Annex 1: List of participants

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Annex 2: Resolutions

WGDEEP - Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources

Approved in Resolutions meeting on 9 November 2022

2022/2/FRSG10 Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP), chaired by Elvar Hallfredsson, Norway and Juan Gil Herrera*, Spain, will meet in Lisbon, Portugal, 3–9 May 2023 to:

a) Address generic ToRs for Regional and Species Working Groups.

b) Complete the development of Stock Annexes for all the stocks assessed by WGDEEP, based on the most recent agreed assessment.

c) Update the description of deep-water fisheries in both the NEAFC Regulatory Area and ICES area(s) by compiling data on catch/landings, fishing effort (inside versus outside the EEZs, in spawning areas, areas of local depletion, etc.), and discard statistics at the finest spatial resolution possible by ICES Subarea and Division and NEAFC Regulatory Area. In particular, describe and prepare a first advice draft of any new emerging deep-water fishery with the available data in the NEAFC Regulatory Area.

d) Continue work on exploratory assessments for deep-water species.

e) Evaluate the status of stocks for the provision of advice in 2023.

The assessments will be carried out on the basis of the stock annex. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group on the dates specified in the 2023 ICES data call.

WGDEEP will report by 26 May 2023 for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

Generic ToRs for Regional and Species Working Groups

Approved in Resolutions meeting on 9 November 2022

The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

a) Consider and comment on Ecosystem and Fisheries Overviews with a focus on:

i) identifying and correcting mistakes and errors (both in the text, tables and figures), and

ii) proposing concrete evidence-based input that is considered essential for the advice but is currently under-developed or missing (with references and Data Profiling Tool entries, as appropriate).

The input will feed into the annual updates of the overviews. Delivery of contributions other than those outlined above is also welcomed but will be utilised during the revision process (around every 5 years).

b) Conduct an assessment on the stock(s) to be addressed in 2023 using the method (assessment, forecast or trends indicators) as described in the stock annex; - complete and document an audit of the calculations and results; and produce a **brief** report of the work carried out regarding the stock, providing summaries of the following where relevant:

i) Input data and examination of data quality; in the event of missing or inconsistent survey or catch information refer to the ACOM document for dealing with missing data and the linked template that formulates how deviations from the stock annex are to be reported.

ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;

iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area), estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2022.

iv) For category 3 and 4 stocks requiring new advice in 2023, implement the methods recommended by WKLIFE X (e.g. SPiCT, rfb, chr, rb rules) to replace the former 2 over 3 advice rule (2 over 5 for elasmobranchs). MSY reference points or proxies for the category 3 and 4 stocks (guidelines)

v) Evaluate spawning stock biomass, total stock biomass, fishing mortality, catches (projected landings and discards) using the method described in the stock annex;

1) for category 1 and 2 stocks, in addition to the other relevant model diagnostics, the recommendations and decision tree formulated by WKFORBIAS (see Annex 2 of https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WKFORBIAS_2019.pdf) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.

2) If the assessment is deemed no longer suitable as basis for advice, provide advice using an appropriate Category 2- 5 approach as described in ICES technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3 or ICES.

3) If the assessment has been moved to a Category 2-5 approach in the past year consider what is necessary to move back to a Category 1 and develop proposal for the appropriate benchmark process.

vi) Catch scenarios for the year(s) beyond the terminal year of the data for the stocks for which ICES has been requested to provide advice on fishing opportunities;

vii) Historical and analytical performance of the assessment and catch options with a succinct description of associated quality issues. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn's rho (assessment retrospective bias analysis) values for time series of recruitment, spawning stock biomass, and fishing mortality rate. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

c) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines.

d) Review progress on benchmark issues and processes of relevance to the Expert Group.
i) update the benchmark issues lists for the individual stocks in SID;
ii) review progress on benchmark issues and identify potential benchmarks to be initiated in 2024 for conclusion in 2025;
iii) determine the prioritization score for benchmarks proposed for 2024–2025;
iv) as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

e) Prepare the data calls for the next year's update assessment and for planned data evaluation workshops;

f) Identify research needs of relevance to the work of the Expert Group.

g) Review and update information regarding operational issues and research priorities on the Fisheries Resources Steering Group SharePoint site.

h) If not completed previously, complete the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity' for the new assessments and data used for the stocks. Also note in the benchmark report how productivity, species interactions, habitat and distributional changes, including those related to climate-change, could be considered in the advice.

i) Deliver conservation status advice in accordance with the "Technical Guidelines on the conservation status advice". The advice is only to be given when conservation aspects were identified and where clear, demonstrable management action can be recommended for any non-catch anthropogenic pressure. It can also be used to highlight clear demonstrable sensitivity to climate change. The qualification required to show clear, demonstratable management action is high. Avoid generic statements that are of no specific application to management.

j) Update SAG and SID with final assessment input and output

Information of the stocks to be considered by each Expert Group is available here.

Annex 3: Working documents

The following eighteen working documents were presented at WGDEEP 2023.

WD01 ICES WGDEEP 2023

Greater forkbeard in Faroese waters (27.5.b).

Lise H. Ofstad, Faroe Marine Research Institute
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Introduction

There is very little catch of greater forkbeard in Faroese waters and a few fish is caught in different surveys. The objective for this document is to provide information on greater forkbeard in Faroese waters (27.5.b).

Methods

The background data is mainly from the annual surveys on the Faroe Plateau in spring (1994-2023) and summer (1996-2022). Some data are also from the deepwater survey (September 2014-2022, no survey in 2021). There are only small amounts of commercial catch, so there is no data individual fish data of this species from landings.

The fishery

There is no directed fishery for greater forkbeard in Faroese waters (5b) and only small amount is landed as bycatch.

Landings

There have always been very little landings of greater forkbeard by the Faroese fishery (Table 10.0d copied from WGDEEP report 2022). The main catch of greater forkbeard in Faroese waters is from Norway and France. The preliminary landing in 5b of greater forkbeard from Faroese in 2021 was 0.1 tons and in 2022 0 (zero) tons of greater forkbeard. NB! In the WGDEEP report 2022 (page 552 and in Table 10.0d page 561) - the landings in 5b of 301 tons in 2011 and 145 tons in 2012 seems to be wrong! In statlant 2011 the Faroese fleet fished 0.310 tons in 5a and in statlant 2012 the Faroese fleet fished 0.062 tons in 5a and 0.083 tons in 5b2 (Table 10.0d copied from WGDEEP report 2022 with only update of year 2011, 2012 and preliminary 2022 data for 5b).

Table 10.0d. Greater forkbeard *(Phycis blennoides)* in Division 5b. Working group estimates of landings.

YEAR	FRANCE	NORWAY	UK (SCOT)(1)	UK (EWNI)	FAROE ISLANDS	RUSSIA	ICELAND	TOTAL
1988	2	0						2
1989	1	0						1
1990	10	28						38
1991	9	44						53
1992	16	33						49
1993	5	22						27
1994	4							4
1995	9							9
1996	7							7
1997	7	0						7
1998	4	4						8
1999	6	28	0					34
2000	4	26	1	0				32
2001	9	92	1	0				102
2002	10	133	5	0				149
2003	11	55	7	0				73
2004	9	37	2	2				50
2005	7	39		0,3				46
2006	8	26			6			39
2007	11	34	0	0	9	2	0	58
2008	10	20	0		4	11	1	46
2009	0	13	3		3	2	0	24
2010	2	45	3	1	11		2	62
2011	7				0		1	8
2012	6	5			0.083	7	7	25
2013	7	3	0				0	11
2014	7	14	0		0		2	24
2015	5	27					2	34
2016	7	3	0				3	13
2016	7	3	0				3	13
2017	9		0					9
2018	5	7						12
2019	7	10						18
2020	7	24	0					31
2021	6	7	0	0	0	0	0	13
2022*	5.436	21.018	0.2528		0			26.7

Spatial distribution

The spatial distribution of greater forkbeard from the bottom trawl groundfish surveys were mainly on the Faroe Plateau deeper than 200 m (Figure 1 and Appendix 1, 2). In the deepwater survey greater forkbeard was caught around the Banks and on the Wyville-Thomson ridge (Figure 2 left and Appendix 3).

In the Faroese 0-group surveys on the Faroe Plateau in June/July there are 26 registrations of greater forkbeard caught pelagic (Figure 2 right). The length was between 8-54 mm, mainly around 30-40 mm. 11 of there were caught in the period 1991-1999, 14 in the period 2001-2005 and one in 2022.

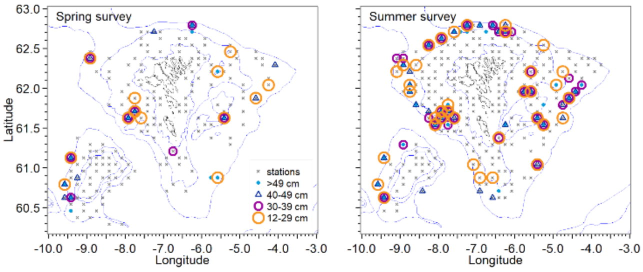


Figure 1. Greater forkbeard 5.b. Spatial distribution of greater forkbeard for all years together divided by size in the annual spring- and summer survey.

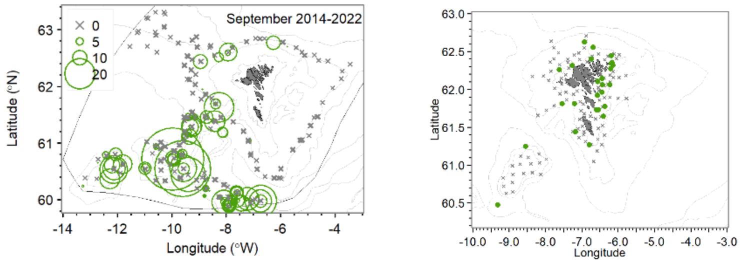


Figure 2. Greater forkbeard 5.b. Spatial distribution of (left) CPUE (kg/h) from the deepwater surveys in September 2014- 2022 (no survey in 2021) and (right) positions of 8-54 mm long greater forkbeard caught pelagic in the 0-group survey in June/July (1983-2022).

Data available

Data available from different surveys in Faroese waters is presented in Table 1. A standardized CPUE is available from the annual spring- and summer surveys on the Faroe Plateau. There are also some data from the deepwater survey and Greenland halibut survey.

Table 1. Greater forkbeard 5.b. Sampling overview from different surveys around the Faroes.

year	length	round weight	gutted weight	gender	maturity	otoliths	aged	gonad	stomach
1994	3	2							
1995	27	5							
1996	26	2							
1997	7	2							
1998	17	2							
1999	27	25							
2000	46	46							
2001	101	86							
2002	55	53							
2003	21	21							
2004	47	47							
2005	24	24							
2006	17	17							
2007	15	15							
2008	13	13							
2009	81	81							
2010	110	109							

2011	92	92							
2012	99	99							
2013	133	117							
2014	257	255	23	37	37	36		2	1
2015	131	130	16	27	27	27			1
2016	89	89	15	18	18	18			
2017	108	108	6	11	11	11			1
2018	96	96		1	1	1			
2019	50	50		7	7	7			
2020	31	31							
2021	36	32		3	3	3			3
2022	39	39		9	9	9		2	2
2023	23	23							
Total	1821	1711	60	113	113	112	0	4	8

Length composition

Annual length-frequency distribution of greater forkbeard from the Faroese groundfish surveys (very few individuals see appendix 4 and 5) and Faroese deep-water surveys for the period 2014-2022 are presented in Figure 3.

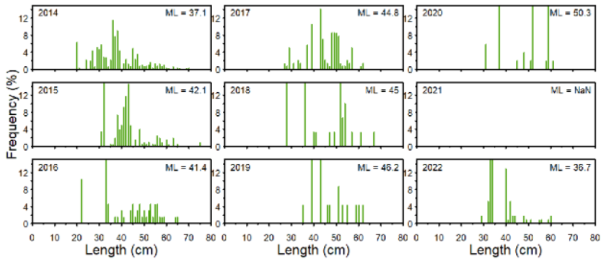


Figure 3. Greater forkbeard 5.b. Length-frequency distribution from the deepwater survey in 2014-2022 (no survey in 2021).

Length-weights

Round weight at length from all surveys showed that 40 cm greater forkbeard was around 0.5 kg and 50 cm around 1.0 kg (Figure 4).

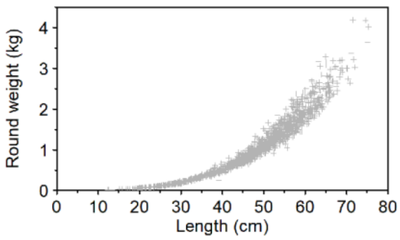


Figure 4. Greater forkbeard 5.b. Length- round weight relation from different surveys.

Catch, effort and research vessel data

Abundance index of greater forkbeard from the annual Faroese groundfish surveys covering the Faroe Plateau is presented in Table 2 and Figure 5.

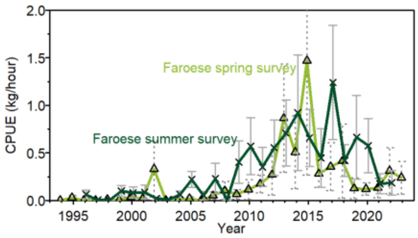
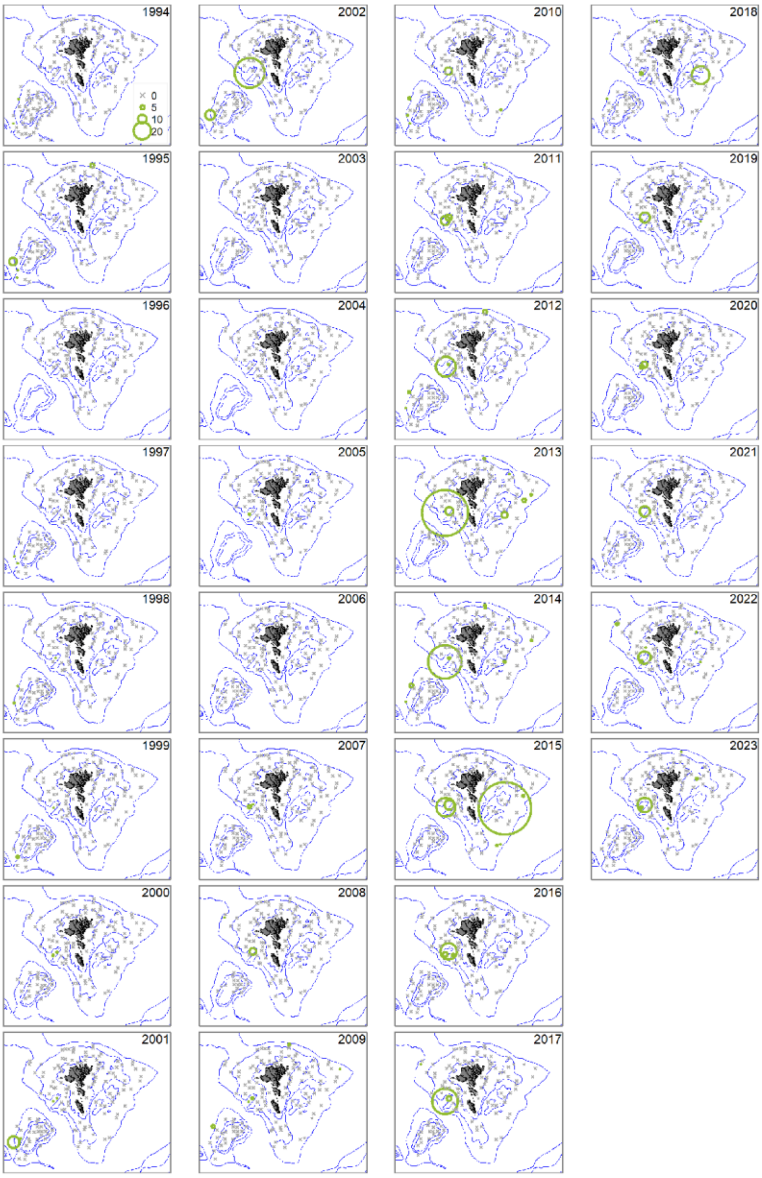


Figure 5. Greater forkbeard 5.b. Standardized cpue (kg/hour) from the Faroese spring- and summer groundfish survey.

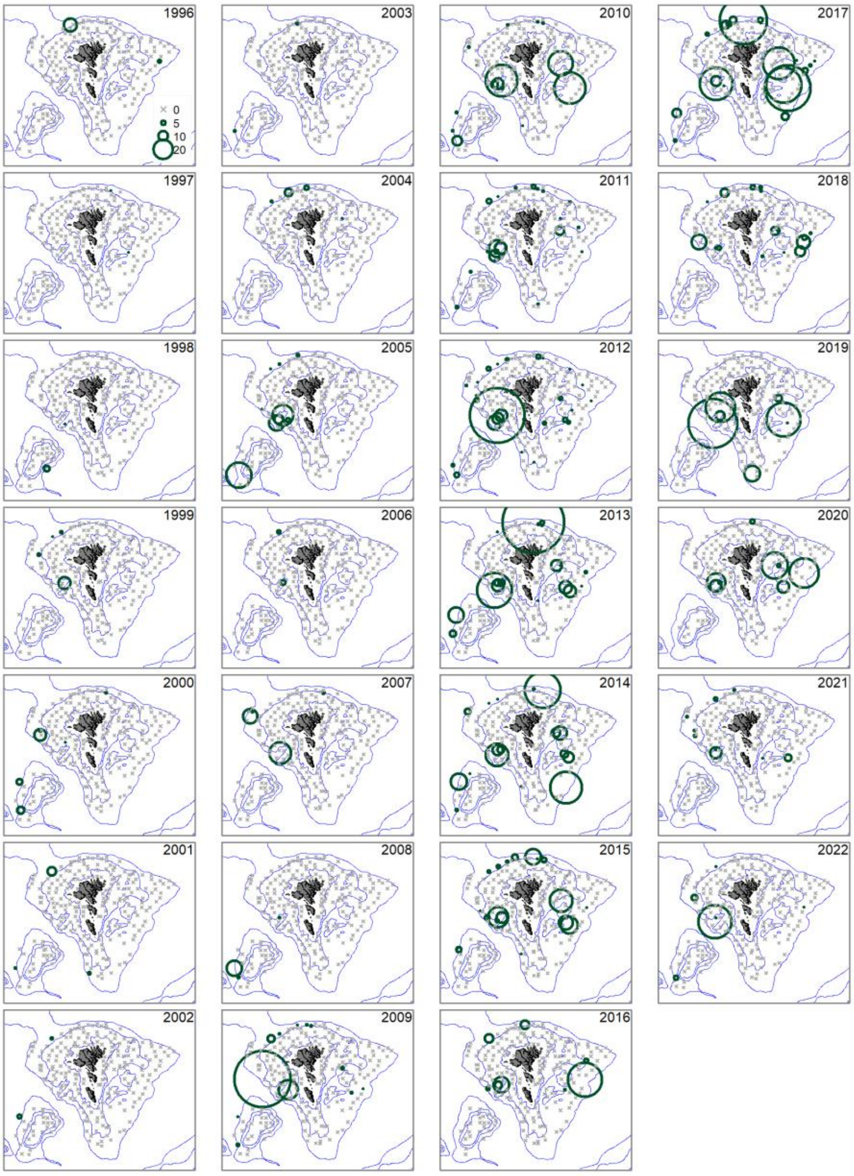
Table 2. Greater forkbeard 5.b. Standardized cpue from Faroe Plateau spring- and summer surveys. N- number of hauls, SE- standard error.

	Spring survey		Summer survey	
year	cpue	se	cpue	se
1994	0.00	0.00		
1995	0.03	0.02		
1996	0.00	0.00	0.06	0.04
1997	0.00	0.00	0.01	0.01
1998	0.01	0.01	0.00	0.00
1999	0.00	0.00	0.10	0.06
2000	0.04	0.02	0.08	0.06
2001	0.02	0.01	0.09	0.07
2002	0.33	0.30	0.02	0.02
2003	0.00	0.00	0.01	0.01
2004	0.00	0.00	0.06	0.04
2005	0.02	0.02	0.22	0.08
2006	0.00	0.00	0.05	0.04
2007	0.05	0.04	0.23	0.16
2008	0.10	0.09	0.01	0.00
2009	0.06	0.05	0.40	0.22
2010	0.12	0.11	0.57	0.30
2011	0.18	0.09	0.35	0.21
2012	0.27	0.21	0.56	0.29
2013	0.86	0.57	0.71	0.35
2014	0.51	0.38	0.92	0.61
2015	1.47	1.21	0.66	0.30
2016	0.28	0.14	0.45	0.31
2017	0.36	0.25	1.24	0.60
2018	0.41	0.39	0.42	0.17
2019	0.13	0.11	0.66	0.44
2020	0.12	0.06	0.58	0.28
2021	0.13	0.10	0.18	0.11
2022	0.26	0.24	0.19	0.13
2023	0.27	0.17		

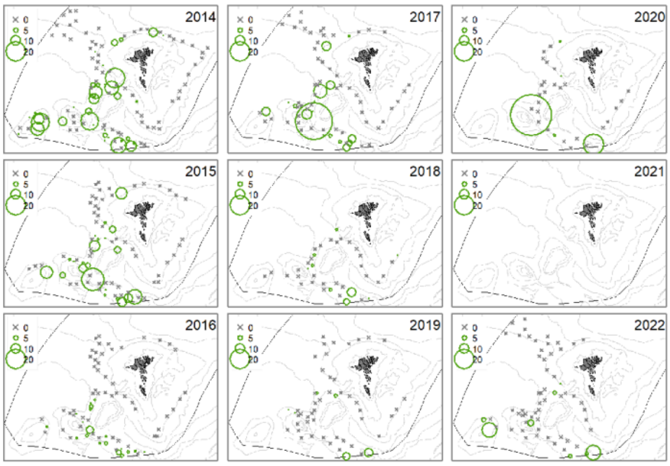
Appendix



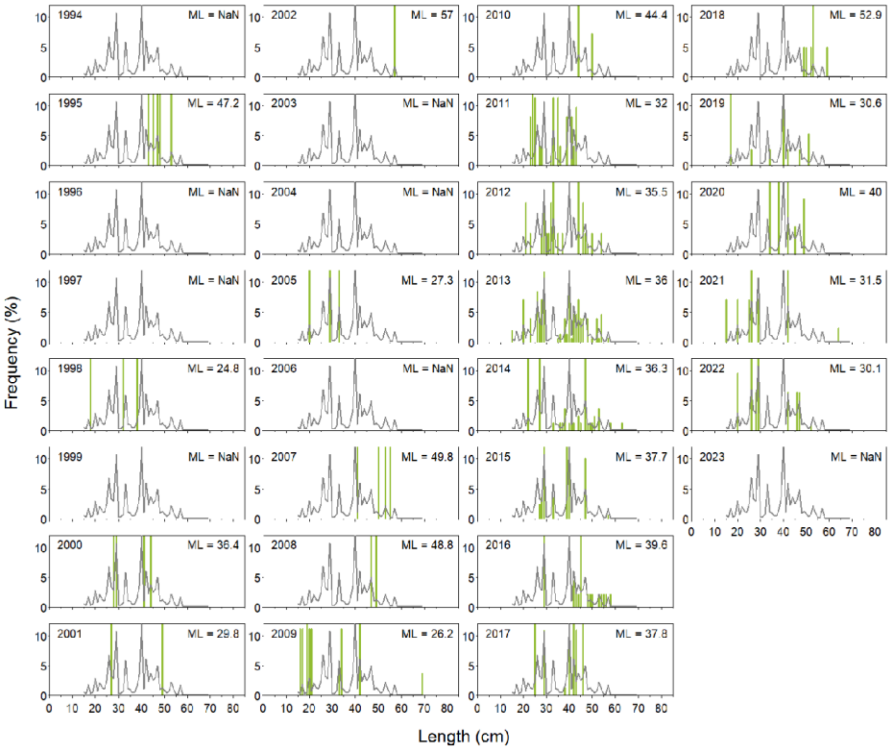
Appendix 1. Greater forkbeard 5.b. Spatial distribution (kg/hour) in the spring survey in February/March.



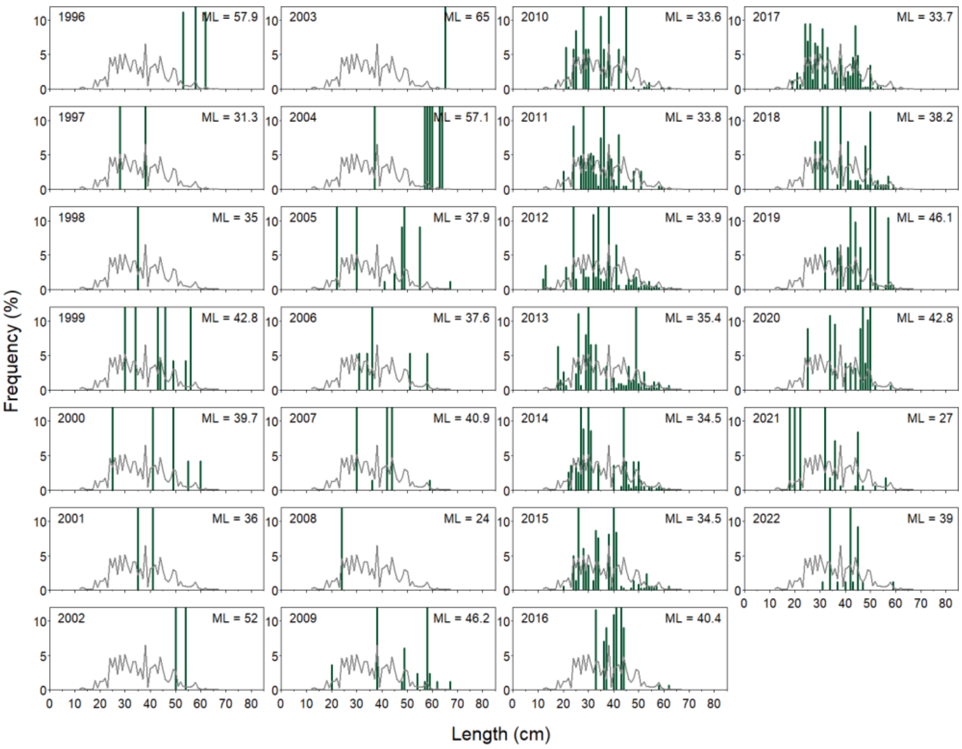
Appendix 2. Greater forkbeard 5.b. Spatial distribution (kg/hour) in the summer survey in August.



Appendix 3. Greater forkbeard 5.b. Spatial distribution (kg/hour) in the deepwater survey in September. No survey in 2021.



Appendix 4. Greater forkbeard 5.b. Length distribution in the spring survey in February/March.



Appendix 5. Greater forkbeard 5.b. Length distribution in the summer survey in August.

WD02 ICES WGDEEP 2023

Black scabbard fish in Faroese waters (27.5.b).

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Introduction

The objective for this document is to provide information on black scabbard fish in Faroese waters (27.5.b).

The fishery

The black scabbard fish fishery in Faroese waters are managed by licences. Since 2013, only one trawler has had licence to fish black scabbard fish as a targeted species. This particular trawler was sold in 2022. In the black scabbard fishery, the commercial trawler used a star trawl with 486 meshes, 160 mm. Mesh size in the net was 80 mm. The usual fishing depth varied between 600-1000 m and the trawling hours varied between six to eight hours, but may last less if the species was very abundant.

The main fishing areas of black scabbard fish in Faroese waters are located on the slope around the Faroe Bank and on the Wyville-Thomsen ridge close to the southernmost Faroese EEZ boarder (Figure 1, Appendix 1).

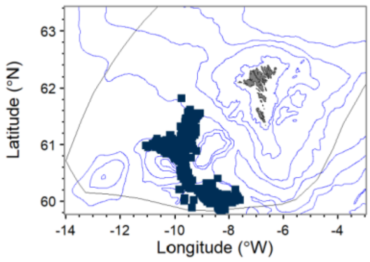

Figure 1. Black scabbard fish 5.b. Spatial distribution of the Faroese commercial trawl fishery of black scabbard fish 2000-2022.

Landings

The mean landings of black scabbard fish in Faroese waters from 1989 to 2018 were 569 t (Figure 2). The highest landings of around 1600-1800 t were in 2002, 2003 and 2008. The preliminary catch data for 2022 showed that the Faroese landings were 13.2 t in 5b2 and 2.9 t in 5b1. French catch was 6.26 t in 5.b.

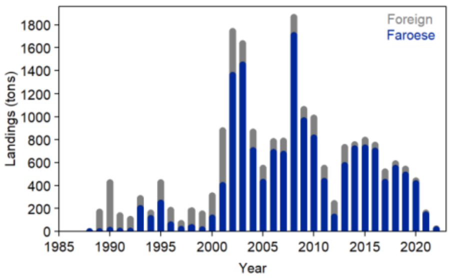

Figure 2. Black scabbard fish 5.b. Nominal landings in Faroese waters.

Spatial distribution

The spatial distribution of black scabbard fish from the deepwater surveys was mainly on the slope north of the Faroe Bank/Bill Bailey bank (Figure 3), which are the main fishing areas. A closer look at different surveys showed that black scabbard fish was only caught in the area north-west of the Faroes and never caught on the Faroe Plateau (Figure 4).

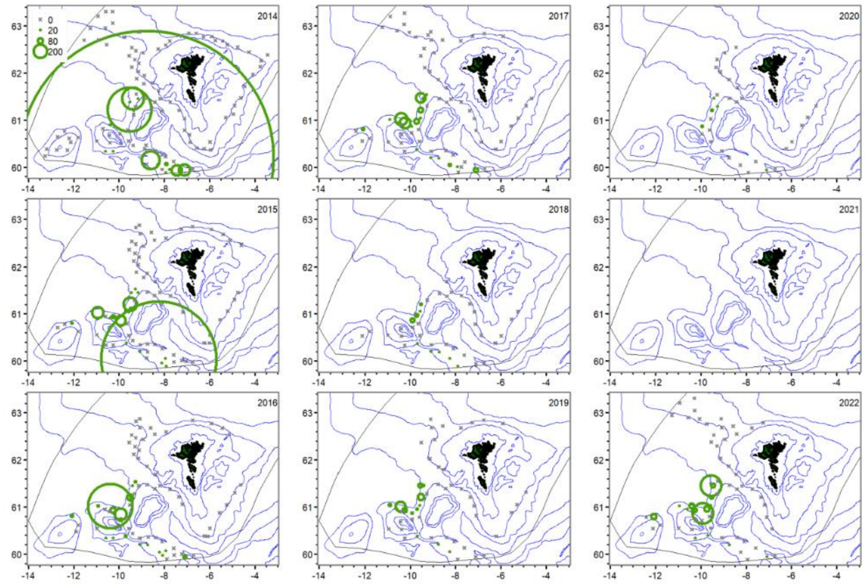

Figure 3. Black scabbard fish 5.b. Spatial distribution of CPUE (kg/h) from the deepwater surveys in 2014-2022 (no survey in 2021).

Length distribution

Annual length-frequency distribution of the Faroese landings data and Faroese deep-water surveys for the period 2014-2022 are presented in Figure 4. The mean length of black scabbard fish in the catches was around 90-92 cm, which is about the same mean length as in the deep-water survey (Figure 4). Numbers of black scabbard fish sampled from the landings and in the deep-water surveys are presented in Table 1. All the sampled fish in the deepwater survey was immature.

Table 1. Black scabbard fish 5.b. Number of fish sampled from the commercial trawler and from the deepwater surveys. * Blue ling survey in April 2018.

	Landings		Deep-water surveys					
Year	Lengths	Weights	Lengths	Round weights	Gender	Maturity	Otoliths	Stomachs
2014	575		4477	785	150	150	150	8
2015	1475		2117	389	78	78	78	9
2016	7603	5077	1271	459	94	94	94	11
2017	4984	4983	874	574	118	118	118	31
2018	4193	4143	598	217	64	64	64	8
2018*			94	94	13	13	13	4
2019	4515	4515	557	483	132	132	132	10
2020	4476	4476	91	67	19	20	20	1
2021	2012	2012	-					
2022	-		1278	474	107	107	107	9

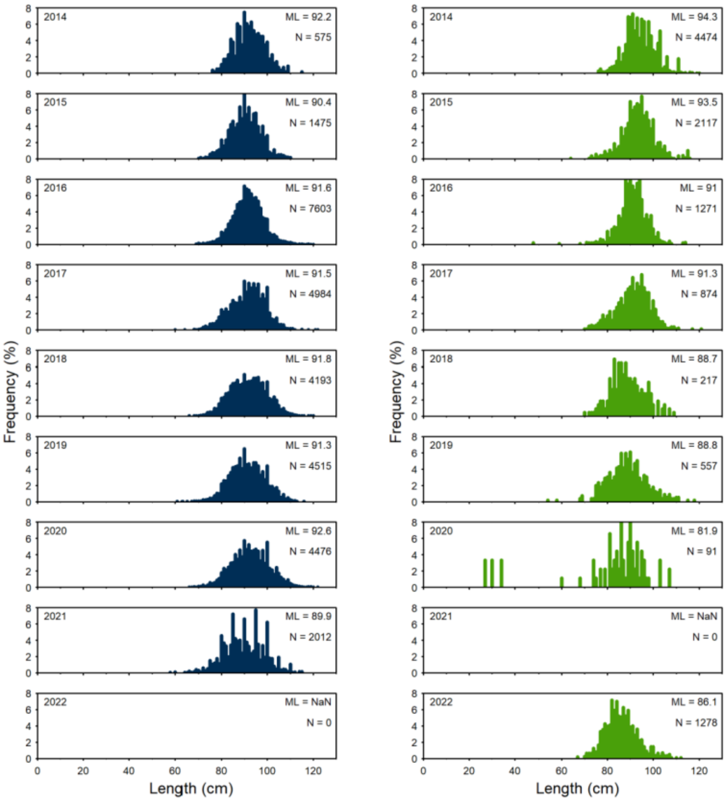

Figure 4. Black scabbard fish 5.b. Length-frequency distribution for the period 2014-2022 from the landings (no samples in 2022) (left) and the deep-water survey (no survey in 2021) (right).

Length-weights

Comparing mean weight at length from the commercial trawler with the deep-water survey showed that the data are similar (Figure 5). Black scabbard fish of 70 cm length had a round weight around 0.4 kg, 100 cm was 1.5 kg; and the largest fish was 114 cm and 2.4 kg.

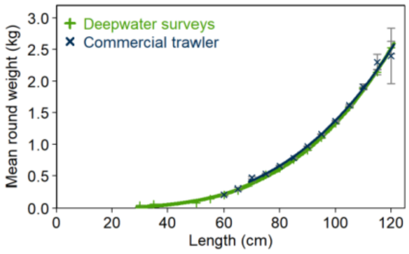

Figure 5. Black scabbard fish 5.b. Length-weight relation comparison between the landings (blue) and the deep-water survey (green).

Commercial cpue

In 2022, the commercial trawler that had a fishery licence for black scabbardfish was sold. This trawler had only 8 black scabbardfish hauls in 2022, so the CPUE-data are not presented. A map of the fishery area is presented in Figure 6.

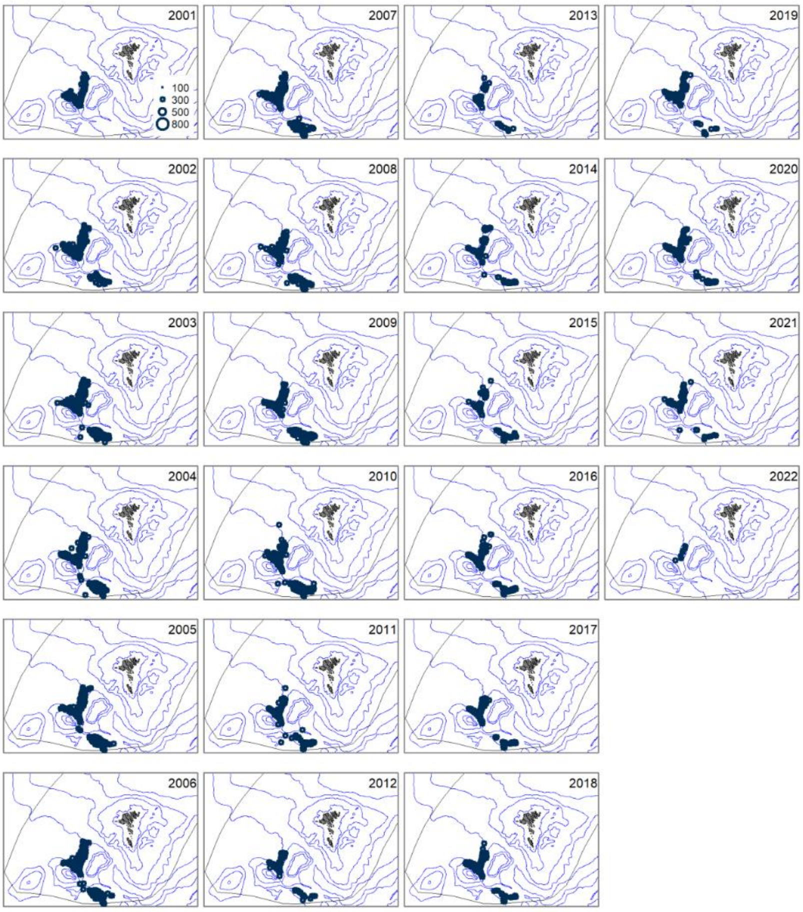

Figure 6. Black scabbard fish 5.b. Spatial distribution (kg/hour) in the commercial trawl fishery per year. Only hauls with more than 30% black scabbard fish of the total catch.

WD03 ICES WGDEEP 2023

Roundnose grenadier in Faroese waters (27.5.b).

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Introduction

The objective for this document is to provide information on roundnose grenadier in Division 27.5.b.

Landings

The landings in Faroese waters (ICES Division 27.5.b) are showed in Table 1.

Table 1. Roundnose grenadier 5.b. Nominal landings in Faroese waters.

Year	Faroes	France	Norway	Germany	Russia	UK (E+W)	UK (Scot.)	Total
1988				1				1
1989	20	181		5	52			258
1990	75	1470		4				1549
1991	22	2281	7	1				2311
1992	551	3259	1	6				3817
1993	339	1328		14				1681
1994	286	381		1				668
1995	405	818						1223
1996	93	983		2				1078
1997	53	1059						1112
1998	50	1617						1667
1999	104	1861	2			29		1996
2000	48	1699		1		43		1791
2001	84	1932						2016
2002	176	774				81		1031
2003	490	1032				10		1532
2004	508	985			6		76	1575
2005	903	884	1		1		48	1837
2006	900	875						1775
2007	838	862						1700
2008	665	447						1112
2009	322	122					2	446
2010	229	381					1	611
2011	63	11						74
2012	16	28						44
2013	24	36						60
2014	33	44						77
2015	24	28						52
2016	30	7						38
2017	9	21						30
2018	0	6						6
2019	19	11						30
2020	20	13						33
2021	12	10						22
2022*	0.732	5.967	0.509				0.345	7.553

Information from deepwater surveys

Overview of the roundnose grenadier sampling from the deepwater surveys in September are showed in Table 2. The mean lengths in the surveys were between 14.8- 17.5 cm (Figure 1). The length- round weight relation is presented in Figure 2. The spatial distribution was mainly on the Wyville-Thomsen ridge (Figure 3).

An investigation of the roundnose grenadier catch according to depth and temperature data showed that roundnose grenadier were distributed in depths deeper than around 600 m and temperatures warmer than 6°C. This is in accordance with the oceanic temperature and depth distribution in Faroese waters.

Table 2. Roundnose grenadier 5.b. Sampling overview from the deepwater survey (no survey in 2021).

Year	Lengths	Round weights	Gender	Maturity	Otoliths	Liver weights	Gonad weights	Stomachs
2014	209	186	72	72	69		18	10
2015	166	103	40	40	40			11
2016	153	139	30	30	30			7
2017	234	174	52	52	52			23
2018	101	92	21	21	21			5
2019	80	80	28	28	25			8
2020	41	31	5	5	5			3
2021	-	-	-	-	-	-	-	-
2022	143	140	46	46	46	11	14	12
Total	1127	945	294	294	288	11	32	79

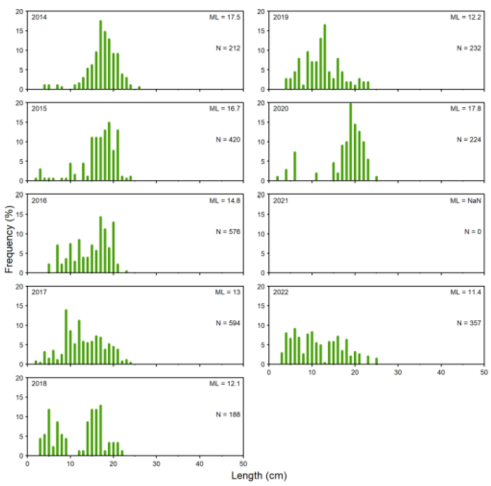

Figure 1. Roundnose grenadier 5.b. Length distribution in the deepwater surveys.

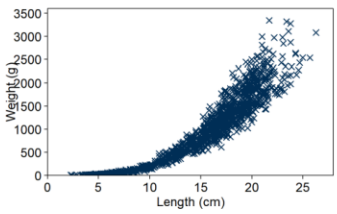

Figure 2. Roundnose grenadier 5.b. Length - round weight relation in the deepwater surveys.

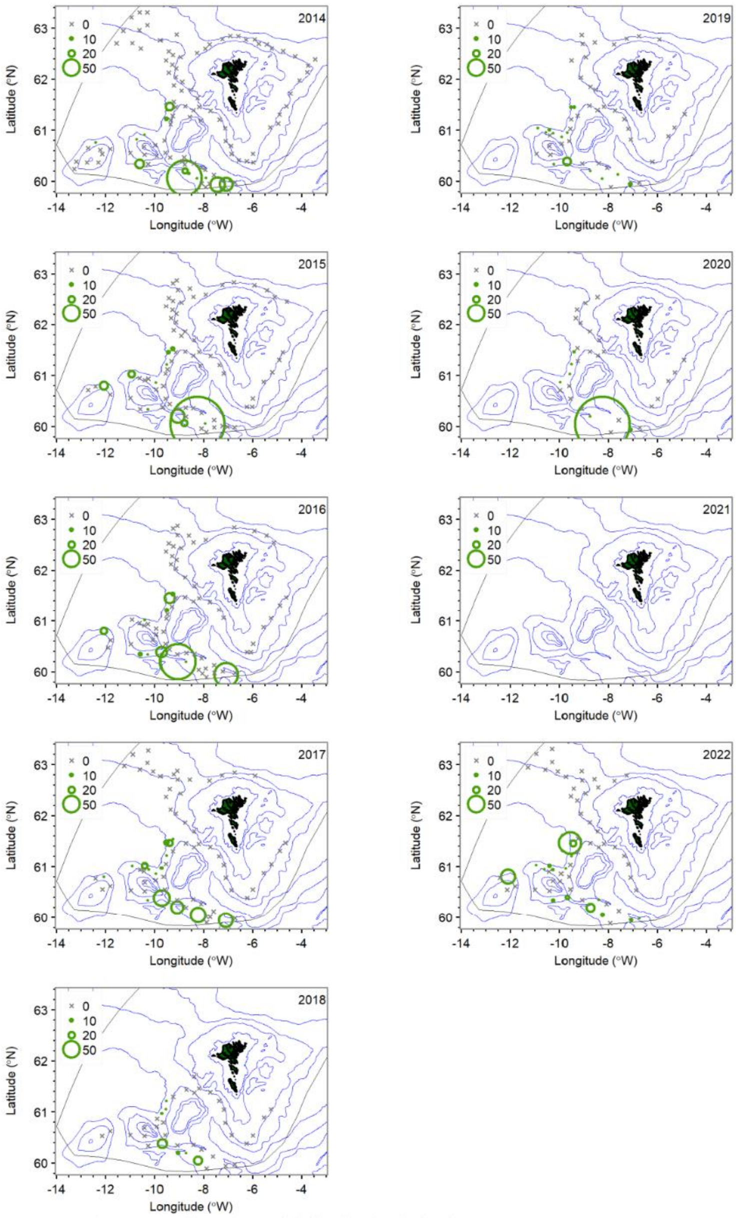

Figure 3. Roundnose grenadier 5.b. Spatial distribution in the deepwater surveys 2014-2022 (no survey in 2021).

WGDEEP 2022, WD xx

CPUE Standardization of Silver smelt in 5b and 6a @ WGDEEP 2022

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Abstract

At the WKGSS 2020 benchmark of Greater silver smelt in 5b and 6a, a combined and standardized CPUE series for the Faroe and EU fleets has been introduced (Quirijns and Pastoors 2020). On checking the data in preparation for WGDEEP 2023, a few errors were detected in the way CPUE was calculated, which was proposed as a correction for the assessment in WGDEEP 2023. These relate to 1. the rounding of CPUE values as the model fitted is a negative binomial (small impact) 2. the introduction of smoothers for the week and depth effect rather than fitting them as independent covariates througout 3. the introduction of a fleet effect to account for a mis-balance in data availability througout the time-series with almost an absence of PFA data in the early part of the time-series where Faroese data was availabe. Furthermore, the method applied in WGDEEP 2023 has been extended to cover the whole time series up to 2022.

It is noted that the signals in the two separate CPUE series are somewhat different in the most recent year, with a decline observed in the Faroese CPUE and an increase observed in the PFA CPUE.

1 Introduction

At the WKGSS 2020 benchmark of Greater silver smelt in 5b and 6a, a combined and standardized CPUE series for the Faroe and EU fleets has been introduced (Quirijns and Pastoors 2020).

2 Results

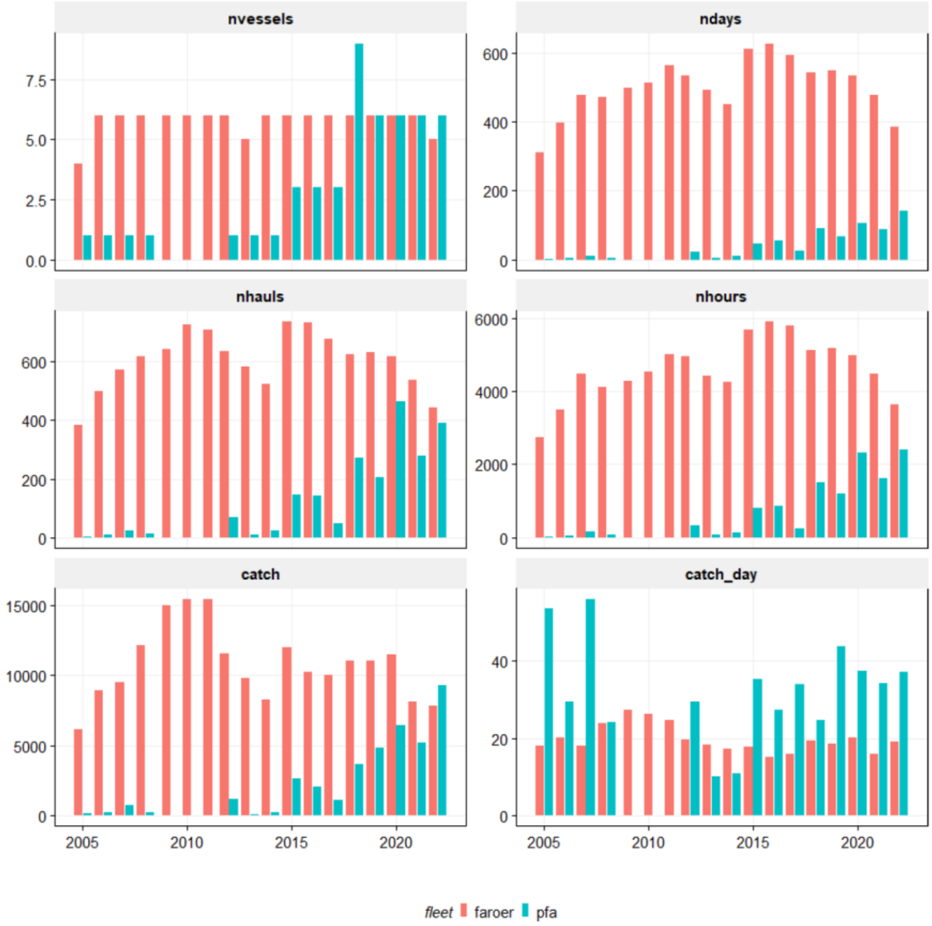


Figure 1: ARU.27.5b6a metrics describing the fisheries

The 'raw' (unstandardized) CPUE is based on the catch per day.

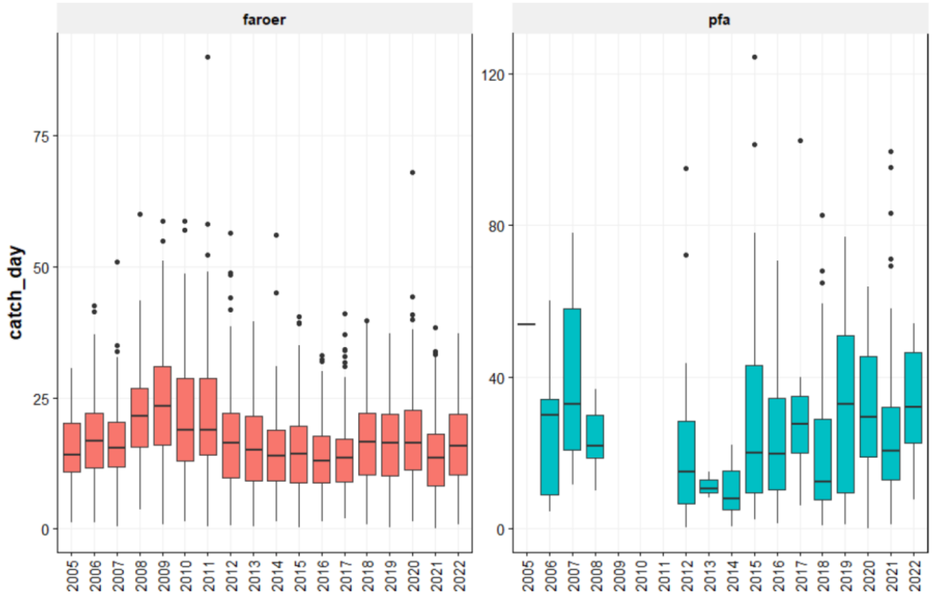


Figure 2: ARU.27.5b6a Catch per unit effort.

For the years 2005-2022, below are the spatial distributions of the used number of hauls by fleet.

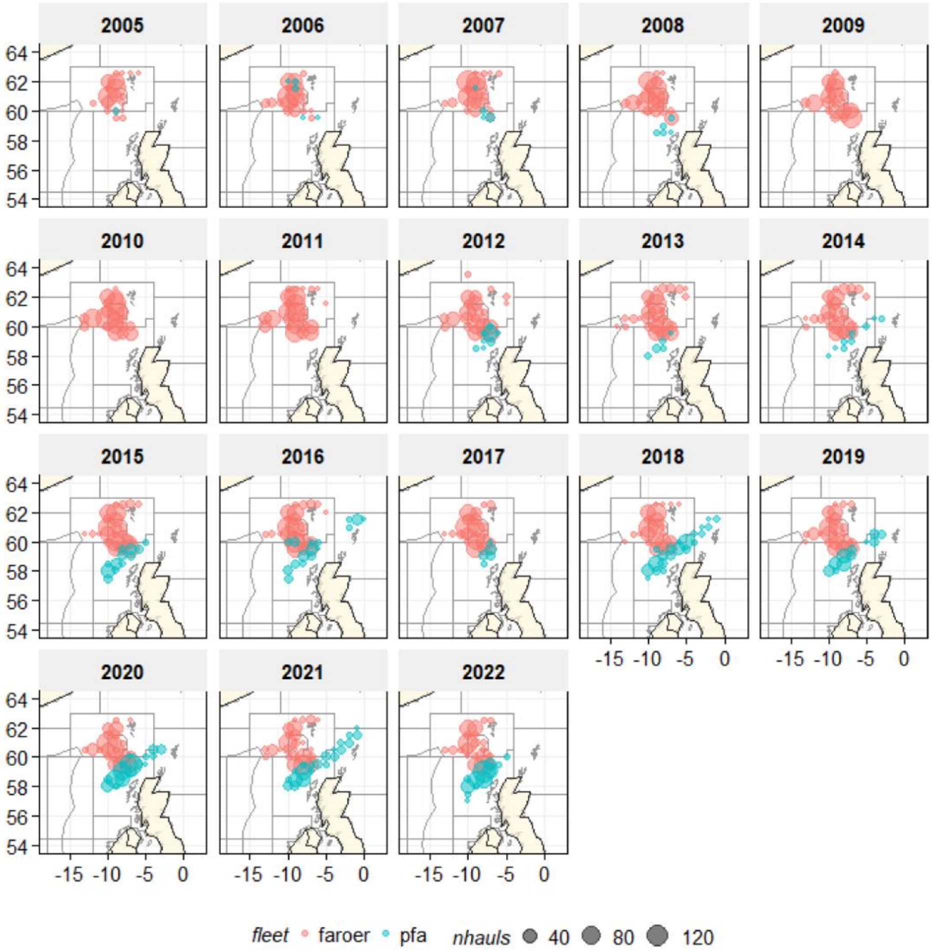


Figure 3: ARU.27.5b6a plot of the number of hauls by rectangle and day

Standardized CPUE index

We applied un updated model for standardization of of CPUE: CPUE ~ year + s(week) + s(depth) + fleet, where CPUE is expressed as catch per day and per rectangle. Catches have first been summed by vessel, year, week and rectangle and the number of hauls and fishing days have been calculated. Then the catches and effort (fishing days) have been summed over all vessels by year, week, fleet and the average depth has been calculated. CPUE was then calculated as the average catch per rectangle and per day by fleet.

The differences in modelling approach are shown below where we compare the model setup used in WGDEEP 2022 with the glm and gam approach.

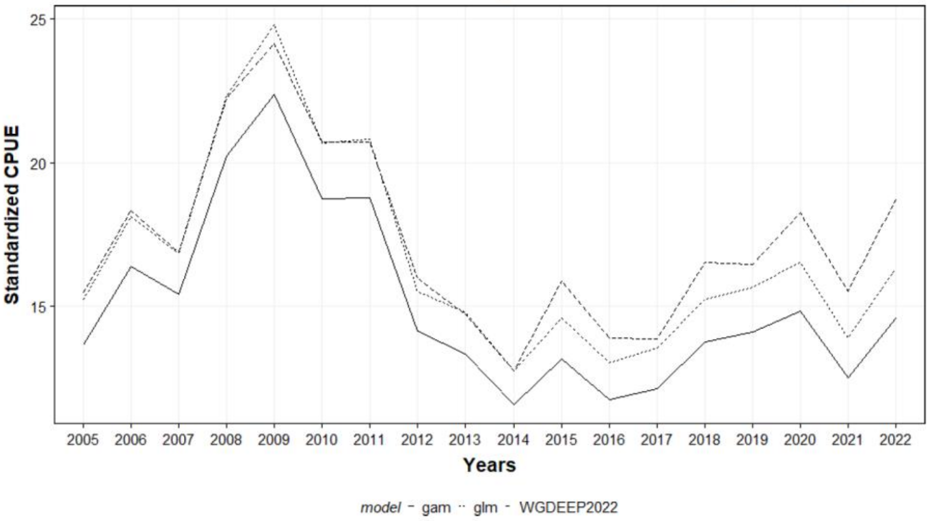


Figure 5: ARU.27.5b6a comparison of standardized CPUE between WGDEEP 2022 and updated model settings

Not only a scaling is visible, but also a change in trend from around 2015 onwards.

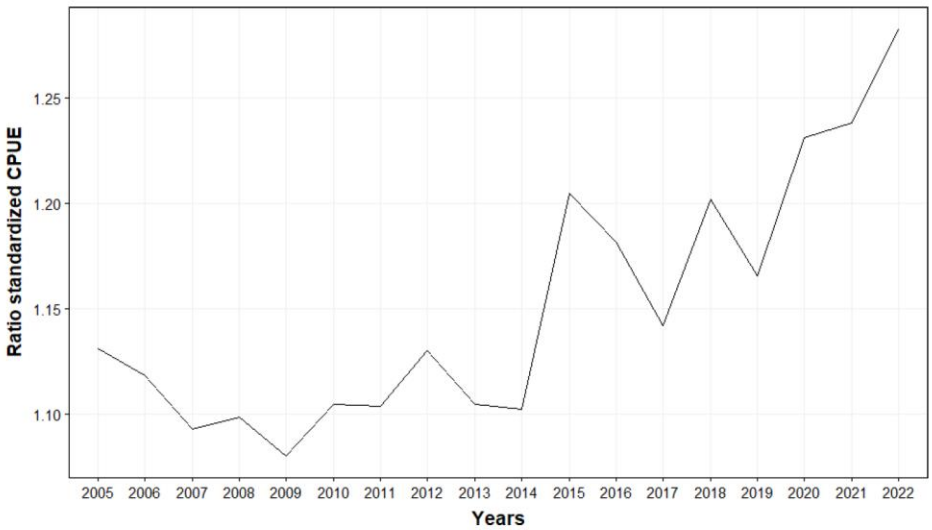


Figure 6: ARU.27.5b6a ratio between WGDEEP 2022 and updated standardized CPUE model settings

Finally, the comparison of the WGDEEP 2022 and WGDEEP 2023 time-series is presented.

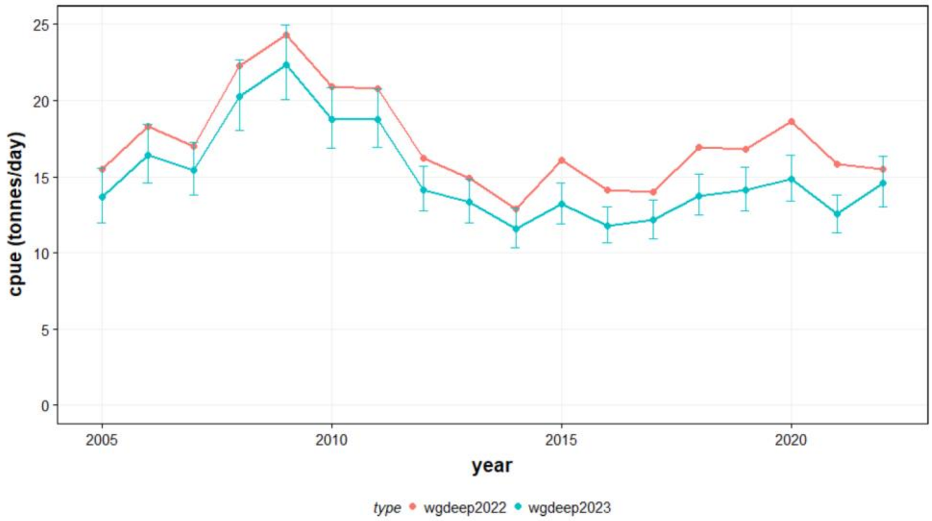
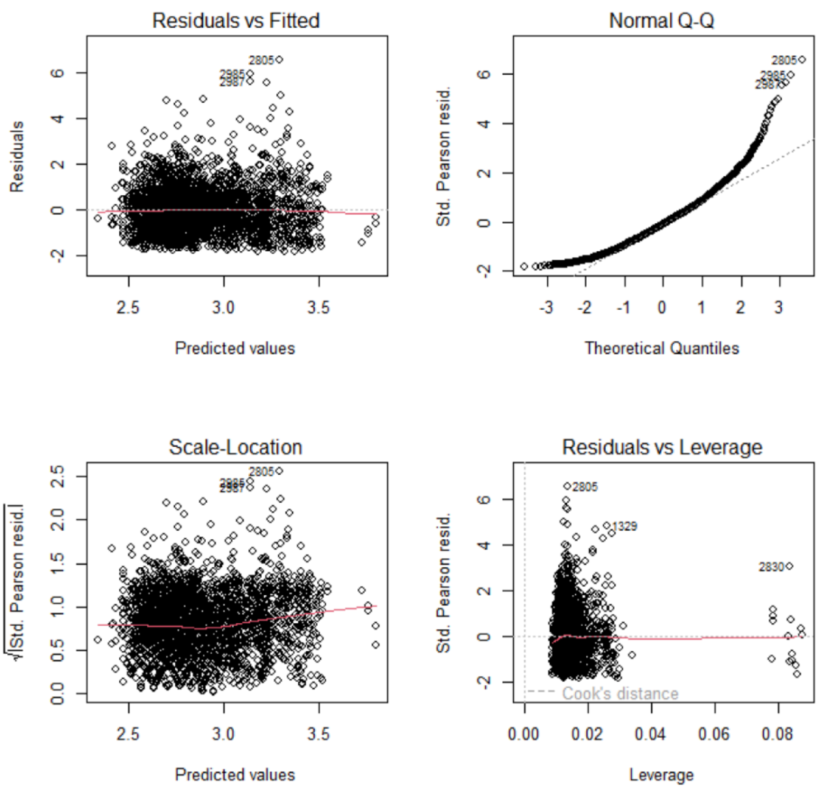


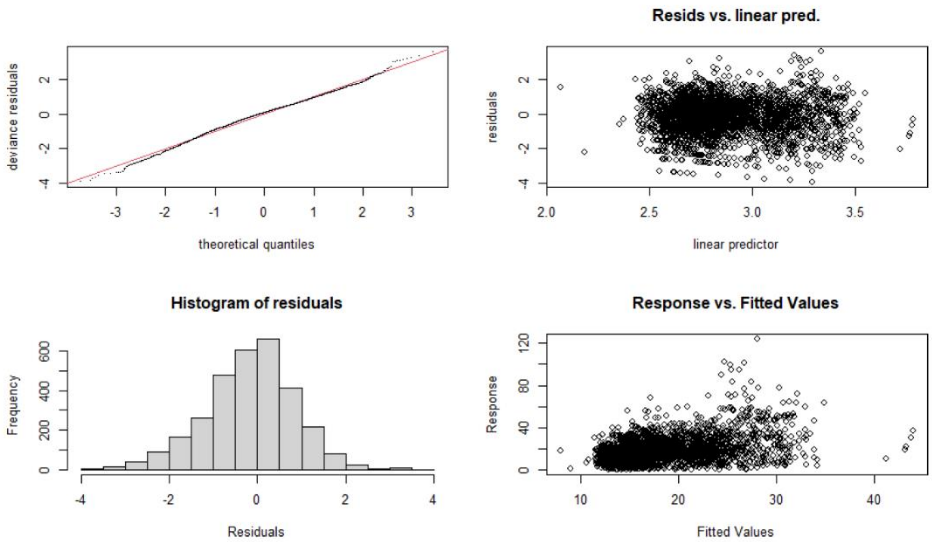
Figure 4: ARU.27.5b6a standardized CPUE (catch per rectangle and day), in comparison with WKGSS series

Model diagnostics




```
Analysis of Deviance Table
Model: Negative Binomial(3.7212), link: log
Response: get(cpuevar)
Terms added sequentially (first to last)
          Df Deviance Resid. Df Resid. Dev Pr(>Chi)
NULL                       3064     3823.0
fyear     17  201.071      3047     3621.9  < 2e-16 ***
fweek     19  160.783      3028     3461.1  < 2e-16 ***
depth_cat  6   11.277      3022     3449.8  0.08017 .
fleet      1  191.585      3021     3258.3  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Figure 7a: ARU.27.5b6a standardized CPUE GLM model diagnostics




```
Method: UBRE   Optimizer: outer newton
full convergence after 5 iterations.
Gradient range [3.912368e-11,1.592991e-10]
(score 0.0805767 & scale 1).
Hessian positive definite, eigenvalue range [0.0002822595,0.0006414133].
Model rank =  37 / 37

Basis dimension (k) checking results. Low p-value (k-index<1) may
indicate that k is too low, especially if edf is close to k'.

           k'  edf k-index p-value
s(week)  9.00 6.16    0.82  <2e-16 ***
s(depth) 9.00 3.85    0.89  <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Figure 7b: ARU.27.5b6a standardized CPUE GAM model diagnostics

Evaluation of explanatory variables

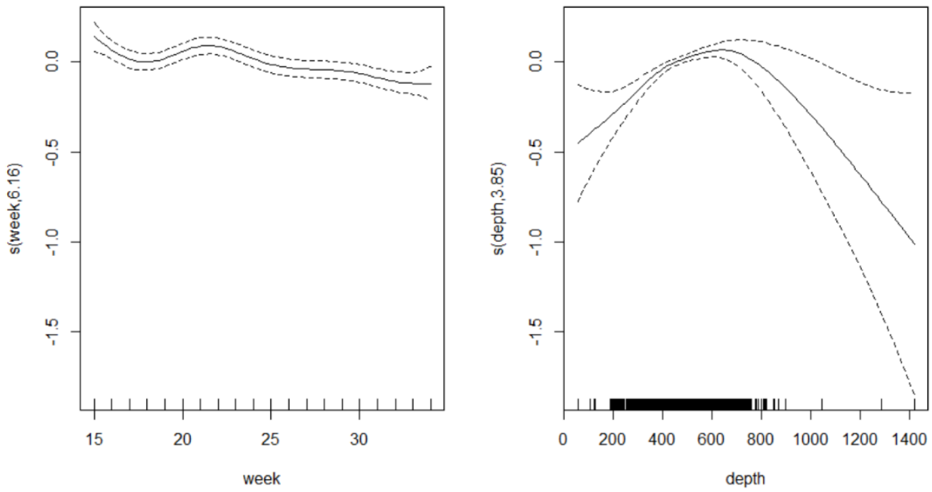


Figure 8: ARU.27.5b6a standardized CPUE explanatory variables

year	cpue	lwr	upr
2005	15.21	13.02	17.78
2006	18.13	15.67	20.97
2007	16.84	14.63	19.38
2008	22.31	19.37	25.69
2009	24.78	21.56	28.48
2010	20.69	18.06	23.72
2011	20.81	18.22	23.77
2012	15.53	13.61	17.73
2013	14.78	12.92	16.92
2014	12.76	11.1	14.66
2015	14.59	12.81	16.62
2016	13.04	11.46	14.84
2017	13.56	11.87	15.49
2018	15.23	13.38	17.34
2019	15.66	13.75	17.84
2020	16.52	14.48	18.85
2021	13.91	12.21	15.84
2022	16.33	14.19	18.79

Table 1: ARU.27.5b6a standardized (GLM) commercial CPUE (tonnes/day) for greater silversmelt, with lower and upper values based on the standard error.

year	cpue	lwr	upr
2005	13.66	11.97	15.59
2006	16.39	14.57	18.43
2007	15.43	13.79	17.25
2008	20.23	18.07	22.65
2009	22.36	20.05	24.94
2010	18.75	16.85	20.87
2011	18.76	16.92	20.79
2012	14.14	12.75	15.68
2013	13.33	11.97	14.84
2014	11.57	10.34	12.94
2015	13.18	11.91	14.58
2016	11.77	10.66	12.99
2017	12.14	10.95	13.46
2018	13.75	12.48	15.15
2019	14.12	12.77	15.61
2020	14.84	13.4	16.43
2021	12.53	11.35	13.83
2022	14.58	13.01	16.33

Table 2: ARU.27.5b6a standardized (GAM) commercial CPUE (tonnes/day) for greater silversmelt, with lower and upper values based on the standard error.

Single fleet analysis

A single fleet analysis was carried out by using the combined raw CPUE datasets and extracting the separate parts for the Faroese and PFA fleets. These data were then processed in a similar fashion as in the combined analysis. It is clear that the Faroese data is substantially more precise that the data from PFA as evident from the confidence intervals. This is likely due to the number of observations, where the dataset from Faroe Islands over all years is based on 10 times the number of hauls compared to the PFA data. In addition, the Faroese fishery is a targeted fishery for silver smelt, while the PFA fishery is a mixed fishery with blue whiting in the daytime and silver smelt in the nighttime.

It is noted that the signals in the two separate CPUE series are somewhat different in the most recent year, with a decline observed in the Faroese CPUE and an increase observed in the PFA CPUE.

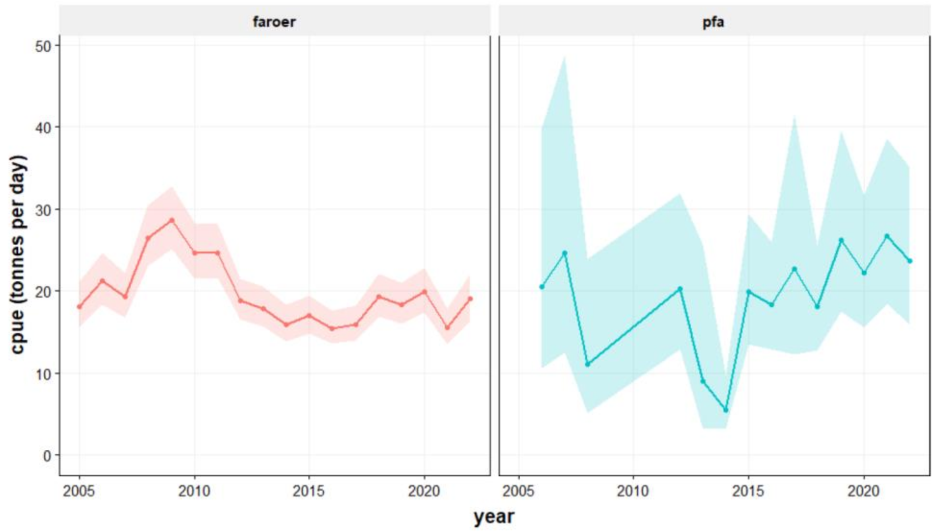


Figure 9: ARU.27.5b6a standardized single fleet CPUE (catch per rectangle and day)

3 Discussion

CPUE standardization using GAM procedures is a common way of dealing with CPUE information. Here we used aggregated data (catch per day) as the main response variable and year, week, depth and fleet as explanatory variables. Both area and period cannot use attributes that are related to the hauls. The standardized CPUE for WGDEEP 2023 shows a marked departure from WGDEEP 2022 time-series owing to the changes in the methodology described above.

Both data sources (Faroese data and PFA data) indicate an increase in CPUE in the last year again after a dip in 2021, although it does not reach the level seen in the late 2000s. The data from the Faroese fisheries are generated from a targetted fishery on silver smelt, while the data from the PFA is from a mixed fishery with blue whiting (blue whiting in the daytime, silver smelt in the nighttime). This probably leads to the higher uncertainties in the CPUE estimates for the PFA compared to the Faroese fleet. It is also noted that the number of observations in the PFA fisheries prior to 2015 is much lower than after 2015, because the self-sampling program only started in 2015.

It is noted that the signals in the two separate CPUE series are somewhat different in the most recent year, with an increase observed in the Faroese CPUE and a decrease observed in the PFA CPUE.

4 References

ICES (2020). Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES Scientific Reports. Volume 2, Issue 38: 928 pp.

Pastoors, M. A. and F. J. Quirijns (2020). Correcting an error in the CPUE Standardizing of Greater silversmelt for WGDEEP 2020, WD05.

Quirijns, F. J. and M. A. Pastoors (2020). CPUE standardization for greater silversmelt in 5b6a. WKGSS 2020, WD03.

PFA self-sampling report for WGDEEP 2023 (v1)

Niels Hintzen, 30/03/2023 22:24:52

Summary

This report summarizes the self-sampling data collected by the Pelagic Freezer-trawler Association (PFA) with a focus on Argentines or Silversmelts. The self-sampling data consists of two main sources: (1) the historical catch per haul data derived from a limited number private logbooks of skippers, and (2) the self-sampling program that has been initiated from 2015 onwards on an increasing number of freezer-trawlers.

The PFA fishery for argentines takes place in the months April and May, and sometimes into June. The predominant fishing area is ICES division 27.6.a with also some catches being taken in 2.a, 4.a and 5.b. The fishery is combined with the fishery for blue whiting, whereby the catches of blue whiting take place during the day and catch of argentines mostly in the night.

Overall, the self-sampling activities for the argentines fisheries during the years 2016 – 2023 covered 42 fishing trips with 1254 hauls, a total catch of 78562 tonnes and 67255 individual length measurements.

The length compositions of argentines are relatively stable over the years, varying between medians of 34 to 36 cm.

1 Introduction

The Pelagic Freezer-trawler Association (PFA) is an association that has nine member companies that together operate 19 freezer trawlers (in 2023) in six European countries (www.pelagicfish.eu). In 2015, the PFA has initiated a self-sampling program that expands the ongoing monitoring programs on board of pelagic freezer-trawlers by the specialized crew of the vessels. The primary objective of that monitoring program is to assess the quality of fish. The expansion in the self-sampling program consists of recording of haul information, recording the species compositions per haul and regularly taking random length-samples from the catch. The self-sampling is carried out by the vessel quality managers on board of the vessels, who have a long experience in assessing the quality of fish, and by the skippers/officers with respect to the haul information. The scientific coordination of the self-sampling program is carried out by Niels Hintzen (PFA chief science officer) with support of Lina de Nijs (PFA) and Floor Quirijns (contractor).

2 Overview of self-sampling methodology

The PFA self-sampling program has been incrementally implemented on freezer-trawler vessels from the Netherlands, UK, Germany, France, Poland and Lithuania during the years 2015-2017. From 2018 onwards, all vessels in the association are covered by the self-sampling program. The program is designed in such a way that it follows as closely as possible the working practices on board of the different vessels and that it delivers the biological and fisheries information needed for the relevant scientific bodies (e.g. ICES, SPRFMO, CECAF), certification bodies (e.g. MSC) and as a mechanism of feedback for the participating companies.

The following main elements can be distinguished in the self-sampling protocol:

- haul information (date, time, position, weather conditions, environmental conditions, gear attributed, estimated catch, optionally: species composition)
- batch information (total catch per batch=production unit, including variables like species, average size, average weight, fat content, gonads y/n and stomach fill)
- linking batch and haul information (essentially a key of how much of a batch is caught in which of the hauls)
- length information (length frequency measurements, either by batch or by haul)
- biological information (measuring individual fish)

The self-sampling information was initially collected using standardized Excel worksheets. From 2018 onwards a transition is being made from Excel spreadsheet to dedicated data-recording software (M-Catch) with live synchronization to a shore-based system. The information collected during a trip will be sent for data processing by the end of the trip. The self-sampling data is being checked and added to the database by Floor Quirijns and/or Martin Pastoors, who also generate standardized trip reports (using RMarkdown) which are being sent back to the vessel and company. The compiled data for all vessels is being used for specific purposes, e.g. reporting to expert groups, addressing specific fishery or biological questions and supporting detailed biological studies. The PFA publishes an annual report on the self-sampling program.

For this report, the PFA self-sampling data has been filtered for vessel-trip-week combinations using the following criteria:

- hauls in divisions 27.6.a; 27.5.b; 27.4.a
- catch of arg by trip and week at least 10% of the total catch of that trip and week.
- catch of arg by trip and week at least 10 tonnes.

The selection resulted in 99 vessel-trip-week combinations over the years 2016-2022.

A particular challenge in the PFA self-sampling program is dealing with the different length metrics in use. Routinely, on freezer-trawlers, fish will be measured in standard length (SL, until the onset of the tail of the fish). However, for scientific purposes, length is required mostly in total length (TL), or, in the case of the South Pacific RFMO, in fork length (FL). The PFA self-sampling program aims to utilize the appropriate scientific length metric: TL in Europe and Africa, FL in the South Pacific. However, in some instances, the quality managers on board of the vessels have used the wrong length metric for the area they were fishing in. Until 2021, these situations were 'corrected' by applying a direct length-to-length conversion based on data from individual measurements of SL, FL and TL. It was recognized that this approach could lead to holes in the length distributions.

In 2022 a new method of converting length-to-length was implemented, based on the paper by Hansen et al (2018). The method consists of generating simulated length-length-keys similar to the often used age-length-keys. The implementation of the new method means to some differences may exist in length data compared to previous reports.

3 Results

3.1 General

An overview of all the self-sampled trips for arg in 27.6.a, 27.5.b, 27.4.a. The percentage non-target species is defined as the catch of non-pelagic species relative to the catch of pelagic species.

year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nontarget	nlength	nbio
2016	2	2	30	65	3,980	133	3.28%	5,478	0
2017	3	3	33	90	7,464	226	1.23%	6,150	0
2018	7	7	67	172	8,426	126	1.79%	10,931	509
2019	6	7	48	118	10,792	225	0.06%	7,450	7
2020	7	9	104	288	15,342	148	0.53%	14,258	131
2021	5	6	59	139	10,704	181	0.74%	6,607	102
2022	6	8	148	382	21,855	148	1.58%	16,381	16
(all)		42	489	1,254	78,563			67,256	765

Table 3.1.1: PFA deepwater fisheries for argentines. Self-sampling Summary of number of vessels, trips, days, hauls, catch (tonnes), catch per day(tonnes/day), percentage non-target species, number of fish measured and number of biological samples

Catch and number of self-sampled hauls by year and division

division	2016	2017	2018	2019	2020	2021	2022	all	perc
27.6.a	3,980	7,464	8,426	10,792	15,342	10,704	21,855	78,563	100.0%
(all)	3,980	7,464	8,426	10,792	15,342	10,704	21,855	78,563	100.0%

division	2016	2017	2018	2019	2020	2021	2022	all	perc
27.6.a	65	90	172	118	288	139	382	1,254	100.0%
(all)	65	90	172	118	288	139	382	1,254	100.0%

*Table 3.1.2: PFA deepwater fisheries for argentines. Self-sampling Summary of catch (top) and number of hauls (bottom) per year and division. * denotes incomplete year*

Catch and number of self-sampled hauls by year and month

month	2016	2017	2018	2019	2020	2021	2022	all	perc
Apr	0	596	2,316	3,557	9,600	3,669	14,048	33,786	43.0%
May	3,033	6,868	6,110	7,234	4,522	7,035	7,807	42,610	54.2%
Jun	946	0	0	0	1,146	0	0	2,092	2.7%
Oct	0	0	0	0	75	0	0	75	0.1%
(all)	3,980	7,464	8,426	10,792	15,342	10,704	21,855	78,563	100.0%

month	2016	2017	2018	2019	2020	2021	2022	all	perc
Apr	0	4	50	33	143	39	247	516	41.1%
May	54	86	122	85	119	100	135	701	55.9%
Jun	11	0	0	0	19	0	0	30	2.4%
Oct	0	0	0	0	7	0	0	7	0.6%
(all)	65	90	172	118	288	139	382	1,254	100.0%

Table 3.1.3: PFA deepwater fisheries for argentines. Self-sampling summary of catch (top) and number of hauls (bottom) per year and month.

Catch and number of self-sampled hauls by year and country (flag)

flag	2016	2017	2018	2019	2020	2021	2022	all	perc
DEU	1,832	0	2,054	3,617	2,711	1,095	1,350	12,659	16.1%
LIT	0	0	0	0	75	0	0	75	0.1%
NL	2,148	7,464	6,372	7,175	12,556	9,610	20,504	65,830	83.8%
(all)	3,980	7,464	8,426	10,792	15,342	10,704	21,855	78,563	100.0%

flag	2016	2017	2018	2019	2020	2021	2022	all	perc
DEU	27	0	59	46	74	27	44	277	22.1%
LIT	0	0	0	0	7	0	0	7	0.6%
NL	38	90	113	72	207	112	338	970	77.4%
(all)	65	90	172	118	288	139	382	1,254	100.0%

Table 3.1.4: PFA deepwater fisheries for argentines. Self-sampling summary of catch (top) and number of hauls (bottom) per year and month.

Catch by species and year

species	english_name	scientific_name	2016	2017	2018	2019	2020	2021	2022	all	perc
whb	blue whiting	Micromesistius poutassou	2,234	5,030	5,082	6,792	9,116	6,093	11,963	46,310	58.9%
arg	argentines	Argentina spp	1,580	2,248	3,013	3,899	5,946	4,398	9,416	30,501	38.8%
mac	mackerel	Scomber scombrus	15	94	179	95	199	132	131	846	1.1%
hke	hake	Merluccius merluccius	113	89	125	3	39	50	277	696	0.9%
sqr	squid	Loligo vulgaris	0	0	4	0	15	5	47	72	0.1%
mcd	NA	Ceratoscopelus maderensis	0	0	0	0	11	18	2	31	0.0%
hom	horse mackerel	Trachurus trachurus	19	0	1	0	0	1	0	21	0.0%
sqm	Broadtail shortfin squid	Illex coindetii	0	0	0	0	0	4	15	19	0.0%
mzz	other fish	Osteichthyes	0	0	19	0	0	0	0	19	0.0%
boc	boarfish	Capros aper	18	0	0	0	0	0	0	18	0.0%
squ	various squids nei	Loliginidae, Ommastrephidae	0	0	0	3	14	0	0	17	0.0%
pok	saithe	Pollachius virens	0	3	2	0	0	3	0	7	0.0%
gfb	NA	Phycis blennoides	0	0	0	0	1	0	3	4	0.0%
brf	NA	Helicolenus dactylopterus	0	0	0	0	0	0	0	1	0.0%
usk	Tusk	Brosme brosme	0	0	0	0	0	0	0	0	0.0%
oth	NA	NA	0	0	0	0	0	0	0	0	0.0%
(all)	(all)	(all)	3,980	7,464	8,426	10,792	15,342	10,704	21,855	78,563	100.0%

Table 3.1.5: PFA deepwater fisheries for argentines. Self-sampling Summary of total catch (tonnes) by species. OTH refers to all other species that are not the main target species

Haul positions

An overview of all self-sampled hauls in the PFA deepwater fisheries for argentines..

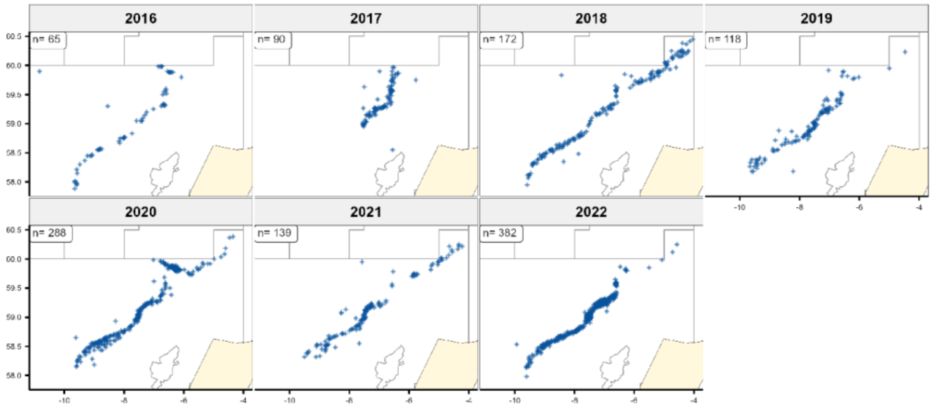


Figure 3.1.1: PFA deepwater fisheries for argentines. Self-sampling haul positions. N indicates the number of hauls.

Catches for the main target species

Summed catches (tonnes) of the main target species aggregated in rectangles.

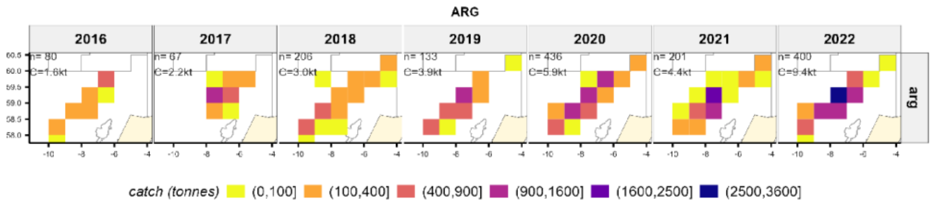


Figure 3.1.2: PFA deepwater fisheries for argentines. Self-sampling catch per species and per rectangle. N indicates the number of hauls. Catch refers to the total catch per year.

Catch rates (catch/day) for the main target species

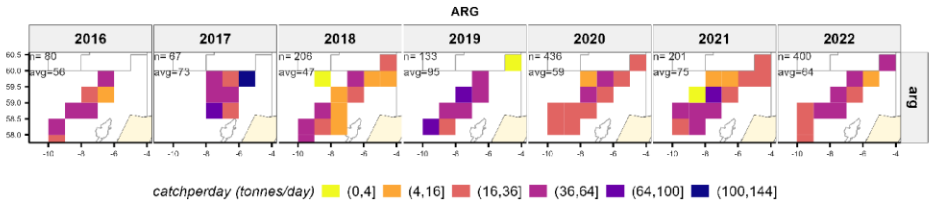


Figure 3.1.3: Average catch per day, per species and per rectangle. N indicates the number of hauls; avg refers to the average catch per day.

Average surface temperature by quarter and by rectangle.

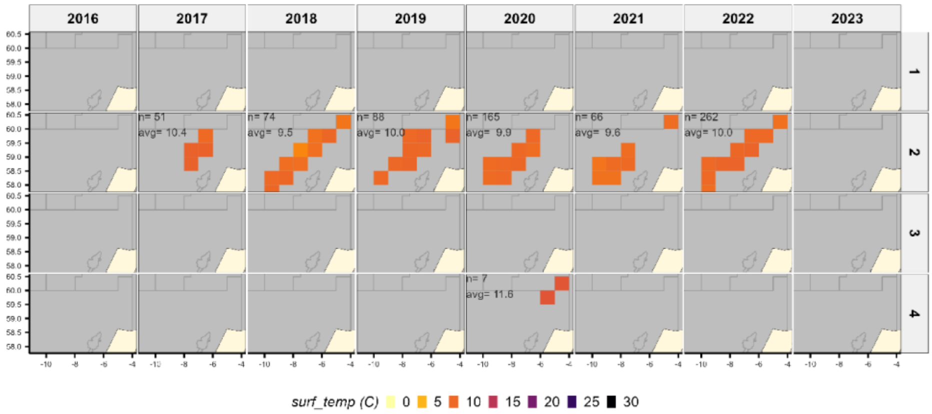


Figure 3.1.4: PFA deepwater fisheries for argentines. Average surface temperature (C) by year and quarter. N indicates the number of hauls. Avg refers to the average temperature.

Average fishing depth.

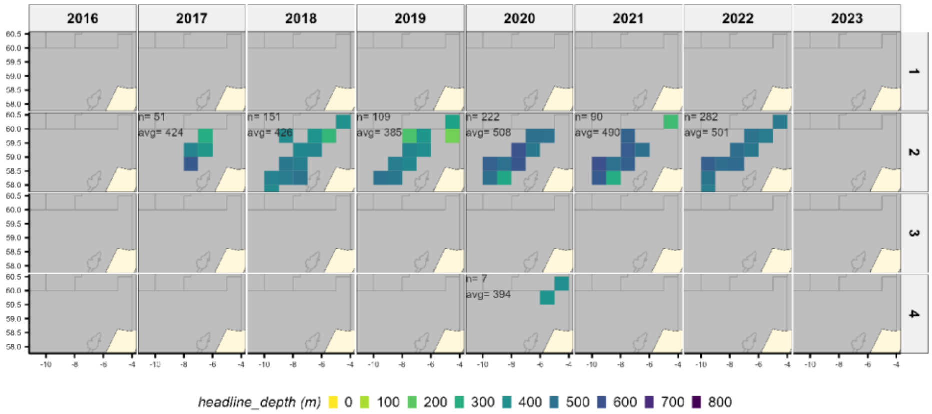


Figure 3.1.5: PFA deepwater fisheries for argentines. Average fishing depth (m) by year and quarter. N indicates the number of hauls. Avg refers to the average fishing depth.

Average wind force.

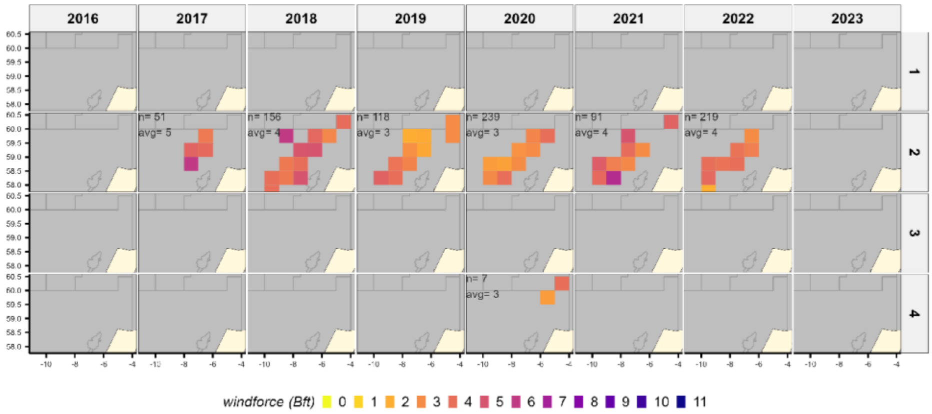


Figure 3.1.6: PFA deepwater fisheries for argentines. Average windforce (Bft) by year and quarter. N indicates the number of hauls. Avg refers to the average windforce.

3.2 Argentines (ARG, Argentinus sp.)

Argentines self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
arg	2016	2	2	28	57	1,580	56	1,063	0
arg	2017	3	3	31	67	2,248	73	668	0
arg	2018	7	7	64	161	3,013	47	968	459
arg	2019	6	7	41	94	3,899	95	3,039	0
arg	2020	7	9	101	273	5,946	59	3,980	32
arg	2021	5	6	59	136	4,398	75	3,099	0
arg	2022	6	8	146	366	9,416	64	6,231	0
(all)	(all)		42	470	1,154	30,501		19,048	491

Table 3.2.1: Argentines. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Argentines. Catch by division

species	division	2016	2017	2018	2019	2020	2021	2022	all	perc
arg	27.6.a	1,580	2,248	3,013	3,899	5,946	4,398	9,416	30,501	100.0%
(all)	(all)	1,580	2,248	3,013	3,899	5,946	4,398	9,416	30,501	100.0%

Table 3.2.2: Argentines. Self-sampling summary with the catch (tonnes) by year and division

Argentines. Catch by month

species	month	2016	2017	2018	2019	2020	2021	2022	all	perc
arg	Apr	0	38	811	720	3,201	1,289	5,739	11,799	38.7%
arg	May	1,333	2,210	2,202	3,179	2,276	3,110	3,677	17,986	59.0%
arg	Jun	248	0	0	0	452	0	0	700	2.3%
arg	Oct	0	0	0	0	16	0	0	16	0.1%
(all)	(all)	1,580	2,248	3,013	3,899	5,946	4,398	9,416	30,501	100.0%

Table 3.2.3: Argentines. Self-sampling summary with the catch (tonnes) by year and month

Argentines. Catch by rectangle

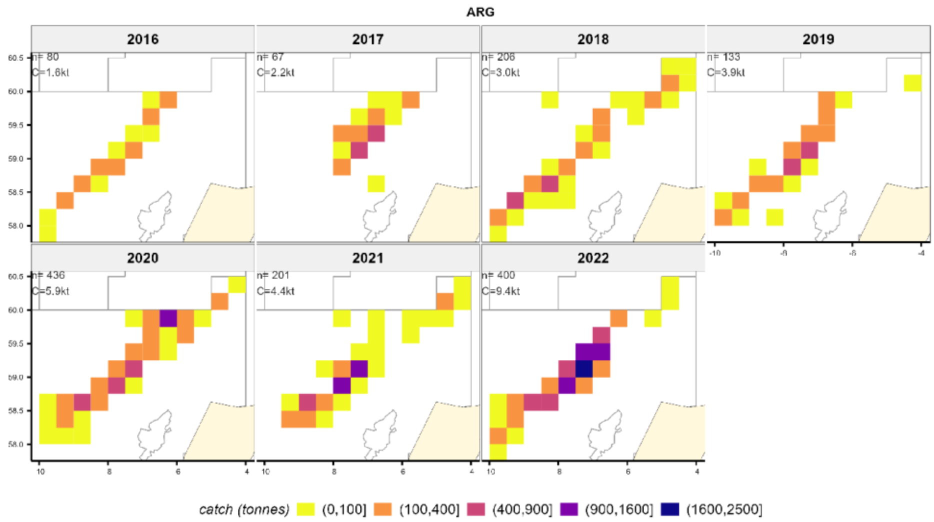


Figure 3.2.1: Argentines. Catch per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Argentines. Catchrate (ton/day) by rectangle

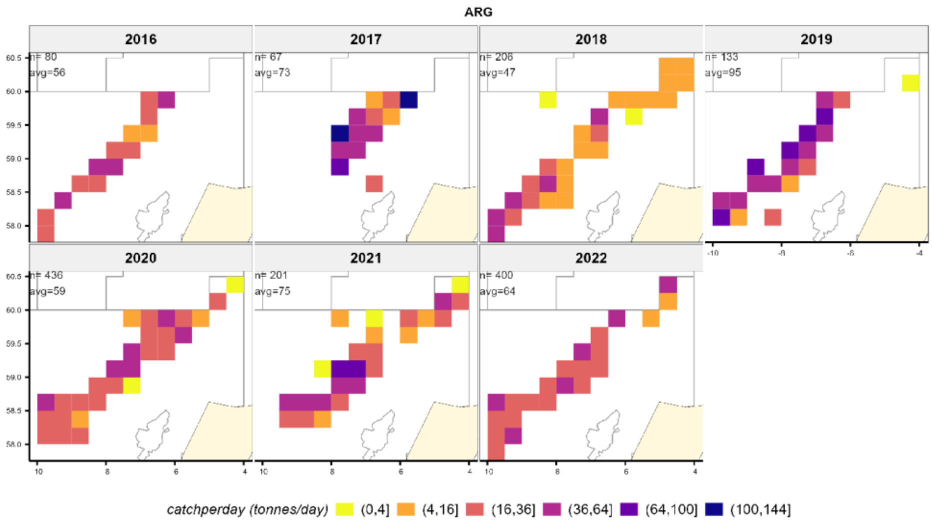


Figure 3.2.2: Argentines. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Argentines. Spatio-temporal evolution of catch by month and rectangle

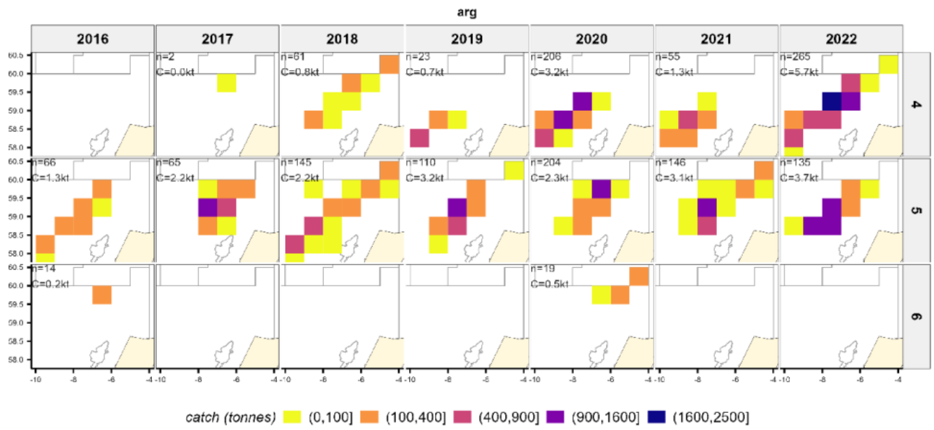


Figure 3.2.3: Argentines. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Argentines. Catch proportion at depth

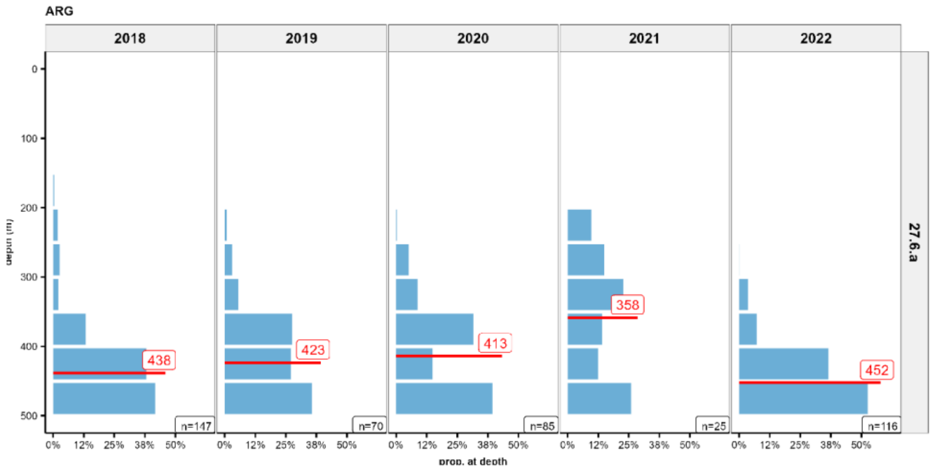


Figure 3.2.4: Argentines. Catch proportion at depth. N indicates the number of hauls.

Argentines. Length distributions of the catch

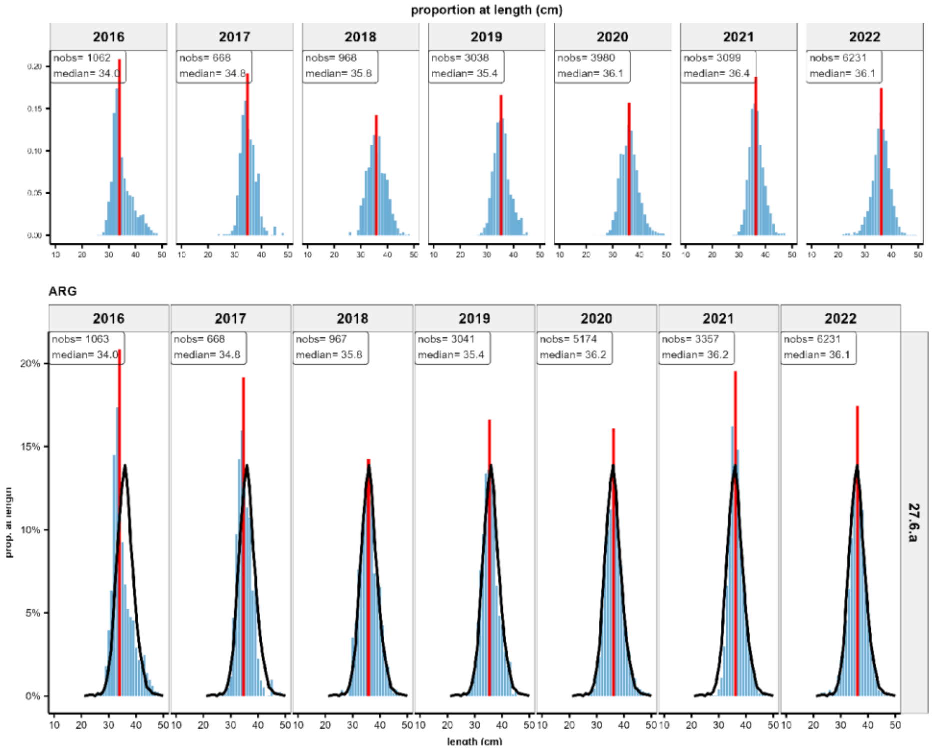


Figure 3.2.5: Argentines. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Argentines. Length distributions as proportions by (large) rectangle

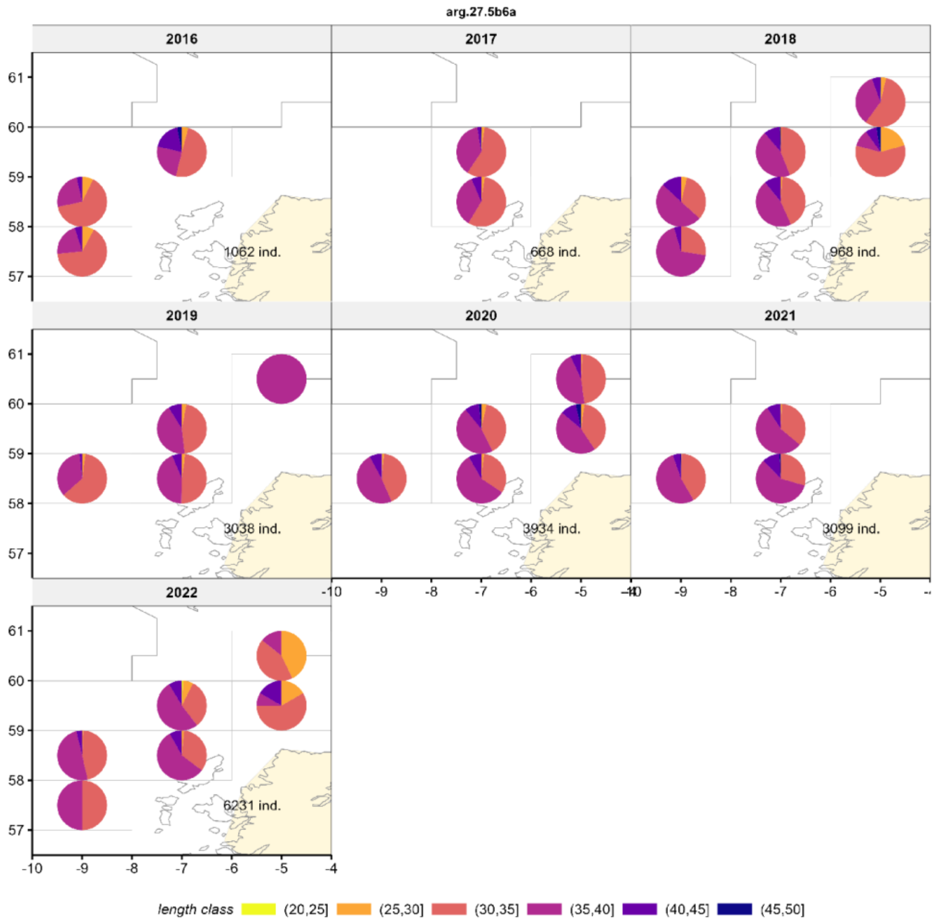


Figure 3.2.6: Argentines. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Argentines. Average length, weight and fat content by year and month

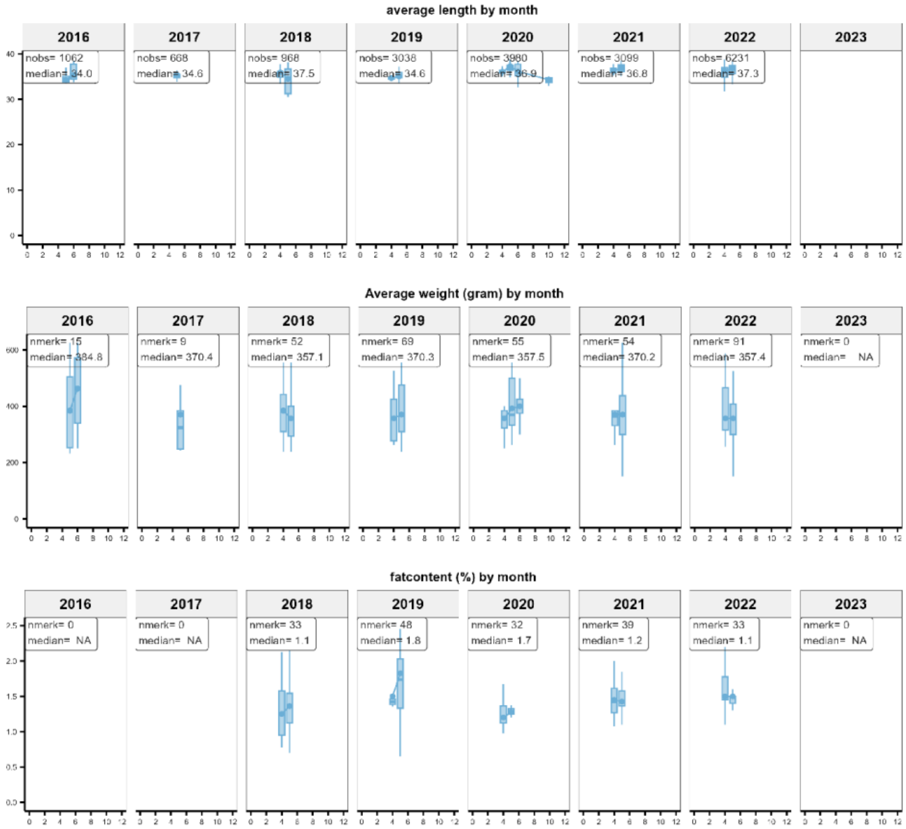


Figure 3.2.7: Argentines. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

4 Discussion and conclusions

From 2018 onwards, all PFA vessels were participating in the PFA self-sampling program.

The definition of what constitutes 'a fishery' for a certain species is not straightforward to resolve. In this report we selected all vessel-trip-week combinations with:

- hauls in divisions 27.6.a; 27.5.b; 27.4.a
- catch of arg by trip and week at least 10% of the total catch of that trip and week.
- catch of arg by trip and week at least 10 tonnes.

Since 2020, the measurements of average weight and fat content are included in the self-sampling report. Weights and fat content are routinely being collected for some of the target species (e.g. herring, mackerel) on the basis of production units (batches). The measurements are being carried out both when the species is the main target of the fishery and when it is a bycatch in other fisheries.

5 Acknowledgements

The skippers, officers and the quality managers of many of the PFA vessels are putting in a lot of effort to make the PFA the self-sampling work. Without their efforts, there would be no self-sampling.

6 References and publications

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7 More information

Please contact Niels Hintzen (nhintzen@pelagicfish.eu) if you would have any questions on the PFA self-sampling program or the specific results presented here.

Working Document No. 06 ICES WGDEEP May 3-9, 2023

Survey results of roughhead grenadier, roundnose grenadier, greater argentine, tusk, blue ling, black scabbard fish, ling, and orange roughy in ICES division 14b in the period 1998-2016 and 2022.

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Abstract
A stratified bottom trawl survey in East Greenland (ICES 14.b) has been conducted by the Greenland Institute of Natural Resources (GINR) from 1998 to 2016 (no survey was conducted in 2001), at depths between 400 to 1500 m with R/V Paamiut, using an Alfredo II bottom trawl gear. In 2017, R/V Paamiut was retired and in 2022 the survey was conducted with a new vessel owned by the GINR, R/V Tarajoq using also a new trawl gear, Bacalao 476. There was unfortunately not any comparative trawling between the old vessel R/V Paamiut and R/V Tarajoq. Survey results include biomass and abundance estimates and length frequency distributions, which are presented for roughhead grenadier (*Macrourus berglax*), roundnose grenadier (*Coryphaenoides rupestris*), greater argentine (*Argentina silus*), tusk (*Brosme brosme*), blue ling (*Molva dypterygia*), black scabbardfish (*Aphanopus carbo*), ling (*Molva molva*), and orange roughy (*Hoplostethus atlanticus*). Only roughhead grenadier and roundnose grenadier from ICES division 14.b have previously been reported to NWWG (Nogueira et al. 2023). This document contains the available information on the species mentioned above, in ICES division 14.b from scientific surveys from 1998 to 2016, and from 2022.

1. Introduction

During the period 1987-1989 the Japan Marine Fishery Resources Research Centre (JAMARC) and the Greenland Institute of Natural Resources (GINR) jointly conducted 3 bottom trawl surveys at East Greenland as part of a joint venture agreement on fisheries development and fisheries research in Greenland waters (Jørgensen and Akimoto 1990; Yatsu and Jørgensen 1988abc; Yatsu and Jørgensen 1989). The surveys were primarily aimed at Greenland halibut (*Reinhardtius hippoglossoides*) and redfish (*Sebastes* spp.) and covered various areas between Cape Farewell and 72°N at depths down to 1500 m. During the period 1989-1996 the GINR conducted annual shrimp trawl surveys with R/V Paamiut off East Greenland (Anon. 1997), but the surveys only covered depths down to 600 m with a poor coverage of depths > 400 m. In 1998, GINR initiated a bottom trawl surveys series with R/V Paamiut, which has been rigged for deep sea trawling. The survey has been carried out between 1998 and 2016 (except in 2001), and in 2017 R/V Paamiut was retired. A new survey was conducted in 2022, with the new R/V Tarajoq, owned by the GINR, using a new gear. There has unfortunately not been any comparative trawling between the Japanese R/V Shinkai Maru and R/V Paamiut, and between R/V Paamiut and R/V Tarajoq making comparisons between the surveys difficult, and there is very little overlap in the depth range between the shrimp trawl survey and the present survey. There was no survey off East Greenland in 2001. The vessel (R/V Paamiut) used for the surveys from 1998-2016 was retired in 2018 before paired trawling experiments with a replacement vessel could be conducted. In 2022, the new vessel owned by GINR, R/V Tarajoq with a Bacalao 476 trawl began a new survey series.

2. Materials and methods

The Greenland halibut surveys in East Greenland (ICES 14.b) were initiated in 1998. Until 2008, the survey was conducted in June, and had in almost all years suffered under the ice coverage found at the east coast of Greenland during early summer. Therefore, from 2008 and onwards surveys have taken place in August/September without ice induced problems. Also, in 2008 the survey was combined with a new shrimp/fish survey using a different trawl gear at more shallow waters than the Greenland halibut survey. The combination of the two surveys led to a change in trawling hours so that most of the stations since 2008 were taken during night-time. In 2022 the Greenland halibut survey was conducted between September 23 and October 7.

Stratification

The survey was planned to cover ICES Division 14.b from between the 3-nm line and the 200-nm line or the midline to Iceland at depths from 400 to 1500 m. The survey area was stratified in 5 Subareas Q1-Q5 (Table 1). Area Q1 consists of one depth stratum 401-600 m on Dohrn Bank in the northern part of the survey area. Area Q2 is the shelf area in the northern part of the survey area and is sub-divided in the depth strata 401-600, 601-800, 801-1000 and 1001-1500 m. Area Q3 is a large area with depths generally below 800 m. The stratification in the area has not been changed: 401-600, 601-800 and 801-1000 m. The slope, >1000 m, has not been covered due to steep and rough bottom. Area Q4 is not covered due to steep and rough bottom. Area Q5 is sub-divided in the depth strata 401-600, 601-800, 801-1200, 1201-1400 and 1401-1500 m. One area, Q6, off Southeast Greenland has been included in previous survey plans, but it has never been possible to make any hauls in the area due to ice and rough bottom. Therefore, Q6 has been excluded from the survey area since 2004. Survey areas of all Q-areas are presented in Table 1. In 2022, the Stratified Random Bottom Trawl Survey has been changed to a fix station allocation design due to many stations being moved and problems finding suitable fishing grounds because of rough sea bed.

Sampling design

From 1998 to 2016, the survey was planned as a Stratified Random Bottom Trawl Survey with a total of 70 hauls, which gives an overall coverage on 527 km^2 per haul. Each stratum was allocated at least two hauls. The remaining hauls were allocated in order to minimize the variance in the estimation of the biomass of Greenland halibut; *i.e.* strata with great variation in the catches of Greenland halibut in the previous year's surveys were assigned relatively more hauls than strata with little variation in the catches.

In 2004 a new method of choosing stations was introduced. The method combines the use of a minimum between-stations-distance rule (buffer zone) with a random allocation scheme (Kingsley et al. 2004). In Q5 depth stratum 801-1200 m had only 7 positions suitable for trawling. The positions of the 3 hauls allocated to this stratum were chosen at random between the 7 trawlable positions.

In 2022, the Stratified Random Bottom Trawl Survey has been changed to a fix station allocation design due to many stations being moved and problems finding suitable fishing grounds because of rough sea bed.

Vessel and gear and handling of the catch

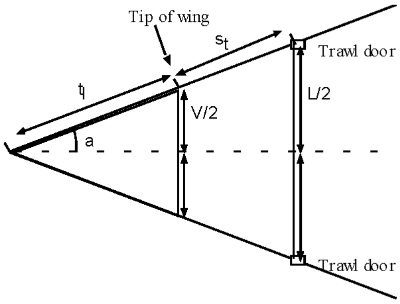
From 1998 to 2017, the survey was conducted by the 1084 GT trawler Paamiut, using an Alfredo III trawl with a mesh size on 140 mm and a 30-mm mesh-liner in the cod-end. The ground gear was of the rock hopper type. The trawl doors were changed to "Injector" type doors weighing 2700 kg in 2004, but this has not affected the performance of the trawl. Figures of rigging and bobbins chain together with further information about the gear is given in Jørgensen (1998). A Furuno net sonde mounted on the head rope measured net height. Scanmar sensors measured the distance between the trawl doors. In 2022, R/V Tarajoq (2896 GT) began a new survey series using a Bacalao 476 trawl with a mesh size of 136 mm and a 30-mm mesh-liner in the cod-end (Table 2). The same doors as on R/V Paamiut are used on R/V Tarajoq.

Swept area calculation

Nominal swept area for each tow was calculated as the straight-line distance between its GPS start and end positions multiplied by the wingspread. The distance between the trawl doors is recorded 3 or 5 times during each tow; provided it was recorded at least 3 times. Wingspread with the Alfredo trawl, taken as the distance between the outer bobbins, was calculated as:

Distance between outer bobbins = 10.122 + distance between trawl doors * 0.142

This relationship was estimated based on flume tank measurements of the trawl and rigging (Jørgensen 1998).
In 2022, the gear was changed to Bacalao 476 gear. The wingspread for a tow was calculated from the mean door spread and the geometry of the trawl as if the shape would be a triangle. V has been calculated as follows; Where the trawl and the trawl plus bridles are assumed to form two similar triangles, bridles and wings making a straight line:



and the lengths of the bridles (s) and the trawl wings (t) are known. The wingspread V is then calculated as:
$V = (t_l \cdot L) / (t_l + s_t)$
where L is the distance between the doors (doorspread). The trawl wing is 26.83 meters and the length of the bridles is 129 m. Because the shape of the Bacalao gear is not a triangle, a constant based on the sensors measurements during the Canadian survey at the same depths was applied. Scanmar sensors measured wingspread during the deep

Canadian survey in Subarea 0A. The difference between our estimation and the sensors measurement in each depth strata has been added as a constant in our wingspread calculations.

Trawling procedure

Towing time is usually 30 min, but towing times down to 15 min are accepted. Towing speed is between 2.5-3.0 kn and is estimated from the start and end positions of the haul. Since 2008, trawling takes place day and night. Previously, trawling was conducted only during day time.

3. Results and discussion

The available data from scientific surveys reveal that the evaluated species are present in ICES division 14.b in very different quantities. Below data are presented for each species with focus on the most recent year the species has been registered. Overall length distributions are shown only for years when more than 20 specimens of a given species were available. In total 73 hauls were made in 2022 (Table 4), with good coverage of all areas.

Roughhead grenadier (*Macrourus berglax*, RHG)

Roughhead grenadier was caught in 59 of the 73 hauls in 2022. Catches ranged from 0.246 kg to 736.33 kg, taken at 677 m in Q2 (Appendix, 1). The species was found in all strata. The vast majority of the biomass was found in Q2, similar to other years (Table 6). The biomass has been at a similar level from 1998 to 2007, where it ranged between 3151 tonnes to 5702 tonnes (Table 5, Fig. 1). The biomass then increased from 2008 until 2016 where it ranged between 5871 tonnes to 9208 tonnes (Table 5, Fig. 1). This increase could be linked to the change in survey design, where most stations from 2008 and onwards were taken during night time. The biomass since 2008 appears stabil although fluctuating (Fig. 1). In 2022, the biomass was 12915 t (S.E. = 3861, Table 5).In 2022, the abundance was estimated $7338*10^3$ (S.E. = $1703*10^3$) and follows a similar distribution pattern as the biomass (Table 6). The overall length distribution in 2022 was dominated by a clear mode at 20 cm similar to previous years (Fig. 4). From 2010 to 2016, a smaller second mode around 30 cm was present in the time series, and it became very high in numbers in 2022. The higher numbers found in the second mode in 2022 could be due to changes in the gear selectivity.

Roundnose grenadier (*Coryphaenoides rupestris* ; RNG)

Roundnose grenadier was caught in 18 of the 73 hauls and catches were generally very low, and were only found in Q2 at 1001-1500 and Q5 between depth of 601 to 1500 m (Table 7 and 8). The total biomass estimate for roundnose grenadier in 2022 is 84 t (S.E. = 17) (Table 7, which is very low. The abundance estimate follows the same pattern with a total estimate of $1364*10^3$ (S.E. = $436*10^3$), (Table 7, Fig. 6). The majority of the fish are found in the deeper parts (800 – 1000 m) of Q2 (Table 8). In 2022, there was a mode in the length distribution around 3 cm (Fig. 8), which may indicate there are currently only smaller individuals and less larger ones (which were previously regularly visible in the length distribution).

Greater argentine (*Argentinus silus*; ARU)

In 2022, greater argentine was caught in 24 of the 74 hauls. Catches ranged from 0.35 kg to 94.04 kg. The vast majority of the biomass was found in Q2 and Q5 at depth less that 1100 m (Table 10, Fig. 11). Biomass for greater argentine has been increasing from 1998 t (6.4 tonnes) to 2016 (808.1 tonnes), peaking in 2014 (2166.7 tonnes)

(Table 9, Fig. 9). In 2022, the biomass was 1061.44 t (SE = 713.84).tonnes In 2022, the abundance was estimated to $2260.9*10^3$ (S.E. = $1653.7*10^3$) and generally follows the same patterns as biomass (Table 10).
The overall length distribution shows that from 2003-2011 and 2014-2016 catches were dominated by a mode around 30-40 cm, whereas a second mode around 20 cm was evident in years 2012-2013 (Fig. 12). In 2022, only one mode around 38 cm was found.

Tusk (*Brosme brosme*, USK)

In 2016, tusk was caught in 17 of the 74 hauls. Catches ranged from 0.9 kg to 13 kg. The species was caught in all subareas but the majority of the biomass was in Q2 similar to previous years (Table 12, Fig. 15) Biomass for tusk has been low until 2010 (mean biomass = 18.2 t), with no catches in 1998, 1999 and 2005. From 2010 untill 2016, the biomass has been distinctly higher (mean biomass = 275 tonnes) ranging from 78.8 tonnes (2014) to 504.0 tonnes (2013) (Table 11, Fig. 13). In 2016, the biomass was 296.83 (SE = 77.86).tonnes
In 2022, the abundance was estimated $153.34*10^3$ (S.E. = $53*10^3$) (Table 12). The overall length distribution for all years are based on relatively low sample sizes (N<100), individual size ranged from 43 cm to 82, and we can not distinguish any mode (Fig. 16). Larger individuals were caught with the new gear in 2022.

Blue ling (*Molva dypterygia*, BLI)

In 2022, blue ling was caught in 12 out of 73 hauls. Catches ranged from 2.25 kg to 28.74 kg. The species was caught in all subareas, but with the vast majority in Q2 in depths between 600 and 800 m (Table 14, Fig. 19). Biomass for blue ling has been low from 1998 to 2005 (mean biomass =138.4 tonnes). From 2006 until 2016, the biomass has been distinctly higher (mean biomass = 786.5 tonnes) ranging from 158 tonnes (2007) to 1365 tonnes (2012) (Table 13, Fig. 17). In 2022, the biomass was 447 t (SE = 164).In 2022, the abundance was estimated to $178*10^3$ (S.E. = $69*10^3$) and generally follows biomass estimates. No mode can be observed in the length distribution. The size of the individuals ranged from 21 to 124 cm. (Fig. 20).

Black scabbardfish (*Aphanopus carbo*, BSF)

Black scabbardfish are rarely caught in this survey.There were no catches in the years 1998, 1999, 2000, 2002, 2003, 2006 and 2016, and neither in 2022. In 2013 and 2015, the species was caught only in 1 station, whereas it was found in 4-6 stations in 2011, 2012 and 2014. For these years, catches ranged from 0.7 kg to 21.7 kg. In 2015, it was only registered in Q5 at depths between 801-1200 m (Table 15, Fig. 23), where the majority of the biomass also has been observed in previous years (Fig. 23). In 2008 and 2010-2012, the biomass was estimated between 32.8 t and 56.4 t, whereas all other years the biomass was less than 7.9 t (Table 15). This is most likely because this pelagic and deep living pelagic fish is not targeted by the applied type of bottom trawl and hence the estimated biomasses (Fig. 21) are not truly representative of actual biomass in the investigated area. Overall length distributions from 2011 and 2012 show a wide mode between 70 cm and 110 cm.

Ling (*Molva molva*; BSF)

Ling are not commonly caught in this survey. There were no catches from 1998 to 2004, 2008, 2013-2014 and 2016. In 2022, only 1 individual was caught in 1 haul out of 74 hauls in Q2 at depths between 601-800 m (Table 16). Except from 2011, where the estimated biomass was 267.8 t (S.E. = 14.8 tonnes) (Table 16), yearly estimates are 10-fold less or zero evidencing that ling do not commonly occur in the investigated area (Table 16, Fig. 24, Fig. 26). In 2022, the estimated biomass was 6 t, estimated abundance was $2*10^3$ (Table 17). The overall length distribution shows that specimens were shorter in 2011 (mode 40-50 cm) than in 2010 (mode=90-100) and further that less fish were caught in 2011 (Fig. 24) where, in contrast, the estimated biomass was more than 10 times higher. This is explained by the fact that in 2011 all ling were caught in Q3 at 601-800 m – a depth stratum which comprises 26.3 % of the total area of all strata combined (Table 1). The size of the individual caught in 2022 was 82 cm.

Orange roughy (*Hoplostethus atlanticus*; ORY)

Orange roughy is not commonly caught in this survey. The species was only caught in 2008, 2013, 2014 and 2015 (Fig. 27). In 2014 and 2015, estimated biomass was 1.7 t and 1.1 t, respectively, and in all other years it was zero or very close to zero (Table 18, Fig. 27). In 2015, all fish were caught in Q3 at depths between 801-1200 m . No length distributions are shown as too few specimens (N<20) were caught.

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Table 1. Areas (km^2) and their percentage distribution for subareas and depth strata (m). Q4 areas are not included.

Subarea	Depth strata	Area	% distribution
Q1	401-600	6975	18.7
Q2	401-600	1246	3.3
Q2	601-800	1475.4	3.9
Q2	801-1000	1988.3	5.3
Q2	1001-1500	6689.4	17.9
Q3	401-600	9830.2	26.3
Q3	601-800	3788.1	10.1
Q3	801-1000	755.4	2.0
Q3	1001-1200	191.1	0.5
Q3	1201-1400	213.3	0.6
Q3	1401-1500	312.9	0.8
Q4	401-600	2053.6	
Q4	601-800	665.7	
Q4	801-1000	336.2	
Q4	1001-1200	549.9	
Q4	1201-1400	1147	
Q4	1401-1500	940.5	
Q5	401-600	1819.4	4.9
Q5	601-800	257.1	0.7
Q5	801-1200	255.6	0.7
Q5	1201-1400	985.5	2.6
Q5	1401-1500	614.5	1.6
Sum (without Q4)		37397.2	100

Table 2.- General survey information and gear specifications for the surveys 1998-2016 on board R/V Paamiut and for the survey in 2022 with R/V Tarajoq.

Procedure	Specifications	
Vessel	R/V Paamiut	R/V Tarajoq
TRB	1084 GT	2896 GT
Dimensions	LOA 58.61m, Beam 11.21 m	LOA 61.4 m, Beam 16.3 m
Main engine	2000BHP, Diesel 257, 1471KW	3943/4896 BHP, Diesel 475, 2900/3600 KW
Survey Area	14b (401- 1500 m)	14b (401- 1500 m)
Years	1998-2016 (no survey 2001)	2022
Time of year	August/September	September/October
Number of days	15	15
Towing speed (knots)	3	3
Tow duration	30 min	30 min
Gear	Alfredo 3	Bacalao 476
Vertical trawl opening (m)	5.6	4.5*
Distance between doors	120 -145 m	151.8*
Winds spread	10.122 + distance between the doors * 0.142.	$V = (t_l * L) / (t_l + s_t)$ + constant
Mesh size (mm)	140 mm	136
Door	until 2003:Greenland Perfect (370*250 cm) from 2004: Shark injector (353*273)	Shark injector (353*273)
Door type (kg)	2400 kg with extra 20 kg	2850
Mesh size (mm)	44	44
Mesh-line in the cod-end	30 mm	30
Sampling design	Buffered Random Stratified	Fix stations
Number of Stations	100	74 fix + 70 extra (min 80)
Number of strata	10	10
Trawling schedule	24 hours	
Criteria for rejecting a haul	Snag of the trawling gear in the bottom Damage in the cod-end or severe damages in large sections of the wings or belly Less than 15 minutes of effective trawling time Gear malfuntion	
Criteria for change haul position	Wrong depth interval Poor bottom conditions	
Samling species	All fish species and invertebrates	
Target species	Greenland halibut	

Table 3.- Number of valid hauls for the period 1998 - 2003. No survey was conducted in 2001.

Subarea	Depth stratum (m)	Area (km2)	1998	1999	2000	2002	2003
Q1	401-600	7444.1	6	4	3	1	4
Q1	601-800	622	3	3	3	3	3
Q1	801-1000	652.3	3	3	3	2	2
Q1	1001-1200	881.8	2	2	2	2	1
Q1	1201-1400	741.4	2	2	2	2	1
Q1	1401-1500	462.3	2	2	2	2	2
Q2	401-600	777	2	2	2	2	3
Q2	601-800	853.4	4	3	3	3	3
Q2	801-1000	1336	5	4	3	4	3
Q2	1001-1200	1699.3	2	2	2	2	2
Q2	1201-1400	1742	2	2	2	0	2
Q2	1401-1500	1162.6	1	2	2	2	1
Q3	401-600	9830.2	6	7	9	3	1
Q3	601-800	3788.1	3	4	4	1	5
Q3	801-1000	755.4	2	0	2	0	2
Q5	401-600	1819.4	2	2	1	0	0
Q5	601-800	257.1	0	2	2	2	1
Q5	801-1000	106.7	0	2	2	2	2
Q5	1001-1200	148.9	2	2	2	2	1
Q5	1201-1400	985.5	2	2	2	3	1
Q5	1401-1500	614.5	3	2	2	2	0
TOTAL			54	54	55	40	40

Table 4.- Number of valid hauls for the period 2004-2016 with R/V Paamiut (no survey in 2001) and in 2022 with R/V Tarajoq, after a new stratification scheme was introduced.

Subarea	Depth stratum (m)	Area (km2)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2022	Total
Q1	401-600	6975	2	0	0	2	4	4	2	8	7	10	7	11	12	0	5	74
Q2	401-600	1246	4	4	5	3	5	4	4	2	4	5	5	5	5	0	7	62
Q2	601-800	1475.4	5	5	6	5	7	5	5	6	9	5	7	7	7	0	5	84
Q2	601-1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Q2	801-1000	1988.3	8	9	12	9	3	9	8	8	9	8	7	8	10	0	8	116
Q2	1001-1500	6689.4	3	3	4	3	4	5	5	4	7	4	7	7	7	0	5	68
Q3	401-600	9830.2	9	1	2	2	2	5	5	6	4	9	7	8	11	0	4	75
Q3	601-800	3788.1	4	8	2	6	6	10	6	7	7	11	12	10	14	0	11	114
Q3	801-1000	755.4	0	2	0	0	2	3	3	5	4	4	5	5	6	0	5	44
Q4	801-1200	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Q5	401-600	1819.4	3	0	1	2	3	2	0	1	2	1	2	3	3	0	4	27
Q5	601-800	257.1	3	1	3	2	3	4	1	3	3	6	6	6	6	0	6	53
Q5	801-1000	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	3
Q5	801-1200	255.6	3	4	3	4	0	4	3	3	4	5	6	2	5	0	2	48
Q5	1201-1400	985.5	5	6	3	5	3	6	5	8	5	9	3	7	9	6	9	89
Q5	1401-1500	614.5	3	4	2	3	1	3	3	5	2	3	3	5	5	4	2	48
		TOTAL	52	47	43	46	47	64	50	66	67	80	78	84	100	10	73	

Table 5.Total biomass (tonnes) with SE, and abundance (10^3) with SE, of roughhead grenadier (*Macrourus berglax*, RHG) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Roughhead grenadier			
Year	**Vessel**	**Biomass**	**SE**	**Abundance**	**SE**
1998	PA	3480.9	546.2	4027.81	639.14
1999	PA	4741.67	803.82	5268.51	979.85
2000	PA	3434.36	351.12	3894.76	380.16
2001	PA	-	-	-	-
2002	PA	4523.51	2095.86	5409.19	3429.93
2003	PA	3100.01	609.13	3421.35	741.1
2004	PA	3150.55	532.5	2813.58	266.75
2005	PA	4237.93	872.42	5230.35	1225.6
2006	PA	3972.49	597.02	4600.06	620.9
2007	PA	3435.29	637.47	3590.22	445.99
2008	PA	6841.49	983.99	6590.11	818.97
2009	PA	7256.96	1425.21	6836.17	1173.32
2010	PA	9201.84	2292.12	7532.03	1162.02
2011	PA	5855.39	1032.07	5678.71	1055.34
2012	PA	7926.09	1330.41	7060.19	1030.43
2013	PA	7604.93	1765.46	5756.69	1212.99
2014	PA	6816.97	1043.22	5426.8	713.5
2015	PA	8751.71	2292.95	5647.58	1239.19
2016	PA	6953.35	1190.37	6004.64	1043.39
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	12913.87	3860.92	7337.53	1703.26

Table 6. Mean Catch (kg/km2), biomass (tonnes) with SE, mean numbers (num/km2) and abundance (10^3) with SE with SE of roughhead grenadier (RHG) by subarea and depth stratum in 2022.

Subarea	Stratum (m)	Area (sq.km)	Tow number	Mean Catch	Biomass	SE	Mean Number	Abundance	SE
Q1	0401-0600	6975	12	10.625	74	67	9	64	46
Q2	0401-0600	1246	5	145.899	182	90	167	208	96
Q2	0601-0800	1475	7	3761.844	5550	2687	1739	2565	1123
Q2	0801-1000	1988	10	1018.74	2026	1358	551	1096	639
Q2	1001-1500	6689	7	695.394	4652	2412	432	2893	1101
Q3	0401-0600	9830	11	10.56	104	50	12	114	50
Q3	0601-0800	3788	14	19.726	75	27	31	118	20
Q3	0801-1000	755	6	25.514	19	7	39	30	10
Q5	0401-0600	1819	3	41.222	75	75	33	60	60
Q5	0601-0800	257	6	27.582	7	7	29	8	7
Q5	0801-1200	256	5	48.005	12	8	76	19	12
Q5	1201-1400	986	9	73.759	73	29	93	92	27
Q5	1401-1500	614	5	106.683	66	17	116	71	11
TOTAL		36678	100	105.26	12915	3861	46.44	7338	1703

Table 7.Total biomass (tonnes) with SE, and abundance (10^3) with SE, of roundnose grenadier (*Coryphaenoides rupestris*, RNG) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Roundnose grenadier			
Year	Vessel	Biomass	SE	Abundance	SE
1998	PA	2877.29	1299.84	6166.28	2654.39
1999	PA	4303.63	463.11	9661.55	1012.45
2000	PA	2294.69	1237.14	5630.96	2486.13
2001	PA	-	-	-	-
2002	PA	1771.06	1224.19	7065.28	4542.48
2003	PA	4459.12	2097	13593.18	4742.32
2004	PA	1151.83	792	4369.14	1841.27
2005	PA	1174	337.77	5883.41	1813.27
2006	PA	689.04	300.31	3781.2	967.65
2007	PA	878.79	250.81	8312.51	2493.72
2008	PA	772.93	242.56	4296.04	1277.88
2009	PA	215.67	52.05	1452.29	368.99
2010	PA	416.21	93.74	2525.65	478.99
2011	PA	3202.25	2821.1	9207.74	6687.45
2012	PA	5379.46	4774.44	15325.86	13521.71
2013	PA	294.99	151.77	1469.95	694.61
2014	PA	106.1	36.39	826.32	322.61
2015	PA	999.46	815.95	3065.97	2106.33
2016	PA	170.25	46.08	530.16	127.62
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	83.68	16.92	1363.29	436.43

Table 8. Mean Catch (kg/km2), biomass (tonnes) with SE, mean numbers (num/km2) and abundance (10^3) with SE with SE of roundnose grenadier (*Coryphaenoides rupestris*, RNG)by subarea and depth stratum

Subarea	Stratum (m)	Area (sq.km)	Tow number	Mean Catch	Biomass	SE	Mean Number	Abundance	SE
Q1	0401-0600	6975	12	0	0	0	0	0	0
Q2	0401-0600	1246	5	0	0	0	0	0	0
Q2	0601-0800	1475	7	0	0	0	0	0	0
Q2	0801-1000	1988	10	0	0	0	0	0	0
Q2	1001-1500	6689	7	2.463	16	11	4	27	17
Q3	0401-0600	9830	11	0	0	0	0	0	0
Q3	0601-0800	3788	14	0	0	0	0	0	0
Q3	0801-1000	755	6	0	0	0	0	0	0
Q5	0401-0600	1819	3	0	0	0	0	0	0
Q5	0601-0800	257	6	14.16	4	3	27	7	6
Q5	0801-1200	256	5	35.336	9	4	4435	1134	432
Q5	1201-1400	986	9	52.526	52	12	183	180	55
Q5	1401-1500	614	5	4.507	3	2	27	16	9
TOTAL		36678	100	0.46	84	17	11.9	1364	436

Table 9.Total biomass (tonnes) with SE, and abundance (10^3) with SE, of greater silver smelt (*Argentinus silus*, ARU) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Argentina silus			
Year	Vessel	Biomass	SE	Abundance	SE
1998	PA	5.39	3.14	11.69	7.73
1999	PA	2.13	2.13	5.32	5.32
2000	PA	6.5	3.54	18.2	9.49
2001	PA	-	-	-	-
2002	PA	53.79	36.23	197.17	141.11
2003	PA	162.26	93.46	493.99	293.54
2004	PA	96.91	36.05	302.86	116.52
2005	PA	55.11	19.63	186.41	67.75
2006	PA	167.25	58.48	471.75	176.95
2007	PA	126.62	45.78	384.07	143.34
2008	PA	240.62	105.47	608.6	279.75
2009	PA	347.48	155.47	747.82	343.53
2010	PA	370.78	100.95	753.41	206.27
2011	PA	432.1	145.02	1145.74	405.38
2012	PA	481.74	166.49	954.86	294.72
2013	PA	643.7	173.47	1239.71	309.73
2014	PA	2046.61	842.8	4127.26	1594.59
2015	PA	257.55	71.72	506.79	119.83
2016	PA	808.11	360.38	1609.62	889.75
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	1061.44	713.84	2260.91	1653.76

Table 10. Mean Catch (kg/km2), biomass (tonnes) with SE, mean numbers (num/km2) and abundance (10^3) with SE of of greater silver smelt (*Argentinus silus*, ARU) by subarea and depth stratum in 2022.

Subarea	Stratum (m)	Area (sq.km)	Tow number	Mean Catch	Biomass	SE	Mean Number	Abundance	SE
Q1	0401-0600	6975	12	0	0	0	0	0	0
Q2	0401-0600	1246	5	63.82	80	46	107	133	81
Q2	0601-0800	1475	7	44.425	66	38	74	109	60
Q2	0801-1000	1988	10	5.185	10	2	11	23	5
Q2	1001-1500	6689	7	0.961	6	6	1	10	10
Q3	0401-0600	9830	11	0	0	0	0	0	0
Q3	0601-0800	3788	14	0	0	0	0	0	0
Q3	0801-1000	755	6	0	0	0	0	0	0
Q5	0401-0600	1819	3	430.82	784	709	982	1787	1648
Q5	0601-0800	257	6	447.65	115	53	772	198	87
Q5	0801-1200	256	5	2.796	1	0	7	2	1
Q5	1201-1400	986	9	0	0	0	0	0	0
Q5	1401-1500	614	5	0	0	0	0	0	0
TOTAL		36678	100	19.46	1062	714	45.09	2262	1654

Table 11. Total biomass (tonnes) with SE, and abundance (10^3) with SE, of tusk (*Brosme brosme*, USK) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Brosme brosme			
Year	Vessel	Biomass	SE	Abundance	SE
1998	PA	0	0	0	0
1999	PA	0	0	0	0
2000	PA	3.75	3.75	0.99	0.99
2001	PA	-	-	-	-
2002	PA	61.06	34.27	194.13	108.82
2003	PA	2.21	1.6	8.82	4.41
2004	PA	4.36	4.36	9.69	9.69
2005	PA	0	0	0	0
2006	PA	16.47	7.74	19.3	7.93
2007	PA	18.42	14.94	11.95	7.28
2008	PA	69.25	29.48	166.13	93.72
2009	PA	47.4	22.34	112.41	54.81
2010	PA	225.8	113.64	369.05	206.85
2011	PA	113.62	48.34	92.71	39.91
2012	PA	349.74	261.82	138.21	67.2
2013	PA	504.06	159.77	286.14	68.41
2014	PA	188.3	111.11	126.96	50
2015	PA	277.94	87.08	186.26	47.79
2016	PA	371.81	92.08	325.44	81.58
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	296.83	77.86	153.34	53.66

Table 12. Mean Catch (kg/km2), biomass (tonnes) with SE, mean numbers (num/km2) and abundance (10^3) with SE of of tusk (*Brosme brosme*, USK) by subarea and depth stratum in 2022.

Subarea	Stratum (m)	Area (sq.km)	Tow number	Mean Catch	Biomass	SE	Mean Number	Abundance	SE
Q1	0401-0600	6975	12	7.863	55	55	7	47	47
Q2	0401-0600	1246	5	92.869	116	37	25	32	9
Q2	0601-0800	1475	7	29.252	43	23	17	25	15
Q2	0801-1000	1988	10	4.602	9	6	3	5	3
Q2	1001-1500	6689	7	0	0	0	0	0	0
Q3	0401-0600	9830	11	5.592	55	29	4	35	18
Q3	0601-0800	3788	14	0	0	0	0	0	0
Q3	0801-1000	755	6	0	0	0	0	0	0
Q5	0401-0600	1819	3	8.593	16	16	4	8	8
Q5	0601-0800	257	6	13.081	3	1	9	2	1
Q5	0801-1200	256	5	0	0	0	0	0	0
Q5	1201-1400	986	9	0	0	0	0	0	0
Q5	1401-1500	614	5	0	0	0	0	0	0
TOTAL		36678	100	2.12	297	78	1.46	154	54

Table 13.Total biomass (tonnes) with SE, and abundance (10^3) with SE, of blue ling (*Molva dypterygia*, BLI) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Molva dypteria			
Year	Vessel	Biomass	SE	Abundance	SE
1998	PA	87.47	42.49	34.41	11.78
1999	PA	163.48	69.45	65.93	27.83
2000	PA	211.09	114.02	161.13	75.62
2001	PA	-	-	-	-
2002	PA	76.26	17.34	86.61	15.93
2003	PA	101.38	31.39	96.62	35.86
2004	PA	81.59	32.72	89.16	42.79
2005	PA	111.08	30.99	83.28	15.38
2006	PA	570.07	264.94	355.56	131.03
2007	PA	158.35	57.06	136.59	57.59
2008	PA	870.02	404.82	1013.83	574.84
2009	PA	1239.68	617.42	860.55	353.19
2010	PA	892.11	157.68	689.48	193.73
2011	PA	588.19	232.69	665.09	318.57
2012	PA	1339.72	194.16	976.82	369.4
2013	PA	1248.22	412.14	571.84	159.41
2014	PA	865.88	288.05	471.72	127.73
2015	PA	417.65	162.08	204.49	74.07
2016	PA	432.5	155.17	182.92	66.68
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	446.04	164.23	176.81	69.22

Table 14. Mean Catch (kg/km2), biomass (tonnes) with SE, mean numbers (num/km2) and abundance (10^3) with SE of of blue ling (*Molva dypterygia*, BLI) by subarea and depth stratum in 2022.

Subarea	Stratum (m)	Area (sq.km)	Tow number	Mean Catch	Biomass	SE	Mean Number	Abundance	SE
Q1	0401-0600	6975	12	7.013	49	49	2	16	16
Q2	0401-0600	1246	5	31.105	39	17	8	10	4
Q2	0601-0800	1475	7	149.958	221	143	49	73	50
Q2	0801-1000	1988	10	0	0	0	0	0	0
Q2	1001-1500	6689	7	0	0	0	0	0	0
Q3	0401-0600	9830	11	7.105	70	47	2	24	16
Q3	0601-0800	3788	14	0	0	0	0	0	0
Q3	0801-1000	755	6	0	0	0	0	0	0
Q5	0401-0600	1819	3	35.538	65	40	30	54	42
Q5	0601-0800	257	6	0	0	0	0	0	0
Q5	0801-1200	256	5	10.252	3	3	4	1	1
Q5	1201-1400	986	9	0	0	0	0	0	0
Q5	1401-1500	614	5	0	0	0	0	0	0
TOTAL		36678	100	4.48	447	164	1.89	178	69

Table 15.Total biomass (tonnes) with SE, and abundance (10^3) with SE, of black scabbardfish (*Aphanopus carbo*, BSF) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Aphanophus carbo			
Year	**Vessel**	**Biomass**	**SE**	**Abundance**	**SE**
1998	PA	0	0	0	0
1999	PA	0	0	0	0
2000	PA	0	0	0	0
2001	PA	-	-	-	-
2002	PA	0	0	0	0
2003	PA	0	0	0	0
2004	PA	0.82	0.82	4.08	4.08
2005	PA	1.71	1.71	1.37	1.37
2006	PA	0	0	0	0
2007	PA	2.33	1.98	7.49	5.35
2008	PA	37.53	33.34	33.79	27.28
2009	PA	2.66	2.66	3.1	3.1
2010	PA	56.38	25.08	82.79	35.31
2011	PA	39.86	26.67	56.44	35.99
2012	PA	33.12	9.57	34.13	12.07
2013	PA	1.81	1.81	2.05	2.05
2014	PA	7.91	4.87	6.85	3.52
2015	PA	1.52	1.52	2.15	2.15
2016	PA	0	0	0	0
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	0	0	0	0

Table 16.Total biomass (tonnes) with SE, and abundance (10^3) with SE, of blue ling (*Molva molva*, LIN) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

Year	Vessel	Biomass	SE	Abundance	SE
1998	PA	0	0	0	0
1999	PA	0	0	0	0
2000	PA	0	0	0	0
2001	PA	-	-	-	-
2002	PA	0	0	0	0
2003	PA	0	0	0	0
2004	PA	0	0	0	0
2005	PA	15.69	15.69	9.26	9.26
2006	PA	29.89	29.89	6.29	6.29
2007	PA	14.61	10.34	25.32	19.91
2008	PA	0	0	0	0
2009	PA	3.09	3.09	3.67	3.67
2010	PA	19.23	0	8.21	0
2011	PA	267.64	251.03	491.56	484.77
2012	PA	19.92	19.92	6.04	6.04
2013	PA	0	0	0	0
2014	PA	0	0	0	0
2015	PA	23.43	14.85	9.18	6.1
2016	PA	0	0	0	0
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	6.43	6.43	2.12	2.12

Table 17. Mean Catch (kg/km2), biomass (tonnes) with SE, mean numbers (num/km2) and abundance (10^3) with SE of of blue ling (*Molva molva*, LIN) by subarea and depth stratum in 2022.

Subarea	Stratum (m)	Area (sq.km)	Tow number	Mean Catch	Biomass	SE	Mean Number	Abundance	SE
Q1	0401-0600	6975	12	0	0	0	0	0	0
Q2	0401-0600	1246	5	0	0	0	0	0	0
Q2	0601-0800	1475	7	4.357	6	6	1	2	2
Q2	0801-1000	1988	10	0	0	0	0	0	0
Q2	1001-1500	6689	7	0	0	0	0	0	0
Q3	0401-0600	9830	11	0	0	0	0	0	0
Q3	0601-0800	3788	14	0	0	0	0	0	0
Q3	0801-1000	755	6	0	0	0	0	0	0
Q5	0401-0600	1819	3	0	0	0	0	0	0
Q5	0601-0800	257	6	0	0	0	0	0	0
Q5	0801-1200	256	5	0	0	0	0	0	0
Q5	1201-1400	986	9	0	0	0	0	0	0
Q5	1401-1500	614	5	0	0	0	0	0	0
TOTAL		36678	100	0.18	6	6	0.06	2	2

Table 18. Total biomass (tonnes) with SE, and abundance (10^3) with SE, of Orange roughy (*Hoplostethus atlanticus*, ORY) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Hoplostethus atlanticus			
Year	**Vessel**	**Biomass**	**SE**	**Abundance**	**SE**
1998	PA	0	0	0	0
1999	PA	0	0	0	0
2000	PA	0	0	0	0
2001	PA	-	-	-	-
2002	PA	0	0	0	0
2003	PA	0	0	0	0
2004	PA	0	0	0	0
2005	PA	0	0	0	0
2006	PA	0	0	0	0
2007	PA	0	0	0	0
2008	PA	0.16	0.16	0.92	0.92
2009	PA	0	0	0	0
2010	PA	0	0	0	0
2011	PA	0	0	0	0
2012	PA	0	0	0	0
2013	PA	0.02	0.02	0.69	0.69
2014	PA	1.74	1.74	2.33	2.33
2015	PA	1.09	1.09	2.15	2.15
2016	PA	0	0	0	0
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	0	0	0	0

Figure 1. Roughhead grenadier (RHG) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

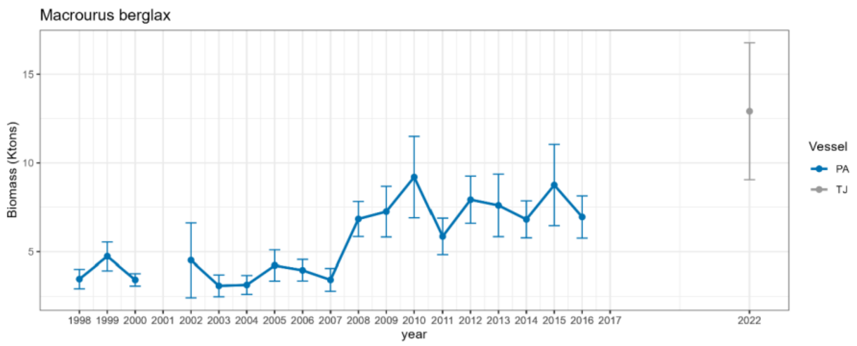


Figure 2. Roughhead grenadier (RHG) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

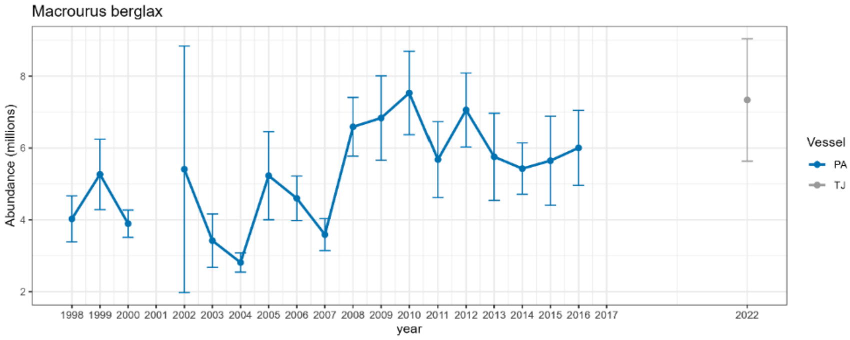


Figure 3. Distribution of survey catches of roughhead grenadier (RHG) off East Greenland (ICES 14.b) from 1998-2016 and 2022.

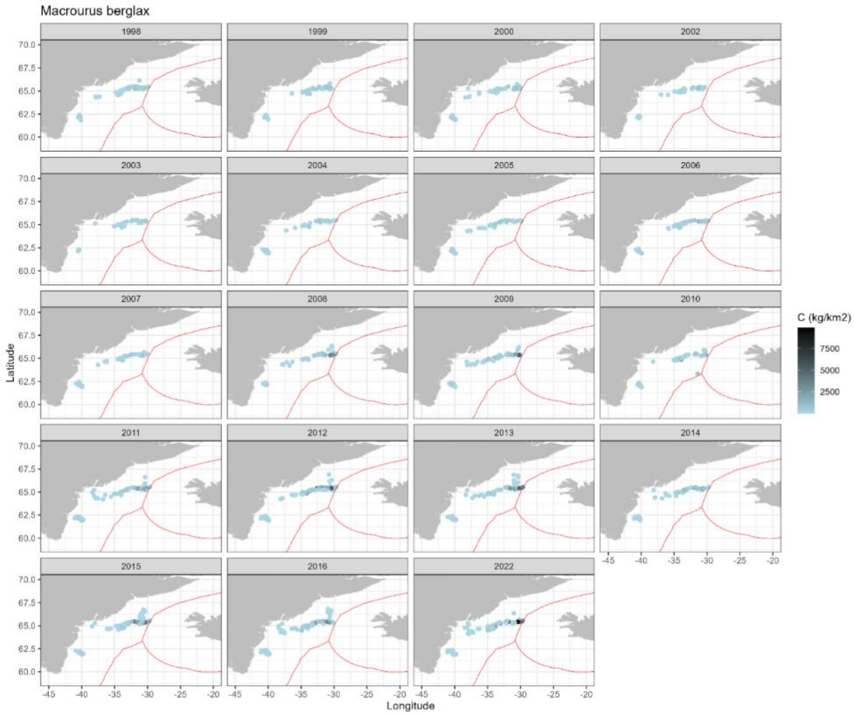


Fig. 4. Length frequency distribution per swept area of roughhead grenadier (RHG) for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

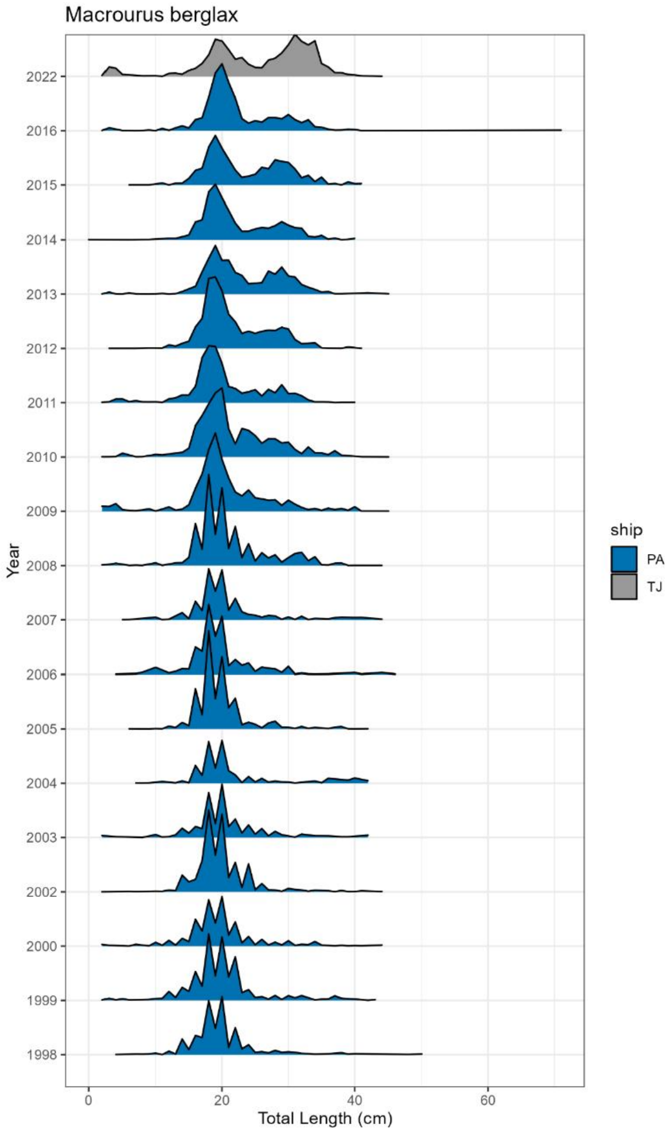


Figure 5.- Roundnose grenadier (RNG) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

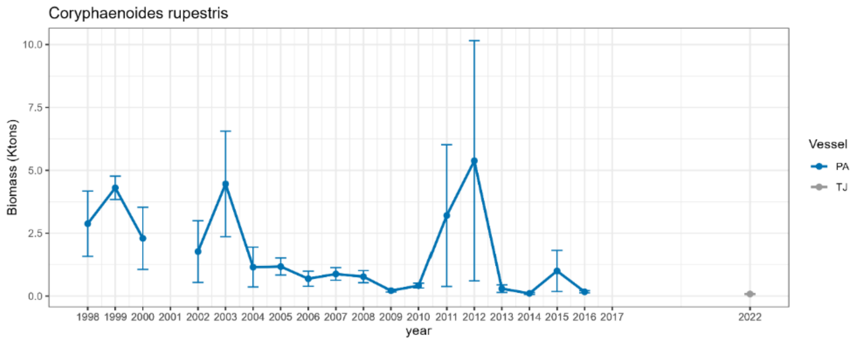


Figure 6.- Roundnose grenadier (RNG) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

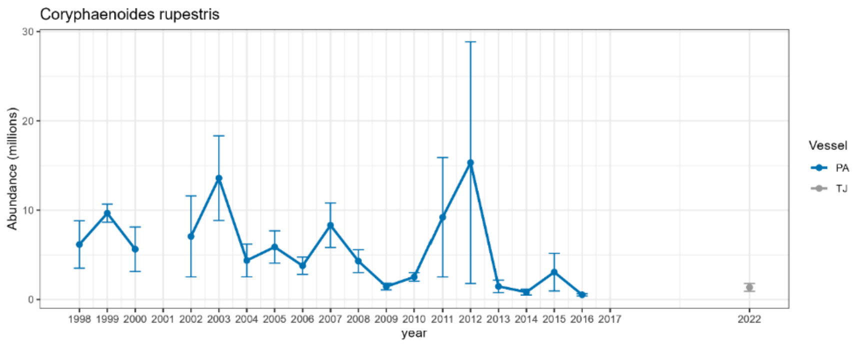


Figure 7. Distribution of survey catches of roundnose grenadier (RNG) off East Greenland (ICES 14.b) from 1998-2016 and 2022.

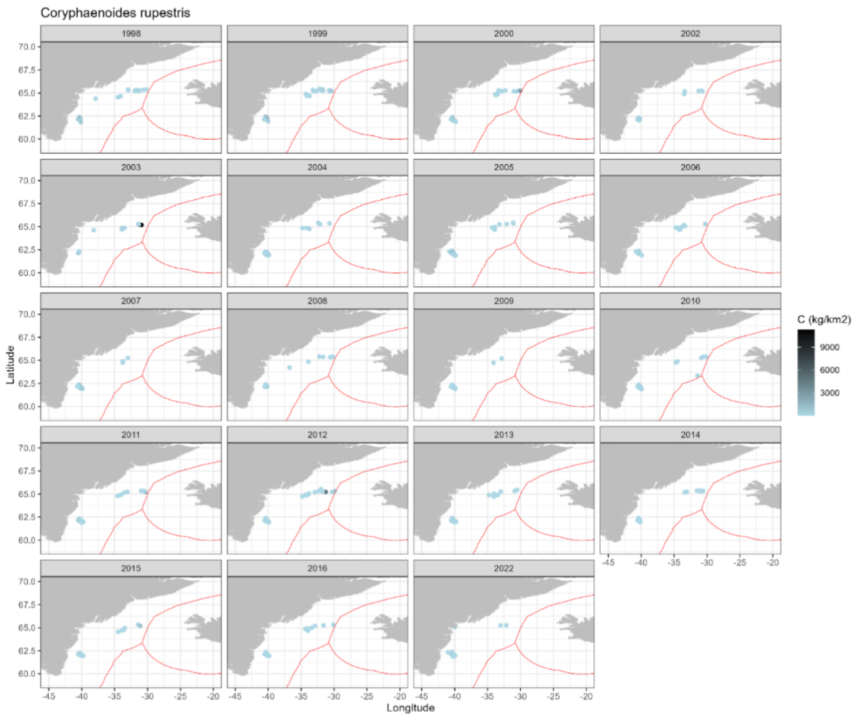


Fig. 8. Length frequency distribution per swept area of roundnose grenadier (RNG) for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

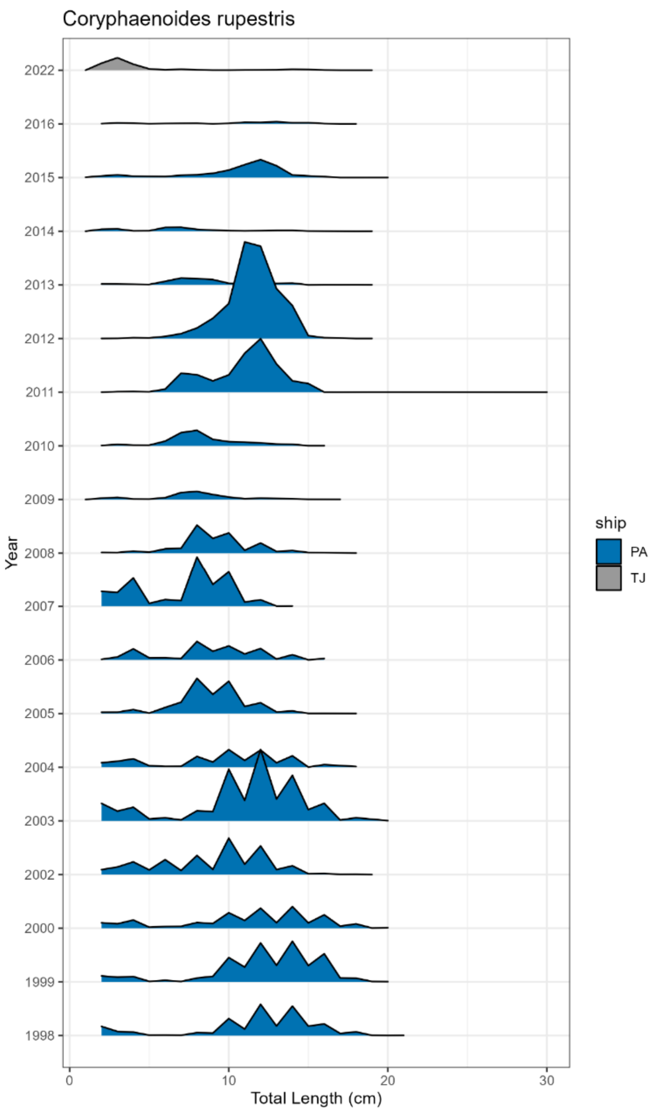


Figure 9. Greater argentine (ARU) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

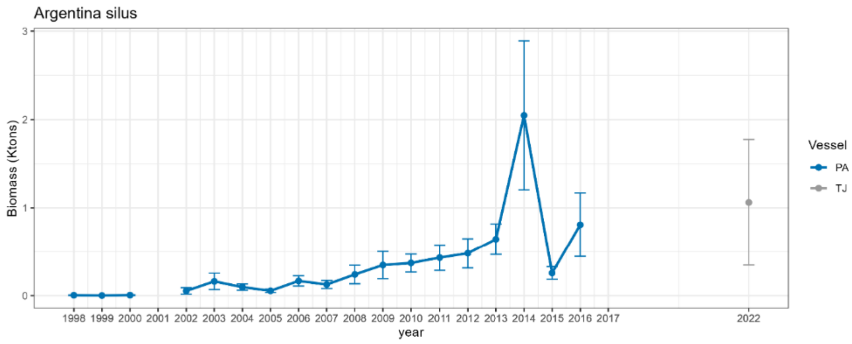


Figure 10. Greater argentine (ARU) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

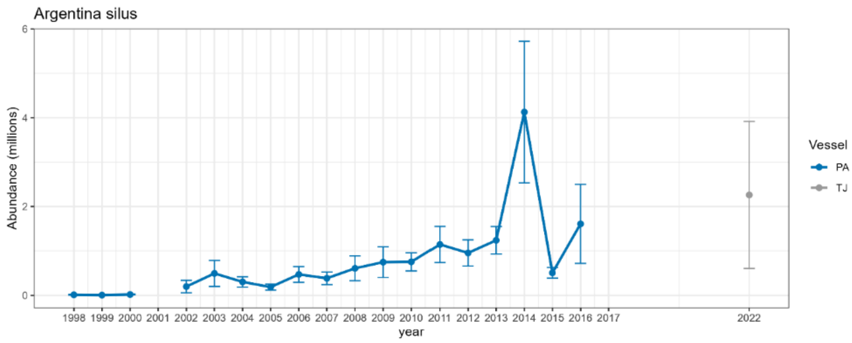


Figure 11. Distribution of survey catches of greater argentine (ARU) off East Greenland (ICES 14.b) from 1998-2016 and 2022.

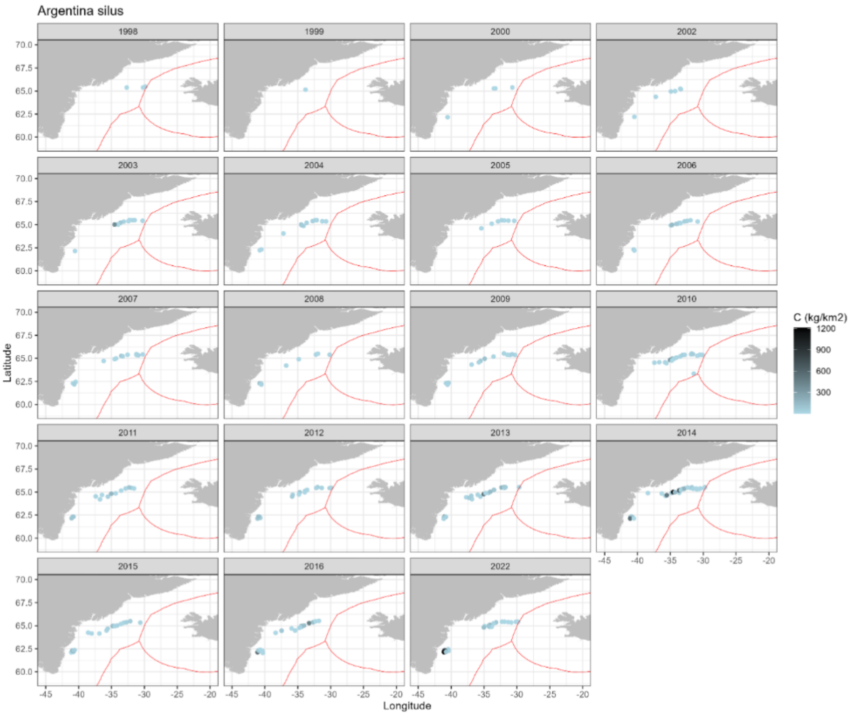


Fig. 12. Length frequency distribution per swept area of greater argentine (ARU) for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

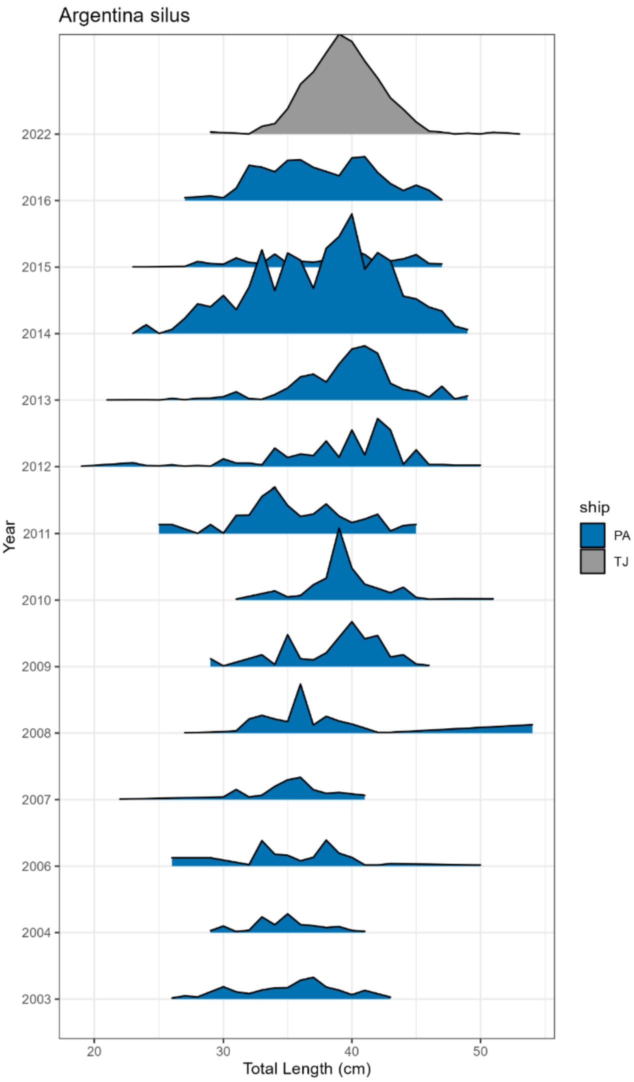


Figure 13. Tusk (USK) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

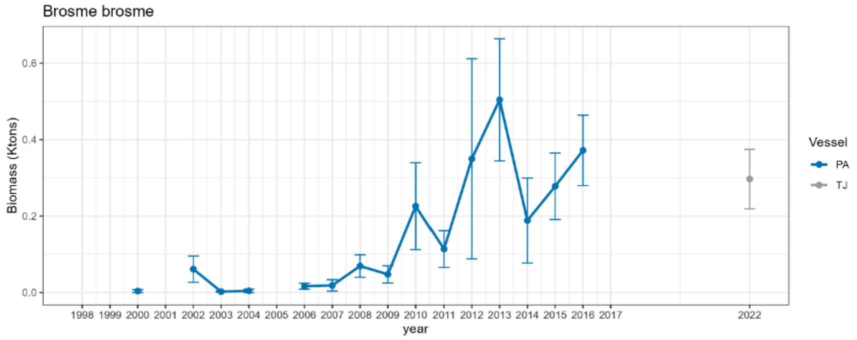


Figure 14. Tusk (USK) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

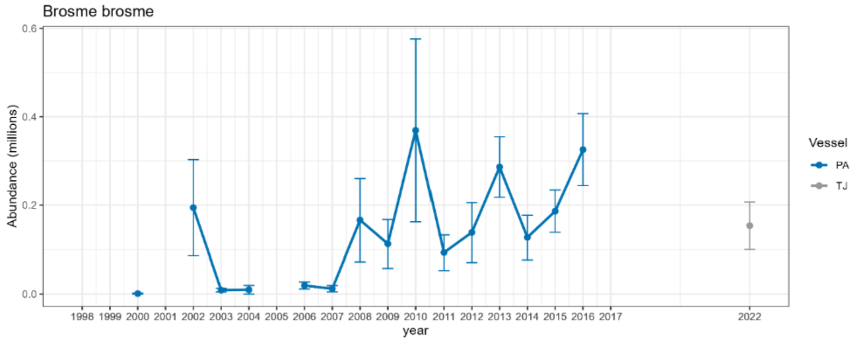


Figure 15. Distribution of survey catches of tusk (USK) off East Greenland (ICES 14.b) from 1998-2016 and 2022.

