6 Greater silver smelt *(Argentine silus)*

6.1 Stock description and management units

At the WGDEEP 2014, it was suggested that unit arg-oth should be further split into advisory units as fishing grounds are sufficiently isolated (WD10, WGDEEP2014, Figure 6.1.1). This change was implemented at the WGDEEP meeting in 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

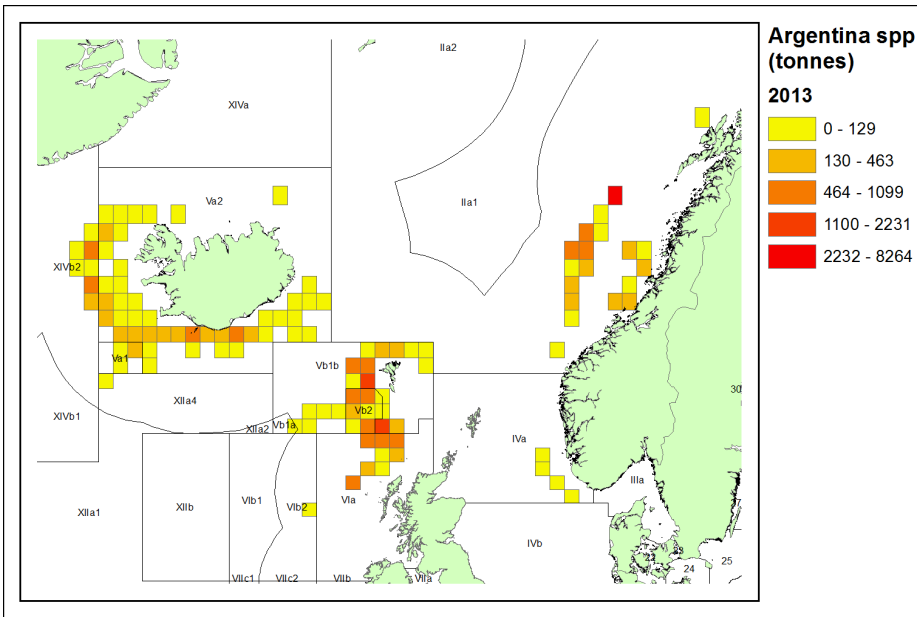

Figure 6.1.1. Catches of greater silver smelt by Iceland, Norway, Faroes and the Netherlands in 2013. Some catches of *A. sphyraena* and *Argentina* unidentified may be included in the Norwegian and Dutch landings.

Stock structure was a subject at the WKGSS 2020 benchmark for greater silver smelt (ICES 2021), where three of these stock units were benchmarked for the first time. The stock in ICES areas 6b, 7-10 and 12 (aru.27.6b7–1012) has not been benchmarked.

Preliminary results from genetic studies presented to the benchmark were not conclusive regarding stock structure (Seljestad et al. 2020, ICES WKGSS WD4). Further genetic investigation should be encouraged to underpin biological segregation of stock units.

6.2 Greater silver smelt (*Argentina silus*) in 1, 2, 3.a and 4

6.2.1 The fishery

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. From the 1970s until the mid-1990s a smaller target fishery existed in Division 3.a (Skagerrak), but landings from that area have since been only minor bycatch.

In addition to the target fisheries in 2.a, 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 the past year (Figure 6.2.1).

6.2.2 Landing trends

International landings are summarised in Tables 6.2.1–6.2.4, and Figures 6.2.1 and 6.2.2. The variation through the time-series prior to 2014 primarily reflects the developments in the Norwegian target fisheries in Subarea 2. The landings from Division 4.a were estimated based on sampling of mixed-species catches at the fishmeal factories, and the quality of the process may have varied somewhat through the time-series. Since 2014 the bycatch in the North Sea (Subarea 4) has been increasing gradually to substantial levels, and in 2020 amounting close to half of the total catch. In the last two years however, the bycatch has decreased and is now less than 40 percent of the total catch.

From peak levels of 10000 t to 11000 t in the 1980s when the targeted fishery developed, the landings (primarily by Norway) from Subareas 1 and 2 declined in the 1990s. Except for 2001, when landings were 14369 t, the landings remained relatively stable at 6–8000 t until 2003. In 2004 to 2006 landings increased sharply to reach 21685 t in 2006. The monitoring of abundance was not satisfactory in that period, but the increase in landings did probably not reflect increased abundance. Since the fishery was not restricted by a TAC, it is thought that temporal variation in landings primarily reflected variation in the market demand. In 2007–2017 the Norwegian catches in targeted fisheries were around 12000 t per year in accordance with annual TAC regulations reintroduced in 2007. In 2018 the landings increased to 15832 t, while in 2019 the landings were 12501 t. In 2020 these catches are reduced to 8705 t, while for 2021 the catches increased by 1000 t to 9706 t. For 2022 the catches is reduced to 7550 t, which is a record low catch amount for the last 20 years.

Since 2014 a marked increase is observed in catches in subareas 3 and 4, and these have risen in 2018, 2019 and 2020 to substantial 8067 t, 7210 t and 7215 t, respectively. In 2021 these catches have declined to 3733 t, while for 2022 the catches has increased to 4634 t. Mostly they are bycatch taken at the southern slope of Norwegian trench, and the bulk of them are reported as lesser silver smelt. There are uncertainties on how well these landings are estimated and about species identification, and this should be addressed with better sampling in cooperation with the industry. In the end of 2018, 267 samples of Argentines from the industry were identified to either *Argentina silus* or *Argentina sphyraena* using different criteria given in the identification key of Argentines; number of muscle segments, number of pectoral fin rays, number of gill rakes on the lower part of the first gill bow and the size of the eye diameter compared to the snout length (ICES WGDEEP 2019 WD7). Preliminary results show that up to 10% of the individuals sampled

might be *A. sphyraena*. In this report, all registered landings are assumed to be greater silver smelt.

In 2020 total landings were 15820 t (Table 6.2.1–6.2.3). Landings from subareas 1 and 2 were 8705 t and the remainder were reported from Subarea 4 and Division 3.a. The total landings were substantially higher than the ICES advice for 2019, primarily due to by-catch landings in the North Sea. In 2021 the total landings were 13271 t, hence landings from subareas 1 and 2 were 9706 t and the remainder were reported from Subarea 4 and Division 3.a. For 2021 the total landings are still higher than the ICES advice given for 2021, however the landings for 2021 are declining compared to 2020. In 2022 the total landings were 12126 t, where landings from subareas 1 and 2 were 7550 t and the remainder from Subarea 4 and Division 3.1. As for 2021, the total landings for 2022 are higher than the ICES advice given for 2022.

6.2.3 ICES Advice

In 2021 ICES advised that, when the precautionary approach is applied, catches should be no more than 10 271 tonnes in each of the years **2022 and 2023**. Discarding is known to take place but is negligible.

6.2.4 Management

For a period after 1983 a Norwegian precautionary unilateral annual TAC was applied in Division 2.a which was always the main fishing area. The landings never exceeded the quota and this regulation was abandoned in 1992. As landings increased substantially in the mid-2000s, a 12000 t unilateral Norwegian TAC was introduced in 2007 and this TAC was maintained until 2015 when for 2016 it was increased to 13047 t, which also was the TAC for 2017. In 2018 and 2019 the TAC was 13770 t. The TAC in the direct fisheries for 2020 and 2021 is 9033 t. The TAC in the direct fisheries is 7603 t for 2022 and 2023. The Norwegian target fishery is further regulated by a licensing system that limits the number of trawlers that can take part and specifies gear restrictions, bycatch restrictions, and an area and time restriction. Usually around 25 trawlers are active in the fishery.

In 2016, RTC-regime (Real Time Closures) was implemented to the direct fisheries in Subarea 2, aimed to limit bycatch of redfish, saithe and haddock. Closing criteria was sat to 1000 kg in combined weight of redfish, saithe and haddock in single catches.

In 2017 a minimum landing size (MLS) in the direct fisheries of 27 cm was implemented in the direct fisheries, with access to 20% mixture of greater silver smelt in numbers under the MLS in single catches. Also, ban on landing greater silver smelt to be processed to fishmeal was repealed in 2017.

In Norway vessels that are not licensed to greater silver smelt fisheries can have up to 10% in weight bycatch of greater silver smelt in single catches and landings. This also applies to vessels that are licenced, but those must subtract the bycatch from their quota.

If the total TAC in the direct fishery is not fished during the year, up to 10% of the total TAC can be transferred to the following year.

There is no Norwegian TAC for fisheries in divisions 4.a and 3.a where targeted fisheries are prohibited, but bycatch restrictions apply. The EU introduced TAC management in 2003 applying to EU vessels fishing in the EU EEZ and international waters. For 2020 the EU TAC for subareas 1+2 was 90 t, and for subareas 4 + 3 the TAC was 1234 t. For 2021 the EU TAC for subareas 1+2 was 34 t, while for subareas 4 + 3 the EU TAC was 796 t. For 2022 the EU TAC is 9 t in UK

and international waters of 1 and 2, and 199 t in UK and EU waters of 4 and EU waters of 3[1] . For both 2021 and 2022 UK TAC was 25 t in area 1 and 2, and 13 t in 3a and 4c [2]. For years 2023 and 2024 the EU TAC and the UK TAC in subareas 1+2 is 34 t and 25 t, respectively. In subarea 3a and 4c, the EU TAC is 796 t and the UK TAC is 13 t for years 2023 and 2024.[3]

6.2.5 Data available

6.2.5.1 Landings and discards

Landings data are presented by ICES Subareas and Divisions and countries (Tables 6.2.1–6.2.4, Figure 6.2.1–6.2.3). Data from 2014–2021 were obtained from national official statistics (Norway) and InterCatch. From earlier years data are WG estimates based on national submissions to ICES which are not fully included in InterCatch.

Discarding is banned in Norway and all catches are assumed to be landed. There is information in InterCatch on very minor discards from non-Norwegian fisheries on this management unit, but bycatches are assumed generally to be landed.

6.2.5.2 Length compositions

Length distributions are presented for target fishery catches from Division 2.a for the period 2009–2022 and for bycatches by Norwegian vessels in Division 4.a for the years 2011, 2013, and 2015-2022 (Figure 6.2.5 and 6.2.6). For each year these distributions are derived by pooling multiple samples from landing sites and samples provided by commercial vessels (Hallfredsson *et al.* 2016, WGDEEP 2016, WD).

Length information is available from the Norwegian slope March/April survey in Division 2.a conducted in 2009 and 2012, and biennially since then (Figure 6.2.7) (Heggebakken *et al.* 2020, WKGSS WD18).

Length information is available from the annual Norwegian shrimp survey in divisions 3.a and 4.a, 1984–2023 (Figure 6.2.8).

Some length distributions from landings and discards from fisheries by Scotland, Sweden and Netherlands are available in InterCatch, but are still to be analysed.

6.2.5.3 Age compositions

Age compositions from Norwegian catches 2013-2020 are presented in Figure 6.2.9. Age distributions from the Norwegian slope survey and the shrimp survey in North Sea/Skagerrak are shown in Figure 6.2.10.

6.2.5.4 Weight-at-age

No new data on weight-at-age were presented to the meeting. Length at age and length-weight relations were scrutinized at the WKGSS 2020 benchmark workshop on greater silver smelt (ICES 2021).

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[1] final-tacs-2022.pdf (europa.eu)

[2] Outcomes of annual negotiations for UK fishing opportunities in 2021 and 2022 (publishing.service.gov.uk)

[3] EU-UK for 2023 (europa.eu)

6.2.5.5 Maturity and natural mortality

No new data on maturity and natural mortality were presented to the meeting, but these were scrutinized at the 2020 benchmark workshop.

6.2.5.6 Catch, effort and research vessel data

A trawl acoustic survey has been conducted in 2009, 2012 and biennially since then, along the continental slope in Norwegian EEZ from 62–74°N (subareas 1 and 2). Additionally, trawl surveys were conducted in Division 2.a in 2003–2005. Acoustic index from this survey is used in the SPiCT assessment.

Surveys were conducted in early 1990-ties in the Norwegian Sea and south–east slope with acoustics, pelagic and bottom trawl (Monstad and Johannessen, 2003), the ones in spring 1990-1992 are used in the SPiCT assessment.

For Subarea 4 and Division 3.a information is available from the Norwegian shrimp survey in years 1984–2023. Stations are in the depth range of 80-660 meters, with around 25% of the stations deeper than 300 meters. The survey has been conducted in different seasons, and this may affect the index for greater silver smelt. The index did not perform well with SPiCT (ICES 2021).

6.2.6 Data analyses

Length and age distributions

In Division 2.a size and age distributions from target fisheries (Figures 6.2.5 and 6.2.9) continue to consist of rather smaller and younger fish than catches in the 1980s during the initial years of the target fisheries (Bergstad, 1993; Monstad and Johannessen, 2003; Johannessen and Monstad, 2003). There are, however, no major changes in the shape of size composition in the recent ten years when the target fishery has been regulated with TACs and other measures.

Age distributions in the Norwegian slope survey are rather even through the years with a mode around age six to eight, while the 2020, 2022 and 2023 age distribution in the North Sea/Skagerrak survey is bimodal with more juveniles of age one to three as well (Figure 6.2.10). The fishery is mainly conducted shallower than 400 m.

The shape of the length distributions in both numbers and biomass in the Norwegian slope survey have varied through the years, but low numbers and biomass are apparent in the 2018 survey while 2020 and 2022 survey shows upward trend (Figure 6.2.7).

In Division 3.a the length distributions throughout the 1984–2023 shrimp survey time-series are bimodal since 2018, as the age distribution in 2020, 2022 and 2023, with marked appearance of larger fish around 30 cm (Figure 6.2.8).

In Division 4.a size distributions from the bycatch (Figure 6.2.6) are to some extent bimodal in years 2015 to 2020 and suggest that the catches comprise rather variable but smaller fish than those in the target fishery landings in Division 2.a. Mean length in 2022 from the target fishery in Division 2.a was 36.45 cm, while mean length from Division 4.a was 17.70 cm in 2022. This probably reflects that the slope of the Norwegian Deep in Division 4.a is comparatively shallow and is mainly a juvenile area and feeding area for dispersed large fish out with the winter-spring aggregatory phase (Bergstad, 1993).

Commercial CPUE and survey series

In Subarea 2 biomass estimates based on the acoustic observations show a decreasing trend from 2014-2018, the 2020 estimate shows an increase, while the acoustic estimates for 2022 are at the same level as for 2018 (strata 1A and 2A in Figure 6.2.11). Greater silver smelt spatial distribution shows highest concentrations in approximately 62-70°N (Figure 6.2.12), which agrees to where the direct fisheries are mostly conducted. The index was recalculated using the StoX software at the 2020 benchmark. The 2020 survey was affected by complications related to covid19 restrictions and bad weather conditions. As a result, the area North of 67°N was not covered, being an area with lowest biomass of greater silver smelt in the survey (stratum 3 in Figure 6.2.11) and it is suggested to exclude that area from the index that is used in SPiCT (ICES 2021).

Swept area biomass indices and swept area abundance indices for greater silver smelt from the annual Norwegian shrimp survey in Division 3.a and south-eastern parts of Division 4.a are shown in Figure 6.2.13. The indices are calculated using StoX, which is now the recommended program for calculating survey estimates from acoustic and swept area surveys at IMR (Johnsen *et al.* 2019) (Heggebakken *et al.* 2020, WKGSS WD18). Seasonality of the survey has varied through the years and this may affect the index for greater silver smelt. It was conducted in October 1984-2002, in May 2004-2005, in February 2006-2007 and in January since then.

The indices in terms of numbers and weight from the survey in divisions 3.a and 4.a suggest pronounced variation and trends (Figure 6.2.13). The survey catches rates first declined steadily and then rather abruptly to unprecedented low levels in 2006. After 2010, indices showed an abrupt increase until around 2015 and have been at a relatively high level since then.

A preliminary catch CPUE based on electronic logbook data from the direct fisheries in Division 2.a is shown in Figure 6.2.14. For the pelagic trawls CPUE, year 2013 is the one with highest value, followed by a declining trend until 2016 and a slight increase after that (Heggebakken *et al.* 2020, WKGSS WD18). For the bottom trawls CPUE, the trend is increasing, apart from year 2015 which showed the lowest CPUE for all years. The CPUE series was examined at the 2020 benchmark and considered not applicable to the assessment at present stage. It is foreseeably a labour-intensive task to get the old logbooks digitalized, and a cost-benefit consideration is needed based on further analysis of the electronical logbook data and experience with CPUE series from other areas.

6.2.7 Assessment

LBI was run in 2023 with updated data in a web-based Shiny app (LBIndicator Application (shinyapps.io)). The results show that in the traffic light system (ICES. 2018) all indicators for conservation, optimal yieald and MSY are green (Figure 6.2.15), except for L_c/L_{mat} (=0.96) for conservation of immatures which is slightly below the expected value of >1. Index ratio of the average length relative to the expected length when fishing mortality equals natural mortality ($L_{mean}/L_{F=M}$) from the LBI can be used for evaluation of exploitation status. The exploitation status is below $F_{MSYproxy}$ when this index ratio value for MSY is ≥1. For the stock $L_{mean}/L_{F=M}$ = 1.09, which indicates that the exploitation status is within sustainable levels.

SPiCT was run in 2023 and the results are shown in Figure 6.2.16-6.2.20.

According to the recommendations from WKLIFE X, the ICES-rfb rule was applied for a trend-based advice (ICES, 2023) and was calculated in the "cat3advice" R-package (shfischer/cat3advice: An R package to apply the ICES category 3 data-limited harvest control rules (rfb/rb/chr) (github.com)). The relative biomass index from SPiCT was used for the stock development. The advice is based on the recent advised catches (2023), multiplied by the ratio of the mean of the last two index values (index A) and the mean of the three preceding values (index B), a ratio of observed mean length in the catch relative to the target mean length, a biomass safeguard, and a precautionary multiplier. The stability clause was considered and not applied since the change from the previous advice was between +20% or −30%. The discard rate is 0.5% and considered negligible.

The relative biomass index, index A and index B is shown in Figure 6.2.22. The pooled lengths from years 2015-2022 is shown in Figure 6.2.23. The parameters from von Bertalanffys growth function used in the rfb calculations were L_∞ = 44.65 cm and k = 0.12 yr^{-1}. $I_{trigger}$ used as in rfb-rule decriptions ($I_{trigger} = I_{loss} \times 1.4$) showed an $I_{trigger}$ at 1.2. However, this level is higher than the index has ever been and alternative calculations for $I_{trigger}$ were suggested. In one scenario the $I_{trigger}$ was set as I_{loss} for the relative biomass index, which gave an value of I_{loss} at 0.8539. The other scenario is based on the SPiCT results were $I_{trigger}$ is sat as (B_{MSY}/meanB)/2 which gave an value of 0.4691. Both these scenarios fitted better with the trend of the relative biomass index. However, currently when the rfb-rule is applied the biomass safeguard b becomes 1, since the multiplier index relative to trigger (b) is the minimum value of either 1 or $I_{2022}/I_{trigger}$ and both sceanarios will give values higher than 1. Figure 6.2.24 gives the index and shows both alternatives for $I_{trigger}$, and decision on which alternative to choose will be brought to the ADG to consider. The stock size is above MSY $B_{trigger\ proxy}$ ($I_{trigger}$) (Figure 6.2.24), and the fishing pressure is below $F_{MSY\ proxy}$ (Figure 6.2.25).

The ADGDEEP 2023 rejected use of SPiCT index into the rfb rule, and recommended rather to use acoustic index from the Norwegian Slope survey with intropolated values for missing years (figure 6.2.26), as input to the rfb rule.

6.2.8 Comments on the assessment

The assessment is in accordance to the WKGSS 2020 benchmark workshop (ICES 2021) and the recommendations from WKLIFE X, regarding applying ICES-rfb rule (ICES, 2023).

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. CPUE from the fisheries is the only known source of data that potentially can give information on historical development of the stock back in time to around 2009. Electronic logbooks were introduced in the Norwegian fisheries in 2011 but are not available digitally for earlier years. Before 2011 the fishing vessels were obliged to keep logbooks, and have them available in case of inspection, but not to deliver them to the government. Thus, it is foreseeably a labour-intensive task to get the old logbooks 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.

6.2.9 Management considerations

Advice is given every second year for this stock and the 2023 advice applies for 2024 and 2025.

The bycatch in Subarea 4 (North Sea) has increased rapidly since 2012 and total catch in this area reached levels of around 7 to 8 thousand tonnes. In 2020 the catches in Subarea 4 were 7115 t, reaching levels not far from to the catches in the direct fisheries in subareas 1 and 2 (8705 t). This is an alarming level as the bycatches are not well regulated. There are uncertainties in how this bycatch is estimated in this fishery, as it is an industry fishery for reduction. Additionally, most of these catches are registered as lesser silver smelt, but there are strong reasons to assume that for the most part they are greater silver smelt catches (Hallfredsson and Heggebakken 2019, ICES WGDEEP 2019 WD7).

6.2.10 References

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6.2.11 Tables

Table 6.2.1. Greater Silver Smelt in 1, 2, 3.a and 4 by countries. WG estimates of landings in tonnes. ICES official statistics. Landings from 1966-2018 are shown in Stock Annex. * Preliminary landings.

year	Denmark	Sweden	Ireland	Germany	Netherlands	Norway	Poland	Russia/USSR	Scotland	France	Faroes	Lithua-nia	Iceland	SUM
1988	1062	0	0	1	0	13014	5	14	0	0	0	0	0	14096
1989	1322	0	0	0	335	10495	0	23	1	0	0	0	0	12176
1990	737	0	0	13	5	10686	0	0	0	0	0	0	0	11441
1991	1421	0	0	0	3	8864	0	0	6	1	0	0	0	10295
1992	3564	0	0	1	70	8932	0	0	101	0	0	0	0	12668
1993	2353	0	0	0	298	8481	0	0	56	0	0	0	0	11188
1994	1118	0	0	0	0	6221	0	0	614	0	0	0	0	7953
1995	1061	0	0	357	0	6419	0	0	20	0	0	0	0	7857
1996	1446	0	0	0	0	6817	0	0	0	0	0	0	0	8263
1997	1455	542	0	1	0	5167	0	0	0	0	0	0	0	7165
1998	748	428	0	169	277	8655	0	0	0	0	0	0	0	10277
1999	1420	0	0	0	7	7151	0	0	18	0	0	0	0	8596
2000	1039	273	10	0	3	6107	0	195	18	9	0	0	0	7654
2001	907	1011	3	0	0	14360	0	7	233	28	0	0	0	16549
2002	614	484	4	0	0	7406	0	0	164	0	0	0	0	8672

year	Denmark	Sweden	Ireland	Germany	Netherlands	Norway	Poland	Russia/USSR	Scotland	France	Faroes	Lithua-nia	Iceland	SUM
2003	918	42	0	4	617	8351	0	7	22	4	4	0	0	9969
2004	910	0	36	4	4277	11574	0	4	12	0	0	0	0	16817
2005	470	0	0	1	28	17066	0	16	0	0	14	0	0	17595
2006	335	0	0	6	0	25149	0	4	2	0	0	0	0	25496
2007	0	0	0	0	0	16373	0	1	0	0	0	0	0	16374
2008	0	0	0	0	0	13424	0	0	0	0	0	0	0	13424
2009	0	0	0	0	0	13495	0	0	0	0	0	0	0	13495
2010	0	0	0	0	0	12865	0	0	33	0	0	0	0	12898
2011	0	0	0	0	0	12060	0	0	0.4	4	0	0	0	12064
2012	0	0	0	0	0	12352	0	0	0	1.2	114	0	18	12485
2013	0	0	0	0	0	13227	0	0	0	2.3	0	0	0	13229
2014	40	1	0	204	345	14471	0	0	0	1	0	0	0	15062
2015	0	1	0	0	0	15235	0	0	0	0	0	0	0	15236
2016	0	1	0	38	11	18835	0	7	0	1.4	0	0	0	18893
2017	0	1	0	0	10	17788	0	35	0	0	0	0	0	17835
2018	18	4	0	67	152	23609	0	9	0	0	0	0	0	23859
2019	0	0	0	143	349	19172	0	8	0	0	0	0	0	19672
2020	309	0	0	0	222	15534	21	8	0	0	0	35	0	16129

year	Denmark	Sweden	Ireland	Germany	Netherlands	Norway	Poland	Russia/USSR	Scotland	France	Faroes	Lithua-nia	Iceland	SUM
2021	0	0	0	439	24	12804	4	0	0	0	0	0	0	13271
2022*	0	0	0	0	2	12124	0	0	0	0	0	0	0	12126

Table 6.2.2. Greater Silver Smelt in 1 and 2. WG estimates of landings in tonnes. *Preliminary landings.

Year	Germany	Netherlands	Norway	Poland	Russia/USSR	Scotland	France	Faroes	Iceland	TOTAL
1988			11332	5	14					11351
1989			8367		23					8390
1990		5	9115							9120
1991			7741							7741
1992			8234							8234
1993			7913							7913
1994			6217			590				6807
1995	357		6418							6775
1996			6604							6604
1997			4463							4463
1998	40		8221							8261
1999			7145			18				7163
2000		3	6075		195	18	2			6293

Year	Germany	Netherlands	Norway	Poland	Russia/USSR	Scotland	France	Faroes	Iceland	TOTAL
2001			14357		7	5				14369
2002			7405			2				7407
2003		575	8345		7	2	4	4		8937
2004		4235	11557		4					15796
2005			17063		16			14		17093
2006			21681		4					21685
2007			13272		1					13273
2008			11876							11876
2009			11929							11929
2010			11831			23				11854
2011			11476			0.4				11476
2012			12002				0.2	114	18	12134
2013			11978				0.3			11979
2014			11752							11752
2015			12049							12049
2016			13115		7		0.4			13122
2017		10	12277		35					12322
2018	0.2	0.4	15823		8.5					15832

Year	Germany	Netherlands	Norway	Poland	Russia/USSR	Scotland	France	Faroes	Iceland	TOTAL
2019			12493		8					12501
2020			8697		8					8705
2021			9706							9706
2022*		1.5	7548			0.4				7550

Table 6.2.3. Greater Silver Smelt in 3. WG estimates of landings in tonnes. Figures in parentheses are discards as recorded in InterCatch. Landings from 1966-2018 are shown in Stock Annex. *Preliminary landings.

Year	Denmark	Germany	Norway	Sweden	TOTAL
1988	1062		27		1089
1989	938		236		1174
1990	732		1150		1882
1991	1421		800		2221
1992	3564		634		4198
1993	2343		487		2830
1994	1108				1108
1995	1061				1061
1996	1389		159		1548
1997	1455		703	542	2700
1998	748		413	428	1589
1999	1420		2		1422
2000	1039		4	273	1316
2001	907			1011	1918
2002	614			484	1098
2003	918			42	960
2004	910		1		911

Year	Denmark	Germany	Norway	Sweden	TOTAL
2005	470				470
2006	324				324
2007					0
2008					0
2009					0
2010					0
2011					0
2012					0
2013					0
2014			2	1	3
2015			22	1	23
2016			101	1	102
2017			3	(1)	3(1)
2018				(3.6)	(3.6)
2019				(66)	(66)
2020	7(4)				7(4)
2021				(1.4)	(1.4)
2022*				(0.2)	(0.2)

Table 6.2.4. Greater Silver Smelt in 4. WG estimates of landings in tonnes. Figures in parentheses are discards as recorded in InterCatch. Landings from 1970-2018 are shown in Stock Annex. *Preliminary landings.

Year	Denmark	France	Germany	Netherlands	Norway	Scotland	Ireland	Russia	Lithuania	Poland	TOTAL
1988			1		1655						1656
1989	384			335	1892	1					2612
1990	5		13		421						439
1991		1		3	323	6					333
1992			1	70	64	101					236
1993	10			298	81	56					445
1994	10				4	24					38
1995					1	20					21
1996	57				54						111
1997			1		1						2
1998			129	277	21						427
1999				7	4						11
2000		7			28		10				45
2001		28			3	228	3				262
2002					1	162	4				167
2003			4	42	6	20					72
2004			4	42	16	12	36				110

Year	Denmark	France	Germany	Netherlands	Norway	Scotland	Ireland	Russia	Lithuania	Poland	TOTAL
2005			1	28	3						32
2006	11		6		3468	2					3487
2007					3101						3101
2008					1548						1548
2009					1566						1566
2010					1034	10					1044
2011		4			584						588
2012		1			350						351
2013		2			1249						1251
2014	40 (7)	1	204	345	2717						3307(7)
2015					3164						3164
2016		1	38	11	5619	(24)					5669(24)
2017					5508	(388)					5508(388)
2018	17(1)		67	152	7786	(38)		6			8028(39)
2019			143	349	6679	(39)					7171(39)
2020	302(15)			222	6837	(100)			35	21	7417(115)
2021			439	24	3098	(168)				4	3565(168)
2022*					4576	(58)					4576(58)

6.2.12 Figures

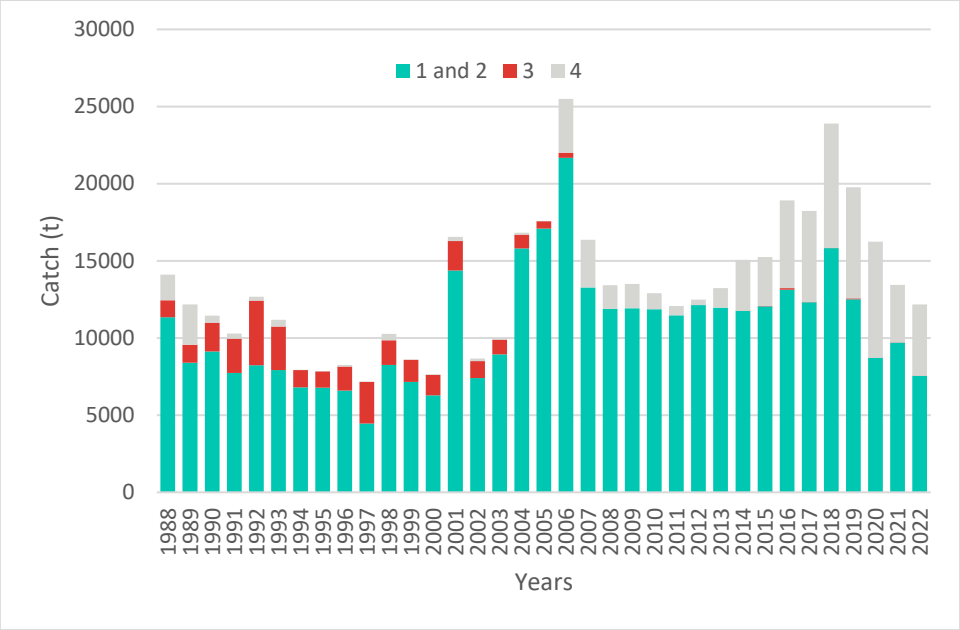


Figure 6.2.1. Total catch of greater silver smelt in subareas 1, 2, 3 and 4.

