BALTIC FISHERIES ASSESSMENT WORKING GROUP (WGBFAS)

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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 2022 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)
- Flounder in SDs 22–23 (Belt Seas and the Sound; stock status advice)
- Flounder in SDs 24–25 (west of Bornholm and southwestern central Baltic; stock status advice)
- Flounder in SDs 26+28 (east of Gotland and Gulf of Gdansk; stock status advice)
- Flounder in SDs 27+29–32 (northern central and northern Baltic Sea; stock status advice)

The working group fulfilled the ToRs in assessing the stock status and produced a draft advice, including where relevant, forecasts for fishing opportunities, for all of the stocks with one exception. The assessment for the Cod in SDs 22–24 (western Baltic) was accepted by the group but not the forecast, due to inconsistencies between previously forecasted and subsequent observed stock development. The assessment of plaice in SDs 24-32 was conducted using the surplus production model SPiCT, according to the methods recommended by WKLIFE X, moving the stock from a data category 3 to a category 2. The assessment was externally reviewed after the WG. The assessment of flounder in SDs 27+29–32 used revised parameters for the length based indicators. This work was externally reviewed after the Working Group (WG).

The WG was not requested to produce an advice for Dab, Turbot and Brill in SDs 22–32 (Baltic Sea). 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. WGBFAS also completed the productivity audit for most stocks, which aims to list the ways in which ecosystem trends and variability are accounted for in each stock assessment, forecast, and reference point or management plan evaluation. The analytical models used for the stock assessments were XSA, SAM and SS3. For most flatfish (data limited stocks), CPUE trends from bottom-trawl surveys were used in the assessment (except plaice in SDs 24–25 for which SPiCT was used).

ii Expert group information

Expert group name	Baltic Fisheries Assessment Working Group (WGBFAS)
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chairs	Mikaela Bergenius Nord, Sweden
	Kristiina Hommik, Estonia
Meeting venue and dates	20-27 April 2022, Rostock, Germany

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

1.2.1 Ecosystem Overview

WGBFAS was asked to consider and comment on 'Baltic Sea Ecoregion – Ecosystem overview' (2021). Some remarks:

Page 9, Figure 9. In the subtitle it is said: 'BIAS survey does not cover the Gulf of Bothnia or the Bothnian Sea.'. However, BIAS survey has covered the Bothnian Sea every year since 2007. In several years, though, herring results from BIAS in the Bothnian Sea were missing from this graph.

Page 18, grey seal: Number of grey seals in the Baltic Sea. Source: web pages of the Natural Resources Institute Finland (in Finnish: https://www.luke.fi/fi/seurannat/merihyljelaskennat-ja-hyljekannan-rakenteen-seuranta/merihyljekantojen-2021-tulokset, published 2021 Nov. 8th). In 2021, 42 000 specimens of grey seals were observed in the Baltic Sea from flights in the moulting time. In addition, there is typically a varying number of specimens that are in the sea and are thus not seen in these countings, due to which the published number is a minimum estimate. The population has increased on average 5 % per year since 2003. The fastest growth during the past 10 years has taken place in the Archipelago Sea and the southern Baltic Sea.

1.2.2 Fisheries Overview

WGBFAS was asked to consider and comment on 'Baltic Sea Ecoregion – Fisheries overview' (2021). Some remarks:

A suggestion: It would clarify the text and figures, if e.g. in Figure 7 it would be added something like below, as the number of species regarded here demersal and benthic is so low in the Baltic Sea.

Left panel (a): Discard rates in 2016–2020 by fish category, shown as percentages (%) of the total annual catch in that category (here benthic species = flatfishes, demersal species = cod). Middle panel (b): Landings (green) and discards (orange) in 2020 by fish category (in thousand tonnes) only of those stocks with recorded discards. Right panel (c): Landings (green) and discards (orange) in 2020 by fish category (in thousand tonnes) of all stocks. (Note that not all stock catches are disaggregated between landings and discards).

As there is no essential targeted fishery on eastern cod stock, this could be updated.

Page 24: Number of grey seals in the Baltic Sea. Source: web pages of the Natural Resources Institute Finland (in Finnish: https://www.luke.fi/fi/seurannat/merihyljelaskennat-ja-hyljekannan-rakenteen-seuranta/merihyljekantojen-2021-tulokset, published 2021 Nov. 8th). In 2021, 42 000 specimens of grey seals were observed in the Baltic Sea from flights in the moulting time.

In addition, there is typically a varying number of specimens that are in the sea and are thus not seen in these countings, due to which the published number is a minimum estimate. The population has increased on average 5% per year since 2003. The fastest growth during the past 10 years has taken place in the Archipelago Sea and the southern Baltic Sea.

Page 25, *Contracaecum osculatum*: Observations from SD29, the Åland Sea show that on the basis of counting *Contracaecum osculatum* on the surfaces of the livers of the cod, *Contracaecum* are abundant in this area, as well, but as the cod here grow to large sizes (they probably grow fast and similarly do liver volumes), the accumulation of *Contracaecum* into the livers is probably not as severe as in the southern parts of the Baltic Sea, and the cod are in good condition (Raitaniemi & Leskelä, 2021).

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

No stocks within the working group were benchmarked in 2022. For 2023 several pelagic stocks in the Baltic are scheduled to be benchmarked (WKBALTPEL) as tabulated below.

For 2024 or later sole in 20-24, plaice in 21-23, plaice in 24-32 and brill are the candidates for benchmark processes. The main issues to be solved under these coming benchmarks and the associated aimed stock category is given below in the table. The brill benchmark needs coordination with North Sea brill benchmark.

Ageing issues of plaice and flounder will be solved in parallel of any benchmarks scheduled here and evaluated for a potential future benchmark.

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.

Stock	Year for benchmark	Issues	Present/aimed category
Herring in SDs 25-29 and 32, excluding the Gulf of Riga	2023	Mixing of Western Baltic spring spawners and CBH components in SD 24–26 Additional tuning indices Move to SS3 from XSA Catch misreporting Spatial assessment to be developed	1/1
Herring in SD 28.1 (Gulf of Riga)	2023	Stock ID: Separation of herring stocks based on otolith macrostructure Tuning indices Moving from XSA to SAM.	1/1
Sprat in SDs 22-32	2023	Update SMS model and M values Misreporting of herring and sprat Moving from XSA to SAM.	1/1
Plaice 21-23	2024	Use of mean values from the available time-series for biological parameters in the model fit. Explore time-variant options in SAM or using sliding window average of most recent data. Use of full time-series median R values in short-term forecast. Consider method sensitivity to large fluctuations in R –	1/1

Stock	Year for benchmark	Issues	Present/aimed category
		Alternate methods than resampling entire series (e.g. time weighting more recent years)? Physical conditions (eg temperature and basin hypoxia) impact upon assessment input data – can variation be accounted for? Stock structure/identity. Connectivity within (SD21 vs 22/23) and between existing stocks (e.g. Skagerrak & ple.27.24-32) and these stock boundaries relative to management boundaries. If plaice stocks are merged – need to consider impact of merging input data.	
Plaice 24-32	2024	Stock structure and stock ID Age reading, age validation Establish Maturity at age Review Survey index and survey parameter	2/1
Brill 22-32	2024	Stock structure; connectivit to North Sea stock; genetic evidence Use of the BITS survey as biomass indicator Use of commercial indices (as applied in the North Sea, using the Dutch beam trawlers)	3/3
Sole 20-24	2024	Stock structure; connectivity to North Sea stock Establish Stock weight at age; survey info Establish Maturity at age; landing sample info Include biomass index from extended survey area since 2016	1/1

1.4 Prepare the data calls for the next year update assessment and for a planned data evaluation workshop

The WGBFAS section of the data call was reviewed, and the following changes were made:

Since there is a rounding issue in InterCatch regarding the field "Official landings", it was decided to request catch data to be uploaded in kilogrammes. The reason was that when data is submitted in tonnes, the official landings get rounded to the nearest ton, which is not always sufficient for BMS landings and logbook registered discards.

In addition, a request to submit number of samples to InterCatch was added to the WGBFAS section 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.

Responsible persons for updating stock research needs/issue list during WGBFAS 2022:

Fish Stock	Stock Coordinator	Assessment Coordinator
bll.27.22-23	Stefan Neuenfeldt	Stefan Neuenfeldt
dab.27.22-32	Sven Stötera	Sven Stötera
tur.27.22-32	Sven Stötera	Sven Stötera
cod.27.21	Francesca Vitale	Johan Lövgren
cod.27.22-24	Uwe Krumme	Marie Storr-Paulsen
cod.27.24-32	Sofia Carlshamre	Margit Eero
sol.27.22-24	Jesper Boje	Jesper Boje
ple.27.21-23	Elliot Brown	Elliot Brown
ple.27.24-32	Sven Stötera	Sven Stötera
fle.27.2223	Sven Stötera	Sven Stötera
bzq.27.2425	Zuzanna Mirny	Zuzanna Mirny
bzq.27.2628	Didzis Ustups	Didzis Ustups
bwp.2729-32	Kristiina Hommik	Kristiina Hommik
Her.27.2527-32	Julita Gutkowska/Szymon Smolinski	Mikaela Bergenius Nord
Her.27.28	Maris Plikshs	Tiit Raid
Her.27.3031	Jukka Pönni	David Gilljam
spr.27.22-32	Olavi Kaljuste	Jan Horbowy

STOCK	BRILL SD 22-32					
Stock coordinator	Stefan Neuenfeldt		**Last benchmark**	-		
Stock assessor	Stefan Neuenfeldt		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Stock identity	At the edge of its distributional area, with the center of gravity being positioned in Kattegat (ICES Subdivision 21). Survey CPUE are very low in the Western Baltic, and 0 in the Eastern Baltic Sea. Hence, the BITS surey is possible not representative.	Production of a working document for SIMWG to review. Check survey time-series for geographic distribution and representativity.	BITS data are available. Need to check for possibility of a commercial index as applied for the North Sea.			

STOCK	DAB SD 22-32					
Stock coordinator	Sven Stötera		**Last benchmark**	2014 (ICES 2014)		
Stock assessor	Sven Stötera		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Biological parameter	Young fish are poorly covered covered/caught by BITS, high uncertainty in biological parameters (used for LBI, e.g. Lmat, Linf)	Better coverage of younger age classes/smaller dab in the survey	Biological data (age. Length, sex, maturity) from smaller/younger dab	WGBIFS	Starting with the next BITS (autumn 2019)	Low
Survey data quality	Units in the HL and CA differ, working with DATRAS data requires beforehand corrections	A unified scale would be beneficial, e.g. for length units, maturity scales and weights	DATRAS database	WGBIFS	To be discussed at the next WGBIFS in 2020?	Medium
Stock identity	At the edge of its distributional area, with the center of gravity being positioned in Kattegat (ICES Subdivision 21). Survey CPUE low in SD25 and 0 further east	Production of a working document for SIMWG to review	Data to produce a combined survey index for dab; update on dab distribution for demersal surveys in Kattegat and Western/Southern Baltic Sea		Before 2023	High
Age reading	Collect age-validated otoliths to improve accuracy	Mark-recapture study involving chemical tagging of otoliths	Age-validated otoliths of juvenile and adult dab		ongoing	medium
Age reading	Improve precision of the age reading based on age-validated material	Exchange of otolith images		Otolith exchange workshop		medium
Age reading	Different methods used for otolith preparation	Assess if method can be standardized (whole and reflecting light; sliced and transmitted light)				medium

Age reading	Assess quality of commercial and survey age data	National checks, otolith exchange and corrections of national age data and DATRAS	Results from national quality checks		Before next benchmark	medium

STOCK	TURBOT SD 22-32					
Stock coordinator	Sven Stötera		**Last benchmark**	-		
Stock assessor	Sven Stötera		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Biological parameter	Young fish are poorly covered covered/caught by BITS, high uncertainty in biological parameters (used for LBI, e.g. Lmat, Linf)	Better coverage of younger age classes/smaller turbot in the survey	Biological data (age. Length, sex, maturity) from smaller/younger turbot; alternative abundance index (e.g. of juveniles)	WGBIFS	Starting with the next BITS (autumn 2019)	Low
Survey data quality	Units in the HL and CA differ, working with DATRAS data requires beforehand corrections	A unified scale would be beneficial, e.g. for length units, maturity scales and weights	DATRAS database	WGBIFS	To be discussed at the next WGBIFS in 2020?	Medium
Commercial data	Discard estimates	Improved sampling	Better coverage of catches			Medium
Biological parameter	Young fish are poorly covered covered/caught by BITS, high uncertainty in biological parameters (used for LBI, e.g. Lmat, Linf), alternative surveys should be investigated for their use in assessing this fraction of the stocks	Better coverage of very small turbot, giving first signals of e.g. incoming yearclass strength and body condition	Thünen OF is conducting a young fish survey at different locations for several years that could be evaluated and considered	Thünen OF	Before next benchmark	Medium
Age	Standardize otolith preparation method	Tests and agree on joined method between labs	Results from otoliths exchanges		Before 2023	medium
Age	Improve precision and accuracy of age reading	Conduct otolith exchange workshops and agree on a common approach; carry out age validation studies	Results from otolith exchanges; recaptures of chemically marked wild fish		Age validation of adults ongoing	medium

Age	Quality of commercial and survey age data	National checks, otolith exchange and corrections of national age data and DATRAS	Results from national quality checks		Before next benchmark	Low
Assessment approach	Change from landing to catch advice	Improve discard data				

STOCK	**COD SD 21 (COD IN KATTEGAT)**					
Stock coordinator	Francesca Vitale		**Last benchmark**	2017 (ICES 2017)		
Stock assessor	Johan Lövgren		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Stock id	Data on the proportion of North Sea cod in the Kattegat.	Analyses of data sampled in future surveys and analyses of otoliths from historical records.	National institutes, Danish /Swedish	WGBFAS	In progress	High
Natural mortality	What is the impact of the seal population on the cod stock in Kattegat?	Analyses and sampling of seal diet data Investigate models to estimate natural mortality	National institutes, Danish /Swedish	WGBFAS	In progress	Medium
Assessment model	Formulation of a Stock Synthesis model (SS3).	Modelling	National institutes, Danish/ Swedish	WGBFAS	In progress	Medium

STOCK	**COD SD 22-24 (WESTERN BALTIC COD)**					
Stock coordinator	Uwe Krumme		**Last benchmark**	Inter-benchmarked in 2021		
Stock assessor	Marie Storr-Paulsen		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Natural mortality	Has been updated at the IB in 2021 as a constant for the whole time-series. However, other causes for natural mortality would be beneficial to investigate.	Alternative causes for natural mortality than the present investigated (cormorants, seals, hypoxia, condition)	Data on seal or cormorant population and other predators, consumption, distribution etc; data on relationships between cod mortality and a hypoxic areas	Data available	Before next benchmark	High
Sampling	Port Catch sampling	Data on the number of sampled boxes by size sorting category and stratum	Compile a time-series and provide it to the RDBES		Before next benchmark	Medium
Survey	Quarter 4 survey – shift in catchability	Maybe due the increased warming in sea temperature and/ or lack of oxygen at the bottom, the cod has shifted distribution at the time for the quarter 4 survey	Oxygen and temperature data from the survey should be analysed	WGBIFS, national institutes	Before next WG	High
Mixing	Sampling in area 1 and area 2 in SD24	Improve and document improved coverage	Better coverage of area 1		Before next benchmark	Medium

Age reading	Improve precision of the age reading based on age-validated material	Regular reports by GER from BITS Q1 and Q4 to DNK and SWE Regular exchange of Q1 age reading results from commercial samples each summer between DNK, SWE and GER Regular exchange of otolith images	Has been conducted on an annual basis since 2019		ongoing	
Age reading	Different methods used for otolith preparation	DNK and GER use slicing while SWE is still reading broken otoliths	SWE to consider applying also slicing and images using transmitted light		ongoing	
Effort data / commercial CPUE	Present model F is very large, to ensure an alternative data source effort should be investigated	Look into Effort data; assess changes in effort and catches of the Danish and German rockhopper fishery during peak summer in SD22 (e.g. using size sorting categories); and commercial CPUE	No need data is needed		Before next benchmark	High
Management measures	Since 2016 spawning closures changed in space and time every year; in addition, measures on Eastern Baltic cod affect the fishing in SD24 since 2019. Overall, this has changed the fishing pattern	Look into fishing reallocation due to management changes.	No need data is needed		Before next benchmark	Medium

Maturity	Proportion of skip spawners in shallow water (i.e. areas shallower than 20 or 15 m water depth not covered by BITS Q1) and interannual changes in the proportion of skip spawners in shallow water during the spawning season are unknown. This could significantly influence the long-term perception of the proportion of spawning individuals from the survey (see considerations from the Interbenchmark report WBPWEB 2021)	Locate relevant data and conduct relevant studies	Data from shallow-water areas during spawning seasons	National institutes	Before next benchmark	Medium

STOCK	**COD SD 24–32 (EASTERN BALTIC COD)**					
Stock coordinator	Sofia Carlshamre		**Last benchmark**	2019 (ICES 2019b)		
Stock assessor	Margit Eero		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Growth	Validated quantitative information on growth in recent years and in future	New method for growth monitoring in future (e.g. based on otolith microchemistry)	TABACOD project results and follow-up scientific developments.	Establish a method for future growth monitoring using otolith micro-chemistry; and thereafter identify sampling and other working procedures to enable implementation of this method in stock assessment.	Some years	high
Ageing error	Age error matrix	Developing an age-error matrix to account for past uncertainties in age information in Stock Synthesis model	Past otolith exchanges plus tagging information	Develop age error matirx	Some years	medium
Sample sizes	Sample size information associated with length distributions of commercial catches	The input to Stock Synthesis model could be improved, if a meaningful measure representing sample size of combined international commercial data could be developed.			unknown	medium/low

STOCK	SOLE SD 20-24					
Stock coordinator	Jesper Boje		Last benchmark	2015 IBP (ICES 2015a)		
Stock assessor	Jesper Boje		Stock category	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Stock identity	Validation of stock entity and connectivity to adjacent stocks (North Sea)	Genetics	Genetic samples Div 4, SD20-21/collaboration with NS surveys/labs	DTU Aqua genetic lab	ongoing	high
		Otolith trace elements	Otoliths from annual sampling	DTU Aqua	Not yet initialized	low
		Tagging	Conventional tagging program	DTU Aqua	Not yet initialized	medium
		Egg/Larvae drift modelling	Biological and hydrographic data	DTU Aqua	2021-23	medium
		Identification of nursery grounds	Sampling from potential grounds		ongoing	medium
WEST	Establishment of stock weight at age	Data compilation	Sole survey	Compilation work	Benchmark 23	high
MAT	Establishment of maturity at age	Data compilation	Fishery sampling	Compilation work	Benchmark 23	high
Survey	Include expanded areas 2017-2020 in biomass index from survey	Deep thoughts	Data available	Compilation work	Benchmark 23	high

STOCK	**PLAICE SD 21-23**		
Stock coordinator	Elliot Brown	**Last benchmark**	2015 (ICES 2015b) (reviewed in 2019)
Stock assessor	Elliot Brown	**Stock category**	1

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Stock identification	How many stocks are there in the Baltic Sea?	Provide results from genetic analyses to SIMWG for review	Genetic samples		Analyses done, paper in review	High
Environmentally driven connectivity	Is there adult mediated connectivity between subareas? Under what conditions are adults more likely to move from one area to another?	Combined genetics and otolith chemistry, or large tag recapture studies	Independent Research Projects / Collaborative transnational research projects			medium
Environmentally driven connectivity	Recruitment may not be coherent across the whole stock area. Under what conditions does each area contribute more or less to the recruitment of themselves and neighbouring areas?	Combined genetics and otolith chemistry studies.	Independent Research Projects / Collaborative transnational research projects			medium
Use of long-term averages in biological parameters for assessment model	The stock annex specifies the use of mean values from the entire time-series of observations in short-term forecasts for stock weight at age and maturity ogives. This reduces the assessment's ability to adapt to changes in stock attributes, whether they are intrinsic, fisheries driven or environmentally driven.	Investigate better methods for estimating biological parameters for short-term forecasts	Model development and or method comparisons	Investigate new SAM model features. Investigate sliding window means. Investigate mechanisms for any changes	Ongoing, implementation of findings for a benchmark	high

Environmental Variation in Survey Indices	Physical conditions such as oxygen, temperature and salinity conditions influence fish distributions. The variability of these parameters in areas where survey hauls are undertaken may lead to survey indices being more or less representative of the stock composition	Investigate the effect of environmental conditions during surveys on variation in survey indices and resultant assessments	Reliable CTD data from surveys, combined with other raw environmental data and hydrographic model output. Independent observations of changes in fish distribution corresponding to survey times.	Feedback and collaboration with ongoing project in Denmark (HypCatch)	2021-2022	high
Age reading	Collect age-validated otoliths to improve acccuracy	Mark-recapture study involving chemical tagging of otoliths	Age-validated otoliths of juvenile and adult plaice		ongoing	
	Improve precision of the age reading based on age-validated material	Exchange of otolith images		Otolith exchange workshop	Once age reading is validated	
	Different methods used for otolith preparation	Assess if method can be standardized (whole and reflecting light; sliced and transmitted light)				
	Quality of commercial and survey age data	National checks, otolith exchange and corrections of national age data and DATRAS	Results from national quality checks		Before next benchmark	medium

STOCK	**PLAICE SD 24-32**		
Stock coordinator	Sven Stötera	**Last benchmark**	2015 (ICES 2015b)
Stock assessor	Sven Stötera	**Stock category**	3

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Stock identification	How many stocks are there in the Baltic Sea?	Provide results from genetic analyses to SIMWG for review	Genetic samples		Analyses done, paper in review	High
Stock identification	Improve knowledge of seasonal and annual migration of plaice in the Baltic, explore possible stock mixing	Tagging experiments, including western and eastern stock	Recaptures of tagged fish		Starting in 2019	
Age reading	Collect age-validated otoliths to improve accuracy	Mark-recapture study involving chemical tagging of otoliths	Age-validated otoliths of juvenile and adult plaice		ongoing	
Age reading	Improve precision of the age reading based on age-validated material	Exchange of otolith images		Otolith exchange workshop	Once age reading is validated	
Age reading	Different methods used for otolith preparation	Assess if method can be standardized (whole and reflecting light; sliced and transmitted light)				
Age reading	Quality of commercial and survey age data	National checks, otolith exchange and corrections of national age data and DATRAS	Results from national quality checks		Before next benchmark	medium

STOCK	Flounder SD 22-23		
Stock coordinator	Sven Stötera	**Last benchmark**	2014 (ICES 2014)
Stock assessor	Sven Stötera	**Stock category**	3

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed / are these available / where should these come from?	Research/ WG input needed	Time-frame	Priority
Biological parameter	Young fish are poorly covered covered/caught by BITS, high uncertainty in biological parameters (used for LBI, e.g. Lmat, Linf)	Better coverage of younger age classes/smaller flounder in the survey	Biological data (age. Length, sex, maturity) from smaller/younger flounder	WGBIFS	Starting with the next BITS (autumn 2019)	Low
Survey data quality	Units in the HL and CA differ, working with DATRAS data requires beforehand corrections	A unified scale would be beneficial, e.g. for length units, maturity scales and weights	DATRAS database	WGBIFS	To be discussed at the next WGBIFS in 2020?	Medium
Age reading	Collect age-validated otoliths to improve accuracy	Mark-recapture study involving chemical tagging of otoliths	Age-validated otoliths of juvenile and adult flounder		ongoing	
Age reading	Improve precision of the age reading based on age-validated material	Exchange of otolith images		Otolith exchange workshop	Once age reading is validated	
Age reading	Different methods used for otolith preparation	Assess if method can be standardized (whole and reflecting light; sliced and transmitted light)				
Age reading	Quality of commercial and survey age data	National checks, otolith exchange and corrections of national age data and DATRAS	Results from national quality checks		Before next benchmark	medium

<table>
<tr><td colspan="2">STOCK</td><td colspan="5">Flounder SD 24-25</td></tr>
<tr><td colspan="2">Stock coordinator</td><td colspan="2">Zuzanna Mirny</td><td>Last bench-mark</td><td colspan="2">2014 (ICES 2014)</td></tr>
<tr><td colspan="2">Stock assessor</td><td colspan="2">Zuzanna Mirny</td><td>Stock category</td><td colspan="2">3</td></tr>
<tr><td>Issue</td><td>Problem/Aim</td><td>Work needed / possible direction of solution</td><td>Data needed / are these available / where should these come from?</td><td>Research/ WG input needed</td><td>Time-frame</td><td>Priority</td></tr>
<tr><td>Stock identity</td><td>Newly described Baltic flounder species share this stock (approx. 20%). It is not possible at this stage to separate the proportion of this species in either stock assessment or fisheries.</td><td>Genetic sampling</td><td>from commercial samples</td><td></td><td></td><td>Medium</td></tr>
<tr><td>Age reading</td><td>Collect age-validated otoliths to improve accuracy</td><td>Mark-recapture study involving chemical tagging of otoliths</td><td>Age-validated otoliths of juvenile and adult flounder</td><td></td><td>ongoing</td><td></td></tr>
<tr><td>Age reading</td><td>Improve precision of the age reading based on age-validated material</td><td>Exchange of otolith images including marked otoliths</td><td>Otoliths from mark-recapture study should be soon available</td><td>Otolith exchange workshop</td><td>Once validated material is available</td><td></td></tr>
<tr><td>Age reading</td><td>Quality of commercial and survey age data</td><td>National checks, otolith exchange and corrections of national age data and DATRAS</td><td>Results from national quality checks</td><td></td><td>Before next benchmark</td><td>medium</td></tr>
<tr><td>Commertial landings</td><td>Abnormally high flounder bycatch in oddicual pelagic trawlers landings</td><td>Verification of those data -</td><td></td><td></td><td>Before the next WG</td><td>High</td></tr>
</table>

STOCK	Flounder SD 26+28					
Stock coordinator	Didzis Ustups		**Last bench-mark**	2014 (ICES 2014)		
Stock assessor	Didzis Ustups		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Stock identity	Newly described Baltic flounder species share this stock (approx. 55%). It is not possible at this stage to separate the proportion of this species in either stock assessment or fisheries.	Genetic sampling	from commercial samples			**High**
	Newly described Baltic flounder species share this stock (approx. 55%). It is not possible at this stage to separate the proportion of this species in either stock assessment or fisheries.	Morphologic measurements to find the way to separate two species without genetic analyses	**Surveys/commercial**			**High**
Age reading	Improve precision of the age reading based on age-validated material to estimate reference points for the stock	Exchange of otolith images	**Surveys**	Otolith exchange	After age validated otoliths are available	**Medium**
Commercial data	Discard estimates	Improved sampling	Better coverage of catches			Medium

STOCK	**Flounder SD 27, 29-32**					
Stock coordinator	Kristiina Hommik	**Last benchmark**	2014 (ICES 2014)			
Stock assessor	Kristiina Hommik	**Stock category**	3			
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Stock ID	Two species in this management area	Genetic analysis	Data from commercial samples			Low
Fishing effort	Fishing effort for Estonia passive gears is missing	Quantifying the effort, as exact data is available only partially	Data is partially available from Estonian ministry		Ongoing	Medium
Age/length data from commercial fishery (gillnets)	Data missing from commercial gillnetters.	Collecting samples from commercial gillnetters.	Data available for four years (2017-2021). Data collecting is ongoing work		Ongoing	High/medium

STOCK	Herring SD 25-27, 28.2, 29, 32 (CENTRAL BALTIC HERRING)					
Stock coordinator	Julita Gutkowska/Szymon Smolinski		**Last bench-mark**	IBPBASH 2020 (ICES 2020), 2013 (ICES 2013)		
Stock assessor	Mikaela Bergenius Nord		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Stock identity	Mixing of Western Baltic spring spawners and CBH components in SD 24–26.	Test the of different of methods	Genetic samples, morphometrics, otolith shapes etc.	Project		high
Tuning series	BIAS data. Do we have new bias data from SD 32 that could be used in the assessment?	Compare new indeces with spaly.	Index produced by WGBIFS members	WGBIFS		high
Biological Parameters	Mean weight in the stock. Equals currently mean weight in the catch!	Sensitivity analyses:	Mean weights at age and landings per SD and quarter.			medium
Assessment method	A possible change to the SAM model instead of the currently used XSA.	Configuration and subsequent testing of the SAM model.	CANUM, WECA, maturity, mortality, etc	DTU aqua		medium
Misreporting of herring and sprat.	Misreporting of herring and sprat in the mixed catches.	To be decided	Logbooks data and VMS data	Project		(high)
Age reading	Quality	Comparison of age readings	Reference otolith collection	Age reading exchange and WK if needed		medium

STOCK	**HERRING SD 28.1 (HERRING IN GULF OF RIGA)**		
Stock coordinator	Maris Plikshs	**Last benchmark**	2008 (ICES 2008)
Stock assessor	Tiit Raid	**Stock category**	1
Additional people	Kristiina Hommik, Ivars Putnis		

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Stock ID and Age reading	Taken outside the SD28.1 in SD 28. 2. Additionally CBH fished in the Gulf of Riga (Sd28.1)	Separation of herring stocks based on otolith macrostructure	Data available from Latvia and Estonia	No	Ongoing	High
Tuning series	Trapnet fleet - Trapnet effort has been kept constant since 2015, as there are problems reproducing the previous trapnet fleet effort calculations.	Estimation of trapnet fleet effort	Data available in national laboratories	No	Ongoing	High
	Commercial trawl CPUE	Investigation into commercial trawl CPUE index	Data available from Latvia and Estonia (need to see how long back in time is available)	No	Ongoing	Medium
	Acoustic survey - There is some reservation concerning the timing of the survey (end of July/beginning of August) and the abundance estimates The exact timing of fish moving from coastal area to open sea is uncertain, it might be that in some years fish move to open seal later and could be underestimated by the GRAHS survey	Extension of BIAS survey into GoR to establish second fishery independent tuning series.	BIAS will extend to GoR starting from 2022.		Ongoing	High
Recruitment	Estimation of recruitment in the forecast basing it on environmental factors	Recruitment modelling	Data available in national laboratories	No	Ongoing	Medium

STOCK	**HERRING SD 30-31 (HERRING IN GULF OF BOTHNIA)**					
Stock coordinator	Jukka Pönni		**Last benchmark**	2021 WKCluB		
Stock assessor	David Gilljam		**Stock category**	1 for 2021		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Analysing maturity ogive (suggestion by 2019 WGBFAS; last examined for 2012 WKPELA benchmark)	Reduction of annual variation	**1**) Examining the correlation of maturity@age to temperature and other environmental aspects. **2**) Testing ogive with e.g. 3-year running averages **3**) smoothening the time-series	Mat data is available from Finnish catch sampling. Finnish environmental institute and Swedish meteorological institute have earlier provided env. data and could be expected to provide update data.		**Next benchmark**	Low
Analysing maturity ogive (checking maturity at age of 2 year-olds)	Reduction of annual variation	Sampling the spawning schools (trapnets) to see if 2-year-olds are there	Age determinations from samples of spawning schools (trapnets) to see if 2-year-olds are there		**Next Benchmark**	Medium

STOCK	**SPRAT SD 22-32 (BALTIC SPRAT)**					
Stock coordinator	Olavi Kaljuste		**Last benchmark**	2013 (ICES 2013)		
Stock assessor	Jan Horbowy		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Natural mortality	Predation mortality is estimated from SMS which is run every several years	Update SMS model and M values every 3-4 years	Data and model available	WGSAM; consider results from recent depth-stratified cod stomach content analyses	Every 3-4 years	
Misreporting of herring and sprat.	Misreporting of herring and sprat in the mixed catches.	To be decided	Logbooks data and VMS data	Project		(high)
Density dependence in sprat growth	Sprat growth is evaluated to be density dependent, while it is not considered in estimation of Fmsy reference points	Attempt to estimate sprat Fmsy considering density dependence in its growth	Data on sprat growth and stock density are available	Develop long-term simulations, considering density dependence in growth		

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. In order to facilitate the inclusion of the Baltic stocks, the WGBFAS meeting decided to meet in the early summer or autumn of 2022. The first meeting would be a meeting where the participants from the different countries tries to identify the major fleet and fisheries. It was further recommended that people involved in the MixFish working group would attend and briefly describe the data needs and the data analyses performed in the group.

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

The presentation of WGBIFS 2022 was composed from two parts focused on the:

- Baltic acoustic-trawl surveys (BIAS, BASS) in 2021,
- BITS surveys in 2021-Q4 and 2022-Q1,

BIAS

BIAS database was updated with the survey results from 2021. The national BIAS 2021 data were also uploaded into the ICES database for acoustic trawl surveys.

The Baltic International Acoustic Survey (BIAS) in September-October 2021 was completed almost according to the plan. However, it did not cover the Russian EEZ, which was not planned either. Finnish suey 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 2021 was demonstrated in consecutive graphs. In September-October 2021, the highest concentrations of herring (age 1+) were detected in the northern and western 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 and in the Gdansk Bay. Total abundance of age 0 herring was very low. Sprat (age 1+) dense shoals were mostly distributed in the ICES SDs 29 and 32. Total abundance of age 0 sprat was very low. Highest abundances of age 0 sprat were recorded in the northeaster part of the Baltic Proper. Both sprat and herring BIAS abundance indices showed a slight increase compared to the previous year. Cod was concentrated mostly in the south-western part of Baltic Proper. Herring abundance in SD 30 was almost twice lower than in 2020 if the age 1 herrings are included into the index. It seems that the catchability of younger age-groups varies strongly there from to year. The data indicate possible year effect for 2017 and 2020 survey results in SD 30, when abundance of the herring younger age-groups was very high. However, the abundance index is in good correlation with the herring CPUE in the survey hauls, which indicates that the reason behind the possible year effect is related to the interannual changes in the herring distribution.

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 calculated by the StoX can be used in assessment of the Gulf of Bothnia herring stock size with the restriction that the age-groups 0 and 1 are excluded from the dataset. The abundance indices for years 2017 and 2020 should be handled with caution due to a possible overestimation of the younger age-groups.

BASS

BASS database was updated with the survey results from 2021. The national BASS 2021 data were also uploaded into the ICES database for acoustic trawl surveys.

The Baltic Acoustic Spring Survey (BASS) in May 2021 was completed almost according to the plan. It covered even the Russian EEZ. One rectangle in Lithuanian waters was not covered due to Lithuanian issues with the vessel. In the May survey, the highest concentrations of sprat were distributed in the middle part of the Baltic Proper. BASS sprat abundance indices showed a slight decrease 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.

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

The **Working Group for Integrated Assessments in the Baltic (WGIAB)** has already suggested in their meeting ToRs for 2022-2024 to assist in the work of WKEBFAB and this collaboration is expressed as an item in the TORs, stating that 'develop ecosystem knowledge to support the progression of ecosystem-based advice.' WGIAB did not meet before WGBFAS. Hence, proceedings can first be reported in next year's report.

1.6.4 Working group on Multispecies Assessment Methods (WGSAM)

The **Working Group on Multispecies Assessment Methods (WGSAM)** aims to advance the oper-ational use of knowledge on predator-prey interactions for advice on fisheries and ecosystem management.

The group shas finished a three-year cycle during which it consolidated criteria to evaluate key-runs and more in general the skills assessment of multispecies models, released key-runs for the Baltic Sea, North Sea and Irish Sea all evaluated with those criteria, progressed in the areas of multiple models comparison, ensemble modelling and on the estimation of biological reference points in the context of multispecies interactions. The updated key-runs for the North Sea and the Baltic Sea provided the best available estimates of predation mortality for a number of key commercial stocks in these two ecoregions which have been already integrated into the stock assessments throughout benchmarks and inter-benchmarks. Analyses accumulate showing that ignoring strong trophic interactions may lead to bias in the perception of stocks status and in the calculation of reference points. Evaluations show advantages of using multi-model ensembles to capture the dynamics of the main stocks and the system overall. Results accumulated so far suggest that the benefits of ensemble modelling exist for both simple models, i.e. multispecies production models, as well as more complex ecosystem models. Various approaches are available to the practice of ensemble modelling, including a fully Bayesian ensemble framework suitable also for multi-model forecasts.

The group also presented progresses with software developments to enhance accessibility of some complex routines, including ensemble modelling beyond "just a simple average approach" and computation of multispecies reference points, to a broader group of modelers and users. The group sees these developments as a great opportunity to work more towards cross-platform comparisons and further on multispecies skill assessment which will remain important themes for continuation of the work. To further progress the use of multispecies and ecosystem models, collection of ecosystem data remains highly relevant, with priority on stomach data and other information on processes affecting trophic interactions and trophodynamics of ecosystems (i.e. predator-prey overlap, temperature-dependent consumption, availability of other food).

1.6.5 Workshop on Ecosystem Based Fisheries Advice for the Baltic (WKEBFAB)

The **Workshop on Ecosystem Based Fisheries Advice for the Baltic (WKEBFAB)** had the specific objective to conclude on ecosystem aspects that could be added to the fisheries advice provided by ICES. The WK reviewed working international EBF approaches, reviewed ecosystem indicators relevant for EBF Advice in the Baltic and evaluated how existing ecosystem models can be used for giving advice on ecosystem-based catch options. The lack of management strategy evaluations implemented for the Baltic Sea became apparent and the WK stresses their development and application as a key step for implementation of EBF Advice. Several ecosystem indicators are currently operational for the Baltic Sea region, mainly via developments in HELCOM and in relation to the Marine Strategy Framework Directive. These indicators could potentially support an EBFAdvice by providing an integrated ecosystem assessment framing, but further work is needed to assess how selected existing indicators could be analytically linked to the developing EBFAdvice. As a central aim for the work, the WK agreed to test the use of Scaling factors for the species-specific long term F_{target} derived catch options (hence, applying an approach similar to the F_{eco} approach developed by WKDICE and WKIRISH). The WK also proposed to produce Ecological and socio-economic profiles (ESP) of the specific stocks, which would identify quantitative indicators/factors for ecological processes that can be used to scale the species-specific F_{targe}t. Additionally, the WK proposed to amend the regular fisheries advice with information on Ecosystem consequences / Ecosystem risks as a result of the stock specific advice in question. The WK agreed that at its first stage of implementation, the EBF Advice would focus on developing the F scaling factor, ESP and risks, as described above, in relation to the already existing single species assessment and stock-prediction models (while in the long term, multi-species or specific food web models would preferentially be used). It was identified that the implementations should be part of the ICES Benchmark process, where the approach would be tested and accepted. The proposed next benchmark of the small pelagic stocks in the Baltic 2022-2023, creates the first window of opportunity to test scaling factors.

The WK recommends that the F scaling factor, ESP and risks be formulated in such a way that they can be integrated into existing ICES advice products, namely the advice on fishing opportunities, the Baltic Sea Ecosystem Overview and the Baltic Sea Fisheries Overview. The WK, further, proposed a number of changes to the ICES advisory process, in order to facilitate the operationalization of the roadmap and EBF Advice. The work required to eventualize the proposed roadmap is dependent on further funding and is foreseen to be facilitated by two more workshops (WKEBFAB 2 and 3).

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 22—24 - short-term forecast was not accepted by the WG this year
b) Cod in the SDs 24—32
c) Sole in Division 3.a + SDs 22—24
d) Plaice in SDs 21—23
e) Plaice in SDs 24—32
f) Herring in SDs 25—29 and 32, excluding SD 28.1
g) Herring in SD 28.1 (Gulf of Riga)
h) Herring in SDs 30—31
i) Sprat in SDs 22—32

Trend-based assessment were carried out for the following stocks:

a) Cod in the Kattegat
b) Flounder in SDs 22–23
c) Flounder in SDs 24–25
d) Flounder in SDs 26 and 28
e) Flounder in SDs 27, 29–32
f) Brill in SDs 22–32
g) Dab in SDs 22–32
h) 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, and sole SDs 20–24. Details on model configuration, including all input data and the results can be viewed at www.stockassessment.org. A VPA tuned assessment using the Extended Survival Analysis (XSA) method (Darby and Flatman, 1994) was used for herring in the SDs 25—29 and 32, excluding Gulf of Riga, Herring in the Gulf of Riga (SD 28.1) and Sprat in the SDs 22—32. The assessments of cod in SDs 24-32 and herring in SDs 30-331 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 brill, dab and turbot, but update assessment were conducted and included in the report.

Overview of the software used:

Software	Purpose
XSA	Historical assessment
RCT3	Recruitment estimates
MFDP	Short-term prediction
SAM	Historical and exploratory assessment, short-term prediction
SS3	Historical assessment and short-term prediction
SPiCT	Historical assessment and short-term prediction

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 climate change. In this chapter the working group reports recent issues discussed during the meeting. Hence, this chapter is not a comprehensive literature review.

1.9.1 Reproduction and recruitment

Analysis of temporal variability in the recruitment of sole (*Solea solea*) showed links to spawner biomass and the presence of regimes when recruit/spawner was consistently higher (or lower) than other time periods. These variations were seen using spawner biomass adjusted recruitment data, indicating that ecosystem processes and their variations have major impacts on the population dynamics in the area. These impacts ultimately affect available biomass for exploitation and require close monitoring of stock status to avoid over-exploitation (Bøje *et al*., 2019).

Rau *et al*. (2019) explore the fine scale spatial and temporal distribution of the entire demersal fish and flatfish assemblages in the Western Baltic with a special focus on the abiotic and biotic drivers influencing the abundance of the three commercially and ecologically important flatfish species, namely flounder (*Platichthys flesus*), plaice (*Pleuronectes platessa*) and dab (*Limanda limanda*). Interannual fluctuations explained a large percentage of the variance in flatfish CPUE whereby salinity, water temperature and sediment type were identified as the most important abiotic drivers. Dab was mainly influenced by sediment type and high salinity, while for flounder the main driver was water temperature. Plaice was also impacted by salinity but was primarily influenced by biotic variables. The availability of benthic prey organisms in the area was verified as biotic driver for flatfish, especially for plaice.

The newly described Baltic flounder *Platichthys solemdali* has adapted to reproduction at low salinity conditions since it colonized the Baltic Sea 7000 years BP; in the area studied (ICES SD 3d

28.2) spawning occurs at 3–20 m depth at ca 7 psu. Nissling & Wallin (2020). The authors monitored variability in year-class strength as newly settled 0-gr fish in three coastal nursery areas, and compared obtained recruitment indices with prevailing temperature and salinity conditions. 0-gr abundance indices varied considerably between years, from 1 to 90, 10–296 and 17–86 at the respective sampling site, and showed strong accordance with the age structure of the adult stock. Variability in temperature showed no effect, but stronger and weaker year-classes respectively were related to variability in salinity in the range 6.6–7.1 psu with stronger year-classes at >6.8 psu. This coincides with variability in spermatozoa motility, fertilization rates and early egg development at different salinities and suggests that the year-class strength may be set already at the egg stage. Thus, only small changes in salinity at spawning may affect reproductive success and ultimately stock development.

Ojaveer *et al*. (2021) combine a suite of methods designed to detect the non-linear, non-stationary and interactive relationships. They re-evaluate the potential drivers and their interactions responsible for the multiannual dynamics of the recruitment dynamics of the Gulf of Riga (Baltic Sea) spring spawning herring population at the longest timespan to date (1958-2015) allowing coverage of variable ecosystem conditions. R was affected significantly by prey density and the severity of the first winter. Although SSB was not a good predictor of R, adding interaction with SSB significantly improved the overall performance of the model, hence the effect of the two environmental variables on R was modulated by SSB. While temporal changes in the environment-R relationship were generally gradual, several abrupt changes were evident in the strength of these relationships.

1.9.2 Natural mortality rates

Natural mortality of Eastern Baltic cod has substantially increased and is estimated more than three times higher than fishing mortality in recent years by this Working Group. Eero et al. (2020) report that there are different views within scientific community on the relative importance of drivers for cod natural mortality, which is subject to ongoing research.

1.9.3 Growth and condition

McQueen et al. (2020) combined data from **cod** tagged in different regions of the Baltic Sea during 2007–2019. An average-sized cod (364 mm) caught in the western Baltic Sea and assigned to the western Baltic cod stock grew at more than double the rate (145 mm $year^{-1}$) on average than a cod of the same size caught in the eastern Baltic Sea and assigned to the eastern Baltic cod stock (58 mm $year^{-1}$), highlighting the current poor conditions for the growth of cod in the eastern Baltic Sea. The regional differences in growth rate were more than twice as large (63 mm $year^{-1}$) as the stock differences (24 mm $year^{-1}$). The authors conclude that although the relative importance of environmental and genetic factors cannot be fully resolved through their study, these results suggest that environmental experience may contribute to growth differences between Baltic cod stocks.

Five decades of stomach content data allowed insight into the development of consumption, diet composition, and resulting somatic growth of *Gadus morhua* (Atlantic cod) in the eastern Baltic Sea. Neuenfeldt *et al*. (2020) show a recent reversal in feeding level over body length. Present feeding levels of small cod indicate severe growth limitation and increased starvation-related mortality. For young cod, the low growth rate and the high mortality rate are manifested through a reduction in size-at-age. The food reduction is amplified by stunted growth leading to high densities of cod of smaller size competing for the scarce resources. The average growth rate is negative, and only individuals with feeding levels well above average will survive, though growing slowly.

Ryberg *et al.* (2020) 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. 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.

Engelhardt *et al*. (2020) 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. Thiamine deficiency increased with age.

In contrast to the observed low-condition cod in the Eastern Baltic Sea, 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 (Raitaniemi & Leskelä, 2021). 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 were examined. The size of measured cod varied from 30 to 120 cm. The number of *Contracaecum osculatum* larvae correlated with cod length, but the number of larvae per liver weight did not. The condition factor of the cod was higher (1.115) and the specimens were larger than compared with recent findings from the Eastern Baltic Sea cod. More importantly, the condition of the cod was not found to be in relation to the number of *Contracaecum* larvae on the liver surface nor the number of larvae per liver weight. The most common food items were Saduria and clupeid fish. It looks probable that when there is enough food for the cod, the effects of *Contracaecum osculatum* infection on the condition and growth of cod are small or even insignificant.

For Western Baltic cod, Funk *et al.* (2020) showed that diet composition in shallow areas (<20 m depth) was dominated by benthic invertebrate species, mainly the common shore crab *Carcinus maneas*. Compared to historic diet data from the 1960s and 1980s (limited to depth >20 m), the contribution of herring *Clupea harengus* decreased and round goby *Neogobius melanostomus* occurred as a new prey species. Generalized additive modelling identified a negative relationship between catch depth and stomach content weight, suggesting reduced food intake in winter when cod use deeper areas for spawning and during peak summer when cod tend to avoid high water temperatures. The results of their study highlight the importance of shallow coastal areas as major feeding habitats of adult cod in the western Baltic Sea, which were previously unknown because samples were restricted to deeper trawlable areas. The results strongly suggest that historic stomach analyses overestimated the role of forage fish and underestimated the role of invertebrate prey.

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 hepato-somatic 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. Their results suggest that stock recovery is unlikely to happen by fisheries management alone if environmental trajectories remain unchanged.

Haase *et al*. (2020) investigated the diets of cod and flounder for the first-time using stomach content data collected simultaneously in 2015-2017 over a large offshore area of the southern Baltic Sea. The diet of flounder was relatively constant between sizes and seasons and was dominated by benthos, with a high proportion in weight of the benthic isopod *Saduria entomon*. The diet of cod differed between seasons and showed an ontogenetic shift with a relative decrease of benthic prey and an increase of fish prey with size. Historic diet data of cod were used to explore cod diet changes over time, revealing a shift from a specialized to generalist feeding mode paralleled by a large relative decline in benthic prey, especially *S. entomon*. Flounder populations have increased in the past 2 decades in the study area, and therefore the authors hypothesized that flounder have deprived cod of important benthic resources through competition. This competition could be exacerbated by the low benthic prey productivity due to increased hypoxia, which could contribute to explaining the current poor status of the Eastern Baltic cod.

Over the last four decades, considerable changes in all trophic levels in the ecosystem of the Baltic Sea have been observed causing the switch from cod to sprat domination in the fish community. In this altered ecosystem, the growth, condition, and weight at age of sprat and herring also experienced remarkable changes (Casini *et al*., 2010). In some areas, the weight at age of adults decreased by 30-50% from the highest values in the early 1980s (Cardinale and Arrhenius, 2000). The decline in the weight at age was asynchronous for the four pelagic stocks (Figure 1.9). In the Central Baltic herring, the main decrease occurred in the years 1980-2000, in the Gulf of Bothnia herring in the years 1995-2005, in the Gulf of Riga herring in the years 1985-1992 and in Baltic sprat in the years 1990-2000. More recently, in 2021 substantial decrease in weight at age was observed in four analysed pelagic stocks when compared to the average in the period 2011-2020 (Table 1.9). In all cases but sprat at age 1 decrease has been observed.

There are several possible explanations for these declines in weight at age of pelagics in different areas of the Baltic Sea. According to Casini *et al.* (2011), the size and distribution of the sprat population mediated changes in both sprat and herring condition and weight at age, evidencing intra- and inter-specific density dependence. The diet shift from a composition of zooplankton, mysids, and amphipods to only zooplankton could have also a significant effect on the herring growth, condition, and weight at age (Arrhenius and Hansson, 1993; Horbowy, 1997). Alternatively, the cod predation hypothesis has been proposed, assuming that predation mortality is greater for small clupeids than for large individuals, thus, under reduced cod predation pressure, more of the slow-growing fish survive (Rudstam *et al*., 1994; Sparholt and Jensen, 1992). Finally, since weight at age decreases from south to north, migration of northern stock components to the southern areas might result in a decrease in weight at age. However, considering that the decrease in weight at age is observed in different areas of the Baltic Sea, this hypothesis seems to be less plausible (Cardinale and Arrhenius, 2000).

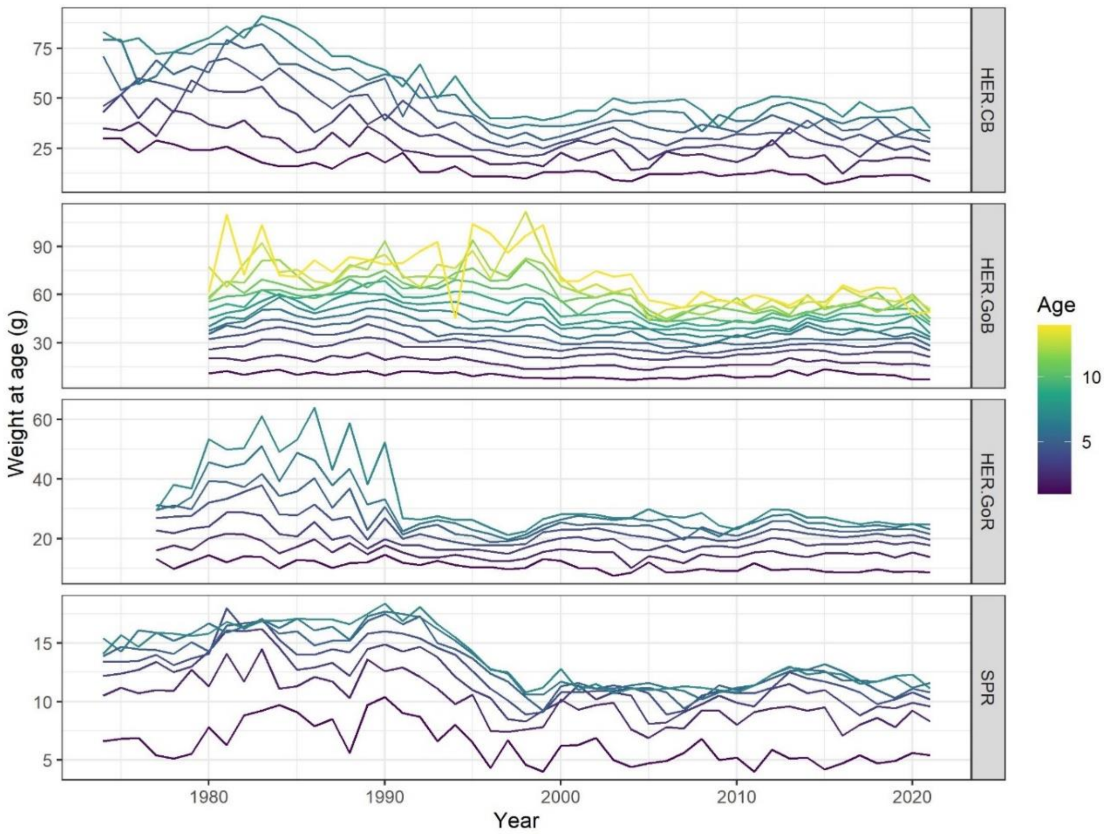


Figure 1.9. Weight at age time-series for pelagic stocks in the Baltic Sea. HER.CB is herring in SD 25–29 and 32, excluding the Gulf of Riga; HER.GoB is herring in SD 30 and 31 (Gulf of Bothnia); HER.GoR is herring in SD 28.1 (Gulf of Riga); SPR is sprat in SD 22–32.

Table 1.9. Comparison of weight at age of Baltic pelagic stocks in 2021 to the average weight at age calculated for the period 2011-2020. In all cases but sprat at age 1 decrease has been observed.

Stock	Age	WAA in 2021	WAA average 2011-2020	Percent	Percent difference
Herring in SD 25–29 and 32, excluding the Gulf of Riga	1	8.6	11.16	77.06093	-22.9391
Herring in SD 25–29 and 32, excluding the Gulf of Riga	2	18.6	20.42	91.08717	-8.91283
Herring in SD 25–29 and 32, excluding the Gulf of Riga	3	21.9	26.77	81.80799	-18.192
Herring in SD 25–29 and 32, excluding the Gulf of Riga	4	28.2	31.98	88.18011	-11.8199
Herring in SD 25–29 and 32, excluding the Gulf of Riga	5	29.6	36.74	80.56614	-19.4339
Herring in SD 25–29 and 32, excluding the Gulf of Riga	6	34	41.09	82.74519	-17.2548
Herring in SD 25–29 and 32, excluding the Gulf of Riga	7	35.1	46.71	75.14451	-24.8555

Stock	Age	WAA in 2021	WAA average 2011-2020	Percent	Percent difference
Herring in SD 25–29 and 32, excluding the Gulf of Riga	8	41.5	51.73	80.224 24	-19.7758
Herring in SD 30 and 31 (Gulf of Bothnia)	1	7.47	10.332	72.299 65	-27.7003
Herring in SD 30 and 31 (Gulf of Bothnia)	2	15.58	17.64	88.322	-11.678
Herring in SD 30 and 31 (Gulf of Bothnia)	3	21.05	24.121	87.268 36	-12.7316
Herring in SD 30 and 31 (Gulf of Bothnia)	4	25.07	28.403	88.265 32	-11.7347
Herring in SD 30 and 31 (Gulf of Bothnia)	5	28.17	31.787	88.621 13	-11.3789
Herring in SD 30 and 31 (Gulf of Bothnia)	6	31.97	35.978	88.859 86	-11.1401
Herring in SD 30 and 31 (Gulf of Bothnia)	7	33.65	38.683	86.989 12	-13.0109
Herring in SD 30 and 31 (Gulf of Bothnia)	8	35.63	42.413	84.007 26	-15.9927
Herring in SD 30 and 31 (Gulf of Bothnia)	9	41.06	46.202	88.870 61	-11.1294
Herring in SD 30 and 31 (Gulf of Bothnia)	10	42.68	49.143	86.848 58	-13.1514
Herring in SD 30 and 31 (Gulf of Bothnia)	11	44.73	52.35	85.444 13	-14.5559
Herring in SD 30 and 31 (Gulf of Bothnia)	12	49.24	53.139	92.662 64	-7.33736
Herring in SD 30 and 31 (Gulf of Bothnia)	13	50.85	56.479	90.033 46	-9.96654
Herring in SD 30 and 31 (Gulf of Bothnia)	14	49.65	58.506	84.863 09	-15.1369
Herring in SD 30 and 31 (Gulf of Bothnia)	15	55.06	62.512	88.079 09	-11.9209
Herring in SD 28.1 (Gulf of Riga)	1	8.6	9.43	91.198 3	-8.8017
Herring in SD 28.1 (Gulf of Riga)	2	13.8	14.88	92.741 94	-7.25806
Herring in SD 28.1 (Gulf of Riga)	3	17.8	18.69	95.238 1	-4.7619
Herring in SD 28.1 (Gulf of Riga)	4	19.6	21.45	91.375 29	-8.62471

Stock	Age	WAA in 2021	WAA average 2011-2020	Percent	Percent difference
Herring in SD 28.1 (Gulf of Riga)	5	21.5	23.52	91.411 56	-8.58844
Herring in SD 28.1 (Gulf of Riga)	6	23.1	25.31	91.268 27	-8.73173
Herring in SD 28.1 (Gulf of Riga)	7	24.7	26.58	92.927 01	-7.07299
Herring in SD 28.1 (Gulf of Riga)	8	25.3	29.39	86.083 7	-13.9163
Sprat in SD 22–32	1	5.4	4.97	108.65 19	8.651911
Sprat in SD 22–32	2	8.3	8.75	94.857 14	-5.14286
Sprat in SD 22–32	3	9.6	10.15	94.581 28	-5.41872
Sprat in SD 22–32	4	10.2	11.1	91.891 89	-8.10811
Sprat in SD 22–32	5	10.8	11.73	92.071 61	-7.92839
Sprat in SD 22–32	6	11.6	12.19	95.159 97	-4.84003
Sprat in SD 22–32	7	11.1	12.15	91.358 02	-8.64198
Sprat in SD 22–32	8	11.6	12	96.666 67	-3.33333

1.9.4 Migrations and spatial distributions

Habitat suitability and mapping was investigated for juvenile sole ages 0 and 1 by means of a beam trawl survey in 2016 directed towards coastal areas in the entire Kattegat. Including historic data from other surveys in Kattegat and the Belts in addition to environmental data it was possible to map predicted juvenile sole habitats in the entire Kattegat, Belts and Western Baltic (Bøje *et al*., 2019). The knowledge on preferred habitat for the recruits (ages 0+1) along with seasonal changes is of vital importance for potential forthcoming monitoring of these age groups. Presently the Fisherman-DTU Aqua survey that is used for abundance of ages 1 to 9 only covers part of these potential areas, e.g. the central-southern Kattegat. It might be considered to change the survey coverage in future in order to better survey the predicted distribution area of ages 1 sole in the areas southwest of Læsø and in the western Baltic (Bøje *et al*., 2019).

Orio *et al*. (2020) used four decades of data on cod and flounder distributions covering the southern and central Baltic Sea to: (1) model and map the changes in the distributions of the two species using generalized additive models; (2) quantify the temporal changes in the potential competitive and predator–prey interactions between them using spatial overlap indices; (3) relate these changes in overlap to the known dynamics of the different cod and flounder populations in the Baltic Sea. Competition overlap has continuously increased for cod, from the beginning of the time-series. This is a possible cause of the observed decline in feeding levels and body condition of small and intermediate sized cod. Flounder overlap with large cod instead has decreased substantially, suggesting a predation release of flounder, potentially triggering its increase in abundance and distribution range observed in the last decades.

Casini *et al.* (2021) show that the depth distribution of Eastern Baltic cod has increased during the past 4 decades at the same time of the expansion, and shallowing, of waters with oxygen concentrations detrimental to cod performance. This has resulted in a progressively increasing spatial overlap between the cod population and low-oxygenated waters after the mid-1990s. This spatial overlap and the actual oxygen concentration experienced by cod therein statistically explained a large proportion of the changes in cod condition over the years. These results complement previous analyses on fish otolith microchemistry that also revealed that since the mid-1990s, cod individuals with low condition were exposed to low-oxygen waters during their life. They conclude that further studies should focus on understanding why the cod population has moved to deeper waters in autumn and on analyzing the overlap with low-oxygen waters in other seasons to quantify the potential effects of the variations in physical properties on cod biology throughout the year.

Krumme *et al.* (2020) report that the coincidence of a validated translucent otolith zone (TZ) formation and observed adverse environmental conditions for cod during peak summer suggests deteriorating conditions for Western Baltic cod given ongoing warming, heat waves and spreading of hypoxic areas in the future. They argue, that during this century, temperatures in the Baltic Sea are predicted to continue to rise (Doscher & Meier, 2004; Meier *et al*., 2006), salinity is predicted to decline (Schrum, 2001), and, if external nutrient loads stay the same, eutrophication and oxygen depletion are predicted to increase (Meier *et al.*, 2012). If the volume, depth and duration of hyperthermic shallow water areas in the western Baltic Sea increase, cod could move deeper, but stratification during summer restricts down-shore movements due to widespread restricts down-shore movements due to widespread hypoxic areas in the deep regions of the western Baltic (Karlson *et al*., 2002, HELCOM 2003). Consequently, the period during which cod are restricted to intermediate depths, sandwiched between unfavourably warm water in the shallows and hypoxic deeper water below, will last longer, and cod will potentially have to aggregate in smaller cells of appropriate water conditions (Funk *et al*., 2020). This may result in negative consequences for cod in these aggregations, such as greater catchability and parasite load, decreased food availability, lower condition or reduced growth, and ultimately in reduced productivity of the stock. Krumme *et al.* (2020) conclude, that a validated TZ formation during summer highlights that this period is an eco-physiological bottleneck for WBC that will probably narrow in the future.

The stock assessment of the Kattegat cod has recently been challenged due to a large "unallocated mortality", i.e. a large fraction of fish that disappears from the area but cannot be explained by mortality due to fishing or natural causes. It has been hypothesized that migration between the Kattegat and the North Sea could explain some of the unallocated mortality. Genetic data revealed that North Sea and local Kattegat/transition zone cod indeed co-occur (mix) within the Kattegat, and that there is a gradient in mixing proportion from high proportion of North Sea cod in the northern parts of the Kattegat to lower proportions in the south (Hemmer-Hansen *et al.*, 2020). The authors conclude that North Sea cod enter the Kattegat as early life stages and migrate back to the North Sea when they reach sexual maturity.

An adapted and validated geolocation model was applied to the temperature-depth DSTs from 28 recaptured Baltic cod assigned to the EBC or Western Baltic cod (WBC) stock by genetics or otolith shape analysis to reconstruct daily positions (Haase, 2021). The temperature and depth profiles were supplemented with information on salinity and oxygen estimates from the regional ocean model also used for geolocation. Individual movements could be classified into three behavioural types: 1) coastal, shallow-water WBC, 2) resident EBC, and 3) migratory EBC. Unlike WBC, EBC generally occupied deeper waters, were exposed to higher salinities and regularly spent short period in hypoxic waters. While resident EBC stayed within the Bornholm Basin year-round, migratory EBC moved between spawning grounds in the Bornholm Basin during summer and coastal feeding grounds during autumn and spring. This study highlights the importance of coastal shallow-water feeding grounds, especially in autumn and spring which are underrepresented in the current bottom trawl survey. In addition, the temperature-depth profiles of all EBC revealed daily vertical movements in the water column which were triggered by twilight and partly followed the lunar cycle.

1.9.5 Changes in the fish community

Olsson et al. (2019) state that declines in predatory fish in combination with the impact of climate change and eutrophication have caused planktivores, including three-spined stickleback (*Gasterosteus aculeatus*), to increase dramatically in parts of the Baltic Sea. Resulting impacts of stickleback on coastal and offshore foodwebs have been observed, highlighting the need for increased knowledge on its population characteristics. They quantify abundance, biomass, size structure, and spatial distribution of stickleback using data from the Swedish and Finnish parts of the Baltic International Acoustic Survey (BIAS) during 2001–2014. The highest abundance was found in the central parts of the Baltic Proper and Bothnian Sea. The proportion of stickleback biomass in the total planktivore biomass increased from 4 to 10% in the Baltic Proper and averaged 6% of the total planktivore biomass in the Bothnian Sea. In some years, however, stickleback biomass has ranged from half to almost twice that of sprat (*Sprattus sprattus*) in both basins. Given the recent population expansion of stickleback and its potential role in the ecosystem, Olsson et al. (2019) recommend that stickleback should be considered in future monitoring programmes and in fisheries and environmental management of the Baltic Sea.

Isotalo (2020) shows that during reproduction, three-spined sticklebacks respond to higher temperatures with increased courtship activity, increased parental activity, quicker breeding cycles, and more weight lost. Parental care activity in constant high temperature decreases from the first to the second breeding cycle, while parental activity in constant low temperature increases. During temperature fluctuations, males experiencing a rise in temperature increase their parental care activity, while males experiencing a drop in temperature demonstrate the opposite. However, no significant consequences of temperature and temperature changes for reproductive success and the viability of offspring were detected during the two breeding cycles. Overall, Isotalo (2020) concludes that the results of this study would indicate that the three-spined stickleback will prove to be a resilient species, and maintain population growth in the face of increased temperatures and temperature fluctuations in the Baltic Sea

Christensen *et al.* (2021) examined the effects of acclimation to temperatures ranging from 5 to 28°C on aerobic metabolic rates, upper temperature tolerance, as well as temperature preference and avoidance of the invasive round goby (*Neogobius melanostomus*). They show that round goby maintained a high aerobic scope from 15 to 28°C; that is, the capacity to increase its aerobic metabolic rate above that of its maintenance metabolism remained high across a broad thermal range. Round goby maintained a large thermal safety margin across acclimation temperatures, indicating a high level of thermal resilience in this species. The unperturbed physiological performance and high thermal resilience were probably facilitated by high levels of phenotypic buffering, which can make species readily adaptable and ecologically competitive in novel and changing environments. The authors suggest that these physiological and behavioural traits could be common for invasive species, which would only increase their success under continued climate change.

1.10 Stock Overviews

In WGBFAS, a total of 3 cod stocks, 3 herring stocks, 1 sprat stock and 10 flatfish stocks are considered. In 2022 analytical assessments were carried out for cod in Kattegat, cod in SDs 22-24 (western stock), cod in SDs 24-32 (eastern stock), herring in SDs 25–29, 32 (excl. GoR), herring in GoR, herring in SDs 30-31, sole in SDs 20-24, sprat in SD 22–32, plaice in SDs 21–23 and plaice in SDs 24-32. ICES has not been requested to advice on fishing opportunities for dab, brill and turbot in SDs22-32, and the four flounder stocks. However, ICES has been requested for updated stock status advice for the four flounder stocks.

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 2021, reported landings were 24 t. The SSB has decreased to historical low levels in 2020. SSB in 2022 is still at a very low level. The mortality has increased from historical low levels since 2014 to historically high mortality levels. The recruitment has been below average since 2014.

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 2021 to about 1/2 of the total catches. Recruitment is variable and the stock is highly dependent upon the strength of incoming year classes. All year classes since 2015 were estimated to be low, and the only recent strong 2016 class is dominating the catches since 2018. The 2021 spawning stock biomass was estimated around 5300 t which is below $B_{trigger}$ (21 876 t) and the lowest in the time-series. The newest incoming year class is slightly higher than the weak 2017-2020 year-classes but has only been seen in the Q4 survey in 2021 and 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 at 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 400 t in recent years. Sole is mainly caught in a mixed fishery as a valuable bycatch; 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 2022 predicted to be at MSY $B_{trigger}$. Fishing mortality has decreased continuously since the mid-1990s and has remained below F_{MSY} since 2009. The recent recruitment is low and record low for the last year 2021. A revision of the survey input data to the assessment have resulted in a downscaling of recruitment year classes 2017-2019 which affected SSB for 2020 to 2021.

1.10.5 Plaice in subdivisions 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. 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- and 2020-year classes are extraordinarily large and will enter the fishery in 2022 and 2023, respectively, likely leading 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 subdivisions 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 fivefold since the start of the survey time-series in 2001. Especially the years 2017 and 2018 (Q1) display a strong increase in plaice abundance. In 2022, a surplus production model (SPiCT) was is used as basis for the advice. The average stock size indicator (biomass index) in the last two years (2020–2021) is 9% lower than the abundance indices in the three previous years (2017–2019), 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. Discards in 2016 were exceptional high (~67%). Since 2017, plaice is under a landing obligation, resulting in additional landings of 8 tonnes of "unwanted catch" (BMS landings) in the most recent year.

1.10.7 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.

1.10.8 Flounder in subdivisions 22–23

The stock size indicator from surveys has increased steadily since 2005 about four-fold but was decreasing since 2016. 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 about 3% 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.

1.10.9 Flounder in subdivisions 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 it is Poland. The majority of landings is taken by Poland. The discard ratio in both subdivisions varies between countries, gear types, and quarters. Discarding practices are controlled by factors such as market price and cod catches. Despite the high variability in discard ratios, discard estimates since 2014 have been used in the advice because discards reporting has improved. A decrease in reporting discards in 2020 and 2021 was caused by COVID-19 related restrictions. The biomass index from surveys has been increasing until 2016, then it was showing a decrease until 2018 followed by an increase from 2019 and decrease in 2021. The average stock size indicator (biomass index) in the last two years (2020–2021) is 25% lower than the biomass-indices in the three previous years (2017–2019). The results of Length Based Indicator (LBI) showed a sustainable exploitation pattern, as fishing pressure on the stock is below F_{MSY} proxy.

1.10.10 Flounder in subdivisions 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. Flounder landings in both subdivisions are dominated by active gears, taking in 80-85% of total landings. Discards are considered to be substantial and determined mainly by market capacity. However, due to COVID -19 restrictions it was not possible to estimate discard for 2021 flounder fishery. 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.

1.10.11 Flounder in subdivisions 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 (80-90% 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 survey 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.

1.10.12 Dab in subdivisions 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. 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.

1.10.13 Brill in subdivisions 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 have been available based on the international coordinated Baltic International Trawl Survey (BITS) since 2001 where standard gear were applied and common survey design were used. 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.

1.10.14 Turbot in subdivisions 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) and mean annual landings are around 200 tonnes since 2013. Biological and fishery data of turbot were available from 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 surveys varied around 1-2 individuals/hour larger or equal to 20 cm total length in the last five year in SD 22–28 and increased to 2-2.5 individuals/hour in the two last years.

1.10.15 Herring in subdivisions 25–29 & 32 excl. Gulf of Riga (Central Baltic herring)

This stock, which is one of the largest herring stocks assessed by the WG, comprises a number of spawning components. 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, in which individuals reach a maximum size of only about 18–20 cm, are dominating in the landings. The latest interbenchmark assessment in March 2020, which introduced updated natural mortalities for 1974-2018, lead to a downward revision of SSB and upward revision of fishing mortality. The latest stronger year-classes were recorded for the years 2002, 2007, 2011 and 2014, respectively. The year-class 2019, which was first estimated to be above average in 2020, but then downgraded during last year's assessment (2021), was again estimated to be 44% above the average level, when comparing the recruitment in the recent period of the years since 1988. Spawning-stock biomass (SSB) has been above B_{lim} since 2002. SBB shows a decreasing trend since 2014 and now reached a low level of 387 kt, which is below MSY $B_{trigger}$. The amount of reported landings taken within the small meshed industrial fisheries may be uncertain as it is mostly caught in mixed fisheries together with sprat. Fishing mortality shows an increasing trend since 2014 and has been above F_{MSY} since 2015. Even so the fishing mortality in 2021 show a slight decrease compared to the previous year.

1.10.16 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 120 000 t in 1994. Since then the SSB has been the range of 71 000–140 000 t. 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 series of rich year-classes and increase of SSB. Due to the only occasional presence of sprat in the Gulf, there is no mixed pelagic fishery in the Gulf of Riga.

1.10.17 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 1970s until the beginning of 1980s, from which it started to increase and peaked in 1994. From there it decreased again until early 2000's and levelled down until a small peak in (2010), after which the spawning stock has again showed a decreasing trend. Recruitment has been on average higher since the higher biomass period starting from the late 1980's, and in addition, favorable environmental conditions have contributed to the production of especially abundant year classes in some years. The most abundant year classes have hatched in very warm summers like 2002, 2006, 2011, and 2014. The decrease of SSB between 2020 and 2021 is presumed to be at least partly a consequence of a remarkable decrease in weight at age and deteriorated body condition, especially in larger herring.

1.10.18 Sprat in subdivisions 22–32

The spawning stock biomass of sprat has been low in the first half of 1980s, when cod biomass was high. At the beginning of 1990s the stock started to increase rapidly and in 1996–1997 it reached the maximum observed SSB of 1.8 million t. The stock size increased due to the combination of strong recruitments and declining natural mortality (effect of quickly decreasing cod biomass). The increase in stock size was followed by large increase in catches (which reached record high level of over half million t. in 1997) and decline in weight at age by about 40%. High catches in following years and five in row below average year-classes (2009-2013) led to stock decline to about 700 000 t. in 2011-2015. 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 y-c is one of the poorest, and stock is predicted to be at level slightly below million t. in 2023-2024.

Spawning stock biomass for over 30 years was higher than precautionary levels, while fishing mortality has been higher than present F_{MSY} in most of years since late 1990s. During recent two decades the stock distribution has been changing with tendency to increase density in north-eastern Baltic, especially in autumn.

1.11 WGBFAS feedback on the 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 2022.

For the first data product package, only TAC species (i.e. herring, sprat, cod and plaice) were provided, each with an identical set of maps, figures and overviews, generated with the most recent RDB data (2021 data) and thus are considered. 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. In Annex 4, data disclaimer with a reference example has been given.

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.

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
- Adding Management area (or Subdivision borders) to the maps
- Monthly (instead of quarterly) overviews for landings and effort for SPF
- Landings: pie-chart per rectangle showing mixing of SPR and HER

Métier overview:

- Should be by species/stock

Sampling intensity and location maps

- Map titles and labels need improvement and better description
- Adding Management area (or Subdivision borders) to the maps
- Sampling intensity needs to be shown by species or stock
- Weight unit maps not needed
- Instead of GPS coordinates, aggregate by rectangle
    - Or as a unit sampled/landings or effort (to lose one of the variables and make the maps easier to read, esp. the quarterly maps)
- Different maps for landings and discards sampling. Colors are hard to distinguish
    - Also here, aggregate by rectangle, improves evaluation

Gear sampling overview

- Limit the gears shown to 5-10? Spell out the gear names for report reader to understand
- Sort gears by importance or landings?
- update gear codes (to 3-letter code) or we need to limit options in the data call
- 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 Sea 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 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.

Most countries reported zero BMS landings for 2021. 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 2021 are shown in Table 2.1.2a. The total provided landings in SD 25-32 in 2021 summed up to 1387 t (Figure 2.1.1), whereof more than 99% were above MCRS and only 4 t were BMS landings (tables 2.1.2b, 2.1.3). The vast majority of the cod landings in 2021 were taken by Russia, as the closure of targeted cod fisheries applies only to EU countries (Table 2.1.1).

Part of the landings of Eastern Baltic cod stock are taken in SD 24, i.e. the management area of Western Baltic cod (Figure 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). 16% of total landings of Eastern Baltic stock are estimated to have been taken in SD 24 in 2021 (Figure 2.1.2; Table 2.1.3).

2.1.1.2 Unallocated landings

For 2021, similar to 2010–2020, 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 in later years was related to a decreasing fishing fleet due to EU vessel scrapping program and improvement of fishing control. The TAC has not been taken since 2009, and misreporting has been considered a minor problem in recent years. However, sine 2019, the substantially reduced quota may have resulted in misreporting of landings.

2.1.1.3 Discards

Due to a combination of a very low fishing effort in the demersal fleet, and disruptions to sampling programmes caused by the covid-19 pandemic, very few discard samples were achieved in 2021. The discard amounts in 2021 are therefore very uncertain, even though believed to be rather limited considering the low fishing effort in the demersal fishery. Only 21% 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 landings from passive gears constituted 24% 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 2021, in Subdivision 25-32, were estimated to 85 t (not including any BMS landings), which constituted 35% 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 2021. 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 2021 was length class 30-34 cm (66% in numbers) followed by length classes 25-29 cm and 35-37cm (26% and 5%, respectively) (Table 2.1.5).

The total discards in tonnes estimated for SD 24 were divided between eastern and western Baltic cod using the same stock splitting information as for landings, which resulted in 28 tonnes of estimated discards of eastern Baltic stock in SD 24 in 2021 (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 (2019) shows a decline in kw-days for demersal trawls in 2012-2019 in the central Baltic Sea, while the effort in gillnet fishery is more stable in these years. No EU STECF effort data from 2020 or 2021 was available at the time of the WGBFAS meeting, but the effort submitted to WGBFAS (days at sea by active/passive gears) showed a very large decline since 2019, especially for active gears.

2.1.2 Biological information for catch

2.1.2.1 Catch in numbers and length composition of the catch

The catch numbers for SDs 25-32 were derived from compilation of biological information submitted to InterCatch. The most abundant length class in the total catch in 2021 was 38-44 cm (32% in numbers), followed by 35-37 cm (30%) and 30-34 cm (22%) (Table 2.1.5). Table 2.1.6 gives the estimated mean weight per length class and gear in the landings and discards 2021.

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.

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 2021. All countries biological data were estimated nationally before being uploaded and further processed in InterCatch. However, the difficulties to collect samples from commercial fisheries, caused by covid-19 and the very low fishing effort in the demersal fishery, led to very low sampling levels in 2021, especially for discards. Numbers and mean weight at length were provided for 91% of the total landings (>MCRS) in weight and for 34% of the estimated discards. No samples were reported for BMS landings. This was a drastic decrease from previous years, particularly for discards, but all catch categories were affected by the disrupted sampling programmes in 2020-2021. Table 2.1.4 shows the decrease in the number of samples by catch category and fleet from 2017-2021. Length distributions should therefore be considered more uncertain than earlier years, especially for discards. However, the resulting overall length distribution of catch in 2021 is similar to that in earlier years.

As in previous years since 2013, the input data for SDs 25-32 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 2013–2021 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 2.1.3). 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 2.1.3).

Nutritional condition

For a number of years, WGBFAS has provided estimates of nutritional condition of the eastern Baltic cod, represented by Fulton's K condition factor for cod at 40-60 cm in length. This has been used as an indicator for stock status, in addition to stock assessment. Fulton's K is not independent of length, but generally has lower values for smaller cod (Figure 2.1.4), leveling off at around 40 cm. This is the reason why Fulton's K has been calculated for 40-60 cm cod. The majority of the cod caught in BITS surveys are between 20-40 cm in length in recent years, and only a small fraction of cod are >40 cm in length. Therefore, WGBFAS in 2022 concluded that Le Cren's condition index (Le Cren, 1951) would be more appropriate, and representative for the population. Le Cren's condition index avoids bias related to fish size, thus cod at all lengths can be included in the index.

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 2.1.5).

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 2020, though the estimates for 2021-2022 are lower again. In Q4, condition has remained at a stable low level since around 2010. Condition is generally worse in Q4 compared to Q1. Close to 40% of the cod at 40-60 cm sampled in Q4 were in a very low condition in latest years (Fulton's K <0.8) (Figure 2.1.5).

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 L_{50} (50% percent mature) has been estimated at around 35-40 cm (males and females combined) in the early 1990s and has declined to around 20 cm since the late 2000s (Figure 2.1.6a). The exact estimates of L_{50} 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 L_{50} estimates from glm analyses shaky and dependent on few individuals. For this reason, the variations in L_{50} estimates in 2020-2022 (Figure 2.1.6a) do not seem to represent true variations in L_{50}, but are more due to measurement errors. Maturity ogives (proportion mature at length) shows similar pattern in recent years (Figure 2.1.6b), suggesting that L_{50} has remained constant low (around 20 cm) in recent years.

Recruitment

Larval abundance from ichthyoplankton surveys in 2021 was slightly higher than in 2018-2020, but still 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. Both in Q1 and Q4, the relative biomass in most recent surveys (2022 in Q1 and 2021 in Q4) is the lowest since 2000, and relatively similar to the estimates in previous surveys (Figure 2.1.8a). The recent trends in relative biomass are similar for all length groups, being relatively stable low in recent years, apart from 35-44 cm cod that shows a further decline in most recent surveys (Figure 2.1.8b). The length corresponding to 95th percentile of length distribution (L_{95} indicator) 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).

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 2021 than in 2020 (Figure 2.1.9), in line with BITS surveys.

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 2.1.7.

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 2021 were compiled from national data provided in IC. For documentation of 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.

The actual catch data are available until 2021. However, to be able to use the survey information from 2022 Q1, the last data year in the Stock Synthesis model is set to 2022. This implies that catches for 2022 need be assumed. The catch in 2022 was set to 2595 tonnes (sum of EU TAC at 595 t plus Russian quota at 2000 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 (1991-2021) and Q4 (1998-2021) 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	1991-2022	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	1986-2021	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	1987-2021	Abundance of larvae during peak spawning, used in SS as pre-recruit survey (survey type 32). Data from ichthyoplankton surveys.

2.1.5 Stock Assessment: Stock Synthesis

2.1.5.1 Model configuration and assumptions

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

Spawning stock and recruitment

Spawning stock biomass is estimated for spawning time (month 5 is used as an average for the entire 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 2020, representing the period for which age and length compositions are available. Recruitment deviates were assumed to have a standard deviation (σR which corresponds to the stochastic recruitment process error) of 0.6. The model assumes a level of steepness (h) of 0.99 for the SRR, assuming that recruitment is mainly environmentally driven in EBC. Settlement time for recruitment is set to month 8 as an average for the entire period.

Growth

Growth parameters were fixed for the period 1946-1990, at the values estimated using historical tagging data. The tagging estimates covered the period 1955-1970 (L_{inf} = 125.27, k= 0.10). Deviations in both L_{inf} and *k* were estimated between 1991 and 2021, 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 2.1.8).

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 2.1.8).

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 2021 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 2.1.8).

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 2.1.8). 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 2.1.9.

The settings and estimated parameters by the model are presented in Table 2.1.8. 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.

The retrospectives of the model were reasonable (Figure 2.1.19). The estimated Hurtado-Ferro (2014) variant of the Mohn´s index was 0.21 for SSB and -0.22 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 (Figure 2.1.20, Table 2.1.10). 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) is presently at the lowest level observed since the 1950s, but stable since 2019 (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 2021 (estimated at 0.02) (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 2.1.10).

The stock numbers and fishing mortalities at age are given in Tables 2.1.11 and 2.1.12.

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/F_{MSY} and B/B_{MSY}), 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/F_{MSY} and B/B_{MSY} 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 B_{MSY} trigger proxy since 2018 (Figure 2.1.23). Fishing mortality, as well as F_{MSY} Proxy are estimated very low, as the estimated F_{MSY} 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 & 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 2021. For maturity and weight at length, the values for the latest time-block were used.

Variable	Value	Notes
Fages 4–6 (2022)	0.03	F based on catch constraint.
SSB (2022)	60 979	Stock Synthesis assessment estimate
R_{age0} (2021-2024)	1 862 290	Average of 2016-2020
Total catch (2022)	2595	EU TAC 595 tonnes + Russian quota 2000 tonnes

Even at no fishing, the SSB is estimated to remain below B_{lim} in 2024, with very high probability (Table 2.1.13).

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 (2022) estimated the B_{lim} to be at 108 036 t (SSB in 2012 in the present assessment).

B_{lim} at 108 036 t corresponds to B_{pa} at 120 637 t ($B_{lim} \times \exp(1.645 \times \sigma)$, where $\sigma = 0.07$).

2.1.9 Quality of the assessment

Sampling of landings and discards was considerably reduced in 2020-2021 due to a combination of COVID-19 disruption and low catches. Low quotas may also have caused misreporting of landings. However, the perception of the stock status is considered robust to possible uncertainties in catch data in latest 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 (≥35 cm) 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 (tonnes) 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
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

Year	Denmark	Estonia	Finland	German Dem.Rep.**	Germany Fed. Rep.	Latvia	Lithuania	Poland	Russia	Sweden	USSR	Faroe Islands^	Norway	Unallocated***	Total
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
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

*** 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.

Table 2.1.2a. Cod in SD 25-32. Landings (tonnes) by fleet, country and subdivision in 2021 (BMS excluded).

Subdivision		25	26	27	28	29	30	31	32	Total 25-32
Fleet	Country									
Active	Denmark	13								13
	Estonia	0	0		0	0			0	0
	Finland		2							2
	Germany	20								20
	Latvia	7								7
	Lithuania		1							1
	Poland	50	3	0	0	0				53
	Russia		951							951
	Sweden	1	0	0		0	0	0		1
Total Active gears		91	957	0	0	0	0	0	0	1047
Passive	Denmark	1								1
	Estonia	0	0		0	1			1	2
	Finland					32	0		0	33
	Latvia		3		2					5
	Lithuania		1							1
	Poland	13	0	0	0	0				13
	Russia		274							274
	Sweden	2	0	1	0	6	0			8
Total Passive gears		16	278	1	2	38	0		1	336
Total All gears		106	1234	1	2	38	0	0	1	1383

Table 2.1.2b. Cod in SD 25-32. Total landings (tonnes) by country in 2021, in SDs 25-32, separated between landings for human consumption (above MCRS) and the reported BMS landings.

Country	Landings for human consumption (t)	BMS landings (t)
Denmark	15	1.28
Estonia	2	0
Finland	35	0
Germany	20	0
Latvia	11	0
Lithuania	2	0
Poland	66	0.01
Russia	1225	0
Sweden	8	2.73
Total	1383	4.0

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

Year	Eastern Baltic cod stock in SD 25-32						Eastern Baltic cod stock in Subdivision 24			Eastern Baltic cod stock in Subdivisions 24+25–32		
	Un allocated*	Landings AMS	Landings BMS	Total landings	Discards	Catch	Total landings	Discards	Catch	Total landings	Discards	Total catch
1992				54882	1904	56786	2324		2324	57206	1904	59110
1993	18978			50711	1558	52269	3885		3885	54596	1558	56154
1994	44000			100856	1956	102812	6551	621	7172	107407	2577	109984
1995	18993			107718	1872	109590	5585	668	6253	113303	2540	115843
1996	10815			124189	1443	125632	10040	1116	11156	134229	2559	136788
1997**				88600	3462	92062	6547	641	7189	95147	4103	99251
1998				67428	2299	69727	4582	631	5213	72010	2930	74940
1999				72995	1838	74833	6221	599	6820	79216	2437	81653
2000	23118			89289	6019	95308	6316	1209	7525	95605	7228	102833
2001	23677			91328	2891	94219	7794	389	8183	99122	3280	102402
2002	17562			67740	1462	69202	5060	562	5622	72800	2024	74824
2003	22147			69477	2024	71501	5729	862	6592	75206	2886	78093
2004	19563			68578	1201	69779	5309	188	5497	73887	1389	75276
2005	14991			55032	1670	56702	6064	1729	7793	61096	3399	64495
2006	17836			65531	4644	70175	6767	144	6911	72298	4788	77086
2007	12418			50843	4146	54989	8792	875	9667	59635	5021	64656
2008	2673			42234	3746	45980	8811	787	9598	51045	4533	55578
2009	3189			48438	3328	51766	8284	464	8747	56722	3792	60513
2010				50276	3543	53819	6049	533	6581	56325	4076	60400
2011				50368	3850	54218	7545	482	8027	57913	4332	62245
2012				51225	6795	58020	8469	536	9004	59694	7331	67024
2013				31355	5020	36375	5359	1243	6602	36714	6263	42977
2014				28909	9627	38536	5455	1298	6753	34364	10925	45289
2015				38079	5970	44049	5029	930	5959	43108	6900	50008
2016				29313	3279	32591	4541	306	4847	33854	3585	37438
2017		25317	179	25496	3238	28734	2004	227	2231	27500	3465	30965
2018		15800	108	15907	3103	19010	2295	300	2595	18202	3403	21605

Year	Eastern Baltic cod stock in SD 25-32						Eastern Baltic cod stock in Subdivision 24			Eastern Baltic cod stock in Subdivisions 24+25–32		
	Un allocated*	Landings AMS	Landings BMS	Total landings	Discards	Catch	Total landings	Discards	Catch	Total landings	Discards	Total catch
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

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

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

Table 2.1.4 Cod SDs 25-32. Number of length samples reported to InterCatch by year, fleet and catch category 2017-2021.

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

Table 2.1.5. Cod in SD 25-32. Numbers (in thousands) of cod by length-groups in landings for wanted (human consumption landings) and unwanted catch (includes both BMS landings and estimated discards) in SDs 25-32 in 2021.

Length class	Wanted catch	Unwanted catch	Total
<20	7	1	8
20-24	11	6	17
25-29	59	84	144
30-34	432	214	646
35-37	845	16	861
38-44	907	2	910
45-49	223	0	223
>=50	69	0	69
Total	2553	324	2877

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 2021.

Fleet	Length class (cm)	Wanted catch	Unwanted catch
Active	<20	55	52
	20-24	106	102
	25-29	172	204
	30-34	312	300
	35-37	419	402
	38-44	595	468
	45-49	907	
	>=50	1329	
Passive	<20		
	20-24	108	
	25-29	187	
	30-34	359	
	35-37	506	
	38-44	780	
	45-49	1041	
	>=50	1375	

Table 2.1.7. 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	1946-2021	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,	2000-2021	5 – 120 cm	
Maturity ogives	Size at 50%maturity(L50) and slope	1946-2021		Yes (1998-2021, time blocks)
Growth	Von Bertalanffy growth parameters	1946-1990		No
Age length keys	Age length keys from BITS Q1 and Q4	1991-2021	0 – 12+	Yes

Type	Name	Year range	Range	Time variant
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	1975-2022		
Length composition of survey catch	Length composition of BITS Q1 and Q4	1991-2022		
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 2.1.8. 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 (2000-2021) of age class 5.5	22	Estimated using random walk annual deviations	(0.1,2.0)	no prior	0.35-0.78
Stock and recruitment					
$Ln(R_0)$	1	14.8	(13,16)	no prior	15.2
Steepness (h)		0.99			
Recruitment variability (σ_R)		0.60			
Ln (recruitment deviations): 1946-2020	75				
Recruitment autocorrelation		0			
Growth					
L_{inf} (cm) (1946-1990)		125.27			
L_{inf} (cm) (1991-2021)	31	Estimated using random walk annual deviations	(40-150)	no prior	122-48
k (1946-1990)		0.10			

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
k (1991-2021)	31	Estimated using random walk annual deviations	(0.07-0.45)	no prior	0.10-0.27
L at minimum age (0.5 years) t_0		12			
CV of young individuals	1	0.290	(0.05-0.8)	no prior	0.26
CV of old individuals		0.05			
Weight (kg) at length (cm)					
a (1946-1990)		6.58e-06			
b (1946-1990)		3.1353			
a (1991-1993, 1994- 1996, 1997- 1999, 2000 -2002, 2003-2005, 2006-2008, 2009-2011, 2012-2014, 2015-2017, 2018-2021)		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, 7.76E-06			
b (1991-1993, 1994- 1996, 1997- 1999, 2000 -2002, 2003-2005, 2006-2008, 2009-2011, 2012-2014, 2015-2017,2018-2021)		3.1353, 3.0636, 3.1062 3.0992, 3.0972, 3.0637 3.0831, 3.0406, 3.0086,3.0501			
Maturity					
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, 2015-2021)		38, 36, 31, 26, 21			
Initial fishing mortality					
Active gears		0.60			
Selectivity (logistic)					
Active gears					
Time-invariant length based logistic selectivity	2	35; 12.68	(20,45; 0.01,50)	no prior	(39; 8.7)
Passive gears					
Time-invariant length based logistic selectivity	2	35; 10	(20,65; -12,15)	no prior	(41.9; 9.0)

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
BITS Q1 survey					
Time-invariant length based logistic selectivity	2	25,10	(15,50; -12,15)	no prior	(27;9.5)
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
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

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

Year	a1	a2	a3	a4	a5	a6	a7	a8+
1946	852	8250	14345	5891	3094	1592	658	776
1947	607	17434	28077	14819	3838	1789	891	791
1948	1058	11247	51264	23964	7700	1737	778	718
1949	1242	16035	27586	36915	10433	2902	627	529
1950	1315	19747	41803	21372	17390	4265	1137	444
1951	1036	20376	49780	30975	9552	6716	1576	571
1952	957	18034	56233	39712	14779	3924	2635	821
1953	803	10617	33128	30791	13077	4190	1062	911
1954	1278	13267	28821	27430	15880	5932	1831	844
1955	1109	17581	30801	20598	12181	6184	2222	981
1956	850	21284	54802	28700	11831	6124	2991	1516
1957	908	16179	62997	46280	14362	5073	2503	1795
1958	1210	11688	33397	37479	16062	4220	1412	1163
1959	1065	19152	29873	24992	16686	6124	1532	912
1960	1552	20655	57387	24938	12016	6758	2347	911
1961	1107	18345	39071	29890	7222	2864	1509	703

Year	a1	a2	a3	a4	a5	a6	a7	a8+
1962	1152	16847	44117	26321	11599	2360	886	664
1963	1346	18759	42862	31197	10676	3954	761	485
1964	1546	15230	34797	22752	9571	2756	965	295
1965	1864	22918	37187	24954	9820	3564	982	438
1966	2497	44156	84032	37844	14879	4994	1727	669
1967	2357	37423	101620	51054	12606	4061	1276	591
1968	2303	38115	91991	66173	18341	3726	1125	499
1969	1820	34918	88505	56881	22488	5111	971	409
1970	1904	27113	79674	54076	19153	6217	1323	345
1971	2135	25683	57383	46162	17474	5110	1556	403
1972	2502	28812	55732	34974	16067	5088	1404	521
1973	2575	32650	61541	34034	12446	4840	1454	534
1974	1299	32042	66523	36736	12201	3844	1429	572
1975	1173	20997	84620	52569	17916	5217	1583	805
1976	1390	16254	52074	65029	25116	7509	2106	943
1977	2523	19361	36756	34743	26871	9122	2630	1045
1978	2220	39354	44889	25329	15201	10510	3461	1369
1979	1305	34386	107195	41153	15399	8382	5644	2553
1980	3018	26991	108235	106070	26336	8855	4675	4493
1981	2468	40807	64014	85031	53751	11871	3853	3917
1982	1772	40904	102738	48174	39978	22285	4746	3051
1983	1035	27173	104837	81300	23965	17604	9476	3258
1984	1081	20508	87524	103749	50475	13095	9267	6566
1985	1270	19218	57012	67736	47224	19651	4864	5729
1986	1921	21324	53468	44918	31206	18482	7315	3840
1987	1289	34763	60308	40033	18947	10987	6150	3603
1988	869	22252	91874	41143	15079	5894	3215	2762
1989	851	14162	55801	60596	15053	4562	1675	1644
1990	808	16693	38833	40103	24223	4967	1411	994

Year	a1	a2	a3	a4	a5	a6	a7	a8+
1991	1209	11363	41383	25894	14360	6973	1325	617
1992	1122	11255	16113	15197	5051	2232	997	266
1993	538	12083	22129	9104	4998	1401	582	319
1994	577	12105	44707	30121	7673	3628	965	602
1995	865	11340	29858	32410	13914	3008	1336	557
1996	666	13699	33582	29347	20295	7711	1572	958
1997	1309	8706	31114	22421	10881	6212	2202	690
1998	1612	16718	20562	20309	7698	2908	1506	669
1999	1397	17262	42255	17312	8737	2472	820	576
2000	1133	21765	49995	34455	6848	2402	576	296
2001	1472	15126	50088	32725	11594	1664	488	160
2002	744	14887	27667	25572	8890	2385	294	104
2003	902	9101	36235	22168	11356	3120	746	115
2004	1704	10829	23210	29320	9957	3881	940	240
2005	1417	19101	23334	15405	10430	2692	906	254
2006	1062	12279	44574	21878	8577	4552	1043	417
2007	817	8814	25463	30847	8870	2680	1242	368
2008	760	8546	22673	19344	12877	2880	762	423
2009	824	9265	25199	23322	10938	5565	1101	421
2010	719	8970	23156	23076	12947	4663	2089	537
2011	826	7680	24723	23092	14228	6380	2025	1073
2012	1552	9669	24878	29248	15993	7672	3026	1354
2013	1234	9153	18231	17769	11723	4666	1905	987
2014	902	11048	25332	18826	10182	4829	1606	901
2015	754	7740	27972	25590	10928	4253	1667	766
2016	368	4673	14065	20914	11682	3721	1220	625
2017	665	3023	10958	13093	12108	5244	1449	657
2018	461	4021	5950	8878	6569	4736	1808	673
2019	111	1852	5945	3846	3555	2035	1296	637

Year	a1	a2	a3	a4	a5	a6	a7	a8+
2020	76	303	1278	1516	589	417	213	196
2021	21	345	395	771	634	207	137	136

Table 2.1.10. 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	High	Low	SSB	High	Low	Fishing Mortality	High	Low
1946	2153930	2418679	1918160	62512	69293	55731	0.40	0.44	0.36
1947	3130800	3450558	2840674	82320	90042	74597	0.51	0.56	0.47
1948	3705730	4058274	3383812	105861	114825	96897	0.58	0.63	0.54
1949	3795980	4152393	3470159	114565	124771	104359	0.56	0.61	0.52
1950	2968300	3284521	2682523	120498	131011	109985	0.59	0.63	0.54
1951	2372940	2660890	2116151	132418	143074	121762	0.59	0.64	0.55
1952	2725780	3040381	2443732	135834	146763	124905	0.66	0.71	0.62
1953	3959470	4332013	3618965	141733	153556	129910	0.49	0.52	0.45
1954	3844370	4199823	3519000	136065	148357	123773	0.53	0.57	0.49
1955	2343080	2615155	2099311	137381	149372	125390	0.49	0.53	0.45
1956	1944860	2186046	1730284	141972	152504	131440	0.61	0.65	0.57
1957	2976670	3262677	2715735	133320	142307	124333	0.74	0.79	0.70
1958	2471330	2732944	2234760	118256	126574	109938	0.64	0.68	0.61
1959	2749660	3023395	2500709	99820	107055	92585	0.70	0.74	0.65
1960	2520350	2796429	2271527	84357	90852	77862	0.91	0.98	0.84
1961	2614610	2919996	2341163	83593	90186	76999	0.74	0.79	0.69
1962	2825410	3169589	2518604	86230	93164	79296	0.74	0.79	0.68
1963	4428710	4855650	4039309	84653	92334	76972	0.79	0.85	0.73
1964	5653450	6168939	5181036	92806	102096	83515	0.60	0.65	0.55
1965	4942530	5422147	4505338	108168	118997	97339	0.58	0.63	0.53
1966	4774110	5235804	4353128	118502	129479	107525	0.88	0.96	0.80
1967	4347970	4785520	3950426	137093	146693	127493	0.85	0.91	0.79
1968	3392480	3779028	3045471	142166	151298	133034	0.88	0.94	0.83
1969	3536050	3941095	3172634	138094	147284	128904	0.88	0.94	0.83
1970	4397870	4880454	3963004	129275	138922	119628	0.87	0.93	0.81
1971	5841460	6421700	5313648	120206	130680	109732	0.79	0.85	0.73
1972	7223770	7880874	6621455	120936	132481	109391	0.73	0.79	0.67
1973	4524300	5071725	4035962	142331	155514	129148	0.63	0.68	0.58
1974	3809770	4331708	3350722	194462	210035	178889	0.50	0.53	0.46
1975	5479410	6147961	4883560	244017	262210	225824	0.51	0.54	0.47
1976	11866400	12884946	10928369	244320	265561	223079	0.50	0.54	0.46

Year	Recruitment	High	Low	SSB	High	Low	Fishing Mortality	High	Low
1977	9644020	10606548	8768840	250960	275268	226652	0.41	0.44	0.37
1978	5712080	6475869	5038376	309221	335924	282518	0.34	0.37	0.31
1979	9518730	10429676	8687348	405502	433789	377215	0.38	0.40	0.35
1980	9620030	10478281	8832076	455506	485891	425121	0.48	0.50	0.45
1981	6336310	6998075	5737124	420049	451150	388948	0.48	0.51	0.45
1982	3932000	4394013	3518566	444880	474122	415638	0.46	0.49	0.43
1983	3373730	3731636	3050151	442621	466925	418317	0.46	0.49	0.44
1984	3538020	3833934	3264946	376758	395446	358070	0.61	0.63	0.58
1985	5322430	5622401	5038463	282484	296691	268277	0.65	0.67	0.62
1986	3230170	3456539	3018626	195127	207218	183036	0.72	0.76	0.68
1987	2016370	2180813	1864327	149816	156730	142902	0.79	0.80	0.77
1988	2036040	2186835	1895643	142466	148418	136514	0.80	0.84	0.77
1989	1492800	1622517	1373453	119437	124659	114215	0.81	0.84	0.78
1990	2986140	3199005	2787439	89960	94849	85071	0.93	0.97	0.89
1991	3546620	3777129	3330179	57477	61079	53875	1.05	1.09	1.01
1992	2395060	2578697	2224500	60988	67362	54614	0.56	0.61	0.51
1993	2016290	2176858	1867566	103033	113441	92625	0.35	0.38	0.32
1994	1971920	2125824	1829159	120338	130919	109757	0.54	0.58	0.50
1995	1467310	1605536	1340985	132087	141749	122425	0.55	0.58	0.52
1996	2751510	2983344	2537691	93773	100955	86591	0.85	0.90	0.80
1997	2798970	3052982	2566092	63253	68811	57694	0.91	0.98	0.85
1998	2869460	3132377	2628611	56034	61053	51016	0.88	0.96	0.81
1999	2229310	2481798	2002509	51983	56778	47188	0.95	1.03	0.87
2000	2905290	3164783	2667074	61685	66545	56824	1.03	1.11	0.96
2001	1912970	2109411	1734823	75634	81117	70150	1.01	1.08	0.94
2002	2344460	2560008	2147061	85295	91132	79457	0.72	0.77	0.67
2003	4038850	4352216	3748047	86984	92814	81153	0.73	0.78	0.68
2004	3167570	3463496	2896928	75945	81738	70152	0.75	0.81	0.69
2005	3919710	4292882	3578977	94711	101271	88151	0.59	0.63	0.54
2006	4119900	4528165	3748445	95354	102340	88368	0.65	0.70	0.60
2007	3879480	4292305	3506360	94102	101637	86567	0.52	0.56	0.48
2008	4073770	4521041	3670748	134027	144031	124023	0.39	0.43	0.36
2009	3508070	3945012	3119523	147125	158058	136192	0.37	0.40	0.34
2010	3762430	4246402	3333617	150960	162136	139784	0.35	0.38	0.33
2011	5106860	5724113	4556168	134254	144515	123993	0.40	0.43	0.37
2012	5203110	5838411	4636938	108036	116922	99150	0.54	0.58	0.49
2013	3230740	3697709	2822743	101880	110383	93377	0.40	0.43	0.36
2014	2614440	3004415	2275084	111734	120924	102544	0.39	0.42	0.35
2015	1795480	2105666	1530988	132770	143423	122117	0.38	0.41	0.34

Year	Recruitment	High	Low	SSB	High	Low	Fishing Mortality	High	Low
2016	2923600	3325246	2570468	114636	123795	105477	0.29	0.32	0.27
2017	2344010	2712954	2025240	86790	93847	79733	0.30	0.33	0.28
2018	1131720	1408165	909546	76007	82394	69619	0.26	0.28	0.24
2019	2020550	2455165	1662871	72083	78298	65868	0.152	0.167	0.138
2020	891549	1290632	615868	68267	74076	62458	0.036	0.039	0.033
2021	1862290*			68443	74396	62490	0.022	0.024	0.0199
2022	1862290*			60979	67706	54252			

***average of 2016-2020**

Table 2.1.11. 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	2289270	451911	124507	26059	10575	4859	1937	2239
1947	1276360	744559	192171	52661	10659	4463	2151	1872
1948	1855220	415030	314047	77494	19600	3982	1727	1565
1949	2195910	603119	173912	122860	27295	6831	1428	1184
1950	2249390	713875	252878	68466	43900	9699	2504	960
1951	1758930	731233	298829	98517	23950	15174	3449	1229
1952	1406140	571789	305997	116187	34321	8234	5364	1646
1953	1615220	457005	237731	115350	38236	10982	2691	2273
1954	2346270	525175	192646	96521	43789	14690	4388	1988
1955	2278060	762787	220617	76874	35475	16148	5612	2435
1956	1388440	740716	321714	89616	29169	13613	6442	3213
1957	1152460	451328	309477	124213	30835	9874	4732	3341
1958	1763880	374465	186223	112470	38208	9060	2940	2381
1959	1464440	573262	155707	70587	37530	12463	3026	1771
1960	1629370	475900	237548	57803	22600	11604	3924	1501
1961	1493480	529228	193899	80550	15550	5592	2860	1314
1962	1549340	485330	218953	70953	24985	4609	1679	1240
1963	1674250	503479	200764	80106	22007	7405	1384	869
1964	2624320	543994	207355	71839	23833	6187	2099	631
1965	3350070	853110	227615	80487	24931	8151	2174	955

Year	a1	a2	a3	a4	a5	a6	a7	a8+
1966	2928800	1089130	357719	89118	28348	8683	2921	1117
1967	2828990	951540	446469	123605	24625	7229	2208	1009
1968	2576470	919145	390765	156197	35039	6493	1908	835
1969	2010280	836976	375927	134430	43019	8918	1650	685
1970	2095350	653026	342105	129186	37006	10950	2266	583
1971	2606040	680651	266934	117962	35867	9531	2820	721
1972	3461470	846717	280056	95190	34905	10019	2683	983
1973	4280590	1124910	350727	102996	29785	10457	3044	1101
1974	2680970	1391500	470043	134612	34884	9863	3545	1396
1975	2257560	871727	586978	190641	50783	13269	3895	1950
1976	3246940	733989	366916	236504	71281	19129	5187	2285
1977	7031690	1055930	310426	149251	89266	27080	7538	2943
1978	5714780	2287090	449192	130881	60512	37206	11820	4591
1979	3384820	1858530	972909	193304	55925	27126	17632	7837
1980	5640530	1100840	789553	412898	80205	24121	12317	11636
1981	5700550	1833820	462697	319548	157611	31202	9793	9774
1982	3754720	1853850	775187	188734	121886	60837	12525	7895
1983	2329990	1220890	782915	318156	73161	48095	25031	8446
1984	1999180	757697	515835	320593	122943	28787	19738	13773
1985	2096530	649982	317826	200654	110764	41648	9995	11583
1986	3153920	681527	271401	121281	67109	36067	13857	7154
1987	1914110	1025280	284123	101142	38335	20229	11002	6350
1988	1194840	622143	425566	103203	30332	10784	5715	4837
1989	1206500	388311	257247	152779	30468	8385	2991	2889
1990	884588	392135	160477	91886	44866	8386	2317	1605
1991	1769490	287350	160043	54408	24438	10853	2007	921
1992	2101620	575172	118271	53295	13355	5215	2240	585
1993	1419250	683264	243737	48100	19489	4760	1892	1013
1994	1194800	461584	290419	106103	20619	8632	2206	1349

Year	a1	a2	a3	a4	a5	a6	a7	a8+
1995	1168510	388487	193664	115307	39118	7487	3199	1305
1996	869483	379656	161259	75022	41249	14150	2788	1667
1997	1630460	282511	155982	56814	21278	10862	3728	1145
1998	1658580	529726	117075	55491	15753	5222	2602	1133
1999	1700350	538604	218714	42937	16016	3990	1270	874
2000	1321020	552456	223529	80487	12222	3771	867	436
2001	1721590	429166	226208	77063	21099	2672	749	240
2002	1133570	559328	177092	78325	20283	4728	553	189
2003	1389260	368421	233660	68469	25523	6075	1377	206
2004	2393300	451521	154159	90037	22266	7444	1703	423
2005	1877010	777748	189023	59568	28807	6324	1990	537
2006	2322700	609832	323810	75135	21101	9532	2044	787
2007	2441330	755299	256617	127221	25408	6404	2735	771
2008	2298880	794126	321816	106891	46876	8616	2072	1084
2009	2414000	747764	337758	138044	42576	17621	3161	1127
2010	2078790	785175	316221	142089	54687	15922	6402	1529
2011	2229510	676120	331501	131502	55453	20397	5764	2823
2012	3026170	725118	284823	135932	48985	19220	6786	2776
2013	3083190	983887	303645	113135	46251	14337	5113	2382
2014	1914440	1002700	414219	125281	42203	15410	4395	2186
2015	1549240	622507	420104	169017	46388	13972	4667	1876
2016	1063950	503737	259756	168783	61700	15242	4217	1863
2017	1732440	346058	211009	105809	63790	21659	5062	1962
2018	1388990	563436	144825	85553	39382	21859	7016	2216
2019	670625	451797	236239	59531	32706	13919	7337	3053
2020	1197320	218226	190449	99719	24333	12835	5339	4061
2021	528309	389680	92303	82317	43520	10718	5772	4558
2022	1103540	171952	164950	40033	36220	19429	4910	5164

Table 2.1.12. 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	0.001	0.029	0.164	0.321	0.414	0.456	0.473	0.478	0.480	0.481	0.481	0.481	0.481	0.486
1947	0.001	0.037	0.211	0.415	0.536	0.590	0.612	0.620	0.622	0.623	0.623	0.623	0.623	0.628
1948	0.001	0.044	0.242	0.471	0.605	0.666	0.690	0.699	0.701	0.702	0.702	0.702	0.702	0.708
1949	0.001	0.043	0.235	0.456	0.586	0.644	0.668	0.676	0.678	0.679	0.679	0.679	0.679	0.684
1950	0.001	0.045	0.246	0.478	0.613	0.675	0.699	0.708	0.711	0.711	0.711	0.711	0.711	0.716
1951	0.001	0.045	0.248	0.482	0.619	0.681	0.706	0.714	0.717	0.718	0.718	0.718	0.718	0.723
1952	0.002	0.051	0.279	0.539	0.691	0.759	0.787	0.796	0.799	0.800	0.800	0.800	0.800	0.805
1953	0.001	0.038	0.205	0.396	0.508	0.558	0.578	0.586	0.588	0.588	0.588	0.588	0.588	0.593
1954	0.001	0.041	0.222	0.428	0.549	0.603	0.625	0.633	0.635	0.635	0.635	0.636	0.636	0.641
1955	0.001	0.037	0.204	0.396	0.509	0.560	0.580	0.587	0.590	0.590	0.590	0.590	0.590	0.596
1956	0.001	0.046	0.255	0.494	0.634	0.698	0.723	0.732	0.734	0.735	0.735	0.735	0.735	0.741
1957	0.002	0.059	0.315	0.606	0.776	0.853	0.883	0.894	0.897	0.898	0.898	0.898	0.898	0.905
1958	0.002	0.051	0.273	0.525	0.671	0.738	0.764	0.773	0.776	0.777	0.777	0.777	0.777	0.783
1959	0.002	0.055	0.294	0.566	0.725	0.797	0.825	0.835	0.838	0.839	0.839	0.839	0.839	0.845
1960	0.002	0.072	0.385	0.740	0.948	1.041	1.079	1.092	1.096	1.097	1.097	1.097	1.097	1.101
1961	0.002	0.056	0.308	0.598	0.767	0.844	0.874	0.885	0.888	0.889	0.889	0.889	0.889	0.895
1962	0.002	0.056	0.309	0.598	0.767	0.844	0.874	0.885	0.888	0.889	0.889	0.889	0.889	0.895
1963	0.002	0.061	0.331	0.639	0.820	0.902	0.934	0.945	0.949	0.950	0.950	0.950	0.950	0.955
1964	0.001	0.045	0.250	0.485	0.624	0.687	0.712	0.720	0.723	0.724	0.724	0.724	0.724	0.729
1965	0.001	0.043	0.241	0.471	0.606	0.667	0.691	0.700	0.703	0.703	0.703	0.703	0.703	0.708
1966	0.002	0.065	0.366	0.713	0.918	1.010	1.047	1.060	1.064	1.065	1.065	1.065	1.065	1.071
1967	0.002	0.064	0.353	0.688	0.884	0.973	1.008	1.021	1.024	1.025	1.026	1.026	1.026	1.032
1968	0.002	0.068	0.370	0.717	0.920	1.011	1.048	1.061	1.064	1.065	1.066	1.066	1.066	1.072
1969	0.002	0.068	0.371	0.717	0.920	1.011	1.047	1.060	1.064	1.065	1.065	1.065	1.065	1.071
1970	0.002	0.068	0.368	0.709	0.908	0.998	1.033	1.046	1.050	1.051	1.051	1.051	1.051	1.057
1971	0.002	0.062	0.334	0.645	0.827	0.909	0.941	0.953	0.956	0.957	0.957	0.957	0.957	0.965
1972	0.002	0.055	0.303	0.589	0.756	0.832	0.862	0.873	0.876	0.877	0.877	0.877	0.877	0.884
1973	0.001	0.046	0.261	0.510	0.656	0.723	0.749	0.758	0.761	0.762	0.762	0.762	0.762	0.769
1974	0.001	0.037	0.206	0.402	0.518	0.570	0.591	0.598	0.601	0.601	0.601	0.601	0.601	0.608
1975	0.001	0.039	0.212	0.411	0.528	0.580	0.601	0.609	0.611	0.611	0.611	0.611	0.611	0.618
1976	0.001	0.034	0.203	0.402	0.519	0.572	0.593	0.601	0.603	0.604	0.604	0.604	0.604	0.611
1977	0.001	0.028	0.167	0.330	0.426	0.470	0.487	0.494	0.495	0.496	0.496	0.496	0.496	0.503
1978	0.001	0.028	0.146	0.277	0.354	0.388	0.401	0.406	0.408	0.408	0.408	0.408	0.408	0.415
1979	0.001	0.030	0.160	0.307	0.392	0.430	0.446	0.451	0.453	0.453	0.453	0.453	0.453	0.460
1980	0.001	0.040	0.208	0.390	0.495	0.542	0.561	0.568	0.569	0.570	0.570	0.570	0.570	0.577
1981	0.001	0.035	0.200	0.391	0.503	0.554	0.574	0.581	0.583	0.584	0.584	0.584	0.584	0.591
1982	0.001	0.036	0.194	0.375	0.481	0.529	0.548	0.555	0.557	0.557	0.558	0.558	0.558	0.564
1983	0.001	0.035	0.196	0.378	0.484	0.532	0.551	0.557	0.559	0.560	0.560	0.560	0.560	0.567
1984	0.001	0.042	0.247	0.490	0.634	0.699	0.725	0.734	0.737	0.738	0.738	0.738	0.738	0.744
1985	0.001	0.047	0.267	0.522	0.673	0.741	0.769	0.778	0.781	0.782	0.782	0.782	0.782	0.788
1986	0.001	0.049	0.290	0.579	0.750	0.828	0.859	0.870	0.874	0.875	0.875	0.875	0.875	0.880
1987	0.001	0.053	0.316	0.631	0.819	0.905	0.939	0.951	0.955	0.956	0.956	0.956	0.956	0.960
1988	0.002	0.057	0.328	0.647	0.837	0.923	0.958	0.970	0.974	0.975	0.975	0.975	0.975	0.979
1989	0.001	0.057	0.333	0.652	0.841	0.927	0.962	0.974	0.978	0.979	0.979	0.979	0.979	0.984
1990	0.002	0.070	0.385	0.752	0.970	1.071	1.111	1.126	1.131	1.132	1.132	1.132	1.132	1.137
1991	0.001	0.061	0.403	0.832	1.096	1.219	1.269	1.288	1.293	1.295	1.295	1.295	1.295	1.299
1992	0.001	0.032	0.203	0.433	0.583	0.655	0.685	0.697	0.700	0.701	0.701	0.701	0.701	0.705
1993	0.001	0.029	0.135	0.274	0.366	0.410	0.429	0.437	0.439	0.440	0.440	0.440	0.440	0.445
1994	0.001	0.042	0.227	0.425	0.564	0.633	0.663	0.675	0.678	0.679	0.680	0.680	0.680	0.685
1995	0.002	0.053	0.252	0.455	0.568	0.629	0.655	0.665	0.668	0.669	0.670	0.670	0.670	0.674
1996	0.002	0.063	0.346	0.687	0.886	0.975	1.018	1.035	1.040	1.042	1.042	1.042	1.042	1.047
1997	0.002	0.055	0.337	0.710	0.956	1.070	1.116	1.136	1.143	1.145	1.146	1.146	1.146	1.152
1998	0.002	0.058	0.306	0.670	0.924	1.055	1.109	1.130	1.138	1.140	1.140	1.141	1.141	1.148
1999	0.002	0.053	0.303	0.684	0.997	1.168	1.245	1.275	1.285	1.289	1.289	1.290	1.290	1.298
2000	0.002	0.067	0.369	0.768	1.075	1.261	1.348	1.384	1.397	1.401	1.402	1.402	1.402	1.409
2001	0.002	0.059	0.364	0.763	1.048	1.218	1.308	1.347	1.361	1.366	1.367	1.367	1.367	1.374
2002	0.002	0.046	0.251	0.545	0.751	0.869	0.931	0.961	0.973	0.977	0.978	0.978	0.979	0.987
2003	0.002	0.043	0.251	0.539	0.767	0.894	0.959	0.992	1.006	1.011	1.012	1.012	1.012	1.021
2004	0.002	0.042	0.242	0.546	0.780	0.926	0.999	1.034	1.050	1.057	1.058	1.059	1.059	1.069
2005	0.002	0.046	0.208	0.433	0.611	0.717	0.775	0.803	0.815	0.820	0.821	0.822	0.822	0.831
2006	0.001	0.033	0.211	0.465	0.677	0.812	0.884	0.922	0.939	0.946	0.948	0.949	0.949	0.958
2007	0.001	0.018	0.143	0.362	0.542	0.663	0.734	0.770	0.788	0.796	0.799	0.799	0.800	0.813
2008	0.001	0.017	0.103	0.265	0.411	0.505	0.563	0.595	0.611	0.618	0.621	0.622	0.622	0.640
2009	0.001	0.020	0.111	0.251	0.388	0.482	0.536	0.568	0.585	0.593	0.596	0.597	0.598	0.618
2010	0.001	0.019	0.112	0.247	0.363	0.453	0.509	0.540	0.557	0.566	0.570	0.572	0.572	0.596
2011	0.001	0.019	0.116	0.275	0.411	0.507	0.576	0.618	0.641	0.654	0.660	0.663	0.663	0.687
2012	0.001	0.023	0.139	0.350	0.557	0.705	0.805	0.875	0.918	0.942	0.954	0.960	0.962	0.987
2013	0.001	0.016	0.093	0.244	0.408	0.539	0.629	0.690	0.733	0.759	0.774	0.782	0.786	0.811
2014	0.001	0.019	0.097	0.238	0.395	0.529	0.629	0.697	0.744	0.776	0.796	0.809	0.815	0.845
2015	0.001	0.021	0.105	0.239	0.383	0.510	0.610	0.684	0.735	0.769	0.794	0.809	0.818	0.848
2016	0.001	0.015	0.084	0.192	0.299	0.393	0.471	0.531	0.577	0.608	0.631	0.647	0.657	0.692
2017	0.001	0.015	0.083	0.197	0.308	0.400	0.477	0.540	0.589	0.628	0.656	0.678	0.691	0.731
2018	0.001	0.012	0.064	0.162	0.266	0.351	0.420	0.478	0.526	0.565	0.601	0.627	0.645	0.686
2019	0.000	0.006	0.035	0.091	0.155	0.211	0.255	0.290	0.320	0.345	0.367	0.388	0.403	0.445
2020	0.000	0.002	0.011	0.023	0.037	0.048	0.058	0.065	0.071	0.076	0.081	0.085	0.089	0.119
2021	0.000	0.002	0.007	0.015	0.022	0.029	0.035	0.039	0.043	0.046	0.049	0.051	0.053	0.083

Table 2.1.13. Eastern Baltic cod in SDs 24-32. Catch scenarios.

Basis	Total catch (2023)	F (2023)	SSB* (2023)	SSB* (2024)	Probability of SSB (2024) > B_{lim} (%)	% SSB change	% Catch change**
F = 0	0	0	60789	64453	<0.01	6	-100
F = 0.05	3553	0.050	59759	62313	<0.01	4	101
F = F (2021)	1589	0.022	60251	63555	<0.01	5	-10
Catch = TAC (2022)	2595	0.037	59973	62875	<0.01	5	47
Catch = 0.75 × TAC (2022)	1946	0.028	60205	63431	<0.01	5	10

***SSB at the spawning time**

****Catch in 2023 compared to catch in 2021 (1764 tonnes).**

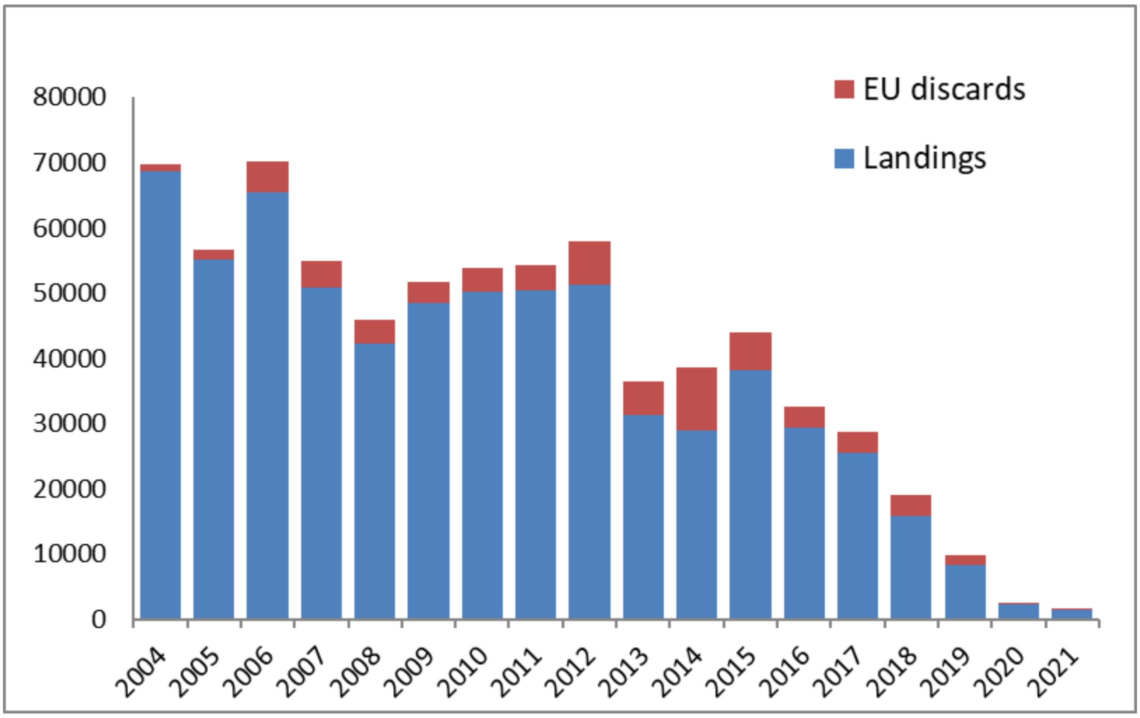


Figure 2.1.1. Eastern Baltic cod in SDs 24-32. Total landings (incl. unallocated for years before 2010) and estimated EU discards in management area of SDs 25-32.

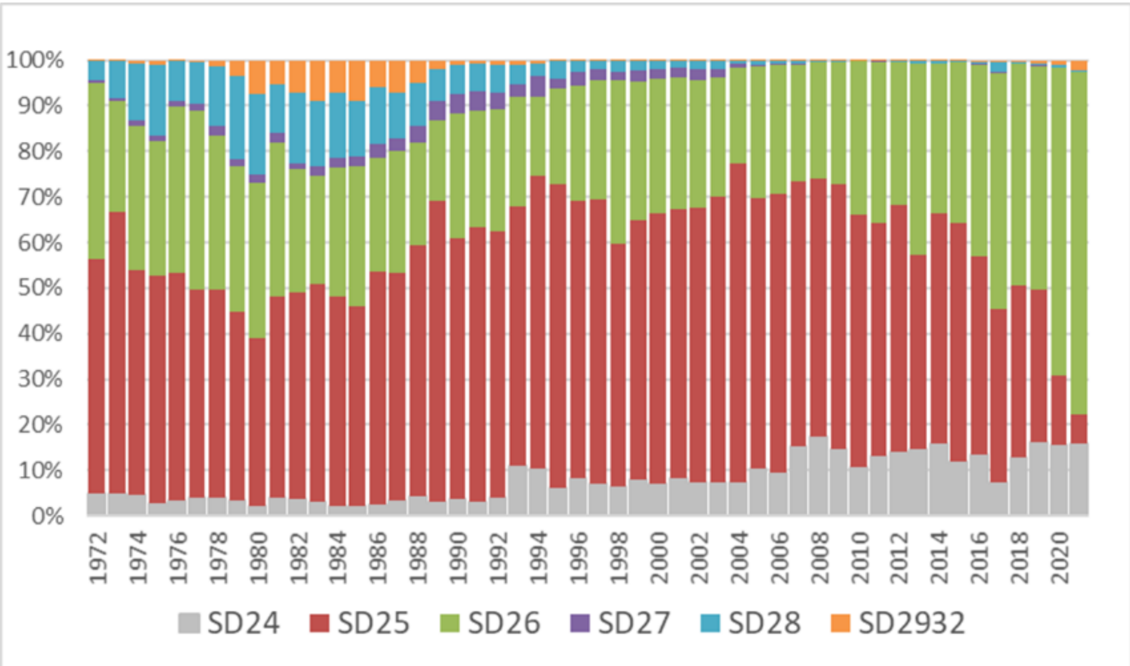


Figure 2.1.2. Eastern Baltic cod in SDs 24-32. Relative distribution of landings of the eastern Baltic cod stock by SD.

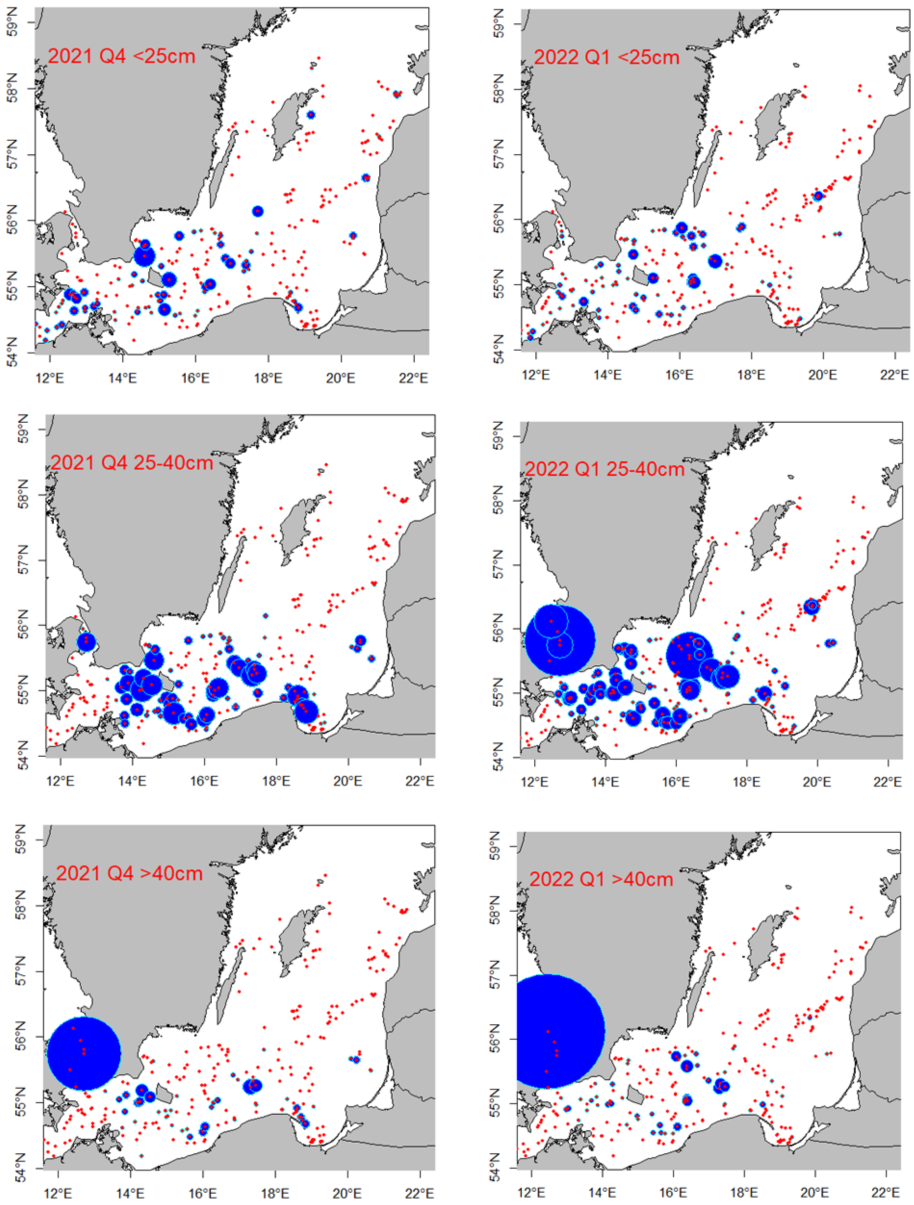


Figure 2.1.3. Eastern Baltic cod in SDs 24-32. Distribution of cod from latest BITS surveys in Q1 (2022) and Q4 (2021) by 3 size-groups (<25 cm, 25-40 cm and >40 cm cod). The scale is comparable between surveys within a size group, but not between size-groups.

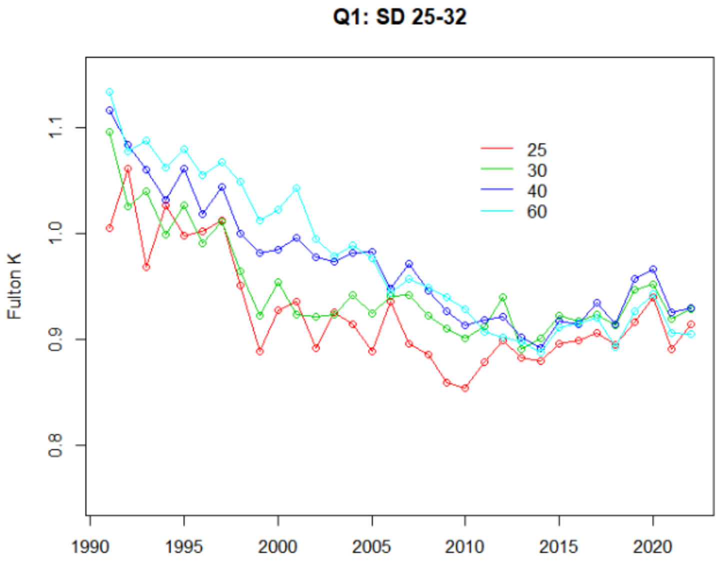


Figure 2.1.4. Eastern Baltic cod in SDs 24-32. Condition (Fulton K) of cod by length groups (<25 cm, 25-30 cm, 30-40 cm, 40-60 cm) in Q1 BITS survey.

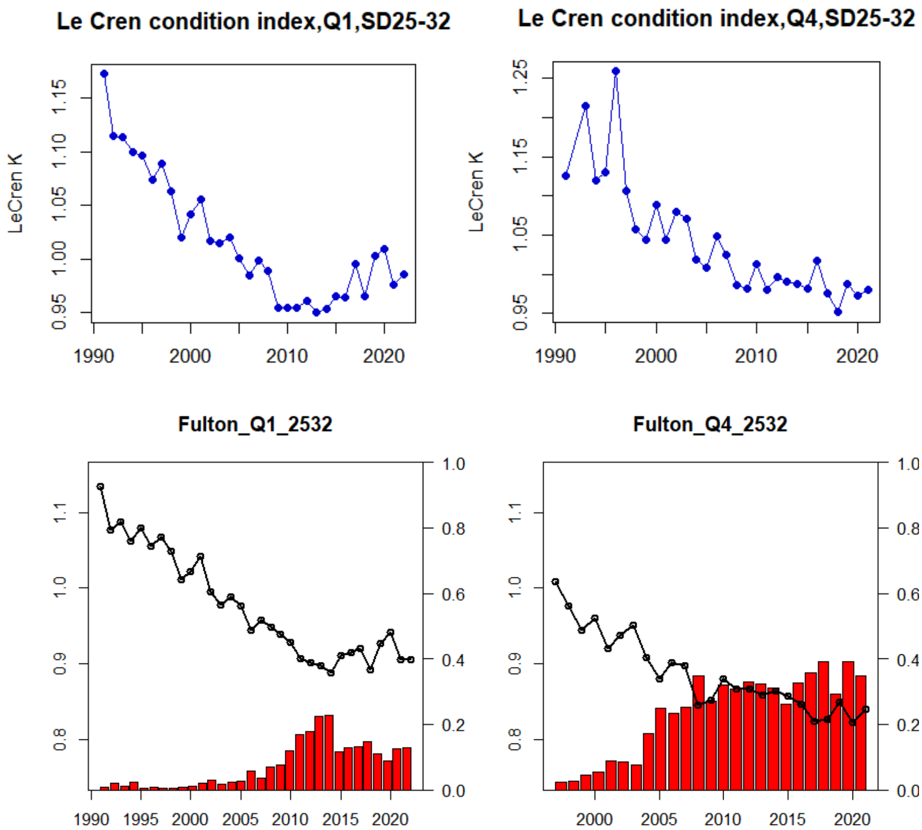


Figure 2.1.5. Eastern Baltic cod in SDs 24-32. Upper panels: average Le Cren condition index (all lengths combined) in Q1 and Q4. Lower panels: Average Fulton's K condition index of cod at 40-60 cm in length (lines) and the proportion of those cods at Fulton K <0.8 (bars), in Q1 and Q4. Data are from BITS surveys in SDs 25-32.

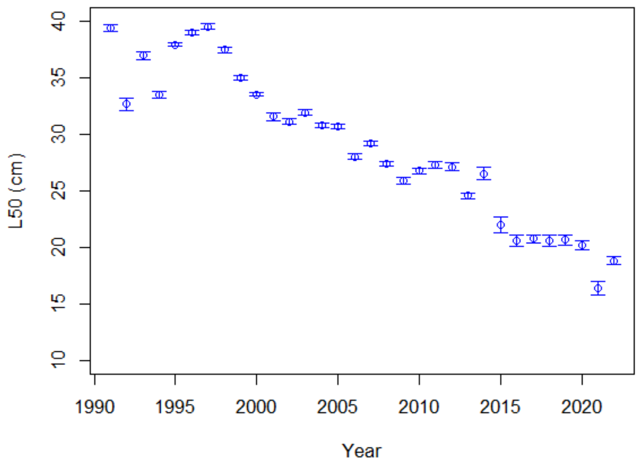


Figure 2.1.6a. Eastern Baltic cod in SDs 24-32. Size (cm) at which 50% of the stock is mature (L_{50}). Data from BITS Q1 survey.

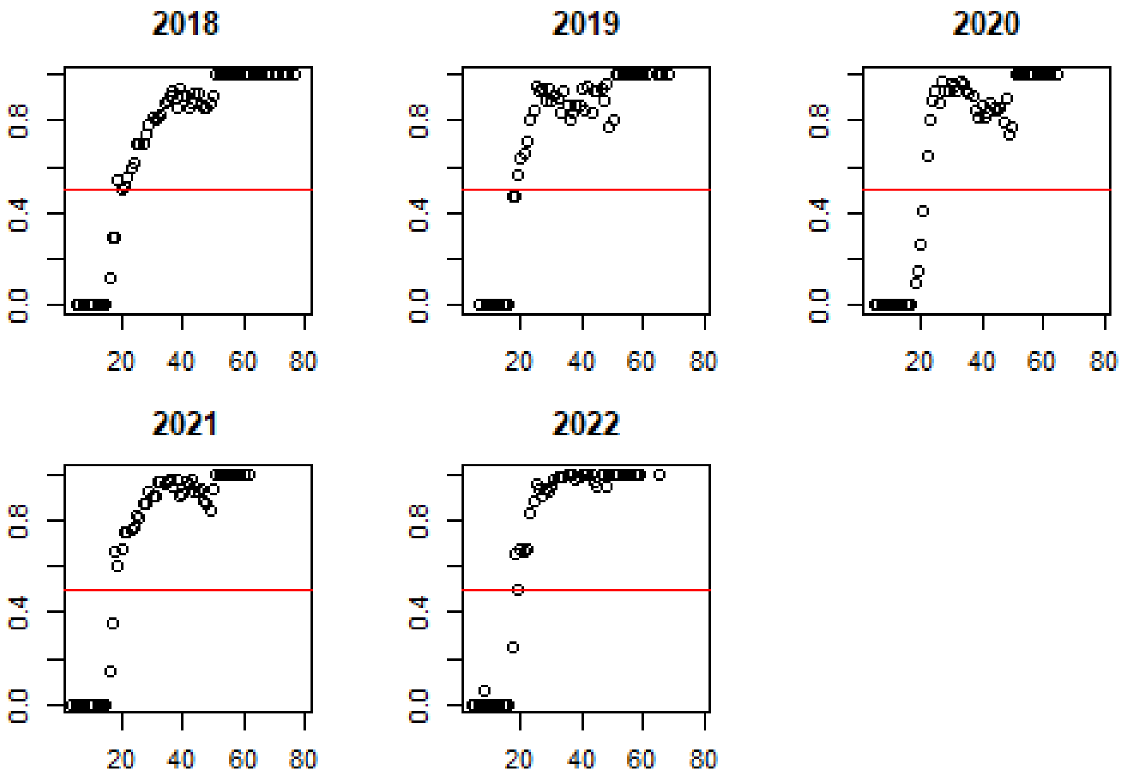


Figure 2.1.6b. Eastern Baltic cod in SDs 24-32. Proportion mature at length. The red line corresponds to 50% mature (L_{50}). Data from BITS Q1 surveys.

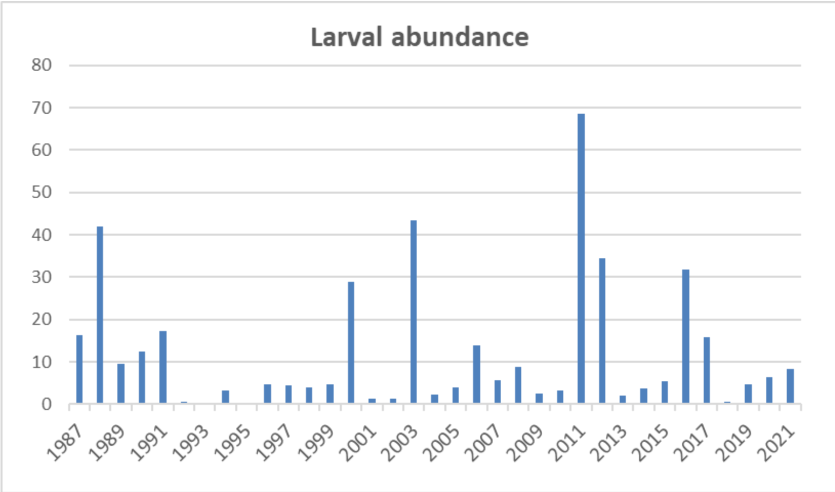


Figure 2.1.7. Eastern Baltic cod in SDs 24-32. Abundance of larvae in the main spawning area during peak spawning time.

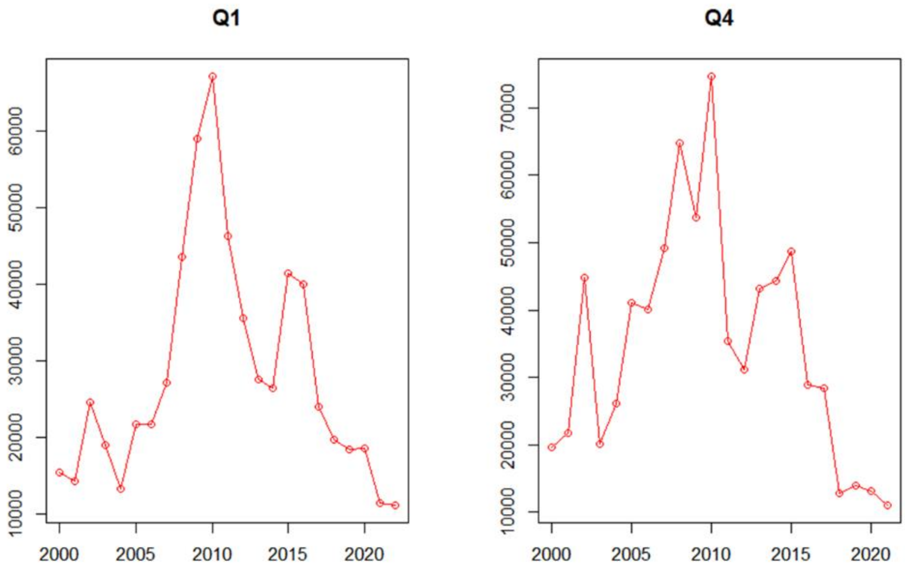


Figure 2.1.8a. Eastern Baltic cod in SDs 24-32. Relative total biomass index (CPUE), estimated from Q1 and Q4 BITS surveys.

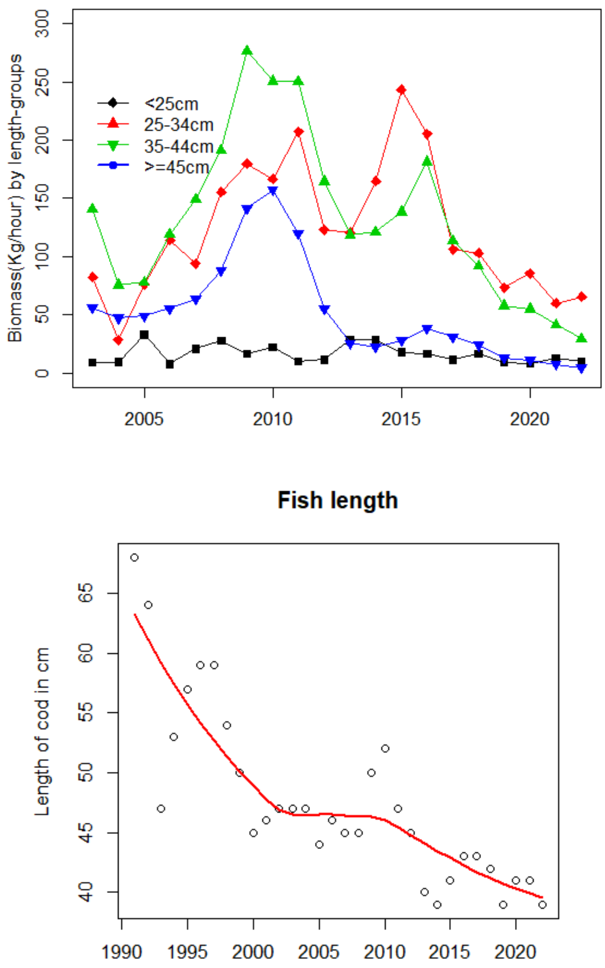


Figure 2.1.8b. Eastern Baltic cod in SDs 24-32. Upper panel: Relative biomass index (CPUE), by length-groups, estimated from Q1 and Q4 BITS surveys combined. Lower panel: Length corresponding to 95% percentile of length distribution (L95), in BITS Q1 survey.

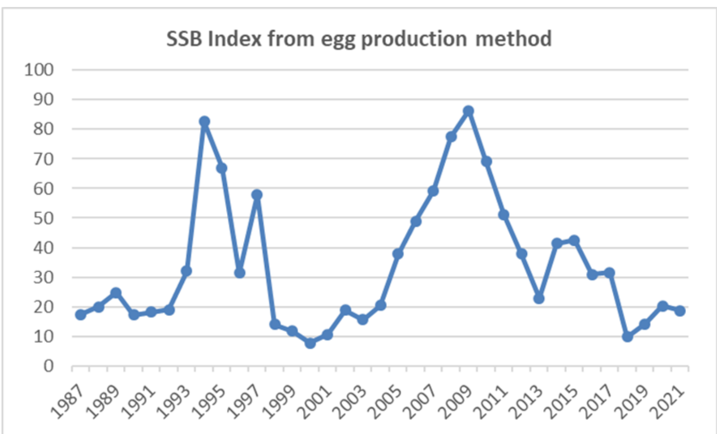


Figure 2.1.9. Eastern Baltic cod in SDs 24-32. Index of spawning stock biomass, calculated from egg production method. Data are from ichthyoplankton surveys.

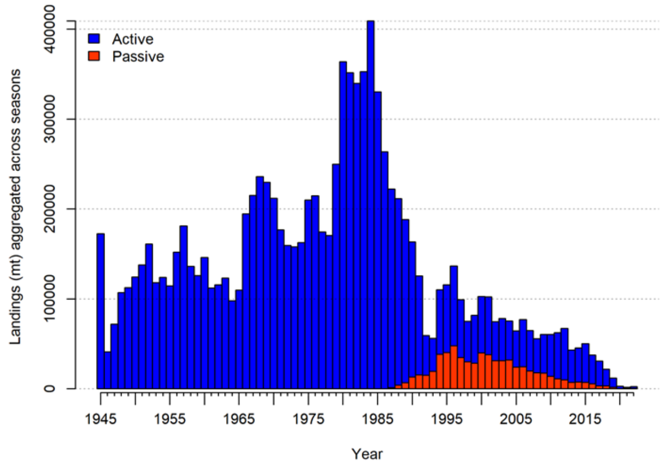


Figure 2.1.10. Eastern Baltic cod in SDs 24-32. Time-series of total catch used in the assessment, by fleets).

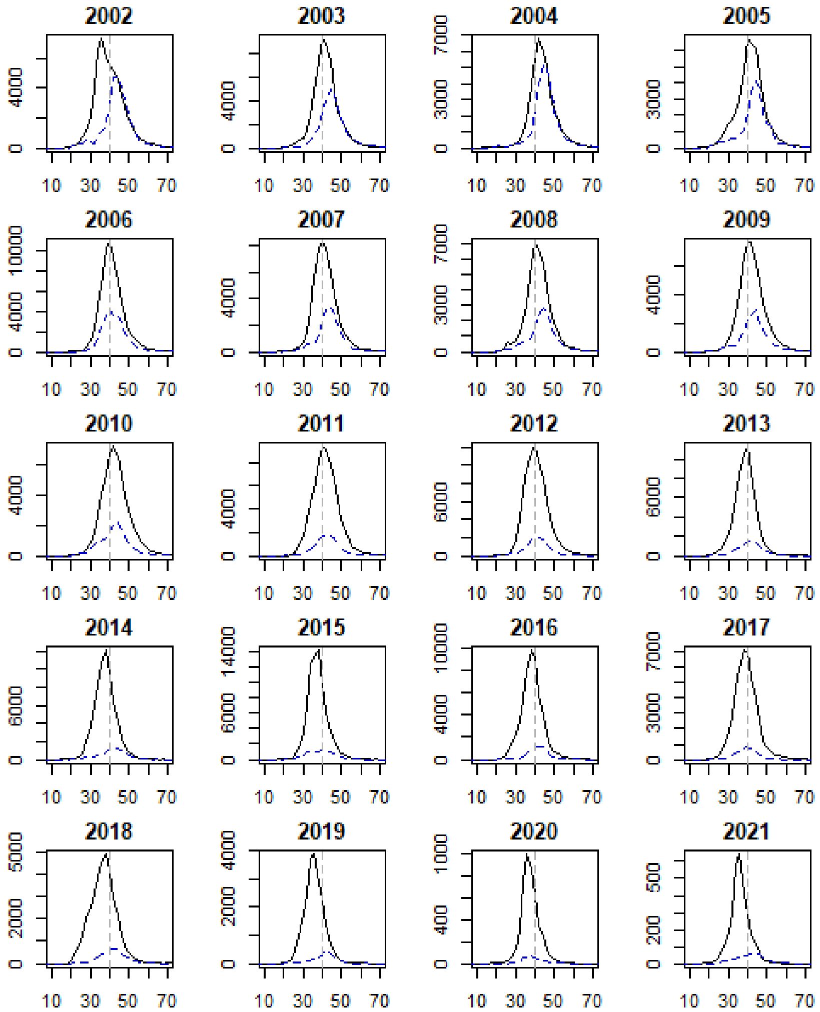
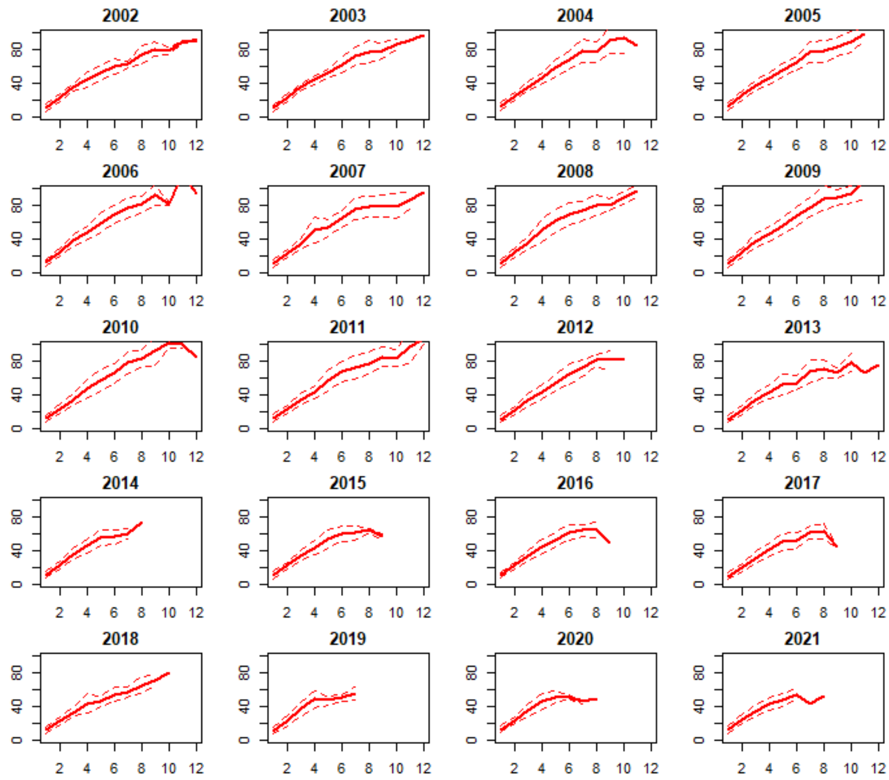


Figure 2.1.11. Eastern Baltic cod in SDs 24-32. Annual length distributions of total commercial catch by Active (in black) and Passive (in blue) gears.



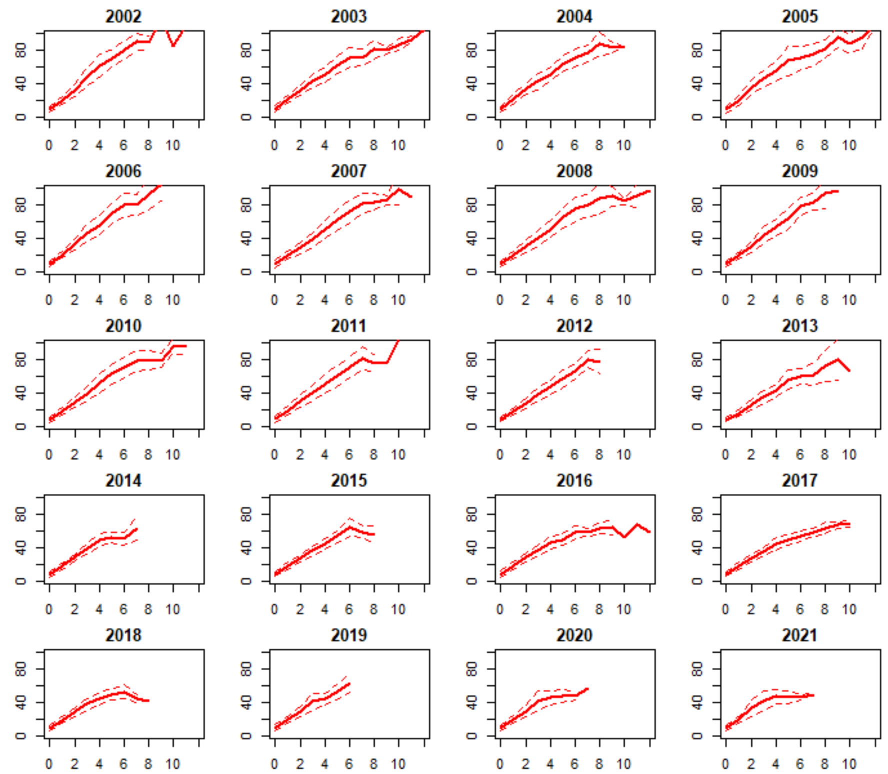


Figure 2.1.12. Eastern Baltic cod in SDs 24-32. Mean length at age (LAA) based on average annual ALKs of all countries included in DATRAS, for BITS Q1 (upper panels) and BITS Q4 (lower panels) (individual sample data only, not raised to the population).

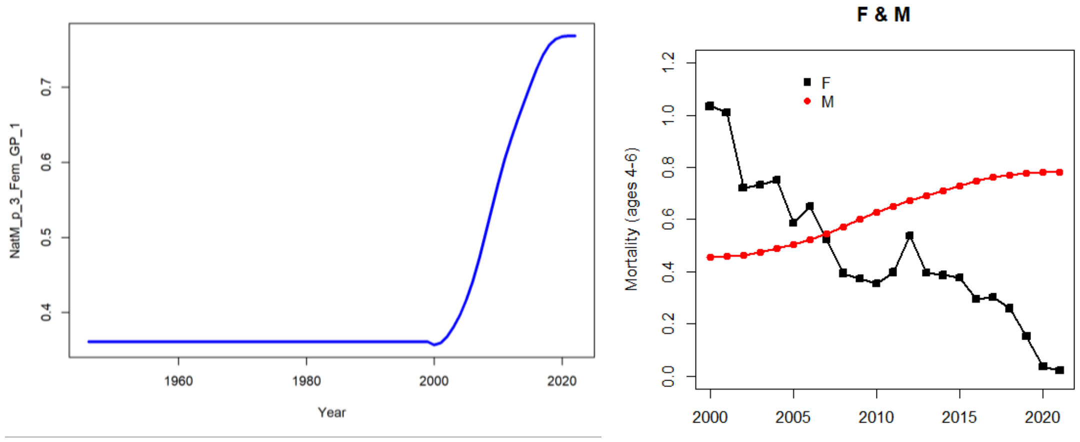


Figure 2.1.13. Eastern Baltic cod in SDs 24-32. Change in natural mortality for age-break 5.5, estimated in Stock Synthesis model (left panel). Fishing mortality (F) and natural mortality (M) for ages 4-6 (right panel).

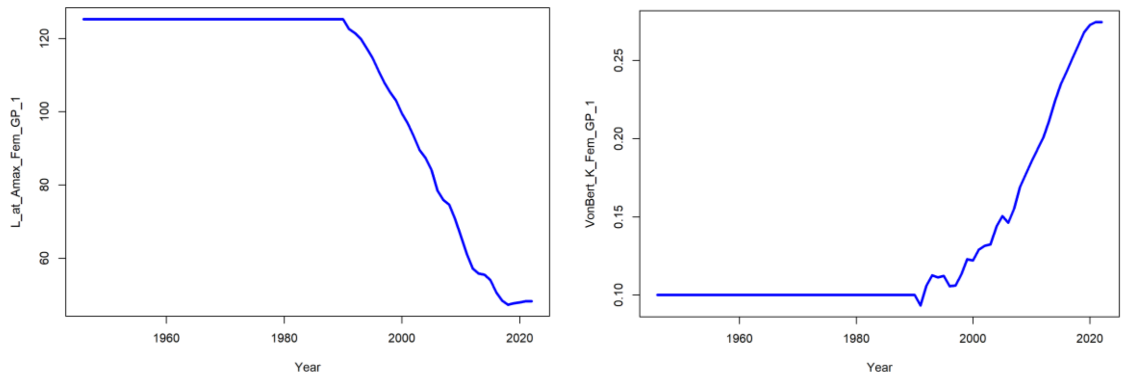


Figure 2.1.14. Eastern Baltic cod in SDs 24-32. Estimated change in von Bertalanffy growth parameters L_{inf} (left panel) and K (right panel) from Stock Synthesis model.