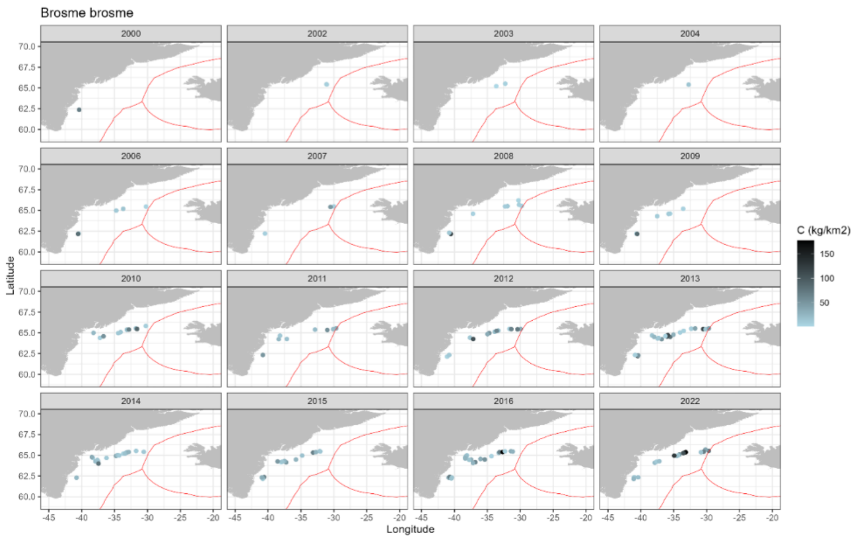


Fig. 16. Length frequency distribution per swept area of tusk (USK) for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq

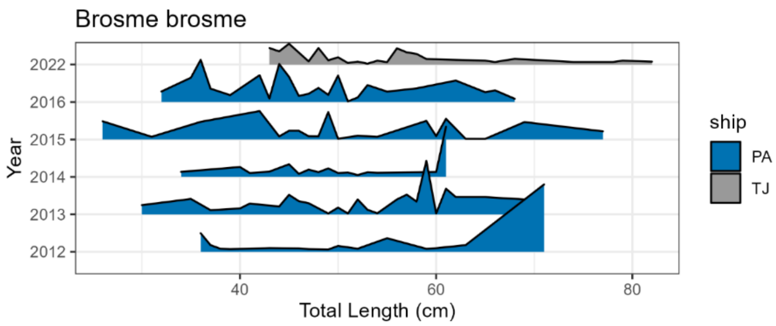


Figure 17. Blue ling (BLI) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

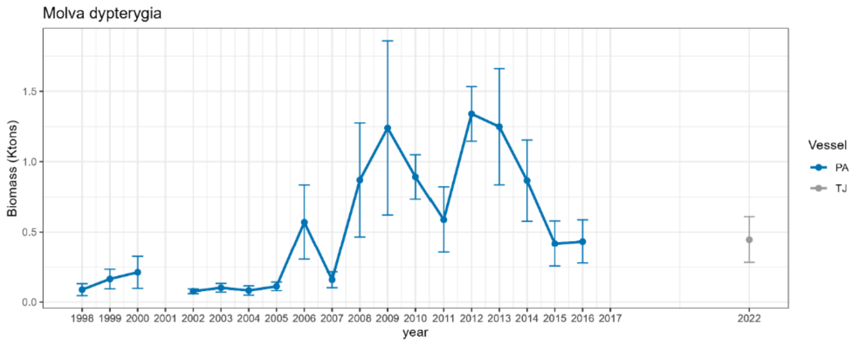


Figure 18. Blue ling (BLI) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

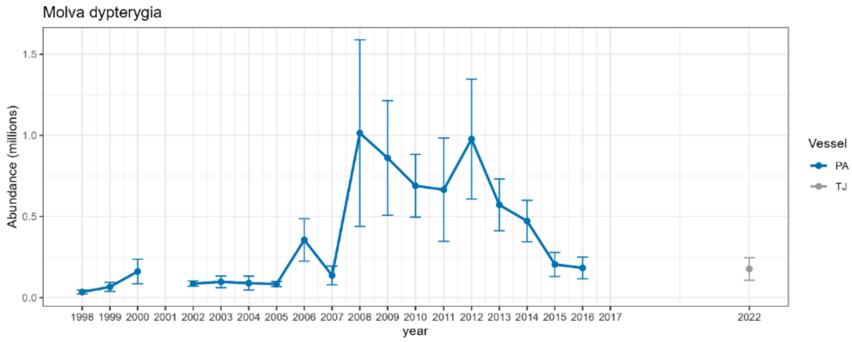


Figure 19. Distribution of survey catches of blue ling (BLI) off East Greenland (ICES 14.b) from 1998-2016 and 2022.

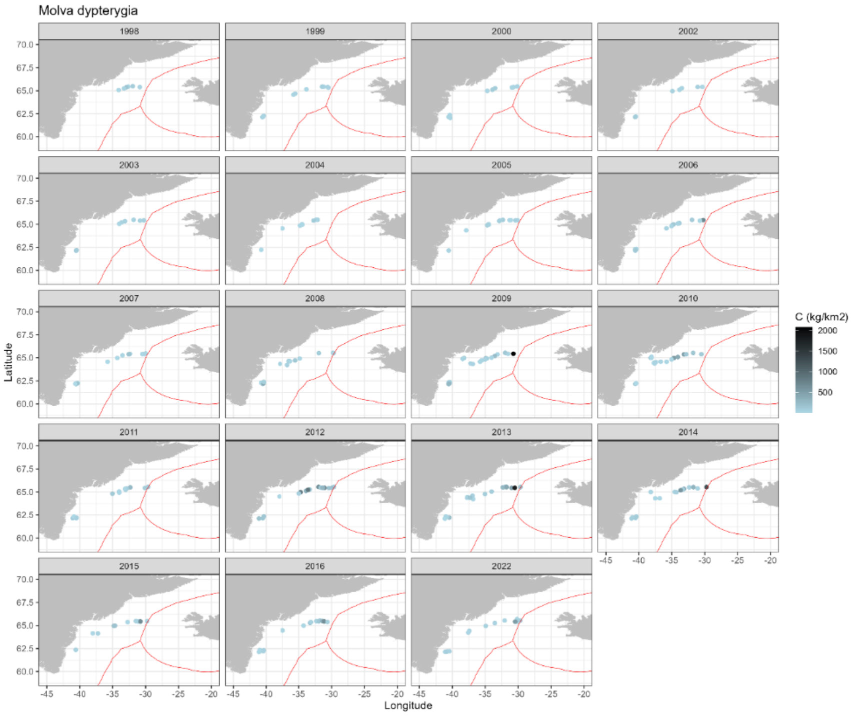


Fig. 20. Length frequency distribution per swept area of blue ling (BLI) for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq

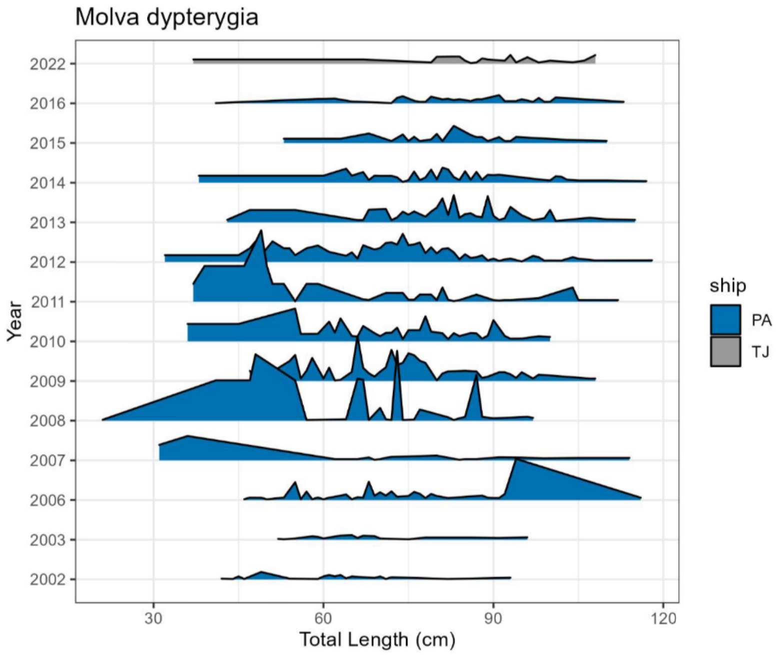


Figure 21.- Black scabbardfish (BSF) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

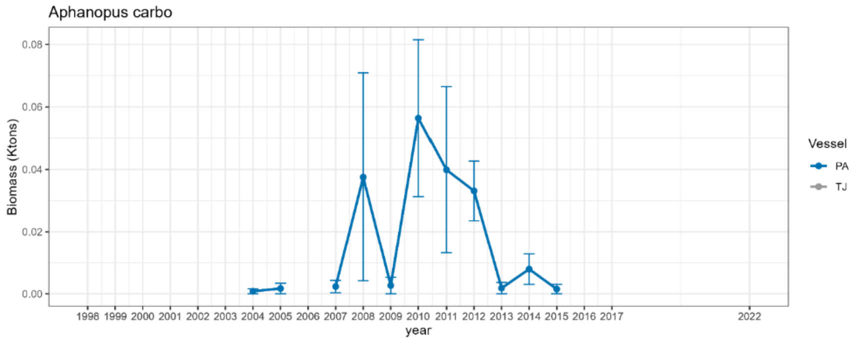


Figure 22.- Black scabbardfish(BSF) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

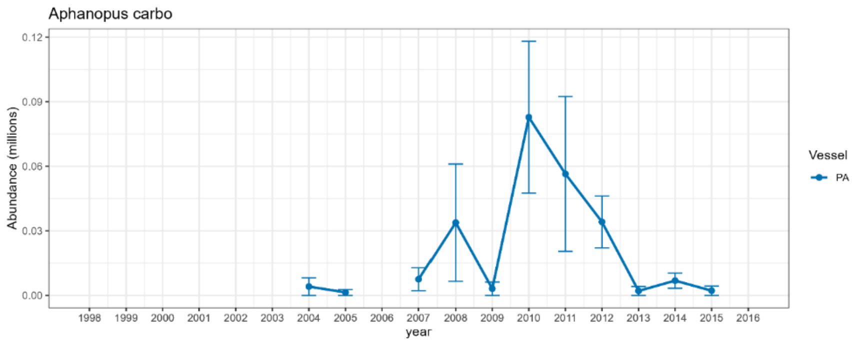


Figure 23. Distribution of survey catches of black scabbardfish (BSF) off East Greenland (ICES 14.b) from 1998-2016 and 2022.

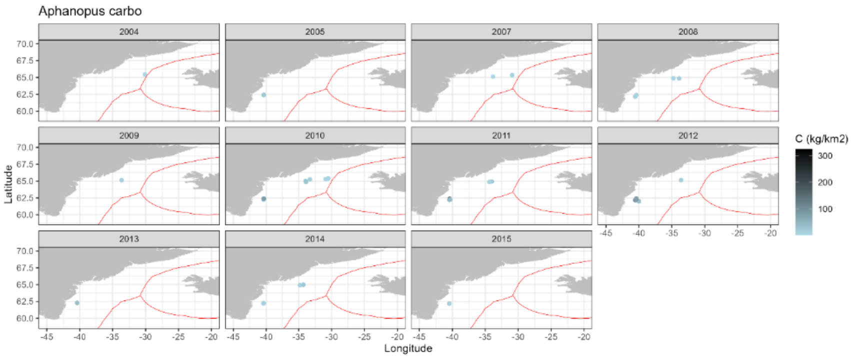


Figure 24.- Ling (LIN) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

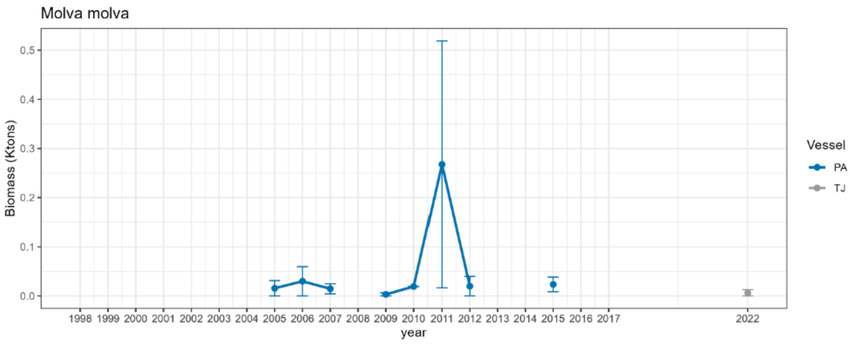


Figure 25.- Ling (LIN) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

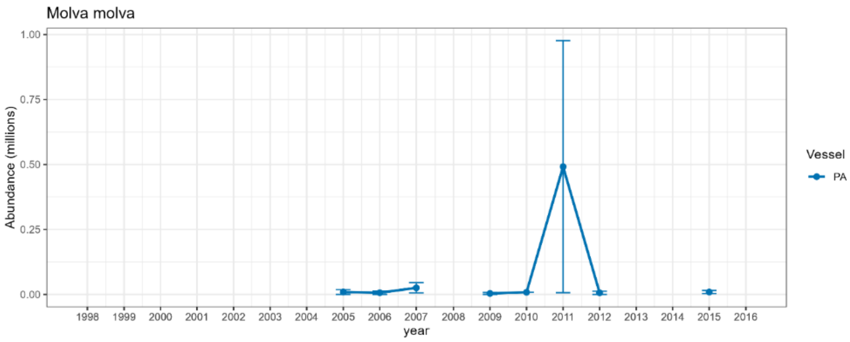


Figure 26. Distribution of survey catches of ling (LIN) off East Greenland (ICES 14.b) from 1998-2016 and 2022**.**

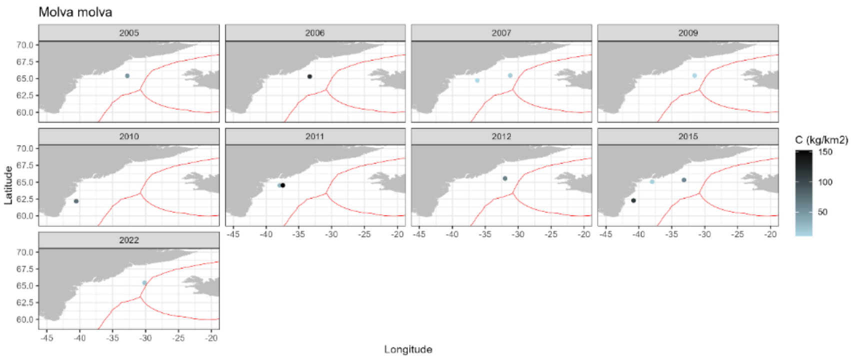


Figure 27.- Orange roughy (ORY) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

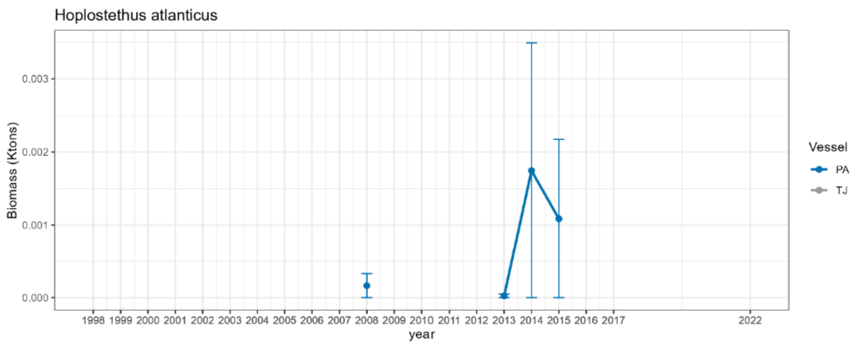


Figure 28.- Orange roughy (ORY) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

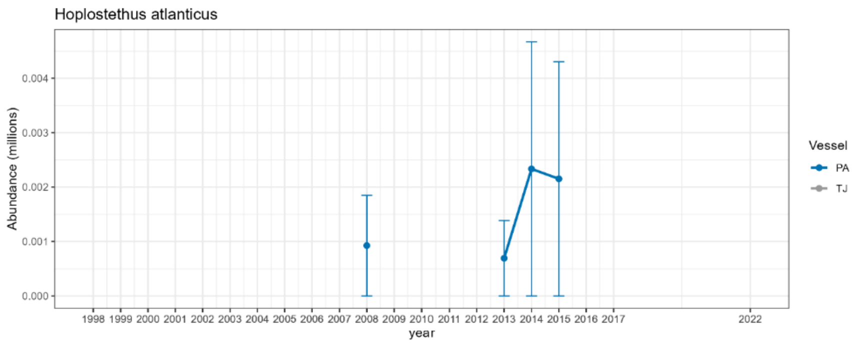
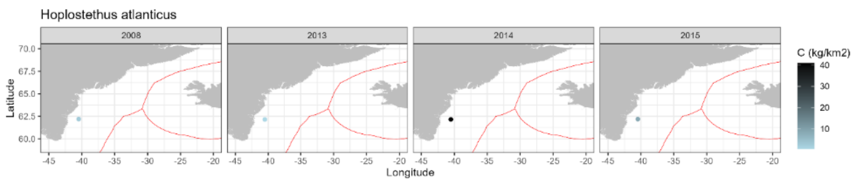


Figure 29. Distribution of survey catches of orange roughy (ORY) off East Greenland (ICES 14.b) in 1998-2016 and 2022.



Appendix 1. Catch weight and numbers (not standardized to kg/km2) of roughhead grenadier, roundnose grenadier, greater silver smelt and tusk by haul, in 2019. Depth in meters, swept area in km2 and bottom temperature in ºC.

						RHG		RNG		ARS		USK	
St. No	Swept Area	Subarea	Stratum	Depth	Bottom Temp.	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number
1	0.0773	Q2	0801-1000	826.5	5.3	20.3	12	0	0	0.3	1	0	0
2	0.0731	Q2	0601-0800	634.5	2.21	244.5	146	0	0	0	0	4.8	4
3	0.0894	Q1	0401-0600	412.5	0.93	4.4	3	0	0	0	0	3.5	3
4	0.092	Q1	0401-0600	458	0.81	0	0	0	0	0	0	0	0
5	0.0923	Q1	0401-0600	507	0.71	0	0	0	0	0	0	0	0
6	0.0832	Q1	0401-0600	498	0.88	0.4	1	0	0	0	0	0	0
7	0.0764	Q1	0401-0600	448.5	0.72	0	0	0	0	0	0	0	0
11	0.1389	Q2	0601-0800	677.5	3.48	736.3	344	0	0	1.5	4	0	0
12	0.0548	Q2	0601-0800	618	3.83	541.8	223	0	0	0	0	3.8	1
13	0.1065	Q2	0801-1000	833.5	3.26	57.2	30	0	0	0.4	1	1.7	1
14	0.0742	Q2	1001-1500	1378	2.41	1.8	14	0	0	0	0	0	0
15	0.1033	Q2	0801-1000	838	2.97	23.8	17	0	0	0.8	2	0	0
16	0.096	Q2	0801-1000	883.5	1.46	553.7	265.2	0	0	0.6	1	0	0
17	0.1121	Q2	0401-0600	523	3.61	12.8	16	0	0	0	0	0	0
20	0.0976	Q2	0801-1000	964	3.04	58	54	0	0	1.1	2	0	0
21	0.0865	Q2	1001-1500	1422	1.93	10.1	8	0.7	1	0	0	0	0
22	0.0615	Q2	1001-1500	1073.5	2.67	131.4	68	0.6	1	0	0	0	0
23	0.0681	Q2	0401-0600	449.5	4.01	27	28	0	0	6.1	10	11.7	3
24	0.0888	Q2	0401-0600	466.5	3.69	17.8	23	0	0	2.2	3	9.7	3
25	0.1079	Q2	0801-1000	861.5	4.65	1.3	2	0	0	0.4	1	0	0
26	0.1019	Q2	0401-0600	441.5	5.45	0.4	1	0	0	20	35	5.6	2
27	0.1003	Q2	1001-1500	1075	2.02	201.8	90	0	0	0.7	1	0	0
28	0.0968	Q2	1001-1500	1208	3.2	8.3	12	0	0	0	0	0	0
29	0.1035	Q2	0801-1000	958.5	2.23	66.9	40	0	0	0.5	1	0	0
30	0.0986	Q2	0601-0800	689	4.8	21.3	12	0	0	8.2	14	1.1	1
31	0.0891	Q2	0801-1000	881.5	3.85	9.2	8	0	0	0	0	1.9	1
32	0.1003	Q2	0401-0600	470	4.49	1.4	1	0	0	0.9	1	13	3
33	0.1013	Q2	0601-0800	739	4.82	6.2	3	0	0	12.9	20	0	0
34	0.1081	Q2	1001-1500	1417.5	2.74	3.4	2	0	0	0	0	0	0
36	0.1015	Q2	1001-1500	1262.5	3.05	47	61	0	0	0	0	0	0
42	0.085	Q3	0601-0800	644.5	3.46	0.8	3	0	0	0	0	0	0
43	0.0974	Q3	0601-0800	680.5	3.45	5.2	4	0	0	0	0	0	0
44	0.0934	Q3	0601-0800	692	3.73	1.8	2	0	0	0	0	0	0
46	0.0884	Q3	0801-1000	842.5	3.72	0.7	1	0	0	0	0	0	0
49	0.0873	Q3	0601-0800	634.5	3.66	1.8	3	0	0	0	0	0	0
50	0.0905	Q3	0601-0800	780.5	3.72	0.8	4	0	0	0	0	0	0
56	0.0961	Q3	0801-1000	866	3.65	2.3	4	0	0	0	0	0	0
57	0.0967	Q3	0401-0600	426.5	3.75	0	0	0	0	0	0	0	0
59	0.0944	Q3	0401-0600	573.5	3.66	4.1	4	0	0	0	0	0	0
61	0.0989	Q3	0801-1000	849	3.61	1.4	2	0	0	0	0	0	0
62	0.0885	Q3	0801-1000	891	3.65	2.1	3	0	0	0	0	0	0
63	0.0898	Q3	0801-1000	817	3.65	5.2	8	0	0	0	0	0	0
64	0.1001	Q3	0401-0600	492.5	3.75	1.5	2	0	0	0	0	0	0
65	0.097	Q3	0401-0600	444	3.81	1.1	2	0	0	0	0	2	1
66	0.0879	Q3	0401-0600	578	3.71	0	0	0	0	0	0	0.9	1
67	0.0989	Q3	0601-0800	663.5	3.67	0.6	1	0	0	0	0	0	0
68	0.0948	Q3	0401-0600	520	3.65	2.4	2	0	0	0	0	1.9	1
69	0.0805	Q3	0401-0600	414.5	3.71	0	0	0	0	0	0	0	0
70	0.11	Q3	0401-0600	432	3.74	0	0	0	0	0	0	0	0
71	0.1007	Q3	0401-0600	424.5	3.77	0	0	0	0	0	0	0	0
80	0.0797	Q5	0401-0600	420.5	4.53	0	0	0	0	0.8	1	0	0
81	0.0752	Q5	0801-1200	912	4.55	0.7	2	1	52	0.4	1	0	0
82	0.0732	Q5	0601-0800	700.5	4.85	0	0	3.7	7	3.1	7	1.4	1
83	0.0717	Q5	0801-1200	897.5	4.65	3.5	5	3.3	502.8	0.4	1	0	0
86	0.0936	Q5	0601-0800	633	5.01	0	0	0	0	14.6	26	0	0
88	0.085	Q5	0601-0800	668.5	5.15	0.2	1	0.5	1	61.6	118.4	1.4	1
89	0.0854	Q5	0601-0800	647.5	5.03	9.2	9	0	0	74.2	113	1.4	1
91	0.0802	Q5	0401-0600	426.5	4.99	9.9	8	0	0	97	224	2.1	1
93	0.0709	Q5	0401-0600	436.5	5.03	0	0	0	0	5.2	10	0	0
94	0.0799	Q5	0801-1200	876	4.84	0	0	1	197.2	0	0	0	0
95	0.0629	Q5	0801-1200	988.5	4.63	8.4	13	4.4	476.3	0	0	0	0
96	0.0928	Q5	1201-1400	1316.5	3.23	6.8	9	3.7	24	0	0	0	0
97	0.0949	Q5	1201-1400	1290	3.38	4.1	8	9.6	44	0	0	0	0
98	0.0847	Q5	1201-1400	1344.5	3.28	9.3	11	3.6	9	0	0	0	0
99	0.0701	Q5	1201-1400	1332.5	3.31	16.3	16	6	10	0	0	0	0
100	0.0973	Q5	1201-1400	1296.5	3.39	2.3	4	6.2	21	0	0	0	0
101	0.0922	Q5	1201-1400	1268.5	3.71	0	0	2	4	0	0	0	0
104	0.0968	Q5	1401-1500	1445	3.25	3.8	6	0.2	7	0	0	0	0
105	0.0761	Q5	1401-1500	1418	2.93	13.6	9	0.3	1	0	0	0	0
106	0.076	Q5	1401-1500	1434	3.03	3.9	7	0	0	0	0	0	0
107	0.0768	Q5	1401-1500	1426	2.98	9.2	12	0	0	0	0	0	0
108	0.0849	Q5	1401-1500	1442	3.26	12.4	13	1.3	4	0	0	0	0
109	0.0827	Q5	1201-1400	1229	3.35	2.9	6	1.1	4	0	0	0	0

Appendix 2. Catch weight and numbers (not standardized to kg/km2) of blue ling, black scabbardfish, ling, and orange roughy by haul, in 2019. Depth in meters, swept area in km2 and bottom temperature in ºC.

St. No	Swept Area	Subarea	Stratum	Depth	ɔttom Tem	BLI Weight (kg)	BLI Number	BSF Weight (kg)	BSF Number	LIN Weight (kg)	LIN Number	HAT Weight (kg)	HAT Number
1	0.0773	Q2	0801-1000	826.5	5.3	0	0	0	0	0	0	0	0
2	0.0731	Q2	0601-0800	634.5	2.21	8.5	2	0	0	0	0	0	0
3	0.0894	Q1	0401-0600	412.5	0.93	3.1	1	0	0	0	0	0	0
4	0.092	Q1	0401-0600	458	0.81	0	0	0	0	0	0	0	0
5	0.0923	Q1	0401-0600	507	0.71	0	0	0	0	0	0	0	0
6	0.0832	Q1	0401-0600	498	0.88	0	0	0	0	0	0	0	0
7	0.0764	Q1	0401-0600	448.5	0.72	0	0	0	0	0	0	0	0
11	0.1389	Q2	0601-0800	677.5	3.48	15.1	5	0	0	3	1	0	0
12	0.0548	Q2	0601-0800	618	3.83	28.7	10	0	0	0	0	0	0
13	0.1065	Q2	0801-1000	833.5	3.26	0	0	0	0	0	0	0	0
14	0.0742	Q2	1001-1500	1378	2.41	0	0	0	0	0	0	0	0
15	0.1033	Q2	0801-1000	838	2.97	0	0	0	0	0	0	0	0
16	0.096	Q2	0801-1000	883.5	1.46	0	0	0	0	0	0	0	0
17	0.1121	Q2	0401-0600	523	3.61	4	2	0	0	0	0	0	0
20	0.0976	Q2	0801-1000	964	3.04	0	0	0	0	0	0	0	0
21	0.0865	Q2	1001-1500	1422	1.93	0	0	0	0	0	0	0	0
22	0.0615	Q2	1001-1500	1073.5	2.67	0	0	0	0	0	0	0	0
23	0.0681	Q2	0401-0600	449.5	4.01	0	0	0	0	0	0	0	0
24	0.0888	Q2	0401-0600	466.5	3.69	5.4	1	0	0	0	0	0	0
25	0.1079	Q2	0801-1000	861.5	4.65	0	0	0	0	0	0	0	0
26	0.1019	Q2	0401-0600	441.5	5.45	0	0	0	0	0	0	0	0
27	0.1003	Q2	1001-1500	1075	2.02	0	0	0	0	0	0	0	0
28	0.0968	Q2	1001-1500	1208	3.2	0	0	0	0	0	0	0	0
29	0.1035	Q2	0801-1000	958.5	2.23	0	0	0	0	0	0	0	0
30	0.0986	Q2	0601-0800	689	4.8	0	0	0	0	0	0	0	0
31	0.0891	Q2	0801-1000	881.5	3.85	0	0	0	0	0	0	0	0
32	0.1003	Q2	0401-0600	470	4.49	5.9	1	0	0	0	0	0	0
33	0.1013	Q2	0601-0800	739	4.82	0	0	0	0	0	0	0	0
34	0.1081	Q2	1001-1500	1417.5	2.74	0	0	0	0	0	0	0	0
36	0.1015	Q2	1001-1500	1262.5	3.05	0	0	0	0	0	0	0	0
42	0.085	Q3	0601-0800	644.5	3.46	0	0	0	0	0	0	0	0
43	0.0974	Q3	0601-0800	680.5	3.45	0	0	0	0	0	0	0	0
44	0.0934	Q3	0601-0800	692	3.73	0	0	0	0	0	0	0	0
46	0.0884	Q3	0801-1000	842.5	3.72	0	0	0	0	0	0	0	0
49	0.0873	Q3	0601-0800	634.5	3.66	0	0	0	0	0	0	0	0
50	0.0905	Q3	0601-0800	780.5	3.72	0	0	0	0	0	0	0	0
56	0.0961	Q3	0801-1000	866	3.65	0	0	0	0	0	0	0	0
57	0.0967	Q3	0401-0600	426.5	3.75	0	0	0	0	0	0	0	0
59	0.0944	Q3	0401-0600	573.5	3.66	3.6	1	0	0	0	0	0	0
61	0.0989	Q3	0801-1000	849	3.61	0	0	0	0	0	0	0	0
62	0.0885	Q3	0801-1000	891	3.65	0	0	0	0	0	0	0	0
63	0.0898	Q3	0801-1000	817	3.65	0	0	0	0	0	0	0	0
64	0.1001	Q3	0401-0600	492.5	3.75	0	0	0	0	0	0	0	0
65	0.097	Q3	0401-0600	444	3.81	0	0	0	0	0	0	0	0
66	0.0879	Q3	0401-0600	578	3.71	2.3	1	0	0	0	0	0	0
67	0.0989	Q3	0601-0800	663.5	3.67	0	0	0	0	0	0	0	0
68	0.0948	Q3	0401-0600	520	3.65	0	0	0	0	0	0	0	0
69	0.0805	Q3	0401-0600	414.5	3.71	0	0	0	0	0	0	0	0
70	0.11	Q3	0401-0600	432	3.74	0	0	0	0	0	0	0	0
71	0.1007	Q3	0401-0600	424.5	3.77	0	0	0	0	0	0	0	0
80	0.0797	Q5	0401-0600	420.5	4.53	0	0	0	0	0	0	0	0
81	0.0752	Q5	0801-1200	912	4.55	0	0	0	0	0	0	0	0
82	0.0732	Q5	0601-0800	700.5	4.85	0	0	0	0	0	0	0	0
83	0.0717	Q5	0801-1200	897.5	4.65	0	0	0	0	0	0	0	0
86	0.0936	Q5	0601-0800	633	5.01	0	0	0	0	0	0	0	0
88	0.085	Q5	0601-0800	668.5	5.15	0	0	0	0	0	0	0	0
89	0.0854	Q5	0601-0800	647.5	5.03	0	0	0	0	0	0	0	0
91	0.0802	Q5	0401-0600	426.5	4.99	2.5	6	0	0	0	0	0	0
93	0.0709	Q5	0401-0600	436.5	5.03	5.3	1	0	0	0	0	0	0
94	0.0799	Q5	0801-1200	876	4.84	0	0	0	0	0	0	0	0
95	0.0629	Q5	0801-1200	988.5	4.63	2.6	1	0	0	0	0	0	0
96	0.0928	Q5	1201-1400	1316.5	3.23	0	0	0	0	0	0	0	0
97	0.0949	Q5	1201-1400	1290	3.38	0	0	0	0	0	0	0	0
98	0.0847	Q5	1201-1400	1344.5	3.28	0	0	0	0	0	0	0	0
99	0.0701	Q5	1201-1400	1332.5	3.31	0	0	0	0	0	0	0	0
100	0.0973	Q5	1201-1400	1296.5	3.39	0	0	0	0	0	0	0	0
101	0.0922	Q5	1201-1400	1268.5	3.71	0	0	0	0	0	0	0	0
104	0.0968	Q5	1401-1500	1445	3.25	0	0	0	0	0	0	0	0
105	0.0761	Q5	1401-1500	1418	2.93	0	0	0	0	0	0	0	0
106	0.076	Q5	1401-1500	1434	3.03	0	0	0	0	0	0	0	0
107	0.0768	Q5	1401-1500	1426	2.98	0	0	0	0	0	0	0	0
108	0.0849	Q5	1401-1500	1442	3.26	0	0	0	0	0	0	0	0
109	0.0827	Q5	1201-1400	1229	3.35	0	0	0	0	0	0	0	0

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Commercial catches of roughhead grenadier, roundnose grenadier, greater argentine, tusk, blue ling, black scabbardfish, ling, and orange roughy in ICES 14 in the period 1999-2022.

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Abstract

Yearly and monthly logbook information, and CPUE distribution from 1999 to 2022 for roughhead grenadier (*Macrourus berglax*; RHG), roundnose grenadier (*Coryphaenoides rupestris*; RNG), greater argentine (*Argentina silus*; ARU), tusk (*Brosme brosme*; USK), blue ling (*Molva dypterygia*; BLI), black scabbardfish (*Aphanopus carbo*; BSF), ling (*Molva molva*; LIN), and orange roughy (*Hoplostethus atlanticus*; ORY), in East Greenland, ICES 14, are presented in this document. Also catches by gear and by division (14a and 14b). Data presented are a mix of targeted catches and bycatch of the Greenland halibut fishery in East Greenland in 14b.

1. Introduction

Commercial trawl and longline fisheries operate in ICES Division 14.b off East Greenland. This document presents information recorded in logbooks of these fisheries in the time period from 1999 to 2022. The species presented here are roughhead grenadier (*Macrourus berglax*; RHG), roundnose grenadier (*Coryphaenoides rupestris*; RNG), greater argentine (*Argentina silus*; ARU), tusk (*Brosme brosme*; USK), blue ling (*Molva dypterygia*; BLI), black scabbardfish (*Aphanopus carbo*; BSF), ling (*Molva molva*; LIN), and orange roughy (*Hoplostethus atlanticus*; ORY). The numbers presented in previous working documents have been updated.

Catch quotas have been set for the following of these species: grenadiers (RNG and RHG combined), tusk, blue ling, and greater argentine. The total allowable catch (TAC) for grenadiers was 3 000 tonnes (t) in 2007, 2 000 t in 2008-2009, and 1 000 tons in 2010-2022. For tusk the TAC was 500 t in 2014 and 1 500 t from 2015-2022. For blue ling the TAC was 500 t in 2014 and no quota has been set since. For greater Argentine the TAC was 10 000 t in 2013-2015 and no quota has been set since. The TAC is set by the Government of Greenland.

2. Materials and Methods

Logbooks have been mandatory for vessels greater than 30 ft (9.4 m) since 2008. Data about all logbooks records are reported to the Greenland Fishery License Authority (GFLK). Trawlers and longliners gather information about their fishery, including effort and location for individual fishing events, and send the data to GFLK on a weekly basis. Data presented here is a mix of targeted catches (greater Argentine fishery from 2015 and 2018 abd tusk fishery from 2014) and bycatch during the fishery for Greenland halibut in ICES Division 14.b (from 1999). From 2005 (except 2006) small catches for grenadiers come from 14a due to the expansion of the Greenland halibut fishery to a norther fishing ground between 67°N and 68°30'N.

3. Results and discussion

Roughhead grenadier (*Macrourus berglax*; RHG)

Only 0.01 t, in 2000, of grenadier were caught between 1999 and 2004. From 2005 to 2013 catches remained very low (mean catches 2005-2013 = 7.8 t), whereas it increased to an average of 71.2 tons between 2014 and 2018. In 2019, catches dropped to only 1 t. Catches have been increasing from 2020 (23.17 t) to 2022 reaching the highest catches since 1999 (85.23t) (Table 1 , 2 and 4, Fig. 1 and 2). From 2014 reported catches of roughhead grenadier on long lines are much higher, which might be linked to the onset of targeted long line fishery after tusk in 2014 (Table 3). There are no explanations for the drastic drop to only 1.0 tons in 2019, which has been reported by only a single vessel. Possibly, this is due to misidentification. Most of the catches are from 14b, a few catches were found years 2013, 2016-2017 and 2021 in 14a, due to the expansion of the Greenland halibut fishery to a northern fishing ground (Table 2, Fig.2 and 3).
From the surveys documents (Nielsen et al., 2019, Nogueira and Christiansen, 2023), it was established that roughhead grenadier is much more common than roundnose grenadier in ICES 14b. Therefore, it is likely that there is misidentification of grenadier species confounding the logbook data of roundnose grenadier and roughhead grenadier. Regardless of this, the TAC of 1.000 tons for grenadiers in East Greenland (roughhead and roundnose combined) is not reached any years.

Roundnose grenadier (*Coryphaenoides rupestris*; RNG)

Catches of roundnose grenadier have been relatively stable (annual mean catch=91.4 tons) throughout the evaluated time period (1999 to 2022) ranging from 30.6 tons (2008) to 167.4 tons (2021) (Table 1 and 5, Fig.1). Most of the catches are also from 14b, a few catches are found from 2005 in 14a, due to the expansion of the Greenland halibut fishery, this year, to a northern fishing ground (Table 2, Fig.4 and 5).The majority of this is caught as bycatch by trawlers, whereas longlines conduct a smaller fraction most of the years, only years 2019 and 2021 catches with lonliners are higher than with trawlers (Table3).
As mentioned for roughhead grenadier, the catch of roudnose grenadier is possibly overestimated due to incorrect species identification.

Greater argentine (*Argentina silus*; ARU)

From 1990 to 2013, there are only reported catches in 2002 (0.4 t). From 2014 to 2022 catches have been very low except years 2017 and 2018 (666.6 t and 425.1 t), which is due to the onset of targeted pelagic trawl fishery for the species since 2015. This targeted fishery ceased in 2019 thus low catches, since then are reported (Table 1, 3 and 6, Fig. 1 and 6).

Tusk (*Brosme brosme*; USK)

Catches of tusk have been low between 1999 to 2013 were much lower (mean annual catch=30.1 tons) compared to catches from 2015 to 2022 (mean annual catch =527.34 tons) (Table 1, 3 and 7, Fig. 1 and 7). The catch is dominated by long lines throughout the time series (Table 3). The increase in catches corresponds with the initiation of targeted fishery in 2014 where TAC was 500 tons, which was increased by the Greenland government to 1500 tons, from 2015 to 2022.

Blue ling (*Molva dypterygia*; BLI)

Catches of blue ling have been low from 1999 to 2009 (annual mean catch =3.2 tons), increasing since then, and picking in 2015 (65.4 t). Catches increased from 2010 (annual mean catch =22.6 tons, Table 1,3 and 8 Fig. 1 and 8). Blue ling was mostly caught in trawl fisheries and the composition between longline and trawl catches remains relatively constant except in 2015, where the largest trawl catch of 65.5 tons was reported (Table 3).

Black scabbardfish (*Aphanopus carbo*; BSF)

Black scabbardfish was only caught in 2010 (30kg) and 2011 (180 kg) in the month of September (Table 1 and 7, Figure 1 and 9).

Ling (*Molva molva*; LIN)

Catches of ling were fluctuating between years with no apparent trend over time (Fig. 7). In 2005, 2006, 2015 and 2016 catches were above 15 tons, whereas catches were below 5 tons in 2000-2003, 2007, 2009-2013 and 2017-2022 (Table 1 , 3 and 10 Fig. 1 and 10). The majority of catches are from trawler, expect in 2015 (Table 3).

Orange roughy (*Hoplostethus antlanticus*; ORY)

Orange roughy was caught only in 2007 and 2010 (0.4 and 0.8 t respectively, Table 1 and 11, Figure 1 and 11).

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Table 1. Total annual commercial catches (tons) of roughhead grenadier (*Macrourus berglax*; RHG), roundnose grenadier (*Coryphaenoides rupestris*; RNG), greater Argentine (*Argentina silus*; ARU), tusk (*Brosme brosme),* blue ling (*Molva dypterygia*; BLI),; USK), black scabbardfish (*Aphanopus carbo*; BSF), ling (*Molva molva*; LIN), and orange roughy (*Hoplostethus atlanticus*; ORY), in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	RHG	RNG	ARU	USK	BLI	BSF	LIN	ORY
1999	0	129.4	0	5.2	0.1	0	8	0
2000	0.01	95.1	0	0	1.4	0	0	0
2001	0	84.5	0	23.3	0.6	0	0.7	0
2002	0	54.7	0.45	0	0.2	0	0.3	0
2003	0	54.2	0	2.2	2.6	0	0.2	0
2004	0	101.4	0	17	7	0	7.1	0
2005	20	61.4	0	39.3	5.6	0	17.7	0
2006	4.4	64.4	0	102.2	5.9	0	18.6	0
2007	3.8	43	0	18.7	1.3	0	1.5	0.4
2008	11.4	30.6	0	20.7	4.8	0	11	0
2009	3.5	44.2	0	15.9	5.4	0	4.6	0
2010	11.4	59.8	0	15.1	7.4	0.03	3.1	0.8
2011	2.2	136.4	0	91.1	8	0.2	4.8	0
2012	13.4	123.3	0	74.6	13	0	5.1	0
2013	0.3	128	0	27.6	15.7	0	2.4	0
2014	61.6	99.7	4.16	167.3	13.9	0	8	0
2015	38.2	139.7	12.21	878.8	65.4	0	20.4	0
2016	75.1	63.5	16.62	562.4	8.6	0	15.2	0
2017	92.8	93.1	666.75	763.2	11.9	0	4.5	0
2018	89.1	128.6	425.19	684.5	33.6	0	4.6	0
2019	0.9	157.1	3.37	386.6	45.4	0	1.9	0
2020	23.2	46.9	28.1	216	26.8	0	1.5	0
2021	55.5	167.4	15.39	720.1	17	0	1.4	0
2022	86.2	134	0.82	367.2	27.3	0	0.7	0

Table 2. Total annual commercial catches (tons) of roughhead grenadier (*Macrourus berglax*; RHG), roundnose grenadier (*Coryphaenoides rupestris*; RNG), greater Argentine (*Argentina silus*; ARU), tusk (*Brosme brosme),* blue ling (*Molva dypterygia*; BLI),; USK), black scabbardfish (*Aphanopus carbo*; BSF), ling (*Molva molva*; LIN), and orange roughy (*Hoplostethus atlanticus*; ORY), in the Greenlandic EEZ zone of ICES in Division 14a and 14b from 1999 to 2022.

	RHG		RNG		ARU	USK		BLI		BSF		LIN	ORY	
Year	14a	14b	14a	14b	14b	14a	14b	14a	14b	14a	14b	14b	14a	14b
1999	0	0	0	129.41	0	0	5.19	0	0.15	0	0	8.05	0	0
2000	0	0.01	0	95.14	0	0	0	0	1.4	0	0	0	0	0
2001	0	0	0	84.52	0	0	23.34	0	0.56	0	0	0.73	0	0
2002	0	0	0	54.73	0.45	0	0	0	0.24	0	0	0.34	0	0
2003	0	0	0	54.24	0	0	2.19	0	2.62	0	0	0.2	0	0
2004	0	0	0	101.45	0	0	16.95	0	7.05	0	0	7.1	0	0
2005	0	19.99	0.18	61.22	0	0	39.32	0	5.64	0	0	17.69	0	0
2006	0	4.37	0	64.42	0	0	102.19	0	5.92	0	0	18.62	0	0
2007	0	3.85	0.01	43.01	0	0	18.66	0	1.27	0	0	1.53	0	0.4
2008	0	11.41	0	30.59	0	0	20.71	0	4.83	0	0	11.05	0	0
2009	0	3.48	0.09	44.07	0	0	15.93	0	5.38	0	0	4.64	0	0
2010	0	11.38	0.04	59.76	0	0	15.1	0	7.45	0	0.03	3.14	0	0.82
2011	0	2.21	0.18	136.25	0	0	91.11	0	7.95	0	0.18	4.79	0	0
2012	0	13.41	0.51	122.82	0	0	74.6	0	13.02	0	0	5.1	0	0
2013	0.01	0.26	0.09	127.94	0	0	27.63	0	15.7	0	0	2.36	0	0
2014	0	61.61	0.9	98.81	4.16	0	167.33	0	13.86	0	0	7.97	0	0
2015	0	38.19	0	139.69	12.21	0	878.76	0	65.42	0	0	20.45	0	0
2016	0.58	74.53	0	63.5	16.62	0	562.4	0	8.63	0	0	15.19	0	0
2017	0.04	92.77	0.44	92.65	666.75	0	763.16	0	11.94	0	0	4.48	0	0
2018	0	89.11	1.7	126.92	425.19	0	684.53	0.03	33.55	0	0	4.58	0	0
2019	0	0.94	0.16	156.93	3.37	0	386.65	0	45.41	0	0	1.89	0	0
2020	0	23.17	0.49	46.45	28.1	0	215.99	0	26.76	0	0	1.53	0	0
2021	1.96	53.54	1.39	166.04	15.39	0	720.1	0	17.04	0	0	1.42	0	0
2022	1	85.25	22.7	111.28	0.82	0	367.24	0	27.29	0	0	0.71	0	0

Table 3. Total annual commercial catches (tons) by gear of roughhead grenadier (*Macrourus berglax*; RHG), roundnose grenadier (*Coryphaenoides rupestris*; RNG), greater Argentine (*Argentina silus*; ARU), tusk (*Brosme brosme),* blue ling (*Molva dypterygia*; BLI),; USK), black scabbardfish (*Aphanopus carbo*; BSF), ling (*Molva molva*; LIN), and orange roughy (*Hoplostethus atlanticus*; ORY), in the Greenlandic EEZ zone of ICES (Divisions 14a and 14b) from 1999 to 2022.

	RHG			RNG			ARY	USK				BLI				BSF	LIN			ORY
Year	BTM	LL	GN	BTM	LL	Other	BTM	BTM	GN	LL	Other	BTM	GN	LL	Other	BTM	BTM	LL	Other	BTM
1999	0	0	0	129.37	0.04	0	0	1.02	0	4.17	0	0	0	0.15	0	0	8.05	0	0	0
2000	0.01	0	0	78.04	17.1	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0
2001	0	0	0	71.96	12.56	0	0	23.34	0	0	0	0.56	0	0	0	0	0.73	0	0	0
2002	0	0	0	52.01	0	2.72	0.45	0	0	0	0	0.24	0	0	0	0	0.34	0	0	0
2003	0	0	0	54.24	0	0	0	2.19	0	0	0	2.62	0	0	0	0	0.2	0	0	0
2004	0	0	0	101.45	0	0	0	16.95	0	0	0	7.05	0	0	0	0	7.1	0	0	0
2005	19.99	0	0	61.4	0	0	0	39.12	0	0	0.2	5.64	0	0	0	0	17.69	0	0	0
2006	4.37	0	0	64.42	0	0	0	100.3	0	1.89	0	5.92	0	0	0	0	18.62	0	0	0
2007	3.85	0	0	42.37	0.65	0	0	11.39	0	7.27	0	0.27	0	1.01	0	0	1.53	0	0	0.4
2008	11.41	0	0	28.91	1.69	0	0	12.74	0	7.97	0	3.64	0	1.19	0	0	10.91	0.14	0	0
2009	3.48	0	0	37.03	0	7.13	0	0	0	0.04	15.89	3.91	0	0	1.48	0	3.41	0	1.22	0
2010	11.38	0	0	53.5	6.31	0	0	0	0	13.94	1.17	2.29	0	5.16	0	0.03	3.14	0	0	0.82
2011	2.21	0	0	130.91	5.52	0	0	0.03	0	91.07	0	5.73	0	2.22	0	0.18	2.98	1.81	0	0
2012	13.34	0.06	0	115.68	7.65	0	0	0	0	59.51	15.09	4.92	0	7.83	0.27	0	4.46	0.64	0	0
2013	0.26	0.01	0	125.89	2.13	0	0	0.46	0	14.37	12.81	15.7	0	0	0	0	0.02	1.86	0.47	0
2014	16.03	21.18	24.4	94.04	5.67	0	4.16	0.04	4.13	163.17	0	8.76	0.74	4.36	0	0	5.39	2.58	0	0
2015	3.48	34.71	0	104.9	34.79	0	12.21	0.57	0	876.76	1.43	64.84	0	0.58	0	0	2.57	17.87	0	0
2016	4.72	70.39	0	55.12	8.38	0	16.62	2.45	0	559.94	0	7.13	0	1.51	0	0	2.09	13.1	0	0
2017	0.41	92.4	0	87.82	5.27	0	666.75	1	0	762.17	0	6.98	0	4.95	0	0	1.02	3.46	0	0
2018	0.6	88.51	0	123.06	5.56	0	425.19	101.44	0	583.09	0	31.9	0	1.68	0	0	4.05	0.52	0	0
2019	0.94	0	0	61.92	95.17	0	3.37	2.25	0	384.4	0	26.79	0	18.62	0	0	1.71	0.17	0	0
2020	8.59	14.57	0	43.42	3.51	0	28.1	2.84	0	213.15	0	24.89	0	1.87	0	0	1.3	0.23	0	0
2021	10.88	44.62	0	54.97	112.46	0	15.39	4.03	0	716.08	0	10.71	0	6.33	0	0	0.88	0.54	0	0
2022	16.96	69.29	0	81.98	51.99	0	0.82	1.47	0	365.77	0	21.73	0	5.56	0	0	0.71	0	0	0

Table 4. Total monthly commercial catches (tons) of roughhead grenadier (RHG) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0.01	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	3.97	10.14	0.22	5.66	0	0	0
2006	0	0	0	0	1.3	1.76	0.21	1.1	0	0	0	0
2007	0	0	0	0	1.69	1.53	0.58	0	0.05	0	0	0
2008	0	0	0	0.39	1.9	1.53	2.71	2.68	1.42	0.77	0	0
2009	0	0	0.13	0.69	1.42	0.37	0	0.05	0.69	0	0.14	0
2010	0	0	0	0	2.16	1	4.05	1.2	0.13	2.82	0	0
2011	0	0	0	0	0	0	0.86	1.35	0	0	0	0
2012	0	0	0	9.05	4.19	0.17	0	0	0	0	0	0
2013	0	0	0	0	0	0.01	0.26	0	0	0	0	0
2014	0	0	0	21.36	28.94	0.34	7.18	0.19	0	0	0	3.61
2015	0	0	17.07	17.65	0	0	0	0	3.48	0	0	0
2016	0.8	25.33	30.85	13.41	0	2.45	1.86	0.4	0	0	0	0
2017	0	0	51.1	41.3	0	0	0	0	0	0.41	0	0
2018	0	0	50.48	37.1	1.53	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0.33	0.62	0	0
2020	0	0.87	0.83	0.54	0.91	2.65	13.59	2.54	0.54	0.62	0.08	0
2021	0	0	0	0.04	3.9	12.55	27.24	8	0.88	1.03	1.32	0.54
2022	0	0.2	15.07	14.1	1.17	0.21	0.58	5.86	8.79	39.62	0.66	0
Total	0.8	26.4	165.53	155.63	49.11	28.54	69.27	23.59	21.97	45.89	2.2	4.15

Table 5. Total monthly commercial catches (tons) of roundnose grenadier (RNG) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	12.78	23.72	20.2	23.52	0.15	5	4.42	4.75	7.04	14.47	11.53	1.83
2000	0.2	21.28	13.37	9.63	5.66	11.76	8.06	10.77	8.27	1.06	3.78	1.29
2001	0	0.01	1.8	0.68	2.71	17.96	26.91	23.9	3.4	2.43	2.37	2.35
2002	0.04	0	2.26	5	3.59	16.32	18.52	4.7	0.94	0.34	2.29	0.73
2003	0	0	1.06	3.25	11.09	10.74	9.78	7.21	4.45	4.68	1.72	0.25
2004	0	0	0.05	7.45	6.31	19.24	31.03	20.36	7.6	3.84	3.31	2.25
2005	0	0	0.04	1.48	2.63	16.29	27.05	10.1	3.06	0.92	0	0.06
2006	0	0.02	0.06	3.51	14.62	8.5	6.52	25.41	2.85	0.38	2.15	0.4
2007	0	0.06	0.26	3.77	12.82	9.06	8.16	4.63	1.59	1.23	0.98	0.45
2008	1.51	0.05	0.2	5.55	6.61	6.32	3.33	3.68	1.43	1.6	0.31	0
2009	0	0	0.86	3.48	9.3	8.48	9.61	4.73	3.55	1.97	1.83	0.35
2010	0	0	0.46	7.43	12.05	8.88	10.28	9.35	6.99	1.35	2.99	0.03
2011	0	0	2.55	7.34	18.88	42	36.48	15.84	5.48	3.8	3.02	1.03
2012	0	0	2.19	9.19	35.59	29.27	19.62	19.94	4.02	3.22	0.26	0
2013	0	0	3.02	15.42	27.68	38.25	21.04	12.41	1.25	5.8	2.89	0.26

2014	0	0.54	4.22	11.99	16.57	19.43	16.31	5.47	8.45	12.14	1.46	3.13
2015	3	0.58	22.35	42.83	16.88	4.6	12.83	12.27	13.27	3.24	1.73	6.09
2016	0	0.81	4.6	10.54	14.43	10.7	15.79	4.53	1.73	0.37	0	0
2017	0	0.67	11.38	17.9	17.13	8.15	20.11	7.83	3.51	5.44	0.41	0.56
2018	0	1.68	17.43	23.29	9.42	11.06	46.75	16.52	1.18	1.26	0.04	0
2019	0	0.73	10.4	10.88	2.45	77.73	38.78	6.88	3.17	6.02	0.06	0
2020	0	0.25	3.96	2.16	4.91	6.12	6.54	8.29	11.34	0.11	1.3	1.96
2021	0	0	0	5.79	15.16	63.52	32.23	27.81	7.88	5.05	9.44	0.54
2022	0.03	0.49	2.68	3.46	6.47	30.82	49.23	12.97	24.58	1	0.61	1.64
Total	17.56	50.89	125.4	235.54	273.11	480.2	479.38	280.35	137.03	81.72	54.48	25.2

Table 6. Total monthly commercial catches (tons) of greater argentine (ARU) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	12.78	23.72	20.2	23.52	0.15	5	4.42	4.75	7.04	14.47	11.53	1.83
2000	0.2	21.28	13.37	9.63	5.66	11.76	8.06	10.77	8.27	1.06	3.78	1.29
2001	0	0.01	1.8	0.68	2.71	17.96	26.91	23.9	3.4	2.43	2.37	2.35
2002	0.04	0	2.26	5	3.59	16.32	18.52	4.7	0.94	0.34	2.29	0.73
2003	0	0	1.06	3.25	11.09	10.74	9.78	7.21	4.45	4.68	1.72	0.25
2004	0	0	0.05	7.45	6.31	19.24	31.03	20.36	7.6	3.84	3.31	2.25
2005	0	0	0.04	1.48	2.63	16.29	27.05	10.1	3.06	0.92	0	0.06
2006	0	0.02	0.06	3.51	14.62	8.5	6.52	25.41	2.85	0.38	2.15	0.4
2007	0	0.06	0.26	3.77	12.82	9.06	8.16	4.63	1.59	1.23	0.98	0.45
2008	1.51	0.05	0.2	5.55	6.61	6.32	3.33	3.68	1.43	1.6	0.31	0
2009	0	0	0.86	3.48	9.3	8.48	9.61	4.73	3.55	1.97	1.83	0.35
2010	0	0	0.46	7.43	12.05	8.88	10.28	9.35	6.99	1.35	2.99	0.03
2011	0	0	2.55	7.34	18.88	42	36.48	15.84	5.48	3.8	3.02	1.03
2012	0	0	2.19	9.19	35.59	29.27	19.62	19.94	4.02	3.22	0.26	0
2013	0	0	3.02	15.42	27.68	38.25	21.04	12.41	1.25	5.8	2.89	0.26
2014	0	0.54	4.22	11.99	16.57	19.43	16.31	5.47	8.45	12.14	1.46	3.13
2015	3	0.58	22.35	42.83	16.88	4.6	12.83	12.27	13.27	3.24	1.73	6.09
2016	0	0.81	4.6	10.54	14.43	10.7	15.79	4.53	1.73	0.37	0	0
2017	0	0.67	11.38	17.9	17.13	8.15	20.11	7.83	3.51	5.44	0.41	0.56
2018	0	1.68	17.43	23.29	9.42	11.06	46.75	16.52	1.18	1.26	0.04	0
2019	0	0.73	10.4	10.88	2.45	77.73	38.78	6.88	3.17	6.02	0.06	0
2020	0	0.25	3.96	2.16	4.91	6.12	6.54	8.29	11.34	0.11	1.3	1.96
2021	0	0	0	5.79	15.16	63.52	32.23	27.81	7.88	5.05	9.44	0.54
2022	0.03	0.49	2.68	3.46	6.47	30.82	49.23	12.97	24.58	1	0.61	1.64
Total	17.56	50.89	125.4	235.54	273.11	480.2	479.38	280.35	137.03	81.72	54.48	25.2

Table 7. Total monthly commercial catches (tons) of tusk (USK) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	0	0	0	0	0	0	4.72	0.48	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	4.72	5.52	10.93	1.58	0.6	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	2.19	0	0	0
2004	0	0	0	0	0.04	0.04	2.28	1.21	4.5	2.35	5.4	1.14
2005	0	0	1.77	0.07	1.64	3.25	3.3	0.32	6.18	9.86	12.73	0.2
2006	0	0	2.45	2.55	4.08	0.8	0.47	6.78	1.05	1.55	3.11	79.4
2007	0	0	0	0	0.03	3.95	7.45	0.23	4.28	2.73	0	0
2008	12.74	0	0	0	1.47	0.6	0	3.69	0	2.2	0	0
2009	0.04	0	0	0.97	1.15	0.14	5.48	8.16	0	0	0	0
2010	0	0	0	0	0.1	0.7	4.67	5.57	4.06	0	0	0
2011	0	0	0.03	0	2.87	5.53	12.92	5.97	15.28	48.51	0	0
2012	0	0	0	0	1.8	13.49	9.99	33.88	11.55	3.88	0	0
2013	0	0	1.34	15.99	1.3	0.75	0.9	0	0.35	6.2	0.8	0
2014	0	0.04	0	4.06	1.52	53.2	29.16	49.65	29.27	0.39	0.04	0
2015	43.24	0	0	0	9.42	46.12	59.75	468.18	251.98	0	0.07	0
2016	0	0	1.38	24.23	48.96	95.1	180.42	34.05	147.58	13.72	3.62	13.3
2017	11.38	44.1	151	1.24	0.14	240	75.79	95.68	103.94	0.98	15.74	22.7
2018	0.79	0	108	52.71	7.96	296.1	44.34	23.54	113.42	9.33	5.26	23.5
2019	8.89	39.2	11.9	59.88	15.14	113.2	92.04	39.91	4.36	0.4	0.12	1.58
2020	7.6	9.22	5.85	86.3	34.46	4.82	45.9	10.57	2.7	3.26	0.46	4.86
2021	0	3.66	25.7	54.43	200.32	198.4	157.48	58.34	10.11	7.02	4.66	0
2022	0.15	0.07	18.2	48.89	28.76	16.87	8.19	4.2	68.78	156.3	3.31	13.5
Total	84.83	96.3	328	351.32	361.16	1093	749.97	855.93	792.51	270.3	55.92	160

Table 8. Total monthly commercial catches (tons) of blue ling (BLI) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1999	0	0	0	0	0	0	0.15	0	0	0	0	0
2000	0	0	0	0	0	0	0	0.16	1.07	0	0.16	0
2001	0	0	0	0	0	0	0.56	0	0	0	0	0

2002	0	0	0.1	0.03	0	0.06	0	0	0.05	0	0	0
2003	0	0	0	0	0.26	0.14	0.95	1.27	0	0	0	0
2004	0	0	0	0.43	0.55	0.15	2.16	1.01	0.83	0.82	0.22	0.88
2005	0	0	0	1	0.13	1.27	2.07	0.38	0.8	0	0	0
2006	0	0	0	0	0	0	0	0.35	0	0.54	1.35	3.67
2007	0	0	0	0	0	0.19	0	0.27	0.74	0.08	0	0
2008	2.83	0	0	0	0.2	0.12	0	0.81	0.09	0.73	0.05	0
2009	0	0	0	0.47	2.7	2.03	0	0	0.18	0	0	0
2010	0	0	0	0	0.44	0.19	0	1.55	4.73	0.26	0.22	0.06
2011	0	0	0.07	0	0.33	2.44	0.22	0.95	0.9	1.96	0.96	0.12
2012	0	0	0.67	2.1	1.82	1.26	0.06	1.93	3.32	1.88	0	0
2013	0	0	1.11	1.09	1.22	0.3	0.15	2.1	0.1	6.98	2.65	0
2014	0	0.59	1.44	0.57	2.13	1.88	0.47	2.88	1.34	2.37	0	0.19
2015	0	1.52	1.92	0.46	0.63	0.4	0.71	0.08	26.05	32.91	0	0.74
2016	0	1	0.92	0.44	1.41	0.13	0.33	0	4.4	0	0	0
2017	0	0.37	3.72	1.81	0.08	0.79	2.1	0.6	1.24	1.23	0	0
2018	1.65	0.61	3.34	8.82	1.77	0.22	0.51	0.1	0.65	15.01	0.91	0
2019	0	0.14	1.12	0.1	0.2	0.58	16.79	6.81	7.24	11.5	0.34	0.6
2020	0	0.27	0.99	0.14	0.2	0.95	4.54	3.46	5.23	5.62	5.38	0
2021	0.27	0	0	0.03	0.03	5.09	5.61	0.23	0.83	1.33	2.51	1.11
2022	0.62	0.11	0.75	0	0.06	0.57	0	0.07	3.98	16.81	2.87	1.43
Total	5.37	4.61	16.15	17.49	14.16	18.76	37.38	25.01	63.77	100.03	17.62	8.8

Table 9. Total monthly commercial catches (tons) of black scabbardfish (BSF) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0.03	0	0	0
2011	0	0	0	0	0	0	0	0	0.18	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0

2021	0	0	0	0	0	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0.21	0	0	0

Table 10. Total monthly commercial catches (tons) of ling (LIN) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	0	0	0	0	0	0.16	0.76	0.57	0.58	2.04	3.83	0.1
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0.52	0.22	0	0	0
2002	0	0	0	0	0	0.25	0.08	0	0	0	0	0
2003	0	0	0	0	0.12	0	0	0	0	0.06	0.03	0
2004	0	0	0	0	0.06	0.13	0.41	0.39	0.52	5.6	0	0
2005	0	0	0.06	0	2.69	0.07	0	4.05	0.7	8.39	1.73	0
2006	0	0	0	0	0.1	0.05	0	0.25	0	0	0	18.22
2007	0	0	0	0.4	0.21	0.16	0.43	0.34	0	0	0	0
2008	10.09	0	0	0	0.14	0	0	0.82	0	0	0	0
2009	0	0	0	0	1.68	0.85	1.26	0.52	0.11	0.22	0	0
2010	0	0	0.11	0.52	0.73	0.11	0.11	0	0	0	1.55	0
2011	0	0	0.62	0.78	0	0	1.64	1.76	0	0	0	0
2012	0	0	0.24	0.2	1.08	0.27	0.09	2.22	0.67	0.1	0.24	0
2013	0	0	0.02	1.36	0	0	0	0	0	0.97	0	0
2014	0	0	0	0.02	0	2.29	3.02	2.44	0.21	0	0	0
2015	9.45	0.11	0	0	0.72	1.9	1.76	3.42	3.09	0	0	0
2016	0	0	0	0.36	0.09	3.54	8.5	0.13	0.95	0.35	0	1.28
2017	0.57	0.34	0	0.36	0.23	0.86	0.74	1.18	0.21	0	0	0
2018	0	0.54	0.07	0	0	0.66	0	3.21	0.11	0	0	0
2019	0	0	0	0	0	0.03	0.04	0.26	0	0	1.56	0
2020	0	0.17	0	0.1	0.13	0.03	0	0	0	0	0	1.1
2021	0	0.13	0.06	0.23	0.45	0.08	0.01	0.03	0	0	0.43	0
2022	0.04	0	0.08	0	0	0.03	0.36	0.2	0	0	0	0
Total	20.15	1.29	1.26	4.33	8.43	11.47	19.21	22.31	7.37	17.73	9.37	20.7

Table 11. Total monthly commercial catches (tons) of orange roughy (ORY) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0.32	0.08	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0.82	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0

2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0.32	0.9	0	0	0	0	0	0

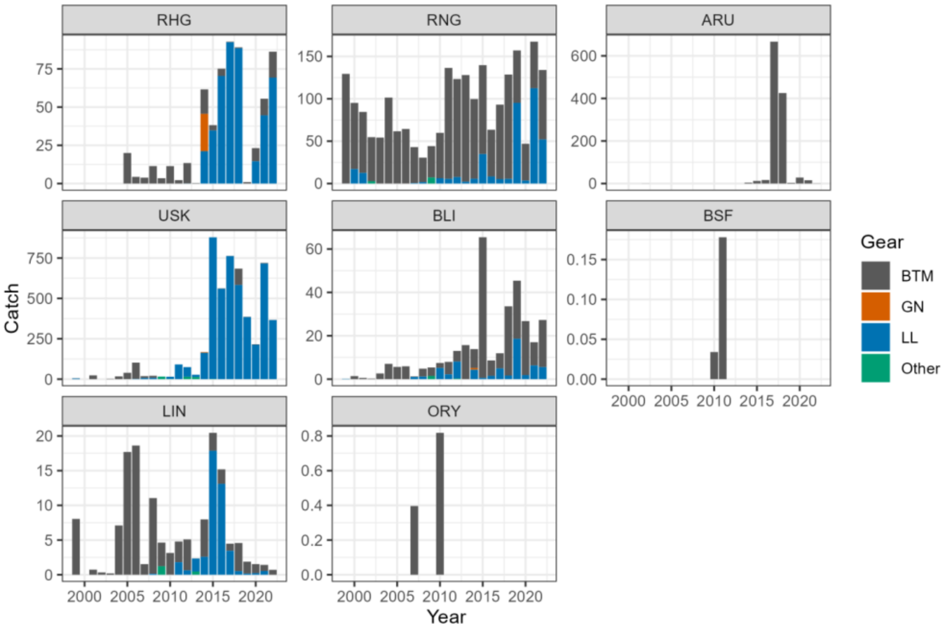

Figure 1. Total annual commercial catches by gear, in tonnes (t) of roughhead grenadier (RHG), roundnose grenadier (RNG), greater argentine (ARU), tusk (USK), blue ling (BLI), black scabbardfish (BSF), ling (LIN), and orange roughy (ORY)in the Greelandic EEZ zone of ICES 14 from 1999 to 2022. Note the different scales of the y axes. Catches for black scabbardfish and orange roughy were very low and can be seen in Table 1.

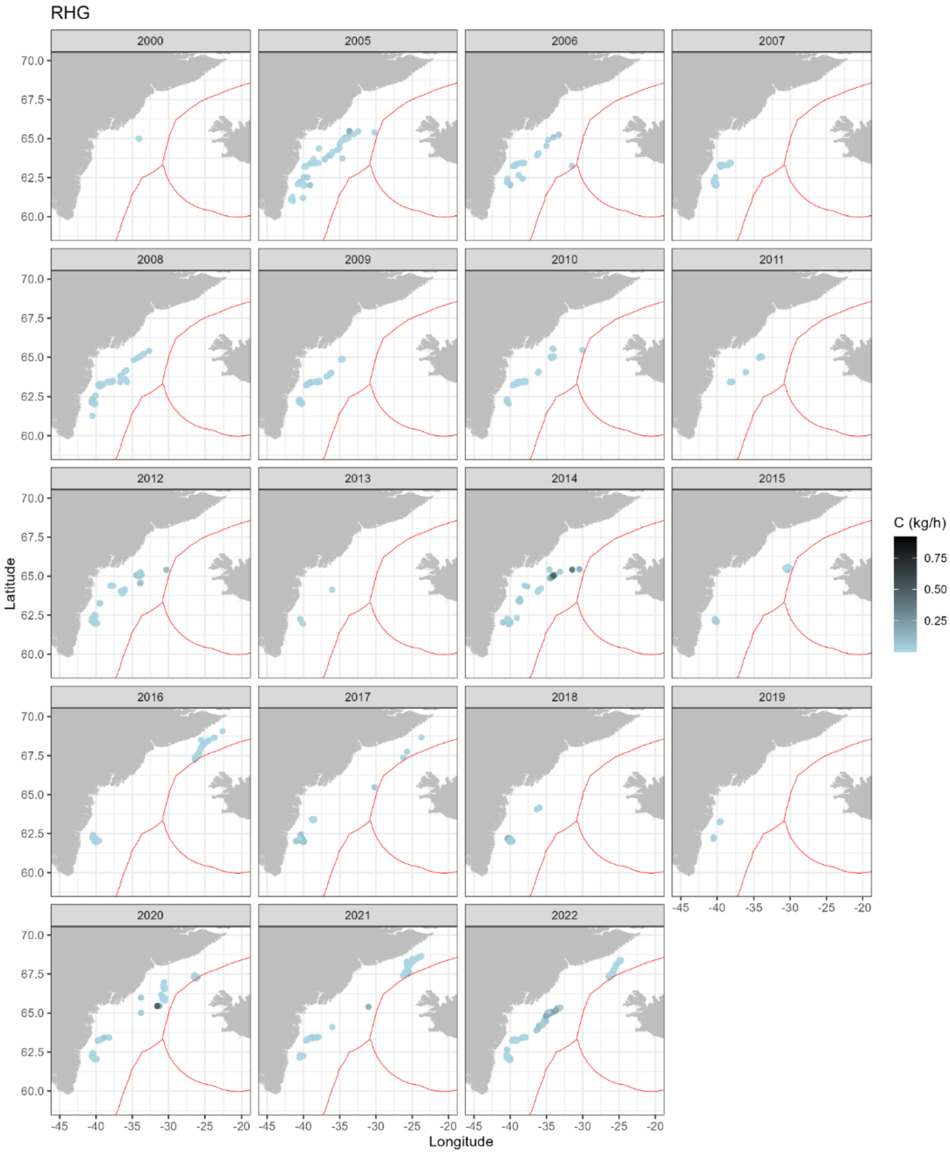

Figure 2: Roughhead grenadier (*Macrourus berglax*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

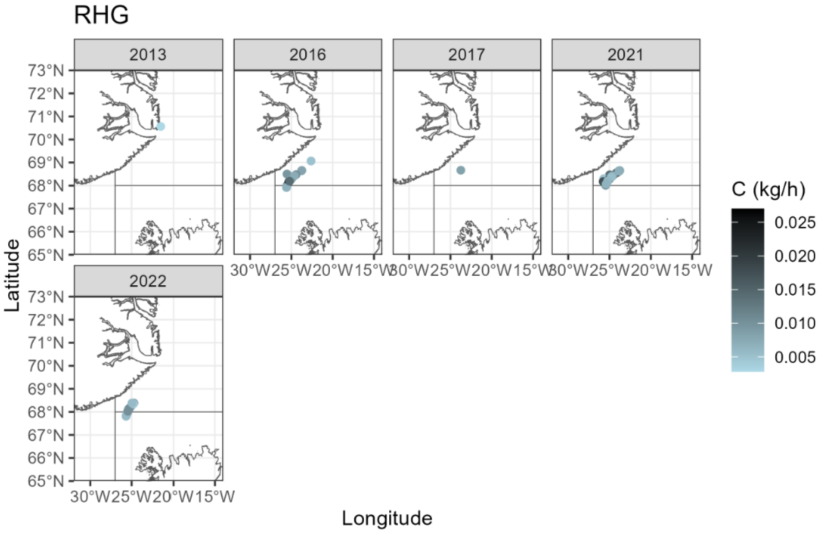

Figure 3: Roughhead grenadier (*Macrourus berglax*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.a.

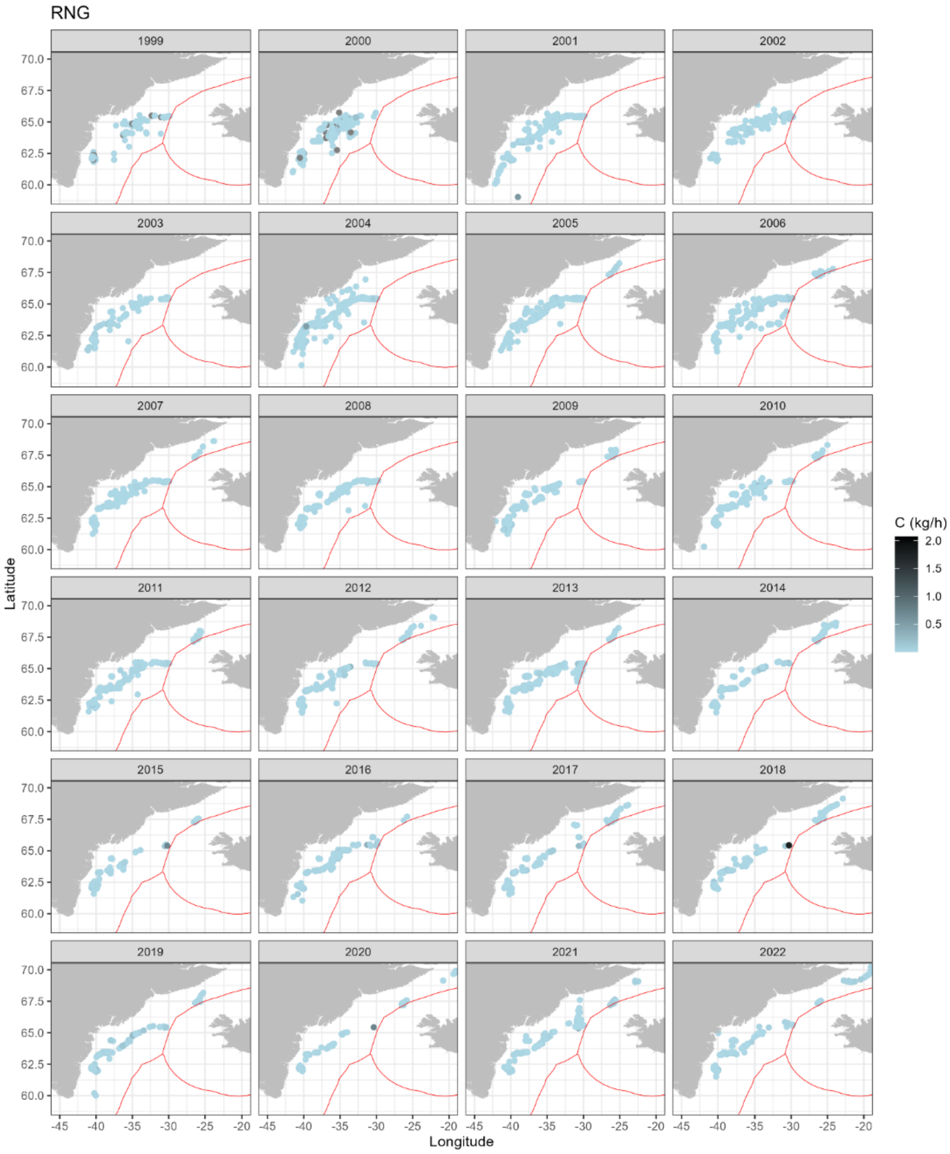

Figure 4: Roundnose grenadier (*Coryphaenoides rupestris*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

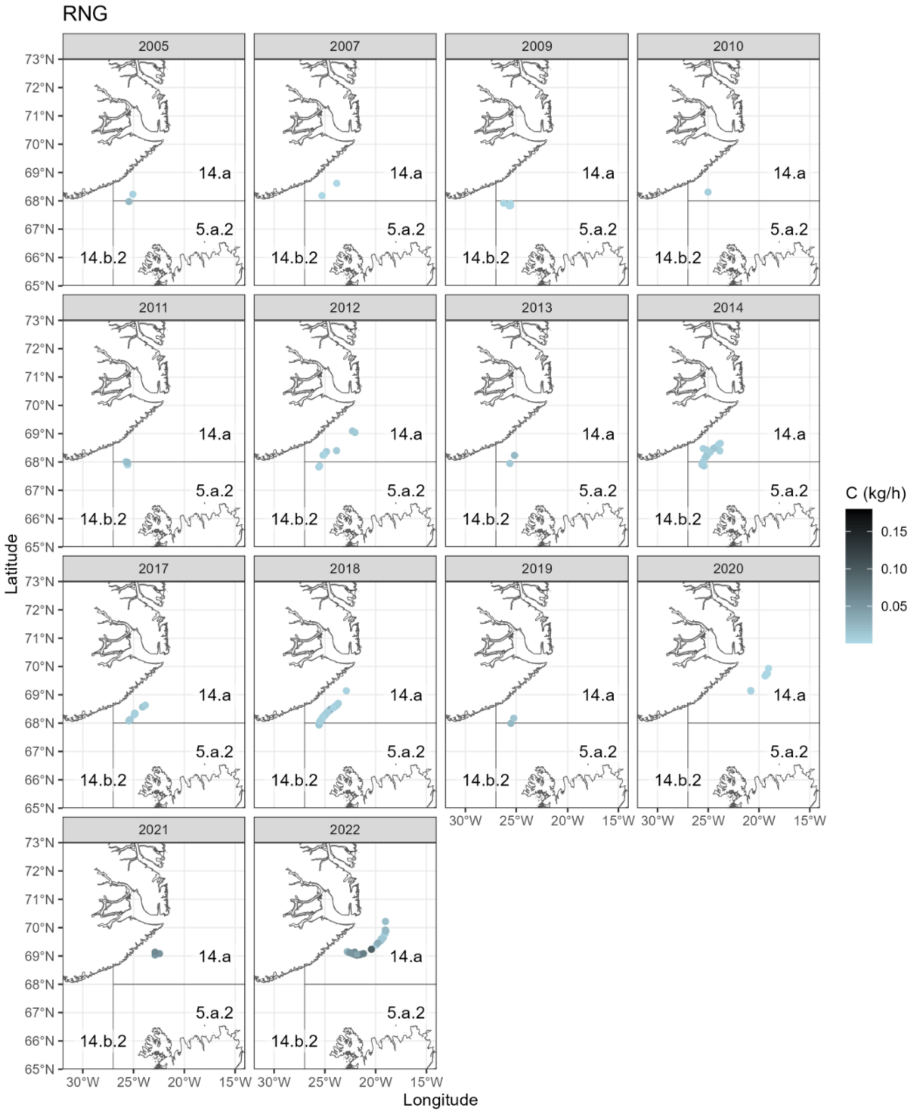

Figure 5: Roundnose grenadier (*Coryphaenoides rupestris*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.a.

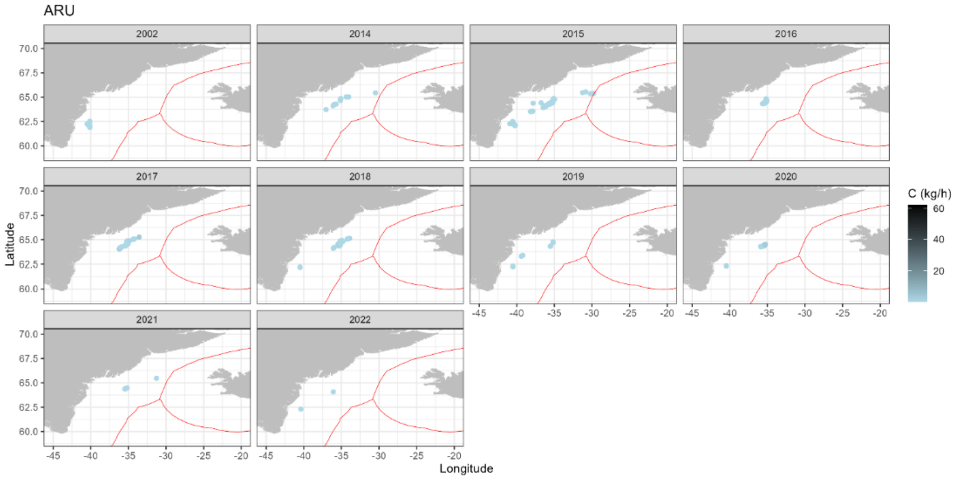

Figure 6: Greater argentine (*Argentina silus*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

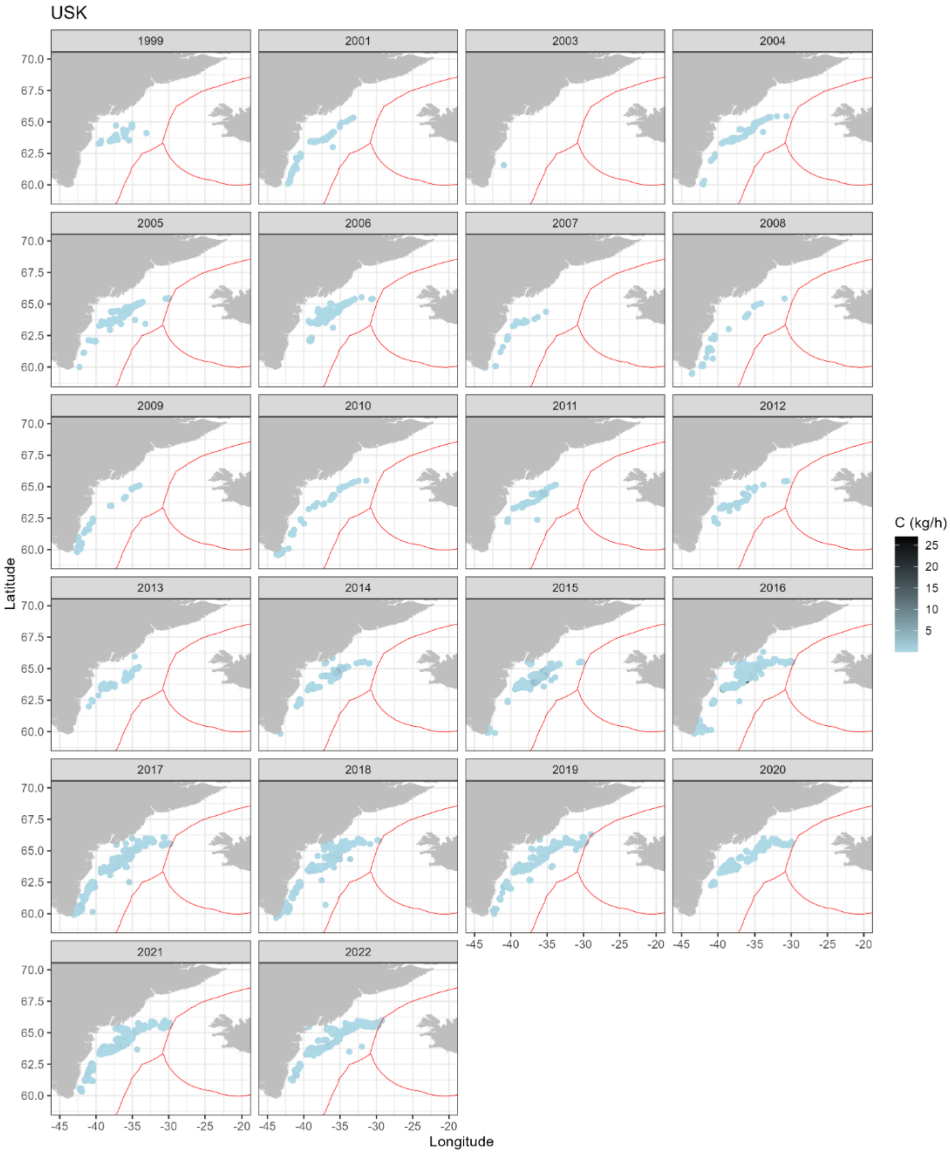

Figure 7: Tusk (*Brosme brosme*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

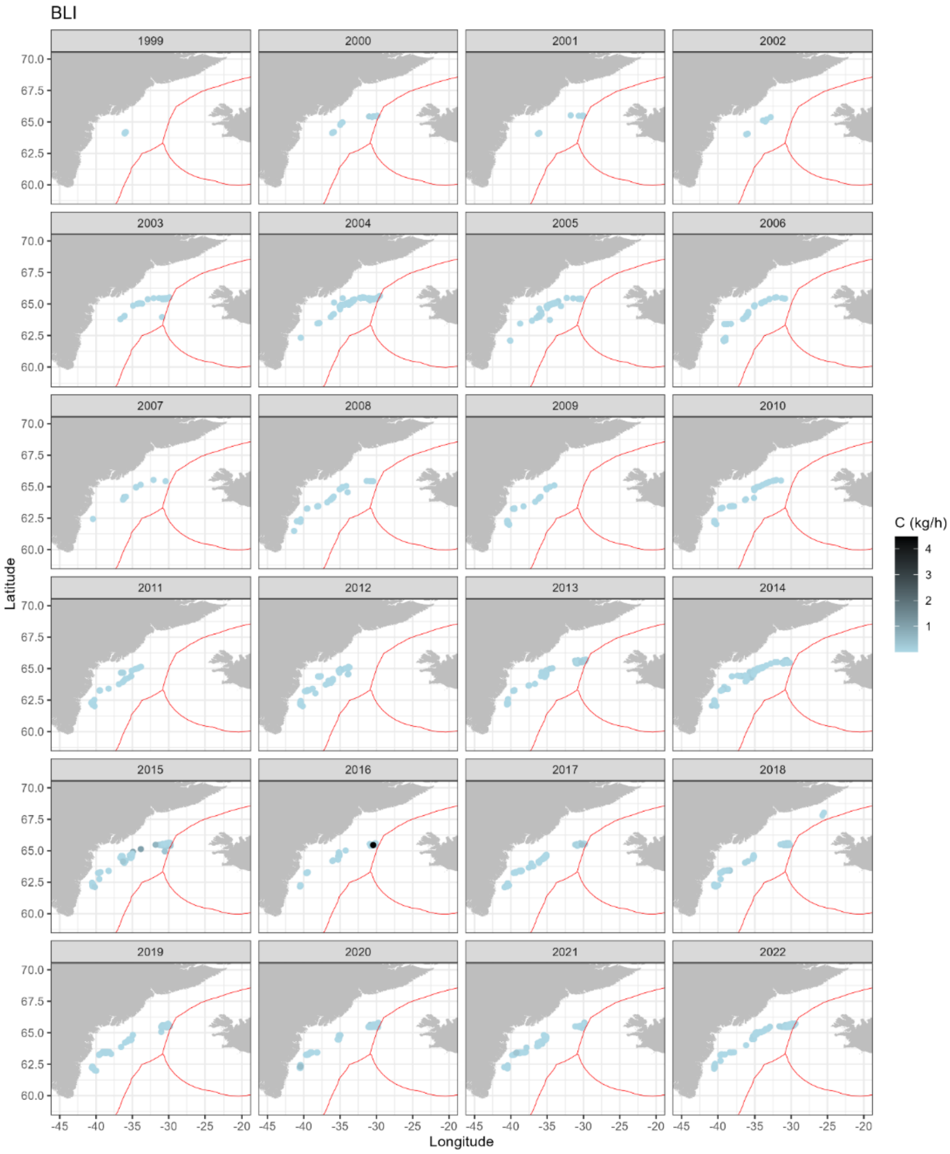

Figure 8: Blue ling (*Molva dypterygia*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

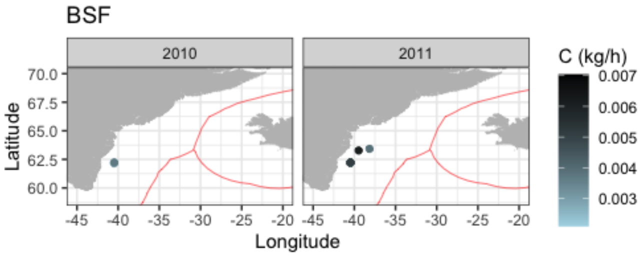

Figure 9: Black scabbardfish (*Aphanopus carbo*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

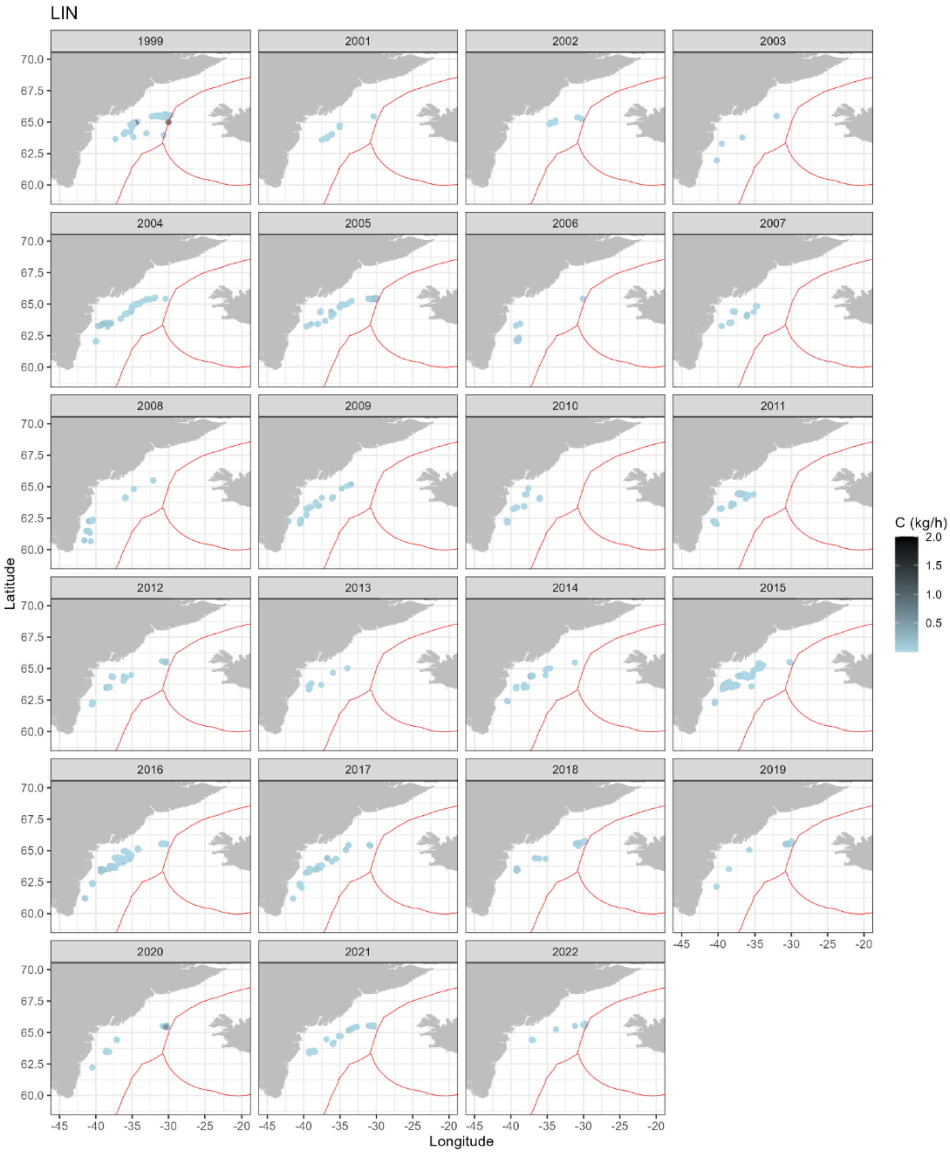

Figure 10: Ling (*Molva molva*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

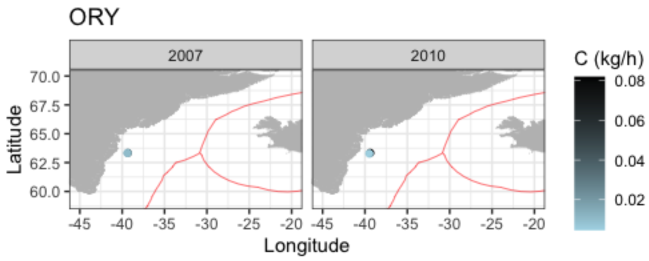

Figure 11: Orange roughy (*Hoplostethus antlanticus)* CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

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Refining stock distribution of the current bli.27.nea ICES assessment unit, based on new evidence of genetic and demographic population structure

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Working document

1. Background

Blue ling *(Molva dypterygia)* is caught over a wide area in northeast Atlantic. At present there are three stock areas for blue ling within WGDEEP (bli.27.nea, bli.27.5b67 and bli.27.5a14).

The stock area bli.27.nea consists of subareas 1, 2, 8, 9, 12 and divisions 3a and 4.a. Historically (within WGDEEP) it was defined as the combination of areas where some blue ling landings were reported from bycatch fisheries without major directed fisheries. Geographically, this stock area is split in three regions (Figure 1). Subareas 8 and 9 is the southernmost. New information suggests that landings from subareas 8 and 9 are Spanish ling (*Molva macrophthalma*) and historical records of blue ling are questionable, see section with Figure 2. Therefore, landings of blue ling from these subareas have been attributed to this Spanish ling since 2010 and, accordingly, the landing tables of the assessment unit bli.27.nea for subareas 8 and 9 have not been updated. There is a need for information and suitable identification sheets to be provided to fisheries for landings from these subareas to be reported as the right species (*M. macrophthalma*, Spanish, FAO code SLI).

Subarea 12 includes parts of the Mid-Atlantic Ridge (in ICES divisions 12.a.1, 12.a.4 and 12.c) and the western slope of the Hatton Bank (in ICES Division 12.b). Since 2014, landings from Subarea 12 have decreased from 80 to 0 tons in 2022. However, based upon the continuity of bathymetric features and lesser abundance, blue ling from the western Hatton Bank (Division 12.b) is likely to be related to those from the northern Hatton Bank (ICES Division 6.b) and blue ling from other divisions of Subarea 12 is more likely to be related to those from Icelandic and east Greenland waters. Following this, it would be more appropriate that blue ling in Division 12.b is combined with stock unit bli.27.5b67, forming a new unit bli.27.5b6712b). Other divisions of 12 should be added to the stock unit bli.5a14, becoming bli.27.5a12ac14.

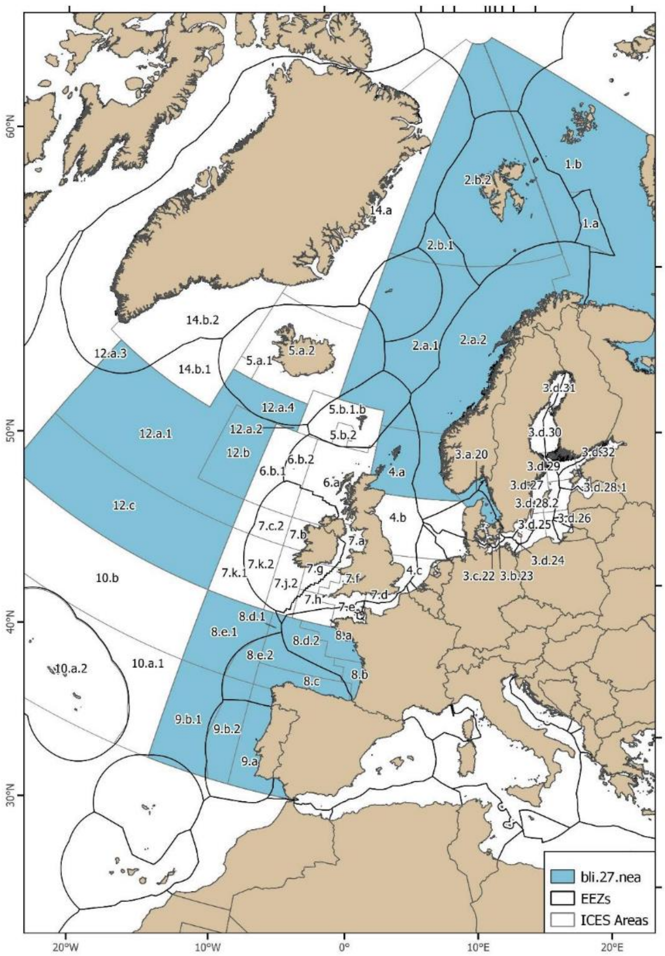

Figure 1. Map showing ICES areas covering the stock unit of Blue ling in subareas 1, 2, 8, 9, 12 and divisions 3a and 4.a (bli.27.nea).

In subareas 1, 2 and divisions 3a and 4a, blue ling inhabit the components of Barents Sea, the western slope of northern Norway, North Sea and the Skagerrak, where the bulk of the catch is from Norwegian fisheries in subareas 2a and 4a. Catches in the North Sea (Subarea 4) come from the Norwegian deep, in the eastern side of the North Sea. There are also some small catches reported from Division 4.b (Denmark and Germany).

In recent years, landings from this stock area are exclusively from subareas 1,2,4 and Division 3a. Norway contributes by far to the landings in Divisions 2.a (77%) and 4.a (77%).

There were landings reported to Intercatch from subareas 8 and 9 in 2022. These landings represent 11% of the total landings from the stock area (75 tonnes). These catches are from France (15%) and Spain (85%). Such landings are ascribed to *M. macrophthalma* and have not been included in the bli.27.nea assessment since 2010. The allocation of catch from Subarea 8 of the Spanish ling comes from the French EVHOE survey, where all individuals of the genus *Molva* caught are checked for correct taxonomic identification. There is a clear distinguishing criterion between blue ling (*Molva dypterygia*) and the Spanish ling *(Molva macrophthalma*) with the latter having the pelvic fin extending beyond the pectoral (Figure 2). All individuals caught in subarea 8 were *M. macrophthalma*.

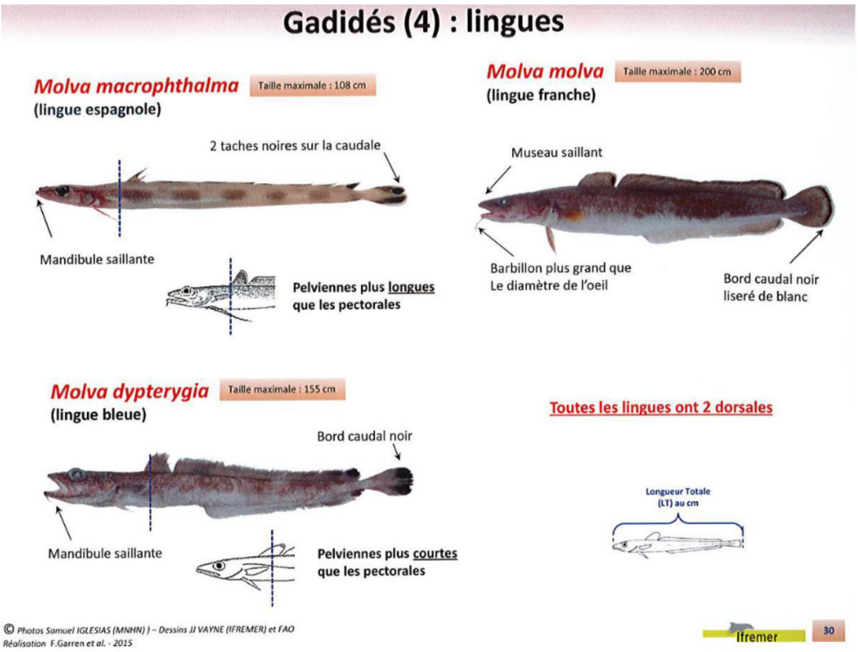

Figure 2. Identification sheet for ling (genus *Molva*) used in French surveys (from Garren, 2020)

2. Fisheries

In Subarea 12 catches have been from multispecies fishery fleets fishing for several deepwater species, primarily roundnose grenadier, black scabbardfish and blue ling, with a component of deepwater sharks and orange roughy in the 1990s. Before the 1990s, the bulk of the landings from Subarea 12 was from target fisheries of seasonal spawning aggregations, like in divisions 5.a and 6.ab. Known spawning areas are now closed seasonally to protect the spawning stock.

There was a directed fishery for blue ling in Division 2.a on spawning areas; mainly Norwegian vessels fishing with nets. The directed fishery was banned in 2009 and has since been regulated by a 10% allowed bycatch from other fisheries. The fishery in divisions 2.a and 4.a is now a bycatch fishery from longlines and nets.

3. Blue ling population structure

3.1. Recent population genetic study

Genetics information is scarce for this species. However, there is new information on population structure of blue ling (McGill *et al*, 2023). Samples from the Atlantic basin covering (Greenland, Rockall, Rosemary Bank, Anton Dohrn and Atlantic slope, i.e. to the West of Scotland) and along the Norwegian Coast, in Division 2.a by 69°N, in Division 4.a by 59-61 °N and South Norway in Division 3.a) were analyzed with Principal Component Analysis (PCA) and the Structure software (Pritchard *et al*., 2000) and the results showed two distinct genetic units (Figure 3). Although there was found some genetic flow between the two areas, there was clearly two separate units. This information supports changing the current stock area to units reflecting better the actual population structure. Further, the current bli.27.nea include subareas 1 and 2 to the East and Subarea 12 to the West, whilst these subareas are separated by the two other assessments units considered by ICES.

Overall, the population genetic study indicated that blue ling from the Atlantic Basin and Norwegian water are distinct, which implies that Subarea 12, which is included in bli.27.nea should be separated from subareas 1 to 4.

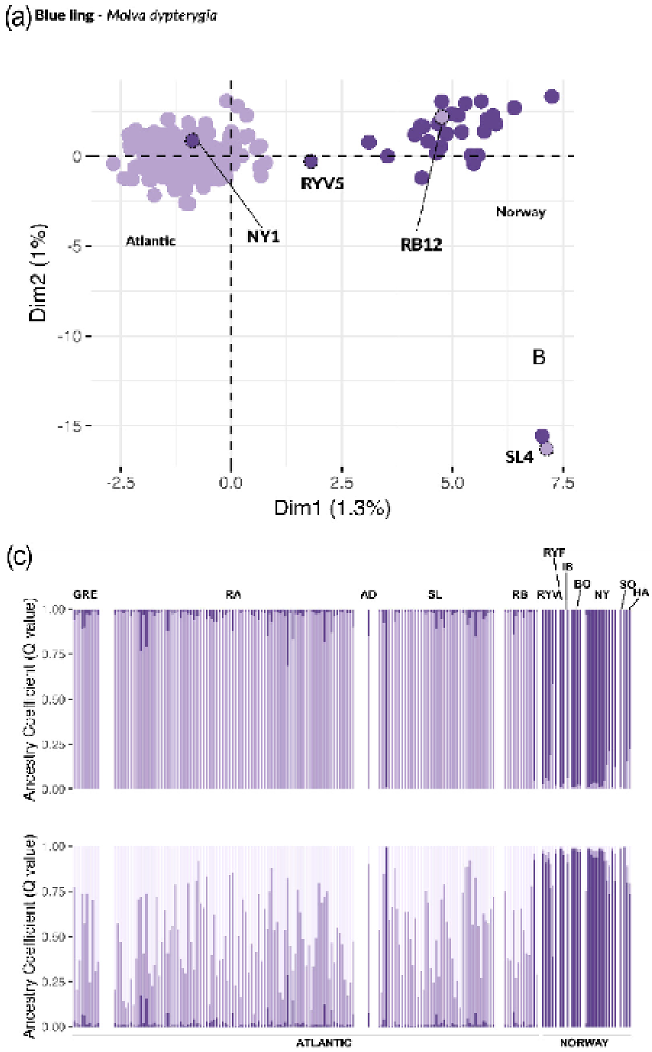

Figure 3. Genetic population structure of blue ling, based on sampling in the Atlantic basin, Norwegian Sea and North Sea. PCA plot (a) and Structure plot (c) (redrawn McGill *et al.*, 2023).

3.2. Population structure in the Atlantic basin.

The population genetic study from Gill *et al.* (2023) did not reveal structure within the Atlantic basin. This would probably need genotyping more individuals from more locations from the Atlantic. The population structure in this basin was considered for long. Biological investigations in the early 1980s suggested that at least two adult stock components were found within the area, a northern stock in Subarea 14 and Division 5.a with a small component in 5.b, and a southern stock in Subarea 6 and adjacent waters in Division 5.b. This was supported by differences in length and age structures between areas as well as in growth and maturity. Egg and larvae data from early studies also suggested the existence of many spawning grounds in each of areas of the northern and southern stocks and this was considered as indications of stock separation. These now historical approaches are the basis for distinguishing the two major current stock units: bli.27.5a14 and bli.27.5b67. To the the west of the British Isles in Subarea 6, small blue ling below 60 cm are not caught by fisheries nor surveys. Fish appear in survey and commercial catch at 60–80 cm possibly suggesting migration of juveniles from other areas. Spawning grounds are known to occur in Subarea 6, along the Scottish slope, on Rockall, Hatton, Lousy and Rosemary Banks (Figure 4, left panel) in Division 5.a, Icelandic grounds, (Figure 4, right panel). Spawning areas have also been identified in Faroese waters (Figure 5).

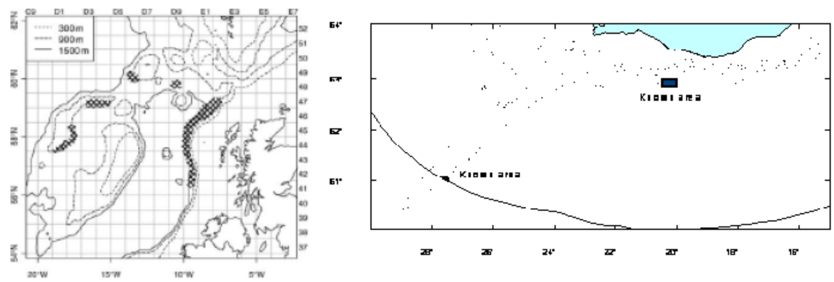

Figure 4. Spatial distribution of blue ling spawning grounds along the Scottish slope, on the Hatton, Lousy and Rosemary Banks (left) and to the South of Iceland (right).

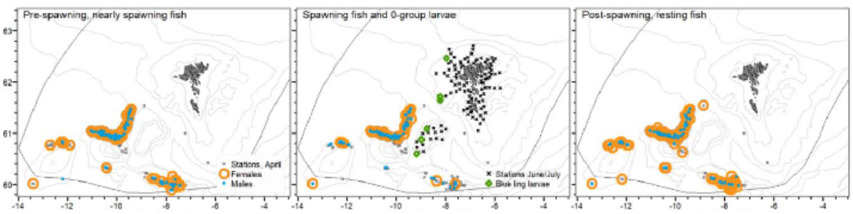

Figure 5. Spatial distribution of blue ling spawning areas in Faroese waters. Data from the blue ling surveys in April, 1995-2003. Observations of nearly spawning fish (left), spawning fish and observations of larvae (middle) and resting fish (right). Larvae data from 0-group survey June/July 1995-2017.

Small blue ling are observed in survey in Icelandic and Greenland waters. In recent decades Icelandic surveys have shown a sudden drop in small blue ling abundance, denoted recruitment (Figure 6.D) in 2008-2010 and remained at low level since. This low recruitment was followed by a decrease in biomass of fish larger than 40 cm from 2012 (Figure 6.B) which was also visible in fish larger than 70 cm TL (Figure 6.C). This suggest that small blue ling observed in Icelandic, actually represent the recruitment to this stock. Small blue ling from 21 cm has also been of observed in survey in Greenland waters since 2002 (Nogueira and Christiansen, 2023). Lastly blue ling smaller than 40 cm TL have also been observed in Faroese surveys, but in a few locations and very small numbers. Pelagic larvae (2-3 cm in length) have also been caught in the annual 0-group trawl survey in June/July (Figure 5, central panel) but in very small numbers only (Ofstad, 2018).

Overall the number of blue ling smaller than 60 cm observed in surveys in the area of the bli.27.5b67 seems very small in comparison to the adult stock, which current biomass is estimated to near 100 000 tonnes. How larvae drift and juveniles migrate to adult grounds, where they recruit to fisheries, is unknown.

If blue ling from Division 5b and subareas 6 and 7 (bli.27.5b67) was demographically connected to bli.27.5a14, the decline in biomass of fish larger than 70 cm observed for bli.27.5a14 from 2012-13 should also have occurred quite at the same time in bli.27.5b67, where blue ling recruit to the fishery at 60-70 cm. No such decline was observed, in contrast the biomass increased rather continuously since the early 2000s (Figure 7), which may have been driven by decreasing catches in the 2000, but after 2010 catches stabilized and eventually started increasing in recent years. Further, the current exploitation level is estimated to be well below MSY for bli.27.5b67 (ICES, 2022a), whilst it is above for bli.27.5a14 (ICES, 2022b). This suggest that the two stock units bli.27.5a14 and bli.27.5b67 are demographically disconnected and support the ICES practice to recognize these two major units in the Atlantic basin.

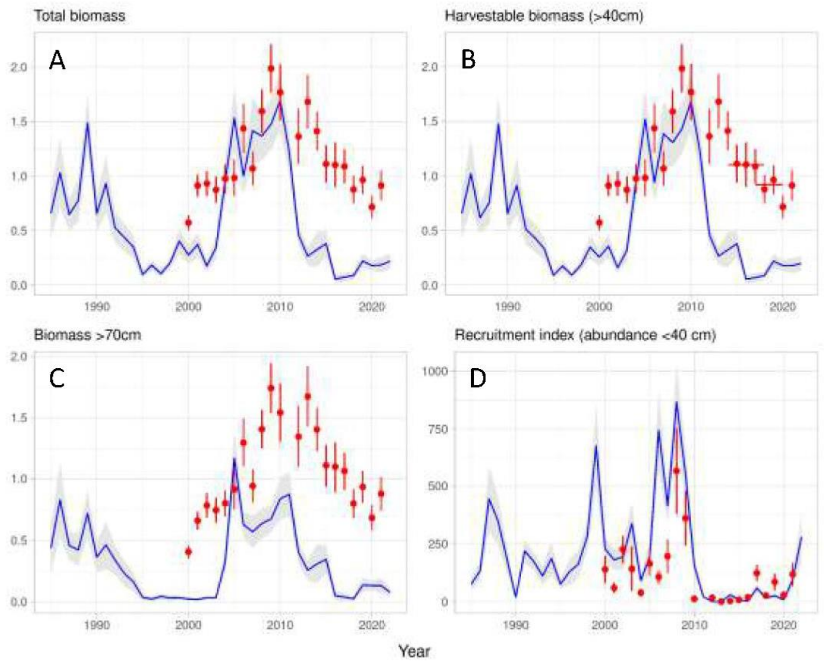

Figure 6. Biomass (thousand tonnes) and abundance (numbers) indices of blue ling in the Icelandic autumn survey since 2000 (red points) and the spring survey since 1985 (blue lines). Total biomass index (top-left), biomass of 40 cm and larger (top-right), biomass of 70 cm and larger (bottom-left) and abundance of small blue ling smaller than 40 cm, considered recruitment. Vertical red lines and shaded area represent standard error of the estimate. Redrawn from ICES (2022c).

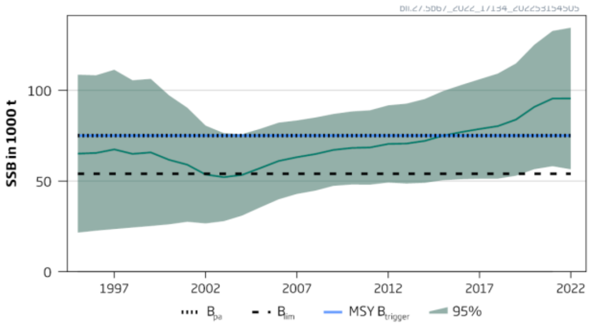

Figure 7. Estimated biomass of the bli.27.5b67 stock (ICES, 2022a).

The remaining issue is how to treat Subarea 12 from which the genetic population study had not samples (Gill *et al.,* 2023). Further, considering that this study did not found difference between samples from south Greenland and those from Rockall and Hatton, blue ling from Subarea 12 may be expected to belong to the same genetic pool.

Blue ling occurs at unknown level in different parts of Subarea 12. Current catches are minor but historical catches suggest that Subarea 12 may accommodate a significant biomass of the species (although the current level of this biomass with respect to the possible carrying capacity of the area in unknown), with 400 to 1300 tonnes landed annually from 1995 to 2005 (ICES, 2002). We suggest treated this subarea based on the continuity of bathymetric features (Figure 8 and 9). Considering that the species has a clearly demersal behavior, migration are expected to follow suitable bottom habitats. Blue ling in Division 12.b occurs on the western Hatton bank, out of this Bank (to the West) the seafloor is too deep for the species. The western Hatton Bank is in continuity with the Rockall and Hatton Banks in Division 6.b. so that blue ling from 12.b is most likely to be related to blue ling from 6.b. Division 12.a.2, is a small area where the seafloor is deeper than 1500 m, so too deep for the species.

3.3 Bathymetric and hydrological features

Oceanographic barriers may play a role in the ability for fish to move across major basins across the Northeast Atlantic. The overflow of Norwegian Sea currents across the Wyville-Thomson Ridge and its confluence with slower currents from subtropical Atlantic Ocean to the south, reaching as far as the Shetlands, associated to the regional topography, offers favourable conditions for the incidence of stratified waters (Hänninen, 2020; Kurekin *et al*., 2020). These hydrographic conditions create barriers to genetic flow and subsequently isolated fish populations (Knutsen *et al*. 2009; Longmore *et al.*, 2011).

Some evidence exists, postulating that the Wyville Thomson Ridge separates fish communities distributed along the Norwegian basin and in the Skagerrak, from those to the West of the British Isles (Campbell *et al.* 2011). The general oceanic circulation patterns in the North Atlantic are suggestive that fish populations present in the Rockall and Faeroe Banks are separated from those in the Icelandic Basin, and the latter is itself separated from the Norwegian Basin by the Iceland-Faeroe Ridge (Gordon, 1986).

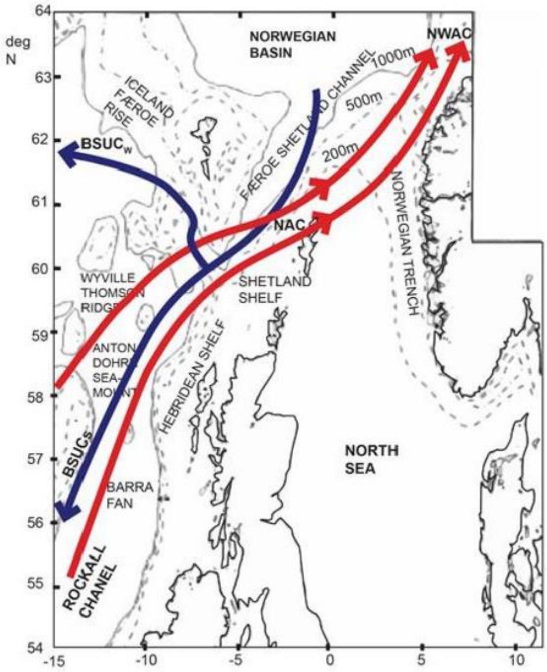

Figure 8. Hydrological circulation in the Norwegian Sea, Rockall-Hatton and Faroe area.

Suitable bottom depths for blue ling in other divisions of Subarea 12 are areas of the Mid-Atlantic Ridge to the West of Division 12.a.4 and in Division 12.a.1 (Figure 9). Blue ling occurring on these grounds is likely to be related to blue ling in Division 5.a. Blue ling is unlikely to occur in divisions 12.a.3 and 12.c, which are too deep.

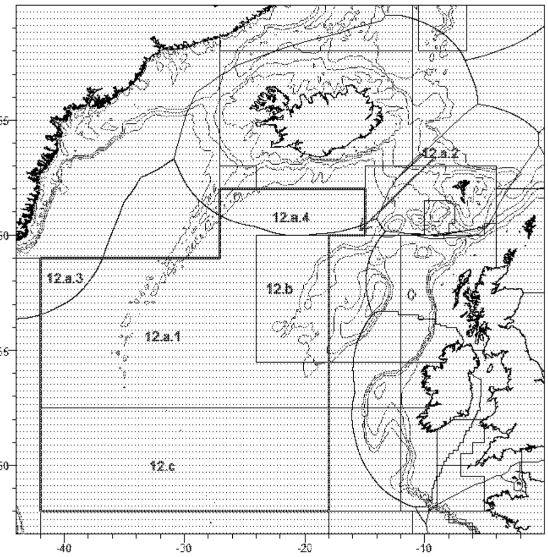

Figure 9. Subarea 12 (brown thick line) and its divisions, over the bathymetry of the Northeast Atlantic (contour lines 200, 500, 1000 and 1500 m). Depths drawn from GEBCO 2022.

Nevertheless, to the very south of the Rockall Hatton area, a small area may include suitable bottom depth for blue ling (see to the South of Division 12.b on Figure 8). Therefore, landings reported in Division 12.a.1, which is included in the NEAFC RA, may come either from this area of from the Mid-Atlantic Ridge and may belong to one stock or the other. Therefore, to be able to ascribe catches of blue ling from Division 12.a.1 to the right stock additional information is needed.

4. Conclusion

A stock area covering wide and disconnected areas is not appropriate. Available evidences suggest that stocks units more aligned to the actual population structure can easily be achieved.

Overall available data suggest that:

- Divisions 12.a.1 and 12.a.4 should be pasted to the area of the assessment unit bli.27.5a14. For simplicity, division 12.a.3 and 12.c may be included in the same stock unit, although blue ling is unlikely to occur in these divisions. The assessment unit bli.27.5a14, would become bli.27.5a12ac14, labelled "Blue ling (*Molva dypterygia*) in subareas 12 and 14 and Division 5.a (Mid-Atlantic Ridge, East Greenland and Iceland grounds)".
- Division 12.b should be pasted to the stock area of the assessment unit bli.27.5b67, which would become bli.27.5b6712b, labelled "Blue ling (*Molva dypterygia*) in subareas 6–7 and division 5.b and 12.b (Celtic Seas, Hatton Bank and Faroes grounds)". For simplicity, the small

Division 12.a.2, may be included in the same unit as this would avoid creating a potential loophole with a small area not covered by a TAC for blue ling.

- Blue ling does not occur to any significant level in subareas 8 and 9, which should therefore not be part of any blue ling stock assessment unit.
- The remaining areas of the current bli.27.nea "Blue ling (*Molva dypterygia*) in subareas 1, 2, 8, 9, and 12, and in divisions 3.a and 4.a (Northeast Atlantic)" form a suitable stock assessment unit bli.27.1-4 which can be labelled "Blue ling (*Molva dypterygia*) in subareas 1 and 2 and divisions 3.a and 4.a (Norwegian Sea, North Sea and Skagerrak)"

It is worth noting that this revision of the stock assessment units for blue ling results in the same number of ICES stocks as previously, the distribution of the new assessment units is clearly better aligned on the meta-population structure of the species than the previous one. The remaining issue of the attribution of catches from Division 12.a.1 to the right stock can be solved be one of the following options:

- **Availablity of catches at the resolution of ICES rectangle for catches coming from the NEAFC RA**. If this data can be made available and included in the WGDEEP data call then the attribution of catch to the right stock is straightforward
- **Addition of one ICES Division**. An additional ICES Division, covering the south of 12.b down to 48°N. This could be labelled, Division 12.d or Division 12.a.5 and have the following limits: Southwest corner at 24°West and 48° North; Northeast corner at 18° West 60°North.
- **Extend Division 12.b towards the South down to 48°N.** This would have the same effect as the previous option, without increasing the number of ICES divisions.

Whichever, approach is the easier to implement should be used as the three options all allow to ascribe catch to the right stock assessment unit.

4.1 Consequence for stock assessment

There was no catch from Subarea 12 in 2022. Catches were smaller than 30 tonnes per year since 2015, which is minor compared to more than 1500 and 3000 tonnes per year caught for bli.27.5b67 and bli.27.5a14 respectively. Fisheries in Subarea 12 seem to have ceased and therefore integrating parts of this Subarea to the two other stock units 5b6-7 and 5a14 would not impact current assessments substantially. Since 2010, landings of Spanish ling from subareas 8 and 9, reported as blue ling have not been included in the advice so that the exclusion of these subareas from the stock unit will not have any impact on subsequent advices either.

Excluding subareas 8 and 9 is recommended because according to survey blue ling does not occur in these subareas where the closely related Spanish ling occurs. The latter has probably a different ecology, in particular it is not known to form spawning aggregation susceptible to be targeted by fisheries. Further, in the EVHOE survey in Subarea 8, small (< 40 cm TL) and adult Spanish ling are caught in the same hauls.

Important note

This working document was presented and discussed during the 2023 meeting of WGDEEP. In additions to authors, all members of the group considered the issue thoroughly and contributed to define the most suitable solution to the stock delineation of blue ling in the ICES area, which lead to add several considerations to the text during the meeting. This final version was approved by the group.

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Working Document to be presented to the Working Group on the Biology and Assessment of Deep Sea Fisheries Resources

ICES WGDEEP, 3rd - 9th May 2023, Lisbon, Portugal

Results on greater forkbeard (*Phycis blennoides*), Spanish ling (*Molva macrophthalma*), roughsnout grenadier (*Trachyrincus scabrus*), bluemouth (*Helicolenus dactylopterus*) and other scarce deep water species on the 2022 Northern Spanish Shelf Groundfish Survey

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Abstract

This working document presents the results on the most significant deep fish species on the Spanish Groundfish Survey on the northern Spanish shelf in 2022. Biomass, abundance, length ranges and geographic distributions were analyzed for greater forkbeard (*Phycis blennoides*), Spanish ling (*Molva macrophthalma*), roughsnout grenadier (*Trachyrincus scabrus*), bluemouth (*Helicolenus dactylopterus*) and other scarce deep sea species. The biomass of *T. scabrus* increased slightly whereas it increased sharply for *P. blennoides, M. macrophthalma* and especially for *H. dactylopterus. Aphanopus carbo, Beryx spp.* and *Pagellus bogaraveo* were scarce as usual and *Coryphaenoides rupestris* has not been found since 2019. Recruitment was significant for *P. blennoides, M. macrophthalma* and *H. dactylopterus*.

Introduction

The bottom trawl survey on the Northern Spanish Shelf has been carried out every autumn since 1983, except in 1987, to provide data and information for the assessment of the commercial fish species and the ecosystems on the Galician and Cantabrian shelves (ICES Divisions 8c and 9a North).

The aim of this working document is to update the results (abundance indices, length frequencies and geographic distribution) of the most common deep water fish species on the bottom trawl surveys on the Northern Spanish Shelf after the results presented previously (Blanco *et al.* 2022, 2019, Fernández-Zapico *et al.* 2020, 2018, Ruiz-Pico *et al.* 2021). The species analyzed are *Phycis blennoides* (greater forkbeard), *Molva macrophthalma* (spanish ling), *Trachyrincus scabrus* (roughsnout grenadier), *Helicolenus dactylopterus* (bluemouth), and some other scarce species as *Aphanopus carbo* (black scabbardfish), *Coryphaenoides rupestris* (roundnose grenadier), *Beryx spp.* (alfonsinos) and *Pagellus bogaraveo* (blackspot seabream). Although results on *Helicolenus dactylopterus* were not included in the ICES data call, they are also updated considering its remarkable abundance and geographical distribution in the surveyed area, and the fact that these indices were used in the WGDEEP report when reviewing the abundance and status of the stock on the north-eastern Atlantic.

Material and methods

The area covered in the Northern Spanish Shelf Groundfish Survey on the Cantabrian Sea and Off Galicia (Divisions 8c and Northern part of 9a; SPNGFS) extends from longitude 1° W to 10° W and from latitude 42° N to 44.5° N, following the standard IBTS methodology for the western and southern areas (ICES, 2017). The sampling design is random stratified with five geographical sectors (MF: Miño-Finisterre, FE: Finisterre-Estaca de Bares, EP: Estaca de Bares - Peñas, PA: Peñas - Ajo, AB: Ajo - Bidasoa) and three depth strata (70-120 m, 121-200 m and 201-500) (Figure 1, ICES, 2017). The shallower depth stratum was changed in 1997 from 30-100 m to 70-120 m, due to the small area and scarcity of trawlable shallower grounds.

Nevertheless, some extra hauls are carried out every year, if possible, to cover shallower (<70 m) and deeper (>500 m) grounds. These additional hauls are plotted in the distribution maps, although they are not included in the calculation of the stratified abundance indices since the coverage of these grounds (shallower and deeper) are not considered representative of the area. However, the information from these depths is considered relevant due to the changes in the depth distribution of fishing activities in the area (Punzón et al. 2011) and these hauls are also used to define the depth range of the species.

The standardized indices of the deep water fishes analyzed in this report probably underestimate its real biomass due to the fact that most of its catches might happen out of the standard stratification area, in additional hauls deeper than 500 m. For this reason, the catches in standard and deeper additional hauls were plotted in this report.

Results

In this last survey 129 valid hauls were carried out, 114 of these were standard hauls and 15 additional hauls (3 of them shallower than 70 m and 12 of them between 500 m and 800 m) (Figure 1).

The total stratified fish catch in biomass per haul increased strongly in 2022, staying within the high values of the time series (Figure 2).

In 2022, as usual, most of the biomass of *P. blennoides, T. scabrus, A. carbo* and *Beryx spp.* was found in the additional deep water hauls (>500 m) in contrast to *H. dactylopterus* which was mainly found in standard hauls. *P. bogaraveo* was scarcely found, mostly out of the stratification in the shallow area (<70 m). However, the species *M. macrophthalma*, traditionally found mainly in additional deep water hauls, increased its presence in standard hauls in the last two years.

The biomass of the species *T. scabrus* increased slightly whereas it increased sharply for *P. blennoides, M. macrophthalma* and especially for *H. dactylopterus*, reaching the highest value of the time series for the last two species. Bluemouth also rose in abundance terms, reaching likewise the highest value in the overall time series. Recruitment was significant for *P. blennoides, M. macrophthalma* and *H. dactylopterus*, being also noticeable the sharply rise on juveniles abundance for the latter species. Only a few specimens of *A. carbo, Beryx spp.* and *P. bogaraveo* were found but *C. rupestris* was not since 2019.

***Phycis blennoides* (greater forkbeard)**

In 2022, 21% of the hauls where *P. blennoides* was found were additional hauls deeper than 500 m and contained 77% of the biomass. This last year the biomass in standard hauls increased steadily, reaching the highest value of the previous eight years. The biomass in additional deep hauls increased even more compared to the previous year, reaching the highest value of the time series (Figure 3).
The geographical distribution of *P. blennoides* remained similar to previous years, being widespread in the sampling area (Figure 4).
The length distribution in standard hauls was similar to the previous year, with a great recruitment again and a mode in 18 cm (Figure 5).
The largest individuals,which ranged from around 24 cm to 66 cm, were found mostly in the additional deeper hauls, with a mode in 38 cm (Figure 6).

***Molva macrophthalma* (Spanish ling)**

In 2022, the biomass of *M. macrophtalma* increased sharply again in standard hauls, reaching the highest value of the time series, as it had already happened the previous year, whereas it decreased slightly in additional hauls deeper than 500 m (Figure 7). Unlike other years in the time series, although following the line of last year, most of the biomass (65 %) was found in standard hauls (70 - 500 m) which were 85 % of the total hauls with *M. macrophtalma.*
The species kept on being widespread in the study area but presented more spots this last survey (Figure 8).
The strong increase of recruitment in standard hauls shown the previous year is repeated in this last survey, showing a mode in 24 cm, and it is noticeable in the increment on the range of sizes, showing a second class of size, with a mode in 39 cm (Figure 9).
In contrast, in additional deeper hauls larger specimens, up to 123 cm, were found (Figure 10).

***Trachyrincus scabrus* (roughsnout grenadier)**

T. scabrus has been found mostly in additional hauls (>500 m) in the last decade. In 2022, this species was caught in five hauls, being all of them deep hauls, out of the standard stratification, and catches increased slightly compared to the previous year (Figure 11).
The geographical distribution showed more or less the same pattern during the time series, being captured in the deep hauls throughout the study area. However, the point of biomass usually caught in recent years on southern MF sector, was not caught this last survey (Figure 12).
Specimens ranged from 40 mm to 245 mm, although more abundance of large specimens (145 to 200 mm) was found, with a mode in 180 mm (Figure 13).

***Helicolenus dactylopterus* (bluemouth)**

Although bluemouth is not requested for ICES DCF Data Call, the biomass and abundance are significant in the area and useful for the assessment of the stock (ICES, 2017).
H. dactylopterus has mainly been found in standard hauls, therefore the catches of the additional deeper hauls are not plotted.
In 2022, both the biomass and abundance rose sharply, increasing five times the biomass value of the previous year and almost four times that of abundance. Both values, which were already high the previous year comparing to the time series, have reached the highest values in the overall time series (Figure 14).

The geographical distribution of *H. dactylopterus* remained similar to the previous year, with greater biomass in the Galician area, but striking in this last survey, and the usual spot in the easternmost Ajo-Bidasoa sector (Figure 15).
Length distribution showed a moderate sign of recruitment, with a small mode in 6 cm, and also a strong increment in the abundance of a second size class individuals ranged among 11 cm and 37 cm, with a marked mode in 12-13 cm (Figure 16).

Other scarce deep water species

Other species scarcely caught in the survey were *Aphanopus carbo*, *Beryx spp.* and *Pagellus bogaraveo*. They have been mainly found out of the standard stratification, the first three species in deeper additional hauls (>500 m) whereas *P. bogaraveo* in shallower additional hauls (< 70 m).
The species *C. rupestris* has continued to be absent since 2019.
A. carbo was caught in three hauls among 559 m and 608 m in easternmost Cantabrian sea (Figure 17 and Figure 18), with a total of six specimens which ranged from 87 to 104 cm.
Beryx spp. were found in two hauls between 540 m and 589 m in Galician waters and in three hauls among 530 m and 609 m in the Cantabrian sea (Figure 19 and Figure 20). Five specimens were *B. decadactylus*, ranged among 25 and 32 cm, and one was *B. splendens* with 29 cm.
Forty nine specimens of *P. bogaraveo* between 8 and 28 cm were found among 40 and 92 m depth in three hauls in the Cantabrian Sea (Figure 21 and Figure 22).

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Figures

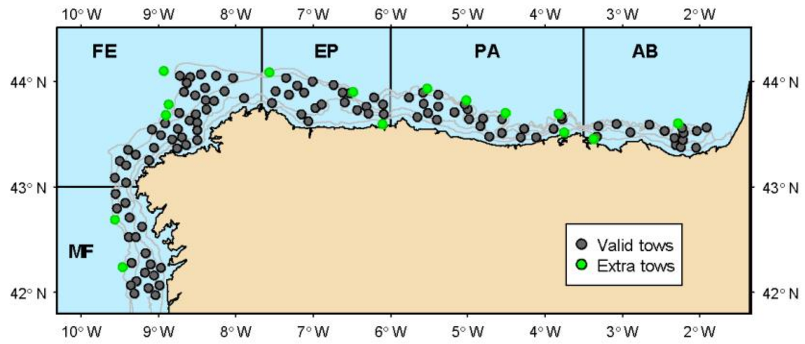

Figure 1 Stratification design and hauls on the Northern Spanish shelf groundfish survey in 2022; Depth strata are: A) 70-120 m, B) 121 – 200 m and C) 201 – 500 m. Geographic sectors are MF: Miño-Finisterre, FE: Finisterre-Estaca, EP: Estaca-cabo Peñas, PA: Peñas-cabo Ajo, and AB: Ajo-Bidasoa

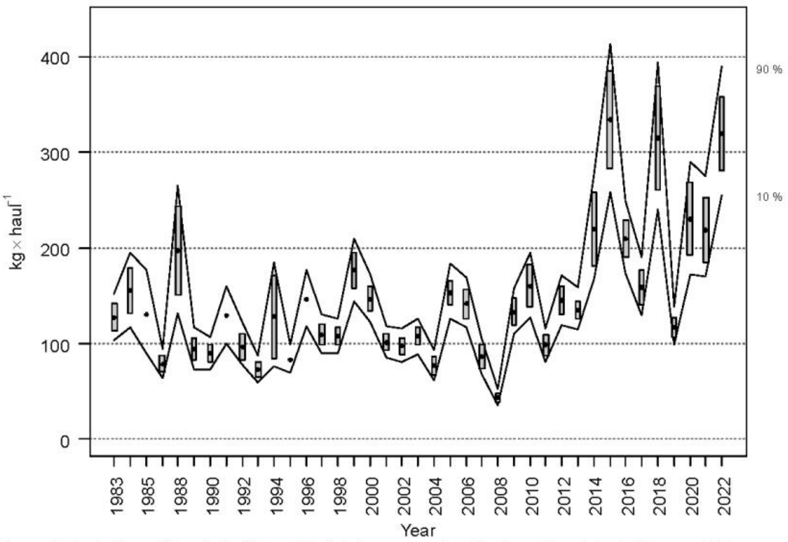

Figure 2 Evolution of the total fish catch in biomass on the Northern Spanish shelf groundfish survey, only standard hauls (>70 m & <500 m considered within the standard sampling stratified to the area.

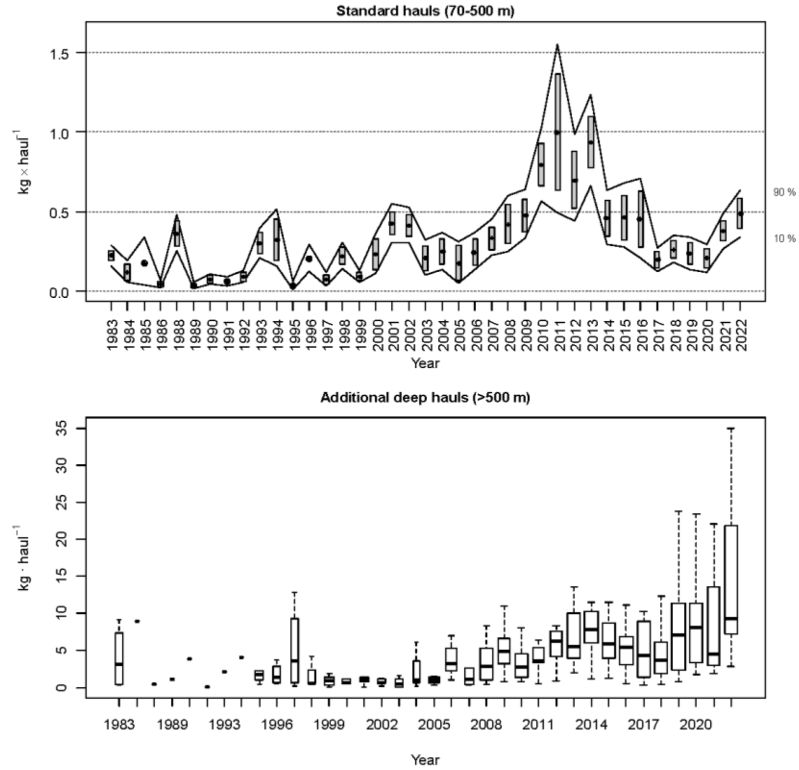

Figure 3 Evolution of *Phycis blennoides* stratified biomass index in standard hauls and additional deep hauls during the North Spanish shelf bottom trawl survey time series. For the standard hauls boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). For the additional deep water hauls boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

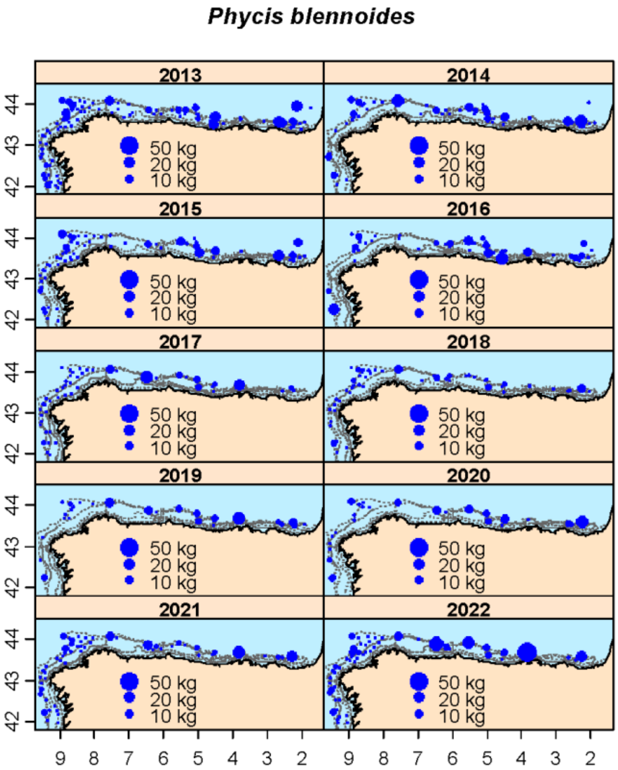

Figure 4 Geographic distribution of *Phycis blennoides* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl surveys in the last decade

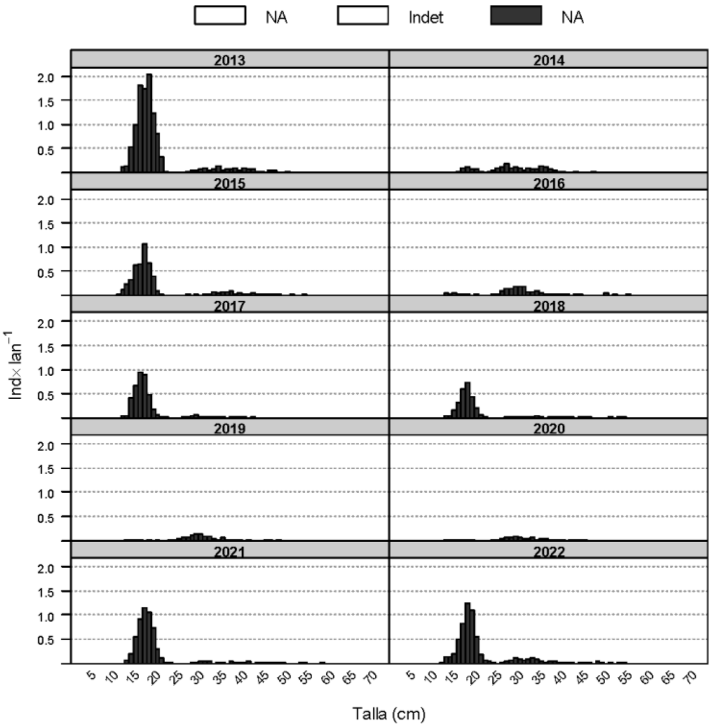

Figure 5 Mean stratified length distributions of *Phycis blennoides* in Northern Spanish Shelf surveys in the last decade

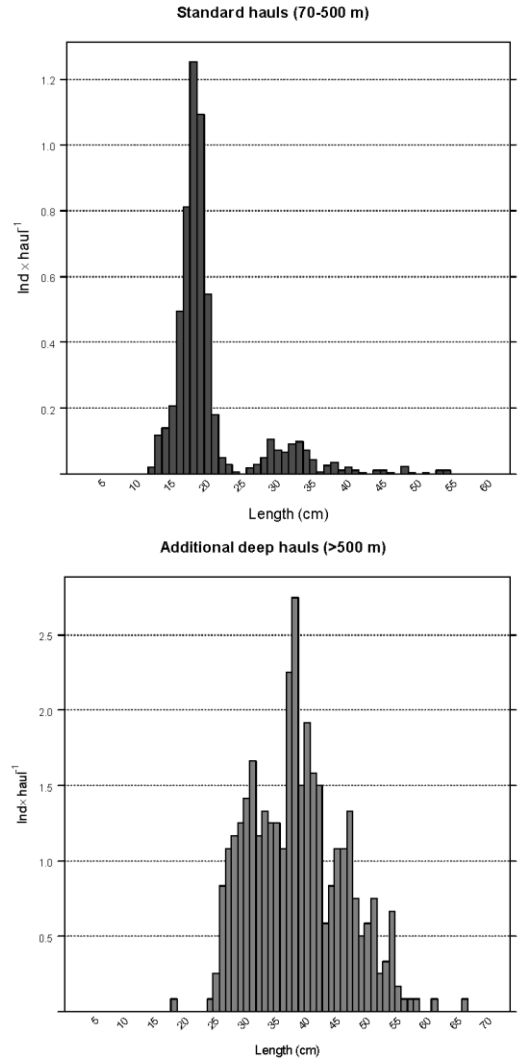

Figure 6 Mean length distributions of *Phycis blennoides* in additional hauls (>500 m) and in the standard hauls (70-500 m) in the North Spanish Shelf survey 2022

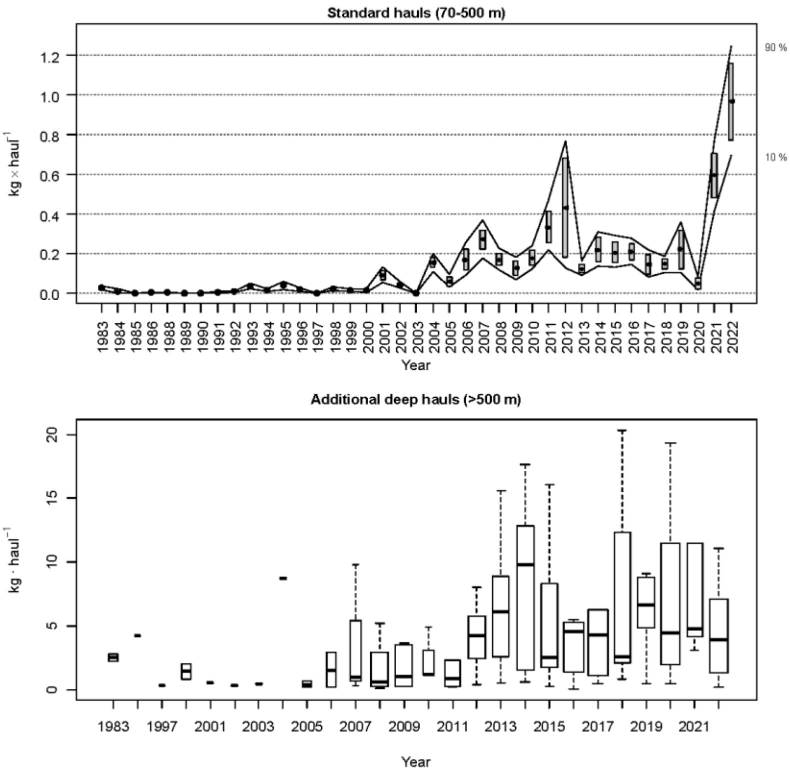

Figure 7 Evolution of *Molva macrophtalma* stratified biomass index in standard hauls and additional deep hauls during the North Spanish shelf bottom trawl survey time series. For the standard hauls boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). For the additional deep water hauls boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

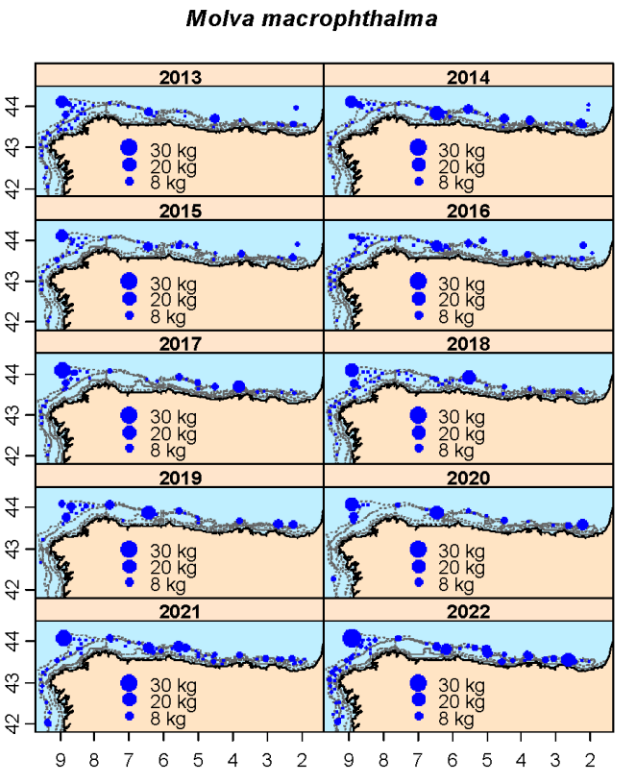

Figure 8 Geographic distribution of *Molva macrophtalma* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl surveys in the last decade

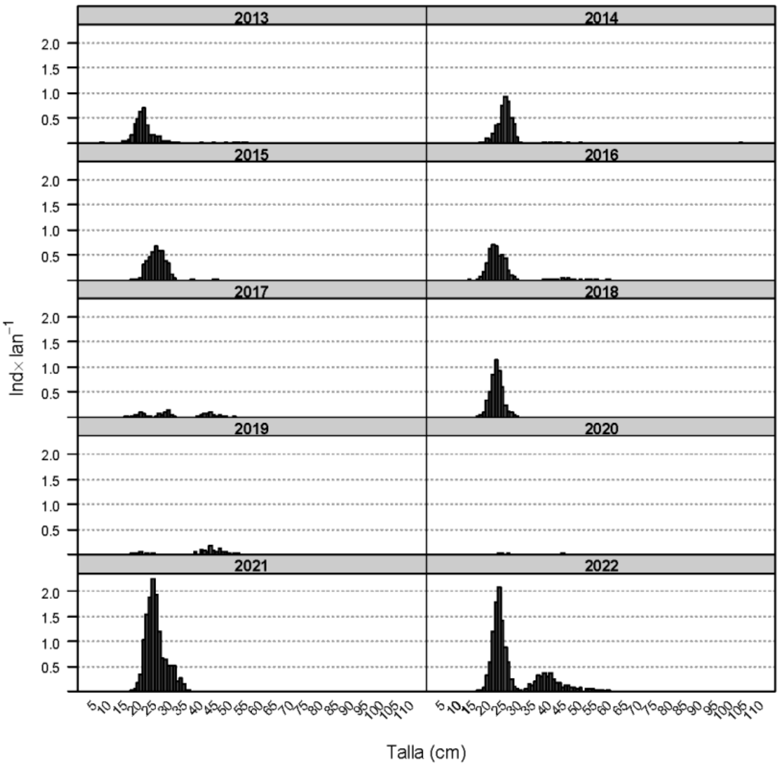

Figure 9 Mean stratified length distributions of *Molva macrophtalma* in Northern Spanish Shelf surveys in the last decade

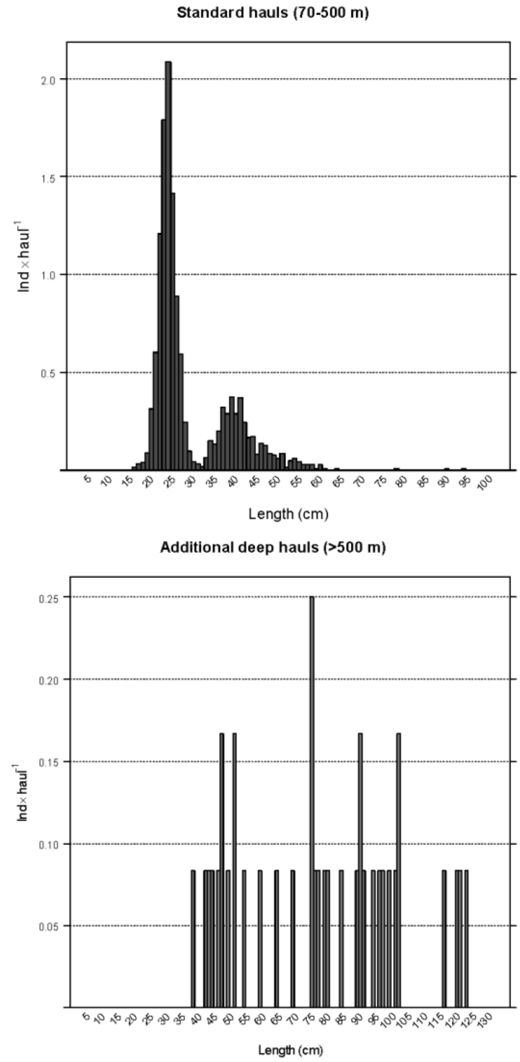

Figure 10 Mean length distributions of *Molva macrophtalma* in additional hauls (>500 m) and in the standard hauls (70-500 m) in the North Spanish Shelf survey 2022

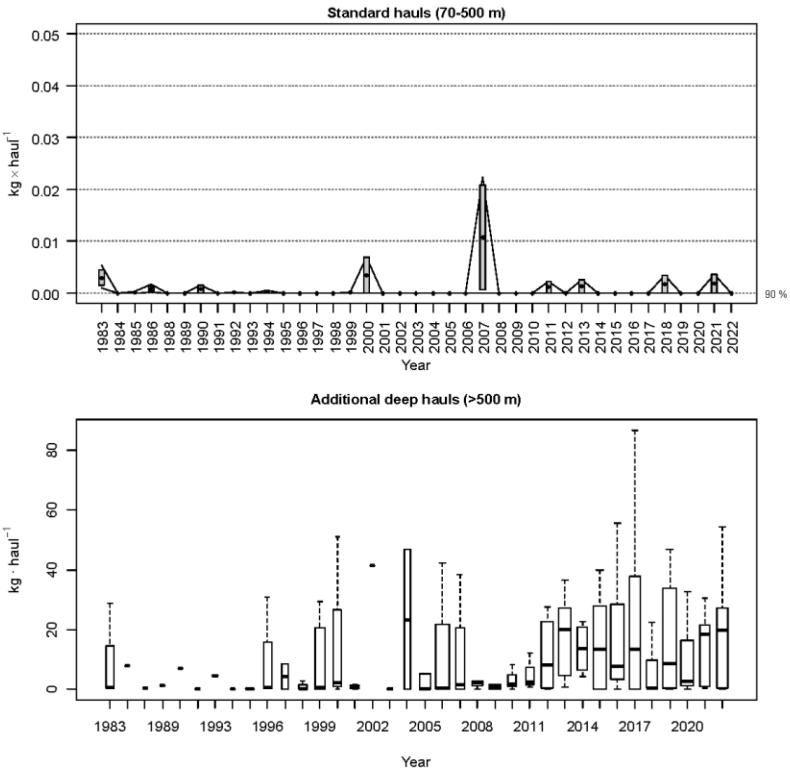

Figure 11 Evolution of *Trachyrincus scabrus* stratified biomass index in standard hauls and additional deep hauls during the North Spanish shelf bottom trawl survey time series. For the standard hauls boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). For the additional deep water hauls boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

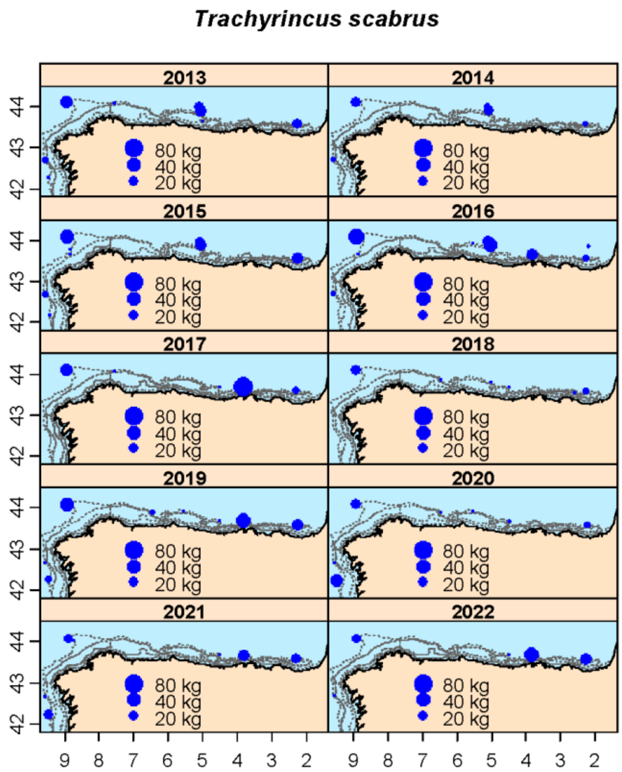

Figure 12 Geographic distribution of *Trachyrincus scabrus* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl surveys in the last decade

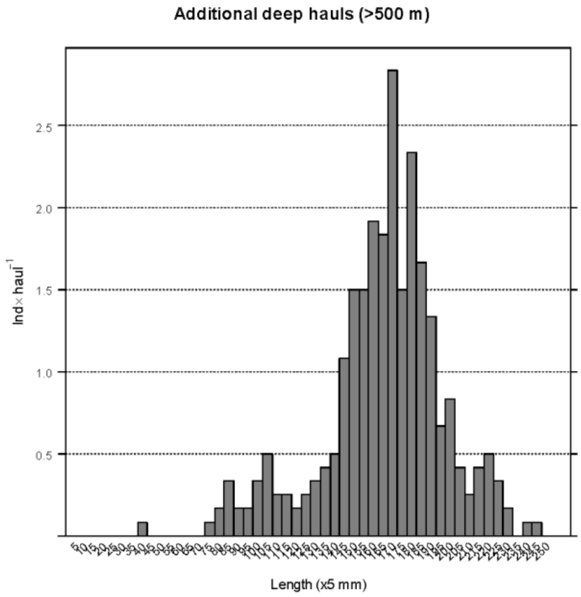

Figure 13 Mean length distributions of *Trachyrincus scabrus* in additional hauls (>500 m) in the North Spanish Shelf survey 2022

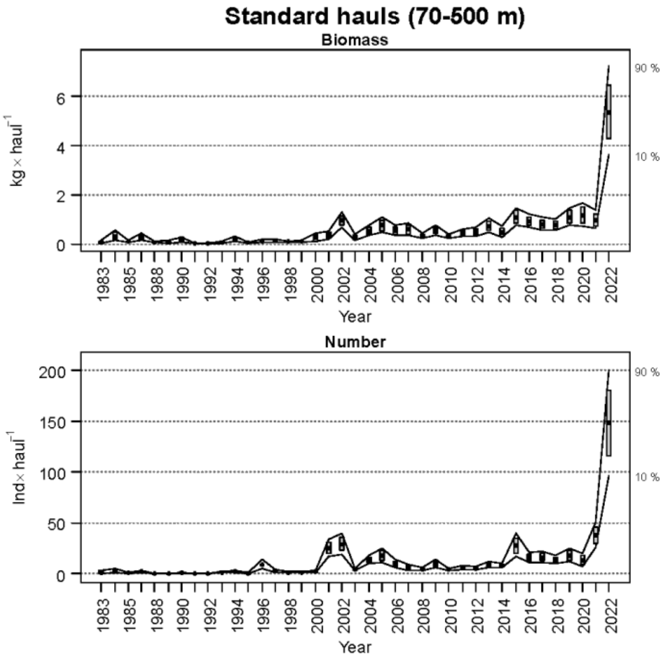

Figure 14 Evolution of *Helicolenus dactylopterus* mean stratified biomass and abundance in Northern Spanish Shelf surveys time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

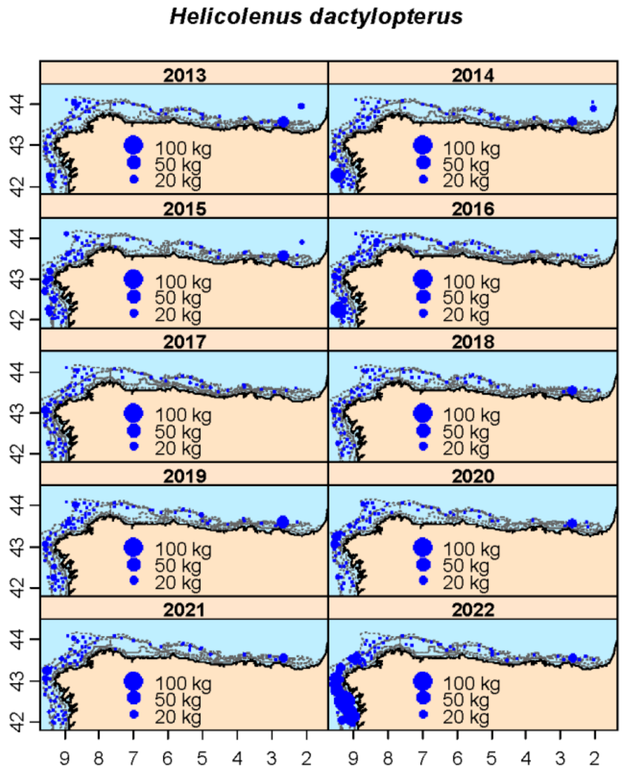

Figure 15 Geographic distribution of *Helicolenus dactylopterus* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl surveys in the last decade

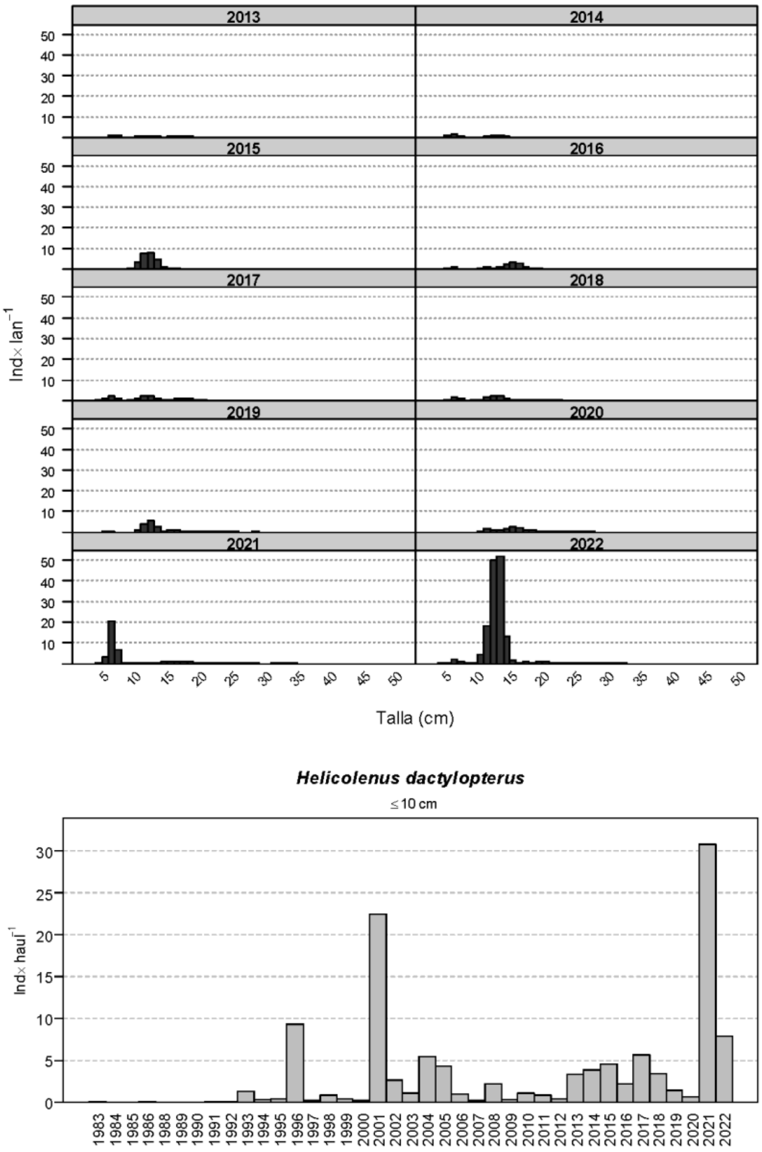

Figure 16 upper plot) Mean stratified length distribution of *Helicolenus dactylopterus* in Northern Spanish Shelf surveys during the last decade
lower plot) *H. dactylopterus* recruitment (< 10 cm) along the north Spanish shelf ground fish survey time series

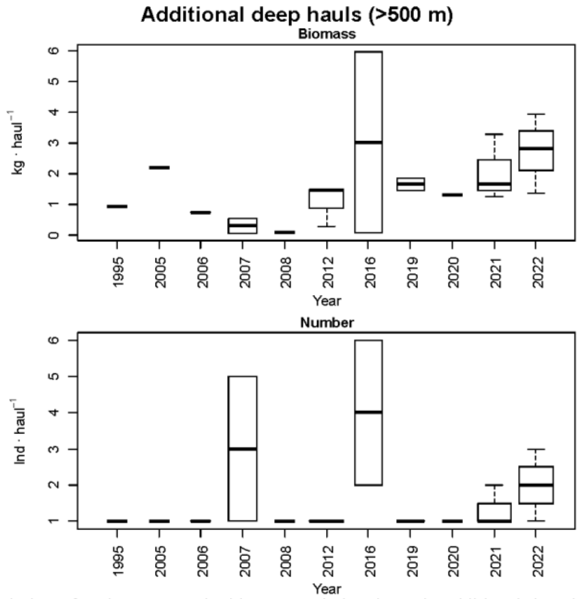

Figure 17 Evolution of *Aphanopus carbo* biomass and abundance in additional deep hauls during the North Spanish shelf bottom trawl survey time series. Boxplots represent the median and interquartiles of the biomass and abundance catches in the deep hauls performed.

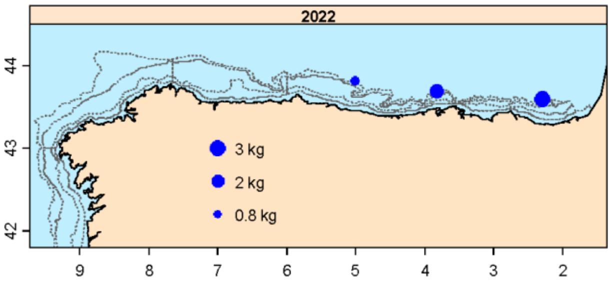

Figure 18 Geographic distribution of *Aphanopus carbo* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl survey 2022

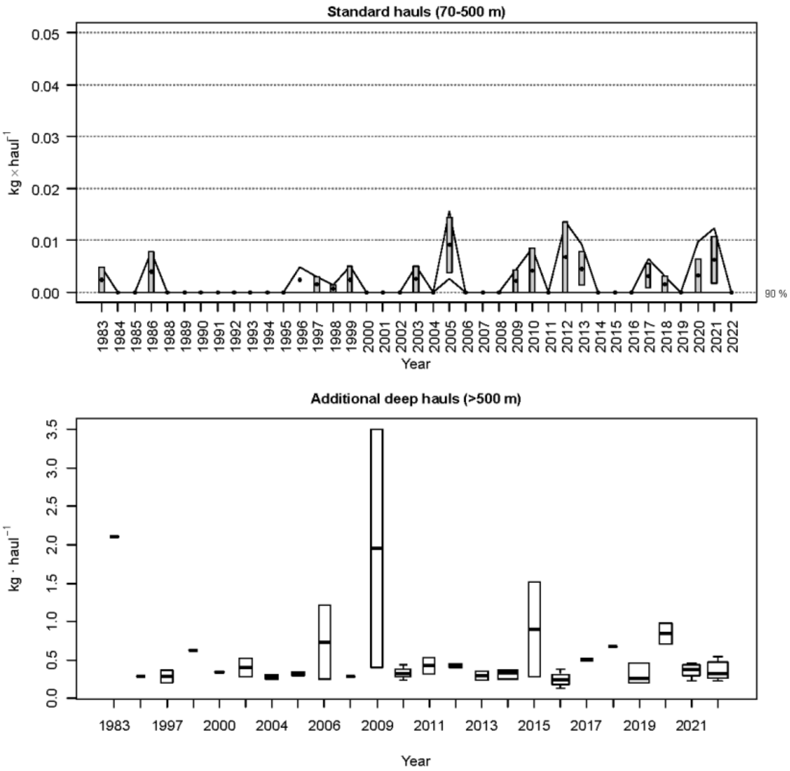

Figure 19 Evolution of *Beryx spp.* stratified biomass index in standard hauls and additional deep hauls during the North Spanish shelf bottom trawl survey time series. For the standard hauls boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). For the additional deep water hauls boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

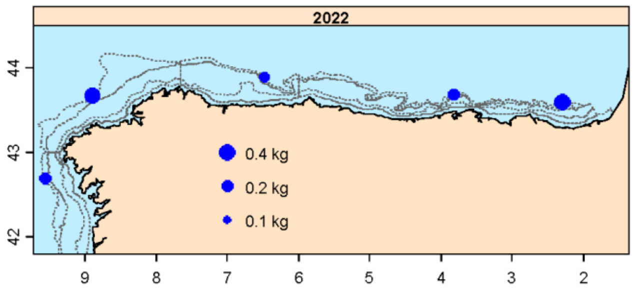

Figure 20 Geographic distribution of *Beryx* spp. catches (kg•haul-1) in the Northern Spanish Shelf bottom trawl survey 2022

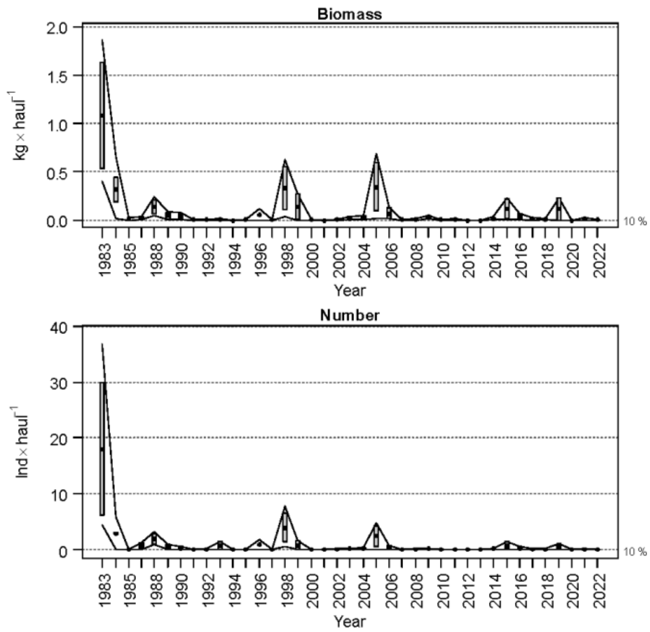

Figure 21 Evolution of *Pagellus bogaraveo* mean stratified biomass and abundance in Northern Spanish Shelf surveys time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

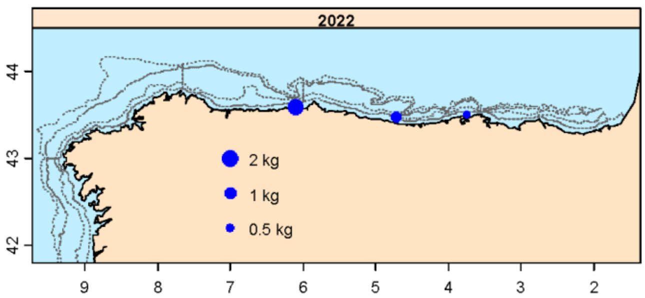

Figure 22 Geographic distribution of *Pagellus bogaraveo* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl survey 2022

Working Document to be presented to the Working Group on the
Biology and Assessment of Deep Sea Fisheries Resources

ICES WGDEEP 3rd - 9th May 2023, Lisbon, Portugal

Results on silver smelt (*Argentina silus* and *A. sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*), roughsnout grenadier (*Trachyrincus scabrus*), Spanish ling and ling (*Molva macrophthalma* and *Molva molva*) from the 2022 Spanish Groundfish Survey on the Porcupine Bank (NE Atlantic)

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Abstract

This working document presents the results of the most significant deep-sea fish species caught in 2022 on the Porcupine Spanish Groundfish Survey (SP-PORC-Q3). Biomass, abundance, geographical distribution and length ranges were analysed for silver smelt (*Argentina silus* and *A. sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater fork-beard (*Phycis blennoides*), roughsnout grenadier (*Trachyrincus scabrus*), Spanish ling and ling (*Molva macrophthalma* and *Molva molva*) and other scarce deep sea species. Overall, the biomass of these target species increased in this last survey, except for *P. blennoides* and *M. macrophthalma*. Despite that raise, the recruitment was poor.