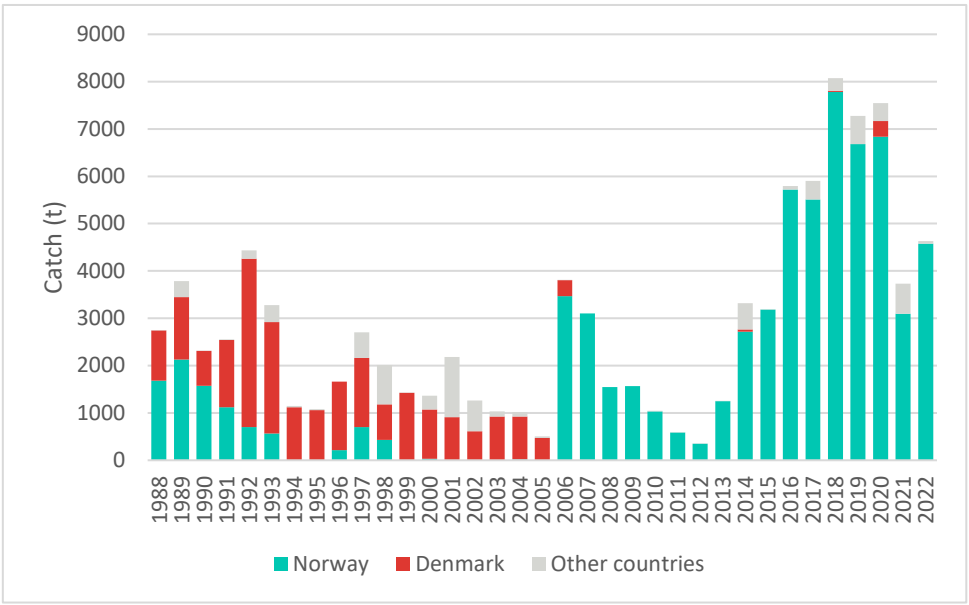


Figure 6.2.2. Total catch of greater silver smelt in subareas 3 and 4, by countries.

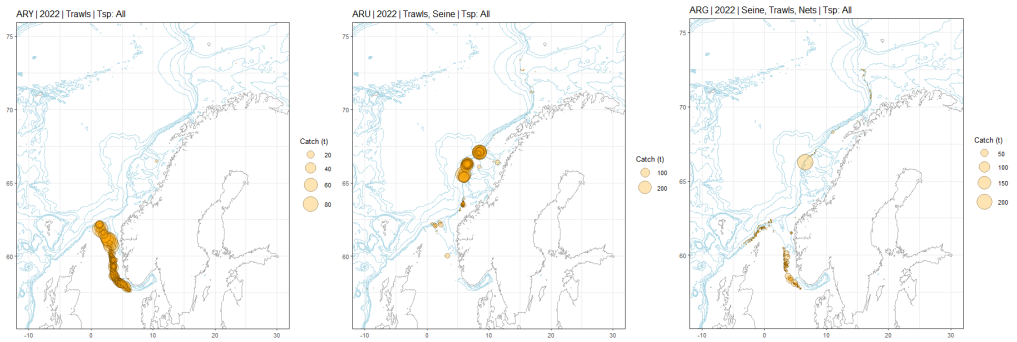


Figure 6.2.3. Norwegian catches in 2022 based on logbooks, including bycatch. Left, middle and right panels show catches registered as lesser silver smelt, greater silver smelt and mix of both species, respectively. Bubble sizes reflect sizes of single catches. NB: Catch representing max bubble size varies between panels.

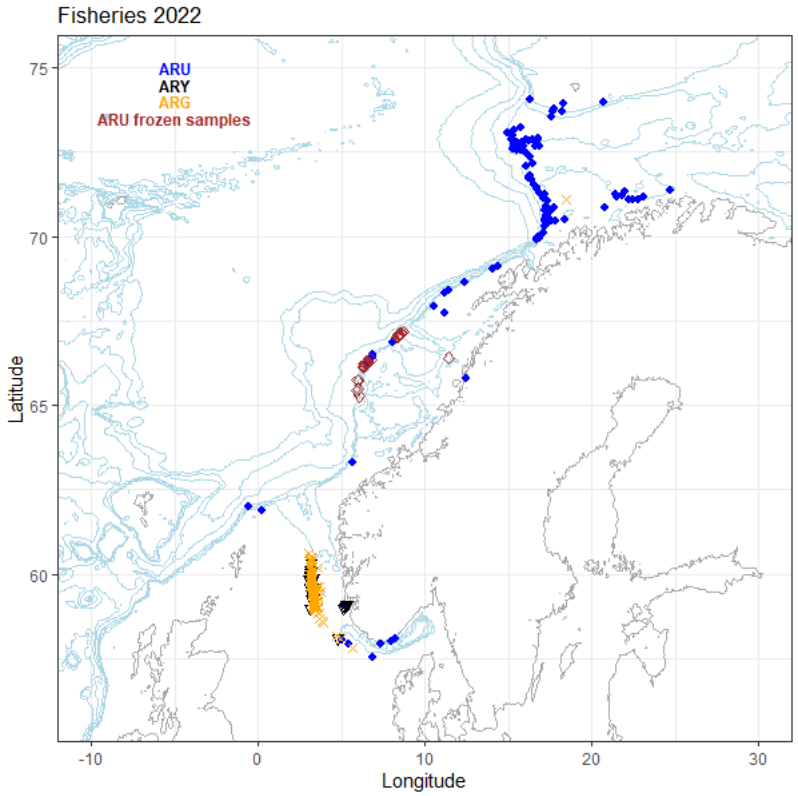


Figure 6.2.4. Positions from the fisheries for 2022 with length measurement landed as GSS, LSS, GSS/LSS and frozen samples.

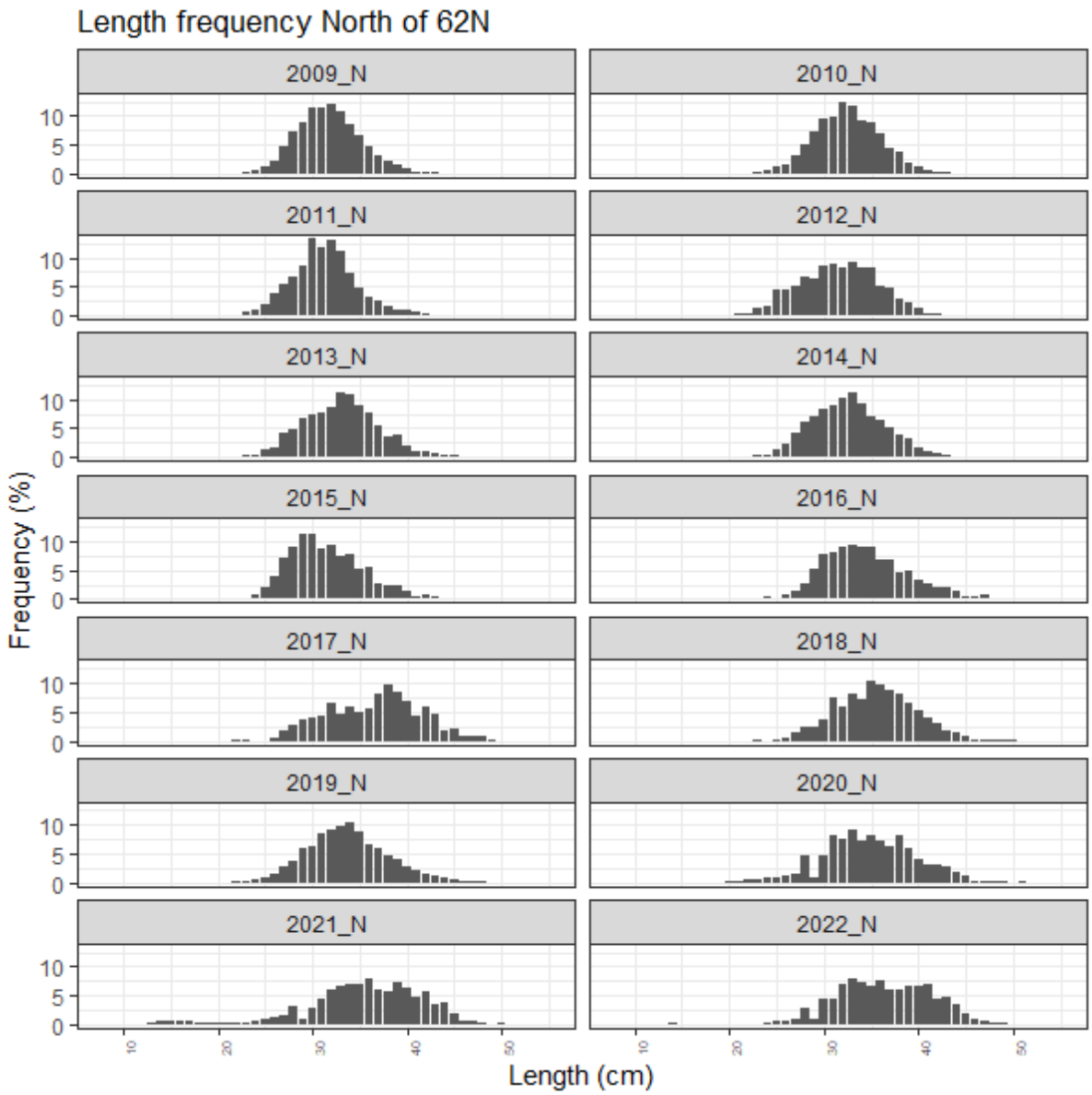


Figure 6.2.5. Greater silver smelt in subareas 1, 2, and 4 and Division 3.a. Length distributions (% numbers) from the target fisheries in 2009–2022 north of 62°N (approximately subareas 1 and 2).

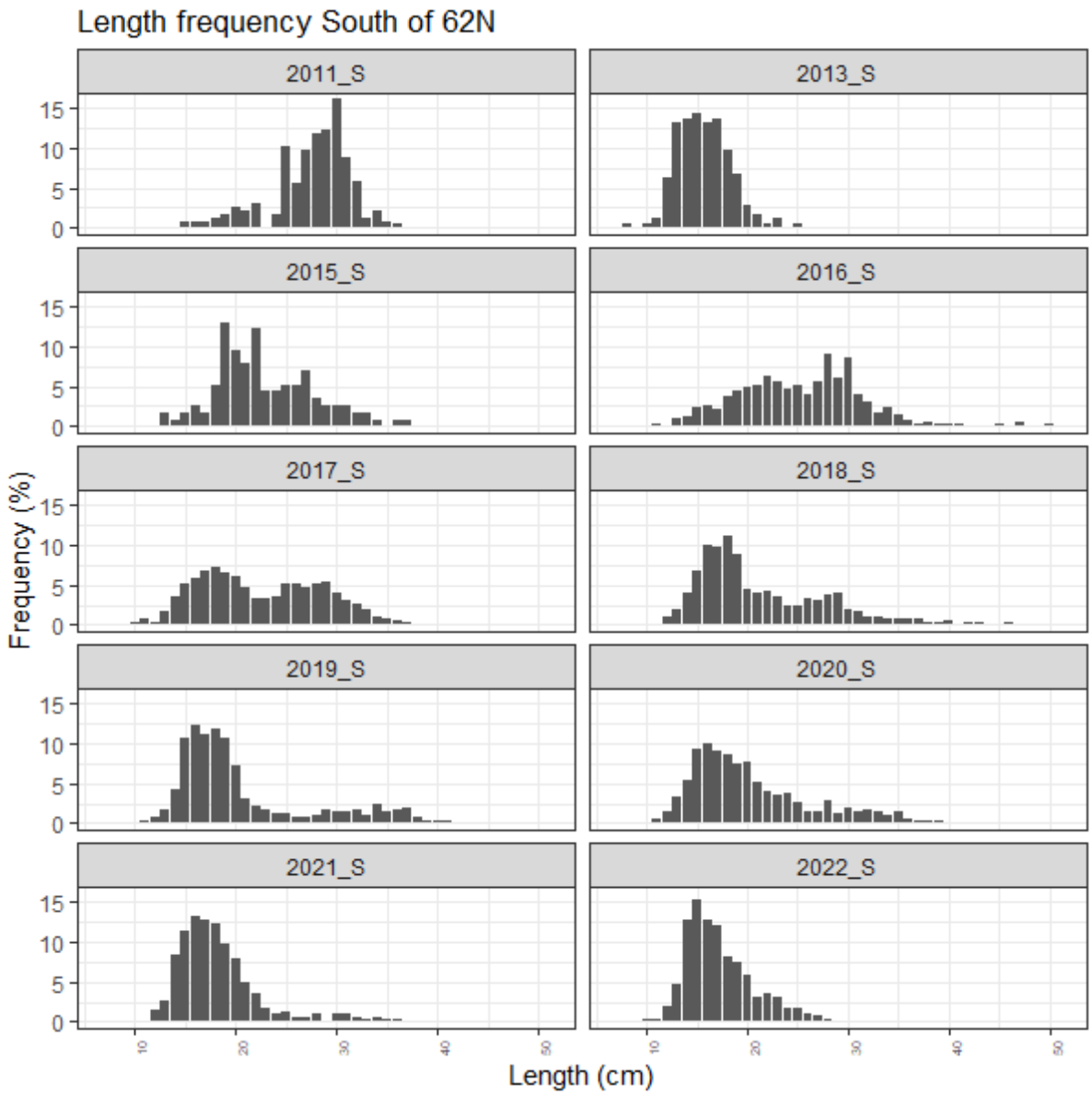


Figure 6.2.6. Greater silver smelt in 1, 2, 3.a and 4. Length distributions in annual samples from Norwegian bycatches south of 62°N (approximately subareas 3 and 4).

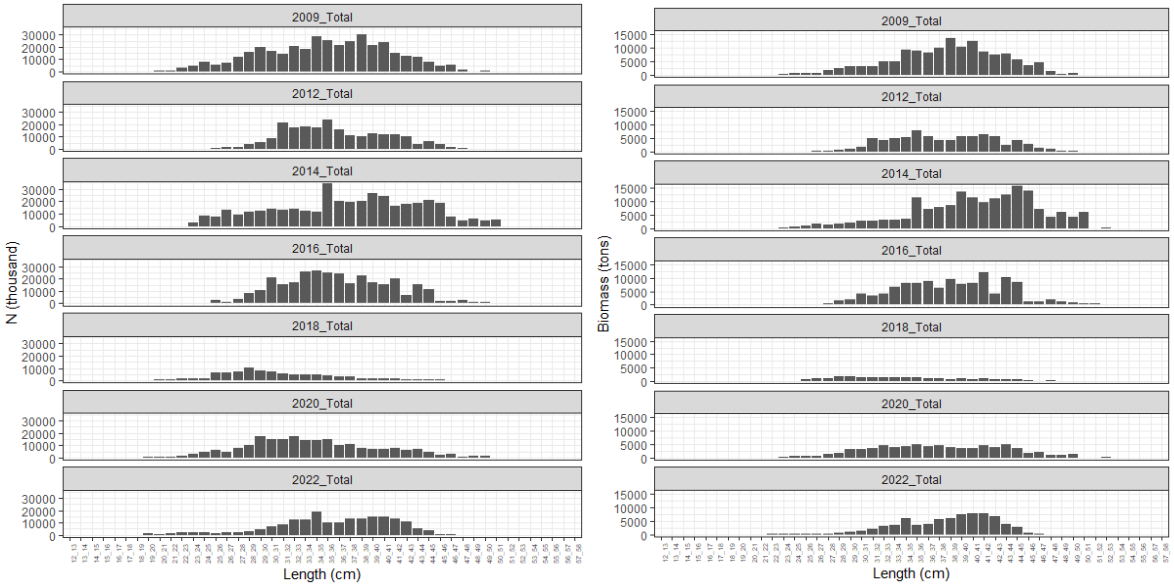


Figure 6.2.7. Length distributions in numbers (left panels) and biomass (tons) (right panels) for greater silver smelt in the Norwegian Sea south-east slope survey in 2009, 2012, 2014, 2016, 2018, 2020 and 2022. Swept area estimates from StoX.

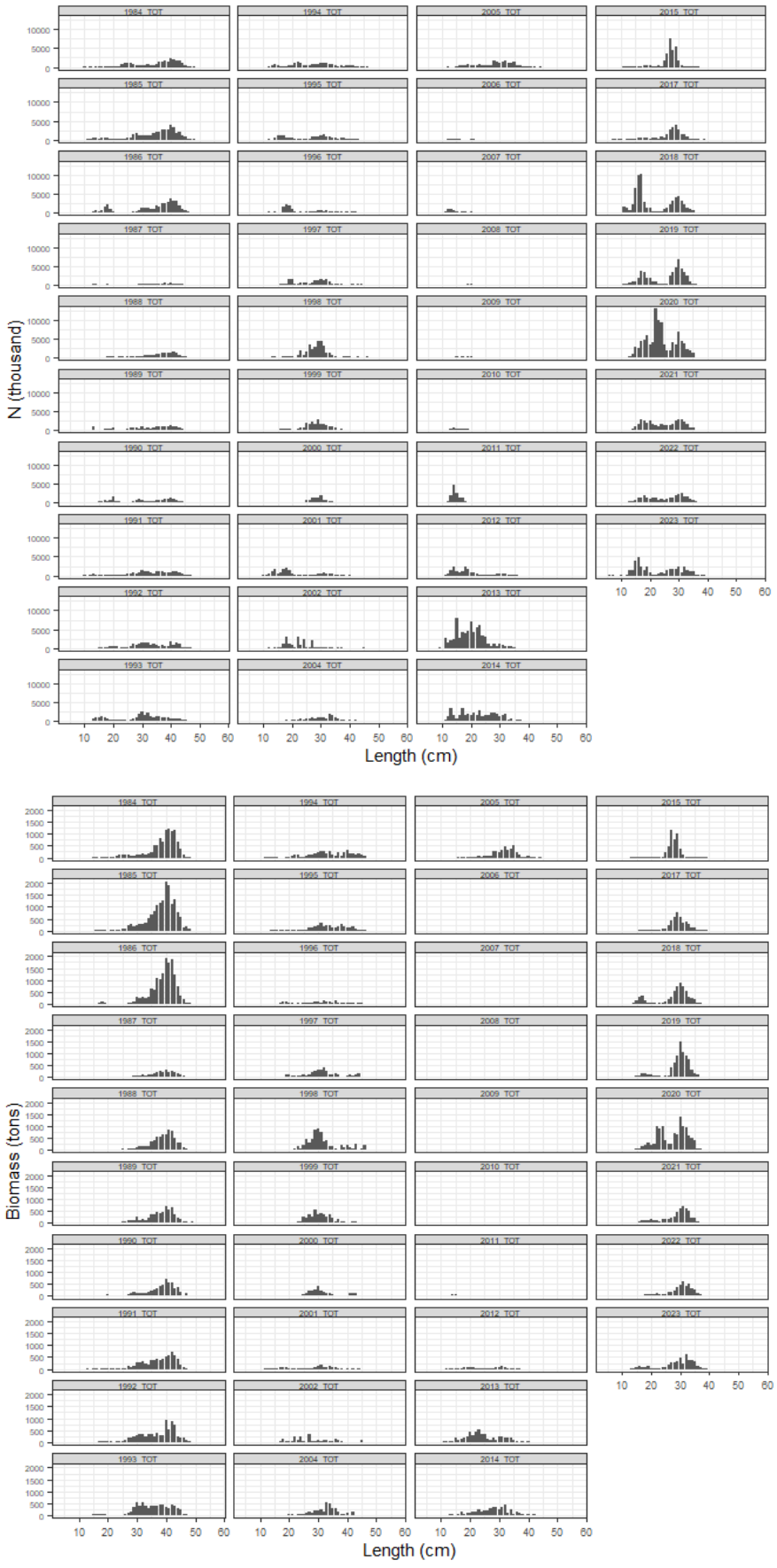


Figure 6.2.8. Length distributions in numbers (upper panels) and biomass (lower panels) for greater silver smelt in the North Sea/Skagerrak survey.

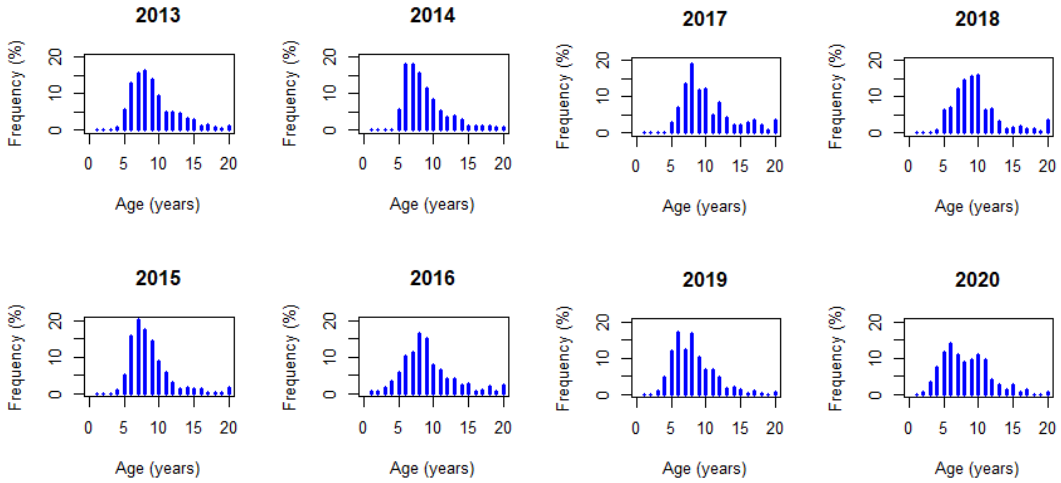


Figure 6.2.9. Greater silver smelt in 1, 2, 3, and 4. Age composition of Norwegian landings samples, 2013-2020.

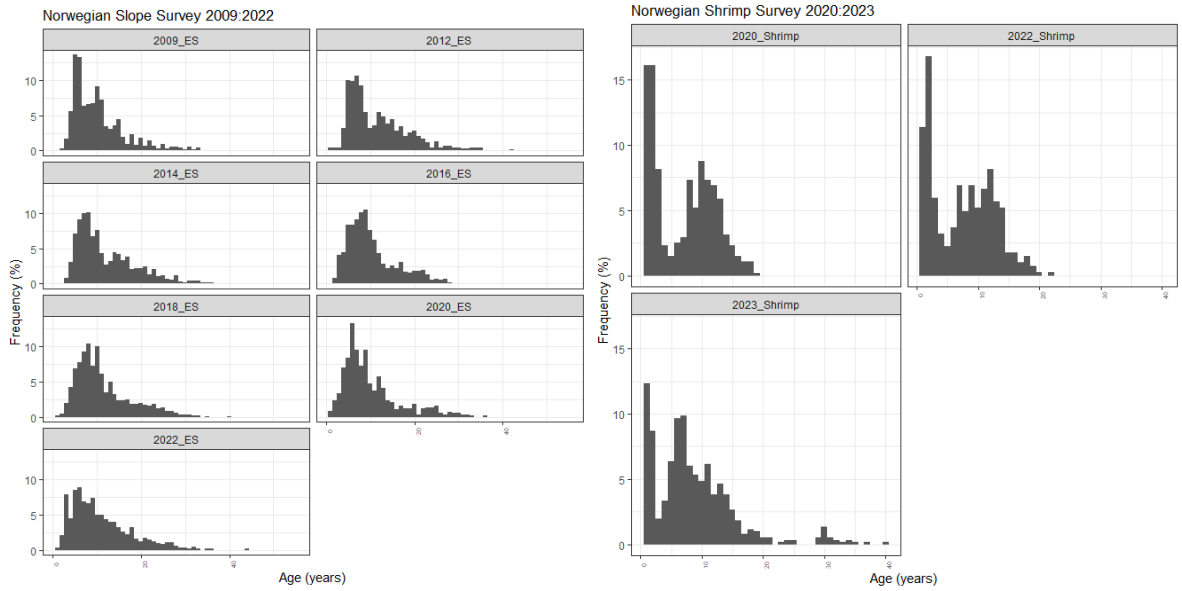


Figure 6.2.10. Age distributions of greater silver smelt from the Norwegian slope survey 2009-2022 (left panels) and the Norwegian Shrimp survey in North Sea/Skagerrak 2020, 2022 and 2023 (right panels).

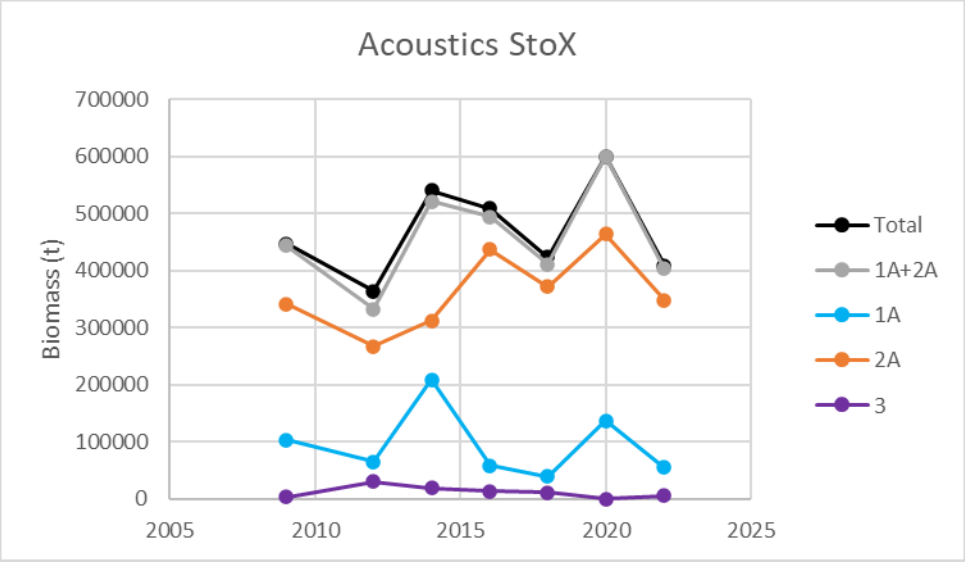


Figure 6.2.11. Acoustic index from the Norwegian Slope survey in subareas 1 and 2. Biomass estimates for different strata (1A, 2A and 3) in the survey are shown, as well as summed estimates for 1A and 2A and total for all strata. Stratum 3 was not covered in 2020 due to covid19 complications in the conduct of the survey.

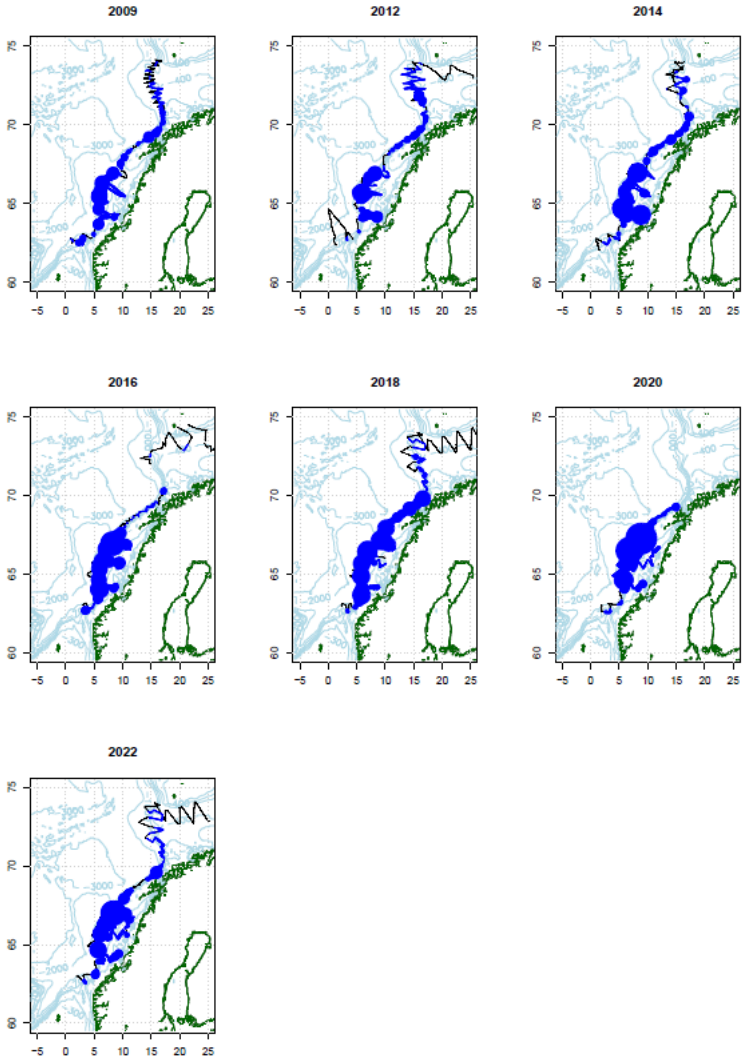


Figure 6.2.12. Greater silver smelt in Division 2.a. Acoustic backscattering strength estimates (SA-values) in Norwegian continental shelf and slope surveys March–April 2009, 2012, 2014, 2016, 2018, 2020 and 2022.

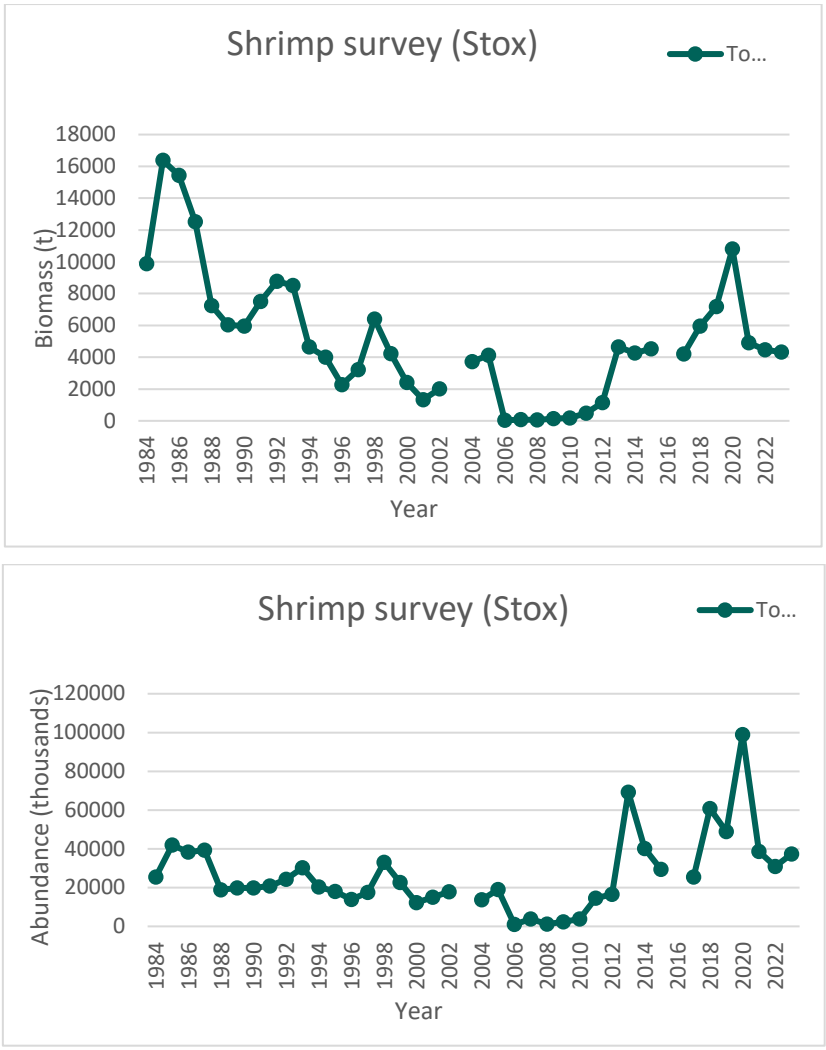


Figure 6.2.13. Swept area total biomass index (upper panel) and swept area total abundance index (lower panel) for greater silver smelt in the shrimp survey in North Sea/Skagerrak. Seasonality of the survey has varied through the years. It was conducted in October 1984-2002, May 2004-2005, February 2006-2007 and in January since then.