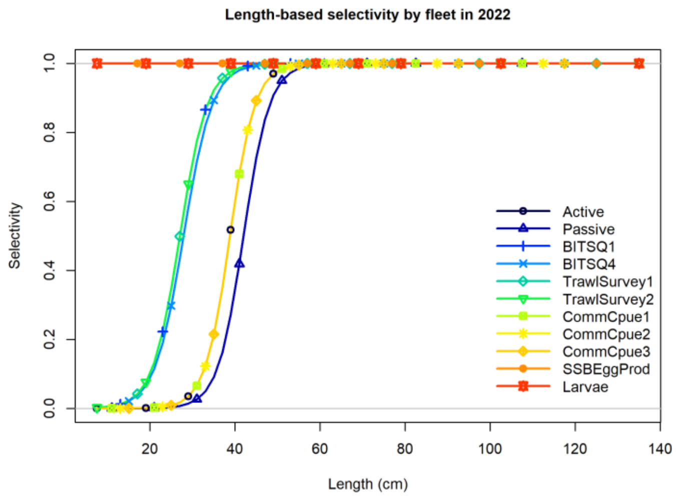
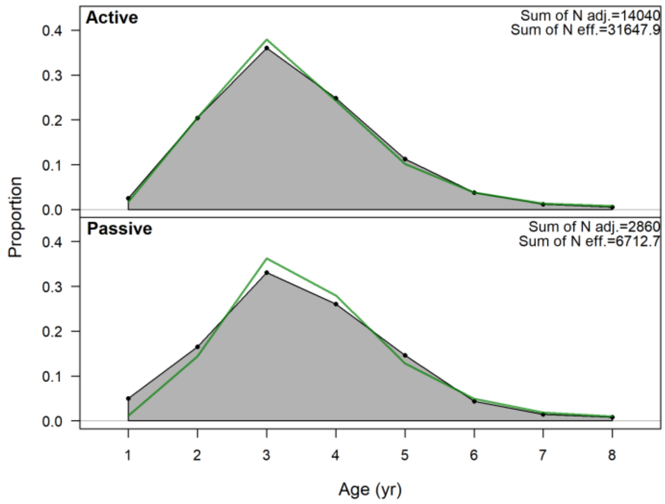


Figure 2.1.15. Eastern Baltic cod in SDs 24-32. Selectivity of different fleets.



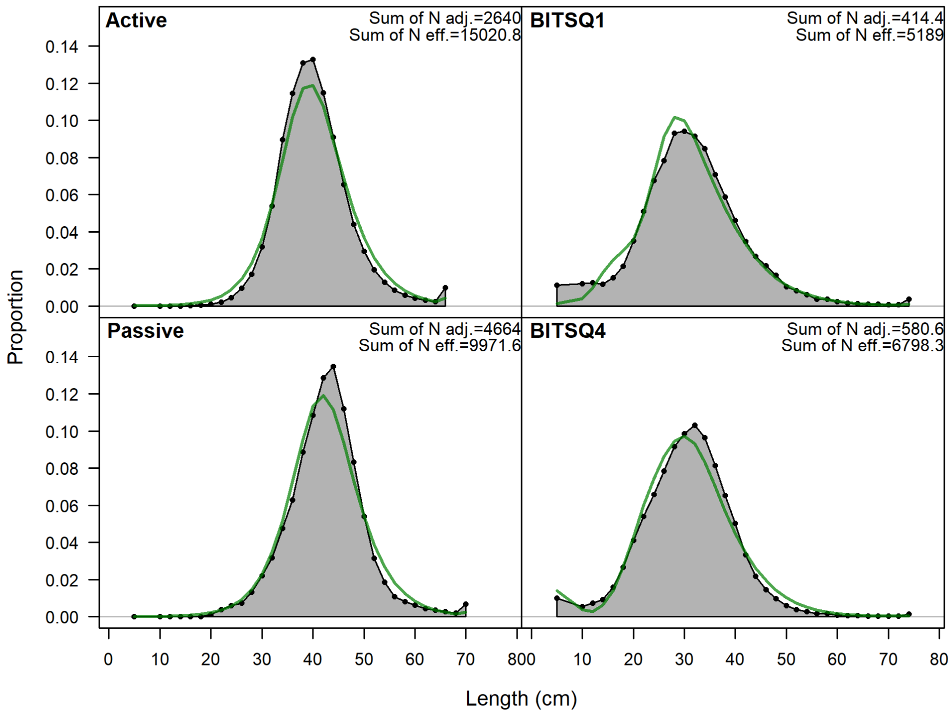
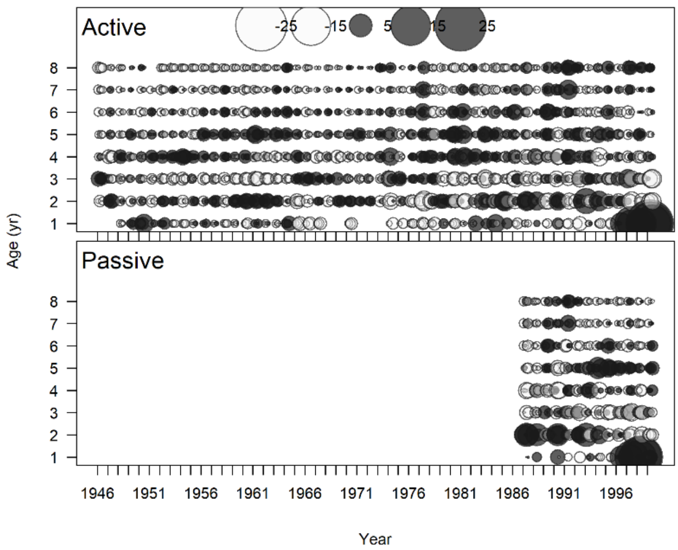


Figure 2.1.16. Eastern Baltic cod in SDs 24-32. Fits to age (upper panels) and length (lower panels) composition data, aggregated across years.



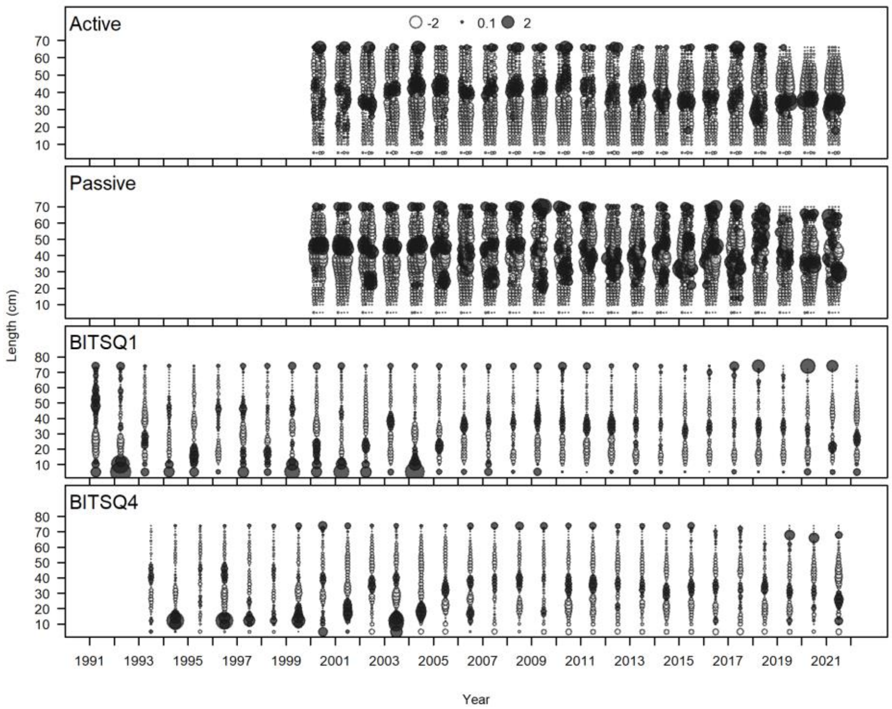


Figure 2.1.17. Eastern Baltic cod in SDs 24-32. Residuals of fits to age (upper panels) and length (lower panels) composition data for different fleets.

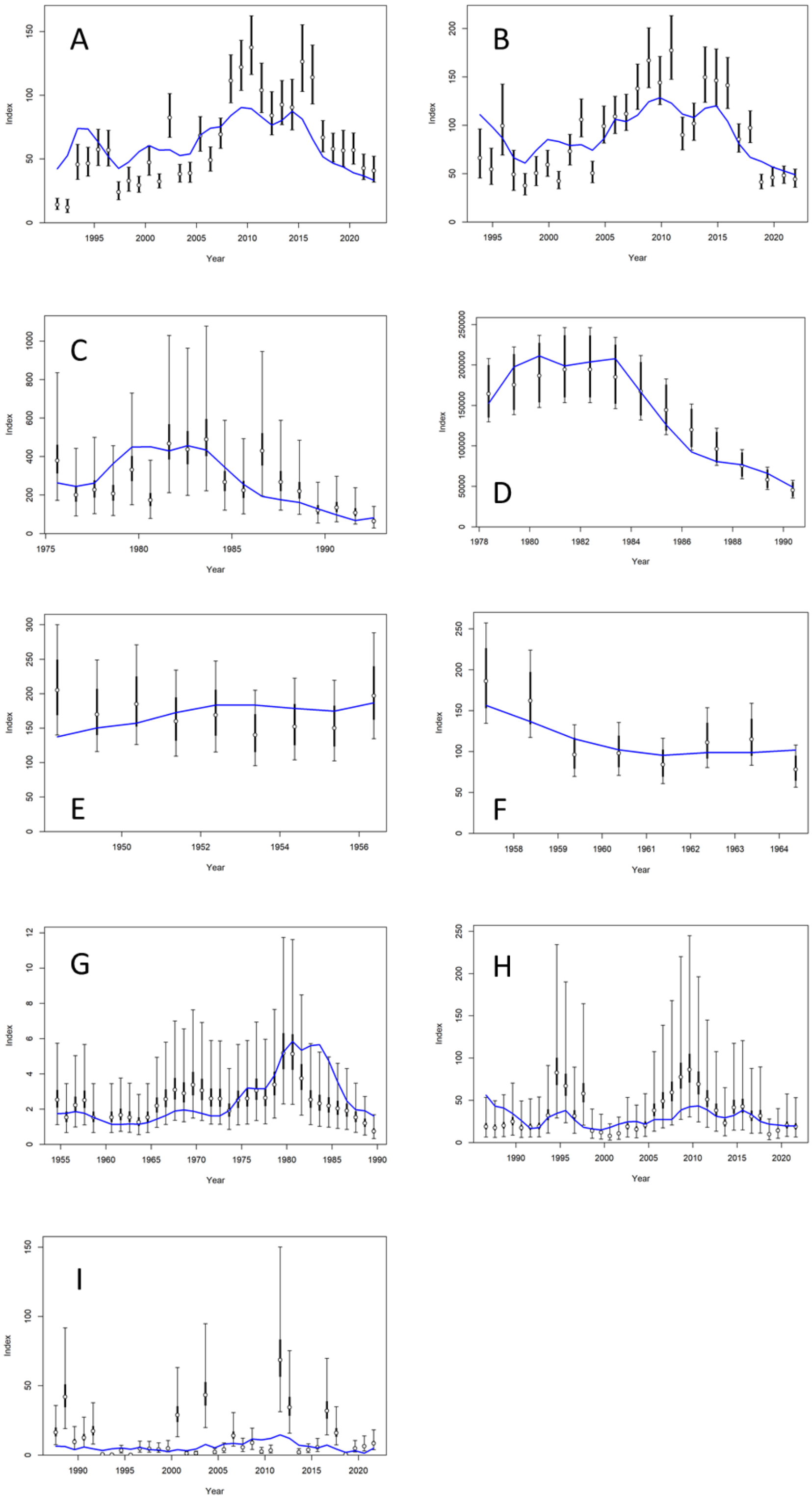


Figure 2.1.18. Eastern Baltic cod in SDs 24-32. Model fits to different tuning indices. A- BITSQ1; B-BITSQ4; C- TrawlSurvey1; D- TrawlSurvey2; E- CommCPUE1; F- CommCPUE2; G- CommCPUE3; H- SSBEggProd; I- Larvae.

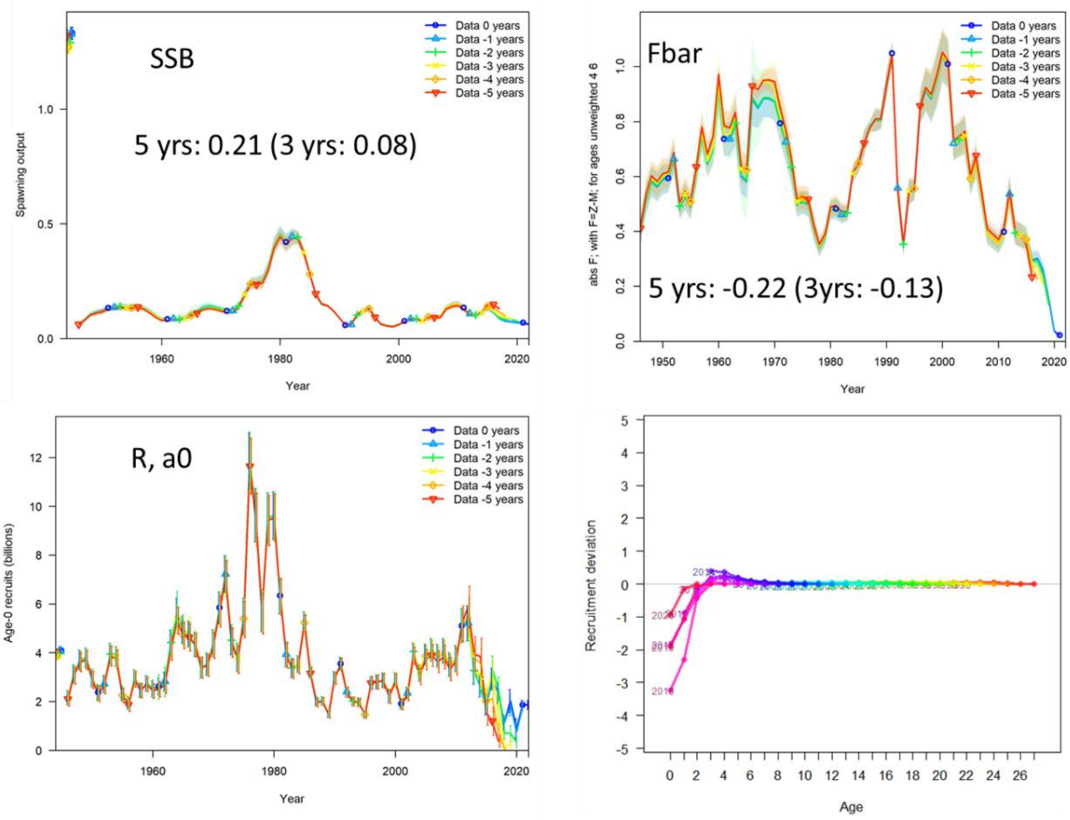


Figure 2.1.19. Eastern Baltic cod in SDs 24-32. Retrospective analyses, including Mohn's Rho values for SSB and F_{bar} estimated for 5 years and 3 years (in brackets).

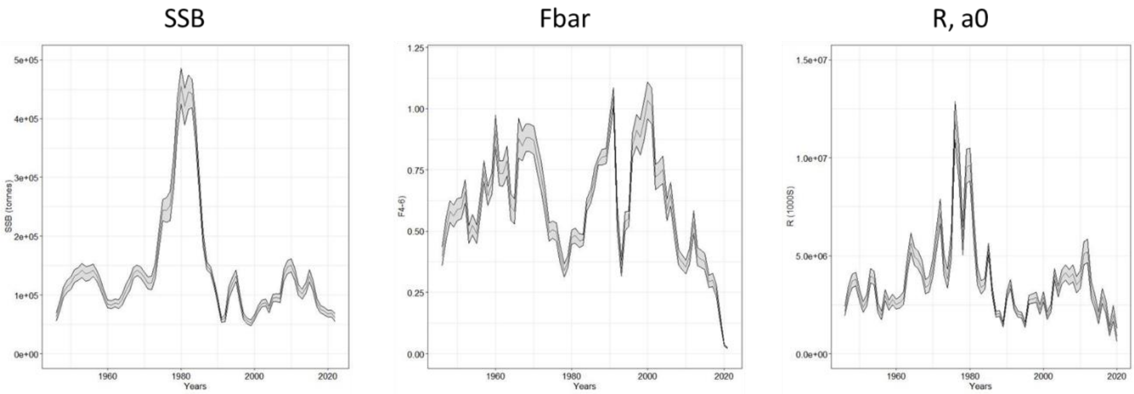


Figure 2.1.20. Eastern Baltic cod in SDs 24-32. Spawning stock biomass, fishing mortality (average of ages 4-6) and recruitment (age 0).

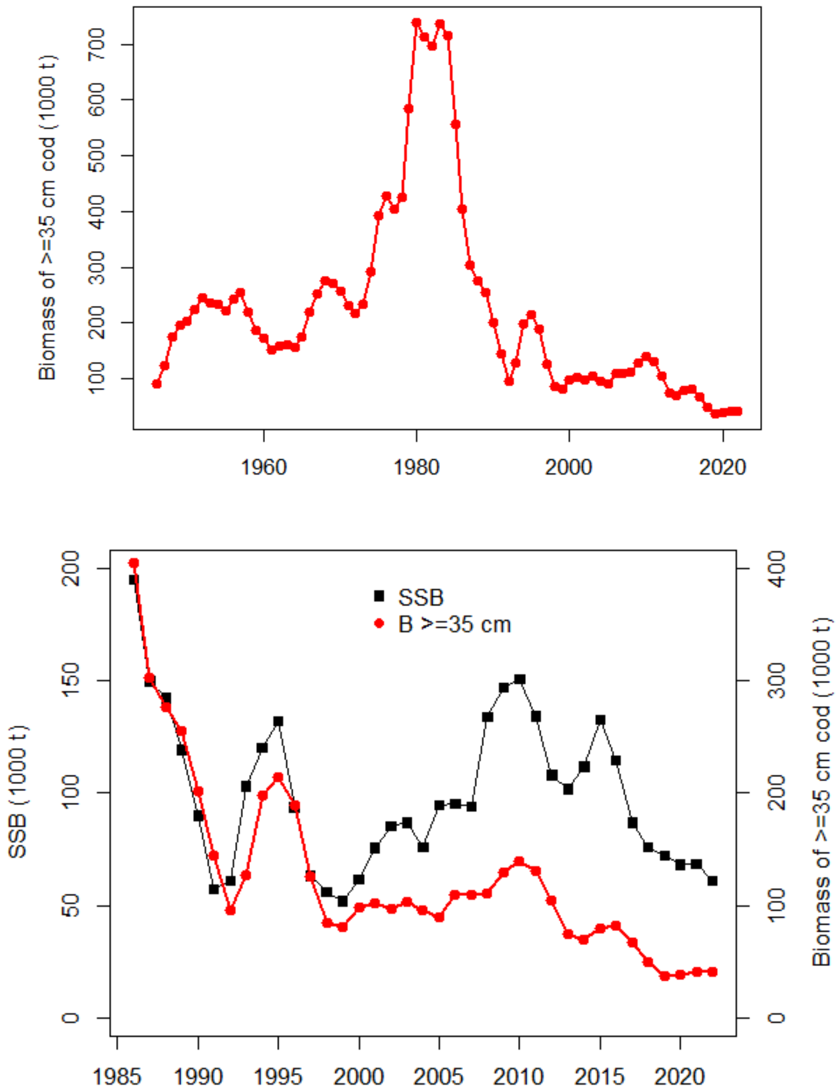


Figure 2.1.21. Eastern Baltic cod in SDs 24-32. Biomass of commercial sized cod (≥35 cm in length) (upper panel), compared to SSB in later years (lower panel).

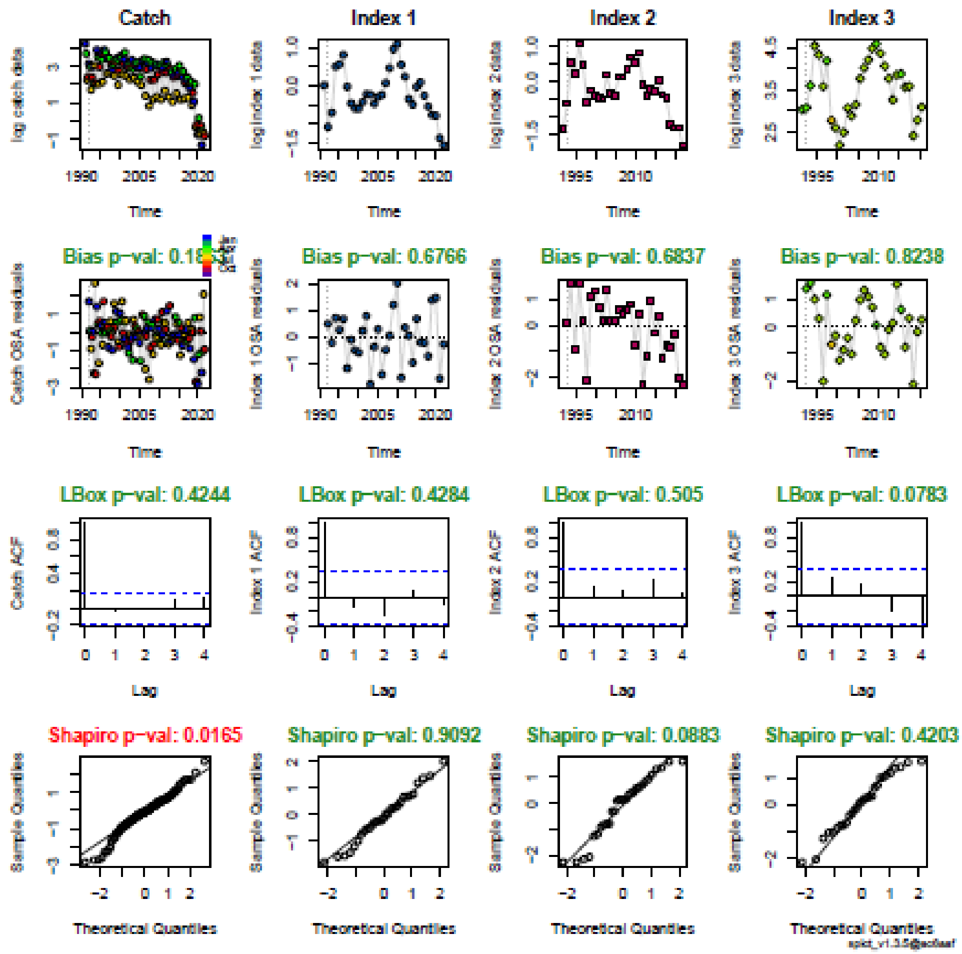


Figure 2.1.22. Eastern Baltic cod in SDs 24-32. Diagnostics of SPICT model.

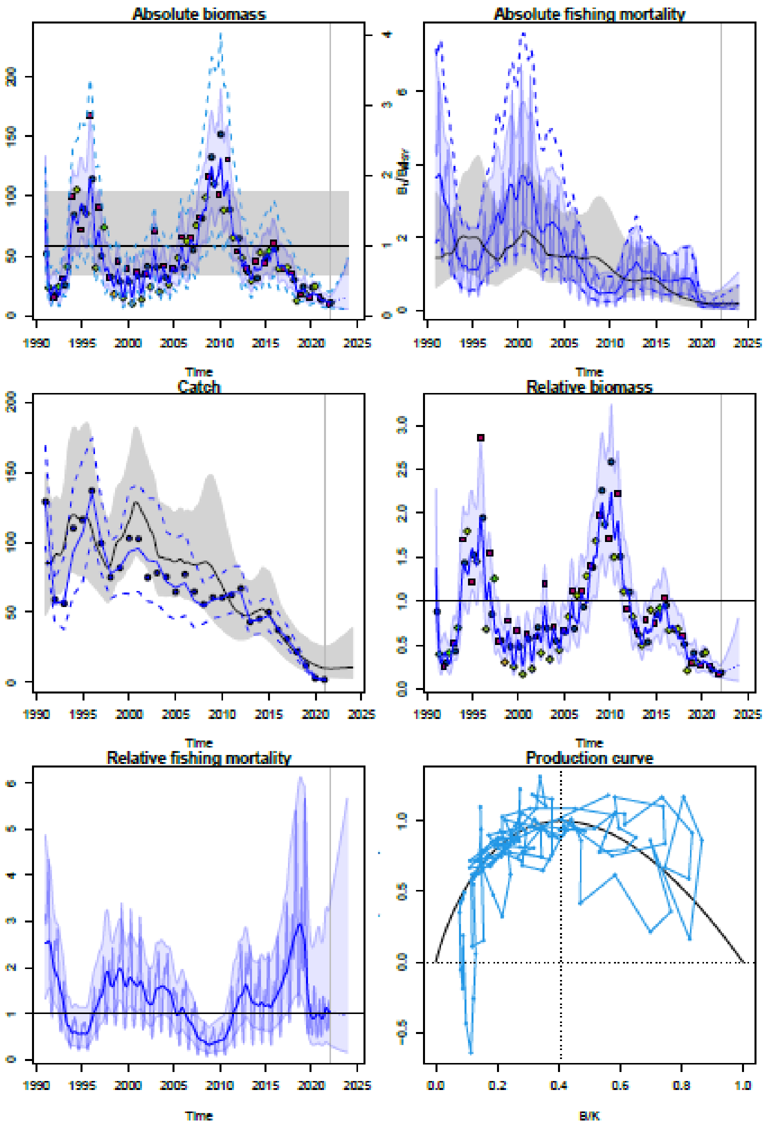


Figure 2.1.23. Eastern Baltic cod in SDs 24-32. Results of SPICT model.

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 bycatch-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.

Due to the Covid-19 disruption in 2020 and 2021 the sampling coverage for Swedish landings was lowered and some quarters (Q1 and Q3) were not sampled. Hence some data manipulation was performed by the Swedish data submitters. Averages were computed and data in Q2 + Q4 were borrowed to compute averages for Q1 and Q3. Also size 3 was used for size 1 and size 2.

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 2021 were 24 tons, 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 1997–2021 and from Denmark for 2000–2021. The estimated discard numbers by age and total discards in tonnes 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 2020, the estimated discards formed about 52% 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 89% of the cod caught in the Kattegat is discarded. Similarly, to previous years, discarding in 2021 has mostly affected ages 1-2, with a larger proportion of age 2 caught compared to last year

Due to the Covid-19 disruption in 2020 and 2022 the sampling coverage for Swedish discards was lowered and some quarters, namely Q2-Q4 for active gears and Q2 and Q4 for passive gears, were not sampled. Hence some data manipulation was performed by the Swedish data submitters. There was no available Swedish discard trips for quarter 1 and 2 2021. The Swedish SELTRA landings was therefore raised using Danish discard ratios for those quarters.

For active gears Q2-Q4 discards were calculated by using average discard per hour fished 2017-2019 * hours fished 2020. Numbers at age and length were calculated as an average of proportion in 2017-2019 per age/length*discard weight calculated as above and then divided by the sampled weight. For passive gears, Q1 was borrowed for Q2 and Q3 was borrowed for Q4.

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 2021. 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 (1997-2021).

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) (1997-2022)
IBTS-3Q	International Bottom Trawl Survey, 3rd quarter, Kattegat (age 1-4) (1997-2021)
IBTS-1Q	International Bottom Trawl Survey, 1st quarter, Kattegat; (Ages 1-6) (1997-2022)
CODS-4Q	Cod survey, 4th Quarter, Kattegat, (ages 1-6). (2008-2021)

There were some corrections in the survey indices for this year's assessment (indicated in table 2.2.10 with bold numbers for years and ages corrected). However, the changes did not affect the assessment results in anyway (less than 0.01% change).

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—2021 with estimating total removals from 2003—2020 within the model based on survey information. (SPALY _Scaling; codkat2022_new on https:/www.stockassessment.org)

Catch (landings and discards) from 1997—2021 without estimating total removals (SPALY_No Scaling; codkat2022_new on stockassessment.org)

Unallocated removals were estimated separately for the years 2003—2021, but common for all age-groups within a year. The scaling factors estimated for 2005—2021 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 Fig 2.2.11.

2.2.3.3 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. There has not been a recruitment above the average since 2013, the year classes of 2018 and 2022 are the lowest in the times-series (Figure 2.2.5,). However, the year class of 2019 was higher than the year classes in 2017 and 2018 but still below average recruitment over the whole time period (figures 2.2.5 and 2.2.10).

2.2.3.4 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 2021.

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 1.1 to2.4. In contrast, the run without estimating total removals in the interval of 0.8 to 1.9. (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—2021, 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 2020, around 348 tonnes, and it is still low in 2021 (368 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 longerterm 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: **Swedish sampling Q1 and Q3 of discards were missing and Danish discards were borrowed for raising Swedish data in the corresponding age classes within quarter..**

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**

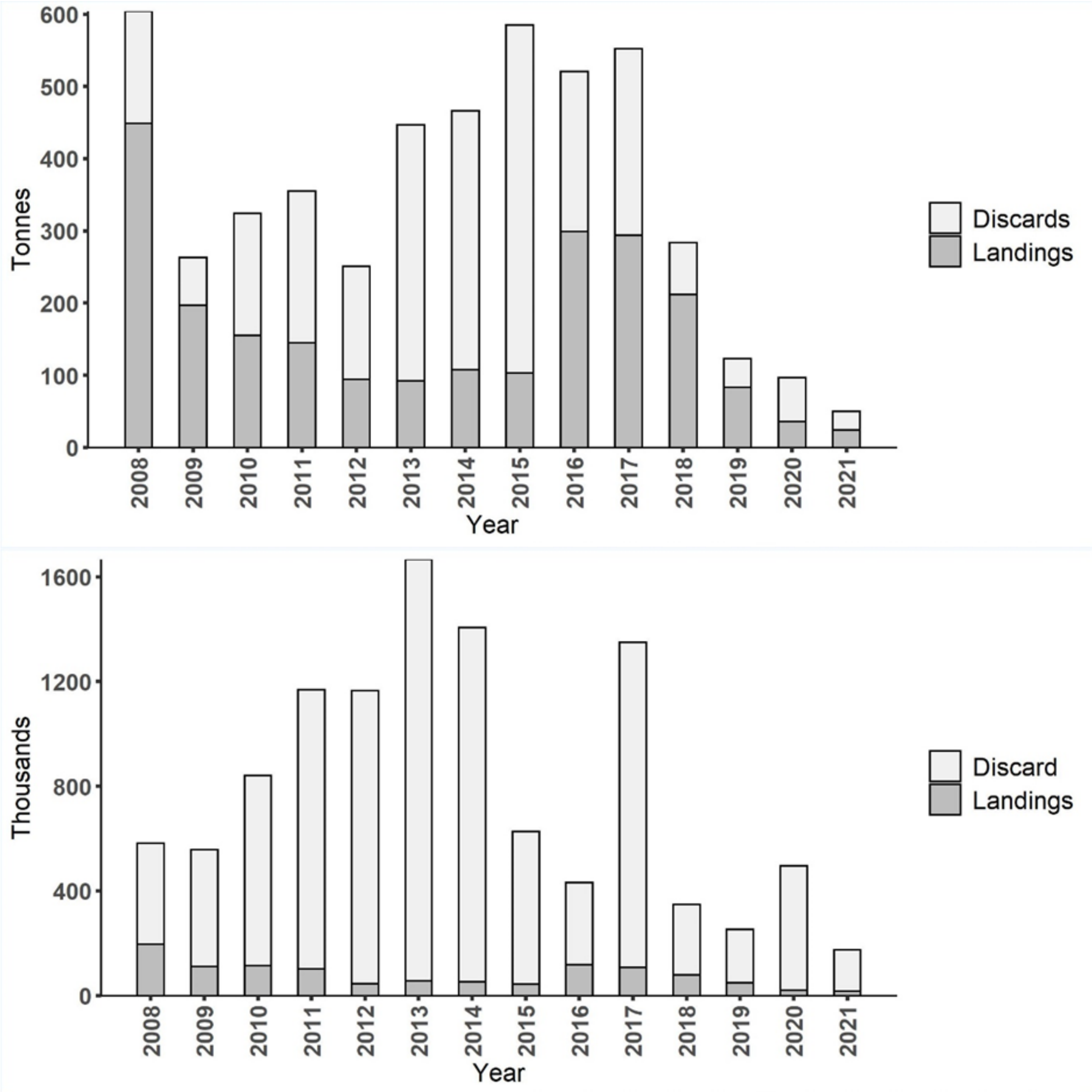


Figure 2.2.1. Cod in the Kattegat. Estimates of discards (Denmark and Sweden combined) compared to reported landings, in weight (upper panel) and in numbers (lower panel).

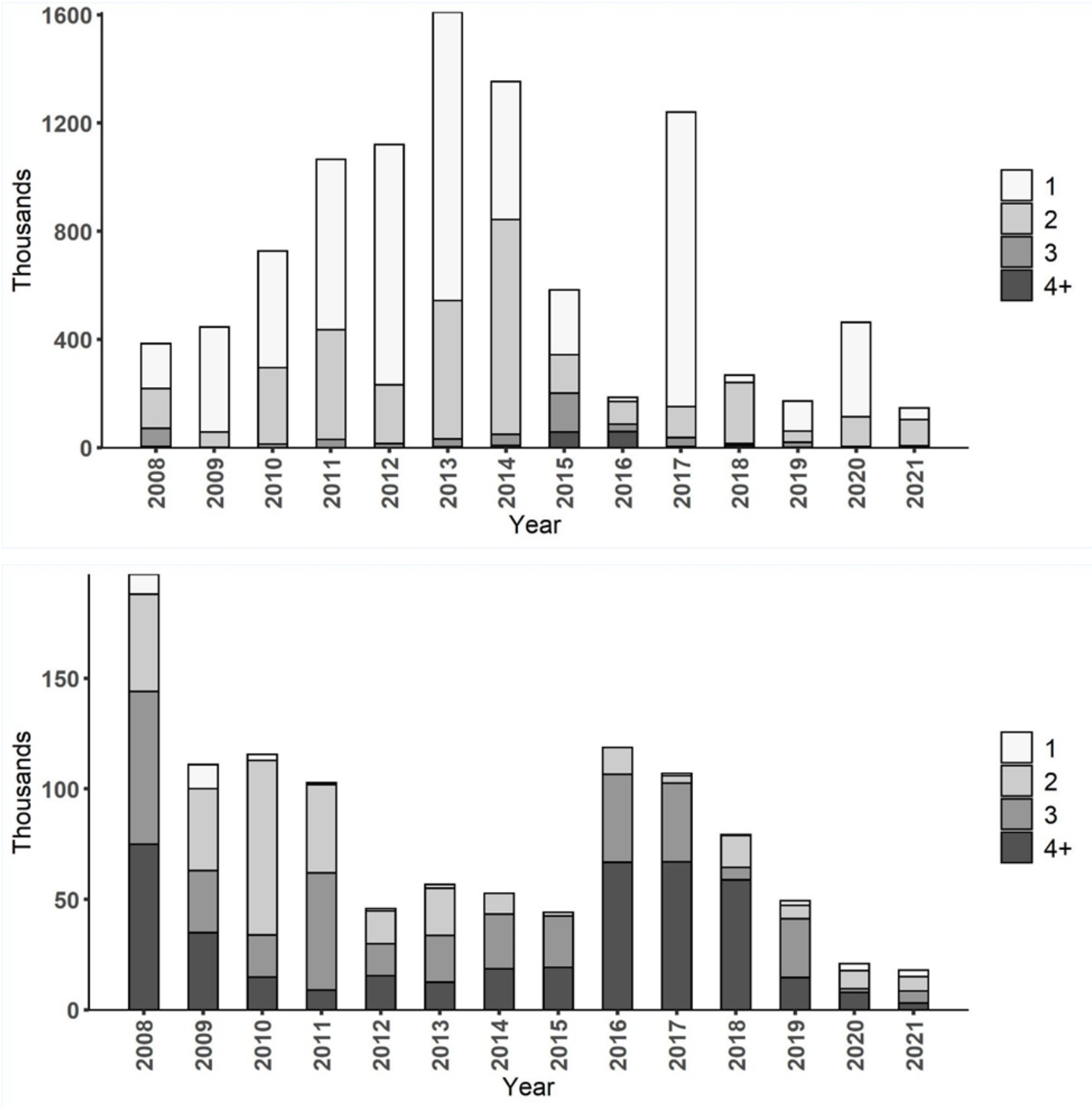
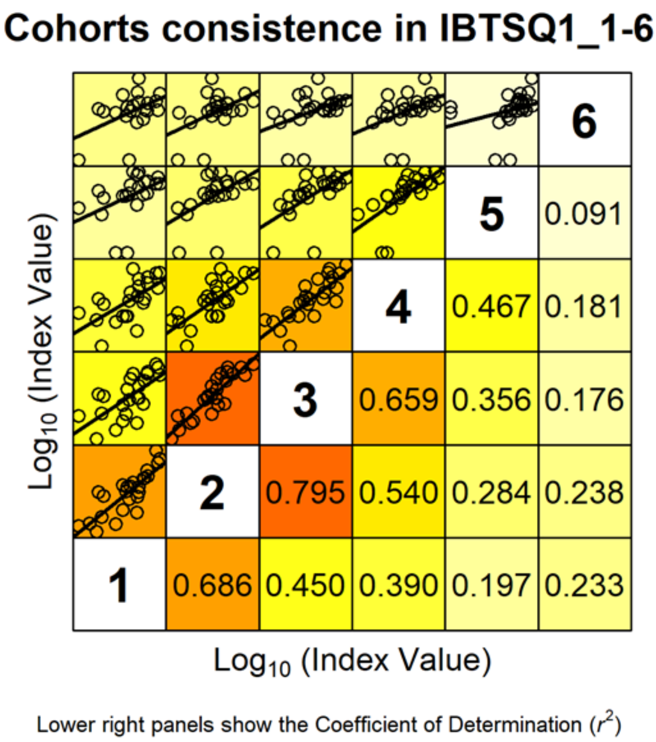


Figure. 2.2.2. Cod in the Kattegat. Estimates of discards in numbers by age in the upper panel and landings in numbers by age in the lower panel (Sweden and Denmark combined).



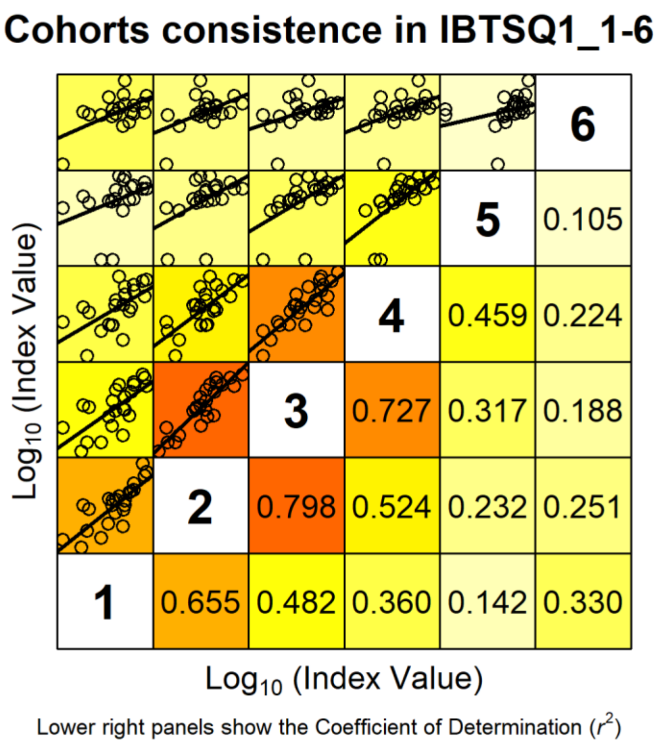
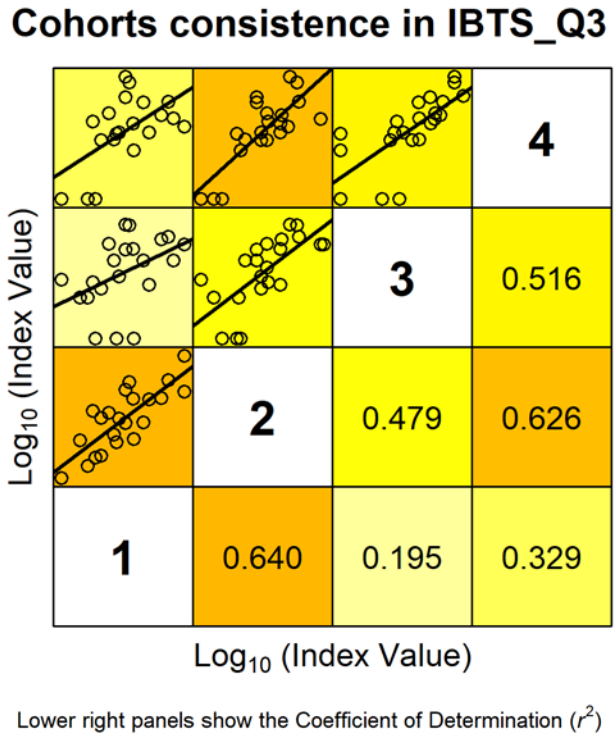


Figure 2.2.3a. Cod in Kattegat. IBTS 1st quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 1997-2022. Upper plot 2022 and lower plot 2021.



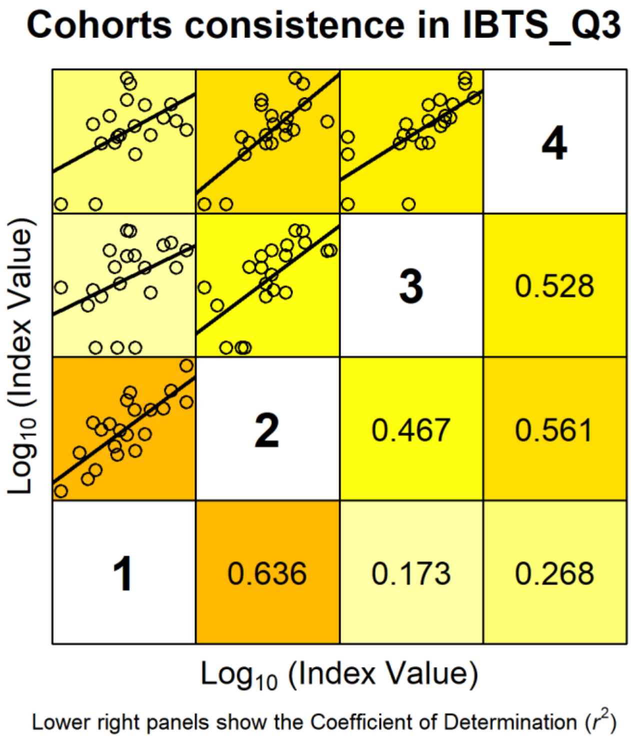
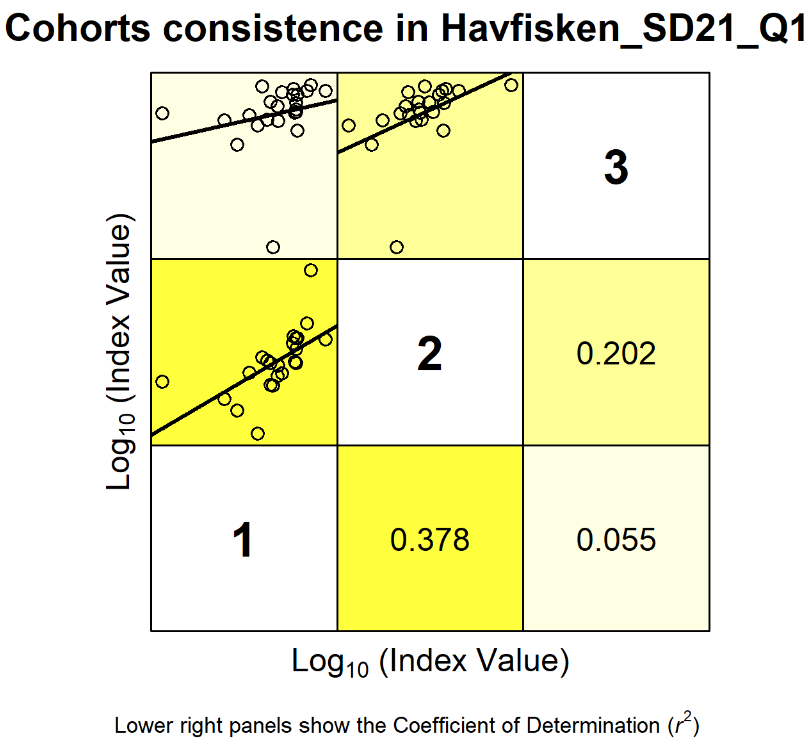


Figure 2.2.3 b. Cod in Kattegat. IBTS 3rd quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 1997-2021. Individual points are given by year-class. Upper plot 2021 and lower plot 2020.



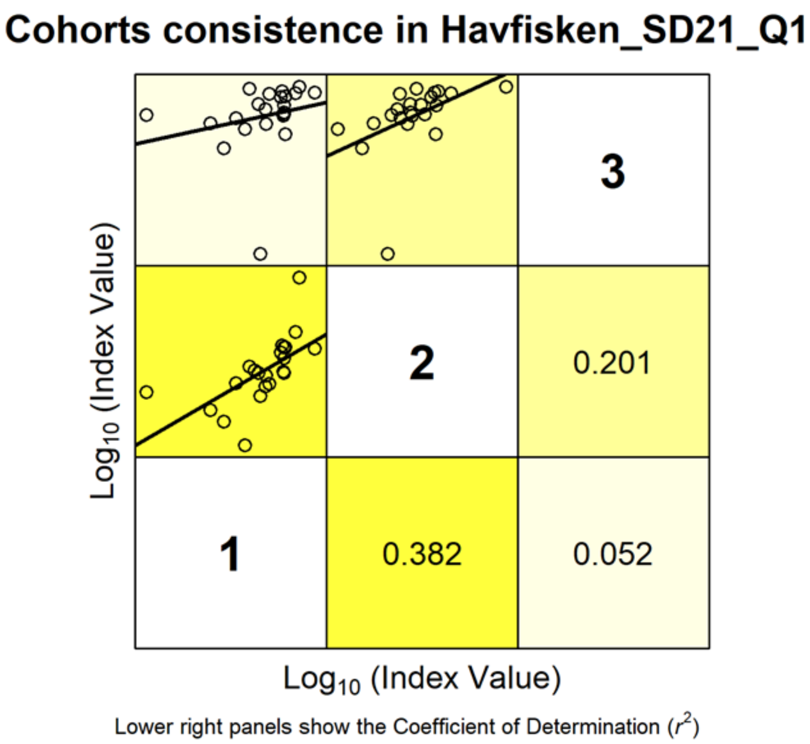
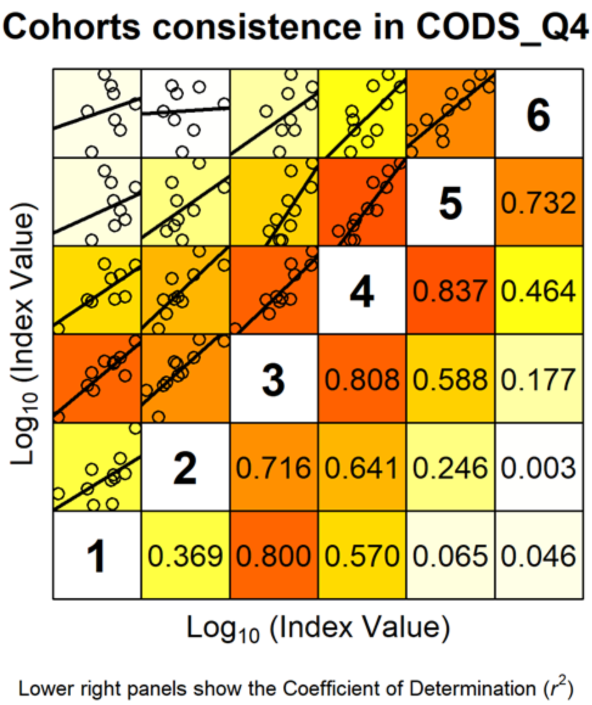


Figure 2.2.3c. Cod in Kattegat. Havfisken 1st quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 1997-2022. Upper plot 2022, lower plot 2021.



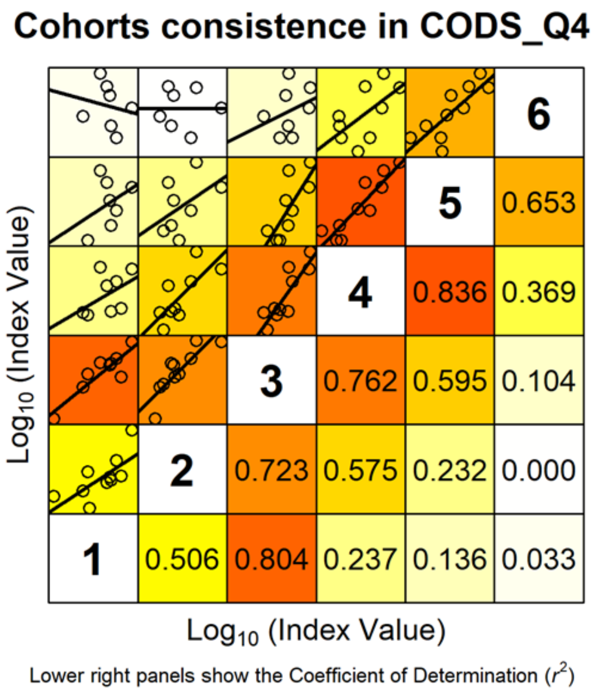


Figure 2.2.3d . Cod in Kattegat. Cod Survey 4th quarter numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2008-2021. Individual points are given by year-class. Red dots highlight the information from the latest year. Upper plot 2021, lower plot 2020.

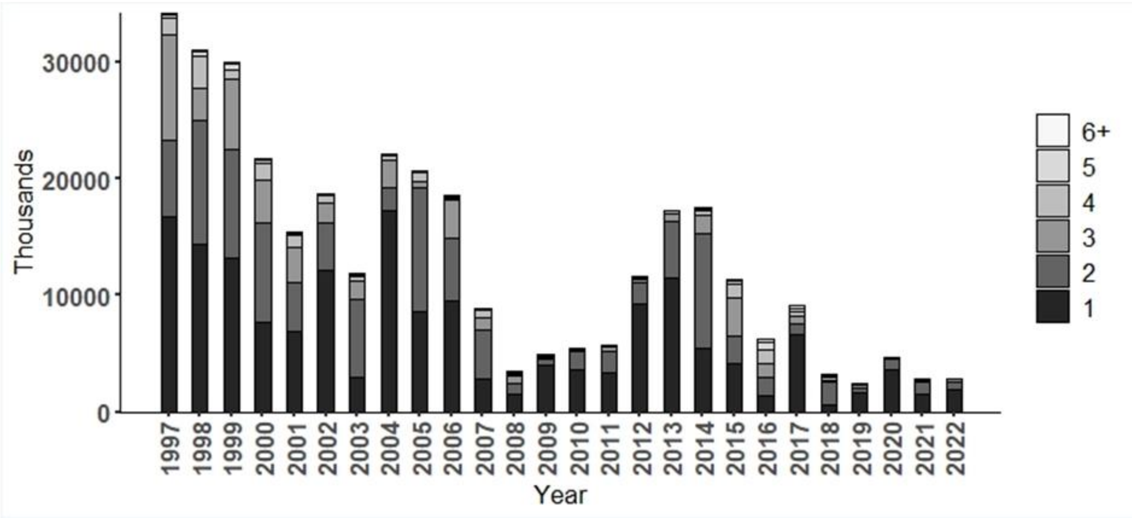


Fig 2.2.4. Cod in Kattegat. Stock numbers at age for the period 1997-2022 from SAM output

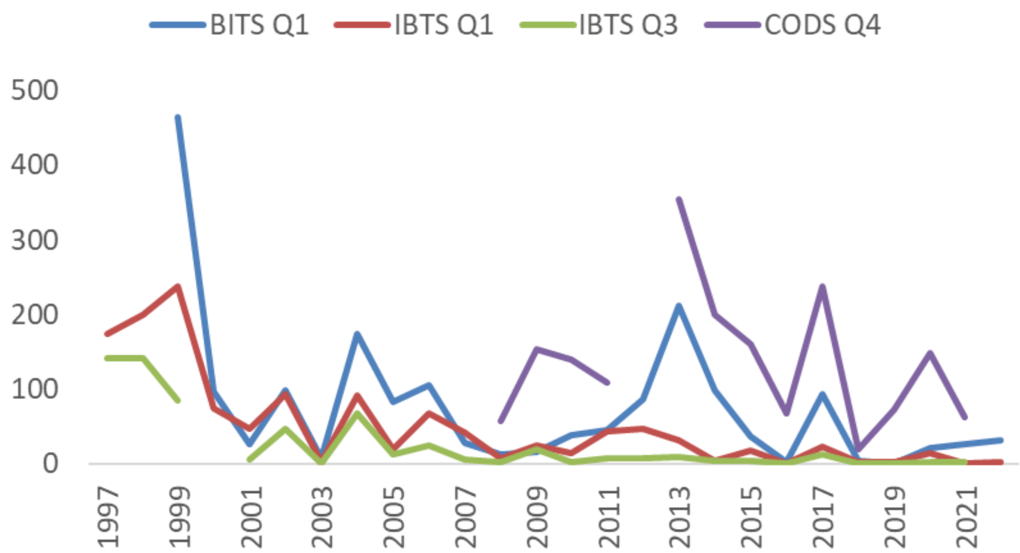


Figure 2.2.5. Cod in the Kattegat. Trends in recruitment index (Age 1) from different surveys.

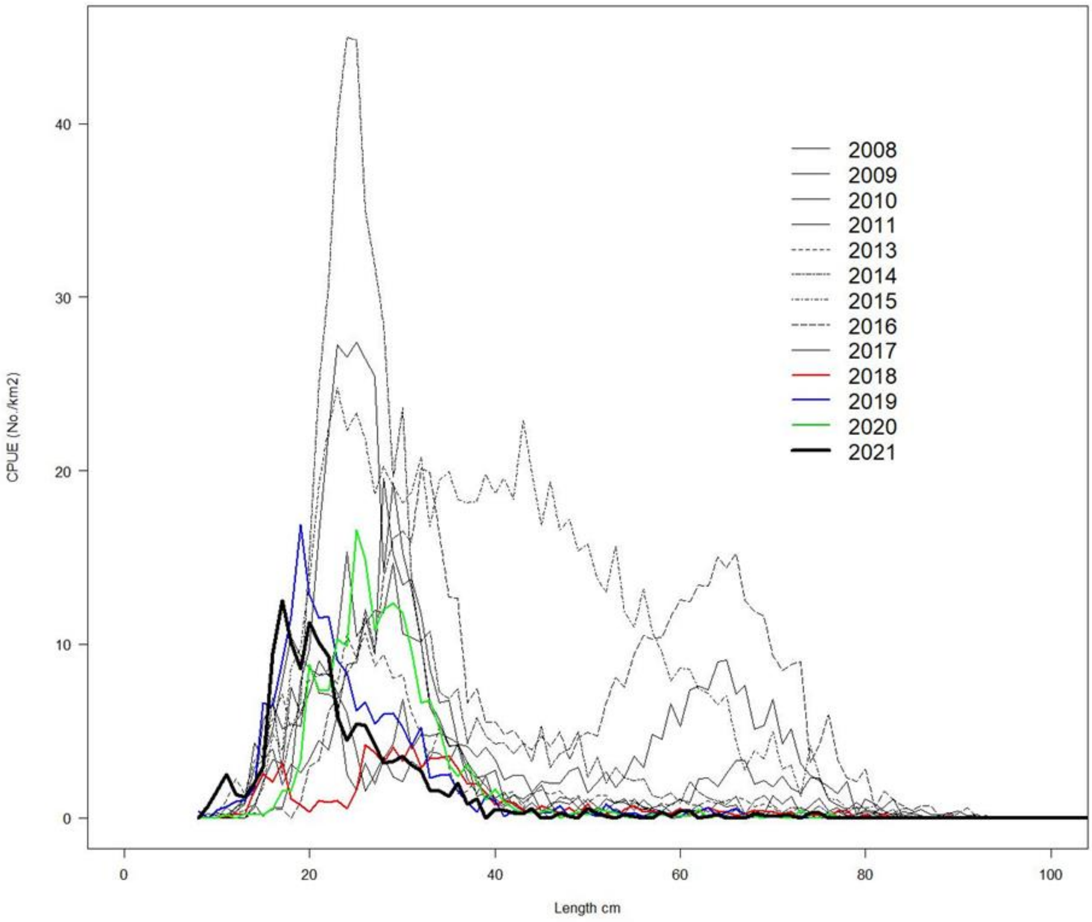


Figure 2.2.6. Cod in Kattegat. Length distributions from the Cod survey 2008-2021.

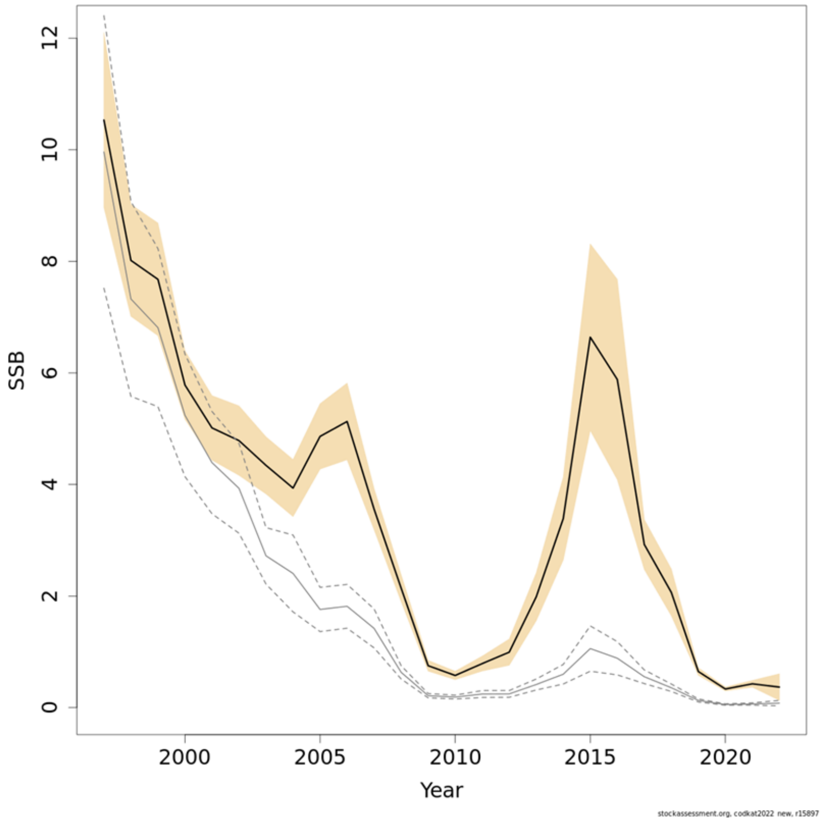


Figure 2.2.7. Cod in Kattegat. SSB in tonnes. SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95% confidence interval).

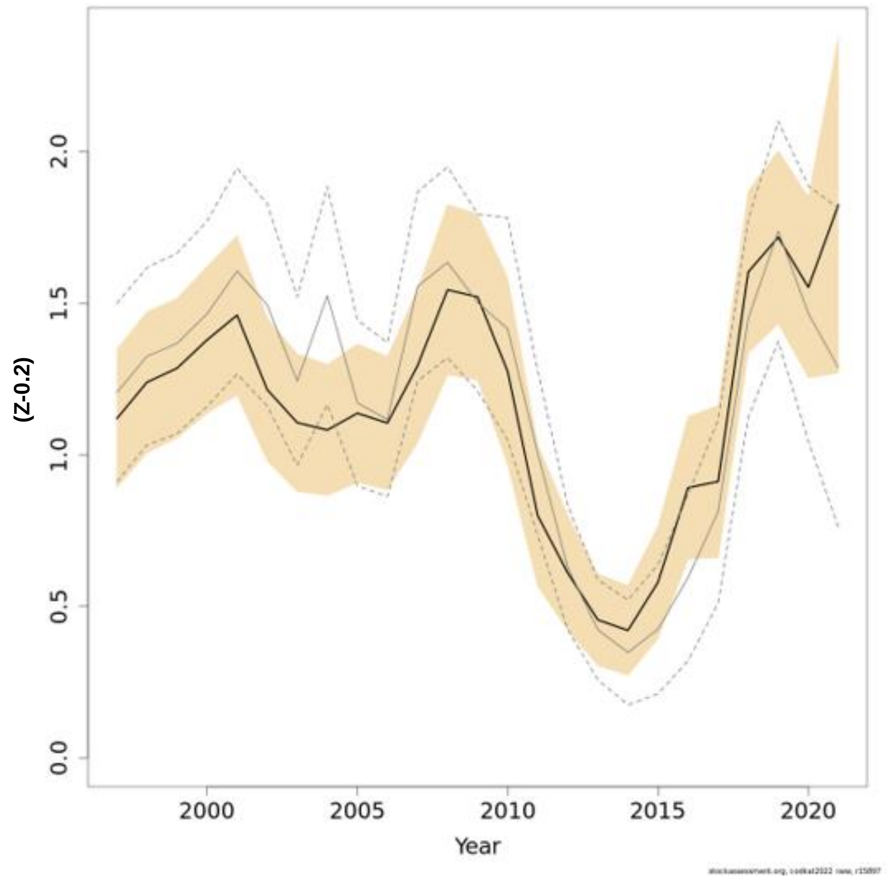


Figure 2.2.8. Cod in Kattegat. Unallocated mortality (Z-0.2) SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95 % confidence interval).

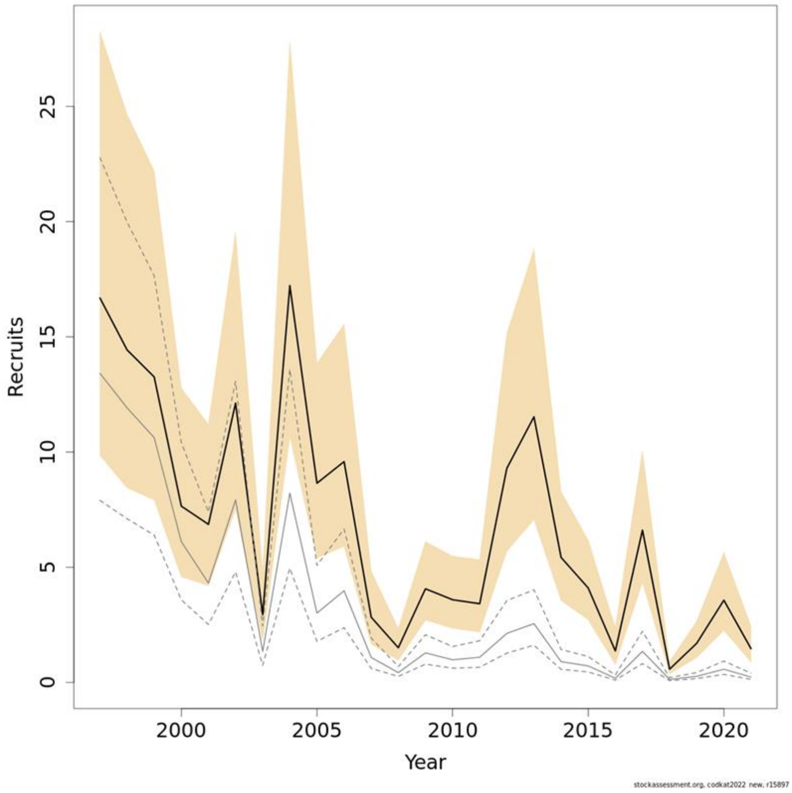
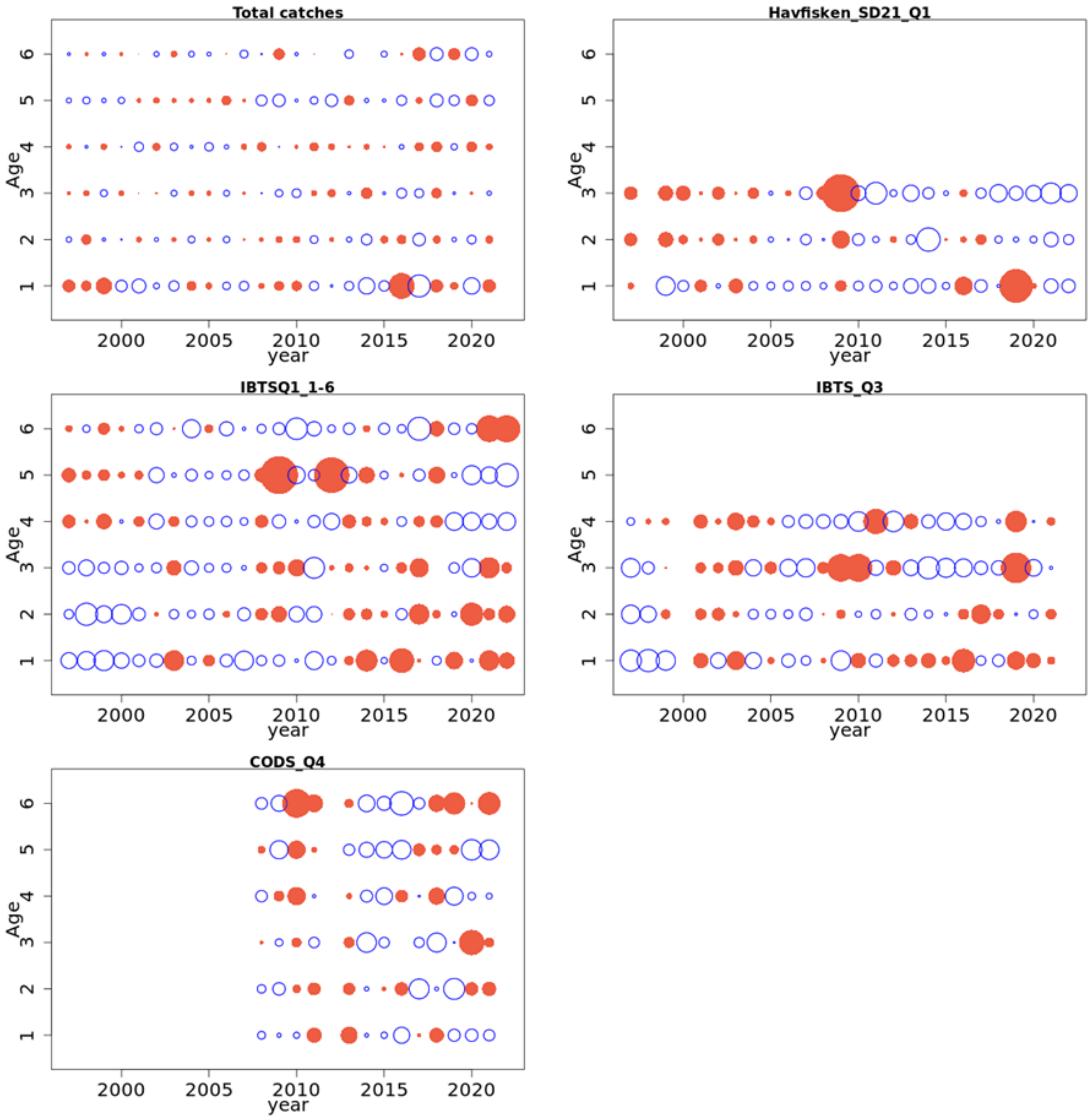


Figure 2.2.9. Cod in Kattegat. Recruitment in millions. SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95% confidence interval).

Year	Catch multiplier
2003	1,48
2004	1,12
2005	2,9
2006	2,75
2007	2,05
2008	3,44
2009	3,59
2010	2,79
2011	2,54
2012	4,12
2013	4,79
2014	6,45
2015	7,64
2016	9,16
2017	6,04
2018	6,3
2019	5,17
2020	6,14

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

a)


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

b)

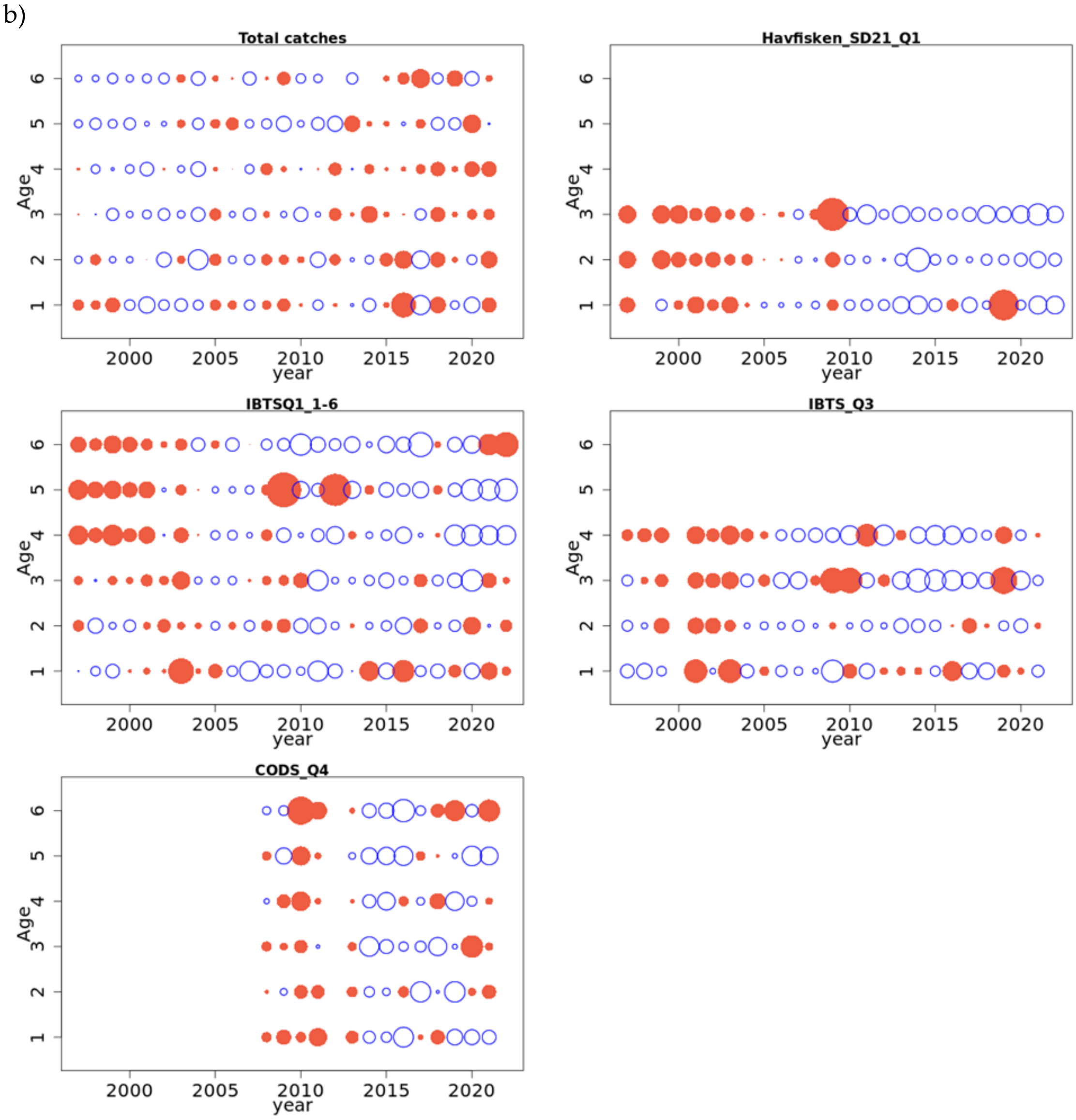


Figure 2.2.11. Cod in Kattegat. Residuals. a) SAM run with scaling b) SAM run without scaling. The figures show normalized residuals for the current run. Blue circles indicate positive residuals (larger than predicted) and filled red circles indicate negative residuals (lower than predicted).

Table 2.2.1 Cod in the Kattegat. Landings (in tonnes) 1971-2021.

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

[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

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

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

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

Table 2.2.4 a Cod in the Kattegat. Sampling level of Danish landings, 2021

Quarter	n. of harbour days	n. of cod aged	n. of cod weighed	n. of cod measured
1	4	73	73	73
2	4	83	83	83
3	5	73	73	73
4	3	140	140	140
Total	16	369	369	369

Table 2.2.4 b Cod in the Kattegat. Sampling level of Swedish landings, 2021

Quarter	n. of hauls	n. of cod aged	n. of cod weighed	n. of cod measured
1	16	390	390	390
2	0	40	50	50
3	11	4	4	4
4	0	70	72	72
Total	27	504	516	516

Table 2.2.5. Cod in the Kattegat. Landings numbers and mean weight at age by quarter and country for 2021

Subdivision 21
Year 2021 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	1,678374	721,03	0,591	759,5262	2,27	731,06
3	2,352751	1402,522	0,495	1837,32	2,85	1478,10
4	0,279316	3229,108	0,032	2921,732	0,31	3197,51
5	1,054491	2996,153	0,21	3420,41	1,26	3066,61
6			0,01	2829,625	0,01	2829,63
7			0,011	4171,05	0,01	4171,05
8			0,001	6165,9	0,00	6165,90
9			0,003	12074,4	0,00	12074,40
10						
SOP (t)	8,57			2,29	10,86	
Landings (t)	8,50			2,10	10,60	

Subdivision 21
Year 2021 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	0,273735	526,1934	0,149	1942,2	0,42	1025,29
3	1,273257	1109,367	0,361	2518,726	1,63	1420,69
4	0,053485	1707,898	0,03	4223,7	0,08	2611,94
5	0,472925	2372,595	0,057	3488,702	0,53	2492,65
6						
7	0,109804	2886,41	0,027	1404	0,14	2593,84
8						
9	0,013243	2103,66			0,01	2103,66
10						
SOP (t)	3,09			1,27	4,68	
Landings (t)	3,00			1,20	4,20	

Subdivision 21
Year 2021 Quarter 3

Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1	0,122345	485,9813	0,034	751,725	0,16	543,77
2	0,763648	998,4022	0,162	1421,856	0,28	1019,18
3	0,324528	2160,972	0,025	1937,427	0,79	1028,17
4					0,32	2160,97
5	0,119973	3440,3	0,006	2752,525	0,13	3407,54
6	0,030699	2501,46			0,03	2501,46
7						
8						
9						
10						

Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
SOP (t)	2,01			0,32	2,39	
Landings (t)	1,90			0,30	2,20	

Subdivision 21
Year 2021 Quarter 4

Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1	2,644518	448,3528	0,142	751,725	2,79	463,81
2	2,11885	1419,551	0,559	1837,249	2,68	1506,75
3	0,367582	2624,281	0,084	2034,792	0,45	2514,63
4	0,101056	2025,596			0,10	2025,60
5	0,269064	2784,793	0,009	2304,9	0,28	2769,26
6						
7						
8						
9						
10						
SOP (t)	6,11			1,33	7,44	
Landings (t)	5,40			1,00	6,40	

Subdivision 21
Year 2021 Quarter all

Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1	2,766863	485,9813	0,176	751,725	2,94	501,87
2	4,834606	1419,551	1,461	1942,2	6,30	1540,84
3	4,318118	2624,281	0,965	2518,726	5,28	2605,00
4	0,433856	3229,108	0,062	4223,7	0,50	3353,47
5	1,916453	3440,3	0,282	3488,702	2,20	3446,51
6	0,030699	2501,46	0,01	4364,1	0,04	2959,12

Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
7	0,109804	2886,41	0,038	4171,05	0,15	3216,69
8			0,001	6165,9	0,01	2388,86
9	0,013243	2103,66	0,003	12074,4	0,00	12074,40
10						
SOP (t)	27,96			6,89	34,85	
Landings (t)	18,80			4,60	23,40	

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

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

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

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

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

```
Tuning Data; Cod in the Kattegat (part of Division IIIa)_07/04/22
      104
Havfisken_SD21_Q1
1997   2022
1    1    0    0.25
1    3
      1 104.55214 24.105792 16.370022
      1        -9        -9        -9
      1 164.86327 25.740582 8.849066
      1 97.616778 44.329152 5.524313
      1 25.789945 30.099007 11.121939
      1 98.272996 16.652928 3.154042
      1 8.341221 47.242162 5.778205
      1 175.05562 11.183467 5.333216
      1 83.149813 86.679328 2.545501
      1 105.14936 38.463297 10.837631
      1 28.874849 46.527366 8.60812
      1 13.097343 6.648042 1.012895
      1 16.212387 0.908864 0.001
      1 38.500592 21.422328 1.388749
      1 46.248519 15.004462 14.262676
      1 86.615477 10.825404 1.844459
      1 212.34369 51.341883 10.257821
      1 98.156821 81.23825 12.338392
      1 37.234105 16.902854 15.665014
      1 2.231747 9.862954 3.595991
      1 93.508641 3.781223 4.307714
      1 4.370284 17.714674 1.90121
      1 0.083652 2.379284 2.978978
      1 21.370972 7.788465 0.443476
      1 25.773155 18.646591 2.920182
      1 31.097559 6.813157 1.958183
IBTSQ1_1-6
1997   2022
1    1    0    0.25
1    6
      1 174.46727 54.179175 108.87401 6.3358 1.379162 1.052075
      1 199.36583 470.64928 47.070787 24.616575 2.672512 1.320837
      1 237.67858 167.79953 62.984275 2.257075 3.113862 0.583337
      1 74.849012 233.6876 47.390075 14.025112 1.3133 1.159887
      1 47.052075 46.059025 24.372962 5.275775 1.692212 0.747912
      1 93.047125 21.154675 15.403625 14.689025 3.2729 1.065962
      1 2.342425 52.462825 3.545637 2.61305 1.69975 0.375
      1 91.015625 14.122475 32.846812 6.007112 2.050562 2.64905
      1 19.990012 86.9476 5.060875 10.69735 1.2 0.3875
      1 67.313625 21.882637 27.469987 2.661387 2.247375 0.9875
      1 41.605512 41.936737 7.399237 7.522862 0.766212 0.827775
      1 8.391675 2.4089 2.224437 0.858337 0.583337 0.416662
      1 25.383325 0.925 0.441675 2.041675 0.001 0.333337
      1 14.635725 22.460112 0.241662 0.333337 0.529162 0.541662
      1 43.726575 24.426037 17.486975 0.6 0.177087 0.125
      1 47.111462 9.586875 2.019437 4.055562 0.001 0.083337
      1 31.39375 14.164225 3.6191 0.877075 1.4125 0.275
      1 3.451525 30.889562 9.951462 3.132475 0.4625 0.333337
      1 18.449825 10.189475 27.393437 9.53065 4.195962 2.151037
      1 0.522925 14.55145 4.311475 18.679587 5.759175 3.000337
      1 23.691662 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 14.406125 0.480375 0.97865 2.338212 0.121875 0.18187525
      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
IBTS_Q3
1997   2021
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   0.20
      1   -9   -9   -9   -9
      1   6.025   2.109   0.458   0.117
      1   46.530   1.566   0.268   0.210
      1   1.701   4.499   0.133   0.050
      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   0.150
      1   19.492   0.217   0.001   0.083
      1   2.504   1.279   0.001   0.075
      1   8.348   1.594   0.450   0.001
      1   8.335   1.248   0.050   0.583
      1   9.925   6.823   1.086   0.050
      1   3.717   9.976   7.543   0.816
      1   4.755   2.104   7.362   3.230
      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   0.140   0.001   0.001
      1   2.558   0.509   0.025   0.025
      1 1.8359   0.23535   0.025   0.001
CODS_Q4
   2008   2021
      1   1   0.83   0.92
      1   6
      1   57.1   24.2   9.1   5.8   2.8   1.0
      1   154.4   20.7   2.7   1.7   2.0   0.8
      1   139.1   39.0   2.0   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   355.0   109.7   21.0   9.7   3.7   0.7
      1   199.2   346.5   164.0   37.6   13.6   4.5
      1   160.4   85.0   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   19.0   41.3   7.0   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
```

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	16691	9859	28255	12732	11072	14642	10534	9078	12224	1.120	0.912	1.374
1998	14436	8451	24660	10540	9322	11917	8017	7075	9084	1.240	1.027	1.496
1999	13261	7922	22200	9575	8328	11009	7677	6732	8755	1.286	1.075	1.538
2000	7656	4587	12777	7189	6455	8007	5783	5201	6429	1.379	1.157	1.644
2001	6864	4206	11200	6290	5623	7036	5014	4468	5626	1.461	1.219	1.750
2002	12126	7523	19546	6038	5345	6822	4786	4203	5450	1.215	1.001	1.476
2003	2948	1809	4803	5231	4664	5867	4342	3860	4884	1.106	0.901	1.358
2004	17230	10672	27818	5377	4682	6176	3936	3457	4480	1.082	0.886	1.321
2005	8651	5401	13855	7348	6490	8319	4862	4310	5484	1.137	0.930	1.390
2006	9587	5908	15559	7019	6109	8064	5129	4487	5864	1.105	0.905	1.349
2007	2834	1664	4826	4433	4011	4900	3556	3208	3942	1.294	1.064	1.574
2008	1511	971	2350	2412	2168	2682	2142	1916	2394	1.545	1.287	1.853
2009	4068	2707	6114	1067	926	1228	752	661	854	1.521	1.270	1.822
2010	3594	2355	5483	1013	867	1185	576	506	656	1.275	1.001	1.625
2011	3421	2191	5339	1192	1008	1410	789	667	934	0.799	0.597	1.070
2012	9297	5702	15158	1629	1295	2050	994	785	1258	0.610	0.447	0.833
2013	11533	7071	18812	3189	2607	3902	1985	1601	2462	0.455	0.327	0.635
2014	5429	3557	8287	6192	5012	7649	3387	2722	4216	0.421	0.296	0.599
2015	4103	2726	6174	9196	7261	11646	6641	5163	8541	0.580	0.421	0.798
2016	1371	787	2387	7137	5381	9465	5882	4336	7980	0.892	0.685	1.160
2017	6612	4345	10062	3693	3185	4282	2924	2510	3406	0.912	0.692	1.202
2018	579	373	901	2472	2138	2857	2066	1687	2530	1.603	1.356	1.895
2019	1703	1085	2673	808	725	901	647	583	718	1.718	1.455	2.029
2020	3574	2261	5648	588	500	692	334	301	371	1.553	1.282	1.882
2021	1472	886	2446	616	525	723	427	371	492	1.825	1.346	2.474
2022	1963	518	7433	487	264	898	368	193	703	1.815	1.111	2.967

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	13421	7907	22780	11879	9459	14917	9962	7795	12730	1.206	0.945	1.539
1998	11922	7110	19988	9594	7836	11747	7325	5772	9296	1.325	1.062	1.653
1999	10625	6397	17649	8409	6895	10254	6811	5532	8386	1.368	1.100	1.701
2000	6114	3590	10415	6436	5300	7816	5240	4249	6461	1.466	1.190	1.805
2001	4316	2518	7397	5390	4451	6527	4392	3564	5411	1.607	1.300	1.985
2002	7924	4803	13070	4810	3969	5828	3931	3203	4823	1.495	1.196	1.869
2003	1351	745	2451	3251	2706	3905	2720	2258	3277	1.243	0.994	1.555
2004	8216	4966	13592	3154	2434	4087	2405	1806	3204	1.526	1.206	1.931
2005	3015	1787	5087	2665	2101	3380	1760	1405	2204	1.172	0.928	1.480
2006	3983	2381	6663	2512	2048	3081	1817	1464	2255	1.116	0.889	1.401
2007	1088	614	1928	1773	1395	2253	1420	1111	1816	1.556	1.273	1.901
2008	429	267	692	715	600	851	633	524	764	1.635	1.349	1.983
2009	1287	799	2075	312	263	371	215	179	257	1.503	1.237	1.825
2010	988	625	1562	328	269	399	190	158	229	1.416	1.093	1.834
2011	1097	663	1816	368	289	469	245	190	315	1.005	0.768	1.316
2012	2131	1277	3556	396	317	495	246	193	315	0.627	0.452	0.870
2013	2554	1621	4025	666	539	823	414	327	525	0.423	0.286	0.624
2014	908	574	1436	1065	808	1404	599	447	802	0.348	0.212	0.572
2015	720	459	1129	1458	1018	2086	1059	721	1554	0.425	0.257	0.701
2016	186	106	326	1071	790	1453	886	632	1240	0.595	0.375	0.943
2017	1355	824	2227	694	565	852	554	444	690	0.813	0.561	1.179
2018	133	83	213	438	365	526	357	297	430	1.449	1.157	1.816
2019	272	171	432	159	130	194	129	105	160	1.738	1.411	2.141
2020	577	356	933	95	78	116	56	45	69	1.467	1.101	1.954
2021	237	138	409	96	70	132	66	49	88	1.287	0.855	1.938
2022	294	88	985	101	58	175	81	44	149	1.276	0.701	2.323

2.3 Western Baltic cod (update assessment)

- The assessment for this stock was inter-benchmarked in June 2021, due to very high retrospective patterns in the spaly assessment (Mohns Rho at 0.53 for SSB and -0.45 for F). At the interbenchmark the group;
- Updated the natural mortality to fit with stock-specific life history parameters.
- Update the survey model
- Change age structure in the survey to 4+ group
- Change from an annual maturity to a fixed value for all years
- Change model setting for F to be an independent random walk for all age groups
- Down-weight catch in last data year
- Update reference points

The full report can be found at ICES. 2021. Inter-Benchmark Process on Western Baltic cod (IBPWEB). ICES Scientific Reports. 3:87. 76 pp. https://doi.org/10.17895/ices.pub.5257

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 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 gillnetters are therefore the main responsible of the commercial cod catches in SD 23. In the second half of 2019 and in 2020 and2021 a large area of SD 24 was closed for a directed cod fishery, to protect the eastern Baltic cod stock component. Overall catches are predominantly Danish, German, with smaller amounts from Sweden and Poland. 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 <1 t in 2021 in the western Baltic management area. Normally trawlers have been responsible for the main landings of cod in the western Baltic but in 2021 the gillnetters were for the first time taking a larger share than the trawlers (55%). Landings by SD, passive and active gear in 2021 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) 2021 was 1329 t (including BMS), which corresponds to 40% of last year's level (3329 t) and a quota utilization of 33% (4000 t), being the historic 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 this changed and was 27% in 2021. This change is 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).

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 2021 due to the very low commercial catches the recreational fraction increased to 47% of total catch, although the actual level of recreational catches was estimated to be historic low (968 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 represented relative proportions of commercial cod landings taken in areas 1 and 2.

2.3.1.1 Regulation

Since 01 January 2015, the EU landing obligation has been 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 and 2021 the spawning closure (1 February to 31 March) 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 2021 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.

2.3.1.2 Discards

All relevant countries uploaded their discard data to InterCatch. Discard data from at-sea observer programs for 2021 were available from Germany, Sweden and Denmark for SD 22–24. Besides the sample level shown in table 2.3.4, several 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 2021 was estimated to be in the same level as in 2020 (5%). Discards in numbers per gear segment and quarter can be seen in Table 2.3.5.

The discard weights at age for SD 22 and SD 23 for 2021 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 (average of the last 10 years) but has been decreasing since 2017 due to the introduction of a bag limit and reduced resource availability. Since Sweden could not deliver recreational data from SD 23 in 2021, gap filling was necessary. The amount of catches taken by Sweden in SD 23 were assumed to be at the same level as in 2020 (113 t) and with the same amount of decrease as has been observed in the Danish recreational fishery in SD 23 (-7% from 2020 to 2021). Due to the decreased commercial catches, the relative contribution of the recreational fisheries to the total catches increased from close to 30% to be 46% in 2021. 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 2021 is estimated to be 968 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

A potential source of unallocated and unreported removals is the passive gear fishing fleet without the obligation to keep a daily logbook or where official sale notes are not available (e.g. part-time fishers and fishers with monthly landings declarations like German vessels <8 m). The TAC for Western Baltic cod is relatively low and unreported landings would be considered to ensure economic viability of the fishers´ activities. However, reliable estimates of the potentially unallocated removals are not available for this or other fleet segments.

In 2015, Germany included for the first-time cod discard estimates from the German pelagic trawl fishery targeting herring in SD24 (PTB_SPF). In 2021, sampling was not possible due to Covid-19-related entry restrictions to the processing plant.

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 2084 t in 2021 (48% of last years´ catches). Landings and discards of eastern Baltic cod in SD 24 is estimated to be 291 t and are shown in Table 2.3.6. By management area, the total catch is estimated to be 2375 t in the western Baltic Sea. Landings by ICES square is mapped in Figure 2.3.5.b.

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 2021 (i.e. the allocation overview) applied in InterCatch is given for landings and discards in Table 2.3.4

The last 2 years with Covid-19 pandemic has together with the decreased fishing in the western Baltic area decreased the sampling level, this indicates that the uncertainty is considered larger than before.

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 2021 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 datasets. 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. Sampling per fleet can been seen in Figure 2.3.5c.

The different sampling units (number of harbour days, number of trips) render between-country comparisons difficult. However, sampling coverage and the number of age-read otoliths decreased compared to the previous year (Table 2.3.4). Possible effects of the differences between national sampling levels on data quality of the international dataset 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.

Another otolith exchange on SmartDots with selected 100 cod caught in 2021 in SDs 22 and 23 was conducted in autumn 2021. The results were very good: based on the 3 readers providing age data for assessment from DK, DE and SWE, the percentage agreement was 97% with a CV of 8%.

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 subareas, marked as Area 1 (Darss sill and entrance of SD 23) and Area 2 (Arkona basin, Rönnebank, Oderbank) in Figure 2.3.3.

In 2021, 27% 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. In 2021 Germany only had 8 cod sampled in SD 24 so that mixing estimates from the Danish fishery were used. The spilt is weighted with landings from Germany, Denmark, Sweden and Poland based on 2021 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 2021 the large 2016-year class amounting to 30% of the total catch in numbers as age 5 (Figure 2.3.6, Table 2.3.15). In the recreational fishery, the contribution of age-5 cod was only 27%, so the influence of the 2016 year class to the total catch has decreased considerably compared to last year (70%) (tables 2.3.12 and 2.3.14).

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. In 2021 the weight estimate for age 5 (the 2016-year class) in the commercial catch was very low (30% below average). 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). This has an effect on the SSB estimate in 2021 as the 2016-year class is still by far the most dominant age group in the stock. In last year's assessment the weight for the intermediate year (2021) was taken as 3 years´ mean as it is usually done. As the observed data being 30% lower than the 3 years´ average, this had an effect on the SSB estimated in 2021, which has become down-weighted in this year's assessment due to the updated weights (Table 2.3.19).

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 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 Figure 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 group < 25 cm, 25-45 cm 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 15 m 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)	2001–2021	age 0–4+
BITS, Q1, SD22–24W (12–13 degrees)	2001–2022	age 1–4+
FEJUCS, SD22	2011-2021	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 2021-year class is in the model estimated to be above average compared to the last 15 years of recruitment, although with wide confidence intervals (Figure 2.3.19).

2.3.4 Assessment

A stochastic state-space model (SAM) is used for assessment of cod in the western Baltic Sea.

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

In this year’s assessment the SSB was downscaled due to an update in the stock weight-at-age for the 2021 value compared to the results from last years´ assessment. 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 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 opposite is seen in the survey data (mainly Q4) where the surveys observed more older fish than the model is estimating (figures 2.3.14 and 2.3.15).

The retrospective pattern (Mohn's Rho) for SSB and F was at 0.15 and –0.09, respectively), and 0.18 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 "WBCod_22".

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 presumably additional mortality are presently unclear but could involve increased natural mortality (increased predation, hypoxia, decreased condition (Receveur *et al.*, 2022), increased water temperatures, unreported catches). However, the effects associated with these drivers are presently not possible to quantify and are therefore difficult to account for in the forecast. A harvest rate plot indicated that the harvest rate has gradually been decreasing since 2013, close to 55%, however this is not evident from the fishing mortality plots Figure 2.3.20.

The SSB development from stock assessment is considered less affected, though the estimates for fishing mortality may include other sources of mortality than those related to fishing.

Please note that a short-term forecast was requested by the Advice Drafting Group for Baltic Sea stocks and this is now provided as Annex 6 to this report.

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 interbenchmark in 2021 to 0.17 (lower), 0.26 (F_{MSY}) and 0.44 (Higher).

Biomass reference points are B_{lim} = 15 067 t 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 $F_{pa} = F_{p0.5} = 0.689$.

2.3.7 Quality of assessment

The uncertainty of the catch matrix is relatively high in this assessment. This seems to be caused by a shift in the fishing pattern due to low levels of landings and further the low sampling level (a combination between the Covid-19 pandemic and a low level of landings) giving conflicting information from the surveys and the catch matrix.

Mixing of the eastern and western Baltic cod stocks is 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.

2.3.8 Comparison with previous assessment

The assessment this year has downscaled the 2021 SSB estimate by32 %. The main reason is the updated weight-at-age in stock weight which reflects the detected decrease in the Fulton condition factor of western Baltic cod (Receveur *et al*., 2022). In the last year's assessment this was a 3-year mean (as the value is not known at the time of the assessment), in this year's assessment the data were updated with the new data point.

2.3.9 Management considerations

The stock is presently at a historic low level and even if the incoming year class (2021) is estimated larger compared to the 2017-2020-year classes, the stock is still very low. As the size and fate of the 2021-year class is still very uncertain, given that only a few, data points are available (Q4 survey in fall 2021 and Q1 survey in 2022, pound net survey), the working group recommends zero catches to protect this single incoming year class.

In 2021 the recreational fishery was fishing close to 50% 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

[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 Subdivision (includes Eastern Baltic cod in SD 24) sorted by column "22–24".

Year 2021
Gear: Active and passive gear combined

Subdivision Country	22	23	24	22-24
Denmark	469	127	105	702
Germany	155	0	43	198
Sweden	1	218	9	227
Poland	0	0	200	200
Total	624	345	357	1327

Year 2021
Gear: Active gear

Subdivision Country	22	23	24	22-24
Denmark	207	9	78	293
Germany	80	0	31	112
Sweden	0	0	0	0
Poland	0	0	187	187
Total	287	9	296	592

Year 2021
Gear: Passive gear

Subdivision Country	22	23	24	22-24
Country:				
Denmark	263	118	28	408
Germany	74	0	12	87
Sweden	1	218	9	227
Poland	0	0	12	12
Total	338	336	61	735

Table 2.3.3a. Cod 22–23. Unsampled landing strata and allocated sampled strata in 2021

DE_27.3.c.22_Active_2_L,DE_27.3.c.22_Active_1_L,X
DE_27.3.c.22_Active_2_L,DK_27.3.c.22_Active_1_L,X
DE_27.3.c.22_Active_2_L,DK_27.3.c.22_Active_2_L,X
DE_27.3.c.22_Active_2_L,DK_27.3.c.22_Active_3_L,X
DE_27.3.c.22_Active_3_L,DE_27.3.c.22_Active_1_L,X
DE_27.3.c.22_Active_3_L,DK_27.3.c.22_Active_3_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_1_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,DE_27.3.c.22_Gillnets set_3_L,X
DE_27.3.c.22_Gillnets set_2_L,DK_27.3.b.23_Gillnets set_2_L,X
DE_27.3.c.22_Gillnets set_2_L,DK_27.3.c.22_Gillnets set_2_L,X
DE_27.3.c.22_Gillnets set_4_L,DE_27.3.c.22_Gillnets set_3_L,X
DE_27.3.c.22_Gillnets set_4_L,DK_27.3.c.22_Gillnets set_4_L,X
DE_27.3.c.22_Longline set_2_L,DE_27.3.c.22_Gillnets set_1_L,X
DE_27.3.c.22_Longline set_2_L,DE_27.3.c.22_Gillnets set_3_L,X
DE_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_2_L,X

DK_27.3.b.23_Longline set_1_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Longline set_1_L,DK_27.3.b.23_Gillnets set_1_L,X
DK_27.3.b.23_Longline set_1_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Longline set_1_L,SE_27.3.b.23_Passive_1_L,X
DK_27.3.b.23_Longline set_2_L,DK_27.3.b.23_Gillnets set_2_L,X
DK_27.3.b.23_Longline set_2_L,SE_27.3.b.23_Passive_2_L,X
DK_27.3.b.23_Longline set_3_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Longline set_3_L,DK_27.3.b.23_Gillnets set_3_L,X
DK_27.3.b.23_Longline set_3_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Longline set_3_L,SE_27.3.b.23_Passive_3_L,X
DK_27.3.b.23_Longline set_4_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.b.23_Longline set_4_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.b.23_Longline set_4_L,SE_27.3.b.23_Passive_4_L,X
DK_27.3.c.22_Longline set_1_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.b.23_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_1_L,SE_27.3.b.23_Passive_1_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.b.23_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_2_L,SE_27.3.b.23_Passive_2_L,X
DK_27.3.c.22_Longline set_3_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.c.22_Active_3_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_4_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_4_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_4_L,SE_27.3.b.23_Passive_4_L,X
SE_27.3.c.22_Passive_3_L,DE_27.3.c.22_Gillnets set_1_L,X
SE_27.3.c.22_Passive_3_L,DE_27.3.c.22_Gillnets set_3_L,X
SE_27.3.c.22_Passive_3_L,DK_27.3.c.22_Gillnets set_3_L,X
SE_27.3.c.22_Passive_4_L,DE_27.3.c.22_Gillnets set_3_L,X
SE_27.3.c.22_Passive_4_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 2021 (SD22-23).

DE_27.3.c.22_1_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
DE_27.3.c.22_2_Active_D,DE_27.3.c.22_1_Active_D,X
DE_27.3.c.22_2_Active_D,DK_27.3.c.22_1_Active_D,X
DE_27.3.c.22_2_Active_D,DK_27.3.c.22_3_Active_D,X
DE_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
DE_27.3.c.22_2_Longline set_D,DE_27.3.c.22_3_Gillnets set_D,X
DE_27.3.c.22_2_Longline set_D,SE_27.3.b.23_2_Passive_D,X
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,DK_27.3.c.22_1_Active_D,X
DE_27.3.c.22_3_Active_D,DK_27.3.c.22_3_Active_D,X
DE_27.3.c.22_4_Active_D,DE_27.3.c.22_1_Active_D,X
DE_27.3.c.22_4_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_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,DK_27.3.c.22_1_Active_D,X
DK_27.3.b.23_1_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
DK_27.3.b.23_2_Active_D,DE_27.3.c.22_1_Active_D,X
DK_27.3.b.23_2_Active_D,DK_27.3.c.22_1_Active_D,X
DK_27.3.b.23_2_Active_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.b.23_2_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
DK_27.3.b.23_3_Active_D,DE_27.3.c.22_1_Active_D,X
DK_27.3.b.23_3_Active_D,DK_27.3.c.22_1_Active_D,X
DK_27.3.b.23_3_Active_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.b.23_3_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
DK_27.3.b.23_4_Active_D,DE_27.3.c.22_1_Active_D,X
DK_27.3.b.23_4_Active_D,DK_27.3.c.22_1_Active_D,X
DK_27.3.b.23_4_Active_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.b.23_4_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
DK_27.3.c.22_1_Gillnets set_D,DE_27.3.c.22_3_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,DK_27.3.c.22_1_Active_D,X
DK_27.3.c.22_2_Active_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
DK_27.3.c.22_3_Gillnets set_D,DE_27.3.c.22_3_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,DK_27.3.c.22_1_Active_D,X
DK_27.3.c.22_4_Active_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.c.22_4_Gillnets set_D,DE_27.3.c.22_3_Gillnets set_D,X
SE_27.3.b.23_1_Passive_D,SE_27.3.b.23_2_Passive_D,X
SE_27.3.b.23_1_Passive_D,SE_27.3.b.23_3_Passive_D,X
SE_27.3.b.23_1_Passive_D,SE_27.3.b.23_4_Passive_D,X
SE_27.3.c.22_3_Passive_D,DE_27.3.c.22_3_Gillnets set_D,X
SE_27.3.c.22_3_Passive_D,SE_27.3.b.23_3_Passive_D,X
SE_27.3.c.22_4_Passive_D,DE_27.3.c.22_3_Gillnets set_D,X
SE_27.3.c.22_4_Passive_D,SE_27.3.b.23_4_Passive_D,X

Table 2.3.4. Cod in subdivisions 22–23 only. Overview of the number of samples (number of trips, harbour visits or number of boxes), number of length measurements and number of otoliths available per stratum in 2021 (upper, middle and lower table, respectively). Color 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	8		2						10		
TAC 44%		Gillnets set										42	**38%**
	Landings *2	Active	10	8	4	4	3	1	1	1	32		
		Gillnets set	10	8	4	4	3	1	1	1	32		
Germany	Discards *1	Active	6								6		
TAC 21%		Gillnets set			4						4		
		Longline set											
	Landings *1	Active	9								9	26	**23%**
		Gillnets set	4		3						7		
		Longline set											
Sweden	BMS *3	Gillnets set						13	7	2	22		
TAC 16%	Discards *2	Gillnets set						13	7	2	22	43	**39%**
	Landings *2	Gillnets set					6	7	3	5	21		
			37	8	13	4	9	21	11	8	111		

*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	7		3						10		
TAC 44%		Gillnets set										652	**25%**
	Landings	Active	230	95	30	60	124	18	58	27	642		
		Gillnets set	230	95	30	60	124	18	58	27	642		
Germany	Discards	Active	91								91		
TAC 21%		Gillnets set			42						42		
		Longline set											
	Landings	Active	349								349	702	**27%**
		Gillnets set	163		57						220		
		Longline set											
Sweden	BMS	Passive						379	215	49	643		
TAC 16%	Discards	Passive						379	215	49	643	1274	**48%**
	Landings	Passive					220	209	94	108	631		
Total			840	95	132	60	344	606	367	184	2628		

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	7		3						10		
TAC 44%		Gillnets set										641	**27%**
	Landings	Active	222	94	30	60	122	18	58	27	631		
		Gillnets set	222	94	30	60	122	18	58	27	631		
Germany	Discards	Active	90								90		
TAC 21%		Gillnets set			28						28		
		Longline set											
	Landings	Active	328								328	479	**20%**
		Gillnets set	18		15						33		
		Longline set											
Sweden	BMS	Passive						379	215	49	643		
TAC 16%	Discards	Passive						379	215	49	643	1274	**53%**
	Landings	Passive					220	209	94	108	631		
Total			665	94	76	60	342	606	367	184	2394		

SD2223		Area	27,3,c,22				27,3,b,23						
Reported Landings 2021 (kg)			Season				Season				Total	Country sum	%
Country		Fleets	1	2	3	4	1	2	3	4			
Denmark	Landings	Active	178	22	0.5	6	3	0.1	0.4	5.8	216	596	**61.5%**
TAC 44%		Gillnets set	92	90	41	40	25.6	18.6	29.0	44.9	381		
Germany	Landings	Active	66	8	1.4	5					80	155	**16.0%**
TAC 21%		Gillnets set	18	12	14	30					74		
		Longline set		0.01							0.005		
Sweden	Landings	Passive			0.52	0.06	54	65	60	39	218	218	**22.5%**
TAC 16%													
	Landings		354	132	57	82	82	84	89	90	969		

TAC: total allowable catches for SD22-24

No BMS reported by Denmark and Germany

Legend:
- (green) sampled stratum
- (orange) duplicated sampled size - discards = BMS
- (red) not sampled but Landings or Discards

Table 2.3.5. Cod 22–23. 2021. 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	30	29	29	20	108
Active gears	13	1	1	2	17
Grand Total	43	31	30	22	125

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 2017-2021 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	2.67
3 avr.					0.15								1.85

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 2021. 1/1

Year:	2021	Gear:	Trawl, gillnet and longlines combined			
Year:	**2021**	**Quarter:**	**1**			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	weight [g]	*10-3	weight [g]	*10-3	weights [g]
1	0	625	0	625	0	625
2	14	770	8	916	22	823
3	11	1774	17	1285	28	1548
4	2	1378	4	1481	5	1430
5	112	2794	30	1873	142	2369
6	2	2793	1	1956	4	2407
7	0	2310	1	2482	1	2396
8						
9						
SOP [t]	361		83		446	
Landings (t)	354		82		437	
Year:	**2021**	**Quarter:**	**2**			
Sub-div,	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	weight [g]	*10-3	weight [g]	*10-3	weights [g]
1	0.3	523	0	625	0.3	557
2	5	870	17	964	22	901
3	3	1630	19	1229	22	1458
4	1	3515	4	1513	5	2657
5	26	3238	21	1860	47	2647
6	0.5	4664	0.4	2494	1	3734
7	1	6989	1	4365	1	6114
8						
9						
SOP [t]	134		85		220	
Landings (t)	132		84		216	
Year:	**2021**	**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	3	532	0.2	539	3	535
2	21	1276	44	1081	64	1192
3	2	1763	12	1361	13	1578
4	0.05	1155	1	1641	1	1332
5	8	3548	9	2267	17	2957
6	0.01	2525	0	1718	0.01	2256
7						
8						
9						
SOP [t]	58		90		149	
Landings (t)	57		89		146	

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 2020. 2/2

Year:	**2021**	**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	3	649	1	578	4	619
2	16	1465	51	1066	67	1294
3	8	2555	8	1530	17	2116
4	0.1	1590	1	1794	1	1692
5	8	3786	8	2167	16	3092
6	0.01	1623	0	1718	0.01	1661
7						
8						
9						
SOP [t]	83		91		175	
Landings (t)	82		90		171	

Year:	**2021**	**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	6	586	1	578	7	583
2	55	1106	120	1020	175	1072
3	24	1941	56	1351	80	1679
4	3	2034	10	1585	13	1834
5	154	3353	68	2042	222	2770
6	3	3265	2	2098	5	2774
7	1	5429	2	3424	2	4627
8						
9						
SOP [t]	637		349		989	
Landings (t)	624		345		969	

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	Percent 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	Percent 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

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

Year	Area (SD)	Time period	restricted distance from coast	Regulation	Baglimits (recreational fishery)	restricted depth
2016	22-24	15.02.-31.03. 1.5 months		2015/2072 17. Nov. 2015	No bag limit	
2017	22-24	01.02.-31.03. 2 months		2016/1903 28. Oct. 2016	5 cod/day 3 cod/day (1/2-31/3)	
2018	22-24	01.02.-31.03. 2 months		2017/1970 27. Oct. 2017	5 cod/day 3 cod/day (1/2-31/3)	
2019	22-24	No clouser		2018/1628 30. Oct. 2018	7 cod/day	
2020	22-23	01.02.-31.03. 2 months		2019/1838 30. Oct. 2019	5 cod / day in time period 01.02-31.03 2 cod / day	not deeper 20 m
	24	entire year 12 months	not further than 6 nm		5 cod / day in time period 01.02-31.03 2 cod / day	not deeper 20 m
2021	22-23	01.02.-31.03. 2 months		2020/1579 29. Oct. 2020	5 cod / day in time period 01.02-31.03 2 cod / day	
	24	entire year 12 months	not further than 6 nm			not deeper 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

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

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

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
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

age	a1	a2	a3	a4	a5	a6	a7+
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

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

age	a1	a2	a3	a4	a5	a6	a7+
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
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

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

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

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

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

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

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

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

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

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

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

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+
1998-2021	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	11197	129982	15772	907
1997	11711	2851	12648	660
1998	25187	8536	564	659
1999	7014	15116	2571	337
2000	10382	6685	6591	1205
2001	4234	5758	1205	761
2002	10517	3512	1823	288
2003	872	5081	573	215
2004	9229	1893	2274	152
2005	6347	37628	1590	863
2006	9536	6982	8351	352
2007	1773	10548	2786	1727
2008	74	1181	1252	702
2009	6412	797	1044	519
2010	2348	11896	452	261
2011	9064	8870	14418	132
2012	1624	3729	1761	1195
2013	6244	3284	2409	447
2014	3771	5109	682	301
2015	2508	5521	2157	226
2016	46	844	621	666
2017	9229	373	1211	700
2018	442	22891	395	1010
2019	480	1466	10989	345
2020	1302	1018	393	2471
2021	3919	2563	426	331
2022	2632	1502	421	103

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

BITS Q4	a0	a1	a2	a3	a4
1999	10663	5870	2550	158	19
2000	3543	3165	756	125	32
2001	21884	2311	962	136	72
2002	2689	7043	800	280	31
2003	23648	3779	1623	94	39
2004	4923	8638	834	262	29
2005	4138	1942	1375	101	68
2006	2365	2872	318	649	86
2007	463	322	183	169	244
2008	19644	45	56	70	75
2009	2763	1898	58	86	28
2010	9892	779	526	25	19
2011	3501	1450	115	155	14
2012	14999	1324	366	72	50
2013	7020	3258	180	71	35
2014	5772	1471	708	114	61
2015	446	730	290	272	60
2016	32759	147	107	39	105
2017	295	6340	101	150	51
2018	1084	306	758	17	58
2019	3579	295	12	97	31
2020	4347	699	27	12	134
2021	9719	976	60	6	49

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

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
1985	47412	25239	89065	35840	27866	46095	1.171	1.009	1.359
1986	132126	71749	243310	24626	20081	30201	1.157	1.014	1.321
1987	43683	24119	79116	26063	20497	33142	1.137	1.005	1.287
1988	19280	10541	35262	27355	20969	35686	1.13	1.003	1.273
1989	22649	12500	41039	19435	15328	24642	1.128	1.004	1.267
1990	35804	19739	64945	13578	11185	16483	1.15	1.029	1.286
1991	58495	32310	105900	11928	9790	14533	1.178	1.055	1.316
1992	116204	63852	211479	13860	11043	17395	1.195	1.069	1.335
1993	42902	23597	77999	22016	16786	28876	1.186	1.063	1.322
1994	96480	53021	175560	32068	24455	42050	1.171	1.052	1.304
1995	155746	85585	283426	36840	29441	46099	1.188	1.065	1.325
1996	43083	23952	77496	47491	37689	59842	1.171	1.052	1.305
1997	134857	79325	229263	49784	37833	65511	1.177	1.057	1.311
1998	217458	128608	367691	37351	30027	46460	1.184	1.063	1.318
1999	75488	46835	121670	41734	33598	51841	1.214	1.082	1.361

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(3-5)	Low	High
2000	77002	48863	121346	39541	31466	49689	1.21	1.077	1.36
2001	50016	31447	79549	36051	29672	43801	1.204	1.069	1.357
2002	106148	66938	168324	32491	26510	39821	1.177	1.048	1.323
2003	30176	18775	48500	29344	24092	35742	1.137	1.017	1.271
2004	117717	74134	186923	28603	22864	35783	1.107	0.991	1.237
2005	33530	21270	52857	33112	26789	40928	1.064	0.951	1.19
2006	38355	24224	60729	31613	24995	39982	1.007	0.89	1.139
2007	11458	7124	18428	29126	23631	35899	0.992	0.878	1.122
2008	4236	2298	7807	20356	16946	24453	1.003	0.894	1.125
2009	47789	29473	77487	14812	12337	17783	1.009	0.902	1.129
2010	16452	10410	26003	14243	11619	17459	1.014	0.906	1.135
2011	25450	15958	40587	14612	11373	18773	0.998	0.891	1.118
2012	19437	12353	30584	15849	12793	19634	0.982	0.876	1.102
2013	48989	30947	77547	13060	10821	15764	0.997	0.886	1.122
2014	28030	17742	44285	16397	13561	19824	0.973	0.863	1.098
2015	16605	10508	26239	17420	14206	21361	0.957	0.843	1.086
2016	3191	1941	5248	12742	10266	15815	0.949	0.829	1.085
2017	57165	34513	94684	9209	7474	11347	0.935	0.807	1.083
2018	2182	1341	3551	10456	8185	13358	0.923	0.783	1.088
2019	3590	2154	5984	12896	9515	17478	0.915	0.762	1.098
2020	8972	5170	15571	9133	6045	13799	0.905	0.74	1.107
2021	15456	8169	29242	5303	3498	8038	0.896	0.719	1.117
2022	28524	11180	72770	5661	3566	8986			

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

Year/Age	0	1	2	3	4	5	6	7
1985	468837	47412	24510	22291	4262	1129	367	210
1986	165284	132126	21680	8656	4841	832	291	141
1987	75364	43683	67532	7752	1984	956	207	111
1988	85937	19280	21494	22585	1995	449	251	94
1989	134089	22649	8126	8336	5208	492	127	93
1990	219775	35804	11465	3399	2257	1263	152	71
1991	404005	58495	18731	4328	814	491	338	73
1992	173164	116204	28409	6523	993	151	119	102
1993	355144	42902	57040	10992	1499	200	23	50
1994	539671	96480	21568	26394	3499	284	33	16
1995	178671	155746	54833	9106	8542	1160	78	8
1996	489809	43083	100701	24660	2149	2393	245	11
1997	758674	134857	14031	46985	5146	593	525	80
1998	294016	217458	62074	5957	9845	1203	164	142
1999	264879	75488	98800	22777	1817	1951	307	96
2000	164622	77002	33829	33661	5750	361	422	85
2001	364764	50016	42207	12235	7839	1413	86	121
2002	108565	106148	27376	15830	2704	1557	375	38
2003	395467	30176	59008	9744	3033	561	351	102
2004	124008	117717	14644	22858	2633	606	162	121
2005	123094	33530	68259	5709	5852	612	137	72
2006	42926	38355	17340	29150	1791	1389	147	39
2007	16314	11458	19679	7991	7940	721	416	53
2008	174103	4236	7059	7449	2684	1769	275	157
2009	63115	47789	4451	4440	2323	825	374	119
2010	102247	16452	29219	2960	1666	656	209	108
2011	76036	25450	8539	14963	1559	476	128	68
2012	184243	19437	12994	4728	4838	721	135	36
2013	108321	48989	9915	6623	1704	1295	255	63

Year/Age	0	1	2	3	4	5	6	7
2014	66890	28030	24860	4566	2197	386	306	65
2015	14233	16605	13316	10815	1408	539	91	103
2016	210649	3191	8568	4732	3277	400	126	55
2017	8414	57165	1808	4021	1379	706	98	49
2018	14495	2182	26530	763	1312	338	148	37
2019	36421	3590	948	13920	316	360	74	39
2020	57927	8972	1674	501	5607	93	79	27
2021	105422	15456	4190	805	162	1743	23	26
2022	105422	28524	7438	2095	285	51	469	13

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	0.1	0.561	1.115	1.282	1.115
1986	0.099	0.557	1.101	1.268	1.103
1987	0.098	0.552	1.083	1.243	1.085
1988	0.097	0.539	1.077	1.226	1.086
1989	0.095	0.526	1.067	1.226	1.09
1990	0.093	0.523	1.07	1.244	1.137
1991	0.092	0.517	1.065	1.257	1.214
1992	0.09	0.503	1.049	1.242	1.293
1993	0.088	0.488	1.026	1.216	1.315
1994	0.087	0.481	1.035	1.164	1.315
1995	0.086	0.476	1.069	1.16	1.335
1996	0.086	0.471	1.096	1.169	1.249
1997	0.084	0.473	1.1	1.205	1.227
1998	0.081	0.485	1.089	1.249	1.214
1999	0.078	0.492	1.106	1.282	1.253
2000	0.075	0.495	1.119	1.276	1.235
2001	0.072	0.494	1.1	1.278	1.235
2002	0.068	0.486	1.067	1.259	1.206

Year Age	age 1	age 2	age 3	age 4	age 5-7
2003	0.066	0.47	1.016	1.223	1.172
2004	0.063	0.453	0.963	1.178	1.181
2005	0.061	0.443	0.907	1.115	1.168
2006	0.06	0.435	0.87	1.044	1.107
2007	0.058	0.429	0.838	1.036	1.103
2008	0.056	0.414	0.819	1.024	1.166
2009	0.055	0.405	0.793	1.031	1.204
2010	0.055	0.385	0.776	1.037	1.229
2011	0.054	0.37	0.762	1.033	1.199
2012	0.054	0.361	0.76	1.042	1.145
2013	0.054	0.356	0.763	1.044	1.185
2014	0.054	0.35	0.761	1.013	1.145
2015	0.054	0.342	0.758	0.978	1.135
2016	0.054	0.331	0.752	0.959	1.135
2017	0.054	0.316	0.729	0.934	1.142
2018	0.055	0.297	0.717	0.908	1.144
2019	0.055	0.289	0.723	0.897	1.124
2020	0.055	0.29	0.72	0.885	1.109
2021	0.055	0.29	0.722	0.88	1.087

Table 2.3.26. Western Baltic cod. Catch constrain set in the intermediate year compared to the SAM estimate the following year and the official (IC) estimate.

assessment year	2016	2017	2018	2019	2020	2021	2022
Total estimated Catch IM year	10327	5090	5612	7988	4488	4953	900
SAM CATCH estimate	9618	6688	7845	7871	5792	4029	
percent difference	-7	31	40	-1	29	-19	
Official estimate	9742	5364	5309	9437	4398	2096	
percent difference	-6	5	-5	18	-2	-58	

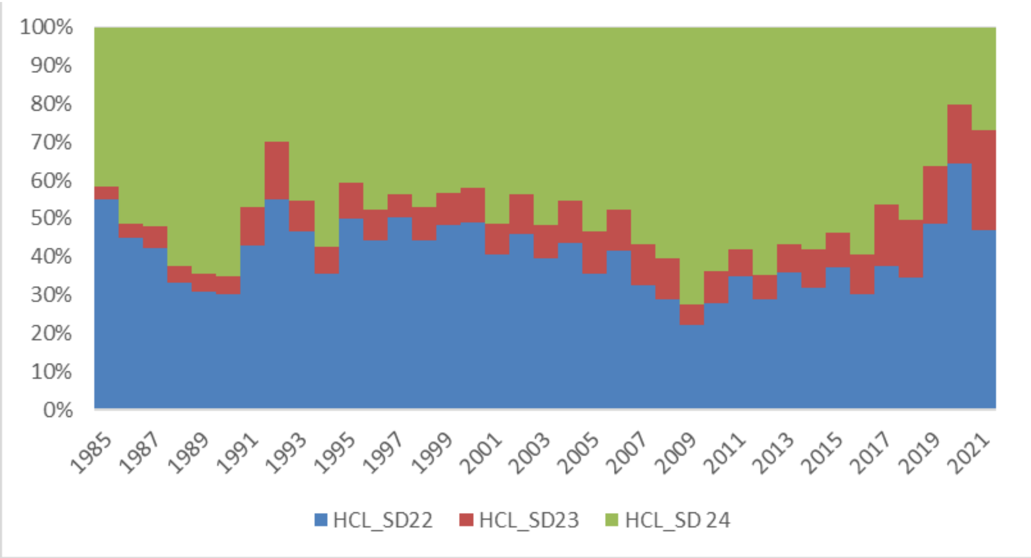


Figure 2.3.1. Western Baltic cod. Relative landings by SD (tonnes) for the western Baltic management area (both east and west cod included). HCL: human consumption landings.

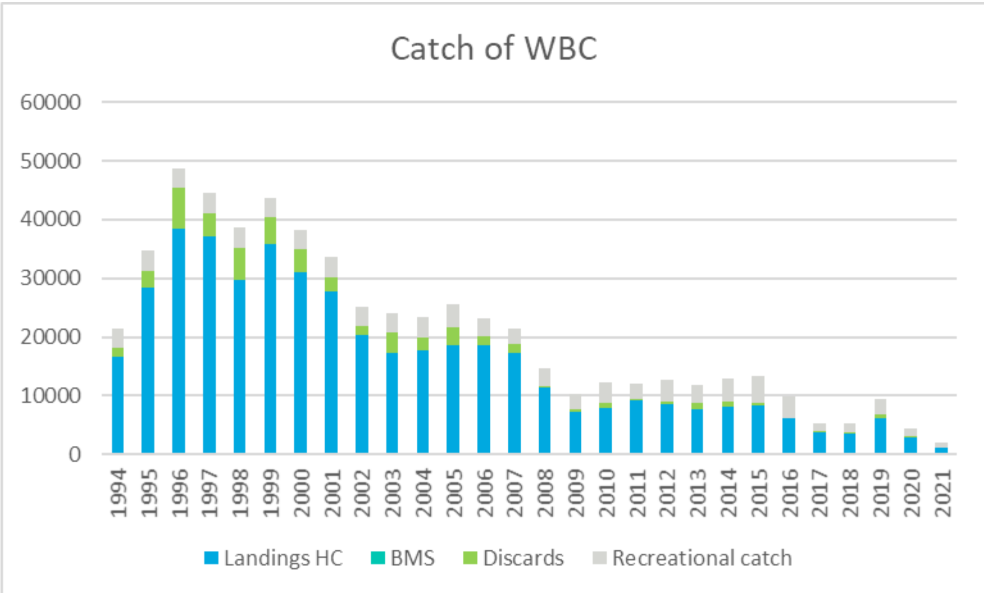


Figure 2.3.2. Western Baltic cod. Commercial landings, discard and recreational catch (tonnes) of the WBC stock.

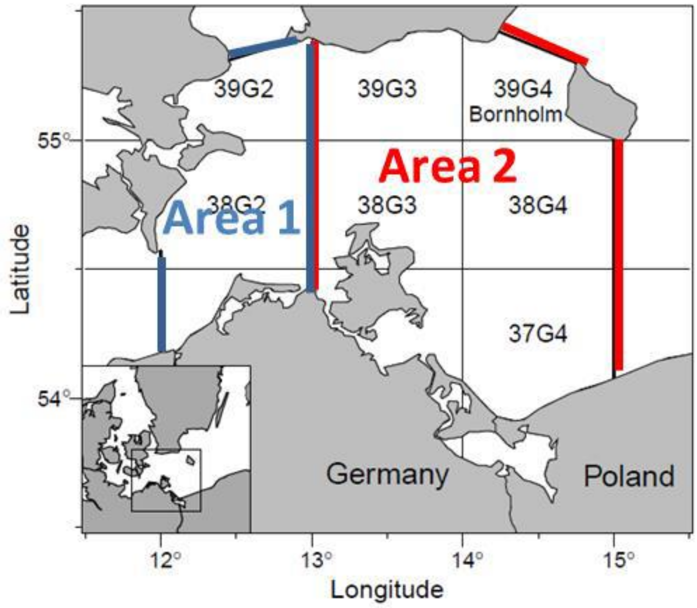


Figure 2.3.3. Western Baltic cod. Subareas (Area 1 and Area 2 within SD 24) for which different keys for splitting between eastern and western Baltic cod catches in SD 24 were applied.

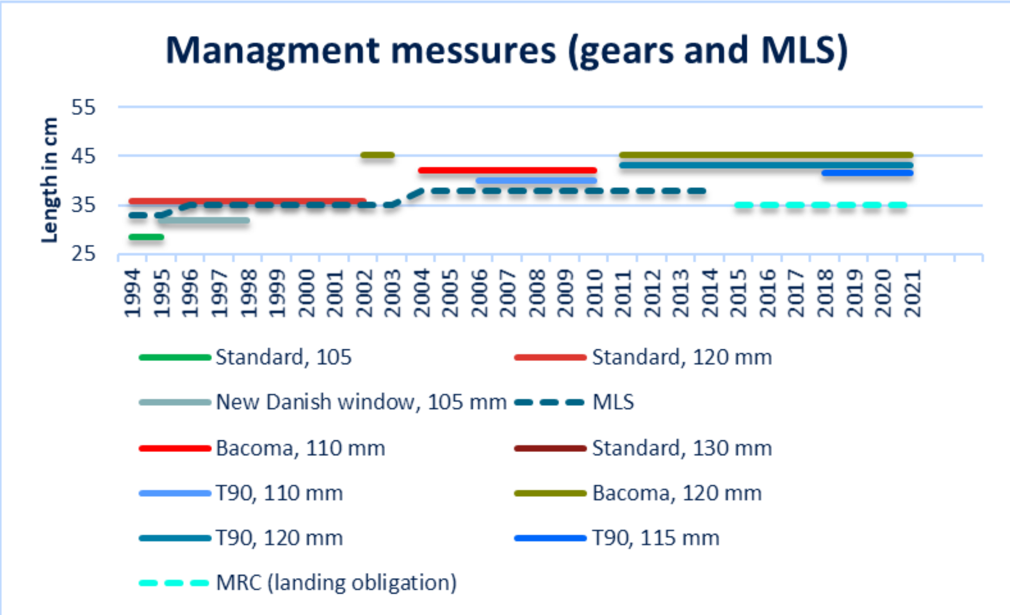


Figure 2.3.4. Western Baltic cod. Management measures for gear and minimum landing size, since 1994.

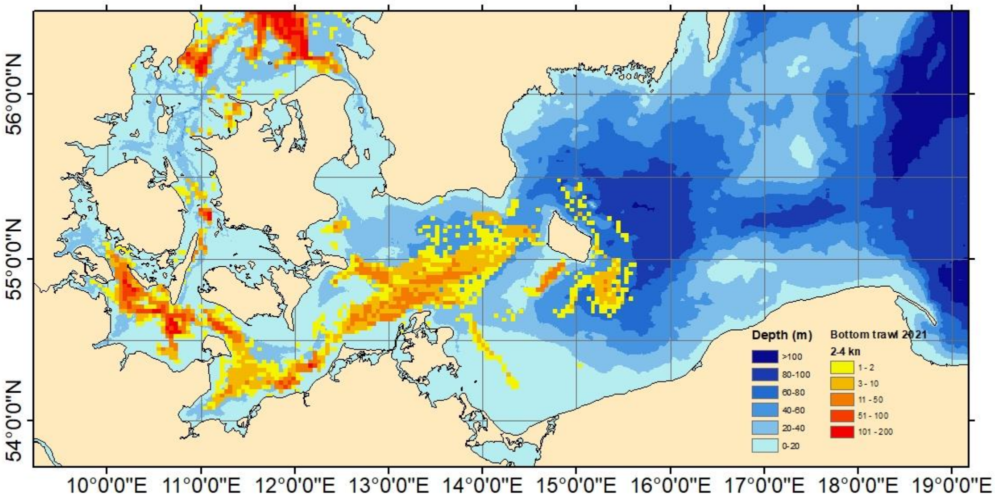


Figure 2.3.5a. Western Baltic cod. Danish VMS data from 2021 from OTB.

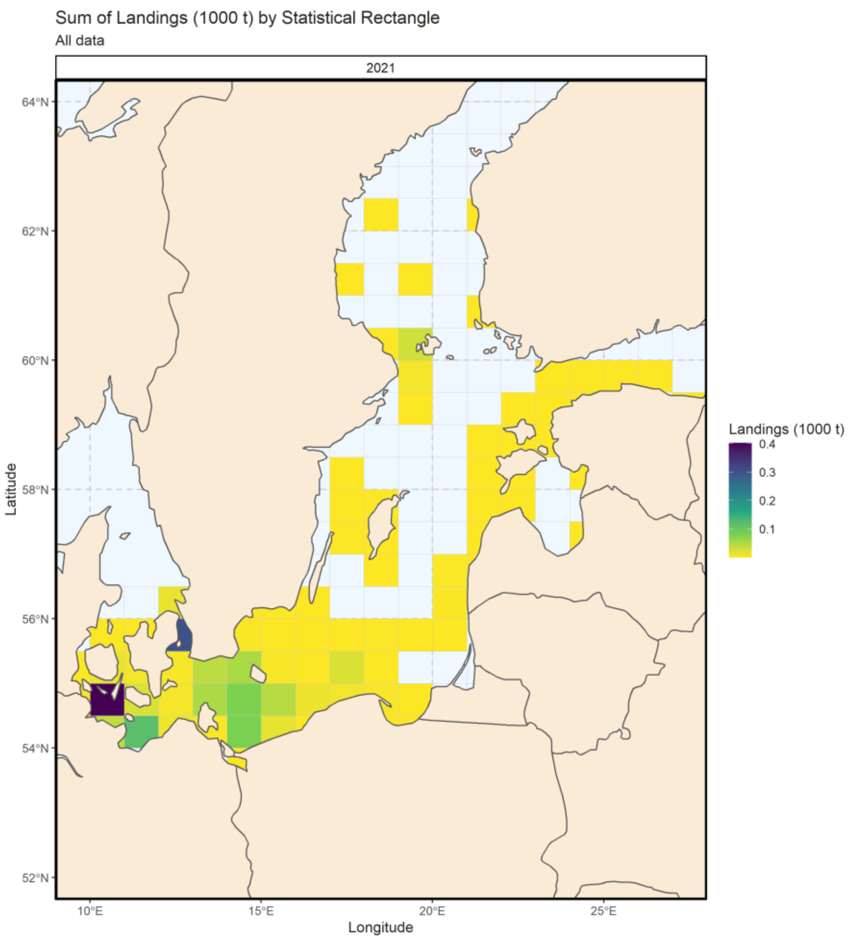


Figure 2.3.5b. Western Baltic cod. Sum of cod landings (1000 t) by Statistical Rectangle.

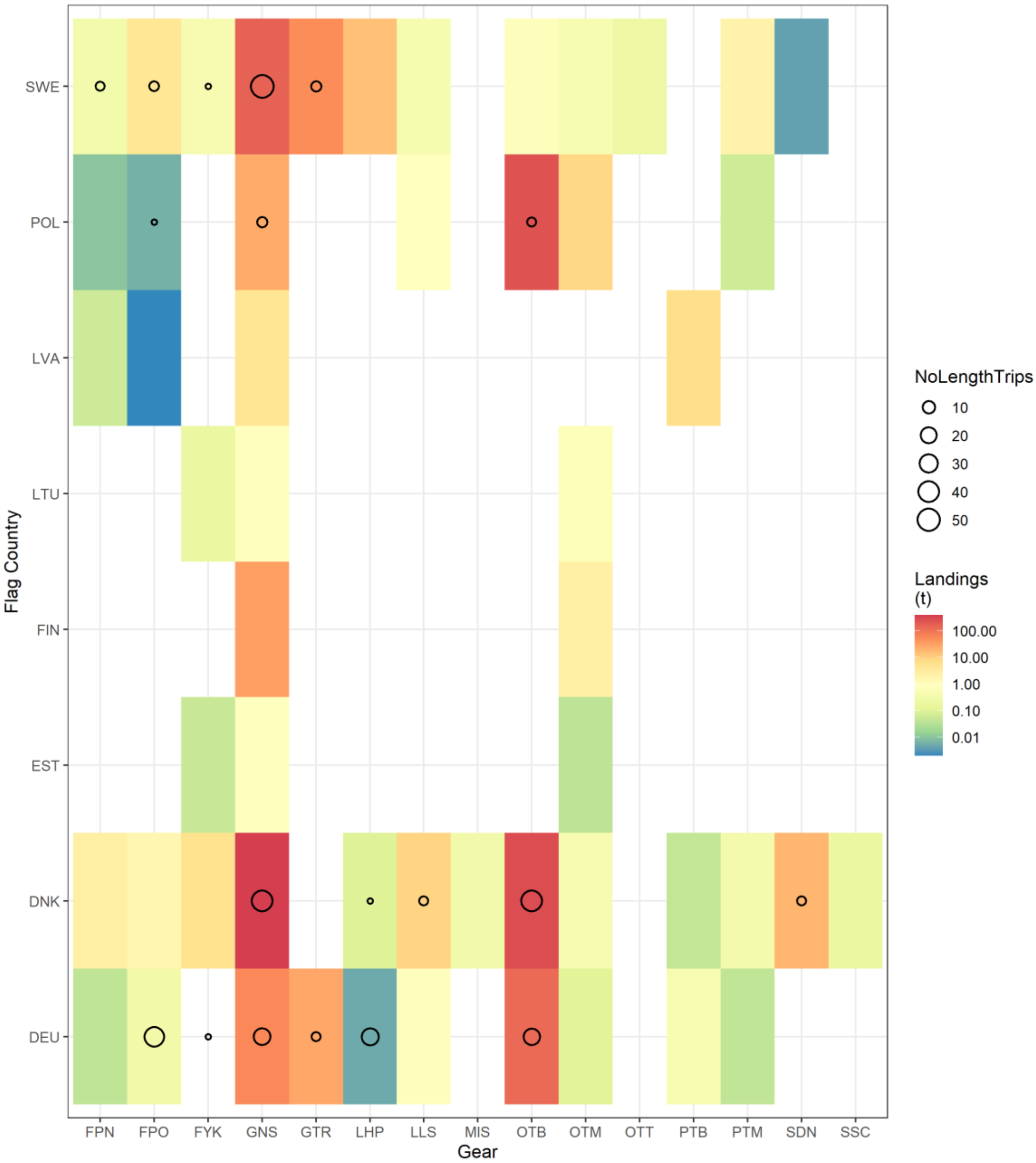


Figure 2.3.5c. Western Baltic cod. Total landings and number of trips sampled with cod, by gear and country.

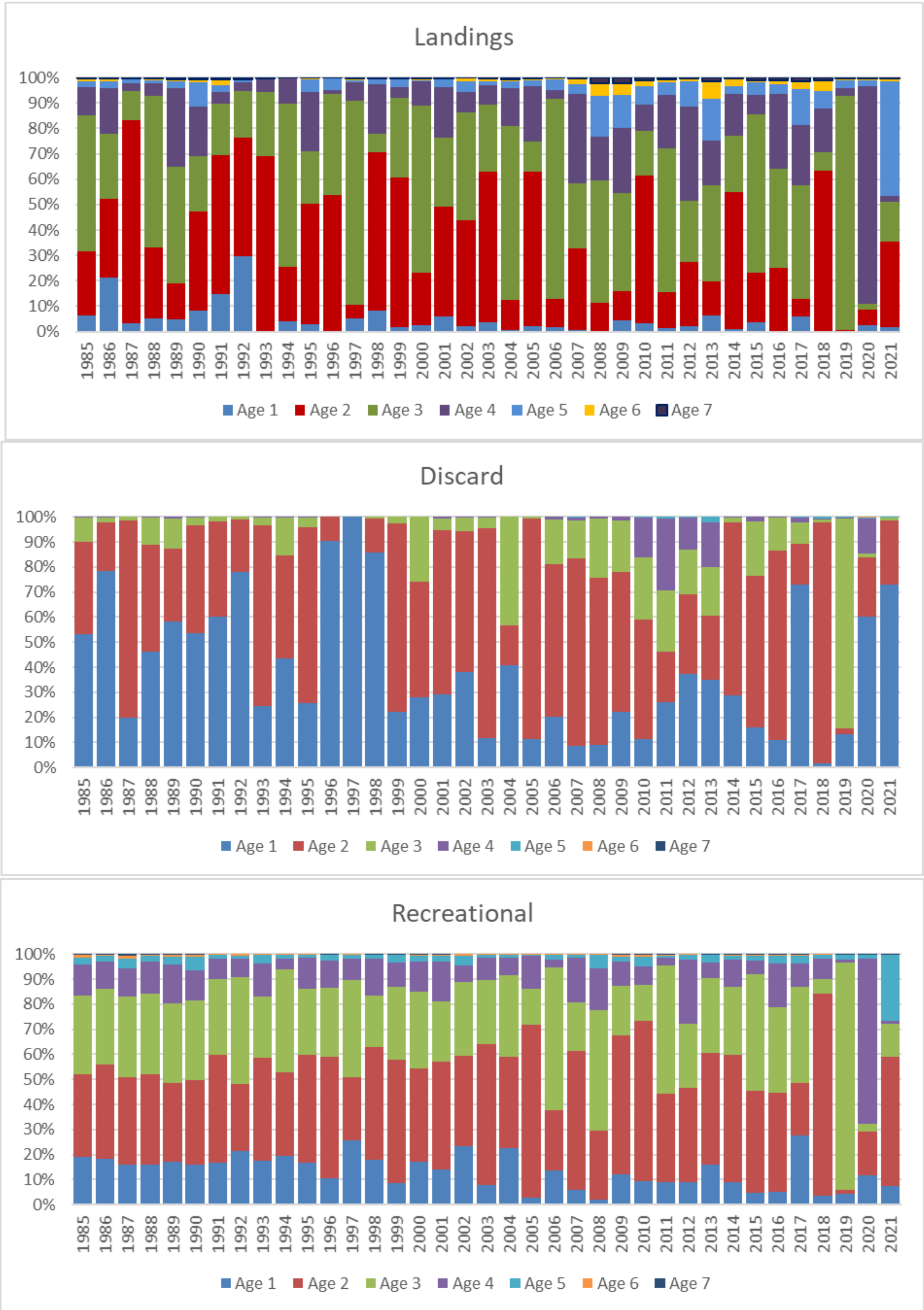


Figure 2.3.6. Western Baltic cod. Number at age distribution of cod in commercial landings, discards and recreational catch (relative proportions).

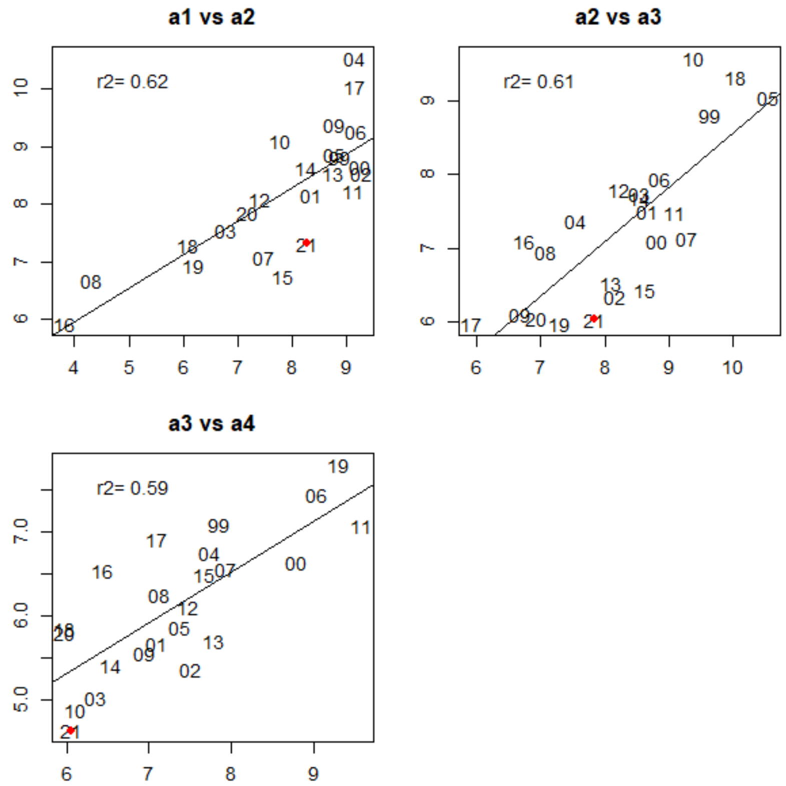


Figure 2.3.7a. Western Baltic cod. Updated CPUE at age i vs numbers at age i +1 in the following year, in BITS Q1 survey. Red dots highlight the information from the latest year.

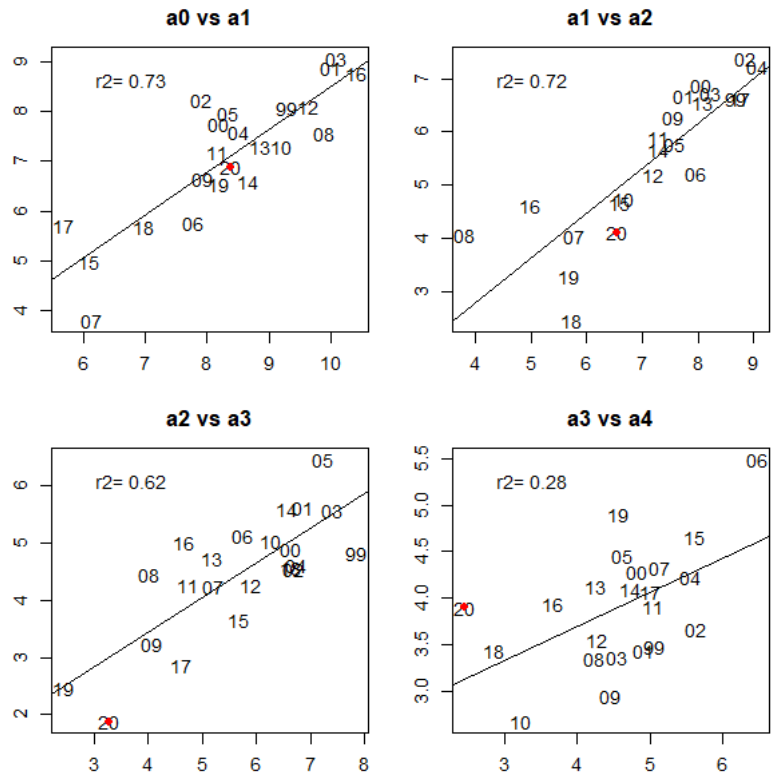


Figure 2.3.7b. Western Baltic cod. Western Baltic cod. Updated CPUE at age i vs numbers at age i +1 in the following year, in BITS Q1 survey. Red dots highlight the information from the latest year.

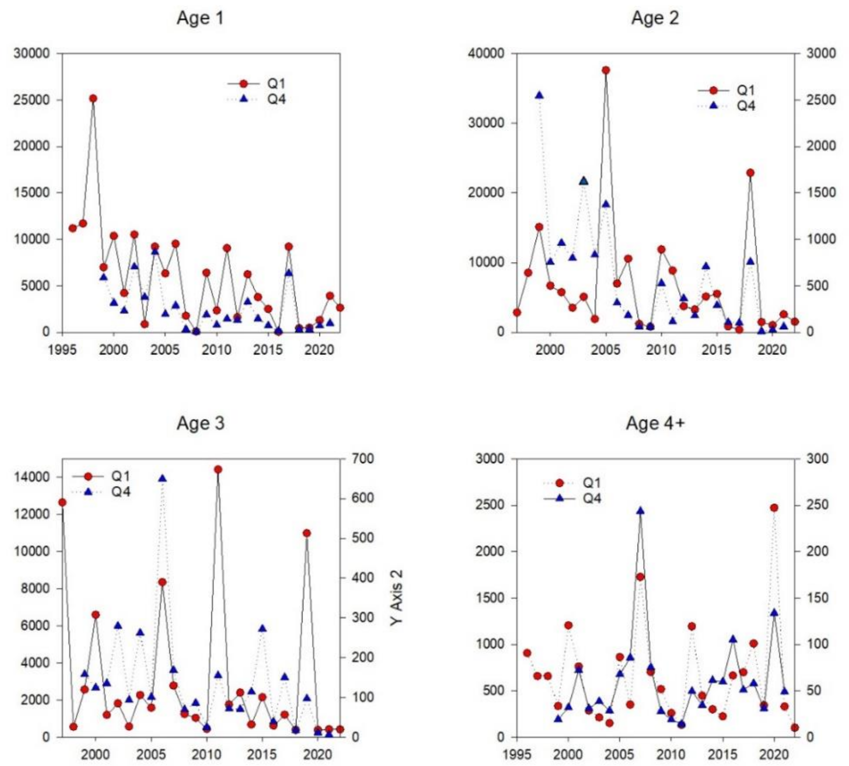


Figure 2.3.8. Western Baltic cod. Time-series of BITS Q1 and BITS Q4 in numbers by age groups.

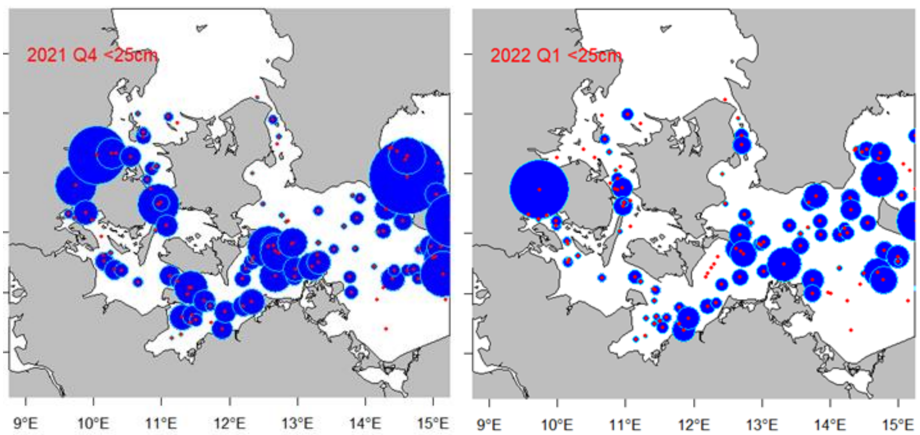


Figure 2.3.9. Western Baltic cod. Distribution of cod<25 cm from BITS Q4 2021 and BITS Q1 2022.

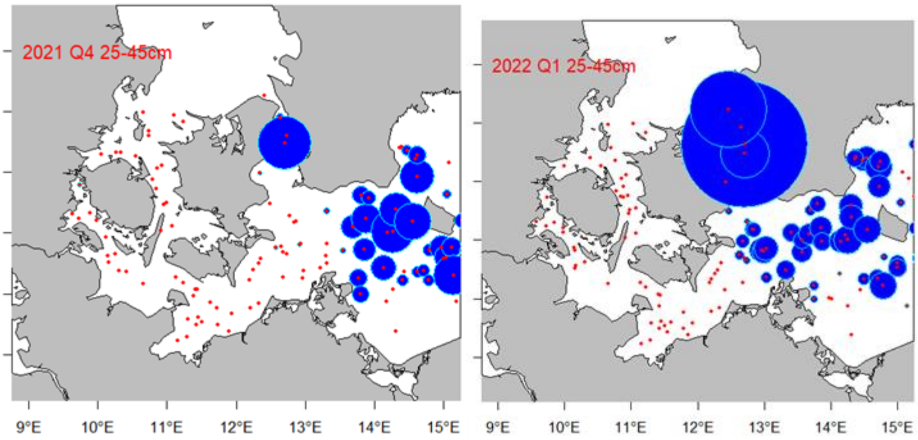


Figure 2.3.10. Western Baltic cod. Distribution of cod 25-45 cm from BITS Q4 2021 and BITS Q1 2022.

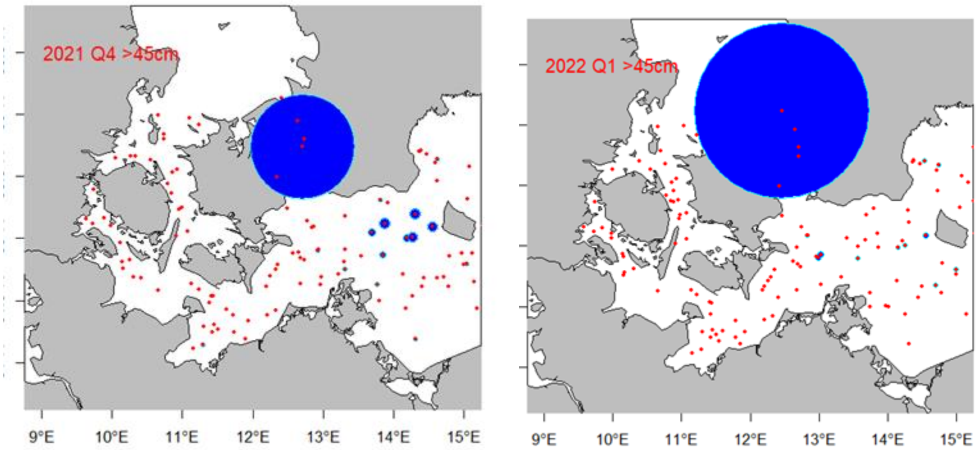


Figure 2.3.11. Western Baltic cod. Distribution of cod 25-45 cm from BITS Q4 2021 and BITS Q1 2022.

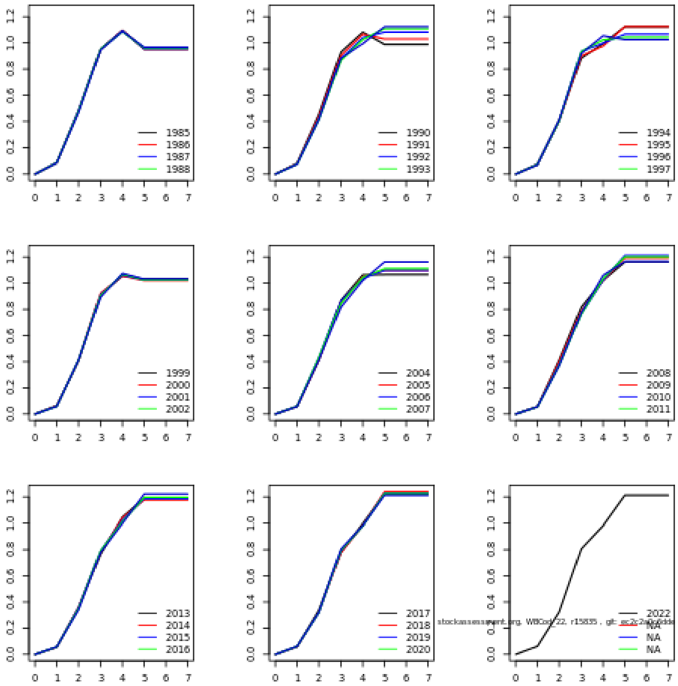


Figure 2.3.12. Western Baltic cod. Selection pattern

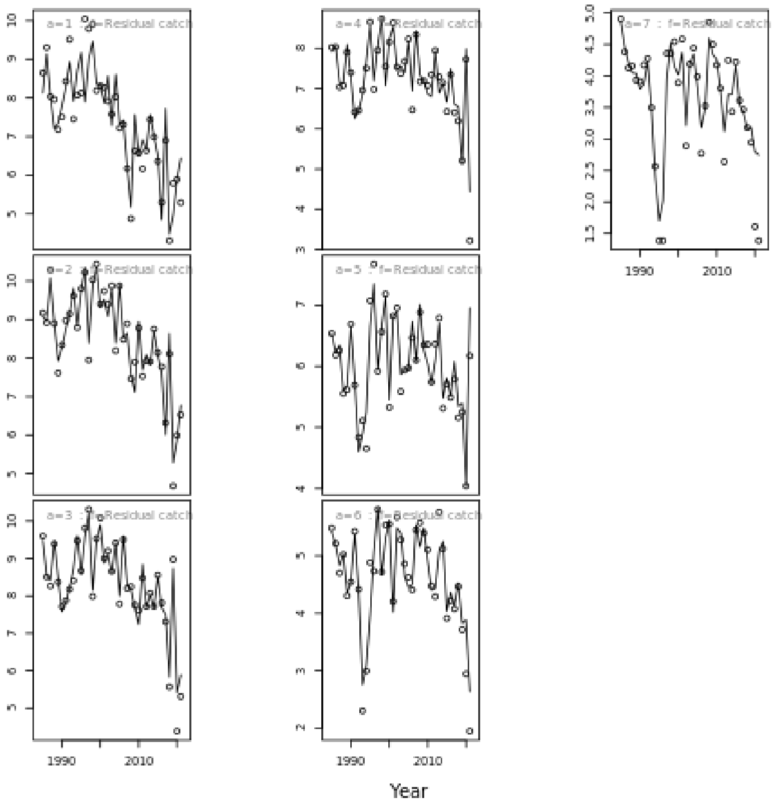


Figure 2.3.13. Western Baltic cod. Model fitting to catch data (line is model and cycles are data points.

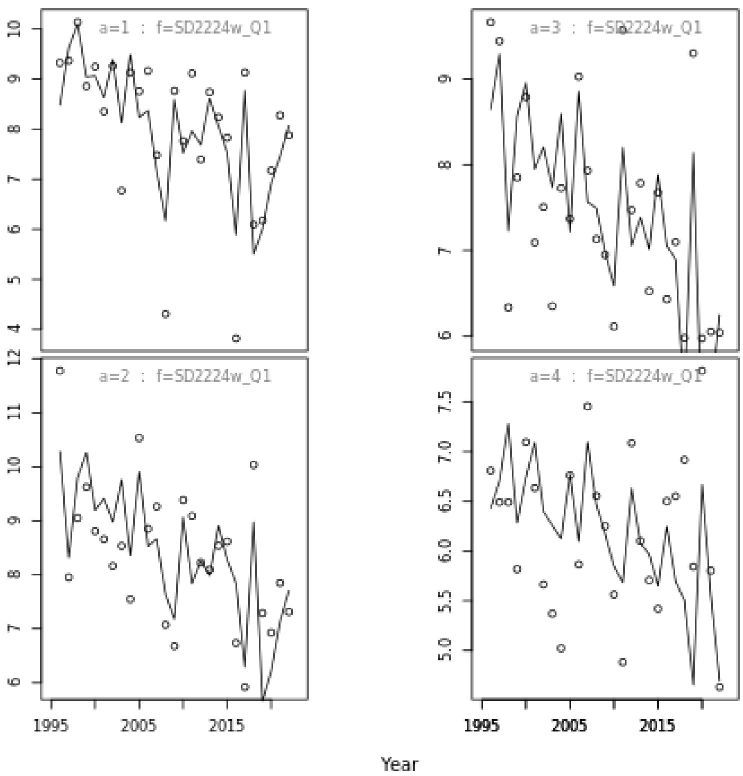


Figure 2.3.14. Western Baltic cod. Model fitting to Q1 survey data (line is model and cycles are data points.

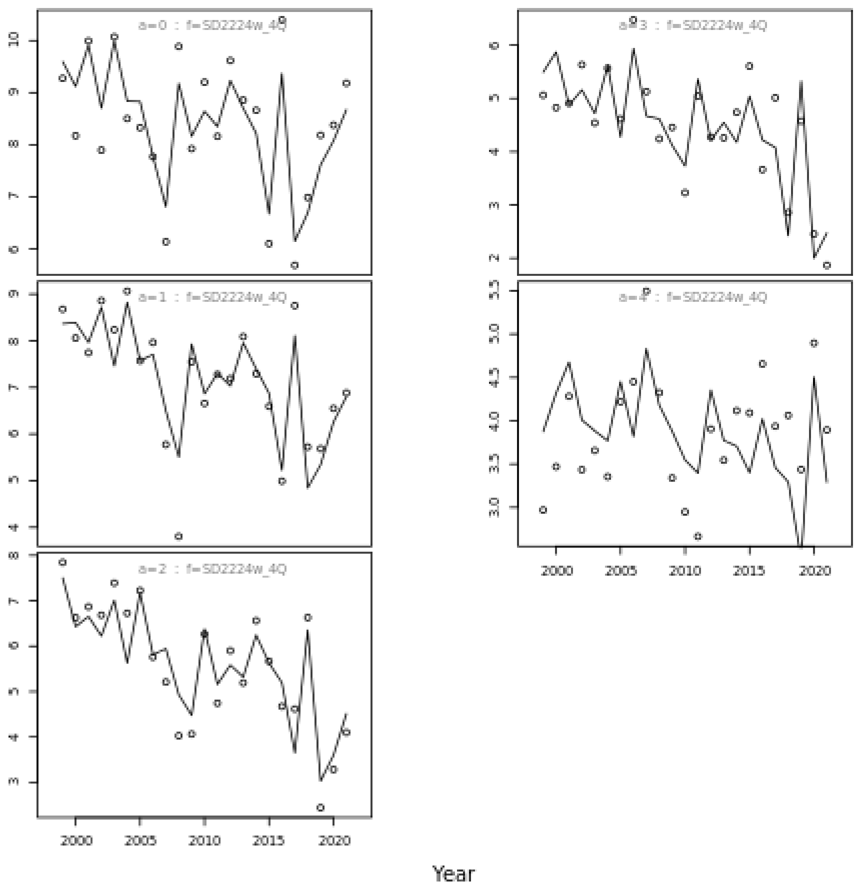


Figure 2.3.15. Western Baltic cod. Model fitting to Q4 survey data (line is model and cycles are data points.