Introduction

The Spanish bottom trawl survey on the Porcupine Bank (ICES Divisions 7c and 7k) has been carried out annually on the third-quarter (September) since 2001 to study the distribution, relative abundance and biological parameters of commercial fish in the area (ICES 2017).

The aim of this working document is to update the results (abundance indices, length frequency and geographic distributions) of the most common deep-sea fish species on the Porcupine bottom trawl surveys after the results presented previously (Baldó *et al.* 2008, Velasco *et al.* 2009, 2011, 2012, 2013, Fernández-Zapico *et al.* 2015, 2017, 2021, 2022, Ruiz-Pico *et al.* 2016, 2018, 2019, 2020). The species analysed were: *Argentina silus* (greater silver smelt), *Argentina sphyraena* (lesser silver smelt), *Helicolenus dactylopterus* (bluemouth), *Phycis blennoides* (greater forkbeard), *Trachyrincus scabrus* (roughsnout grenadier), *Molva molva* (ling) and *Molva macrophthalma* (Spanish ling) and some other scarce deep sea species as *Aphanopus carbo* (black scabbardfish), *Brosme brosme* (tusk) *Coryphaenoides rupestris* (roundnose grenadier), *Hoplostethus atlanticus* and *Beryx* spp.

Material and methods

The Spanish Ground Fish Survey on the Porcupine Bank (SP-PORC-Q3) has been annually carried out since 2001 onboard the R/V "*Vizconde de Eza*", a stern trawler of 53 m and 1800 Kw. The area covered extends from longitude 12° W to 15° W and from latitude 51° N to 54° N, following the standard IBTS methodology for the western and southern areas (ICES 2017). The sampling design was random stratified to the area (Velasco and Serrano, 2003) with two geographical sectors (Northern and Southern) and three depth strata (< 300 m, 300 – 450 m and 450 - 800 m) (Figure 1). Hauls allocation is proportional to the strata area following a buffered random sampling procedure (as proposed by Kingsley et al., 2004) to avoid the selection of adjacent 5×5 nm rectangles. Extra hauls were performed within the standard stratification to improve coverage in gaps left by random sampling and outside the standard stratification to explore the continuity of the fish community in Porcupine Seabight.

More details on the survey design and methodology are presented in ICES (2017).

The tow duration is 20 min since 2016, but the results were extrapolated to 30 min of trawling time to keep up the time series.

Results and discussion

In 2022, 80 valid standard hauls and 11 extra hauls were carried out, 6 of them below 1000 m in the Porcupine Seabight (Figure 1).

The total stratified catch per haul increased in 2022 reaching the highest value of the time series (Figure 2). Fish represented 95% of the total catch, and the selected deep water fish represented 13% of that total fish catch, with the following percentages per species: *Argentina silus* (38%), *Helicolenus dactylopterus* (31%), *Argentina sphyraena* (14%), *Trachyrincus scabrus* (11%), *Phycis blennoides* (5%), *Molva macrophthalma* (0.5%) and *Molva molva* (0.2%).

In 2022, the biomass of two *Argentina* species, *H. dactylopterus* and *T. scabrus* increased and even reached the highest values of the time series in the two last species. However, the biomass of *P. blennoides* and the two *Molva* species remained among the low values of the time series. Overall, recruitment decreased or remained at low values similar to those of the previous year. The species *Aphanopus carbo, Brosme brosme, Coryphaenoides rupestris, Hoplostethus atlanticus* and *Beryx spp.* were scarce and were found mainly outside the standard stratification, except *Beryx spp.*

***Argentina silus* (greater silver smelt) and *Argentina sphyraena* (lesser silver smelt)**

In 2022, the biomass and abundance of both species of *Argentina* increased, to high values of the time series for *A. sphyraena* whereas only to low-medium values for *A. silus*, the species that historically contributes most to the genus in the survey (Figure 3; Figure 4; Figure 5).

Both species were more abundant in the north of the bank, in particular in the northeast area in this last survey. *A. silus* was also found in the south of the study area, as usual, but mainly in the deeper southeastern strata in this last survey (Figure 6 and Figure 7).

The sizes of both species kept a similar distribution to previous years, *A. sphyraena* with a single mode around 23 cm and *A. silus* with two smaller modes, one rough of 22 cm and a smooth one around 30 cm (Figure 8).

***Helicolenus dactylopterus* (bluemouth)**

Although bluemouth is not requested in the ICES DCF Data Call, biomass and abundance are significant in the area and useful for the assessment of the species (ICES, 2015).

Biomass and abundance of *H. dactylopterus* followed the upward trend of the last three years reaching an all-time record high this last survey (Figure 9). However, recruitment has been falling for the last two years and was even lower in this last survey (Figure 10).

H. dactylopterus was found throughout the study area, even in the northwest of the bank where the largest biomass patches were found. However, recruits were hardly found in their usual areas, the Irish shelf and the southeastern area of the bank (Figure 11).

In the size distribution of H. dactylopterus in this latest survey only one mode was found, but a record size of about 17 cm (Figure 12). The few recruits were mainly of 7 and 8 cm, unlike the previous year when 11-12 cm specimens were more abundant.

***Trachyrincus scabrus* (roughsnout grenadier)**

T. scabrus increased sharply breaking the downward trend of the three previous years and reaching the highest value in the time series (Figure 13).

The species was found in the deepest southeastern and western area, as usual, but more abundantly in this lastest survey (Figure 14).

The length distribution in 2022 showed a marked mode around 18 cm in contras to the smooth outline of the previous year. Specimens of 11 to 13 cm were scarce in this last survey, but a few more recruits of 6 and 11 cm were found (Figure 15).

***Phycis blennoides* (greater fork-beard)**

Biomass and abundance of *P. blennoides* decreased slightly and remained among the lowest values of the time series (Figure 16).

Biomass patches were widely found in the south, west and east, but scarcely in the north, as in previous years (Figure 17).

Most specimens were from 28 cm to 35 cm in this last survey and fewer recruits were found in contrast to the previous year (Figure 18).

***Molva molva* (ling) and *Molva macrophthalma* (Spanish ling)**

These two species were analysed comparatively in this working document, as in previous reports.

M. molva was scarcer than *M. macrophthalma* in the area. Both species have been on a downward trend since 2014 and has not yet been reverted. In this last survey, the biomass and abundance of *M. macrophthalma* decreased further, reaching the lowest value of the time series (1.02 kg $haul^{-1}$ and 1.27 ind. $haul^{-1}$), whereas *M. molva* increased slightly (Figure 19).

The few biomass patches of *M. molva* were found in the west and southeast of the bank whereas *M. macrophthalma* was found in the west but further south and in the south of the study area, though scarcer than in previous years (Figure 20).

Only 9 specimens of *M. molva* were found, ranging from 31 to 99 cm. Specimens of *M. macrophthalma*, a few more, sized from 14 to 97 cm (Figure 21).

Other deep-sea fish species

The deep water species *Aphanopus carbo, Brosme brosme, Coryphaenoides rupestris, Hoplostethus atlanticus* and *Beryx spp.* were scarcely or not found in the standard stratification of the study area, but were found outside of it, except for *Beryx* spp.

In 2022, the species *C. rupestris* and *H. atlanticus* were only found in deep hauls carried out in the Porcupine Seabight, outside the stratification, the first species in five hauls from 1039 and 1477 m and the second one in three hauls between 1302 and 1477 m.

The species *A. carbo* was found from 626 and 1492 m, mainly in deep hauls in the Porcupine Seabight, but also in four hauls in the standard stratification.

The species *Brosme brosme* was not found in the three previous years, but in this last survey was found again, one specimen in one haul in the standard stratification at 489 m and also two specimens in one haul in the Porcupine Seabight at 1032 m.

Species of the genus *Beryx* were found in the standard stratification, *Beryx splendes* in the southern part of the bank (three specimens of 25, 29 and 30 cm) and *Beryx decadatylus* in the east area, but only two specimens of 28 and 30 cm, in one haul.

Acknowledgements

We would like to thank the *R/V Vizconde de Eza* crew and the IEO scientific teams that made the Porcupine Spanish Groundfish Survey possible. Included in the ERDEM project, the survey has been co-funded by the EU through the European Maritime and Fisheries Fund (EMFF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

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Figures

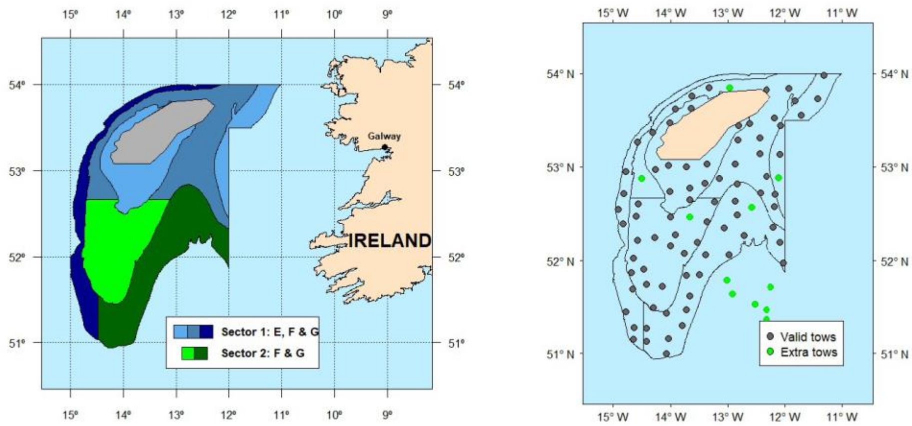


Figure 1. Left: Stratification design used in Porcupine surveys from 2003, previous data were re-stratified. Depth strata are: E) shallower than 300 m, F) 301 – 450 m and G) 451 – 800 m. The grey area in the middle of Porcupine bank corresponds to a large non-trawlable area, not considered for area measurements and stratification. Right: Distribution of hauls performed in the last survey.

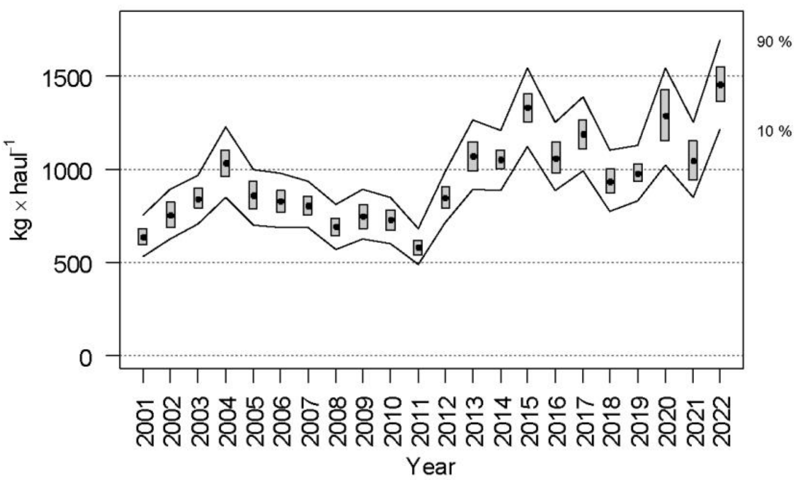


Figure 2. Evolution of the total fish catch in biomass in the Porcupine surveys.

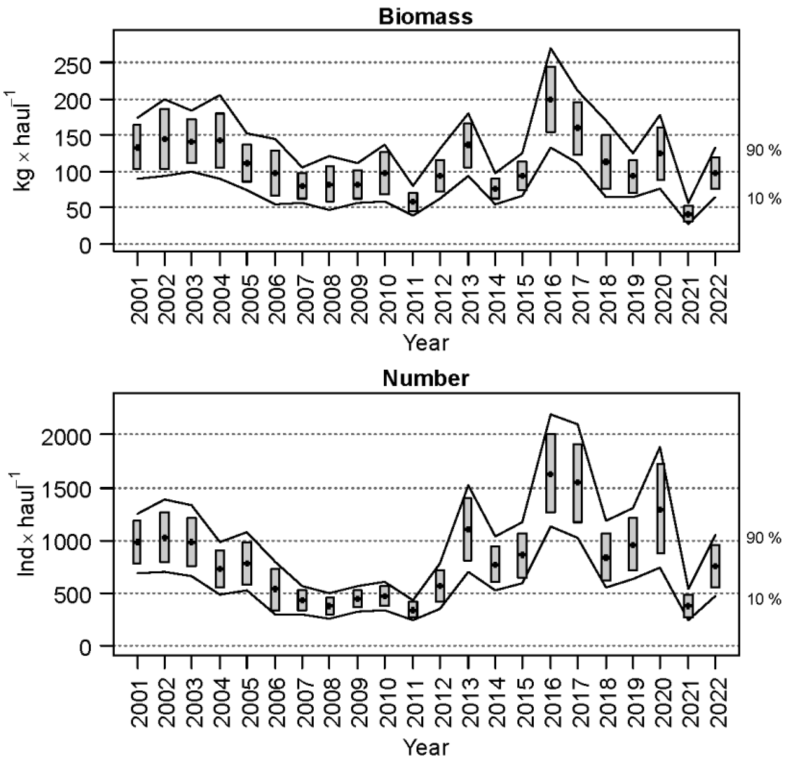


Figure 3. Evolution of biomass and abundance indices *Argentina* spp. (mainly *Argentina silus*) in the Porcupine surveys. Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals ($\alpha = 0.80$, bootstrap iterations = 1000).

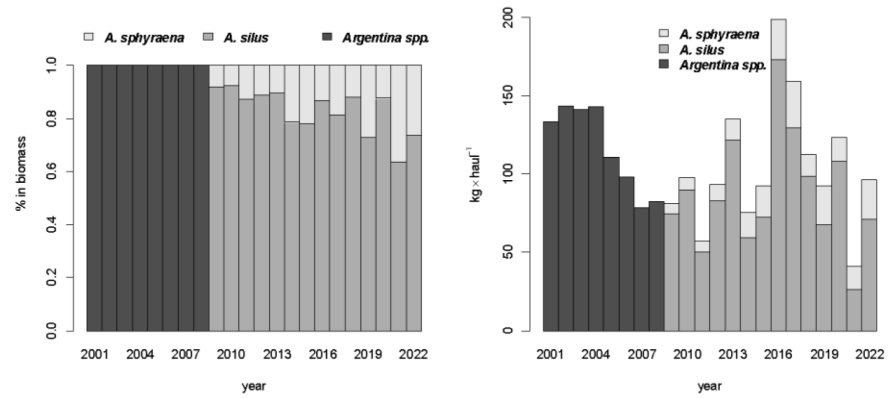


Figure 4. Share and abundance of Argentine species in the Porcupine surveys.

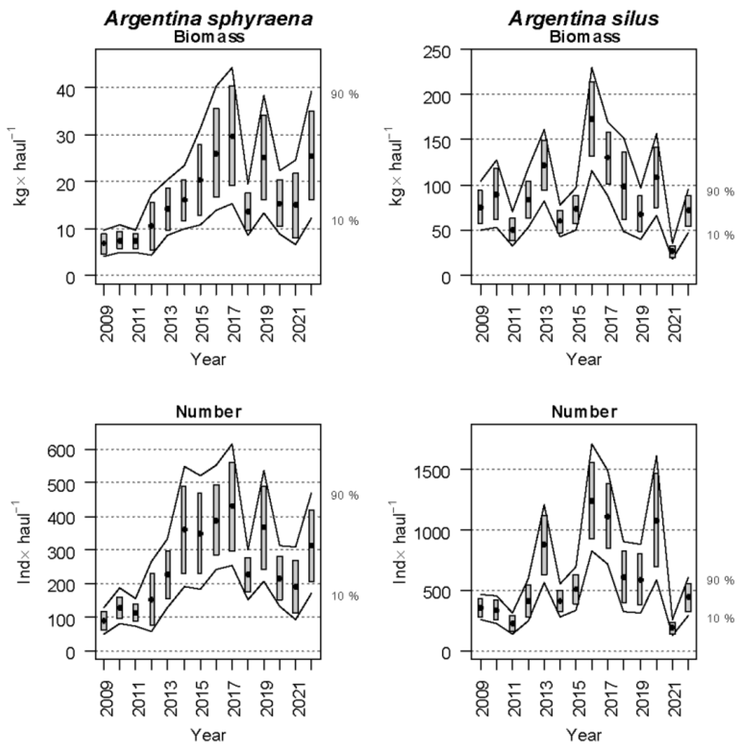


Figure 5. Evolution of biomass and abundance indices of *Argentina sphyraena* and *Argentina silus* in the Porcupine surveys. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000).

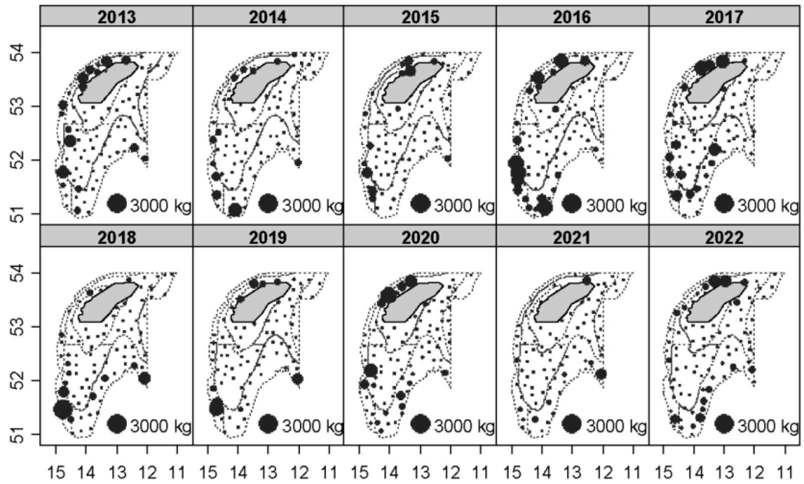
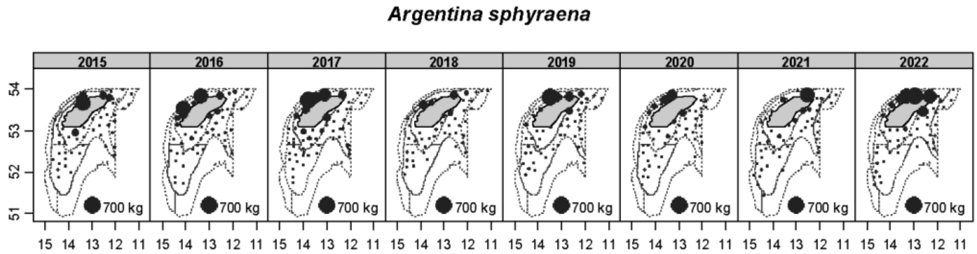


Figure 6. Geographic distribution of *Argentina* spp. catches (kg/30 min haul) in Porcupine surveys over the last decade.



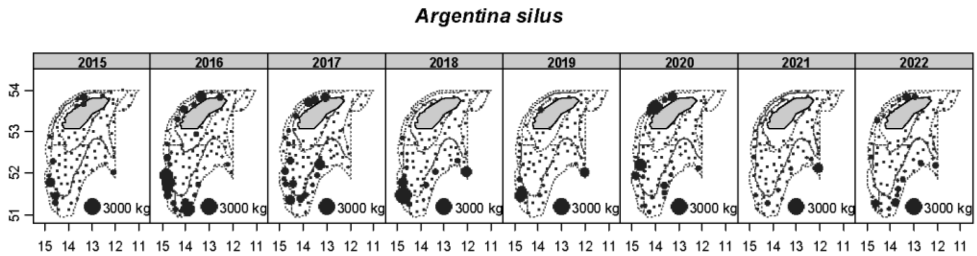


Figure 7. Geographic distribution of *Argentina sphyraena* and *Argentina silus* catches (kg/30 min haul) in Porcupine surveys (2015 - 2022).

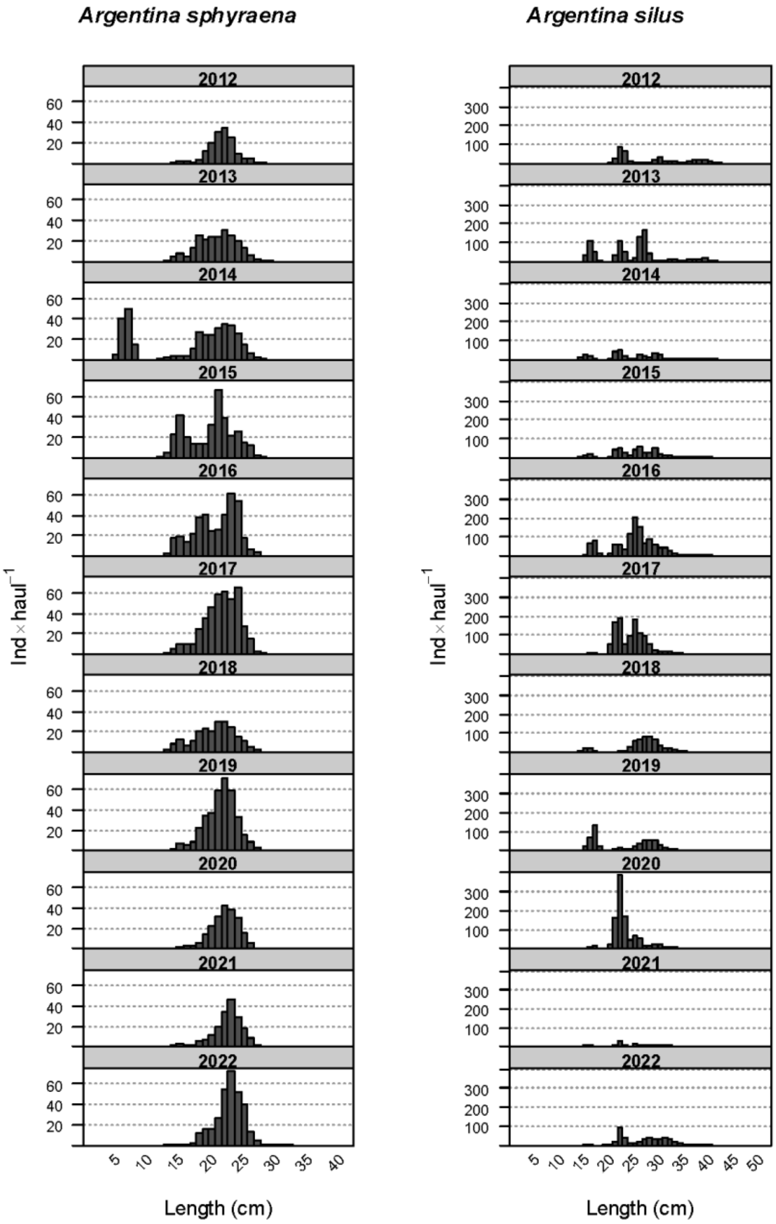


Figure 8. Mean stratified length distributions of *Argentina sphyraena* and *Argentina silus* in the Porcupine surveys (2012-2022).

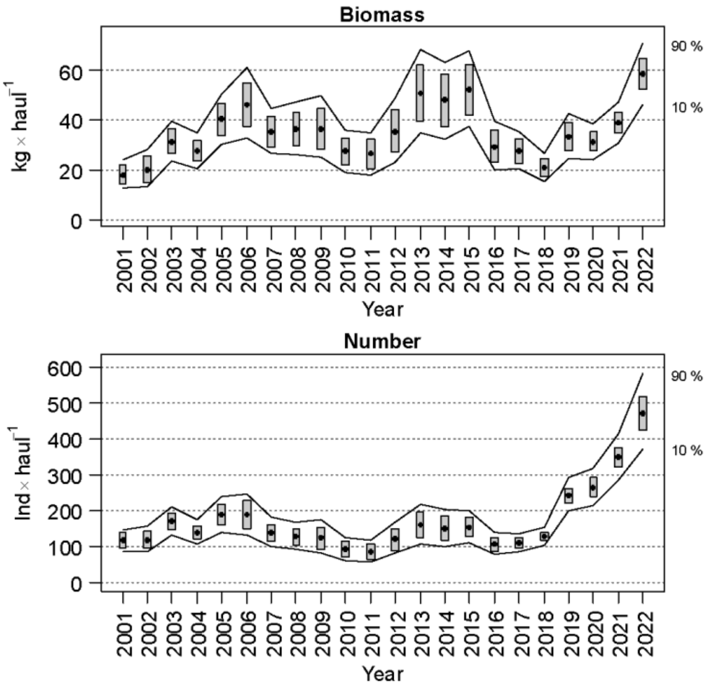


Figure 9. Evolution of biomass and abundance indices of *Helicolenus dactylopterus* in the Porcupine surveys. Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000).

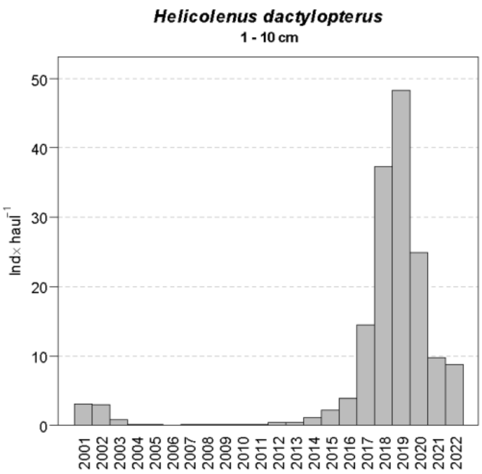


Figure 10. Mean stratified abundance of *Helicolenus dactylopterus* recruits (1-10 cm) in the Porcupine surveys.

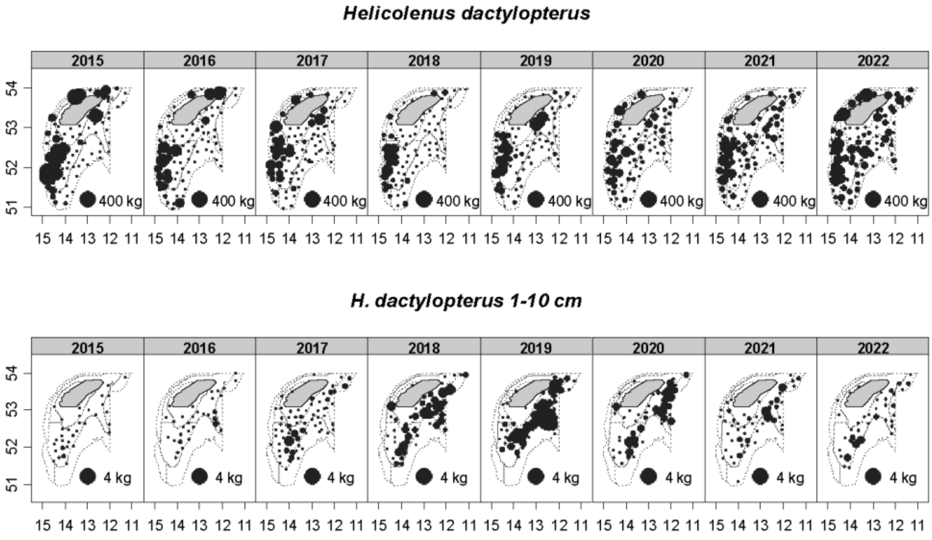


Figure 11. Geographic distribution of *Helicolenus dactylopterus* catches (kg×30 min haul-1) and recruits (1-10 cm) in the Porcupine surveys (2015-2022).

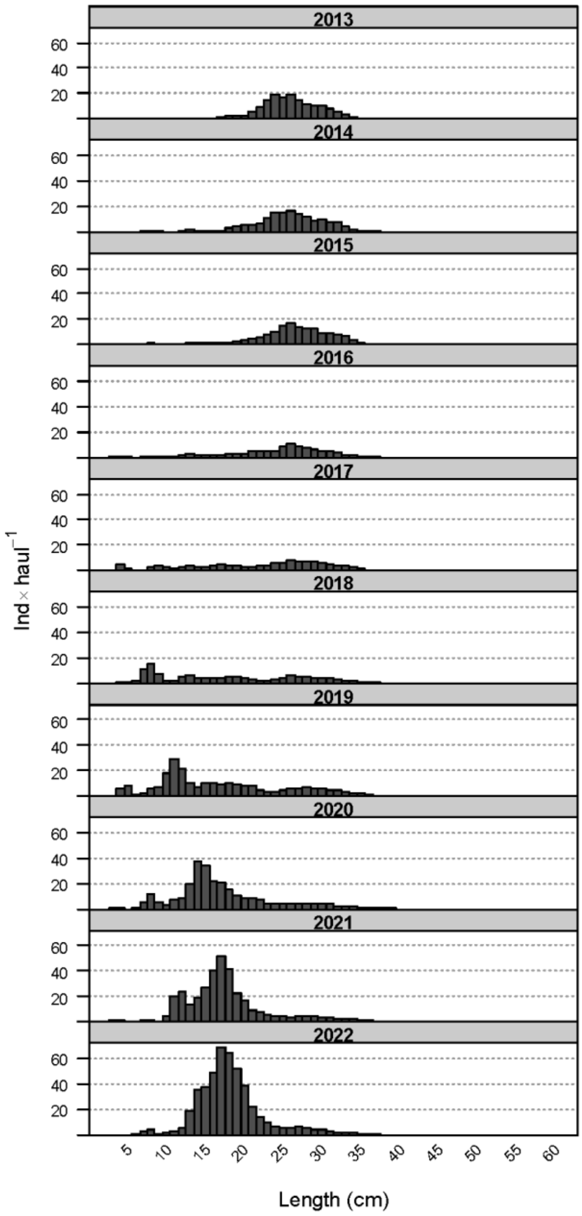


Figure 12. Mean stratified length distributions of *Helicolenus dactylopterus* in the Porcupine surveys (2013-2022).

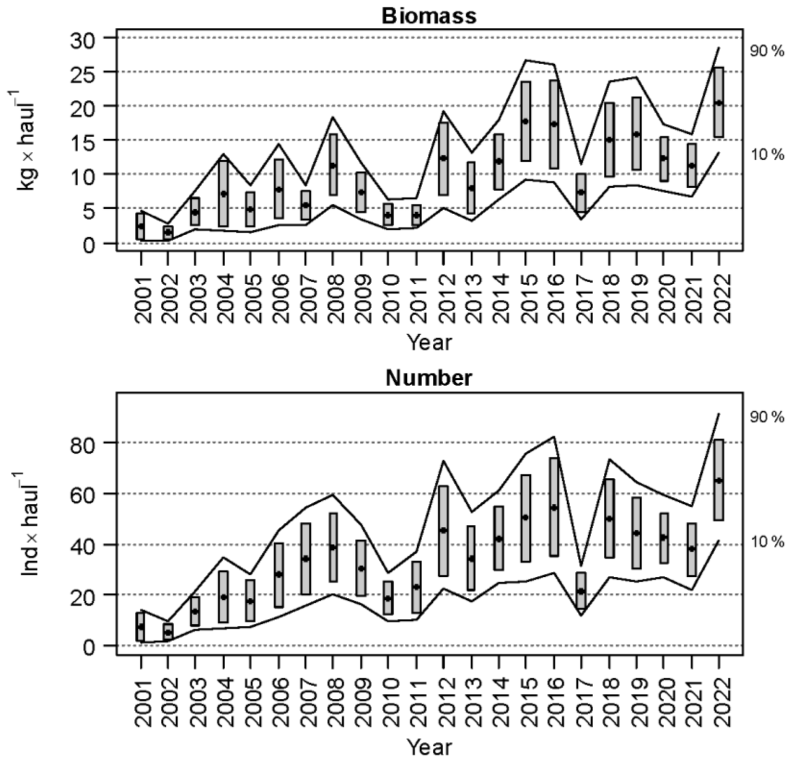


Figure 13. Evolution of biomass and abundance indices of *Trachyrincus scabrus* in the Porcupine surveys. Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals ($\alpha = 0.80$, bootstrap iterations = 1000).

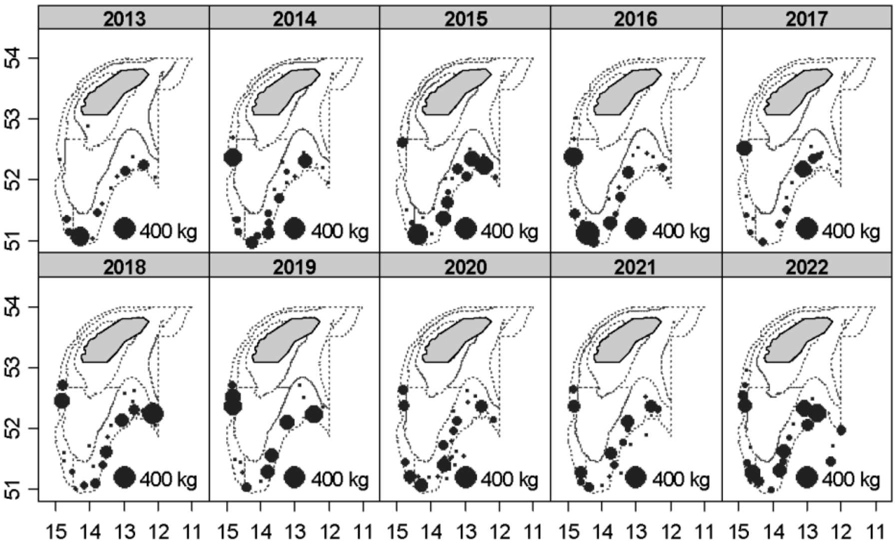


Figure 14. Geographic distribution of *Trachyrincus scabrus* catches (kg/30 min haul) in the Porcupine surveys over the last decade.

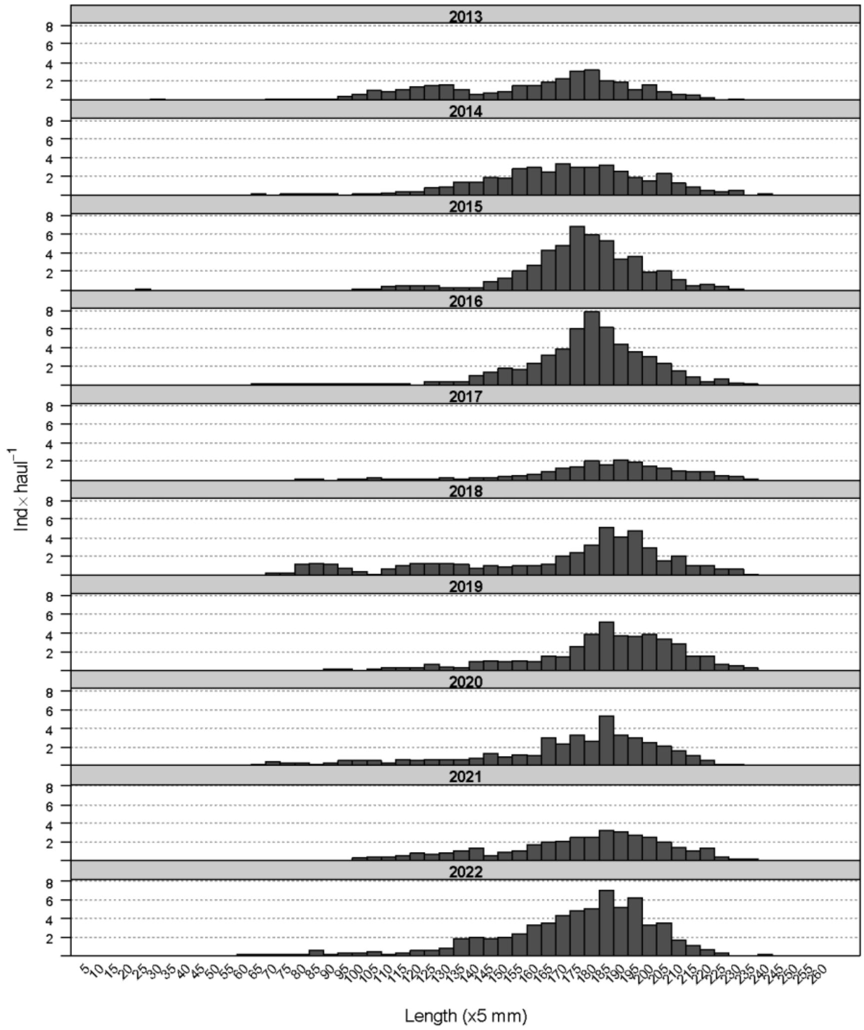


Figure 15. Mean stratified length distributions of *Trachyrincus scabrus* in the Porcupine surveys (2013-2022).

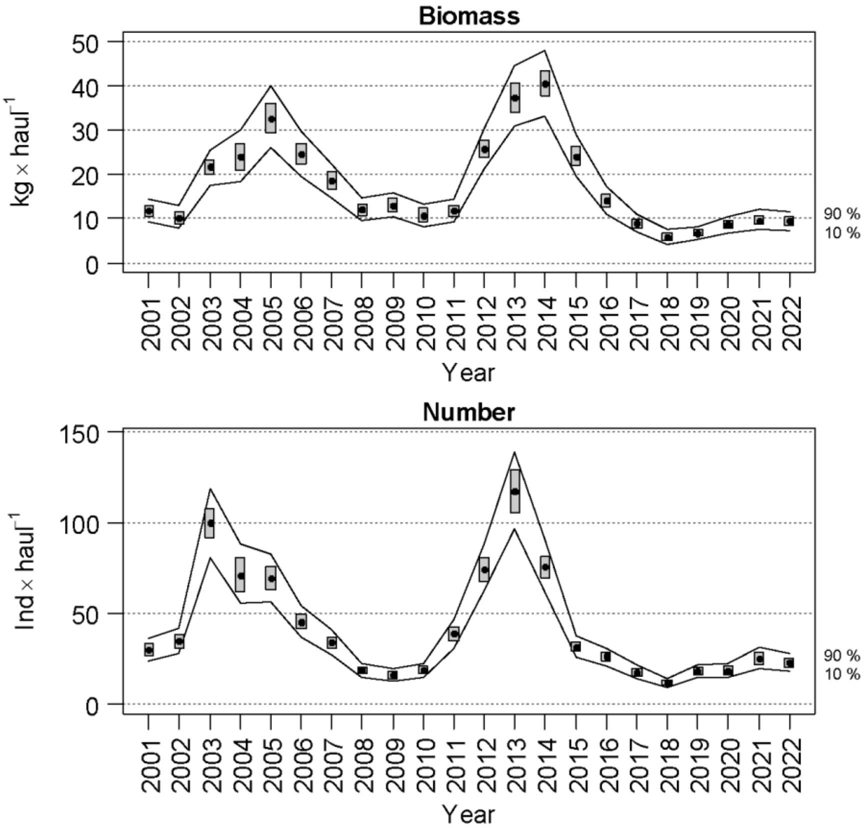


Figure 16. Evolution of biomass and abundance indices of *Phycis blennoides* in the Porcupine surveys. Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000).

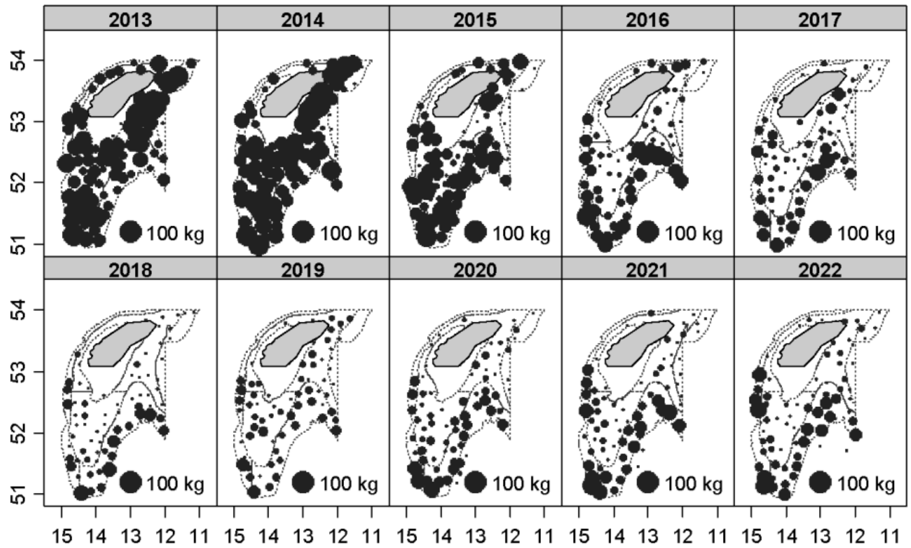


Figure 17. Geographic distribution of *Phycis blennoides* catches (kg×30 min haul^{-1}) in the Porcupine surveys over the last decade.

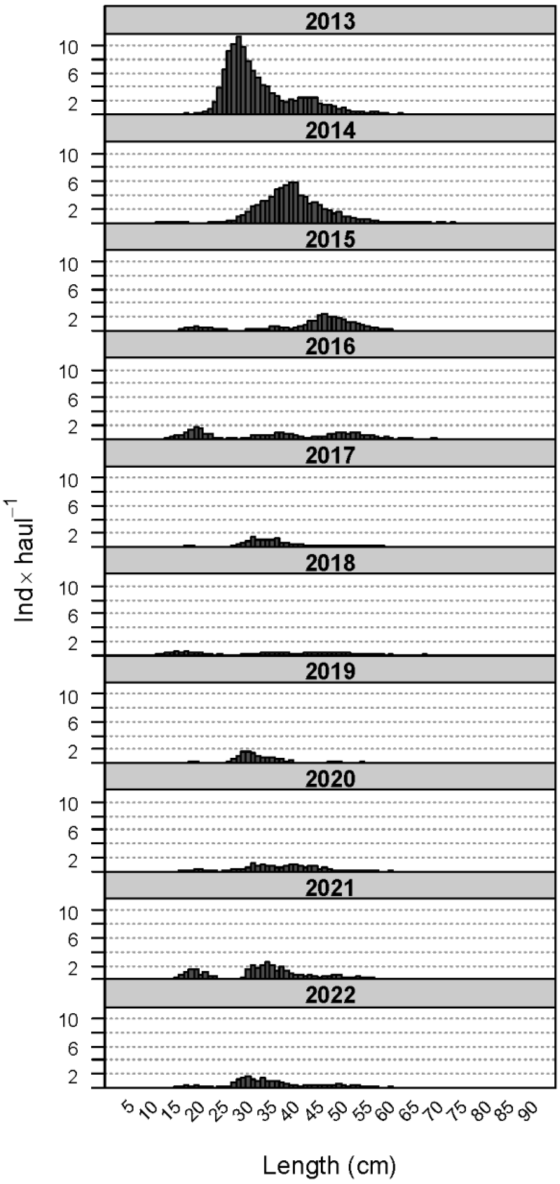


Figure 18. Mean stratified length distributions of *Phycis blennoides* in the Porcupine surveys (2013-2022).

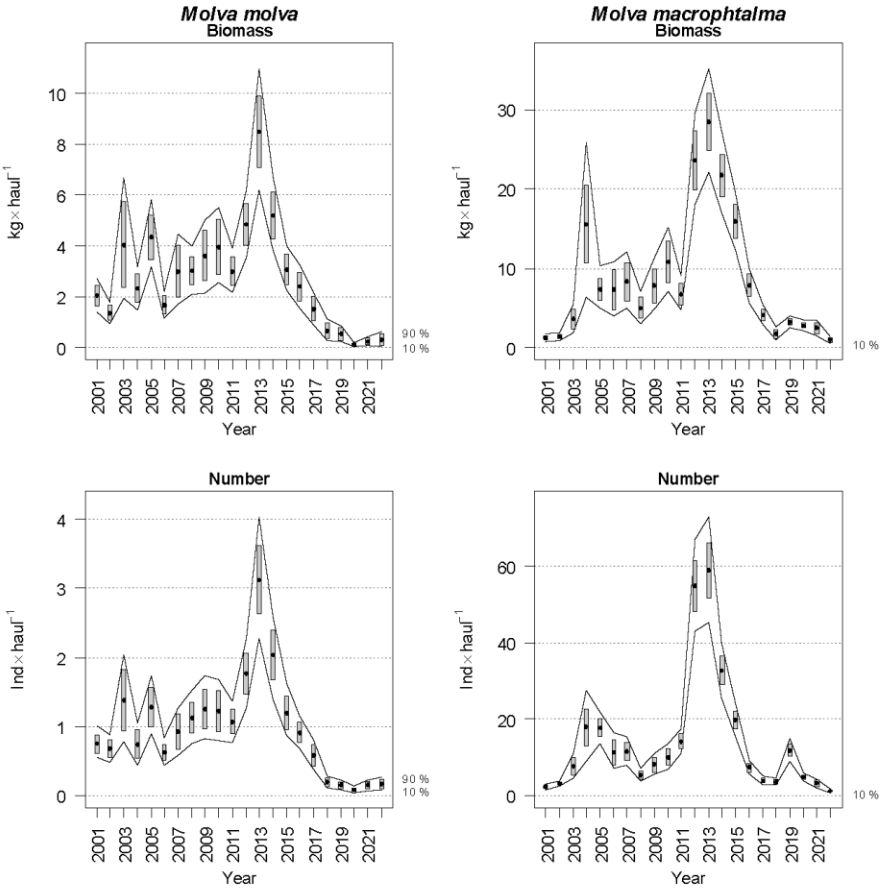


Figure 19. Evolution of biomass and abundance indices of *Molva molva* and *Molva macrophthalma* in the Porcupine surveys. Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000).

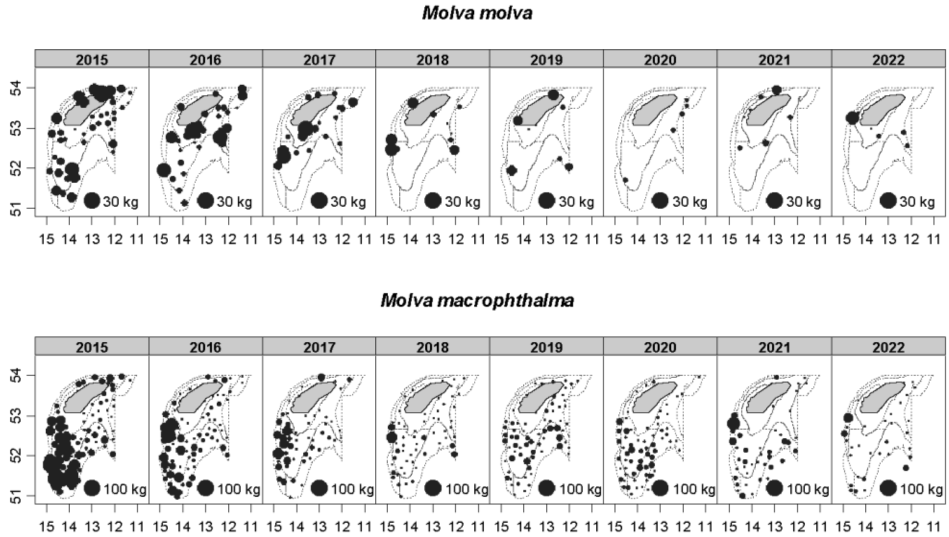


Figure 20. Geographic distribution of *Molva molva* and *Molva macrophthalma* catches (kg×30 min haul^{-1}) in the Porcupine surveys (2015-2022).

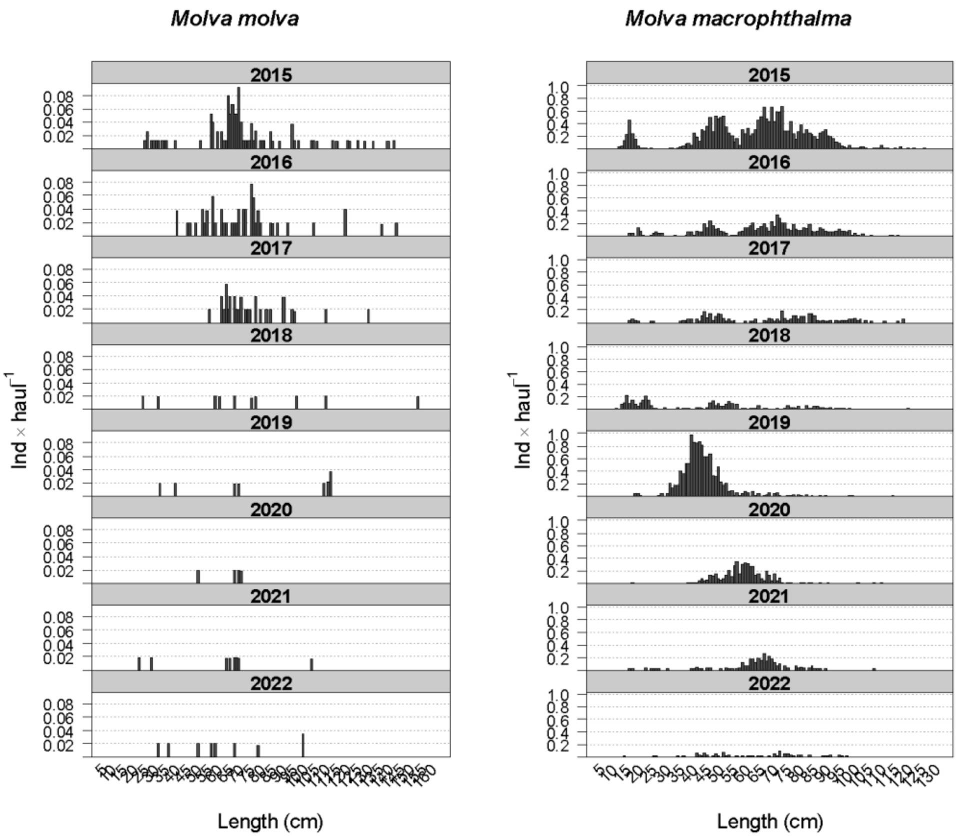


Figure 21. Mean stratified length distributions of *Molva molva* and *Molva macrophthalma* in the Porcupine surveys (2015-2022).

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Update on Norwegian fishery independent information on abundance, recruitment, size distributions, and exploitation of roundnose grenadier (*Coryphaenoides rupestris*) in the Skagerrak and north-eastern North Sea (ICES Division IIIa)

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Introduction

The roundnose grenadier is a long-lived deepwater species which in the relevant study area reaches ages of 70 years or more and attains maturity at the age of 8-12 years (Bergstad 1990). It has a limited area of distribution within the Norwegian deep and in the deep Skagerrak basin (300-720m) (ICES Div. 4a & 3a). Analyses using microsatellite DNA have demonstrated that the Skagerrak grenadier is currently likely to be isolated from grenadier elsewhere in its North Atlantic distribution area (Knutsen *et al.*, 2012). In 2003-2005 a major expansion of the previously quite minor targeted grenadier fishery occurred, and this expansion was followed by a complete closure of the fishery from 2006 onwards. Apart from previous targeted exploitation, grenadier is now a minor by-catch in the traditional trawl fishery for *Pandalus borealis* which is currently the major demersal trawl fishery in the area. Most shrimp fishing occurs shallower than the main distribution area of the grenadier.

This Working Document presents results derived from a research vessel bottom trawl survey conducted annually during the past 40 years (1984-2023). While the main objective of the survey is to monitor *Pandalus borealis*, the survey samples the entire depth range and distribution area of roundnose grenadier.

We report temporal variation in survey catch rates in terms of biomass and abundance (kg/hour and number/hour), length distributions, occurrence of recruits, and geographical distribution. We also give an estimate of by-catch in the commercial shrimp fishery from Reference fleet data. Most of the information in this Working Document is an update of a WD first submitted to WGDEEP in 2009 (Bergstad *et al*. 2009). The survey series is currently the only information available to assess temporal variation and trends for the grenadier in this area. A full analysis of the time-series has been published (Bergstad *et al*., 2014), but this working paper extends the series to also include the years 2014-2023.

Material and Methods

Data was collected from the annual *Pandalus borealis* shrimp survey performed by the Institute of Marine Research in the years 1984-2023 (Table 1). The survey is a depth stratified shrimp trawl survey with approximately 25% of the stations deeper than 300 m (depth range 117-534 m). The trawl used has small meshes overall and a 6mm cod-end liner and retains all sizes of grenadiers, including the smallest newly settled juveniles (Bergstad 1990, Bergstad and Gordon 1994). The stations are placed at random within strata and subareas, and the same sites sampled every year. Although some changes occurred over the years (Table 1), the overall standardization was maintained throughout the time series (Bergstad *et al.* 2014).

Catch rates in terms of biomass and abundance were calculated for stations 300 m and deeper, i.e. excluding shallower survey depths where the species only occurs sporadically in small numbers (Bergstad 1990). Stations with zero catches were included, and the catches at non-zero stations were standardized by tow duration.

Annual length distributions were derived for the pooled standardized catches at 300m and beyond. In cases where catches were subsampled, length distributions were raised to the total catch prior to pooling.

Age data from selected surveys in 1987 and 2007-2023 were calculated as cumulative age distributions. Age and length data from 2008-2023 were analyzed for growth parameters.

Standardized mean catches by number of small juveniles of PAFL ≤ 5 cm were calculated to show recruitment during the survey period.

A time series of maps showing geographical distributions by year were plotted, representing scaled catch rates at the actual sample sites for each survey year.

Data from the Norwegian reference fleet (2013-2019) was collected to report bycatch on roundnose grenadier in the Norwegian shrimp fishery.

Results

Biomass and abundance

The estimates of catch rates in terms of biomass (kg/h) and abundance (nos/h) varied substantially through the time series (Fig.1), but elevated levels were observed from 1998 to 2004. The decline from 2005 continued through the time series until 2017 which was the lowest on record. The observations from 2018-2023 remained low, but with a slight increase compared with 2017.

Size and age distributions

The time series of annual length distributions show a major shift in the early 1990s (Fig. 2). From 1992 the proportion of large fish with PAFL>15cm declined to less than 10% which contrasts with the pre-1990 distributions dominated by large fish. From 1992, a pronounced mode of small fish can be followed in subsequent years, with modal length increasing through the time series.

In 2018 there is another shift in the length distributions. The very recent distributions (2018-2023) contrasts with earlier distributions by having very low proportions of large fish. The distributions are dominated by small fish but at low levels compared to the 1990's. The situation in 2023 is the same as in 2022.

Age distributions and growth

The cumulative age distribution from the extracted data from 1987 (Bergstad, 1990) contrasts substantially with the distributions from 2007-2023 in terms of proportions of old fish (e.g. >20 years). In 1987, the proportion of fish > 20 years was over 50% (Table 4). In 2008, i.e. after the relatively large expansion in landings in 2003-2005 and ban on direct fishing introduced in 2006, only 8% of the aged fish were older than 20 years. In subsequent years the proportion of older fish apparently increased, and recent distribution from 2023 now show 21% fish > 20 years (Table 4). This is still very low compared with the 1987 situation.

Age at length was analyzed for the years 2008-2023 (Figure 5) and compared with data from 1987 (Bergstad, 1990) (Table 3). The growth rate coefficient (k) and the length infinity ($L\infty$) for females is in the same range as the data from 1987, but slightly lower for 2008-2023 data compared with data from 1987, especially for females.

Occurrence of juveniles <5cm PAFL

There are no positive signs of recruitment in 2023. There is no indication of a pronounced recruitment pulse as that observed in the early 1990s, neither in the length distributions (Fig 2.), or in the time series of mean abundance of small fish < 5 cm (Fig. 3).

Geographical distribution

The area sampled in given year and the corresponding geographical distribution of grenadier catches is presented in Figure 4. The overall distribution area does not seem to have changed considerably during the time series 1984-2023. Catches of roundnose grenadier are restricted to the Norwegian Deep north to 59°N and extend eastwards into the Skagerrak basin. The highest catches were always found in the eastern Skagerrak part of the Norwegian Deep.

Commercial by-catch

For an assessment of the bycatch of roundnose grenadier in the Norwegian shrimp fishery, data from the Norwegian Reference fleet showed that < 1% of the tows with shrimp trawl caught roundnose grenadier (Table 5). The values for catch weights from the Reference fleet are low and in same level as the reported landings for the recent years. This indicates that the low reported Norwegian landings are realistic and that the landings are the bycatch amount taken by the Norwegian shrimp fishery.

Discussion

Despite high inter annual variability, the catch rates in terms of biomass and abundance from the survey suggest long term pattern of variation through the time series 1984-2023. An increase in biomass and abundance from the late 1980s until 1998-2004 seemed to be followed by a major decline from the mid-2000s onwards. In 2023 abundance and biomass estimates were still at low levels.

The survey catch rate declined in all areas, also where high survey catches were common, i.e. in the eastern part of the Skagerrak (Fig. 4).

The time-series of size distributions also suggest pronounced structural changes during the period 1984-2023. The distributions from the 1980s with a dominance of fish around 15 cm PAFL contrasts with those from the early 1990s when the population was apparently rejuvenated by a pulse in recruitment from 1991-1992 onwards. The recruits from 1991-1992 can be tracked as a mode in the size distributions for 15 years until 2005. The distributions were dominated by old fish until 2012 although with consecutively low concentrations. From 2018, the older fish is almost disappeared and the distributions changed to younger fish primarily but still with low levels.

The difference in age distribution between 1987 and 2023 is primarily seen in the proportion of older fish, i.e. there is almost no fish older than 30 years in 2023 while almost 25% of the fish was older than 30 years in 1987. The most prominent difference between recent situation and that of 1987 concerning growth, was seen for females. It seems that the bulk of very large and old female individuals seen in 1987 is no longer present in recent years (Table 3).

High mean survey biomass coincided with very high commercial landings in 2004-05 (Figure 6). The fishery may have utilized a period of elevated abundance resulting from what appears to be the single large pulse in recruitment in the 40 years surveyed. From recent length distributions no similar pulse in recruitment has been observed.

An interpretation of the patterns observed in the time-series of size and age distributions, the survey abundance index for small juveniles, and the survey index of all sizes combined is that the enhanced fishery in 2003-2005 had the combined effect of eroding both the accumulated fraction of older fish around 30 years that were found in the population in 1987 prior to the fishery and the younger fish resulting mainly from the recruitment pulse in the early 1990s. The very old fish never reappeared, and for three decades, recruitment has been consistently at a level well below the level observed in the single high event in the early 1990s. The recent recruitment has probably been too low to produce any increase in abundance.

The reported landings peaked in 2005 at about 11000 tons (Figure 6) and have since declined to about a ton per year. From 2006 onwards this decline in landings is a result of regulations (Bergstad 2006) as the targeted fishery ceased. By-catches from shrimp fisheries still occur, however. The data from the Norwegian Reference fleet suggests that current levels are minor, probably reflecting low grenadier abundance at relevant depths and introduction of sorting grids to the fishery.
The Norwegian bycatch of roundnose grenadier thus is well described through the reported landings. The Swedish and Danish fishery reports both landings and discards and therefore the bycatch from these fisheries should be counted for in the statistics. The level of landings and discards in recent years has been in total less than 2 tons per year.

Conclusion

The decline in abundance after 2005-2006 suggested by the survey catch rates may reflect the combined effect of the enhanced targeted exploitation in 2003-2005 and the low recruitment in the years following the single recruitment pulse in the early 1990s. The percentage of fish >15cm is now lower than recent years and there is no suggestion of a new recruitment pulse as seen in the 1990s. The current low abundance and truncated age structure in the population thus reflect both the exploitation and recruitment history spanning the past 2-3 decades. Since the targeted fishery has stopped and the by-catch in the shrimp fishery are low, there is a potential for recovery of the roundnose grenadier in Skagerrak. However, rejuvenation and growth of the population would at present seem unlikely due to low recruitment during the recent decades. The survey information suggests that it may be a feature of this population that only a single good recruitment event may be expected in a period of 3 decades.

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Knutsen, H., Jorde, P.E., Bergstad, O.A., and Skogen, M. 2012. Population genetic structure in a deepwater fish *Coryphaenoides rupestris*: patterns and processes. Marine Ecology Progress Series, 460: 233–246.

Table 1. Summary of data on the bottom trawl survey series, 1984-2023. Rg- rockhopper ground gear. 'Strapping' – maximum width of trawl constrained by rope connecting warps in front of otter doors. MS – RV Michael Sars, HM – RV Håkon Mosby, KB – RV Kristine Bonnevie. Data from 2023 survey is included. All trawls were fitted with a 6mm mesh cod-end liner.

YEAR	Survey month	Vessel	IMR Gear code	Additional gear info.	No. trawls >300m	No. trawls >400m	No. trawls survey
1984	OCT	MS	3230	Shrimp trawl (see text)	10	1	67
1985	OCT	MS	3230	"	21	5	107
1986	OCT/NOV	MS	3230	"	24	9	74
1987	OCT/NOV	MS	3230	"	35	14	120
1988	OCT/NOV	MS	3230	"	31	11	122
1989	OCT	MS	3236	Campelen 1800 35mm/40, Rg	31	7	106
1990	OCT	MS	3236	"	26	5	89
1991	OCT	MS	3236	"	28	9	123
1992	OCT	MS	3236	"	27	10	101
1993	OCT	MS	3236	"	30	10	125
1994	OCT/NOV	MS	3236	"	27	10	109
1995	OCT	MS	3236	"	29	12	103
1996	OCT	MS	3236	"	27	11	105
1997	OCT	MS	3236	"	25	6	97
1998	OCT	MS	3270	Campelen 1800 20mm/40, Rg	23	6	97
1999	OCT	MS	3270	"	27	8	99
2000	OCT	MS	3270	"	25	10	109
2001	OCT	MS	3270	"	18	4	87
2002	OCT	MS	3270	"	24	6	82
2003	OCT/NOV	HM	3230	Shrimp trawl (as in 1984-1988)	13	0	68
2004	MAY	HM	3270	Campelen 1800 20mm/40, Rg	17	6	65
2005	MAY	HM	3270	"	23	8	98
2006	FEB	HM	3270	"	10	0	45
2007	FEB	HM	3270	"	11	1	66
2008	FEB	HM	3271	Campelen 1800 20mm/40, Rg and strapping*	18	5	73
2009	JAN/FEB	HM	3271	"	25	7	91
2010	JAN	HM	3271	"	24	7	98
2011	JAN	HM	3271	"	22	7	93
2012	JAN	HM	3271	"	20	5	65
2013	JAN	HM	3271	"	28	8	101
2014	JAN	HM	3271	"	16	7	69
2015	JAN	HM	3271	"	28	9	92
2016	JAN	HM	3271	"	28	9	108
2017	JAN	KB	3271	"	30	9	128
2018	JAN	KB	3271	Campelen 1800 20mm/40, Rg and strapping**	27	8	111
2019	JAN	KB	3296	Campelen 1800 20mm/40, Rg and strapping***	27	8	108
2020	JAN	KB	3296	"	26	7	106

Table 1. Continued

YEAR	Survey month	Vessel	IMR Gear code	Additional gear info.	No. trawls >300m	No. trawls >400m	No. trawls survey
2021	JAN	KB	3296	Campelen 1800 20mm/40, Rg and strapping***	27	8	113
2022	JAN	KB	3296	‘’	28	8	119
2023	JAN	KB	3296	‘’	29	8	116

* Path width of the tow constrained by a 10 m rope connecting the warps, 200 m in front of otter boards. ** Path width of the tow constrained to a 15 m rope connecting the warps, 100 m in front of the otter boards. *** Same trawl and strapping but from 2019 there are inserted several floaters on the trawl to lighten the trawl (Nordsjørigging).

Table 2. Mean biomass index and mean abundance index from shrimp survey 1984-2023. Missing data are from surveys that are not representable according to roundnose grenadier catches (few stations > 300 m). Data from 2016 are considered unreliable according to gear inconsistencies.
Mean biomass (kg/h), Mean abundance (n/h), Number (n) and Standard error (SE)

Year	n	(kg/h)	SE(kg/h)	(n/h)	SE(n/h)
1984	10				
1985	21	108.12	38.32	149.95	49.43
1986	24	83.75	32.16	117.83	46.99
1987	35	76.15	13.56	125.80	24.60
1988	31	72.14	13.92	105.19	21.22
1989	31	122.69	43.48	195.94	73.07
1990	26	49.81	18.20	72.66	27.55
1991	28	107.14	22.27	176.86	38.75
1992	27	188.54	67.53	698.52	337.67
1993	30	58.59	19.42	190.33	74.15
1994	27	87.19	21.21	372.96	143.56
1995	29	118.30	32.36	440.62	144.41
1996	27	99.63	31.68	268.01	116.92
1997	25	113.86	66.47	362.72	222.08
1998	23	255.54	87.80	812.82	336.85
1999	27	149.30	42.85	388.83	122.54
2000	25	129.27	30.39	389.06	107.71
2001	18	105.33	51.84	272.99	151.99
2002	24	174.77	66.27	371.70	129.97
2003	13				
2004	17	324.38	125.48	1143.35	487.33
2005	23	193.65	93.81	550.42	260.94
2006	10				
2007	11				
2008	18	95.58	65.81	259.10	208.53
2009	25	72.72	39.81	207.41	121.84
2010	24	33.24	21.47	77.21	54.81
2011	22	26.84	12.61	54.76	27.05
2012	20	16.69	11.97	34.40	23.83
2013	28	11.48	4.92	35.06	16.90
2014	16	25.62	15.76	49.56	28.69
2015	28	7.28	4.59	21.19	12.14
2016	28				
2017	30	6.64	2.41	15.74	6.73
2018	27	12.88	6.60	41.91	26.13
2019	27	14.59	5.77	40.09	18.05
2020	26	18.72	11.48	63.02	38.07
2021	27	9.59	5.03	26.14	14.19
2022	28	23.87	10.94	75.20	35.61
2023	29	19.24	8.89	38.81	19.10

Table 3. Estimated parameters of von Bertalanffy growth function on data from Skagerrak shrimp survey 2008-2023 and Skagerrak survey in 1987 as reported by Bergstad 1990. k=growth coefficient, L_∞=asymptotic length, t_0=theoretical age when length is zero, SE=standard error				
	Estimated parameter			
Parameter	**Shrimp survey 2008-2022**		**Skagerrak survey 1987**	
	Females (SE)	**Males (SE)**	**Females**	**Males**
k	0.085 (±0.004)	0.076 (±0.010)	0.100	0.105
L_∞	16.8 (±0.233)	14.9 (±0.548)	18.1	14.7
t_0	-2.7 (±0.278)	-5.7 (±1.022)	-0.9	-1.5

Table 4. Cumulative percentages (%) for selected ages from 1987 and 2007-2023.					
	Age				
Year	**5**	**10**	**20**	**30**	**50**
1987	9	21	45	75	96
2007	10	23	83	94	96
2008	22	40	92	99	100
2009	14	30	88	93	100
2010	12	29	71	96	99
2011	6	23	65	94	99
2012	10	28	48	96	100
2013	14	28	56	92	99
2014					
2015	7	17	48	95	100
2016					
2017	14	52	81	94	99
2018	23	50	77	99	100
2019	8	37	64	92	100
2020	40	64	83	97	100
2021	20	55	83	97	100
2022	33	53	81	95	99
2023	22	50	79	92	100

Table 5. Proportion of tows with shrimp trawl that caught roundnose grenadier. Data from Norwegian Reference fleet.				
Year	Total number of shrimp trawl	Number of trawl hauls that caught roundnose grenadier	Catch of roundnose grenadier (kg)	% of the total catch
2013	243	0		0
2014	288	2		0,69
2015	1489	14		0.94
2016	4811	23		0,48
2017	3798	20	29	0,53
2018	2849	19		0,67
2019	1233	4	80	0,32

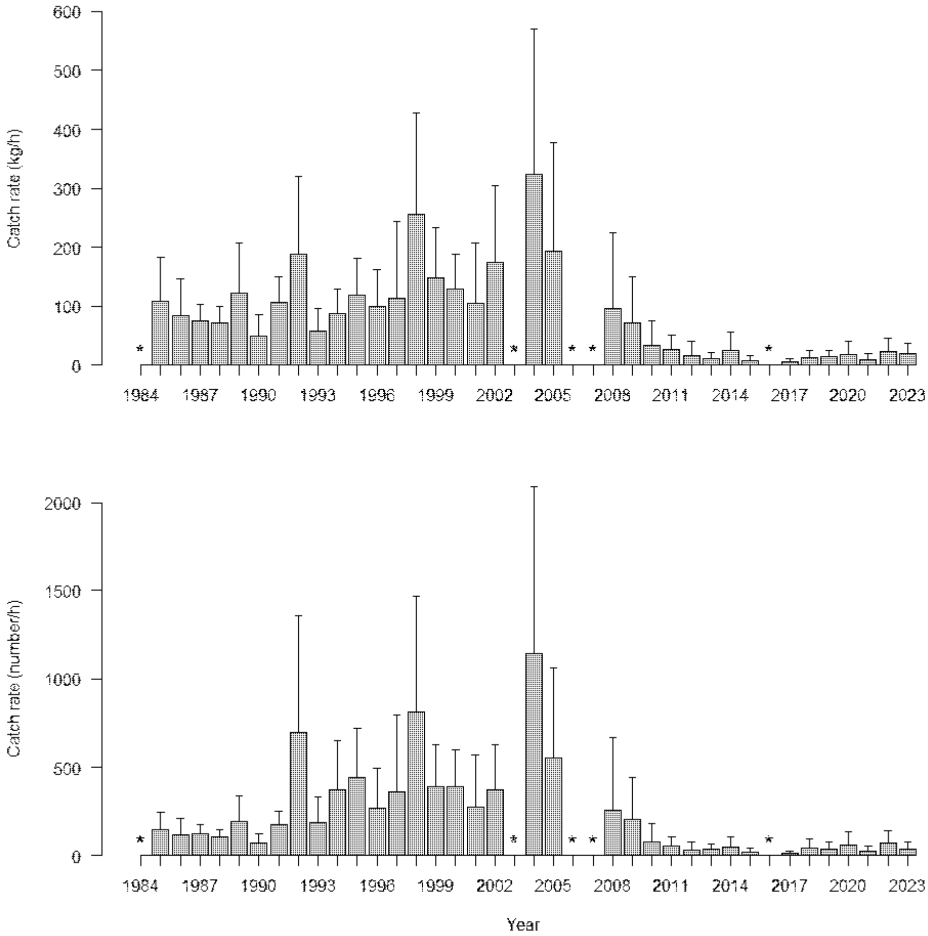


Figure 1. Standardized survey catch rates of roundnose grenadier, 1984-2023. Upper: Biomass (kg/h), Lower: Abundance (number/h). Standard error (2SE) shown by lines on top of bar. *In 1984, 2003, 2006 and 2007, only one single or no trawls were made deeper than 400 m, and data from those years were excluded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.

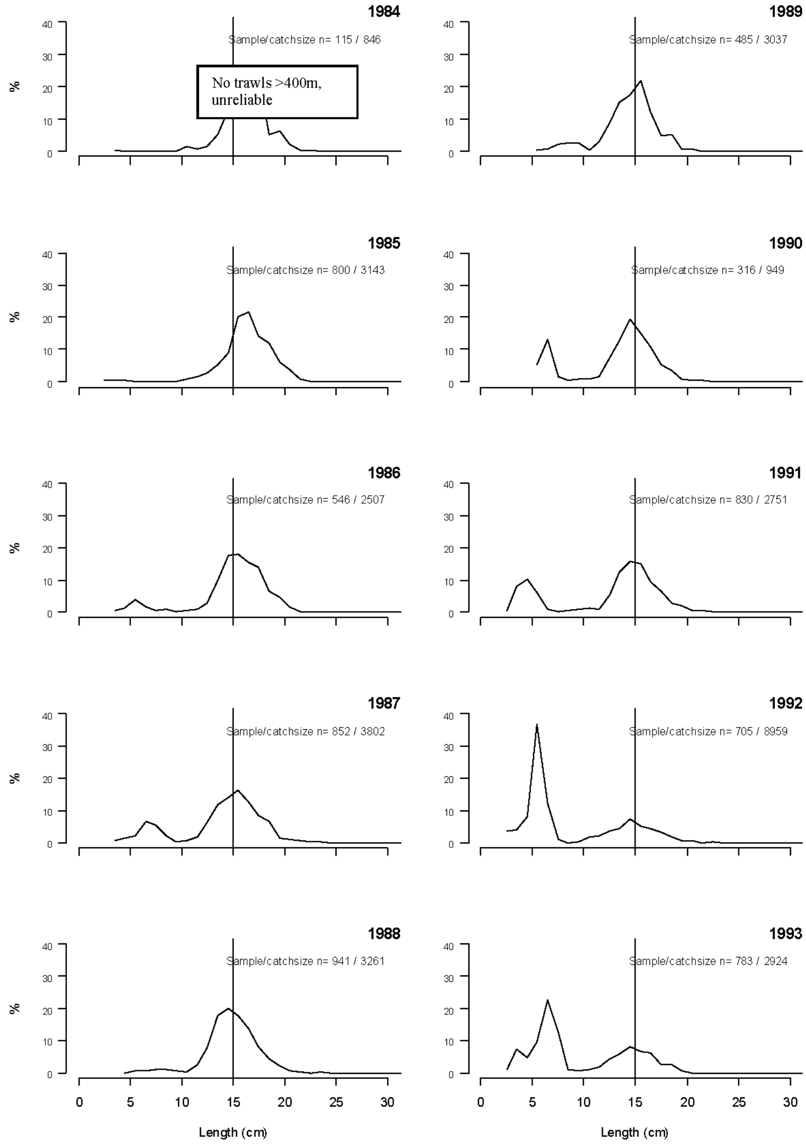
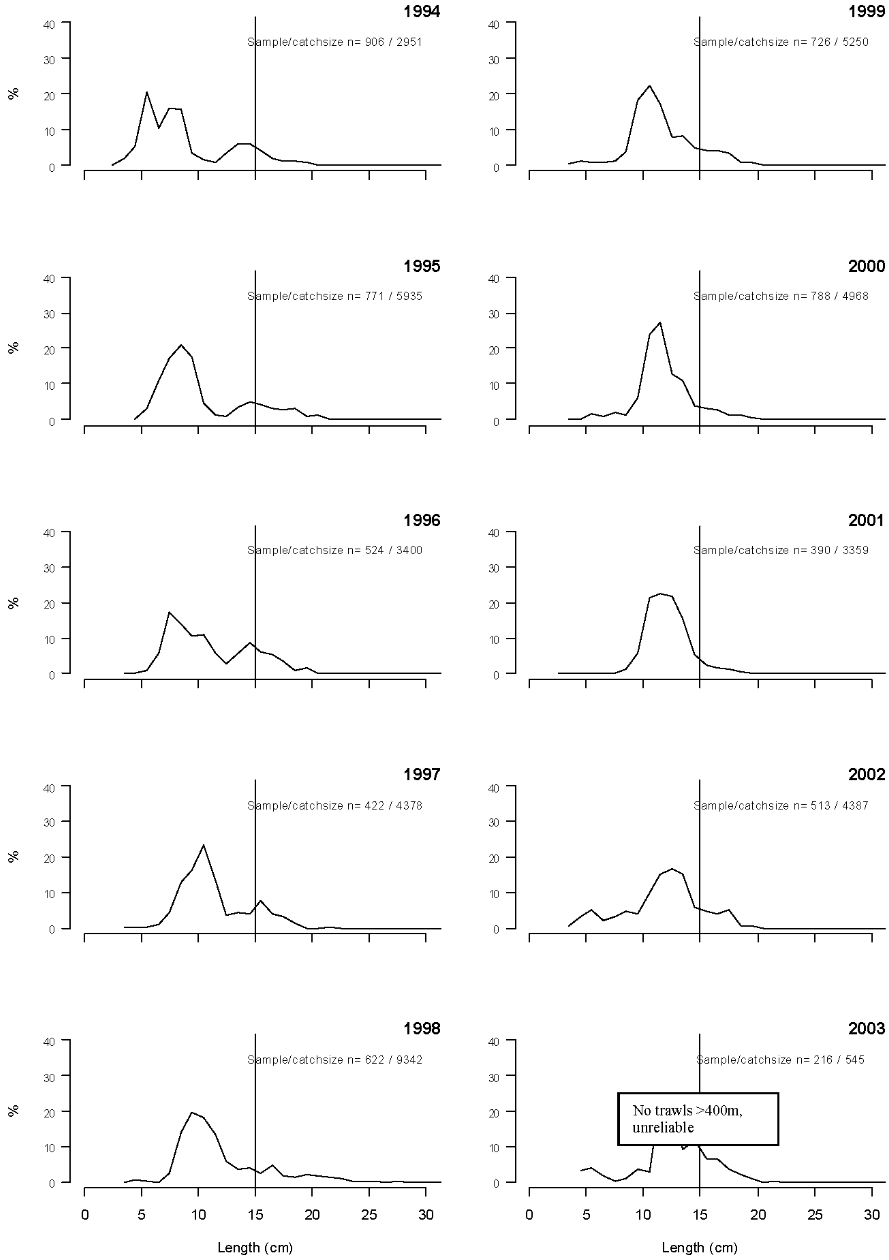


Figure 2. Length distributions of roundnose grenadier from annual *P. borealis* surveys, 1984-2023. Length is measured as PAFL (cm). The length distributions are calculated as percentage number of fish in each centimetre length interval standardized to total catch number and trawling distance for each station each year. *In 1984, 2003, 2006 and 2007, only one single or no trawls were made deeper than 400 m, and data from those years should be excluded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.



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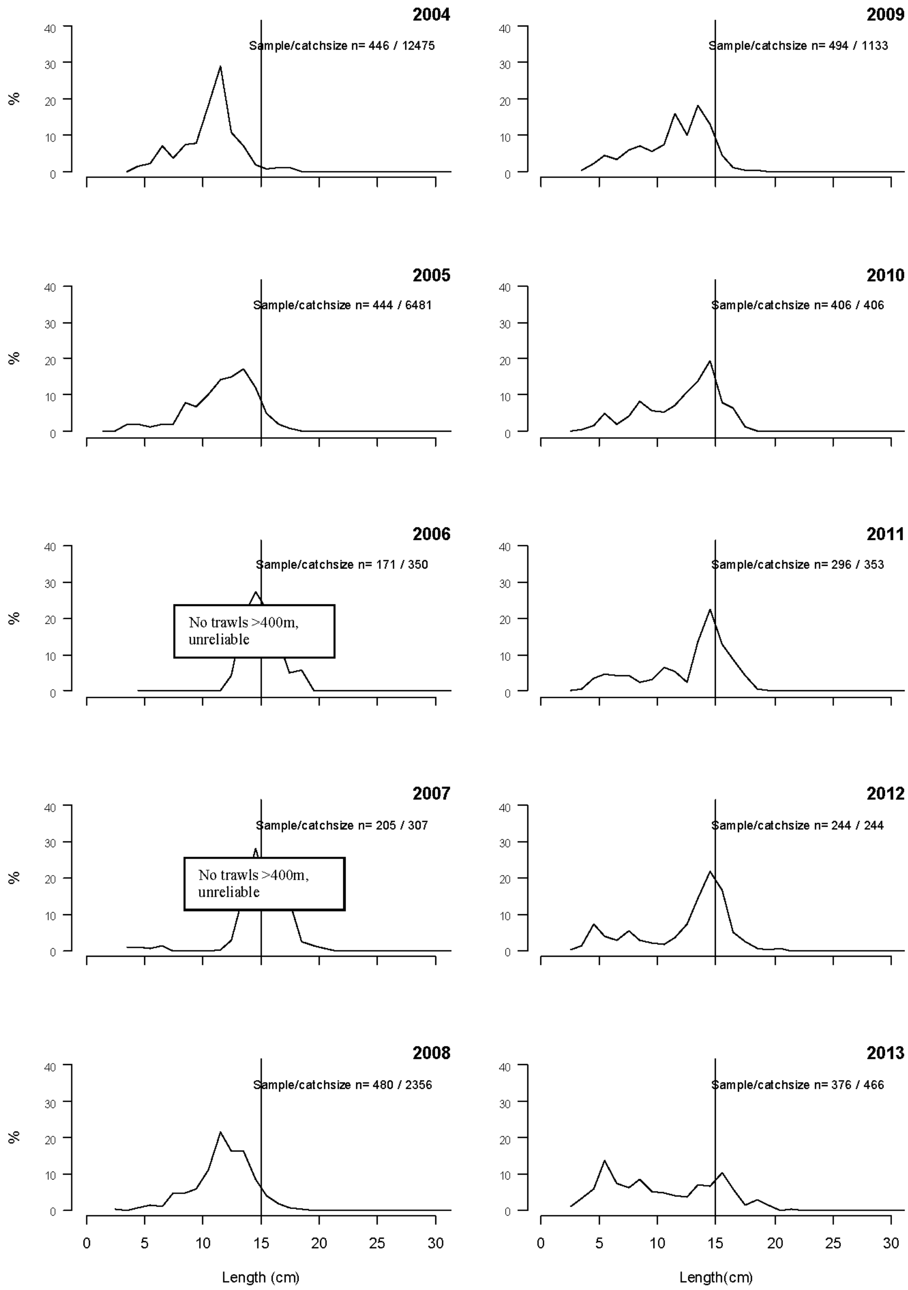

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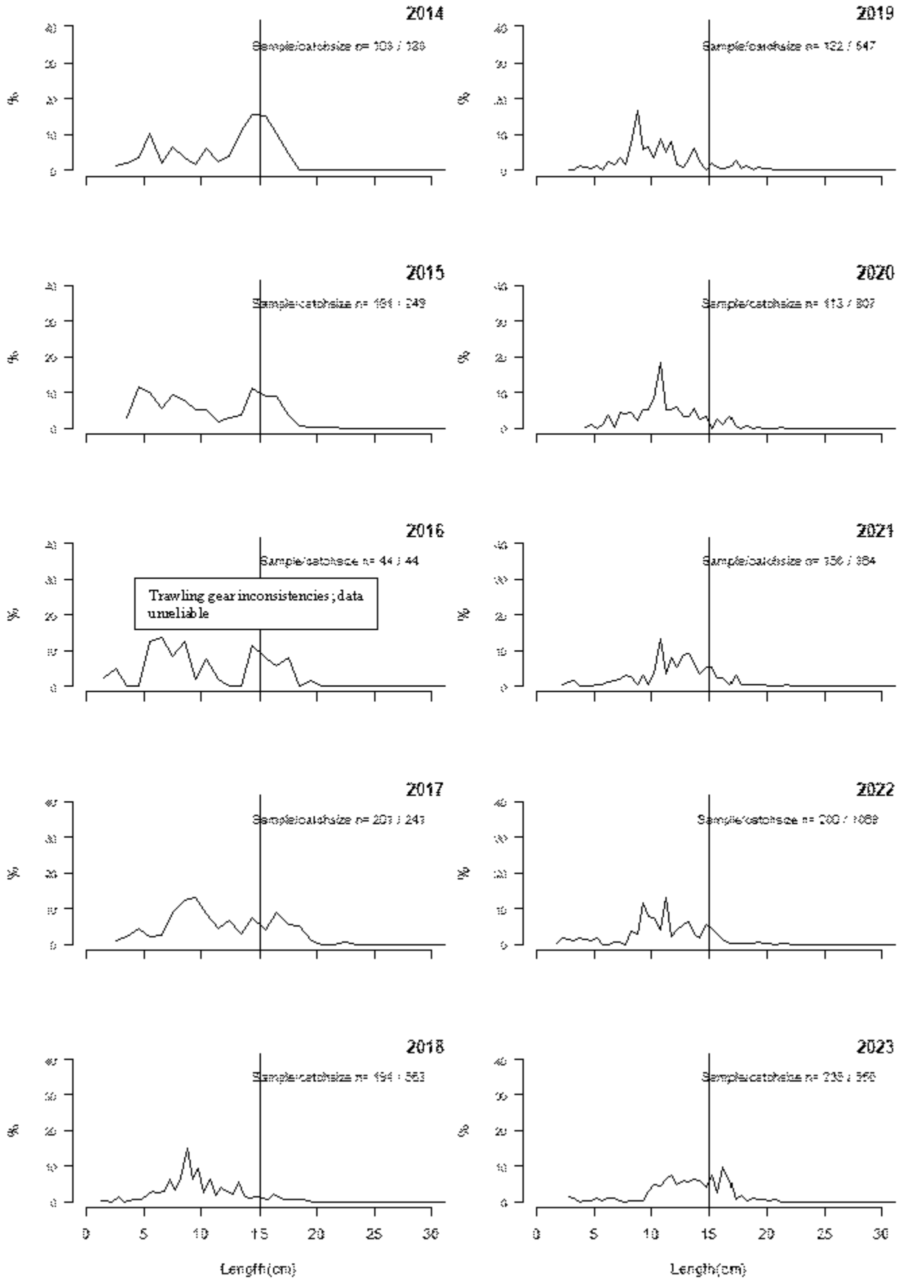

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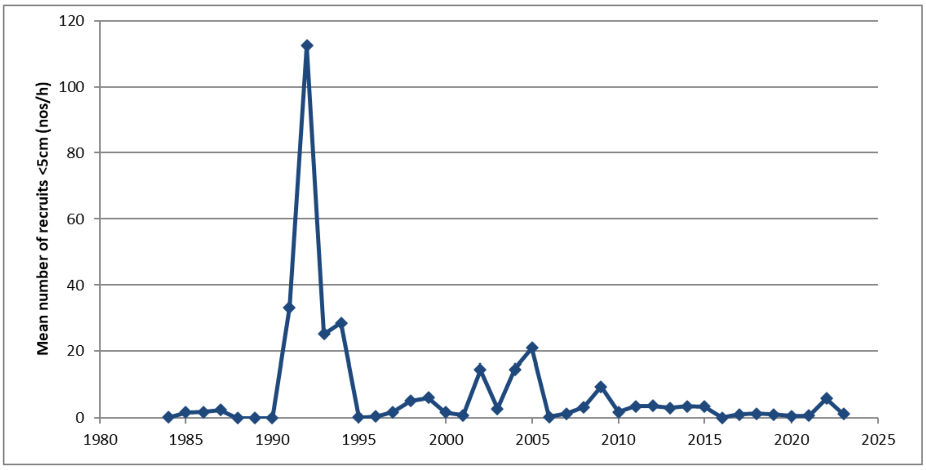


Figure 3. Mean catch rate of roundnose grenadier of PAFL ≤ 5 cm, 1984-2023. Data from shrimp survey, trawls deeper than 300 m. *In 1984,2003,2006 and 2007, no trawls were made deeper than 400 m, and data from these years should be disregarded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.

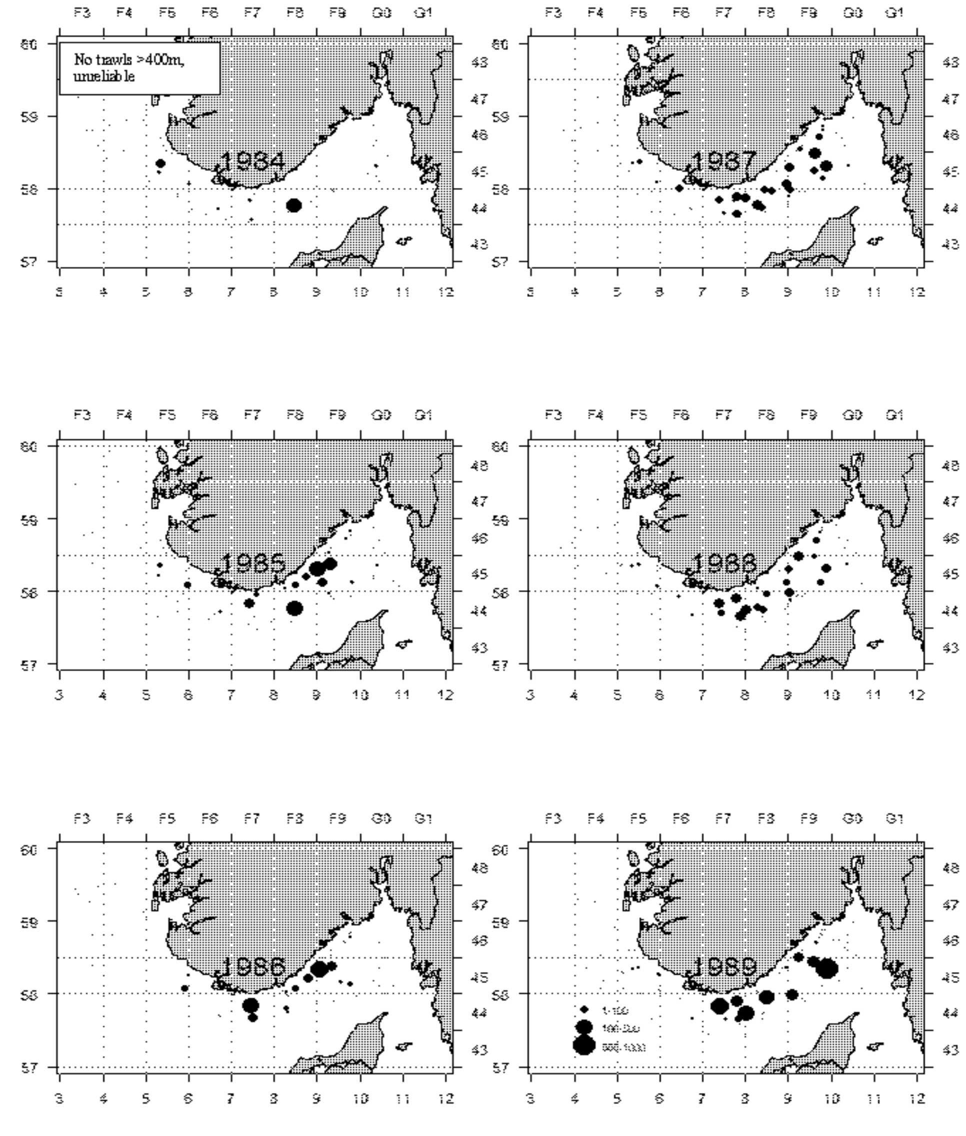
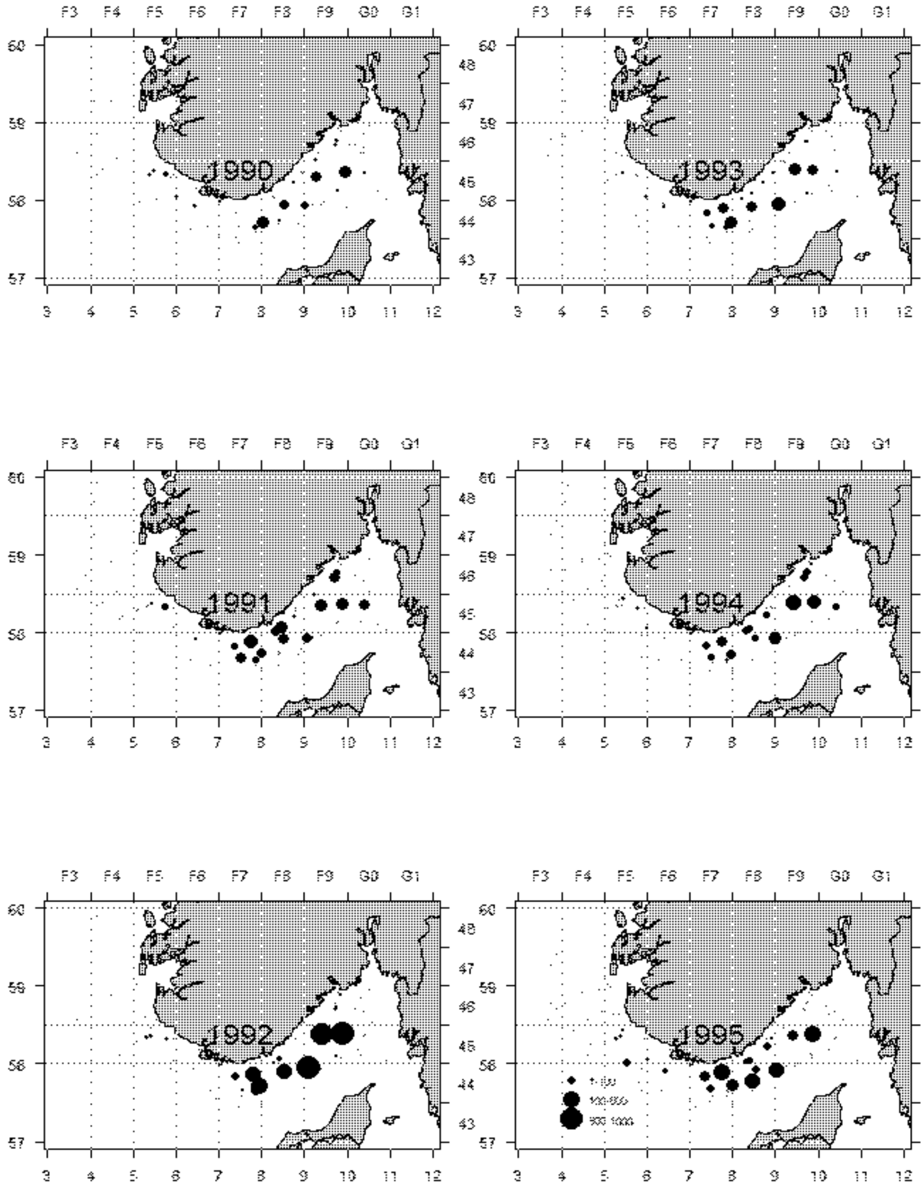


Figure 4. Geographical distribution of catches of roundnose grenadier (kg/h) from 1984-2023. Data from shrimp survey, trawls deeper than 300 m. Grey circles are trawls with no catch of grenadier. *In 1984, 2003, 2006 and 2007, only one single or no trawls were made deeper than 400 m, and data from those years should be excluded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.



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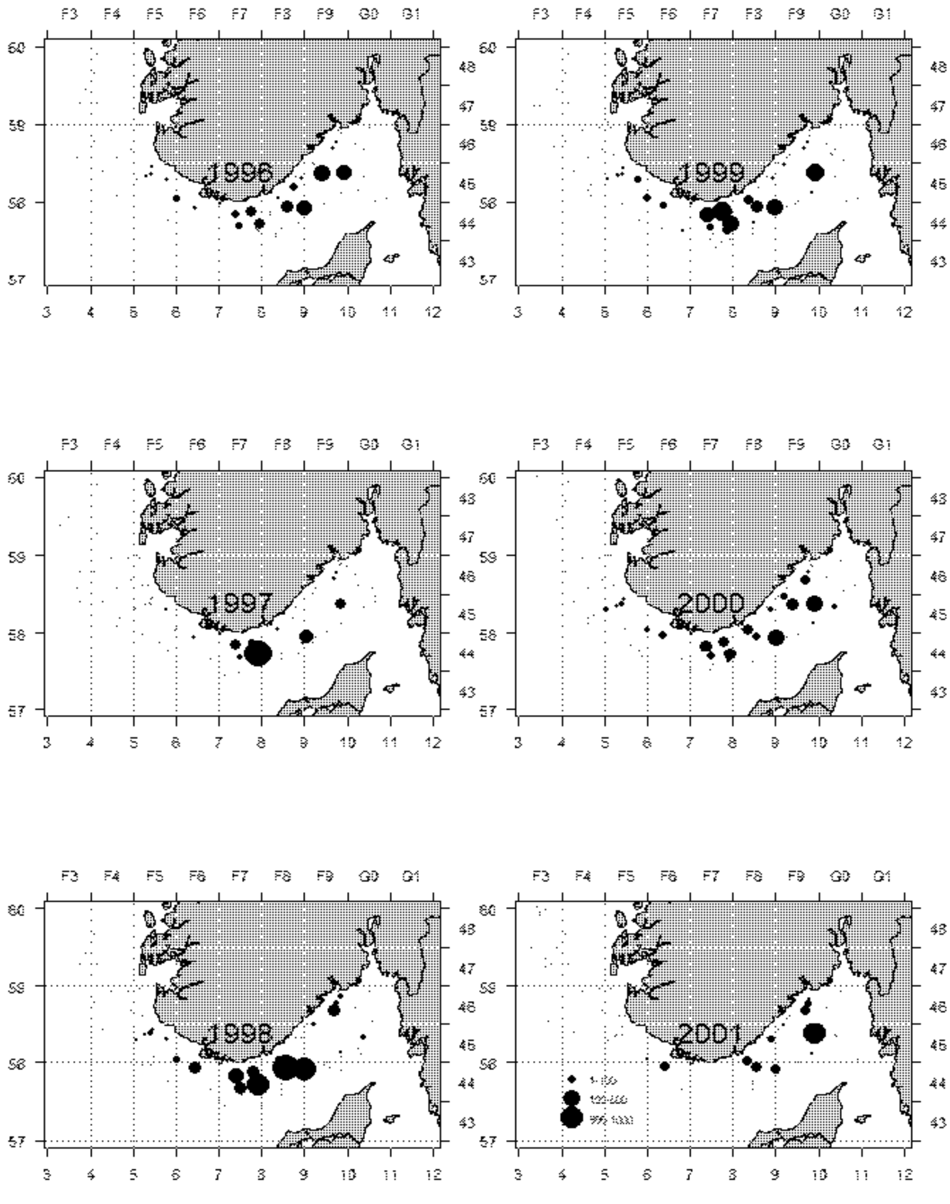

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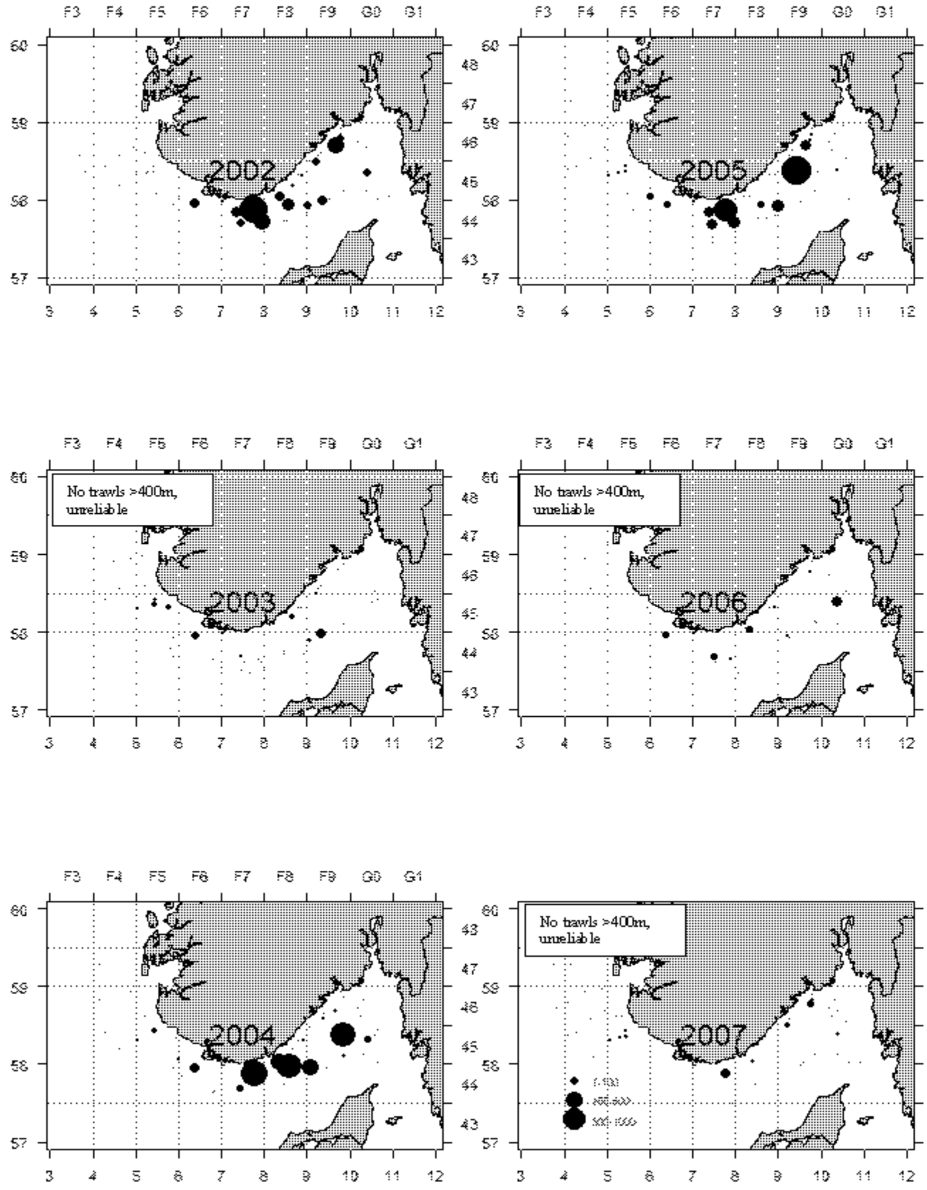

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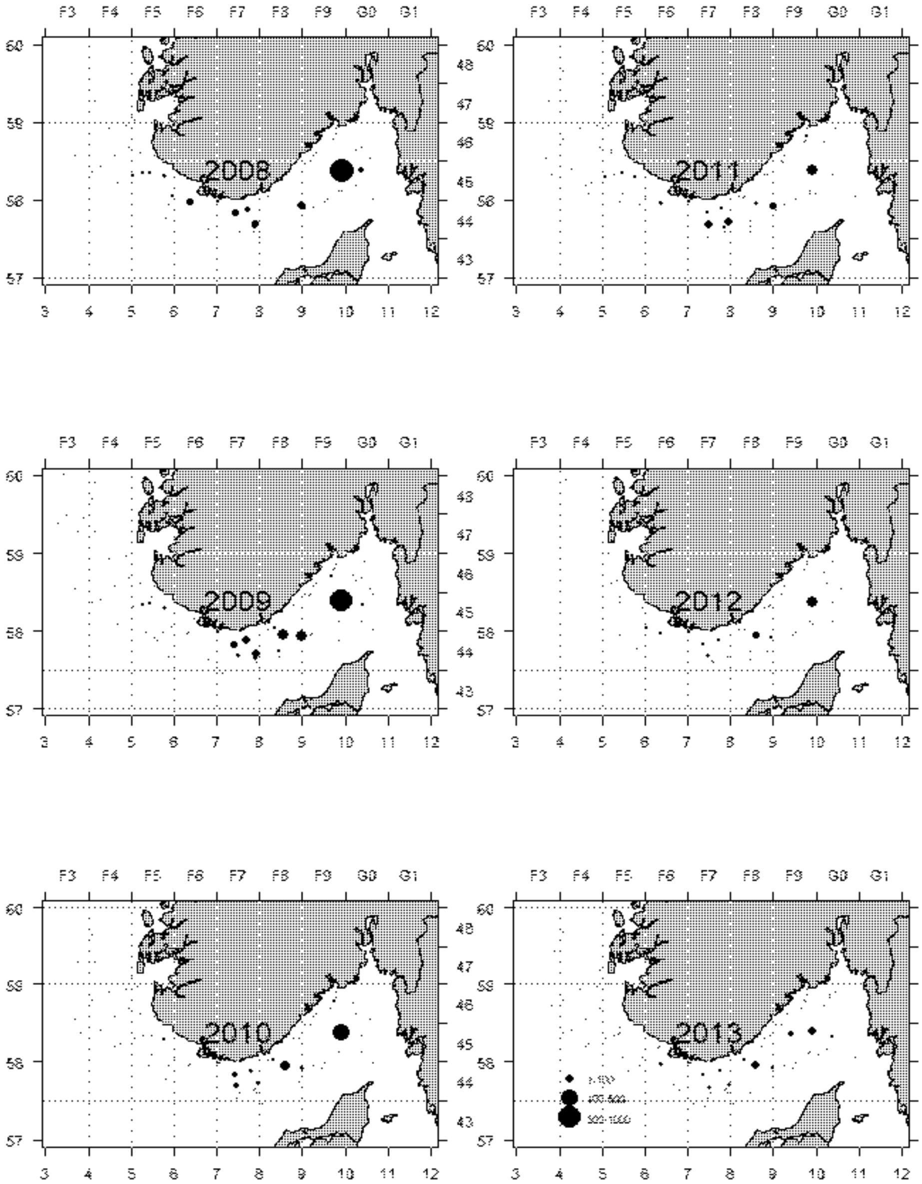

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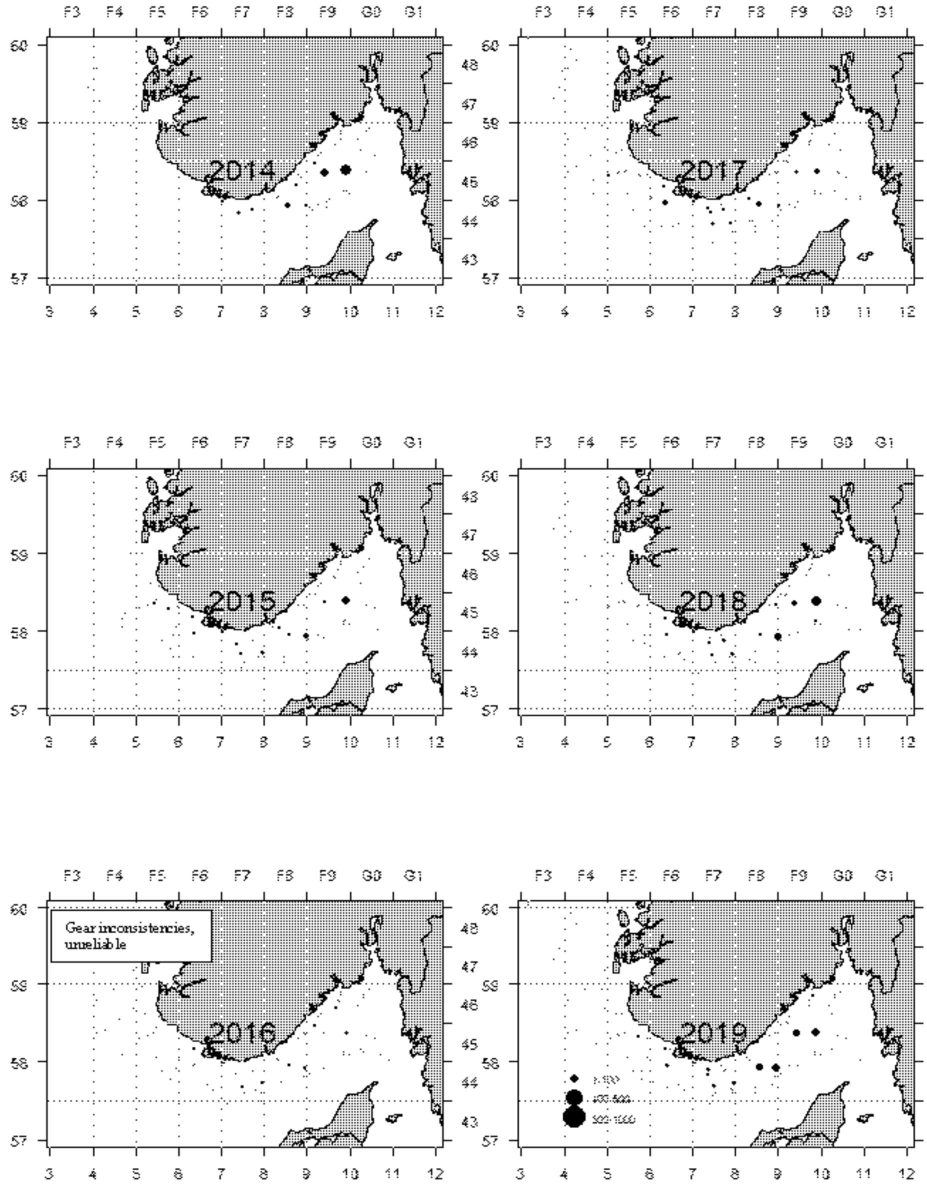

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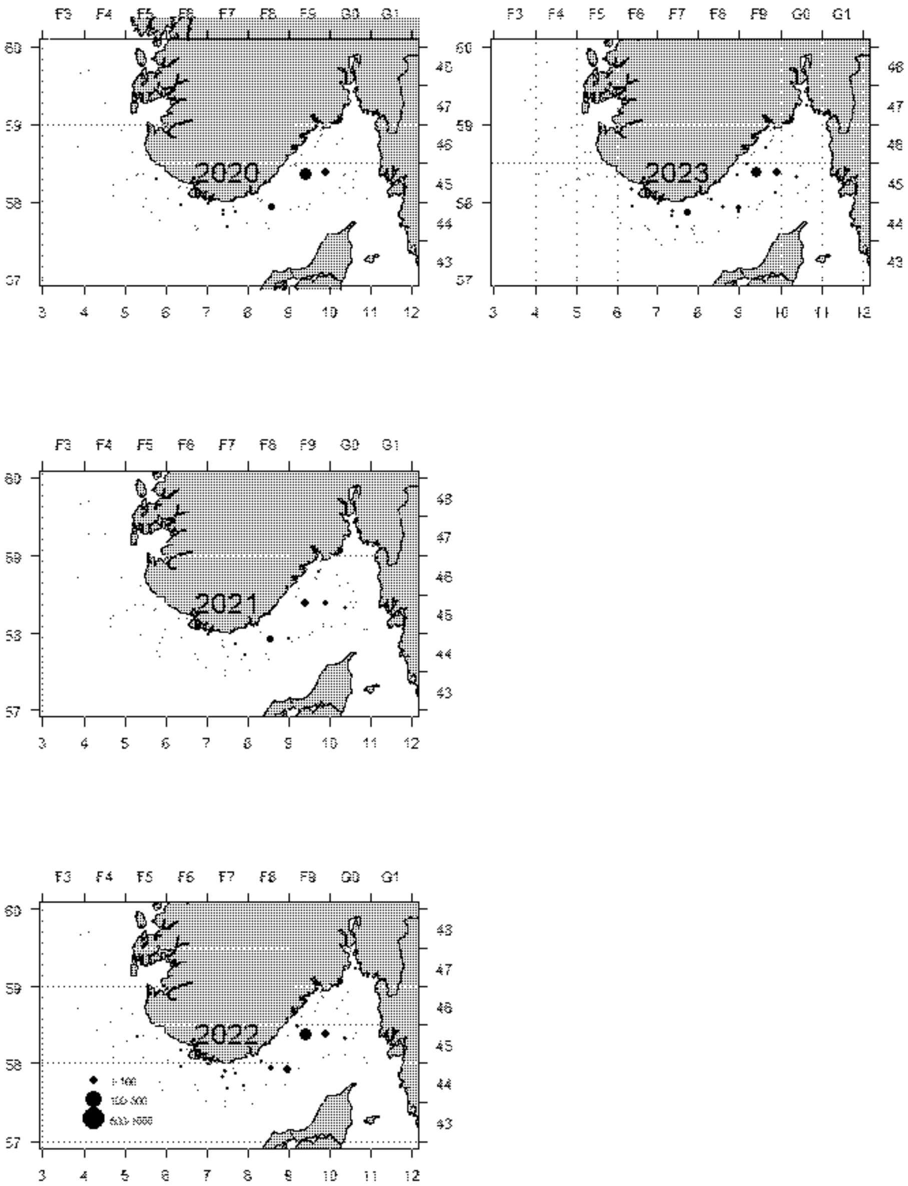

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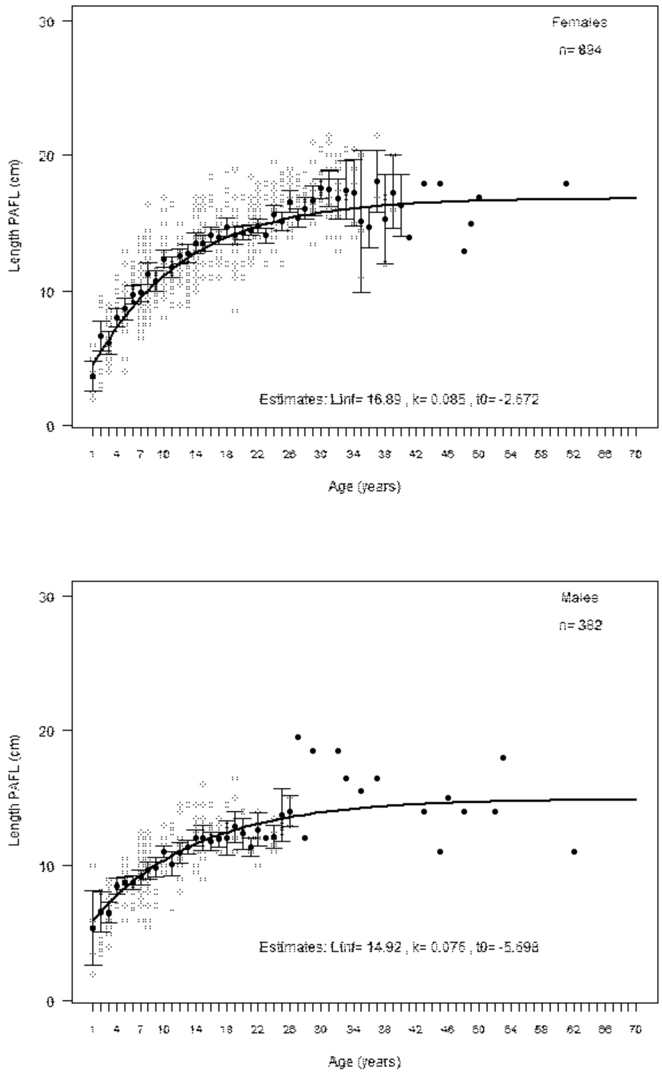

Figure 5. Length at age for female and male roundnose grenadier; data from Skagerrak 2008-2023. Mean values are estimated with ±2SE where there is more than one value. Estimated von Bertalanffy growth curves with parameters for females and males.

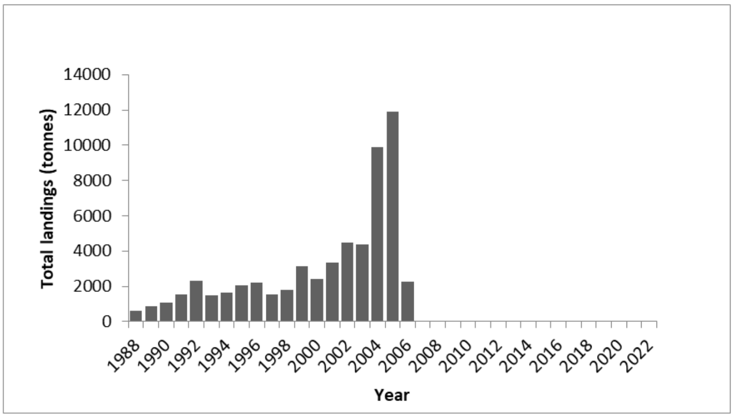

Figure 6. Total reported landings of roundnose grenadier in ICES Division 3a, 1988-2022. Landings from 2007 and later are very small and all less than 2 tons.

Working Document presented to the ICES Working Group on the
Biology and Assessment of Deep Sea Fisheries Resources

ICES WGDEEP, 3 - 9 May 2023

The Blackspot seabream Spanish target fishery of the Strait of Gibraltar: updating the available information

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Abstract

This paper includes the available information of the Blackspot seabream (Pagellus bogaraveo) Spanish target fishery in the Strait of Gibraltar updating the documents presented in previous years with the information from 2022. So, data about landings, fishing effort, CPUEs and landings length frequencies are presented to its inclusion in the 2023 WGDEEP Report.

1. Introduction and fishery description

Since the earlies 1980´s a Spanish artisanal fishery targeting to Blackspot seabream (*Pagellus bogaraveo*, namely "*voraz*") have been developed in the Strait of Gibraltar area (ICES 9a South). This fishery has already been broadly described in previous Working Documents presented to the ICES WGDEEP (Gil *et al.*, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021 and 2022). Blackspot seabream Spanish fishery in the Strait of Gibraltar is almost a mono-specific fishery with a clear target species which represents the 74% from the total landed species which constitutes a fleet component by itself (Silva *et al.*, 2002).

In 2006, 2008, 2010, 2012 and 2016 different trials were attempted to assess this resource within the ICES WGDEEP (ICES, 2006, 2008, 2010, 2012, 2016 and 2018). Finally, 2018 scientific advice was based on abundance indexes (DLS category 3). All the available information from this target fishery (including the biomass index used as the basis for the assessment) were updated with the most recent (2022) data.

Thus, the main objective of this paper is to provide to the 2023 ICES WGDEEP a summary of the available information of this deep-water fishery located in a very narrow place of the ICES area 9.

2. Material and methods

Fishery information from the sale sheets was gathered for the period 1983-2021: monthly landings, monthly number of sales (as a proxy of fishing trip) and the number of days in which those sales were carried out. Moreover, landings length distributions was also estimated from the data collected by IEO monitoring programme (Gil *et al.*, 2000).

Geo-referenced information from SLSEPA devices (a sort of Vessel Monitoring System) on the "*voracera*" fleet operating at the Strait of Gibraltar were more recently available (from 2009 onwards): this monitoring system, locally called "green boxes" (to differentiate them from the EU VMS "blue boxes"), send every three minutes to a control centre several information about the fishing boat: time, positions, course and speed. Data were filtered and analyzed, according to the protocols proposed by Burgos *et al.* in 2013, to estimate fishing effort and catch rates of the Blackspot seabream Spanish target fishery.

3. Results and discussion

- Landings data: Figure 1 shows a continuous increase of Spanish landings from the beginning of the time series to reach a maximum in 1994. Since then landings´ trend decreased till 2002, despite the peaks in 1996 and 1997. Again, it shows an increasing trend from 2003 to 2009, decreasing afterwards except for a slight increase in 2014. Landings since 2018 show the lowest values of the series, with a 2020-2022 mean of about 7 tons (but less than 1 ton in the last year) landed by the Spanish "voracera" fleet.

Until now, discards can be assumed to be zero or negligible. However, the established minimum landing size of 33 centimeters for the species (both for NE Atlantic and Mediterranean Sea) and the landing obligation (EU Regulation 2013/1380) don´t might have an effect on the discards of this target fishery because its high survival exemption.

Hence landings are currently being used as a proxy of catches. However, it should be noted that not all the Spanish catches/landings come exclusively from ICES area 9 but they are considered from the same stock unit because the fishing area (Strait of Gibraltar) is placed between different Advice bodies/Regional Fisheries Organizations (ICES, GCFM and CECAF) boundaries. In fact, since 2015 Spanish Blackspot seabream landings available at InterCatch tool comprise different areas: 27.9.a (ICES), 34.1.11 (CECAF) and 37.1.1 (GFCM).

Data from Moroccan longliners fishing Blackspot seabream in the Strait of Gibraltar area are available since 2001. The information are available on FAO GFCM statistics (WGSAD-SAC and SRC-WW) so, when possible, it is included in the WGDEEP landings estimates because

Moroccan boats target the same population, sharing the main Strait of Gibraltar fishing grounds with Spain (ICES, 2016).

- CPUEs: Nominal biomass index shows ups and downs throughout the historical series (Figure 2). It is important to emphasize that the effort unit chosen (number of sales) may not be appropriate as does not consider the missing effort. So in the most recent years, when the resource is not quite abundant, the missing effort might increase substantially (fishing boats with no catches and no sale sheet records). Therefore, the LPUE trend since the first fishery´s decline (1997) should be interpreted with caution because it cannot be a real image of the resource abundance. Anyway, a severe and continuous decreasing trend is observed since 2016, with CPUEs lower than 40 kilos per fishing trip till about 20 kilos per fishing year in 2021 and less than 10 kilos in 2022.

Table 1 updates the available information from regional VMS (SLSEPA), following the data compilation and process described by Burgos *et al*. in 2013.

Table I. Estimates of fishing effort and CPUEs (2009-2022) from the "*voracera*" fleet targeting Blackspot seabream based on regional VMS (SLSEPA) and fishery statistics (sales sheets).

Data source		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
VMS	Landings (k)	459,010	274,882	190,786	79,163	37,799	94,261	137,444	73,508	24,716	4,402	4,825	1,579	2,614	313
	No. sales	7,200	5,863	4,711	2,946	2,086	2,989	3,079	1,873	1,017	309	248	62	89	36
	Fishing days (fishing trips)	8,373	7,238	6,160	3,686	2,695	4,191	4,234	2,724	1,740	1,046	607	125	266	235
	CPUE 1 (landings/no. sales)	64	47	40	27	18	32	45	39	24	14	19	25	29	9
	CPUE 2 (landings/fishing days)	55	38	31	21	14	22	32	27	14	4	8	13	10	1
	Missing effort (%)	14	19	24	20	23	29	27	31	42	70	59	50	67	80
TOTAL	Landings (k)	579,140	316,365	239,790	126,006	66,159	137,623	166,440	99,726	42,991	7,633	18,693	12,838	8,412	488
	No. sales	8,892	6,932	5,659	3,638	2,222	3,527	3,384	2,418	1,308	429	794	525	404	72
	CPUE 1 (landings/no. sales)	65	46	42	35	30	39	49	41	33	18	24	24	21	7

CPUE 2 (landings/fishing days), where the effort is estimated from the VMS device also declined with lower values than CPUE 1 because the fact of the missing effort. So, as expected, CPUEs estimates from VMS analysis shows the same trend but lower values than the nominal one, from sale sheets (Figure 2).

- Length frequencies: The mean length of landings seems to have decreased in two different periods: from 1995 to 1998 and from 2009 to 2013 (Figure 3). 2021 mean length estimate shows a significant increase (about 5 cm) but data should be revised because is not consistent with previous and following years.

4. Main conclusions

The general trend for the time series of both, landings and CPUEs, continues showing a decreasing pattern over recent years, exhibiting the lowest values of the whole series. This might be a consequence of an overexploitation status of the stock, which is addressing the fishery into a critical situation.

It should be noted that GFCM establish a management plan for the Blackspot seabream fishery of the Strait of Gibraltar in 2022 (GFCM/45/2022/3 on a multiannual management plan for the sustainable exploitation of blackspot seabream in the Alboran Sea, geographical subareas 1 to 3). The update of benchmark assessment (gadget model) for blackspot seabream in the Strait of Gibraltar was presented in the last GCFM WGSAD (December 2022). Results indicated that the stock is depleted with unsustainable exploitation and low fishing mortality. The recommendation was to proceed with immediate reduction of fishing mortality, implementing also a recovery plan (GFCM, 2022).

Acknowledgments

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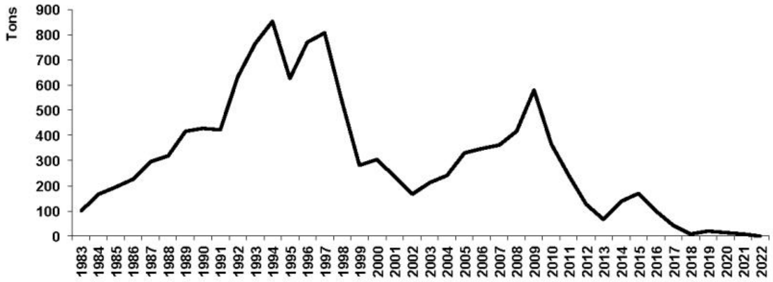

Figure 1. Blackspot seabream Spanish "*voracera*" fishery of the Strait of Gibraltar: total landings (1983-2022).

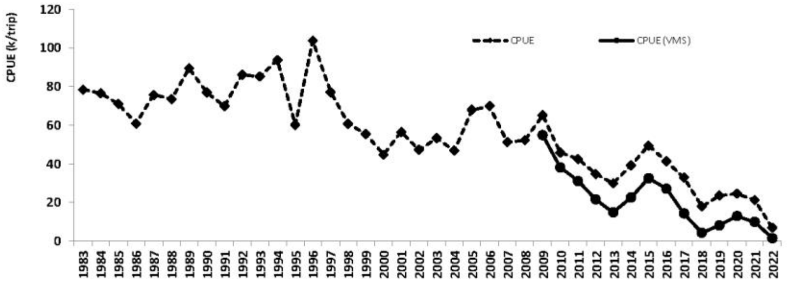

Figure 2. Blackspot seabream Spanish "*voracera*" fishery of the Strait of Gibraltar: nominal (sale sheets) CPUE (1983-2022) and (VMS) CPUE (2009-2022).

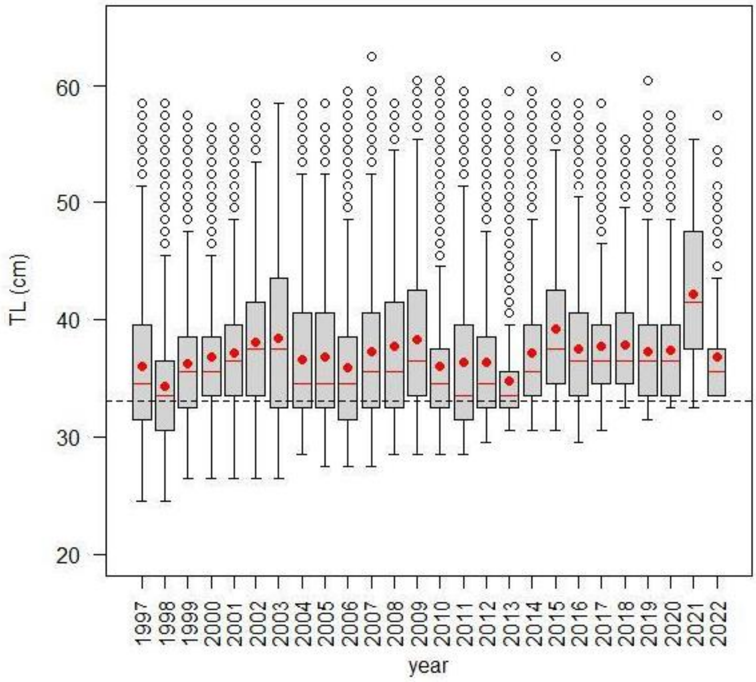

Figure 3. Blackspot seabream Spanish *"voracera"* fishery of the Strait of Gibraltar: landings length distribution descriptive statistics (red dot: mean value, red line: median value, box and whiskers: Interquartile Range plus Q_1-3IQR and Q_3+3IQR, circles: outliers).

Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources

3rd – 9th April 2023

Greater forkbeard *Phycis blennoides* in Portuguese waters (ICES Division 27.9.a)

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Abstract

This working document updates the information presented in previous WGDEEP meetings for the greater forkbeard *Phycis blennoides* in ICES Division 27.9.a (continental Portugal), particularly fishery dependent data and MSY length-based indicators (LBI). Length-based indicators LBI used to classify the stocks according to conservation/sustainability, yield optimization and MSY were estimated for the exploited population in continental Portugal based on length samples collected under the Portuguese DCF program.

1. General considerations

The greater forkbeard *Phycis blennoides* (Brünnich, 1768) is a demersal species from the family Gadidae. This species is widely distributed in the northeast Atlantic from Norway and Iceland to Cape Blanc in West Africa and in the Mediterranean Sea (Massutí et al., 1996), and occurs preferentially along the continental shelf and slope, at depths ranging between 60 and 1000 m deep (Massutí et al., 1996; Casas and Piñeiro 2000; García et al., 2000).

The greater forkbeard has a discrete recruitment period along the year and is available to fishing at the first years of life (Ragonese et al., 2002). The size of transition from the pelagic to the demersal habitat occurs at lengths around 6 cm in Atlantic waters (Casas and Piñeiro, 2000) and at a smaller size (4.5-5.0 cm total length) in the Mediterranean (Ragonese et al., 2002). In the Gulf of Tunis, age parameters were estimated as TL_{inf} = 57.17 cm, k = 0.193 year^{-1}, t_0 = −1.578 year for females, and TL_{inf} =44.74 cm, k = 0.313 year^{-1}, and t_0 =−1.210 year for males. Females grow faster than males, and the latter did not exceed 45 cm (Romdhani et al., 2016).

1.1. The greater forkbeard in Portuguese waters from ICES Division 27.9.a

In Portuguese continental waters, the length structure and the biology of greater forkbeard, namely reproduction, suggests that it completes the whole life cycle in the area (Lagarto et al., 2017). As in other geographic areas where the species occurs (e.g., in the Mediterranean), a depth effect on specimen's size is observed (Massutí et al., 1996) with larger specimens occurring at higher depths (>600 m deep) (Fig.1).

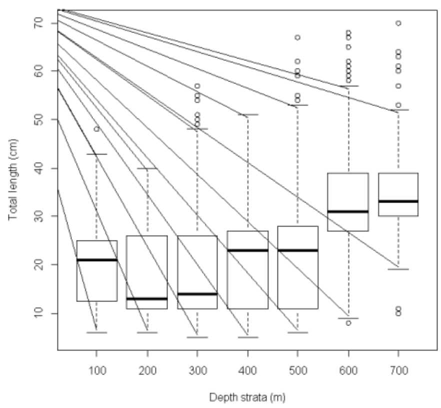

Figure 1. Inter-quartile total length range of *P. blennoides* by depth strata (m) caught during the Portuguese Crustacean Surveys/Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) undertaken between 1997 and 2016 (no survey was conducted in 2012). (from Lagarto et al., 2017)

2. Fishery dependent data in Portuguese waters from ICES Division 27.9.a

In continental Portugal there are no fisheries targeting the greater forkbeard. This species is mainly caught as by-catch of other fisheries, particularly from the polyvalent fleet segment or multi-gear fleet, which is responsible for ~98% of the species total landings.

The Portuguese polyvalent segment includes vessels of different sizes usually licensed to operate with more than one fishing gear (e.g. gill and trammel nets, longlines, and traps). At each fishing trip, vessels belonging to this segment may deploy more than one fishing gear, depending on the targeted species and on the fishing grounds. The analysis of logbook data further indicates that, within the polyvalent segment, the greater forkbeard is mainly caught by demersal longlines (Moura and Figueiredo, 2020).

Most greater forkbeard landings are reported at Peniche landing port, in the Centre of Portugal. A marked seasonal pattern on Portuguese landings is observed with higher values between May and July (Lagarto et al., 2017). Although the reasons for this seasonality are unknown, it is considered that they might be related to the dynamics of the fleets and particularly to changes on their target species.

2.1. Commercial landings

Official Portuguese annual greater forkbeard landing estimates in ICES Division 27.9.a are presented in Table 1. It is worth mentioning that landings are likely to be biased due to species misidentification problems. It is admitted that greater forkbeard can be misidentified with its congener *Phycis phycis*. Moreover, the two *Phycis* species, and particularly at the beginning of time series, might be landed under the designation of *Phycis* spp. However, the fraction of *Phycis* spp. landings corresponding to *P. blennoides* is unknown and cannot be estimated as the level of DCF sampling coverage is insufficient.

Historically, the landings of greater forkbeard species are low, either because of its relatively low commercial value or to the low fishing effort at deeper fishing grounds.

Table 1. Official landings (ton) of *Phycis blennoides*, *Phycis phycis* and *Phycis* spp. by fleet from 2003 to 2022. *Phycis* spp. includes landings of *P. blennoides* and *P. phycis*. Source: DGRM (official landings).

	Phycis blennoides				*Phycis phycis*				*Phycis* spp.			
Year	TRAWL	PSEINERS	ARTISANAL	TOTAL	TRAWL	PSEINERS	ARTISANAL	TOTAL	TRAWL	PSEINERS	ARTISANAL	TOTAL
2003	0.08		10.87	10.95	0.75		5.69	6.44	7.87	0.50	314.14	322.51
2004	0.10	0.05	9.84	9.98	0.11		3.59	3.70	7.85	0.60	295.10	303.55
2005	0.17	0.03	14.00	14.20	1.06	0.02	83.49	84.57	5.68	0.13	183.03	188.84
2006	0.17		9.66	9.84	2.11	0.08	176.24	178.43	3.22	0.01	56.05	59.28
2007	0.10	0.02	13.40	13.52	2.69	0.28	215.65	218.62	4.01		25.20	29.21
2008	0.18	0.01	12.05	12.23	4.79	0.10	234.03	238.92	0.14		25.03	25.17
2009	0.10		14.64	14.74	11.20		452.92	464.13			18.61	18.61
2010	0.10		11.53	11.63	14.24		472.11	486.36			8.68	8.69
2011	0.04		13.43	13.48	7.08	0.01	450.68	457.76			5.91	5.91
2012	0.08		5.58	5.66	4.24	0.03	456.11	460.38			5.24	5.24
2013	0.11		7.67	7.78	4.22	0.92	274.22	279.35			3.78	3.78
2014	0.13		6.09	6.22	2.27	0.80	170.97	174.04			2.39	2.39
2015	0.04		7.39	7.43	5.32	0.73	154.72	160.77			1.58	1.58
2016	0.12		6.69	6.81	6.72	1.41	181.31	189.44			1.81	1.81
2017	0.20		8.85	9.05	4.13	1.69	172.38	178.21	0.00		1.27	1.28
2018	0.19		9.23	9.42	2.70	0.35	129.27	132.31			0.64	0.64
2019	0.02		7.12	7.14	2.03	0.313	133.35	135.69			1.34	1.34
2020	0.08		4.80	4.88	1.61	0.30	137.78	139.69			0.99	0.99
2021	0.09		11.16	11.25	1.66	0.53	331.83	334.01			0.66	0.66
2022	0.19		8.47	8.66	0.80	0.13	327.63	328.55			0.86	0.86

2.2. Length data

The greater forkbeard is sampled for length at several landing ports along the Portuguese continental coast under the national data collection program (PNAB/DCF). The total length of specimens sampled from 2014 to 2022 (under DCF market and onboard programs) ranged between 17 and 78 cm (Farias et al., 2021). The length frequency distributions slightly differed between the trawl and the polyvalent fleet segments (the length of specimens caught by trawlers are skewed to sizes smaller than those caught by polyvalent vessels) (Moura and Figueiredo, 2020). Given the very low landing values attributed to the trawl segment, the length frequency distribution of the greater forkbeard exploited population is mainly derived from the polyvalent fleet segment catches.

Length-based indicators (LBI) screening methods were applied to the length frequency distributions of the greater forkbeard landed in continental Portugal for the period 2019-2022. The procedure followed the ICES Technical guidance for providing reference points for stocks in categories 3 and 4 (Table 2) (ICES, 2017). The L_{mat} and L_{inf} estimates adopted were those made available by Spain for sexes combined: 53.89 cm and 91.46 cm, respectively (ICES WGDEEP datacall, 2018). The length-weight relationship parameters ($Wt = 0.016\ TL^{2.843}$) were defined by Mendes et al. (2004).

Table 2. Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system (from ICES, 2017).

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	Pmega	> 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 > L_c	$L_{opt} = {}^{2}/_{3}\ L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{max_y}	Length class with maximum biomass in catch	$Lopt = {}^{2}/_{3}\ L_{inf}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals > L_c	$L_{F=M} = (0.75L_c+0.25\ L_{inf})$	L_{mean} / $L_{F=M}$	≥ 1	MSY

Results from the LBI screening method are shown in Tables 3a and 3b and Figure 2.

Table 3a. Results from LBI screening: indicator values.

Year	L_{75}	L_{25}	L_{med}	L_{90}	L_{95}	L_{mean}	L_c	$L_{F=M}$	L_{maxy}	L_{mat}	L_{opt}	L_{inf}	$L_{max5\%}$
2019	51.5	45.5	49.5	58.5	63.5	52.57	46	57.365	51.5	53.89	60.97	91.46	66.47
2020	44.5	42.5	44.5	53.5	53.5	46.03	42	54.365	44.5	53.89	60.97	91.46	53.50
2021	46.5	40.5	43.5	48.5	53.5	46.54	42	54.365	48.5	53.89	60.97	91.46	59.55
2022	62.5	56.5	58.5	64.5	65.5	59.21	46	57.365	58.5	53.89	60.97	91.46	65.50

All LBI estimates increased between 2021 and 2022 (Table 3a).

Table 3b. Results from LBI screening: indicator ratios. Ref., Reference expected values from ICES (2017).

		Conservation					Optimizing Yield	MSY
		L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{95\%}/L_{inf}$	L_{maxy}/L_{opt}	$L_{max5\%}/L_{inf}$	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Year	Ref.	> 1	> 1	> 0.8	≈ 1	> 0.8	≈ 1 (>0.9)	≥ 1
2019		0.85	0.84	0.69	0.84	0.73	0.86	0.92
2020		0.78	0.79	0.58	0.73	0.58	0.75	0.85
2021		0.78	0.75	0.58	0.80	0.65	0.76	0.86
2022		0.85	1.05	0.72	0.96	0.72	0.97	1.03

Most of the ratios between indicators estimates (Table 3b) are below the proposed expected values (see Table 3). These results are related to the poor representation, on landings, of all the size ranges of the population. Discards are known to occur but are unquantifiable. It is acknowledged that the largest specimens are discarded from the deep-water longline fisheries but numbers are relatively low (Lagarto et al., 2017). In addition, onboard data for this fleet is derived from a small area of the total stock distribution in the Portuguese continental waters. Thus, the fishing effort affecting the largest individuals is relatively low.

Conservation ratio estimates increased in 2022 in relation to previous years and $L_{25\%}/L_{mat}$ and L_{maxy}/L_{opt} were above the reference values in 2022 (Table 3b and Figure 2). The Optimizing Yield indicator ratio increased between 2021 and 2022 to values above the reference, which indicates that the stock is being fished above optimum yield. The indicator for MSY increased from 2020 to 2022 and is now consistent with an adequate exploitation.

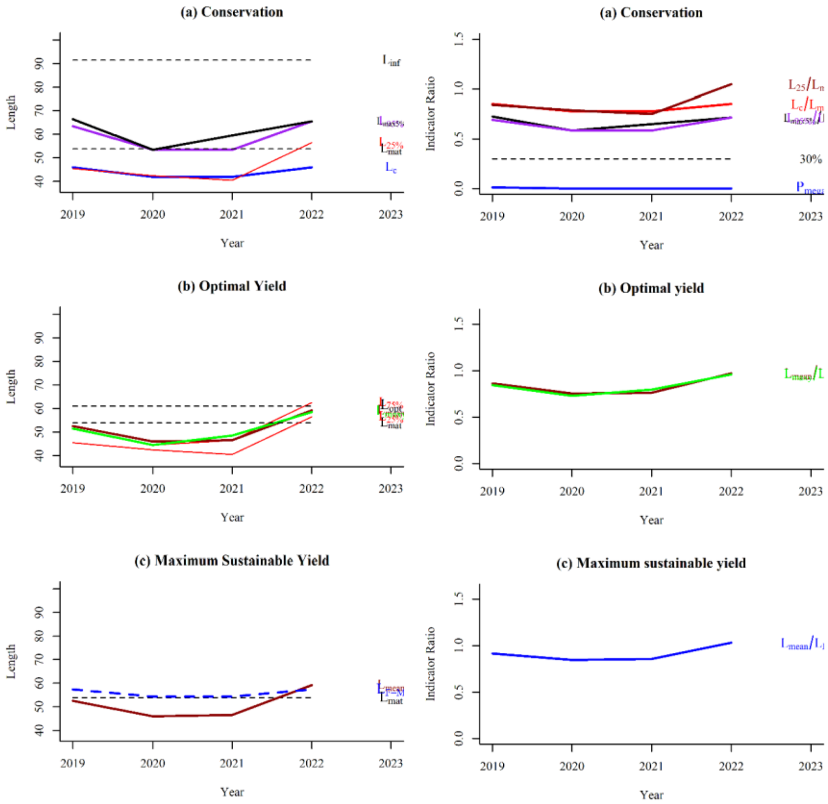

Figure 2. Results from LBI screening.

3. Fishery independent data in Portuguese waters from ICES division 27.9.a

Fishery independent data available from the Portuguese Crustacean Surveys/ Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) has been used to estimate a standardized relative biomass index between 1997 and 2018 (Farias et al., 2021). In 2019 and 2020, the PT-CTS (UWTV (FU 28-29)) survey was not performed. In 2021, the R/V Mário Ruivo started to operate, but the survey's spatial coverage was smaller and fishing stations in the area where the species is traditionally more abundant were missing (Moura et al., 2022). The standardized biomass index has not been updated since 2021 (Farias et al., 2021).

4. Conclusions

Two standardized CPUE series based on commercial data suggested that the status of the greater forkbeard population inhabiting the Portuguese continental waters in recent years has been stable (Farias et al., 2021).

The standardized survey biomass estimates, which represents a relatively long time series, were well above the overall mean and showed an increasing trend in the last years of the time series (Farias et al., 2021). For the period between 1997 and 2016, an increasing trend was also observed for the juvenile component of the population, indicating that the fishing pressure over the Portuguese population had not seriously impaired the recruitment (Lagarto et al., 2017).

In general, LBI screening results, particularly the indicator of MSY, are above the reference values, suggesting that the stock is in a fair status.

Given the fact that this species is not targeted by any fishery, the results obtained suggest that the Portuguese fisheries are not impairing the population of greater forkbeard, whose information for the Portuguese waters further indicates that the species is able to complete the whole life cycle in the area.

Worth to mention that the relative low fishing impact of the Portuguese fisheries in deeper grounds reduces the impact over the fraction of larger specimens of the population, as the species tends to be larger at greater depths.

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Comparison between Greater silver smelt in ICES Subarea 5.a and Division 14 assessed using Gadget2 versus Gadget3 implementations

Will Butler, Pamela J. Woods, and Magnús Thorlacius

2023-05-03

Contents

Recently, a new implementation of Gadget has been designed and tested, and is being used for assessment of Greenland halibut (*Reinhardtius hippoglossoides*) and beaked redfish (*Sebastes mentella*) (ICES, 2023). The operational model is essentially the same as in previous implementations with some additional options (Lentin *et al.*, 2022). However, as it is based on the TMB package (Uffe *et al.*, 2017) in R statistical software (R Core Team, 2023), it can use different optimization routines. The Gadget3 model shown here was optimized using the BFGS algorithm, rather than the three-step routine used under Gadget2 implementation, which included simulated annealing, followed by Hooke and Jeeves, and finally BFGS optimizations. The largest benefit of using the Gadget3 implementation rather than the Gadget2 implementation is access to auto-differentiation libraries that greatly speeds the optimization time, which in the past has been a limitation to being able to produce confidence intervals based on a spatial bootstrap method (Elvarsson *et al.*, 2018). Another benefit is that in the future, it is more likely that Gadget3 will be maintained. We propose here to switch the implementation platform of the assessment model for Greater silver smelt in ICES Subarea 14 and Division 5.a (East Greenland and Iceland grounds) to Gadget3 from the Gadget2, as it would alleviate time constraints while producing results that correspond well with results from Gadget2. Fits to survey indices are very similar (Figure 1), as are fits to autumn survey length and age-length distribution data (Figures 2 and 4) and the commercial length and age-length distribution data (Figures 3 and 5) . Model results are also very similar (Figure), and the analytical retrospective analyses, both of which show very low Mohn's rho values, can essentially not be distinguished (Figures 6 vs.).

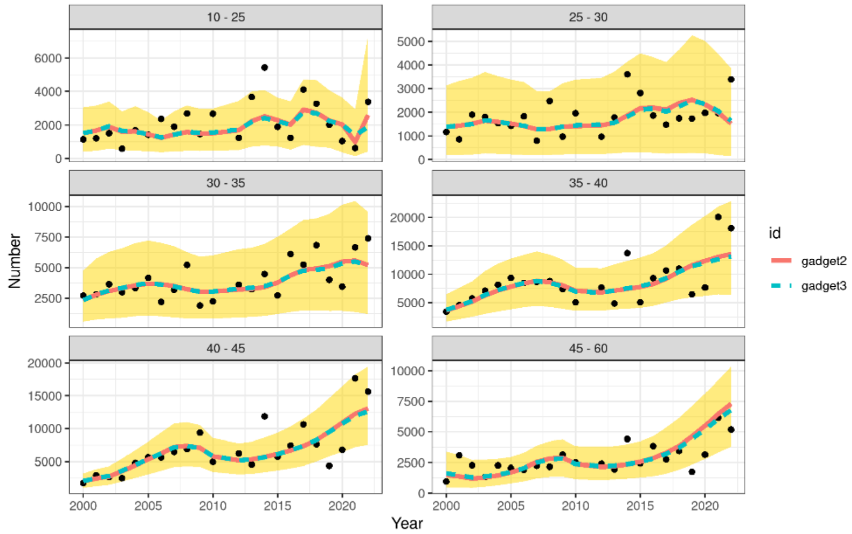


Figure 1: Greater silver smelt in 5a and 14. Comparison of fits to the survey index data implemented using Gadget3, as done in this year's assessment, versus Gadget2 (implementation platform from previous years). Red lines indicate Gadget2, blue dashed lines indicate Gadget3.

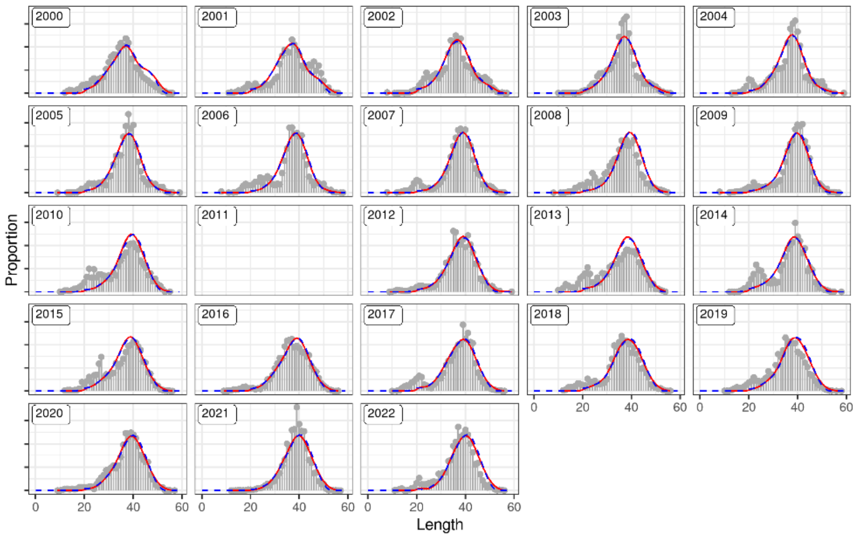


Figure 2: Greater silver smelt in 5a and 14. Comparison of fits to the autumn survey length distribution data implemented using Gadget3, as done in this year's assessment, versus Gadget2 (implementation platform from previous years). Red lines indicate Gadget2, blue dashed lines indicate Gadget3.

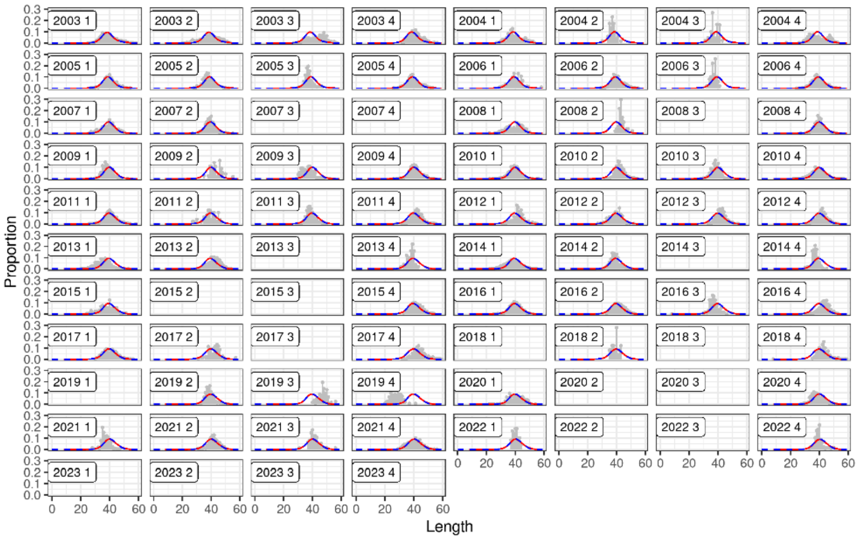


Figure 3: Greater silver smelt in 5a and 14. Comparison of fits to the commercial length distribution data implemented using Gadget3, as done in this year's assessment, versus Gadget2 (implementation platform from previous years). Red lines indicate Gadget2, blue dashed lines indicate Gadget3.

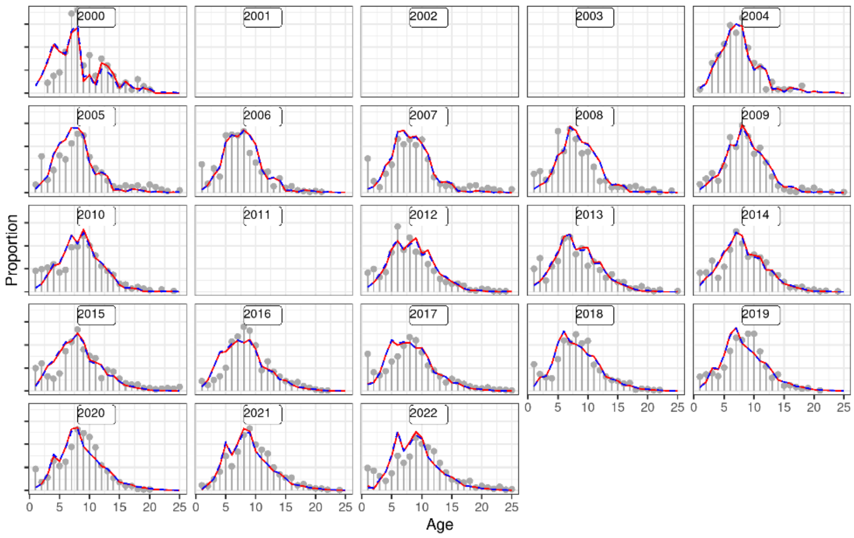


Figure 4: Greater silver smelt in 5a and 14. Comparison of fits to the autumn survey age-length distribution data implemented using Gadget3, as done in this year's assessment, versus Gadget2 (implementation platform from previous years). Red lines indicate Gadget2, blue dashed lines indicate Gadget3.

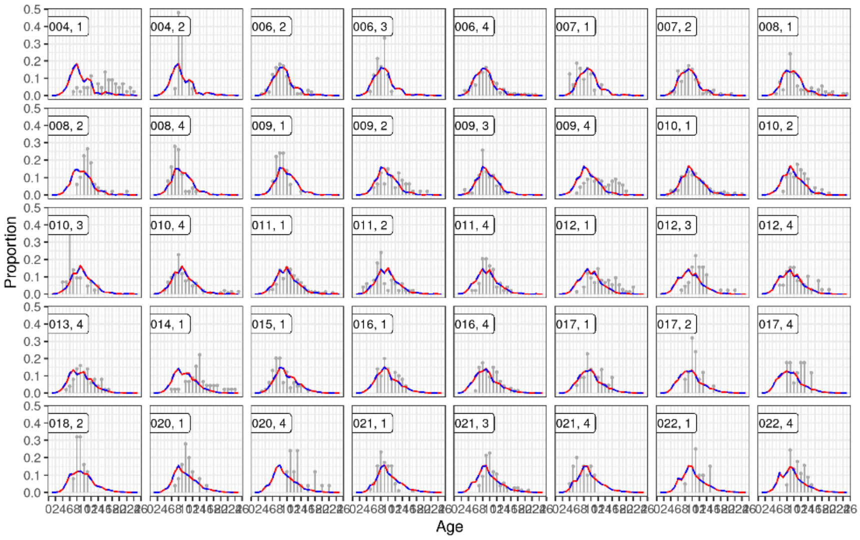


Figure 5: Greater silver smelt in 5a and 14. Comparison of fits to the commercial age-length distribution data implemented using Gadget3, as done in this year's assessment, versus Gadget2 (implementation platform from previous years). Red lines indicate Gadget2, blue dashed lines indicate Gadget3.

\begin{figure}
\caption{Greater silver smelt in 5a and 14. Comparison of assesssment results when implemented using Gadget3, as done in this year's assessment, versus Gadget2 (implementation platform from previous years). Yellow bands indicate 90% confidence intervals based on a spatial bootstrap generated from the Gadget3 model.} \end{figure}

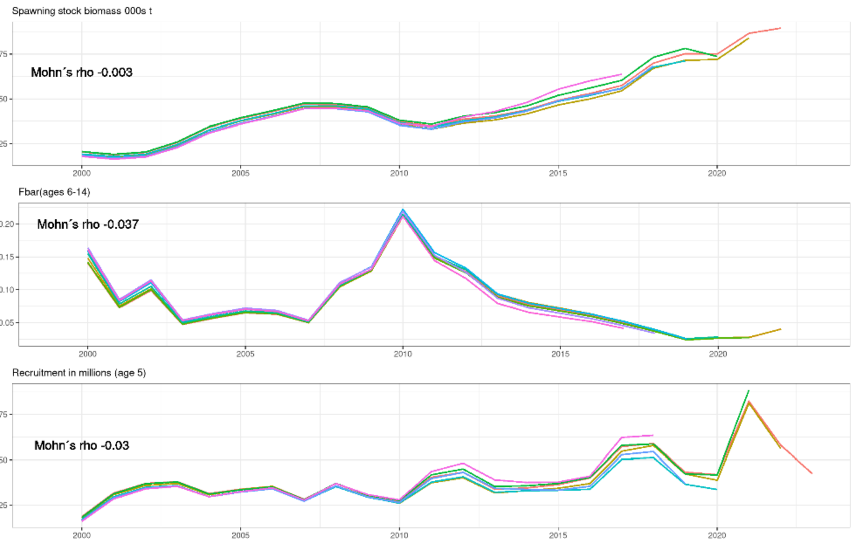
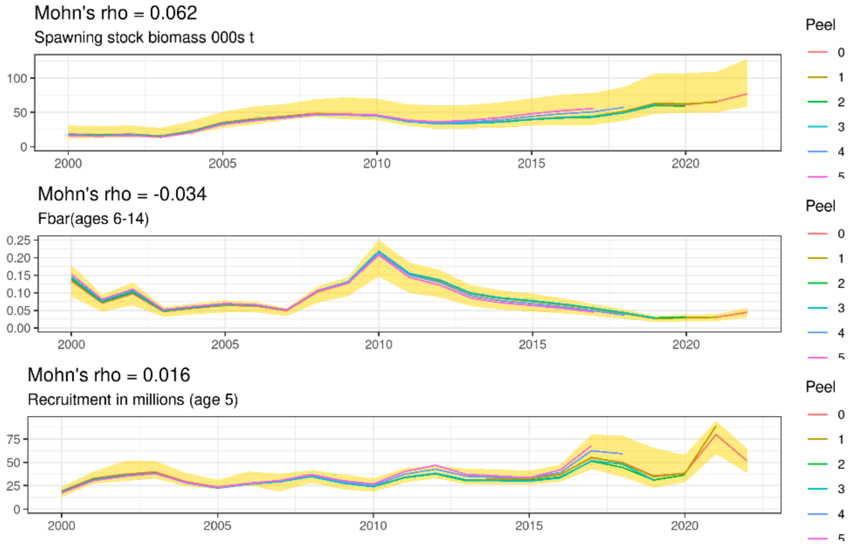


Figure 6: Greater silver smelt in 5a and 14. Analytical retrospective pattern resulting when implemented using Gadget2, implementation platform from previous years.



\begin{figure}
\caption{Greater silver smelt in 5a and 14. Analytical retrospective pattern resulting when implemented using Gadget3, as done in this year's assessment. Yellow bands indicate 90% confidence intervals based on a spatial bootstrap generated from the Gadget3 model.} \end{figure}

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***Pagellus bogaraveo* in Portuguese continental waters (ICES Division 27.9.a)**

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1. Introduction

Pagellus bogaraveo (Brünnich, 1768), the blackspot seabream, distributes between southern Norway and Cape Blanc, in the Mediterranean Sea, and in the Azores, Madeira, and Canary Archipelagos (Desbrosses, 1932; Pinho and Menezes, 2005).

Spawning occurs in shallow waters, where juveniles of age groups 0 and 1 are reported to remain at depths lower than 170 m, close to the coast, in the Azores (Menezes et al., 2001), the Bay of Biscay (Lorance, 2011), and the Mediterranean Sea (Biagi et al., 1998; Félix-Hackradt et al., 2013). When juveniles reach 150–180 mm total length (TL), they migrate along the slope to depths deeper than 200 m, following an ontogenetic migration towards deeper waters (Olivier, 1928; Desbrosses, 1932; Morato et al., 2001; Spedicato et al., 2002). Nevertheless, fish with sizes larger than 40 cm have been occasionally caught in coastal waters (Priol, 1932).

The blackspot seabream is a protandric hermaphrodite – individuals are first functional males and then develop into functional females (Buxton and Garratt, 1990; Krug, 1990; Gil, 2006). In the Azores, the age of first maturity is about 8 years old for females (Krug, 1990). In Cadiz waters, the main spawning period occurs during the 1st quarter (Gil, 2010), whereas in the Azores spawning is from March to April (Martins *et al.*, 2007).

In the Northeast Atlantic, *P. bogaraveo*'s stock structure is still unknown. Genetic studies showed a restricted gene flow among the populations located in the Azores (ICES Division 27.10.a.2) and those on the Portuguese continental slope (ICES Division 27.9.a) and Madeira (CECAF FAO Division 34.1.2) (Stockley *et al.*, 2005; Pinera et al., 2013). Mitochondrial control region showed similar genetic diversity among sampling sites in the NE Atlantic and the Mediterranean, and no differentiation between the Azores and the remaining locations (Robalo et al., 2021). More recently, a genomic study using biological samples from different geographic areas supported the existence of three well-differentiated clusters in the Atlantic: (i) the Azores; (ii) Cadiz; and (iii) the continental Atlantic coast (Cunha et al., submitted). Those results confirmed that the Azorean population is isolated from the other populations and support the separation of the population occurring off Cadiz from the remaining Iberian area.

Despite the poor knowledge on the species stock structure, ICES adopts three management components for management purposes: (a) Subareas 27.6, 27.7, and 27.8; (b) Subarea 27.9; and (c) Subarea 27.10 (Azores) (ICES, 2007). These components were established to better record the available information and do not have implicit the existence of three different stocks of *P. bogaraveo*. There is no evidence of movements between the northernmost component and the southern part of Subarea 27.9 where a targeted fishery takes place in the Strait of Gibraltar (ICES, 2019).

The Spanish longline fishery operating in the Strait of Gibraltar has been managed as a regulated open-access fishery since its initial exploitation, in 1983 (Gil et al., 2019). In 2001, Moroccan longliners started a target fishery in the same area. Therefore, two directed fisheries are presently taking place in the Spanish and Moroccan Exclusive Economic Zone (EEZ) (ICES, 2017).

Total Allowable Catch (TAC), Portuguese quota, and official landings are presented for continental Portugal (ICES Division 27.9.a) for the period between 2014 and 2022 (Table 1).

Table 1. *Pagellus bogaraveo* Total Allowable Catch (TAC) and Portuguese quota and official landings in ICES Subarea 27.9, between 2014 and 2022.

Year	TAC EU ICES Subarea 27.9	Portugal quota ICES Subarea 27.9	Official Portuguese landings ICES Division 27.9.a
2014	780	166	59
2015	374	80	66
2016	183	39	70
2017	174	37	69
2018	165	35	58
2019	149	32	36
2020	149	32	43
2021	119	25	29
2022	119	25	32
2023	114	24	
2024	114	24	

1.1. Fishery in Portugal continental

In continental Portugal, *P. bogaraveo* is mainly caught as by-catch of fisheries targeting other species, although some vessels are licensed to target the species.

Fishery data and information collected through enquiries made to Peniche (Portuguese central western coast) skippers with experience on *P. bogaraveo* fishing has shown that: (i) the species tends to gather at specific fishing grounds with particular seamount-like topographic features, being mainly caught at depths around 250 m; (ii) the fishing grounds substrates are mainly composed by muddy sand, rock, and sand; (iii) the species length range is not different between the different fishing grounds. Some skippers additionally referred that, during winter, the species migrates, driven by environmental factors or biological conditions, such as reproduction (Araújo et al., 2016).

Information on blackspot seabream collected from 1990 to 2018 in the Portuguese Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) and the Portuguese Autumn Groundfish Surveys (PT-GFS) conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA) supports the hypothesis of a patchy distribution, as the species is more frequently caught at specific grounds (Farias and Figueiredo, 2019). It is important to note that the PT-CTS (UWTV (FU 28-29)) survey design is considered inadequate to estimate the species abundance or biomass, as the species distributes preferentially at non-trawlable areas.

2. Methodology

1.1. Fishery dependent data

1.1.1. Landings and mean price in continental Portugal

Portuguese landings in ICES Division 27.9.a were characterized. Fishery dependent data were collected from commercial landings for the period between 2009 and 2022.

Pagellus bogaraveo total landings in weight (ton) and value (euro) were analysed by year, fishing segment and NUTS (Nomenclature of Territorial Units for Statistics). The EU NUTS classification system (https://ec.europa.eu/eurostat/web/regions/background) is a regional system that divides each EU Member State’s territorial area into units, providing a harmonised hierarchy between regions. Following the criteria adopted under this system, continental Portugal is divided into 5 different NUTS II (level 2), namely: North; Centre; Lisbon Metropolitan Area; Alentejo; and Algarve.

1.1.2. Landings and mean price by fleet and selected NUTS II

Pagellus bogaraveo total landings in weight (ton) and value (euro) were analysed throughout the year, between 2009 and 2022, by fishing segment (polyvalent and trawl), considering the NUTS II with the most representative landings of the species: North, Centre, and Algarve.

1.1.3. Landings in the most important Portuguese continental ports

Pagellus bogaraveo total landings in weight (ton) were analysed throughout the year, between 2009 and 2022, by fishing segment (polyvalent and trawl) for NUTS II landing ports with the highest landings of the species: Matosinhos port belongs to NUTS II North; Aveiro, Nazaré, and Peniche ports belong to NUTS II Centre; and Sagres belongs to NUTS II Algarve.

1.2. LPUE

1.2.1. Reference fleet

Reference fleets for the polyvalent and for the trawl fishing segments were defined for the most important landing port considering total landings and value of the species, Peniche. The criteria adopted for the selection of fishing vessels were defined according to the number of fishing trips with positive landings of the species and the number of months of the year with positive landings of the species, during the period between 2015 and 2022.

For the polyvalent fishing segment, the criteria adopted for the selection of fishing vessel were: more than 9 fishing trips per year and more than 6 months with positive landings of the species.

For the trawl fishing segment, the criteria adopted for the selection of fishing vessel where: more than 9 fishing trips per year and more than 5 months with positive landings of the species.

In 2023, vessels with low or null fishing trips with landings of the species in the period between 2019 and 2022 were excluded.

1.2.2. CPUE adjustment

For each selected vessel, data available at fishing trip level was further analysed. The landed weight of the species (in kg) per fishing trip corresponds to the total weight landed by the vessel after each trip. A trip is defined from the moment the vessel leaves the dock to when it returns to the dock.

The landed weight per fishing trip was considered as an indicator of biomass index, further referred as CPUE. Important to note that discards of the species are negligible in Portuguese continental fisheries.

CPUE data were standardized through the adjustment of generalized linear models (GLM). The model with the best adjustment was selected based on the AIC criterion and on the analysis of residuals.

1.3. Length distribution

Pagellus bogaraveo length sampling data available from the national Data Collection Framework (DCF) for the polyvalent and the trawl segments for continental Portugal were analysed by year in the period between 2014 and 2022. Numbers-at-length were raised to the total landings of the species.

1.4. LBI

Length-based indicators (LBI) screening methods were applied to *P. bogaraveo* length data for continental Portugal. The procedure followed the ICES Technical guidance for providing reference points for stocks in categories 3 and 4 (ICES, 2017b). The L_{mat} and L_{inf} estimates were adopted from Gil et al. (2009) and CopeMed II (2019), respectively. The length-weight relationship parameters ($W = 1.17542e\text{-}05 \times L^{3.0366}$) were estimated based on biological sampling data collected in 2020 and following the procedure in fishR Vignette (Ogle, 2013). Selected indicators, reference points, indicator ratios and their expected values are presented in Table 2 (ICES, 2017b).

