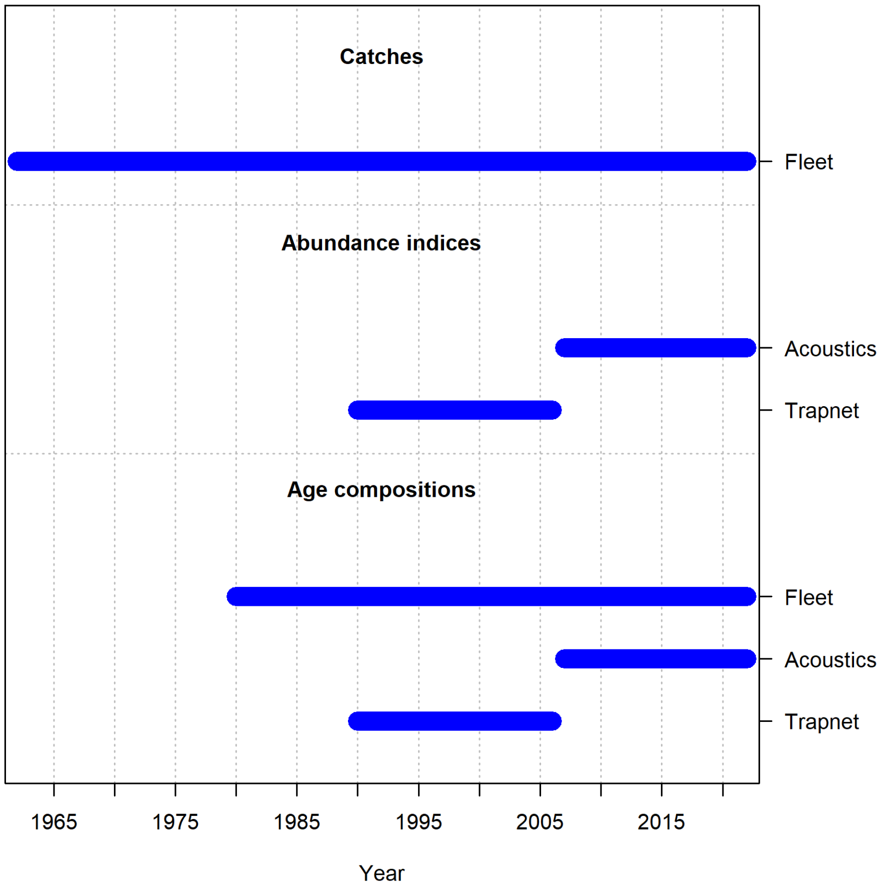


Figure 4.4.11. Herring in SDs 30 and 31. Model input data.

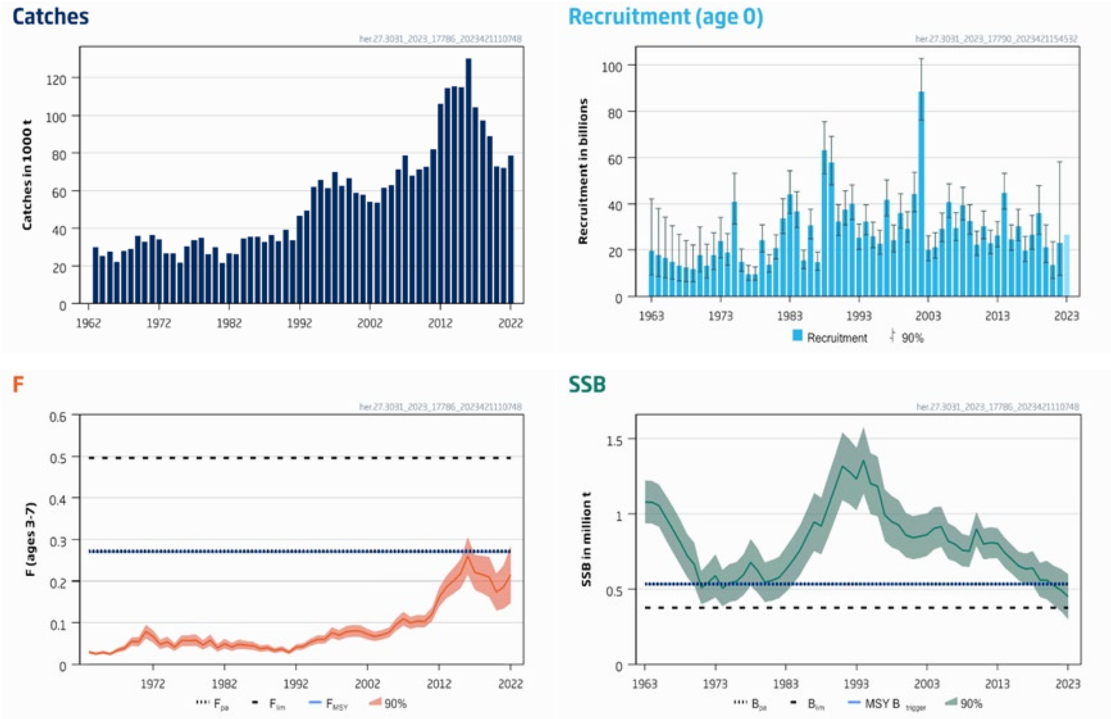

Catches
Catches in 1000 t
Recruitment (age 0)
Recruitment in billions
Recruitment
90%
F
F (ages 3-7)
Fpa
Flim
FMSY
90%
SSB
SSB in million t
Bpa
Blim
MSY B trigger
90%

Figure 4.4.12. Herring in SDs 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 2023 is shaded in a lighter colour.

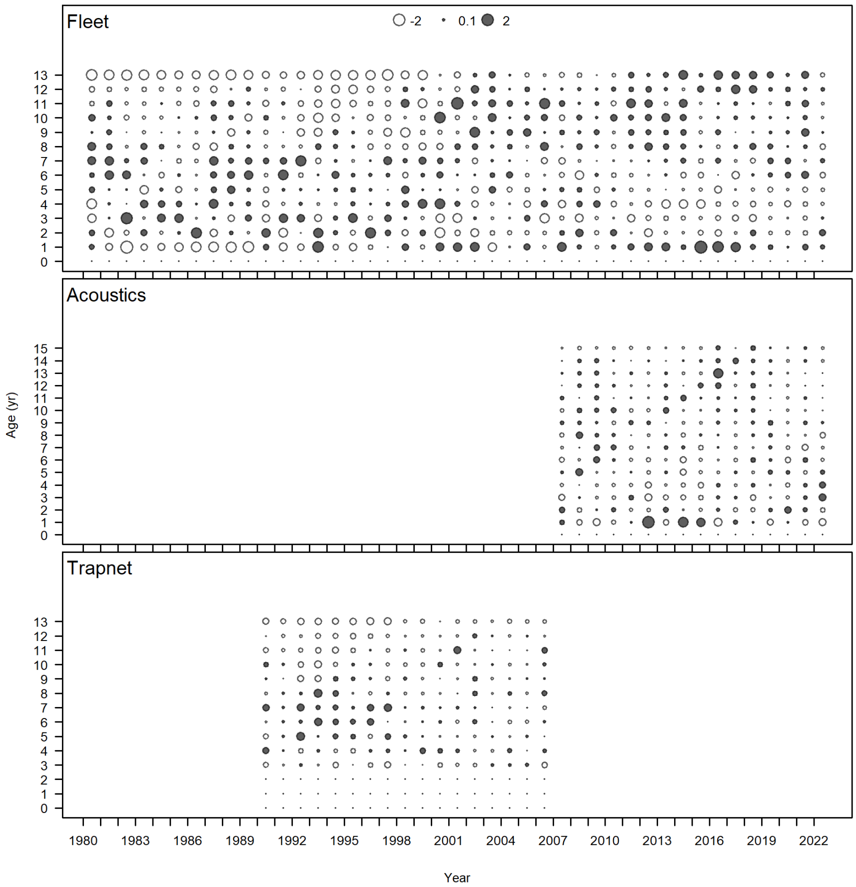


Figure 4.4.13. Herring in SDs 30 and 31. Pearson residuals for commercial (upper), acoustic (middle) and trapnet (lower) data, in 1980-2022. Residuals are within the range [-2.2 2.2]. Filled and open bubbles denote positive and negative residuals respectively.

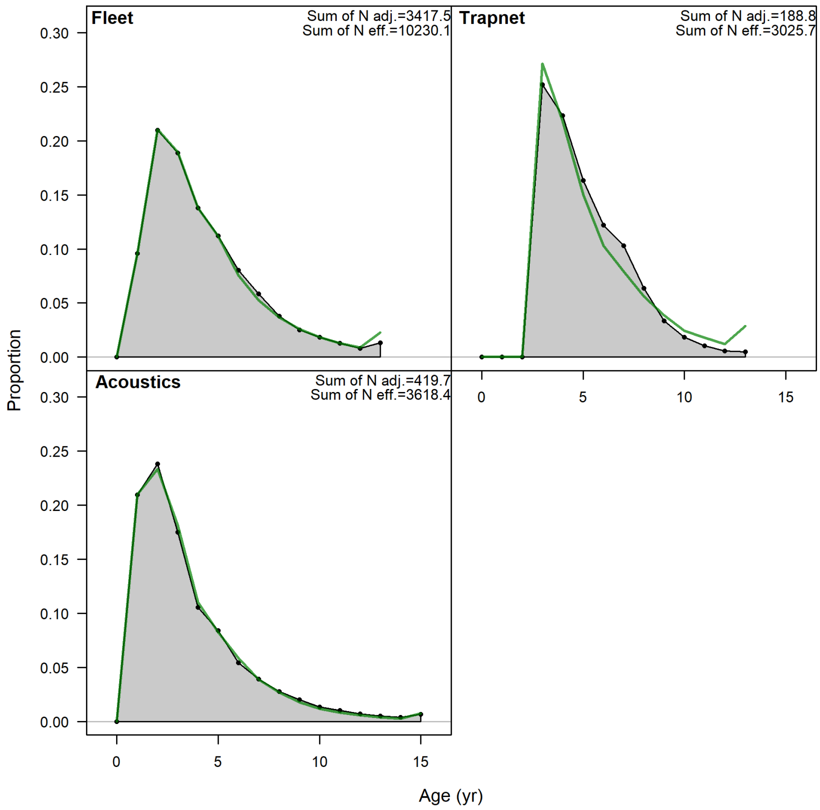
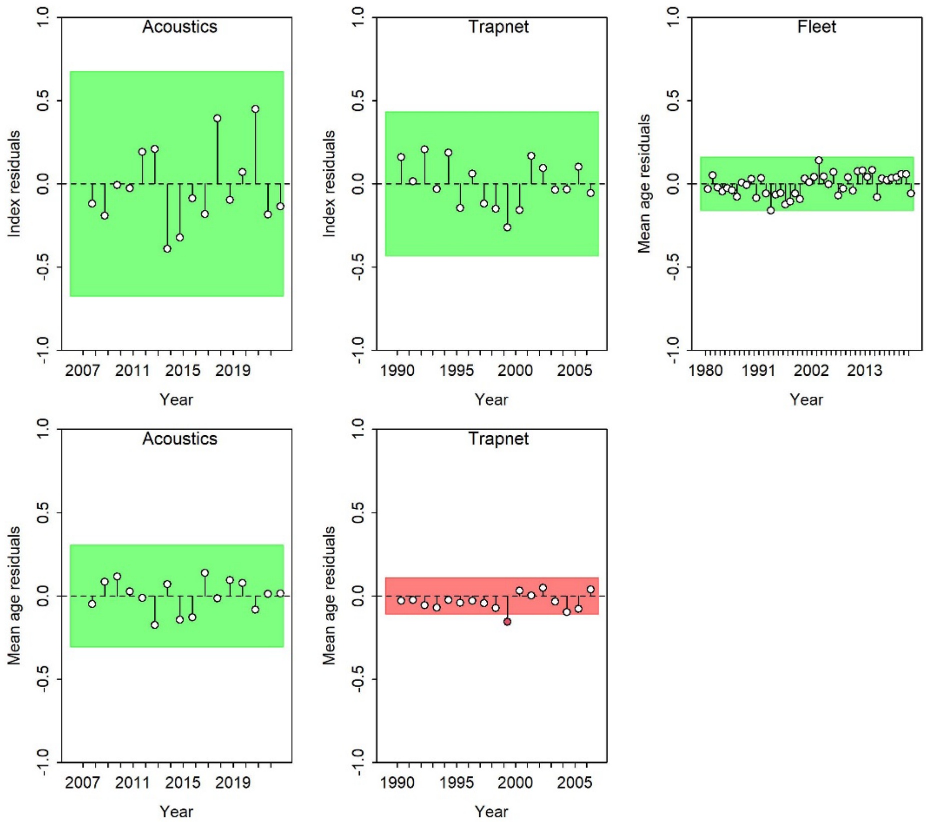


Figure 4.4.14. Herring in SDs 30 and 31. Age-composition fit of model (green line) with commercial (upper left), acoustic (upper right) and trapnet (lower) data, aggregated across time.

A



B

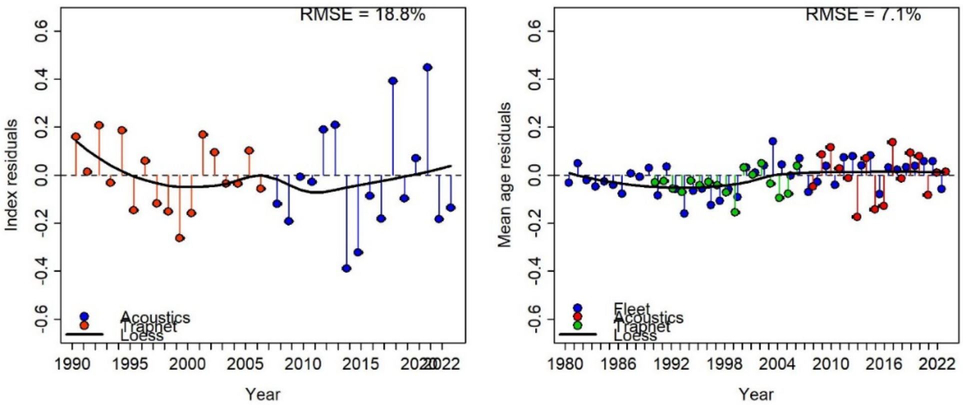


Figure 4.4.15. Herring in SDs 30 and 31. Residuals from Runs test analyses for the age distributions and the fit to the acoustic and trapnet survey indices (A) and from the RMSE test analyses for the age distributions and the fit to the acoustic and trapnet survey indices (B).

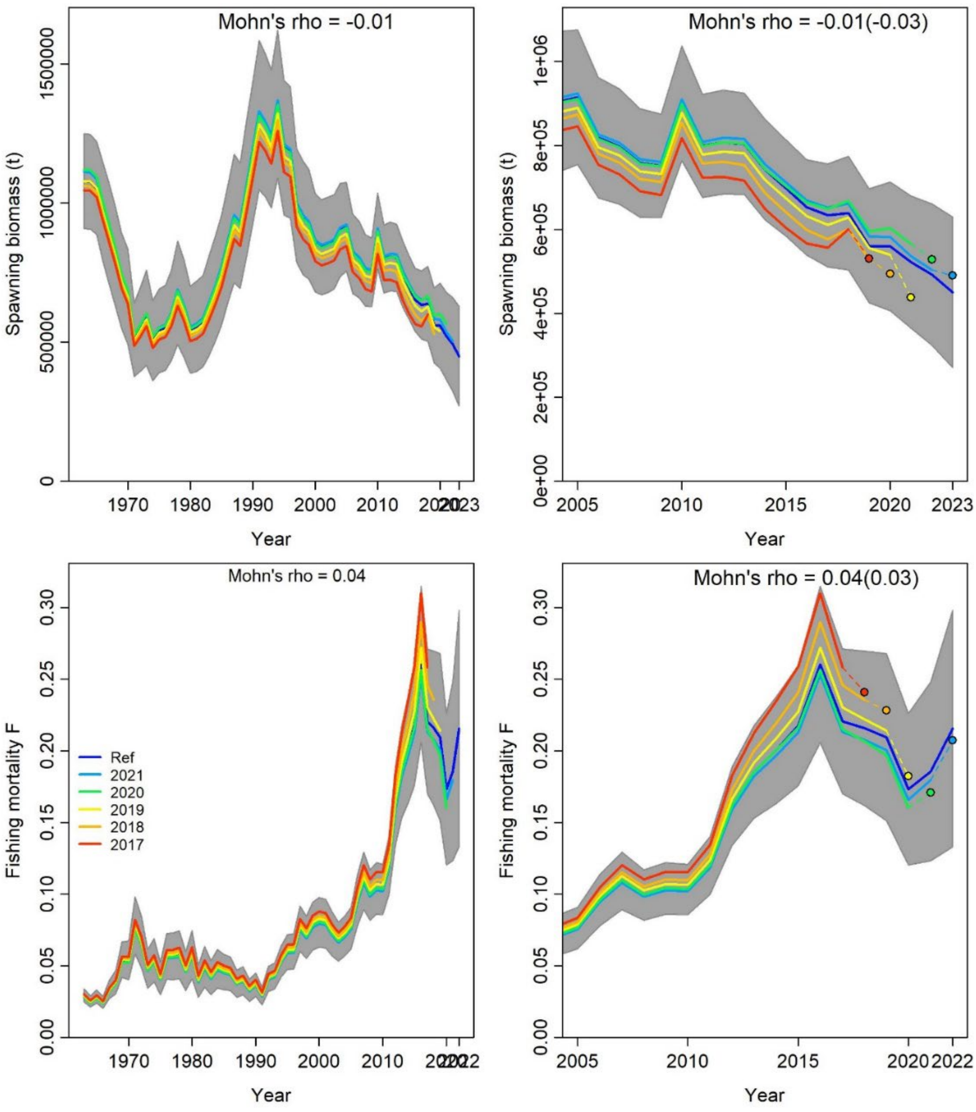


Figure 4.4.16. Herring in SD's 30 and 31. Retrospective analyses for spawning-stock biomass (upper) and fishing mortality (lower), showing 5 years peels with 95% confidence bands for the reference year 2022. Left column shows the full time-series whereas the right column shows the last 18 years.

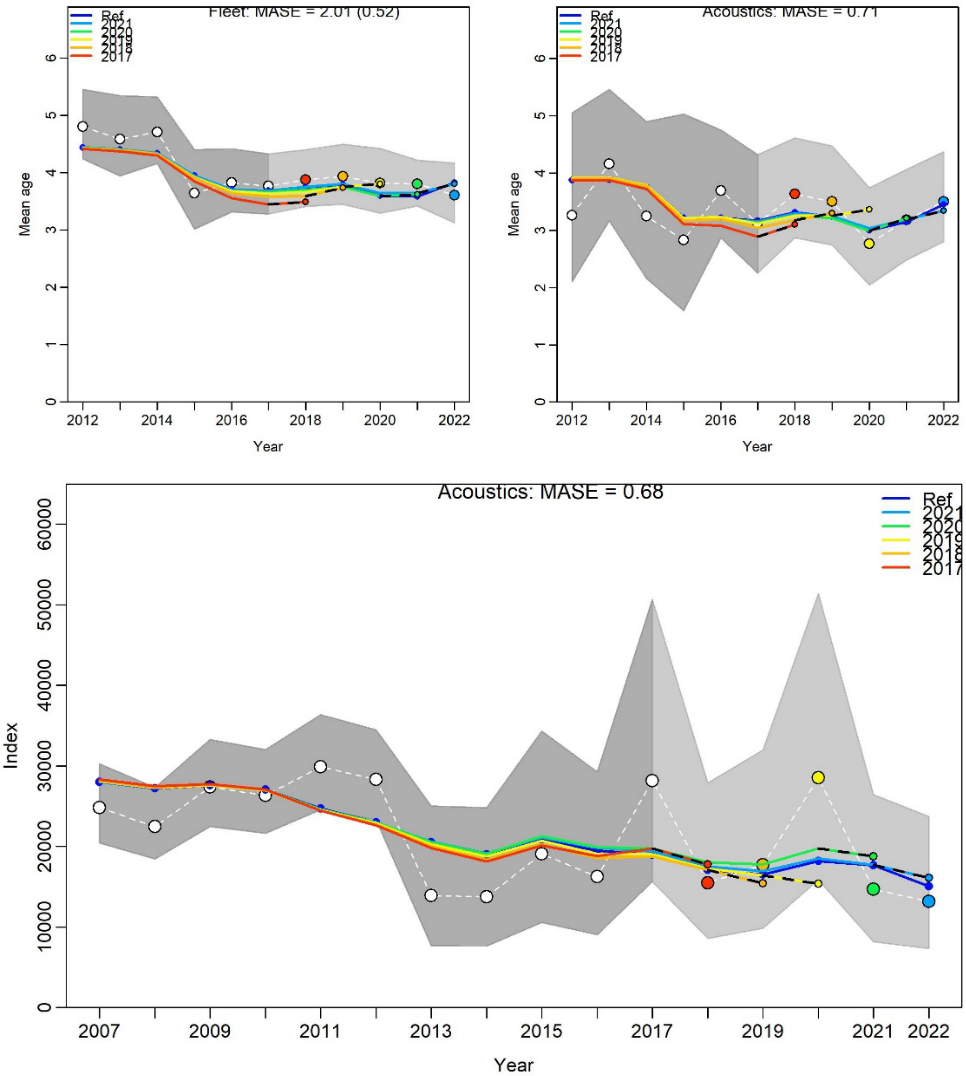


Figure 4.4.17. Herring in SD 30 and 31. Model prediction skill evaluated using the mean absolute scaled error (MASE) score, for mean age commercial (upper left; 0.52) and survey (upper right; 0.71), and survey index (lower; 0.68) model fits (coloured lines), compared to one-year-ahead forecasts (black dashed lines). Large dots connected by dashed white lines show the observed values.

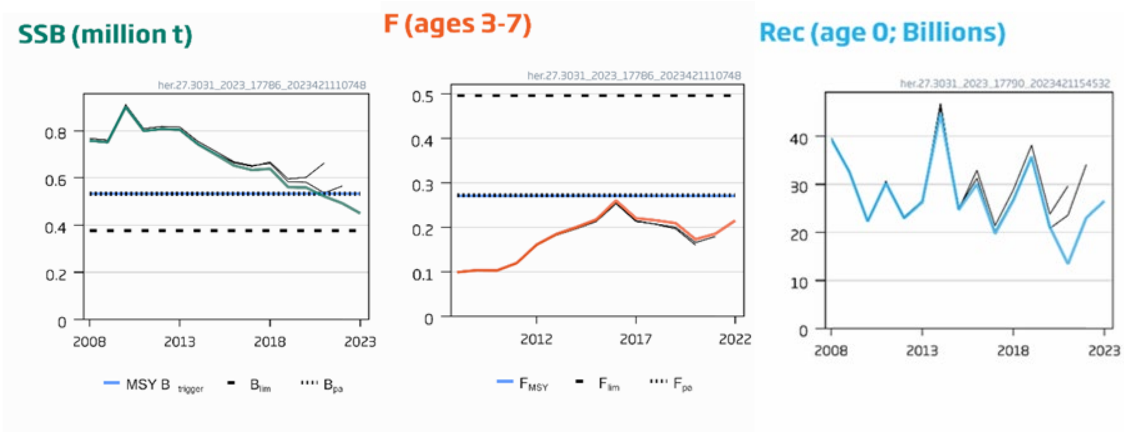


Figure 4.4.18. Herring in subdivisions 30 and 31. Historical assessment results (final-year recruitment estimates included). The stock was benchmarked in 2021 and upgraded to category 1. Only assessment results following the benchmark are shown.

5 Plaice

5.1 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 stock was, as a consequence of the benchmark in February 2015 upgraded to category 1 (full analytical age-based assessment).

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.

Minimum Landing Size in SD 22 and SD 23 is 25 cm.

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 (13 t in 2022), 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 (2002–2021). The practice of utilizing the artificially extended time-series should be reviewed at the next benchmark.

Discard and landings (2022) 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 ~36%% in 2022; up slightly from 30% in 2021 and 24% in 2020, and surpassing that of 2019. The discard ratio now equals the median of the time series (Figure 5.2.4b).

In 2022, the discards ratio was estimated as 68% in Kattegat (SD 21), 27% in SD 22 and 16% 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. A similar exercise would be beneficial for ple.27.21-23 and ple27.24-32 and is being planned by Denmark in preparation for a benchmark of this stock in 2024.

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 71% 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 strong year classes are coming up from 2019, 2020, and 2021.

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 density dependence as stock size and recruitment both continue to reach record high observations, year-on-year since 2020. This change in mean stock weight at age can have significant effects on the estimated stock biomass, and therefore, 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 for that period and this holds the majority of the assessment period aligned 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).

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 2002–2022 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.

Globally, the internal consistency of the catch matrix is not very high, and it is difficult to follow clearly the large year-classes over time (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 the 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. From 2020 onwards, the Q3/4 indices for plaice have been calculated without the 2019 data and this year's indices are considered missing in the assessment (i.e. set to "-9"). A project has been initiated in Denmark (HypCatch) to investigate the possibility of using hydrographic data to reduce the variability in survey tuning indices and was presented at the WGBFAS group in 2020. Preliminary analysis in this project has so far shown this to be unlikely but work continues on this subject.

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 2023 followed this method and only survey data until 2022 have been included in this assessment (although the data from 2023 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 1% for the SSB and 3% for F (Figure 5.2.14).

This SPALY run in SAM is named: ple.27.21-23_WGBFAS_2023_SPALY_v1. The assessment is available at “stockassessment.org” and is visible for everybody.

While the SPALY assessment fit well, the stock size estimates were inflated by the use of the mean of the whole time series’ stock weight at age whilst these values have been steadily decreasing in the last three years (see above section on stock weight at age data). A new assessment was run with annually varying stock weight at age for the most recent years (2020 – current year) according to a WGBFAS group decision. This assessment is available at stockassessment.org: ple.27.21-23_WGBFAS_2023_ALT_v1.

The estimated stock size decreased substantially relative to the SPALY assessment but remains at a record high (see SSB plot: Figure 5.2.1.3), the estimated fishing pressure and recruitment show little to no deviation from the SPALY assessment. The retrospective patterns were comparable to the SPALY run (Figure 5.2.13) and the fit looks good.

The input data for the final assessment run, ple.27.21-23_WGBFAS_2023_ALT_v1, are given in tables 5.2.4a to 5.2.4i, and the summary of the results is given Table 5.2.5. Estimated fishing mortality is given on Table 5.2.6 and stock numbers at age in Table 5.2.7

5.2.4.1 Recruitment estimates

Estimates of recruitment have drastically increased year on year to unseen levels for the 2019-2021-year classes. Age 1 recruitment estimates for 2020, 2021, and 2022 are the absolute highest seen for this stock (~132, ~181, and ~277 million individuals, respectively). While not utilized in the assessment, the Q1 2023 surveys indicate that this 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.

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 2022, at ~13 kt. Historically, population growth was boosted by sporadically large recruitment pulses, however, since 2020, we can the theoretical relationship between SSB and Recruitment start to take off, where the large stock size appears to be supporting a sustained high level of recruitment. This draws into question the relevance of using a resampled median recruitment value from the time series in the forecasts. This recruitment assumptions 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 (2023) assumption is status quo F (0. 149 in 2023, = F_{2022}). Recruitment for 2023 and 2024, 2025 is a median, resampled from the entire time-series. This approach, specified in the stock annex, looks to have been a sensible approach, however, in the recent three 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. 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 are expected to enter the fishery fully from 2023. These two large cohorts 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 2021 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 has improved in 2022 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.

While the 2023 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 2021. This procedure was adopted in 2016 and has been in use since then.

The catch ratio between SD 21 and SDs 22–23 in 2021 was used to calculate a split of the advised catches for 2024, 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 3,788 tonnes in SD 21 and 17,947 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
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

	21			22			23		Total
Year	Denmark	Germany	Sweden	Denmark	Germany	Sweden	Denmark	Sweden	
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
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

Table 5.2.2. Catches from ple.27.21-23 in 2022 by catch category, by fleet and over quarters (tonnes).

Subdivision	CatchCategory	Fleet	Q1	Q2	Q3	Q4
27.3.a.21	Discards	Active	59	86	99	75
27.3.a.21	Discards	Passive	7	6	5	0
27.3.a.21	Landings	Active	36	20	30	57
27.3.a.21	Landings	Passive	5	5	7	2
27.3.b.23	Discards	Active	1			0
27.3.b.23	Discards	Passive	2	2	8	0
27.3.b.23	Landings	Active	1	0	0	0
27.3.b.23	Landings	Passive	5	28	22	8
27.3.c.22	Discards	Active	41	190	23	153
27.3.c.22	Discards	Passive	5	18	23	5
27.3.c.22	Landings	Active	164	193	38	216
27.3.c.22	Landings	Passive	162	180	114	173

Table 5.2.3. Plaice in SD 27.21–23. Sampling effort 2022 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	211.789	47	3497	47	686
27.3.a.21	Discards	Denmark	Passive	12.137	2	171	2	35
27.3.a.21	Discards	Germany	Active	21.591	0	0	0	0
27.3.a.21	Discards	Germany	Passive	1.784	0	0	0	0
27.3.a.21	Discards	Sweden	Active	85.67	22	1996	23	857
27.3.a.21	Discards	Sweden	Passive	4.659	2	38	8	273
27.3.a.21	Landings	Denmark	Active	126.177	15	2788	15	685
27.3.a.21	Landings	Denmark	Passive	13.974	15	2788	15	685
27.3.a.21	Landings	Germany	Active	7.604	0	0	0	0
27.3.a.21	Landings	Germany	Passive	2.481	0	0	0	0
27.3.a.21	Landings	Sweden	Active	9.086	0	0	0	0
27.3.a.21	Landings	Sweden	Passive	2.408	0	0	0	0
27.3.b.23	Discards	Denmark	Active	0.952	0	0	0	0

Subdivision	Catch Category	Country	Fleet	Catch (tonnes)	Length Samples	Lengths Measured	Age Samples	Ages Read
27.3.b.23	Discards	Denmark	Passive	9.423	6	109	6	29
27.3.b.23	Discards	Sweden	Passive	1.964	0	0	0	0
27.3.b.23	Landings	Denmark	Active	0.945	0	0	0	0
27.3.b.23	Landings	Denmark	Passive	46.331	1	165	1	33
27.3.b.23	Landings	Sweden	Passive	17.005	0	0	0	0
27.3.c.22	Discards	Denmark	Active	213.376	4	282	4	64
27.3.c.22	Discards	Denmark	Passive	43.886	9	333	9	91
27.3.c.22	Discards	Germany	Active	192.91	14	5917	14	940
27.3.c.22	Discards	Germany	Passive	7.303	10	256	10	84
27.3.c.22	Discards	Sweden	Passive	0.001	0	0	0	0
27.3.c.22	Landings	Denmark	Active	324.594	30	5443	30	1225
27.3.c.22	Landings	Denmark	Passive	325.007	30	5443	30	1225
27.3.c.22	Landings	Germany	Active	285.657	14	3942	14	994
27.3.c.22	Landings	Germany	Passive	305.547	21	5153	21	747
27.3.c.22	Landings	Sweden	Passive	0.011	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

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
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
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

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 (2002-2022)	0.23	0.55	0.72	0.81	0.9	0.94	0.97	0.97	0.98	0.93

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

Year	1	2	3	4	5	6	7	8	9	10+
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
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

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

Year	1	2	3	4	5	6	7	8	9	10+
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
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

Table 5.2.4f. Plaice in SD 27.21–23. Mean weight (kg) in stock by age used in 2023 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

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
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

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
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
1999	1484.27	11514.11	5414.85	1379.78	711.88	60.46
2000	3733.94	29605.15	13043.96	2084.45	639.29	363.53
2001	1137.08	16103.95	16473.44	3776.98	514.16	213.04
2002	1828.82	4577.73	12323.52	6300.49	1272.65	308.29
2003	1728.57	19021.17	8525.55	9230.28	4725.09	646.30
2004	1200.28	7103.71	14624.93	6385.39	4002.02	2477.93
2005	1511.68	15824.67	13845.53	7276.93	2502.48	2193.07
2006	369.03	9804.71	21578.69	8188.50	3077.24	655.67
2007	1347.63	8710.29	15477.52	11247.69	2758.38	1173.49
2008	1747.58	6219.44	8124.12	4186.51	1367.36	448.98
2009	809.56	5287.75	8967.21	4147.63	1464.72	545.73
2010	4019.78	9912.72	12107.08	5952.11	2289.18	534.64
2011	1445.58	14611.13	11683.00	5521.52	2657.48	1054.76
2012	2593.87	11365.14	12667.67	5118.28	1270.35	460.17
2013	551.24	7830.67	19462.22	9591.74	5512.41	1278.90
2014	271.84	8831.35	15686.38	14036.66	6314.95	2173.36
2015	585.63	10975.98	15471.21	11504.13	7184.54	3461.40
2016	1242.69	16053.45	22174.72	13677.24	6501.54	3218.78
2017	4203.64	15918.42	21792.45	9646.48	4941.99	2266.52
2018	3703.35	21858.44	19832.57	10590.82	5930.65	1875.88
2019	609.71	19079.40	25908.68	10077.22	2991.44	2069.01
2020	7951.05	8203.09	13832.70	14596.55	6114.20	1736.12
2021	12614.87	80491.26	27891.98	10842.68	7313.49	3641.64
2022	22879.42	160526.14	79314.61	18312.72	9516.73	4725.54

3rd and 4th quarter (2019 set to "missing" with "-9")

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1999	27903.68	19308.48	3381.38	358.18	433.88	88.40
2000	11796.85	21993.34	7286.22	113.20	74.80	126.15
2001	4290.12	13939.48	6255.84	1335.15	150.86	197.84
2002	9836.70	5410.18	6542.45	4113.36	852.02	152.82
2003	4324.21	15056.90	4132.02	3003.83	1536.31	257.94
2004	8062.78	8586.58	13824.15	3527.88	2201.14	1593.07
2005	7776.55	11219.61	3158.27	1582.47	453.43	550.80
2006	7178.47	10566.15	9506.90	1956.16	925.52	572.49
2007	5622.16	10552.33	4298.27	2561.85	683.90	335.54
2008	2520.65	11004.36	9041.67	3211.39	912.48	209.44
2009	4870.32	9987.14	10511.82	1945.34	394.57	221.27
2010	4837.42	6853.47	4462.84	3649.90	1103.30	579.03
2011	11578.03	12407.07	7545.33	2607.59	567.48	266.70
2012	11290.91	12879.67	9698.76	4784.41	1124.42	298.48
2013	5187.04	11124.22	10805.68	4675.89	2154.97	862.26
2014	10558.44	11479.96	10424.48	5666.26	2976.22	822.57
2015	6043.76	14811.93	12485.19	8910.69	4353.24	1038.09
2016	12704.59	13737.26	10308.37	4551.33	2286.21	1204.01
2017	26745.15	12303.58	7061.25	4141.74	1745.37	1182.42
2018	16594.72	20838.78	8672.09	3325.32	1128.43	1089.83
2019	-9.00	-9.00	-9.00	-9.00	-9.00	-9.00
2020	55880.50	16809.78	8545.88	6034.64	1504.23	685.31
2021	93553.66	56779.34	17074.26	5334.95	4260.90	1497.61
2022	107652.59	77461.71	49226.59	14088.66	2519.35	1774.69

Table 5.2.5 Plaice in SD 27.21–23. SAM results from the final assessment (ALT_v1). Estimated recruitment (000s), spawning stock biomass (SSB in tonnes), and average fishing mortality for ages 3 to 5 ($F_{3\text{-}5}$). High and low refers to 95% confidence intervals.

	Recruitment (Age1)			SSB (tonnes)			Fbar(3-5)		
Year	Median	High	Low	Median	High	Low	Median	High	Low
1999	49311	68407	35546	4791	5895	3893	1.06	1.37	0.83
2000	45762	62654	33425	5333	6445	4413	1.12	1.39	0.9
2001	24995	34497	18110	6067	7366	4998	1	1.23	0.81
2002	42495	61133	29540	6404	7831	5237	0.95	1.18	0.77
2003	22817	31391	16585	5677	6783	4752	0.79	0.99	0.63
2004	28934	39530	21179	5162	6120	4353	0.71	0.91	0.56
2005	24668	33748	18031	4825	5699	4085	0.7	0.91	0.54
2006	15543	22066	10948	4944	5920	4129	0.8	1.01	0.63
2007	18579	25526	13522	4298	5127	3603	0.78	1	0.61
2008	23930	33623	17031	3994	4755	3354	0.83	1.04	0.66
2009	21297	29063	15606	3747	4473	3139	0.76	0.97	0.6
2010	33570	46430	24271	3738	4435	3151	0.64	0.85	0.49
2011	34441	47213	25124	4364	5196	3664	0.71	0.95	0.53
2012	35938	49982	25840	4876	5848	4066	0.46	0.64	0.33
2013	28308	38880	20610	6108	7332	5089	0.42	0.58	0.3
2014	21263	30055	15043	7111	8553	5911	0.4	0.55	0.29
2015	20764	28939	14898	7686	9237	6396	0.42	0.57	0.31
2016	29382	40483	21325	7886	9459	6575	0.52	0.69	0.39
2017	51118	72860	35864	7797	9392	6472	0.51	0.67	0.38
2018	42873	61848	29720	8352	10089	6914	0.53	0.69	0.4
2019	26739	39351	18169	9040	11091	7368	0.51	0.68	0.38
2020	131944	198520	87695	8129	10021	6593	0.44	0.61	0.31
2021	180585	275442	118396	8870	11216	7014	0.26	0.38	0.179
2022	276601	476634	160517	13254	17671	9942	0.149	0.23	0.095
2023	29382*	276601*	15543*	23194	33422	16184			

*** 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	0.05	0.36	0.8	1.25	1.14	1.02	1.02
2000	0.05	0.38	0.83	1.31	1.21	1.12	1.12
2001	0.05	0.38	0.76	1.15	1.09	1.03	1.03
2002	0.05	0.41	0.78	1.08	1	0.94	0.94
2003	0.05	0.35	0.65	0.89	0.83	0.78	0.78
2004	0.04	0.3	0.58	0.8	0.75	0.7	0.7
2005	0.04	0.29	0.56	0.78	0.75	0.7	0.7
2006	0.04	0.32	0.64	0.89	0.87	0.8	0.8
2007	0.04	0.31	0.62	0.86	0.84	0.75	0.75
2008	0.05	0.36	0.68	0.91	0.89	0.76	0.76
2009	0.05	0.35	0.64	0.84	0.81	0.68	0.68
2010	0.04	0.31	0.56	0.7	0.67	0.55	0.55
2011	0.05	0.34	0.61	0.77	0.75	0.62	0.62
2012	0.03	0.23	0.4	0.49	0.48	0.39	0.39
2013	0.03	0.21	0.37	0.45	0.43	0.35	0.35
2014	0.03	0.18	0.34	0.43	0.42	0.33	0.33
2015	0.02	0.17	0.34	0.46	0.46	0.36	0.36
2016	0.03	0.21	0.42	0.56	0.57	0.45	0.45
2017	0.02	0.18	0.39	0.55	0.58	0.46	0.46
2018	0.02	0.17	0.39	0.57	0.61	0.5	0.5
2019	0.02	0.15	0.36	0.55	0.6	0.5	0.5
2020	0.02	0.13	0.31	0.48	0.52	0.43	0.43
2021	0.01	0.07	0.18	0.28	0.32	0.28	0.28
2022	0.01	0.04	0.1	0.16	0.19	0.16	0.16

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	49311	30802	10734	5181	3069	318	1001
2000	45762	40653	18351	4168	1515	931	484
2001	24995	37033	26487	7229	1151	496	474
2002	42495	17773	24695	13548	2151	397	318
2003	22817	30421	10850	10698	4870	718	255
2004	28934	16139	16539	5820	4105	2098	394
2005	24668	24045	10646	6992	2237	1751	1062
2006	15543	19733	16940	5766	2836	973	1222
2007	18579	14070	12691	7543	2067	1043	801
2008	23930	15786	10731	6030	2502	764	772
2009	21297	16742	10791	5201	2029	891	631
2010	33570	16616	10088	4877	2055	771	735
2011	34441	25719	12104	4847	1910	927	828
2012	35938	25128	15568	6433	1874	709	834
2013	28308	26084	19340	8939	3585	1007	856
2014	21263	23471	18394	12241	5128	1974	1074
2015	20764	20494	16925	11622	6812	2858	1831
2016	29382	19983	16429	10475	6071	3529	2657
2017	51118	22224	14915	9783	5116	2895	3394
2018	42873	36984	17235	8824	5318	2499	3397
2019	26739	31689	27251	11160	4213	2674	3179
2020	131944	23185	20350	16152	5901	2028	3118
2021	180585	96522	20606	12118	8296	3319	3087
2022	276601	148811	71506	16379	7963	4935	4291

Table 5.2.8. Plaice in SD 27.21–23. Reference points for 2023, 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.
Precautionary approach	B_{lim}	3 635	B_{loss} (lowest observed biomass=Biomass in 2009)
	B_{pa}	4 730	$B_{lim} \times e^{1.645\sigma}$, σ = 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 2022	Landings 2022	ICES stock advice 2024 (catch)	
Stock area-based	SDs 21-23	2274	1467	17254	
	SDs 24-32	608	458	4481	
Total advised catch, 2023 (SDs 21-32)				21735	
Management area-based	SD 21	499	162		
	SDs 22-23	1775	1305		
	SDs 22-32	2383	1763		
		Calculation			Result
Share of SD 21 of the total catch in SDs 21–23 in 2022		= 499 / 2274			0.22
		(catch in 2022 SD 21 / catch in2022SDs 21–23)			
Catch in 2024 for SD 21		= 17254 * 0.22			3788
		(ICES stock advice in 2024 (catch) for SDs 21–23 × share)			
Catch in 2024 for SD 22-32		= 21735 - 3788			17947
		(total advised catch in 2024 SDs 21–32 minus catch SD 21)			
Share of SD 21 of the total landings in SDs 21–23 in 2022		= 162 / 1467			0.101
		(landings in 2022 SD 21 / landings in 2022 SDs 21–23			

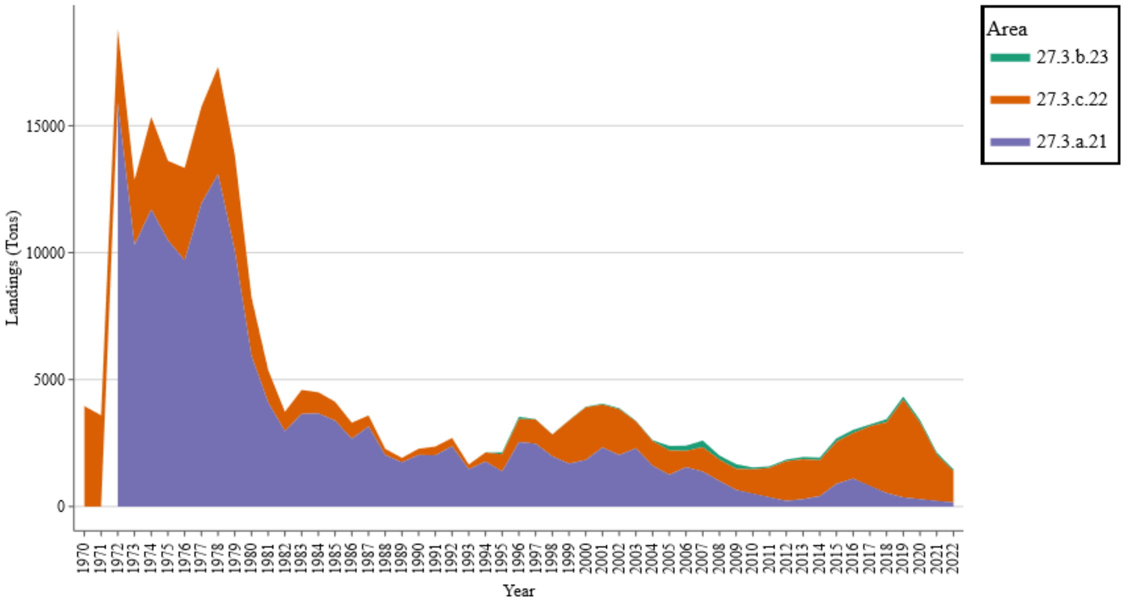


Figure 5.2.1. Plaice in SD 27.21–23. Landings by subdivision by year.

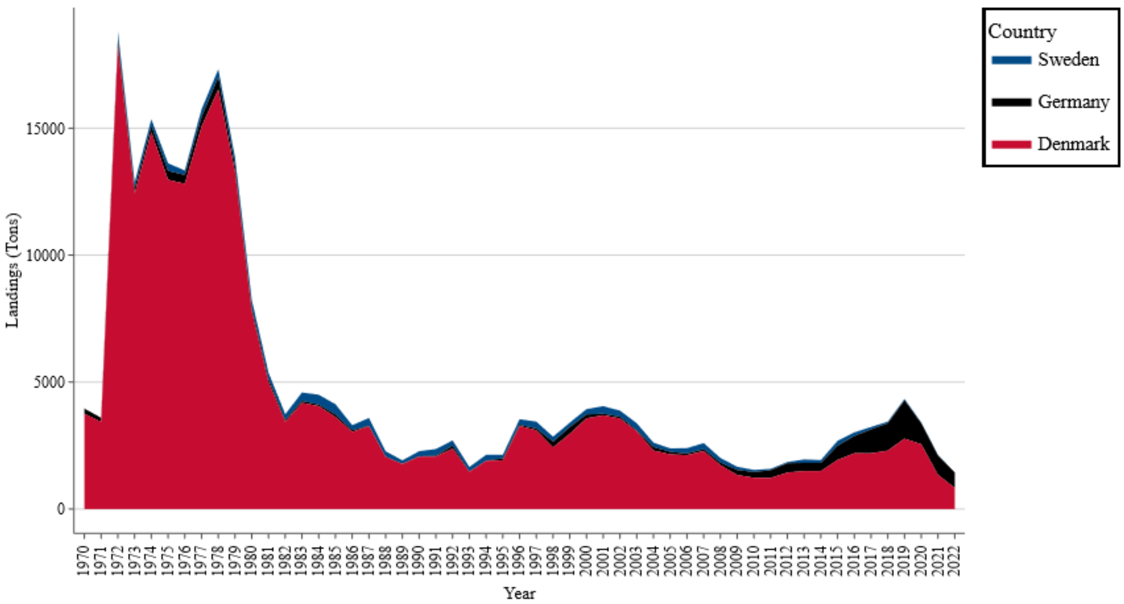


Figure 5.2.2. Plaice in SD 27.21–23. Landings (t) by country by year.

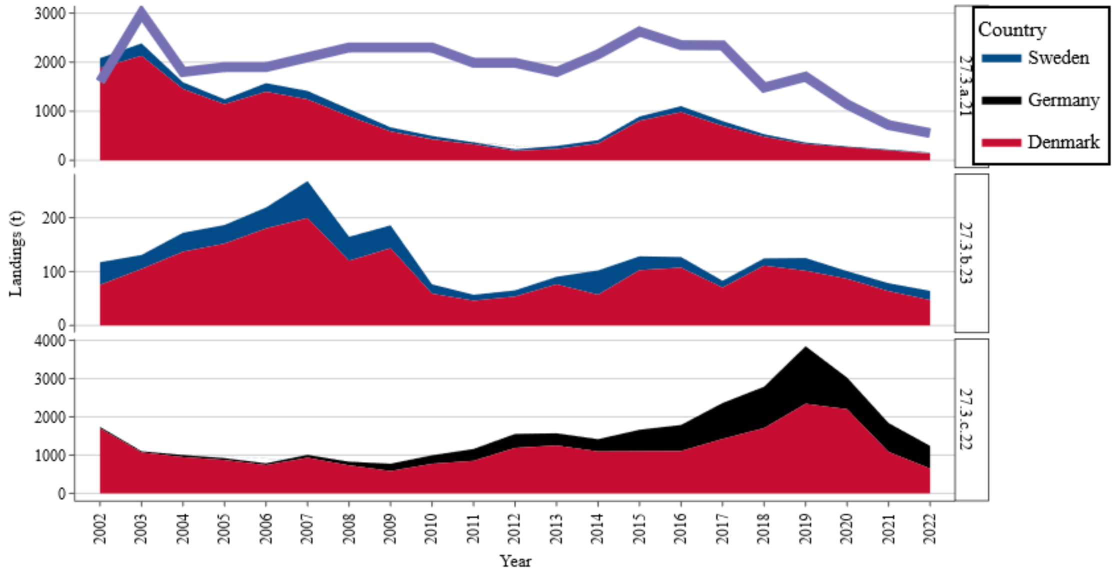


Figure 5.2.3. Plaice in SD 27.21–23. Landings (t) by country by year across areas. Advised TAC for SD 21 shown as a purple line.

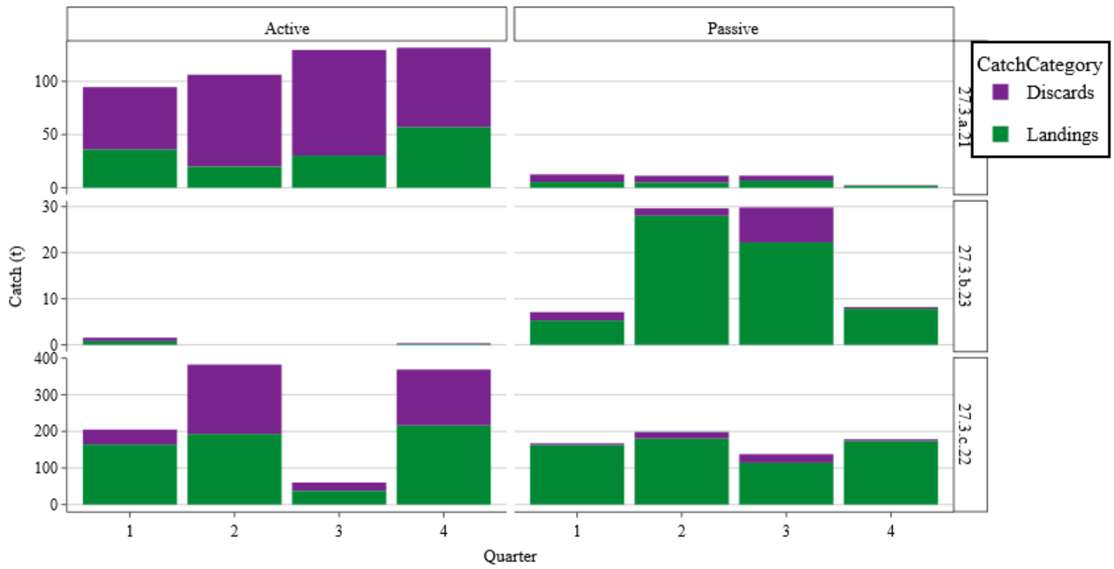


Figure 5.2.4a. Plaice in SD 27.21–23. Catches (t) in 2021 by gear type, area, quarter and catch category. Note varying y-axis values by area.

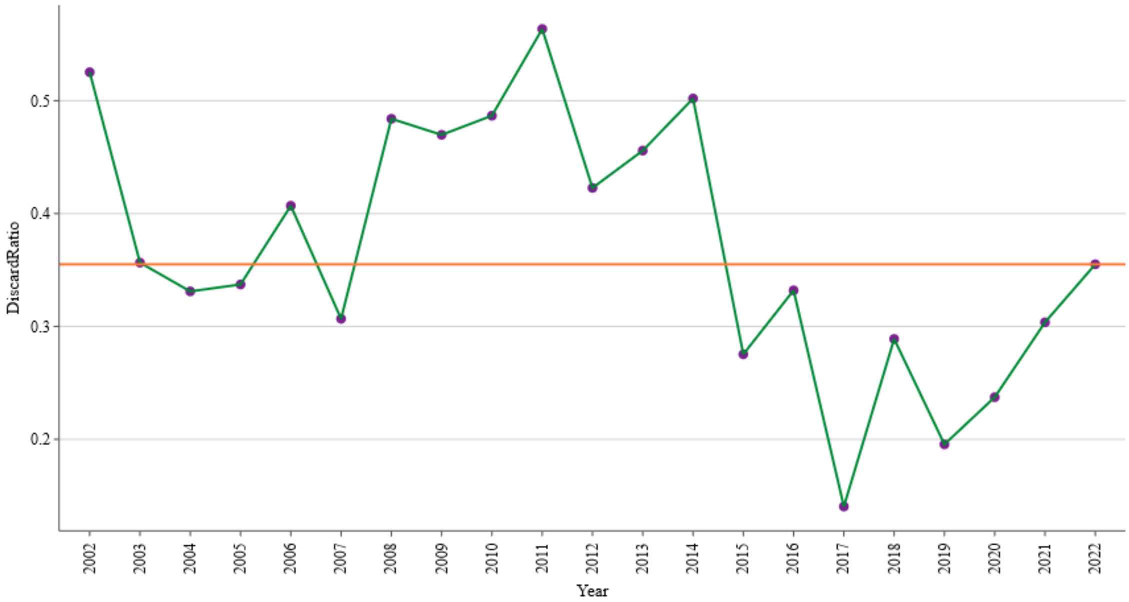


Figure 5.2.4b. Plaice in SD 27.21–23. Discard ratio over time, orange line is the median of the time series.