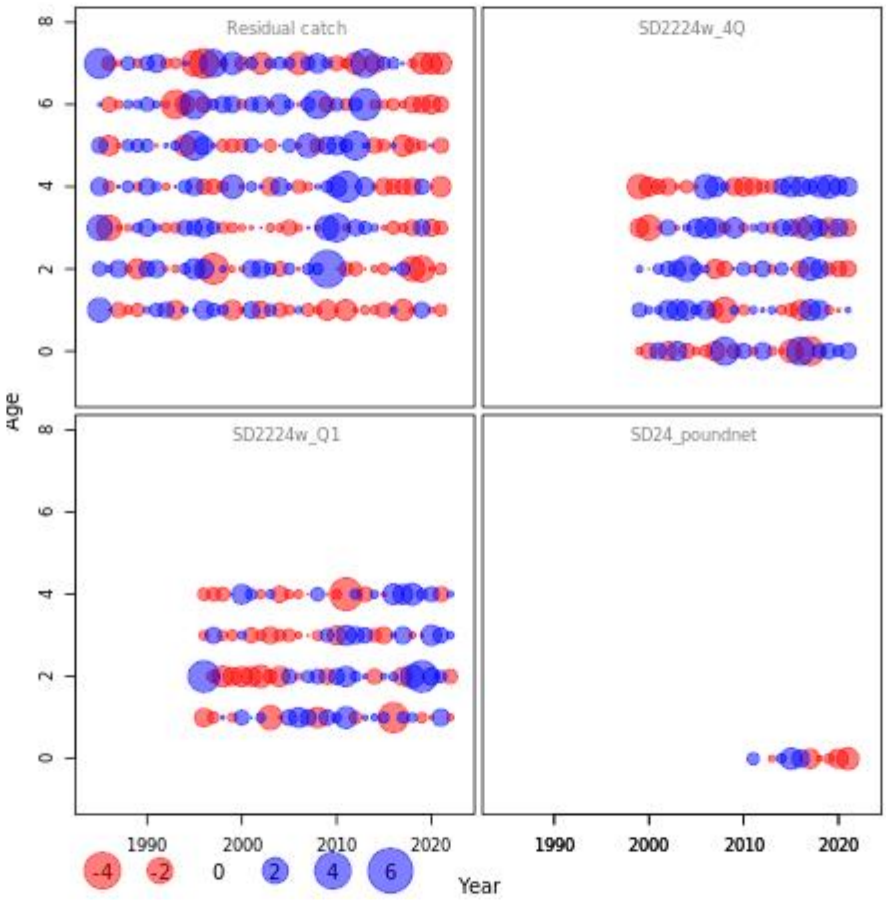


Figure 2.3.16. Western Baltic cod. Residuals in catch data and surveys.

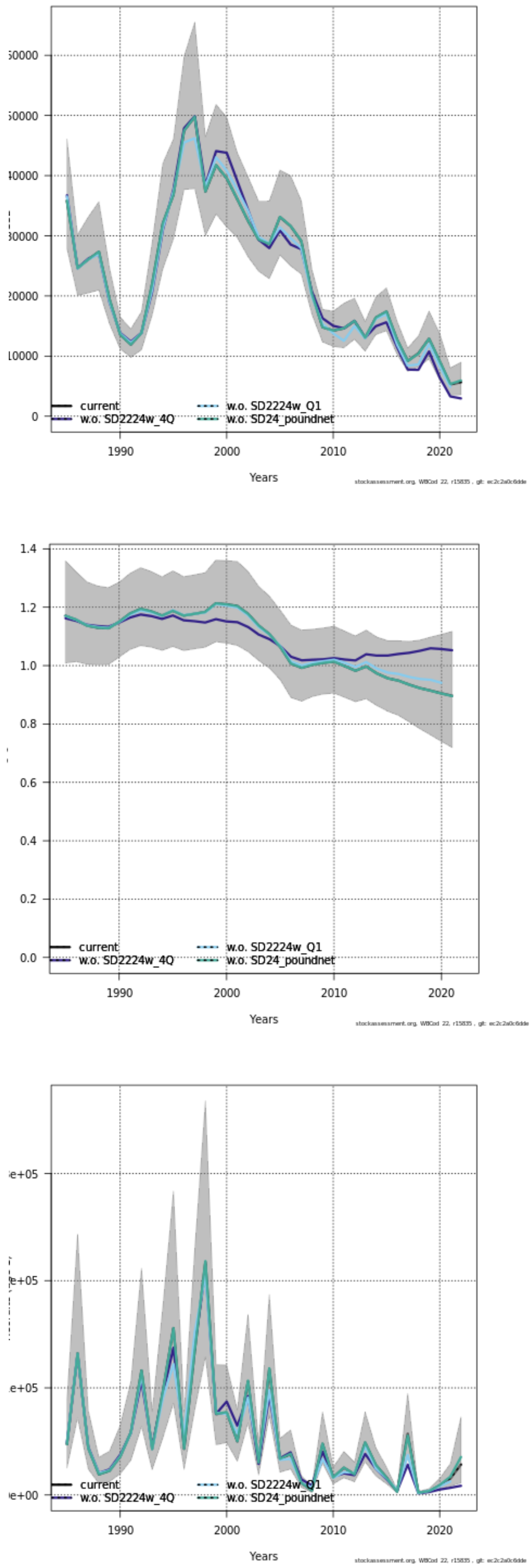


Figure 2.3.17. Western Baltic cod. Leave one out

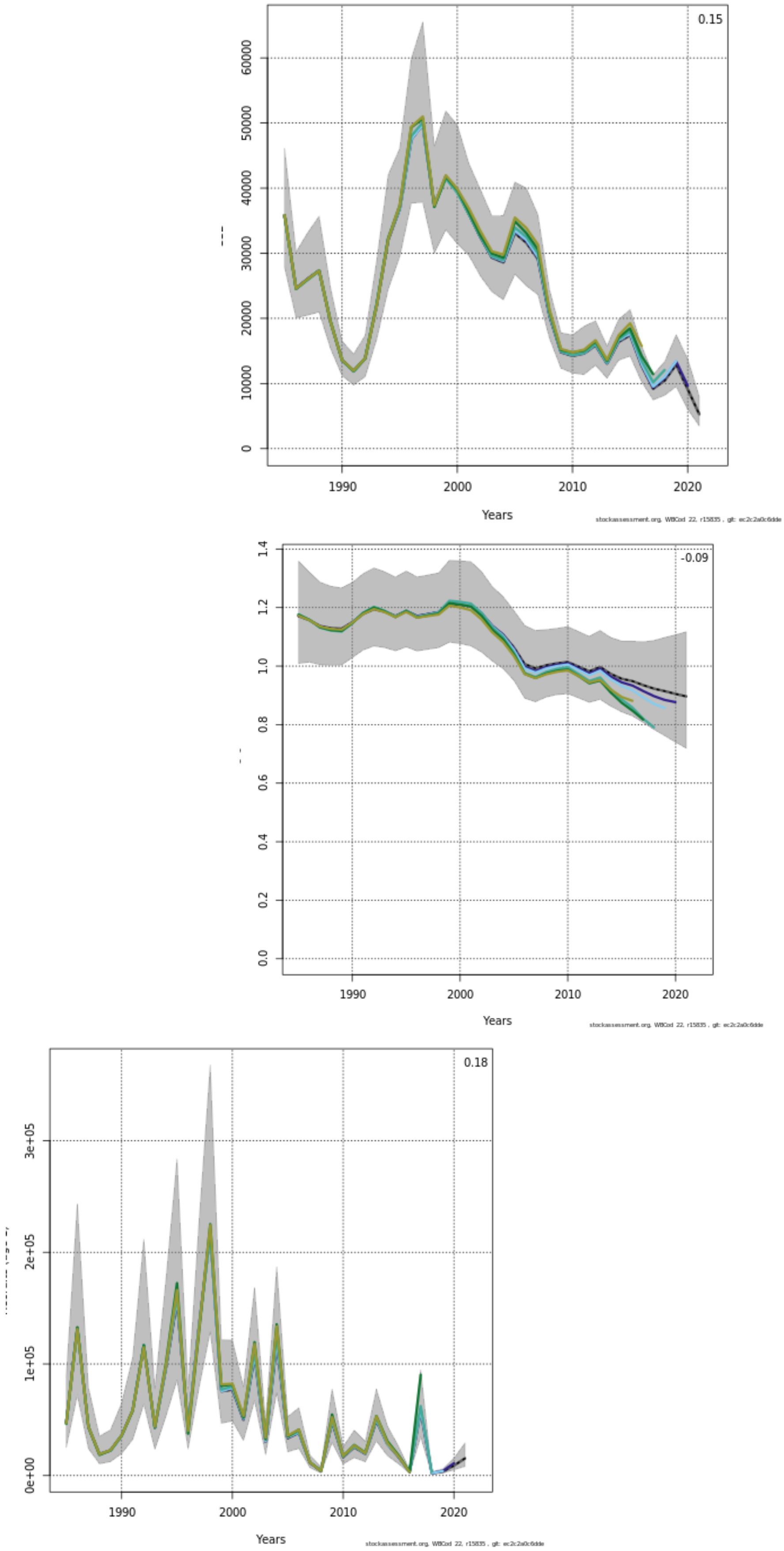


Figure 2.3.18. Western Baltic cod. Retrospective pattern in SSB, F and R. Mohn's Rho is indicated in the figures.

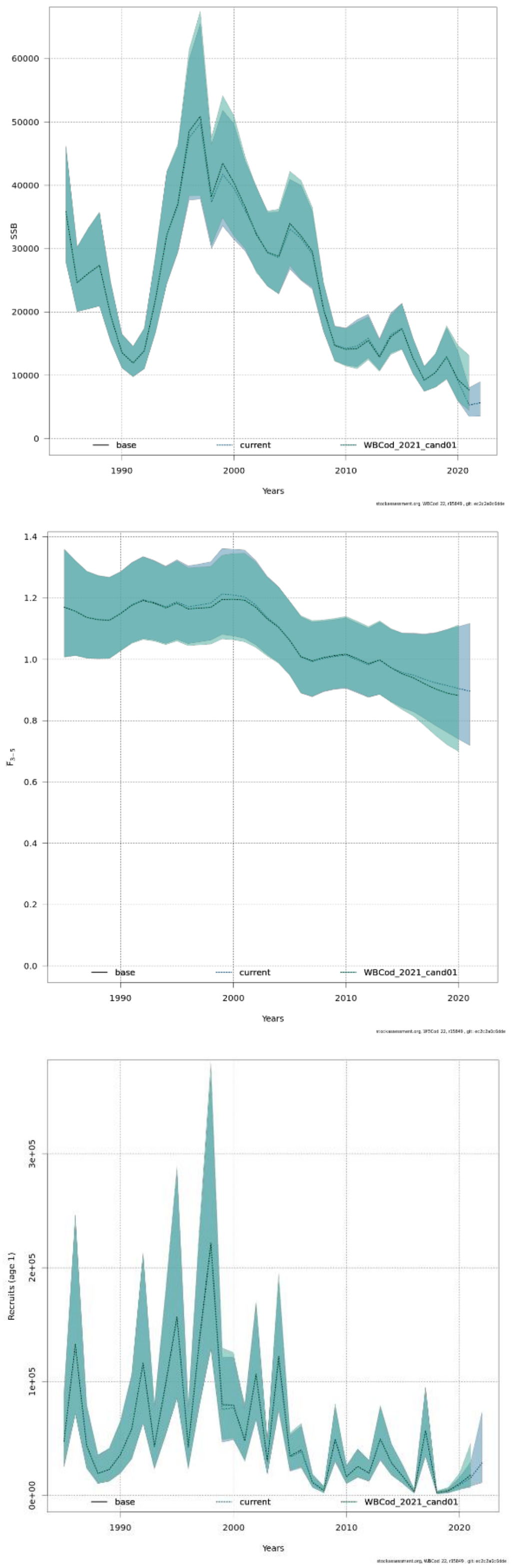


Figure 2.3.19. Western Baltic cod. Final assessment with SSB, F and R (age 1). Last years assessment indicated in green colours.

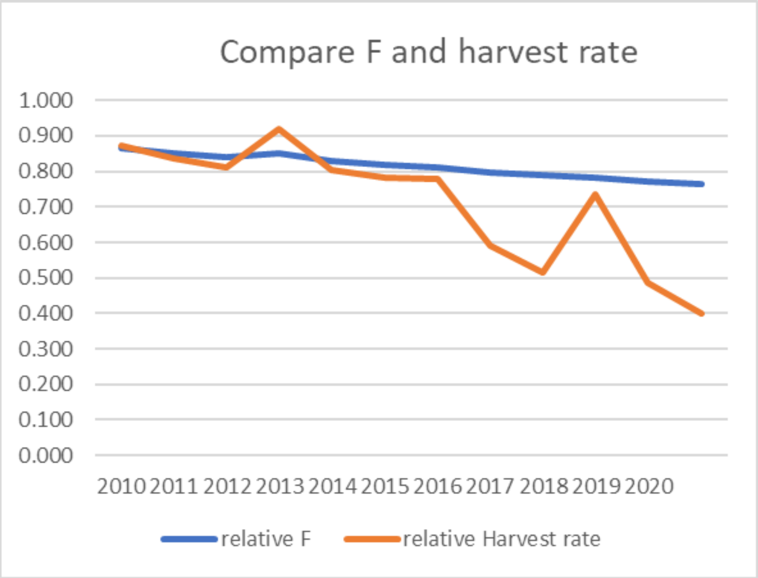


Figure 2.3.20. Western Baltic cod. Relative harvest rate and F

3 Flounder in the Baltic

3.1 Introduction

3.1.1.1 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 pelagic, and the demersal spawners. 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 feeding grounds in summer - autumn (Nissling and Dahlman, 2010).

Demersal spawners 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).

Pelagic spawners 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 pelagic spawners, 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 (demersal vs. pelagic spawners) in subdivisions. An estimate of 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 ecotype, furthermore the proportion differs between SD 26 and 28 such that 28 is dominated by demersal ecotype while SD 26 is dominated by the pelagic ecotype. 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 pelagic ecotypes per SD.

Subdivision	Proportion of pelagic spawners
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 flesus*) 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 2009–2020 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 provide most of the landings in SD 22 (ca. 55%), landings from passive gears are low but increasing in recent years and account for 45% of landings in 2021. However, in SD 23, passive gears provide around >90% of total flounder landings (for the Swedish fleet 98–100%) in this area. Flounder was mostly caught 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 2021 were at about 526 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; only a few biological samples are available. 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. Table 3.2.3 gives an overview of total landings and the estimated discard weights and empty strata. 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 2021 are estimated to be around 38 tonnes, which would result in a discard ratio of 7% of the total catch, which is the 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 (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. 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 3.2.7).

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 of 2020 and 2021 was 21% lower than the mean of the biomass index from 2017–2019 (Figure 3.2.7). The length-based indicators are suggesting a good status of the stock. A precautionary buffer was applied the last time in 2014. 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 2014–2021 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 2021, 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

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

Table 3.2.3. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Overview of sampling intensity and discard estimations (no additional survival rate is added to this calculation).

Year	landings	estimates discard	ratio	total strata*	Unsampled strata
2006	1452	532	0.27	29	20
2007	1287	629	0.33	28	19
2008	1421	447	0.24	29	14
2009	1172	1027	0.47	29	15
2010	1051	536	0.34	31	16
2011	1040	534	0.34	31	7
2012	1220	563	0.32	29	12
2013	1453	502	0.26	26	13
2014	1193	540	0.31	26	11
2015	1130	314	0.22	28	14
2016	1153	495	0.30	28	10
2017	1158	249	0.18	31	13
2018	809	173	0.18	29	16
2019	1114	243	0.18	29	16
2020	775	121	0.14	30	7
2021	526	38	0.07	34	15

Table 3.2.4. fle.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	$L_{opt} = \frac{3}{3+{M}/{k}} \times L_{inf}$	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 3.2.5. 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} / $L_{F=M}$
2019	0.61	1.34	0.89	0.28	1.02	1.47
2020	0.80	1.34	0.91	0.36	1.04	1.31
2021	0.66	1.34	0.92	0.31	1.03	1.43

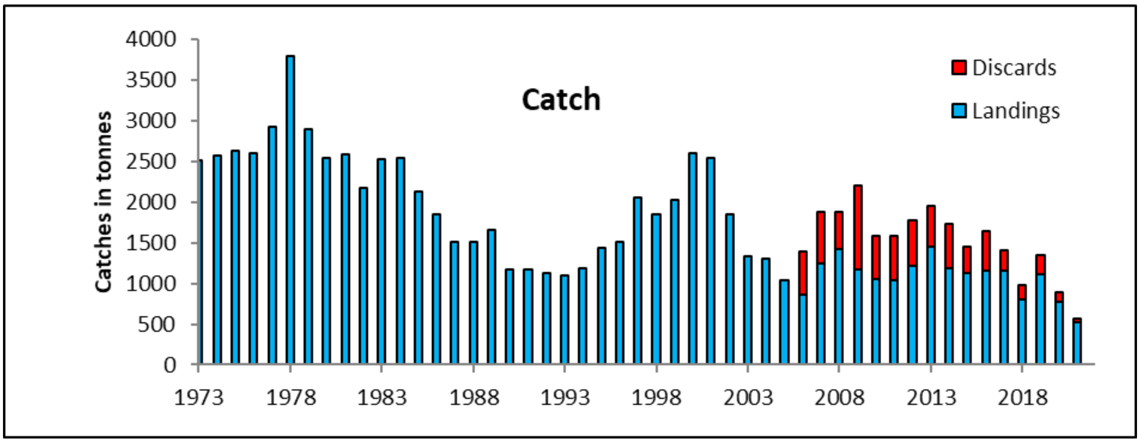


Figure 3.2.1. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings of flounder in tonnes for subdivisions SD 22–23 (Western Baltic Sea). ICES discard estimates are included from 2006 onwards.

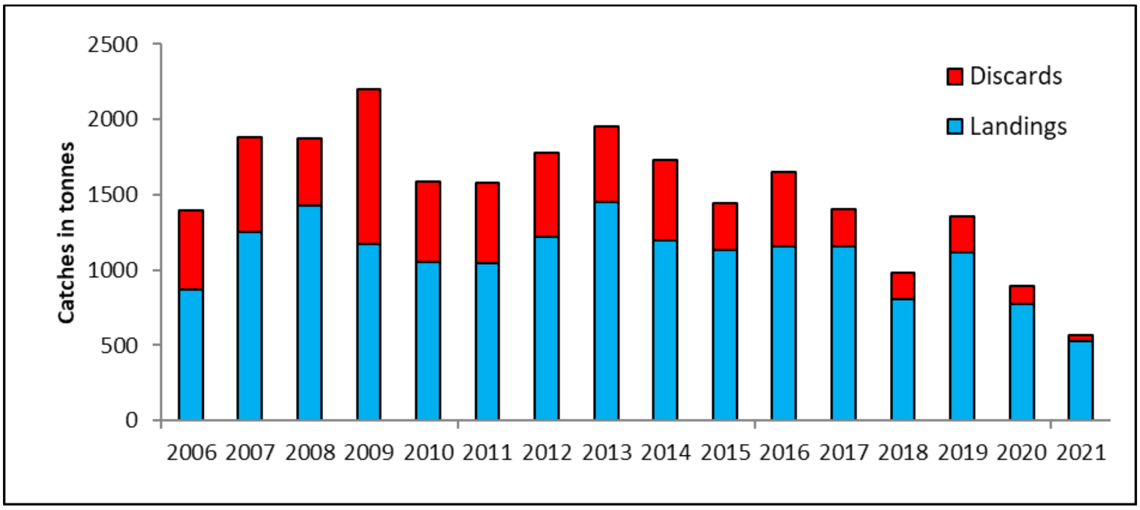


Figure 3.2.2. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings and calculated discards (in tonnes) of flounder for subdivisions SD 22–23 (Western Baltic Sea).

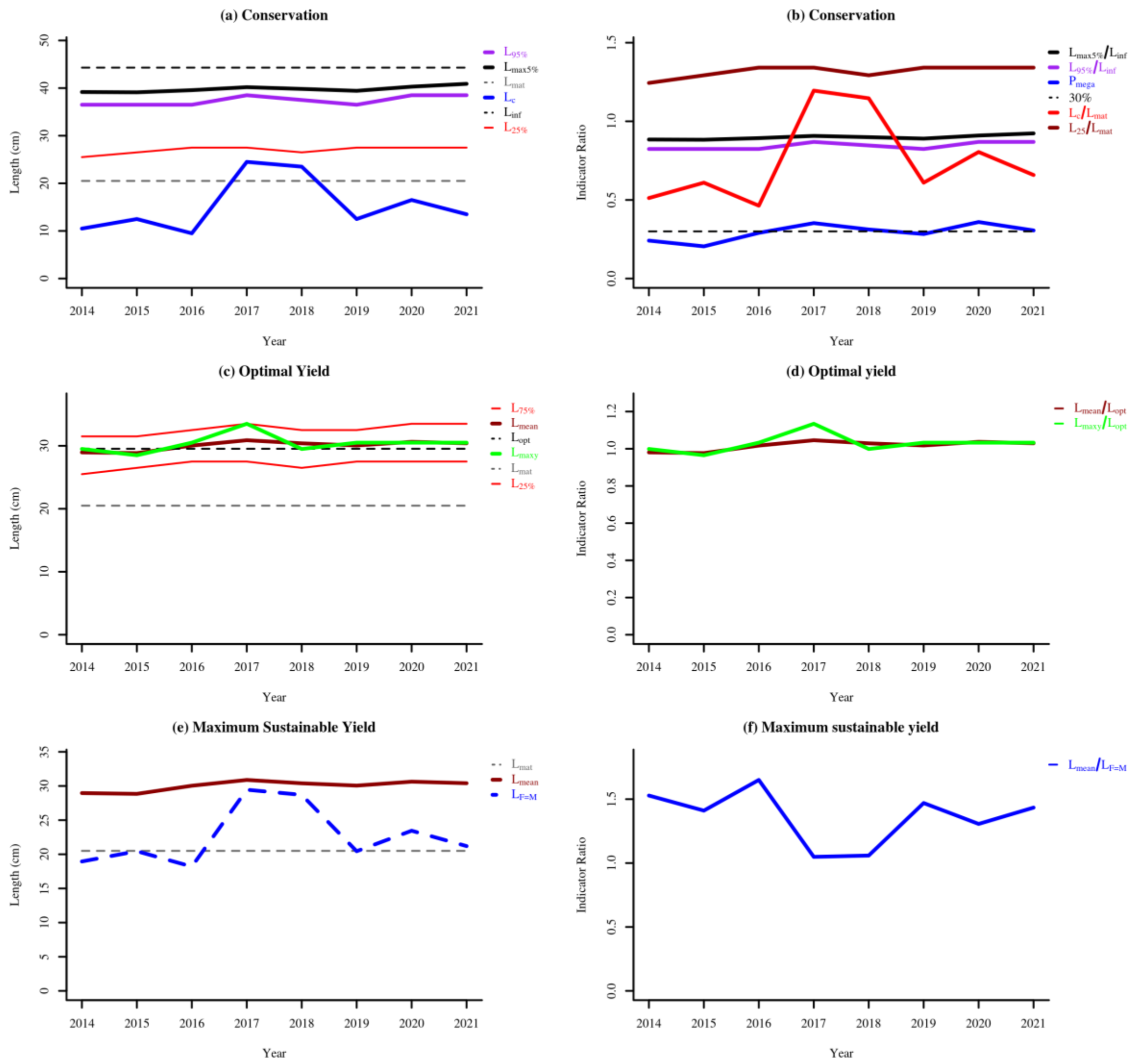


Figure 3.2.3. fle.27.2223. LBI indicator trends

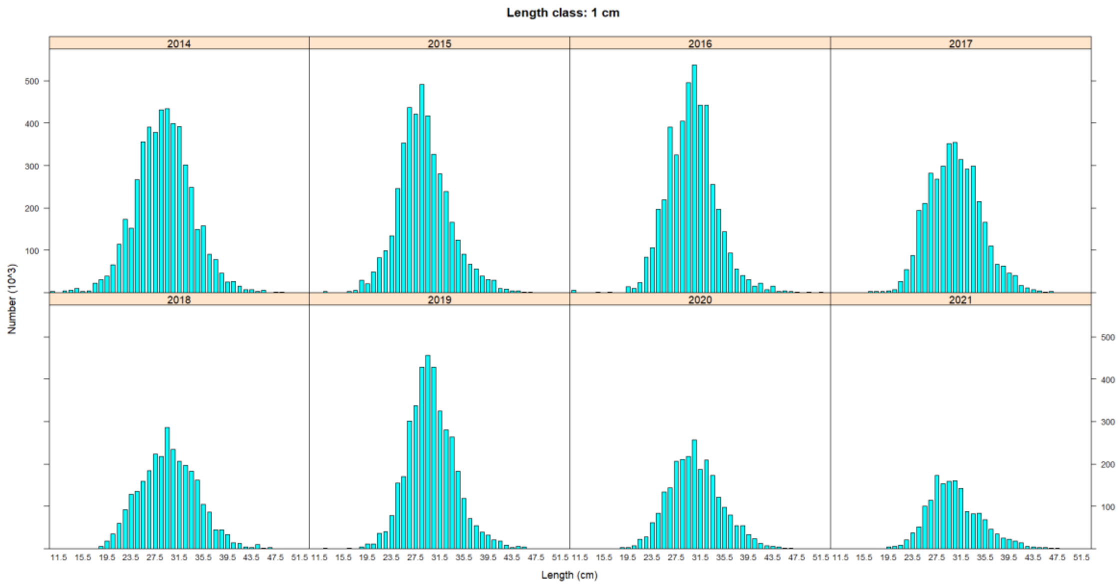


Figure 3.2.4. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Catch in numbers per length class in Subdivision 22 and 23 (Belts and Sound). All countries and fleets were combined.

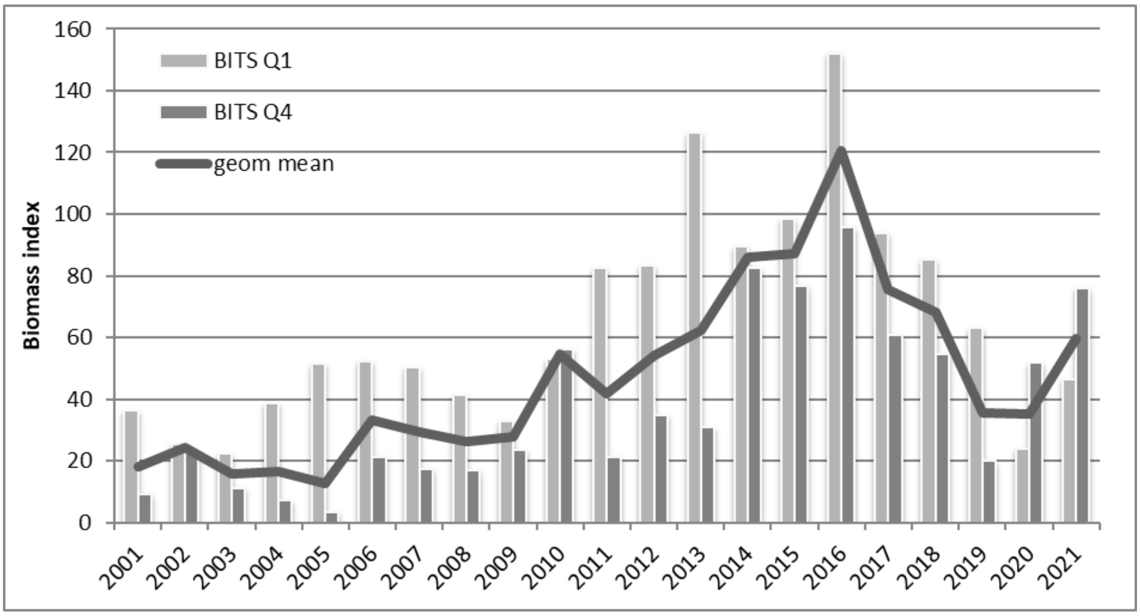


Figure 3.2.7. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Survey-biomass-index (BITS).

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 SD's 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 in the SD 25; in the SD 24 it was substantially lower. This year, as well as in 2020, because of lack of observers onboard due to COVID-19 restrictions, it was impossible to get any direct and reliable observations on this procedure. However, these data seem to be unreliable and need further analysis and verification. Significant part of this bycatch is assumed to be misreported sprat.

This 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 are mainly taken with active gears. Including bycatch from pelagic trawlers, around 85% of total landings were taken by those gears in 2021 (Figure 3.3.3). If we consider only demersal landings, then the contribution for active gears dropped to 79% of total landings.

In 2021 landings amounted to 11 414 tonnes (1964 and 9450 tonnes for SD 24 and SD 25, respectively). After excluding OTM bycatch, the landings in 2021 were 7910 tonnes (1 879 and 6032 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 8287 tonnes in 2021 (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 2021 were available for only 26% of the strata with landings and were even lower than compared to last year (31%). A decrease in the sampling of discards in 2020 and 2021 was caused by COVID-19 related restrictions, which in some countries prevented observers from sampling onboard. Due to the poor availability of discard information, discards estimated in 2020 and 2021 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, in 2020 and 2021 the discards proportion in the catches was similar in all main fishing countries and didn't exceed 12% (Table 3.3.1b; Figure 3.3.5). This was likely related to the cod fishery closure in SD 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 2021 for both SDs was 0.05, with discard equal to 377 tonnes, which is the lowest estimate in time-series (since 2014).

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:

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

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

The effort in 2021 was close to the one in 2020, 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 2020 and 2021 it was slightly worse than in 2019. That was due to COVID-19 related restrictions, which in some countries prevented observers from sampling onboard. Flounder discard in SD 24 was sampled by Germany and Denmark and in SD 25 only by Germany.

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 1st and 4th quarter. BITS surveys in SD 24 are performed by Germany, Sweden, Denmark and between 2016 and 2019 Q1 also by Poland and in SD 25 by Poland, Denmark and Sweden. 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 a decrease in 2021 (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 2014–2021 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 (2019 – 2021) was equal to 21.8 cm and L_{mean} - 28.1 cm. Only the indicator ratio L_c/L_{mat} in 2019 and 2021 was below expected value, which indicated that some immature individuals were present in the catch. 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.

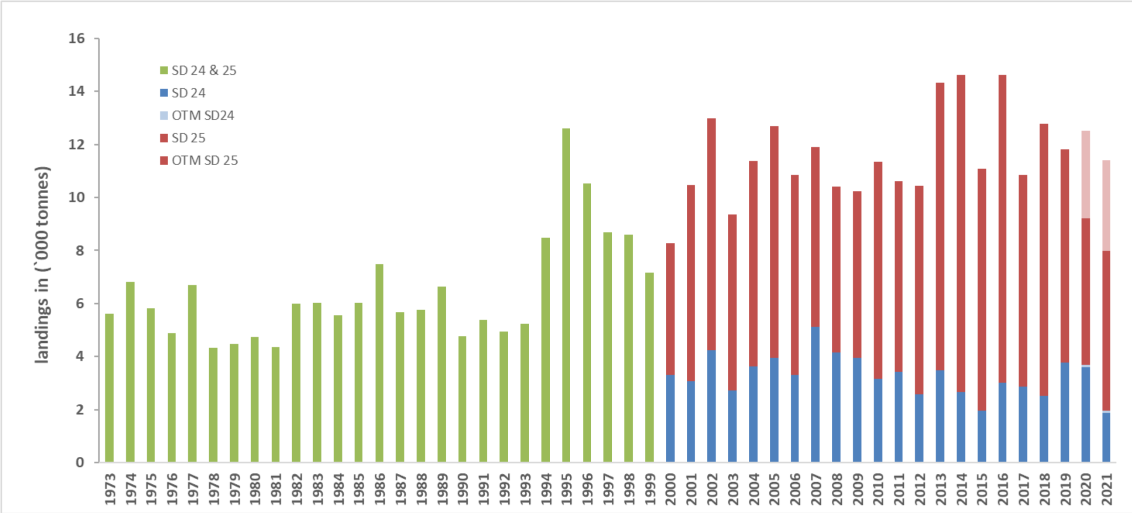


Figure 3.3.1. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Landings in thousand tonnes; bycatch from pelagic trawlers included in 2020 and 2021 (light blue and red colour)

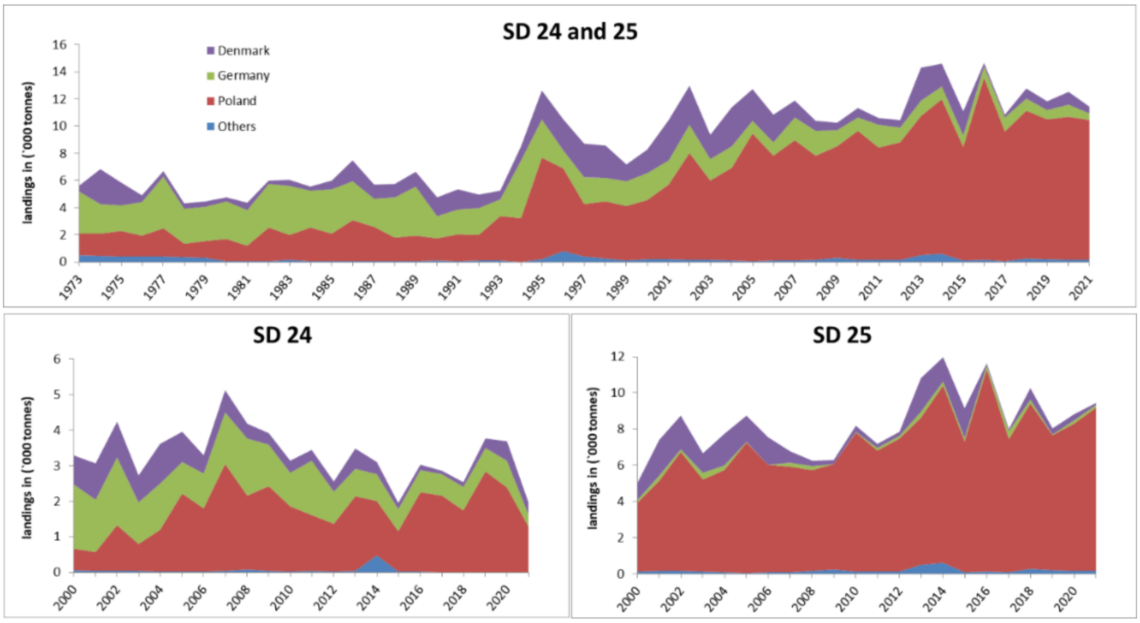


Figure 3.3.2. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Landings by country in thousand tonnes; bycatch from pelagic trawlers included in 2020 and 2021 Polish landings (for merged SD 24–25 – upper plot and separately for SD 24 and SD 25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

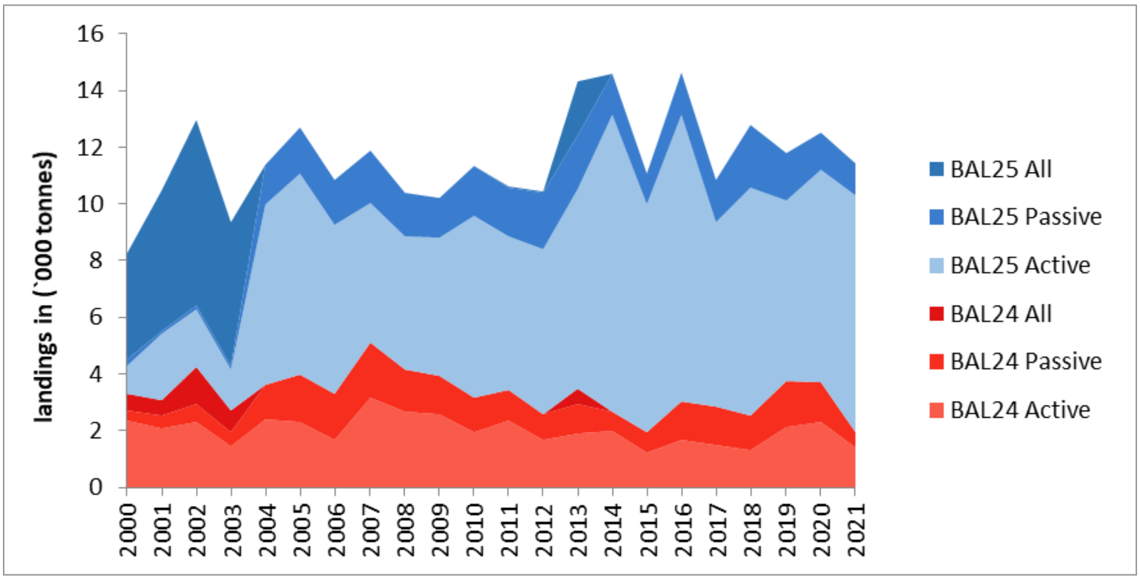


Figure 3.3.3. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Landings by fleet type in thousand tonnes (SD 24 - reddish colors, SD 25 – bluish); bycatch from pelagic trawlers included in 2020 and 2021 active gears

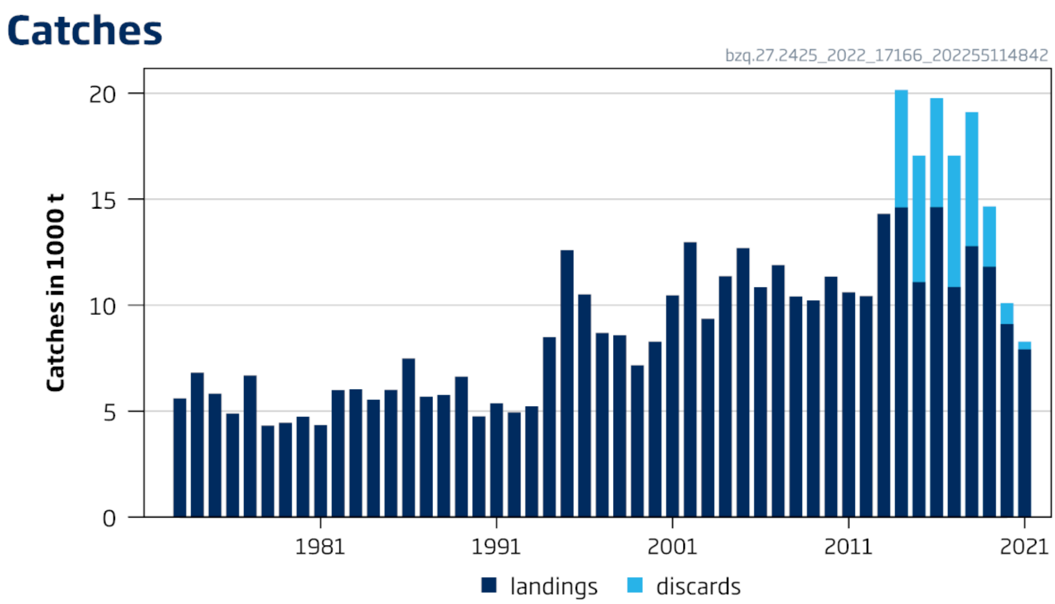


Figure 3.3.4. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Catches (ICES estimates) in subdivisions 24–25. Discard data have only been included since 2014.

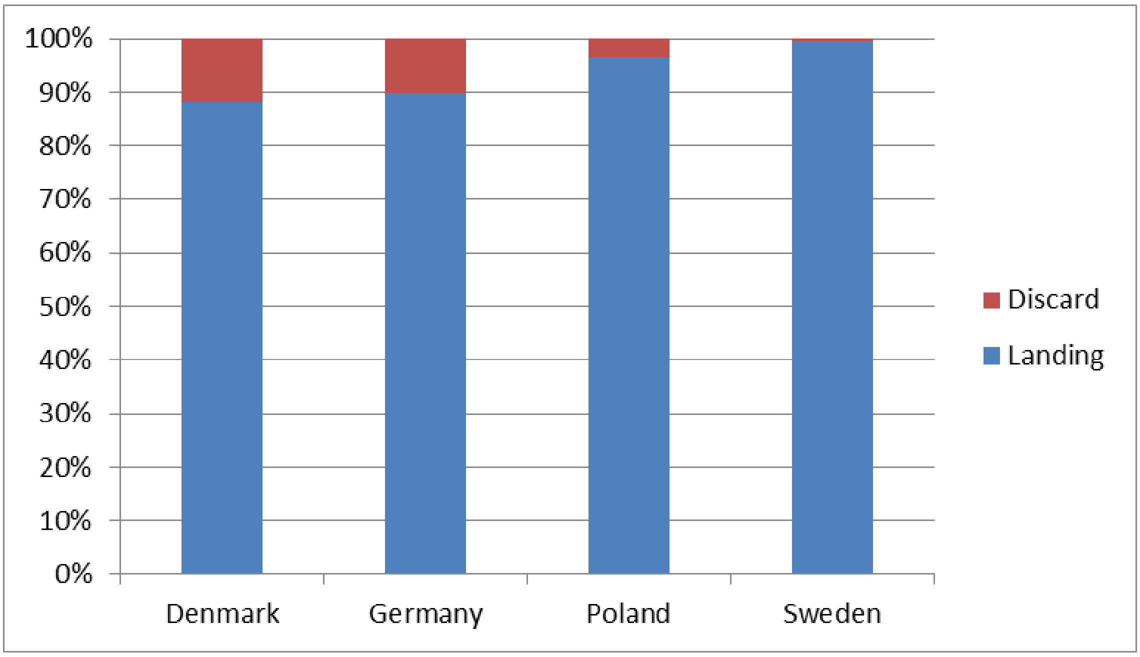


Figure 3.3.5. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Discard and landing proportion in 2021 catches in main fishing countries

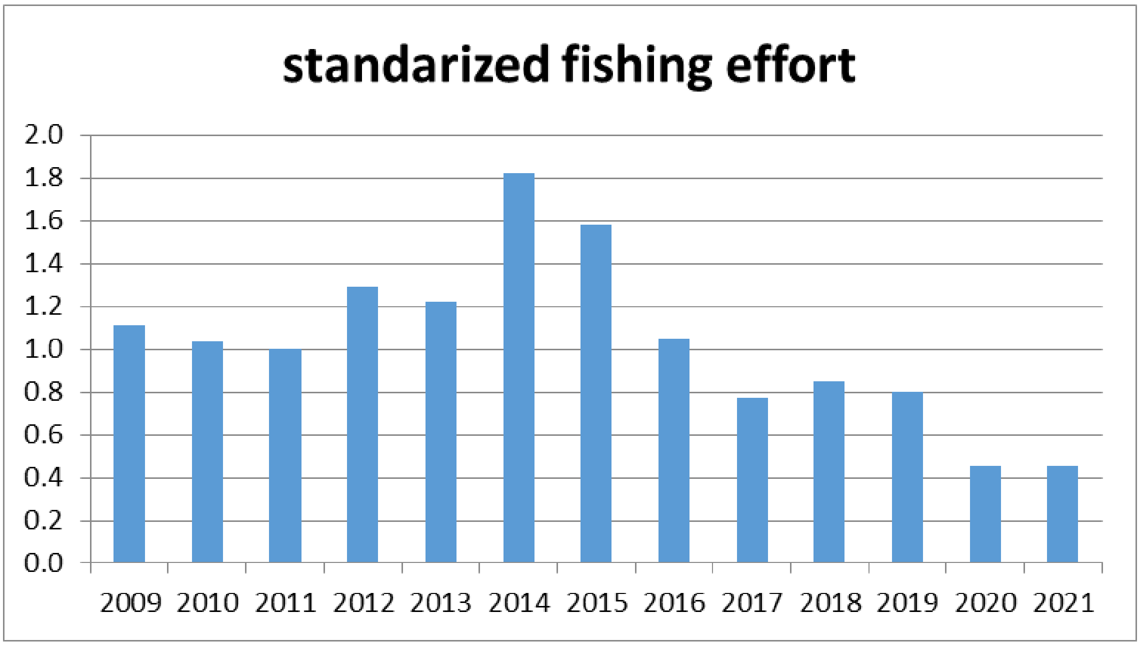


Figure 3.3.6. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Standardized fishing effort (standardized within each country and weighted by the national flounder or demersal fish landings from SD 24–25)

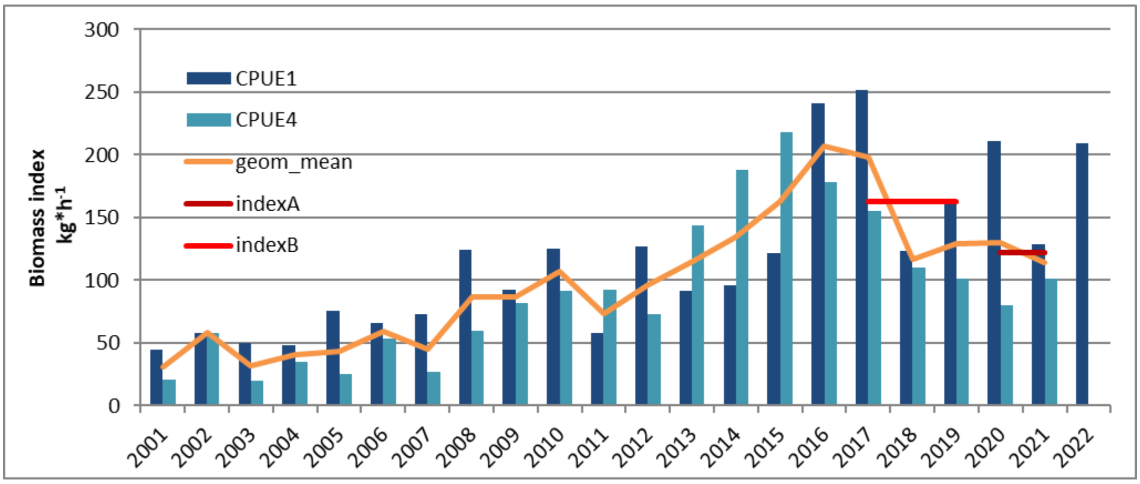


Figure 3.3.7. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Survey-biomass-index (BITS) for Q1 and Q4 from 2001-2021; Q1 2022 and geometric mean (line);

Stock trends from Baltic International Trawl Survey (BITS)

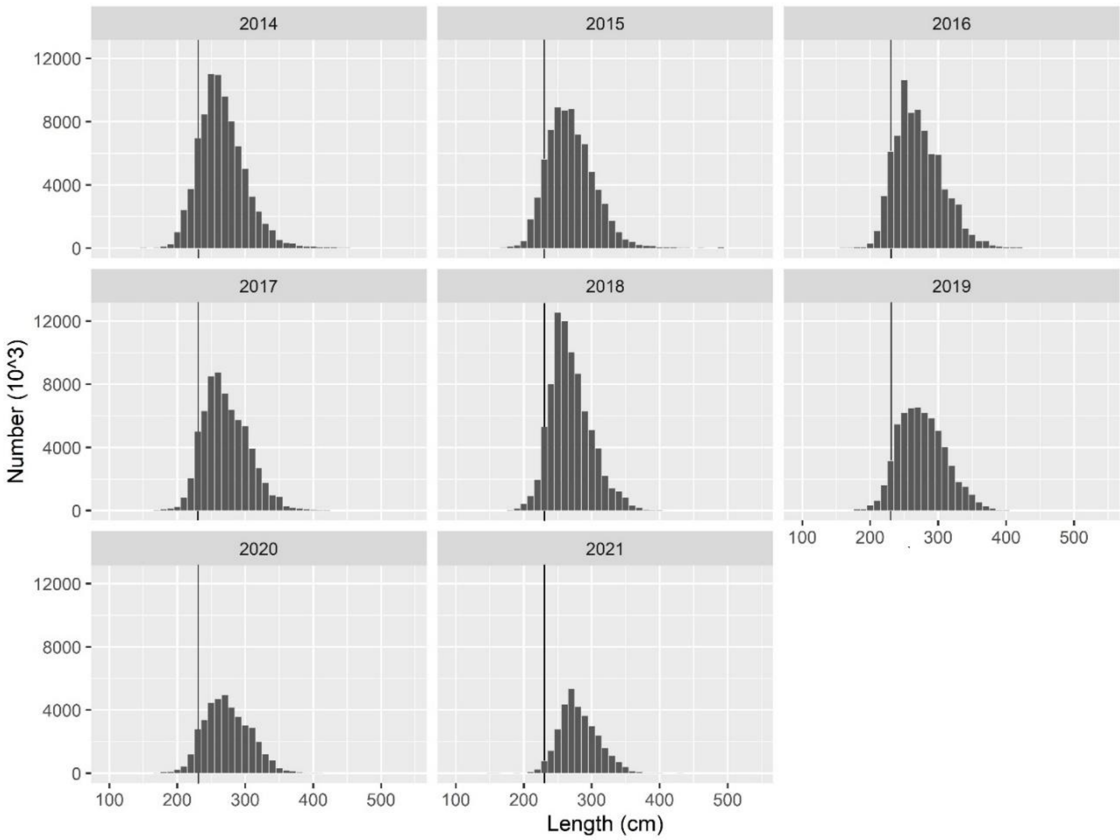


Figure 3.3.8. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Catch in numbers (CANUM) per length classes; black vertical lines at length 23 cm indicates minimum landing size.

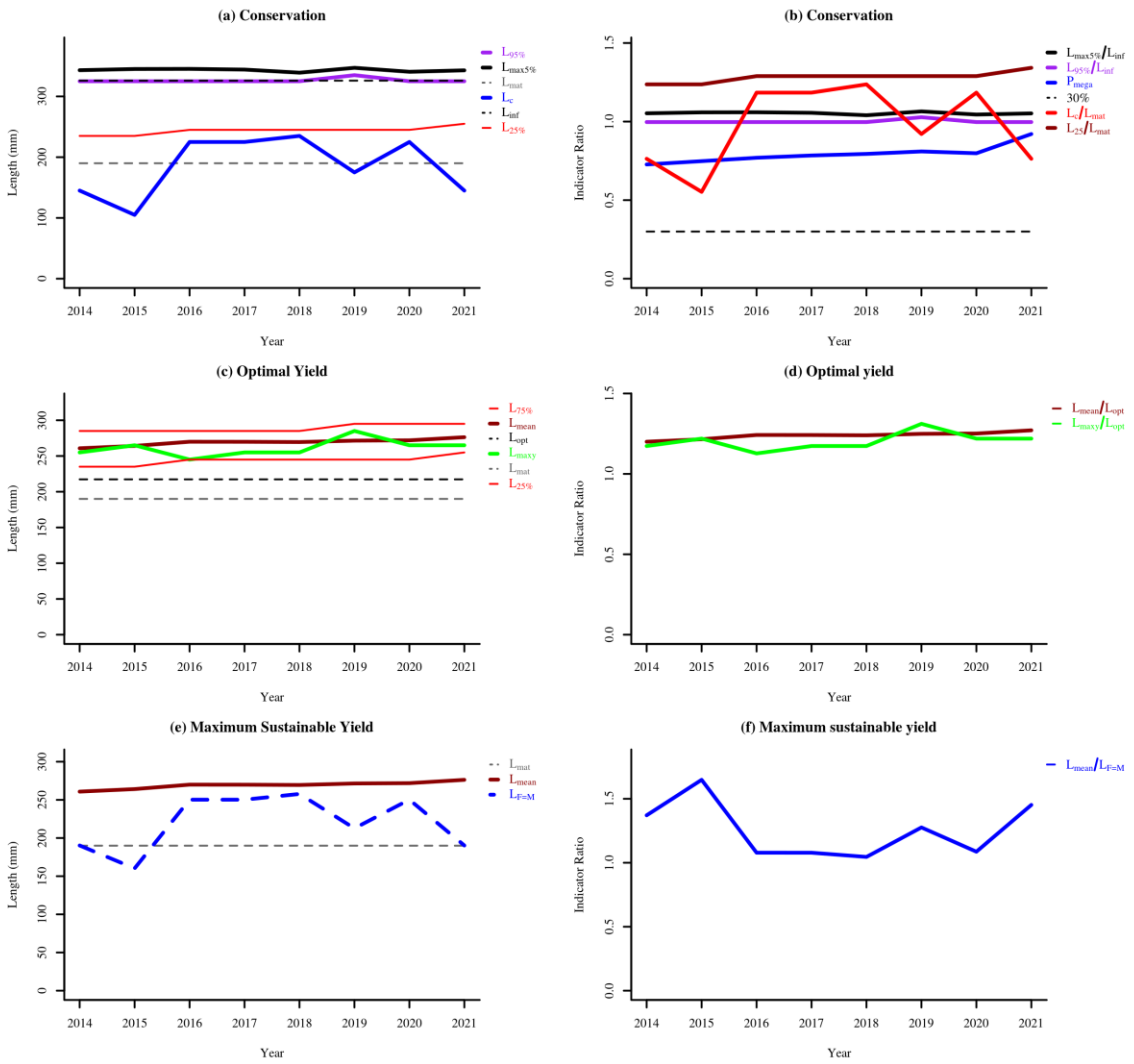


Figure 3.3.9. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); LBI indicators trends.

Table 3.3.1a. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic);

Total landings (tonnes) 1973–2021 by Subdivision and country

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

*** 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) 2014–2021 by subdivision and country.

Zero values indicate discards under 0.5 tonnes.

	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
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

Table 3.3.2. Flounder (*Platichthys* spp.) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic); Discard allocation scheme for 2021; green cells – reported estimated discard, grey cells – allocated discard.

24		2021				
fleet	**quarter**	**Denmark**	**Germany**	**Latvia**	**Poland**	**Sweden**
Active	1				DE_A_1_24	DK_A_1_24
	2	DK_A_1_24			DE_A_2_24	
	3	DK_A_4_24			DE_A_3_24	
	4				DE_A_4_24	DK_A_4_24
Passive	1		DE_P_4_24		DE_P_4_24	DK_P_1_24
	2	DK_P_1_24	DE_P_3_24		DE_P_3_24	DE_P_3_24
	3	DK_P_1_24			DE_P_3_24	DE_P_3_24
	4	DK_P_1_24			DE_P_4_24	DE_P_4_24
25		**2021**				
fleet	**quarter**	**Denmark**	**Germany**	**Latvia**	**Poland**	**Sweden**
Active	1				Lv_A_1_25	DK_A_1_25
	2	DK_A_1_25	DE_A_2_24		Lv_A_2_25	Lv_A_2_25
	3				DE_A_3_24	DE_A_3_24
	4				DE_A_4_24	DE_A_4_24
Passive	1				DK_P_1_25	DK_P_1_25
	2	DK_P_1_25			DE_P_3_24	DE_P_3_24
	3	DK_P_1_25			DE_P_3_24	DE_P_3_24
	4	DK_P_1_25			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 2021 in subdivisions 24 and 25.

Area: 27.3.d.24

Country	Catch category	Catch [t]	No. of length samples in numbers	No. Measured in numbers
Denmark	Landings	332	2	238
Germany		347	9	2329
Poland		1195	9	980
Sweden		4	0	0
Denmark	Discards	40	5	345
Germany		24	6	497
	Total	1943	31	4389

Area: 27.3.d.25

Country	Catch category	Catch [t]	No. of length samples in numbers	No. Measured in numbers
Denmark	Landings	121	2	205
Germany		147	1	145
Latvia		67	0	0
Poland		5598	9	949
Sweden		99	0	0
Denmark	Discards	0	0	0
Germany		19	1	108
	Total	6050	13	1407

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
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	46	40	76	62
average	49	45	96	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	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	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 > 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} / $L_{F=M}$
2019	0.92	1.29	1.06	0.81	1.25	1.28
2020	1.18	1.29	1.04	0.80	1.25	1.09
2021	0.76	1.34	1.05	0.92	1.27	1.45

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 2021 and were 1911 tonnes, lowest in this century. Decrease of landings was observed since 2014 (figures 3.4.1. and 3.4.2.) and only in Russia significant increase of landings were observed on 2021. The highest landings in 2021 were recorded in Russia (1245 tonnes), Latvia (369 tonnes), and Poland (236 tonnes). The major part of the landings was realised with active fishing gears (1592 tonnes or 83%).

Major part of the landings was taken in Subdivision 26 (80%) and in trawl fishery (82%). Russia has the highest landings in Subdivision 26 – 82% or 1245 tonnes, while Poland landings in 2021 was well below long term average – 236 tonnes.

The total landings in Subdivision 28 amounted to about 391, what was lower just below 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 realised by Latvian fishermen (348 tons).

Flounder fishery in 2021 were heavily affected due to cod fishing restriction and in some countries due to COVID 19 pandemic.

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 2021. In Russia and Estonia discarding of flounder is forbidden, while in other countries (e.g. Latvia, Poland) due to COVID 19 restrictions it was not possible to collect biological samples on board, and all samples were collected on harbour. It should be mentioned that according to national legislation it is forbidden to discard any flounder in Russia and Estonia.

If discard rates from 2020 would be applied to 2021 flounder landings, then discard estimated would be 4% or 79 tonnes. Expert group decided not to included discard estimates in the advice and therefore landing only were included for 2021 (Figure 3.4.3)

3.4.1.4 Effort and CPUE data

Time-series from 2009–2021 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 significantly decreased last year (Figure 3.4.5). Only effort data from Russia was in the range of fluctuation of previous 10 years. 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. COVID 19 pandemic influenced fishing activity differently in each country.

The highest landings per unit effort in 2021 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 13 394 flounder were measured from the landings ((67 samples) Table 3.4.3). Totally 93% of landings were covered with length information. No length samples from discard were available for the expert group. Length measurements Russia has the most length data (53 samples, 10 705 flounder), following Latvia (6 samples, 1470 flounder), Poland (10 samples, 906 flounder) and Lithuania (4 samples, 313 flounder).

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 2014–2021 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 analyse, 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 bzq.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	1209,74	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	1047,1	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		
	SD 26	SD 28	Total
Denmark	0		
Finland	1	0	1
Germany	1		1
Poland	236		236
Sweden	3	8	11
Estonia		26	40
Latvia	20	348	369
Lithuania	14	8	22
Russia	1245		1 245
Total	1520	391	1911

Table 3.4.2. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Discards were not estimated for 2021.

Country	Landings	Discards	Catch	Discard ratio
Estonia	26.1	NA	NA	NA
Germany	1.5	NA	NA	NA
Latvia	368.6	NA	NA	NA
Lithuania	22.1	NA	NA	NA
Poland	235.7	NA	NA	NA
Sweden	11.5	NA	NA	NA
Russia	1245.2	NA	NA	NA
Finland	0.6	NA	NA	NA
Total	1911.2	NA	NA	NA

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.

Country	Length measurements	Number of samples
Latvia	1470	6
Lithuania	313	4
Poland	906	10
Russia	10705	53
Total	13394	73

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

Year	1st quarter	4th quarter	Combined index
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
2019	203.9	119	156.0
2020	120.4	69	91.3
2021	205.6	72	122.0
2022	55.5		

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
	L_c / L_{mat}	L25% / L_{mat}	$L_{max\ 5}$ / L_{inf}	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
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

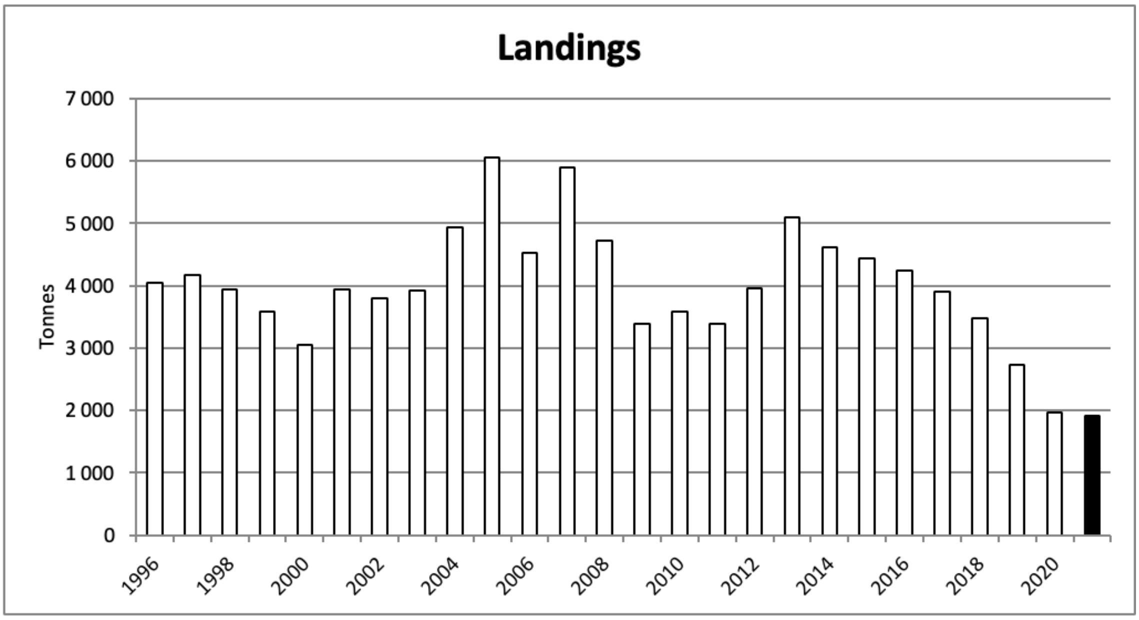


Figure 3.4.1. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder in subdivisions 26 and 28.

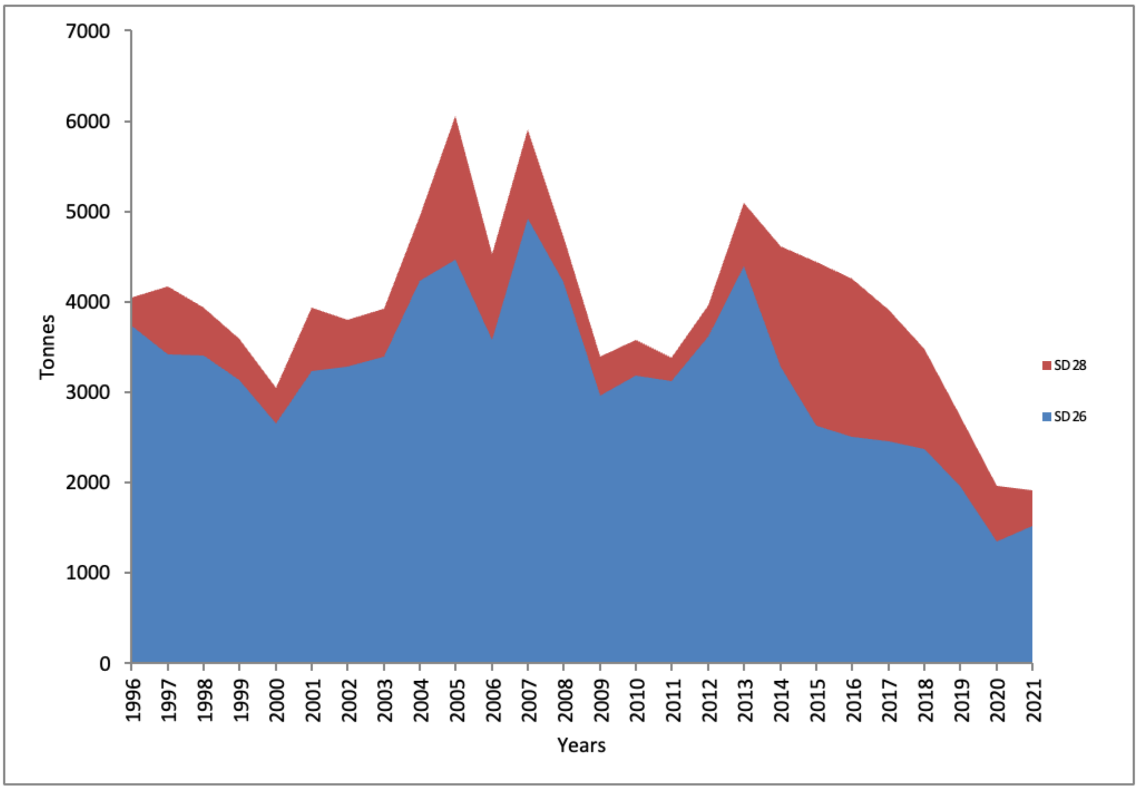


Figure 3.4.2. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder by subdivisions.

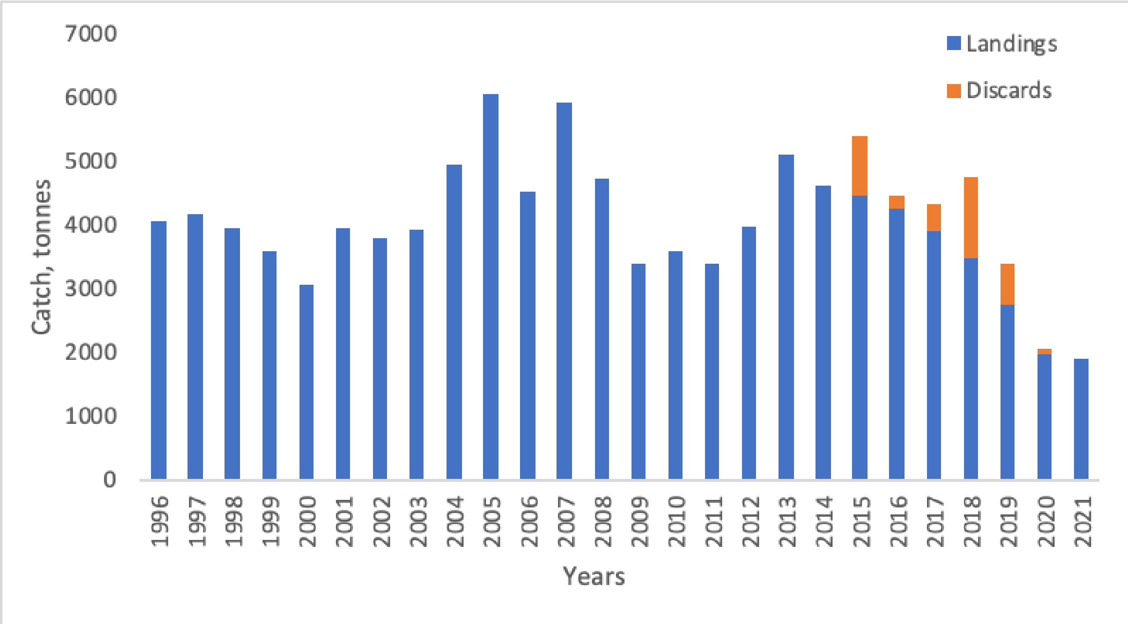


Figure 3.4.3. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES catch of flounder in subdivisions 26 and 28. Discards in 2021 were not estimated.

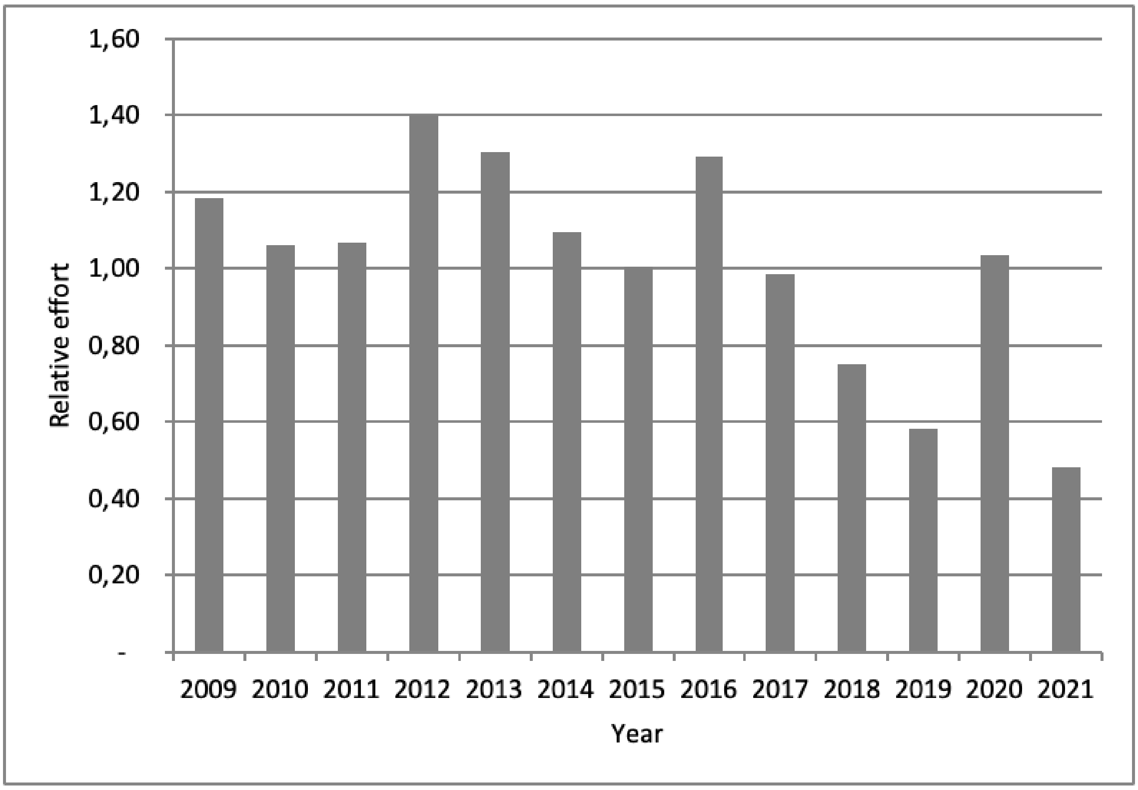


Figure 3.4.4. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Effort data (days-at-sea) of flounder in subdivisions 26 and 28 (days-at-sea).

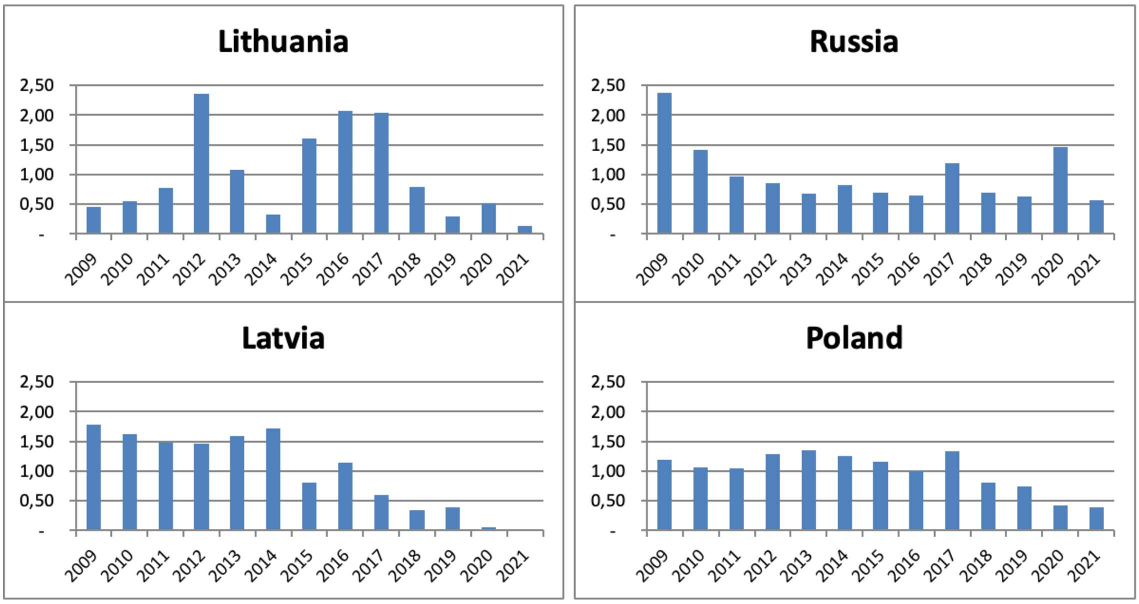


Figure 3.4.5. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Effort data of flounder in subdivisions 26 and 28 by main fishing countries (days-at-sea).

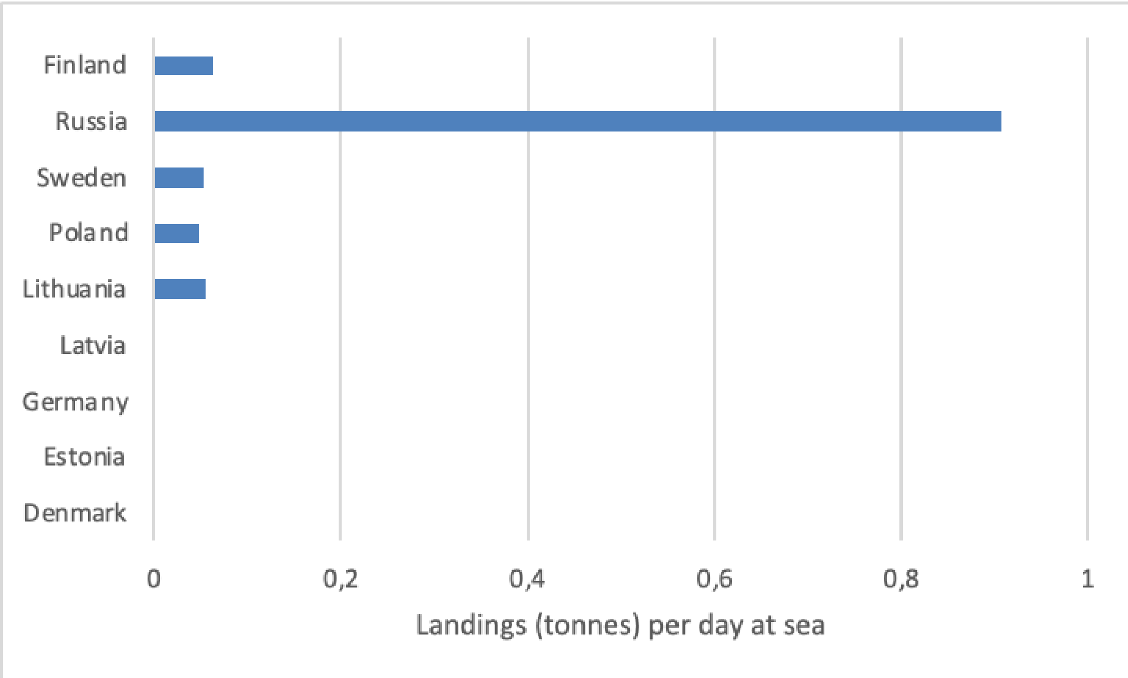


Figure 3.4.6. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Landings of flounder in tones per days-at-sea by country in subdivisions 26 and 28.

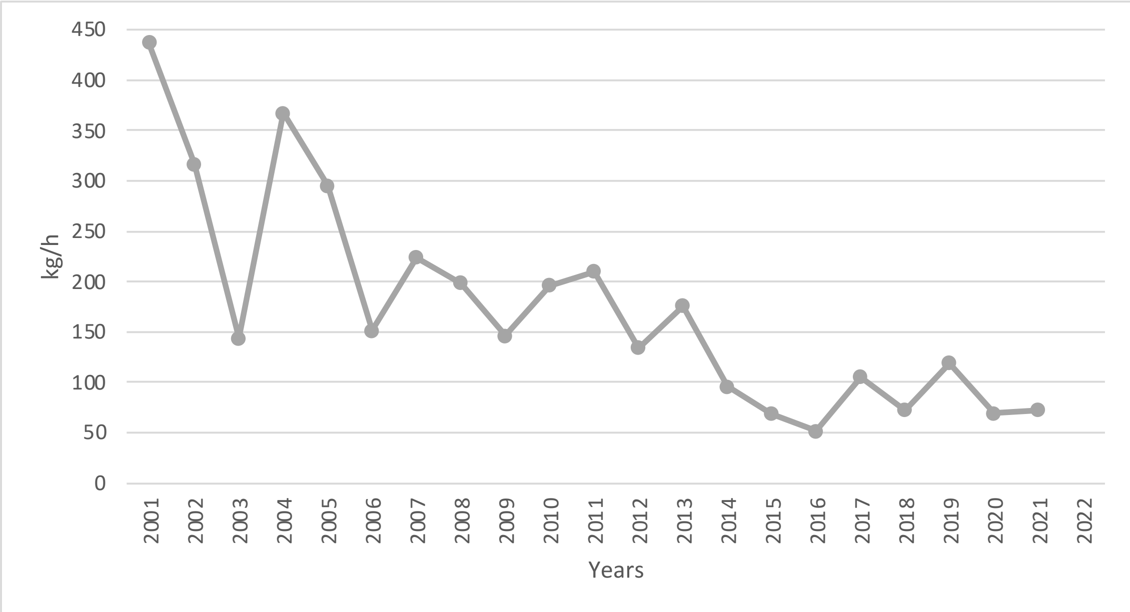


Figure 3.4.7. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch per unit of effort (kg per hour) from BITS Survey in 4th Quarter. subdivisions 26 and 28.

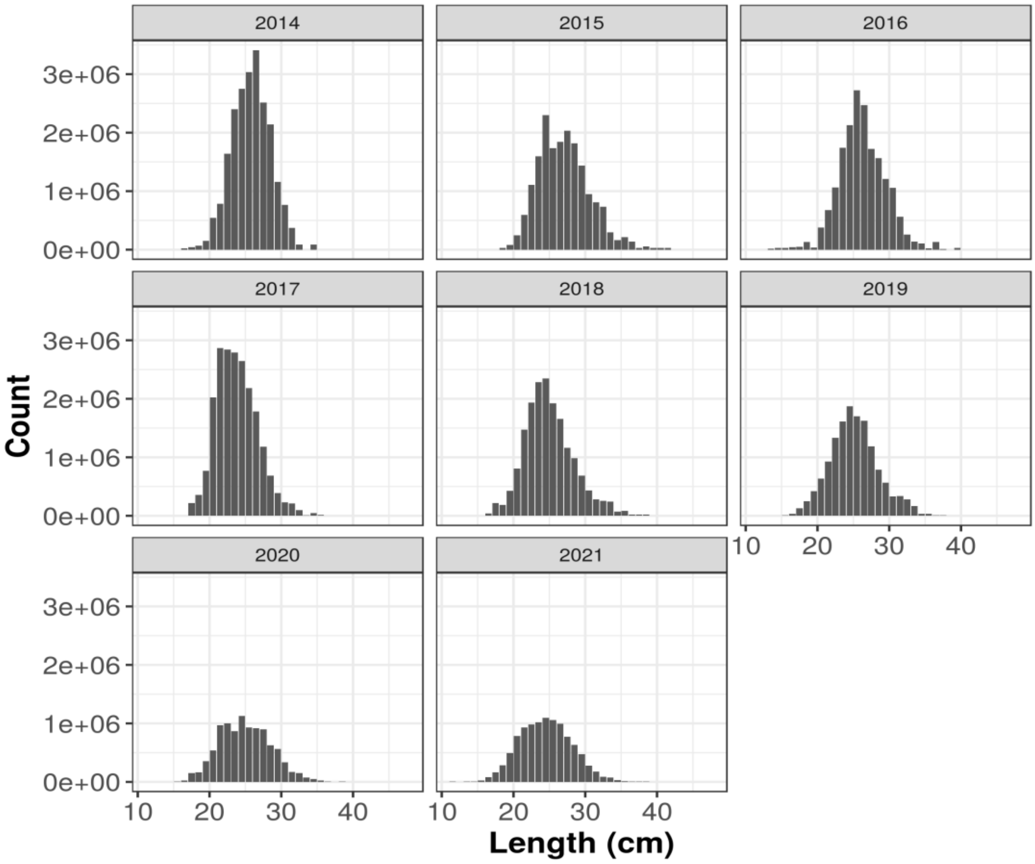


Figure 3.4.8. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch in numbers (CANUM) per length classes.

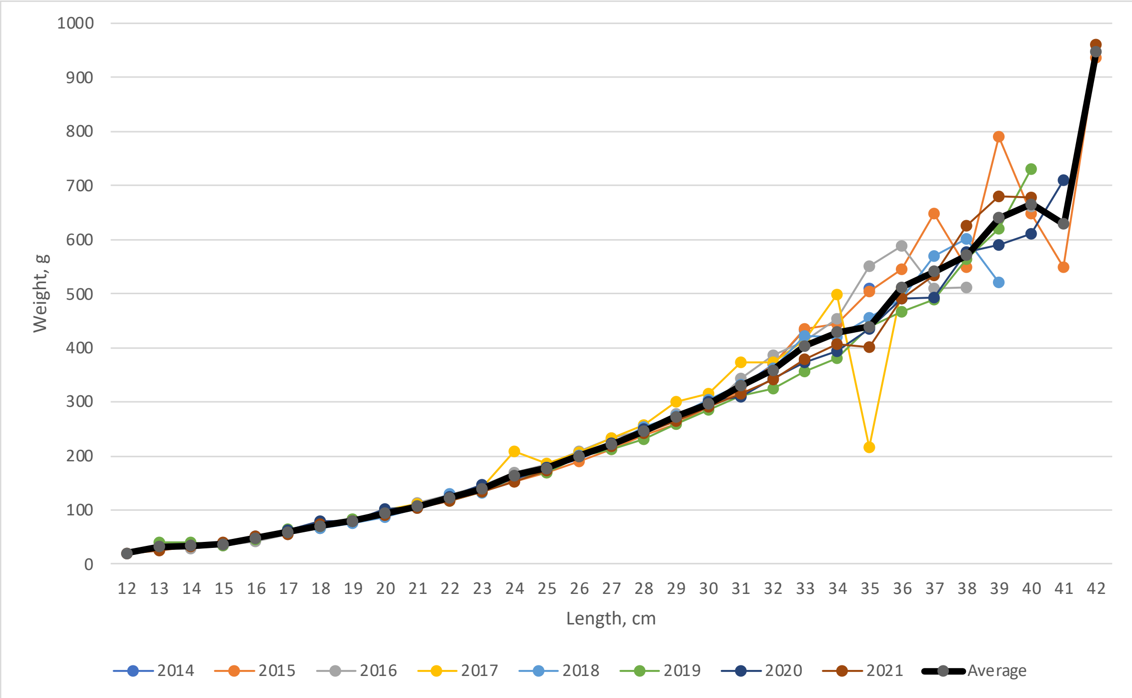


Figure 3.4.9. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Average weight (WECA) per length classes.

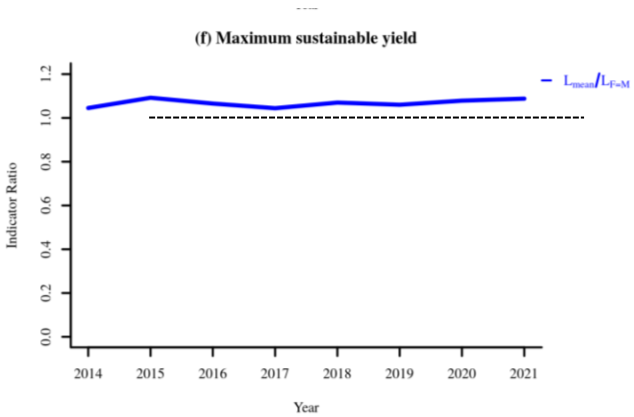


Figure 3.4.10. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Index ratio $L_{mean}/L_{F=M}$ from the length-based indicator method (LBI; ICES. 2015) used for the evaluation of the exploitation status. The exploitation status is below the F_{MSY} proxy when the index ratio value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

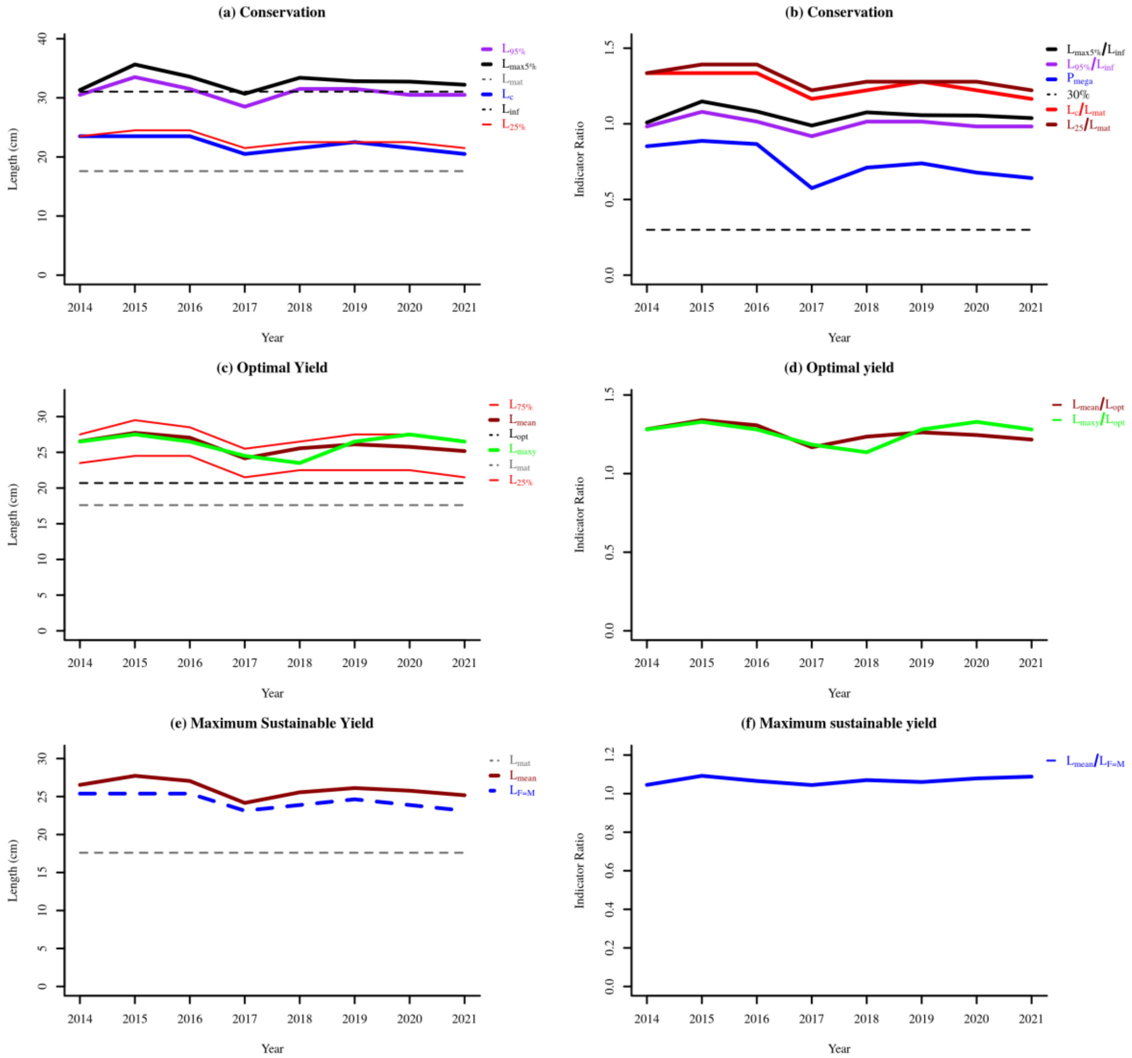


Figure 3.4.11. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Length based indicator trends.

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

Based on the decision by Benchmark Workshop on Baltic Flatfish Stocks (WKBALFLAT; 26-28 November 2013; 27-31 January 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, while stronger and weaker year classes respectively were related to variability in salinity in the range 6.6–7.1 psu with stronger year classes at >6.8 psu (Nissling &Walin, 2020).

This means that, flounder in subdivisions 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 1980's but have been decreasing form end of 1980's, reaching level below 150 tonnes since 2017. 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).

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. For 2020 and 2021 no discard estimates from SD25 are available, instead average of three latest years is used. 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). 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, same seems to be true for Finland. In Estonia the reported recreational catch with gillnets is on average equivalent to 20-40% of the commercial landings. Using the estimates from WKBALFLAT (2014) total recreational catches in this area are up to 30% of the commercial landings, however the quality of the estimates is not well known, and the data is therefore not included in the advice.

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 new method (i.e. sectioning and staining or breaking and burning of otoliths technique) 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. 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. From 2019 ICES has been requested to provide information 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 in 2017 it was decided that most appropriate approach for providing MSY proxy reference points is using the length-based indicators.

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 and having the five years of data can be used to re-calculate the length-based indicators. 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. However, comparing the L_{∞} with the commercial gillnet and Küdema survey length frequency distribution it is noticeable that there is significant amount of larger fish present then the specified L_{∞} (27.45 cm) (figures 3.5.2; 3.5.5). This itself can't be considered unusual as the 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. In ICES Technical Guidelines (ICES, 2018) it is suggested that L_{∞} should generally be greater than L_{max}. If L_{∞} is being underestimated, the resulting LBIs may give the impression that a stock is in a better state than it actually is. Therefore, it was deemed appropriate to recalculate L_{∞}. Age readings are available from Küdema survey up to 2012. Von Bertalanffy growth curve was constructed using the age-length data from Küdema survey years 2000-2011 and only female fish were used. The new estimated von Bertalanffy growth parameters are in Table 3.5.5 and the fit is shown in Figure 3.5.6.

LBIs were calculated using the commercial gillnet length frequency data. Biological parameters used in the analysis 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=1.

L_{opt} is calculated:

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

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).

The revision of biological parameters and length-frequency data that is used as input for the LBI analysis will be reviewed externally after the WG.

Table 3.5.1. Baltic flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Total landings (tonnes) by Subdivision and country.

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
1980	Finland*		27	14	1	11	53
	Sweden	20	32				52
	USSR		334			1 080	1 414
	Total	20	393	14	1	1 091	1 519
1981	Finland*		67	4		7	78
	Sweden	21	34				55
	USSR		445			1 078	1 523
	Total	21	546	4	0	1 085	1 656
1982	Finland*		38	6		6	50
	Sweden	65	3				68
	USSR		615			1 121	1 736
	Total	65	656	6	0	1 127	1 854
1983	Finland*		28	7		3	38
	Sweden	212	9				221
	USSR		497			1 114	1 611
	Total	212	534	7	0	1 117	1 870
1984	Finland*		27	10		6	43
	Sweden	53	2				55
	USSR		286			1 226	1 512
	Total	53	315	10	0	1 232	1 610
1985	Finland*		21	9		7	37
	Sweden	47	2				49
	USSR		265			806	1 071
	Total	47	288	9	0	813	1 157
1986	Finland*		36	11		5	52
	Sweden	60	3				63
	USSR		281			556	837
	Total	60	320	11	0	561	952

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
1987	Denmark	1					1
	Finland*		37	18		3	58
	Sweden	51	2				53
	USSR		279			397	676
	Total	52	318	18	0	400	788
1988	Finland*		43	21		5	69
	Sweden	68	3				71
	USSR		257			331	588
	Total	68	303	21	0	336	728
1989	Finland*		39	24		6	69
	Sweden	66	3				69
	USSR		214			214	428
	Total	66	256	24	0	220	566
1990	Finland*		35	19		4	58
	USSR		144			141	285
	Total	0	179	19	0	145	343
1991	Finland*		53	17		5	75
	Sweden	88					88
	Estonia		135			51	186
	Total	88	188	17	0	56	349
1992	Finland*		48	10		5	63
	Sweden	86	3				89
	Estonia		47			46	93
	Total	86	98	10	0	51	245
1993	Finland*		52	26		5	83
	Sweden	83					83
	Estonia		86			55	141
	Total	83	138	26	0	60	307
1994	Denmark	9					9

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Finland*		47	24		8	79
	Sweden	33	10				43
	Estonia		3			4	7
	Total	42	60	24	0	12	138
1995	Denmark		1				1
	Finland*		54	29		6	89
	Sweden	81					81
	Estonia		52			35	87
	Total	81	107	29	0	41	258
1996	Finland*		47	36		9	92
	Sweden	114					114
	Estonia		99			145	244
	Total	114	146	36	0	154	450
1997	Finland*		35	32		13	80
	Sweden	105					105
	Estonia		96			125	221
	Total	105	131	32	0	138	406
1998	Finland*		36	21		14	71
	Sweden	70					70
	Estonia		79			87	166
	Total	70	115	21	0	101	307
1999	Denmark	0	1				1
	Finland*		43	22	2	9	76
	Sweden	15					15
	Estonia		150			164	314
	Total	15	194	22	2	173	406
2000	Denmark	1					1
	Finland*		34	13	0	9	56
	Sweden	73					73

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Estonia**		166			126	292
	Total	74	200	13	0	135	422
2001	Denmark	10					10
	Finland*		28	14	0	7	50
	Sweden	85			3		88
	Estonia**		135			220	355
	Total	100	164	14	3	227	503
2002	Finland*		16	8		11	35
	Sweden	90		5			95
	Estonia**		166			226	392
	Total	90	182	13	0	247	523
2003	Denmark	1					1
	Finland*	0	16	9	0	7	31
	Sweden	57					57
	Estonia****		156			128	284
	Total	57	172	9	0	135	374
2004	Finland*		13	18	0	4	34
	Sweden	45					45
	Estonia**		127			167	294
	Total	45	140	18	0	171	373
2005	Finland*		11	10	0	3	23
	Sweden	47	2	0			49
	Estonia		144			114	258
	Total	47	157	10	0	117	330
2006	Finland*		11	4.166	0	2	17
	Sweden	33					33
	Estonia		165			129	294
	Total	33	176	4	0	131	344
2007	Finland*		6	1	0	2	9

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Sweden	39	0	0	0		39
	Estonia**		110			104	214
	Total	39	116	1	0	107	263
2008	Finland		5	1	0	5	11
	Sweden	49	0	0			49
	Estonia**		103			86	189
	Total	49	108	1	0	89	249
2009	Finland		6	1	0	3	10
	Sweden	41	0	0			41
	Estonia**		109			102	210
	Total	41	115	1	0	105	262
2010	Finland	0	6	1	0	3	10
	Sweden	36	0	0			36
	Estonia**		85			96	180
	Total	36	91	1	0	99	227
2011	Finland	0	5	1	0	2	9
	Sweden	34	0	0	1		35
	Estonia**	0	94	0	0	83	177
	Total	34	99	1	1	85	221
2012****	Finland		3	0	0	1	5
	Poland***		3				3
	Sweden	36	0		0		36
	Estonia**		79			67	147
	Total	36	85	0	0	69	190
2013	Finland		3	1	0	1	5
	Poland		3				3
	Sweden	31	0				31
	Estonia		123			75	198
	Total	31	129	1	0	77	237

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
2014	Finland		2	0	0	1	4
	Poland		0				
	Sweden	29	0				29
	Estonia		85			65	150
	Total	29	87	0	0	67	183
2015	Finland		3	0	0	1	4
	Poland		0				0
	Sweden	26	0	0			27
	Estonia		81			64	145
	Total	26	85	0	0	64	176
2016	Finland		2	0	0	1	3
	Poland						0
	Sweden	22	0				22
	Estonia		96			52	148
	Total	22	98	0	0	53	173
2017	Finland		3	0	0	1	4
	Poland						0
	Sweden	18	0				18
	Estonia		95			33	128
	Total	18	98	0	0	34	150
2018	Finland		2	0	0	1	3
	Sweden	14	0				14
	Estonia		78			31	109
	Total	14	80	0	0	32	127
2019	Finland		2	0	0	0	3
	Estonia		76			30	106
	Sweden	12	0				12
	Total	12	79	0	0	31	121
2020	Finland		2	0	0	3	4

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Estonia		96			34	130
	Sweden	15	0				15
	Total	15	98	0	0	36	149
2021	Finland		0	0		0	1
	Estonia		90			18	108
	Sweden	15	0		0		15
	Total	15	90	0	0	19	124

*** Finland 1980-2007: Catches of SDs 27&28 are included in SD 29 & catches of SD 31 are included in SD 30**

**** 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 fisheries catch estimates for Estonia and Finland.

	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
2014	1	9	1	0	19.6	16.9
2016	6	5	0	0	16.6	15.0
2017	6	5	0	0	28.0	15.7
2018	6	5	0	0	20.0	15.0
2019	1	4	0	0	13.1	12.9
2020	1	4	0	0	14.8	13.7
2021	1	4	0	0	13.2	11.2

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	Total
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	22570
2020	19	683	2	19412	1641.0	21757
2021	59	729	1	22392	865.0	24046

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

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)
2013	0.128	2.03	0.32	0.95	0.63	1.22
2014	0.090	2.35	0.43	0.98	0.70	1.26
2015	0.070	8.70	0.53	1.32	0.92	4.36
2016	0.111	1.90	0.43	0.76	0.60	1.18
2017	0.164	2.72	0.57	0.50	0.54	1.88
2018	0.151	1.57	0.088	0.08	0.083	1.04
2019	0.071	1.60	0.075	0.147	0.111	1.07
2020	0.032	1.11	0.26	0.30	0.28	0.76
2021	0.046	0.54	0.22	0.149	0.183	0.43

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	2017-2022	
Linf	Küdema survey (2000-2011)	31.88cm	females only
K		$0.22 year^{-1}$	
Lmat	2011 survey in Hiiumaa (Q2)	16.8 cm	females only
Lmat95		20.89 cm	
M/K		1	

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

	Conservation	Optimaizing Yield	MSY		
Year	**Lc/Lmat**	**Lmean/Lopt**	**Lmean/Lf=m**	**Lmean**	**Lf=m**
Ref	**>1**	**~1(>0.9)**	**≥1**	**cm**	**cm**
2017	1.25	0.99	0.96	23.56	24.63
2018	1.25	0.99	0.96	23.56	24.63
2019	1.25	0.98	0.95	23.51	24.63
2020	1.25	1.00	0.97	23.90	24.63
2021	1.31	1.02	0.97	24.47	25.29

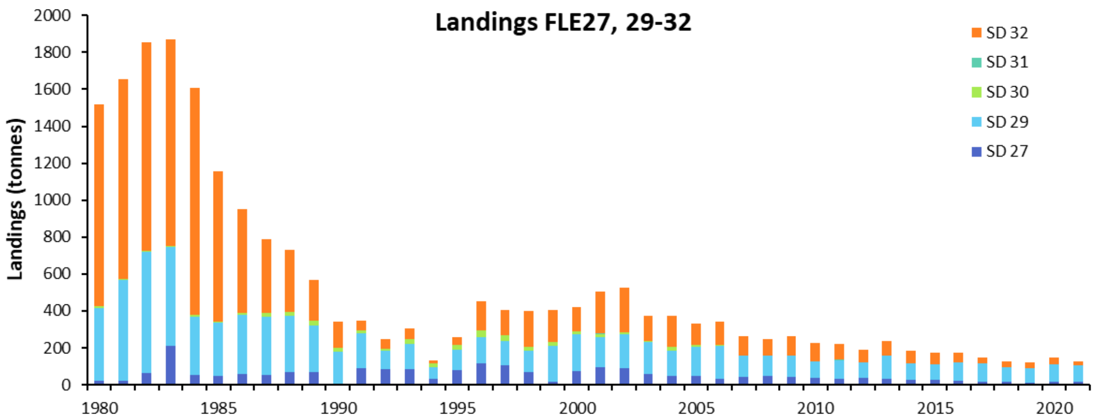


Figure 3.5.1. Baltic flounder SD27, 29-32 (Northern Baltic Sea). Landings (tonnes) in subdivisions (SDs) 27 and 29-32 from 1980-2021.

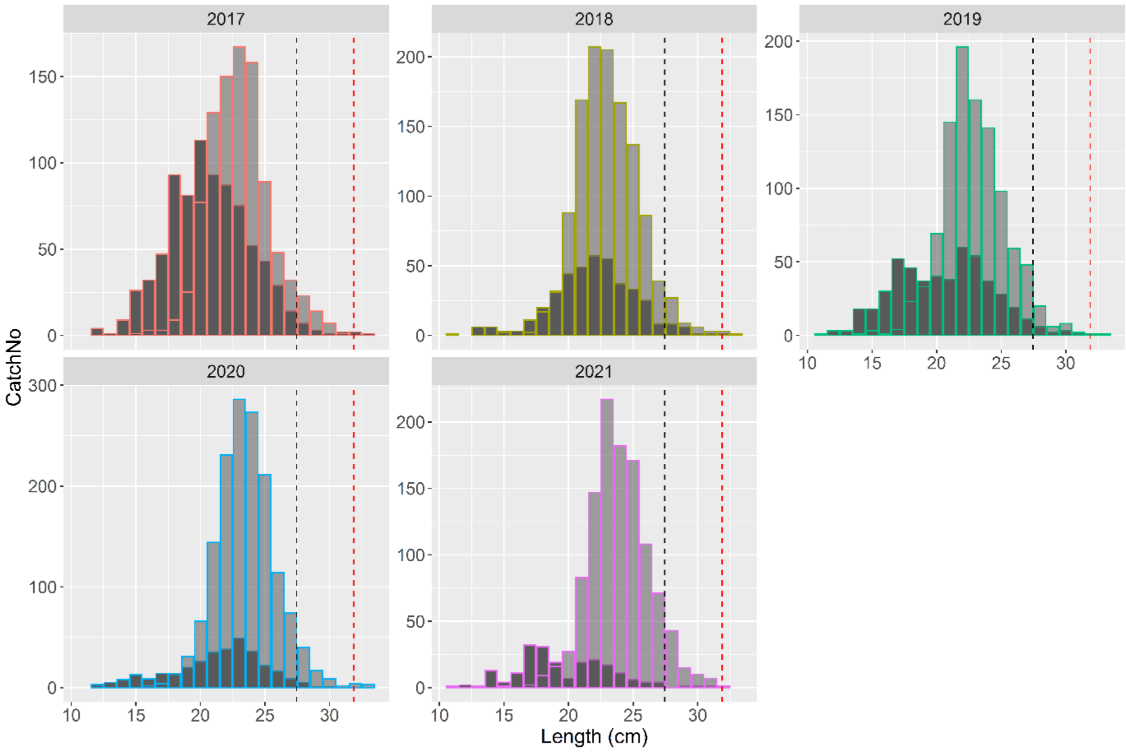


Figure 3.5.2. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Length frequency distribution from commercial gillnets (lighter colour) years 2017-2021 compared to Küdema survey data (darker colour). Note the differences in y-axis scale. Black dashed line indicates L_∞=27.45 cm, and red dashed line indicates L_∞=31.88 cm.

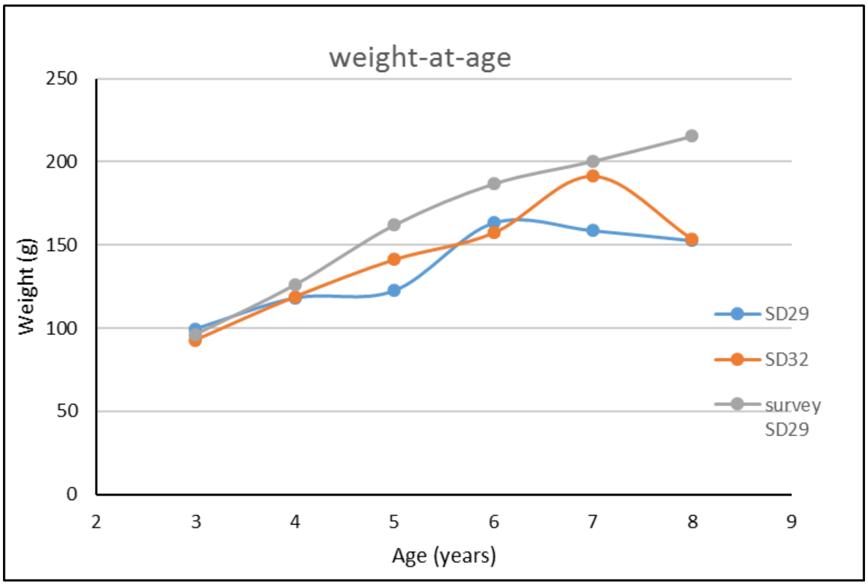


Figure 3.5.3. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Mean weights per age for Estonian commercial trap net landings (2011-2016) per Subdivision (Q3+4) and for survey in SD29 (2000-2012).

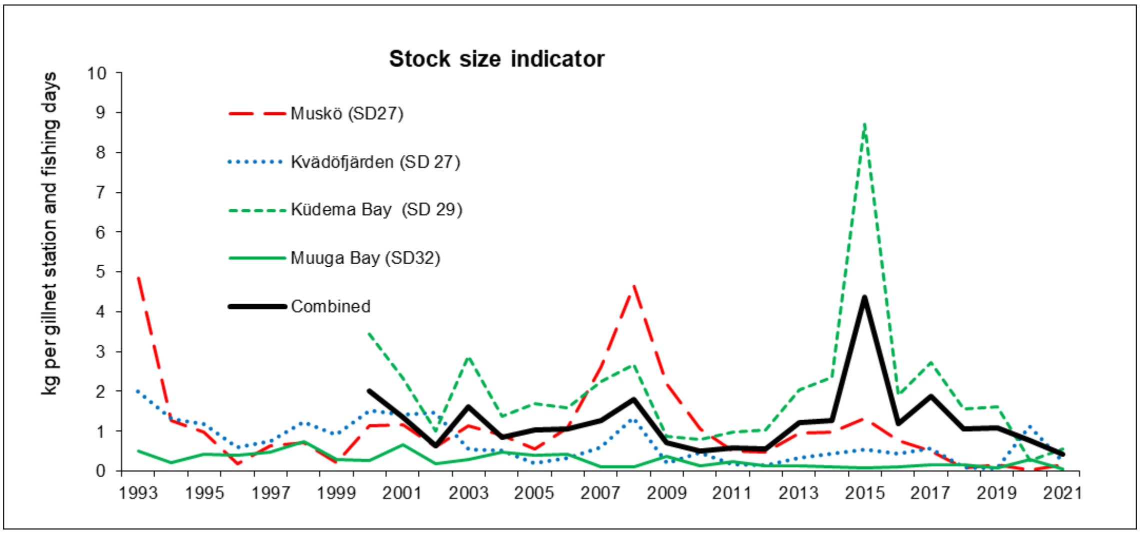


Figure 3.5.4. Baltic flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Biomass indices of Muuga Bay (SD 32) (solid green line), Küdema Bay (SD 29) (dashed green line), Muskö (SD 27) (red dash line), Kvädöfjärden (SD 27) (dotted blue line) surveys and combined index (kg per gillnet station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

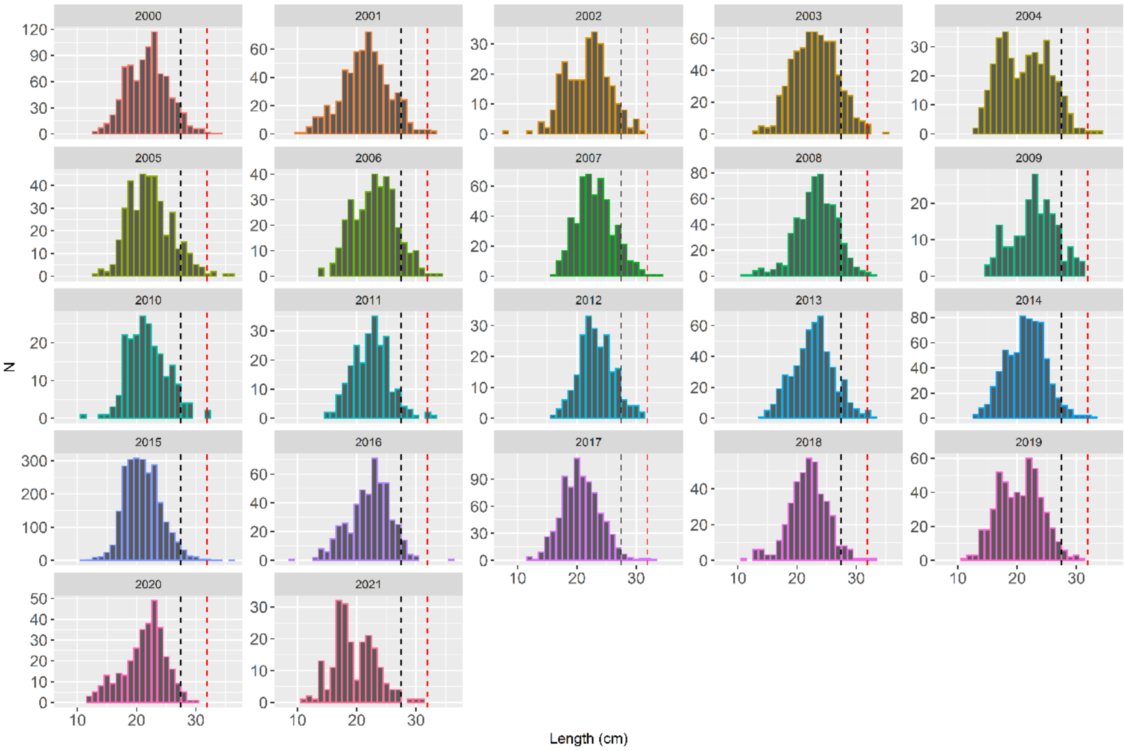


Figure 3.5.5. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Length frequency distribution from Küdema survey (SD29), years 2000-2021. Note the differences in y-axis scale. Black dashed line indicates L_{∞}=27.45 cm, and red dashed line indicates L_{∞}=31.88 cm.

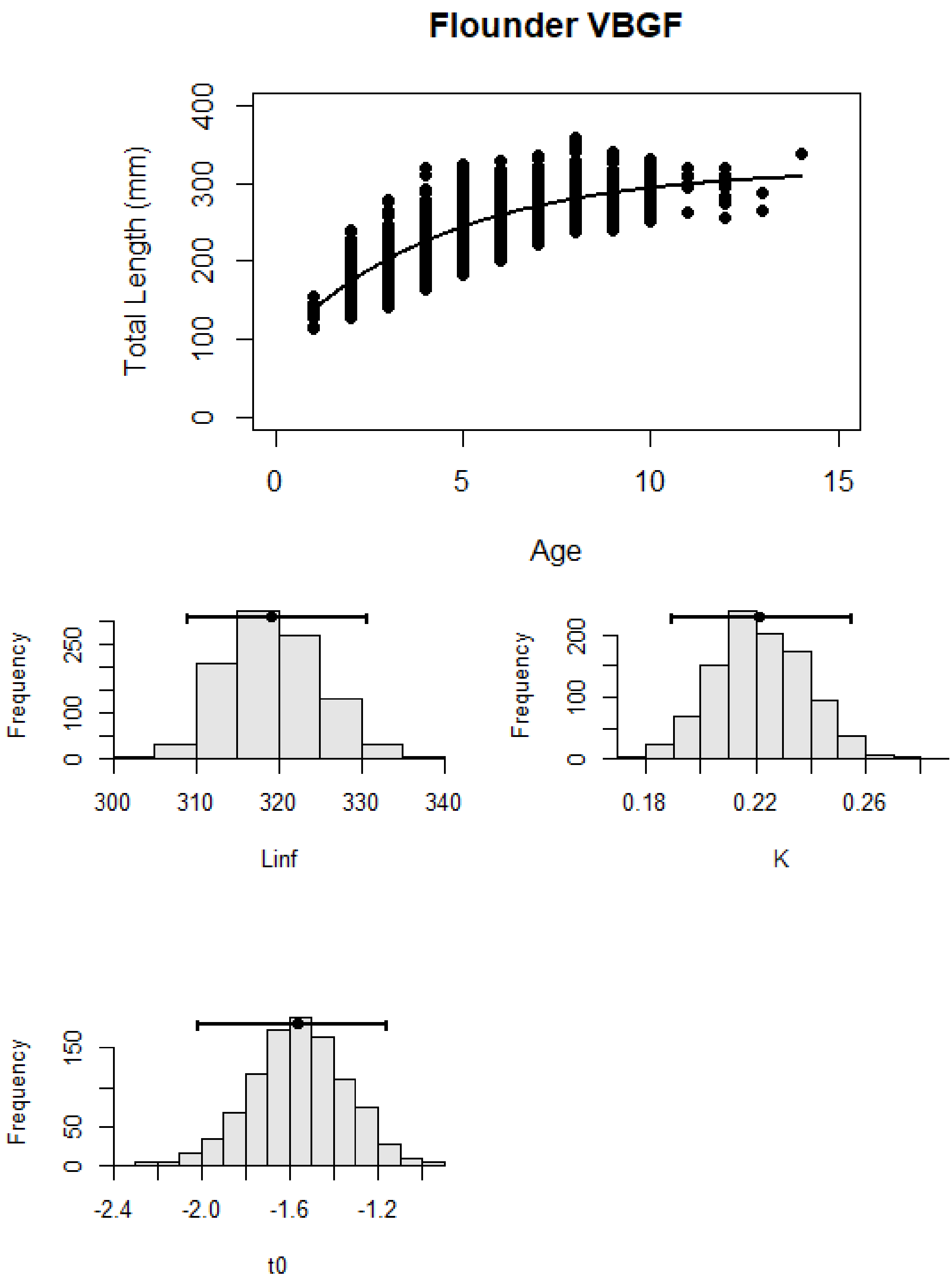


Figure 3.5.6. Baltic flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Von Bertalanffy growth curve fit (upper) and corresponding parameter estimate distributions (lower).

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 by subdivision of reported landings of herring and sprat in 2021 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 2021 together with the proportion of herring in the acoustic survey in the fourth quarter. It is tacitly assumed that the acoustic survey would yield a reasonably good picture of the spatial distribution of the pelagic stocks. Consequently, some resemblance to the distribution of landings of the two species could be expected.

Table 4.1.3 shows the total reported landings of herring by quarter for 2021, along with the number of samples, the number of fish measured and the number of fish 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. It is recommended that this issue is explored further.

4.1.2 Fisheries Management

4.1.2.1 Management units

Sprat is managed in the Baltic Sea by two quotas: one EC and one Russian quota.

Herring has in former time been managed by three TAC's:

- SD 22–29S and 32 (excl. Gulf of Riga),
- Gulf of Riga (SD 28.1),
- SD 29N, 30, 31.

The units were changed in 2005 to be:

- SD 22–24,
- SD 25–27, 28.2, 29 and 32 (EC and Russian quotas),
- Gulf of Riga (SD 28.1),
- SD 30, 31.

The historical development of agreed TACs and reported landings for these management units are illustrated in Figure 4.1.1.

Management 2021 and 2022 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 2021 in relation to SSB_{2020} MSY & PA & MP	Stock status ACOM 2021 in relation to F_{2019} MSY & PA & MP	ICES Advice for 2022 (Basis) (t)	TAC 2022 (t)
SPRAT				
SD 22-32	Above trigger & Full reproductivity& Above	Above & Harvested sustainably & Within range	214000– 373210 (MAP applied)	*305500
HERRING				
SD 25–29&32 (excl. GOR)	Below trigger & Increased risk & Below	Above & Increased risk & Above the range	52443–87581 (MAP applied)	*82015
SD 28.1 (Gulf of Riga)	Above trigger & Full reproductivity & Above	Below & Harvested sustainably& Within the ranges	34797-52132 (MAP applied)	47697
SD 30–31 (Bothnian Sea)	Above trigger & Full reproductivity& Above	Below & Harvested sustainably& Within the ranges	86 729 – 111 714 (MAP applied)	111345

***EC + Russian quotas**

4.1.3 Catch options by management unit for herring

The herring assessed in SD 25–29 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%

Year	WBSSH** caught in SD 22–24 (1000 tonnes)*	Total catches of the WBSSH stock (1000 tonnes)*	% of WBSSH caught in SD 22–24
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%
Mean	30.0	58.6	48.5%

***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%
Mean	3.8	143.2	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%
Mean	0.5	32.3	1.5%

***corrected at WGBFAS 2020**

The two tables above are used for the calculation of the fishing quotas in 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 2021 by subdivision and quarter.

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
SD 25	**Landings ('000 t)**	47.29	18.02	5.67	12.50	**83.49**
	Herring (%)	15.47	24.35	71.36	62.11	**28.17**
	Sprat (%)	84.53	75.65	28.64	37.89	**71.83**
SD 26	**Landings ('000 t)**	97.36	26.44	4.90	24.47	**153.17**
	Herring (%)	12.79	27.76	57.65	37.05	**20.68**
	Sprat (%)	87.21	72.24	42.35	62.95	**79.32**
SD 27	**Landings ('000 t)**	14.13	4.83	0.00	0.31	**19.27**
	Herring (%)	60.01	42.30	100.00	86.60	**56.00**
	Sprat (%)	39.99	57.70	0.00	13.40	**44.00**
SD 28*	**Landings ('000 t)**	42.42	22.19	7.17	31.76	**103.54**
	Herring (%)	45.85	72.19	49.27	45.62	**51.66**
	Sprat (%)	54.15	27.81	50.73	54.38	**48.34**
SD 29	**Landings ('000 t)**	24.55	4.06	0.64	13.38	**42.63**
	Herring (%)	49.52	99.90	47.10	48.33	**53.90**
	Sprat (%)	50.48	0.10	52.90	51.67	**46.10**
SD 30	**Landings ('000 t)**	31.02	20.43	4.98	15.90	**72.33**
	Herring (%)	98.61	98.47	98.69	94.65	**97.71**
	Sprat (%)	1.39	1.53	1.31	5.35	**2.29**
SD 31	**Landings ('000 t)**	0.00	0.57	0.47	0.09	**1.13**
	Herring (%)	#DIV/0!	100.00	100.00	100.00	**100.00**
	Sprat (%)	#DIV/0!	0.00	0.00	0.00	**0.00**
SD 32	**Landings ('000 t)**	14.68	6.99	5.15	18.26	**45.08**
	Herring (%)	56.52	88.47	34.49	38.82	**51.79**
	Sprat (%)	43.48	11.53	65.51	61.18	**48.21**
Total	**Landings ('000 t)**	**271.45**	**103.52**	**28.98**	**116.68**	**520.63**
	Herring (%)	**36.38**	**58.64**	**61.64**	**51.67**	**45.64**
	Sprat (%)	**63.62**	**41.36**	**38.36**	**48.33**	**54.36**

*** Gulf of Riga included**

Table 4.1.2.Proportion of herring in landings 2021.

COUNTRY	QUARTER	SUBDIVISION							
		25	26	27	28*	29	30	31	32
DEN	1	0.23	0.05	0.50	0.12	0.50			
	2	0.03		0.24					
	3								
	4	0.42	0.07		0.10				
EST*	1				0.01	0.26			0.41
	2				0.05	1.00			0.75
	3				0.00	1.00			0.32
	4				0.00	0.21			0.20
FIN	1		0.01	0.94	0.09	0.69	0.98		0.58
	2		0.28	0.90	0.03	1.00	0.99	1.00	0.98
	3				0.51	0.47	0.98	1.00	0.35
	4				0.65	0.60	0.93	1.00	0.47
GER	1	0.04	0.04		0.03	0.06			
	2	0.17	0.03	0.04					
	3								
	4	0.00			0.04	0.04			
LAT*	1		0.06		0.00				
	2		0.14		0.00				
	3		0.44		0.00				
	4		0.22		0.00				
LIT	1		0.23		0.14	0.10			0.68
	2		0.16		0.20				
	3		0.96		0.02				
	4		0.84		0.34				
POL	1	0.14	0.15		0.06				
	2	0.21	0.27		0.26				
	3	0.64	0.42		0.67				
	4	0.62	0.41		0.44				
RUS	1		0.15						0.95
	2		0.32						0.97
	3		0.90						
	4		0.30						0.83
SWE	1	0.20	0.13	0.63	0.37	0.61	1.00		
	2	0.65	0.30	0.49	0.73	1.00	0.98	1.00	
	3	0.89		1.00	0.86	1.00	0.99	1.00	
	4	0.80	0.35	0.87	0.50	0.56	0.99	1.00	
Total	1	0.15	0.13	0.60	0.15	0.50	0.99		0.57
	2	0.24	0.28	0.42	0.13	1.00	0.98	1.00	0.88
	3	0.71	0.58	1.00	0.14	0.47	0.99	1.00	0.34
	4	0.62	0.37	0.87	0.25	0.48	0.95	1.00	0.39
Acoust. Stock**	4	0.60	0.72	0.51	0.36***	0.32	0.92		0.10

* Gulf of Riga included

** SD 32 was covered by the acoustic survey only very partially (only the westermost part)

*** Gulf of Riga excluded

Table 4.1.3. Herring in subdivisions 25–32. Samples of commercial catches by quarter and subdivision for 2021 available to the Working Group.

	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 25	1	7,316	38	1,609	1,264
	2	4,389	12	1,143	592
	3	4,048	15	1,087	771
	4	7,765	21	1,681	963
	Total	23,519	86	5,520	3,590
Subdivision 26	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
	1	12,453	46	8,047	2,301
	2	7,340	27	5,048	1,786
	3	2,823	20	5,934	701
	4	9,065	39	8,984	1,308
	Total	31,680	132	28,013	6,096
Subdivision 27	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
	1	8,477	10	418	418
	2	2,044	4	104	104
	3	1	0	0	0
	4	272	0	0	0
	Total	10,794	14	522	522
Subdivision 28*	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
	1	19,452	26	3,299	2,494
	2	16,016	63	6,330	5,681
	3	3,534	14	2,867	1,542
	4	14,491	31	3,241	2,187
	Total	53,492	134	15,737	11,904
Subdivision 29	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
	1	12,154	19	2,399	697
	2	4,052	13	3,485	490
	3	302	4	799	632
	4	6,468	20	2,057	910
	Total	22,976	56	8,740	2,729
Subdivision 30	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
	1	30,592	37	10,956	702
	2	20,114	33	7,928	706
	3	4,914	8	3,209	308
	4	15,054	20	8,036	272
	Total	70,674	98	30,129	1,988
Subdivision 31	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
	1	0	0	0	0
	2	568	9	3282	374
	3	466	5	1511	80
	4	91	3	677	30
	Total	1,125	17	5,470	484
Subdivision 32	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
	1	8,299	33	4,111	1,912
	2	6,183	48	8,023	1,634
	3	1,776	3	230	227
	4	7,088	40	5,693	1,916
	Total	23,346	124	18,057	5,689
Subdivisions 25-32	**Quarter**	**Landings in tons**	**Number of samples**	**Number of fish meas.**	**Number of fish aged**
	1	**98,742**	**209**	**30,839**	**9,788**
	2	**60,706**	**209**	**35,343**	**11,367**
	3	**17,864**	**69**	**15,637**	**4,261**
	4	**60,294**	**174**	**30,369**	**7,586**
	Total	**237,606**	**661**	**112,188**	**33,002**

* Gulf of Riga included

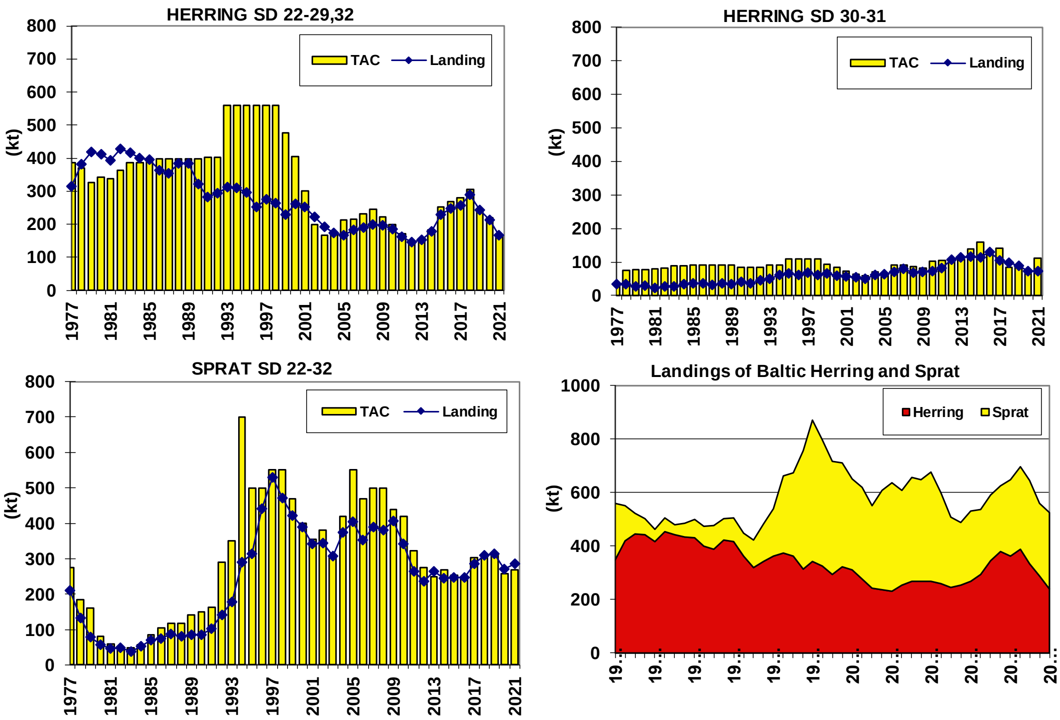


Figure 4.1. Reported landings of herring and sprat and agreed TACs in the Baltic Sea. (since 2007 TACs for herring and sprat: EC quota + Russian TAC).

4.2 Herring in subdivisions 25–27, 28.2, 29 and 32

4.2.1 The Fishery

4.2.1.1 Landings

The total reported catches by country, which also include the fraction of the Central Baltic Herring that is caught in the Gulf of Riga (SD 28.1, see Section 4.1.3), are given in Table 4.2.1. Catches in 2021 amounted to 128 961 t, which is 27 % lower than last year. Catches decreased for all countries: Denmark (-29%), Estonia (-27%), Finland (-38%), Germany (-24%), Latvia (-27%), Lithuania (-22%), Poland (-26%), Russia (-9%) and Sweden (-32%). The largest part of the catches in 2021 was taken by Sweden (24%), followed by Poland (21%) and by Russia (18%).

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 2021 the spatial distribution of catches was as follows: 24.6% in SD 26, 18.2% in SD 25, 18.1% in SD 32, 17.8% in SD 29, 12.9% in SD 28.2 and 8.4% in SD27.

4.2.1.2 Discards

There was only one country, Finland, reporting logbook registered discards of 5.6 t (<0.01% of total catch) in 2021. No discards have been reported before 2016. Discarding at sea is regarded to be negligible.

4.2.1.3 Unallocated removals

A working document was presented in 2013 with a compilation on species measurement error for mixed pelagic species (ICES CM 2012/ACOM:10: WD 5 Walther *et al.*). The conclusion was that it is hard to make an accurate estimate on the proportion of herring and sprat in the catches from industrial trawl fisheries with small meshed trawls. In area 24–26 misreporting of herring exists and is accounted for by Denmark and Poland. Some catches are hard to sample because they are landed in foreign ports.

This was followed up by a questionnaire sent out before the benchmarking WKBALT in 2013 (ICES CM 2013/ACOM:43: WD 5 Krumme, Gröhsler). The result of this questionnaire was that, at the time of the questionnaire, countries that seemingly have problems estimating the proportion of herrings in the catches are dealing with this on a national level with additional sampling and correct the input figures for assessment to assure as high accuracy as possible. The correction by country for this misreporting is however variable from year to year and thus misreporting can in recent years (in the years after the benchmark) be a potential problem and should be investigated further.

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

Most countries provided the age composition of their major catches (caught in their waters by quarter and subdivision). The catches for which age composition was missing represented about 11% of the total catches in 2021. All German catches, which only represent a minor part (0.5%) of the total catches, were landed in foreign ports and therefore no age composition of catches could be provided from Germany.

The compilation of 2021 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 78% in 2020 and 84% in 2021 of the catches in numbers respectively (Figure 4.2.1). The strong year class of 2014 is in 2021 7 years old and still is contributing to the fishery with 7% 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 or overall even slightly better compared 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 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 2021 (Table 4.2.4) and then combined to give the mean weight-at-age for the whole catch. 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 particular strong year class occurs, like 2002, 2007 and 2014, 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. 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 to a real decrease in growth but also where the larger proportion of herring is caught (Figure 4.2.4). As in the years before, the mean weight in the catch was also used as the mean weight in the stock. There is no survey information in the first quarter available, which could be used to calculate the mean weight in the stock (ICES CM 2013/ACOM:43). The mean weights in the catch from the first quarter could also be a candidate to be taken as mean weight in the stock. However, no corresponding data were available when conducting the benchmark in 2013 (ICES CM 2013/ACOM:43).

4.2.2.3 Maturity at age

The constant maturity ogive used by the WG is based on data between 1974–2011, based on the work of the Study Group on Baltic Herring and Sprat Maturity (ICES, 2002).

Source	Age 1	Age 2	Age 3	Age 4	Age 5+
Mean	0.016	0.67	0.90	0.94	0.97
WG ogive	0	0.70	0.90	1.00	1.00

An attempt to update the maturity ogive was done before the benchmark group (see Section 4.2.2.2 and ICES CM 2013/ACOM:43). The new maturity ogive was however not used due to inconsistencies in some parts of the data, a very high maturity at age 1 with a notable year and country effect. The new maturity ogive was also, apart from inconsistencies mentioned, similar to the old ogive and therefore it was decided to keep the old maturity ogive static between 1974-2021 (Table 4.2.8).

4.2.2.4 Natural mortality

As in previous years the natural mortalities used varied between years and ages as an effect of cod predation.

In 2019 new estimates of predation mortality (M_2) covering 1974-2018 were available from updated SMS (ICES 2019/ICES Scientific Reports. 1:91), using analytical estimates of cod stock as external variable. The M for 2019 was assumed equal to the 2018 values. At WGBFAS in 2021 and 2022 the average M_2 for 2020 and 2021 were estimated from regression of average M_2 in 1974-2018 against biomass of cod at length ≥20 cm ($R^2 = 0.93$, Figure 4.2.5), using cod biomass estimates for 2020 and 2021 as predictors. Next, the average value was distributed into ages following distribution of M_2 by ages in recent 10 years. M was obtained by adding 0.1 to M_2. The resulting M values are given in Table 4.2.7. Note that this means that also M_2 for 2020 was updated since last year, as the cod biomass estimate in 2020 changed slightly in the 2021 update of the index. A sensitivity run was made with the updated M_2 for 2020 in the assessment made last year. The difference between the run with the last year's accepted assessment and the assessment with the updated mortality value for 2020 was negligible.

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 2021 is given in Table 4.2.2. The overall frequency was 4.1 samples, 577 fish measured and 221 fish aged per 1000 tonnes landed. In 2021, sampling was most frequent in SD 28.2 followed by SD 32 and SD 26. Compared to 2020 the sampling has decreased in all subdivisions, except SDs 25 and 28.2.

Recent investigations indicated a mixing of Central Baltic herring (CBH) and Western Baltic spring spawning herring (WBSSH) in SDs 24–26 (ICES CM 2012/ACOM:10: WD 6 Gröhsler *et al.*; ICES HAWG 2018, ICES WKPELA 2018). Growth curve analyses of both WBSSH and CBH from survey data showed that a significant difference in growth parameters can be used to allocate an individual herring of unknown stock to either WBSSH or CBH based on a Stock Separation Function (SF) with length-at-age as a measure (Gröhsler *et al.*, 2013). It is recommended to estimate the degree of the mixing of WBSSH and CBH in SD 24–26. For this, it is needed that all countries catching herring in this area apply the SF. To verify and improve the quality of assignment of stock identity and novel methods (e.g. genetic) a first workshop was conducted in 2018 (ICES CM 2018/ACOM:63).

Mixed fisheries are generally not considered a problem in the Baltic Sea. However, the catch data are regarded as uncertain for this fishery, particularly from 1992 and onwards due to the mixing of sprat and herring in the catches. Analysis of a questionnaire answered by all Baltic countries during 2012 revealed that misreporting is mainly an issue of the industrial trawl fishery targeting sprat-herring mix in near shore waters, e.g. archipelago area of Sweden or the Kolobrzeg-Darlowo fishing ground off Poland (further details see Annex H3 of WKBALT 2013/ICES CM 2013/ACOM:43). 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. At the time of the questionnaire, countries that seemingly have problems estimating the proportion of herrings in the catches were dealing with this on a national level with additional sampling and correct the input figures for assessment to assure as high accuracy as possible. The correction by the country for this misreporting is however variable from year to year and there are again indications that misreporting is a problem in some nations (Hentati-Sundberg *et al.*, 2014). The lack of appropriate information to account for this in the reporting of official catch figures can thus be a potential problem for the perception of these stocks. The possibility to find a method to correct this should be investigated further.

4.2.3 Fishery independent information

As in the last year, the stock abundance estimates from the Baltic International Acoustic October Survey (BIAS) were available to tune the XSA (1991–latest year, ages 1–8+). The tuning index covers the area of SD 25–27, 28.2 and 29. All available data covering the southern and northern parts of SD 29 are used within the compilation. As in previous years, the estimates for the years

1993, 1995 and 1997 were excluded due to an incomplete coverage of the standard survey area. The BIAS index for ages 1–8+ is given in Table 4.2.11.

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 4.2.6). Including the 2021 data lead to a small decrease in the internal consistency for ages 1\2, 2\3, 3\4 and 5\6 compared to last year. A small improvement was noted for ages 4\5 and 6\6.

4.2.4 Assessment

4.2.4.1 Recruitment estimates

The data series of 0 group herring from the acoustic surveys in subdivisions 25–27, 28.2 and 29 (including southern and northern data) in 1991–2020 was used in a RCT3 analysis to estimate the year class 2021 at age 1 for 2022. The RCT3 input and result are presented in tables 4.2.17 and 4.2.18. The estimate of the year class 2021 (Age 1 in 2022: 9.597 billion) is below the average recruitment of age 1 of the whole time-series (1974–2021: 15.209 billion).

4.2.4.2 Exploration of SAM

During the benchmark assessment in 2013 (ICES CM 2013/ACOM:43) the state-space assessment model SAM was explored as an alternative method to assess the central Baltic herring stock. This year's final but still preliminary configuration of SAM is given in Table 4.2.16. The assessment run and the software internal code are available at https:/www.stockassessment.org, CHB_WGBFAS_2022. Results of SAM compared to XSA are presented in Figure 4.2.11. In general SAM, produces similar results since the year 2000. For the earlier period, 1974 – 1999, SAM gives lower estimates of SSB and recruitment (age 1), whereas it shows higher fishing mortality ($F_{3\text{–}6}$). The retrospective pattern of SAM is different from the XSA output showing a general tendency to underestimate fishing mortality and overestimate spawning stock biomass (Figure 4.2.12).

4.2.4.3 XSA

An inter-benchmark assessment was carried out in 2020 (ICES 2020/ICES Scientific Reports. 2:34) to incorporate in the assessment the new natural mortality estimates (for the years 1974-2018) obtained from a SMS run conducted in November 2019 (ICES 2019/ICES Scientific Reports. 1:9). Natural mortality estimates have since then been included as described in section 4.2.2.4.

The assessment performed at this year's WGBFAS meeting is an updated XSA assessment.

The XSA settings were established in the benchmark assessment performed in 2013 and were decided to be i.e. catchability dependent on stock size at age <2 and independent of age ≥6, but with the application of a weak shrinkage (S.E. = 1.5).

The input data for catch-at-age analysis are found in tables 4.2.5–4.2.11, containing catches in numbers-at-age, mean weights at age in the catch and in the stock, tuning fleet and natural mortality by age and year, proportion of F and M before spawning time and the proportion mature fish by age. As in previous years, the mean weight in the stock was taken as the mean weight in the catch.

The diagnostics of the final XSA run, which converged after 51 iterations, are shown in Table 4.2.12. Since no values corresponding to the regression statistics were printed for the final run, the values could be taken from a run, which was stopped after 50 iterations. Fishing mortalities and stock number are given in Table 4.2.13 and Table 4.2.14, respectively. The summary is presented in Table 4.2.15.

The development of herring biomass as estimated by the acoustic surveys and by XSA is illustrated in Figure 4.2.7. During the years, 2019-2021 acoustic and XSA SSB and total biomass estimates both show a similar slightly decreasing trend. In the latest year, 2021, however, the acoustic estimates are increasing while the XSA estimates for total biomass continues to decrease and the SSB is relatively stable.

A retrospective analysis for the whole time series is given in Figure 4.2.8 and shows no concerning pattern (Mohn's rho: SSB: 0.0898, Recruitment: 0.0514, F_{bar}: -0.0428). Fishing mortality were somewhat underestimated and the spawning stock biomass overestimated when removing 2-3 years, while the retrospective patterns for F and SSB are negligible in recent time.

The overall rather small log catchability residuals show some year effects with only positive or negative residuals (Figure 4.2.9). Last year values are small and positive and negative values are fluctuating without any trend. The catchability residuals are overall considered acceptable.

The abundance by age group of the tuning fleet was plotted against the estimated stock numbers (Figure 4.2.10). The regression analyses gave R (squared) values in the range 0.5–0.9, which is similar compared to last year's estimates.

4.2.4.4 Historical stock trend

Spawning-stock biomass (SSB) has been above B_{lim} since 2002. SBB shows a decreasing trend since 2014 and is below MSY $B_{trigger}$ in 2021. Fishing mortality has shown an increasing trend since 2014 and has been above FMSY since 2014 (Figure 4.2.13). The present low SSB estimate of 387 kt for 2021 is 53% below the long-term average (1974–2021: 827 kt). 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. In numbers, the metrics show a spawning stock that decreased from 42 billion fish in 1974 to 19 billion fish in 1990. The spawning stock then varies around 21–24 billion fish in the period 1991–1997. The stock starts to decrease in 1998, to reach a value of 13 billion fish in 2003, which is the lowest value of the whole time series. Since then the spawning stock numbers increased to 30 billion fish in 2016. Since 2017 the numbers start to decrease again and reached 15 billion fish in 2020 and 19 billion in 2021 (Figure 4.2.14).

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 1 was high at the beginning of the 1980s, but being on a low level for some years afterwards (Figure 4.2.13). Since the mid-1980s recruitment has varied between 6 and 30 billion, without a clear trend. The year class 2014 is, however, estimated to be more than 50 percent higher than the last strong year class 2007, and is one of the largest year classes in the time series (31.6 billion). The strong year class 2014 was followed by four years of below or on average recruitment. In 2020 the year class 2019 was estimated to be well above average. However, in 2021 this year class was downscaled to be below the long-term average. In this year's assessment the 2019-year class is again estimated to be close to the long-term average recruitment.

4.2.5 Short-term forecast and management options

The input data of the short-term prediction are presented in Table 4.2.19. The mean weights at age in the prediction, for both catch and stock, were the average of 2019-2021. The estimate of recruitment of age 1 for 2022 (2021-year class) was taken from the RCT3 analysis (tables 4.2.17 and 4.2.18: 9.6 billion), whereas recruits in 2023 and 2024 were the GM for 1988–2020, 12.1 billion). The natural mortalities at age were assumed as the average of 2019–2021. The exploitation pattern was taken as the average over 2019–2021. The TAC constraint of 84 767 tonnes (EU share 53 653 tonnes + Russian quota 28 362 tonnes + central Baltic herring stock caught in Gulf of Riga 3448 tonnes (mean 2016–2020) − Gulf of Riga herring stock caught in central Baltic Sea 696 tonnes (mean 2016–2020)) was used in the predictions in the intermediate year 2022 since the total TAC in 2021 was almost fully exploited (and status quo F resulted in 151 kt, which is above this TAC constraint). This resulted in fishing mortality of 0.20 (Table 4.2.20), which lies below the present estimated F in 2021 of 0.39 and F_{MSY} (0.21). The SSB is expected to be 446 582 t in 2022, which lies below MSY $B_{trigger}$ (460 000 t). The Russian quota of 28 362 tonnes were estimated from the positive relationship between the EU TAC and the Russian TAC for the years 2017–2021. The regression (y = 0.0082x + 27.922) was subsequently used to predict the Russian quota in 2022 with the EU TAC 2022 as the predictor.

Please note *that the official Russian quota for 2022 was made available after ADGBS. As recommended by ACOM a new Short-Term Forecast was produced taking in consideration the official Russian quota of 27 100 tonnes. See Annex 7 for summary tables of the forecast.*

It should be noted that the large year class 2014 will still a contributor to the yields in 2022. The stock status in the next years depends on the 2019-year class and the development of the incoming year classes 2020. These year classes will contribute to a larger extent to the yield in 2023 and to the SSB in 2023 and 2024.

4.2.6 Reference points

Both MSY and PA reference points were re-estimated during an Inter-Benchmark Process (**IBP**) on **BA**ltic **S**prat (*Sprattus sprattus*) and **H**erring (*Clupea harengus*) (IBPBASH) in March 2020 (ICES 2020/ICES Scientific Reports. 2:34). Following the ACOM's decision in 2020 (see Expert Groups general ToR c) vi)), the basis for F_{pa} was changed in 2021 to $F_{p.05}$. The corresponding value $F_{p.05}$ of 0.32 was also calculated during Inter-Benchmark process in March 2020 (ICES 2020/ICES Scientific Reports. 2:34).

The present reference points are provided in the text table below.

Reference Points	Values	Rationale
Blim	330 000 t	The lowest SSB that has given rise to above average recruitment, i.e. year 2002. (The SSB in 2002 happens to correspond to Bloss)
Bpa	460 000 t	1.4* Blim
MSY Btrigger	460 000 t	Bpa
Fmsy	0.21	Estimated by EqSim
FmsyUpper	0.26	Estimated by EqSim as the upper value of F at 95% of the landings of Fmsy
FmsyLower	0.15	Estimated by EqSim as the lower value of F at 95% of the landings of Fmsy

Flim	0.59	Estimated by EqSim as the F with 50% probability of SSB being less than Blim
Fpa	0.32	Fp.05. The F that leads to SSB ≥ Blim with 95% probability

4.2.7 Quality of assessment

The assessment has been benchmarked in 2013 (ICES CM 2013/ACOM:43). An Inter-Benchmark Process (IBP) on BAltic Sprat (*Sprattus sprattus*) and Herring (*Clupea harengus*) (IBPBASH) was carried out in March 2020 (ICES 2020/ICES Scientific Reports. 2:34).

The natural mortality was provided from multi-species models for the years 1974–2018 (ICES 2019/ICES Scientific Reports. 1:91), M for 2019 was set equal to 2018 and M for 2020 and 2021 was taken from a regression with eastern Baltic cod biomass of individuals ≥20 cm (see 4.2.2.4.).

Recruitment data are derived from a 0-group acoustic index, which was revised in 2013 (ICES CM 2013/SSGESST:08) and since then includes area corrected values. The 2013-2016 values were revised by WGBFIS in 2020.

Catches of central Baltic spring-spawning herring taken in the Gulf of Riga are included in the assessment.

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 is however not well known. Analysis of a questionnaire answered by all Baltic countries during 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. The official catch figures of both sprat and herring are modified by Poland and Denmark, but not currently in Sweden. A worst-case scenario using the permitted margin of tolerance of 10% in the logbooks of the quantities by species on board (EU 1224/2009) revealed that sprat catches may be underestimated by 5% and that herring catches may be underestimated by 4%. It was, therefore, concluded at the time after the questionnaire that that species misreporting could be regarded as minor importance. However, as Sweden is not currently correcting for this misreporting and preliminary analyses by Sweden suggests that misreporting of herring and sprat is significantly worse than 5 and 4%, this issue needs to be investigated as soon as possible and when data available addressed in a benchmark. Significant misreporting can potentially be a large problem with regards to our perception of these stocks.

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. A working group has been initiated to look further into this issue.

4.2.8 Comparison with previous assessment

Compared to last year the present assessment resulted in a 5% higher SSB for 2020. In 2020 $F_{(3–6)}$ was estimated to be 4% lower compared to last year's assessment and recruitment-at-age 1 in 2020 was estimated to be 35% higher in this year's assessment.

Category	Parameter	Assessment WGBFAS 2021	Assessment WGBFAS 2022	Diff. (+/-)%
Data input	Maturity ogives	age 1: 0%, age 2/3: 70% age >=4:100%	age 1: 0%, age 2/3: 70% age >=4:100%	No
	Natural mortality	$M_{1974–2018}$ estimated in SMS, $M_{2018} = M_{2019}$, M_{2020} from regression with eastern Baltic cod biomass TL>=20 cm	$M_{1974–2018}$ estimated in SMS, $M_{2018} = M_{2019}$, M_{2020} and M_{2021} from regression with eastern Baltic cod biomass TL>=20 cm	1.5% for average M_{2020} at age
XSA input	Catchability dependent on year class strength	Age < 2	Age < 2	No
	Catchability independent on age	Age > = 6	Age > = 6	No
	SE of the F shrinkage mean	1.5	1.5	No
	Time weighting	Tricubic, 20 years	Tricubic, 20 years	No
	Tuning data	International acoustic autumn	International acoustic autumn	No
XSA results	SSB 2020 (1000 t)	364.981	384.556	5.4%
	TSB 2020 (1000 t)	638.194	715.967	12.2%
	F(3–5) 2020	0.4600	0.4414	-4.0%
	Recruitment (age 1) 2020 (billions)	12.950346	17.421222	34.5%

4.2.9 Management considerations

SBB shows a decreasing trend since 2014 and is below MSY $B_{trigger}$ in 2021. The present SSB estimate for 2021 is far below the long-term average (1974–2021). Fishing mortality ($F_{3–6}$ of 0.29) is far higher than the adopted F_{MSY} of 0.21 (ICES 2020/ICES Scientific Reports. 2:34). 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). It is also important to note that the large year class 2014 is still a contributor to the yield in 2022 (included in the 8+ age group, Figure 4.2.15). The strong year class 2014 was followed by four years of below or on average recruitment. The year class 2019, which was estimated to well above average 2020, was downscaled to be below average last year, but was during this year's assessment estimated to be at an average level. As there has been no other strong recruitment since 2015, resulting in a low number of older ages, the increase in stock status in the next years will depend on the development of this single year class contributing to the spawning stock.

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 2019 (ICES 2019/ICES Scientific Reports. 1:91) were used also in the 2020 assessment. Since then M (for 2020 and 2021) has been estimated from a regression with the eastern Baltic cod biomass TL≥20 cm. Since the cod biomass is reestimated every year also back in time, the 2020 value for M was updated also this year (see section 4.2.2.2). By 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	4.2		50.4				55.5	100.9	25.4	236.4
1988	10.8		58.1				57.2	106.0	33.4	265.5
1989	7.3		50.0				51.8	105.0	55.4	269.5
1990	4.6		26.9				52.3	101.3	44.2	229.3
1991	6.8	27.0	18.1		20.7	6.5	47.1	31.9	36.5	194.6
1992	8.1	22.3	30.0		12.5	4.6	39.2	29.5	43.0	189.2
1993	8.9	25.4	32.3		9.6	3.0	41.1	21.6	66.4	208.3
1994	11.3	26.3	38.2	3.7	9.8	4.9	46.1	16.7	61.6	218.6
1995	11.4	30.7	31.4	0.0	9.3	3.6	38.7	17.0	47.2	189.3
1996	12.1	35.9	31.5	0.0	11.6	4.2	30.7	14.6	25.9	166.7
1997	9.4	42.6	23.7	0.0	10.1	3.3	26.2	12.5	44.1	172.0
1998	13.9	34.0	24.8	0.0	10.0	2.4	19.3	10.5	71.0	185.9
1999	6.2	35.4	17.9	0.0	8.3	1.3	18.1	12.7	48.9	148.7
2000	15.8	30.1	23.3	0.0	6.7	1.1	23.1	14.8	60.2	175.1
2001	15.8	27.4	26.1	0.0	5.2	1.6	28.4	15.8	29.8	150.2
2002	4.6	21.0	25.7	0.3	3.9	1.5	28.5	14.2	29.4	129.1
2003	5.3	13.3	14.7	3.9	3.1	2.1	26.3	13.4	31.8	113.8
2004	0.2	10.9	14.5	4.3	2.7	1.8	22.8	6.5	29.3	93.0
2005	3.1	10.8	6.4	3.7	2.0	0.7	18.5	7.0	39.4	91.6
2006	0.1	13.4	9.6	3.2	3.0	1.2	16.8	7.6	55.3	110.4
2007	1.4	14.0	13.9	1.7	3.2	3.5	19.8	8.8	49.9	116.0
2008	1.2	21.6	19.1	3.4	3.5	1.7	13.3	8.6	53.7	126.2
2009	1.5	19.9	23.3	1.3	4.1	3.6	18.4	***11.8	50.2	134.1
2010	5.4	17.9	21.6	2.2	3.9	1.5	25.0	9.1	50.0	136.7
2011	1.8	14.9	19.2	2.7	3.4	2.0	28.0	8.5	36.2	116.8
2012	1.4	****11.4	18.0	0.9	2.6	1.8	25.5	13.0	26.2	101.0
2013	3.4	12.6	18.2	1.4	3.5	1.7	20.6	10.0	29.5	101.0
2014	2.7	15.3	27.9	1.7	4.9	2.1	27.3	15.9	34.9	132.7
2015	0.3	18.8	31.6	2.9	5.7	4.7	39.0	20.9	50.6	174.4
2016	4.0	20.1	28.9	4.3	8.4	5.2	41.0	24.2	56.0	192.1
2017	9.3	23.3	40.7	3.6	7.9	4.0	40.1	22.3	51.2	202.5
2018	11.4	24.3	45.4	4.0	11.2	6.6	49.3	25.4	66.9	244.4
2019	8.9	21.5	37.0	1.8	7.6	6.1	40.3	25.8	55.6	204.4
2020	9.3	17.1	31.9	0.8	5.2	5.6	35.9	26.0	45.3	177.1
2021*	6.6	12.5	19.8	0.6	3.8	4.3	26.7	23.7	30.8	129.0

*** Preliminary**

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

***** Updated in 2011**

****** Updated in 2013 from 8.3 kt to 11.4 kt and included in 2014 assessment (WGBFAS 2014).**

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2021 available to the Working Group.
1/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 25	Denmark	1	1 406	8	161	161
		2	18	0	0	0
		3				
		4	753	0	0	0
		Total	2 177	8	161	161
	Germany	1	127	0	0	0
		2	182	0	0	0
		3				
		4				
		Total	309	0	0	0
	Poland	1	4 108	12	613	273
		2	2 985	5	793	242
		3	2 571	2	437	123
		4	5 005	5	910	192
		Total	14 668	24	2 753	830
	Sweden	1	1 675	18	835	830
		2	1 205	7	350	350
		3	1 477	13	650	648
		4	2 008	16	771	771
		Total	6 365	54	2 606	2 599
	Total	1	7 316	38	1 609	1 264
		2	4 389	12	1 143	592
		3	4 048	15	1 087	771
		4	7 765	21	1 681	963
		Total	23 519	86	5 520	3 590

(cont').

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2021 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	533	0	0	0
		2				
		3				
		4	12	0	0	0
		Total	545	0	0	0
	Finland	1	6	0	0	0
		2	128	0	0	0
		3				
		4				
		Total	134	0	0	0
	Germany	1	225	0	0	0
		2	17	0	0	0
		3				
		4				
		Total	242	0	0	0
	Latvia	1	68	0	0	0
		2	72	0	0	0
		3	86	0	0	0
		4	148	0	0	0
		Total	374	0	0	0
	Lithuania	1	963	8	2 039	1 082
		2	415	5	1 012	696
		3	292	1	310	137
		4	824	7	1 469	467
		Total	2 494	21	4 830	2 382
	Poland	1	3 634	13	521	263
		2	2 010	4	123	70
		3	1 305	4	1 006	263
		4	4 637	6	1 177	389
		Total	11 586	27	2 827	985
	Russia	1	4 396	22	5 432	901
		2	4 284	18	3 913	1 020
		3	1 140	15	4 618	301
		4	3 231	24	6 285	400
		Total	13 051	79	20 248	2 622
	Sweden	1	2 626	3	55	55
		2	415	0	0	0
		3				
		4	213	2	53	52
		Total	3 254	5	108	107
	Total	1	12 453	46	8 047	2 301
		2	7 340	27	5 048	1 786
		3	2 823	20	5 934	701
		4	9 065	39	8 984	1 308
		Total	31 680	132	28 013	6 096

(cont').

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2021 available to the Working Group.
3/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Subdivision 27	Denmark	1	1 877	1	4	4
		2	291	1	13	13
		3				
		4				
		Total	2 168	2	17	17
	Finland	1	121	0	0	0
		2	208	0	0	0
		3				
		4				
		Total	329	0	0	0
	Germany	1				
		2	10	0	0	0
		3				
		4				
		Total	10	0	0	0
	Sweden	1	6 479	9	414	414
		2	1 535	3	91	91
		3	1	0	0	0
		4	272	0	0	0
		Total	8 287	12	505	505
	Total	1	8 477	10	418	418
		2	2 044	4	104	104
		3	1	0	0	0
		4	272	0	0	0
		Total	10 794	14	522	522

(cont').

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2021 available to the Working Group.
4/6

Subdivision 28.2 (includes landings of Central Baltic Herring from Gulf of Riga)

Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Denmark	1	467	1	5	5
	2				
	3				
	4	11	0	0	0
	Total	478	1	5	5
Estonia	1	287	12	460	460
	2	1,319	3	300	300
	3	39	2	183	183
	4	315	13	607	607
	Total	1,960	30	1,550	1,550
Finland	1	0	0	0	0
	2	0	0	0	0
	3	305	0	0	0
	4	634	0	0	0
	Total	940	0	0	0
Germany	1	16	0	0	0
	2				
	3				
	4	3	0	0	0
	Total	19	0	0	0
Latvia	1	974	10	2,008	1,206
	2	1,131	39	4,467	3,922
	3	169	12	2,683	1,359
	4	1,181	12	2,136	1,086
	Total	3,455	73	11,294	7,573
Lithuania	1	361	0	0	0
	2	85	0	0	0
	3	2	0	0	0
	4	1,316	0	0	0
	Total	1,763	0	0	0
Poland	1	25	0	0	0
	2	90	0	0	0
	3	64	0	0	0
	4	262	0	0	0
	Total	441	0	0	0
Sweden	1	3,049	1	33	32
	2	704	6	263	259
	3	241	0	0	0
	4	3,597	10	418	415
	Total	7,591	17	714	706
Total	1	5,179	24	2,506	1,703
	2	3,328	48	5,030	4,481
	3	820	14	2,866	1,542
	4	7,319	35	3,161	2,108
	Total	16,646	121	13,563	9,834

(cont').

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2021 available to the Working Group.
5/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Subdivision 29	Denmark	1	1,258	1	5	5
		2				
		3				
		4				
		Total	1,258	1	5	5
	Estonia	1	1,648	12	460	460
		2	172	3	300	300
		3	6	2	183	183
		4	703	13	607	607
		Total	2,530	30	1,550	1,550
	Finland	1	4,125	6	1,934	232
		2	3,874	10	3,185	190
		3	296	2	616	449
		4	5,515	7	1,450	303
		Total	13,810	25	7,185	1,174
	Germany	1	40	0	0	0
		2				
		3				
		4	11	0	0	0
		Total	51	0	0	0
	Lithuania	1	68	0	0	0
		2				
		3				
		4				
		Total	68	0	0	0
	Sweden	1	5,015	0	0	0
		2	6	0	0	0
		3	0	0	0	0
		4	239	0	0	0
		Total	5,260	0	0	0
	Total	1	12,154	19	2,399	697
		2	4,052	13	3,485	490
		3	302	4	799	632
		4	6,468	20	2,057	910
		Total	22,976	56	8,740	2,729

(cont').

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2021 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	3 577	17	1 546	1 546
		2	1 999	14	1 308	1 308
		3	410	2	117	117
		4	2 045	14	1 322	1 322
		Total	8 031	47	4 293	4 293
	Finland	1	1 314	2	671	56
		2	19	5	1 633	86
		3	1 366	1	113	110
		4	1 909	3	713	392
		Total	4 609	11	3 130	644
	Lithuania	1	13	0	0	0
		2				
		3				
		4				
		Total	13	0	0	0
	Russia	1	3 395	14	1 894	310
		2	4 164	29	5 082	240
		3				
		4	3 134	23	3 658	202
		Total	10 693	66	10 634	752
	Total	1	8 299	33	4 111	1 912
		2	6 183	48	8 023	1 634
		3	1 776	3	230	227
		4	7 088	40	5 693	1 916
		Total	23 346	124	18 057	5 689
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	**53 877**	**170**	**19 090**	**8 295**
		2	**27 336**	**152**	**22 833**	**9 087**
		3	**9 770**	**56**	**10 916**	**3 873**
		4	**37 978**	**155**	**21 576**	**7 205**
		Total	**128 961**	**533**	**74 415**	**28 460**

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

Catch by country and SD and mean weight by SD in 2021.