Table 2. Selected indicators for LBI screening plots (ICES, 2017b).

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	Pmega	> 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 > L_c	$L_{opt} = {}^2/_3\ L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{max_y}	Length class with maximum biomass in catch	$Lopt = {}^2/_3\ L_{inf}$	L_{maxy} / L_{opt}	≈1	

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
L_{mean}	Mean length of individuals > L_c	$L_{F=M}$ = $(0.75L_c+0.25L_{inf})$	L_{mean} / $L_{F=M}$	≥ 1	MSY

2. Results and discussion

2.1. Fishery dependent data

2.1.1. Landings and mean price in continental Portugal

In the period between 2009 and 2022, the species was landed in all five NUTS II of the Portuguese continental coast (Figure 1). Landing ports in central Portugal (NUTS II "Centro") showed the highest landings in weight followed by the Algarve (South Portugal), that was around four times lower, and the North (NUTS II "Norte") that was up to 8 times lower. Similar proportions were found between the NUTS in terms of value of the species (Figure 2).

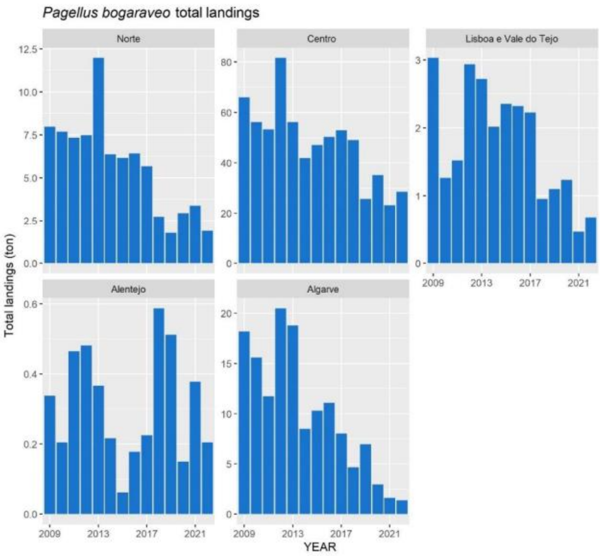

Figure 1. *Pagellus bogaraveo* total landings in tonnes in each NUTS II in continental Portugal between 2009 and 2022.

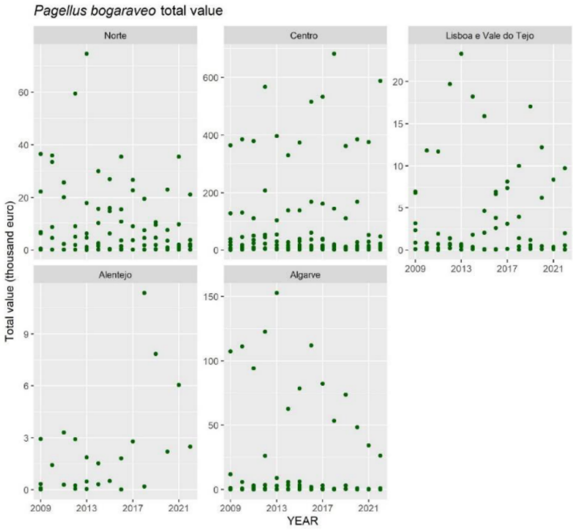

Figure 2. *Pagellus bogaraveo* total value in thousands of euros in each NUTS II in continental Portugal between 2009 and 2022.

In all NUTS II, the polyvalent fishing segment presented the highest landing values, followed by the trawl segment, with purse seine showing nearly negligible landings (Figure 3). These differences were more evident in central Portugal (NUTS II "Centro"), where the polyvalent represented around 60% of the species landings, the trawl segment represented nearly 40%, and the purse-seine fishery less than 1%.

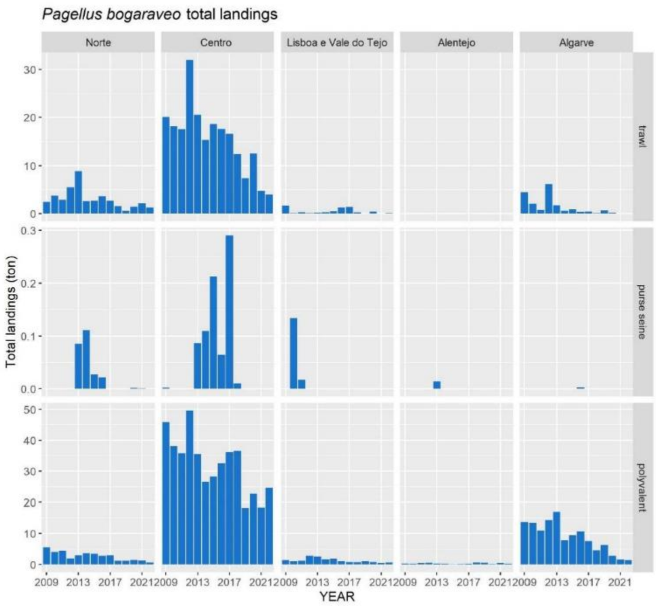

Figure 3. *Pagellus bogaraveo* total landings in tonnes by fishing segment (trawl, purse seine, and polyvalent) in each NUTS II in continental Portugal between 2009 and 2022.

The number of vessels landing *P. bogaraveo* was higher for the polyvalent fishing segment than for the trawl segment in all NUTS II (Figure 4). For the period between 2009 and 2022, a decreasing trend in the number of vessels landing the species was observed in the Centre, Lisbon area, and Algarve (NUTS II "Norte", "Lisboa e Vale do Tejo", and "Centro", respectively), which is probably associated with the continuous EU TAC reduction in Subarea 27.9 since 2004 (ICES, 2017a). However, the number of polyvalent and trawl vessels landing *P. bogaraveo* increased between 2019 and 2020, followed by a decrease in the subsequent years in the North (NUTS II "Norte") and Centre (NUTS II "Centro).

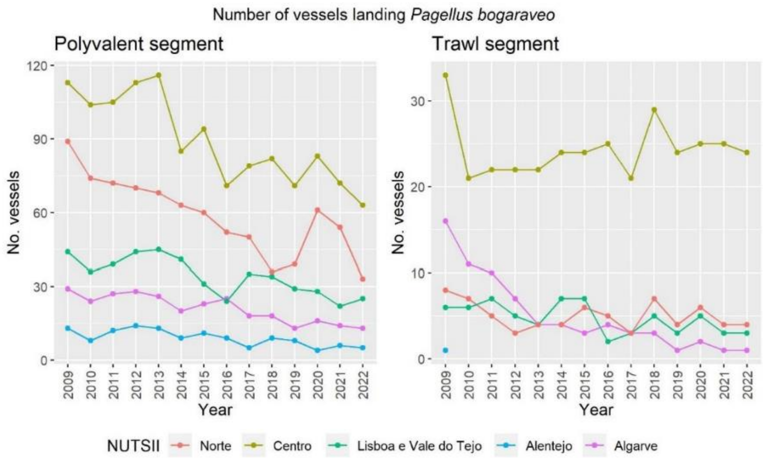

Figure 4. Number of vessels landing *Pagellus bogaraveo* in each NUTS II in continental Portugal, by year and by fishing segment (polyvalent and trawl), from 2009 to 2022.

2.1.2. Landings and mean price by fleet and selected NUTS II

Polyvalent fishing segment landings were higher in the winter months (late and early months of the year), more accentuated in the Centre region (NUTS II "Centro") (Figure 5). In the North (NUTS II "Norte") and Algarve, some years showed a peak in summer months but with little effect in terms of total landings when considering all the regions. From 2009 to 2022, there was a decreasing trend in the species landings in the three considered NUTS II, with the exception of the Centre region were the monthly landings increased between 2021 and 2022.

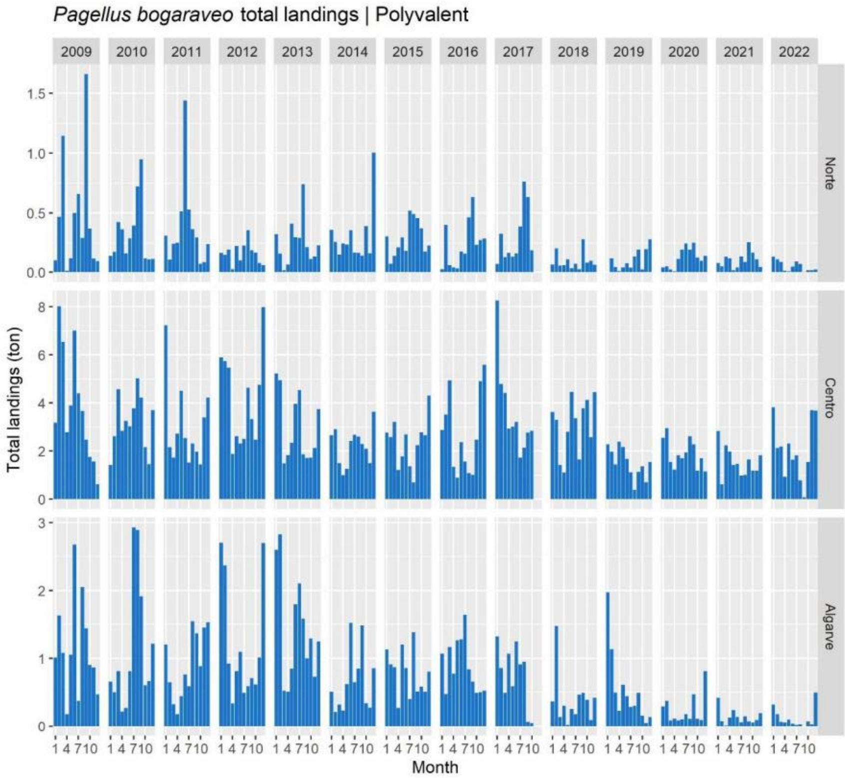

Figure 5. *Pagellus bogaraveo* landings (tons) from the polyvalent fleet by month and year at the three most important NUTS II in continental Portugal, from 2009 to 2022.

The trawl fishing segment shows a sharp decrease in total landings by month from 2012-2013 to 2022 (Figure 6). In the North (NUTS II "Norte") and in the Centre (NUTS II "Centro"), landings were higher at the beginning of the year. In the South (NUTS II "Algarve"), landings occurred mainly in the summer months, being nearly negligible between 2020 and 2022.

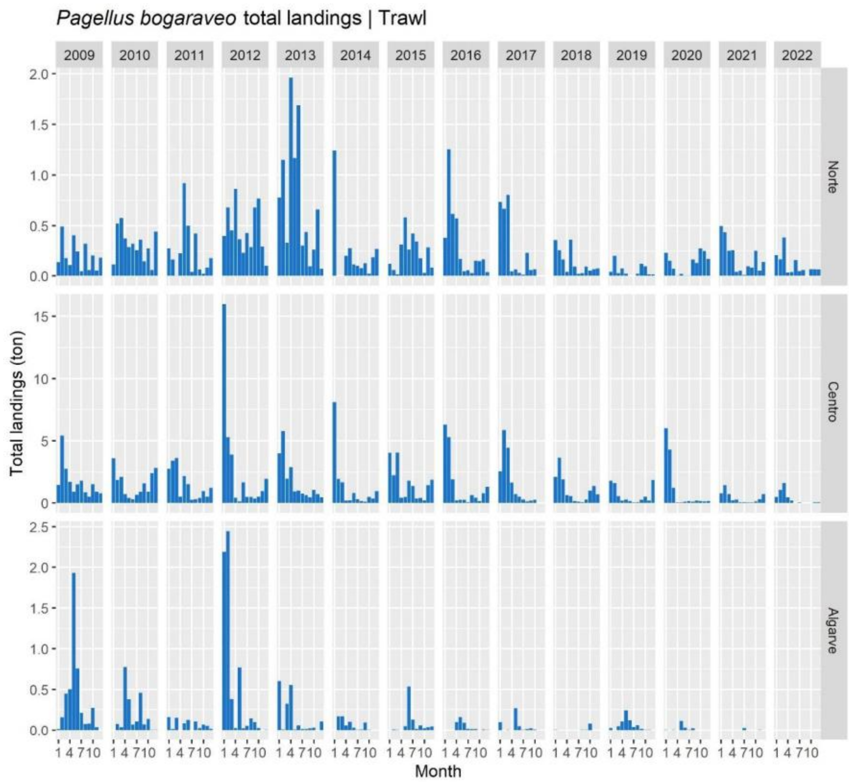

Figure 6. *Pagellus bogaraveo* landings (tons) from the trawl fleet by month and year at the three most important NUTS II in continental Portugal, from 2009 to 2021.

For the three main NUTS II, the mean price per Kg showed variations along the months of the year for the polyvalent fleet (Figure 7) and the trawl fleet (Figure 8), being those variations more noticeable in the polyvalent segment and in the last months of the year, since 2016.

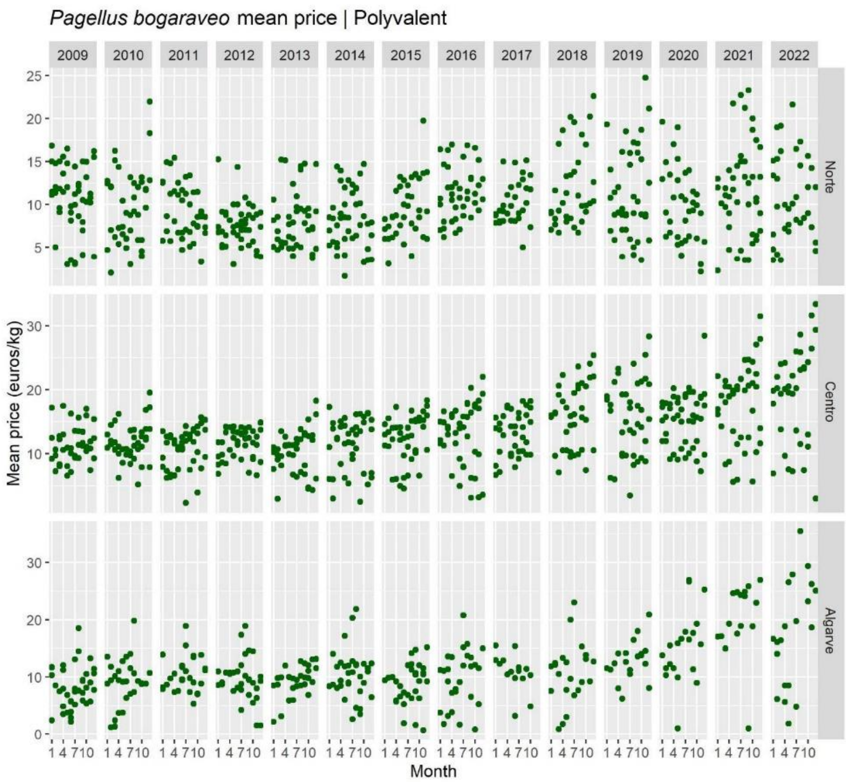

Figure 7. Mean price (in euro per Kg) of *Pagellus bogaraveo* landed by the polyvalent fishing segment by month and year for the three main NUTS II in continental Portugal between 2009 and 2022.

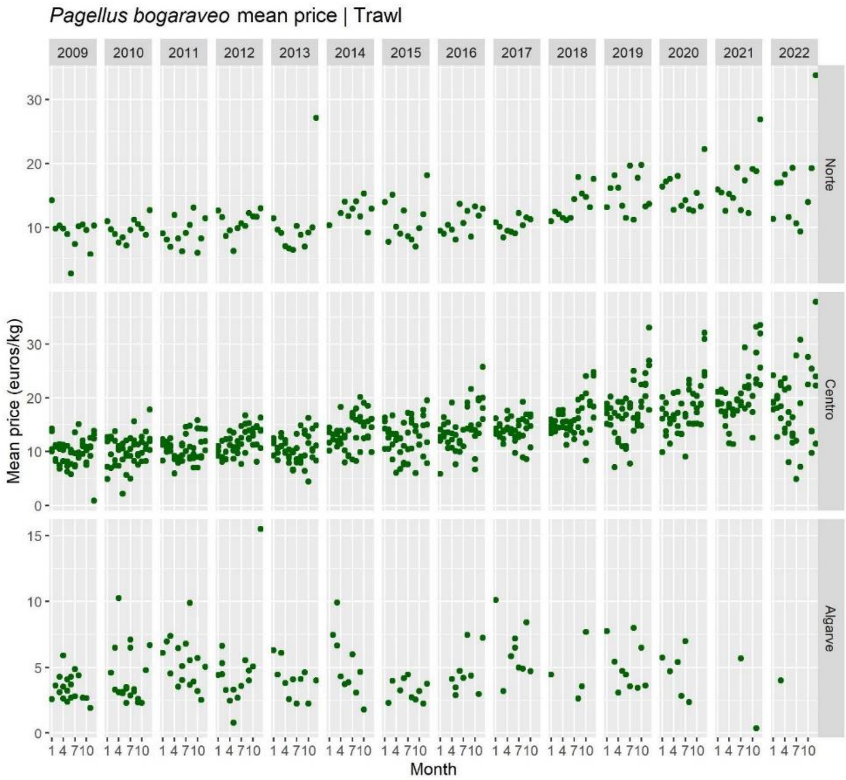

Figure 8. Mean price (in euro per Kg) of *Pagellus bogaraveo* landed by the trawl fishing segment by month and year for the three main NUTS II in continental Portugal between 2009 and 2022.

2.1.3. Landings in the most important Portuguese continental ports

P. bogaraveo landed weight by trip is presented in Figure 9 for the polyvalent segment and in Figure 10 for the trawl segment. Peniche port (Portuguese central western coast) was the most important landing port (landings between 2015 and 2022 represented nearly 50% of the Portuguese landings of the species in ICES Division 27.9.a) for both fishing segments. Extreme values were excluded from the plots for better visualization of data. In the later years, the highest landing values are registered between December and March for the polyvalent segment in Peniche.

P. bogaraveo total landings by most important ports and by fleet segment are summarised in Annex 1.

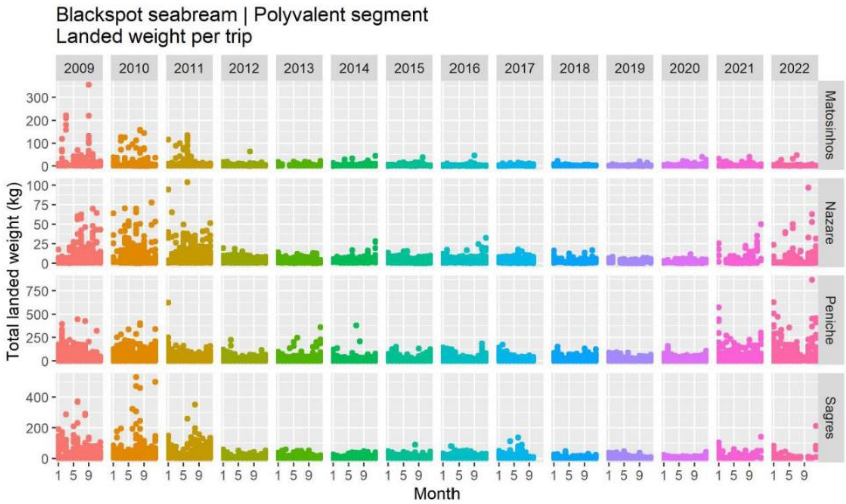

Figure 9. *Pagellus bogaraveo* total landed weight (kg) from the polyvalent fishing segment by month and year at the most important ports in Portugal continental, from 2009 to 2022.

Figure 10. *Pagellus bogaraveo* total landed weight (kg) from the trawl fishing segment by month and year at the most important ports in continental Portugal, from 2009 to 2022.

2.2. LPUE

2.2.1. Reference fleet

A total of 36 fishing vessels were selected for the polyvalent fleet landing in Peniche port and a total of 10 fishing vessels were selected for the trawl fleet landing in Peniche port.

2.2.2. CPUE adjustment

GLM was adjusted to annual log-CPUE estimations for Peniche's polyvalent reference fleet considering a normal distribution and the identity link function. The GLM estimates of the annual CPUE for Peniche's polyvalent reference fleet for the selected model are presented in Figure 11 and Table 3. CPUE for the polyvalent reference fleet has been stable throughout the considered time period, showing a slight decrease from 2018 to 2019 and an increasing trend from 2019 to 2022.

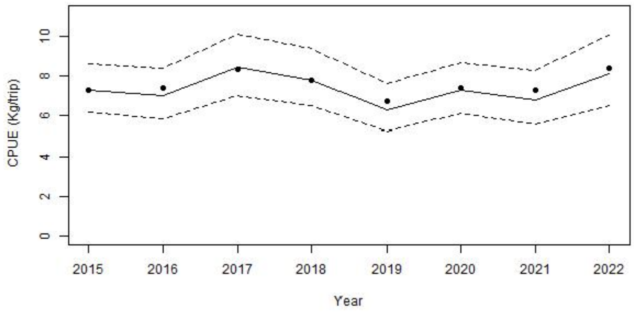

Figure 11. *Pagellus bogaraveo* standardized annual estimates of CPUE for Peniche polyvalent fishing segment reference fleet from 2015 to 2022.

Table 3. *Pagellus bogaraveo* CPUE series estimates for Peniche polyvalent reference fleet. 95% confidence interval.

Year	CPUE obs	CPUE pred.lower	CPUE pred	CPUE pred.upper
2015	7.31	6.18	7.31	8.65
2016	7.40	5.88	7.03	8.40
2017	8.34	7.03	8.44	10.12
2018	7.81	6.51	7.82	9.39
2019	6.71	5.23	6.33	7.65
2020	7.42	6.13	7.28	8.65
2021	7.28	5.61	6.82	8.29
2022	8.38	6.51	8.10	10.08

The analysis of the residuals of the fitted model is presented in Figure 12.

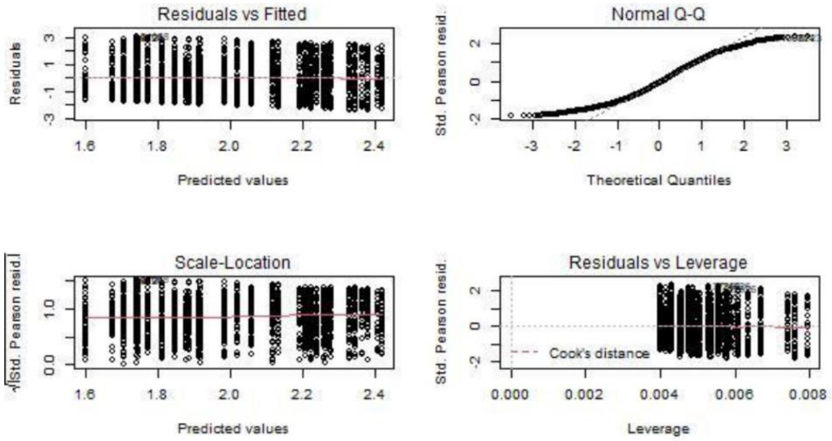

Figure 12. *Pagellus bogaraveo* analysis of the residuals of standardized annual estimates of CPUE for Peniche polyvalent fishing segment reference fleet from 2015 to 2022.

GLM was adjusted to annual log-CPUE estimations for Peniche's trawl reference fleet considering a normal distribution and the identity link function. The model was selected based on AIC and analysis of the residuals. The GLM estimates of the annual CPUE for Peniche's trawl reference fleet for the selected model are presented in Figure 13 and Table 4. CPUE for the trawl reference fleet showed a decreasing trend until 2019, followed by an increasing in that year, and has been stable since 2021.

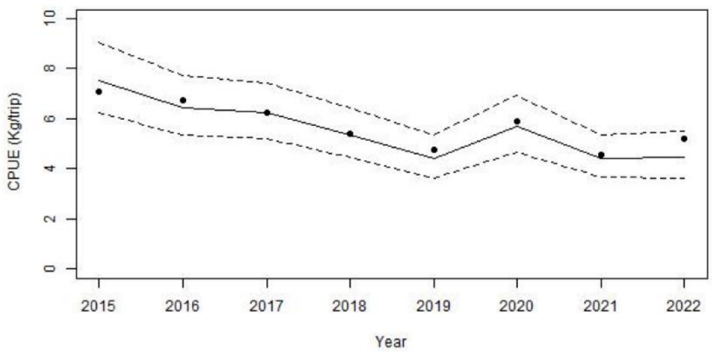

Figure 13. *Pagellus bogaraveo* standardized annual estimates of CPUE for Peniche trawl fishing segment reference fleet from 2015 to 2022.

Table 4. *Pagellus bogaraveo* CPUE series estimates for Peniche trawl reference fleet. 95% confidence interval.

Year	CPUE obs	CPUE pred. lower	CPUE pred	CPUE pred. upper
2015	7.06	6.22	7.51	9.06
2016	6.70	5.32	6.41	7.73
2017	6.21	5.19	6.21	7.43
2018	5.40	4.43	5.35	6.45
2019	4.74	3.59	4.38	5.35
2020	5.87	4.63	5.66	6.92
2021	4.57	3.64	4.40	5.33
2022	5.21	3.63	4.45	5.47

The analysis of the residuals of the fitted model is presented in Figure 14.

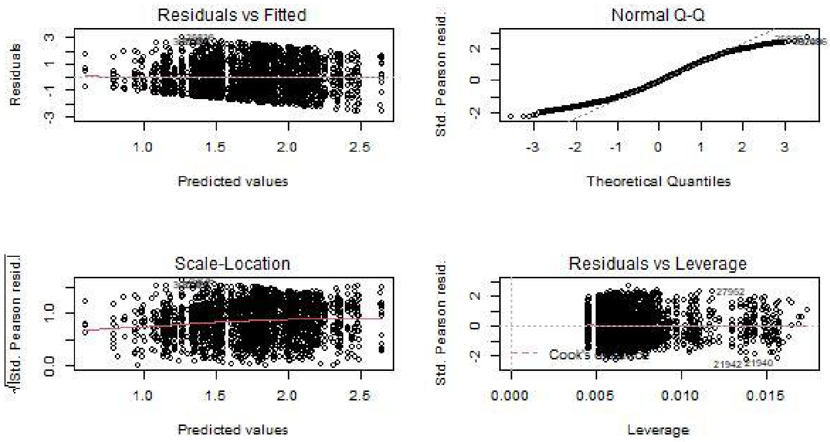

Figure 14. *Pagellus bogaraveo* analysis of the residuals of standardized annual estimates of CPUE for Peniche trawl fishing segment reference fleet from 2015 to 2022.

2.3. Length distribution

P. bogaraveo length distributions were extrapolated from DCF length sampling data available for the polyvalent (Figure 15) and the trawl (Figure 16) fishery segments for Portugal continental by year in the period between 2014 and 2022. The smaller sizes are poorly represented probably because the minimum landing size of *P. bogaraveo* is 33 cm and the discards of specimens bellow that size are negligible given that the species shows a very high survival rate (Serra-Pereira et al., 2019). In 2020, only 4 samples were measured from the polyvalent segment, which corresponded to 72 specimens, and only 4 samples from the trawl segment, which included 52 specimens (Farias and Figueiredo, 2021).

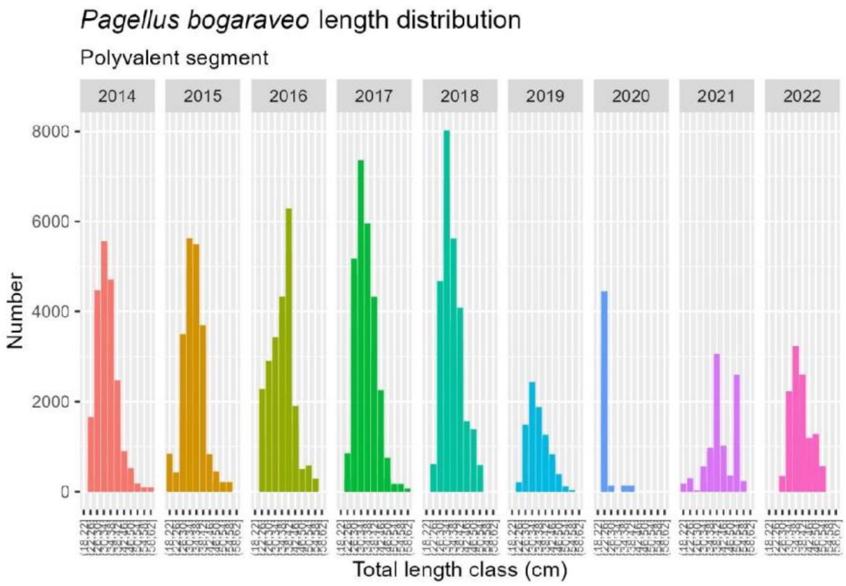

Figure 15. *Pagellus bogaraveo* extrapolated length frequency distributions for the polyvalent fishing segment for the years between 2014 and 2022. (4 cm total length classes)

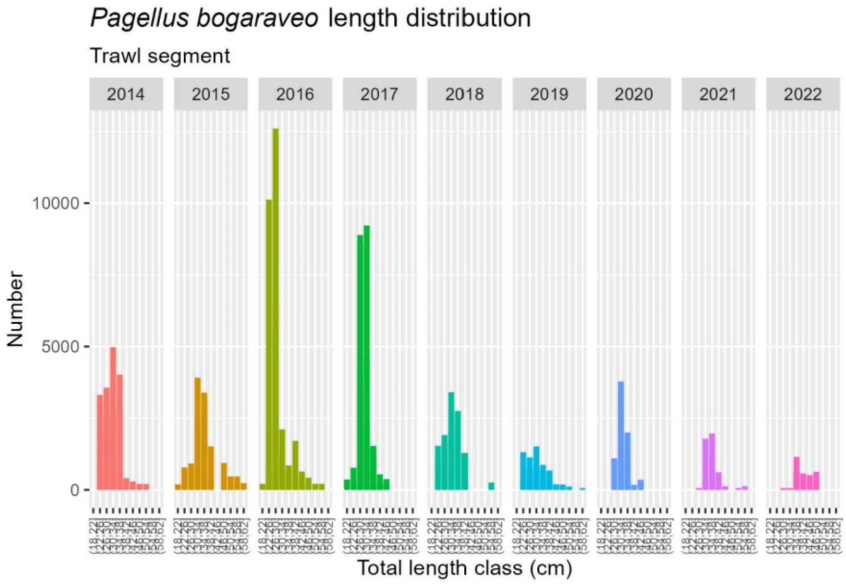

Figure 16. *Pagellus bogaraveo* extrapolated length frequency distributions for the trawl fishing segment for the years between 2014 and 2022. (4 cm total length classes)

Differences in length distribution between the polyvalent segment and the trawl segment result from the fact that polyvalent vessels operate in areas farther from the coast and at higher depths, where larger fish are more common (Farias et al., 2018).

2.4. LBI

Results from the LBI screening method are shown in Tables 5 and 6 and Figures 17 and 18.

Table 5. *Pagellus bogaraveo* in ICES Division 27.9.a. Results from LBI screening.

Year	L_{75}	L_{25}	L_{med}	L_{90}	L_{95}	L_{mean}	L_c	$L_{F=M}$	L_{maxy}	L_{mat}	L_{opt}	L_{inf}	$L_{max5\%}$
2014	36	29	33	39	42	33.39	26	35.00	34	35.1	41.33	62	46.88
2015	38	32	35	41	45	36.50	30	38.00	36	35.1	41.33	62	52.09
2016	38	27	31	42	45	33.52	26	35.00	40	35.1	41.33	62	49.58
2017	36	30	32	40	43	34.95	30	38.00	31	35.1	41.33	62	46.15
2018	38	31	34	41	44	35.78	30	38.00	37	35.1	41.33	62	47.60
2019	39	31	34	43	46	35.28	26	35.00	38	35.1	41.33	62	49.03
2020	34	25	32	37	38	33.35	26	35.00	34	35.1	41.33	62	41.42
2021	43	36	39	52	54	40.29	22	32.00	52	35.1	41.33	62	54.53
2022	43	35	38	47	49	40.60	34	41.00	38	35.1	41.33	62	50.01

All LBI estimates increased between 2020 and 2021, except L_c and $L_{F=M}$, which increased between 2021 and 2022 (Table 5).

Table 6. *Pagellus bogaraveo* in ICES Division 27.9.a. LBI screening ratios.

		Conservation						Optimizing Yield	MSY
		L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{95\%}/L_{inf}$	L_{maxy}/L_{opt}	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Year	Ref.	> 1	> 1	> 0.8	≈ 1	> 0.8	>30%	≈ 1 (>0.9)	≥ 1
2014		0.74	0.83	0.68	0.82	0.76	3%	0.81	0.95
2015		0.85	0.91	0.73	0.87	0.84	5%	0.88	1.04
2016		0.74	0.77	0.73	0.97	0.80	5%	0.81	0.96
2017		0.85	0.85	0.69	0.75	0.74	2%	0.85	1.00
2018		0.85	0.88	0.71	0.90	0.77	4%	0.87	1.02
2019		0.74	0.88	0.74	0.92	0.79	6%	0.85	1.01
2020		0.74	0.71	0.61	0.82	0.67	0%	0.81	0.95
2021		0.63	1.03	0.87	1.26	0.88	20%	0.97	1.15
2022		0.97	1.00	0.79	0.92	0.81	16%	0.98	1.16

Most ratio estimates of conservation increased in 2021 in relation to previous years and remained close to the reference values in 2022, including the L_c/L_{mat} which increased had been at lower levels (Table 6). The Optimizing Yield indicator ratio increased between 2020 and 2021 and remained at the same level in 2022, which indicates that the stock is being fished at levels close to optimum yield. The indicator for MSY ($L_{mean}/L_{F=M}$) was above the reference value in most of the years of the series, including 2020 and 2021, being consistent with an adequate exploitation.

The values estimated for the conservation ratios results might reflect some of EU size measures, such as the adopted minimum landing size (MLS). L_c/L_{mat} and $L_{25\%}/L_{mat}$ low estimates might be related with the fact that the L_{mat} of females, which is above the MLS, was assumed in the screening since *P. bogaraveo* is a protandric hermaphrodite.

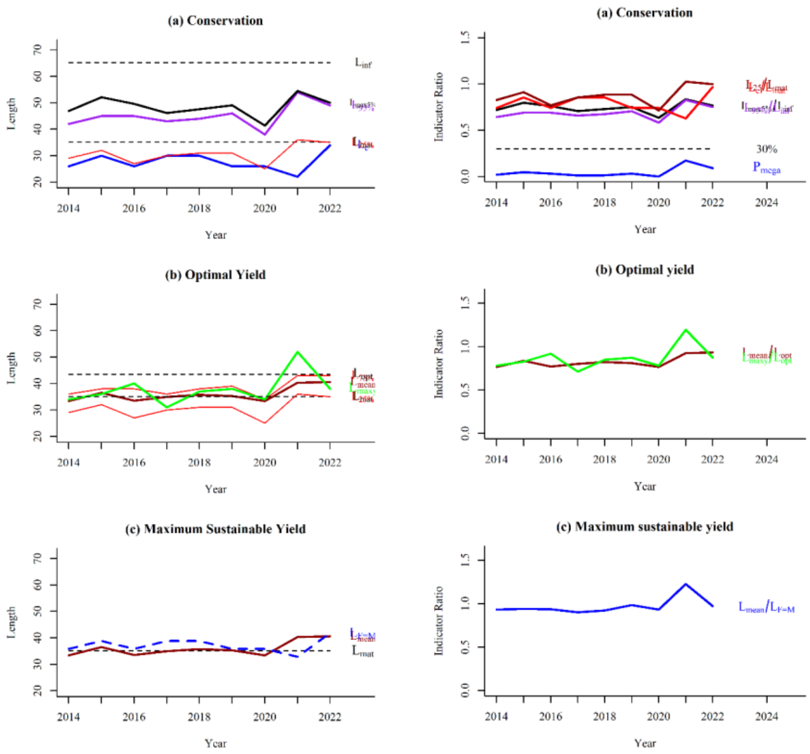

Figure 17. *Pagellus bogaraveo* in ICES Division 27.9.a. Results from LBI screening (left) and LBI screening ratios (left).

Time-series plots show that most of the indicators had low variability between 2014 and 2022.

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ANNEX I

Table 7. *Pagellus bogaraveo* total landed weight (ton) by fleet segment in the six most important landing ports for the species. Ports are organized by NUTS II between 2009 and 2022.

		North			Centre				Lisbon Metrop. Area	Algarve	
Year	Gear	Matosinhos	Povoa do Varzim	Viana do Castelo	Aveiro	Figueira da Foz	Nazare	Peniche	Sesimbra	Sagres	Portimao
2009	Polyvalent	4.24	0.66	0.5734	0.06	0.43	3.42	41.98	0.59	13.47	0.05
	Trawl	2.43	-	-	1.43	0.64	2.69	15.32	1.55	-	4.32
2010	Polyvalent	2.64	0.45	0.8427	0.09	0.50	3.83	33.65	0.91	13.33	0.05
	Trawl	3.73	-	-	1.12	1.05	1.47	14.50	0.05	0.00	1.90
2011	Polyvalent	2.27	0.34	1.8148	0.52	0.20	3.92	31.09	0.97	10.63	0.20
	Trawl	2.90	-	-	3.03	0.79	2.32	11.43	0.32	-	0.74
2012	Polyvalent	1.03	0.29	0.5313	0.53	0.24	3.99	44.85	2.18	13.88	0.05
	Trawl	5.56	-	-	3.63	1.80	5.33	21.29	0.09	-	6.14
2013	Polyvalent	1.55	0.52	0.6831	0.74	0.10	2.60	32.05	2.21	16.70	0.03
	Trawl	8.91	-	-	4.79	1.51	3.34	10.89	0.18	-	1.73
2014	Polyvalent	1.05	0.35	1.9169	0.36	0.02	1.80	24.36	1.55	6.89	0.41
	Trawl	2.62	-	-	1.09	0.48	1.11	12.61	0.31	-	0.62
2015	Polyvalent	1.32	0.80	1.3293	0.55	0.06	2.82	24.88	1.46	8.65	0.07
	Trawl	2.70	-	-	1.99	0.93	1.38	14.30	0.51	-	0.90
2016	Polyvalent	0.86	0.35	1.3854	0.34	0.09	2.28	29.87	0.49	10.45	0.02
	Trawl	3.62	-	-	3.68	0.70	0.95	12.26	1.26	-	0.40
2017	Polyvalent	1.73	0.43	0.775	0.55	0.09	2.43	33.04	0.58	7.35	-
	Trawl	2.71	-	-	2.78	1.12	0.57	12.09	1.41	-	0.46
2018	Polyvalent	0.54	0.19	0.4024	0.20	0.02	1.02	35.40	0.52	4.50	0.00
	Trawl	1.58	-	-	1.07	1.10	0.60	9.66	0.28	-	0.09
2019	Polyvalent	0.49	0.23	0.3601	0.31	0.03	0.49	17.35	0.95	6.25	-
	Trawl	0.63	-	-	0.58	0.44	0.35	6.08	0.02	-	0.66
2020	Polyvalent	0.90	0.14	0.3199	1.37	0.04	0.53	20.72	0.73	2.60	0.10
	Trawl	1.46	-	-	1.51	0.40	0.12	10.54	0.46	-	0.17
2021	Polyvalent	0.62	0.15	0.11	0.48	0.03	0.56	17.33	0.42	1.57	-
	Trawl	2.15	-	-	0.68	1.21	0.61	2.28	0.02	-	0.02
2022	Polyvalent	0.28	0.18	0.10	0.44	0.01	1.02	23.15	0.55	1.18	0.00
	Trawl	1.29	-	-	0.67	0.73	0.59	1.99	0.09	-	0.00

Working Document for the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources

Lisbon, 03rd - 09th May 2023

Scabbard fish in the Madeira archipelago (CECAF 34.1.2)

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Abstract

This working document updates the information existing from the previous WGDEEP meeting of 2022 for the *Aphanopus* spp. in CECAF fishing area 34. Mainly an update on the time-series of annual Portuguese landings (by vessel segment), length distributions and unstandardized CPUE at CECAF area. A standardized biomass index series based on daily landings of commercial horizontal mid-water drifting longline fishery in Madeira was also updated with data from 2022.

1. INTRODUCTION

The fishery for deep-water species carried out in the Madeira EEZ and international adjacent waters (CECAF 34.1.2. area), dates back to the 17th century (Merrett and Haedrich, 1997) and for several decades this was the only fishery targeting scabbard fish in the Northeast Atlantic (Bordalo-Machado and Figueiredo, 2009). This fishery as an important and irreplaceable economic and social value in the Madeira fisheries sector. In Madeira, exploited deep-water fish stocks are overwhelmingly dominated by two scabbard fish species: *Aphanopus carbo* Lowe 1839 and *Aphanopus intermedius* Parin, 1983, which represent about half of the overall landings throughout the year (Delgado et al., 2013, 2018; Hermida and Delgado, 2016). This deep-sea fishery targeting the black and intermediate scabbard fish, off the Madeira archipelago, is recognized as an artisanal and selective activity targeting predominantly adult individuals and presenting a low rate of bycatch (Severino et al., 2009).

Both scabbard fish species occur at a wide depth range, from 200 m in the northern part of the NE Atlantic (Nakamura and Parin, 1993) to 2300 m off the Canary Islands (Pajuelo et al., 2008) for *A. carbo*, although more frequent at 800-1300 m in Madeira (Morales-Nin and Sena-Carvalho, 1996) and to 1350 m for *A. intermedius* (Delgado et al., 2013). *Aphanopus carbo* and *A. intermedius* seem to be adapted to a strong activity of migrating upwards at night to feed on crustaceans, cephalopods, and fishes (Tuset et al., 2010). Furthermore, these two sympatric species move to reproduction areas off Macaronesian archipelagos (i.e., Madeira and the Canary

Islands) and the northwest coast of Africa (Figueiredo et al., 2003; Pajuelo et al., 2008; Perera 2008; Farias et al., 2013). The spawning season of both *Aphanopus* species has been reported to take place from October to December (Figueiredo et al., 2003; Delgado et al., 2013).

The black and intermediate scabbard fish fishery represents one of the most profitable commercial activities on small-scale fisheries in Madeira archipelago. In 2022, the commercial landings in weight of *Aphanopus* spp. reached annual catches of up to 2259 tonnes yielding a total first sale value of approximately 7.5 M€.

WGDEEP does not assess fisheries in Madeira (Eastern Central Atlantic area, CECAF) or in other areas outside the ICES area. Nonetheless, it is admitted that the incorporation of reliable CECAF data could provide a wider perception of the stock dynamics of these migratory species in the northeast Atlantic.

1.1. Fishery in Madeira

In compliance with the Multiannual Union Programme for Data Collection (EU-MAP), the Madeira fishing fleet targeting the deep-water species, *A. carbo* and *A. intermedius*, uses a specialized fishing gear with longlines (LLD_DWF_0_0_0). The fishing gear is a mid-water horizontal drifting longline, set in the water column usually at depths of between 800 and 1300 m (Figure 1).

The fishing gear used to catch the scabbardfishes is a drifting longline always set at least more than 100 m above the bottom of the sea. This is an important aspect of the fishery as, in normal circumstances, the gear does not contact the sea floor thus is not a menace to hypothetical Vulnerable Marine Ecosystems (VME).

This fishery is known by its highly selective nature, concerning the bycatches of non-target species and the length structure of the catches of the targeted species – constituted almost exclusively by adult specimens over 90 cm total length. The catches of sub adult individuals scarcely achieve around 0.5% of the total number of individuals captured.

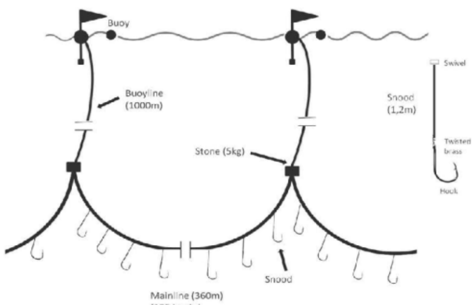


Figure 1 – Mid-water horizontal drifting longline used by the Madeira fishing fleet.

There is a combination of prevailing factors that result in a fishery with such unique features. Such factors are the geographical area of the fishery, where, according to the migratory model proposed by Farias et al. (2013), only adult specimens are available to this type of fishery and the highly selective nature of the fishing methodology itself, namely the fact that the passive fishing gear is operated strictly within a depth layer of the water column, between 800 and 1300 meters deep, without being anchored, and always well above the seafloor. The gear aims to catch the black scabbard fish in its daily vertical migration to feed, thus minimizing the probability of capture of benthic bycatch species.

This fishery, carried out by the fishing vessels targeting the black and intermediate scabbard fish registered in Madeira, which was traditionally performed mostly around the islands of Madeira and Porto Santo and the seamounts inside the Madeira EEZ, has undergone considerable geographic expansion in recent decades in the Northeast Atlantic, mostly from 2005 onwards, and initiated a process of expansion looking for new fishing areas (Figure 2). Progressively, new fishing grounds located in international waters SE of the Azores, off the Canaries and the "rediscovery" of the seamounts within the Madeira EEZ became indispensable for this fishery and bilateral agreements with the Azores and the Canaries were made to allow the fleet access to those areas.

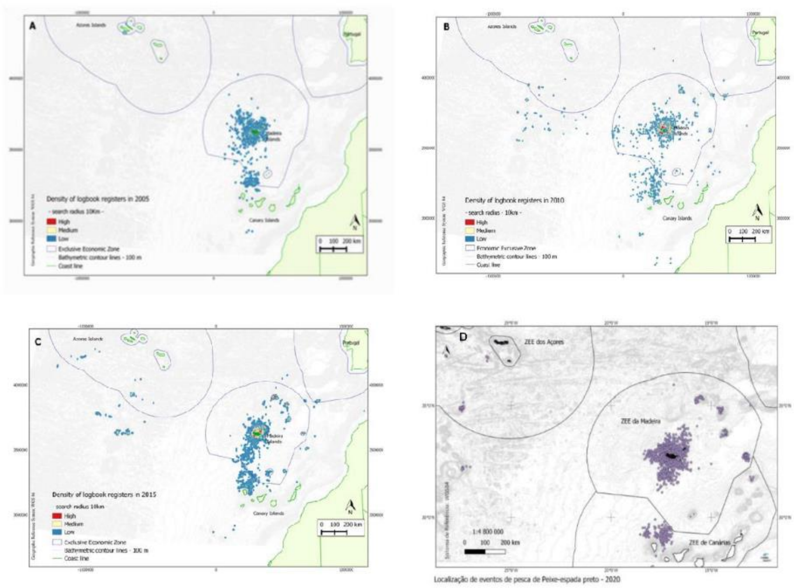


Figure 2 - Density plots illustrating the geographical distribution of the fishing sets with catches in 2005 (A), 2010 (B), 2015 (C) and 2020 (D): density maps estimated with the software Quantum GIS 2.2, module "heatmap" covering a search radius of 10 Km (Regional Directorate of the Sea - Madeira).

In 2015, STECF provided an exploratory assessment of the status of the species around Madeira (STECF-14–15). It was mentioned that, for the period 2000-2013, there was a general decline in fishing capacity and fishing effort. The number of vessels has also declined by 41% (34 to 20 vessels). Furthermore, in the second half of the last decade, some Madeiran vessels targeting the black and intermediate scabbard fish have moved to new fishing grounds, some of them located outside the EEZ of Madeira (SE of the Azores and off the NW of the Canaries) (Figure 2).

From 2019 to the present, most of fishery targeting the black and intermediate scabbard fish have been carried out within the Madeira EEZ. However, the fishing grounds off the Northwest of Canaries continues to be a relevant fishing area for the Madeira fishing fleet, due to the availability of black and intermediate scabbard fish and the lack of interest in these species by the Canary fishing fleet, which makes profitability the capture of them by the fishing fleet from Madeira. The capture of *Aphanopus* spp. in the Azores fishing grounds by the fishing fleet from Madeira has been decreasing since 2015. According to the fishermen fishing in Azores is not profitable due to the distance between Madeira and Azores.

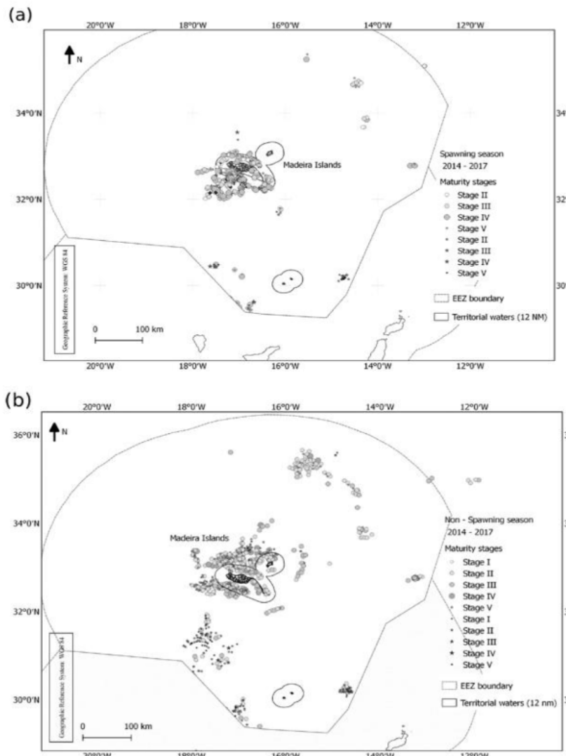


Figure 3 - Map showing both *Aphanopus* species distribution, *A. carbo* (grey circles) and *A. intermedius* (grey stars), during spawning (a) and non-spawning (b) seasons according to the distance from the coast (<12 and >12 nautical miles; 1 n.m. = 1.852 km) (Vasconcelos et al., 2020).

The enlargement of the maritime area covered by the fishing operations was prompted by the decrease of the abundance of the resource in the traditional fishing grounds, near the islands of Madeira and Porto Santo. And also due to the improvement of the fishing fleet of Madeira verified in the last years. This search for new fishing grounds was driven by the need to stabilise catches that suffered a severe decline from 2000 onwards. A relative stabilisation of the fishery was achieved in the last years but the enormous increase in the costs led several vessels to leave the activity.

Though, most of the *Aphanopus* spp. fishery still remains concentrated off the islands of Madeira and Porto Santo, especially during the spawning season from October to December, mainly the fishery operated by the small vessels (< 12 m). Migrations to areas less than 12 n.m. from the coast, were observed for *A. carbo* throughout the spawning season (Figure 3) (interannual database from 2014-2017; Vasconcelos et al., 2020). The mature stages IV and V were the ones that overwhelmingly dominated this migration pattern to shallower areas. This migration of mature adults towards areas near the coast, especially during spawning, occurs simultaneously with a noticeable increase of the proportion of fishing events inside the EEZ (<12 n.m.), making them more susceptible to mid-water drifting longline fishery (Vasconcelos et al., 2020).

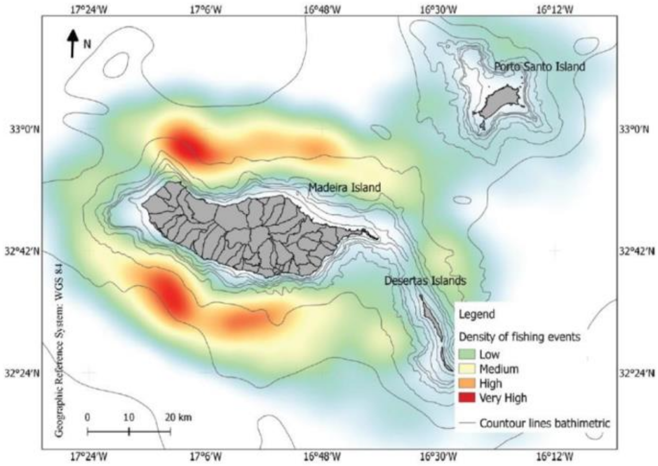


Figure 4 - Kernel density estimation plot showing the mean density values of the fishing events during the spawning season per compartment of 10 km × 10 km generated for the study area and for the period 2014–2017. Low: 1–10; Medium: 11–20; High: 21–30; and Very High: >31 fishing events (Vasconcelos et al., 2020).

There are three main aggregation areas identified off Madeira (Figure 4), where fishing events occurs during spawning, mainly the fishing grounds from Câmara de Lobos and Ribeira Brava at the south coast of Madeira and Porto do Moniz-Seixal at the north coast (Vasconcelos et al., 2020). The fishing grounds are located at an average distance of 2 to 4 n.m. offshore, although the same depths are found over a wider range of 3 to 6 n.m. offshore (Vasconcelos et al., 2020). Most likely, these areas correspond to areas with environmental and sea bottom topography that favour reproduction, as these areas generally correspond to canyons where there are prominent folds in the bathymetry towards the coast and its nearby steep slopes. These represent very closed geological formations with the dimension of extensive canyons, probably protected from strong currents and where high densities of spawning individuals aggregate, facilitating high probability of successful external fertilization (Vasconcelos et al., 2020).

2. METHODS

2.1. Fishery dependent data

2.1.1. Landings and mean price in Madeira archipelago

Portuguese total landings of *Aphanopus* spp. in CECAF area 34 (in weight, ton, and value, euro) were analysed by year. Fishery dependent data were collected from commercial landings for the period between 1990 and 2022.

2.1.2. Landings and mean price in Madeira archipelago by vessel length category

Portuguese landings of *Aphanopus* spp. in CECAF area 34 (in weight, tonnes, and value, euro) were analysed by year and by fishing vessel segment (vessel length category). Fishery dependent data were collected from commercial landings for the period between 2008 and 2022. The active fishing fleet at CECAF area is grouped into the following categories: VL0010 (vessel size less than 10 m), VL1012 (vessel size between 10 and 11.99 m), VL1218 (vessel size between 12 and 17.99 m) and VL1824 (vessel size between 18 and 23.99 m).

2.2. Length distribution

Aphanopus spp. length sampling data available for Madeira were analysed considering both species combined by year for the period between 2009 and 2022. Numbers-at-length were raised to the total landings.

2.3. CPUE

All landings from the commercial mid-water drifting longline fishery at all the fishing ports of Madeira (mainly port of Funchal), in the Northeast Atlantic (32°00'–33°30'N, 15°30'–18°00'W) were considered for this analysis, during the period between 2008 and 2022. From each fishing trip data on total weight landed of the species (in kg), vessel name and corresponding length category, engine power (KW), number of days at sea, number of fishing days and fishing operations, and the total number of hooks were examined. A trip was defined from the moment the vessel leaves the dock to when it gets back to the dock.

The standardized CPUE model based on daily landings of commercial mid-water horizontal drifting longline fishery in Madeira was updated with data from 2022.

3. RESULTS AND DISCUSSION

3.1. Fishery dependent data

3.1.1. Landings and mean price in Madeira archipelago

The annual landings of black and intermediate scabbard fish derived from Madeiran mid-water longliners for the period between 1990 and 2022 are presented in Figure 5.

Catches in CECAF 34 area were updated with fishery data from Madeiran mid-water longliners landings from 1990 to 2022. These catches are recorded by the Regional Fisheries Department of Madeira (Figure 5). CECAF catches have been decreasing after the 1998 peak, but an increase was observed from 2012 onwards. Between 2020 and 2021 a decrease was observed mainly due to the reduction in fishing days caused by the COVID-19 pandemic. In 2022, an increase of 386 tonnes was observed when comparing with 2021.

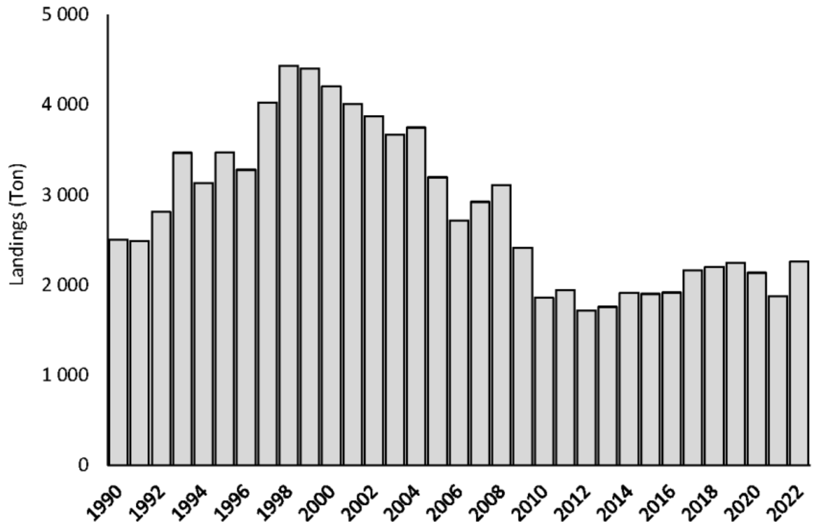


Figure 5 - Time-series of annual Portuguese landings of *Aphanopus* spp. at CECAF area (1990-2022).

The EU TAC and total catches for CECAF 34 area from 2005 to 2022 are presented in Table 1. It was observed a relevant decrease in the EU TAC for the *Aphanopus* spp. fishery in CECAF 34.1.2, from 4285 tons in 2005 to 2259 tons in 2022.

Table 1 - Black scabbard fish TACs and total landings in CECAF area 34, between 2010 and 2022, for both species (*Aphanopus carbo* and *Aphanopus intermedius*).

Year	EU TAC CECAF 34.1.2 area	Landings CECAF 34.1.2. Area
2005	4 285	3 195
2006	4 285	2 717
2007	4 285	2 922
2008	4 285	3 109
2009	4 285	2 413
2010	4 285	1 860
2011	4 071	1 941
2012	3 867	1 716
2013	3 674	1 758
2014	3 490	1 913
2015	3 141	1 902
2016	2 827	1 917
2017	2 488	2 163
2018	2 189	2 199
2019	2 189	2 246
2020	2 189	2 136
2021	2 189	1873
2022	2 189	2259

Following the methodology adopted at WGDEEP 2016 (ICES, 2016), standardised annual catch estimates for the period from 1990 to 2022 of the nineteen fishing resources (ordered in terms of total weight catch) and grouped into four groups (1, large pelagics; 2, elasmobranchs; 3, small pelagics; and 4, demersals) were determined based on data extracted from DSEIMar/DRM database (Figure 6).

The results do not support that given the diversity of species, which includes different taxonomic groups, lifestyles and both short- and long-lived organisms, the declining trends are reflecting changes on resources abundance which may imply that Madeiran waters are subject to severe over-exploitation. Further studies and a careful interpretation of trend variations of some resources are still required. It may happen that in some cases landing trends are not only related to the resources' abundance in Madeiran waters, but subject to other factors like variations on the market regulation (e.g. small pelagic fishery), environmental, application of TAC's and quotas, among others.

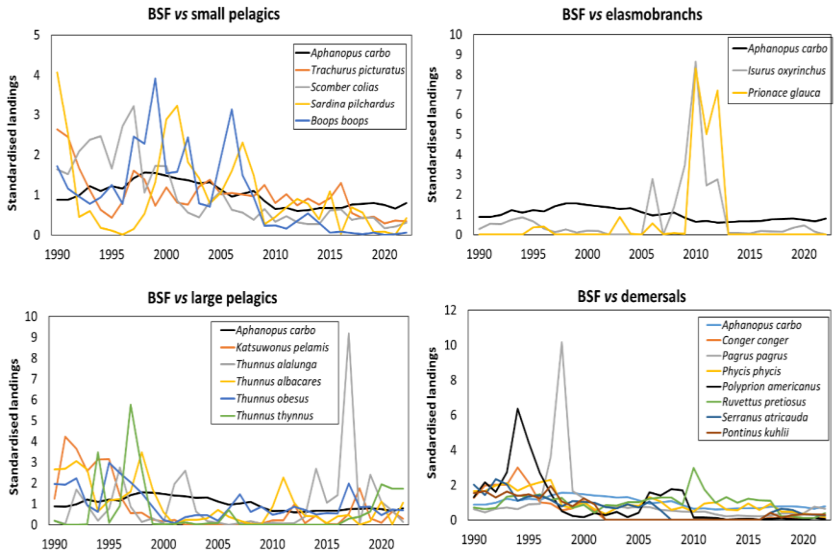


Figure 6 - Trends in standardised landings of scabbard fishes and the 19 other top ranked species in Madeiran landings.

The first sale value of *Aphanopus* spp., in millions of euros, for the period between 2008 and 2022 is presented in Figure 7. This value followed the same trend observed in the annual landings in terms of weight. The reduction in the economic value observed in 2020 and 2021 is related to the decrease in effort due to COVID 19 Pandemic. In 2022, the total first sale value achieved 7.5M€, increasing 1.7M€ in relation to 2021.

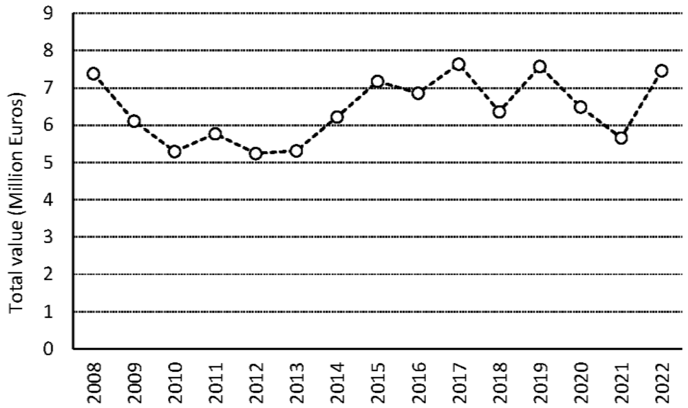


Figure 7 – Economic value of the catches of *Aphanopus* spp., in millions of euros, for CECAF 34.1.2., between 2008 and 2022.

3.1.2. Landings and mean price in Madeira archipelago by vessel length category

The number of vessels in activity in Madeiran longline fleet has steadily decreased during the last two decades (Figure 8).

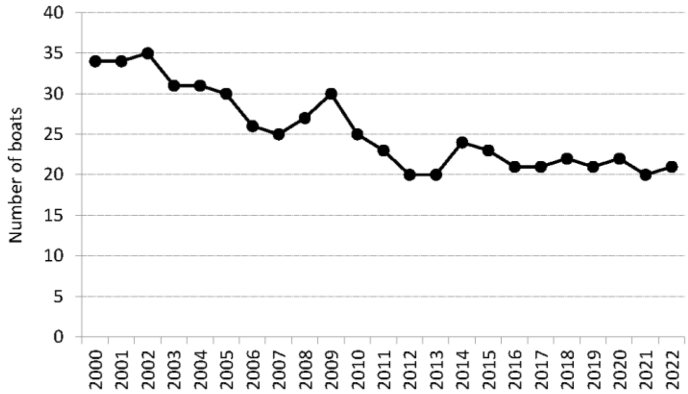


Figure 8 - Number of vessels active in the fishery of *Aphanopus* spp. at CECAF 34.1.2 area between 2000 and 2022.

Though, in the last years, the fishery as achieved a certain stability in the number of active vessels, as the small number of vessels remaining in the fishery are small artisanal vessels (Figure 9). In 2022, 52% of the active vessels were grouped between 12 and 18 m of overall length, thus hardly having operational conditions to make any significant increase in the present total number of hooks used in each fishing set.

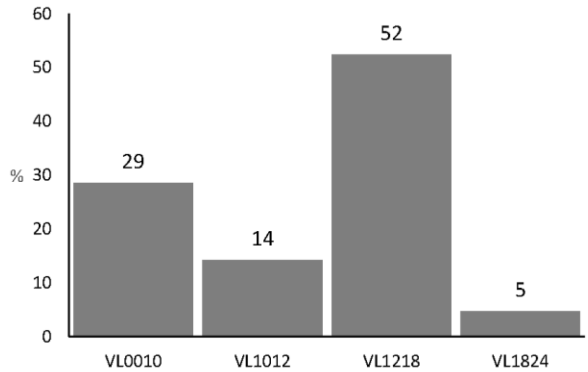


Figure 9 - Composition of the active fleet in the fishery of *Aphanopus* spp. at CECAF 34.1.2 area in 2022 per vessel length category (n=21 vessels).

A time-series of annual Portuguese landings at CECAF 34.1.2 area per vessel length is represented in Figure 10. The majority of the annual landings in Madeira are made by vessels of the length segments VL1218 and VL1824, wherein *ca.* 79% of the total landings in 2022 were captured by VL1218.

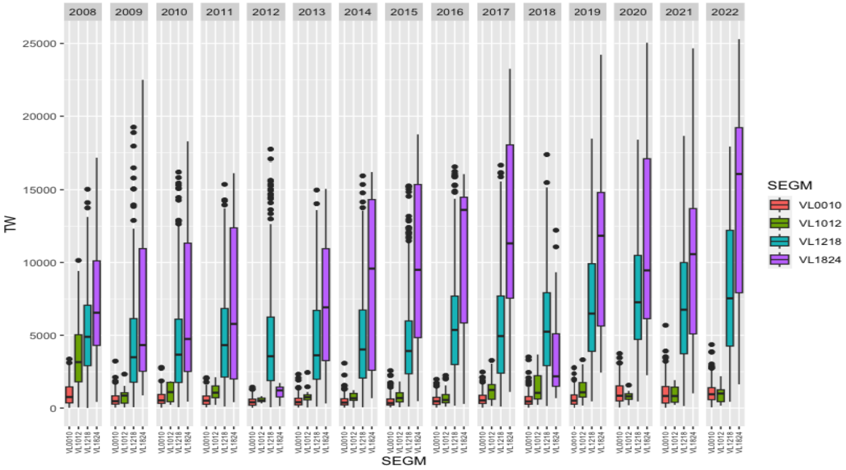


Figure 10 - Time-series of annual Portuguese landings of *Aphanopus* spp. at CECAF 34.1.2 area per vessel length category (SEGM), from 2008 to 2022.

The vessel length category VL1218 presented the highest landing and first sale values, followed by the vessel segment VL1824 (Figure 11). Though the number of vessels in the segment VL1824 represents only 5% of the total active fleet in Madeira, their contribution is higher (*ca.* 12.6%) than both vessel segments VL0010 and VL1012 together (*ca.* 8.5%). In 2022, it was observed an increase in the landings and economic values for all segments being more pronounced in the segment VL1824.

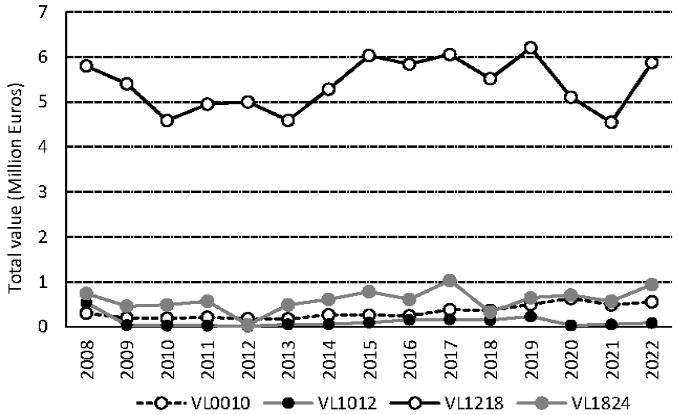


Figure 11 – Economic value of the catches of *Aphanopus* spp., in millions of euros per vessel category between 2008 and 2022.

3.2. Length distribution

The analysis of data indicates neither great changes on the length range between years nor on the mean length (around 114-118 cm total length, TL). From 2010 to 2018 the mean length was between 117 and 118 cm TL, occurring a slight decrease in 2019-2022 (115-116 cm TL).

Annual total length–frequency distributions of the exploited population caught by the Madeiran longline fleet in CECAF 34.1.2 area for the period 2010-2022 are presented in Figure 12. The range of scabbardfish total length varied between 87 cm and 155 cm.

Overall, between 2010 and 2022 there was verified a stability in the composition of lengths and average lengths for scabbardfish species caught by the Madeiran fleet.

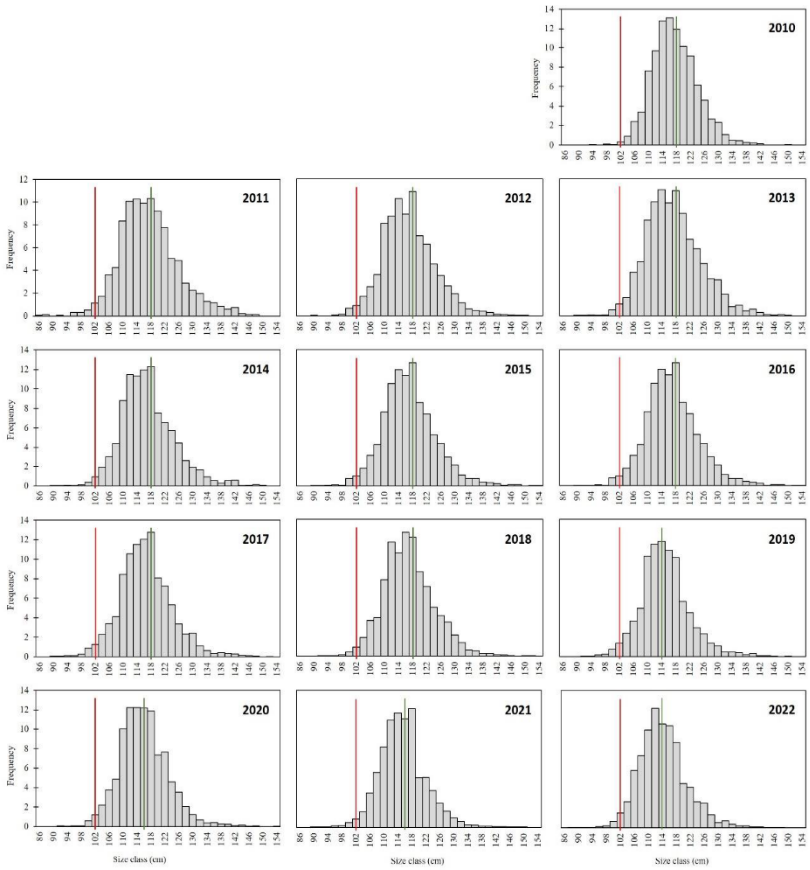


Figure 12 - Annual length–frequency distribution of specimens of *Aphanopus* spp. landed by the Portuguese middle-water longliners operating along CECAF area 34.1.2, from 2010 to 2022. Red line represents the length at first maturity according to Figueiredo et al. (2003) and green line represents the annual mean total length.

3.3. CPUE

Fishing effort in total number of hooks accumulated per year is represented in Figure 13. There was an overall decrease in the available period, reflecting the decline of the number of vessels. The year of 2004 stands for the highest total number of hooks (*ca.* 22.3 M) in the period available, since then effort has declined, and it is rather constant in the last years around 14-11 M hooks per year. In 2022, the total number of hooks was approximately 11.8 M.

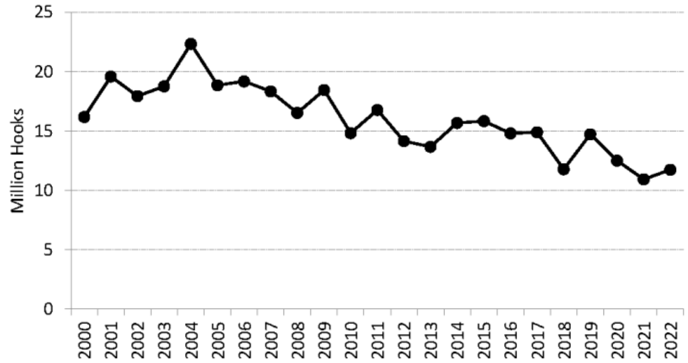


Figure 13 - Time-series of the total annual effort estimated for the CECAF 34.1.2 area (million hooks) for the *Aphanopus* spp. fishery, between 2000 and 2022.

The unstandardized CPUE had an overall decline along the analysed period (Figure 14). The variation observed in the years 2000-2006 was about -45% in CPUE, corresponding to an increase of 16% in the fishing effort. From 2006 to 2008 there was a slight recovery of the landings and of the unstandardized CPUE. The decreasing trend of landings restarted in 2008, but all indicators analysed reached a certain level of stability between 2010 and 2016, and even a recovery was observed since 2020, with an increase of 21 kg/1000 hooks from 2021 to 2022.

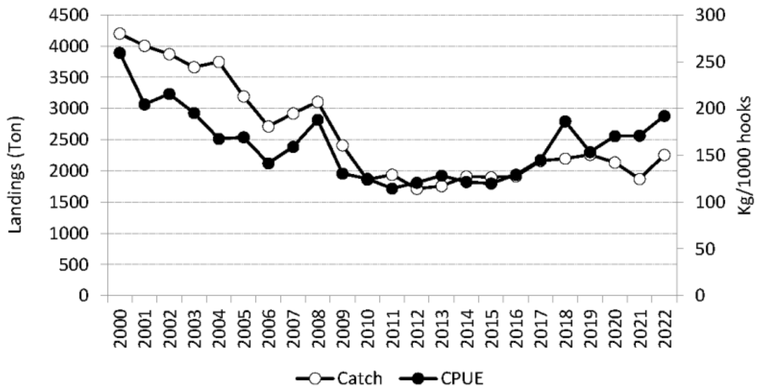


Figure 14 - Time-series of Landings per unit effort, CPUE unstandardized (kg / thousand hooks) of *Aphanopus* spp. in CECAF 34.1.2 area, between 2000 and 2022.

A standardized CPUE model based on daily landings of commercial drifting longline fishery in CECAF 34.1.2 area is being developed for the period of 2008-2022. An exploratory data analysis showed a high correlation between the number of hooks and the number of hauls (Figure 15), but no other variable showed highly correlation with the number hooks per haul.

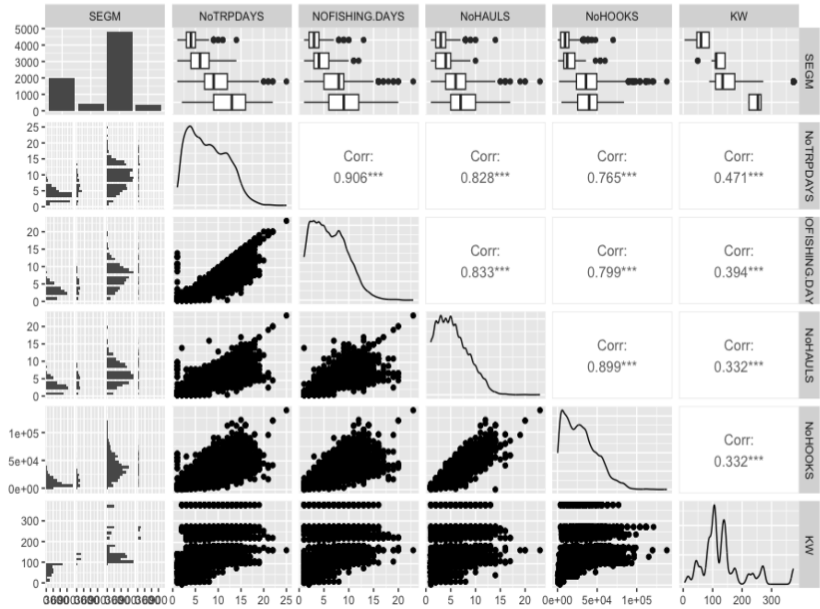
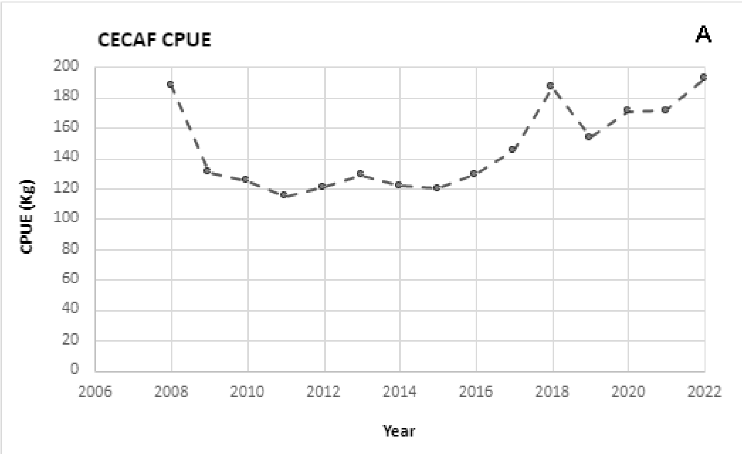


Figure 15 - Exploratory data analysis showing the correlation between the potential variables for the CPUE standardised model of *Aphanopus* spp.

For the period from 2008 to 2022, a standardised CPUE was obtained by adjusting a GLM model based on daily landings of commercial mid-water horizontal drifting longline fishery in CECAF 34.1.2 (Figure 16). The response variable (CPUE) was black and intermediate scabbard fish catches in weight per hook.

The exploratory standardised CPUE data analysis per year and by vessel segment (Figure 16B) showed a recovery in the last five years, especially in the vessel segments smaller than 18 meters, which represents 95% of the Madeira mid-water drifting longline fleet. However, these are just preliminary results and further analysis will be performed.



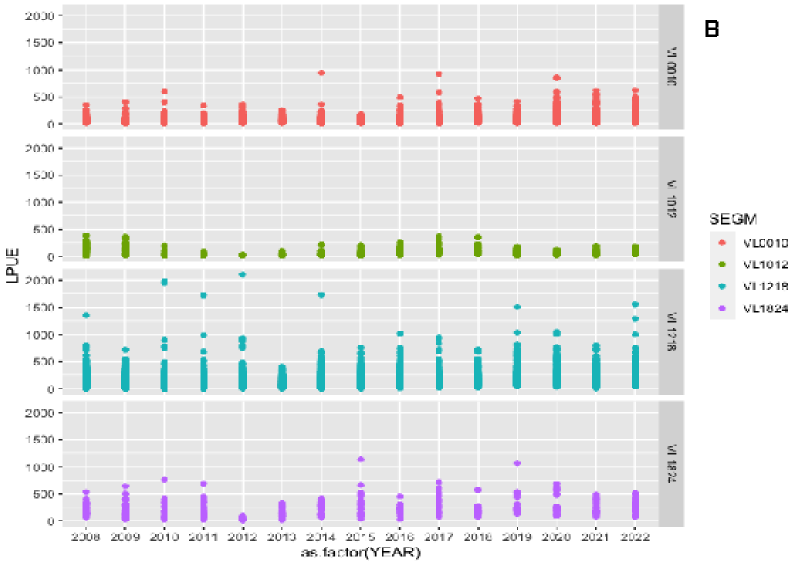


Figure 16 - Time-series of the CPUE (kg/hooks) of *Aphanopus* spp. for all segments combined (A), and standardised CPUE per vessel segment (B).

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Exploratory surplus production models assessment of *Pagellus bogaraveo* **in Subarea 10 (Azores grounds)**

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1. Introduction

Blackspot seabream *Pagellus bograveo* is a sparid fish distributed in the Northeast Atlantic, from south of Norway to Cape Blanc in Mauritania, including Azores, Madeira, and Canary Archipelagos, and the Mediterranean Sea (Froese & Pauly, 2019). This species presents complex life-history and biological dynamics in the face of slow growth, sequential hermaphrodism, and discontinuous essential habitat including coastal areas of the islands and seamounts (Krug, 1990; ICES, 2012). It is considered a deep-water species and, since the stock structure is unknown, three management units have been adopted for assessment purposes in the Northeast Atlantic: (a) Subareas 27.6, 27.7, and 27.8; (b) Subarea 27.9; and (c) Subarea 27.10 (Azores) (ICES, 2007).

The availability and market demand for blackspot seabream to drive the dynamics of the multi-specific demersal, mixed hook, and line fishery in the Azores. Blackspot seabream is the main target species owing to its high selling price (Pinho, 2003; Santos et al., 2019), and ranks first in terms of total landed value in the region (Santos et al., 2020). The status of the stock is uncertain, although recent studies using length-based data-limited assessment suggest being exploited at or above the Maximum Sustainable Yield (MSY) levels (Medeiros-Leal et al., 2023). Consequently, of this historical exploitation, several management measures to limit catch, fishing effort and minimum landing size have implemented along the years (ICES, 2022).

Blackspot seabream stocks can easily be overexploited, as shown by the Bay of Biscay stock collapse in the 1980s (Lorance, 2011). This case was a wake-up call for scientists and fisheries managers to the vulnerability of the species related with the life history traits (protandrous hermaphroditism and late maturity). Surplus production models (SPM) are the only data-limited method that allows for a full assessment of fish stocks. These models provide exploitation and stock status assessment based on MSY reference points and catch forecasts based on alternative scenarios. For this study, were employed two SPMs to assess the stock of blackspot seabream in Azorean waters (ICES 27.10.a.2): 1) Just Another Bayesian Biomass Assessment (JABBA); 2) Stochastic Surplus Production Model (SPiCT).

2. Methodology

2.1. Fishery dependent data

2.1.1. Landings and abundance indeces in Azorean waters.

The data used in this study came from the database of the Department of Oceanography and Fisheries, University of the Azores (DOP/UAz) and were obtained from the Azores Auction Services and collected through fishing inquiries under the DCF. Official landings were recorded from 1985 to 2017 for each fishing trip (*n* = 3,679,979) and included vessel size, *métier* (*i.e.*, a group of fishing operations targeting a specific assemblage of species, using a specific gear, during a precise period of the year and/or within the specific area; EC, 2008) and catch in kg by species. Between 1990 and 2017, 31,616 fishing inquiries were conducted to harbor-present vessel captains at the moment of landing. These inquiries were undertaken to complete the information for fishing effort and covered all fleet segments, with a focus on those that are not obliged to maintain a logbook (*i.e.*, vessels <10 m in length). Each inquiry included the size of the vessel, the number of days it spent at sea and information about the fishing operation, such as the type of gear used, the average depth at which fishing took place and the catch in kg by species.

LPUE (Kg per landings^{-1} vessel^{-1}) and CPUE (Kg days at sea^{-1} vessel^{-1}) were estimated for blackspot seabream. To reduce the influence of potential drivers (*e.g.*, targeted species, vessel size, fishing gear) on these catch rates, generalized linear models (GLMs) were utilized to calculate standardized abundance indices (Santos et al., 2022; Santos et al., 2023). Details on the procedure for selecting the interactions and explanatory factors that explained most of the variability in the data, model validation and catch standardization can be found in Santos et al. (2022).

2.2. Fishery independent data

2.2.1. Survey derived abundance index.

Survey-derived abundance indices (RPN; individuals per 1000 hooks) were calculated for the period 1996-2019 and came from the Azorean spring bottom longline survey (Pinho et al., 2020). Surveys followed a stratified random design and covered the main islands and major seamounts. To estimate de annual index used in further analysis, were only considered the exploited biomass (LT > 33cm).

2.3. Population parameters

Surplus production models, such as JABBA and SPiCT, are age and size aggregated models that approximate changes in biomass as a function of the biomass of the preceding year, the surplus production biomass, and the removal by the fishery in the form of catch. Somatic growth, reproduction, natural mortality and associated density-dependent process are inseparably captured in the estimated surplus production function that is governed by three parameters: 1) the intrinsic rate of population increase (r); 2) the shape parameter and 3) the unfished equilibrium biomass. However, there is a direct link between age-structured stock parameters and the expected surplus production function, so that stock parameters describing, length-at-age, weight-at-age, maturity-at-age, and selectivity-at-age, natural mortality, and the steepness parameter of the assumed Beverton and Hold SSR can be used to approximate the surplus production (Winker et al., 2020). To estimate the three parameters used as priors in surplus production models were used the R package SPMprior available on github.com/henning-winker/SPMpriors. The life-history parameters used to estimate the priors are presented at Table 1.

Table 1. Input constant parameters used in the age-structured model for blackspot seabream *Pagellus bogaraveo* of the Azores (ICES area 10).

PARAMETERS	VALUE	DEFINITION	OBS.
L_{∞} (cm)	55.12	Asymptotic average maximum length	Medeiros-Leal et al. (2023)
K (year-1)	0.12	Growth coefficient of the von Bertalanffy growth model	Medeiros-Leal et al. (2023)
T_0 (year-1)	-1.46	Hypothetical age at which the species has zero length	ICES, 2012
a=	0.0172	Condition factor parameter of length-weight relationship	Rosa et al. (2006)
b=	3.0273	Slope parameter of length–weight relationship	Rosa et al. (2006)
L_{max} (L_F, cm)	55	Maximum length usually observed on the population (not the max ever observed)	Pinho et al. (2012)
L_{mat} (L_F, cm)	29	Length at size first maturity	Santos et al. (2020)
M	0.3	Natural mortality	Silva et al. (2021)
M/k	1.67	Ratio natural mortality over growth coefficient	Medeiros-Leal et al. (2023)

2.4. Surplus production models

2.4.1. Just Another Bayesian Biomass Assessment (JABBA)

JABBA is a Bayesian state-space surplus production model with a Bayesian framework that reduces uncertainty in the model with reasonable prior information and state-space modelling that estimates both process and observation errors (REF). To reduce the uncertainty of the reference points estimates, sensitivity analysis was performed using priors derived from different steepness (h=0.5 and h=0.6), for five scenarios. Detailed information about each specific scenarios are presented at Table 2.

2.4.2. Stochastic Surplus Production model in Continuous Time (SPiCT)

SPiCT, a stochastic surplus production model in continuous time, incorporates dynamics in both biomass and fisheries, and observation error of both catches and biomass indices (REF). To reduce the uncertainty of the reference points estimates, sensitivity analysis was performed using priors derived from different steepness (h=0.5 and h=0.6), for five scenarios. Detailed information about each specific scenarios are presented at Table 2.

Table 2. Definition of each five scenarios used for the sensitivity analysis (ICES area 10).

Scenario	Definition
1	r + Bmsy/K + All time series
2	r + Bmsy/K + Edit Survey
3	r + Bmsy/K + Edit Survey/CPUE/LPUE
4	r + Bmsy/K + All time series + Uncertainty Catches
5	r + Bmsy/K + Edit Survey/CPUE/LPUE + Uncertainty Catches

3. Results and discussion

3.1.1. Landings and abundance indices (fishery dependent and independent)

Official landings are reported by Azores since 1985. The discard rates are considered negligible because was estimated at 6%, and with a high survivorship that corresponding mortality is likely smaller than 5%. The Azorean landings were TAC constrained from 2013 to 2022 and a decrease of the landings were registered since them (Figure 1).

Pronounced differences in the LPUE after 2000s could indicate that the stock has declined or that productivity of the stocks changed (Figure 1). However, these statements could not be fully accepted, because the LPUE trends indicate a fast and high decline of the productivity after 2000s, meanwhile the CPUE and Survey indices did not follow the same pattern (Figure 1). The most plausible justification for these differences between the three abundance indices is related with changes in the data collection program sample design. Since 2000s the data collection program became the responsibility of the EU Data Collection Framework (DCF), before holding by the Department of Oceanography and Fisheries of University of the Azores. For this reason, was decided to work in further stock assessment analysis with two time-blocs for LPUE indices, the first between 1985-2006 and the second 2007-2017.

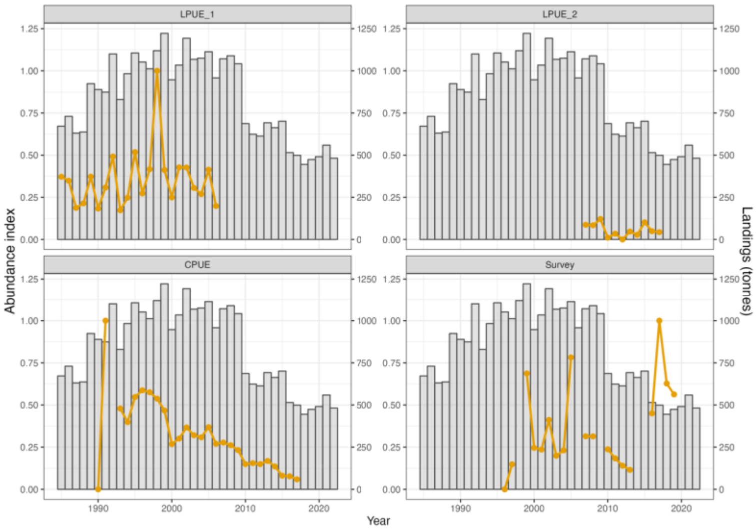

Figure 1. Standardized and scaled to mean LPUE (Kg landings^{-1} vessel^{-1}), CPUE (Kg days at sea^{-1} vessel^{-1}) from the Azorean bottom longline fishery (1985-2017), and exploited biomass (>33 cm) of Annual abundance in number (Relative Population Number) from the bottom longline survey (1996-2019) for blackspot seabream *Pagellus bogaraveo* from the Azorean bottom longline fishery.

3.2. Population parameters

We applied the age-structured stock parameters approach to transform a total of 8 parameters, describing the age-structured and demographics of blackspot seabream, into the surplus production function parameters r and m, which we approximated as function of either exploited biomass (EB_{MSY}) or spawning biomass (SB_{MSY}) (Figure 2). Our results confirmed that the functional of the parameter age-structured yield curve can be closely approximated by the derived parametrization equivalent surplus production curves (Figure 2). The effect of h on r can be inferred from the notable change in central r values for three alternative steepness assumptions (Figure 2).

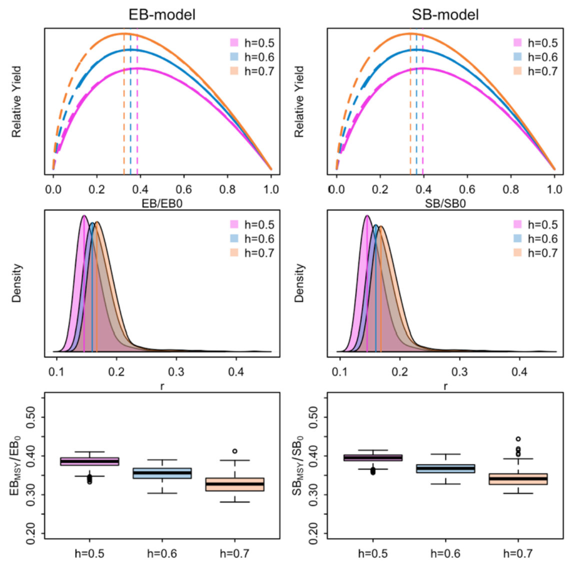

Figure 2. (Top Panel) Showing the functional from of the yield curves produced from the Age-Structured Equilibrium Model (ASME; solid line) and the formulation of the Surplus Production function (solid) as a function of EB/EB0 and SB/SB0 for a range of fixed steepness values of the spawning recruitment relationship(h = 0.5, h = 0.6, h = 0.7) (top panel); (Middle Panel) density distributions of simulated r values from Monte-Carlo simulations based on the EB-model and SB-model; and (Lower Panel) boxplot generated inflection points of EB_{MSY}/EB_0 and SB_{MSY}/SB_0 for each of the fixed steepness h input values.

3.3.3. Surplus production models

3.3.3.1. Just Another Bayesian Biomass Assessment (JABBA)

The sensitivity analysis showed that the reference points results F/F_{MSY}, B/B_{MSY} and MSY were more reliable when the h=0.5 steepness was used. The steepness h= 0.5 also provide an improvement of the residual's diagnostics and retrospectivity analysis (Table 3). Besides that, the scenario 3 model using the h=0.5 presented the best fit of the 10 scenarios and was defined as the base case model, and the next results for the stock assessment purposes are based on this model (Table 3). Results of JABBA model suggests a carrying capacity (K) of 14853 t, a B_{MSY} of 5644 t, F_{MSY} = 0.14 year^{-1} and MSY=811 t for blackspot seabream in Azores. The stock biomass at the end of 2019 was 20% of the B_{MSY} and the fishing mortality was 29% of the F_{MSY}. Biomass presented a continuous decreased period from 1995 to 2010, with a stable period between 2011 to 2015, and a very slight increase since thereafter (Figure 3), while the fishing mortality was above F_{MSY} between 1998 to 2015. The relative biomass (B_{2019}/B_{MSY}) and exploitation level (F_{2019}/F_{MSY}) in 2019 were 0.81 and 0.72 respectively, indicating that the blackspot seabream fishery in the Azores was in a recovering status. The default JABBA plots are shown in Figures

12.4.10. JABBA model presented a good fit of the residual's diagnostics and retrospectivity analysis, and the convergence was achieved (Figure 4).

Table 3. Results of the steepness sensitivity analysis using JABBA model for blackspot seabream *Pagellus bogaraveo* of the Azores (ICES area 10).

		Reference points				Residuals Diagnostics				Retrospective analysis	
Scenarios	Stepness	B/BMSY	F/FMSY	FMSY	MSY	Posteriores	Process dev	Residuals	Runs test	Retro	Hindcast
1	h=0.6	0.88	0.62	0.17	861	Yes	Yes	55.20%	No	Yes	2.47
2	h=0.6	0.87	0.62	0.17	870	Yes	Yes	48.60%	No	Yes	1.88
3	h=0.6	0.80	0.70	0.17	839	Yes	Yes	45.80%	No	Yes	3.88
4	h=0.6	0.92	0.58	0.17	963	Yes	Yes	48.80%	No	Yes	2.48
5	h=0.6	0.76	0.73	0.17	930	Yes	Yes	45.80%	No	Yes	3.85
1	h=0.5	1.14	0.49	0.15	848	Yes	Yes	45.80%	No	Yes	2.5
2	h=0.5	0.84	0.7	0.14	811	Yes	Yes	36.80%	No	Yes	5.06
3	h=0.5	0.84	0.7	0.16	778	Yes	Yes	34.80%	Yes	Yes	5.72
4	h=0.5	0.89	0.65	0.14	814	Yes	Yes	38.60%	No	Yes	2.53
5	h=0.5	0.83	0.7	0.14	890	Yes	Yes	36.90%	Yes	Yes	5.67

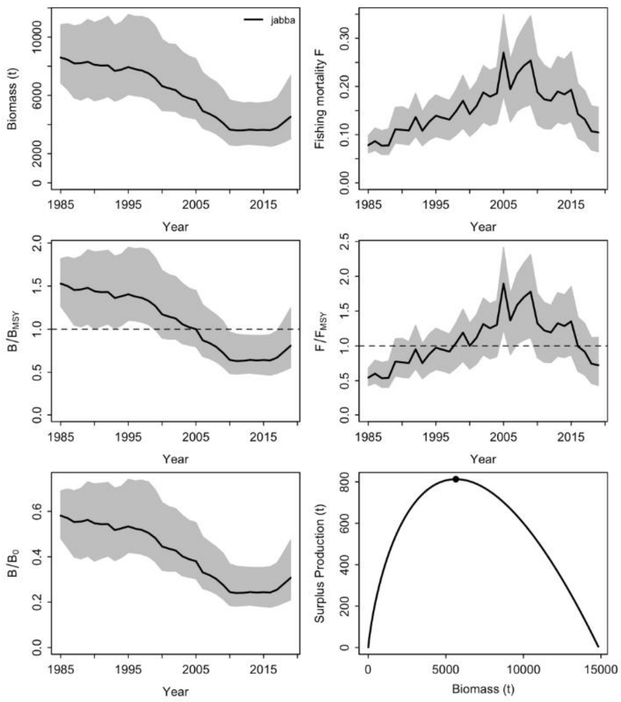

Figure 3. Basic results of JABBA model for the blackspot seabream *Pagellus bogaraveo* from the Azores using standardized CPUE, LPUE and Survey data (ICES, 10.a.2).

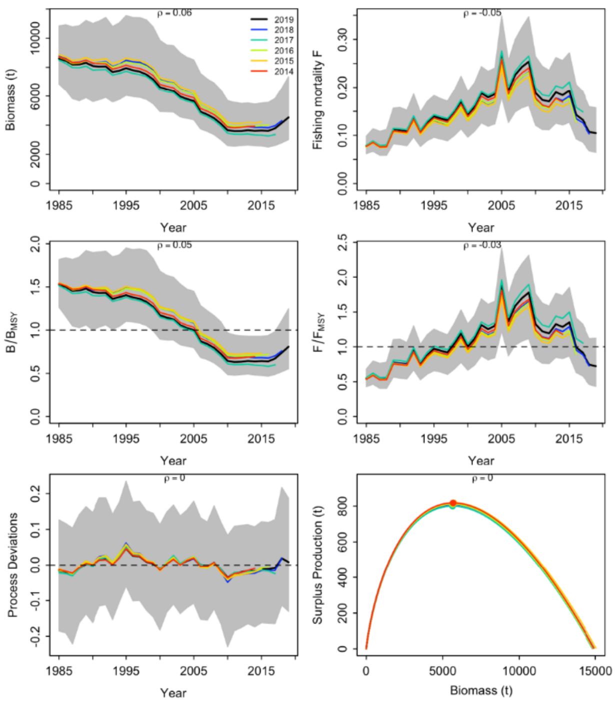

Figure 4. Retrospectivity analysis from JABBA model applied to the blackspot seabream *Pagellus bogaraveo* from the Azores using CPUE, LPUE and Survey data (ICES, 10.a.2).

3.3.3.2. Stochastic Surplus Production model in Continuous Time (SPiCT)

The sensitivity analysis showed that the reference points results F/F_{MSY}, B/B_{MSY} and MSY were more reliable when the h=0.5 steepness was used. The steepness h= 0.5 also provide an improvement of the residual's diagnostics and retrospectivity analysis (Table 4). Besides that, the scenario 3 model using the h=0.5 presented the best fit of the 10 scenarios and was defined as the base case model, and the next results for the stock assessment purposes are based on this model (Table 4). Results of SPiCT model suggests a carrying capacity (K) of 13061 t, a B_{MSY} of 4378 t, F_{MSY} = 0.17 year^{-1} and MSY=753 t for blackspot seabream in Azores. The stock biomass at the end of 2019 was 22 % of the B_{MSY} and the fishing mortality was 12% of the F_{MSY}. Biomass presented a continuous decreased period from 1999 to 2010, with a stable period between 2011 to 2015, and a very slight increase since thereafter (Figure 5), while the fishing mortality was above F_{MSY} until 2015. The relative biomass (B_{2019}/B_{MSY}) and exploitation level (F_{2019}/F_{MSY}) in 2019 were 0.78 and 0.85 respectively, indicating that the blackspot seabream fishery in the Azores was in a recovering status. The default SPiCT plots are shown in Figures 12.4.12. SPiCT model presented a good fit of the residual's diagnostics and retrospectivity analysis, and the convergence was achieved (Figures 6 and 7).

Table 3. Results of the steepness sensitivity analysis using JABBA model for blackspot seabream *Pagellus bogaraveo* of the Azores (ICES area 10).

		Reference points				Residuals Diagnostics				Retrospective analysis	
Scenarios	Stepness	B/BMSY	F/FMSY	FMSY	MSY	Posteriores	Process dev	Residuals	Runs test	Retro	Hindcast
1	h=0.6	1.5	0.07	0.22	1033	Yes			No	No	2.5
2	h=0.6	1.41	0.35	0.23	992	Yes			No	No	5.06
3	h=0.6	0.88	0.73	0.21	783	Yes			Yes	Yes	5.72
4	h=0.6	1.4	0.33	0.23	1136	Yes			No	No	2.53
5	h=0.6	0.88	0.73	0.21	861	Yes			Yes	Yes	5.67
1	h=0.5	1.14	0.49	0.15	848	Yes			No	Yes	2.5
2	h=0.5	1.07	0.52	0.15	849	Yes			No	Yes	5.06
3	h=0.5	0.72	0.91	0.16	752	Yes			Yes	Yes	5.72
4	h=0.5	1.03	0.55	0.15	923	Yes			No	Yes	2.53
5	h=0.5	0.83	0.7	0.14	890	Yes			Yes	Yes	5.67

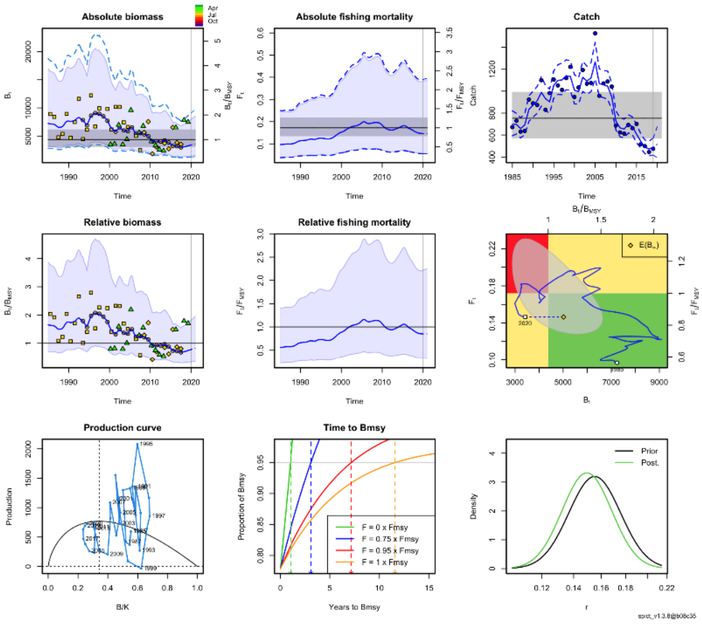

Figure 5. Basic results of SPICT model for the blackspot seabream *Pagellus bogaraveo* from the Azores using CPUE, LPUE and Survey data (ICES, 10.a.2).

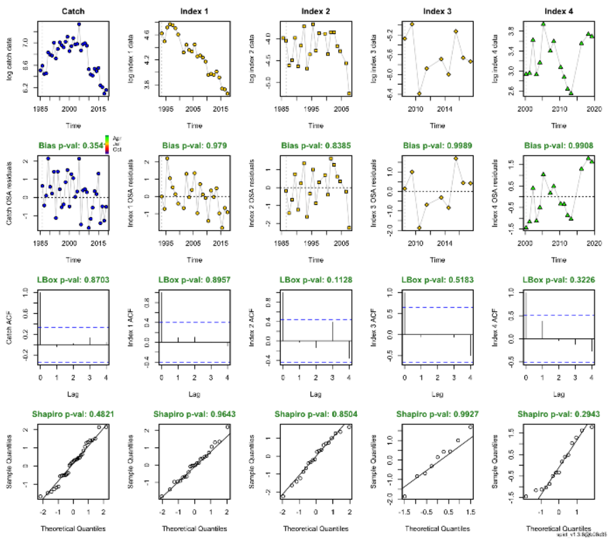

Figure 6. Residual results from SPICT model applied to the blackspot seabream *Pagellus bogaraveo* from the Azores using CPUE, LPUE and Survey data (ICES, 10.a.2).

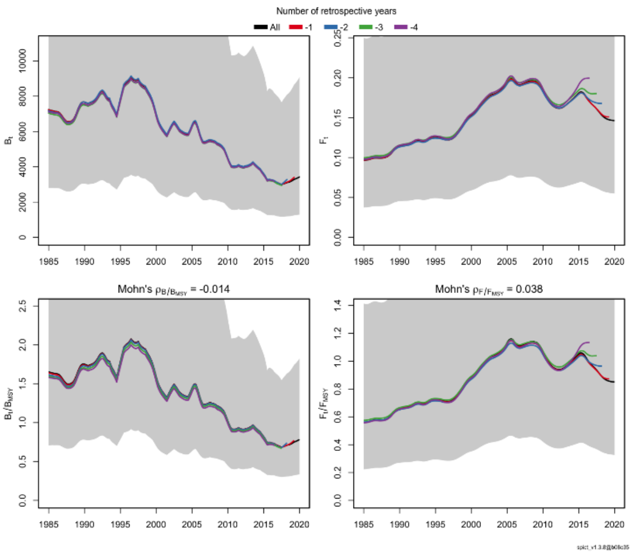

Figure 7. Retrospectivity analysis results from SPICT model applied to the blackspot seabream *Pagellus bogaraveo* from the Azores using CPUE, LPUE and Survey data (ICES, 10.a.2).

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The development of the Norwegian longline fleet's fishery for ling, tusk and blue ling during the period 2000-2022

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Introduction

Ling, tusk and blue ling were fished by Norway for centuries, and the amount landed has been recorded since 1896 (Figure 1). The major catches of these species are taken by longliners, and the catches are to a large degree bycatches. The fishery for these species is influenced by the size of various quotas for other species, especially the quota for Arcto Norwegian cod. Therefore, total catch may not be a good indicator of the condition of these stocks (Figure 2).

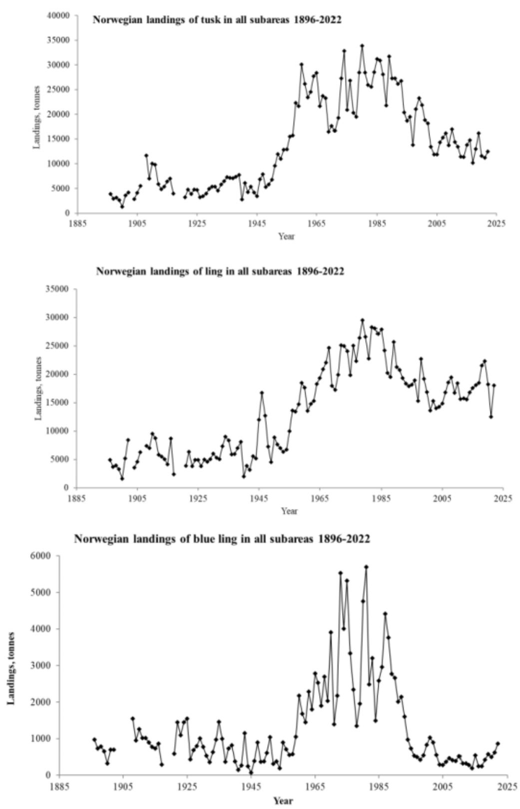


Figure 1. Reported Norwegian landings of tusk, ling and blue ling for the period 1896 -2022.

Scientific surveys do not cover the main habitats of ling, blue ling and tusk. Therefore, these stocks need to be monitored based on commercial data. One possible way to track their abundance, based only on commercial data, would be to develop a catch per unit of effort series for the fishery. But again, the major challenge for any cpue series: It is easy to generate a cpue series, and it is difficult to determine if the series track abundance.

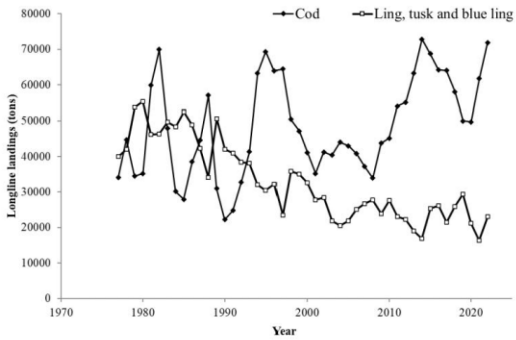


Figure 2. Total landings by longliners of cod (diamonds) and the combined total landings of ling, tusk and blue ling (open squares) for the period 1977- 2022.

Development of the Norwegian fleet of longliners, 1977- 2022

In addition to data on total landings*, the Norwegian Directorate of Fisheries (NDF) provides data on number of fishing vessels participated in the fishery, the gear employed, areas fished and changes in vessel ownership. In Table 1 are the number of long liners during the period 1977 to 2022, the total landed catch by the fleet, and the average annual catch per vessel. The number of vessels increased from 36 in 1977 to a peak of 72 in 2000, and after that the number decreased to 25 in 2014-2017, the last few years the number of vessels has stabilized at 26 vessels fishing more than 8 tons ling, tusk and blue ling.

The number of vessels declined mainly because of changes in the law concerning the quotas for cod. The decrease in the number of vessels was accompanied by a decrease in total catches until 2004; afterwards, the landings have been varying but stable (Figure 3a). The catch-per-vessel was stable from 1980 until 2003. In the period 2003- 2019 there was a steady increase in catch-per-vessel with a sharp decrease in 2021 followed by an increase in 2022 (Figure 3b).

* The data provided by the NDF are; the total landed catch, the logbook data, and the catch along with its location.

In 2012 new regulations were initiated and the number of cod quotas for each vessel increased from 3 to 5. This caused a further reduction in the number of long liners; from 36 in 2012, to 25 in 2015 to 2018. In 2022 there were 26 vessels.

a) b)

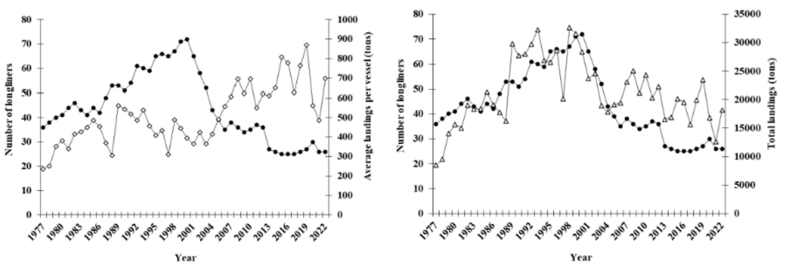


Figure 3. a) The number of long liners (filled circles) and the average landings per vessel of ling and tusk (open diamonds) in the period 1977-2022 and, b) the number of longliners and the total landings of ling and tusk (open triangles).

Logbooks

All available logbooks for the years 2000-2022 are now in the database, and the data have undergone extensive quality control procedures. The data for 2010 is incomplete because of problems getting some of the logbook data, both for the paper logbooks and for the electronic logbooks. In 2010, electronic logbooks were implemented for the longline fleet. The Norwegian Directorate of Fisheries has received the data, but because of lack of quality control, the 2010 data will not be released. Some fishers did not send paper logbooks because they had delivered the data electronically. Because of this, logbooks from only 11 of 35 vessels are available for 2010. The quality of the logbooks varies considerably, and a serious problem is that some lack information on the number of hooks used per day. The data from 2011 are almost complete with data from 35 of 37 vessels. In 2012 to 2022 all logbooks are available, though some days have been deleted due to punching errors.

Days in the fishery

The Norwegian longline logbooks provide information on the geographical distribution of the fleet. In Table 2 are the average number of days a vessel spent fishing for tusk, ling and blue ling, jointly or separately, for all ICES Subareas and Divisions. After 2000, when new quota regulations for cod were introduced, the number of days each vessel fished for three-deep-water species increased, and by 2005 the number of days in the fishery was twice that was in 2000. The data for 2006 show that the number of days in the fishery has decreased by more than 20 percent compared with 2005 and 2007. The data was checked for errors, but none were discovered. The number of fishing days has trended downward since 2007, most likely because of the record large stock of Arcto Norwegian cod. This trend changed dramatically in 2019 when the number of fishing days per vessel increased from 134 days in 2018 to 192 days in the tusk fishery and in the ling fishery it changed from 94 in 2018 to 125 in 2019. However, in 2020 the total number of fishing days had declined to 147.

Division 2a has been the main fishing grounds since 2000, followed by 4a and 5b (Table 2).

Average number of hooks per day

Table 3 are estimates of the average number of hooks used per day in each ICES area and in the total fishery for the 2000-2022. For all areas combined, there was a steady increase in the number of hooks used from 2000 through 2009. This is also the general trend for subareas (Figure 4). The combined time series for 1972-1994 (Bergstad and Hareide, 1996) and the series based on data from 2000-2012 show that the average number of hooks has increased from 10 000 hooks per day in 1972 to around 39 000 in 2022 (Figure 6).

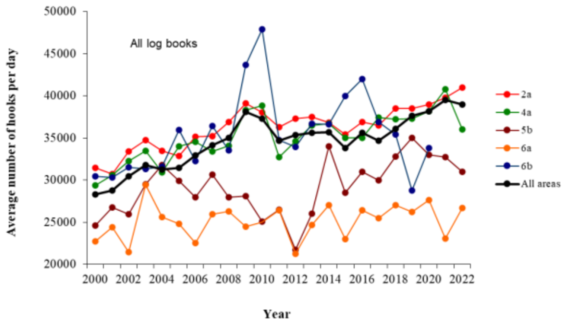


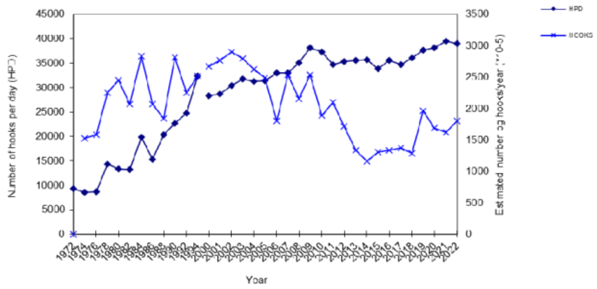
Figure 4. Average number of hooks the Norwegian longliner fleet used per day in each of the ICES subareas and in the total fishery for the years 2000-2022 for the fishery for tusk, ling and blue ling.

Total number of hooks per year

Based on the number of vessels, the number of hooks per day, and the number of days each vessel participated in the fishery, estimates of the total number of hooks used per year were generated (Tables 1, 2 and 3). Table 4 and Figure 5 show the estimated number of hooks (in thousands) set in each of the ICES subareas and in the total for all areas for the years 2000-2022 During the period 1974 to 2013 the total number of hooks per year has varied considerably, after this the number of hooks per year have been stable but with an increase from 2019 and 2021 (Figure 6).

The total number of hooks per year considers; the number of vessels, the number of hooks per day, and the number of days each vessel participated in the fishery, may be a suitable measure of tracked applied effort. Based on this measure of effort, it appears that the average effort for the years 2011-2021 is 40% less than the average effort during the years 2000-2003.

a.



b.

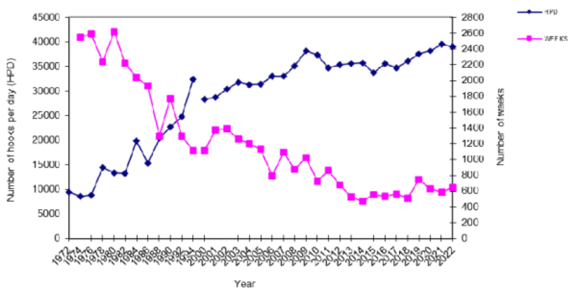


Figure 5. The combined time series for 1972-1994 (Bergstad and Hareide, 1996) and the series based on data from 2000-2022: a) The numbers of hooks used per day, and the total number of hooks used per year; b) The numbers of hooks used per day, and the total number of weeks the long liners participated in the fishery for ling and tusk.

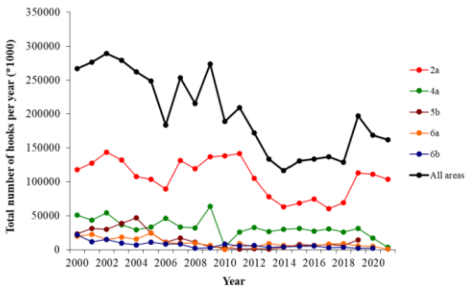


Figure 6. Estimated total number of hooks (in thousands) the Norwegian longliner fleet used in the ICES subareas with highest catches and in the total fishery for the years 2000-2022 for the fishery for tusk, ling and blue ling.

The size of the vessels

There was a steady increase in the average size of the vessels from 34 m in 1977 to 46.6 m in 2022. Figure 7 show the average size of the vessels and the smallest and the largest vessel in the fleet for the period 1977 to 2022.

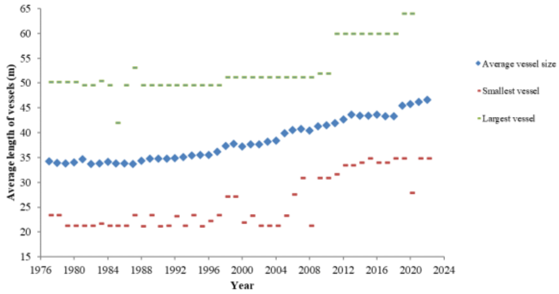


Figure 7. Average size of longliners >21 m for the period 1977-2022.

Fishing area

Approximately 65-70% of the commercial catches of ling are taken by vessels using demersal longlines, either target species or bycatch (Helle and Pennington, 2015), and the remains are taken mainly by gillnets but also some by trawlers. Although the tusk fishery takes place from Rockall to the southern Barents Sea (Helle and Pennington, 2004), between 70 to 80 percent of the catches by Norwegian vessels are from the Norwegian Economic Zone.

Figure 8 shows all the catches of ling registered in the electronic logbooks by longliners in 2013-2020 in areas 1 and 2.

Tusk are mainly caught by longliners (approximately 90 percent of the total catch). Figure 9 shows all catches of tusk registered in the electronic logbooks by longliners in Areas 1 and 2 during the period 2013 to 2022.

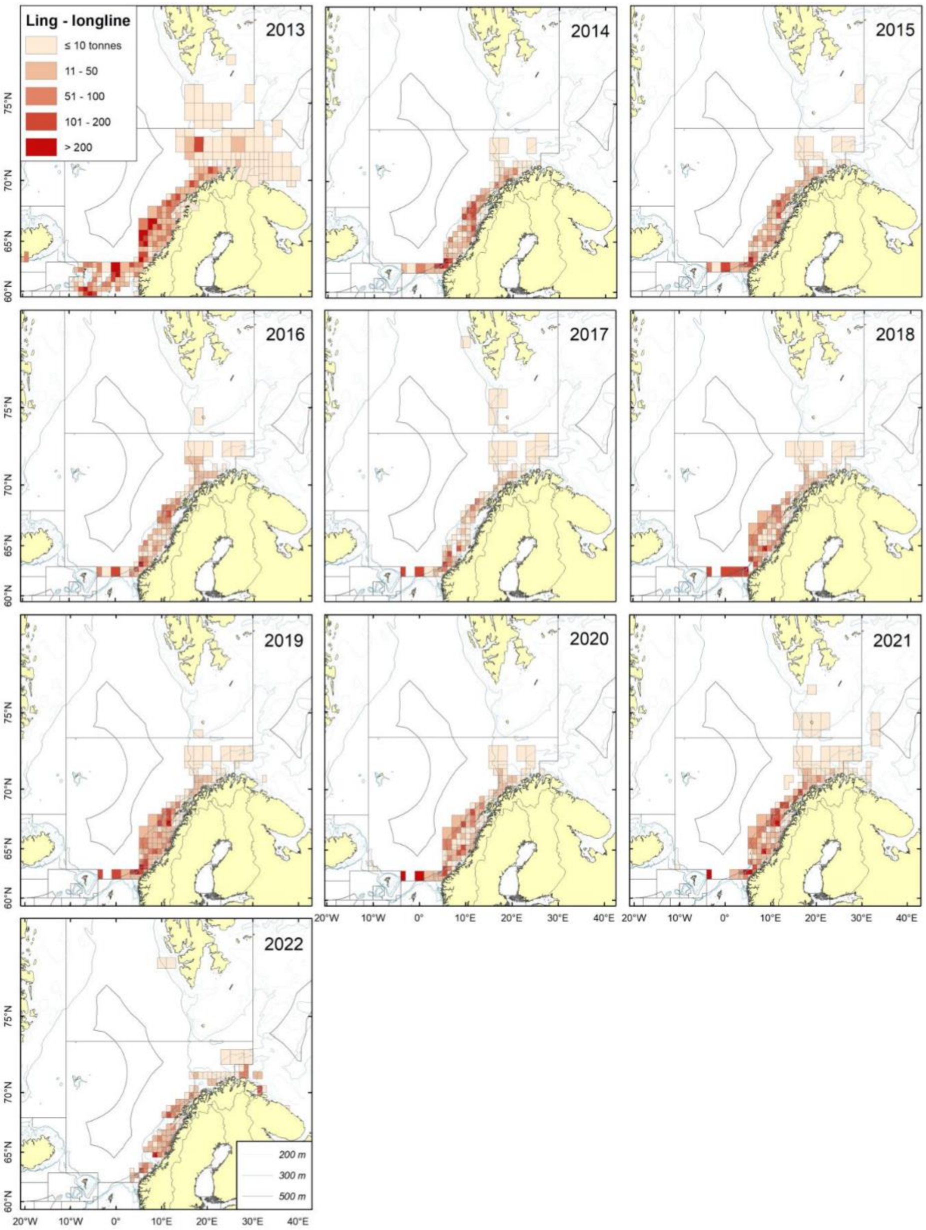


Figure 8. Distribution of the catches using longlines by the Norwegian fishery for ling in 2013 to 2022 in areas 1 and 2.

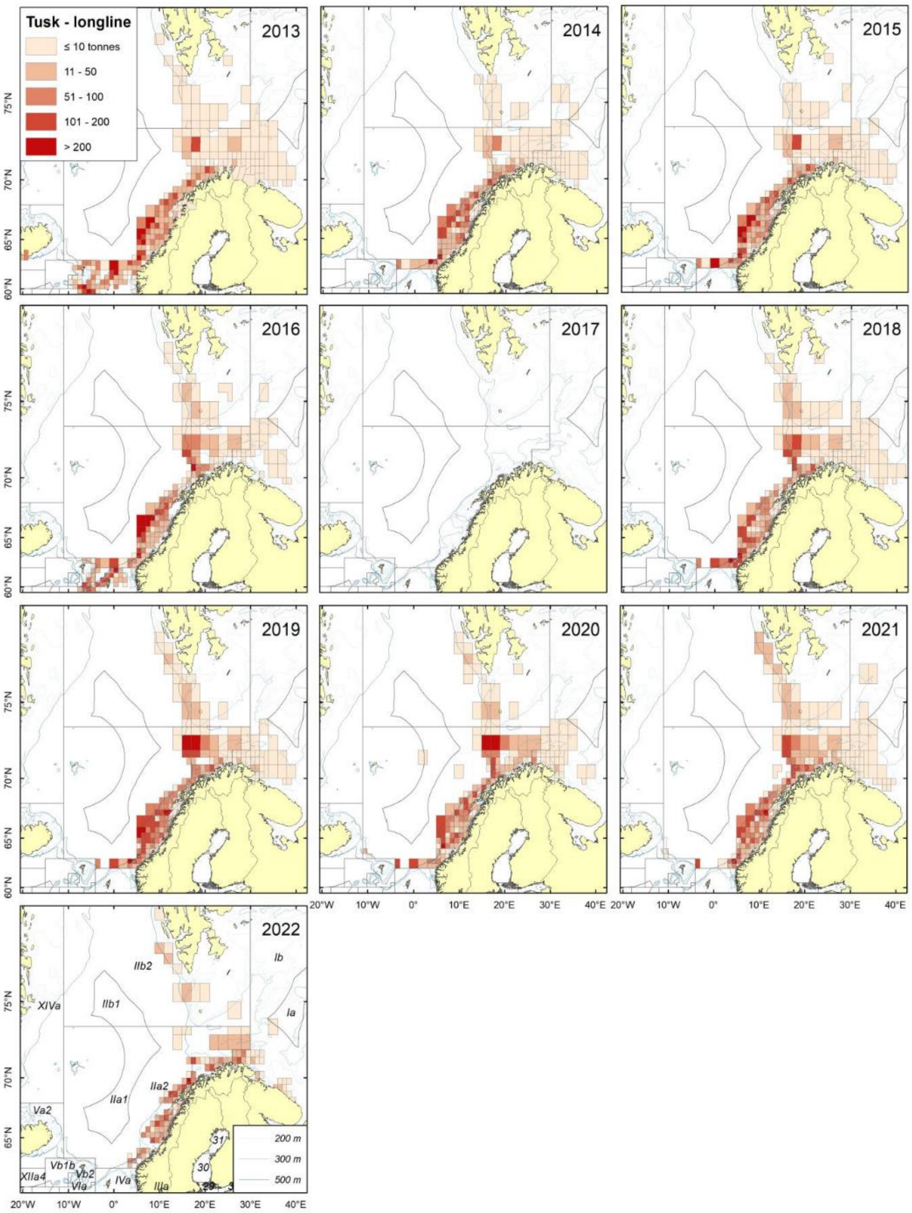


Figure 9. Distribution of the catches using longlines by the Norwegian fishery for tusk in 2013 to 2022 in areas 1 and 2.

CPUE

Based on methods described in Helle *et al.*, 2015 to derive a cpue series were for ling and tusk calculated two ways; using all data available and catches for which ling and tusk were targeted (>30 percent of the daily total catch).

In Figures 11 and 13 are plots of the estimated cpue series for the most important ICES subareas for ling and tusk: based on all the available data, and a cpue series based on only those catches that ling or tusk appear to be targeted; included plots of estimated 95% confidence intervals.

Ling:

Both cpue series for ling in 2a have been relatively stable since 2011, but with a declining trend the last four years for the targeted fishery.

In Areas 4a there was a steady increase in cpue from 2002 until 2016 and were down in 2017 and 2018 but with a slight increase in 2019 and 2020. In 2021 there were little or no fishing in the traditional areas due to no agreement about the TAC in the area. The estimate is therefore based on very limited data and does not present a correct picture of the stock situation. In 2022 the index was at the same level as in 2020.

In 6a and 6b there was also a positive trend from 2002 to 2016 with a varying but stable index. The Norwegian fleet had limited access to the areas in 2021 and there was very little fishery in 2022. There was no fishing in area 6b the two last years.

When all ling data for Areas 3.a, 4, 6, are combined for a cpue series, and ling was targeted a cpue series, both indicate a steady increase since 2003 to 2017 and then a decline in 2018. In 2020 there were an increase. The estimates for 2021 do not represent the normal fishery in the areas and should not be considered valid. In 2022 the index was at the same level as in 2020.

Tusk:
Both cpue series in Area 2a have been relatively stable since 2011.

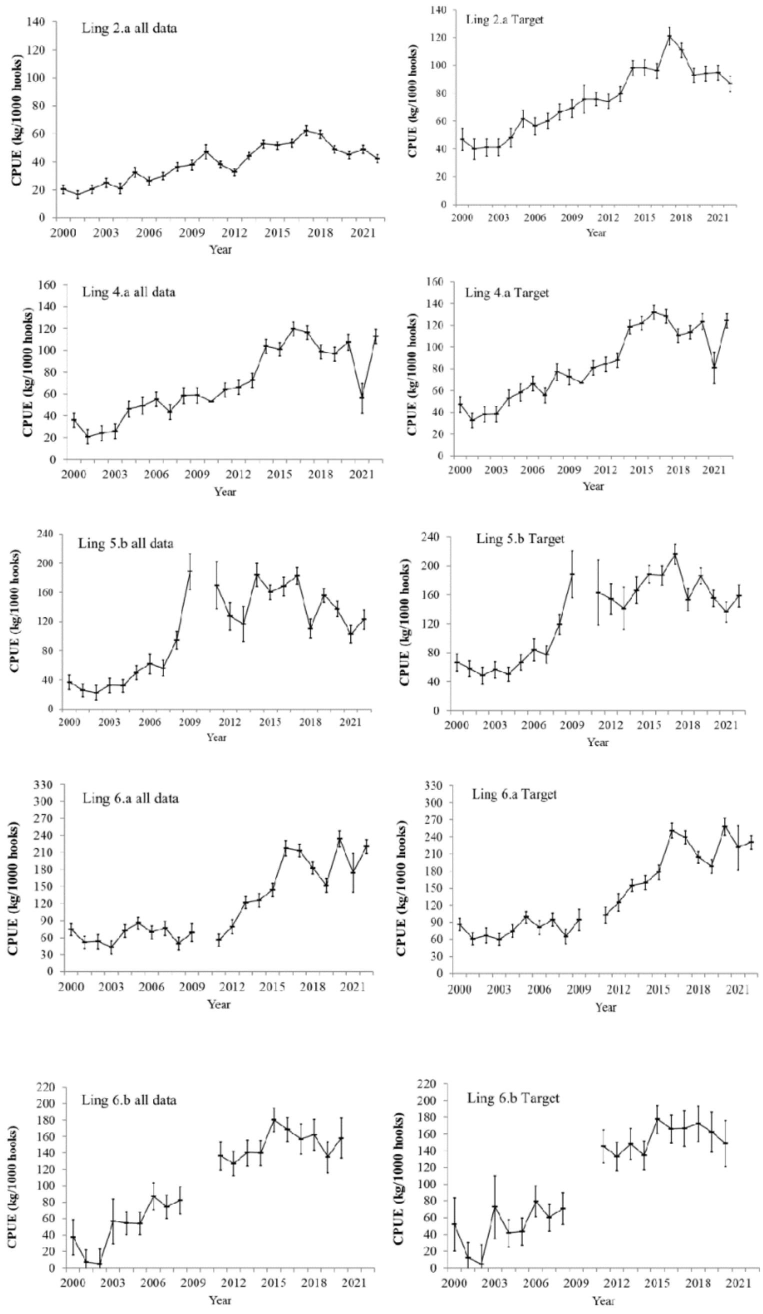
The series in Area 4a based on all the catches indicates at first a stable series and then a slightly decreasing trend for the last six years, while the series based on the targeted fishery shows a clear and positive upward trend from 2002 until 2013, after this there was a declining trend, and this trend is especially clear for the targeted fishery.

The series in Area 5b shows a stable trend from 2000 to 2008, afterwards it increased until 2012, then decreased until 2017 and a relatively large increase in 2018 and a decreasing trend after 2018.

In area 6a a cpue series based on the Norwegian longline data shows an increase in cpue from 2004 to 2008, afterwards it has remained at a high and slightly increasing level when all data are used, and a sharp increase from 2018 to 2019 for the targeted fishery followed by a decrease in 2020 (Figure 13). In 2022 the index was at the same level as during the period 2011-2016.

The combined cpue series for areas 4a, 5b and 6a. shows an increasing trend from 2000 to 2010, after 2010 cpue was at a high and stable level, declined in 2017.. After 2017 the index has been varying but in 2022 the index was at the same level as during the period 2011-2016.

The cpue series for Area 6b when all data were used, a catch from longliners show a decrease from 2000 to 2006. After 2006, the cpue was low but at a stable level. There was no direct fishery for tusk in the last years.



Ling 2.a all data
Ling 2.a Target
Ling 4.a all data
Ling 4.a Target
Ling 5.b all data
Ling 5.b Target
Ling 6.a all data
Ling 6.a Target
Ling 6.b all data
Ling 6.b Target
CPUE (kg/1000 hooks)
Year

Figure 11. Estimated cpue (kg/1000 hooks) of ling in Subareas 2a, 4a, 5b, 6a and 6b based on skipper's logbooks during the period 2000-2022. The bars denote the 95% confidence intervals.

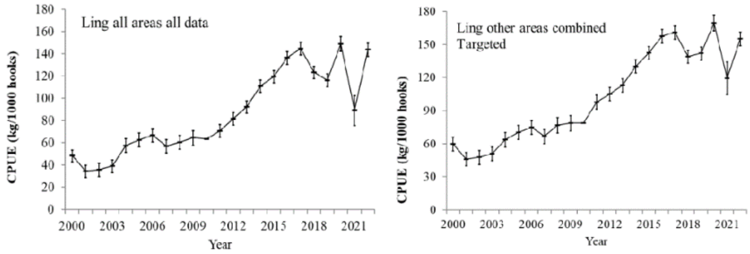


Figure 12. Ling areas combined (3, 4, 6) based on skipper's logbooks during the period 2000-2022. The bars denote the 95% confidence intervals.

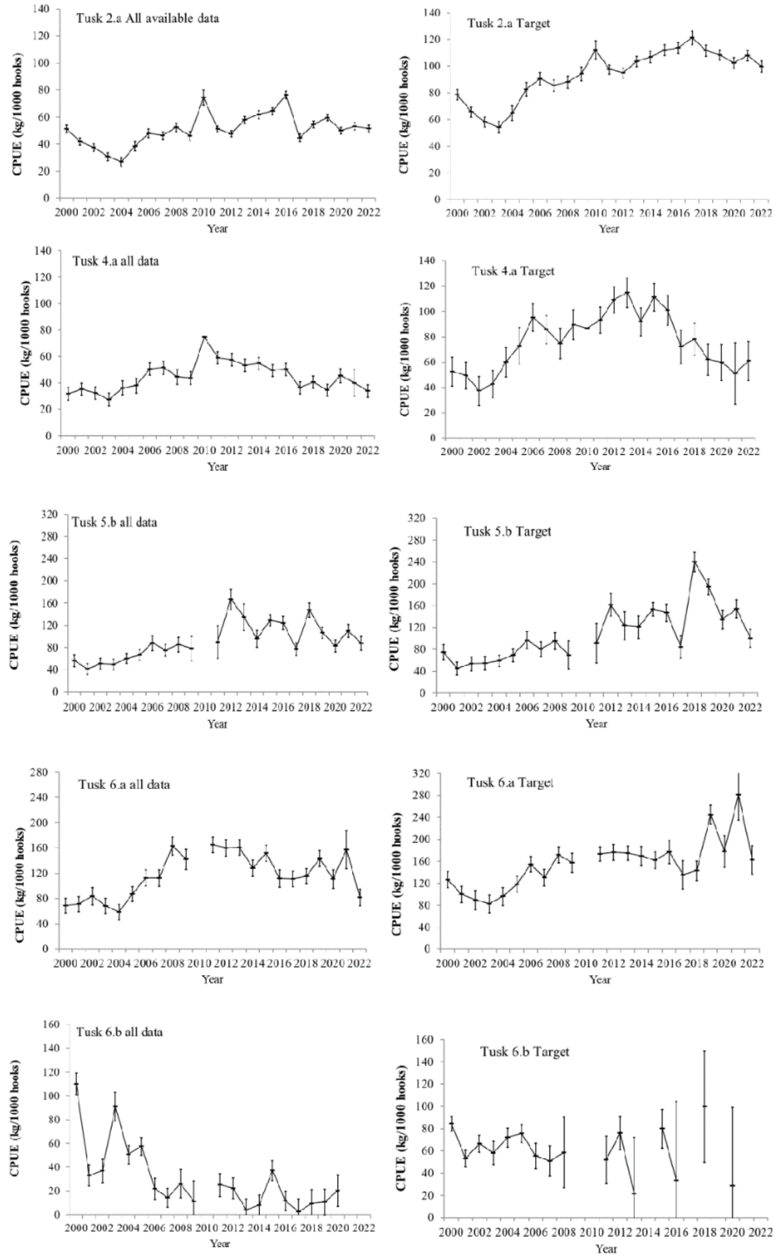


Figure 13. Estimated cpue (kg/1000 hooks) of tusk in Subareas 2a, 4a, 5b, 6a and 6b based on skipper's logbooks during the period 2000-2022. The bars denote the 95% confidence intervals.

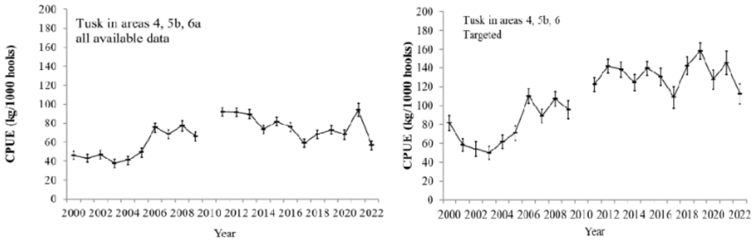


Figure 14. Tusk in other areas combined (4, 5b, 6a) based on skipper's logbooks during the period 2000-2021. The bars denote the 95% confidence intervals.

Blue ling

The cpue series for blue ling based on longline data shows a low and stable level for the Areas 1, 2, 3a and 4. Although there was no direct fishery in these areas, the stock doesn't seem to show any recovery.

A low and steady population for blue ling were in subareas 5a and 14 and in Areas 5b, 6 and 7. When only data from 6a, there was a positive trend from 2004 to 2015, after this the trend has been at a lower level.

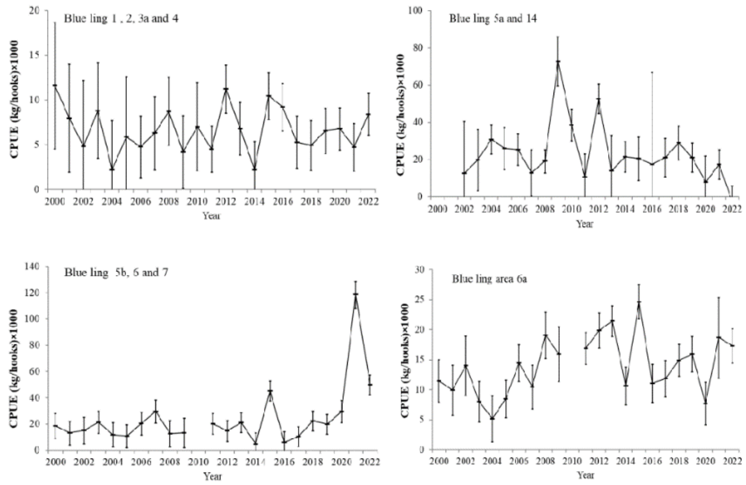


Figure 15. Estimated cpue (kg/1000 hooks) of blue ling in Subareas: 1, 2, 3.a; 4, 5.a; 14, 5.b, 6; 7; and in Subarea 6.a. All data from skipper's logbooks during the period 2000-2022. The bars denote the 95% confidence intervals.

Conclusions and discussion.

Legislation enacted since 2000 for regulating the cod fishery caused a continuous reduction in the number of longliners in the fishery for tusk, ling and blue ling, and by 2009, there were only 34 vessels above 21m in the fishery. Due to recent regulations, the number of vessels was 26 in 2021. Because of this decrease the number of vessels were 58 % fewer since 2000, the total number of hooks employed reduced, the total number of weeks fished, and until 2021, there were a significant reduction in effort. Compared with 2000, a decrease in total effort has occurred even though there was an increase in the number of hooks set per vessel/day until 2021. The large increase in effort in 2019 is probably due to a reduction in cod quotas. This fishery should be monitored and reported to prevent overfishing (Figures 5 and 6).

During the period 1998 through 2003, the total landings declined from 32 675 to 19 000 tons, while the catch-per-vessel remained relatively constant. The total catches were stable during the years 2004 through 2006, but after that, there was a sharp increase in 2007 and 2008. The average catch-per-vessel increased considerably during 2003- 2008, afterwards the catch has been relatively stable.

It should be noted that using the total landings as a measure of stock development can be very misleading. For example, there is a negative correlation between the landings of cod and the total landings of ling, blue ling and tusk (Figure 2), which is due to cod being the most valued species. Therefore, the decrease in total landings does not indicate a reduced stock size, but only an increase in cod quotas.

If a stock is not covered by a scientific survey, then a commercial cpue index is often used to track temporal trends in abundance. It is widely recognised that caution must be used when interpreting a cpue series based on commercial catch data. But by considering: the application and distribution of fishing effort; species specific knowledge, such as when a species is targeted or if it is a preferred species; patterns in the total catch by fleet and by vessel; etc., then based on all these factors, a reliable assessment of a stock's condition.

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Table 1. Summary statistics for the Norwegian longliner fleet during the period 1995-2022 (vessels exceeding 21m).

Year	Number of longliners	Total landed catch by fleet	Catch per vessel (Tons)
1977	36	8471	235
1978	38	9563	252
1979	40	14038	351
1980	41	15651	382
1981	44	15002	341
1982	46	19079	415
1983	43	18338	426
1984	41	18398	449
1985	44	21364	486
1986	42	19080	454
1987	48	17788	371
1988	53	16253	307
1989	53	29816	563
1990	51	27726	544
1991	54	27979	518
1992	61	29718	487
1993	60	32290	538
1994	59	26908	456
1995	65	26571	409
1996	66	28645	434
1997	65	20173	310
1998	67	32675	488
1999	71	31528	444
2000	72	28391	394
2001	65	23681	364
2002	58	24619	424
2003	52	18969	365
2004	43	17815	414
2005	39	19106	490
2006	35	19475	556
2007	38	23060	607
2008	36	25069	696
2009	34	21158	622
2010	35	24360	696
2011	37	20344	550
2012	36	22302	620
2013	27	16522	612
2014	26	16907	650
2015	25	20189	808
2016	25	19478	779
2017	25	15663	627
2018	26	19895	765
2019	27	23498	870
2020	30	16827	561
2021	26	12621	485
2022	26	18134	698

Table 2. Average number of days that each Norwegian longliner operated in an ICES subarea/division.

All species	1	2a	2b	3a	4a	4b	5a	5b	6a	6b	7c	12	14b	All areas
2000	9	54	2	+	24	2		13	12	10	2	+	6	131
2001	5	64	9		22		1	18	14	6	1	5	3	148
2002	10	74	2		29			20	12	8		1	8	164
2003	12	73	3	1	21	1	3	25	12	6		3	9	169
2004	20	75	11		22		2	34	14	5	1	1	9	195
2005	23	81	14		25		2	21	25	8	0,4		5	203
2006	11	73	3		38		3	11	13	7				159
2007	15	101	21		27	3	2	15	10	6	1			201
2008	7	90	18	1	26		4	11	10	2			2	171
2009	19	103	20	1	49	1	2	4	7	2			3	211
2010	8	104	13		3		1	3		5			5	145
2011	12	103	4		21	3	2	1	9	4				159
2012	9	78	4		26	1	2	2	5	5	1		2	135
2013	6	63	2		22	2	2	1	11	4			1	114
2014	5	66	2		31	1	2	4	9	4			2	126
2015	8	77	4		36	1	2	11	9	5			2	155
2016	4	81	7		31	1	2	8	8	5			3	150
2017	12	66	15		33		2	10	13	3			4	158
2018	4	69	6		27	1	2	7	13	4			4	137
2019	5	109	14		31	1	2	15	8	3			6	194
2020	6	95	7		15		2	11	6	2			3	147
2021	16	100	20		3		2	10	1	0			6	158
2022	9	95	18		34		2	8	7				5	178

Tusk	1	2a	2b	4a	4b	5a	5b	6a	6b	7c	12	14b	All areas
2000	3	34	1	18	1		11	12	4	2	1	2	88
2001	1	57		22		1	18	14	6	1	3	1	124
2002	5	66	2	28			20	12	8			2	141
2003	5	58		19	2	3	25	12	5			1	130
2004	6	60	1	21		2	34	14	5	1		3	148
2005	5	69	2	25		2	21	23	8	0		3	158
2006	1	67	1	37		3	11	13	7				140
2007	5	89	3	26		2	15	10	6	0			157
2008	4	92	4	30		4	14	15	5				169
2009	6	87	2	56	2	2	4	7	2			1	159
2010	4	93	2	2		3			4			2	112
2011	12	103	4	21		2	1	9	4				155
2012	9	78	4	25		2	2	5	4	1		2	132
2013	6	63	2	22		2	1	11	3			1	111
2014	5	66	2	31		2	4	9	3			2	125
2015	8	77	4	36	1	2	11	9	5			2	154
2016	4	81	7	30		2	8	8	5			3	148
2017	12	66	15	31		2	10	13	2			3	154
2018	4	69	6	26		2	7	13	3			4	134
2019	5	109	14	30	1	2	15	8	2			6	192
2020	6	95	7	15		2	11	6	2			3	146
2021	16	99	20	3		2	10	1				6	157
2022	9	91	18	34		2	8	7				5	174

Ling	2a	3a	4a	4b	5a	5b	6a	6b	7c	14b	All areas
2000	23	+	19	1		12	13	4	3		76
2001	40		22	+	1	17	13	5	1		100
2002	50		29			18	11	7			114
2003	40	1	20	1	3	24	12	4			104
2004	37		22		2	34	14	5	1		115
2005	51		25		2	21	23	8	+		126
2006	54		38		3	11	13	7			126
2007	65		27	3	2	15	10	6	1		128
2008	52	1	25		4	11	9	2			104
2009	65	1	49		2	4	7	2			130
2010	70		3		3			7			83
2011	73		21	3	4	2	8	4			113
2012	59		26	1	2	2	5	5	1		98
2013	44		22	1	2	1	11	4			85
2014	53		31	1	2	4	9	4		1	106
2015	54		37	1	2	11	9	5		1	122
2016	55		31	1	2	7	8	5		1	111
2017	27		33		2	10	13	3			88
2018	41		27	1	2	6	13	4			94
2019	66		31	1	2	14	8	3			125
2020	47		15		2	10	6	2			83
2021	53		3		1	9	1				67
2022	53		34		1	7	7				102

Blue ling	2a	4a	5a	5b	6a	6b	12	14b	All areas
2000	1	1		4	9	1	2	+	18
2001	1	+	1	3	6	1	5		15
2002	1	1		4	4	2		+	11
2003	1		1	5	8	2	2	+	14
2004	+	1	2	5	6	+		+	14
2005	+	1	1	1	10			+	14
2006	1	2	2	4	8	+			18
2007	1	2	1	5	6	1			16
2008	2	4	3	4	10			1	25
2009	1	4	2	3	6			1	17
2010	2	1	2					2	7
2011	2	2		1	7				12
2012	1	2		2	5			1	12
2013	1	2		1	8				13
2014	1	3	1	2	5	1		1	12
2015	3	4	1	5	7				20
2016	1	4		3	6				15
2017	1	3		5	7			1	17
2018	1	3		4	8			1	17
2019	4	3		6	6			2	21
2020	6	4		3	4				17
2021	6		1	4	1			1	13
2022	5	9	1	4	6			1	26

Table 3. Average number of hooks that the Norwegian longliner fleet used per day in each of the ICES subareas/divisions and in the total fishery for the years 2000-2022 in the fishery for tusk, ling and blue ling. n is the total number of days with hook information contained in the logbooks.

All		1	2a	2b	3a	4a	4b	5a	5b	6a	6b	7c	12	14b	All areas
2000	**Average**	31688	31439	35409	30250	29378	30263		24594	22763	30471	29600	18136	2815	28325
	n	353	1916	71	4	685	38		411	435	227	80	22	191	4429
2001	**Average**	33325	30703	34638		30553	33500		26760	24419	30340	33108	17548	2465	28743
	n	163	2196	315		727	10		613	447	140	37	175	135	4958
2002	**Average**	35432	33431	34756		32291	33867		25939	21484	31557			9458	30432
	n	263	2031	45		667	15		475	186	149			251	4083
2003	**Average**	35045	34766	34776	33037	33484	32559	22605	29513	29421	31325		13063	11515	31794
	n	376	1839	67	27	510	34	38	515	302	97		48	228	4081
2004	**Average**	32431	33475	31859		30934		25815	31804	25636	31559	25250		12474	31285
	n	433	1389	217		439		54	693	308	111	28		105	3777
2005	**Average**	32671	32861	35082		34039		23100	29885	24807	35949	33429		18960	31438
	n	316	1248	207		331		30	374	369	137	7		91	3110
2006	**Average**	33182	35140	39298		34561		21526	27943	22504	32273				32959
	n	187	1252	57		673		57	159	248	139				2711
2007	**Average**	34380	35207	37881	35000	33414	38086	25414	30681	25958	36400	31071			34110
	n	318	2103	328	8	587	58	58	355	249	145	14			4223
2008	**Average**	36833	36890	39650	36467	34056	31500	32704	27968	26319	33514			9464	35042
	n	96	1500	297	15	395	10	71	188	138	35			45	2790
2009	**Average**	39184	39142	43744	34636	38299	30167	26106	28123	24455	43645			7034	38127
	n	267	1419	281	11	680	6	33	57	99	31			38	2922
2010	**Average**	40519	38057	41607		38838		20182	25067		47904			7672	37296
	n	19	1089	135		37		11	30		52			58	1491
2011	**Average**	37205	36260	35280	35275	32737	37343	28062	26492	26424	34727			25750	34668
	n	411	3622	126	8	740	104	63	24	310	137			4	5549
2012	**Average**	36434	37298	38357		34639		33647	21702	21249	33934	39064		9091	35381
	n	307	2817	157		933		68	63	196	176	22		59	4765
2013	**Average**	39500	37500	42000		36500	43000	30900	26000	24700	36700	31000		27500	35600
	n	211	2073	81		710	34	69	34	351	132	10		36	3678
2014	**Average**	37699	36782	39660		36715	44614	35015	34000	26979	36551			22374	35676
	n	112	1501	44		707	22	46	101	214	97			65	2909
2015	**Average**	36100	35400	43500		35000	40800	31600	32400	30700	29000			29800	33800
	n	209	1902	91		908	33	54	276	222	130			53	3878
2016	**Average**	40000	36900	42000		35000	35000	37000	31000	26400	42000			31400	35600
	n	100	2025	175		775	25	50	200	200	125			75	3750
2017	**Average**	41700	36500	43000		37400	40300	33700	30000	25500	36900			25400	34700
	n	302	1660	374		815	11	54	260	320	78			89	3963
2018	**Average**	42800	38500	42000		37200	44500	42600	32800	27000	35400			35400	36100
	n	99	1776	142		692	34	51	148	295	96			105	3738
2019	**Average**	43000	38500	44300		37300	43800	38400	35000	26200	28800			26800	37600
	n	123	2956	381		842	31	63	393	218	79			172	5258
2020	**Average**	44600	39000	45900		38200		41400	33000	27600	33800			23300	38200
	n	168	2853	221		464		59	315	181	56			88	4405
2021	**Average**	43700	39800	46400		40800	47800	30000	32700	23100				34300	39500
	n	408	2600	524		80	6	42	250	17				150	4077
2022	Average	46900	41000	48600		36000		35000	31000	26700				31100	39000
	n	233	2353	459		900		45	200	191				120	4500

Table 4. Estimated total number of hooks (in thousands) that the Norwegian longliner fishery for tusk, ling and blue ling used in each of the ICES subareas/divisions and in the total area for the years 2000-2022.

All	1	2a	2b	3a	4a	4b	5a	5b	6a	6b	7c	12	14b	All areas
2000	20534	117708	5099	218	50765	4358		23020	19667	21939	4262	1306	1216	267161
2001	10831	127724	20263		43691			31309	22221	11833	2152	5703	481	276508
2002	20551	143486	4032		54313			30089	14953	14642			4389	289469
2003	21868	131972	5425	1718	36565	1693	3526	38367	18359	9773		2038	5389	279406
2004	27891	107957	15069		29264		2220	46497	15433	6785	1086		4827	262325
2005	29306	103808	19155		33188		1802	24476	24187	11216	521		3697	248895
2006	12775	89783	4126		45966		2260	10758	10239	7907				183567
2007	19081	131569	29434		33381	4228	1881	17028	9604	8081	1150			253676
2008	9282	119524	25693	1313	31876		4709	11075	9475	2413			681	215719
2009	25313	137075	29746	1178	63806	1026	1775	3825	5820	2968			717	273523
2010	11345	138527	18931		4078		706	2632		8383			1343	189277
2011	16965	141922	5363		26124	4257	2133	1007	9037	5279				209464
2012	11805	104733	5523		32422	1230	2423	1566	3825	6108			655	171952
2013	7821	77963	2772		26500	1419	2039	858	8966	3633			1815	133752
2014	4901	63118	2062		29592	1160	1821	3536	6313	3801			1163	116875
2015	7220	68145	4350	0	31500	1020	1580	8910	6907,5	3625	0	0	1490	130975
2016	4000	74722	7350	0	27125	875	1850	6200	5280	5250	0	0	2355	133500
2017	12510	60225	16125	0	30855		1685	7500	8288	2768	0	0	2540	137065
2018	4451	69069	6552	0	26114	1157	2215	5970	9126	3682	0	0	3682	128588
2019	5805	113306	16745	0	31220	1183	2074	14175	5659	2333	0	0	4342	196949
2020	8028	111150	9639	0	17190	0	2484	10890	4968	2028	0	0	2097	168462
2021	18179	103480	24128	0	3182		1560	8502	601	0	0	0	5351	162266
2022	10975	101270	22745	0	31824		1820	6448	4859	0	0	0	4043	180492

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Greater forkbeard in Faroese waters (27.5.b).

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Introduction

There is very little catch of greater forkbeard in Faroese waters and a few fish is caught in different surveys. The objective for this document is to provide information on greater forkbeard in Faroese waters (27.5.b).

Methods

The background data is mainly from the annual surveys on the Faroe Plateau in spring (1994-2023) and summer (1996-2022). Some data are also from the deepwater survey (September 2014-2022, no survey in 2021). There are only small amounts of commercial catch, so there is no data individual fish data of this species from landings.

The fishery

There is no directed fishery for greater forkbeard in Faroese waters (5b) and only small amount is landed as bycatch.

Landings

There have always been very little landings of greater forkbeard by the Faroese fishery (Table 10.0d copied from WGDEEP report 2022). The main catch of greater forkbeard in Faroese waters is from Norway and France. The preliminary landing in 5b of greater forkbeard from Faroese in 2021 was 0.1 tons and in 2022 0 (zero) tons of greater forkbeard. NB! In the WGDEEP report 2022 (page 552 and in Table 10.0d page 561) - the landings in 5b of 301 tons in 2011 and 145 tons in 2012 seems to be wrong! In statlant 2011 the Faroese fleet fished 0.310 tons in 5a and in statlant 2012 the Faroese fleet fished 0.062 tons in 5a and 0.083 tons in 5b2 (Table 10.0d copied from WGDEEP report 2022 with only update of year 2011, 2012 and preliminary 2022 data for 5b).

Table 10.0d. Greater forkbeard *(Phycis blennoides)* in Division 5b. Working group estimates of landings.

YEAR	FRANCE	NORWAY	UK (SCOT)(1)	UK (EWNI)	FAROE ISLANDS	RUSSIA	ICELAND	TOTAL
1988	2	0						2
1989	1	0						1
1990	10	28						38
1991	9	44						53
1992	16	33						49
1993	5	22						27
1994	4							4
1995	9							9
1996	7							7
1997	7	0						7
1998	4	4						8
1999	6	28	0					34
2000	4	26	1	0				32
2001	9	92	1	0				102
2002	10	133	5	0				149
2003	11	55	7	0				73
2004	9	37	2	2				50
2005	7	39		0,3				46
2006	8	26			6			39
2007	11	34	0	0	9	2	0	58
2008	10	20	0		4	11	1	46
2009	0	13	3		3	2	0	24
2010	2	45	3	1	11		2	62
2011	7				0		1	8
2012	6	5			0.083	7	7	25
2013	7	3	0				0	11
2014	7	14	0		0		2	24
2015	5	27					2	34
2016	7	3	0				3	13
2016	7	3	0				3	13
2017	9		0					9
2018	5	7						12
2019	7	10						18
2020	7	24	0					31
2021	6	7	0	0	0	0	0	13
2022*	5.436	21.018	0.2528		0			26.7

Spatial distribution

The spatial distribution of greater forkbeard from the bottom trawl groundfish surveys were mainly on the Faroe Plateau deeper than 200 m (Figure 1 and Appendix 1, 2). In the deepwater survey greater forkbeard was caught around the Banks and on the Wyville-Thomson ridge (Figure 2 left and Appendix 3).

In the Faroese 0-group surveys on the Faroe Plateau in June/July there are 26 registrations of greater forkbeard caught pelagic (Figure 2 right). The length was between 8-54 mm, mainly around 30-40 mm. 11 of there were caught in the period 1991-1999, 14 in the period 2001-2005 and one in 2022.

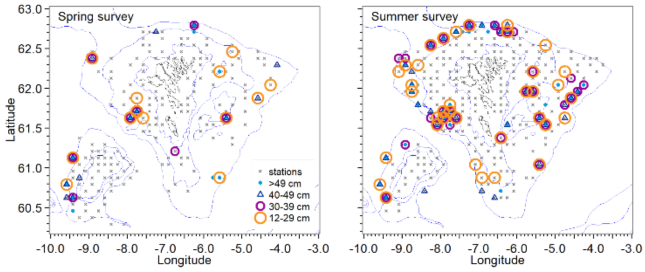


Figure 1. Greater forkbeard 5.b. Spatial distribution of greater forkbeard for all years together divided by size in the annual spring- and summer survey.

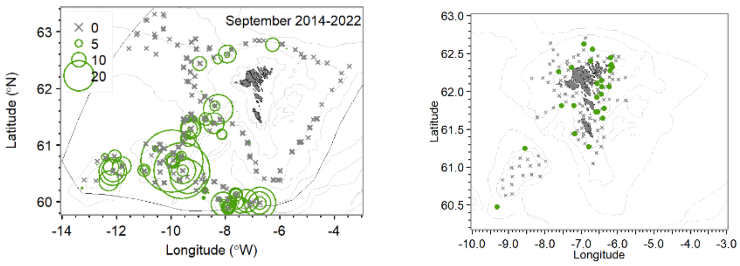


Figure 2. Greater forkbeard 5.b. Spatial distribution of (left) CPUE (kg/h) from the deepwater surveys in September 2014- 2022 (no survey in 2021) and (right) positions of 8-54 mm long greater forkbeard caught pelagic in the 0-group survey in June/July (1983-2022).

Data available

Data available from different surveys in Faroese waters is presented in Table 1. A standardized CPUE is available from the annual spring- and summer surveys on the Faroe Plateau. There are also some data from the deepwater survey and Greenland halibut survey.

Table 1. Greater forkbeard 5.b. Sampling overview from different surveys around the Faroes.

year	length	round weight	gutted weight	gender	maturity	otoliths	aged	gonad	stomach
1994	3	2							
1995	27	5							
1996	26	2							
1997	7	2							
1998	17	2							
1999	27	25							
2000	46	46							
2001	101	86							
2002	55	53							
2003	21	21							
2004	47	47							
2005	24	24							
2006	17	17							
2007	15	15							
2008	13	13							
2009	81	81							
2010	110	109							

2011	92	92							
2012	99	99							
2013	133	117							
2014	257	255	23	37	37	36		2	1
2015	131	130	16	27	27	27			1
2016	89	89	15	18	18	18			
2017	108	108	6	11	11	11			1
2018	96	96		1	1	1			
2019	50	50		7	7	7			
2020	31	31							
2021	36	32		3	3	3			3
2022	39	39		9	9	9		2	2
2023	23	23							
Total	1821	1711	60	113	113	112	0	4	8

Length composition

Annual length-frequency distribution of greater forkbeard from the Faroese groundfish surveys (very few individuals see appendix 4 and 5) and Faroese deep-water surveys for the period 2014-2022 are presented in Figure 3.

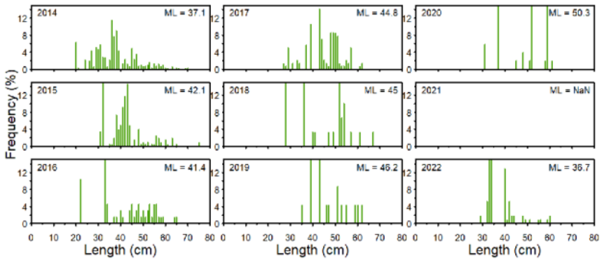


Figure 3. Greater forkbeard 5.b. Length-frequency distribution from the deepwater survey in 2014-2022 (no survey in 2021).

Length-weights

Round weight at length from all surveys showed that 40 cm greater forkbeard was around 0.5 kg and 50 cm around 1.0 kg (Figure 4).

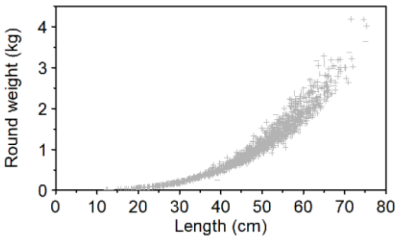


Figure 4. Greater forkbeard 5.b. Length- round weight relation from different surveys.

Catch, effort and research vessel data

Abundance index of greater forkbeard from the annual Faroese groundfish surveys covering the Faroe Plateau is presented in Table 2 and Figure 5.

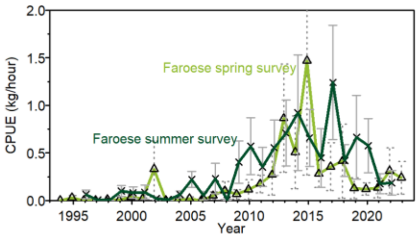
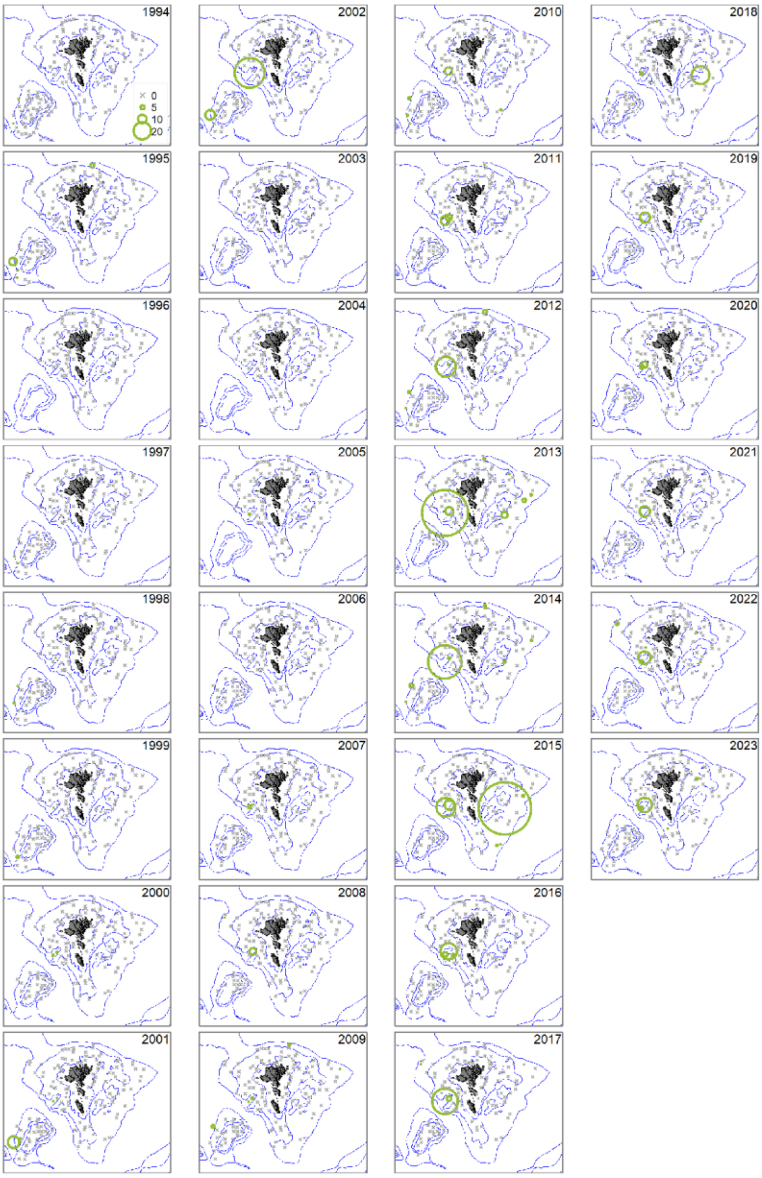


Figure 5. Greater forkbeard 5.b. Standardized cpue (kg/hour) from the Faroese spring- and summer groundfish survey.

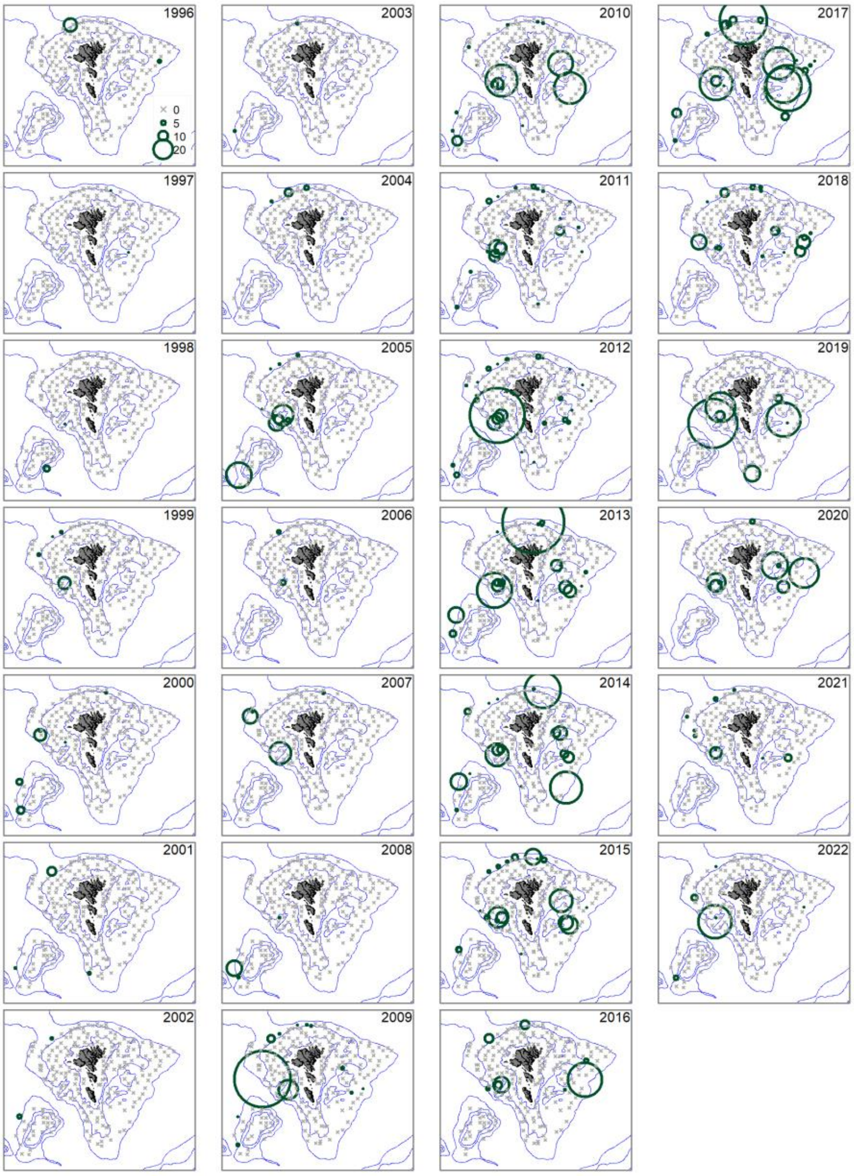
Table 2. Greater forkbeard 5.b. Standardized cpue from Faroe Plateau spring- and summer surveys. N- number of hauls, SE- standard error.