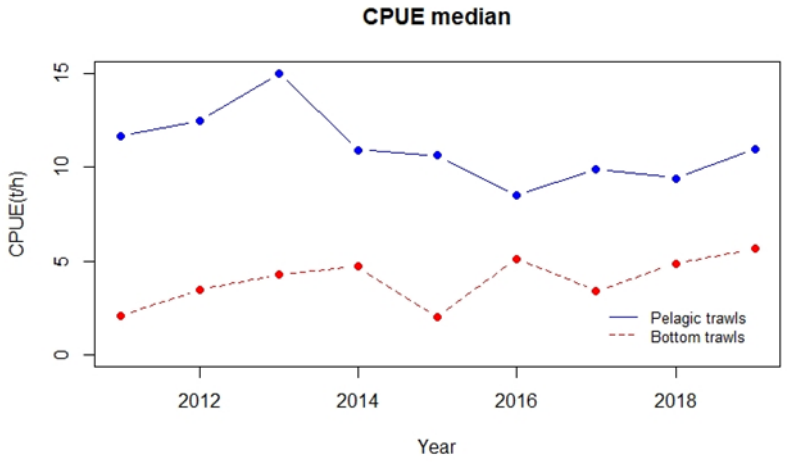
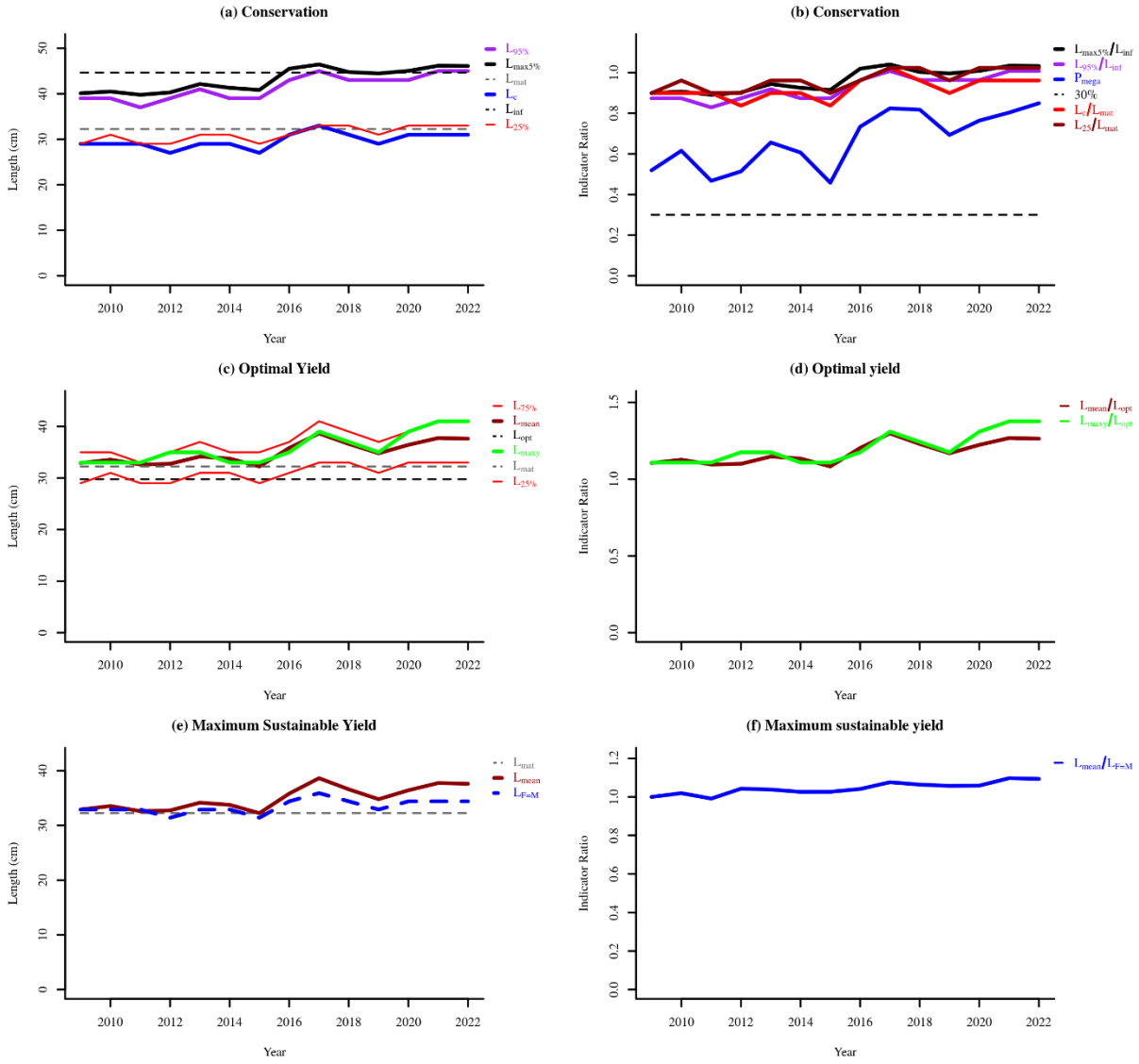


Figure 6.2.14. CPUE from the Norwegian direct fisheries on greater silver smelt in Division 2.a, based on electronic logbooks 2011-2019.



Indicator status for the most recent three years

	Conservation				Optimizing Yield	MSY
Year	L_c / L_{mat}	$L_{25\%}$ / L_{mat}	$L_{max\ 5}$ / L_{inf}	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
2020	0.96	1.02	1.01	0.76	1.22	1.06
2021	0.96	1.02	1.03	0.80	1.27	1.10
2022	0.96	1.02	1.03	0.85	1.26	1.09

Figure 6.2.15. Results from the length-based indicator method (LBI) used for the evaluation of the exploitation status in subareas 1 and 2 run in 2023. Panels a to f show status of conservation, optimising yield, and MSY for all years with length distributions available from the fisheries, and the traffic light system (ICES 2018) table below shows the same in more detail for the last three years.

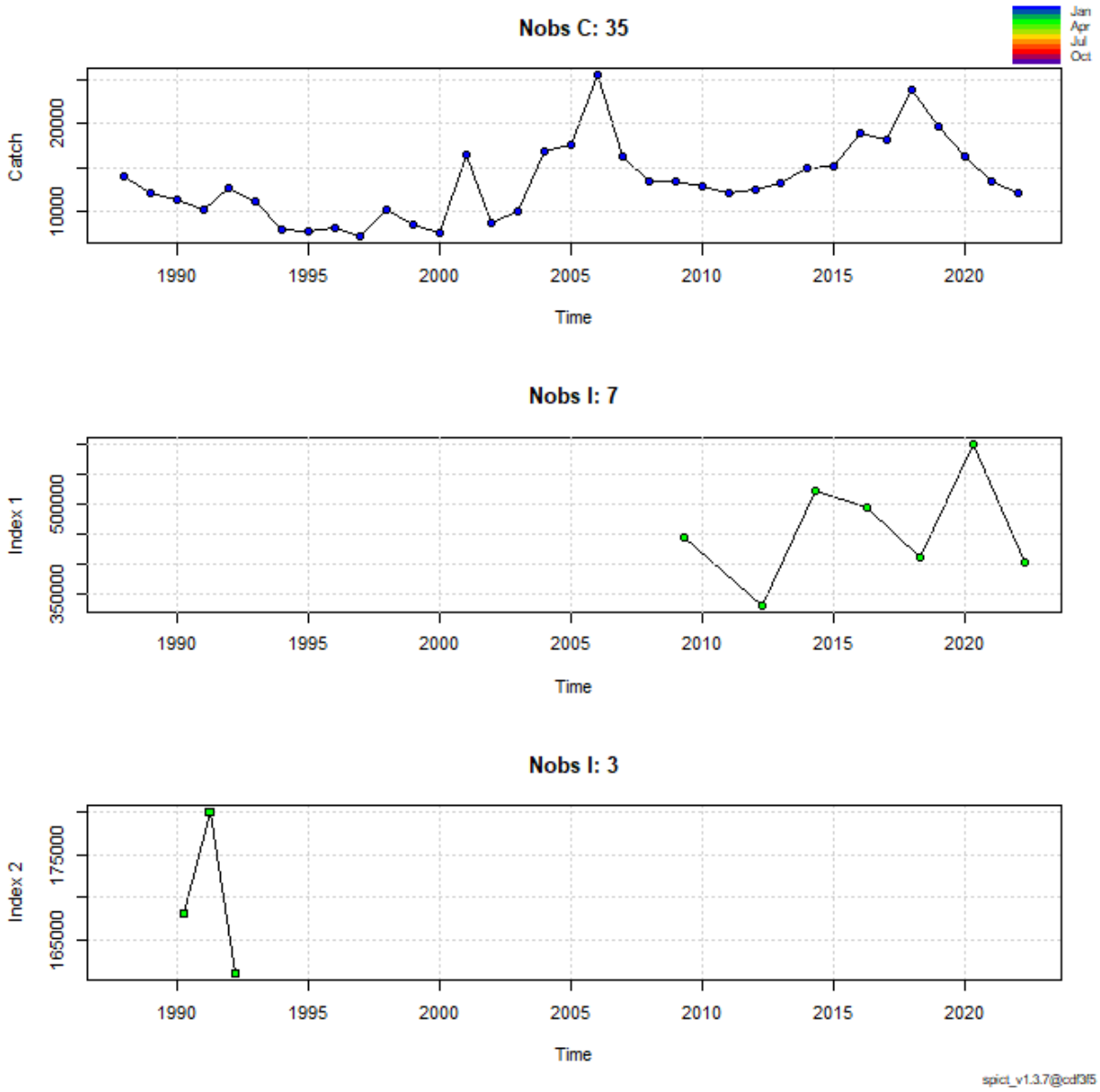


Figure 6.2.16. Input data to the SPiCT analysis. Uppermost panel is catch in tonnes, midpanel is acoustic index from the Norwegian slope survey and lowest panel is acoustic index from surveys at the slope in the 1990s.

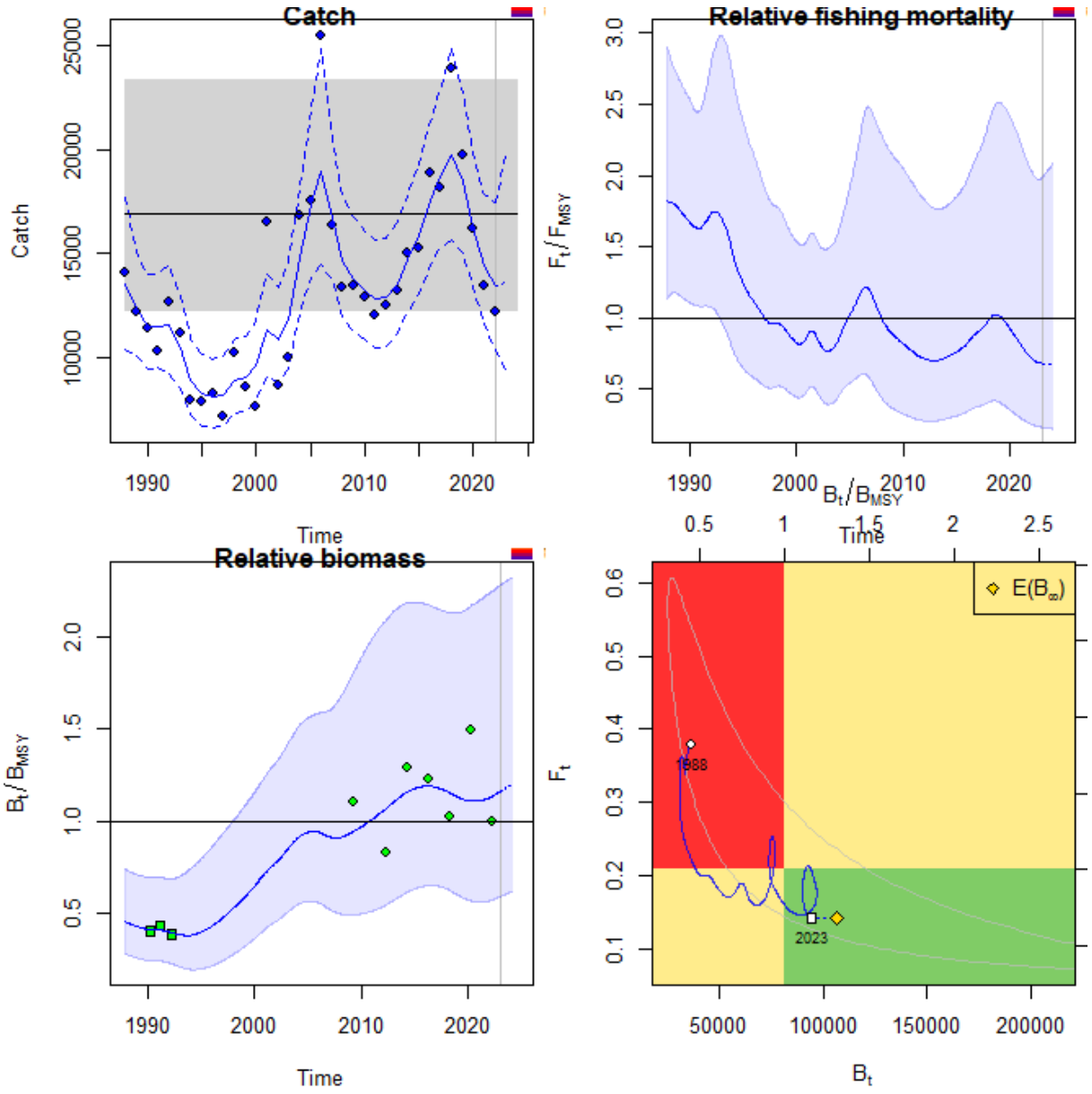


Figure 6.2.17. Results from the SPiCT analysis.

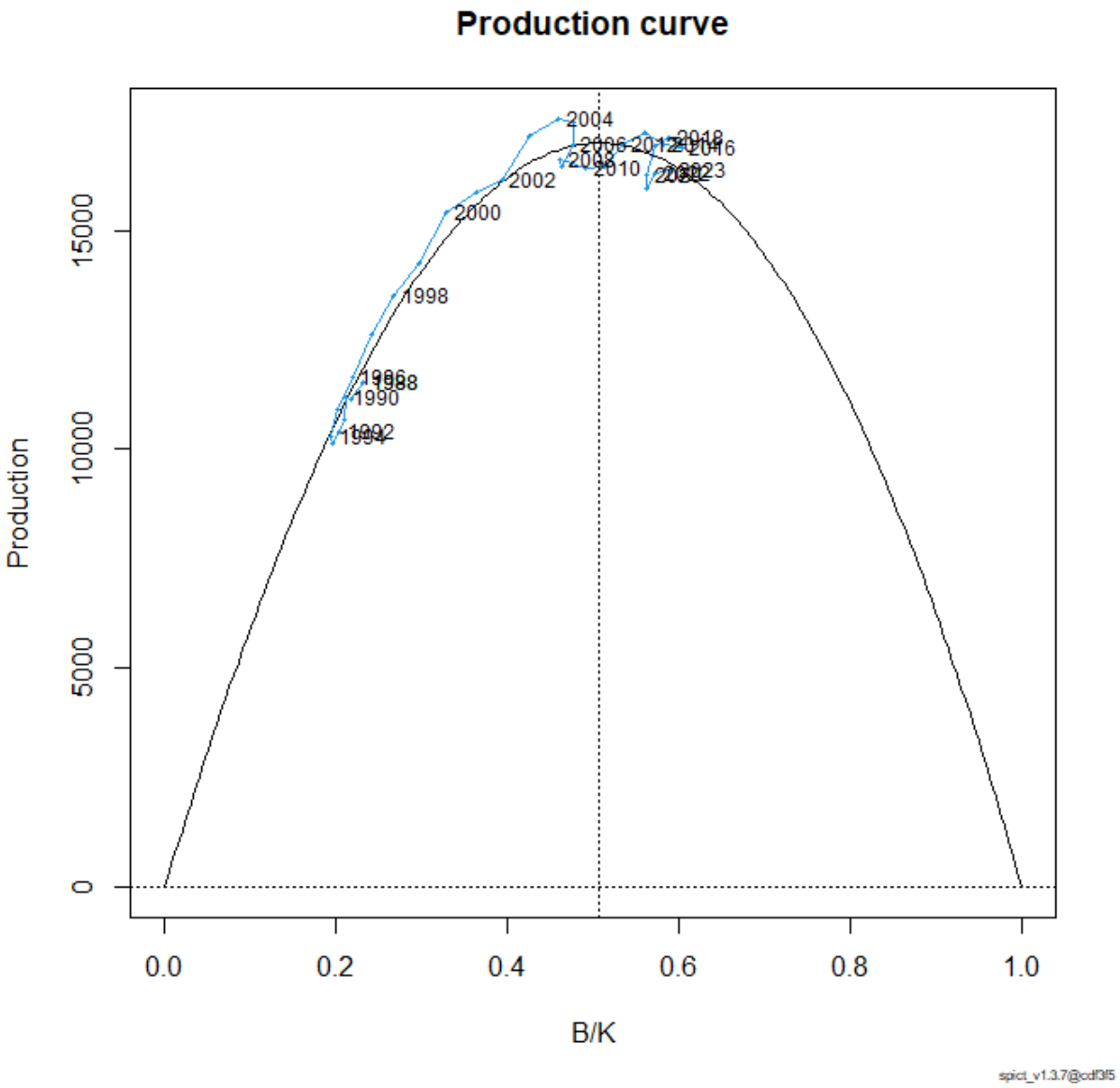


Figure 6.2.18 Production curve from the SPiCT analysis.

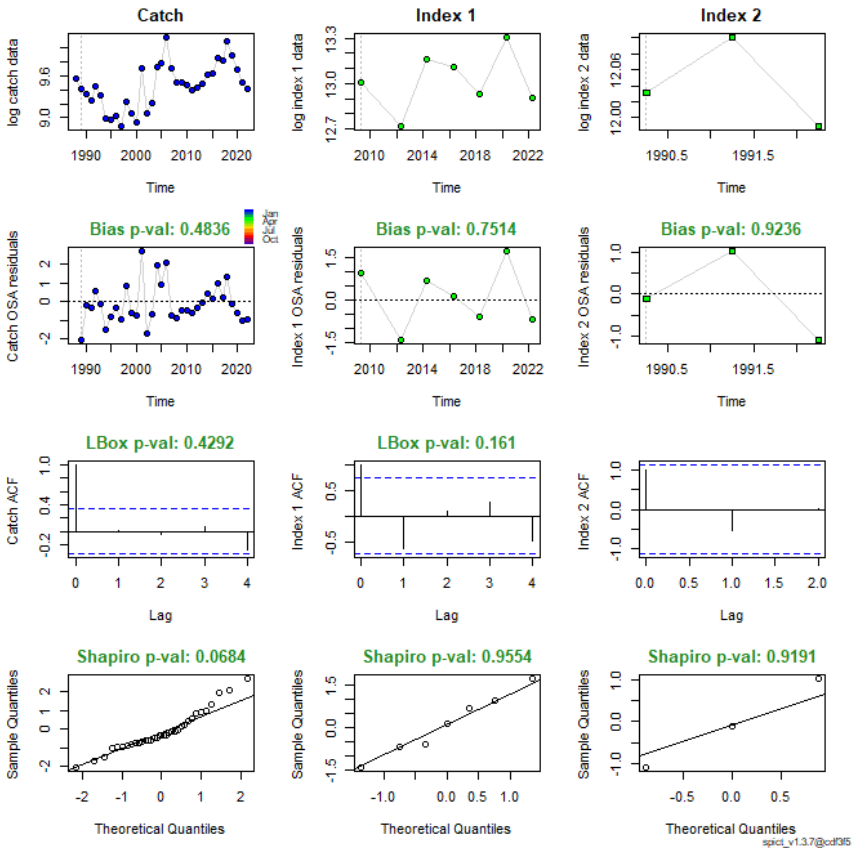


Figure 6.2.19. Diagnostics from the SPiCT analysis.

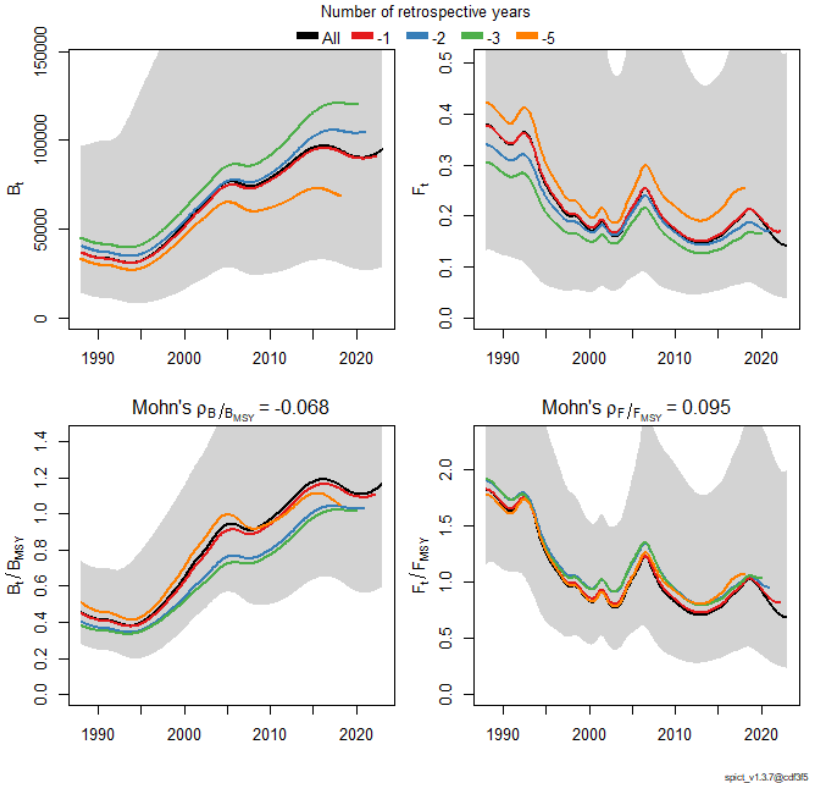


Figure 6.2.20. Retrospective analysis from the SPiCT analysis.

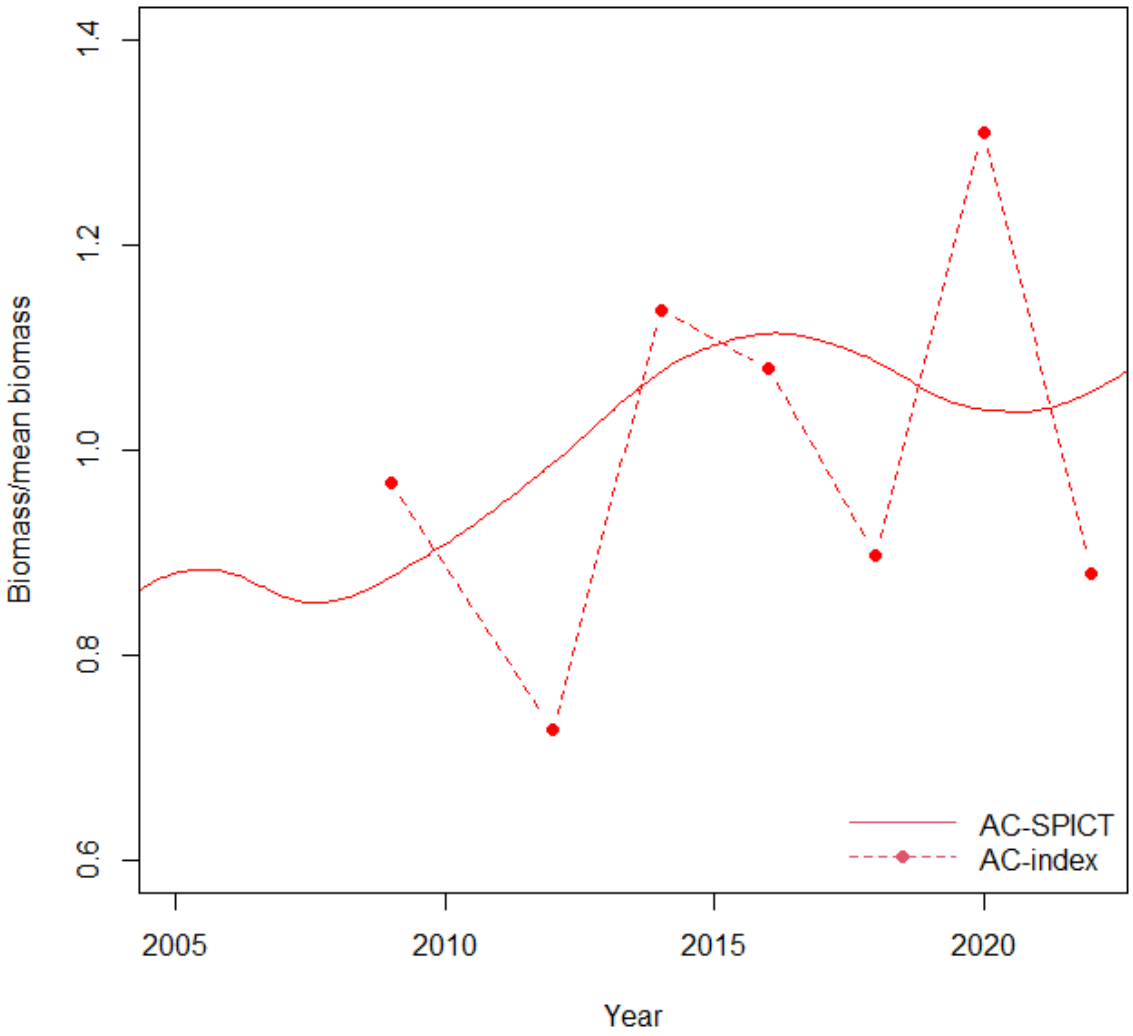


Figure 6.2.21. Relative biomass (estimated biomass/mean) from the SPiCT analysis with the acoustic index from the Norwegian slope survey.

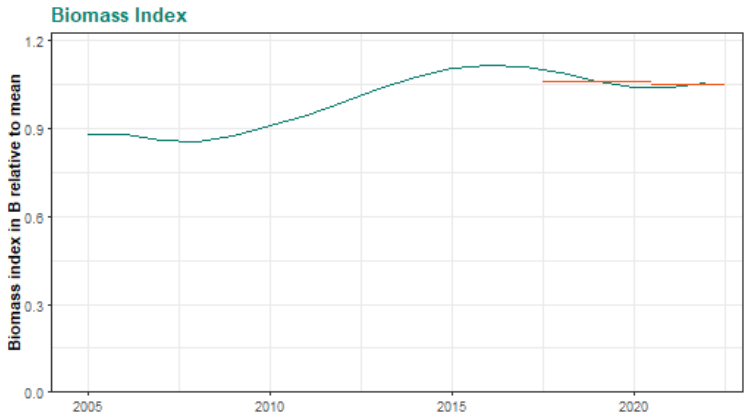


Figure 6.2.22. Relative biomass (estimated biomass/mean) used in rfb-rule, index A and index B.

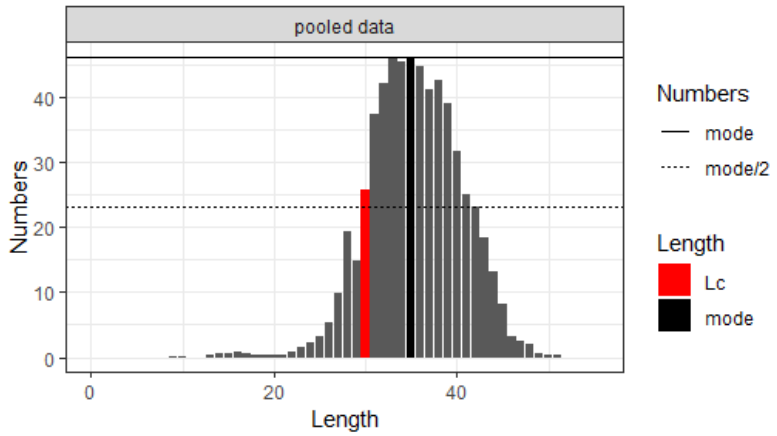


Figure 6.2.23. Pooled length distributions (year 2015-2022), including Lc and mode length.

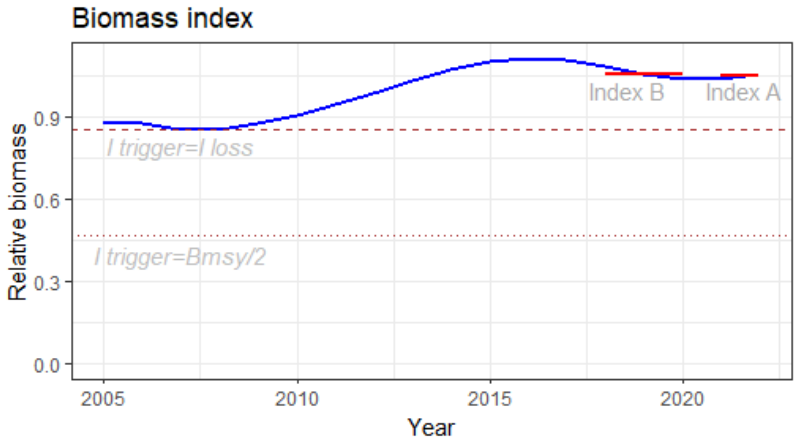


Figure 6.2.24. Relative biomass used in rfb-rule, including lines showing index A, index B, $I_{trigger} = I_{loss}$, and $I_{trigger} = B_{MSY}/2$.

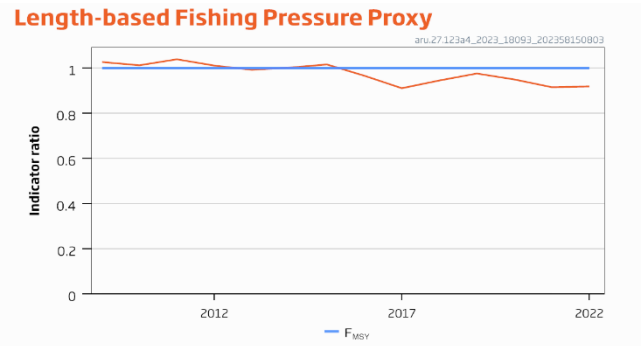


Figure 6.2.25. Length-based fishing pressure proxy. Indicator ratio LF= M/Lmean (inverse of the indicator ratio, f) from the length-based indicator (LBI) method is used for the evaluation of the exploitation status. The proxy fishing pressure is less than that corresponding to the FMSY proxy (LF= M) when the indicator ratio value is lower than 1 (shown by the horizontal blue line).