CATCH (1000 T) BY COUNTRY AND SD							
Country	**Total**	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
Denmark	6.625	2.177	0.545	2.168	0.478	1.258	0.000
Estonia	12.521	0.000	0.000	0.000	1.960	2.530	8.031
Finland	19.822	0.000	0.134	0.329	0.940	13.810	4.609
Germany	0.631	0.309	0.242	0.010	0.019	0.051	0.000
Latvia*	3.828	0.000	0.374	0.000	3.455	0.000	0.000
Lithuania	4.338	0.000	2.494	0.000	1.763	0.068	0.013
Poland	26.695	14.668	11.586	0.000	0.441	0.000	0.000
Russia	23.744	0.000	13.051	0.000	0.000	0.000	10.693
Sweden	30.757	6.365	3.254	8.287	7.591	5.260	0.000
Total	**128.961**	**23.519**	**31.680**	**10.794**	**16.646**	**22.976**	**23.346**

*Catches in SD 28.2 include 738 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	58384	1255	7424	27	1109	45666	2904
1	691437	23642	75572	31374	7701	322540	230608
2	1805171	106410	331339	334863	175379	447206	409974
3	831906	82102	87815	74302	89135	157181	341371
4	867236	132588	165166	81058	142926	144657	200840
5	519655	84625	72207	46225	81067	102770	132761
6	377932	80291	75629	28037	82874	63273	47827
7	373009	102548	72015	30808	71454	55264	40920
8	92436	18198	20023	2718	4386	26637	20475
9	26494	8850	6325	0	5680	4448	1191
10+	11046	1872	4060	0	2527	1685	901
Total N	**5654706**	**642380**	**917575**	**629414**	**664239**	**1371327**	**1429772**
CATON	**128.961**	**23.519**	**31.680**	**10.794**	**16.646**	**22.976**	**23.346**
Mean weight (g)							
AGE	Mean	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
0	5.5	17.7	11.1	14.9	11.5	4.1	5.0
1	8.6	24.4	16.5	5.3	15.2	7.5	6.2
2	18.6	31.2	31.7	13.4	18.2	14.9	13.4
3	21.9	35.2	32.5	20.0	23.9	20.0	16.7
4	28.2	35.2	38.0	23.3	26.7	23.3	22.3
5	29.6	36.9	37.8	24.8	28.6	27.0	24.8
6	34.0	40.5	42.7	24.9	29.0	31.3	27.1
7	35.1	41.2	44.1	26.5	31.4	27.5	27.1
8	39.6	50.8	51.7	41.8	33.9	36.1	23.2
9	43.4	48.2	55.1	40.3	35.3	30.1	34.0
10+	53.1	70.6	66.4	60.0	39.4	32.5	33.3

CATON is given in 1000 tons

Table 4.2.4. Herring in SD 25–29, 32 (excl. GoR). Catch in number-at-age (millions) per SD and quarter in 2021. 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	397.867	7.080	16.366	27.146	0.112	210.102	137.061
2	931.132	28.802	142.779	282.838	49.470	239.908	187.335
3	344.008	21.573	29.432	50.044	20.306	99.864	122.790
4	368.266	36.208	83.574	60.230	40.026	74.813	73.416
5	197.286	22.789	31.682	35.631	24.234	51.664	31.287
6	168.062	27.172	30.097	22.908	30.642	44.006	13.237
7	194.977	50.620	33.115	27.146	37.165	32.195	14.735
8	31.982	10.818	8.182	1.701	0.744	8.707	1.830
9	11.658	2.561	3.747	0.000	1.329	3.620	0.401
10+	4.773	0.733	2.398	0.000	0.289	0.953	0.401
Total N	2650.011	208.355	381.372	507.643	204.318	765.831	582.492
CATON	53.877	7.316	12.453	8.477	5.179	12.154	8.299
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	110.761	4.516	46.760	4.067	0.160	21.193	34.064
2	342.868	10.913	99.043	48.443	28.152	75.377	80.941
3	197.177	7.473	8.925	22.506	15.491	20.880	121.902
4	187.276	27.580	23.979	18.439	33.009	31.032	53.237
5	144.823	15.118	7.927	9.162	19.471	38.803	54.342
6	81.326	7.666	15.117	4.067	23.593	12.488	18.396
7	67.098	29.275	12.973	3.050	13.935	3.129	4.737
8	21.166	3.781	4.101	1.017	2.559	8.632	1.077
9	10.511	5.359	1.357	0.000	3.094	0.301	0.400
10+	3.442	0.338	1.145	0.000	1.458	0.100	0.400
Total N	1166.448	112.017	221.328	110.751	140.922	211.935	369.495
CATON	27.336	4.389	7.340	2.044	3.328	4.052	6.183
Quarter:	3						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	7.692	0.060	0.121	0.000	0.246	7.265	0.000
1	50.494	2.699	3.284	0.002	2.549	14.369	27.590
2	78.172	24.055	14.260	0.007	7.164	2.701	29.985
3	42.862	20.436	11.543	0.004	4.547	0.492	5.841
4	57.142	22.117	14.163	0.006	5.911	0.296	14.649
5	32.927	14.361	11.430	0.002	2.300	0.267	4.568
6	29.277	12.656	11.461	0.003	2.731	0.103	2.324
7	23.468	6.762	6.613	0.003	3.513	0.227	6.349
8	14.786	0.933	2.286	0.001	0.724	0.287	10.554
9	1.252	0.281	0.460	0.000	0.320	0.000	0.190
10+	0.377	0.000	0.189	0.000	0.188	0.000	0.000
Total N	338.448	104.360	75.809	0.029	30.193	26.007	102.051
CATON	9.770	4.048	2.823	0.001	0.820	0.302	1.776
Quarter:	4						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	50.692	1.195	7.303	0.026	0.863	38.401	2.904
1	132.316	9.347	9.162	0.159	4.879	76.877	31.892
2	453.000	42.641	75.257	3.575	90.594	129.220	111.714
3	247.858	32.622	37.914	1.748	48.790	35.944	90.839
4	254.551	46.683	43.450	2.384	63.981	38.516	59.538
5	144.619	32.357	21.168	1.430	35.062	12.037	42.565
6	99.267	32.797	18.955	1.059	25.908	6.677	13.870
7	87.466	15.891	19.314	0.609	16.841	19.713	15.098
8	24.503	2.667	5.454	0.000	0.358	9.011	7.013
9	3.073	0.648	0.761	0.000	0.938	0.527	0.200
10+	2.454	0.801	0.328	0.000	0.591	0.632	0.100
Total N	1499.799	217.648	239.065	10.991	288.806	367.554	375.734
CATON	37.978	7.765	9.065	0.272	7.319	6.468	7.088

continued

Table 4.2.4. 2/2 **Herring in SD 25–29, 32 (excl. GoR). Mean weight-at-age per SD and quarter in 2021. Mean weight (g).**

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	5.5	16.3	14.7	5.2	6.4	5.4	4.2
2	15.9	27.6	28.5	13.1	14.4	13.6	12.3
3	20.5	32.2	29.0	20.0	23.9	19.7	16.7
4	27.4	33.4	36.0	23.4	27.4	23.4	21.8
5	29.6	34.2	34.6	25.1	30.6	29.4	26.1
6	32.3	38.9	38.3	24.4	28.8	31.4	29.6
7	33.2	38.2	39.5	26.1	31.4	27.9	31.7
8	43.2	48.1	51.3	31.3	36.8	34.8	31.3
9	44.0	58.2	52.5	0.0	36.5	28.6	37.0
10+	55.1	80.2	61.2	0.0	52.6	32.0	30.0
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	9.0	16.8	13.5	5.2	3.6	5.2	4.6
2	19.9	31.4	33.9	14.3	15.3	13.8	11.8
3	18.5	35.7	38.2	19.8	20.8	16.6	15.8
4	27.5	37.3	42.9	22.5	23.7	23.3	22.1
5	26.4	38.5	39.4	22.9	25.2	23.9	24.0
6	33.2	42.5	45.4	26.6	28.3	33.2	26.9
7	39.5	44.5	47.5	29.4	29.6	32.4	26.5
8	46.5	58.8	53.4	59.4	29.6	43.7	27.2
9	38.7	39.7	56.3	0.0	31.1	31.1	30.9
10+	53.9	89.7	73.7	0.0	36.5	36.5	35.0
Quarter:	**3**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	4.3	18.7	7.5	6.8	6.8	4.0	0.0
1	14.3	34.4	27.0	18.7	17.5	12.6	11.5
2	25.3	34.4	31.7	21.6	21.2	18.0	16.7
3	32.9	38.8	31.8	26.8	26.6	20.6	20.3
4	32.2	37.8	36.5	27.8	28.1	23.2	21.3
5	37.9	43.9	38.2	30.8	30.9	24.5	22.8
6	39.1	39.5	43.6	34.5	34.6	26.1	21.0
7	38.3	43.9	47.3	37.6	37.8	24.1	23.6
8	28.4	51.5	50.5	42.2	42.2	30.3	20.6
9	54.3	76.5	57.1	40.3	40.3	0.0	38.2
10+	69.1	0.0	78.1	60.0	60.0	0.0	0.0
Quarter:	**4**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	5.7	17.7	11.2	15.0	12.9	4.1	5.0
1	15.1	31.3	31.3	14.9	14.6	12.7	11.7
2	22.0	31.7	35.1	20.3	20.8	17.8	15.5
3	24.5	34.8	34.0	24.1	24.6	22.5	17.7
4	29.1	34.0	39.8	27.0	27.6	23.1	23.2
5	30.9	35.0	41.8	28.9	29.1	26.5	25.1
6	36.2	41.8	47.0	28.6	29.3	27.1	26.0
7	35.0	43.3	48.8	29.8	31.5	26.0	24.2
8	35.6	49.9	51.3	0.0	42.2	30.2	24.4
9	52.6	66.0	64.4	0.0	45.6	39.9	30.0
10+	45.3	53.8	72.0	0.0	33.7	32.6	39.3

Table 4.2.5. Herring in SD 25–29, 32 (excl. GoR). XSA input: Catch in numbers (thousands).

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+	SOPCOF %
1974	2436300	1553800	1090600	1347900	483100	343500	619000	285100	99.5
1975	1861800	1229200	1405600	829900	870700	364000	274800	546800	100.2
1976	2093100	1114800	1034000	907300	476800	558500	246500	494400	100.0
1977	1258500	1825900	773600	608300	621700	365300	284000	545400	99.9
1978	1044000	1298700	1575100	436800	355100	370700	186800	478300	100.0
1979	405300	1195500	873200	1159500	338900	278700	281200	478500	100.0
1980	1037000	907100	977400	524600	654900	182500	204400	550500	100.0
1981	1325500	1523500	680000	615000	343600	436300	146600	527500	100.2
1982	867000	2277000	810100	334200	312000	188100	250500	420700	99.6
1983	744300	1698700	1875700	625300	233100	245700	162500	433400	100.3
1984	822000	1177900	1282900	1145700	374300	165500	166300	421100	100.0
1985	1237800	2124100	1076100	867300	707200	240300	131000	346900	99.9
1986	552824	1733617	1601914	838843	614707	320221	114772	208901	100.4
1987	920000	726000	1445000	1237000	607000	461000	238000	194000	100.1
1988	474000	2091300	746300	1009600	849400	354300	254200	210100	100.1
1989	792900	540600	1988300	580000	840700	695100	266500	336600	99.9
1990	643300	1194800	585500	1245900	419400	541100	370500	306000	100.4
1991	372900	1571700	1286100	512700	807700	278400	265900	238200	100.1
1992	1112600	1139400	1696900	702900	324100	422300	157700	218600	100.7
1993	826300	1852600	1503000	1473400	615700	274000	197500	140100	99.8
1994	486870	1138560	1559930	1068900	1057400	495520	213790	282450	100.5
1995	820500	960200	1742700	1555400	645700	440400	205200	212100	100.5
1996	985800	1441300	1095900	1216600	798100	492000	301100	223800	99.3
1997	549200	1350300	1738700	1173900	904800	492600	244200	186100	99.9
1998	1873286	947360	1810804	1781642	813071	481770	211361	186102	100.1
1999	628815	1660328	949293	1307772	950155	340256	185943	119952	102.9
2000	1842170	940000	1682170	818970	864530	567220	191280	185030	99.9
2001	1052466	1930067	605055	1010660	375834	391122	303247	199646	99.4
2002	1034640	1012975	1339851	456838	522442	179710	169851	230139	98.6
2003	1347364	782607	687478	686673	261252	226812	89925	202367	101.1
2004	656630	1242941	673629	568055	384598	162350	119700	129883	100.0
2005	326272	753498	1187077	557148	378447	219723	82530	159318	101.2
2006	808387	505592	754016	1104978	409059	264865	154493	147666	100.8
2007	457582	920291	630258	703185	823805	268661	135977	112019	101.2
2008	789388	735511	968418	461494	485798	711012	165897	215625	99.4
2009	653043	1395081	745935	855049	302486	340499	486075	239340	100.0
2010	546352	645269	1357314	661735	630229	283763	283721	362390	101.0
2011	293118	568892	770797	1130531	415505	312765	128881	235287	101.0
2012	333355	317009	416640	517743	642002	234424	160708	208441	100.0
2013	470327	655679	260040	410703	467439	403588	172879	224139	100.0
2014	470062	902642	1003705	385671	488077	409753	285297	250759	100.0
2015	1415576	745130	1264634	1252762	378036	384811	369954	473420	100.0
2016	602141	3014945	934748	1188734	838456	331740	465961	629002	100.0
2017	983743	823614	2898360	840730	923686	527598	248465	411819	100.0
2018	1737640	1280367	1174100	2637412	789008	663989	398905	335250	99.9
2019	416846	1561422	1127576	891782	1957135	485302	396557	239356	98.8
2020	1644919	781308	1423813	788676	662488	1080601	199821	228471	99.8
2021	691437	1805171	831906	867236	519655	377932	373009	129976	99.7

Table 4.2.6. Herring in SD 25–29, 32 (excl. GoR). XSA input: Mean weight in the catch and in the stock (Kilograms).

	WECA (= WEST): Mean weight in Catch (Total International Catch) (Total) (Kilograms)							
Year	**Age 1**	**Age 2**	**Age 3**	**Age 4**	**Age 5**	**Age 6**	**Age 7**	**Age 8+**
1974	0.0300	0.0350	0.0430	0.0460	0.0710	0.0790	0.0830	0.0750
1975	0.0300	0.0340	0.0520	0.0520	0.0540	0.0790	0.0780	0.0790
1976	0.0230	0.0380	0.0400	0.0600	0.0580	0.0570	0.0800	0.0810
1977	0.0290	0.0310	0.0500	0.0580	0.0690	0.0610	0.0720	0.0910
1978	0.0270	0.0440	0.0430	0.0560	0.0620	0.0730	0.0730	0.0810
1979	0.0240	0.0420	0.0590	0.0530	0.0660	0.0720	0.0770	0.0860
1980	0.0240	0.0370	0.0540	0.0680	0.0630	0.0770	0.0800	0.0940
1981	0.0260	0.0350	0.0530	0.0700	0.0790	0.0770	0.0860	0.1000
1982	0.0220	0.0390	0.0530	0.0650	0.0750	0.0840	0.0800	0.1010
1983	0.0180	0.0310	0.0560	0.0590	0.0770	0.0870	0.0910	0.1030
1984	0.0160	0.0300	0.0460	0.0650	0.0670	0.0820	0.0890	0.1010
1985	0.0160	0.0230	0.0420	0.0580	0.0670	0.0750	0.0850	0.1020
1986	0.0180	0.0250	0.0330	0.0510	0.0630	0.0690	0.0790	0.0990
1987	0.0150	0.0330	0.0380	0.0450	0.0590	0.0640	0.0710	0.0920
1988	0.0200	0.0260	0.0470	0.0510	0.0530	0.0650	0.0710	0.0900
1989	0.0230	0.0360	0.0370	0.0520	0.0570	0.0590	0.0670	0.0820
1990	0.0180	0.0310	0.0420	0.0390	0.0600	0.0620	0.0640	0.0770
1991	0.0230	0.0240	0.0350	0.0490	0.0410	0.0600	0.0560	0.0690
1992	0.0130	0.0230	0.0310	0.0420	0.0570	0.0500	0.0670	0.0710
1993	0.0130	0.0210	0.0320	0.0350	0.0440	0.0510	0.0500	0.0660
1994	0.0160	0.0210	0.0280	0.0380	0.0420	0.0520	0.0610	0.0640
1995	0.0110	0.0210	0.0240	0.0320	0.0410	0.0420	0.0490	0.0540
1996	0.0110	0.0170	0.0240	0.0280	0.0330	0.0370	0.0400	0.0510
1997	0.0110	0.0170	0.0220	0.0260	0.0300	0.0350	0.0400	0.0440
1998	0.0100	0.0180	0.0210	0.0280	0.0330	0.0370	0.0410	0.0460
1999	0.0130	0.0160	0.0220	0.0250	0.0290	0.0360	0.0390	0.0540
2000	0.0130	0.0230	0.0260	0.0280	0.0310	0.0360	0.0410	0.0460
2001	0.0140	0.0190	0.0290	0.0300	0.0340	0.0370	0.0440	0.0470
2002	0.0133	0.0216	0.0271	0.0330	0.0366	0.0392	0.0438	0.0454
2003	0.0094	0.0242	0.0298	0.0355	0.0388	0.0446	0.0501	0.0549
2004	0.0086	0.0143	0.0265	0.0304	0.0389	0.0418	0.0474	0.0540
2005	0.0122	0.0152	0.0193	0.0292	0.0356	0.0434	0.0481	0.0561
2006	0.0120	0.0234	0.0237	0.0263	0.0339	0.0435	0.0486	0.0553
2007	0.0123	0.0215	0.0254	0.0300	0.0330	0.0427	0.0497	0.0603
2008	0.0133	0.0222	0.0257	0.0302	0.0370	0.0335	0.0439	0.0498
2009	0.0112	0.0199	0.0268	0.0295	0.0354	0.0418	0.0357	0.0464
2010	0.0120	0.0183	0.0258	0.0322	0.0332	0.0385	0.0450	0.0450
2011	0.0125	0.0215	0.0246	0.0317	0.0375	0.039	0.0474	0.0475
2012	0.0142	0.0291	0.0268	0.0329	0.0417	0.0458	0.0511	0.0597
2013	0.0120	0.0210	0.0351	0.0324	0.0386	0.0480	0.0505	0.0566
2014	0.0118	0.0201	0.0294	0.0390	0.0350	0.0446	0.0492	0.0553
2015	0.0071	0.0217	0.0272	0.0331	0.0399	0.0403	0.0471	0.0512
2016	0.0086	0.0123	0.0256	0.0293	0.0339	0.0374	0.0407	0.0470
2017	0.0109	0.0192	0.0208	0.0321	0.0347	0.0403	0.0482	0.0518
2018	0.0111	0.0187	0.0279	0.0284	0.0398	0.0408	0.0432	0.0521
2019	0.0118	0.0203	0.0242	0.0312	0.0314	0.0404	0.0441	0.0490
2020	0.0116	0.0203	0.0261	0.0297	0.0349	0.0343	0.0456	0.0471
2021	0.0086	0.0186	0.0219	0.0282	0.0296	0.0340	0.0351	0.0415

Table 4.2.7. Herring in SD 25–29, 32 (excl. GoR). XSA input: Natural mortality.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.4330	0.3070	0.2510	0.2330	0.2200	0.2190	0.2050	0.1760
1975	0.4760	0.3400	0.2780	0.2570	0.2430	0.2440	0.2290	0.1950
1976	0.4120	0.3030	0.2580	0.2400	0.2290	0.2280	0.2160	0.1870
1977	0.4650	0.3200	0.2700	0.2510	0.2380	0.2370	0.2220	0.1910
1978	0.6760	0.3850	0.3420	0.3220	0.3020	0.2780	0.2620	0.2330
1979	0.8480	0.4200	0.3580	0.3500	0.3350	0.3250	0.2910	0.2440
1980	0.8690	0.5340	0.4320	0.3860	0.3940	0.3440	0.3170	0.2830
1981	0.7930	0.5210	0.4090	0.3560	0.3250	0.3270	0.2900	0.2520
1982	0.8210	0.5140	0.4230	0.3580	0.3200	0.3010	0.3010	0.2420
1983	0.7310	0.5560	0.3960	0.3750	0.3310	0.2990	0.2830	0.2510
1984	0.6160	0.4880	0.3860	0.3130	0.3120	0.2810	0.2580	0.2330
1985	0.5190	0.4240	0.3240	0.2800	0.2500	0.2460	0.2320	0.2110
1986	0.4830	0.3780	0.3360	0.2670	0.2450	0.2270	0.2130	0.1900
1987	0.4910	0.3180	0.2710	0.2560	0.2230	0.2070	0.1950	0.1770
1988	0.4980	0.3740	0.2700	0.2590	0.2440	0.2190	0.2020	0.1800
1989	0.4150	0.2900	0.2900	0.2430	0.2190	0.2080	0.1900	0.1710
1990	0.2810	0.2090	0.1890	0.1950	0.1700	0.1630	0.1570	0.1490
1991	0.2290	0.1930	0.1680	0.1520	0.1620	0.1440	0.1470	0.1380
1992	0.2400	0.1970	0.1750	0.1490	0.1410	0.1500	0.1370	0.1340
1993	0.2980	0.2470	0.2120	0.1960	0.1780	0.1680	0.1760	0.1550
1994	0.3080	0.2570	0.2300	0.2010	0.1900	0.1780	0.1640	0.1630
1995	0.2710	0.2340	0.2180	0.2010	0.1900	0.1850	0.1730	0.1700
1996	0.2350	0.2140	0.1950	0.1860	0.1790	0.1710	0.1660	0.1550
1997	0.2150	0.2000	0.1820	0.1730	0.1650	0.1590	0.1550	0.1500
1998	0.2220	0.1930	0.1800	0.1660	0.1580	0.1510	0.1500	0.1390
1999	0.2530	0.2140	0.1910	0.1820	0.1690	0.1580	0.1550	0.1440
2000	0.3060	0.2300	0.2170	0.2070	0.1960	0.1830	0.1740	0.1740
2001	0.3180	0.2410	0.2140	0.2080	0.1940	0.1890	0.1810	0.1800
2002	0.3310	0.2490	0.2200	0.1990	0.1910	0.1830	0.1770	0.1760
2003	0.2910	0.2050	0.1900	0.1790	0.1720	0.1660	0.1590	0.1550
2004	0.2700	0.2460	0.1910	0.1800	0.1640	0.1590	0.1540	0.1470
2005	0.3230	0.2760	0.2480	0.2070	0.1860	0.1720	0.1650	0.1550
2006	0.3420	0.2390	0.2350	0.2240	0.2020	0.1770	0.1690	0.1600
2007	0.3440	0.2430	0.2280	0.2100	0.2040	0.1790	0.1690	0.1540
2008	0.3640	0.2590	0.2410	0.2210	0.1970	0.2060	0.1830	0.1720
2009	0.3740	0.2790	0.2410	0.2320	0.2080	0.1910	0.2040	0.1830
2010	0.4030	0.3080	0.2580	0.2290	0.2250	0.2100	0.1950	0.1930
2011	0.4000	0.2810	0.2550	0.2240	0.2040	0.1990	0.1850	0.1860
2012	0.3630	0.2110	0.2170	0.1950	0.1740	0.1680	0.1590	0.1490
2013	0.3550	0.2310	0.1810	0.1880	0.1690	0.1560	0.1530	0.1460
2014	0.3530	0.2340	0.1960	0.1650	0.1710	0.1560	0.1500	0.1440
2015	0.2980	0.2030	0.1850	0.1670	0.1550	0.1550	0.1480	0.1420
2016	0.2880	0.2540	0.1850	0.1740	0.1640	0.1560	0.1510	0.1440
2017	0.2680	0.2070	0.1950	0.1640	0.1580	0.1480	0.1390	0.1360
2018	0.2440	0.1880	0.1620	0.1600	0.1420	0.1410	0.1390	0.1330
*2019	0.2440	0.1880	0.1620	0.1600	0.1420	0.1410	0.1390	0.1330
**2020	0.2654	0.1984	0.1758	0.1633	0.1543	0.1479	0.1439	0.1392
**2021	0.2550	0.1922	0.1710	0.1593	0.1509	0.1449	0.1412	0.1367

1974-2018 based on the latest SM-data provided by WGSAM 2019 (ICES 2019/ICES Scientific Reports. 1:91),

***M in 2019 = M in 2018,**

****2020 and 2021 from regression with eastern Baltic cod biomass TL>20 cm.**

Table 4.2.8. Herring in SD 25–29, 32 (excl. GoR). XSA input: Proportion mature at year start.

	MATPROP: Proportion of Mature at Year Start (Total international Catch) (Total)							
Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2021	0.0	0.7	0.9	1.0	1.0	1.0	1.0	1.0

Table 4.2.9. Herring in SD 25–29, 32 (excl. GoR). XSA input: Proportion of M before spawning.

	MPROP: Proportion of M before Spawning (Total International Catch) (Total)							
Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2021	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table 4.2.10. Herring in SD 25–29, 32 (excl. GoR). XSA input: Proportion of F before spawning.

	FPROP: Proportion of F before Spawning (Total international Catch) (Total)							
Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2021	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35

Table 4.2.11. Herring in SD 25–29, 32 (excl. GoR). XSA input: Tuning Fleet/International Acoustic Survey.

	Fleet: International Acoustic Survey (Catch: Millions)								
Year	Fish. Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	1	6943	20002	11964	4148	9643	2511	2280	2453
1992	1	7417	9156	13178	7156	4108	2274	1540	1167
*1993	1	-11	-11	-11	-11	-11	-11	-11	-11
1994	1	3924	11881	20304	11527	5653	2099	941	829
*1995	1	-11	-11	-11	-11	-11	-11	-11	-11
1996	1	3985	13762	9989	7361	4533	2359	1179	777
*1997	1	-11	-11	-11	-11	-11	-11	-11	-11
1998	1	4285	2171	6617	6521	2584	1524	791	430
1999	1	1754	4742	3194	4251	3680	1428	833	630
2000	1	10151	2560	9874	4838	5200	3234	3007	2061
2001	1	4029	8194	3286	4661	1567	1238	861	464
2002	1	2687	4242	6508	2842	2326	870	741	455
2003	1	16704	9116	10643	6690	2320	1778	755	1156
2004	1	4914	13229	6789	4672	2500	1132	604	680
2005	1	1920	8251	15345	7123	4356	2541	1096	1129
2006	1	7317	8060	12700	21121	7336	3068	1701	1212
2007	1	5401	6587	2975	4191	7093	1697	883	807
2008	1	6842	6822	7589	3613	4927	3563	877	807
2009	1	6409	12141	6820	5551	2059	2969	2089	614
2010	1	3829	8279	12048	5006	3543	1685	1902	1600
2011	1	2339	5668	10993	12669	5525	3257	1448	2242
2012	1	14948	3630	7545	9345	9200	2685	2262	2082
**2013	1	5749	8664	3553	6384	6987	7040	2127	3395
**2014	1	3675	8563	13770	5861	6585	5993	4619	3561
**2015	1	31108	9401	15006	15430	5440	4799	3600	4252
**2016	1	6885	27705	7260	7311	4046	2003	1460	1464
2017	1	4454	5362	20367	3945	3663	1824	628	1210
2018	1	6306	9085	8408	26663	5606	4625	2016	1311
2019	1	3209	4878	4676	3949	9016	1344	1178	765
2020	1	6916	3725	6332	3985	3270	4662	488	908
2021	1	3745	14373	6159	6295	4264	3194	2526	835

*not used due to incomplete coverage **revised by WGBIFS 2020 (WGBFAS 2020)

Table 4.2.12. Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run: Diagnostics. 1/4

Lowestoft VPA Version 3.1
11/04/2022 17:15
Extended Survivors Analysis
-Herring in Sub-div. 25 to 29 and 32 (excl. Gulf of Riga)
CPUE data from file bias.tun

Catch data for 48 years. 1974 to 2021. Ages 1 to 8.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
BIAS SD 25-27&28.2&29S&N	1991	2021	1	7	0.8	0.9

Time series weights :
Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :
Catchability dependent on stock size for ages < 2
Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 2
Catchability independent of age for ages >= 6

Terminal population estimation :
Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.
S.E. of the mean to which the estimates are shrunk = 1.500
Minimum standard error for population
estimates derived from each fleet = .300
Prior weighting not applied

Tuning converged after 51 iterations

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	0.030	0.039	0.056	0.055	0.069	0.118	0.183	0.069	0.114	0.087
2	0.094	0.083	0.107	0.130	0.174	0.133	0.229	0.254	0.182	0.182
3	0.105	0.103	0.178	0.217	0.237	0.260	0.279	0.314	0.380	0.295
4	0.141	0.144	0.213	0.346	0.318	0.337	0.390	0.338	0.361	0.405
5	0.213	0.179	0.248	0.320	0.395	0.421	0.577	0.531	0.431	0.409
6	0.233	0.194	0.226	0.303	0.488	0.441	0.575	0.805	0.593	0.441
7	0.246	0.258	0.194	0.310	0.693	0.791	0.660	0.764	0.885	0.390

XSA population numbers (Thousands)

	AGE						
YEAR	1	2	3	4	5	6	7
2012	1.37E+07	3.93E+06	4.65E+06	4.34E+06	3.65E+06	1.23E+06	7.99E+05
2013	1.48E+07	9.27E+06	2.90E+06	3.37E+06	3.10E+06	2.48E+06	8.20E+05
2014	1.02E+07	1.00E+07	6.77E+06	2.18E+06	2.42E+06	2.19E+06	1.75E+06
2015	3.05E+07	6.78E+06	7.11E+06	4.66E+06	1.49E+06	1.59E+06	1.50E+06
2016	1.05E+07	2.14E+07	4.86E+06	4.76E+06	2.79E+06	9.28E+05	1.01E+06
2017	1.01E+07	7.35E+06	1.39E+07	3.19E+06	2.91E+06	1.59E+06	4.87E+05
2018	1.17E+07	6.89E+06	5.23E+06	8.84E+06	1.93E+06	1.63E+06	8.85E+05
2019	7.09E+06	7.65E+06	4.54E+06	3.37E+06	5.10E+06	9.42E+05	7.96E+05
2020	1.74E+07	5.18E+06	4.91E+06	2.82E+06	2.04E+06	2.60E+06	3.66E+05
2021	9.46E+06	1.19E+07	3.54E+06	2.82E+06	1.67E+06	1.14E+06	1.24E+06

Estimated population abundance at 1st Jan 2022

0.00E+00	6.44E+06	8.80E+06	2.12E+06	1.60E+06	9.48E+05	6.30E+05

Taper weighted geometric mean of the VPA populations:

1.20E+07	8.29E+06	5.53E+06	3.76E+06	2.40E+06	1.45E+06	8.14E+05

Standard error of the weighted Log(VPA populations) :

0.4088	0.4231	0.4054	0.3814	0.3686	0.3787	0.4745

continued

Table 4.2.12 2/4 **Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run: Diagnostics.**

Log catchability residuals.
Fleet : BIAS SD 25-27&28.2&29S&N

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
2	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	99.99	-0.41	0.60	-0.15	-0.67	0.14	0.04	-0.36	-0.08	-0.26
2	99.99	-0.20	0.55	0.08	0.10	0.47	-0.25	0.00	-0.04	-0.08
3	99.99	0.03	0.65	0.16	0.13	0.44	-0.60	-0.18	-0.08	-0.11
4	99.99	-0.11	0.30	0.02	0.41	0.63	-0.50	-0.21	-0.26	-0.18
5	99.99	-0.12	0.03	-0.38	0.30	0.81	-0.14	-0.04	-0.47	-0.30
6	99.99	-0.36	0.16	-0.26	0.01	0.44	-0.14	-0.28	-0.11	-0.13
7	99.99	-0.41	0.03	-0.36	0.14	0.07	-0.28	-0.18	-0.04	0.06

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	-0.20	0.81	-0.23	-0.29	0.71	0.27	-0.11	0.13	-0.14	-0.21
2	-0.13	-0.09	-0.07	-0.13	0.34	0.35	-0.29	0.36	-0.34	-0.28
3	0.10	-0.01	-0.32	0.26	0.32	-0.01	0.00	0.08	-0.33	-0.04
4	0.13	0.01	-0.12	0.27	0.59	-0.19	-0.40	0.53	-0.46	-0.25
5	0.23	0.05	-0.10	0.16	0.49	-0.36	-0.48	0.47	-0.06	-0.24
6	0.07	-0.14	0.08	0.07	0.23	0.05	-0.63	0.39	-0.10	-0.05
7	0.26	0.12	0.04	0.00	0.00	-0.17	-0.22	0.24	-0.10	-0.10

Age	2021
1	-0.25
2	0.24
3	0.18
4	0.24
5	0.21
6	0.26
7	-0.10

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	2	3	4	5	6	7
Mean Log q	-6.6395	-6.1415	-5.8675	-5.7051	-5.6433	-5.6433
S.E(Log q)	0.2686	0.2268	0.3622	0.3392	0.2672	0.1565

Regression statistics (No output values (technical issue) from converged run after 51 iterations. Therefore missing values taken from run stopped after 50 iterations!)

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.7	1.725	9.99	0.77	20	0.24	-7.29

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	0.82	1.188	8.33	0.81	20	0.22	-6.64
3	0.85	1.055	7.55	0.83	20	0.19	-6.14
4	0.71	1.490	8.53	0.73	20	0.24	-5.87
5	1.59	-1.391	0.44	0.36	20	0.52	-5.71
6	1.01	-0.050	5.55	0.66	20	0.28	-5.64
7	0.96	0.444	6.01	0.91	20	0.15	-5.67

Continued

Table 4.2.12. Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run: Diagnostics. 3/4

Fleet disaggregated estimates of survivors :

Age 1 Catchability dependent on age and year class strength

Year class = 2020

BIAS SD 25-27&28.2&29S&N

Age	1							
Survivors	5239092							
Raw Weights	6.368							
Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F	
BIAS SD 25-27&28.2&29S&N	5239092	0.379	0	0	1	0.514	0.11	
P shrinkage mean	8292148	0.42				0.451	0.071	
F shrinkage mean	5183836	1.5				0.036	0.111	
Weighted prediction :								
Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F			
6440610	0.28	0.22	3	0.784	0.087			

Age 2 Catchability constant w.r.t. time and dependent on age

Year class = 2019

BIAS SD 25-27&28.2&29S&N

Age	2	1					
Survivors	10391020	6617126					
Raw Weights	9.26	5.161					
Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD 25-27&28.2&29S&N	8841267	0.236	0.216	0.92	2	0.97	0.17
F shrinkage mean	7608909	1.5				0.03	0.195
Weighted prediction :							
Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F		
8801676	0.23	0.15	3	0.651	0.182		

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2018

BIAS SD 25-27&28.2&29S&N

Age	3	2	1				
Survivors	2668720	1687888	1934119				
Raw Weights	8.27	6.891	4.01				
Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD 25-27&28.2&29S&N	2116131	0.186	0.147	0.79	3	0.977	0.308
F shrinkage mean	2221985	1.5				0.023	0.295
Weighted prediction :							
Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F		
2118473	0.19	0.12	4	0.642	0.295		

Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 2017

BIAS SD 25-27&28.2&29S&N

Age	4	3	2	1			
Survivors	2043464	1539190	1137957	1824641			
Raw Weights	4.694	5.062	3.916	2.023			
Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD 25-27&28.2&29S&N	1588181	0.174	0.128	0.74	4	0.972	0.408
F shrinkage mean	1906233	1.5				0.028	0.351
Weighted prediction :							
Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F		
1596187	0.17	0.11	5	0.638	0.405		

Continued

Table 4.2.12. Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run: Diagnostics. 4/4

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2016

BIAS SD 25-27&28.2&29S&N

Age	5	4	3	2	1		
Survivors	1177540	743419	684072	1371170	857426		
Raw Weights	5.333	3.258	3.746	2.96	1.621		
Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
BIAS SD 25-27&28.2&29S&N	952015	0.162	0.137	0.84	5	0.974	0.41
F shrinkage mean	795422	1.5				0.026	0.474
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
947646	0.16	0.12	6	0.747	0.409		

Age 6 Catchability constant w.r.t. time and dependent on age

Year class = 2015

BIAS SD 25-27&28.2&29S&N

Age	6	5	4	3	2	1	
Survivors	825952	500751	401610	689211	472510	829659	
Raw Weights	7.149	3.356	2.094	2.482	2.143	1.222	
Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
BIAS SD 25-27&28.2&29S&N	635686	0.152	0.124	0.82	6	0.976	0.44
F shrinkage mean	443133	1.5				0.024	0.584
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
630312	0.15	0.11	7	0.748	0.441		

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 6

Year class = 2014

BIAS SD 25-27&28.2&29S&N

Age	7	6	5	4	3	2	1
Survivors	658618	692402	685723	1239334	728433	1038306	1479282
Raw Weights	7.522	4.154	1.76	1.037	1.244	1.021	0.583
Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
BIAS SD 25-27&28.2&29S&N	739077	0.158	0.088	0.56	7	0.975	0.385
F shrinkage mean	665168	1.5				0.025	0.42
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
737131	0.16	0.08	8	0.509	0.39		

Table 4.2.13. Herring in SD 25–29, 32 (excl. GoR). Fishing Mortality (F) at age.

YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Age 1	0.1338	0.1376	0.0725	0.0790	0.0566	0.0269	0.0522	0.0430	0.0308	0.0369	0.0306	0.0646
Age 2	0.1097	0.1124	0.1397	0.0994	0.1390	0.1226	0.1297	0.1717	0.1567	0.1299	0.1157	0.1452
Age 3	0.1474	0.1515	0.1450	0.1491	0.1341	0.1571	0.1783	0.1820	0.1740	0.2488	0.1837	0.1842
Age 4	0.1971	0.1694	0.1471	0.1260	0.1302	0.1618	0.1605	0.2010	0.1554	0.2466	0.2823	0.2110
Age 5	0.1465	0.1967	0.1453	0.1484	0.1091	0.1623	0.1553	0.1776	0.1724	0.1810	0.2693	0.3104
Age 6	0.1503	0.1624	0.1942	0.1639	0.1317	0.1322	0.1430	0.1750	0.1572	0.2255	0.2123	0.3041
Age 7	0.1653	0.1771	0.1629	0.1467	0.1243	0.1531	0.1541	0.1859	0.1629	0.2194	0.2565	0.2770
Age 8+	0.1653	0.1771	0.1629	0.1467	0.1243	0.1531	0.1541	0.1859	0.1629	0.2194	0.2565	0.2770
FBAR 3-6	**0.1603**	**0.1700**	**0.1579**	**0.1469**	**0.1263**	**0.1533**	**0.1593**	**0.1839**	**0.1648**	**0.2255**	**0.2369**	**0.2524**

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Age 1	0.0599	0.0494	0.0674	0.0776	0.0469	0.0352	0.0816	0.0654	0.0493	0.0576	0.0843	0.0834
Age 2	0.1583	0.1289	0.1955	0.1255	0.1816	0.1611	0.1457	0.1992	0.1311	0.1399	0.1425	0.1622
Age 3	0.1891	0.2203	0.2105	0.3370	0.2034	0.2995	0.2573	0.2927	0.2687	0.3174	0.2387	0.2552
Age 4	0.2381	0.2435	0.2542	0.2683	0.3857	0.2668	0.2531	0.3663	0.3528	0.4802	0.3844	0.4265
Age 5	0.2439	0.2858	0.2785	0.3653	0.3196	0.4537	0.2534	0.3525	0.4862	0.3722	0.4820	0.5370
Age 6	0.2347	0.3006	0.2756	0.3996	0.4209	0.3460	0.4321	0.3348	0.5216	0.3777	0.5302	0.6025
Age 7	0.2402	0.2781	0.2709	0.3464	0.3773	0.3571	0.3140	0.3531	0.4562	0.4124	0.4683	0.5251
Age 8+	0.2402	0.2781	0.2709	0.3464	0.3773	0.3571	0.3140	0.3531	0.4562	0.4124	0.4683	0.5251
FBAR 3-6	**0.2265**	**0.2626**	**0.2547**	**0.3426**	**0.3324**	**0.3415**	**0.2990**	**0.3366**	**0.4073**	**0.3869**	**0.4088**	**0.4553**

YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Age 1	0.1779	0.1126	0.1732	0.1424	0.1471	0.0875	0.0695	0.0519	0.0744	0.0520	0.0472	0.0551
Age 2	0.2034	0.2416	0.2572	0.3017	0.2177	0.1704	0.1170	0.1149	0.1157	0.1254	0.1232	0.1253
Age 3	0.3363	0.3200	0.4208	0.2688	0.3679	0.2301	0.2169	0.1645	0.1712	0.2147	0.1973	0.1873
Age 4	0.4379	0.4247	0.5058	0.4922	0.3372	0.3260	0.2974	0.2803	0.2367	0.2452	0.2478	0.2797
Age 5	0.5703	0.4253	0.5492	0.4607	0.5130	0.3230	0.2961	0.3244	0.3445	0.2832	0.2683	0.2592
Age 6	0.5857	0.4729	0.4737	0.5131	0.4123	0.4276	0.3280	0.2651	0.3880	0.3957	0.4260	0.3036
Age 7	0.5344	0.4434	0.5130	0.4921	0.4302	0.3610	0.4011	0.2640	0.2919	0.3415	0.4450	0.5901
Age 8+	0.5344	0.4434	0.5130	0.4921	0.4302	0.3610	0.4011	0.2640	0.2919	0.3415	0.4450	0.5901
FBAR 3-6	**0.4826**	**0.4107**	**0.4874**	**0.4337**	**0.4076**	**0.3267**	**0.2846**	**0.2586**	**0.2851**	**0.2847**	**0.2849**	**0.2575**

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	F_{BAR} 19-21
Age 1	0.0635	0.0593	0.0296	0.0386	0.0565	0.0554	0.0686	0.1177	0.1833	0.0688	0.1141	0.0866	0.0898
Age 2	0.0819	0.1010	0.0940	0.0827	0.1070	0.1297	0.1744	0.1328	0.2285	0.2541	0.1821	0.1823	0.2061
Age 3	0.1862	0.1452	0.1052	0.1035	0.1785	0.2171	0.2368	0.2604	0.2789	0.3138	0.3804	0.2953	0.3298
Age 4	0.2629	0.2446	0.1409	0.1438	0.2135	0.3459	0.3184	0.3371	0.3904	0.3383	0.3614	0.4055	0.3684
Age 5	0.3552	0.2671	0.2132	0.1790	0.2483	0.3198	0.3950	0.4214	0.5769	0.5313	0.4306	0.4089	0.4570
Age 6	0.4188	0.3033	0.2333	0.1938	0.2259	0.3032	0.4884	0.4405	0.5754	0.8052	0.5933	0.4409	0.6131
Age 7	0.4440	0.3394	0.2456	0.2581	0.1937	0.3097	0.6926	0.7909	0.6598	0.7644	0.8852	0.3902	0.6799
Age 8+	0.4440	0.3394	0.2456	0.2581	0.1937	0.3097	0.6926	0.7909	0.6598	0.7644	0.8852	0.3902	
FBAR 3-6	**0.3058**	**0.2400**	**0.1731**	**0.1550**	**0.2165**	**0.2965**	**0.3596**	**0.3648**	**0.4554**	**0.4971**	**0.4414**	**0.3877**	

Table 4.2.14 Herring in SD 25–29, 32 (excl. GoR). Stock number-at-age (Number*10-4).**

YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Age 1	2415240	1837802	3676369	2089793	2659328	2335585	3148344	4683049	4315211	2964321	3709793	2564667	1210822
Age 2	1743321	1370226	995012	2264605	1212930	1278203	973739	1253168	2029848	1841146	1375462	1943251	1430784
Age 3	902148	1149206	871583	639107	1488848	718210	742934	501405	626879	1037953	927252	752044	1099878
Age 4	846394	605695	747971	582495	420291	924848	429072	403567	277667	345088	544673	524546	452400
Age 5	395706	550507	395442	507904	399539	267399	554394	248418	231216	166167	185336	300319	321044
Age 6	274684	274283	354639	271985	345136	264861	162618	320078	150283	141310	99587	103639	171479
Age 7	450039	189872	182678	232504	182146	229111	167679	99918	193754	95039	83632	60811	59789
Age 8+	203539	369790	359682	437948	457528	378688	440911	350463	314139	247664	207634	158285	107011
TOTAL	**7231071**	**6347382**	**7583375**	**7026341**	**7165745**	**6396905**	**6619690**	**7860067**	**8138995**	**6838687**	**7133367**	**6407561**	**4853207**

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Age 1	2437773	932609	1307202	1614803	1208195	1600557	1515109	1181779	1677271	1371370	764049	1284256	670314
Age 2	703571	1419979	529837	798766	1163324	927656	1160364	1053476	826770	1207462	996514	566915	860933
Age 3	836910	449992	803451	349694	540490	816428	658531	742671	714598	568856	845338	693696	381390
Age 4	650580	512053	278310	429201	236202	338658	529883	397545	451030	418353	368665	545928	413929
Age 5	272990	394803	306517	166906	240145	155377	226533	301985	228487	228235	236492	202435	298453
Age 6	196899	164127	234139	170882	102290	129744	104739	133268	153572	130231	117851	117205	97718
Age 7	108069	118516	100092	127525	95305	62666	72493	63349	66205	87485	64593	55031	56105
Age 8+	86831	96361	124459	104319	84579	86368	50606	83047	67851	64217	48738	47855	35774
TOTAL	**5293622**	**4088441**	**3684006**	**3762096**	**3670531**	**4117454**	**4318257**	**3957119**	**4185784**	**4076209**	**3442240**	**3513322**	**2814615**

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Age 1	1349997	929461	892496	1859183	1119116	758468	1337166	1072783	2054296	1469562	1086413	621868	1372528
Age 2	465068	836038	586504	553313	1273276	796939	521350	881721	721999	1361709	956859	681398	392852
Age 3	545888	285723	485897	367787	380118	885694	539091	365654	610008	492638	908844	647893	465043
Age 4	228796	288481	176313	269913	241628	252801	586296	359147	234871	393522	321010	582864	434210
Age 5	225650	112171	143223	103140	162887	149908	155295	369846	227809	146978	235902	196294	364818
Age 6	164730	107104	58281	70835	62869	102818	89981	89915	227203	143052	92116	132054	122549
Age 7	51996	85419	53074	32135	39126	38633	66409	51141	50612	120763	87231	49120	79911
Age 8+	49864	55723	71335	71766	42062	73880	62877	41592	64929	58238	110348	89122	102720
TOTAL	**3081987**	**2700121**	**2467123**	**3328073**	**3321083**	**3059141**	**3358465**	**3231798**	**4191729**	**4186463**	**3798723**	**3000613**	**3334631**

YEAR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	GMST 74-19	AMST 74-19
Age 1	1482189	1021400	3046155	1049478	1012606	1172118	708551	1742122	946369	0	1532157	1751988
Age 2	926910	999888	678212	2139203	734719	688513	764533	518244	1192488	644061	974429	1062788
Age 3	289594	677309	710976	486288	1393826	523078	453963	491370	354385	880168	634467	682061
Age 4	336947	217894	465755	475605	318940	883977	336572	282084	281684	211847	405412	436534
Age 5	310319	241813	149238	278882	290680	193244	509812	204486	166961	159619	247318	268493
Age 6	247704	219110	158998	92825	159454	162845	94169	260024	113961	94765	145434	160562
Age 7	82044	174595	149561	100556	48733	88522	79550	36558	123900	63031	88885	105077
Age 8+	105574	152513	189961	134044	79879	73583	47438	41244	42863	99014		
TOTAL	**3781280**	**3704522**	**5548855**	**4756880**	**4038838**	**3785881**	**2994589**	**3576133**	**3222612**	**2152505**		
	Age 1 Geometric mean 1988-2020:				12,085,821 thousands							

Table 4.2.15. Herring in SD 25–29, 32 (excl. GoR). Output from XSA: Stock Summary.

Run title : Herring in Sub-div. 25 to 29 and 32 (excl. Gulf of Riga)

At 11/04/2022 17:17

Table 16 Summary (without SOP correction)

Year	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 6
1974	24152396	3136138	1932049	368652	0.1908	0.1603
1975	18378024	2883958	1864358	354851	0.1903	0.1700
1976	36763692	2890070	1672283	305420	0.1826	0.1579
1977	20897926	3047768	1944702	301952	0.1553	0.1469
1978	26593278	3130503	1905016	278966	0.1464	0.1263
1979	23355852	2880570	1814695	278182	0.1533	0.1533
1980	31483436	2831923	1626620	270282	0.1662	0.1593
1981	46830484	3083547	1438156	293615	0.2042	0.1839
1982	43152104	3025649	1520923	273134	0.1796	0.1648
1983	29643208	2481656	1421081	307601	0.2165	0.2255
1984	37097924	2276758	1266531	277926	0.2194	0.2369
1985	25646666	1969472	1177170	275760	0.2343	0.2524
1986	12108219	1643080	1090962	240516	0.2205	0.2265
1987	24377732	1652323	1011768	248653	0.2458	0.2626
1988	9326093	1515159	1013758	255734	0.2523	0.2547
1989	13072021	1415370	856399	275501	0.3217	0.3426
1990	16148029	1220574	714738	228572	0.3198	0.3324
1991	12081950	1133557	647405	197676	0.3053	0.3415
1992	16005570	1073507	675675	189781	0.2809	0.2990
1993	15151085	1059567	649450	209094	0.3220	0.3366
1994	11817790	1057255	651933	218260	0.3348	0.4073
1995	16772708	901215	540068	188181	0.3484	0.3869
1996	13713703	801031	484751	162578	0.3354	0.4088
1997	7640494	694757	454223	160002	0.3523	0.4553
1998	12842558	683752	419320	185780	0.4431	0.4826
1999	6703138	575207	364352	145922	0.4005	0.4107
2000	13499970	661969	354684	175646	0.4952	0.4874
2001	9294614	599917	337937	148404	0.4391	0.4337
2002	8924963	566147	327979	129222	0.3940	0.4076
2003	18591826	641195	356515	113584	0.3186	0.3267
2004	11191155	583410	366701	93006	0.2536	0.2846
2005	7584684	616444	408566	91592	0.2242	0.2586
2006	13371659	723249	443921	110372	0.2486	0.2851
2007	10727826	733082	461666	116030	0.2513	0.2847
2008	20542962	876164	461038	126155	0.2736	0.2849
2009	14695621	865648	517884	134127	0.2590	0.2575
2010	10864127	846017	544829	136706	0.2509	0.3058
2011	6218677	759111	537669	116785	0.2172	0.2400
2012	13725282	887121	574973	100893	0.1755	0.1731
2013	14821888	923200	606569	100954	0.1664	0.1550
2014	10213996	958208	672220	132700	0.1974	0.2165
2015	30461546	1002324	625069	174433	0.2791	0.2965
2016	10494777	850403	560793	192056	0.3425	0.3596
2017	10126062	873728	582760	202517	0.3475	0.3648
2018	11721181	875775	571495	244365	0.4276	0.4554
2019	7085511	710130	464975	204438	0.4397	0.4971
2020	17421222	715967	384556	177079	0.4605	0.4414
2021	9463690	609680	387052	128961	0.3332	0.3877
Arith. Mean	17349987	1373818	827255	200888	0.2816	0.2977
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 4.2.16.Herring in SD 25–29, 32 (excl. GoR). Configuration settings of SAM.

Min Age (should not be modified unless data is modified accordingly)
1
Max Age (should not be modified unless data is modified accordingly)
8
Max Age considered a plus group (0=No, 1=Yes)
1
The following matrix describes the coupling
of fishing mortality STATES
Rows represent fleets.
Columns represent ages.
1 2 3 4 5 6 7
7
0 0 0 0 0 0 0
0
Use correlated random walks for the fishing mortalities
(0 = independent, 1 = correlation estimated)
1
Coupling of catchability PARAMETERS
0 0 0 0 0 0 0
0
1 2 3 4 5 6 7
8
Coupling of power law model EXPONENTS (if used)
0 0 0 0 0 0 0
0
1 0 0 0 0 0 0
0
Coupling of fishing mortality RW VARIANCES
1 1 1 1 1 1 1
1
0 0 0 0 0 0 0
0
Coupling of log N RW VARIANCES
1 2 2 2 2 2 2
2
Coupling of OBSERVATION VARIANCES
1 2 2 2 2 2 2
2
3 3 3 3 3 3 3
3
Stock recruitment model code (0=RW, 1=Ricker, 3=BH, ... more in time)
0
Years in which catch data are to be scaled by an estimated parameter
0
first the number of years
Then the actual years
Them the model config lines years cols ages
Define Fbar range
3 6

Table 4.2.17. Herring in SD 25–29, 32 (excl. GoR). Input for RCT3 analysis.

Yearclass	VPA Age 1 backshift. (millions)	Acoustic (SD 25-29S+N) Age 0 (millions)			
1991	16006	13733		16006	13733
1992	15151	1608		15151	1608
1993	11818	-11		11818	-11
1994	16773	6122		16773	6122
1995	13714	-11		13714	-11
1996	7640	336		7640	336
1997	12843	-11		12843	-11
1998	6703	508		6703	508
1999	13500	2591		13500	2591
2000	9295	1319		9295	1319
2001	8925	2123		8925	2123
2002	18592	16046		18592	16046
2003	11191	9067		11191	9067
2004	7585	1587		7585	1587
2005	13372	5568		13372	5568
2006	10728	1990		10728	1990
2007	20543	12197		20543	12197
2008	14696	8673		14696	8673
2009	10864	3366		10864	3366
2010	6219	1178		6219	1178
2011	13725	10098		13725	10098
2012	14822	11141		14822	11141
2013	10214	**2582**		10214	2582
2014	30462	**30301**		30462	30301
2015	10495	**7175**	**revised by WGBIFS 2020**	10495	7175
2016	10126	**2956**		10126	2956
2017	11721	7184		11721	7184
2018	7086	2052		7086	2052
2019	17421	22620		17421	22620
2020	-11	5763		-11	5763
2021	-11	3072		-11	3072

Table 4.2.18. Herring in SD 25–29, 32 (excl. GoR). Output from RCT3 analysis.

Analysis by RCT3 ver3.1 of data from file : rct3in.txt
Herring 25-32 (excl. GOR). RCT3 input data
Data for 1 surveys over 30 years : 1991 - 2020
Regression type = C
Tapered time weighting applied
power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E. for any survey taken as .20
Minimum of 3 points used for regression
Forecast/Hindcast variance correction used.

Yearclass		**2015**								
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.46	5.46	0.2	0.825	22	7.99	9.15	0.233	0.761
				VPA	Mean =		9.44	0.416	0.239
Yearclass		**2016**							
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.45	5.64	0.19	0.854	21	8.88	9.61	0.214	0.802
				VPA	Mean =		9.46	0.43	0.198
Yearclass =		**2017**							
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.46	5.44	0.19	0.837	23	8.88	9.56	0.216	0.781
				VPA	Mean =		9.43	0.408	0.219
Yearclass =		**2018**							
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.47	5.35	0.19	0.829	24	7.63	8.95	0.225	0.755
				VPA	Mean =		9.43	0.396	0.245
Yearclass =		**2019**							
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.49	5.21	0.18	0.849	25	10.03	10.1	0.23	0.765
				VPA	Mean =		9.39	0.415	0.235
Yearclass =		**2020**							
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.46	5.39	0.19	0.844	26	8.66	9.4	0.214	0.791
				VPA	Mean =		9.42	0.416	0.209
Yearclass =		**2021**							
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.46	5.38	0.19	0.847	26	8.03	9.1	0.222	0.783
				VPA	Mean =		9.42	0.421	0.217

Year Class	**Weighted Average Prediction**	**Log WAP**	**Int Std Error**	**Ext Std Error**	**Var Ratio**	**VPA**	**Log VPA**
2015	14207	9.56	0.19	0.06	0.09	10496	9.26
2016	10112	9.22	0.20	0.12	0.37	10127	9.22
2017	13818	9.53	0.19	0.05	0.08	11721	9.37
2018	8684	9.07	0.20	0.21	1.1	7086	8.87
2019	20513	9.93	0.20	0.30	2.23	17421	9.77
2020	12118	9.40	0.19	0.01	0.00		
2021	9597	9.17	0.20	0.13	0.44		

Table 4.2.19. Herring in SD 25–29, 32 (excl. GoR). Input data for short-term predictions.

MFDP version 1a
Run: initial/sq
Time and date: 18:38 4/14/2022
Fbar age range: 3-6

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	9597000	0.2547	0	0.35	0.3	0.0107	0.0898	0.0107
2	6440610	0.1927	0.7	0.35	0.3	0.0197	0.2062	0.0197
3	8801680	0.1697	0.9	0.35	0.3	0.0241	0.3298	0.0241
4	2118470	0.1607	1	0.35	0.3	0.0297	0.3684	0.0297
5	1596190	0.1490	1	0.35	0.3	0.0320	0.4569	0.0320
6	947650	0.1447	1	0.35	0.3	0.0362	0.6131	0.0362
7	630310	0.1413	1	0.35	0.3	0.0416	0.6799	0.0416
8	990140	0.1363	1	0.35	0.3	0.0459	0.6799	0.0459

2023

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	12085820	0.2547	0	0.35	0.3	0.0107	0.0898	0.0107
2		0.1927	0.7	0.35	0.3	0.0197	0.2062	0.0197
3		0.1697	0.9	0.35	0.3	0.0241	0.3298	0.0241
4		0.1607	1	0.35	0.3	0.0297	0.3684	0.0297
5		0.1490	1	0.35	0.3	0.0320	0.4569	0.0320
6		0.1447	1	0.35	0.3	0.0362	0.6131	0.0362
7		0.1413	1	0.35	0.3	0.0416	0.6799	0.0416
8		0.1363	1	0.35	0.3	0.0459	0.6799	0.0459

2024

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	12085820	0.2547	0	0.35	0.3	0.0107	0.0898	0.0107
2		0.1927	0.7	0.35	0.3	0.0197	0.2062	0.0197
3		0.1697	0.9	0.35	0.3	0.0241	0.3298	0.0241
4		0.1607	1	0.35	0.3	0.0297	0.3684	0.0297
5		0.1490	1	0.35	0.3	0.0320	0.4569	0.0320
6		0.1447	1	0.35	0.3	0.0362	0.6131	0.0362
7		0.1413	1	0.35	0.3	0.0416	0.6799	0.0416
8		0.1363	1	0.35	0.3	0.0459	0.6799	0.0459

Input units are thousands and kg - output in tonnes

M =	Natural mortality
MAT =	Maturity ogive
PF =	Proportion of F before spawning
PM =	Proportion of M before spawning
SWT =	Weight in stock (kg)
Sel =	Exploit. Pattern
CWT =	Weight in catch (kg)

N_{2022} Age 1:	Output form RCT3 Analysis (Table 6.2.17)
N_{2022} Age 2-8+:	Output from VPA (Table 6.2.14)
$N_{2023/2024}$ Age 1:	Geometric Mean from VPA-Output of age 1 (Table 6.2.14) for the years **1988-2020**
Natural Mortality (M):	Average of 2019-2021
Weight in the Catch/Stock (CWt/SWt):	Average of 2019-2021
Expoitation pattern (Sel):	Average of 2019-2021

Table 4.2.20. Herring in SD 25–29, 32 (excl. GoR). Output from short-term predictions with management option table for *'TAC constraint' in 2022.

MFDP version 1a
Run: TACConstraint
CBH Prediction
Time and date: 14:32 4/24/2022
Fbar age range: 3-6

2022				
Biomass	SSB	FMult	FBar	Landings
661205	446582	1	0.2011	84767

2023					2024	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
738679	529347	0	0	0	904801	672994
	525991	0.1	0.0201	10228	893925	658564
	522658	0.2	0.0402	20264	883251	644513
	519349	0.3	0.0603	30112	872775	630829
	516064	0.4	0.0804	39778	862492	617501
	512803	0.5	0.1006	49264	852399	604519
	509565	0.6	0.1207	58576	842491	591871
	506351	0.7	0.1408	67716	832764	579549
	503159	0.8	0.1609	76688	823214	567542
	499991	0.9	0.1810	85496	813838	555842
	496845	1.0	0.2011	94144	804631	544439
	493721	1.1	0.2212	102635	795591	533324
	490620	1.2	0.2413	110972	786713	522490
	487541	1.3	0.2614	119159	777993	511927
	484484	1.4	0.2815	127199	769430	501629
	481448	1.5	0.3017	135095	761018	491587
	478434	1.6	0.3218	142850	752756	481794
	475442	1.7	0.3419	150467	744639	472243
	472471	1.8	0.3620	157949	736665	462927
	469521	1.9	0.3821	165299	728831	453840
	466592	2.0	0.4022	172520	721134	444974

Input units are thousands and kg - output in tonnes

*'Catch constraint' in 2022:		
EU	53,653	t
+ EU/Russia	28,362	t (= assumed based on regression of Russian and EU share)#
+ CBH in GOR	3,448	t (= mean catches 16-20)
- GORH	696	t (= mean catches 16-20)
Total	84,767	t

There was a positive relationship between the EU TAC and the Russian TAC for the years 2017 to 2021. The regression (y = 0.0082x + 27.922) was used to predict the Russian quota in 2022 from the EU TAC 2022.

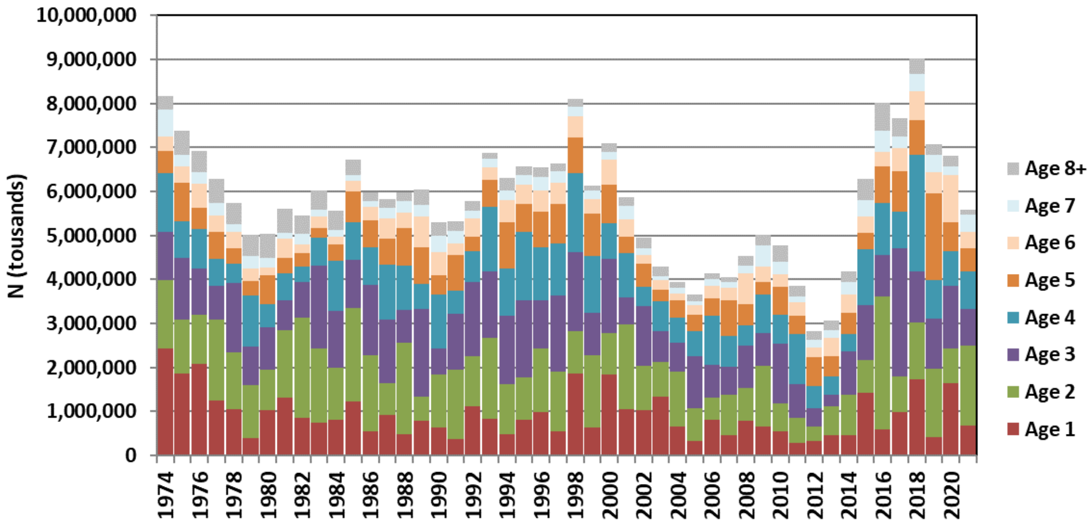


Figure 4.2.1. Herring in SD 25–29, 32 (excl. GoR). Proportions of age groups (numbers) in total catch (CANUM).

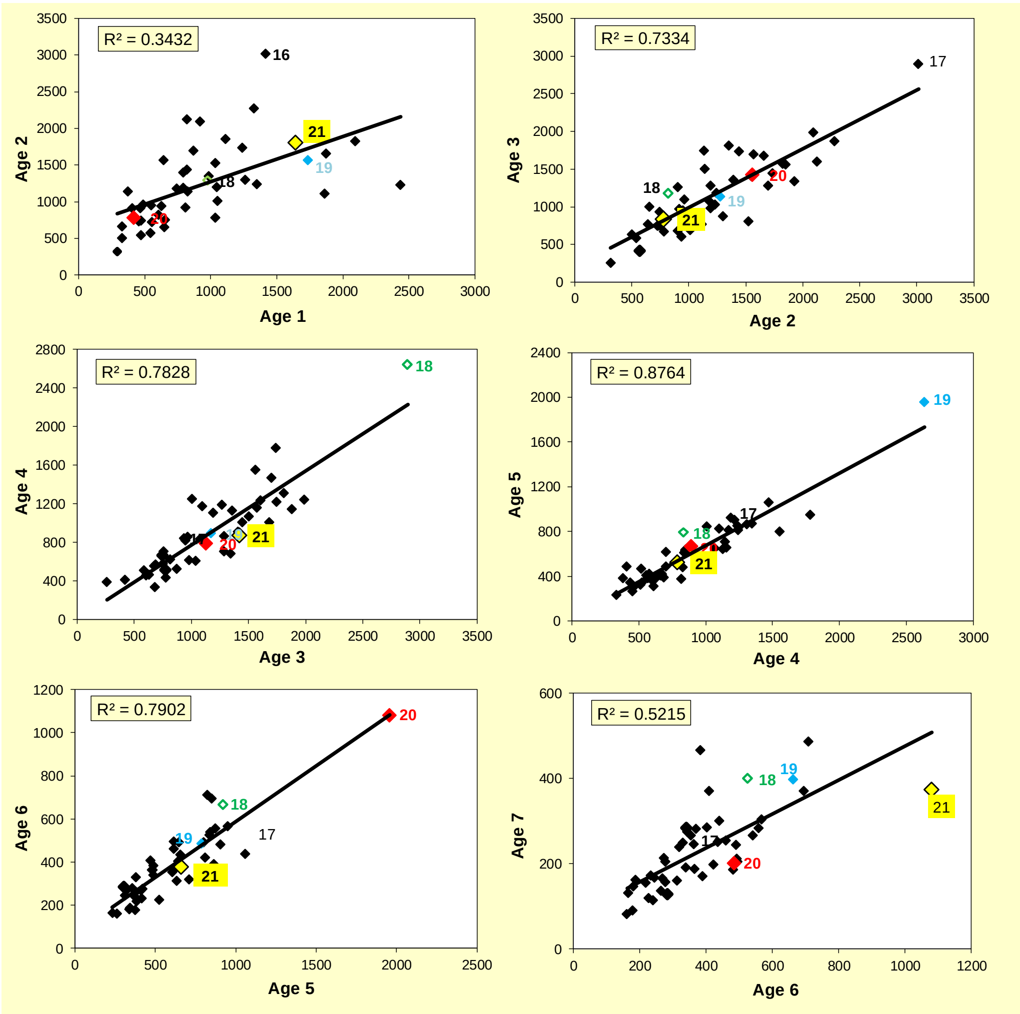


Figure 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Catch in numbers (thousands) at age vs. numbers-at-age +1 of the same cohort in the following year in the period 1974–2021.

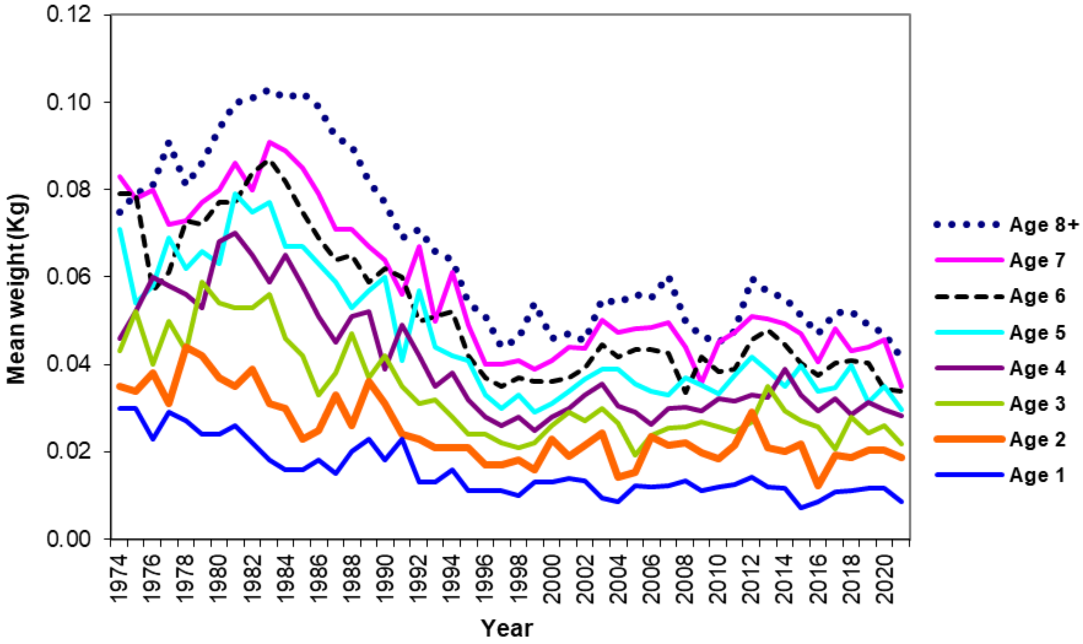


Figure 4.2.3. Herring in SD 25–29, 32 (excl. GoR).
Trends in the mean weights at age (kg) in the catch (WECA).

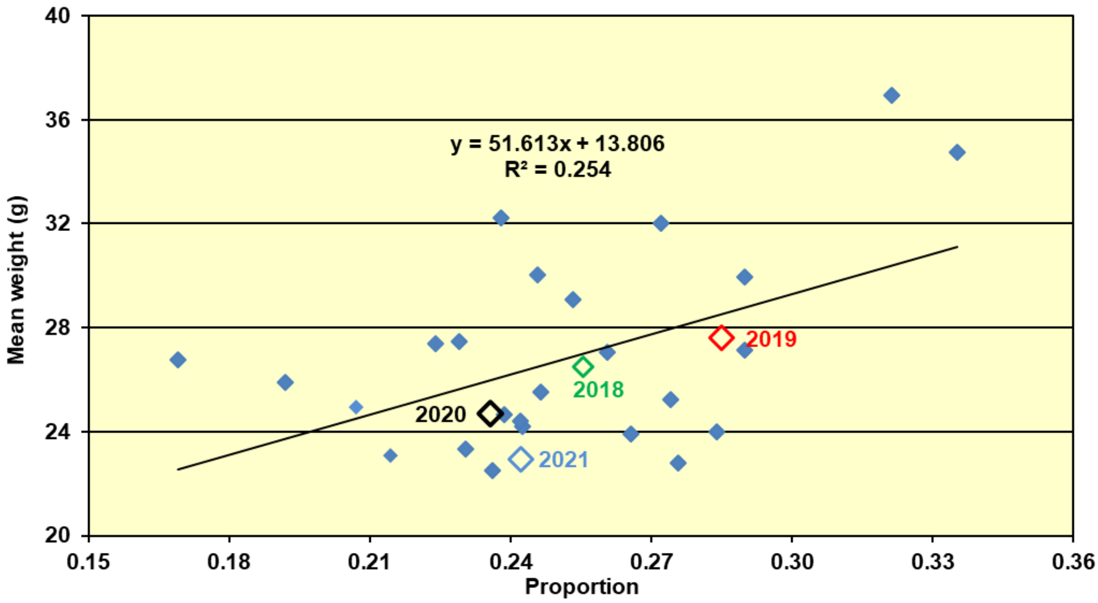


Figure 4.2.4. Herring in SD 25–29, 32 (excl. GoR). Average individual weight in catches vs. the proportion of catches taken in SD 25 and plus SD 26 (1993–2021).

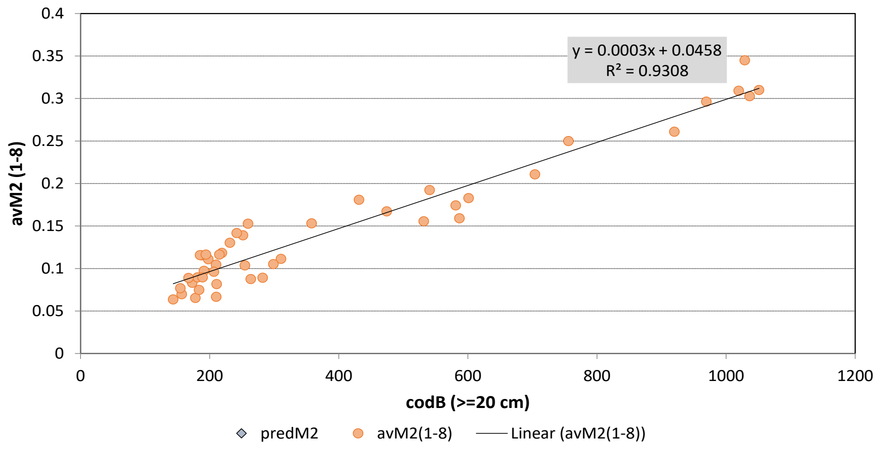


Figure 4.2.5. Herring in SD 25-29, 32 (excl. GOR). Regression of average M2 in 1974-2018 against biomass of cod at length >=20 cm.

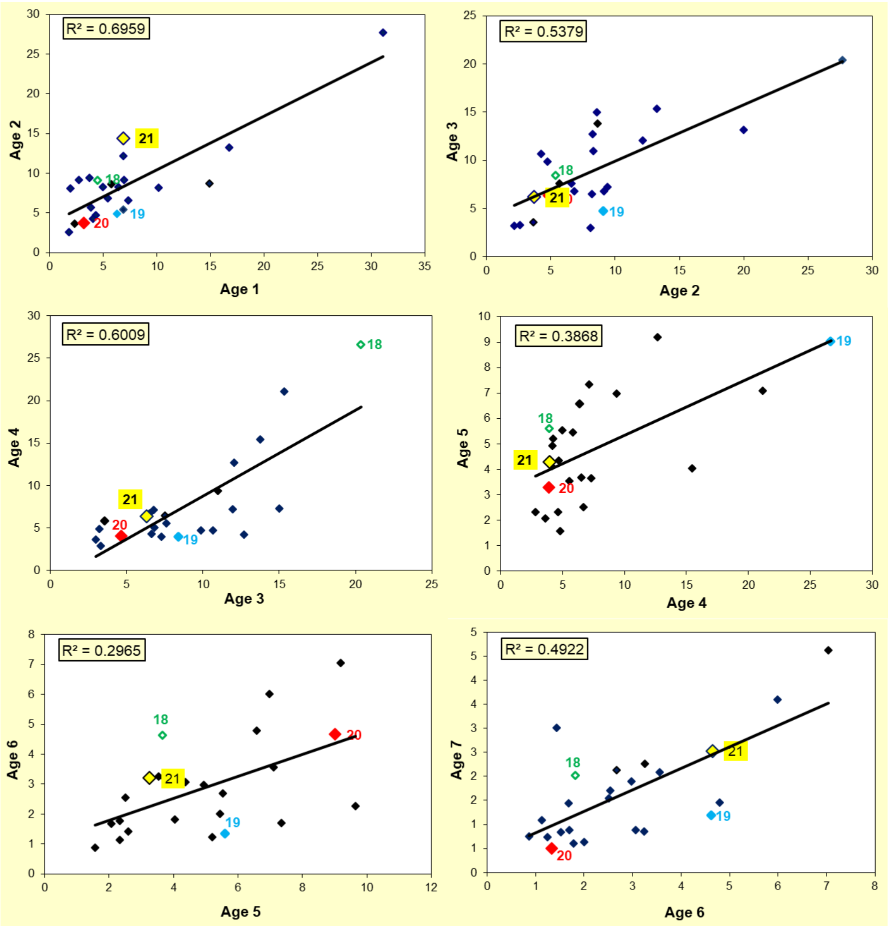


Figure 4.2.6. Herring in SD 25–29, 32 (excl. GoR). Acoustic survey numbers-at-age vs. numbers-at-age +1 of the same cohort in the following year in the period 1991–2021 (STANDARD INDEX). Years 1993, 1995, and 1997 were excluded.

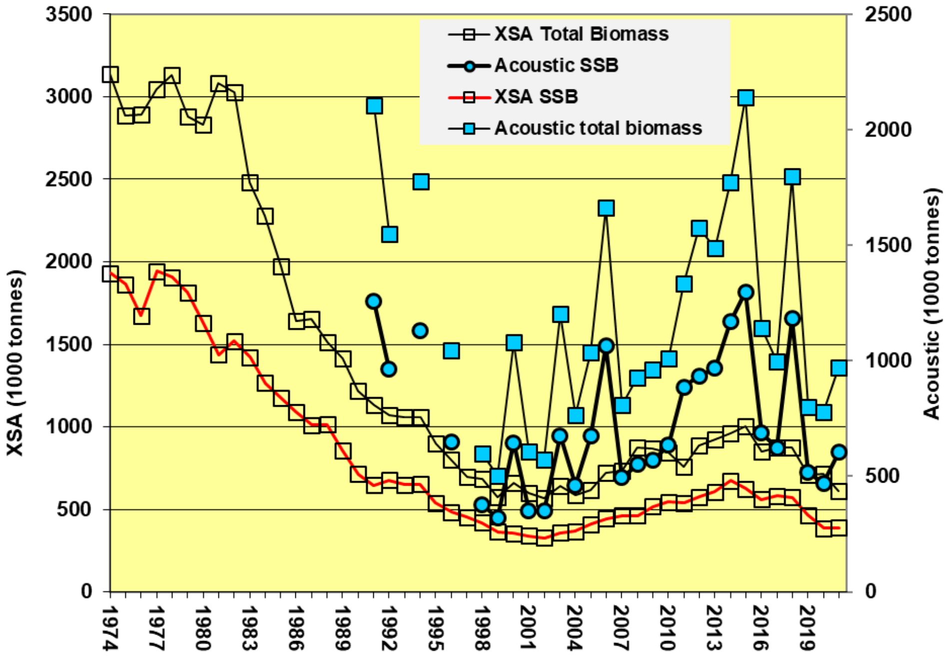


Figure 4.2.7. Herring in SD 25-29, 32 (excl. GOR). Estimates of biomass and SSB from acoustic surveys (BIAS) and from XSA. Acoustic biomasses = Acoustic abundances x WECA ; Acoustic SSB = Acoustic abundances x WECA x MATPROP

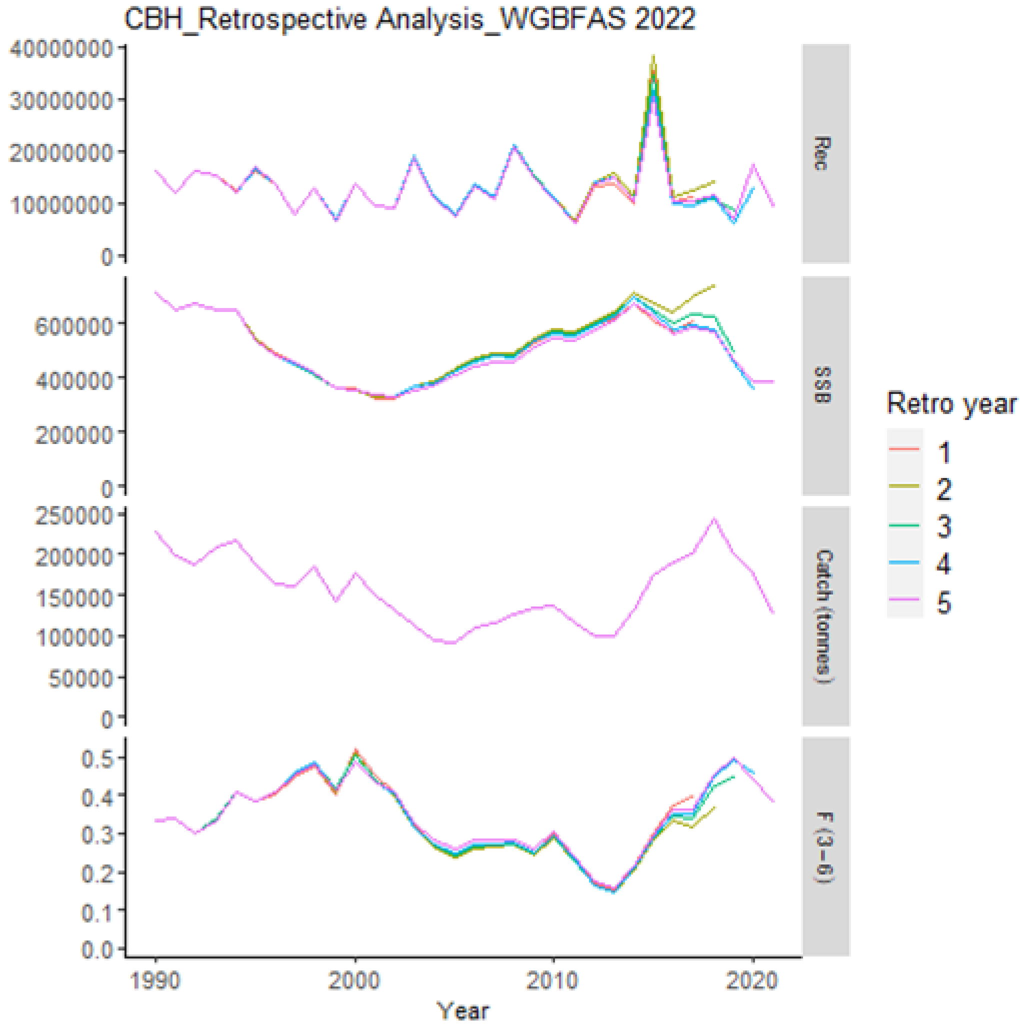


Figure 4.2.8. Herring in SD 25–29, 32 (excl. GoR). Retrospective Analysis.
Mohn's rho

SSB:	**0.0895**
Recruitment:	**0.0514**
Fbar:	**-0.0428**

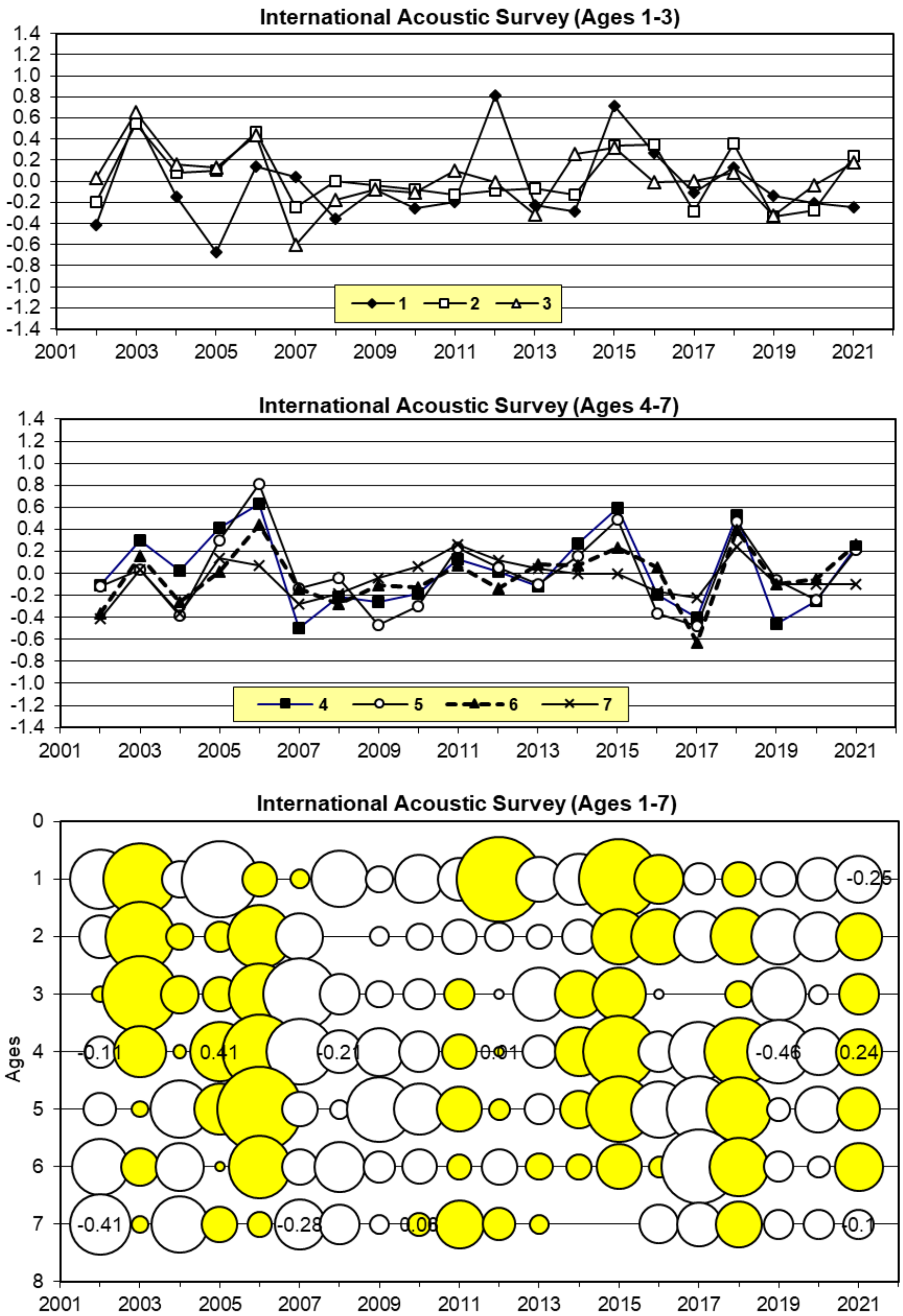


Figure 4.2.9. Herring in SD 25–29, 32 (excl. GoR). International Acoustic Survey (Ages 1–7): Log Catchability residuals. Standardized log catchability residuals (top figure). Observed (circles) vs predicted (line) numbers (bottom figure).

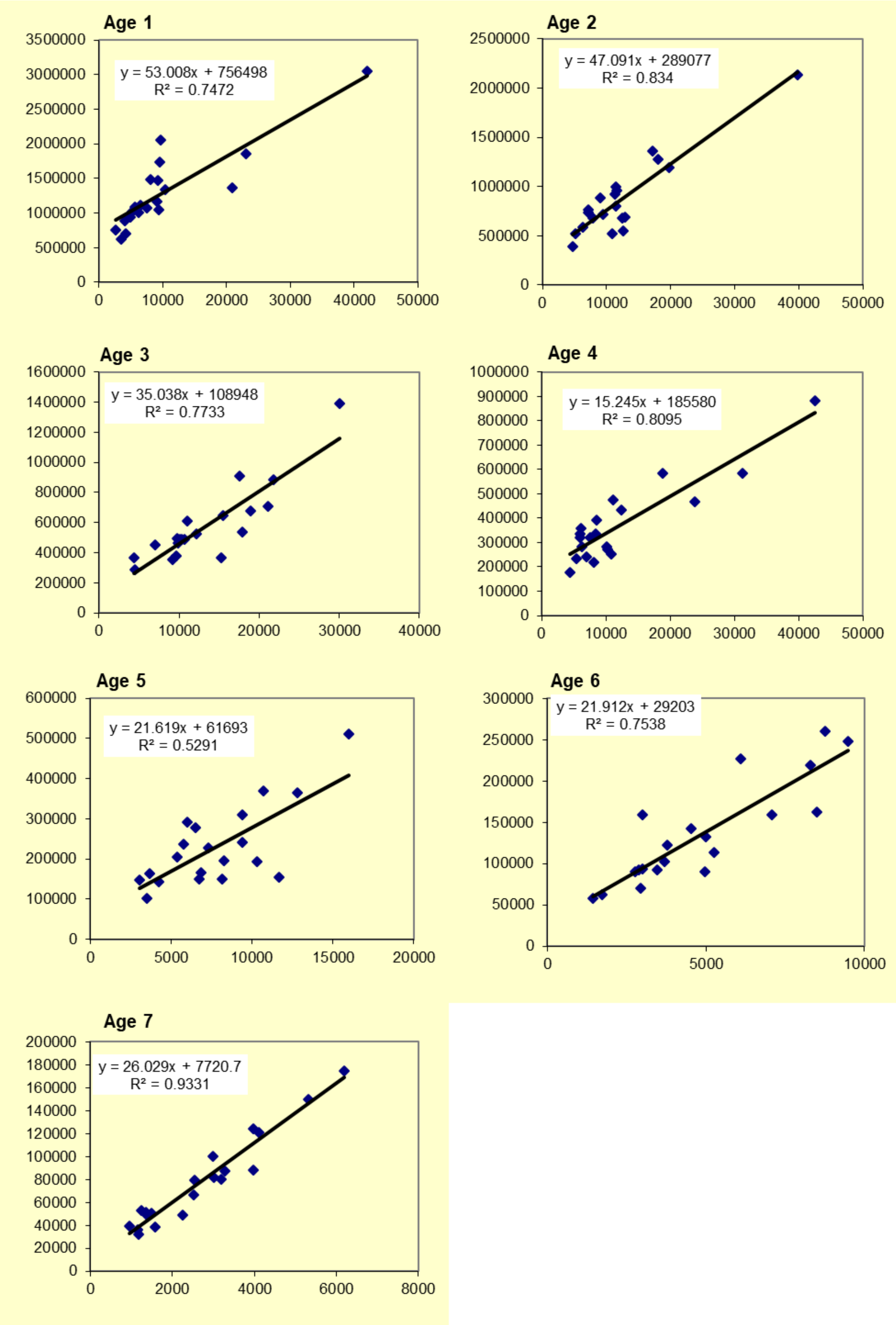


Figure 4.2.10. Herring in SD 25–29, 32 (excl. GoR). Regression of XSA population vs. acoustic survey population numbers. x-axis = Acoustic estimates; y-axis = XSA.

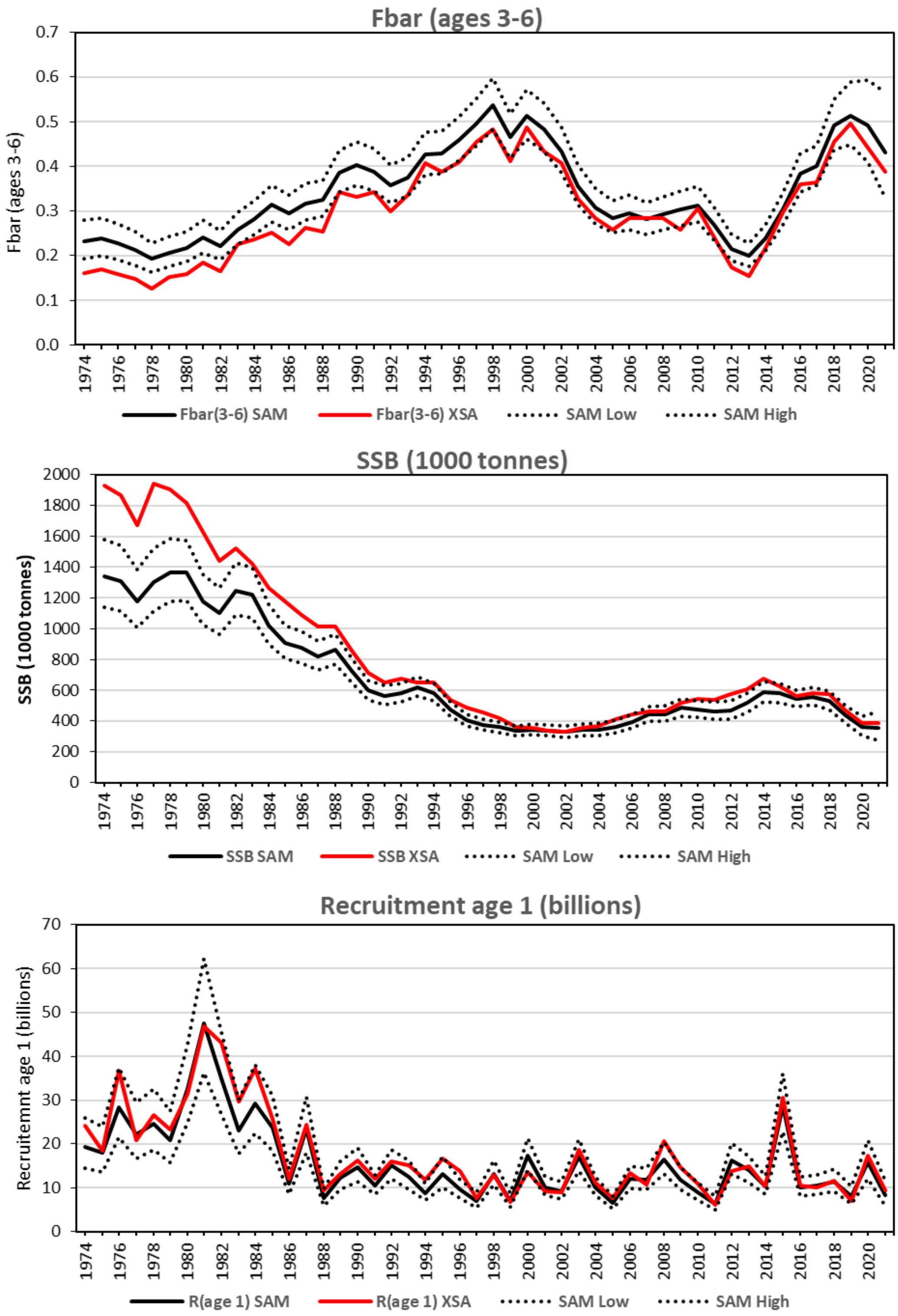


Figure 4.2.11. Herring in SD 25–29, 32 (excl. GoR). Comparison of fishing mortality (F_{3-6}), spawning stock biomass (SSB) and recruitment (age 1) from XSA and SAM (the dotted line represents the 95% confidence intervals of the SAM results).

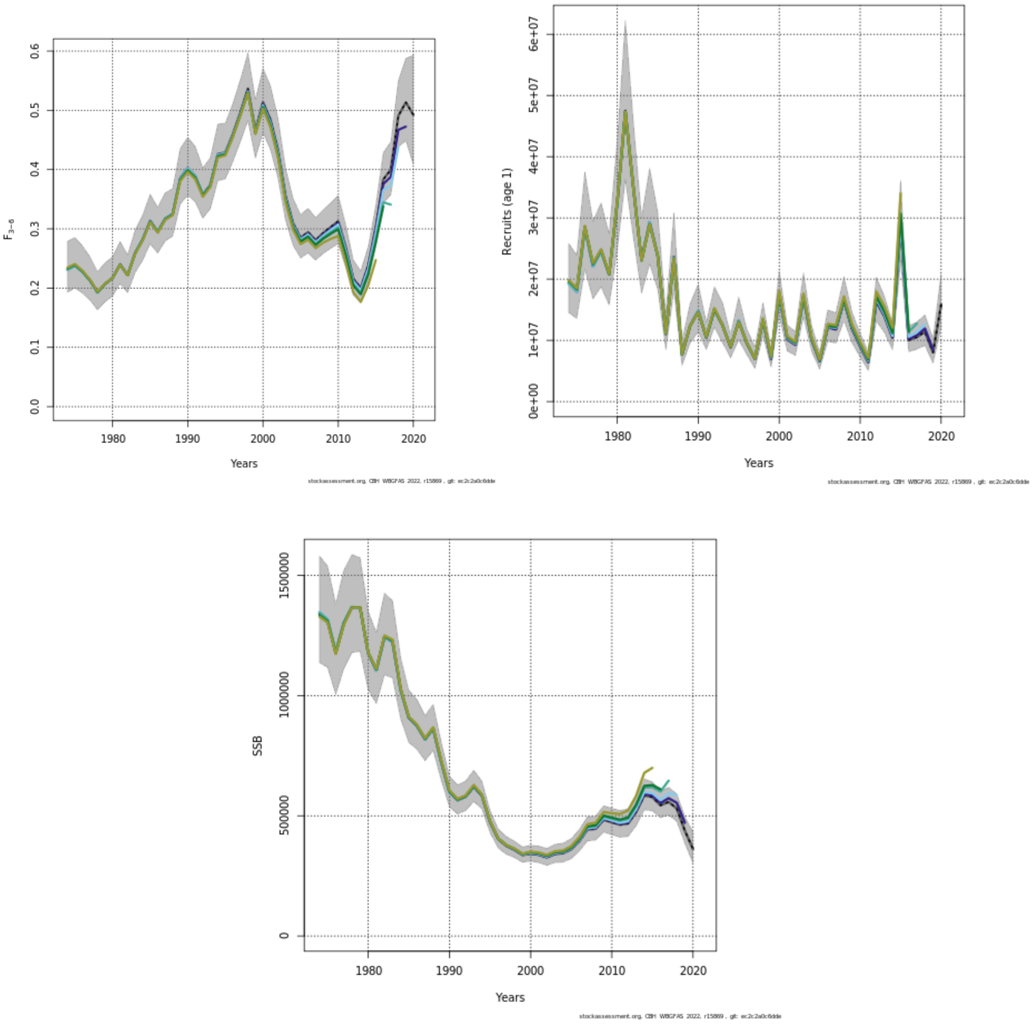


Figure 4.2.12. Herring in SD 25–29, 32 (excl. GoR). Retrospective of SAM.

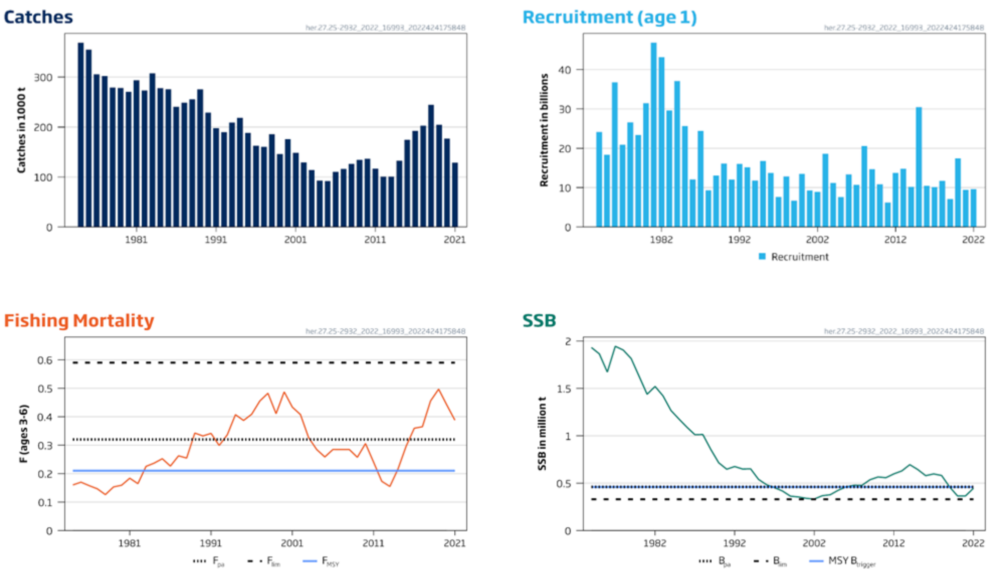


Figure 4.2.13. Herring in SD 25–29, 32 (excl. GoR). Summary sheet plots: Catches, fishing mortality, recruitment (age 1) and SSB. (Recruitment in 2022 from RCT3 & SSB in 2022 predicted)

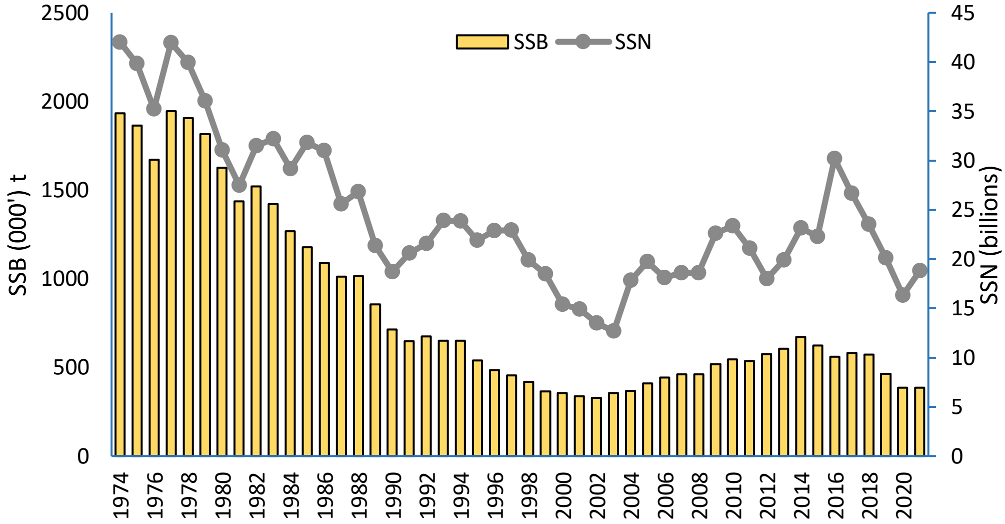


Figure 4.2.14. Herring in SD 25–29, 32 (excl. GoR). SSB (000' t) and Spawning Stock in Numbers (SSN) (billions).

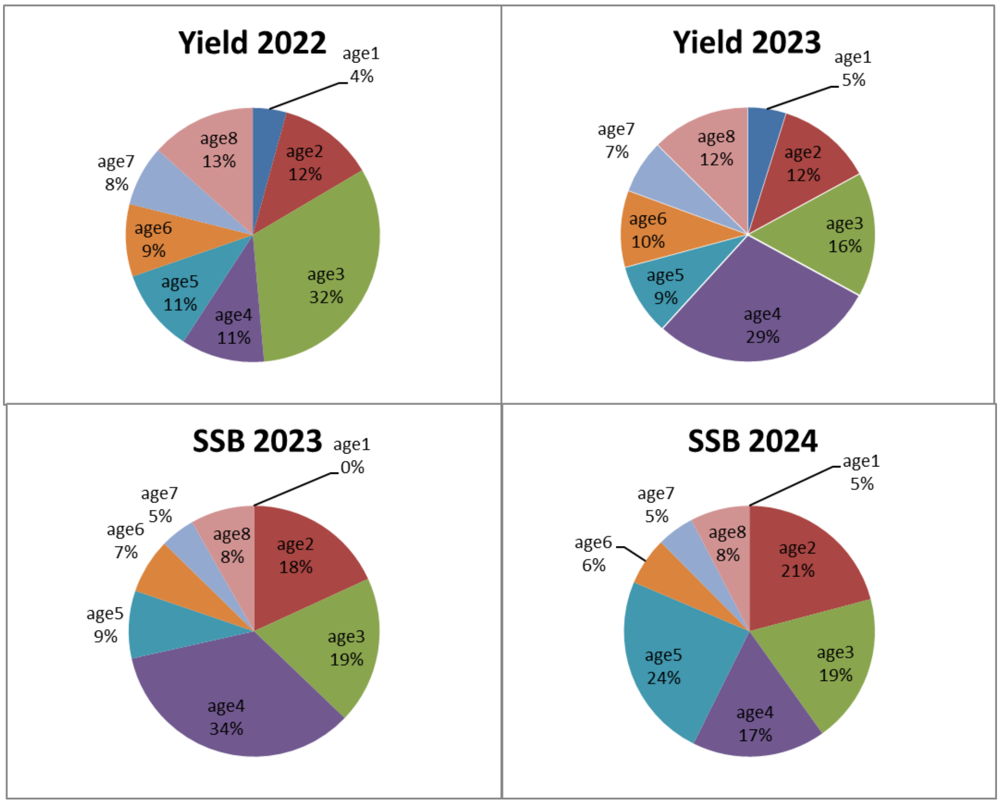


Figure 4.2.15. Herring in SD 25–29, 32 (excl. GoR). Yield and SSB at age 1-8+ as estimated in the short-term forecast for 2022-2024 under the TAC constraint 2022.

4.3 Gulf of Riga herring (Subdivision 28.1) (update assessment)

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 smallest 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 differences in otolith structure serve as a basis for discrimination of Baltic herring populations (ICES, 2005; Ojaveer *et al.*, 1981; Raid *et al.* 2005). When fish are aged they are also assigned their population belonging. The stock does not migrate into the Baltic Proper; only minor part of the older herring leaves the gulf after spawning season in summer –autumn period but afterwards returns to the gulf. There is evidence, that the migrating fish 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 fish was considered negligible. Since the beginning of 1990s when the stock size increased also the number of migrating fish increased and the catches of the Gulf of Riga herring outside the Gulf of Riga in Subdivision 28.2 are taken into account 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 2021 these catches were 775 t, while the average catches in the last five years were 794 t. These catches are included in the total Gulf of Riga herring landings (Table 4.3.1b) and CATON (Table 4.3.4).

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 rather stable following the changes of TAC which is usually almost fully utilised. In 2021 the total catches of herring in the Gulf of Riga were 38 110 t (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 2020 and 2021 the catches of the Gulf of Riga herring stock increased and were 33 215 t and 35 758 t respectively (Table 4.3.1b).

The landings of Central Baltic herring in the Gulf of Riga were 3126 t in 2021 (Table 4.3.1b). The average catch of Central Baltic herring in the last five years was 3 211t.

The trap-net catches of Gulf of Riga herring were 7022 t and almost equal to those in 2020 and 18% higher than in 2019. The fishing effort in trap-net fishery has remained the same since 2015. The trap-net catches comprised 20% of the total catches of Gulf of Riga herring in 2021.

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. In the 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 were assumed in 2011–2021. The level of misreporting in Estonian herring fishery has been low in 1995–2021 and therefore the official catch figures were used in the assessment.

4.3.2 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.

4.3.3 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. In 2021 the number of trap-nets remained at the same level as in the previous year (Table 4.3.8). Until the beginning of 2000s the trawl fishery has been permanently performed by 70 Latvian and 5–10 Estonian vessels with 150–300 HP engines. A considerable increase (more than 270%) in trawl catches of Gulf of Riga herring was observed in Estonia in 2002–2004 but was substantially reduced in 2005–2018. In Latvia the number of trawl fleet vessels is gradually decreasing due to scrapping and there were 20 active vessels in 2021. 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.

4.3.4 Biological composition of the catch

4.3.4.1 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 4.3.3, figures 4.3.1 and 4.3.2). The available catch-at-age data are for ages 1–8+. In XSA ages 1–8+ and in tuning fleets ages 1–8 are used.

4.3.4.2 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 4.3.2. In 2021 the sample number per 1000 t was as follows: in Estonia 2.0 samples and in Latvia 3.1 samples. The check of consistency of catch-at-age data is shown in Figure 4.3.3.

4.3.4.3 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 4.3.6, 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. Particularly low mean weight was recorded for 1-year-old herring (abundant year class of 2002), that was the lowest on record. In 2009 the mean weight-at-age decreased in most of the age groups in comparison with the previous year and stayed low also in 2010. In 2011–2013 the feeding conditions in the Gulf of Riga were favourable for herring and the mean weight-at-age increased in all age groups while the average Fulton's condition factor of herring in autumn of 2011 was the highest in the last 20 years (Putnis *et al.*, 2011). Since 2012 mean weight-at-age slightly fluctuated and showed a decreased trend for older age groups. In 2021 the mean weight-at-age decreased in most of the age groups (Figure 4.3.4).

4.3.4.4 Maturity at age

As no special surveys on herring maturity are performed in the Gulf of Riga it was decided to use the same maturity ogives as in previous years (Table 4.3.5).

4.3.4.5 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 (Table 4.3.7). 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.

4.3.5 Tuning Fleets

Two tuning fleets were available: from trap-net fishery (1996–present) and from fishery independent joint Estonian-Latvian hydro-acoustic survey in the Gulf of Riga which has been carried out in the end of July-beginning of August since 1999. The tuning data are given in Tables 4.3.8 and 4.3.9. The check of internal consistency of tuning data is shown in figures 4.3.5 and 4.3.6.

In trap-net fleet (Figure 4.3.5) the internal consistencies between age groups in 2021 correlated well with those in earlier years. In acoustic fleet the correlation did not change significantly, however the survey results of 2018 indicated a strong year effect (Figures 4.3.7 and 4.3.8b). Due to exceptional environment situation (very warm summer) of 2018, the age group 0 herring were more distributed offshore in main survey area giving strong acoustic signal. The echo energy of those individuals is represented in NASC estimates, but not represented in control catches (e.g. some scatters in the water may not be represented in the hauls). Thus, the total acoustic estimate of 2018 was elevated. The acoustic estimates from the 2020 and 2021 surveys confirmed that the abundance of the 2017-year class is well above the average and the 2019-year class is also abundant.

4.3.6 Assessment (update assessment)

4.3.6.1 Recruitment estimates

The historical dynamics of the recruitment (age 1) reveal a trend rather similar to that of the spawning stock biomass. The recruitment fluctuated between 500–3000 millions in the 1970s and

1980s mainly having the values at the lower end. In the 1990s the reproduction of Gulf of Riga herring improved and recruitment had values above long-term average in most of the years (Table 4.3.13). In 2000s two record high year classes appeared reaching values over 7000 million at age 1 in the beginning of the year.

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. In 2012, it was decided to use for the short-term forecast geometric mean of year classes over the period from 1989 corresponding to period of improved reproduction conditions and prevalence of mild winters. Hence, since 2012 the estimate of recruitment (age 1) for short-term forecast is calculated as geometric mean of year classes 1989 – present-1 (excluding the latest year-class). The corresponding estimate for year-class 2021 in this year short-term forecast is 3358.1 million of age group 1 in the beginning of 2022. The same value for recruitment was used also for year-classes 2022 and 2023.

4.3.6.2 Assessment (Update)

The assessment was performed with the same settings in XSA as in the previous year and in accordance with the stock annex. The tuning used in the assessment were the effort in the commercial trap-nets directed at the Gulf of Riga herring in the Estonian and Latvian trap-net fishery and the corresponding abundance of Gulf of Riga herring in trap-net catches and the data from the hydro-acoustic survey (tables 4.3.8 and 4.3.9). The catchability was assumed to be independent of stock size for all ages, and the catchability independent of age for age ≥5 was selected. The default level of shrinkage (SE = 0.5) was used in terminal population estimation. The diagnostics from XSA is presented in Table 4.3.10 and the XSA results are shown in tables 4.3.11–4.3.13. In general, the diagnostics were similar compared to the last year. Log catchability, survival estimated and scaled weights are shown in figures 4.3.8a, 4.3.8ab, and 4.3.9. For acoustic fleet some year effect is seen in the beginning of time-series, 2011 and in 2018, 2020 (Figure 4.3.8b). Year effect is also seen in years 2005 and 2006 for trap-net fleet. The retrospective analysis is shown in Figure 4.3.10. The overall trend is that fishing mortality has been overestimated, whereas the spawning stock biomass has been underestimated comparing to previous years.

4.3.6.3 Exploration of SAM

During WGBFAS 2019 the state-space assessment model SAM was explored as an alternative method to assess the Gulf of Riga herring stock. This year's preliminary configuration of SAM is given in Table 4.3.14. The assessment run and the software internal code are available at https:/www.stockassessment.org, GoRH_2022. Log catchability residuals of SAM run by fleets are shown in Figure 4.3.11. Results of SAM and its comparison with updated XSA run are presented in Figure 4.3.12. In general SAM produces slightly lower estimates of SSB, Fishing mortality (F_{3-7}) and recruitment (age 1). The Mohn's Rho index (average for last 5 years) for fishing mortality, SSB and recruitment is -0.01, 0 and -0.07 respectively and it is lower than in XSA. In most years the XSA estimates are in the confidence intervals of the SAM run.

4.3.6.4 Historical stock trends

The resulting estimates of the main stock parameters (Table 4.3.13, Figure 4.3.13) 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, reaching the record high level of 124 969 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 70 000 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 150 673 t in 2014 but has decreased since then. In 2017-2021 the SSB increased again, reaching 165 395 t in 2021 that is historically highest. The mean fishing mortality in age groups 3–7 has been rather high in 1970s and 1980s fluctuating between 0.35 and 0.71. It has decreased below 0.4 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 2017-2021 the fishing mortality was in the range of 0.19-0.24 that is below the F_{MSY} (0.32). The estimate for 2021 was 0.221.

4.3.7 Short-term forecast and management options

The input data and summary of short-term forecast with management options are presented in the tables 4.3.15- 4.3.17. For prediction the mean weights-at-age were taken to be equal to the average of the last three years 2019–2021. The exploitation pattern was taken equal to the average of 2019–2021 and was not scaled to the last year. Since the cod abundance is still at a very low level in the eastern Baltic and absent in the Gulf of Riga, the natural mortality was assumed to remain at the level of 0.2. The abundance of age group 1 in 2022–2024 (year classes of 2021, 2022, and 2023) were taken to be equal to the geometric mean of year classes over the period 1989–2019.

Taking into account that the herring TAC for the Gulf of Riga is usually almost utilised the catch constraint of 44 945 t for the intermediate year was used. The value is equal with the ICES last year's advice for the Gulf of Riga herring which was accepted by the managers. The SSB in 2022 would be 169.9 thousand tonnes (equals to the 2021 prediction). Under MSY scenario, SSB in 2023–2024 will remain on high level of 150 and 133 thousand tons, respectively. The catch corresponding to F_{MSY} (0.32) would be 43.2 thousand tonnes in 2023. In 2022 the catches will be dominated by year classes of 2017, 2019 and 2020 by 62%. The SSB in 2023 will be dominated by year classes of 2018-2020 (68%). SSB in 2024 will be dominated by age groups of 2-5 (80%) (Figure 4.3.14). The share of younger age groups (1–3) in the yield of 2022–2023 will be 51% and 42% respectively.

4.3.8 Reference points

The biological reference points for the Gulf of Riga herring were estimated at WGBFAS meeting in 2015 (ICES, 2015). Following the ACOM decision in 2020 (see Expert Groups general ToR c) vi)), the basis for F_{pa} was changed in 2021 to $F_{p.05}$, the F that leads SSB ≥ B_{lim} with 95% probability. The new corresponding F_{pa} = 0.38 (ICES, 2020).

The B_{lim} value was obtained estimating the stock-recruitment relationship and the knowledge about fisheries and stock development of the Gulf of Riga herring. It was considered that Gulf of Riga herring belongs to the stocks with no evidence that recruitment has been impaired or that a relation exists between stock and recruitment for which B_{lim} = B_{loss} is applied. The corresponding value is B_{lim} = 40 800 t. The B_{pa} value was obtained from the following equation: $B_{pa} = B_{lim} \times \exp(\sigma \times 1.645) = B_{lim} \times 1.4 = 57\,100$ t.

F_{lim} was then derived from B_{lim} in the following way. R/SSB was calculated at B_{lim}, and the slope of the replacement line at B_{lim}, and then it was inverted to give SSB/R. This SSB/R was used to derive F_{lim} from the curve of SSB/R against F. The obtained value F_{lim} = 0.88.
Instead of MBAL estimate of 50 000 t used previously, the $B_{trigger}$ value of 60 000 t selected at the Workshop on Multi-annual Management of Pelagic Fish Stocks in the Baltic (ICES, 2009) was used.

4.3.9 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 4.3.2.). 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 number of trap-nets directed at the Gulf of Riga herring in the Estonian and Latvian trap-net fishery and the corresponding abundance of Gulf of Riga herring in trap-net catches are used for tuning VPA. These data could be very sensitive to changes in market demand and could be affected by fishery regulation. Therefore, the joint Estonian-Latvian hydro-acoustic surveys were started in 1999 to obtain the additional 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 0.26, -0.12 and -0.15 respectively. If index is obtained as average for last 3 years, then for fishing mortality, SSB and recruitment it is 0.16, -0.03 and -0.08 respectively.

4.3.10 Comparison with the previous assessment

Compared to last year, the present assessment resulted in 4.7% increase in SSB for 2020, and 7.1% decrease for the 2019-year class estimate. $F_{(3\text{-}7)}$ estimate in 2020 was lowered by 8.6% in this year’s assessment.

Comparison of XSA settings from assessments performed in 2021 and 2022

Category	Parameter	Assessment 2021	Assessment 2022	Diff.
XSA Setting	Catchability dependent on stock	Independent for all ages	Independent for all ages	No
	Catchability independent of age	≥5	≥5	No
	Survivor estimates shrinkage towards mean F of	Final 5 years, 3 oldest ages	Final 5 years, 3 oldest ages	No
	S.E. of the mean for shrinkage	0.5	0.5	No
Tuning fleet	Trap-nets	1996–2020	1996–2021	No
	Acoustic survey	1999–2020	1999–2021	No

Comparison of SSB and F estimates from assessments performed in 2021 and 2022

Assessment year	Tuning fleet	SSB (2020) (t)	FBAR3-7 (2020)	Recruitment (age1)
2021 (update)	Trap-nets+acoustics	146 956	0.2433	7 101 760
2022 (update)	Trap-nets+acoustics	153 857	0.2224	6 594 147
Diff. (+/-)%		+4.7%	-8.6%	-7.1%

Comparison of predictions	Prediction in 2021	Prediction in 2022	Actual yield 2021 (t)	Diff. (+/-)%
Yield 2021 (t)	35 771		35 758	-0.04
SSB 2022 (t)	167 666	169 866		+1.3
Yield 2022 (t)	44 945	44 945		0.0

4.3.11 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 reduced. It should be taken into account 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 2023 (Subdivision 28.1) is 3211 tonnes (average 2017–2021);
2. Gulf of Riga herring assumed to be taken in Subdivision 28.2 in 2023 is 794 tonnes (average 2017–2021).

As an example, following ICES MSY approach (here identical to the MAP F_{MSY}), catches from the Gulf of Riga herring stock in 2023 should be no more than 43 226 tonnes. The corresponding TAC in the Gulf of Riga management area for 2023 would be calculated as:

43 226 tonnes – 794 tonnes + 3211 tonnes = 45 643 tonnes.

4.3.12 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
2021	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	7410	13481	-	20891
1992	9742	14204	-	23946
1993	9537	13554	2209	25300
1994	9636	14050	3514	27200
1995	16008	17016	3332	36356
1996	11788	17362	3534	32684
1997	15819	21116	4308	41243
1998	11313	16125	3305	30743
1999	10245	20511	3077	33803
2000	12514	21624	2631	36769
2001	14311	22775	3399	40485
2002	16962	22441	3398	42801
2003	19647	21780	3276	44703
2004	18218	20903	3094	42215
2005	11213	19741	3071	34025
2006	11924	19186	2922	34032
2007	12764	19425	2953	35142
2008	15877	19290	1970	37137
2009	17167	18323	1864	37354
2010	15422	17751	1791	34974
2011	14721	20218	-	35039
2012	13789	17926	-	31715
2013	11898	18413	-	30311
2014	10541	20012	-	30553
2015	16509	21010	-	37519
2016	15814	19066	-	34880
2017	13772	17948	-	31720
2018	12521	16904	-	29424

Year	Estonia	Latvia	Unallocated landings	Total
2019	13320	17961	-	31281
2020	12231	21019	-	33249
2021	16099	22011	-	38110

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	18700	3500	23946	1300	20000
1993	21000	4300	25300	1200	22200
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

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
2000	32169	4600	36769	1900	34069
2001	37585	2900	40485	1200	38785
2002	39301	3500	42801	400	39701
2003	40403	4300	44703	400	40803
2004	38915	3300	42215	200	39115
2005	31725	2300	34025	500	32225
2006	30832	3200	34032	400	31232
2007	33642	1500	35142	100	33742
2008	31037	6100	37137	100	31137
2009	32454	4900	37354	100	32554
2010	29774	5200	34974	400	30174
2011	29539	5500	35039	100	29639
2012	27915	3800	31715	200	28115
2013	26211	4100	30311	300	26511
2014	26053	4500	30553	200	26253
2015	32551	4968	37519	316	32851
2016	30565	4315	34880	289	30865
2017	27824	3896	31720	234	28058
2018	25217	4208	29424	530	25747
2019	27721	3560	31281	1200	28922
2020	31986	1264	33249	1229	33215
2021	34984	3126	38110	775	35758

Table 4.3.2. Sampling of herring landings in the Gulf of Riga in 2021

Country	Quarter	Landings	Samples	Measured	Aged
Estonia	I	6549	11	1100	1099
	II	9055	18	1600	1500
	III	6	0	0	0
	IV	489	4	400	400
	Total	16099	33	3100	2999
Latvia	I	7625	9	1819	1110
	II	5311	39	4467	3922
	III	2705	11	2443	1237
	IV	6370	9	1515	820
	Total	22011	68	10244	7089
Total	I	14174	20	2919	2209
	II	14366	57	6067	5422
	III	2711	11	2443	1237
	IV	6858	13	1915	1220
Grand total	Total	38110	101	13344	10088

Table 4.3.3. Gulf of Riga herring. Catch in numbers 1977-2021 in thousands.

Year	1	2	3	4	5	6	7	8+
1977	69500	885100	141400	109700	35300	15700	16000	600
1978	112000	97300	403900	39200	35900	9300	3200	5700
1979	76700	176500	103800	342500	22100	19300	6800	5500
1980	101000	125900	99600	55400	133100	10500	8600	2500
1981	62500	172500	112000	83000	51400	71700	7400	3500
1982	80000	96000	116900	68800	43000	29900	24500	3300
1983	49700	225300	138300	77700	38900	23300	15500	9600
1984	44000	152100	255100	96300	56700	32500	14700	11900
1985	23200	283900	203900	121700	31800	23700	8000	6100
1986	9200	106700	246900	110600	66500	19600	8000	5800
1987	70000	49000	110000	205000	75000	32000	5000	2000
1988	6000	197700	112700	112400	144600	38700	27800	5900
1989	61100	47400	492700	143000	76300	53900	6500	5400
1990	88100	83100	67100	263500	66800	27600	14600	4100
1991	119500	234000	94500	40800	180500	40500	35400	40800
1992	150300	339100	369300	91300	33200	157400	19000	47600
1993	192200	381400	298100	224400	66800	19000	78800	26900
1994	164230	288440	368870	263500	192700	46080	9410	56150
1995	232400	316900	363000	426900	277200	170900	39300	51500
1996	428800	450100	281400	247600	291000	183800	105600	57000
1997	204200	930700	559700	345400	242800	186700	90600	61100
1998	239360	282060	505410	274890	172470	114020	90230	67650
1999	361890	446500	157050	316480	157200	83650	60670	81050
2000	259030	552300	359430	123730	258070	83980	35120	53370
2001	819480	461570	378160	261040	81170	120980	56040	70710
2002	304160	1182680	360540	202120	118950	36310	48060	44940
2003	596730	396180	922840	231180	107440	70510	19990	58640
2004	166760	1342020	306210	505770	129160	64390	33200	62270
2005	383307	197546	873585	171434	186054	50952	27898	28826

Year	1	2	3	4	5	6	7	8+
2006	787870	600120	113610	467380	100900	70420	16470	20010
2007	305070	1145970	441270	83890	303940	59690	33710	24170
2008	599430	340150	707460	166050	21870	112520	11600	26250
2009	284970	787100	206390	505640	109220	20860	101490	29430
2010	469190	407890	515480	109990	275720	55630	7760	75000
2011	94610	346460	325910	398850	86030	168030	35030	44130
2012	458920	123970	276010	196090	245430	39330	90650	33980
2013	435220	596630	95600	143650	86850	128500	21350	57920
2014	76960	553760	443440	68530	115750	62060	80660	58830
2015	277380	141080	575230	394950	68160	82500	63190	117450
2016	467310	287890	110350	427240	291430	43770	50850	94760
2017	291780	449000	219830	59410	251400	183300	24030	94910
2018	357867	295664	329437	150533	46463	149032	88866	36412
2019	174379	629505	255381	267814	117162	48007	116436	60657
2020	623754	285022	512507	192367	158621	85216	23743	109093
2021	314882	794199	268629	384044	148641	123598	49741	70121

Table 4.3.4. Gulf of Riga herring. Catch in tonnes (CATON).

Year	Catch
1977	24186
1978	16728
1979	17142
1980	14998
1981	16769
1982	12777
1983	15541
1984	15843
1985	15575
1986	16927
1987	12884

Year	Catch
1988	16791
1989	16783
1990	14931
1991	14791
1992	20000
1993	22200
1994	24300
1995	32656
1996	32584
1997	39843
1998	29443
1999	31403
2000	34069
2001	38785
2002	39701
2003	40803
2004	39115
2005	32225
2006	31232
2007	33742
2008	31137
2009	32554
2010	30174
2011	29639
2012	28115
2013	26511
2014	26253
2015	32851
2016	30865
2017	28058

Year	Catch
2018	25747
2019	28922
2020	33215
2021	35758

Table 4.3.5. Gulf of Riga herring. Proportion of mature at beginning the year in 1977-2021.

Period	1	2	3	4	5	6	7	8+
1977-2021	0	0.93	0.98	0.98	1	1	1	1

Table 4.3.6. Gulf of Riga herring. Weights (kg) in catch and stock in 1977-2021.

Year	Age 1	2	3	4	5	6	7	8+
1977	0.0132	0.0160	0.0227	0.0269	0.0295	0.0312	0.0294	0.0508
1978	0.0098	0.0177	0.0219	0.0273	0.0311	0.0304	0.0381	0.0504
1979	0.0122	0.0162	0.0234	0.0276	0.0298	0.0340	0.0368	0.036
1980	0.0145	0.0201	0.0241	0.0321	0.0393	0.0456	0.0533	0.0711
1981	0.0121	0.0216	0.0288	0.0334	0.0390	0.0439	0.0499	0.0595
1982	0.0141	0.0214	0.0287	0.0357	0.0372	0.0451	0.0503	0.06837
1983	0.0138	0.0193	0.0276	0.0379	0.0416	0.0509	0.0610	0.0913
1984	0.0100	0.0150	0.0215	0.0281	0.0343	0.0391	0.0491	0.0559
1985	0.0129	0.0172	0.0208	0.0278	0.0358	0.0487	0.0531	0.0665
1986	0.0126	0.0198	0.0256	0.0314	0.0402	0.0462	0.0639	0.0709
1987	0.0101	0.0154	0.0197	0.0263	0.0303	0.0379	0.0431	0.0905
1988	0.0117	0.0186	0.0210	0.0273	0.0368	0.0434	0.0586	0.075
1989	0.0120	0.0148	0.0166	0.0196	0.0230	0.0315	0.0382	0.0364
1990	0.0146	0.0178	0.0198	0.0269	0.0306	0.0331	0.0522	0.0554
1991	0.0119	0.0154	0.0178	0.0199	0.0214	0.0225	0.0269	0.0336
1992	0.0112	0.0136	0.0177	0.0215	0.0236	0.0250	0.0264	0.0359
1993	0.0125	0.0136	0.0161	0.0201	0.0247	0.0263	0.0275	0.0352
1994	0.0112	0.0146	0.0162	0.0188	0.0215	0.0252	0.0263	0.03
1995	0.0104	0.0136	0.0164	0.0179	0.0209	0.0229	0.0263	0.0291

Year	Age 1	2	3	4	5	6	7	8+
1996	0.0105	0.0125	0.0157	0.0177	0.0189	0.0215	0.0235	0.028
1997	0.0097	0.0124	0.0149	0.0178	0.0191	0.0196	0.0212	0.0242
1998	0.0101	0.0133	0.0169	0.0182	0.0203	0.0213	0.0225	0.024
1999	0.0131	0.0155	0.0189	0.0221	0.0231	0.0245	0.0265	0.0289
2000	0.0125	0.0165	0.0201	0.0229	0.0254	0.0264	0.0282	0.0296
2001	0.0102	0.0160	0.0205	0.0230	0.0245	0.0277	0.0283	0.0307
2002	0.0100	0.0153	0.0193	0.0236	0.0250	0.0271	0.0280	0.0309
2003	0.0075	0.0153	0.0199	0.0223	0.0248	0.0263	0.0268	0.0276
2004	0.0086	0.0101	0.0165	0.0210	0.0242	0.0268	0.0271	0.0331
2005	0.0120	0.0142	0.0159	0.0204	0.0244	0.0260	0.0298	0.0308
2006	0.0086	0.0132	0.0178	0.0191	0.0228	0.0266	0.0275	0.0296
2007	0.0089	0.0117	0.0154	0.0202	0.0196	0.0237	0.0271	0.0278
2008	0.0098	0.0148	0.0173	0.0204	0.0238	0.0233	0.0286	0.0327
2009	0.0092	0.0140	0.0176	0.0191	0.0218	0.0207	0.0244	0.0294
2010	0.0091	0.0138	0.0169	0.0194	0.0209	0.0237	0.0231	0.026
2011	0.0118	0.0153	0.0184	0.0211	0.023	0.0255	0.0262	0.0324
2012	0.0094	0.0159	0.0203	0.0232	0.0258	0.0277	0.0299	0.0334
2013	0.0097	0.0146	0.0197	0.0227	0.0257	0.0282	0.0295	0.0319
2014	0.0098	0.0138	0.0176	0.0216	0.0236	0.0253	0.0271	0.0302
2015	0.0089	0.0150	0.0182	0.0211	0.0230	0.0252	0.0272	0.0295
2016	0.0086	0.0152	0.0181	0.0204	0.0223	0.0239	0.0260	0.0283
2017	0.0087	0.0147	0.0185	0.0209	0.0225	0.0241	0.0248	0.0276
2018	0.0097	0.0153	0.0191	0.0216	0.0230	0.0245	0.0256	0.0284
2019	0.0087	0.0136	0.0181	0.0207	0.0232	0.0237	0.0248	0.0262
2020	0.0090	0.0154	0.0189	0.0212	0.0231	0.0250	0.0247	0.0260
2021	0.0086	0.0138	0.0178	0.0196	0.0215	0.0231	0.0247	0.0253

Table 4.3.7. Gulf of Riga herring. Natural mortality.

Year	1	2	3	4	5	6	7	8+
1977-1978	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
1979	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1980	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1981	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1982	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1983	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1984-2021	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Table 4.3.8. Gulf of Riga herring. Tuning fleet: trap-nets (effort number of trap-nets).

Year	Effort	Age2	Age3	Age4	Age5	Age6	Age7	Age8*
1996	94.0	84.40	87.40	88.80	95.60	67.90	33.40	8.70
1997	101.0	115.50	115.70	85.10	68.20	46.70	18.80	12.40
1998	70.0	65.38	122.80	65.70	36.40	20.80	20.20	6.60
1999	78.0	34.56	21.36	101.42	51.14	25.81	18.47	18.49
2000	84.0	91.12	89.00	27.79	114.19	31.05	5.96	5.12
2001	100.0	124.13	149.34	118.20	37.23	59.59	27.53	10.40
2002	90.0	207.06	107.78	61.26	39.47	8.93	12.12	6.11
2003	86.0	77.79	265.91	72.98	23.36	25.15	3.17	6.07
2004	68.0	109.49	79.51	114.20	29.77	15.85	7.43	1.68
2005	51.0	23.01	162.65	31.30	51.30	13.68	6.04	4.31
2006	49.0	81.76	27.33	101.11	34.88	23.22	6.76	3.77
2007	57.0	126.63	108.24	24.53	91.65	16.98	9.91	2.59
2008	50.0	64.97	179.19	48.29	7.15	37.46	1.92	6.85
2009	60.0	159.17	45.13	165.51	40.41	7.13	35.53	4.37
2010	45.0	44.1	98.18	21.26	67.95	15.61	2.1	13.44
2011	45.0	40.8	62.4	96.73	15.04	44.65	7.68	3.3
2012	43.0	19.42	49.24	47.99	54.99	7.76	21.69	3.78
2013	45.0	107.13	26.36	37.23	26.01	35.77	4.71	11.23
2014	45.0	148.61	119.84	17.15	22.46	8.66	15.28	1.82

Year	Effort	Age2	Age3	Age4	Age5	Age6	Age7	Age8*
2015	43.0	15.96	128.17	76.97	9.93	11.83	8.64	19.22
2016	43.0	50.18	25.23	117.5	92.86	10.77	12.14	6.08
2017	43.0	59.77	57.57	14.58	85.75	56.75	5.08	6.19
2018	43.0	57.64	100.37	49.12	11.54	44.28	28.32	2.26
2019	43.0	93.15	59.61	75.4	30.14	8.13	29.05	11.53
2020	43.0	53.68	136.63	50	49.23	23.9	4.97	14.04
2021	43.0	91.64	71.79	98.17	37.86	34.97	13.83	2.17

*Age 8 is true age group

Table 4.3.9. 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	61
2000	1	4486	4012	1791	609	682	336	151	147
2001	1	7567	2004	1447	767	206	296	58	66
2002	1	3998	5994	1068	526	221	87	165	34
2003	1	12441	1621	2251	411	263	269	46	137
2004	1	3177	10694	675	1352	218	195	94	25
2005	1	8190	1564	4532	337	691	92	75	62
2006	1	12082	1986	213	937	112	223	36	33
2007	1	1478	3662	1265	143	968	116	103	24
2008	1	9231	2109	4398	816	134	353	16	23
2009	1	6422	4703	870	1713	284	28	223	10
2010	1	5353	2432	1813	256	618	111	13	50
2011	1	3162	5289	2503	2949	597	865	163	58
2012	1	5957	758	1537	774	1035	374	308	134
2013	1	9435	5552	592	1240	479	827	187	318
2014	1	1109	3832	2237	276	570	443	466	46
2015	1	3221	539	1899	1110	255	346	181	197
2016	1	4542	1081	504	1375	690	152	113	40
2017	1	3231	3442	874	402	1632	982	137	459
2018	1	11216	4529	3607	776	338	1439	755	165

Year	Effort	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8*
2019	1	4912	7007	2237	1335	475	228	681	148
2020	1	9947	2637	3571	1189	985	344	186	585
2021	1	6171	4885	990	2085	793	670	257	139

***Age 8 is true age group**

Table 4.3.10. Gulf of Riga herring. XSA diagnostics.

Lowestoft VPA Version 3.1
13/04/2022 15:22

Extended Survivors Analysis
Index File; Gulf of Riga herring
CPUE data from file Tuning.dat

Catch data for 45 years. 1977 to 2021. Ages 1 to 8.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
Trap-nets	1996	2021	2	7	0.33	0.58
Acoustics	1999	2021	1	7	0.55	0.6

Time series weights :
Tapered time weighting applied
Power = 3 over 20 years
Catchability analysis :
Catchability independent of stock size for all ages
Catchability independent of age for ages >= 5

Terminal population estimation :
Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.
S.E. of the mean to which the estimates are shrunk = .500
Minimum standard error for population
estimates derived from each fleet = .300
Prior weighting not applied

Tuning converged after 48 iterations

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99
	0.997	1	1			

Fishing mortalities

Age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021

1	0.09	0.08	0.074	0.119	0.124	0.103	0.064	0.066	0.11	0.086
2	0.163	0.162	0.138	0.187	0.174	0.168	0.144	0.154	0.148	0.2
3	0.261	0.182	0.174	0.208	0.219	0.195	0.179	0.178	0.181	0.202
4	0.297	0.21	0.192	0.232	0.236	0.176	0.199	0.216	0.197	0.201
5	0.286	0.207	0.262	0.297	0.269	0.212	0.203	0.234	0.192	0.231
6	0.246	0.238	0.225	0.302	0.316	0.27	0.188	0.334	0.267	0.225
7	0.259	0.205	0.231	0.375	0.308	0.287	0.203	0.219	0.274	0.246

XSA population numbers (Thousands)

Year/Age	1	2	3	4	5	6	7
2012	5.88E+06	9.13E+05	1.33E+06	8.43E+05	1.09E+06	1.99E+05	4.39E+05
2013	6.27E+06	4.40E+06	6.35E+05	8.37E+05	5.13E+05	6.70E+05	1.28E+05
2014	1.20E+06	4.74E+06	3.06E+06	4.34E+05	5.56E+05	3.41E+05	4.33E+05
2015	2.74E+06	9.12E+05	3.38E+06	2.11E+06	2.93E+05	3.50E+05	2.23E+05
2016	4.44E+06	1.99E+06	6.19E+05	2.25E+06	1.37E+06	1.78E+05	2.12E+05
2017	3.31E+06	3.21E+06	1.37E+06	4.07E+05	1.45E+06	8.55E+05	1.06E+05
2018	6.34E+06	2.44E+06	2.22E+06	9.24E+05	2.80E+05	9.63E+05	5.34E+05
2019	3.00E+06	4.87E+06	1.73E+06	1.52E+06	6.20E+05	1.87E+05	6.54E+05
2020	6.59E+06	2.30E+06	3.42E+06	1.19E+06	1.00E+06	4.02E+05	1.09E+05
2021	4.21E+06	4.83E+06	1.62E+06	2.33E+06	7.98E+05	6.77E+05	2.52E+05

Estimated population abundance at 1st Jan 2022

0.00E+00	3.16E+06	3.24E+06	1.09E+06	1.56E+06	5.19E+05	4.43E+05

Taper weighted geometric mean of the VPA populations:

3.61E+06	2.60E+06	1.66E+06	1.06E+06	6.21E+05	3.68E+05	2.04E+05

Standard error of the weighted Log(VPA populations) :

0.5655	0.5985	0.6138	0.6699	0.6768	0.7377	0.8349

Log catchability residuals.

Fleet : Trap-nets

Age	1996	1997	1998	1999	2000	2001
1	No data for this fleet at this age					
2	99.99	99.99	99.99	99.99	99.99	99.99
3	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99

7	99.99	99.99	99.99	99.99	99.99	99.99

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	No data for this fleet at this age									
2	0.14	0.15	-0.48	0.31	0.41	-0.14	0.61	0.23	-0.1	-0.12
3	0.18	0.46	0.35	0.12	0.48	0.5	0.19	-0.06	-0.16	0.09
4	0.12	0.37	0.52	0.22	0.1	0.74	0.27	0.29	-0.19	0.14
5	0.18	-0.24	0.39	0.75	0.99	0.31	0.16	0.33	0.1	-0.14
6	-0.12	0.5	0.31	0.71	0.72	0.98	0.06	0.51	0.17	0.18
7	-0.11	-0.41	0.3	0.36	0.72	0.34	-0.29	0.3	0.14	-0.06

Age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	No data for this fleet at this age									
2	-0.05	0.04	0.28	-0.23	0.12	-0.18	0.05	-0.16	0.04	-0.15
3	-0.07	-0.04	-0.1	-0.08	0	0.02	0.09	-0.19	-0.03	0.08
4	0.24	-0.1	-0.22	-0.24	0.12	-0.28	0.12	0.06	-0.11	-0.11
5	0.02	-0.06	-0.26	-0.38	0.31	0.14	-0.22	-0.04	-0.05	-0.07
6	-0.26	0.01	-0.74	-0.38	0.21	0.28	-0.12	-0.11	0.17	0.01
7	-0.02	-0.38	-0.41	-0.21	0.15	-0.04	0.03	-0.14	-0.09	0.08

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	2	3	4	5	6	7
Mean Log q	-14.3048	-13.6809	-13.5442	-13.4515	-13.4515	-13.4515
S.E(Log q)	0.2049	0.1455	0.2255	0.2572	0.362	0.2349

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	1	0.006	14.31	0.9	20	0.21	-14.3
3	1.06	-0.746	13.64	0.94	20	0.16	-13.68
4	0.98	0.167	13.55	0.9	20	0.23	-13.54
5	0.9	0.94	13.44	0.9	20	0.23	-13.45
6	1.11	-0.661	13.5	0.78	20	0.41	-13.43
7	1.04	-0.488	13.55	0.93	20	0.25	-13.5

Fleet : Acoustics

Age	1996	1997	1998	1999	2000	2001
1	No data for this fleet at this age					
2	99.99	99.99	99.99	99.99	99.99	99.99
3	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99

5	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.25	0.21	0.84	0.62	0.2	-0.64	0.15	0.46	0.31	0.61
2	0.38	0.01	0.69	0.84	-0.14	-0.37	0.37	0.06	0.08	0.91
3	0.11	0.2	-0.15	0.51	-0.44	0.14	0.42	0.11	-0.33	0.71
4	0.13	-0.09	0.6	-0.11	-0.44	-0.09	0.35	0.06	-0.56	0.7
5	-0.24	0	-0.02	0.66	-0.58	0.06	0.34	-0.28	-0.54	0.7
6	0.02	0.7	0.41	-0.08	0.23	0.35	-0.45	-0.67	-0.72	0.29
7	0.37	0.09	0.44	0.18	-0.37	0.08	-0.91	-0.42	-0.89	0.14

Age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	-0.32	0.06	-0.43	-0.16	-0.29	-0.35	0.22	0.14	0.09	0.04
2	-0.28	0.14	-0.32	-0.6	-0.69	-0.02	0.52	0.27	0.04	-0.06
3	0.25	-0.02	-0.26	-0.51	-0.13	-0.39	0.54	0.31	0.1	-0.43
4	0.11	0.54	-0.31	-0.48	-0.33	0.12	-0.03	0.02	0.14	0.03
5	0.05	-0.01	0.12	-0.03	-0.59	0.18	0.25	-0.19	0.03	0.07
6	0.71	0.29	0.33	0.1	-0.04	0.23	0.45	0.33	-0.06	0.06
7	-0.26	0.44	0.15	-0.05	-0.51	0.36	0.4	0.11	0.63	0.1

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	1	2	3	4	5	6	7
Mean Log q	-6.4033	-6.6104	-6.7434	-6.8213	-6.7328	-6.7328	-6.7328
S.E(Log q)	0.3257	0.4314	0.3839	0.3438	0.3256	0.3851	0.4363

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	0.99	0.07	6.51	0.76	20	0.34	-6.4
2	0.88	0.631	7.62	0.72	20	0.39	-6.61
3	1	-0.008	6.73	0.72	20	0.4	-6.74
4	1.01	-0.049	6.76	0.79	20	0.36	-6.82
5	1.25	-1.441	5.09	0.77	20	0.39	-6.73
6	0.88	0.952	7.37	0.86	20	0.32	-6.6

Terminal year survivor and F summaries:

Age 1 Catchability constant w.r.t. time and dependent on age

Year class = 2020

Fleet	Estimated survivors	Int s.e	Ext s.e	Var ratio	N	Scaled weights	Estimated F
Trap-nets	1	0	0	0	0	0	0
Acoustics	3299084	0.339	0	0	1	0.666	0.083
F shrinkage mean	2896698	0.5				0.334	0.094

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
3158915	0.28	0.08	2	0.268	0.086

Age 2 Catchability constant w.r.t. time and dependent on age

Year class = 2019

Fleet	Estimated survivors	Int s.e	Ext s.e	Var ratio	N	Scaled weights	Estimated F
Trap-nets	2793735	0.3	0	0	1	0.386	0.229
Acoustics	3337692	0.271	0.069	0.26	2	0.444	0.195
F shrinkage mean	4196601	0.5				0.17	0.158

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
3239623	0.19	0.09	4	0.489	0.2

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2018

Fleet	Estimated survivors	Int s.e	Ext s.e	Var ratio	N	Scaled weights	Estimated F
Trap-nets	1150606	0.213	0.019	0.09	2	0.48	0.192
Acoustics	996121	0.225	0.182	0.81	3	0.407	0.218
F shrinkage mean	1152737	0.5				0.113	0.191

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
1085283	0.15	0.08	6	0.541	0.202

Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 2017

Fleet	Estimated survivors	Int s.e	Ext s.e	Var ratio	N	Scaled weights	Estimated F
Trap-nets	1415141	0.175	0.035	0.2	3	0.51	0.22
Acoustics	1785918	0.193	0.054	0.28	4	0.402	0.178
F shrinkage mean	1521207	0.5				0.088	0.206

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
1564006	0.13	0.05	8	0.391	0.201

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2016

Fleet	Estimated survivors	Int s.e	Ext s.e	Var ratio	N	Scaled weights	Estimated F
Trap-nets	476572	0.153	0.044	0.29	4	0.518	0.249
Acoustics	574020	0.171	0.124	0.73	5	0.406	0.211
F shrinkage mean	538126	0.5				0.076	0.223

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
518692	0.11	0.06	10	0.564	0.231

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5
Year class = 2015

Fleet	Estimated survivors	Int s.e	Ext s.e	Var ratio	N	Scaled weights	Estimated F
Trap-nets	438333	0.145	0.043	0.3	5	0.515	0.227
Acoustics	467708	0.161	0.095	0.59	6	0.411	0.214
F shrinkage mean	350959	0.5				0.074	0.277

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
442811	0.11	0.05	12	0.474	0.225

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5
Year class = 2014

Fleet	Estimated survivors	Int s.e	Ext s.e	Var ratio	N	Scaled weights	Estimated F
Trap-nets	173737	0.136	0.031	0.23	6	0.547	0.23
Acoustics	140766	0.158	0.082	0.52	7	0.377	0.277
F shrinkage mean	183036	0.5				0.076	0.22

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
161138	0.1	0.05	14	0.462	0.246

Table 4.3.11. Gulf of Riga herring. XSA output: Fishing mortality at age.

Year	1	2	3	4	5	6	7	8+	Fbar (3-7)
1977	0.0849	0.4228	0.6604	0.618	0.6456	0.8246	0.7027	0.7027	0.6903
1978	0.1222	0.1644	0.3472	0.3809	0.4184	0.3452	0.384	0.384	0.3751
1979	0.0932	0.2963	0.2727	0.5812	0.3965	0.4304	0.474	0.474	0.431
1980	0.1088	0.2304	0.2875	0.2419	0.4997	0.3523	0.3678	0.3678	0.3498
1981	0.0812	0.2904	0.351	0.4407	0.3946	0.5949	0.4815	0.4815	0.4525
1982	0.0552	0.1824	0.347	0.403	0.4594	0.4484	0.4411	0.4411	0.4198
1983	0.046	0.2295	0.4624	0.437	0.4467	0.5205	0.4727	0.4727	0.4679
1984	0.0243	0.1988	0.4555	0.7187	0.6948	0.8899	0.7755	0.7755	0.7068
1985	0.0186	0.2153	0.4464	0.4097	0.552	0.7179	0.5645	0.5645	0.5381
1986	0.0091	0.1117	0.2946	0.4665	0.4124	0.8087	0.5673	0.5673	0.5099
1987	0.0199	0.0614	0.1612	0.4268	0.6778	0.3567	0.4909	0.4909	0.4227
1988	0.0119	0.0718	0.196	0.2462	0.6137	0.9443	0.6067	0.6067	0.5214
1989	0.0537	0.1226	0.257	0.4088	0.2633	0.4873	0.389	0.389	0.3611
1990	0.0271	0.096	0.2557	0.2125	0.3398	0.1428	0.2329	0.2329	0.2367
1991	0.0364	0.0932	0.1508	0.2438	0.2207	0.3563	0.2751	0.2751	0.2493
1992	0.0392	0.1377	0.2087	0.2134	0.3208	0.3052	0.2813	0.2813	0.2659

Year	1	2	3	4	5	6	7	8+	Fbar (3-7)
1993	0.0674	0.1323	0.1726	0.189	0.2389	0.307	0.2463	0.2463	0.2308
1994	0.0673	0.1368	0.1829	0.2274	0.2462	0.258	0.2451	0.2451	0.2319
1995	0.0769	0.1792	0.2554	0.3336	0.3976	0.3602	0.3662	0.3662	0.3426
1996	0.107	0.2096	0.2394	0.2776	0.4001	0.5033	0.3963	0.3963	0.3633
1997	0.1519	0.356	0.4373	0.52	0.4832	0.487	0.5006	0.5006	0.4856
1998	0.1008	0.3241	0.3335	0.3991	0.5377	0.4406	0.4626	0.4626	0.4347
1999	0.1487	0.2767	0.3015	0.3607	0.4195	0.548	0.4459	0.4459	0.4151
2000	0.1148	0.3551	0.3761	0.4135	0.5666	0.4156	0.4687	0.4687	0.4481
2001	0.1611	0.3075	0.4408	0.5191	0.5282	0.5735	0.5447	0.5447	0.5213
2002	0.1581	0.3685	0.4207	0.4489	0.4761	0.4784	0.4712	0.4712	0.459
2003	0.0957	0.318	0.5527	0.5271	0.4586	0.5824	0.5319	0.5319	0.5305
2004	0.1952	0.3227	0.4361	0.6812	0.6416	0.5549	0.6061	0.6061	0.584
2005	0.1398	0.3738	0.3607	0.4682	0.5773	0.5681	0.4986	0.4986	0.4946
2006	0.1285	0.3381	0.3833	0.3339	0.5608	0.4481	0.3595	0.3595	0.4171
2007	0.1749	0.2793	0.4484	0.5469	0.3781	0.7839	0.4013	0.4013	0.5117
2008	0.1219	0.3014	0.2783	0.3011	0.2637	0.2329	0.332	0.332	0.2816
2009	0.1093	0.2258	0.2921	0.3203	0.325	0.4233	0.3351	0.3351	0.3392
2010	0.1921	0.2356	0.2336	0.2578	0.297	0.2785	0.2796	0.2796	0.2693
2011	0.0896	0.212	0.3	0.286	0.3298	0.2977	0.2837	0.2837	0.2994
2012	0.0902	0.1626	0.261	0.2973	0.2861	0.2461	0.2594	0.2594	0.27
2013	0.0798	0.1624	0.1818	0.2102	0.2073	0.2381	0.2046	0.2046	0.2084
2014	0.0736	0.1381	0.1744	0.1919	0.2617	0.2245	0.2308	0.2308	0.2167
2015	0.1186	0.1875	0.2082	0.2323	0.297	0.3016	0.3755	0.3755	0.2829
2016	0.1238	0.1739	0.2194	0.2357	0.2687	0.3165	0.308	0.308	0.2696
2017	0.1026	0.168	0.195	0.1759	0.212	0.2703	0.2872	0.2872	0.2281
2018	0.0644	0.1436	0.179	0.1986	0.203	0.1875	0.2031	0.2031	0.1942
2019	0.0664	0.1541	0.1779	0.2165	0.2342	0.3341	0.2192	0.2192	0.2364
2020	0.1104	0.1475	0.1812	0.1974	0.1922	0.2672	0.274	0.274	0.2224
2021	0.0864	0.2004	0.2021	0.2007	0.2306	0.2252	0.2463	0.2463	0.221

Table 4.3.12. Gulf of Riga herring. XSA output: Stock numbers at age (start of year) (10^3)

Year	1	2	3	4	5	6	7	8+	Total
1977	943220	2836940	323310	262990	82020	30900	35030	1300	4515700
1978	1076480	709360	1521820	136760	116060	35210	11090	19600	3626370
1979	976940	780010	492730	880500	76500	62530	20410	16310	3305930
1980	1110340	693160	451710	292140	383480	40070	31670	9110	3011680
1981	908420	775600	428730	263900	178630	181190	21940	10250	2768650
1982	1689000	652320	451810	235050	132270	93750	77840	10360	3342410
1983	1253650	1244800	423310	248710	122340	65070	46630	28520	3433030
1984	2027220	932490	770620	207620	125120	60950	30110	24030	4178160
1985	1388060	1619930	625830	400110	82850	51140	20500	15460	4203870
1986	1120350	1115460	1069400	327890	217460	39060	20420	14640	3924690
1987	3928660	908940	816710	652150	168380	117870	14250	5640	6612590
1988	560970	3153170	699840	569140	348440	69990	67550	14170	5483270
1989	1292400	453860	2402710	471000	364260	154440	22290	18370	5179340
1990	3645560	1002840	328700	1521360	256230	229200	77680	21690	7083260
1991	3690000	2905010	745870	208400	1007160	149340	162680	186330	9054790
1992	4319410	2912990	2166690	525160	133710	661270	85630	213160	11018010
1993	3257360	3400440	2078120	1439780	347350	79430	398980	135420	11136880
1994	2788660	2492990	2438940	1431690	975750	223940	47840	283820	10683630
1995	3469310	2134560	1780100	1663060	933740	624510	141650	184200	10931140
1996	4668320	2630150	1460880	1128960	975330	513660	356670	190940	11924920
1997	1601060	3434110	1746110	941450	700280	535220	254240	169760	9382240
1998	2757920	1126070	1969480	923160	458260	353650	269270	200010	8057810
1999	2894440	2041410	666730	1155160	507090	219140	186370	246730	7917060
2000	2640150	2042310	1267360	403770	659400	272930	103720	156150	7545780
2001	6085440	1927190	1172360	712400	218620	306360	147470	184100	10753940
2002	2299180	4240840	1160200	617680	347060	105550	141360	130940	9042810
2003	7226980	1607200	2401980	623660	322830	176520	53560	155480	12568200
2004	1039280	5377000	957380	1131550	301430	167090	80720	176440	9230910
2005	3247200	700000	3188010	506770	468800	129920	78540	80360	8399590

Year	1	2	3	4	5	6	7	8+	Total
2006	7219180	2311750	394360	1819660	259790	215470	60270	72670	12353150
2007	2101660	5197670	1349690	220080	1066910	121400	112700	80130	10250230
2008	5774650	1444650	3218580	705750	104280	598500	45380	102010	11993790
2009	2926690	4185500	875000	1995010	427570	65580	388200	111720	10975270
2010	2967050	2147970	2734190	534940	1185730	252920	35170	341020	10198990
2011	1219880	2004680	1389540	1772140	338450	721310	156740	196250	7798980
2012	5880710	913150	1327800	842760	1090010	199260	438520	163350	10855550
2013	6274170	4399470	635450	837370	512570	670350	127550	344280	13801200
2014	1199120	4743050	3062130	433760	555600	341070	432560	313760	11081050
2015	2740810	912120	3382220	2105820	293120	350150	223090	411390	10418720
2016	4436510	1993000	619130	2248640	1366730	178320	212030	392450	11446810
2017	3305450	3209470	1371240	407050	1454450	855290	106390	417500	11126820
2018	6344140	2442260	2221420	923770	279510	963320	534390	217860	13926670
2019	2997770	4870330	1732020	1520660	620110	186800	653850	338820	12920360
2020	6594150	2296580	3417890	1186980	1002680	401690	109500	500010	15509480
2021	4206170	4834440	1622380	2334600	797760	677400	251770	352880	15077400
2022	0	3158910	3239620	1085280	1564010	518690	442810	386970	10396300

Table 4.3.13. Gulf of Riga herring. XSA output: Summary.