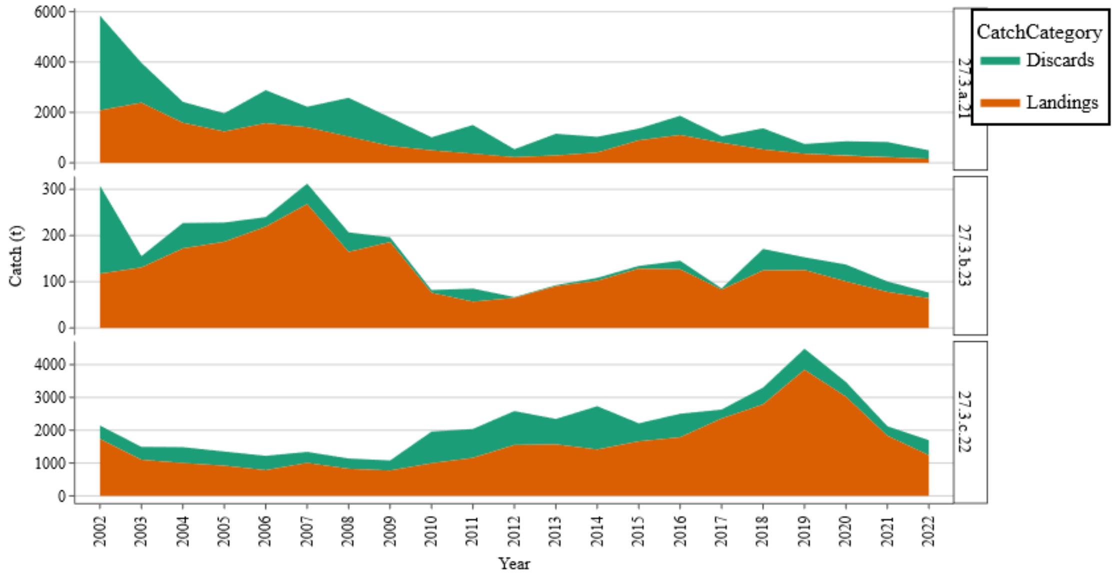


Figure 5.2.4c. Plaice in SD 27.21–23. Catch components over time by Subdivision. Note varying y-axes by subdivision.

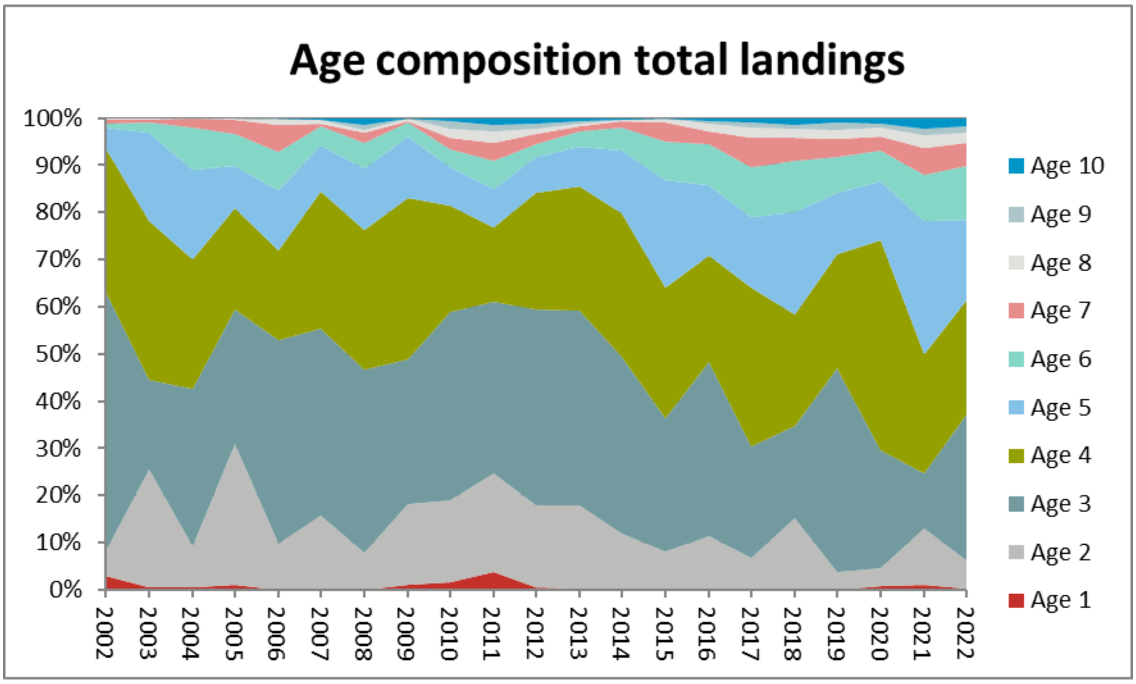


Figure 5.2.5a. Plaice in SD 27.21–23. Age composition for landings over time.

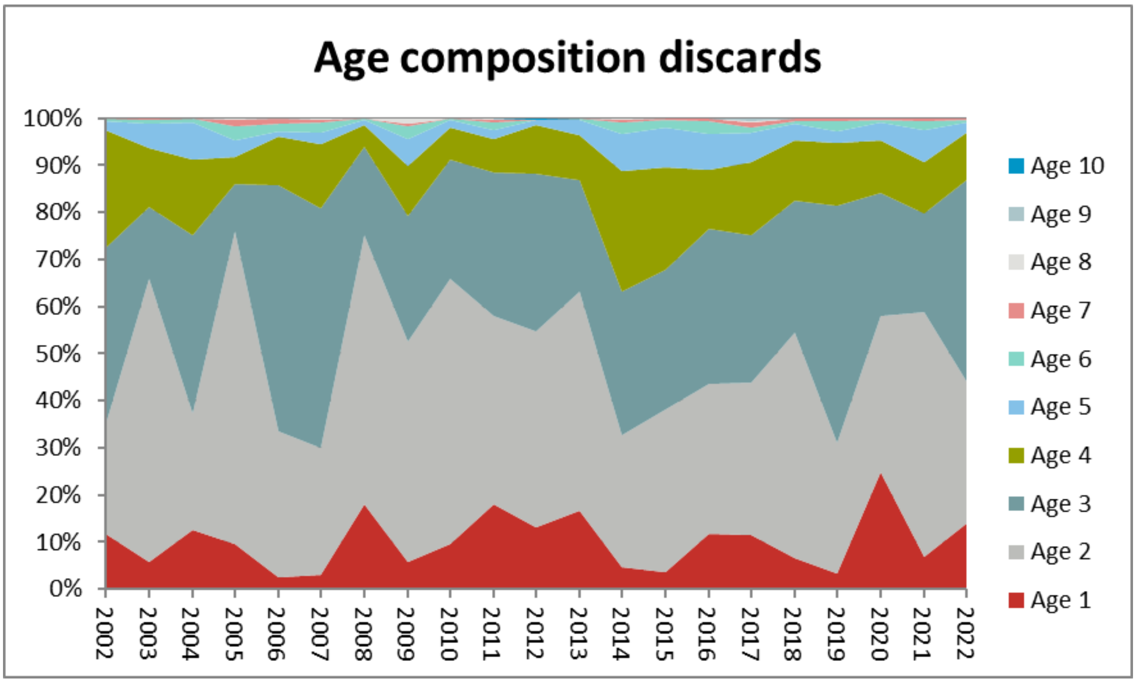


Figure 5.2.5b. Plaice in SD 27.21–23. Age composition for discards over time.

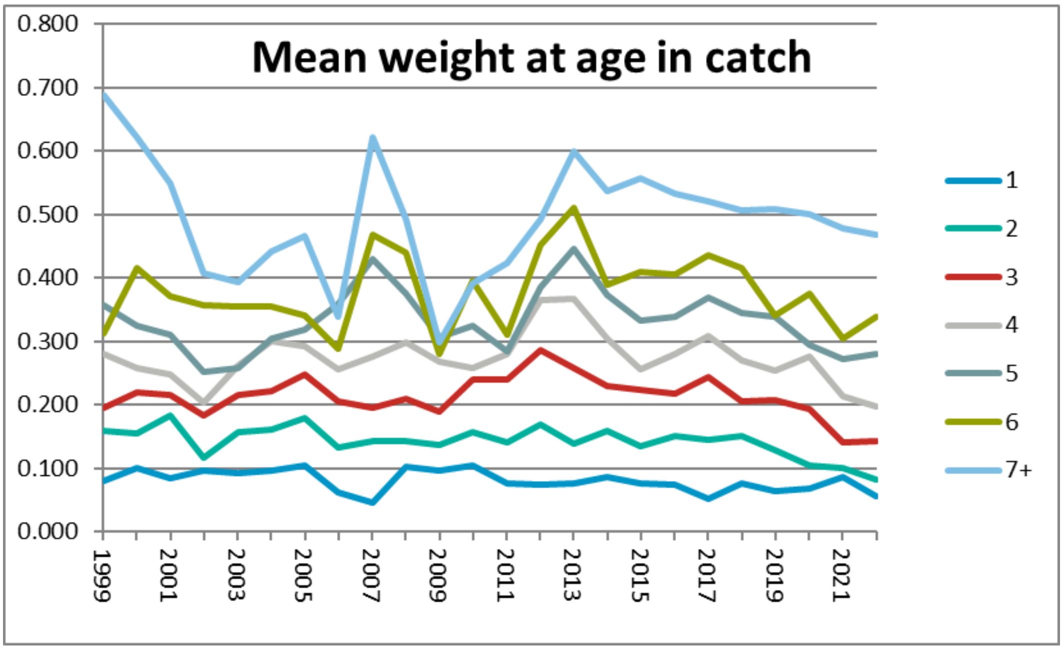


Figure 5.2.6. Plaice in SD 27.21–23. Mean weight (kg) at-age in catch.

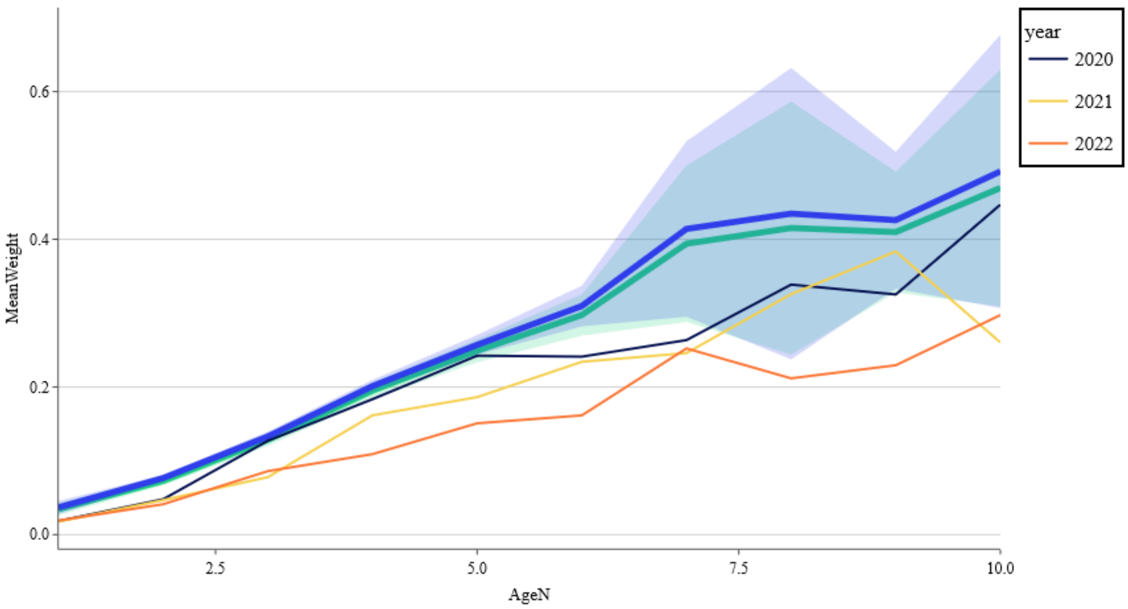


Figure 5.2.7. Plaice in SD 27.21–23. Mean weight (kg) at-age in stock. Blue line with ribbon is the mean of the whole time series, used in the SPALY assessment according to the stock annex. Green line with ribbon is the mean applied to the period 1999:2019 in the assessment, similar to the stock annex. 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.

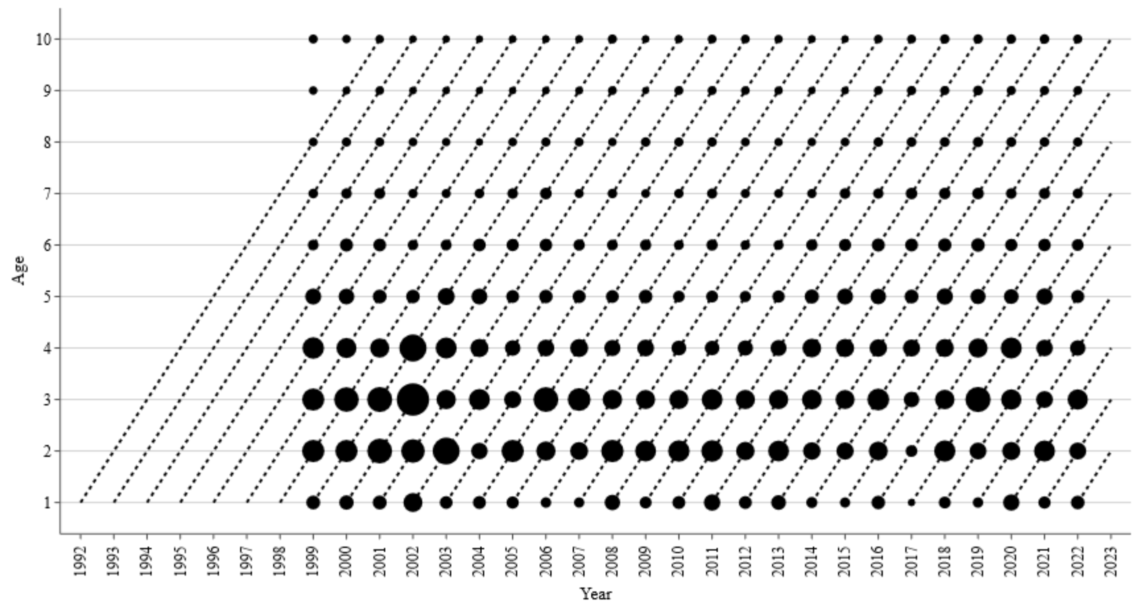


Figure 5.2.8. Plaice in SD 27.21–23. Cohort tracking of the catch-at-age matrix

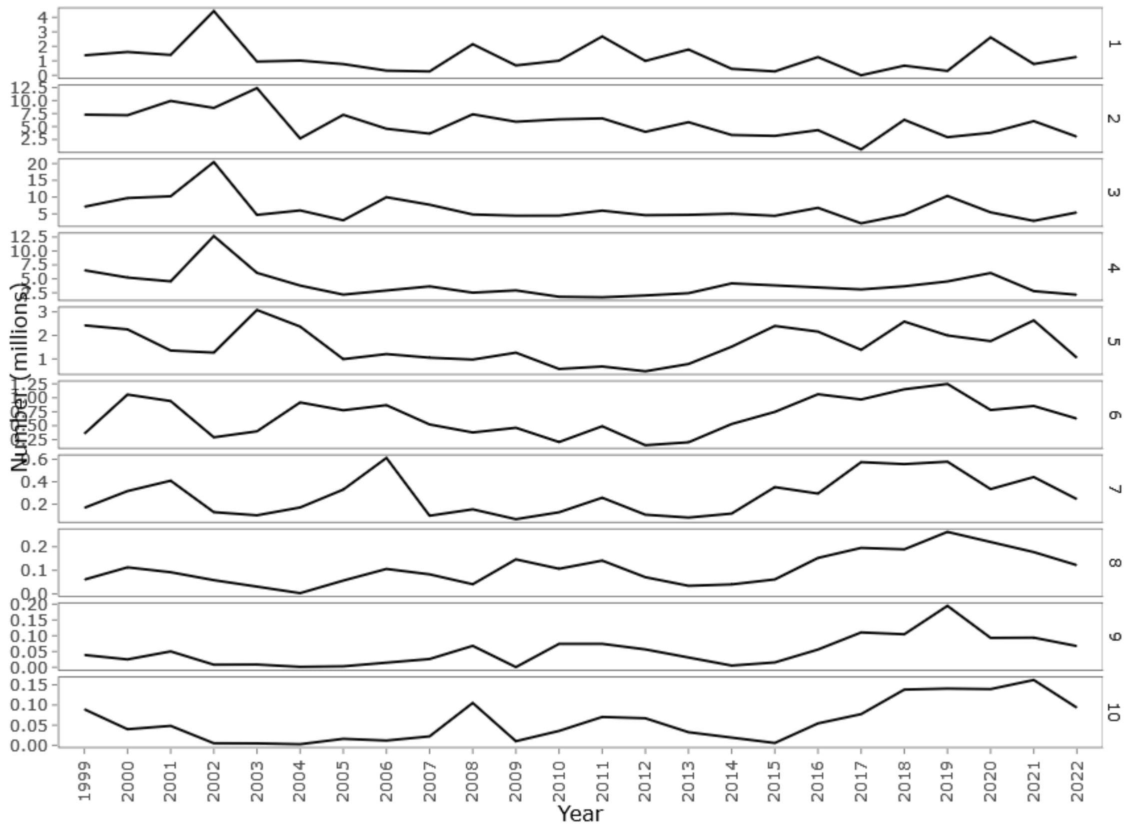


Figure 5.2.9. Plaice in SD 27.21–23. Catch-at-age over time.

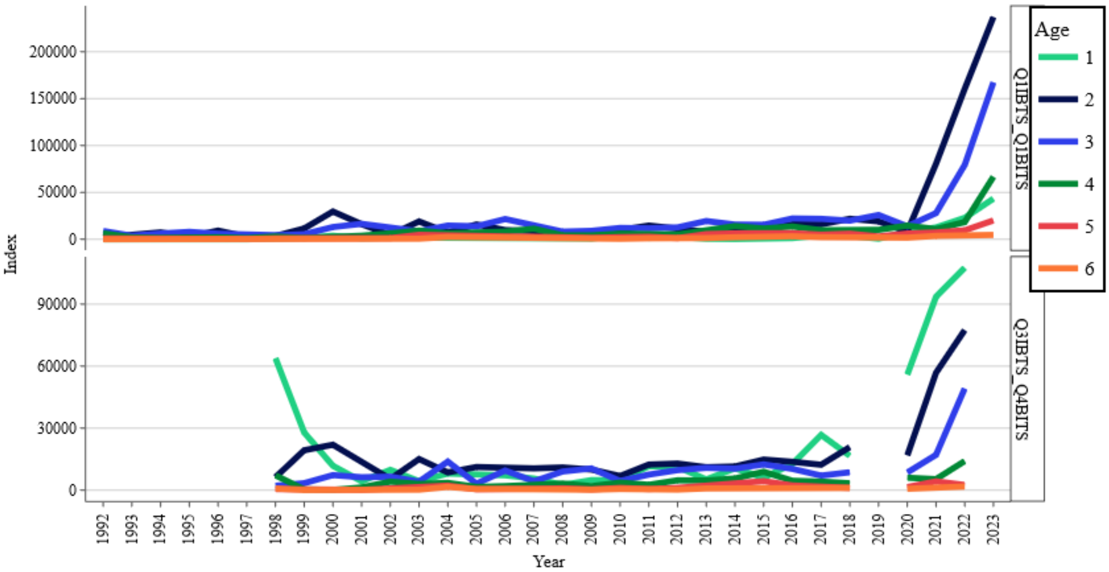


Figure 5.2.10. Plaice in SD 27.21-23. Survey indices over time (re-calculated within assessment year with all available data). Top: Q1 combined indices (note 2023 data not used in calculation of indices for the 2023 assessment. Bottom: Q3-4 combined indices (note 2019 data not used in calculation of indices for the 2023 assessment).

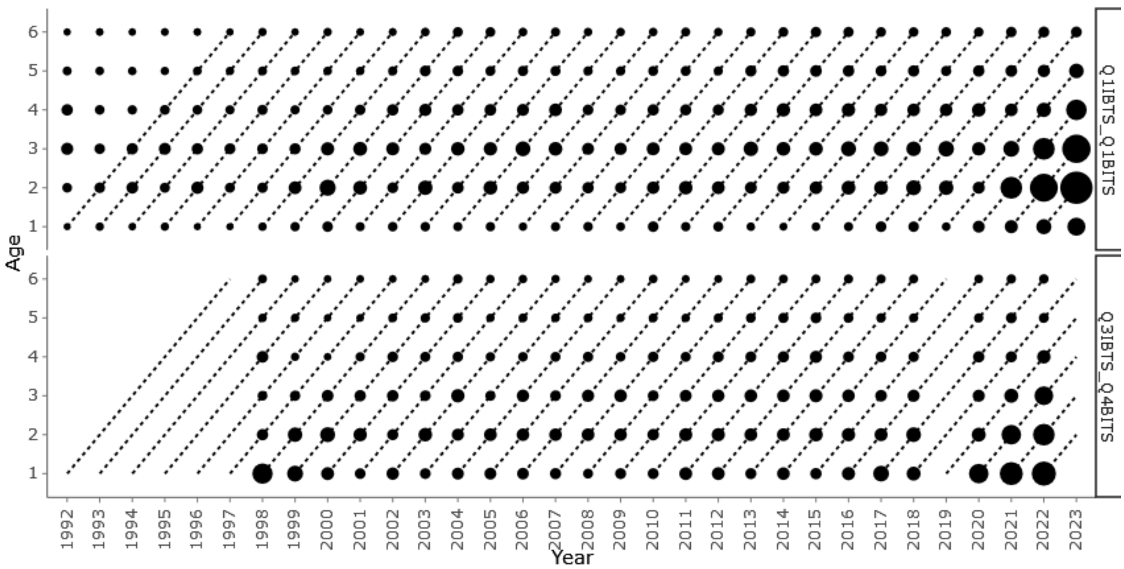
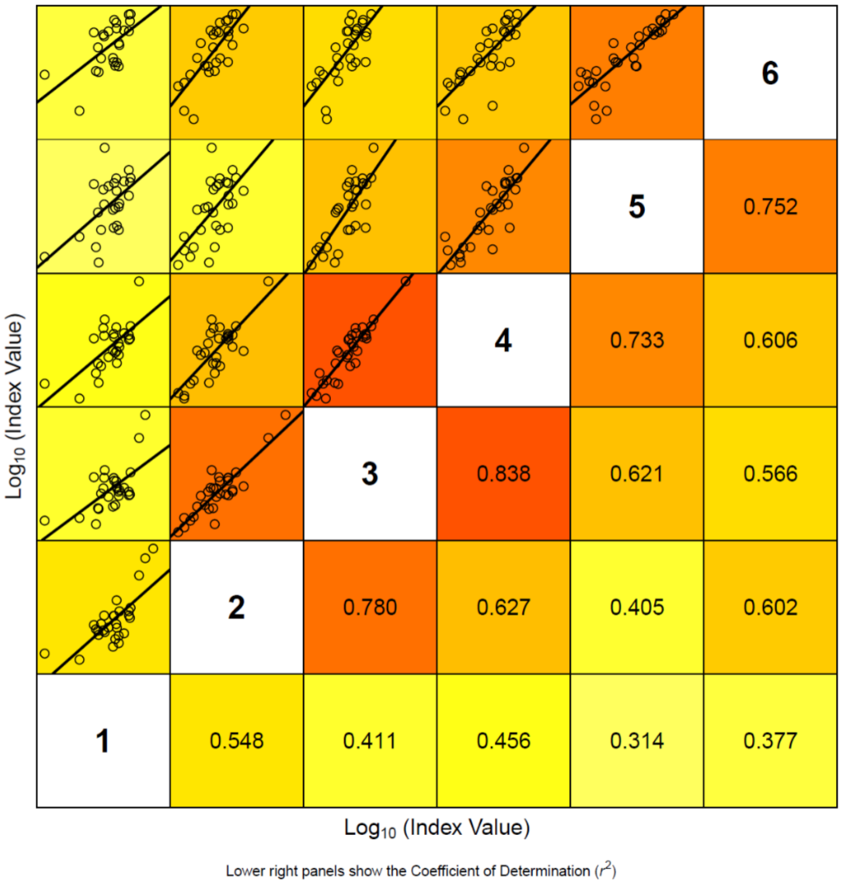


Figure 5.2.11. Plaice in SD 27.21-23. Cohort-tracking through survey indices by age. Bubble size relative to within year index by age recalculated from total data series available at time of assessment in 2023. Top: Combined Q1 survey indices (note 2023 data not used in assessment). Bottom: Combined Q3-4 survey indices (note 2019 excluded from calculation of all indices according to decision in 2019 assessment).



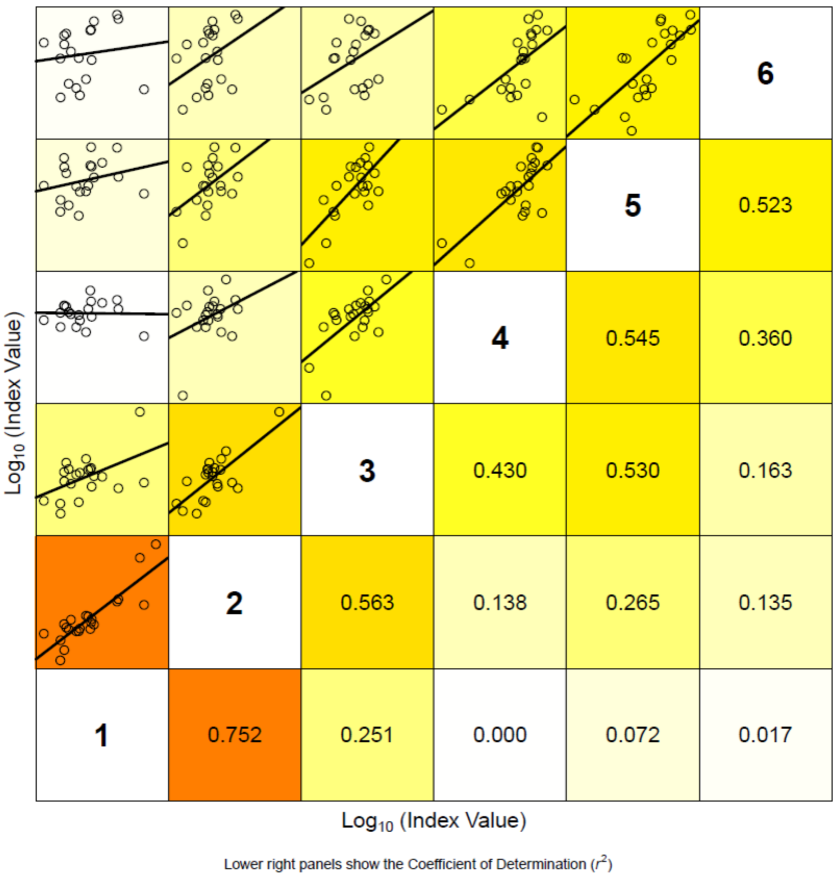
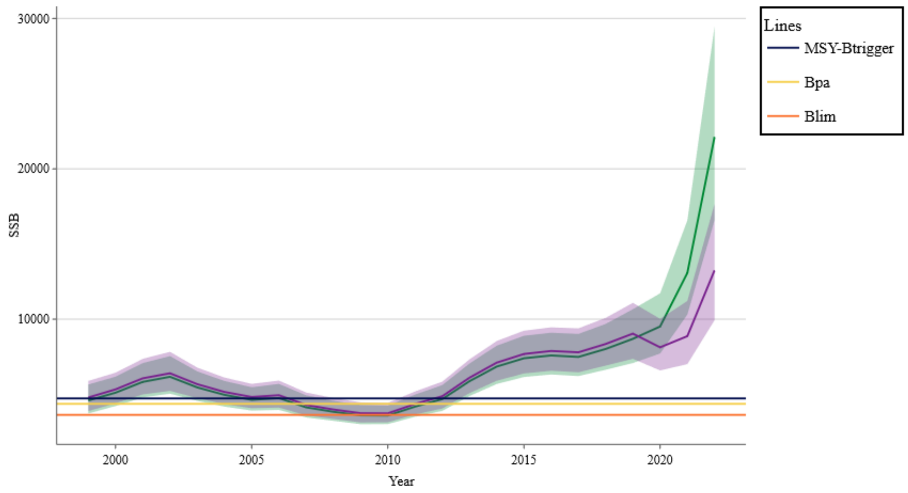
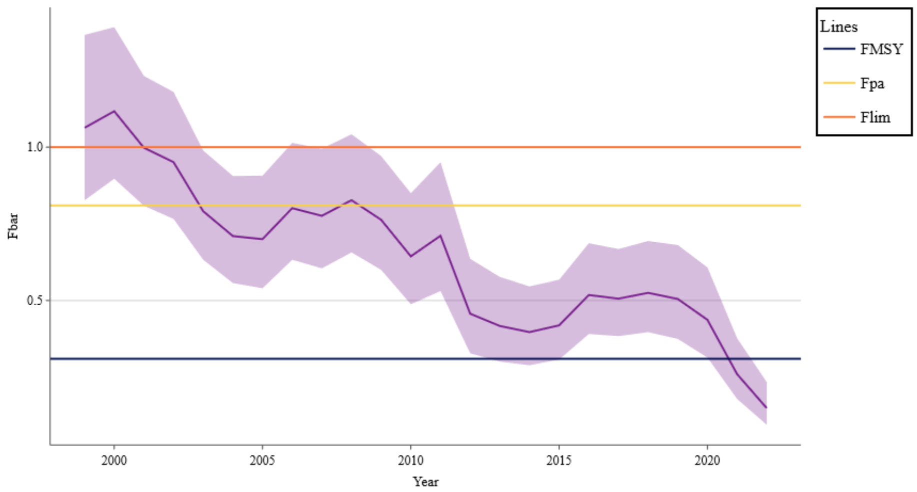
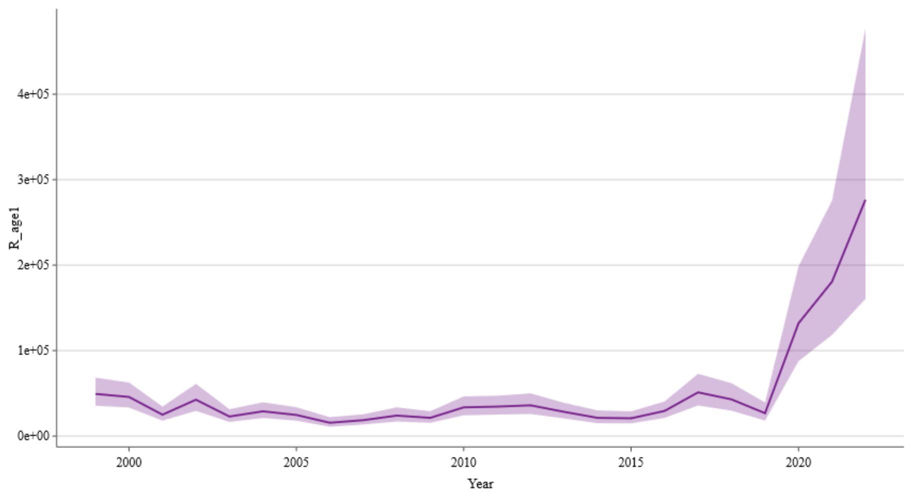


Figure 5.2.12. Plaice in SD 27.21–23. Internal consistency of the two survey indices. Top: Q1 survey. Bottom: Q3-4 survey.


Lines
MSY-Btrigger
Bpa
Blim
30000
20000
10000
SSB
2000
2005
2010
2015
2020
Year


Lines
FMSY
Fpa
Flim
1.0
0.5
Fbar
2000
2005
2010
2015
2020
Year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3e+05
2e+05
1e+05
0e+00
R_age1
2000
2005
2010
2015
2020
Year

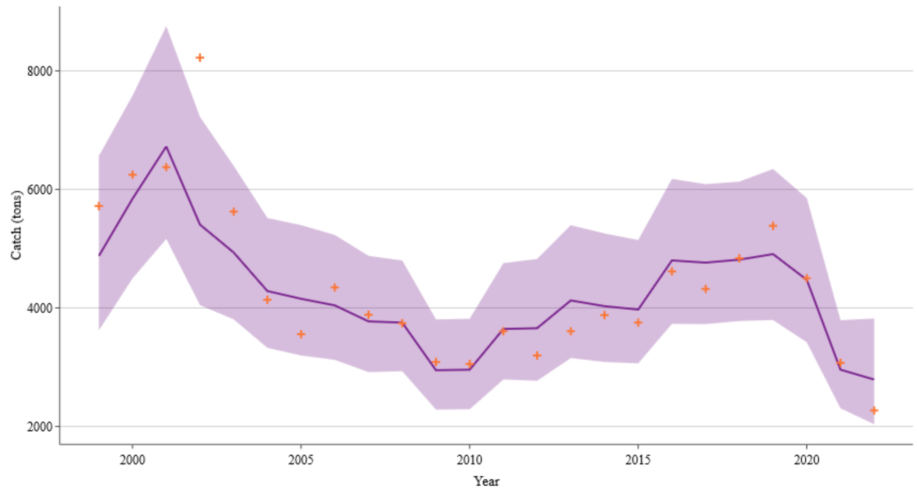


Figure 5.2.13. Plaice in SD 27.21–23. SPALY (green) and Alternative (purple) SAM runs. The Alternative assessment is the one used to generate advice.

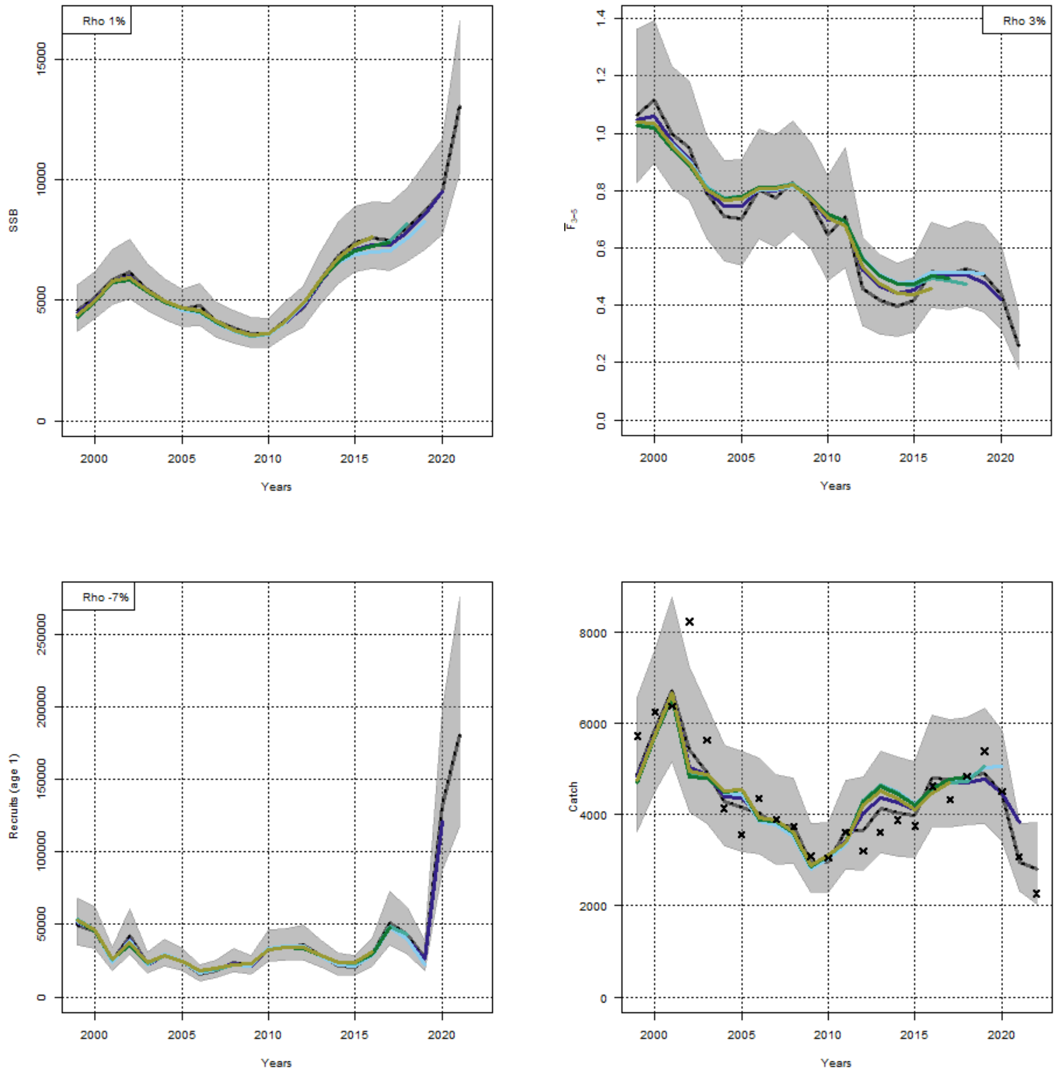


Figure 5.2.14. Plaice in SD 27.21–23. Alternative SAM run Retrospective patterns (model used in generating advice).

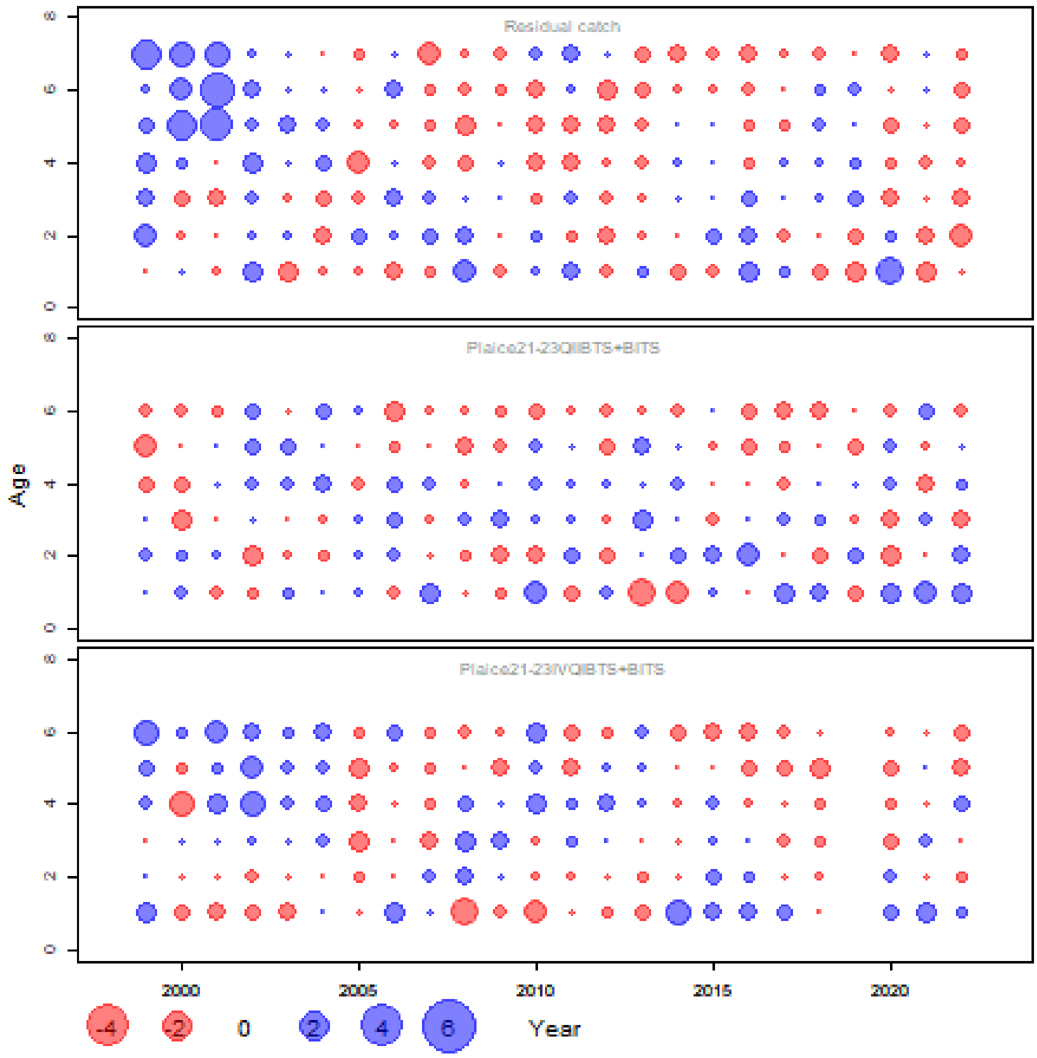


Figure 5.2.15. Plaice in SD 27.21–23. Alternative SAM Residuals by Fleet, Age and Year. The top panel represent catches, the middle the combined Q1 survey indices and the bottom the combined Q3-Q4 survey indices.

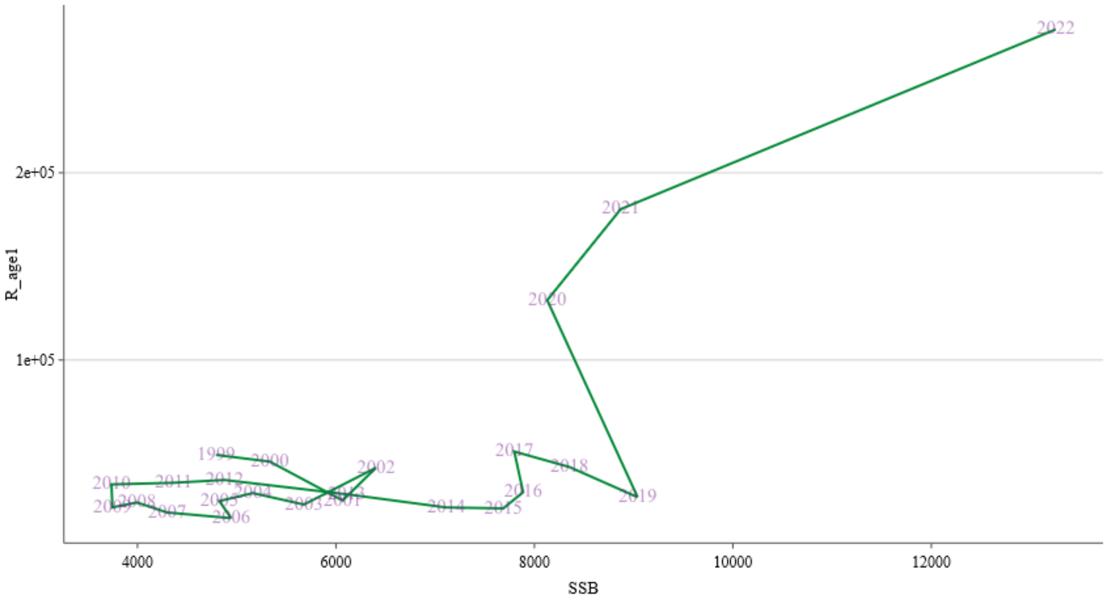


Figure 5.2.16. Stock recruitment relationship for plaice in SD 27.21–23 based on the Alternative SAM Run.

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 tonnes for 2022 and increased to 11 313 tonnes in 2023. 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 2022.

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, Sweden, Poland, Germany, and Finland (traded quota from Sweden) have a TAC for landing plaice. 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 2022 decreased to about 458 tonnes and is the lowest since the mid-1990s. Since 2017, a landing obligation is in place, resulting in an additional 7.5 tonnes of “BMS landings” (i.e. landings of plaice below the minimum conservation reference size of 25 cm) in 2022, which accounted for 1.2% 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 and Denmark provided discard estimates in 2022 (Figure 5.3.3a).

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 observers onboard on fishing vessels. Discards in the most recent year (2022) were around 150 tonnes (i.e. 25% of the total catch), about 50% less than in the previous year 2021, where large year classes entered the fisheries in the unwanted catch fraction.

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 5.3.4). However, only Germany was able to provide biological sampling data in landings and discards in 2022. Denmark provided two samples from the active fisheries, covering the discarded fraction of the catch. Other member states have not been able to sample harbors or vessels for plaice (Figure 5.3.3b). The overall 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 5.3.5). The length distribution indicates that these cohorts enter fisheries in 2021 and be fully covered by fisheries in 2023. The average length in the catches decreased strongly in 2021 and 2022 (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. However, the cohort signals could not be clearly identified in the ple.27.d.24-32 stock in the 2022 commercial fisheries due to low sampling coverage at low fishing intensity.

In 2022, the average length-at-catch in the landing fraction was about 27.4 cm, whereas the average length-at-catch in the discard fraction was about 17.7 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 (2022) 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 3, originating from the strong 2019 cohort, is the most abundant, accounting for 41% of the catch fraction. Age class 2, originating from the strong 2020 cohort, accounted for 35% of the catch fraction. Only around 5% of discarded plaice were above age class 5 (Figure 5.3.6).

5.3.2.4 Mean weight-at-age

Recent years show a decrease in the average weight for almost all age classes (Figure 5.3.7). 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 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 2023 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 5.3.9). A length-based index or young fish survey index would be more appropriate to display and account for smaller plaice.

Biomass index correction

Following up on suggestions made during the review of the SPiCT assessment in May 2022, the scripts that calculate the biomass index were updated. In the course of this a calculation error was found in the script, where, instead of taking an average CPUE per depth stratum, the sum was used (and thus losing "zero catch" entries). The Error was corrected and the biomass index script is now identical to those already used for five other flatfish stocks in the Baltic Sea.

The corrected biomass index now includes zero catch hauls and is therefore lower in terms of total biomass (Figure 5.3.10). The trends, however, remained identical and the influence on the performed assessment calculations is minimal (see 5.1.4).

5.3.4 Assessment

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.

Following an independent review, plaice is assessed as a category 2 stock using SPiCT as basis for the assessment and advice (ICES, 2022).

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 2021 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 5.3.11) of the stock, where F is below F_{MSY} and B above $B_{trigger}$ (Figure 5.3.12) and thus confirming the results of the previously conducted SAM assessment and the stock trend of the BITS. Retrospective analysis of the SPiCT data series indicating a consistent pattern in catches and survey indices (Figure 5.3.13)).

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}.

Biomass index correction and updated 2022 assessment

The biomass index used for the assessment has changed due to a corrected calculation error (see 5.1.3). The 2022 SPiCT assessment was performed again with the new biomass index (all other settings and data were identical), resulting in only a very small difference in advice total catch of around -49 tons (or -1.8% compared to the advised catch of 4 633 tons). Calculations in the current advice (for 2024, using 2023 as an interim year) will be based on the corrected values and therefore used in the catch scenario tables. And updated advice for 2023 will be published along with the current assessment year's advice.

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 (BMSY/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_2023

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 consistency 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 5.3.5.

If the TAC is assumed unlikely to be caught 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 2022, 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 (2023). An F_{sq} ($F = F_{2022}$) assumption leads to a catch of 728 t in 2023 (compared to a catch of 608 t in 2022). The basis for F_{sq} (F_{2022}) is the most recent F scaled to the intermediate year (= 0.123). Assumptions for the intermediate year are provided in Table 5.3.5.

Given the F_{sq} assumption, SSB in the beginning of 2023 is estimated at around 21 200 t (or B_{2022}/B_{MSY} at 1.75; 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 2024 will be based on the MSY approach (“ices rule”). With these assumptions, the forecast predicts that advised fishing in 2024 will lead to a total yield of 4 481 t. At this level of exploitation, spawning stock biomass is estimated at around 20 900 t in 2024.

Catch in 2024 in predicted to be dominated by the relatively large 2019 and 2020-year classes of age 3 and 4 (age 4 to 5 in 2024) plaice that are dominating the discards and accounts for >47% of catches in 2022. However, given the lower growth rates registered in the 2022 samples, the strong year class of 2020 mightstill dominate the discard fraction of the catch and not be fully included in the landing fraction in 2024 (Figure 5.3.6). Following the MSY approach, the adviced catch will be 4 481 tonnes, resulting in a change in biomass of about -8% (Table 5.3.8).

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. 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

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 2022 using the SPiCT r package (Pedersen and Berg, 2016). The summary plots are shown in figures 5.3.11 and 5.3.12, retrospective patterns are shown in Figure 5.3.13. 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.

5.3.8.1 Additional exploration of stock ple.27.24-32, using SAM

Although not used to give advice in 2023, an additional SAM assessment was conducted to test the results of SPiCT. The final run in SAM is named: ple.27.2432_SAM_2023_V2

The stock is in a very good condition. The result (Figures 5.3.15a-c, Table 5.3.10) shows an increase in SSB from < 3 000 tonnes in 2010 to around 5 000 tonnes in 2015 and estimated to 40 683 tonnes in the intermediate year 2023. The increase is probably resulting out of the high amount of discard in 2016, 2017 and gain in 2020 and 2021, the very high index values of the survey index and the respective higher total catch in 2020 and 2021. The incoming high amount of small plaice is influencing not only SSB but also the recruitment. The F in 2022 decreased significantly compared to the previous two years (0.103 in 2022, 0.27 in 2021, 0.35 in 2020) and has been constantly decreasing in the whole period. This is the case for all age groups, whereas older age groups (7, 8, 9+) used to have a slight increase in previous years (Figure. 5.3.15). The decreasing F is most likely a result of more reduced fishing effort and hence less landings due to the COVID-19 pandemic and restrictions in fishing time of the cod fisheries (e.g. closures for directed cod trawling). Previous years showed an increasing plaice-targeted fishery due to the bad condition and reduced availability of the eastern cod stock. It is to be expected that F will increase once fishery can resume their regular fishing pattern. The recruitment is regarded as constantly increasing but with significant variation. The recruitment in 2022 was exceptionally high and continued and the intermediate year 2023 suggested another strong increase as the strong year classes are entering into the indices and fisheries data. First signals of the 2023 BITS index show a strong increase in age 0 and age 1 plaice, indicating another strong year class that is likely to be picked up in the indices in 2023 and in fisheries discard during the intermediate year 2023 and 2024.

The normalized residuals show some year effects for the commercial catches in the last two years. Year effects also occur in the CPUE of BITS, especially for the latest surveys, which have high numbers of smaller plaice in the catches, resulting in a high index value. The retrospective analysis is less robust even when considering the short time series. Only the last 3 years are within the confidence intervals. The F has been estimated to be within the confidence intervals.

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 2022 has been very low, with only one member state providing data, although plaice samples are a mandatory part of national sampling schemes, given its status as a TAC species. 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 run. 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 looks acceptable (Figure 5.3.16).

5.3.10 Comparison with previous assessment

Compared to the catch advice given on an exploratory SAM assessment, 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

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 output. 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.

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							
1995	343				91		233	2	13	10	1						
1996	263				77		183	5	28	23	10	1					

Year/SD	Denmark			Germ. Dem. Rep*	Germany, FRG		Poland		Sweden**						Finland		
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

***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 2022 by Subdivision, catch category, country and quarter.

Area	Country	CatchCategory	1	2	3	4	Total*
27.3.d.24	Denmark	Landings	12.73	17.45	50.25	72.57	153.00
		Discards	4.19	6.31	18.36	23.69	52.55
		BMS landing	1.06	0.08	0.15	0.37	1.65
	Germany	Landings	2.06	3.02	98.74	37.91	141.73
		Discards	0.53	0.41	33.85	11.82	46.61
		BMS landing	1.66		1.66	1.68	5.00
	Poland	Landings	4.10	18.85	10.47	35.24	68.65
		Discards	0.69	4.64	2.63	11.55	19.51
		BMS landing				0.23	0.23
	Sweden	Landings	0.16	0.22	0.16	0.05	0.59
		Discards	0.02	0.03	0.02	0.01	0.08
		BMS landing	0.05	0.00	0.00	0.02	0.08
27.3.d.25	Denmark	Landings	3.99	0.03		0.70	4.71
		Discards	6.95	0.00		0.22	7.18
		BMS landing	0.00	0.00	0.00	0.00	0.00
	Germany	Landings	0.52				0.52
		Discards	0.17				0.17
		BMS landing	0.21				0.21
	Poland	Landings	27.77	19.15	20.82	15.14	82.88
		Discards	8.43	4.21	5.28	4.91	22.84
		BMS landing	0.00				0.00
	Sweden	Landings	0.04	0.52	0.51	0.00	1.07
		Discards	0.01	0.07	0.07	0.00	0.15
		BMS landing	0.00	0.00	0.00	0.00	0.00
27.3.d.26	Denmark	BMS landing	0.00	0.00	0.00	0.00	0.00
	Germany	Landings	0.37				0.37
		Discards	0.12				0.12
	Lithuania	Landings	0.00	0.00		0.00	0.00

Area	Country	CatchCategory	1	2	3	4	Total*
	Poland	Landings	0.03	2.12	1.65	0.38	4.18
		Discards	0.01	0.29	0.28	0.12	0.69
	Sweden	Landings	0.00		0.00		0.00
		BMS landing			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
	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.29	Denmark	BMS landing	0.00	0.00	0.00	0.00	0.00
	Sweden	Landings		0.00	0.00		0.00
		BMS landing		0.00			0.00
27.3.d.30	Denmark	BMS landing	0.00	0.00	0.00	0.00	0.00
	Sweden	Landings	0.00	0.00		0.00	0.00
27.3.d.31	Sweden	Landings			0.00	0.00	0.00
		BMS landing			0.00	0.00	0.00

***BMS landings are included in the discards and need to be subtracted from the total sum**

Table 5.3.3: average length-at-catch ($\bar{L}_C$) in commercial fisheries of ple.27.24-32 of the last five years, all gears and areas combined.