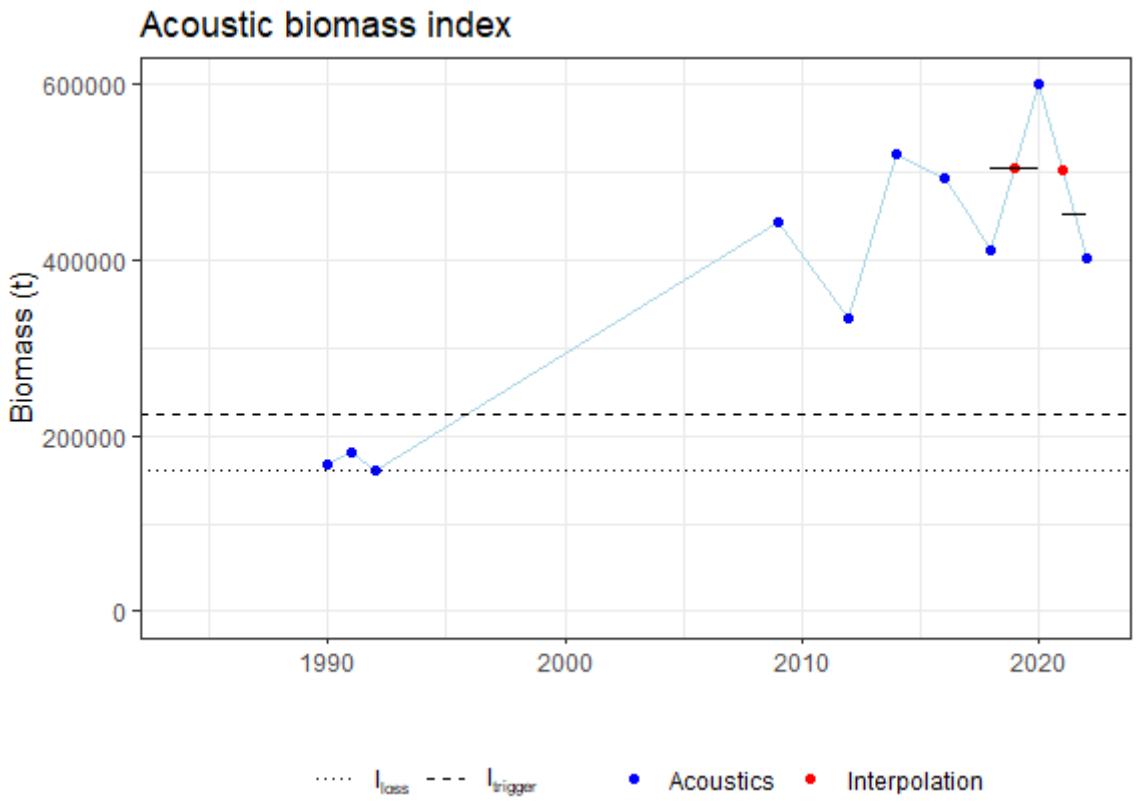


Figure 6.2.26. Acoustic biomass used in rfb-rule Reference valus I_{loss} and $I_{trigger}$ are shown, and index value A and B (blak solid lines).

6.3 Greater silver smelt (*Argentina silus*) in 5.a and 14

6.3.1 The fishery

Greater silver smelt is mostly fished along the south and southwest coast of Iceland, at depths between 500 and 800 m, as targeted fishing is only allowed at depths greater than 400 m (Figure 6.3.1). Greater silver smelt has been caught in bottom trawls for years as a bycatch in the redfish fishery. Only small amounts were reported prior to 1996 as most of the greater silver smelt was discarded. However, discarding is not considered significant because of the relatively large mesh size used in the redfish fishery. Since 1997, a directed fishery for greater silver smelt has been ongoing. This caused the landings to increase significantly in the past with the highest amount recorded in 2010, despite relatively low recent levels (Table 6.3.1).

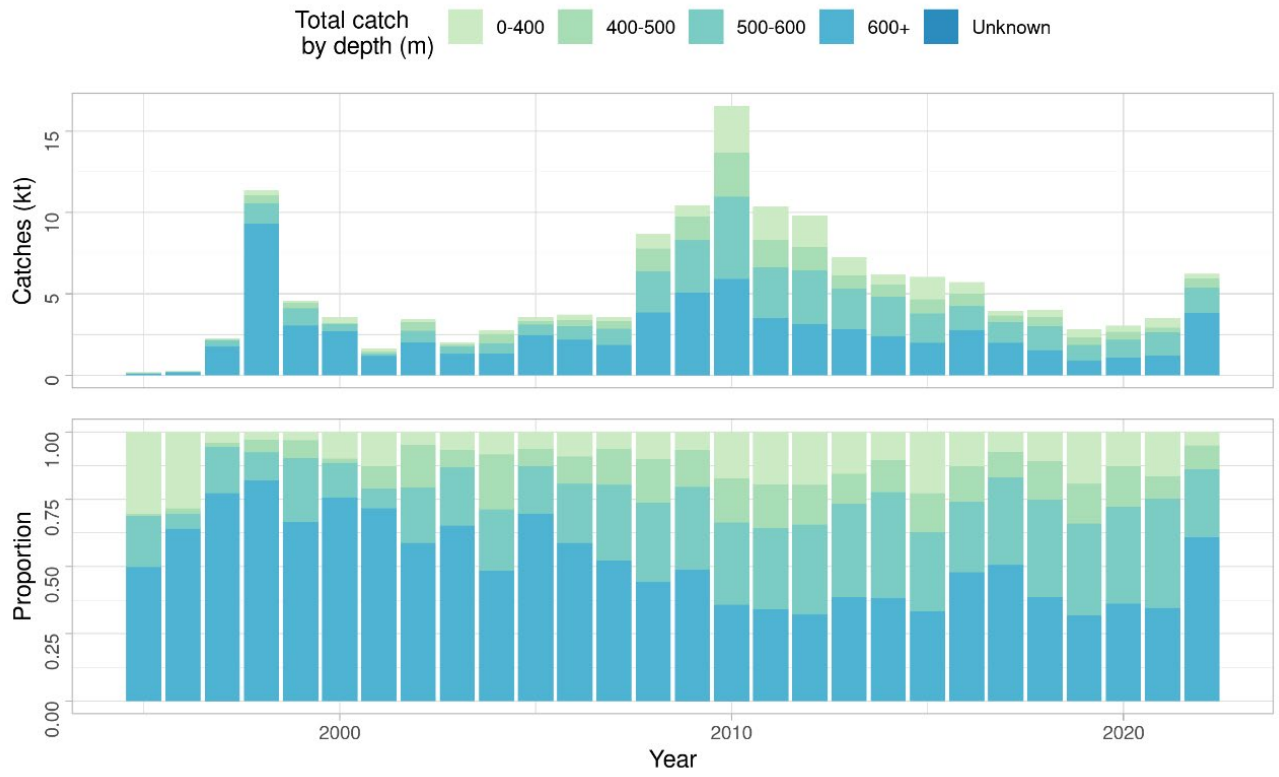


Figure 6.3.1: Greater silver smelt in 5.a and 14. Depth distribution of catches in 5.a according to Icelandic logbooks. All gear combined.

Table. 6.3.1. Greater silver smelt in 5.a and 14. Landings (tonnes) records from the Icelandic directorate of Fisheries and Greenland (WD05, annexed to this report).

Year	Inside the NEAFC RA	Outside the NEAFC RA		Landings (tonnes)
		Section 5.a	Section 14.b	
1988				240
1989				8
1990				113
1991				246
1992				657
1993				1526
1994				756
1995				586
1996				881
1997				3935
1998				15242

Year	Inside the NEAFC RA	Outside the NEAFC RA		Landings (tonnes)
		Section 5.a	Section 14.b	
1999				6681
2000				5657
2001				3043
2002				4960
2003				2680
2004				3645
2005				4482
2006				4769
2007				4227
2008				8778
2009				10828
2010				16428
2011				10516
2012				9289
2013	0	7155		7155
2014	0	6344	4	6348
2015	0	6058	12	6070
2016	0	5646	16	5662
2017	0	4344	666	5010
2018	0	4035	425	4460
2019	0	3208-9	1	3210
2020	0	3775	22	3797
2021	0	4140	15	4155
2022	0	6886	28	6914

6.3.2 Fleets

Since 1996 between 20 and 40 trawlers have annually reported catches of greater silver smelt in 5.a (WGDEEP 2019, Table 6.3.2). The trawlers participating in the greater silver smelt fishery also target redfish (*Sebastes marinus* and *S. mentella*) and to a lesser extent Greenland halibut and blue ling. The number of hauls peaked in 2010, but the number of hauls have decreased since then in line with lower total catches. In most years, over 50% of the greater silver smelt catches were taken in hauls where the species composed more than 50% of the catch (Table 6.3.2).

Table 6.3.2: Greater silver smelt in 5.a. Information on the fleet reporting catches of greater silver smelt.

Year	Number of trawlers	Number of hauls	Reported catch (kg)	No. hauls which GSS > 50% of catch	Proportion of reported catch in hauls where GSS > 50%
1987	1	14	4740	3	0.6751055
1988	2	146	224700	50	0.5718736
1990	1	24	46350	10	0.6256742
1991	13	114	74210	7	0.2641153
1992	23	275	230782	16	0.2032221
1993	25	317	772031	98	0.7282091
1994	16	151	304550	52	0.7832868
1995	24	200	180736	21	0.4039040
1996	22	307	259660	29	0.4039898
1997	26	874	2281654	355	0.8216162
1998	40	2683	11388707	1991	0.9465763
1999	25	1509	4563652	810	0.8485031
2000	23	1301	3549812	608	0.7971971
2001	26	794	1606420	245	0.6920637
2002	32	1160	3158313	468	0.7440289
2003	30	1176	2005477	213	0.4732091
2004	27	1052	2732879	292	0.6527805
2005	30	1388	3557625	335	0.7069759
2006	31	1554	3735916	355	0.6897529
2007	27	1275	3469927	416	0.7179114
2008	31	3256	8568592	848	0.6478629
2009	34	3555	10425146	1010	0.6804055
2010	36	4846	16499826	1821	0.7271470
2011	34	3309	10237373	961	0.7151100
2012	31	3395	9775676	988	0.7103783

Year	Number of trawlers	Number of hauls	Reported catch (kg)	No. hauls which GSS > 50% of catch	Proportion of reported catch in hauls where GSS > 50%
2013	31	2743	7246715	609	0.6418890
2014	24	2363	6195337	487	0.6076312
2015	24	2195	5835439	356	0.5735490
2016	26	2096	5718623	385	0.5926304
2017	21	1363	3894310	236	0.5844221
2018	20	1440	3892702	215	0.4785869
2019	28	1169	2569762	143	0.5063064
2020	25	1170	2968000	174	0.4750000
2021	27	1166	3438890	189	0.6629520
2022	18	782	2802636	223	0.7358009

6.3.3 Targeting and mixed fisheries issues in the Greater Silver Smelt fishery in 5.a

6.3.3.1 Mixed fisheries issues: species composition in the fishery

Redfish spp. (*Sebastus marinus* and *S. mentella*) are the main bycatch species in the mixed fishery encompassing greater silver smelt. Other species of lesser importance are Greenland halibut, blue ling and ling. Other species than these rarely exceed 10% of the bycatch in the greater silver smelt fishery in 5.a (ICES 2021).

6.3.3.2 Spatial distribution of catches through time

Spatial distribution of catches (5.a and 14) in 2000– 2021 is presented in Figure 6.3.2 and Figure 6.3.3. Most of the catches have been from the southern edge of the Icelandic shelf. However, since 1993, there has been a gradual increase in the proportion caught in the western area and even in the north western area. The likely reason for this is that the fleet focusing on redfish and Greenland halibut in more northern regions also takes a few hauls of greater silver smelt in the area (Figure 6.3.2).

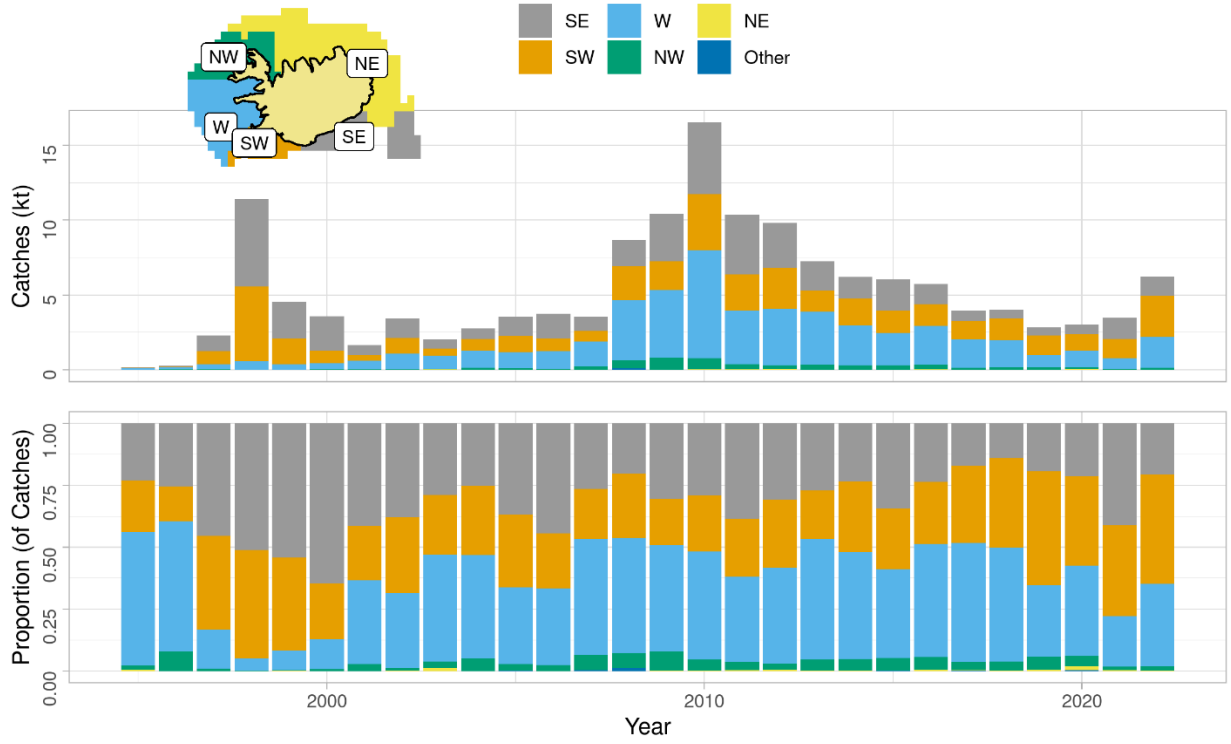


Figure 6.3.2: Greater silver smelt in 5.a and 14. Spatial distribution of catches defined by regions deeper than 400 m by year (See stock annex for details). Above are the catches on absolute scale and below in proportions. All gears combined.

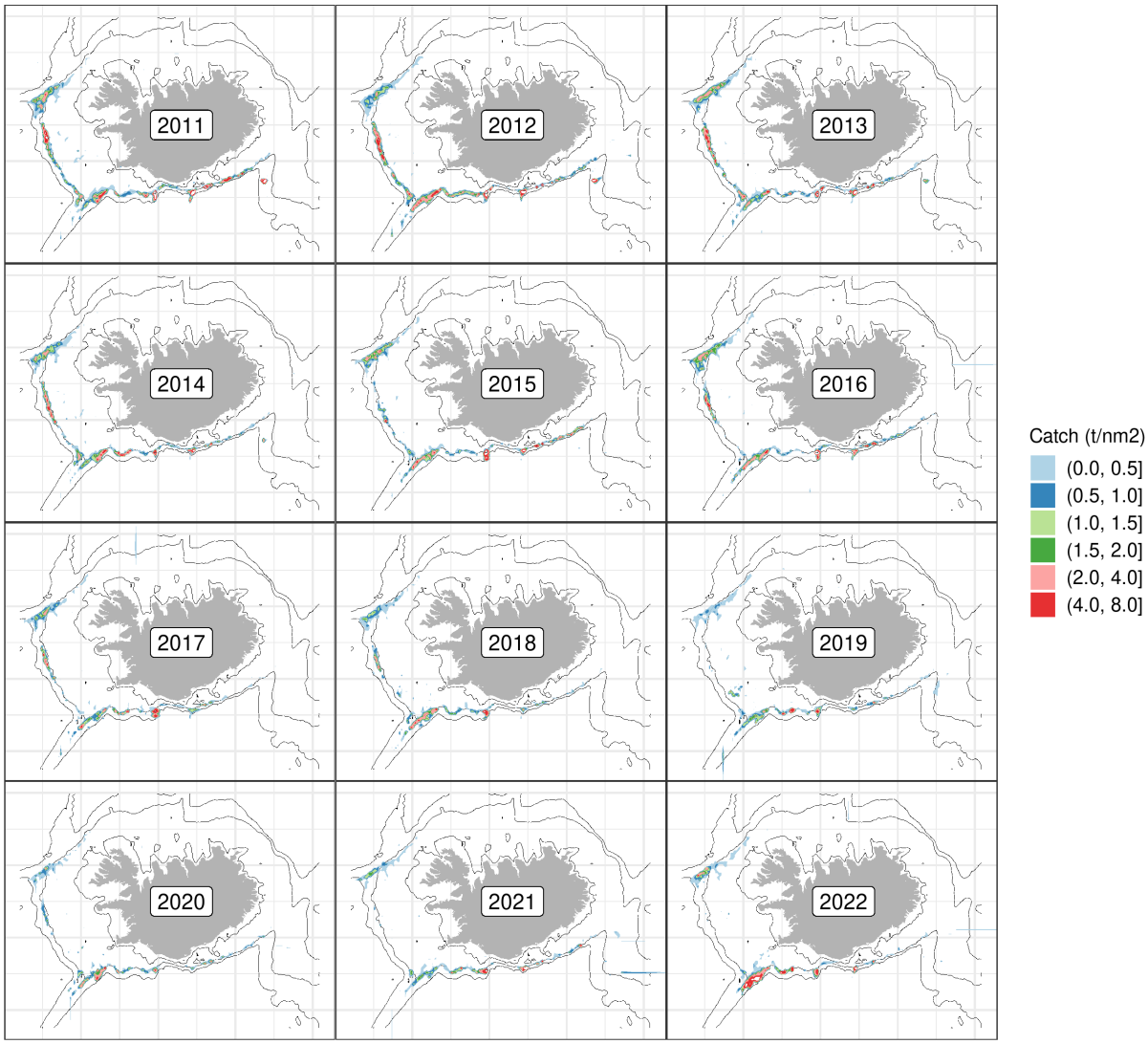


Figure 6.3.3: Greater silver smelt in 5.a and 14. Spatial distribution of the Icelandic fishery catches as reported in logbooks. All gears combined.

6.3.4 Landing trends

Landings of Greater Silver Smelt are presented in Table 6.3.1 and Figure 6.3.4. Since directed fishery started in 1997–1998, the landings increased from 800 t in 1996 to 13 000 t in 1998. Between 1999 and 2007 catches varied between 2 600 to 6 700 t. After 2007 landings increased substantially, from 4 200 t in 2007 to almost 16 500 t in 2010. In 2011 landings started to decrease due to increased management actions, and landings in 2022 amounted to 6914 tonnes in 14 and 5.a. Substantial landings were reported in Greenlandic waters in 2017 and 2018; however, these exploratory directed fisheries appear to have ceased in 2019 but should be monitored for reappearance.

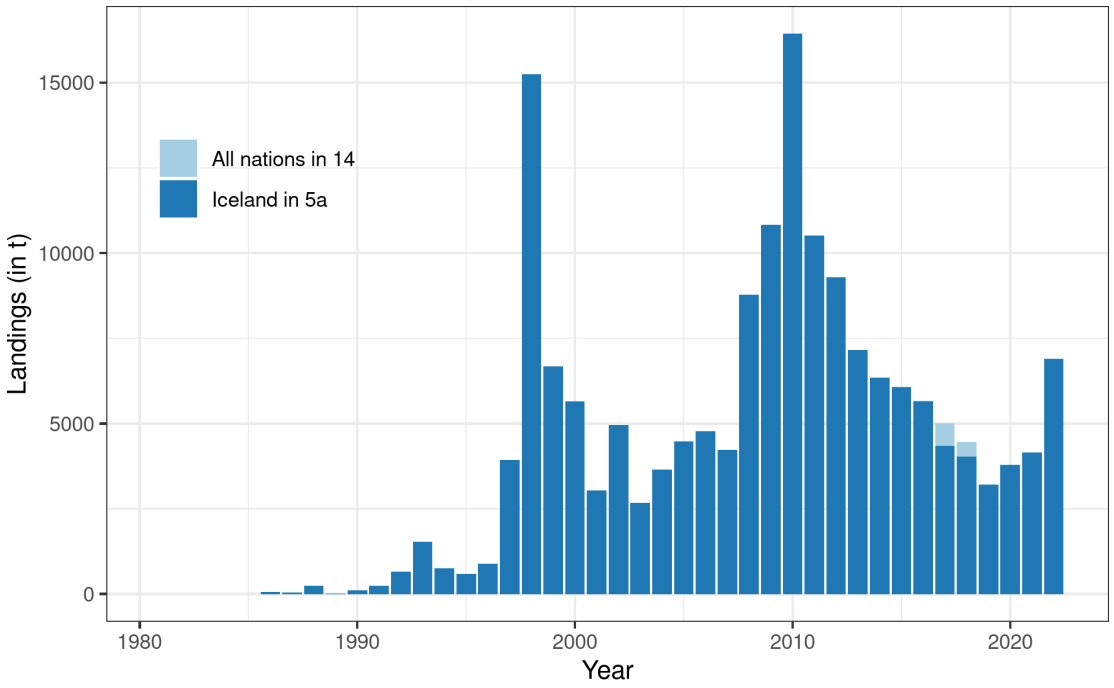


Figure 6.3.4: Greater silver smelt in 5.a and 14. Nominal landings. 23 tonnes were landed by foreign vessels (England and Wales) in 1999, which is the only year of catches reported by foreign vessels.

6.3.5 Data available

In general sampling is considered representative from commercial catches, as one of the requirements of owning a fishing license for greater silver smelt is the retention of scientific samples (Table 6.3.3). Samples were only obtained from bottom trawls. The sampling does seem to cover the spatial and temporal distribution of catches. The sampling coverage in 2020 is shown in Figure 6.3.5. However, recent years have experienced a large decline in sampling. No age data were collected in 2019.

Table 6.3.3: Greater silver smelt in 5.a. Summary of sampling intensity and overview of available data.

Year	No. length samples	No. length measurements	No. otolith samples	No. otoliths	No. otoliths aged
1997	48	4991	31	1447	1059
1998	148	15557	114	6966	889
1999	58	4163	44	2180	82
2000	27	2967	18	1011	113
2001	10	489	6	245	17
2002	21	2270	10	360	127
2003	63	5095	13	425	
2004	34	996	7	225	84
2005	49	3708	14	772	
2006	29	4186	13	616	525
2007	14	2158	8	285	272

Year	No. length samples	No. length measurements	No. otolith samples	No. otoliths	No. otoliths aged
2008	44	3726	39	1768	1387
2009	53	5701	36	1746	1574
2010	134	16351	68	3370	3120
2011	63	6866	40	1953	1774
2012	43	4440	31	1492	603
2013	47	4925	34	710	704
2014	39	4709	16	350	340
2015	11	1275	8	221	217
2016	45	5879	13	285	283
2017	29	3466	21	430	416
2018	12	1437	9	185	181
2019	8	1010	0	40	40
2020	8	1566	2	130	130
2021	13	1205	4	195	194
2022	4	381	2	105	105

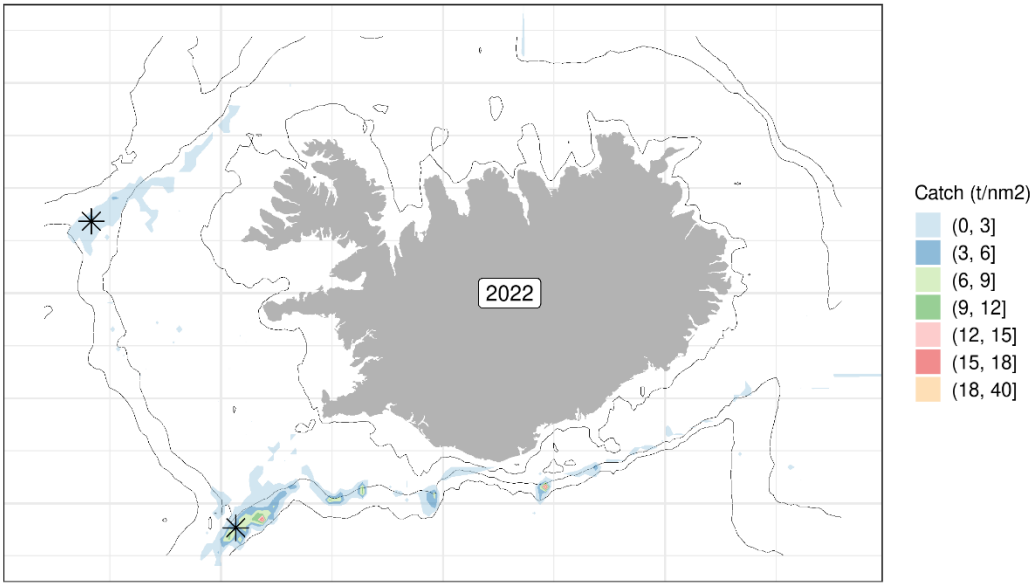


Figure 6.3.5: Greater silver smelt in 5.a and 14. Fishing grounds in 2022 as catches reported in logbooks (tiles) and positions of samples taken from landings (asterisks).

6.3.6 Landings and discards

Landings by Icelandic vessels are given by the Icelandic Directorate of Fisheries. Discarding is banned in Icelandic waters, and currently there is no available information on greater silver smelt discards. It is however likely that unknown quantities of greater silver smelt were discarded prior to 1996.

6.3.7 Catch, effort and research vessel data

6.3.7.1 Catch per unit of effort and effort data from commercial fisheries

At WKDEEP 2010 a glm cpue series was presented (WKDEEP 2010, GSS-05), however because of strong residual patterns the group concluded that the glm-cpue series was not suitable to use as an indicator of stock trends. The cpue is not considered to represent changes in stock abundance as the fishery is mostly controlled by market factors, oil prices and quota status in other species, mainly redfish.

6.3.7.2 Icelandic survey data

The Icelandic spring groundfish survey, which has been conducted annually in March since 1985, gives trends on fishable biomass of many exploited stocks on the Icelandic fishing grounds. In total, about 550 stations are taken annually at depths down to 500 m. The survey area does not cover the most important distribution area of the greater silver smelt fishery in 5.a and is therefore not considered representative of stock biomass. The survey may be indicative of recruitment; however, the data have not been explored in sufficient detail to be used for this purpose. In addition, the autumn survey was commenced in 1996 and expanded in 2000. A detailed description of the autumn groundfish survey is given in the stock annex for greater silver smelt in 5.a. The survey is considered representative of stock biomass of greater silver smelt since it was expanded in 2000, as it covers deeper waters where larger greater silver smelt are found and fished (> 400 m, due to a regulation requiring this). Figure 6.3.6 gives trends in biomass density and juvenile density (numbers) for the spring survey in 1985 to 2022 and for the autumn survey to 2021. Figure 6.3.7 gives the most recent catch quantities and locations of surveys. Due to industrial action in 2011 the autumn survey was cancelled after about one week of survey time. Greater Silver Smelt is among the most difficult demersal fish stocks to get reliable information on from bottom-trawl surveys. This is in large part because most of the greater silver smelt caught in the survey is taken in few but relatively large hauls. This can result in very high indices with large variances particularly if the tow-station in question happens to be in a large stratum with relatively few tow-stations. For example, survey indices in 1999, 2014, 2021 and 2022 are especially high in comparison with survey indices from adjacent years (Figure 6.3.6). For this reason, winsorisation has been done in the past to reduce the effects of these hauls. However, winsorisation is not necessary for the gadget model and has not been used since 2020. No substantial changes in proportional catch by area is seen in general (Figure 6.3.8).

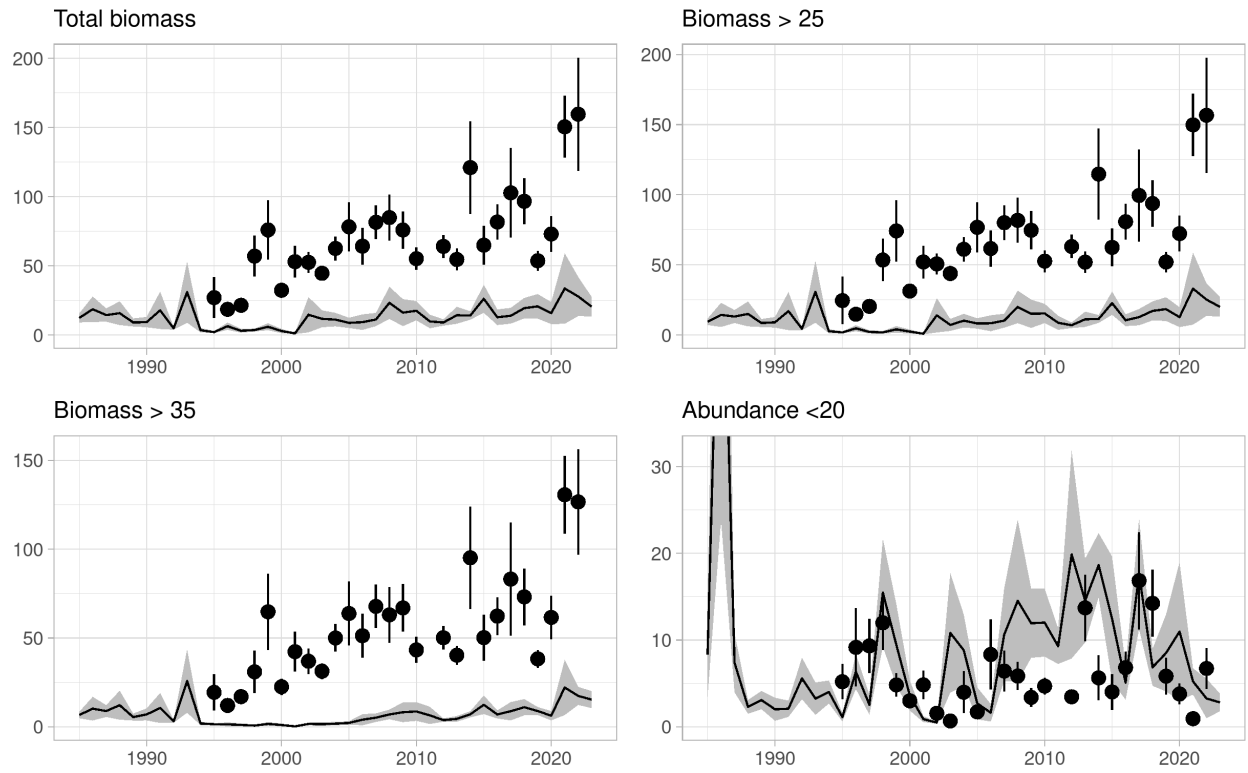


Figure 6.3.6. Greater silver smelt in 5.a and 14. Indices calculated from the Icelandic spring survey (black lines and shaded area) and from the autumn survey (dots and vertical lines). Vertical lines and shaded area represent +/- 1 standard error.