Year	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR(3-7)
1977	943222	76734	54522	24186	0.4436	0.69
1978	1076482	66256	49356	16728	0.3389	0.38
1979	976944	66131	46739	17142	0.3668	0.43
1980	1110341	69530	46712	14998	0.3211	0.35
1981	908421	65532	47221	16769	0.3551	0.45
1982	1689001	72906	42758	12777	0.2988	0.42
1983	1253654	76284	50858	15541	0.3056	0.47
1984	2027216	66159	39914	15843	0.3969	0.71
1985	1388061	77482	51937	15575	0.2999	0.54
1986	1120348	86765	64284	16927	0.2633	0.51

Year	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR(3-7)
1987	3928655	97612	51523	12884	0.2501	0.42
1988	560972	116328	96702	16791	0.1736	0.52
1989	1292403	86106	63293	16783	0.2652	0.36
1990	3645558	139192	77333	14931	0.1931	0.24
1991	3690000	141622	87278	14791	0.1695	0.25
1992	4319409	167236	106143	20000	0.1884	0.27
1993	3257358	175768	120790	22200	0.1838	0.23
1994	2788656	170452	124969	24300	0.1944	0.23
1995	3469309	166976	116715	32656	0.2798	0.34
1996	4668324	168018	105798	32584	0.3080	0.36
1997	1601060	134252	103579	39843	0.3847	0.49
1998	2757920	120612	82165	29443	0.3583	0.43
1999	2894438	136841	84164	31403	0.3731	0.42
2000	2640146	132921	83954	34069	0.4058	0.45
2001	6085443	156993	79299	38785	0.4891	0.52
2002	2299182	144415	100850	39701	0.3937	0.46
2003	7226977	158875	86879	40803	0.4697	0.53
2004	1039278	122606	93605	39115	0.4179	0.58
2005	3247198	128507	75943	32225	0.4243	0.49
2006	7219180	149838	74243	31232	0.4207	0.42
2007	2101655	133819	96751	33742	0.3488	0.51
2008	5774650	169247	97697	31137	0.3187	0.28
2009	2926691	162418	116044	32554	0.2805	0.34
2010	2967051	153683	110515	30174	0.2730	0.27
2011	1219882	144669	113059	29639	0.2622	0.30
2012	5880709	168513	99487	28115	0.2826	0.27
2013	6274168	203440	124628	26511	0.2127	0.21
2014	1199120	183407	150673	26253	0.1742	0.22
2015	2740812	177834	134894	32851	0.2435	0.28
2016	4436513	176885	121596	30865	0.2538	0.27

Year	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR(3-7)
2017	3305446	177311	130577	28058	0.2149	0.23
2018	6344144	211185	132469	25747	0.1944	0.19
2019	2997768	199051	151441	28921	0.191	0.24
2020	6594147	233386	153857	33215	0.2159	0.22
2021	4206171	225471	165395	35758	0.2162	0.22
Arith. mean	3113202	139095	93525	26324	0.2981	0.378