Year	2018	2019	2020	2021	2022
$\bar{L}_C$	46.28	43.18	41.16	33.50	26.98

Table 5.3.4.: timeline settings for the assessment model (SPiCT).

Observations	Intermediate	Management
2002.00 - 2023.00	2023.00 - 2024.00	2024.00 - 2025.00
Management evaluation: 2025.00		

Table 5.3.5: Values in the forecast and the interim year.

Variable	Value	Notes
F_{2023}/F_{MSY}	0.123	Status quo F: F_{sq} (equal to F_{2022})
B_{2024}/B_{MSY}	1.71	Fishing at F_{sq}
Catch (2023)	744	Fishing at F_{sq}; in tonnes
Projected landings (2023)	560	Marketable landings assuming 2022 discard rate; in tonnes
Projected discards (2023)	184	Based on 2022 discard rate; in tonnes

Table 5.3.6.ple.27.24-32. Overview of SPiCT result values on catch and survey data 2002–2022.

Deterministic reference points (Drp)					
	Bmsyd	12273.5695	6219.1712	24221.9584	9.4152
	Fmsyd	0.2838	0.1944	0.4142	-1.2596
	MSYd	3482.9725	2263.5737	5359.2676	8.1556
	Bmsyd	12273.5695	6219.1712	24221.9584	9.4152
Stochastic reference points (Srp)					
		estimate	cilow	ciupp	log.est
	Bmsys	11895.3680	6076.0594	23288.0840	9.3839
	Fmsys	0.2775	0.1887	0.4082	-1.2819
	MSYs	3298.7784	2174.0670	5005.3374	8.1013
States	w	0.95	CI	(inp$msytype:	s)
		estimate	cilow	ciupp	log.est
	B_2022.94	20965.530	10299.820	42675.830	9.951
	F_2022.94	0.033	0.013	0.086	-3.412
	B_2022.94/Bmsy	1.758	1.313	2.354	0.564
	F_2022.94/Fmsy	0.119	0.053	0.270	-2.127
Predictions	w	0.950	CI	(inp$msytype:	s)
	B_2024.00	21635.84	10507.67	44549.30	9.98
	F_2024.00	0.03	0.01	0.11	-3.41
	B_2024.00/Bmsy	1.81	1.34	2.45	0.60
	F_2024.00/Fmsy	0.12	0.04	0.35	-2.13
	Catch_2023.00	703.38	321.53	1538.70	6.56
	E(B_inf)	22058.08	NA	NA	10.00
	B_2024.00	21635.84	10507.67	44549.30	9.98

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}		
	Relative SSB	High	Low			Ages 2–5	High	Low
2002	0.27	0.42	0.179	915	353	1.37	2.71	0.69
2003	0.30	0.46	0.20	1 281	271	1.64	2.88	0.93
2004	0.24	0.35	0.164	1 081	214	1.68	2.96	0.96
2005	0.27	0.39	0.182	1 081	166	1.30	2.24	0.76
2006	0.38	0.54	0.26	1 012	818	1.15	1.97	0.66
2007	0.48	0.71	0.32	1 167	491	1.05	1.89	0.58
2008	0.57	0.84	0.38	1 102	294	0.81	1.51	0.44
2009	0.70	1.06	0.47	1 226	418	0.70	1.33	0.36
2010	0.78	1.15	0.52	903	998	0.73	1.40	0.38
2011	0.79	1.16	0.54	748	1 377	0.76	1.47	0.39
2012	0.85	1.26	0.58	848	917	0.68	1.32	0.35
2013	0.90	1.33	0.61	738	781	0.55	1.07	0.28
2014	0.94	1.39	0.63	534	481	0.38	0.73	0.196
2015	1.13	1.65	0.77	427	220	0.24	0.48	0.117
2016	1.39	2.00	0.97	521	1 058	0.23	0.44	0.121
2017	1.56	2.20	1.11	650	408	0.25	0.46	0.131
2018	1.80	2.55	1.28	1 644	711	0.27	0.51	0.147
2019	1.88	2.67	1.33	1 741	617	0.34	0.68	0.173
2020	1.88	2.67	1.33	1 024	223	0.27	0.51	0.142
2021	1.79	2.47	1.29	767	550	0.21	0.40	0.113
2022	1.76	2.41	1.28	458	150	0.151	0.29	0.08
2023	1.75	2.38	1.29					

*** Below minimum size (BMS) landings are included since 2017.**

Table 5.3.8: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2024)	Projected landings (2024)*	Projected discards (2024)**	F_{2024}/F_{MSY}	B_{2025}/B_{MSY}	% biomass change^	% advice change^^
ICES advice basis							
MSY approach (35th percentile of predicted catch distribution under $F = F_{MSY}$)	4481	3 375	1 106	0.82	1.57	−8	-1
Other scenarios							
F_{MSY}	5386	4057	1329	1.00	1.50	-12	+18
F_{2023}	728	548	180	0.123	1.83	+7	−82
F = 0	0	0	0	0.0	1.88	+8	−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).

Table 5.3.9: stochastic reference point estimate

	estimate	cilow	ciupp	log.est
B_{MSYs}	11895.3680	6076.0594	23288.0840	9.3839
F_{MSYs}	0.2775	0.1887	0.4082	-1.2819
MSYs	3298.7784	2174.0670	5005.3374	8.1013

Table 5.3.10. ple.27.24-32. Results from the additionally conducted SAM assessment. Estimated recruitment (thousands), total stock biomass (TBS), spawning stock biomass (SSB), and average fishing mortality for ages 2 to 5 (F_{25}).

Year	Recruits	Low	High	SSB	Low	High	F_{25}	Low	High	TSB	Low	High
2002	4213	2900	6121	1045	695	1570	0.916	0.622	1.348	2160	1509	3091
2003	6001	4330	8317	1135	838	1536	1.135	0.820	1.570	2491	1904	3259
2004	7656	5416	10823	1295	1003	1672	0.626	0.443	0.884	3022	2330	3920
2005	6386	4487	9089	1814	1403	2345	0.336	0.225	0.501	3647	2810	4732
2006	5781	4060	8232	2447	1882	3182	0.414	0.287	0.596	4267	3302	5515
2007	4195	2929	6008	2736	2097	3571	0.571	0.398	0.818	4276	3315	5517
2008	4127	2870	5933	2466	1904	3194	0.563	0.398	0.797	3790	2965	4844
2009	7058	4908	10150	2279	1791	2900	0.590	0.422	0.826	3915	3095	4952
2010	12988	8751	19276	2471	1960	3116	0.632	0.455	0.878	5135	3959	6660
2011	13870	9299	20689	3125	2405	4059	0.645	0.462	0.901	6518	4899	8673
2012	7896	5743	10856	3615	2718	4807	0.687	0.490	0.962	6505	4923	8595
2013	12723	9361	17293	3531	2719	4585	0.718	0.502	1.028	6619	5209	8411
2014	14263	10328	19696	3621	2934	4470	0.297	0.184	0.478	7129	5737	8858
2015	17722	12662	24805	5086	4126	6268	0.256	0.165	0.396	9533	7666	11856
2016	24781	17161	35785	7053	5700	8728	0.289	0.188	0.444	13000	10348	16331
2017	24945	17472	35616	9235	7405	11518	0.238	0.145	0.390	16040	12760	20162
2018	23221	15786	34156	11808	9370	14882	0.411	0.254	0.664	18896	15015	23781
2019	21300	13157	34485	12283	9629	15669	0.316	0.183	0.544	18980	14822	24304
2020	80996	47208	138966	15119	11314	20205	0.198	0.107	0.368	29892	21338	41875
2021	184819	94266	362359	25822	18028	36985	0.145	0.073	0.290	60105	38083	94862
2022	471921	149567	1489028	53869	31724	91470	0.149	0.049	0.452	139785	64859	301264

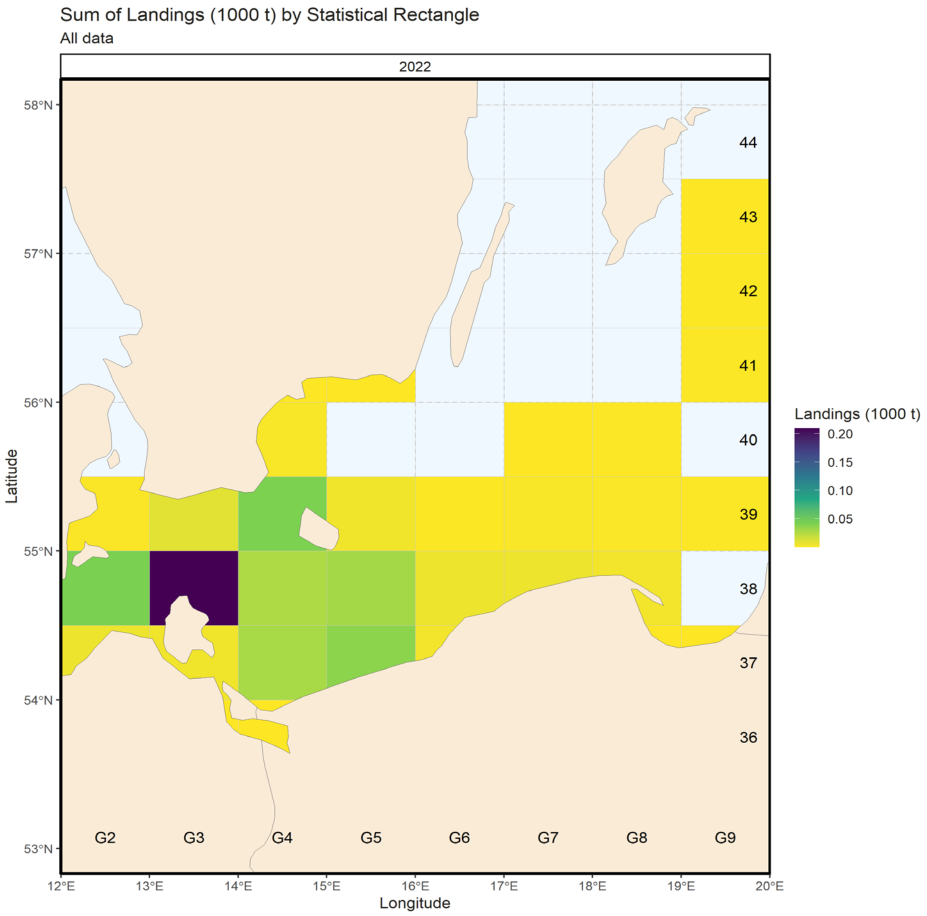


Figure 5.3.1ple.27.24-32: annual main fishing areas of Baltic Sea plaice in 27.3.d.24-26 (RCG Baltic, 2023).

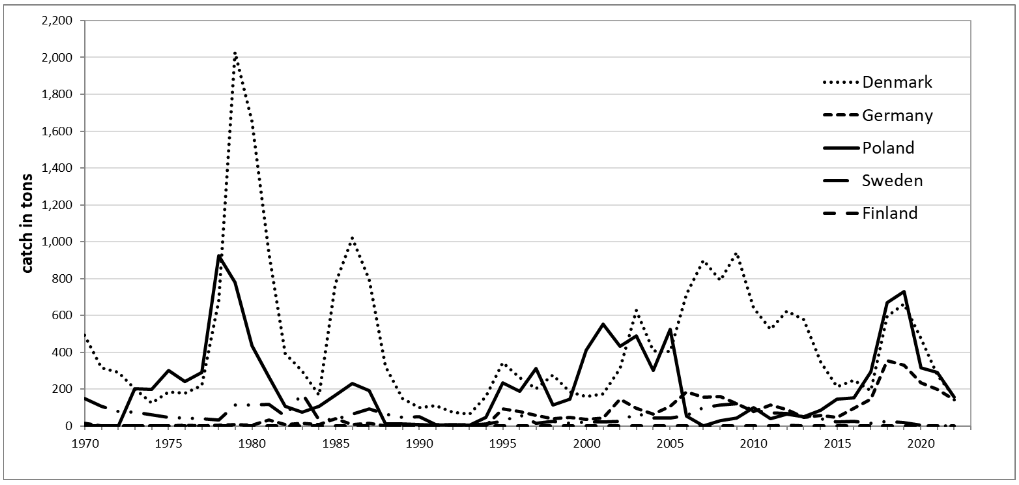


Figure 5.3.2. ple.27.24-32. Historical landings per country (in tonnes).

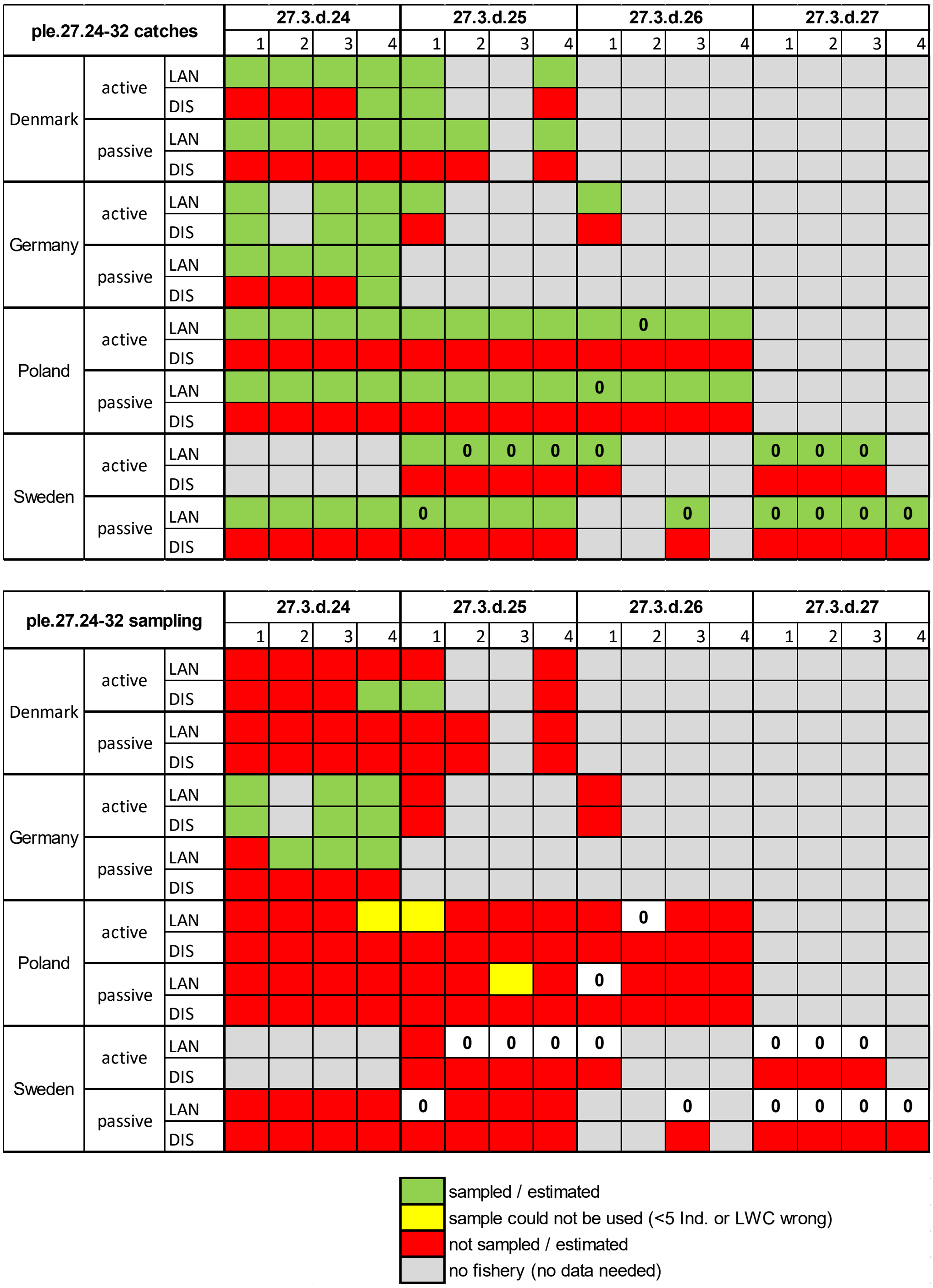


Figure 5.3.3. Sampling coverage and quality of ple.27.24-32.

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)

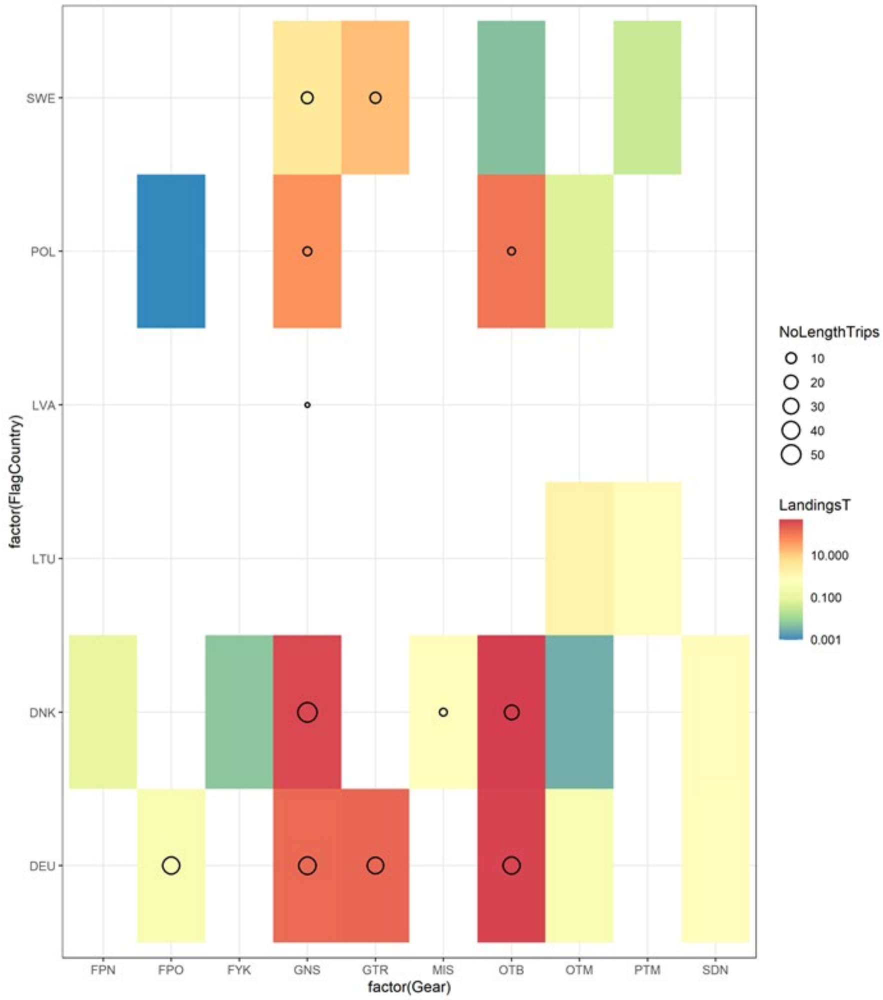


Figure 5.3.4. ple.27.24-32. Main fishing gear by member state (coloured squares, x and y axis) and respective sampling coverage (number of trips with length sampling conducted, bubble size according to number of trips sampled). (RCG Baltic, 2023)

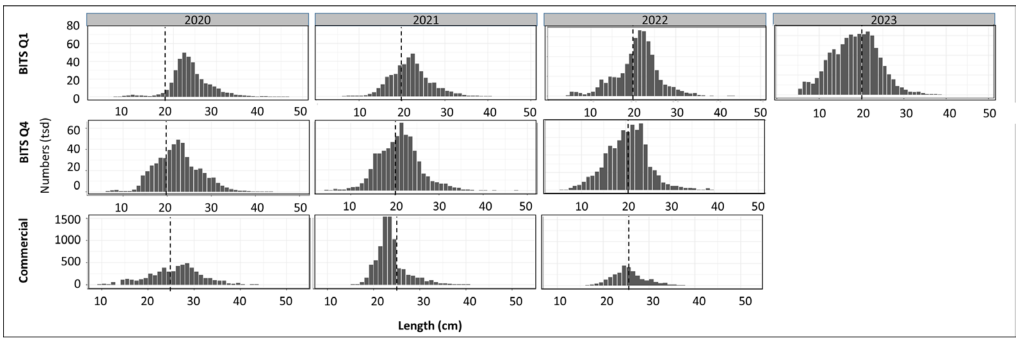


Figure 5.3.5.ple.27.24-32. Length distribution in BITS Survey Q1 and Q4 and commercial samples. Dotted line marks the minimum size for survey index inclusion (20cm, BITS) and minimum landings size (25cm, commercial fisheries)

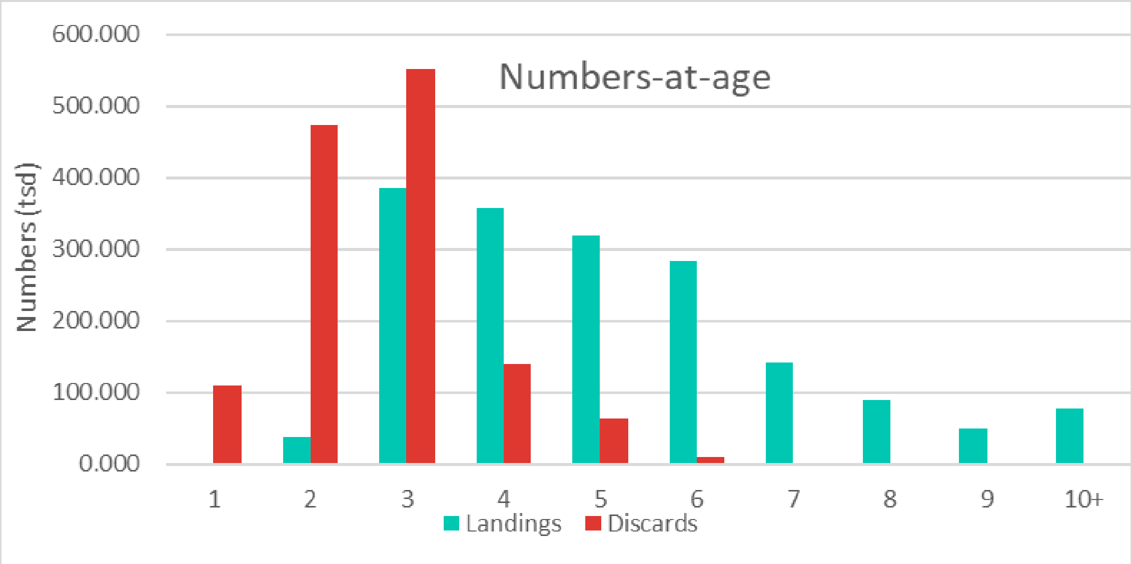


Figure 5.3.6.ple.27.24-32. Numbers-at-age in commercial fisheries catch fractions

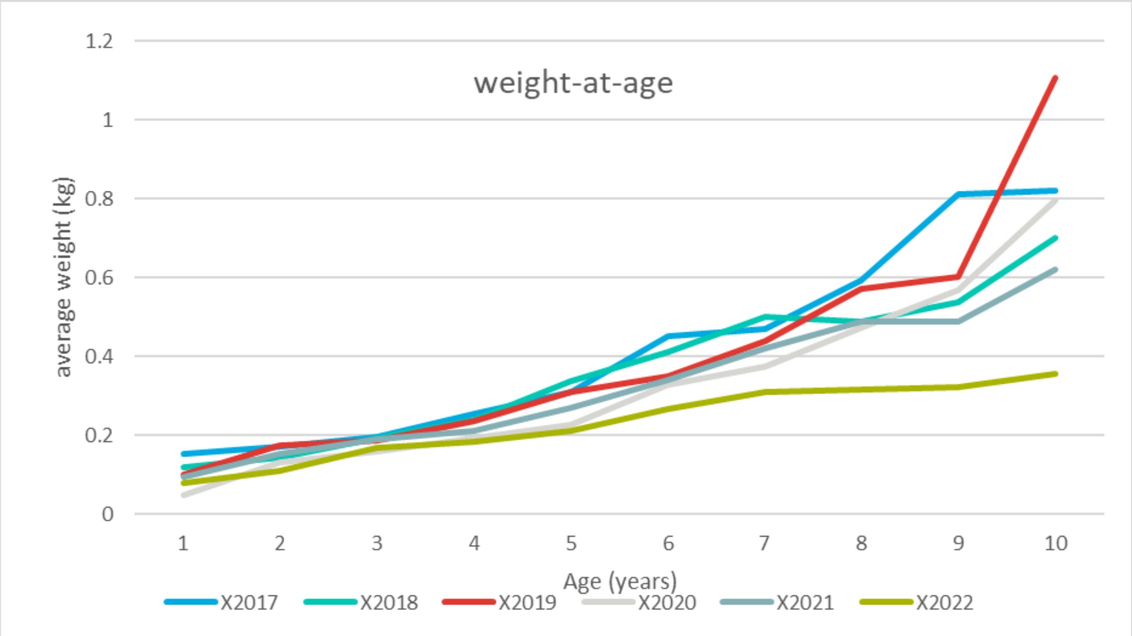


Figure 5.3.7. ple.27.24-32. Average weight-at-age for the age classes 1 to 10 in subdivisions 24 and 25. All countries and fleets were combined. Shown for the latest year of the assessment and the five years before.

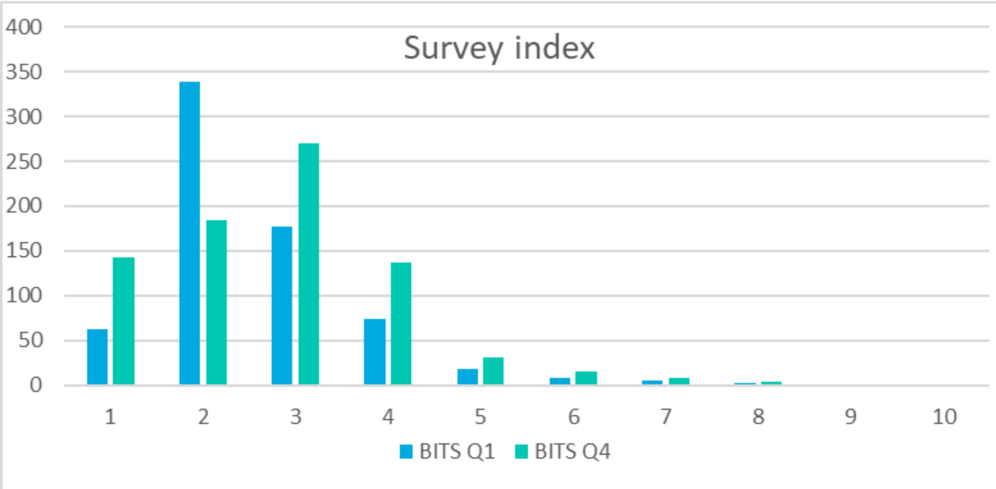


Figure 5.3.8. ple.27.24-32. Number-at-age index of the BITS Survey Q1 and Q4 for 2022

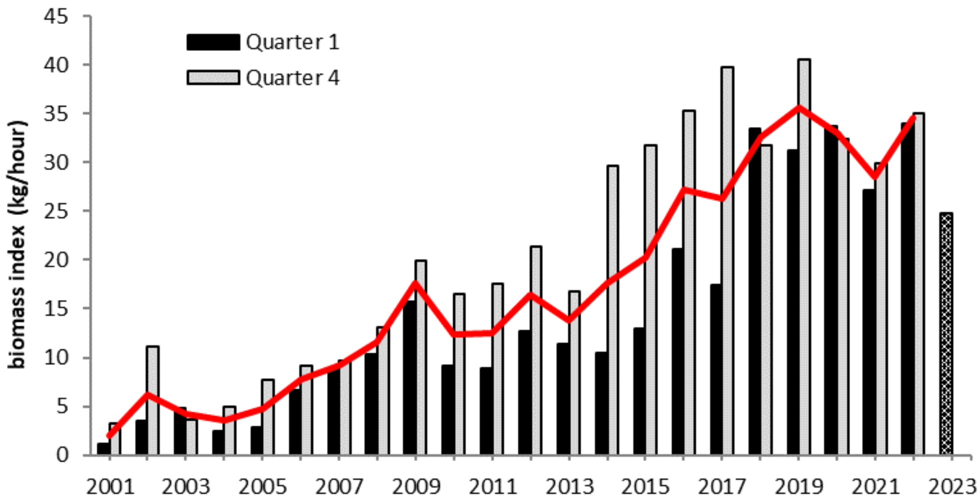
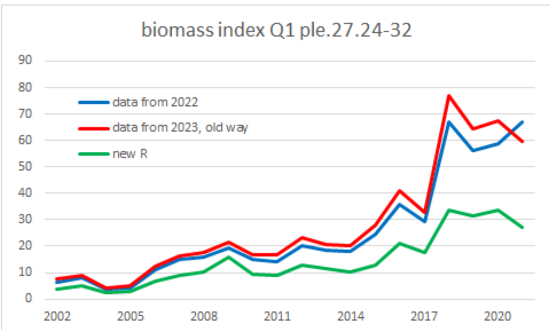


Figure 5.3.9. ple.27.24-32. Average biomass index from Q1 and Q4 BITS from SD24-SD26 (no plaice catches in SD27+). 2023 data (Q1) are preliminary.



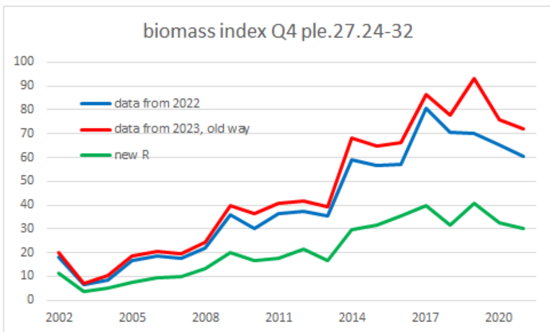


Figure 5.3.10. ple.27.24.32. Comparison of the BITS biomass index, using the corrected calculation (accounting for zero catch hauls), compared to last year and this year's biomass index using the wrong calculations.

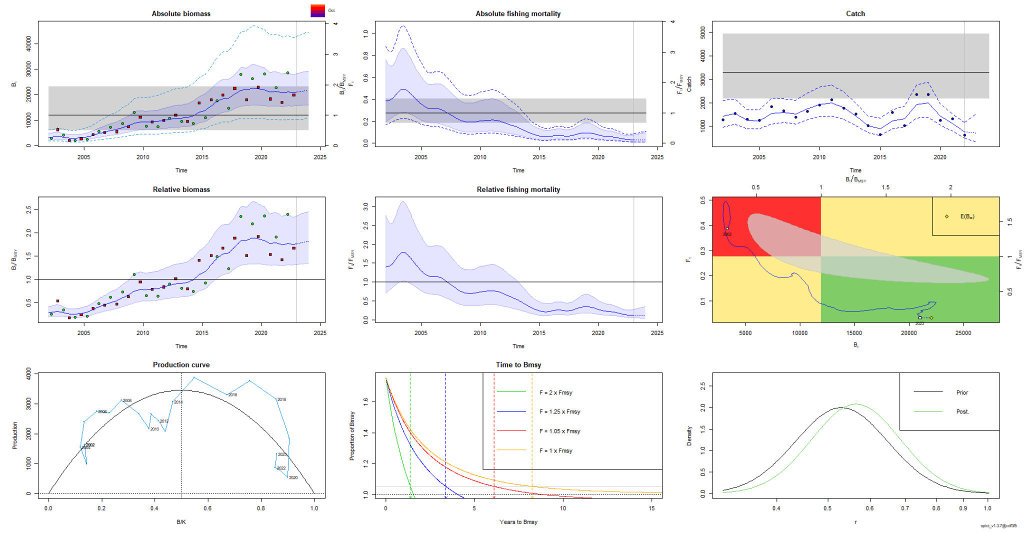


Figure 5.3.11.ple.27.24-32. Overview of the results of the surplus production model (SPiCT) on catch and survey data 2002–2022.

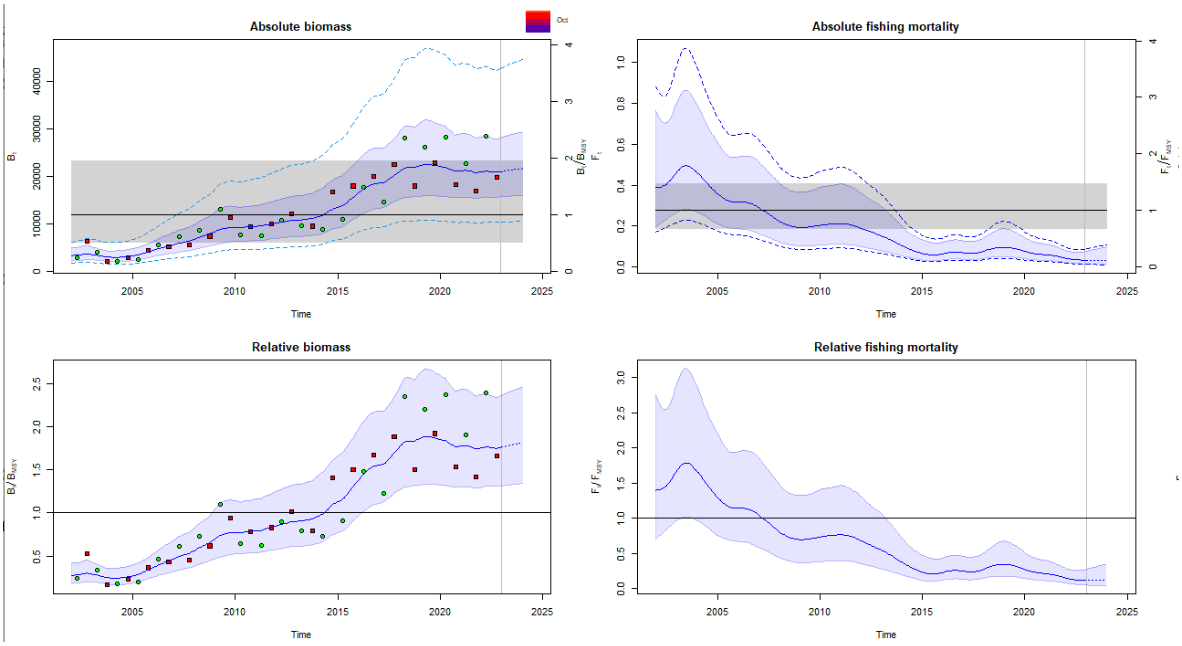


Figure 5.3.12. ple.27.24-32. Overview of the results of the surplus production model (SPiCT) on catch and survey data 2002–2022. Absolute and relative B and F and their respective estimated reference points.

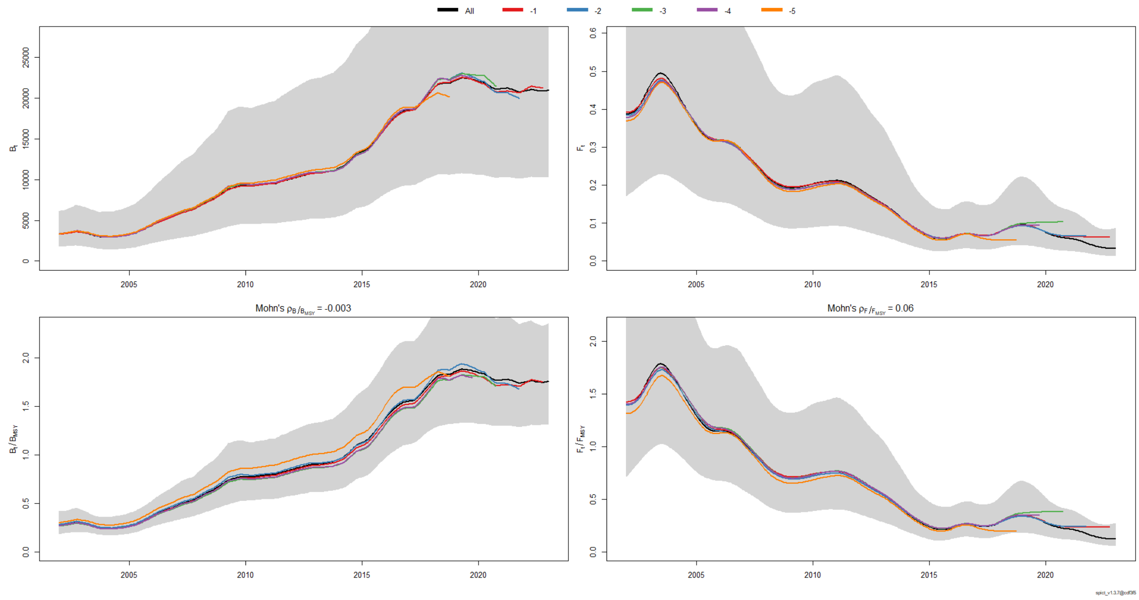


Figure 5.3.13. ple.27.24-32. Overview of the retrospective analysis of the surplus production model (SPiCT) on catch and survey data 2002–2022

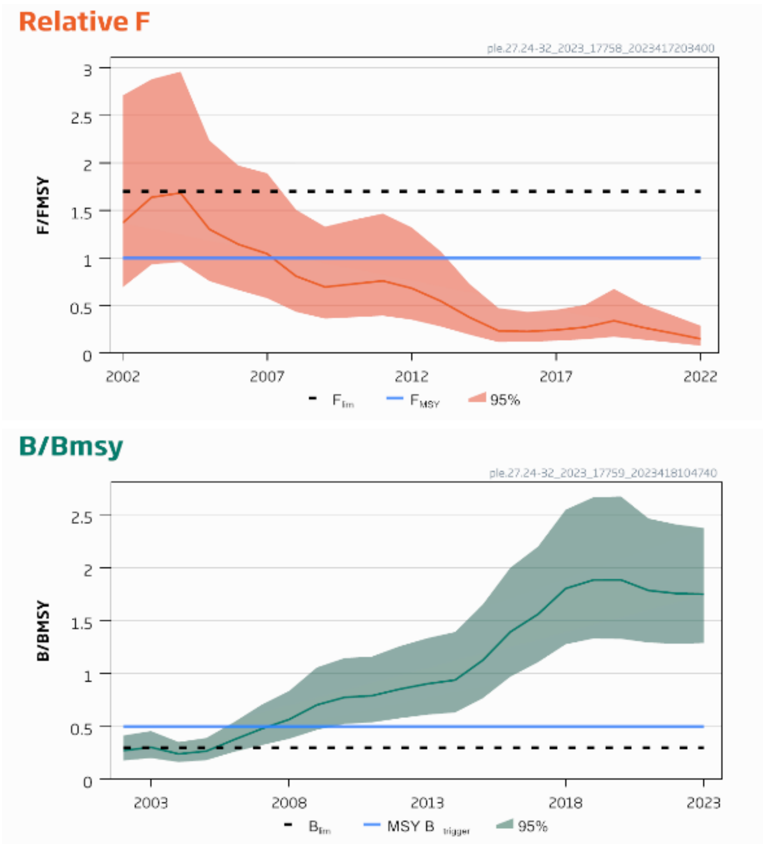


Figure 5.3.14. ple.27.24-32. Stock assessment graphs, relative F and SSB

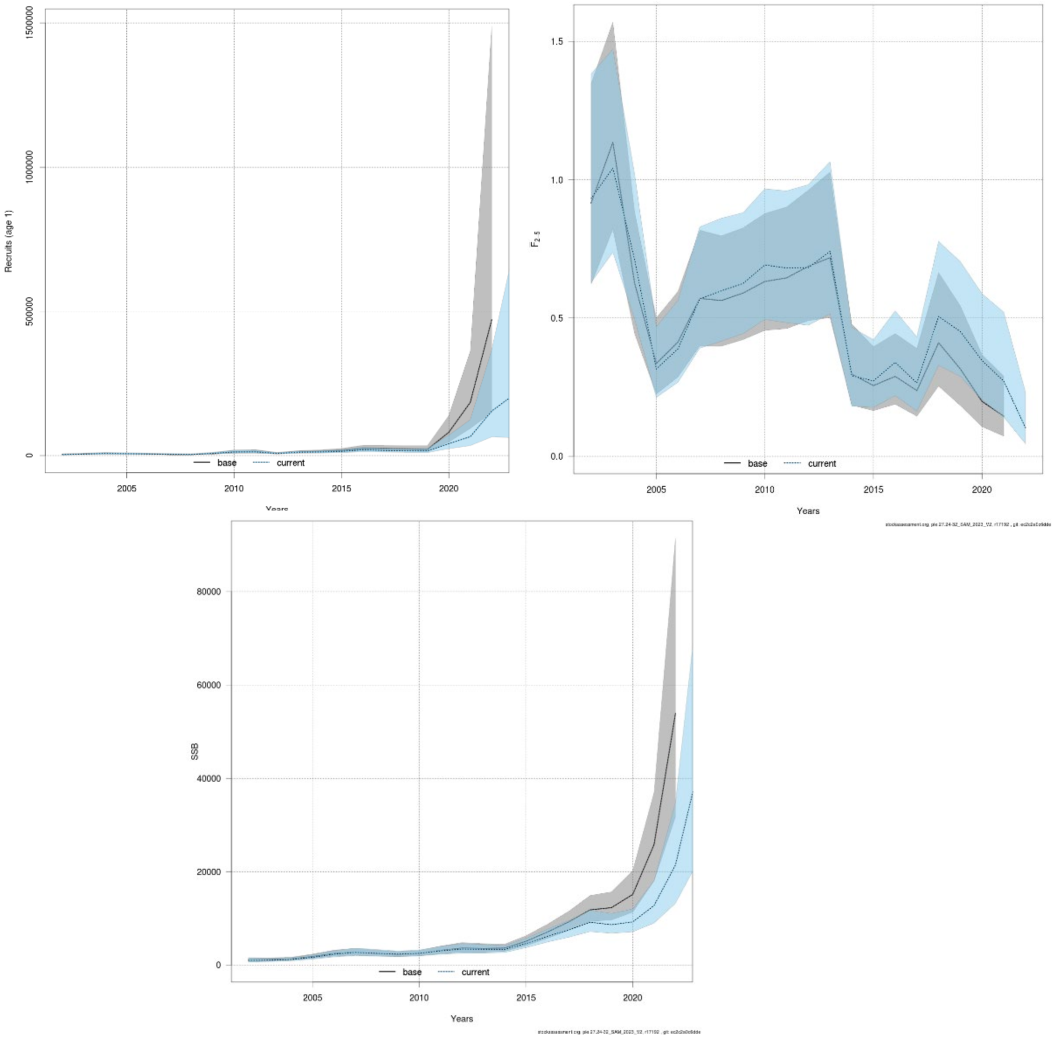


Figure 5.3.15. ple.27.24-32. Results from the exploratory SAM assessment: a) total SSB, b) F (age2–5,) and c) recruitment

6 Sole in Subdivisions 20–24 (Skagerrak, Kattegat, the Belts and Western Baltic)

6.1 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 2022 the majority is taken by passive gears (42/58 ratio). 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). The season for gillnet fishery for sole is from April to September. During this season, about 80% of the gillnet catches are sole. Additional information of the sole fishery is in the Stock Annex (Annex 5).

6.1.1 Landings

The officially reported landings by area, gear and country for 2022 are given in Table 6.1. Total landings in 2022 amounted to 302 t (28% decrease from 2021) where Denmark took 82% 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 southwards into the southern Belts.

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 about 300-400 t. Figure 6.2 provide the Danish catches cumulated by month since 1998 including preliminary 1st quarter catches of 2023, indicating seasonal trends in the fishery.

6.1.2 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 2022 amounts to 7.1% of the catches by weight based on sampling from trawlers and gillnetters (Table 6.3). The average of the recent 5 years is 3% discard (used in advice to add up to total catches).

Since the discards overall are considered insignificant and rather 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.

6.1.3 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).

6.2 Biological composition of the catch

6.2.1 Catch in numbers

Sampling of age structure of the catch was available only for the Danish fishery (Table 6.4). Overall the sampling has improved from the past (approx. 650 specimens from the catches). In 2022 landings from the Belts were not sampled. The age structure of the Danish catch was applied to the total international catch (Table 6.6).

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).

6.2.2 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 2022 mean weights of most age groups decreased.

6.2.3 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).

6.2.4 Natural mortality

The natural mortality is unknown and was assumed to be 0.1 per year for all ages and years.

6.2.5 Quality of catch and biological data

Denmark provided statistics on catch sampling for the Kattegat, Skagerrak and the Belts/western Baltic (Table 6.4). The Belts and western Baltic was not sampled in 2022. 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.

6.3 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 (Figure 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. Figure 6.5 show the progressive expansion of the survey since 2015. The stations in the extended area are not included in the survey index calculation, but awaits a longer time series. A forthcoming benchmark in 2025 will address this issue.

Based on 62 successful hauls in 2022, 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 shows a decreasing trend in catch rates since 2018. Further, recruitment (age 1) is still observed to be very low though increasing from the record 2021 value (Figure 6.3 and Table 6.5).

6.4 Assessment

Since the benchmark in 2010 (WKFLAT) the SAM model has been used to assess the stock. Final assessment in 2023 is named 'sole20_24_2023' and is visible at stockassessment.org.

6.4.1 Model residuals

Model residuals for the survey and catches are provided in Figure 6.8. No blocks of either negative or positive residuals are apparent for both survey indices and catch numbers.

6.4.2 Fleet sensitivity analysis

In order to examine the effect of the single fleet calibration indices on the F and SSB estimates, SAM runs were conducted with the single fleets 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, with only the catch matrix along with the two-commercial series from back in time, the leave-one-out analysis suggests a recent lower fishing mortality and a similarly a higher SSB.

6.4.3 Final stock and fishery estimation and historical stock trends

Stock summary (SSB, fishing mortality and recruitment) as estimated from the SAM model is provided in Figure 6.10. and in Table 6.10. The SSB has increased since 2013 and is in 2022 estimated to be at 2177 t. Estimated fishing mortalities and stock numbers by age are provided in Tables 6.8 and 6.9.

Fishing mortality has decreased since 2017 and has been below F_{MSY} since then. Recruitment calculated as age 1 has since 2008 been low but with two relatively good year-classes in 2014 and 2017. The recent recruitment is low with the 2020 year-class the lowest observed in the time series (Figure 6.10, Table 6.10).

6.4.4 Retrospective analysis

The assessment is considered robust with no observed retrospective bias (Figure 6.11) of the SSB and F estimates. Mohn's rho are in the range +-0.03 for SSB and F, and 0.09 for recruitment. The assessment consistency has most likely improved from higher effort in sampling from the fishery (see section 6.2.1).

6.5 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 comprise 7.0% in weight in 2022 (Table 6.3). The average of the discard in the recent 5 years (3.0%) is added to landings to derive advised catches for 2024.

Assumed recruitment ages 1 randomly drawn from 2004-2022 led to an assumed median recruitment 2023-2024 of 2109 thou. individuals.

As in previous years TAC was not fully utilized in 2022 and preliminary information for Danish catches in the first quarter of 2023 suggest low catches in 2023. Therefore, the TAC of 498 t for 2023 (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 (2023). An Fsq (F = F2021) assumption leads to a catch of 366 t in 2023 (compared to a catch of 325 t in 2022). The basis for Fsq (F2023) is an average of recent Fs (e.g. 3 years) scaled to the final year (=0.178). Assumptions for the intermediate year are provided in Table 6.12.

Given the Fsq assumption, SSB in the beginning of 2024 is estimated at 2250 t (Table 6.12) which is below the MSY Btrigger (2600 t). Therefore, the advice for 2024 will be based on a reduced F corresponding to Fmsy*SSB2024/MSY Btrigger (eq F=0.225). With these assumptions, the forecast predicts that advised fishing in 2024 will lead to a total yield of 436 t. At this level of exploitation, spawning stock biomass is estimated at 2233 t in 2025. Catch in 2024 in predicted to be dominated by ages 5-6 (Figure 6.13).

EC has since 2018 requested advice for the sole stock in SD 20–24 based on F_{MSY} ranges. Catches in 2024 corresponding to F_{MSY} upper and lower range (F = 0.16–0.23) are 327–436 t.

A yield-per-recruit analysis was made with long term 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 0.8 and that $F_{0.1}$ is estimated to 0.19.

6.6 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} × e 1.645σ, σ = 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.		

6.7 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 now non-present.

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. Work is ongoing to improve knowledge on stock identity for sole in the region, especially the relation between Skagerrak and the North Sea and this will be considered in a forthcoming benchmark.

6.8 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 could be that the mean weight at age used to compute SSB for the assessment year (5 year average) are too optimistic when averaged over a period when weight at age are decreasing. Historically this has not been an issue since weight at age are variable without a trend.

6.9 Management considerations

Management of the sole fishery should take into account that particular the trawl fishery is a mixed fishery with cod and *Nephrops*. 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 for sole and cod 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.

6.10 Issues relevant for a forthcoming benchmark

DTU Aqua finalized a project in 2018 aimed to investigate stock structure of sole in SDs 20-24, improve biological parameters such as growth and recruitment monitoring, evaluate the sole surveys that is basis for the assessment, evaluate sampling strategies from the fishery and finally to estimate selectivity parameters for the most commonly used active gear types. The project achieved many of its objectives but on the stock structure, the results were not conclusive. Genetics and partly growth analyses pointed to a difference between the sole populations in Kattegat and Skagerrak, while recruitment patterns pointed to a common population. DTU Aqua has presently continued this study aiming to investigate stock structure further. The main bullets in this recent study are:

- The connection between the sole stock in SD 20-24 and the North Sea stock Div 4.
- Recruitment areas that contribute to the adult sole stock in SDs 20-24 including validation of nursery grounds within SDs 20-24 and nursery grounds outside SDs 20-24 that contribute to the 20-24 stock.

To achieve these goals the studies will include following methods:

1. Genetics; genotyping spawning fish from the North Sea adjacent to Skagerrak along with spawners from 20-24 in order to identify stock structure in SD 20–24 and adjacent waters to identify main self-reproducing units. In addition, juveniles from both the North sea and 20-24 will be examined for genetic differentiation to evaluate feeding migrations within SD 20-24 and Division 4.
2. Otolith trace element analysis to identify the origin of sole sampled both in the North Sea and in SD 20-24.

In addition to the above research items, the issues below should be considered:

- 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.
- Inclusion of survey data from the gradually expanded survey area since 2015 (Skagerrak, the Belts and the western Baltic). This is required for representation of the stock distribution because the fishery have also expanded in the same areas, suggesting that the stock have expanded its main distribution area.

Table 6.1. Sole 20-24. Landings (t) of sole in 2022 by area, nation, quarter and gear.