	Spring survey		Summer survey	
year	cpue	se	cpue	se
1994	0.00	0.00		
1995	0.03	0.02		
1996	0.00	0.00	0.06	0.04
1997	0.00	0.00	0.01	0.01
1998	0.01	0.01	0.00	0.00
1999	0.00	0.00	0.10	0.06
2000	0.04	0.02	0.08	0.06
2001	0.02	0.01	0.09	0.07
2002	0.33	0.30	0.02	0.02
2003	0.00	0.00	0.01	0.01
2004	0.00	0.00	0.06	0.04
2005	0.02	0.02	0.22	0.08
2006	0.00	0.00	0.05	0.04
2007	0.05	0.04	0.23	0.16
2008	0.10	0.09	0.01	0.00
2009	0.06	0.05	0.40	0.22
2010	0.12	0.11	0.57	0.30
2011	0.18	0.09	0.35	0.21
2012	0.27	0.21	0.56	0.29
2013	0.86	0.57	0.71	0.35
2014	0.51	0.38	0.92	0.61
2015	1.47	1.21	0.66	0.30
2016	0.28	0.14	0.45	0.31
2017	0.36	0.25	1.24	0.60
2018	0.41	0.39	0.42	0.17
2019	0.13	0.11	0.66	0.44
2020	0.12	0.06	0.58	0.28
2021	0.13	0.10	0.18	0.11
2022	0.26	0.24	0.19	0.13
2023	0.27	0.17		

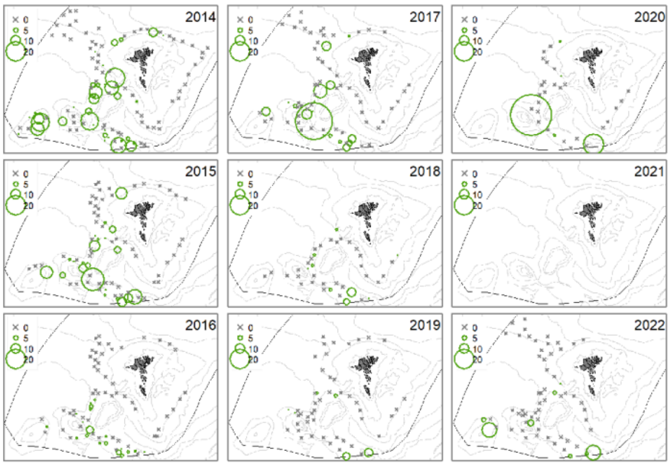
Appendix



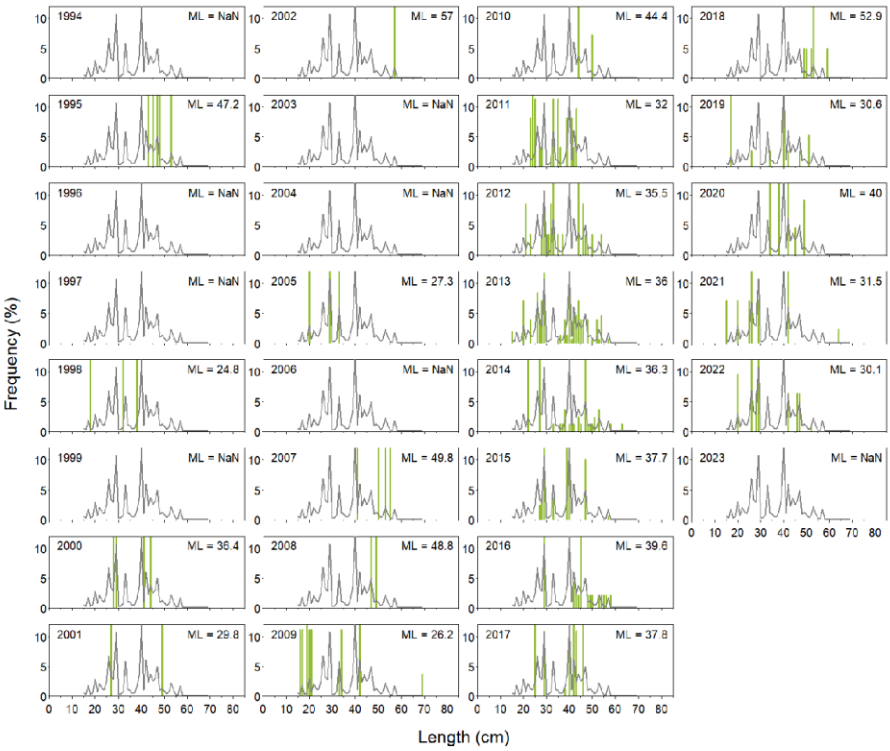
Appendix 1. Greater forkbeard 5.b. Spatial distribution (kg/hour) in the spring survey in February/March.



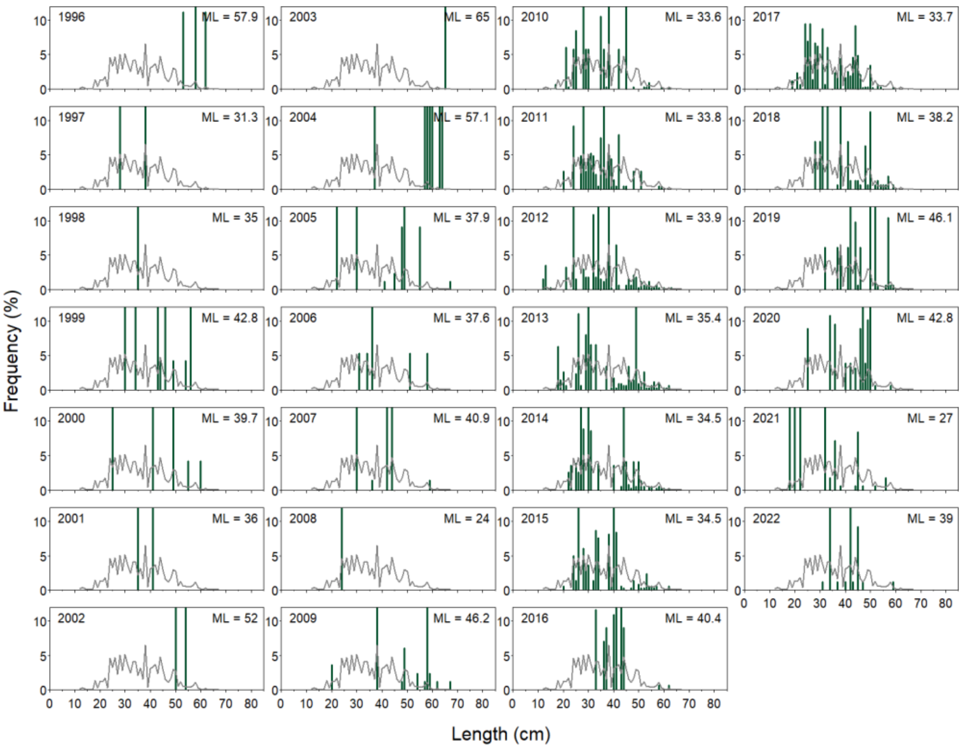
Appendix 2. Greater forkbeard 5.b. Spatial distribution (kg/hour) in the summer survey in August.



Appendix 3. Greater forkbeard 5.b. Spatial distribution (kg/hour) in the deepwater survey in September. No survey in 2021.



Appendix 4. Greater forkbeard 5.b. Length distribution in the spring survey in February/March.



Appendix 5. Greater forkbeard 5.b. Length distribution in the summer survey in August.

WD02 ICES WGDEEP 2023

Black scabbard fish in Faroese waters (27.5.b).

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Introduction

The objective for this document is to provide information on black scabbard fish in Faroese waters (27.5.b).

The fishery

The black scabbard fish fishery in Faroese waters are managed by licences. Since 2013, only one trawler has had licence to fish black scabbard fish as a targeted species. This particular trawler was sold in 2022. In the black scabbard fishery, the commercial trawler used a star trawl with 486 meshes, 160 mm. Mesh size in the net was 80 mm. The usual fishing depth varied between 600-1000 m and the trawling hours varied between six to eight hours, but may last less if the species was very abundant.

The main fishing areas of black scabbard fish in Faroese waters are located on the slope around the Faroe Bank and on the Wyville-Thomsen ridge close to the southernmost Faroese EEZ boarder (Figure 1, Appendix 1).

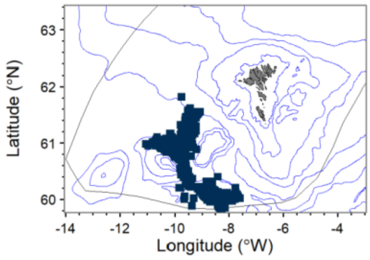

Figure 1. Black scabbard fish 5.b. Spatial distribution of the Faroese commercial trawl fishery of black scabbard fish 2000-2022.

Landings

The mean landings of black scabbard fish in Faroese waters from 1989 to 2018 were 569 t (Figure 2). The highest landings of around 1600-1800 t were in 2002, 2003 and 2008. The preliminary catch data for 2022 showed that the Faroese landings were 13.2 t in 5b2 and 2.9 t in 5b1. French catch was 6.26 t in 5.b.

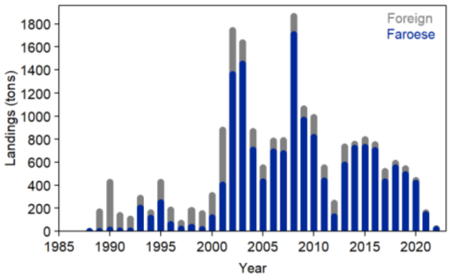

Figure 2. Black scabbard fish 5.b. Nominal landings in Faroese waters.

Spatial distribution

The spatial distribution of black scabbard fish from the deepwater surveys was mainly on the slope north of the Faroe Bank/Bill Bailey bank (Figure 3), which are the main fishing areas. A closer look at different surveys showed that black scabbard fish was only caught in the area north-west of the Faroes and never caught on the Faroe Plateau (Figure 4).

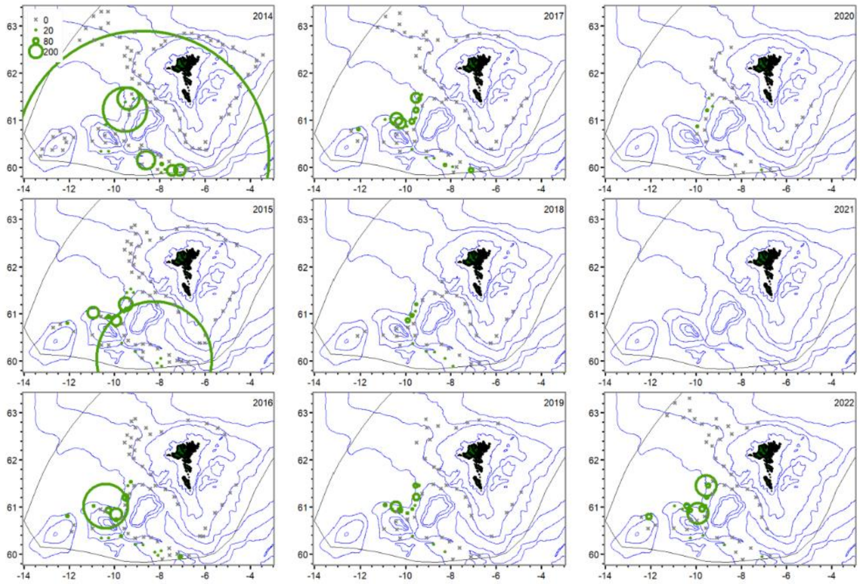

Figure 3. Black scabbard fish 5.b. Spatial distribution of CPUE (kg/h) from the deepwater surveys in 2014-2022 (no survey in 2021).

Length distribution

Annual length-frequency distribution of the Faroese landings data and Faroese deep-water surveys for the period 2014-2022 are presented in Figure 4. The mean length of black scabbard fish in the catches was around 90-92 cm, which is about the same mean length as in the deep-water survey (Figure 4). Numbers of black scabbard fish sampled from the landings and in the deep-water surveys are presented in Table 1. All the sampled fish in the deepwater survey was immature.

Table 1. Black scabbard fish 5.b. Number of fish sampled from the commercial trawler and from the deepwater surveys. * Blue ling survey in April 2018.

	Landings		Deep-water surveys					
Year	Lengths	Weights	Lengths	Round weights	Gender	Maturity	Otoliths	Stomachs
2014	575		4477	785	150	150	150	8
2015	1475		2117	389	78	78	78	9
2016	7603	5077	1271	459	94	94	94	11
2017	4984	4983	874	574	118	118	118	31
2018	4193	4143	598	217	64	64	64	8
2018*			94	94	13	13	13	4
2019	4515	4515	557	483	132	132	132	10
2020	4476	4476	91	67	19	20	20	1
2021	2012	2012	-					
2022	-		1278	474	107	107	107	9

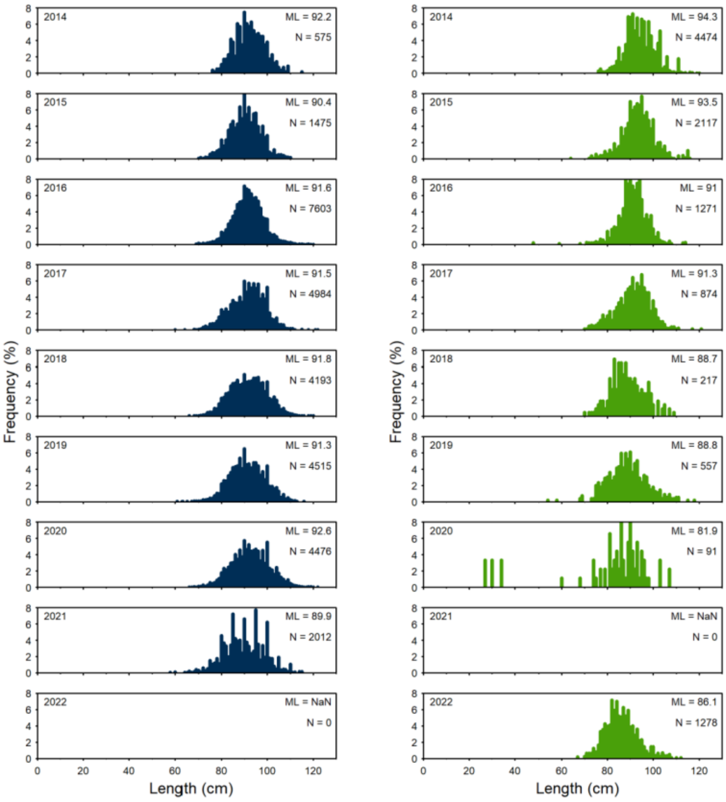

Figure 4. Black scabbard fish 5.b. Length-frequency distribution for the period 2014-2022 from the landings (no samples in 2022) (left) and the deep-water survey (no survey in 2021) (right).

Length-weights

Comparing mean weight at length from the commercial trawler with the deep-water survey showed that the data are similar (Figure 5). Black scabbard fish of 70 cm length had a round weight around 0.4 kg, 100 cm was 1.5 kg; and the largest fish was 114 cm and 2.4 kg.

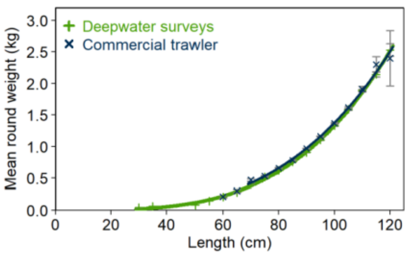

Figure 5. Black scabbard fish 5.b. Length-weight relation comparison between the landings (blue) and the deep-water survey (green).

Commercial cpue

In 2022, the commercial trawler that had a fishery licence for black scabbardfish was sold. This trawler had only 8 black scabbardfish hauls in 2022, so the CPUE-data are not presented. A map of the fishery area is presented in Figure 6.

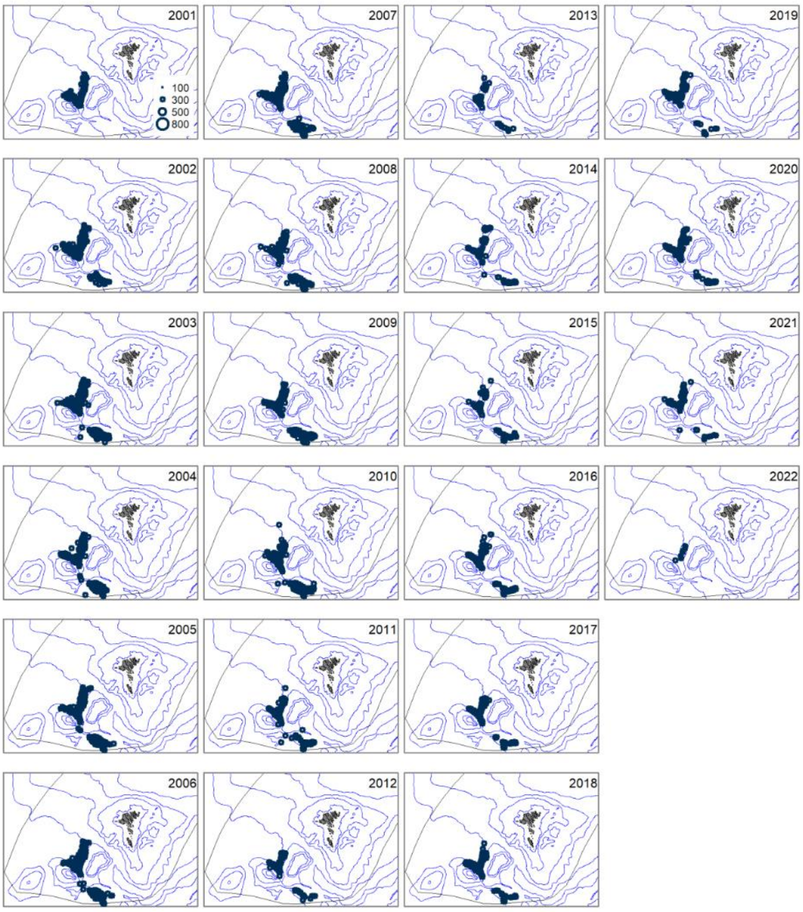

Figure 6. Black scabbard fish 5.b. Spatial distribution (kg/hour) in the commercial trawl fishery per year. Only hauls with more than 30% black scabbard fish of the total catch.

WD03 ICES WGDEEP 2023

Roundnose grenadier in Faroese waters (27.5.b).

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Introduction

The objective for this document is to provide information on roundnose grenadier in Division 27.5.b.

Landings

The landings in Faroese waters (ICES Division 27.5.b) are showed in Table 1.

Table 1. Roundnose grenadier 5.b. Nominal landings in Faroese waters.

Year	Faroes	France	Norway	Germany	Russia	UK (E+W)	UK (Scot.)	Total
1988				1				1
1989	20	181		5	52			258
1990	75	1470		4				1549
1991	22	2281	7	1				2311
1992	551	3259	1	6				3817
1993	339	1328		14				1681
1994	286	381		1				668
1995	405	818						1223
1996	93	983		2				1078
1997	53	1059						1112
1998	50	1617						1667
1999	104	1861	2			29		1996
2000	48	1699		1		43		1791
2001	84	1932						2016
2002	176	774				81		1031
2003	490	1032				10		1532
2004	508	985			6		76	1575
2005	903	884	1		1		48	1837
2006	900	875						1775
2007	838	862						1700
2008	665	447						1112
2009	322	122					2	446
2010	229	381					1	611
2011	63	11						74
2012	16	28						44
2013	24	36						60
2014	33	44						77
2015	24	28						52
2016	30	7						38
2017	9	21						30
2018	0	6						6
2019	19	11						30
2020	20	13						33
2021	12	10						22
2022*	0.732	5.967	0.509				0.345	7.553

Information from deepwater surveys

Overview of the roundnose grenadier sampling from the deepwater surveys in September are showed in Table 2. The mean lengths in the surveys were between 14.8- 17.5 cm (Figure 1). The length- round weight relation is presented in Figure 2. The spatial distribution was mainly on the Wyville-Thomsen ridge (Figure 3).

An investigation of the roundnose grenadier catch according to depth and temperature data showed that roundnose grenadier were distributed in depths deeper than around 600 m and temperatures warmer than 6°C. This is in accordance with the oceanic temperature and depth distribution in Faroese waters.

Table 2. Roundnose grenadier 5.b. Sampling overview from the deepwater survey (no survey in 2021).

Year	Lengths	Round weights	Gender	Maturity	Otoliths	Liver weights	Gonad weights	Stomachs
2014	209	186	72	72	69		18	10
2015	166	103	40	40	40			11
2016	153	139	30	30	30			7
2017	234	174	52	52	52			23
2018	101	92	21	21	21			5
2019	80	80	28	28	25			8
2020	41	31	5	5	5			3
2021	-	-	-	-	-	-	-	-
2022	143	140	46	46	46	11	14	12
Total	1127	945	294	294	288	11	32	79

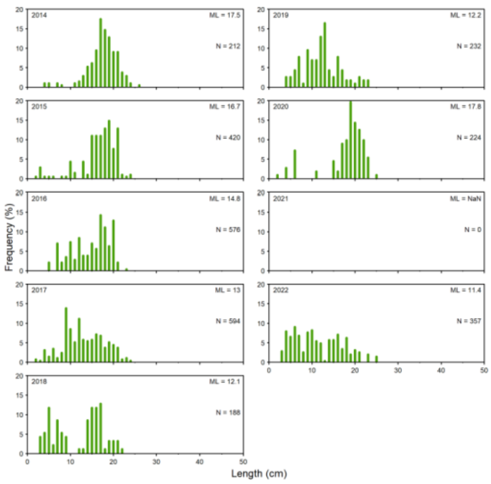


Figure 1. Roundnose grenadier 5.b. Length distribution in the deepwater surveys.

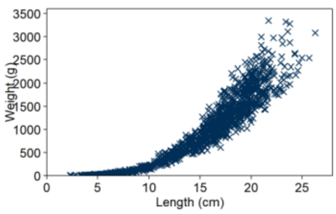


Figure 2. Roundnose grenadier 5.b. Length - round weight relation in the deepwater surveys.

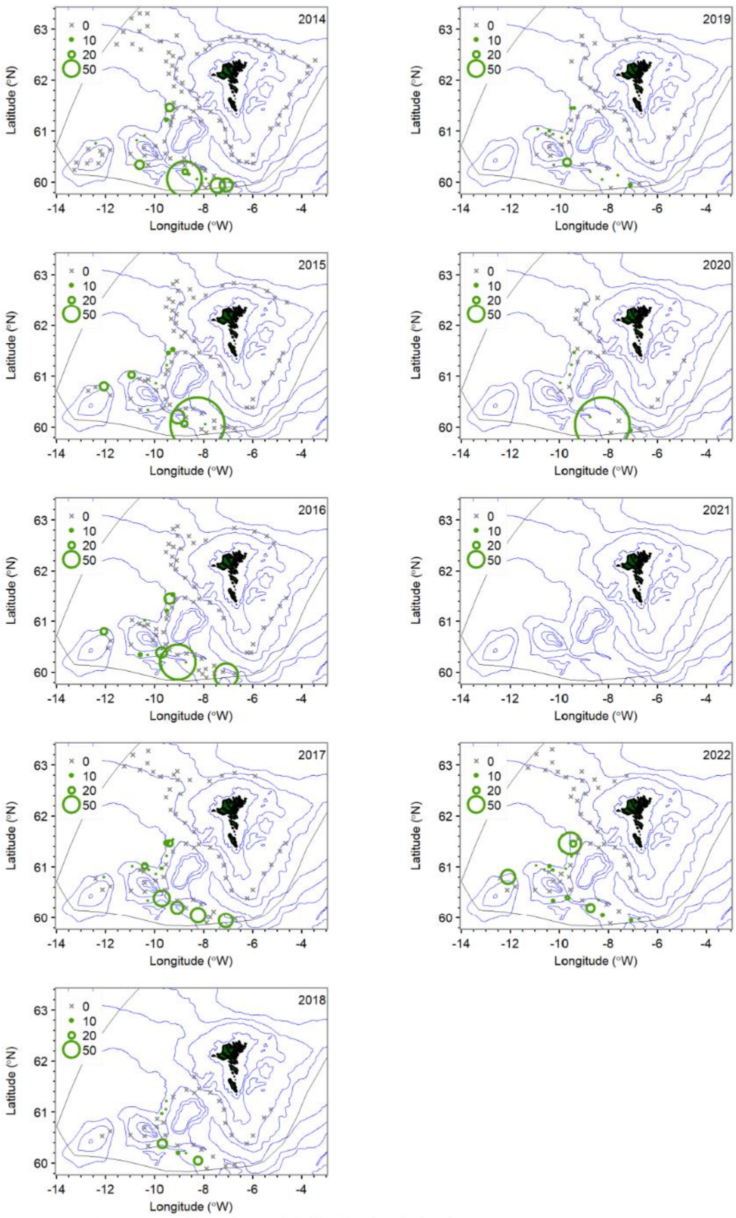


Figure 3. Roundnose grenadier 5.b. Spatial distribution in the deepwater surveys 2014-2022 (no survey in 2021).

WGDEEP 2022, WD xx

CPUE Standardization of Silver smelt in 5b and 6a @ WGDEEP 2022

N.T. Hintzen and H. Olsen

Corresponding author: nhintzen@pelagicfish.eu

24/04/2023

Abstract

At the WKGSS 2020 benchmark of Greater silver smelt in 5b and 6a, a combined and standardized CPUE series for the Faroe and EU fleets has been introduced (Quirijns and Pastoors 2020). On checking the data in preparation for WGDEEP 2023, a few errors were detected in the way CPUE was calculated, which was proposed as a correction for the assessment in WGDEEP 2023. These relate to 1. the rounding of CPUE values as the model fitted is a negative binomial (small impact) 2. the introduction of smoothers for the week and depth effect rather than fitting them as independent covariates througout 3. the introduction of a fleet effect to account for a mis-balance in data availability througout the time-series with almost an absence of PFA data in the early part of the time-series where Faroese data was availabe. Furthermore, the method applied in WGDEEP 2023 has been extended to cover the whole time series up to 2022.

It is noted that the signals in the two separate CPUE series are somewhat different in the most recent year, with a decline observed in the Faroese CPUE and an increase observed in the PFA CPUE.

1 Introduction

At the WKGSS 2020 benchmark of Greater silver smelt in 5b and 6a, a combined and standardized CPUE series for the Faroe and EU fleets has been introduced (Quirijns and Pastoors 2020).

2 Results

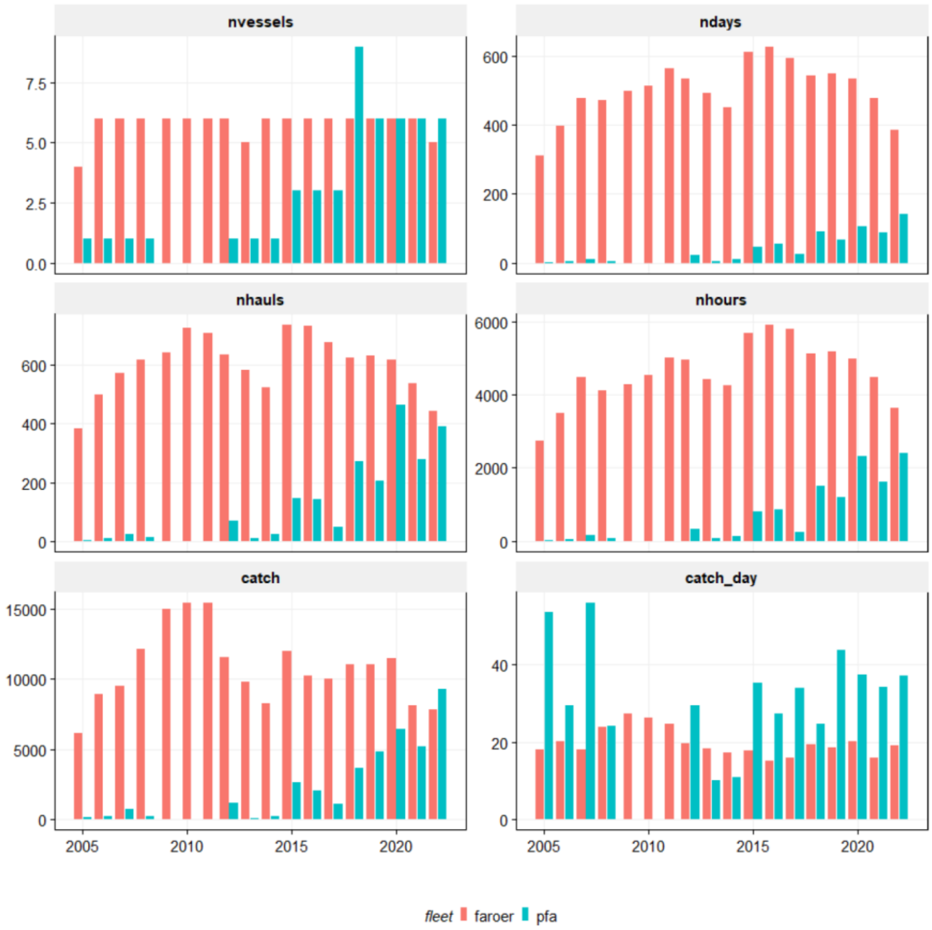


Figure 1: ARU.27.5b6a metrics describing the fisheries

The 'raw' (unstandardized) CPUE is based on the catch per day.

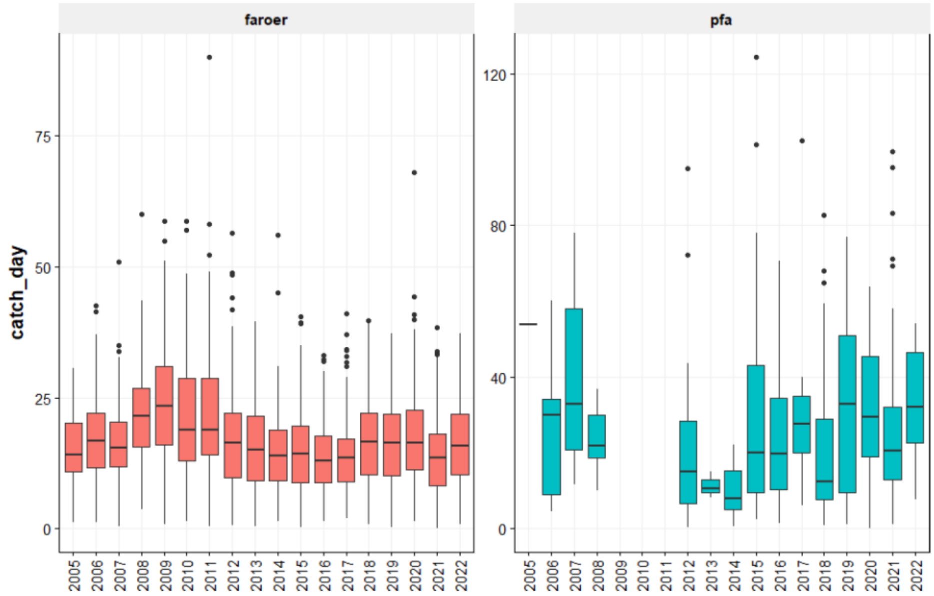


Figure 2: ARU.27.5b6a Catch per unit effort.

For the years 2005-2022, below are the spatial distributions of the used number of hauls by fleet.

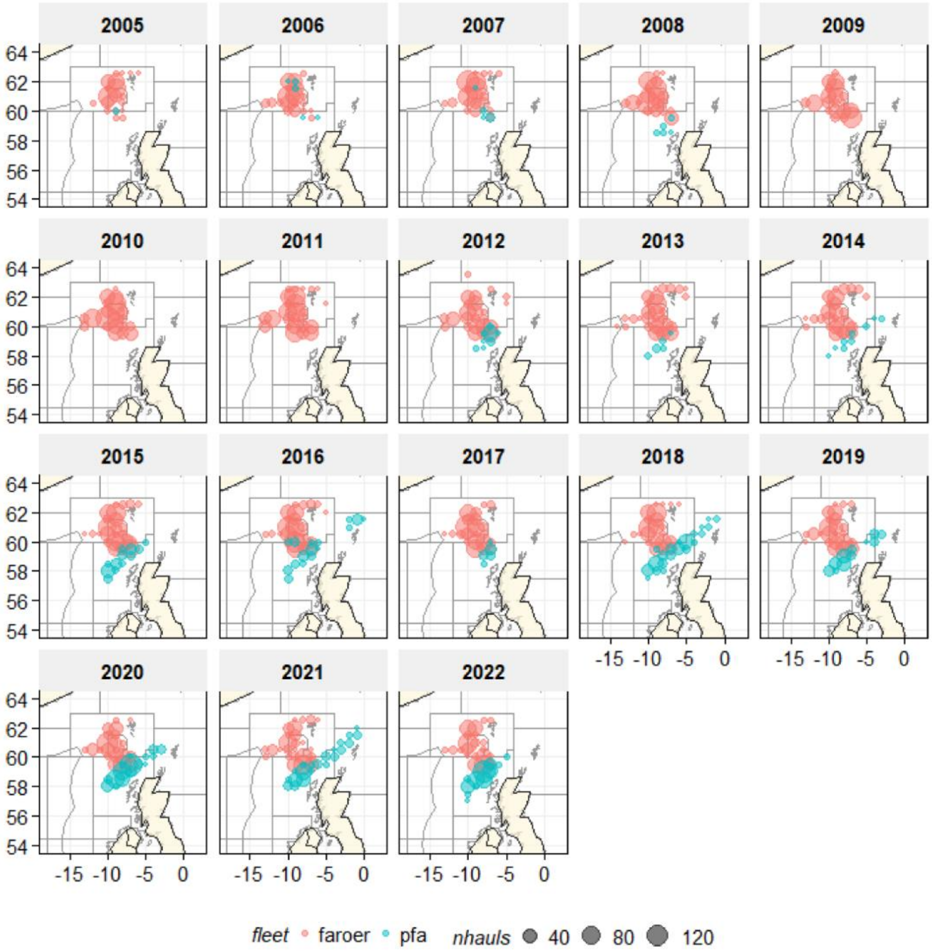


Figure 3: ARU.27.5b6a plot of the number of hauls by rectangle and day

Standardized CPUE index

We applied un updated model for standardization of of CPUE: CPUE ~ year + s(week) + s(depth) + fleet, where CPUE is expressed as catch per day and per rectangle. Catches have first been summed by vessel, year, week and rectangle and the number of hauls and fishing days have been calculated. Then the catches and effort (fishing days) have been summed over all vessels by year, week, fleet and the average depth has been calculated. CPUE was then calculated as the average catch per rectangle and per day by fleet.

The differences in modelling approach are shown below where we compare the model setup used in WGDEEP 2022 with the glm and gam approach.

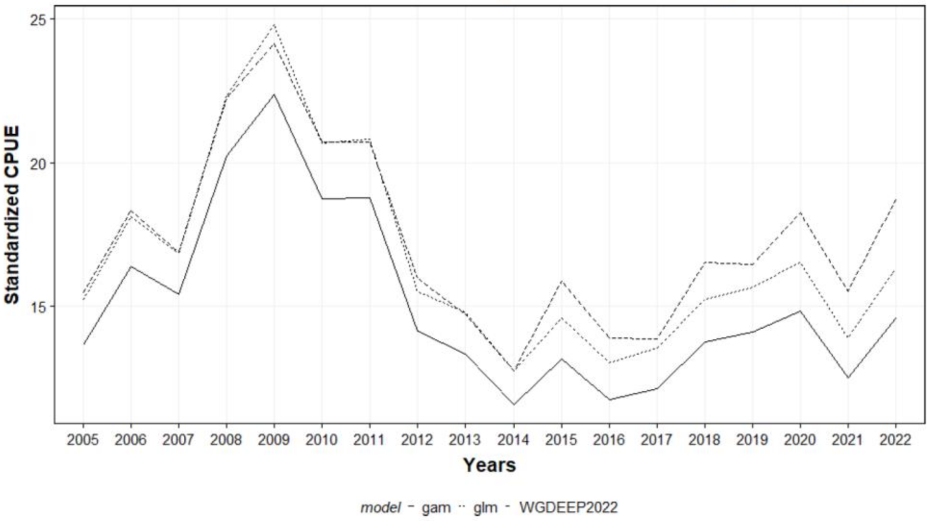


Figure 5: ARU.27.5b6a comparison of standardized CPUE between WGDEEP 2022 and updated model settings

Not only a scaling is visible, but also a change in trend from around 2015 onwards.

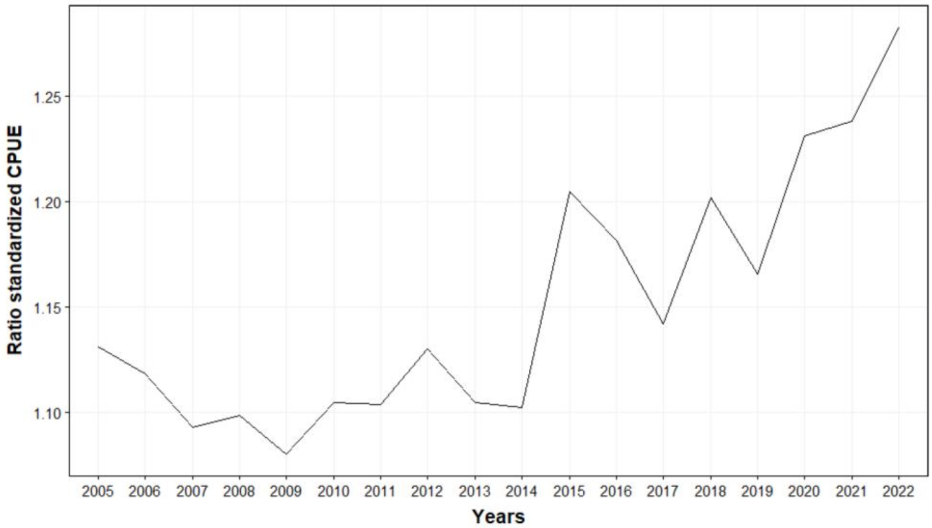


Figure 6: ARU.27.5b6a ratio between WGDEEP 2022 and updated standardized CPUE model settings

Finally, the comparison of the WGDEEP 2022 and WGDEEP 2023 time-series is presented.

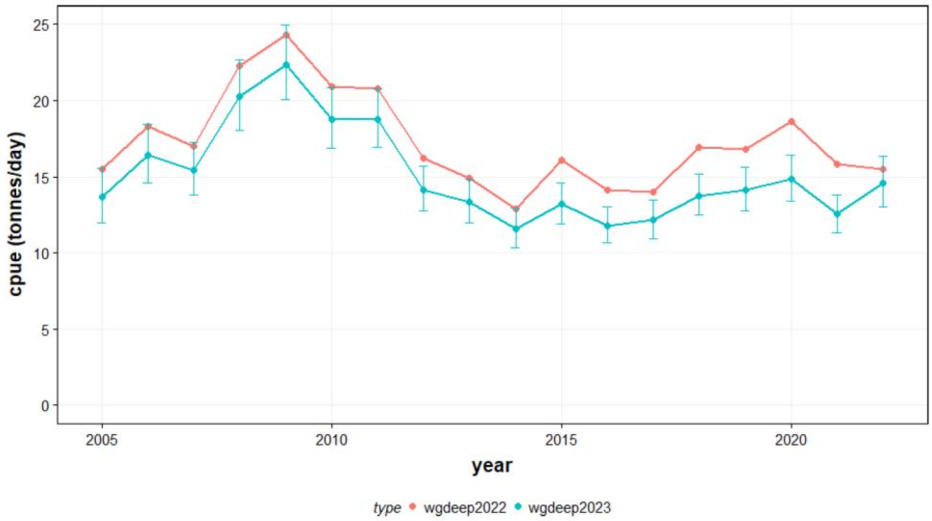
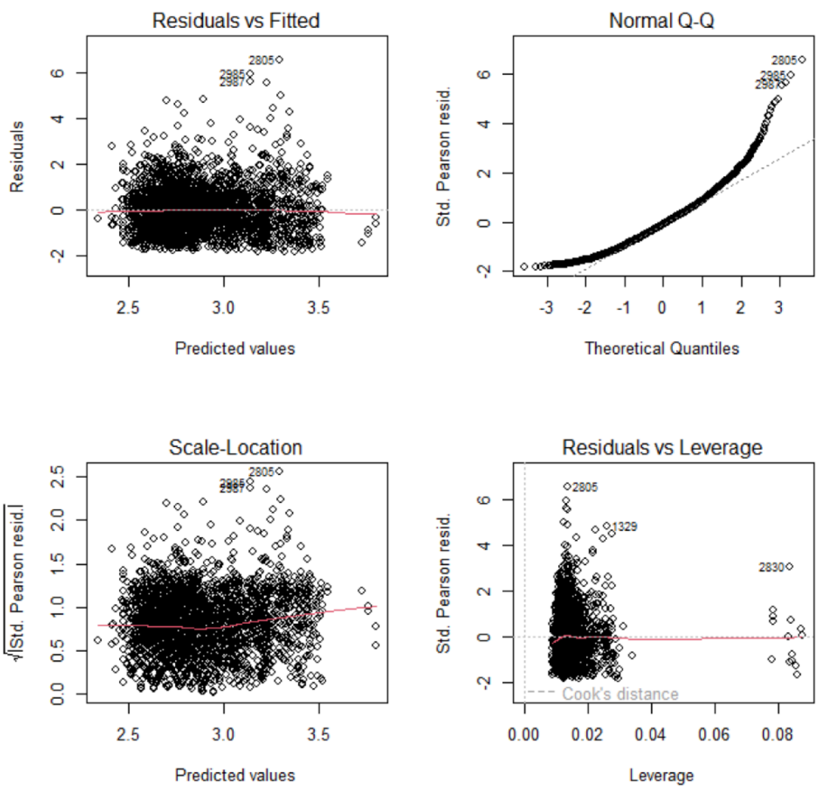


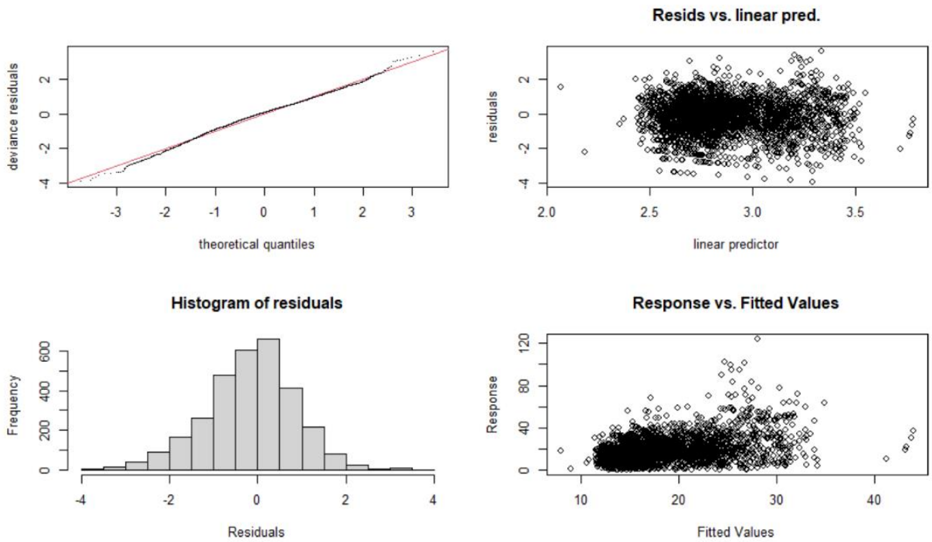
Figure 4: ARU.27.5b6a standardized CPUE (catch per rectangle and day), in comparison with WKGSS series

Model diagnostics




```
Analysis of Deviance Table

Model: Negative Binomial(3.7212), link: log

Response: get(cpuevar)

Terms added sequentially (first to last)

          Df Deviance Resid. Df Resid. Dev Pr(>Chi)
NULL                       3064     3823.0
fyear     17  201.071      3047     3621.9  < 2e-16 ***
fweek     19  160.783      3028     3461.1  < 2e-16 ***
depth_cat  6   11.277      3022     3449.8  0.08017 .
fleet      1  191.585      3021     3258.3  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Figure 7a: ARU.27.5b6a standardized CPUE GLM model diagnostics




```
Method: UBRE   Optimizer: outer newton
full convergence after 5 iterations.
Gradient range [3.912368e-11,1.592991e-10]
(score 0.0805767 & scale 1).
Hessian positive definite, eigenvalue range [0.0002822595,0.0006414133].
Model rank =  37 / 37

Basis dimension (k) checking results. Low p-value (k-index<1) may
indicate that k is too low, especially if edf is close to k'.

           k'  edf k-index p-value
s(week)  9.00 6.16    0.82  <2e-16 ***
s(depth) 9.00 3.85    0.89  <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Figure 7b: ARU.27.5b6a standardized CPUE GAM model diagnostics

Evaluation of explanatory variables

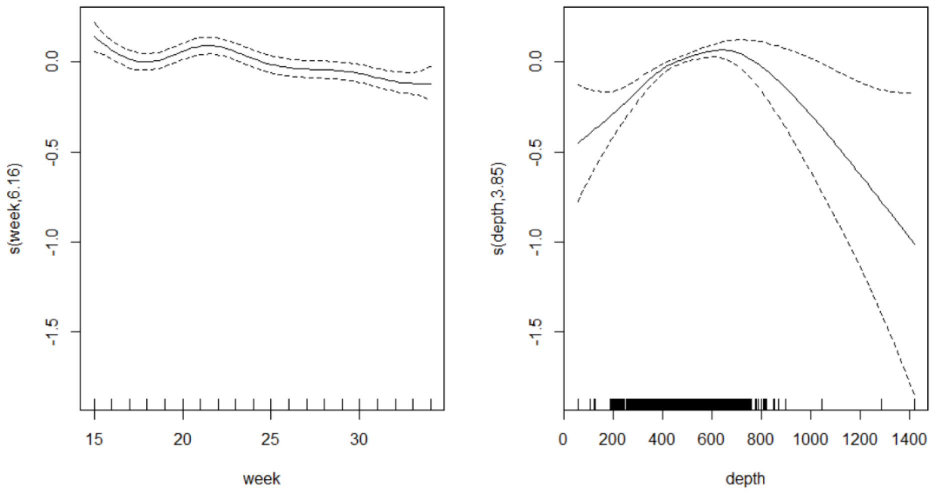


Figure 8: ARU.27.5b6a standardized CPUE explanatory variables

year	cpue	lwr	upr
2005	15.21	13.02	17.78
2006	18.13	15.67	20.97
2007	16.84	14.63	19.38
2008	22.31	19.37	25.69
2009	24.78	21.56	28.48
2010	20.69	18.06	23.72
2011	20.81	18.22	23.77
2012	15.53	13.61	17.73
2013	14.78	12.92	16.92
2014	12.76	11.1	14.66
2015	14.59	12.81	16.62
2016	13.04	11.46	14.84
2017	13.56	11.87	15.49
2018	15.23	13.38	17.34
2019	15.66	13.75	17.84
2020	16.52	14.48	18.85
2021	13.91	12.21	15.84
2022	16.33	14.19	18.79

Table 1: ARU.27.5b6a standardized (GLM) commercial CPUE (tonnes/day) for greater silversmelt, with lower and upper values based on the standard error.

year	cpue	lwr	upr
2005	13.66	11.97	15.59
2006	16.39	14.57	18.43
2007	15.43	13.79	17.25
2008	20.23	18.07	22.65
2009	22.36	20.05	24.94
2010	18.75	16.85	20.87
2011	18.76	16.92	20.79
2012	14.14	12.75	15.68
2013	13.33	11.97	14.84
2014	11.57	10.34	12.94
2015	13.18	11.91	14.58
2016	11.77	10.66	12.99
2017	12.14	10.95	13.46
2018	13.75	12.48	15.15
2019	14.12	12.77	15.61
2020	14.84	13.4	16.43
2021	12.53	11.35	13.83
2022	14.58	13.01	16.33

Table 2: ARU.27.5b6a standardized (GAM) commercial CPUE (tonnes/day) for greater silversmelt, with lower and upper values based on the standard error.

Single fleet analysis

A single fleet analysis was carried out by using the combined raw CPUE datasets and extracting the separate parts for the Faroese and PFA fleets. These data were then processed in a similar fashion as in the combined analysis. It is clear that the Faroese data is substantially more precise that the data from PFA as evident from the confidence intervals. This is likely due to the number of observations, where the dataset from Faroe Islands over all years is based on 10 times the number of hauls compared to the PFA data. In addition, the Faroese fishery is a targeted fishery for silver smelt, while the PFA fishery is a mixed fishery with blue whiting in the daytime and silver smelt in the nighttime.

It is noted that the signals in the two separate CPUE series are somewhat different in the most recent year, with a decline observed in the Faroese CPUE and an increase observed in the PFA CPUE.

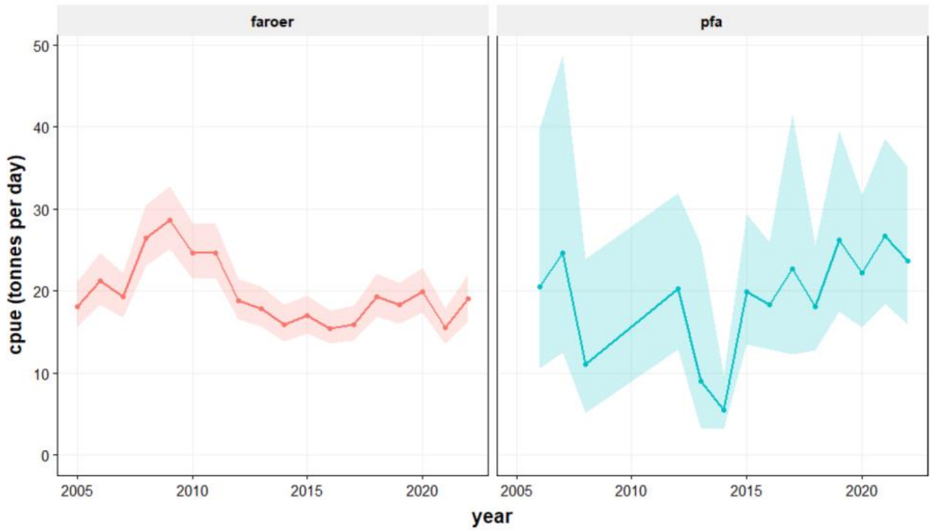


Figure 9: ARU.27.5b6a standardized single fleet CPUE (catch per rectangle and day)

3 Discussion

CPUE standardization using GAM procedures is a common way of dealing with CPUE information. Here we used aggregated data (catch per day) as the main response variable and year, week, depth and fleet as explanatory variables. Both area and period cannot use attributes that are related to the hauls. The standardized CPUE for WGDEEP 2023 shows a marked departure from WGDEEP 2022 time-series owing to the changes in the methodology described above.

Both data sources (Faroese data and PFA data) indicate an increase in CPUE in the last year again after a dip in 2021, although it does not reach the level seen in the late 2000s. The data from the Faroese fisheries are generated from a targetted fishery on silver smelt, while the data from the PFA is from a mixed fishery with blue whiting (blue whiting in the daytime, silver smelt in the nighttime). This probably leads to the higher uncertainties in the CPUE estimates for the PFA compared to the Faroese fleet. It is also noted that the number of observations in the PFA fisheries prior to 2015 is much lower than after 2015, because the self-sampling program only started in 2015.

It is noted that the signals in the two separate CPUE series are somewhat different in the most recent year, with an increase observed in the Faroese CPUE and a decrease observed in the PFA CPUE.

4 References

ICES (2020). Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES Scientific Reports. Volume 2, Issue 38: 928 pp.

Pastoors, M. A. and F. J. Quirijns (2020). Correcting an error in the CPUE Standardizing of Greater silversmelt for WGDEEP 2020, WD05.

Quirijns, F. J. and M. A. Pastoors (2020). CPUE standardization for greater silversmelt in 5b6a. WKGSS 2020, WD03.

PFA self-sampling report for WGDEEP 2023 (v1)

Niels Hintzen, 30/03/2023 22:24:52

Summary

This report summarizes the self-sampling data collected by the Pelagic Freezer-trawler Association (PFA) with a focus on Argentines or Silversmelts. The self-sampling data consists of two main sources: (1) the historical catch per haul data derived from a limited number private logbooks of skippers, and (2) the self-sampling program that has been initiated from 2015 onwards on an increasing number of freezer-trawlers.

The PFA fishery for argentines takes place in the months April and May, and sometimes into June. The predominant fishing area is ICES division 27.6.a with also some catches being taken in 2.a, 4.a and 5.b. The fishery is combined with the fishery for blue whiting, whereby the catches of blue whiting take place during the day and catch of argentines mostly in the night.

Overall, the self-sampling activities for the argentines fisheries during the years 2016 – 2023 covered 42 fishing trips with 1254 hauls, a total catch of 78562 tonnes and 67255 individual length measurements.

The length compositions of argentines are relatively stable over the years, varying between medians of 34 to 36 cm.

1 Introduction

The Pelagic Freezer-trawler Association (PFA) is an association that has nine member companies that together operate 19 freezer trawlers (in 2023) in six European countries (www.pelagicfish.eu). In 2015, the PFA has initiated a self-sampling program that expands the ongoing monitoring programs on board of pelagic freezer-trawlers by the specialized crew of the vessels. The primary objective of that monitoring program is to assess the quality of fish. The expansion in the self-sampling program consists of recording of haul information, recording the species compositions per haul and regularly taking random length-samples from the catch. The self-sampling is carried out by the vessel quality managers on board of the vessels, who have a long experience in assessing the quality of fish, and by the skippers/officers with respect to the haul information. The scientific coordination of the self-sampling program is carried out by Niels Hintzen (PFA chief science officer) with support of Lina de Nijs (PFA) and Floor Quirijns (contractor).

2 Overview of self-sampling methodology

The PFA self-sampling program has been incrementally implemented on freezer-trawler vessels from the Netherlands, UK, Germany, France, Poland and Lithuania during the years 2015-2017. From 2018 onwards, all vessels in the association are covered by the self-sampling program. The program is designed in such a way that it follows as closely as possible the working practices on board of the different vessels and that it delivers the biological and fisheries information needed for the relevant scientific bodies (e.g. ICES, SPRFMO, CECAF), certification bodies (e.g. MSC) and as a mechanism of feedback for the participating companies.

The following main elements can be distinguished in the self-sampling protocol:

- haul information (date, time, position, weather conditions, environmental conditions, gear attributed, estimated catch, optionally: species composition)
- batch information (total catch per batch=production unit, including variables like species, average size, average weight, fat content, gonads y/n and stomach fill)
- linking batch and haul information (essentially a key of how much of a batch is caught in which of the hauls)
- length information (length frequency measurements, either by batch or by haul)
- biological information (measuring individual fish)

The self-sampling information was initially collected using standardized Excel worksheets. From 2018 onwards a transition is being made from Excel spreadsheet to dedicated data-recording software (M-Catch) with live synchronization to a shore-based system. The information collected during a trip will be sent for data processing by the end of the trip. The self-sampling data is being checked and added to the database by Floor Quirijns and/or Martin Pastoors, who also generate standardized trip reports (using RMarkdown) which are being sent back to the vessel and company. The compiled data for all vessels is being used for specific purposes, e.g. reporting to expert groups, addressing specific fishery or biological questions and supporting detailed biological studies. The PFA publishes an annual report on the self-sampling program.

For this report, the PFA self-sampling data has been filtered for vessel-trip-week combinations using the following criteria:

- hauls in divisions 27.6.a; 27.5.b; 27.4.a
- catch of arg by trip and week at least 10% of the total catch of that trip and week.
- catch of arg by trip and week at least 10 tonnes.

The selection resulted in 99 vessel-trip-week combinations over the years 2016-2022.

A particular challenge in the PFA self-sampling program is dealing with the different length metrics in use. Routinely, on freezer-trawlers, fish will be measured in standard length (SL, until the onset of the tail of the fish). However, for scientific purposes, length is required mostly in total length (TL), or, in the case of the South Pacific RFMO, in fork length (FL). The PFA self-sampling program aims to utilize the appropriate scientific length metric: TL in Europe and Africa, FL in the South Pacific. However, in some instances, the quality managers on board of the vessels have used the wrong length metric for the area they were fishing in. Until 2021, these situations were 'corrected' by applying a direct length-to-length conversion based on data from individual measurements of SL, FL and TL. It was recognized that this approach could lead to holes in the length distributions.

In 2022 a new method of converting length-to-length was implemented, based on the paper by Hansen et al (2018). The method consists of generating simulated length-length-keys similar to the often used age-length-keys. The implementation of the new method means to some differences may exist in length data compared to previous reports.

3 Results

3.1 General

An overview of all the self-sampled trips for arg in 27.6.a, 27.5.b, 27.4.a. The percentage non-target species is defined as the catch of non-pelagic species relative to the catch of pelagic species.

year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nontarget	nlength	nbio
2016	2	2	30	65	3,980	133	3.28%	5,478	0
2017	3	3	33	90	7,464	226	1.23%	6,150	0
2018	7	7	67	172	8,426	126	1.79%	10,931	509
2019	6	7	48	118	10,792	225	0.06%	7,450	7
2020	7	9	104	288	15,342	148	0.53%	14,258	131
2021	5	6	59	139	10,704	181	0.74%	6,607	102
2022	6	8	148	382	21,855	148	1.58%	16,381	16
(all)		42	489	1,254	78,563			67,256	765

Table 3.1.1: PFA deepwater fisheries for argentines. Self-sampling Summary of number of vessels, trips, days, hauls, catch (tonnes), catch per day(tonnes/day), percentage non-target species, number of fish measured and number of biological samples

Catch and number of self-sampled hauls by year and division

division	2016	2017	2018	2019	2020	2021	2022	all	perc
27.6.a	3,980	7,464	8,426	10,792	15,342	10,704	21,855	78,563	100.0%
(all)	3,980	7,464	8,426	10,792	15,342	10,704	21,855	78,563	100.0%

division	2016	2017	2018	2019	2020	2021	2022	all	perc
27.6.a	65	90	172	118	288	139	382	1,254	100.0%
(all)	65	90	172	118	288	139	382	1,254	100.0%

*Table 3.1.2: PFA deepwater fisheries for argentines. Self-sampling Summary of catch (top) and number of hauls (bottom) per year and division. * denotes incomplete year*

Catch and number of self-sampled hauls by year and month

month	2016	2017	2018	2019	2020	2021	2022	all	perc
Apr	0	596	2,316	3,557	9,600	3,669	14,048	33,786	43.0%
May	3,033	6,868	6,110	7,234	4,522	7,035	7,807	42,610	54.2%
Jun	946	0	0	0	1,146	0	0	2,092	2.7%
Oct	0	0	0	0	75	0	0	75	0.1%
(all)	3,980	7,464	8,426	10,792	15,342	10,704	21,855	78,563	100.0%

month	2016	2017	2018	2019	2020	2021	2022	all	perc
Apr	0	4	50	33	143	39	247	516	41.1%
May	54	86	122	85	119	100	135	701	55.9%
Jun	11	0	0	0	19	0	0	30	2.4%
Oct	0	0	0	0	7	0	0	7	0.6%
(all)	65	90	172	118	288	139	382	1,254	100.0%

Table 3.1.3: PFA deepwater fisheries for argentines. Self-sampling summary of catch (top) and number of hauls (bottom) per year and month.

Catch and number of self-sampled hauls by year and country (flag)

flag	2016	2017	2018	2019	2020	2021	2022	all	perc
DEU	1,832	0	2,054	3,617	2,711	1,095	1,350	12,659	16.1%
LIT	0	0	0	0	75	0	0	75	0.1%
NL	2,148	7,464	6,372	7,175	12,556	9,610	20,504	65,830	83.8%
(all)	3,980	7,464	8,426	10,792	15,342	10,704	21,855	78,563	100.0%

flag	2016	2017	2018	2019	2020	2021	2022	all	perc
DEU	27	0	59	46	74	27	44	277	22.1%
LIT	0	0	0	0	7	0	0	7	0.6%
NL	38	90	113	72	207	112	338	970	77.4%
(all)	65	90	172	118	288	139	382	1,254	100.0%

Table 3.1.4: PFA deepwater fisheries for argentines. Self-sampling summary of catch (top) and number of hauls (bottom) per year and month.

Catch by species and year

species	english_name	scientific_name	2016	2017	2018	2019	2020	2021	2022	all	perc
whb	blue whiting	Micromesistius poutassou	2,234	5,030	5,082	6,792	9,116	6,093	11,963	46,310	58.9%
arg	argentines	Argentina spp	1,580	2,248	3,013	3,899	5,946	4,398	9,416	30,501	38.8%
mac	mackerel	Scomber scombrus	15	94	179	95	199	132	131	846	1.1%
hke	hake	Merluccius merluccius	113	89	125	3	39	50	277	696	0.9%
sqr	squid	Loligo vulgaris	0	0	4	0	15	5	47	72	0.1%
mcd	NA	Ceratoscopelus maderensis	0	0	0	0	11	18	2	31	0.0%
hom	horse mackerel	Trachurus trachurus	19	0	1	0	0	1	0	21	0.0%
sqm	Broadtail shortfin squid	Illex coindetii	0	0	0	0	0	4	15	19	0.0%
mzz	other fish	Osteichthyes	0	0	19	0	0	0	0	19	0.0%
boc	boarfish	Capros aper	18	0	0	0	0	0	0	18	0.0%
squ	various squids nei	Loliginidae, Ommastrephidae	0	0	0	3	14	0	0	17	0.0%
pok	saithe	Pollachius virens	0	3	2	0	0	3	0	7	0.0%
gfb	NA	Phycis blennoides	0	0	0	0	1	0	3	4	0.0%
brf	NA	Helicolenus dactylopterus	0	0	0	0	0	0	0	1	0.0%
usk	Tusk	Brosme brosme	0	0	0	0	0	0	0	0	0.0%
oth	NA	NA	0	0	0	0	0	0	0	0	0.0%
(all)	(all)	(all)	3,980	7,464	8,426	10,792	15,342	10,704	21,855	78,563	100.0%

Table 3.1.5: PFA deepwater fisheries for argentines. Self-sampling Summary of total catch (tonnes) by species. OTH refers to all other species that are not the main target species

Haul positions

An overview of all self-sampled hauls in the PFA deepwater fisheries for argentines..

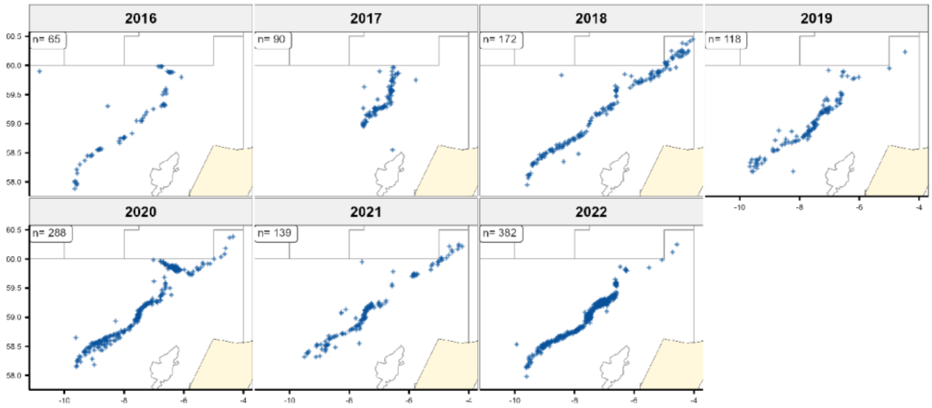


Figure 3.1.1: PFA deepwater fisheries for argentines. Self-sampling haul positions. N indicates the number of hauls.

Catches for the main target species

Summed catches (tonnes) of the main target species aggregated in rectangles.

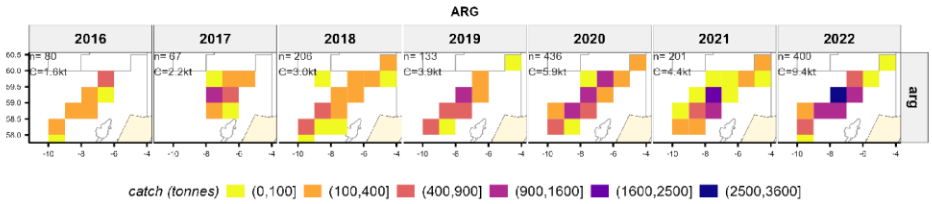


Figure 3.1.2: PFA deepwater fisheries for argentines. Self-sampling catch per species and per rectangle. N indicates the number of hauls. Catch refers to the total catch per year.

Catch rates (catch/day) for the main target species

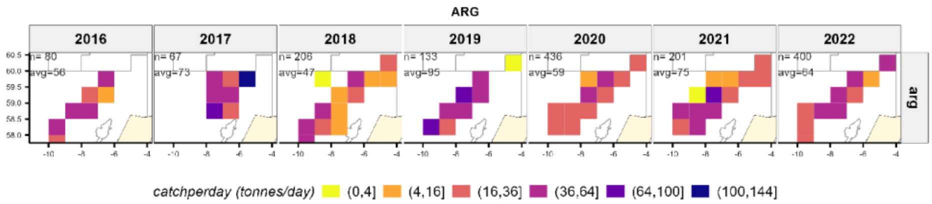


Figure 3.1.3: Average catch per day, per species and per rectangle. N indicates the number of hauls; avg refers to the average catch per day.

Average surface temperature by quarter and by rectangle.

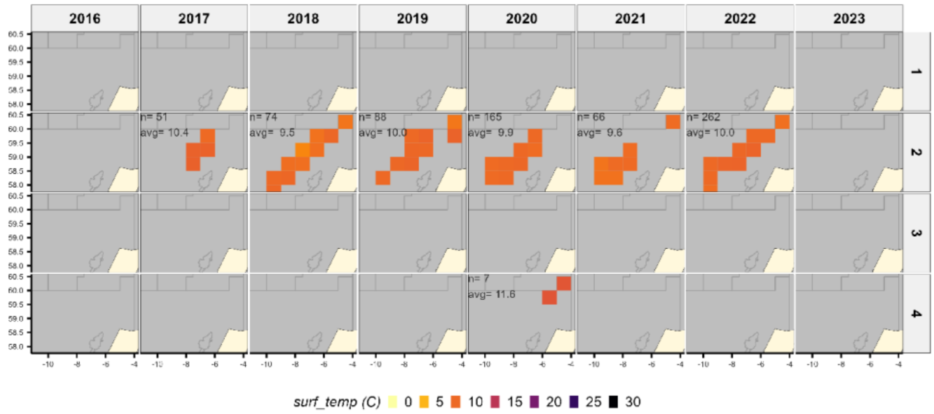


Figure 3.1.4: PFA deepwater fisheries for argentines. Average surface temperature (C) by year and quarter. N indicates the number of hauls. Avg refers to the average temperature.

Average fishing depth.

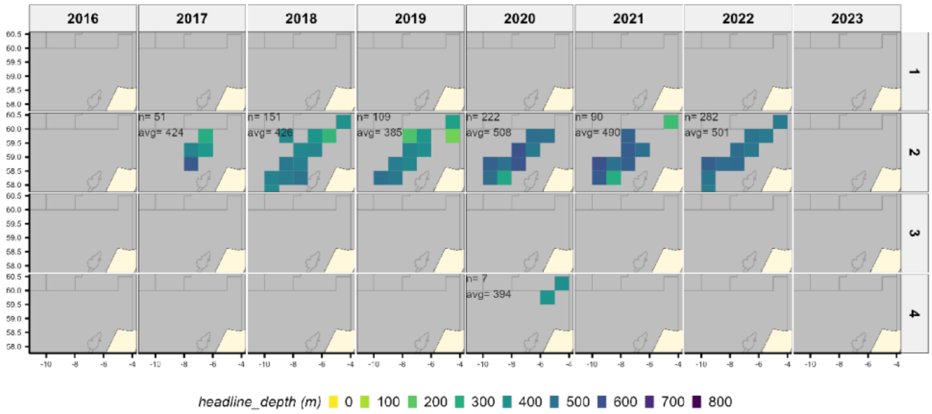


Figure 3.1.5: PFA deepwater fisheries for argentines. Average fishing depth (m) by year and quarter. N indicates the number of hauls. Avg refers to the average fishing depth.

Average wind force.

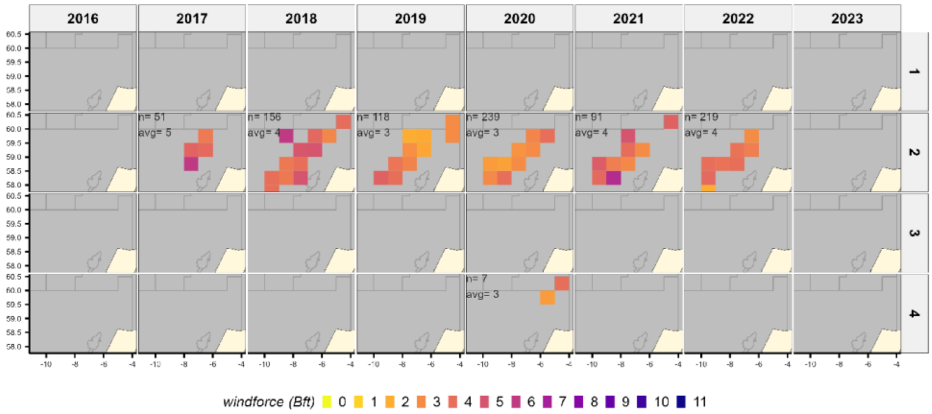


Figure 3.1.6: PFA deepwater fisheries for argentines. Average windforce (Bft) by year and quarter. N indicates the number of hauls. Avg refers to the average windforce.

3.2 Argentines (ARG, Argentinus sp.)

Argentines self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
arg	2016	2	2	28	57	1,580	56	1,063	0
arg	2017	3	3	31	67	2,248	73	668	0
arg	2018	7	7	64	161	3,013	47	968	459
arg	2019	6	7	41	94	3,899	95	3,039	0
arg	2020	7	9	101	273	5,946	59	3,980	32
arg	2021	5	6	59	136	4,398	75	3,099	0
arg	2022	6	8	146	366	9,416	64	6,231	0
(all)	(all)		42	470	1,154	30,501		19,048	491

Table 3.2.1: Argentines. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Argentines. Catch by division

species	division	2016	2017	2018	2019	2020	2021	2022	all	perc
arg	27.6.a	1,580	2,248	3,013	3,899	5,946	4,398	9,416	30,501	100.0%
(all)	(all)	1,580	2,248	3,013	3,899	5,946	4,398	9,416	30,501	100.0%

Table 3.2.2: Argentines. Self-sampling summary with the catch (tonnes) by year and division

Argentines. Catch by month

species	month	2016	2017	2018	2019	2020	2021	2022	all	perc
arg	Apr	0	38	811	720	3,201	1,289	5,739	11,799	38.7%
arg	May	1,333	2,210	2,202	3,179	2,276	3,110	3,677	17,986	59.0%
arg	Jun	248	0	0	0	452	0	0	700	2.3%
arg	Oct	0	0	0	0	16	0	0	16	0.1%
(all)	(all)	1,580	2,248	3,013	3,899	5,946	4,398	9,416	30,501	100.0%

Table 3.2.3: Argentines. Self-sampling summary with the catch (tonnes) by year and month

Argentines. Catch by rectangle

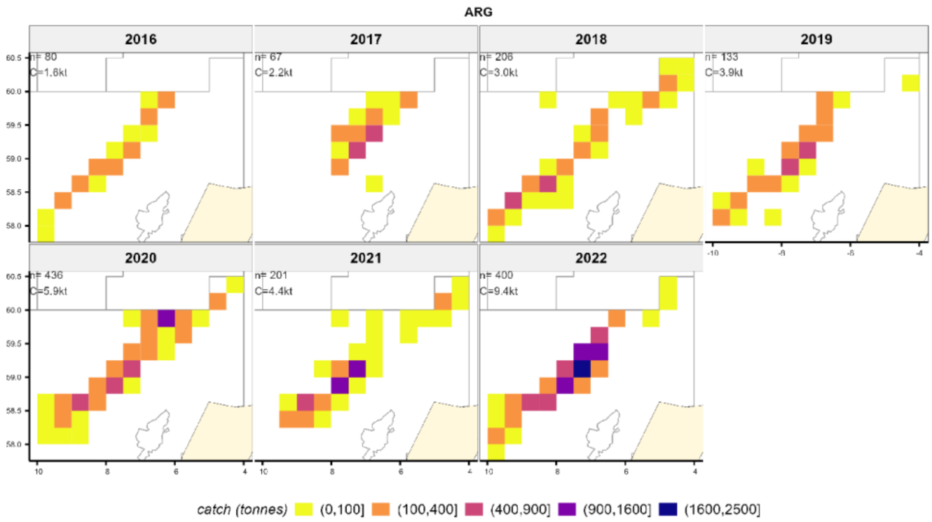


Figure 3.2.1: Argentines. Catch per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Argentines. Catchrate (ton/day) by rectangle

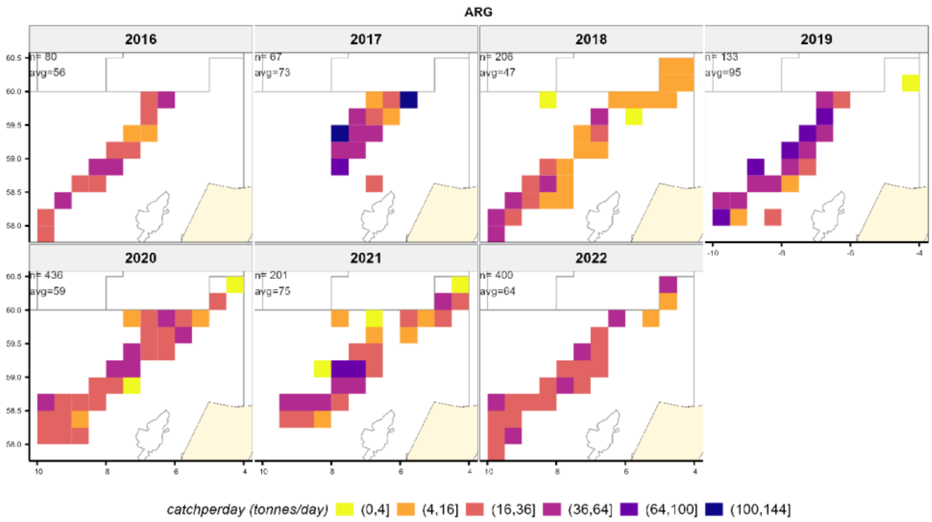


Figure 3.2.2: Argentines. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Argentines. Spatio-temporal evolution of catch by month and rectangle

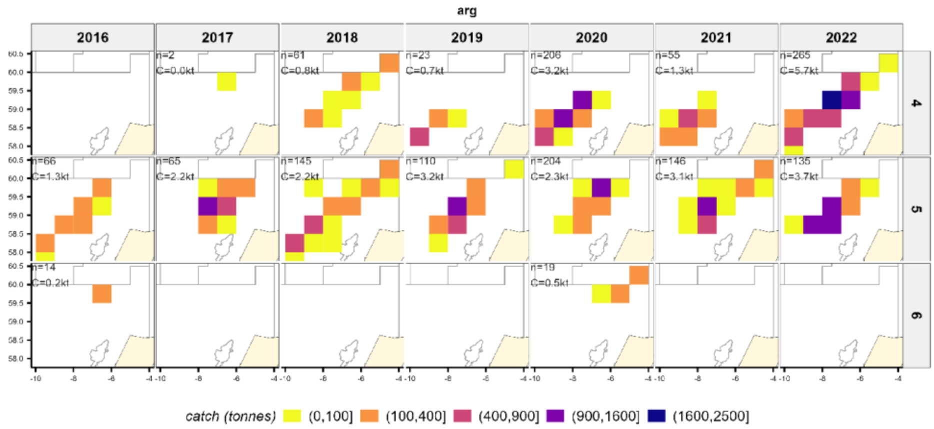


Figure 3.2.3: Argentines. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Argentines. Catch proportion at depth

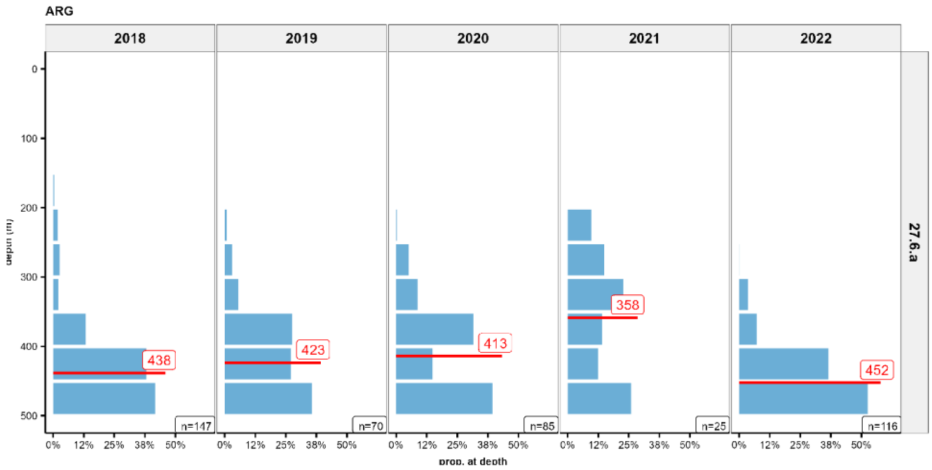


Figure 3.2.4: Argentines. Catch proportion at depth. N indicates the number of hauls.

Argentines. Length distributions of the catch

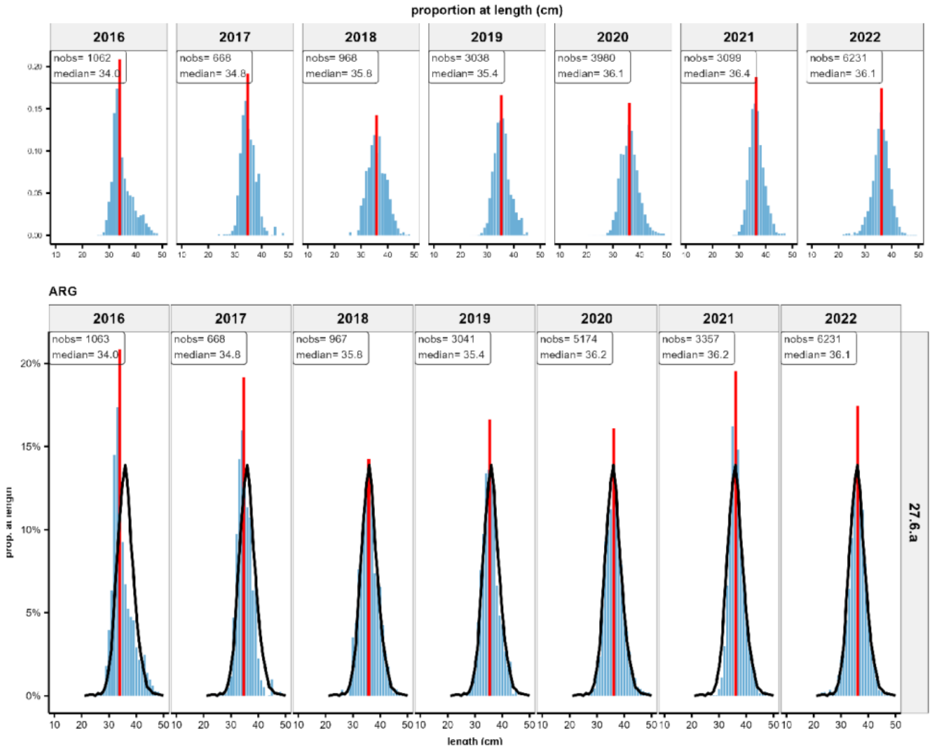


Figure 3.2.5: Argentines. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Argentines. Length distributions as proportions by (large) rectangle

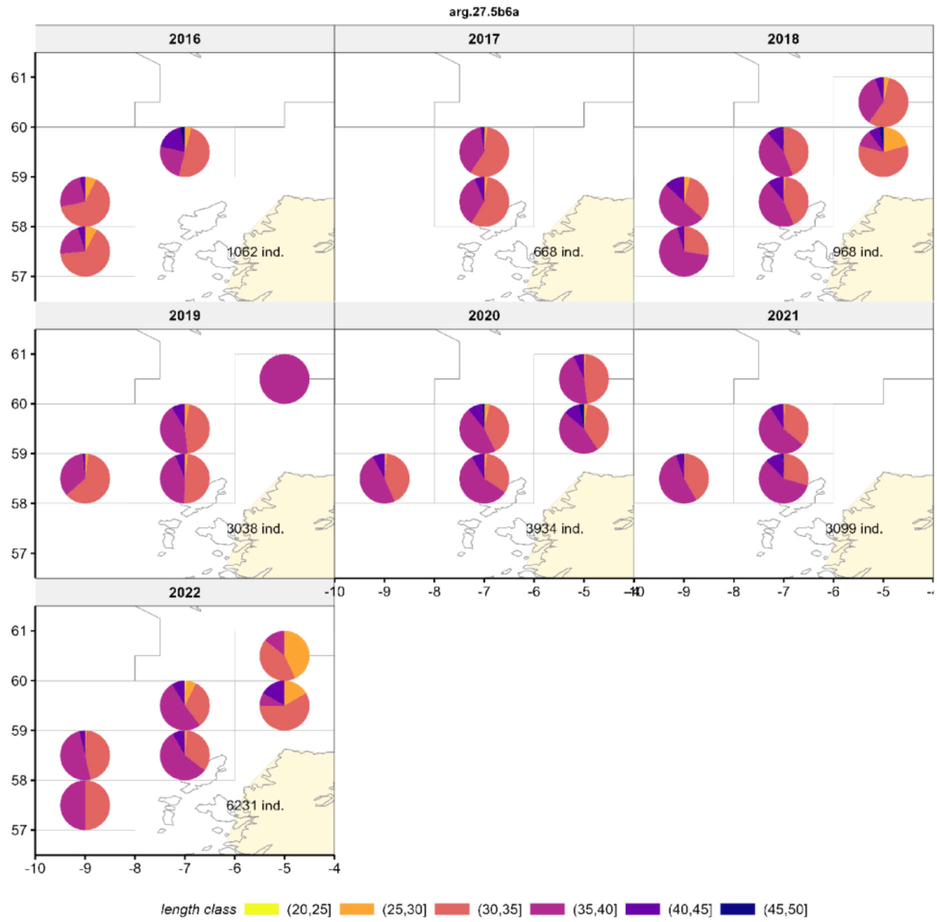


Figure 3.2.6: Argentines. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Argentines. Average length, weight and fat content by year and month

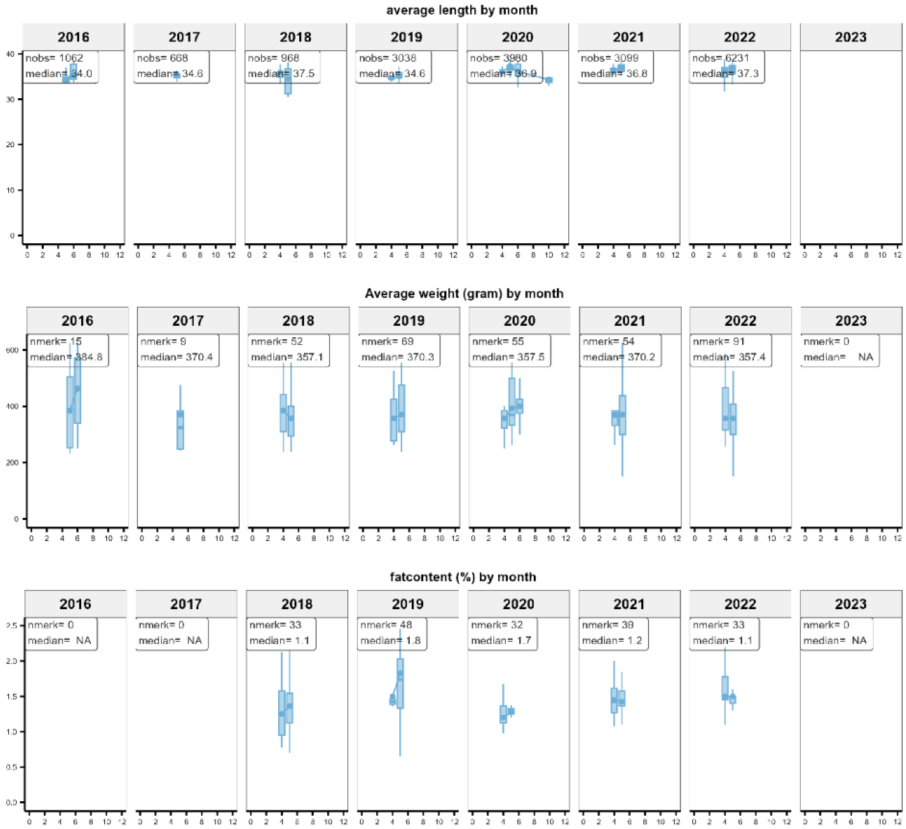


Figure 3.2.7: Argentines. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

4 Discussion and conclusions

From 2018 onwards, all PFA vessels were participating in the PFA self-sampling program.

The definition of what constitutes 'a fishery' for a certain species is not straightforward to resolve. In this report we selected all vessel-trip-week combinations with:

- hauls in divisions 27.6.a; 27.5.b; 27.4.a
- catch of arg by trip and week at least 10% of the total catch of that trip and week.
- catch of arg by trip and week at least 10 tonnes.

Since 2020, the measurements of average weight and fat content are included in the self-sampling report. Weights and fat content are routinely being collected for some of the target species (e.g. herring, mackerel) on the basis of production units (batches). The measurements are being carried out both when the species is the main target of the fishery and when it is a bycatch in other fisheries.

5 Acknowledgements

The skippers, officers and the quality managers of many of the PFA vessels are putting in a lot of effort to make the PFA the self-sampling work. Without their efforts, there would be no self-sampling.

6 References and publications

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7 More information

Please contact Niels Hintzen (nhintzen@pelagicfish.eu) if you would have any questions on the PFA self-sampling program or the specific results presented here.

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Survey results of roughhead grenadier, roundnose grenadier, greater argentine, tusk, blue ling, black scabbard fish, ling, and orange roughy in ICES division 14b in the period 1998-2016 and 2022.

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Abstract

A stratified bottom trawl survey in East Greenland (ICES 14.b) has been conducted by the Greenland Institute of Natural Resources (GINR) from 1998 to 2016 (no survey was conducted in 2001), at depths between 400 to 1500 m with R/V Paamiut, using an Alfredo II bottom trawl gear. In 2017, R/V Paamiut was retired and in 2022 the survey was conducted with a new vessel owned by the GINR, R/V Tarajoq using also a new trawl gear, Bacalao 476. There was unfortunately not any comparative trawling between the old vessel R/V Paamiut and R/V Tarajoq. Survey results include biomass and abundance estimates and length frequency distributions, which are presented for roughhead grenadier (*Macrourus berglax*), roundnose grenadier (*Coryphaenoides rupestris*), greater argentine (*Argentina silus*), tusk (*Brosme brosme*), blue ling (*Molva dypterygia*), black scabbardfish (*Aphanopus carbo*), ling (*Molva molva*), and orange roughy (*Hoplostethus atlanticus*). Only roughhead grenadier and roundnose grenadier from ICES division 14.b have previously been reported to NWWG (Nogueira et al. 2023). This document contains the available information on the species mentioned above, in ICES division 14.b from scientific surveys from 1998 to 2016, and from 2022.

1. Introduction

During the period 1987-1989 the Japan Marine Fishery Resources Research Centre (JAMARC) and the Greenland Institute of Natural Resources (GINR) jointly conducted 3 bottom trawl surveys at East Greenland as part of a joint venture agreement on fisheries development and fisheries research in Greenland waters (Jørgensen and Akimoto 1990; Yatsu and Jørgensen 1988abc; Yatsu and Jørgensen 1989). The surveys were primarily aimed at Greenland halibut (*Reinhardtius hippoglossoides*) and redfish (*Sebastes* spp.) and covered various areas between Cape Farewell and 72°N at depths down to 1500 m. During the period 1989-1996 the GINR conducted annual shrimp trawl surveys with R/V Paamiut off East Greenland (Anon. 1997), but the surveys only covered depths down to 600 m with a poor coverage of depths > 400 m. In 1998, GINR initiated a bottom trawl surveys series with R/V Paamiut, which has been rigged for deep sea trawling. The survey has been carried out between 1998 and 2016 (except in 2001), and in 2017 R/V Paamiut was retired. A new survey was conducted in 2022, with the new R/V Tarajoq, owned by the GINR, using a new gear. There has unfortunately not been any comparative trawling between the Japanese R/V Shinkai Maru and R/V Paamiut, and between R/V Paamiut and R/V Tarajoq making comparisons between the surveys difficult, and there is very little overlap in the depth range between the shrimp trawl survey and the present survey. There was no survey off East Greenland in 2001. The vessel (R/V Paamiut) used for the surveys from 1998-2016 was retired in 2018 before paired trawling experiments with a replacement vessel could be conducted. In 2022, the new vessel owned by GINR, R/V Tarajoq with a Bacalao 476 trawl began a new survey series.

2. Materials and methods

The Greenland halibut surveys in East Greenland (ICES 14.b) were initiated in 1998. Until 2008, the survey was conducted in June, and had in almost all years suffered under the ice coverage found at the east coast of Greenland during early summer. Therefore, from 2008 and onwards surveys have taken place in August/September without ice induced problems. Also, in 2008 the survey was combined with a new shrimp/fish survey using a different trawl gear at more shallow waters than the Greenland halibut survey. The combination of the two surveys led to a change in trawling hours so that most of the stations since 2008 were taken during night-time. In 2022 the Greenland halibut survey was conducted between September 23 and October 7.

Stratification

The survey was planned to cover ICES Division 14.b from between the 3-nm line and the 200-nm line or the midline to Iceland at depths from 400 to 1500 m. The survey area was stratified in 5 Subareas Q1-Q5 (Table 1). Area Q1 consists of one depth stratum 401-600 m on Dohrn Bank in the northern part of the survey area. Area Q2 is the shelf area in the northern part of the survey area and is sub-divided in the depth strata 401-600, 601-800, 801-1000 and 1001-1500 m. Area Q3 is a large area with depths generally below 800 m. The stratification in the area has not been changed: 401-600, 601-800 and 801-1000 m. The slope, >1000 m, has not been covered due to steep and rough bottom. Area Q4 is not covered due to steep and rough bottom. Area Q5 is sub-divided in the depth strata 401-600, 601-800, 801-1200, 1201-1400 and 1401-1500 m. One area, Q6, off Southeast Greenland has been included in previous survey plans, but it has never been possible to make any hauls in the area due to ice and rough bottom. Therefore, Q6 has been excluded from the survey area since 2004. Survey areas of all Q-areas are presented in Table 1. In 2022, the Stratified Random Bottom Trawl Survey has been changed to a fix station allocation design due to many stations being moved and problems finding suitable fishing grounds because of rough sea bed.

Sampling design

From 1998 to 2016, the survey was planned as a Stratified Random Bottom Trawl Survey with a total of 70 hauls, which gives an overall coverage on 527 km^2 per haul. Each stratum was allocated at least two hauls. The remaining hauls were allocated in order to minimize the variance in the estimation of the biomass of Greenland halibut; *i.e.* strata with great variation in the catches of Greenland halibut in the previous year's surveys were assigned relatively more hauls than strata with little variation in the catches.

In 2004 a new method of choosing stations was introduced. The method combines the use of a minimum between-stations-distance rule (buffer zone) with a random allocation scheme (Kingsley et al. 2004). In Q5 depth stratum 801-1200 m had only 7 positions suitable for trawling. The positions of the 3 hauls allocated to this stratum were chosen at random between the 7 trawlable positions.

In 2022, the Stratified Random Bottom Trawl Survey has been changed to a fix station allocation design due to many stations being moved and problems finding suitable fishing grounds because of rough sea bed.

Vessel and gear and handling of the catch

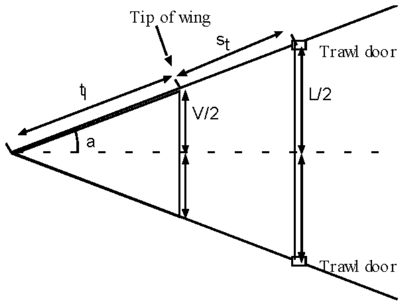
From 1998 to 2017, the survey was conducted by the 1084 GT trawler Paamiut, using an Alfredo III trawl with a mesh size on 140 mm and a 30-mm mesh-liner in the cod-end. The ground gear was of the rock hopper type. The trawl doors were changed to "Injector" type doors weighing 2700 kg in 2004, but this has not affected the performance of the trawl. Figures of rigging and bobbins chain together with further information about the gear is given in Jørgensen (1998). A Furuno net sonde mounted on the head rope measured net height. Scanmar sensors measured the distance between the trawl doors. In 2022, R/V Tarajoq (2896 GT) began a new survey series using a Bacalao 476 trawl with a mesh size of 136 mm and a 30-mm mesh-liner in the cod-end (Table 2). The same doors as on R/V Paamiut are used on R/V Tarajoq.

Swept area calculation

Nominal swept area for each tow was calculated as the straight-line distance between its GPS start and end positions multiplied by the wingspread. The distance between the trawl doors is recorded 3 or 5 times during each tow; provided it was recorded at least 3 times. Wingspread with the Alfredo trawl, taken as the distance between the outer bobbins, was calculated as:

Distance between outer bobbins = 10.122 + distance between trawl doors * 0.142

This relationship was estimated based on flume tank measurements of the trawl and rigging (Jørgensen 1998).
In 2022, the gear was changed to Bacalao 476 gear. The wingspread for a tow was calculated from the mean door spread and the geometry of the trawl as if the shape would be a triangle. V has been calculated as follows; Where the trawl and the trawl plus bridles are assumed to form two similar triangles, bridles and wings making a straight line:



and the lengths of the bridles (s) and the trawl wings (t) are known. The wingspread V is then calculated as:
$V = (t_l \cdot L) / (t_l + s_t)$
where L is the distance between the doors (doorspread). The trawl wing is 26.83 meters and the length of the bridles is 129 m. Because the shape of the Bacalao gear is not a triangle, a constant based on the sensors measurements during the Canadian survey at the same depths was applied. Scanmar sensors measured wingspread during the deep

Canadian survey in Subarea 0A. The difference between our estimation and the sensors measurement in each depth strata has been added as a constant in our wingspread calculations.

Trawling procedure

Towing time is usually 30 min, but towing times down to 15 min are accepted. Towing speed is between 2.5-3.0 kn and is estimated from the start and end positions of the haul. Since 2008, trawling takes place day and night. Previously, trawling was conducted only during day time.

3. Results and discussion

The available data from scientific surveys reveal that the evaluated species are present in ICES division 14.b in very different quantities. Below data are presented for each species with focus on the most recent year the species has been registered. Overall length distributions are shown only for years when more than 20 specimens of a given species were available. In total 73 hauls were made in 2022 (Table 4), with good coverage of all areas.

Roughhead grenadier (*Macrourus berglax*, RHG)

Roughhead grenadier was caught in 59 of the 73 hauls in 2022. Catches ranged from 0.246 kg to 736.33 kg, taken at 677 m in Q2 (Appendix, 1). The species was found in all strata. The vast majority of the biomass was found in Q2, similar to other years (Table 6). The biomass has been at a similar level from 1998 to 2007, where it ranged between 3151 tonnes to 5702 tonnes (Table 5, Fig. 1). The biomass then increased from 2008 until 2016 where it ranged between 5871 tonnes to 9208 tonnes (Table 5, Fig. 1). This increase could be linked to the change in survey design, where most stations from 2008 and onwards were taken during night time. The biomass since 2008 appears stabil although fluctuating (Fig. 1). In 2022, the biomass was 12915 t (S.E. = 3861, Table 5).In 2022, the abundance was estimated $7338*10^3$ (S.E. = $1703*10^3$) and follows a similar distribution pattern as the biomass (Table 6). The overall length distribution in 2022 was dominated by a clear mode at 20 cm similar to previous years (Fig. 4). From 2010 to 2016, a smaller second mode around 30 cm was present in the time series, and it became very high in numbers in 2022. The higher numbers found in the second mode in 2022 could be due to changes in the gear selectivity.

Roundnose grenadier (*Coryphaenoides rupestris* ; RNG)

Roundnose grenadier was caught in 18 of the 73 hauls and catches were generally very low, and were only found in Q2 at 1001-1500 and Q5 between depth of 601 to 1500 m (Table 7 and 8). The total biomass estimate for roundnose grenadier in 2022 is 84 t (S.E. = 17) (Table 7, which is very low. The abundance estimate follows the same pattern with a total estimate of $1364*10^3$ (S.E. = $436*10^3$), (Table 7, Fig. 6). The majority of the fish are found in the deeper parts (800 – 1000 m) of Q2 (Table 8). In 2022, there was a mode in the length distribution around 3 cm (Fig. 8), which may indicate there are currently only smaller individuals and less larger ones (which were previously regularly visible in the length distribution).

Greater argentine (*Argentinus silus*; ARU)

In 2022, greater argentine was caught in 24 of the 74 hauls. Catches ranged from 0.35 kg to 94.04 kg. The vast majority of the biomass was found in Q2 and Q5 at depth less that 1100 m (Table 10, Fig. 11). Biomass for greater argentine has been increasing from 1998 t (6.4 tonnes) to 2016 (808.1 tonnes), peaking in 2014 (2166.7 tonnes)

(Table 9, Fig. 9). In 2022, the biomass was 1061.44 t (SE = 713.84).tonnes In 2022, the abundance was estimated to 2260.9*10^3 (S.E. = 1653.7*10^3) and generally follows the same patterns as biomass (Table 10).
The overall length distribution shows that from 2003-2011 and 2014-2016 catches were dominated by a mode around 30-40 cm, whereas a second mode around 20 cm was evident in years 2012-2013 (Fig. 12). In 2022, only one mode around 38 cm was found.

Tusk (*Brosme brosme*, USK)

In 2016, tusk was caught in 17 of the 74 hauls. Catches ranged from 0.9 kg to 13 kg. The species was caught in all subareas but the majority of the biomass was in Q2 similar to previous years (Table 12, Fig. 15) Biomass for tusk has been low until 2010 (mean biomass = 18.2 t), with no catches in 1998, 1999 and 2005. From 2010 untill 2016, the biomass has been distinctly higher (mean biomass = 275 tonnes) ranging from 78.8 tonnes (2014) to 504.0 tonnes (2013) (Table 11, Fig. 13). In 2016, the biomass was 296.83 (SE = 77.86).tonnes
In 2022, the abundance was estimated 153.34*10^3 (S.E. = 53*10^3) (Table 12). The overall length distribution for all years are based on relatively low sample sizes (N<100), individual size ranged from 43 cm to 82, and we can not distinguish any mode (Fig. 16). Larger individuals were caught with the new gear in 2022.

Blue ling (*Molva dypterygia*, BLI)

In 2022, blue ling was caught in 12 out of 73 hauls. Catches ranged from 2.25 kg to 28.74 kg. The species was caught in all subareas, but with the vast majority in Q2 in depths between 600 and 800 m (Table 14, Fig. 19). Biomass for blue ling has been low from 1998 to 2005 (mean biomass =138.4 tonnes). From 2006 until 2016, the biomass has been distinctly higher (mean biomass = 786.5 tonnes) ranging from 158 tonnes (2007) to 1365 tonnes (2012) (Table 13, Fig. 17). In 2022, the biomass was 447 t (SE = 164).In 2022, the abundance was estimated to 178*10^3 (S.E. = 69*10^3) and generally follows biomass estimates. No mode can be observed in the length distribution. The size of the individuals ranged from 21 to 124 cm. (Fig. 20).

Black scabbardfish (*Aphanopus carbo*, BSF)

Black scabbardfish are rarely caught in this survey.There were no catches in the years 1998, 1999, 2000, 2002, 2003, 2006 and 2016, and neither in 2022. In 2013 and 2015, the species was caught only in 1 station, whereas it was found in 4-6 stations in 2011, 2012 and 2014. For these years, catches ranged from 0.7 kg to 21.7 kg. In 2015, it was only registered in Q5 at depths between 801-1200 m (Table 15, Fig. 23), where the majority of the biomass also has been observed in previous years (Fig. 23). In 2008 and 2010-2012, the biomass was estimated between 32.8 t and 56.4 t, whereas all other years the biomass was less than 7.9 t (Table 15). This is most likely because this pelagic and deep living pelagic fish is not targeted by the applied type of bottom trawl and hence the estimated biomasses (Fig. 21) are not truly representative of actual biomass in the investigated area. Overall length distributions from 2011 and 2012 show a wide mode between 70 cm and 110 cm.

Ling (*Molva molva*; BSF)

Ling are not commonly caught in this survey. There were no catches from 1998 to 2004, 2008, 2013-2014 and 2016. In 2022, only 1 individual was caught in 1 haul out of 74 hauls in Q2 at depths between 601-800 m (Table 16). Except from 2011, where the estimated biomass was 267.8 t (S.E. = 14.8 tonnes) (Table 16), yearly estimates are 10-fold less or zero evidencing that ling do not commonly occur in the investigated area (Table 16, Fig. 24, Fig. 26). In 2022, the estimated biomass was 6 t, estimated abundance was 2*10^3 (Table 17). The overall length distribution shows that specimens were shorter in 2011 (mode 40-50 cm) than in 2010 (mode=90-100) and further that less fish were caught in 2011 (Fig. 24) where, in contrast, the estimated biomass was more than 10 times higher. This is explained by the fact that in 2011 all ling were caught in Q3 at 601-800 m – a depth stratum which comprises 26.3 % of the total area of all strata combined (Table 1). The size of the individual caught in 2022 was 82 cm.

Orange roughy (*Hoplostethus atlanticus*; ORY)

Orange roughy is not commonly caught in this survey. The species was only caught in 2008, 2013, 2014 and 2015 (Fig. 27). In 2014 and 2015, estimated biomass was 1.7 t and 1.1 t, respectively, and in all other years it was zero or very close to zero (Table 18, Fig. 27). In 2015, all fish were caught in Q3 at depths between 801-1200 m . No length distributions are shown as too few specimens (N<20) were caught.

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Table 1. Areas (km^2) and their percentage distribution for subareas and depth strata (m). Q4 areas are not included.

Subarea	Depth strata	Area	% distribution
Q1	401-600	6975	18.7
Q2	401-600	1246	3.3
Q2	601-800	1475.4	3.9
Q2	801-1000	1988.3	5.3
Q2	1001-1500	6689.4	17.9
Q3	401-600	9830.2	26.3
Q3	601-800	3788.1	10.1
Q3	801-1000	755.4	2.0
Q3	1001-1200	191.1	0.5
Q3	1201-1400	213.3	0.6
Q3	1401-1500	312.9	0.8
Q4	401-600	2053.6	
Q4	601-800	665.7	
Q4	801-1000	336.2	
Q4	1001-1200	549.9	
Q4	1201-1400	1147	
Q4	1401-1500	940.5	
Q5	401-600	1819.4	4.9
Q5	601-800	257.1	0.7
Q5	801-1200	255.6	0.7
Q5	1201-1400	985.5	2.6
Q5	1401-1500	614.5	1.6
Sum (without Q4)		37397.2	100

Table 2.- General survey information and gear specifications for the surveys 1998-2016 on board R/V Paamiut and for the survey in 2022 with R/V Tarajoq.

Procedure	**Specifications**	
Vessel	R/V Paamiut	R/V Tarajoq
TRB	1084 GT	2896 GT
Dimensions	LOA 58.61m, Beam 11.21 m	LOA 61.4 m, Beam 16.3 m
Main engine	2000BHP, Diesel 257, 1471KW	3943/4896 BHP, Diesel 475, 2900/3600 KW
Survey Area	14b (401- 1500 m)	14b (401- 1500 m)
Years	1998-2016 (no survey 2001)	2022
Time of year	August/September	September/October
Number of days	15	15
Towing speed (knots)	3	3
Tow duration	30 min	30 min
Gear	Alfredo 3	Bacalao 476
Vertical trawl opening (m)	5.6	4.5*
Distance between doors	120 -145 m	151.8*
Winds spread	10.122 + distance between the doors * 0.142.	$V = (t_l * L) / (t_l + s_t)$ + constant
Mesh size (mm)	140 mm	136
Door	until 2003:Greenland Perfect (370*250 cm) from 2004: Shark injector (353*273)	Shark injector (353*273)
Door type (kg)	2400 kg with extra 20 kg	2850
Mesh size (mm)	44	44
Mesh-line in the cod-end	30 mm	30
Sampling design	Buffered Random Stratified	Fix stations
Number of Stations	100	74 fix + 70 extra (min 80)
Number of strata	10	10
Trawling schedule	24 hours	
Criteria for rejecting a haul	Snag of the trawling gear in the bottom Damage in the cod-end or severe damages in large sections of the wings or belly Less than 15 minutes of effective trawling time Gear malfuntion	
Criteria for change haul position	Wrong depth interval Poor bottom conditions	
Samling species	All fish species and invertebrates	
Target species	Greenland halibut	

Table 3.- Number of valid hauls for the period 1998 - 2003. No survey was conducted in 2001.

Subarea	Depth stratum (m)	Area (km2)	1998	1999	2000	2002	2003
Q1	401-600	7444.1	6	4	3	1	4
Q1	601-800	622	3	3	3	3	3
Q1	801-1000	652.3	3	3	3	2	2
Q1	1001-1200	881.8	2	2	2	2	1
Q1	1201-1400	741.4	2	2	2	2	1
Q1	1401-1500	462.3	2	2	2	2	2
Q2	401-600	777	2	2	2	2	3
Q2	601-800	853.4	4	3	3	3	3
Q2	801-1000	1336	5	4	3	4	3
Q2	1001-1200	1699.3	2	2	2	2	2
Q2	1201-1400	1742	2	2	2	0	2
Q2	1401-1500	1162.6	1	2	2	2	1
Q3	401-600	9830.2	6	7	9	3	1
Q3	601-800	3788.1	3	4	4	1	5
Q3	801-1000	755.4	2	0	2	0	2
Q5	401-600	1819.4	2	2	1	0	0
Q5	601-800	257.1	0	2	2	2	1
Q5	801-1000	106.7	0	2	2	2	2
Q5	1001-1200	148.9	2	2	2	2	1
Q5	1201-1400	985.5	2	2	2	3	1
Q5	1401-1500	614.5	3	2	2	2	0
TOTAL			54	54	55	40	40

Table 4.- Number of valid hauls for the period 2004-2016 with R/V Paamiut (no survey in 2001) and in 2022 with R/V Tarajoq, after a new stratification scheme was introduced.

Subarea	Depth stratum (m)	Area (km2)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2022	Total
Q1	401-600	6975	2	0	0	2	4	4	2	8	7	10	7	11	12	0	5	74
Q2	401-600	1246	4	4	5	3	5	4	4	2	4	5	5	5	5	0	7	62
Q2	601-800	1475.4	5	5	6	5	7	5	5	6	9	5	7	7	7	0	5	84
Q2	601-1000	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Q2	801-1000	1988.3	8	9	12	9	3	9	8	8	9	8	7	8	10	0	8	116
Q2	1001-1500	6689.4	3	3	4	3	4	5	5	4	7	4	7	7	7	0	5	68
Q3	401-600	9830.2	9	1	2	2	2	5	5	6	4	9	7	8	11	0	4	75
Q3	601-800	3788.1	4	8	2	6	6	10	6	7	7	11	12	10	14	0	11	114
Q3	801-1000	755.4	0	2	0	0	2	3	3	5	4	4	5	5	6	0	5	44
Q4	801-1200	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Q5	401-600	1819.4	3	0	1	2	3	2	0	1	2	1	2	3	3	0	4	27
Q5	601-800	257.1	3	1	3	2	3	4	1	3	3	6	6	6	6	0	6	53
Q5	801-1000	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	3
Q5	801-1200	255.6	3	4	3	4	0	4	3	3	4	5	6	2	5	0	2	48
Q5	1201-1400	985.5	5	6	3	5	3	6	5	8	5	9	3	7	9	6	9	89
Q5	1401-1500	614.5	3	4	2	3	1	3	3	5	2	3	3	5	5	4	2	48
		TOTAL	52	47	43	46	47	64	50	66	67	80	78	84	100	10	73	

Table 5.Total biomass (tonnes) with SE, and abundance (10^3) with SE, of roughhead grenadier (*Macrourus berglax*, RHG) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Roughhead grenadier			
Year	**Vessel**	**Biomass**	**SE**	**Abundance**	**SE**
1998	PA	3480.9	546.2	4027.81	639.14
1999	PA	4741.67	803.82	5268.51	979.85
2000	PA	3434.36	351.12	3894.76	380.16
2001	PA	-	-	-	-
2002	PA	4523.51	2095.86	5409.19	3429.93
2003	PA	3100.01	609.13	3421.35	741.1
2004	PA	3150.55	532.5	2813.58	266.75
2005	PA	4237.93	872.42	5230.35	1225.6
2006	PA	3972.49	597.02	4600.06	620.9
2007	PA	3435.29	637.47	3590.22	445.99
2008	PA	6841.49	983.99	6590.11	818.97
2009	PA	7256.96	1425.21	6836.17	1173.32
2010	PA	9201.84	2292.12	7532.03	1162.02
2011	PA	5855.39	1032.07	5678.71	1055.34
2012	PA	7926.09	1330.41	7060.19	1030.43
2013	PA	7604.93	1765.46	5756.69	1212.99
2014	PA	6816.97	1043.22	5426.8	713.5
2015	PA	8751.71	2292.95	5647.58	1239.19
2016	PA	6953.35	1190.37	6004.64	1043.39
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	12913.87	3860.92	7337.53	1703.26

Table 6. Mean Catch (kg/km2), biomass (tonnes) with SE, mean numbers (num/km2) and abundance (10^3) with SE with SE of roughhead grenadier (RHG) by subarea and depth stratum in 2022.

Subarea	**Stratum (m)**	**Area (sq.km)**	**Tow number**	**Mean Catch**	**Biomass**	**SE**	**Mean Number**	**Abundance**	**SE**
Q1	0401-0600	6975	12	10.625	74	67	9	64	46
Q2	0401-0600	1246	5	145.899	182	90	167	208	96
Q2	0601-0800	1475	7	3761.844	5550	2687	1739	2565	1123
Q2	0801-1000	1988	10	1018.74	2026	1358	551	1096	639
Q2	1001-1500	6689	7	695.394	4652	2412	432	2893	1101
Q3	0401-0600	9830	11	10.56	104	50	12	114	50
Q3	0601-0800	3788	14	19.726	75	27	31	118	20
Q3	0801-1000	755	6	25.514	19	7	39	30	10
Q5	0401-0600	1819	3	41.222	75	75	33	60	60
Q5	0601-0800	257	6	27.582	7	7	29	8	7
Q5	0801-1200	256	5	48.005	12	8	76	19	12
Q5	1201-1400	986	9	73.759	73	29	93	92	27
Q5	1401-1500	614	5	106.683	66	17	116	71	11
TOTAL		36678	100	105.26	12915	3861	46.44	7338	1703

Table 7.Total biomass (tonnes) with SE, and abundance (10^3) with SE, of roundnose grenadier (*Coryphaenoides rupestris*, RNG) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Roundnose grenadier			
Year	Vessel	Biomass	SE	Abundance	SE
1998	PA	2877.29	1299.84	6166.28	2654.39
1999	PA	4303.63	463.11	9661.55	1012.45
2000	PA	2294.69	1237.14	5630.96	2486.13
2001	PA	-	-	-	-
2002	PA	1771.06	1224.19	7065.28	4542.48
2003	PA	4459.12	2097	13593.18	4742.32
2004	PA	1151.83	792	4369.14	1841.27
2005	PA	1174	337.77	5883.41	1813.27
2006	PA	689.04	300.31	3781.2	967.65
2007	PA	878.79	250.81	8312.51	2493.72
2008	PA	772.93	242.56	4296.04	1277.88
2009	PA	215.67	52.05	1452.29	368.99
2010	PA	416.21	93.74	2525.65	478.99
2011	PA	3202.25	2821.1	9207.74	6687.45
2012	PA	5379.46	4774.44	15325.86	13521.71
2013	PA	294.99	151.77	1469.95	694.61
2014	PA	106.1	36.39	826.32	322.61
2015	PA	999.46	815.95	3065.97	2106.33
2016	PA	170.25	46.08	530.16	127.62
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	83.68	16.92	1363.29	436.43

Table 8. Mean Catch (kg/km2), biomass (tonnes) with SE, mean numbers (num/km2) and abundance (10^3) with SE with SE of roundnose grenadier (*Coryphaenoides rupestris*, RNG)by subarea and depth stratum

Subarea	Stratum (m)	Area (sq.km)	Tow number	Mean Catch	Biomass	SE	Mean Number	Abundance	SE
Q1	0401-0600	6975	12	0	0	0	0	0	0
Q2	0401-0600	1246	5	0	0	0	0	0	0
Q2	0601-0800	1475	7	0	0	0	0	0	0
Q2	0801-1000	1988	10	0	0	0	0	0	0
Q2	1001-1500	6689	7	2.463	16	11	4	27	17
Q3	0401-0600	9830	11	0	0	0	0	0	0
Q3	0601-0800	3788	14	0	0	0	0	0	0
Q3	0801-1000	755	6	0	0	0	0	0	0
Q5	0401-0600	1819	3	0	0	0	0	0	0
Q5	0601-0800	257	6	14.16	4	3	27	7	6
Q5	0801-1200	256	5	35.336	9	4	4435	1134	432
Q5	1201-1400	986	9	52.526	52	12	183	180	55
Q5	1401-1500	614	5	4.507	3	2	27	16	9
TOTAL		36678	100	0.46	84	17	11.9	1364	436

Table 9.Total biomass (tonnes) with SE, and abundance (10^3) with SE, of greater silver smelt (*Argentinus silus*, ARU) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Argentina silus			
Year	Vessel	Biomass	SE	Abundance	SE
1998	PA	5.39	3.14	11.69	7.73
1999	PA	2.13	2.13	5.32	5.32
2000	PA	6.5	3.54	18.2	9.49
2001	PA	-	-	-	-
2002	PA	53.79	36.23	197.17	141.11
2003	PA	162.26	93.46	493.99	293.54
2004	PA	96.91	36.05	302.86	116.52
2005	PA	55.11	19.63	186.41	67.75
2006	PA	167.25	58.48	471.75	176.95
2007	PA	126.62	45.78	384.07	143.34
2008	PA	240.62	105.47	608.6	279.75
2009	PA	347.48	155.47	747.82	343.53
2010	PA	370.78	100.95	753.41	206.27
2011	PA	432.1	145.02	1145.74	405.38
2012	PA	481.74	166.49	954.86	294.72
2013	PA	643.7	173.47	1239.71	309.73
2014	PA	2046.61	842.8	4127.26	1594.59
2015	PA	257.55	71.72	506.79	119.83
2016	PA	808.11	360.38	1609.62	889.75
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	1061.44	713.84	2260.91	1653.76

Table 10. Mean Catch (kg/km2), biomass (tonnes) with SE, mean numbers (num/km2) and abundance (10^3) with SE of of greater silver smelt (*Argentinus silus*, ARU) by subarea and depth stratum in 2022.

Subarea	Stratum (m)	Area (sq.km)	Tow number	Mean Catch	Biomass	SE	Mean Number	Abundance	SE
Q1	0401-0600	6975	12	0	0	0	0	0	0
Q2	0401-0600	1246	5	63.82	80	46	107	133	81
Q2	0601-0800	1475	7	44.425	66	38	74	109	60
Q2	0801-1000	1988	10	5.185	10	2	11	23	5
Q2	1001-1500	6689	7	0.961	6	6	1	10	10
Q3	0401-0600	9830	11	0	0	0	0	0	0
Q3	0601-0800	3788	14	0	0	0	0	0	0
Q3	0801-1000	755	6	0	0	0	0	0	0
Q5	0401-0600	1819	3	430.82	784	709	982	1787	1648
Q5	0601-0800	257	6	447.65	115	53	772	198	87
Q5	0801-1200	256	5	2.796	1	0	7	2	1
Q5	1201-1400	986	9	0	0	0	0	0	0
Q5	1401-1500	614	5	0	0	0	0	0	0
TOTAL		36678	100	19.46	1062	714	45.09	2262	1654

Table 11. Total biomass (tonnes) with SE, and abundance (10^3) with SE, of tusk (*Brosme brosme*, USK) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Brosme brosme			
Year	**Vessel**	**Biomass**	**SE**	**Abundance**	**SE**
1998	PA	0	0	0	0
1999	PA	0	0	0	0
2000	PA	3.75	3.75	0.99	0.99
2001	PA	-	-	-	-
2002	PA	61.06	34.27	194.13	108.82
2003	PA	2.21	1.6	8.82	4.41
2004	PA	4.36	4.36	9.69	9.69
2005	PA	0	0	0	0
2006	PA	16.47	7.74	19.3	7.93
2007	PA	18.42	14.94	11.95	7.28
2008	PA	69.25	29.48	166.13	93.72
2009	PA	47.4	22.34	112.41	54.81
2010	PA	225.8	113.64	369.05	206.85
2011	PA	113.62	48.34	92.71	39.91
2012	PA	349.74	261.82	138.21	67.2
2013	PA	504.06	159.77	286.14	68.41
2014	PA	188.3	111.11	126.96	50
2015	PA	277.94	87.08	186.26	47.79
2016	PA	371.81	92.08	325.44	81.58
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	296.83	77.86	153.34	53.66

Table 12. Mean Catch (kg/km2), biomass (tonnes) with SE, mean numbers (num/km2) and abundance (10^3) with SE of of tusk (*Brosme brosme*, USK) by subarea and depth stratum in 2022.

Subarea	Stratum (m)	Area (sq.km)	Tow number	Mean Catch	Biomass	SE	Mean Number	Abundance	SE
Q1	0401-0600	6975	12	7.863	55	55	7	47	47
Q2	0401-0600	1246	5	92.869	116	37	25	32	9
Q2	0601-0800	1475	7	29.252	43	23	17	25	15
Q2	0801-1000	1988	10	4.602	9	6	3	5	3
Q2	1001-1500	6689	7	0	0	0	0	0	0
Q3	0401-0600	9830	11	5.592	55	29	4	35	18
Q3	0601-0800	3788	14	0	0	0	0	0	0
Q3	0801-1000	755	6	0	0	0	0	0	0
Q5	0401-0600	1819	3	8.593	16	16	4	8	8
Q5	0601-0800	257	6	13.081	3	1	9	2	1
Q5	0801-1200	256	5	0	0	0	0	0	0
Q5	1201-1400	986	9	0	0	0	0	0	0
Q5	1401-1500	614	5	0	0	0	0	0	0
TOTAL		36678	100	2.12	297	78	1.46	154	54

Table 13.Total biomass (tonnes) with SE, and abundance (10^3) with SE, of blue ling (*Molva dypterygia*, BLI) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Molva dypteria			
Year	Vessel	Biomass	SE	Abundance	SE
1998	PA	87.47	42.49	34.41	11.78
1999	PA	163.48	69.45	65.93	27.83
2000	PA	211.09	114.02	161.13	75.62
2001	PA	-	-	-	-
2002	PA	76.26	17.34	86.61	15.93
2003	PA	101.38	31.39	96.62	35.86
2004	PA	81.59	32.72	89.16	42.79
2005	PA	111.08	30.99	83.28	15.38
2006	PA	570.07	264.94	355.56	131.03
2007	PA	158.35	57.06	136.59	57.59
2008	PA	870.02	404.82	1013.83	574.84
2009	PA	1239.68	617.42	860.55	353.19
2010	PA	892.11	157.68	689.48	193.73
2011	PA	588.19	232.69	665.09	318.57
2012	PA	1339.72	194.16	976.82	369.4
2013	PA	1248.22	412.14	571.84	159.41
2014	PA	865.88	288.05	471.72	127.73
2015	PA	417.65	162.08	204.49	74.07
2016	PA	432.5	155.17	182.92	66.68
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	446.04	164.23	176.81	69.22

Table 14. Mean Catch (kg/km2), biomass (tonnes) with SE, mean numbers (num/km2) and abundance (10^3) with SE of of blue ling (*Molva dypterygia*, BLI) by subarea and depth stratum in 2022.

Subarea	Stratum (m)	Area (sq.km)	Tow number	Mean Catch	Biomass	SE	Mean Number	Abundance	SE
Q1	0401-0600	6975	12	7.013	49	49	2	16	16
Q2	0401-0600	1246	5	31.105	39	17	8	10	4
Q2	0601-0800	1475	7	149.958	221	143	49	73	50
Q2	0801-1000	1988	10	0	0	0	0	0	0
Q2	1001-1500	6689	7	0	0	0	0	0	0
Q3	0401-0600	9830	11	7.105	70	47	2	24	16
Q3	0601-0800	3788	14	0	0	0	0	0	0
Q3	0801-1000	755	6	0	0	0	0	0	0
Q5	0401-0600	1819	3	35.538	65	40	30	54	42
Q5	0601-0800	257	6	0	0	0	0	0	0
Q5	0801-1200	256	5	10.252	3	3	4	1	1
Q5	1201-1400	986	9	0	0	0	0	0	0
Q5	1401-1500	614	5	0	0	0	0	0	0
TOTAL		36678	100	4.48	447	164	1.89	178	69

Table 15.Total biomass (tonnes) with SE, and abundance (10^3) with SE, of black scabbardfish (*Aphanopus carbo*, BSF) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Aphanophus carbo			
Year	**Vessel**	**Biomass**	**SE**	**Abundance**	**SE**
1998	PA	0	0	0	0
1999	PA	0	0	0	0
2000	PA	0	0	0	0
2001	PA	-	-	-	-
2002	PA	0	0	0	0
2003	PA	0	0	0	0
2004	PA	0.82	0.82	4.08	4.08
2005	PA	1.71	1.71	1.37	1.37
2006	PA	0	0	0	0
2007	PA	2.33	1.98	7.49	5.35
2008	PA	37.53	33.34	33.79	27.28
2009	PA	2.66	2.66	3.1	3.1
2010	PA	56.38	25.08	82.79	35.31
2011	PA	39.86	26.67	56.44	35.99
2012	PA	33.12	9.57	34.13	12.07
2013	PA	1.81	1.81	2.05	2.05
2014	PA	7.91	4.87	6.85	3.52
2015	PA	1.52	1.52	2.15	2.15
2016	PA	0	0	0	0
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	0	0	0	0

Table 16. Total biomass (tonnes) with SE, and abundance (10^3) with SE, of blue ling (*Molva molva*, LIN) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

Year	Vessel	Biomass	SE	Abundance	SE
1998	PA	0	0	0	0
1999	PA	0	0	0	0
2000	PA	0	0	0	0
2001	PA	-	-	-	-
2002	PA	0	0	0	0
2003	PA	0	0	0	0
2004	PA	0	0	0	0
2005	PA	15.69	15.69	9.26	9.26
2006	PA	29.89	29.89	6.29	6.29
2007	PA	14.61	10.34	25.32	19.91
2008	PA	0	0	0	0
2009	PA	3.09	3.09	3.67	3.67
2010	PA	19.23	0	8.21	0
2011	PA	267.64	251.03	491.56	484.77
2012	PA	19.92	19.92	6.04	6.04
2013	PA	0	0	0	0
2014	PA	0	0	0	0
2015	PA	23.43	14.85	9.18	6.1
2016	PA	0	0	0	0
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	6.43	6.43	2.12	2.12

Table 17. Mean Catch (kg/km2), biomass (tonnes) with SE, mean numbers (num/km2) and abundance (10^3) with SE of of blue ling (*Molva molva*, LIN) by subarea and depth stratum in 2022.

Subarea	Stratum (m)	Area (sq.km)	Tow number	Mean Catch	Biomass	SE	Mean Number	Abundance	SE
Q1	0401-0600	6975	12	0	0	0	0	0	0
Q2	0401-0600	1246	5	0	0	0	0	0	0
Q2	0601-0800	1475	7	4.357	6	6	1	2	2
Q2	0801-1000	1988	10	0	0	0	0	0	0
Q2	1001-1500	6689	7	0	0	0	0	0	0
Q3	0401-0600	9830	11	0	0	0	0	0	0
Q3	0601-0800	3788	14	0	0	0	0	0	0
Q3	0801-1000	755	6	0	0	0	0	0	0
Q5	0401-0600	1819	3	0	0	0	0	0	0
Q5	0601-0800	257	6	0	0	0	0	0	0
Q5	0801-1200	256	5	0	0	0	0	0	0
Q5	1201-1400	986	9	0	0	0	0	0	0
Q5	1401-1500	614	5	0	0	0	0	0	0
TOTAL		36678	100	0.18	6	6	0.06	2	2

Table 18. Total biomass (tonnes) with SE, and abundance (10^3) with SE, of Orange roughy (*Hoplostethus atlanticus*, ORY) for the period 1998-2016 (no survey in 2001) on board R/V Paamiut (PA) and for 2022 on board R/V Tarajoq (TJ).

		Hoplostethus atlanticus			
Year	**Vessel**	**Biomass**	**SE**	**Abundance**	**SE**
1998	PA	0	0	0	0
1999	PA	0	0	0	0
2000	PA	0	0	0	0
2001	PA	-	-	-	-
2002	PA	0	0	0	0
2003	PA	0	0	0	0
2004	PA	0	0	0	0
2005	PA	0	0	0	0
2006	PA	0	0	0	0
2007	PA	0	0	0	0
2008	PA	0.16	0.16	0.92	0.92
2009	PA	0	0	0	0
2010	PA	0	0	0	0
2011	PA	0	0	0	0
2012	PA	0	0	0	0
2013	PA	0.02	0.02	0.69	0.69
2014	PA	1.74	1.74	2.33	2.33
2015	PA	1.09	1.09	2.15	2.15
2016	PA	0	0	0	0
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	TJ	0	0	0	0

Figure 1. Roughhead grenadier (RHG) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

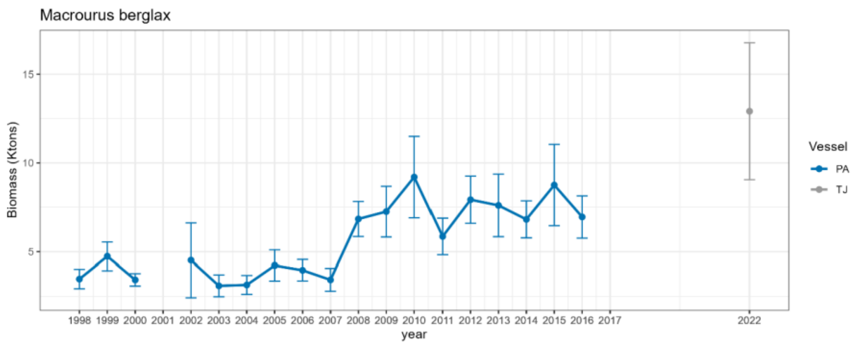


Figure 2. Roughhead grenadier (RHG) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

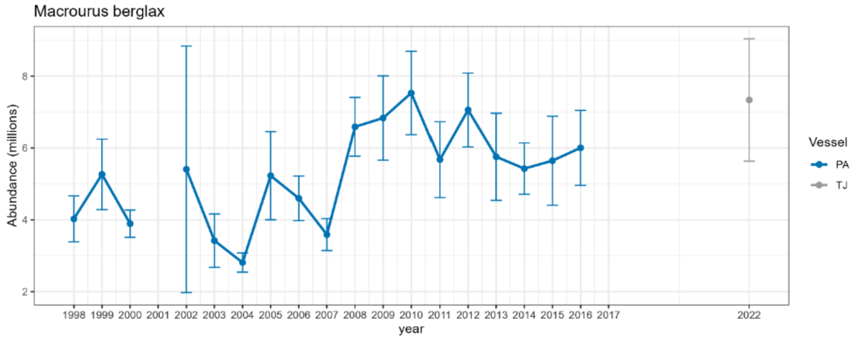


Figure 3. Distribution of survey catches of roughhead grenadier (RHG) off East Greenland (ICES 14.b) from 1998-2016 and 2022.

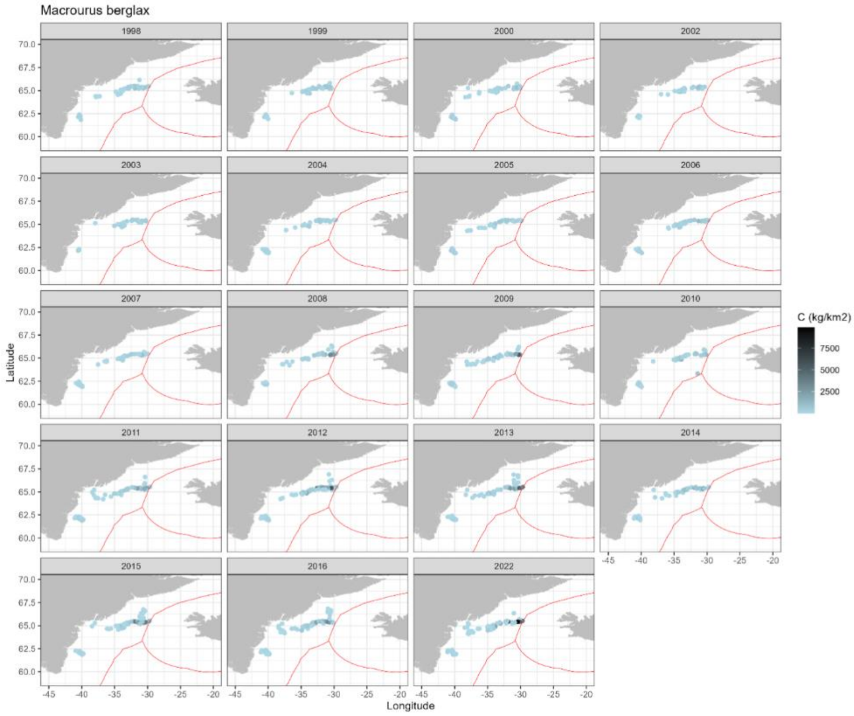


Fig. 4. Length frequency distribution per swept area of roughhead grenadier (RHG) for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

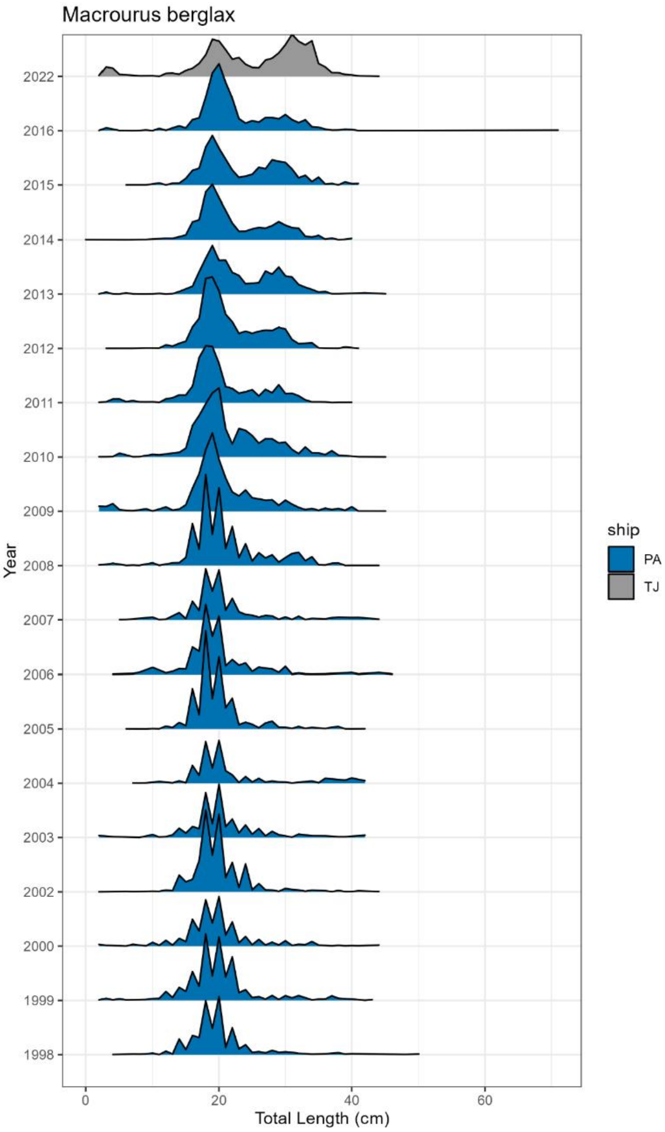


Figure 5.- Roundnose grenadier (RNG) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

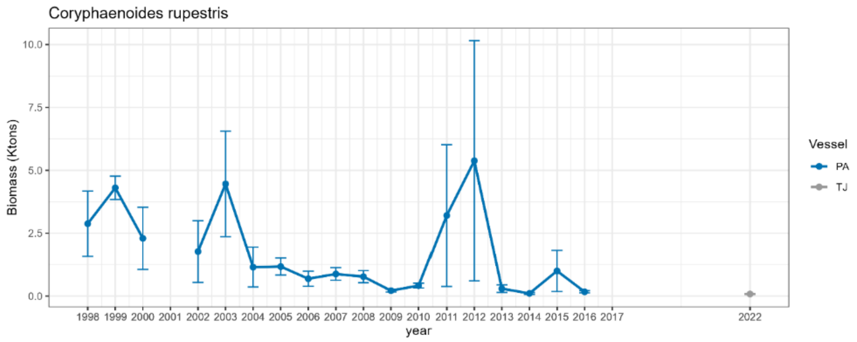


Figure 6.- Roundnose grenadier (RNG) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

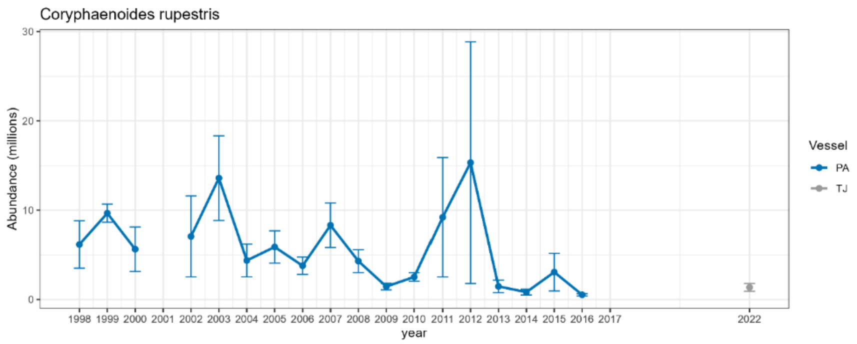


Figure 7. Distribution of survey catches of roundnose grenadier (RNG) off East Greenland (ICES 14.b) from 1998-2016 and 2022.

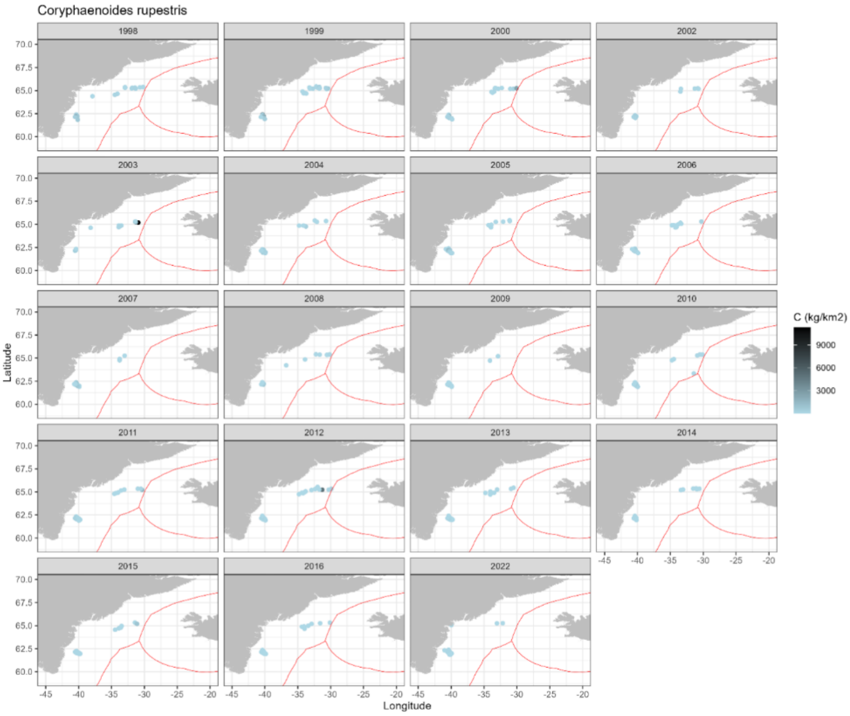


Fig. 8. Length frequency distribution per swept area of roundnose grenadier (RNG) for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

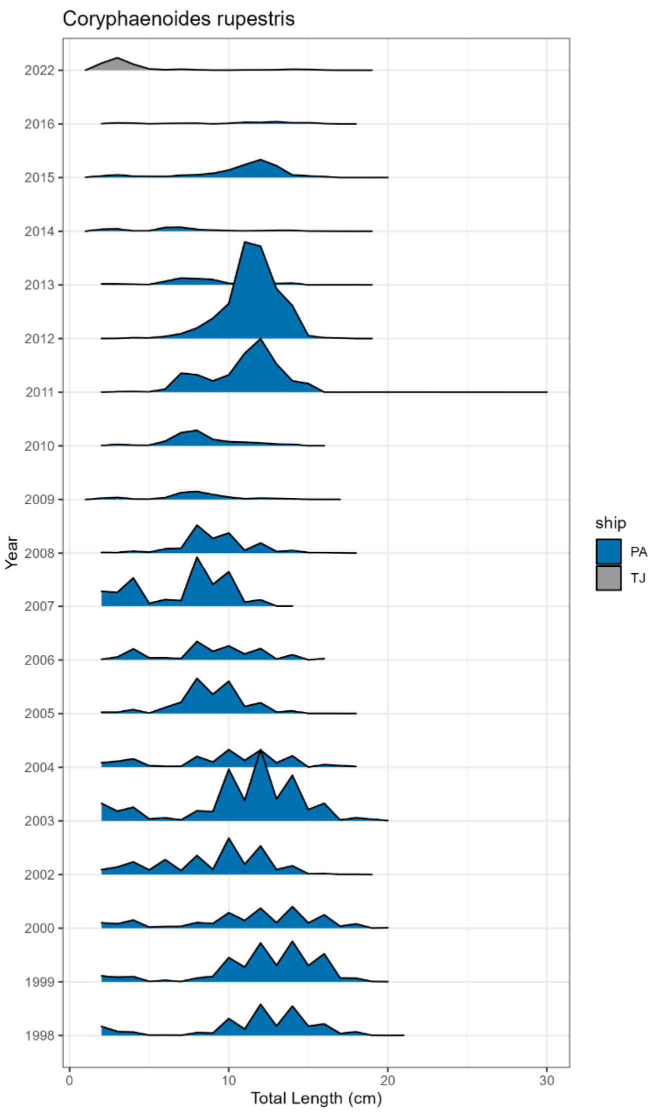


Figure 9. Greater argentine (ARU) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

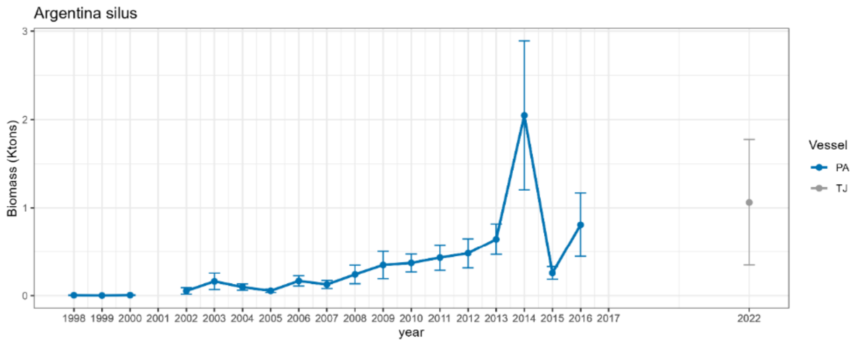


Figure 10. Greater argentine (ARU) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

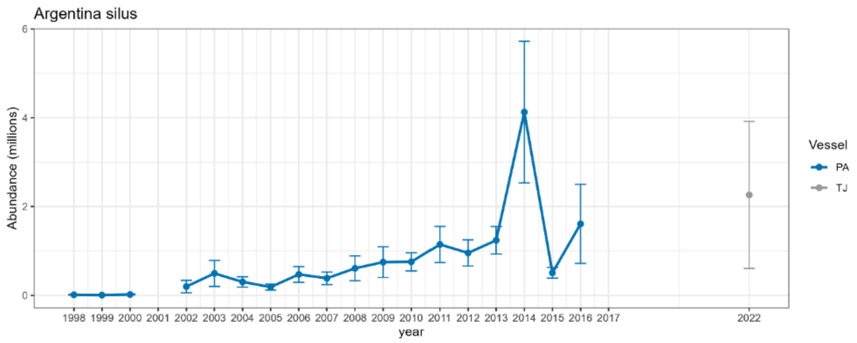


Figure 11. Distribution of survey catches of greater argentine (ARU) off East Greenland (ICES 14.b) from 1998-2016 and 2022.

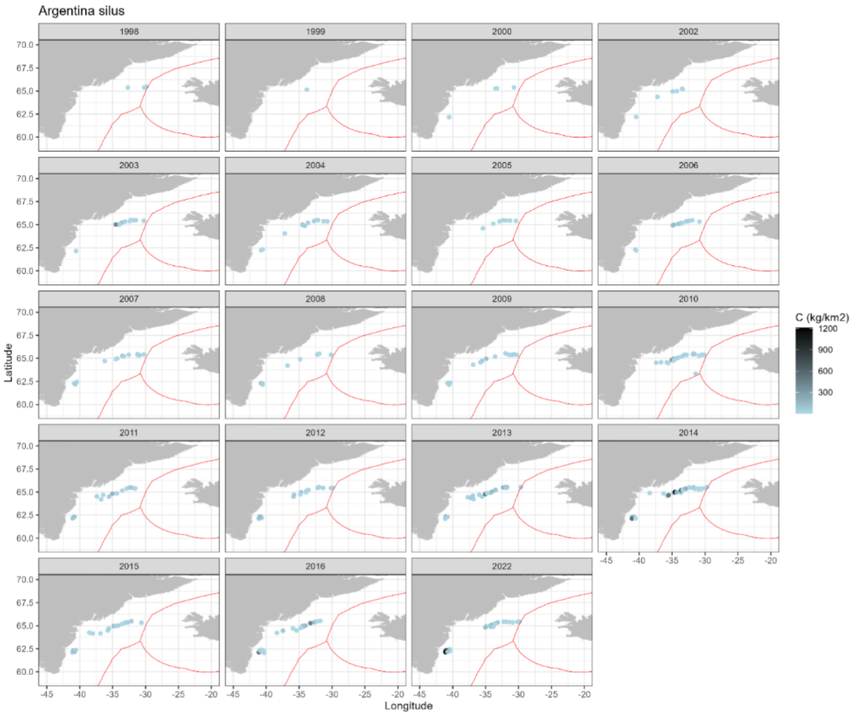


Fig. 12. Length frequency distribution per swept area of greater argentine (ARU) for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

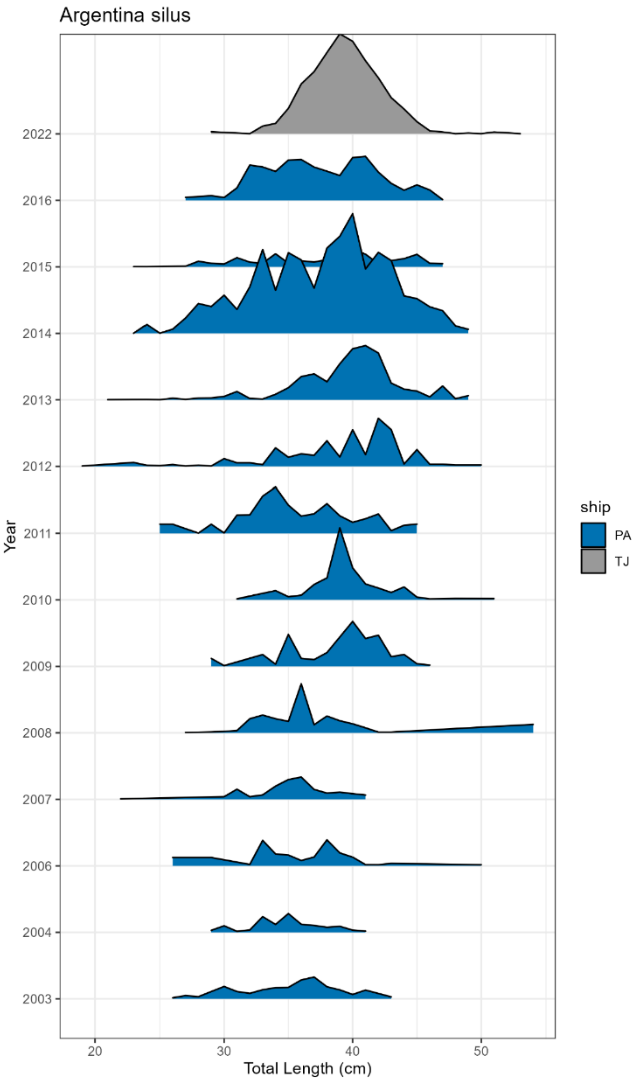


Figure 13. Tusk (USK) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

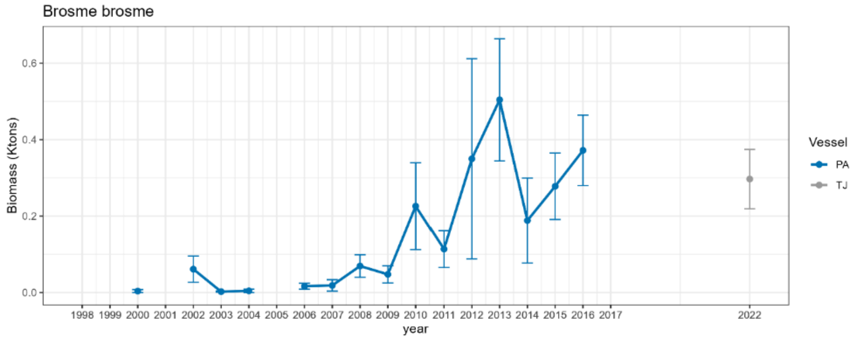


Figure 14. Tusk (USK) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

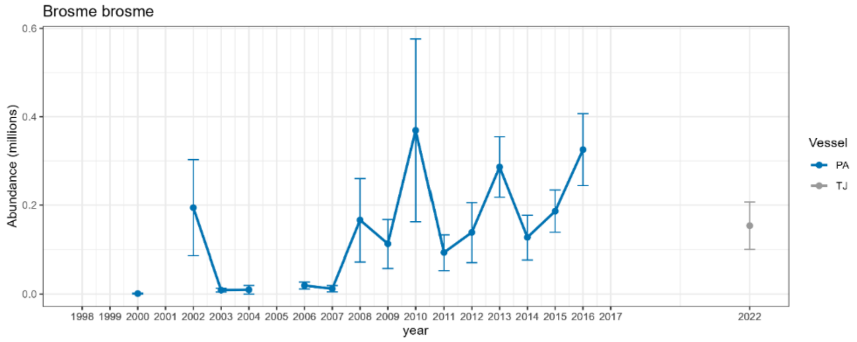


Figure 15. Distribution of survey catches of tusk (USK) off East Greenland (ICES 14.b) from 1998-2016 and 2022.

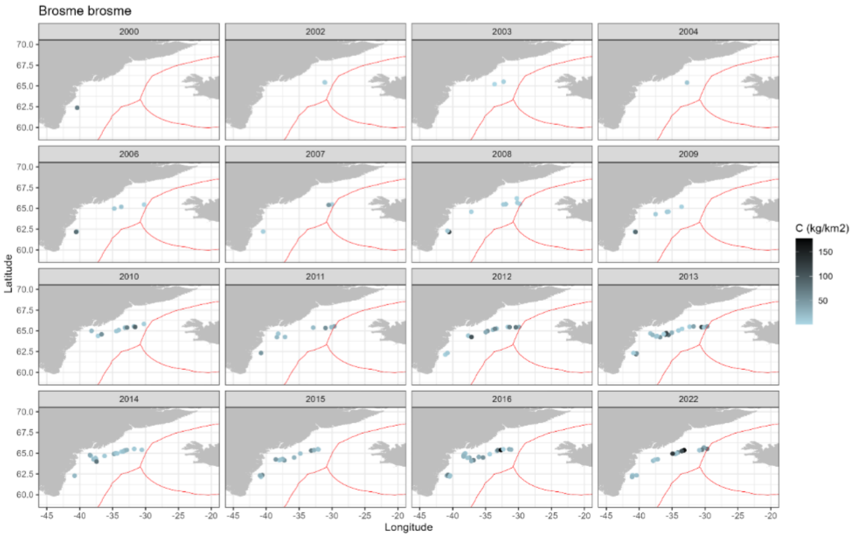


Fig. 16. Length frequency distribution per swept area of tusk (USK) for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq

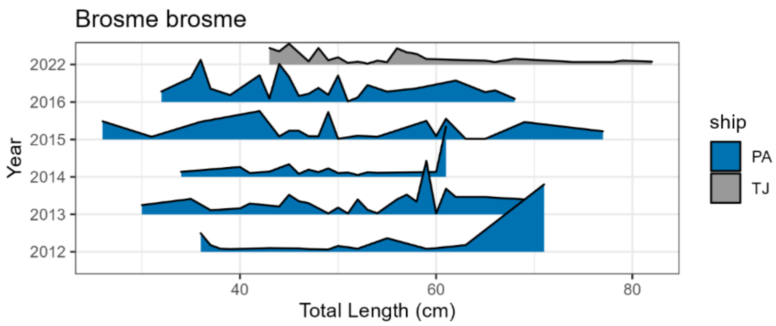


Figure 17. Blue ling (BLI) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

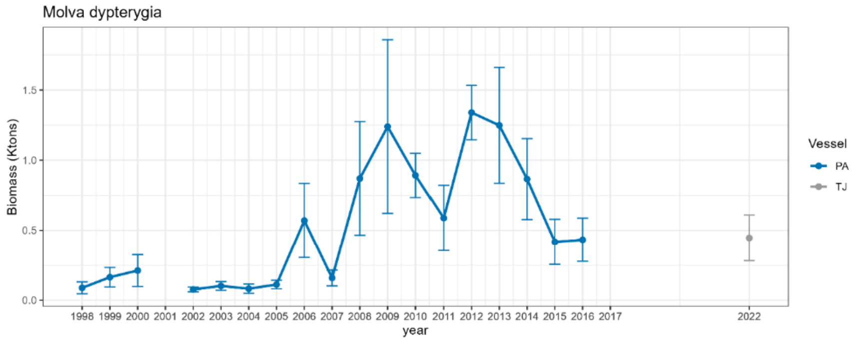


Figure 18. Blue ling (BLI) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

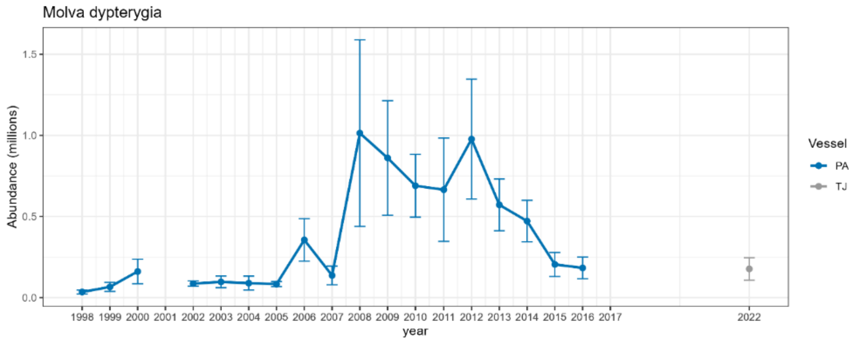


Figure 19. Distribution of survey catches of blue ling (BLI) off East Greenland (ICES 14.b) from 1998-2016 and 2022.

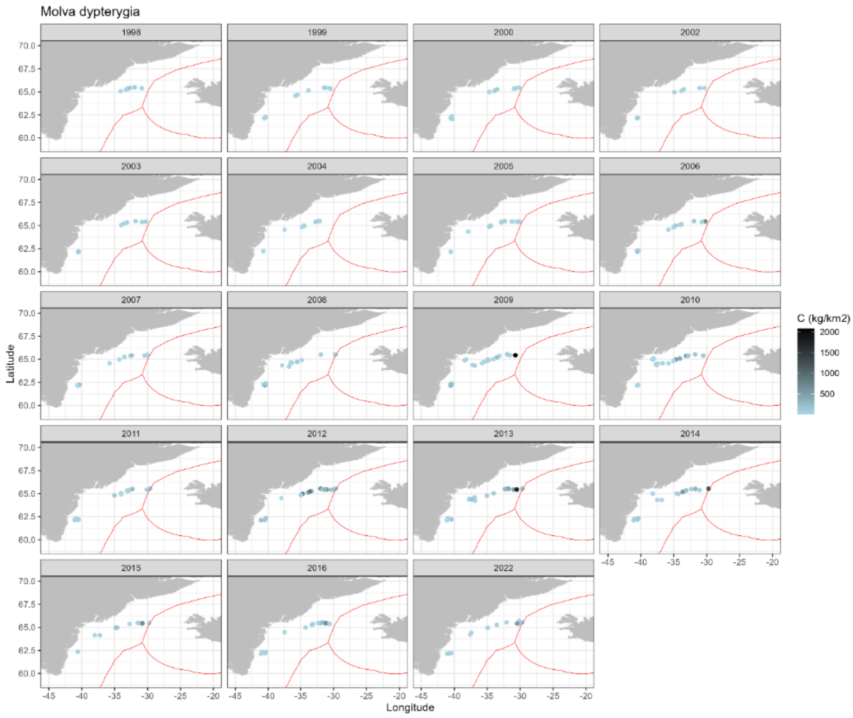


Fig. 20. Length frequency distribution per swept area of blue ling (BLI) for the period 1998-2019 on board R/V Paamiut and on 2022 on board R/V Tarajoq

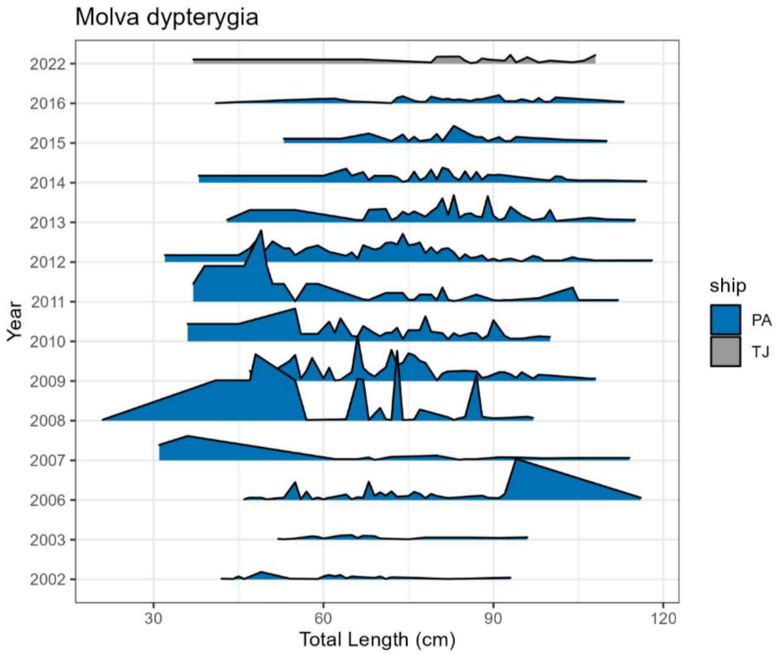


Figure 21.- Black scabbardfish (BSF) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

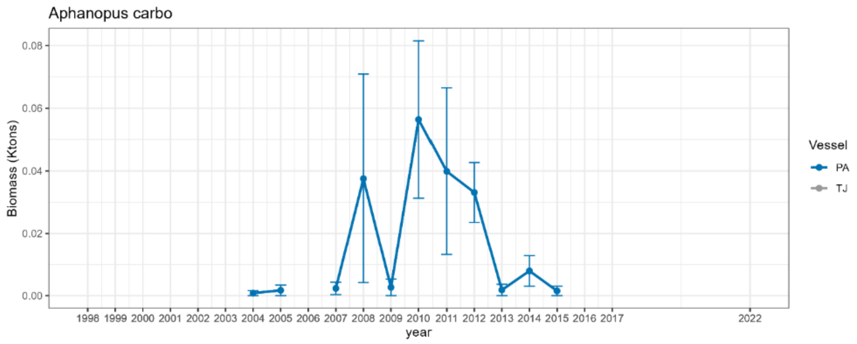


Figure 22.- Black scabbardfish(BSF) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

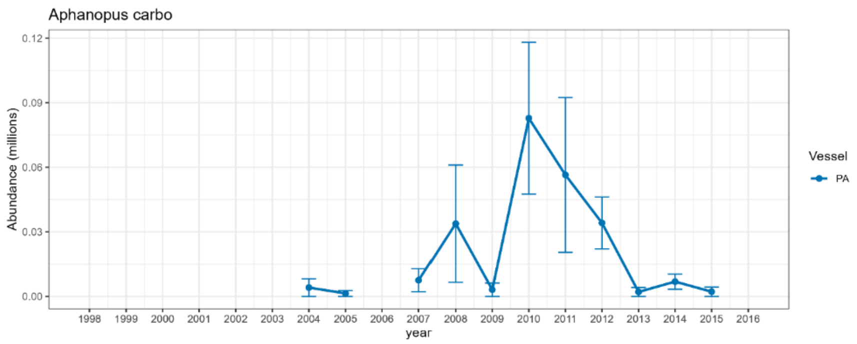


Figure 23. Distribution of survey catches of black scabbardfish (BSF) off East Greenland (ICES 14.b) from 1998-2016 and 2022.

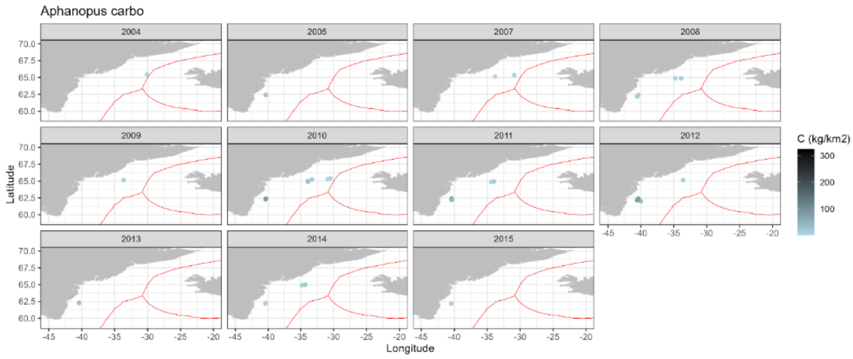


Figure 24.- Ling (LIN) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

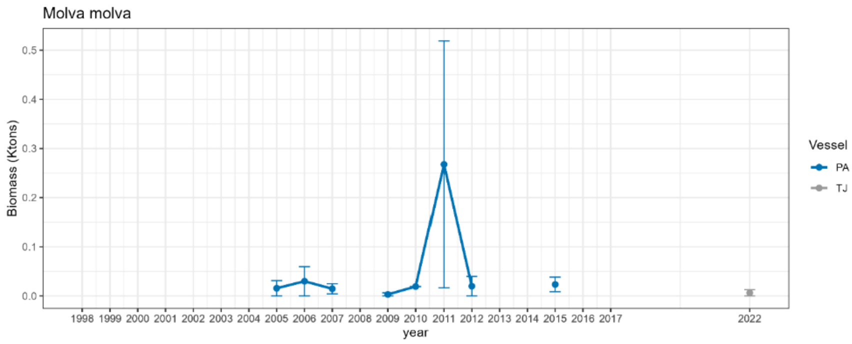


Figure 25.- Ling (LIN) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

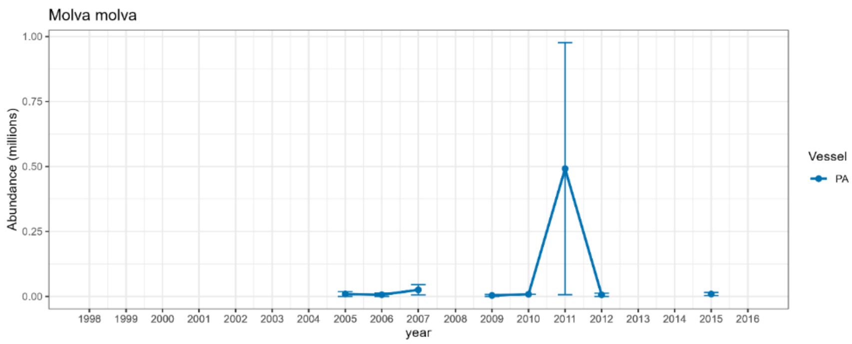


Figure 26. Distribution of survey catches of ling (LIN) off East Greenland (ICES 14.b) from 1998-2016 and 2022**.**

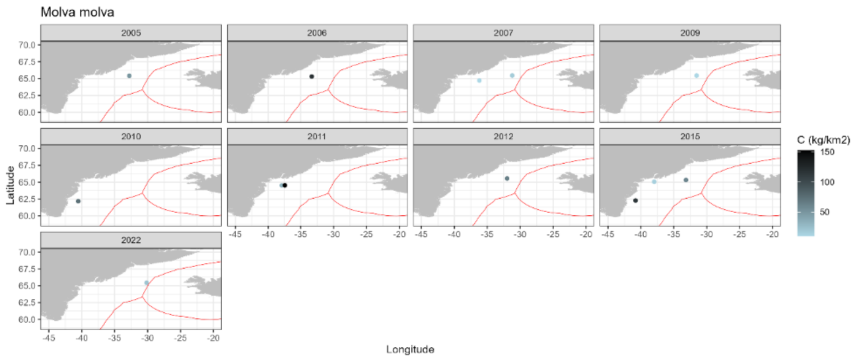


Figure 27.- Orange roughy (ORY) biomass (tonnes) calculated by swept area method in tonnes and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

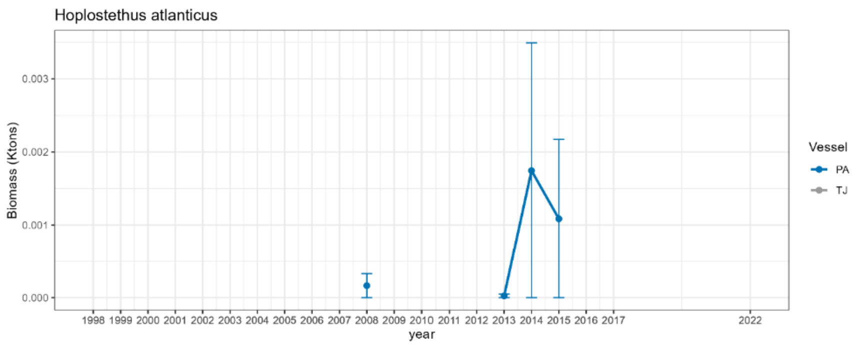


Figure 28.- Orange roughy (ORY) abundance ('000s) calculated by swept area method and +/- S.E. by year for the period 1998-2016 on board R/V Paamiut and on 2022 on board R/V Tarajoq.

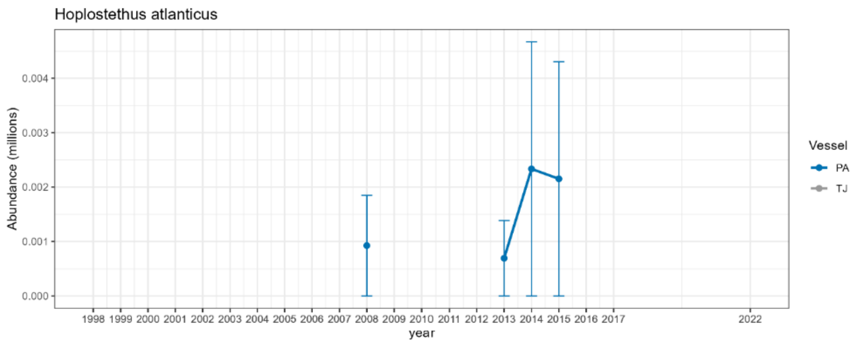
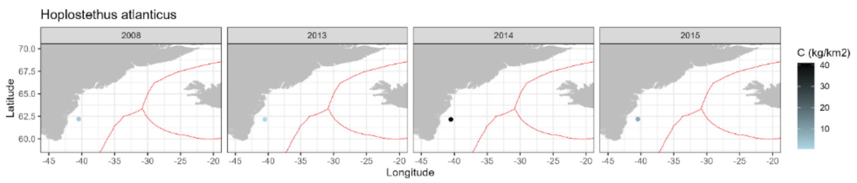


Figure 29. Distribution of survey catches of orange roughy (ORY) off East Greenland (ICES 14.b) in 1998-2016 and 2022.



Appendix 1. Catch weight and numbers (not standardized to kg/km2) of roughhead grenadier, roundnose grenadier, greater silver smelt and tusk by haul, in 2019. Depth in meters, swept area in km2 and bottom temperature in ºC.