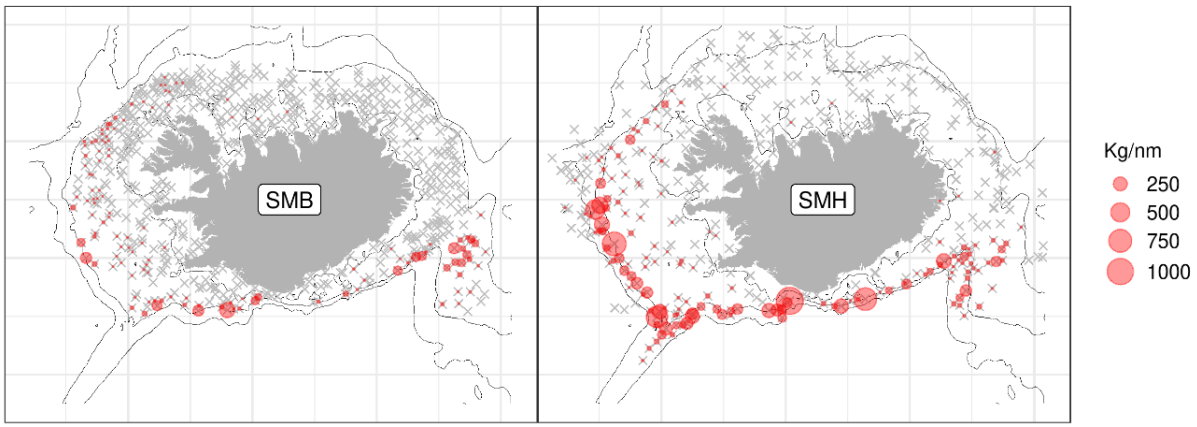


Figure 6.3.7: Greater silver smelt in 5.a and 14. Abundance and distribution of greater silver smelt in the spring survey (SMB) in 2023 and in the autumn survey (SMH) in 2022.

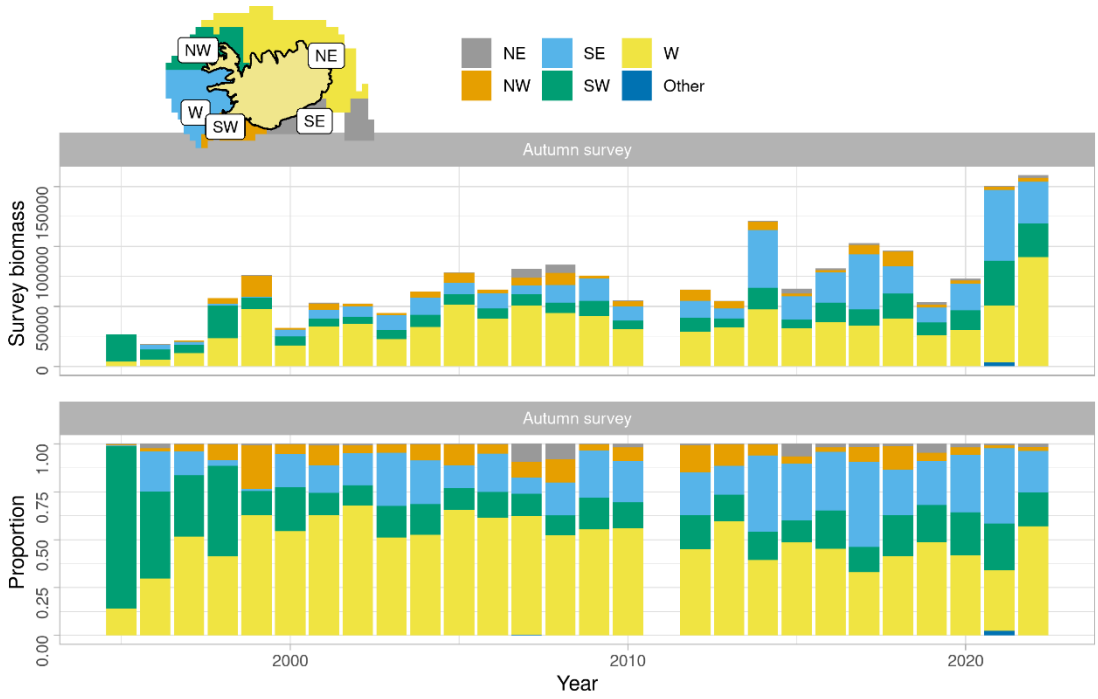


Figure 6.3.8: Greater silver smelt in 5.a and 14. Estimated survey biomass in the autumn survey by year from different parts of the continental shelf (upper panel) and as a proportion of the total (lower panel).

6.3.7.3 Length compositions

Table 6.3.2 gives the number of samples and measurements available for calculations of catch in numbers of Greater Silver Smelt in 5.a. Length distributions from autumn survey and commercial samples are presented in Figure 6.3.9 and Figure 6.3.10 respectively. Length distributions from the autumn survey are rather stable, with 2022 being close to the long-term average (Figure 6.3.9).

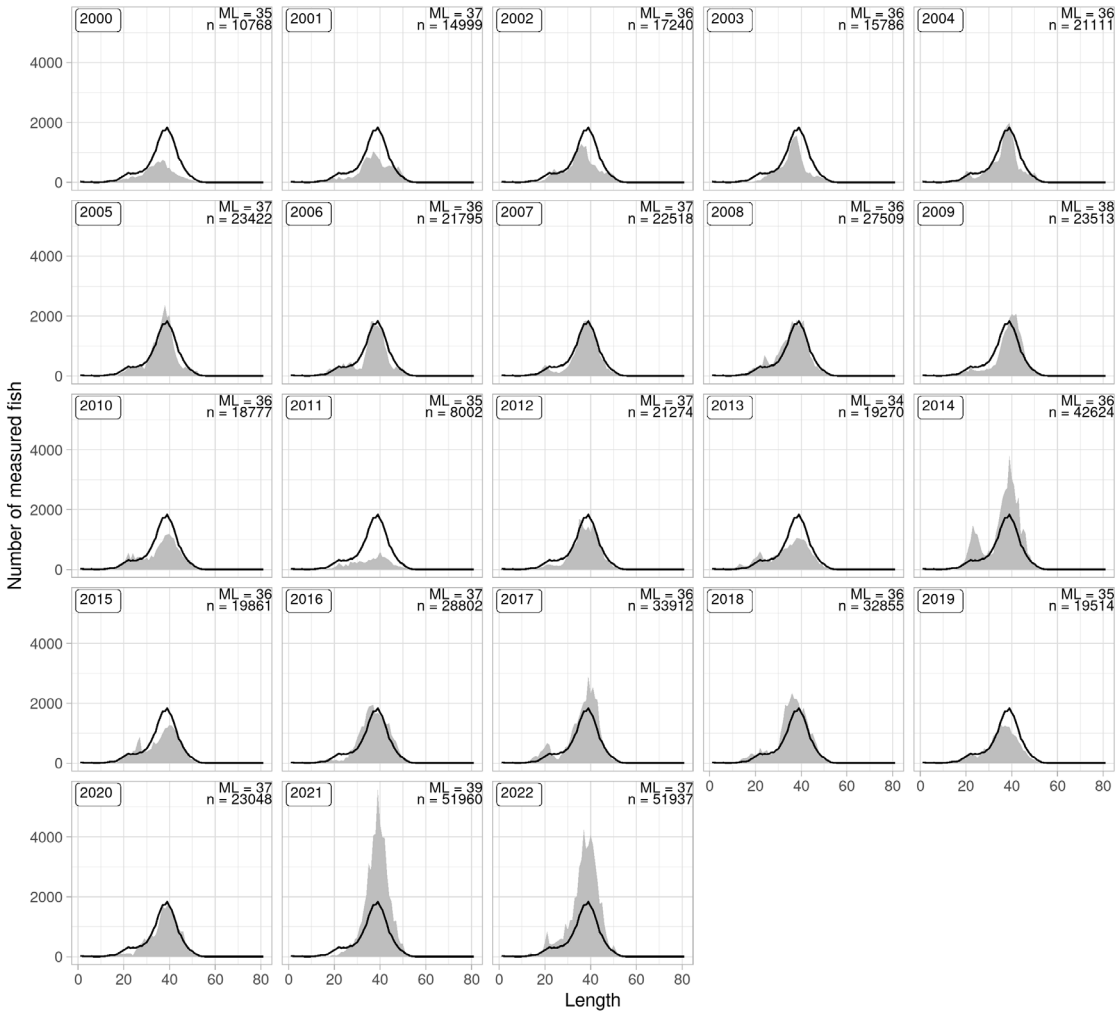


Figure 6.3.9: Greater silver smelt in 5.a and 14. Length distribution from the autumn survey. The black line shows the mean for all years.

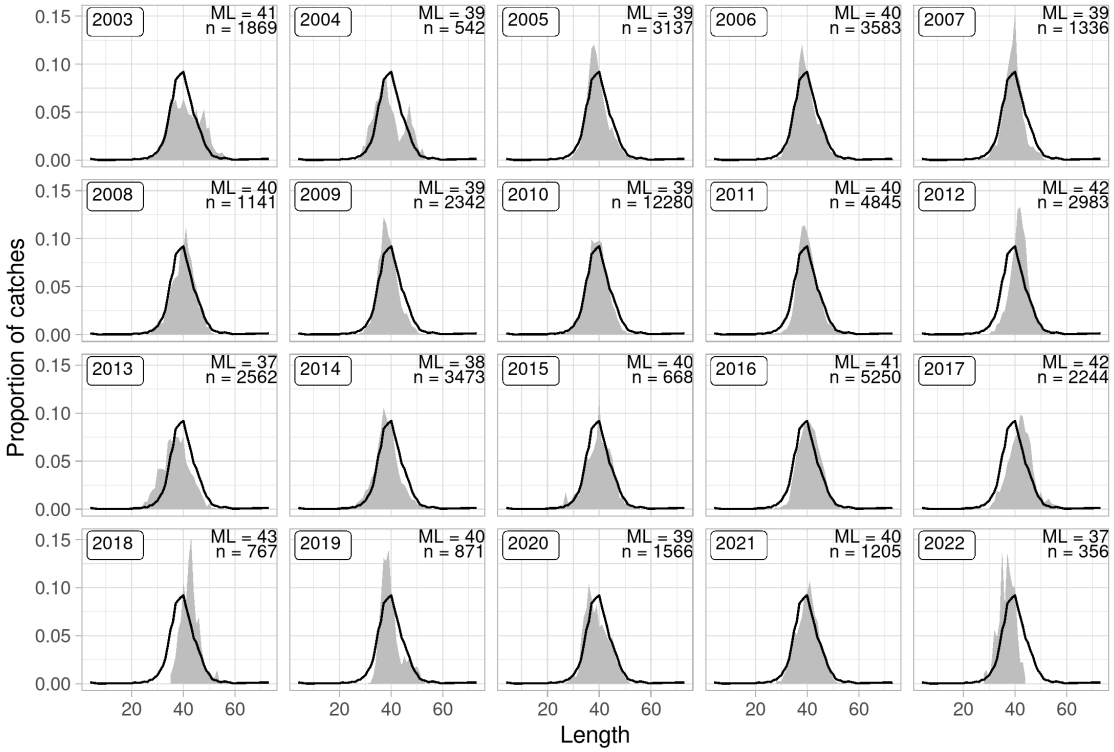


Figure 6.3.10: Greater silver smelt in 5.a and 14. Length distributions from commercial catches.

6.3.7.4 Age compositions

Table 6.3.2 gives the number of samples and measurements available for calculations of catch in numbers of greater silver smelt in 5.a. Age distributions estimated as catch in numbers are given in Figure 6.3.11 & 6.3.12.

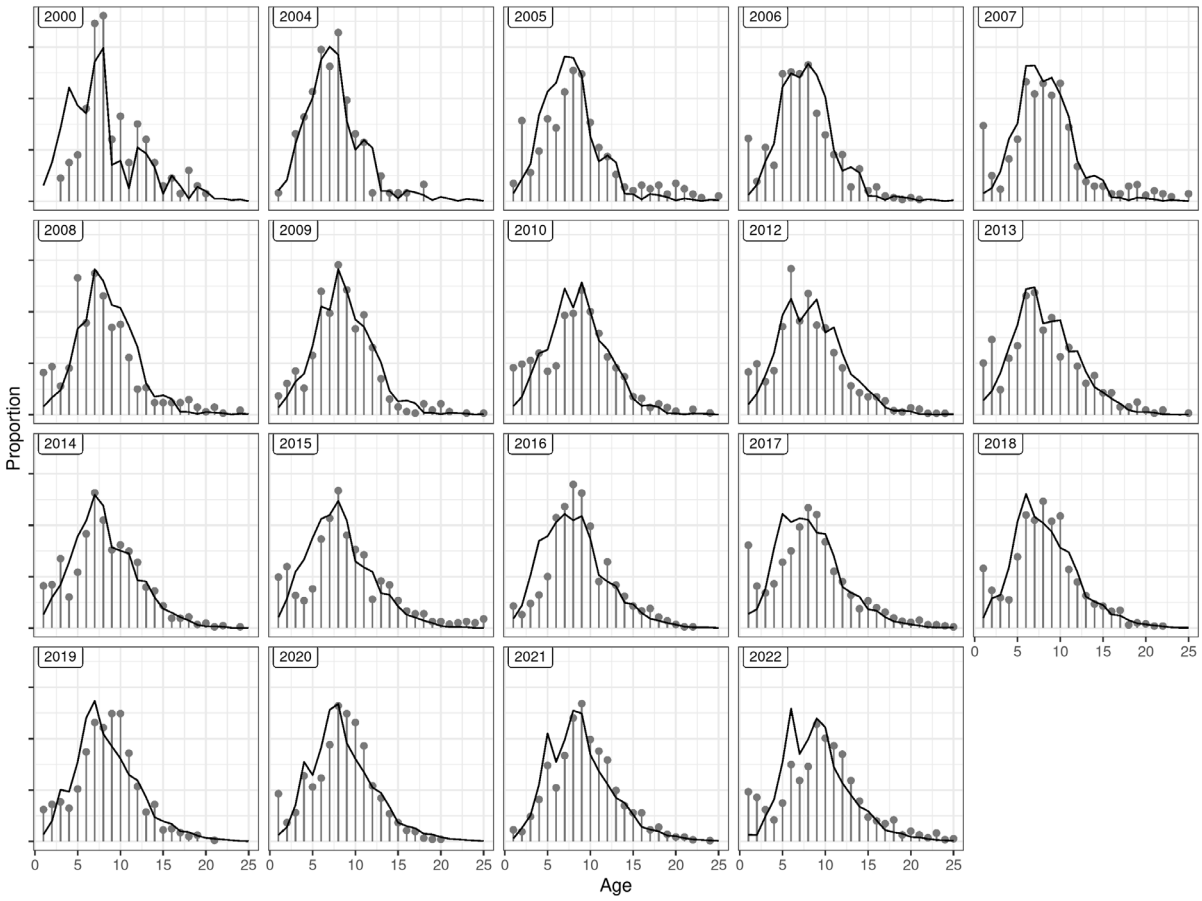


Figure 6.3.11: Greater silver smelt in 5.a and 14. Age distributions in proportions in 5.a from the Icelandic autumn survey.

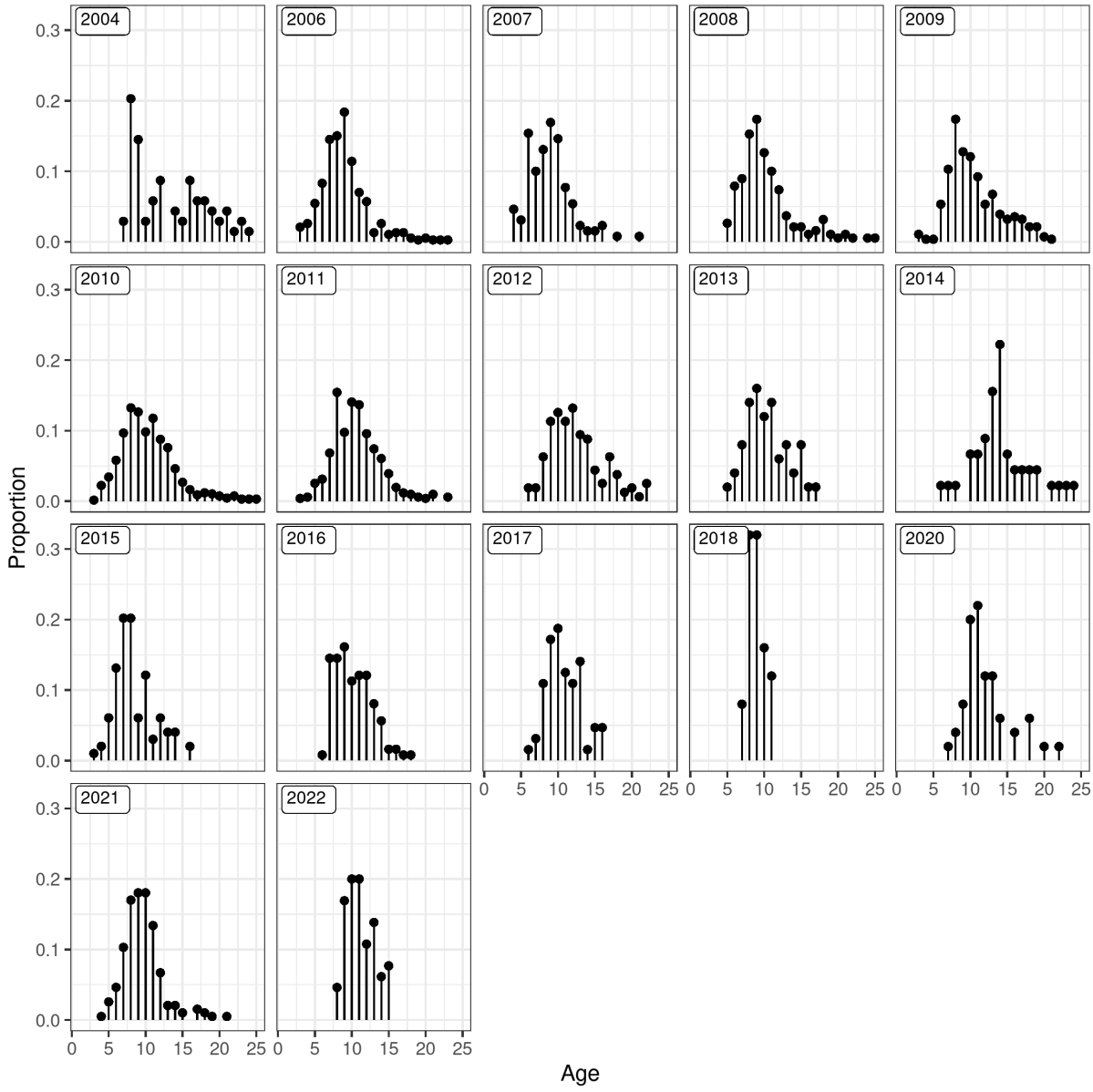


Figure 6.3.12: Greater silver smelt in 5.a and 14. Catch in numbers at age. Estimates for 2002 are based on limited number of aged otoliths. No age data are available for 2019.

6.3.7.5 Weight at age

Biological data from spring, fall, and commercial data were combined to analyse growth. Von Bertalanffy growth curves were fitted and plotted within a series of time periods, including 2016–2019, 2011–2015, 2006–2010, 2001–2005, 1994–2000, and prior to 1994 to increase sample sizes for estimating each curve. The exponential length–weight relationship is extremely consistent across periods. In general, there is very little variation between periods, although females can be seen to grow to larger sizes than males.

6.3.7.6 Maturity at age and natural mortality

Estimates of maturity ogives of greater silver smelt in 5.a were presented at the WKGSS 2020 meeting for both age and length (WKGSS 2020) using data collected in the Icelandic autumn survey (See stock annex for details). Males tend on average to mature at a slightly higher age or at 6.5 compared to 5.6 for females but at a similar length as females 35.3 cm. Most of the greater silver smelt caught in commercial catches in 5.a are mature.

No information exists on natural mortality of greater silver smelt in 5.a.

6.3.8 Data analyses

6.3.8.1 Landings and sampling

Spatial distribution of catches in 5.a did not change markedly between 2015 and 2016 and fishing for greater silver smelt in the NW area seems to have stopped (Figure 6.3.2 and Figure 6.3.3). Landings of greater silver smelt increased rapidly from 2007 to 2010 when they peaked at around 16 000 tonnes, since then they have decreased to 6889 tonnes in 2022 (Figure 6.3.4 and Table 6.3.1). The decrease in catches is the result of increased vigilance by the managers to constrain catches to those advised and also lesser interest by the fleet in the stock. At the same time mean length in catches decreased from around 44 cm in 1998 to 38–40 in 2008 to 2011. However, there is a slight increase in mean length in 2012 which can also be seen in recent years (Figure 6.3.10). A similar continuous downward trend in mean age in the commercial catches is also observed. Mean age in the fishery has decreased since the late nineties from around 16 to around 10 in 2006 to 2011. However, as is the case for mean length, mean age in catches in 2012 increased, and is estimated closer to 11 years in the most recent years (Figure 6.3.12). The reason for this change is not known as there is no marked difference in the spatial distribution of the fishery; however, reduced fishing pressure may be a factor.

6.3.9 Surveys

As mentioned above, greater silver smelt is a difficult species to survey in trawl surveys and the indices derived from the both the spring and autumn surveys have high CVs. Occasional spikes in the indices without any clear trend characterize the spring survey biomass indices (without stratification). The only thing that can be derived from the spring survey is that the biomass indices (total and >25 cm), in 1985–1993 and again from 2002 to 2022 are at a higher level than in 1994–2001. The juvenile index (spring survey) has a very high peak in 1986 but then hardly any juveniles are detected in the survey in 1987 to 1995. Since 1998 there have been several small spikes in the recruitment index (Figure 6.3.6).

The observed trends in the biomass indices from the autumn survey have a considerably different trend than those observed in the spring survey (Figure 6.3.6). According to the autumn survey, biomass increased more or less year on year from 2000 to 2008 but then decreased in 2009 and 2010. The total biomass index in the autumn survey showed slight variations until 2014 when the index increased to a high value, and thereafter has been relatively stable but with high variability. In 2021, the index peaked and in 2022, the highest value in the timeseries was observed.

There is a clear gradient in mean length of greater silver smelt with depth, larger fish being in deeper water, and therefore no abundance index is presented for the spring survey. Fishing for greater silver smelt in 5.a is banned at depths less than 400 meters. The autumn survey index for depth greater than 400 meters is therefore considered the best indicator of available biomass to the fishery and is used in the advice procedure.

6.3.9.1 Analytical assessment using Gadget

In 2020 a model of greater silver smelt in Icelandic and Greenlandic waters developed in the Gadget framework (see http://www.hafro.is/gadget for further details) was benchmarked for the use in assessment (WKGSS 2020). In 2022, Gadget version 3 was used instead of Gadget 2 which was used in the benchmark. Gadget 3 is the same in every way, except that it uses template model builder (TMB), which allows it to utilize TMB's automatic differentiation procedures. This way it produces models that can be optimized faster by using R optimisers (rather than gadget 2 which only has inbuilt optimisers). Further comparison between Gadget 2 and 3 can be found in working document nr 14.

6.3.9.2 Data used and model settings

Data used for tuning and model settings used in the Gadget model are described in more detail in the stock annex (ICES 2020).

6.3.9.3 Diagnostics

6.3.9.4 Observed and predicted proportions by fleet

Overall fit to the predicted proportional length and age–length distributions is close to the observed distributions, with the exception of a small peak of small-sized fish (Figures 6.3.14, 6.3.15, 6.3.16, 6.3.17). This peak does not shift from year to year and therefore is considered to exist because of high catchability in aggregations of small fish rather than cohorts in recruitment peaks. These peaks are likely absent from commercial data due to the requirement of fishing at > 400 m depth.

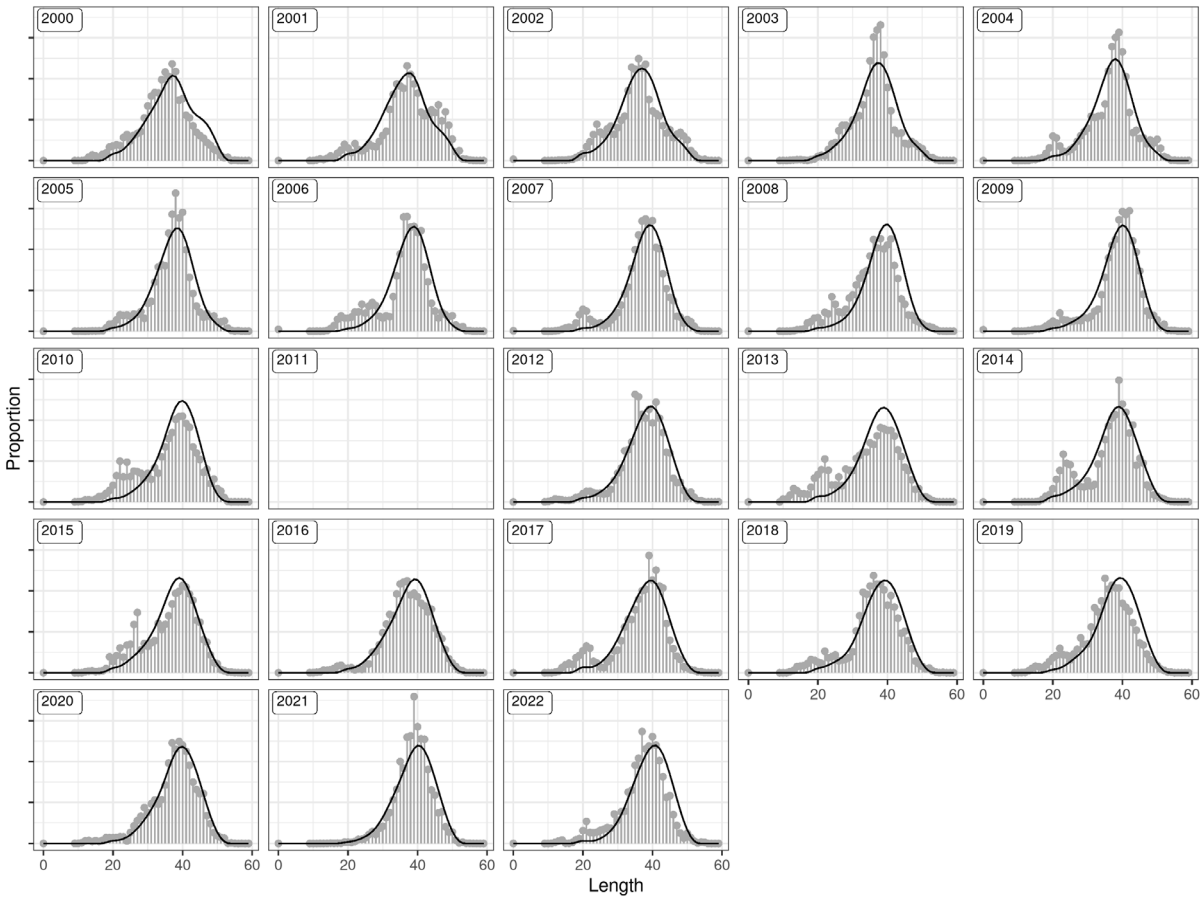


Figure 6.3.14: Greater silver smelt in 5.a. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the autumn survey (grey lines and points)

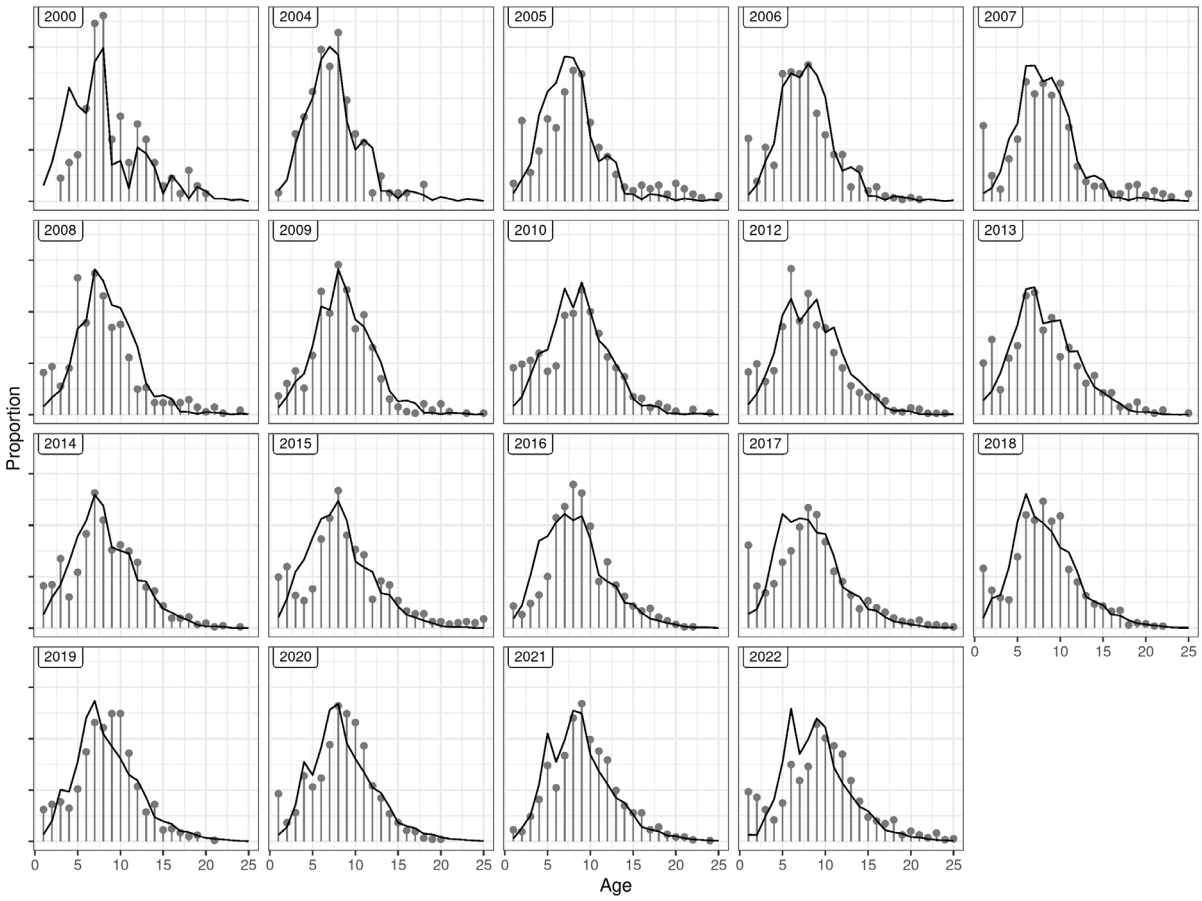


Figure 6.3.15: Greater silver smelt in 5.a. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the autumn survey catches (grey lines and points).