Skagerrak (SD20)	**Quarter**				**Gear**		**Total**
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	10	47	9	15	28	51	79
Germany	0	9	0	0	0	9	9
Sweden	0	0	0	0	1	0	1
Netherlands	8	0	0	6	14	0	14
Norway	0	0	0	0	0	0	1
Total	18	55	9	21	43	60	103
Kattegat (SD21)	Quarter				Gear		Total
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	20	11	8	31	57	14	71
Germany	0	0	18	4	2	21	22
Sweden	1	1	3	1	2	4	6
Total	21	13	29	36	60	39	99
Belts and Baltic (SD22-24)	Quarter				Gear		Total
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	3	19	21	53	22	75	97
Germany	0	0	0	0	0	1	1
Sweden	0	1	0	0	0	2	2
Total	0	0	1	0	22	78	99

Table 6.2. Sole 20--24. Catches (tons) in the Skagerrak, Kattegat and the Belts 1952–2022. 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

Considerable non-reporting assumed for the period 1991–1993. 2Catches 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. 3Assuming 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
1	128	490	3,128	1,156	5,913	254	230	219	348	494	56
2	1,326	2,392	2,492	828	2,761	2,095	476	1,415	1,236	1,421	2,333
3	1,782	1,872	19,126	-	1,800	9,733	2,457	1,281	3,686	786	1,119
4	4,032	954	1,316	1,076	3,408	1,117	568	2,465	474	1,676	6,033
5	680	510	1,785	981	14	1,404	1,379	1,306	973	294	7,302
6	928	1,232	972	264	315	692	588	518	703	615	1,193
7	570	1,030	1,800	-	702	315	716	155	1,093	363	3,915
8	248	416	1,220	296	-	603	30	441	1,105	431	1,333
9	572	708	232	-	172	345	143	103	2,319	350	274
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	23
Landings(t)	359	332	335	224	348	520	348	417	424	387	302
Catches	370	342	367	230	365	537	355	425	436	393	325
Discard %	3%	3%	9%	2%	5%	3%	2%	2%	2.7%	1.5%	7%

Table 6.4. Sole 20-24. Sampling in 2022 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	3,874	-	-	18,001	9,533	66	20,534	20,008	184	42,409	29,541	250
2	19,764	-	-	55,598	46,660	98	12,602	11,467	88	87,964	58,127	186
3	21,977	-	-	8,780	8,516	24	29,311	8,082	18	60,067	16,598	42
4	53,774	-	-	21,015	14,563	66	36,476	31,450	118	111,265	46,013	184
Total	99,388	0	0	103,394	79,272	254	98,923	71,007	408	301,705	150,279	662

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

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	1

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.

Catch numbers at age Numbers*10**-3

YEAR,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,
AGE									
2,	64,	786,	258,	391,	516,	863,	1209,	530,	506,
3,	638,	594,	1255,	857,	1035,	613,	1300,	1301,	1178,
4,	240,	190,	671,	1018,	897,	847,	651,	928,	939,
5,	117,	55,	210,	434,	484,	592,	564,	334,	493,
6,	31,	60,	33,	174,	129,	404,	310,	345,	320,
7,	33,	16,	36,	64,	37,	83,	167,	302,	178,
8,	40,	8,	33,	31,	23,	30,	27,	180,	166,
+gp,	175,	69,	63,	87,	60,	52,	31,	76,	239,
0 TOTALNUM,	1338,	1778,	2559,	3056,	3181,	3484,	4259,	3996,	4019,
TONSLAND,	337,	397,	643,	722,	706,	824,	1050,	1011,	1294,
SOPCOF %,	99,	100,	100,	100,	100,	100,	100,	95,	93,

YEAR,	1993,	1994,	1995,	1996,	1997,	1998,	1999,	2000,	2001,	2002,
AGE										
2,	523,	127,	272,	316,	54,	303,	249,	142,	170,	655,
3,	1804,	1037,	622,	1015,	251,	146,	826,	483,	369,	758,
4,	1251,	1451,	1359,	537,	440,	212,	150,	771,	360,	285,
5,	826,	752,	1226,	691,	365,	299,	228,	114,	354,	423,
6,	418,	444,	600,	440,	505,	267,	177,	130,	68,	472,
7,	117,	152,	385,	232,	360,	250,	165,	123,	84,	94,
8,	137,	45,	142,	148,	262,	218,	167,	135,	36,	85,
+gp,	157,	59,	104,	203,	263,	292,	233,	306,	205,	464,
0 TOTALNUM,	5233,	4067,	4710,	3582,	2500,	1987,	2195,	2204,	1646,	3236,
TONSLAND,	1439,	1198,	1297,	1059,	814,	605,	638,	646,	476,	862,
SOPCOF %,	100,	99,	98,	98,	100,	100,	100,	100,	99,	100,

YEAR,	2003,	2004,	2005,	2006,	2007,	2008,	2009,	2010,	2011,	2012,
AGE										
2,	48,	195,	231,	122,	293,	313,	554,	230,	138,	26,
3,	431,	602,	1015,	400,	420,	330,	683,	591,	558,	157,
4,	480,	814,	1083,	857,	384,	354,	445,	458,	613,	284,
5,	280,	475,	583,	734,	583,	297,	285,	211,	246,	160,
6,	344,	257,	276,	505,	299,	489,	139,	132,	65,	111,
7,	197,	187,	117,	169,	135,	240,	92,	67,	28,	36,
8,	25,	86,	102,	67,	81,	179,	29,	83,	14,	54,
+gp,	210,	171,	91,	116,	108,	202,	88,	103,	106,	192,
0 TOTALNUM,	2015,	2787,	3498,	2970,	2303,	2404,	2315,	1875,	1768,	1020,
TONSLAND,	619,	824,	990,	836,	633,	656,	640,	541,	507,	358,
SOPCOF %,	100,	99,	98,	98,	97,	102,	98,	101,	100,	100,

YEAR,	2013,	2014,	2015,	2016,	2017,	2018,	2019,	2020,	2021,	2022,
AGE										
2,	48,	13,	37,	110,	137,	32,	163,	45,	63,	55,
3,	226,	66,	81,	273,	181,	131,	59,	325,	181,	72,
4,	286,	178,	95,	190,	347,	268,	309,	96,	202,	234,
5,	194,	109,	109,	175,	195,	201,	268,	228,	65,	176,

6, 137, 199, 89, 82, 186, 97, 93, 243, 126, 47,

7, 62, 105, 81, 38, 163, 144, 54, 120, 122, 120,

8, 23, 68, 18, 50, 120, 104, 83, 34, 92, 137,

+gp, 96, 69, 93, 181, 301, 157, 235, 214, 224, 123,

0 TOTALNUM, 1072, 807, 603, 1099, 1630, 1134, 1264, 1305, 1075, 964,

TONSLAND, 332, 331, 215, 348, 520, 434, 417, 424, 387, 302,

SOPCOF %, 109, 100, 100, 101, 100, 100, 99, 100, 99, 100,

Table 6.7 Sole 20-24. Weight at age (kg) in the catch and in the stock.

Catch weights at age (kg)

YEAR, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992,

AGE

2, .1830, .1740, .1650, .1600, .1590, .1760, .1800, .1740, .2130,

3, .2130, .2340, .2310, .1940, .1970, .2210, .2280, .2290, .2520,

4, .2570, .2830, .2870, .2450, .2350, .2550, .2510, .2750, .3360,

5, .2940, .2910, .2970, .2740, .2510, .2660, .3080, .2920, .4120,

6, .2970, .3350, .4090, .3190, .3350, .2710, .3330, .3460, .4300,

7, .2800, .2920, .2670, .3600, .3480, .3520, .4000, .3090, .4910,

8, .3210, .2790, .2620, .4170, .3630, .3000, .5470, .3860, .5660,

+gp, .3680, .3640, .3830, .3610, .3520, .3550, .5550, .5030, .6220,

0 SOPCOFAC, .9930, .9984, .9995, 1.0027, 1.0032, .9964, .9970, .9508, .9304,

YEAR, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002,

AGE

2, .1780, .1740, .1870, .1760, .1980, .1610, .1620, .1690, .1840, .1720,

3, .2240, .2290, .2000, .2180, .2720, .2190, .2320, .2360, .2420, .2050,

4, .2740, .2800, .2480, .2670, .2960, .3160, .3040, .3040, .2900, .2940,

5, .3280, .3420, .2910, .3070, .3080, .3220, .3680, .3440, .3780, .3730,

6, .3740, .3880, .3510, .3390, .3450, .3500, .3600, .3190, .3460, .3860,

7, .4030, .4450, .3820, .4040, .3590, .3580, .3780, .3640, .3080, .2140,

8, .3880, .4480, .4320, .4570, .3640, .3770, .3970, .3520, .3620, .2920,

+gp, .4740, .3940, .3830, .6640, .3610, .3270, .3500, .3280, .2810, .2760,

0 SOPCOFAC, .9980, .9931, .9767, .9826, .9983, 1.0006, 1.0041, 1.0004, .9941, .9967,

YEAR, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012,

AGE

2, .1740, .2030, .1920, .2010, .2110, .2150, .2110, .2580, .2610, .2850,

3, .2100, .2370, .2230, .2150, .2280, .2460, .2590, .2700, .2710, .2790,

4, .2460, .2910, .3000, .2630, .2950, .2670, .3010, .2830, .2920, .3170,

5, .3600, .3280, .3240, .3170, .3020, .2800, .3190, .3240, .2770, .3750,

6, .3820, .3710, .3670, .3390, .3540, .2900, .4030, .3110, .3580, .4060,

7, .4310, .4010, .3710, .3210, .3390, .2960, .4390, .3690, .4760, .4060,

8, .2610, .3700, .4210, .2930, .3800, .3010, .4390, .3100, .2850, .3500,

+gp, .3820, .3150, .3720, .3440, .2440, .2460, .2630, .2630, .3010, .4060,

0 SOPCOFAC, .9971, .9916, .9841, .9794, .9654, 1.0209, .9832, 1.0103, 1.0003, 1.0006,

YEAR, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022,

AGE

2, .2390, .2270, .2210, .2340, .2160, .2100, .2000, .1820, .1930, .1730, 3, .2250, .2830, .2390, .2670, .2650, .2280, .2880, .2400, .2640, .2150,

4, .2760, .3720, .2860, .2680, .2920, .3130, .2900, .2650, .3220, .2690,

5, .3040, .4210, .3910, .2830, .2990, .3680, .3840, .3470, .3370, .3060,

6, .3730, .4430, .4040, .3410, .3260, .3570, .4230, .3570, .3680, .4350,

7, .3050, .4860, .3880, .3300, .3770, .4630, .4590, .3000, .4110, .3110,

8, .3060, .4540, .5010, .5440, .3340, .4750, .3860, .4790, .4180, .3480,

+gp, .2870, .4060, .4340, .4390, .3950, .5640, .3440, .4360, .4870, .4510,

0 SOPCOFAC, 1.0891, .9976, 1.0043, 1.0051, 1.0034, 1.0007, .9949, 1.0022, .9899, .9977,

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	0.083	0.384	0.476	0.403	0.378	0.378	0.378	0.378
1985	0.075	0.303	0.374	0.340	0.294	0.294	0.294	0.294
1986	0.085	0.314	0.413	0.394	0.349	0.349	0.349	0.349
1987	0.099	0.332	0.446	0.454	0.450	0.450	0.450	0.450
1988	0.098	0.312	0.415	0.412	0.405	0.405	0.405	0.405
1989	0.102	0.317	0.425	0.429	0.416	0.416	0.416	0.416
1990	0.097	0.302	0.412	0.417	0.380	0.380	0.380	0.380
1991	0.098	0.305	0.424	0.443	0.484	0.484	0.484	0.484
1992	0.097	0.305	0.423	0.464	0.579	0.579	0.579	0.579
1993	0.095	0.305	0.423	0.474	0.583	0.583	0.583	0.583
1994	0.082	0.263	0.363	0.412	0.448	0.448	0.448	0.448
1995	0.087	0.286	0.382	0.437	0.480	0.480	0.480	0.480
1996	0.084	0.284	0.355	0.402	0.428	0.428	0.428	0.428
1997	0.079	0.257	0.337	0.384	0.425	0.425	0.425	0.425
1998	0.074	0.239	0.313	0.373	0.403	0.403	0.403	0.403
1999	0.069	0.225	0.295	0.343	0.367	0.367	0.367	0.367
2000	0.065	0.214	0.289	0.327	0.359	0.359	0.359	0.359
2001	0.056	0.184	0.241	0.286	0.306	0.306	0.306	0.306
2002	0.063	0.198	0.264	0.323	0.415	0.415	0.415	0.415
2003	0.056	0.172	0.248	0.302	0.388	0.388	0.388	0.388
2004	0.065	0.196	0.291	0.347	0.436	0.436	0.436	0.436
2005	0.074	0.223	0.323	0.373	0.436	0.436	0.436	0.436
2006	0.075	0.228	0.319	0.375	0.369	0.369	0.369	0.369

Year Age	2	3	4	5	6	7	8	9
2007	0.078	0.236	0.318	0.352	0.304	0.304	0.304	0.304
2008	0.087	0.267	0.365	0.372	0.316	0.316	0.316	0.316
2009	0.078	0.254	0.354	0.327	0.194	0.194	0.194	0.194
2010	0.071	0.252	0.353	0.316	0.170	0.170	0.170	0.170
2011	0.055	0.205	0.310	0.257	0.128	0.128	0.128	0.128
2012	0.044	0.158	0.262	0.225	0.141	0.141	0.141	0.141
2013	0.039	0.135	0.236	0.209	0.144	0.144	0.144	0.144
2014	0.033	0.102	0.194	0.183	0.148	0.148	0.148	0.148
2015	0.029	0.087	0.158	0.171	0.128	0.128	0.128	0.128
2016	0.035	0.100	0.188	0.206	0.169	0.169	0.169	0.169
2017	0.043	0.108	0.219	0.256	0.264	0.264	0.264	0.264
2018	0.039	0.092	0.186	0.219	0.238	0.238	0.238	0.238
2019	0.038	0.091	0.178	0.206	0.213	0.213	0.213	0.213
2020	0.039	0.097	0.176	0.203	0.215	0.215	0.215	0.215
2021	0.038	0.089	0.159	0.185	0.204	0.204	0.204	0.204
2022	0.036	0.081	0.152	0.170	0.190	0.190	0.190	0.190

Table 6.9. Sole 20-24. Stock number at age from assessment.

Year / Age	1	2	3	4	5	6	7	8	9
1984	6409	2584	1618	509	365	133	80	126	478
1985	5236	5980	2314	928	266	220	89	45	349
1986	4818	4653	4964	1649	597	173	143	70	262
1987	4324	4376	3882	3259	988	363	123	91	220
1988	5903	3671	3786	2700	1867	493	177	71	180
1989	7627	5386	2665	2569	1678	1159	265	102	149
1990	7545	7186	4429	1748	1580	1012	698	143	141
1991	8541	6689	5661	2867	1034	942	663	464	185
1992	6512	8205	5436	3527	1577	585	510	369	392
1993	3563	6197	6929	3640	2114	879	286	265	369
1994	3513	2948	5249	4839	2203	1213	413	141	296
1995	2280	3387	2600	3941	3134	1442	762	264	281
1996	1534	2052	2920	1854	2417	1739	854	428	373
1997	3632	1147	1441	1731	1242	1513	1119	623	543
1998	3681	3737	867	943	985	773	852	688	742
1999	3098	3426	3675	634	725	613	521	522	884
2000	4418	2588	2674	2535	430	503	372	364	957
2001	5922	4035	2173	1952	1591	297	375	211	899
2002	4433	5854	3765	1549	1494	1151	225	274	838
2003	4503	3830	4404	2721	1141	1046	636	120	644
2004	2904	4365	3735	3275	1742	758	583	346	444
2005	2473	2730	4521	3339	2197	972	379	291	350
2006	3189	2358	2255	3461	2157	1419	558	231	420
2007	3422	2673	1946	1617	2194	1083	793	360	494
2008	2021	3187	1929	1413	1081	1396	650	542	593
2009	2109	1891	2668	1279	991	686	890	358	679
2010	1966	1945	1863	1778	754	662	436	668	803
2011	1743	1843	1820	1442	1154	491	461	269	1109
2012	1521	1530	1506	1389	925	816	339	369	1085

Year / Age	1	2	3	4	5	6	7	8	9
2013	1529	1347	1360	1203	1021	665	633	241	989
2014	2520	1283	1149	1010	847	779	454	527	887
2015	3215	2270	1124	1010	696	667	551	304	1233
2016	2637	2837	2108	959	927	488	456	398	1359
2017	1545	2608	2407	1717	686	780	383	335	1432
2018	3409	1175	2197	2002	1205	443	574	284	1275
2019	2512	3240	846	1807	1494	861	272	410	1255
2020	1663	2260	2694	624	1286	1145	664	183	1304
2021	1156	1484	2039	1895	440	843	796	473	1073
2022	1435	1048	1186	1694	1365	314	624	642	1097

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	6409	3920	10481	861	695	1066	0.403	0.304	0.532	1719	1402	2107
1985	5236	3394	8077	1121	898	1400	0.319	0.243	0.418	2476	1977	3099
1986	4818	3181	7299	2025	1616	2538	0.371	0.293	0.469	3082	2535	3747
1987	4324	2815	6641	2100	1742	2531	0.450	0.355	0.570	3060	2589	3615
1988	5903	3896	8942	2165	1823	2570	0.409	0.322	0.518	3102	2654	3627
1989	7627	5022	11582	2181	1856	2563	0.421	0.334	0.530	3587	3056	4209
1990	7545	4993	11402	2708	2302	3185	0.394	0.314	0.493	4454	3779	5250
1991	8541	5576	13083	3190	2693	3778	0.463	0.375	0.573	4866	4146	5712
1992	6512	4300	9862	4160	3537	4892	0.525	0.423	0.651	6298	5355	7408
1993	3563	2366	5366	3965	3350	4693	0.529	0.424	0.661	5282	4514	6179
1994	3513	2343	5266	4145	3546	4844	0.424	0.340	0.529	4868	4209	5631
1995	2280	1508	3446	3428	2968	3959	0.452	0.365	0.559	4198	3664	4810
1996	1534	967	2434	3252	2830	3736	0.408	0.332	0.503	3705	3245	4229
1997	3632	2383	5536	2633	2291	3027	0.399	0.324	0.492	3078	2700	3510
1998	3681	2456	5517	1882	1623	2184	0.379	0.305	0.471	2705	2341	3126
1999	3098	2050	4682	2246	1914	2636	0.348	0.281	0.431	2987	2567	3475

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(4-8)	Low	High	TSB	Low	High
2000	4418	2949	6617	2287	1954	2677	0.338	0.272	0.420	2990	2582	3462
2001	5922	3907	8978	2241	1925	2608	0.289	0.230	0.364	3338	2873	3879
2002	4433	2962	6636	2589	2215	3025	0.366	0.294	0.457	3861	3293	4527
2003	4503	3023	6709	2956	2532	3452	0.343	0.271	0.434	3893	3377	4487
2004	2904	2047	4118	3192	2763	3689	0.389	0.312	0.486	4253	3701	4887
2005	2473	1730	3537	3472	2990	4031	0.401	0.321	0.501	4144	3601	4770
2006	3189	2224	4573	2951	2530	3442	0.360	0.290	0.447	3616	3128	4181
2007	3422	2399	4881	2493	2146	2896	0.316	0.251	0.398	3263	2827	3765
2008	2021	1377	2966	2061	1756	2418	0.337	0.264	0.431	2867	2458	3345
2009	2109	1477	3011	2395	2006	2859	0.252	0.196	0.326	2920	2479	3440
2010	1966	1375	2810	2036	1699	2439	0.235	0.181	0.306	2655	2241	3145
2011	1743	1195	2543	2040	1686	2468	0.190	0.146	0.248	2625	2194	3142
2012	1521	986	2345	2245	1834	2749	0.182	0.139	0.239	2773	2290	3357
2013	1529	1006	2323	1747	1427	2139	0.176	0.134	0.230	2161	1785	2615
2014	2520	1756	3616	2223	1832	2696	0.164	0.126	0.214	2665	2222	3197
2015	3215	2205	4687	2000	1648	2429	0.143	0.108	0.189	2695	2250	3228
2016	2637	1844	3770	2212	1833	2669	0.180	0.140	0.232	3350	2803	4003
2017	1545	1025	2330	2421	2018	2904	0.253	0.194	0.330	3262	2735	3891
2018	3409	2272	5115	2849	2362	3436	0.224	0.174	0.288	3709	3092	4450
2019	2512	1741	3626	2420	2003	2924	0.205	0.158	0.265	3392	2825	4074
2020	1663	1141	2424	2522	2067	3079	0.205	0.157	0.267	3266	2708	3940
2021	1156	745	1794	2654	2165	3254	0.191	0.144	0.254	3068	2527	3725
2022	1435	830	2481	2177	1733	2734	0.178	0.130	0.244	2516	2027	3124

Table 6.11. Sole 20-24. Input to short term prediction.
2023

Age	N	M	Mat	PF	PM	SWt	pF	CWt
1	2109	0.1	0	0	0	0.140	0.000	0.140
2	1309	0.1	0	0	0	0.183	0.020	0.183
3	911	0.1	1	0	0	0.240	0.070	0.240
4	999	0.1	1	0	0	0.285	0.110	0.285
5	1328	0.1	1	0	0	0.330	0.130	0.330
6	1079	0.1	1	0	0	0.387	0.130	0.387
7	239	0.1	1	0	0	0.341	0.130	0.341
8	465	0.1	1	0	0	0.415	0.130	0.415
9	1332	0.1	1	0	0	0.458	0.130	0.458

2024

Age	N	M	Mat	PF	PM	SWt	pF	CWt
1	2109	0.1	0	0	0	0.140	0.000	0.140
2	1936	0.1	0	0	0	0.183	0.020	0.183
3	1157	0.1	1	0	0	0.240	0.070	0.240
4	757	0.1	1	0	0	0.285	0.110	0.285
5	771	0.1	1	0	0	0.330	0.130	0.330
6	1003	0.1	1	0	0	0.387	0.130	0.387
7	803	0.1	1	0	0	0.341	0.130	0.341
8	182	0.1	1	0	0	0.415	0.130	0.415
9	1363	0.1	1	0	0	0.458	0.130	0.458

2025

Age	N	M	Mat	PF	PM	SWt	pF	CWt
1	2109	0.1	0	0	0	0.140	0.000	0.140
2	1929	0.1	0	0	0	0.183	0.020	0.183
3	1764	0.1	1	0	0	0.240	0.070	0.240
4	1018	0.1	1	0	0	0.285	0.110	0.285
5	673	0.1	1	0	0	0.330	0.130	0.330
6	669	0.1	1	0	0	0.387	0.130	0.387
7	877	0.1	1	0	0	0.341	0.130	0.341
8	703	0.1	1	0	0	0.415	0.130	0.415
9	1376	0.1	1	0	0	0.458	0.130	0.458

Input units are thousands and kg

Table 6.12. Sole 20-24. Basis for forecasts and management options table for short term predictions.

Variable	Value	Notes
F ages 4–8 (2023)	0.178	Fsq (=avg F2020-22 rescaled to F2022)
SSB (2024)	2250 tonnes	When fishing at F=0.178 in 2023
Rage1 (2023)	2109 thousands	Resampled from recruitment (2004-2022)
Rage1 (2024)	2109 thousands	Resampled from recruitment (2004-2022)
Projected landings (2023)	354 tonnes	Fishing at F=0.178 in 2023
Projected discards (2023)	12 tonnes	Mean discard rate in weight (2018-2022):3.025%.
Total catch (2023)	366 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 (2024) *	Projected landings (2024) **	Projected discard (2024 **	F projected landings (4–8) (2024)	SSB (2025)	% SSB change ***	% TAC change ^	% Advice change ^^
ICES advice basis								
EU MAP#: $F_{MSY*SSB2023/MSY\ Btrigger}$	436	423	13	0.225	2233	-0.8	-12.5	-13.5
EU MAP#: $F_{lower*SSB2023/MSY\ Btrigger}$	327	317	10	0.164	2340	4.0	-34.4	-14.1
EU MAP#: $F_{upper*SSB2023/MSY\ Btrigger}$	436	423	13	0.225	2233	-0.8	-12.5	-13.5
Other options								
F = 0	0	0	0	0	2665	18.4	-100.0	-100.0
$F_{pa,\ Fmsy}$	496	481	15	0.26	2169	-3.6	-0.5	-1.7
F_{lim}	585	568	17	0.315	2080	-7.6	17.5	16.1
TAC 2022*1.2	598	580	18	0.322	2068	-8.1	20.0	18.6
SSB (2025) = Blim	822	798	24	0.475	1850	-17.8	65.1	63.1
SSB (2025) = Bpa	64	62	2	0.03	2600	15.6	-87.2	-87.3
SSB (2025) = MSY Btrigger	64	62	2	0.03	2600	15.6	-87.2	-87.3
F = F_{2023}	351	341	10	0.178	2314	2.8	-29.5	-30.3

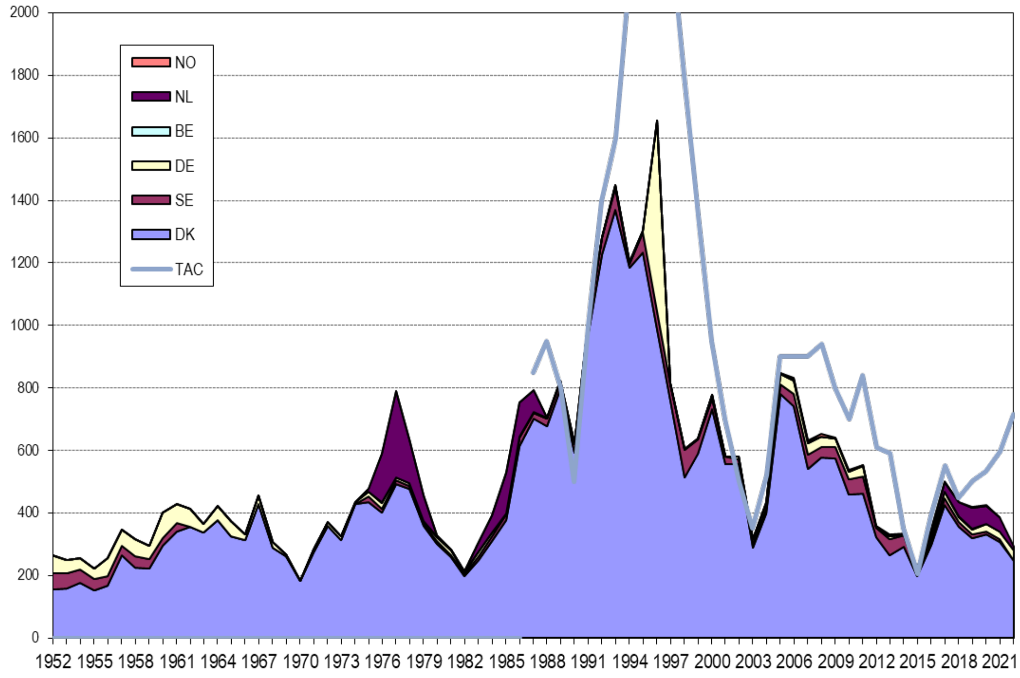


Figure. 6.1. Sole 20-24. Landings of sole in Divisions 20-24 by nation since 1952 and for TAC since 1986.

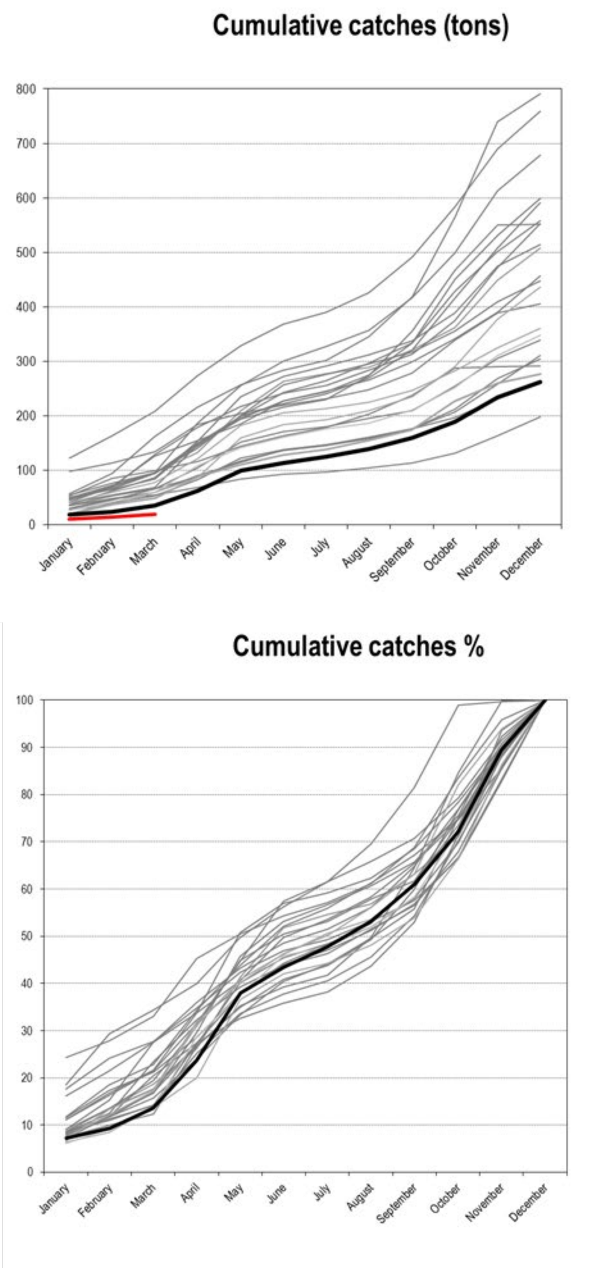
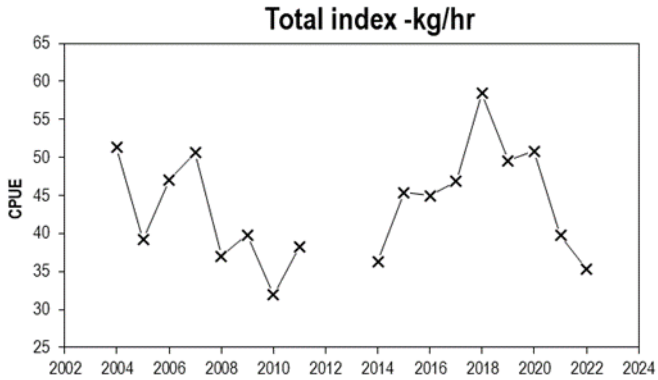


Figure 6.2. Sole 20-24. Cumulative Danish landings of sole by month. Black bold curves are 2022 and red bold curve is 2023 January to March.



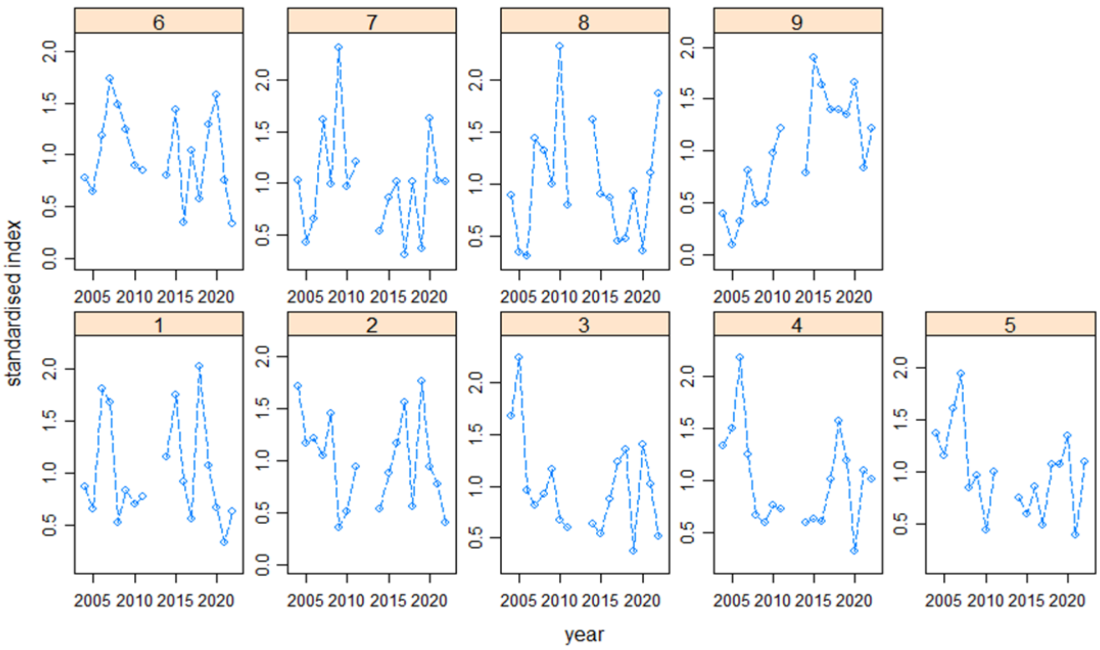


Figure 6.3. Sole 20-24. Upper: Age aggregated catch rates from Fisherman/DTU Aqua survey. Lower: age dis-aggregated indices from the survey.

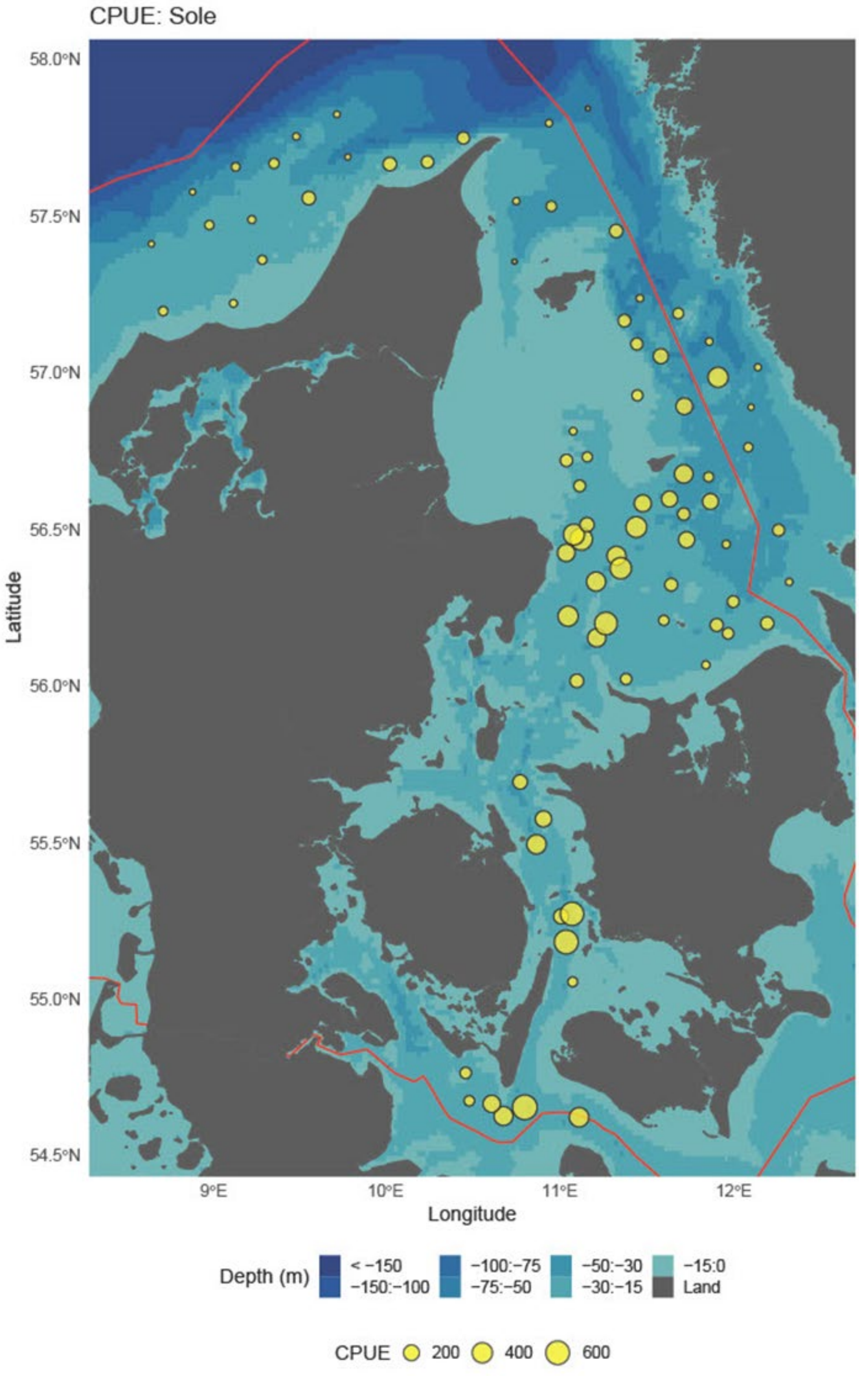


Figure 6.4.1 Fisherman-DTU Aqua survey. Catch rate distribution of stations in 2022.

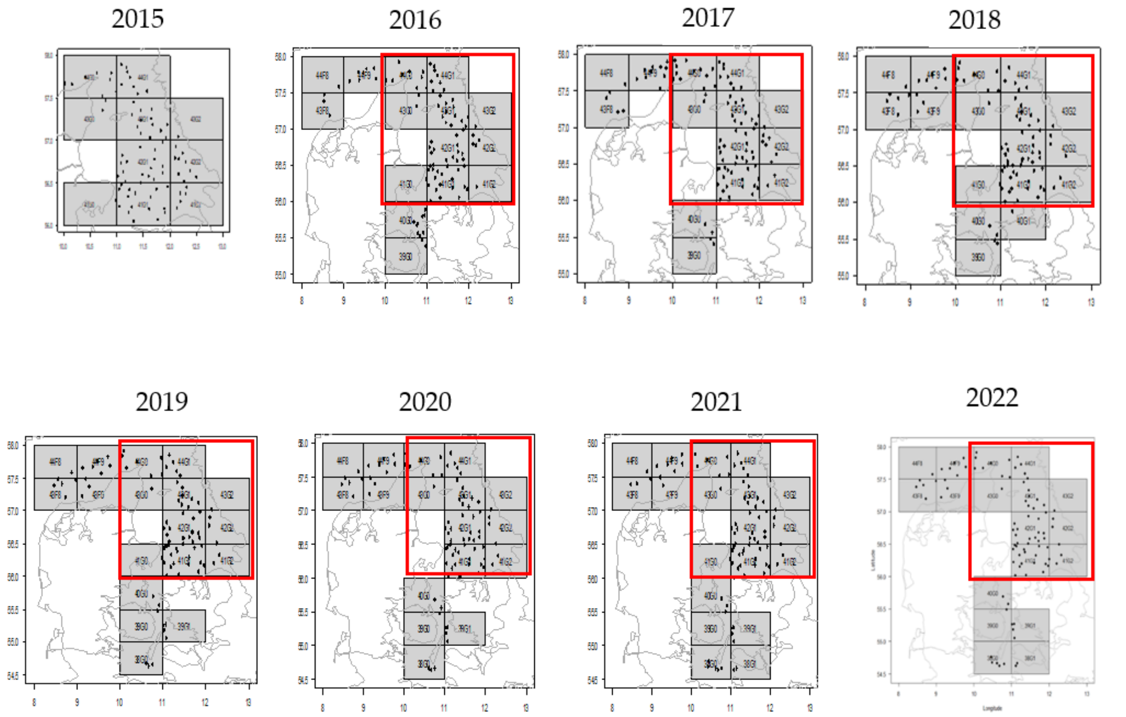


Figure 6.5. Sole 20-24. Map of sole survey station distribution in 2015 – 2022. The red boxes indicate the core area (Kattegat) as surveyed prior to 2016 (here exemplified with 2015 distribution). The gradual expansion of the survey is marked with grey shaded rectangles. Only hauls in the core area are used for estimation of survey indices for assessment calibration.

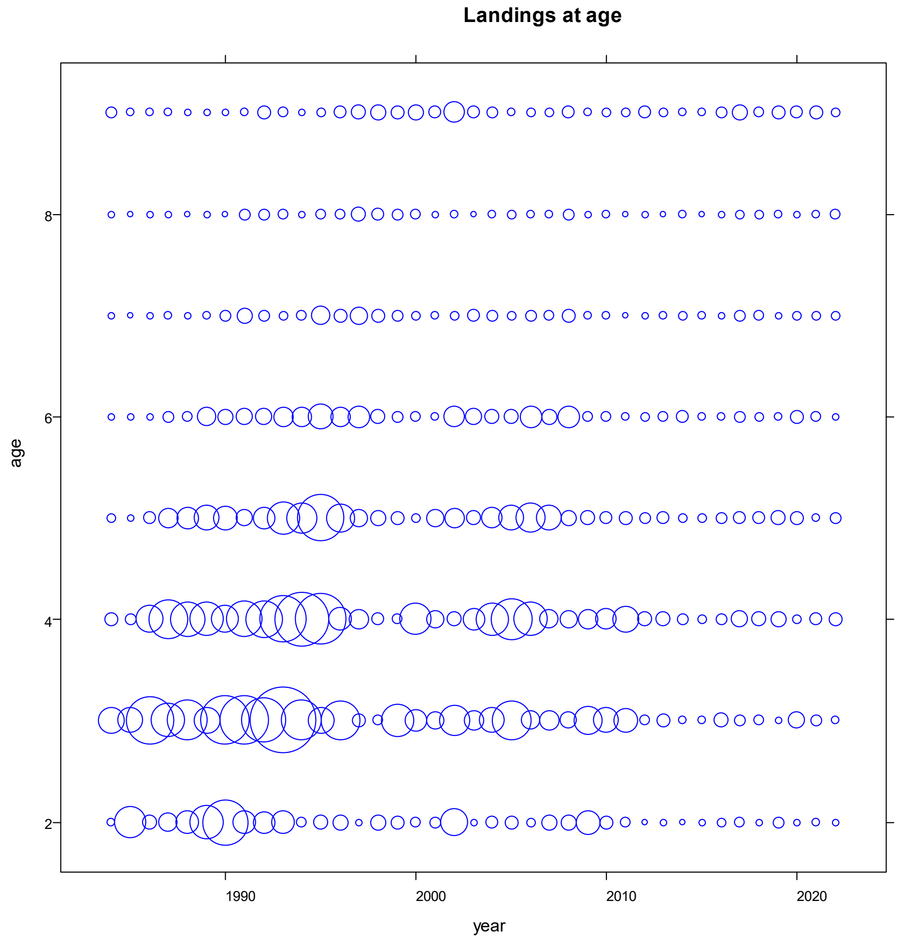


Figure 6.6. Sole 20-24. Landing numbers at age.

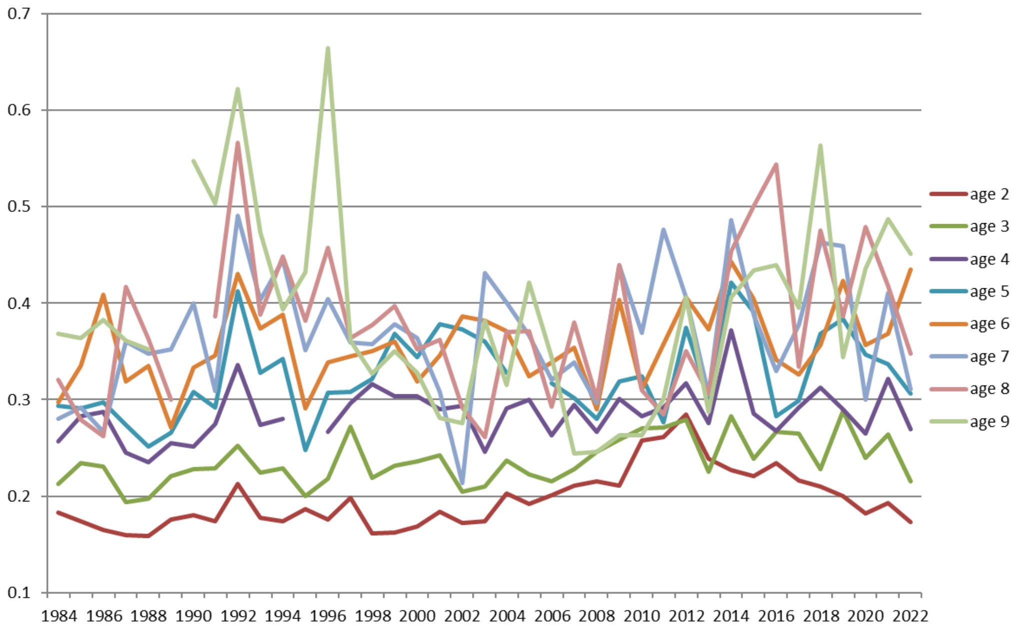


Figure 6.7. Sole in 20-24. Landings weight-at-age.

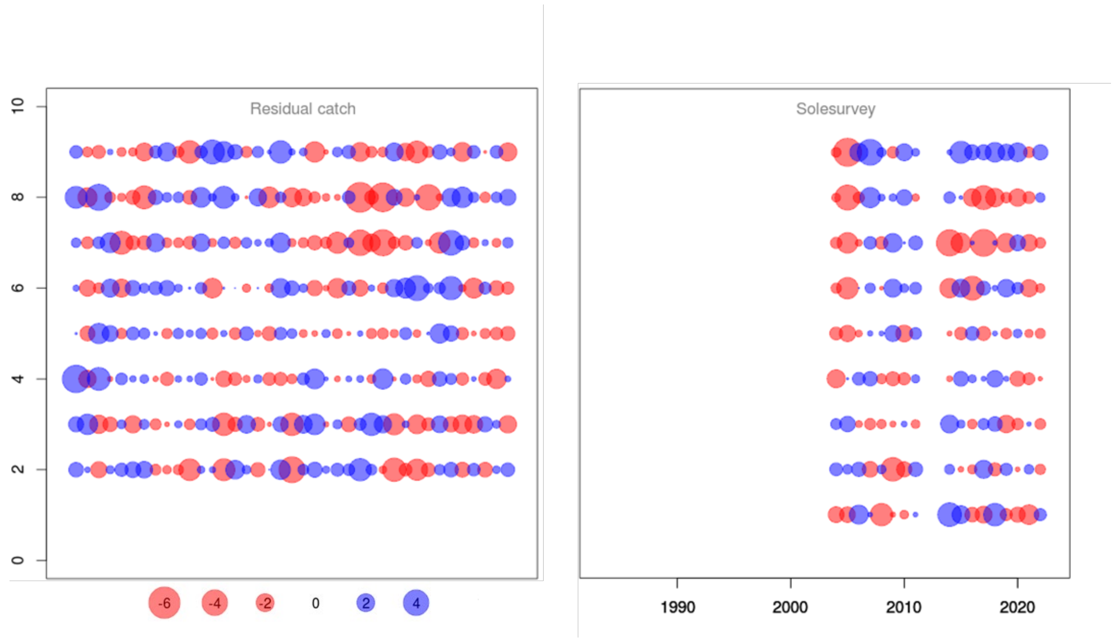


Figure 6.8. Sole 20-24. Model residuals for landings and survey.

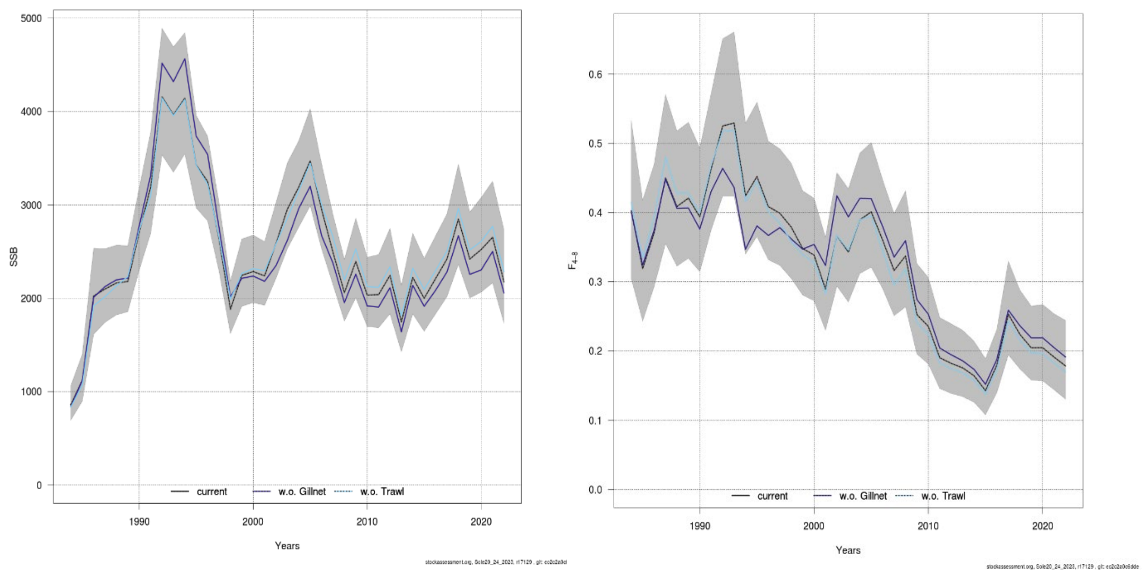


Figure 6.9. 20-24. Fleet sensitivity. Estimated SSB, and fishing mortality from runs leaving single fleets out. Recruitment (age 1) plot is not possible to provide since only the survey contains age 1 group.

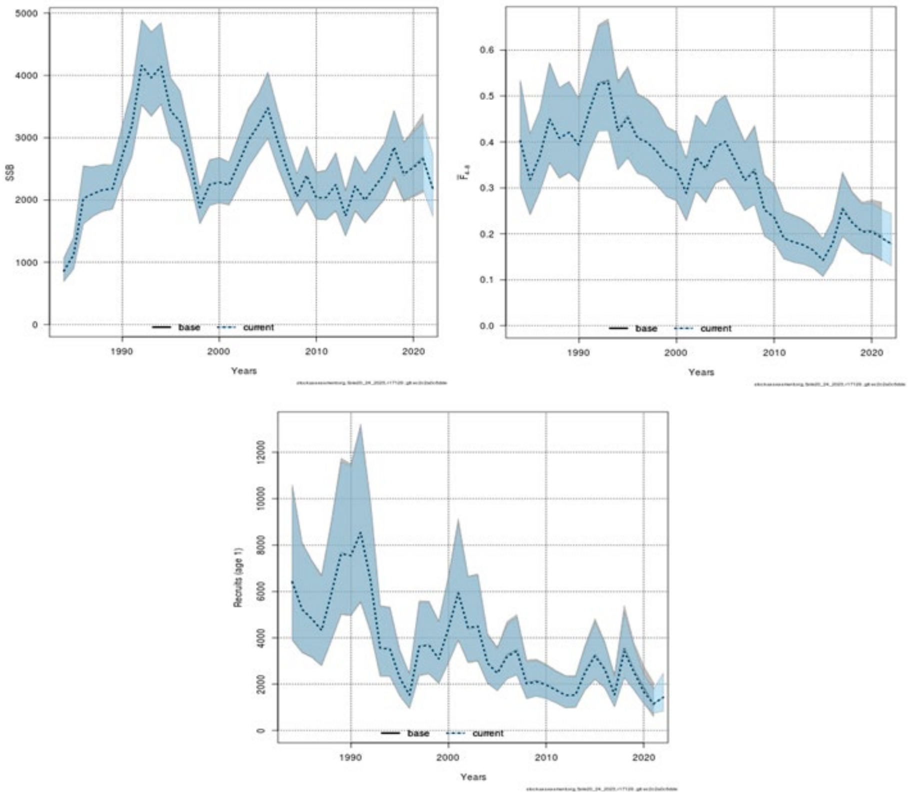


Figure 6.10. Sole 20-24. Stock summary; SSB, F(4-8) and R (age 1) compared to last year's assessment.

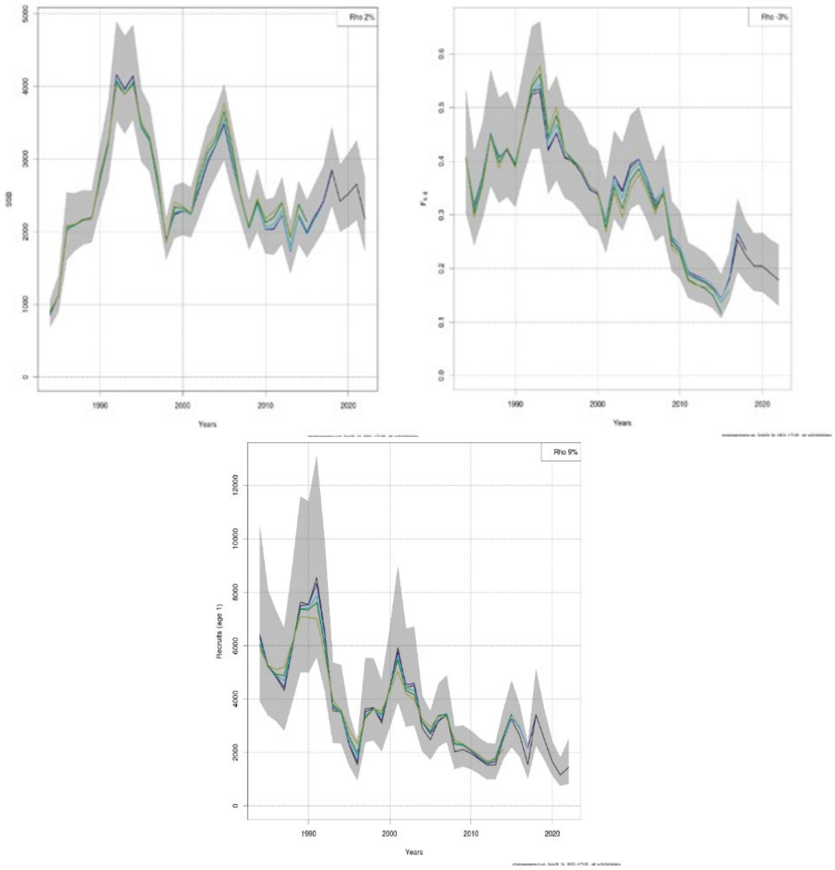


Figure 6.11. Sole 20-24. Retrospective analyses for SSB, F, and recruitment. Confidence limits are provided for the 2022 scenario.