						RHG		RNG		ARS		USK	
St. No	Swept Area	Subarea	Stratum	Depth	Bottom Temp.	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number
1	0.0773	Q2	0801-1000	826.5	5.3	20.3	12	0	0	0.3	1	0	0
2	0.0731	Q2	0601-0800	634.5	2.21	244.5	146	0	0	0	0	4.8	4
3	0.0894	Q1	0401-0600	412.5	0.93	4.4	3	0	0	0	0	3.5	3
4	0.092	Q1	0401-0600	458	0.81	0	0	0	0	0	0	0	0
5	0.0923	Q1	0401-0600	507	0.71	0	0	0	0	0	0	0	0
6	0.0832	Q1	0401-0600	498	0.88	0.4	1	0	0	0	0	0	0
7	0.0764	Q1	0401-0600	448.5	0.72	0	0	0	0	0	0	0	0
11	0.1389	Q2	0601-0800	677.5	3.48	736.3	344	0	0	1.5	4	0	0
12	0.0548	Q2	0601-0800	618	3.83	541.8	223	0	0	0	0	3.8	1
13	0.1065	Q2	0801-1000	833.5	3.26	57.2	30	0	0	0.4	1	1.7	1
14	0.0742	Q2	1001-1500	1378	2.41	1.8	14	0	0	0	0	0	0
15	0.1033	Q2	0801-1000	838	2.97	23.8	17	0	0	0.8	2	0	0
16	0.096	Q2	0801-1000	883.5	1.46	553.7	265.2	0	0	0.6	1	0	0
17	0.1121	Q2	0401-0600	523	3.61	12.8	16	0	0	0	0	0	0
20	0.0976	Q2	0801-1000	964	3.04	58	54	0	0	1.1	2	0	0
21	0.0865	Q2	1001-1500	1422	1.93	10.1	8	0.7	1	0	0	0	0
22	0.0615	Q2	1001-1500	1073.5	2.67	131.4	68	0.6	1	0	0	0	0
23	0.0681	Q2	0401-0600	449.5	4.01	27	28	0	0	6.1	10	11.7	3
24	0.0888	Q2	0401-0600	466.5	3.69	17.8	23	0	0	2.2	3	9.7	3
25	0.1079	Q2	0801-1000	861.5	4.65	1.3	2	0	0	0.4	1	0	0
26	0.1019	Q2	0401-0600	441.5	5.45	0.4	1	0	0	20	35	5.6	2
27	0.1003	Q2	1001-1500	1075	2.02	201.8	90	0	0	0.7	1	0	0
28	0.0968	Q2	1001-1500	1208	3.2	8.3	12	0	0	0	0	0	0
29	0.1035	Q2	0801-1000	958.5	2.23	66.9	40	0	0	0.5	1	0	0
30	0.0986	Q2	0601-0800	689	4.8	21.3	12	0	0	8.2	14	1.1	1
31	0.0891	Q2	0801-1000	881.5	3.85	9.2	8	0	0	0	0	1.9	1
32	0.1003	Q2	0401-0600	470	4.49	1.4	1	0	0	0.9	1	13	3
33	0.1013	Q2	0601-0800	739	4.82	6.2	3	0	0	12.9	20	0	0
34	0.1081	Q2	1001-1500	1417.5	2.74	3.4	2	0	0	0	0	0	0
36	0.1015	Q2	1001-1500	1262.5	3.05	47	61	0	0	0	0	0	0
42	0.085	Q3	0601-0800	644.5	3.46	0.8	3	0	0	0	0	0	0
43	0.0974	Q3	0601-0800	680.5	3.45	5.2	4	0	0	0	0	0	0
44	0.0934	Q3	0601-0800	692	3.73	1.8	2	0	0	0	0	0	0
46	0.0884	Q3	0801-1000	842.5	3.72	0.7	1	0	0	0	0	0	0
49	0.0873	Q3	0601-0800	634.5	3.66	1.8	3	0	0	0	0	0	0
50	0.0905	Q3	0601-0800	780.5	3.72	0.8	4	0	0	0	0	0	0
56	0.0961	Q3	0801-1000	866	3.65	2.3	4	0	0	0	0	0	0
57	0.0967	Q3	0401-0600	426.5	3.75	0	0	0	0	0	0	0	0
59	0.0944	Q3	0401-0600	573.5	3.66	4.1	4	0	0	0	0	0	0
61	0.0989	Q3	0801-1000	849	3.61	1.4	2	0	0	0	0	0	0
62	0.0885	Q3	0801-1000	891	3.65	2.1	3	0	0	0	0	0	0
63	0.0898	Q3	0801-1000	817	3.65	5.2	8	0	0	0	0	0	0
64	0.1001	Q3	0401-0600	492.5	3.75	1.5	2	0	0	0	0	0	0
65	0.097	Q3	0401-0600	444	3.81	1.1	2	0	0	0	0	2	1
66	0.0879	Q3	0401-0600	578	3.71	0	0	0	0	0	0	0.9	1
67	0.0989	Q3	0601-0800	663.5	3.67	0.6	1	0	0	0	0	0	0
68	0.0948	Q3	0401-0600	520	3.65	2.4	2	0	0	0	0	1.9	1
69	0.0805	Q3	0401-0600	414.5	3.71	0	0	0	0	0	0	0	0
70	0.11	Q3	0401-0600	432	3.74	0	0	0	0	0	0	0	0
71	0.1007	Q3	0401-0600	424.5	3.77	0	0	0	0	0	0	0	0
80	0.0797	Q5	0401-0600	420.5	4.53	0	0	0	0	0.8	1	0	0
81	0.0752	Q5	0801-1200	912	4.55	0.7	2	1	52	0.4	1	0	0
82	0.0732	Q5	0601-0800	700.5	4.85	0	0	3.7	7	3.1	7	1.4	1
83	0.0717	Q5	0801-1200	897.5	4.65	3.5	5	3.3	502.8	0.4	1	0	0
86	0.0936	Q5	0601-0800	633	5.01	0	0	0	0	14.6	26	0	0
88	0.085	Q5	0601-0800	668.5	5.15	0.2	1	0.5	1	61.6	118.4	1.4	1
89	0.0854	Q5	0601-0800	647.5	5.03	9.2	9	0	0	74.2	113	1.4	1
91	0.0802	Q5	0401-0600	426.5	4.99	9.9	8	0	0	97	224	2.1	1
93	0.0709	Q5	0401-0600	436.5	5.03	0	0	0	0	5.2	10	0	0
94	0.0799	Q5	0801-1200	876	4.84	0	0	1	197.2	0	0	0	0
95	0.0629	Q5	0801-1200	988.5	4.63	8.4	13	4.4	476.3	0	0	0	0
96	0.0928	Q5	1201-1400	1316.5	3.23	6.8	9	3.7	24	0	0	0	0
97	0.0949	Q5	1201-1400	1290	3.38	4.1	8	9.6	44	0	0	0	0
98	0.0847	Q5	1201-1400	1344.5	3.28	9.3	11	3.6	9	0	0	0	0
99	0.0701	Q5	1201-1400	1332.5	3.31	16.3	16	6	10	0	0	0	0
100	0.0973	Q5	1201-1400	1296.5	3.39	2.3	4	6.2	21	0	0	0	0
101	0.0922	Q5	1201-1400	1268.5	3.71	0	0	2	4	0	0	0	0
104	0.0968	Q5	1401-1500	1445	3.25	3.8	6	0.2	7	0	0	0	0
105	0.0761	Q5	1401-1500	1418	2.93	13.6	9	0.3	1	0	0	0	0
106	0.076	Q5	1401-1500	1434	3.03	3.9	7	0	0	0	0	0	0
107	0.0768	Q5	1401-1500	1426	2.98	9.2	12	0	0	0	0	0	0
108	0.0849	Q5	1401-1500	1442	3.26	12.4	13	1.3	4	0	0	0	0
109	0.0827	Q5	1201-1400	1229	3.35	2.9	6	1.1	4	0	0	0	0

Appendix 2. Catch weight and numbers (not standardized to kg/km2) of blue ling, black scabbardfish, ling, and orange roughy by haul, in 2019. Depth in meters, swept area in km2 and bottom temperature in ºC.

						BLI		BSF		LIN		HAT	
St. No	Swept Area	Subarea	Stratum	Depth	ottom Tem	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number
1	0.0773	Q2	0801-1000	826.5	5.3	0	0	0	0	0	0	0	0
2	0.0731	Q2	0601-0800	634.5	2.21	8.5	2	0	0	0	0	0	0
3	0.0894	Q1	0401-0600	412.5	0.93	3.1	1	0	0	0	0	0	0
4	0.092	Q1	0401-0600	458	0.81	0	0	0	0	0	0	0	0
5	0.0923	Q1	0401-0600	507	0.71	0	0	0	0	0	0	0	0
6	0.0832	Q1	0401-0600	498	0.88	0	0	0	0	0	0	0	0
7	0.0764	Q1	0401-0600	448.5	0.72	0	0	0	0	0	0	0	0
11	0.1389	Q2	0601-0800	677.5	3.48	15.1	5	0	0	3	1	0	0
12	0.0548	Q2	0601-0800	618	3.83	28.7	10	0	0	0	0	0	0
13	0.1065	Q2	0801-1000	833.5	3.26	0	0	0	0	0	0	0	0
14	0.0742	Q2	1001-1500	1378	2.41	0	0	0	0	0	0	0	0
15	0.1033	Q2	0801-1000	838	2.97	0	0	0	0	0	0	0	0
16	0.096	Q2	0801-1000	883.5	1.46	0	0	0	0	0	0	0	0
17	0.1121	Q2	0401-0600	523	3.61	4	2	0	0	0	0	0	0
20	0.0976	Q2	0801-1000	964	3.04	0	0	0	0	0	0	0	0
21	0.0865	Q2	1001-1500	1422	1.93	0	0	0	0	0	0	0	0
22	0.0615	Q2	1001-1500	1073.5	2.67	0	0	0	0	0	0	0	0
23	0.0681	Q2	0401-0600	449.5	4.01	0	0	0	0	0	0	0	0
24	0.0888	Q2	0401-0600	466.5	3.69	5.4	1	0	0	0	0	0	0
25	0.1079	Q2	0801-1000	861.5	4.65	0	0	0	0	0	0	0	0
26	0.1019	Q2	0401-0600	441.5	5.45	0	0	0	0	0	0	0	0
27	0.1003	Q2	1001-1500	1075	2.02	0	0	0	0	0	0	0	0
28	0.0968	Q2	1001-1500	1208	3.2	0	0	0	0	0	0	0	0
29	0.1035	Q2	0801-1000	958.5	2.23	0	0	0	0	0	0	0	0
30	0.0986	Q2	0601-0800	689	4.8	0	0	0	0	0	0	0	0
31	0.0891	Q2	0801-1000	881.5	3.85	0	0	0	0	0	0	0	0
32	0.1003	Q2	0401-0600	470	4.49	5.9	1	0	0	0	0	0	0
33	0.1013	Q2	0601-0800	739	4.82	0	0	0	0	0	0	0	0
34	0.1081	Q2	1001-1500	1417.5	2.74	0	0	0	0	0	0	0	0
36	0.1015	Q2	1001-1500	1262.5	3.05	0	0	0	0	0	0	0	0
42	0.085	Q3	0601-0800	644.5	3.46	0	0	0	0	0	0	0	0
43	0.0974	Q3	0601-0800	680.5	3.45	0	0	0	0	0	0	0	0
44	0.0934	Q3	0601-0800	692	3.73	0	0	0	0	0	0	0	0
46	0.0884	Q3	0801-1000	842.5	3.72	0	0	0	0	0	0	0	0
49	0.0873	Q3	0601-0800	634.5	3.66	0	0	0	0	0	0	0	0
50	0.0905	Q3	0601-0800	780.5	3.72	0	0	0	0	0	0	0	0
56	0.0961	Q3	0801-1000	866	3.65	0	0	0	0	0	0	0	0
57	0.0967	Q3	0401-0600	426.5	3.75	0	0	0	0	0	0	0	0
59	0.0944	Q3	0401-0600	573.5	3.66	3.6	1	0	0	0	0	0	0
61	0.0989	Q3	0801-1000	849	3.61	0	0	0	0	0	0	0	0
62	0.0885	Q3	0801-1000	891	3.65	0	0	0	0	0	0	0	0
63	0.0898	Q3	0801-1000	817	3.65	0	0	0	0	0	0	0	0
64	0.1001	Q3	0401-0600	492.5	3.75	0	0	0	0	0	0	0	0
65	0.097	Q3	0401-0600	444	3.81	0	0	0	0	0	0	0	0
66	0.0879	Q3	0401-0600	578	3.71	2.3	1	0	0	0	0	0	0
67	0.0989	Q3	0601-0800	663.5	3.67	0	0	0	0	0	0	0	0
68	0.0948	Q3	0401-0600	520	3.65	0	0	0	0	0	0	0	0
69	0.0805	Q3	0401-0600	414.5	3.71	0	0	0	0	0	0	0	0
70	0.11	Q3	0401-0600	432	3.74	0	0	0	0	0	0	0	0
71	0.1007	Q3	0401-0600	424.5	3.77	0	0	0	0	0	0	0	0
80	0.0797	Q5	0401-0600	420.5	4.53	0	0	0	0	0	0	0	0
81	0.0752	Q5	0801-1200	912	4.55	0	0	0	0	0	0	0	0
82	0.0732	Q5	0601-0800	700.5	4.85	0	0	0	0	0	0	0	0
83	0.0717	Q5	0801-1200	897.5	4.65	0	0	0	0	0	0	0	0
86	0.0936	Q5	0601-0800	633	5.01	0	0	0	0	0	0	0	0
88	0.085	Q5	0601-0800	668.5	5.15	0	0	0	0	0	0	0	0
89	0.0854	Q5	0601-0800	647.5	5.03	0	0	0	0	0	0	0	0
91	0.0802	Q5	0401-0600	426.5	4.99	2.5	6	0	0	0	0	0	0
93	0.0709	Q5	0401-0600	436.5	5.03	5.3	1	0	0	0	0	0	0
94	0.0799	Q5	0801-1200	876	4.84	0	0	0	0	0	0	0	0
95	0.0629	Q5	0801-1200	988.5	4.63	2.6	1	0	0	0	0	0	0
96	0.0928	Q5	1201-1400	1316.5	3.23	0	0	0	0	0	0	0	0
97	0.0949	Q5	1201-1400	1290	3.38	0	0	0	0	0	0	0	0
98	0.0847	Q5	1201-1400	1344.5	3.28	0	0	0	0	0	0	0	0
99	0.0701	Q5	1201-1400	1332.5	3.31	0	0	0	0	0	0	0	0
100	0.0973	Q5	1201-1400	1296.5	3.39	0	0	0	0	0	0	0	0
101	0.0922	Q5	1201-1400	1268.5	3.71	0	0	0	0	0	0	0	0
104	0.0968	Q5	1401-1500	1445	3.25	0	0	0	0	0	0	0	0
105	0.0761	Q5	1401-1500	1418	2.93	0	0	0	0	0	0	0	0
106	0.076	Q5	1401-1500	1434	3.03	0	0	0	0	0	0	0	0
107	0.0768	Q5	1401-1500	1426	2.98	0	0	0	0	0	0	0	0
108	0.0849	Q5	1401-1500	1442	3.26	0	0	0	0	0	0	0	0
109	0.0827	Q5	1201-1400	1229	3.35	0	0	0	0	0	0	0	0

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Commercial catches of roughhead grenadier, roundnose grenadier, greater argentine, tusk, blue ling, black scabbardfish, ling, and orange roughy in ICES 14 in the period 1999-2022.

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Abstract

Yearly and monthly logbook information, and CPUE distribution from 1999 to 2022 for roughhead grenadier (*Macrourus berglax*; RHG), roundnose grenadier (*Coryphaenoides rupestris*; RNG), greater argentine (*Argentina silus*; ARU), tusk (*Brosme brosme*; USK), blue ling (*Molva dypterygia*; BLI), black scabbardfish (*Aphanopus carbo*; BSF), ling (*Molva molva*; LIN), and orange roughy (*Hoplostethus atlanticus*; ORY), in East Greenland, ICES 14, are presented in this document. Also catches by gear and by division (14a and 14b). Data presented are a mix of targeted catches and bycatch of the Greenland halibut fishery in East Greenland in 14b.

1. Introduction

Commercial trawl and longline fisheries operate in ICES Division 14.b off East Greenland. This document presents information recorded in logbooks of these fisheries in the time period from 1999 to 2022. The species presented here are roughhead grenadier (*Macrourus berglax*; RHG), roundnose grenadier (*Coryphaenoides rupestris*; RNG), greater argentine (*Argentina silus*; ARU), tusk (*Brosme brosme*; USK), blue ling (*Molva dypterygia*; BLI), black scabbardfish (*Aphanopus carbo*; BSF), ling (*Molva molva*; LIN), and orange roughy (*Hoplostethus atlanticus*; ORY). The numbers presented in previous working documents have been updated.

Catch quotas have been set for the following of these species: grenadiers (RNG and RHG combined), tusk, blue ling, and greater argentine. The total allowable catch (TAC) for grenadiers was 3 000 tonnes (t) in 2007, 2 000 t in 2008-2009, and 1 000 tons in 2010-2022. For tusk the TAC was 500 t in 2014 and 1 500 t from 2015-2022. For blue ling the TAC was 500 t in 2014 and no quota has been set since. For greater Argentine the TAC was 10 000 t in 2013-2015 and no quota has been set since. The TAC is set by the Government of Greenland.

2. Materials and Methods

Logbooks have been mandatory for vessels greater than 30 ft (9.4 m) since 2008. Data about all logbooks records are reported to the Greenland Fishery License Authority (GFLK). Trawlers and longliners gather information about their fishery, including effort and location for individual fishing events, and send the data to GFLK on a weekly basis. Data presented here is a mix of targeted catches (greater Argentine fishery from 2015 and 2018 abd tusk fishery from 2014) and bycatch during the fishery for Greenland halibut in ICES Division 14.b (from 1999). From 2005 (except 2006) small catches for grenadiers come from 14a due to the expansion of the Greenland halibut fishery to a norther fishing ground between 67°N and 68°30'N.

3. Results and discussion

Roughhead grenadier (*Macrourus berglax*; RHG)

Only 0.01 t, in 2000, of grenadier were caught between 1999 and 2004. From 2005 to 2013 catches remained very low (mean catches 2005-2013 = 7.8 t), whereas it increased to an average of 71.2 tons between 2014 and 2018. In 2019, catches dropped to only 1 t. Catches have been increasing from 2020 (23.17 t) to 2022 reaching the highest catches since 1999 (85.23t) (Table 1 , 2 and 4, Fig. 1 and 2). From 2014 reported catches of roughhead grenadier on long lines are much higher, which might be linked to the onset of targeted long line fishery after tusk in 2014 (Table 3). There are no explanations for the drastic drop to only 1.0 tons in 2019, which has been reported by only a single vessel. Possibly, this is due to misidentification. Most of the catches are from 14b, a few catches were found years 2013, 2016-2017 and 2021 in 14a, due to the expansion of the Greenland halibut fishery to a northern fishing ground (Table 2, Fig.2 and 3).
From the surveys documents (Nielsen et al., 2019, Nogueira and Christiansen, 2023), it was established that roughhead grenadier is much more common than roundnose grenadier in ICES 14b. Therefore, it is likely that there is misidentification of grenadier species confounding the logbook data of roundnose grenadier and roughhead grenadier. Regardless of this, the TAC of 1.000 tons for grenadiers in East Greenland (roughhead and roundnose combined) is not reached any years.

Roundnose grenadier (*Coryphaenoides rupestris*; RNG)

Catches of roundnose grenadier have been relatively stable (annual mean catch=91.4 tons) throughout the evaluated time period (1999 to 2022) ranging from 30.6 tons (2008) to 167.4 tons (2021) (Table 1 and 5, Fig.1). Most of the catches are also from 14b, a few catches are found from 2005 in 14a, due to the expansion of the Greenland halibut fishery, this year, to a northern fishing ground (Table 2, Fig.4 and 5).The majority of this is caught as bycatch by trawlers, whereas longlines conduct a smaller fraction most of the years, only years 2019 and 2021 catches with lonliners are higher than with trawlers (Table3).
As mentioned for roughhead grenadier, the catch of roudnose grenadier is possibly overestimated due to incorrect species identification.

Greater argentine (*Argentina silus*; ARU)

From 1990 to 2013, there are only reported catches in 2002 (0.4 t). From 2014 to 2022 catches have been very low except years 2017 and 2018 (666.6 t and 425.1 t), which is due to the onset of targeted pelagic trawl fishery for the species since 2015. This targeted fishery ceased in 2019 thus low catches, since then are reported (Table 1, 3 and 6, Fig. 1 and 6).

Tusk (*Brosme brosme*; USK)

Catches of tusk have been low between 1999 to 2013 were much lower (mean annual catch=30.1 tons) compared to catches from 2015 to 2022 (mean annual catch =527.34 tons) (Table 1, 3 and 7, Fig. 1 and 7). The catch is dominated by long lines throughout the time series (Table 3). The increase in catches corresponds with the initiation of targeted fishery in 2014 where TAC was 500 tons, which was increased by the Greenland government to 1500 tons, from 2015 to 2022.

Blue ling (*Molva dypterygia*; BLI)

Catches of blue ling have been low from 1999 to 2009 (annual mean catch =3.2 tons), increasing since then, and picking in 2015 (65.4 t). Catches increased from 2010 (annual mean catch =22.6 tons, Table 1,3 and 8 Fig. 1 and 8). Blue ling was mostly caught in trawl fisheries and the composition between longline and trawl catches remains relatively constant except in 2015, where the largest trawl catch of 65.5 tons was reported (Table 3).

Black scabbardfish (*Aphanopus carbo*; BSF)

Black scabbardfish was only caught in 2010 (30kg) and 2011 (180 kg) in the month of September (Table 1 and 7, Figure 1 and 9).

Ling (*Molva molva*; LIN)

Catches of ling were fluctuating between years with no apparent trend over time (Fig. 7). In 2005, 2006, 2015 and 2016 catches were above 15 tons, whereas catches were below 5 tons in 2000-2003, 2007, 2009-2013 and 2017-2022 (Table 1 , 3 and 10 Fig. 1 and 10). The majority of catches are from trawler, expect in 2015 (Table 3).

Orange roughy (*Hoplostethus antlanticus*; ORY)

Orange roughy was caught only in 2007 and 2010 (0.4 and 0.8 t respectively, Table 1 and 11, Figure 1 and 11).

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Table 1. Total annual commercial catches (tons) of roughhead grenadier (*Macrourus berglax*; RHG), roundnose grenadier (*Coryphaenoides rupestris*; RNG), greater Argentine (*Argentina silus*; ARU), tusk (*Brosme brosme),* blue ling (*Molva dypterygia*; BLI),; USK), black scabbardfish (*Aphanopus carbo*; BSF), ling (*Molva molva*; LIN), and orange roughy (*Hoplostethus atlanticus*; ORY), in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	RHG	RNG	ARU	USK	BLI	BSF	LIN	ORY
1999	0	129.4	0	5.2	0.1	0	8	0
2000	0.01	95.1	0	0	1.4	0	0	0
2001	0	84.5	0	23.3	0.6	0	0.7	0
2002	0	54.7	0.45	0	0.2	0	0.3	0
2003	0	54.2	0	2.2	2.6	0	0.2	0
2004	0	101.4	0	17	7	0	7.1	0
2005	20	61.4	0	39.3	5.6	0	17.7	0
2006	4.4	64.4	0	102.2	5.9	0	18.6	0
2007	3.8	43	0	18.7	1.3	0	1.5	0.4
2008	11.4	30.6	0	20.7	4.8	0	11	0
2009	3.5	44.2	0	15.9	5.4	0	4.6	0
2010	11.4	59.8	0	15.1	7.4	0.03	3.1	0.8
2011	2.2	136.4	0	91.1	8	0.2	4.8	0
2012	13.4	123.3	0	74.6	13	0	5.1	0
2013	0.3	128	0	27.6	15.7	0	2.4	0
2014	61.6	99.7	4.16	167.3	13.9	0	8	0
2015	38.2	139.7	12.21	878.8	65.4	0	20.4	0
2016	75.1	63.5	16.62	562.4	8.6	0	15.2	0
2017	92.8	93.1	666.75	763.2	11.9	0	4.5	0
2018	89.1	128.6	425.19	684.5	33.6	0	4.6	0
2019	0.9	157.1	3.37	386.6	45.4	0	1.9	0
2020	23.2	46.9	28.1	216	26.8	0	1.5	0
2021	55.5	167.4	15.39	720.1	17	0	1.4	0
2022	86.2	134	0.82	367.2	27.3	0	0.7	0

Table 2. Total annual commercial catches (tons) of roughhead grenadier (*Macrourus berglax*; RHG), roundnose grenadier (*Coryphaenoides rupestris*; RNG), greater Argentine (*Argentina silus*; ARU), tusk (*Brosme brosme),* blue ling (*Molva dypterygia*; BLI),; USK), black scabbardfish (*Aphanopus carbo*; BSF), ling (*Molva molva*; LIN), and orange roughy (*Hoplostethus atlanticus*; ORY), in the Greenlandic EEZ zone of ICES in Division 14a and 14b from 1999 to 2022.

	RHG		RNG		ARU	USK		BLI		BSF		LIN	ORY	
Year	14a	14b	14a	14b	14b	14a	14b	14a	14b	14a	14b	14b	14a	14b
1999	0	0	0	129.41	0	0	5.19	0	0.15	0	0	8.05	0	0
2000	0	0.01	0	95.14	0	0	0	0	1.4	0	0	0	0	0
2001	0	0	0	84.52	0	0	23.34	0	0.56	0	0	0.73	0	0
2002	0	0	0	54.73	0.45	0	0	0	0.24	0	0	0.34	0	0
2003	0	0	0	54.24	0	0	2.19	0	2.62	0	0	0.2	0	0
2004	0	0	0	101.45	0	0	16.95	0	7.05	0	0	7.1	0	0
2005	0	19.99	0.18	61.22	0	0	39.32	0	5.64	0	0	17.69	0	0
2006	0	4.37	0	64.42	0	0	102.19	0	5.92	0	0	18.62	0	0
2007	0	3.85	0.01	43.01	0	0	18.66	0	1.27	0	0	1.53	0	0.4
2008	0	11.41	0	30.59	0	0	20.71	0	4.83	0	0	11.05	0	0
2009	0	3.48	0.09	44.07	0	0	15.93	0	5.38	0	0	4.64	0	0
2010	0	11.38	0.04	59.76	0	0	15.1	0	7.45	0	0.03	3.14	0	0.82
2011	0	2.21	0.18	136.25	0	0	91.11	0	7.95	0	0.18	4.79	0	0
2012	0	13.41	0.51	122.82	0	0	74.6	0	13.02	0	0	5.1	0	0
2013	0.01	0.26	0.09	127.94	0	0	27.63	0	15.7	0	0	2.36	0	0
2014	0	61.61	0.9	98.81	4.16	0	167.33	0	13.86	0	0	7.97	0	0
2015	0	38.19	0	139.69	12.21	0	878.76	0	65.42	0	0	20.45	0	0
2016	0.58	74.53	0	63.5	16.62	0	562.4	0	8.63	0	0	15.19	0	0
2017	0.04	92.77	0.44	92.65	666.75	0	763.16	0	11.94	0	0	4.48	0	0
2018	0	89.11	1.7	126.92	425.19	0	684.53	0.03	33.55	0	0	4.58	0	0
2019	0	0.94	0.16	156.93	3.37	0	386.65	0	45.41	0	0	1.89	0	0
2020	0	23.17	0.49	46.45	28.1	0	215.99	0	26.76	0	0	1.53	0	0
2021	1.96	53.54	1.39	166.04	15.39	0	720.1	0	17.04	0	0	1.42	0	0
2022	1	85.25	22.7	111.28	0.82	0	367.24	0	27.29	0	0	0.71	0	0

Table 3. Total annual commercial catches (tons) by gear of roughhead grenadier (*Macrourus berglax*; RHG), roundnose grenadier (*Coryphaenoides rupestris*; RNG), greater Argentine (*Argentina silus*; ARU), tusk (*Brosme brosme),* blue ling (*Molva dypterygia*; BLI),; USK), black scabbardfish (*Aphanopus carbo*; BSF), ling (*Molva molva*; LIN), and orange roughy (*Hoplostethus atlanticus*; ORY), in the Greenlandic EEZ zone of ICES (Divisions 14a and 14b) from 1999 to 2022.

	RHG			RNG			ARY	USK				BLI				BSF	LIN			ORY
Year	BTM	LL	GN	BTM	LL	Other	BTM	BTM	GN	LL	Other	BTM	GN	LL	Other	BTM	BTM	LL	Other	BTM
1999	0	0	0	129.37	0.04	0	0	1.02	0	4.17	0	0	0	0.15	0	0	8.05	0	0	0
2000	0.01	0	0	78.04	17.1	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0
2001	0	0	0	71.96	12.56	0	0	23.34	0	0	0	0.56	0	0	0	0	0.73	0	0	0
2002	0	0	0	52.01	0	2.72	0.45	0	0	0	0	0.24	0	0	0	0	0.34	0	0	0
2003	0	0	0	54.24	0	0	0	2.19	0	0	0	2.62	0	0	0	0	0.2	0	0	0
2004	0	0	0	101.45	0	0	0	16.95	0	0	0	7.05	0	0	0	0	7.1	0	0	0
2005	19.99	0	0	61.4	0	0	0	39.12	0	0	0.2	5.64	0	0	0	0	17.69	0	0	0
2006	4.37	0	0	64.42	0	0	0	100.3	0	1.89	0	5.92	0	0	0	0	18.62	0	0	0
2007	3.85	0	0	42.37	0.65	0	0	11.39	0	7.27	0	0.27	0	1.01	0	0	1.53	0	0	0.4
2008	11.41	0	0	28.91	1.69	0	0	12.74	0	7.97	0	3.64	0	1.19	0	0	10.91	0.14	0	0
2009	3.48	0	0	37.03	0	7.13	0	0	0	0.04	15.89	3.91	0	0	1.48	0	3.41	0	1.22	0
2010	11.38	0	0	53.5	6.31	0	0	0	0	13.94	1.17	2.29	0	5.16	0	0.03	3.14	0	0	0.82
2011	2.21	0	0	130.91	5.52	0	0	0.03	0	91.07	0	5.73	0	2.22	0	0.18	2.98	1.81	0	0
2012	13.34	0.06	0	115.68	7.65	0	0	0	0	59.51	15.09	4.92	0	7.83	0.27	0	4.46	0.64	0	0
2013	0.26	0.01	0	125.89	2.13	0	0	0.46	0	14.37	12.81	15.7	0	0	0	0	0.02	1.86	0.47	0
2014	16.03	21.18	24.4	94.04	5.67	0	4.16	0.04	4.13	163.17	0	8.76	0.74	4.36	0	0	5.39	2.58	0	0
2015	3.48	34.71	0	104.9	34.79	0	12.21	0.57	0	876.76	1.43	64.84	0	0.58	0	0	2.57	17.87	0	0
2016	4.72	70.39	0	55.12	8.38	0	16.62	2.45	0	559.94	0	7.13	0	1.51	0	0	2.09	13.1	0	0
2017	0.41	92.4	0	87.82	5.27	0	666.75	1	0	762.17	0	6.98	0	4.95	0	0	1.02	3.46	0	0
2018	0.6	88.51	0	123.06	5.56	0	425.19	101.44	0	583.09	0	31.9	0	1.68	0	0	4.05	0.52	0	0
2019	0.94	0	0	61.92	95.17	0	3.37	2.25	0	384.4	0	26.79	0	18.62	0	0	1.71	0.17	0	0
2020	8.59	14.57	0	43.42	3.51	0	28.1	2.84	0	213.15	0	24.89	0	1.87	0	0	1.3	0.23	0	0
2021	10.88	44.62	0	54.97	112.46	0	15.39	4.03	0	716.08	0	10.71	0	6.33	0	0	0.88	0.54	0	0
2022	16.96	69.29	0	81.98	51.99	0	0.82	1.47	0	365.77	0	21.73	0	5.56	0	0	0.71	0	0	0

Table 4. Total monthly commercial catches (tons) of roughhead grenadier (RHG) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0.01	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	3.97	10.14	0.22	5.66	0	0	0
2006	0	0	0	0	1.3	1.76	0.21	1.1	0	0	0	0
2007	0	0	0	0	1.69	1.53	0.58	0	0.05	0	0	0
2008	0	0	0	0.39	1.9	1.53	2.71	2.68	1.42	0.77	0	0
2009	0	0	0.13	0.69	1.42	0.37	0	0.05	0.69	0	0.14	0
2010	0	0	0	0	2.16	1	4.05	1.2	0.13	2.82	0	0
2011	0	0	0	0	0	0	0.86	1.35	0	0	0	0
2012	0	0	0	9.05	4.19	0.17	0	0	0	0	0	0
2013	0	0	0	0	0	0.01	0.26	0	0	0	0	0
2014	0	0	0	21.36	28.94	0.34	7.18	0.19	0	0	0	3.61
2015	0	0	17.07	17.65	0	0	0	0	3.48	0	0	0
2016	0.8	25.33	30.85	13.41	0	2.45	1.86	0.4	0	0	0	0
2017	0	0	51.1	41.3	0	0	0	0	0	0.41	0	0
2018	0	0	50.48	37.1	1.53	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0.33	0.62	0	0
2020	0	0.87	0.83	0.54	0.91	2.65	13.59	2.54	0.54	0.62	0.08	0
2021	0	0	0	0.04	3.9	12.55	27.24	8	0.88	1.03	1.32	0.54
2022	0	0.2	15.07	14.1	1.17	0.21	0.58	5.86	8.79	39.62	0.66	0
Total	0.8	26.4	165.53	155.63	49.11	28.54	69.27	23.59	21.97	45.89	2.2	4.15

Table 5. Total monthly commercial catches (tons) of roundnose grenadier (RNG) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	12.78	23.72	20.2	23.52	0.15	5	4.42	4.75	7.04	14.47	11.53	1.83
2000	0.2	21.28	13.37	9.63	5.66	11.76	8.06	10.77	8.27	1.06	3.78	1.29
2001	0	0.01	1.8	0.68	2.71	17.96	26.91	23.9	3.4	2.43	2.37	2.35
2002	0.04	0	2.26	5	3.59	16.32	18.52	4.7	0.94	0.34	2.29	0.73
2003	0	0	1.06	3.25	11.09	10.74	9.78	7.21	4.45	4.68	1.72	0.25
2004	0	0	0.05	7.45	6.31	19.24	31.03	20.36	7.6	3.84	3.31	2.25
2005	0	0	0.04	1.48	2.63	16.29	27.05	10.1	3.06	0.92	0	0.06
2006	0	0.02	0.06	3.51	14.62	8.5	6.52	25.41	2.85	0.38	2.15	0.4
2007	0	0.06	0.26	3.77	12.82	9.06	8.16	4.63	1.59	1.23	0.98	0.45
2008	1.51	0.05	0.2	5.55	6.61	6.32	3.33	3.68	1.43	1.6	0.31	0
2009	0	0	0.86	3.48	9.3	8.48	9.61	4.73	3.55	1.97	1.83	0.35
2010	0	0	0.46	7.43	12.05	8.88	10.28	9.35	6.99	1.35	2.99	0.03
2011	0	0	2.55	7.34	18.88	42	36.48	15.84	5.48	3.8	3.02	1.03
2012	0	0	2.19	9.19	35.59	29.27	19.62	19.94	4.02	3.22	0.26	0
2013	0	0	3.02	15.42	27.68	38.25	21.04	12.41	1.25	5.8	2.89	0.26

2014	0	0.54	4.22	11.99	16.57	19.43	16.31	5.47	8.45	12.14	1.46	3.13
2015	3	0.58	22.35	42.83	16.88	4.6	12.83	12.27	13.27	3.24	1.73	6.09
2016	0	0.81	4.6	10.54	14.43	10.7	15.79	4.53	1.73	0.37	0	0
2017	0	0.67	11.38	17.9	17.13	8.15	20.11	7.83	3.51	5.44	0.41	0.56
2018	0	1.68	17.43	23.29	9.42	11.06	46.75	16.52	1.18	1.26	0.04	0
2019	0	0.73	10.4	10.88	2.45	77.73	38.78	6.88	3.17	6.02	0.06	0
2020	0	0.25	3.96	2.16	4.91	6.12	6.54	8.29	11.34	0.11	1.3	1.96
2021	0	0	0	5.79	15.16	63.52	32.23	27.81	7.88	5.05	9.44	0.54
2022	0.03	0.49	2.68	3.46	6.47	30.82	49.23	12.97	24.58	1	0.61	1.64
Total	17.56	50.89	125.4	235.54	273.11	480.2	479.38	280.35	137.03	81.72	54.48	25.2

Table 6. Total monthly commercial catches (tons) of greater argentine (ARU) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	12.78	23.72	20.2	23.52	0.15	5	4.42	4.75	7.04	14.47	11.53	1.83
2000	0.2	21.28	13.37	9.63	5.66	11.76	8.06	10.77	8.27	1.06	3.78	1.29
2001	0	0.01	1.8	0.68	2.71	17.96	26.91	23.9	3.4	2.43	2.37	2.35
2002	0.04	0	2.26	5	3.59	16.32	18.52	4.7	0.94	0.34	2.29	0.73
2003	0	0	1.06	3.25	11.09	10.74	9.78	7.21	4.45	4.68	1.72	0.25
2004	0	0	0.05	7.45	6.31	19.24	31.03	20.36	7.6	3.84	3.31	2.25
2005	0	0	0.04	1.48	2.63	16.29	27.05	10.1	3.06	0.92	0	0.06
2006	0	0.02	0.06	3.51	14.62	8.5	6.52	25.41	2.85	0.38	2.15	0.4
2007	0	0.06	0.26	3.77	12.82	9.06	8.16	4.63	1.59	1.23	0.98	0.45
2008	1.51	0.05	0.2	5.55	6.61	6.32	3.33	3.68	1.43	1.6	0.31	0
2009	0	0	0.86	3.48	9.3	8.48	9.61	4.73	3.55	1.97	1.83	0.35
2010	0	0	0.46	7.43	12.05	8.88	10.28	9.35	6.99	1.35	2.99	0.03
2011	0	0	2.55	7.34	18.88	42	36.48	15.84	5.48	3.8	3.02	1.03
2012	0	0	2.19	9.19	35.59	29.27	19.62	19.94	4.02	3.22	0.26	0
2013	0	0	3.02	15.42	27.68	38.25	21.04	12.41	1.25	5.8	2.89	0.26
2014	0	0.54	4.22	11.99	16.57	19.43	16.31	5.47	8.45	12.14	1.46	3.13
2015	3	0.58	22.35	42.83	16.88	4.6	12.83	12.27	13.27	3.24	1.73	6.09
2016	0	0.81	4.6	10.54	14.43	10.7	15.79	4.53	1.73	0.37	0	0
2017	0	0.67	11.38	17.9	17.13	8.15	20.11	7.83	3.51	5.44	0.41	0.56
2018	0	1.68	17.43	23.29	9.42	11.06	46.75	16.52	1.18	1.26	0.04	0
2019	0	0.73	10.4	10.88	2.45	77.73	38.78	6.88	3.17	6.02	0.06	0
2020	0	0.25	3.96	2.16	4.91	6.12	6.54	8.29	11.34	0.11	1.3	1.96
2021	0	0	0	5.79	15.16	63.52	32.23	27.81	7.88	5.05	9.44	0.54
2022	0.03	0.49	2.68	3.46	6.47	30.82	49.23	12.97	24.58	1	0.61	1.64
Total	17.56	50.89	125.4	235.54	273.11	480.2	479.38	280.35	137.03	81.72	54.48	25.2

Table 7. Total monthly commercial catches (tons) of tusk (USK) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	0	0	0	0	0	0	4.72	0.48	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	4.72	5.52	10.93	1.58	0.6	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	2.19	0	0	0
2004	0	0	0	0	0.04	0.04	2.28	1.21	4.5	2.35	5.4	1.14
2005	0	0	1.77	0.07	1.64	3.25	3.3	0.32	6.18	9.86	12.73	0.2
2006	0	0	2.45	2.55	4.08	0.8	0.47	6.78	1.05	1.55	3.11	79.4
2007	0	0	0	0	0.03	3.95	7.45	0.23	4.28	2.73	0	0
2008	12.74	0	0	0	1.47	0.6	0	3.69	0	2.2	0	0
2009	0.04	0	0	0.97	1.15	0.14	5.48	8.16	0	0	0	0
2010	0	0	0	0	0.1	0.7	4.67	5.57	4.06	0	0	0
2011	0	0	0.03	0	2.87	5.53	12.92	5.97	15.28	48.51	0	0
2012	0	0	0	0	1.8	13.49	9.99	33.88	11.55	3.88	0	0
2013	0	0	1.34	15.99	1.3	0.75	0.9	0	0.35	6.2	0.8	0
2014	0	0.04	0	4.06	1.52	53.2	29.16	49.65	29.27	0.39	0.04	0
2015	43.24	0	0	0	9.42	46.12	59.75	468.18	251.98	0	0.07	0
2016	0	0	1.38	24.23	48.96	95.1	180.42	34.05	147.58	13.72	3.62	13.3
2017	11.38	44.1	151	1.24	0.14	240	75.79	95.68	103.94	0.98	15.74	22.7
2018	0.79	0	108	52.71	7.96	296.1	44.34	23.54	113.42	9.33	5.26	23.5
2019	8.89	39.2	11.9	59.88	15.14	113.2	92.04	39.91	4.36	0.4	0.12	1.58
2020	7.6	9.22	5.85	86.3	34.46	4.82	45.9	10.57	2.7	3.26	0.46	4.86
2021	0	3.66	25.7	54.43	200.32	198.4	157.48	58.34	10.11	7.02	4.66	0
2022	0.15	0.07	18.2	48.89	28.76	16.87	8.19	4.2	68.78	156.3	3.31	13.5
Total	84.83	96.3	328	351.32	361.16	1093	749.97	855.93	792.51	270.3	55.92	160

Table 8. Total monthly commercial catches (tons) of blue ling (BLI) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	0	0	0	0	0	0	0.15	0	0	0	0	0
2000	0	0	0	0	0	0	0	0.16	1.07	0	0.16	0
2001	0	0	0	0	0	0	0.56	0	0	0	0	0

2002	0	0	0.1	0.03	0	0.06	0	0	0.05	0	0	0
2003	0	0	0	0	0.26	0.14	0.95	1.27	0	0	0	0
2004	0	0	0	0.43	0.55	0.15	2.16	1.01	0.83	0.82	0.22	0.88
2005	0	0	0	1	0.13	1.27	2.07	0.38	0.8	0	0	0
2006	0	0	0	0	0	0	0	0.35	0	0.54	1.35	3.67
2007	0	0	0	0	0	0.19	0	0.27	0.74	0.08	0	0
2008	2.83	0	0	0	0.2	0.12	0	0.81	0.09	0.73	0.05	0
2009	0	0	0	0.47	2.7	2.03	0	0	0.18	0	0	0
2010	0	0	0	0	0.44	0.19	0	1.55	4.73	0.26	0.22	0.06
2011	0	0	0.07	0	0.33	2.44	0.22	0.95	0.9	1.96	0.96	0.12
2012	0	0	0.67	2.1	1.82	1.26	0.06	1.93	3.32	1.88	0	0
2013	0	0	1.11	1.09	1.22	0.3	0.15	2.1	0.1	6.98	2.65	0
2014	0	0.59	1.44	0.57	2.13	1.88	0.47	2.88	1.34	2.37	0	0.19
2015	0	1.52	1.92	0.46	0.63	0.4	0.71	0.08	26.05	32.91	0	0.74
2016	0	1	0.92	0.44	1.41	0.13	0.33	0	4.4	0	0	0
2017	0	0.37	3.72	1.81	0.08	0.79	2.1	0.6	1.24	1.23	0	0
2018	1.65	0.61	3.34	8.82	1.77	0.22	0.51	0.1	0.65	15.01	0.91	0
2019	0	0.14	1.12	0.1	0.2	0.58	16.79	6.81	7.24	11.5	0.34	0.6
2020	0	0.27	0.99	0.14	0.2	0.95	4.54	3.46	5.23	5.62	5.38	0
2021	0.27	0	0	0.03	0.03	5.09	5.61	0.23	0.83	1.33	2.51	1.11
2022	0.62	0.11	0.75	0	0.06	0.57	0	0.07	3.98	16.81	2.87	1.43
Total	5.37	4.61	16.15	17.49	14.16	18.76	37.38	25.01	63.77	100.03	17.62	8.8

Table 9. Total monthly commercial catches (tons) of black scabbardfish (BSF) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0.03	0	0	0
2011	0	0	0	0	0	0	0	0	0.18	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0

2021	0	0	0	0	0	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0.21	0	0	0

Table 10. Total monthly commercial catches (tons) of ling (LIN) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	0	0	0	0	0	0.16	0.76	0.57	0.58	2.04	3.83	0.1
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0.52	0.22	0	0	0
2002	0	0	0	0	0	0.25	0.08	0	0	0	0	0
2003	0	0	0	0	0.12	0	0	0	0	0.06	0.03	0
2004	0	0	0	0	0.06	0.13	0.41	0.39	0.52	5.6	0	0
2005	0	0	0.06	0	2.69	0.07	0	4.05	0.7	8.39	1.73	0
2006	0	0	0	0	0.1	0.05	0	0.25	0	0	0	18.22
2007	0	0	0	0.4	0.21	0.16	0.43	0.34	0	0	0	0
2008	10.09	0	0	0	0.14	0	0	0.82	0	0	0	0
2009	0	0	0	0	1.68	0.85	1.26	0.52	0.11	0.22	0	0
2010	0	0	0.11	0.52	0.73	0.11	0.11	0	0	0	1.55	0
2011	0	0	0.62	0.78	0	0	1.64	1.76	0	0	0	0
2012	0	0	0.24	0.2	1.08	0.27	0.09	2.22	0.67	0.1	0.24	0
2013	0	0	0.02	1.36	0	0	0	0	0	0.97	0	0
2014	0	0	0	0.02	0	2.29	3.02	2.44	0.21	0	0	0
2015	9.45	0.11	0	0	0.72	1.9	1.76	3.42	3.09	0	0	0
2016	0	0	0	0.36	0.09	3.54	8.5	0.13	0.95	0.35	0	1.28
2017	0.57	0.34	0	0.36	0.23	0.86	0.74	1.18	0.21	0	0	0
2018	0	0.54	0.07	0	0	0.66	0	3.21	0.11	0	0	0
2019	0	0	0	0	0	0.03	0.04	0.26	0	0	1.56	0
2020	0	0.17	0	0.1	0.13	0.03	0	0	0	0	0	1.1
2021	0	0.13	0.06	0.23	0.45	0.08	0.01	0.03	0	0	0.43	0
2022	0.04	0	0.08	0	0	0.03	0.36	0.2	0	0	0	0
Total	20.15	1.29	1.26	4.33	8.43	11.47	19.21	22.31	7.37	17.73	9.37	20.7

Table 11. Total monthly commercial catches (tons) of orange roughy (ORY) in the Greenlandic EEZ zone of ICES 14 from 1999 to 2022.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0.32	0.08	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0.82	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0

2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0.32	0.9	0	0	0	0	0	0

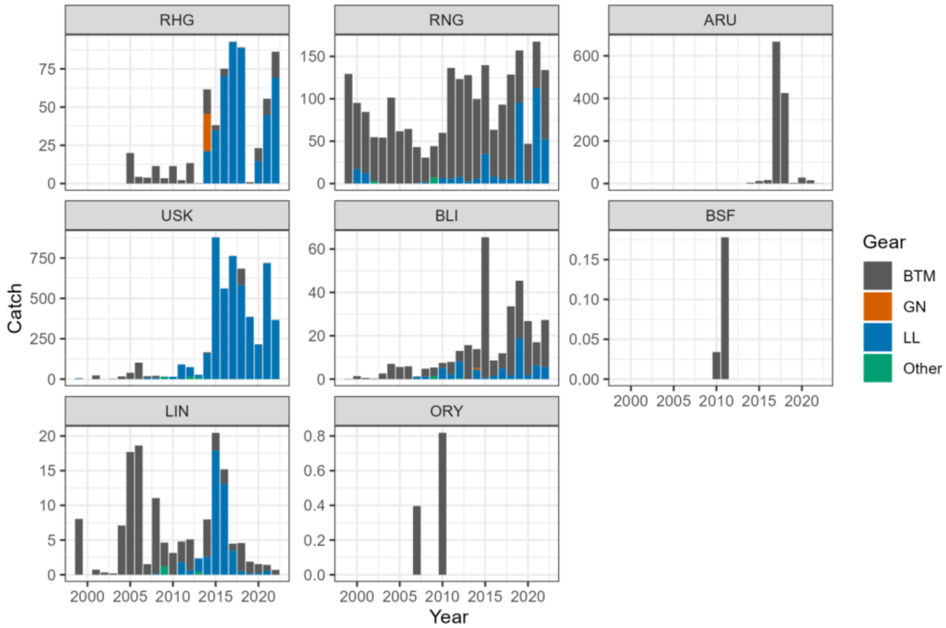

Figure 1. Total annual commercial catches by gear, in tonnes (t) of roughhead grenadier (RHG), roundnose grenadier (RNG), greater argentine (ARU), tusk (USK), blue ling (BLI), black scabbardfish (BSF), ling (LIN), and orange roughy (ORY)in the Greelandic EEZ zone of ICES 14 from 1999 to 2022. Note the different scales of the y axes. Catches for black scabbardfish and orange roughy were very low and can be seen in Table 1.

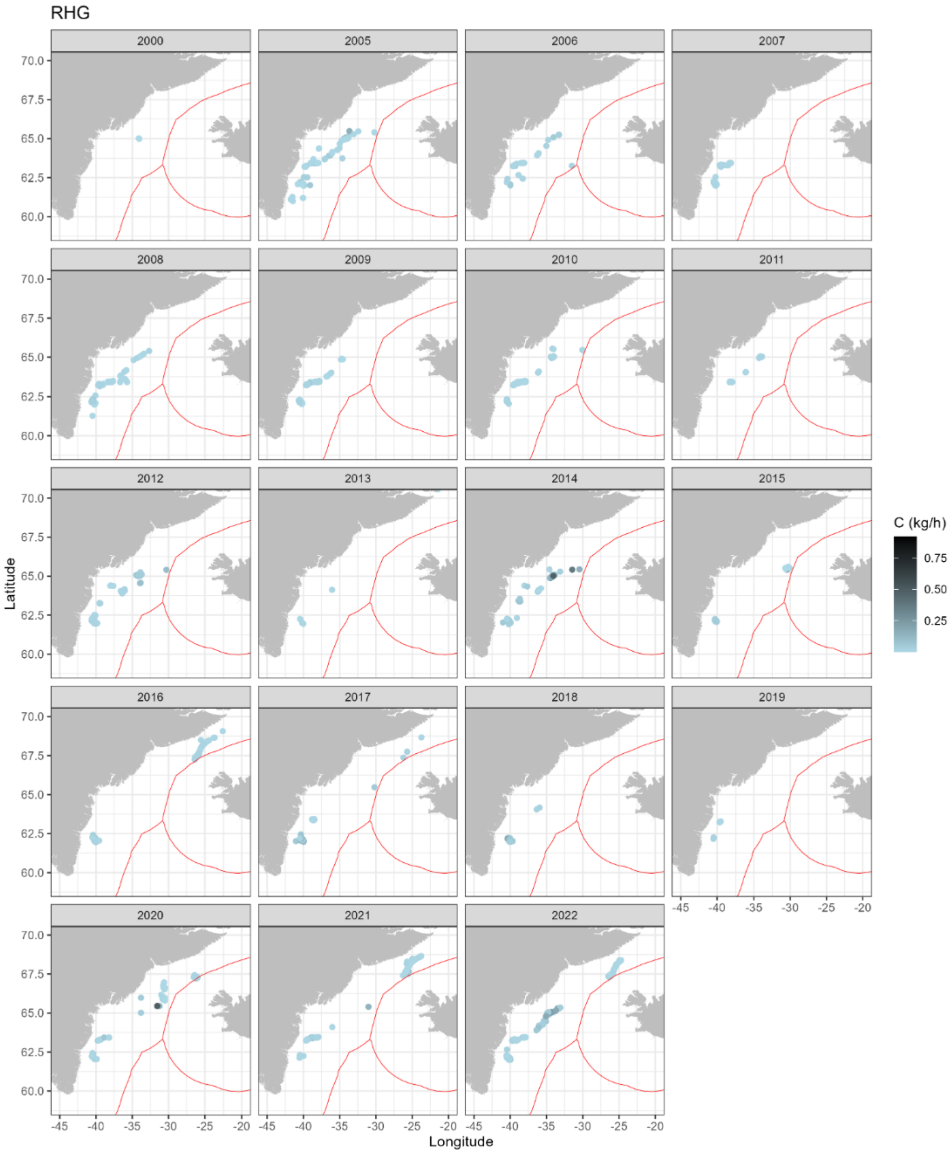

Figure 2: Roughhead grenadier (*Macrourus berglax*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

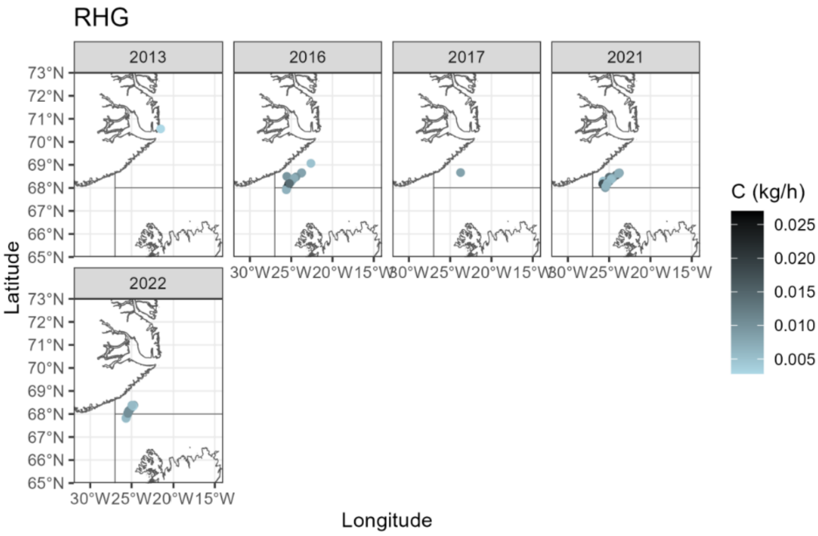

Figure 3: Roughhead grenadier (*Macrourus berglax*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.a.

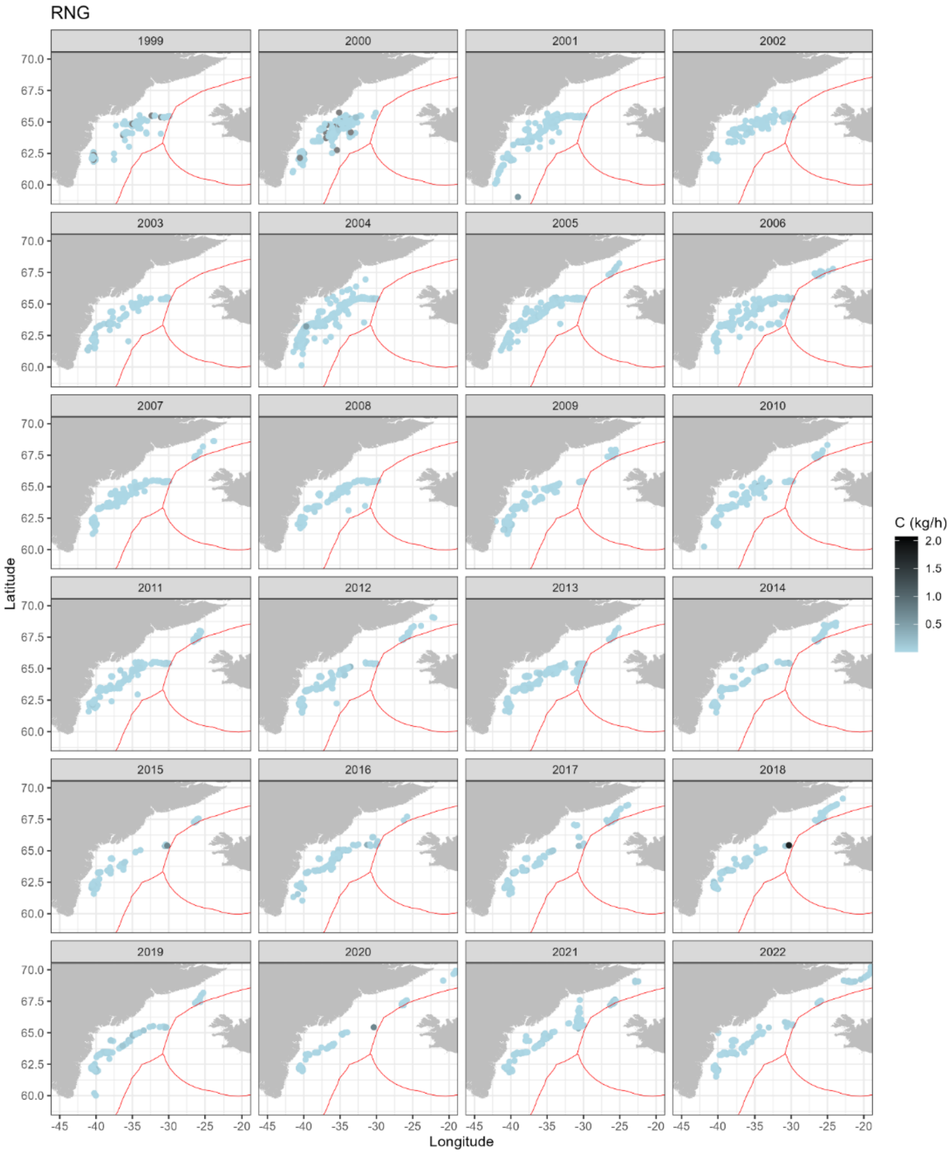

Figure 4: Roundnose grenadier (*Coryphaenoides rupestris*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

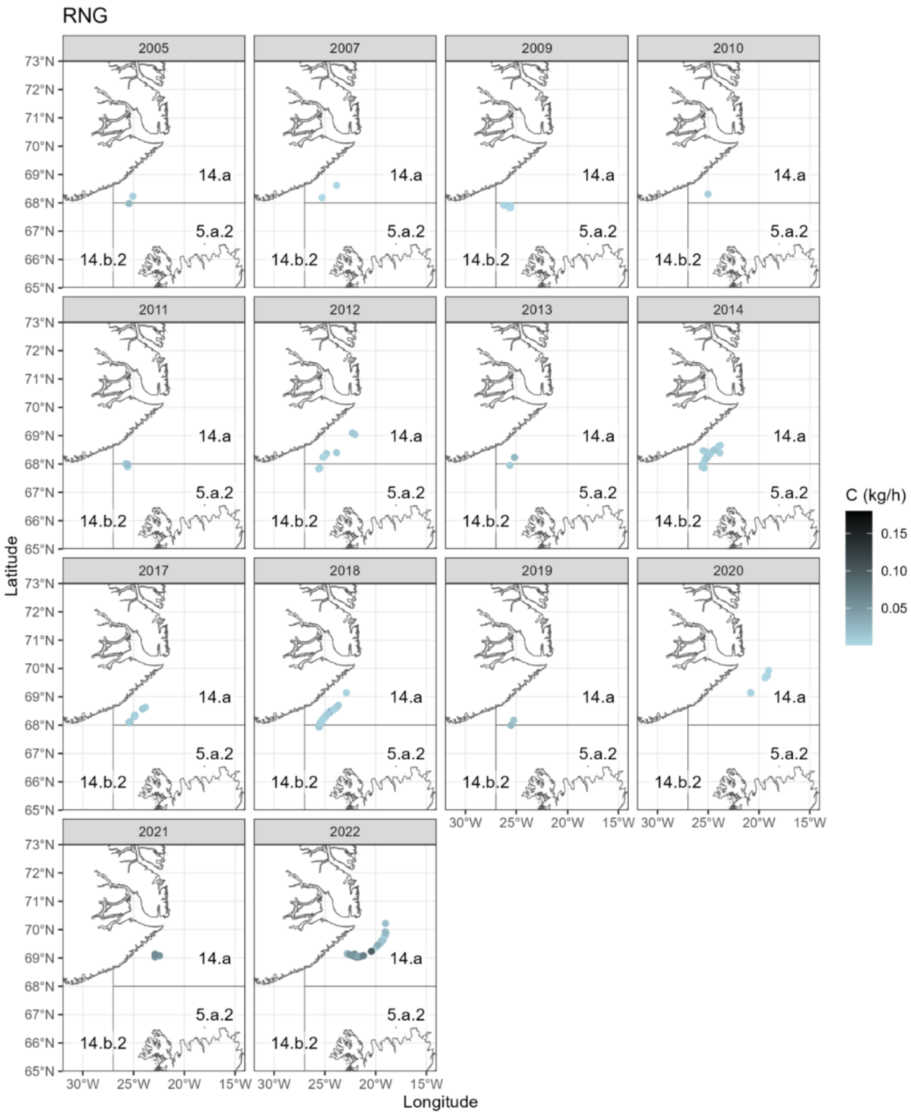

Figure 5: Roundnose grenadier (*Coryphaenoides rupestris*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.a.

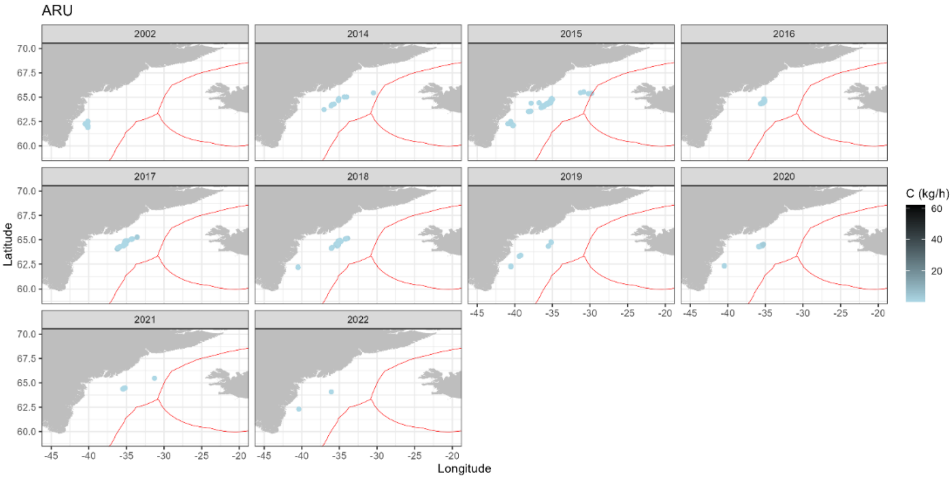

Figure 6: Greater argentine (*Argentina silus*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

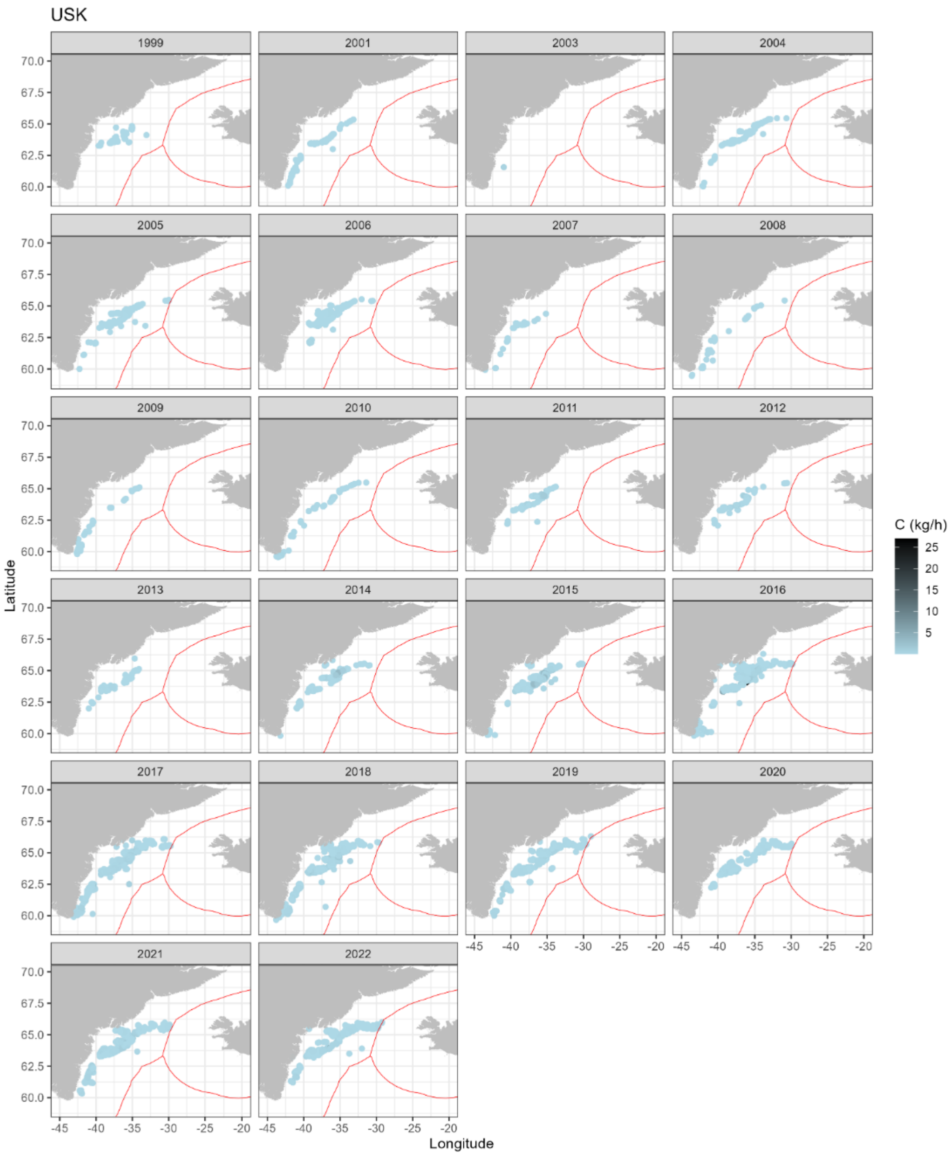

Figure 7: Tusk (*Brosme brosme*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

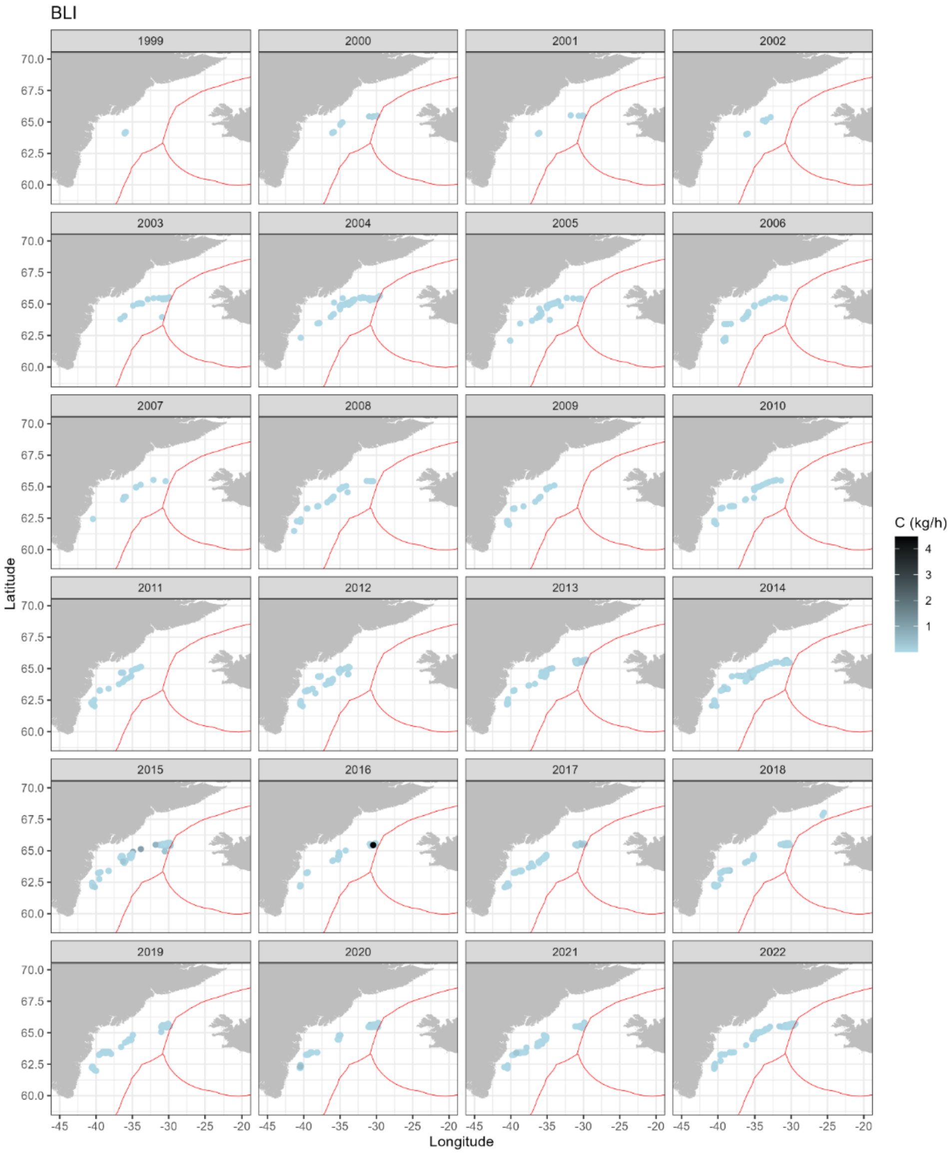

Figure 8: Blue ling (*Molva dypterygia*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

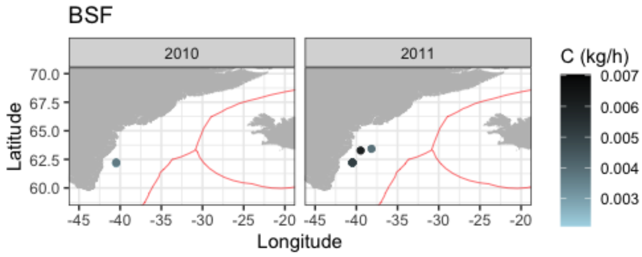

Figure 9: Black scabbardfish (*Aphanopus carbo*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

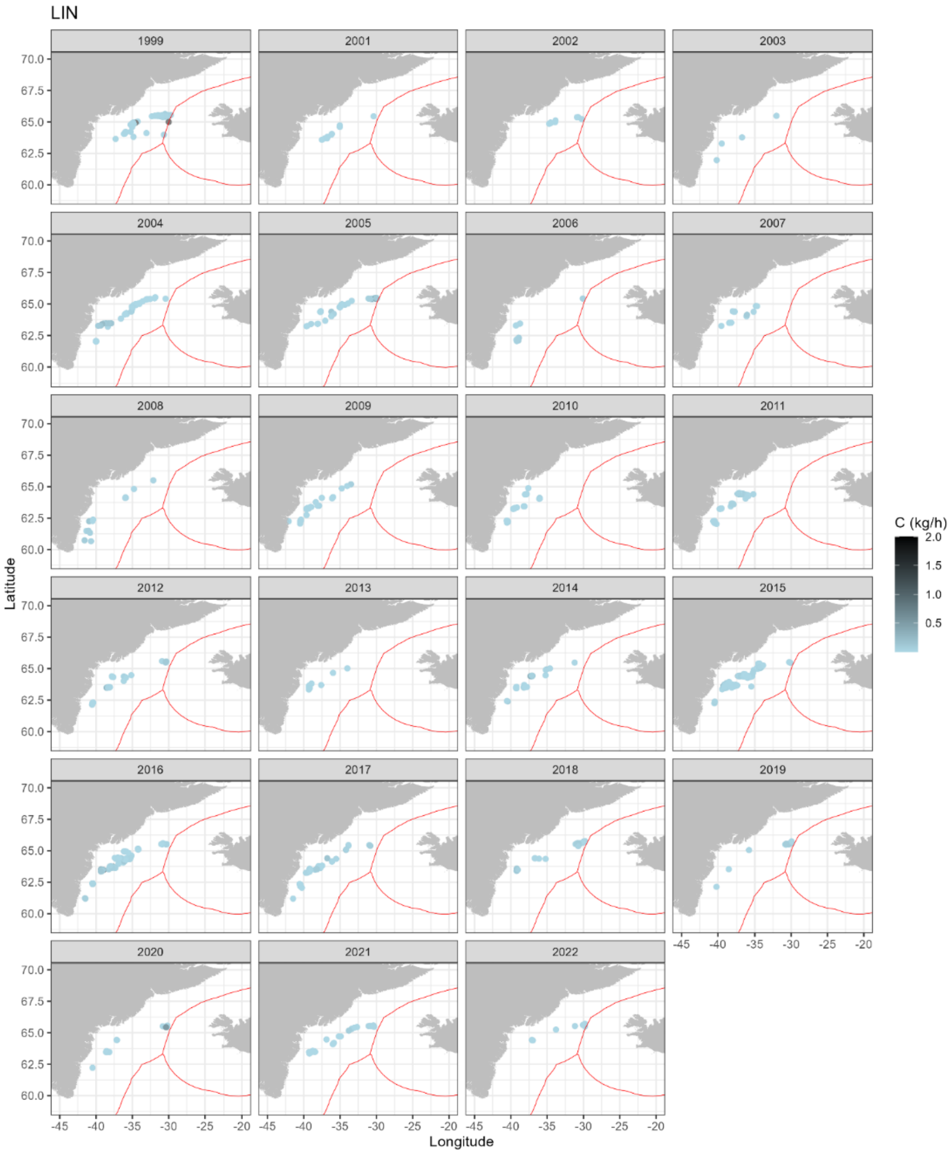

Figure 10: Ling (*Molva molva*) CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

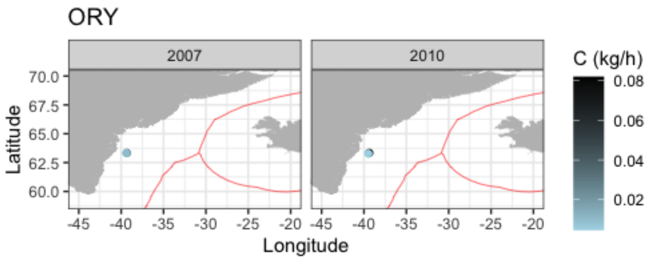

Figure 11: Orange roughy (*Hoplostethus antlanticus)* CPUE (kg/h) distribution in the Greenlandic EEZ of ICES 14.b.

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Not to be cited without prior reference to the authors

Refining stock distribution of the current bli.27.nea ICES assessment unit, based on new evidence of genetic and demographic population structure

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Working document

1. Background

Blue ling (*Molva dypterygia*) is caught over a wide area in northeast Atlantic. At present there are three stock areas for blue ling within WGDEEP (bli.27.nea, bli.27.5b67 and bli.27.5a14).

The stock area bli.27.nea consists of subareas 1, 2, 8, 9, 12 and divisions 3a and 4.a. Historically (within WGDEEP) it was defined as the combination of areas where some blue ling landings were reported from bycatch fisheries without major directed fisheries. Geographically, this stock area is split in three regions (Figure 1). Subareas 8 and 9 is the southernmost. New information suggests that landings from subareas 8 and 9 are Spanish ling (*Molva macrophthalma*) and historical records of blue ling are questionable, see section with Figure 2. Therefore, landings of blue ling from these subareas have been attributed to this Spanish ling since 2010 and, accordingly, the landing tables of the assessment unit bli.27.nea for subareas 8 and 9 have not been updated. There is a need for information and suitable identification sheets to be provided to fisheries for landings from these subareas to be reported as the right species (*M. macrophthalma*, Spanish, FAO code SLI).

Subarea 12 includes parts of the Mid-Atlantic Ridge (in ICES divisions 12.a.1, 12.a.4 and 12.c) and the western slope of the Hatton Bank (in ICES Division 12.b). Since 2014, landings from Subarea 12 have decreased from 80 to 0 tons in 2022. However, based upon the continuity of bathymetric features and lesser abundance, blue ling from the western Hatton Bank (Division 12.b) is likely to be related to those from the northern Hatton Bank (ICES Division 6.b) and blue ling from other divisions of Subarea 12 is more likely to be related to those from Icelandic and east Greenland waters. Following this, it would be more appropriate that blue ling in Division 12.b is combined with stock unit bli.27.5b67, forming a new unit bli.27.5b6712b). Other divisions of 12 should be added to the stock unit bli.5a14, becoming bli.27.5a12ac14.

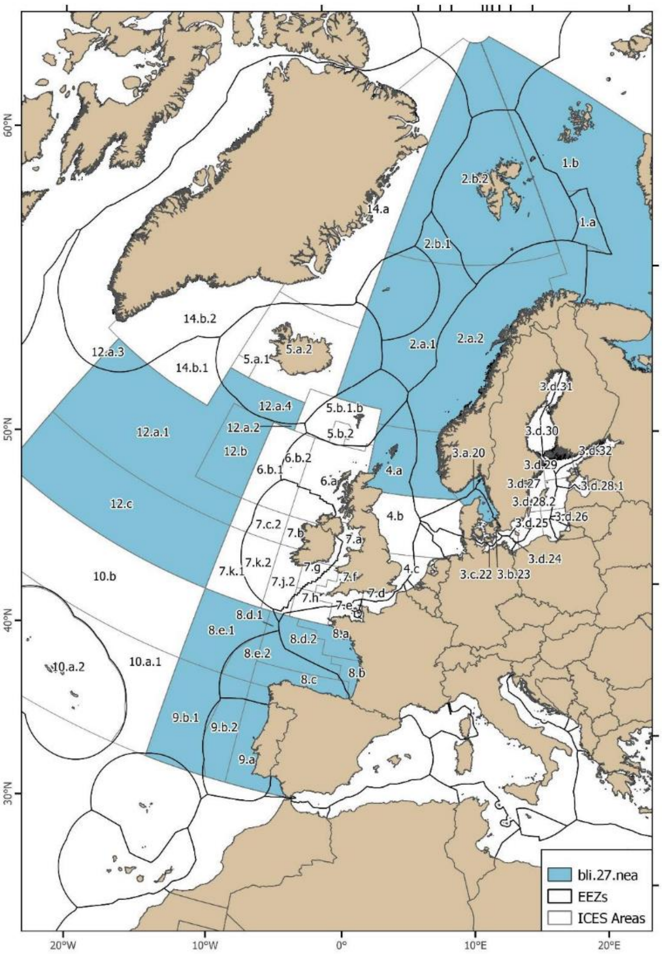

Figure 1. Map showing ICES areas covering the stock unit of Blue ling in subareas 1, 2, 8, 9, 12 and divisions 3a and 4.a (bli.27.nea).

In subareas 1, 2 and divisions 3a and 4a, blue ling inhabit the components of Barents Sea, the western slope of northern Norway, North Sea and the Skagerrak, where the bulk of the catch is from Norwegian fisheries in subareas 2a and 4a. Catches in the North Sea (Subarea 4) come from the Norwegian deep, in the eastern side of the North Sea. There are also some small catches reported from Division 4.b (Denmark and Germany).

In recent years, landings from this stock area are exclusively from subareas 1,2,4 and Division 3a. Norway contributes by far to the landings in Divisions 2.a (77%) and 4.a (77%).

There were landings reported to Intercatch from subareas 8 and 9 in 2022. These landings represent 11% of the total landings from the stock area (75 tonnes). These catches are from France (15%) and Spain (85%). Such landings are ascribed to *M. macrophthalma* and have not been included in the bli.27.nea assessment since 2010. The allocation of catch from Subarea 8 of the Spanish ling comes from the French EVHOE survey, where all individuals of the genus *Molva* caught are checked for correct taxonomic identification. There is a clear distinguishing criterion between blue ling (*Molva dypterygia*) and the Spanish ling *(Molva macrophthalma*) with the latter having the pelvic fin extending beyond the pectoral (Figure 2). All individuals caught in subarea 8 were *M. macrophthalma*.

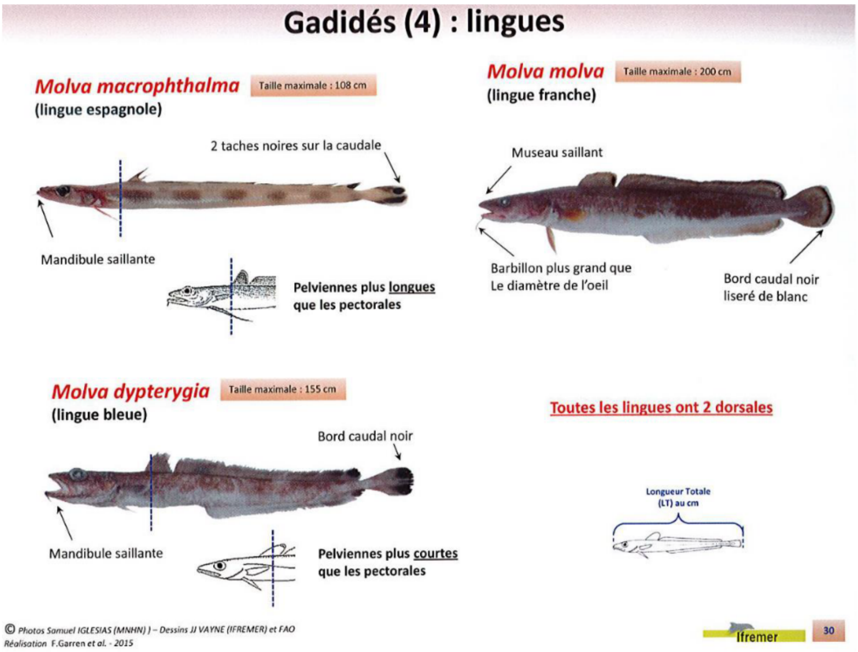

Figure 2. Identification sheet for ling (genus *Molva*) used in French surveys (from Garren, 2020)

2. Fisheries

In Subarea 12 catches have been from multispecies fishery fleets fishing for several deepwater species, primarily roundnose grenadier, black scabbardfish and blue ling, with a component of deepwater sharks and orange roughy in the 1990s. Before the 1990s, the bulk of the landings from Subarea 12 was from target fisheries of seasonal spawning aggregations, like in divisions 5.a and 6.ab. Known spawning areas are now closed seasonally to protect the spawning stock.

There was a directed fishery for blue ling in Division 2.a on spawning areas; mainly Norwegian vessels fishing with nets. The directed fishery was banned in 2009 and has since been regulated by a 10% allowed bycatch from other fisheries. The fishery in divisions 2.a and 4.a is now a bycatch fishery from longlines and nets.

3. Blue ling population structure

3.1. Recent population genetic study

Genetics information is scarce for this species. However, there is new information on population structure of blue ling (McGill *et al*, 2023). Samples from the Atlantic basin covering (Greenland, Rockall, Rosemary Bank, Anton Dohrn and Atlantic slope, i.e. to the West of Scotland) and along the Norwegian Coast, in Division 2.a by 69°N, in Division 4.a by 59-61 °N and South Norway in Division 3.a) were analyzed with Principal Component Analysis (PCA) and the Structure software (Pritchard *et al.*, 2000) and the results showed two distinct genetic units (Figure 3). Although there was found some genetic flow between the two areas, there was clearly two separate units. This information supports changing the current stock area to units reflecting better the actual population structure. Further, the current bli.27.nea include subareas 1 and 2 to the East and Subarea 12 to the West, whilst these subareas are separated by the two other assessments units considered by ICES.

Overall, the population genetic study indicated that blue ling from the Atlantic Basin and Norwegian water are distinct, which implies that Subarea 12, which is included in bli.27.nea should be separated from subareas 1 to 4.

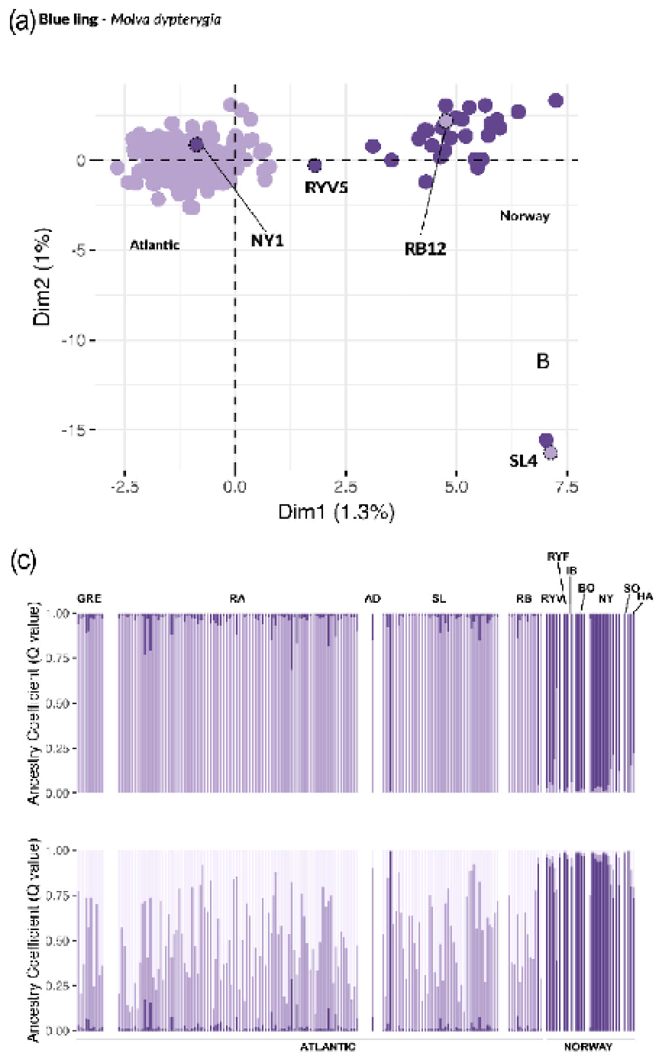

Figure 3. Genetic population structure of blue ling, based on sampling in the Atlantic basin, Norwegian Sea and North Sea. PCA plot (a) and Structure plot (c) (redrawn McGill *et al.*, 2023).

3.2. Population structure in the Atlantic basin.

The population genetic study from Gill *et al.* (2023) did not reveal structure within the Atlantic basin. This would probably need genotyping more individuals from more locations from the Atlantic. The population structure in this basin was considered for long. Biological investigations in the early 1980s suggested that at least two adult stock components were found within the area, a northern stock in Subarea 14 and Division 5.a with a small component in 5.b, and a southern stock in Subarea 6 and adjacent waters in Division 5.b. This was supported by differences in length and age structures between areas as well as in growth and maturity. Egg and larvae data from early studies also suggested the existence of many spawning grounds in each of areas of the northern and southern stocks and this was considered as indications of stock separation. These now historical approaches are the basis for distinguishing the two major current stock units: bli.27.5a14 and bli.27.5b67. To the the west of the British Isles in Subarea 6, small blue ling below 60 cm are not caught by fisheries nor surveys. Fish appear in survey and commercial catch at 60–80 cm possibly suggesting migration of juveniles from other areas. Spawning grounds are known to occur in Subarea 6, along the Scottish slope, on Rockall, Hatton, Lousy and Rosemary Banks (Figure 4, left panel) in Division 5.a, Icelandic grounds, (Figure 4, right panel). Spawning areas have also been identified in Faroese waters (Figure 5).

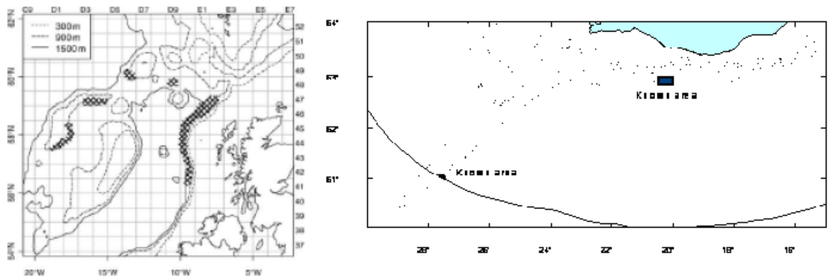

Figure 4. Spatial distribution of blue ling spawning grounds along the Scottish slope, on the Hatton, Lousy and Rosemary Banks (left) and to the South of Iceland (right).

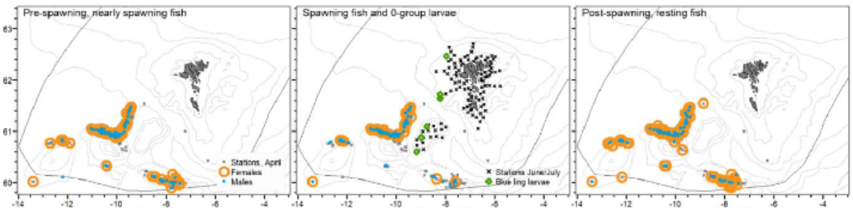

Figure 5. Spatial distribution of blue ling spawning areas in Faroese waters. Data from the blue ling surveys in April, 1995-2003. Observations of nearly spawning fish (left), spawning fish and observations of larvae (middle) and resting fish (right). Larvae data from 0-group survey June/July 1995-2017.

Small blue ling are observed in survey in Icelandic and Greenland waters. In recent decades Icelandic surveys have shown a sudden drop in small blue ling abundance, denoted recruitment (Figure 6.D) in 2008-2010 and remained at low level since. This low recruitment was followed by a decrease in biomass of fish larger than 40 cm from 2012 (Figure 6.B) which was also visible in fish larger than 70 cm TL (Figure 6.C). This suggest that small blue ling observed in Icelandic, actually represent the recruitment to this stock. Small blue ling from 21 cm has also been of observed in survey in Greenland waters since 2002 (Nogueira and Christiansen, 2023). Lastly blue ling smaller than 40 cm TL have also been observed in Faroese surveys, but in a few locations and very small numbers. Pelagic larvae (2-3 cm in length) have also been caught in the annual 0-group trawl survey in June/July (Figure 5, central panel) but in very small numbers only (Ofstad, 2018).

Overall the number of blue ling smaller than 60 cm observed in surveys in the area of the bli.27.5b67 seems very small in comparison to the adult stock, which current biomass is estimated to near 100 000 tonnes. How larvae drift and juveniles migrate to adult grounds, where they recruit to fisheries, is unknown.

If blue ling from Division 5b and subareas 6 and 7 (bli.27.5b67) was demographically connected to bli.27.5a14, the decline in biomass of fish larger than 70 cm observed for bli.27.5a14 from 2012-13 should also have occurred quite at the same time in bli.27.5b67, where blue ling recruit to the fishery at 60-70 cm. No such decline was observed, in contrast the biomass increased rather continuously since the early 2000s (Figure 7), which may have been driven by decreasing catches in the 2000, but after 2010 catches stabilized and eventually started increasing in recent years. Further, the current exploitation level is estimated to be well below MSY for bli.27.5b67 (ICES, 2022a), whilst it is above for bli.27.5a14 (ICES, 2022b). This suggest that the two stock units bli.27.5a14 and bli.27.5b67 are demographically disconnected and support the ICES practice to recognize these two major units in the Atlantic basin.

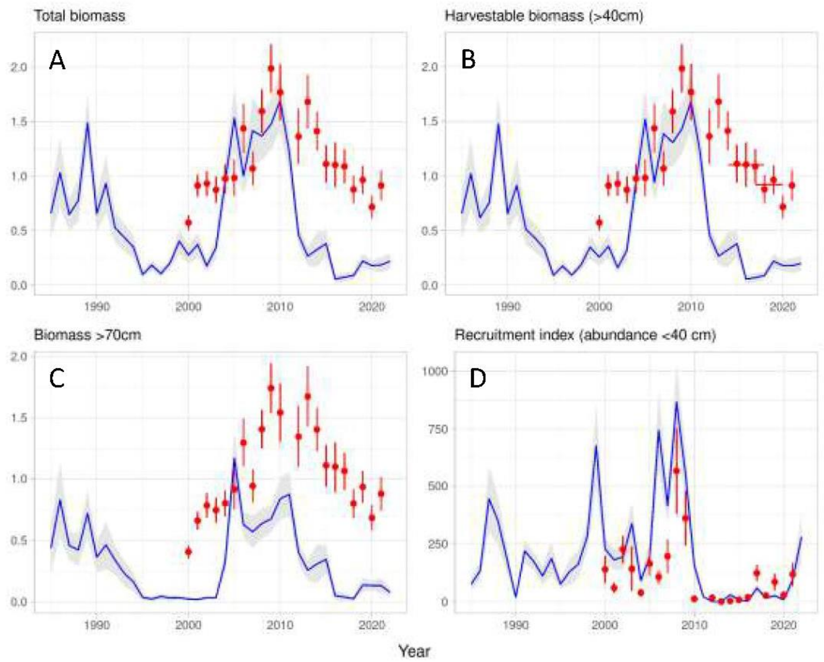

Figure 6. Biomass (thousand tonnes) and abundance (numbers) indices of blue ling in the Icelandic autumn survey since 2000 (red points) and the spring survey since 1985 (blue lines). Total biomass index (top-left), biomass of 40 cm and larger (top-right), biomass of 70 cm and larger (bottom-left) and abundance of small blue ling smaller than 40 cm, considered recruitment. Vertical red lines and shaded area represent standard error of the estimate. Redrawn from ICES (2022c).

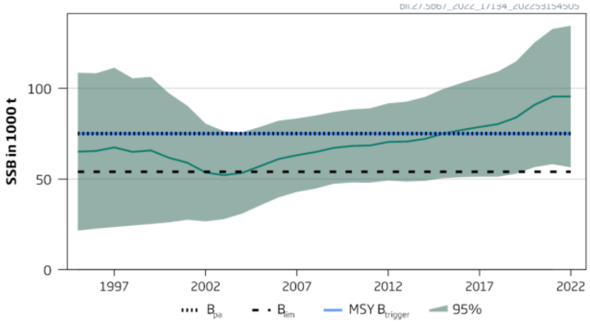

Figure 7. Estimated biomass of the bli.27.5b67 stock (ICES, 2022a).

The remaining issue is how to treat Subarea 12 from which the genetic population study had not samples (Gill *et al.,* 2023). Further, considering that this study did not found difference between samples from south Greenland and those from Rockall and Hatton, blue ling from Subarea 12 may be expected to belong to the same genetic pool.

Blue ling occurs at unknown level in different parts of Subarea 12. Current catches are minor but historical catches suggest that Subarea 12 may accommodate a significant biomass of the species (although the current level of this biomass with respect to the possible carrying capacity of the area in unknown), with 400 to 1300 tonnes landed annually from 1995 to 2005 (ICES, 2002). We suggest treated this subarea based on the continuity of bathymetric features (Figure 8 and 9). Considering that the species has a clearly demersal behavior, migration are expected to follow suitable bottom habitats. Blue ling in Division 12.b occurs on the western Hatton bank, out of this Bank (to the West) the seafloor is too deep for the species. The western Hatton Bank is in continuity with the Rockall and Hatton Banks in Division 6.b. so that blue ling from 12.b is most likely to be related to blue ling from 6.b. Division 12.a.2, is a small area where the seafloor is deeper than 1500 m, so too deep for the species.

3.3 Bathymetric and hydrological features

Oceanographic barriers may play a role in the ability for fish to move across major basins across the Northeast Atlantic. The overflow of Norwegian Sea currents across the Wyville-Thomson Ridge and its confluence with slower currents from subtropical Atlantic Ocean to the south, reaching as far as the Shetlands, associated to the regional topography, offers favourable conditions for the incidence of stratified waters (Hänninen, 2020; Kurekin *et al*., 2020). These hydrographic conditions create barriers to genetic flow and subsequently isolated fish populations (Knutsen *et al*. 2009; Longmore *et al.*, 2011).

Some evidence exists, postulating that the Wyville Thomson Ridge separates fish communities distributed along the Norwegian basin and in the Skagerrak, from those to the West of the British Isles (Campbell *et al.* 2011). The general oceanic circulation patterns in the North Atlantic are suggestive that fish populations present in the Rockall and Faeroe Banks are separated from those in the Icelandic Basin, and the latter is itself separated from the Norwegian Basin by the Iceland-Faeroe Ridge (Gordon, 1986).

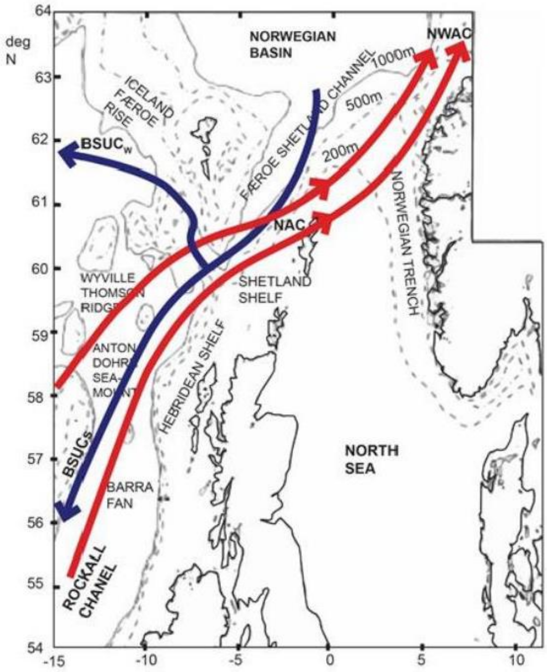

Figure 8. Hydrological circulation in the Norwegian Sea, Rockall-Hatton and Faroe area.

Suitable bottom depths for blue ling in other divisions of Subarea 12 are areas of the Mid-Atlantic Ridge to the West of Division 12.a.4 and in Division 12.a.1 (Figure 9). Blue ling occurring on these grounds is likely to be related to blue ling in Division 5.a. Blue ling is unlikely to occur in divisions 12.a.3 and 12.c, which are too deep.

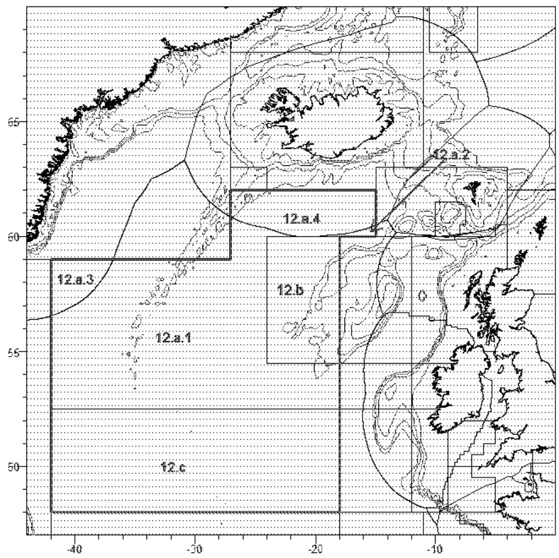

Figure 9. Subarea 12 (brown thick line) and its divisions, over the bathymetry of the Northeast Atlantic (contour lines 200, 500, 1000 and 1500 m). Depths drawn from GEBCO 2022.

Nevertheless, to the very south of the Rockall Hatton area, a small area may include suitable bottom depth for blue ling (see to the South of Division 12.b on Figure 8). Therefore, landings reported in Division 12.a.1, which is included in the NEAFC RA, may come either from this area of from the Mid-Atlantic Ridge and may belong to one stock or the other. Therefore, to be able to ascribe catches of blue ling from Division 12.a.1 to the right stock additional information is needed.

4. Conclusion

A stock area covering wide and disconnected areas is not appropriate. Available evidences suggest that stocks units more aligned to the actual population structure can easily be achieved.

Overall available data suggest that:

- Divisions 12.a.1 and 12.a.4 should be pasted to the area of the assessment unit bli.27.5a14. For simplicity, division 12.a.3 and 12.c may be included in the same stock unit, although blue ling is unlikely to occur in these divisions. The assessment unit bli.27.5a14, would become bli.27.5a12ac14, labelled "Blue ling (*Molva dypterygia*) in subareas 12 and 14 and Division 5.a (Mid-Atlantic Ridge, East Greenland and Iceland grounds)".
- Division 12.b should be pasted to the stock area of the assessment unit bli.27.5b67, which would become bli.27.5b6712b, labelled "Blue ling (*Molva dypterygia*) in subareas 6–7 and division 5.b and 12.b (Celtic Seas, Hatton Bank and Faroes grounds)". For simplicity, the small

Division 12.a.2, may be included in the same unit as this would avoid creating a potential loophole with a small area not covered by a TAC for blue ling.

- Blue ling does not occur to any significant level in subareas 8 and 9, which should therefore not be part of any blue ling stock assessment unit.
- The remaining areas of the current bli.27.nea "Blue ling (*Molva dypterygia*) in subareas 1, 2, 8, 9, and 12, and in divisions 3.a and 4.a (Northeast Atlantic)" form a suitable stock assessment unit bli.27.1-4 which can be labelled "Blue ling (*Molva dypterygia*) in subareas 1 and 2 and divisions 3.a and 4.a (Norwegian Sea, North Sea and Skagerrak)"

It is worth noting that this revision of the stock assessment units for blue ling results in the same number of ICES stocks as previously, the distribution of the new assessment units is clearly better aligned on the meta-population structure of the species than the previous one. The remaining issue of the attribution of catches from Division 12.a.1 to the right stock can be solved be one of the following options:

- **Availablity of catches at the resolution of ICES rectangle for catches coming from the NEAFC RA**. If this data can be made available and included in the WGDEEP data call then the attribution of catch to the right stock is straightforward
- **Addition of one ICES Division**. An additional ICES Division, covering the south of 12.b down to 48°N. This could be labelled, Division 12.d or Division 12.a.5 and have the following limits: Southwest corner at 24°West and 48° North; Northeast corner at 18° West 60°North.
- **Extend Division 12.b towards the South down to 48°N.** This would have the same effect as the previous option, without increasing the number of ICES divisions.

Whichever, approach is the easier to implement should be used as the three options all allow to ascribe catch to the right stock assessment unit.

4.1 Consequence for stock assessment

There was no catch from Subarea 12 in 2022. Catches were smaller than 30 tonnes per year since 2015, which is minor compared to more than 1500 and 3000 tonnes per year caught for bli.27.5b67 and bli.27.5a14 respectively. Fisheries in Subarea 12 seem to have ceased and therefore integrating parts of this Subarea to the two other stock units 5b6-7 and 5a14 would not impact current assessments substantially. Since 2010, landings of Spanish ling from subareas 8 and 9, reported as blue ling have not been included in the advice so that the exclusion of these subareas from the stock unit will not have any impact on subsequent advices either.

Excluding subareas 8 and 9 is recommended because according to survey blue ling does not occur in these subareas where the closely related Spanish ling occurs. The latter has probably a different ecology, in particular it is not known to form spawning aggregation susceptible to be targeted by fisheries. Further, in the EVHOE survey in Subarea 8, small (< 40 cm TL) and adult Spanish ling are caught in the same hauls.

Important note

This working document was presented and discussed during the 2023 meeting of WGDEEP. In additions to authors, all members of the group considered the issue thoroughly and contributed to define the most suitable solution to the stock delineation of blue ling in the ICES area, which lead to add several considerations to the text during the meeting. This final version was approved by the group.

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Working Document to be presented to the Working Group on the
Biology and Assessment of Deep Sea Fisheries Resources

ICES WGDEEP, 3rd - 9th May 2023, Lisbon, Portugal

Results on greater forkbeard (*Phycis blennoides*), Spanish ling (*Molva macrophthalma*), roughsnout grenadier (*Trachyrincus scabrus*), bluemouth (*Helicolenus dactylopterus*) and other scarce deep water species on the 2022 Northern Spanish Shelf Groundfish Survey

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Abstract

This working document presents the results on the most significant deep fish species on the Spanish Groundfish Survey on the northern Spanish shelf in 2022. Biomass, abundance, length ranges and geographic distributions were analyzed for greater forkbeard (*Phycis blennoides*), Spanish ling (*Molva macrophthalma*), roughsnout grenadier (*Trachyrincus scabrus*), bluemouth (*Helicolenus dactylopterus*) and other scarce deep sea species. The biomass of *T. scabrus* increased slightly whereas it increased sharply for *P. blennoides, M. macrophthalma* and especially for *H. dactylopterus. Aphanopus carbo, Beryx spp.* and *Pagellus bogaraveo* were scarce as usual and *Coryphaenoides rupestris* has not been found since 2019. Recruitment was significant for *P. blennoides, M. macrophthalma* and *H. dactylopterus*.

Introduction

The bottom trawl survey on the Northern Spanish Shelf has been carried out every autumn since 1983, except in 1987, to provide data and information for the assessment of the commercial fish species and the ecosystems on the Galician and Cantabrian shelves (ICES Divisions 8c and 9a North).

The aim of this working document is to update the results (abundance indices, length frequencies and geographic distribution) of the most common deep water fish species on the bottom trawl surveys on the Northern Spanish Shelf after the results presented previously (Blanco *et al.* 2022, 2019, Fernández-Zapico *et al.* 2020, 2018, Ruiz-Pico *et al.* 2021). The species analyzed are *Phycis blennoides* (greater forkbeard), *Molva macrophthalma* (spanish ling), *Trachyrincus scabrus* (roughsnout grenadier), *Helicolenus dactylopterus* (bluemouth), and some other scarce species as *Aphanopus carbo* (black scabbardfish), *Coryphaenoides rupestris* (roundnose grenadier), *Beryx spp.* (alfonsinos) and *Pagellus bogaraveo* (blackspot seabream). Although results on *Helicolenus dactylopterus* were not included in the ICES data call, they are also updated considering its remarkable abundance and geographical distribution in the surveyed area, and the fact that these indices were used in the WGDEEP report when reviewing the abundance and status of the stock on the north-eastern Atlantic.

Material and methods

The area covered in the Northern Spanish Shelf Groundfish Survey on the Cantabrian Sea and Off Galicia (Divisions 8c and Northern part of 9a; SPNGFS) extends from longitude 1° W to 10° W and from latitude 42° N to 44.5° N, following the standard IBTS methodology for the western and southern areas (ICES, 2017). The sampling design is random stratified with five geographical sectors (MF: Miño-Finisterre, FE: Finisterre-Estaca de Bares, EP: Estaca de Bares - Peñas, PA: Peñas - Ajo, AB: Ajo - Bidasoa) and three depth strata (70-120 m, 121-200 m and 201-500) (Figure 1, ICES, 2017). The shallower depth stratum was changed in 1997 from 30-100 m to 70-120 m, due to the small area and scarcity of trawlable shallower grounds.

Nevertheless, some extra hauls are carried out every year, if possible, to cover shallower (<70 m) and deeper (>500 m) grounds. These additional hauls are plotted in the distribution maps, although they are not included in the calculation of the stratified abundance indices since the coverage of these grounds (shallower and deeper) are not considered representative of the area. However, the information from these depths is considered relevant due to the changes in the depth distribution of fishing activities in the area (Punzón et al. 2011) and these hauls are also used to define the depth range of the species.

The standardized indices of the deep water fishes analyzed in this report probably underestimate its real biomass due to the fact that most of its catches might happen out of the standard stratification area, in additional hauls deeper than 500 m. For this reason, the catches in standard and deeper additional hauls were plotted in this report.

Results

In this last survey 129 valid hauls were carried out, 114 of these were standard hauls and 15 additional hauls (3 of them shallower than 70 m and 12 of them between 500 m and 800 m) (Figure 1).

The total stratified fish catch in biomass per haul increased strongly in 2022, staying within the high values of the time series (Figure 2).

In 2022, as usual, most of the biomass of *P. blennoides, T. scabrus, A. carbo* and *Beryx spp.* was found in the additional deep water hauls (>500 m) in contrast to *H. dactylopterus* which was mainly found in standard hauls. *P. bogaraveo* was scarcely found, mostly out of the stratification in the shallow area (<70 m). However, the species *M. macrophthalma*, traditionally found mainly in additional deep water hauls, increased its presence in standard hauls in the last two years.

The biomass of the species *T. scabrus* increased slightly whereas it increased sharply for *P. blennoides, M. macrophthalma* and especially for *H. dactylopterus*, reaching the highest value of the time series for the last two species. Bluemouth also rose in abundance terms, reaching likewise the highest value in the overall time series. Recruitment was significant for *P. blennoides, M. macrophthalma* and *H. dactylopterus*, being also noticeable the sharply rise on juveniles abundance for the latter species. Only a few specimens of *A. carbo, Beryx spp.* and *P. bogaraveo* were found but *C. rupestris* was not since 2019.

***Phycis blennoides* (greater forkbeard)**

In 2022, 21% of the hauls where *P. blennoides* was found were additional hauls deeper than 500 m and contained 77% of the biomass. This last year the biomass in standard hauls increased steadily, reaching the highest value of the previous eight years. The biomass in additional deep hauls increased even more compared to the previous year, reaching the highest value of the time series (Figure 3).

The geographical distribution of *P. blennoides* remained similar to previous years, being widespread in the sampling area (Figure 4).

The length distribution in standard hauls was similar to the previous year, with a great recruitment again and a mode in 18 cm (Figure 5).

The largest individuals,which ranged from around 24 cm to 66 cm, were found mostly in the additional deeper hauls, with a mode in 38 cm (Figure 6).

***Molva macrophthalma* (Spanish ling)**

In 2022, the biomass of *M. macrophtalma* increased sharply again in standard hauls, reaching the highest value of the time series, as it had already happened the previous year, whereas it decreased slightly in additional hauls deeper than 500 m (Figure 7). Unlike other years in the time series, although following the line of last year, most of the biomass (65 %) was found in standard hauls (70 - 500 m) which were 85 % of the total hauls with *M. macrophtalma.*

The species kept on being widespread in the study area but presented more spots this last survey (Figure 8).

The strong increase of recruitment in standard hauls shown the previous year is repeated in this last survey, showing a mode in 24 cm, and it is noticeable in the increment on the range of sizes, showing a second class of size, with a mode in 39 cm (Figure 9).

In contrast, in additional deeper hauls larger specimens, up to 123 cm, were found (Figure 10).

***Trachyrincus scabrus* (roughsnout grenadier)**

T. scabrus has been found mostly in additional hauls (>500 m) in the last decade. In 2022, this species was caught in five hauls, being all of them deep hauls, out of the standard stratification, and catches increased slightly compared to the previous year (Figure 11).

The geographical distribution showed more or less the same pattern during the time series, being captured in the deep hauls throughout the study area. However, the point of biomass usually caught in recent years on southern MF sector, was not caught this last survey (Figure 12).

Specimens ranged from 40 mm to 245 mm, although more abundance of large specimens (145 to 200 mm) was found, with a mode in 180 mm (Figure 13).

***Helicolenus dactylopterus* (bluemouth)**

Although bluemouth is not requested for ICES DCF Data Call, the biomass and abundance are significant in the area and useful for the assessment of the stock (ICES, 2017).

H. dactylopterus has mainly been found in standard hauls, therefore the catches of the additional deeper hauls are not plotted.

In 2022, both the biomass and abundance rose sharply, increasing five times the biomass value of the previous year and almost four times that of abundance. Both values, which were already high the previous year comparing to the time series, have reached the highest values in the overall time series (Figure 14).

The geographical distribution of *H. dactylopterus* remained similar to the previous year, with greater biomass in the Galician area, but striking in this last survey, and the usual spot in the easternmost Ajo-Bidasoa sector (Figure 15).
Length distribution showed a moderate sign of recruitment, with a small mode in 6 cm, and also a strong increment in the abundance of a second size class individuals ranged among 11 cm and 37 cm, with a marked mode in 12-13 cm (Figure 16).

Other scarce deep water species

Other species scarcely caught in the survey were *Aphanopus carbo*, *Beryx spp.* and *Pagellus bogaraveo.* They have been mainly found out of the standard stratification, the first three species in deeper additional hauls (>500 m) whereas *P. bogaraveo* in shallower additional hauls (< 70 m).
The species *C. rupestris* has continued to be absent since 2019.
A. carbo was caught in three hauls among 559 m and 608 m in easternmost Cantabrian sea (Figure 17 and Figure 18), with a total of six specimens which ranged from 87 to 104 cm.
Beryx spp. were found in two hauls between 540 m and 589 m in Galician waters and in three hauls among 530 m and 609 m in the Cantabrian sea (Figure 19 and Figure 20). Five specimens were *B. decadactylus*, ranged among 25 and 32 cm, and one was *B. splendens* with 29 cm.
Forty nine specimens of *P. bogaraveo* between 8 and 28 cm were found among 40 and 92 m depth in three hauls in the Cantabrian Sea (Figure 21 and Figure 22).

Acknowledgements

We would like to thank R/V *Miguel Oliver* crew and the scientific team from IEO that made possible SPNSGFS Surveys.
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Figures

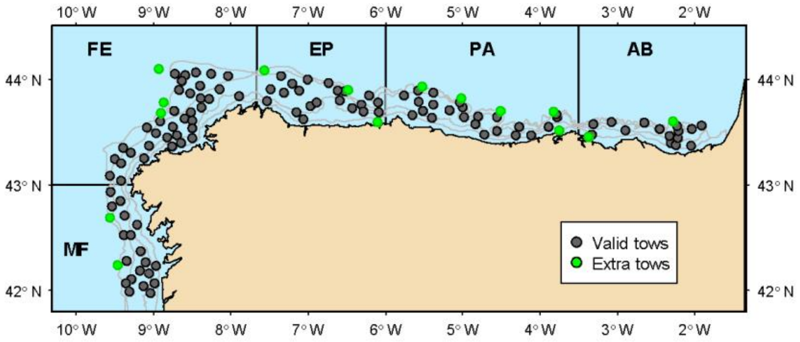

Figure 1 Stratification design and hauls on the Northern Spanish shelf groundfish survey in 2022; Depth strata are: A) 70-120 m, B) 121 – 200 m and C) 201 – 500 m. Geographic sectors are MF: Miño-Finisterre, FE: Finisterre-Estaca, EP: Estaca-cabo Peñas, PA: Peñas-cabo Ajo, and AB: Ajo-Bidasoa

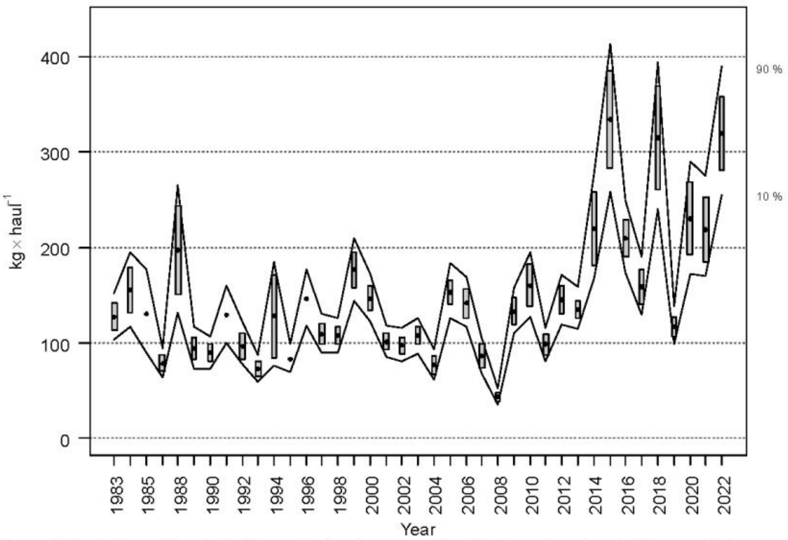

Figure 2 Evolution of the total fish catch in biomass on the Northern Spanish shelf groundfish survey, only standard hauls (>70 m & <500 m considered within the standard sampling stratified to the area.

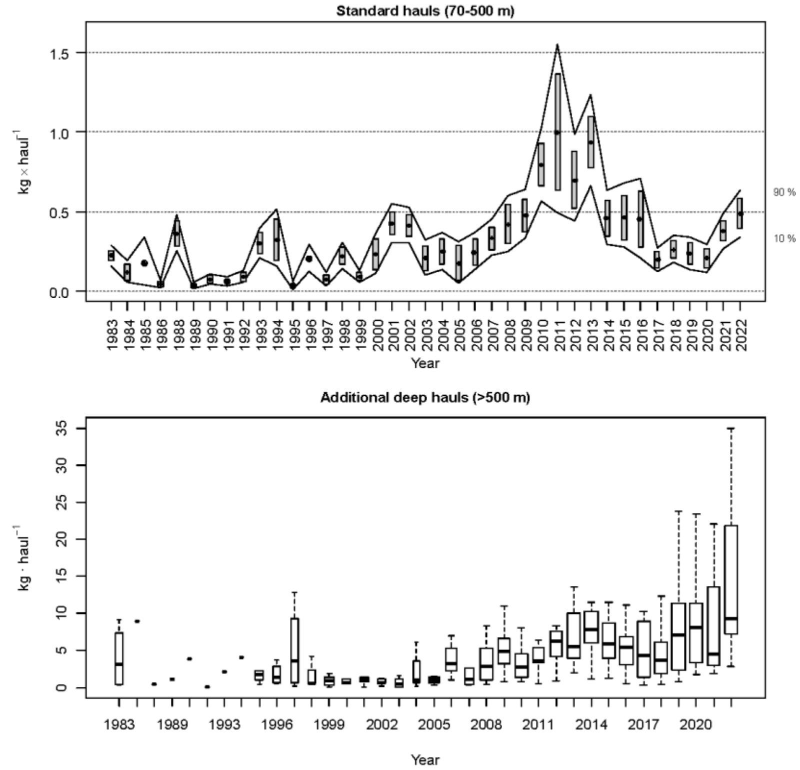

Figure 3 Evolution of *Phycis blennoides* stratified biomass index in standard hauls and additional deep hauls during the North Spanish shelf bottom trawl survey time series. For the standard hauls boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). For the additional deep water hauls boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

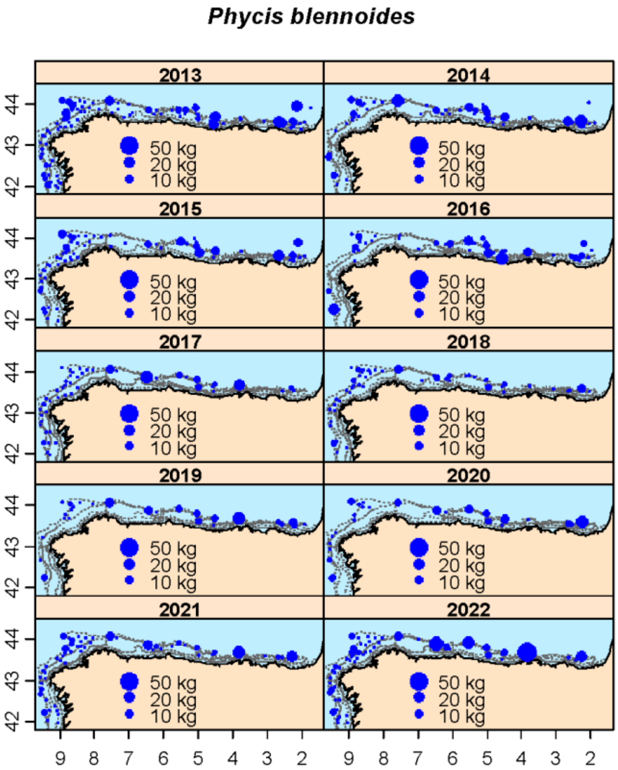

Figure 4 Geographic distribution of *Phycis blennoides* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl surveys in the last decade

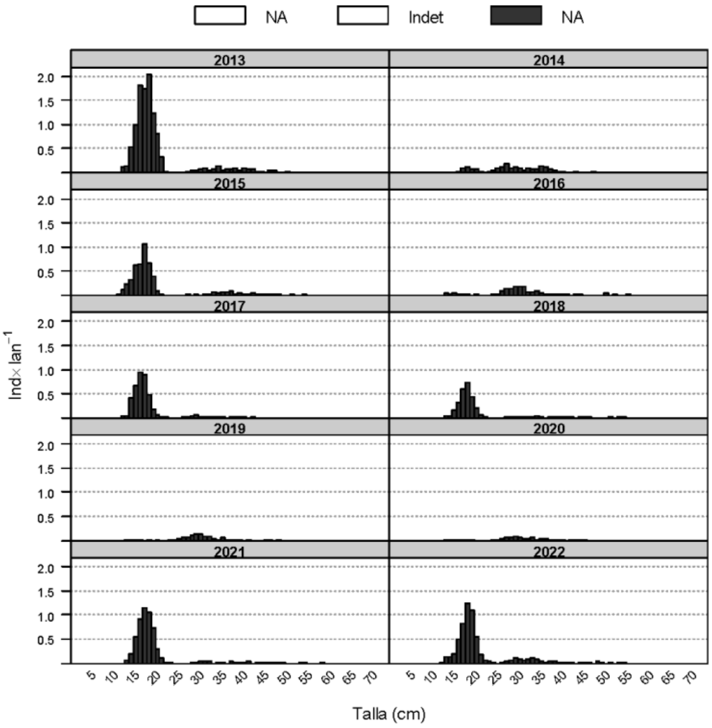

Figure 5 Mean stratified length distributions of *Phycis blennoides* in Northern Spanish Shelf surveys in the last decade

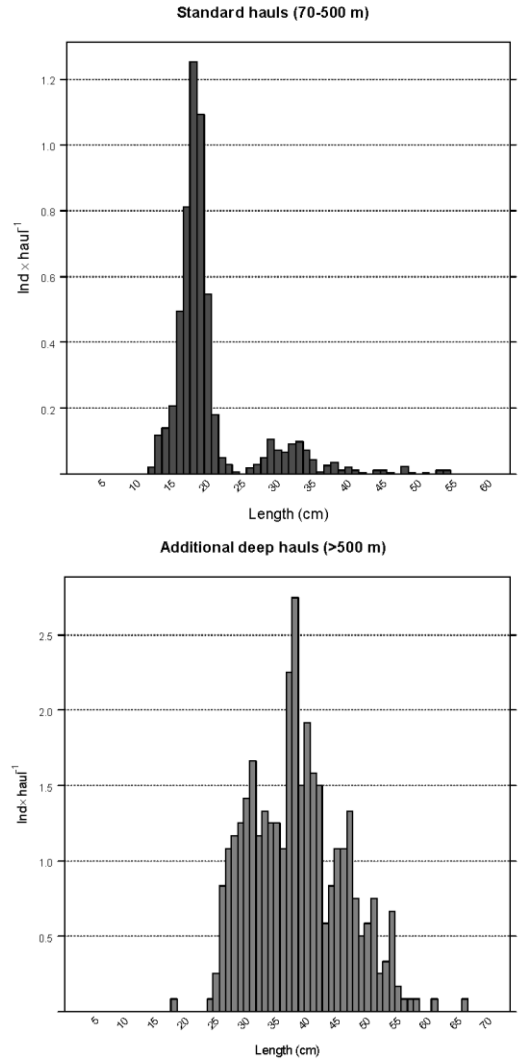

Figure 6 Mean length distributions of *Phycis blennoides* in additional hauls (>500 m) and in the standard hauls (70-500 m) in the North Spanish Shelf survey 2022

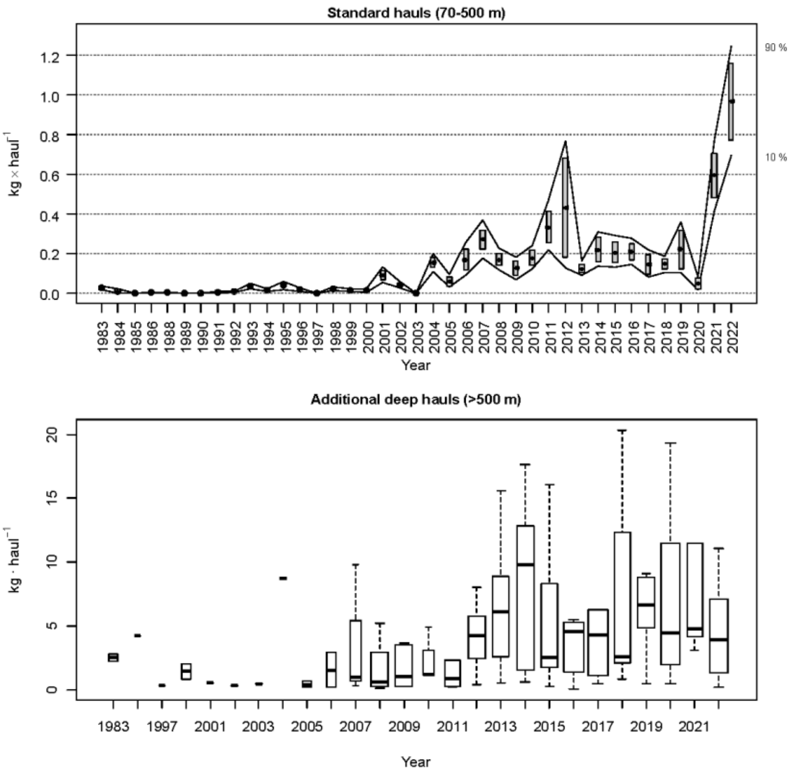

Figure 7 Evolution of *Molva macrophtalma* stratified biomass index in standard hauls and additional deep hauls during the North Spanish shelf bottom trawl survey time series. For the standard hauls boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). For the additional deep water hauls boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

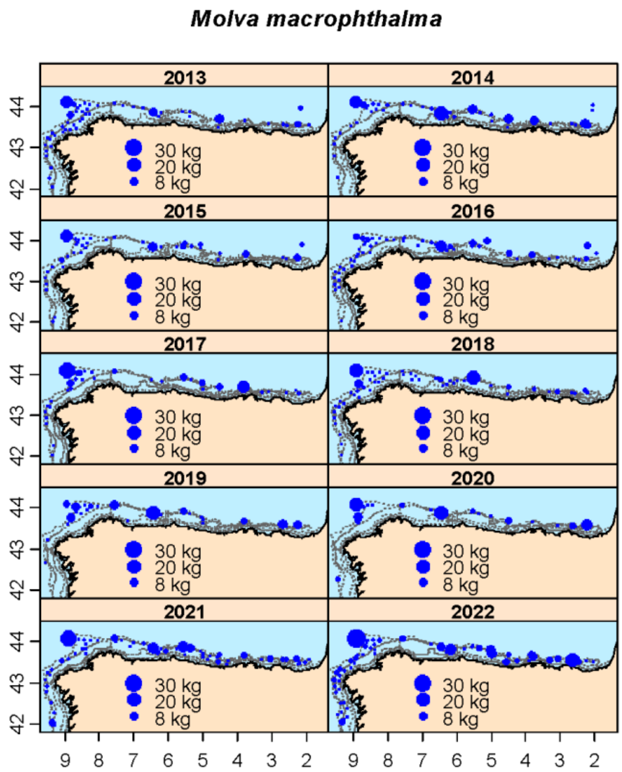

Figure 8 Geographic distribution of *Molva macrophtalma* catches (kg·haul[-1]) in the Northern Spanish Shelf bottom trawl surveys in the last decade

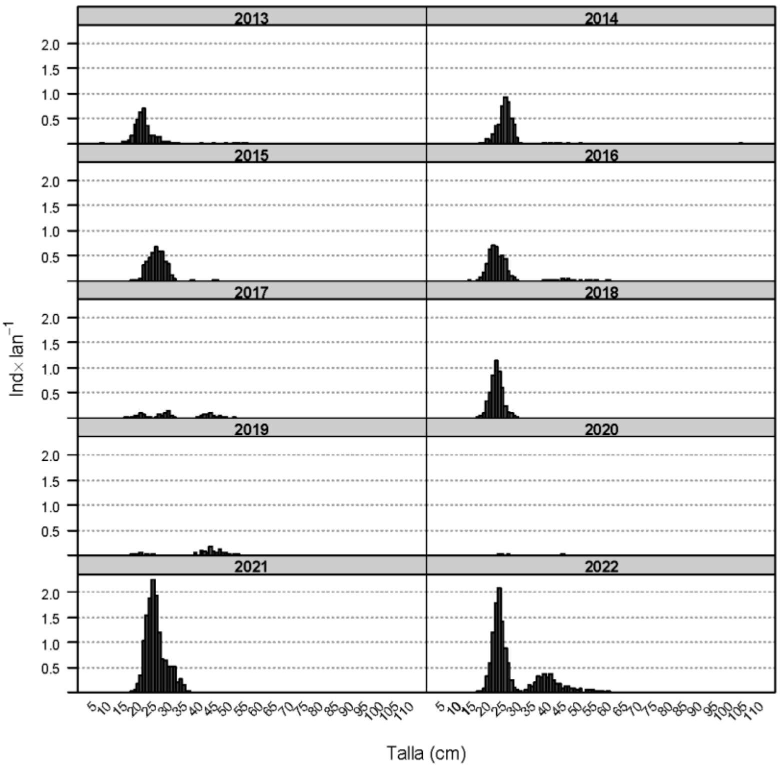

Figure 9 Mean stratified length distributions of *Molva macrophtalma* in Northern Spanish Shelf surveys in the last decade

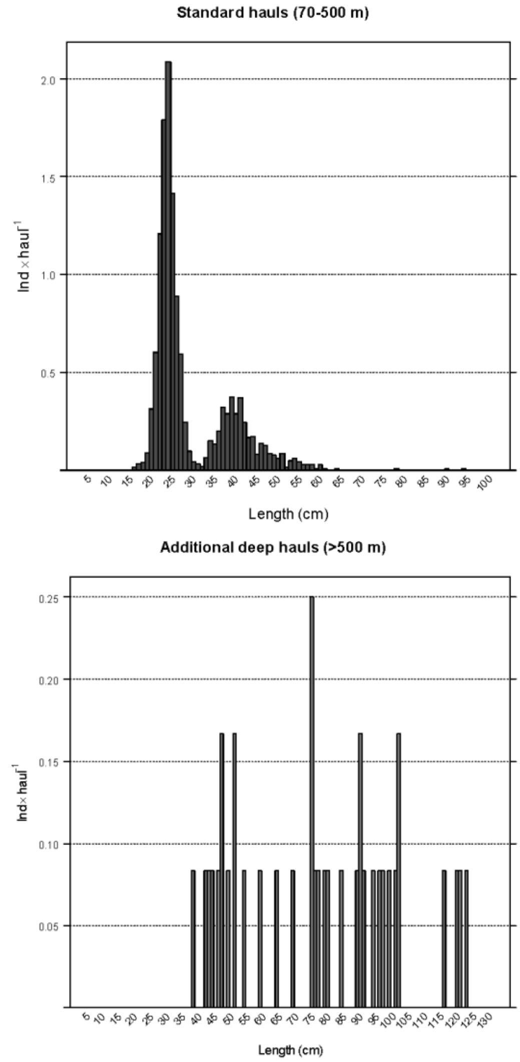

Figure 10 Mean length distributions of *Molva macrophtalma* in additional hauls (>500 m) and in the standard hauls (70-500 m) in the North Spanish Shelf survey 2022

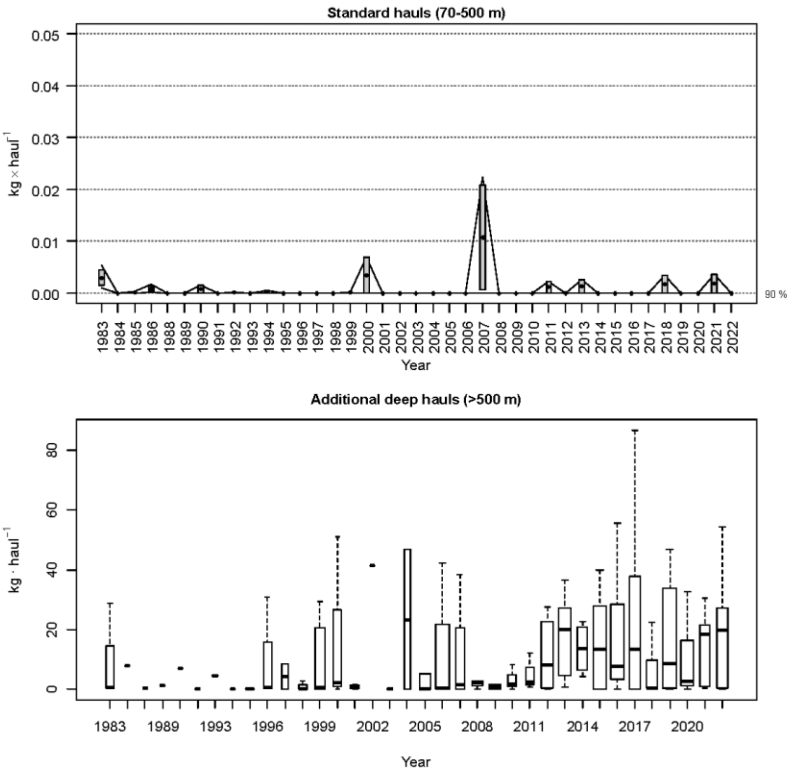

Figure 11 Evolution of *Trachyrincus scabrus* stratified biomass index in standard hauls and additional deep hauls during the North Spanish shelf bottom trawl survey time series. For the standard hauls boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). For the additional deep water hauls boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

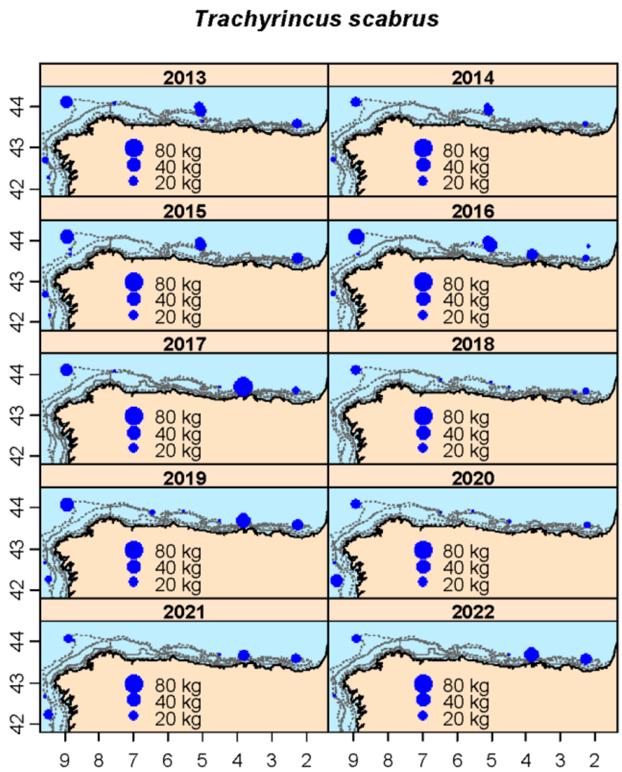

Figure 12 Geographic distribution of *Trachyrincus scabrus* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl surveys in the last decade

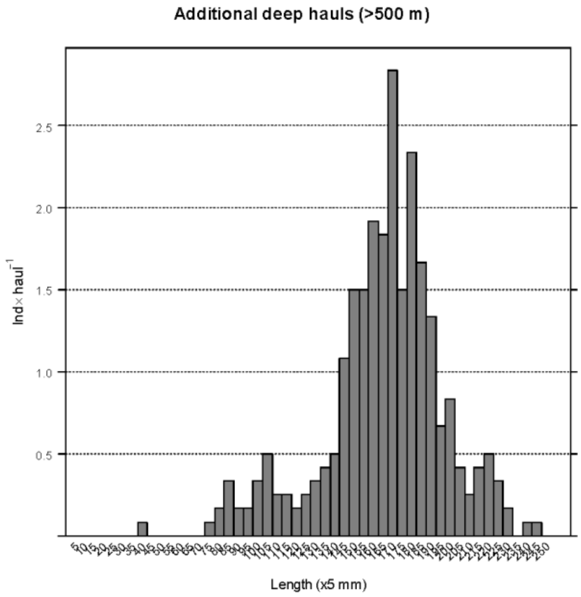

Figure 13 Mean length distributions of *Trachyrincus scabrus* in additional hauls (>500 m) in the North Spanish Shelf survey 2022

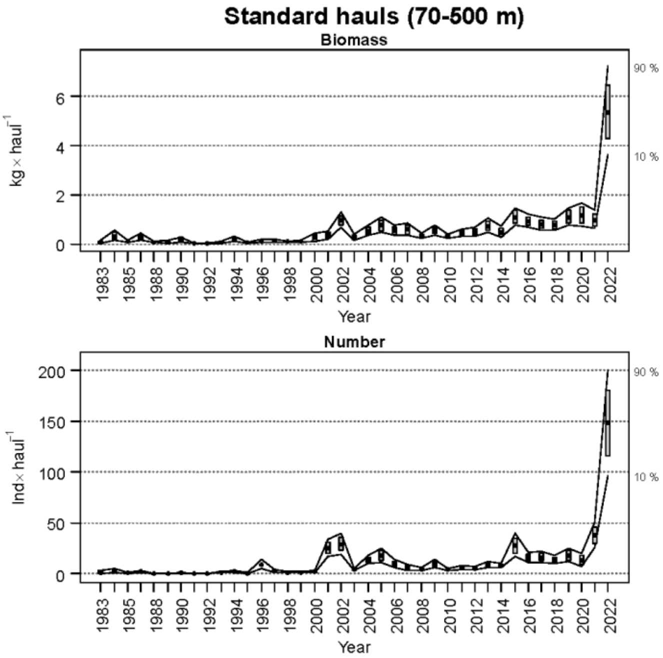

Figure 14 Evolution of *Helicolenus dactylopterus* mean stratified biomass and abundance in Northern Spanish Shelf surveys time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

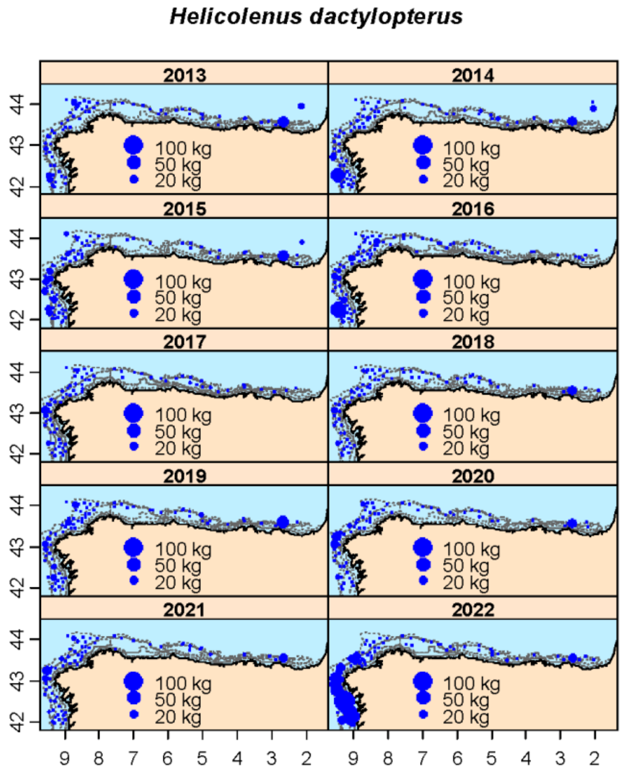

Figure 15 Geographic distribution of *Helicolenus dactylopterus* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl surveys in the last decade

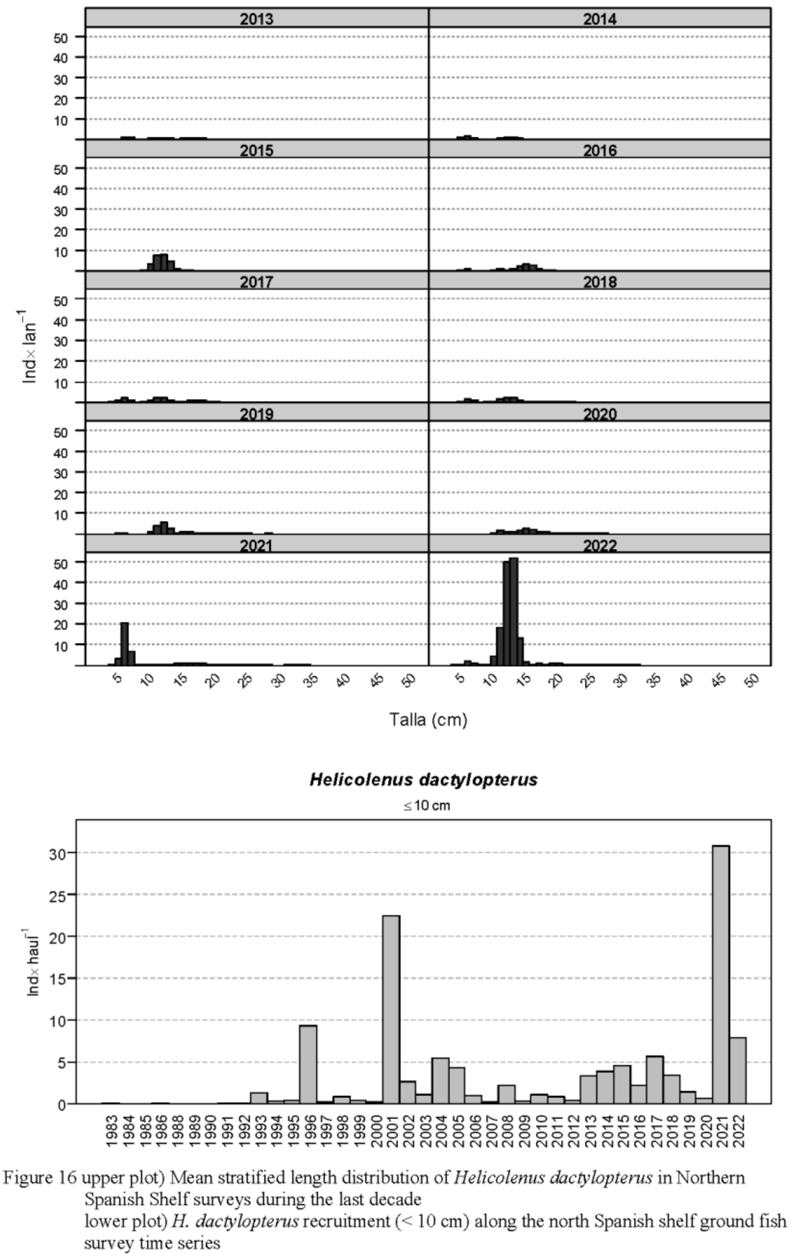

Figure 16 upper plot) Mean stratified length distribution of *Helicolenus dactylopterus* in Northern Spanish Shelf surveys during the last decade
lower plot) *H. dactylopterus* recruitment (< 10 cm) along the north Spanish shelf ground fish survey time series

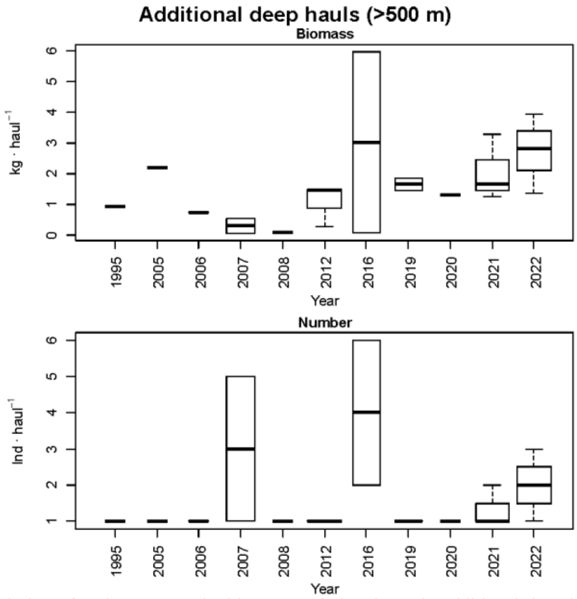

Figure 17 Evolution of *Aphanopus carbo* biomass and abundance in additional deep hauls during the North Spanish shelf bottom trawl survey time series. Boxplots represent the median and interquartiles of the biomass and abundance catches in the deep hauls performed.

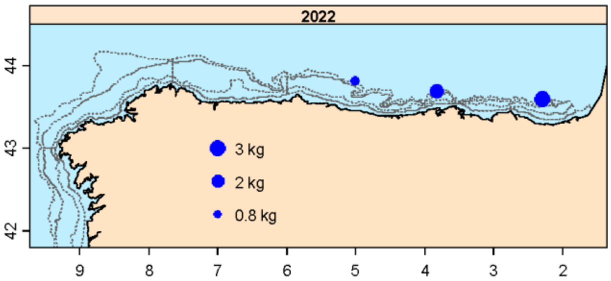

Figure 18 Geographic distribution of *Aphanopus carbo* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl survey 2022

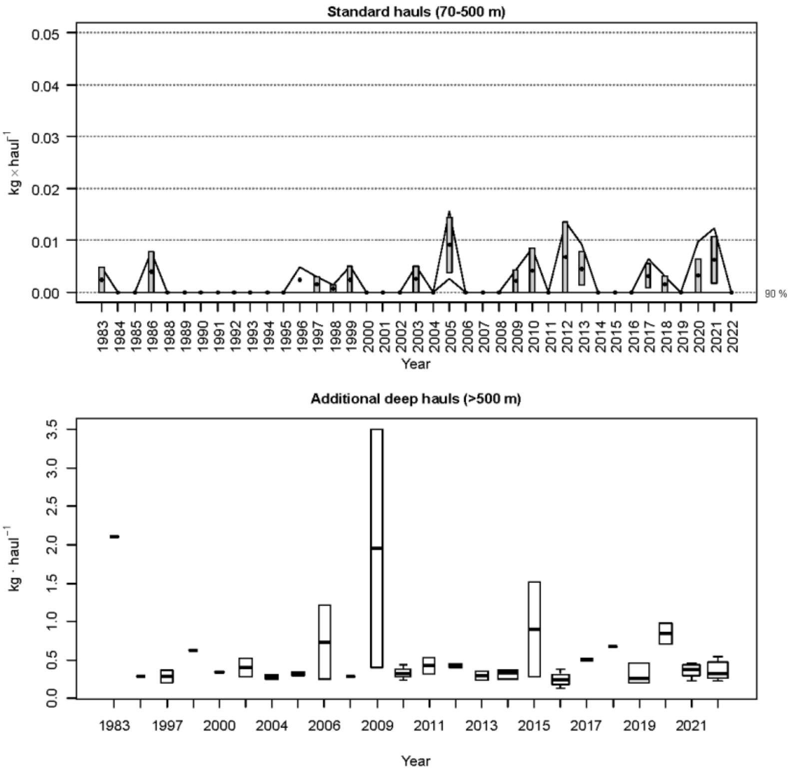

Figure 19 Evolution of *Beryx spp.* stratified biomass index in standard hauls and additional deep hauls during the North Spanish shelf bottom trawl survey time series. For the standard hauls boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000). For the additional deep water hauls boxplots represent the median and interquartiles of the biomass catches in the deep hauls performed.

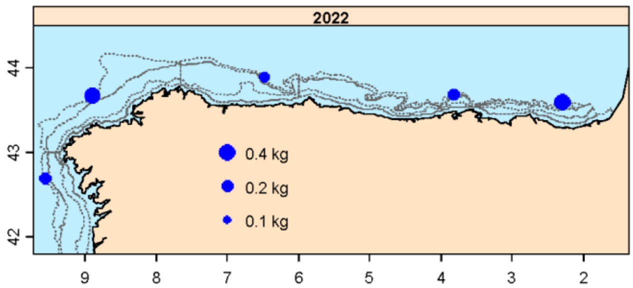

Figure 20 Geographic distribution of *Beryx* spp. catches (kg•haul-1) in the Northern Spanish Shelf bottom trawl survey 2022

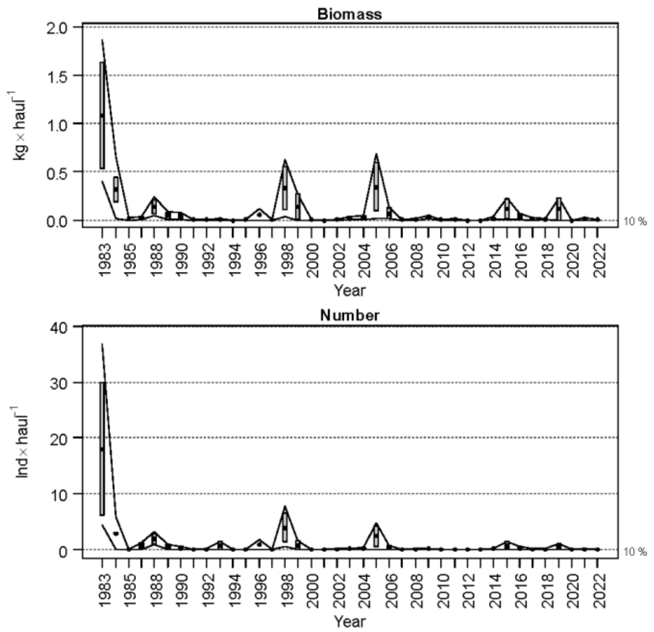

Figure 21 Evolution of *Pagellus bogaraveo* mean stratified biomass and abundance in Northern Spanish Shelf surveys time series. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

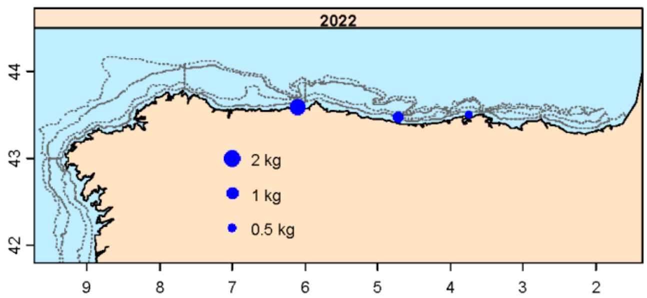

Figure 22 Geographic distribution of *Pagellus bogaraveo* catches (kg·haul^{-1}) in the Northern Spanish Shelf bottom trawl survey 2022

Working Document to be presented to the Working Group on the
Biology and Assessment of Deep Sea Fisheries Resources
ICES WGDEEP 3rd - 9th May 2023, Lisbon, Portugal

Results on silver smelt (*Argentina silus* and *A. sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*), roughsnout grenadier (*Trachyrincus scabrus*), Spanish ling and ling (*Molva macrophthalma* and *Molva molva*) from the 2022 Spanish Groundfish Survey on the Porcupine Bank (NE Atlantic)

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Abstract

This working document presents the results of the most significant deep-sea fish species caught in 2022 on the Porcupine Spanish Groundfish Survey (SP-PORC-Q3). Biomass, abundance, geographical distribution and length ranges were analysed for silver smelt (*Argentina silus* and *A. sphyraena*), bluemouth (*Helicolenus dactylopterus*), greater fork-beard (*Phycis blennoides*), roughsnout grenadier (*Trachyrincus scabrus*), Spanish ling and ling (*Molva macrophthalma* and *Molva molva*) and other scarce deep sea species. Overall, the biomass of these target species increased in this last survey, except for *P. blennoides* and *M. macrophthalma*. Despite that raise, the recruitment was poor.

Introduction

The Spanish bottom trawl survey on the Porcupine Bank (ICES Divisions 7c and 7k) has been carried out annually on the third-quarter (September) since 2001 to study the distribution, relative abundance and biological parameters of commercial fish in the area (ICES 2017).

The aim of this working document is to update the results (abundance indices, length frequency and geographic distributions) of the most common deep-sea fish species on the Porcupine bottom trawl surveys after the results presented previously (Baldó *et al.* 2008, Velasco *et al.* 2009, 2011, 2012, 2013, Fernández-Zapico *et al.* 2015, 2017, 2021, 2022, Ruiz-Pico *et al.* 2016, 2018, 2019, 2020). The species analysed were: *Argentina silus* (greater silver smelt), *Argentina sphyraena* (lesser silver smelt), *Helicolenus dactylopterus* (bluemouth), *Phycis blennoides* (greater forkbeard), *Trachyrincus scabrus* (roughsnout grenadier), *Molva molva* (ling) and *Molva macrophthalma* (Spanish ling) and some other scarce deep sea species as *Aphanopus carbo* (black scabbardfish), *Brosme brosme* (tusk) *Coryphaenoides rupestris* (roundnose grenadier), *Hoplostethus atlanticus* and *Beryx* spp.

Material and methods

The Spanish Ground Fish Survey on the Porcupine Bank (SP-PORC-Q3) has been annually carried out since 2001 onboard the R/V "*Vizconde de Eza*", a stern trawler of 53 m and 1800 Kw. The area covered extends from longitude 12° W to 15° W and from latitude 51° N to 54° N, following the standard IBTS methodology for the western and southern areas (ICES 2017). The sampling design was random stratified to the area (Velasco and Serrano, 2003) with two geographical sectors (Northern and Southern) and three depth strata (< 300 m, 300 – 450 m and 450 - 800 m) (Figure 1). Hauls allocation is proportional to the strata area following a buffered random sampling procedure (as proposed by Kingsley et al., 2004) to avoid the selection of adjacent 5×5 nm rectangles. Extra hauls were performed within the standard stratification to improve coverage in gaps left by random sampling and outside the standard stratification to explore the continuity of the fish community in Porcupine Seabight.

More details on the survey design and methodology are presented in ICES (2017).

The tow duration is 20 min since 2016, but the results were extrapolated to 30 min of trawling time to keep up the time series.

Results and discussion

In 2022, 80 valid standard hauls and 11 extra hauls were carried out, 6 of them below 1000 m in the Porcupine Seabight (Figure 1).

The total stratified catch per haul increased in 2022 reaching the highest value of the time series (Figure 2). Fish represented 95% of the total catch, and the selected deep water fish represented 13% of that total fish catch, with the following percentages per species: *Argentina silus* (38%), *Helicolenus dactylopterus* (31%), *Argentina sphyraena* (14%), *Trachyrincus scabrus* (11%), *Phycis blennoides* (5%), *Molva macrophthalma* (0.5%) and *Molva molva* (0.2%).

In 2022, the biomass of two *Argentina* species, *H. dactylopterus* and *T. scabrus* increased and even reached the highest values of the time series in the two last species. However, the biomass of *P. blennoides* and the two *Molva* species remained among the low values of the time series. Overall, recruitment decreased or remained at low values similar to those of the previous year. The species *Aphanopus carbo, Brosme brosme, Coryphaenoides rupestris, Hoplostethus atlanticus* and *Beryx spp.* were scarce and were found mainly outside the standard stratification, except *Beryx spp.*

***Argentina silus* (greater silver smelt) and *Argentina sphyraena* (lesser silver smelt)**

In 2022, the biomass and abundance of both species of *Argentina* increased, to high values of the time series for *A. sphyraena* whereas only to low-medium values for *A. silus*, the species that historically contributes most to the genus in the survey (Figure 3; Figure 4; Figure 5).

Both species were more abundant in the north of the bank, in particular in the northeast area in this last survey. *A. silus* was also found in the south of the study area, as usual, but mainly in the deeper southeastern strata in this last survey (Figure 6 and Figure 7).

The sizes of both species kept a similar distribution to previous years, *A. sphyraena* with a single mode around 23 cm and *A. silus* with two smaller modes, one rough of 22 cm and a smooth one around 30 cm (Figure 8).

***Helicolenus dactylopterus* (bluemouth)**

Although bluemouth is not requested in the ICES DCF Data Call, biomass and abundance are significant in the area and useful for the assessment of the species (ICES, 2015).

Biomass and abundance of *H. dactylopterus* followed the upward trend of the last three years reaching an all-time record high this last survey (Figure 9). However, recruitment has been falling for the last two years and was even lower in this last survey (Figure 10).

H. dactylopterus was found throughout the study area, even in the northwest of the bank where the largest biomass patches were found. However, recruits were hardly found in their usual areas, the Irish shelf and the southeastern area of the bank (Figure 11).

In the size distribution of H. dactylopterus in this latest survey only one mode was found, but a record size of about 17 cm (Figure 12). The few recruits were mainly of 7 and 8 cm, unlike the previous year when 11-12 cm specimens were more abundant.

***Trachyrincus scabrus* (roughsnout grenadier)**

T. scabrus increased sharply breaking the downward trend of the three previous years and reaching the highest value in the time series (Figure 13).

The species was found in the deepest southeastern and western area, as usual, but more abundantly in this lastest survey (Figure 14).

The length distribution in 2022 showed a marked mode around 18 cm in contras to the smooth outline of the previous year. Specimens of 11 to 13 cm were scarce in this last survey, but a few more recruits of 6 and 11 cm were found (Figure 15).

***Phycis blennoides* (greater fork-beard)**

Biomass and abundance of *P. blennoides* decreased slightly and remained among the lowest values of the time series (Figure 16).

Biomass patches were widely found in the south, west and east, but scarcely in the north, as in previous years (Figure 17).

Most specimens were from 28 cm to 35 cm in this last survey and fewer recruits were found in contrast to the previous year (Figure 18).

***Molva molva* (ling) and *Molva macrophthalma* (Spanish ling)**

These two species were analysed comparatively in this working document, as in previous reports.

M. molva was scarcer than *M. macrophthalma* in the area. Both species have been on a downward trend since 2014 and has not yet been reverted. In this last survey, the biomass and abundance of *M. macrophthalma* decreased further, reaching the lowest value of the time series (1.02 kg haul^{-1} and 1.27 ind. haul^{-1}), whereas *M. molva* increased slightly (Figure 19).

The few biomass patches of *M. molva* were found in the west and southeast of the bank whereas *M. macrophthalma* was found in the west but further south and in the south of the study area, though scarcer than in previous years (Figure 20).

Only 9 specimens of *M. molva* were found, ranging from 31 to 99 cm. Specimens of *M. macrophthalma*, a few more, sized from 14 to 97 cm (Figure 21).

Other deep-sea fish species

The deep water species *Aphanopus carbo, Brosme brosme, Coryphaenoides rupestris, Hoplostethus atlanticus* and *Beryx spp.* were scarcely or not found in the standard stratification of the study area, but were found outside of it, except for *Beryx* spp.

In 2022, the species *C. rupestris* and *H. atlanticus* were only found in deep hauls carried out in the Porcupine Seabight, outside the stratification, the first species in five hauls from 1039 and 1477 m and the second one in three hauls between 1302 and 1477 m.

The species *A. carbo* was found from 626 and 1492 m, mainly in deep hauls in the Porcupine Seabight, but also in four hauls in the standard stratification.

The species *Brosme brosme* was not found in the three previous years, but in this last survey was found again, one specimen in one haul in the standard stratification at 489 m and also two specimens in one haul in the Porcupine Seabight at 1032 m.

Species of the genus *Beryx* were found in the standard stratification, *Beryx splendes* in the southern part of the bank (three specimens of 25, 29 and 30 cm) and *Beryx decadatylus* in the east area, but only two specimens of 28 and 30 cm, in one haul.

Acknowledgements

We would like to thank the *R/V Vizconde de Eza* crew and the IEO scientific teams that made the Porcupine Spanish Groundfish Survey possible. Included in the ERDEM project, the survey has been co-funded by the EU through the European Maritime and Fisheries Fund (EMFF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

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Figures

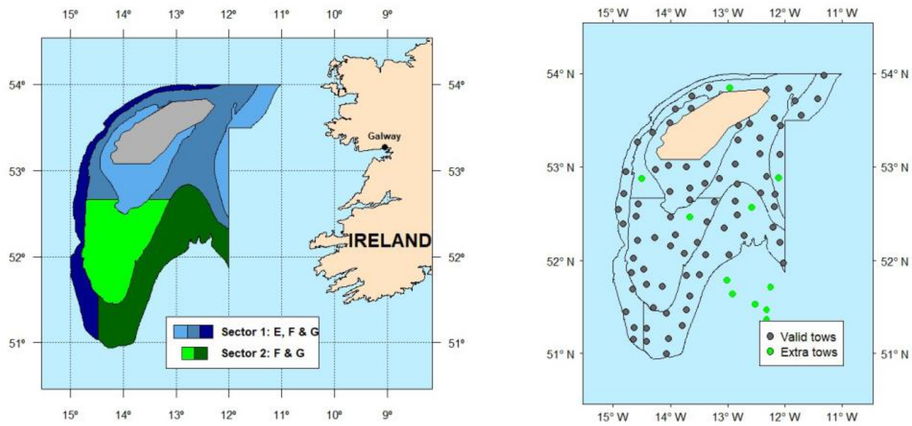

Figure 1. Left: Stratification design used in Porcupine surveys from 2003, previous data were re-stratified. Depth strata are: E) shallower than 300 m, F) 301 – 450 m and G) 451 – 800 m. The grey area in the middle of Porcupine bank corresponds to a large non-trawlable area, not considered for area measurements and stratification. Right: Distribution of hauls performed in the last survey.

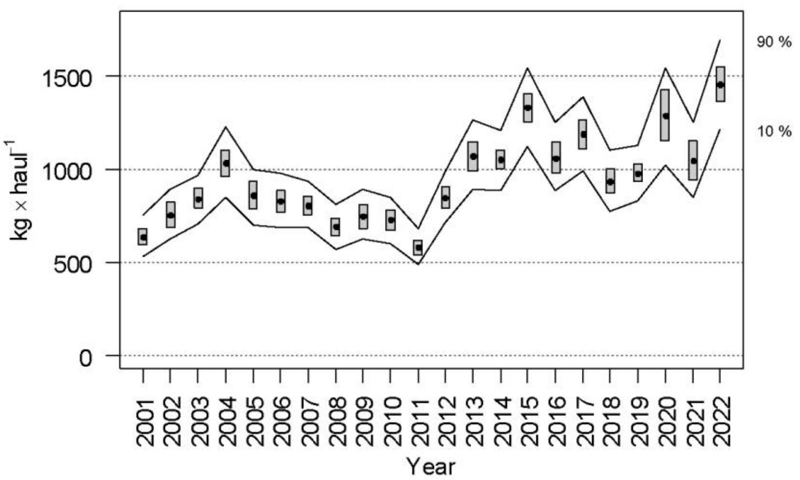

Figure 2. Evolution of the total fish catch in biomass in the Porcupine surveys.

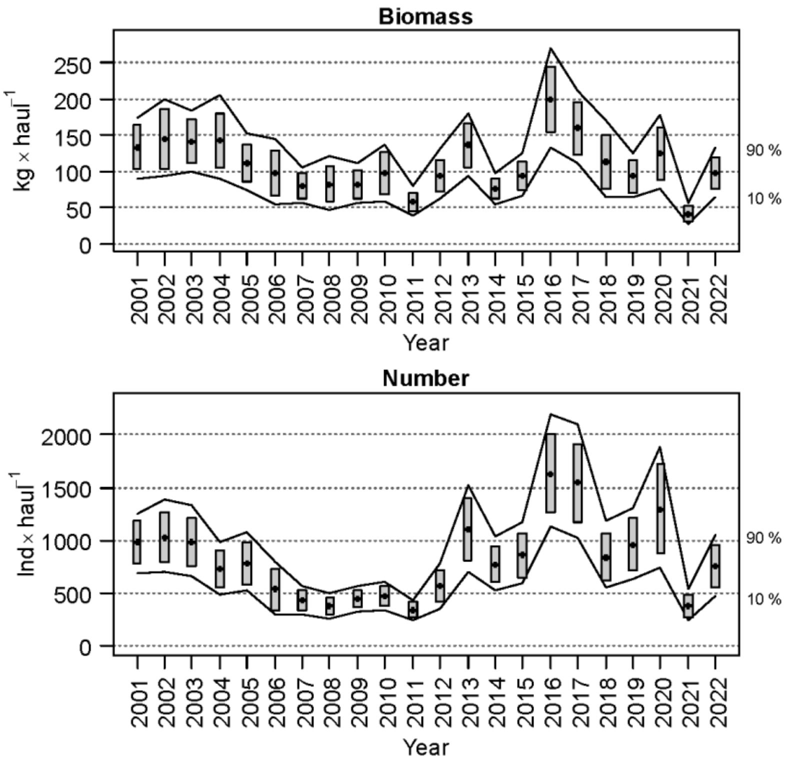

Figure 3. Evolution of biomass and abundance indices *Argentina* spp. (mainly *Argentina silus*) in the Porcupine surveys. Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals ($\alpha = 0.80$, bootstrap iterations = 1000).

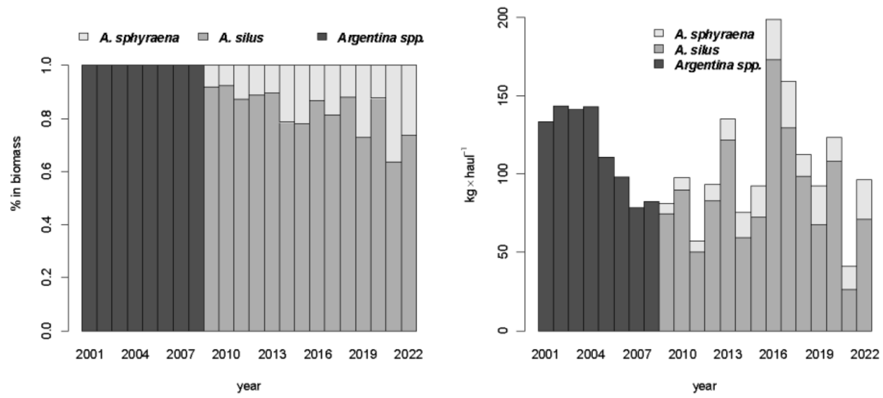

Figure 4. Share and abundance of Argentine species in the Porcupine surveys.

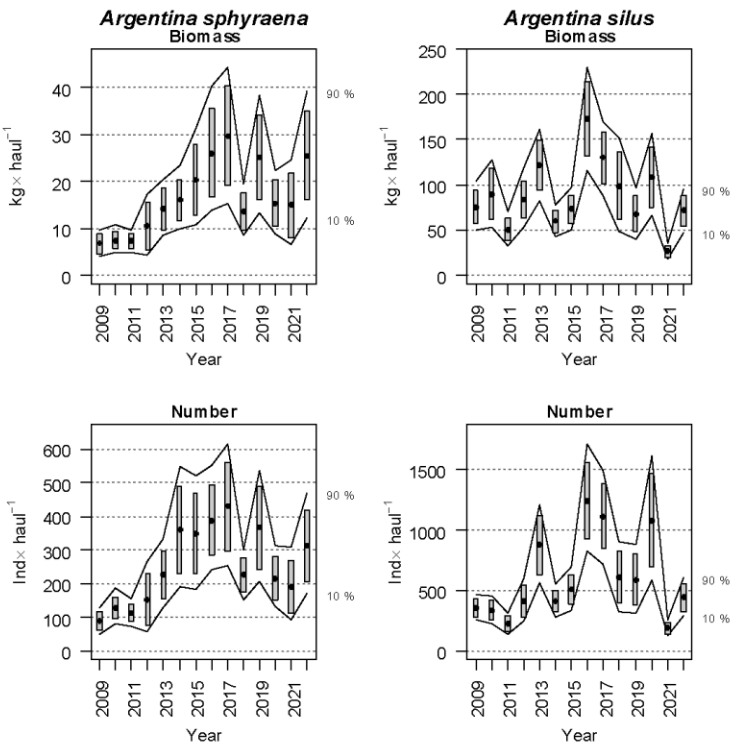

Figure 5. Evolution of biomass and abundance indices of *Argentina sphyraena* and *Argentina silus* in the Porcupine surveys. Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations =1000).