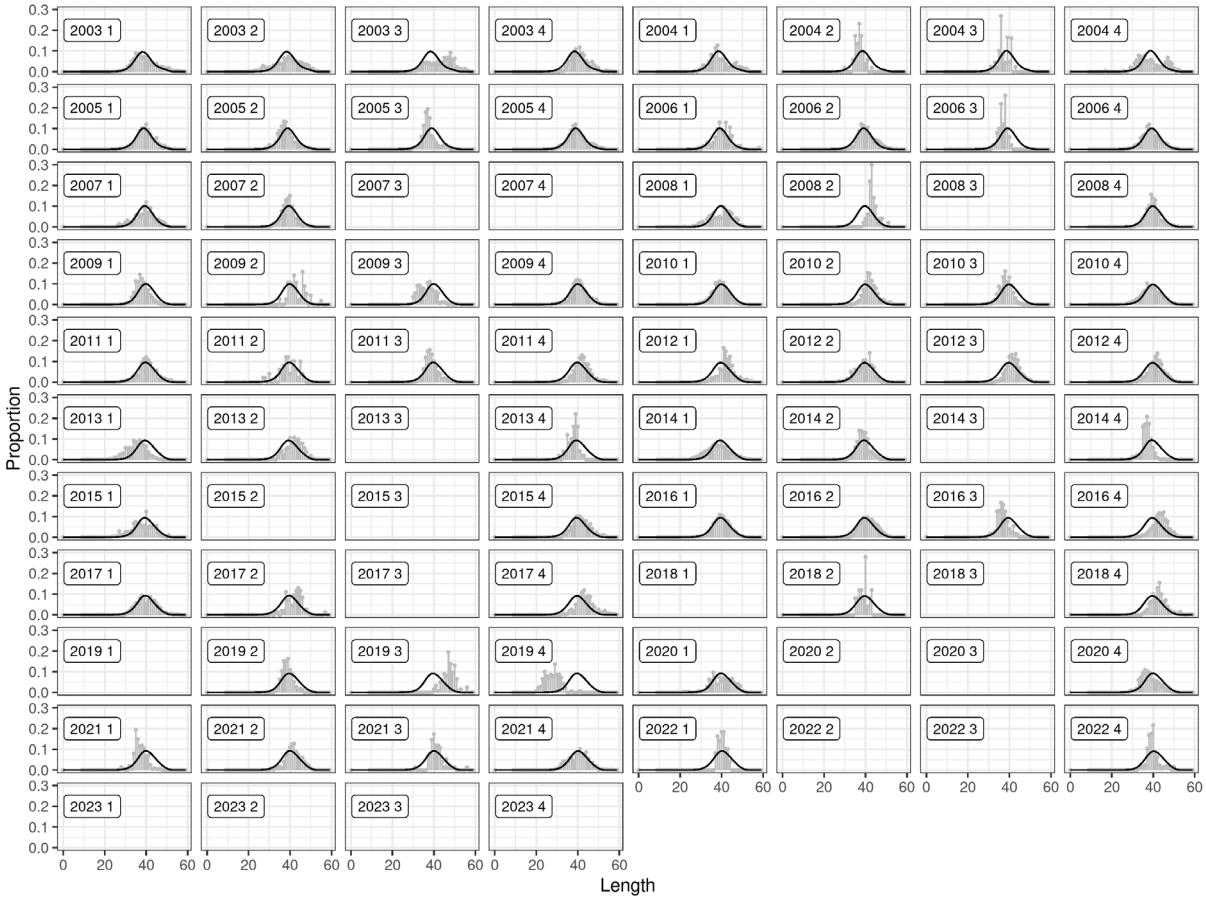


Figure 6.3.16: Greater silver smelt in 5.a. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from commercial catches (grey lines and points).

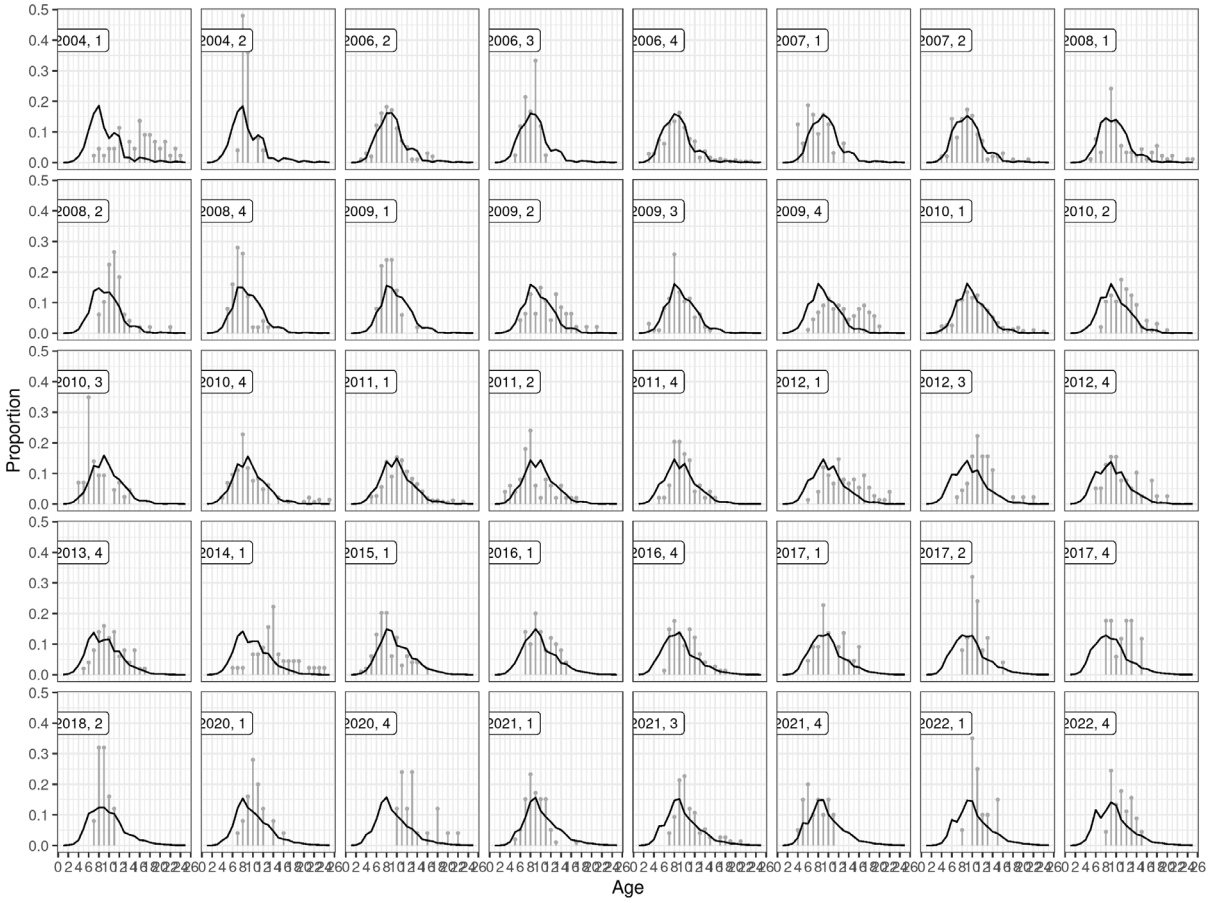


Figure 6.3.17: Greater silver smelt in 5.a. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in commercial catches (grey lines and points).

6.3.9.5 Model fit

Figure 6.3.18 shows the overall fit to the survey indices described in the stock annex. In general, the model appears to follow the stock trends historically. In previous category 3 assessments of this stock, the autumn survey was winsorized due to high variability in the survey index, which can also be seen here, as survey indices are not winsorized or standardized before being used. The peak observed in the two smallest size classes (10-25 and 25-30) are likely due to selectivity and aggregation and not cohort dynamics. The terminal estimate has a large overestimation indicating the potential for overestimation of biomass However, this year's indices for large-sized fish are at a historical high, indicating that last year's values were more likely to be relatively accurate. These high values may be the result of high variability in the survey index numbers in general, however. If survey indices are lower again next year, the model fit is likely to experience a correction to lower predicted index values.

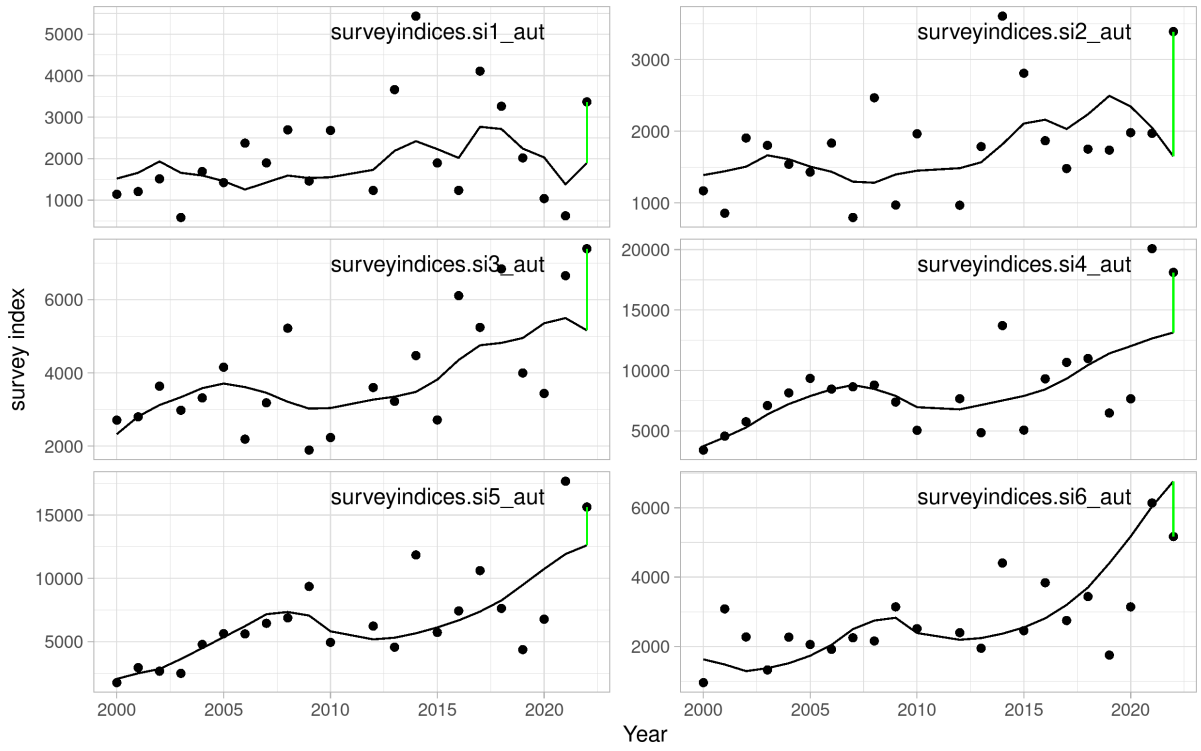


Figure 6.3.18: Greater silver smelt in 5.a. Fitted autumn survey index by length group from the Gadget model (black line) and the observed number of greater silver smelt caught in the survey (points). The green line indicates the difference between the terminal fit and the observations.

6.3.10 Results

The results are presented in Table 6.3.4 and Figure 6.3.19. Recruitment has been increasing over the past decade, but the most recent very high estimate in 2021 may be the result of recent high variability in survey indices, and are therefore likely to be revised downwards in the next few years. Spawning–stock biomass has increased since 2012 and reached the highest SSB estimate in 2021 after a slight decrease in 2020. Fishing mortality for greater silver smelt (age 6–14) has decreased from around 0.2 in 2010 to 0.04 over the past several years, due to greater regulation of the fishery as well as reduced commercial interest. Uncertainty was estimated by spatially bootstrapping the data and refitting the assessment model to resampled data. The spatial bootstrap entails refitting the model to 100 sets of data resampled by spatial areas to maintain spatial correlation in the data (see the stock annex). The base model assessment results appear unbiased as it corresponds well with the median of results (Figure 6.3.19) Asymmetry in the confidence intervals is likely to be the result of a small number of model runs with a set of resampled data that are a poor representation of the actual data. For this reason, it was suggested by WGDEEP to improve the spatial bootstrap methods so that they better represent variation in the data.

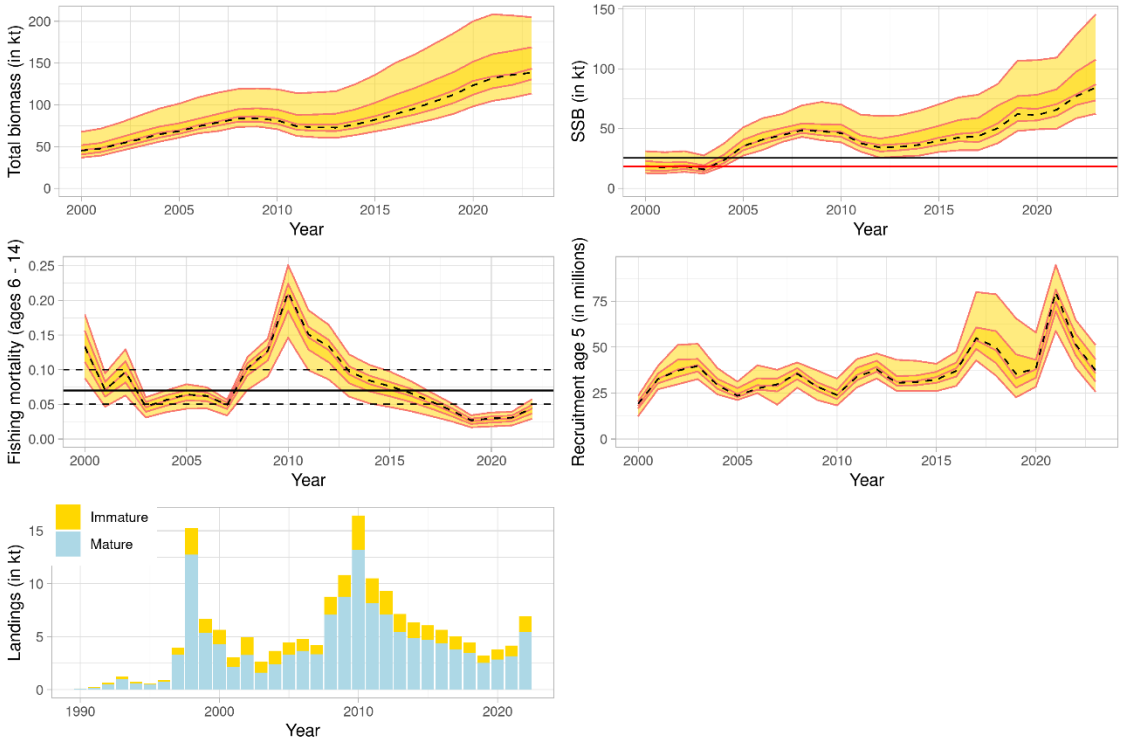


Figure 6.3.19: Greater silver smelt in 5.a and 14. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fishes, recruitment and total catches. The black solid line in the SSB plot represents Bpa and the solid red line indicates Blim. The horizontal solid line in the fishing mortality plot indicates the fishing mortality used in the ICES MSY advice rule, whereas the horizontal dashed lines indicate the bounds of the realized fishing mortality resulting from the advice rule given the uncertainty in the assessment. Uncertainty was estimated by spatially bootstrapping the data and refitting the assessment model to resampled data. Outer yellow ribbons with red borders indicate 90% interquantile ranges, whereas inner yellow ribbons indicate 50% interquantile ranges. The central red line indicates the median, and the dashed red line is the base model run for the assessment upon which advice is based.

Table 6.3.4: Greater silver smelt in 5.a. Gadget assessment model results including input catch values (tonnes), estimated spawning stock biomass (SSB, tonnes), recruitment (Rec., age 5 in millions), and fishing mortality (age 5). Projections are given in the last year. All values in 2023 result from projections, as well as F and Catch values from 2022.

Year	Total Biomass	Catch	SSB	Rec.	F
2000	45118	5.657	18382	19.08215	0.133
2001	47556	3.043	17527	32.64511	0.07
2002	53394	4.961	18352	37.19779	0.097
2003	58708	2.68	15731	39.75649	0.047
2004	64762	3.645	23181	29.21376	0.056
2005	68392	4.482	35361	23.52586	0.064
2006	74260	4.769	40766	27.52963	0.062
2007	78868	4.227	44515	29.77001	0.049
2008	83431	8.778	48580	35.50917	0.102
2009	83704	10.828	47648	28.45587	0.127
2010	81310	16.428	46220	23.96504	0.211

Year	Total Biomass	Catch	SSB	Rec.	F
2011	74263	10.516	37651	33.78942	0.151
2012	72964	9.289	34076	37.84254	0.134
2013	72678	7.155	34690	30.54237	0.097
2014	76439	6.348	36379	31.05902	0.084
2015	82088	6.07	39812	32.26439	0.076
2016	88663	5.662	42368	37.11361	0.067
2017	95443	5.011	43544	54.86462	0.055
2018	103717	4.46	50414	49.92427	0.042
2019	112007	3.21	62072	35.40619	0.027
2020	123221	3.797	61228	38.40801	0.03
2021	131900	4.156	65763	79.98619	0.031
2022	135830	6.914	77111	51.55442	0.044
2023	138445	9.188	84291	36.54049	0.071

6.3.10.1 Retrospective analysis

An analytical retrospective analysis is presented. The analysis indicates that there were downward revisions of biomass over the first four years of the 5-year peel followed by a upward revision of biomass (SSB) over the last year. As a result, there was an upward then downward revision of F. Estimates of recruitment are decently stable.

Mohn's rho was estimated to be 0.062 for SSB, -0.032 for F, and 0.016 for recruitment.

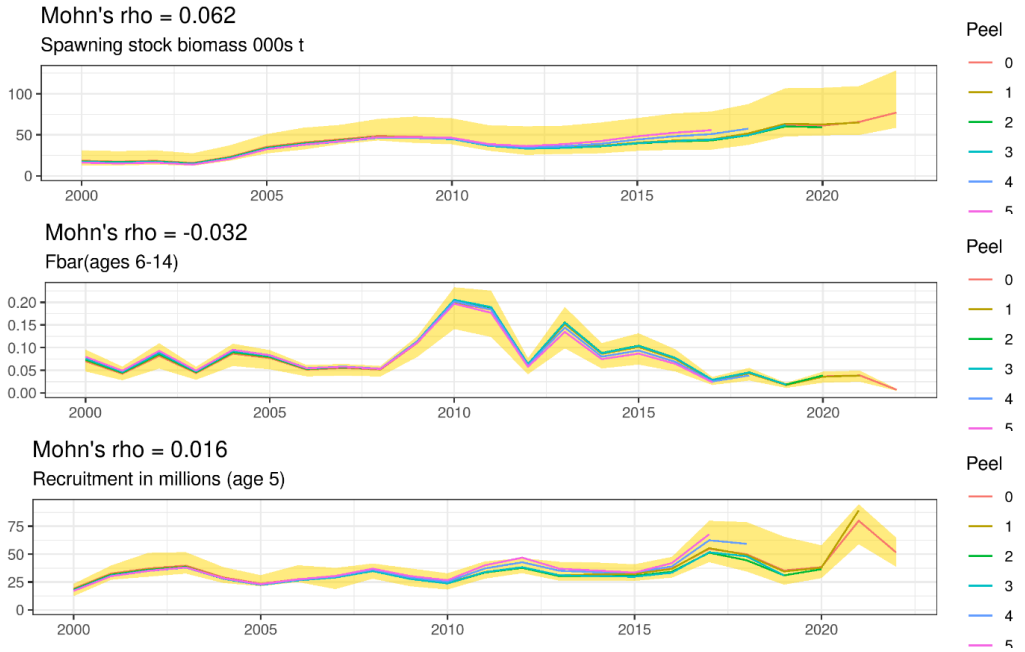


Figure 6.3.20: Greater silver smelt in 5.a and 14. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 5) are shown.

6.3.11 ICES advice

In 2020 this stock was benchmarked (WKGSS 2020) and a length- and age-based assessment was accepted as a category 1 assessment method. The ICES MSY advice rule is applied for this stock in 2021/2022 advice. Last year's advice amounted to 11520 tonnes.

6.3.12 Management

The Icelandic Ministry of Industries and Innovation is responsible for management of the Icelandic fisheries and implementation of legislation. The Ministry issues regulations for commercial fishing for each fishing year (1 September–31 August), including an allocation of the TAC for each stock subject to such limitations. Before the 2013/2014 fishing year the Icelandic fishery was managed as an exploratory fishery subject to licensing since 1997. A detailed description of regulations on the fishery of greater silver smelt in 5.a is given in the stock annex (ICES 2016).

The TAC for the 2013/2014 fishing year was set at 8 000 based on the recommendations of MRI using a preliminary Gadget model and the 2014/2015 fishing year the recommendation was to maintain the catches at 8 000 t. For the fishing year 2015/2016 it was also maintained at 8 000 t, but was 7 885 t for 2016/2017, 9 310 t for 2017/2018, 7 603 t for 2018/2019, 9 142 t for 2019/20, 8729 for 2020/21, and 9244 for 2021/22 (Table 6.3.5). Flexibility is built into the Icelandic fisheries management system in which quota is automatically transformed for use for constraining species when it is available. As this stock is consistently caught at levels lower than the TAC in recent years, it has been a source of quota that may be used to fish other species (Table 6.3.5).

Table 6.3.5: Greater silver smelt in 5.a. TAC recommended for greater silver smelt in 5.a by the Marine and Fisheries Research Institute, national TAC and total landings.

Fishing Year	MFRI Advice	National TAC	Landings
2010/11	8 000		12 091
2011/12	8 000		8 410
2012/13	8 000		11 038
2013/14	8 000	8 000	7 243
2014/15	8 000	8 000	6 849
2015/16	8 000	8 000	6 018
2016/17	7 885	7 885	3 570
2017/18	9 310	9 310	5 159
2018/19	7 603	7 603	2 807
2019/20	9 124	9124	3775
2020/21	8729	8729	4282
2021/22	9244	9244	6550
2022/23	11520	11520	

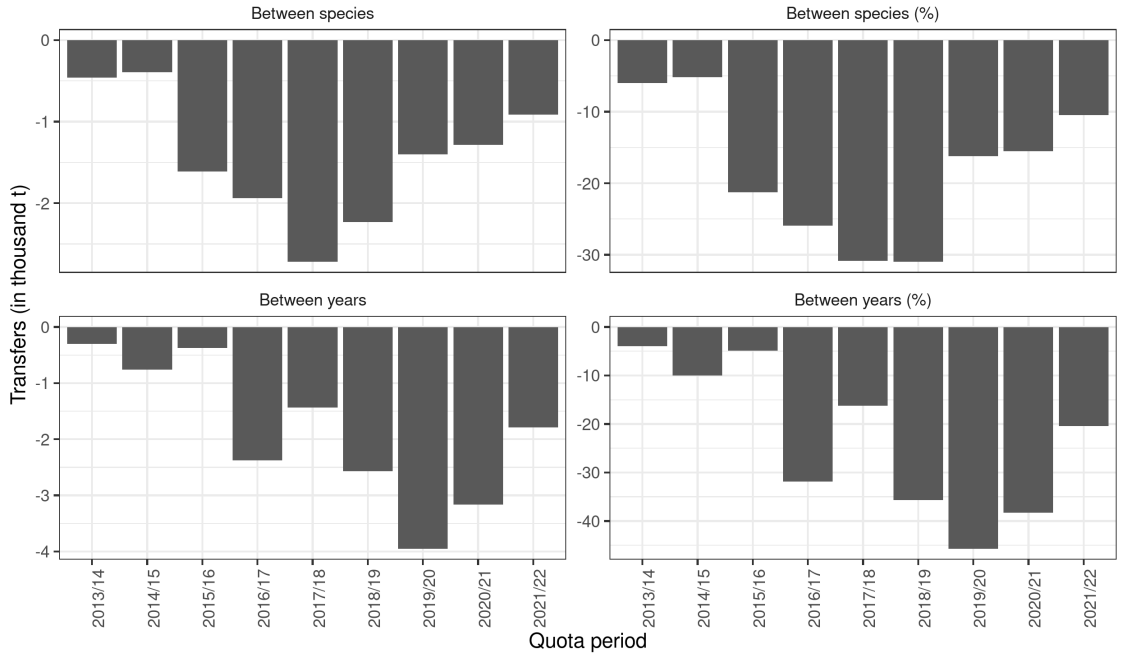


Figure 6.3.21: Greater silver smelt in 5.a and 14. An overview of the net transfers of quota between years and species transformations in the fishery in 5.a.

6.3.13 Current advisory framework

As a part of the WKGSS 2020 benchmark proceedings (WKGSS 2020), the following reference points were defined for the stock:

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	25.44 kt	B_{pa}
-	F_{msy}	0.14	Median F that maximises the median long-term catch in stochastic simulations with 7-year block-bootstrapped recruitment, scaled according to a hockey stick recruitment function with the breakpoint set to B_{lim}.
-	$F_{p.05}$	0.07	The fishing mortality that has an annual 5% probability of of SSB < B_{lim}.
Precautionary approach	B_{lim}	18.3 kt	SSB(2003), corresponding to B_{loss} as the fishing level in relation to F_{msy} is unclear and model uncertainty high
-	B_{pa}	25.44 kt	$B_{lim} * e^{1.645*\sigma}$ where $\sigma = 0.2$
-	F_{lim}	0.24	F corresponding to 50% long-term probability of SSB > B_{lim}
-	F_{pa}	0.16	$F_{lim}/e^{1.645*\sigma}$ where $\sigma = 0.25$
MSY advice rule	F_{msy}	0.07	F such that $F \leq F_{msy}$, $F \leq F_{pa}$, and $F \leq F_{0.05}$, long-term yield is consistent with MSY while leading to high stock biomass
-	MSY $B_{trigger}$	25.44	Set as B_{pa}

Figure 6.3.22: Greater silver smelt in 5.a and 14. Reference points.

The ICES MSY advice rule is applied for this stock. The decision which allocates catches to the fleets requires 1) an expected quantity of catch to be removed that will complete total catch removals for the current fishing season, 2) a 1-year projection to determine the amount of biomass available to fish, and 3) application of projected fishing effort according to F_{msy} to determine the expected catch from fishing at this level. Advised catch is set to this value while $SSB_y > B_{trigger}$, scaled by $\frac{SSB_y}{B_{trigger}}$ while while $B_{lim} \leq SSB_y < B_{trigger}$, and set to 0 while $SSB_y \leq B_{lim}$. Further information on how these reference points were generated and the model setting for short-term projections can be found in WKGSS 2020 report (WKGSS 2020).

The current intermediate year assumption regarding catch is set equal to the TAC during the fishing season (last quarter of year y and quarters 1 – 3 in year y + 1) and projections for the following year run at a selected harvest rate. However, the recommended TAC in recent years has been much higher than recorded landings. Therefore, for sensitivity analysis, projections were also run using intermediate year catch assumptions which are more indicative of recorded landings than TAC. Catches were previously assumed to be *status quo*, calculated as the average of the previous three years, but catches in 2022 were much higher than in previous years. The average of the previous three years is, hence, not representative of the current year. Catches were calculated by summing up the first quarter of 2023 with quarter 2 and 3 in 2021 and forecast catches at F_{mgt} in the fourth quarter.

Age 1 recruitment estimates are highly uncertain from the most recent three years. Therefore, in forecasts, it is proposed to use the geometric mean of the three years previous to these values (e.g. for 2023, this would be the geometric mean of age 1 recruitment estimates from years 2020–2022). The projected

recruitment reported from the model output is for age 5 because recruitment estimated for ages 1-4 are highly uncertain.

6.3.14 Management considerations

Exploitation of greater silver smelt has been reduced in recent years, coming down from relatively high levels in 1998 and 2010, to levels lower than the average exploitation rate in the reference period.

6.3.14.1 Ecosystem considerations for management

Shorter periods of reduced biomass due to high fishing rates are observed in the history of greater silver smelt fishing in Iceland. However, there has been a general trend since the mid-1990s of a decrease in biomass levels from the mid-1980s to the mid-1990s, during which catch records are unreliable so the general reduction cannot directly be attributed to fishing, followed by a general increase in biomass in the past two decades. It is likely that a combination of lower fishing rates and favourable environmental conditions have led to high recruitment levels over the past decade.

6.3.15 References

ICES. 2014. "Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP). ICES Scientific Reports. 1:21., Copenhagen, Denmark. ICES Cm 2014/Acom:17." International Council for the Exploration of the Seas; ICES publishing. https://doi.org/10.17895/ices.pub.5262.

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ICES. 2021. 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.

Thorson, J.T., Shelton, A.O., Ward, E.J., Skaug, H.J., 2015. Geostatistical delta-generalized linear mixed models improve precision for estimated abundance indices for West Coast groundfishes. ICES J. Mar. Sci. J. Cons. 72(5), 1297-1310. doi:10.1093/icesjms/fsu243. URL: http://icesjms.oxfordjournals.org/content/72/5/1297

6.4 Greater silver smelt (*Argentina silus*) in 5 b and 6 a

6.4.1 The fishery

The fishery on greater silver smelt in Divisions 5.b and 6.a is mainly conducted by Faroese and European trawlers. In 2022, catches in 5.b were mainly taken by two pairs of Faroese pair trawlers deploying bentho-pelagic trawls (98%) while catches in 6.a were mostly taken by European trawlers (68%) and the remainder mainly by previously mentioned Faroese trawlers (24%, inside the Faroese EEZ) (Table 6.4.1 and Figure 6.4.1).

Historically, greater silver smelt was caught as bycatch in the shelf-edge deep-water fisheries and either discarded or landed in small quantities. The fishery for greater silver smelt in Faroese waters in 5.b did not develop until the mid-1990s and for 6.a in the early 1990s.

Fishing grounds for greater silver smelt in Faroese waters were located north and west on the Faroe Plateau and around the banks southwest of Faroe Plateau mainly at depths between 300 and 700 meters (mid-1990s to 2007). Since 2008 the Faroese fishery has extended fishing activities to include areas on the Wyville-Thomson Ridge south of the Faroe Plateau. Around 50% of the Faroese catches are caught on the Wyville-Thomson Ridge (in Divisions 5.b and 6.a, inside the Faroese EEZ) since 2012.

European fishery on silver smelt takes place mostly on the shelf edge within Divisions 6.a, 5.b and 4.a. Information from the self-sampling program carried out by the European fisheries (Pelagic Freezer-trawler Association, PFA) has been presented since 2018. The self-sampling program consists of

historical information derived from skipper's notes (2002 - present) and new information collected as part of the research program within the PFA. An overview of catch rates of silver smelt (*Argentina spp.*) from both the Faroese and European fisheries is shown in Figure 6.4.2.

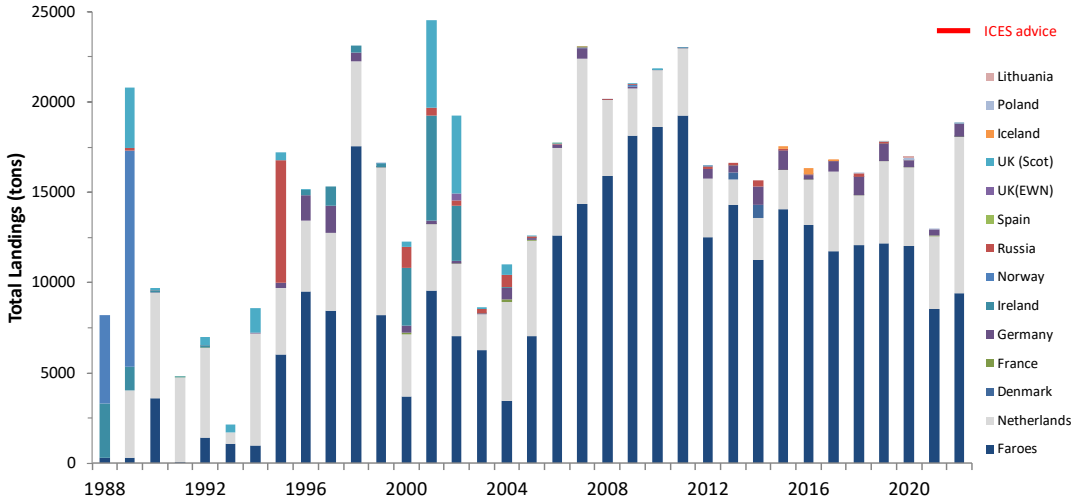

Figure 6.4.1. Greater silver smelt in 5.b and 6.a. Total landings of greater silver smelt in 5.b and 6.a by countries since 1988.