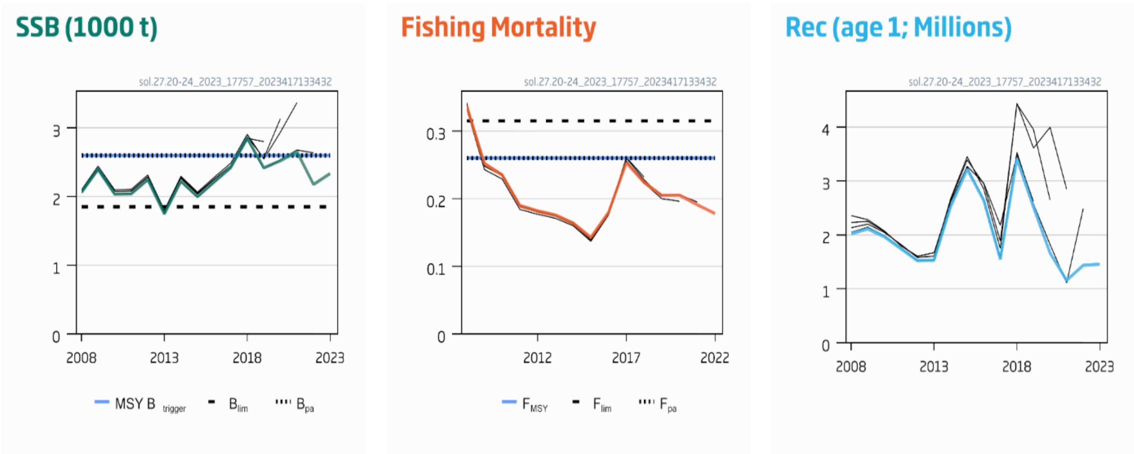


Figure 6.12. Sole 20-24. Historical performance of F, SSB and recruitment.

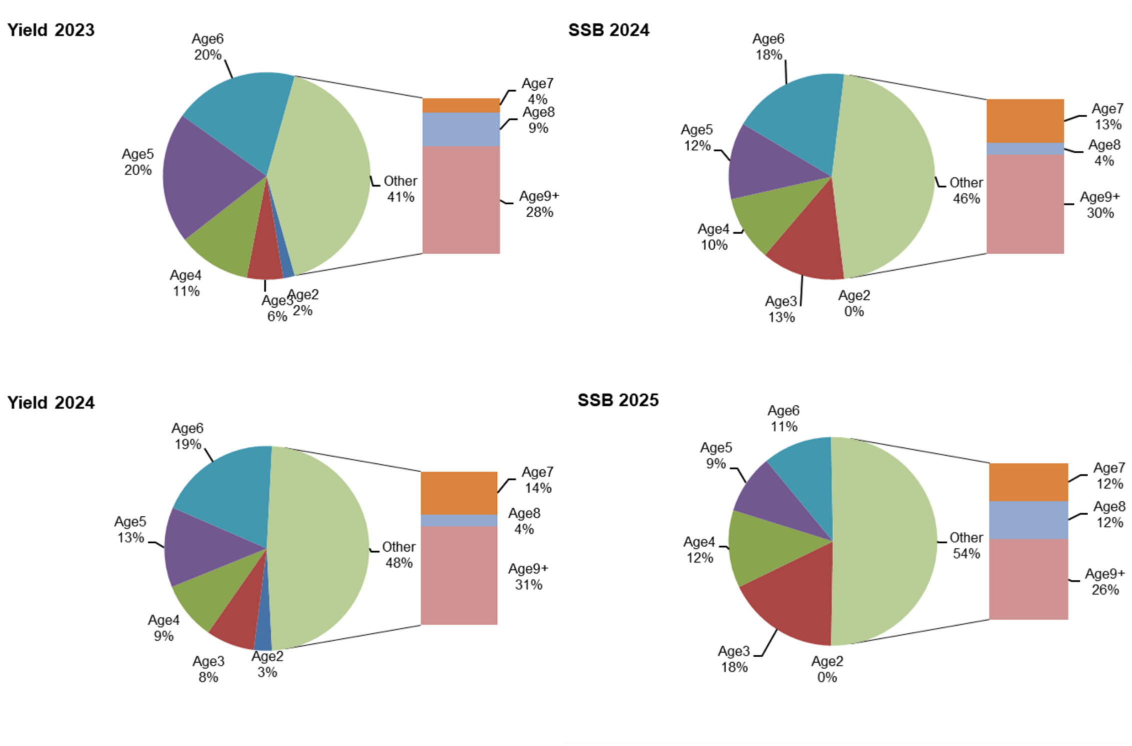


Figure 6.13. Sole 20-24. Short-term forecast for 2023-2025. Yield and SBB at age 2-9+ assuming fishery at F_{sq} in 2023-24.

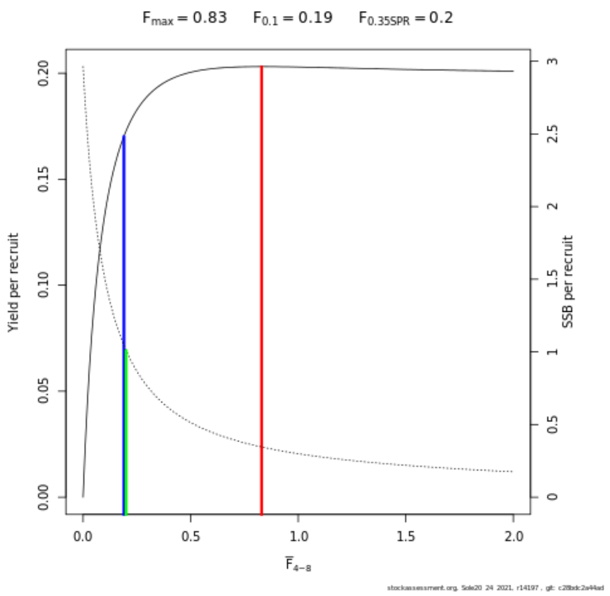


Figure 6.14. Sole 20-24 Yield per recruit curve and reference point estimates (red=Fmax, green=F35%SPR and blue=F0.1)

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.

Natural mortality of sprat depends on the size of the cod stock (due to predation mortality) and estimates of this mortality are used in the assessment. In 2022 the SMS model was updated and new estimates of M are available covering period till 2021 (WGSAM 2022).

7.1 The Fishery

7.1.1 Landings

No information on Russian catches for 2022 was officially reported to ICES. Russian catch amount for 2022 included in the assessment was based on approximate information available in http://atlant.vniro.ru/index.php/novosti2/item/993-predvaritelnye-itogi-promysla-2022-g-v-baltijskom-more-i-ego-zalivakh?highlight=WyJcdTA0M2VcdTA0MzRcdTA0NDMiXQ ; no biological information on composition of these catches was available to ICES. In the above-mentioned website are given the Russian catches of sprat as of December 6, 2022 and 2021. The value from December 6, 2022 was scaled up to estimate Russian 2022 total catch using the scaling factor that was calculated based on 2021 catch figures (Russian 2021 ICES reported catches divided by the Russian 2021 catches as of December 6, 2021). This estimated Russian 2022 total catch was distributed to the ICES subdivisions and divided between different quarters based on the average Russian catch composition in 2019-2021. Next, assessed in this way Russian 2022 sprat catches were uploaded to InterCatch by the sprat stock coordinator of WGBFAS. According to the data uploaded to the InterCatch, sprat catches in 2022 were 301 409 t, which is 6% more than in 2021 and 45% less than the record high value of 543 228 t in 1997. In 2022 total TAC set by the EU plus the Russian autonomous quota was 296 143t, which was utilized in 102%. The largest increase in catches was observed for Germany and Sweden (24 and 20%, respectively). At the same time, the Finnish catches decreased by 9% compared to 2021.

The spatial distribution (by subdivision) of sprat catches was similar to previous years. Subdivision 26 dominated the catches with a 44% share in the sprat catch. Other important areas are subdivisions 28 and 25 (25 and 17%, 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 2001–2022. 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 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.

7.1.4 Effort and CPUE data

Only Denmark and Lithuania uploaded the fishing effort data for 2014 into the InterCatch in 2015. No new fishing effort data were provided in 2016, 2017 and 2018. Russia provided in 2021 the updated data on fishing effort and CPUE for Subdivision 26 in 1995–2020 (Table 7.4). There were no updates presented in 2022 and 2023. 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 catch species composition 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 1999–2022 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. 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 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 but 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 (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 2022 by quarter, ICES subdivision, and country are presented in Table 7.5. These data show that generally in 2022 the sampling activity by ICES subdivision exceeded much the levels indicated in the EC regulation No. 1639/2001, i.e. at least 1 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 3times 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 2000-2022 (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 2001-2022 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 2010-2022; 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, 2023). 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, 2023).

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 prediction of recruitment in intermediate year.

Retrospective analysis shows some tendency to overestimate biomass and recruitment and underestimate fishing mortality (Figure 7.9). However, Mohn's rho values are acceptable and equal to 0.05, -0.06, and 0.06 for SSB, F_{bar}, and recruitment, respectively. Quality of the assessment in terms of retrospective deviations is higher than in previous XSA assessment, 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 relatively consistent with previous XSA assessment (Figure 7.11). In most years XSA estimates lie within SAM confidence intervals.

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 2022). This year class is estimated at 43.77 billions, which is well below average of 81.4 billions in 1991-2022.

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 2014 has led to a marked increase of stock biomass in 2016-2017. The estimate of SSB for 2023 (assuming TAC constraint) is 903 773 tonnes.

Weight-at-age has decreased since the early 1990s, and has remained low since then. This is likely due to density-dependent effects. 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, 2023).

7.5 Short-term forecast and management options

The short-term forecast was performed using forecast procedure in stockassessment package. The 2022-year class at age 1 was estimated in SAM. The 2023- and 2024-year classes were resampled from SAM estimates of the recruitment at age 1 in 1991–2022 (period of recruitment fluctuations without a clear trend). The natural mortalities, mean weights, and fishing pattern were assumed as averages of 2020–2022 values. Fishing mortality in the intermediate year was estimated consistent with TAC in 2023 (TAC defined as EU quota of 224.1 kt plus assumed Russian quota of 45.1 kt, in total 269.2 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 2023 was performed; that produced catches in 2023 at 274 kt, only 2% higher than the TAC. The differences between the two predictions are very small and the group considers TAC constraint prediction as the basis for the advice.

This year forecast at F_{MSY} shows 3% lower catches compared to last year forecast, though F_{MSY} increased from former 0.31 to 0.34. The change in advice is mainly due to decline in stock size (the SSB in 2023 declined by 20% compared to 2022 estimate) and too optimistic assumptions on recruitment in last year predictions.

Comparison of present SAM and previous XSA assessments in terms of ratios of estimated stock numbers is presented in Table 7.22. Major difference is for estimate of 2021 and 2018 y-c (age 1 and 4 in 2022). Age 1 in previous assessment was estimated from RCT3 using shrinkage options (SE of 0.5) which overestimated that y-c; now it appears to be the weakest y-c since 1990s. A reason for over 40% difference in estimate of the 2018 y-c at age 4 is not clear, this y-c appeared higher in SAM than in XSA also at ages 1-3.

Stock numbers at the beginning of advice year for predictions given this year and in 2022 are compared in Figure 7.12. In addition, in the Figure SAM estimates of stock numbers for 2023 are shown to compare them with values predicted last year. The major relative differences between predicted last year and estimated this year numbers for 2023 are at age 1 and 2. Abundance of age 1 last year was assumed at GM recruitment; this year assessment showed that y-c 2022 is much weaker. Age 2 refers to 2021 y-c, and the reason for its overestimation last year was presented above.

The forecast assumptions are presented in Table 7.23 and comparison of weights, selectivities and natural mortalities used in predictions for 2023 and 2024 are shown in Figure 7.13. Differences between compared values are small.

7.6 Reference points

Below, the estimation of BRPs is presented and at the end of the section, the new BRPs are shown.

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 Beverton and Holt 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 Beverton and Holt and the segmented regression is 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 $F_{MSY-upper}$ 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 $F_{msy-upper}$ 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 show moderate deviations of estimates for certain years. In the case of fishing mortality, the deviations are 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 (GM) 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. recently 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 2022 (XSA) and 2023 (SAM) assessments is presented in the text table below. Both assessments are relatively consistent though some changes in tuning fleets, natural mortality and model settings were implemented. SAM assessment produces 15% higher SSB and 15% lower F in in compared year 2021.

Category	Parameter	Assessment 2022, XSA	Assessment 2023, SAM	Diff. (+/-) %
Data input	Maturity ogives	age 1 – 17%, age 2 – 93%	age 1 – 17%, age 2 – 93%	No
	Natural mortality	M in 1974–2018 estimated in SMS (2018), M2019=M2018, M2020-2021 estimated from regression of M against cod biomass (>20 cm)	M in 1974–2021 estimated in updated SMS (2022), M2022=M2021,	On average up to 5%, in individual years/ages up to +/-20%
Assessment input	Catchability dependent on year class strength	Age<2	Age<2	No
	Catchability independent on age	Age >=5	Age >=6	Yes
	SE of the F shrinkage mean	0.75	Not applicable	yes
	Time weighting	Tricubic, 20 years	Not applicable	yes
	Tuning data	International acoustic autumn, International Acoustic May	International acoustic autumn, International Acoustic May	Yes, autumn acoustic now includes sub-division 32, it is separated into two fleets
		Acoustic on age 0 (subdiv. 22–29)	Acoustic on age 0 (subdiv. 22–29)	Yes, now index includes sub-division 32
Assessment results	SSB 2021 (million t) F(3-5) 2021 Recruitment (bilions)	0.939 0.42 95.6	1.085 0.36 100.7	15% -15% 5%

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 2016–17. 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-year class is 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	42.8	53.8	301.4

*** Sum of landings by Estonia, Latvia, Lithuania, and Russia.**

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	42.8					41.704						1.089
Sweden	53.8				8.812	22.094	4.858	17.634	0.247	0.155		
Total	301.4	0.001	0.0	2.0	50.3	132.9	6.1	75.0	12.3	2.4	0.0	20.5

Table 7.3. Sprat in SD 22–32. Catch in numbers and weight-at-age by quarter and Subdivision in 2022

Subdivision 22

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0			0.0		0.0			4.6	
1		0.0	0.0	0.0	0.0		5.1	8.5	13.5
2		0.0	0.0	0.0	0.0		10.9	12.4	11.4
3		0.0	0.0	0.0	0.0		12.7	13.2	13.1
4		0.0	0.0	0.0	0.0		15.0	14.3	13.6
5		0.0	0.0	0.0	0.0		13.1	14.2	14.2
6		0.0	0.0	0.0	0.0		14.1	13.6	13.9
7		0.0	0.0	0.0	0.0		17.8	15.8	15.1
8			0.0	0.0	0.0			14.4	16.4
9			0.0		0.0			15.2	
10				0.0	0.0				16.4
Sum	0.0	0.0	0.0	0.0	0.1				
SOP	0.0	0.0	0.3	0.5	0.8				
Catch	0.0	0.0	0.3	0.5	0.8				

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				
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			0.0		0.0			4.5	
1	20.1	25.6	0.6	2.6	49.0	5.1	5.1	8.5	13.5
2	13.8	17.6	1.0	5.4	37.9	10.9	10.9	12.4	11.4
3	8.8	11.2	3.7	6.6	30.2	12.7	12.7	13.2	13.1
4	6.4	8.1	2.2	8.6	25.2	15.0	15.0	14.3	13.6
5	3.6	4.6	1.8	7.9	17.9	13.1	13.1	14.1	14.2
6	5.3	6.7	0.7	2.6	15.3	14.1	14.1	13.6	13.9
7	0.9	1.2	0.5	0.3	2.9	17.8	17.8	15.8	15.1
8			0.8	0.3	1.1			14.4	16.4
9			0.2		0.2			15.2	

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
10				0.2	0.2				16.4
Sum	58.9	75.1	11.4	34.4	179.8				
SOP	598.5	762.4	154.0	460.3	1975.1				
Catch	597.0	760.5	154.2	460.6	1972.3				

Subdivision 25

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0			0.4		0.4			4.5	
1	41.2	24.7	5.0	22.7	93.6	5.4	6.4	8.5	13.5
2	405.6	137.3	9.2	46.4	598.5	9.6	7.8	12.4	11.4
3	783.3	367.9	33.1	56.8	1241.1	11.4	9.4	13.2	13.1
4	554.0	215.3	19.7	73.6	862.6	12.8	10.5	14.3	13.6
5	442.3	327.4	15.9	67.9	853.5	13.4	10.8	14.1	14.2
6	193.9	77.2	6.7	22.1	299.9	13.7	11.5	13.6	13.9
7	198.1	24.3	4.6	2.7	229.7	14.3	12.8	15.8	15.0
8	65.0	49.4	7.1	2.7	124.2	13.7	12.2	14.4	16.4
9	5.9	1.0	1.7		8.5	14.6	14.1	15.2	
10	1.0	1.0		1.3	3.3	12.1	12.5		16.4
Sum	2690.3	1225.3	103.5	296.4	4315.4				
SOP	32541.5	12309.9	1393.6	3960.7	50205.8				
Catch	32557.5	12334.8	1395.7	3963.9	50251.9				

Subdivision 26

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0			10.5	88.3	98.8			4.1	4.1
1	309.9	39.2	13.2	110.8	473.1	4.8	5.3	10.0	10.0
2	2870.8	932.8	37.0	310.9	4151.6	8.4	8.1	11.1	11.1
3	3529.5	863.4	38.0	318.7	4749.6	9.7	9.0	11.6	11.6

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
4	1547.6	469.9	21.4	179.5	2218.4	10.6	9.8	12.4	12.4
5	841.4	340.7	11.3	94.4	1287.7	11.1	10.4	11.9	11.9
6	341.6	128.2	2.4	19.8	491.9	11.2	11.4	12.4	12.4
7	219.9	75.1			295.0	11.9	10.4		
8	94.4	5.1	0.3	2.2	102.0	11.2	12.0	14.2	14.2
9	13.0	3.1			16.1	12.9	13.8		
10	10.9	0.6			11.5	10.6	9.9		
Sum	9779.0	2858.1	134.0	1124.6	13895.7				
SOP	93365.4	26034.3	1459.0	12243.9	133102.7				
Catch	93181.4	26001.1	1457.6	12231.9	132872.0				

Subdivision 27

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0			0.0	0.0	0.0			3.7	4.6
1	18.4	19.2	0.0	0.1	37.7	3.7	3.8	9.5	10.1
2	205.7	146.8	0.0	0.2	352.8	7.7	6.7	10.2	10.1
3	95.2	48.0	0.0	0.4	143.6	9.4	8.4	10.8	11.0
4	67.6	23.0	0.0	0.2	90.8	10.2	9.1	11.2	11.7
5	46.1	14.4	0.0	0.1	60.6	10.9	9.8	11.8	12.1
6	9.2	4.8	0.0	0.0	14.0	11.1	9.8	11.7	12.8
7	24.6	4.8	0.0	0.0	29.4	10.8	9.4	12.1	12.6
8	18.4	6.7	0.0	0.0	25.2	12.7	9.2	11.8	12.3
9	3.1	1.0		0.0	4.0	14.9	11.5		11.1
10	3.1			0.0	3.1	11.7			12.3
Sum	491.3	268.6	0.1	1.1	761.1				
SOP	4421.7	1974.6	0.8	12.1	6409.2				
Catch	4433.0	1619.7	0.8	12.2	6065.7				

Subdivision 28

	Numbers (milions)					Weight (g)			
Age	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
0			0.2	49.1	49.3			3.7	4.6
1	95.9	23.2	52.4	129.1	300.7	4.1	4.9	9.5	10.1
2	1722.8	357.1	138.6	416.9	2635.5	7.4	7.8	10.2	10.3
3	1762.4	344.1	206.0	623.8	2936.2	8.8	9.5	10.8	11.1
4	463.5	76.4	49.8	315.2	905.0	9.9	10.2	11.2	11.7
5	264.9	60.5	43.5	192.6	561.4	10.5	10.7	11.8	12.1
6	115.3	21.3	22.0	45.7	204.3	10.3	11.5	11.7	12.9
7	108.2	21.5	5.9	36.6	172.2	10.8	11.8	12.0	12.3
8	117.4	42.1	34.0	62.6	256.1	10.5	11.4	11.8	12.4
9	12.9	0.5		1.3	14.7	10.1	10.0		11.1
10				0.6	0.6				12.3
Sum	4663.2	946.8	552.4	1873.5	8035.9				
SOP	39739.7	8579.0	5937.1	20603.9	74859.7				
Catch	39833.1	8588.5	5942.8	20621.8	74986.2				

Subdivision 29

	Numbers (milions)					Weight (g)			
Age	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
0			2.8	114.4	117.2			3.0	4.9
1	89.0	6.2	4.6	62.5	162.3	3.4	3.2	8.0	8.9
2	173.6	9.0	18.5	242.3	443.3	6.5	6.3	9.1	10.1
3	150.7	9.4	12.0	162.0	334.0	8.4	8.4	9.9	10.8
4	56.5	1.9	6.5	69.8	134.7	9.5	8.9	11.2	11.4
5	36.8	1.6	5.5	27.9	71.9	9.7	9.5	10.7	11.7
6	18.7	0.7	8.3	20.3	47.9	9.6	9.8	11.3	12.2
7	22.3	2.0	3.7	11.3	39.3	9.8	9.9	12.2	12.6
8	29.7	1.4	10.2	23.7	64.9	9.7	10.0	10.9	11.8
9					0.0				

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
10					0.0				
Sum	577.1	32.2	72.0	734.2	1415.5				
SOP	4275.0	228.0	713.5	7105.1	12321.6				
Catch	4284.5	229.4	699.8	7095.0	12308.8				

Subdivision 30

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0				6.8	6.8				4.9
1	10.1	9.2	0.3	2.7	22.3	3.4	3.2	10.3	8.9
2	17.9	10.1	0.2	23.1	51.3	6.5	6.3	11.9	10.1
3	27.2	22.1	0.1	23.4	72.7	8.4	8.4	12.5	10.8
4	11.6	4.8	0.1	13.8	30.3	9.5	8.9	13.5	11.4
5	8.4	6.2	0.0	6.3	21.0	9.7	9.5	13.5	11.7
6	5.2	3.0	0.0	5.8	14.0	9.6	9.8	14.3	12.2
7	5.9	12.9	0.0	3.7	22.5	9.8	9.9	14.9	12.6
8	9.1	13.5	0.1	8.1	30.7	9.7	10.0	14.9	11.8
9					0.0				
10					0.0				
Sum	95.4	81.6	0.8	93.8	271.6				
SOP	766.9	671.0	9.3	988.4	2435.7				
Catch	768.2	672.0	9.3	987.0	2436.4				

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				

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
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			4.4	89.0	93.4			3.2	4.2
1	37.6	4.8	14.1	100.1	156.6	3.4	3.5	7.6	8.8
2	271.5	57.6	83.0	383.0	795.1	6.7	6.7	9.1	9.6
3	262.4	44.8	94.6	244.1	645.8	8.3	8.4	9.9	10.4
4	68.2	18.4	42.5	76.0	205.1	9.2	9.4	10.6	11.0
5	51.5	8.3	22.7	46.0	128.4	9.7	9.8	11.0	11.3
6	32.2	7.2	7.8	21.0	68.1	9.4	9.7	10.6	11.0
7	48.3	9.7	7.8	22.0	87.8	10.0	9.8	11.6	12.1
8	51.6	11.4	12.0	47.1	122.1	9.7	9.4	11.1	11.4
9					0.0				
10					0.0				
Sum	823.2	162.3	288.9	1028.2	2302.5				
SOP	6537.2	1306.0	2819.4	9858.5	20521.1				
Catch	6540.6	1306.3	2816.2	9852.2	20515.2				

Subdivision 22-32

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0			18.4	347.6	366.1			3.7	4.5
1	622.3	152.1	90.2	430.7	1295.2	4.4	4.9	9.1	9.8
2	5682.0	1668.3	287.6	1428.1	9066.0	8.0	7.8	10.0	10.3
3	6619.3	1710.7	387.4	1435.7	10153.2	9.6	9.2	10.9	11.1
4	2775.4	817.9	142.1	736.7	4472.1	10.9	10.0	11.7	12.0
5	1694.9	763.6	100.7	443.1	3002.4	11.5	10.6	12.0	12.3
6	721.3	249.0	47.9	137.3	1155.6	11.6	11.4	11.8	12.6
7	628.1	151.4	22.6	76.6	878.7	12.2	10.9	12.8	12.4
8	385.5	129.6	64.4	146.8	726.3	11.1	11.3	11.9	12.1
9	34.8	5.6	1.8	1.3	43.5	12.3	13.1	15.2	11.1
10	14.9	1.6		2.1	18.7	10.9	11.5		15.2
Sum	19178.5	5649.9	1163.1	5186.2	31177.6				
SOP	182246.1	51865.2	12487.1	55233.4	301831.8				
Catch	182195.2	51512.2	12476.8	55225.1	301409.3				

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

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]
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
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 2022 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	0.0	0	0	0
		3	0.3	0	0	0
		4	0.5	0	0	0
		Total	0.8	0	0	0
	Total	1	-	0	0	0
		2	0.0	0	0	0
		3	0.3	0	0	0
		4	0.5	0	0	0
		Total	0.8	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	0.2	0	0	0
		3				
		4				
		Total	0.2	0	0	0
	Finland	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Germany	1	449.9	2	377	93
		2	575.3	0	0	0
		3	0.0	0	0	0
		4	4.6	0	0	0
		Total	1 029.9	2	377	93
	Latvia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Lithuania	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Poland	1	147.1	0	0	0
		2	185.0	0	0	0
		3	154.2	0	0	0
		4	456.0	0	0	0
		Total	942.3	0	0	0
	Sweden	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Total	1	597.0	2	377	93
		2	760.5	0	0	0
		3	154.2	0	0	0
		4	460.6	0	0	0
		Total	1 972.3	2	377	93

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2022 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	5 897.9	16	1639	829
		2				
		3				
		4				
		Total	5 897.9	16	1639	829
	Estonia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Finland	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Germany	1	954.7	4	908	168
		2				
		3				
		4	59.5	1	167	34
		Total	1 014.2	5	1075	202
	Latvia	1	120.7	0	0	0
		2	260.9	0	0	0
		3				
		4				
		Total	381.5	0	0	0
	Lithuania	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Poland	1	18 537.8	8	1821	546
		2	10 907.9	3	453	61
		3	1 075.1	0	0	0
		4	3 625.5	1	217	54
		Total	34 146.3	12	2491	661
	Sweden	1	7 046.4	14	659	657
		2	1 166.0	5	300	250
		3	320.6	5	250	247
		4	278.9	0	0	0
		Total	8 812.0	24	1209	1154
	Total	1	32 557.5	42	5027	2200
		2	12 334.8	8	753	311
		3	1 395.7	5	250	247
		4	3 963.9	2	384	88
		Total	50 251.9	57	6414	2846

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2022 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	10 336.4	12	1194	603
		2				
		3	-	0	0	0
		4	129.7	0	0	0
		Total	10 466.2	12	1194	603
	Estonia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Finland	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Germany	1	8 646.8	5	1216	208
		2	616.8	1	249	42
		3				
		4				
		Total	9 263.6	6	1465	250
	Latvia	1	1 264.7	1	214	99
		2	390.3	0	0	0
		3	223.2	0	0	0
		4	380.4	0	0	0
		Total	2 258.6	1	214	99
	Lithuania	1	2 852.4	3	398	232
		2	1 322.5	2	399	133
		3				
		4	18.5	0	0	0
		Total	4 193.4	5	797	365
	Poland	1	27 114.5	18	3913	1084
		2	8 994.5	4	888	246
		3	1 006.4	0	0	0
		4	5 776.3	9	688	217
		Total	42 891.7	31	5489	1547
	Russia	1	21 392.0	0	0	0
		2	14 157.0	0	0	0
		3	228.0	0	0	0
		4	5 927.0	0	0	0
		Total	41 704.0	0	0	0
	Sweden	1	21 574.5	17	849	802
		2	520.0	4	200	200
		3				
		4				
		Total	22 094.5	21	1049	1002
	Total	1	93 181.4	56	7784	3028
		2	26 001.1	11	1736	621
		3	1 457.6	0	0	0
		4	12 231.9	9	688	217
		Total	132 872.0	76	10208	3866

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2022 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	673.8	0	0	0
		2				
		3				
		4				
		Total	673.8	0	0	0
	Estonia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Finland	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Germany	1	529.6	0	0	0
		2	4.3	0	0	0
		3				
		4				
		Total	533.9	0	0	0
	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	3 229.6	6	160	160
		2	1 615.4	8	293	280
		3	0.8	0	0	0
		4	12.2	0	0	0
		Total	4 858.0	14	453	440
	Total	1	4 433.0	6	160	160
		2	1 619.7	8	293	280
		3	0.8	0	0	0
		4	12.2	0	0	0
		Total	6 065.7	14	453	440

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2022 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	7 047.4	3	308	151
		2				
		3				
		4	1 395.1	1	92	50
		Total	8 442.5	4	400	201
	Estonia	1	2 390.7	21	2832	1633
		2				
		3	296.0	2	400	200
		4	2 807.7	11	1378	878
		Total	5 494.5	34	4610	2711
	Finland	1				
		2				
		3	456.0	0	0	0
		4	3 116.8	0	0	0
		Total	3 572.8	0	0	0
	Germany	1	2 391.3	2	491	82
		2	173.3	0	0	0
		3				
		4	329.4	0	0	0
		Total	2894.0	2	491	82
	Latvia	1	9 884.2	11	2321	1113
		2	5 782.7	9	1844	856
		3	4 734.0	6	1218	567
		4	8 312.1	4	806	390
		Total	28 713.0	30	6189	2926
	Lithuania	1	3 461.5	0	0	0
		2	1 164.5	0	0	0
		3	188.1	0	0	0
		4	1 649.8	1	284	70
		Total	6 463.9	1	284	70
	Poland	1	334.1	0	0	0
		2	831.7	0	0	0
		3	125.7	0	0	0
		4	480.6	0	0	0
		Total	1 772.1	0	0	0
	Russia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Sweden	1	14 324.0	14	700	700
		2	636.3	4	200	200
		3	142.9	0	0	0
		4	2 530.3	12	456	456
		Total	17 633.5	30	1356	1356
	Total	1	39 833.1	51	6652	3679
		2	8 588.5	13	2044	1056
		3	5 942.8	8	1618	767
		4	20 621.8	29	3016	1844
		Total	74 986.2	101	13330	7346

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2022 available to the Working Group. 6/8

Sub-division 29	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1				
		2				
		3				
		4	572.3	0	0	0
		Total	572.3	0	0	0
	Estonia	1	2905.0	4	876	350
		2	168.9	2	520	200
		3	75.8	2	400	200
		4	3530.1	7	1395	700
		Total	6679.8	15	3191	1450
	Finland	1	1135.6	10	1120	0
		2	0.4	4	38	0
		3	603.3	0	0	621
		4	2227.7	16	2360	0
		Total	3967.1	30	3518	621
	Germany	1				
		2				
		3				
		4	133.5	0	0	0
		Total	133.5	0	0	0
	Latvia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Lithuania	1	63.9	0	0	0
		2	60.1	0	0	0
		3	20.7	0	0	0
		4	564.3	0	0	0
		Total	709.1	0	0	0
	Poland	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Sweden	1	180.0	0	0	0
		2				
		3				
		4	67.0	3	150	149
		Total	247.0	3	150	149
	Total	1	4284.5	14	1996	350
		2	229.4	6	558	200
		3	699.8	2	400	821
		4	7095.0	26	3905	849
		Total	12308.8	48	6859	2220

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Sub-division for 2022 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	33.5	0	0	0
		2	97.4	0	0	0
		3				
		4				
		Total	130.9	0	0	0
	Finland	1	673.7	15	2068	0
		2	481.7	15	652	0
		3	9.3	4	354	1880
		4	985.8	9	411	0
		Total	2150.6	43	3485	1880
	Sweden	1	61.0	0	0	0
		2	92.8	0	0	0
		3				
		4	1.2	0	0	0
		Total	155.0	0	0	0
	Total	1	768.2	15	2068	0
		2	672.0	15	652	0
		3	9.3	4	354	1880
		4	987.0	9	411	0
		Total	2436.4	43	3485	1880

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 2022 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	5 095.0	11	3266	1100
		2	1 119.9	9	2660	900
		3	1 339.4	4	1037	400
		4	7 557.4	8	2136	800
		Total	15 111.7	32	9099	3200
	Finland	1	921.7	2	370	0
		2	0.1	4	37	0
		3	1 453.7	0	0	95
		4	1 420.2	4	740	0
		Total	3 795.8	10	1147	95
	Lithuania	1	258.8	0	0	0
		2	20.3	0	0	0
		3	23.1	0	0	0
		4	216.6	0	0	0
		Total	518.8	0	0	0
	Russia	1	265.0	0	0	0
		2	166.0	0	0	0
		3	-	0	0	0
		4	658.0	0	0	0
		Total	1 089.0	0	0	0
	Total	1	6 540.6	13	3636	1100
		2	1 306.3	13	2697	900
		3	2 816.2	4	1037	495
		4	9 852.2	12	2876	800
		Total	20 515.2	42	10246	3295
Sub-divisions 22-32	**Total**	**Quarter**	**Landings in tons**	**Number of samples**	**Number of fish measured**	**Number of fish aged**
		1	**182 195.2**	**199**	**27700**	**10610**
		2	**51 512.2**	**74**	**8733**	**3368**
		3	**12 476.8**	**23**	**3659**	**4210**
		4	**55 225.1**	**87**	**11280**	**3798**
		Total	**301 409.3**	**383**	**51372**	**21986**

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	1295232	9065967	10153185	4472122	3002395	1155567	878697	788424

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
1979	5.50	12.70	13.00	13.70	15.10	15.80	15.60	16.20

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
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
2008	6.83	9.15	9.83	10.51	10.34	10.23	11.16	12.19

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
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

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
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

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
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
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

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
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

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+
1974-2022	0.170	0.930	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+
1974-2022	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+
1974-2022	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