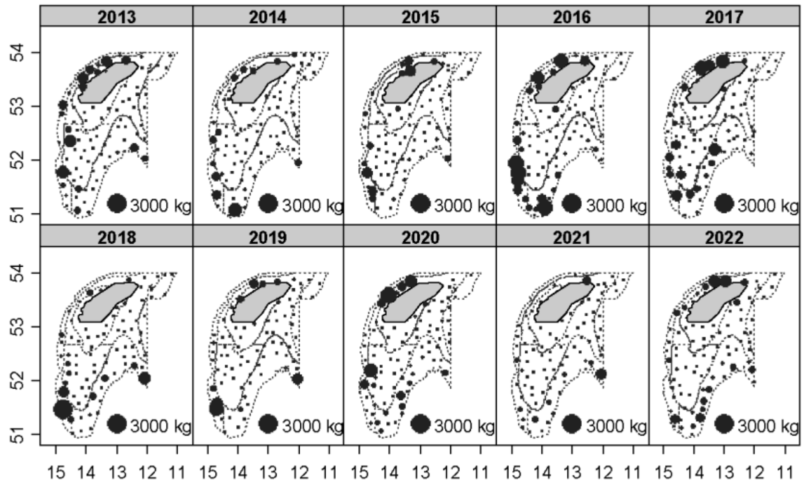

Figure 6. Geographic distribution of *Argentina* spp. catches (kg/30 min haul) in Porcupine surveys over the last decade.

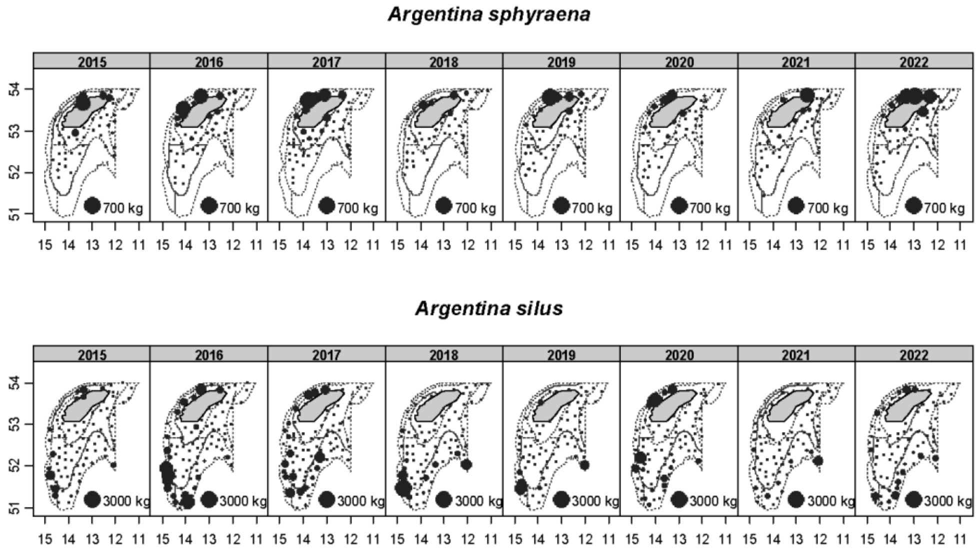

Figure 7. Geographic distribution of *Argentina sphyraena* and *Argentina silus* catches (kg/30 min haul) in Porcupine surveys (2015 - 2022).

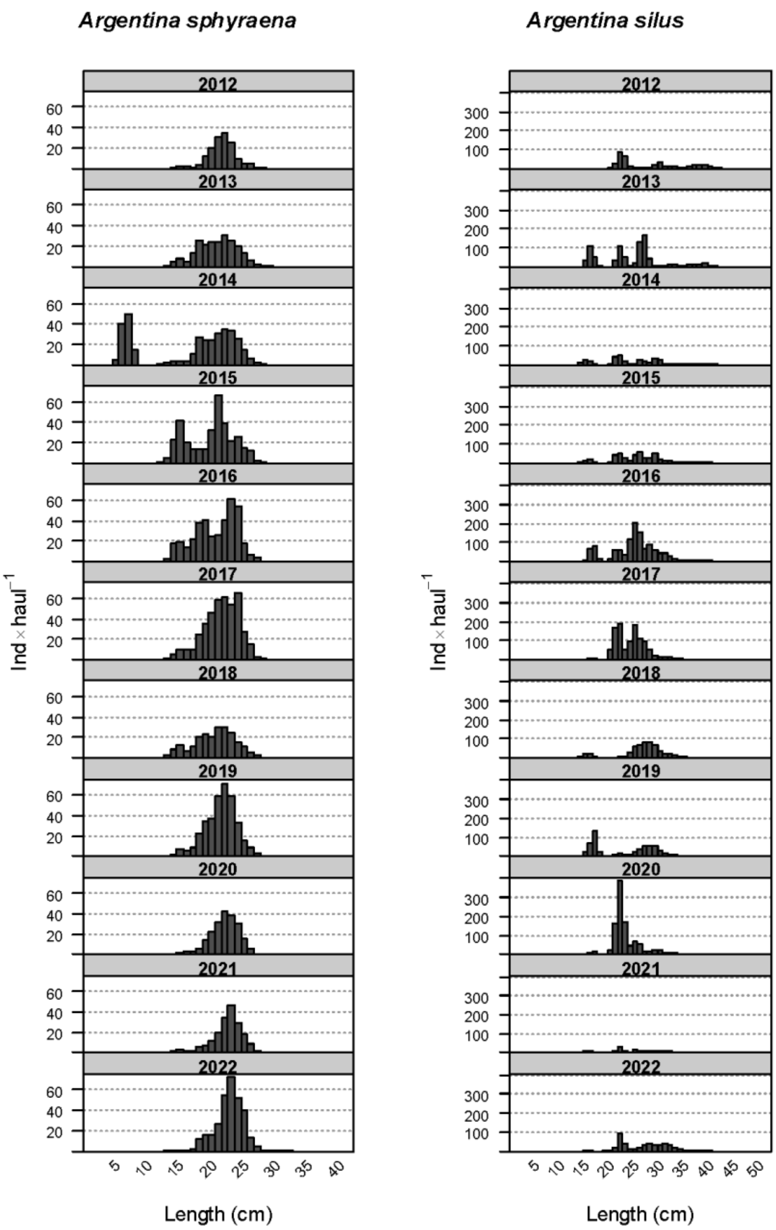

Figure 8. Mean stratified length distributions of *Argentina sphyraena* and *Argentina silus* in the Porcupine surveys (2012-2022).

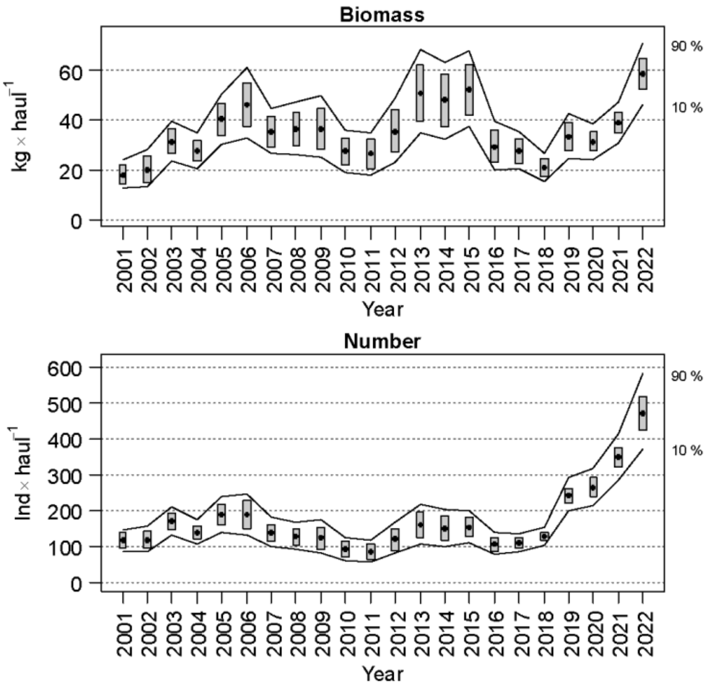

Figure 9. Evolution of biomass and abundance indices of *Helicolenus dactylopterus* in the Porcupine surveys. Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000).

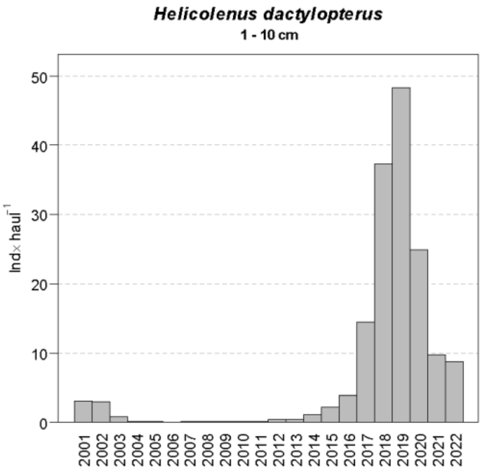

Figure 10. Mean stratified abundance of *Helicolenus dactylopterus* recruits (1-10 cm) in the Porcupine surveys.

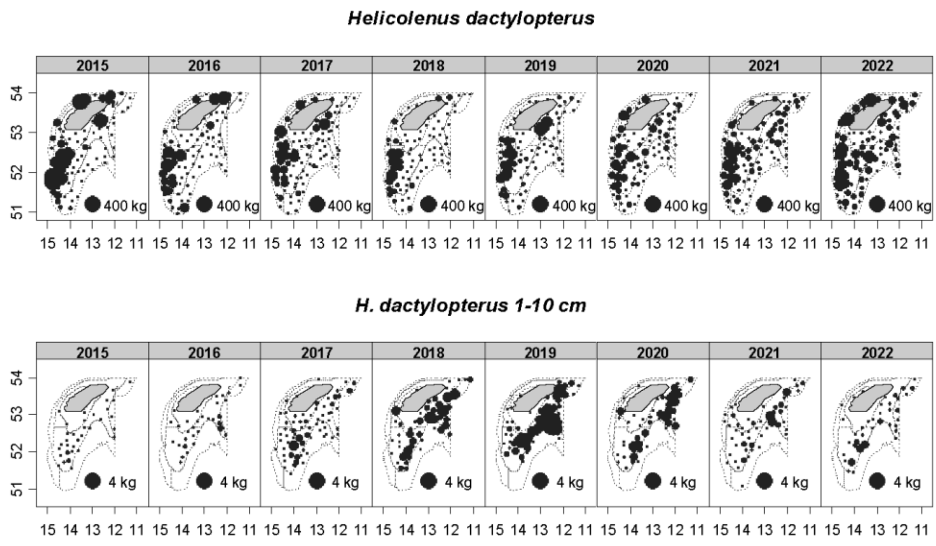

Figure 11. Geographic distribution of *Helicolenus dactylopterus* catches (kg×30 min haul-1) and recruits (1-10 cm) in the Porcupine surveys (2015-2022).

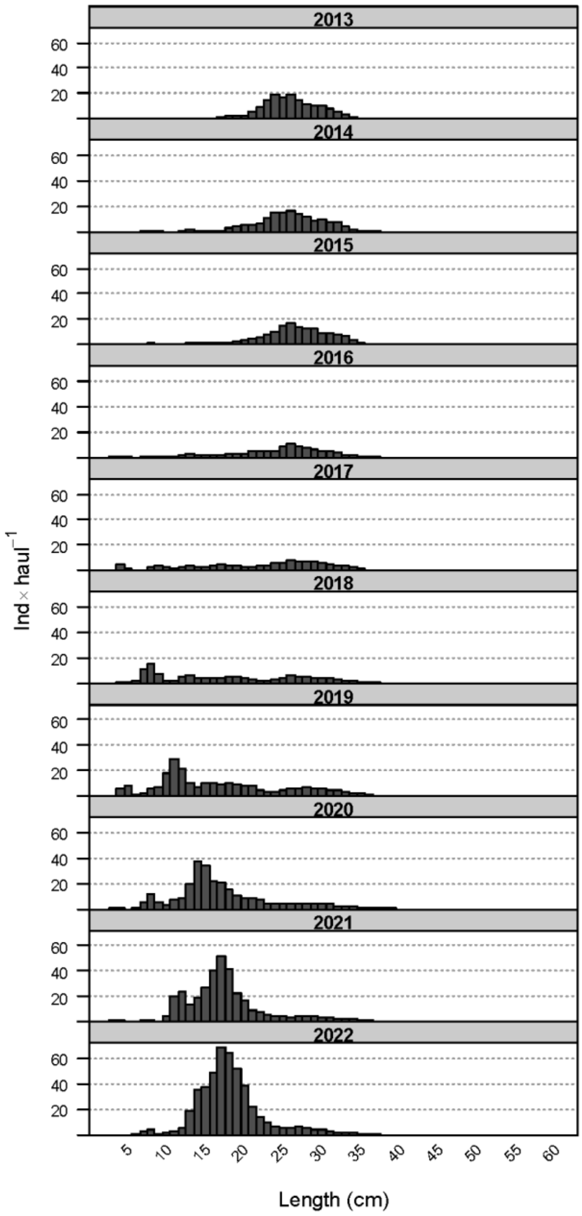

Figure 12. Mean stratified length distributions of *Helicolenus dactylopterus* in the Porcupine surveys (2013-2022).

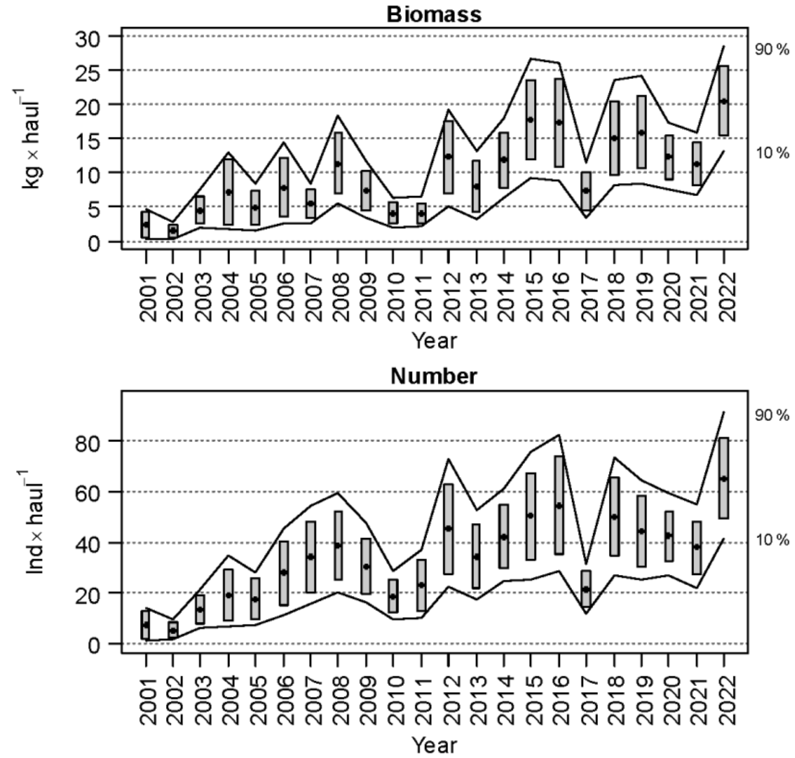

Figure 13. Evolution of biomass and abundance indices of *Trachyrincus scabrus* in the Porcupine surveys. Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals ($\alpha = 0.80$, bootstrap iterations = 1000).

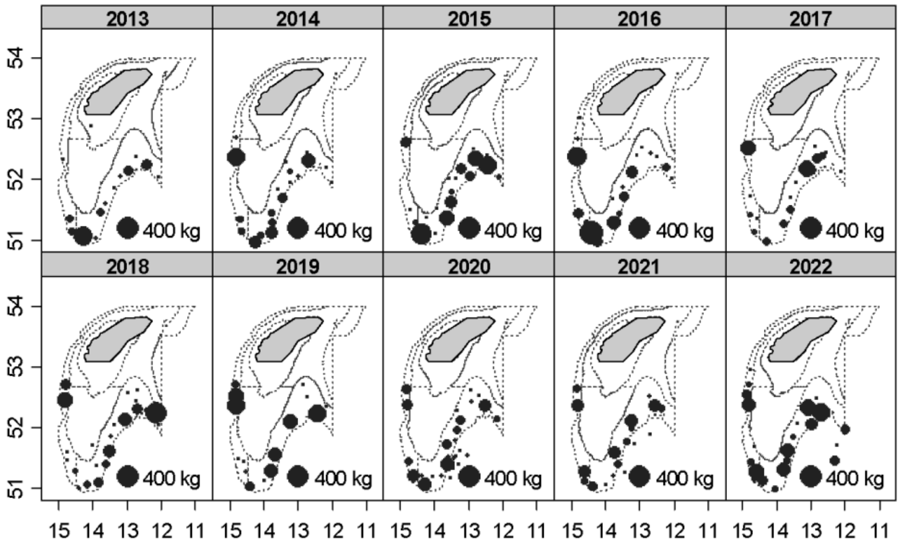

Figure 14. Geographic distribution of *Trachyrincus scabrus* catches (kg/30 min haul) in the Porcupine surveys over the last decade.

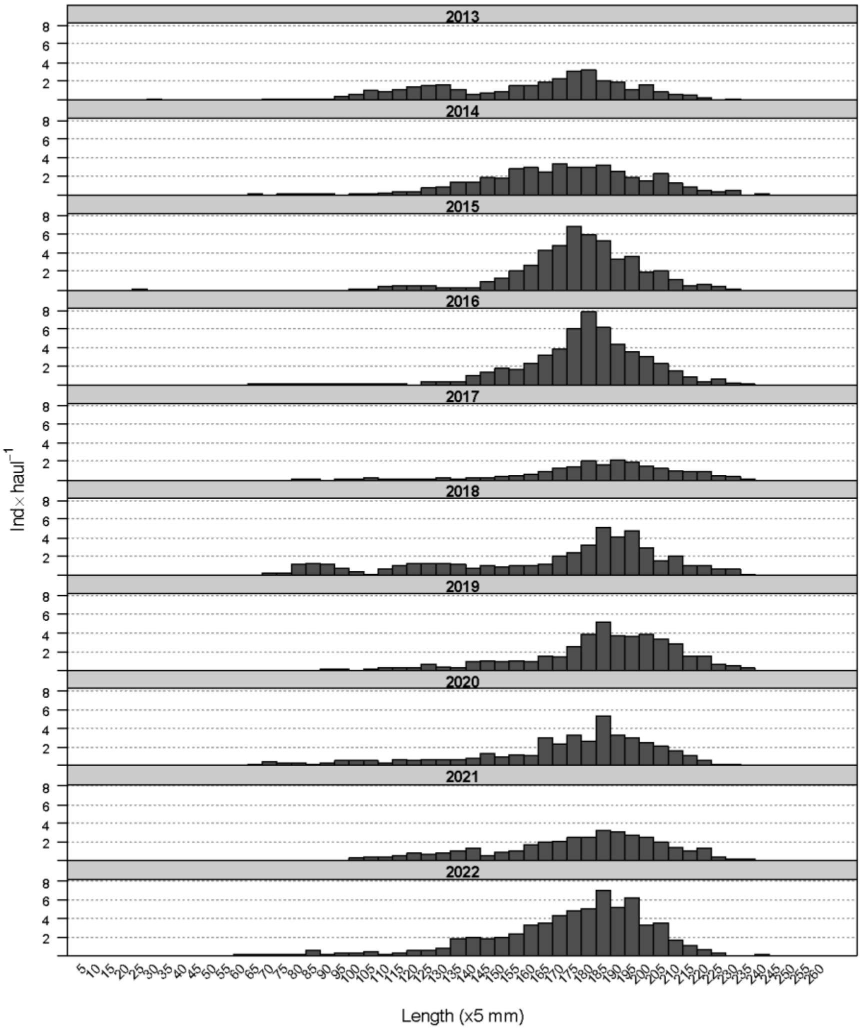

Figure 15. Mean stratified length distributions of *Trachyrincus scabrus* in the Porcupine surveys (2013-2022).

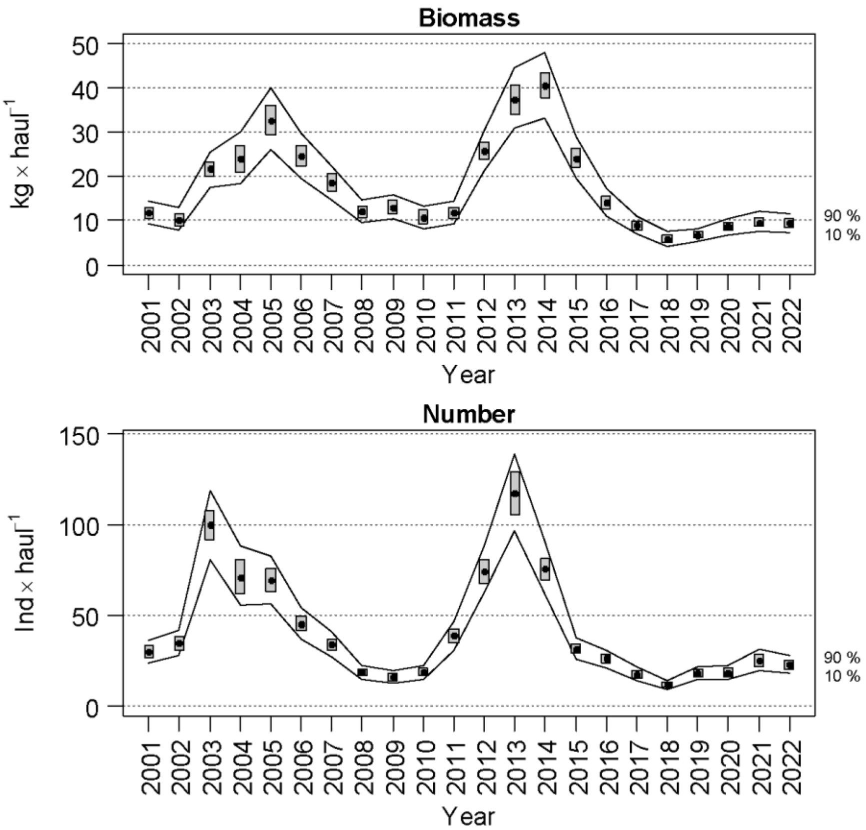

Figure 16. Evolution of biomass and abundance indices of *Phycis blennoides* in the Porcupine surveys. Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000).

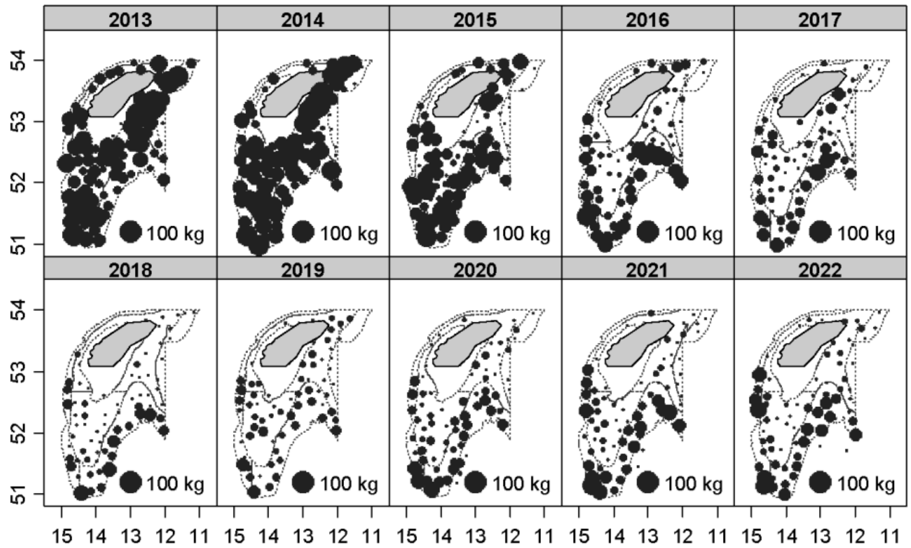

Figure 17. Geographic distribution of *Phycis blennoides* catches (kg×30 min haul^{-1}) in the Porcupine surveys over the last decade.

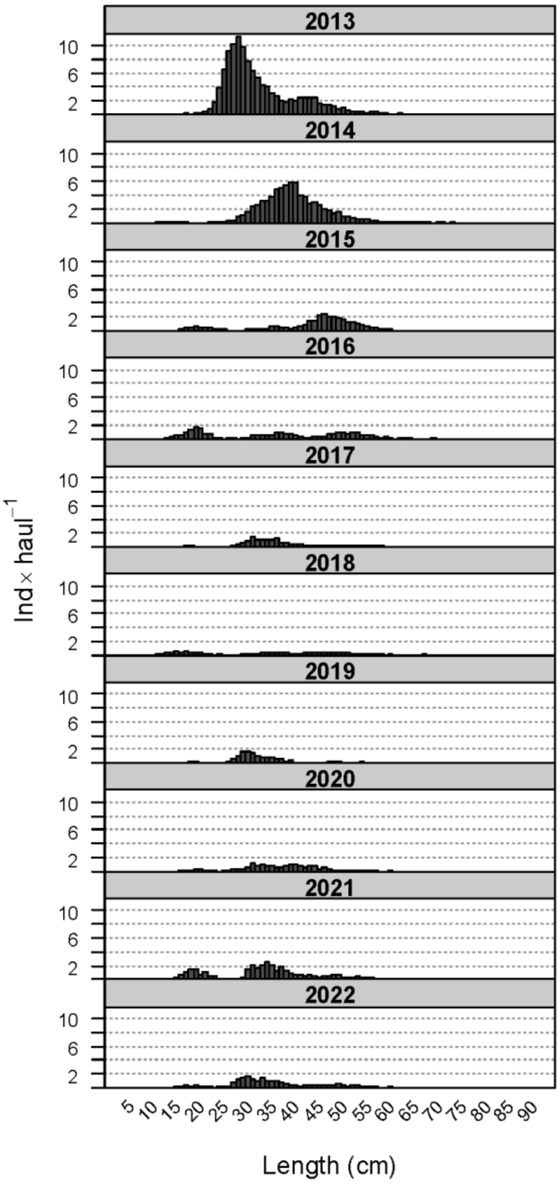

Figure 18. Mean stratified length distributions of *Phycis blennoides* in the Porcupine surveys (2013-2022).

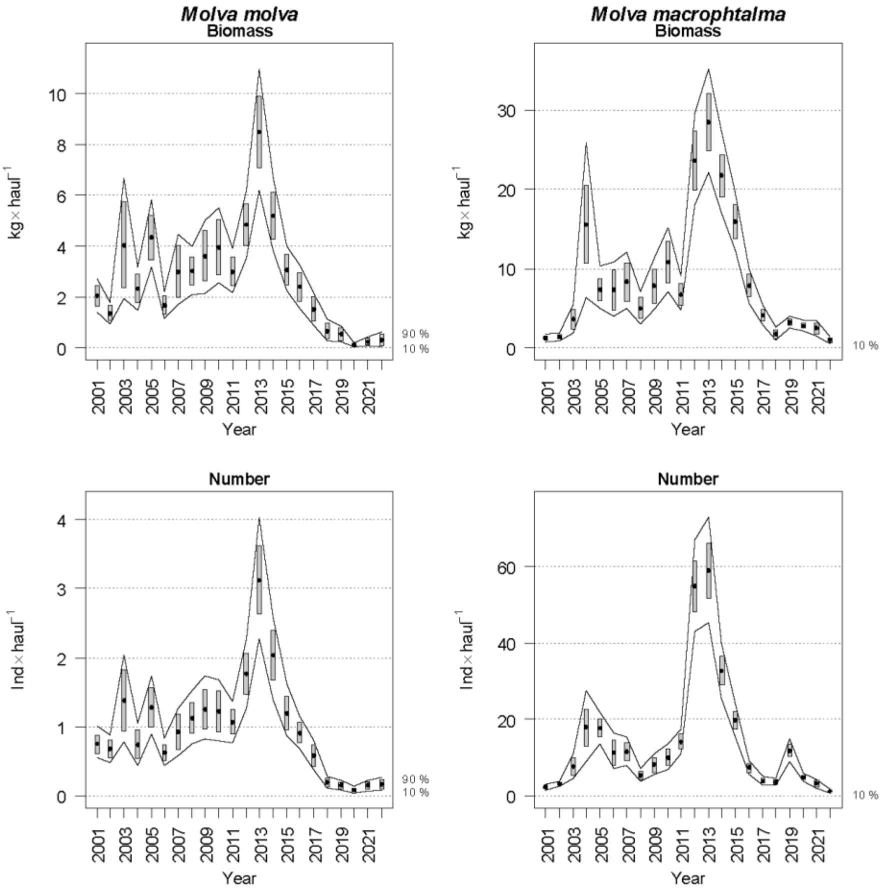

Figure 19. Evolution of biomass and abundance indices of *Molva molva* and *Molva macrophthalma* in the Porcupine surveys. Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals ($\alpha = 0.80$, bootstrap iterations = 1000).

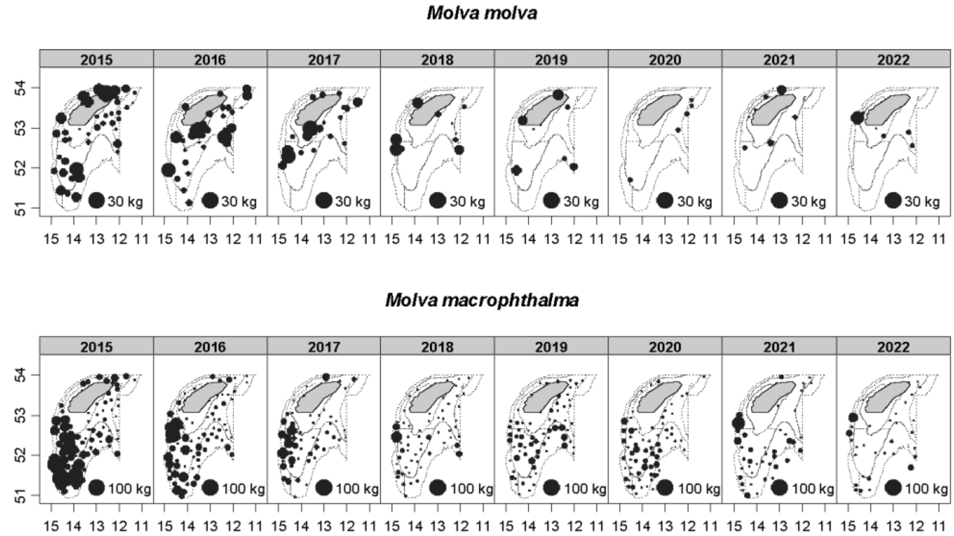

Figure 20. Geographic distribution of *Molva molva* and *Molva macrophthalma* catches (kg×30 min haul^{-1}) in the Porcupine surveys (2015-2022).

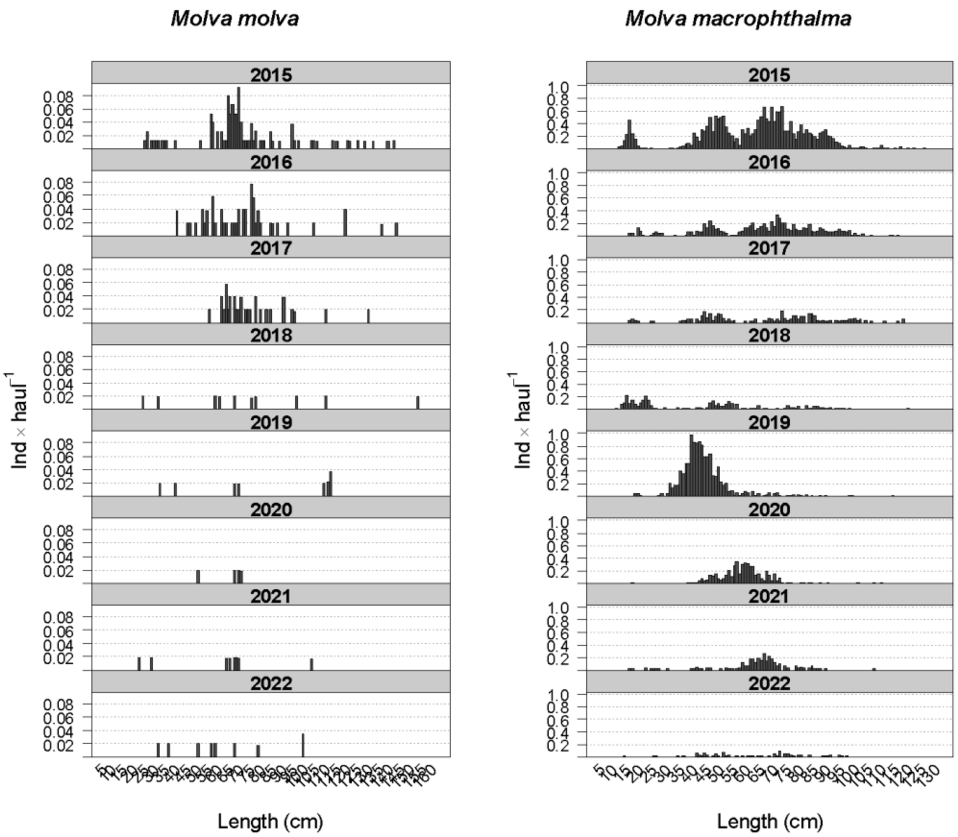

Figure 21. Mean stratified length distributions of *Molva molva* and *Molva macrophthalma* in the Porcupine surveys (2015-2022).

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Update on Norwegian fishery independent information on abundance, recruitment, size distributions, and exploitation of roundnose grenadier (*Coryphaenoides rupestris*) in the Skagerrak and north-eastern North Sea (ICES Division IIIa)

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Introduction

The roundnose grenadier is a long-lived deepwater species which in the relevant study area reaches ages of 70 years or more and attains maturity at the age of 8-12 years (Bergstad 1990). It has a limited area of distribution within the Norwegian deep and in the deep Skagerrak basin (300-720m) (ICES Div. 4a & 3a). Analyses using microsatellite DNA have demonstrated that the Skagerrak grenadier is currently likely to be isolated from grenadier elsewhere in its North Atlantic distribution area (Knutsen *et al*., 2012). In 2003-2005 a major expansion of the previously quite minor targeted grenadier fishery occurred, and this expansion was followed by a complete closure of the fishery from 2006 onwards. Apart from previous targeted exploitation, grenadier is now a minor by-catch in the traditional trawl fishery for *Pandalus borealis* which is currently the major demersal trawl fishery in the area. Most shrimp fishing occurs shallower than the main distribution area of the grenadier.

This Working Document presents results derived from a research vessel bottom trawl survey conducted annually during the past 40 years (1984-2023). While the main objective of the survey is to monitor *Pandalus borealis*, the survey samples the entire depth range and distribution area of roundnose grenadier.

We report temporal variation in survey catch rates in terms of biomass and abundance (kg/hour and number/hour), length distributions, occurrence of recruits, and geographical distribution. We also give an estimate of by-catch in the commercial shrimp fishery from Reference fleet data. Most of the information in this Working Document is an update of a WD first submitted to WGDEEP in 2009 (Bergstad *et al*. 2009). The survey series is currently the only information available to assess temporal variation and trends for the grenadier in this area. A full analysis of the time-series has been published (Bergstad *et al*., 2014), but this working paper extends the series to also include the years 2014-2023.

Material and Methods

Data was collected from the annual *Pandalus borealis* shrimp survey performed by the Institute of Marine Research in the years 1984-2023 (Table 1). The survey is a depth stratified shrimp trawl survey with approximately 25% of the stations deeper than 300 m (depth range 117-534 m). The trawl used has small meshes overall and a 6mm cod-end liner and retains all sizes of grenadiers, including the smallest newly settled juveniles (Bergstad 1990, Bergstad and Gordon 1994). The stations are placed at random within strata and subareas, and the same sites sampled every year. Although some changes occurred over the years (Table 1), the overall standardization was maintained throughout the time series (Bergstad *et al.* 2014).

Catch rates in terms of biomass and abundance were calculated for stations 300 m and deeper, i.e. excluding shallower survey depths where the species only occurs sporadically in small numbers (Bergstad 1990). Stations with zero catches were included, and the catches at non-zero stations were standardized by tow duration.

Annual length distributions were derived for the pooled standardized catches at 300m and beyond. In cases where catches were subsampled, length distributions were raised to the total catch prior to pooling.

Age data from selected surveys in 1987 and 2007-2023 were calculated as cumulative age distributions. Age and length data from 2008-2023 were analyzed for growth parameters.

Standardized mean catches by number of small juveniles of PAFL $\leq$ 5 cm were calculated to show recruitment during the survey period.

A time series of maps showing geographical distributions by year were plotted, representing scaled catch rates at the actual sample sites for each survey year.

Data from the Norwegian reference fleet (2013-2019) was collected to report bycatch on roundnose grenadier in the Norwegian shrimp fishery.

Results

Biomass and abundance

The estimates of catch rates in terms of biomass (kg/h) and abundance (nos/h) varied substantially through the time series (Fig.1), but elevated levels were observed from 1998 to 2004. The decline from 2005 continued through the time series until 2017 which was the lowest on record. The observations from 2018-2023 remained low, but with a slight increase compared with 2017.

Size and age distributions

The time series of annual length distributions show a major shift in the early 1990s (Fig. 2). From 1992 the proportion of large fish with PAFL>15cm declined to less than 10% which contrasts with the pre-1990 distributions dominated by large fish. From 1992, a pronounced mode of small fish can be followed in subsequent years, with modal length increasing through the time series.

In 2018 there is another shift in the length distributions. The very recent distributions (2018-2023) contrasts with earlier distributions by having very low proportions of large fish. The distributions are dominated by small fish but at low levels compared to the 1990's. The situation in 2023 is the same as in 2022.

Age distributions and growth
The cumulative age distribution from the extracted data from 1987 (Bergstad, 1990) contrasts substantially with the distributions from 2007-2023 in terms of proportions of old fish (e.g. >20 years). In 1987, the proportion of fish > 20 years was over 50% (Table 4). In 2008, i.e. after the relatively large expansion in landings in 2003-2005 and ban on direct fishing introduced in 2006, only 8% of the aged fish were older than 20 years. In subsequent years the proportion of older fish apparently increased, and recent distribution from 2023 now show 21% fish > 20 years (Table 4). This is still very low compared with the 1987 situation.

Age at length was analyzed for the years 2008-2023 (Figure 5) and compared with data from 1987 (Bergstad, 1990) (Table 3). The growth rate coefficient (k) and the length infinity ($L\infty$) for females is in the same range as the data from 1987, but slightly lower for 2008-2023 data compared with data from 1987, especially for females.

Occurrence of juveniles <5cm PAFL
There are no positive signs of recruitment in 2023. There is no indication of a pronounced recruitment pulse as that observed in the early 1990s, neither in the length distributions (Fig 2.), or in the time series of mean abundance of small fish < 5 cm (Fig. 3).

Geographical distribution
The area sampled in given year and the corresponding geographical distribution of grenadier catches is presented in Figure 4. The overall distribution area does not seem to have changed considerably during the time series 1984-2023. Catches of roundnose grenadier are restricted to the Norwegian Deep north to 59°N and extend eastwards into the Skagerrak basin. The highest catches were always found in the eastern Skagerrak part of the Norwegian Deep.

Commercial by-catch
For an assessment of the bycatch of roundnose grenadier in the Norwegian shrimp fishery, data from the Norwegian Reference fleet showed that < 1% of the tows with shrimp trawl caught roundnose grenadier (Table 5). The values for catch weights from the Reference fleet are low and in same level as the reported landings for the recent years. This indicates that the low reported Norwegian landings are realistic and that the landings are the bycatch amount taken by the Norwegian shrimp fishery.

Discussion

Despite high inter annual variability, the catch rates in terms of biomass and abundance from the survey suggest long term pattern of variation through the time series 1984-2023. An increase in biomass and abundance from the late 1980s until 1998-2004 seemed to be followed by a major decline from the mid-2000s onwards. In 2023 abundance and biomass estimates were still at low levels.

The survey catch rate declined in all areas, also where high survey catches were common, i.e. in the eastern part of the Skagerrak (Fig. 4).

The time-series of size distributions also suggest pronounced structural changes during the period 1984-2023. The distributions from the 1980s with a dominance of fish around 15 cm PAFL contrasts with those from the early 1990s when the population was apparently rejuvenated by a pulse in recruitment from 1991-1992 onwards. The recruits from 1991-1992 can be tracked as a mode in the size distributions for 15 years until 2005. The distributions were dominated by old fish until 2012 although with consecutively low concentrations. From 2018, the older fish is almost disappeared and the distributions changed to younger fish primarily but still with low levels.

The difference in age distribution between 1987 and 2023 is primarily seen in the proportion of older fish, i.e. there is almost no fish older than 30 years in 2023 while almost 25% of the fish was older than 30 years in 1987. The most prominent difference between recent situation and that of 1987 concerning growth, was seen for females. It seems that the bulk of very large and old female individuals seen in 1987 is no longer present in recent years (Table 3).

High mean survey biomass coincided with very high commercial landings in 2004-05 (Figure 6). The fishery may have utilized a period of elevated abundance resulting from what appears to be the single large pulse in recruitment in the 40 years surveyed. From recent length distributions no similar pulse in recruitment has been observed.

An interpretation of the patterns observed in the time-series of size and age distributions, the survey abundance index for small juveniles, and the survey index of all sizes combined is that the enhanced fishery in 2003-2005 had the combined effect of eroding both the accumulated fraction of older fish around 30 years that were found in the population in 1987 prior to the fishery and the younger fish resulting mainly from the recruitment pulse in the early 1990s. The very old fish never reappeared, and for three decades, recruitment has been consistently at a level well below the level observed in the single high event in the early 1990s. The recent recruitment has probably been too low to produce any increase in abundance.

The reported landings peaked in 2005 at about 11000 tons (Figure 6) and have since declined to about a ton per year. From 2006 onwards this decline in landings is a result of regulations (Bergstad 2006) as the targeted fishery ceased. By-catches from shrimp fisheries still occur, however. The data from the Norwegian Reference fleet suggests that current levels are minor, probably reflecting low grenadier abundance at relevant depths and introduction of sorting grids to the fishery.
The Norwegian bycatch of roundnose grenadier thus is well described through the reported landings. The Swedish and Danish fishery reports both landings and discards and therefore the bycatch from these fisheries should be counted for in the statistics. The level of landings and discards in recent years has been in total less than 2 tons per year.

Conclusion

The decline in abundance after 2005-2006 suggested by the survey catch rates may reflect the combined effect of the enhanced targeted exploitation in 2003-2005 and the low recruitment in the years following the single recruitment pulse in the early 1990s. The percentage of fish >15cm is now lower than recent years and there is no suggestion of a new recruitment pulse as seen in the 1990s. The current low abundance and truncated age structure in the population thus reflect both the exploitation and recruitment history spanning the past 2-3 decades. Since the targeted fishery has stopped and the by-catch in the shrimp fishery are low, there is a potential for recovery of the roundnose grenadier in Skagerrak. However, rejuvenation and growth of the population would at present seem unlikely due to low recruitment during the recent decades. The survey information suggests that it may be a feature of this population that only a single good recruitment event may be expected in a period of 3 decades.

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Table 1. Summary of data on the bottom trawl survey series, 1984-2023. Rg- rockhopper ground gear. 'Strapping' – maximum width of trawl constrained by rope connecting warps in front of otter doors. MS – RV Michael Sars, HM – RV Håkon Mosby, KB – RV Kristine Bonnevie. Data from 2023 survey is included. All trawls were fitted with a 6mm mesh cod-end liner.

YEAR	Survey month	Vessel	IMR Gear code	Additional gear info.	No. trawls >300m	No. trawls >400m	No. trawls survey
1984	OCT	MS	3230	Shrimp trawl (see text)	10	1	67
1985	OCT	MS	3230	"	21	5	107
1986	OCT/NOV	MS	3230	"	24	9	74
1987	OCT/NOV	MS	3230	"	35	14	120
1988	OCT/NOV	MS	3230	"	31	11	122
1989	OCT	MS	3236	Campelen 1800 35mm/40, Rg	31	7	106
1990	OCT	MS	3236	"	26	5	89
1991	OCT	MS	3236	"	28	9	123
1992	OCT	MS	3236	"	27	10	101
1993	OCT	MS	3236	"	30	10	125
1994	OCT/NOV	MS	3236	"	27	10	109
1995	OCT	MS	3236	"	29	12	103
1996	OCT	MS	3236	"	27	11	105
1997	OCT	MS	3236	"	25	6	97
1998	OCT	MS	3270	Campelen 1800 20mm/40, Rg	23	6	97
1999	OCT	MS	3270	"	27	8	99
2000	OCT	MS	3270	"	25	10	109
2001	OCT	MS	3270	"	18	4	87
2002	OCT	MS	3270	"	24	6	82
2003	OCT/NOV	HM	3230	Shrimp trawl (as in 1984-1988)	13	0	68
2004	MAY	HM	3270	Campelen 1800 20mm/40, Rg	17	6	65
2005	MAY	HM	3270	"	23	8	98
2006	FEB	HM	3270	"	10	0	45
2007	FEB	HM	3270	"	11	1	66
2008	FEB	HM	3271	Campelen 1800 20mm/40, Rg and strapping*	18	5	73
2009	JAN/FEB	HM	3271	"	25	7	91
2010	JAN	HM	3271	"	24	7	98
2011	JAN	HM	3271	"	22	7	93
2012	JAN	HM	3271	"	20	5	65
2013	JAN	HM	3271	"	28	8	101
2014	JAN	HM	3271	"	16	7	69
2015	JAN	HM	3271	"	28	9	92
2016	JAN	HM	3271	"	28	9	108
2017	JAN	KB	3271	"	30	9	128
2018	JAN	KB	3271	Campelen 1800 20mm/40, Rg and strapping**	27	8	111
2019	JAN	KB	3296	Campelen 1800 20mm/40, Rg and strapping***	27	8	108
2020	JAN	KB	3296	"	26	7	106

Table 1. Continued

YEAR	Survey month	Vessel	IMR Gear code	Additional gear info.	No. trawls >300m	No. trawls >400m	No. trawls survey
2021	JAN	KB	3296	Campelen 1800 20mm/40, Rg and strapping***	27	8	113
2022	JAN	KB	3296	‘’	28	8	119
2023	JAN	KB	3296	‘’	29	8	116

* Path width of the tow constrained by a 10 m rope connecting the warps, 200 m in front of otter boards. ** Path width of the tow constrained to a 15 m rope connecting the warps, 100 m in front of the otter boards. *** Same trawl and strapping but from 2019 there are inserted several floaters on the trawl to lighten the trawl (Nordsjørigging).

Table 2. Mean biomass index and mean abundance index from shrimp survey 1984-2023. Missing data are from surveys that are not representable according to roundnose grenadier catches (few stations > 300 m). Data from 2016 are considered unreliable according to gear inconsistencies.
Mean biomass (kg/h), Mean abundance (n/h), Number (n) and Standard error (SE)

Year	n	(kg/h)	SE(kg/h)	(n/h)	SE(n/h)
1984	10				
1985	21	108.12	38.32	149.95	49.43
1986	24	83.75	32.16	117.83	46.99
1987	35	76.15	13.56	125.80	24.60
1988	31	72.14	13.92	105.19	21.22
1989	31	122.69	43.48	195.94	73.07
1990	26	49.81	18.20	72.66	27.55
1991	28	107.14	22.27	176.86	38.75
1992	27	188.54	67.53	698.52	337.67
1993	30	58.59	19.42	190.33	74.15
1994	27	87.19	21.21	372.96	143.56
1995	29	118.30	32.36	440.62	144.41
1996	27	99.63	31.68	268.01	116.92
1997	25	113.86	66.47	362.72	222.08
1998	23	255.54	87.80	812.82	336.85
1999	27	149.30	42.85	388.83	122.54
2000	25	129.27	30.39	389.06	107.71
2001	18	105.33	51.84	272.99	151.99
2002	24	174.77	66.27	371.70	129.97
2003	13				
2004	17	324.38	125.48	1143.35	487.33
2005	23	193.65	93.81	550.42	260.94
2006	10				
2007	11				
2008	18	95.58	65.81	259.10	208.53
2009	25	72.72	39.81	207.41	121.84
2010	24	33.24	21.47	77.21	54.81
2011	22	26.84	12.61	54.76	27.05
2012	20	16.69	11.97	34.40	23.83
2013	28	11.48	4.92	35.06	16.90
2014	16	25.62	15.76	49.56	28.69
2015	28	7.28	4.59	21.19	12.14
2016	28				
2017	30	6.64	2.41	15.74	6.73
2018	27	12.88	6.60	41.91	26.13
2019	27	14.59	5.77	40.09	18.05
2020	26	18.72	11.48	63.02	38.07
2021	27	9.59	5.03	26.14	14.19
2022	28	23.87	10.94	75.20	35.61
2023	29	19.24	8.89	38.81	19.10

Table 3. Estimated parameters of von Bertalanffy growth function on data from Skagerrak shrimp survey 2008-2023 and Skagerrak survey in 1987 as reported by Bergstad 1990. k=growth coefficient, L_∞=asymptotic length, t_0=theoretical age when length is zero, SE=standard error

	Estimated parameter			
Parameter	**Shrimp survey 2008-2022**		**Skagerrak survey 1987**	
	Females (SE)	**Males (SE)**	**Females**	**Males**
k	0.085 (±0.004)	0.076 (±0.010)	0.100	0.105
L_∞	16.8 (±0.233)	14.9 (±0.548)	18.1	14.7
t_0	-2.7 (±0.278)	-5.7 (±1.022)	-0.9	-1.5

Table 4. Cumulative percentages (%) for selected ages from 1987 and 2007-2023.

	Age				
Year	**5**	**10**	**20**	**30**	**50**
1987	9	21	45	75	96
2007	10	23	83	94	96
2008	22	40	92	99	100
2009	14	30	88	93	100
2010	12	29	71	96	99
2011	6	23	65	94	99
2012	10	28	48	96	100
2013	14	28	56	92	99
2014					
2015	7	17	48	95	100
2016					
2017	14	52	81	94	99
2018	23	50	77	99	100
2019	8	37	64	92	100
2020	40	64	83	97	100
2021	20	55	83	97	100
2022	33	53	81	95	99
2023	22	50	79	92	100

Table 5. Proportion of tows with shrimp trawl that caught roundnose grenadier. Data from Norwegian Reference fleet.

Year	Total number of shrimp trawl	Number of trawl hauls that caught roundnose grenadier	Catch of roundnose grenadier (kg)	% of the total catch
2013	243	0		0
2014	288	2		0,69
2015	1489	14		0.94
2016	4811	23		0,48
2017	3798	20	29	0,53
2018	2849	19		0,67
2019	1233	4	80	0,32

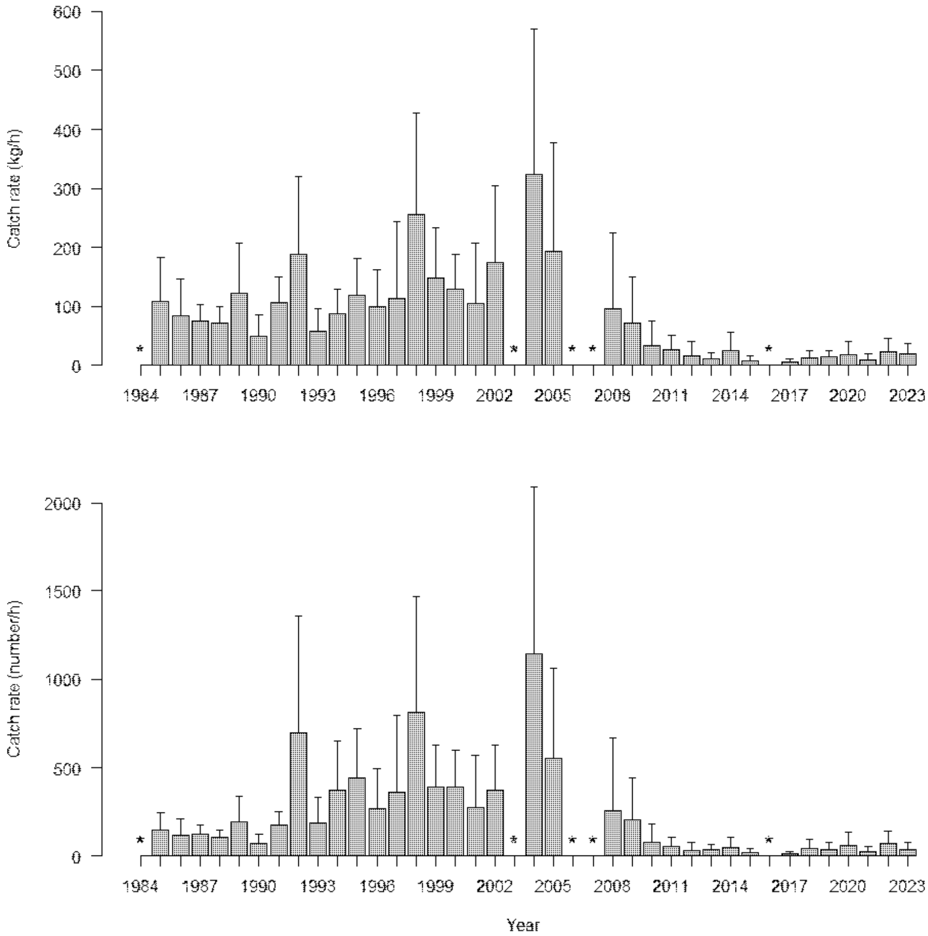


Figure 1. Standardized survey catch rates of roundnose grenadier, 1984-2023. Upper: Biomass (kg/h), Lower: Abundance (number/h). Standard error (2SE) shown by lines on top of bar. *In 1984, 2003, 2006 and 2007, only one single or no trawls were made deeper than 400 m, and data from those years were excluded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.

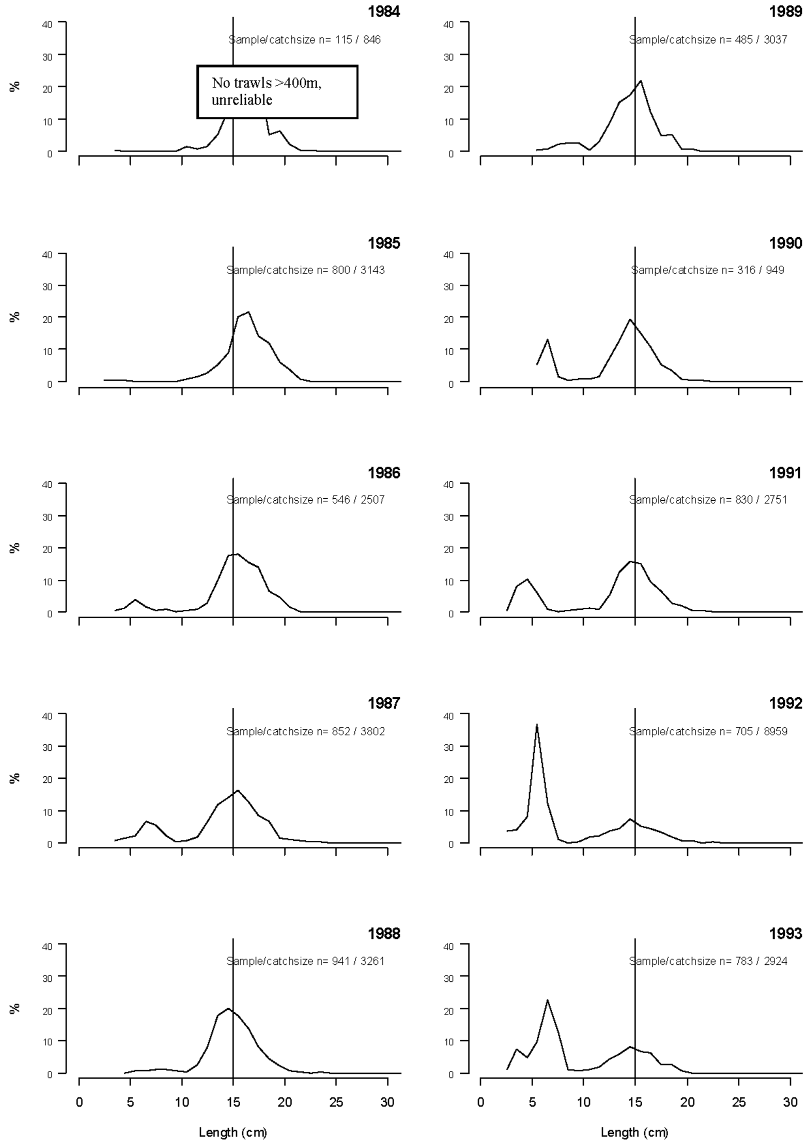
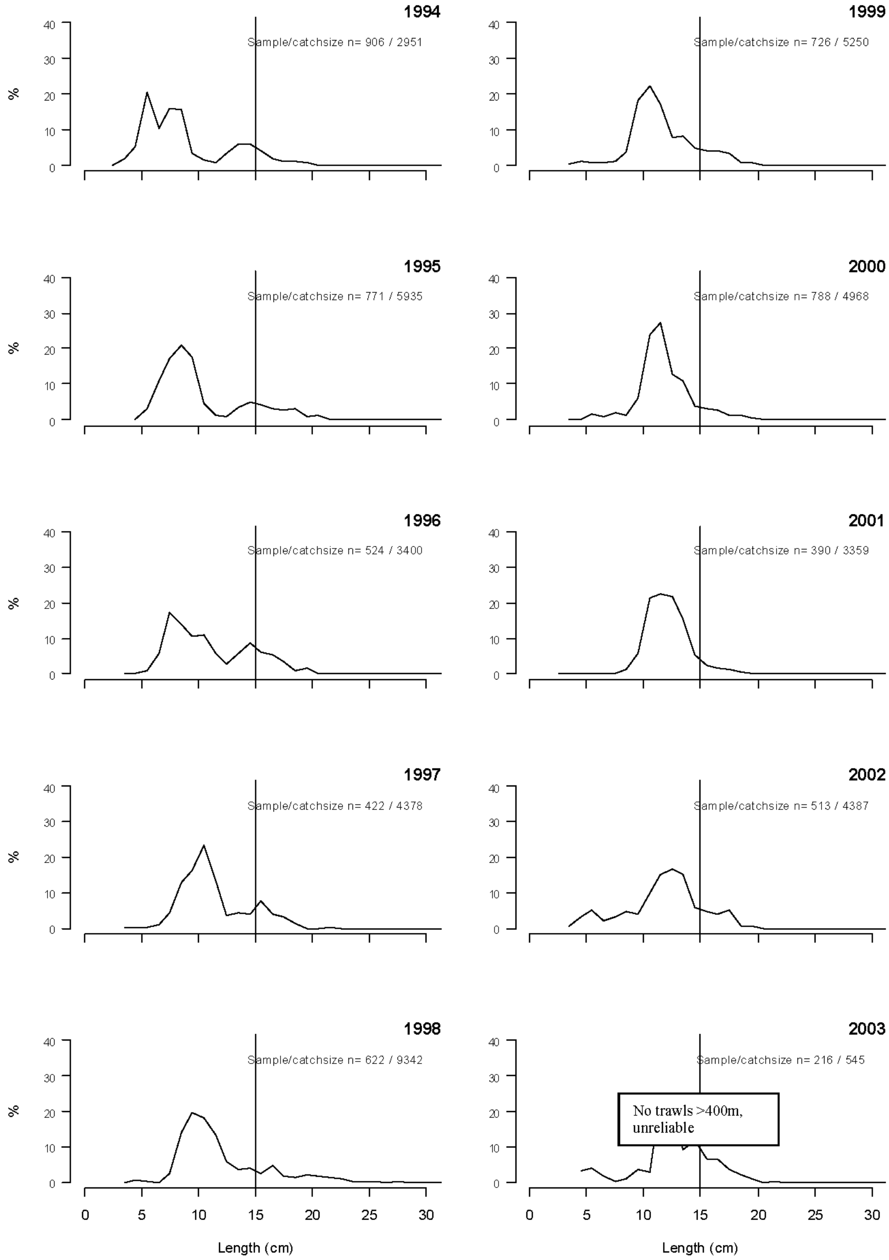


Figure 2. Length distributions of roundnose grenadier from annual *P. borealis* surveys, 1984-2023. Length is measured as PAFL (cm). The length distributions are calculated as percentage number of fish in each centimetre length interval standardized to total catch number and trawling distance for each station each year. *In 1984, 2003, 2006 and 2007, only one single or no trawls were made deeper than 400 m, and data from those years should be excluded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.



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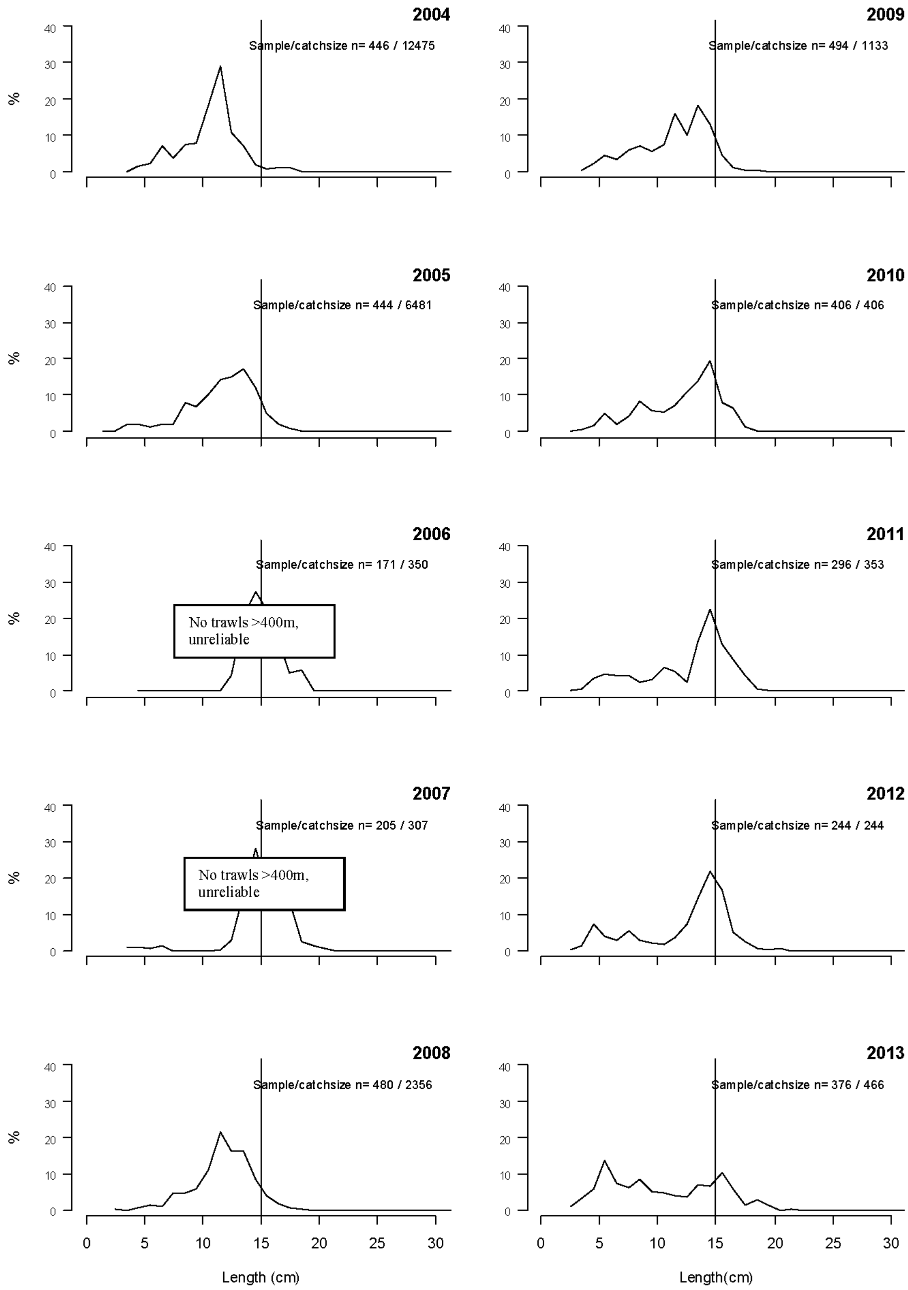

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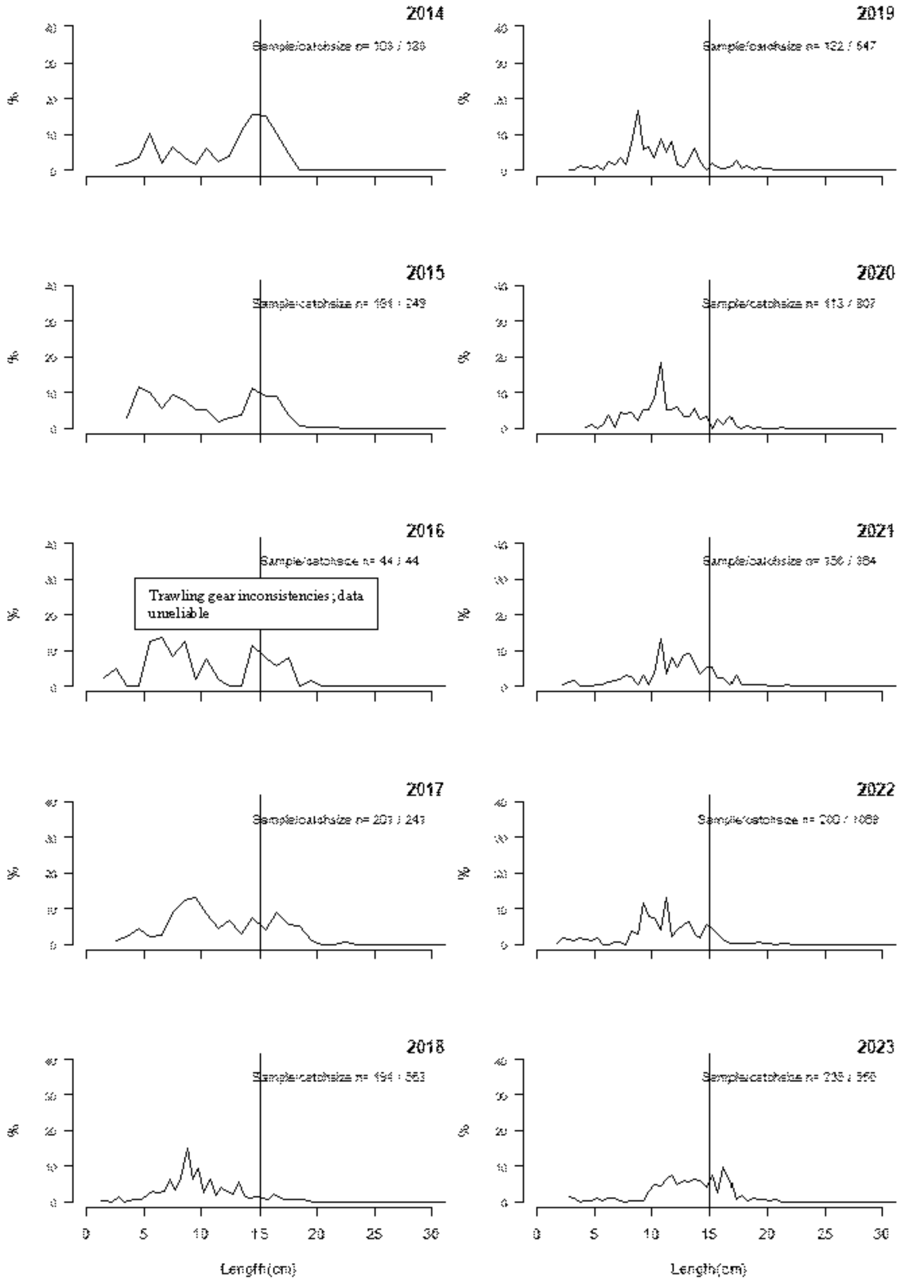

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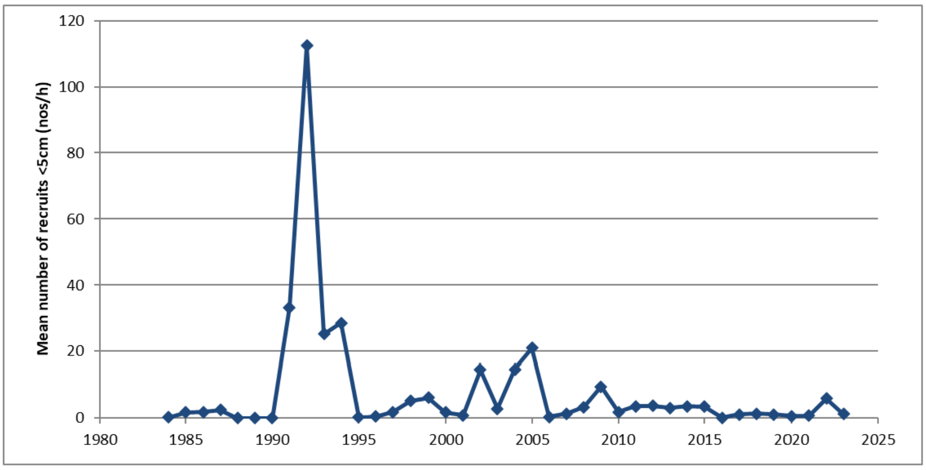


Figure 3. Mean catch rate of roundnose grenadier of PAFL ≤ 5 cm, 1984-2023. Data from shrimp survey, trawls deeper than 300 m. *In 1984,2003,2006 and 2007, no trawls were made deeper than 400 m, and data from these years should be disregarded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.

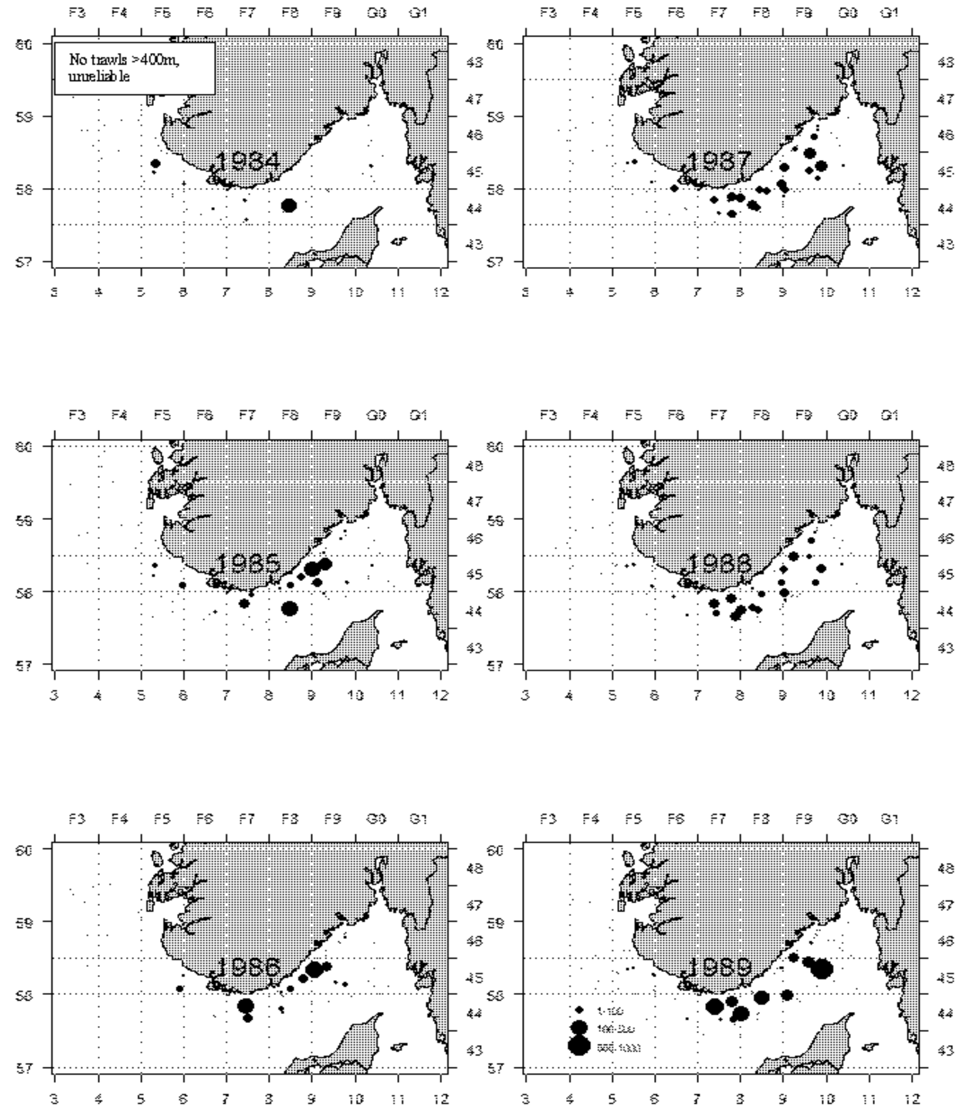
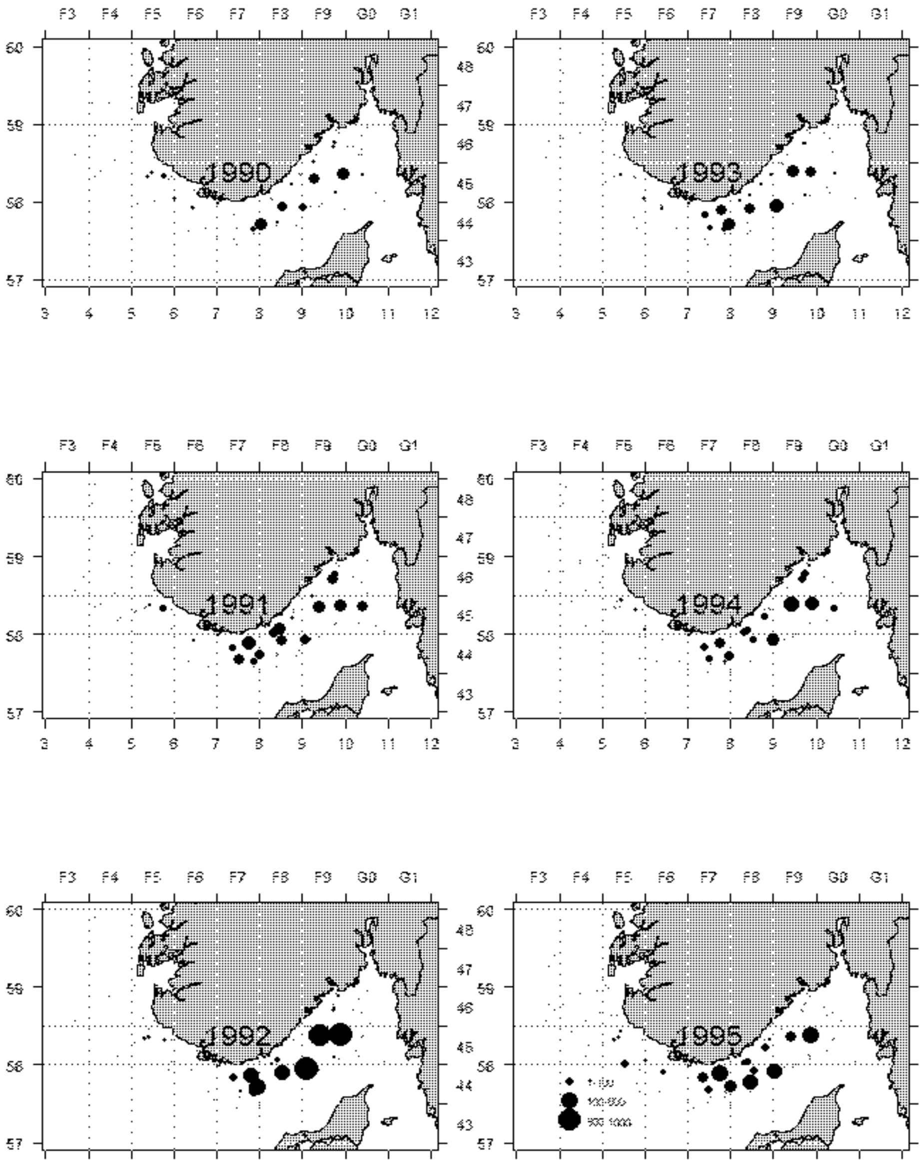


Figure 4. Geographical distribution of catches of roundnose grenadier (kg/h) from 1984-2023. Data from shrimp survey, trawls deeper than 300 m. Grey circles are trawls with no catch of grenadier. *In 1984, 2003, 2006 and 2007, only one single or no trawls were made deeper than 400 m, and data from those years should be excluded; in 2016 data from shrimp survey is regarded as unreliable due to inconsistencies with trawling gear and data from that year should be excluded.



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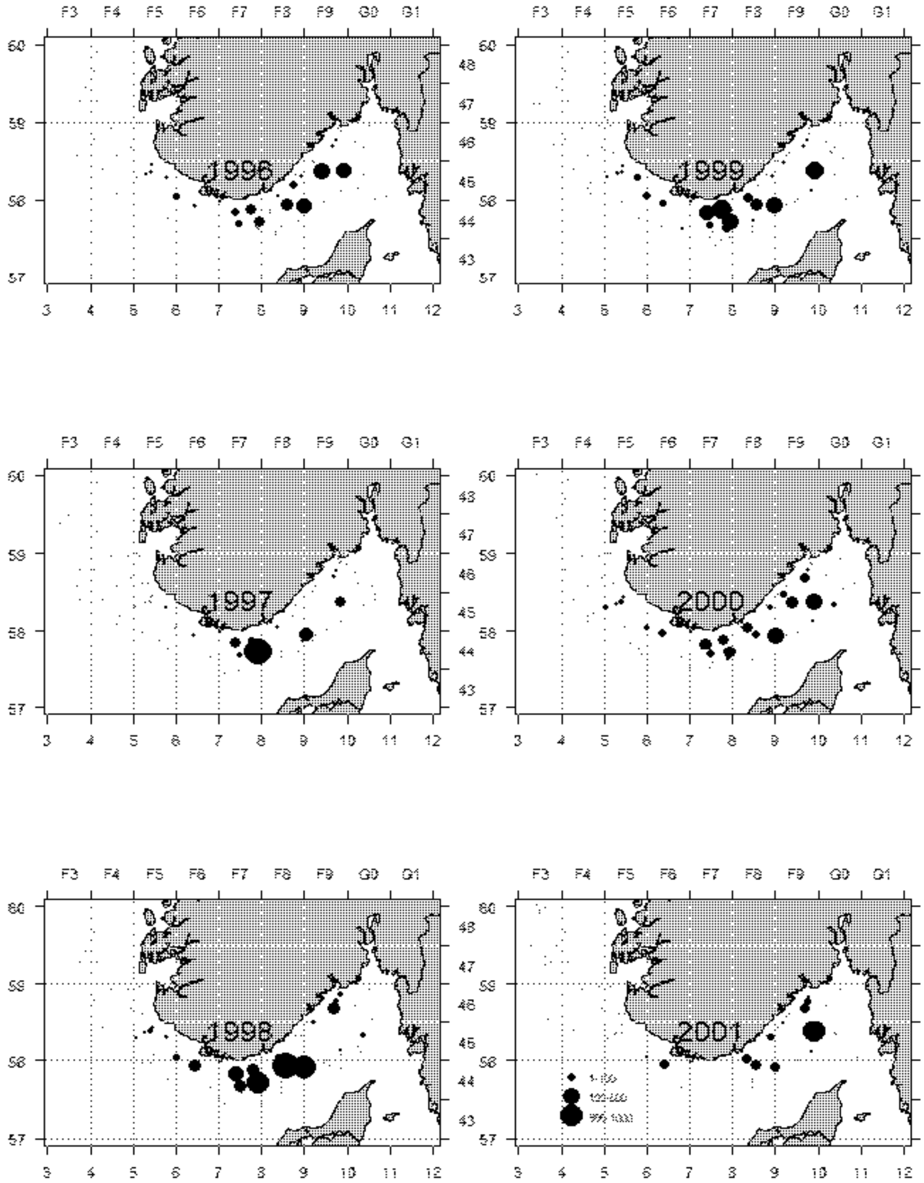

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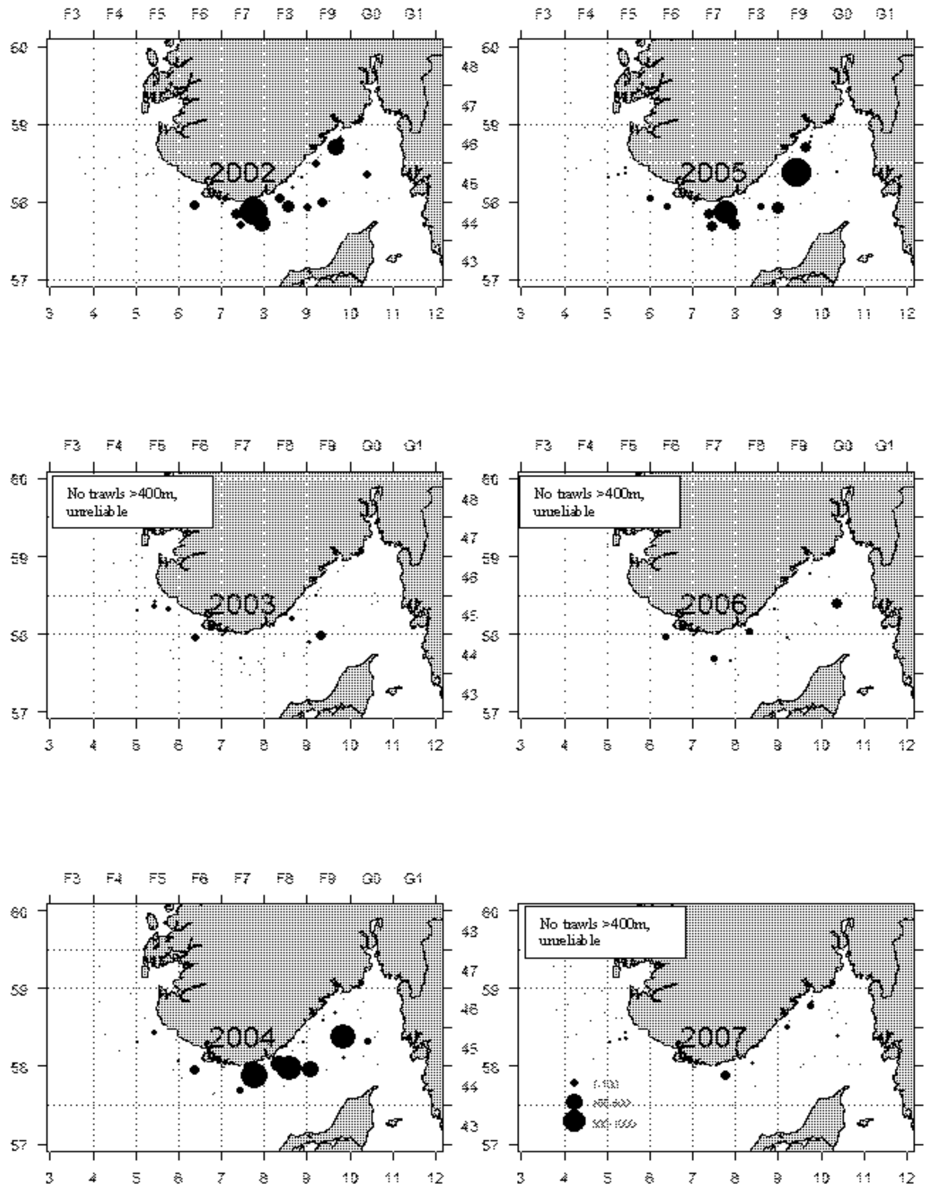

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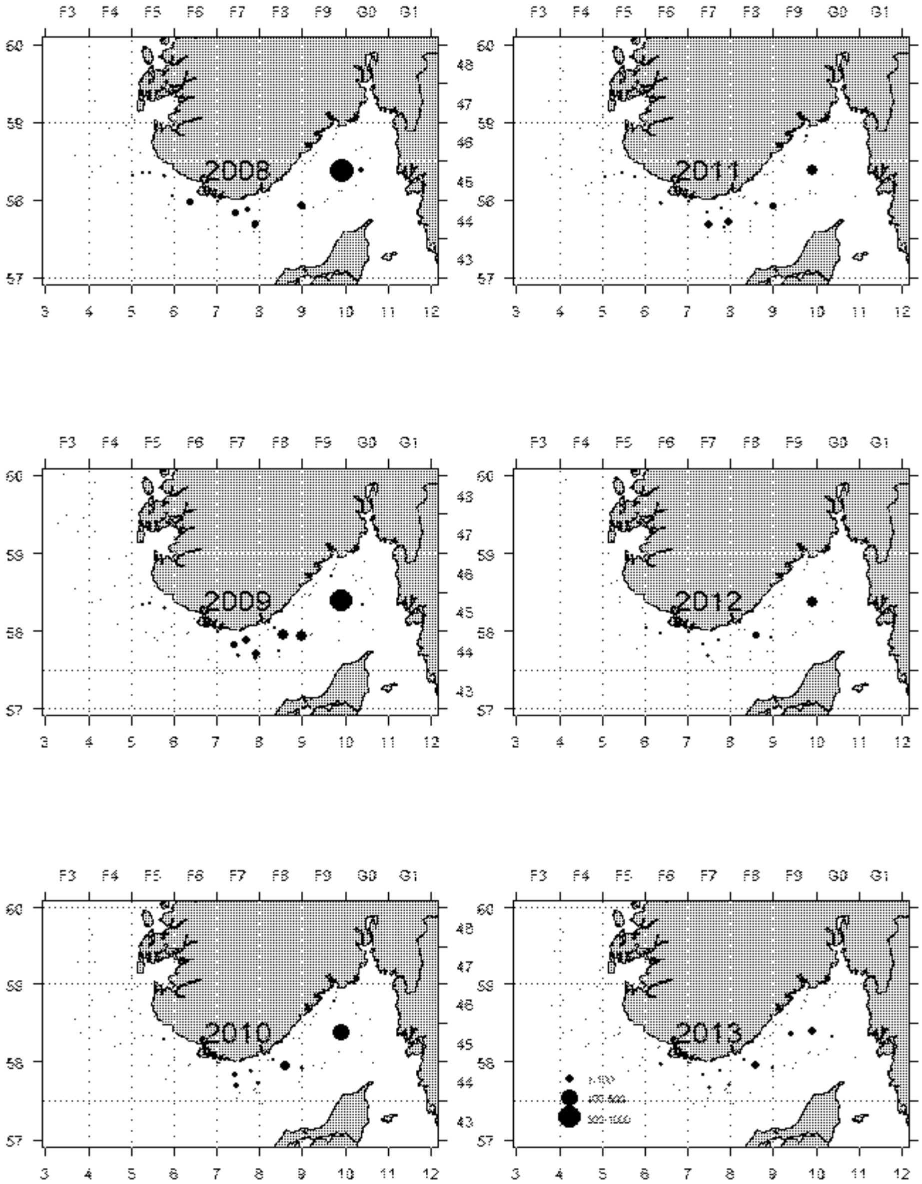

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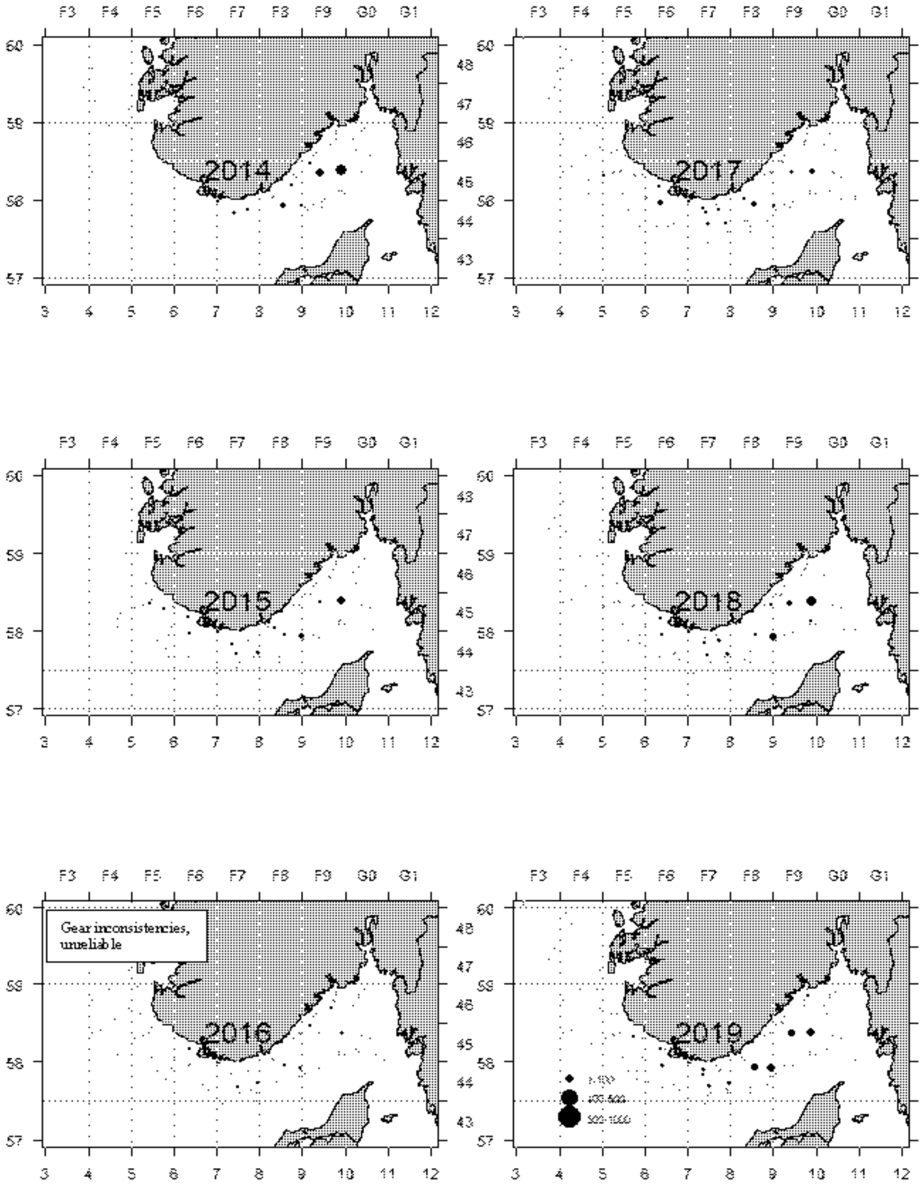

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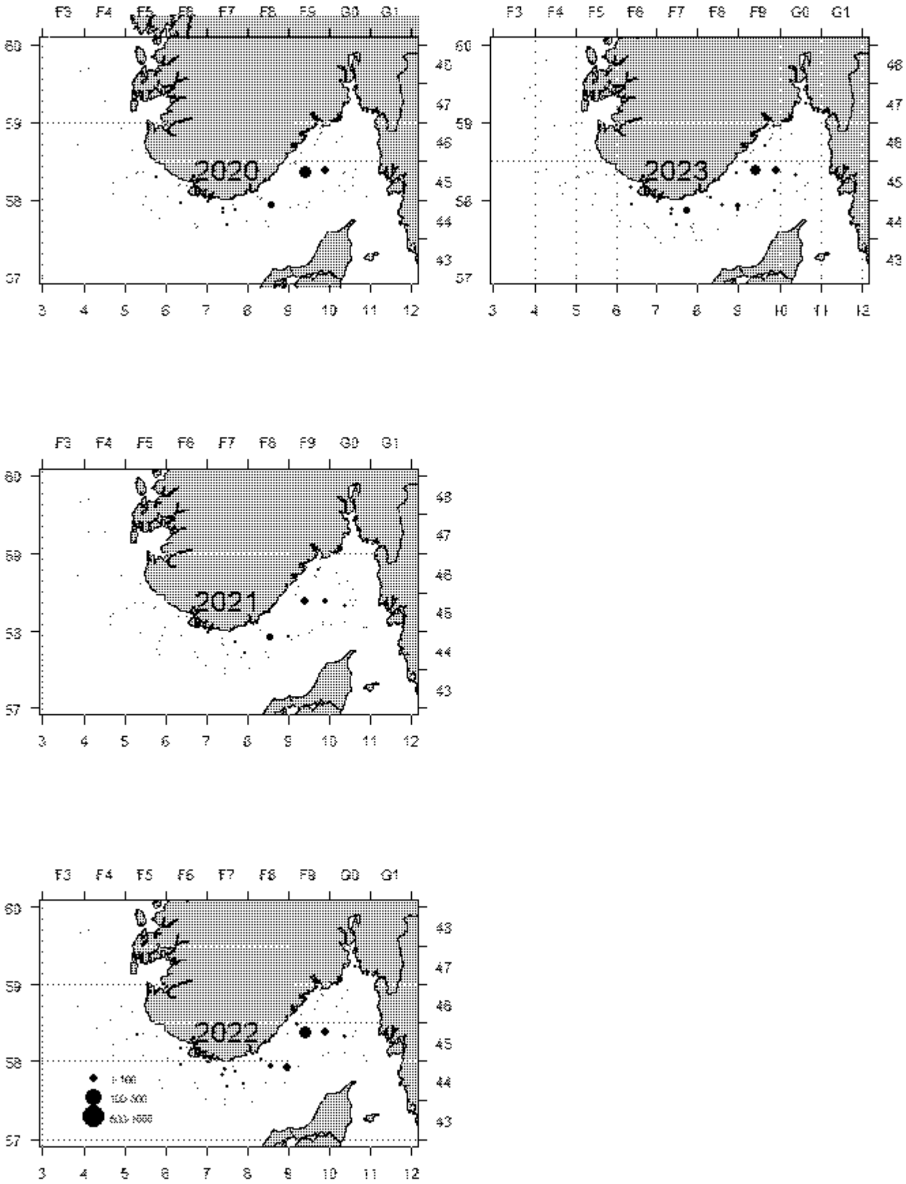

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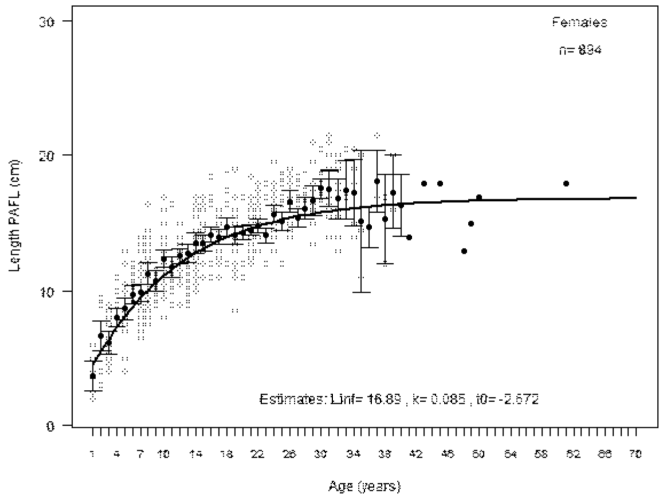

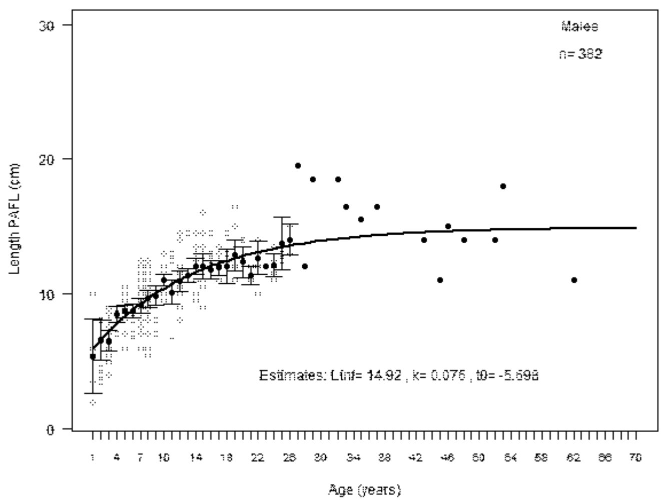

Figure 5. Length at age for female and male roundnose grenadier; data from Skagerrak 2008-2023. Mean values are estimated with ±2SE where there is more than one value. Estimated von Bertalanffy growth curves with parameters for females and males.

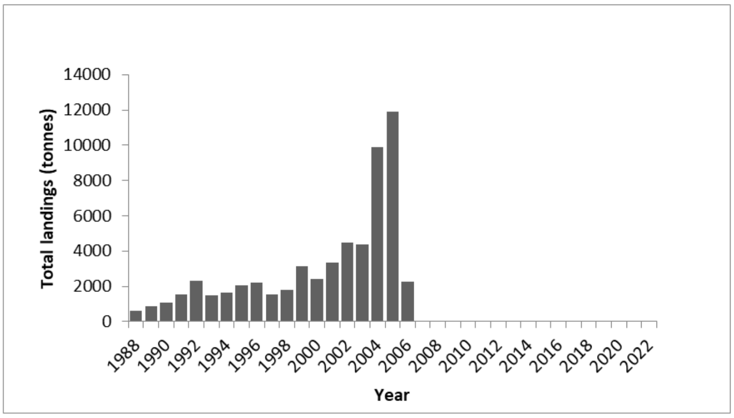

Figure 6. Total reported landings of roundnose grenadier in ICES Division 3a, 1988-2022. Landings from 2007 and later are very small and all less than 2 tons.

Working Document presented to the ICES Working Group on the
Biology and Assessment of Deep Sea Fisheries Resources

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This Working Document has not been peer-reviewed by ICES WGDEEP and should not being interpreted as the view of the Group. The Working Document is appended for information only.

The Blackspot seabream Spanish target fishery of the Strait of Gibraltar: updating the available information

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Abstract

This paper includes the available information of the Blackspot seabream (Pagellus bogaraveo) Spanish target fishery in the Strait of Gibraltar updating the documents presented in previous years with the information from 2022. So, data about landings, fishing effort, CPUEs and landings length frequencies are presented to its inclusion in the 2023 WGDEEP Report.

1. Introduction and fishery description

Since the earlies 1980´s a Spanish artisanal fishery targeting to Blackspot seabream (*Pagellus bogaraveo*, namely "*voraz*") have been developed in the Strait of Gibraltar area (ICES 9a South). This fishery has already been broadly described in previous Working Documents presented to the ICES WGDEEP (Gil *et al.*, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021 and 2022). Blackspot seabream Spanish fishery in the Strait of Gibraltar is almost a mono-specific fishery with a clear target species which represents the 74% from the total landed species which constitutes a fleet component by itself (Silva *et al.*, 2002).

In 2006, 2008, 2010, 2012 and 2016 different trials were attempted to assess this resource within the ICES WGDEEP (ICES, 2006, 2008, 2010, 2012, 2016 and 2018). Finally, 2018 scientific advice was based on abundance indexes (DLS category 3). All the available information from this target fishery (including the biomass index used as the basis for the assessment) were updated with the most recent (2022) data.

Thus, the main objective of this paper is to provide to the 2023 ICES WGDEEP a summary of the available information of this deep-water fishery located in a very narrow place of the ICES area 9.

2. Material and methods

Fishery information from the sale sheets was gathered for the period 1983-2021: monthly landings, monthly number of sales (as a proxy of fishing trip) and the number of days in which those sales were carried out. Moreover, landings length distributions was also estimated from the data collected by IEO monitoring programme (Gil *et al.*, 2000).

Geo-referenced information from SLSEPA devices (a sort of Vessel Monitoring System) on the "*voracera*" fleet operating at the Strait of Gibraltar were more recently available (from 2009 onwards): this monitoring system, locally called "green boxes" (to differentiate them from the EU VMS "blue boxes"), send every three minutes to a control centre several information about the fishing boat: time, positions, course and speed. Data were filtered and analyzed, according to the protocols proposed by Burgos *et al.* in 2013, to estimate fishing effort and catch rates of the Blackspot seabream Spanish target fishery.

3. Results and discussion

- Landings data: Figure 1 shows a continuous increase of Spanish landings from the beginning of the time series to reach a maximum in 1994. Since then landings´ trend decreased till 2002, despite the peaks in 1996 and 1997. Again, it shows an increasing trend from 2003 to 2009, decreasing afterwards except for a slight increase in 2014. Landings since 2018 show the lowest values of the series, with a 2020-2022 mean of about 7 tons (but less than 1 ton in the last year) landed by the Spanish "voracera" fleet.

Until now, discards can be assumed to be zero or negligible. However, the established minimum landing size of 33 centimeters for the species (both for NE Atlantic and Mediterranean Sea) and the landing obligation (EU Regulation 2013/1380) don´t might have an effect on the discards of this target fishery because its high survival exemption.

Hence landings are currently being used as a proxy of catches. However, it should be noted that not all the Spanish catches/landings come exclusively from ICES area 9 but they are considered from the same stock unit because the fishing area (Strait of Gibraltar) is placed between different Advice bodies/Regional Fisheries Organizations (ICES, GCFM and CECAF) boundaries. In fact, since 2015 Spanish Blackspot seabream landings available at InterCatch tool comprise different areas: 27.9.a (ICES), 34.1.11 (CECAF) and 37.1.1 (GFCM).

Data from Moroccan longliners fishing Blackspot seabream in the Strait of Gibraltar area are available since 2001. The information are available on FAO GFCM statistics (WGSAD-SAC and SRC-WW) so, when possible, it is included in the WGDEEP landings estimates because

Moroccan boats target the same population, sharing the main Strait of Gibraltar fishing grounds with Spain (ICES, 2016).

- <u>CPUEs</u>: Nominal biomass index shows ups and downs throughout the historical series (Figure 2). It is important to emphasize that the effort unit chosen (number of sales) may not be appropriate as does not consider the missing effort. So in the most recent years, when the resource is not quite abundant, the missing effort might increase substantially (fishing boats with no catches and no sale sheet records). Therefore, the LPUE trend since the first fishery´s decline (1997) should be interpreted with caution because it cannot be a real image of the resource abundance. Anyway, a severe and continuous decreasing trend is observed since 2016, with CPUEs lower than 40 kilos per fishing trip till about 20 kilos per fishing year in 2021 and less than 10 kilos in 2022.

Table 1 updates the available information from regional VMS (SLSEPA), following the data compilation and process described by Burgos *et al*. in 2013.

Table I. Estimates of fishing effort and CPUEs (2009-2022) from the "*voracera*" fleet targeting Blackspot seabream based on regional VMS (SLSEPA) and fishery statistics (sales sheets).

Data source		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
VMS	Landings (k)	459,010	274,882	190,786	79,163	37,799	94,261	137,444	73,508	24,716	4,402	4,825	1,579	2,614	313
	No. sales	7,200	5,863	4,711	2,946	2,086	2,989	3,079	1,873	1,017	309	248	62	89	36
	Fishing days (fishing trips)	8,373	7,238	6,160	3,686	2,695	4,191	4,234	2,724	1,740	1,046	607	125	266	235
	CPUE 1 (landings/no. sales)	64	47	40	27	18	32	45	39	24	14	19	25	29	9
	CPUE 2 (landings/fishing days)	55	38	31	21	14	22	32	27	14	4	8	13	10	1
	Missing effort (%)	14	19	24	20	23	29	27	31	42	70	59	50	67	80
TOTAL	Landings (k)	579,140	316,365	239,790	126,006	66,159	137,623	166,440	99,726	42,991	7,633	18,693	12,838	8,412	488
	No. sales	8,892	6,932	5,659	3,638	2,222	3,527	3,384	2,418	1,308	429	794	525	404	72
	CPUE 1 (landings/no. sales)	65	46	42	35	30	39	49	41	33	18	24	24	21	7

CPUE 2 (landings/fishing days), where the effort is estimated from the VMS device also declined with lower values than CPUE 1 because the fact of the missing effort. So, as expected, CPUEs estimates from VMS analysis shows the same trend but lower values than the nominal one, from sale sheets (Figure 2).

- <u>Length frequencies</u>: The mean length of landings seems to have decreased in two different periods: from 1995 to 1998 and from 2009 to 2013 (Figure 3). 2021 mean length estimate shows a significant increase (about 5 cm) but data should be revised because is not consistent with previous and following years.

4. Main conclusions

The general trend for the time series of both, landings and CPUEs, continues showing a decreasing pattern over recent years, exhibiting the lowest values of the whole series. This might be a consequence of an overexploitation status of the stock, which is addressing the fishery into a critical situation.

It should be noted that GFCM establish a management plan for the Blackspot seabream fishery of the Strait of Gibraltar in 2022 (GFCM/45/2022/3 on a multiannual management plan for the sustainable exploitation of blackspot seabream in the Alboran Sea, geographical subareas 1 to 3). The update of benchmark assessment (gadget model) for blackspot seabream in the Strait of Gibraltar was presented in the last GCFM WGSAD (December 2022). Results indicated that the stock is depleted with unsustainable exploitation and low fishing mortality. The recommendation was to proceed with immediate reduction of fishing mortality, implementing also a recovery plan (GFCM, 2022).

Acknowledgments

We would like to express our most sincere gratefulness to all those institutions and people for their collaboration in the execution of the monitoring of the Spanish "*voracera*" fishery: Spanish Institute of Oceanography (IEO, CSIC), Consejería de Agricultura y Pesca de la Junta de Andalucía and Tarifa´s Fishermen Brotherhood and 1st sale fishmarket.

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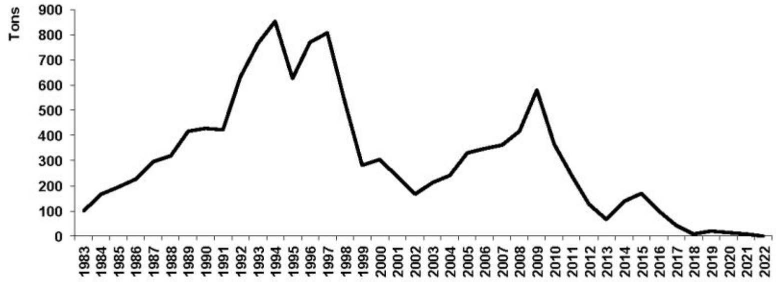

Figure 1. Blackspot seabream Spanish *"voracera"* fishery of the Strait of Gibraltar: total landings (1983-2022).

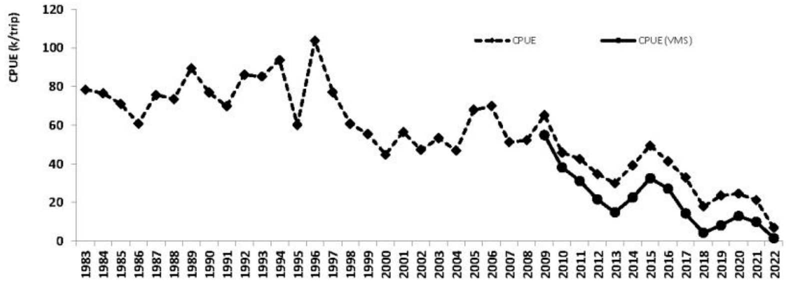

Figure 2. Blackspot seabream Spanish *"voracera"* fishery of the Strait of Gibraltar: nominal (sale sheets) CPUE (1983-2022) and (VMS) CPUE (2009-2022).

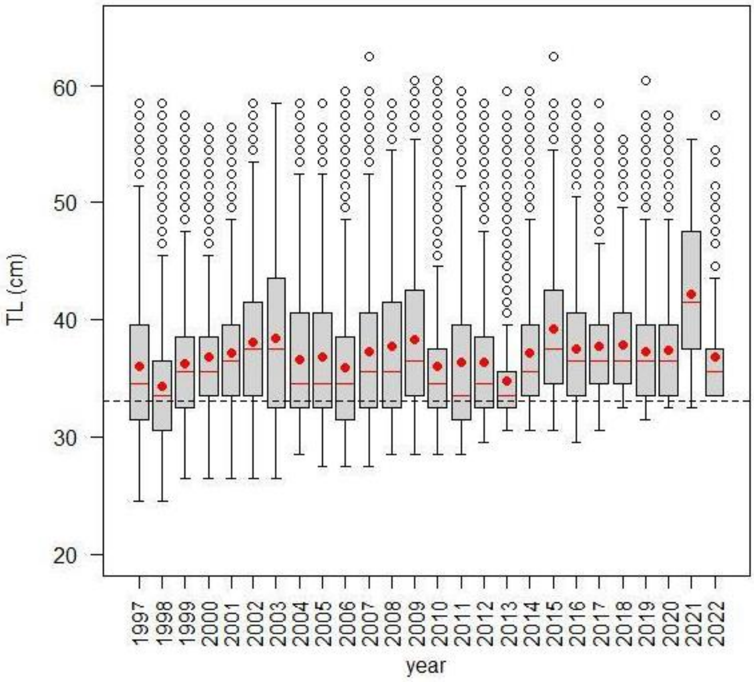

Figure 3. Blackspot seabream Spanish *"voracera"* fishery of the Strait of Gibraltar: landings length distribution descriptive statistics (red dot: mean value, red line: median value, box and whiskers: Interquartile Range plus Q_1-3IQR and Q_3+3IQR, circles: outliers).

Working Document for the ICES Working Group on Biology and Assessment of Deep-sea Fisheries Resources

3rd – 9th April 2023

Greater forkbeard *Phycis blennoides* in Portuguese waters (ICES Division 27.9.a)

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Abstract

This working document updates the information presented in previous WGDEEP meetings for the greater forkbeard *Phycis blennoides* in ICES Division 27.9.a (continental Portugal), particularly fishery dependent data and MSY length-based indicators (LBI). Length-based indicators LBI used to classify the stocks according to conservation/sustainability, yield optimization and MSY were estimated for the exploited population in continental Portugal based on length samples collected under the Portuguese DCF program.

1. General considerations

The greater forkbeard *Phycis blennoides* (Brünnich, 1768) is a demersal species from the family Gadidae. This species is widely distributed in the northeast Atlantic from Norway and Iceland to Cape Blanc in West Africa and in the Mediterranean Sea (Massutí et al., 1996), and occurs preferentially along the continental shelf and slope, at depths ranging between 60 and 1000 m deep (Massutí et al., 1996; Casas and Piñeiro 2000; García et al., 2000).

The greater forkbeard has a discrete recruitment period along the year and is available to fishing at the first years of life (Ragonese et al., 2002). The size of transition from the pelagic to the demersal habitat occurs at lengths around 6 cm in Atlantic waters (Casas and Piñeiro, 2000) and at a smaller size (4.5-5.0 cm total length) in the Mediterranean (Ragonese et al., 2002). In the Gulf of Tunis, age parameters were estimated as TL_{inf} = 57.17 cm, k = 0.193 year^{-1}, t_0 = –1.578 year for females, and TL_{inf} =44.74 cm, k = 0.313 year^{-1}, and t_0 =–1.210 year for males. Females grow faster than males, and the latter did not exceed 45 cm (Romdhani et al., 2016).

1.1. The greater forkbeard in Portuguese waters from ICES Division 27.9.a

In Portuguese continental waters, the length structure and the biology of greater forkbeard, namely reproduction, suggests that it completes the whole life cycle in the area (Lagarto et al., 2017). As in other geographic areas where the species occurs (e.g., in the Mediterranean), a depth effect on specimen's size is observed (Massutí et al., 1996) with larger specimens occurring at higher depths (>600 m deep) (Fig.1).

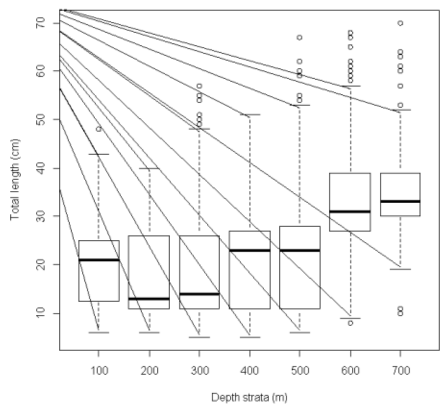

Figure 1. Inter-quartile total length range of *P. blennoides* by depth strata (m) caught during the Portuguese Crustacean Surveys/Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) undertaken between 1997 and 2016 (no survey was conducted in 2012). (from Lagarto et al., 2017)

2. Fishery dependent data in Portuguese waters from ICES Division 27.9.a

In continental Portugal there are no fisheries targeting the greater forkbeard. This species is mainly caught as by-catch of other fisheries, particularly from the polyvalent fleet segment or multi-gear fleet, which is responsible for ~98% of the species total landings.

The Portuguese polyvalent segment includes vessels of different sizes usually licensed to operate with more than one fishing gear (e.g. gill and trammel nets, longlines, and traps). At each fishing trip, vessels belonging to this segment may deploy more than one fishing gear, depending on the targeted species and on the fishing grounds. The analysis of logbook data further indicates that, within the polyvalent segment, the greater forkbeard is mainly caught by demersal longlines (Moura and Figueiredo, 2020).

Most greater forkbeard landings are reported at Peniche landing port, in the Centre of Portugal. A marked seasonal pattern on Portuguese landings is observed with higher values between May and July (Lagarto et al., 2017). Although the reasons for this seasonality are unknown, it is considered that they might be related to the dynamics of the fleets and particularly to changes on their target species.

2.1. Commercial landings

Official Portuguese annual greater forkbeard landing estimates in ICES Division 27.9.a are presented in Table 1. It is worth mentioning that landings are likely to be biased due to species misidentification problems. It is admitted that greater forkbeard can be misidentified with its congener *Phycis phycis*. Moreover, the two *Phycis* species, and particularly at the beginning of time series, might be landed under the designation of *Phycis* spp. However, the fraction of *Phycis* spp. landings corresponding to *P. blennoides* is unknown and cannot be estimated as the level of DCF sampling coverage is insufficient.

Historically, the landings of greater forkbeard species are low, either because of its relatively low commercial value or to the low fishing effort at deeper fishing grounds.

Table 1. Official landings (ton) of *Phycis blennoides*, *Phycis phycis* and *Phycis* spp. by fleet from 2003 to 2022. *Phycis* spp. includes landings of *P. blennoides* and *P. phycis*. Source: DGRM (official landings).

	Phycis blennoides				*Phycis phycis*				*Phycis* spp.			
Year	TRAWL	PSEINERS	ARTISANAL	TOTAL	TRAWL	PSEINERS	ARTISANAL	TOTAL	TRAWL	PSEINERS	ARTISANAL	TOTAL
2003	0.08		10.87	10.95	0.75		5.69	6.44	7.87	0.50	314.14	322.51
2004	0.10	0.05	9.84	9.98	0.11		3.59	3.70	7.85	0.60	295.10	303.55
2005	0.17	0.03	14.00	14.20	1.06	0.02	83.49	84.57	5.68	0.13	183.03	188.84
2006	0.17		9.66	9.84	2.11	0.08	176.24	178.43	3.22	0.01	56.05	59.28
2007	0.10	0.02	13.40	13.52	2.69	0.28	215.65	218.62	4.01		25.20	29.21
2008	0.18	0.01	12.05	12.23	4.79	0.10	234.03	238.92	0.14		25.03	25.17
2009	0.10		14.64	14.74	11.20		452.92	464.13			18.61	18.61
2010	0.10		11.53	11.63	14.24		472.11	486.36			8.68	8.69
2011	0.04		13.43	13.48	7.08	0.01	450.68	457.76			5.91	5.91
2012	0.08		5.58	5.66	4.24	0.03	456.11	460.38			5.24	5.24
2013	0.11		7.67	7.78	4.22	0.92	274.22	279.35			3.78	3.78
2014	0.13		6.09	6.22	2.27	0.80	170.97	174.04			2.39	2.39
2015	0.04		7.39	7.43	5.32	0.73	154.72	160.77			1.58	1.58
2016	0.12		6.69	6.81	6.72	1.41	181.31	189.44			1.81	1.81
2017	0.20		8.85	9.05	4.13	1.69	172.38	178.21	0.00		1.27	1.28
2018	0.19		9.23	9.42	2.70	0.35	129.27	132.31			0.64	0.64
2019	0.02		7.12	7.14	2.03	0.313	133.35	135.69			1.34	1.34
2020	0.08		4.80	4.88	1.61	0.30	137.78	139.69			0.99	0.99
2021	0.09		11.16	11.25	1.66	0.53	331.83	334.01			0.66	0.66
2022	0.19		8.47	8.66	0.80	0.13	327.63	328.55			0.86	0.86

2.2. Length data

The greater forkbeard is sampled for length at several landing ports along the Portuguese continental coast under the national data collection program (PNAB/DCF). The total length of specimens sampled from 2014 to 2022 (under DCF market and onboard programs) ranged between 17 and 78 cm (Farias et al., 2021). The length frequency distributions slightly differed between the trawl and the polyvalent fleet segments (the length of specimens caught by trawlers are skewed to sizes smaller than those caught by polyvalent vessels) (Moura and Figueiredo, 2020). Given the very low landing values attributed to the trawl segment, the length frequency distribution of the greater forkbeard exploited population is mainly derived from the polyvalent fleet segment catches.

Length-based indicators (LBI) screening methods were applied to the length frequency distributions of the greater forkbeard landed in continental Portugal for the period 2019-2022. The procedure followed the ICES Technical guidance for providing reference points for stocks in categories 3 and 4 (Table 2) (ICES, 2017). The L_{mat} and L_{inf} estimates adopted were those made available by Spain for sexes combined: 53.89 cm and 91.46 cm, respectively (ICES WGDEEP datacall, 2018). The length-weight relationship parameters ($Wt = 0.016\ TL^{2.843}$) were defined by Mendes et al. (2004).

Table 2. Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system (from ICES, 2017).

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	Pmega	> 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 > L_c	$L_{opt} = {}^2/_3\ L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{max_y}	Length class with maximum biomass in catch	$Lopt = {}^2/_3\ L_{inf}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals > L_c	$L_{F=M} = (0.75L_c+0.25\ L_{inf})$	L_{mean} / $L_{F=M}$	≥ 1	MSY

Results from the LBI screening method are shown in Tables 3a and 3b and Figure 2.

Table 3a. Results from LBI screening: indicator values.

Year	L_{75}	L_{25}	L_{med}	L_{90}	L_{95}	L_{mean}	L_c	$L_{F=M}$	L_{maxy}	L_{mat}	L_{opt}	L_{inf}	$L_{max5\%}$
2019	51.5	45.5	49.5	58.5	63.5	52.57	46	57.365	51.5	53.89	60.97	91.46	66.47
2020	44.5	42.5	44.5	53.5	53.5	46.03	42	54.365	44.5	53.89	60.97	91.46	53.50
2021	46.5	40.5	43.5	48.5	53.5	46.54	42	54.365	48.5	53.89	60.97	91.46	59.55
2022	62.5	56.5	58.5	64.5	65.5	59.21	46	57.365	58.5	53.89	60.97	91.46	65.50

All LBI estimates increased between 2021 and 2022 (Table 3a).

Table 3b. Results from LBI screening: indicator ratios. Ref., Reference expected values from ICES (2017).

		Conservation					Optimizing Yield	MSY
		L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{95\%}/L_{inf}$	L_{maxy}/L_{opt}	$L_{max5\%}/L_{inf}$	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Year	Ref.	> 1	> 1	> 0.8	≈ 1	> 0.8	≈ 1 (>0.9)	≥ 1
2019		0.85	0.84	0.69	0.84	0.73	0.86	0.92
2020		0.78	0.79	0.58	0.73	0.58	0.75	0.85
2021		0.78	0.75	0.58	0.80	0.65	0.76	0.86
2022		0.85	1.05	0.72	0.96	0.72	0.97	1.03

Most of the ratios between indicators estimates (Table 3b) are below the proposed expected values (see Table 3). These results are related to the poor representation, on landings, of all the size ranges of the population. Discards are known to occur but are unquantifiable. It is acknowledged that the largest specimens are discarded from the deep-water longline fisheries but numbers are relatively low (Lagarto et al., 2017). In addition, onboard data for this fleet is derived from a small area of the total stock distribution in the Portuguese continental waters. Thus, the fishing effort affecting the largest individuals is relatively low.

Conservation ratio estimates increased in 2022 in relation to previous years and $L_{25\%}/L_{mat}$ and L_{maxy}/L_{opt} were above the reference values in 2022 (Table 3b and Figure 2). The Optimizing Yield indicator ratio increased between 2021 and 2022 to values above the reference, which indicates that the stock is being fished above optimum yield. The indicator for MSY increased from 2020 to 2022 and is now consistent with an adequate exploitation.

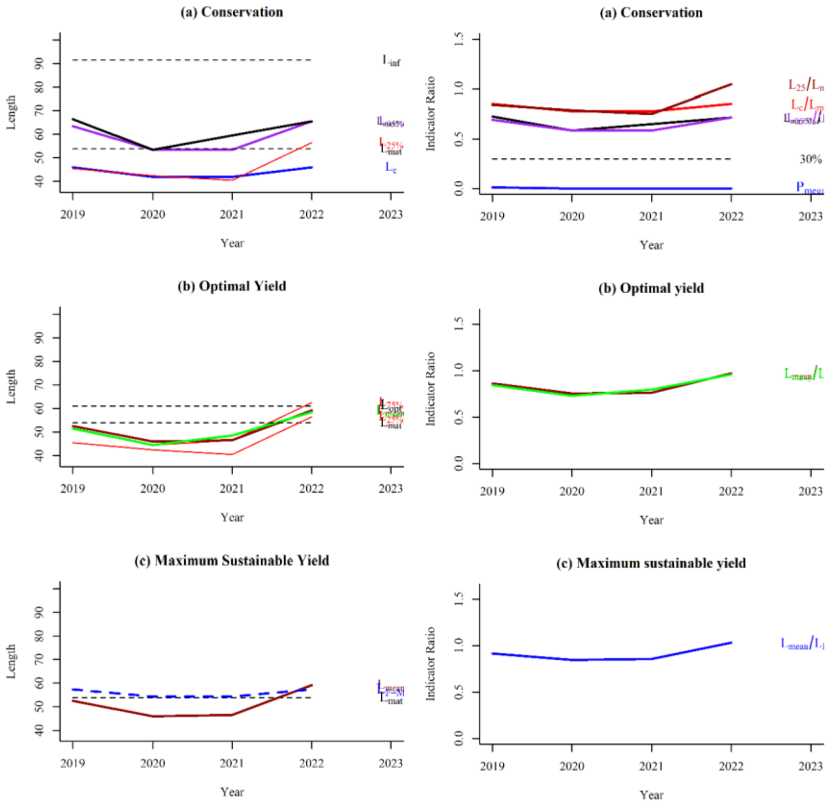

Figure 2. Results from LBI screening.

3. Fishery independent data in Portuguese waters from ICES division 27.9.a

Fishery independent data available from the Portuguese Crustacean Surveys/ Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) has been used to estimate a standardized relative biomass index between 1997 and 2018 (Farias et al., 2021). In 2019 and 2020, the PT-CTS (UWTV (FU 28-29)) survey was not performed. In 2021, the R/V Mário Ruivo started to operate, but the survey's spatial coverage was smaller and fishing stations in the area where the species is traditionally more abundant were missing (Moura et al., 2022). The standardized biomass index has not been updated since 2021 (Farias et al., 2021).

4. Conclusions

Two standardized CPUE series based on commercial data suggested that the status of the greater forkbeard population inhabiting the Portuguese continental waters in recent years has been stable (Farias et al., 2021).

The standardized survey biomass estimates, which represents a relatively long time series, were well above the overall mean and showed an increasing trend in the last years of the time series (Farias et al., 2021). For the period between 1997 and 2016, an increasing trend was also observed for the juvenile component of the population, indicating that the fishing pressure over the Portuguese population had not seriously impaired the recruitment (Lagarto et al., 2017).

In general, LBI screening results, particularly the indicator of MSY, are above the reference values, suggesting that the stock is in a fair status.

Given the fact that this species is not targeted by any fishery, the results obtained suggest that the Portuguese fisheries are not impairing the population of greater forkbeard, whose information for the Portuguese waters further indicates that the species is able to complete the whole life cycle in the area.

Worth to mention that the relative low fishing impact of the Portuguese fisheries in deeper grounds reduces the impact over the fraction of larger specimens of the population, as the species tends to be larger at greater depths.

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Comparison between Greater silver smelt in ICES Subarea 5.a and Division 14 assessed using Gadget2 versus Gadget3 implementations

Will Butler, Pamela J. Woods, and Magnús Thorlacius

2023-05-03

Contents

Recently, a new implementation of Gadget has been designed and tested, and is being used for assessment of Greenland halibut (*Reinhardtius hippoglossoides*) and beaked redfish (*Sebastes mentella*) (ICES, 2023). The operational model is essentially the same as in previous implementations with some additional options (Lentin *et al.*, 2022). However, as it is based on the TMB package (Uffe *et al.*, 2017) in R statistical software (R Core Team, 2023), it can use different optimization routines. The Gadget3 model shown here was optimized using the BFGS algorithm, rather than the three-step routine used under Gadget2 implementation, which included simulated annealing, followed by Hooke and Jeeves, and finally BFGS optimizations. The largest benefit of using the Gadget3 implementation rather than the Gadget2 implementation is access to auto-differentiation libraries that greatly speeds the optimization time, which in the past has been a limitation to being able to produce confidence intervals based on a spatial bootstrap method (Elvarsson *et al.*, 2018). Another benefit is that in the future, it is more likely that Gadget3 will be maintained. We propose here to switch the implementation platform of the assessment model for Greater silver smelt in ICES Subarea 14 and Division 5.a (East Greenland and Iceland grounds) to Gadget3 from the Gadget2, as it would alleviate time constraints while producing results that correspond well with results from Gadget2. Fits to survey indices are very similar (Figure 1), as are fits to autumn survey length and age-length distribution data (Figures 2 and 4) and the commercial length and age-length distribution data (Figures 3 and 5) . Model results are also very similar (Figure), and the analytical retrospective analyses, both of which show very low Mohn's rho values, can essentially not be distinguished (Figures 6 vs.).

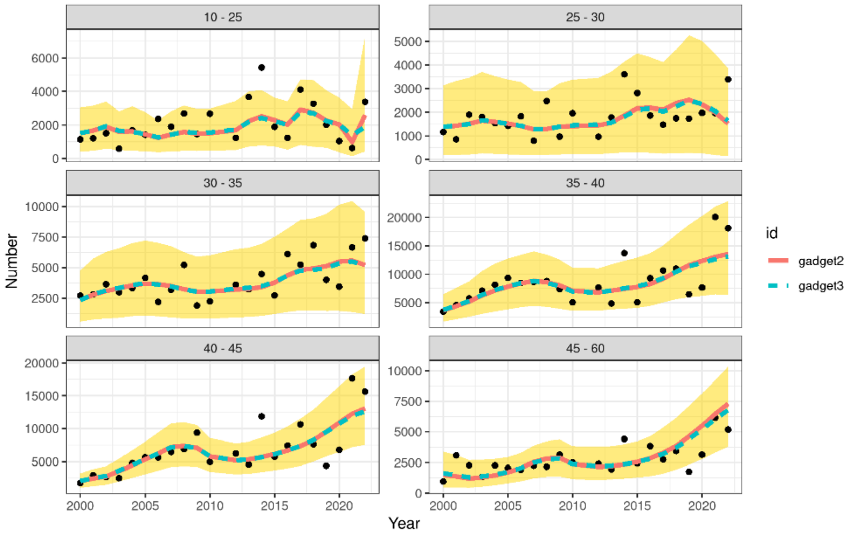


Figure 1: Greater silver smelt in 5a and 14. Comparison of fits to the survey index data implemented using Gadget3, as done in this year's assessment, versus Gadget2 (implementation platform from previous years). Red lines indicate Gadget2, blue dashed lines indicate Gadget3.

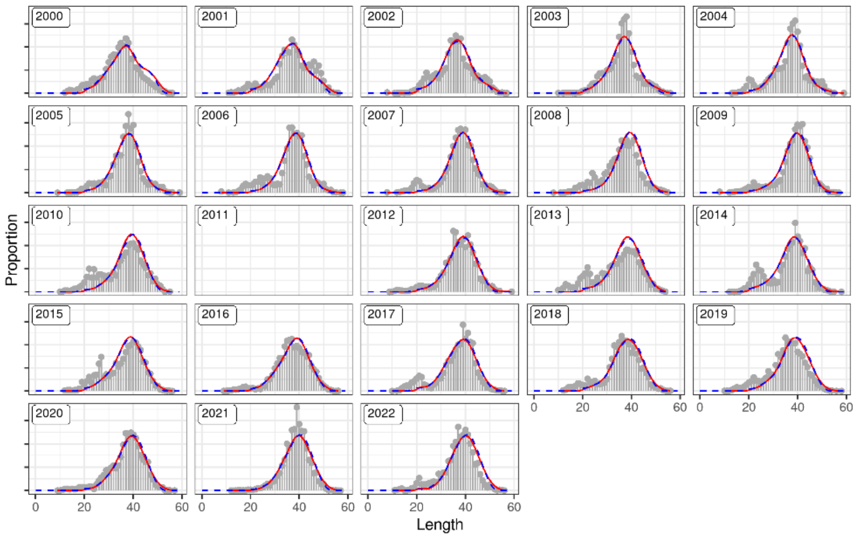


Figure 2: Greater silver smelt in 5a and 14. Comparison of fits to the autumn survey length distribution data implemented using Gadget3, as done in this year's assessment, versus Gadget2 (implementation platform from previous years). Red lines indicate Gadget2, blue dashed lines indicate Gadget3.

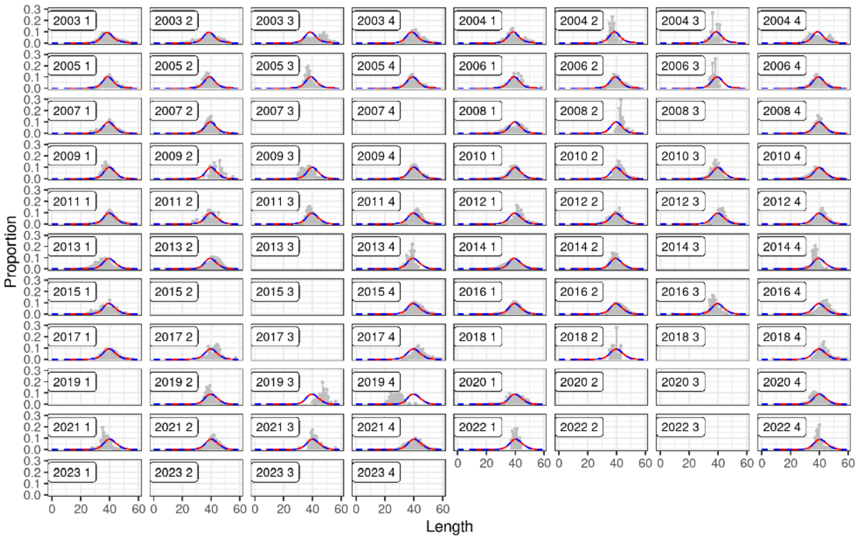


Figure 3: Greater silver smelt in 5a and 14. Comparison of fits to the commercial length distribution data implemented using Gadget3, as done in this year's assessment, versus Gadget2 (implementation platform from previous years). Red lines indicate Gadget2, blue dashed lines indicate Gadget3.

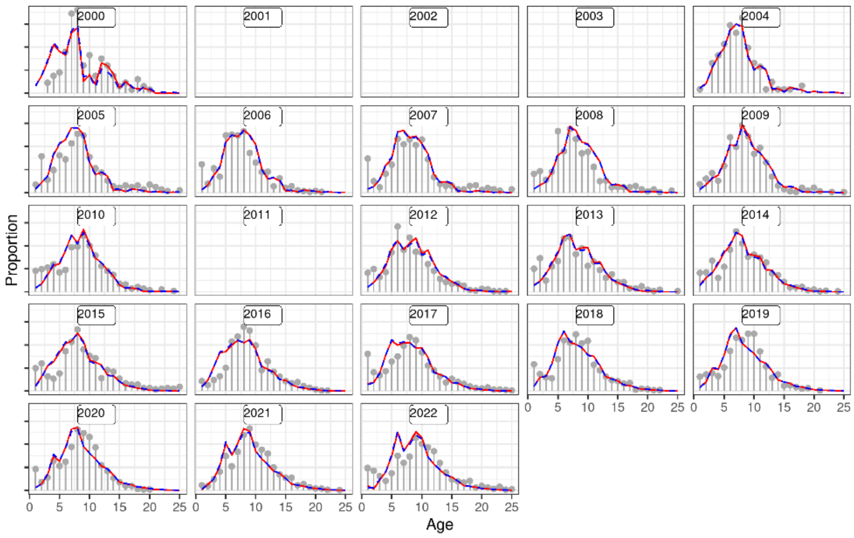


Figure 4: Greater silver smelt in 5a and 14. Comparison of fits to the autumn survey age-length distribution data implemented using Gadget3, as done in this year's assessment, versus Gadget2 (implementation platform from previous years). Red lines indicate Gadget2, blue dashed lines indicate Gadget3.

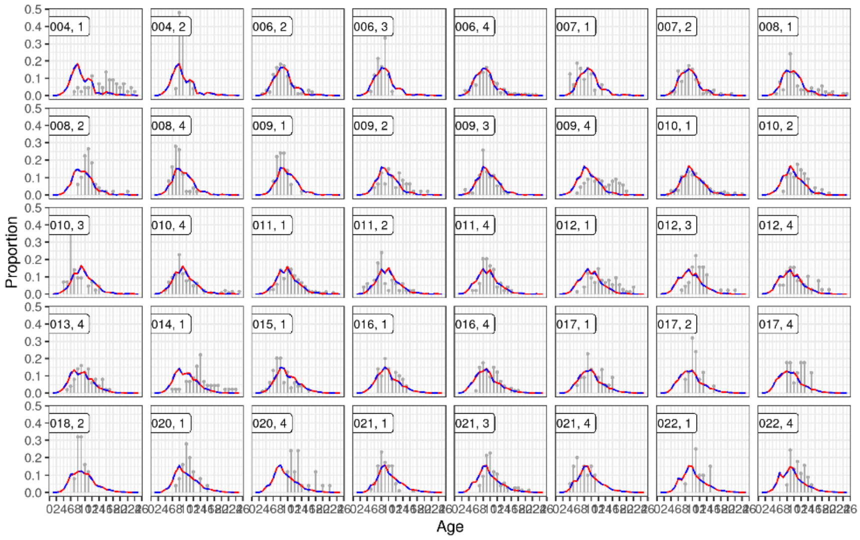
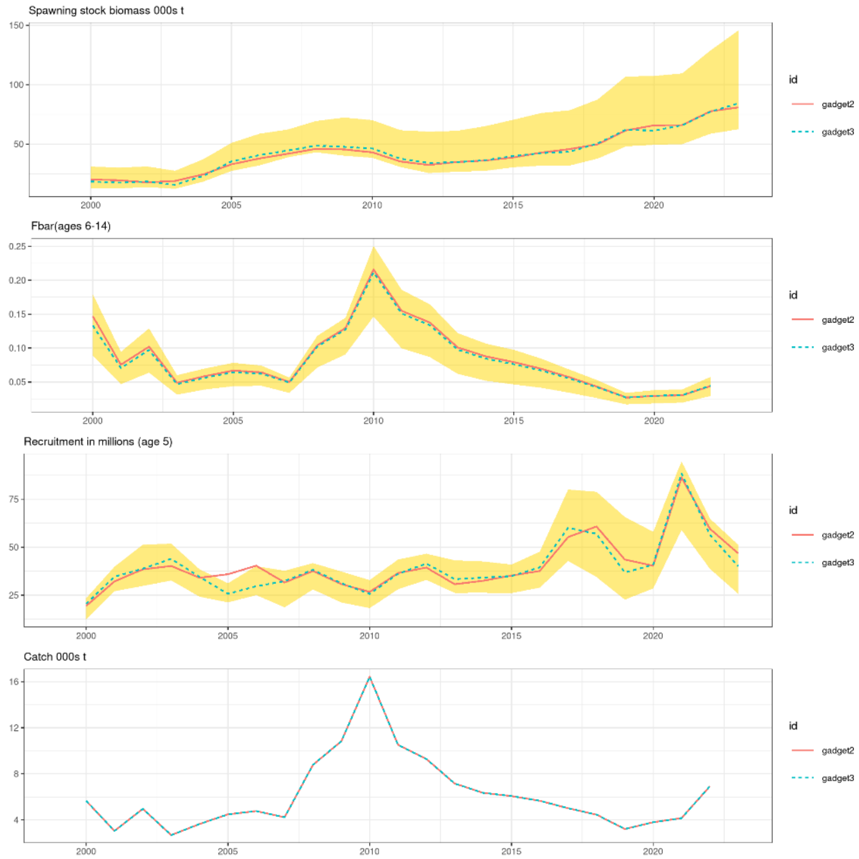


Figure 5: Greater silver smelt in 5a and 14. Comparison of fits to the commercial age-length distribution data implemented using Gadget3, as done in this year's assessment, versus Gadget2 (implementation platform from previous years). Red lines indicate Gadget2, blue dashed lines indicate Gadget3.



\begin{figure}
\caption{Greater silver smelt in 5a and 14. Comparison of assesssment results when implemented using Gadget3, as done in this year's assessment, versus Gadget2 (implementation platform from previous years). Yellow bands indicate 90% confidence intervals based on a spatial bootstrap generated from the Gadget3 model.} \end{figure}

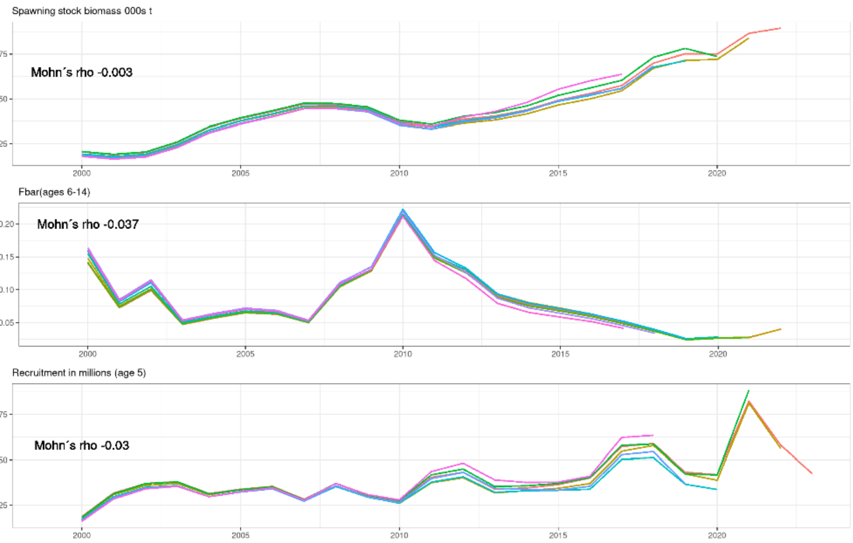
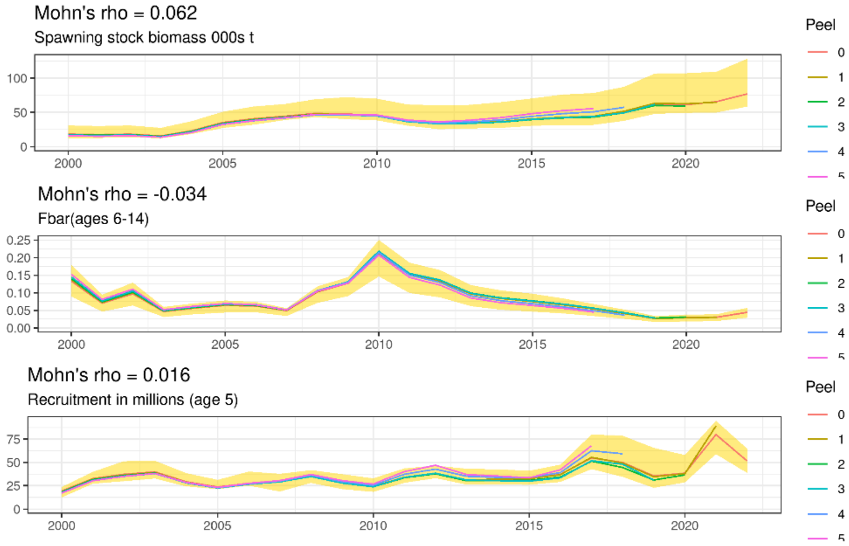


Figure 6: Greater silver smelt in 5a and 14. Analytical retrospective pattern resulting when implemented using Gadget2, implementation platform from previous years.



\begin{figure}
\caption{Greater silver smelt in 5a and 14. Analytical retrospective pattern resulting when implemented using Gadget3, as done in this year's assessment. Yellow bands indicate 90% confidence intervals based on a spatial bootstrap generated from the Gadget3 model.} \end{figure}

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Pagellus bogaraveo **in Portuguese continental waters (ICES Division 27.9.a)**

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1. Introduction

Pagellus bogaraveo (Brünnich, 1768), the blackspot seabream, distributes between southern Norway and Cape Blanc, in the Mediterranean Sea, and in the Azores, Madeira, and Canary Archipelagos (Desbrosses, 1932; Pinho and Menezes, 2005).

Spawning occurs in shallow waters, where juveniles of age groups 0 and 1 are reported to remain at depths lower than 170 m, close to the coast, in the Azores (Menezes et al., 2001), the Bay of Biscay (Lorance, 2011), and the Mediterranean Sea (Biagi et al., 1998; Félix-Hackradt et al., 2013). When juveniles reach 150–180 mm total length (TL), they migrate along the slope to depths deeper than 200 m, following an ontogenetic migration towards deeper waters (Olivier, 1928; Desbrosses, 1932; Morato et al., 2001; Spedicato et al., 2002). Nevertheless, fish with sizes larger than 40 cm have been occasionally caught in coastal waters (Priol, 1932).

The blackspot seabream is a protandric hermaphrodite – individuals are first functional males and then develop into functional females (Buxton and Garratt, 1990; Krug, 1990; Gil, 2006). In the Azores, the age of first maturity is about 8 years old for females (Krug, 1990). In Cadiz waters, the main spawning period occurs during the 1st quarter (Gil, 2010), whereas in the Azores spawning is from March to April (Martins *et al.*, 2007).

In the Northeast Atlantic, *P. bogaraveo*'s stock structure is still unknown. Genetic studies showed a restricted gene flow among the populations located in the Azores (ICES Division 27.10.a.2) and those on the Portuguese continental slope (ICES Division 27.9.a) and Madeira (CECAF FAO Division 34.1.2) (Stockley *et al.*, 2005; Pinera et al., 2013). Mitochondrial control region showed similar genetic diversity among sampling sites in the NE Atlantic and the Mediterranean, and no differentiation between the Azores and the remaining locations (Robalo et al., 2021). More recently, a genomic study using biological samples from different geographic areas supported the existence of three well-differentiated clusters in the Atlantic: (i) the Azores; (ii) Cadiz; and (iii) the continental Atlantic coast (Cunha et al., submitted). Those results confirmed that the Azorean population is isolated from the other populations and support the separation of the population occurring off Cadiz from the remaining Iberian area.

Despite the poor knowledge on the species stock structure, ICES adopts three management components for management purposes: (a) Subareas 27.6, 27.7, and 27.8; (b) Subarea 27.9; and (c) Subarea 27.10 (Azores) (ICES, 2007). These components were established to better record the available information and do not have implicit the existence of three different stocks of *P. bogaraveo*. There is no evidence of movements between the northernmost component and the southern part of Subarea 27.9 where a targeted fishery takes place in the Strait of Gibraltar (ICES, 2019).

The Spanish longline fishery operating in the Strait of Gibraltar has been managed as a regulated open-access fishery since its initial exploitation, in 1983 (Gil et al., 2019). In 2001, Moroccan longliners started a target fishery in the same area. Therefore, two directed fisheries are presently taking place in the Spanish and Moroccan Exclusive Economic Zone (EEZ) (ICES, 2017).

Total Allowable Catch (TAC), Portuguese quota, and official landings are presented for continental Portugal (ICES Division 27.9.a) for the period between 2014 and 2022 (Table 1).

Table 1. *Pagellus bogaraveo* Total Allowable Catch (TAC) and Portuguese quota and official landings in ICES Subarea 27.9, between 2014 and 2022.

Year	TAC EU ICES Subarea 27.9	Portugal quota ICES Subarea 27.9	Official Portuguese landings ICES Division 27.9.a
2014	780	166	59
2015	374	80	66
2016	183	39	70
2017	174	37	69
2018	165	35	58
2019	149	32	36
2020	149	32	43
2021	119	25	29
2022	119	25	32
2023	114	24	
2024	114	24	

1.1. Fishery in Portugal continental

In continental Portugal, *P. bogaraveo* is mainly caught as by-catch of fisheries targeting other species, although some vessels are licensed to target the species.
Fishery data and information collected through enquiries made to Peniche (Portuguese central western coast) skippers with experience on *P. bogaraveo* fishing has shown that: (i) the species tends to gather at specific fishing grounds with particular seamount-like topographic features, being mainly caught at depths around 250 m; (ii) the fishing grounds substrates are mainly composed by muddy sand, rock, and sand; (iii) the species length range is not different between the different fishing grounds. Some skippers additionally referred that, during winter, the species migrates, driven by environmental factors or biological conditions, such as reproduction (Araújo et al., 2016).
Information on blackspot seabream collected from 1990 to 2018 in the Portuguese Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29))) and the Portuguese Autumn Groundfish Surveys (PT-GFS) conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA) supports the hypothesis of a patchy distribution, as the species is more frequently caught at specific grounds (Farias and Figueiredo, 2019). It is important to note that the PT-CTS (UWTV (FU 28-29)) survey design is considered inadequate to estimate the species abundance or biomass, as the species distributes preferentially at non-trawlable areas.

2. Methodology

1.1. Fishery dependent data

1.1.1. Landings and mean price in continental Portugal

Portuguese landings in ICES Division 27.9.a were characterized. Fishery dependent data were collected from commercial landings for the period between 2009 and 2022.

Pagellus bogaraveo total landings in weight (ton) and value (euro) were analysed by year, fishing segment and NUTS (Nomenclature of Territorial Units for Statistics). The EU NUTS classification system (https://ec.europa.eu/eurostat/web/regions/background) is a regional system that divides each EU Member State's territorial area into units, providing a harmonised hierarchy between regions. Following the criteria adopted under this system, continental Portugal is divided into 5 different NUTS II (level 2), namely: North; Centre; Lisbon Metropolitan Area; Alentejo; and Algarve.

1.1.2. Landings and mean price by fleet and selected NUTS II

Pagellus bogaraveo total landings in weight (ton) and value (euro) were analysed throughout the year, between 2009 and 2022, by fishing segment (polyvalent and trawl), considering the NUTS II with the most representative landings of the species: North, Centre, and Algarve.

1.1.3. Landings in the most important Portuguese continental ports

Pagellus bogaraveo total landings in weight (ton) were analysed throughout the year, between 2009 and 2022, by fishing segment (polyvalent and trawl) for NUTS II landing ports with the highest landings of the species: Matosinhos port belongs to NUTS II North; Aveiro, Nazaré, and Peniche ports belong to NUTS II Centre; and Sagres belongs to NUTS II Algarve.

1.2. LPUE

1.2.1. Reference fleet

Reference fleets for the polyvalent and for the trawl fishing segments were defined for the most important landing port considering total landings and value of the species, Peniche. The criteria adopted for the selection of fishing vessels were defined according to the number of fishing trips with positive landings of the species and the number of months of the year with positive landings of the species, during the period between 2015 and 2022.

For the polyvalent fishing segment, the criteria adopted for the selection of fishing vessel were: more than 9 fishing trips per year and more than 6 months with positive landings of the species.

For the trawl fishing segment, the criteria adopted for the selection of fishing vessel where: more than 9 fishing trips per year and more than 5 months with positive landings of the species.

In 2023, vessels with low or null fishing trips with landings of the species in the period between 2019 and 2022 were excluded.

1.2.2. CPUE adjustment

For each selected vessel, data available at fishing trip level was further analysed. The landed weight of the species (in kg) per fishing trip corresponds to the total weight landed by the vessel after each trip. A trip is defined from the moment the vessel leaves the dock to when it returns to the dock.

The landed weight per fishing trip was considered as an indicator of biomass index, further referred as CPUE. Important to note that discards of the species are negligible in Portuguese continental fisheries.

CPUE data were standardized through the adjustment of generalized linear models (GLM). The model with the best adjustment was selected based on the AIC criterion and on the analysis of residuals.

1.3. Length distribution

Pagellus bogaraveo length sampling data available from the national Data Collection Framework (DCF) for the polyvalent and the trawl segments for continental Portugal were analysed by year in the period between 2014 and 2022. Numbers-at-length were raised to the total landings of the species.

1.4. LBI

Length-based indicators (LBI) screening methods were applied to *P. bogaraveo* length data for continental Portugal. The procedure followed the ICES Technical guidance for providing reference points for stocks in categories 3 and 4 (ICES, 2017b). The L_{mat} and L_{inf} estimates were adopted from Gil et al. (2009) and CopeMed II (2019), respectively. The length-weight relationship parameters ($W = 1.17542e\text{-}05 \times L^{3.0366}$) were estimated based on biological sampling data collected in 2020 and following the procedure in fishR Vignette (Ogle, 2013). Selected indicators, reference points, indicator ratios and their expected values are presented in Table 2 (ICES, 2017b).

Table 2. Selected indicators for LBI screening plots (ICES, 2017b).

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	Pmega	> 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 > L_c	$L_{opt} = {}^2/_3\ L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{max_y}	Length class with maximum biomass in catch	$Lopt = {}^2/_3\ L_{inf}$	L_{maxy} / L_{opt}	≈1	

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
L_{mean}	Mean length of individuals > L_c	$L_{F=M}$ = $(0.75L_c+0.25L_{inf})$	$L_{mean} / L_{F=M}$	≥ 1	MSY

2. Results and discussion

2.1. Fishery dependent data

2.1.1. Landings and mean price in continental Portugal

In the period between 2009 and 2022, the species was landed in all five NUTS II of the Portuguese continental coast (Figure 1). Landing ports in central Portugal (NUTS II "Centro") showed the highest landings in weight followed by the Algarve (South Portugal), that was around four times lower, and the North (NUTS II "Norte") that was up to 8 times lower. Similar proportions were found between the NUTS in terms of value of the species (Figure 2).

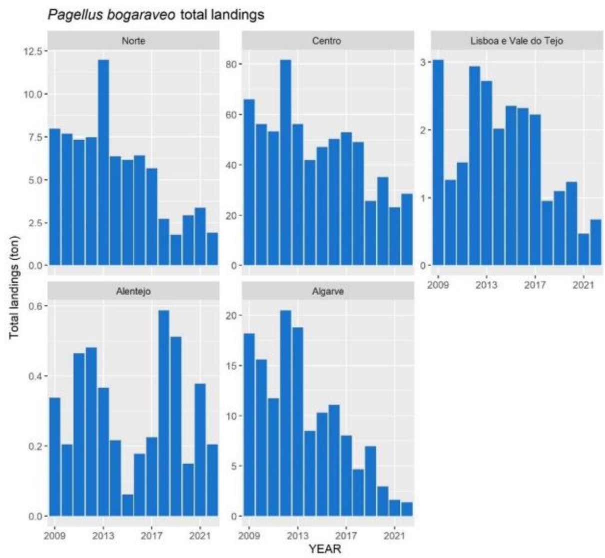

Figure 1. *Pagellus bogaraveo* total landings in tonnes in each NUTS II in continental Portugal between 2009 and 2022.

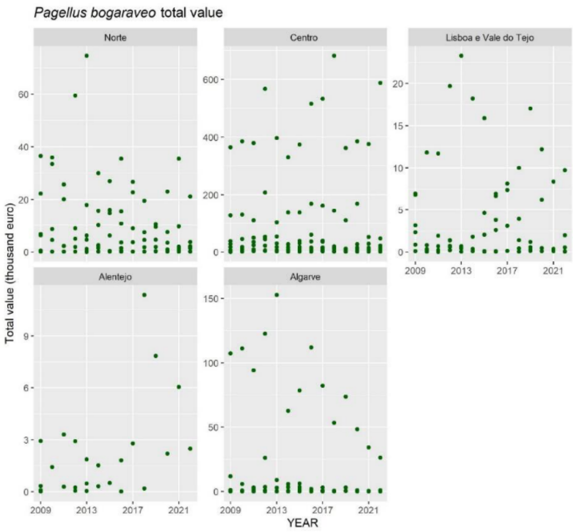

Figure 2. *Pagellus bogaraveo* total value in thousands of euros in each NUTS II in continental Portugal between 2009 and 2022.

In all NUTS II, the polyvalent fishing segment presented the highest landing values, followed by the trawl segment, with purse seine showing nearly negligible landings (Figure 3). These differences were more evident in central Portugal (NUTS II "Centro"), where the polyvalent represented around 60% of the species landings, the trawl segment represented nearly 40%, and the purse-seine fishery less than 1%.

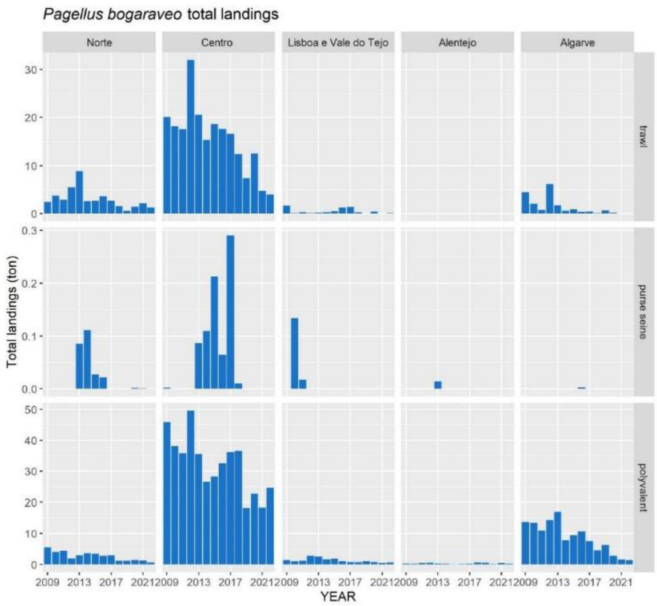

Figure 3. *Pagellus bogaraveo* total landings in tonnes by fishing segment (trawl, purse seine, and polyvalent) in each NUTS II in continental Portugal between 2009 and 2022.

The number of vessels landing *P. bogaraveo* was higher for the polyvalent fishing segment than for the trawl segment in all NUTS II (Figure 4). For the period between 2009 and 2022, a decreasing trend in the number of vessels landing the species was observed in the Centre, Lisbon area, and Algarve (NUTS II "Norte", "Lisboa e Vale do Tejo", and "Centro", respectively), which is probably associated with the continuous EU TAC reduction in Subarea 27.9 since 2004 (ICES, 2017a). However, the number of polyvalent and trawl vessels landing *P. bogaraveo* increased between 2019 and 2020, followed by a decrease in the subsequent years in the North (NUTS II "Norte") and Centre (NUTS II "Centro).

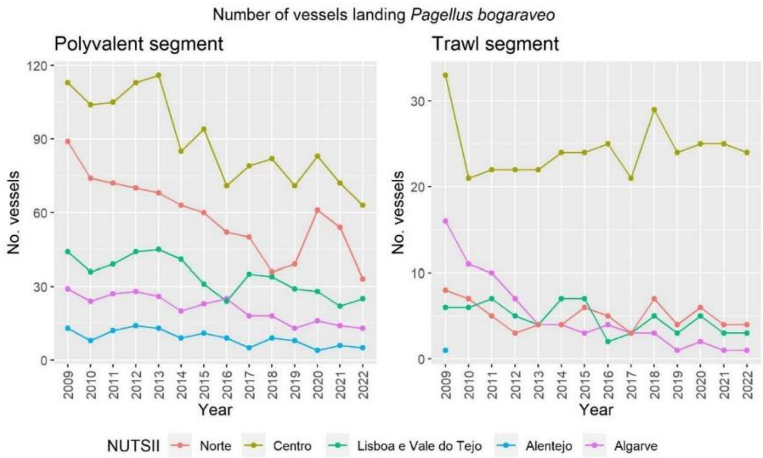

Figure 4. Number of vessels landing *Pagellus bogaraveo* in each NUTS II in continental Portugal, by year and by fishing segment (polyvalent and trawl), from 2009 to 2022.

2.1.2. Landings and mean price by fleet and selected NUTS II

Polyvalent fishing segment landings were higher in the winter months (late and early months of the year), more accentuated in the Centre region (NUTS II "Centro") (Figure 5). In the North (NUTS II "Norte") and Algarve, some years showed a peak in summer months but with little effect in terms of total landings when considering all the regions. From 2009 to 2022, there was a decreasing trend in the species landings in the three considered NUTS II, with the exception of the Centre region were the monthly landings increased between 2021 and 2022.

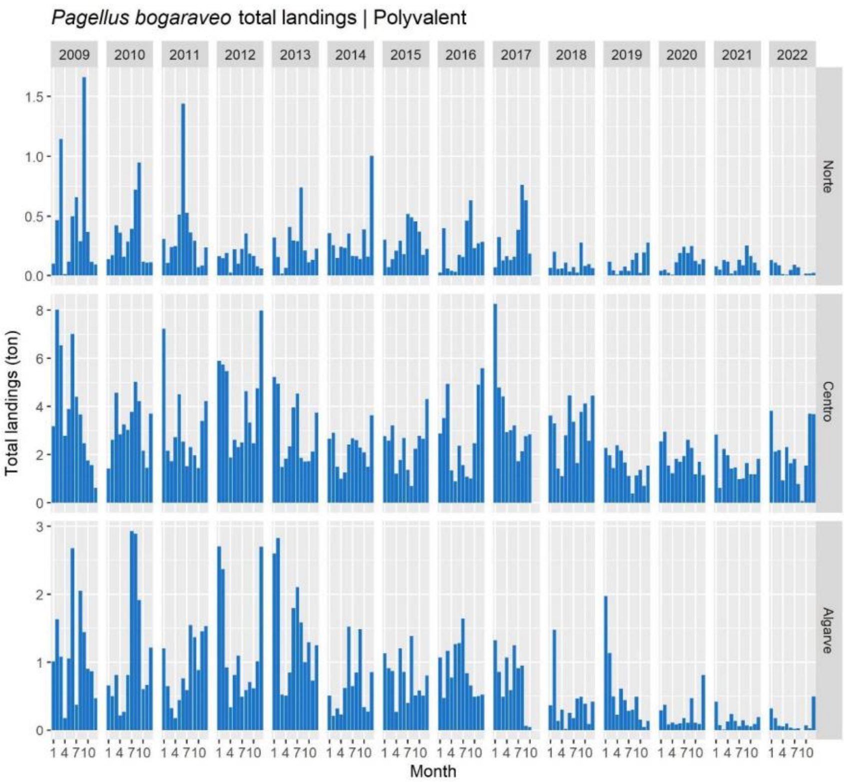

Figure 5. *Pagellus bogaraveo* landings (tons) from the polyvalent fleet by month and year at the three most important NUTS II in continental Portugal, from 2009 to 2022.

The trawl fishing segment shows a sharp decrease in total landings by month from 2012-2013 to 2022 (Figure 6). In the North (NUTS II "Norte") and in the Centre (NUTS II "Centro"), landings were higher at the beginning of the year. In the South (NUTS II "Algarve"), landings occurred mainly in the summer months, being nearly negligible between 2020 and 2022.

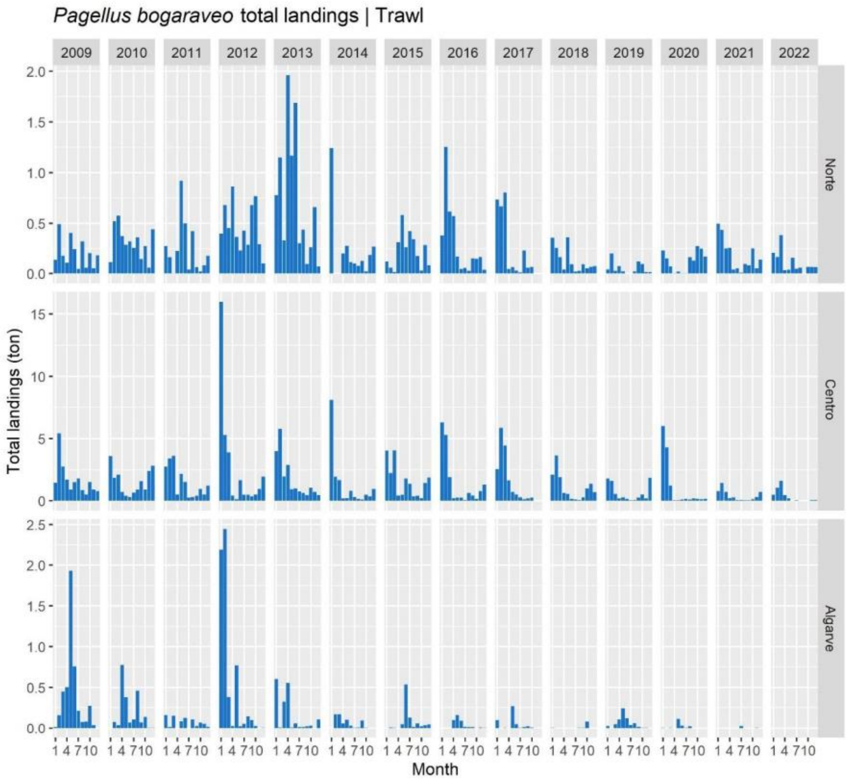

Figure 6. *Pagellus bogaraveo* landings (tons) from the trawl fleet by month and year at the three most important NUTS II in continental Portugal, from 2009 to 2021.

For the three main NUTS II, the mean price per Kg showed variations along the months of the year for the polyvalent fleet (Figure 7) and the trawl fleet (Figure 8), being those variations more noticeable in the polyvalent segment and in the last months of the year, since 2016.

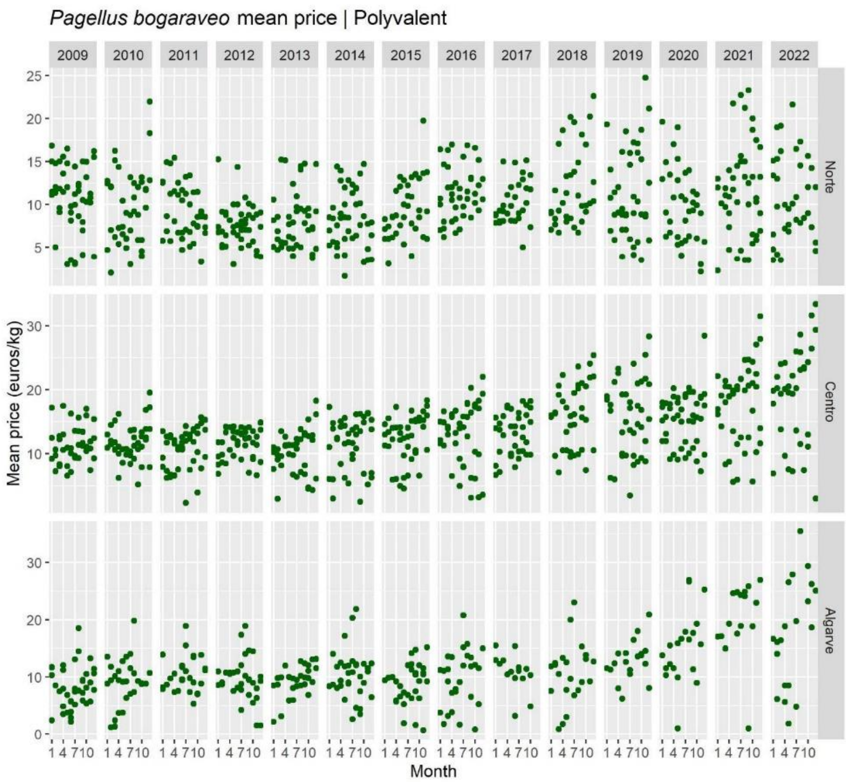

Figure 7. Mean price (in euro per Kg) of *Pagellus bogaraveo* landed by the polyvalent fishing segment by month and year for the three main NUTS II in continental Portugal between 2009 and 2022.