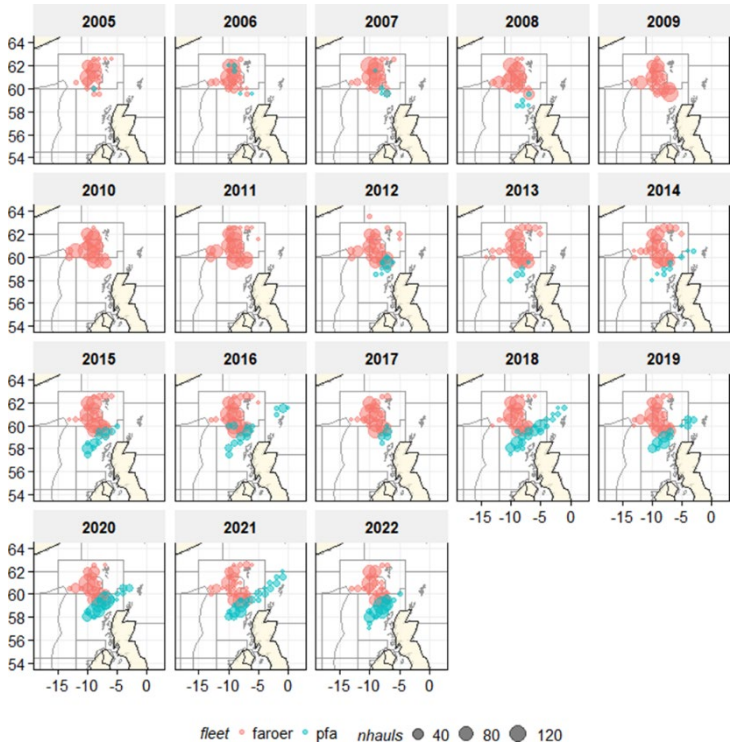

Figure 6.4.2. Greater silver smelt in 5.b and 6.a. Effort (number of hauls) of commercial fisheries available for standardized CPUE calculation in Faroese fishery (red circles) and PFA fishery (blue circles) since 2005.

6.4.1.1 Landing trends

Landings in Division 5.b increased rapidly from 2004 (5300 tonnes) to 2006 (12 500 tonnes) and further increased in 2011 to 15 600 tonnes (Table 6.4.2). Landings have oscillated between 10 000 to 13 000 tonnes since 2012. The reduction of catches in 5.b since 2012 was probably due to several factors, e.g.,

the introduction of quotas for greater silver smelt in Faroese waters, a shift for mackerel and the relocation of effort to the Wyville-Thomson Ridge.

Landings in Division 6.a have been fairly stable at around six to eight thousand tonnes but for two peaks in 1989 (20 581 tonnes) and 2001 (14 466 tonnes). Landings have ranged between 5000 and 7500 tonnes since 2004.

Catches in 2022 were 6383 tonnes in Division 5.b and 12467 tonnes in Division 6.a.

6.4.2 ICES Advice

ICES advises that when the MSY approach is applied, catches in **2023** should be no more than 17 695 tonnes.

6.4.3 Management

The EU introduced total allowable catch (TAC) management for greater silver smelt in 2003 setting a TAC quota for the EU fishery in Subareas 5, 6 and 7 (separate EU TACs exist for greater silver smelt in areas 1 and 2, and in areas 3.a and 4). TAC quotas for the EU fishery in Subareas 5, 6 and 7 since 2014 are presented in the Table 6.4.3.

Since 2021 (Brexit) the UK has set a species-specific TAC quota for greater silver smelt in Subareas 5, 6 and 7. The TAC quotas for the UK fishery in Subareas 5, 6 and 7 since 2021 are also presented in the Table 6.4.3.

From 2010 to 2013, the Faroese greater silver smelt fishery was managed by an agreement between the Faroese fleet and the management authorities that the total annual landings should not exceed 18 000 tonnes in the Faroese EEZ. This management was based on scientific advice from the Faroe Marine Research Institute (FAMRI) on the Faroese "stock" component. The management of the fishery was regulated by fishing days for the trawler fleet. There are also other technical limitations such as minimum size, bycatch, mesh size and area restrictions.

In 2014, the Faroese authorities introduced a species-specific TAC quota for greater silver smelt for Faroese trawlers (6 vessels) within the Faroese EEZ. Faroese TACs are presented in Table 6.4.3 too. A decrease in the biomass index as estimated by the age-based exploratory assessment resulted in a decline of TAC from 2014 to 2017.

ICES advice, TACs issued by UK, EU and Faroese authorities are summarised in Table 6.4.3.

The ICES advised catch for 2022 was nearly three times as high as the last catch advice issued in 2019 for 2020 and 2021. The advice in 2019 was based on a category 3 trend-based assessment and has now been upgraded to an analytical assessment; advice is provided following the MSY approach.

6.4.4 Data available

Data on length, round weight and age are available for greater silver smelt from Faroese and European landings. Catch and effort data from Faroese trawler logbooks and from the PFA fisheries in the Northeast Atlantic are also available (WGDEEP 2021, WD02).

Fishery-independent biological data is available from the annual ground fish summer survey on the Faroe Plateau since 1995. The survey targets cod, haddock and saithe. In addition, a deepwater survey has been conducted since 2014 covering the fishery distribution within the Faroese EEZ.

Acottish deepwater survey (MSS Deepwater Slope Survey) is also included in the SAM assessment as a biomass index. The survey covers the distribution of the European fishery in 6.a (Campbell 2020, WD01 WKGSS).

6.4.4.1 Landings and discards

The landings statistics are regarded as being adequate for assessment purposes. Landing data for all relevant fleets disaggregated by area and country is presented in Tables 6.4.1 and 6.4.2, and Figure 6.4.1.

Discarding is prohibited within the Faroese EEZ. All catches are assumed to be landed. A landing obligation in the European Union for pelagic fisheries was implemented in 2015. Catches of all species in the pelagic fishery are to be landed, except for protected species which are to be immediately released after capture. The EU landing obligation was applied to demersal fisheries in 2019.

Discards from foreign nations are reported to ICES (Table 6.4.4). Bycatches are assumed to be landed.

Substantial levels of discards occur in the trawl fishery conducted in Subareas 6 and 7 on the continental slope at depths of 300 to 700 m (Girard and Biseau, WD 2004). Discards reported by Spain in 2012 and 2013 were revised downwards. No discards from Spain were reported in Subarea 6 in 2014 - 2018.

Based upon on-board observations from the EU data collection framework (DCF) sampling, the catch composition in the French mixed trawl fisheries for 2011 in 5.b, 6 and 7 include 5.3% of greater silver smelt representing 25.3% of the discards in that fishery (Dubé *et al*., 2012). Most of the discards in Division 6.a were reported in the French and Scottish deep-water fisheries since 2014 (data from ICES) (Table 6.4.4). Discard data reported to ICES represent on average 3.0% of the total catches since 2014.

6.4.4.2 Length compositions

Commercial length frequency distributions are available from the Faroese pairtrawler fleet in 5.b and 6.a (Figure 6.4.3) and from PFA fisheries in Divisions 4a, 5b and 6a (Figure 6.4.4).

Fishery-independent length compositions data is obtained from the Faroese summer ground fish survey on the Faroe Plateau in Division 5.b are presented in Figures 6.4.5. Length distributions from the Faroese deep water survey are presented in Figure 6.4.6.

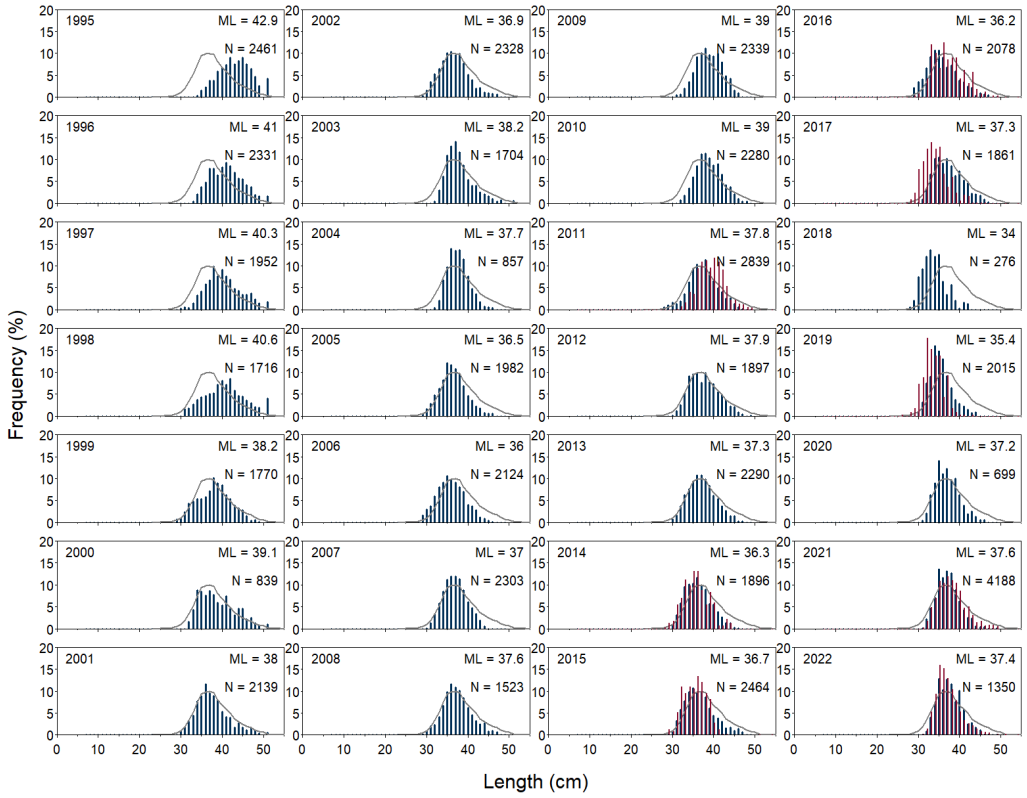

Figure 6.4.3. Greater silver smelt in 5.b. Length frequencies of greater silver smelt in the Faroese catches from 1995 to present. Blue bars are catches within area 5b and red bars are catches within area 6a. Curves are the average over whole time frame. ML= mean length (cm) and N= number of length measurements.

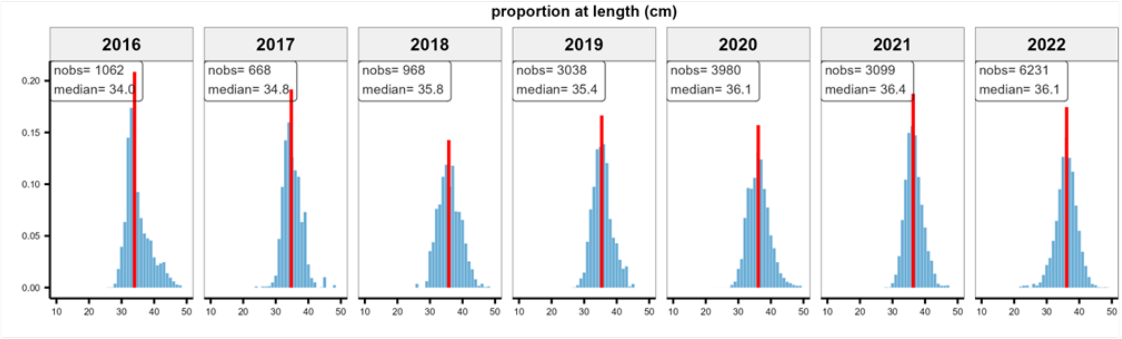

Figure 6.4.4. Silver smelt (*Argentine spp.)* in 5.b and 6.a. Relative length frequencies in PFA self-sampled fisheries in division 4a, 5b and 6a from 2016 to present. Number of length measurement (nobs) and median length (cm, red) in top left.

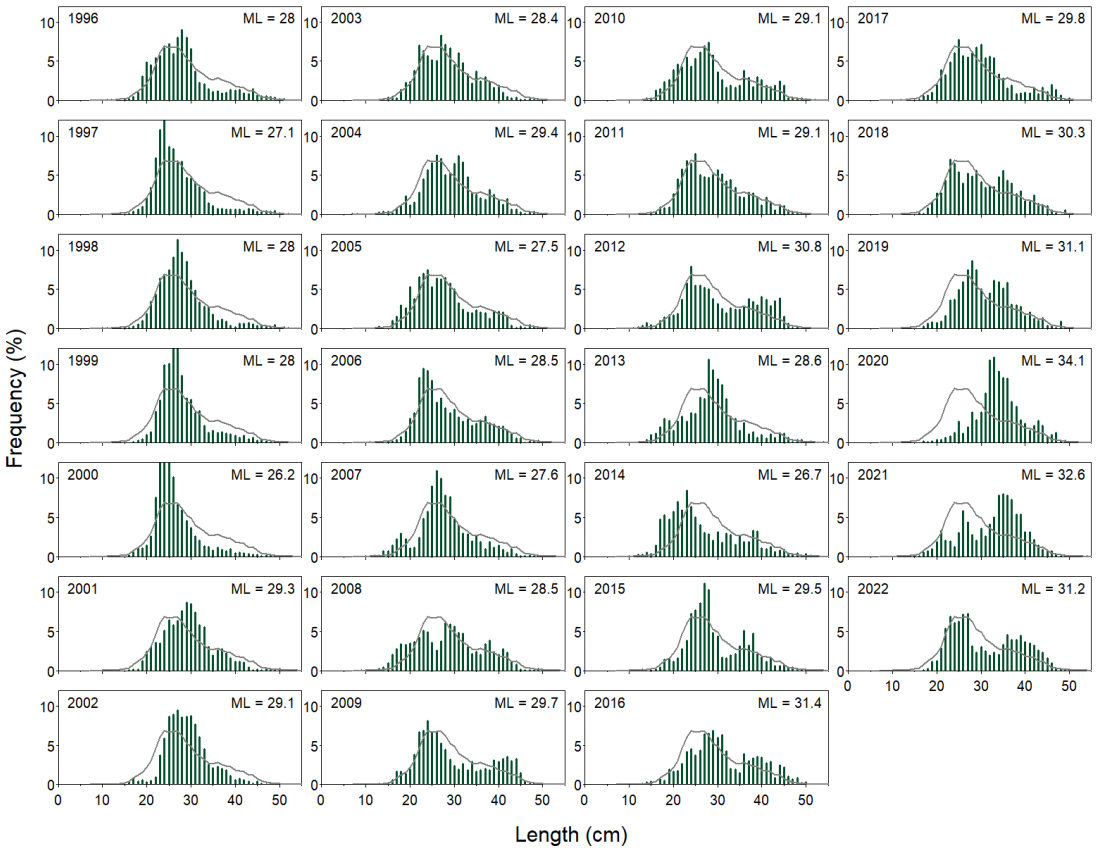

Figure 6.4.5. Greater silver smelt in 5.b. Length frequencies from Faroese ground fish summer survey from 1996 to present. Greater silver smelt is sub sampled of the total catch i.e., the values of greater silver smelt are scaled to reflect total catch. ML= mean length.

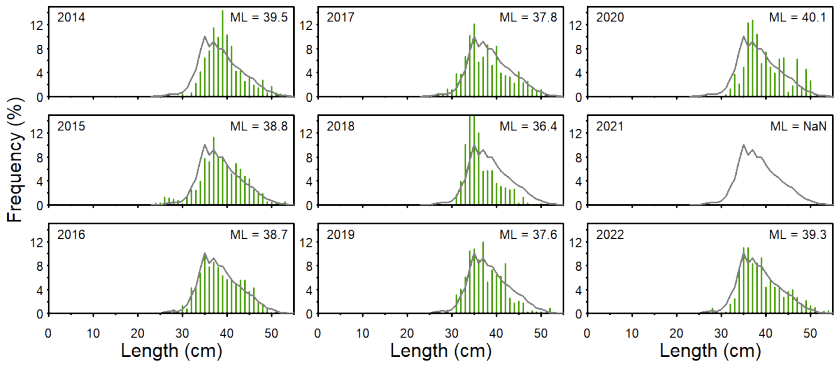

Figure 6.4.6. Greater silver smelt in 5.b. Length frequencies from the Faroese deep water survey from 2014 to present, excluding 2021 when the deepwater survey was not conducted .. ML = mean length.

6.4.4.3 Catch at age (CAA)

Catch at age compiled in InterCatch framework is presented in Figure 6.4.7 and Table 6.4.5. These data are used in the age-based state-space fish stock assessment SAM. Additional data from the Netherland and Scottish fishery in Division 6.a is also used in the compilation of the catch at age. The computation of the catch at age is described in detail in the stock annex.

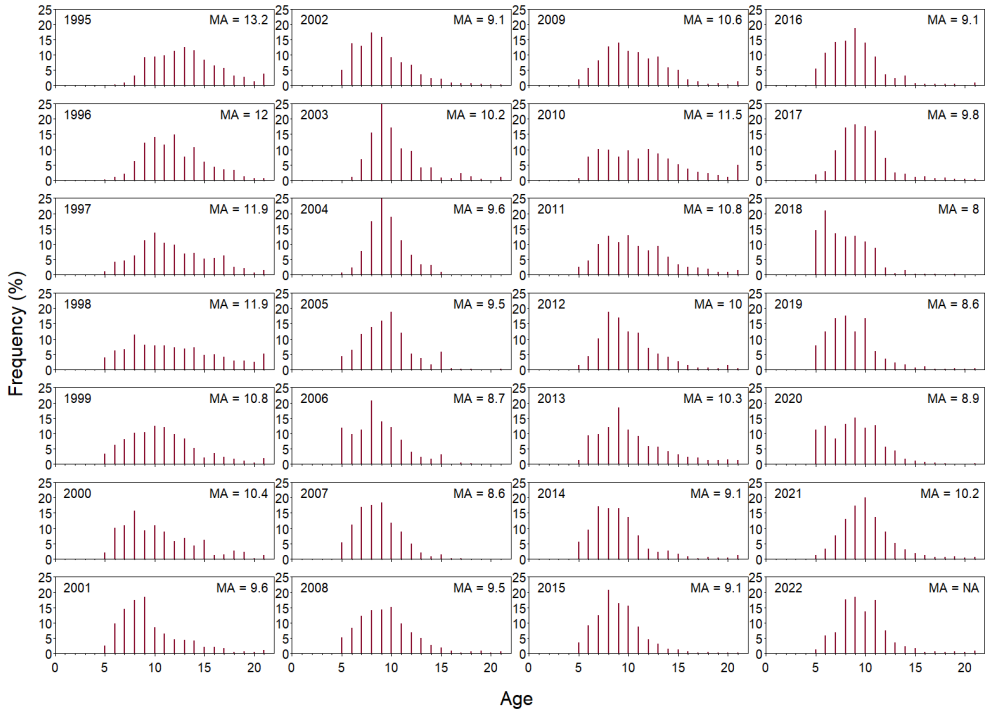

Figure 6.4.7. Greater silver smelt in 5.b and 6.a. Catch at Age (CAA) used in the SAM assessment in 1995 to present. Prior to 2005 only CAA from the Faroese data has been used. From 2005 to present the combined CAA from Faroese and EU data have been used (compiled in InterCatch). MA= mean age.

6.4.4.4 Weight-at-age

Catch weight at age is compiled in InterCatch framework (Figure 6.4.8 and Table 6.4.6). Data from 1995 to 2005 is only available from the Faroese fishery in Division 5.b. The low weight at age values of greater silver smelt older than 15 years in 2019 are potentially due to the low age sample size of old fish (Figure 6.4.8). Stock weights are assumed to be equal to catch weight.

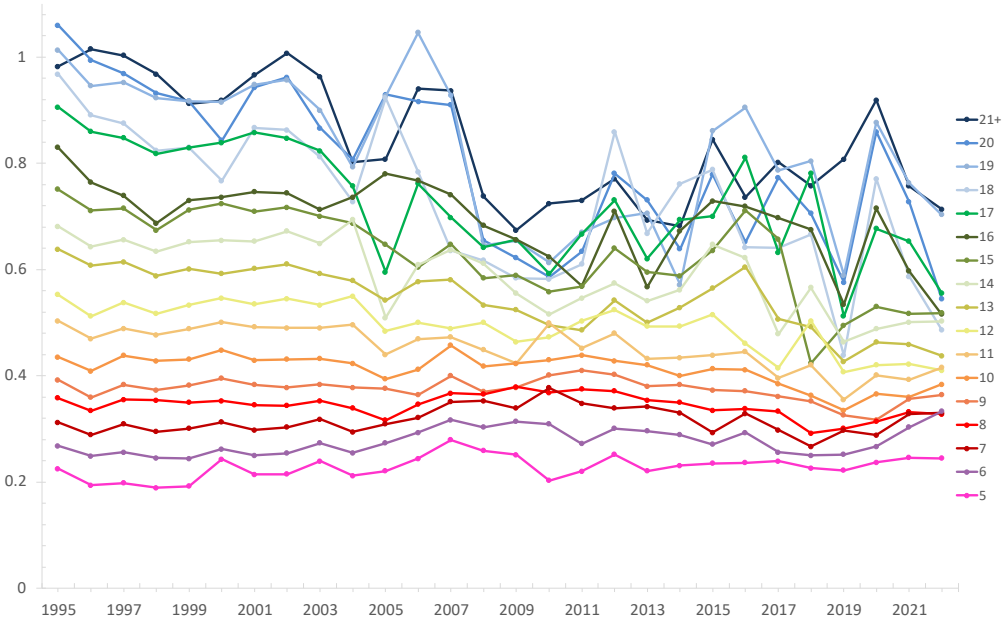

Figure 6.4.8. Greater silver smelt 5.b and 6a. Mean weight-at-age of greater silver smelt in the commercial catch within 5.b and 6.a.

6.4.4.5 Maturity and natural mortality

The composition of the commercial catches consists mostly of mature individuals in Division 5.b (ICES, 2021).

Maturity at age is estimated from the Faroese surveys for the period 2000-2019 and it is fixed for the whole assessment period (Table 6.4.7).

Natural mortality is set to 0.15 (ICES, 2021).

6.4.4.6 Catch, effort and research vessel data

Fishery-dependent data is available from Faroese trawler logbooks (1995-2021) and the PFA self-sampling program (2005-2008, 2012-2021). The catch from Faroese trawlers accounts for more than 80% of the total Faroese landings since 2005. Therefore, the period 2005-2021 was chosen for calculating a CPUE index. The PFA self-sampling logbooks account for varying percentages of the total registered catch by Germany and Netherland in Division 5.b and 6.a.

The Faroese summer groundfish survey is used as a tuning series for the assessment. The survey is carried annually on the Faroe Plateau since 1996 (Figure 6.4.9; ICES, 2023, Stock annex). It has to be noted that the summer survey has very few stations deeper than 500 m and are therefore likely to only cover the greater silver smelt juveniles adequately. The adult part of the population is not fully covered by the survey and they may not necessarily reflect correctly the temporal variation of the biomass of the stock that is better covered by the Faroese deep water survey. The spring survey series, conducted in February/March since 1994, needs closer investigation before it can be used as a tuning series because of large interannual variations.

The Faroese deep-water trawl survey has been conducted in September since 2014, covering the slope and banks including the fishing grounds for greater silver smelt in the Faroese EEZ (5.b and 6.a) (ICES, 2023, Stock annex). No Faroese deep water survey was conducted in 2021. The standardized index is presented in Figure 6.4.9.

The Scottish MSS Deepwater slope survey covers the fish community in the deep waters to the north-west of Scotland and has been conducted irregularly since 1998. It has shown that greater silver smelt are found at depths between 400m and 750m (Campbell, WD Nov. 2019). A CPUE from this survey has been standardized (Figure 6.4.9) and the number of hauls per year where greater silver smelt is encountered is generally around 10 (ICES, 2023, stock annex).

At the benchmark meeting in 2020, another standardized combined CPUE series for the Faroese and European (PFA) fisheries was presented using a GLM model that incorporates year, week and depth category as explanatory variables (Figure 6.4.9; WKGSS 2020, WD03; WGDEEP 2021, WD01). A single fleet analysis is also routinely carried out to assess the year trends in CPUE for the data by Faroese and PFA fisheries separately. This indicates that the variability is substantially higher in the PFA series compared to the Faroese series (See stock annex). Parameter estimates for explanatory variables are routinely checked and described in WD04, WGDEEP 2023. Commercial CPUE may be influenced by changes in greater silver smelt quotas and fishing season/market factors but these influences were regarded as minor in comparison to variations in stock biomass. A review of the commercial CPUE index was conducted at WGDEEP 2023, see detailed results in section 6.4.5.2.1.3.

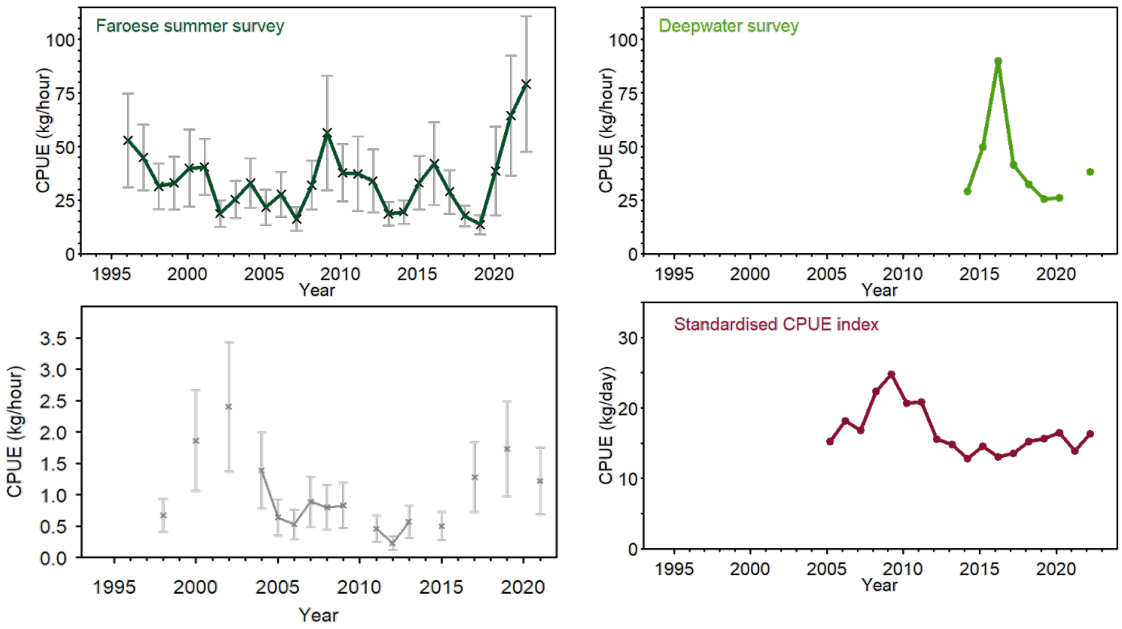

Figure 6.4.9. Survey indices with confidence intervals from 1) the Faroese summer survey (since 1995) top left, 2) Faroese deepwater survey (since 2014, excluding 2021) top right, 3) MSS Slope Deep Water (since 1998, irregularly) bottom left, and 4) combined standardized CPUE with confidence intervals from Faroese and EU fisheries from 2005 to last data year

6.4.5 Data analyses

6.4.5.1 Length and age distributions

In Division 5.b the mean length and age of greater silver smelt in the Faroese landings decreased from 1994 to 2000 and have been stable since then (Figures 6.4.3, 6.4.10). This trend probably reflects a gradual change during and following the first years of exploitation of a virgin stock (Ofstad, WD WKDEEP 2010). The variation in mean length during recent years could be due to different depths sampled in the various areas as the size of greater silver smelt is known to increase with increasing depth as reported in WKGSS 2020. Generally, the Faroese bottom surveys catch individuals with length less than 30 cm at depths shallower than 350 m whereas larger individuals (35–40 cm) are found deeper.

Mean landing size from the Netherland is around 34-38 cm (Figure 6.4.10).

Since 2003, mean length of greater silver smelt from Faroese and Netherland trawlers is very similar, around 36–39 cm (Figure 6.4.10). The low mean lengths observed in the Netherlands fishery (1996, 1999, 2002) could be due to the catch being a mixture of *Argentina silus* and *A. spyraena* or due to the Netherland trawlers operating in shallower waters. Another explanation could be that the data are from discard not landings.

Mean length in the catch from the fishery in the Faroes, PFA and Netherland as well as from the Faroese deepwater survey are comparable allowing the use of Faroese age-length data in the age-based assessment. The Faroese summer survey on the other hand has a lower mean length which is due to the shallow waters covered in the summer survey (Figure 6.4.10). However, this survey covers the distribution of juveniles which the other indices do not.

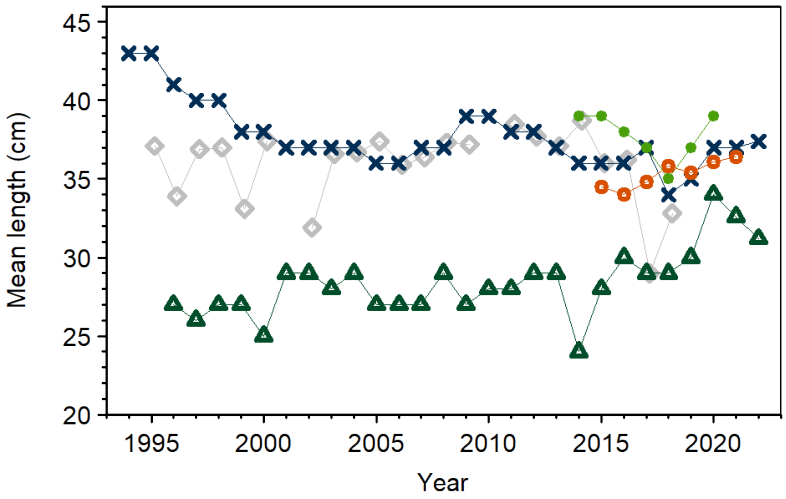

Figure 6.4.10. Greater silver smelt in 5.b and 6.a. Comparison of median lengths at year from Faroese catches (Blue crosses), PFA (open orange circles) and Netherland (grey diamonds) catches and from the Faroese summer (dark green triangles) and deep-water surveys (green filled circles).

6.4.5.2 Stock assessment

The SAM model is based on catch at age for ages 5 to 21+ and initiated in 1995 (Table 6.4.5). Catch at age data from 1995 to 2004 is derived from Faroese sampling raised to international catches. Catch at age data since is derived from InterCatch whereby the age-based data is only contributed by Faroe Islands and the Netherlands. Age classes of 5-year-old and older are used in the assessment. However, information on younger age groups (2-4) is available in InterCatch.

Maturity at age is fixed for the assessment period and natural mortality is set to 0.15 for all ages and years (ICES, 2021)

The age-disaggregated tuning series were the Faroese summer survey, ages 5 to 12 years (since 1997, Table 6.4.8) and the Faroese deepwater survey, ages 5 to 14 years (2014-2020, Table 6.4.9).

The Scottish deepwater slope survey (since 1998, irregular, Table 6.4.10) and the combined commercial Faroese and EU trawlers catch per unit effort (since 2005, Table 6.4.10) were used as biomass indices in the tuning of the assessment.

The model configuration has a correlated error structure for the age-based survey information (Faroese summer survey, Faroese deepwater survey). The model configuration required 23 estimated parameters (Table 6.4.11).

Other details regarding the age based state-space fish stock assessment (SAM) can be found in the Stock annex.

6.4.5.2.1 **Preliminary analyses**

In preparation for the WGDEEP meeting several preliminary analyses were undertaken to investigate four different elements:

1. The impact of replacing missing catch-weights at ages 19-21+ in years 2005-2007 and 2018 with 10-year averages
2. The impact of changing the parameter binding for the F-process to numerical order
3. The impact of adding a fleet effect to the CPUE standardisation for the combined Faroese – PFA fleet
4. The impact of changing the model configuration to estimate catch more accurately

6.4.5.2.1.1 Replacing missing catch-weights

The catch weight at age matrix contained -1 values for ages 19-21+ in 2005-2007 and 2018. SAM cannot estimate these missing values in its current formulation although SAM can estimate missing catch numbers at age. These missing weights were replaced by an average from the 10 previous years. The impact is minor and only leads to subtle changes in SSB for these years. Figure 6.4.11 shows the impact of changing the stock weights.