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

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
2021	1	111155
2022	1	12442

Table 7.16. Configuration file for sprat assessment with SAM.

```
#
$minAge
# The minimium 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 (nomally 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 (nomally 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 higest 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 2023 refer to spawning time and are estimated assuming F in 2023 the same as F in 2022, other F assumptions in 2023 may be used for short-term predictions).

summary(fit1)

	R(age1)	Low	High	SSB	Low	High	Fbar(3-5)	Low	High
1974	76036	51850	111504	1058866	780789	1435981	0.311	0.224	0.431
1975	23172	15927	33712	842638	620904	1143557	0.302	0.219	0.418
1976	148600	102082	216318	639077	470318	868391	0.299	0.214	0.416
1977	76165	52290	110941	924505	673158	1269702	0.288	0.205	0.403
1978	21470	14663	31436	695260	506314	954717	0.249	0.177	0.35
1979	60686	41369	89022	379087	274248	524002	0.225	0.16	0.316
1980	19907	13339	29710	281603	203671	389356	0.243	0.172	0.341
1981	108320	73200	160291	282460	205326	388571	0.189	0.134	0.268
1982	19802	13350	29373	346178	248340	482561	0.195	0.139	0.273
1983	125861	85271	185773	345553	251470	474834	0.127	0.09	0.179
1984	62754	43219	91118	558549	408670	763396	0.149	0.109	0.203
1985	33762	23468	48571	613036	460731	815689	0.161	0.12	0.217
1986	24377	16900	35164	548550	421552	713809	0.18	0.136	0.238
1987	45367	31781	64759	472561	368643	605772	0.227	0.173	0.299
1988	4627	3239	6610	466539	361624	601893	0.234	0.179	0.305
1989	90499	63991	127988	449517	355567	568293	0.24	0.186	0.309
1990	58045	41916	80380	747099	587007	950853	0.196	0.155	0.248
1991	64498	48481	85806	941255	767996	1153602	0.18	0.147	0.222
1992	86918	65526	115293	1005998	835410	1211418	0.202	0.166	0.246
1993	87111	63567	119375	1274757	1040313	1562033	0.219	0.179	0.267
1994	36621	27697	48420	1419210	1183002	1702582	0.273	0.227	0.328
1995	182003	132794	249446	1127016	946365	1342152	0.352	0.292	0.425
1996	165178	124979	218306	1622978	1341151	1964028	0.398	0.334	0.474

	R(age1)	Low	High	SSB	Low	High	Fbar(3-5)	Low	High
1997	31626	23413	42722	1731148	1431383	2093691	0.433	0.361	0.518
1998	163343	125390	212784	1169072	994799	1373876	0.472	0.399	0.558
1999	27691	21331	35947	1269998	1075192	1500098	0.433	0.367	0.511
2000	132494	102385	171457	1036823	889350	1208751	0.423	0.358	0.499
2001	41597	32626	53034	1039610	891756	1211978	0.424	0.361	0.498
2002	84985	66912	107938	900779	780414	1039709	0.419	0.357	0.492
2003	125933	98956	160265	847891	734807	978379	0.413	0.351	0.485
2004	259245	202693	331576	957173	820415	1116728	0.462	0.392	0.545
2005	32149	25299	40853	1337981	1118441	1600615	0.419	0.356	0.494
2006	116972	91371	149746	1046256	883237	1239363	0.369	0.312	0.438
2007	144407	113869	183135	926017	797901	1074704	0.443	0.377	0.522
2008	69170	54525	87748	1025209	877388	1197936	0.436	0.371	0.512
2009	203407	159601	259235	968966	834334	1125322	0.454	0.385	0.536
2010	47020	37031	59705	1042774	873214	1245259	0.4	0.336	0.475
2011	95396	74693	121838	867977	733927	1026511	0.324	0.272	0.387
2012	95726	74650	122753	867086	740913	1014746	0.311	0.26	0.372
2013	84482	66465	107383	895339	762161	1051788	0.353	0.296	0.421
2014	60061	47248	76349	775753	660584	911002	0.371	0.312	0.442
2015	241043	187246	310297	795903	679211	932644	0.341	0.285	0.408
2016	61370	47248	79711	1194339	980265	1455163	0.312	0.259	0.376
2017	71818	56190	91792	1197166	1002663	1429400	0.326	0.273	0.391
2018	97829	76388	125289	1018449	867674	1195422	0.354	0.297	0.423
2019	66306	51263	85762	917639	783321	1074990	0.405	0.339	0.484
2020	113258	88428	145060	892322	763308	1043141	0.373	0.311	0.448
2021	100704	77458	130926	1082149	911068	1285355	0.356	0.295	0.43
2022	25210	18181	34956	1127237	920393	1380565	0.358	0.287	0.447
2023	43773	21757	88067						

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	76036	63805	23086	9075	9189	4251	6545	1520
1975	23172	25623	38375	12161	4100	4967	1664	3581
1976	148600	8874	13819	17251	4712	1738	2889	2400
1977	76165	76608	5672	8516	8204	1737	806	2328
1978	21470	32498	37263	2769	4096	4397	582	1421
1979	60686	6925	8938	16165	1163	1161	2531	977
1980	19907	15399	2665	2912	8111	427	479	1636
1981	108320	9580	3921	776	745	3950	120	836
1982	19802	30073	3718	1564	396	404	1952	427
1983	125861	6524	8093	1203	508	131	183	1395
1984	62754	46030	4502	3931	576	294	75	750
1985	33762	28500	26537	3359	2017	230	149	495
1986	24377	18124	14876	15070	2068	1239	116	367
1987	45367	7138	11256	9881	9022	1105	820	379
1988	4627	30906	5183	6591	4036	4022	389	741
1989	90499	3568	13576	2305	3564	1820	1957	657
1990	58045	46022	3162	6695	1186	1881	723	1229
1991	64498	41133	24504	2853	3798	759	1014	1028
1992	86918	39475	24429	10443	2171	1754	569	836
1993	87111	72004	27074	13050	5164	1355	1093	1084
1994	36621	71785	48918	17335	9235	3204	759	910
1995	182003	22178	37371	25374	10667	5510	1783	1113
1996	165178	171582	21124	22515	10792	4519	1978	1099
1997	31626	131150	98627	17507	11477	5053	1857	837
1998	163343	23778	67569	56092	7584	4713	2955	1139
1999	27691	111837	20059	32558	27054	3562	2015	1471
2000	132494	16968	60118	9747	13818	12274	1766	1921
2001	41597	69555	11999	31270	5676	7297	6177	1454
2002	84985	29599	41412	11329	13887	3144	3009	3852

	1	2	3	4	5	6	7	8
2003	125933	40454	18442	17761	6828	6456	2331	4180
2004	259245	73431	19484	9512	8061	3506	3105	3535
2005	32149	171932	44869	9661	5053	2802	1930	2148
2006	116972	20547	95786	25372	4740	2164	1396	1881
2007	144407	59271	13603	42911	11846	1838	861	1549
2008	69170	77225	25852	8648	18326	6337	916	1199
2009	203407	45143	38344	11514	5524	9009	3203	1119
2010	47020	114848	21378	14009	4043	2694	3485	1640
2011	95396	25414	62333	11382	6074	2233	1477	2336
2012	95726	41650	14863	31206	5349	3001	1253	1937
2013	84482	56165	20274	8962	13393	2580	1253	1316
2014	60061	45898	27588	8938	4932	5101	1260	1311
2015	241043	32463	24350	12331	4306	2532	2216	1178
2016	61370	147522	21446	10829	4749	1844	1375	1591
2017	71818	48044	91663	12946	5390	2303	846	1361
2018	97829	42049	30168	47535	6426	2155	958	822
2019	66306	55743	23830	18591	23688	2588	934	835
2020	113258	37705	29140	13044	9409	11548	1059	770
2021	100704	79139	24892	17370	6913	5373	6111	992
2022	25210	65202	47469	15635	9362	3800	2987	3131
2023	43773	17340	41584	27685	8188	4711	1949	3207

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	0.246	0.337	0.350	0.328	0.280	0.280
1975	0.048	0.149	0.239	0.328	0.340	0.313	0.266	0.266
1976	0.047	0.150	0.236	0.322	0.338	0.311	0.266	0.266
1977	0.046	0.154	0.235	0.309	0.319	0.288	0.243	0.243
1978	0.042	0.142	0.208	0.266	0.273	0.241	0.203	0.203

	1	2	3	4	5	6	7	8
1979	0.038	0.133	0.190	0.239	0.246	0.222	0.193	0.193
1980	0.040	0.143	0.205	0.258	0.265	0.245	0.214	0.214
1981	0.034	0.119	0.163	0.200	0.205	0.192	0.170	0.170
1982	0.032	0.113	0.162	0.206	0.216	0.202	0.181	0.181
1983	0.021	0.070	0.102	0.134	0.145	0.141	0.134	0.134
1984	0.022	0.076	0.116	0.157	0.173	0.168	0.158	0.158
1985	0.023	0.079	0.124	0.171	0.189	0.183	0.171	0.171
1986	0.024	0.084	0.135	0.191	0.213	0.207	0.192	0.192
1987	0.026	0.095	0.164	0.240	0.277	0.274	0.258	0.258
1988	0.028	0.103	0.175	0.247	0.279	0.275	0.261	0.261
1989	0.029	0.107	0.180	0.251	0.287	0.287	0.280	0.280
1990	0.025	0.090	0.149	0.205	0.233	0.233	0.234	0.234
1991	0.023	0.084	0.138	0.189	0.215	0.215	0.223	0.223
1992	0.026	0.093	0.153	0.210	0.244	0.249	0.267	0.267
1993	0.029	0.102	0.166	0.226	0.265	0.279	0.308	0.308
1994	0.038	0.129	0.208	0.283	0.327	0.340	0.369	0.369
1995	0.047	0.156	0.257	0.366	0.434	0.462	0.510	0.510
1996	0.060	0.190	0.302	0.417	0.475	0.494	0.548	0.548
1997	0.070	0.212	0.335	0.458	0.506	0.513	0.569	0.569
1998	0.082	0.233	0.368	0.496	0.551	0.571	0.648	0.648
1999	0.088	0.233	0.354	0.455	0.491	0.496	0.551	0.551
2000	0.091	0.230	0.343	0.441	0.485	0.495	0.555	0.555
2001	0.091	0.227	0.338	0.440	0.493	0.497	0.542	0.542
2002	0.097	0.234	0.345	0.437	0.475	0.460	0.486	0.486
2003	0.097	0.228	0.337	0.427	0.474	0.454	0.477	0.477
2004	0.110	0.250	0.371	0.476	0.539	0.518	0.534	0.534
2005	0.110	0.239	0.344	0.434	0.481	0.458	0.463	0.463
2006	0.105	0.221	0.308	0.384	0.416	0.403	0.406	0.406
2007	0.125	0.267	0.371	0.465	0.493	0.488	0.486	0.486

	1	2	3	4	5	6	7	8
2008	0.125	0.267	0.368	0.461	0.478	0.473	0.462	0.462
2009	0.134	0.283	0.387	0.482	0.493	0.484	0.469	0.469
2010	0.121	0.253	0.341	0.423	0.434	0.428	0.415	0.415
2011	0.102	0.213	0.280	0.342	0.351	0.344	0.335	0.335
2012	0.088	0.192	0.262	0.327	0.345	0.338	0.329	0.329
2013	0.097	0.217	0.297	0.371	0.391	0.374	0.358	0.358
2014	0.098	0.222	0.309	0.390	0.416	0.399	0.386	0.386
2015	0.083	0.193	0.275	0.358	0.390	0.378	0.368	0.368
2016	0.068	0.163	0.239	0.326	0.371	0.375	0.376	0.376
2017	0.068	0.168	0.247	0.342	0.390	0.394	0.389	0.389
2018	0.078	0.193	0.279	0.374	0.410	0.400	0.383	0.383
2019	0.091	0.226	0.323	0.430	0.463	0.447	0.425	0.425
2020	0.074	0.192	0.287	0.396	0.436	0.429	0.415	0.415
2021	0.065	0.175	0.269	0.378	0.421	0.413	0.395	0.395
2022	0.064	0.174	0.270	0.381	0.424	0.410	0.384	0.384

Table 7.20. Sprat in SD 22–32. Input data for short-term prediction. Recruitment in 2024 and 2025 are resampled from SAM estimated recruitment in 1991-2022.

2023

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	43773.0	0.314	0.17	0.4	0.4	5.9	0.0677	5.9
2	17420.6	0.276	0.93	0.4	0.4	8.6	0.1800	8.6
3	41660.8	0.270	1	0.4	0.4	9.8	0.2753	9.8
4	27709.8	0.267	1	0.4	0.4	10.6	0.3850	10.6
5	8191.1	0.264	1	0.4	0.4	11.1	0.4273	11.1
6	4711.8	0.261	1	0.4	0.4	11.5	0.4173	11.5
7	1949.0	0.261	1	0.4	0.4	11.8	0.3980	11.8
8	1566.0	0.261	1	0.4	0.4	11.8	0.3980	11.8

Table 7.21. Sprat in SD 22–32. Output from short-term prediction for TAC constrained fishery in 2023 for range of F values

	Fmsy	FF=	0.34									
	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high
2023	**0.354**	0.249	0.511	44341	21437	90063	**903773**	669735	1261572	**269202**	186823	390668
2024	**0.34**	0.239	0.49	86918	25210	241043	**808959**	552670	1207410	**241604**	166212	355754
2025	**0.34**	0.239	0.49	86918	25210	259245	**941534**	553840	1916895	**253127**	161789	452154
2026	**0.34**	0.239	0.49	86918	25210	241043	**1125421**	556038	2202227	**287402**	160189	547717

	Fmsy-low	FF=	0.26									
	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high
2023	**0.354**	0.249	0.511	44341	21437	90063	**903773**	669735	1261572	**269202**	186823	390668
2024	**0.26**	0.183	0.375	86918	25210	241043	**831149**	566749	1231771	**191075**	131211	282206
2025	**0.26**	0.183	0.375	86918	25210	259245	**1010476**	599770	2014265	**209494**	133967	365956
2026	**0.26**	0.183	0.375	86918	25210	241043	**1218838**	622566	2361970	**244259**	137551	460647

	Fmsy-up=Fp05	FF=	0.35									
	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high
2023	**0.354**	0.249	0.511	44341	21437	90063	**903773**	669735	1261572	**269202**	186823	390668
2024	**0.35**	0.246	0.504	86918	25210	241043	**806225**	550978	1204406	**247704**	170360	364584
2025	**0.35**	0.246	0.504	86918	25210	259245	**934567**	548854	1905215	**258067**	164409	462204
2026	**0.35**	0.246	0.504	86918	25210	241043	**1113197**	548588	2180657	**292632**	162609	557166

		FF=	0									
	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high
2023	**0.354**	0.249	0.511	44341	21437	90063	**903773**	669735	1261572	**269202**	186823	390668
2024	**0**	0	0	86918	25210	241043	**908746**	620107	1328043	**0**	0	0

		FF=	0									
	fbar: median	**fbar:low**	**fbar:high**	**rec:median**	**rec:low**	**rec:high**	**ssb:median**	**ssb:low**	**ssb:high**	**catch: median**	**catch:low**	**catch:high**
2025	**0**	0	0	86918	25210	259245	**1262057**	776312	2367168	**0**	0	0
2026	**0**	0	0	86918	25210	241043	**1636103**	922925	3028823	**0**	0	0

		FF=	0.49									
	fbar: median	**fbar:low**	**fbar:high**	**rec:median**	**rec:low**	**rec:high**	**ssb: median**	**ssb:low**	**ssb:high**	**catch:median**	**catch:low**	**catch:high**
2023	**0.354**	0.249	0.511	44341	21437	90063	**903773**	669735	1261572	**269202**	186823	390668
2024	**0.49**	0.344	0.706	86918	25210	241043	**770944**	520892	1160416	**328510**	227617	479630
2025	**0.49**	0.344	0.706	86918	25210	259245	**842300**	476228	1760092	**319311**	201178	581813
2026	**0.49**	0.344	0.706	86918	25210	241043	**972698**	460255	1941379	**348158**	188359	665149

	Flim	FF=	0.58									
	fbar: median	fbar:low	fbar: high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch: median	catch:low	catch:high
2023	0.354	0.249	0.511	44341	21437	90063	903773	669735	1261572	269202	186823	390668
2024	0.58	0.407	0.836	86918	25210	241043	751215	502741	1132668	374838	261896	546718
2025	0.58	0.407	0.836	86918	25210	259245	789146	437582	1680768	349093	218600	640022
2026	0.58	0.407	0.836	86918	25210	241043	897464	419271	1809585	373886	199487	719712

	F23	**FF=**	**0.354**									
	fbar: median	**fbar:low**	**fbar:high**	**rec:median**	**rec:low**	**rec:high**	**ssb:median**	**ssb:low**	**ssb:high**	**catch: median**	**catch:low**	**catch: high**
2023	**0.354**	0.249	0.511	44341	21437	90063	**903773**	669735	1261572	**269202**	186823	390668
2024	**0.354**	0.249	0.51	86918	25210	241043	**805115**	550067	1203208	**250130**	172098	368093
2025	**0.354**	0.249	0.51	86918	25210	259245	**931804**	546875	1900553	**259921**	165433	465947
2026	**0.354**	0.249	0.51	86918	25210	241043	**1108227**	545649	2174632	**294499**	163777	560736

Table 7.22. Ratio of SAM estimates (2023 assessment) to XSA estimates (2022 assessment) of stock numbers by age and year

	2018	2019	2020	2021	2022	2023
1	1.33	1.28	1.13	1.05	0.57	NA
2	1.09	1.16	1.16	1.16	0.97	NA
3	0.90	1.02	1.07	1.26	1.11	NA
4	1.02	0.95	1.02	1.13	1.46	NA
5	1.22	0.98	0.95	1.06	1.23	NA
6	0.96	1.09	0.97	1.03	1.19	NA
7	0.81	0.79	0.93	0.99	1.16	NA
8	0.87	0.88	1.00	1.04	0.86	NA

(light shading)	5-10% difference
(medium shading)	10-15% diffrence
(dark shading)	>15% difference

Table 7.23. Forecast assumptions.

	Year*	Current assessment (2023)	Previous assessment (2022)
assumed	2022	25210	44213
recruitment	2023	44341	87472
catch	2022	301.4	295.3
F	2022	0.358	0.361
Target F for TAC	2023	0.354	0.34

*’2022’ = Intermediate year in the previous assessment;

*‘2023’ = advice year in the previous assessment

8 Turbot, dab, and brill in the Baltic Sea

8.1 Turbot

8.1.1 Fishery

8.1.1.1 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 1210 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 8.1.1, 8.1.2, Figure 8.1.1). 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 360 t from 1999 to 2003. Swedish landings are taken mainly from a gillnet fishery that reached a maximum of 250 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 140 tonnes of turbot from subdivisions 22 and 24. Poland, Russia and Sweden are the main fishing countries in the Eastern Baltic and landed about 65 tonnes from subdivisions 25–28. Total landings in 2022 were about 134 tonnes.

Due to the low stock level, the fishery targeting turbot was totally closed for some years in the EEZ of Latvia and restrictions were implemented in Lithuania from 1 to 30 July according to international regulations.

8.1.1.2 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 2022. 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 were exceptionally low in 2022 (Figure 8.1.2a) however. Discards in 2020 and 2021 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. However, 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.

Table 8.1.1. 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

8.1.2 Biological composition of the catch

Available age data were compared during the WKFLABA (2012) meeting. Results using sliced otoliths were remarkably better than using whole otoliths. These two ageing methods showed significantly different results. Applying the new method (i.e. slicing), the fishing mortality estimate declined by a factor of about two. WKFLABA did not make suggestions on age reading for turbot stocks in the Baltic Sea. Genetic information did not show any stock structure while tagging data indicated the existence of small local stocks. Further investigations, especially in the Eastern part of Baltic Sea, are recommended.

Given its status as a category 3 stock, only numbers-at-length and weight-at-length from the commercial fisheries and a combined survey biomass index are used for stock status evaluation. Additional life history parameters and indices are generated from Survey data.

8.1.3 Fishery independent information

A recommendation of the 2021 ADG suggested to investigate the option to change the index of turbot from a CPUE index (in numbers/hours) to a biomass index (in kg/hour). Different growth parameter were calculated from BITS data (CA, 2002-2021, three options: all quarter and sexes combined, only quarter 4 and only females) and commercial data (CS, 2015-2021, all quarter, catch categories and fleets combined) using von Bertalanffy growth function. The differences between growth parameter of the different data sets were negligible and therefore the largest dataset (BITS, 200-2021, all quarter and sexes combined) was used:

a: 0.001603 b: 3.06338

No differences in the general trend between the two indices was detected and WGBFAS decided to change the index to a biomass index.

were estimated as mean catch-in-number per hour for turbot with a length of ≥ 20 cm and multiplied with the respective average length class weight.. The CPUE values of the small BITS trawl

(TVS) were multiplied with a conversion factor of 1.4 (Figure 8.1.3). Stable indices with low fluctuations were observed for the time period since 2001. The index of 2022 remained stable compared to the previous year. The length distribution indicates a higher number of turbot (around 20% larger than in previous years) entering the index in 2023, as it only considers turbot larger 20 cm TL. A similar signal of incoming smaller turbot was also seen in the commercial fisheries data 2021 where discards of turbot <25 cm increased to over 60%. This signal continued in 2022, but was hampered by very poor sampling of the commercial fishing fleets.

8.1.3.1 Catch in numbers

The catch in numbers per length for the three most recent years is given in Figure 8.1.4. Almost no turbot above 35 cm are caught. High numbers of smaller turbot <25 cm were caught. Poor sampling coverage hampered the analysis of the length distribution and is covering signals of incoming cohorts.

8.1.4 Assessment

An update advice was last given in 2021. However, only landings and trends in the survey were used to estimate stock status for the advice. The report is giving an update on the stock status and the proxy reference points. The stock status is based on the data-limited approach of ICES. Exploitation is below with F_{MSY} proxy ($L_{F=M}$) and optimal yield in 2022 due to the high amount of small turbot in the commercial CANUM and WECA data. MSY $B_{trigger}$ is unknown. The length-based indicator are stating an unsustainable stock status (Figure 8.1.5). This is however un uncertain result, as the length distribution gained from the poor sampling might not reflect the actual length distribution of the stock

8.1.5 Reference points

The stock status was evaluated by calculating length-based indicators applying the LBI method developed by WKLIFE V (2015) (Table 8.1.2). CANUM and WECA of commercial catches from 2014–2022 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

- L_{inf}: average of 2002–2018, both quarters, only females→ Linf = 54.7 cm
- Lmat: average of 2002–2018, quarter 1, only females → L_{mat} = 20.5 cm

The results of LBI (Figure 8.1.5) show that the stock status of tur.27.22–32 is below possible reference points (Table 8.1.4). Some truncation in the length distribution in the catches might take place. Mega spawners seem to be lacking, as P_{mega} is much smaller than 30% of the catch. It did increase though, after being at the lowest level (<1%) for the previous two years, which is likely caused by the large amount of small turbot influencing the ratio. An overfishing of immatures (L_c/L_{mat}) is also indicated as the small turbot are entering into the fishery as discards. Catch is close to the theoretical length of L_{opt} and L_{mean} is stable over time and close to 1, indicating fishing close to the optimal yield/exploitation consistent with F_{MSY} proxy ($L_{F=M}$), but underperfomed in the previous two years. This might be an artifact of the high amount of small turbot, as the amount of larger individuals did not decrease significantly.

Table 8.1.2. Turbot in the Baltic Sea. Total landings (tonnes) by ICES Subdivision and country.

Year/SD	Denmark					Germ. Dem. Rep.[1]		Germany, 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	<0.5			20	32	2		245	65		5	2	15		7	21	2	8	18	50								
2003	48		28	5	<0.5			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	<0.5			22	34	<0.5		83	8		0	5	5		2	15	<0.5	1	12	24								
2008	79	5	33	6				24	30	<0.5		95	15		1	7	11		8	17			10	14								
2009	111	6	35	7	<0.5			33	50	1		92	11		1	6	10	<0.5	5	6	<0.5	<0.5	11	8								
2010	102	6	31	4	<0.5			24	35	<0.5		38	1		1	4	16	<0.5	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	<0.5			23	40	<0.5	0	61	12	0	1	6	16	<0.5	1	3	5	4	13	20	16	0	0	0	0	0	<0.5	<0.5
2014	84	5	27	1	0			35	30	0	0	25	5	0	1	3	13	<0.5	2	4	2	5	7	6	<0.5		<0.5	0	0	0	<0.5	
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	<0.5			25	23	1	0	43	13	0	2	5	9	<0.5	1	1	1	5	7	6	<0.5	0	0	0	0	0	<0.5	<0.5
2017	76	5	18	3	<0.5			41	33	<0.5	0	55	8	0	1	2	4	<0.5	1	1	<0.5	1	7	7	<0.5	0	<0.5	0	0	0	<0.5	<0.5
2018	103	9	41	3	0			37	55	<0.5	0	72	4	<0.5	1	14	11	0	1	2	1	5	<0.5	7	0	0	<0.5	0	0	<0.5	<0.5	<0.5
2019	53	2	25	1	0			20	26	<0.5	0	50	5	<0.5	1	3	2	0	1	2	1	4	5	1	0	0	<0.5	0	0	<0.5	0	0
2020	57	3	26	0	0			28	19	<0.5	0	42	3	0	<0.5	3	5	0	2	2	<0.5	2	2	<0.5	0	0	0	0	0	0	<0.5	<0.5
2021	49	6	17	1	0			33	10	<0.5	0	66	5	0	1	6	4	0	2	3	<0.5	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		1	3	1	0	0	0	0	0	<0.5	<0.5	<0.5

***Russian landings are estimates from **(insert website here)**

Table 8.1.1. 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	<0.5	313
2014	110	3	55	69	19	0	6	0	262
2015	59	3	43	56	45	0	5	0	211
2016	88	5	83	77	50	1	7	<0.5	313
2017	119	5	60	39	19	2	9	0	253
2018	141	5	45	87	13	1	7	0	299
2019	73	3	69	38	11	1	6	<0.5	201
2020	86	4	62	34	5	2	5	<0.5	197
2021	83	7	54	49	10	2	5	<0.5	209
2022	58	4	28	30	7	2	5	<0.5	133

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 8.1.3. Turbot in the Baltic Sea. Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

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 Lopt + 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	$L_{opt} = \frac{3}{3+ M/k} \times L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{maxy}	Length class with maximum biomass in catch	$L_{opt} = \frac{3}{3+ M/k} \times L_{inf}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals > Lc	LF=M = (0.75Lc+0.25Linf)	L_{mean} / LF=M	≥ 1	MSY

Table 8.1.4. Turbot in the Baltic Sea Indicator status for the most recent three years 220-2022.

	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} / $L_{F = M}$**
2020	1.10	1.15	0.82	0.05	0.86	0.94
2021	1.15	1.20	0.81	0.04	0.90	0.95
2022	0.90	1.05	0.98	0.14	0.89	1.08

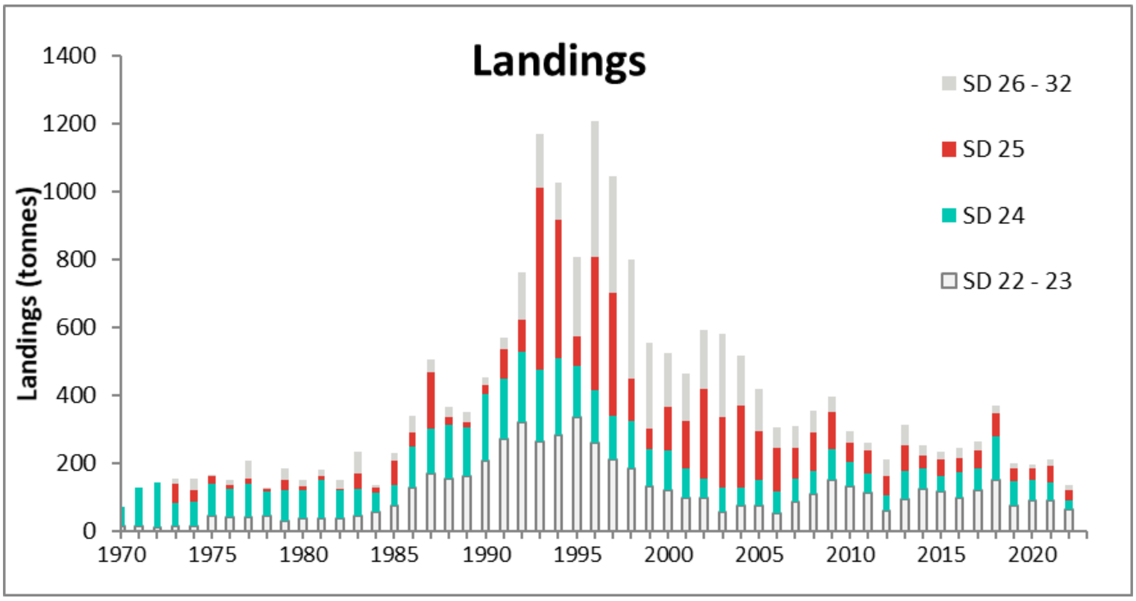


Figure 8.1.1. Turbot in the Baltic Sea. Development of turbot landings [t] from 1970 onwards by ICES subdivision (SD).

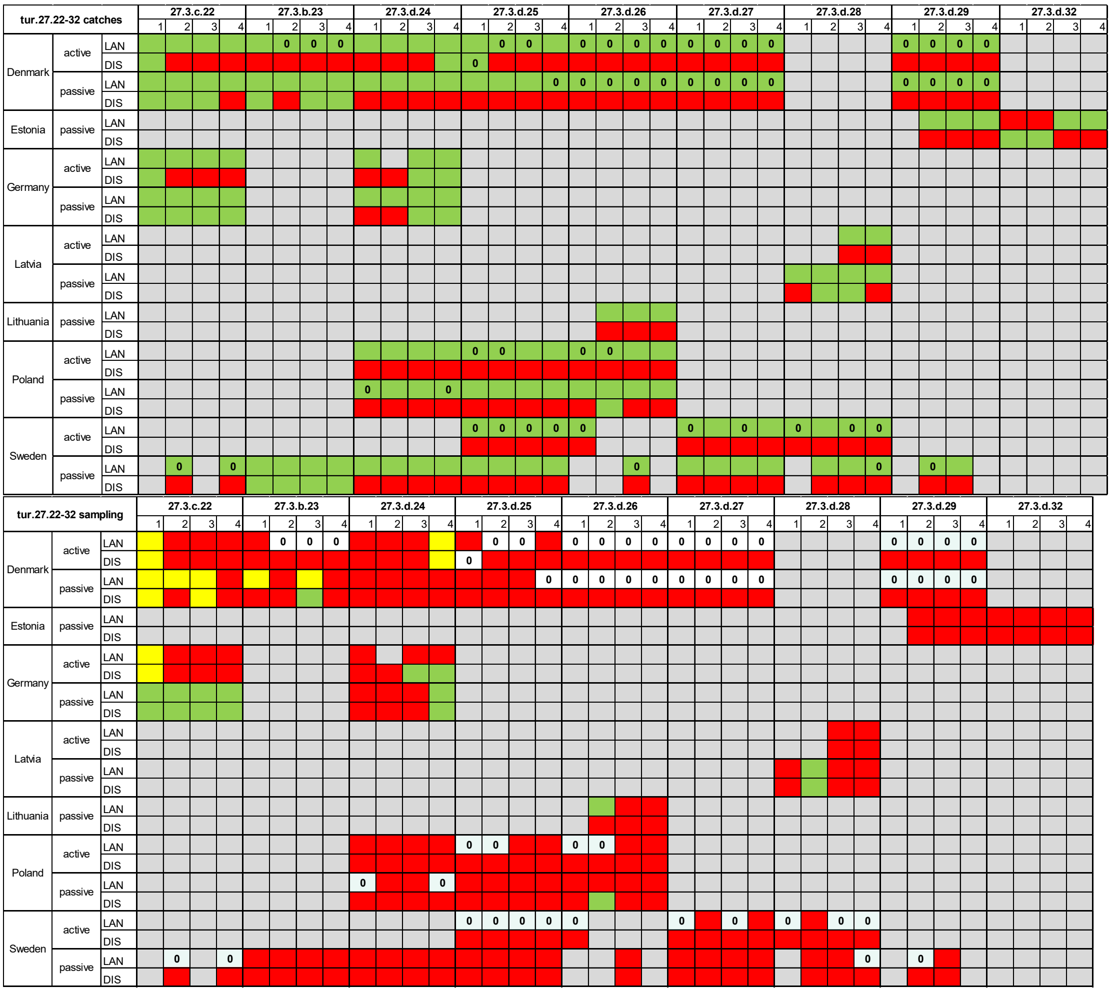


Figure 8.1.2. Sampling coverage and quality of tur.27.22-32.

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)

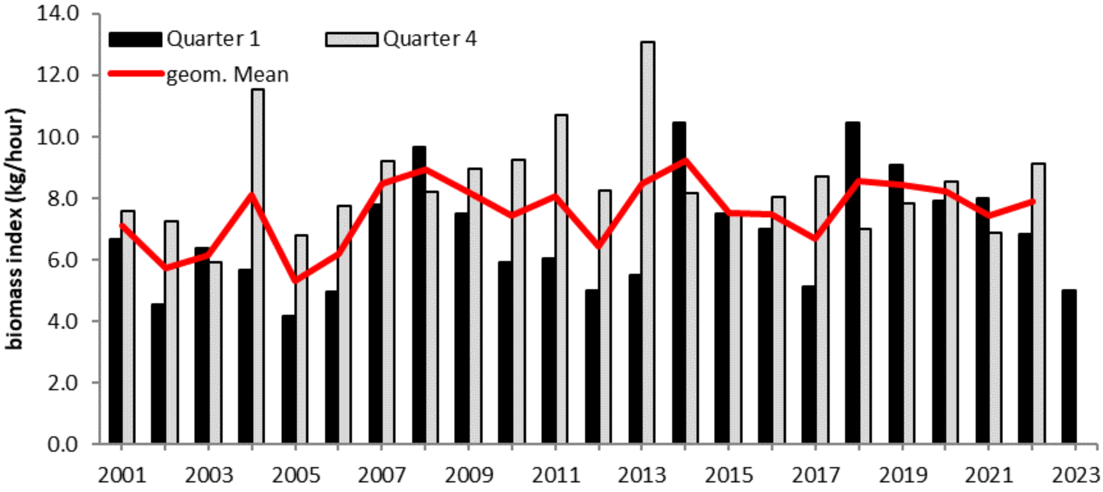


Figure 8.1.3. Turbot in the Baltic Sea. Mean CPUE (biomass index, kg/hr.) of turbot with L ≥ 20 cm based on geometric mean of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–28.

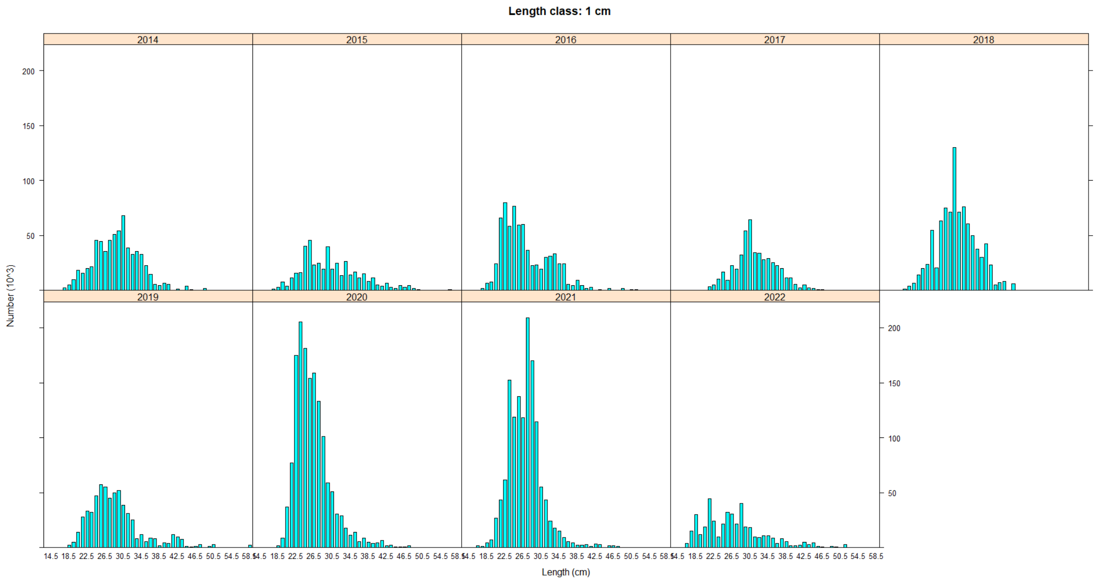


Figure 8.1.4. Turbot in subdivisions 22 to 32. Binned length frequency distributions.

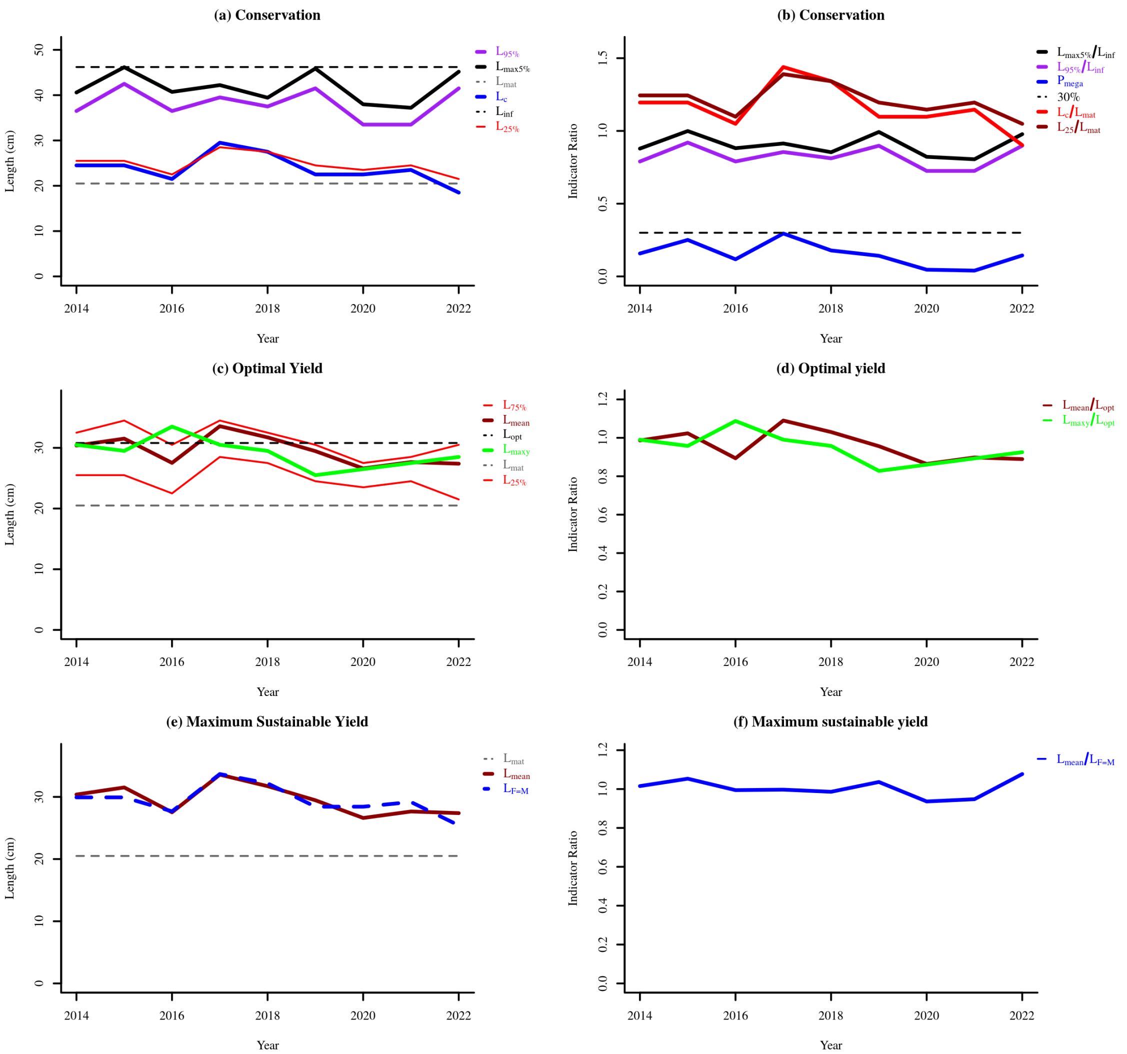


Figure 8.1.5. Turbot in subdivisions 22 to 32. Indicator trends

8.2 Dab

8.2.1 Fishery

8.2.1.1 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 8.2.1). 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 2022, landings decreased to below 256 t, the lowest amount since the beginning of the recording in 1970.

The largest amount of dab landings is reported by Denmark (subdivisions 22 and 24) and Germany (mainly in Subdivision 22, Figure 8.2.1). 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.

8.2.1.2 Discard

Estimates of discards are available from Denmark and Germany since 2012 (Figure 8.2.2a), covering the main fishing areas in SD 22 and Sd 24. Occasional samples and discard estimates are taken from SD 23 and SD 25.

The data illustrate the high variability of the relation between landings and discards and support the conclusion of the benchmark workshop (WKBALFLAT 2014) that the application of the relation between landings and discards of one year in another year results in uncertain estimates.

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

8.2.2 Biological composition of the catch

Age samples were collected from 2008 onwards by Germany and Denmark during the Baltic International Trawl Survey (BITS) and commercial fishery. Age data were not available for 2000–2007. The length distributions reported for this period were transferred into age distributions by slicing of the length distributions. Two slicing methods were applied. To assess the quality of the slicing methods, data of SD 22 from 2008 to 2012 were used. The length frequencies were sliced by both available methods and the estimated age frequencies were compared with the age frequencies estimated with the standard method described in the BITS manual. Unfortunately, estimated age frequencies based on age data and slicing methods were significantly different.

It was agreed during the benchmark that a data-limited approach based on landings and indices of BITS will also be used in the next years because the estimation of discards is uncertain and agreement was not possible concerning the method of slicing applied for dab.

It was further agreed during benchmark that the mean weight of dab ≥15 cm captured per hour in units of TVL is used instead of the CPUE in number. The limit of 15 cm was chosen because more than 50% of dab >14 cm of both sexes were maturing during quarter 1, however with large fluctuations between years. The geometric mean of the new indices of quarter 1 and quarter 4 was used as proxy of the development of the SSB.

8.2.2.1 Catch in numbers

The catch in numbers per length for the three most recent years is given in Figure 8.2.3. Almost no dab above 35 cm were caught. Sampling coverage of the fishing activities is good, covering most of the important fishing areas (Figure 8.2.2.b)

8.2.2.2 Fishery independent information

The stock indices, mean weight of dab ≥15 cm captured per hour in units of TVL, were calculated based on the mean catch in number per hour in units of TVL and the mean weight-length relation (Figure 8.2.3). The CPUE values of the small TV were multiplied with a conversion factor of 1.4. Estimates of quarter 1 and quarter 4 BITS were combined by geometric mean.

8.2.3 Assessment

Advice on dab is given every four years. ICES is not requested to provide catch advice, instead, a stock status update is given (last time in 2021), which is based on the data-limited approach of ICES. In 2018 the advice based on landings has been changed to advice based on catches; and the estimated discards have been included.

A stock size indicator and additional proxy reference points evaluate the stock status. The stock size is estimated by a biomass survey index using the BITS Q1 and Q4 surveys. The mean biomass index of 2021 and 2022 has increased by about 30% compared to the previous years' index values (Figure 8.2.4). The length-based indicators (proxy reference points) are stating a good status of the stock. The latest index value (BITS 2022, Q4) is exceptionally high and preliminary index values of the 2023 Q1 BITS are also 50% higher than in previous years, potentially marking a large year class

Reference points

The stock status was evaluated by calculating length-based indicators applying the LBI method developed by WKLIFE V (2015) (Table 8.2.2). CANUM and WECA of commercial catches from 2014–2022 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

- Linf: average of 2002–2018, both quarter and sexes → Linf = 35.61 cm
- L_{mat}: average of 2002–2018, quarter 1 only, females only → L_{mat} = 18 cm

The results of LBI (Figure 8.2.4) show that stock status of dab.27.22-32 is slightly above possible reference points (Table 8.2.3). Some truncation in the length distribution in the catches might take place. P_{mega} is lower than 30% of the catch, indicating the lack of large individuals. In the most recent year, an overfishing on immatures is indicated (L_c/L_{mat}<1) but on a lower level than in previous years. Catch is close to the theoretical length of L_{opt} and L_{mean} is stable over time and the ratio $L_{mean}/L_{F=M}$ is close to 1, indicating fishing close to the optimal yield. Exploitation is consistent with F_{MSY} proxy ($L_{F=M}$) and is used as proxy reference point to evaluate the stock status.

8.2.4 Catch advice based on the harvest control rule

WKLIFE VIII developed a harvest control rule to provide MSY advice for category 3 and 4 stocks based on the "2-over-3 rule", which compares the trend in stock index of the two most recent years to the preceding three years (WKMSYcat34; ICES, 2017a). The recommended harvest rule improves on 2-over-3 with the addition of multipliers based on the stock's life history characteristics, the status of the stock in terms of relative biomass, and the status of the stock relative to a target reference length (Section 3, WKLIFE VIII; ICES, 2018). The catch rule is defined as:

$$C_{y+1} = m \times C_y \times r \times f \times b$$

where the catch (C) for next year y+1 is based on the current year's catch C_y adjusted by three additional components (Table 3.2.6), which are defined by the length-distribution of the catch, a relative index factor and a multiplier, using the van Bertalanffy growth ration k.

Table 3.2.6.: Definition and use of the LBI-based harvest control rule for category 3 and 4 stocks

	Definition and use
r	The rate of change in the index, based on the average of the two most recent years of data (y−2 to y−1) relative to the average of the three years prior to the most recent two (y−3 to y−5), and termed the "2-over-3" rule.
f	The ratio of the mean length in the observed catch that is above the length of first capture relative to the target reference length (mean length/target reference length).
b	Adjustment to reduce catch when the most recent index data I_{y-1} is less than 1.4 × $I_{trigger}$ such that *b* is set equal to I_{y-1}/(1.4 × $I_{trigger}$). When the most recent index data I_{y-1} is greater than 1.4 × $I_{trigger}$, *b* is set equal to 1. $I_{trigger}$ is generally defined as the lowest observed index value for that stock.
m	Multiplier applied to the harvest control rule to maintain the probability of the biomass declining below B_{lim} to less than 5%. May range from 0 to 1.0.
Stability clause	Limits the amount the advised catch can change upwards or downwards between years. The recommended values are +20% and −30%, i.e. the catch would be limited to a 20% increase or a 30% decrease relative to the previous year's catch.

Dab advice will be given in 2022 and not include the new rfb rule. However, the new method of calculation was already exploratory conducted on the data of 2022.

C_y = **389**t (total catch), 256t (total landings)

r = **1.30** (last 2-y index of *146.49* kg/h vs. last 3-y index of *113.21 kg/h*)

f = **1.1344** (avg L_{CAT} = *26.59cm* $L_{F=M}$ = *19.78cm*) #please note, that $L_{F=M}$ has not been defined but is calculated each year by the LBI (alternatively, L_{opt} might be applicable as well.

b = **1** ($I_{trigger}$ = 0.23 I_{y-1} = 2.4 → I_{y-1} > 1.4x$I_{trigger}$)

m = **0.9** (v.B. growth rate k = 0.291)

Using these values, the avised catch would be $Advice_{catch}$ = **612 tonnes total catch**, if applying the „*Stability clause*" (max -30% decrease) the advised catch for 2022 would be **428 tonnes**. Applying the current „2-over-3 rule" of the previous advice, the advised total catch woul have been at 467 tonnes total catch.

8.2.5 Data Quality

To improve the stock status analysis 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 stock definition needs further validation. Distributional maps from the BITS Survey suggest that the Baltic Sea dab is part of the larger stock of the Kattegat, ranging southwards into the western Baltic. More information about spatio-temporal distribution, spawning grounds and ideally genetic stock information should be gained before a benchmark.

Table 8.2.1. 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		
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

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 8.2.2. Dab in subdivisions 22 to 32. Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

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	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{maxy}	Length class with maximum biomass in catch	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals > Lc	LF=M = ($0.75L_c+0.25L_{inf}$)	L_{mean} / LF=M	≥ 1	MSY

Table 8.2.3. Dab in subdivisions 22 to 32. Indicator status for the most recent three years. Indicator values above the expected value (i.e., signalling a good stock status) are given in green; values below the expected value are given in red.

	Conservation				Optimizing Yield	MSY
Year	L_c / L_{mat}	$L_{25\%}$ / L_{mat}	L_{max5} / L_{inf}	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
2020	1.03	1.14	0.89	0.25	1.02	1.06
2021	1.08	1.08	0.87	0.23	1.02	1.03
2022	1.19	1.14	0.90	0.28	1.07	1.02

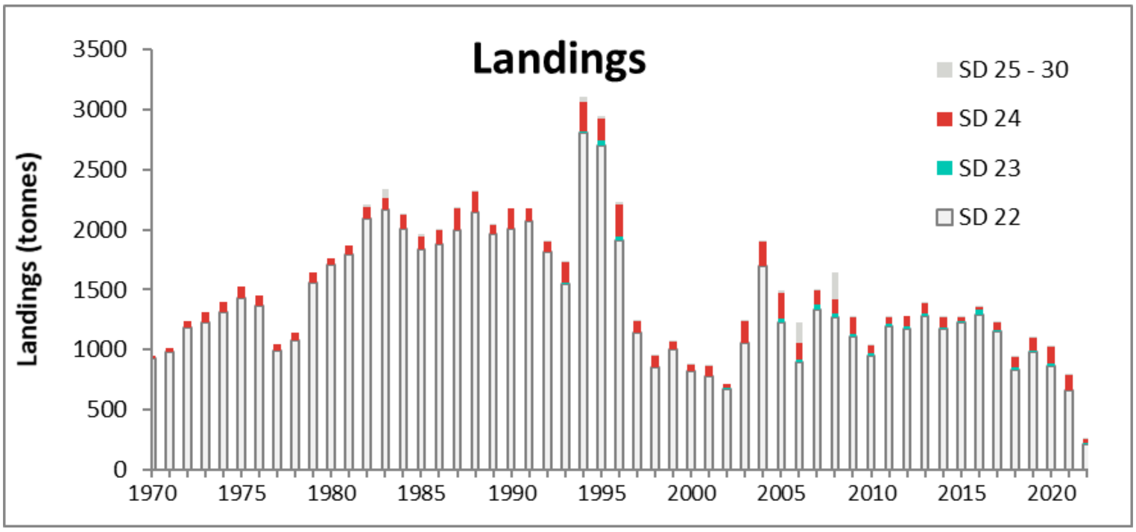


Figure 8.2.1. Dab in subdivisions 22 to 32. Development of dab landings [t] from 1970 onwards by ICES subdivision (SD).

dab.27.22-32 catches			27.3.c.22				27.3.b.23				27.3.d.24				27.3.d.25			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Denmark	active	LAN																
		DIS													0			
	passive	LAN																
		DIS																
Germany	active	LAN																
		DIS																
	passive	LAN																
		DIS																
Sweden	active	LAN													0	0	0	0
		DIS																
	passive	LAN		0		0				0			0	0	0	0		0
		DIS																

dab.27.22-32 sampling			27.3.c.22				27.3.b.23				27.3.d.24				27.3.d.25			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Denmark	active	LAN																
		DIS													0			
	passive	LAN																
		DIS																
Germany	active	LAN																
		DIS																
	passive	LAN																
		DIS																
Sweden	active	LAN													0	0	0	0
		DIS																
	passive	LAN		0		0				0			0	0	0	0		0
		DIS																

Figure 8.2.2. Sampling coverage and quality of dab.27.22-32.
8.2.2.a: Upper plot: provided official landings and discard estimates (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)

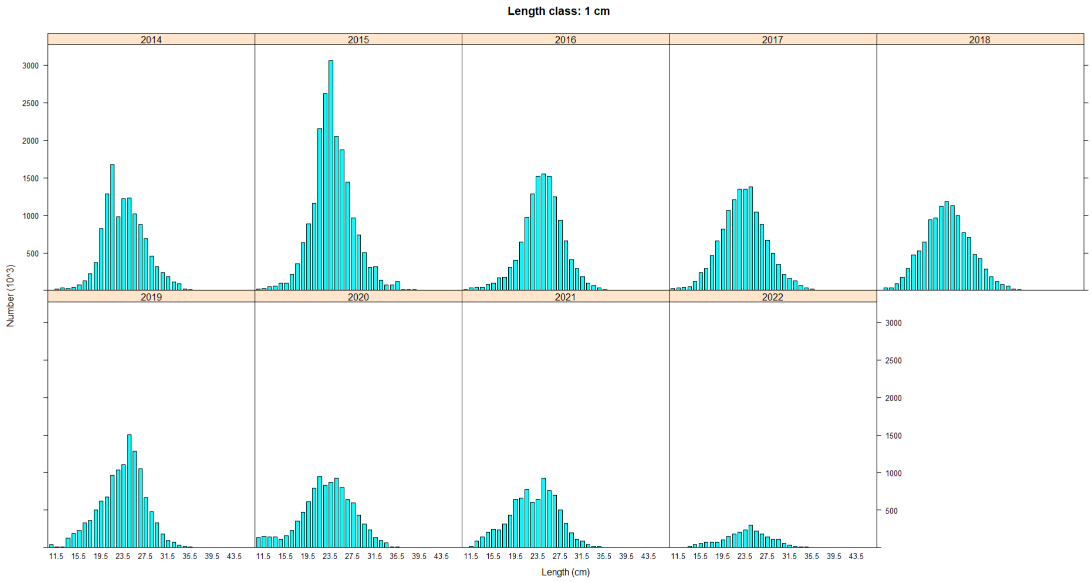


Figure 8.2.3. Dab in subdivisions 22 to 32. Catch in numbers per length for the years 2014–2022.

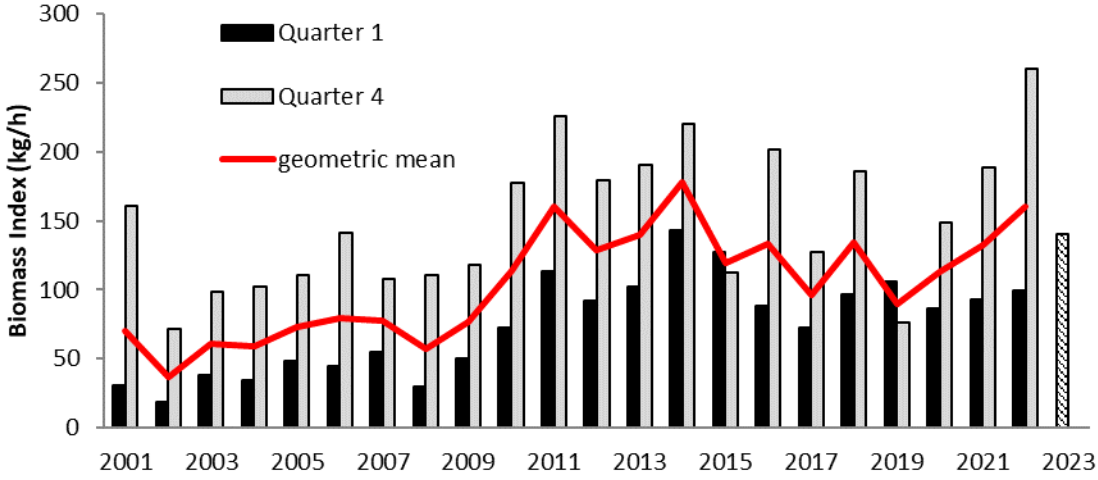


Figure 8.2.4. Dab in subdivisions 22 to 32. Mean biomass (kg hr^{-1}) of dab with L ≥ 15 cm based of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–24.