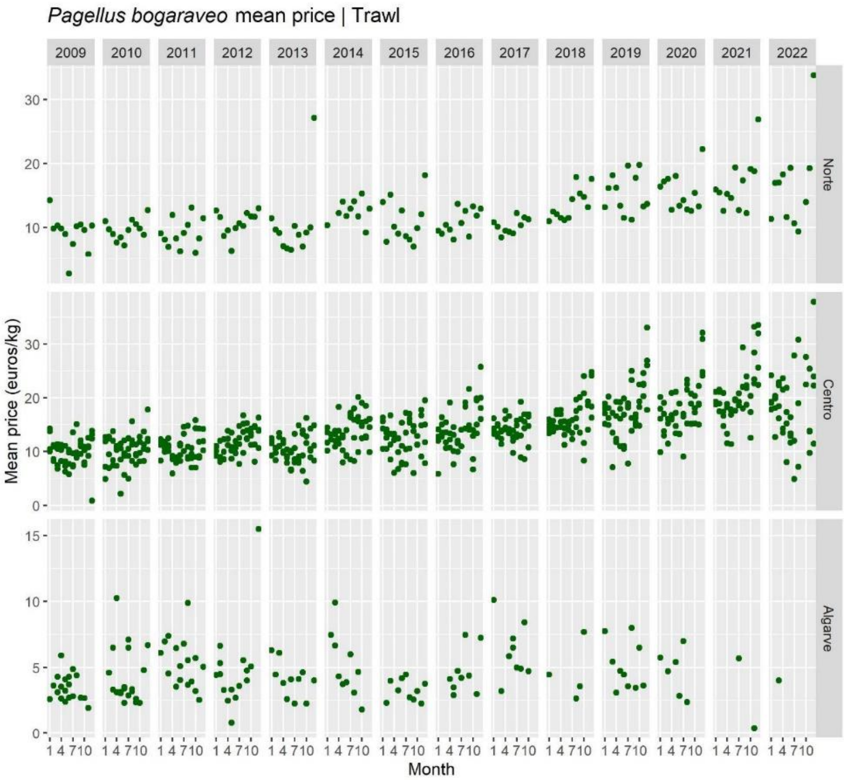

Figure 8. Mean price (in euro per Kg) of *Pagellus bogaraveo* landed by the trawl fishing segment by month and year for the three main NUTS II in continental Portugal between 2009 and 2022.

2.1.3. Landings in the most important Portuguese continental ports

P. bogaraveo landed weight by trip is presented in Figure 9 for the polyvalent segment and in Figure 10 for the trawl segment. Peniche port (Portuguese central western coast) was the most important landing port (landings between 2015 and 2022 represented nearly 50% of the Portuguese landings of the species in ICES Division 27.9.a) for both fishing segments. Extreme values were excluded from the plots for better visualization of data. In the later years, the highest landing values are registered between December and March for the polyvalent segment in Peniche.

P. bogaraveo total landings by most important ports and by fleet segment are summarised in Annex 1.

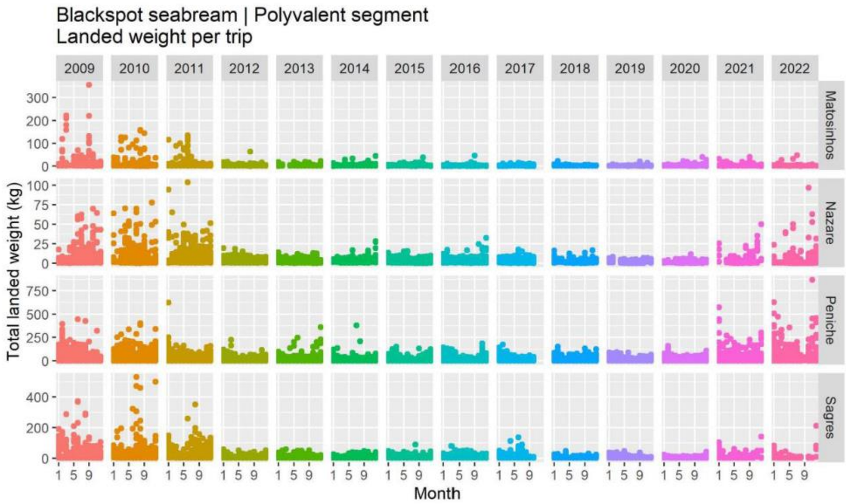

Figure 9. *Pagellus bogaraveo* total landed weight (kg) from the polyvalent fishing segment by month and year at the most important ports in Portugal continental, from 2009 to 2022.

Figure 10. *Pagellus bogaraveo* total landed weight (kg) from the trawl fishing segment by month and year at the most important ports in continental Portugal, from 2009 to 2022.

2.2. LPUE

2.2.1. Reference fleet

A total of 36 fishing vessels were selected for the polyvalent fleet landing in Peniche port and a total of 10 fishing vessels were selected for the trawl fleet landing in Peniche port.

2.2.2. CPUE adjustment

GLM was adjusted to annual log-CPUE estimations for Peniche's polyvalent reference fleet considering a normal distribution and the identity link function. The GLM estimates of the annual CPUE for Peniche's polyvalent reference fleet for the selected model are presented in Figure 11 and Table 3. CPUE for the polyvalent reference fleet has been stable throughout the considered time period, showing a slight decrease from 2018 to 2019 and an increasing trend from 2019 to 2022.

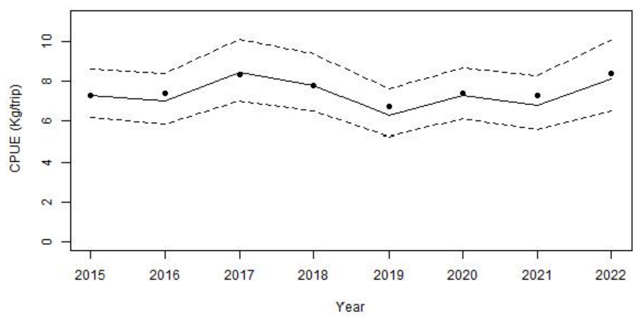

Figure 11. *Pagellus bogaraveo* standardized annual estimates of CPUE for Peniche polyvalent fishing segment reference fleet from 2015 to 2022.

Table 3. *Pagellus bogaraveo* CPUE series estimates for Peniche polyvalent reference fleet. 95% confidence interval.

Year	CPUE obs	CPUE pred.lower	CPUE pred	CPUE pred.upper
2015	7.31	6.18	7.31	8.65
2016	7.40	5.88	7.03	8.40
2017	8.34	7.03	8.44	10.12
2018	7.81	6.51	7.82	9.39
2019	6.71	5.23	6.33	7.65
2020	7.42	6.13	7.28	8.65
2021	7.28	5.61	6.82	8.29
2022	8.38	6.51	8.10	10.08

The analysis of the residuals of the fitted model is presented in Figure 12.

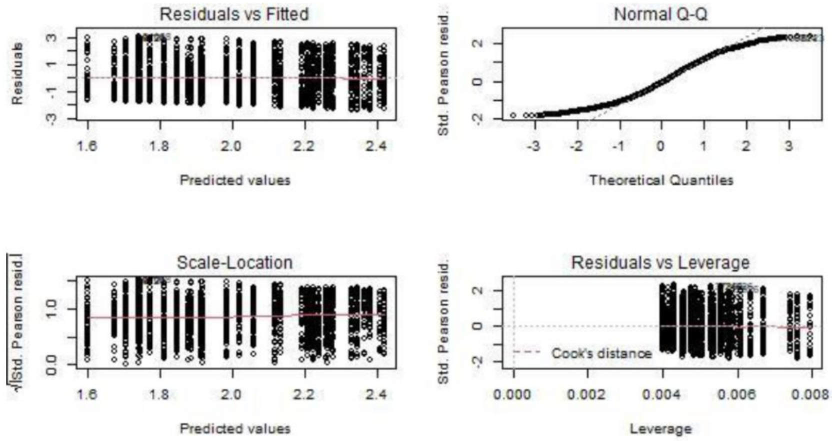

Figure 12. *Pagellus bogaraveo* analysis of the residuals of standardized annual estimates of CPUE for Peniche polyvalent fishing segment reference fleet from 2015 to 2022.

GLM was adjusted to annual log-CPUE estimations for Peniche's trawl reference fleet considering a normal distribution and the identity link function. The model was selected based on AIC and analysis of the residuals. The GLM estimates of the annual CPUE for Peniche's trawl reference fleet for the selected model are presented in Figure 13 and Table 4. CPUE for the trawl reference fleet showed a decreasing trend until 2019, followed by an increasing in that year, and has been stable since 2021.

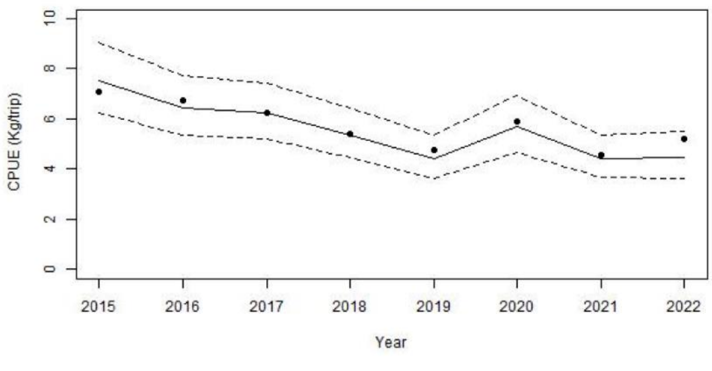

Figure 13. *Pagellus bogaraveo* standardized annual estimates of CPUE for Peniche trawl fishing segment reference fleet from 2015 to 2022.

Table 4. *Pagellus bogaraveo* CPUE series estimates for Peniche trawl reference fleet. 95% confidence interval.

Year	CPUE obs	CPUE pred. lower	CPUE pred	CPUE pred. upper
2015	7.06	6.22	7.51	9.06
2016	6.70	5.32	6.41	7.73
2017	6.21	5.19	6.21	7.43
2018	5.40	4.43	5.35	6.45
2019	4.74	3.59	4.38	5.35
2020	5.87	4.63	5.66	6.92
2021	4.57	3.64	4.40	5.33
2022	5.21	3.63	4.45	5.47

The analysis of the residuals of the fitted model is presented in Figure 14.

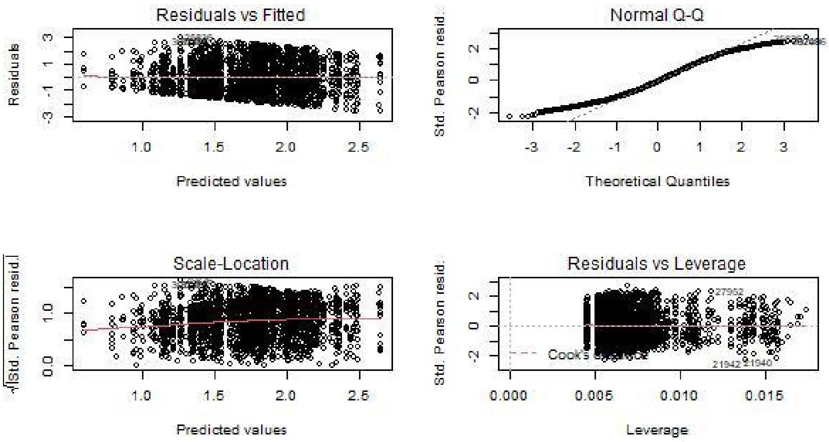

Figure 14. *Pagellus bogaraveo* analysis of the residuals of standardized annual estimates of CPUE for Peniche trawl fishing segment reference fleet from 2015 to 2022.

2.3. Length distribution

P. bogaraveo length distributions were extrapolated from DCF length sampling data available for the polyvalent (Figure 15) and the trawl (Figure 16) fishery segments for Portugal continental by year in the period between 2014 and 2022. The smaller sizes are poorly represented probably because the minimum landing size of *P. bogaraveo* is 33 cm and the discards of specimens bellow that size are negligible given that the species shows a very high survival rate (Serra-Pereira et al., 2019). In 2020, only 4 samples were measured from the polyvalent segment, which corresponded to 72 specimens, and only 4 samples from the trawl segment, which included 52 specimens (Farias and Figueiredo, 2021).

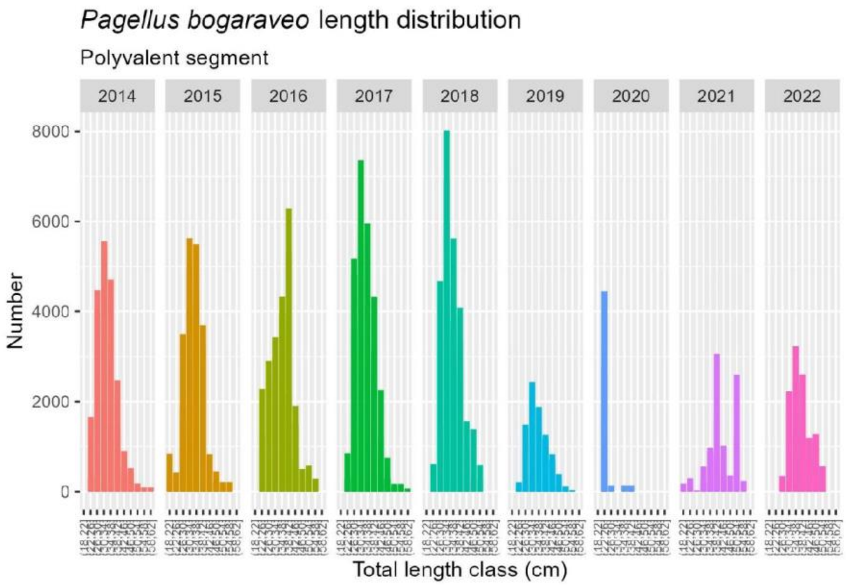

Figure 15. *Pagellus bogaraveo* extrapolated length frequency distributions for the polyvalent fishing segment for the years between 2014 and 2022. (4 cm total length classes)

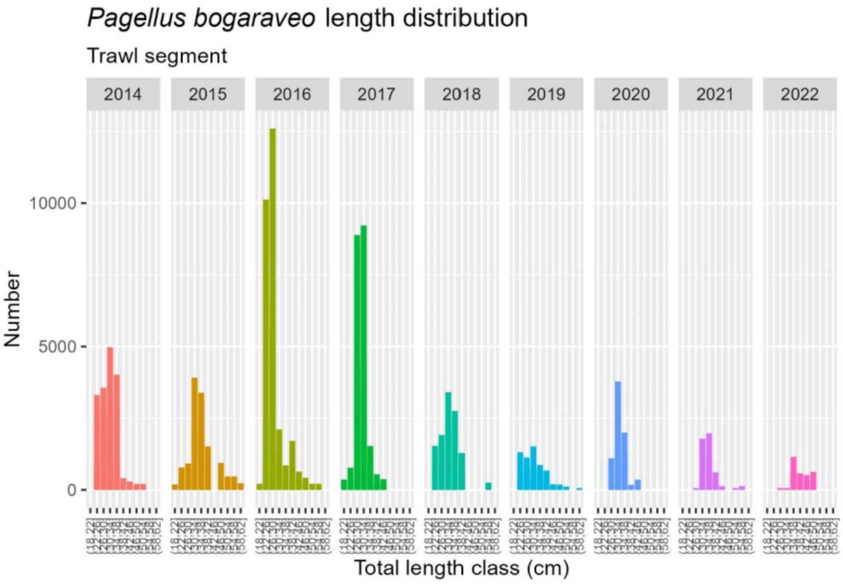

Figure 16. *Pagellus bogaraveo* extrapolated length frequency distributions for the trawl fishing segment for the years between 2014 and 2022. (4 cm total length classes)

Differences in length distribution between the polyvalent segment and the trawl segment result from the fact that polyvalent vessels operate in areas farther from the coast and at higher depths, where larger fish are more common (Farias et al., 2018).

2.4. LBI

Results from the LBI screening method are shown in Tables 5 and 6 and Figures 17 and 18.

Table 5. *Pagellus bogaraveo* in ICES Division 27.9.a. Results from LBI screening.

Year	L_{75}	L_{25}	L_{med}	L_{90}	L_{95}	L_{mean}	L_c	$L_{F=M}$	L_{maxy}	L_{mat}	L_{opt}	L_{inf}	$L_{max5\%}$
2014	36	29	33	39	42	33.39	26	35.00	34	35.1	41.33	62	46.88
2015	38	32	35	41	45	36.50	30	38.00	36	35.1	41.33	62	52.09
2016	38	27	31	42	45	33.52	26	35.00	40	35.1	41.33	62	49.58
2017	36	30	32	40	43	34.95	30	38.00	31	35.1	41.33	62	46.15
2018	38	31	34	41	44	35.78	30	38.00	37	35.1	41.33	62	47.60
2019	39	31	34	43	46	35.28	26	35.00	38	35.1	41.33	62	49.03
2020	34	25	32	37	38	33.35	26	35.00	34	35.1	41.33	62	41.42
2021	43	36	39	52	54	40.29	22	32.00	52	35.1	41.33	62	54.53
2022	43	35	38	47	49	40.60	34	41.00	38	35.1	41.33	62	50.01

All LBI estimates increased between 2020 and 2021, except L_c and $L_{F=M}$, which increased between 2021 and 2022 (Table 5).

Table 6. *Pagellus bogaraveo* in ICES Division 27.9.a. LBI screening ratios.

		Conservation						Optimizing Yield	MSY
		L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{95\%}/L_{inf}$	L_{maxy}/L_{opt}	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Year	Ref.	> 1	> 1	> 0.8	≈ 1	> 0.8	>30%	≈ 1 (>0.9)	≥ 1
2014		0.74	0.83	0.68	0.82	0.76	3%	0.81	0.95
2015		0.85	0.91	0.73	0.87	0.84	5%	0.88	1.04
2016		0.74	0.77	0.73	0.97	0.80	5%	0.81	0.96
2017		0.85	0.85	0.69	0.75	0.74	2%	0.85	1.00
2018		0.85	0.88	0.71	0.90	0.77	4%	0.87	1.02
2019		0.74	0.88	0.74	0.92	0.79	6%	0.85	1.01
2020		0.74	0.71	0.61	0.82	0.67	0%	0.81	0.95
2021		0.63	1.03	0.87	1.26	0.88	20%	0.97	1.15
2022		0.97	1.00	0.79	0.92	0.81	16%	0.98	1.16

Most ratio estimates of conservation increased in 2021 in relation to previous years and remained close to the reference values in 2022, including the L_c/L_{mat} which increased had been at lower levels (Table 6). The Optimizing Yield indicator ratio increased between 2020 and 2021 and remained at the same level in 2022, which indicates that the stock is being fished at levels close to optimum yield. The indicator for MSY ($L_{mean}/L_{F=M}$) was above the reference value in most of the years of the series, including 2020 and 2021, being consistent with an adequate exploitation.

The values estimated for the conservation ratios results might reflect some of EU size measures, such as the adopted minimum landing size (MLS). L_c/L_{mat} and $L_{25\%}/L_{mat}$ low estimates might be related with the fact that the L_{mat} of females, which is above the MLS, was assumed in the screening since *P. bogaraveo* is a protandric hermaphrodite.

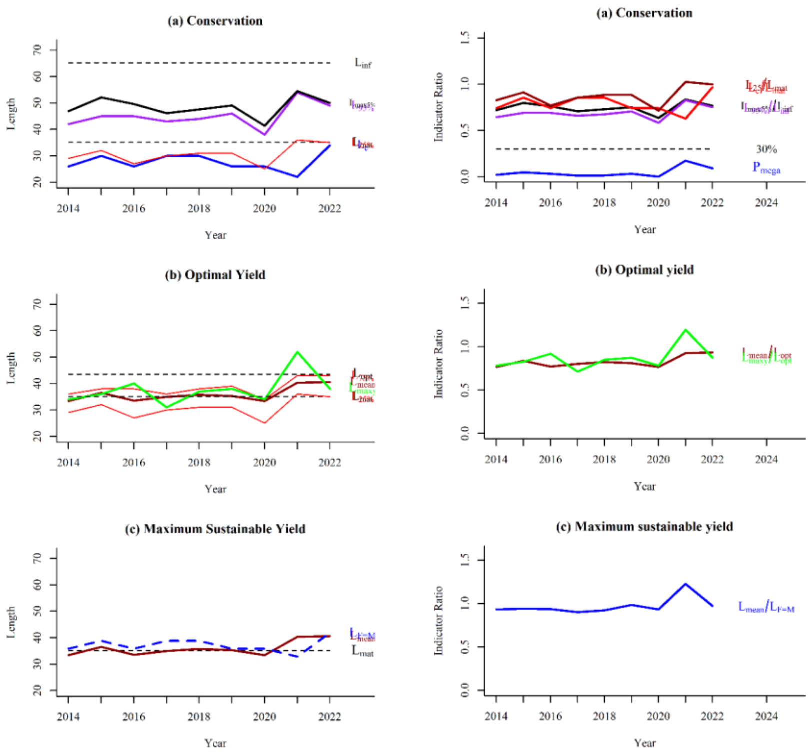

Figure 17. *Pagellus bogaraveo* in ICES Division 27.9.a. Results from LBI screening (left) and LBI screening ratios (left).

Time-series plots show that most of the indicators had low variability between 2014 and 2022.

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ANNEX I

Table 7. *Pagellus bogaraveo* total landed weight (ton) by fleet segment in the six most important landing ports for the species. Ports are organized by NUTS II between 2009 and 2022.

		North			Centre				Lisbon Metrop. Area	Algarve	
Year	Gear	Matosinhos	Povoa do Varzim	Viana do Castelo	Aveiro	Figueira da Foz	Nazare	Peniche	Sesimbra	Sagres	Portimao
2009	Polyvalent	4.24	0.66	0.5734	0.06	0.43	3.42	41.98	0.59	13.47	0.05
	Trawl	2.43	-	-	1.43	0.64	2.69	15.32	1.55	-	4.32
2010	Polyvalent	2.64	0.45	0.8427	0.09	0.50	3.83	33.65	0.91	13.33	0.05
	Trawl	3.73	-	-	1.12	1.05	1.47	14.50	0.05	0.00	1.90
2011	Polyvalent	2.27	0.34	1.8148	0.52	0.20	3.92	31.09	0.97	10.63	0.20
	Trawl	2.90	-	-	3.03	0.79	2.32	11.43	0.32	-	0.74
2012	Polyvalent	1.03	0.29	0.5313	0.53	0.24	3.99	44.85	2.18	13.88	0.05
	Trawl	5.56	-	-	3.63	1.80	5.33	21.29	0.09	-	6.14
2013	Polyvalent	1.55	0.52	0.6831	0.74	0.10	2.60	32.05	2.21	16.70	0.03
	Trawl	8.91	-	-	4.79	1.51	3.34	10.89	0.18	-	1.73
2014	Polyvalent	1.05	0.35	1.9169	0.36	0.02	1.80	24.36	1.55	6.89	0.41
	Trawl	2.62	-	-	1.09	0.48	1.11	12.61	0.31	-	0.62
2015	Polyvalent	1.32	0.80	1.3293	0.55	0.06	2.82	24.88	1.46	8.65	0.07
	Trawl	2.70	-	-	1.99	0.93	1.38	14.30	0.51	-	0.90
2016	Polyvalent	0.86	0.35	1.3854	0.34	0.09	2.28	29.87	0.49	10.45	0.02
	Trawl	3.62	-	-	3.68	0.70	0.95	12.26	1.26	-	0.40
2017	Polyvalent	1.73	0.43	0.775	0.55	0.09	2.43	33.04	0.58	7.35	-
	Trawl	2.71	-	-	2.78	1.12	0.57	12.09	1.41	-	0.46
2018	Polyvalent	0.54	0.19	0.4024	0.20	0.02	1.02	35.40	0.52	4.50	0.00
	Trawl	1.58	-	-	1.07	1.10	0.60	9.66	0.28	-	0.09
2019	Polyvalent	0.49	0.23	0.3601	0.31	0.03	0.49	17.35	0.95	6.25	-
	Trawl	0.63	-	-	0.58	0.44	0.35	6.08	0.02	-	0.66
2020	Polyvalent	0.90	0.14	0.3199	1.37	0.04	0.53	20.72	0.73	2.60	0.10
	Trawl	1.46	-	-	1.51	0.40	0.12	10.54	0.46	-	0.17
2021	Polyvalent	0.62	0.15	0.11	0.48	0.03	0.56	17.33	0.42	1.57	-
	Trawl	2.15	-	-	0.68	1.21	0.61	2.28	0.02	-	0.02
2022	Polyvalent	0.28	0.18	0.10	0.44	0.01	1.02	23.15	0.55	1.18	0.00
	Trawl	1.29	-	-	0.67	0.73	0.59	1.99	0.09	-	0.00

Working Document for the ICES Working Group on Biology and Assessment of Deep-Sea Fisheries Resources

Lisbon, 03rd - 09th May 2023

Scabbard fish in the Madeira archipelago (CECAF 34.1.2)

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Abstract

This working document updates the information existing from the previous WGDEEP meeting of 2022 for the *Aphanopus* spp. in CECAF fishing area 34. Mainly an update on the time-series of annual Portuguese landings (by vessel segment), length distributions and unstandardized CPUE at CECAF area. A standardized biomass index series based on daily landings of commercial horizontal mid-water drifting longline fishery in Madeira was also updated with data from 2022.

1. INTRODUCTION

The fishery for deep-water species carried out in the Madeira EEZ and international adjacent waters (CECAF 34.1.2. area), dates back to the 17th century (Merrett and Haedrich, 1997) and for several decades this was the only fishery targeting scabbard fish in the Northeast Atlantic (Bordalo-Machado and Figueiredo, 2009). This fishery as an important and irreplaceable economic and social value in the Madeira fisheries sector. In Madeira, exploited deep-water fish stocks are overwhelmingly dominated by two scabbard fish species: *Aphanopus carbo* Lowe 1839 and *Aphanopus intermedius* Parin, 1983, which represent about half of the overall landings throughout the year (Delgado et al., 2013, 2018; Hermida and Delgado, 2016). This deep-sea fishery targeting the black and intermediate scabbard fish, off the Madeira archipelago, is recognized as an artisanal and selective activity targeting predominantly adult individuals and presenting a low rate of bycatch (Severino et al., 2009).

Both scabbard fish species occur at a wide depth range, from 200 m in the northern part of the NE Atlantic (Nakamura and Parin, 1993) to 2300 m off the Canary Islands (Pajuelo et al., 2008) for *A. carbo*, although more frequent at 800-1300 m in Madeira (Morales-Nin and Sena-Carvalho, 1996) and to 1350 m for *A. intermedius* (Delgado et al., 2013). *Aphanopus carbo* and *A. intermedius* seem to be adapted to a strong activity of migrating upwards at night to feed on crustaceans, cephalopods, and fishes (Tuset et al., 2010). Furthermore, these two sympatric species move to reproduction areas off Macaronesian archipelagos (i.e., Madeira and the Canary

Islands) and the northwest coast of Africa (Figueiredo et al., 2003; Pajuelo et al., 2008; Perera 2008; Farias et al., 2013). The spawning season of both *Aphanopus* species has been reported to take place from October to December (Figueiredo et al., 2003; Delgado et al., 2013).

The black and intermediate scabbard fish fishery represents one of the most profitable commercial activities on small-scale fisheries in Madeira archipelago. In 2022, the commercial landings in weight of *Aphanopus* spp. reached annual catches of up to 2259 tonnes yielding a total first sale value of approximately 7.5 M€.

WGDEEP does not assess fisheries in Madeira (Eastern Central Atlantic area, CECAF) or in other areas outside the ICES area. Nonetheless, it is admitted that the incorporation of reliable CECAF data could provide a wider perception of the stock dynamics of these migratory species in the northeast Atlantic.

1.1. Fishery in Madeira

In compliance with the Multiannual Union Programme for Data Collection (EU-MAP), the Madeira fishing fleet targeting the deep-water species, *A. carbo* and *A. intermedius*, uses a specialized fishing gear with longlines (LLD_DWF_0_0_0). The fishing gear is a mid-water horizontal drifting longline, set in the water column usually at depths of between 800 and 1300 m (Figure 1).

The fishing gear used to catch the scabbardfishes is a drifting longline always set at least more than 100 m above the bottom of the sea. This is an important aspect of the fishery as, in normal circumstances, the gear does not contact the sea floor thus is not a menace to hypothetical Vulnerable Marine Ecosystems (VME).

This fishery is known by its highly selective nature, concerning the bycatches of non-target species and the length structure of the catches of the targeted species – constituted almost exclusively by adult specimens over 90 cm total length. The catches of sub adult individuals scarcely achieve around 0.5% of the total number of individuals captured.

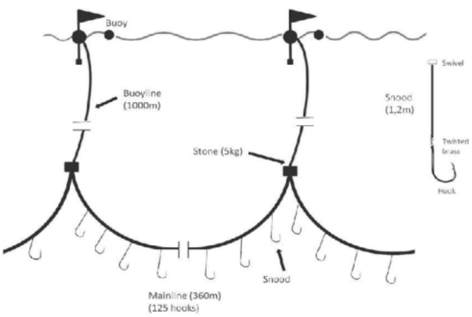

Figure 1 – Mid-water horizontal drifting longline used by the Madeira fishing fleet.

There is a combination of prevailing factors that result in a fishery with such unique features. Such factors are the geographical area of the fishery, where, according to the migratory model proposed by Farias et al. (2013), only adult specimens are available to this type of fishery and the highly selective nature of the fishing methodology itself, namely the fact that the passive fishing gear is operated strictly within a depth layer of the water column, between 800 and 1300 meters deep, without being anchored, and always well above the seafloor. The gear aims to catch the black scabbard fish in its daily vertical migration to feed, thus minimizing the probability of capture of benthic bycatch species.

This fishery, carried out by the fishing vessels targeting the black and intermediate scabbard fish registered in Madeira, which was traditionally performed mostly around the islands of Madeira and Porto Santo and the seamounts inside the Madeira EEZ, has undergone considerable geographic expansion in recent decades in the Northeast Atlantic, mostly from 2005 onwards, and initiated a process of expansion looking for new fishing areas (Figure 2). Progressively, new fishing grounds located in international waters SE of the Azores, off the Canaries and the "rediscovery" of the seamounts within the Madeira EEZ became indispensable for this fishery and bilateral agreements with the Azores and the Canaries were made to allow the fleet access to those areas.

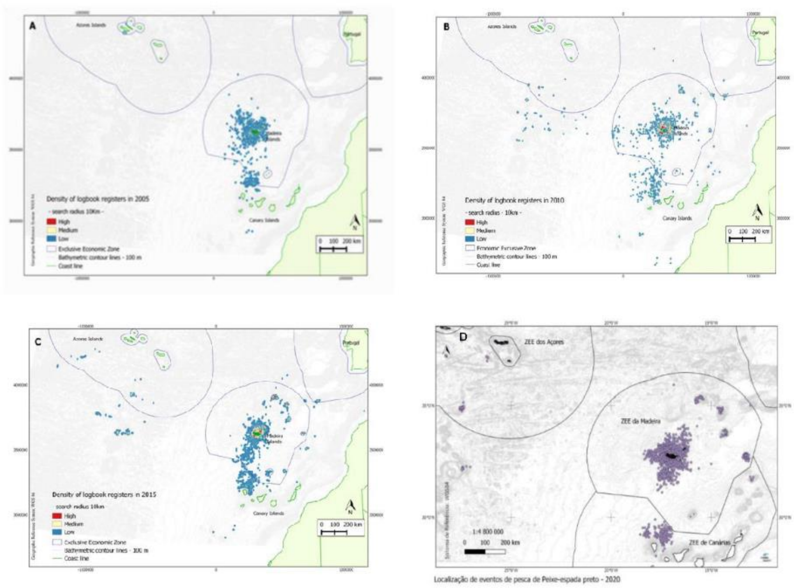

Figure 2 - Density plots illustrating the geographical distribution of the fishing sets with catches in 2005 (A), 2010 (B), 2015 (C) and 2020 (D): density maps estimated with the software Quantum GIS 2.2, module "heatmap" covering a search radius of 10 Km (Regional Directorate of the Sea - Madeira).

In 2015, STECF provided an exploratory assessment of the status of the species around Madeira (STECF-14–15). It was mentioned that, for the period 2000-2013, there was a general decline in fishing capacity and fishing effort. The number of vessels has also declined by 41% (34 to 20 vessels). Furthermore, in the second half of the last decade, some Madeiran vessels targeting the black and intermediate scabbard fish have moved to new fishing grounds, some of them located outside the EEZ of Madeira (SE of the Azores and off the NW of the Canaries) (Figure 2).

From 2019 to the present, most of fishery targeting the black and intermediate scabbard fish have been carried out within the Madeira EEZ. However, the fishing grounds off the Northwest of Canaries continues to be a relevant fishing area for the Madeira fishing fleet, due to the availability of black and intermediate scabbard fish and the lack of interest in these species by the Canary fishing fleet, which makes profitability the capture of them by the fishing fleet from Madeira. The capture of *Aphanopus* spp. in the Azores fishing grounds by the fishing fleet from Madeira has been decreasing since 2015. According to the fishermen fishing in Azores is not profitable due to the distance between Madeira and Azores.

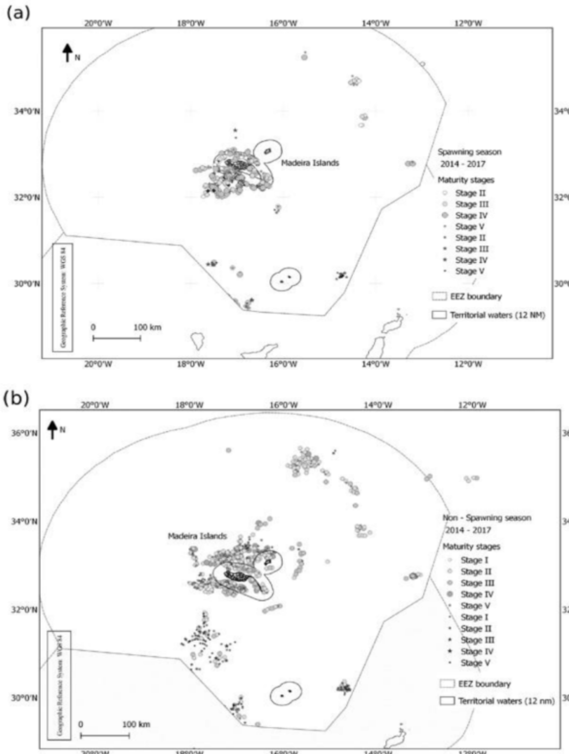

Figure 3 - Map showing both *Aphanopus* species distribution, *A. carbo* (grey circles) and *A. intermedius* (grey stars), during spawning (a) and non-spawning (b) seasons according to the distance from the coast (<12 and >12 nautical miles; 1 n.m. = 1.852 km) (Vasconcelos et al., 2020).

The enlargement of the maritime area covered by the fishing operations was prompted by the decrease of the abundance of the resource in the traditional fishing grounds, near the islands of Madeira and Porto Santo. And also due to the improvement of the fishing fleet of Madeira verified in the last years. This search for new fishing grounds was driven by the need to stabilise catches that suffered a severe decline from 2000 onwards. A relative stabilisation of the fishery was achieved in the last years but the enormous increase in the costs led several vessels to leave the activity.

Though, most of the *Aphanopus* spp. fishery still remains concentrated off the islands of Madeira and Porto Santo, especially during the spawning season from October to December, mainly the fishery operated by the small vessels (< 12 m). Migrations to areas less than 12 n.m. from the coast, were observed for *A. carbo* throughout the spawning season (Figure 3) (interannual database from 2014-2017; Vasconcelos et al., 2020). The mature stages IV and V were the ones that overwhelmingly dominated this migration pattern to shallower areas. This migration of mature adults towards areas near the coast, especially during spawning, occurs simultaneously with a noticeable increase of the proportion of fishing events inside the EEZ (<12 n.m.), making them more susceptible to mid-water drifting longline fishery (Vasconcelos et al., 2020).

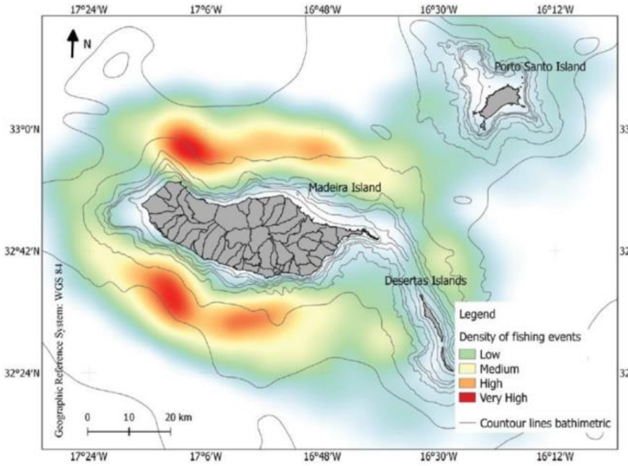

Figure 4 - Kernel density estimation plot showing the mean density values of the fishing events during the spawning season per compartment of 10 km × 10 km generated for the study area and for the period 2014–2017. Low: 1–10; Medium: 11–20; High: 21–30; and Very High: >31 fishing events (Vasconcelos et al., 2020).

There are three main aggregation areas identified off Madeira (Figure 4), where fishing events occurs during spawning, mainly the fishing grounds from Câmara de Lobos and Ribeira Brava at the south coast of Madeira and Porto do Moniz-Seixal at the north coast (Vasconcelos et al., 2020). The fishing grounds are located at an average distance of 2 to 4 n.m. offshore, although the same depths are found over a wider range of 3 to 6 n.m. offshore (Vasconcelos et al., 2020). Most likely, these areas correspond to areas with environmental and sea bottom topography that favour reproduction, as these areas generally correspond to canyons where there are prominent folds in the bathymetry towards the coast and its nearby steep slopes. These represent very closed geological formations with the dimension of extensive canyons, probably protected from strong currents and where high densities of spawning individuals aggregate, facilitating high probability of successful external fertilization (Vasconcelos et al., 2020).

2. METHODS

2.1. Fishery dependent data

2.1.1. Landings and mean price in Madeira archipelago

Portuguese total landings of *Aphanopus* spp. in CECAF area 34 (in weight, ton, and value, euro) were analysed by year. Fishery dependent data were collected from commercial landings for the period between 1990 and 2022.

2.1.2. Landings and mean price in Madeira archipelago by vessel length category

Portuguese landings of *Aphanopus* spp. in CECAF area 34 (in weight, tonnes, and value, euro) were analysed by year and by fishing vessel segment (vessel length category). Fishery dependent data were collected from commercial landings for the period between 2008 and 2022. The active fishing fleet at CECAF area is grouped into the following categories: VL0010 (vessel size less than 10 m), VL1012 (vessel size between 10 and 11.99 m), VL1218 (vessel size between 12 and 17.99 m) and VL1824 (vessel size between 18 and 23.99 m).

2.2. Length distribution

Aphanopus spp. length sampling data available for Madeira were analysed considering both species combined by year for the period between 2009 and 2022. Numbers-at-length were raised to the total landings.

2.3. CPUE

All landings from the commercial mid-water drifting longline fishery at all the fishing ports of Madeira (mainly port of Funchal), in the Northeast Atlantic (32°00'–33°30'N, 15°30'–18°00'W) were considered for this analysis, during the period between 2008 and 2022. From each fishing trip data on total weight landed of the species (in kg), vessel name and corresponding length category, engine power (KW), number of days at sea, number of fishing days and fishing operations, and the total number of hooks were examined. A trip was defined from the moment the vessel leaves the dock to when it gets back to the dock.

The standardized CPUE model based on daily landings of commercial mid-water horizontal drifting longline fishery in Madeira was updated with data from 2022.

3. RESULTS AND DISCUSSION

3.1. Fishery dependent data

3.1.1. Landings and mean price in Madeira archipelago

The annual landings of black and intermediate scabbard fish derived from Madeiran mid-water longliners for the period between 1990 and 2022 are presented in Figure 5.

Catches in CECAF 34 area were updated with fishery data from Madeiran mid-water longliners landings from 1990 to 2022. These catches are recorded by the Regional Fisheries Department of Madeira (Figure 5). CECAF catches have been decreasing after the 1998 peak, but an increase was observed from 2012 onwards. Between 2020 and 2021 a decrease was observed mainly due to the reduction in fishing days caused by the COVID-19 pandemic. In 2022, an increase of 386 tonnes was observed when comparing with 2021.

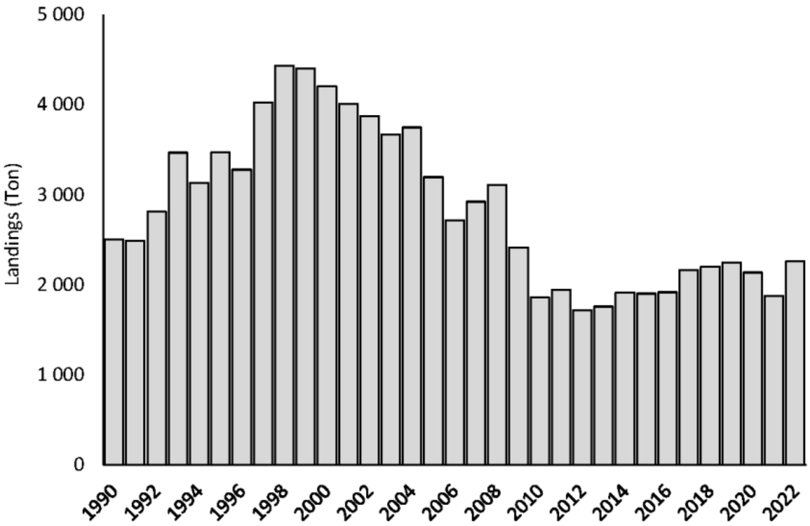

Figure 5 - Time-series of annual Portuguese landings of *Aphanopus* spp. at CECAF area (1990-2022).

The EU TAC and total catches for CECAF 34 area from 2005 to 2022 are presented in Table 1. It was observed a relevant decrease in the EU TAC for the *Aphanopus* spp. fishery in CECAF 34.1.2, from 4285 tons in 2005 to 2259 tons in 2022.

Table 1 - Black scabbard fish TACs and total landings in CECAF area 34, between 2010 and 2022, for both species (*Aphanopus carbo* and *Aphanopus intermedius*).

Year	EU TAC CECAF 34.1.2 area	Landings CECAF 34.1.2. Area
2005	4 285	3 195
2006	4 285	2 717
2007	4 285	2 922
2008	4 285	3 109
2009	4 285	2 413
2010	4 285	1 860
2011	4 071	1 941
2012	3 867	1 716
2013	3 674	1 758
2014	3 490	1 913
2015	3 141	1 902
2016	2 827	1 917
2017	2 488	2 163
2018	2 189	2 199
2019	2 189	2 246
2020	2 189	2 136
2021	2 189	1873
2022	2 189	2259

Following the methodology adopted at WGDEEP 2016 (ICES, 2016), standardised annual catch estimates for the period from 1990 to 2022 of the nineteen fishing resources (ordered in terms of total weight catch) and grouped into four groups (1, large pelagics; 2, elasmobranchs; 3, small pelagics; and 4, demersals) were determined based on data extracted from DSEIMar/DRM database (Figure 6).

The results do not support that given the diversity of species, which includes different taxonomic groups, lifestyles and both short- and long-lived organisms, the declining trends are reflecting changes on resources abundance which may imply that Madeiran waters are subject to severe over-exploitation. Further studies and a careful interpretation of trend variations of some resources are still required. It may happen that in some cases landing trends are not only related to the resources' abundance in Madeiran waters, but subject to other factors like variations on the market regulation (e.g. small pelagic fishery), environmental, application of TAC's and quotas, among others.

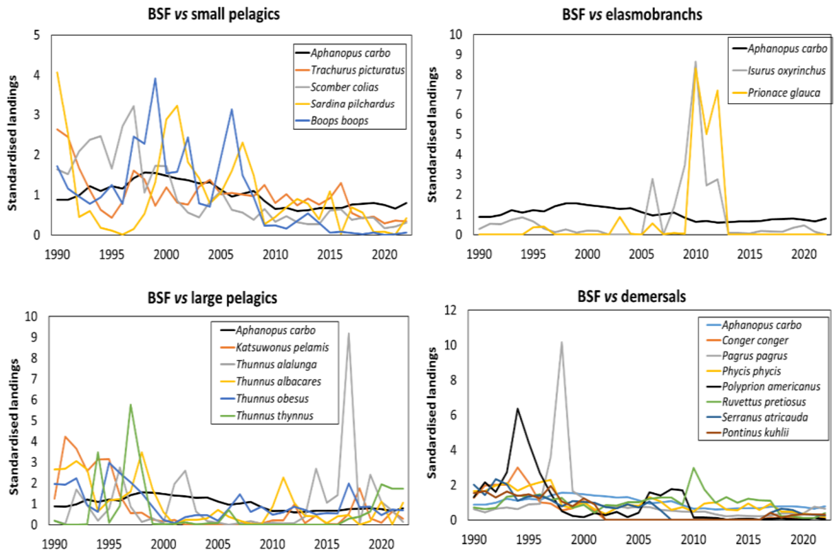

Figure 6 - Trends in standardised landings of scabbard fishes and the 19 other top ranked species in Madeiran landings.

The first sale value of *Aphanopus* spp., in millions of euros, for the period between 2008 and 2022 is presented in Figure 7. This value followed the same trend observed in the annual landings in terms of weight. The reduction in the economic value observed in 2020 and 2021 is related to the decrease in effort due to COVID 19 Pandemic. In 2022, the total first sale value achieved 7.5M€, increasing 1.7M€ in relation to 2021.

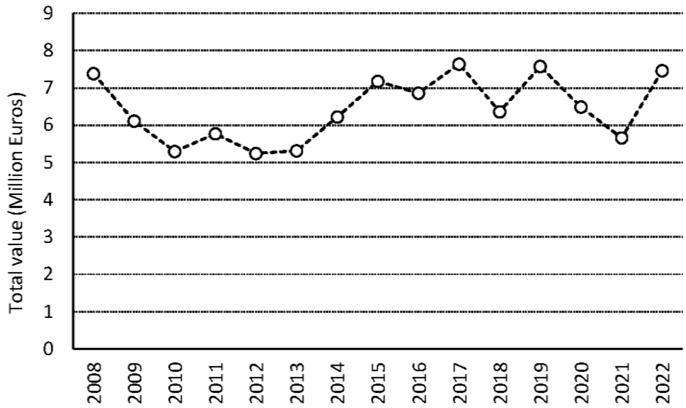

Figure 7 – Economic value of the catches of *Aphanopus* spp., in millions of euros, for CECAF 34.1.2., between 2008 and 2022.

3.1.2. Landings and mean price in Madeira archipelago by vessel length category

The number of vessels in activity in Madeiran longline fleet has steadily decreased during the last two decades (Figure 8).

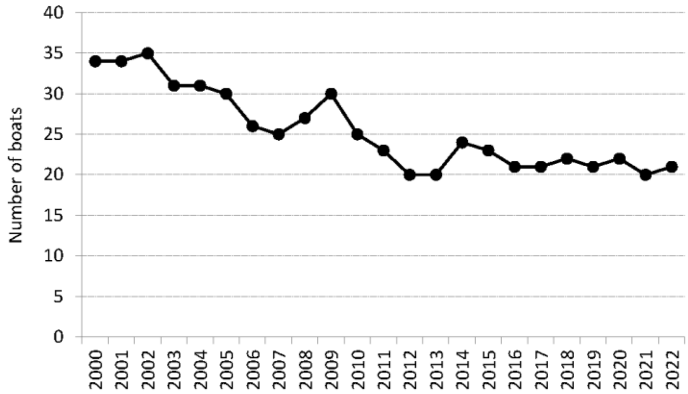

Figure 8 - Number of vessels active in the fishery of *Aphanopus* spp. at CECAF 34.1.2 area between 2000 and 2022.

Though, in the last years, the fishery as achieved a certain stability in the number of active vessels, as the small number of vessels remaining in the fishery are small artisanal vessels (Figure 9). In 2022, 52% of the active vessels were grouped between 12 and 18 m of overall length, thus hardly having operational conditions to make any significant increase in the present total number of hooks used in each fishing set.

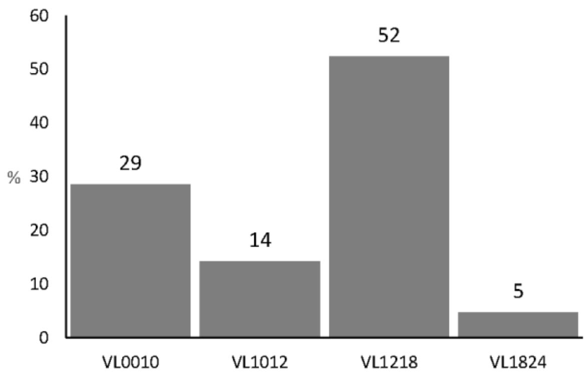

Figure 9 - Composition of the active fleet in the fishery of *Aphanopus* spp. at CECAF 34.1.2 area in 2022 per vessel length category (n=21 vessels).

A time-series of annual Portuguese landings at CECAF 34.1.2 area per vessel length is represented in Figure 10. The majority of the annual landings in Madeira are made by vessels of the length segments VL1218 and VL1824, wherein *ca*. 79% of the total landings in 2022 were captured by VL1218.

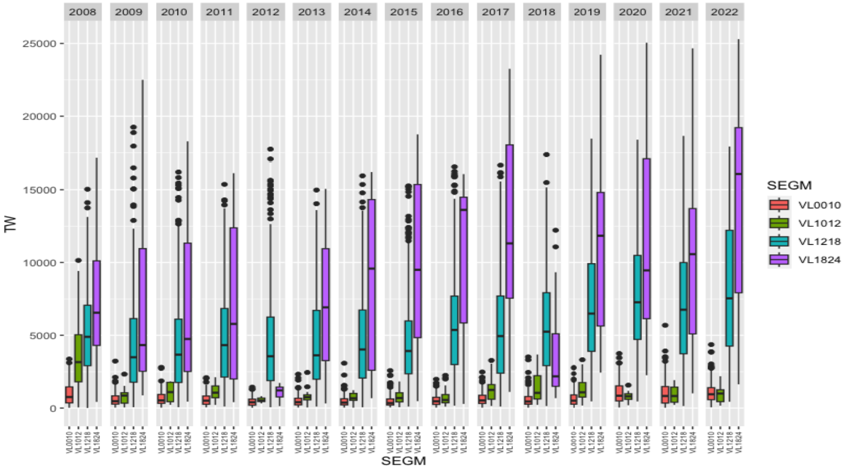

Figure 10 - Time-series of annual Portuguese landings of *Aphanopus* spp. at CECAF 34.1.2 area per vessel length category (SEGM), from 2008 to 2022.

The vessel length category VL1218 presented the highest landing and first sale values, followed by the vessel segment VL1824 (Figure 11). Though the number of vessels in the segment VL1824 represents only 5% of the total active fleet in Madeira, their contribution is higher (*ca.* 12.6%) than both vessel segments VL0010 and VL1012 together (*ca.* 8.5%). In 2022, it was observed an increase in the landings and economic values for all segments being more pronounced in the segment VL1824.

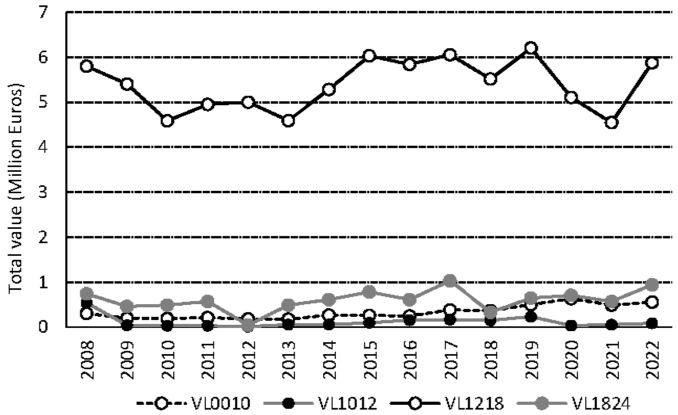

Figure 11 – Economic value of the catches of *Aphanopus* spp., in millions of euros per vessel category between 2008 and 2022.

3.2. Length distribution

The analysis of data indicates neither great changes on the length range between years nor on the mean length (around 114-118 cm total length, TL). From 2010 to 2018 the mean length was between 117 and 118 cm TL, occurring a slight decrease in 2019-2022 (115-116 cm TL).

Annual total length–frequency distributions of the exploited population caught by the Madeiran longline fleet in CECAF 34.1.2 area for the period 2010-2022 are presented in Figure 12. The range of scabbardfish total length varied between 87 cm and 155 cm.

Overall, between 2010 and 2022 there was verified a stability in the composition of lengths and average lengths for scabbardfish species caught by the Madeiran fleet.

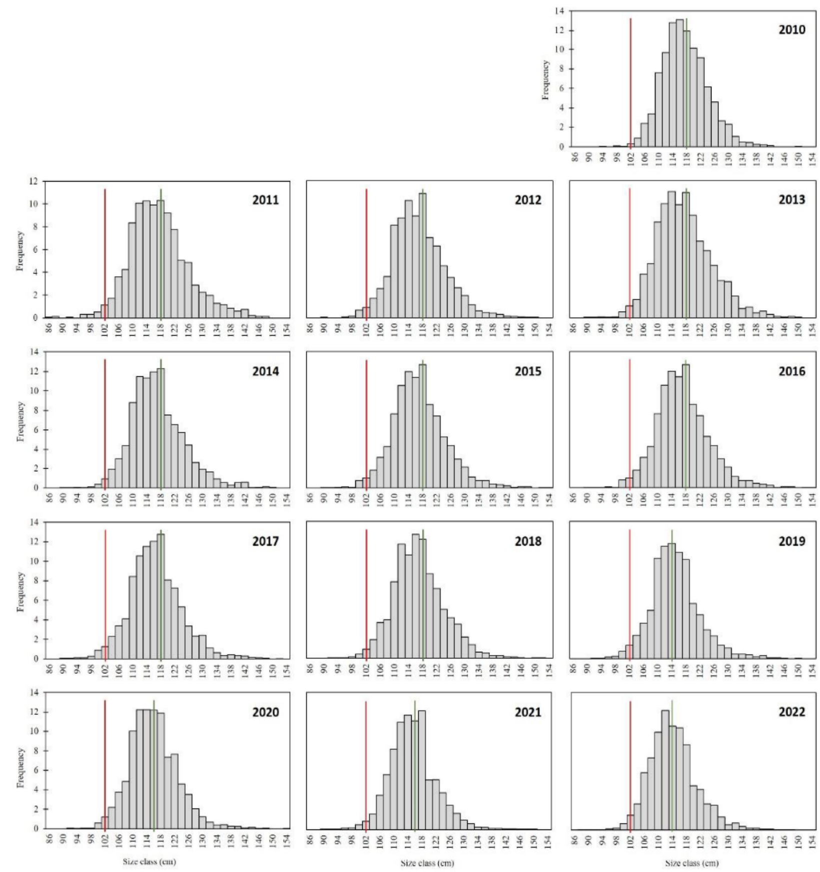

Figure 12 - Annual length–frequency distribution of specimens of *Aphanopus* spp. landed by the Portuguese middle-water longliners operating along CECAF area 34.1.2, from 2010 to 2022. Red line represents the length at first maturity according to Figueiredo et al. (2003) and green line represents the annual mean total length.

3.3. CPUE

Fishing effort in total number of hooks accumulated per year is represented in Figure 13. There was an overall decrease in the available period, reflecting the decline of the number of vessels. The year of 2004 stands for the highest total number of hooks (*ca.* 22.3 M) in the period available, since then effort has declined, and it is rather constant in the last years around 14-11 M hooks per year. In 2022, the total number of hooks was approximately 11.8 M.

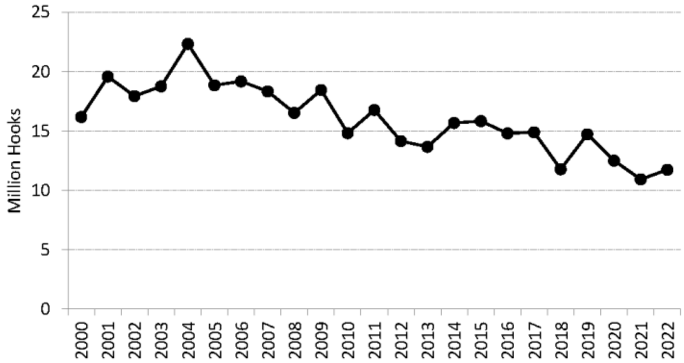

Figure 13 - Time-series of the total annual effort estimated for the CECAF 34.1.2 area (million hooks) for the *Aphanopus* spp. fishery, between 2000 and 2022.

The unstandardized CPUE had an overall decline along the analysed period (Figure 14). The variation observed in the years 2000-2006 was about -45% in CPUE, corresponding to an increase of 16% in the fishing effort. From 2006 to 2008 there was a slight recovery of the landings and of the unstandardized CPUE. The decreasing trend of landings restarted in 2008, but all indicators analysed reached a certain level of stability between 2010 and 2016, and even a recovery was observed since 2020, with an increase of 21 kg/1000 hooks from 2021 to 2022.

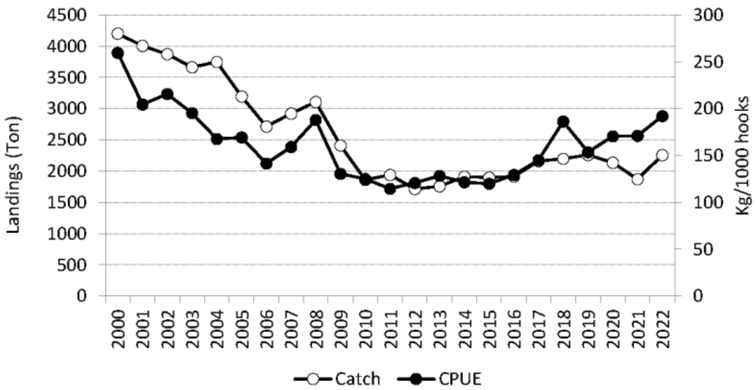

Figure 14 - Time-series of Landings per unit effort, CPUE unstandardized (kg / thousand hooks) of *Aphanopus* spp. in CECAF 34.1.2 area, between 2000 and 2022.

A standardized CPUE model based on daily landings of commercial drifting longline fishery in CECAF 34.1.2 area is being developed for the period of 2008-2022. An exploratory data analysis showed a high correlation between the number of hooks and the number of hauls (Figure 15), but no other variable showed highly correlation with the number hooks per haul.

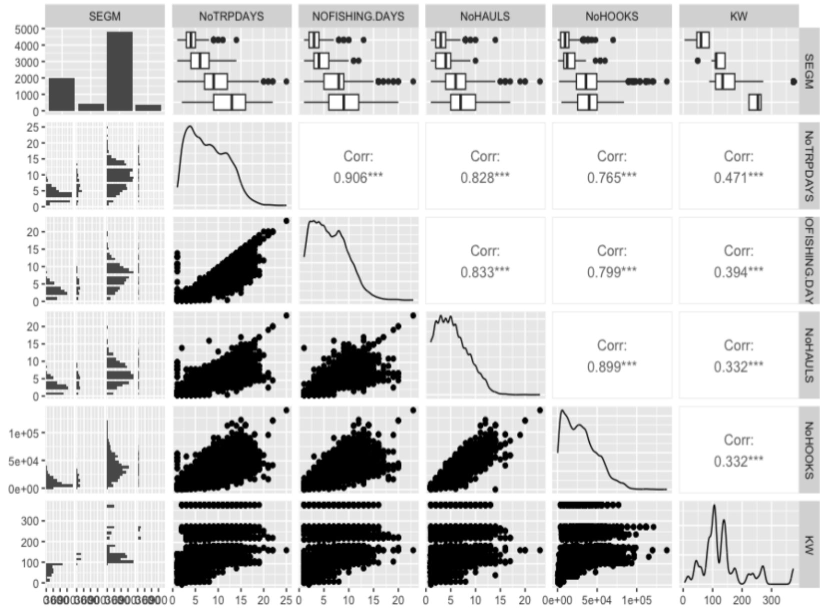

Figure 15 - Exploratory data analysis showing the correlation between the potential variables for the CPUE standardised model of *Aphanopus* spp.

For the period from 2008 to 2022, a standardised CPUE was obtained by adjusting a GLM model based on daily landings of commercial mid-water horizontal drifting longline fishery in CECAF 34.1.2 (Figure 16). The response variable (CPUE) was black and intermediate scabbard fish catches in weight per hook.

The exploratory standardised CPUE data analysis per year and by vessel segment (Figure 16B) showed a recovery in the last five years, especially in the vessel segments smaller than 18 meters, which represents 95% of the Madeira mid-water drifting longline fleet. However, these are just preliminary results and further analysis will be performed.

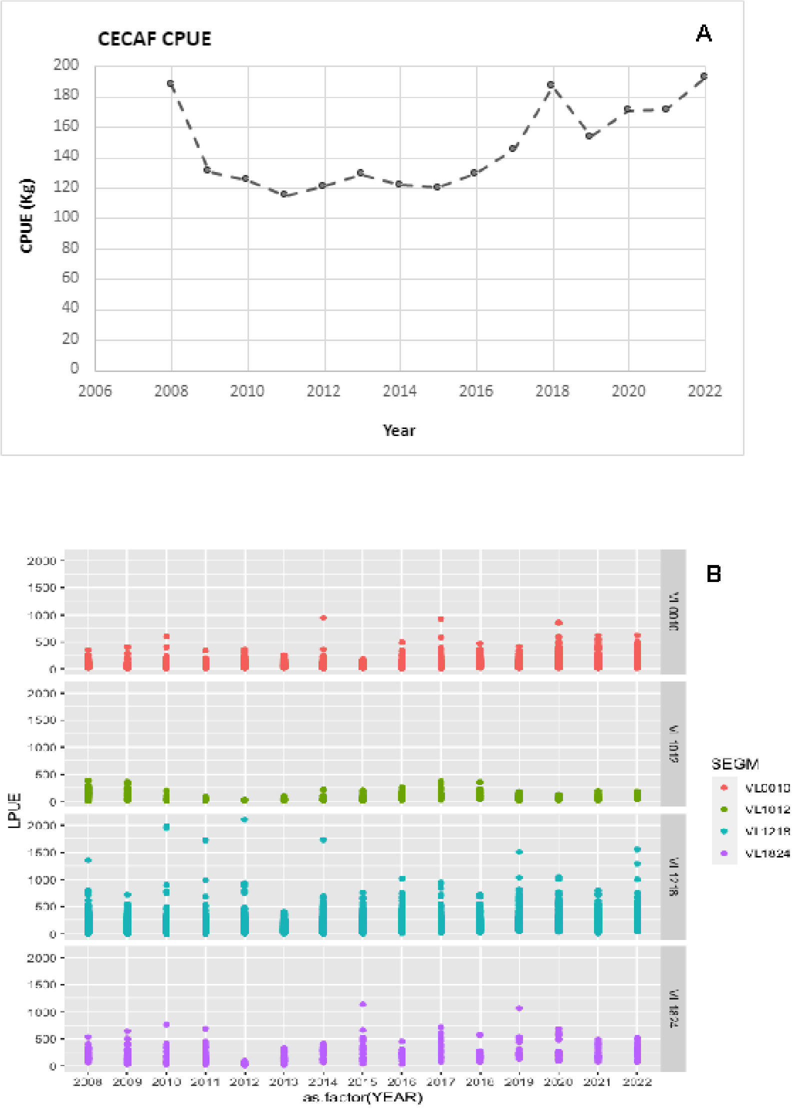

Figure 16 - Time-series of the CPUE (kg/hooks) of *Aphanopus* spp. for all segments combined (A), and standardised CPUE per vessel segment (B).

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Exploratory surplus production models assessment of *Pagellus bogaraveo* **in Subarea 10 (Azores grounds)**

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1. Introduction

Blackspot seabream *Pagellus bograveo* is a sparid fish distributed in the Northeast Atlantic, from south of Norway to Cape Blanc in Mauritania, including Azores, Madeira, and Canary Archipelagos, and the Mediterranean Sea (Froese & Pauly, 2019). This species presents complex life-history and biological dynamics in the face of slow growth, sequential hermaphrodism, and discontinuous essential habitat including coastal areas of the islands and seamounts (Krug, 1990; ICES, 2012). It is considered a deep-water species and, since the stock structure is unknown, three management units have been adopted for assessment purposes in the Northeast Atlantic: (a) Subareas 27.6, 27.7, and 27.8; (b) Subarea 27.9; and (c) Subarea 27.10 (Azores) (ICES, 2007).

The availability and market demand for blackspot seabream to drive the dynamics of the multi-specific demersal, mixed hook, and line fishery in the Azores. Blackspot seabream is the main target species owing to its high selling price (Pinho, 2003; Santos et al., 2019), and ranks first in terms of total landed value in the region (Santos et al., 2020). The status of the stock is uncertain, although recent studies using length-based data-limited assessment suggest being exploited at or above the Maximum Sustainable Yield (MSY) levels (Medeiros-Leal et al., 2023). Consequently, of this historical exploitation, several management measures to limit catch, fishing effort and minimum landing size have implemented along the years (ICES, 2022).

Blackspot seabream stocks can easily be overexploited, as shown by the Bay of Biscay stock collapse in the 1980s (Lorance, 2011). This case was a wake-up call for scientists and fisheries managers to the vulnerability of the species related with the life history traits (protandrous hermaphroditism and late maturity). Surplus production models (SPM) are the only data-limited method that allows for a full assessment of fish stocks. These models provide exploitation and stock status assessment based on MSY reference points and catch forecasts based on alternative scenarios. For this study, were employed two SPMs to assess the stock of blackspot seabream in Azorean waters (ICES 27.10.a.2): 1) Just Another Bayesian Biomass Assessment (JABBA); 2) Stochastic Surplus Production Model (SPiCT).

2. Methodology

2.1. Fishery dependent data

2.1.1. Landings and abundance indeces in Azorean waters.

The data used in this study came from the database of the Department of Oceanography and Fisheries, University of the Azores (DOP/UAz) and were obtained from the Azores Auction Services and collected through fishing inquiries under the DCF. Official landings were recorded from 1985 to 2017 for each fishing trip (n = 3,679,979) and included vessel size, *métier* (*i.e.*, a group of fishing operations targeting a specific assemblage of species, using a specific gear, during a precise period of the year and/or within the specific area; EC, 2008) and catch in kg by species. Between 1990 and 2017, 31,616 fishing inquiries were conducted to harbor-present vessel captains at the moment of landing. These inquiries were undertaken to complete the information for fishing effort and covered all fleet segments, with a focus on those that are not obliged to maintain a logbook (*i.e.*, vessels <10 m in length). Each inquiry included the size of the vessel, the number of days it spent at sea and information about the fishing operation, such as the type of gear used, the average depth at which fishing took place and the catch in kg by species.

LPUE (Kg per landings^{-1} vessel^{-1}) and CPUE (Kg days at sea^{-1} vessel^{-1}) were estimated for blackspot seabream. To reduce the influence of potential drivers (*e.g.*, targeted species, vessel size, fishing gear) on these catch rates, generalized linear models (GLMs) were utilized to calculate standardized abundance indices (Santos et al., 2022; Santos et al., 2023). Details on the procedure for selecting the interactions and explanatory factors that explained most of the variability in the data, model validation and catch standardization can be found in Santos et al. (2022).

2.2. Fishery independent data

2.2.1. Survey derived abundance index.

Survey-derived abundance indices (RPN; individuals per 1000 hooks) were calculated for the period 1996-2019 and came from the Azorean spring bottom longline survey (Pinho et al., 2020). Surveys followed a stratified random design and covered the main islands and major seamounts. To estimate de annual index used in further analysis, were only considered the exploited biomass (LT > 33cm).

2.3. Population parameters

Surplus production models, such as JABBA and SPiCT, are age and size aggregated models that approximate changes in biomass as a function of the biomass of the preceding year, the surplus production biomass, and the removal by the fishery in the form of catch. Somatic growth, reproduction, natural mortality and associated density-dependent process are inseparably captured in the estimated surplus production function that is governed by three parameters: 1) the intrinsic rate of population increase (r); 2) the shape parameter and 3) the unfished equilibrium biomass. However, there is a direct link between age-structured stock parameters and the expected surplus production function, so that stock parameters describing, length-at-age, weight-at-age, maturity-at-age, and selectivity-at-age, natural mortality, and the steepness parameter of the assumed Beverton and Hold SSR can be used to approximate the surplus production (Winker et al., 2020). To estimate the three parameters used as priors in surplus production models were used the R package SPMprior available on github.com/henning-winker/SPMpriors. The life-history parameters used to estimate the priors are presented at Table 1.

Table 1. Input constant parameters used in the age-structured model for blackspot seabream *Pagellus bogaraveo* of the Azores (ICES area 10).

PARAMETERS	VALUE	DEFINITION	OBS.
L_{oo} (cm)	55.12	Asymptotic average maximum length	Medeiros-Leal et al. (2023)
K (year-1)	0.12	Growth coefficient of the von Bertalanffy growth model	Medeiros-Leal et al. (2023)
T_0 (year-1)	-1.46	Hypothetical age at which the species has zero length	ICES, 2012
a=	0.0172	Condition factor parameter of length-weight relationship	Rosa et al. (2006)
b=	3.0273	Slope parameter of length–weight relationship	Rosa et al. (2006)
L_{max} (L_F, cm)	55	Maximum length usually observed on the population (not the max ever observed)	Pinho et al. (2012)
L_{mat} (L_F, cm)	29	Length at size first maturity	Santos et al. (2020)
M	0.3	Natural mortality	Silva et al. (2021)
M/k	1.67	Ratio natural mortality over growth coefficient	Medeiros-Leal et al. (2023)

2.4. Surplus production models

2.4.1. Just Another Bayesian Biomass Assessment (JABBA)

JABBA is a Bayesian state-space surplus production model with a Bayesian framework that reduces uncertainty in the model with reasonable prior information and state-space modelling that estimates both process and observation errors (REF). To reduce the uncertainty of the reference points estimates, sensitivity analysis was performed using priors derived from different steepness (h=0.5 and h=0.6), for five scenarios. Detailed information about each specific scenarios are presented at Table 2.

2.4.2. Stochastic Surplus Production model in Continuous Time (SPiCT)

SPiCT, a stochastic surplus production model in continuous time, incorporates dynamics in both biomass and fisheries, and observation error of both catches and biomass indices (REF). To reduce the uncertainty of the reference points estimates, sensitivity analysis was performed using priors derived from different steepness (h=0.5 and h=0.6), for five scenarios. Detailed information about each specific scenarios are presented at Table 2.

Table 2. Definition of each five scenarios used for the sensitivity analysis (ICES area 10).

Scenario	Definition
1	r + Bmsy/K + All time series
2	r + Bmsy/K + Edit Survey
3	r + Bmsy/K + Edit Survey/CPUE/LPUE
4	r + Bmsy/K + All time series + Uncertainty Catches
5	r + Bmsy/K + Edit Survey/CPUE/LPUE + Uncertainty Catches

3. Results and discussion

3.1.1. Landings and abundance indices (fishery dependent and independent)

Official landings are reported by Azores since 1985. The discard rates are considered negligible because was estimated at 6%, and with a high survivorship that corresponding mortality is likely smaller than 5%. The Azorean landings were TAC constrained from 2013 to 2022 and a decrease of the landings were registered since them (Figure 1).

Pronounced differences in the LPUE after 2000s could indicate that the stock has declined or that productivity of the stocks changed (Figure 1). However, these statements could not be fully accepted, because the LPUE trends indicate a fast and high decline of the productivity after 2000s, meanwhile the CPUE and Survey indices did not follow the same pattern (Figure 1). The most plausible justification for these differences between the three abundance indices is related with changes in the data collection program sample design. Since 2000s the data collection program became the responsibility of the EU Data Collection Framework (DCF), before holding by the Department of Oceanography and Fisheries of University of the Azores. For this reason, was decided to work in further stock assessment analysis with two time-blocs for LPUE indices, the first between 1985-2006 and the second 2007-2017.

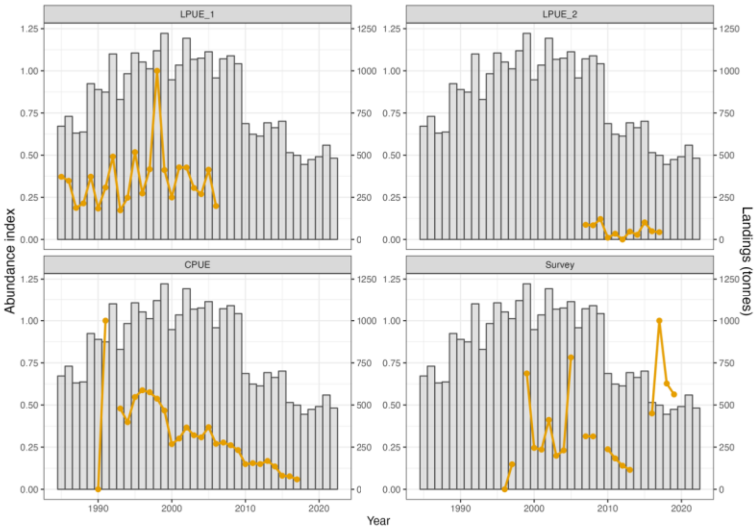

Figure 1. Standardized and scaled to mean LPUE (Kg landings^{-1} vessel^{-1}), CPUE (Kg days at sea^{-1} vessel^{-1}) from the Azorean bottom longline fishery (1985-2017), and exploited biomass (>33 cm) of Annual abundance in number (Relative Population Number) from the bottom longline survey (1996-2019) for blackspot seabream *Pagellus bogaraveo* from the Azorean bottom longline fishery.

3.2. Population parameters

We applied the age-structured stock parameters approach to transform a total of 8 parameters, describing the age-structured and demographics of blackspot seabream, into the surplus production function parameters r and m, which we approximated as function of either exploited biomass (EB_{MSY}) or spawning biomass (SB_{MSY}) (Figure 2). Our results confirmed that the functional of the parameter age-structured yield curve can be closely approximated by the derived parametrization equivalent surplus production curves (Figure 2). The effect of h on r can be inferred from the notable change in central r values for three alternative steepness assumptions (Figure 2).

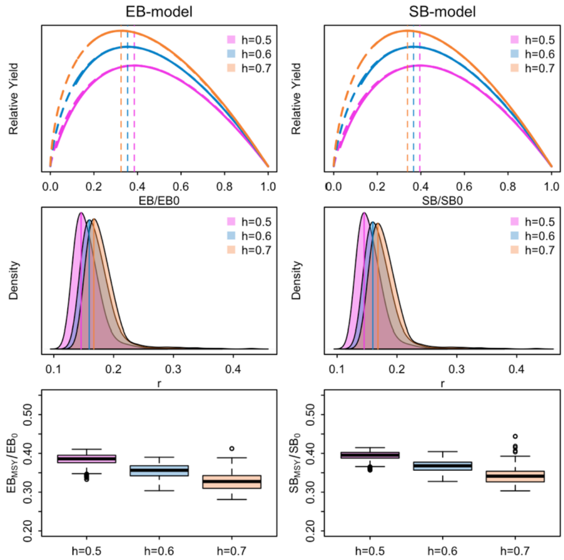

Figure 2. (Top Panel) Showing the functional from of the yield curves produced from the Age-Structured Equilibrium Model (ASME; solid line) and the formulation of the Surplus Production function (solid) as a function of EB/EB0 and SB/SB0 for a range of fixed steepness values of the spawning recruitment relationship(h = 0.5, h = 0.6, h = 0.7) (top panel); (Middle Panel) density distributions of simulated r values from Monte-Carlo simulations based on the EB-model and SB-model; and (Lower Panel) boxplot generated inflection points of EB_{MSY}/EB_0 and SB_{MSY}/SB_0 for each of the fixed steepness h input values.

3.3.3. Surplus production models

3.3.3.1. Just Another Bayesian Biomass Assessment (JABBA)

The sensitivity analysis showed that the reference points results F/F_{MSY}, B/B_{MSY} and MSY were more reliable when the h=0.5 steepness was used. The steepness h= 0.5 also provide an improvement of the residual's diagnostics and retrospectivity analysis (Table 3). Besides that, the scenario 3 model using the h=0.5 presented the best fit of the 10 scenarios and was defined as the base case model, and the next results for the stock assessment purposes are based on this model (Table 3). Results of JABBA model suggests a carrying capacity (K) of 14853 t, a B_{MSY} of 5644 t, F_{MSY} = 0.14 year^{-1} and MSY=811 t for blackspot seabream in Azores. The stock biomass at the end of 2019 was 20% of the B_{MSY} and the fishing mortality was 29% of the F_{MSY}. Biomass presented a continuous decreased period from 1995 to 2010, with a stable period between 2011 to 2015, and a very slight increase since thereafter (Figure 3), while the fishing mortality was above F_{MSY} between 1998 to 2015. The relative biomass (B_{2019}/B_{MSY}) and exploitation level (F_{2019}/F_{MSY}) in 2019 were 0.81 and 0.72 respectively, indicating that the blackspot seabream fishery in the Azores was in a recovering status. The default JABBA plots are shown in Figures

12.4.10. JABBA model presented a good fit of the residual's diagnostics and retrospectivity analysis, and the convergence was achieved (Figure 4).

Table 3. Results of the steepness sensitivity analysis using JABBA model for blackspot seabream *Pagellus bogaraveo* of the Azores (ICES area 10).

		Reference points				Residuals Diagnostics				Retrospective analysis	
Scenarios	Stepness	B/BMSY	F/FMSY	FMSY	MSY	Posteriores	Process dev	Residuals	Runs test	Retro	Hindcast
1	h=0.6	0.88	0.62	0.17	861	Yes	Yes	55.20%	No	Yes	2.47
2	h=0.6	0.87	0.62	0.17	870	Yes	Yes	48.60%	No	Yes	1.88
3	h=0.6	0.80	0.70	0.17	839	Yes	Yes	45.80%	No	Yes	3.88
4	h=0.6	0.92	0.58	0.17	963	Yes	Yes	48.80%	No	Yes	2.48
5	h=0.6	0.76	0.73	0.17	930	Yes	Yes	45.80%	No	Yes	3.85
1	h=0.5	1.14	0.49	0.15	848	Yes	Yes	45.80%	No	Yes	2.5
2	h=0.5	0.84	0.7	0.14	811	Yes	Yes	36.80%	No	Yes	5.06
3	h=0.5	0.84	0.7	0.16	778	Yes	Yes	34.80%	Yes	Yes	5.72
4	h=0.5	0.89	0.65	0.14	814	Yes	Yes	38.60%	No	Yes	2.53
5	h=0.5	0.83	0.7	0.14	890	Yes	Yes	36.90%	Yes	Yes	5.67

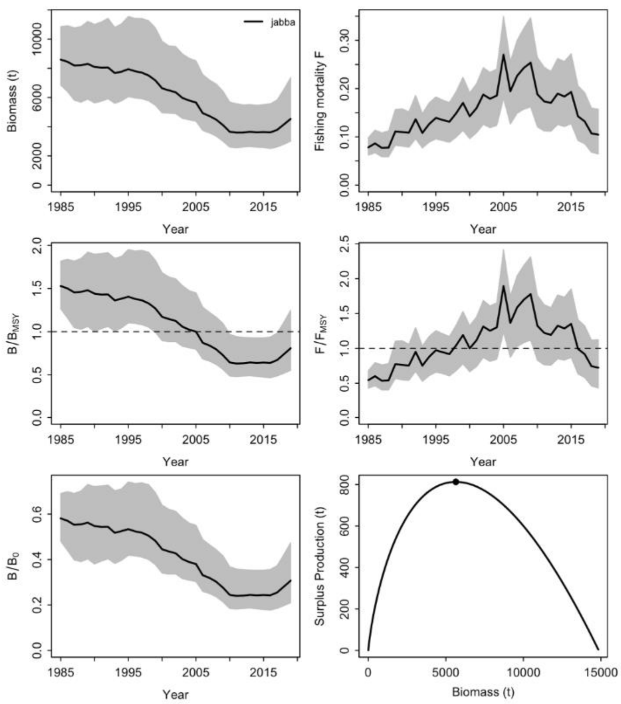

Figure 3. Basic results of JABBA model for the blackspot seabream *Pagellus bogaraveo* from the Azores using standardized CPUE, LPUE and Survey data (ICES, 10.a.2).

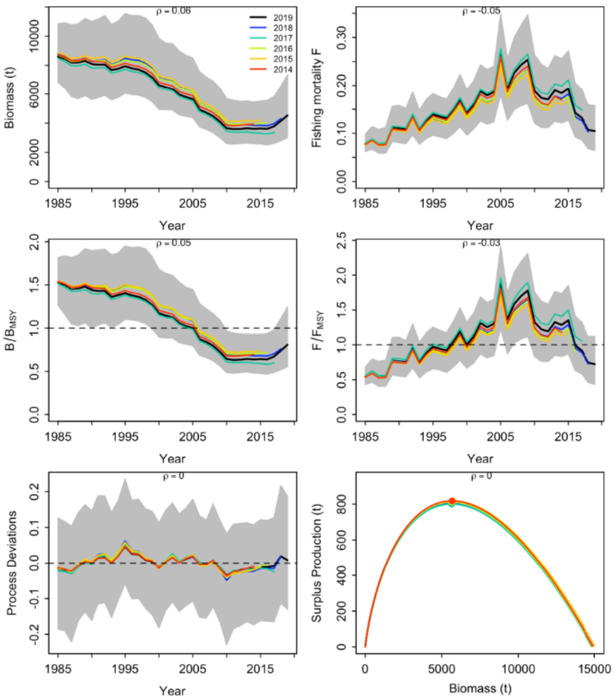

Figure 4. Retrospectivity analysis from JABBA model applied to the blackspot seabream *Pagellus bogaraveo* from the Azores using CPUE, LPUE and Survey data (ICES, 10.a.2).

3.3.3.2. Stochastic Surplus Production model in Continuous Time (SPiCT)

The sensitivity analysis showed that the reference points results F/F_{MSY}, B/B_{MSY} and MSY were more reliable when the h=0.5 steepness was used. The steepness h= 0.5 also provide an improvement of the residual's diagnostics and retrospectivity analysis (Table 4). Besides that, the scenario 3 model using the h=0.5 presented the best fit of the 10 scenarios and was defined as the base case model, and the next results for the stock assessment purposes are based on this model (Table 4). Results of SPiCT model suggests a carrying capacity (K) of 13061 t, a B_{MSY} of 4378 t, F_{MSY} = 0.17 year^{-1} and MSY=753 t for blackspot seabream in Azores. The stock biomass at the end of 2019 was 22 % of the B_{MSY} and the fishing mortality was 12% of the F_{MSY}. Biomass presented a continuous decreased period from 1999 to 2010, with a stable period between 2011 to 2015, and a very slight increase since thereafter (Figure 5), while the fishing mortality was above F_{MSY} until 2015. The relative biomass (B_{2019}/B_{MSY}) and exploitation level (F_{2019}/F_{MSY}) in 2019 were 0.78 and 0.85 respectively, indicating that the blackspot seabream fishery in the Azores was in a recovering status. The default SPiCT plots are shown in Figures 12.4.12. SPiCT model presented a good fit of the residual's diagnostics and retrospectivity analysis, and the convergence was achieved (Figures 6 and 7).

Table 3. Results of the steepness sensitivity analysis using JABBA model for blackspot seabream *Pagellus bogaraveo* of the Azores (ICES area 10).

		Reference points				Residuals Diagnostics				Retrospective analysis	
Scenarios	Stepness	B/BMSY	F/FMSY	FMSY	MSY	Posteriores	Process dev	Residuals	Runs test	Retro	Hindcast
1	h=0.6	1.5	0.07	0.22	1033	Yes			No	No	2.5
2	h=0.6	1.41	0.35	0.23	992	Yes			No	No	5.06
3	h=0.6	0.88	0.73	0.21	783	Yes			Yes	Yes	5.72
4	h=0.6	1.4	0.33	0.23	1136	Yes			No	No	2.53
5	h=0.6	0.88	0.73	0.21	861	Yes			Yes	Yes	5.67
1	h=0.5	1.14	0.49	0.15	848	Yes			No	Yes	2.5
2	h=0.5	1.07	0.52	0.15	849	Yes			No	Yes	5.06
3	h=0.5	0.72	0.91	0.16	752	Yes			Yes	Yes	5.72
4	h=0.5	1.03	0.55	0.15	923	Yes			No	Yes	2.53
5	h=0.5	0.83	0.7	0.14	890	Yes			Yes	Yes	5.67

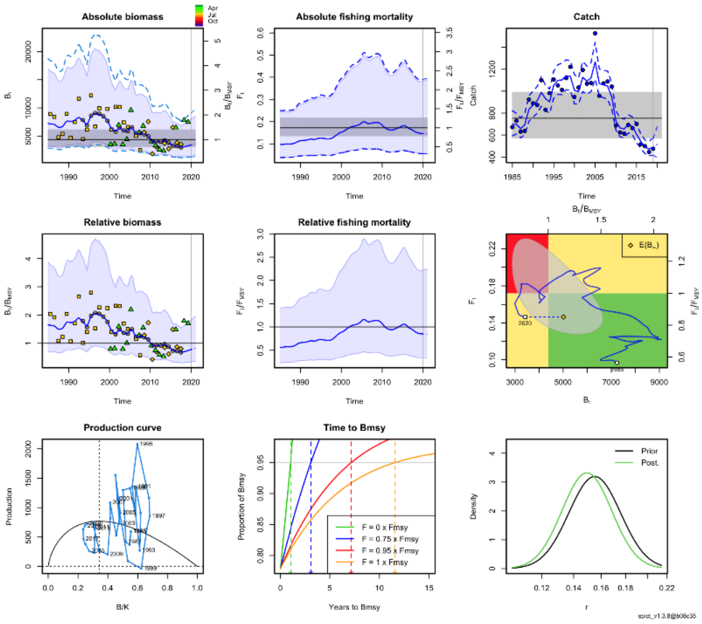

Figure 5. Basic results of SPICT model for the blackspot seabream *Pagellus bogaraveo* from the Azores using CPUE, LPUE and Survey data (ICES, 10.a.2).

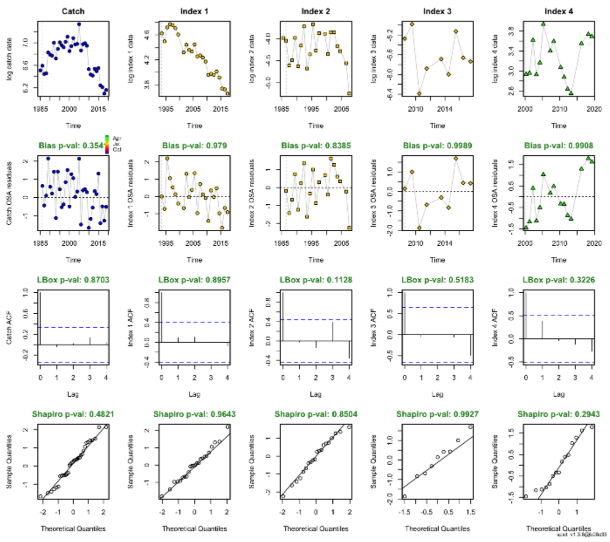

Figure 6. Residual results from SPICT model applied to the blackspot seabream *Pagellus bogaraveo* from the Azores using CPUE, LPUE and Survey data (ICES, 10.a.2).

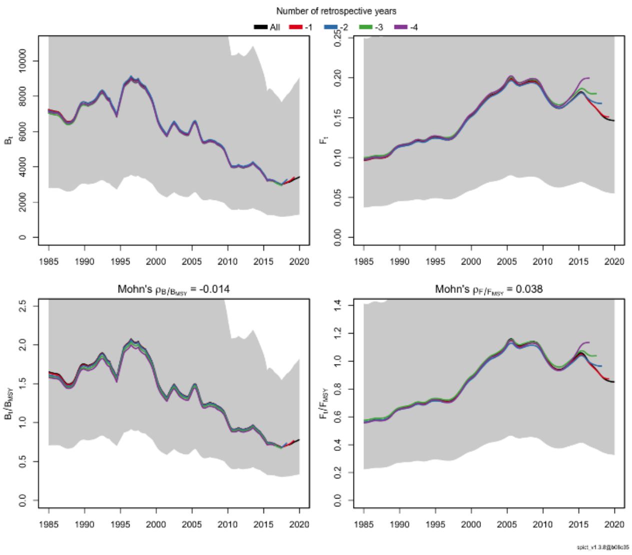

Figure 7. Retrospectivity analysis results from SPICT model applied to the blackspot seabream *Pagellus bogaraveo* from the Azores using CPUE, LPUE and Survey data (ICES, 10.a.2).

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The development of the Norwegian longline fleet's fishery for ling, tusk and blue ling during the period 2000-2022

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Introduction

Ling, tusk and blue ling were fished by Norway for centuries, and the amount landed has been recorded since 1896 (Figure 1). The major catches of these species are taken by longliners, and the catches are to a large degree bycatches. The fishery for these species is influenced by the size of various quotas for other species, especially the quota for Arcto Norwegian cod. Therefore, total catch may not be a good indicator of the condition of these stocks (Figure 2).

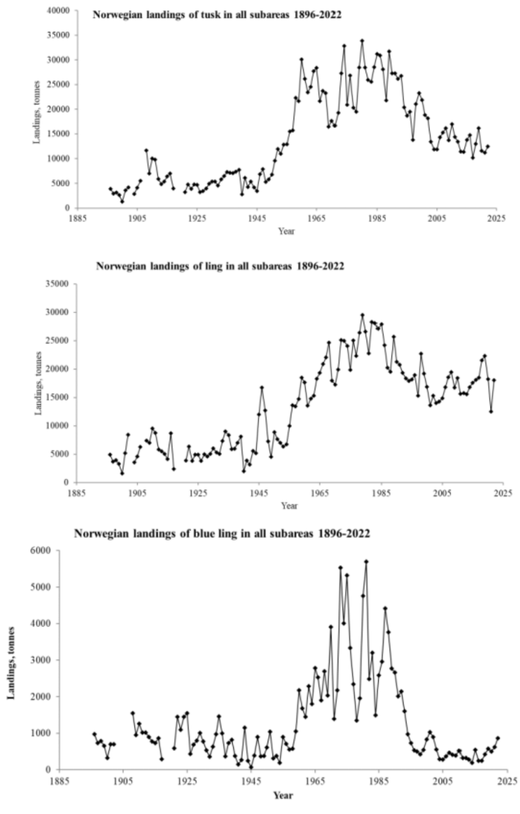


Figure 1. Reported Norwegian landings of tusk, ling and blue ling for the period 1896 -2022.

Scientific surveys do not cover the main habitats of ling, blue ling and tusk. Therefore, these stocks need to be monitored based on commercial data. One possible way to track their abundance, based only on commercial data, would be to develop a catch per unit of effort series for the fishery. But again, the major challenge for any cpue series: It is easy to generate a cpue series, and it is difficult to determine if the series track abundance.

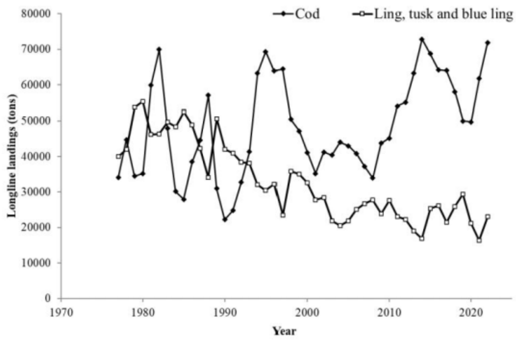


Figure 2. Total landings by longliners of cod (diamonds) and the combined total landings of ling, tusk and blue ling (open squares) for the period 1977- 2022.

Development of the Norwegian fleet of longliners, 1977- 2022

In addition to data on total landings*, the Norwegian Directorate of Fisheries (NDF) provides data on number of fishing vessels participated in the fishery, the gear employed, areas fished and changes in vessel ownership. In Table 1 are the number of long liners during the period 1977 to 2022, the total landed catch by the fleet, and the average annual catch per vessel. The number of vessels increased from 36 in 1977 to a peak of 72 in 2000, and after that the number decreased to 25 in 2014-2017, the last few years the number of vessels has stabilized at 26 vessels fishing more than 8 tons ling, tusk and blue ling.

The number of vessels declined mainly because of changes in the law concerning the quotas for cod. The decrease in the number of vessels was accompanied by a decrease in total catches until 2004; afterwards, the landings have been varying but stable (Figure 3a). The catch-per-vessel was stable from 1980 until 2003. In the period 2003- 2019 there was a steady increase in catch-per-vessel with a sharp decrease in 2021 followed by an increase in 2022 (Figure 3b).

* The data provided by the NDF are; the total landed catch, the logbook data, and the catch along with its location.

In 2012 new regulations were initiated and the number of cod quotas for each vessel increased from 3 to 5. This caused a further reduction in the number of long liners; from 36 in 2012, to 25 in 2015 to 2018. In 2022 there were 26 vessels.

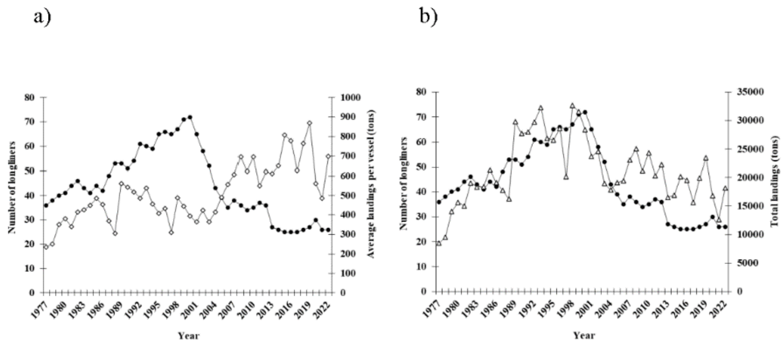


Figure 3. a) The number of long liners (filled circles) and the average landings per vessel of ling and tusk (open diamonds) in the period 1977-2022 and, b) the number of longliners and the total landings of ling and tusk (open triangles).

Logbooks

All available logbooks for the years 2000-2022 are now in the database, and the data have undergone extensive quality control procedures. The data for 2010 is incomplete because of problems getting some of the logbook data, both for the paper logbooks and for the electronic logbooks. In 2010, electronic logbooks were implemented for the longline fleet. The Norwegian Directorate of Fisheries has received the data, but because of lack of quality control, the 2010 data will not be released. Some fishers did not send paper logbooks because they had delivered the data electronically. Because of this, logbooks from only 11 of 35 vessels are available for 2010. The quality of the logbooks varies considerably, and a serious problem is that some lack information on the number of hooks used per day. The data from 2011 are almost complete with data from 35 of 37 vessels. In 2012 to 2022 all logbooks are available, though some days have been deleted due to punching errors.

Days in the fishery

The Norwegian longline logbooks provide information on the geographical distribution of the fleet. In Table 2 are the average number of days a vessel spent fishing for tusk, ling and blue ling, jointly or separately, for all ICES Subareas and Divisions. After 2000, when new quota regulations for cod were introduced, the number of days each vessel fished for three-deep-water species increased, and by 2005 the number of days in the fishery was twice that was in 2000. The data for 2006 show that the number of days in the fishery has decreased by more than 20 percent compared with 2005 and 2007. The data was checked for errors, but none were discovered. The number of fishing days has trended downward since 2007, most likely because of the record large stock of Arcto Norwegian cod. This trend changed dramatically in 2019 when the number of fishing days per vessel increased from 134 days in 2018 to 192 days in the tusk fishery and in the ling fishery it changed from 94 in 2018 to 125 in 2019. However, in 2020 the total number of fishing days had declined to 147.

Division 2a has been the main fishing grounds since 2000, followed by 4a and 5b (Table 2).

Average number of hooks per day

Table 3 are estimates of the average number of hooks used per day in each ICES area and in the total fishery for the 2000-2022. For all areas combined, there was a steady increase in the number of hooks used from 2000 through 2009. This is also the general trend for subareas (Figure 4). The combined time series for 1972-1994 (Bergstad and Hareide, 1996) and the series based on data from 2000-2012 show that the average number of hooks has increased from 10 000 hooks per day in 1972 to around 39 000 in 2022 (Figure 6).

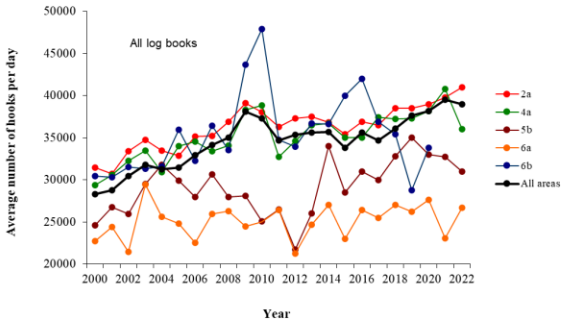


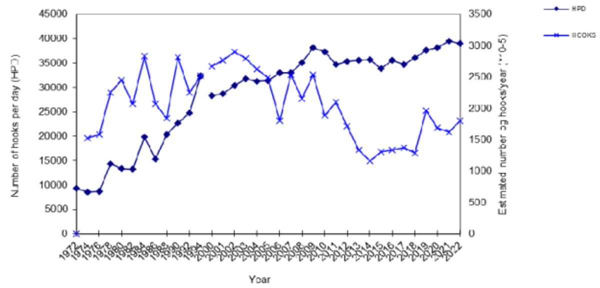
Figure 4. Average number of hooks the Norwegian longliner fleet used per day in each of the ICES subareas and in the total fishery for the years 2000-2022 for the fishery for tusk, ling and blue ling.

Total number of hooks per year

Based on the number of vessels, the number of hooks per day, and the number of days each vessel participated in the fishery, estimates of the total number of hooks used per year were generated (Tables 1, 2 and 3). Table 4 and Figure 5 show the estimated number of hooks (in thousands) set in each of the ICES subareas and in the total for all areas for the years 2000-2022 During the period 1974 to 2013 the total number of hooks per year has varied considerably, after this the number of hooks per year have been stable but with an increase from 2019 and 2021 (Figure 6).

The total number of hooks per year considers; the number of vessels, the number of hooks per day, and the number of days each vessel participated in the fishery, may be a suitable measure of tracked applied effort. Based on this measure of effort, it appears that the average effort for the years 2011-2021 is 40% less than the average effort during the years 2000-2003.

a.



b.

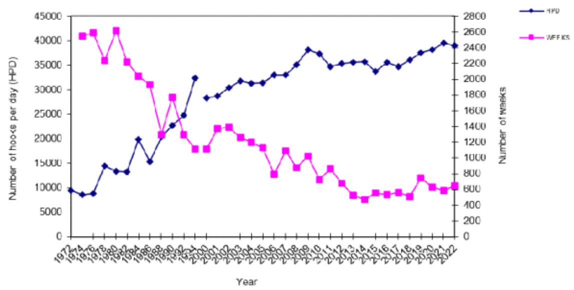


Figure 5. The combined time series for 1972-1994 (Bergstad and Hareide, 1996) and the series based on data from 2000-2022: a) The numbers of hooks used per day, and the total number of hooks used per year; b) The numbers of hooks used per day, and the total number of weeks the long liners participated in the fishery for ling and tusk.

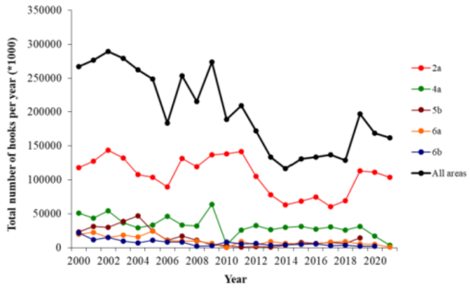


Figure 6. Estimated total number of hooks (in thousands) the Norwegian longliner fleet used in the ICES subareas with highest catches and in the total fishery for the years 2000-2022 for the fishery for tusk, ling and blue ling.

The size of the vessels

There was a steady increase in the average size of the vessels from 34 m in 1977 to 46.6 m in 2022. Figure 7 show the average size of the vessels and the smallest and the largest vessel in the fleet for the period 1977 to 2022.

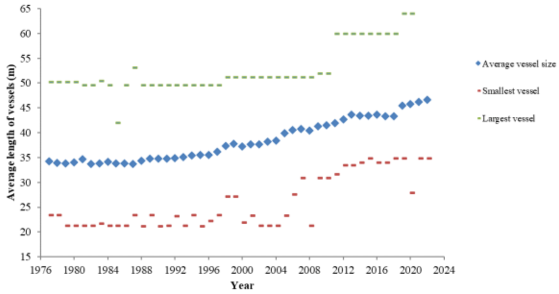


Figure 7. Average size of longliners >21 m for the period 1977-2022.

Fishing area

Approximately 65-70% of the commercial catches of ling are taken by vessels using demersal longlines, either target species or bycatch (Helle and Pennington, 2015), and the remains are taken mainly by gillnets but also some by trawlers. Although the tusk fishery takes place from Rockall to the southern Barents Sea (Helle and Pennington, 2004), between 70 to 80 percent of the catches by Norwegian vessels are from the Norwegian Economic Zone.

Figure 8 shows all the catches of ling registered in the electronic logbooks by longliners in 2013-2020 in areas 1 and 2.

Tusk are mainly caught by longliners (approximately 90 percent of the total catch). Figure 9 shows all catches of tusk registered in the electronic logbooks by longliners in Areas 1 and 2 during the period 2013 to 2022.

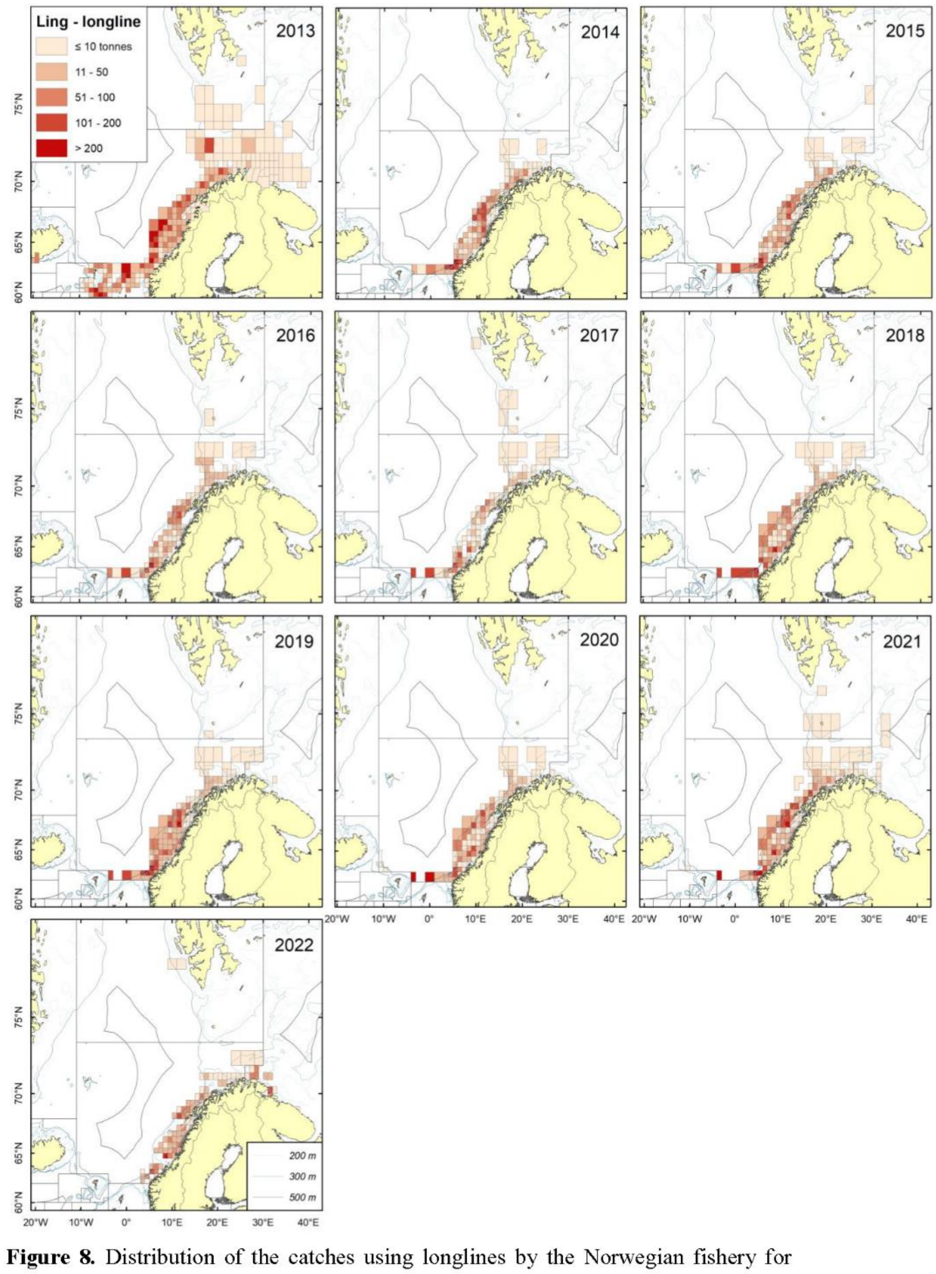


Figure 8. Distribution of the catches using longlines by the Norwegian fishery for ling in 2013 to 2022 in areas 1 and 2.

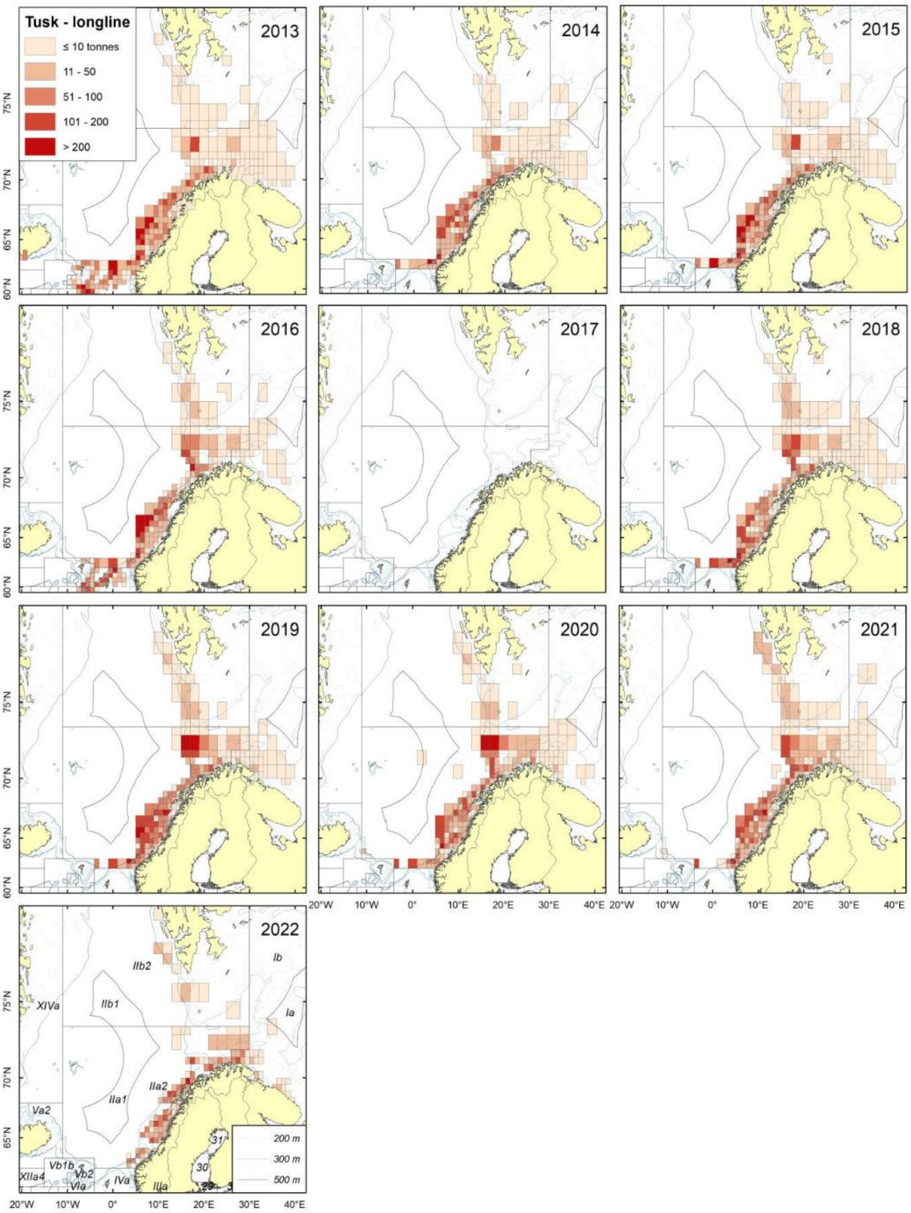


Figure 9. Distribution of the catches using longlines by the Norwegian fishery for tusk in 2013 to 2022 in areas 1 and 2.

CPUE

Based on methods described in Helle *et al*., 2015 to derive a cpue series were for ling and tusk calculated two ways; using all data available and catches for which ling and tusk were targeted (>30 percent of the daily total catch).

In Figures 11 and 13 are plots of the estimated cpue series for the most important ICES subareas for ling and tusk: based on all the available data, and a cpue series based on only those catches that ling or tusk appear to be targeted; included plots of estimated 95% confidence intervals.

Ling:

Both cpue series for ling in 2a have been relatively stable since 2011, but with a declining trend the last four years for the targeted fishery.

In Areas 4a there was a steady increase in cpue from 2002 until 2016 and were down in 2017 and 2018 but with a slight increase in 2019 and 2020. In 2021 there were little or no fishing in the traditional areas due to no agreement about the TAC in the area. The estimate is therefore based on very limited data and does not present a correct picture of the stock situation. In 2022 the index was at the same level as in 2020.

In 6a and 6b there was also a positive trend from 2002 to 2016 with a varying but stable index. The Norwegian fleet had limited access to the areas in 2021 and there was very little fishery in 2022. There was no fishing in area 6b the two last years.

When all ling data for Areas 3.a, 4, 6, are combined for a cpue series, and ling was targeted a cpue series, both indicate a steady increase since 2003 to 2017 and then a decline in 2018. In 2020 there were an increase. The estimates for 2021 do not represent the normal fishery in the areas and should not be considered valid. In 2022 the index was at the same level as in 2020.

Tusk:

Both cpue series in Area 2a have been relatively stable since 2011.

The series in Area 4a based on all the catches indicates at first a stable series and then a slightly decreasing trend for the last six years, while the series based on the targeted fishery shows a clear and positive upward trend from 2002 until 2013, after this there was a declining trend, and this trend is especially clear for the targeted fishery.

The series in Area 5b shows a stable trend from 2000 to 2008, afterwards it increased until 2012, then decreased until 2017 and a relatively large increase in 2018 and a decreasing trend after 2018.

In area 6a a cpue series based on the Norwegian longline data shows an increase in cpue from 2004 to 2008, afterwards it has remained at a high and slightly increasing level when all data are used, and a sharp increase from 2018 to 2019 for the targeted fishery followed by a decrease in 2020 (Figure 13). In 2022 the index was at the same level as during the period 2011-2016.

The combined cpue series for areas 4a, 5b and 6a. shows an increasing trend from 2000 to 2010, after 2010 cpue was at a high and stable level, declined in 2017.. After 2017 the index has been varying but in 2022 the index was at the same level as during the period 2011-2016.

The cpue series for Area 6b when all data were used, a catch from longliners show a decrease from 2000 to 2006. After 2006, the cpue was low but at a stable level. There was no direct fishery for tusk in the last years.

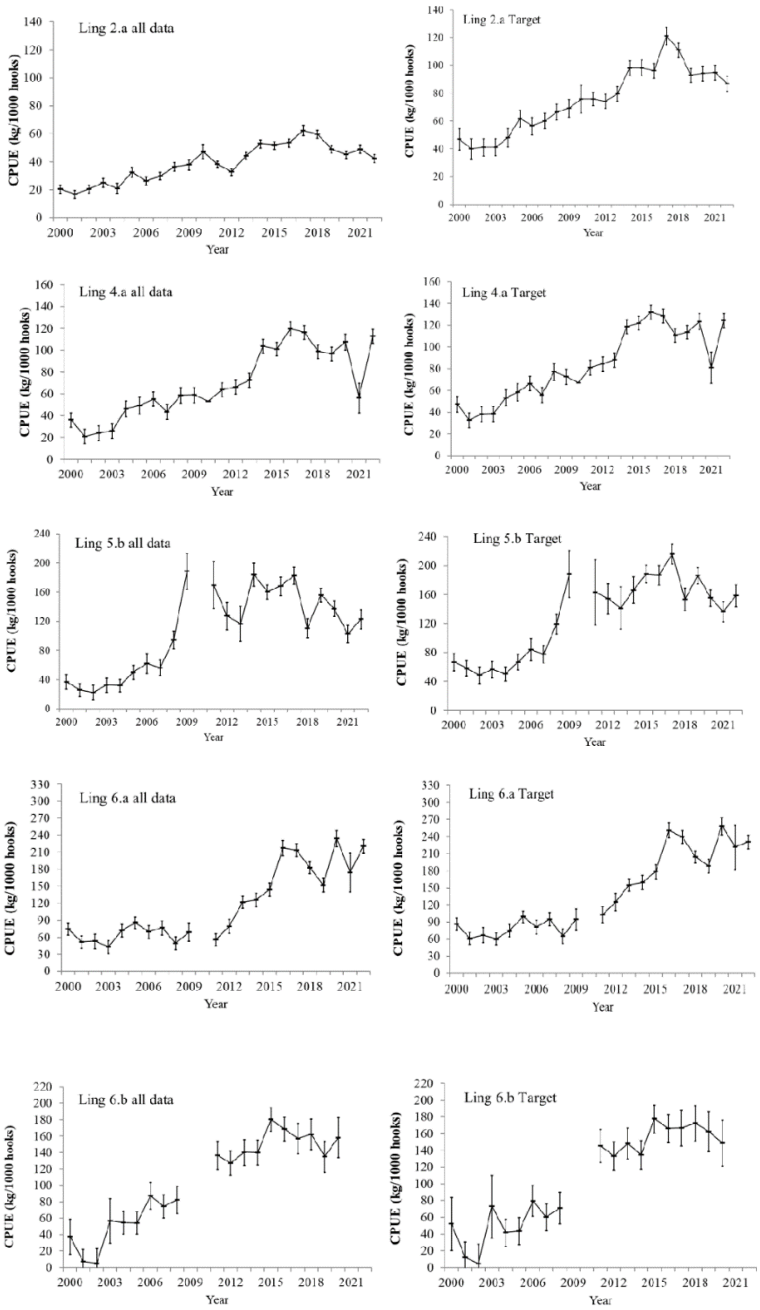

Ling 2.a all data
Ling 2.a Target
Ling 4.a all data
Ling 4.a Target
Ling 5.b all data
Ling 5.b Target
Ling 6.a all data
Ling 6.a Target
Ling 6.b all data
Ling 6.b Target
CPUE (kg/1000 hooks)
Year

Figure 11. Estimated cpue (kg/1000 hooks) of ling in Subareas 2a, 4a, 5b, 6a and 6b based on skipper's logbooks during the period 2000-2022. The bars denote the 95% confidence intervals.

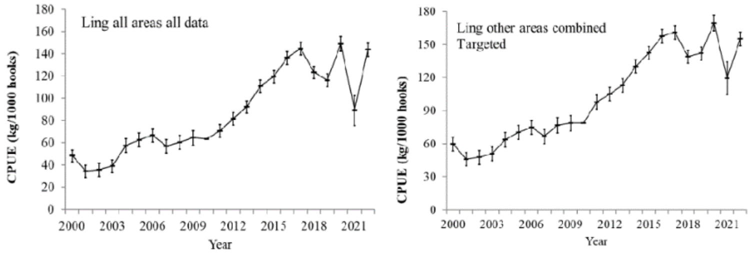


Figure 12. Ling areas combined (3, 4, 6) based on skipper's logbooks during the period 2000-2022. The bars denote the 95% confidence intervals.

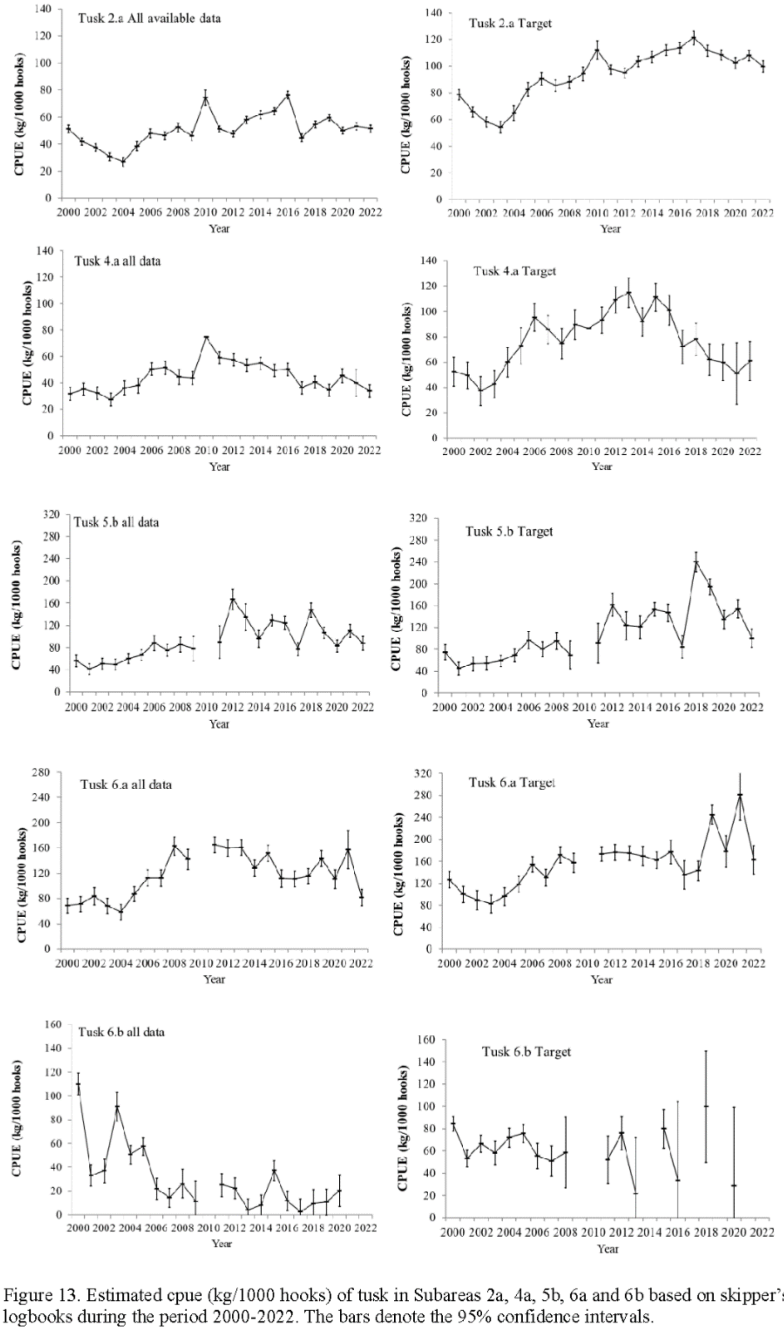


Figure 13. Estimated cpue (kg/1000 hooks) of tusk in Subareas 2a, 4a, 5b, 6a and 6b based on skipper's logbooks during the period 2000-2022. The bars denote the 95% confidence intervals.

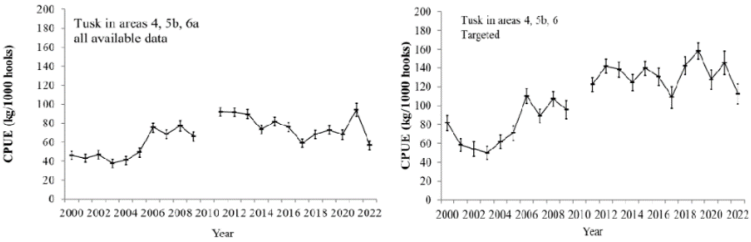


Figure 14. Tusk in other areas combined (4, 5b, 6a) based on skipper's logbooks during the period 2000-2021. The bars denote the 95% confidence intervals.

Blue ling

The cpue series for blue ling based on longline data shows a low and stable level for the Areas 1, 2, 3a and 4. Although there was no direct fishery in these areas, the stock doesn't seem to show any recovery.

A low and steady population for blue ling were in subareas 5a and 14 and in Areas 5b, 6 and 7. When only data from 6a, there was a positive trend from 2004 to 2015, after this the trend has been at a lower level.

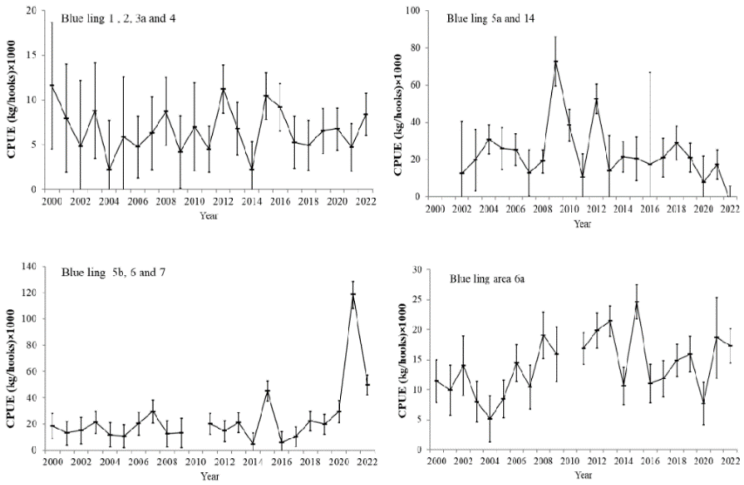


Figure 15. Estimated cpue (kg/1000 hooks) of blue ling in Subareas: 1, 2, 3.a; 4, 5.a; 14, 5.b, 6; 7; and in Subarea 6.a. All data from skipper's logbooks during the period 2000-2022. The bars denote the 95% confidence intervals.

Conclusions and discussion.

Legislation enacted since 2000 for regulating the cod fishery caused a continuous reduction in the number of longliners in the fishery for tusk, ling and blue ling, and by 2009, there were only 34 vessels above 21m in the fishery. Due to recent regulations, the number of vessels was 26 in 2021. Because of this decrease the number of vessels were 58 % fewer since 2000, the total number of hooks employed reduced, the total number of weeks fished, and until 2021, there were a significant reduction in effort. Compared with 2000, a decrease in total effort has occurred even though there was an increase in the number of hooks set per vessel/day until 2021. The large increase in effort in 2019 is probably due to a reduction in cod quotas. This fishery should be monitored and reported to prevent overfishing (Figures 5 and 6).

During the period 1998 through 2003, the total landings declined from 32 675 to 19 000 tons, while the catch-per-vessel remained relatively constant. The total catches were stable during the years 2004 through 2006, but after that, there was a sharp increase in 2007 and 2008. The average catch-per-vessel increased considerably during 2003- 2008, afterwards the catch has been relatively stable.

It should be noted that using the total landings as a measure of stock development can be very misleading. For example, there is a negative correlation between the landings of cod and the total landings of ling, blue ling and tusk (Figure 2), which is due to cod being the most valued species. Therefore, the decrease in total landings does not indicate a reduced stock size, but only an increase in cod quotas.

If a stock is not covered by a scientific survey, then a commercial cpue index is often used to track temporal trends in abundance. It is widely recognised that caution must be used when interpreting a cpue series based on commercial catch data. But by considering: the application and distribution of fishing effort; species specific knowledge, such as when a species is targeted or if it is a preferred species; patterns in the total catch by fleet and by vessel; etc., then based on all these factors, a reliable assessment of a stock's condition.

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Table 1. Summary statistics for the Norwegian longliner fleet during the period 1995-2022 (vessels exceeding 21m).

Year	Number of longliners	Total landed catch by fleet	Catch per vessel (Tons)
1977	36	8471	235
1978	38	9563	252
1979	40	14038	351
1980	41	15651	382
1981	44	15002	341
1982	46	19079	415
1983	43	18338	426
1984	41	18398	449
1985	44	21364	486
1986	42	19080	454
1987	48	17788	371
1988	53	16253	307
1989	53	29816	563
1990	51	27726	544
1991	54	27979	518
1992	61	29718	487
1993	60	32290	538
1994	59	26908	456
1995	65	26571	409
1996	66	28645	434
1997	65	20173	310
1998	67	32675	488
1999	71	31528	444
2000	72	28391	394
2001	65	23681	364
2002	58	24619	424
2003	52	18969	365
2004	43	17815	414
2005	39	19106	490
2006	35	19475	556
2007	38	23060	607
2008	36	25069	696
2009	34	21158	622
2010	35	24360	696
2011	37	20344	550
2012	36	22302	620
2013	27	16522	612
2014	26	16907	650
2015	25	20189	808
2016	25	19478	779
2017	25	15663	627
2018	26	19895	765
2019	27	23498	870
2020	30	16827	561
2021	26	12621	485
2022	26	18134	698

Table 2. Average number of days that each Norwegian longliner operated in an ICES subarea/division.

All species	1	2a	2b	3a	4a	4b	5a	5b	6a	6b	7c	12	14b	All areas
2000	9	54	2	+	24	2		13	12	10	2	+	6	131
2001	5	64	9		22		1	18	14	6	1	5	3	148
2002	10	74	2		29			20	12	8		1	8	164
2003	12	73	3	1	21	1	3	25	12	6		3	9	169
2004	20	75	11		22		2	34	14	5	1	1	9	195
2005	23	81	14		25		2	21	25	8	0,4		5	203
2006	11	73	3		38		3	11	13	7				159
2007	15	101	21		27	3	2	15	10	6	1			201
2008	7	90	18	1	26		4	11	10	2			2	171
2009	19	103	20	1	49	1	2	4	7	2			3	211
2010	8	104	13		3		1	3		5			5	145
2011	12	103	4		21	3	2	1	9	4				159
2012	9	78	4		26	1	2	2	5	5	1		2	135
2013	6	63	2		22	2	2	1	11	4			1	114
2014	5	66	2		31	1	2	4	9	4			2	126
2015	8	77	4		36	1	2	11	9	5			2	155
2016	4	81	7		31	1	2	8	8	5			3	150
2017	12	66	15		33		2	10	13	3			4	158
2018	4	69	6		27	1	2	7	13	4			4	137
2019	5	109	14		31	1	2	15	8	3			6	194
2020	6	95	7		15		2	11	6	2			3	147
2021	16	100	20		3		2	10	1	0			6	158
2022	9	95	18		34		2	8	7				5	178

Tusk	1	2a	2b	4a	4b	5a	5b	6a	6b	7c	12	14b	All areas
2000	3	34	1	18	1		11	12	4	2	1	2	88
2001	1	57		22		1	18	14	6	1	3	1	124
2002	5	66	2	28			20	12	8			2	141
2003	5	58		19	2	3	25	12	5			1	130
2004	6	60	1	21		2	34	14	5	1		3	148
2005	5	69	2	25		2	21	23	8	0		3	158
2006	1	67	1	37		3	11	13	7				140
2007	5	89	3	26		2	15	10	6	0			157
2008	4	92	4	30		4	14	15	5				169
2009	6	87	2	56	2	2	4	7	2			1	159
2010	4	93	2	2		3			4			2	112
2011	12	103	4	21		2	1	9	4				155
2012	9	78	4	25		2	2	5	4	1		2	132
2013	6	63	2	22		2	1	11	3			1	111
2014	5	66	2	31		2	4	9	3			2	125
2015	8	77	4	36	1	2	11	9	5			2	154
2016	4	81	7	30		2	8	8	5			3	148
2017	12	66	15	31		2	10	13	2			3	154
2018	4	69	6	26		2	7	13	3			4	134
2019	5	109	14	30	1	2	15	8	2			6	192
2020	6	95	7	15		2	11	6	2			3	146
2021	16	99	20	3		2	10	1				6	157
2022	9	91	18	34		2	8	7				5	174

Ling	2a	3a	4a	4b	5a	5b	6a	6b	7c	14b	All areas
2000	23	+	19	1		12	13	4	3		76
2001	40		22	+	1	17	13	5	1		100
2002	50		29			18	11	7			114
2003	40	1	20	1	3	24	12	4			104
2004	37		22		2	34	14	5	1		115
2005	51		25		2	21	23	8	+		126
2006	54		38		3	11	13	7			126
2007	65		27	3	2	15	10	6	1		128
2008	52	1	25		4	11	9	2			104
2009	65	1	49		2	4	7	2			130
2010	70		3		3			7			83
2011	73		21	3	4	2	8	4			113
2012	59		26	1	2	2	5	5	1		98
2013	44		22	1	2	1	11	4			85
2014	53		31	1	2	4	9	4		1	106
2015	54		37	1	2	11	9	5		1	122
2016	55		31	1	2	7	8	5		1	111
2017	27		33		2	10	13	3			88
2018	41		27	1	2	6	13	4			94
2019	66		31	1	2	14	8	3			125
2020	47		15		2	10	6	2			83
2021	53		3		1	9	1				67
2022	53		34		1	7	7				102

Blue ling	2a	4a	5a	5b	6a	6b	12	14b	All areas
2000	1	1		4	9	1	2	+	18
2001	1	+	1	3	6	1	5		15
2002	1	1		4	4	2		+	11
2003	1		1	5	8	2	2	+	14
2004	+	1	2	5	6	+		+	14
2005	+	1	1	1	10			+	14
2006	1	2	2	4	8	+			18
2007	1	2	1	5	6	1			16
2008	2	4	3	4	10			1	25
2009	1	4	2	3	6			1	17
2010	2	1	2					2	7
2011	2	2		1	7				12
2012	1	2		2	5			1	12
2013	1	2		1	8				13
2014	1	3	1	2	5	1		1	12
2015	3	4	1	5	7				20
2016	1	4		3	6				15
2017	1	3		5	7			1	17
2018	1	3		4	8			1	17
2019	4	3		6	6			2	21
2020	6	4		3	4				17
2021	6		1	4	1			1	13
2022	5	9	1	4	6			1	26

Table 3. Average number of hooks that the Norwegian longliner fleet used per day in each of the ICES subareas/divisions and in the total fishery for the years 2000-2022 in the fishery for tusk, ling and blue ling. n is the total number of days with hook information contained in the logbooks.

All		1	2a	2b	3a	4a	4b	5a	5b	6a	6b	7c	12	14b	All areas
2000	**Average**	31688	31439	35409	30250	29378	30263		24594	22763	30471	29600	18136	2815	28325
	n	353	1916	71	4	685	38		411	435	227	80	22	191	4429
2001	**Average**	33325	30703	34638		30553	33500		26760	24419	30340	33108	17548	2465	28743
	n	163	2196	315		727	10		613	447	140	37	175	135	4958
2002	**Average**	35432	33431	34756		32291	33867		25939	21484	31557			9458	30432
	n	263	2031	45		667	15		475	186	149			251	4083
2003	**Average**	35045	34766	34776	33037	33484	32559	22605	29513	29421	31325		13063	11515	31794
	n	376	1839	67	27	510	34	38	515	302	97		48	228	4081
2004	**Average**	32431	33475	31859		30934		25815	31804	25636	31559	25250		12474	31285
	n	433	1389	217		439		54	693	308	111	28		105	3777
2005	**Average**	32671	32861	35082		34039		23100	29885	24807	35949	33429		18960	31438
	n	316	1248	207		331		30	374	369	137	7		91	3110
2006	**Average**	33182	35140	39298		34561		21526	27943	22504	32273				32959
	n	187	1252	57		673		57	159	248	139				2711
2007	**Average**	34380	35207	37881	35000	33414	38086	25414	30681	25958	36400	31071			34110
	n	318	2103	328	8	587	58	58	355	249	145	14			4223
2008	**Average**	36833	36890	39650	36467	34056	31500	32704	27968	26319	33514			9464	35042
	n	96	1500	297	15	395	10	71	188	138	35			45	2790
2009	**Average**	39184	39142	43744	34636	38299	30167	26106	28123	24455	43645			7034	38127
	n	267	1419	281	11	680	6	33	57	99	31			38	2922
2010	**Average**	40519	38057	41607		38838		20182	25067		47904			7672	37296
	n	19	1089	135		37		11	30		52			58	1491
2011	**Average**	37205	36260	35280	35275	32737	37343	28062	26492	26424	34727			25750	34668
	n	411	3622	126	8	740	104	63	24	310	137			4	5549
2012	**Average**	36434	37298	38357		34639		33647	21702	21249	33934	39064		9091	35381
	n	307	2817	157		933		68	63	196	176	22		59	4765
2013	**Average**	39500	37500	42000		36500	43000	30900	26000	24700	36700	31000		27500	35600
	n	211	2073	81		710	34	69	34	351	132	10		36	3678
2014	**Average**	37699	36782	39660		36715	44614	35015	34000	26979	36551			22374	35676
	n	112	1501	44		707	22	46	101	214	97			65	2909
2015	**Average**	36100	35400	43500		35000	40800	31600	32400	30700	29000			29800	33800
	n	209	1902	91		908	33	54	276	222	130			53	3878

20

2016	**Average**	40000	36900	42000		35000	35000	37000	31000	26400	42000			31400	35600
	n	100	2025	175		775	25	50	200	200	125			75	3750
2017	**Average**	41700	36500	43000		37400	40300	33700	30000	25500	36900			25400	34700
	n	302	1660	374		815	11	54	260	320	78			89	3963
2018	**Average**	42800	38500	42000		37200	44500	42600	32800	27000	35400			35400	36100
	n	99	1776	142		692	34	51	148	295	96			105	3738
2019	**Average**	43000	38500	44300		37300	43800	38400	35000	26200	28800			26800	37600
	n	123	2956	381		842	31	63	393	218	79			172	5258
2020	**Average**	44600	39000	45900		38200		41400	33000	27600	33800			23300	38200
	n	168	2853	221		464		59	315	181	56			88	4405
2021	**Average**	43700	39800	46400		40800	47800	30000	32700	23100				34300	39500
	n	408	2600	524		80	6	42	250	17				150	4077
2022	Average	46900	41000	48600		36000		35000	31000	26700				31100	39000
	n	233	2353	459		900		45	200	191				120	4500

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Table 4. Estimated total number of hooks (in thousands) that the Norwegian longliner fishery for tusk, ling and blue ling used in each of the ICES subareas/divisions and in the total area for the years 2000-2022.

All	1	2a	2b	3a	4a	4b	5a	5b	6a	6b	7c	12	14b	All areas
2000	20534	117708	5099	218	50765	4358		23020	19667	21939	4262	1306	1216	267161
2001	10831	127724	20263		43691			31309	22221	11833	2152	5703	481	276508
2002	20551	143486	4032		54313			30089	14953	14642			4389	289469
2003	21868	131972	5425	1718	36565	1693	3526	38367	18359	9773		2038	5389	279406
2004	27891	107957	15069		29264		2220	46497	15433	6785	1086		4827	262325
2005	29306	103808	19155		33188		1802	24476	24187	11216	521		3697	248895
2006	12775	89783	4126		45966		2260	10758	10239	7907				183567
2007	19081	131569	29434		33381	4228	1881	17028	9604	8081	1150			253676
2008	9282	119524	25693	1313	31876		4709	11075	9475	2413			681	215719
2009	25313	137075	29746	1178	63806	1026	1775	3825	5820	2968			717	273523
2010	11345	138527	18931		4078		706	2632		8383			1343	189277
2011	16965	141922	5363		26124	4257	2133	1007	9037	5279				209464
2012	11805	104733	5523		32422	1230	2423	1566	3825	6108			655	171952
2013	7821	77963	2772		26500	1419	2039	858	8966	3633			1815	133752
2014	4901	63118	2062		29592	1160	1821	3536	6313	3801			1163	116875
2015	7220	68145	4350	0	31500	1020	1580	8910	6907,5	3625	0	0	1490	130975
2016	4000	74722	7350	0	27125	875	1850	6200	5280	5250	0	0	2355	133500
2017	12510	60225	16125	0	30855		1685	7500	8288	2768	0	0	2540	137065
2018	4451	69069	6552	0	26114	1157	2215	5970	9126	3682	0	0	3682	128588
2019	5805	113306	16745	0	31220	1183	2074	14175	5659	2333	0	0	4342	196949
2020	8028	111150	9639	0	17190	0	2484	10890	4968	2028	0	0	2097	168462
2021	18179	103480	24128	0	3182		1560	8502	601	0	0	0	5351	162266
2022	10975	101270	22745	0	31824		1820	6448	4859	0	0	0	4043	180492

Annex 4: Audit reports

Review of ICES Scientific Report, Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP) 2022, 3rd - 09th May 2023

Reviewers: Ricardo Sousa

Expert group Chair: Elvar Hallfredsson (NOR) & Juan Gil Herrera (ES)

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
Assessment was performed according to the stock annex.

For single-stock summary sheet advice

Stock Tusk (*Brosme brosme*) in Subarea 14 and Division 5.a (East Greenland and Iceland grounds) - **usk.27.5a14**

Short description of the assessment as follows:

1) **Assessment type:** Analytical age-based assessment (SAM model).
2) **Assessment:** Update.
3) **Forecast:** Presented.
4) **Assessment model:** Precautionary approach and conforms to ICES MSY framework.
5) **Consistency:** Advice is consistent with reported data.
6) **Stock status:** Fishing pressure on the stock is below FMSY, and spawning-stock size is above MSY Btrigger, Bpa, and Blim.
7) **Management plan:** Yes. Management plan for the stock component in Division 5.a. (Icelandic tusk), which has been evaluated by ICES.

General comments

The advice sheet was easy to follow and interpret.

Data have been updated with available information.

Last benchmarked in 2022.

Technical comments
No additional comments.

Conclusions

The assessment has been performed correctly.

Review of ICES Scientific Report. Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 2023, 3 - 9 May

Reviewers: Bruno Almón

Expert group Chair: Elvar Hallfredsson and Juan Gil

Secretariat representative: David Miller

General

Assessment was made according to the benchmark conclusions and updated with the new information.

For single-stock summary sheet advice

Stock

Atlantic wolffish (*Anarhichas lupus*) in Division 5.a (Iceland grounds)

Short description of the assessment as follows (examples in grey text):

1) Assessment type: Update
2) Assessment: Analytical age-based assessment
3) Forecast: accepted
4) Assessment model: SAM model
5) Consistency: The Icelandic Ministry of Industries and Innovation's fisheries management plan for Icelandic Atlantic wolffish has been evaluated by ICES in 2022. It was considered to be precautionary and conforms to ICES MSY approach, and a SAM model was agreed upon for use in the assessment
6) Stock status: SSB has been rather stable over the time period, while fishing mortality has gradually decreased, and recruitment has slightly decreased after 2001 but remained stable.
7) Management plan: Icelandic management plan, benchmarked in 2022 (ICES, 2022a).

General comments
In the evaluation of the management plan, the basis for the assessment was revised and the adopted harvest control rule (HCR) was considered in accordance with the precautionary approach and consistent with the ICES MSY framework.

Technical comments
The catch scenario is provided for the fishery year from 1 September 2022 to 31 August 2023.

Conclusions
The assessment has been performed correctly.

Format for audits (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, WGDEEP, 2023, 3. - 9. May

Reviewer: **Lise Helen Ofstad**

Expert group Chairs: **Elvar Hallfredsson and Juan Gil Herrera**

Secretariat representative: **David Miller**

General
Assessment was made according to the rbf rule.

Stock **Ling 27.1-2**,

1) Assessment type: "update"
2) Assessment: accepted
3) Forecast: not presented
4) Assessment model: rbf rule instead of 3/2 rule. Standardized CPUE index from Norwegian longline target fishery (where ling >30% of catch), data since 2000. LBI, data since 2001.
5) Consistency: the rbf rule was applied for the first time this year
6) Stock status: The estimated biomass index has decreased by 9% (A/B=0.91). The abundance index has decreased in resent years, but is well above the mean value. The exploitation status from LBI has been below the $F_{MSY\ proxy}$ for the whole period (data since 2000). The fishing pressure proxy relative to MSY proxy was 0.95.
7) Management plan: None

General comments
The rbf rule, from the ICES framework for category 3 stocks, was used for the first time this year. The assessment appears to have been carried out according to the agreed use of the rbf rule. The report and stock annex will be fully updated with information about the rbf rule and the numbers used in it.

This stock has never been benchmarked. It seems that there exist enough data to do an exploratory age-based assessment on this stock. There have been routinely collected lengths, weights and ages from the landings (since 2002), and the cpue from the reference fleet could be used as tuning series (data since 2000).

Technical comments
None

Conclusions
The assessment has been completed correctly

Format for audits (to be drawn up by expert groups and not review groups)

Audit of Ling in Division 5.a (Iceland grounds) (WGDEEP 2023)

Reviewers: Erik Berg

Expert group Chair: Elvar Hallfredsson

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
Lin.27.5a assessment and draft advice have been approved by the Working Group (WGDEEP).

For single-stock summary sheet advice

Stock: Ling (*Molva molva*) in Division 5.a (Iceland grounds); lin.27.5a

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: not presented in the report. Some results presented in the advice sheet.
4) Assessment model: SAM
5) Consistency: Seems to overestimate stock in assessment year
6) Stock status: B > B_{lim}, B_{pa}, $B_{trigger}$; F_{lim} < F = F_{pa}; R uncertain, seems to be lower than in the period 2000-2010.
7) Management plan: agreed in 2022: The plan is evaluated and considered to be precautionary and conforms to ICES MSY approach.

General comments
This was a well-documented and ordered section. It was easy to follow and interpret. The stock was benchmarked in 2022 and a new model is used (now SAM, earlier Gadget). The stock annex is not updated since 2017 and it's therefore not possible to audit the assessment according to the stock annex.

The forecast (short time prediction) should be included in the report. It's impossible to audit the forecast without knowing model used in forecast in addition to the numbers going in and the numbers coming out of the forecast.

Technical comments
No technical comments.

Conclusions
The assessment has "probably" been performed correctly and gives a valid basis for advice. Stock annex should be updated.

Review of **Ling 27.5b**, WGDEEP 2023, 03 th May to 09th May

Reviewers: **Wendell Medeiros-Leal**

Expert group Chair: **Elvar Hallfredsson and Juan Gil Herrera**

Secretariat representative: **David Miller**

Stock: Ling (*Molva Molva*) in Division 5.b

Short description of the assessment as follows:

1) **Assessment type:** Category 1. Benchmarked in 2021
2) **Assessment:** Accepted
3) **Forecast**: Accepted
4) **Assessment model:** Age-based analytical assessment (SAM) that uses catches in the model and in the forecast. Tunning series; Faroese spring and summer groundfish surveys.
5) **Consistency:** The assessment of ling in division 5.b was upgraded from category 3 to category 1 in 2021. A revision of the stock size and SSB trend showed large decrease in recruitment in recent years.
6) **Stock status**: F_{pa} and F_{lim} < Fishing mortality > $F_{MSY;}$ SBB > MSY $B_{trigger}$ and between B_{pa} and $Bl_{im;}$ R and SSB have decreasing in the last 5 years; F shows an increasing trend in recent years.
7) **Management plan:** Adjust effort corresponding to catch advice was adopted in 2020 and applied in 2021. For 2022 ICES is not aware of any agreed precautionary management plan for ling in this area.

General comments

The text it is according to the standards sentences and tables for the advice sheets. Stock development over time, quality and basis of the assessment, reference points and history of the catch and landings are well described. The advice was updated in the stock annex.

Technical comments

The stock annex was fully updated. A description of the fishery dependent and independent data, the traits of life-history, biology of ling in division 5.b, and detailed information about the age-based analytical assessment (SAM) are provided. Minor comments suggested in the report section.

Conclusions

The assessment has been performed correctly and according to the stock annex.

<u>Format for audits</u> (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, Working Group on Biology and Assessment of Deep-sea fisheries resources (WGDEEP) , 2023, 2nd-9th May

Reviewers: Inês Farias

Expert group Chair: Elvar Halfredsson, Juan Gil

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)
Since 2015, greater silver smelt is now divided into four management units by ICES areas;

- aru.27.123a4 in ICES areas 1, 2, 3a and 4;
- aru.27.5a14 in ICES areas 5a and 14;
- aru.27.5b6a in ICES areas 5b and 6a;
- aru.27.6b7–1012 in ICES areas 6b, 7-10 and 12.

The targeted fishery is primarily conducted by Norwegian midwater and bottom trawlers in Division 2.a, and the fishery was initiated in the early 1980s.
Additionally, trawl fisheries for other species along the Norwegian Deep in Division 4.a (northern North Sea) result in variable but sometimes significant landed bycatch of greater silver smelt. These landings can also contain, presumably minor, quantities of the lesser silver smelt (*Argentina sphyraena*) which has a more southern and shallower distribution then greater silver smelt. Catches in this area increased substantially after 2012 with peak in 2018. While the years 2019-2021 show a declining trend, the catches from this area has increased again in 2022.

For single-stock summary sheet advice

Stock **aru.27.123a4**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: MSY approach
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: rfb rule applied for a trend-based advice. The relative biomass index from SPiCT was used for the stock development.
5) Consistency: Last assessment was in 2021 (after benchmark in 2020) and was accepted; this year's accepted. Both accepted the 2 over 3 rule.
6) Stock status: Relative biomass is above MSY Btrigger proxy (Itrigger) and the fishing pressure is below FMSY proxy
7) Management plan: ICES is not aware of any agreed precautionary management plan for greater silver smelt in these areas.

General comments

Due to covid19 complications, the 2020 Norwegian slope survey in subareas 1 and 2 did not cover the northernmost survey area (stratum 3). The biomass estimates for this stratum has been minor compared to stratum 1A and 2A (Figure 6.2.11). Thus, the SPiCT analysis was run with summed biomass estimates for stratum 1A and 2A, leaving out stratum 3. The SPiCT analysis for 2022 are run with the acoustic index from the Norwegian slope survey conducted in 2022.

Existing abundance, length and age data series for this stock are rather short compared to potential life span of the species (approx. 30 years). However, if the time-series are maintained they may support more analytical assessment in a near future.

It is foreseeably a labour-intensive task to get the logbooks prior to 2011 digitalized, and a cost-benefit consideration is needed based on further analysis of the electronic logbook data and experience with CPUE series from other areas. It is currently unknown if the CPUE reliably will reflect the dynamics in the population.

Technical comments

The assessment is in accordance to the WKGSS 2020 benchmark workshop and the recommendations from WKLIFE X, regarding applying ICES-rfb rule.

Conclusions

The assessment is in accordance with the WKGSS 2020 benchmark workshop.

The advice is in accordance with the SA.

Review of ICES Scientific Report, Working group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 2023, 3rd – 9th of May.

Reviewers: Magnús Thorlacius

Expert group Chair: Elvar Hallfreðsson and Juan Gil Herrera

Secretariat representative: David Miller

General
The assessment was made according to the benchmark conclusions and updated with the new information.

For single-stock summary sheet advice

Stock
Greater silver smelt (Argentina silus) in Divisions 5.b and 6.a (Faroese grounds)

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: Analytical age-based assessment
3) Forecast: accepted
4) Assessment model: SAM model
5) Consistency: The management plan has been evaluated by ICES in 2021. Despite a discrepancy in calculated catch (InterCatch) and SAM estimates, the model is considered to be precautionary and conforms with ICES MSY approach. The SAM model was agreed upon for use in the assessment.
6) Stock status: The stock SSB is in decline but fishing mortality is below FMSY, recruitment is increasing and an upward retrospective SSB change occurred from 2022 to 2023, limiting the change in advice since last year.
7) Management plan: the current management plan was benchmarked in 2021 (ICES, 2021)

General comments

In the evaluation of the management plan, the basis for the assessment was revised and the adopted harvest control rule (HCR) was considered in accordance with the precautionary approach and consistent with the ICES MSY framework.

Technical comments

Conclusions
The assessment has been performed correctly.

References

ICES. 2021a. Benchmark Workshop of Greater silver smelt (WKGSS; Outputs from 2020 meeting). ICES Scientific Reports, 3:5. 485 pp. https://doi.org/10.17895/ices.pub.5986

Review of ICES Scientific Report. Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 3 - 9 May 2023

Reviewers: Hannipoula Olsen

Expert group Chair: Elvar Hallfredsson and Juan Gil

Secretariat representative: David Miller

General

The assessment for aru27.6b7-1012 is a category 3 assessment giving advice every other year and last assessment was based on the 2 over 3 rule. This year the ICES-rfb rule was implemented for a trend-based advice.

For single-stock summary sheet advice

Stock **ARU.27.6b7-1012**

Short description of the assessment as follows:

1) Assessment type: update
2) Assessment: accepted
3) Forecast: not presented
4) Assessment model: Survey trends-based assessment using the ICES rfb rule for the first time with index from Spanish Porcupine Bank Bottom Trawl survey (SP-PORC [G5768]). VBGF L_∞ used is 48 cm. VBGF k used is 0.225.
5) Consistency: new approach using rfb rule applied to previous 2 over 3 rule
6) Stock status: $B>B_{trigger\ proxy}$ ($L_{trigger}$); $F>F_{msy\ proxy}$; R uncertain
7) Management plan: EU introduced TAC management in 2003. For 2023 and 2024, EU TAC is 7670 t and UK TAC is 454t in subareas 5, 6 and 7 which includes directed and mixed fishery in another stock unit. Bycatch of greater silver smelt may be unavoidable in blue withing fishery.

General comments:

The Stock Annex report is updated and well documented making it easy to interpret. With the new and implemented ICES framework for category 3 stocks – the rfb rule, reference points have been defined allowing for MSY approach to be applied.

Technical comments

Are landings and discard tables in Stock annex needed? These are already listed in report.

Conclusions

Assessment is made correctly, and in accordance to the stock annex; advice is given upon ICES standards.

Review of ICES Scientific Report Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 3 - 9 May 2023

Reviewers: Guzman Diez

Expert group Chair: Elvar Hallfredsson and Juan Gil

Secretariat representative: David Miller

General

Assessment was made according to the stock annex

For single-stock summary sheet advice

Stock **bli.27.5a14**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: ICES cat 3, based on Survey trends-based assessment (ICES, 2022a) with the Icelandic autumn survey (IS-SMH [G4493])
2) Assessment: accepted
3) Forecast: not presented, no forecast for cat 3
4) Assessment model: based on the rfb rule
5) Consistency: the rfb rule was applied in 2022 for the first time
6) Stock status: unknown, recent index values are low. Recruitment in the five last years is is lower than in 2008-2009, and similar to the period 1999-2007. The average of the biomass index (2 over 3 years) shows a decrease.
7) Management plan: no management plan for blue ling in this area.

General comments

Time series for the stock suggest pulses of catches and recruitment. Because of it being formed of several cohorts, the SSB (represented by the survey index of adult fish) displays a smoother time-series. For this stock the productivity aspect would deserve investigations such as exploring the difference between years with high and low catches (may be also impacted by fisheries activity) and recruitment.

Technical comments

It is a roll-over advice so the advice is the same of the previous year.
Auditors in 2022 commented that ~~T~~two survey indices (Spring and Autumn surveys) are presented in the report but only Autumn ~~one~~ is used for the advice. Although this is argued in the stock annex, it would be good to provide the arguments also in the WG report. Has the recommendation from the stock annex to explore the use of the spring survey for young fish been explored?

The stock annex has not been updated with the use of the rfb rule.

Conclusions

Assessment was made according to the stock annex. Report produced according to ICES standards, with useful and good quality figures

<u>Format for audits</u> (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, WGDEEP 2023 3 to 9 May 2023

Reviewers: Ivone Figueiredothe

Expert group Chair: Elvar H. Hallfredsson, UK (elvar.hallfredsson@hi.no) and Juan Gil Herrera, Spain (juan.gil@ieo.csic.es)

Secretariat representative: David Miller (david.miller@ices.dk)

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations

The stock structure of blackspot seabream in ICES area is unknown but for stock assessment and scientific advice on management purposes ICES considers three different components. One of these component is Subarea 10 (Azores region). This component is assessed using a survey trend analysis. (category 3). In recent years and due to several constrains some Azorean surveys were not conducted.

In 2021, the survey did not perform all the planned fishing stations. As a consequence, the annual abundance estimate was restricted to areas I and II.

In WGDEEP 2023, length data from the fishery were only made available at the beginning of the meeting. Despite the delay the group decided to accept the data and the stock was assessed using the rfb ICES advice .

For advice other than single-stock summary fisheries advice

For single-stock summary sheet advice

Stock

Short description of the assessment as follows (examples in grey text):

1) Assessment type: MSY approach (data-limited assessment)
2) Assessment: accepted
3) Forecast:N.A.
4) Assessment model: empirical rfb rul
5) Consistency: last year's assessment adopted the 2 over 3 rule.
6) Stock status: Stock size is above MSY Btrigger proxy (Itrigger), and the fishing pressure is above FMSYproxy
7) Management plan: ICES is not aware of any agreed precautionary management plan for blackspot seabream in this area.

General comments

In 2023 the "rfb" rule was applied to the stock. Due to the interruption of COVID-19 and a strike of the crew members of the research vessel, the annual Azorean spring bottom longline survey was not carried in 2020 and in 2022. As conseuquence, the WGDEEP 2023 decided to present two alternative bases for advice:

> Scenario A: Last year´s ICES fishing opportunity advice Ay. The numerator abundance index A was calculated using 2021. The denominator abundance index B was based on an interpolated value for 2020 and 2018, 2019, 2020 indices were averaged. The r - stock abundance trend correspond to index ratio A/B. The fishing pressure proxy (f) was calculated using the length-composition from the fishery for the period 2019-2022..

/

Scenario B: Average of the catches from latest three years Cy (average 2020-2022). The numerator abundance index A was calculated using 2021. The denominator abundance index B was based on an interpolated value for 2020 and 2018, 2019, 2020 indices were averaged. The r - stock abundance trend correspond to index ratio A/B. The fishing pressure proxy (f) was calculated using the length-composition from the fishery for the period 2019-2022.

For the last five years (2016-2021), survey data show an important increase in the relative abundance index relatively to the previous period.

Technical comments

Conclusions

The increase of abundance observed in the survey in recent years appears i to be consistent through all statistical survey areas. This increase may be a consequence of the restrictive management measures adopted by the Regional Azorean Government.

<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: Adriana Nogueira-Gassent

Expert group Chair: Elvar Hallfredsson and Juan Gil

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

- Lack of scientific information for that stock
- Stock is considered depleted
- No assessment for that stock
- The precautionary approach is applied

For single-stock summary sheet advice

Stock **bli27.nea (ICES 1,2,3a,4 and 12)**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: no assessment
3) Forecast: not presented
4) Assessment model: no model. Advice is based on precautionary approach (stock category 5).
5) Consistency: last assessment in 2019 was catch trends-based assessment, the precautionary approach was also applied and same advice was given (zero catches for the 3 years advice period). Consistent.
6) Stock status: the stock is considered depleted, and no sign of stock rebuilding. No reference points for this stock.
7) Management plan: ICES is not aware of any agreed precautionary management plan for blue ling in these areas

General comments

There are no more directed fisheries for that stock, it is taken only as bycatch in those areas. Since 2010, M.dypteria has been adscribe as M. macrophthalma in Subareas 8 and 9, so landings reported in the advice sheet are not from these Subareas.

Landing have been decreasing from high levels in the 1988-1993 to a 19% of that level. The stock is considered depleted.

The report was well documented. Summary advice sheet was consistent with the report. Some numbers in a table of the report had to be updated to be consistent with the advice summary sheet and it has been done.

Technical comments

None

Conclusions

Advice sheet is consistent with the information provided by the report.

Format for audits

Review of ICES Scientific Report, (*Working Group on the Biology and Assessment of Deep-sea Fisheries Resources/WGDEEP / 3. -9. May 2023*)

Reviewers: Anika Sonjudóttir

Expert group Chairs: Elvar H. Hallfredsson and Juan Gil Herrera

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)
1)
For single-stock summary sheet advice

Stock**: Ling in subareas 3,4, 6–9, 12, and 14 (Northeast Atlantic and Arctic Ocean)**

Short description of the assessment as follows (examples in grey text):

1) **Assessment type:** ICES framework for category 3 stocks was applied (rfb rule, method 2.1).
2) **Assessment**: accepted
3) **Forecast**: not presented
4) **Assessment model**: a standardized CPUE series from the Norwegian longline fleet
5) **Data issues:** advice is based on indices from fleet operating in subareas 4 and 6 but the advice applies for all areas.
6) **Consistency**: new approach (rfb) applied**.**
7) **Stock status**: Fishing pressure is above FMSY. No reference points for stock size have been defined.
8) **Management Plan:** ICES is not aware of any agreed precautionary management plan for ling in these areas.

General comments
The report was well documented with updated data. The advice was drafted consistently with the correspondent chapter in the report.

Conclusions
The assessment has been performed correctly

Review of ICES Scientific Report, (*WGDEEP*) *(2023)* (*May 3th – May 9th*)

Reviewers: Lise Heggebakken

Expert group Chair: Elvar Hallfredsson and Juan Gil

Secretariat representative: David Miller

General

The assessment for rng.27.1245a8914ab is a category 6 stock assessment and was previous based on average landings data from 2014-2018. Greenland provided new catch data in 2023, however there is still uncertainty over the reliability of historical landings in Subarea 13, consequently the basis for the advice given in 2023 was revised based on previous landings advice. The fishery is a bycatch fishery and trend in landings may reflect changes in activity in other fisheries rather than in stock abundance. Therefore, ICES consider that a precautionary reduction of catches should be implemented, hence the precautionary buffer was applied. It is a precautionary approach and there is no management plan.

For single-stock summary sheet advice

Stock: rng.27.1235a8914ab (Roundnose grenadier (*Coryphaenoides rupestris*) in subareas 1,2,4,8, and 9, Division 14a, and in subdivisions 14.b.2 and 5.a.2 (Northeast Atlantic and Arctic Ocean).

Short description of the assessment as follows:

1) Assessment type: no assessment
2) Assessment: accepted
3) Forecast: not presented
4) Assessment model: no model to this assessment
5) Consistency: last assessment accepted – this year's accepted with previous landings advice as basis
6) Stock status: unknown
7) Management plan: no management plan

General comments

Landings data may be overreported due to species misidentification (potential confusion in logbooks between roughhead and roundnose grenadier in divisions 2.a and 14.b). Work is underway to revise historical landings.

Technical comments

The report is well documented and easy to interpret; the documentation for the advice is fully described in the report. The advice is written according to the framework for the catch scenarios. For the basis for the advice, the previous landings advice was used instead of the average landings from four latest year, due to uncertainty in the reported landings.

Conclusions

The assessment has been performed correctly.

<u>Format for audits</u> (to be drawn up by expert groups and not review groups)

Review of ICES Scientific Report, (*WGDEEP*) *(2023)* (*May 3th – May 9th*)

Reviewers: Hege Øverbø Hansen

Expert group Chair: Elvar Hallfredsson and Juan Gil

Secretariat representative: David Miller

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

The assessment for rng.27.5a10b12ac14b is a category 5 stock assessment and was based on landings data; discards were poorly known and effort data was highly uncertain. It is a precautionary approach and there is no management plan.

For single-stock summary sheet advice

Stock rng.27.5a10b12ac14b

Short description of the assessment as follows:

1) Assessment type: update
2) Assessment: accepted
3) Forecast: not presented
4) Assessment model: no model to this assessment
5) Consistency: last year assessment accepted – this year's accepted
6) Stock status: unknown
7) Management plan: no management plan

General comments

Substantial landings were recorded in the 1970s and 1980s. Since then, landings have been variable and have decreased to 0 in 2022. There is no data on abundance trends but in the absence of fishing, the stock is expected to rebuild from the past depletion state caused by exploitation before the 2000s.

Technical comments

The report is well documented and easy to interpret; the documentation for the advice is fully described in the report. The advice is written according to the framework for the catch scenarios, basis of the advice and assessment.

Conclusions

The assessment has been performed correctly.

Audit usk.27.1-2

Review of ICES Scientific Report. Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 3. -9. May 2023, Lisbon (hybrid meeting)

Reviewers: Pascal Lorance

Expert group Chair: : Elvar H. Hallfredsson and Juan Gil Herrera

Secretariat representative: David Miller

General

For single-stock summary sheet advice

Stock **usk.27.1-2 Tusk (*Brosme brosme*) in subareas 1 and 2 (Northeast Arctic)**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: MSY approach using the rfb rule (ICES framework for ICES Category 3 stocks)Assessment: accepted
2) Forecast: not presented
3) Assessment model: rfb rule, with *r* estimated from the CPUE of the Norwegian longline fleet targeting ling in the stock area, *f* estimated from the length distribution of the catch and b, estimted to be 1 as the CPUE trend show a clear increase since a low level in 2003. The availability of more data for several stocks of ling and tusk
4) Consistency: The previous (2021) assessment was based upon the 2 over 3 rule and was accepted. The 2023 assessment was based on the rfb rule, so not directly comparable to the previous. The *r* of the rfb rule is based on the same time-series (updated) as the biomass index from the previous assessment. It is a CPUE of Norwegian longline fleet targeting ling in the stock area. This fleet makes up the bulk of the catch. As discards are forbidden in the stock area, the assessment and advice are based on catches (=landings). The biomass biomass is decreasing since 2017 after a sustained increase in 2003-2017.
5) Stock status:exploited near MSY levels
6) Management plan: None.

General comments Current levels of the biomass index (*r* of the rfb rule) are well above the early 2000s level so the *b* factor of the rfb rule is 1. The more advanced rfb rule, compared to the 2 over 3 rule, includes the *f* multiplier which is a length-based proxy for fishing pressure relative to F_{MSY}. Here *f* suggest the stock is exploited below F_{MSY} . Other stocks where Norwegian longliner are one of the main fleet showed different stock status (e.g. lin.27.346-91214 was assessed as exploited above MSY, f<1). Lastly the rule was applied with the multiplier m=0.95, clealry appropriate for tusk, as relatively long-lived species so k<0.2). The time series of the LBI used for the evaluation of the exploitation status (inverse of the *f* of rhe rfb rule), suggests the stock has been exploited below F_{MSY} in the past 20 years, which is in line with the general increase of the CPUE.

Technical comments The availability of more data for several stocks of ling and tusk including some with survey data available was discussed at the EG, which considered the CPUE data was reliable.

Conclusions
Assessment and adive are correct, suitable detail are provided in the report

Audit usk.27.3a45b6a7-912b, Tusk (Brosme brosme) in subareas 4 and 7–9, and in divisions 3.a, 5.b, 6.a, and 12.b (Northeast Atlantic)

Review of ICES Scientific Report. Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 3. -9. May 2023, Lisbon (hybrid meeting)

Reviewers: Pascal Lorance

Expert group Chair: : Elvar H. Hallfredsson and Juan Gil Herrera

Secretariat representative: David Miller

General
None

For single-stock summary sheet advice

Stock **usk.27.3a45b6a7-912b, Tusk (Brosme brosme) in subareas 4 and 7–9, and in divisions 3.a, 5.b, 6.a, and 12.b (Northeast Atlantic**

Short description of the assessment :

1) Assessment type: MSY approach using the rfb rule (ICES framework for ICES Category 3 stocks)
2) Assessment: accepted
3) Forecast: not presented
4) Assessment model: rfb rule, with *r* estimated from the CPUE of the Norwegian longline fleet targeting ling in the stock area, *f* estimated from the length distribution of the catch and b, estimted to be 1 as the CPUE trend show a clear increase since a low level in 2003.
5) Consistency: The previous (2021) assessment was based upon the 2 over 3 rule and was accepted. The 2023 assessment was based on the rfb rule, so not directly comparable to the previous. The *r* of the rfb rule is based on the same time-series (updated) as the biomass index from the previous assessment. It is a CPUE of Norwegian longline fleet targeting ling in the stock area, the main fishing fleet for the stock. Discards are minor but are considered in the assessement. The biomass index shows strong year-to-year variations, which are unlikely to be related to actual year-to-year changes in stock biomass. These may rather come from fishing strategy (e.g. target species or accurate spatial or depth distribution of the fishing) is decreasing since 2017 after a sustained increase in 2003-2017.
6) Stock status:exploited near MSY levels
7) Management plan: None.

General comments Current levels of the biomass index (*r* of the rfb rule) are well above the early 2000s level, so the *b* factor of the rfb rule is 1. The more advanced rfb rule, compared to the 2 over 3 rule, includes the *f* multiplier which is a length-based proxy for fishing pressure relative to F_{MSY}. Here *f* suggest the stock is exploited below F_{MSY} but the combination with the low *r* lead to an advised catch smaller than the previous advice. The rule was applied with the multiplier m=0.95, clealry appropriate for tusk, as relatively long-lived species so $k<0.2$). The time series of the LBI used for the evaluation of the exploitation status (inverse of the *f* of rhe rfb rule), suggests that the stock has been exploited at F_{MSY} at the beginning of the time-series (2003-2008) and below F_{MSY} afterwards (Figure 2 in the advice). This is in aggrement with the general increase of the CPUE from 2006-07 to 2018-2020. In recent years the biomass indicator seems to level off, with the actual *r* multiplier (2 over 3 rule) decreasing.

Technical comments None

Conclusions
The assessment and adive are correct.

Annex 5: Stock annex edits

ICES. 2023. Stock Annex: Greater silver smelt (*Argentina silus*) in divisions 5.b and 6.a (Faroes grounds and west of Scotland). ICES Stock Annexes. Report. https://doi.org/10.17895/ices.pub.23599581

ICES2023. Stock annex: Greater silver smelt (*Argentina silus*) in subareas 7–10 and 12, and Division 6.b (other areas). ICES Stock Annexes. Report. https://doi.org/10.17895/ices.pub.23599617

ICES. 2023. Stock annex: Greater forkbeard (*Phycis blennoides*) in subareas 1–10, 12 and 14 (the Northeast Atlantic and adjacent waters). ICES Stock Annexes. Report. https://doi.org/10.17895/ices.pub.23599638

ICES. 2023. Stock annex: Ling (*Molva molva*) in Division 5.a (Iceland grounds). ICES Stock Annexes. Report. https://doi.org/10.17895/ices.pub.23599644

ICES. 2023. Stock annex: Ling (*Molva molva*) in Division 5.b (Faroes grounds). ICES Stock Annexes. Report. https://doi.org/10.17895/ices.pub.23599662

ICES. 2023. Stock annex: Tusk (*Brosme brosme*) in Subarea 14 and Division 5.a (East Greenland, and Iceland grounds). ICES Stock Annexes. Report. https://doi.org/10.17895/ices.pub.23599668