Table 4.3.14. The configuration of SAM model for Gulf of Riga herring

```
# Configuration saved: Tue Apr 14 15:26:55 2020
# Where a matrix is specified rows corresponds to fleets and columns to ages.
# Same number indicates same parameter used
# Numbers (integers) starts from zero and must be consecutive
#
$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 (1 yes, or 0 no).
 1
$keyLogFsta
# Coupling of the fishing mortality states (nomally 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
$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)
 2
$keyLogFpar
# Coupling of the survey catchability parameters (nomally first row is not used, as that is cov-
ered by fishing mortality).
 -1 -1 -1 -1 -1 -1 -1 -1
 -1  0  1  2  3  4  5  6
  7  8  9  10 11 12 13 14
$keyQpow
# Density dependent catchability power parameters (if any).
 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1
$keyVarF
# Coupling of process variance parameters for log(F)-process (nomally only first row is used)
  0  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 1 1 1 1 1 1 1
  2 2 2 2 2 2 2 2
  3 3 3 3 3 3 3 3
$obsCorStruct
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured).
| Possible values are: "ID" "AR" "US"
 "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
 -1 NA NA NA NA NA NA
 NA NA NA NA NA NA NA
$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt).
 2
$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 7
$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).
 -1 -1 -1
$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "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
$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
NA -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1

Table 4.3.15. Gulf of Riga herring. Short-term forecast input.

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	3358136	0.2	0	0.2	0.3	0.0088	0.0877	0.0088
2	3158910	0.2	0.93	0.2	0.3	0.0143	0.1673	0.0143
3	3239620	0.2	0.98	0.2	0.3	0.0183	0.1871	0.0183
4	1085280	0.2	0.98	0.2	0.3	0.0205	0.2049	0.0205
5	1564010	0.2	1	0.2	0.3	0.0226	0.2190	0.0226
6	518690	0.2	1	0.2	0.3	0.0239	0.2755	0.0239
7	442810	0.2	1	0.2	0.3	0.0247	0.2465	0.0247
8	386970	0.2	1	0.2	0.3	0.0258	0.2465	0.0258

2023

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	3358136	0.2	0	0.2	0.3	0.0088	0.0877	0.0088
2	.	0.2	0.93	0.2	0.3	0.0143	0.1673	0.0143
3	.	0.2	0.98	0.2	0.3	0.0183	0.1871	0.0183
4	.	0.2	0.98	0.2	0.3	0.0205	0.2049	0.0205
5	.	0.2	1	0.2	0.3	0.0226	0.2190	0.0226
6	.	0.2	1	0.2	0.3	0.0239	0.2755	0.0239
7	.	0.2	1	0.2	0.3	0.0247	0.2465	0.0247
8	.	0.2	1	0.2	0.3	0.0258	0.2465	0.0258

2024

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	3358136	0.2	0	0.2	0.3	0.0088	0.0877	0.0088
2	.	0.2	0.93	0.2	0.3	0.0143	0.1673	0.0143
3	.	0.2	0.98	0.2	0.3	0.0183	0.1871	0.0183
4	.	0.2	0.98	0.2	0.3	0.0205	0.2049	0.0205
5	.	0.2	1	0.2	0.3	0.0226	0.2190	0.0226
6	.	0.2	1	0.2	0.3	0.0239	0.2755	0.0239
7	.	0.2	1	0.2	0.3	0.0247	0.2465	0.0247
8	.	0.2	1	0.2	0.3	0.0258	0.2465	0.0258

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)

$N_{2022\text{-}2024}$ Age1: geometric mean from XSA-estimates at age 1 for the year classes 1989-2019
N_{2022} Age 2-8+: survivors estimates from XSA
Natural mortality (M): average 2019-2021
CWt/SWt=average 2019-2021
Sel=average 2019-2021

Table 4.3.16. Gulf of Riga herring. Short-term prediction results.

2022

Biomass	SSB	FMult	FBar	Landings
224642	169866	1.3362	0.3028	44945

2023 and 2024

2023					2024	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
202489	159163	0	0	0	227315	182424
.	158274	0.1	0.0303	4627	222543	176996
.	157391	0.2	0.0606	9132	217896	171742
.	156512	0.3	0.0908	13520	213371	166655
.	155639	0.4	0.1211	17793	208966	161730
.	154771	0.5	0.1514	21954	204676	156961
.	153907	0.6	0.1817	26007	200499	152343
.	153049	0.7	0.2119	29955	196431	147871
.	152195	0.8	0.2422	33800	192469	143541
.	151347	0.9	0.2725	37546	188611	139347
.	150503	1.0	0.3028	41195	184852	135285
.	149664	1.1	0.3331	44750	181192	131350
.	148830	1.2	0.3633	48214	177626	127539
.	148000	1.3	0.3936	51589	174153	123847
.	147176	1.4	0.4239	54877	170770	120271
.	146356	1.5	0.4542	58081	167473	116806
.	145541	1.6	0.4845	61203	164262	113449
.	144730	1.7	0.5147	64246	161133	110196
.	143924	1.8	0.545	67212	158085	107044
.	143123	1.9	0.5753	70102	155114	103989
.	142326	2.0	0.6056	72919	152220	101029

Input units are thousand and kg – output in tonnes

Table 4.3.17. Gulf of Riga herring. Short-term results as used in ICES advice.

Basis	Total catch (2023)	F (2023)	SSB (2023)	SSB (2024)	%SSB change**	%Advice change***
ICES advice basis						
EU MAP*: F_{MSY}	43 226	0.32	150 026	133 034	-11.3%	-3.8%
EU MAP*: F_{MSY} lower^	33 519	0.24	152 258	143 856	-5.5%	-3.7%
EU MAP*: F_{MSY} upper^^	50 079	0.38	148 373	125 496	-15.4%	-3.9%
Other scenarios						
ICES MSY approach: F_{MSY}	43 226	0.32	150 026	133 034	-11.3%	-3.8%
F= 0	0	0	159 163	182 424	14.6%	-100%
F= F_{pa}	50 079	0.38	148 373	125 496	-15.4%	11.4%
F= F_{lim}	95 373	0.88	135 331	78 079	-42%	112%
SSB (2024) = B_{lim}	135 147	1.60	118 582	40 800	-66%	201%
SSB (2024) = B_{pa}	117 106	1.22	127 103	57 100	-55%	161%
SSB (2024) = MSY $B_{trigger}$	114 006	1.17	128 390	60 000	-53%	154%
SSB (2024) = SSB (2023)	24 318	0.169	154 267	154 267	0%	-46%
F=F_{2022}	41 195	0.30	150 503	135 285	-10.1%	-8.3%

*** MAP Multiannual plan (EU, 2016)**

**** SSB 2024 relative to SSB 2023.**

*****Total catch in 2023 relative to ICES advice for 2022 (44 954 tonnes for the Gulf of Riga herring stock).**

^ ICES advice for F_{lower} in 2022 relative to ICES advice for F_{lower} in 2021 (34 797 tonnes)

^^ ICES advice for F_{upper} in 2022 relative to ICES advice for F_{upper} in 2021 (52 132 tonnes)

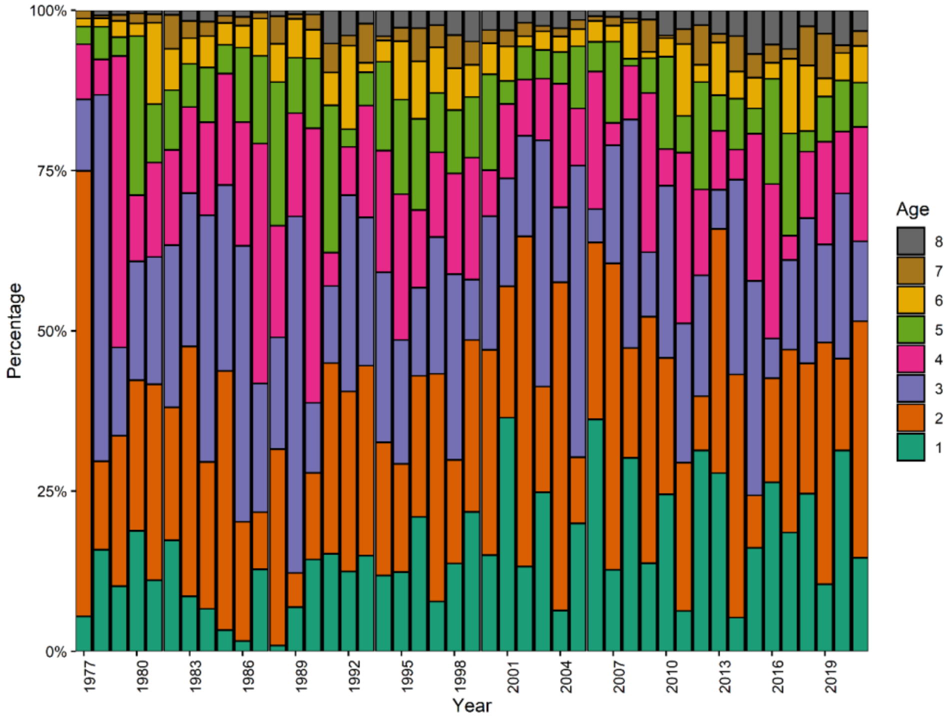


Figure 4.3.1. Gulf of Riga herring. Relative catch at age in numbers in 1977-2021.

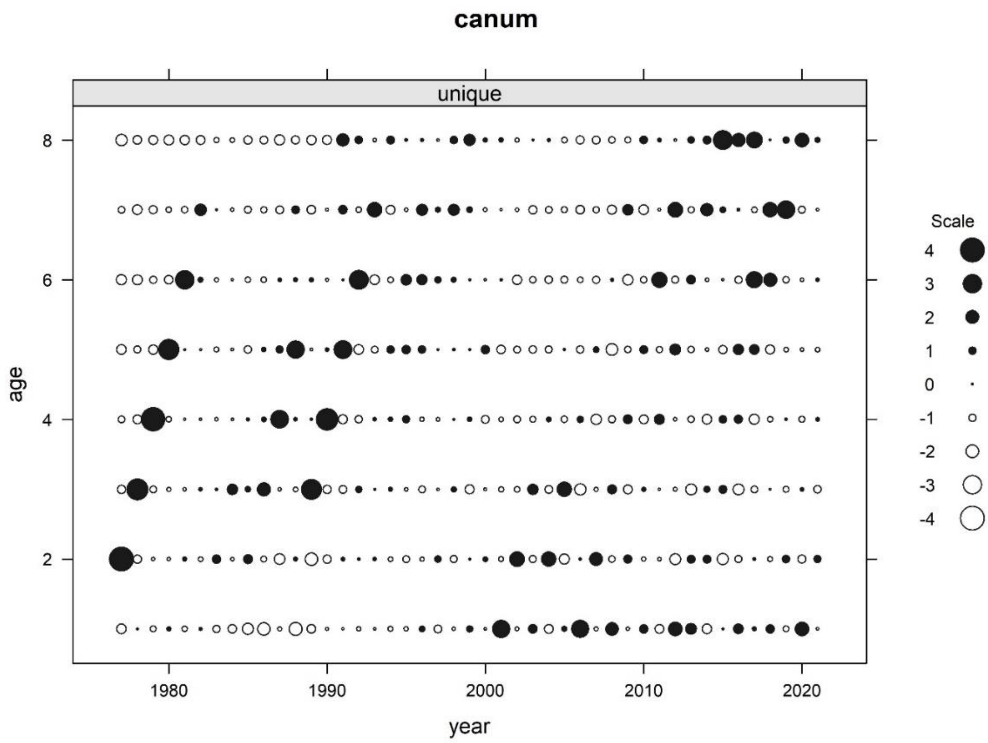


Figure 4.3.2. Gulf of Riga herring. Catch proportion at age.

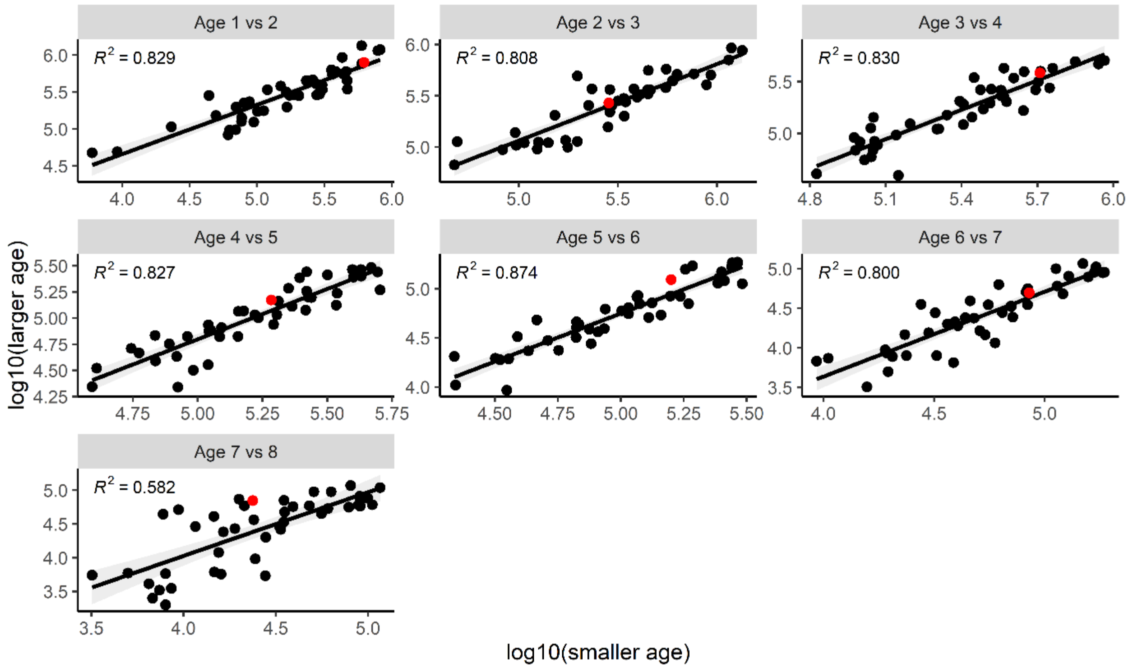


Figure 4.3.3. Gulf of Riga herring. Internal consistency in catch-at-age. Latest year is shown in red.

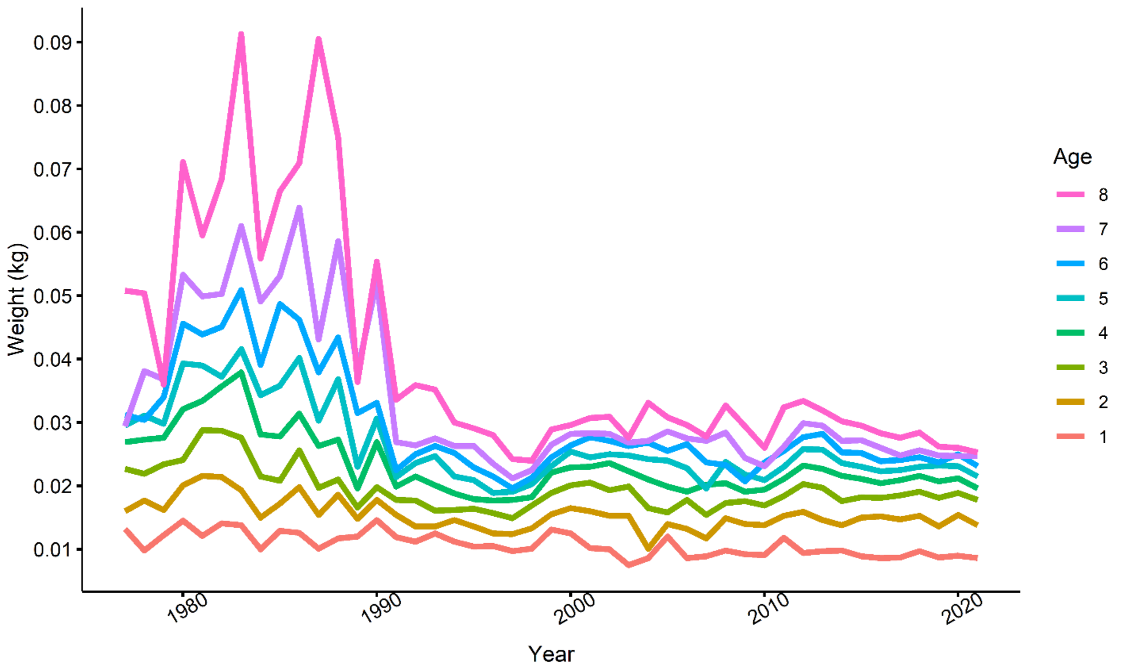


Figure 4.3.4. Gulf of Riga herring. Mean weight at age in the catches.

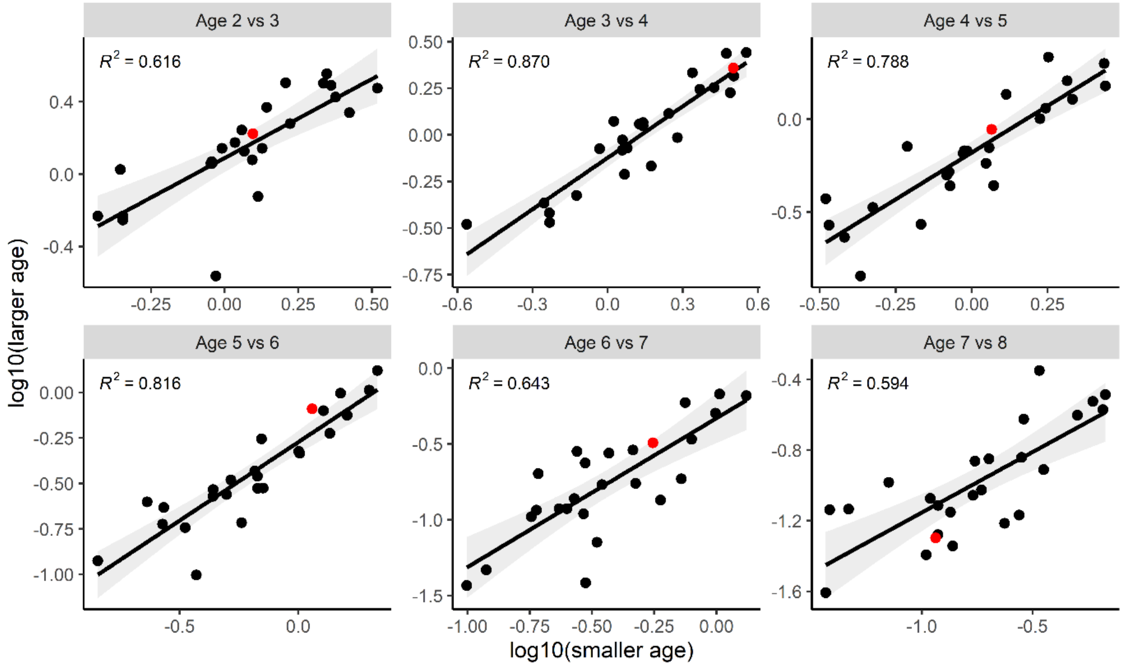


Figure 4.3.5. Gulf of Riga herring. Internal consistency in trap-net tuning fleet. Latest year is shown in red.

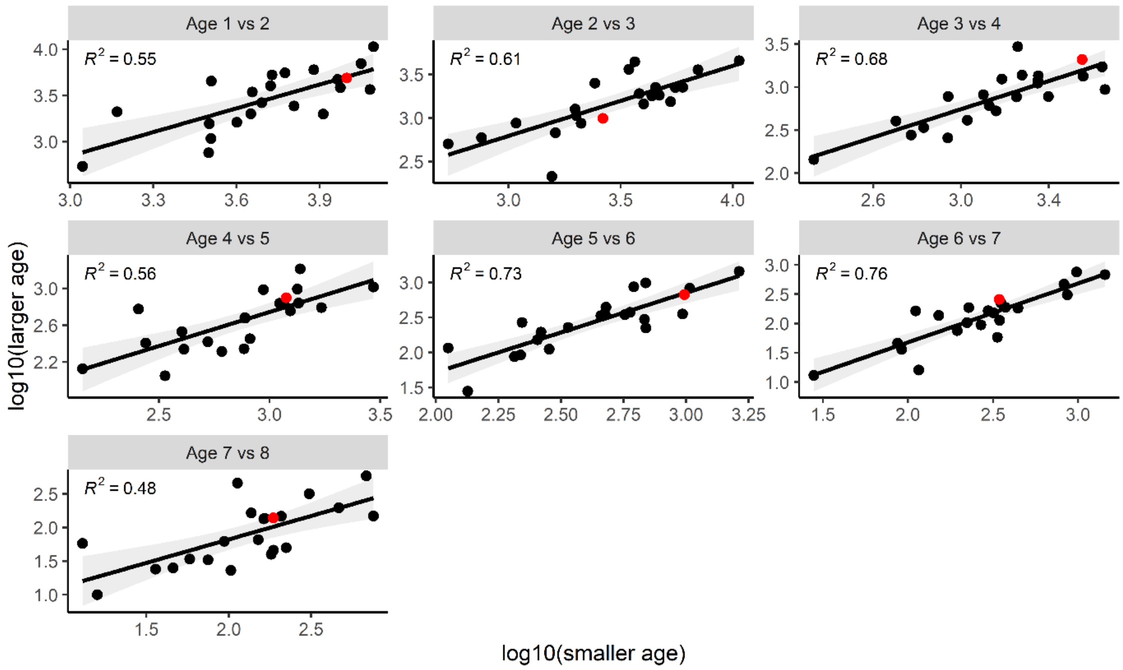


Figure 4.3.6. Gulf of Riga herring. Internal consistency in hydro-acoustics tuning fleet. Latest year is shown in red.

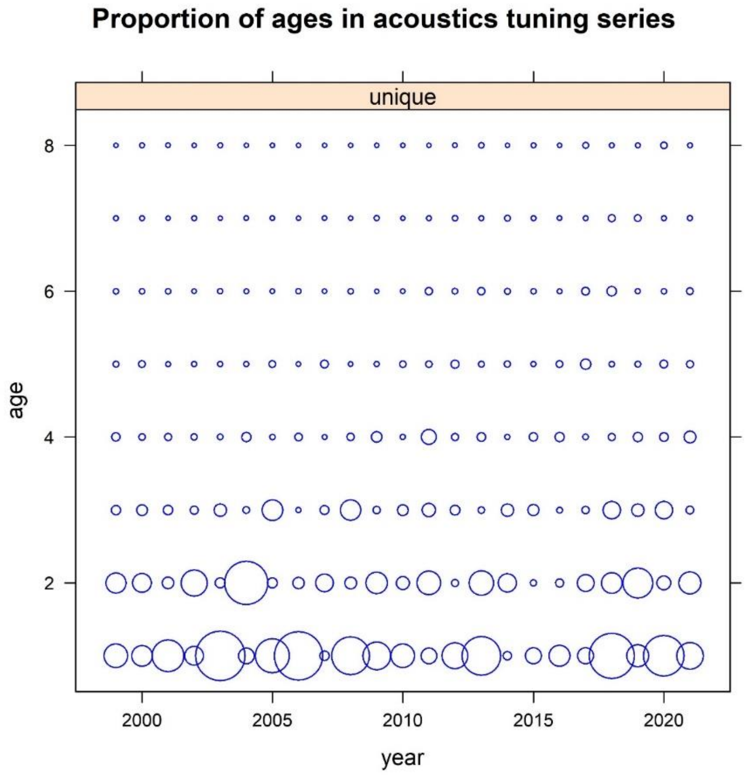
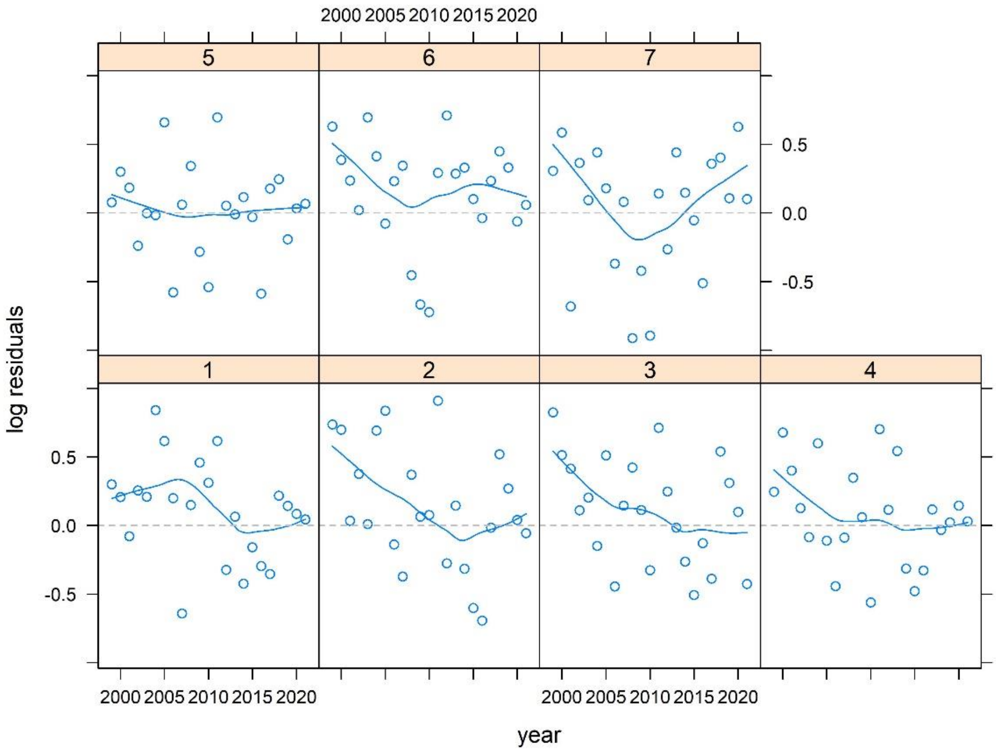


Figure 4.3.7. Gulf of Riga herring. Proportion of ages in hydro-acoustics tuning fleet.



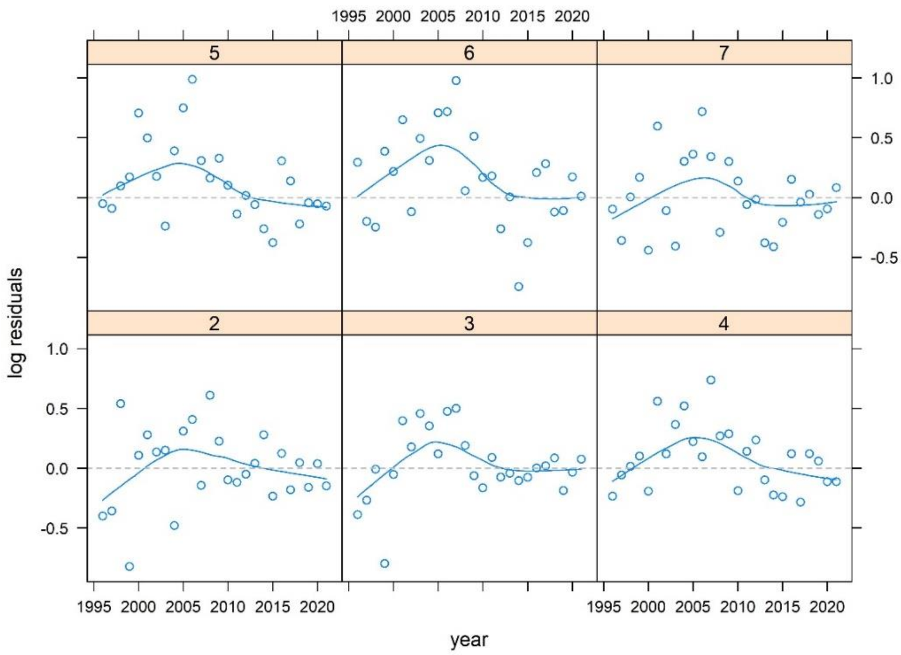


Figure 4.3.8a. Gulf of Riga herring. Log catchability residuals for acoustics survey (top) and trap-nets (bottom).

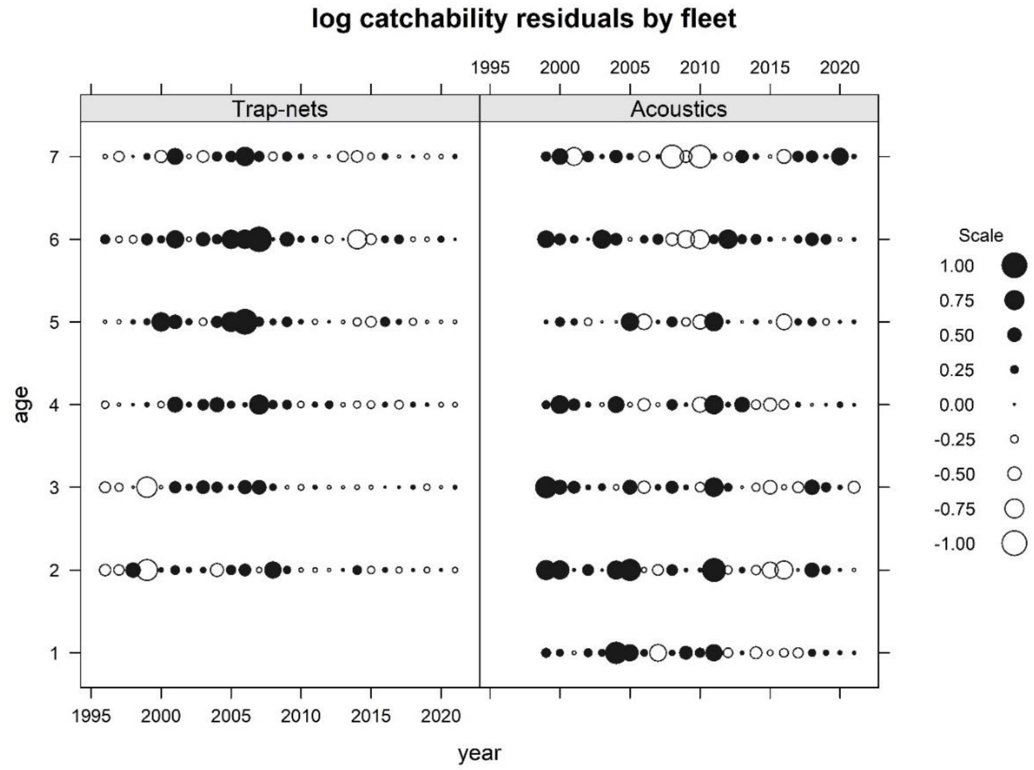


Figure 4.3.8b. Gulf of Riga herring. Log catchability residuals of trap-net fleet (left) and hydro-acoustics fleet (right).

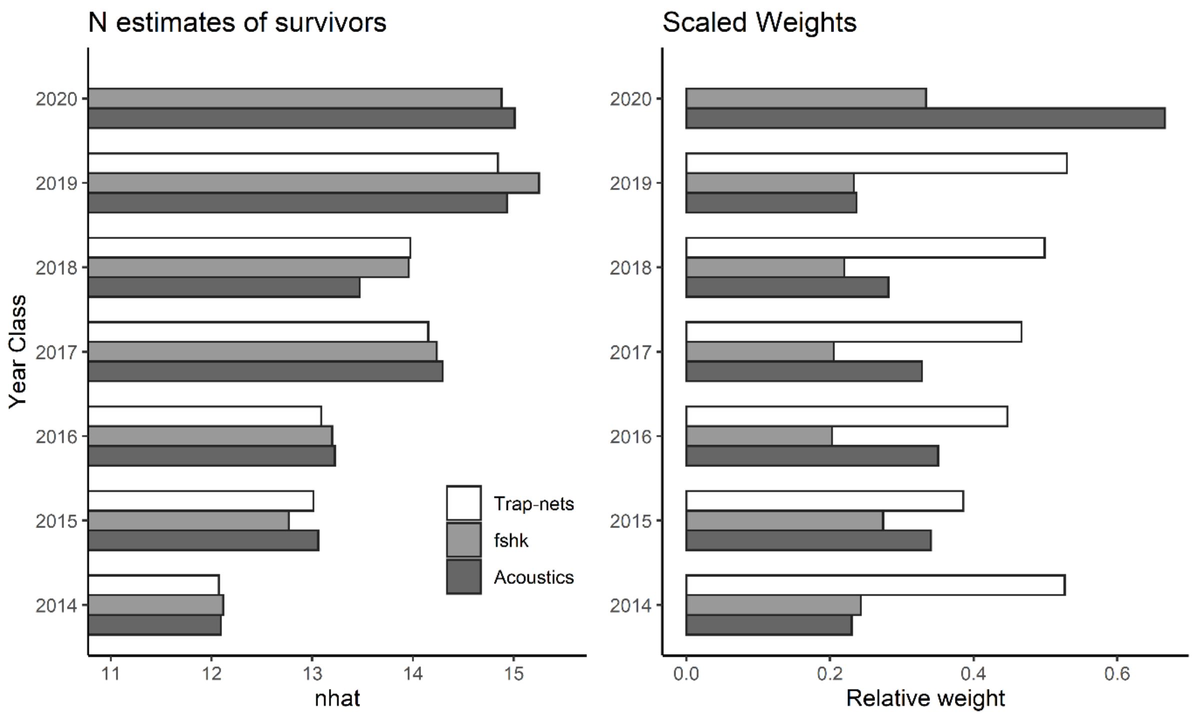


Figure 4.3.9. Gulf of Riga herring. Survivors estimates and scaled weights for both tuning fleets.

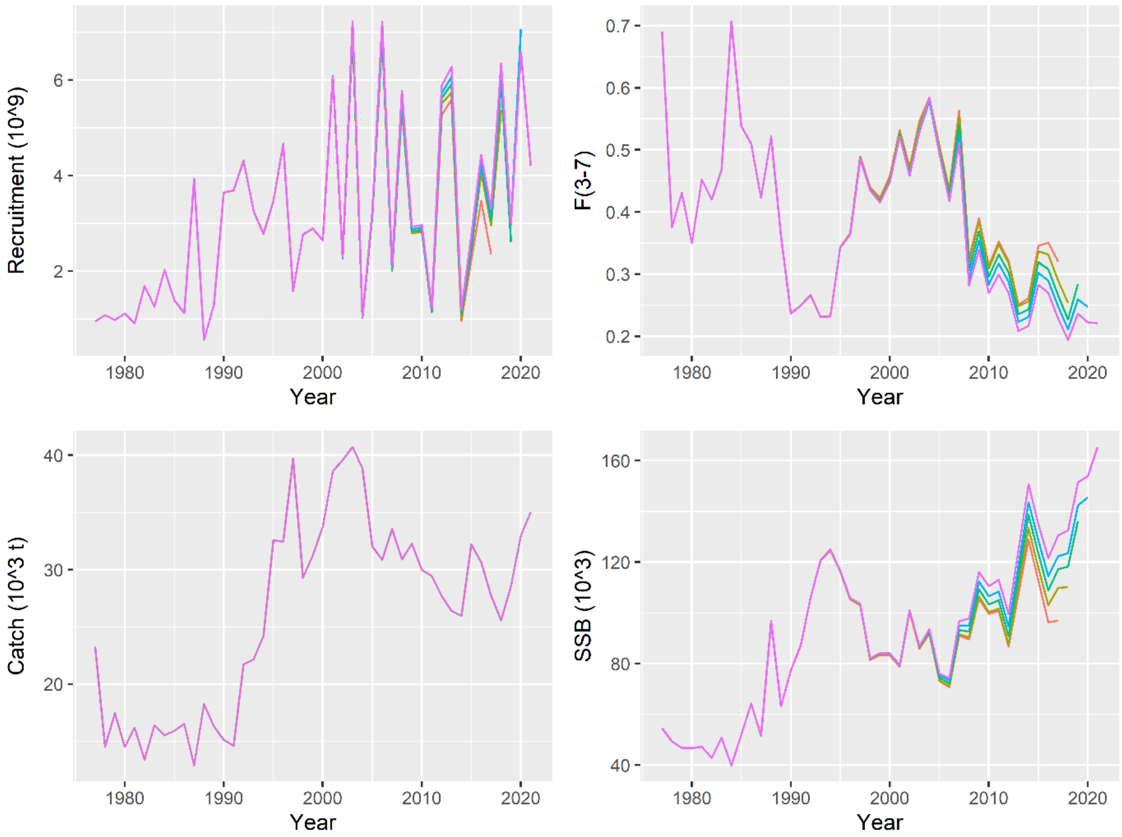


Figure 4.3.10. Gulf of Riga herring. Retrospective analysis (5 years).

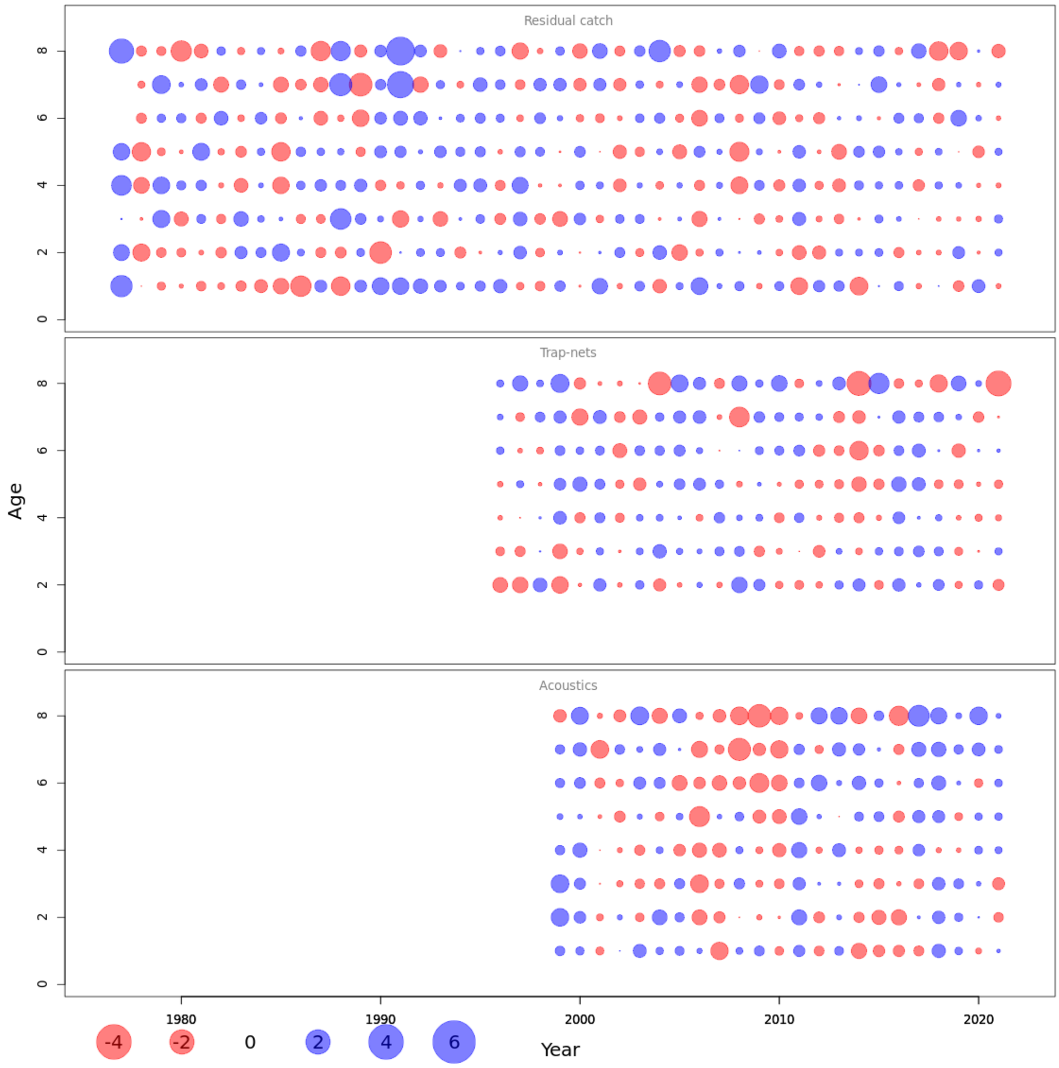


Figure 4.3.11. Gulf of Riga herring. Log catchability residuals from SAM run by fleet and catch.

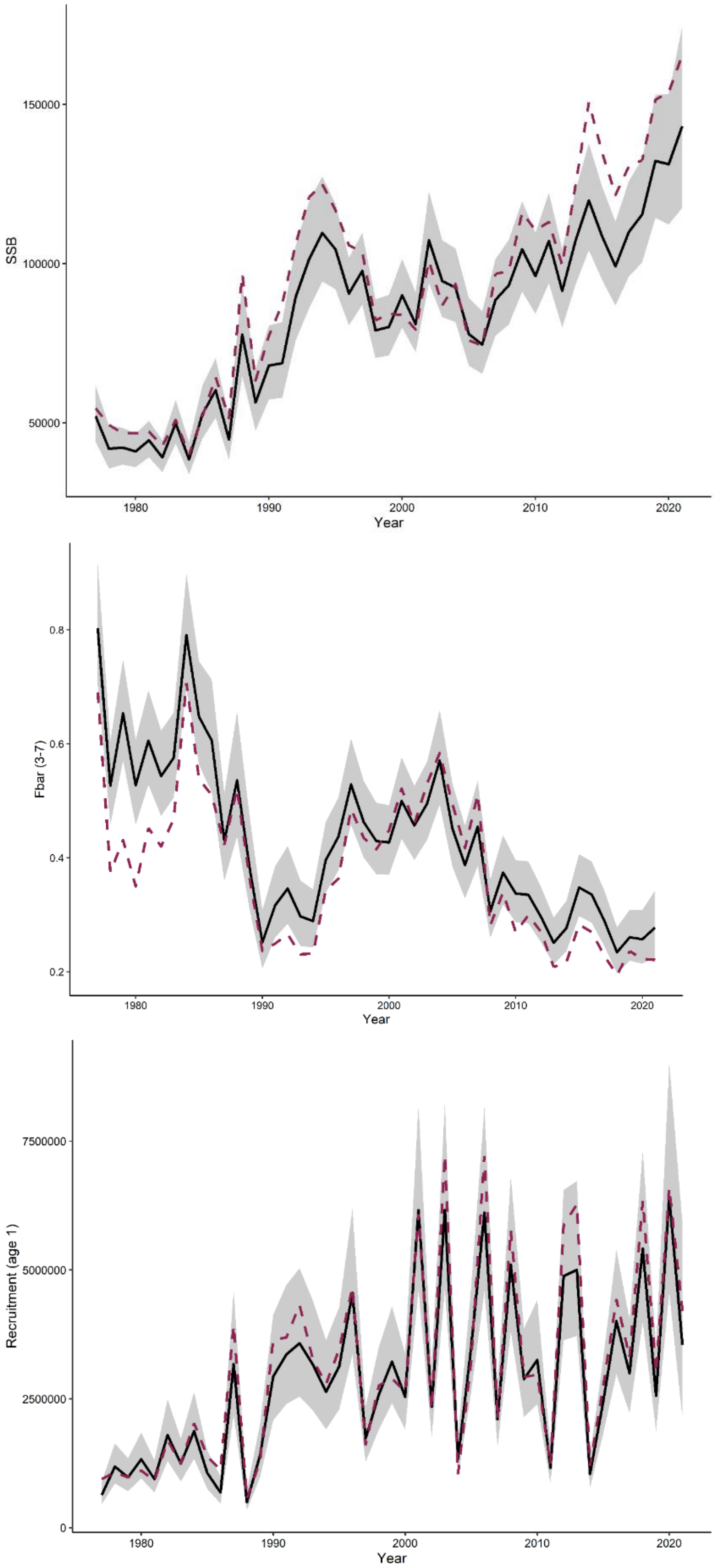


Figure 4.3.12. Gulf of Riga herring. Comparison of spawning stock biomass (SSB in tonnes), fishing mortality ($F_{3\text{-}7}$) and recruitment (age 1 in thousands) from XSA (dashed purple line) and SAM (black, grey shading represents the 95% confidence intervals of the SAM results).

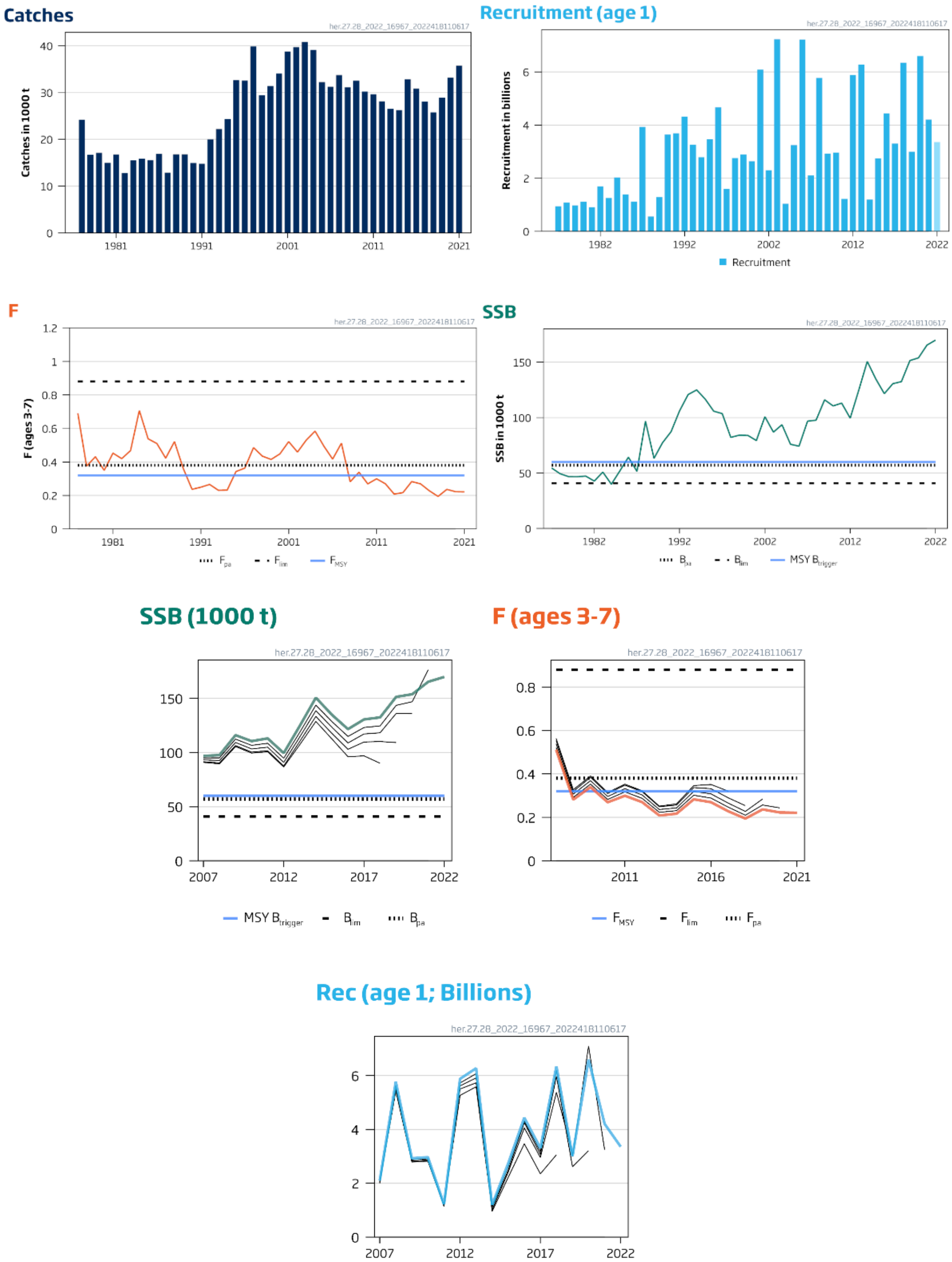


Figure 4.3.13. Gulf of Riga herring. Summary sheet plots: Catches, fishing mortality, recruitment (age 1) and SSB. (Recruitment and SSB in 2022 is predicted). Historical assessment results.

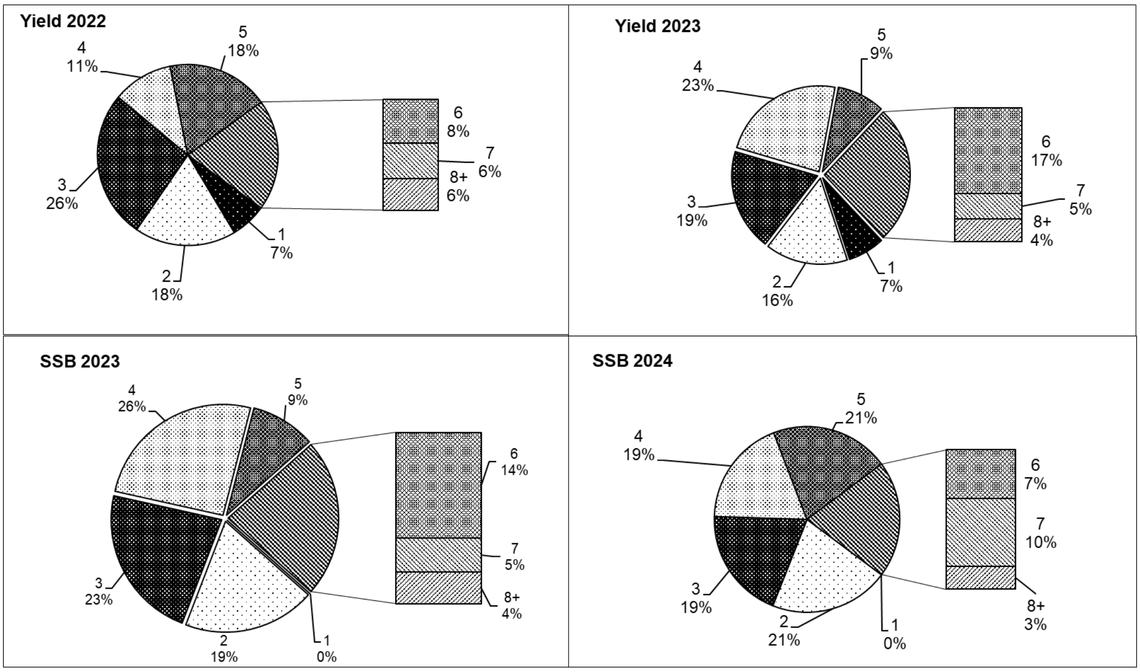


Figure 4.3.14. Gulf of Riga herring. Short term prediction. Age composition of catches and SSB.

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 2021, 95% of the Finnish catches came from trawl fishery, 5% with trapnets, and 0.2% with gillnets. In 2021, 98% of the Swedish catches came from trawls, 2% with gillnets and 0.1% with other fishing gears.

4.4.1.1 Landings

The total catch in the Gulf of Bothnia decreased by 1033 tonnes (1%) from 72 956 tonnes in 2020 to 71 924 in 2021 (Figure 4.4.1), of which 79% (56 924 tonnes) was Finnish catch and 21% (14 999 tonnes) was Swedish catch (Table 4.4.1). The Finnish catch decreased by 6% (3621 tonnes) while the Swedish catch increased by 21% (2588 tonnes) compared to 2020.

4.4.1.2 Unallocated removals

No unallocated removals were reported.

4.4.1.3 Discards

Discarding rates in both Finnish and Swedish fisheries are small (reported discards sum up less than 0,2% of total catches) but those have been taken into account as catches in the assessment. Sweden is catching herring primarily for human consumption, and the preferred fish size is about 16 cm, while smaller sized fish are presumably discarded. Another 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 discards are reported in the herring fishery with nets. In Sweden, however, the previously made interviews of fishermen indicated that they estimated the discard rate to be about 10% for the entire year.

This has historically constituted at most up to 1% of the total herring catches in SD 30 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 4.4.3). 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 (rectangles 23, 42 and 47) (Figure 4.4.4). 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 4.4.5). 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 2021 Finnish and Swedish unsampled catches were mostly allocated in InterCatch according to the Finnish sampling and mostly from respective fisheries. Finnish and Swedish sampled catches are shown in Table 4.4.2. When merging the SD 30 and SD 31 in 2017 the SD 30 time-series was shortened (starting in 1980) to increase the compatibility with the SD 31 time-series, which doesn't contain any Finnish data before 1980. The most common age-group in catches (both in numbers and in terms of biomass) during 2021 was age-group 2. 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 4.4.6.

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 4.4.7), 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.

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 4.4.8a. 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 determination of maturity ogives (ICES 2012).

4.4.2.4 Quality of catch and biological information

From Finnish commercial catches, 77 samples were taken during 2021, as well as 38 samples from the Swedish fisheries. In total, during 2021, 35 599 herrings were length-measured and 2472 were aged (Table 4.4.2). The COVID pandemic did not influence the catch-sampling in either country.

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 (Figure 4.4.8). As low condition as that of 2021 in larger herring size groups has not been observed earlier during the period of 1973–2021 (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 4.4.7).

The practical starving of larger herring may be 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. Smaller sized herring compete efficiently with larger herring for zooplankton and have thrived well. The abundance of the youngest age groups in the surveys is uncertain, but if it were very high in 2020 and 2021, it together with reduced mysids could explain the poor condition of larger herring. In BIAS in subdivisions 29 and 32, the condition of herring in 2015 was found to decrease remarkably, probably as a consequence of the very abundant 2014-year class of sprat in the same area.

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 2018-2021 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 4.4.9). 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 4.4.10) 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 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.

The biological samples for ages from the surveys in 2013–2019 and 2021 have been used for 3rd and/or 4th quarter ALK's for length distributions from commercial sampling and calculations for mean weights at age in the input data.

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 from year 1963 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 4.4.9) 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 1960s 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 4.4.11, 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. SSB in 2022 is estimated to have increased slightly from 2021. 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 4.4.11, 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 ($F_{2016} = 0.25$), and has decreased since except for the final year in the assessment; 2021. (Figure 4.4.11, Table 4.4.7).

The fit of the model is good with age compositions well reconstructed (Figure 4.4.12-13). Pearson residuals are within the range [-2.2 2.2] without any particularly worrying patterns. 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 2021 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 4.4.14 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 4.4.14 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 4.4.14 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 4.4.15). The estimated Hurtado-Ferro et al. (2014) Mohn's rho indices were inside the bounds of recommended values for SSB (-0.10) and F (0.17), using 5-year peels. Forecast Mohn's rho values were -0.14 and 0.18 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 (0.55) and survey data (0.59), and the predictions of the tuning index (0.73) scored better relative to the naïve model (Figure 4.4.16).

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 2022 was based on fishing at F_{SQ} (i.e. F_{2022} = estimated F_{2021}; Table 4.4.7). The short-term forecasts show that with a fishing mortality at the F ranges in the multiannual plan ($F_{lower} = 0.206$; $F_{upper} = 0.272$; $F_{MSY} = 0.271$), herring catches in the Gulf of Bothnia in 2023 would be between 80 047 tonnes and 103 059 tonnes (Table 4.4.8). The resulting catches at MSY in 2023 is 102 719 tonnes, a decrease by 7.7% relative to the catches at MSY in 2022. Note that out of the EU MAP scenarios above, only F_{lower} will keep the stock above $B_{trigger}$ in 2024.

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 in 2021 and decreased condition and weight at age of 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.

The assessment follows the same procedures as set out by the benchmark (ICES, 2021), thus including age-1 and all years of the BIAS tuning index data. In 2022, WGBIFS recommended that, in addition to age 1, also years 2017 and 2020 index data should be handled with caution due to a possible relative overestimation of the younger age groups (WGBIFS, 2022). The current assessment's diagnostic scores (residual tests, retrospective analyses and prediction skill evaluation) are within the range of accepted values (and shows an improvement compared to the assessment performed in 2021), however it should be noted that SSB for the last 5-6 years of the time series is sensitive to the inclusion or exclusion of the years 2017 and 2020 of the BIAS index data.

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 a decreasing trend since 2010 and is in 2022 estimated to be close to $B_{trigger}$. Depending on the catch in 2022, the stock will be below or above $B_{trigger}$ in 2023. Assuming F_{SQ} in 2022, out of the EU MAP scenarios, only F_{lower} will keep the stock above $B_{trigger}$ in 2024.

The decrease in SSB is likely related to decreased weight at age of especially the larger herring. Mean weight at age has been at low levels for 15 years and decreased even further in 2021 (Figure 4.4.6). In addition, the present low state of the body condition of larger herring has not previously been observed in the time series (Figure 4.4.8b).

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

Year	Finland	Sweden	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	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

Table 4.4.2. Herring in GoB. Sampling by country and SD

Country	SD	Q	Catches in tonnes	Number of samples	Number of fish measured	Number of fish aged
FI	30	1	24974	16	4 969	702
		2	17038	28	5658	465
		3	3532	4	1214	80
		4	10440	13	3619	272
		Total	55985	61	15 460	1 519
FI	31	1	0	0	0	0
		2	532	8	2848	213
		3	355	5	1511	80
		4	52	3	677	30
		Total	939	16	5 036	323
SE	30	1	5619	21	5 987	0
		2	3144	5	2270	241
		3	1418	4	1995	228
		4	4617	7	4417	0

Country	SD	Q	Catches in tonnes	Number of samples	Number of fish measured	Number of fish aged
		Total	14797	37	14 669	469
SE	31	1	0	0	0	0
		2	40	1	434	161
		3	117	0	0	0
		4	45	0	0	0
		Total	202	1	434	161
FI + SE Total	30+31	1	30593	37	10 956	702
		2	20754	42	11210	1080
		3	5422	13	4720	388
		4	15155	23	8713	302
		Total	71924	115	35 599	2 472

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	331769,5	982264,1	626256,2	297292,6	296916,5	225031,5	173385,7	74886	63698	36557	27501	16293	18579	12198	27063

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

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

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

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

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

Year	Recruitment Age 0	90%	10%	SSB	SSB* 90%	10%	Total Catch	F Ages 3–7	90%	10%
	thousands				tonnes		tonnes			
1963	20040600	42945588	9351965	1112470	1265594	959346	29739	0.029	0.033	0.025
1964	18358400	38677790	8713808	1110570	1262766	958374	25204	0.024	0.028	0.021
1965	16780500	34774311	8097506	1086830	1236831	936829	27541	0.028	0.032	0.024
1966	15243400	31092146	7473310	1002390	1160188	844592	22164	0.024	0.028	0.020
1967	13607400	27278677	6787768	920385	1080915	759855	27772	0.033	0.038	0.027
1968	12546600	24524586	6418749	835102	993317	676887	28966	0.038	0.044	0.031
1969	11946400	22566198	6324347	742591	892628	592554	35996	0.053	0.063	0.043
1970	18015100	30352224	10692588	683686	833834	533538	32790	0.052	0.063	0.041
1971	13472600	22770458	7971335	524871	640974	408768	36347	0.076	0.092	0.060
1972	17960200	27747331	11625219	561023	692903	429143	34092	0.065	0.080	0.050
1973	24079800	34565398	16775064	604175	753924	454426	26507	0.047	0.058	0.035
1974	19294600	27605959	13485552	519516	645811	393221	26776	0.053	0.065	0.040
1975	41294600	54094621	31523356	553410	685123	421697	21811	0.040	0.050	0.031
1976	15111100	20815696	10969863	563442	696927	429957	30520	0.055	0.069	0.042
1977	9686550	13521900	6939058	608444	750846	466042	33634	0.056	0.069	0.042
1978	9501910	12989688	6950613	690201	852967	527435	34873	0.057	0.071	0.043
1979	24668500	31467425	19338567	633178	787041	479315	26109	0.046	0.057	0.034
1980	13880300	18304844	10525232	555661	693215	418107	29809	0.057	0.071	0.043
1981	20968800	26929793	16327291	567556	709357	425755	21526	0.039	0.048	0.029
1982	34167900	42756473	27304530	586751	730236	443266	26499	0.048	0.060	0.037
1983	44536900	54922439	36115211	641418	798347	484489	26208	0.041	0.051	0.031
1984	37009900	45763653	29930581	702712	867529	537895	34545	0.047	0.059	0.036
1985	15556400	20189495	11986510	771238	943979	598497	35432	0.045	0.056	0.035
1986	30756900	38036362	24870594	865664	1049983	681345	35579	0.044	0.054	0.034
1987	14803100	19323795	11339997	958958	1160115	757801	32628	0.037	0.045	0.029
1988	63695000	76290162	53179243	931468	1127746	735190	36418	0.039	0.048	0.031
1989	58146200	69950995	48333560	1063290	1277930	848650	33086	0.033	0.039	0.026

Year	Recruitment Age 0 (thousands)	90%	10%	SSB (tonnes)	SSB* 90%	10%	Total Catch (tonnes)	F Ages 3–7	90%	10%
1990	32521500	40083080	26386395	1195250	1418639	971861	39180	0.036	0.044	0.029
1991	37733700	46081111	30898389	1331360	1566039	1096681	33419	0.029	0.034	0.023
1992	40179300	48586111	33227112	1293280	1517990	1068570	46610	0.041	0.048	0.033
1993	25347000	31576426	20346521	1244590	1461107	1028073	49314	0.042	0.050	0.035
1994	32616000	39827734	26710117	1370970	1603080	1138861	61986	0.052	0.062	0.043
1995	26093800	32351314	21046638	1213120	1424838	1001402	65547	0.059	0.069	0.049
1996	22926900	28742907	18287738	1195050	1401583	988517	61303	0.059	0.070	0.049
1997	42102700	50781976	34906821	1002100	1180652	823548	69808	0.075	0.089	0.062
1998	24387100	30993305	19189004	958338	1136432	780244	62474	0.069	0.082	0.057
1999	36377300	44706189	29600106	934555	1107423	761687	66502	0.077	0.091	0.063
2000	29410400	36851494	23471820	867516	1021720	713312	58852	0.080	0.094	0.065
2001	44486400	54109251	36574888	850179	999315	701043	57806	0.079	0.093	0.064
2002	89118900	1.04E+08	76459420	858746	1009070	708422	53969	0.071	0.085	0.058
2003	20231900	26474450	15461314	869988	1017359	722617	53644	0.066	0.078	0.055
2004	21558600	27928897	16641303	912214	1059009	765419	61423	0.070	0.082	0.058
2005	29426100	36495321	23726202	923961	1064366	783556	62911	0.076	0.088	0.063
2006	40984000	49113115	34200402	827024	952690	701358	71318	0.095	0.110	0.079
2007	29672400	36440984	24161020	806697	927863	685531	78678	0.108	0.125	0.091
2008	39729300	47611327	33152138	767511	881711	653311	67914	0.098	0.113	0.083
2009	32851900	39932063	27027087	760341	869926	650756	71248	0.103	0.118	0.087
2010	22516700	28438110	17828251	910410	1032437	788383	72590	0.102	0.117	0.087
2011	30676700	37438184	25136367	808856	918850	698862	81850	0.119	0.136	0.101
2012	23279400	29049188	18655615	818278	929735	706821	106007	0.159	0.183	0.135
2013	26625200	32977509	21496508	815673	925389	705957	114396	0.182	0.211	0.154
2014	46048800	55303570	38342769	755009	864769	645249	115366	0.197	0.230	0.164
2015	25170100	31878492	19873397	711913	818824	605002	114942	0.213	0.250	0.176
2016	31302900	39805827	24616284	668702	776949	560455	130029	0.253	0.302	0.205
2017	20301600	27285325	15105371	652292	770967	533617	104358	0.213	0.259	0.168

Year	Recruitment Age 0	90%	10%	SSB* SSB	90%	10%	Total Catch	F Ages 3–7	90%	10%
	thousands			tonnes			tonnes			
2018	27090000	36961886	19854726	661535	794483	528587	97366	0.208	0.256	0.159
2019	35332400	49771083	25082406	583644	718126	449162	88907	0.200	0.253	0.148
2020	20821500	33893336	12791153	581614	734127	429101	72956	0.166	0.214	0.118
2021	23595100	59636184	9335419	536457	692642	380272	71924	0.180	0.237	0.122
2022	34097000**			565634	751690	379578				

*** 1 January.**

**** Arithmetic mean of years 2012–2021.**

Table 4.4.8 Herring in subdivisions 30 and 31. The basis made for the interim year 2022 and in the forecast for 2023.

Variable	Value	Notes
$F_{ages\ 3–7}$ (2022)	0.18	$F_{2022}= F_{SQ}$
SSB (2023)	538 857	Short term forecast*; tonnes
$R_{age\ 0}$ (2022–2024)	34 097 000	Average of recruitment (2012–2021); thousands
Total catch (2022)	72 033	Based on $F=F_{2022}$; tonnes

*** Based on stochastic calculations.**

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

Basis	Total catch (2023)	F (2023)	SSB (2024)*	% SSB change **	% Advice change ***
EU MAP^^^: F_{MSY}	102 719	0.271	511 754	-5.0%	-7.7%
EU MAP^^^: F_{lower}	80 047	0.206	533 549	-1.0%	-7.7%^
EU MAP^^^: F_{upper}	103 059	0.272	511 427	-5.1%	-7.7%^^
Other scenarios					
F_{MSY}	102 719	0.271	511 754	-5.0%	-7.7%
F = 0	0	0.000	610 774	13%	-100%
F = F_{pa}	103 059	0.272	511 427	-5.1%	-7.4%
F = F_{lim}	172 890	0.496	444 558	-18%	55%
SSB (2024) = B_{lim}	254 409	0.818	367 116	-32%	129%
SSB (2024) = B_{pa}	80 047	0.206	533 549	-1.0%	-28%
SSB (2024) = MSY $B_{trigger}$	80 047	0.206	533 549	-1.0%	-28%
SSB (2024) = SSB (2023)	75 011	0.192	538 396	-0.09%	-33%
F = F_{2022}	70 649	0.180	542 595	0.7%	-37%

* Based on stochastic calculations, using an identical random seed for all scenarios.

** SSB 2024 relative to SSB 2023.

*** Advice value in 2023 relative to advice value for EU MAP: F_{MSY} 2022 (111 345 tonnes).

^ Advice value for 2023 relative to advice value for EU MAP: F_{lower} 2022 (86 279 tonnes).

^^ Advice value for 2023 relative to advice value for EU MAP: F_{upper} 2022 (111 714 tonnes).

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

Based on stochastic forecasts, using the F with three decimals getting the closest to the biomass target. SSB (2024) = B_{lim}: 2.5%; SSB (2024) = B_{pa} = MSY $B_{trigger}$: <0.0%; SSB (2024) = SSB (2023): -0.8%.

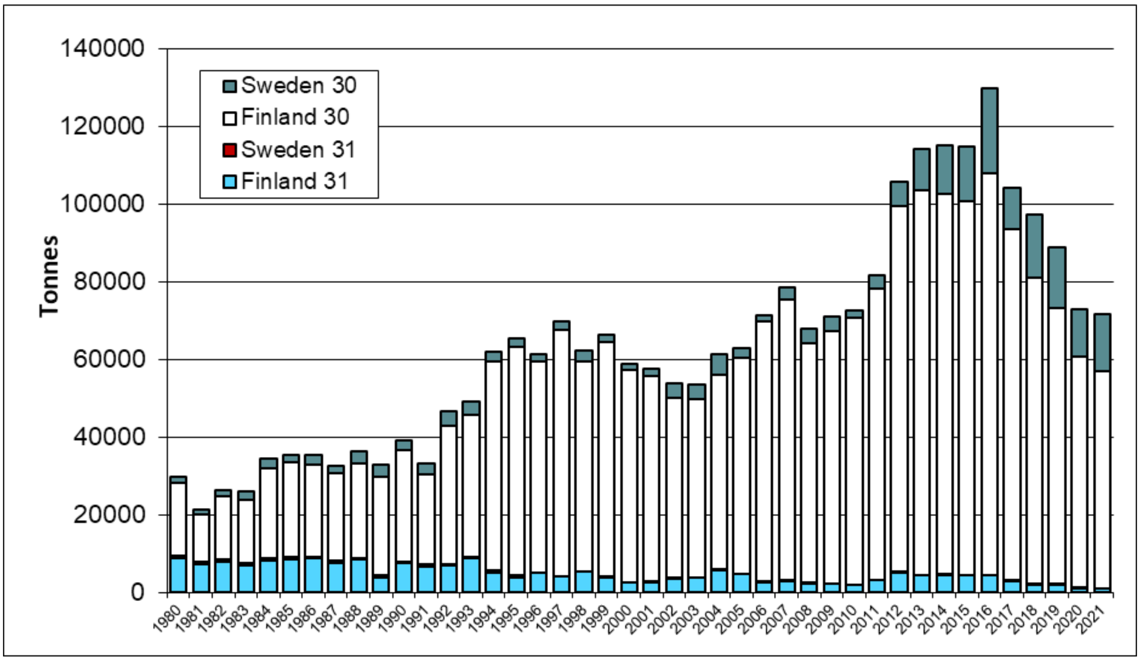


Figure 4.4.1 Herring in SD's 30 and 31. Catches (tonnes) by country

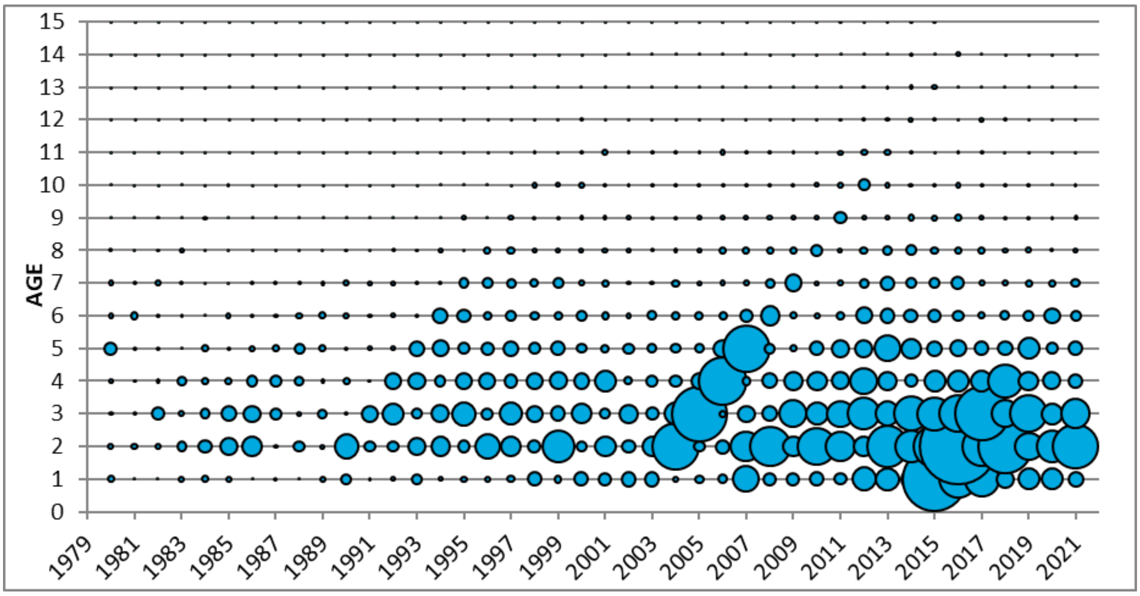


Figure 4.4.2. Herring in SD's 30 and 31. Age composition in commercial catch.

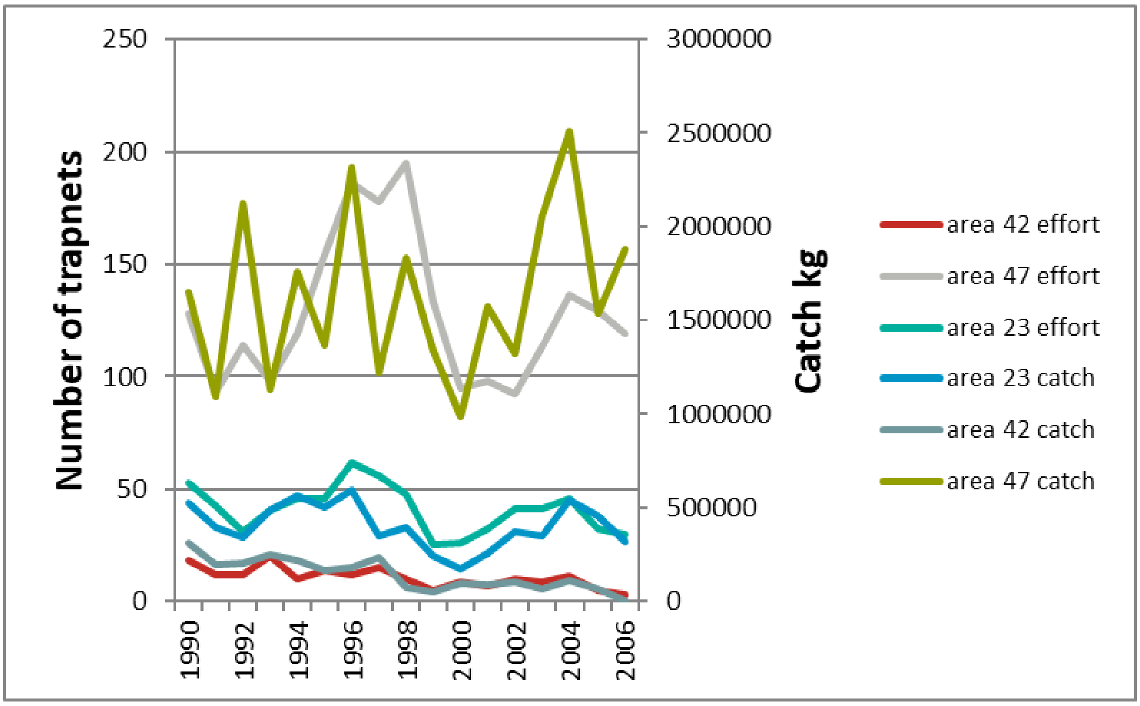


Figure 4.4.3. Herring in SD's 30 and 31. Trapnets catch (kg) and effort (number of traps) in three different areas used to calculate the trap net tuning index..

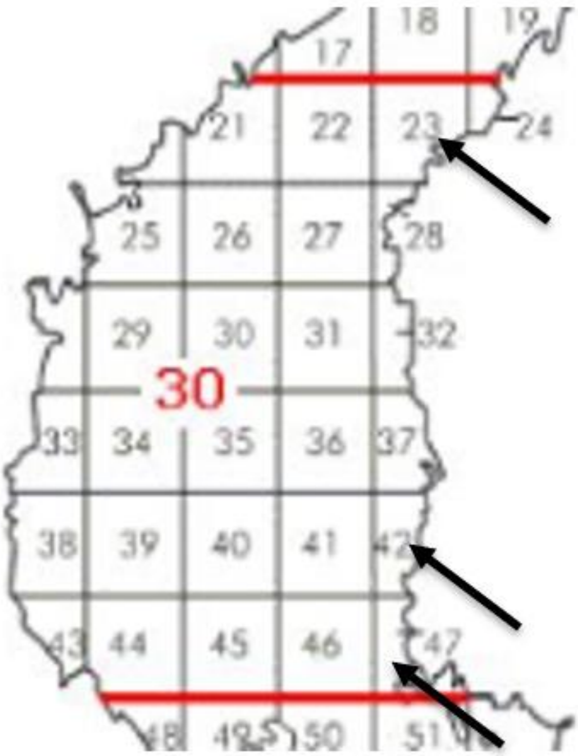


Figure 4.4.4. Herring in SD's 30 and 31. The areas (statistical rectangles) where the Trapnets were situated.

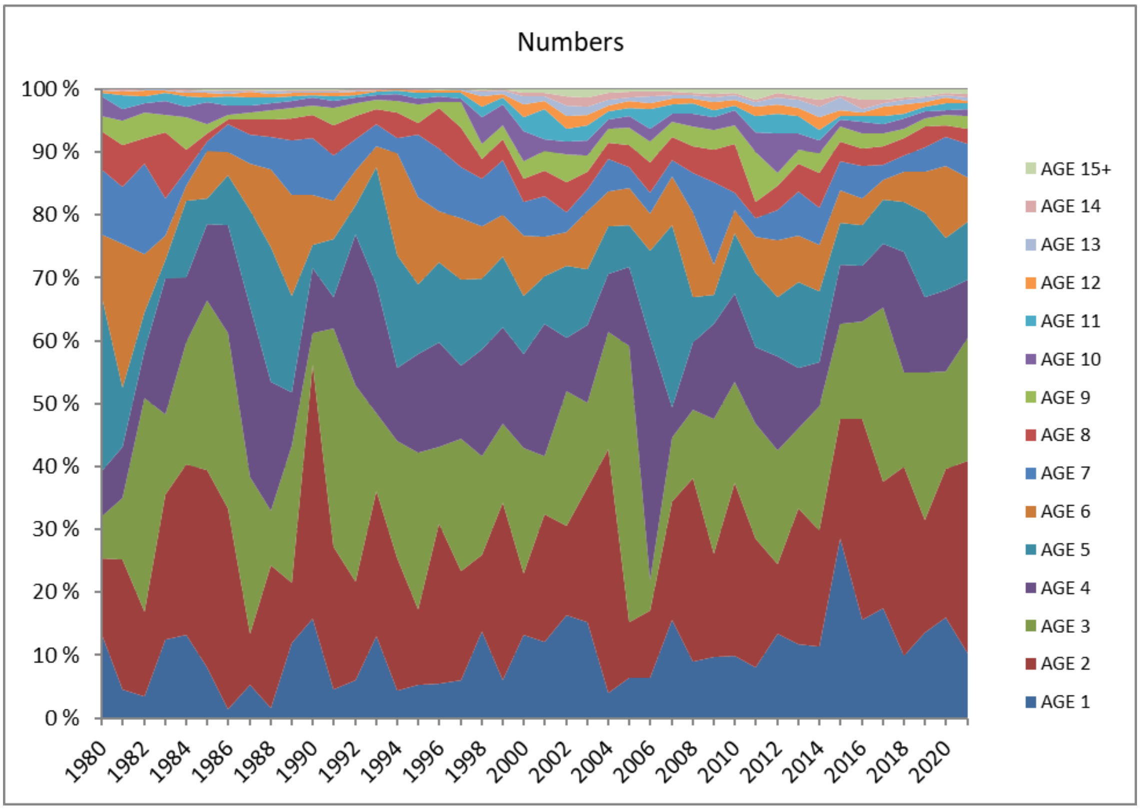


Figure 4.4.5. Herring in SD's 30 and 31. Shares of age-groups in catches (Canum)

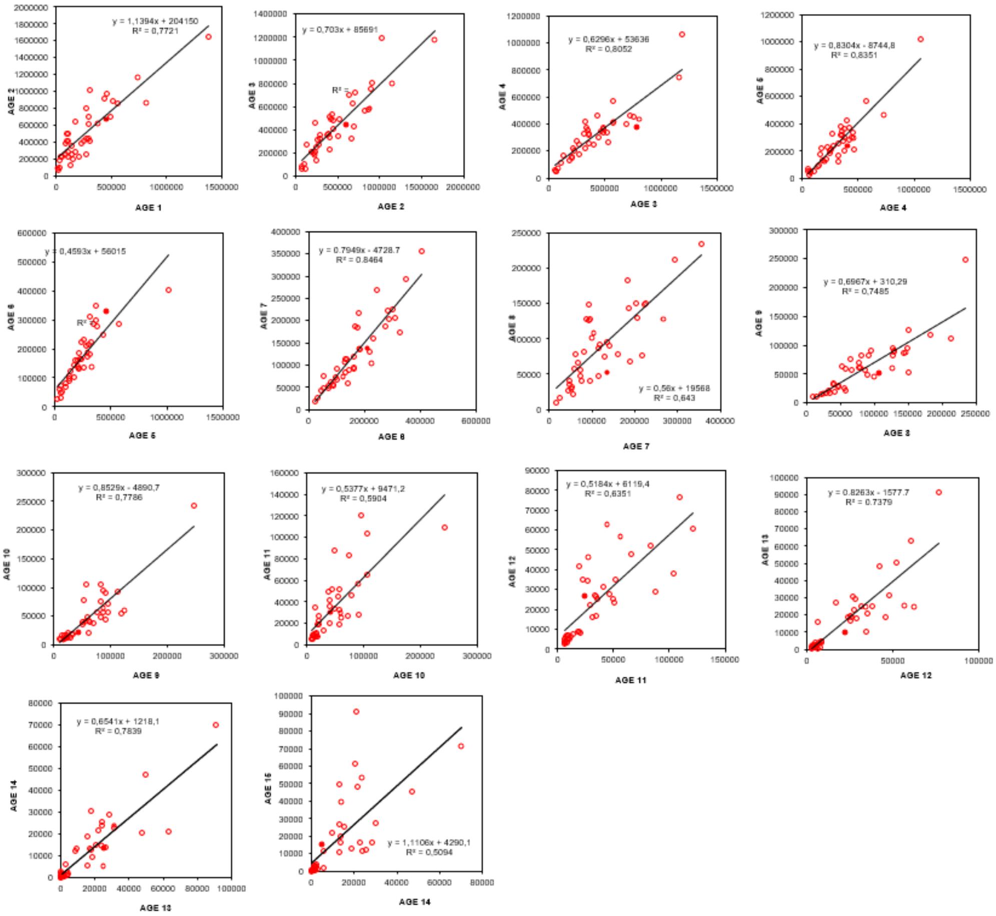


Figure 4.4.6. Herring in SD's 30 and 31. Consistency in catch at age data.

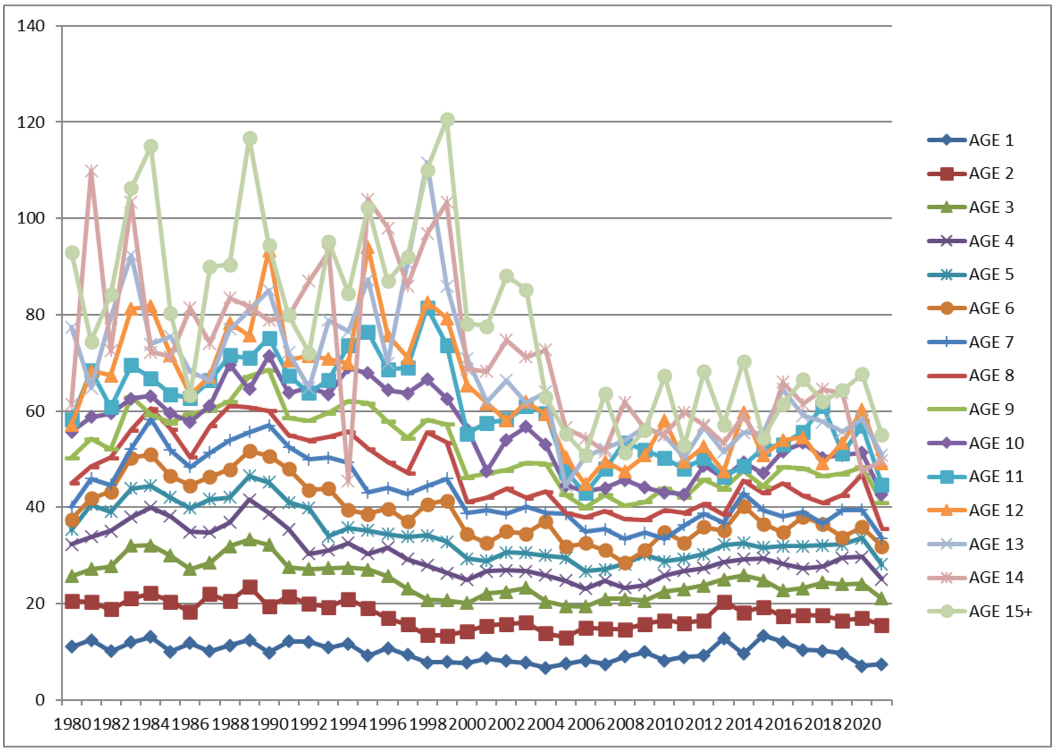


Figure 4.4.7. Herring in SDs 30 and 31. Mean weights-at-age in catches

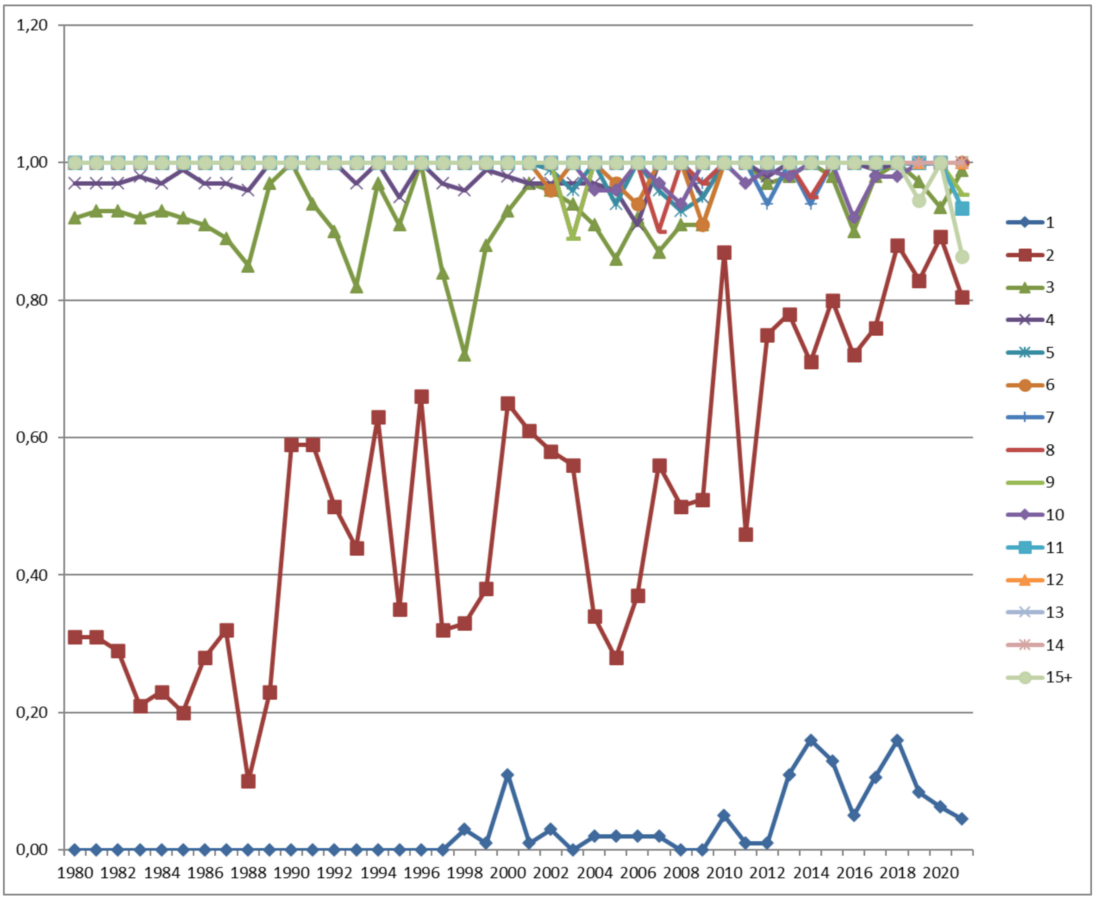


Figure 4.4.8a. Herring in SDs 30 and 31. Maturity-at-age

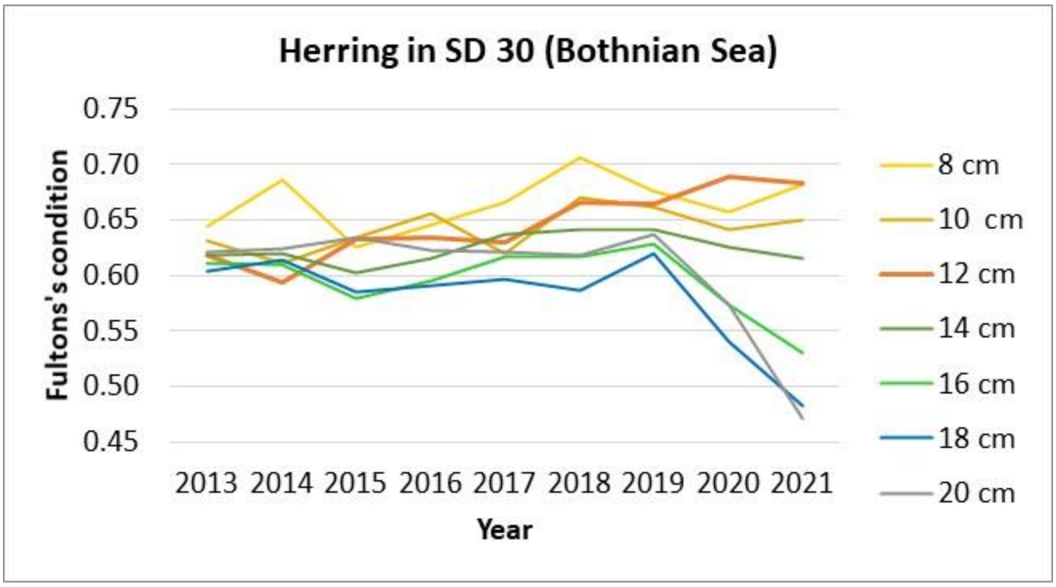


Figure 4.4.8b. Herring in SDs 30 and 31. Fulton's condition (K = W/L³) of herring in different length classes (total length) in BIAS surveys in 2013–2021.

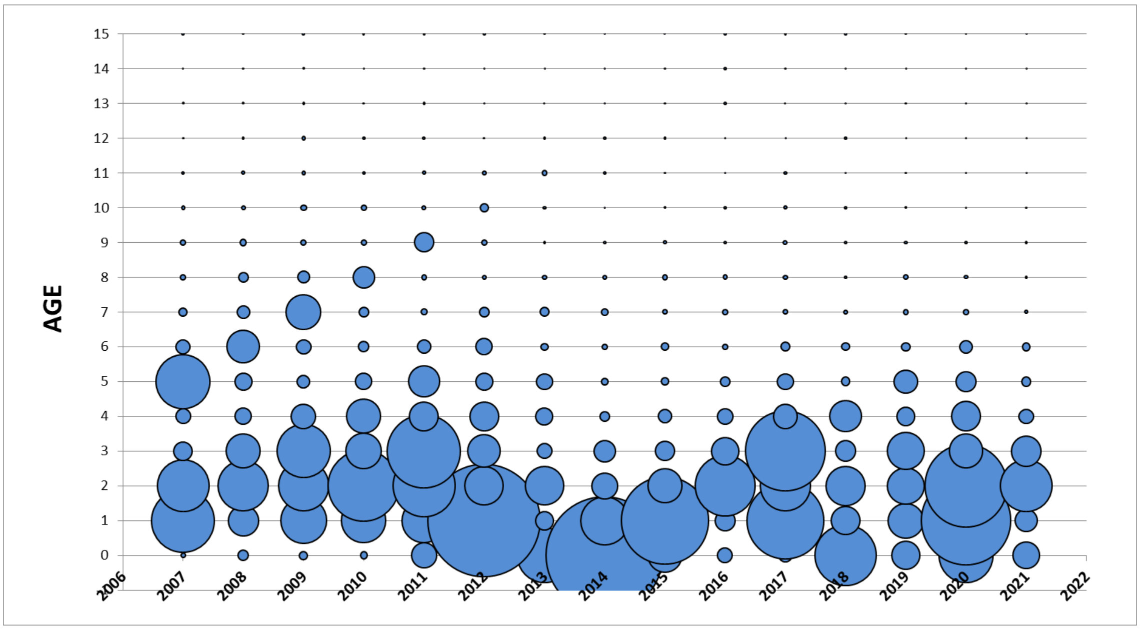


Figure 4.4.9. Herring in SD's 30 and 31. Year class strength in acoustic estimates in ages 0-15+

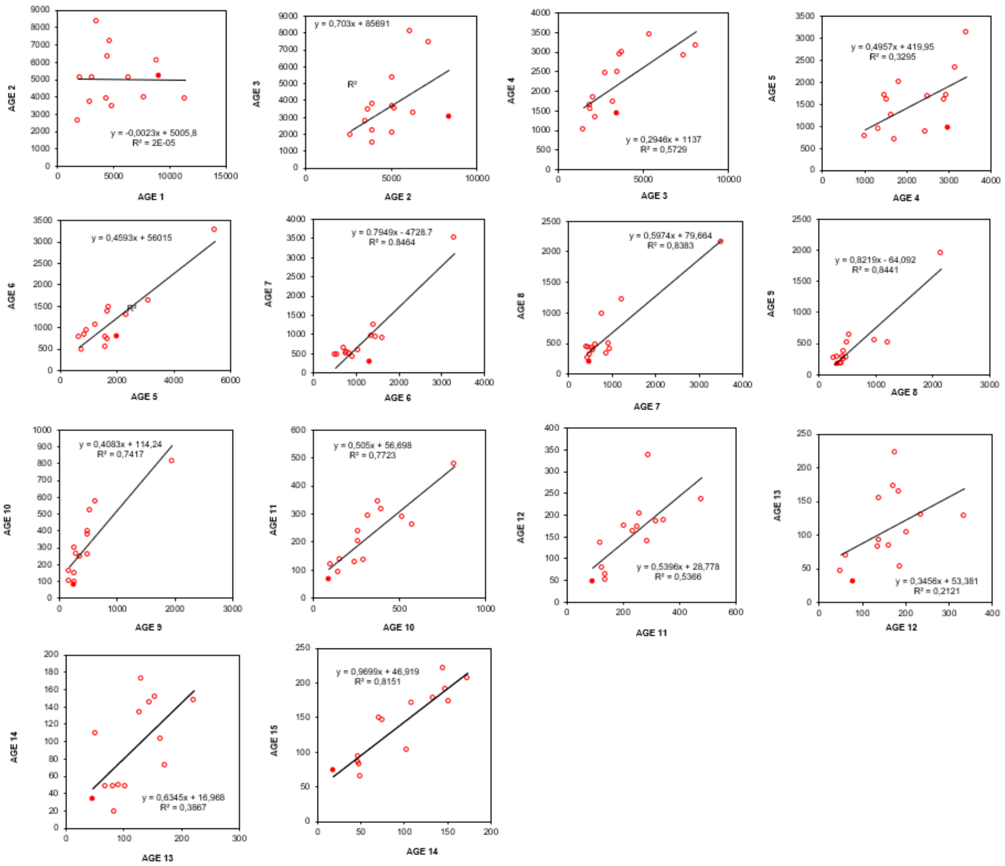


Figure 4.4.10. Herring in SDs 30 and 31. Internal consistency in the acoustic age matrix.

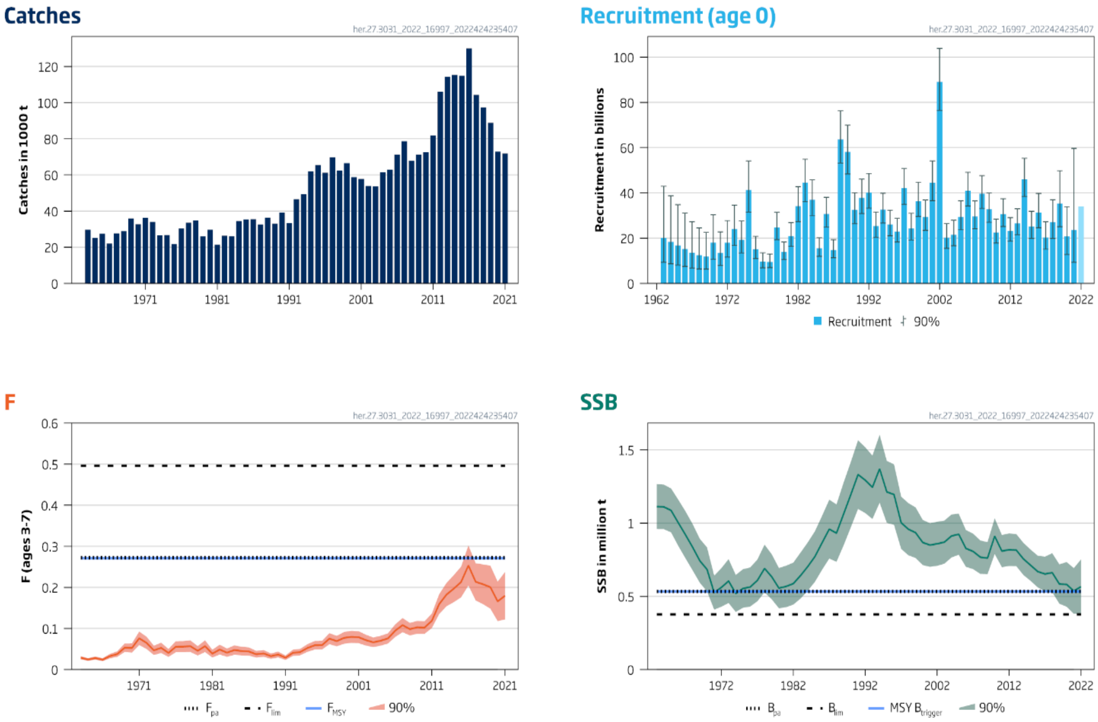


Figure 4.4.11. Herring in SD's 30 and 31. Stock summary. Estimated spawning-stock biomass (SSB), recruitment (R) and fishing pressure (F). R, F, and SSB show confidence intervals (90%) in the plot. The assumed recruitment for 2022 is shaded in a lighter colour.

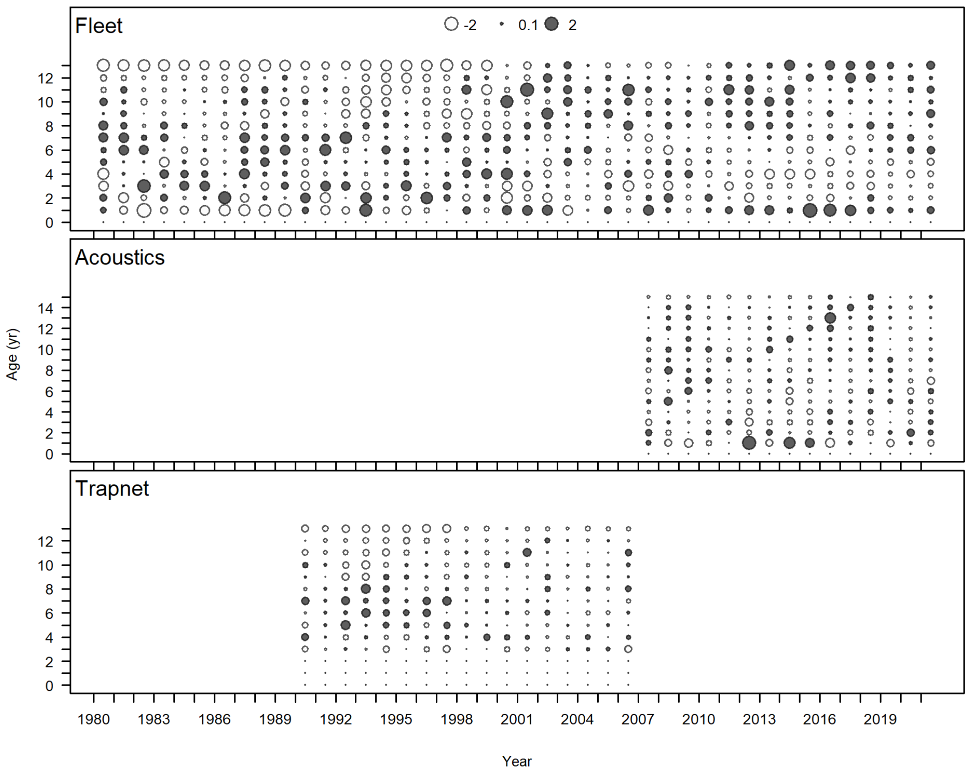


Figure 4.4.12. Herring in SD's 30 and 31. Pearson residuals for commercial (upper), acoustic (middle) and trapnet (lower) data, in 1980-2021. Residuals are within the range [-2.2 2.2]. Filled and open bubbles denote positive and negative residuals respectively.

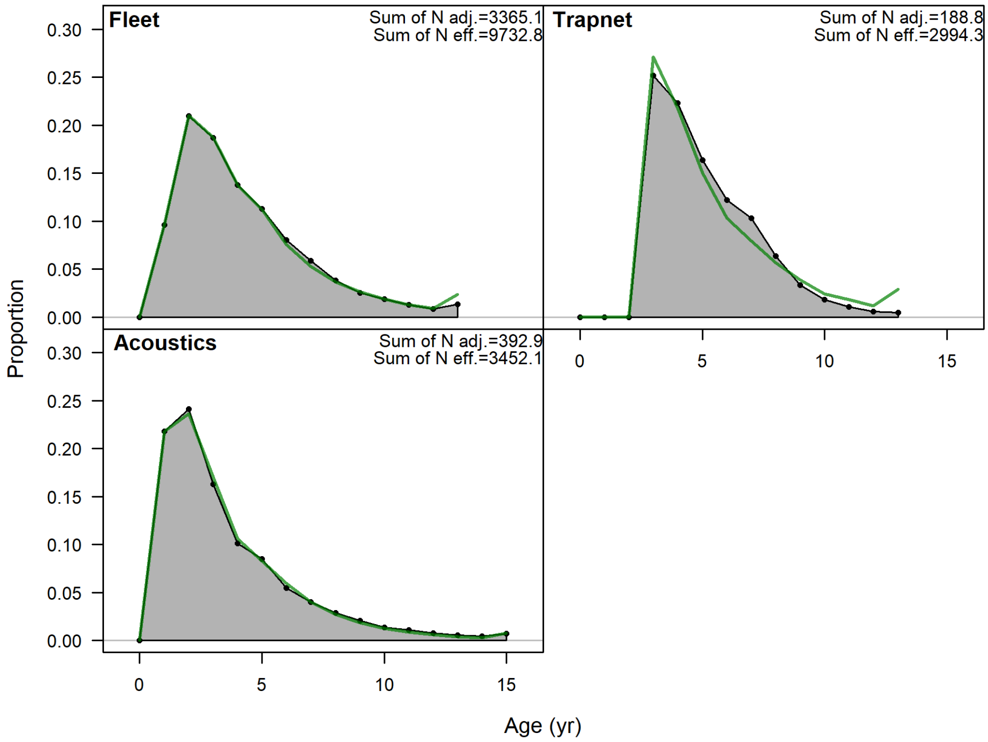


Figure 4.4.13. Herring in SD's 30 and 31. Age-composition fit of model (green line) with commercial (upper left), acoustic (upper right) and trapnet (lower) data, aggregated across time.

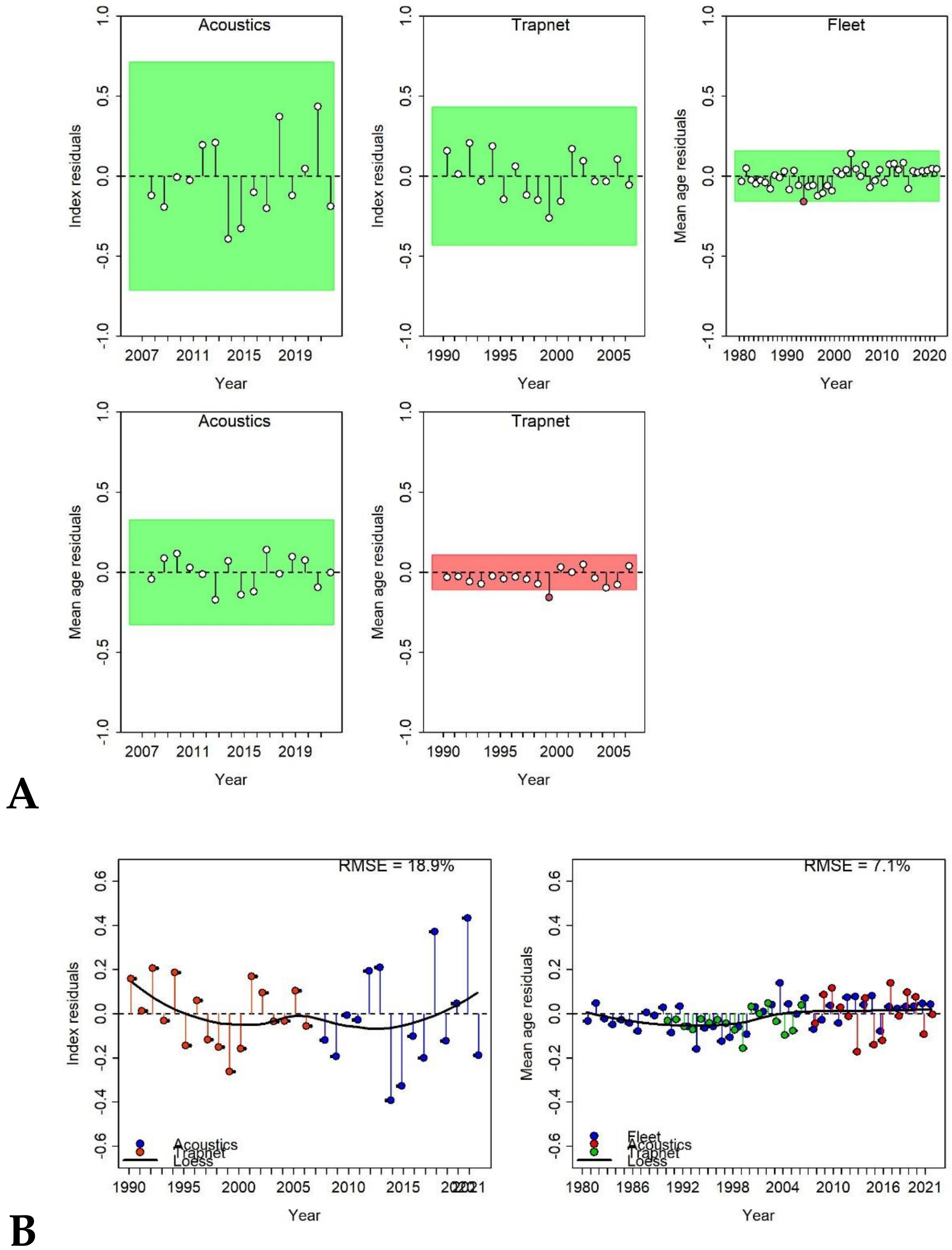


Figure 4.4.14. Herring in SD's 30 and 31. Residuals from Runs test analyses for the age distributions and the fit to the acoustic and trapnet survey indices (A) and from the RMSE test analyses for the age distributions and the fit to the acoustic and trapnet survey indices (B).

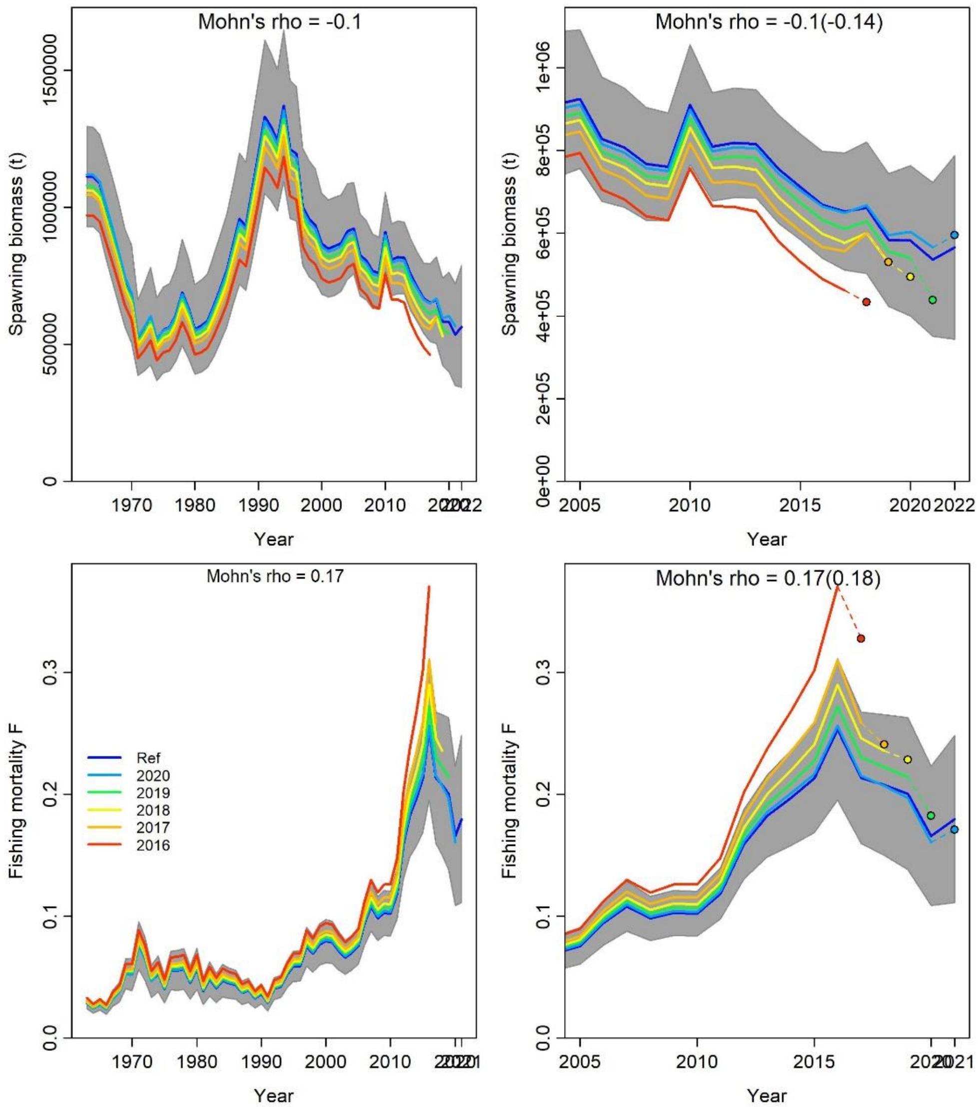


Figure 4.4.15. Herring in SDs 30 and 31. Retrospective analyses for spawning-stock biomass (upper) and fishing pressure (lower), showing 5 years peels with 95% confidence bands for the reference year 2021. Left column shows the full time-series whereas the right column shows the las 17 years.

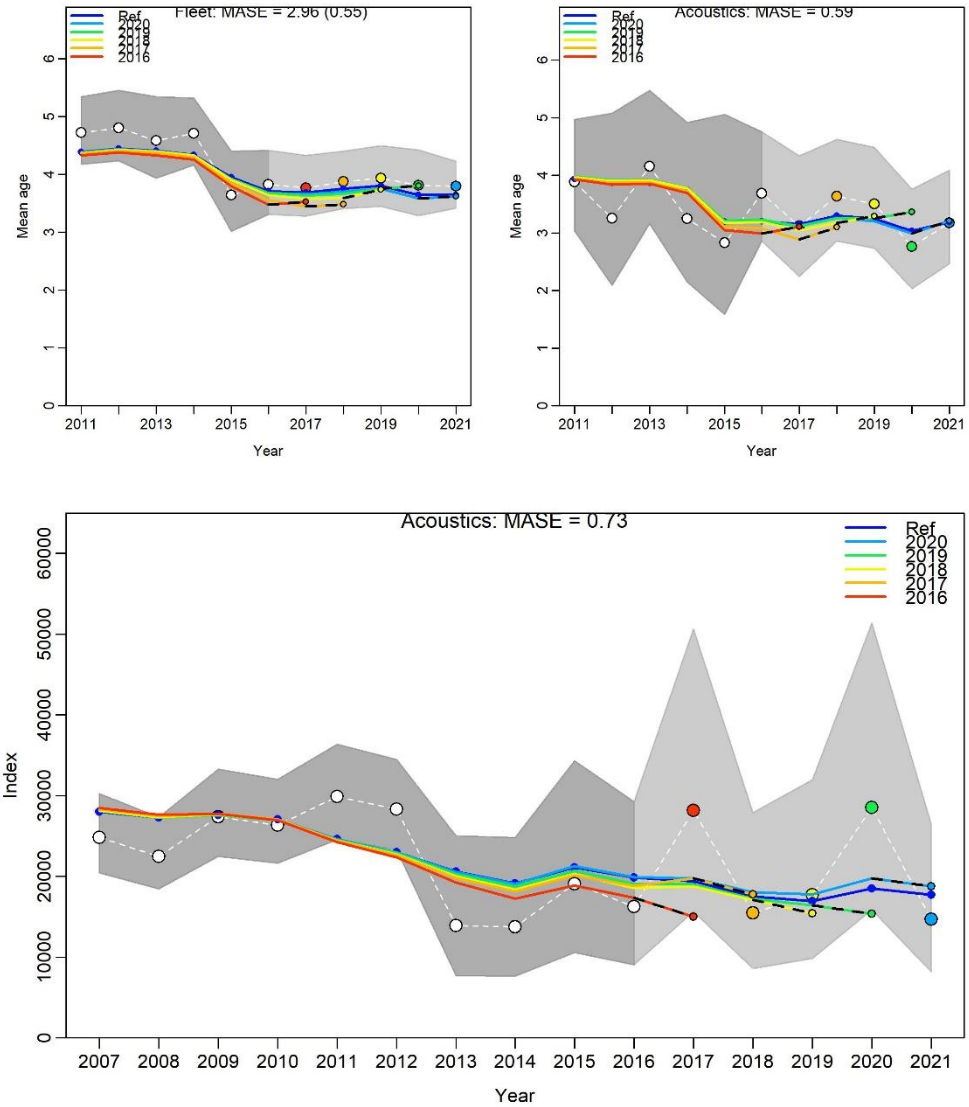


Figure 4.4.16. Herring in SDs 30 and 31. Model prediction skill evaluated using the mean absolute scaled error (MASE) score, for mean age commercial (upper left; 0.55) and survey (upper right; 0.59), and survey index (lower; 0.73) model fits (coloured lines), compared to one-year-ahead forecasts (black dashed lines). Large dots connected by dashed white lines show the observed values.

5 Plaice

5.1 Introduction

5.1.1 Biology

5.1.1.1 Assessment units for plaice stocks

The plaice stocks within inner Danish waters and the Baltic consists 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. Each stock is managed based on individual assessments. ple.27.21–23 is a category 1 stock and ple.27.24–32 is a category 3 stock.

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 2019-2022 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 (2021) by gear type and quarter is 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 30% in 2021; up slightly from 24% in 2020 and 20% in 2019, and surpassing that of 2018. However, it remains lower than the median of the time-series (35%) (Figure 5.2.4b).

In 2021, the discards ratio was estimated as 74% in Kattegat (SD 21), 14% in SD 22 and 23% 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.

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 93% of the total landings, and 80% 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 2017, 2018, and 2020.

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 but is used as an average from 1999–2021. The procedure for calculating this average was updated in 2019 (the same procedure as used for Western Baltic cod) (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 2002–2021 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 2022 followed this method and only survey data until 2021 have been included in this assessment. 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 deviations from last year (Figure 5.2.13) but performed well. This is observed in retrospective patterns, with a Mohn's rho estimate of 5% for the SSB and -1% for F (Figure 5.2.14).

This SPALY run in SAM is named: ple.27.21-23_WGBFAS_2022_SPALY_v1. The assessment is available at "stockassessment.org" and is visible for everybody.

The input data for the final run ("…Annex_v2") 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

The high recruitment estimates for 2017 and 2018 from earlier assessments were reduced in the 2020 assessment, while the have drastically increased to unseen levels for the 2019- and 2020-year classes. Age 1 recruitment estimates for 2020 and 2021 are the absolute highest seen for this stock (~147 million and ~183 million, respectively). While not utilized in the assessment, the Q1 2022 surveys indicate that this second, extraordinarily large pulse appears to be true (Figure 5.2.11) and is corroborated by a pulse in the neighboring 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 observed SSB at 3.6 kt in 2009, to the highest observed SSB at ~24 kt in 2020. This population growth is boosted by sporadically large recruitment pulses which seem to be increasing in frequency with SSB.

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 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 2021 as the base year and project until 2024. Intermediate year (2022) assumption is status quo F (0. 268 in 2022, = F_{2021}). Recruitment for 2022 and 2023, 2024 is resampled from the entire time-series. Weight-at-age, selectivity and landings fraction at age are taken as average over the last three years (2019-2021).

As described above, this stock is doing well with two extraordinary recruitment years from the 2019 and 2020 cohorts. The large recruitment pulses observed in 2020 and 2021 are expected to begin to enter the fishery in 2022 and 2023, respectively. 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 an increase this year (2021 advice) 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 likely due to changes in the fishery associated with a switch to a directed fishery in SD22 (where the majority of catches are fished) and extraordinarily good year classes coming through.

While the 2022 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 estimated that in-turn supports a growing SSB, Fishing mortality remains just 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 2023, 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 3,232 tonnes in SD 21 and 13,315 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. 1970–2019.

	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

	21			22			23		Total
Year	Denmark	Germany	Sweden	Denmark	Germany	Sweden	Denmark	Sweden	
1996	2337	0	205	859	43	1	81	13	3526
1997	2198	25	255	902	51			13	3431
1998	1786	10	185	642	213			13	2836
1999	1510	20	161	1456	244	1		13	3392
2000	1644	10	184	1932	140			26	3910
2001	2069		260	1627	58			39	4014
2002	1806	26	198	1759	46			42	3835
2003	2037	6	253	1024	35	0		26	3355
2004	1395	77	137	911	60			35	2580
2005	1104	47	100	908	51		145	35	2355
2006	1355	20	175	600	46		166	39	2362
2007	1198	10	172	894	63		193	69	2531
2008	866	6	136	750	92	0	116	45	1966
2009	570	5	84	633	194	0	139	42	1626
2010	428	3	66	748	221	0	57	17	1524
2011	328	0	40	851	310		46	11	1575
2012	196	0	30	1189	365	7	54	12	1841
2013	232	0	60	1253	319	0	14	76	1955
2014	343	1	68	1097	320	0	57	45	1931
2015	807	0	87	1103	560	0	26	103	2687
2016	984	1	121	1108	680	0	107	20	3020
2017	703	1	97	1424	939	0	70	13	3247
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

Table 5.2.2. Catches from ple.27.21-23 in 2021 by catch category, by fleet and over quarters (tonnes).

Subdivision	CatchCategory	Fleet	Q1	Q2	Q3	Q4
27.3.a.21	Discards	Active	167	108	178	154
27.3.a.21	Discards	Passive	1	2	2	2
27.3.a.21	Landings	Active	61	32	36	61
27.3.a.21	Landings	Passive	8	4	6	7
27.3.b.23	Discards	Active	12	0	0	2
27.3.b.23	Discards	Passive	1	3	1	3
27.3.b.23	Landings	Active	4	0	0	1
27.3.b.23	Landings	Passive	9	25	25	13
27.3.c.22	Discards	Active	68	101	22	92
27.3.c.22	Discards	Passive	3	0	4	1
27.3.c.22	Landings	Active	566	239	33	334
27.3.c.22	Landings	Passive	224	194	107	138

Table 5.2.3. Plaice in SD 27.21–23. Sampling effort 2021 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	504.554	55	3901	55	686
27.3.a.21	Discards	Denmark	Passive	4.353	0	0	0	0
27.3.a.21	Discards	Germany	Active	11.467	0	0	0	0
27.3.a.21	Discards	Germany	Passive	0.464	0	0	0	0
27.3.a.21	Discards	Sweden	Active	91.904	0	0	0	0
27.3.a.21	Discards	Sweden	Passive	1.053	0	0	0	0
27.3.a.21	Landings	Denmark	Active	174.984	11	2342	11	512
27.3.a.21	Landings	Denmark	Passive	21.873	11	2342	11	512
27.3.a.21	Landings	Germany	Active	3.81	0	0	0	0
27.3.a.21	Landings	Germany	Passive	1.278	0	0	0	0
27.3.a.21	Landings	Sweden	Active	10.817	0	0	0	0
27.3.a.21	Landings	Sweden	Passive	1.82	0	0	0	0
27.3.b.23	Discards	Denmark	Active	14.996	0	0	0	0
27.3.b.23	Discards	Denmark	Passive	5.836	0	0	0	0

Subdivision	Catch Category	Country	Fleet	Catch (tonnes)	Length Samples	Lengths Measured	Age Samples	Ages Read
27.3.b.23	Discards	Sweden	Passive	1.9	0	0	0	0
27.3.b.23	Landings	Denmark	Active	5.669	1	41	1	24
27.3.b.23	Landings	Denmark	Passive	57.606	1	41	1	24
27.3.b.23	Landings	Sweden	Passive	14.723	0	0	0	0
27.3.c.22	Discards	Denmark	Active	32.553	14	1559	14	175
27.3.c.22	Discards	Denmark	Passive	4.711	0	0	0	0
27.3.c.22	Discards	Germany	Active	250.48	12	2871	12	857
27.3.c.22	Discards	Germany	Passive	2.821	13	92	13	46
27.3.c.22	Discards	Sweden	Passive	0	0	0	0	0
27.3.c.22	Landings	Denmark	Active	681.319	25	5626	25	1188
27.3.c.22	Landings	Denmark	Passive	399.606	25	5626	25	1188
27.3.c.22	Landings	Germany	Active	490.37	11	3632	11	857
27.3.c.22	Landings	Germany	Passive	262.358	21	2739	21	747
27.3.c.22	Landings	Sweden	Passive	0.014	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	0.00	0.24	0.30	0.59	0.80	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	1.00	0.78	0.91
2003	0.06	0.24	0.50	0.67	0.74	0.67	0.59	1.00	1.00	1.00
2004	0.05	0.29	0.52	0.67	0.75	0.92	1.00	0.99	1.00	1.00
2005	0.12	0.34	0.76	0.82	0.73	0.72	0.75	0.49	0.38	0.68
2006	0.00	0.18	0.37	0.56	0.90	0.77	0.79	0.96	1.00	1.00
2007	0.02	0.37	0.44	0.68	0.80	0.67	0.55	0.57	0.78	0.98
2008	0.00	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	1.00	0.37
2010	0.08	0.14	0.45	0.63	0.71	0.91	0.97	0.97	0.98	0.99
2011	0.07	0.15	0.28	0.42	0.56	0.55	0.73	0.73	0.86	0.98

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
2012	0.02	0.23	0.46	0.63	0.82	0.96	0.99	0.93	1.00	0.83
2013	0.01	0.16	0.47	0.59	0.57	0.85	0.88	0.82	1.00	0.87
2014	0.00	0.20	0.42	0.42	0.49	0.55	0.56	0.54	0.68	0.83
2015	0.00	0.20	0.50	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	0.90	1.00
2017	0.01	0.27	0.58	0.80	0.81	0.95	0.92	0.89	0.83	0.94
2018	0.01	0.24	0.41	0.66	0.86	0.97	0.88	0.99	0.96	0.97
2019	0.00	0.18	0.57	0.74	0.89	0.85	0.93	0.99	1.00	0.98
2020	0.03	0.11	0.51	0.81	0.78	0.93	0.96	0.98	0.92	0.94
2021	0.1	0.13	0.28	0.61	0.73	0.78	0.89	0.99	0.97	0.99

Table 5.2.4b. Plaice in SD 27.21–23. Maturity ogive (corrected methodology since 2021)

	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10
Mean (2002-2021)	0.23	0.53	0.71	0.81	0.9	0.95	0.97	0.97	0.98	0.96

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	0.220	0.283	0.291	0.329	0.374	0.371	0.412	0.862	0.569	1.274
2000	0.220	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	1.190
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	0.300	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	0.270	0.308	0.326	0.319	0.350	0.411	0.598	1.451
2006	0.166	0.243	0.294	0.313	0.335	0.316	0.344	0.451	0.530	0.884
2007	0.238	0.236	0.273	0.323	0.455	0.482	0.515	0.540	0.398	0.773
2008	0.225	0.225	0.256	0.303	0.376	0.442	0.499	0.558	0.481	0.529
2009	0.212	0.240	0.280	0.316	0.430	0.577	0.621	0.877	0.644	1.152
2010	0.227	0.292	0.292	0.310	0.379	0.403	0.399	0.372	0.369	0.421
2011	0.237	0.308	0.322	0.343	0.340	0.427	0.481	0.462	0.446	0.441
2012	0.265	0.300	0.335	0.393	0.404	0.462	0.426	0.466	0.565	0.546

Year	1	2	3	4	5	6	7	8	9	10+
2013	0.241	0.301	0.317	0.390	0.489	0.565	0.574	0.562	0.648	0.807
2014	0.241	0.270	0.308	0.341	0.408	0.433	0.509	0.682	1.106	0.780
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	0.300	0.360	0.422	0.504	0.477	0.568	0.553
2019	NA	0.248	0.270	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	0.450	0.471	0.680	0.575
2021	0.369	0.233	0.235	0.274	0.322	0.363	0.426	0.501	0.557	0.635

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	0.120	0.156	0.208	0.288	0.242	0.289	0.436	0.622	1.154
2000	0.081	0.120	0.156	0.208	0.288	0.242	0.289	0.436	0.622	1.154
2001	0.081	0.120	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	0.120	0.149	0.165	0.138	0.110	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	0.300	0.394	0.535	0.724	1.054	1.394
2006	0.061	0.110	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	0.210
2010	0.095	0.121	0.130	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	0.070	0.131	0.244	0.320	0.298	0.183	0.181	0.643	0.178	0.586
2013	0.074	0.106	0.206	0.332	0.390	0.207	0.295	0.242	0.411	0.789

Year	1	2	3	4	5	6	7	8	9	10+
2014	0.087	0.130	0.171	0.279	0.339	0.335	0.424	0.405	1.140	0.465
2015	0.077	0.100	0.144	0.160	0.212	0.235	0.321	0.200	0.130	0.321
2016	0.070	0.107	0.140	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	0.490	0.579	0.460
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	0.170	0.350
2020	0.068	0.105	0.193	0.276	0.294	0.375	0.450	0.468	0.643	0.573
2021	0.055	0.081	0.103	0.116	0.137	0.100	0.096	0.385	0.211	0.469

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

	1	2	3	4	5	6	7	8	9	10+
Mean(2002–2021)	0.055	0.081	0.103	0.116	0.137	0.1	0.096	0.385	0.211	0.469

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

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

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

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

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	1384.6432	10767.6737	5005.2657	1251.4676	646.2843	57.0233
2000	3483.9655	27533.6921	12156.8526	1903.2778	580.0148	338.3361
2001	1097.6546	15217.6993	15464.214	3483.3936	475.9495	201.1619
2002	1749.9214	4337.3904	11652.0806	5813.9429	1174.224	292.0357
2003	1660.5423	18089.6936	8062.8004	8433.9823	4316.1019	606.167
2004	1147.347	6672.9745	13597.0264	5825.9771	3635.4356	2301.8471
2005	1404.6383	14789.8445	12972.566	6632.6044	2260.169	2031.0631
2006	353.6555	9206.9911	20095.5036	7515.4438	2868.0953	611.9705
2007	1250.9344	8144.6894	14489.1146	10307.8701	2520.7962	1095.6357
2008	1667.676	5982.6509	7650.2637	3848.0605	1260.851	427.9504
2009	846.2779	5055.9614	8522.0964	3876.4269	1365.0393	520.4401
2010	3886.6085	9683.9138	11778.2833	5693.0279	2159.0245	515.3885
2011	1439.4141	14324.6174	11725.3328	5443.4593	2545.2617	1013.3355
2012	2529.9541	11659.5892	12584.2955	4922.0771	1216.2331	442.2893
2013	528.0897	7472.3717	19093.4517	9136.7878	5181.1425	1229.5273
2014	267.2425	8697.7672	14953.7745	13296.5173	6007.6506	2117.2011
2015	641.5488	11363.0477	15452.9886	10991.5546	6984.5394	3400.1867
2016	1226.2738	16149.3595	22202.298	12945.5417	6189.3206	3220.9652
2017	4256.3122	15925.2447	21486.6232	9578.7035	4837.7998	2261.9179
2018	3872.7064	23365.8138	21123.0628	11226.9851	6434.7379	1945.9502
2019	629.4831	19972.4101	26633.1346	10255.4211	2998.4529	2151.6872
2020	8688.526	8400.8681	14990.9888	16039.7699	7171.6078	1898.5497
2021	15460.7569	86380.0095	30288.8437	11461.1412	8042.5048	4019.8905

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

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1999	27960.7222	18404.9991	3151.4031	316.0378	390.0188	78.5382
2000	12051.8476	21390.04	6873.085	122.6661	91.8595	149.5755
2001	4429.042	13285.1744	5688.5352	1252.9958	139.9652	179.0248
2002	9853.9576	5162.6223	5927.4818	3760.29	785.408	140.5031
2003	4371.9344	14219.2211	3737.1491	2686.7379	1381.1826	232.1173
2004	8122.6983	8063.9168	12440.1948	3241.7719	1986.8066	1437.1117
2005	7857.2154	10777.3083	2940.1697	1461.9785	416.4515	499.2881
2006	7205.1668	10045.3056	8615.2984	1813.1367	858.2088	536.9235
2007	5745.9763	10116.3154	3917.4452	2321.4225	620.6025	301.6386
2008	2588.229	10451.8419	8244.4691	3004.2173	785.7404	185.4868
2009	4996.6768	9569.1374	9644.8854	1750.2086	351.0551	199.7718
2010	5049.5136	6945.0517	4332.2606	3418.2475	1026.841	545.9239
2011	12050.8494	12540.808	7273.6139	2433.495	527.1428	249.4304
2012	11099.9355	12765.4859	9435.5251	4579.4776	1053.6282	276.4359
2013	5197.5966	10545.2286	10053.7228	4269.374	1988.5818	799.291
2014	10836.3834	11272.3998	9801.1047	5411.3635	2874.1705	800.7776
2015	6410.6033	14670.916	11493.4338	8128.1147	4047.2032	995.0688
2016	12985.9649	13480.1026	9861.8852	4329.8913	2152.4889	1166.6036
2017	28482.687	12389.6117	6852.4813	4194.4922	1743.978	1234.555
2018	17907.134	21431.9188	8777.8992	3252.3116	1154.795	1103.1738
2019	-9	-9	-9	-9	-9	-9
2020	59914.3386	17695.1879	8726.0034	6373.0714	1631.4925	695.866
2021	113519.2752	65763.9796	19844.8222	6261.1982	4848.74	1910.3169

Table 5.2.5 Plaice in SD 27.21–23. SAM results from the final assessment (SPALY_v1). Estimated recruitment (000s), spawning stock biomass (SSB in tonnes), and average fishing mortality for ages 3 to 5 (F_{35}). High and low refers to 95% confidence intervals.

	Recruitment (Age1)			SSB (tonnes)			Fbar(3-5)		
Year	Median	Low	High	Median	Low	High	Median	Low	High
1999	50709	36883	69717	4473	3600	5559	1.043	0.827	1.316
2000	45753	34011	61550	5054	4186	6101	1.058	0.866	1.292
2001	24316	17895	33042	5796	4788	7016	0.977	0.808	1.181
2002	39797	27769	57035	5983	4919	7278	0.916	0.751	1.116
2003	22443	16616	30312	5403	4538	6433	0.796	0.654	0.97
2004	28863	21494	38759	4952	4197	5843	0.737	0.596	0.911
2005	24380	18151	32747	4642	3939	5471	0.739	0.591	0.925
2006	16494	11652	23350	4617	3873	5503	0.803	0.655	0.984
2007	18919	14020	25530	4097	3450	4864	0.799	0.649	0.985
2008	22768	16479	31458	3778	3187	4479	0.824	0.675	1.006
2009	22158	16507	29745	3548	2990	4210	0.769	0.626	0.944
2010	33536	24671	45588	3618	3068	4267	0.683	0.541	0.862
2011	35028	26071	47063	4197	3552	4959	0.694	0.54	0.891
2012	34859	25487	47679	4837	4068	5751	0.505	0.373	0.684
2013	28306	21045	38071	5939	5002	7052	0.45	0.332	0.612
2014	22779	16420	31600	6846	5751	8150	0.425	0.316	0.571
2015	22356	16482	30324	7383	6176	8825	0.436	0.331	0.574
2016	30226	22393	40799	7587	6318	9111	0.493	0.383	0.635
2017	52233	37374	72998	7694	6384	9274	0.482	0.373	0.622
2018	44137	30849	63148	8392	6922	10174	0.474	0.359	0.627
2019	29240	19803	43174	9367	7604	11539	0.434	0.318	0.592
2020	142019	91041	221541	10786	8618	13498	0.366	0.26	0.516
2021	183127	104968	319481	15186	11523	20012	0.268	0.171	0.42
2022	29240*	16494*	183127*	23849	16518	34374			

*** 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	0.049	0.391	0.812	1.198	1.118	1.006	1.006
2000	0.051	0.400	0.821	1.212	1.140	1.036	1.036
2001	0.050	0.386	0.768	1.110	1.054	0.970	0.970
2002	0.050	0.385	0.742	1.032	0.974	0.892	0.892
2003	0.044	0.340	0.649	0.895	0.844	0.772	0.772
2004	0.040	0.311	0.600	0.827	0.783	0.711	0.711
2005	0.039	0.306	0.596	0.828	0.793	0.715	0.715
2006	0.041	0.326	0.643	0.898	0.867	0.775	0.775
2007	0.041	0.326	0.642	0.893	0.863	0.757	0.757
2008	0.045	0.350	0.670	0.917	0.885	0.765	0.765
2009	0.043	0.335	0.633	0.852	0.822	0.699	0.699
2010	0.040	0.306	0.571	0.755	0.722	0.609	0.609
2011	0.041	0.311	0.579	0.764	0.738	0.621	0.621
2012	0.031	0.229	0.424	0.554	0.536	0.451	0.451
2013	0.027	0.204	0.380	0.495	0.477	0.397	0.397
2014	0.024	0.184	0.352	0.467	0.455	0.377	0.377
2015	0.023	0.180	0.354	0.479	0.474	0.393	0.393
2016	0.025	0.197	0.396	0.542	0.541	0.446	0.446
2017	0.023	0.184	0.378	0.529	0.537	0.446	0.446
2018	0.021	0.172	0.364	0.521	0.537	0.448	0.448
2019	0.018	0.152	0.329	0.476	0.497	0.417	0.417
2020	0.015	0.128	0.277	0.402	0.420	0.355	0.355
2021	0.011	0.091	0.200	0.293	0.311	0.266	0.266

Table 5.2.7. Plaice in SD 27.21–23. Estimated stock numbers at age.

Year / Age	1	2	3	4	5	6	7
1999	50709	30330	10049	4832	2915	301	1073
2000	45753	41473	17816	3902	1432	894	488
2001	24316	36615	26485	7027	1120	468	478
2002	39797	17702	23600	12904	2112	383	327
2003	22443	29181	10972	10490	4691	718	264
2004	28863	16442	16574	5690	3996	1974	405
2005	24380	23586	10774	7228	2196	1673	1030
2006	16494	19426	16077	5572	2802	924	1177
2007	18919	14364	12446	7289	2017	1042	822
2008	22768	15621	10432	5862	2454	746	779
2009	22158	16510	10477	5094	2010	885	632
2010	33536	17343	10184	4852	2012	777	701
2011	35028	25801	12342	4934	1876	878	753
2012	34859	26320	16184	6645	1958	734	777
2013	28306	25875	19612	9191	3521	1008	818
2014	22779	23263	18330	12241	5082	1917	1041
2015	22356	20744	16838	11481	6754	2822	1758
2016	30226	20052	16361	10394	6062	3592	2643
2017	52233	23387	14867	10047	5247	3056	3508
2018	44137	39163	18033	8910	5510	2674	3683
2019	29240	33423	29123	11869	4489	2952	3617
2020	142019	24570	22680	18405	6762	2362	3802
2021	183127	109813	20987	14478	10758	4123	3910

Table 5.2.8. Plaice in SD 27.21–23. Reference points for 2021, 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 2021	Landings 2021	ICES stock advice 2023 (catch)	
Stock area-based	SDs 21-23	3053	2126	11914	
	SDs 24-32	1317	767	4633	
Total advised catch, 2022 (SDs 21-32)				16547	
Management area-based	SD 21	828	215		
	SDs 22-23	2225	1912		
	SDs 22-32	3542	2679		
		Calculation			Result
Share of SD 21 of the total catch in SDs 21–23 in 2021		= 828 / 3053			0.271
		(catch in 2021 SD 21 / catch in2021SDs 21–23)			
Catch in 2023 for SD 21		= 11914 * 0.271			3232
		(ICES stock advice in 2023 (catch) for SDs 21–23 × share)			
Catch in 2023 for SD 22-32		= 16547 - 3232			13315
		(total advised catch in 2023 SDs 21–32 minus catch SD 21)			
Share of SD 21 of the total landings in SDs 21–23 in 2021		= 215 / 2126			0.101
		(landings in 2021 SD 21 / landings in 2021 SDs 21–23)			

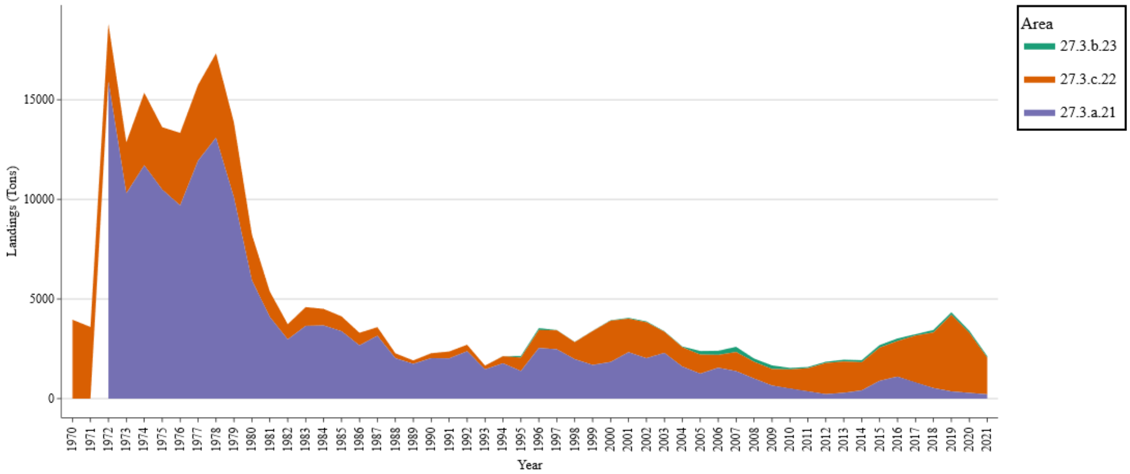


Figure 5.2.1. Plaice in SD 27.21–23. Landings by subdivision by year.

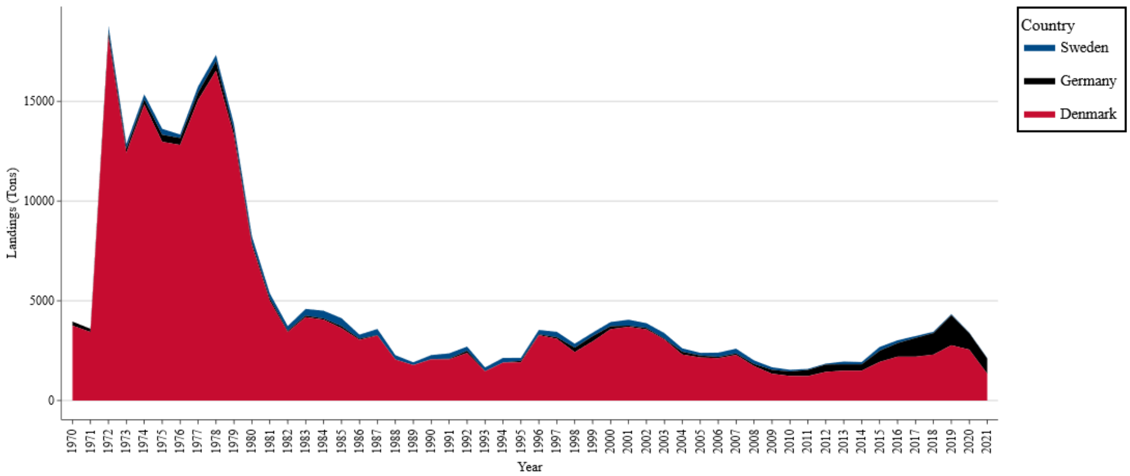


Figure 5.2.2. Plaice in SD 27.21–23. Landings (t) by country by year.

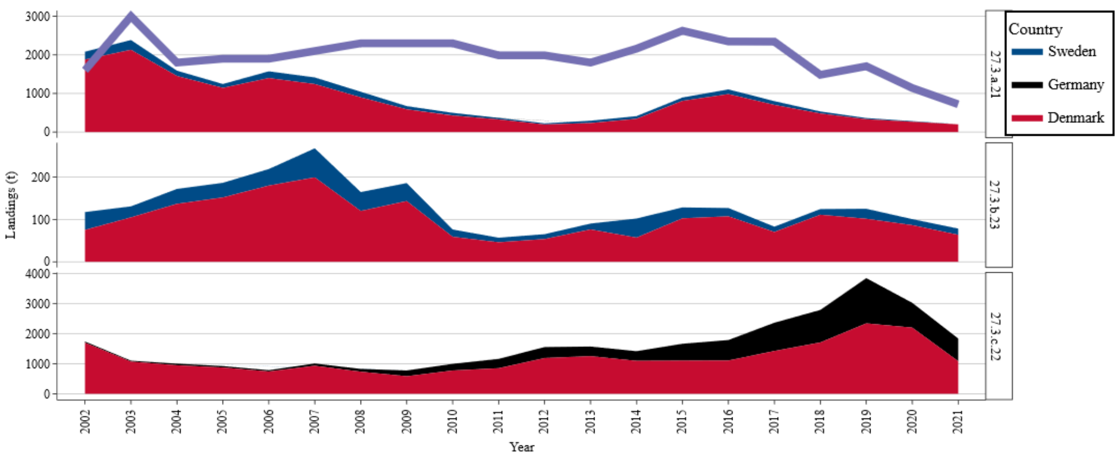


Figure 5.2.3. Plaice in SD 27.21–23. Landings (t) by country by year across areas. Advised TAC for SD 21 shown as a purple line.

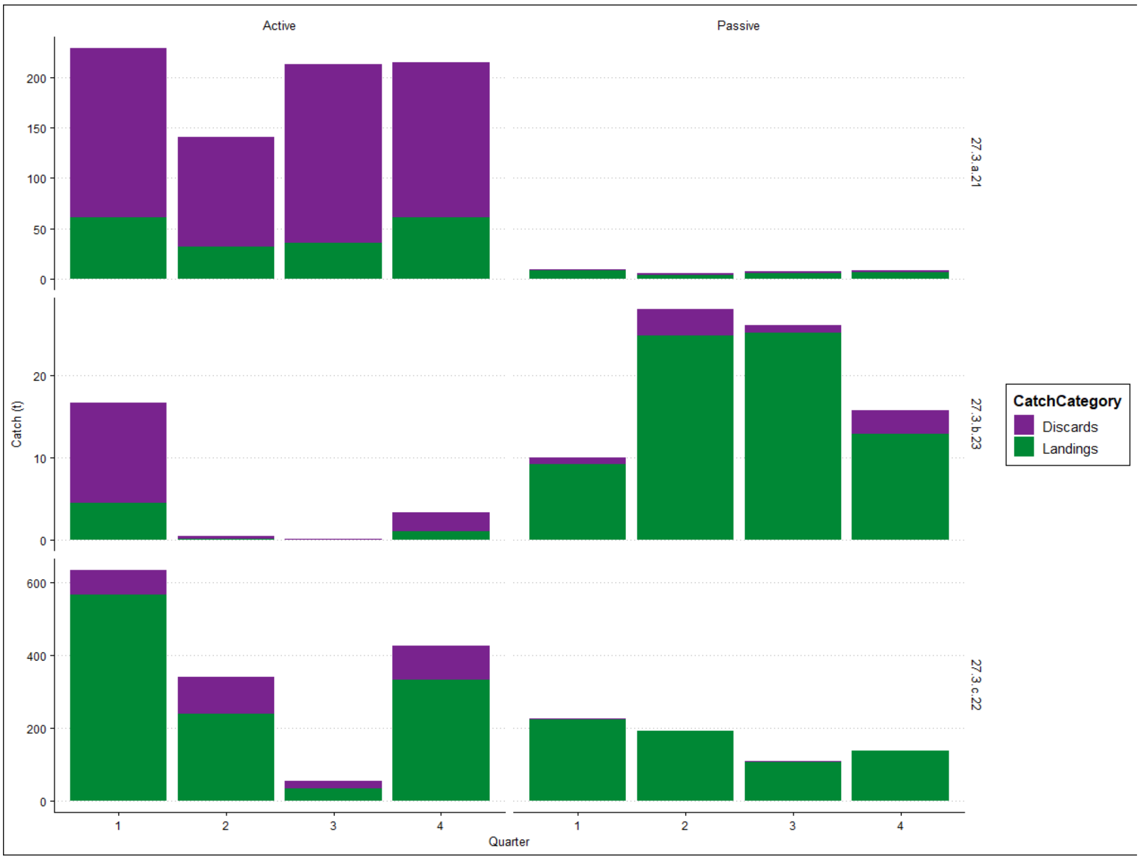


Figure 5.2.4a. Plaice in SD 27.21–23. Catches (t) in 2021 by gear type, area, quarter and catch category. Note varying y-axis values by area.

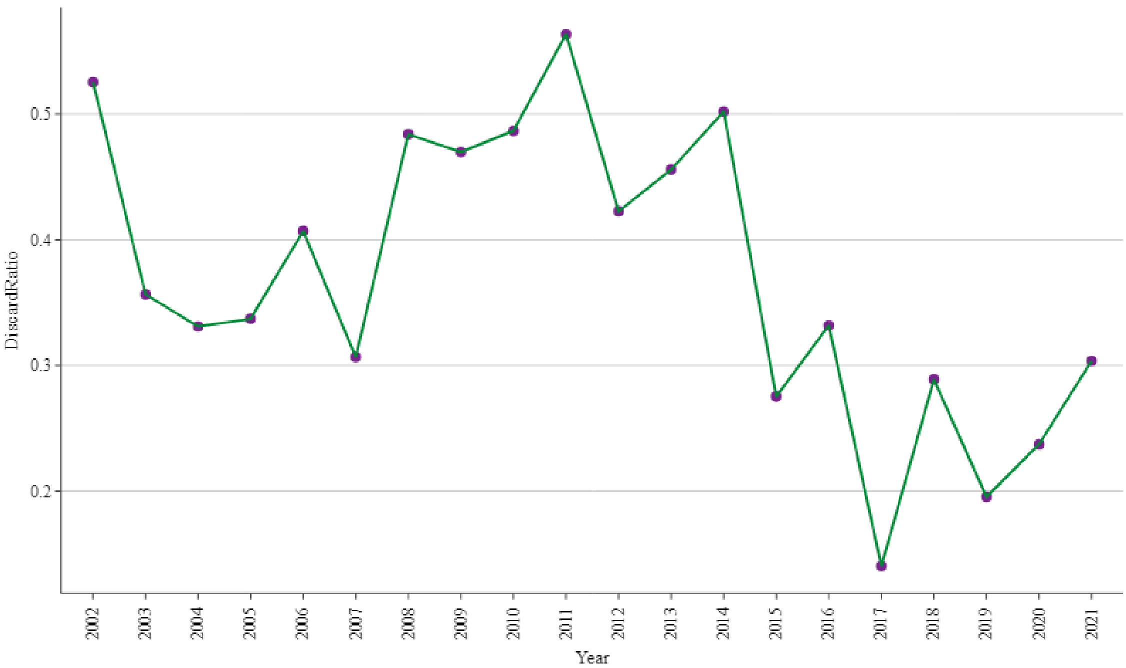


Figure 5.2.4b. Plaice in SD 27.21–23. Discard ratio over time.

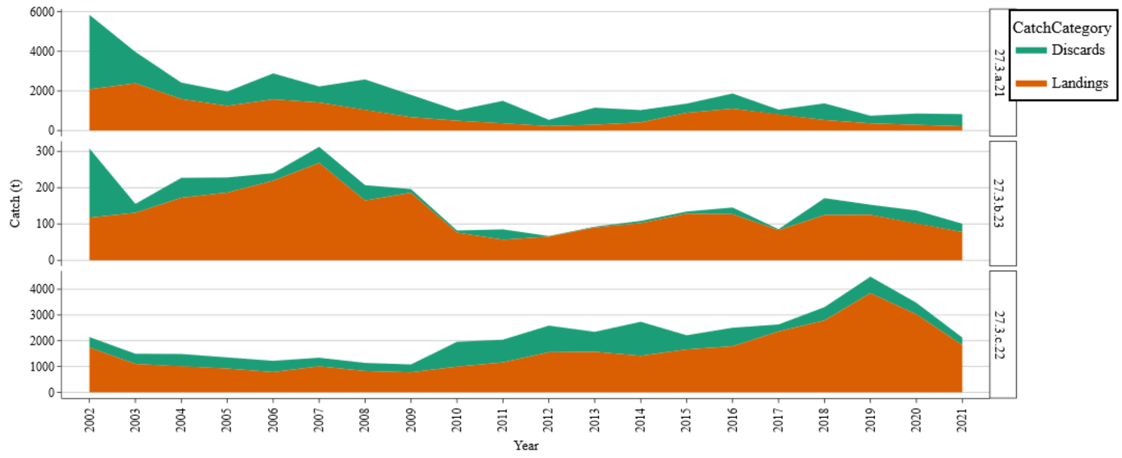


Figure 5.2.4c. Plaice in SD 27.21–23. Catch components over time by Subdivision. Note varying y-axes by subdivision.

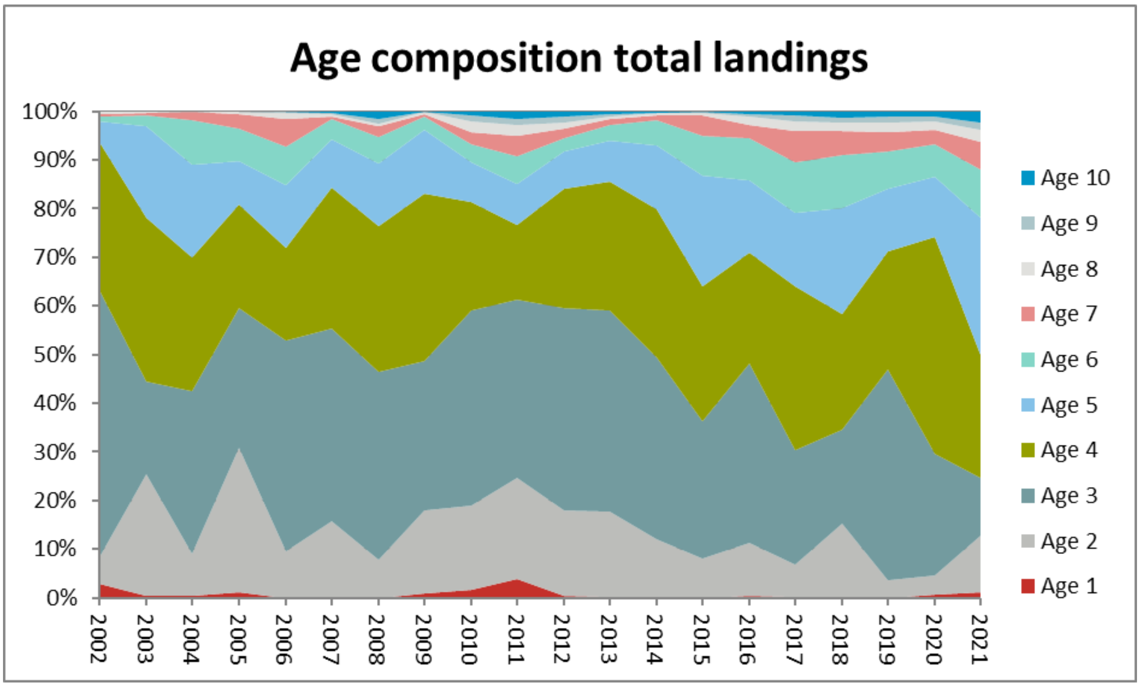


Figure 5.2.5a. Plaice in SD 27.21–23. Age composition for landings from 2002 to 2021.

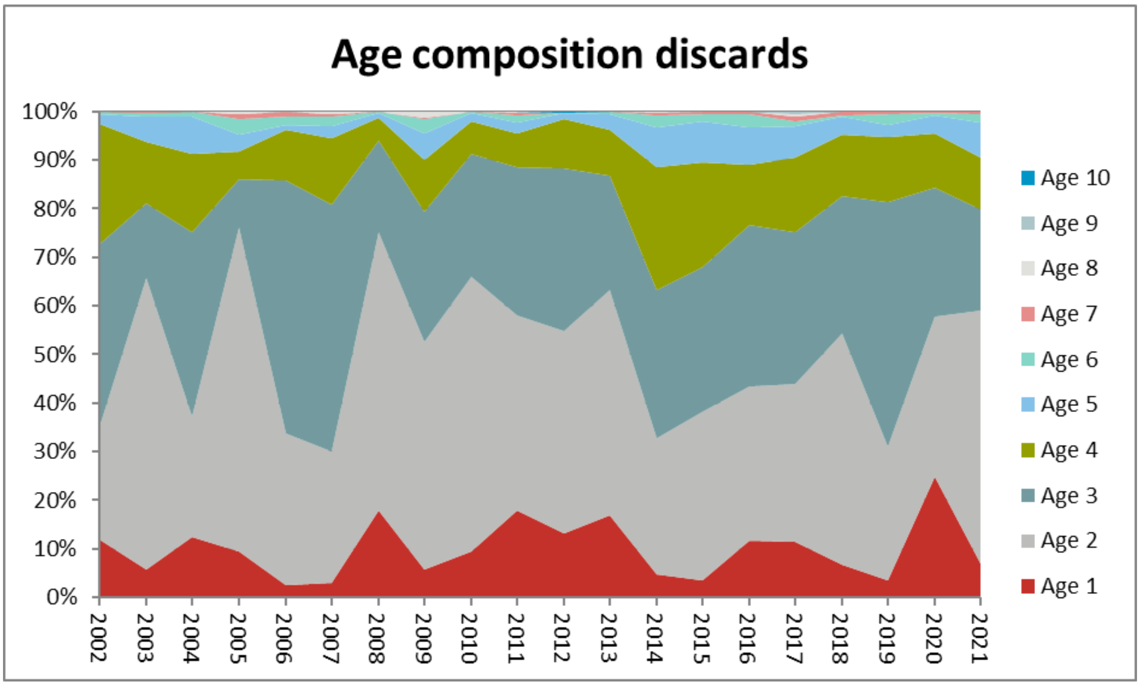


Figure 5.2.5b. Plaice in SD 27.21–23. Age composition for discards from 2002 to 2021.

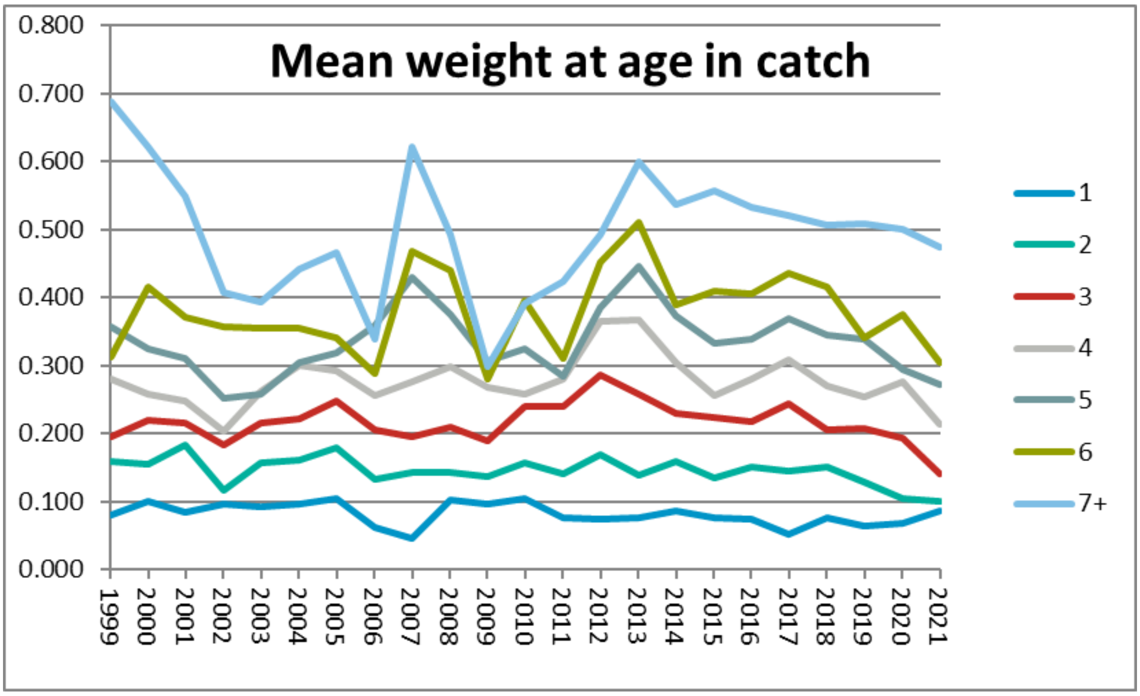


Figure 5.2.6. Plaice in SD 27.21–23. Mean weight (kg) at-age in catch.

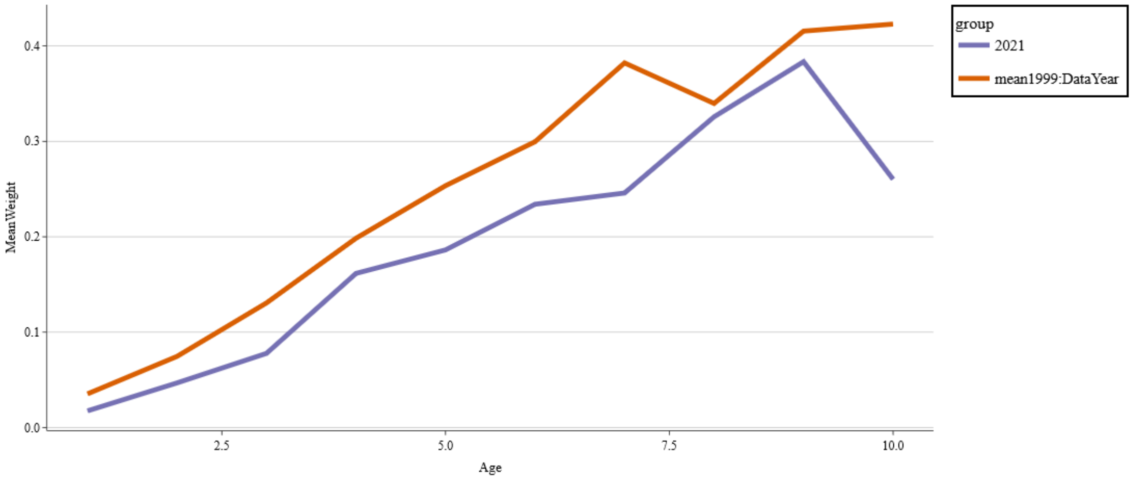


Figure 5.2.7. Plaice in SD 27.21–23. Mean weight (kg) at-age in stock.

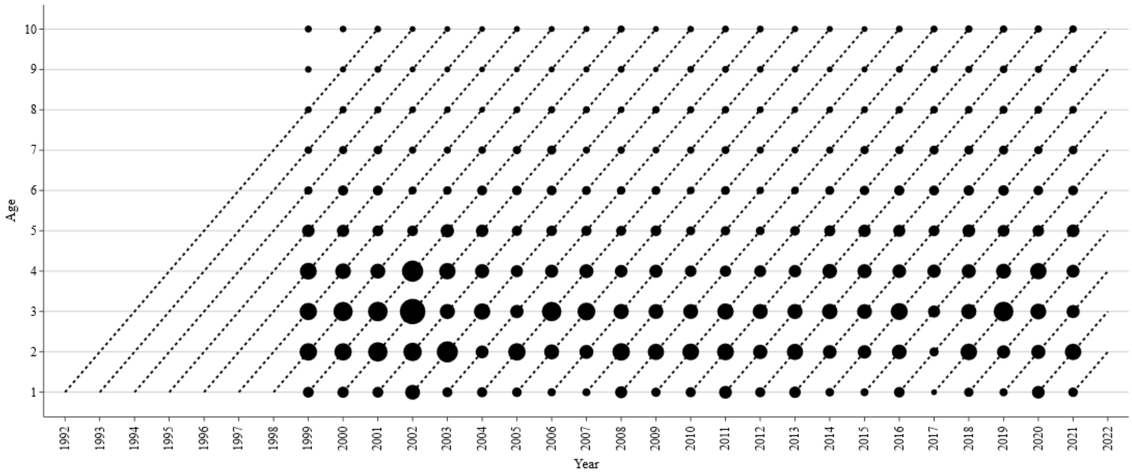


Figure 5.2.8. Plaice in SD 27.21–23. Cohort tracking of the catch-at-age matrix

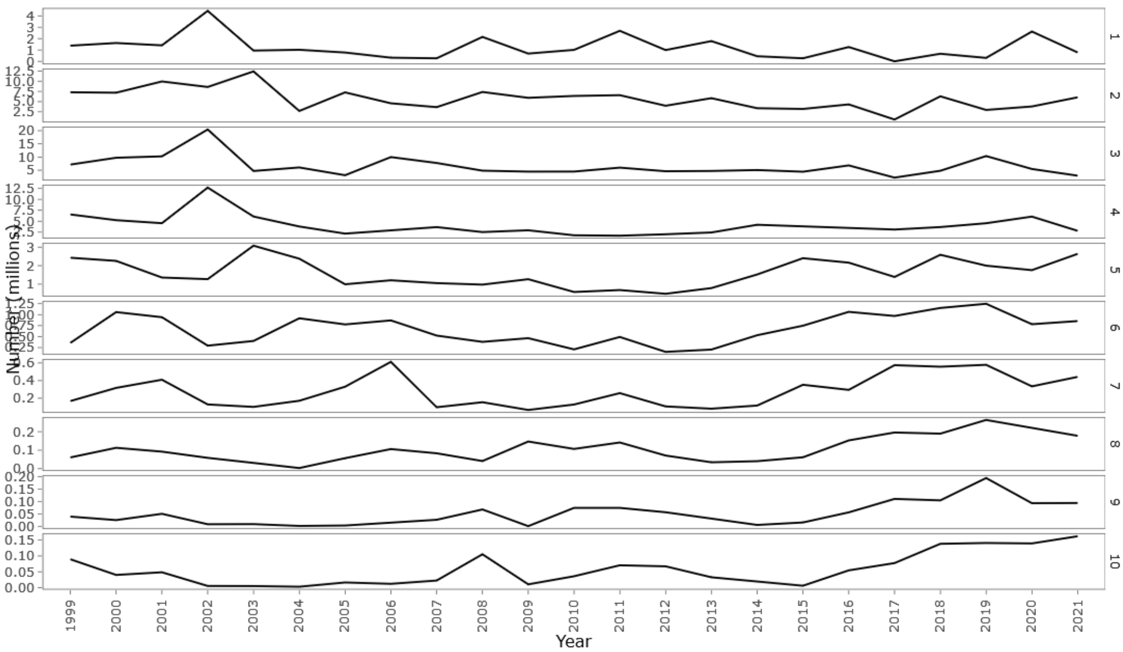


Figure 5.2.9. Plaice in SD 27.21–23. Catch-at-age 1999-2021

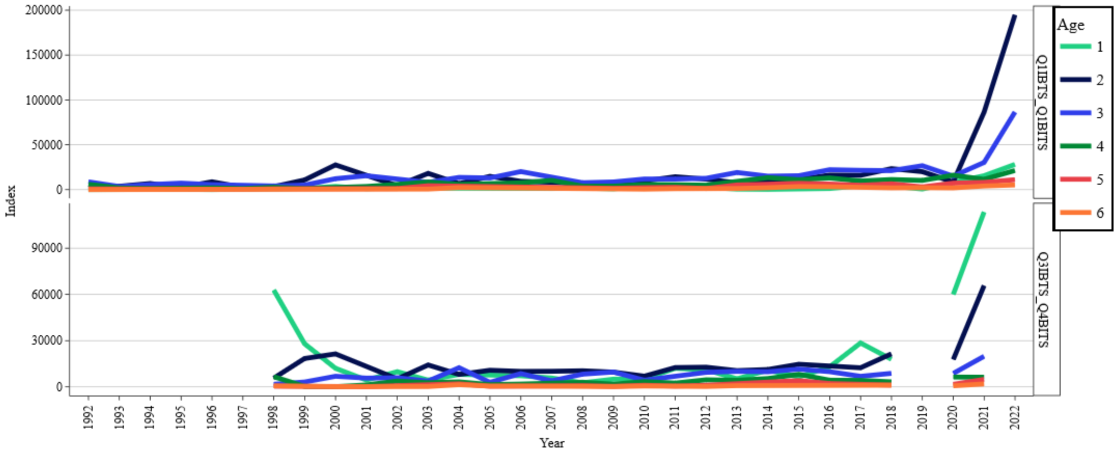


Figure 5.2.10. Plaice in SD 27.21-23. Survey indices over time (re-calculated within assessment year with all available data). Top: Q1 combined indices (note 2022 data not used in calculation of indices for the 2022 assessment. Bottom: Q3-4 combined indices (note 2019 data not used in calculation of indices for the 2022 assessment).

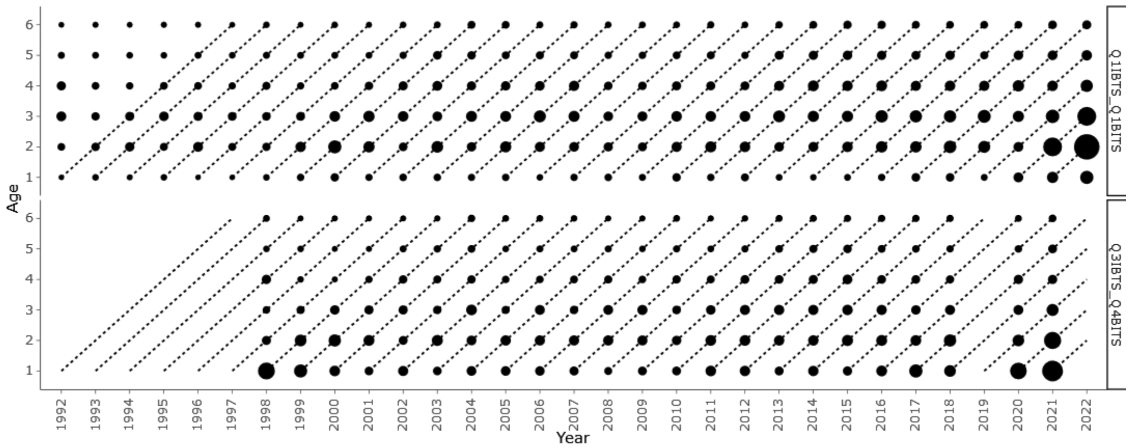
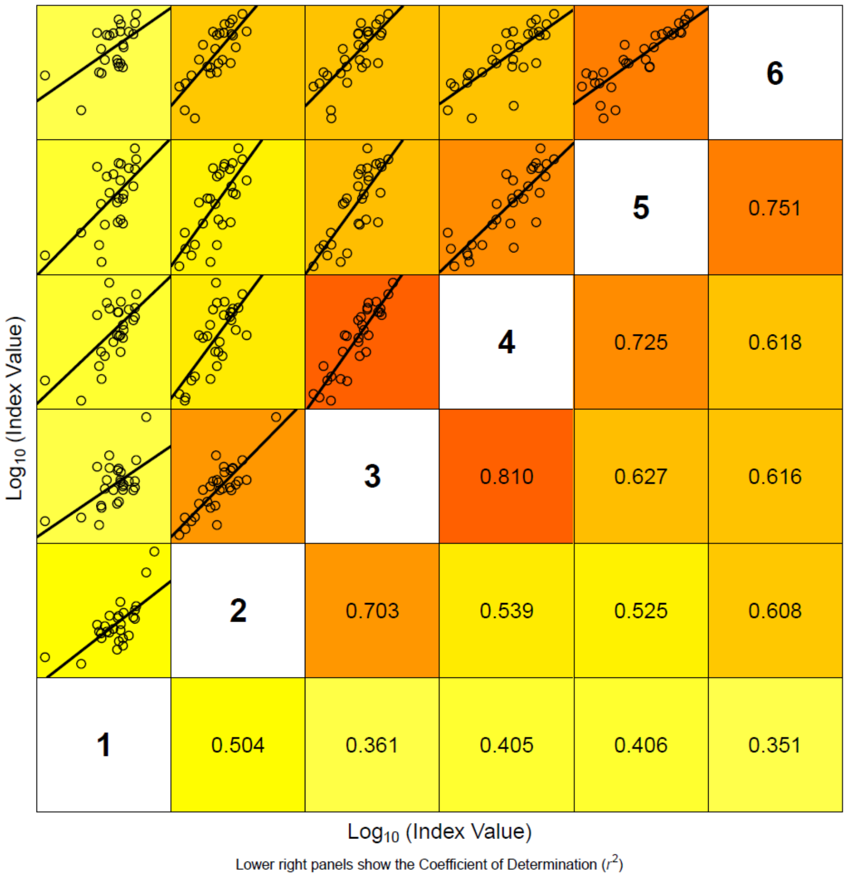


Figure 5.2.11. Plaice in SD 27.21-23. Cohort-tracking through survey indices by age. Bubble size relative to within year index by age recalculated from total data series available at time of assessment in 2022. Top: Combined Q1 survey indices (note 2022 data not used in assessment). Bottom: Combined Q3-4 survey indices (note 2019 excluded from calculation of all indices according to decision in 2019 assessment).



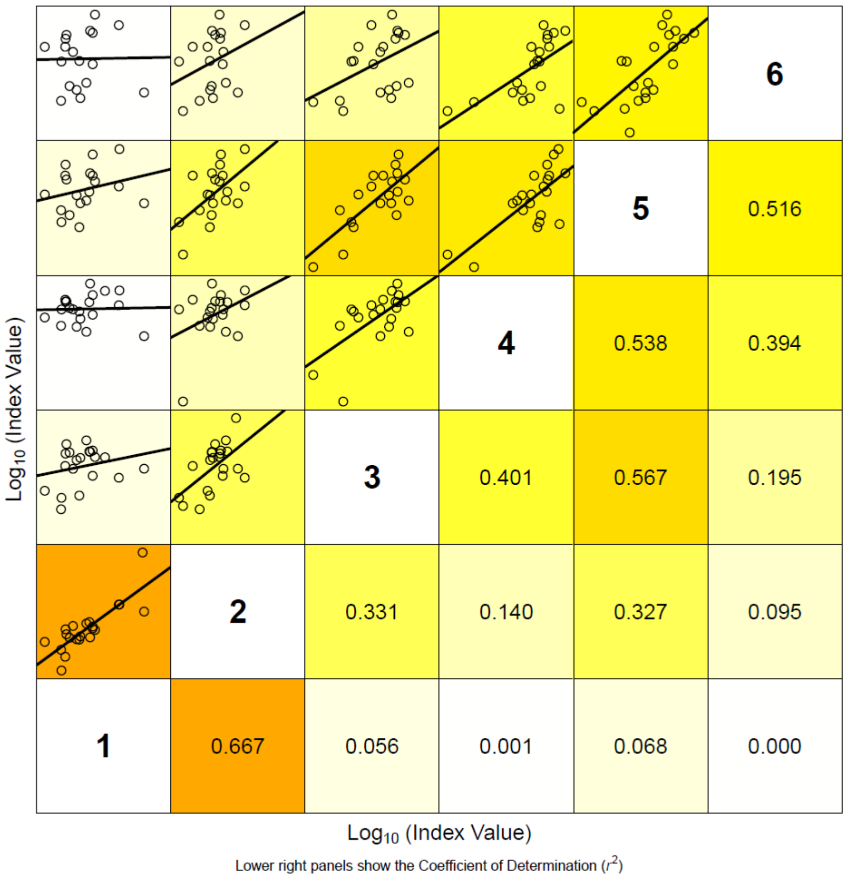


Figure 5.2.12. Plaice in SD 27.21–23. Internal consistency of the two survey indices. Top: Q1 survey. Bottom: Q3-4 survey.

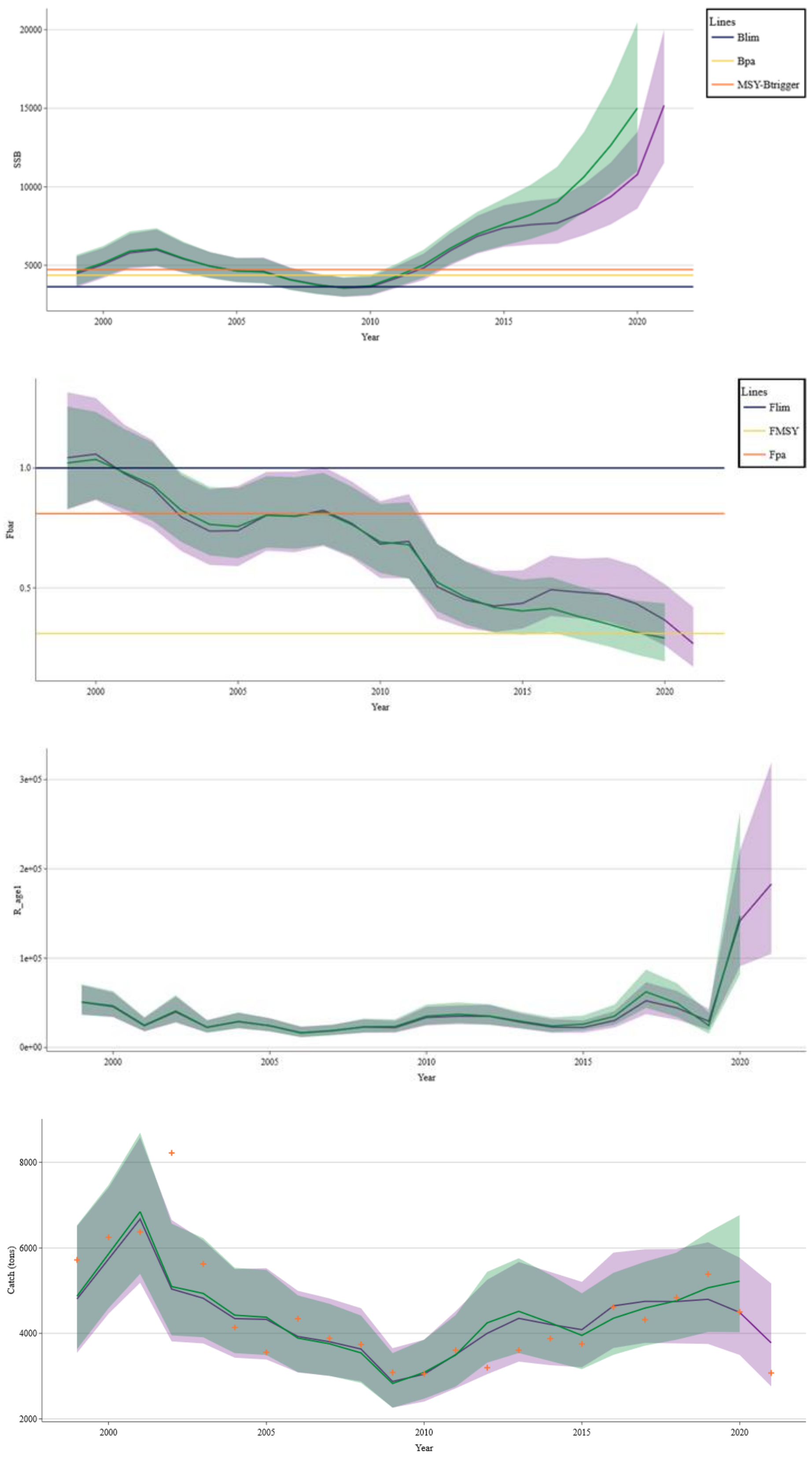


Figure 5.2.13. Plaice in SD 27.21–23. SPALY SAM run (in purple) in comparison with last year's assessment (in green).

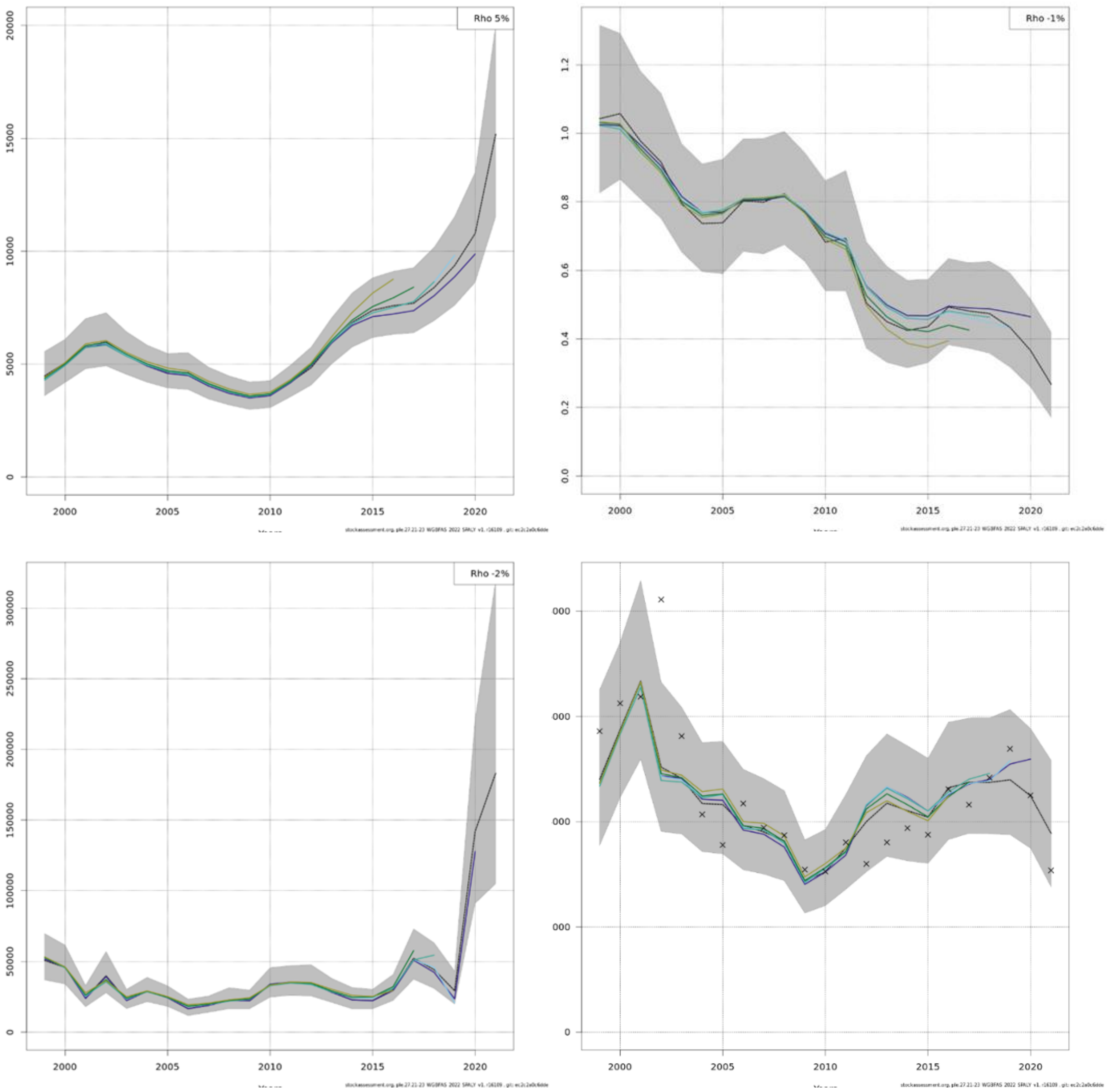


Figure 5.2.14. Plaice in SD 27.21–23. SPALY SAM run. Retrospective pattern

Figure 5.2.15. Plaice in SD 27.21–23. SPALY 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.

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 7240 tonnes for 2021 and increased to 9050 tonnes in 2022. 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 2021, active gears provide most of the landings in SD 24 (ca. 93%) and SD 25 (ca. 68%) while passive gears provided most of the landings in SD 26 (ca. 99%); passive gears provided on average 7% of total plaice landings in 2021.

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 2021 decreased to about 756 tonnes. Since 2017, a landing obligation is in place, resulting in an additional 5.9 tonnes of "BMS landings" (i.e. landings of plaice below the minimum conservation reference size of 25 cm) in 2021, which accounted for 0.77% 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.

However, the available data on discards are incomplete for all subdivisions. National discard estimations were missing in some strata, especially where fishing effort has been reduced due to historically low cod quota and fishing closures.

Sampling coverage, esp. in the passive-gear segment has 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. 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. Discards in the most recent year (2021) were around 550 tonnes (i.e. 42% of the total catch), about threefold than in previous years.

All major fishing gears are covered by biological sampling, with sampling effort adjusted to fishing activity (i.e. more prominent fishing gears are covered by a higher number of samples, Figure 5.3.3).

5.3.2 Biological composition of the catch

5.3.2.1 Age composition

Age class 3 is most abundant in the landing fraction of plaice. In the two most recent years (2020, 2021) ages classes 3 and 4 have increased. In the discard fraction, age class2 is by far the most abundant, accounting for 48% of the catch fraction. Almost 20% of discarded plaice were above age class 5 (Figure 5.3.4).

5.3.2.2 Mean weight-at-age

Recent years show a decrease in the average weight for almost all age classes (Figure 5.3.5). The age classes above 7 are usually not very well sampled, causing some fluctuations in the average weight. Passive gears often catch larger fishes and have a lower discard-rate. The strong incoming year class of 2019 (now age 2) resulted in a much higher discard ratio in active gears in 2021, as these nets catch smaller fish.

5.3.2.3 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.

5.3.2.4 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:

Average number of plaice ≥20 cm weighted by the area of each depth stratum which all together covers the area covered by the stock. (Figure 5.3.4).

The internal consistency plots of the surveys (figures 5.3.7.a and 5.3.7.b) indicate an overestimation of younger age classes, especially between age 1-2 and age 2-3. The effect is more prominent in BITS Q-1 than in BITS Q-4 and more prominent in recent years. Younger fish in Q1 show low consistency following the cohorts because the trend in some cases is defined by one outlying measuring point. The medium and older aged fish show better consistency. The preliminary 2022 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. A 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 5.3.6). A length-based index or young fish survey index would be more appropriate to display and account for smaller plaice.

5.3.4 Assessment

The stock was as a result of the WKPLE in February 2015 upgraded to Category 3.2.0 (DLS; exploratory assessment with SSB trends). The State based Assessment Model (SAM) was used until 2021. The assessment is an update of the benchmark assessment (ICES WKPLE) and the settings are according to the stock annex (ple.27.24-32).

The assessment has been changed fro a category 3 to a category 2 assessment in 2022. The stock was assessed using a surplus production model (SPiCT).

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 5.3.8) of the stock, where F is below F_{MSY} and B above $B_{trigger}$ and thus confirming the results of the previously conducted SAM assessment and the stock trend of the BITS index (Figure 5.3.9, Table 5.3.6). The results are however uncertain with considerable confidence intervals. The high variance of previous runs of the model were accounted for by fixing the production curve to a Schaefer curve and adding a prior on the intrinsic growth rate r, which is improving model performance and reducing uncertainty in retrospective patterns (Figure 5.3.9).

The remaining uncertainty might be attributed to inconsistency between catch and index time-series and missing contrast in the catch time-series. Alternative time-series were used to test the model performance, but did not improve the results, thus the timeseries of 2002 to 2021 was kept and used for the advice. From 2018 on, SPiCT results were used to give information on proxy reference points. The recent time-series of 19 years combined with continuously increasing data quality (in terms of spatiotemporal sampling coverage, number of samples and error/consistency checks) and the comparison with the other stock trends (SAM, BITS) justifies the use of this model for giving advice for 2023.

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}.

Technical criteria for accepting a SPiCT assessment

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

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

The plaice dataset and results of the SpiCT were tested for all the above criteria. All technical criteria were fulfilled. The current B_{MSY}/K is at 48% (2021 estimates). Several different runs with manually changed priors were conducted to test the variance parameters and determined if the calculated default values are reliable.

The final run in SPiCT is named: ple.27.2432_2022_spict_v3

5.3.4.2 Historical stock trends

Before the benchmark in 2015, trends in the stock were evaluated by survey-indices only. The survey indices are shown in Figure 5.3.4. See section 5.3.1 under "Description of the fishery" for historical trend details. From 2016 to 2021, an exploratory SAM assessment was conducting and relative SSB trends were used to give catch advice. From 2018, SPiCT and LBI were additionally conduted to assess MSY reference points according to category 3 (DLS) stocks. From 2022, plaice is assessed as a category 2 stock, using SPiCT.

5.3.5 Recruitment estimates

No recruitment estimates are given for the stock.

5.3.6 Short-term forecast and management options

Input data to short term prediction are provided in Tables 5.3.7 and 5.3.8.

TAC was not utilized in 2021, total catches were about 30% of the TAC. Therefore, the TAC of 3 965t for 2022 (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 (2022). An F_{sq} ($F = F_{2021}$) assumption leads to a catch of 1344 t in 2022 (compared to a catch of 1317 t in 2021). The basis for F_{sq} (F_{2022}) is the most recent F scaled to the intermediate year (= 0.23). Assumptions for the intermediate year are provided in Table 5.3.7.

Table 5.3.7: Values in the forecast and the interim year.

Variable	Value	Notes
F_{2022}/F_{MSY}	0.23	Status quo F: F_{sq} (equal to F_{2021})
B_{2023}/B_{MSY}	1.73	Fishing at F_{sq}
Catch (2022)	1325	Fishing at F_{sq}; in tonnes
Projected landings (2022)	772	Marketable landings assuming 2021 discard rate; in tonnes
Projected discards (2022)	553	Based on 2021 discard rate; in tonnes

Given the F_{sq} assumption, SSB in the beginning of 2022 is estimated at around 21 000 t (or B_{2022}/B_{MSY} at 1.69; Table 5.3.6, Table 5.3.9) and well above the MSY $B_{trigger}$ (ca. 12 000 t or B/B_{MSY} at 1). Therefore, the advice for 2023 will be based on the MSY approach (“ices rule”). With these assumptions, the forecast predicts that advised fishing in 2023 will lead to a total yield of 4633 t. At this level of exploitation, spawning stock biomass is estimated at around 22 000 t in 2024.

Catch in 2023 in predicted to be dominated by the relatively large 2019-year class of age 3 (age 4 in 2023) plaice that is dominating the discards and accounts for >40% of catches in 2021, whereas the strong year class of 2020 might enter the fisheries and dominate the discard fraction of the catch (Figure 5.3.4).

Table 5.3.8: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2023)	Projected Landings (2023)*	Projected Discards (2023)**	F_{2023}/F_{MSY}	B_{2024}/B_{MSY}	% B change ^	% advice change ^^
ICES advice basis							
MSY approach (35th percentile of predicted catch distribution under $F = F_{MSY}$)	4633	2698	1935	0.84	1.53	-10	+13
Other scenarios							
F_{MSY}	5447	3172	2275	1.00	1.47	-13	+38
F_{2022}	1347	785	563	0.23	1.75	+3	-34
F=0	0	0	0	0.0	1.82	+9	−100

*** Marketable landings assuming 2021 discard rate.**

**** Including BMS landings (EU stocks), assuming 2021 discard rate.**

^ Biomass 2024 relative to biomass 2023.

^^ Advice value for 2023 relative to the advice value for 2022 (3956 tonnes).

5.3.7 Biological reference points (Precautionary approach)

F_{MSY}, B_{MSY} and the yield at MSY are all directly estimated in the model. It should be noted that these will vary when new survey and catch information is added. B_{pa} and B_{lim} are defined as 50%B_{MSY} and 30%B_{MSY} respectively. 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 Figure 5.3.8, retrospective patterns are shown in Figure 5.3.11. The stochastic reference point estimates are shown below (Table 5.3.8). These are not significantly different to the results obtained by WGBFAS last year.

Table 5.3.8: stochastic reference point estimate

	estimate	cilow	ciupp	log.est
B_{MSYs}	12431.06	6340.94	24370.43	9.43
F_{MSYs}	0.27	0.19	0.40	-1.29
MSYs	3407.24	2228.71	5208.97	8.13

5.3.8.1 Additional exploration of stock ple.27.24-32, using SAM

Although not used to give advice in 2022, an additional SAM assessment was conducted to test the results of SPiCT. The final run in SAM is named: ple.27.2432_2022_SAM_v2

The stock is in a very good condition. The result (Figures 5.3.12a-c) shows an increase in SSB from <3000 tonnes in 2010 to >5600 tonnes in 2015 and estimated to 53 869 tonnes in the intermediate year 2022. 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 2021 increased significantly compared to the previous two years (0.149 in 2021, 0.145 in 202020, 0.198 in 2019) 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. 5.3.9). 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 is exceptionally high at estimated 47.2 mill. which is the highest value since 2002 and more than double compared to the previous year (i.e. 18.4 m in 2021). First signals of the 2022 BITS index show an increase in age 0 and age 1 plaice, indicating another strong year class that is likely to be picked up in the indices in 2022 and in fisheries discard during the intermediate year 2022.

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 (Figure. 5.3.12).

Before upgrading to category 2 in 2022, the factor for the catch advice was calculated using the “2-over-3-rule” for data-limited stocks. For plaice, the ratio is calculated by the relative SSB average of 2 most recent years (2022–2021) divided with the relative SSB average of the preceding three years (2020–2018) - this estimate gives an increase of 66%. An uncertainty cap would be applied as the calculated trend exceeds the limit of 20% change. Following that approach, the advised total catch for 2022 is 4747 tonnes. A pa buffer would not have to be applied, as both proxy reference points are stating a good stock status (a pa buffer is applied, if $B < B_{trigger}$ or $F > F_{MSY}$).

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). 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 2022. The conducted SPiCT also confirms stock trends of earlier years. This is expressed in the retrospective analysis which looks acceptable (Figure 5.3.10).

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. The estimated relative F for 2021 (0.23) decreased compared to 2020 (0.27), which resulted out of a more plaice-targeted fisheries since 2018 but also low catches due to fishing restrictions inflicted by COVID-19 measures and strongly reduced fishing opportunities for cod; the relative recruitment estimates (3.8) increased strongly compared to the previous assessment (1.67). The relative SSB increased at the same level (0.8 to 3.1 in the last three years). Data quality is improving annually and with increased sampling by the member states.

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, especially 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, not all available information was uploaded by every country. 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, a respective issue list in being produced and the above-mentioned points will be added.

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		
Area	24(+25)	25	26+27	24	24(+25)	25	25(+24)	26	24	25	26	27	28	29	24	25	26
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

***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 2021 by Subdivision, catch category, country, and quarter.

Area	Country	CatchCategory	1	2	3	4	Total*
27.3.d.24	Denmark	Landings	691.59	186.12	1213.08	2267.30	4358.09
		Discards	169.90	13.32	115.03	48.42	346.67
		BMS landing	0.98	0.00	1.34	13.73	16.04
	Germany	Landings	132.39	226.61	1062.84	765.38	2187.21
		Discards	33.15	18.07	82.06	201.61	334.88
		BMS landing	5.00	0.00	5.00	6.00	16.00
	Poland	Landings	955.61	175.27	499.95	385.98	2016.81
		Discards	101.92	2.46	14.55	83.78	202.72
		BMS landing	0.50	0.00	0.00	0.15	0.65
	Sweden	Landings	5.52	2.52	0.39	1.19	9.62
		Discards	1.29	0.11	0.01	0.45	1.86
		BMS landing	0.00	0.00	0.00	0.00	0.00
27.3.d.25	Denmark	Landings	48.04	0.26	0.22	17.79	66.31
		Discards	18.25	0.01	0.02	2.03	20.31
		BMS landing	0.00	0.00	0.00	0.00	0.00
	Germany	Landings	9.59	4.75	3.75	0.00	18.10
		Discards	2.45	0.38	0.36	0.00	3.19
		BMS landing	3.99	0.06	0.00	0.23	4.28
	Lithuania	Landings	5.00				5.00
	Poland	Landings	206.64	90.77	283.36	451.90	1032.67
		Discards	54.52	1.55	24.15	87.21	167.43
		BMS landing	0.96	0.00	0.05	0.00	1.01
	Sweden	Landings	29.38	2.08	2.12	4.49	38.07
		Discards	7.49	0.06	0.05	0.51	8.11
		BMS landing	0.00	0.00	0.00	0.00	0.00
27.3.d.26	Denmark	Landings	0.00	0.00	0.00	0.00	0.00
		BMS landing	0.00	0.00	0.00	0.00	0.00
	Latvia	Landings			0.00	0.00	0.00

Area	Country	CatchCategory	1	2	3	4	Total*
		Discards			0.63	0.31	0.95
		Logbook Registered Discard			0.00	0.00	0.00
	Lithuania	Landings	0.00	0.00	0.00	0.00	0.00
		Discards			0.00	0.00	0.00
	Poland	Landings	0.00	0.63	0.38	26.36	27.37
		Discards	0.00	0.01	0.01	7.71	7.73
27.3.d.27	Denmark	Landings	0.00	0.00	0.00	0.00	0.00
		BMS landing	0.00	0.00	0.00	0.00	0.00
	Sweden	Landings	0.00	0.00	0.01	0.00	0.01
		Discards			0.00		0.00
		BMS landing	0.00	0.00	0.00	0.00	0.00
27.3.d.28	Lithuania	Landings	0.00	0.00	0.00	0.00	0.00
	Sweden	Landings		0.00	0.00	0.00	0.00
		BMS landing		0.00	0.00	0.00	0.00
27.3.d.29	Denmark	Landings	0.00	0.00	0.00	0.00	0.00
		BMS landing	0.00	0.00	0.00	0.00	0.00
	Sweden	Landings		0.01	0.04	0.01	0.06
		Discards		0.00	0.00	0.00	0.00
		BMS landing		0.00	0.00	0.00	0.00
27.3.d.31	Sweden	Landings		0.00	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. 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

Table 5.3.4. ple.27.24-32. Final results from the additionally conducted SAM assessment run.

Year	Relative recruitment (age 1)	Relative SSB	Landings	Discards	Relative mean F (ages 2–5)
2002	0.087	0.061	915	353	0.918
2003	0.124	0.066	1281	271	1.137
2004	0.158	0.075	1081	214	0.627
2005	0.132	0.106	1081	166	0.337
2006	0.119	0.142	1012	818	0.415
2007	0.087	0.159	1167	491	0.572
2008	0.085	0.143	1102	294	0.564
2009	0.146	0.133	1226	418	0.591
2010	0.268	0.144	903	998	0.633
2011	0.286	0.182	748	1377	0.646
2012	0.163	0.210	848	917	0.688
2013	0.262	0.205	738	781	0.719
2014	0.294	0.211	534	481	0.298
2015	0.365	0.296	427	220	0.256
2016	0.511	0.410	521	1058	0.289
2017	0.514	0.537	650	408	0.238
2018	0.479	0.687	1644	711	0.412
2019	0.439	0.715	1741	617	0.317
2020	1.670	0.880	1024	223	0.198
2021	3.811	1.503	767	550	0.145
2022		3.135			

Table 5.3.6. ple.27.24-32. Overview of SPiCT result values on catch and survey data 2002–2021.

Deterministic reference points (Drp)					
		estimate	cilow	ciupp	log.est
	Bmsyd	12842.29	6512.29	25325.09	9.46
	Fmsyd	0.28	0.19	0.41	-1.27
	MSYd	3605.74	2337.49	5562.10	8.19
Stochastic reference points (Srp)					
		estimate	cilow	ciupp	log.est
	Bmsys	12431.06	6340.94	24370.43	9.43
	Fmsys	0.27	0.19	0.40	-1.29
	MSYs	3407.24	2228.71	5208.97	8.13
States	w	0.95	CI	(inp$msytype:	s)
		estimate	cilow	ciupp	log.est
	B_2021.94	21035.86	10191.86	43417.72	9.95
	F_2021.94	0.06	0.03	0.15	-2.78
	B_2021.94/Bmsy	1.69	1.22	2.35	0.53
	F_2021.94/Fmsy	0.23	0.11	0.46	-1.48
Predictions	w	0.950	CI	(inp$msytype:	s)
	B_2023.00	21507.04	10151.74	45563.91	9.98
	F_2023.00	0.06	0.02	0.18	-2.78
	B_2023.00/Bmsy	1.73	1.23	2.43	0.55
	F_2023.00/Fmsy	0.23	0.09	0.59	-1.48
	Catch_2022.00	1325.24	688.35	2551.41	7.19
	E(B_inf)	21526.37	NA	NA	9.98
	B_2023.00	21507.04	10151.74	45563.91	9.98

Table 5.3.9. 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	0.266	0.42	0.168	915	353	1.45	2.8	0.75
2003	0.276	0.422	0.181	1281	271	1.70	2.9	0.99
2004	0.224	0.339	0.149	1081	214	1.71	2.9	1.00
2005	0.251	0.382	0.165	1081	166	1.33	2.2	0.79
2006	0.36	0.54	0.24	1012	818	1.17	1.97	0.70
2007	0.453	0.693	0.297	1167	491	1.08	1.90	0.62
2008	0.515	0.775	0.342	1102	294	0.87	1.57	0.48
2009	0.618	0.936	0.408	1226	418	0.75	1.38	0.41
2010	0.711	1.086	0.466	903	998	0.76	1.41	0.41
2011	0.749	1.139	0.493	748	1377	0.77	1.43	0.41
2012	0.823	1.259	0.538	848	917	0.68	1.28	0.36
2013	0.876	1.335	0.575	738	781	0.54	1.01	0.28
2014	0.95	1.45	0.622	534	481	0.37	0.69	0.195
2015	1.119	1.695	0.739	427	220	0.24	0.47	0.119
2016	1.34	1.978	0.907	521	1058	0.23	0.43	0.124
2017	1.508	2.181	1.042	650	408	0.24	0.44	0.134
2018	1.812	2.648	1.24	1644	711	0.27	0.48	0.147
2019	1.927	2.831	1.311	1741	617	0.33	0.62	0.172
2020	1.834	2.625	1.281	1024	223	0.27	0.49	0.146
2021	1.734	2.427	1.239	767	550	0.23	0.43	0.122
2022	1.695	2.354	1.22					

*** Below minimum size (BMS) landings are included since 2017.**

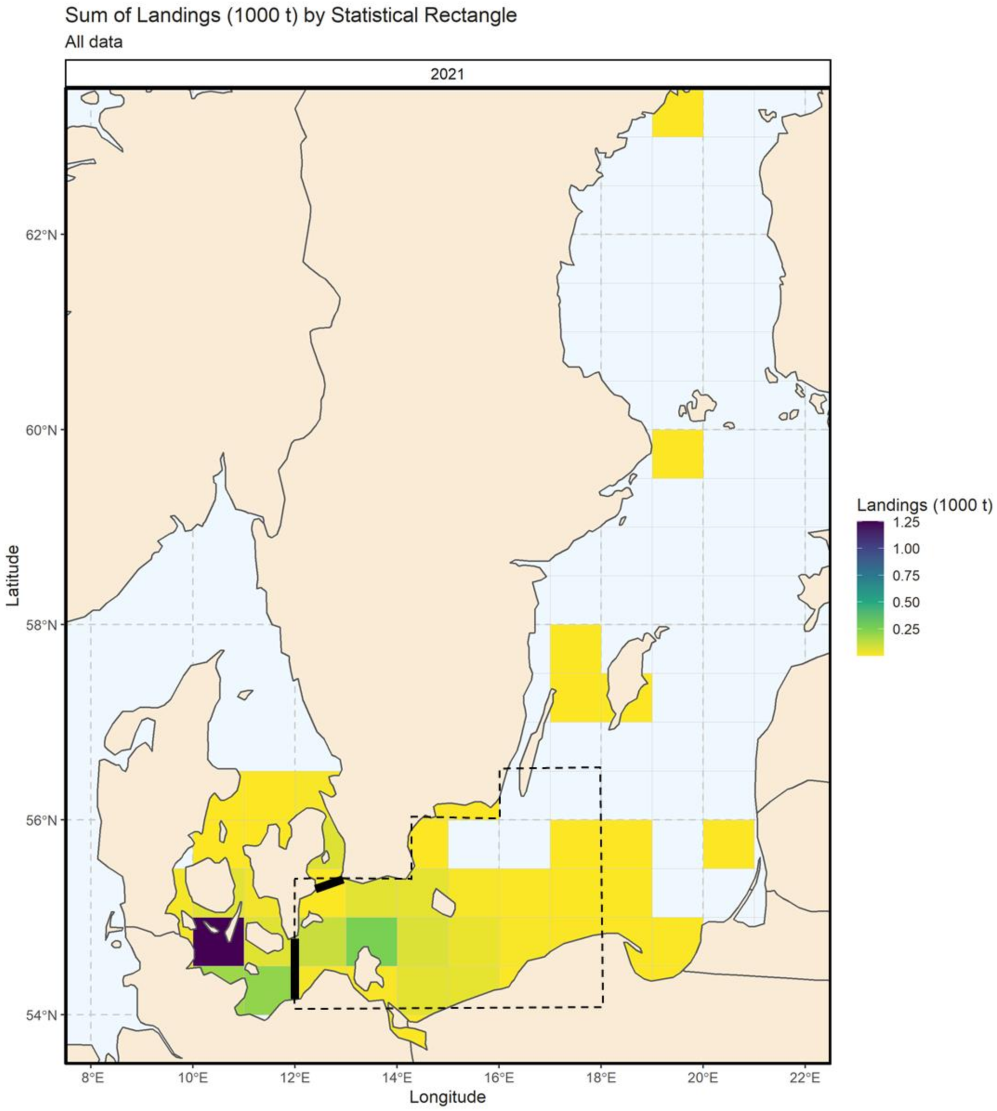


Figure 5.3.1. ple.27.24-32: annual main fishing areas of Baltic Sea plaice divided by stocks (solid line; west: ple.27.21-23, east: ple.27.24-32), indicating main fishing area of ple.27.24-32 (dotted line) (RCG Baltic, 2022)

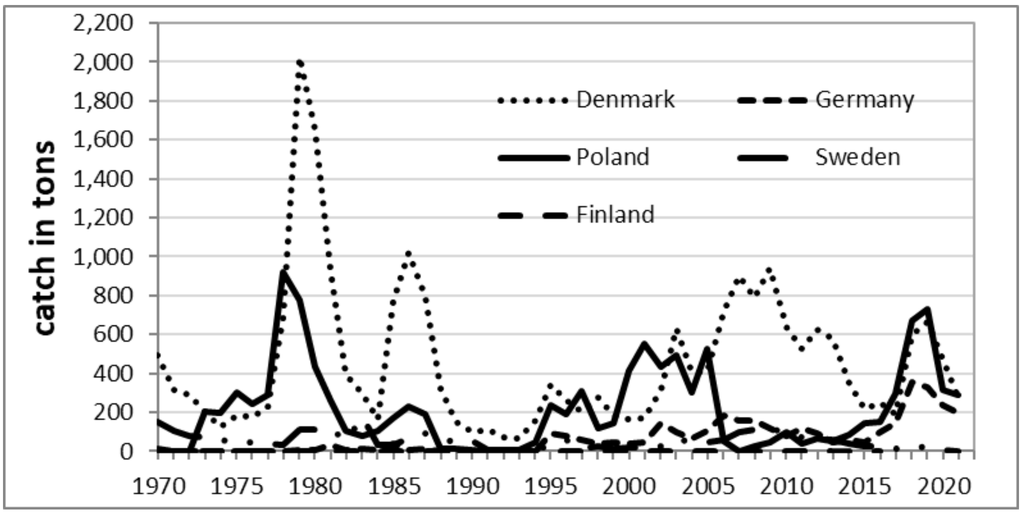


Figure 5.3.2. ple.27.24-32. Historical landings per country (in tonnes).

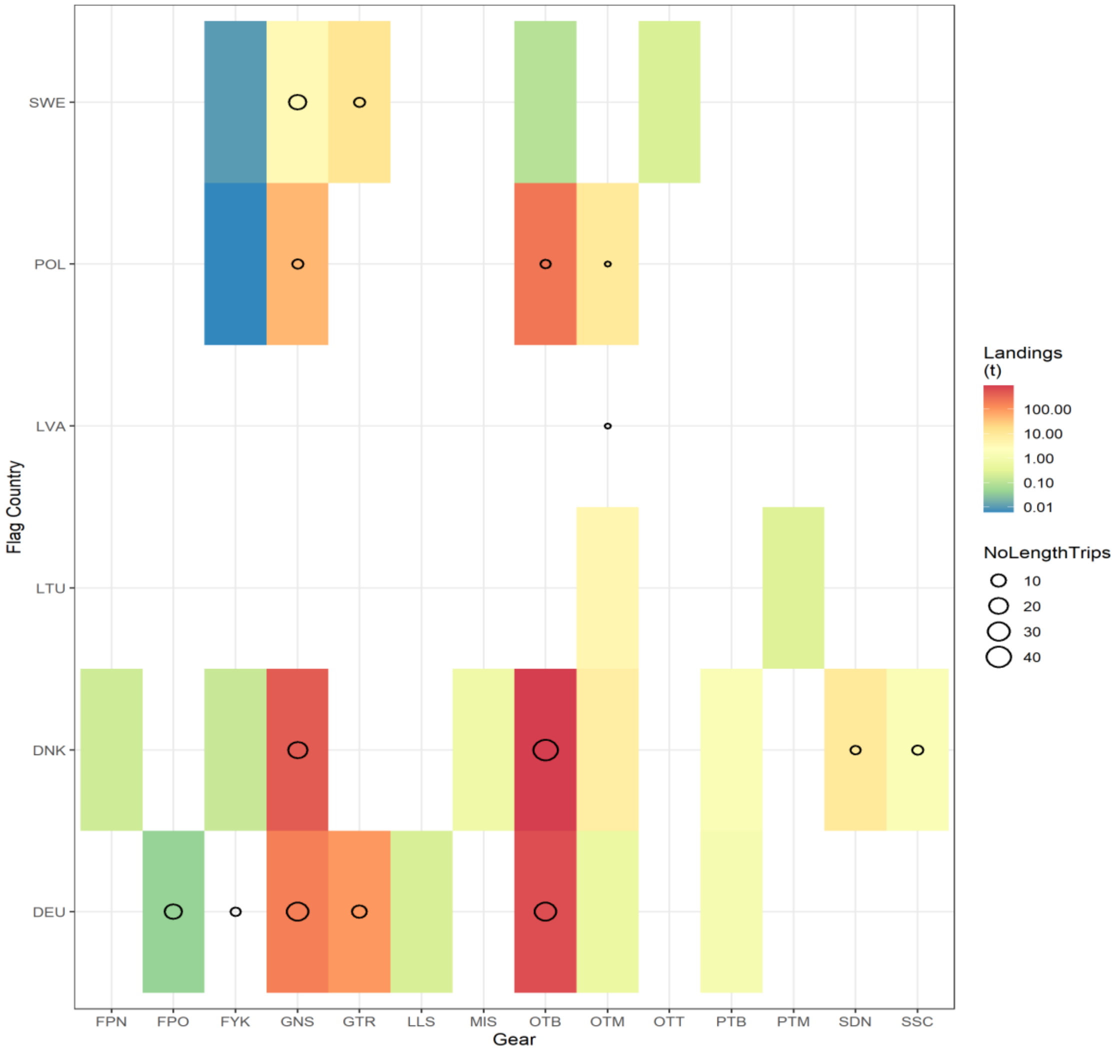


Figure 5.3.3. ple.27.24-32. Main fishing gear by member state (coloured squares, x and y axis) and respective sampling coverage (number of trips with length sampling conducted, bubble size according to number of trips sampled). (RCG Baltic, 2022)

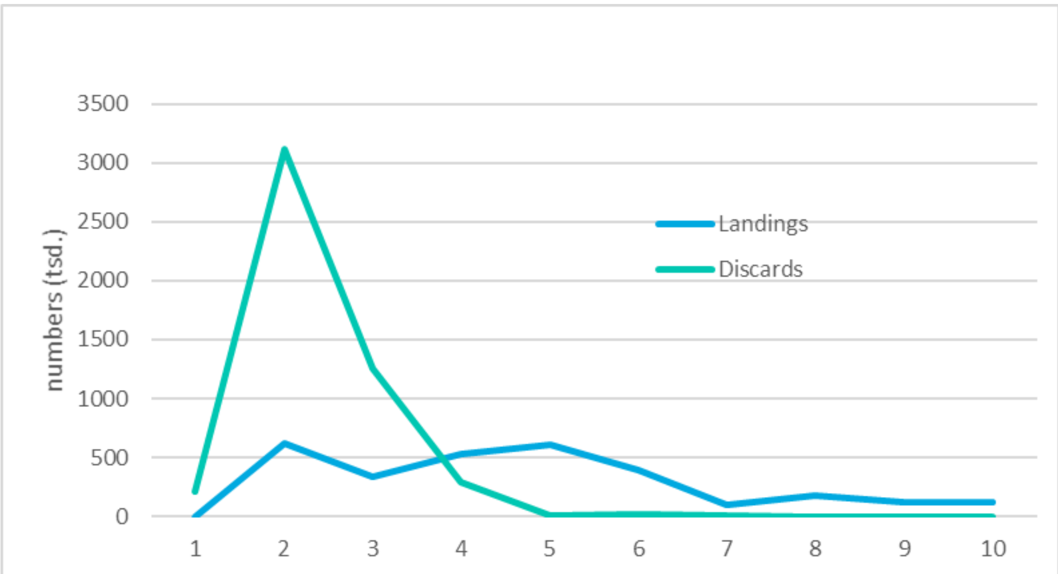


Figure 5.3.4. ple.27.24-32. Catch in numbers per age class and catch category in Subdivision 24 and 25. All countries and fleets were combined.

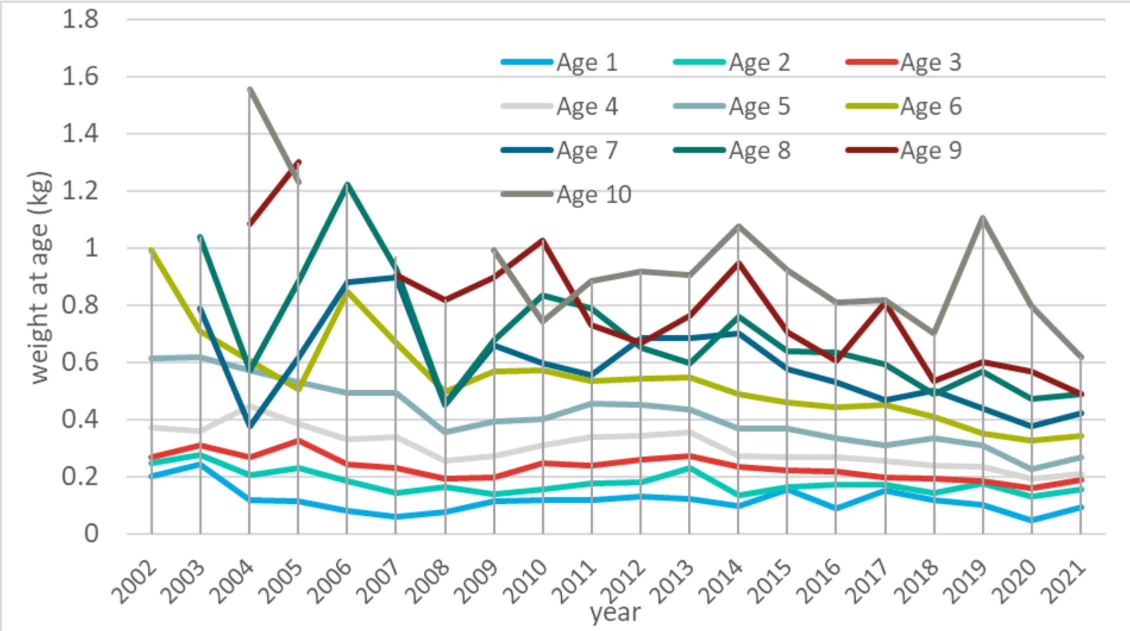


Figure 5.3.5. ple.27.24-32. Average weight-at-age for the age classes 1 to 10 in subdivisions 24 and 25. All countries and fleets were combined.

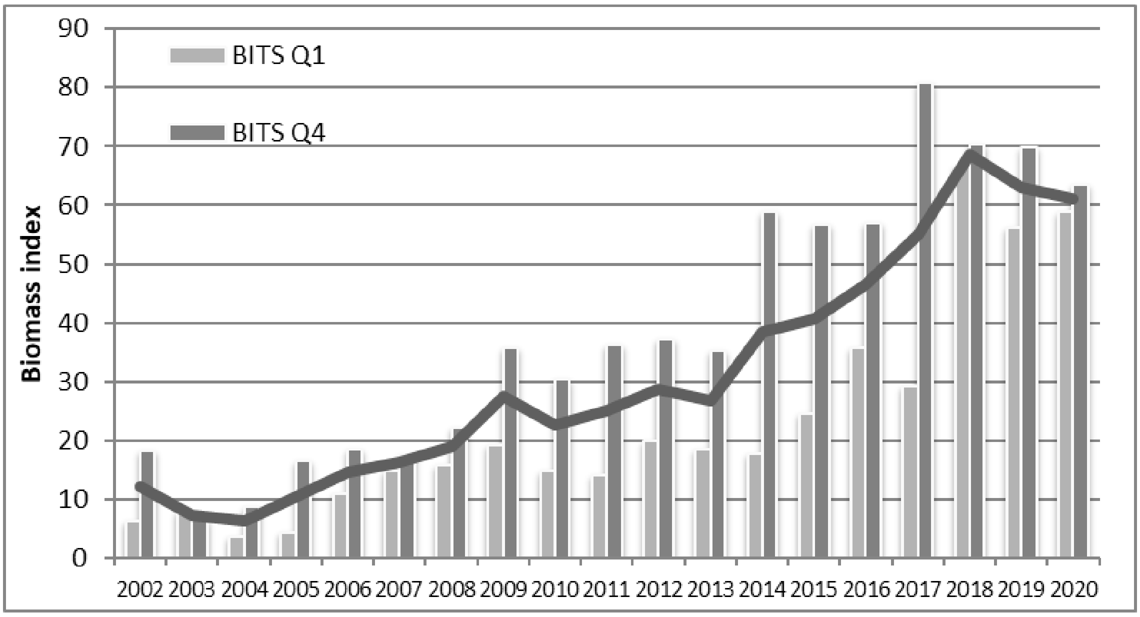


Figure 5.3.6. ple.27.24-32. Average CPUE index from Q1 and Q4 BITS from SD24-SD26 (no plaice catches in SD27+). 2020 data (Q1) are preliminary.

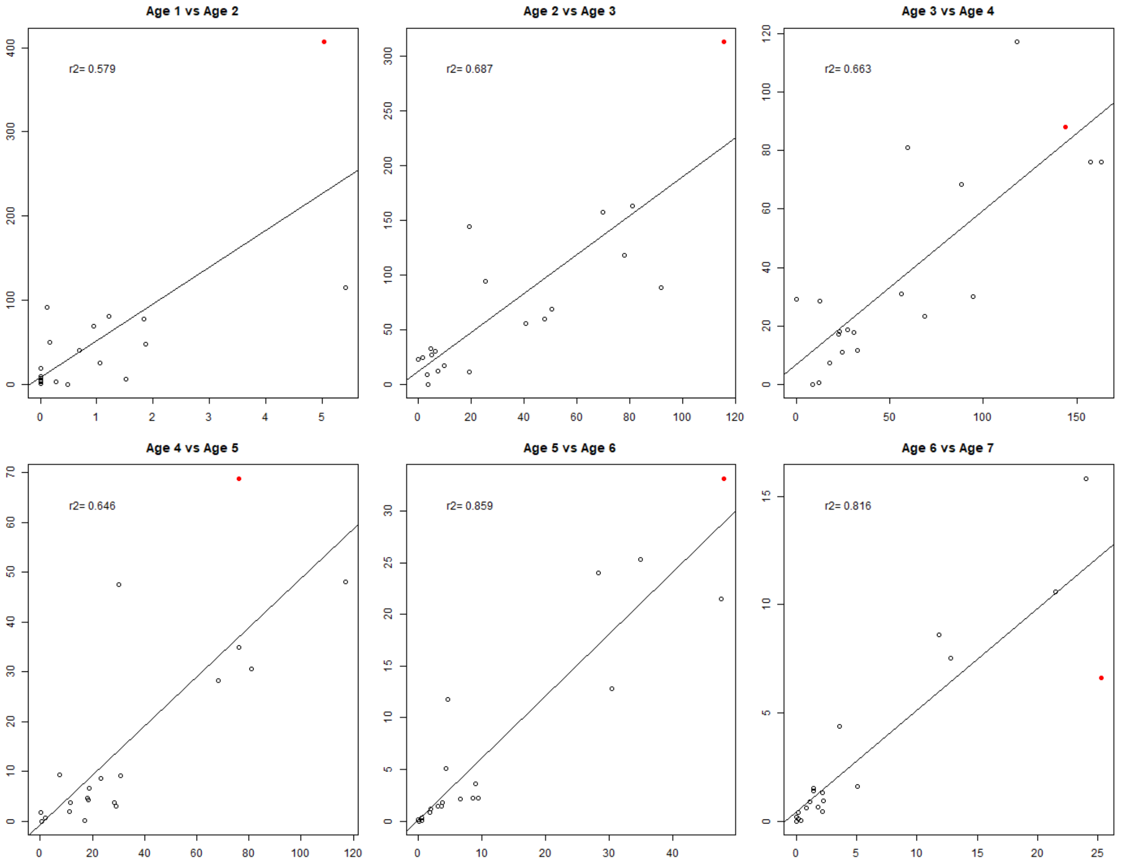


Figure 5.3.7.a. ple.27.24-32. Internal consistency of age classes 1–7 from Q1 BITS.

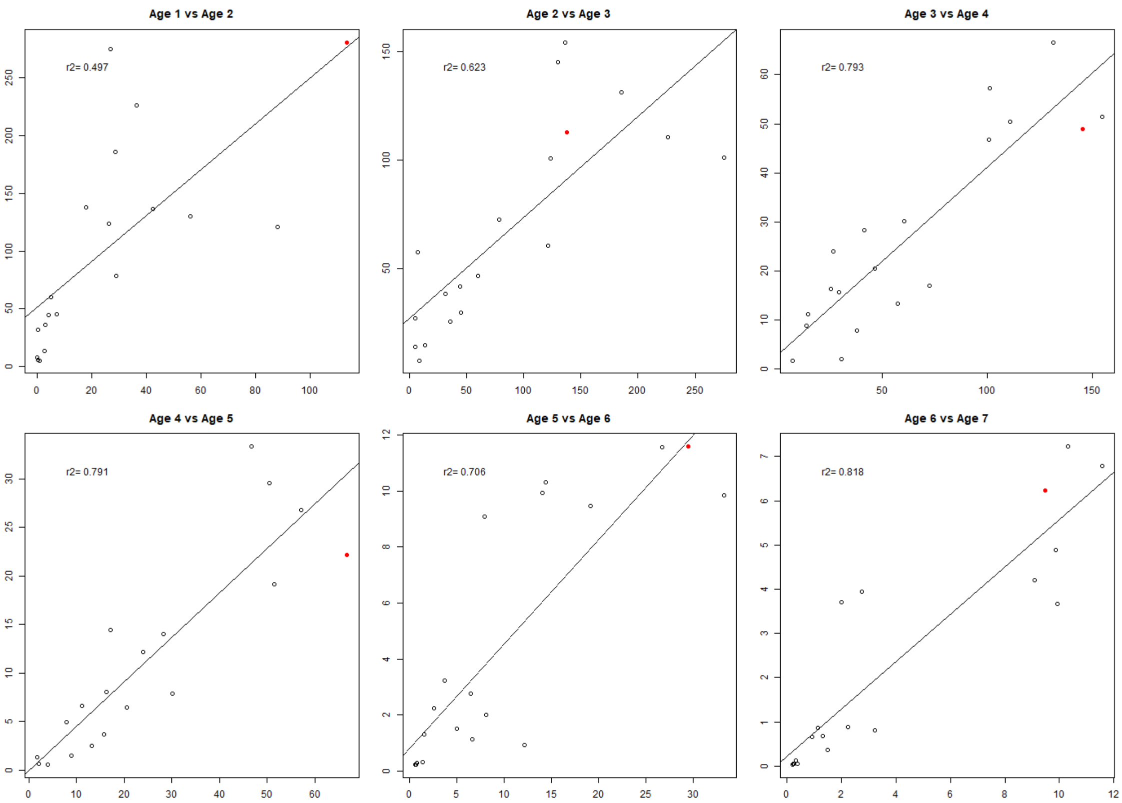


Figure 5.3.7.b. ple.27.24-32. Internal consistency of age classes 1–7 from Q4 BITS.

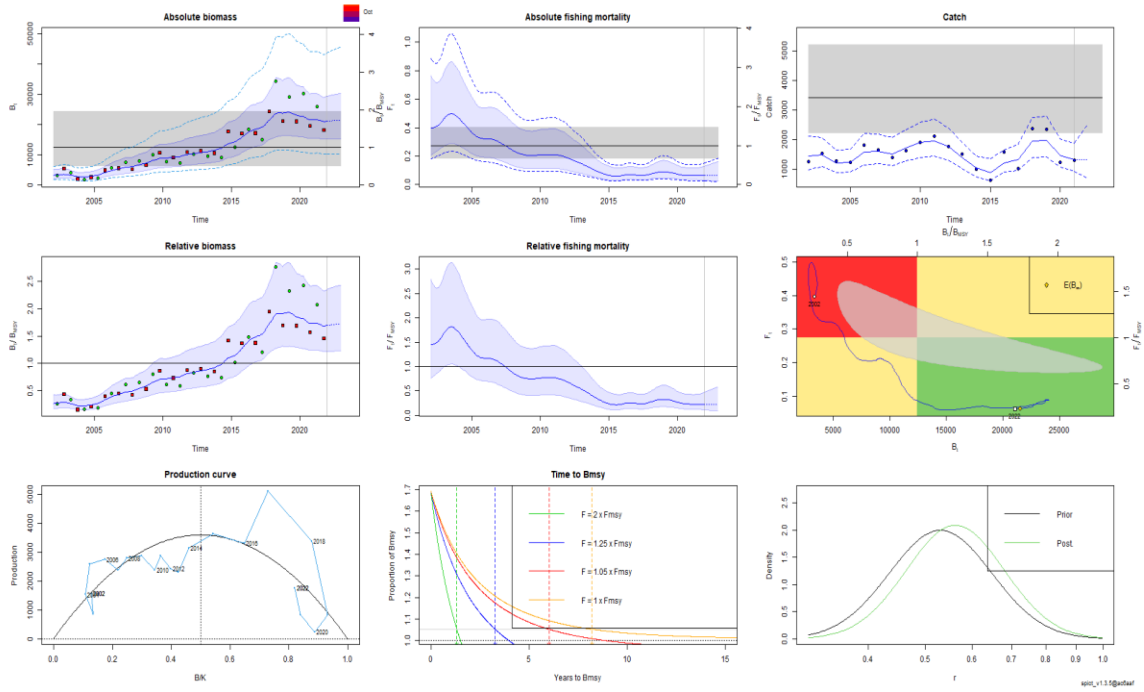


Figure 5.3.8. ple.27.24-32. Overview of the results of the surplus production model (SPiCT) on catch and survey data 2002–2021.

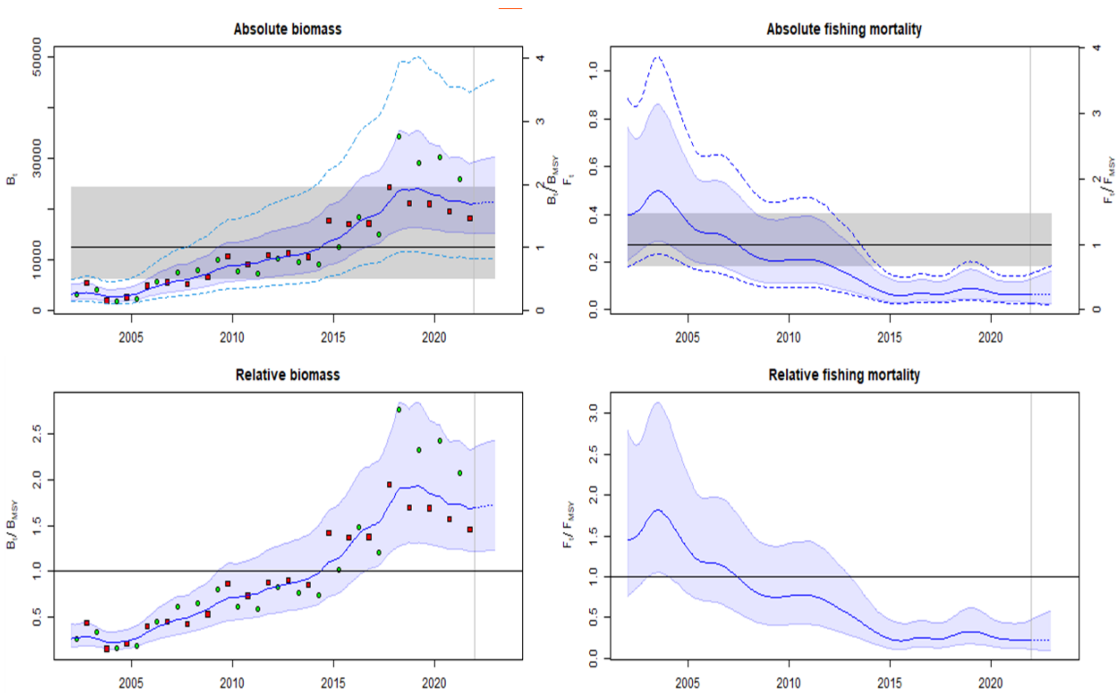


Figure 5.3.9. ple.27.24-32. Overview of the results of the surplus production model (SPiCT) on catch and survey data 2002–2021. Absolute and relative B and F and their respective estimated reference points.

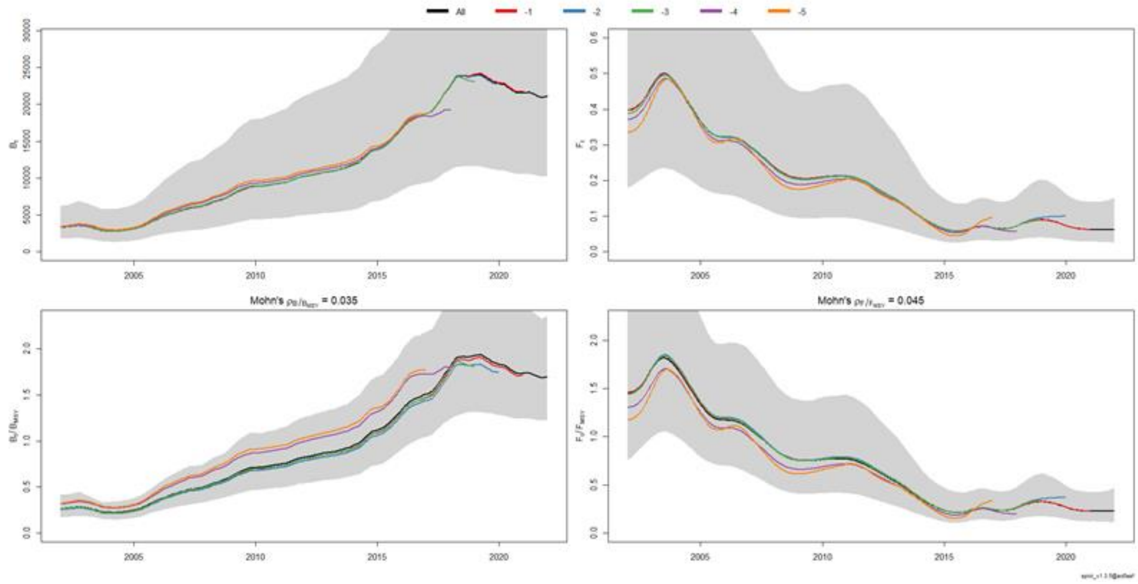


Figure 5.3.10. ple.27.24-32. Overview of the retrospective analysis of the surplus production model (SPiCT) on catch and survey data 2002–2021

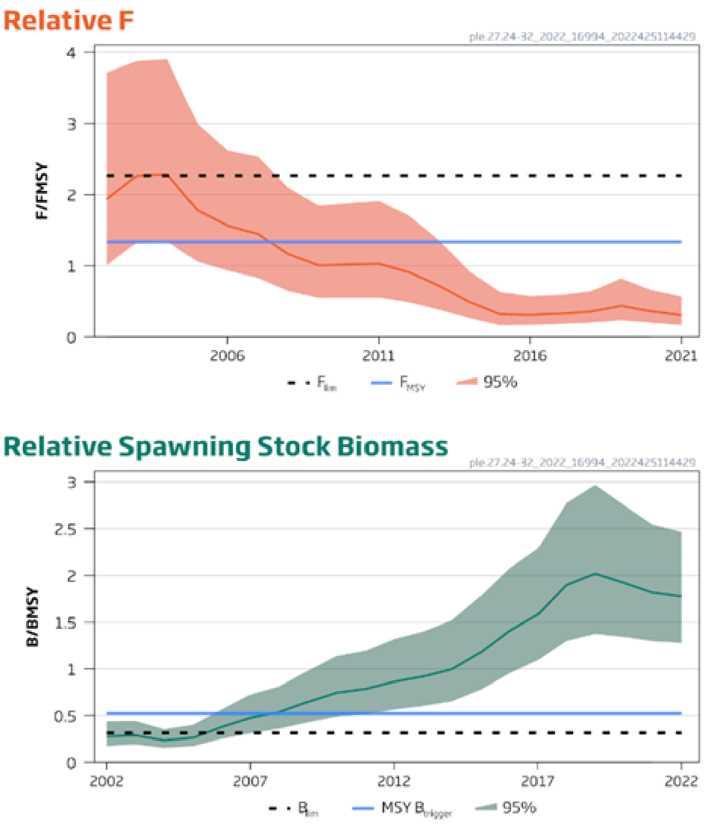


Figure 5.3.11. ple.27.24-32. Stock assessment graphs, relative F and SSB

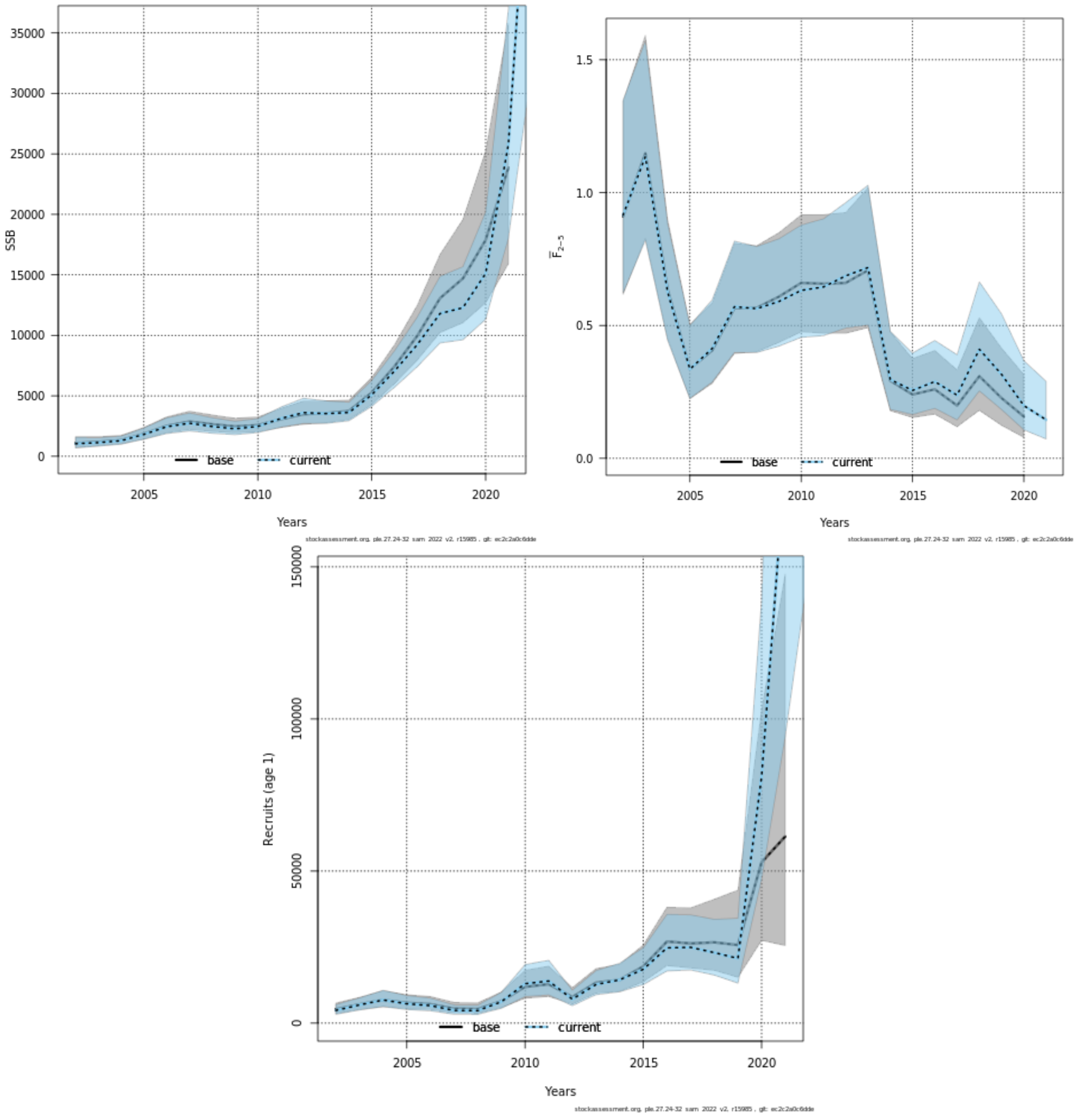


Figure 5.3.12. ple.27.24-32. Results from the exploratory SAM assessment: a) total SSB, b) F (age2–5,) and c) recruitment

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 is approx. 55/45 variable between years. 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 are in the Stock Annex.

6.1.1 Landings

The officially reported landings by area, gear and country for 2021 are given in Table 6.1. Total landings in 2021 amounted to 387 t (9% decrease from 2020) where Denmark took 79% of the total catch. Kattegat has traditionally been the most important area, but in recent years the proportion between the three areas are rather equal though with highest catches in Skagerrak.

Historical catches, including the working group corrections, are provided in Figure 6.1 and Table 6.2. The fishery fluctuated between 200 and 500 t annually prior to the mid-1980s and increased to a high in 1993 (1400 t). Since then, landings have decreased to about 300-500 t along with decreasing TACs. Figure 6.2 provide the Danish catches cumulated by month since 1998 including preliminary 1st quarter catches of 2022, 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 2021 amounts to 1.6% of the catches by weight based on sampling from trawlers (Table 6.3) and the average of the recent 5 years are 2.3% discard (used in advice, to add up to total catches).

Since the discards overall are estimated to be 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 only 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. 800 specimens from the catches). In 2021 landings from the Belts were not successfully 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. From 2020 to 2021 mean weights of the younger (2-4) age groups increase in weight while the older age groups have mixed signals.

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 (Table 6.4). The Belts was not sampled in 2021. 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 with Danish fishermen was designed with fixed haul positions chosen by both scientific and fishermen. The survey takes place in November-December and covers the central part of the stock (Figure 6.3.3). The survey was not conducted in in 2012–13. Since 2016 the survey was redesigned to cover more areas in Skagerrak and also in the Belts. Figure 6.3.3. show the progressive expansion of the survey since 2015. The extended area is not intended to be utilized in the survey index calculation, but awaits a longer time series for further evaluation.

An error was found in the program coding for the standardisation of the survey catch rates (see stock annex for standardisation procedure). Since 2018 the surveyed area included in the estimation of indices have erroneously not been limited to the same basis area (core area prior to 2016) but some rectangles within the extended survey area have been included in the index estimates. The correct area basis for the survey indices is the core area that was surveyed up to 2015 (Figure 6.3.3). The difference between the two estimations is visible mainly within age group 1 and 2 (Figure 6.3.4). Age 1 abundance in 2020 is reduced by 57% with the corrected estimation procedure and similarly age 2 and age 3 is reduced by 22% and 16%, respectively. For the remaining age groups there is no difference or the corrected abundance is up to 23% higher (age 9). Since the survey is the only contributor to the recruitment in the assessment (age 1), the recent development of recruitment is changed considerably since last year and has also affected the SSB development since 2019 (figures 6.10 and 6.12).

Based on 87 successful hauls out of 90 planned hauls in 2021, age disaggregated indices from the survey are used for the analytical assessment (Figure 6.3.1, Table 6.5). The index is estimated by a GAM model that takes into account spatial diversity of growth and that the survey coverage has been reduced over time (see stock annex). Survey CPUE in 2021 was highest in southern Kattegat and in the Belts (Figure 6.3.2). The aggregated index shows a decreasing trend in catch rates since 2018 and age 1, the recruitment age in the assessment, is the lowest observed in the time series. (Figure 6.3.1 and Table 6.5).

6.4 Assessment

Since the benchmark in 2010 (WKFLAT) SAM has been used as the assessment model. Final assessment in 2022 is named 'sole20_24_2022vs21' and is visible at stockassessment.org.

6.4.1 Model residuals

Model residuals for the survey and catches are provided in Figure 6.8. Minor negative residuals are noted for the last year 2021 for the survey, indicating that the survey has caught somewhat less numbers for most age groups than expected except for age 2 and 3.

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 visible. However, with only the catch matrix along with the two commercial series from back in time 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 2021 estimated to be at 2680 t. 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). The correction of the survey indices estimation (section 6.3) has resulted in a downscaling of the recent recruitment. This recent lower recruitment will impact the SSB negatively in the coming years (tables 6.9 –6.10 and Figure 6.13).

Estimated fishing mortalities and stock numbers by age are provided in tables 6.8 and 6.9.

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 0.07 to -0.03 for SSB, F and 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 1.6% in weight in 2021 (Table 6.3). The average of the discard in the recent 5 years (2.3%) is added to landings to derive advised catches for 2022.

Assumed recruitment ages 1 randomly drawn from 2004-2021 led to an assumed median recruitment 2022-2023 of 2485 thou. individuals.

TAC was not utilized in 2021 and preliminary information on Danish catches in the first quarter of 2022 suggest low catches in 2022. Therefore, the TAC of 715 t for 2022 (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 (2022). An F_{sq} ($F = F_{2021}$) assumption leads to a catch of 418 t in 2022 (compared to a catch of 387 t in 2021). The basis for F_{sq} (F_{2022}) is an average of recent Fs (e.g. 3 years) scaled to the final year (= 0.195). Assumptions for the intermediate year are provided in Table 6.12.

Given the F_{sq} assumption, SSB in the beginning of 2023 is estimated at 2441 t (Table 6.13) and below the MSY $B_{trigger}$ (2600 t). Therefore, the advice for 2023 will be based on a reduced F corresponding to F_{MSY}*SSB_{2023}/MSY $B_{trigger}$ (0.244). With these assumptions, the forecast predicts that advised fishing in 2023 will lead to a total yield of 504 t. At this level of exploitation, spawning stock biomass is estimated at 2403 t in 2024. Catch in 2023 in predicted to be dominated by the relatively large 2017 yc at age 6 sole (Figure 6.13).

EC has since 2018 requested advice for the sole stock in SD 20–24 based on F_{MSY} ranges. Catches in 2023 corresponding to F_{MSY} upper and lower range (F = 0.19–0.244) are 380–504 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

Reference points were redefined under the interbenchmark, IBPSOLKAT (ICES, 2015) in November 2015. Since 2021 the basis for F_{pa} have been decided to be based on F_{p05} (estimated to 0.26 in 2015 benchmark). This has caused F_{pa} to change from 0.23 (capped previously by F_{pa}) to the F_{MSY} estimate derived from stochastic equilibrium scenarios at 0.26. F_{MSY} lower is not recalculated since the F_{MSY} remain the uncapped value estimated in 2015. The present reference points are as follows:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	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 (2015-2016) but mainly 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 set to age 3+, the true SSB for the stock is uncertain. Present assumption is that maturity is constant over time. Any future adoption of an observed maturity ogive (derived from the sole survey) might therefore change the perception of the stock history and stock-recruitment relations. This again will have an impact on the estimates of biomass reference points. Similarly, establishment of a weight-at-age in the stock from the survey will have implications on perception of present stock biomass. Work is ongoing to improve the biological parameters for sole in the assessment and will be dealt with at 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 stock status in relation to reference points are unchanged from last year, but SSB in 2023 is expected to be below MSY $B_{trigger}$ with the interim year assumptions. The historical performance of the assessment is provided in Figure 6.12.

An error correction within the standardisation procedure for the survey indices have resulted in a downscaling of the recent recruitment abundance and younger age groups (see section 6.3). This change in the main data input for recruitment and fishery independent information to the assessment has caused estimates of SSB and recruitment to lower in recent years compared to the previous assessment.

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, combined with the landing obligation cod is potentially being a choke species in the mixed fishery. If the mixed fishery for sole and cod could be un-coupled, management in the Kattegat 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 Div 4.
2. Abundance and distribution of juveniles; identification of potential nursery grounds was done under the previous project, however, validation of those identified areas needs to be done. That will include sampling/monitoring by various small and operational gears in the potential coastal and shallow waters.
3. Otolith trace element analysis to identify the origin of sole sampled both in the North Sea and in SD 20-24.
4. Drift modelling of egg/larvae releases from potential spawning grounds and/or reverse modelling from known/potential nursery grounds.
5. Conventional tagging of mature/immature sole in SD 20-21 and in the North Sea adjacent to Skagerrak in order to verify migrations and mix. This method is not included in present project scheme but aimed for future studies.

The project is expected to provide the first results in late 2022.

In addition to the above research items, the assessment needs improvements such as:

- 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.
- Potential inclusion of gradually expanded survey area since 2015 (Skagerrak, the Belts and the western Baltic).

Table 6.1. Sole 20-24. Landings (t) of sole in 2021 by area, nation, quarter and gear.

Skagerrak (SD20)	**Quarter**				**Gear**		**Total**
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	10	64	13	29	41	75	116
Germany	0	5	0	0	0	5	5
Sweden	0	0	0	0	1	0	1
Netherlands	6	1	1	39	47	0	47
Norway	0	0	0	0		0	
Total	17	69	14	68	89	79	168

Kattegat (SD21)	**Quarter**				**Gear**		**Total**
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	41	16	11	54	101	20	121
Germany	0	2	9	5	2	15	17
Sweden	1	2	2	2	3	4	7
Total	43	20	22	61	107	39	145

Belts and Baltic (SD22-24)	**Quarter**				**Gear**		**Total**
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	5	21	19	26	13	57	70
Germany	0	1	0	0	1	1	1
Sweden	1	1	0	0	0	2	2
Total	0	0	1	0	14	59	73

Table 6.2. Sole 20--24. Catches (tons) in the Skagerrak, Kattegat and the Belts 1952–2021. 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			145	990
						Norway			
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

Considerable non-reporting assumed for the period 1991–1993. [2]Catches from Skagerrak were reduced by these amounts because of misreporting from the North Sea. The subtracted amount has been added to the North Sea sole catches. Total landings for these years in IIIA has been reduced by the amount of misreporting. [3]Assuming misreporting rates at 50, 100, 100 and 20% in 2002-2005, respectively.

Table 6.3 Sole 20-24. Discard from active gears as obtained from observers.

Discard in weight (kg)/ Age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	128	490	3128	1156	5913	254	230	219	348	494
2	1326	2392	2492	828	2761	2095	476	1415	1236	1421
3	1782	1872	19 126	-	1800	9733	2457	1281	3686	786
4	4032	954	1316	1076	3408	1117	568	2465	474	1676
5	680	510	1785	981	14	1404	1379	1306	973	294
6	928	1232	972	264	315	692	588	518	703	615
7	570	1030	1800	-	702	315	716	155	1093	363
8	248	416	1220	296	-	603	30	441	1105	431
9	572	708	232	-	172	345	143	103	2319	350
10	393	224	-	832	1456	379	45	182	-	
11	345			118	-	169	-	211	-	
Total (t)	11	10	32	6	17	17	7	8	12	6
Landings(t)	359	332	335	224	348	520	348	417	424	387
Catches	370	342	367	230	365	537	355	425	436	393
Discard %	3%	3%	9%	2%	5%	3%	2%	2%	2.7%	1.634%

Table 6.4 Sole 20-24. Sampling and ageing in 2021 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	5,340	-	-	16,916	10,223	162	42,612	41,315	224	64,868	51,538	386
2	21,644	-	-	69,243	63,848	104	19,963	-	-	110,850	63,848	104
3	19,019	-	-	14,098	-	-	22,016	-	-	55,133	-	-
4	27,221	-	-	68,231	28,540	130	60,723	53,635	166	156,176	82,175	296
Total	73,224	0	0	168,489	102,611	396	145,314	94,950	390	387,027	197,561	786

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	2021								
1	1	0.8	1						
1	9								
1	16.859625	55.63743	51.25082	32.12494	22.20887	9.310701	7.66656	4.612178	6.238217
1	12.746525	37.85718	68.41383	36.224114	18.696127	7.677196	3.251101	1.801281	1.532472
1	35.133022	39.50066	29.29465	52.555169	25.988508	14.178392	4.917416	1.613704	5.143157
1	32.541623	34.10023	24.84114	30.199843	31.446713	20.685411	12.054617	7.432666	13.052035
1	10.24085	47.07506	28.15955	15.966224	13.652893	17.682597	7.447549	6.813955	7.798046
1	16.080123	11.39743	35.48561	14.2116	15.564937	14.909888	17.299559	5.185324	7.971787
1	13.709053	16.60382	20.42419	18.387521	7.023587	10.711562	7.295555	11.993375	15.584841
1	15.010561	30.35226	18.17989	17.40126	16.091086	10.076212	9.011582	4.137883	19.458829
1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1	22.456468	17.38115	19.30901	14.368023	12.067207	9.590962	4.023162	8.365093	12.580716
1	33.96722	28.53565	16.67462	15.122148	9.693589	17.183578	6.422476	4.673582	30.38403
1	17.748358	37.94521	26.88038	14.521379	13.9044	4.172301	7.633703	4.480278	26.260421
1	10.796492	50.54734	37.52496	24.329357	7.883941	12.43821	2.319349	2.338682	22.415873
1	39.262031	18.17896	41.44222	37.899907	17.414193	6.922358	7.636913	2.474638	22.438707
1	20.822342	57.37614	11.27727	28.775805	17.331886	15.474933	2.7942	4.820038	21.642324
1	13.042378	30.49211	42.73166	7.692297	21.696922	18.858316	12.217454	1.842754	26.575741
1	6.492096	25.20489	31.06281	26.437808	6.277524	8.937632	7.711412	5.702597	13.349359

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.

Numbers*10**-3

YEAR	1984	1985	1986	1987	1988	1989	1990	1991
AGE								
2	64	786	258	391	516	863	1209	530
3	638	594	1255	857	1035	613	1300	1301
4	240	190	671	1018	897	847	651	928
5	117	55	210	434	484	592	564	334
6	31	60	33	174	129	404	310	345
7	33	16	36	64	37	83	167	302
8	40	8	33	31	23	30	27	180
+gp	175	69	63	87	60	52	31	76
TOTALNUM	1338	1778	2559	3056	3181	3484	4259	3996
TONSLAND	337	397	643	722	706	824	1050	1011
SOPCOF %	99	100	100	100	100	100	100	95

Numbers*10**-3

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
2	506	523	127	272	316	54	303	249	142	170
3	1178	1804	1037	622	1015	251	146	826	483	369
4	939	1251	1451	1359	537	440	212	150	771	360
5	493	826	752	1226	691	365	299	228	114	354
6	320	418	444	600	440	505	267	177	130	68
7	178	117	152	385	232	360	250	165	123	84
8	166	137	45	142	148	262	218	167	135	36
+gp	239	157	59	104	203	263	292	233	306	205
TOTALNUM	4019	5233	4067	4710	3582	2500	1987	2195	2204	1646
TONSLAND	1294	1439	1198	1297	1059	814	605	638	646	476
SOPCOF %	93	100	99	98	98	100	100	100	100	99

Numbers*10**-3

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE										
2	655	48	195	231	122	293	313	554	230	138
3	758	431	602	1015	400	420	330	683	591	558
4	285	480	814	1083	857	384	354	445	458	613
5	423	280	475	583	734	583	297	285	211	246
6	472	344	257	276	505	299	489	139	132	65
7	94	197	187	117	169	135	240	92	67	28
8	85	25	86	102	67	81	179	29	83	14
+gp	464	210	171	91	116	108	202	88	103	106
TOTALNUM	3236	2015	2787	3498	2970	2303	2404	2315	1875	1768
TONSLAND	862	619	824	990	836	633	656	640	541	507
SOPCOF %	100	100	99	98	98	97	102	98	101	100

YEAR	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
AGE										
2	26	48	13	37	110	137	32	163	45	63
3	157	226	66	81	273	181	131	59	325	181
4	284	286	178	95	190	347	268	309	96	202
5	160	194	109	109	175	195	201	268	228	65
6	111	137	199	89	82	186	97	93	243	126
7	36	62	105	81	38	163	144	54	120	122
8	54	23	68	18	50	120	104	83	34	92
+gp	192	96	69	93	181	301	157	235	214	224
TOTALNUM	1020	1072	807	603	1099	1630	1134	1264	1305	1075
TONSLAND	358	332	331	215	348	520	434	417	424	387
SOPCOF %	100	109	100	100	101	100	100	99	100	99

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
AGE								
2	.1830	.1740	.1650	.1600	.1590	.1760	.1800	.1740
3	.2130	.2340	.2310	.1940	.1970	.2210	.2280	.2290
4	.2570	.2830	.2870	.2450	.2350	.2550	.2510	.2750
5	.2940	.2910	.2970	.2740	.2510	.2660	.3080	.2920
6	.2970	.3350	.4090	.3190	.3350	.2710	.3330	.3460
7	.2800	.2920	.2670	.3600	.3480	.3520	.4000	.3090
8	.3210	.2790	.2620	.4170	.3630	.3000	.5470	.3860
+gp	.3680	.3640	.3830	.3610	.3520	.3550	.5550	.5030
SOPCOFAC	.9930	.9984	.9995	1.0027	1.0032	.9964	.9970	.9508

Catch weights at age (kg)

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
2	.2130	.1780	.1740	.1870	.1760	.1980	.1610	.1620	.1690	.1840
3	.2520	.2240	.2290	.2000	.2180	.2720	.2190	.2320	.2360	.2420
4	.3360	.2740	.2800	.2480	.2670	.2960	.3160	.3040	.3040	.2900
5	.4120	.3280	.3420	.2910	.3070	.3080	.3220	.3680	.3440	.3780
6	.4300	.3740	.3880	.3510	.3390	.3450	.3500	.3600	.3190	.3460
7	.4910	.4030	.4450	.3820	.4040	.3590	.3580	.3780	.3640	.3080
8	.5660	.3880	.4480	.4320	.4570	.3640	.3770	.3970	.3520	.3620
+gp	.6220	.4740	.3940	.3830	.6640	.3610	.3270	.3500	.3280	.2810
SOPCOFAC	.9304	.9980	.9931	.9767	.9826	.9983	1.0006	1.0041	1.0004	.9941

Catch weights at age (kg)

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE										
2	.1720	.1740	.2030	.1920	.2010	.2110	.2150	.2110	.2580	.2610

3,	.2050,	.2100,	.2370,	.2230,	.2150,	.2280,	.2460,	.2590,	.2700,	.2710,
4,	.2940,	.2460,	.2910,	.3000,	.2630,	.2950,	.2670,	.3010,	.2830,	.2920,
5,	.3730,	.3600,	.3280,	.3240,	.3170,	.3020,	.2800,	.3190,	.3240,	.2770,
6,	.3860,	.3820,	.3710,	.3670,	.3390,	.3540,	.2900,	.4030,	.3110,	.3580,
7,	.2140,	.4310,	.4010,	.3710,	.3210,	.3390,	.2960,	.4390,	.3690,	.4760,
8,	.2920,	.2610,	.3700,	.4210,	.2930,	.3800,	.3010,	.4390,	.3100,	.2850,
+gp,	.2760,	.3820,	.3150,	.3720,	.3440,	.2440,	.2460,	.2630,	.2630,	.3010,
S OPCOFAC,	.9967,	.9971,	.9916,	.9841,	.9794,	.9654,	1.0209,	.9832,	1.0103,	1.0003,

Catch weights at age (kg)

YEAR,	2012,	2013,	2014,	2015,	2016,	2017,	2018,	2019,	2020,	2021,
AGE										
2,	.2850,	.2390,	.2270,	.2210,	.2340,	.2160,	.2100,	.2000,	.1820,	.1930,
3,	.2790,	.2250,	.2830,	.2390,	.2670,	.2650,	.2280,	.2880,	.2400,	.2640,
4,	.3170,	.2760,	.3720,	.2860,	.2680,	.2920,	.3130,	.2900,	.2650,	.3220,
5,	.3750,	.3040,	.4210,	.3910,	.2830,	.2990,	.3680,	.3840,	.3470,	.3370,
6,	.4060,	.3730,	.4430,	.4040,	.3410,	.3260,	.3570,	.4230,	.3570,	.3680,
7,	.4060,	.3050,	.4860,	.3880,	.3300,	.3770,	.4630,	.4590,	.3000,	.4110,
8,	.3500,	.3060,	.4540,	.5010,	.5440,	.3340,	.4750,	.3860,	.4790,	.4180,
+gp,	.4060,	.2870,	.4060,	.4340,	.4390,	.3950,	.5640,	.3440,	.4360,	.4870,
SOPCOFAC,	1.0006,	1.0891,	.9976,	1.0043,	1.0051,	1.0034,	1.0007,	.9949,	1.0022,	.9899,

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
91984	0.083	0.387	0.478	0.402	0.378	0.378	0.378	0.378
1985	0.074	0.303	0.372	0.337	0.291	0.291	0.291	0.291
1986	0.085	0.314	0.413	0.393	0.347	0.347	0.347	0.347
1987	0.100	0.332	0.446	0.455	0.451	0.451	0.451	0.451
1988	0.099	0.312	0.414	0.411	0.404	0.404	0.404	0.404
1989	0.103	0.317	0.426	0.430	0.417	0.417	0.417	0.417
1990	0.097	0.302	0.412	0.417	0.378	0.378	0.378	0.378
1991	0.098	0.304	0.423	0.442	0.485	0.485	0.485	0.485
1992	0.097	0.304	0.422	0.464	0.584	0.584	0.584	0.584
1993	0.095	0.305	0.424	0.476	0.589	0.589	0.589	0.589
1994	0.081	0.263	0.363	0.413	0.450	0.450	0.450	0.450
1995	0.087	0.287	0.383	0.440	0.484	0.484	0.484	0.484
1996	0.084	0.285	0.356	0.403	0.430	0.430	0.430	0.430
1997	0.078	0.257	0.337	0.384	0.426	0.426	0.426	0.426
1998	0.074	0.239	0.314	0.374	0.404	0.404	0.404	0.404
1999	0.069	0.225	0.295	0.344	0.368	0.368	0.368	0.368
2000	0.065	0.215	0.291	0.328	0.359	0.359	0.359	0.359
2001	0.056	0.184	0.241	0.286	0.304	0.304	0.304	0.304
2002	0.062	0.198	0.263	0.323	0.416	0.416	0.416	0.416
2003	0.055	0.170	0.246	0.301	0.386	0.386	0.386	0.386
2004	0.064	0.195	0.290	0.346	0.435	0.435	0.435	0.435
2005	0.073	0.222	0.322	0.373	0.436	0.436	0.436	0.436
2006	0.075	0.229	0.319	0.376	0.370	0.370	0.370	0.370
2007	0.078	0.236	0.319	0.352	0.305	0.305	0.305	0.305
2008	0.087	0.268	0.366	0.374	0.320	0.320	0.320	0.320
2009	0.078	0.256	0.357	0.328	0.194	0.194	0.194	0.194
2010	0.071	0.255	0.355	0.317	0.170	0.170	0.170	0.170
2011	0.054	0.207	0.313	0.257	0.128	0.128	0.128	0.128
2012	0.043	0.158	0.262	0.224	0.142	0.142	0.142	0.142

Year / Age	2	3	4	5	6	7	8	9
2013	0.038	0.136	0.237	0.209	0.145	0.145	0.145	0.145
2014	0.031	0.102	0.194	0.183	0.149	0.149	0.149	0.149
2015	0.028	0.087	0.157	0.171	0.128	0.128	0.128	0.128
2016	0.033	0.100	0.187	0.207	0.169	0.169	0.169	0.169
2017	0.041	0.108	0.218	0.260	0.267	0.267	0.267	0.267
2018	0.036	0.092	0.183	0.222	0.241	0.241	0.241	0.241
2019	0.035	0.091	0.173	0.209	0.215	0.215	0.215	0.215
2020	0.034	0.099	0.167	0.207	0.219	0.219	0.219	0.219
2021	0.033	0.095	0.149	0.189	0.212	0.212	0.212	0.212

Table 6.9. Sole 20-24. Stock number-at-age from assessment.

Year Age	1	2	3	4	5	6	7	8	9
1984	6421	2572	1623	511	366	133	80	126	480
1985	5218	5999	2316	926	265	221	89	45	349
1986	4807	4631	4970	1659	598	172	144	71	262
1987	4333	4364	3865	3258	995	365	124	91	221
1988	5923	3677	3784	2697	1863	492	176	71	180
1989	7663	5405	2655	2569	1679	1159	264	101	149
1990	7544	7231	4445	1746	1581	1012	696	142	140
1991	8547	6680	5672	2873	1033	942	666	466	185
1992	6507	8222	5423	3518	1575	585	509	369	394
1993	3544	6199	6936	3631	2111	878	285	263	368
1994	3529	2922	5248	4846	2194	1210	410	139	292
1995	2291	3410	2590	3952	3139	1439	762	263	279
1996	1529	2064	2946	1850	2416	1730	850	426	375
1997	3638	1138	1436	1733	1241	1514	1118	627	546
1998	3693	3753	860	935	982	771	849	688	747
1999	3096	3442	3709	631	724	612	521	520	885
2000	4422	2581	2671	2545	428	502	371	366	960
2001	5968	4037	2172	1948	1589	296	377	210	905

Year Age	1	2	3	4	5	6	7	8	9
2002	4406	5925	3787	1545	1497	1156	227	276	848
2003	4493	3793	4419	2735	1144	1052	637	120	649
2004	2918	4358	3726	3287	1745	760	585	346	445
2005	2485	2743	4533	3364	2205	971	379	290	348
2006	3243	2366	2254	3463	2170	1426	556	232	418
2007	3472	2702	1944	1610	2186	1078	789	358	493
2008	2048	3216	1929	1407	1077	1390	646	540	592
2009	2142	1921	2679	1280	989	683	879	352	674
2010	1987	1974	1889	1775	752	660	433	662	796
2011	1764	1857	1845	1459	1149	489	457	265	1101
2012	1519	1543	1507	1400	932	811	335	367	1079
2013	1535	1341	1374	1204	1029	672	627	237	976
2014	2555	1287	1139	1016	845	787	456	523	871
2015	3260	2294	1127	1002	699	666	554	302	1215
2016	2666	2857	2124	963	924	491	453	398	1345
2017	1577	2629	2397	1720	689	779	388	335	1420
2018	3534	1195	2199	1979	1200	442	574	288	1259
2019	2574	3370	858	1807	1461	852	272	409	1249
2020	1822	2286	2826	640	1281	1093	659	182	1305
2021	1110	1711	2036	2047	462	831	722	471	1085

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	6421	3885	10614	864	696	1072	0.403	0.303	0.535	1720	1398	2115
1985	5218	3351	8126	1121	895	1403	0.316	0.240	0.416	2477	1971	3115
1986	4807	3146	7345	2030	1615	2550	0.369	0.291	0.469	3082	2529	3757
1987	4333	2796	6714	2099	1739	2534	0.451	0.355	0.573	3058	2583	3620
1988	5923	3876	9051	2163	1818	2572	0.408	0.321	0.518	3103	2649	3635
1989	7663	5000	11743	2179	1851	2565	0.421	0.333	0.532	3590	3052	4223
1990	7544	4949	11499	2709	2299	3193	0.393	0.313	0.493	4464	3777	5276
1991	8547	5529	13213	3195	2693	3791	0.464	0.375	0.575	4870	4140	5728
1992	6507	4258	9944	4153	3525	4892	0.527	0.424	0.655	6295	5340	7421
1993	3544	2331	5387	3961	3340	4697	0.533	0.426	0.668	5277	4501	6186
1994	3529	2333	5338	4138	3534	4846	0.425	0.340	0.532	4858	4192	5630
1995	2291	1501	3497	3428	2964	3965	0.455	0.367	0.565	4203	3662	4825
1996	1529	953	2454	3251	2825	3742	0.410	0.332	0.505	3706	3241	4238
1997	3638	2364	5599	2635	2288	3034	0.400	0.323	0.494	3078	2695	3516
1998	3693	2442	5586	1877	1615	2182	0.380	0.305	0.474	2703	2334	3131
1999	3096	2029	4723	2252	1915	2650	0.349	0.280	0.433	2996	2568	3495
2000	4422	2926	6683	2290	1953	2686	0.339	0.272	0.422	2992	2578	3472
2001	5968	3896	9142	2240	1920	2612	0.288	0.228	0.363	3341	2867	3892
2002	4406	2915	6659	2599	2217	3046	0.366	0.293	0.459	3882	3298	4569
2003	4493	2986	6761	2968	2535	3476	0.341	0.267	0.434	3898	3373	4504
2004	2918	2037	4180	3197	2760	3703	0.388	0.310	0.487	4256	3695	4904
2005	2485	1717	3597	3483	2991	4056	0.400	0.319	0.502	4159	3603	4801
2006	3243	2234	4707	2957	2528	3460	0.361	0.289	0.450	3627	3128	4206
2007	3472	2411	5001	2483	2132	2893	0.317	0.251	0.402	3262	2818	3776
2008	2048	1376	3048	2055	1745	2419	0.340	0.265	0.437	2869	2450	3359
2009	2142	1489	3083	2388	1991	2864	0.253	0.195	0.329	2922	2470	3456
2010	1987	1379	2863	2036	1691	2451	0.237	0.181	0.309	2664	2239	3170
2011	1764	1200	2595	2044	1680	2486	0.190	0.145	0.250	2634	2190	3168

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(4-8)	Low	High	TSB	Low	High
2012	1519	974	2370	2245	1823	2765	0.182	0.138	0.241	2776	2281	3379
2013	1535	999	2360	1749	1420	2153	0.176	0.134	0.232	2161	1776	2631
2014	2555	1762	3706	2217	1817	2706	0.165	0.126	0.216	2663	2208	3211
2015	3260	2204	4822	1992	1631	2432	0.142	0.107	0.189	2694	2236	3246
2016	2666	1847	3847	2210	1822	2682	0.180	0.139	0.233	3359	2794	4037
2017	1577	1036	2400	2416	2003	2915	0.256	0.195	0.335	3268	2725	3920
2018	3534	2313	5400	2832	2333	3439	0.225	0.174	0.292	3719	3078	4495
2019	2574	1749	3788	2405	1972	2932	0.205	0.157	0.269	3411	2814	4135
2020	1822	1192	2784	2536	2049	3140	0.206	0.155	0.274	3317	2714	4053
2021	1110	595	2070	2680	2122	3386	0.195	0.141	0.269	3133	2510	3909

Table 6.11. Sole 20-24. Input to short term prediction.

2022

Age	N	M	Mat	PF	PM	SWt	pF	CWt
1	2485	0.1	0	0	0	0.146	0.000	0.146
2	1013	0.1	0	0	0	0.192	0.030	0.192
3	1488	0.1	1	0	0	0.264	0.070	0.264
4	1694	0.1	1	0	0	0.292	0.160	0.292
5	1611	0.1	1	0	0	0.356	0.180	0.356
6	357	0.1	1	0	0	0.383	0.200	0.383
7	617	0.1	1	0	0	0.390	0.200	0.390
8	528	0.1	1	0	0	0.428	0.200	0.428
9	1165	0.1	1	0	0	0.422	0.200	0.422

2023

Age	N	M	Mat	PF	PM	SWt	pF	CWt
1	2142	0.1	0	0	0	0.146	0.000	0.146
2	2049	0.1	0	0	0	0.192	0.030	0.192
3	900	0.1	1	0	0	0.264	0.070	0.264
4	1223	0.1	1	0	0	0.292	0.160	0.292
5	1313	0.1	1	0	0	0.356	0.180	0.356
6	1187	0.1	1	0	0	0.383	0.200	0.383
7	260	0.1	1	0	0	0.390	0.200	0.390
8	459	0.1	1	0	0	0.428	0.200	0.428
9	1263	0.1	1	0	0	0.422	0.200	0.422

2024

Age	N	M	Mat	PF	PM	SWt	pF	CWt
1	2142	0.1	0	0	0	0.146	0.000	0.146
2	2047	0.1	0	0	0	0.192	0.030	0.192
3	1809	0.1	1	0	0	0.264	0.070	0.264
4	751	0.1	1	0	0	0.292	0.160	0.292
5	1001	0.1	1	0	0	0.356	0.180	0.356
6	1012	0.1	1	0	0	0.383	0.200	0.383
7	915	0.1	1	0	0	0.390	0.200	0.390
8	201	0.1	1	0	0	0.428	0.200	0.428
9	1365	0.1	1	0	0	0.422	0.200	0.422

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 (2022)	0.195	Fsq (=avg F2019-21 rescaled to F2021)
SSB (2023)	2441 tonnes	When fishing at F=0.195 in 2022
Rage1 (2022-2023)	2485 thousands	Median value, resampled from recruitment (2004-2021), full distribution used in forecast
Projected landings (2022)	409 tonnes	Fishing at F=0.195 in 2022
Projected discards (2022)	9 tonnes	Mean discard rate in weight (2017-2021): 2.3%.