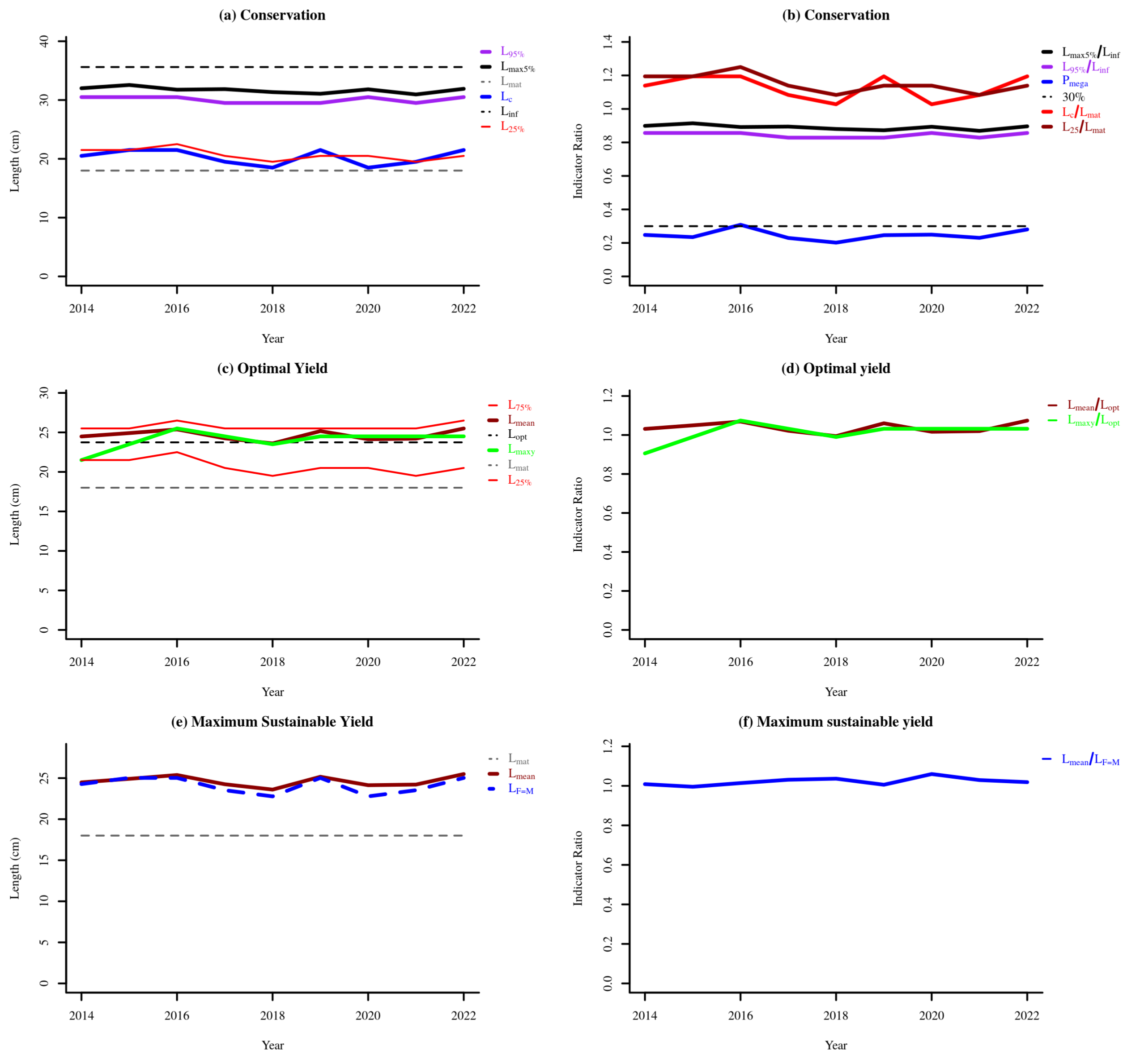


Figure 8.2.5. Dab in subdivisions 22 to 32. LBI F_{MSY} Proxy reference points

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. The landings averaged about 25 t if the years 1994–1996 are excluded. 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. Decreasing trend has been observed since 2009. Slightly increase of landings was reported for 2015 with 40 t, for 2016, 2017 with 39 t and 53 t in 2018, followed by a slight decrease in 2019, but increased again in 2020 to 69 t. In 2021, landings were 53 t. In 2022, landings decreased slightly to 40 t.

8.3.1.2 Discards

Less than 100 kg of brill was discarded in 2012. The amount of discards increased to 299 kg in 2013 and further increased to 4200 kg in 2014. Discards of brill were not reported in 2015. For 2016, 400 kg discard were reported. For 2 For 2020, 6.1 tonnes of discards have been reported. Discards in 2021 decreased to 1.8 t. Most of these discards have been generated in Sub-division 22, in proportion with the landings in Sub-division 22, which constantly contributes 60- 80 % of the total.

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 (Vandammem 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 bycatch species of cod fishery and fisheries directed to other flatfish.

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. As weights applied were the sizes of the sub-areas sampled in the ICES sub-divisions. The CPUE values of the small TV were multiplied with a conversion factor of 1.4 (Figure 8.3.2).

The area data are 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). It was not possible to match exactly the same data as in the assessments used before 2018. This is probably due to some selective weightings of sub-areas done in former assessments, that has not been possible to reconstruct. However, the new and old calculation routine yield the same trends in CPUE and it is considered important from now on to derive the stock indices in a transparent and reproducible way.

Stable index with low fluctuations were observed between 2007 and 2017. CPUE values follow in general fisheries landings.

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.

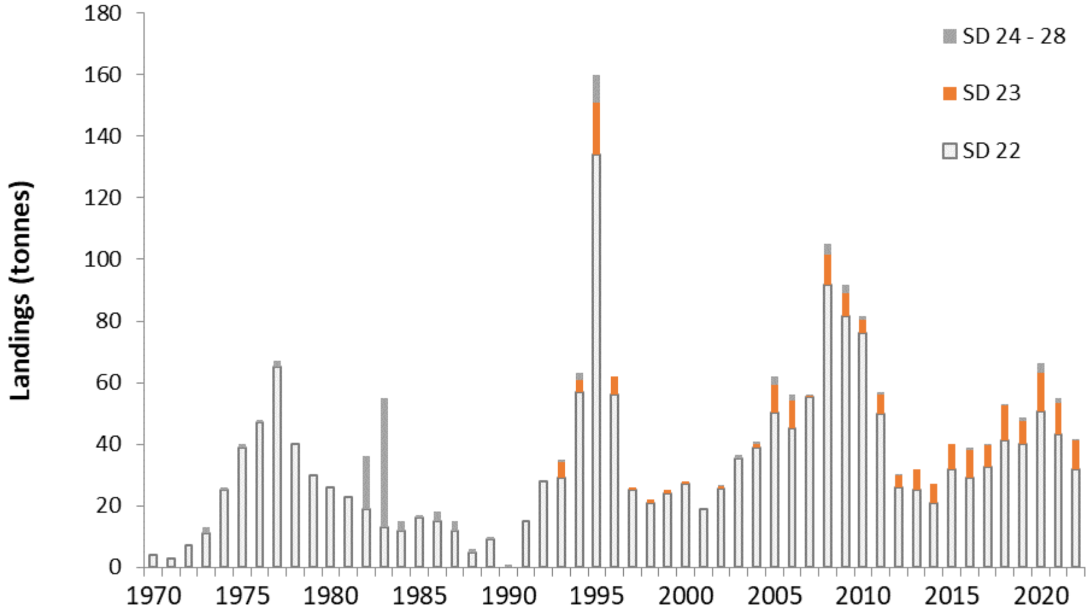


Figure 8.3.1 Development of brill landings [t] from 1970 onwards by ICES subdivision (SD).

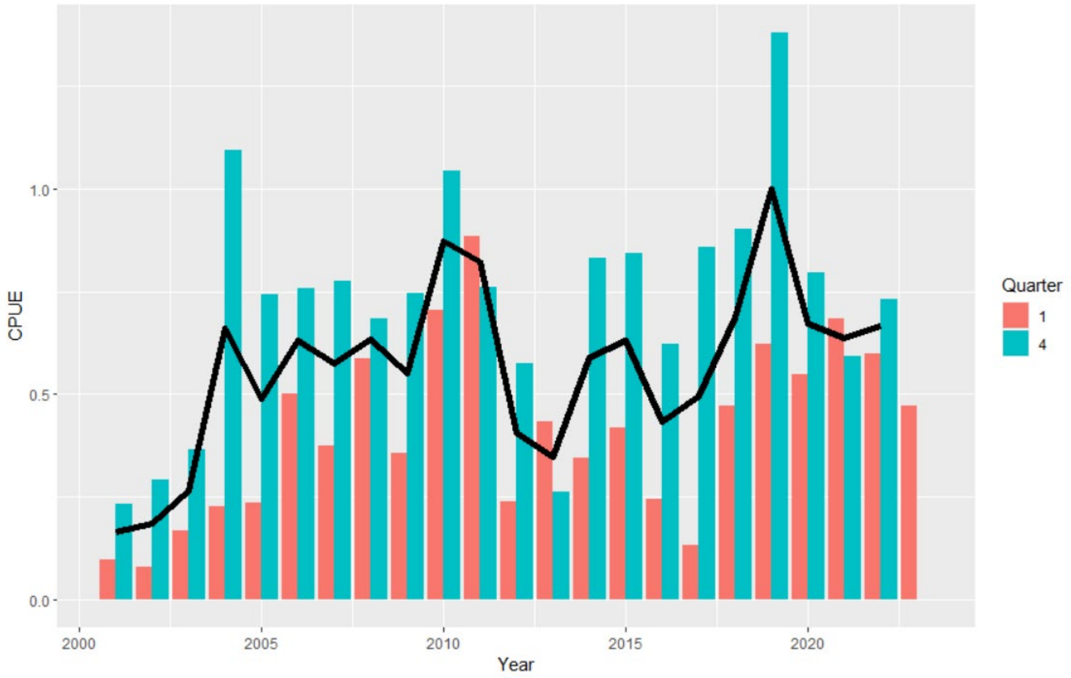


Figure 8.3.2 Mean CPUE (no. hr^{-1}) of brill with L ≥ 20 cm.

Table 8.3.1 Brill in the Baltic Sea: total landings (tonnes) by Subdivision and country.

Year	Denmark			Germany		Sweden		Total			Total
	22	23	24-28	22	24	23	24-28	22	23	24-28	SD 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

Year	Denmark			Germany		Sweden		Total			Total
	22	23	24-28	22	24	23	24-28	22	23	24-28	SD 22-28
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	0	2	0	1	0	21	6	0	28
2015	29	7	0	3	0	1	0	32	8	0	40
2016	28	8	0	2	0	1	0	29	9	1	39
2017	35	8	1	4	1	0	0	39	9	1	49
2018	37	12	1	6	1	1	0	43	13	1	57
2019	44	8	3	6	2	1	0	50	10	3	63
2020	45	12	1	9	2	1	0	54	14	1	69
2021	34	8	0	9	1	2	0	43	10	1	53
2022	27	6	0	5	0	3	0	30	10	0	40

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Annex 1: List of participants

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Annex 2: Resolution

2022/2/FRSG07 The Baltic Fisheries Assessment Working Group (WGBFAS), chaired by Kristiina Hommik, Estonia, will meet on 18-25 April 2023 in ICES HQ, Copenhagen, Denmark to:

Address generic ToRs for Regional and Species Working Groups

Review the main result from WGMIXFISH, WGIAB, WGSAM, WGBIFS, and WKBALTPEL, 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 annex. 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 specified in the 2023 ICES data call.

WGBFAS will report by 8 May 2023 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.27.24-32)

Date: 2023-05-10
Auditor: Marie Storr-Paulsen, Johan Lövgren

General
For single stock summary sheet advice:

1) **Assessment type:** Update assessment.
2) **Assessment**: Analytical.
3) **Forecast**: Presented. Stochastic.
4) **Assessment model**: Stock synthesis (SS3) fitted to 9 indices (BITS Q1 & Q4, 2 trawl surveys, 3 commercial CPUE series, SSB and abundance index from ichthyoplankton surveys). Length-based, one area, quarterly model comprised of 15+ age-classes, both sexes combined, where SSB is estimated at spawning time.
   An exploratory SPICT assessment was also presented.
5) **Data issues:** . Low quotas may have caused misreporting of landings. Further all discard estimates are derived from only 2 discard trips conducted by one country and raised to all other countries. However, the perception of the stock status and present advice are considered robust to possible uncertainties in catch data in latest years. Russian catch amount for 2022 included in the assessment was based on approximate information available on *http://atlant.vniro.ru;* but no information on length composition of these catches was available to ICES, therefore the length information from 2022= length distribution in 2021 . However, the perception of the stock status and present advice are considered robust to uncertainties in catch data in recent years. Further, some smaller cod <25 cm entered the eastern Baltic in the 2023 Q1 survey, however as they have not been present there as smaller fish the SS3 are mainly ignored in the model. These cod could be of western Baltic origin
6) **Consistency**: Results consistent with previous year's assessment.
7) **Stock status**: SSB is below Blim and Bpa. No reference points for fishing pressure have been defined for this stock. The exploratory SPICT assessment showed results in line with the main SS3 assessment.
8) **Management Plan**: This stock is shared between the EU and Russia. An EU multiannual plan (MAP) that includes cod is in place for stocks in the Baltic Sea (EU, 2016, 2019,) but FMSY ranges are not available for this stock. Russia does not have a management plan for this stock.

General comments
The report was well documented, describing the data and SS3 assessment in a clear way.

Technical comments
No specific comments.

Conclusions
The assessment has been 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 update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **Yes**

Audit of Cod (*Gadus morhua*) in Subdivision 21 (Kattegat) cod.27.21

Date: 27.04.2023
Auditor: Margit Eero, Didzis Ustups

General

For single stock summary sheet advice:

9) **Assessment type:** update/SALY.
10) **Assessment**: trends
11) **Forecast**: not performed.
12) **Assessment model**: state-space assessment model (SAM), considered indicative of trends only, plus 4 surveys.
13) **Data issues:** assessment performed according to Stock Annex. No issues raised.
14) **Consistency**: Same procedure as last year. Results consistant with pevious year's assessment.
15) **Stock status**: Ref points are not defined for this stock. SSB is last years is at a lowest level on record, and it would be at or below possible Blim.
16) **Management Plan**: NA for this stock.

General comments

The assessment was performed correctly according to Stock Annex.

Technical comments

A few technical issues in the report were discovered during audit, and were subsequently corrected.

A minor tehnical issue, to consider changing for next year is the Figure 2.2.10, that shows catch multiplier. It would be more appropriate to present this information as a Table., as it has a table format.

Additional remark: the results from stock assessment runs are not available in www.stockassessment.org, as otherwise stated in the report. Only input files are visible. It is possibly a technical issue with the homepage and the adminsitrators of the page should be notified, that it could be fixed.

Conclusions

The assessment has been 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? **YES**
- 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 of Western Baltic Cod (cod.27.22-24)

Date: 05-05-2022
Auditor: Elliot Brown and Johan Lövgren

General

The catches and estimated stock size are at all time lows. With little to no directed fishery, the catch data are spurious, calling their reliability for informing on stock status into question.
The assessment model has high retrospective patterns and is unfit for making forecasts.
In order to really understand the dynamic of the stock, there should be a series of scoping meetings that scrutinizes the potential processes that affect this stock.

For single stock summary sheet advice:

1) **Assessment type: Update according to 2021 interbenchmark practice.**
2) **Assessment**: Age-based analytical.
3) **Forecast**: not presented
4) **Assessment model**: Stochastic state-space assessment model (SAM) – Tuning with two trawl surveys BITS Q1 and Q4 as well as a local pound net survey of juveniles.
5) **Data issues:** Due to a combination of low stock size and fisheries restrictions, all forms of data in recent years is poor.
6) **Consistency**: The assessment this year was accepted.
7) **Stock status**: SSB remains below Blim. F remains consistently above Fpa but with increasing uncertainty. R is low relative to historic levels and remains sporadic.
8) **Management Plan**: EU Baltic Sea Multi Annual Plan (MAP)

General comments

Stock coordinators, the assessor and supporting participants have gone to great lengths to solve problems with this stock assessment. From investigating and updating underlying assumptions to fine-tuning model configurations. However, the stock remains in a very poor state and thus there is only poor data to be able to try and salvage an assessment from.

Technical comments

The assessment is run according to the updated annex from the IBP in 2021. No forecast is presented due to the uncertainty in the processes driving stock demographics. These could be external to the model (e.g. additional mortality, decreased condition, loss of functional connectivity, etc.) or could simply be stochasticity at these very low abundances and densities).

Conclusions

The assessment has been performed correctly and zero catch advice is warranted.

Audit of Flounder in Sub-divisions 27.26-28 (bwq.27.2628)

Format for audits (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, (WGBFAS_ 18-25.04-2023)
Reviewer: 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 for 2023-2024.
The assessment has been conducted according to the stock annex.
Stock has been last time benchmarked in 2014

For single-stock summary sheet advice

Stock **Flounder in Sub-divisions 27.26-28 (bwq.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: This is a category 3 stock. Stock trend model based on scientific surveys (Baltic International Trawl Survey BITS–Q4, G8863) and commercial landings. No reference points for stock size have been defined for this stock. The stock status was evaluated by calculating length-based indicator.
XSA + VPA Bayesian assess – proposed by expert group, accepted by review group – tuning by three comm + two surveys
5) Consistency: Consistent with last year's assessment

6) Stock status: Fishing pressure on the stock is below F_{MSY} proxy. The stock size indicator shows a general decrease in stock size over time although the estimated indices in last years are fluctuating without any clear trend.
$B < B_{lim}$ for a while; $F_{lim} < F < F_{pa}$; R uncertain, seems to be high in recent years

7) Management plan: Bycatch of this species is considered in the EU Multi-annual 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 45% and 55% 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

Discard estimates, available since 2015 show strong year effect and remain uncertain. Like in 2021 no discard estimates except one sample from Poland, were available for 2022. Therefore, only estimates of landings are available for 2021-2022.

According to the stock annex, weight at length was estimated as an average weight at length in Sub-divisions 26 and 28 for 1991-2013 (calculation of Biomass Index from BITS Q4 surveys). The calculation would benefit by including data from the recent years available in DATRAS.

Historical BITS data (1991-1998) has been updated in DATRAS database recently, therefore survey estimates in 2023 assessment differ from the respective values in 2021 assessment. Historical data were not used in the Advice.

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: 27.04.2023

Format for audits (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, WGBFAS 2023 18-25 April

Reviewers: Olavi Kaljuste, David Gilljam

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.27.25-2932**

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: SS3 tuned with 1 acoustic survey index (BIAS A1588)
5) Consistency: The assessment is consistent with the benchmark 2023 assessment (setup and assumptions). The retrospective pattern shows an overestimation of SSB and an underestimation of F.
6) Stock status: SSB is below MSY Btrigger, Bpa and Blim, F is below Fmsy and Fpa
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 (*Clupea harengus*) in Subdivision 28.1 (Gulf of Riga), her.27.28

Date: 26.04.2023

<u>Format for audits</u> (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, WGBFAS 2023 18-25 April

Reviewers: Olavi Kaljuste, Szymon Smoliński

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). The retrospective pattern shows an underestimation of SSB and an overestimation of F and in certain years underestimation of R, but these patterns improved in comparison to the last year's assessment (XSA). Some year effects are evident from the residual plots of the tuning series. 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 time period 1989 to data year -1.

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: 25.04.2023
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.

For single stock summary sheet advice:

17) **Assessment type:** Update assessment
18) **Assessment**: age-based analytical and fully stochastic model analytical (SS3)
19) **Forecast**: presented, according to the MAP. The decreased catch advice is an effect of the continued decrease in SSB, likely to be the result of a combination of a downward revision of recruitment and stock numbers in 2021 and 2022 and continuous low condition and weight at age of larger herring.
20) **Assessment model**: Stock Synthesis (SS3) – fitted to 2 abundance indices (one acoustic survey (BIAS, A1588: 2007-2022) 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.
21) **Data issues:** Mean weight at age has been now at low levels for 15 years, and decreased but slightly increased in 2022. In addition, the present low state of the body condition of larger herring has not improved.
22) **Consistency**: in early 2021 upgraded to category 1, before that category 5. The 2023 assessment is consistent with 2022 assessment and was accepted.
23) **Stock status**: spawning biomass is estimated at the beginning of the year. Fishing pressure on the stock is below FMSY and spawning-stock size is below MSY Btrigger and between Bpa and Blim.
24) **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.

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 update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **Yes**

Audit of ple.27.21-23 (Plaice in SD 21-23)

Date: 10 May 2023
Review of ICES Scientific Report, WGBFAS 18-25.04-2023
Reviewers: Jan Horbowy, Stefan Neuenfeldt

Expert group Chair: Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General
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.

For single-stock summary sheet advice

Stock: ple.27.21-23 (Plaice in SD 21-23)

Short description of the assessment as follows:

1) Assessment type: Category 1 full age-based analytical assessment
2) Assessment: accepted
3) Forecast: presented, based on MSY
4) Assessment model: SAM state-based model
5) Consistency: A new assessment was run with annually varying stock weight at age for the most recent years (2020 – current year) according to a WGBFAS group decision. The estimated stock size decreased substantially but remains at a record high, the estimated fishing pressure and recruitment show little to no deviation from the earlier assessment. The retrospective patterns were comparable to the SPALY run and the fit looks good.
6) Stock status: B > MSY Btrigger, F < Fmsy
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.

Technical comments
NA
Conclusions

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 of ple.27.24-32 (Plaice in SD 24-32)

Date: 25 April 2023

Review of ICES Scientific Report, WGBFAS 18-25.04-2023
Reviewers: Stefanie Haase, Jukka Pönni

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:

8) Assessment type: Surplus Production model, reviewed in 2022
9) Assessment: accepted
10) Forecast: presented, based on MSY
11) Assessment model: Surplus Production model in Continuous Time (SPiCT; ICES, 2022)
12) Consistency: A new assessment approach and change from category 3 to category 2 in 2022. The assessment is consistent with last year's advice. There was a change in the biomass index due to calculation errors in previous years. The effect on the assessment was minor.
13) Stock status: B > MSY $B_{trigger}$, F < F_{msy}
14) 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.

Technical comments
NA
Conclusions

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 of sol.27.20-24 (Sole in SD 20-24)

Review of ICES Scientific Report, WGBFAS 2022, 18-25 April 2022
Reviewers: Zuzanna Mirny, Nicolas Goñi

Expert group Chair: Kristiina Hommik

Secretariat representative: 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.27.2024**

Short description of the assessment as follows:

15) **Assessment type:** update
16) **Assessment**: accepted
17) **Forecast**: accepted
18) **Assessment model**: Age-based analytical stochastic assessment (SAM) that uses landings only in the model. Discards are included in the forecast. Input data: Commercial catches (international landings, ages and length frequencies from catch sampling), one survey index (Fishermen–DTU Aqua sole survey, 2004–2022, [G4052]), two commercial indices: (private logbook gillnetters (1994–2007), private logbook trawlers (1987–2008)); fixed maturity and fixed natural mortality (0.1) for all age groups
19) **Consistency**: The assessment of recent years including the 2022 assessment have been accepted. This year's assessment is conducted as in previous years and in accordance with the procedure described in the stock annex.
20) **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}.
21) **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 precautionary.

General comments
Report is well documented and enables to follow the assessment.

Technical comments

- There is a mismatch between table 6.2 and figure 6.1. The biggest landings value in table 6.2 is 1439 t (in 1993), but in figure 6.1 it's over 1600 t (in ~1995).

- The probability of SSB getting under Blim should be added in table 6.12

- Retrospective analysis shows robustness of F but suggests a pattern of overestimation of SSB and of R, although within reasonable ranges (3% for SSB, 9% for R). Too high weight-at-age for forecast years possibly leads to overestimating SSB, while the weight-at-age of age-2 individuals has followed a decreasing trend since 2012

- Catches were sampled only in Skagerrak and Kattegat, discards were sampled also in the Belts

Conclusions
The assessment has been 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 update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **YES**

Audit of spr.27.22-32 (Sprat in SD 22-32)

Review of ICES Scientific Report, WGBFAS 18-25.04-2023
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 previously benchmarked at WKBBALTPEL. Accordingly, the model used for the 2023 stock assessment was changed from XSA to SAM.
- A second abundance index – also derived from BIAS survey – is now in use. It includes SD32, following recommendations given at WKBBTALTPEL.

For single-stock summary sheet advice

Stock: Spr.27.22-32

1) Assessment type: first assessment after benchmark
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SAM, validated through WKBBALTPEL benchmark
5) Consistency: for the last years, SAM estimates higher SSB values and lower F values compared with XSA, but long-term trends are similar. A detailed comparison is provided in the report.
6) Stock status: $B > B_{pa}$ but F still slightly $> F_{pa}$ despite lower F estimate by SAM. The abundance of age-0 class was still low in 2022, the last good recruitment occurred in 2020.
7) 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

- Updated predation mortality estimates were obtained from the SMS model
- The Danish historic sprat catches were updated
- Catch data from Russia were completed according to the highest values provided on *atlantniro* webpage
- Within-cohort correlations are high, a bit less for age 1 with age 2
- The residuals are ok except for age 0 class that displays a temporal pattern
- The same sensitivity to survey indices as with XSA model was observed
- The retrospective estimates show a pattern of overestimation for SSB and underestimation for F, but the Mohn's rho values are acceptable and improved compared with XSA

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

Audit of tur.27.22-32 (Turbot in SD 22-32)

Date: 25 April 2023

Review of ICES Scientific Report, (*expert group/workshop title*) (*year*) (*dates*)
Reviewers: Jari Raitaniemi

Expert group Chair: Kristiina Hommik

Secretariat representative: Ruth 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 2024.

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 (examples in grey text):

1) Assessment type: An update advice was last given in 2021
2) Assessment: An update of stock status in the report
3) Forecast: not presented
4) Assessment model: Landings and survey trends
5) Consistency: An update advice was last given in 2021
6) Stock status: The index of 2022 remained stable compared to the previous year. The length distribution indicates a higher number of turbot (around 20% larger than in previous years) entering the index in 2023.
7) Management plan: There is no management plan for dab in this area.

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

Conclusions

Audit of dab.27.22-32 (Dab in SD 22-32)

Date: 25 April 2023

Review of ICES Scientific Report, (*expert group/workshop title*) (*year*) (*dates*)
Reviewers: Jari Raitaniemi

Expert group Chair: Kristiina Hommik

Secretariat representative: Ruth 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 2024, 2025, or 2026.

For single-stock summary sheet advice

Stock dab.27.22-32 (Dab in SD 22-32)

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: not presented
4) Assessment model: Survey trends
5) Consistency: From 2019 on, no catch advice requested. Stock size indicator presented since 2002, landing tonnes since 1970 and discards since 2012 in the stock summary.
6) Stock status: Fishing pressure on the stock is below the FMSY proxy
7) Management plan: There is no management plan for dab in this area.

General comments
In general, this was a well-documented, well ordered and considered section.

Technical comments

In advice table 6, total catch is not always the sum of the catches in the columns to the left of it, especially in 2022 some information is missing.

Conclusions

Audit of Brill (*Scophthalmus rhombus*) in subdivisions 22-32 (Baltic Sea), bll.27.22-32

Date: 25.04.2023

<u>Format for audits</u> (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, (*expert group/workshop title*) (*year*) (*dates*)
Reviewer: Tomas Zolubas

Expert group Chair: Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General
There is no advice on fishing opportunities for this stock. Information on stock status only has been provided.

For single-stock summary sheet advice

Stock bll.27.22-32

Short description of the assessment as follows:

1) Assessment type: stock status update
2) Assessment: accepted
3) Forecast: Not presented since ICES has not been requested to provide fishing opportunities for this stock
4) Assessment model: Survey trends
5) Consistency: NA
6) Stock status: the relatively stable index but the index is considered uncertain due to the low catch rate in the surveys.
7) Management plan: Bycatch of this species is considered in an EU multiannual plan for Baltic Sea stocks.

General comments

It was easy to follow and interpret.

Technical comments
The stock status update is performed according to the stock annex.

Conclusions
The assessment has been performed correctly.

Annex 4: Updated Biological Reference Points for Central Baltic Herring (WKBBALTPEL Annex)

The WKBBALTPEL group proposed a set of target and trigger reference points derived from MSE with implementation error set to 0.165 with standard deviation equal to 0.149 (see relevant section of the main WKBBALTPEL report). This procedure had been followed previously for a *Pandalus* stock (pra.27.3a4, ICES, 2022) for which ICES provides catch advice. At WKBBALTPEL B_{lim} was defined as 15% of B_0 (unexploited SSB at current conditions).

The ICES Advisory Committee (ACOM) accepted the new definition of Blim. However, after the WKBBALTPEL was adjourned and during WGBFAS 2023, ACOM considered that it was more appropriate to adopt reference points derived from MSE without implementation error. ACOM will discuss how to handle implementation error and produce guidelines on this for both MSE in general and the estimation of reference points in particular. The selection of references points based on MSE is not straightforward (several F_{brp}, B_{trg} and $B_{trigger}$ combinations can be selected according to stock-specific productivity and trade-offs) and therefore ACOM suggested that the decision on the new set of reference point should be taken at WGBFAS 2023.

The Table below includes the set of agreed reference points at WGBFAS 2023.

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 (2023b)
	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 $B_{trigger}$

References:

ICES. 2022. Benchmark workshop on *Pandalus* stocks (WKPRAWN). ICES Scientific Reports. 4:20. 249 pp. http://doi.org/10.17895/ices.pub.19714204

ICES. 2023a. Baltic Fisheries Assessment Working Group (WGBFAS). ICES Scientific Reports. 5:58 https://doi.org/10.17895/ices.pub.23123768

ICES. 2023b. Benchmark Workshop on Baltic Pelagic stocks (WKBBALTPEL). ICES Scientific Reports. 5:47. https://doi.org/10.17895/ices.pub.23216492

Annex 5: 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	Title
ple.27.24-32	Stock Annex: Plaice (*Pleuronectes platessa*) in subdivisions 24–32 (Baltic Sea, excluding the Sound and Belt Seas)
her.27.25-2932	Stock Annex: Herring (*Clupea harengus*) in subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea)
her.27.28	Stock Annex: Herring (*Clupea harengus*) in Subdivision 28.1 (Gulf of Riga)
spr.27.22-32	Stock Annex: Sprat (Sprattus sprattus) in subdivisions 22–32 (Baltic Sea)

Annex 6: Working Documents

Effect of thermal habitat variability on the proportions on juvenile Bothnian herring observed during the Baltic International Acoustic Survey

Nicolas Goñi[1 1], Juha Lilja[2]

1. Background

The time series of the abundance index derived from the Baltic International Acoustic Survey (BIAS) displays internal inconsistencies, specially regarding juvenile age-groups (ages 0, 1 and 2), for which estimated abundances of age-group *a* in year *y* are in some cases (for example 2017 and 2022) superior to the estimated abundance of age-group *a-1* in year *y-1*. During the WGBIFS meeting that took place in March 2022, a recommendation of caution was emitted regarding the inclusion of years 2017 and 2020 in the index used to calibrate the stock assessment. In the meeting of November 2022, it was hypothesized that the proportions of juvenile age-groups observed during the survey are possibly affected by oceanographic parameters, and it was proposed to test this hypothesis, starting with thermal variables.

2. Data and Methods

The raw data used for the analysis comprised the number of herring by age group in each haul operated during the BIAS in the years 2013 to 2022, and the CTD profiles operated after each of the corresponding hauls. From these data were derived the proportions of herrings of age groups 0, 1 and 2, as well as four variables describing the thermal habitat of juvenile herrings:

- Sea surface temperature (SST) i.e. the first value of the CTD profiles with non-0 salinity
- Sea bottom temperature (SBT) i.e. the temperature at maximum depth
- Mixed layer depth (MLD) calculated using the function *thermo.depth* in R package *rLakeAnalyzer*
- Thermocline intensity (TCI) i.e. the maximum value of $\frac{\Delta T^{o}}{\Delta Depth}$ in the CTD profile, after standardazing the depth intervals for years previous to 2017 in which a different equipment was used and the variables were measured along shorter and unequal depth intervals.

The analysis was done in two steps, first an exploratory approach to observe temperature-related traits of each year and possible colinearities, and to identify variables potentially affecting the proportions of the juvenile age groups considered. In a second step we used an inferential approach through Generalized Additive Models (GAMs) using a Beta regression family as the response variable is a proportion i.e. distributed on (0,1). To deal with colinearities among explanatory variables, they were not used as such in the GAMs, we instead used a Principal Component Analysis, of which the principal components were used as non-colinear explanatory variables.

3. Results

3.1. Pair correlations

The pair plots (Fig. 1) show significant linear correlations between the four thermal variables considered. Mixed layer depth is negatively correlated with sea surface temperature and thermocline intensity, the two latter being positively correlated. Sea bottom temperature appears negatively correlated with thermocline intensity and positively correlated with mixed layer depth.

As for the proportion of juvenile herrings in the catches, the proportion of age-0 individuals appears positively correlated with mixed layer depth. The proportion of age-1 individuals also appears positively correlated with mixed layer depth, with sea bottom temperature, and negatively with thermocline intensity. As for age-2

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individuals, their proportion appears positively correlated with both sea surface and sea bottom temperature, and negativey with mixed layer depth unlike age-0 and age-1 individuals.

Due to the colinearities among the four thermal variables considered, a PCA will enable synthetizing their variability while avoiding redundant information.

3.2. Synthesis of thermal variables

The four thermal variables were used in a PCA, of which the first component indicates mixing, with a positive semi-axis corresponding to deep and weak thermocline associated with low SST, and a negative semi-axis corresponding to stratified situations with shallow and intense thermocline associated with high SST. The second component is clearly thermal, with the positive semi-axis corresponding to both high SST and SBT. The third component is related to situations of both intense and deep thermoclines, not reflected in the first component. The fourth component is related to conditions of high SST and low SBT with weak thermoclines, not reflected in the first and second components. The coordinates of the hauls on the first and second components of the PCA show that observations of different years appear structured mostly along the first component (Fig. 2,3,4), with more mixing in years 2014, 2017, 2018 and 2020, versus more stratification in the years 2015, 2016, 2019 and 2022, whereas 2013 and 2021 display a more diverse profile with a broader distribution along the first component. Secondarily, hauls of different years also structure along the second component, with the years 2015, 2016 and 2021 being warmer and 2013, 2017 and 2018 being cooler.

3.3. Effect of thermal habitat on the proportion of juvenile age-groups

On the proportion of age-0 we noticed a significant effect of MLD, but the model explained only 4,08% of the variance and the residuals distribution showed a pattern, so this model was discarded. No other variables showed any effect on the proportion of age-0 individuals.

Regarding age-1 individuals, the GAM showed a significant effect of mixing (i.e. first component) and temperature (i.e. second component) with 33,3% of the variance explained (Tab. 2). The model fit suggests that age-1 individuals are vertically limited by stratified conditions (positive effect of mixing) and prefer warmer waters (Fig. 5).

Regarding age-2 individuals, the GAM showed a significant effect of temperature (i.e. second component), and of deep and intense thermoclines (i.e. third component), although the model only explains 9,95% of the variance (Tab. 3). The model fit suggests that age-2 individuals prefer warmer waters and are vertically limited by deep and intense thermoclines (Fig. 6).

After removing the effect of these variables on the proportion of age-1 and age-2 individuals in each haul and recalculating the acoustic index accordingly for each rectangle, we notice that the five highest annual values for age-1 individuals, observed in the years 2020, 2015, 2017, 2014 and 2019 (by decreasing order) are all corrected downwards, whereas the two lowest values, observed in the years 2013 and 2022, are corrected upwards (Fig. 7). Regarding age-2 individuals, the corrections are of lower magnitude, but the two highest values are also corrected downwards. However, when using the index values after removal of the environmental effects in the stock assessment, the outputs are relatively similar in terms of SSB, also in terms of recruitment except for the year 2021 in which the recruitment is estimated 22.8% higher when using the values after removal of environmental effects, compared with the base case (Fig. 8), possibly due to the important correction of the proportion of age-1 individuals for the year 2022.

4. Perspectives

The present work is preliminar but can be developed through including additionsal environmental such as salinity and oxygen, including age groups 3 and older, considering, spatial correlation, interaction between year and environmental parameters. However, this analysis shows important effects of the thermal habitat on the perceived proportion of age-1 individuals in the populations, with potential effects on the estimated recruitment of the stock.

Table 1: correlation of the four thermal variables (Mixed layer depth (MLD), Thermocline intensity (TCI), Sea surface temperature (SST), Sea bottom temperature (SBT)) with the four components of the PCA. The background colors are indicative of the correlation level, from blue (weak correlation) to red (strong correlation).

	Comp.1	Comp.2	Comp.3	Comp.4
MLD	0.532	0.255	0.716	0.373
TCI	-0.578	0.165	0.628	-0.494
SST	-0.526	0.557	-0.135	0.629
SBT	0.326	0.773	-0.273	-0.47

Table 2: GAM of the proportion of age-1 individuals in the hauls of the BIAS survey in the years 2013 to 2022, as a function of the first and second components of the PCA, corresponding to mixing and temperature, respectively

```
Formula:
p1 ~ s(MIX) + s(TEM)

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.57856    0.05588  -28.25   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
         edf Ref.df Chi.sq p-value
s(MIX) 4.158  5.182  36.84 3.3e-06 ***
s(TEM) 5.306  6.481  36.93 < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =   0.19   Deviance explained = 33.3%
-REML = -214.39  Scale est. = 1         n = 256
```

Table 3: GAM of the proportion of age-2 individuals in the hauls of the BIAS survey in the years 2013 to 2022, as a function of the second and third components of the PCA, corresponding to temperature and to conditions of deep and intense thermoclines, respectively

```
Formula:
p2 ~ s(TEM) + s(DIT)

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.218749   0.006166   35.48   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
         edf Ref.df     F  p-value
s(TEM) 1.344  1.621  5.62  0.00526 **
s(DIT) 1.000  1.000 17.11 4.81e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) =  0.0912   Deviance explained = 9.95%
GCV = 0.009861  Scale est. = 0.0097322  n = 256
```

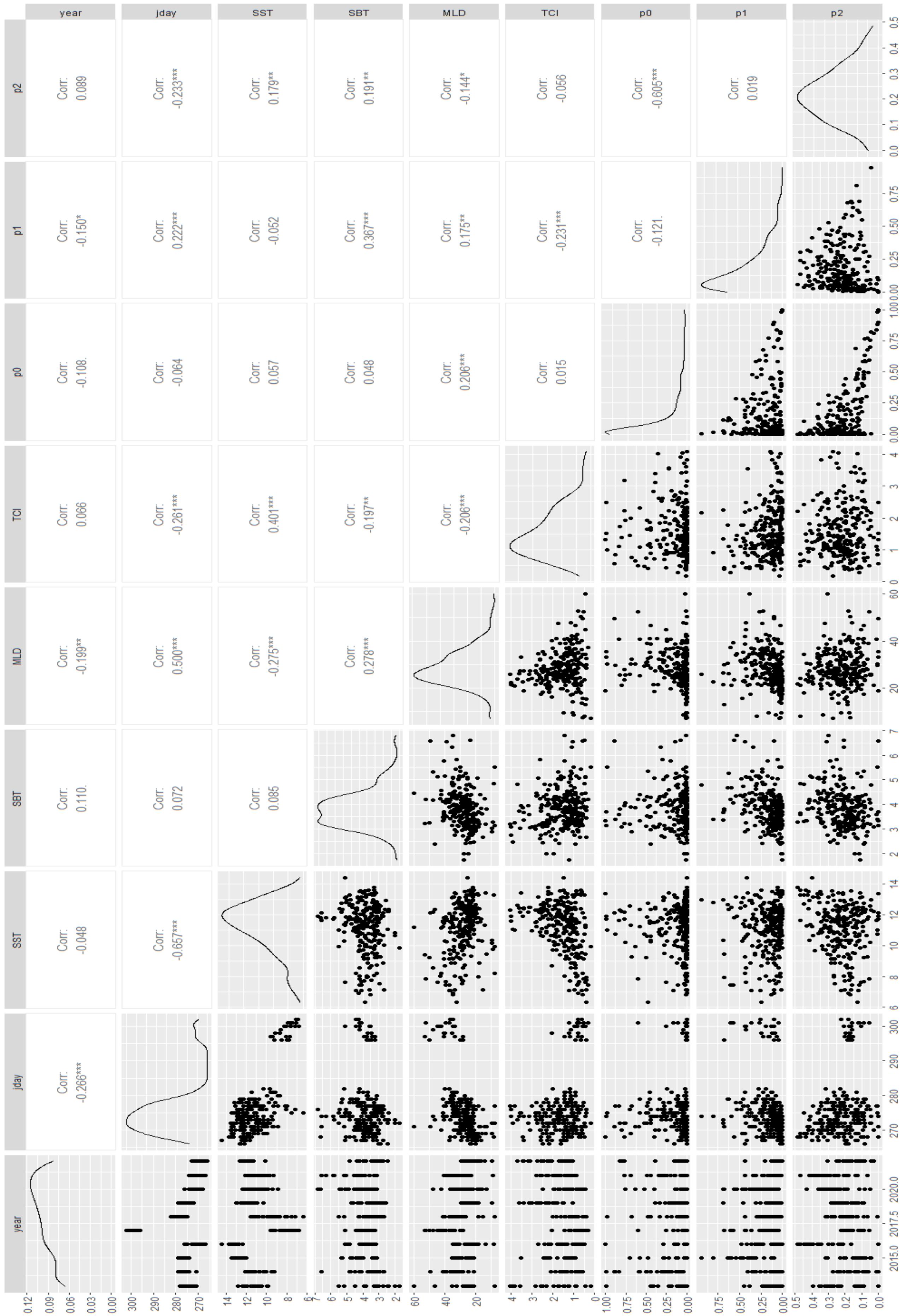


Figure 1: pair-plotting of year, julian day, SST, SBT, MLD, TCI and proportions of age-0, age-1 and age-2 individuals in the hauls of the BIAS survey during years 2013 to 2022 in the Bothnian Sea.

Figure 2: Coordinates of the hauls of years 2013 and 2021 on the first and second component of the PCA

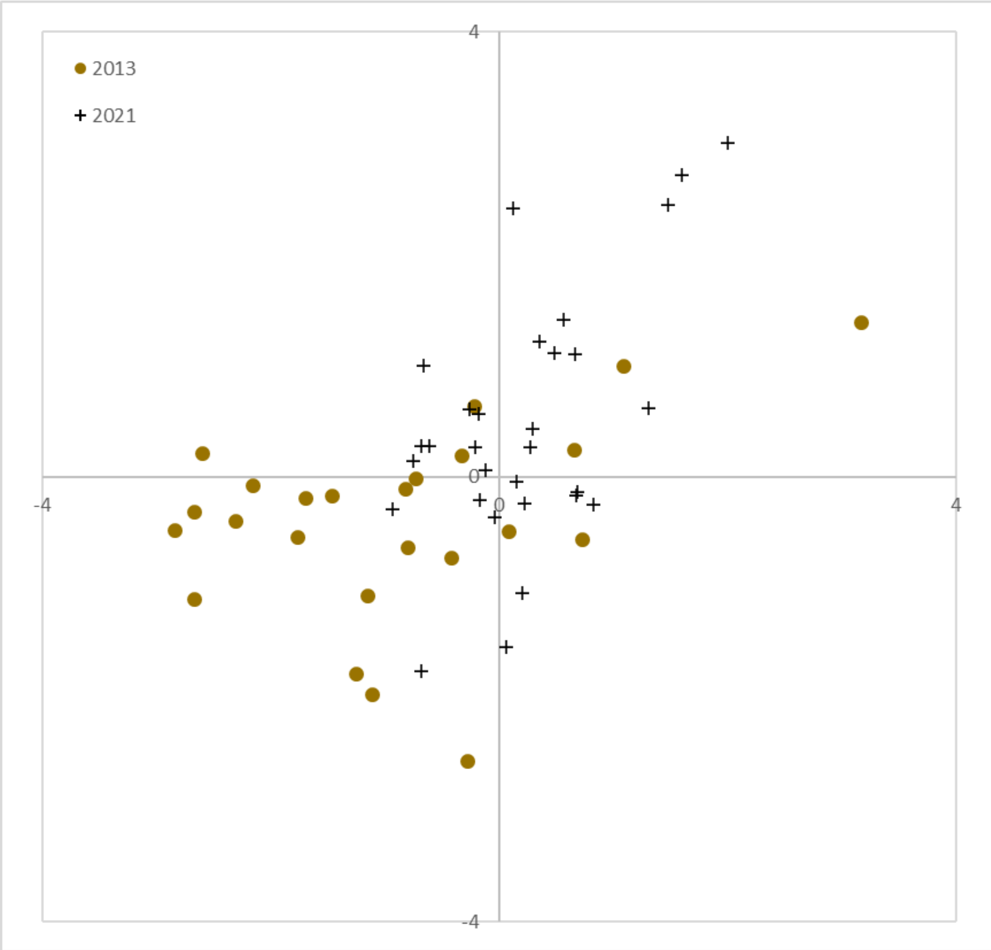


Figure 3: Coordinates of the hauls of years 2014, 2017, 2018 and 2020 on the first and second component of the PCA

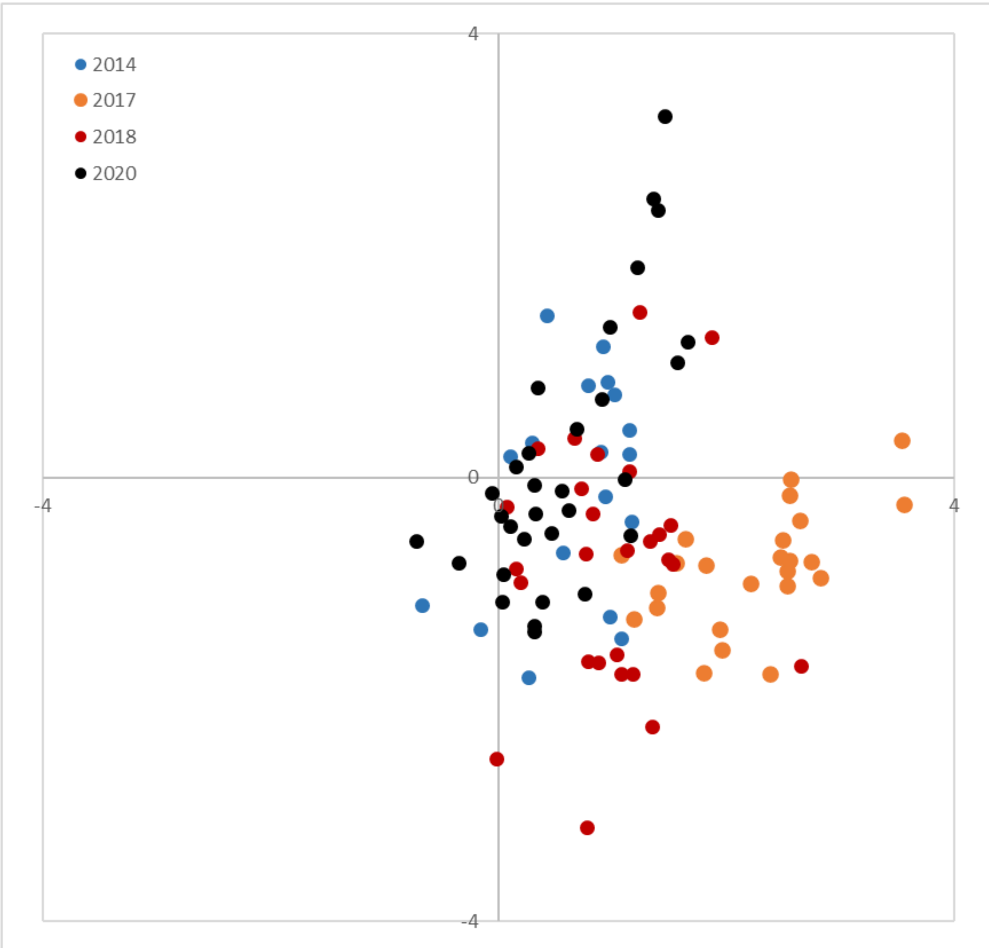
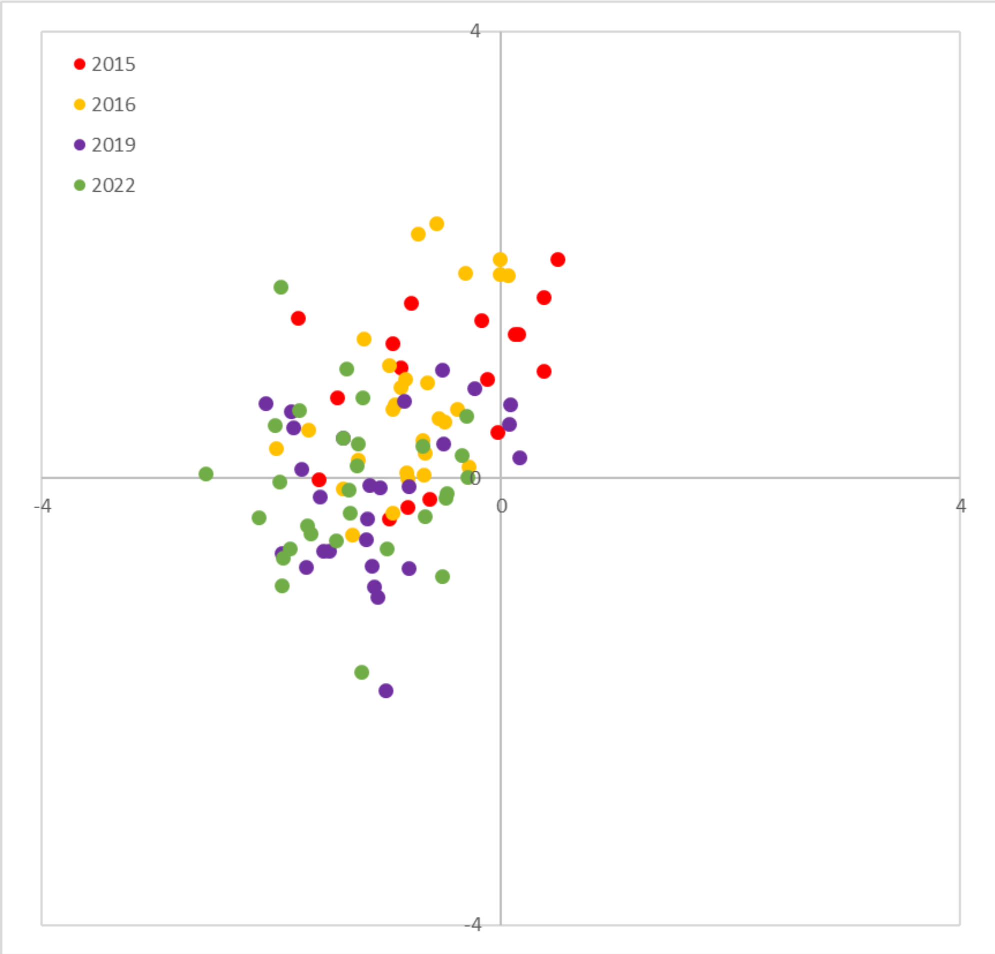


Figure 4: Coordinates of the hauls of years 2015, 2016, 2019 and 2022 on the first and second component of the PCA



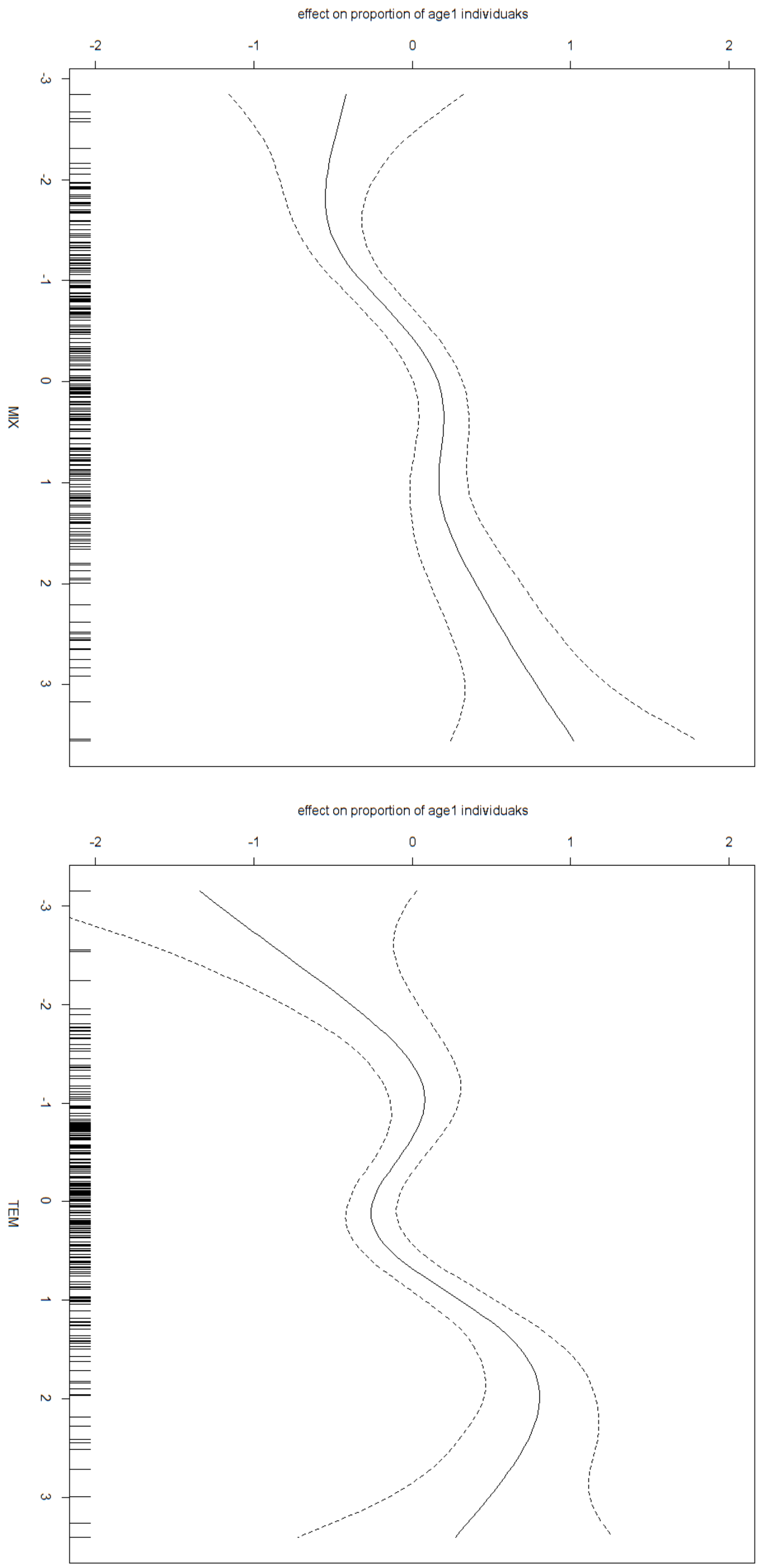


Figure 5: GAM of the proportion of age-1 individuals in the hauls of the BIAS survey in the years 2013 to 2022, as a function of the first (MIX) and second (TEM) components of the PCA.

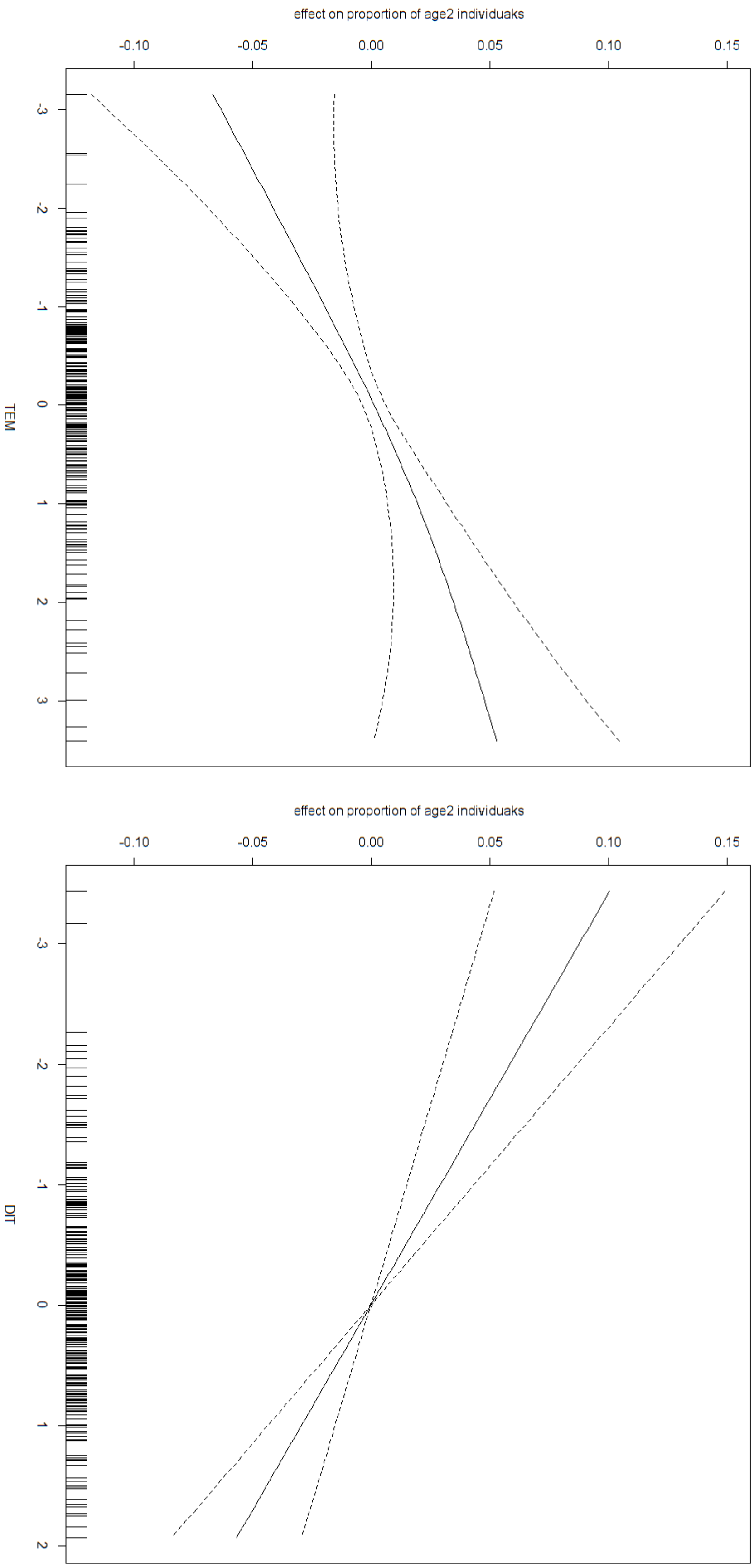


Figure 6: GAM of the proportion of age-2 individuals in the hauls of the BIAS survey in the years 2013 to 2022, as a function of the second (TEM) and third (DIT) components of the PCA.

Figure 7: acoustic index values for age-1 (upper pane) and age-2 (lower pane), comparing base values and values after removal of environmental effects.

Figure 8: relative difference of recruitment estimate values when using the acoustic index values after removal of environmental effects, compared with the base case

CODS Q4 2022 – the Swedish and Danish survey for cod in the Kattegat, November-December 2022

Patrik Börjesson[1] and Marie Storr-Paulsen[2]

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Abstract

An annual survey targeting cod in Kattegat was initiated in 2008 and has then been continued every year with the exemption of 2012. The survey is conducted in November-December using chartered commercial trawlers and R/V Havfisken. The survey design has been largely unchanged during the years, but a fourth stratum representing the closed area in Southern Kattegat was added in 2013. The total swept area biomass of cod was estimated to 453 tonnes in 2022. This corresponds to a reduction of almost 95% compared to 2015 when the highest biomass was observed and represents the third lowest observation since the survey started in 2008. At the same time the number of cod have increased from an estimated 0.78 million individuals in 2018 to 2.28 million in 2022. The length distribution is dominated by young individuals, around 20 cm and the number of age class zero cod was the highest observed since the start of the survey in 2008. The majority of young fish were caught in the southeastern part of the survey area.

Introduction

The condition of the Kattegat cod stock has been deteriorating since the 1990s and is presently in a poor state. Assessments in the early 2000s showed that there were inconsistencies between the reported landings and the total removals from the stock, with unallocated mortality that ICES mainly ascribed to discard. However, other factors primarily migration of cod from the North Sea/Skagerrak, but also non-reported landings, and re-allocation of catches, have been identified to be part of the problem.

Because of these issues, ICES considers the cod assessment in Kattegat uncertain, and the analytical assessment has not been accepted by ACOM since 2006. The assessment has therefore largely relied on information from fisheries-independent surveys. However, the surveys available in the Kattegat area were not well suited for estimating the total cod abundance, mainly due to low coverage and sampling intensity. The relative abundance indices were also quite noisy, especially for older ages. It was generally agreed among scientists and fishermen organizations that the assessment of the cod stock would benefit significantly from a survey directly aimed at cod.

In 2008, the European Commission provided funding to Sweden for a project aimed at fostering collaboration between fishermen and scientists in the Kattegat area. As an outcome of this, it was decided to set up a survey that would utilize the knowledge of fishermen and be designed in a statistically sound manner for use in the stock assessment of Kattegat cod. Initially, the survey was a Swedish project, but the involvement of Denmark has been seen as an improvement, and the survey's design has been agreed upon in detail by fishermen and scientists from both countries. The survey has been conducted since 2008 with a gap in 2012 and only Swedish vessels participating in 2013.

The goal of the Kattegat cod survey is to provide fisheries independent data for monitoring trends in abundance, biomass, recruitment and distribution of cod. The results should be used to strengthen the scientific advice on the cod stock in Kattegat. Due to considerably better coverage compared to previous surveys, the joint Swedish and Danish survey improves the knowledge of spatial distribution of cod by size/age-groups and provides valuable information for monitoring the effect of the closed areas established in the Kattegat from January 1st 2009. Although the survey was primarily designed for cod stock assessment, data for all species are collected and survey products are generated for other species and/or purposes, e.g. CPUE-indices for elasmobranchs.

Materials and Methods

Survey area

The survey area covers the Kattegat Sea and the northern part of the Sound (FAO area 27.3.a.21 and 27.2.b.23). It is bounded to the north by a line from Skagen to Tistlarna and Vallda Sandö, to the southwest by a line between Gniben and Hassensør on Djursland, and to the southeast by a southeastward line between Ellekilde Hage and Lerbjerg (Figure 1). Furthermore, the area is largely restricted by the 20 m depth contour line, although some areas in Laholmsbukten and Skälderviken may be shallower than 20 m. The total survey area is 10 204 km2.

Stratification

The survey has a stratified random design with 80 hauls distributed within a survey grid of 5×5 nautical miles survey squares. The grid was initially partitioned into four geographical strata based on information from commercial fishers regarding expected densities of cod. The strata consisted of one stratum with expected high density of cod, one with medium density and one with low density. For logistic reasons, the low-density stratum was subdivided into a northern and a southern stratum.

In 2010 and 2011, minor changes were made to align the stratification with the catch information collected during the initial years. A fifth stratum was created in 2013 to ensure the collection of data from the closed area in the southeastern Kattegat (Figure 1 and Annex 1).

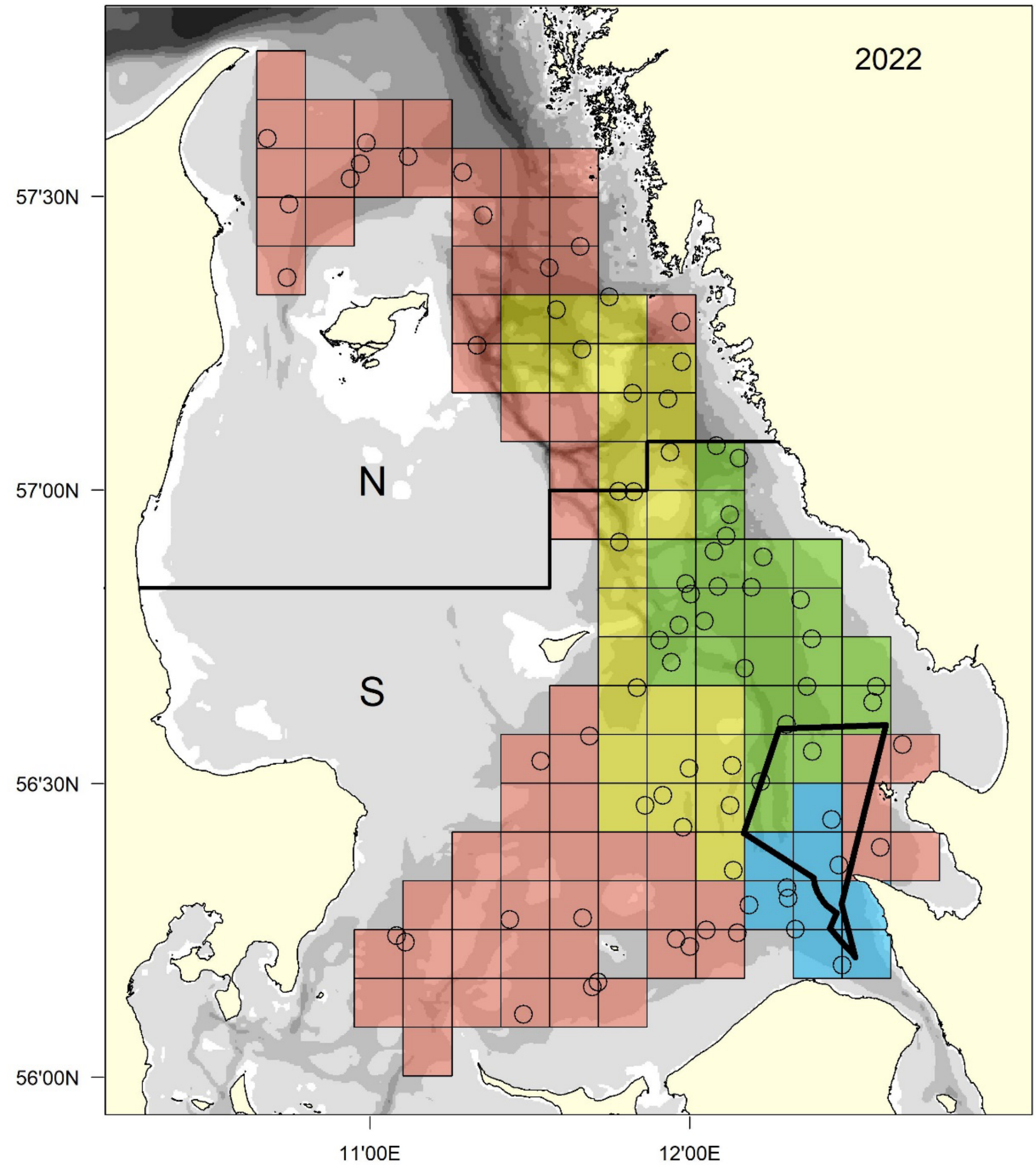

Figure 1. Survey stratification and sampled stations in 2022. Green represents the high-density stratum; yellow the medium-density stratum and red the low-density stratum. In 2013 a fourth stratum was added (marked in blue) to ensure sufficient sampling in the closed area. N (north) and S (south) identifies the two domains used for biological sampling. The outlined area show the Skånska Kattegat, a recently implemented marine protected area in southeastern Kattegat.

Allocation of trawl stations

The original survey design involved four chartered commercial trawlers, with two operating in the northern range and two in the southern range of the survey area. Each vessel was assigned the same number of survey squares in each stratum, for a total of n = 80 hauls. Since 2016, two chartered Swedish trawlers and the Danish research vessel R/V Havfisken participate in the survey. R/V Havfisken covers twice as many survey squares (n = 40) as the Swedish vessels (each n = 20) keeping the total number of hauls at the same level as previous years. Each vessel is now assigned the same proportion of survey squares in each stratum.

In the low-density strata, survey squares are selected through simple random sampling without replacement (SRS). In the remaining three strata, independent SRS samples of squares (“random groups”) are selected for each vessel, using the independent random groups (IRG) method (Särndal et al, 1992, sec 11.3.1). Since the random groups are selected independently, a square can be selected and trawled more than once (by different vessels). The skippers decide on suitable starting positions and tow direction within each survey square depending on weather, wind, and current. This means that the position of the haul within the square is not strictly random. The allocation of sampling effort varies across strata, with relatively more hauls being allocated to the high-density, medium-density and closed area strata than to the low-density strata (Annex 2, table A2.1 & A2.2).

In 2022, access to the marine protected area Skånska Kattegatt was restricted, resulting in fewer hauls (N=36) than originally planned (N=40). The county board of Skåne granted access to three stations within the area, but only under the condition that alternative methods to replace the demersal trawl were explored. To meet this requirement, a pilot study using baited remote underwater stereo-video systems (BRUV) was conducted. This data is still being analysed.

Fishing gear

The standard fishing gear is a 112 feet commercial bottom trawl with 70 mm full mesh in the cod end (see Annex 3). The ground gear consists of a ground rope with four-inch rubber discs spaced 10 cm apart. The bridles should be 27 meters long, but sweep lengths can be adjusted between 54 and 154 meters depending on the depth, resulting in a total length between 81 and 181 meters. The skipper decides on the warp to depth ratio and the sweep length. Actual sweep length should be noted for each individual haul.

The otter boards may vary among vessels, but should be adequate for the fishing gear. Door spread sensors and whenever possible wing spread sensors and trawl eye, for measuring gear geometry is strongly recommended. Vessel specific details are given in Annex 2.

Fishing operation

Trawling shall be performed using a standard towing speed of 3 knots over ground (2.7 to 3.4 knots accepted but should not vary within station).

The start of the haul is defined as the moment when the vertical and horizontal net opening have stabilized, which typically occurs within a few minutes after the warps have been completely shot and the winches have been braked. Whenever possible, sensors should be utilized to verify the start and end of the haul. The nominal haul duration is 60 minutes (down to 25 minutes accepted as valid), but up to 50% of the stations can be completed using 30-minute hauls. The cruise leader decides the duration of each haul, but the proportion of long and short hauls should be evenly distributed throughout the stratified survey area. The haul ends when hauling the net back in starts.

Trawled distance is estimated either from GPS-positions or from the mean towing speed and the haul duration. A maximum of 5 minutes of the tow duration are allowed outside the assigned survey square. If the 5 minutes are exceeded the haul should be terminated. Trawling is restricted to daylight hours, specifically from 15 minutes before sunrise to 15 minutes after sunset.

Sampling of trawl catches

Two technicians/scientists from SLU-Aqua (Swedish vessels) or DTU-Aqua (R/V Havfisken) on each vessel are responsible for processing the catch. The catch is processed in accordance with BITS/IBTS standard operating procedures (ICES 2017; 2020). After each haul, the catch is sorted by species and, for elasmobranchs, by sex. It is then weighed to the nearest 0.1 kg, and the number of specimens is recorded. The length distributions of all fish species caught are recorded. Total length is measured from the tip of the snout to the tip of the caudal fin, and is measured to 0.5 cm below for herring, sprat, and sandeel, and to 1 cm below for all other fish species. In addition, for Norwegian lobster, carapace length is measured to 0.1 cm below.

Biological sampling is presently only carried out for cod. One individual (both otoliths) per cm length class and station are to be collected. The Swedish protocol for age sampling changed in 2016 and the number of individuals sampled by haul is one per length class for cod sizes 10-40 cm, two per length class for cod sizes 41-60 cm and three per length class for cod larger than 60 cm. Individual weights are measured for all specimens for which age data are collected, but sex and maturity is not routinely reported. Genetic samples of cod are sampled from a minimum of two stations per stratum. One DNA-sample per cm length class and station is to be collected.

In addition to biological sampling of cod, several other sampling campaigns have been conducted, including genetic sampling of cod, starry ray (Amblyraja radiata), and thornback ray (Raja clavata), as well as sampling of individual weights to establish local weight-length relationships for rare species. Litter is collected according to the ICES manual (ICES 2022).

Data management

All trawl data (set/haul positions, door spread, towing speed etc.), catch data (species weights, length frequencies) and individual cod data are screened for unrealistic figures before submission to local storage. Data is stored in national databases, but could be uploaded to the ICES DATRAS system.

Estimation of stock indices

Biomass and abundance

The catch in each tow (in numbers or weight) is standardized by swept area (in km^2) prior to further calculations. Swept area is calculated using recorded tow distance and estimated wingspread based on door spread and trawl dimensions (Anon. 2006, Annex 1).

Weight-at-length is estimated from calculated weight-length regressions, and age-at-length from an age-length-key generated from the sample data. Missing age-length data are imputed using the multinomial approach by Gerritsen et al (2006).

In order to simplify the estimation, we here assume that our data come from a stratified SRS of hauls, thus ignoring the IRG design used in some of the strata. Under this simplifying assumption, the population mean for a variable y, $\bar{Y}$, is unbiasedly estimated by

$$\bar{y}_{st} = \sum_{h=1}^{L} W_h \, \bar{y}_h \qquad (1)$$

where $W_h = N_h/N$ is the stratum weight for stratum h, N_h is the number of survey squares in stratum h, N is the total number of survey squares in the survey area, $\bar{y}_h$ is the sample mean for stratum h, and L is the total number of strata (Cochran, 1977, Theorem 5.1).

Again assuming stratified SRS, the variance of $\bar{y}_{st}$, $V(\bar{y}_{st})$, is estimated by

$$v(\bar{y}_{st}) = \sum_{h=1}^{L} \frac{W_h^2 s_h^2}{n_h} \qquad (2)$$

where n_h is the number of hauls in stratum h and s_h^2 is the sample variance for stratum $h.$ From Cochran (1977, Theorem 5.5), the variance estimator in (2) is approximately unbiased for $V(\bar{y}_{st})$ ("approximately" since we omit the finite population correction).

By use of the variance estimator in (2), the standard deviation of $\bar{y}_{st}$ is given by

$$\text{Stdev}(\bar{y}_{st}) = \sqrt{v(\bar{y}_{st})} \qquad (3)$$

When a balanced design is used, where each vessel samples the same number of squares per stratum as originally designed and implemented from 2008 to 2015, the point estimate for SRS and IRG is the same, but the variance estimate differs between the two designs. However, the introduction of an unbalanced design in 2016, where R/V Havfisken made twice the number of hauls compared to each of the chartered trawlers, results in different point estimates between the two estimation methods.

Results

Cod abundance

The trawlable biomass of cod in 2022 was estimated to 453 tons, compared to 286 tons in 2021 and 498 tons in 2020 (Table 1). This corresponds to an increase in biomass with 58% the last year, but is still among the three lowest observations since the survey started in 2008. In fact, with the exception of a dip in 2021 the estimated biomass have been remarkably stable at a very low level for the last five years. The numbers of cod however, seems to be increasing slightly. From the all-time low in 2018 with 0.78 million fish to 2.28 million fish in 2022 (Table 1).

Table 1. Biomass per km^2 and total biomass in tonnes. Numbers per km^2 and total abundance in 1000's.

Year	Biomass (kg/km^2)	Stdev	Biomass (t)	Number/km^2	Stdev	Abundance
2008	102.6	80.2	1047.1	150.5	12.3	1535.8
2009	72.6	71.1	740.5	206.8	14.4	2110.1
2010	69.5	79.7	708.8	203.3	14.3	2074.4
2011	90.5	90.5	923.1	196.3	14	2002.8
2013	211.5	177.4	2158.5	516.5	22.7	5269.9
2014	705.6	1023.7	7200.1	817.1	28.6	8337.6
2015	882.3	1017.7	9002.5	553	23.5	5643.3
2016	429.7	271.3	4385	289.2	17	2951.4
2017	202	175.6	2061.4	342.3	18.5	3492.8
2018	49.9	48.8	509.3	76.9	8.8	784.6
2019	40.1	32	409.1	175.3	13.2	1788.8
2020	48.8	49.3	497.8	179.1	13.4	1827.3
2021	28.1	31.9	286.5	139.2	11.8	1420.5
2022	44.4	43.8	453.2	223.5	14.9	2280.4

Figure 2a presents the annual distribution of large cod (>=25 cm) from 2008-2022, while Figure 2b shows the distribution of small cod (<25 cm). The years 2014 and 2015 stand out in terms of biomass, with quantities significantly higher than the levels before and after. In 2014, there was also the highest abundance in the time series. However, while larger cod appear to be concentrated in the central to southeastern parts of the survey area, younger cod (<25 cm) tend to appear either in the southern or northern parts of the survey area. For example, in 2017 and 2022, there seem to be concentrations of small cod in the south, whereas in 2019 and 2021, most small cod were found in the north. It is necessary to investigate whether these patterns reflect the origin of recruits.

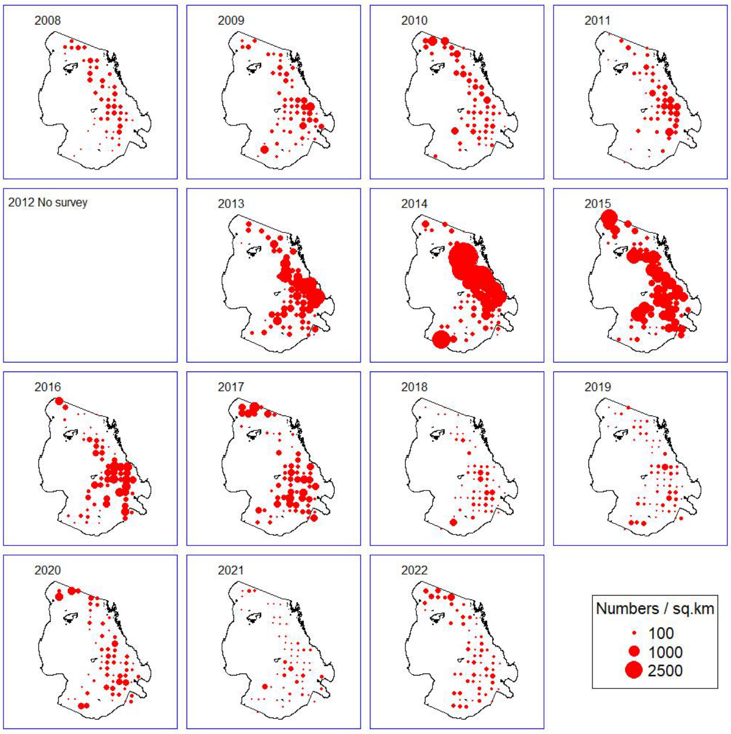

Figure 2a. Abundance of large cod (>=25 cm) calculated as the average number per km2 in each survey square.

Figure 2b. Abundance of small cod (<25 cm) calculated as the average number per km2 in each survey square.

Length distribution

In 2022, the overall length distribution (weighted by stratum area) ranged from 12 to 75 cm with a distinct peak around 20 cm (young of the year cod). The highest densities of small cod were found in the southern low density and the blue strata (Figure 3). Raised length distributions for the entire survey period are shown in figure 4.

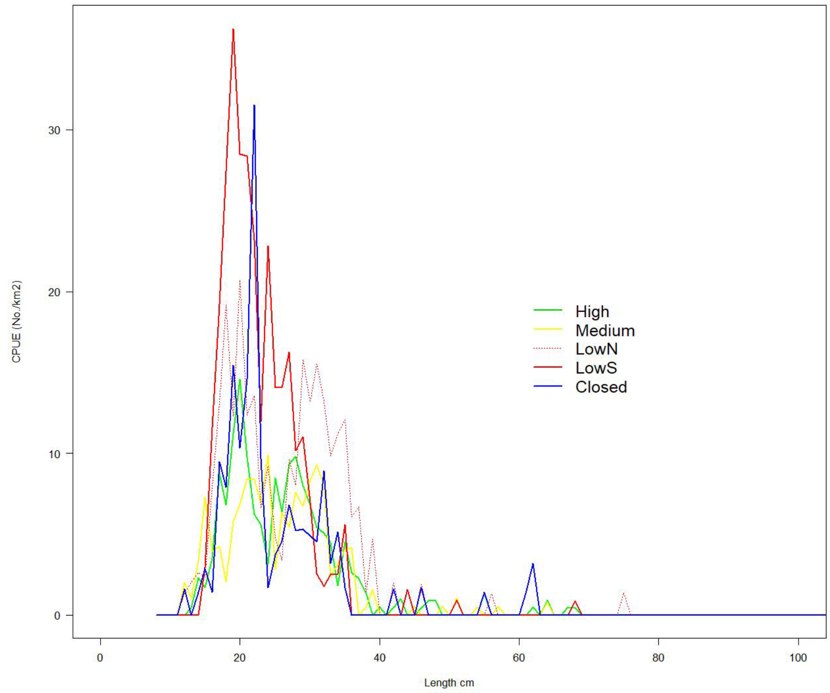

Figure 3. Cod length distribution by strata in 2022.

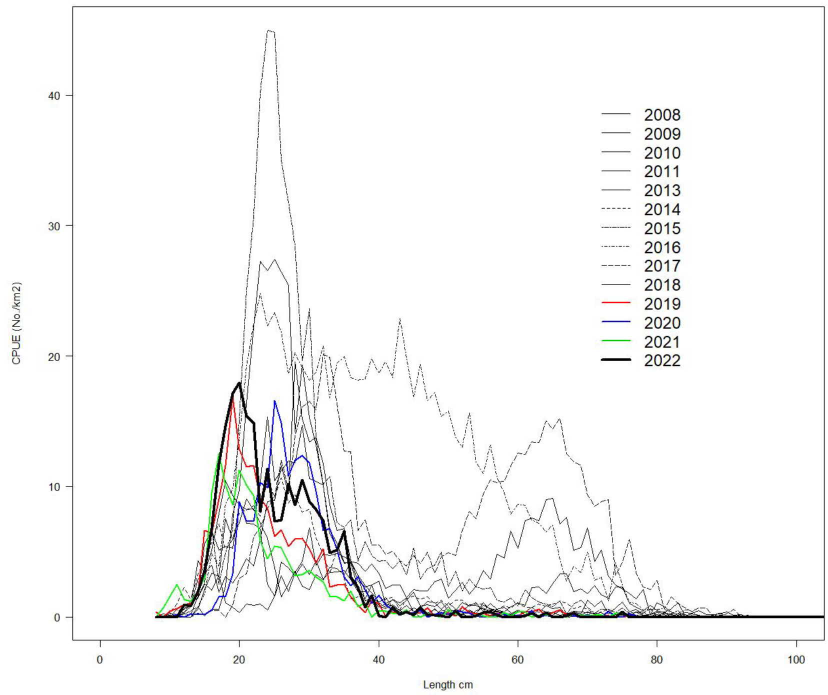

Figure 4. Cod length distribution in the total survey area by year, 2008-2022.

Age distribution

From 2008 to 2013 was the age distribution dominated by age class 1-4. The proportion of older fish (age 5 and 6+) increased in the catches from 2013 and peaked in 2015. Older fish continued to make up a relatively high proportion of the catches during 2016-2017 but decreased in 2018 even though they still made up a significant proportion of the biomass. From 2019 the older fish is virtually absent from the catches, decreasing to zero in 2021 and 2022. The number of recruits (age 0 and 1) which in 2018 was the lowest in the entire time series has increased since 2019 and in 2022 and the number of age 0 cod is the highest observed since the start of the survey (table 2 & 3).

Table 2. Estimated numbers at age (in 1000's) in the survey area by year.

year	a0	a1	a2	a3	a4	a5	a6+
2008	515.7	582.3	247	92.9	59.3	28.8	10
2009	250	1575.9	211	27.1	17.6	20.4	8
2010	230.7	1419.5	398.2	19.9	3.9	2	0.3
2011	397.2	1107.6	313.1	165.3	14.6	3.9	1
2013	170.9	3622.2	1118.9	213.9	99.4	37.3	7.2
2014	527.5	2032.9	3535.6	1673.7	383.9	138.6	45.4
2015	27	1637.2	867.4	1467.2	1216.7	322.2	105.6
2016	338.8	686.1	349.9	301.6	335.4	593.7	346
2017	32	2419.5	509.5	203.3	137.1	96.6	94.8
2018	49.6	193.4	421.9	71.1	15.3	18	15.2
2019	805.3	743.2	167.3	54.1	11.9	5.9	1
2020	192	1512	97.4	1.1	19	2.4	3.4
2021	645.2	647	104	13.8	1.1	9.3	0
2022	962.4	1186.9	111.2	18.2	2.9	0	0

Table 3. Estimated biomass at age (in tonnes) in the survey area by year.

year	a0	a1	a2	a3	a4	a5	a6+
2008	39,81	170,39	184,43	212,99	220,96	150,75	67,75
2009	14,34	378,11	116,5	44,03	53,98	88	45,56
2010	9,98	324,33	299,78	44,87	22,5	6,38	0,97
2011	18,67	202,87	228,75	390,88	58	19,48	4,44
2013	6,69	639,31	721,48	360	238,61	156,08	36,34
2014	37,28	414,5	2568,15	2655,33	924,11	433,65	167,09
2015	1,71	453,57	551,65	3049,57	3322,39	1196,81	426,81
2016	20,62	100,43	245,47	350,47	833,68	1726,13	1108,15
2017	1,42	415,77	165,61	336,2	480,82	327,83	333,8
2018	1,94	29,66	187,47	96,59	47,8	71,82	74,04
2019	48,23	146	68,84	99,88	24	17,55	4,58
2020	14,19	345,44	59,44	2,79	56,47	5,18	14,26
2021	33,89	110,09	66,51	40,18	2,93	32,91	0
2022	62,67	278,3	57,96	46,63	8,93	0	0

Acknowledgments

We would like to express our gratitude to the crews of Havfisken, Tärnan, and Cindy Vester, as well as the dedicated field staff involved in the data collection and age reading. The Swedish participation in the survey 2020-2022 was funded by the Swedish Agency for Water and Marine Management, contract no. 1049-20.

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Annexes

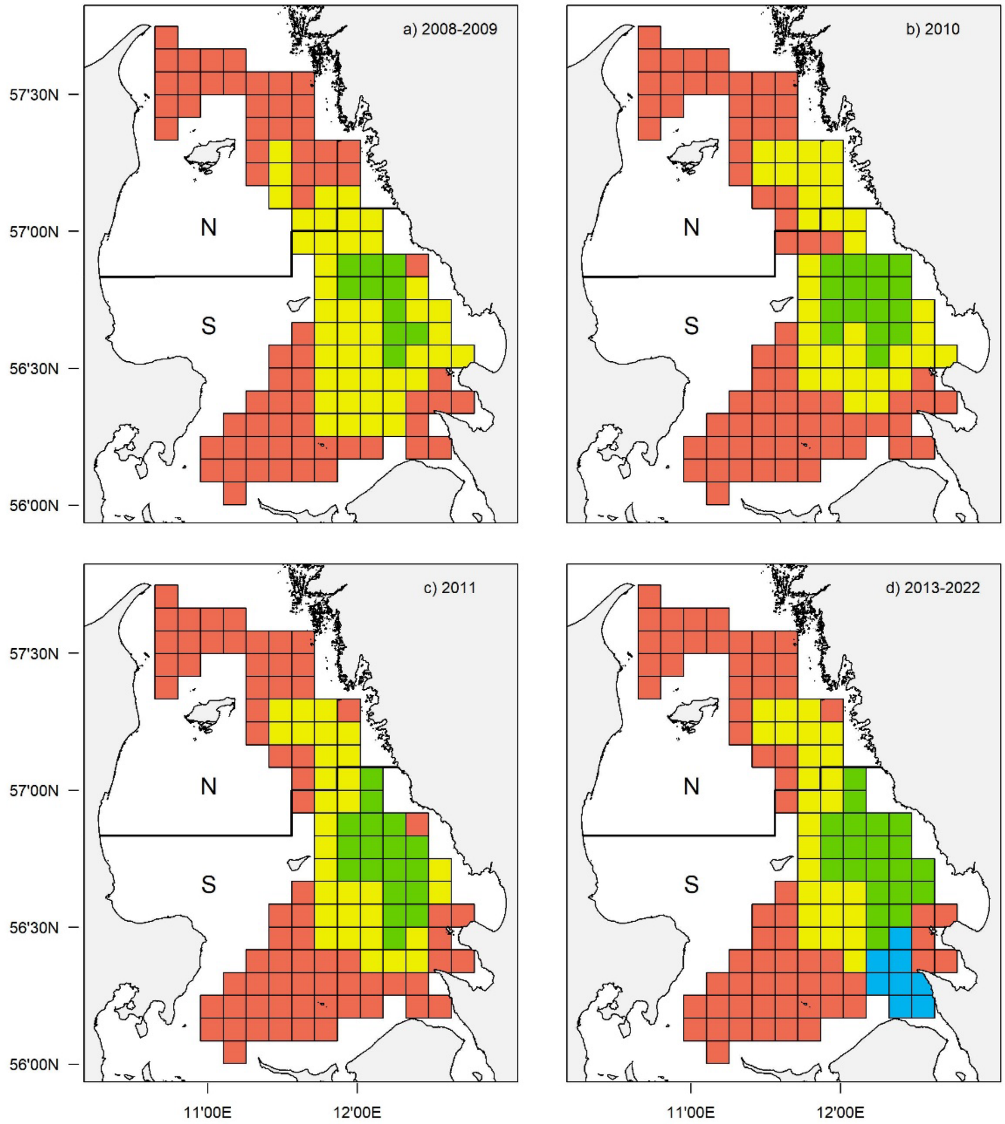
Annex 1. Figure A1 a-d. Survey stratification 2008 – 2023

Annex 1. Table A1. Total number of survey squares by strata and year.

Annex 2. V112 – 24 – 464. The commercial bottom trawl developed in the LOT 3 project.

Annex 3. Calculation of door spread and wing spread

Annex 1. Survey stratification 2008 – 2022

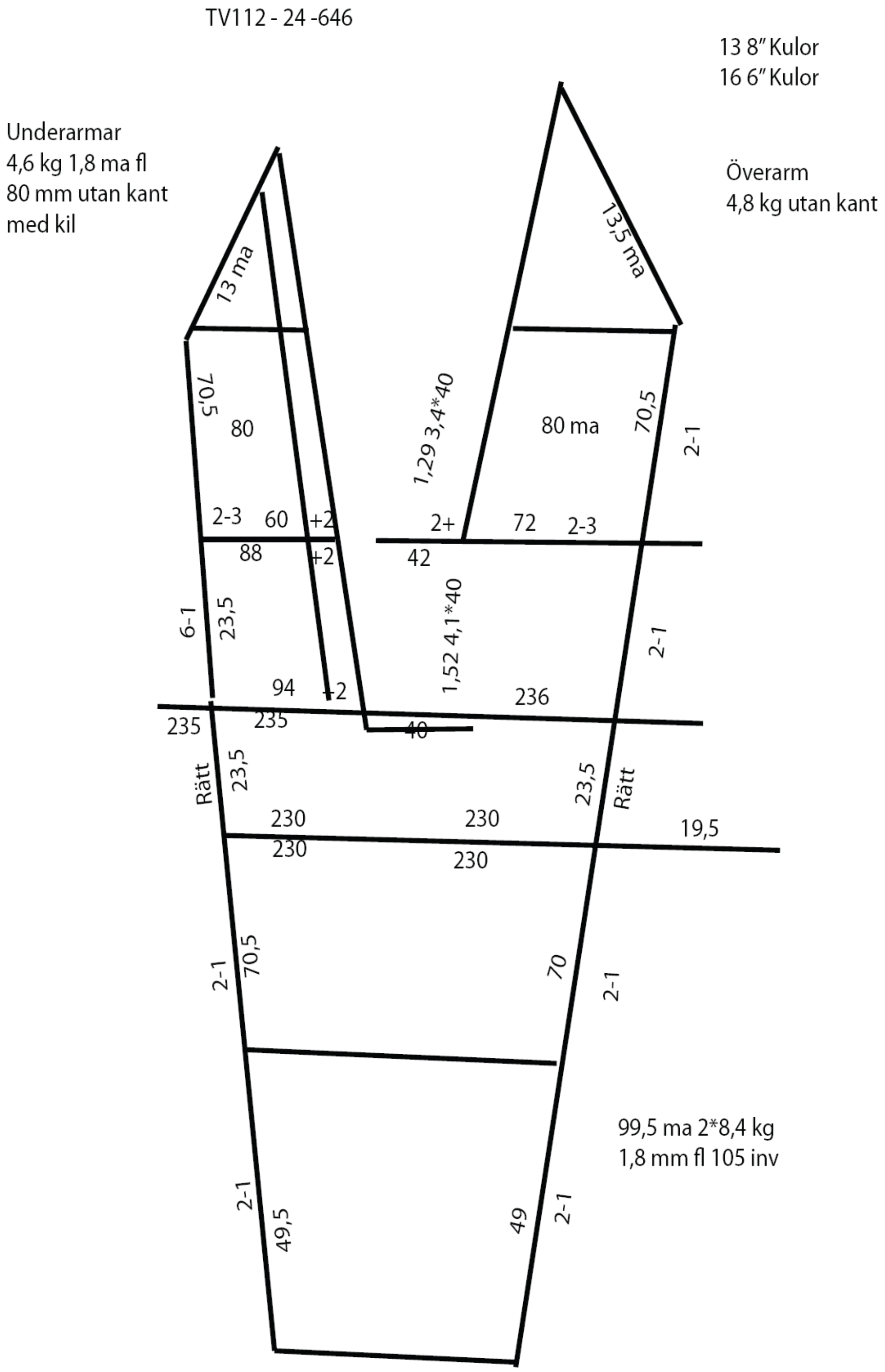


Survey stratification 2008-2022. Green represents the high-density stratum; yellow the medium-density stratum and red the low-density stratum. In 2013 a fourth (blue) stratum was added to ensure sufficient sampling in the closed areas.

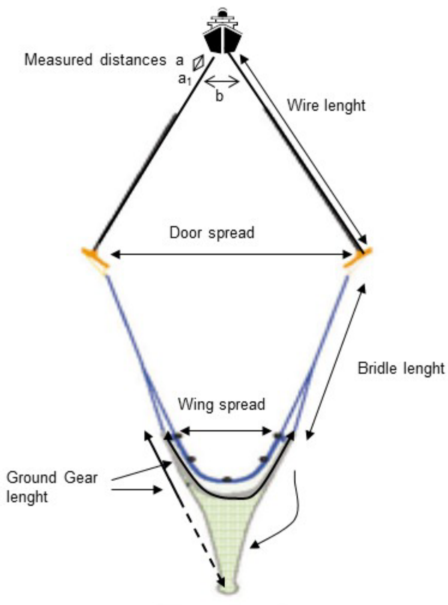
Table A1. Total number of survey squares by strata and year.

Year	High density	Medium density	Low density	Closed area	Total
2008 – 2009	10	44	65		119
2010	15	32	72		119
2011	18	31	70		119
2013 – 2017	21	26	65	8	120
2018 – 2023	21	26	64	8	119

Annex 2. TV112 – 24 – 464. The commercial bottom trawl developed in the LOT 3 project.



Annex 3. Calculation of door spread and wing spread



Calculations of door spread and wing spread

Assuming that the distance between the trawl doors and the wires form an equilateral triangle, the door spread have been calculated as

$$\text{Door spread} = \frac{\text{Wire length} \times \text{measured distance b}}{\text{measured distance a}}$$

For every haul, a length on the wire (distance a) and the length between the wires measured at a_1 (distance b) have been recorded.

Wing spread is estimated as:

$$\text{Wing spread} = \frac{\text{Ground gear length} \times \text{Door spread}}{\text{Bridle length} + \text{Ground gear length}}$$

(Calculation from "Course in Trawl Gear Technology", May 2006, SeaFish Flume Tank, Hull, UK)

NOTE: Figure not according to scale

Annex 7: Ecosystem-Based Fisheries Advice for the Baltic II- (WKEBFABII) – preliminary conclusions and perspective

WKEBFABII participants led by Maciej T. Tomczak, Mikaela Bergenius-Nord, Stefan Neuenfeldt

Please note that work is still ongoing and the information given here may change.

The specific aims of this work were to: (i) develop an F scaling factor (Feco) to tune the long-term Fmsy and, in this way, account for medium-term ecosystem-driven variability in productivity in the ICES advice on fishing opportunities for pelagic stocks (Central Baltic Herring stock – ICES SD 25-29 ex GOR; Baltic Sprat ICES SD 22-32) in the Baltic Sea and (ii) produce drafts of Ecological (and socio-economic) profiles (ESP) of the pelagic stocks in the Baltic. These profiles should identify quantitative indicators/factors for ecological processes that can be used to scale the species-specific Feco.

We developed potential Feco scaling factor(s) and produced very early drafts of Ecological profiles (ESP) of some of the pelagic stocks in the Baltic. Additionally, the results from the project are part of the work of the ICES Baltic Fisheries Assessment Working Group (WGBFAS) and ICES/HELCOM Working Group on Integrated Assessment of the Baltic Sea (WGIAB). Because of international efforts in data collection, mutual interest, and the need for Ecosystem-Based Advice, results and approach will be discussed and further developed at the ICES WGIAB.

Feco, developed by (Howell et al., 2021) for the Irish Sea, is a promising approach for Baltic stocks. However, over this work, we learned that it couldn't be used directly in the same way as in the Irish Sea due to different ecosystem processes and variables controlling ecological processes.

We used the Spawning Stock Biomass (SSB) and recruitment (R1) time series to reflect overall stock productivity. Based on cross-correlations and regression-based GAM models with environmental and ecosystem variables, we identified a suit of the most influential factors. It seems that there is no single factor to describe the productivity of the stocks, and a combination of factors representing different processes works better than only one variable. However, a single factor can also help explain part of stock productivity. The best candidates were biomass of zooplankton (Acartia and Pseudocalanus in spring or summer), Sea Surface Salinity in Summer and Salinity and Temperature at 60m in summer. The sea surface temperature at 60m in summer agreed with findings by (Casini et al., 2006) for the stock-recruitment relationship, but in our analysis, it was not the most influential factor for sprat.

It is also important to recognise that ecosystem scaling factors, such as Pseudocalanus biomass, may lead to misleading conclusions when used at Feco, despite explaining stock productivity well, i.e leading to Feco way below Fmsy lower or at the Fmsy upper depending on assuming top-down or bottom–up control in the food-web. The dynamic of some zooplankton species is driven by clupeids' consumption through top-down control in the ecosystem. That is why it's essential to understand the ecology of the food web and further discuss the results in the broader expert group in the WGIAB before they are applied.

Another question raised during the analyses is the shape of the relationship between stock productivity and environmental variable. For example, the Feco approach used linear scaling for Fmsy, while as given by GAMs, none of the relationships are linear. This suggests the need to modify the Feco approach for the Baltic using non-linear shapes or long-term state and trends (ICES 2017).

In light of using environmental variables as a scaling factor in the long- or midterm, changes in the relationship over time must be considered. STARS results in the five and decade windows show that even if we see influential factors in the long term, about 30 years, for some variables, the time series correlations are different for different periods. An understanding of this is crucial when deciding on the scaling factors. One solution could be to choose the scaling variable with a stable relationship with stock or a subset of data and repeat the analysis for a shorter period i.e. after 1991 (after the regime shift), as suggested by our analysis. That also allows to identify if variables with long-term influence can be used when the ecosystem and stock are in different regimes.

The changes in the interannual relationship it is another issue when choosing the Feco scaling variable. The spatial distributions of the CBH and Sprat stocks have changed significantly over the last years and may differ between years and regions, depending on where the bulk of stock biomass is concentrated. Using spatial distribution modelling (Orio et al., 2017) may help to identify the most influential factors in considering different ecosystem processes in different parts of the Baltic.

While we have in this project identified indicators for stock productivity, and run the Feco type of HCR (as an example) we are not at the application phase yet. To test the Feco HCR/reference points as a fishing opportunity advice use of the Management Strategy Evaluation (MSE) framework is a critical step that needs to be done. Using MSE factors like variability in the Feco HCR and uncertainty in the fisheries assessment (Gårdmark et al., 2011), need to be also taken into account when assessing the risk of applying that into the ICES advisory system. Extending the MSE with the operating model cover food-web as used by (Lucey et al., 2021) will also allow testing zooplankton biomass variables as a scaling factor for Feco in the trophic-control and changing environmental context.

Summary of next steps needed:

While we have in this project identified potential indicators for stock productivity, and run the Feco type of HCR (as an example), we are not at the application phase yet. To test the Feco HCR/reference points as a fishing opportunity advice use of the Management Strategy Evaluation (MSE) framework is a critical step that needs to be done. Using MSE factors like variability in the Feco HCR, and uncertainty in the fisheries assessment (Gårdmark et al., 2011), need to be also considered when assessing the risk of applying that into the ICES advisory system. Extending the MSE with the operating model cover food-web as used by (Lucey et al., 2021) will also allow testing zooplankton biomass variables as a scaling factor for Feco in the trophic-control and changing environmental context.

Analysis to perform and tools to apply for indicator selection and testing environmentally based HCR:

- Analyse broader context of stock productivity in the ecosystem context (see ICES/WGIAB ToRs) for a better understanding of relationships between stocks and the ecosystem i.e. zooplankton
- Regresion models for testing after a regime-shift time period and potential thresholds
- Test STARS for a post-regime period and stability of correlations
- Create and perform full loop MSE procedure for Baltic stocks evaluate Feco and eniviroemnatlly/ecosystem-based HCR to support ICES advice on fishing opportunities
- Support development and application of ecosystem operational models for MSE

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Annex 8: Western Baltic cod (*Gadus morhua*) in Subdivision SD 22-24 category 3 assessment and review

Assessment

WD Downgrading Western Baltic cod stock assessment from category 1 to 3

Marie Storr-Paulsen, DTU Aqua May 2023

Background

The Western Baltic cod category 1 assessment has in later years shown very high F value although there are strong indication from both VMS and effort numbers (days at sea and KWdays) that the fishery has declined significantly (figure 1). In this years assessment the difference between the model estimated catch and the catch derived from the data were more than a factor 6.

Table 1. Difference between SAM estimated catch and SOP catch from data

Total catch estimate (tonnes)			
	SAM estimate	SOP	decrease
2020	5475	4398	20%
2021	3424	2096	39%
2022	3261	508	84%

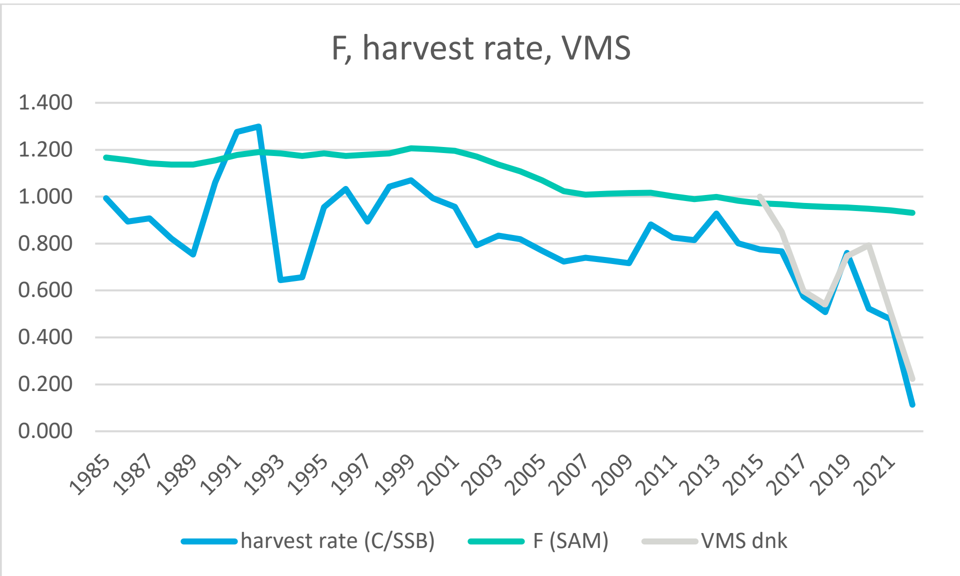

Figure 1. Comparison between harvest rate, F value from the SAM assessment model (WBCod23 in stockassessment.org) and VMS pings from the Danish VMS fishing with bottom trawl in western Baltic Sea. Time series for VMS data and harvest rate have been standardized to the first year shown in the graph.

Further, 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, with SSB subsequently considerably lower than was predicted. Such a pattern suggests that processes other than those captured by catch and assumed natural mortality data are influencing the SSB of the western Baltic cod stock. The sources for the presumably additional mortality are presently unclear but could involve e.g. increased natural mortality (due to increased predation, hypoxia, decreased condition, increased water temperatures and migration towards the eastern Baltic) and unreported catches. However, the effects associated with these drivers are presently not possible to identify and quantify.

As it does not seem to be possible to differentiate between the fishing and natural mortality in the present assessment the assessment working group (WGBFAS) did not trust the F values produced in the assessment and only trusted the SSB and recruitment as relative values to the average of the time series (figure 2). For this reason the assessment working group down scaled the assessment to a category 3 assessment.

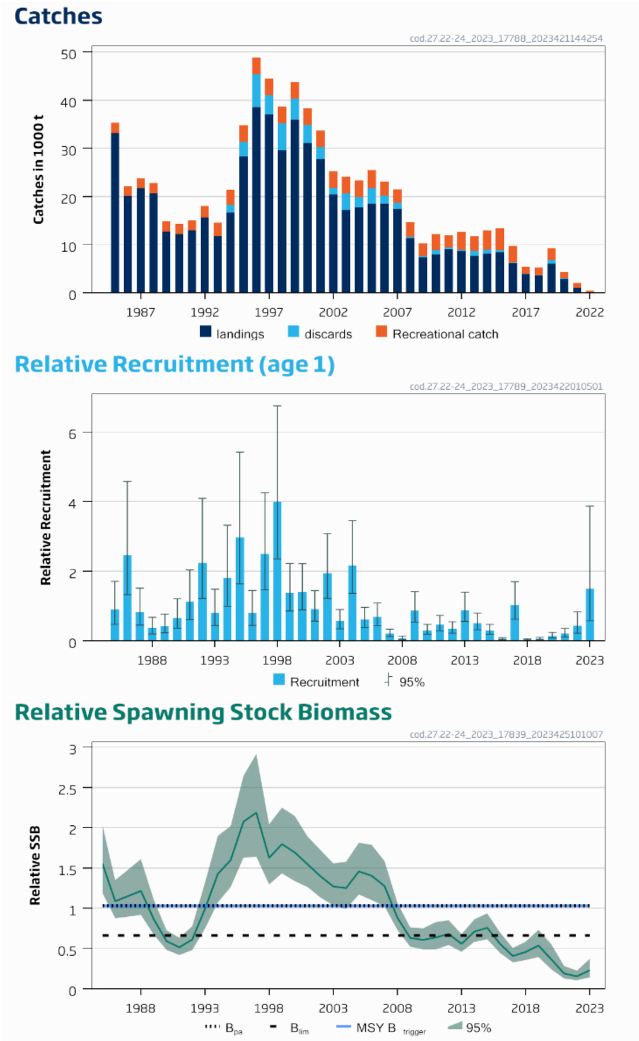

Figure 2. Relative SSB and recruitment from SAM model.

A SPiCT model was tried for the stock and not considered appropriate at the WGBFAS in due to very large CI for the reference points (figure 3).

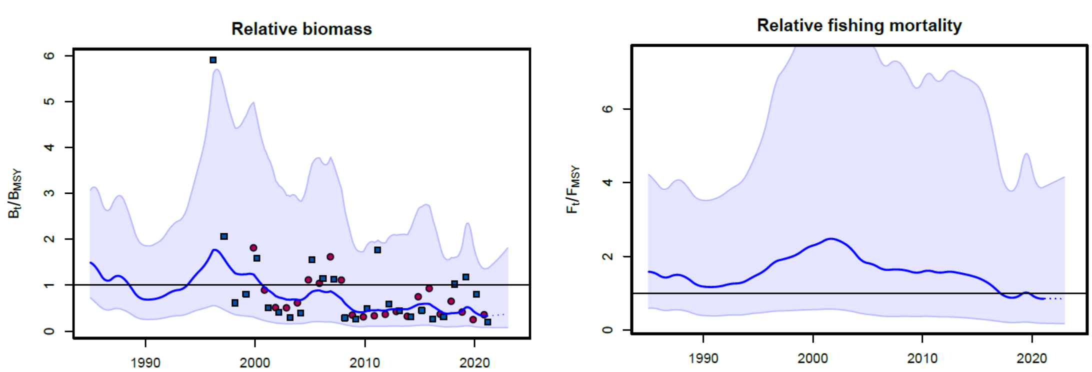

Figure 3. SPiCT model with reference points.

Advice

As length data is presently not available for this stock, 68% of the catches are from the recreational fishery and as one of the assumptions in the method 2 (ICES 2022) is a constant harvest rate, it was decided to give catch advice based on method 3.2 the rb rule. The rb rule is a simpler version of the rfb rule and is meant to cover those cases where length data are not available or insufficient.

The rb rule is defined as:

$C_{y+1} = A_y \times r \times b \times m$

where

C_{y+1} : Catch Advice for next year

r: biomass ratio (in this case based on the relative SSB trend from the SAM assessment)

Ay: Advice in year y. In this case it was replaced by realized catch in 2022 (Cy) since catches have been declining in recent years and the previous advice was based on an estimate of fishing mortality which is now considered unreliable (403 t)

b = (biomass safeguard)

m = 0.5 (multiplier; tuning parameter)

b is in the guideline defined as

Biomass safeguard. Adjustment to reduce catch when the most recent index data I_{y-1} is less than $I_{trigger}$=1.4I_{loss} such that b is set equal to $I_{y-1}/I_{trigger}$. When the most recent index data I_{y-1} is greater than Itrigger, b is set equal to 1. Iloss is generally defined as the lowest observed index value for that stock. Itrigger may need to be adapted if the stock has been exploited only heavily or lightly in the past.

However, as Itrigger is a proxy for Btrigger and this value is available for this stock it was decided to use the Btrigger value (Btrigger = 1.03) as ltrigger

b= 1.03/0.23=0.2233

As b<1, the Stability clause cannot be used.

Year	Relative SSB index
2010	0.61
2011	0.64
2012	0.68
2013	0.56
2014	0.71
2015	0.76
2016	0.56
2017	0.41
2018	0.46
2019	0.54
2020	0.37
2021	0.192
2022	0.156
2023	0.23

Average for 2019-2021=0.367, average for 2022-2023=0.193

r= 0.525

$C_{y+1} = A_y \times r \times b \times m$

403*0.525*0.2233*0.5= 24 t

Advice for 2024= 24 tonnes.

Reference

ICES. 2022. ICES technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3. *In* Report of ICES Advisory Committee, 2022. ICES Advice 2022, Section 16.4.11. https://doi.org/10.17895/ices.advice.19801564

Review

1. **Assessment Type:** Update, inter-benchmarked in 2021
2. **Assessment:** Accept with caveats
3. **Forecast:**

- Forecast is not provided for this stock due to inconsistencies between previously forecasted and subsequently observed stock development.
- No medium or long term was carried out.

4. **Assessment Model:** Category 3, relative SSB trend-based assessment, rb rule

5. **Consistency:**
   - The western Baltic cod stock assessment has been downgraded from a category 1 assessment to a category 3 assessment, wherein only the trends of SSB and recruitment are considered reliable. This downgrading is due to the high level of uncertainty associated with the estimated fishing mortality in the assessment model
   - In the latest years, the reliability in the commercial data was downscaled in the inter-benchmark (to 1/10), mainly due to reduced sampling levels that are linked to very low landing levels and Covid-19 pandemic. However, the limited sampling conducted, influenced by both the Covid-19 pandemic and reduced landings, introduces conflicting information between the survey results and the catch matrix. Specifically, in 2022, it is estimated that 68% of the total catch originated from recreational fishing, which adds further uncertainty due to the absence of logbooks and comprehensive catch reporting mechanisms.
   - The assessment this year is shown in relative terms and therefore it is not directly comparable to last years' assessment.
   - For natural mortality, the Then growth method was used which was decided at the inter-benchmark in June 2021.

6. **Stock Status:**
   - Currently, the stock is at a historical low level, and despite the expected larger size of the incoming 2022 year class in comparison to the year classes of 2017-2021, the overall stock remains critically low.
   - The estimated SSB is below the biological reference point, and the model estimated fishing mortality was considered unreliable due to high uncertainty.

7. **Management Plan:**
   - Catch advice for 2023 was no more than 943t.
   - Catch advice for 2024 is 24 tonnes. The WG recommends zero catches to protect the 2022 year class.
   - Catch shows a decreasing trend in recent years. Catch in 2021 was 2,084t.
   - Biological reference points were re-evaluated in 2022.
   - The stock is currently managed by technical measures, i.e. spawning closure, minimum conservation reference size, fishery prohibition, special regulations for active and passive gear fisheries
   - B_{pa} is considered to correspond to $B_{MSY\ trigger}$.
   - Minimum conservation reference size was 35 cm.
   - In 2022 the recreational fishery bag limit is 0 during the spawning closure and 1 per angler and day in the rest of the year
   - Current biological reference points;

- F_{lim} = 1.23
- F_{pa} = 0.689
- B_{lim} = 15,067t
- B_{pa} = 32,492 t
- B_{pa} is considered to correspond to B_{MSY} trigger.

8. **General Comments:**

- In the advice sheet:

The rb rule was used for catch advice for the Western Baltic cod. In this case, r (biomass ratio) in the function of the rb rule was based on the relative SSB trend from the SAM assessment. The RG suggests the WG to specify the reason for the relative SSB trend used rather than the survey index which is commonly used in the rfb rule.

- In the assessment report:
  - Comparing data between countries becomes challenging due to the use of different units of sampling effort. The RG proposes that the WG assess the potential effects of these differences in national sampling levels on the overall data quality of the international dataset. This evaluation will gain a better understanding of the implications of varying sampling efforts and ensure accurate and reliable comparisons between countries.
  - The RG agrees with the WG's assessment that the SSB is influenced by factors beyond those accounted for in the available data on fisheries catches and assumed natural mortality. To gain a better understanding of these influences, the RG encourages the WG to explore the potential impacts of environmental factors on SSB and recruitment using historical data for analysis.
  - The WG expressed concerns about the reliability of the model-estimated fishing mortality and decided to rely solely on the estimated trends of SSB and recruitment. However, discrepancies between the catch and survey data, as indicated by the residuals, suggested that the model provided inaccurate estimates. Additionally, the model overestimated the number of older fish. Taking these observations into account, the RG advises the WG to conduct a more detailed examination of the residuals to investigate potential factors that contribute to the observed patterns.

9. **Technical Comments**

- Advice sheet Figure 2.: The unit of relative recruitment needs to be added;
- Advice sheet The title of the table can be added to make it clear.
- Assessment report Table 2.3.4: Text is too small to read, color codes (legend) need to be added;
- Assessment report Table 2.3.24 ： The column names need to be added;
- Assessment report Figure 2.3.2 ： The Y-axis title can be added to make the figure easier to understand and read;
- Assessment report Figure 2.3.4b: The abbreviations of X and Y axes need to be specified;

- Assessment report Figures 2.3.9 and 2.3.11: Latitude, longitude and legend need to be added;
- Assessment report Figure 2.3.10: The figure was not provided, only a title was available;
- Assessment report Figures 2.3.13, 2.3.14, 2.3.15, 2.3.17 and 2.3.18: The meaning of the Y-axis needs to be indicated;
- Assessment report Figure 2.3.18: The colors of lines (legend) need to be added;
- There were two figures named Figure 2.3.20 in the assessment report.

10. Conclusions

- The assessment of Western Baltic cod (*Gadus orhua*) in Subareas SD 22–24 seems to be well done.
- The RG recommends accepting the report, contingent upon the provision of additional investigation into the potential factors that contribute to the observed patterns in the residuals.

Annex 9: Feedback on the WGBFAS overviews of the RCG ISSG on catch, sampling and effort overviews

In 2020, WGBFAS made a request/recommendation towards the Regional Coordination Group for the Baltic (RCG Baltic) to access and use some of the RDB fisheries overviews that the RCG Baltic is producing for their annual work. The request was picked up and evaluated during the RCG technical meeting in 2021 it was agreed to use the request as a test case for RCG/ICES WG collaborations. In consultation with the RDBES team, ICES data center and the National correspondents, WGBFAS will be supplied with a data product package each year by the RCG subgroup "ISSG on catch, sampling and effort overviews". The provision of such RDB data products is a pilot study on future collaborations between RCG groups and ICES WGs to test and evaluate how RDB data can be requested, provided and where agreements and exemptions of data policies have to be made. RCG Baltic will evaluate the responses and feedback from WGBFAS during their technical meeting in June 2023.

The data product package comprised of the four Baltic Sea TAC species (i.e. herring, sprat, cod and plaice), each with an identical set of maps, figures and overviews, generated with the most recent RDB data (2022 data) and thus are considered preliminary. The data products can be used in the report or for internal working group discussions to get a better understanding of e.g. fishing intensities, sampling coverage and the importance of different gear types.

WGBFAS is exempted from the RCG and ICES data policy and therefore can use any combination of the figures and maps provided by the RCG Baltic group in their reports; reference and a data disclaimer have to be given however.

Larger changes in the data products need permission by the National correspondents, but smaller changes (such as different scaling, color codes or variable names) can be done intersessional.

Several of the graphs (e.g. annual landings by species and by stock perrectangle; Total landings number of trips sampled for lengths/ages; Annual fishing effort) will be used in the report and have proven very helpful in discussions during the groups meeting in April 2023. WGBFAS will also inquire the possibility to use some of the graphs in the Fisheries overview section (which is managed by WKFOG and thus needs their approval).

The group appreciates the support by the ISSG and requests the provision of a similar document for Baltic Sea flounder and its stocks.

WGBFAS made several suggestions on how to improve the maps and figures:

<u>Landing and effort maps:</u>

- Map titles and labels need improvement and better description

- For herring and sprat: Monthly (instead of quarterly) overviews for landings and effort
- For herring and sprat: Landings: pie-chart per rectangle showing mixing of SPR and HER

Métier overview:

- Should be by species/stock

Sampling intensity and location maps (*large interest to use after correction by WGBFAS*)

- Map titles and labels need improvement and better description
- Adding Management area (or Subdiv borders) to the maps
- Sampling intensity needs to be shown by species or stock (bubbles are now identical between the documents and stocks)
- Instead of GPS coordinate bubbles, aggregate by rectangle?
  - Or combine landings and sample bubbles to a unit sampled/landings or effort (to lose one of the variables and make the maps easier to read, esp. the quarterly maps)

Gear sampling overview (*highly appreciated by WGBFAS*)

- Spell out the gear names for report reader to understand
- Sort gears by importance or landings?
- similar to sampling maps: maybe combine variable to a sampling cpue and reduce variables displayed (only color code for landings vs. sampled)

Annex 10: Additional catch scenario for sole (*Solea solea*) in subdivisions 20–24 (Skagerrak and Kattegat, western Baltic Sea)

For the stock of sole in subdivisions 20-24, EU DGMARE requested ICES to provide an additional scenario with the catch figure which corresponds exactly to the 5.0% probability of the spawning stock biomass to fall below B_{lim} in 2025.

This scenario was produced by the stock assessor based on ICES data sources and approved stock assessment methods as described in the stock annex. The results are available in stock-assessment.org under the run "Sole20-24_2023" and the forecast table number 13.

The additional catch scenario is reported here (Table 1) and corresponds to catches of 124 tonnes in 2024 and an estimated 12.9% increase in SSB in 2025.

Table 1 Sole in subdivisions 20–24. Additional catch scenario. Weights are in tonnes.

Basis	Total catch* (2024)	Projected landings (2024)	Projected discards (2024)	F projected landings (4–8) (2024)	SSB (2025)	% SSB change**	% TAC change^	% advice change^^	%Prob SSB 2025 < Blim
P(SSB(2025)<Blim)=5%	124	120	4	0.059	2540	12.9	-75	-76	5

*** Total catch is calculated based on projected landings and assuming 3.03% discard ratio (in weight).**

**** SSB 2025 relative to SSB 2024.**

^ Total catch in 2024 relative to the TAC in 2023 (498 tonnes in 2023).

^^ Advice value 2024 relative to the advice value 2023 (504 tonnes).