Total catch (2022)	418 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 (2023) *	Projected landings (2023) **	Projected discard (2023) **	F projected landings (4–8) (2023)	SSB (2024)	% SSB change ***	% TAC change ^	% Advice change ^^
ICES advice basis								
EU MAP#: $F_{MSY*SSB2023/MSY\ Btrigger}$	504	493	11	0.244	2403	-1.6	-29.5	-30.3
EU MAP#: $F_{lower*SSB2023/MSY\ Btrigger}$	380	372	8	0.178	2527	3.5	-46.8	-30.1
EU MAP#: $F_{upper*SSB2023/MSY\ Btrigger}$	504	493	11	0.244	2403	-1.6	-29.5	-30.3
Other options								
F = 0	0	0	0	0	2920	19.6	-100.0	-100.0
F_{pa}, F_{msy}	534	522	12	0.26	2373	-2.8	-25.3	-26.2
F_{lim}	628	614	14	0.315	2271	-7.0	-12.2	-13.1
TAC 2022*1.2	858	839	19	0.46	2030	-16.8	20.0	18.7
SSB (2024) = Blim	1031	1008	23	0.585	1850	-24.2	44.2	42.6
SSB (2024) = Bpa	306	299	7	0.14	2600	6.5	-57.2	-57.7
SSB (2024) = MSY Btrigger	306	299	7	0.14	2600	6.5	-57.2	-57.7
F = F_{2022}	413	404	9	0.195	2633	7.9	-42.2	-42.9

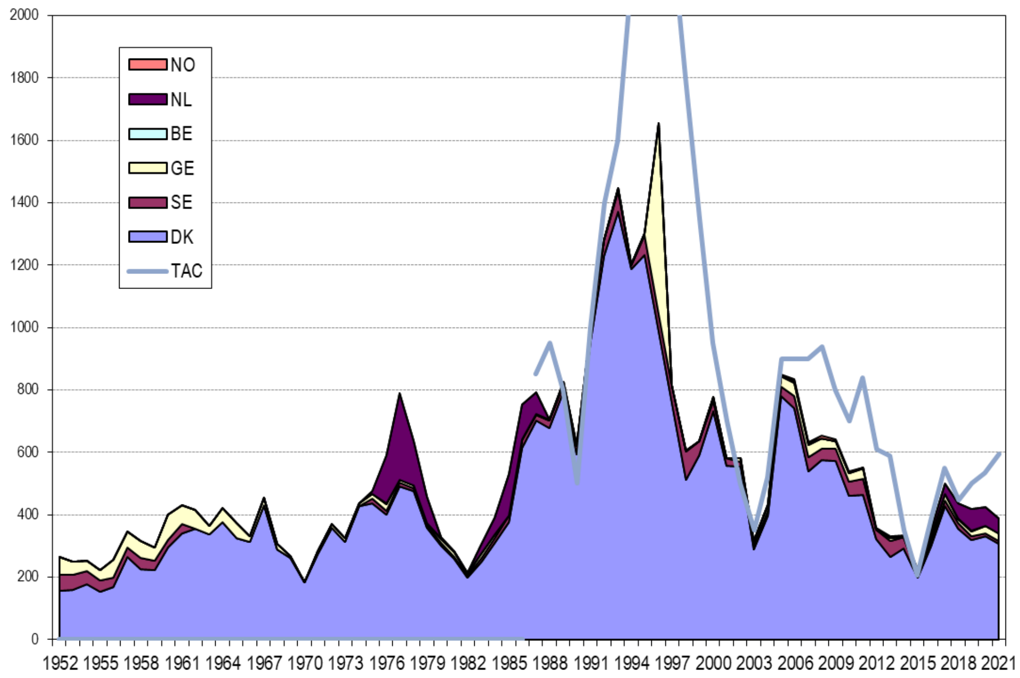
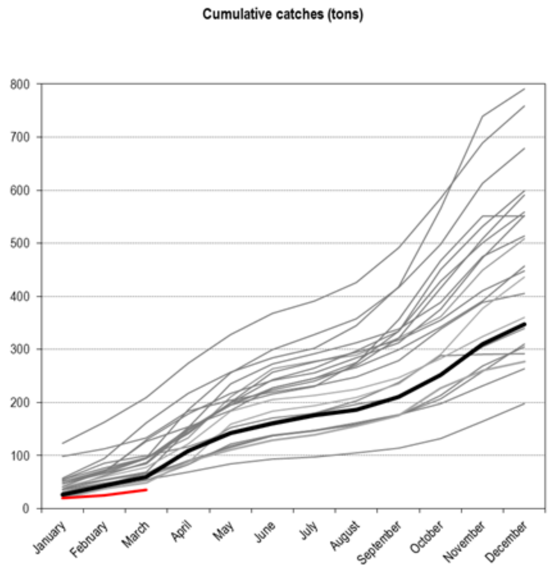


Figure 6.1. Sole 20-24. Landings of sole in divisions 20-24 by nation since 1952 and for TAC since 1986.



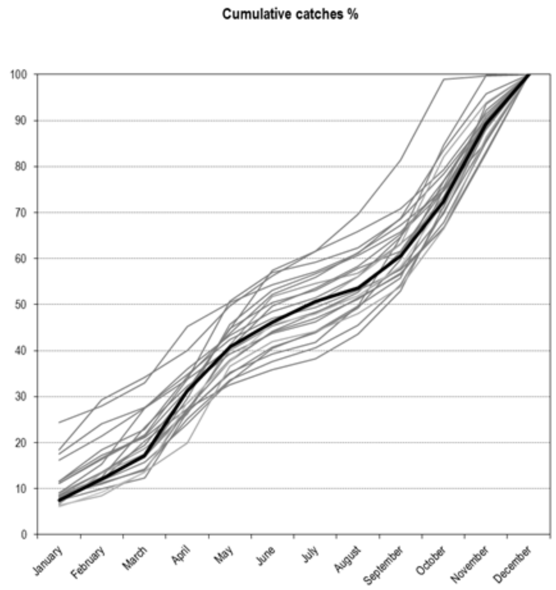
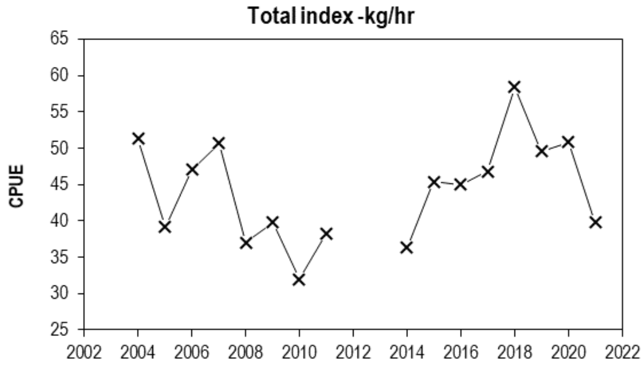


Figure 6.2. Sole 20-24. Cumulative Danish landings of sole by month. Black bold curves are 2021 and red bold curve is 2022 including March.



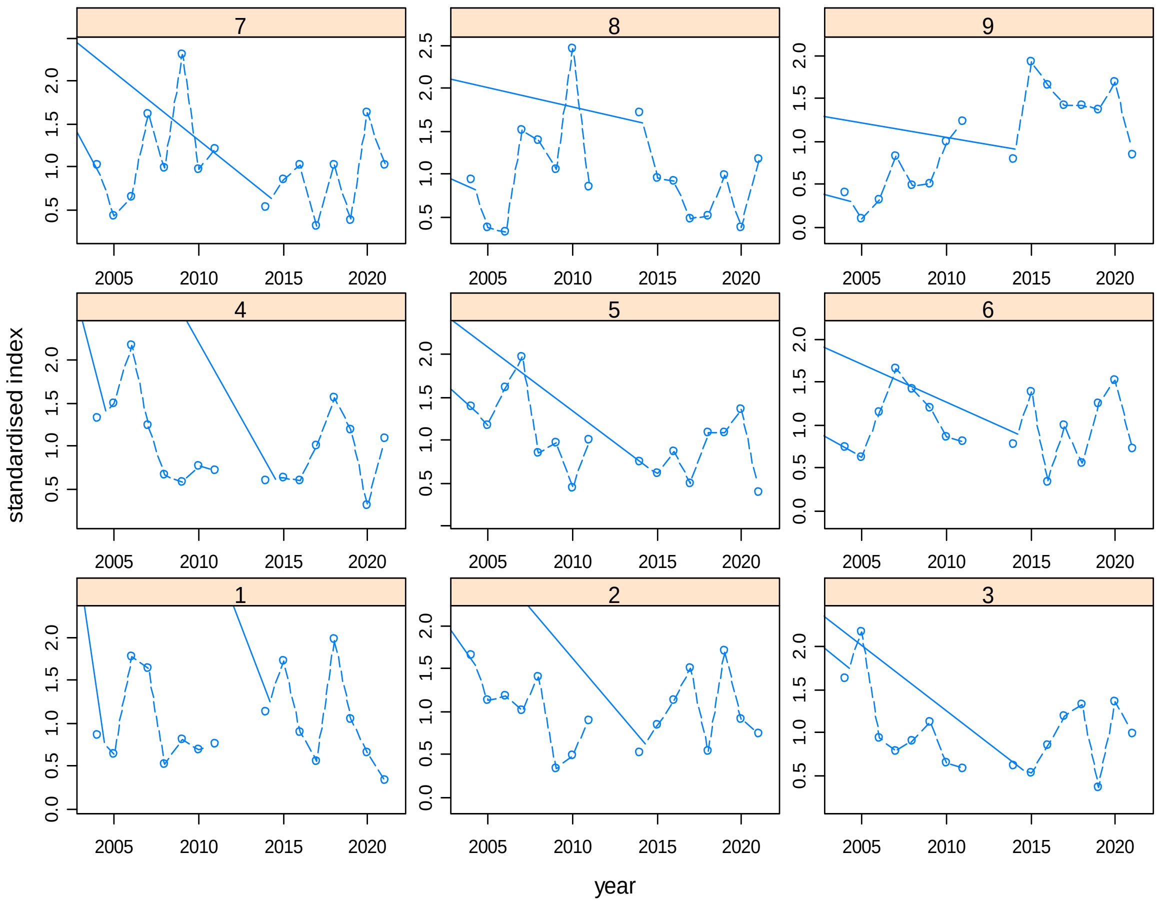


Figure 6.3.1. Sole 20-24. Upper: Age aggregated catch rates from Fisherman/DTU Aqua survey. Lower: age dis-aggregated indices from the survey.

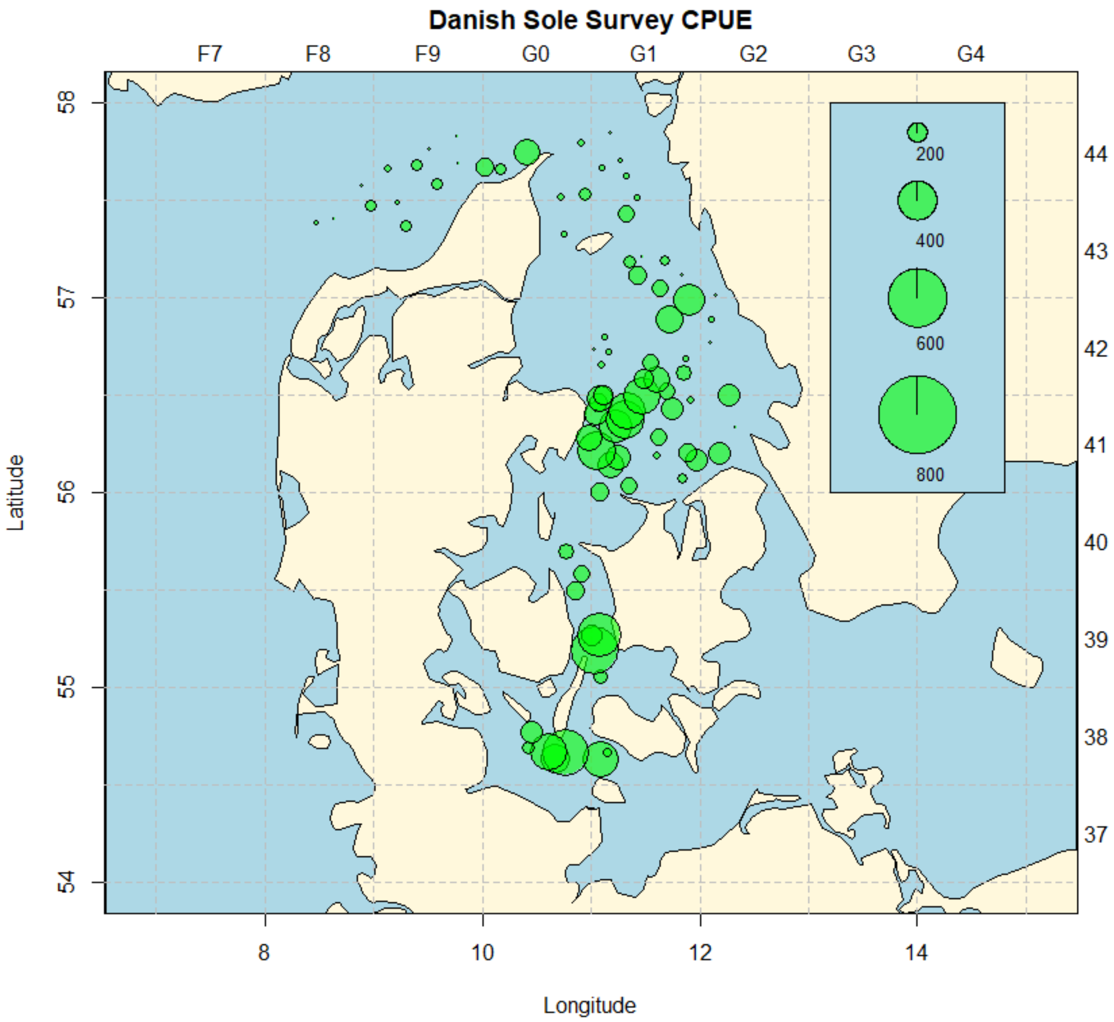


Figure 6.3.2 Fisherman-DTU Aqua survey. Catch rate distribution of stations in 2021.

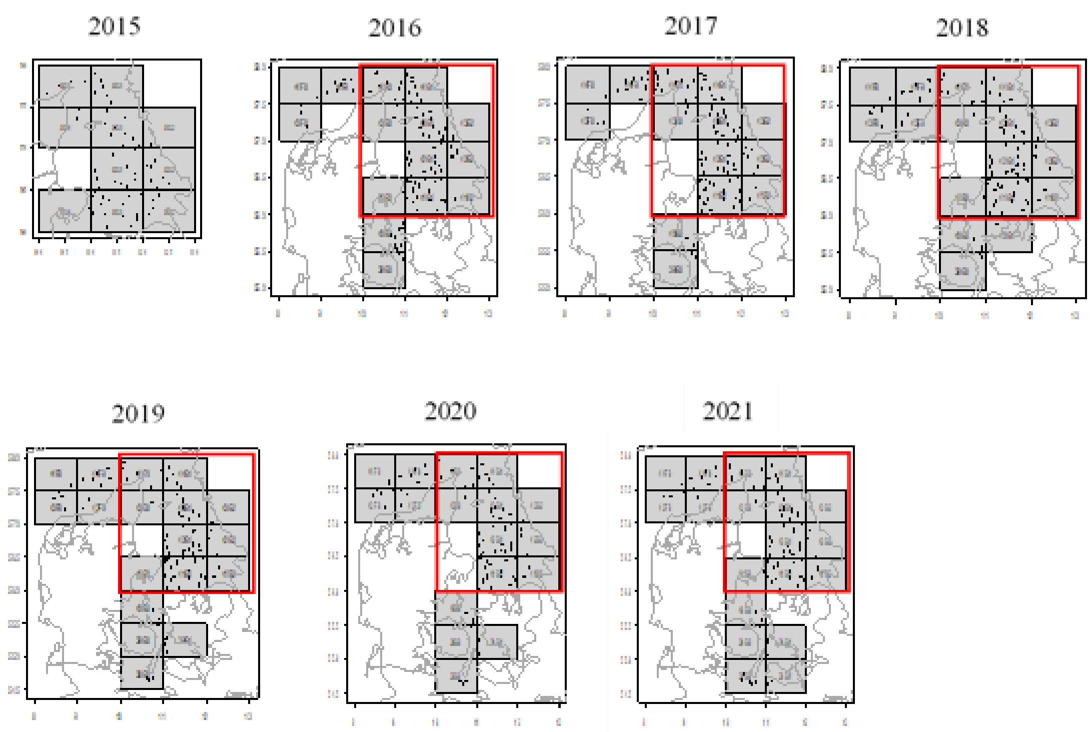


Figure 6.3.3. Sole 20-24. Upper: Map of sole survey station distribution in 2015 - 2021, the red box indicates the core area (Kattegat) as surveyed prior to 2016 and the remaining is the successively extended survey areas (in Subdivs 20 and 22). Only hauls in the core area has been used for estimation of survey indices for assessment calibration.

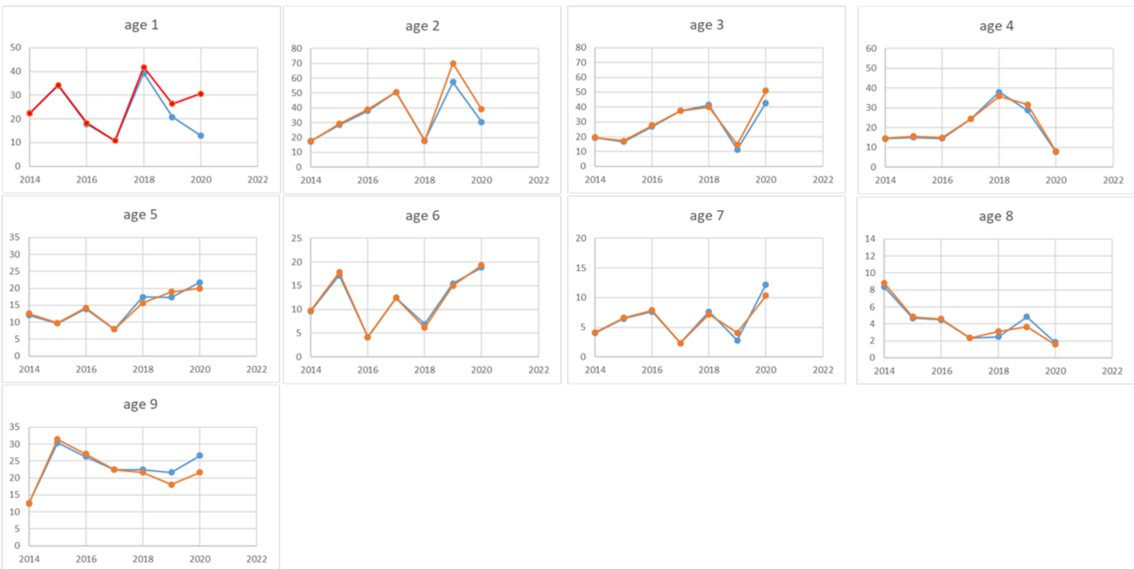


Figure 6.3.4. Sole 20-24. Sole survey indices based on previous standardisation code (red) and with the corrected code (blue) based on the core area (Fig. 6.5.1).

Figure 6.6. Sole 20-24. Landing numbers at age.

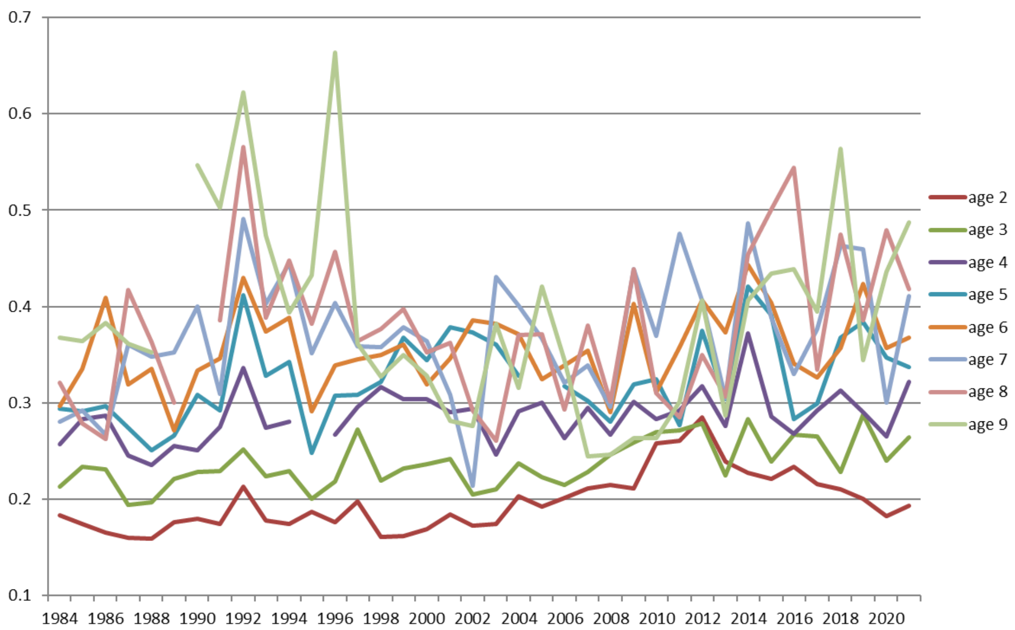


Figure 6.7. Sole in 20-24. Landings weight-at-age.

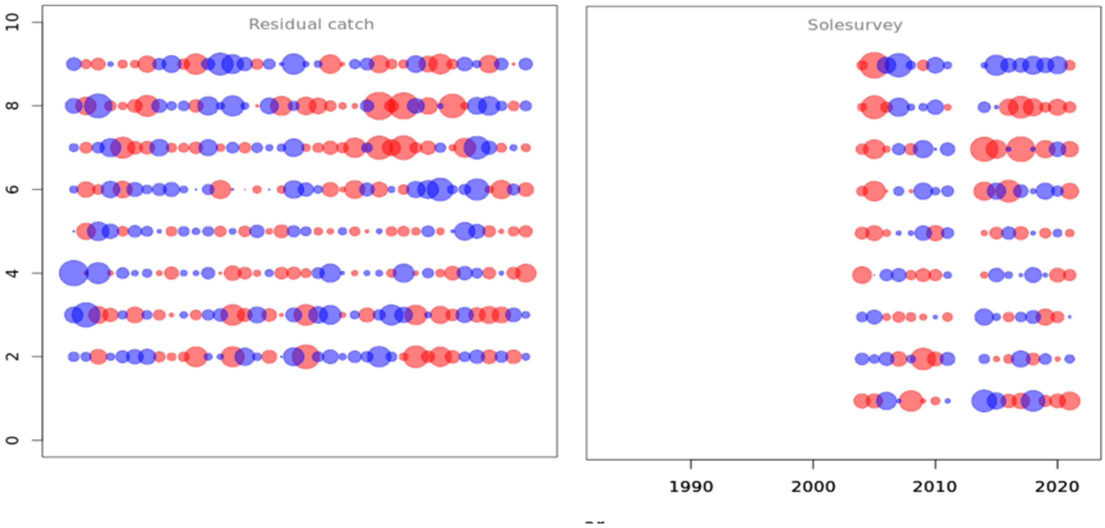


Figure 6.8. Sole 20-24. Model residuals for landings and survey.

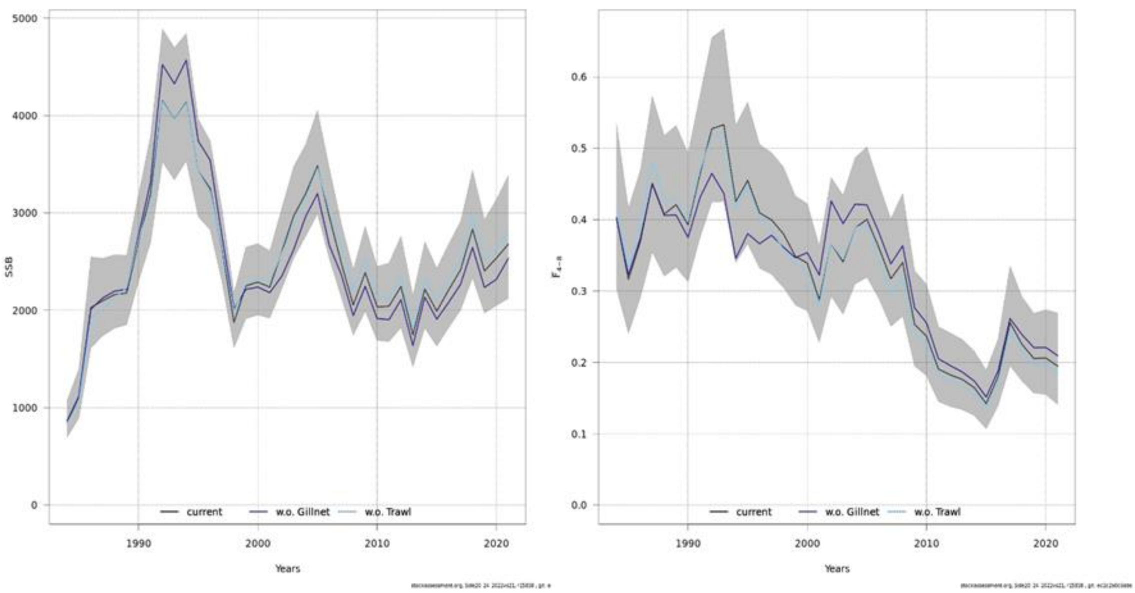


Figure 6.9. 20-24. Fleet sensitivity. Estimated SSB, and fishing mortality from runs leaving single fleets out. Recruitment (age 1) plot is not possible to provide since only the survey contains age 1 group.

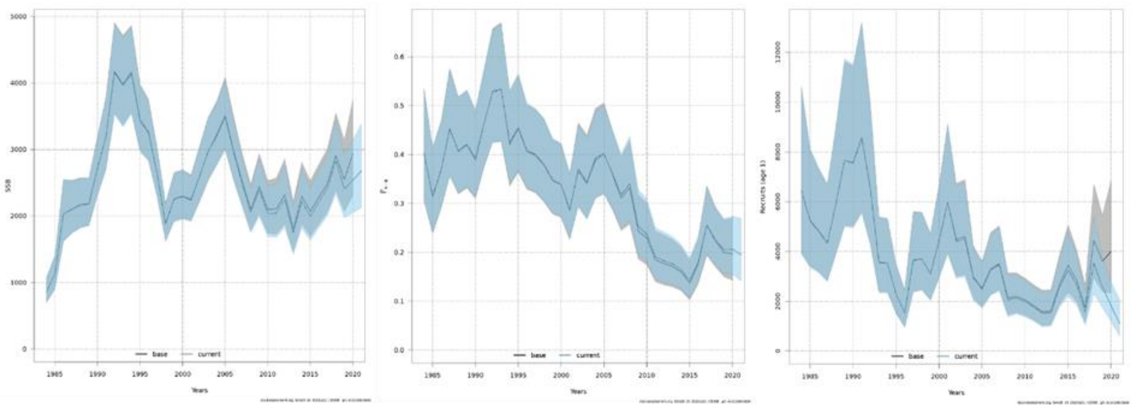


Figure 6.10. Sole 20-24. Stock summary; SSB, F(4-8) and R (age 1) compared to last year’s assessment.

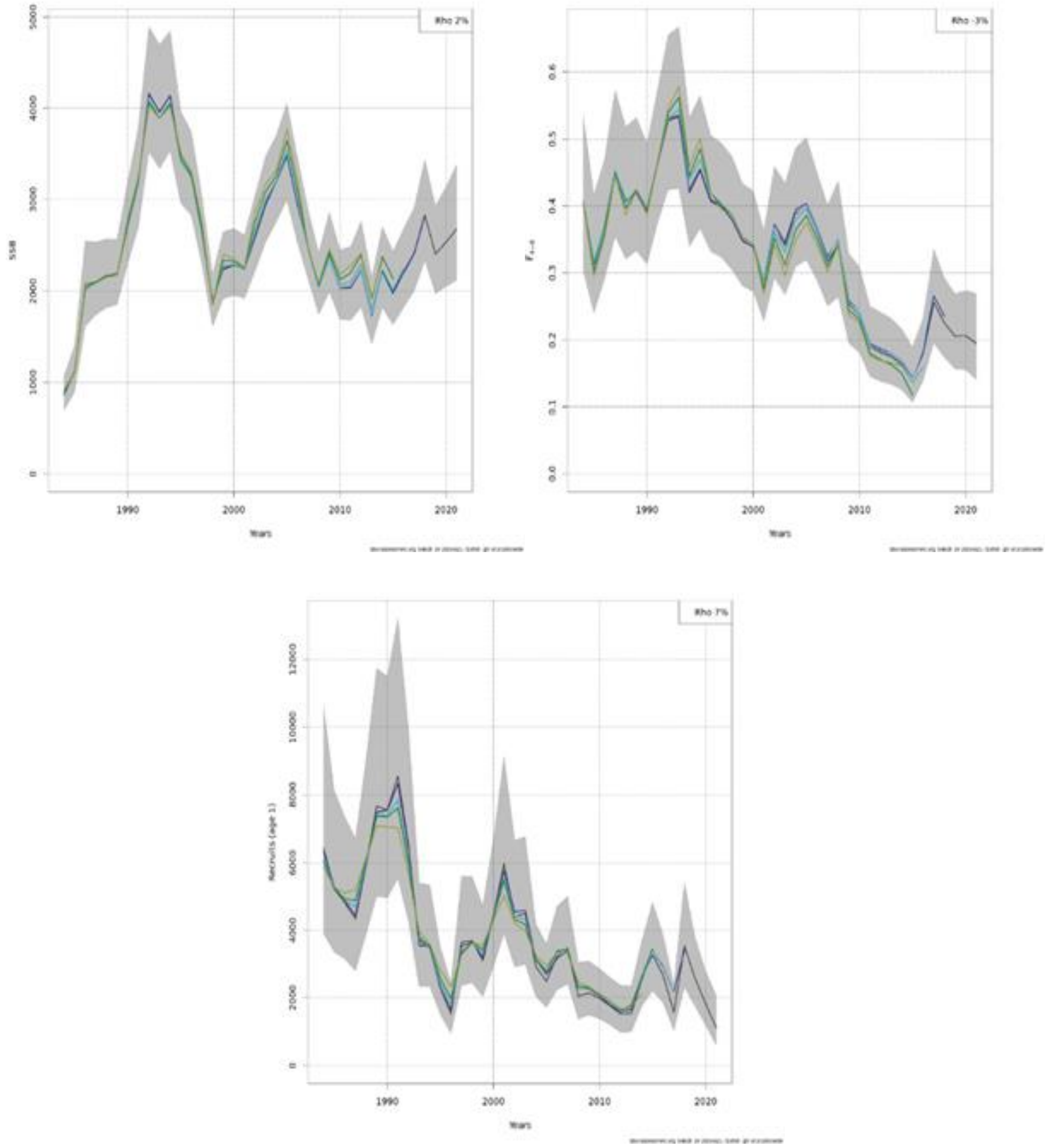


Figure 6.11. Sole 20-24. Retrospective analyses for SSB, F, and recruitment. Confidence limits are provided for the 2021 scenario.

Figure 6.12. Sole 20-24. Historical performance of F, SSB and recruitment.

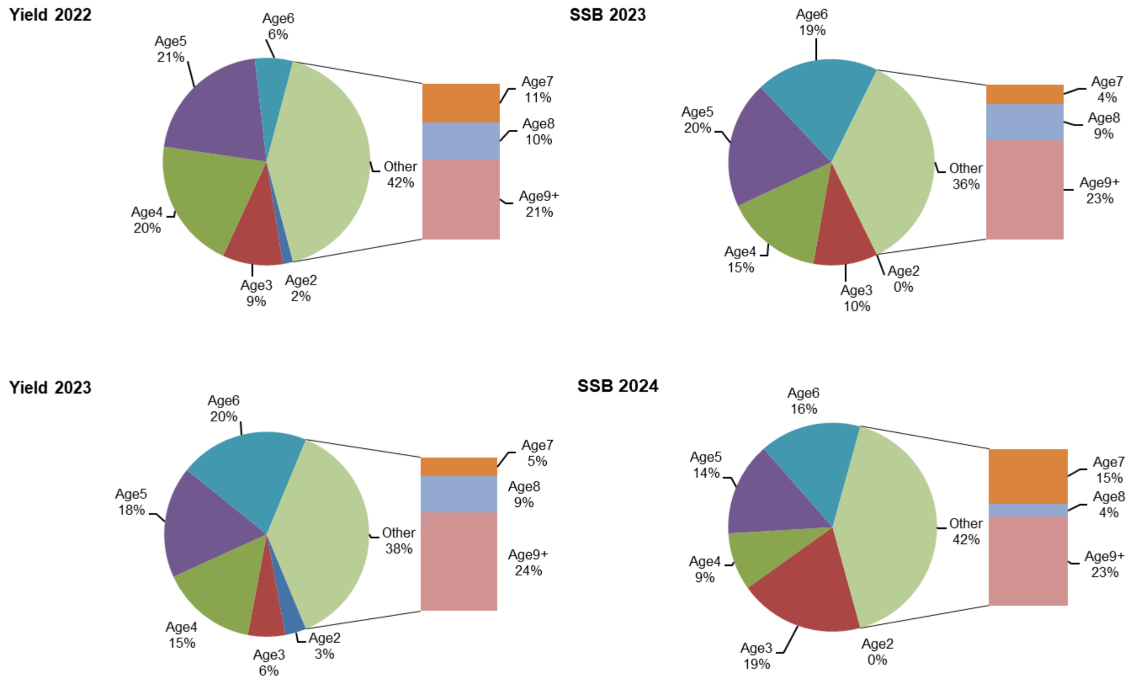


Figure 6.13. Sole 20-24. Short-term forecast for 2022-2024. Yield and SBB at age 2-9+ assuming fishery at Fsq in 2022.

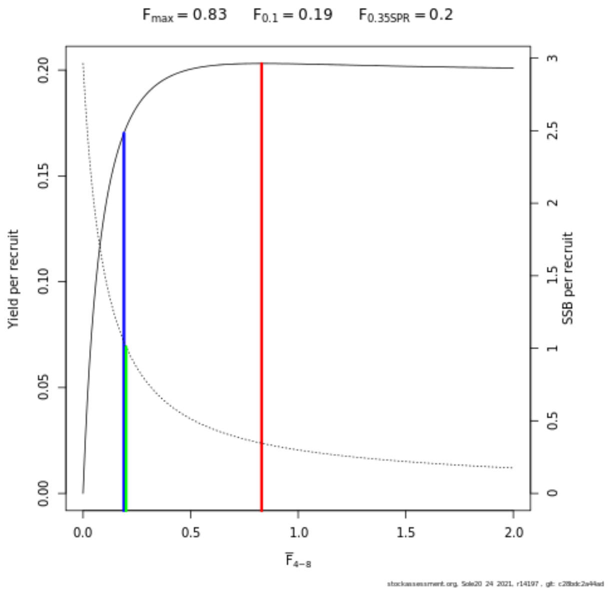


Figure 6.14 Sole 20-24 Yield per recruit curve and reference point estimates (red=Fmax, green=F35%SPR and blue=F0.1)

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).

In 2013 the sprat assessment was benchmarked at WKBALT (2013) and the present assessment of sprat has been conducted following the procedure agreed during the benchmark. The major change at benchmark workshop was the change of predation mortality from estimates provided by MSVPA to estimates obtained with the SMS model.

In addition, at benchmark the tuning fleet from Age 0 index, in previous assessment constrained to subdivisions 26+28, was extended to cover subdivisions 22–29. In some years minor revisions were made in other tuning fleets data (May and October acoustic surveys).

Following extensive analysis of the XSA options, no reason was found to change previous settings (age 1 with catchability, q, dependent on stock size, q plateau at age 5, shrinkage SE of 0.75).

The SAM model was attempted at benchmark as an alternative assessment model; it produced slightly lower SSB and higher Fs than the XSA. However, the XSA has been still considered as the main assessment model for sprat stock.

Maturity estimates were obtained from several countries but only 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. However, further analysis of maturity data would be needed by employing statistical methods (e.g. GLM). For such analysis there was not enough time at benchmark workshop.

Natural mortality of sprat depends on cod stock and estimates of this mortality are used in the assessment. In previous assessments, they were available from multispecies model SMS up to 2011, and from regression between cod biomass and predation mortality in the next years. In 2019 the SMS model was updated and new estimates of M have been available (WGSAM 2019). The effects of these estimates on sprat assessment and BRPs were investigated through Inter-benchmark Process on Baltic Sprat (*Sprattus sprattus*) and Herring (*Clupea harengus*) (IBPBASH 2020). The ToRs of the inter-benchmark were to: a) Evaluate the appropriateness of the use of the natural mortality estimates derived from the multispecies SMS key-run for the Baltic in the stock assessments for herring and sprat; b) Update the stock annex as appropriate; c) Re-examine and update MSY and PA reference points according to ICES guidelines (see Technical document on reference points).

7.1 The Fishery

7.1.1 Landings

According to the data uploaded to the InterCatch, sprat catches in 2021 were 284 890 t, which is 5% more than in 2020 and 46% less than the record high value of 529 400 t in 1997. In 2021 total TAC set by the EU plus the Russian autonomous quota was 268.5 kt, which was utilized in 106%. The largest increase in catches was observed for Germany 34%). At the same time, the Russian and Demarks catches decreased by 5 and 6% compared to 2020 respectively.

The spatial distribution (by subdivision) of sprat catches was similar to previous years. Subdivision 26 dominated the catches with a 43% share in the sprat catch. Other important areas are subdivisions 25 and 28 (21 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 2001–2021. Table 7.3 contains landings, catch numbers, and weight-at-age by subdivision and quarter.

7.1.2 Unallocated removals

No information on unallocated catches was presented to the group. It is expected, however, that misreporting of catches occurs, as the estimates of species composition of the clupeid catches are imprecise in some mixed pelagic fisheries.

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.

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. 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 does not reflect the stock size estimates from the analytical models (XSA or 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 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 only about 6% of the total. Only 45% of the German catches were landed in foreign ports and were not very well sampled, in a result only 90% of German total landings were sampled. 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 not very precise.

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 7.4a). In 1999–2020 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 2019 new estimates of predation mortality (M2) covering 1974-2018 were available from updated SMS (WGSAM 2019), using analytical estimates of cod stock as an external variable. The M2 for 2019 was assumed equal to the 2018 values. At present WGBFAS the average M2 for 2020-2021 was estimated from regression of average M2 in 1974-2018 against biomass of cod at length ≥20 cm ($R = 0.95$, Figure 7.4b), using cod biomass estimates for 2020 and 2021 as predictors. Next, the average value was distributed into ages following the distribution of M2 by ages in recent 10 years. M was obtained by adding 0.2 to M2. 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, 2013a) 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 2021 by quarter, ICES subdivision, and country are presented in Table 7.5. These data show that generally in 2021 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 3-5 times higher than indicated in the directive.

7.3 Fishery independent information

Two tuning datasets covering subdivisions 22–29 were available: from Baltic International Acoustic Survey (BIAS) in autumn in 1991–2021 and one dataset covering subdivisions 24–26 and 28 from international Baltic Acoustic Spring Survey (BASS) in May in 2001–2021 (Tables 7.12–7.14). The survey data were corrected for area coverage (WGBIFS, ICES, 2022). 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**. Such was also recommendation from WGBIFS (ICES, 2017). 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, 2022).

The internal consistency of the survey at age estimates and consistency between surveys was checked on graphs (Figures 7.5a-c). The correlation between CPUE at a given age and the CPUE of the same generation one year later is high ranging between 0.7–0.9.

7.4 Assessment

7.4.1 XSA

The input data for the catch-at-age analysis are presented in tables 7.6–7.14. The settings for the parameterisation of XSA were the same as specified in the benchmark assessment:

1. tricubic time weighting,
2. catchability dependent on year class strength at age 1 (only for this age group the slopes of regressions were significantly different from 1),
3. catchability independent of age for ages 5 and older,
4. the SE of the F shrinkage mean equal 0.75.

Table 7.15 contains the diagnostic of the run. The log q residuals are presented in Figure 7.6. The residuals are moderately noisy and slightly lower for the October fleet (SE of log q = 0.2-0.4) than for the May survey (SE’s range of 0.3–0.4, except age 7 (0.7)). The residuals from the acoustic survey on age 0 (shifted to represent age 1) are rather high at the beginning of the time-series but they decline at later years (regression SE about 0.3). The correlations between XSA estimates and survey indices are quite high (R^2 mostly at a level of 0.6–0.8).

October survey gets higher weight in survivors estimates (mostly 35–60%) than the May survey (weight of 20–45%). The weight of estimates resulting from the F shrinkage is low (up to 6%) and the P-shrinkage gets 14% weight in survivors estimates at age 1 (Figure 7.7a). The survey estimates of survivors are quite consistent at most ages – consistency is somewhat lower at age 1 and 4, where estimate based on Age0 survey is much higher than the estimate using October and May surveys (Figure 7.7b). The estimates based on Age0 acoustic fleet are down-weighted with increasing age.

Retrospective analysis (Figure 7.8) shows moderately scattered estimates for F_{bar} defined as average F at ages 3-5 (five years Mohn's rho of -0.15), and recruitment (Mohn's rho = 0.15).
The $F_{(3–5)}$ estimates may be noisy as they are based on Fs from 3 ages only. In addition, recruitment of sprat is very variable which easily can lead to overestimation of F for weak year classes when they neighbour strong year classes, due to possible misspecification of age readings from these strong generations. The retrospective estimates of SSB (five years Mohn's rho of 0.07) are relatively consistent in most years.

The fishing mortalities, stock numbers and summary of assessment are presented in tables 7.16–7.18. Fish stock summary plots are presented in Figure 7.9. Trends in the survey indices of stock size and XSA estimates of stock biomass are quite consistent (Figure 7.10).

7.4.2 Exploration of SAM

The SAM model was attempted at the benchmark workshop as the second assessment model for sprat. This year SAM estimates have been updated. Results of SAM parameterised in a similar way as XSA are compared with XSA estimates in Figure 7.11. The XSA and SAM estimates of SSB, F, and recruitment are similar and the XSA estimates are mostly contained within SAM confidence intervals. The distributions of residuals for the SAM model show similar patterns as in the case of XSA (Figure 7.12a). The retrospective analysis shows more consistent estimates for SAM than for XSA (Figure 7.12b). The assessment with SAM is available at https://www.stockassessment.org.

7.4.3 Recruitment estimates

The acoustic estimates on age-0 sprat in subdivisions 22–29 (shifted to represent age 1) and XSA estimates were analysed using the RCT3 program (Tables 7.19 and 7.20). The R^2 between XSA numbers and acoustic indices are high, generally at a range of 0.7–0.8. Estimates are mainly determined by survey (weight of about 60%). The 2021-year class was estimated very poor; 44 billion individuals, 50% below the average from the years 1991 onwards.

7.4.4 Historical stock trends

In the 1990s the SSB exceeded 1 million t, being record high in 1996–1997 (about 1.8 million t). These values were several times higher than the SSB estimates of 200 000 t in the early 1980s. Since 1997 the SSB has been generally decreasing, and reached 0.6-0.7 million tonnes in 2012-2015. The strong year-class 2014 has led to a marked increase of stock biomass in 2016-2017. The estimate of SSB for 2022 (assuming TAC constraint) is slightly above one million 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, 2022).

7.5 Short-term forecast and management options

The RCT3 program estimate of the 2021-year class at age 1 was used in the predictions. The 2022- and 2023-year classes were assumed as the geometric mean of the recruitment at age 1 in 1991–

2021 (period of recruitment fluctuations without a clear trend, the 2021 value is well estimated in the assessment). The natural mortalities, mean weights, and fishing pattern were assumed as averages of 2019–2021 values. Fishing mortality in the intermediate year was estimated consistent with TAC in 2022 (TAC defined as EU quota of 251.9 kt plus assumed Russian quota of 53.6 kt). Input data for catch prediction are presented in Table 7.21.

To perform predictions with TAC constraint Russian quota for 2022 was needed. Due to Russian aggression on Ukraine, this was not available this year. Russian quota in 2022 was predicted from the ratio of Russian quota and UE TAC in 2019-2020, which on average was 0.21 (0.22 and 0.20, respectively in 2019 and 2020; in 2017-2018 this ratio was 0.16). That approach led to Russian predicted TAC in 2022 at 53.6 kt (UE TAC for 2022 was 251.9 kt).

Please note *that the official Russian quota for 2022 was made available after ADGBS. As recommended by ACOM a new Short-Term Forecast was produced taking in consideration the official Russian quota of 43.4 kt. See Annex8 for summary tables of the forecast.*

Prediction results with TAC constraint are shown in Table 7.22a. In addition, a prediction option with F_{sq} in 2022 was performed (scaled F, Table 7.22b); that produced catches in 2022 at 338 kt, 10% higher than the TAC. The differences between the two predictions are small, e.g. the difference between total biomass in 2023 is about 2%. The group considers TAC constraint prediction as the basis for the advice.

In Figure 7.13 the sensitivity of the projection to the assumed strength (GM) of the 2022- and 2023-year classes and the estimate of the 2021-year class is presented. The assumed level of the 2022-year class contributes 12% to the predicted catch in 2023 and with an assumed level of the 2023-year class contributes 48% to SSB in 2024. The level of these sensitivities is higher than in previous years, due to very poor 2021 year-class.

7.6 Reference points

Below recent history of estimates of BRPs is presented and at the end of the section new BRPs are shown.

During the benchmark assessment (ICES, 2013) 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. They all showed similar fits to the available range of data, explaining only about 11% of the recruitment variance. The B_{lim} was estimated as the biomass that produces half of maximal (from the model) recruitment (410 000 t; close to an average of outcomes from different recruitment models) and $B_{MSYtrigger}$=B_{pa} at 574 000 t (B_{pa} = B_{lim} *1.4).

The method of equilibrium yield and biomass (Horbowy and Luzenczyk, 2012) was used to estimate the F_{MSY} reference points. The uncertainty included in the estimating procedure was from assessment errors in SSB and R, which are then used to estimate the S-R relationship. In addition, uncertainty was imposed on weight, natural mortality, selection and maturity-at-age. The CV was assumed at 0.2 for SSB, R and maturity, and it was estimated using data from the most recent ten years for weight, selection and M. 1000 replications were performed to determine the distribution of the MSY parameters. The F_{MSY} was estimated at 0.29 (median from stochastic simulations, SD = 0.11) and B_{MSY} at 617 thousand t (SD = 161).

During the workshop on BRP (ICES-MYFISH Workshop to consider the basis for FMSY ranges for all stocks (WKMSYREF3; ICES, 2014)) the F_{MSY} reference points were revised and ranges for them estimated. The new estimate of F_{MSY} was 0.26, while ranges are provided in the text table below.

Stock	MSY Flower	FMSY	MSY Fupper with AR	MSY Btrigger (thousand t)	MSY Fupper with no AR
Sprat in subdivisions 22–32 (Baltic Sea)	0.19	0.26	0.27	570	0.21

The biological reference points derived based on the replacement lines depend on the natural mortality, weight-at-age, and maturity data used. The changes in these data may have a large impact on estimates of the fishing mortality reference points. Both natural mortalities and weights were variable historically.

In 2019 new estimates of natural mortality from SMS were provided and BRPs were updated (ICES, 2020, IBPBASH report). In addition, F_{pa} estimated in 2020 at 0.45 was replaced by $F_{p.05}$ estimated at IBPBASH at 0.41.

New estimates and their basis is given below.

Reference Point	Value	Rationale
B_{lim}	410 000t	The average SSB producing 50% of maximal recruitment from the Beverton and Holt S-R function (470 000 t) and from the Ricker S-R function (345 000t).
B_{pa}	570 000t	1.4* B_{lim}
MSY $B_{trigger}$	570 000t	B_{pa}
F_{msy}	0.31	Estimated by EqSim
$F_{msyUpper}$	0.41	Estimated by EqSim as the F producing 95% of the landings at F_{msy}
$F_{msyLower}$	0.22	Estimated by EqSim as the F producing 95% of the landings of F_{msy}
F_{lim}	0.63	Estimated by EqSim as the F with 50% probability of SSB being less than B_{lim}
F_{pa}	0.41	$F_{p.05}$, F with 95% probability of being above B_{lim}

The biomass reference points are the same as the previous, but fishing mortality reference points changed markedly. That is mainly due to low cod stock size and thus lower predation mortality of cod on sprat stock.

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 quite large 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 (2013) and recently within Inspire project (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 2021 and 2022 assessments is presented in the text table below. Both assessments are very consistent. The XSA settings were the same in both years.

Category	Parameter	Assessment 2021	Assessment 2022	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, M2019-2018, M2020 estimated from regression of M against cod biomass (>20 cm)	M in 1974–2018 estimated in SMS, M2019=M2018, M2020-2021 estimated from regression of M against cod biomass (>20 cm)	No
XSA input	Catchability dependent on year class strength	Age<2	Age<2	No
	Catchability independent on age	Age >=5	Age >=5	No
	SE of the F shrinkage mean	0.75	0.75	No
	Time weighting	Tricubic, 20 years	Tricubic, 20 years	No
	Tuning data	International acoustic autumn, International Acoustic May	International acoustic autumn, International Acoustic May	No
		Acoustic on age 0 (subdiv. 22–29)	Acoustic on age 0 (subdiv. 22–29)	No
XSA results	SSB 2020 (million t)	0.82	0.84	2%
	TSB 2020 (million t)	1.53	1.54	2%
	F(3-5) 2020	0.37	0.37	0%
	Recruitment (age 1) in 2020 (billions)	102.5	100.6	-2%

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 inter-benchmark process, the F_{MSY} and ranges were redefined as 0.22-0.31 and 0.31-0.41 (ICES, 2020, IBPBASH).

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 1.8 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 declined to 0.6-0.7 million tonnes in 2012–15. Very strong year-class of 2014 has led to a marked increase in stock size, SSB reached 1.1 million tonnes in 2016–18 and is predicted to stay close to one million tonnes in 2024 if stock is exploited at F_{MSY}. After 2000 fishing mortality increased and next fluctuated, exceeding F_{MSY} in most years. Among the year classes 2009–2018, 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	German 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	2.6	2.8	1.3	1.1	32.0	3.5	44.9	88.2
1988	2.0	3.0	1.2	0.3	22.2	7.3	44.2	80.3
1989	5.2	2.8	1.2	0.6	18.6	3.5	54.0	85.8
1990	0.8	2.7	0.5	0.8	13.3	7.5	60.0	85.6
1991	10.0	1.6		0.7	22.5	8.7	59.7*	103.2

Year	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden	Total
1992	24.3	4.1	1.8	0.6	17.4	3.3	28.3	8.1	54.2	142.1
1993	18.4	5.8	1.7	0.6	12.6	3.3	31.8	11.2	92.7	178.1
1994	60.6	9.6	1.9	0.3	20.1	2.3	41.2	17.6	135.2	288.8
1995	64.1	13.1	5.2	0.2	24.4	2.9	44.2	14.8	143.7	312.6
1996	109.1	21.1	17.4	0.2	34.2	10.2	72.4	18.2	158.2	441.0
1997	137.4	38.9	24.4	0.4	49.3	4.8	99.9	22.4	151.9	529.4
1998	91.8	32.3	25.7	4.6	44.9	4.5	55.1	20.9	191.1	470.8
1999	90.2	33.2	18.9	0.2	42.8	2.3	66.3	31.5	137.3	422.6
2000	51.5	39.4	20.2	0.0	46.2	1.7	79.2	30.4	120.6	389.1
2001	39.7	37.5	15.4	0.8	42.8	3.0	85.8	32.0	85.4	342.2
2002	42.0	41.3	17.2	1.0	47.5	2.8	81.2	32.9	77.3	343.2
2003	32.0	29.2	9.0	18.0	41.7	2.2	84.1	28.7	63.4	308.3

Year	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden	Total
2004	44.3	30.2	16.6	28.5	52.4	1.6	96.7	25.1	78.3	373.7
2005	46.5	49.8	17.9	29.0	64.7	8.6	71.4	29.7	87.8	405.2
2006	42.1	46.8	19.0	30.8	54.6	7.5	54.3	28.2	68.7	352.1
2007	37.6	51.0	24.6	30.8	60.5	20.3	58.7	24.8	80.7	388.9
2008	45.9	48.6	24.3	30.4	57.2	18.7	53.3	21.0	81.1	380.5
2009	59.7	47.3	23.1	26.3	49.5	18.8	81.9	25.2	75.3	407.1
2010	43.6	47.9	24.4	17.8	45.9	9.2	56.7	25.6	70.4	341.5
2011	31.4	35.0	15.8	11.4	33.4	9.9	55.3	19.5	56.2	267.9
2012	11.4	27.7	9.0	11.3	30.7	11.3	62.1	25.0	46.5	235.0
2013	25.6	29.8	11.1	10.3	33.3	10.4	79.7	22.6	49.7	272.4
2014	26.6	28.5	11.7	10.2	30.8	9.6	56.9	23.4	46.0	243.8
2015	22.5	24.0	12.0	10.3	30.5	11.0	62.2	30.7	44.1	247.2
2016	19.1	23.7	16.9	10.9	28.1	11.6	59.3	34.6	42.4	246.5
2017	27.1	25.3	16.1	13.6	35.7	12.5	68.4	38.7	48.3	285.7
2018	24.6	29.3	16.4	15.2	37.1	16.2	79.4	41.4	49.1	308.8
2019	30.9	29.2	16.1	14.6	38.9	16.2	82.4	40.7	45.1	314.1
2020	26.4	24.3	12.5	8.9	28.9	11.2	72.5	45.7	41.1	271.5
2021	24.8	25.6	14.8	12.0	29.1	11.4	79.2	43.4	44.8	284.9

*** Sum of landings by Estonia, Latvia, Lithuania, and Russia.**

Table 7.2. Sprat landings in the Baltic Sea by country and Subdivision. (thousand tonnes).

2001

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	39.7	-	-	39.7	-	-	-	-	-	-	-
Estonia	37.5	-	-	-	-	-	6.3	16.1	-	-	15.1
Finland	15.4	-	-	-	-	-	-	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	-	-	-	3	-	-	-	-	-	-
Poland	85.8	-	0.4	46.3	39.1	-	-	-	-	-	-
Russia	32	-	-	-	29.6	-	2.3	-	-	-	-

Country	Total	22	24	25	26	27	28	29	30	31	32
Sweden	85.4	-	1	2.9	4.8	27.8	30.2	18.1	-	-	0.5
Total	342.2	0.02	2.1	90	83.5	27.8	73.5	38.7	3.2	0.001	23.2

2002

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	42.0	4.7	1.0	22.5	7.7	0.7	4.6	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	343.2	4.8	4.8	79.3	92.4	28.1	76.8	30.1	4.8	0.0	22.1

2003

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	32.0	8.2	0.7	10.4	8.9	1.8	1.7	0.3	-	-	-
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
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	308.3	8.3	3.5	44.6	115.1	35.6	69.6	21.5	1.5	0.001	8.5

2004

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	44.3	16.0	5.5	16.8	0.5	0.5	3.9	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	373.7	16.8	9.7	65.8	108.8	34.8	85.6	36.9	3.0	0.003	12.2

2005

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	46.5	17.6	2.1	11.1	5.4	0.3	10.0	-	-	-	-
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
Sweden	87.8	-	0.7	11.1	10.3	25.1	24.5	16.2	-	-	-
Total	405.2	18.8	5.0	47.9	111.7	36.2	104.5	47.9	3.2	0.005	30.2

2006

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	42.1	19.4	1.7	6.9	9.9	0.3	2.6	1.2	-	-	-
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	-	-	-

Country	Total	22	24	25	26	27	28	29	30	31	32
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	0.0	0.7	4.6	25.3	13.7	16.6	7.6	0.0	0.0	0.2
Total	352.1	20.5	3.4	31.3	122.8	28.3	78.9	38.3	3.5	0.007	25.1

2007

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	37.6	9.6	0.7	6.4	17.0	-	3.0	0.8	-	-	-
Estonia	51.0	-	-	2.2	0.8	0.1	4.3	15.3	-	-	28.3
Finland	24.6	0.0	0.0	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	388.9	10.4	3.8	50.5	145.4	18.7	79.8	40.6	7.3	0.002	32.4

2008

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	45.9	5.6	1.0	5.6	4.0	7.1	13.2	0.3	-	-	9.2
Estonia	48.6	-	-	0.3	0.0	-	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

Country	Total	22	24	25	26	27	28	29	30	31	32
Total	380.5	6.9	7.1	56.0	82.4	21.4	115.2	45.3	5.2	0.0002	41.0

2009

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	59.7	3.8	0.5	0.7	9.7	14.3	0.3	22.1	8.3	-	-	-
Estonia	47.3	-	-	-	0.6	-	-	2.5	13.7	-	-	30.5
Finland	23.1	-	-	-	0.0	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	-	-	0.0	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	407.1	5.2	0.9	5.9	54.8	104.6	24.9	118.3	52.3	4.4	0.0001	35.9

2010

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	43.6	8.0	-	0.7	5.2	12.3	2.4	9.6	5.3	-	-	-
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	-	-	-
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	341.5	9.8	0.02	2.5	31.2	95.7	34.1	85.0	44.5	3.3	0.002	35.2

2011

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	31.4	7.1		0.426	2.4	4.0	0.13	8.9	8.1			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	267.9	8.3	0.00	2.4	22.7	83.8	11.8	66.1	41.2	3.6	0.000	28.0

2012

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	11.4	4.73	0.00	0.23	2.5	1.4	0.13	-	2.45	-	-	-
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
Total	235.0	5.7	0.00	4.4	39.3	73.0	5.6	56.0	28.7	2.5	0.022	19.8

2013

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	25.6	7.10		0.36	3.31	2.2	0.7	3.4	8.4			
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	272.4	7.7	0.00	1.6	33.5	94.0	14.2	50.0	47.9	3.0	0.000	20.5

2014

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	26.6	1.07		1.50	6.52	4.8	0.2	5.7	6.8			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	243.8	1.7	0.00	3.1	40.2	74.5	7.5	53.6	35.9	3.0	0.001	24.3

2015

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	22.5	4.239		0.265	0.077	2.918	2.038	9.562	3.133	0.222		
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	247.2	4.9	0.00	3.1	40.5	71.9	16.3	59.5	28.9	2.4	0.0003	19.7

2016

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	19.1	2.911		1.199	3.851	0.973	1.775	2.860	5.504			
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	246.5	3.3	0.0	5.0	41.4	75.1	8.2	58.1	32.8	5.8	0.0	16.9

2017

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	27.1	1.158		1.030	5.657	8.056	3.703	4.991	2.522			
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			
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	285.7	1.8	0.0	5.5	43.4	106.8	17.5	61.1	29.9	2.4	0.001	17.2

2018

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	24.6	4.461		0.119	5.700	6.323	0.517	6.145	1.326			
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	308.8	5.9	0.0	2.4	51.2	120.8	7.4	72.9	28.9	2.1	0.181	17.2

2019

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	30.9	0.001		0.008	11.701	8.081	2.410	5.224	3.464			
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		
Total	314.1	0.4	0.0	2.4	66.5	116.5	15.0	64.0	23.8	0.9	0.040	24.6

2020

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	26.4	0.000		0.004	16.387	1.216	0.727	4.051	4.063			
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	271.5	0.001	0.0	2.5	74.4	89.2	7.3	56.1	22.2	0.8	0.019	19.1

2021

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	24.8			0.002	6.411	10.831	2.804	3.426	1.278			
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	0.000	7.879	18.764	5.425	9.140	3.449	0.145		
Total	284.9	0.0005	0.0	1.9	60.0	121.5	8.5	50.0	19.6	1.7	0.00002	21.7

Table 7.3. Sprat in SD 22-32. Catch in numbers and weight-at-age by quarter and Subdivision in 2021.

Subdivision 22

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0				0.0	0.0				4.9
1			0.0	0.0	0.0			13.1	10.1
2	0.0		0.0	0.0	0.0	11.0		12.0	11.8
3	0.0		0.0	0.0	0.0	11.4		12.5	13.3
4	0.0		0.0	0.0	0.0	12.4		11.9	13.6
5	0.0		0.0	0.0	0.0	16.4		12.4	14.1
6	0.0		0.0	0.0	0.0	14.1		14.2	14.0
7	0.0		0.0	0.0	0.0	13.9		15.8	14.3
8			0.0	0.0	0.0			11.9	14.7
9				0.0	0.0				14.0
10					0.0				
Sum	0.0	0.0	0.0	0.0	0.0				
SOP	0.5	0.0	0.0	0.0	0.5				
Catch	0.5	0.0	0.0	0.0	0.5				

Subdivision 23

	Numbers (millions)					Weight (g)			
Age	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
0					0.0				
1					0.0				
2		0.0			0.0		11.0		
3		0.0			0.0		11.4		
4		0.1			0.0		12.4		
5		0.0			0.0		16.4		
6		0.0			0.0		14.1		
7		0.0			0.0		13.9		
8					0.0				
9					0.0				
10					0.0				
Sum	0.0	0.2	0.0	0.0	0.0				
SOP	0.0	2.2	0.0	0.0	2.2				
Catch	0.0	2.2	0.0	0.0	2.2				

Subdivision 24

	Numbers (millions)					Weight (g)			
Age	**Q1**	**Q2**	**Q3**	**Q4**	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
0				0.6	0.6	0.0	0.0	0.0	4.9
1			0.4	2.3	2.7	0.0	0.0	13.1	10.1
2	10.1	5.8	1.9	6.7	24.5	11.0	11.0	12.0	11.8
3	15.8	9.0	3.7	7.0	35.4	11.4	11.4	12.5	13.3
4	19.7	11.3	2.4	5.6	39.0	12.4	12.4	11.9	13.6
5	0.6	0.3	3.3	3.5	7.7	16.4	16.4	12.4	14.1
6	7.7	4.4	1.7	3.9	17.7	14.1	14.1	14.2	14.0
7	11.5	6.6	1.1	1.2	20.3	13.9	13.9	15.8	14.3
8			0.0	0.2	0.2	0.0	0.0	11.9	14.7
9				0.0	0.0	0.0	0.0	0.0	14.0

	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
10				0.0	0.0	0.0	0.0	0.0	18.3
Sum	65.3	37.3	14.4	31.0	148.1				
SOP	812.9	464.5	184.5	398.8	1860.7				
Catch	813.7	465.0	183.8	398.4	1860.8				

Subdivision 25

	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0				7.0	7.0	0.0	0.0	0.0	4.9
1	65.3	2.2	3.7	27.5	98.6	4.4	3.8	10.8	10.1
2	803.6	261.1	16.8	79.4	1160.9	9.1	9.2	12.0	11.8
3	811.2	184.0	32.3	83.2	1110.7	10.4	10.2	12.5	13.3
4	813.4	264.8	20.9	67.1	1166.2	11.3	11.1	11.9	13.6
5	459.2	108.7	29.0	41.6	638.5	12.1	11.1	12.4	14.1
6	384.8	235.3	15.4	45.8	681.3	12.1	12.6	14.3	13.9
7	308.0	178.8	9.4	14.2	510.3	12.4	11.9	15.6	14.3
8	37.9	2.7	0.2	2.4	43.2	13.6	12.3	11.9	14.7
9	12.4	5.9		0.5	18.8	13.4	14.6	0.0	14.0
10	2.3	0.7		0.1	3.1	12.4	13.6	0.0	18.3
Sum	3698.1	1244.1	127.7	368.7	5438.7				
SOP	39970.1	13653.6	1622.5	4738.0	59984.3				
Catch	39972.9	13634.1	1624.9	4737.3	59969.2				

Subdivision 26

	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0				36.7	36.7	0.0	0.0	0.0	5.0
1	1942.3	241.5	82.1	340.3	2606.1	4.1	4.5	8.1	9.7
2	3675.0	920.3	62.9	455.2	5113.3	7.9	8.1	8.8	10.9
3	1982.8	443.0	22.0	232.7	2680.4	9.0	9.2	10.6	12.2

	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
4	1609.3	451.7	14.7	174.5	2250.1	9.5	9.9	11.3	12.6
5	641.5	111.9	21.8	57.8	833.0	10.0	10.2	11.6	13.7
6	353.6	57.9	14.3	56.7	482.5	11.1	11.6	13.4	14.0
7	322.4	23.2	0.6	24.4	370.7	10.9	12.4	11.5	14.0
8	41.5	1.2	0.2	2.5	45.5	11.4	17.1	14.3	13.5
9	10.6	0.7		0.5	11.8	10.0	12.5	0.0	15.9
10	0.5				0.5	17.0	0.0	0.0	0.0
Sum	10579.5	2251.3	218.6	1381.3	14430.7				
SOP	84571.2	19218.2	2072.2	15452.6	121314.3				
Catch	84904.9	19102.3	2073.1	15404.7	121484.9				

Subdivision 27

	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0				0.2	0.2	0.0	0.0		4.3
1	26.3	116.9		1.3	144.5	2.9	2.8		8.5
2	233.5	181.1		1.2	415.8	7.4	7.0		10.2
3	99.3	51.0		0.6	150.9	8.6	8.1		10.8
4	122.0	54.0		0.4	176.4	9.7	9.0		11.1
5	72.1	15.2		0.2	87.6	10.0	8.8		11.8
6	40.7	5.6		0.2	46.5	10.0	11.2		11.8
7	57.1	11.3		0.2	68.6	10.6	8.6		12.2
8	5.3			0.0	5.3	11.3	0.0		12.6
9	1.3			0.0	1.3	13.7	0.0		10.0
10				0.0	0.0	0.0	0.0		18.3
Sum	657.6	435.1	0.0	4.3	1097.0				
SOP	5652.7	2787.5	0.0	42.9	8483.1				
Catch	5648.7	2788.7	0.0	42.0	8479.4				

Subdivision 28

	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0				30.7	30.7	0.0	0.0	0.0	4.6
1	174.5	31.4	60.8	462.1	728.9	3.4	3.6	8.3	8.6
2	1479.9	352.0	132.3	485.8	2450.0	7.4	8.1	9.6	10.3
3	349.4	86.4	57.6	284.3	777.6	8.5	9.2	10.1	10.7
4	417.0	88.3	36.4	164.2	705.8	9.2	9.7	10.7	10.8
5	167.6	36.9	27.0	89.9	321.5	9.3	9.9	11.0	11.7
6	98.7	36.2	4.3	58.2	197.3	10.3	10.1	11.6	11.7
7	186.8	72.2	41.5	108.9	409.4	10.1	10.1	11.4	11.8
8	19.6	7.6	6.4	20.1	53.8	10.6	11.4	11.5	12.8
9		0.5		1.9	2.3	0.0	10.2	0.0	9.5
10		0.3			0.3	0.0	10.8	0.0	0.0
Sum	2893.6	711.8	366.2	1706.2	5677.7				
SOP	23020.9	6170.4	3638.7	17228.3	50058.2				
Catch	22969.2	6170.5	3639.3	17270.6	50049.5				

Subdivision 29

	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0			1.7	79.3	81.0	0.0	0.0	3.6	3.1
1	411.8	0.2	6.3	345.9	764.2	2.4	2.9	7.5	7.2
2	807.5	0.1	13.8	268.1	1089.5	7.2	8.6	8.9	9.0
3	128.7	0.0	3.2	75.5	207.5	8.6	9.3	9.7	9.7
4	203.9	0.1	5.4	50.5	259.9	9.1	10.1	10.2	10.2
5	88.9	0.0	0.8	20.8	110.6	9.4	10.9	10.6	10.6
6	93.6	0.1	1.1	9.7	104.4	9.6	10.0	11.3	10.6
7	130.7	0.1	3.3	27.6	161.6	9.6	11.3	10.7	11.6
8	24.1	0.0	1.8	1.8	27.7	10.3	11.6	11.0	11.7
9					0.0	0.0	0.0	0.0	0.0

	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
10					0.0	0.0	0.0	0.0	0.0
Sum	1889.1	0.6	37.3	879.4	2806.5				
SOP	13001.1	4.9	338.0	7062.7	20406.7				
Catch	12392.0	4.0	339.2	6914.0	19649.2				

Subdivision 30

	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0			0.4	5.1	5.5	0.0	0.0	3.6	3.6
1	10.4	8.6	2.9	37.9	59.8	2.3	2.3	8.6	8.6
2	6.5	2.1	1.3	17.6	27.6	6.9	6.9	10.5	10.5
3	4.0	1.9	0.3	4.2	10.4	8.3	8.3	11.3	11.3
4	8.2	4.8	1.0	12.7	26.7	8.5	8.5	12.1	12.1
5	3.7	2.4	0.1	1.1	7.2	8.6	8.6	13.6	13.6
6	10.4	8.5	0.1	1.9	21.0	9.2	9.2	14.0	14.0
7	9.4	6.7	0.4	5.6	22.1	8.6	8.6	12.8	12.8
8	5.8	7.4	0.0	0.4	13.7	8.9	8.9	15.3	15.3
9					0.0	0.0	0.0	0.0	0.0
10					0.0	0.0	0.0	0.0	0.0
Sum	58.4	42.4	6.6	86.5	194.0				
SOP	431.6	313.8	65.1	850.4	1660.9				
Catch	431.1	313.2	65.1	850.7	1660.1				

Subdivision 31

	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0					0.0				
1		0.0			0.0		2.3		
2		0.0			0.0		6.9		
3		0.0			0.0		8.3		

	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
4		0.0			0.0		8.5		
5		0.0			0.0		8.6		
6		0.0			0.0		9.2		
7		0.0			0.0		8.6		
8		0.0			0.0		8.9		
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 (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0				33.3	33.3				3.7
1	103.6	18.1	41.2	398.2	561.1	2.7	3.4	6.4	6.8
2	292.1	36.2	166.3	454.8	949.3	7.7	7.9	8.7	8.8
3	76.3	8.9	31.2	113.1	229.4	9.4	9.8	9.7	9.6
4	120.5	11.0	36.2	114.9	282.6	9.5	10.1	9.6	9.8
5	44.6	2.8	20.0	45.1	112.5	9.7	10.4	10.4	10.0
6	40.4	6.0	13.3	41.1	100.8	10.5	11.1	10.8	10.8
7	88.5	12.7	56.5	107.7	265.4	9.6	10.2	9.9	9.6
8	27.4	2.8	9.1	21.0	60.3	10.6	11.1	11.5	11.0
9					0.0				
10					0.0				
Sum	793.2	98.5	373.8	1329.2	2594.7				
SOP	6385.6	802.3	3376.4	11204.9	21769.2				
Catch	6384.2	805.4	3373.6	11170.8	21734.0				

Subdivision 22-32

	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0			2.1	192.9	194.9			3.6	3.9
1	2734.3	418.8	197.5	1615.5	4966.0	3.7	3.9	7.9	8.1
2	7308.3	1758.6	395.3	1768.8	11230.9	7.8	8.2	9.2	9.9
3	3467.4	784.3	150.1	800.6	5202.4	9.3	9.4	10.7	11.2
4	3314.0	886.0	116.9	589.9	4906.8	9.9	10.2	10.7	11.5
5	1478.0	278.3	102.0	260.2	2118.5	10.5	10.4	11.5	12.2
6	1029.8	354.1	50.3	217.5	1651.6	11.2	12.1	12.8	12.6
7	1114.4	311.6	112.8	289.7	1828.6	10.9	11.3	11.0	11.3
8	161.7	21.6	17.8	48.6	249.7	11.4	10.9	11.5	12.1
9	24.3	7.0		2.9	34.3	11.9	14.1		11.4
10	2.8	1.1		0.1	3.9	13.2	12.7		18.3
Sum	20634.9	4821.4	1144.7	5786.7	32387.7				
SOP	173846.5	43417.6	11297.4	56978.6	285540.1				
Catch	173517.0	43285.4	11298.9	56788.4	284889.7				

Table 7.4. Sprat in SD 22-32. Fishing effort and CPUE data.

Year	Russia - Sub-division 26			
	Type of vessels			
	*)SRTM (51 m length, 1100 hp)		MRTK (27 m length, 300 hp)	
	Effort	CPUE,	Effort	CPUE,
	[h]	[kg/h]	[h]	[kg/h]
1995	8907	647	8760	601
1996	12129	620	7810	953
1997	17140	470	10691	746
1998	13469	646	9986	782
1999	13898	869	15967	965
2000	14417	766	13501	1031
2001	12837	937	12912	1282
2002	11789	884	18979	1012
2003	5869	958	14128	1285
2004	2973	895	14751	1394
2005	1696	1323	21908	1115
2006	877	1362	16592	1406
2007			16032	1303
2008			14428	1306
2009			17966	1258
2010			14179	1276
2011			9373	1125
2012			13308	1877
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 Sub-divisions 22-32. Samples of commercial catches by quarter, country and Sub-division for 2021 available to the Working Group.

Subdivision 22

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
Denmark	1				
	2				
	3				
	4				
	Total	-	0	0	0
Germany	1	0.5	0	0	0
	2				
	3	0.0	0	0	0
	4	0.0	0	0	0
	Total	0.5	0	0	0
Total	1	0.5	0	0	0
	2	-	0	0	0
	3	0.0	0	0	0
	4	0.0	0	0	0
	Total	0.5	0	0	0

Subdivisions 23 + 24

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
Denmark	1				
	2	0.6	0	0	0
	3	0.1	0	0	0
	4	1.3	0	0	0
	Total	2.0	0	0	0
Finland	1				
	2				
	3				

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
	4				
	Total	0.0	0	0	0
Germany	1				
	2	0.7	0	0	0
	3				
	4	2.9	0	0	0
	Total	3.6	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	813.7	1	223	70
	2	463.7	0	0	0
	3	183.7	0	0	0
	4	394.0	0	0	0
	Total	1855.1	1	223	70
Sweden	1				
	2	2.2	0	0	0
	3				
	4	0.1	0	0	0
	Total	2.3	0	0	0
Total	1	813.7	1	223	70
	2	467.2	0	0	0

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
	3	183.8	0	0	0
	4	398.4	0	0	0
	Total	1863.0	1	223	70

Subdivision 25

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
Denmark	1	4786.8	9	1102	497
	2	595.1	0	0	0
	3				
	4	1029.4	0	0	0
	Total	6411.3	9	1102	497
Estonia	1				
	2				
	3				
	4				
	Total	0.0	0	0	0
Finland	1				
	2				
	3				
	4				
	Total	0.0	0	0	0
Germany	1	2829.6	8	1836	343
	2	912.7	2	472	69
	3				
	4	86.8	0	0	0
	Total	3829.2	10	2308	412
Latvia	1				
	2				

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
	3				
	4				
	Total	-	0	0	0
Lithuania	1				
	2				
	3				
	4				
	Total	-	0	0	0
Poland	1	25 806.4	15	2867	974
	2	11 481.5	1	244	67
	3	1435.6	1	175	66
	4	3125.9	4	801	289
	Total	41 849.4	21	4087	1396
Sweden	1	6550.1	20	1054	1044
	2	644.8	7	250	249
	3	189.3	7	162	162
	4	495.2	13	502	501
	Total	7879.3	47	1968	1956
Total	1	39,972.9	52	6859	2858
	2	13 634.1	10	966	385
	3	1624.9	8	337	228
	4	4737.3	17	1303	790
	Total	59 969.2	87	9465	4261

Subdivision 26

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
Denmark	1	10 662.5	1	102	51
	2				

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
	3				
	4	168.6	0	0	0
	Total	10 831.2	1	102	51
Estonia	1				
	2				
	3				
	4				
	Total	0.0	0	0	0
Finland	1	694.3	0	0	0
	2	335.6	0	0	0
	3				
	4				
	Total	1029.9	0	0	0
Germany	1	5835.9	4	985	206
	2	538.2	0	0	0
	3				
	4				
	Total	6374.1	4	985	206
Latvia	1	1027.4	1	210	96
	2	427.5	0	0	0
	3	110.3	0	0	0
	4	521.7	2	411	185
	Total	2,086.9	3	621	281
Lithuania	1	3141.0	11	1192	644
	2	2203.3	3	222	156
	3	11.3	0	0	0
	4	155.7	4	253	208
	Total	5511.4	18	1667	1008
Poland	1	20 329.2	19	4346	1360

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
	2	5573.4	5	1134	335
	3	1818.1	3	250	91
	4	6738.1	6	1134	390
	Total	34 458.8	33	6864	2176
Russia	1	25 823.3	21	4135	431
	2	9046.4	17	3234	434
	3	133.4	17	3014	286
	4	7425.5	25	5206	288
	Total	42 428.6	80	15589	1439
Sweden	1	17 391.2	8	400	400
	2	978.0	0	0	0
	3				
	4	395.0	2	100	100
	Total	18 764.2	10	500	500
Total	1	84 904.9	65	11370	3188
	2	19 102.3	25	4590	925
	3	2073.1	20	3264	377
	4	15 404.7	39	7104	1171
	Total	121 484.9	149	26328	5661

Subdivisions 27

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
Denmark	1	1873.5	1	181	41
	2	930.9	1	115	56
	3				
	4				
	Total	2804.4	2	296	97
Estonia	1				

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
	2				
	3				
	4				
	Total	0.0	0	0	0
Finland	1	7.7	0	0	0
	2	23.1	0	0	0
	3				
	4				
	Total	30.9	0	0	0
Germany	1				
	2	219.3	0	0	0
	3				
	4				
	Total	219.3	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

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
Sweden	1	3767.5	8	323	321
	2	1615.4	3	150	149
	3				
	4	42.0	0	0	0
	Total	5424.9	11	473	470
Total	1	5648.7	9	504	362
	2	2788.7	4	265	205
	3	-	0	0	0
	4	42.0	0	0	0
	Total	8479.4	13	769	567

Subdivision 28

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
Denmark	1	3328.4	1	120	50
	2				
	3				
	4	97.9	0	0	0
	Total	3426.3	1	120	50
Estonia	1	1027.6	14	2089	1182
	2	158.4	6	466	366
	3	117.0	2	264	164
	4	1655.4	9	1286	786
	Total	2958.4	31	4105	2498
Finland	1	0.1	0	0	0
	2	3.9	0	0	0
	3	292.1	0	0	0
	4	344.9	0	0	0
	Total	641.0	0	0	0

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
Germany	1	569.7	1	238	33
	2				
	3				
	4	66.4	0	0	0
	Total	636.1	1	238	33
Latvia	1	10 258.6	9	1940	916
	2	5147.0	7	1493	696
	3	3083.8	6	1121	510
	4	8514.4	7	1405	646
	Total	27 003.9	29	5959	2768
Lithuania	1	2191.3	1	109	50
	2	339.4	0	0	0
	3	76.2	0	0	0
	4	2601.9	0	0	0
	Total	5208.8	1	109	50
Poland	1	408.3	0	0	0
	2	259.3	0	0	0
	3	31.2	0	0	0
	4	335.9	0	0	0
	Total	1034.7	0	0	0
Russia	1				
	2				
	3				
	4				
	Total	0.0	0	0	0
Sweden	1	5185.1	1	50	50
	2	262.5	6	297	297
	3	39.0	0	0	0
	4	3653.7	10	363	247

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
	Total	9140.3	17	710	594
Total	1	22 969.2	27	4546	2281
	2	6170.5	19	2256	1359
	3	3639.3	8	1385	674
	4	17 270.6	26	3054	1679
	Total	50 049.5	80	11 241	5993

Subdivision 29

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
Denmark	1	1277.6	1	130	53
	2				
	3				
	4				
	Total	1277.6	1	130	53
Estonia	1	4758.3	14	2811	1400
	2				
	3				
	4	2723.0	8	1600	800
	Total	7481.4	22	4411	2200
Finland	1	1850.9	6	556	0
	2	4.0	4	551	0
	3	339.2	2	223	0
	4	3708.7	7	833	0
	Total	5902.8	19	2163	0
Germany	1	599.4	1	227	47
	2				
	3				
	4	296.3	0	0	0

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
	Total	895.7	1	227	47
Latvia	1				
	2				
	3				
	4				
	Total	0.0	0	0	0
Lithuania	1	643.2	0	0	0
	2				
	3				
	4				
	Total	643.2	0	0	0
Poland	1				
	2				
	3				
	4				
	Total	0.0	0	0	0
Sweden	1	3262.5	0	0	0
	2				
	3				
	4	186.0	0	0	0
	Total	3448.5	0	0	0
Total	1	12 392.0	22	3724	1500
	2	4.0	4	551	0
	3	339.2	2	223	0
	4	6914.0	15	2433	800
	Total	19 649.2	43	6931	2300

Subdivision 30

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
Denmark	1				
	2				
	3				
	4				
	Total	0.0	0	0	0
Finland	1	418.2	16	972	0
	2	237.2	18	359	0
	3	56.0	0	0	0
	4	803.2	12	580	0
	Total	1514.6	46	1911	0
Sweden	1	12.8	0	0	0
	2	76.1	0	0	0
	3	9.1	0	0	0
	4	47.5	0	0	0
	Total	145.4	0	0	0
Total	1	431.1	16	972	0
	2	313.2	18	359	0
	3	65.1	0	0	0
	4	850.7	12	580	0
	Total	1660.1	46	1911	0

Subdivision 31

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
Finland	1				
	2	0.02	0	0	0
	3				
	4				

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
	Total	0.02	0	0	0
Sweden	1				
	2				
	3				
	4				
	Total	0.0	0	0	0
Total	1	0.00	0	0	0
	2	0.02	0	0	0
	3	0.00	0	0	0
	4	0.00	0	0	0
	Total	0.02	0	0	0

Subdivision 32

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
Denmark	1				
	2				
	3				
	4				
	Total	0.0	0	0	0
Estonia	1	5246.0	17	3588	1590
	2	666.2	9	2266	840
	3	853.9	3	721	300
	4	8376.0	12	2890	1200
	Total	15 142.1	41	9465	3930
Finland	1	962.9	2	197	0
	2	0.5	3	46	0
	3	2519.7	2	186	0
	4	2171.0	2	197	0

Country	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
	Total	5654.1	9	626	0
Lithuania	1	6.0	0	0	0
	2				
	3				
	4				
	Total	6.0	0	0	0
Russia	1	169.3	2	288	151
	2	138.8	2	250	100
	3				
	4	623.7	13	1359	246
	Total	931.8	17	1897	497
Total	1	6384.2	21	4073	1741
	2	805.4	14	2562	940
	3	3373.6	5	907	300
	4	11 170.8	27	4446	1446
	Total	21 734.0	67	11988	4427

Subdivisions 22-32

Total	Quarter	Landings in tonnes	Number of samples	Number of fish	
				measured	aged
	1	173 517.0	213	32 271	12 000
	2	43 285.4	94	11 549	3814
	3	11 298.9	43	6116	1579
	4	56 788.4	136	18 920	5886
	Total	284 889.7	486	68 856	23 279

Table 7.6. Sprat in SD 22-32. Catch in Numbers (Thousands). CANUM: Catch in numbers (Total International Catch) (Thousands)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	2615000	6172000	3618000	1940000	1929000	933000	1213000	278000
1975	628000	2032000	5678000	2387000	790000	878000	247000	546000
1976	4682000	818000	2106000	3510000	1040000	350000	548000	422000
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	779000	394000	1320000	1833000	1805000	227000	149000	73000
1988	78000	2696000	730000	1149000	762000	760000	65000	141000
1989	2102000	290000	1772000	404000	739000	390000	398000	137000
1990	1049000	3171000	346000	952000	188000	316000	112000	200000
1991	1044000	2649000	2439000	407000	569000	106000	160000	152000
1992	1782000	2939000	3040000	1643000	444000	311000	121000	163000
1993	1832000	5685000	3244000	1898000	884000	267000	244000	257000
1994	1079000	8169000	8176000	3525000	2201000	779000	193000	208000
1995	6373000	2341000	6643000	6636000	3366000	1902000	627000	409000
1996	8389000	27675000	4704000	6517000	3323000	1499000	690000	403000
1997	1718000	23182000	23395000	6343000	4108000	1651000	683000	279000
1998	11018000	3803000	17688000	19618000	2659000	1778000	1468000	489000
1999	2082000	19901000	5832000	9972000	8836000	1180000	687000	515000
2000	10535000	2948000	14716000	2870000	4284000	4077000	707000	761000
2001	2776000	11557000	2670000	9252000	1999000	2651000	2264000	523000

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2002	6648000	5429000	10781000	3835000	4308000	998000	880000	1340000
2003	9366000	7109000	4805000	5067000	2396000	1903000	833000	1383000
2004	23264000	13094000	5448000	3086000	3246000	1334000	1143000	1364000
2005	2843000	30968000	11254000	2934000	1868000	843000	659000	615000
2006	10851000	3266000	21097000	6832000	1380000	614000	405000	530000
2007	13796000	11968000	3706000	13723000	3855000	623000	301000	539000
2008	6391000	15479000	6684000	2937000	5719000	2255000	299000	362000
2009	21145000	8891000	10181000	3905000	1795000	2837000	1008000	353000
2010	4584000	21493000	5363000	4234000	1239000	881000	994000	511000
2011	8799000	4361000	12720000	2749000	1471000	549000	379000	568000
2012	5218000	5712000	2727000	7041000	1246000	736000	298000	437000
2013	6266000	9569000	4486000	2391000	3849000	682000	310000	317000
2014	4911208	7619008	6498613	2373559	1458602	1402152	352393	371808
2015	17057263	4720316	5121411	3272068	1244627	659072	584565	292838
2016	2973969	18520734	3801288	2547751	1226450	508161	406247	450644
2017	3579884	6141001	16543725	3195711	1563614	675502	241309	398356
2018	6278336	6497104	6473215	12795134	1871268	610191	255558	207540
2019	5962092	10263401	5560056	5543538	7445687	777196	290655	235195
2020	6439838	5655737	6219636	3809510	2817502	3492510	340448	234291
2021	4966000	11230937	5202421	4906849	2118510	1651561	1828589	287878

Table 7.7. Sprat in SD 22-32. Mean weight in the Catch and in the Stock (Kilograms). WECA (=WEST): Mean weight in Catch (Kilograms)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.0066	0.0105	0.0122	0.0134	0.0139	0.0154	0.0141	0.0143
1975	0.0068	0.0112	0.0124	0.0134	0.0147	0.0143	0.0157	0.0135
1976	0.0069	0.0107	0.0127	0.0135	0.0145	0.0161	0.0147	0.0143
1977	0.0054	0.0110	0.0134	0.0140	0.0144	0.0159	0.0159	0.0158
1978	0.0051	0.0109	0.0125	0.0131	0.0141	0.0152	0.0158	0.0151
1979	0.0055	0.0127	0.0130	0.0137	0.0151	0.0158	0.0156	0.0162
1980	0.0078	0.0113	0.0143	0.0141	0.0143	0.0167	0.0158	0.0160
1981	0.0063	0.0141	0.0161	0.0180	0.0165	0.0159	0.0168	0.0161
1982	0.0088	0.0117	0.0160	0.0162	0.0167	0.0164	0.0163	0.0173
1983	0.0092	0.0145	0.0162	0.0171	0.0169	0.0170	0.0169	0.0168
1984	0.0097	0.0111	0.0146	0.0153	0.0158	0.0163	0.0169	0.0172
1985	0.0091	0.0113	0.0127	0.0140	0.0160	0.0171	0.0171	0.0158
1986	0.0079	0.0121	0.0129	0.0140	0.0148	0.0161	0.0170	0.0167
1987	0.0085	0.0117	0.0133	0.0145	0.0152	0.0164	0.0170	0.0176
1988	0.0056	0.0103	0.0122	0.0142	0.0152	0.0153	0.0166	0.0170
1989	0.0097	0.0136	0.0145	0.0158	0.0169	0.0173	0.0175	0.0181
1990	0.0104	0.0126	0.0149	0.0160	0.0175	0.0177	0.0184	0.0181
1991	0.0090	0.0129	0.0143	0.0158	0.0166	0.0175	0.0169	0.0169
1992	0.0087	0.0121	0.0147	0.0154	0.0173	0.0172	0.0181	0.0184
1993	0.0066	0.0111	0.0138	0.0146	0.0150	0.0162	0.0166	0.0166
1994	0.0080	0.0098	0.0121	0.0140	0.0145	0.0152	0.0155	0.0159
1995	0.0065	0.0106	0.0110	0.0126	0.0137	0.0141	0.0143	0.0145
1996	0.0043	0.0075	0.0103	0.0111	0.0124	0.0128	0.0127	0.0129
1997	0.0067	0.0074	0.0085	0.0101	0.0117	0.0124	0.0125	0.0127
1998	0.0046	0.0076	0.0083	0.0089	0.0104	0.0106	0.0108	0.0118
1999	0.0040	0.0078	0.0092	0.0091	0.0092	0.0106	0.0112	0.0110
2000	0.0062	0.0102	0.0100	0.0108	0.0113	0.0117	0.0128	0.0134
2001	0.0063	0.0093	0.0114	0.0108	0.0116	0.0113	0.0110	0.0118

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2002	0.0069	0.0097	0.0102	0.0109	0.0111	0.0111	0.0115	0.0117
2003	0.0050	0.0099	0.0108	0.0109	0.0114	0.0111	0.0107	0.0108
2004	0.0044	0.0076	0.0105	0.0112	0.0111	0.0114	0.0111	0.0113
2005	0.0047	0.0069	0.0081	0.0107	0.0112	0.0116	0.0110	0.0113
2006	0.0049	0.0078	0.0082	0.0089	0.0108	0.0112	0.0111	0.0114
2007	0.0056	0.0077	0.0091	0.0092	0.0094	0.0109	0.0113	0.0110
2008	0.0068	0.0092	0.0098	0.0105	0.0103	0.0102	0.0112	0.0122
2009	0.0050	0.0092	0.0105	0.0109	0.0114	0.0108	0.0110	0.0120
2010	0.0052	0.0080	0.0099	0.0107	0.0110	0.0112	0.0108	0.0114
2011	0.0040	0.0091	0.0096	0.0107	0.0114	0.0114	0.0114	0.0124
2012	0.0059	0.0094	0.0111	0.0112	0.0120	0.0123	0.0123	0.0121
2013	0.0051	0.0096	0.0115	0.0125	0.0126	0.0129	0.0130	0.0125
2014	0.0052	0.0092	0.0107	0.0120	0.0127	0.0127	0.0123	0.0123
2015	0.0042	0.0095	0.0110	0.0117	0.0126	0.0132	0.0125	0.0122
2016	0.0047	0.0071	0.0099	0.0113	0.0118	0.0126	0.0123	0.0122
2017	0.0054	0.0080	0.0088	0.0108	0.0118	0.0118	0.0115	0.0109
2018	0.0047	0.0086	0.0096	0.0098	0.0110	0.0117	0.0117	0.0111
2019	0.0049	0.0078	0.0094	0.0102	0.0103	0.0121	0.0122	0.0119
2020	0.0056	0.0092	0.0099	0.0108	0.0111	0.0112	0.0123	0.0124
2021	0.0054	0.0083	0.0096	0.0102	0.0108	0.0116	0.0111	0.0116

Table 7.8. Sprat in SD 22-32. Natural Mortality. NATMOR: Natural Mortality.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.69	0.51	0.46	0.44	0.44	0.42	0.44	0.44
1975	0.70	0.53	0.49	0.46	0.46	0.44	0.46	0.46
1976	0.59	0.46	0.43	0.41	0.41	0.40	0.41	0.41
1977	0.78	0.54	0.49	0.47	0.47	0.44	0.46	0.46
1978	1.07	0.74	0.68	0.63	0.62	0.61	0.61	0.61
1979	1.14	0.79	0.74	0.75	0.69	0.69	0.71	0.71
1980	1.17	0.84	0.75	0.73	0.74	0.70	0.72	0.72
1981	1.06	0.71	0.68	0.62	0.62	0.67	0.60	0.60
1982	1.06	0.75	0.69	0.67	0.63	0.67	0.68	0.68
1983	0.83	0.66	0.61	0.60	0.58	0.57	0.57	0.57
1984	0.69	0.58	0.52	0.52	0.50	0.49	0.49	0.49
1985	0.60	0.50	0.47	0.46	0.44	0.42	0.44	0.44
1986	0.63	0.48	0.46	0.44	0.42	0.42	0.41	0.41
1987	0.63	0.47	0.44	0.42	0.42	0.41	0.40	0.40
1988	0.59	0.47	0.45	0.43	0.41	0.41	0.40	0.40
1989	0.50	0.40	0.38	0.37	0.36	0.35	0.35	0.35
1990	0.35	0.30	0.30	0.29	0.29	0.29	0.28	0.28
1991	0.32	0.27	0.27	0.26	0.26	0.26	0.26	0.26
1992	0.34	0.28	0.27	0.27	0.26	0.26	0.26	0.26
1993	0.37	0.33	0.32	0.31	0.31	0.30	0.30	0.30
1994	0.37	0.33	0.31	0.31	0.30	0.30	0.30	0.30
1995	0.33	0.30	0.30	0.29	0.29	0.29	0.28	0.28
1996	0.30	0.29	0.28	0.27	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	0.28	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	0.36	0.31	0.31	0.31	0.31	0.30	0.30	0.30
2001	0.37	0.32	0.31	0.31	0.31	0.31	0.31	0.31
2002	0.39	0.33	0.33	0.32	0.32	0.32	0.32	0.32

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2003	0.35	0.31	0.30	0.30	0.30	0.30	0.30	0.30
2004	0.34	0.31	0.29	0.29	0.29	0.29	0.29	0.29
2005	0.39	0.35	0.34	0.32	0.32	0.32	0.32	0.32
2006	0.41	0.36	0.36	0.35	0.33	0.33	0.33	0.33
2007	0.41	0.36	0.35	0.35	0.35	0.33	0.33	0.33
2008	0.43	0.36	0.36	0.35	0.35	0.36	0.34	0.34
2009	0.43	0.36	0.35	0.35	0.35	0.35	0.35	0.35
2010	0.46	0.40	0.38	0.37	0.37	0.37	0.37	0.37
2011	0.46	0.38	0.38	0.37	0.36	0.36	0.36	0.36
2012	0.45	0.36	0.34	0.34	0.33	0.33	0.33	0.33
2013	0.46	0.36	0.34	0.33	0.33	0.33	0.33	0.33
2014	0.45	0.36	0.34	0.33	0.32	0.32	0.33	0.33
2015	0.38	0.32	0.30	0.30	0.29	0.29	0.30	0.30
2016	0.37	0.33	0.30	0.29	0.29	0.29	0.29	0.29
2017	0.35	0.31	0.30	0.29	0.28	0.28	0.28	0.28
2018	0.32	0.29	0.28	0.28	0.27	0.27	0.27	0.27
2019	0.32	0.29	0.28	0.28	0.27	0.27	0.27	0.27
2020	0.31	0.27	0.27	0.26	0.26	0.26	0.26	0.26
2021	0.29	0.26	0.26	0.26	0.25	0.25	0.25	0.25

Table 7.9. Sprat in SD 22-32. Proportion Mature at Spawning Time. MATPROP: Proportion of Mature at Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2021	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. MPROP: Proportion of M before Spawning

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2021	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. FPROP: Proportion of F before Spawning

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2021	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/Baltic International Acoustic Survey (SD 22-29).

Fleet 03. Age 0 shifted to represent age 1 from international acoustic survey (BIAS) in October corrected by area surveyed (Abundance: Millions)

Year	Fish. Effort	Age 1
1992	1	59473
1993	1	48035
1994	1	-11
1995	1	64092
1996	1	-11
1997	1	3842
1998	1	-11
1999	1	1279
2000	1	33320
2001	1	4601
2002	1	12001
2003	1	79551
2004	1	1E+05
2005	1	3562
2006	1	41863
2007	1	66125
2008	1	17821

Year	Fish. Effort	Age 1
2009	1	1E+05
2010	1	12798
2011	1	41916
2012	1	45186
2013	1	33653
2014	1	24921
2015	1	2E+05
2016	1	42251
2017	1	30848
2018	1	78167
2019	1	18542
2020	1	95603
2021	1	1E+05

Table 7.13. SPRAT in SD 22-32. Tuning Fleet/Baltic International Acoustic Survey (SD 22-29).

Fleet 01. International acoustic survey (BIAS) in October corrected by area surveyed (Abundance: Millions)

Year	Fish. Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+	total
1991	1	46488	40299	43681	2743	8924	1851	1957	3117	1E+05
1992	1	36519	26991	24051	9289	1921	2437	714	560	1E+05
1993	1	-11	-11	-11	-11	-11	-11	-11	-11	-11
1994	1	12532	44588	43274	17272	11925	5112	1029	1559	1E+05
1995	1	-11	-11	-11	-11	-11	-11	-11	-11	-11
1996	1	69994	1E+05	20797	23241	12778	6405	3697	1311	3E+05
1997	1	-11	-11	-11	-11	-11	-11	-11	-11	-11
1998	1	1E+05	21975	55422	36291	8056	4735	1623	1011	2E+05
1999	1	4892	90050	15989	35717	38820	5231	3290	1738	2E+05
2000	1	58703	5285	49635	5676	13933	15835	1554	2678	2E+05
2001	1	12047	35687	6927	30237	4028	9606	6370	2407	1E+05
2002	1	31209	14415	36763	5733	18735	2638	5037	4345	1E+05
2003	1	99129	32270	24035	23198	8016	13163	4831	8536	2E+05

Year	Fish. Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+	total
2004	1	1E+05	47027	11638	7929	4876	2450	2389	3552	2E+05
2005	1	7082	1E+05	48724	10035	5116	3011	2364	3325	2E+05
2006	1	36531	11774	1E+05	32412	7937	4583	2111	2947	2E+05
2007	1	51888	21665	8175	26102	9800	1067	470	1578	1E+05
2008	1	28805	45118	20134	5350	18820	5678	1241	1917	1E+05
2009	1	77343	25333	20840	6547	4667	7023	2011	1376	1E+05
2010	1	11638	51321	10654	6663	1684	1958	2572	1168	87658
2011	1	20620	11657	43357	9990	6747	2615	1795	2808	99589
2012	1	40516	16525	7935	18413	3494	1733	606	1368	90590
2013	1	19703	20486	11243	6040	10792	1882	766	1161	72073
2014	1	10665	8623	9735	4933	2034	3779	681	774	41224
2015	1	#####	17406	19932	11138	3456	3574	2795	1548	#####
2016	1	20629	81157	24161	9343	3771	1492	1195	1253	#####
2017	1	30171	33937	78088	13673	6372	2681	823	925	#####
2018	1	26879	19204	14849	29575	9135	3134	1182	1336	#####
2019	1	13510	18518	13046	11131	19904	1747	1119	837	79813
2020	1	38625	14226	15142	7984	6799	11730	1037	861	96403
2021	1	42641	27589	17058	13062	5008	4812	7116	1711	#####

Table 7.15. Sprat XSA diagnostics

Lowestoft VPA Version 3.1

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Extended Survivors Analysis

Sprat 22 32

CPUE data from file z:\SprDat21\Fleet3xsa.txt

Catch data for 48 years. 1974 to 2021. Ages 1 to 8.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLT01:	1991	2021	1	7	0.75	0.85
FLT02: International	2001	2021	1	7	0.35	0.42
FLT03: Latvian/Russi	1992	2021	1	1	0	0.01

Time series weights :

Tapered time weighting applied

Power = 3 over 20 years

Catchability analysis :

Catchability dependent on stock size for ages < 2

Regression type = C

Minimum of 5 points used for regression

Survivor estimates shrunk to the population mean for ages < 2

Catchability independent of age for ages >= 5

Terminal population estimation :

Survivor estimates shrunk towards the mean F

of the final 5 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = .750

Minimum standard error for population

estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 80 iterations

Total absolute residual between iterations

79 and 80 = .00027

Final year F values

Age	1	2	3	4	5	6	7
Iteration 79	0.062	0.2076	0.3564	0.4506	0.4599	0.4476	0.4119
Iteration 80	0.062	0.2076	0.3563	0.4505	0.4599	0.4476	0.4118

1

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976
0.99	0.997	1	1		

Fishing mortalities

Age	2012	2013	2014	2015	2016	2017
	2018	2019	2020	2021		
1	0.094	0.131	0.117	0.099	0.046	0.075
	0.105	0.145	0.078	0.062		
2	0.253	0.315	0.294	0.193	0.175	0.147
	0.215	0.283	0.223	0.208		
3	0.212	0.385	0.439	0.385	0.266	0.266
	0.253	0.319	0.303	0.356		
4	0.425	0.342	0.424	0.481	0.378	0.422
	0.378	0.395	0.413	0.451		
5	0.39	0.518	0.422	0.475	0.373	0.472
	0.523	0.434	0.389	0.46		
6	0.444	0.451	0.418	0.389	0.403	0.404
	0.372	0.469	0.405	0.448		
7	0.483	0.396	0.524	0.35	0.496	0.377
	0.286	0.331	0.418	0.412		

1

XSA population numbers (Thousands)

	AGE						
YEAR	1	2	3	4	5	6	7
2012	72800	30600	16900	24100	4560	2420	918
2013	64300	42300	16600	9720	11200	2210	1120
2014	55700	35800	21700	8090	4980	4820	1020
2015	219000	31500	18700	9950	3820	2370	2300
2016	79400	136000	18900	9370	4560	1770	1200
2017	59200	52500	82400	10700	4790	2340	884
2018	73700	38700	33400	46800	5260	2250	1180
2019	51800	48100	23400	19600	24200	2370	1180
2020	101000	32500	27200	12800	9960	12000	1130
2021	95600	68400	19700	15400	6520	5200	6150

Estimated population abundance at 1st Jan 2022

	0	67000	42700	10700	7590	3200	2580

Taper weighted geometric mean of the VPA populations:

	80000	48000	26400	14100	6750	3190
	1470					

Standard error of the weighted Log(VPA populations) :

	0.4332	0.4739	0.4902	0.5272	0.5659	0.5935
	0.5875					

1

Log catchability residuals.

Fleet : FLT01: International

Age	1992	1993	1994	1995	1996	1997
	1998	1999	2000	2001		
1	99.99	99.99	99.99	99.99	99.99	99.99
	99.99	99.99	99.99	99.99		
2	99.99	99.99	99.99	99.99	99.99	99.99
	99.99	99.99	99.99	99.99		
3	99.99	99.99	99.99	99.99	99.99	99.99
	99.99	99.99	99.99	99.99		
4	99.99	99.99	99.99	99.99	99.99	99.99
	99.99	99.99	99.99	99.99		
5	99.99	99.99	99.99	99.99	99.99	99.99
	99.99	99.99	99.99	99.99		
6	99.99	99.99	99.99	99.99	99.99	99.99
	99.99	99.99	99.99	99.99		
7	99.99	99.99	99.99	99.99	99.99	99.99
	99.99	99.99	99.99	99.99		

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.41	0.39	-0.1	-0.65	0.18	0.18	0.18	-0.02	-0.19	0.17
2	-0.09	0.7	0.1	0.55	-0.4	0.08	0.56	0.36	0.17	-0.19
3	0.49	0.6	-0.1	0.3	0.6	-0.65	0.32	0.18	-0.22	0.29
4	-0.83	0.62	0.05	0.34	0.43	-0.12	-0.57	-0.08	-0.24	0.33
5	0.43	0.05	-0.2	0.35	0.74	-0.17	0.23	-0.09	-0.77	0.42
6	-0.66	0.79	-0.41	0.05	1.07	-0.5	0.16	0.12	-0.12	0.44
7	0.43	0.63	-0.14	0.34	0.38	-0.37	0.45	0.08	-0.07	0.63

Age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	0.39	0.01	-0.3	-0.07	-0.26	0.31	0.01	-0.12	-0.06	0.05
2	0.17	0.11	-0.6	0.11	0.18	0.22	0	-0.2	-0.13	-0.23
3	-0.46	0.04	-0.32	0.47	0.55	0.25	-0.53	-0.25	-0.28	0.2
4	0.04	-0.24	-0.2	0.43	0.23	0.51	-0.24	-0.33	-0.24	0.1
5	-0.14	0.19	-0.75	0.07	-0.11	0.44	0.74	-0.08	-0.31	-0.14
6	-0.16	0.01	-0.1	0.51	-0.06	0.24	0.4	-0.16	0.06	0.04

7	-0.21	-0.25	-0.17	0.26	0.18	0.01
	0	-0.02	0.01	0.23		

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

Age	2	3	4	5	6	7
Mean Log q	-0.2975	0.1472	0.3036	0.4482	0.4482	0.4482
S.E(Log q)	0.2778	0.382	0.3123	0.4269	0.2979	0.2494

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg
s.e	Mean Log q					
1	0.74	1.7	3.47	0.8	20	0.22
	-0.65					

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg
s.e	Mean Q					
2	0.84	1.093	1.98	0.82	20	0.23
	-0.3					
3	0.89	0.534	1.03	0.68	20	0.35
	0.15					
4	1.22	-1.008	-2.46	0.68	20	0.38
	0.3					
5	1.03	-0.135	-0.76	0.62	20	0.46
	0.45					
6	1.07	-0.43	-1.13	0.8	20	0.31
	0.55					
7	0.89	1.056	0.39	0.89	20	0.21
	0.51					
1						

Fleet : FLT02: International

Age	2002	2003	2004	2005	2006	2007
	2008	2009	2010	2011		
1	0.46	-0.42	0.51	-1.24	-0.57	0.45
	-0.77	-0.3	-0.44	0.1		
2	-0.11	-0.29	0.15	-0.11	-1.06	-0.01
	0.08	0.06	-0.05	-1.04		
3	0.01	-0.88	-0.25	-0.86	-0.15	-1.31
	-0.17	0.2	-0.34	0.24		
4	-0.19	-0.39	-0.22	-0.6	-0.59	-0.44
	-1.1	-0.27	-0.03	0.22		
5	-0.3	-0.77	0.19	-0.59	-0.1	-0.93
	-0.17	-0.29	-0.17	0.37		
6	-1.12	-0.29	-0.6	-0.49	-0.29	-0.83
	-0.69	0.27	-0.82	0.39		
7	-0.34	-0.91	0.54	-0.42	-0.4	-0.77
	-0.56	0.47	0.19	0.39		

Age	2012	2013	2014	2015	2016	2017
	2018	2019	2020	2021		
1	0.08	0.3	-0.41	0.03	99.99	0.58
	0.19	0.05	0.19	-0.24		
2	0.14	0.31	0.19	0.18	99.99	0.03
	0.01	-0.06	0.21	0		
3	-0.51	0.06	-0.1	0.42	99.99	0.38
	0.04	0.25	-0.03	-0.06		
4	0.08	-0.19	-0.39	0.34	99.99	0.33
	0.05	0.59	0.09	-0.17		
5	0.15	-0.01	-0.14	0.42	99.99	0.01
	0	-0.14	0.24	-0.08		
6	0.4	0.1	-0.58	0.18	99.99	-0.4
	-0.45	0.01	-0.39	-0.04		
7	0.09	0.32	-0.12	-0.26	99.99	-0.46
	-0.55	-1.28	-1.24	-0.51		

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

Age	2	3	4	5	6	7
Mean Log q	-0.2291	0.3143	0.6002	0.6257	0.6257	0.6257
S.E(Log q)	0.3376	0.3594	0.3807	0.2706	0.4377	0.6818

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q

1	0.95 -1.03	0.191	1.56	0.6	19	0.39

Ages with q independent of year class strength and constant w.r.t. time.

Age s.e	Slope Mean Q	t-value	Intercept	RSquare	No Pts	Reg
2	0.94 -0.23	0.202	0.83	0.57	19	0.33
3	0.81 0.31	1.061	1.71	0.77	19	0.29
4	0.94 0.6	0.25	-0.04	0.69	19	0.38
5	1.19 0.63	-1.107	-2.45	0.78	19	0.32
6	1.18 0.45	-0.695	-1.97	0.63	19	0.48
7	0.89 0.27	0.409	0.57	0.6	19	0.53
1						

Fleet : FLT03: Latvian/Russi

Age	1992 1998	1993 1999	1994 2000	1995 2001	1996	1997

1	99.99	99.99	99.99	99.99	99.99	99.99
	99.99	99.99	99.99	99.99		
2	No data for this fleet at this age					
3	No data for this fleet at this age					
4	No data for this fleet at this age					
5	No data for this fleet at this age					
6	No data for this fleet at this age					
7	No data for this fleet at this age					

Age	2002	2003	2004	2005	2006	2007
	2008	2009	2010	2011		
1	-0.58	-0.15	-0.38	-1.3	-0.13	-0.09
	-0.5	-0.22	-0.44	0.23		
2	No data for this fleet at this age					
3	No data for this fleet at this age					
4	No data for this fleet at this age					
5	No data for this fleet at this age					
6	No data for this fleet at this age					
7	No data for this fleet at this age					

Age	2012	2013	2014	2015	2016	2017
	2018	2019	2020	2021		
1	0.08	0.01	-0.05	-0.18	-0.14	0.03
	0.43	-0.16	0.25	0.35		
2	No data for this fleet at this age					
3	No data for this fleet at this age					
4	No data for this fleet at this age					
5	No data for this fleet at this age					
6	No data for this fleet at this age					
7	No data for this fleet at this age					

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg
s.e	Mean Log q					
1	0.66	1.639	4.24	0.69	20	0.3
	-0.55					
1						

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 2020

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	70404	0.3	0	0	1	0.337	0.059
FLT02: International	52466	0.409	0	0	1	0.181	0.079
FLT03: Latvian/Russi	94825	0.328	0	0	1	0.282	0.044
P shrinkage mean	47955	0.47				0.143	0.086
F shrinkage mean	45350	0.75				0.057	0.09

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F

66996	0.18	0.14	5	0.798	0.062

1

Age 2 Catchability constant w.r.t. time and dependent on age

Year class = 2019

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	36807	0.212	0.089	0.42	2	0.469	0.237
FLT02: International	46055	0.27	0.089	0.33	2	0.292	0.194
FLT03: Latvian/Russi	54736	0.326	0	0	1	0.191	0.165
F shrinkage mean	42127	0.75				0.048	0.21

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F

42671	0.15	0.08	6	0.529	0.208

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2018

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	10317	0.189	0.102	0.54	3	0.465	0.367
FLT02: International	11402	0.221	0.083	0.37	3	0.356	0.337
FLT03: Latvian/Russi	9075	0.332	0	0	1	0.127	0.408
F shrinkage mean	13944	0.75				0.052	0.284

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
10682	0.13	0.06	8	0.445	0.356

1

Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 2017

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	7155	0.169	0.088	0.52	4	0.492	0.472
FLT02: International	7226	0.198	0.068	0.35	4	0.362	0.469
FLT03: Latvian/Russi	11640	0.322	0	0	1	0.092	0.316
F shrinkage mean	8756	0.75				0.053	0.401

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7591	0.12	0.06	10	0.532	0.451

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2016

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	2959	0.164	0.1	0.61	5	0.428	0.489
FLT02: International	3405	0.175	0.098	0.56	5	0.453	0.437
FLT03: Latvian/Russi	3311	0.322	0	0	1	0.066	0.447
F shrinkage mean	3354	0.75				0.053	0.443

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3198	0.12	0.06	12	0.517	0.46

1

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2015

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	2275	0.156	0.102	0.65	6	0.511	0.495
FLT02: International	3068	0.178	0.102	0.57	5	0.383	0.388
FLT03: Latvian/Russi	2244	0.323	0	0	1	0.053	0.5
F shrinkage mean	2834	0.75				0.053	0.414

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2579	0.11	0.07	13	0.641	0.448

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2014

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	3490	0.153	0.063	0.41	7	0.609	0.38
FLT02: International	2710	0.19	0.117	0.62	6	0.305	0.467
FLT03: Latvian/Russi	2636	0.361	0	0	1	0.029	0.477
F shrinkage mean	2781	0.75				0.058	0.457

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3163	0.12	0.06	15	0.509	0.412

1

Table 7.16. SPRAT IN SD 22-32. Output from XSA. Fishing mortality (F) at age

Run title : Sprat 22 32

At 6/04/2022 10:55

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1974	1975	1976	1977	1978	1979	1980	1981
AGE								
1	0.073	0.049	0.035	0.081	0.053	0.076	0.034	0.063
2	0.121	0.114	0.123	0.119	0.291	0.181	0.266	0.247
3	0.332	0.216	0.225	0.298	0.147	0.249	0.316	0.197
4	0.443	0.531	0.266	0.443	0.346	0.163	0.336	0.203
5	0.335	0.441	0.642	0.268	0.529	0.376	0.25	0.149
6	0.627	0.33	0.474	0.658	0.231	0.283	0.431	0.253
7	0.477	0.443	0.469	0.466	0.379	0.283	0.351	0.206
+gp	0.477	0.443	0.469	0.466	0.379	0.283	0.351	0.206
0 FBAR 3- 5	**0.37**	**0.40**	**0.38**	**0.34**	**0.34**	**0.26**	0.301	0.183

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
AGE										
1	0.018	0.023	0.029	0.018	0.038	0.026	0.007	0.065	0.025	0.022
2	0.188	0.036	0.062	0.094	0.065	0.055	0.174	0.043	0.164	0.092
3	0.303	0.093	0.091	0.12	0.142	0.132	0.182	0.212	0.077	0.201
4	0.271	0.186	0.155	0.199	0.184	0.364	0.21	0.183	0.195	0.134
5	0.337	0.129	0.293	0.179	0.301	0.31	0.325	0.253	0.139	0.185
6	0.221	0.146	0.212	0.236	0.234	0.44	0.263	0.34	0.186	0.117
7	0.285	0.157	0.223	0.207	0.243	0.377	0.27	0.261	0.174	0.146
+gp	0.285	0.157	0.223	0.207	0.243	0.377	0.27	0.261	0.174	0.146
0 FBAR 3- 5	**0.30**	**0.14**	**0.18**	**0.17**	**0.21**	**0.27**	**0.24**	**0.22**	**0.14**	**0.17**

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
1	0.021	0.024	0.02	0.03	0.063	0.035	0.088	0.045	0.13	0.067
2	0.087	0.099	0.167	0.061	0.198	0.276	0.11	0.256	0.095	0.242
3	0.156	0.144	0.232	0.226	0.185	0.281	0.386	0.272	0.347	0.131
4	0.218	0.152	0.261	0.337	0.401	0.446	0.442	0.435	0.233	0.44
5	0.227	0.192	0.299	0.483	0.309	0.522	0.368	0.404	0.38	0.286
6	0.156	0.227	0.29	0.517	0.453	0.267	0.487	0.301	0.369	0.492
7	0.202	0.192	0.286	0.451	0.392	0.415	0.437	0.384	0.331	0.411
+gp	0.202	0.192	0.286	0.451	0.392	0.415	0.437	0.384	0.331	0.411
0 FBAR 3- 5	**0.20**	**0.16**	**0.26**	**0.35**	**0.30**	**0.42**	**0.40**	**0.37**	**0.32**	**0.29**

YEAR		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE											
	1	0.147	0.088	0.117	0.065	0.169	0.167	0.119	0.155	0.114	0.205
	2	0.216	0.275	0.196	0.265	0.119	0.355	0.356	0.304	0.299	0.193
	3	0.437	0.346	0.396	0.298	0.349	0.229	0.417	0.515	0.371	0.363
	4	0.325	0.436	0.441	0.44	0.352	0.487	0.342	0.563	0.514	0.407
	5	0.436	0.396	0.636	0.605	0.446	0.411	0.464	0.434	0.42	0.41
	6	0.257	0.401	0.45	0.374	0.474	0.437	0.549	0.538	0.479	0.405
	7	0.342	0.406	0.507	0.479	0.357	0.532	0.46	0.623	0.441	0.477
+gp		0.342	0.406	0.507	0.479	0.357	0.532	0.46	0.623	0.441	0.477
0 FBAR 3- 5		**0.40**	**0.39**	**0.49**	**0.45**	**0.38**	**0.38**	**0.41**	**0.50**	**0.44**	**0.39**

YEAR		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	
AGE												
	1	0.094	0.131	0.117	0.099	0.046	0.075	0.105	0.145	0.078	0.062	0.095
	2	0.253	0.315	0.294	0.193	0.175	0.147	0.215	0.283	0.223	0.208	0.238
	3	0.212	0.385	0.439	0.385	0.266	0.266	0.253	0.319	0.303	0.356	0.326
	4	0.425	0.342	0.424	0.481	0.378	0.423	0.378	0.395	0.414	0.451	0.42
	5	0.39	0.518	0.422	0.475	0.373	0.473	0.523	0.434	0.389	0.46	0.428
	6	0.444	0.451	0.418	0.389	0.404	0.404	0.372	0.469	0.405	0.448	0.441
	7	0.483	0.396	0.524	0.35	0.496	0.377	0.286	0.331	0.418	0.412	0.387
+gp		0.483	0.396	0.524	0.35	0.496	0.377	0.286	0.331	0.418	0.412	
0 FBAR 3- 5		**0.34**	**0.41**	**0.43**	**0.45**	**0.34**	**0.39**	**0.38**	**0.38**	**0.37**	**0.42**	

Table 7.17. SPRAT IN SD 22-32. Output from XSA. Stock number at age (Numbers*10^-6)

Run title : Sprat 22 32

At 6/04/2022 10:55

Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year)

	197	197	197	197	197	197	198	198
YEAR	4	5	6	7	8	9	0	1
AGE								
	527	187	2E+	450	164	325	200	642
1	88	04	05	92	04	58	55	16
	698	246	889	982	190	535	961	599
2	16	25	1	90	06	0	5	4
	161	372	129	495	506	680	202	318
3	50	60	49	2	51	3	8	5
	676	730	184	673	225	221	252	
4	4	3	65	3	1	00	9	699

	845	279	269	936	270		891	
5	8	6	9	2	7	847	3	869
	247	389	113		448			330
6	2	4	1	940	7	861	292	0
	397		179			193		
7	5	868	7	474	314	7	325	94
		187	135	131			109	
+gp	889	1	3	5	785	696	2	701
0	2E+	973	2E+	2E+	966	711	448	790
TOTAL	05	22	05	05	05	52	49	58

	198	198	198	198	198	198	198	198	199	199
YEAR	2	3	4	5	6	7	8	9	0	1
AGE										
	341	1E+	499	427	181	408	152	427	505	576
1	60	05	16	31	70	20	99	88	62	62
	208	115	532	243	229	930	212	838	244	346
2	71	86	74	74	62	6	58	9	41	10
	229	815	575	281	134	133	549	112	539	153
3	7	9	7	54	86	10	4	16	1	27
	132		403	312	155	741	751	291	623	370
4	7	851	8	7	86	3	3	4	3	0
				206	161	833	337	396	167	382
5	306	518	389	5	7	5	7	5	5	8
					110		402	161	214	109
6	401	117	255	176	7	783	3	4	9	5
	131							206		133
7	0	165	57	126	91	578	335	3	806	9
		132							142	126
+gp	279	6	519	425	280	278	716	701	9	5
0	609	1E+	1E+	1E+	733	808	580	736	926	1E+
TOTAL	52	05	05	05	00	25	15	50	87	05

	199	199	199	199	199	199	199	199	200	200
YEAR	2	3	4	5	6	7	8	9	0	1
AGE										
	1E+	925	673	3E+	2E+	585	2E+	555	1E+	513
1	05	74	62	05	05	36	05	76	05	98
	408	709	624	456	2E+	1E+	419	1E+	379	631
2	16	65	85	78	05	05	71	05	56	76
	240	282	462	380	318	1E+	634	283	587	253
3	55	93	47	78	90	05	97	25	41	40
	959	157	178	267	225	201	630	326	161	304
4	1	07	77	96	93	23	11	93	12	07
	248	590	991	101	143	115	988	307	157	938
5	8	6	6	51	10	10	3	64	97	1
	245	152	359	543	470	803	526	523	153	796
6	7	8	4	3	2	0	8	4	76	6
		162		199	243	228	474	248	291	785
7	754	3	901	2	6	6	2	1	6	3
	100	169		128	140		156	183	310	178
+gp	8	5	961	2	6	923	0	7	2	8
0	2E+	2E+	2E+	4E+	4E+	3E+	3E+	3E+	3E+	2E+
TOTAL	05	05	05	05	05	05	05	05	05	05

	199	199	199	199	199	199	199	199	200	200
YEAR	2	3	4	5	6	7	8	9	0	1

AGE										
	1E+	925	673	3E+	2E+	585	2E+	555	1E+	513
1	05	74	62	05	05	36	05	76	05	98
	408	709	624	456	2E+	1E+	419	1E+	379	631
2	16	65	85	78	05	05	71	05	56	76
	240	282	462	380	318	1E+	634	283	587	253
3	55	93	47	78	90	05	97	25	41	40
	959	157	178	267	225	201	630	326	161	304
4	1	07	77	96	93	23	11	93	12	07
	248	590	991	101	143	115	988	307	157	938
5	8	6	6	51	10	10	3	64	97	1
	245	152	359	543	470	803	526	523	153	796
6	7	8	4	3	2	0	8	4	76	6
		162		199	243	228	474	248	291	785
7	754	3	901	2	6	6	2	1	6	3
	100	169		128	140		156	183	310	178
+gp	8	5	961	2	6	923	0	7	2	8
0	2E+	2E+	2E+	4E+	4E+	3E+	3E+	3E+	3E+	2E+
TOTAL	05	05	05	05	05	05	05	05	05	05

	200	200	200	200	200	200	200	200	201	201
YEAR	2	3	4	5	6	7	8	9	0	1
AGE										
	588	1E+	2E+	546	852	1E+	705	2E+	533	597
1	22	05	05	17	50	05	90	05	47	26
	330	345	858	2E+	348	479	619	407	1E+	301
2	58	42	94	05	19	98	69	21	05	31
	359	191	192	518	856	215	234	301	208	505
3	04	20	91	42	36	19	34	58	85	40
	162	166	999	968	273	423	120	108	126	989
4	64	93	3	6	73	29	80	07	55	6
	143	851	797	482	452	135	183	606	434	523
5	23	2	4	0	7	87	81	2	3	6
	518	670	424	316	191	207	637	812	277	197
6	0	4	9	4	6	9	8	0	9	8
	357	290	332	203	158			258	334	119
7	2	5	0	0	9	859	962	4	5	5
	536	475	390	186	205	151	114		168	175
+gp	7	5	1	3	0	0	4	885	8	7
0	2E+	2E+	4E+	3E+	2E+	2E+	2E+	3E+	2E+	2E+
TOTAL	05	05	05	05	05	05	05	05	05	05

	201	201	201	201	201	201	201	201	202	202	202	GMST 74-**	
YEAR	2	3	4	5	6	7	8	9	0	1	2	AMST 74-**	
AGE													
	727	642	556	2E+	793	592	737	517	1E+	956			
1	74	60	79	05	87	26	10	86	05	44	0	64732	81284
	306	423	357	314	1E+	525	387	480	324	683	669		
2	11	25	78	80	05	24	31	73	54	76	96	36318	49381
	169	166	216	186	189	823	333	234	271	197	426		
3	24	23	64	63	42	81	72	13	57	44	71	19698	27975
	241	972	808	995	937	107	467	195	128	153	106		
4	02	3	7	0	2	11	90	50	31	69	82	10054	14794
	455	112	497	381	456	478	526	242	995	652	759		
5	7	15	5	6	1	5	4	40	6	3	1	4847	7261
	242	221	481	236	176	234	224	237	119	519	319		
6	1	1	8	6	9	3	8	4	53	6	8	2211	3300

		111	101	229	120		117	118	113	614	257		
7	918	5	7	8	1	884	9	3	3	9	9	1082	1669
	132	112	105	113	131	144					365		
+gp	2	3	4	7	3	2	949	945	771	957	6		
0	2E+	1E+	1E+	3E+	3E+	2E+	2E+	2E+	2E+	2E+	1E+		
TOTAL	05	05	05	05	05	05	05	05	05	05	05		

Table 7.18. Sprat in SD 22-32. Output from XSA. Stock summary (biomass in kt, numbers in milions).
At 6/04/2022 10:55
Table 16 Summary (without SOP correction)
Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 5
1974	52788	1594	940	242	0.257	0.370
1975	18704	1099	726	201	0.278	0.396
1976	182883	1874	625	195	0.312	0.378
1977	45092	1663	1044	181	0.173	0.336
1978	16404	1077	695	132	0.190	0.341
1979	32558	706	377	77	0.204	0.263
1980	20055	485	227	58	0.256	0.301
1981	64216	633	199	49	0.248	0.183
1982	34160	641	254	49	0.191	0.303
1983	124733	1498	394	37	0.095	0.136
1984	49916	1242	616	53	0.085	0.180
1985	42731	1111	605	70	0.115	0.166
1986	18170	862	570	76	0.133	0.209
1987	40820	895	461	88	0.191	0.269
1988	15299	609	403	80	0.199	0.239
1989	42788	882	423	86	0.203	0.216
1990	50562	1122	556	86	0.154	0.137
1991	57662	1370	775	103	0.133	0.173
1992	101915	1999	1045	142	0.136	0.201
1993	92574	2187	1360	178	0.131	0.163
1994	67362	2189	1374	289	0.210	0.264
1995	254162	3155	1429	313	0.219	0.349
1996	158602	2882	1810	441	0.244	0.299

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 5
1997	58536	2618	1776	529	0.298	0.416
1998	152162	2335	1354	471	0.348	0.399
1999	55576	1967	1353	421	0.311	0.370
2000	103359	2227	1322	389	0.294	0.320
2001	51398	1835	1199	342	0.286	0.286
2002	58822	1590	944	343	0.363	0.399
2003	133174	1650	833	308	0.370	0.393
2004	249547	2283	1045	374	0.358	0.491
2005	54617	2010	1331	405	0.305	0.448
2006	85250	1747	1061	352	0.332	0.382
2007	110412	1750	906	388	0.429	0.376
2008	70590	1686	928	381	0.410	0.408
2009	182171	1916	834	407	0.488	0.504
2010	53347	1566	955	342	0.358	0.435
2011	59726	1222	758	268	0.354	0.393
2012	72774	1287	700	231	0.330	0.342
2013	64260	1245	712	272	0.382	0.415
2014	55679	1097	627	244	0.389	0.429
2015	219398	1664	689	247	0.359	0.447
2016	79387	1739	1099	247	0.224	0.339
2017	59226	1691	1120	286	0.255	0.387
2018	73710	1567	996	309	0.310	0.385
2019	51786	1352	868	314	0.362	0.383
2020	100551	1537	835	272	0.325	0.369
2021	95644	1640	939	285	0.303	0.422
Mean	81985	1562	877	243	0.269	0.329
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 7.19. Sprat in SD 22-32. Input data for RCT3 analysis.
Sprat 22-32: Acoustic on age 0 in subdiv. 22-29, shifted to represent age1

Year	VPA, age 1	Acoustic, Age 0
1991	101915	59473
1992	92574	48035
1993	67362	-11
1994	254162	64092
1995	158602	-11
1996	58536	3842
1997	152162	-11
1998	55576	1279
1999	103359	33320
2000	51398	4601
2001	58822	12001
2002	133174	79551
2003	249547	146335
2004	54617	3562
2005	85250	41863
2006	110412	66125
2007	70590	17821
2008	182171	115698
2009	53347	12798
2010	59726	41158
2011	72774	45186
2012	64260	33653
2013	55679	24921
2014	219398	168125
2015	79387	42251
2016	59226	30848
2017	73710	78167
2018	51786	18542

Year	VPA, age 1	Acoustic, Age 0
2019	100551	95603
2020	95644	102931
2021	-11	8849.1

Table 7.20. Sprat in SD 22-32. Output from RCT3 analysis.

Analysis by RCT3 ver3.1 of data from file z:\recsprl1.txt

Sprat 22-32: YFS data from international acoustic survey on age 0

Data for 1 surveys over 30 years: 1991-2021

Regression type=C

Tapered time weighting applied

power = 3 over 20 years
Survey weighting not applied

Final estimates shrunk towards mean

Minimum S.E for any survey taken as 0.2

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

Yearclass = 2019

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept		Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0.68		4.09	0.37	0.646	24	9.83	10.78	0.44	0.545
VPA	Mean	=						11.32	0.481	0.455

Yearclass = 2020

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept		Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0.67		4.16	0.31	0.697	26	11.54	11.87	0.375	0.596

VPA	Mean	=						11.28	0.455	0.404

Yearclass = 2021

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Pre- dicted Value	Std Error	WAP Weights
Acoust	0.65	4.3	0.3	0.703	27	9.09	10.21	0.393	0.548
VPA	Mean	=					11.29	0.433	0.452

Year class	Weighted Average Prediction (Age 1)	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2007	90142	11.41	0.32	0.04	0.02	70590	11.16
2008	142417	11.87	0.32	0.33	1.07	182171	12.11
2009	80291	11.29	0.29	0.13	0.19	53348	10.88
2010	108422	11.59	0.3	0.1	0.12	59727	11
2011	103980	11.55	0.34	0.13	0.14	72774	11.2
2012	91720	11.43	0.34	0.05	0.02	64261	11.07
2013	80863	11.3	0.34	0.04	0.02	55680	10.93
2014	127464	11.76	0.35	0.48	1.91	219398	12.3
2015	92981	11.44	0.34	0.05	0.02	79388	11.28
2016	80747	11.3	0.32	0.06	0.03	59227	10.99
2017	110905	11.62	0.32	0.23	0.52	73711	11.21
2018	61262	11.02	0.32	0.27	0.69	51787	10.85
2019	111748	11.62	0.31	0.3	0.95	100552	11.52
2020	112574	11.63	0.29	0.29	0.99	95645	11.47
2021	**44213**	10.7	0.29	0.54	3.42		

Table 7.21. Sprat in SD 22-32. Input data for short-term prediction.
MFDP version 1a
Run: rSQ
Time and date: 13:36 2022-04-08
Fbar age range: 3-5

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	44213	0.31	0.17	0.4	0.4	0.0053	0.1025	0.0053
2	66996	0.28	0.93	0.4	0.4	0.0084	0.2568	0.0084
3	42671	0.27	1	0.4	0.4	0.0096	0.3522	0.0096
4	10682	0.27	1	0.4	0.4	0.0104	0.4529	0.0104
5	7591	0.26	1	0.4	0.4	0.0107	0.4616	0.0107
6	3198	0.26	1	0.4	0.4	0.0116	0.4755	0.0116
7	2579	0.26	1	0.4	0.4	0.0119	0.4176	0.0119
8	3656	0.26	1	0.4	0.4	0.0120	0.4176	0.0120

2023

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	87472	0.31	0.17	0.4	0.4	0.0053	0.1025	0.0053
2	.	0.28	0.93	0.4	0.4	0.0084	0.2568	0.0084
3	.	0.27	1	0.4	0.4	0.0096	0.3522	0.0096
4	.	0.27	1	0.4	0.4	0.0104	0.4529	0.0104
5	.	0.26	1	0.4	0.4	0.0107	0.4616	0.0107
6	.	0.26	1	0.4	0.4	0.0116	0.4755	0.0116
7	.	0.26	1	0.4	0.4	0.0119	0.4176	0.0119
8	.	0.26	1	0.4	0.4	0.0120	0.4176	0.0120

2024

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	87472	0.31	0.17	0.4	0.4	0.0053	0.1025	0.0053
2	.	0.28	0.93	0.4	0.4	0.0084	0.2568	0.0084
3	.	0.27	1	0.4	0.4	0.0096	0.3522	0.0096
4	.	0.27	1	0.4	0.4	0.0104	0.4529	0.0104
5	.	0.26	1	0.4	0.4	0.0107	0.4616	0.0107

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
6	.	0.26	1	0.4	0.4	0.0116	0.4755	0.0116
7	.	0.26	1	0.4	0.4	0.0119	0.4176	0.0119
8	.	0.26	1	0.4	0.4	0.0120	0.4176	0.0120

Input units are millions and kg - output in kilotonnes

M = Natural mortality, MAT = Maturity ogive, PF = Proportion of F before spawning,

PM = Proportion of M before spawning, SWT = Weight in stock (kg), Sel = Exploit. Pattern

CWT = Weight in catch (kg)

Table 7.22a. Sprat in SD 22-32. Output from short-term prediction -TAC constraint in 2022
MFDP version 1a
Run: rTAC
Sprat
Time and date: 14:38 2022-04-08
Fbar age range: 3-5

2022

Biomass	SSB	FMult	FBar	Landings
1515	1022	0.9602	0.3756	305

2023 and 2024

Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
1514	998	0	0	0	1870	1299
.	985	0.1	0.0391	35	1836	1252
.	972	0.2	0.0782	68	1804	1208
.	959	0.3	0.1174	101	1772	1166
.	947	0.4	0.1565	133	1741	1125
.	935	0.5	0.1956	163	1711	1086
.	923	0.6	0.2347	193	1682	1049
.	911	0.7	0.2739	222	1654	1013
.	899	0.8	0.313	250	1626	979
.	888	0.9	0.3521	277	1600	946
.	876	1	0.3912	303	1574	915
.	865	1.1	0.4303	329	1549	885
.	854	1.2	0.4695	353	1525	856
.	843	1.3	0.5086	378	1502	829

Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
.	832	1.4	0.5477	401	1479	802
.	822	1.5	0.5868	424	1457	777
.	811	1.6	0.626	446	1435	753
.	801	1.7	0.6651	467	1415	730
.	791	1.8	0.7042	488	1394	707
.	781	1.9	0.7433	508	1375	686
.	771	2	0.7824	528	1355	665

Input units are millions and kg - output in kilotonnes

Table 7.22b. Sprat in SD 22-32. Output from short-term prediction; F-status quo in 2022
MFDP version 1a
Run: rSQ
Sprat
Time and date: 13:36 2022-04-08
Fbar age range: 3-5

2022

Biomass	SSB	FMult	FBar	Landings
1515	1008	1.0000	0.4222	338

2023 and 2024

Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
1483	970	0	0	0	1845	1276
.	956	0.1	0.0422	36	1810	1227
.	943	0.2	0.0844	71	1775	1181
.	930	0.3	0.1267	105	1742	1137
.	917	0.4	0.1689	138	1710	1094
.	904	0.5	0.2111	170	1679	1054
.	892	0.6	0.2533	201	1649	1016
.	880	0.7	0.2956	231	1619	979
.	868	0.8	0.3378	260	1591	944
.	856	0.9	0.38	287	1564	910
.	844	1	0.4222	314	1538	878
.	832	1.1	0.4645	341	1512	848
.	821	1.2	0.5067	366	1487	819

Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
.	810	1.3	0.5489	391	1463	791
.	798	1.4	0.5911	414	1440	764
.	788	1.5	0.6334	437	1417	739
.	777	1.6	0.6756	460	1396	714
.	766	1.7	0.7178	481	1374	691
.	756	1.8	0.76	502	1354	669
.	745	1.9	0.8022	523	1334	647
.	735	2	0.8445	542	1315	627

Input units are millions and kg - output in kilotonnes

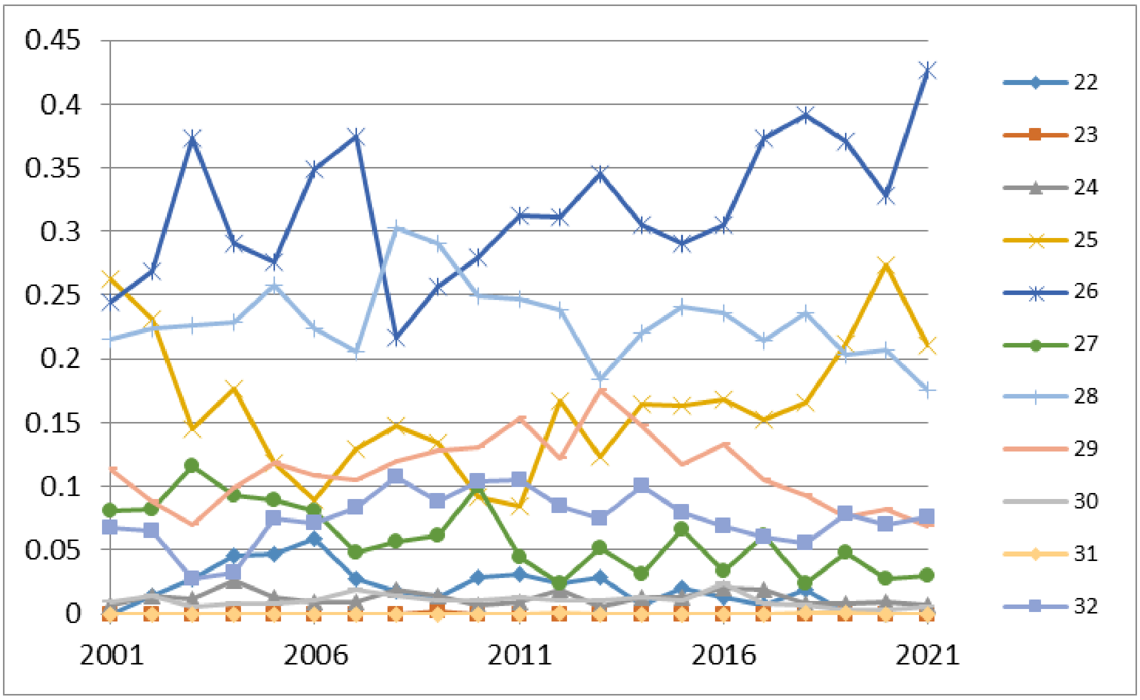


Figure 7.1 Sprat in Subdivisions 22-32. Share of catches by Sub-division in 2001-2021

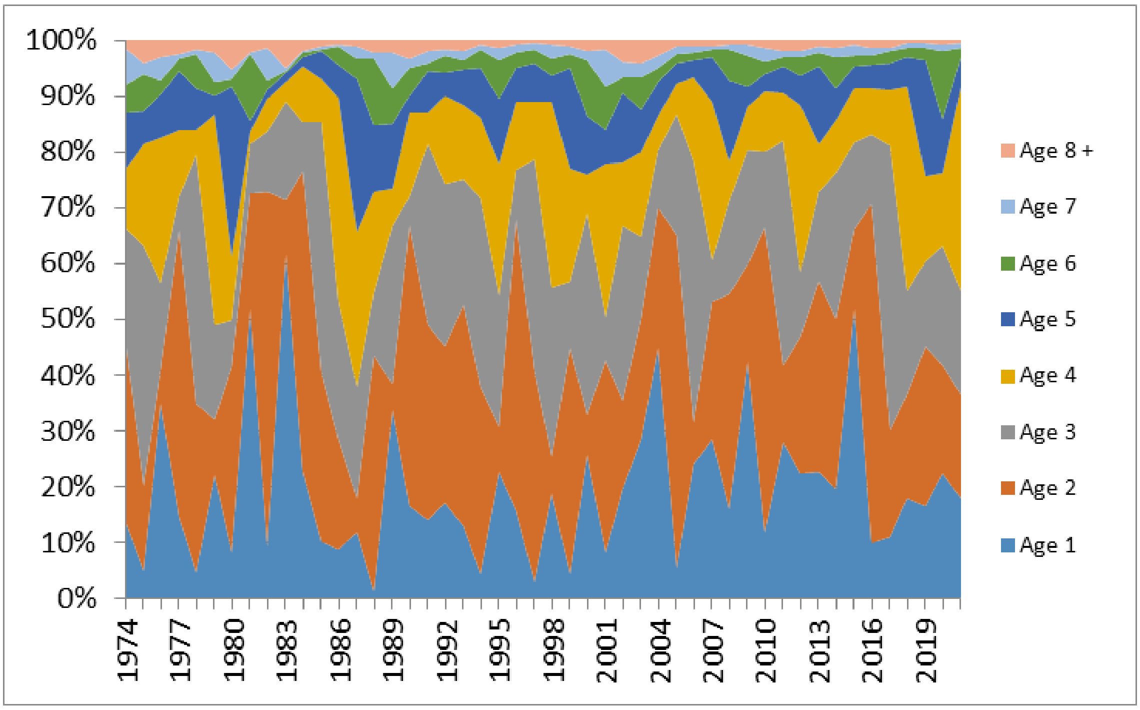


Figure 7.2. Sprat in SD 22-32. Relative catch-at-age in numbers.

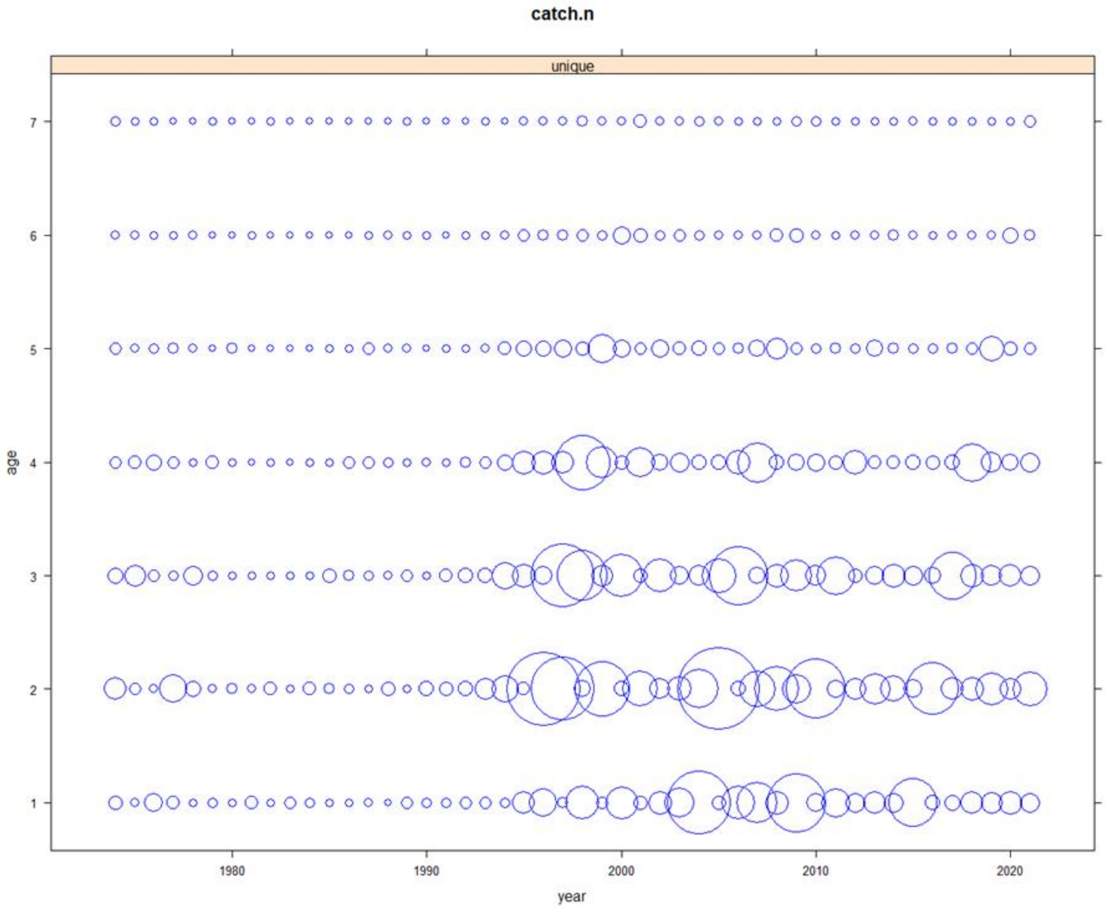
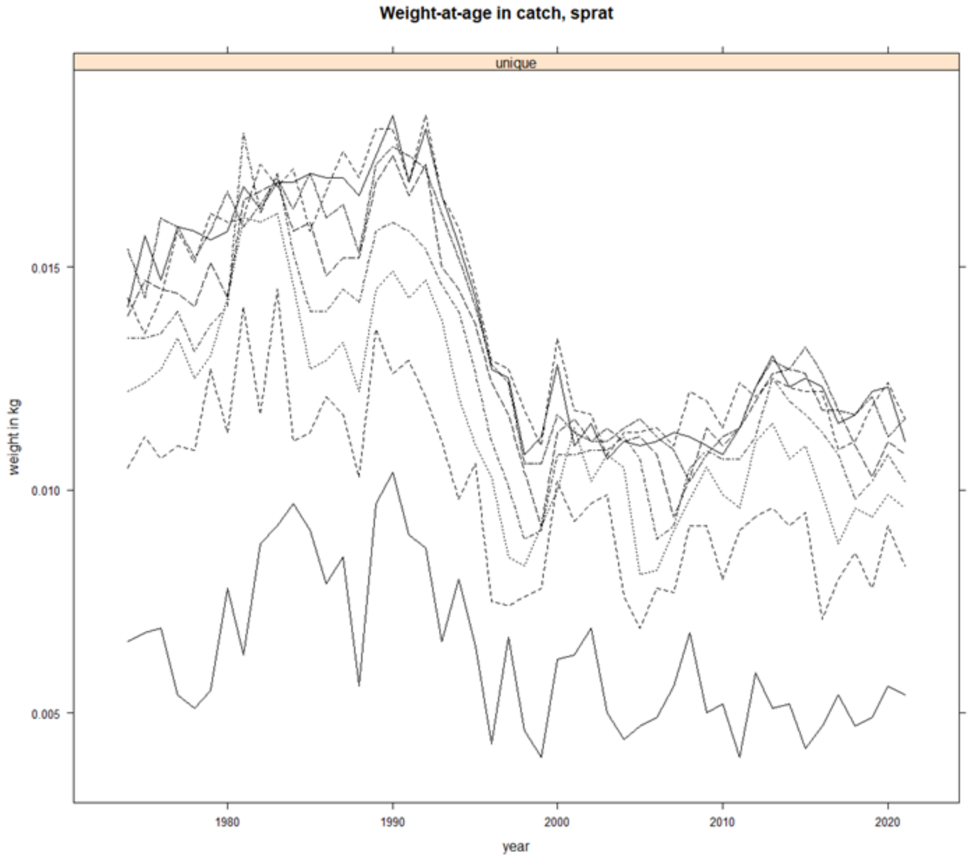


Figure 7.3. Sprat in SD 22-32. CANUM consistency check.



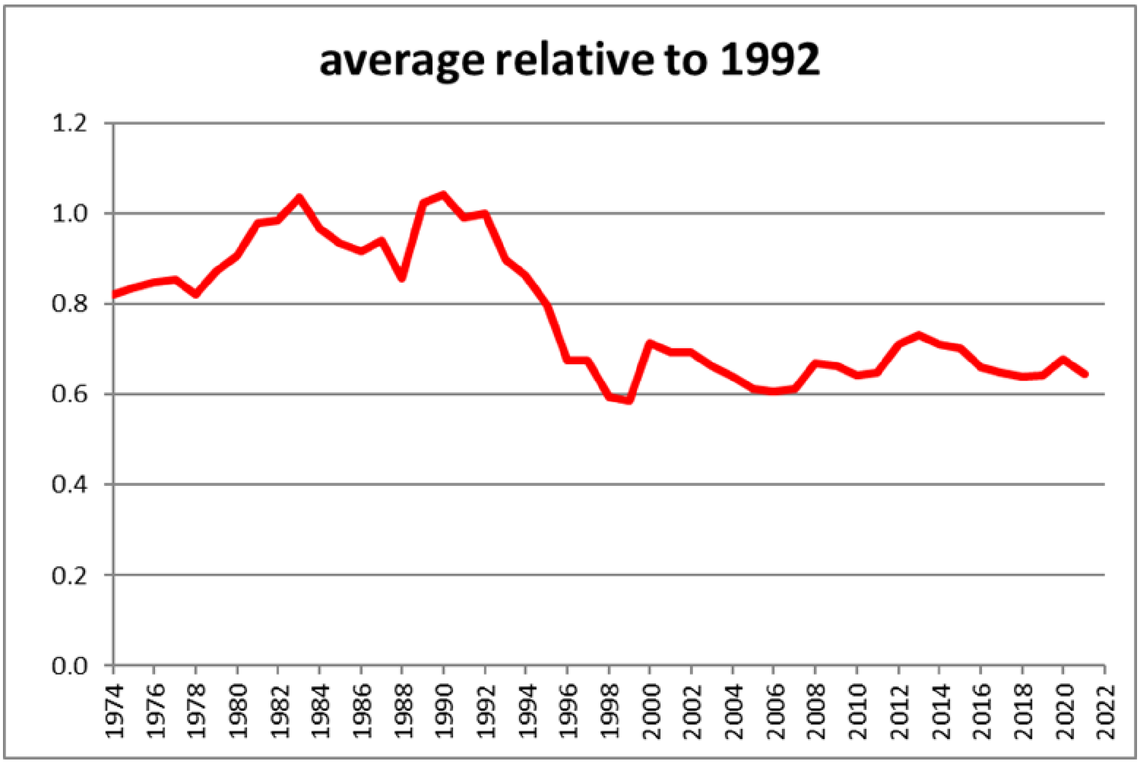


Figure 7.4a. Sprat in SD 22-32: mean weight-at-age in the catches by ages and average of values relative to weights in 1992 (weight in the stock assumed as in the catches).

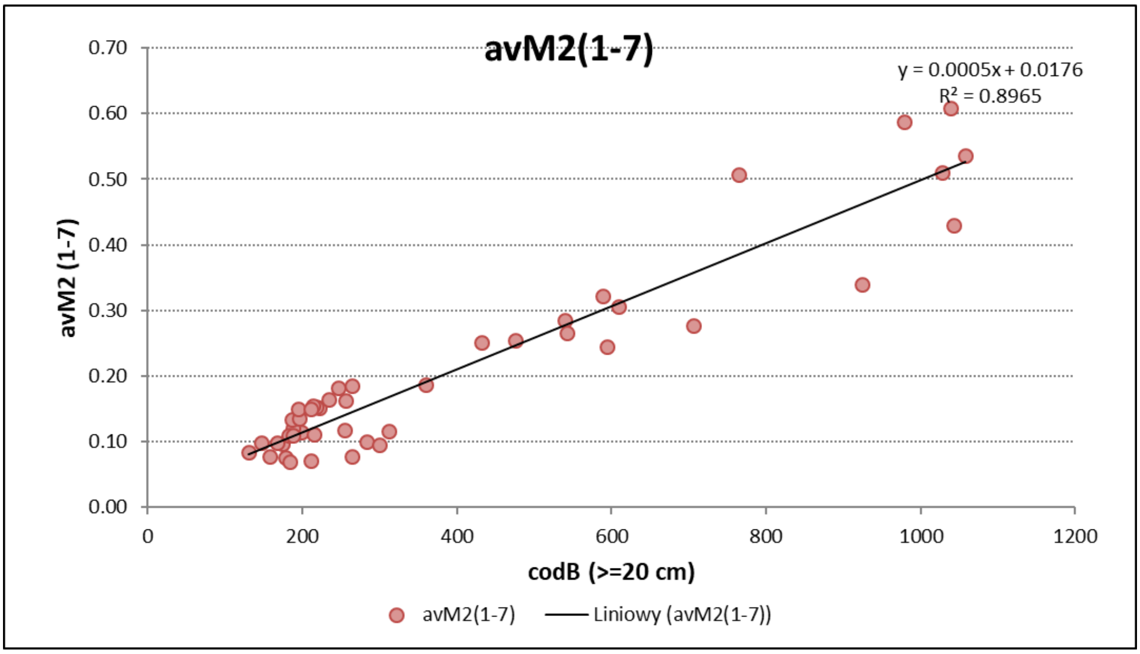


Figure 7.4b. Sprat in SD 22-32: regression of mean predation mortality, avM2, against biomass of cod at length >=20 cm.

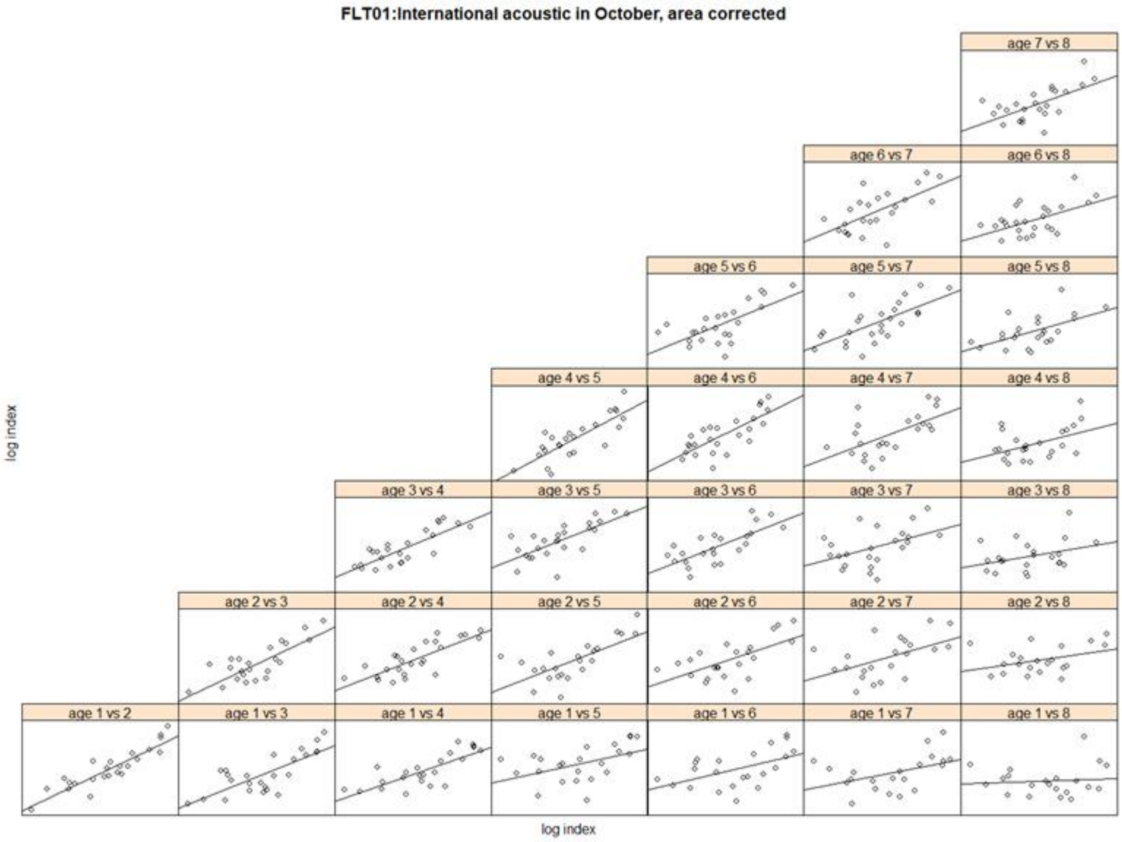


Figure 7.5a. Sprat in SD 22-32. Check for consistency in October acoustic survey estimates.

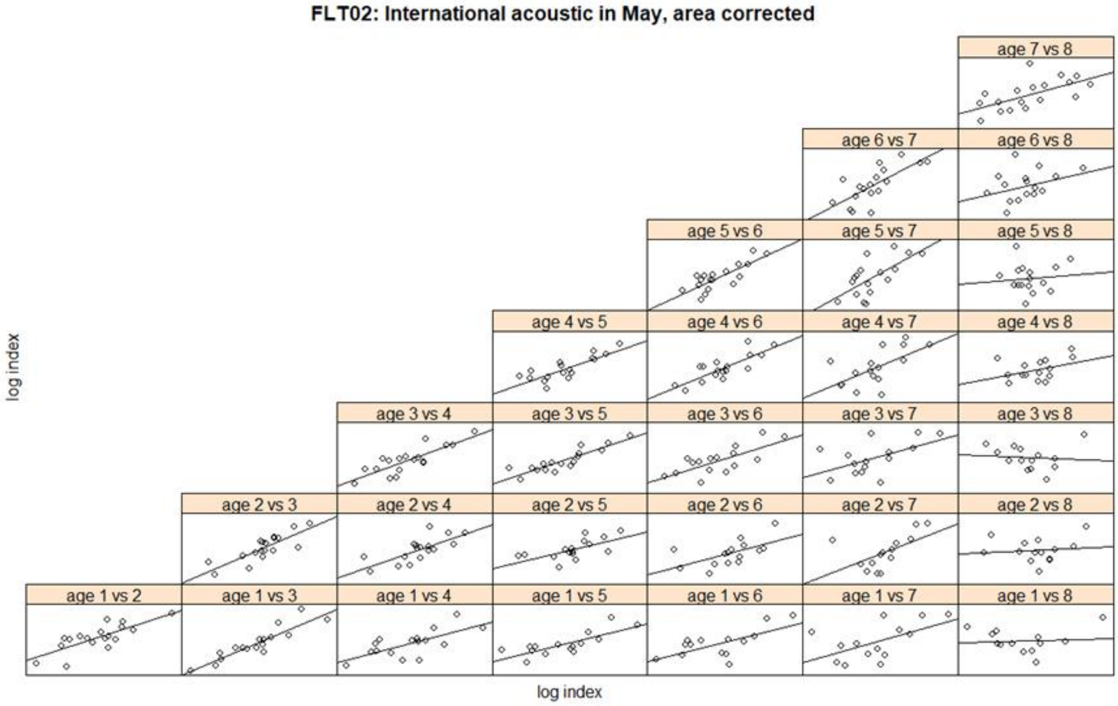


Figure 7.5b. Sprat in SD 22-32. Check for consistency in May acoustic survey estimates.

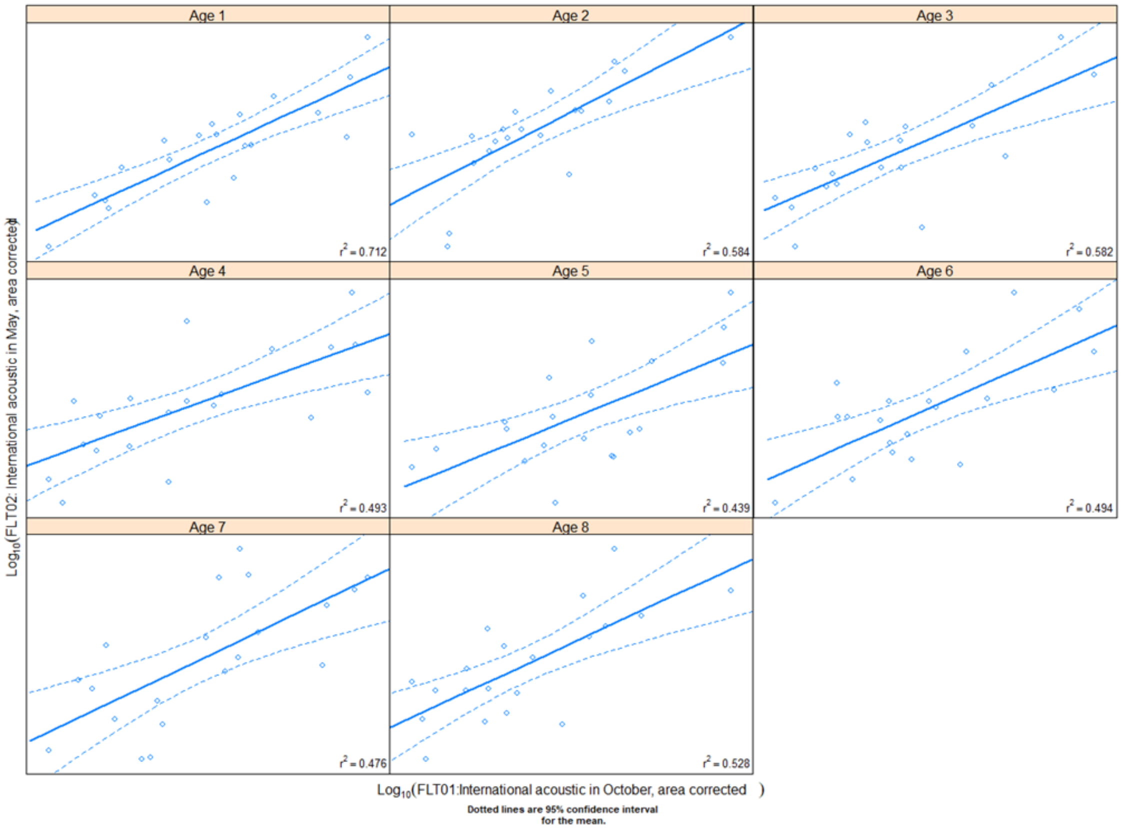


Figure 7.5c. Sprat in SD 22-32. Check for consistency between May and October surveys.

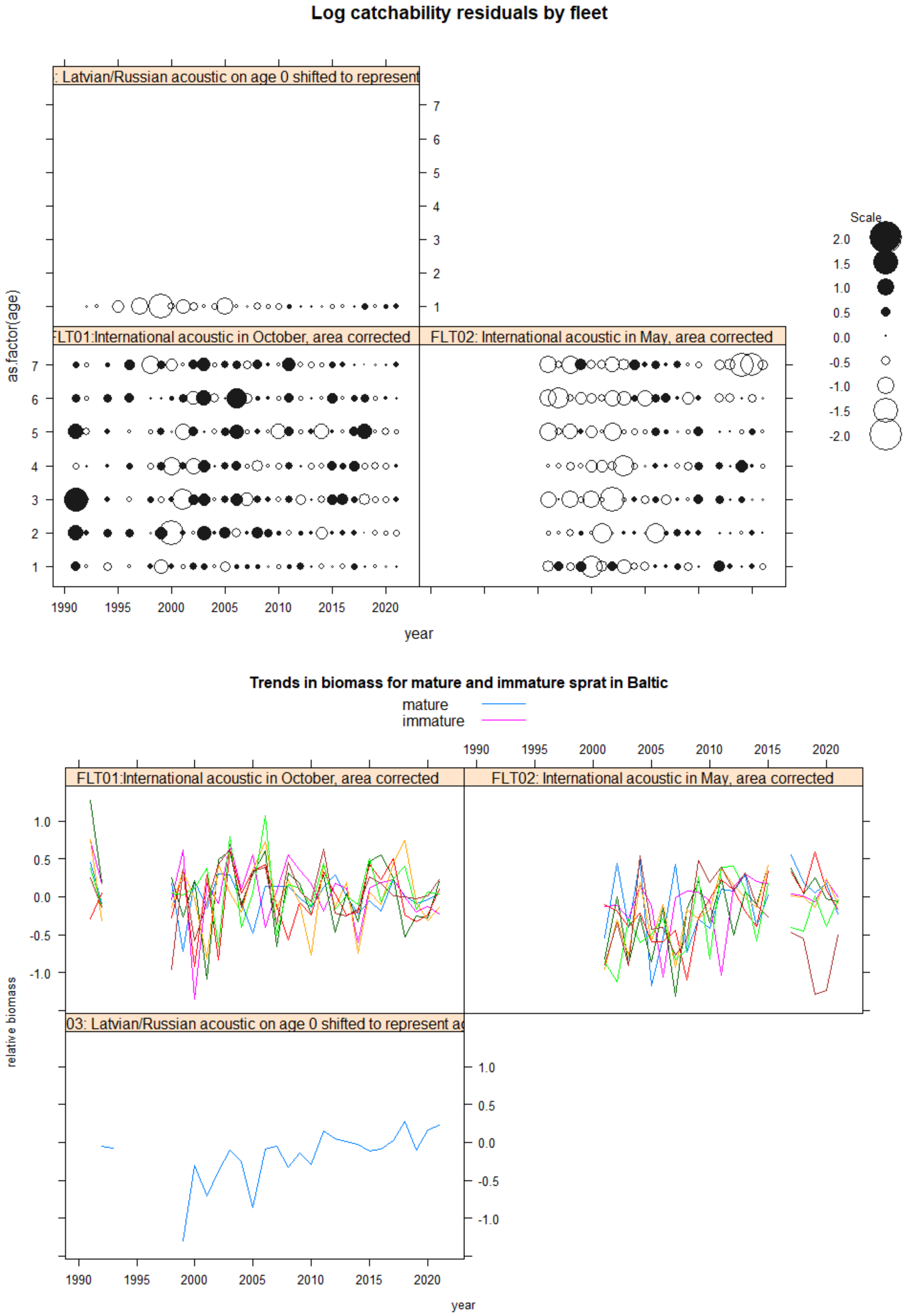


Figure 7.6. Sprat in SD 22-32. Log catchability residuals by fleet presented in two ways.

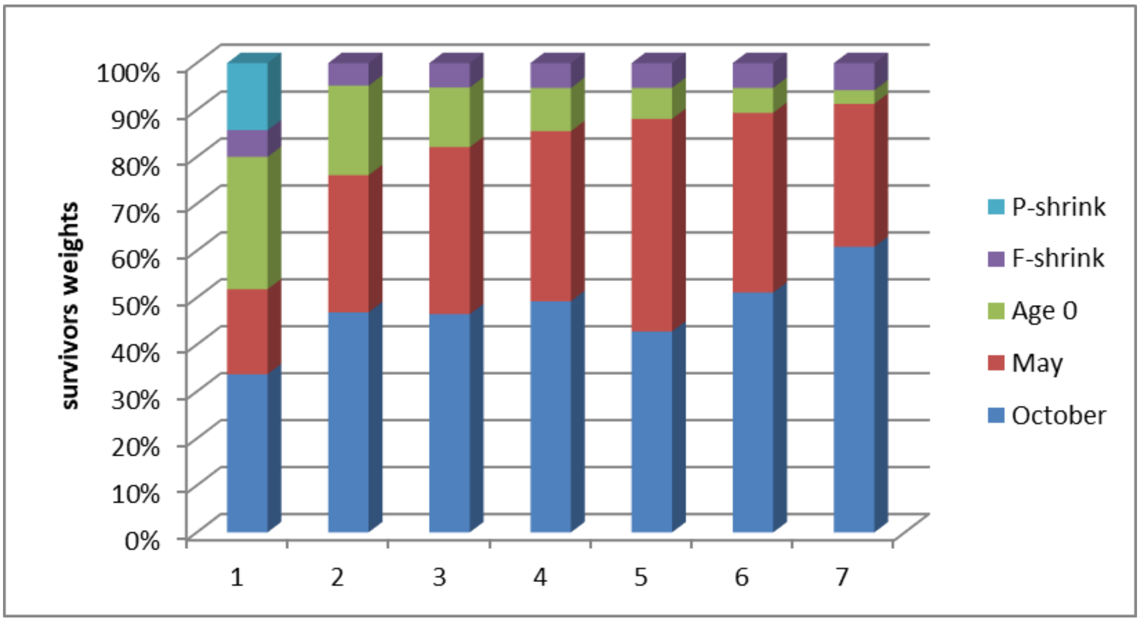


Figure 7.7a. Sprat In SD 22-32. Weights of survivors estimates by fleet used to provide final survivors estimates.

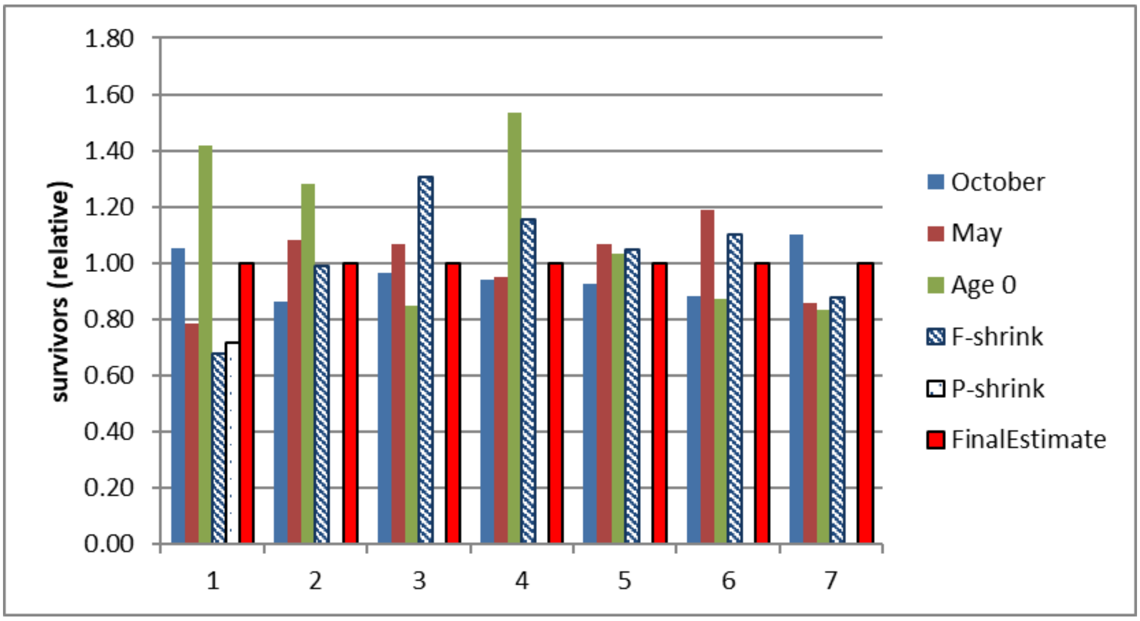


Figure 7.7b. Sprat in SD 22-32. Survivors estimates by fleet and age relative to final estimate.

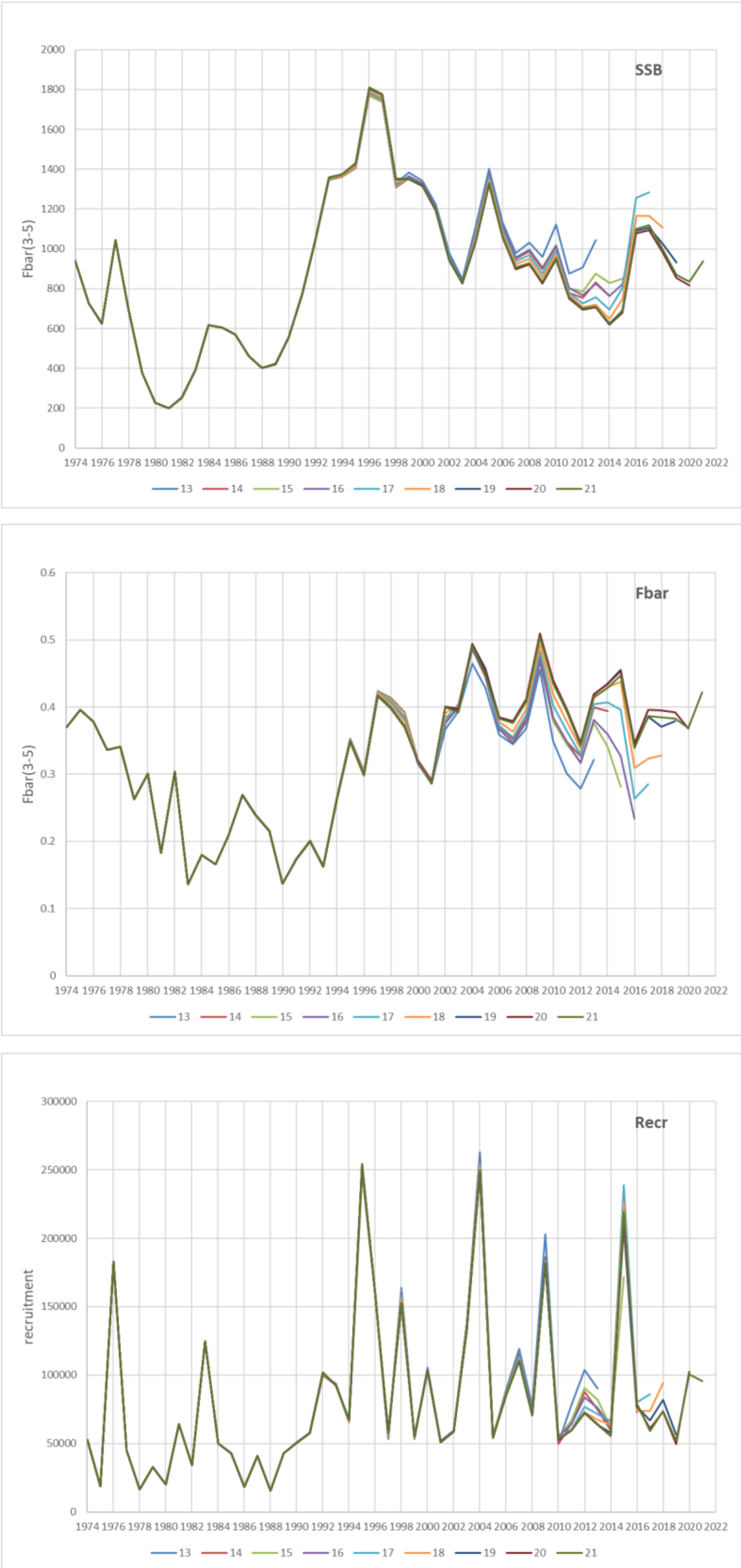


Figure 7.8. Sprat in SD 22-32. Retrospective analysis from XSA.

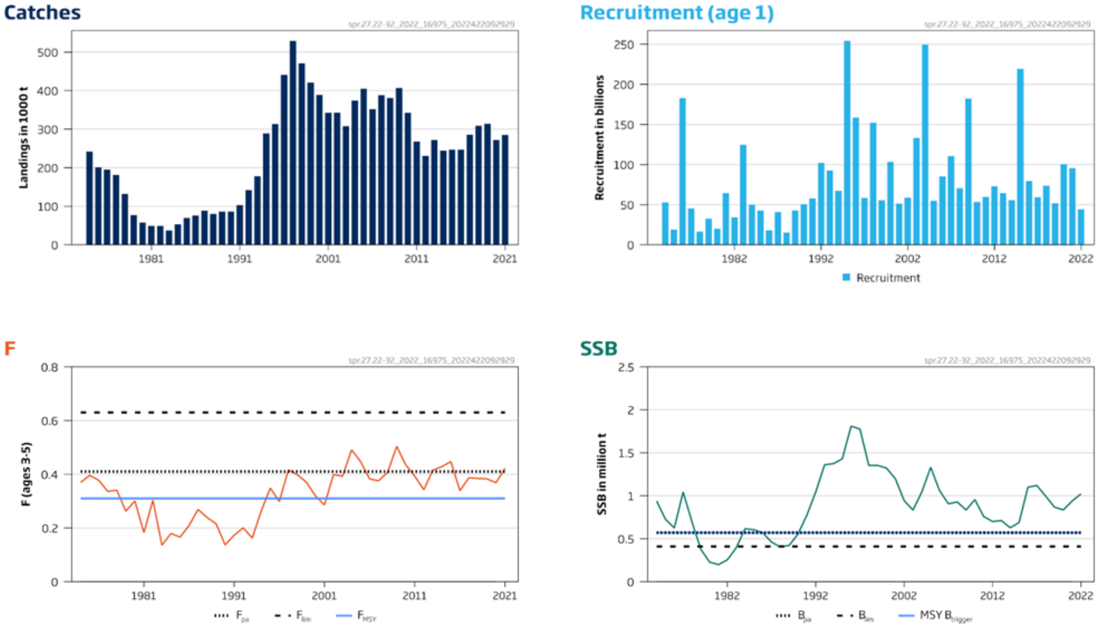


Figure 7.9 Sprat in SD 22–32. Summary sheet plots: landings, fishing mortality, recruitment (age 1) and spawning stock biomass.

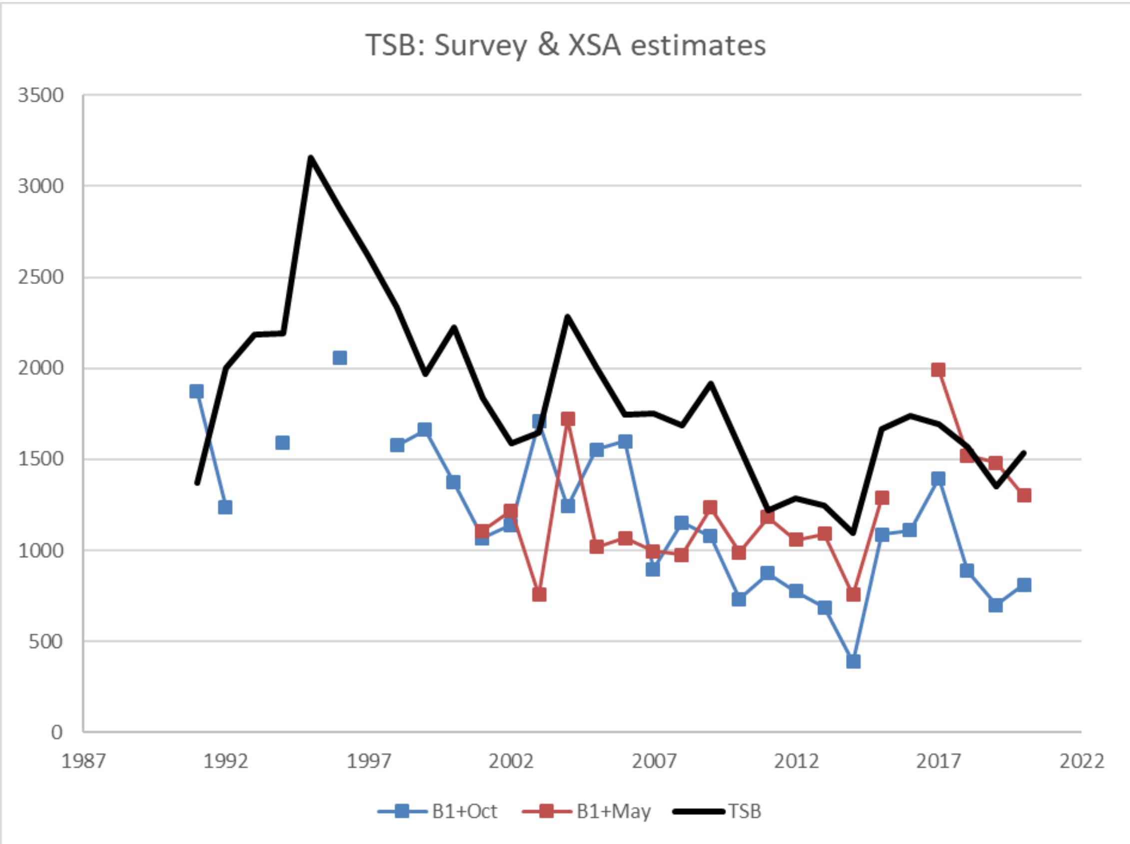


Figure 7.10 Sprat in SD 22-32. Comparison of survey (age 1+) stock size estimates with TSB.

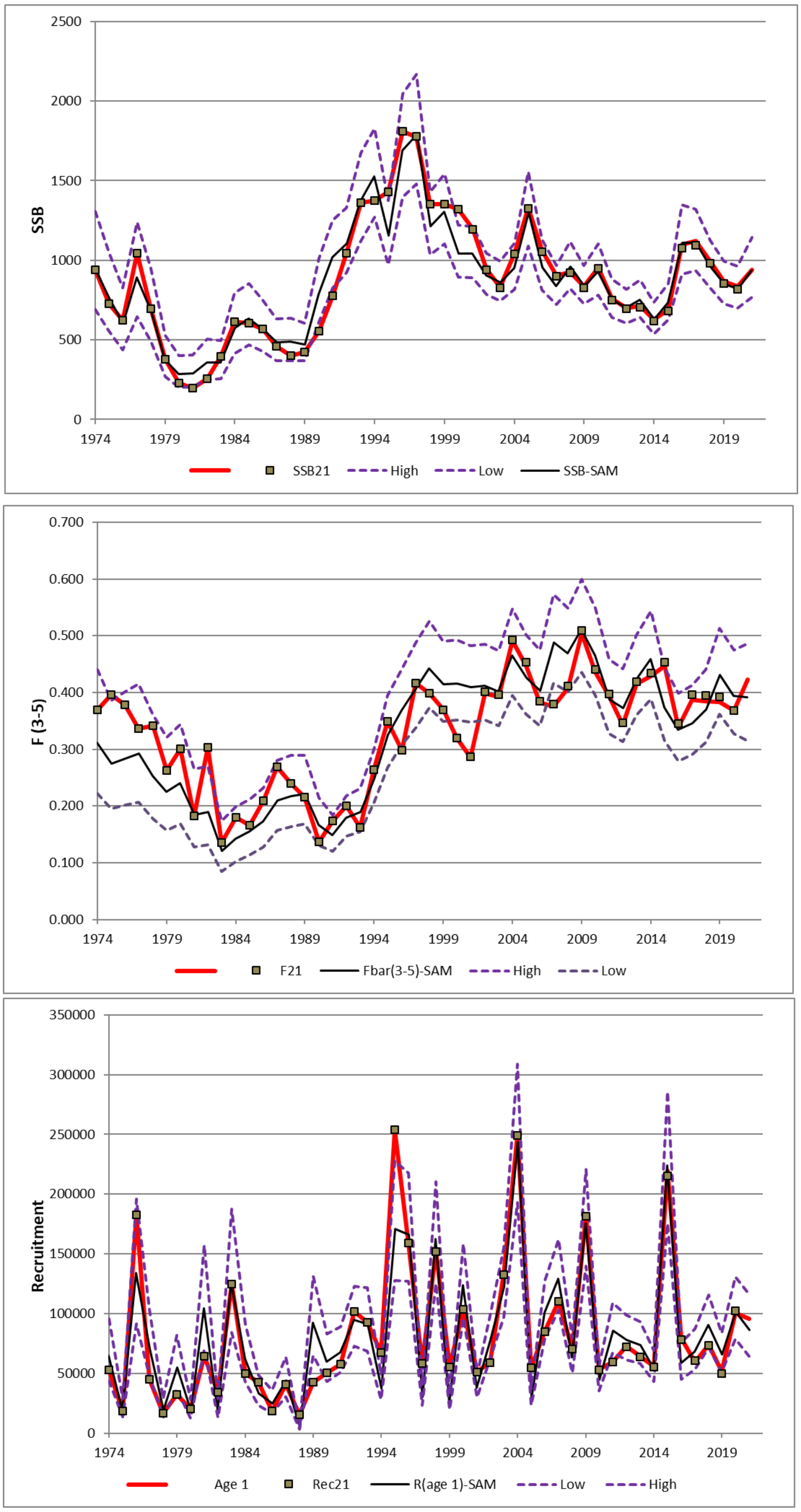


Figure 7.11. Sprat in SD 22-32. Comparison of spawning stock biomass, fishing mortality, and recruitment (age 1) from present XSA (red line), 2021 XSA (squares) and SAM (black). Uncertainties of SAM estimates are shown (thin, broken lines).

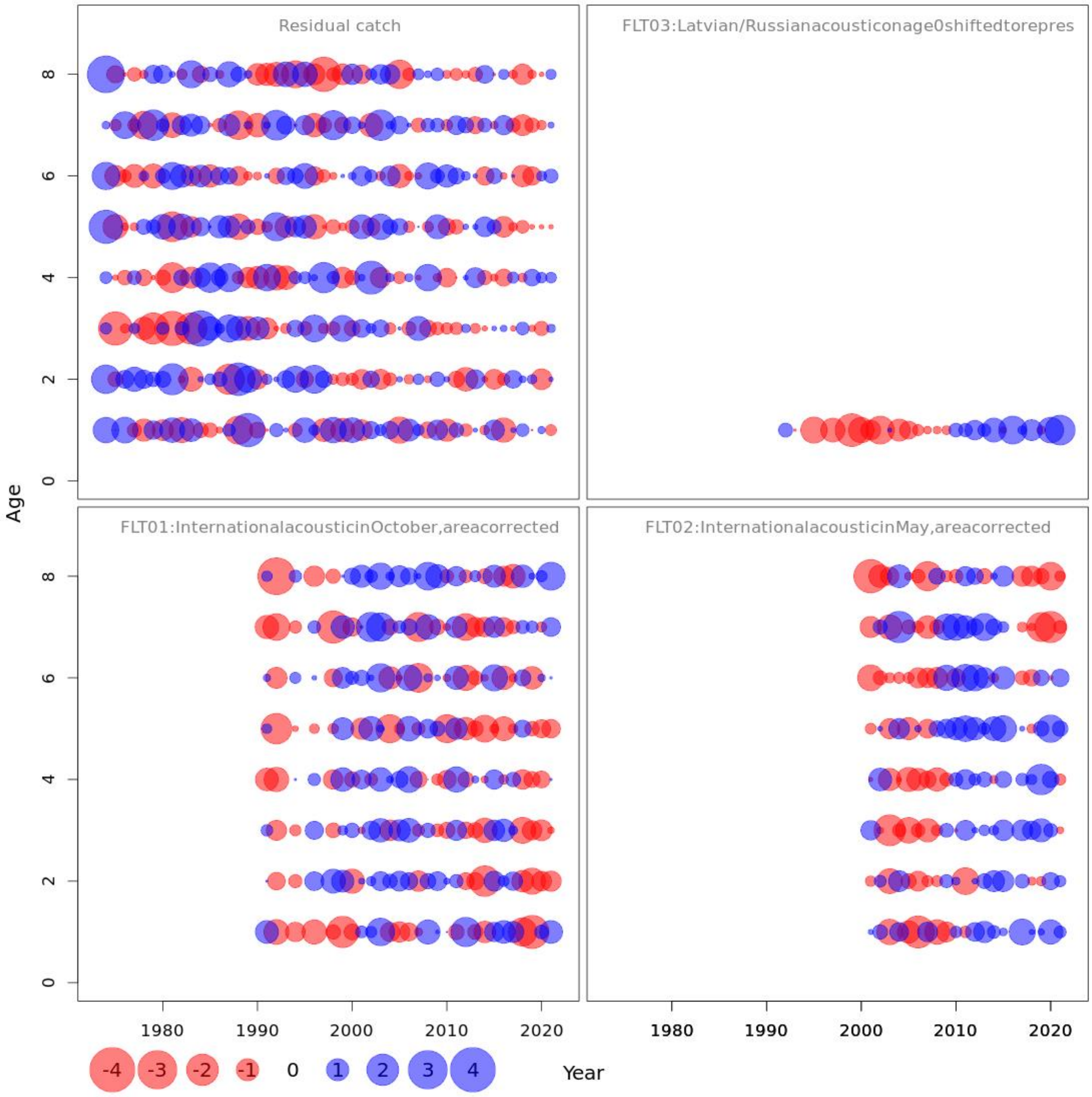


Figure 7.12a. Sprat in SD 22-32. Log catchability residuals by fleet from SAM.

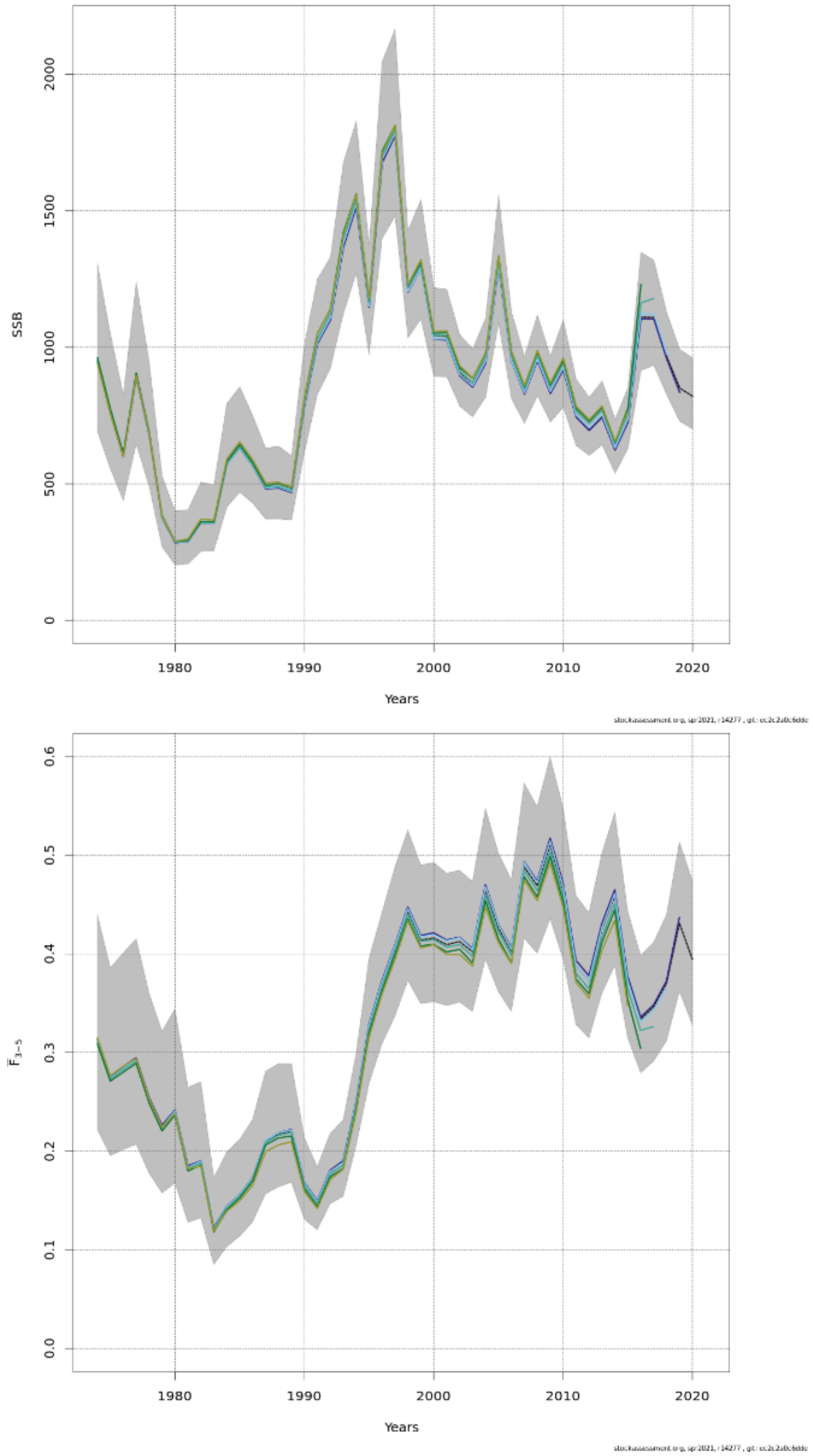


Figure 7.12b. Sprat in SD 22-32. Retrospective analysis from SAM.

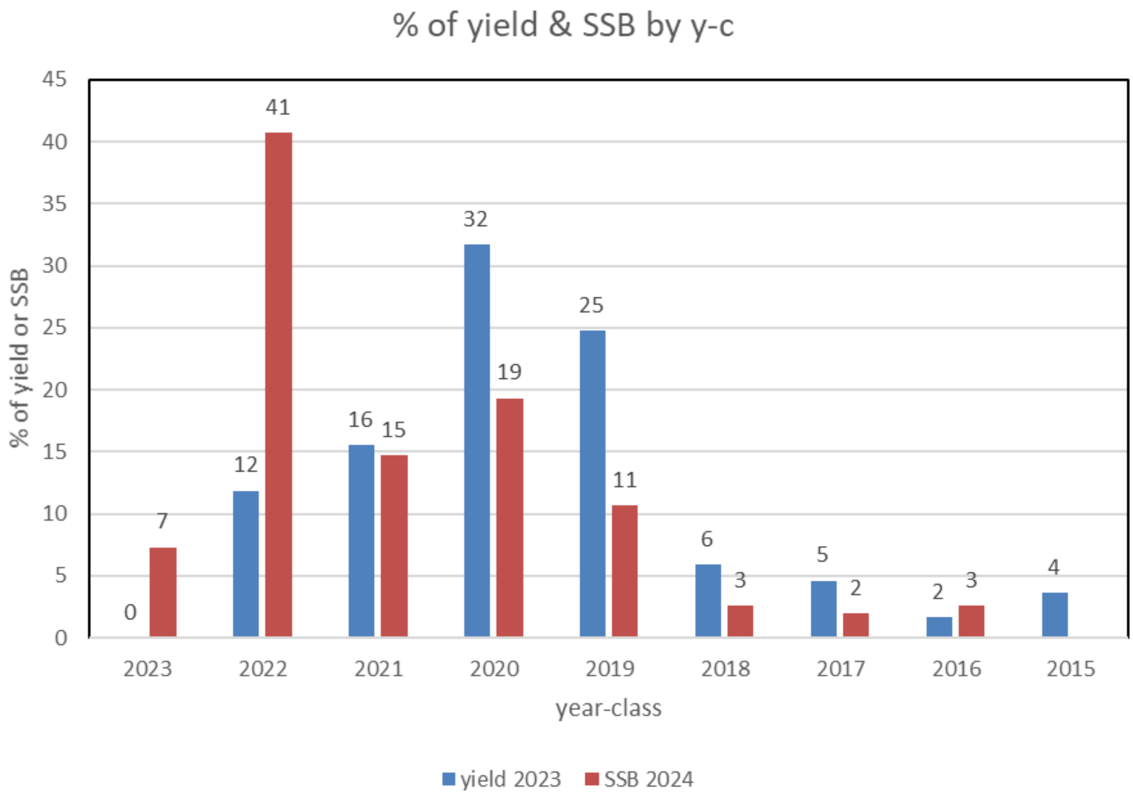


Figure 7.13. Share of year classes in sprat yield in 2023 and spawning biomass in 2024 (sensitivity of short-term prediction).

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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, 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 2021 were about 209 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 were available from all 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 2021. Due to the low sampling coverage of the discarded catch fraction in the past, the estimates are considered too imprecise to be used for catch advice. The advice is given for landings only.

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 is increasing. Discards in 2020 and 2021 were exceptionally high, about three times higher (>60%) than the average discard since the beginning of the time-series. An increasing amount of smaller turbot was caught, especially in trawl fisheries. Similar, a signal of above-average recruitment is apparent in the most recent survey index.

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

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.

8.1.3 Fishery independent information

Stock indices (CPUE) were estimated as mean catch-in-number per hour for turbot with a length of ≥ 20 cm. The CPUE values of the small BITS trawl (TVS) were multiplied with a conversion factor of 1.4 (Figure 8.1.2). Stable indices with low fluctuations were observed for the time period since 2001. The index of 2021 remained stable compared to the previous year but is still on a low level (~1.73 turbot/hour) compared to earlier years. The length distribution indicates a higher much number of turbot (around 20% larger than in previous years) entering the index in 2022, as it only considers turbot larger 20 cm TL. A similar signal of incoming smaller turbot was also seen in the commercial fisheries data where discards of turbot <25 cm increased to over 60%.

The index changed compared to previous years due to new submissions of previously missing “zero catch” strata. Since the numbers of caught turbot are relatively low, even small updates in the database can cause large changes in the index. The trend of the index however did not change.

8.1.3.1 Catch in numbers

The catch in numbers per length for the three most recent years is given in Figure 8.1.3. Almost no turbot above 35 cm are caught. High numbers of smaller turbot <25 cm were caught.

8.1.3.2 Biomass Index considerations

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

A direct comparison between the CPUE index and the biomass index is given in Figure 8.1.5. No differences in the general trend between the two indices was detected and WGBFAS decided to keep the currently used index. A biomass index shall, however, be investigated and considered during the benchmark and will be included at the issue list for the Baltic Sea turbot benchmark.

8.1.4 Assessment

An update advice was 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 2021 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 8.1.4).

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 2014–2021 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 8.1.4) show that the stock status of tur.27.22–32 is below possible reference points (Table 8.1.3). 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 is, in fact at the lowest level (<1%) for the second year now, 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 2021. This might be an artifact of the high amount of small turbot, as the amount of larger individuals did not decrease significantly.

Table 8.1.1. 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			20	32	2		245	65		5	2	15		7	21	2	8	18	50								
2003	48		28	5	0			10	39	1		184	178		1	2	18		3	14	7	2	13	28								
2004	61		27	7				12	27	1		225	96		1	1	8		3	14	3	8	7	15								
2005	57	5	36	12				14	35	1		123	57		1	3	6		5	21	1	6	18	19								
2006	30	5	16	33				19	45	1		87	11		1	2	5	0	4	19	3	3	9	12								
2007	60	5	26	5	0			22	34	0		83	8		0	5	5		2	15	0	1	12	24								
2008	79	5	33	6				24	30	0		95	15		1	7	11		8	17			10	14								
2009	111	6	35	7	0			33	50	1		92	11		1	6	10	0	5	6	0	0	11	8								
2010	102	6	31	4	0			24	35	0		38	1		1	4	16	0	4	8	3	7	9	2								
2011	84	3	24	3	0			26	31	0		66	11	0	0	0	0	0	0	0	3	6	0	5	0	0	0	0	0	0	0	0
2012	43	3	16	1	0			16	27	0	0	55	11	0	0	0	0	0	0	0	5	5	14	15	0	0	0	0	0	0	0	0
2013	66	5	21	1	0			23	40	0	0	61	12	0	1	6	16	0	1	3	5	4	13	20	16	0	0	0	0	0	0	0
2014	84	5	27	1	0			35	30	0	0	25	5	0	1	3	13	0	2	4	2	5	7	6	0		0				0	
2015	84	5	22	1	0			27	19	0	0	41	8	0	0	4	9	0	1	1	0	4	4	3	0	0	0	0	0	0	0	0
2016	68	4	37	3	0			25	23	1		43	13	0	2	5	9	0	1	1	1	5	7	6	0	0	0	0	0	0	0	0
2017	76	5	18	3	0			41	33	0		55	8	0	1	2	4	0	1	1	0	1	7	7	0	0	0	0	0	0	0	0
2018	103	9	41	3	0			37	55	<0.5		72	4	<0.5	1	14	11	0	1	2	1	5	<0.5	7	0	0	<0.5	0	0	0	<0.5	<0.5
2019	53	2	25	1	0			20	26	<0.5		50	5	0	1	3	2	0	1	2	1	4	5	1			0			0	0	0
2020	57	3	26	0				28	19	<0.5		42	3	0	<0.5	3	5	0	2	2	0	2	2	0	0	0	0	0	0	0	<0.5	<0.5
2021	49	6	17	1				33	10	<0.5		66	5	0	1	6	4	0	2	3	0	2	4	<0.5	0	0	0	0	0	0	<0.5	<0.5

continued

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	313
2014	119	5	60	39	19	2	9	0	253
2015	111	5	45	51	15	1	5	0	233
2016	94	6	64	56	28	1	7	0	255
2017	117	5	53	63	23	1	2	0	265
2018	141	10	111	87	13	1	7	0	370
2019	73	3	69	38	11	1	6	0	201
2020	86	4	62	34	5	2	5	0	197
2021	83	7	54	49	10	2	5	0	209

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 8.1.2. 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 8.1.3. Turbot in the Baltic Sea Indicator status for the most recent three years 2019-2021.

	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} / $L_{F=M}$**
2019	0.80	1.20	0.84	0.08	0.79	1.10
2020	1.10	1.15	0.69	0.01	0.73	0.87
2021	0.71	1.20	0.68	0.01	0.74	1.10

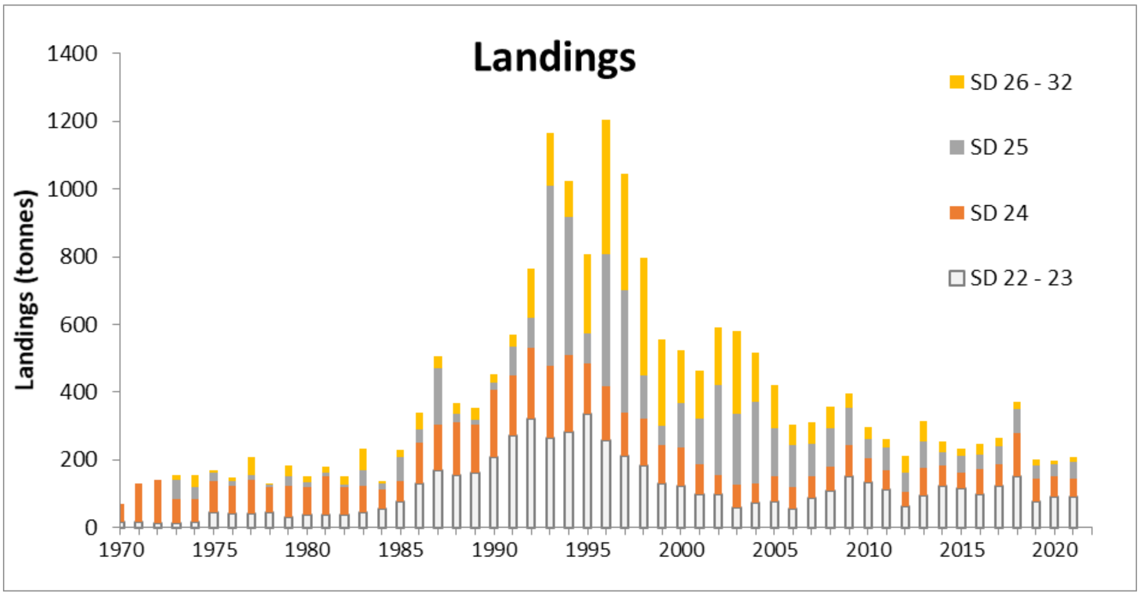

Figure 8.1.1. Turbot in the Baltic Sea. Development of turbot landings [t] from 1970 onwards by ICES subdivision (SD).

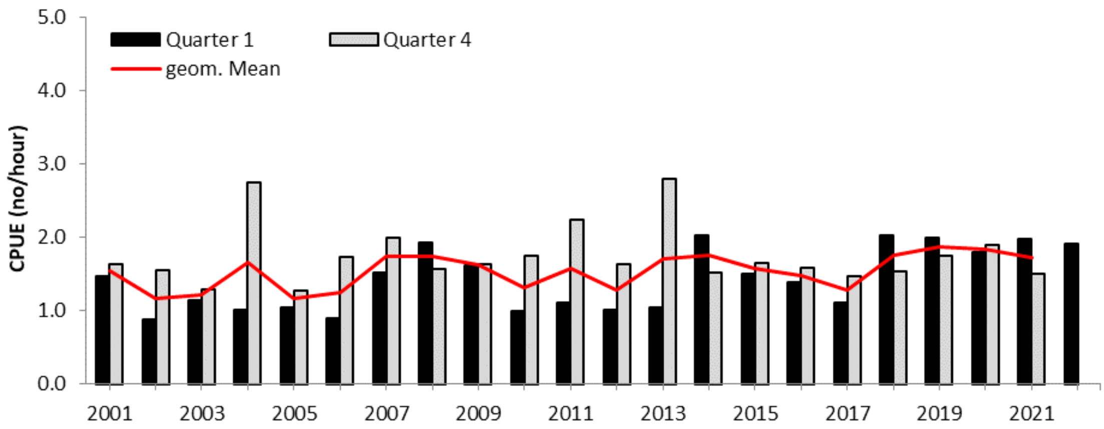

Figure 8.1.2. Turbot in the Baltic Sea. Mean CPUE (no. hr^{-1}) of turbot with L ≥ 20 cm based on arithmetic mean of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–28.

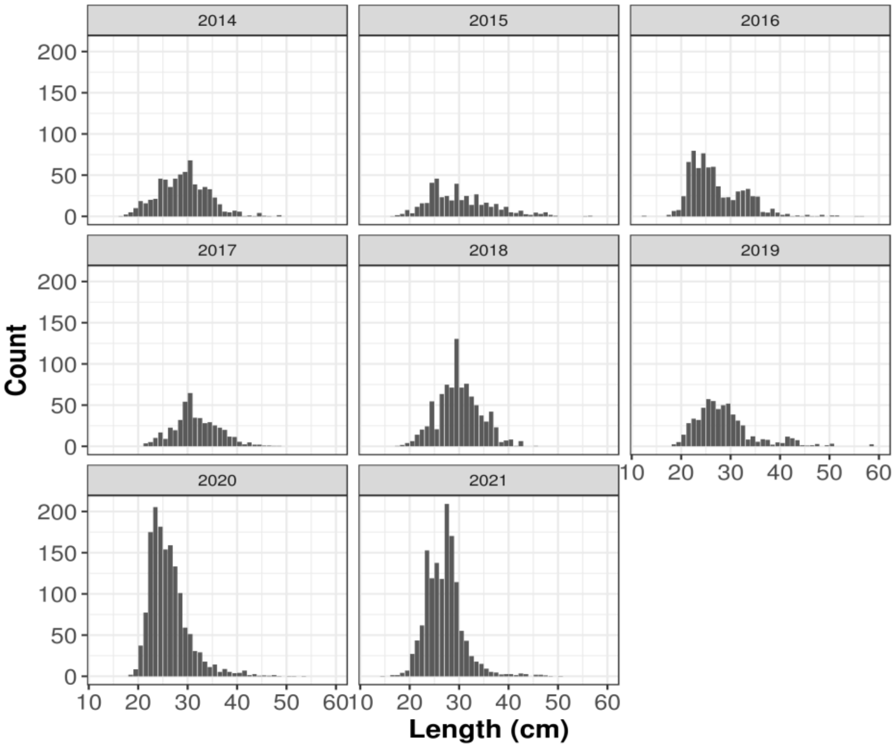

Figure 8.1.3. Turbot in subdivisions 22 to 32. Binned length frequency distributions.

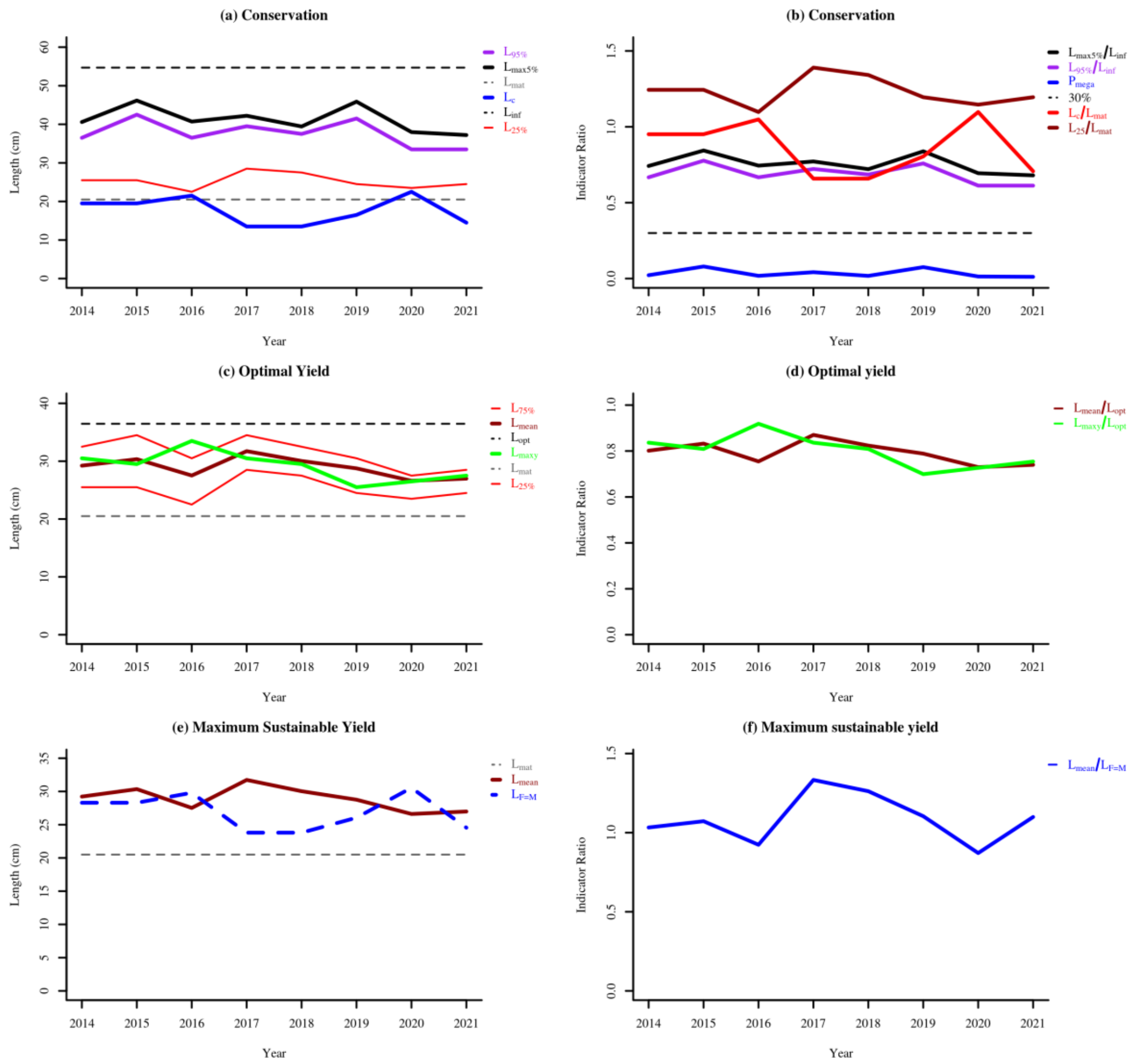

Figure 8.1.4. Turbot in subdivisions 22 to 32. Indicator trends

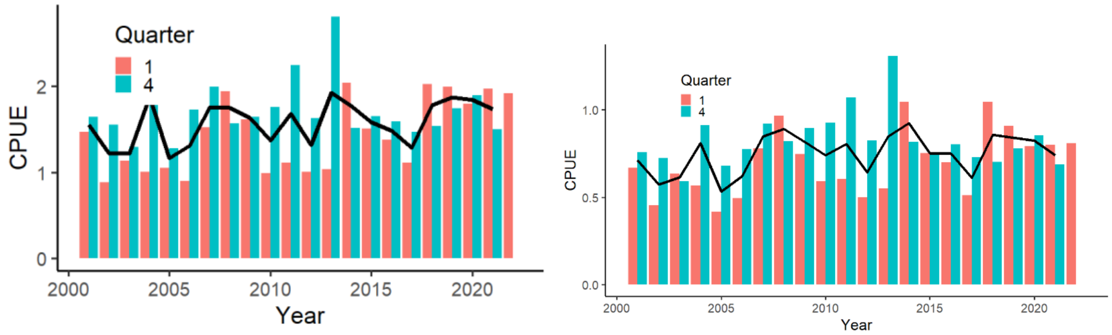

Figure 8.1.5. Turbot in subdivisions 22 to 32. Survey index difference in CPUE (no/hour, left) and biomass (kg/hour, right)

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 2021, landings decreased to below 793 t.

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 bycatches of the directed cod fishery and the target of a mixed flatfish fisheries.

8.2.1.2 Discard

Estimates of discards are available from Denmark and Germany since 2012.

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

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 8.2.2. Almost no dab above 35 cm were caught.

8.2.3 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.

8.2.4 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 an 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 2020 has increased by about 10% compared to the previous years' index values (Figure 8.2.3). The length-based indicators (proxy reference points) are stating a good status of the stock. 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 2014–2021 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.

8.2.5 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				Ger. Dem. Rep.[1]		Germany, FRG				Sweden[2]								Total									Total
	22	23	24(+25)	25-28	22	24	22	24	25	26	22	23	24	25	27	28	29	30	22	23	24[3]	25[5]	26	27	28	29	30	SD 22-30
1970	845		20		11		74												930	0	20	0	0	0	0	0	0	950
1971	911		26		10		64												985	0	26	0	0	0	0	0	0	1011
1972	1110		30		9		63						23						1182	0	53	0	0	0	0	0	0	1235
1973	1087		58		18		118						30						1223	0	88	0	0	0	0	0	0	1311
1974	1178		51		18		118						34						1314	0	85	0	0	0	0	0	0	1399
1975	1273		74		20		131						32						1424	0	106	0	0	0	0	0	0	1530
1976	1238		60		17		114						27						1369	0	87	0	0	0	0	0	0	1456
1977	889		32		13		89						25						991	0	57	0	0	0	0	0	0	1048
1978	928		51		19	14	128	4											1075	0	69	0	0	0	0	0	0	1144
1979	1413		50		18	25	123	1					9						1554	0	85	0	0	0	0	0	0	1639
1980	1593		21		15	25	101						3						1709	0	49	0	0	0	0	0	0	1758
1981	1601		32		24	39	164						5						1789	0	76	0	0	0	0	0	0	1865
1982	1863		50		46	38	182	4					6	5	8	6		1	2091	0	98	5	0	8	6	0	1	2209
1983	1920		42		46	28	198						24	20	32	22		2	2164	0	94	20	0	32	22	0	2	2334
1984	1796		65		30	47	175	2					4	3	5	4		1	2001	0	118	3	0	5	4	0	1	2132
1985	1593		58		52	51	187	2					3	3	5	3		1	1832	0	114	3	0	5	3	0	1	1958
1986	1655		85		36	35	185	1					1	1	1	1			1876	0	122	1	0	1	1	0	0	2001
1987	1706		93		14	87	276	4					1	1	1	1			1996	0	185	1	0	1	1	0	0	2184
1988	1846		75		22	91	281	1					1	1	1	1			2149	0	168	1	0	1	1	0	0	2320
1989	1722		48		26	19	218	1					1	1	2	1			1966	0	69	1	0	2	1	0	0	2039
1990	1743		146		14	11	252	1					8						2009	0	166	0	0	0	0	0	0	2175
1991	1731		95				340	5					1						2071	0	101	0	0	0	0	0	0	2172
1992	1406		81				409	6						1	1		4		1815	0	87	1	0	1	0	4	0	1908
1993	996		155				556	10				7	1	1			1		1552	7	166	1	0	0	0	1	0	1727
1994	1621		163				1190	80	45			5	1	1					2811	5	244	46	0	0	0	0	0	3106
1995	1510	47	127	10			1185	49	3			5	1	5		1			2695	52	177	18	0	0	1	0	0	2943
1996	913	37	128				991	134	13	2	3		3	4	1				1907	37	265	17	2	1	0	0	0	2229
1997	728		60				413	21	2			5	5	10	3	1			1141	5	86	12	0	3	1	0	0	1248
1998	569		89				280	6	2			7	3	3	1				849	7	98	5	0	1	0	0	0	960
1999	664		59				339	4				3	1	1					1003	3	64	1	0	0	0	0	0	1071
2000	612		46				212	3				2		1					824	2	49	1	0	0	0	0	0	876
2001	586		72				191	5				4	1	2					777	4	78	2	0	0	0	0	0	861
2002	502		31				173	5				4							675	4	36	0	0	0	0	0	0	715
2003	559		171				494	7	0			1	0						1053	1	179	0						1233
2004	953		185				745	10	0			1	1	0					1698	1	196	0						1894
2005	752	34	163	16			474	45	9			1	1	0					1226	35	209	25	0	0	0	0	0	1495
2006	400	23	112	161			494	24	11			1	2	0		0			894	24	138	172						1228
2007	860	40	108	7			472	18	0			0	0	0	0	0			1332	40	126	7						1504
2008	757	36	86	222			507	33	0			3	0	1	1	2			1264	39	119	223		1	2			1648
2009	521	25	97	0			587	32	0			2	0	0	1	3			1108	27	129	1		1	3			1268
2010	552	18	51	0			398	17	2			1	0	0					950	19	69	2						1041
2011	544	20	39	0			647	15	0			1	0	1	0	0			1192	21	53	1						1268
2012	481	22	69	0			692	20	0	0	0	1	0	0	0	1	0	0	1173	23	89	0						1285
2013	445	18	69	0			834	17	0	0		0	0	1	0	0	1		1279	18	86	1						1384
2014	373	11	57	0			801	25	2	0		0	0	0	0	0			1174	11	82	2						1269
2015	268	9	21	0	0	0	955	14	0	0	0	0	0	0	1	0	0	0	1223	9	35	0	0	1	0	0	0	1268
2016	268	14	21				1027	23	1	0	0	0	0	0	1	1	0	0	1295	38	23	1	0	1	1	0	0	1358
2017	276	9	15				874	50			0.0	0.1	0	0.4	0	0.6	0.7	0	1150.7	59.3	15.1	0.4	0	0	0.6	0.7	0	0
2018	273	18	20	0			560	66			0.0	1.3	0	0.1	0	0.0	0.0	0	833.2	86.1	19.9	0.2	0	0	0.0	0.0	0	0
2019	388	15	68	0			592	37			0.2	2.4	0	0.0	0	0.0	0.0	0	979.6	54.3	67.8	0.0	0	0	0.0	0.0	0	0
2020	398	13	95	0			469	49			0.0	1.3	0	0.1	1	0.0					95.0	0.1	0	1	0.0	0,0	0	1
2021	243	7	89	0			414	37	0		0.0	0.8	0	0.0	1	0.0	0.0	0	657.2	44.8	89.4	0.0	0	1	0.0	0.0	0	1

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}**	**$L_{max 5}$ / L_{inf}**	**P_{mega}**	**L_{mean} / L_{opt}**	**L_{mean} / $L_{F = M}$**
2019	0.53	1.14	0.87	0.25	0.98	1.45
2020	0.58	1.14	0.89	0.25	0.96	1.36
2021	0.75	1.08	0.87	0.23	0.96	1.20

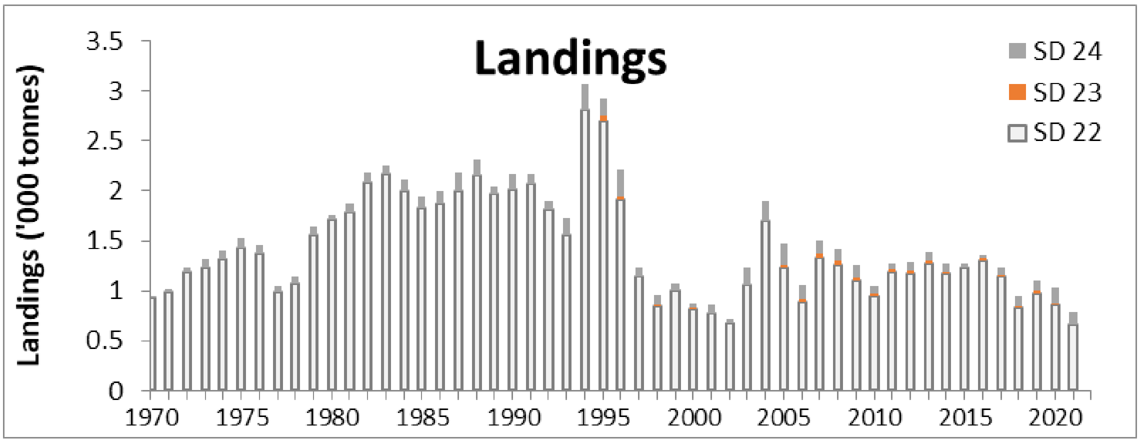

Figure 8.2.1. Dab in subdivisions 22 to 32. Development of dab landings [t] from 1970 onwards by ICES subdivision (SD).

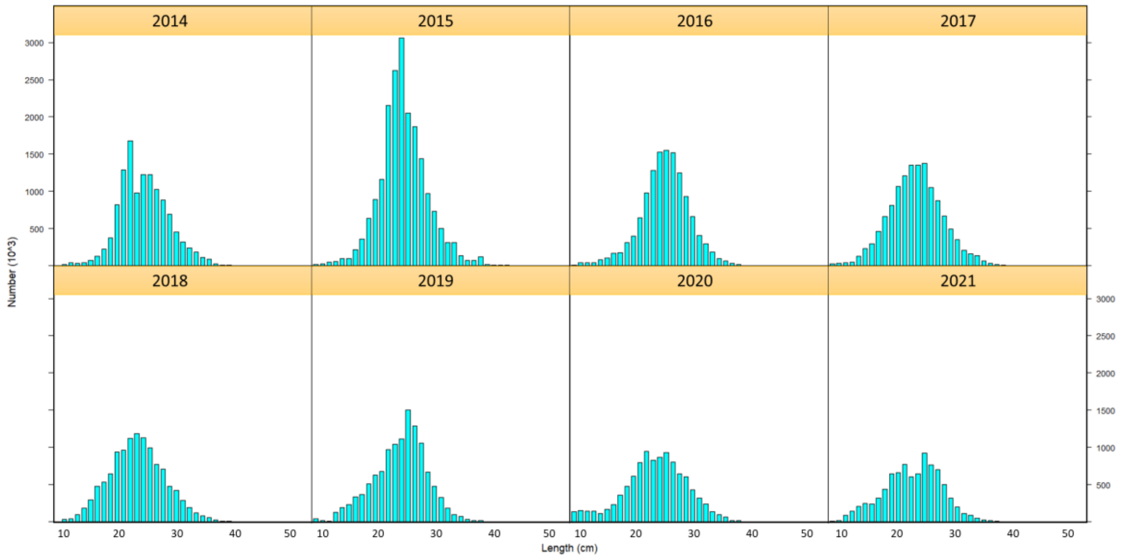

Figure 8.2.2. Dab in subdivisions 22 to 32. Catch in numbers per length for the years 2014–2021.

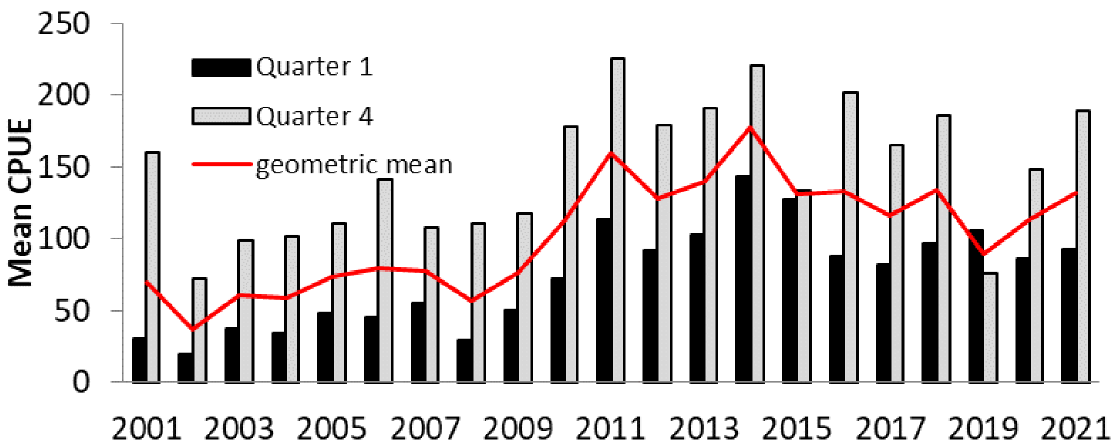

Figure 8.2.3. Dab in subdivisions 22 to 32. Mean biomass (kg hr^{-1}) of dab with L ≥ 15 cm based of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–24.

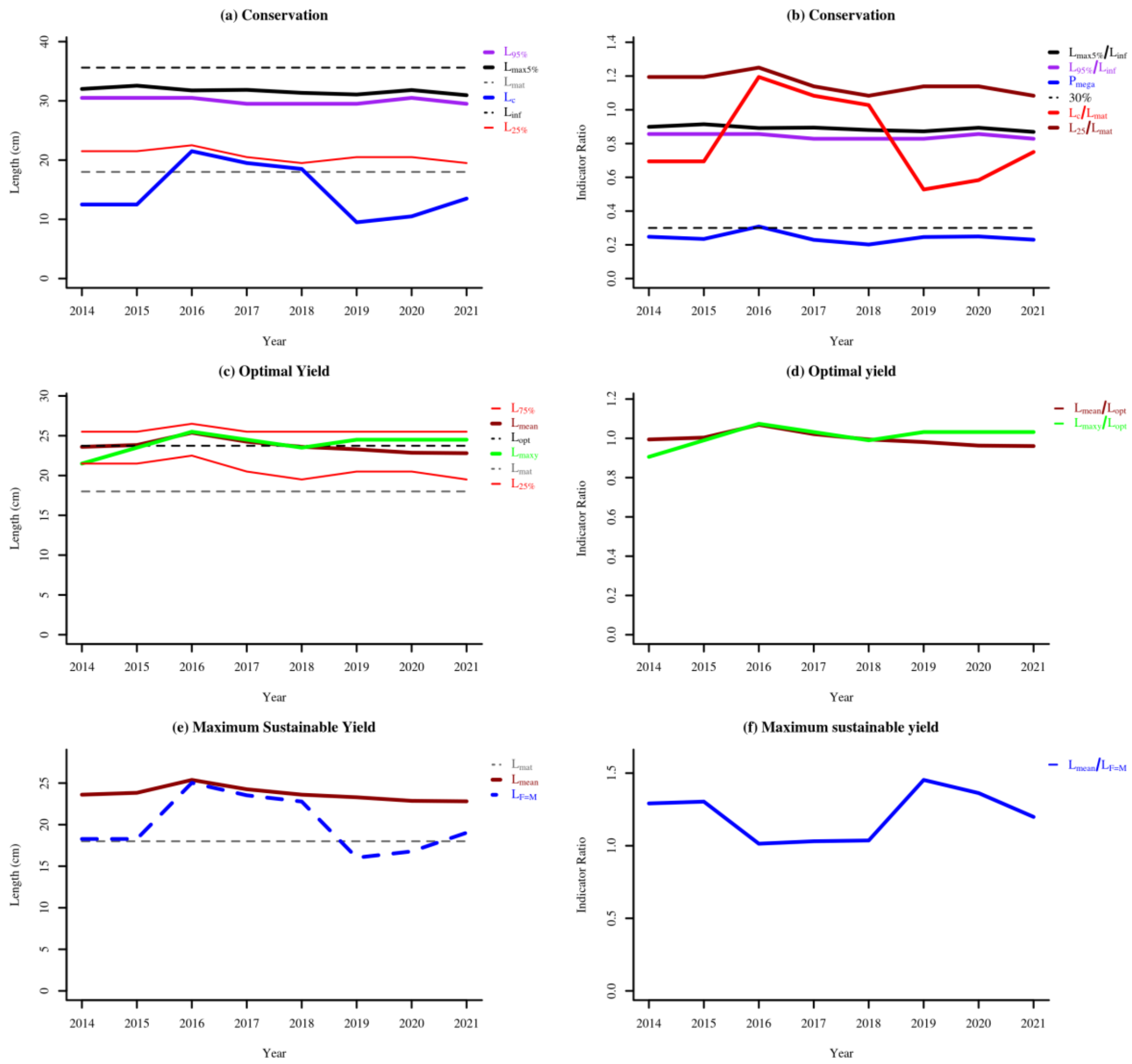

Figure 8.2.4. Dab in subdivisions 22 to 32. LBI F_{MSY} Proxy reference points

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 which is continued with landings of 30 t in 2012, 31 t in 2013 and 28 t in 2014. 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 65 t. In 2021, landings were 55 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 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 Subdivision 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 analyzed 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 (Van damme, 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 subareas sampled in the ICES subdivisions. 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. Since 2018 the index increased, but decreased in 2020 and 2021. 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. Survey catches are highest in the Kattegat and the Belt Seas (Figure 8.3.3). It might be worth-while considering how to best combine Brill stocks assessed by ICES.

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

Year	Denmark			Germany		Sweden		Total			Total
	22	23	24-28	22	24	23	24-28	22	23	24-28	SD 22-28
1994	57	4	1				1	57	4	2	63
1995	134	12	1			5	8	134	17	9	160
1996	56	6						56	6	0	62
1997	25					1		25	1	0	26
1998	21					1		21	1	0	22
1999	24					1		24	1	0	25
2000	27					1		27	1	0	28
2001	19							19	0	0	19
2002	25		0			1		25	1	0	27
2003	35		1			0		35	0	1	36
2004	39		1			1	0	39	1	1	41
2005	50	9	3			0	0	50	9	3	62
2006	42	9	2	3		0	0	45	9	2	56
2007	50			5		0	0	55	0	0	56
2008	81	9	3	11		1	1	92	10	3	105
2009	70	7	2	11		1	0	82	8	3	92
2010	65	4	1	10		0	0	76	5	1	82
2011	46	5	1	4		1	0	50	6	1	57
2012	24	4	0	2		1	0	26	4	0	31
2013	24	6	0	1	0	1	0	25	7	0	31
2014	19	5	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	29	6	0	4	0	0	0	33	6	0	39
2018	36	11	1	6	1	1	0	41	11	1	53
2019	35	6	1	5	0	1	0	40	7	1	48
2020	43	11	2	8	0	1	0	51	12	2	65
2021	34	9	2	8	1	2	0	42	11	1	55

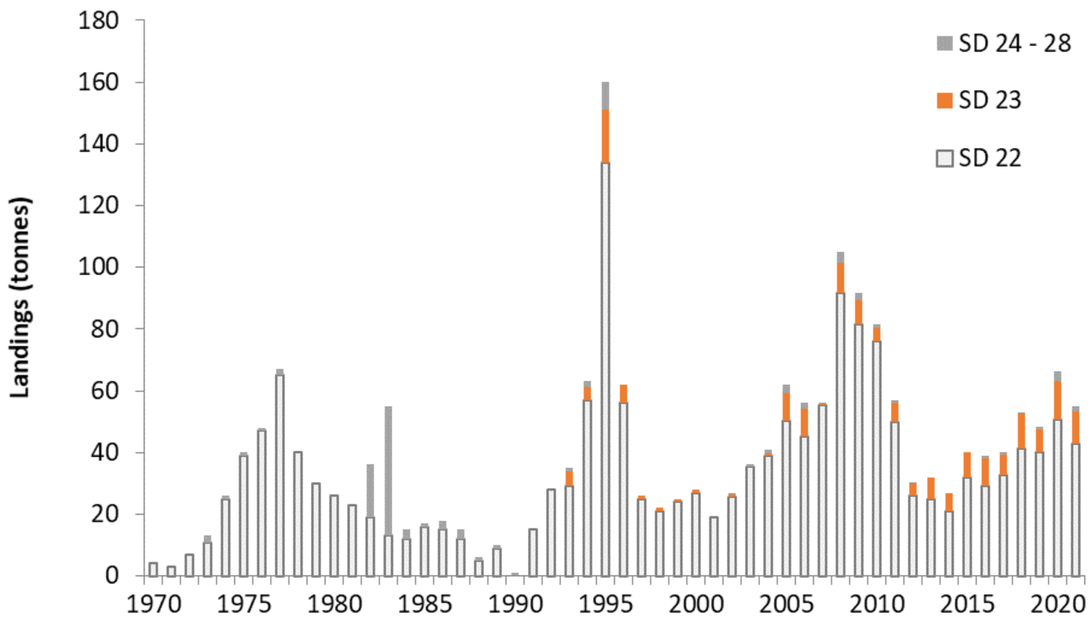

Figure 8.3.1. Development of brill landings [t] from 1970 onwards by ICES subdivision (SD).

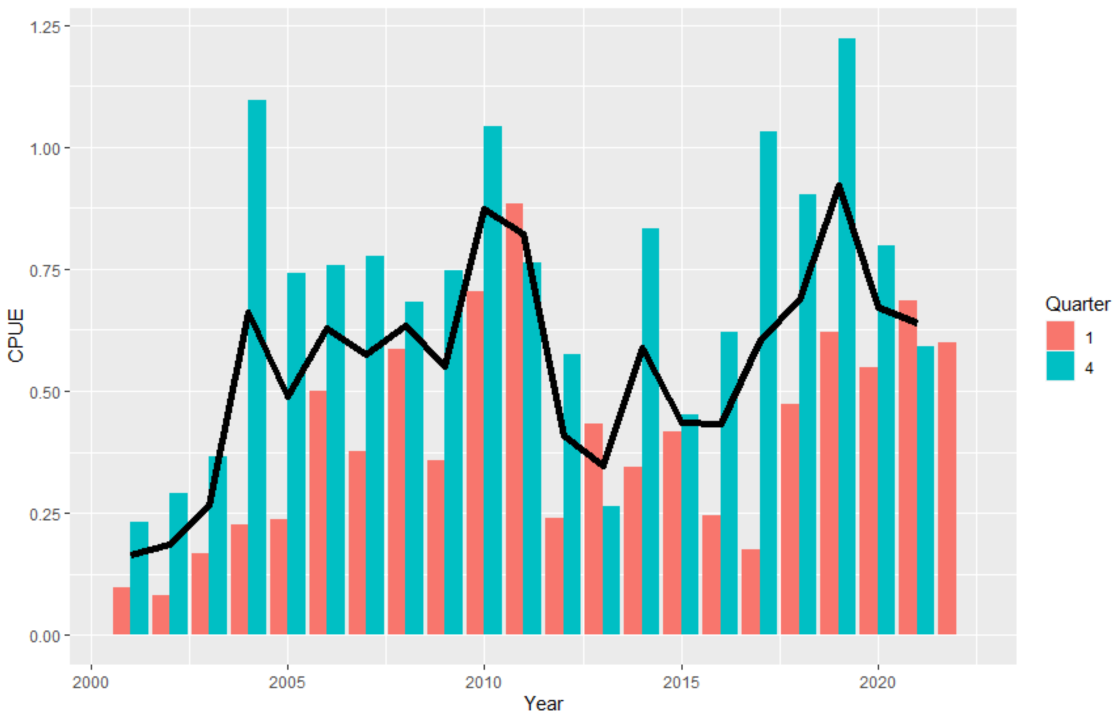

Figure 8.3.2. Mean CPUE (no. hr^{-1}) of brill with L ≥20 cm.

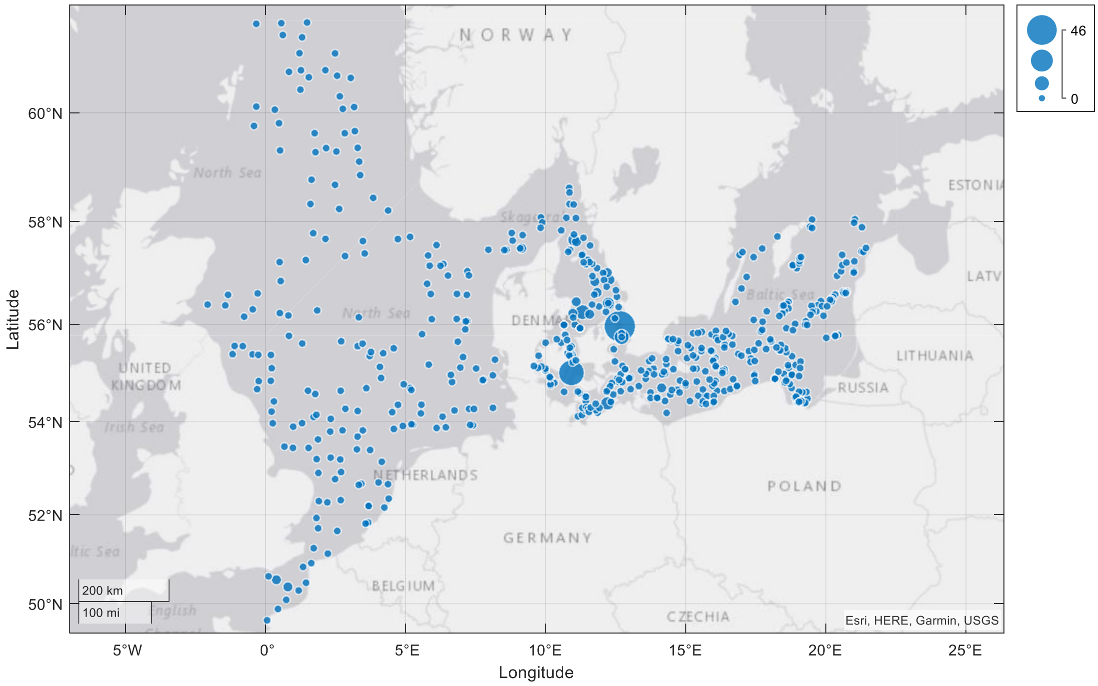

Figure 8.3.3 Brill distribution in the Baltic Sea, CPUE in numbers per hour indicated in colour bars.

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Annex 2: Reviews

Review of ple.27.2432

This review concerns the stock assessment of Plaice in areas 27 and 24-32. The main method applied for the advice is a SPiCT surplus production model, supplemented by an exploratory SAM model.

The SPiCT assessment provides reasonable output given the available data, which has a moderately short timeframe. The availability of both models on stockassessment.org was very helpful in analyzing the stock review.

There are two issues with the SPiCT model:

1) The fit to the two survey indices show substantial autocorrelated residuals in recent years. One survey is consistently underestimated, and the other is consistently overestimated. As the surveys both provide a similar direction (i.e., biomass moving upwards), the general trend of the stock appears to be well estimated by SPiCT. Some of this could be due to survey smoothing, but the documentation of the survey standardization was too vague to determine that.
2) It is unclear what the introduction on the fairly narrow prior on *r* means for the fit to data and the associated reference points. I would recommend conducting a sensitivity analysis on both the standard deviation and the mean of the prior to clarify that the prior choice doesn't impact reference points and estimated values.

General comments

The whole document is messy and unclear. Several tables are not referenced in the text, and two of the first tables have estimates of recruitment, Fbar and SSB from a model that is not the primary assessment model. A lot of the figures require an additional look at the caption to explain colors and linetypes. The figures are not denoted (e.g., A-D) either, even though they are references in the main text as denoted. In general the documentation seems to be ported from last years assessment which concerned a different assessment model (exploratory SAM).

The two models (SPiCT and SAM) appear to draw different conclusions on the terminal years in the stock assessment, where SPiCT plateaus and SAM has almost exponential growth. I think this comes down to the relative fit to the two surveys, but could also be in the age-structure component from SAM. Before using both models for advice or exploration it would be relevant to determine where these differences come from.

The catch residuals change quite a lot over time with the most recent years showing much higher variability.

I recommend acceptance of the current stock assessment for advice, but suggest analyzing the above comments in detail for future years.

Specific comments

Section 5.1.2.2

Does the mean weight at age calculation take into account the different gears used for survey/catch?

Section 5.1.2.3

Parts of this natural mortality section does not fit into the document. The main assessment model is SPiCT where you do not specify natural mortality (as listed here). I would recommend moving the assumptions on natural mortality (and other life history parameters) into a separate section concerning the exploratory SAM model.

Section 5.1.2.4

The maturity ogive here is relevant, but it is not used as input in the SPiCT model.

Section 5.1.3

The description of the survey standardization is vague and unclear. Please provide a mathematical formulation of the survey index. I am unsure whether this data has been standardized in a GAM or GLM model (which would be appropriate).

Section 5.1.4

'fro' should be 'from'

Section 5.1.4.1

Note that the 'B_{msy}/K is at 48% (2021 estimates).' Is the stochastic reference point. Since a Schaefer model structure is assumed Bmsy/K should always be 0.5.

Section 5.1.4.2

'Coduted' should be 'conducted'

Section 5.1.6

The tables provided here are inline in comparison with the other tables in the document. The order of the tables appears to be incorrect as well.

I am not sure that I understand what it means that the F is scaled to the intermediate year. Please clarify.

Table 5.3.7

Is the 35th percentile a standard ICES control rule (sorry for my ignorance). Perhaps refer to the document that establishes this HCR and why it is used here. I did not seem to

F2022 Total catch is inconsistent with the value provided in the text (1347.4 vs 1344).

Section 5.1.6 continued

"It should be noted that these will vary when new survey and catch information is added."

Uncertainty should become smaller, but hopefully the reference points should not change much over time; if they do it means there's a large retro.

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

The surplus production should include fisheries catches

Section 5.1.7

These are not significantly different to the results obtained by WGBFAS last year.

Is this significance tested or do they just look similar?

Table 5.3.8

This data is already in table 5.3.5. The cilow and ciupp names don't make sense. Change to 'upper 95th confidence interval' and so forth.

Section 5.1.7.1

The life history information provided earlier should be listed in this section where it is actually used.

"The result (Figures 5.3.12a-c) shows"

a-c is not denoted in the figures.

"47.2 mill. which is the highest value since 2002 and more than double compared to the previous year (i.e. 18.4m in 2021). First signals of the 2022 BITS index show an increase in age 0 and age 1 plaice, "

Age 0 is not included in the BITS index (at least not on stock assessment.org). I would be mindful of this result – it is based solely on one datapoint on a size class that has significant uncertainty attached to it (gear effect). The actual recruitment will become more clear when there's a quarter 4 and new quarter 1 datapoint to follow the cohort in.

"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 (Figure. 5.3.12). "

In regards to the comment above, it is also worth noting that the BITS quarter 4 has very strong negative residuals in recent years, suggesting that the model overestimates the abundance. It's hard to see the retro from figure 3.5.2. Perhaps clarify what base and current in the legend is, or do some plots with a couple of more peels.

Section 5.1.9

"the relative recruitment estimates (3.8) increased strongly compared to the previous assessment (1.67). "

Note that this is for the exploratory model only. SPiCT doesn't provide recruitment estimates. Perhaps it would be relevant to comment on the surplus production here.

Section 5.1.10

"The conducted SPiCT assessment relies strongly on survey data and catches; adding a tuning fleet using commercial effort might be beneficial to improve the quality of the ouput."

Adding commercial CPUE would not be a good addition to this spict model – given the high rate of discards the CPUE is unlikely to explain any trend in population abundance, as it is not the main target of the fishery.

Table 5.3.3 and 5.3.4

These tables are not referenced in the text, and only contain information from the exploratory SAM model – SpiCT doesn't provide estimates of Fbar or recruitment. Please clarify the captions for the table or perhaps even leave them out of the document, as it is not the final model.

Table 5.3.5

The table headers in this table should probably have meaningful names rather than their R values. (e.g., upper confidence interval etc.). See also comment on table 5.3.8.

Figure 1

The reference in the caption is missing from the document (it has no bibliography).

Figure 5.3.4

What does tsd mean (as noted on the y axis).

Figure 5.3.5

A matter of taste, but to me the gridding on the figure is confusing. Perhaps clarify how the fleets were combined and why there are missing data points.

Figure 5.3.6

Does catches in this caption mean survey CPUE index? Usually catches refer to commercial catch

Figure 5.3.9

Color scale for the dots are missing. The second y-axis doesn't really make sense in the two top figures (they are listed in the figures below). Two of the figures are identical to the figures in figure 5.3.8

Figure 5.3.10

The retro looks fine on these figures. It would be helpful with a table with the four values of Mohns rho

Review of bwp.27.2729-32 Report (Flounder in Subdivision 27, 29-32)

General Summary:

This is a review of the assessment of demersal spawning flounder inhabiting mainly the Northern Baltic Proper (SD 27, 29-32). No advice on fishing opportunities was requested; therefore the assessment's only objective was to evaluate stock status. The results support the main conclusion that the stock has been overfished over the last five years. However, there is a lack of clarity in methodology and some sensitivity runs are missing. The report also indicates that fishing is occurring at the optimal size (L_{mean}/Lopt ~ 1), which appears well supported.

Stock status advice was provided using category 3 assessment methods of length-based indicators (LBI) and length-based spawning potential ratio (LB-SPR), but only results from the former were presented. Justification for omitting LB-SPR analysis and the results from both analyses should be reported. Both methods are approved and appropriate for assessing this data-limited stock, but clarification and additional information are necessary. Specifically, the LBI analysis results in Table 3.5.7, which were based on the Estonian commercial gillnet records, according to supplementary material bwp.272932_LBI_review, should be explicitly compared to the LBI analysis using the Küdema survey data. The latter analysis was not reported outside of supplementary material (LBI_results_survey Excel file). In addition, it should be clearly reported that sensitivity analyses using M/K=1 and M/K=1.5 yielded similar results.

Further, supplementary materials justified using M/K = 1 based on previous assessments, but whether this value is appropriate remains unstated. Multiple plots of the LBI analysis (indicators and indicators ratios) were also missing from the reports. Finally, the report does not explicitly state that males were excluded in von Bertalanffy analyses and LBI (although it is mentioned in the supplementary report).

The recalculation of L_∞ appears to be an improvement from previous work. Sensitivity analyses regarding the new lower and upper bounds of L_∞ were computed but were not discussed; results appear robust to variation in L_∞ values. However, no sensitivity analyses appear to be conducted for L_{mat}. Authors acknowledged both the bell-shaped selectivity curves of commercial landing gear due to limited mesh sizes (50 and 55 mm bar length) and how this biased the estimate of L_{mean}, but failed to comment on whether this results in an under or overestimation of length-based indicators. The report also does not emphasize the overall declining trends in CPUE across the four fishery-independent surveys since 2017 and their current status of being the lowest values on record.

Background:

This is a data-limited stock with commercial catch predominantly landed using passive gears, gillnets, in the countries of Estonia (80%) and Sweden (10-15%), with Finland and sometimes Poland reporting the remainder of landings. This assessment is primarily focused on a new species, *Platichthys solemdal* (Momigliano et. al 2018), although this is only mentioned in the supplemental material. The extent of discards is unknown and recreational fishing may be substantial but cannot be verified, and therefore recreational fishing was not included. Little age data is currently available, but in 2017 Estonia began sampling commercial gillnet catches from SDs 29 and 32. Four fishery-independent surveys appear appropriate, two in Estonia and two in Sweden. A biomass index was calculated for all four surveys based on CPUE (kg per fishing station and fishing day). LBI and LB-SPR were used to calculate MSY proxy reference points.

Technical Comments:

Two different length-based methods were utilized to assess stock status, although only results from the LBI analysis were presented. While the report declares that LBI based reference points were the most appropriate after an external review, no explanation or summary of the criteria used in the decision was presented. Without strong reasoning to support the assertion that LBI was more appropriate, the review panel believes presenting results for both methods and discussing their properties would be best.

It is unclear whether previous assessments on North flounder used LBI analyses and calculations recently shifted to the commercial data or if both were calculated at this time. The report states, "Up to 2021 the LBI analysis was done using the Küdema survey data, as no representative commercial gillnet length data was available", while information in the supplemental material appears to conflict with this by implying that commercial data has been used since 2017. If the LBI analysis switched from fishery-independent survey data to commercial data this year then a continuity run should be undertaken to identify how the results compare. Authors acknowledge that the commercial gear uses a narrow range of mesh sizes, resulting in a bell-shaped selectivity curve. While this does not result in a critical error, authors should quantify the direction of the biased estimation in Lmean and the consequences of this bias (e.g., more conservative Lmean/Lopt and Lmean/LF=M ratios). Additionally, sensitivity analysis conducted to evaluate the difference between these two data sources should be discussed and presented in the final report.

No information regarding the appropriateness of the assumption M/K=1 was presented in either the report or the supplementary information. A sensitivity analysis between M/K=1 and M/K=1.5 was completed but not mentioned or presented outside of supplementary material. The report also did not address alternative methods of selecting values for M and K (ICES 2018).

The LBI analysis requires equilibrium conditions, and it is difficult to assess if modes within the annual length-frequency distributions migrate between years due to the variable y-axis on figures 3.5.2 and 3.5.5.

Best practices for LBI analysis include recalculating indicators using the upper and lower bounds for both L_∞ and L_{mat} to evaluate the sensitivity of the results (ICES 2018). No sensitivity analysis was performed for L_{mat}, and results from the L_∞ sensitivity runs were not discussed or presented within the report. Plots of the indicators and indicators ratios (ICES 2018) were missing at all L_∞ levels.

Additional Recommendations:

The following would not alter the analysis but may substantially improve the clarity of the report.

1. References and in-text citations were missing from the assessment, resulting in an overall lack of clarity.

2. The report should clarify that there is a newly identified flounder species in the Baltic and expand on how it may or may not confound assessment results.

3. Plots of indicators and indicator ratios (Table 3.5.7) over time were missing from the report and would aid in visualizing results.

4. Figure 3.5.3 (mean weight at age) should be updated to include confidence intervals around estimates or sample sizes or both to improve clarity and conceptualize uncertainty in the aforementioned estimates.

5. The evident decline in stock status seen in the CPUEs from 2017 to 2021, per Figure 3.5.4., should be discussed as a second indicator of poor stock status.

6. Captions for all figures and tables should be updated and provide more detail to better relay the information.

Conclusions

Given the length-based indicators, the stock appears overfished over the last five years. Trends in CPUE for all fishery-independent surveys support this finding as values are the lowest on record, with a noticeable decline since 2017. A justification should be added regarding why LB-SPR results were not included and the appropriateness of assuming M/K=1. Multiple sensitivity analyses evaluating the dependence of analysis outcomes on supplied M/K and L_∞ values were conducted but not summarized in the report, and sensitivity analyses regarding L_{mat} are missing. It is also recommended to include plots of indicators and indicator ratios.

References:

ICES. 2018. ICES reference points for stocks in categories 3 and 4. ICES Technical Guidelines. Published 13 February 2018. https://doi.org/10.17895/ices.pub.4128.

Momigliano, P., Denys, G. P. J., Jokinen, H., & Merilä, J. (2018). *Platichthys solemdali* sp. nov. (*Actinopterygii, Pleuronectiformes*): A New Flounder Species From the Baltic Sea. *Frontiers in Marine Science*, *5*. https://www.frontiersin.org/article/10.3389/fmars.2018.00225

Annex 3: Audits

Audit of Eastern Baltic cod (cod.27.24-32)

Date: 2022-05-04
Auditor: D. Gilljam

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:** Sampling of landings and discards was considerably reduced in 2020 and 2021 due to a combination of COVID-19 disruption and low catches. Low quotas may also have caused misreporting of landings. However, the perception of the stock status and present advice are considered robust to possible uncertainties in catch data in latest years.
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 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 Cod (*Gadus morhua*) in Subdivision 21 (Kattegat) cod.27.21

Date: 02.05.2022
Auditor: Margit Eero, Maris Plikshs

General

For single stock summary sheet advice:

1) **Assessment type:** update/SPALY.
2) **Assessment**: trends
3) **Forecast**: not performed.
4) **Assessment model**: state-space assessment model (SAM), considered indicative of trends only, plus 4 surveys.
5) **Data issues:** assessment performed according to Stock Annex. No issues raised.
6) **Consistency**: Same procedure as last year. Results consistant with pevious year's assessment.
7) **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.
8) **Management Plan**: NA for this stock.

General comments

The assessment was performed correctly according to Stock Annex.

Technical comments

No issues.

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 flounder in subdivisions 27.2628 (bzq.27.2628)

Review of ICES Scientific Report, (WGBFAS_ 20-27.04-2022)

Reviewers: Tiit Raid, Ivars Putnis
Expert group Chair: M. Bergenius Nord, 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 benchmarked in 2014

For single-stock summary sheet advice

Stock **Flounder in Sub-divisions 27.26-28 (bzq.27.2628)**

Short description of the assessment as follows (examples in grey text):

1. Assessment type: Update assessment
2. Assessment: accepted
3. Forecast: not presented
4. Assessment model: This is a category 3. 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.
5. XSA + VPA Bayesian assess – proposed by expert group, accepted by review group – tuning by three comm + two surveys
6. Consistency: Consistent with last year's assessment
7.
8. Stock status: Fishing pressure on the stock is below FMSY proxy. The stock size indicator shows a general decrease in stock size over time. B < Blim for a while; Flim < F < Fpa; R uncertain, seems to be high in recent years
9. Management plan: Bycatch of this species is considered in the EU Multiannual Plan for the Baltic Sea

   agreed in 2006: SSB to be above 35 000 t within ten years and fishing mortality to be reduced to 0.27. The main elements in the plan are a 10% annual reduction in F and a 15% constrain on TAC change between years. Plan is not evaluated by ICES.

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. No estimates were available for 2021 (due to COVID -19 restrictions). Therefore, only landings estimate is available for that year.

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 2022 assessment differ from the respective values in 2021 assessment. Historical data were not used in the Advice.

Conclusions

The assessment has been performed correctly.

(Single tables or figures can be added in the text, longer texts should be added as annexes.)

Audit of flounder SD2425

Date: 27.04.2022
Auditor: Uwe Krumme

General

Use bullet points and subheadings (Recommendations, General remarks, etc.) if needed

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

1. Assessment type: update
2. Assessment: trends-based assessment based on data from the Baltic International Trawl Survey (BITS – Q1 (G2916) and BITS Q4 (G8863), and commercial catch sampling data.
3. Forecast: Not presented. ICES has not requested to provide fishing opportunities of this stock.
4. Assessment model: A length-based indicator method (LBI) using catch data from commercial samplings and the biological parameters of the Q1 and Q4 BITS is used to assess the stock status.
5. Data issues: Data are available as described in the stock annex. However, there are three issues that should be noted because they may come with some additional uncertainty in the evaluation of the stock status: 1) Due to the Covid-19 pandemy in 2021 there was no biological sampling by Poland, the major fishing country, 2) the bycatch quota for Eastern Baltic cod in 2021 reduced the fishing effort and also affected the fishing patterns on flounder. 3) This is the second year that Polish fishers likely (mis-)report several thousand tonnes of sprat as flounder in the pelagic fisheries (OTM), mainly from SD25. Poland again could not clarify this issue.
6. Consistency: Not applicable
7. Stock status: F below FMSY proxy
8. Management Plan: Bycatch of this species is considered in the EU Multiannual Plan for the Baltic Sea.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

(Include comments on points where the draft report contains errors, is unclear and if the assessment is done according to the stock annex)

Conclusions

The assessment has been performed correctly

(If needed describe if relevant what extra things need to be done for a correct final assessment)

(Include suggestions for future benchmarks, and things to be done before ADG)

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?
  No management plan for this stock
- 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?
  Not applicable.

Audit of FLE2223

Date: 28.04.2022
Review of ICES Scientific Report, WGBFAS 20-27.04-2022
Expert group Chair: M. Bergenius Nord, K. Hommik
Secretariat representative: Ruth Fernandez
Auditors: Uwe Krumme, Zuzanna Mirny

General

No remarks

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: trends-based assessment based on data from the Baltic International Trawl Survey (BITS – Q1 (G2916) and BITS Q4 (G8863)
3) **Forecast**: Not presented. ICES has not requested to provide fishing opportunities of this stock.
4) **Assessment model**: A length-based indicator method (LBI) using commercial landings data and the biological parameters of the Q1 and Q4 BITS is used to assess the stock status.
5) **Data issues:** There is no data issue.
6) **Consistency**: NA
7) **Stock status**: The length-based indicators are suggesting a good status of the stock.
8) **Management Plan**: There is no management plan for this stock

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

Some minor typing errors were detected in the report text and some suggestions for improvements were made. This was considered in the final report.

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? *No management plan.*
- 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? *Survey trend only*
- 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? *No advice this year*

Format for audits (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, (WGBFAS_ 20-27.04-2022)

Reviewers: Tiit Raid and Uwe Krumme

Expert group Chair: M. Bergenius Nord, K. Hommik

Secretariat representative: R. Fernandez

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

This was a well-documented, well ordered and considered section.

It was easy to follow and interpret.

ICES has not been requested to provide advice on fishing opportunities for this stock for 2023-2024.

The assessment has been conducted according to the stock annex.

Stock has been benchmarked in 2014.

For single-stock summary sheet advice

Audit of Flounder in Subdivisions 27.24-25 (bzq.27.2425)

Short description of the assessment as follows (examples in grey text):

1. Assessment type: Update assessment
2. Assessment: accepted
3. Forecast: not presented since ICES has not been requested to provide fishing opportunities for this stock.
4. Assessment model: This is a category 3 stock. A length-based indicator method (LBI) using catch data from commercial samplings and abundance estimates from Baltic International Trawl Survey (BITS – Q1 (G2916) and BITS Q4 (G8863) to assess the stock status.
5. Consistency: Consistent with last year's assessment
6. Stock status: Stock has decreased from historical highs since 2016. Fishing pressure is below FMSY proxy
7. Management plan: Bycatch of this species is considered in the EU Multiannual Plan for the Baltic Sea

General comments

Two flounder species are present in the management area. The proportion of European flounder (*Platichthys flesus*) and Baltic flounder (*Platichthys solemdali*) in this management area were estimated at approximately 85% and 15% respectively. However, the it is not feasible to separate the proportions of the two species in neither the stock assessment nor the fisheries.

Technical comments

Data are available as described in the stock annex. The level of length sampling from the fishery looks adequate to provide a reliable length-based indicator of flounder exploitation. Discarding seem to be decreasing since 2020 but discard values are still highly uncertain.

Additionally, significant part of this bycatch is assumed to be misreported sprat.

There are three issues that should be noted because they may come with some additional uncertainty in the evaluation of the stock status: 1) Due to the Covid-19 pandemic in 2021 there was no biological sampling by one MS, the major fishing country in that fishery, 2) the bycatch quota for Eastern Baltic cod in 2021 reduced the fishing effort and also affected the fishing patterns on flounder. 3) This is the second year that the fishers of the same MS likely (mis-)report several thousand tonnes of sprat as flounder in the pelagic fisheries (OTM), mainly from SD25.

Conclusions

The assessment has been performed correctly.

(Single tables or figures can be added in the text, longer texts should be added as annexes.)

Audit of bwp.27.2729-32 (Baltic flounder in SD 2729-32)

Date: 26 April 2022

<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*)

Reviewers: Didzis Ustups, Jari Raitamieni

Expert group Chair: Mikaela Bergenius Nord, Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General

- *ICES has not been requested to provide advice on fishing opportunities for this stock for 2023.*
- *Two flounder species occur in the Baltic Sea, European flounder P. flesus and Baltic flounder P. solemdali. The predominant flounder species in this area is the Baltic flounder, however mixing occurs between these two species in the catches. The species can be identified with genetic methods or gamete physiology, but not from appearance.*

For single-stock summary sheet advice

Stock bwp.27.2729-32 (Baltic flounder in SD 2729-32)

Short description of the assessment as follows:

1) Assessment type: update
2) Assessment: accepted
3) Forecast: not presented
4) Assessment model: Length-based Indicators used as proxy for exploitation
5) Consistency: New reference point (Linf) was presented to working group, as result stock status changed significantly.
6) Stock status: According to new reference points, assessment shows that fishing pressure is above the FMSY proxy reference point,
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

<u>General comments</u>

In general, this was a well-documented, well ordered and considered section.

New reference points were presented to expert group and were sent or the review. In Linf calculations females only were used, as a result a new estimated Linf is higher than previous one.

<u>Technical comments</u>

NA

Conclusions

The assessment has been sent to reviewers to review new reference points.

Audit of Her.27.25-2932

<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*)
Reviewers: **Francesca Vitale, Jukka Ponni**

Expert group Chairs: **Mikaela Bergenius Nord, Kristiina Hommik**

Secretariat representative: Ruth Fernandez

Audience to write for: ADG, ACOM, benchmark groups and WGBFAS

General
The assessment has been conducted according to the stock annex as an update assessment. Some catch data (<1% of the total catches were not delivered at the time of the working group. This was deemed to have a negligible impact on the quality of the assessment. This stock has been inter-benchmarked in 2020 and a full benchmark is planned for 2023.

For single-stock summary sheet advice

Stock **Her.27.25-2932**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: **Update**
2) Assessment: **Accepted**
3) Forecast: **Accepted**
4) Assessment model: **XSA + tuning with one acoustic survey index (BIAS A1588)**
5) Consistency: **The 2022 assessment is consistent with 2021 assessment and was accepted both years.**
6) Stock status: B< MSY Btrigger and Bpa< B <Blim. since 2020, F>FMSY and Fpa<F<Flim, R is below the average recruitment of age 1 of the whole time series
7) Management plan: This stock is shared between the EU and Russia. An EU multiannual plan (MAP) in place for stocks in the Baltic Sea includes herring (EU, 2016, 2019). The advice, based on the FMSY ranges used in the management plan, is considered precautionary. Russia does not have a management plan for this stock.

<u>General comments:</u>

The report was well documented, describing the stock and the assessment in an exhaustive and clear way.

<u>Technical comments (FV)</u>

No technical issues.

<u>Conclusions</u>

(Single tables or figures can be added in the text, longer texts should be added as annexes.)

The assessment has been performed correctly

Audit of Herring (*Clupea harengus*) in Subdivision 28.1 (Gulf of Riga), her.27.28

Date: 05.05.2022

<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*)
Reviewers: Stefan Neuenfeldt, Tomas Zolubas

Expert group Chair: Mikaela Bergenius Nord, Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General

The assessment have been conducted according to the stock annex as an update 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: analytical (category 1)
3) Forecast: presented
4) Assessment model: XSA and SAM – tuning by 1 commercial CPUE (trapnet) + 1 acoustic survey indices
5) Consistency: The assessment is consistent with last years assessment (setup and assumptions). Retrospective pattern shows clear underestimation of SSB and overestimation of F. In certain years even underestimation of R. Some year effects are evident from the residual plots of the tuning series. The SAM model is not showing the same magnitude of these differences, however, XSA output is within the confidence limits projected by SAM
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 precautionaryEU Baltic multiannual plan

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

Advice looks fine.

Conclusions

The assessment has been performed correctly.

Audit of Herring in the Gulf of Bothnia (her.27.3031)

Date: 03.05.2022
Auditors: T. Gröhsler, 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 stock was temporarily downgraded to category 5 before. The main features of the stock as change in age composition, in growth and in 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:

1) **Assessment type:** in 2021 again category 1 aftter **t**emporarily downgraded to category 5,: update assement during WGBFAS 2022
2) **Assessment**: age-based analytical and fully stochastic model analytical
3) **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 in 2021 and decreased condition and weight at age of larger herring.
4) **Assessment model**: Stock Synthesis (SS3) – fitted to 2 abundance indices (one acoustic survey (BIAS, A1588: 2007-2021) and one historic commercial trapnet survey (1990-2006)). Annual maturity data from Finnish commercial trawl catches before spawning; age-specific natural mortalities, constant through time. Discards are included but considered negligible. Model starts in 1963 and uses 20+ internal age-classes.
5) **Data issues:** effect of excluding age 1 and years 2017 and 2019 (recommendation of WGBIFS 2022) from the BIAS index was explored and resulted in the best residual scores, but the worst retrospective and predictive scores. It was therefore decided by WGBFAS not to exclude age 1 and the years 2017 and 2020 from the BIAS index. Mean weight at age has been now at low levels for 15 years, and decreased even further in 2021. In addition, the present low state of the body condition of larger herring has not previously been observed in the time series.
6) **Consistency**: in early 2021 upgaraded to category 1, before that category 5. The 2022 assessment is consistent with 2021 assessment and was accepted.
7) **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 above MSY Btrigger, Bpa , and Blim. SSB is decreasing since 2012 and is just above MSY Btrigger in 2021.
8) **Management Plan**: EU multiannual plan (MAP) that includes cod 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.27.24-32 (Plaice in SD 24-32)

Date: 26 April 2022

Format for audits (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, (*expert group/workshop title*) *(year*) (*dates*)
Reviewers: Jari Raitaniemi, Maris Plikshs

Expert group Chair: Mikaela Bergenius Nord, 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.

For single-stock summary sheet advice

Stock: ple.27.24-32 (Plaice in SD 24-32)

Short description of the assessment as follows:

1) Assessment type: Surplus Production model, reviewed in 2022
2) Assessment: accepted
3) Forecast: presented, based on MSY
4) Assessment model: Surplus Production model in Continuous Time (SPiCT; ICES, 2022)
5) Consistency: A new assessment approach and change from category 3 to category 2.
6) Stock status: B > MSY $B_{trigger}$, F < F_{msy}
7) Management plan: The EU multiannual plan for the Baltic Sea (EU, 2016, 2019) applies to bycatches of this stock taken when fishing for the target stocks described in the plan

General comments

In general, this was a well-documented, well ordered and considered section.

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? **NO (annex need o be updated due to assessment model change)**
- 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? **NO**
- 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 Plaice in Sub-divisions 27.21-23

Date: 2.05.2022
Auditor: Jan Horbowy, Tomas Gröhsler

Audience to write for: ADG, ACOM, benchmark groups and EG next year.

General

The assessment has been conducted according to the stock annex as an update assessment.

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented, based on MSY
4) **Assessment model**: Age-based analytical assessment with SAM; for tuning two combined surveys indices have been used, both combine Baltic and NS surveys in 1st and 3rd - 4th quarter. The surveys have been combined into indexes applying GAMs.
5) **Data issues:** as in 2020 & 2021 the 2019 combined survey index from 3rd&4th quarter was excluded when tuning the model; that was accepted at ADG in 2020 and 2021, these survey indices were low probably due to abnormally low oxygen conditions. Data available for the assessment were: Commercial catches; two combined survey indices (NS-IBTSQ1 [G1022] and BITS–Q1 [G2916], NS-IBTSQ3 [G2829] and BITS–Q4 [G8863]); mean maturity data for the modelled period (Q1 surveys); natural mortalities are fixed and assumed to be 0.1 except for age 1, which has 0.2.
6) **Consistency**: The 2022 assessment is very consistent with assessments from 2021 and was accepted. Retrospective analysis indicates Mohn's rho estimate of 5% for the SSB and -1% for F.
7) **Stock status**: The spawning-stock biomass (SSB) is well above all biomass reference points. The year class 2019 & 2020 are estimated very strong. Fishing mortality (F) declined below F_{MSY} in 2021.
8) **Management Plan**: The EU Multiannual Plan for the Baltic Sea (EU, 2016) takes bycatch of this species into account. ICES is not aware of any agreed precautionary management plan for plaice insubdivision 21.

General comments

The assessment is well documented.

Technical comments

No specific comments. The assessment and forecast have been done following procedure agreed at benchmark in 2015 and updated in 2019.

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 sol.27.20-24

Review of ICES Scientific Report, WGBFAS 2022, 20-27 April 2022
Reviewers: Zuzanna Mirny and Nicolas Goñi

Expert group Chair: Mikaela Bergenius Nord, 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 (examples in grey text):

1. Assessment type: update
2. Assessment: accepted
3. Forecast: accepted
4. Assessment model: Age-based analytical stochastic assessment (SAM) that uses landings only in the model. Discards are included afterwards in the forecast. Commercial catches (international landings, ages and length frequencies from catch sampling), one survey index (Fishermen–DTU Aqua sole survey, 2004–2021, [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
5. Data issues: The data are available as described in stock annex. Sampling since 2017 has improved. In 2020 landings from the Belts and the Skagerrak were not succesfully sampled. Since the discards are insignificant and constant over time seies, they were not included in the assessment.
6. Consistency: The assessment of recent years including the 2021 assessment have been accepted.
7. Stock status: Fishing pressure on the stock is below FMSY, Fpa and Flim, and spawning stock size is above MSY Btrigger and Blim.
8. Management plan: EU multiannual plan (MAP) for stocks in the North Sea. The plan specifies conditions for setting fishing opportunities depending on stock status and making use of the FMSY range for the stock. ICES considers that the FMSY range for this stock used in the MAP is precautionary.

General comments

Report is well documented and enables to follow the assessment.

Technical comments

- Since 2021 the basis for Fpa have been decided to be based on Fp05 (estimated to 0.26 in 2015 benchmark). This has caused Fpa to change from 0.23 (capped previously by Fpa) to the Fmsy estimate derived from stochastic equilibrium scenarios at 0.26. Fmsy lower is not recalculated since the Fmsy remain the uncapped value estimated in 2015.

- An issue in the survey data standardization (erroneous inclusion of sectors out of the core area) was identified and properly solved prior to the assessment. Since the survey is the only contributor to the recruitment in the assessment (age 1), recruitment and SSB estimates have changed noticeably.

- The extended survey area is not intended to be utilized yet in the survey index calculation, but awaits a longer time series for further evaluation.

Conclusions

The assessment has been performed correctly.

Audit of Sprat in Subdivisions 27.22-32

Date: 26.04.2022
Auditor: Stefanie Haase, Szymon Smoliński

Audience to write for: ADG, ACOM, benchmark groups and EG next year.

General

The assessment has been conducted according to the stock annex as an update assessment. The present assessment is based on new natural mortality (M from updated SMS for the period 1974-2018, M for 2019 assumed as in 2018, and M 2020-2021 from regression of M2 vs cod≥20cm biomass) and updated reference points, introduced at the interbenchmark in March 2020.

For single stock summary sheet advice:

9) **Assessment type: update**

1) **Assessment**: analytical

2) **Forecast**: presented

3) **Assessment model**: Age-based analytical assessment (XSA-tuning by 2 acoustic surveys including age-0 survey)

4) **Data issues:** Data provided as tables and figures in the sharepoint Report folder.

5) **Consistency**: The 2022 assessment is consistent with 2021 assessment and was accepted both years.

6) **Stock status**: The spawning-stock biomass (SSB) is above MSY $B_{trigger}$. The 2020 and 2021 year classes are above long-term average. Fishing mortality (F) has remained above F_{MSY} and is above F_{pa} in 2021.

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

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 tur.27.22-32 (Turbot in SD 22-32)

Date: 27 April 2022

Format for audits (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, (*expert group/workshop title*) *(year*) (*dates*)
Reviewers: Jari Raitaniemi

Expert group Chair: Mikaela Bergenius Nord, Kristiina Hommik

Secretariat representative: Ruth Fernandez

Audience to write for: ADGBS, ACOM, WGBFAS

General
stock status only is presented

For single-stock summary sheet advice

Stock: tur.27.22-32 (Turbot in SD 22-32)

Short description of the assessment as follows:

1) Assessment type: Update
2) Assessment: accepted
3) Forecast: not presented
4) Assessment model: CPUE trends of small BITS trawl, length-based indicators (LBI method).
5) Consistency: The index changed compared to previous years due to new submissions of previously missing "zero catch" strata. Since the numbers of caught turbot are relatively low, even small updates in the database can cause large changes in the index. The trend of the index however did not change.
6) Stock status: . Length-based indicator: below possible reference points. FMSY proxy (LF=M) and optimal yield in 2021, MSY $B_{trigger}$ is unknown
7) Management plan: The EU multiannual plan for the Baltic Sea (MAP; EU, 2016) takes bycatch of this species into account.

General comments

In general, this was a well-documented, well ordered and considered section.

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). A direct comparison between the CPUE index and the biomass index was conducted. No differences in the general trend between the two indices was detected and WGBFAS decided to keep the currently used index. A biomass index shall, however, be investigated and considered during the benchmark and will be included at the issue list for the Baltic Sea turbot benchmark.

Technical comments

NA

Conclusions

The assessment has been performed correctly.

Audit of dab in SD 22-32 (dab.27.2-32)

Date: 26.04.2022
Auditor: S. Haase

Audience to write for: ADG, ACOM, benchmark groups and EG next year.

General

Information on stock status and historical trends have been provided.

For single stock summary sheet advice: not given

1) **Assessment type: stock status update**
2) **Assessment**: Survey trend-based assessment (biomass index)
3) **Forecast**: not presented since ICES has only been requested to provide stock status but not fishing opportunities for this stock.
4) **Assessment model**: NA
5) **Data issues:** Stock size indicator uncertain because mixing with dab in SD21 is unclear but significant seasonal movements are known
6) **Consistency**: NA
7) **Stock status**: Length based indicators (LBI) as developed by WKLIFE (2015) indicate that large dabs are still missing from the stock (P_{mega}=0.23, expected >0.3). In 2021 overfishing of immature individuals is indicated (L_c/L_{mat}=0.75, expected >1).
8) **Management Plan**: No management plan for this stock

General comments

This was a well documented, well ordered and considered section. 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. Stock separation between dab2232 and dab in the Kattegat may be evaluated.

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?
  No management plan for this stock
- 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 Brill (*Scophthalmus rhombus*) in subdivisions 22-32 (Baltic Sea), bll.27.22-32

Date: 27.04.2022

Format for audits (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: Mikaela Bergenius Nord, 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: NA
5) Consistency: NA
6) Stock status: stable index with low fluctuations were observed between 2007 and 2017. Since 2018 the index increased, but decreased in 2020 and 2021.
7) Management plan: No management plan for this stock

General comments

This is a well-documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

The stock status update is performed according according to the stock annex.

Conclusions

The assessment has been performed correctly.

Annex 4: RCG Data policy decision and reference example

Request mode	**Requester**	**Responsible contact**	**Approval needed**	**Data access**	**Citation**
0	Other ISSG	ISSG chairs	No, but RCG chairs in cc	No restrictions	None (RDB or survey data: extraction date)
1	Pre-approved WGs (by SCRDB for aggregated RDB data), COM	ISSG chairs, RCG chairs	Yes, general approval of NCs needed. For reoccurring standard request (e.g. inventories), approval could be given until further notice	Restricted, according to Data policy and NC decision	In Text/figure caption: *RCG ([year], prelim. Data)* In References: *RCG ([year]). Regional Coordination meeting [area]. Report of the ISSG on [topic], prelim. data*
2	Other ICES WGs	RCG chairs, NCs	Yes, approval (or non-objection) by NCs needed	Restricted, according to Data policy, after report is published or if approval is given beforehand	In Text/figure caption: *RCG ([year])* In References: *Respective RCG report* OR: Request mode 1 citation.
3	Third party	RCG chairs	Yes, TBD	Restricted, TBD	TBD

Example:

➔ Request by WGBFAS in 2020 to use the following graph in the report. ISSG chair was contacted and RCG chairs agreed on providing the graph. Aggregation follows RDB data policy.

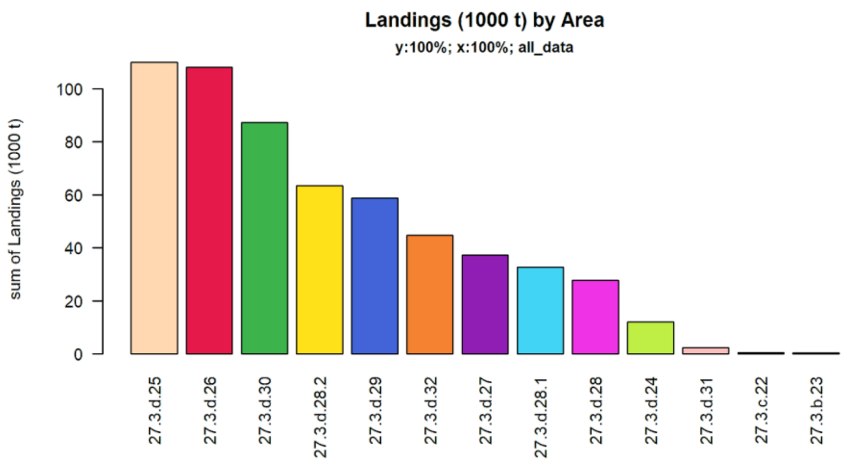

Figure X. Landings of small pelagics (in 1000 t) in the Baltic Sea by Area in 2019 (RCG 2020, prelim. Data).

Reference before publication:

RCG (2020). Regional Coordination Meeting BANANSEA - Report of the ISSG on fisheries and sampling overviews. Preliminary data of the RDB (https://www.ices.dk/data/data-portals/Pages/RDB-FishFrame.aspx) .

After publication: Recommended format for purposes of citation:

RCG. [year]. Regional Coordination Group BANANSEA. XX pgs. (https://datacollection.jrc.ec.europa.eu/docs/rcg)

To add at respective Report section:

The material in this report may be reused using the recommended citation. The RCG may only grant usage rights of information, data, images, graphs, etc. of which it has ownership. For other third-party material cited in this report, you must contact the original copyright holder for permission. For citation of datasets or use of data to be included in other databases, please refer to the latest RCG and ICES data policy on the ICES website. All extracts must be acknowledged. For other reproduction requests please contact the authors. This document is the product of a Regional Coordination Group under the auspices of the Expert Group on Fisheries Data Collection (EC - DCF) and does not necessarily represent the view of the EU Expert Group (NCs).

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Annex 5: List of 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
bll.27.22-32	Brill (*Scophthalmus rhombus*) in subdivisions 22-32 (Baltic Sea)
bwp.27.2729-32	Baltic flounder (*Platichthys solemdali*) in subdivisions 27 and 29–32 (northern central and northern Baltic Sea)
bzq.27.2425	Flounder (*Platichthys* spp) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic)
bzq.27.2628	Flounder (*Platichthys* spp) in subdivisions 26 and 28 (east of Gotland and Gulf of Gdansk)
cod.27.21	Cod (*Gadus morhua*) in Subdivision 21 (Kattegat)
cod.27.22-24	Cod (*Gadus morhua*) in subdivisions 22-24, western Baltic stock (western Baltic Sea)
cod.27.24-32	Cod (*Gadus morhua*) in subdivisions 24-32, eastern Baltic stock (eastern Baltic Sea)
dab.27.22-32	Dab (Limanda limanda) in subdivisions 22-32 (Baltic Sea)
fle.27.2223	Flounder (Platichthys flesus) in subdivisions 22 and 23 (Belt Seas and the Sound)
her.27.25-2932	Herring (Clupea harengus) in subdivisions 25-29 and 32, excluding the Gulf of Riga (central Baltic Sea)
her.27.28	Herring (*Clupea harengus*) in Subdivision 28.1 (Gulf of Riga)
her.27.3031	Herring (*Clupea harengus*) in Subdivisions 30 and 31 (Gulf of Bothnia)
ple.27.21-23	Plaice (Pleuronectes platessa) in subdivisions 21-23 (Kattegat, Belt Seas, and the Sound)
ple.27.24-32	Plaice (Pleuronectes platessa) in subdivisions 24-32 (Baltic Sea, excluding the Sound and Belt Seas)

Name	Title
sol.27.20-24	Sole (Solea solea) in subdivisions 20-24 (Skagerrak and Kattegat, western Baltic Sea)
spr.27.22-32	Sprat (*Sprattus sprattus*) in Subdivisions 22-32 (Baltic Sea)
tur.27.22-32	Turbot (Scophthalmus maximus) in Subdivisions 22-32 (Baltic Sea)

Annex 6: Short-term forecast for Western Baltic Cod

By request of the Advice Drafting Group for Baltic Sea stocks (ADGBS) in May 2022, a short-term forecast was conducted for western Baltic cod. Values in the forecast and for the interim year as well as resulting annual catch scenarios are shown in the tables below.

Table 1 Cod in subdivisions 22–24, western Baltic stock. Values in the forecast and for the interim year.

Variable	Value	Notes
$F_{ages\ 3–5}$ (2022)	0.90	Equal to F in 2021 (F_{sq})
SSB (2023)	9299	Short-term forecast; tonnes
$R_{age\ 1}$ (2022)	28966	From the assessment; thousands
$R_{age\ 1}$ (2023)	17015	Sampled from the last ten years; thousands*
$R_{age\ 1}$ (2024)	17187	Sampled from the last ten years; thousands*
Total catch (2022)	4295	Based on F in 2021

* Recruitment is randomly resampled from the assessment estimates of the last ten years and the median of these random draws is used. This will vary slightly every time this is carried out.

Table 2 Cod in subdivisions 22–24, western Baltic stock. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total} (2023)	SSB (2024)	% SSB change***	% Advice change^	% Probability of SSB to be below B_{lim} in 2024##
ICES advice basis						
MSY approach: F_{MSY} × SSB (2023) /MSY $B_{trigger}$	943	0.103	17918	93	35	31
Other scenarios						
EU MAP**: F_{MSY} × SSB (2023) /MSY $B_{trigger}$	943	0.103	17918	93	35	31
EU MAP**: $F_{MSY\ lower}$ SSB (2023)/ MSY $B_{trigger}$	621	0.067	18240	96	34	29
Zero catch	0	0	18859	103	-100	25
F = F_{pa}	5277	0.69	13581	46	656	60
F = F_{lim}	8175	1.23	10698	15	1071	76
SSB (2024) = B_{lim}	3753	0.46	15067	62	438	50
SSB (2024) = B_{pa}#	-	-	-	-	-	-

Basis	Total catch* (2023)	F_{total} (2023)	SSB (2024)	% SSB change***	% Advice change^	% Probability of SSB to be below B_{lim} in 2024##
SSB (2024) = MSY $B_{trigger}$#	-	-	-	-	-	-
F_{sq} (F = 2021)	6485	0.90	12361	33	829	66
TAC_{2022} (489 t)+ Estimated recreational catch 2022 (494 t)	983	0.108	17872	92	41	32

* Includes commercial and recreational catch.

** EU Multiannual Plan for the Baltic Sea (EU, 2016, 2019).

*** SSB 2024 relative to SSB 2023.

^ Total catch in 2023 relative to total catch corresponding to the MAP F_{MSY} advice for 2022 (698 tonnes), including commercial and recreational catch.

The B_{pa}, and MSY $B_{trigger}$ options were left blank because B_{pa}, and MSY $B_{trigger}$ cannot be achieved in 2024 even with zero catch in 2023.

Note 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.

Annex 7: New short-term forecast for central Baltic herring

The official Russian quota for Baltic herring for 2022 was made available after the Advice Drafting Group Baltic Sea. By recommendation from ACOM a new short term forecast was produced taken into consideration the official Russian quota of 27100 tonnes.

Table 1 Herring in subdivisions 25–29 and 32, excluding the Gulf of Riga. Values in the forecast and for the interim year.

Variable	Value	Notes
$F_{ages\ 3–6}$ (2022)	0.20	Based on a Catch constraint *
SSB (2022)	446 582	Projected at spawning time; tonnes
$R_{age\ 1}$ (2022)	9 597 000	RCT3 estimate; thousands
$R_{age\ 1}$ (2023–2024)	12 085 820	Geometric mean 1988–2020; thousands
Total catch (2022)	83 505	Catch constraint *; tonnes

* Catch constraint in 2022: EU share (53 653 tonnes) + Russian quota (27 100 tonnes) + central Baltic herring stock caught in Gulf of Riga (3 448 tonnes [mean 2016–2020]) − Gulf of Riga herring stock caught in central Baltic Sea (696 tonnes [mean 2016–2020])
= 83 505 tonnes.

Table 2 Herring in subdivisions 25–29 and 32, excluding the Gulf of Riga. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2023)	F_{total} (2023)	SSB # (2023)	SSB # (2024)	% SSB change *	% Advice change **
ICES advice basis						
EU MAP ^^: F = F_{MSY} × SSB_{2022}/MSY $B_{trigger}$	95 643	0.20	497 552	543 708	9%	33%
EU MAP ^^: F = MAP range F_{lower} × SSB_{2022}/MSY $B_{trigger}$	70 130	0.146	506 752	577 547	14%	34%***
Other scenarios						
F_{MSY}	98 153	0.21	496 630	540 417	9%	36%
F = 0	0	0.00	530 608	674 227	27%	−100%
F = F_{pa}	142 511	0.32	479 824	483 450	1%	98%
F = F_{lim}	234 722	0.59	441 245	372 387	-16%	226%
SSB (2024) = B_{lim}	269620	0.71	425 098	333 000	-22%	275%
SSB (2024) = B_{pa}	161 231	0.37	472 416	460 000	-3%	124%
SSB (2024) = MSY $B_{trigger}$	161 231	0.37	472 416	460 000	-3%	124%
SSB (2024) = SSB (2023)	146 680	0.33	478 191	478 212	0%	104%
F = F_{2022}	92 956	0.20	498 535	547 237	10%	29%

* SSB 2024 relative to SSB 2023.
** Advice value in 2023 relative to advice value for EU MAP: F_{MSY} 2022 = F_{MSY} × SSB_{2021}/MSY $B_{trigger}$ (71 939 tonnes).
*** Advice value for 2023 relative to advice value for EU MAP range F_{lower} 2022 (52 443 tonnes).
# For spring-spawning stocks, the SSB is determined at spawning time and is influenced by fisheries and natural mortality between the
1st of January and spawning time (April).
^^ MAP multiannual plan (EU, 2016, 2019).

Annex 8: New short-term forecast for Baltic sprat

The official Russian quota for Baltic sprat for 2022 was made available after the Advice Drafting Group Baltic Sea. By recommendation from ACOM a new short-term forecast was produced taken into consideration the official Russian quota of 43 400 tonnes.

Table 1 Sprat in subdivisions 22–32. Values in the forecast and for the interim year.

Variable	Value	Notes
$F_{ages\ 3–5}$ (2022)	0.38	F based on catch constraint
SSB (2022)	1 022 000	Predicted SSB at spawning time; tonnes
$R_{age\ 1}$ (2022)	4 421 3000	RCT3 estimate; thousands
$R_{age\ 1}$ (2023–2024)	8 747 2000	Geometric mean 1991–2021; thousands
Total catch (2022)	295 300	Catch constraint (295 300 t = EU quota of 251 900 t + assumed Russian quota of 43 400 t); tonnes

Table 2 Sprat in subdivisions 22–32. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2023)	F_{total} (2023)	SSB (2023)	SSB (2024)	% SSB change *	% TAC change **	% advice change ***
ICES advice basis							
EU MAP^^: F_{MSY}	249 237	0.31	907 905	986 716	8.7	-16	-15
EU MAP^^range F_{lower}	183 749	0.22	935 258	1 067 775	14	-38	-14^
EU MAP^^range F_{upper}	317 905	0.41	878 469	904 540	3.0	7.7	-15^
Other scenarios							
F_{MSY}	249 237	0.31	907 905	986 716	8.7	-16	-15
F = 0	0	0	1 006 000	1 306 000	30	-100	-100
F = F_{pa}	317 905	0.41	878 469	904 540	3.0	7.7	9.0
F = F_{lim}	452 071	0.63	816 965	753 170	-7.8	53	55
SSB (2024) = B_{lim}	801 586	1.47	623 172	410 000	-34	171	175
SSB (2024) = B_{pa}	630 357	1.01	723 893	570 000	-21	113	116
SSB (2024) = MSY $B_{trigger}$	630 357	1.01	723 893	570 000	-21	113	116
SSB (2024) = SSB (2023)	354 500	0.47	862 333	862 333	0	20	22
F = F_{2022}	284 943	0.36	892 853	943 758	5.7	-3.5	-2.3

* SSB_{2024} relative to SSB_{2023}.

** Catch in 2023 relative to the sum of autonomous quotas in 2022 (295 300 tonnes = EU quota of 251 900 tonnes + assumed Russian quota of 43 400 tonnes).

*** Advice value this year relative to the advice value last year (291 745 tonnes).

^ Advice value this year relative to the advice value last year for the MAP range F_{lower} (214 000 tonnes) and MAP range F_{upper} (373 210 tonnes)

^^ MAP multiannual plan (EU, 2016, 2019).

Annex 9: Resolution

Approved in November 2021

2021/2/FRSG08 The Baltic Fisheries Assessment Working Group (WGBFAS), chaired by Mikaela Bergenius Nord, Sweden and Kristiina Hommik*, Estonia, will meet on 20-27 April 2022 in Rostock, Germany to:

a) Address generic ToRs for Regional and Species Working Groups

b) Review the main result from WGMIXFISH, WGIAB, WGSAM, WGBIFS and WKEBFAB. 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 2022 ICES data call.

WGBFAS will report by 12 May 2022 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 10: Working documents

Pelagics WAA

Over the last four decades, considerable changes in all trophic levels in the ecosystem of the Baltic Sea have been observed causing the switch from cod to sprat domination in the fish community. In this altered ecosystem, the growth, condition, and weight at age of sprat and herring also experienced remarkable changes (Casini et al., 2010). In some areas, the weight at age of adults decreased by 30-50% from the highest values in the early 1980s (Cardinale and Arrhenius, 2000). The decline in the weight at age was asynchronous for the four pelagic stocks (Fig. X). In the Central Baltic herring, the main decrease occurred in the years 1980-2000, in the Gulf of Bothnia herring in the years 1995-2005, in the Gulf of Riga herring in the years 1985-1992 and in Baltic sprat in the years 1990-2000. More recently, in 2021 substantial decrease in weight at age was observed in four analyzed pelagic stocks when compared to the average in the period 2011-2020 (Table X). In all cases but sprat at age 1 decrease has been observed.

There are several possible explanations for these declines in weight at age of pelagics in different areas of the Baltic Sea. According to Casini et al. (2011), the size and distribution of the sprat population mediated changes in both sprat and herring condition and weight at age, evidencing intra- and inter-specific density dependence. The diet shift from a composition of zooplankton, mysids, and amphipods to only zooplankton could have also a significant effect on the herring growth, condition, and weight at age (Arrhenius and Hansson, 1993; Horbowy, 1997). Alternatively, the cod predation hypothesis has been proposed, assuming that predation mortality is greater for small clupeids than for large individuals, thus, under reduced cod predation pressure, more of the slow-growing fish survive (Rudstam et al., 1994; Sparholt and Jensen, 1992). Finally, since weight at age decreases from south to north, migration of northern stock components to the southern areas might result in a decrease in weight at age. However, considering that the decrease in weight at age is observed in different areas of the Baltic Sea, this hypothesis seems to be less plausible (Cardinale and Arrhenius, 2000).

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Sparholt, H., Jensen, I.B., 1992. The effect of cod predation on the weight-at-age of herring in the Baltic. Hydrobiol. Var. ICES Area, 1980-1989 195, 488–491.

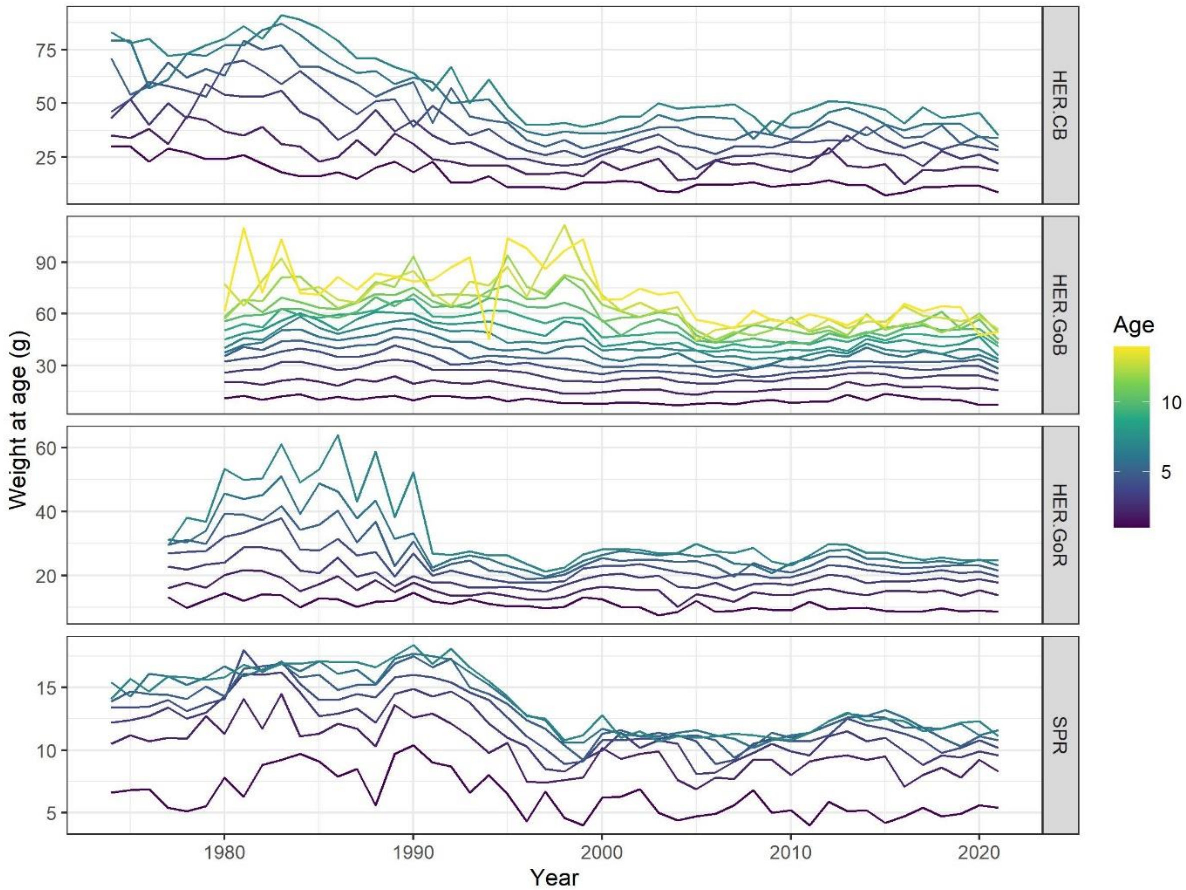


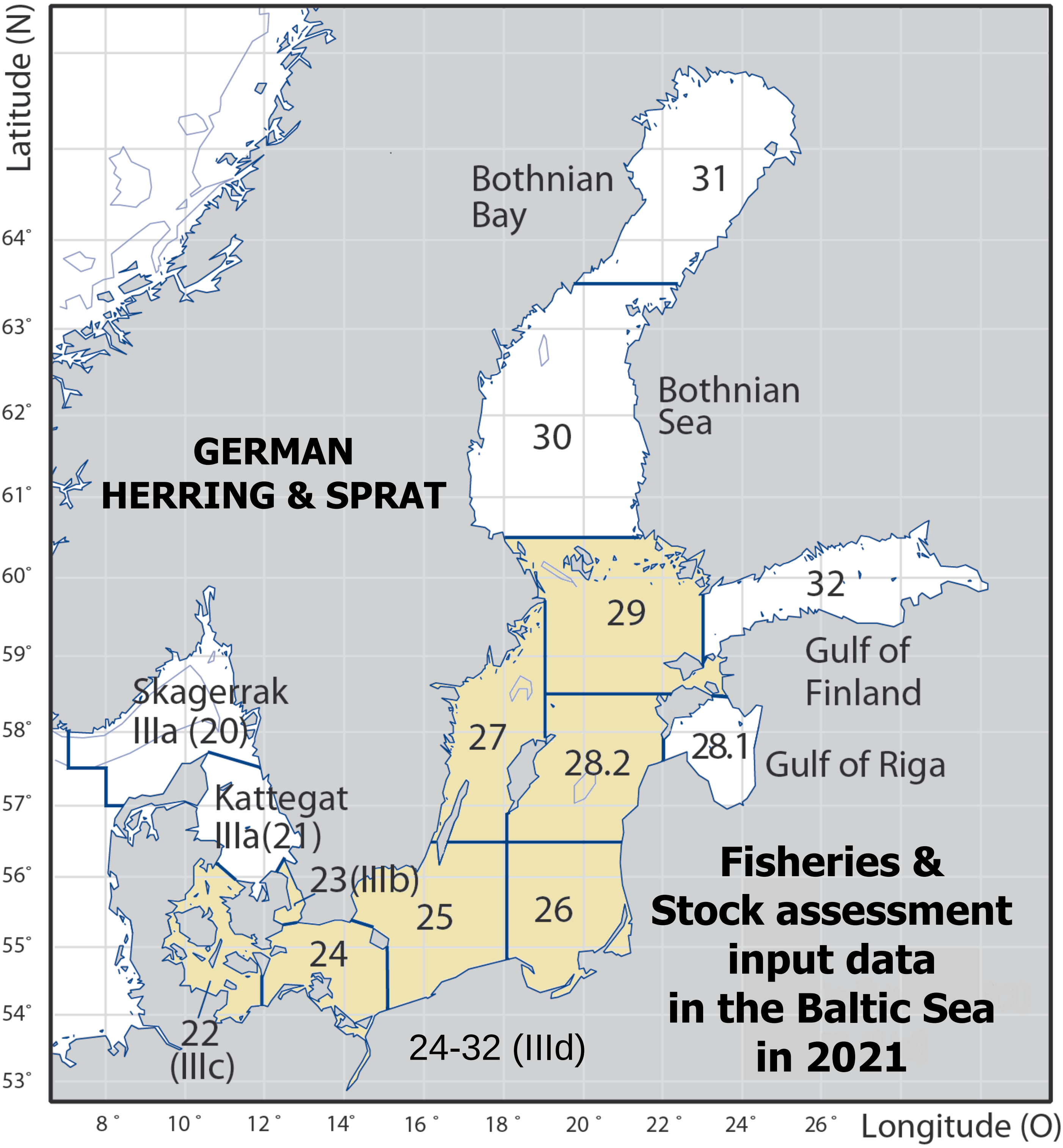
Fig. X. Weight at age time series for pelagic stocks in the Baltic Sea. HER.CB is herring in SD 25–29 and 32, excluding the Gulf of Riga; HER.GoB is herring in SD 30 and 31 (Gulf of Bothnia); HER.GoR is herring in SD 28.1 (Gulf of Riga); SPR is sprat in SD 22–32.

Table. X. Comparison of weight at age of Baltic pelagic stocks in 2021 to the average weight at age calculated for the period 2011-2020. In all cases but sprat at age 1 decrease has been observed.

Stock	Age	WAA in 2021	WAA average 2011-2020	Percent	Percent difference
Herring in SD 25–29 and 32, excluding the Gulf of Riga	1	8.6	11.16	77.06093	-22.9391
Herring in SD 25–29 and 32, excluding the Gulf of Riga	2	18.6	20.42	91.08717	-8.91283
Herring in SD 25–29 and 32, excluding the Gulf of Riga	3	21.9	26.77	81.80799	-18.192
Herring in SD 25–29 and 32, excluding the Gulf of Riga	4	28.2	31.98	88.18011	-11.8199
Herring in SD 25–29 and 32, excluding the Gulf of Riga	5	29.6	36.74	80.56614	-19.4339
Herring in SD 25–29 and 32, excluding the Gulf of Riga	6	34	41.09	82.74519	-17.2548
Herring in SD 25–29 and 32, excluding the Gulf of Riga	7	35.1	46.71	75.14451	-24.8555
Herring in SD 25–29 and 32, excluding the Gulf of Riga	8	41.5	51.73	80.22424	-19.7758
Herring in SD 30 and 31 (Gulf of Bothnia)	1	7.47	10.332	72.29965	-27.7003
Herring in SD 30 and 31 (Gulf of Bothnia)	2	15.58	17.64	88.322	-11.678

Herring in SD 30 and 31 (Gulf of Bothnia)	3	21.05	24.121	87.26836	-12.7316
Herring in SD 30 and 31 (Gulf of Bothnia)	4	25.07	28.403	88.26532	-11.7347
Herring in SD 30 and 31 (Gulf of Bothnia)	5	28.17	31.787	88.62113	-11.3789
Herring in SD 30 and 31 (Gulf of Bothnia)	6	31.97	35.978	88.85986	-11.1401
Herring in SD 30 and 31 (Gulf of Bothnia)	7	33.65	38.683	86.98912	-13.0109
Herring in SD 30 and 31 (Gulf of Bothnia)	8	35.63	42.413	84.00726	-15.9927
Herring in SD 30 and 31 (Gulf of Bothnia)	9	41.06	46.202	88.87061	-11.1294
Herring in SD 30 and 31 (Gulf of Bothnia)	10	42.68	49.143	86.84858	-13.1514
Herring in SD 30 and 31 (Gulf of Bothnia)	11	44.73	52.35	85.44413	-14.5559
Herring in SD 30 and 31 (Gulf of Bothnia)	12	49.24	53.139	92.66264	-7.33736
Herring in SD 30 and 31 (Gulf of Bothnia)	13	50.85	56.479	90.03346	-9.96654
Herring in SD 30 and 31 (Gulf of Bothnia)	14	49.65	58.506	84.86309	-15.1369
Herring in SD 30 and 31 (Gulf of Bothnia)	15	55.06	62.512	88.07909	-11.9209
Herring in SD 28.1 (Gulf of Riga)	1	8.6	9.43	91.1983	-8.8017
Herring in SD 28.1 (Gulf of Riga)	2	13.8	14.88	92.74194	-7.25806
Herring in SD 28.1 (Gulf of Riga)	3	17.8	18.69	95.2381	-4.7619
Herring in SD 28.1 (Gulf of Riga)	4	19.6	21.45	91.37529	-8.62471
Herring in SD 28.1 (Gulf of Riga)	5	21.5	23.52	91.41156	-8.58844
Herring in SD 28.1 (Gulf of Riga)	6	23.1	25.31	91.26827	-8.73173
Herring in SD 28.1 (Gulf of Riga)	7	24.7	26.58	92.92701	-7.07299
Herring in SD 28.1 (Gulf of Riga)	8	25.3	29.39	86.0837	-13.9163
Sprat in SD 22–32	1	5.4	4.97	108.6519	8.651911
Sprat in SD 22–32	2	8.3	8.75	94.85714	-5.14286
Sprat in SD 22–32	3	9.6	10.15	94.58128	-5.41872
Sprat in SD 22–32	4	10.2	11.1	91.89189	-8.10811
Sprat in SD 22–32	5	10.8	11.73	92.07161	-7.92839
Sprat in SD 22–32	6	11.6	12.19	95.15997	-4.84003
Sprat in SD 22–32	7	11.1	12.15	91.35802	-8.64198
Sprat in SD 22–32	8	11.6	12	96.66667	-3.33333

Fisheries and Stock Assessement input data in the Baltic Sea in 2021 – German Herring ans Sprat



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1 HERRING

1.1 Fisheries

In 2021 the total German herring landings from the Western Baltic Sea in **Subdivisions (SD) 22 and 24** amounted to 843 t, which represents a decrease of 59 % compared to the landings in 2020 (2,069 t). The lower landings in 2021 were caused by a further decrease of the German quota (869 t), which was used by 97 % (2020: 95 %, 2019: 97 %, 2018: 94 %). The fishing activities in one of the main fishing areas, the Greifswald Bay (SD 24), started in mid-February. As in last year, the main German fishery stopped their activities at the end of April.
Only a small part of the total German landings was taken **in Subdivisions 25-29** (2021: 631 t; 2020: 833 t, 2019: 1,752 t). The German quota of 569 t was used by 111 % (2020: 90 %, 2019: 99.7 %). As in the years before, all landings in this area were taken by the trawl fishery. Only 56 % were landed in foreign ports (2020: 96 %, 2019: 95 %).

The landings (t) by quarter and Subdivision (SD) including information about the landings in foreign ports are shown in the table below:

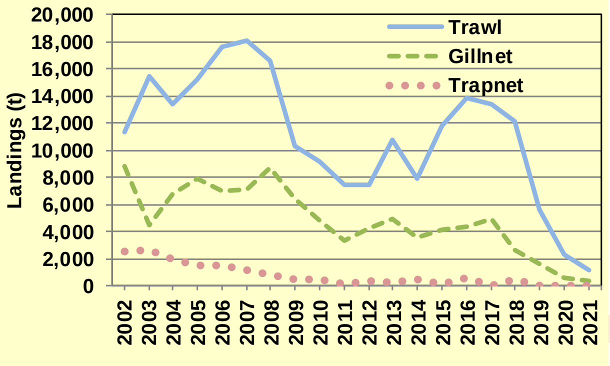
Quarter	SD 22	SD 24	SD 25	SD 26	SD 27	SD 28.2	SD 29	(1) Total SD 25-29	% (1)/(2)	(2) Total SD 22-29	% (2)
I	14.105	246.241	126.503	225.000		16.067	39.717	407.287	61.0%	**667.633**	45.3%
	-	-	31.043	96.324	-	-	-	127.367	100.0%	127.367	36.3%
II	4.394	87.141	182.384	16.892	10.323	-	-	209.599	69.6%	**301.134**	20.4%
	-	-	182.384	16.892	10.323	-	-	209.599	100.0%	209.599	59.7%
III	0.167	0.045	-	-	-	-	-	0.000		**0.212**	0.0%
	-	-	-	-	-	-	-	0.000		0.000	0.0%
IV	2.849	488.310	-	-	-	2.990	10.964	13.954	2.8%	**505.113**	34.3%
	-	-	-	-	-	2.990	10.964	13.954	100.0%	13.954	4.0%
Total	**21.515**	**821.737**	**308.887**	**241.892**	**10.323**	**19.057**	**50.681**	**630.840**	**42.8%**	**1,474.092**	**100.0%**
	0.000	0.000	213.427	113.216	10.323	2.990	10.964	350.920	100.0%	350.920	100.0%

= Fraction of total landings (t) in foreign ports	55.6%	23.8%
	2021/2020:	**2021/2020:**
= Fraction of total landings (t)	75.7%	50.8%
= Fraction of total landings (t) in foreign ports	43.7%	43.7%

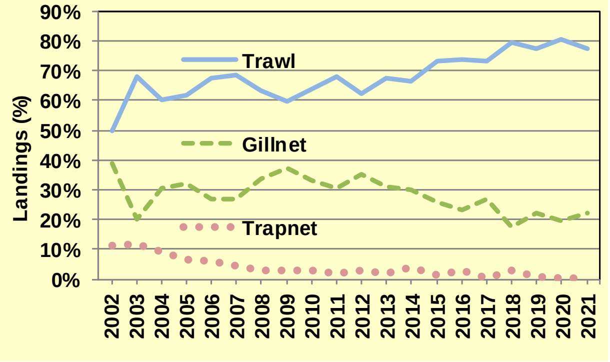
The main fishing season was during spring time as in former years. About 65 % of all herring (SDs 22-29) were caught between January and April (2020: 75 %, 2019: 85 %). 56 % of the German herring landings were taken in Subdivision 24 (2020: 71 %, 2019: 75 %). The German herring fishery in the Baltic Sea is conducted with gillnets, trapnets and trawls. All landings in the area of the Central Baltic Sea (SDs 25-29) are taken by the trawl fishery.

Until 2000 the dominant part of herring was caught in the passive fishery by gillnets and trapnets. Since 2001 the activities in the trawl fishery increased. The total amount of herring, which was caught by trawls in SDs 22-29, reached 78 % in 2021 (2020: 80 %; 2019: 77 %). The significant change in fishing pattern was caused by the perspective of a new fish factory on the Island of Rügen, which finally started the production in autumn 2003. This factory can process up to 50,000 t fish per year.

Landings in Subdivisions 22-29 (t)				
Year/Gear	Trawl	Gillnet	Trapnet	Total
2002	11,317.813	8,783.392	2,559.662	22,660.867
2003	15,433.154	4,545.312	2,658.148	22,636.614
2004	13,429.394	6,796.747	2,016.542	22,242.683
2005	15,277.320	7,924.007	1,551.530	24,752.857
2006	17,604.485	6,959.530	1,539.467	26,103.482
2007	18,044.233	7,077.135	1,133.806	26,255.174
2008	16,640.802	8,760.611	789.005	26,190.418
2009	10,305.056	6,403.312	523.998	17,232.366
2010	9,216.880	4,804.818	452.182	14,473.880
2011	7,424.844	3,301.890	189.673	10,916.407
2012	7,491.038	4,252.694	322.308	12,066.040
2013	10,768.220	4,933.173	304.427	16,005.820
2014	7,959.719	3,562.980	449.724	11,972.423
2015	11,839.151	4,183.129	183.533	16,205.813
2016	13,834.307	4,362.550	569.558	18,766.415
2017	13,370.750	4,898.840	19.104	18,288.694
2018	12,136.988	2,663.317	455.174	15,255.479
2019	5,664.366	1,615.909	42.112	7,322.387
2020	2,329.441	571.981	0.711	2,902.133
2021	1,143.915	326.705	3.472	1,474.092



Landings in Subdivisions 22-29 (% t)				
Year/Gear	Trawl	Gillnet	Trapnet	Total
2002	50%	39%	11%	100%
2003	68%	20%	12%	100%
2004	60%	31%	9%	100%
2005	62%	32%	6%	100%
2006	67%	27%	6%	100%
2007	69%	27%	4%	100%
2008	64%	33%	3%	100%
2009	60%	37%	3%	100%
2010	64%	33%	3%	100%
2011	68%	30%	2%	100%
2012	62%	35%	3%	100%
2013	67%	31%	2%	100%
2014	66%	30%	4%	100%
2015	73%	26%	1%	100%
2016	74%	23%	3%	100%
2017	73%	27%	0%	100%
2018	80%	17%	3%	100%
2019	77%	22%	1%	100%
2020	80%	20%	0%	100%
2021	78%	22%	0%	100%



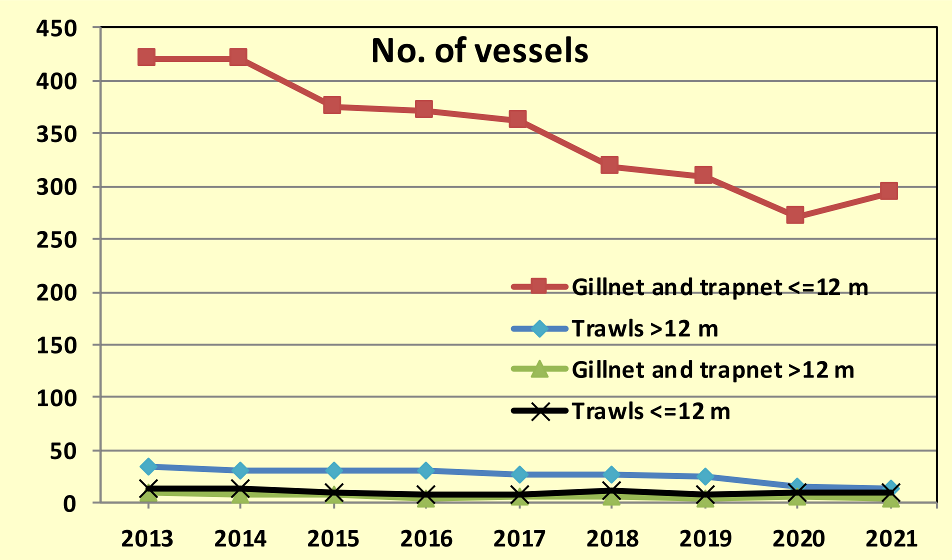
1.2 Fishing fleet

The herring fishing fleet in the Baltic Sea, where all catches are taken in a directed fishery, consists of a:

- coastal fleet with undecked vessels (rowing/motor boats <=12 m and engine power <=100 HP)
- cutter fleet with decked vessels and total lengths between 12 m and 40 m.

In the years from 2013 until 2021 the following types of fishing vessels carried out the herring fishery in the Baltic (only referring to vessels, which are contributing to the overall total landings per year with more than 20 %):

	Type of gear	Vessel length (m)	No. of vessels	GRT	kW
2013	Fixed gears	<=12	421	1,459	14,289
	(gillnet and trapnet)	>12	9	186	1,005
	Trawls	<=12	14	173	1,557
		>12	35	2,638	7,960
	TOTAL		**479**	**4,456**	**24,811**
2014	Fixed gears	<=12	421	1,443	14,351
	(gillnet and trapnet)	>12	8	149	970
	Trawls	<=12	13	170	1,502
		>12	31	2,469	7,205
	TOTAL		**473**	**4,231**	**24,028**
2015	Fixed gears	<=12	375	1,341	13,163
	(gillnet and trapnet)	>12	7	133	802
	Trawls	<=12	9	122	991
		>12	31	2,503	7,148
	TOTAL		**422**	**4,099**	**22,104**
2016	Fixed gears (gillnet and trapnet)	<=12	371	1,341	13,532
	(gillnet and trapnet)	>12	5	103	699
	Trawls	<=12	8	137	997
		>12	30	2,599	8,205
	TOTAL		**414**	**4,180**	**23,433**
2017	Fixed gears	<=12	362	1,237	12,158
	(gillnet and trapnet)	>12	6	148	874
	Trawls	<=12	8	113	872
		>12	27	2,910	7,816
	TOTAL		**403**	**2,910**	**21,720**
2018	Fixed gears	<=12	319	1,049	10,572
	(gillnet and trapnet)	>12	6	148	874
	Trawls	<=12	11	143	1,080
		>12	26	3,093	8,815
	TOTAL		**362**	**4,433**	**21,341**
2019	Fixed gears	<=12	309	1,008	10,374
	(gillnet and trapnet)	>12	4	100	598
	Trawls	<=12	8	114	897
		>12	25	2,655	8,025
	TOTAL		**346**	**3,877**	**19,894**
2020	Fixed gears	<=12	271	938	9,524
	(gillnet and trapnet)	>12	6	100	920
	Trawls	<=12	10	128	983
		>12	165	2,668	7,077
	TOTAL		**303**	**3,835**	**18,504**
2021	Fixed gears	<=12	293	990	10,087
	(gillnet and trapnet)	>12	4	77	523
	Trawls	<=12	10	122	900
		>12	14	2,385	6,551
	TOTAL		**321**	**3,574**	**18,061**


No. of vessels
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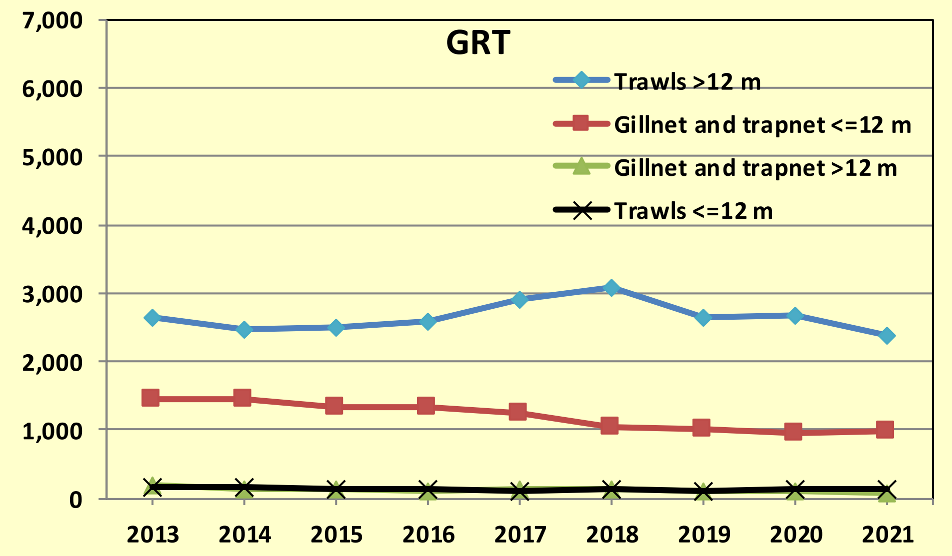
400
350
300
250
200
150
100
50
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
Gillnet and trapnet <=12 m
Trawls >12 m
Gillnet and trapnet >12 m
Trawls <=12 m


GRT
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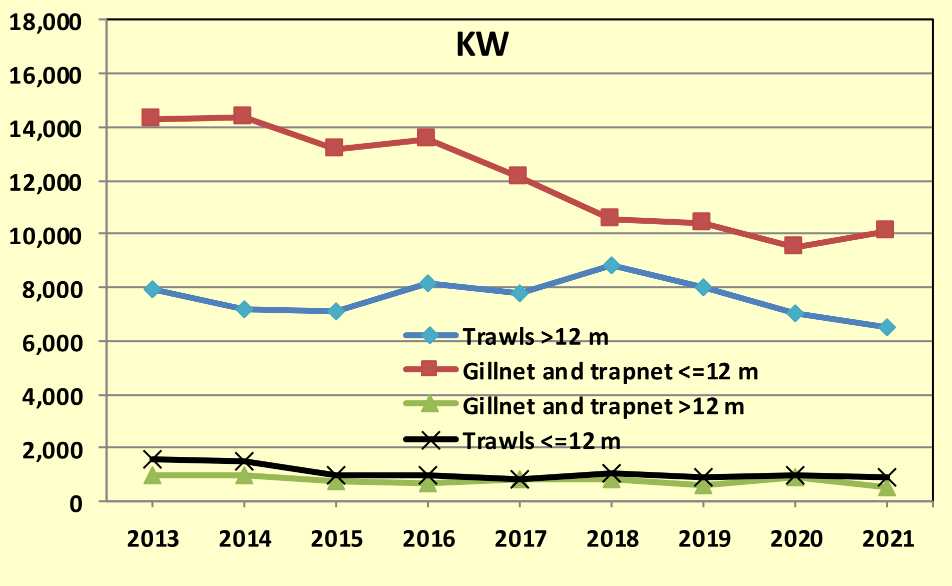
6,000
5,000
4,000
3,000
2,000
1,000
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m


KW
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16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m

1.3 Species composition of landings

The catch composition from gillnet and trapnet consists of nearly 100 % of herring.

The results from the species composition of German trawl catches, which were sampled in **Subdivision 24** of 4 in 2021, are given below:

SD 24/Quarter IV		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
Octob.	1									
	2									
	3									
	Mean									
Novemb.	1	43.65	0.04	0.00	0.00	43.69	99.92	0.08	0.00	0.00
	2	36.31	0.02	0.00	0.00	36.33	99.94	0.06	0.00	0.00
	3	37.30	0.00	0.00	0.00	37.30	100.00	0.00	0.00	0.00
	4	30.12	0.05	0.00	0.00	30.17	99.85	0.15	0.00	0.00
	Mean	36.85	0.03	0.00	0.00	36.87	99.93	0.07	0.00	0.00
Decemb.	1	26.17	0.00	0.00	0.00	26.17	100.00	0.00	0.00	0.00
	2	27.72	0.00	0.00	0.00	27.72	100.00	0.00	0.00	0.00
	3									
	Mean	26.95	0.00	0.00	0.00	26.95	100.00	0.00	0.00	0.00
Q IV	Mean	31.90	0.01	0.00	0.00	31.91	99.96	0.04	0.00	0.00

The officially reported total trawl landings of herring in Subdivision 24 (see 2.1) in combination with the detected mean species composition in the samples (see above) results in the following differences:

Subdiv.	Quarter	Trawl landings (t)	Mean Contribution of Herring (%)	Total Herring corrected (t)	Difference (t)
24	IV	**468.759**	99.96	468.571	-0.188

The officially reported trawl landings in Subdivision 24 (see 2.1) and the referring assessment input data (see 2.2 and 2.3) were as in last years not corrected since the results would only result in overall very small changes of the official statistics (<0.1 % difference).

1.4 Logbook registered discards/BMS landings

No BMS landings (new catch categories since 2015) of herring have been reported in the German herring fisheries in 2021 (no BMS landing have been reported since 2015). In 2021 a total amount of logbook registered discards (new catch categories since 2015) of 14.643 t were recorded by the German fisherman (as predation by seals) in the gillnet fisheries in SD 24 (2020 22/24 gillnet/trapnet fisheries: 32.437 t; 2019/SD 22/24 gillnet/trapnet fisheries: 21.882 t; 2018/SD 24/gillnet fisheries: 14.510 t). Neither discards nor logbook registered discards have been reported before 2018.

		Trapnet			Gillnet			Total		
		27.3.c.22	27.3.d.24	Total	27.3.c.22	27.3.d.24	Total	27.3.c.22	27.3.d.24	Total
Month	1	0.000	0.000	0.000	0.000	0.221	0.221	0.000	0.221	0.221
	2	0.000	0.000	0.000	0.000	0.335	0.335	0.000	0.335	0.335
	3	0.000	0.000	0.000	0.000	8.744	8.744	0.000	8.744	8.744
	4	0.000	0.000	0.000	0.000	3.698	3.698	0.000	3.698	3.698
	5	0.000	0.000	0.000	0.000	0.210	0.210	0.000	0.210	0.210
	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.480	0.480	0.000	0.480	0.480
	11	0.000	0.000	0.000	0.000	0.845	0.845	0.000	0.845	0.845
	12	0.000	0.000	0.000	0.000	0.110	0.110	0.000	0.110	0.110
Quarter	1	0.000	0.000	0.000	0.000	9.300	9.300	0.000	9.300	9.300
	2	0.000	0.000	0.000	0.000	3.908	3.908	0.000	3.908	3.908
	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	4	0.000	0.000	0.000	0.000	1.435	1.435	0.000	1.435	1.435
Total		0.000	0.000	0.000	0.000	14.643	14.643	0.000	14.643	14.643

1.5 Central Baltic herring

In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring Spawning herring (WBSSH) and the Central Baltic herring (CBH) overlap. German autumn acoustic survey (GERAS) results indicated in the recent years that in SD 24, which is part of the WBSSH management area, a considerable fraction of CBH is present and correspondingly erroneously allocated to WBSSH stock indices (ICES, 2013). Accordingly, a stock separation function (SF) based on growth parameters in 2005 to 2010 has been developed to quantify the proportion of CBH and WBSSH in the area (Gröhsler et al., 2013, Gröhsler et al., 2016). The estimates of the growth parameters based on baseline samples of WBSSH and CBH support the applicability of SF in 2011-2018 and 2020-2021 (no update for 2019, due CBH occurring in baseline samples in SD 21 and SD 23, Oeberst et al., 2013, WD Oeberst et al., 2014, WD Oeberst et al., 2015; WD Oeberst et al., 2016; WD Oeberst et al., 2017; WD Gröhsler, T. and Schaber, M., 2018, WD Gröhsler, T. and Schaber, M., 2019, WD Gröhsler, T. and Schaber, M., 2021, WD Gröhsler, T. and Schaber, M., 2022). SF (slightly modified by commercial samples) was employed in the years 2005-2016 to identify the fraction of Central Baltic Herring in German commercial herring landings from SD 22 and 24 (WD Gröhsler et al., 2013; ICES, 2018). These results and further results of the years 2017-2020 showed a rather low share of CBH in landings from all métiers but indicated that the actual degree of mixing might be underrepresented in commercial landings as German commercial fisheries target pre-spawning and spawning aggregations of WBSSH.

1.6 References

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1.7 Landings (tons) and sampling effort under COVID-19 conditions

The sampling in SDs 22-24 was carried out as usual without constraints caused by COVID-19. Independent of Covid-19, it was not possible - as in the years before - to get any samples from the area of SDs 25-29 since 56 % of all herring landings (631 t) were landed in foreign ports.

1.7.1 Subdivisions 22 and 24

Gear	Quarter	SUBDIVISION 22				SUBDIVISION 24				TOTAL SUBDIVISIONS 22 & 24			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	1.062	0	0	0	42.430	0	0	0	43.492	0	0	0
	Q 2	0.008	0	0	0	0.706	0	0	0	0.714	0	0	0
	Q 3	0.050	-	-	-	0.000	-	-	-	0.050	-	-	-
	Q 4	0.060	0	0	0	468.759	6	1,624	640	468.819	6	1,624	640
	Total	1.180	0	0	0	511.895	6	1,624	640	513.075	6	1,624	640
GILLNET	Q 1	11.662	3	526	86	203.729	9	1,598	312	215.391	12	2,124	398
	Q 2	3.606	0	0	0	85.982	5	1,051	171	89.588	5	1,051	171
	Q 3	0.100	0	0	0	0.045	0	0	0	0.145	0	0	0
	Q 4	2.693	0	0	0	18.888	0	0	0	21.581	0	0	0
	Total	18.061	3	526	86	308.644	14	2,649	483	326.705	17	3,175	569
TRAPNET	Q 1	1.381	2	568	83	0.082	0	0	0	1.463	-	-	-
	Q 2	0.780	3	958	145	0.453	0	0	0	1.233	3	958	145
	Q 3	0.017	0	0	0	0.000	-	-	-	0.017	0	0	0
	Q 4	0.096	0	0	0	0.663	0	0	0	0.759	0	0	0
	Total	2.274	5	1,526	228	1.198	0	0	0	3.472	3	958	145
TOTAL	Q 1	14.105	5	1,094	169	246.241	9	1,598	312	260.346	14	2,692	481
	Q 2	4.394	3	958	145	87.141	5	1,051	171	91.535	8	2,009	316
	Q 3	0.167	0	0	0	0.045	0	0	0	0.212	0	0	0
	Q 4	2.849	0	0	0	488.310	6	1,624	640	491.159	6	1,624	640
	Total	21.515	8	2,052	314	821.737	20	4,273	1,123	843.252	28	6,325	1,437

1.7.2 Subdivisions 25-29

All herring in this area was caught by trawls.

Gear	Quarter	SUBDIVISION 25				SUBDIVISION 26				SUBDIVISION 27			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	126.503	0	0	0	225.000	0	0	0	0.000	-	-	-
	Q 2	182.384	0	0	0	16.892	0	0	0	10.323	0	0	0
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Total	308.887	0	0	0	241.892	0	0	0	10.323	0	0	0

Gear	Quarter	SUBDIVISION 28.2				SUBDIVISION 29				SUBDIVISION 25-29			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	16.067	0	0	0	39.717	0	0	0	407.287	0	0	0
	Q 2	0.000	-	-	-	0.000	-	-	-	209.599	0	0	0
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	0	0	0
	Q 4	2.990	0	0	0	10.964	0	0	0	13.954	0	0	0
	Total	19.057	0	0	0	50.681	0	0	0	630.840	0	0	0

1.8 Catch in numbers (millions)

1.8.1 Subdivisions 22 and 24

No replacement has been carried out for trawl landings in quarter 1 and 2 of SDs 22&24.

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0			0.000002	0.000002				0.019			0.00000	0.019
	1			0.00001	0.00001				0.066			0.00001	0.066
	2			0.00006	0.00008				0.601			0.00006	0.602
	3			0.00013	0.00015				1.173			0.00013	1.173
	4			0.00010	0.00012				0.921			0.00010	0.922
	5			0.00005	0.00005				0.427			0.00005	0.427
	6			0.00003	0.00004				0.296			0.00003	0.296
	7			0.00002	0.00003				0.209			0.00002	0.209
	8+			0.00001	0.00001				0.070			0.00001	0.070
	Sum			0.00040	0.00048				3.783			0.00040	3.783
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0												
	1												
	2												
	3	0.0001	0.0001	0.000003	0.0001		0.003	0.00000	0.001	0.000	0.003	0.00000	0.001
	4	0.004	0.0010	0.000027	0.0007	0.061	0.023	0.00001	0.005	0.066	0.024	0.00004	0.006
	5	0.029	0.0030	0.000084	0.0023	0.096	0.072	0.00004	0.016	0.124	0.075	0.00012	0.018
	6	0.026	0.0067	0.000186	0.0050	0.404	0.160	0.00008	0.035	0.431	0.166	0.00027	0.040
	7	0.004	0.0039	0.000109	0.0029	0.248	0.094	0.00005	0.021	0.252	0.097	0.00016	0.023
	8+	0.011	0.0075	0.000207	0.0056	0.301	0.178	0.00009	0.039	0.311	0.185	0.00030	0.045
	Sum	0.074	0.0222	0.000616	0.0166	1.110	0.530	0.00028	0.116	1.185	0.552	0.00089	0.133
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0												
	1												
	2		0.001	0.000015	0.00008		0.0004		0.0006		0.0011	0.00001	0.00065
	3	0.000	0.002	0.000045	0.00025	0.00002	0.0012		0.0018	0.0004	0.0033	0.00004	0.00201
	4	0.003	0.002	0.000046	0.00026	0.00018	0.0012		0.0018	0.0032	0.0033	0.00005	0.00204
	5	0.005	0.004	0.000093	0.00052	0.00032	0.0025		0.0036	0.0056	0.0067	0.00009	0.00414
	6	0.002	0.001	0.000012	0.00007	0.00012	0.0003		0.0005	0.0021	0.0009	0.00001	0.00054
	7	0.000	0.000	0.000004	0.00002	0.00001	0.0001		0.0001	0.0002	0.0003	0.00000	0.00016
	8+	0.001	0.000	0.000000	0.00000	0.00004	0.0000		0.0000	0.0008	0.0000	0.00000	0.00001
	Sum	0.012	0.010	0.00021	0.00121	0.00069	0.0057		0.0083	0.0122	0.0155	0.00021	0.00955
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0			0.000002	0.00000				0.019			0.00000	0.019
	1			0.00001	0.00001				0.066			0.00001	0.066
	2		0.0007	0.00008	0.00016		0.000		0.602		0.0011	0.00008	0.602
	3	0.0005	0.0022	0.00017	0.00049	0.000	0.004	0.00000	1.176	0.001	0.0062	0.00017	1.176
	4	0.0073	0.0031	0.00017	0.00110	0.062	0.024	0.00001	0.928	0.069	0.0274	0.00018	0.929
	5	0.0339	0.0073	0.00022	0.00285	0.096	0.075	0.00004	0.447	0.130	0.0822	0.00026	0.450
	6	0.0282	0.0073	0.00023	0.00511	0.405	0.160	0.00008	0.331	0.433	0.1673	0.00031	0.336
	7	0.0046	0.0041	0.00013	0.00298	0.248	0.094	0.00005	0.230	0.253	0.0977	0.00018	0.233
	8+	0.0113	0.0075	0.00021	0.00558	0.301	0.178	0.00009	0.109	0.312	0.1854	0.00031	0.115
	Sum	0.0858	0.0320	0.00123	0.0183	1.111	0.535	0.00028	3.907	1.197	0.5673	0.00151	3.925

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	3 & 4	24	Trawl	4	Gillnet	3 & 4	24	Gillnet	2
Gillnet	2-4	24	Gillnet	2	Trapn	1	22	Trapn	1
Trapn	3 & 4	22	Trapn	2	Trapn	2 & 4	22	Trapn	2
Trawl	1 & 2	with no filling			Trawl	1 & 2	with no filling		

1.8.2 Subdivisions 25-29

No sampling.

1.9 Mean weight in the catch (grams)

1.9.1 Subdivisions 22 and 24

No replacement has been carried out for trawl landings in quarter 1 and 2 of SDs 22&24.

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0			20.1	20.1				20.1			20.1	20.1
	1			38.4	38.4				38.4			38.4	38.4
	2			83.2	83.2				83.2			83.2	83.2
	3			106.8	106.8				106.8			106.8	106.8
	4			135.3	135.3				135.3			135.3	135.3
	5			150.1	150.1				150.1			150.1	150.1
	6			171.1	171.1				171.1			171.1	171.1
	7			182.1	182.1				182.1			182.1	182.1
	8+			187.2	187.2				187.2			187.2	187.2
	Sum			123.9	123.9				123.9			123.9	123.9
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0												
	1												
	2												
	3	107.8	111.4	111.4	111.4		111.4	111.4	111.4	107.8	111.4	111.4	111.4
	4	139.5	136.2	136.2	136.2	152.4	136.2	136.2	136.2	151.5	136.2	136.2	136.2
	5	153.4	153.3	153.3	153.3	171.3	153.3	153.3	153.3	167.2	153.3	153.3	153.3
	6	156.6	161.2	161.2	161.2	182.2	161.2	161.2	161.2	180.6	161.2	161.2	161.2
	7	166.5	165.8	165.8	165.8	187.6	165.8	165.8	165.8	187.2	165.8	165.8	165.8
	8+	171.1	169.6	169.6	169.6	192.1	169.6	169.6	169.6	191.4	169.6	169.6	169.6
	Sum	157.0	162.4	162.4	162.4	183.5	162.4	162.4	162.4	181.8	162.4	162.4	162.4
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0												
	1												
	2		49.5	49.5	49.5		49.5		49.5		49.5	49.5	49.5
	3	78.8	54.8	54.8	54.8	78.8	54.8		54.8	78.8	54.8	54.8	54.8
	4	96.3	79.6	79.6	79.6	96.3	79.6		79.6	96.3	79.6	79.6	79.6
	5	122.8	92.8	92.8	92.8	122.8	92.8		92.8	122.8	92.8	92.8	92.8
	6	139.0	93.0	93.0	93.0	139.0	93.0		93.0	139.0	93.0	93.0	93.0
	7	134.2	107.8	107.8	107.8	134.2	107.8		107.8	134.2	107.8	107.8	107.8
	8+	161.6	200.0	200.0	200.0	161.6	200.0		200.0	161.6	200.0	200.0	200.0
	Sum	119.7	79.4	79.4	79.4	119.7	79.4		79.4	119.7	79.4	79.4	79.4
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0			20.1	20.1				20.1			20.1	20.1
	1			38.4	38.4				38.4			38.4	38.4
	2		49.5	77.0	65.8		49.5		83.2		49.5	77.0	83.2
	3	86.3	57.9	93.4	80.9	78.8	94.7	111.4	106.7	86.0	81.8	93.6	106.7
	4	121.7	97.5	120.5	122.8	152.2	133.3	136.2	135.2	149.0	129.3	121.6	135.2
	5	148.6	118.0	127.4	142.1	171.2	151.3	153.3	149.7	165.3	148.3	131.2	149.7
	6	155.4	155.9	158.9	160.3	182.2	161.1	161.2	169.9	180.4	160.8	159.5	169.8
	7	165.4	163.4	166.9	165.5	187.6	165.7	165.8	180.6	187.2	165.6	166.6	180.4
	8+	170.5	169.6	170.2	169.6	192.1	169.6	169.6	180.9	191.3	169.6	170.0	180.4
	Sum	152.0	137.0	135.4	155.9	183.5	161.5	162.4	125.0	181.2	160.1	140.4	125.1

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	3 & 4	24	Trawl	4	Gillnet	3 & 4	24	Gillnet	2
Gillnet	2-4	24	Gillnet	2	Trapn	1	22	Trapn	1
Trapn	3 & 4	22	Trapn	2	Trapn	2 & 4	22	Trapn	2
Trawl	1 & 2	with no filling			Trawl	1 & 2	with no filling		

1.9.2 Subdivisions 25 and 29

No sampling.

1.10 Mean length in the catch (cm)

1.10.1 Subdivisions 22 and 24

No replacement has been carried out for trawl landings in quarter 1 and 2 of SDs 22&24.

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0			14.9	14.9				14.9			14.9	14.9
	1			18.4	18.4				18.4			18.4	18.4
	2			23.0	23.0				23.0			23.0	23.0
	3			24.6	24.6				24.6			24.6	24.6
	4			26.2	26.2				26.2			26.2	26.2
	5			27.0	27.0				27.0			27.0	27.0
	6			28.2	28.2				28.2			28.2	28.2
	7			28.8	28.8				28.8			28.8	28.8
	8+			29.4	29.4				29.4			29.4	29.4
	Sum			25.4	25.4				25.4			25.4	25.4
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0												
	1												
	2												
	3	24.3	24.6	24.6	24.6		24.6	24.6	24.6	24.3	24.6	24.6	24.6
	4	26.3	26.2	26.2	26.2	27.2	26.2	26.2	26.2	27.1	26.2	26.2	26.2
	5	27.3	27.3	27.3	27.3	28.4	27.3	27.3	27.3	28.1	27.3	27.3	27.3
	6	27.6	28.0	28.0	28.0	29.1	28.0	28.0	28.0	29.0	28.0	28.0	28.0
	7	28.2	28.3	28.3	28.3	29.5	28.3	28.3	28.3	29.5	28.3	28.3	28.3
	8+	28.6	28.6	28.6	28.6	29.8	28.6	28.6	28.6	29.8	28.6	28.6	28.6
	Sum	27.6	28.0	28.0	28.0	29.2	28.0	28.0	28.0	29.1	28.0	28.0	28.0
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0												
	1												
	2		19.5	19.5	19.5		19.5		19.5		19.5	19.5	19.5
	3	23.0	20.3	20.3	20.3	23.0	20.3		20.3	23.0	20.3	20.3	20.3
	4	24.1	23.1	23.1	23.1	24.1	23.1		23.1	24.1	23.1	23.1	23.1
	5	26.0	24.2	24.2	24.2	26.0	24.2		24.2	26.0	24.2	24.2	24.2
	6	27.0	24.1	24.1	24.1	27.0	24.1		24.1	27.0	24.1	24.1	24.1
	7	26.8	25.1	25.1	25.1	26.8	25.1		25.1	26.8	25.1	25.1	25.1
	8+	28.5	29.3	29.3	29.3	28.5	29.3		29.3	28.5	29.3	29.3	29.3
	Sum	25.7	22.8	22.8	22.8	25.7	22.8		22.8	25.7	22.8	22.8	22.8
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0			14.9	14.9				14.9			14.9	14.9
	1			18.4	18.4				18.4			18.4	18.4
	2		19.5	22.3	21.2		19.5		22.9		19.5	22.3	22.9
	3	23.3	20.5	23.4	22.4	23.0	23.3	24.6	24.6	23.3	22.3	23.5	24.6
	4	25.4	24.0	25.4	25.4	27.2	26.0	26.2	26.2	27.0	25.8	25.4	26.2
	5	27.1	25.5	25.9	26.7	28.4	27.2	27.3	27.0	28.0	27.1	26.2	27.0
	6	27.5	27.7	27.8	27.9	29.1	28.0	28.0	28.2	29.0	27.9	27.8	28.2
	7	28.2	28.1	28.3	28.3	29.5	28.3	28.3	28.8	29.5	28.3	28.3	28.7
	8+	28.6	28.6	28.6	28.6	29.8	28.6	28.6	29.1	29.8	28.6	28.6	29.1
	Sum	27.3	26.4	26.3	27.6	29.2	28.0	28.0	25.5	29.1	27.9	26.6	25.5

REPLACEMENT OF MISSING SAMPLES:

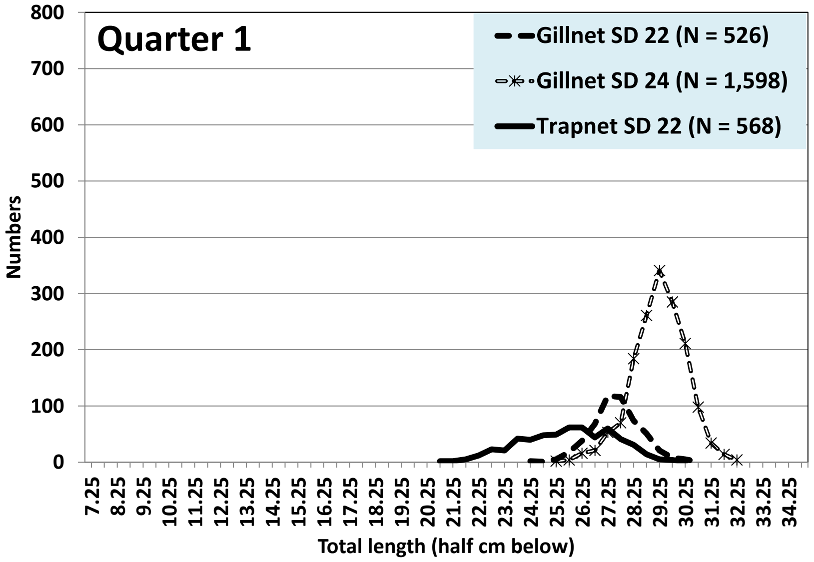
SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	3 & 4	24	Trawl	4	Gillnet	3 & 4	24	Gillnet	2
Gillnet	2-4	24	Gillnet	2	Trapn	1	22	Trapn	1
Trapn	3 & 4	22	Trapn	2	Trapn	2 & 4	22	Trapn	2
Trawl	1 & 2	with no filling			Trawl	1 & 2	with no filling		

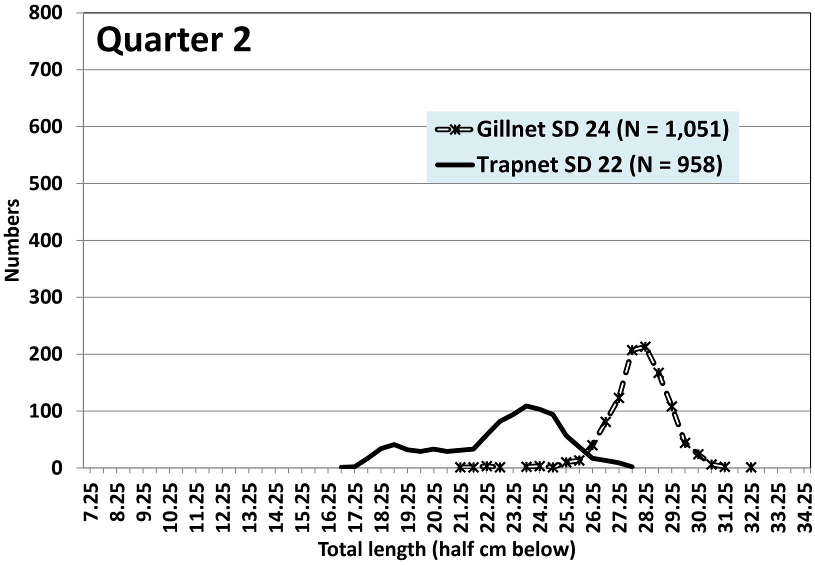
1.10.2 Subdivisions 25 and 29

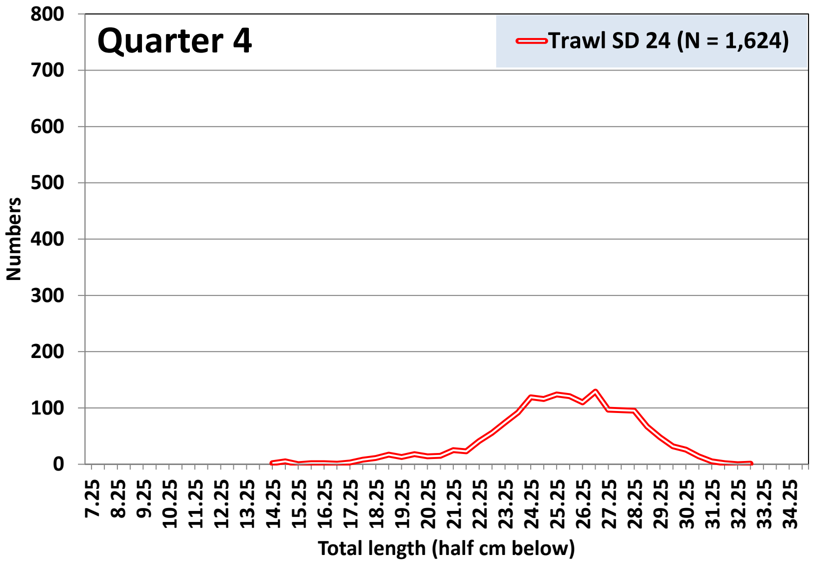
No sampling.

1.11 Sampled length distributions by Subdivision, quarter and type of gear

1.11.1 Subdivisions 22 and 24







1.11.2 Subdivisions 25 and 29

No sampling.

2 SPRAT

2.1 Fisheries

The provisional sprat **landings in Subdivisions 22-29 in 2021 reached** according to the
(a) share of the EU quota (2021: 13,933 t) and
(b) further transfer of quota (overall 1,930 t were transferred to other Baltic countries)

11,959 t,

which represents a utilization of the final overall quota in 2021 (12,003 t) of 99,6 % (2020: 96.2 %). Only 45 % of the sprat landings were landed in foreign ports in 2021 (2020: 87 %).

As in previous years most sprat was

- caught in the first quarter (2021: 82 %, 2020: 54 %, 2019: 62 %),
- caught in Subdivisions 25-29 (2021: 99,97 %, 2020: 99.8 %, 2019: 97 %)

The landings (t) by quarter and Subdivision including information about the landings in foreign ports are shown in the table below:

Quarter	SD 22	SD 24	SD 25	SD 26	SD 27	SD 28	SD 29	(1) Total SD 25-29	% (1)/(2)	(2) Total SD 22-29	% (2)
I	0.462	-	2,829.636	5,835.929	-	569.735	599.433	9,834.733	100.0%	9,835.195	82.2%
	-	-	1,001.664	2,218.966	-	75.635	-	3,296.265	100.0%	3,296.265	60.9%
II	-	0.700	912.682	538.175	219.257	-	-	1,670.114	100.0%	1,670.814	14.0%
	-	-	912.192	538.175	219.257	-	-	1,669.624	100.0%	1,669.624	30.8%
III	0.005	-	-	-	-	-	-	0.000	0.0%	**0.005**	0.0%
	-	-	-	-	-	-	-	-	-	-	-
IV	0.002	2.948	86.844	-	-	66.410	296.291	449.545	99.3%	452.495	3.8%
	-	-	86.844	-	-	66.410	296.291	449.545	100.0%	449.545	8.3%
Total	**0.469**	**3.648**	**3,829.162**	**6,374.104**	**219.257**	**636.145**	**895.724**	**11,954.392**	**100.0%**	**11,958.509**	100.0%
	0.000	0.000	2,000.700	2,757.141	219.257	142.045	296.291	5,415.434	100.0%	5,415.434	45.3%
								2021/2020		**2021/2020**	
								134.2%		**133.9%**	
	Fraction of total landings (t) in foreign ports							69.6%		69.5%	
									Proportion landed in foreign ports in 2021:	**45.3%**	

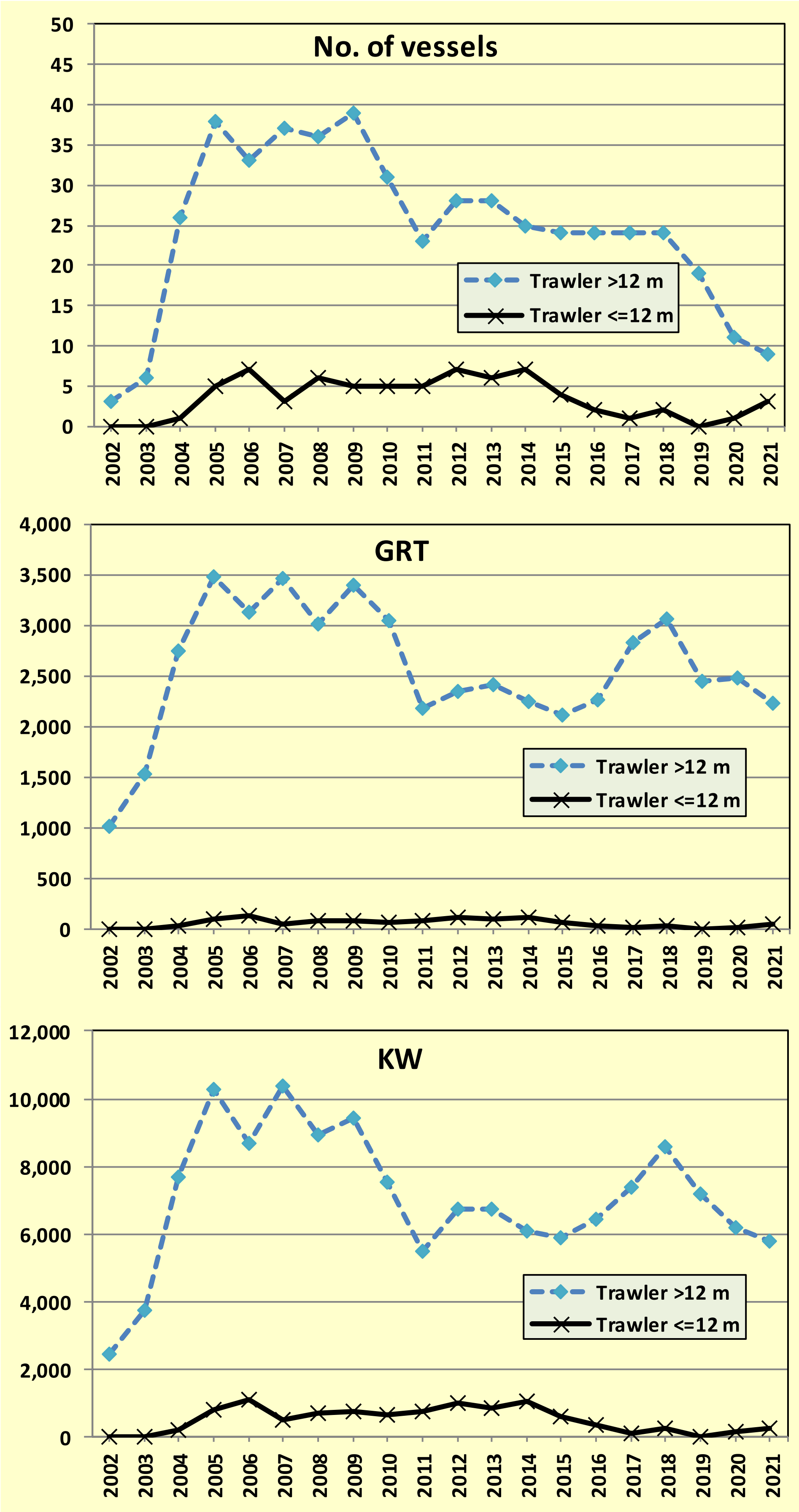
2.2 Fishing fleet

The German fishing fleet in the Baltic Sea consists of only one fleet where all catches for sprat are taken in a directed trawl fishery:

- cutter fleet of total length <= 12 m,
- cutter fleet of total length > 12 m.

In the years 2002 – 2021 the following type of fishing vessels were available to carry out the sprat fishery in the Baltic Sea (only referring to vessels, which are contributing to the overall total landings per year with more than 20 %):

Year	Vessel length (m)	No. of vessels	GRT	kW
2002	<=12	0	0	0
	>12	3	1,009	2,434
2003	<=12	0	0	0
	>12	6	1,531	3,716
2004	<=12	1	24	220
	>12	26	2,750	7,682
2005	<=12	5	93	798
	>12	38	3,479	10,289
2006	<=12	7	123	1,090
	>12	33	3,134	8,685
2007	<=12	3	43	492
	>12	37	3,454	10,396
2008	<=12	6	72	679
	>12	36	3,014	8,913
2009	<=12	5	79	761
	>12	39	3,389	9,438
2010	<=12	5	69	664
	>12	31	3,041	7,525
2011	<=12	5	74	756
	>12	23	2,174	5,494
2012	<=12	7	107	1.007
	>12	28	2.345	6.727
2013	<=12	6	94	868
	>12	28	2,411	6,728
2014	<=12	7	112	1,019
	>12	25	2,241	6,070
2015	<=12	4	69	596
	>12	24	2,119	5,892
2016	<=12	2	37	345
	>12	24	2,254	6,424
2017	<=12	1	17	100
	>12	24	2,821	7,396
2018	<=12	2	32	246
	>12	24	3,052	8,560
2019	<=12	0	0	0
	>12	19	2,445	7,179
2020	<=12	1	16	143
	>12	11	2,476	6,166
2021	<=12	3	48	260
	>12	9	2,224	5,761


No. of vessels
Trawler >12 m
Trawler <=12 m
50
45
40
35
30
25
20
15
10
5
0
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
GRT
Trawler >12 m
Trawler <=12 m
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
KW
Trawler >12 m
Trawler <=12 m
12,000
10,000
8,000
6,000
4,000
2,000
0
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021

2.3 Species composition of landings

The results from the species composition of German trawl catches, which were sampled in **Subdivision 25 of quarter 1 and 2** in 2021, are given below:

SD 25/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January	1	8.3	0.1	0.0	0.0	8.4	98.9	1.1	0.0	0.0
	Mean	8.3	0.1	0.0	0.0	8.4	98.9	1.1	0.0	0.0
February										
	Mean									
March	1	6.6	0.2	0.0	0.0	6.8	96.9	3.1	0.0	0.0
	2	6.7	0.1	0.0	0.0	6.8	98.9	1.1	0.0	0.0
	3	7.3	0.2	0.0	0.0	7.5	97.6	2.4	0.0	0.0
	4	7.1	0.2	0.0	0.0	7.3	96.6	3.4	0.0	0.0
	5	6.3	0.1	0.0	0.2	6.6	95.2	1.9	0.0	2.9
	6	6.7	0.0	0.0	0.3	6.7	99.5	0.5	0.0	4.4
	7	7.7	0.0	0.0	0.0	7.7	100.0	0.0	0.0	0.0
	Mean	6.9	0.1	0.0	0.1	7.0	97.8	1.8	0.0	1.0
Q I	Mean	7.6	0.1	0.0	0.0	7.7	98.3	1.4	0.0	0.5

SD 25/Quarter II		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
April	1	7.2	0.1	0.0	0.0	7.3	99.1	0.9	0.0	0.0
	2	8.3	0.2	0.0	0.0	8.5	97.1	2.9	0.0	0.0
	Mean	7.8	0.2	0.0	0.0	7.9	98.1	1.9	0.0	0.0
May										
	Mean									
June										
	Mean									
Q II	Mean	7.8	0.2	0.0	0.0	7.9	98.1	1.9	0.0	0.0

The results from the species composition of German trawl catches, which were sampled in **Subdivision 26 of quarter 1** in 2021 are given below:

SD 26/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January	1	7.4	0.0	0.0	0.0	7.4	100.0	0.0	0.0	0.0
	2	7.2	0.0	0.0	0.0	7.2	100.0	0.0	0.0	0.0
	Mean	7.3	0.0	0.0	0.0	7.3	100.0	0.0	0.0	0.0
February	3	7.3	0.0	0.0	0.0	7.3	100.0	0.0	0.0	0.0
	4	7.9	0.0	0.0	0.0	7.9	100.0	0.0	0.0	0.0
	Mean	7.6	0.0	0.0	0.0	7.6	100.0	0.0	0.0	0.0
March										
	Mean									
Q I	Mean	7.5	0.0	0.0	0.0	7.5	100.0	0.0	0.0	0.0

The results from the species composition of German trawl catches, which were sampled in **Subdivision 28 of quarter 1** in 2021, are given below:

SD 28/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January	1	6.2	0.0	0.0	0.0	6.2	100.0	0.0	0.0	0.0
	Mean	6.2	0.0	0.0	0.0	6.2	100.0	0.0	0.0	0.0
February										
	Mean									
March										
	Mean									
Q I	Mean	6.2	0.0	0.0	0.0	6.2	100.0	0.0	0.0	0.0

The results from the species composition of German trawl catches, which were sampled in **Subdivision 29 of quarter 1** in 2021, are given below:

SD 29/Quartal 1		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January										
	Mean									
February	1	7.6	0.7	0.0	0.0	8.3	91.4	8.6	0.0	0.0
	Mean	7.6	0.7	0.0	0.0	8.3	91.4	8.6	0.0	0.0
March										
	Mean									
Q I	Mean	7.6	0.7	0.0	0.0	8.3	91.4	8.6	0.0	0.0

The officially reported total trawl landings of sprat in Subdivisions 25-29 (see 2.1) in combination with the noticed mean species composition in the samples (see above) would result in the following differences:

Subdiv.	Quarter	Trawl landings (t)	Mean Contribution of Sprat (%)	Total Sprat corrected (t)	Difference (t)
25	I	2,830	98.3	2,782	48
	II	913	98.1	895	17
26	I	5,836	100.0	5,836	0
28	I	570	100.0	570	0
29	I	599	91.4	548	52

The overall difference amounted to -117 t, which would represent a change of the total landing value for Germany in 2021 of -1 % [total landings in SD 22-29 in 2021 of 11,959 t - 117 t ->11,842 t, 2019-2020: -3 %, 2018: -12 %, 2017: -4 %, 2016: -11 %, 2015: -14 %; 2014: -7 %, 2013: -6 %]. The officially reported trawl landings (see 2.1) and the referring assessment input data (see 2.5 and 2.6) were not corrected these small differences in 2021. However, an implementation error of about at least 1-14 % regarding the total landing figure for Germany could be explored during the next benchmark process.

2.4 Logbook registered discards/BMS landings

No logbook registered discards or BMS landings (both new catch categories since 2015) of sprat have been reported in the German fisheries in 2021 (almost no BMS landing have been reported in 2015 - 2018 and no discards/logbook registered discards have been reported before 2019).

2.5 Landings (tons) and sampling effort under Covid-19 conditions

Only 45 % sprat was landed in foreign ports in 2021 (2020: 87%, 2019: 89 %, 2018: 90 %). In contrast to last year where it was only possible to sample 55 % of the total landings (most likely caused by a combination of COVID-19 restrictions and reduced quota), the sampling in 2021 got back to the higher levels before 2020. In 2021 it was possible to sample 90 % of the sprat landings (2019: 90 %, 2018: 93 %).

Gear	Quarter	SUBDIVISION 22[1]				SUBDIVISION 24[2]				SUBDIVISION 25[3]			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	0.462	0	0	0	0.000	-	-	-	2,829.636	8	1,836	343
	Q 2	0.000	-	-	-	0.700	0	0	0	912.682	2	472	69
	Q 3	0.005	0	0	0	0.000	-	-	-	0.000	-	-	-
	Q 4	0.002	0	0	0	2.948	0	0	0	86.844	0	0	0
	Total	0.469	0	0	0	3.648	0	0	0	3,829.162	10	2,308	412

Gear	Quarter	SUBDIVISION 26[3]				SUBDIVISION 27[3]				SUBDIVISION 28[3]			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	5,835.929	4	985	206	0.000	-	-	-	569.735	1	238	33
	Q 2	538.175	-	-	-	219.257	-	-	-	0.000	-	-	-
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.000	-	-	-	0.000	-	-	-	66.410	-	-	-
	Total	6,374.104	4	985	206	219.257	0	0	0	636.145	1	238	33

Gear	Quarter	SUBDIVISION 29[3]				SUBDIVISIONS 22-29[4]			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	599.433	1	227	47	9,835.195	14	3,286	629
	Q 2	0.000	-	-	-	1,670.814	2	472	69
	Q 3	0.000	-	-	-	0.005	0	0	0
	Q 4	296.291	-	-	-	452.495	0	0	0
	Total	895.724	1	227	47	11,958.509	16	3,758	698

Fraction of landings in foreign ports:

[1]SD 22: 0 %
[2]SD 24: 0 %
[3]SD 25-29: 5,415 t (45 %)
[4]SD 22-29: 5,415 t (45 %)

2.6 Catch in numbers (millions)

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISION 25				SUBDIVISION 26			
	Age	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0																
	1									6.009	1.659			59.443			
	2									101.173	39.132			326.773			
	3									52.220	19.488			99.524			
	4									61.513	20.935			82.970			
	5									20.138	9.107			42.753			
	6									28.597	3.872			27.992			
	7									5.011	3.664			6.261			
	8+									0.450							
	Sum									275.110	97.857			645.716			

		SUBDIVISION 27				SUBDIVISION 28				SUBDIVISION 29				SUBDIVISIONS 22-29			
	Age	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0																
	1					15.244				6.186				86.882	1.659		
	2					19.103				46.882				493.931	39.132		
	3					20.466				5.990				178.201	19.488		
	4					5.910				6.251				156.644	20.935		
	5					16.803				2.279				81.972	9.107		
	6					0.327				6.316				63.232	3.872		
	7													11.272	3.664		
	8+													0.450			
	Sum					77.853				73.904				1072.584	97.857		

2.7 Mean weight in the catch (grams)

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISION 25				SUBDIVISION 26			
	Age	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0																
	1									3.8	3.6			4.1			
	2									9.1	8.1			8.7			
	3									10.7	9.9			9.9			
	4									11.1	10.2			10.5			
	5									12.2	11.2			11.3			
	6									11.8	11.5			11.6			
	7									11.9	10.4			11.3			
	8+									16.4							
	Sum									10.3	9.3			9.0			

		SUBDIVISION 27				SUBDIVISION 28				SUBDIVISION 29				SUBDIVISIONS 22-29			
	Age	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0																
	1					6.1				2.4				4.3	3.6		
	2					6.8				7.9				8.7	8.1		
	3					7.9				9.8				9.9	9.9		
	4					7.6				10.3				10.6	10.2		
	5					8.2				11.3				10.9	11.2		
	6					9.9				10.0				11.5	11.5		
	7													11.6	10.4		
	8+													16.4			
	Sum					7.3				8.1				9.2	9.3		

2.8 Mean length in the catch (cm)

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISION 25				SUBDIVISION 26			
	Age	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0																
	1									8.9	8.8			9.0			
	2									11.5	11.1			11.2			
	3									12.2	12.1			11.7			
	4									12.4	12.2			12.0			
	5									12.8	12.6			12.4			
	6									12.6	12.7			12.5			
	7									12.7	12.3			12.4			
	8+									14.3							
	Sum									12.0	11.7			11.3			

		SUBDIVISION 27				SUBDIVISION 28				SUBDIVISION 29				SUBDIVISIONS 22-29			
	Age	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0																
	1					10.2				7.9				9.2	8.8		
	2					10.7				10.7				11.2	11.1		
	3					11.5				11.7				11.8	12.1		
	4					11.4				12.0				12.1	12.2		
	5					11.7				12.5				12.3	12.6		
	6					13.3				11.8				12.5	12.7		
	7													12.5	12.3		
	8+													14.3			
	Sum					11.1				10.8				11.4	11.7		

2.9 Sampled length distributions of sprat by Subdivision and quarter