6.4.5.2.1.2 Changing the order of F-process parameters

In SAM, the number of F processes to be estimated is set in the configuration file by listing parameter numbers per age. For this stock, separate F processes are estimated for ages 5-10 and the same F process is estimated for ages 11+. The numerical order for these parameters followed 0-4,6,5,5,5,… rather than 0-6,6,6,6,… This aspects was likely overlooked at the benchmark and has a minor impact on the assessment but does affect the estimation of the F processes as these are correlated between ages. In the original case, the F process of age 11+ was correlated with the F process of age 9 with a lag of 1 rather than a lag of 2 (etc for the other ages but with higher lags).

6.4.5.2.1.3 Adding a fleet effect in the CPUE standardisation for the Faroese and PFA vessels

During preparation of the standardized CPUE time series for WGDEEP 2023, it was noticed that the generalized linear model treats data from both fleets the same, i.e., it does not differentiate the different fleets by including a fleet effect (or alike). Upon investigation it was found that introducing a fleet effect was highly significant. There are several reasons why this is relevant: (a) the fleets do not overlap in space, both fleets fish in a different area (see WD04), (b) the time-series for both fleets start at a different moment in time; notably at 2005 for the Faroese fleet and from 2015 onwards there is broad coverage in the catch per day information from the PFA fleet although data from years before that period are available as well. This leads to a data unbalance in the CPUE calculation which has not been taken into account. During the benchmark, the scientists involved considered including a fleet effect but found that it was insignificant at that time. Upon further investigation, the scientists had included a latitudinal effect at the same time as the fleet effect. A latitudinal effect has a similar effect as a fleet effect in this instance as the fleets are more or less separated by the ~59° latitudional line. As latitude was not included in the model either an effect to include fleet differentiation is required for appropriate model fitting.

The impact of including a fleet effect is described in WD04 and is substantial as it changes the trajectory of the CPUE mainly from 2015 onwards. It shows a much lower increase in relative biomass than would be the case for the model excluding a fleet effect. This change is more in line with the development of the Faroese CPUE that has remained more or less stable since 2012. As the assessment fits the CPUE well, this change downscales SSB, increases F and decreases the estimates of R for the period from 2015 onwards.

The experts investigated whether fitting a GAM rather than a GLM would be appropriate but this led to minor differences although the number of parameters reduced greatly through the use of smoother functions for the co-variates of depth and week. To remain as close as possible to the stock annex, experts decided to prefer the GLM model over the GAM model.

6.4.5.2.1.4 Estimating catch more accurately

Preliminary analyses were undertaken to find a model configuration that would fit the ICES estimated catch better within the assessment model. The main driver for the misfitting of catch in the model is the lack of process error at age 6+. This value was changed in last years assessment from log(0.0001) and is now set to log(0.01) to have the assessment model converge as the cohort data is likely not good enough to inform the assessment model sufficiently to estimate this parameter value. Setting the value this low means that there is almost no deviation in cohort signal compared to the assumed survivor equation.

As the model assumes catches up to the age of 21, any incorrect estimation of cohort size at a young age can have a long-lasting effect up to older ages. Allowing for more process error to take place leads to an overly uncertain stock assessment and retrospective patterns. It requires extensive explorations to see if other model configurations can be used to minimize the impact on parameter uncertainty and retrospective pattern.

6.4.5.2.2 Final model

The working group accepted changes 1-3 as mentioned above which results in SSB, F and Rec estimates as shown below.

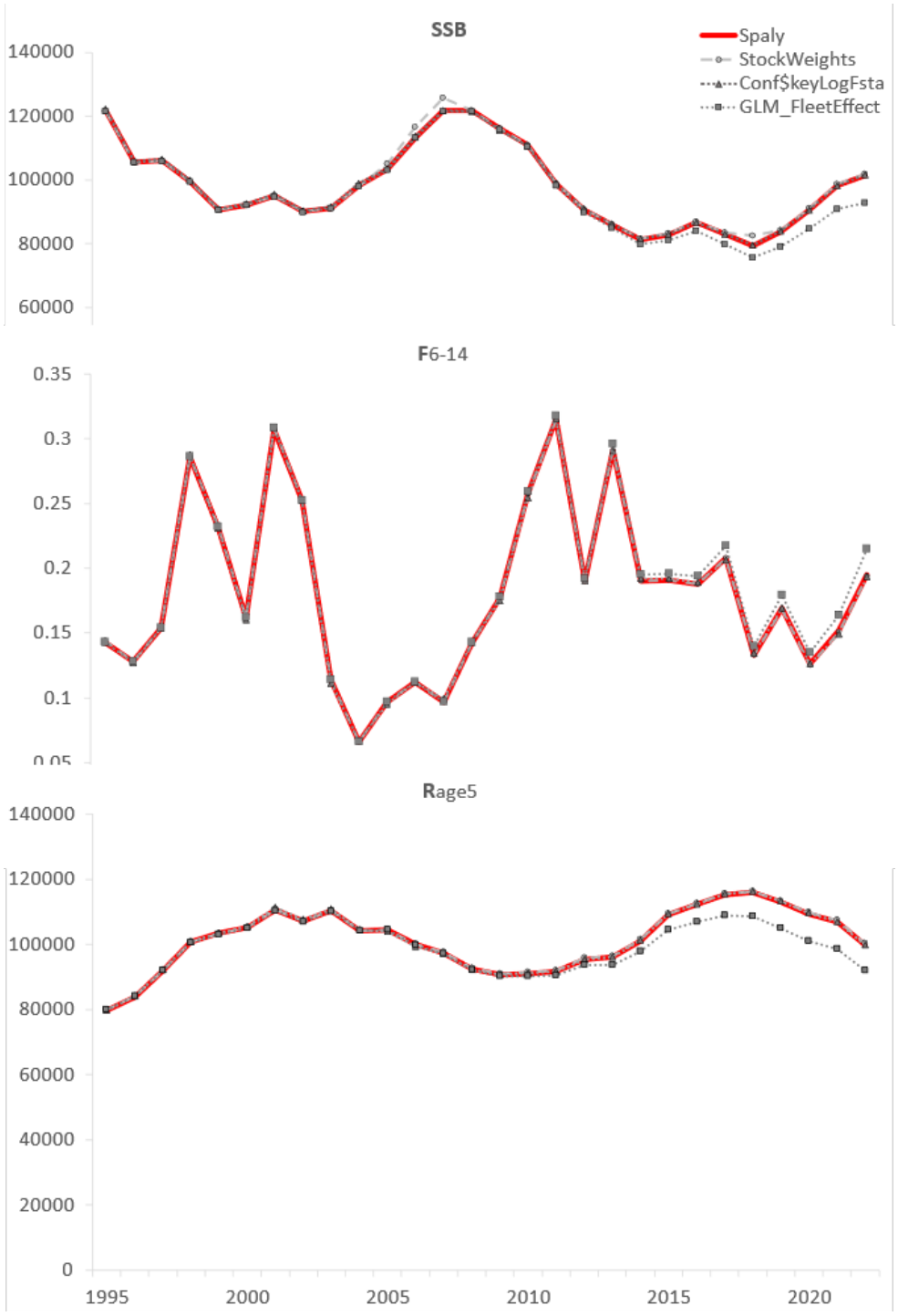

Figure 6.4.11 Greater silver smelt in 5.b and 6.a. Impact on SSB, F and R for changes in catch and stock weights, changing the F-process binding and the impact of adding a fleet effect to the CPUE standardisation.

Diagnostics and results of the SAM model ARU _27.5b6a_WGDEEP2023 @ stockassessment.org are shown in the Figures and Tables below:

- Model fits to the data (Figures 6.4.12-6.4.13)
- Standardized one-step-ahead residuals (Figure 6.4.14)
- Leave-one-out analysis (Figure 6.4.15)
- Retrospective analysis (Figure 6.4.16)
- Estimated correlations between age groups for each fleet (Figure 6.4.17)

- Comparison of SSB, Fbar, Recruitment and Catch between last years and present year SAM runs(Figure 6.4.18 and Table 6.4.13)
- Parameter estimates (Figure 6.4.19, Table 6.4.12)
- Selectivity patterns by pentad (Figure 6.4.20)

In order to minimize systematic year effects, the final SAM model included correlated errors across ages (Figure 6.4.19). Residuals were more randomly distributed after the correlated errors were taken into account.

The retrospective pattern shows that recruitment has been underestimated (Figure 6.4.16). All the retrospective runs fall within the confidence intervals of the final assessment. Mohn's rho parameters are estimated at -4%, 4% and -11% for the spawning stock biomass, F and recruitment, respectively.

The results from SAM shows that the spawning stock biomass (SSB) currently around 93 000 tonnes (Figure 6.4.18, Tables 6.4.13, 6.4.15) which is above B_{pa} and $MSYB_{trigger}$. The fishing mortality ($F_{6\text{-}14}$) has varied but has been below F_{MSY} since 2014 (Figure 6.4.18, Tables 6.4.13, 6.4.14). The model-estimated catch in the years since 2014 has been lower than the observed catch except in 2021.

Parameter estimates of the model are in the Table 6.4.12 and compared with the previous assessment in the Figure 6.4.19. Overall, parameter estimates are highly comparable between years.

The estimated selectivity by year is shown in Figure 6.4.20, organized by pentad. The estimated selectivities are highly variable between years and show large variations in estimated selectivities, especially at the older ages. This has impacts on the short term forecast that is based on the most recent selectivity taken forward.

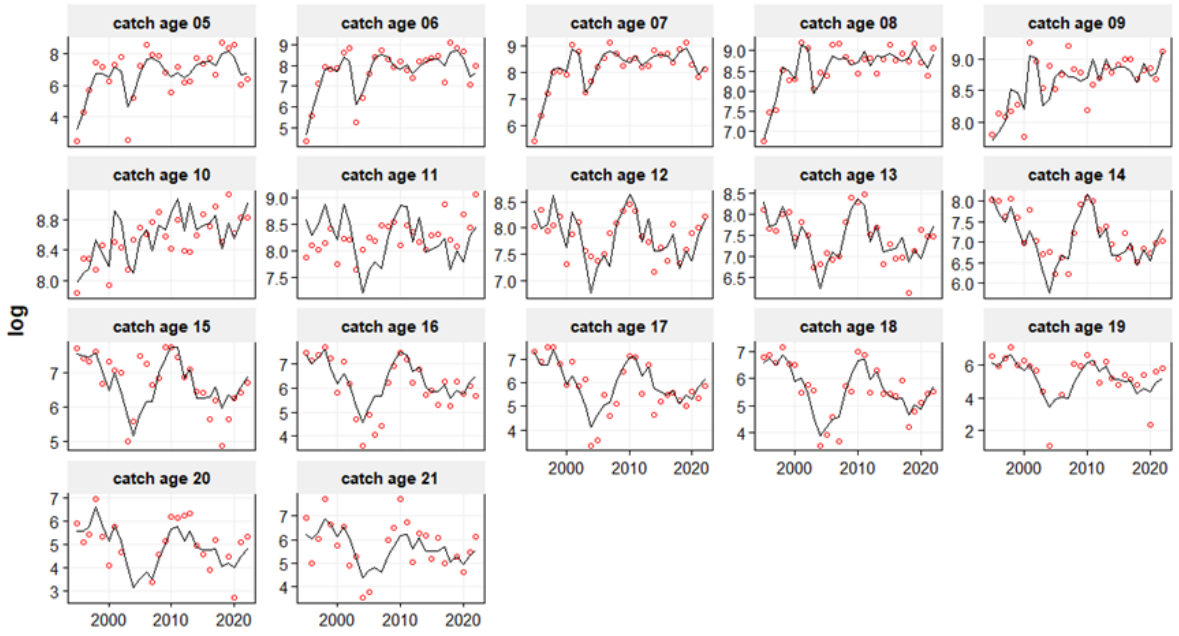

Figure 6.4.12. Greater silver smelt in 5.b and 6.a. Fit of the assessment model to the catches at age.

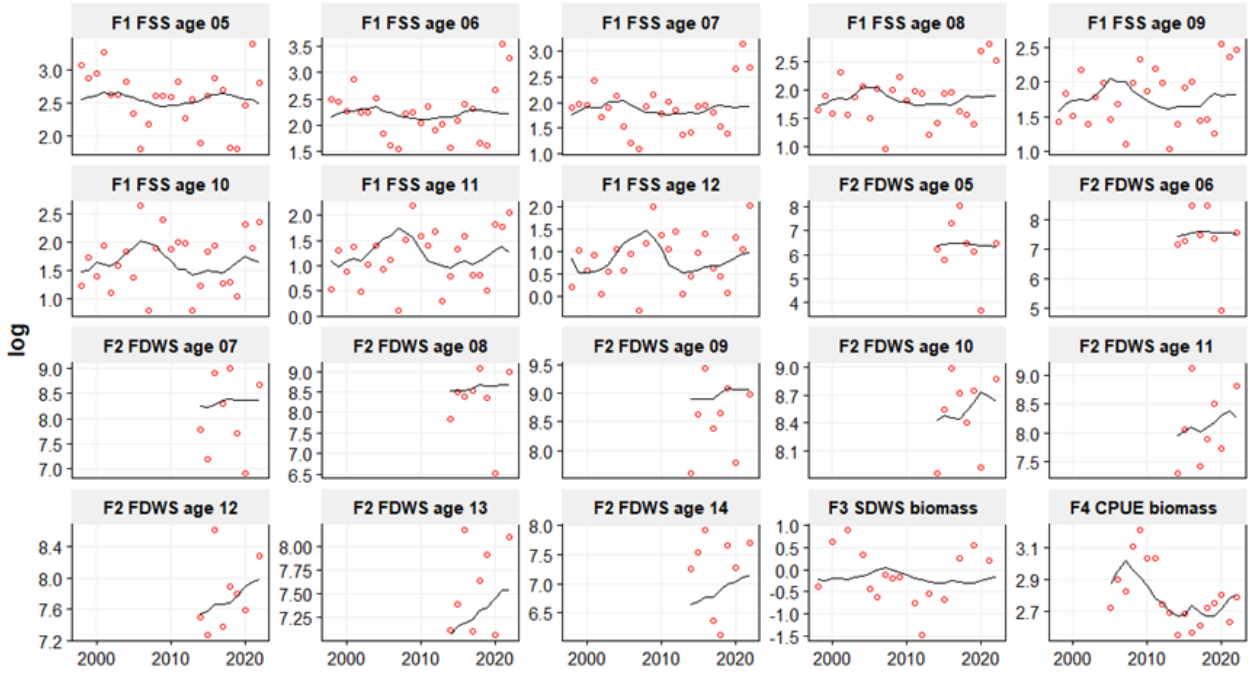

Figure 6.4.13. Greater silver smelt in 5.b and 6.a. Fit of the assessment model to the Faroese summer survey (F1 FSS), the Faroese deepwater survey (F2 FDWS), the MSS Deepwater slope survey (F3 SDWS) and the Faroese-EU standardized CPUE series (F4 CPUE).

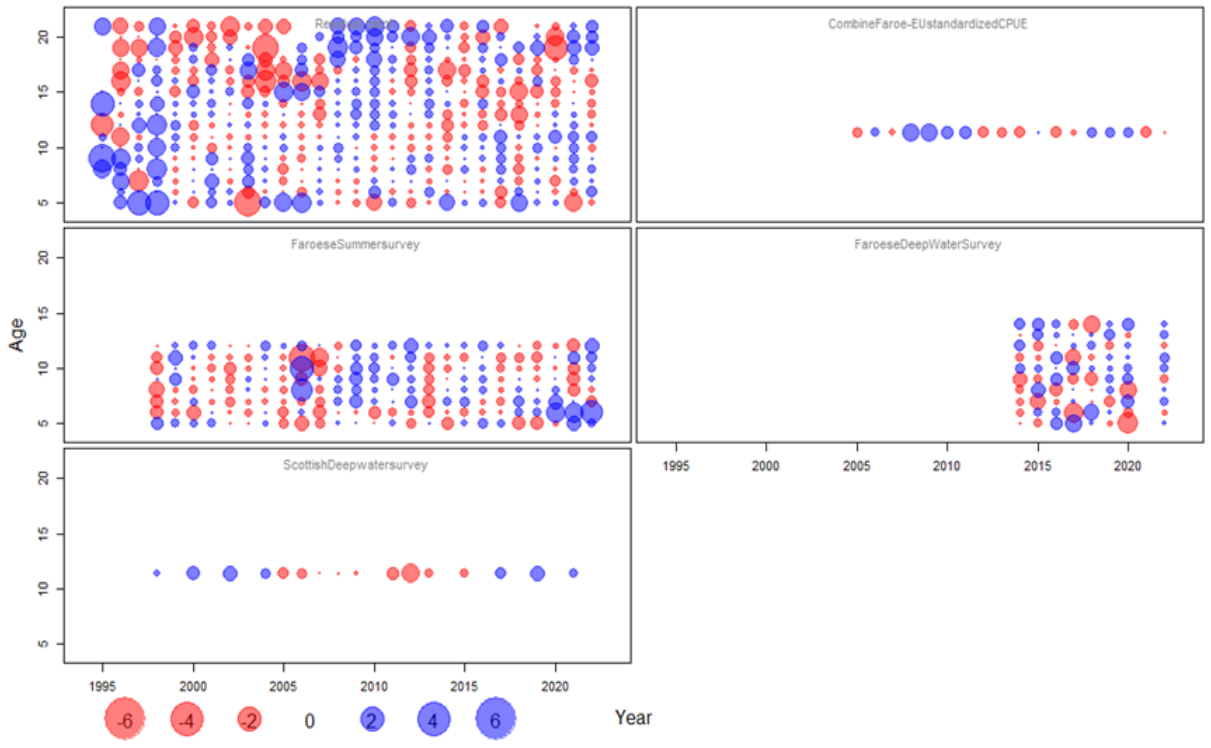

Figure 6.4.14. Greater silver smelt in 5b and 6a. Standardized one-step-ahead residuals from the SAM model.

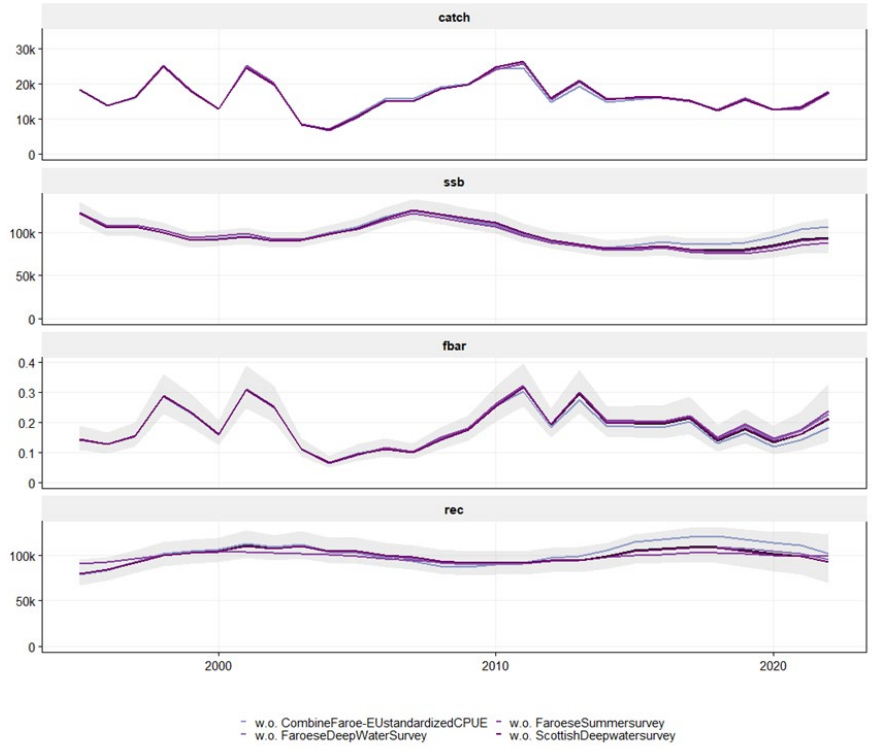

Figure 6.4.15. Greater silver smelt in 5b and 6a. Leave-one-out analysis of Catch (1st), SSB (2nd), fishing mortality (3rd), recruitment (4th). Black line and grey band indicated the final assessment with 95th percentiles.

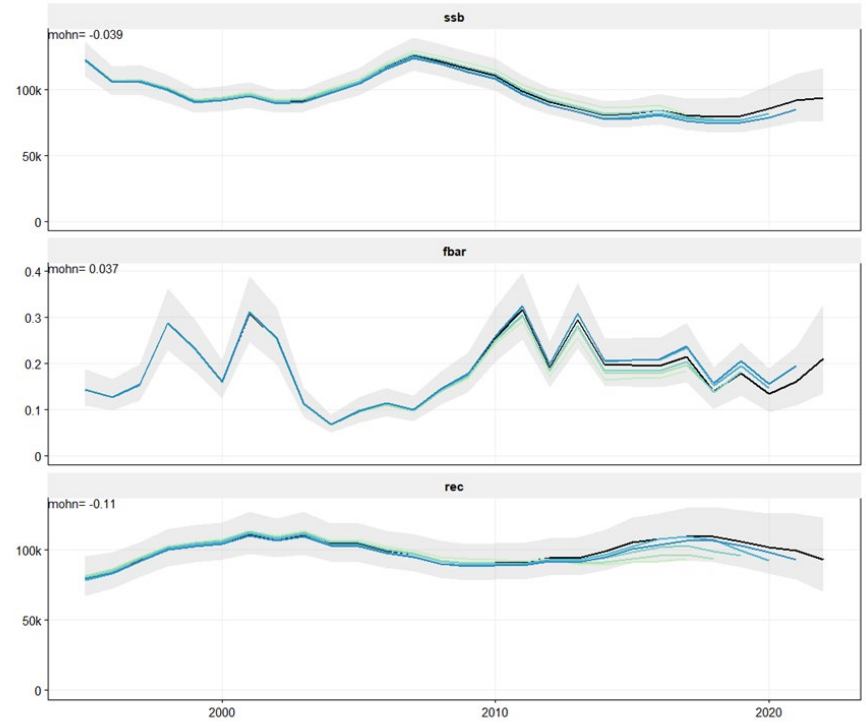

Figure 6.4.16. Greater silver smelt in 5b and 6a. Retrospective analysis with 5 peels in SSB (upper), fishing mortality (middle), recruitment (lower). Mohn's rho value indicated in top left of each panel.

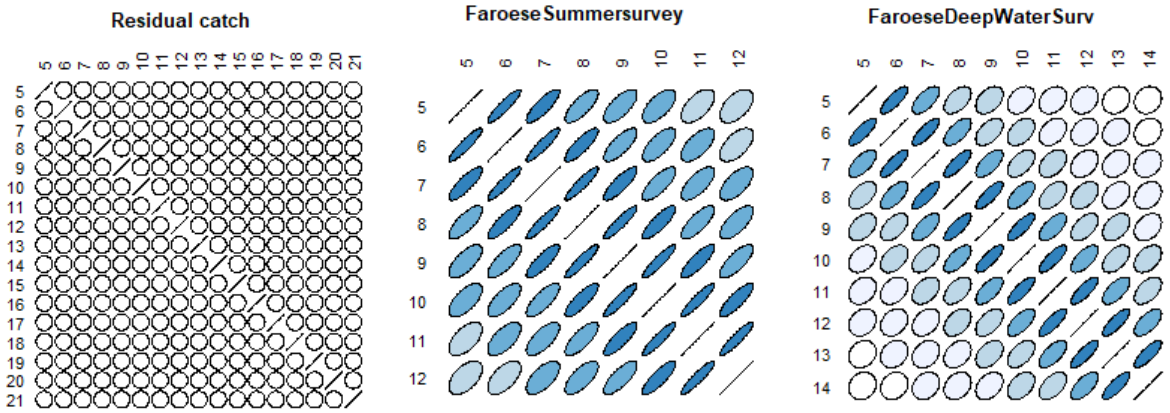

Figure 6.4.17. Greater silver smelt in 5b and 6a. Estimated correlations between age groups for catch (left), Faroese summer survey (middle) and Faroese deepwater survey (right).

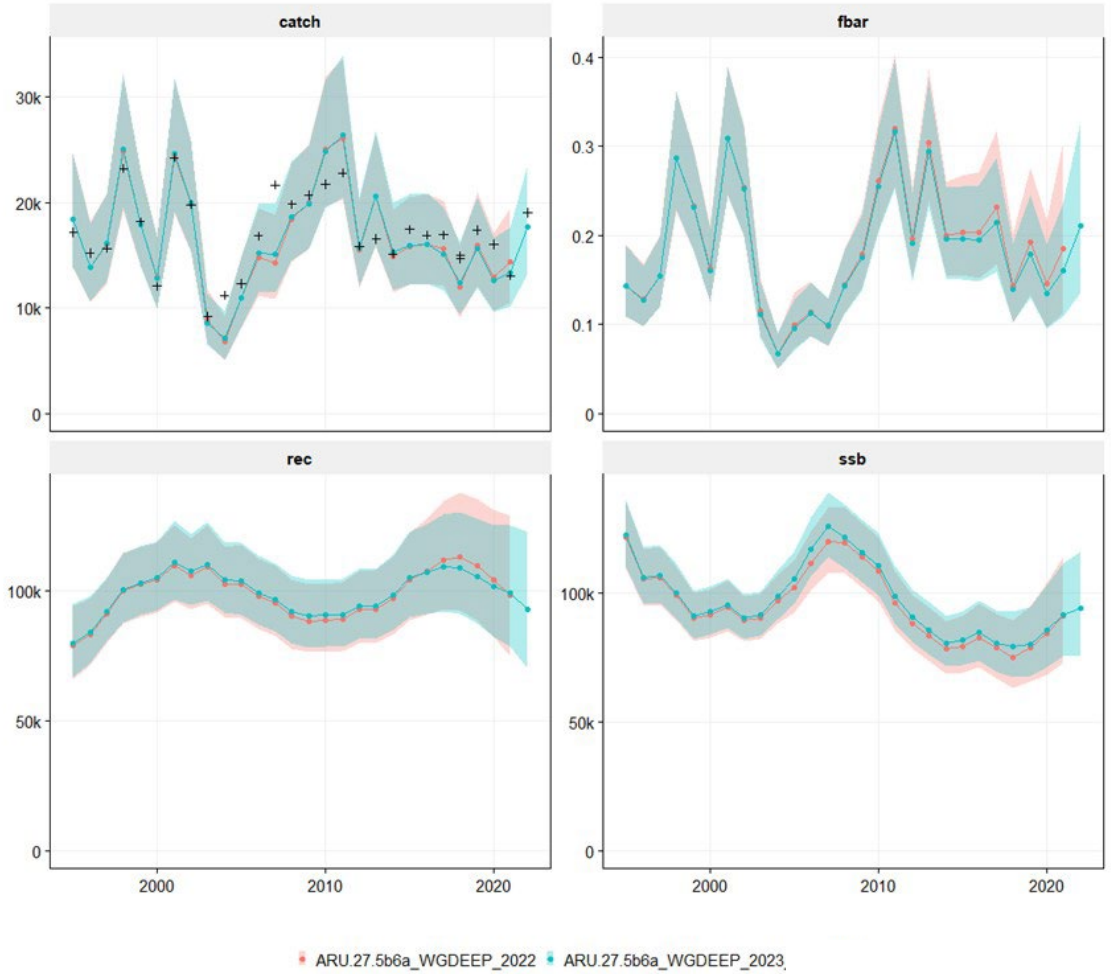

Figure 6.4.18. Greater silver smelt in 5.b and 6.a. Comparisons of present assessment (green blue) and previous assessment (red). Catch in tonnes (upper left), fishing mortality (upper right), recruitment (lower left) and SSB (lower right).

Figure 6.4.19. Greater silver smelt in 5.b and 6.a. Comparison of parameter estimates from present assessment (green blue) and previous assessment (red).

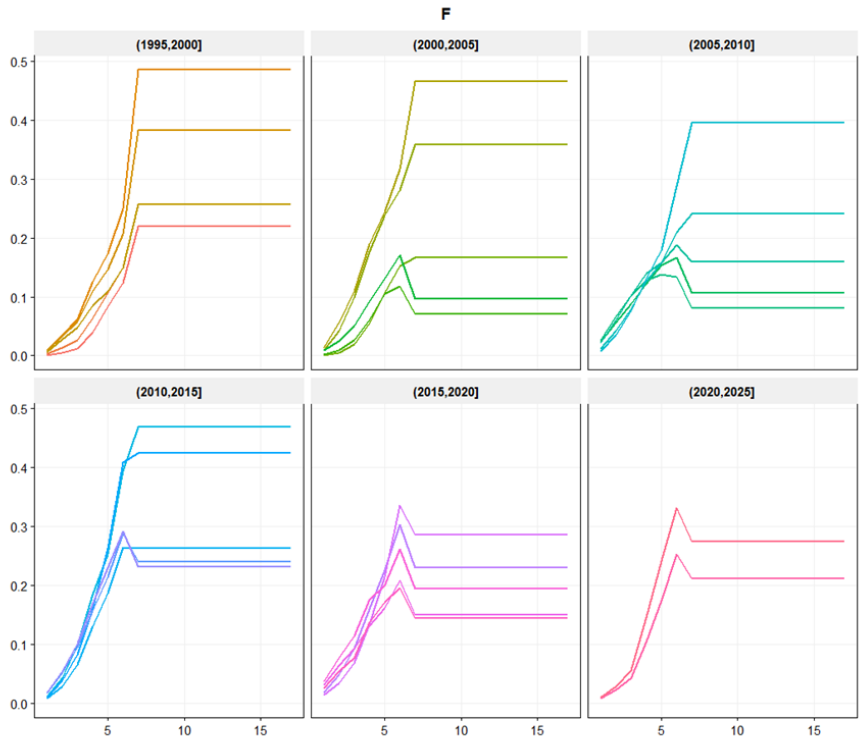

Figure 6.4.20. Greater silver smelt in 5.b and 6.a. Selectivities from the SAM model by year, organized by pentad of 5 years.

6.4.6 Quality of the assessment

The assessment of greater silver smelt was benchmarked in 2020 (ICES, 2021), where the assessment was upgraded from a trend-based to a SAM state-space model using catch at age information and four indexes. A comparison of parameter estimates between the previous assessment and present assessment indicates that the model results are largely comparable, although both F and recruitment are estimated somewhat higher than in the 2023 assessment (Figure 6.4.20). The Mohn's rho values from the retrospective analysis are below the required thresholds.

In the 2021 assessment, a substantial discrepancy was discovered between the calculated catch in tonnes from InterCatch and the SAM estimated catch in tonnes. The discrepancy mostly occurred in the period from 2015 to 2020. Part of the discrepancy derives from the truncation of the age-range used in the assessment model where only age 5 and up have been used whereas in InterCatch catch at age information is available from age 2 onwards. A comparison of the catch in tonnes that is and that is not included in the assessment explains part of the discrepancy between observed catch and modelled catch, but still a noticeable discrepancy remains (WGDEEP2021). This could potentially be due to a mismatch between the catch at age information from InterCatch and the SAM model configuration. Unfortunately, this issue has not been resolved prior to WGDEEP 2023 but will be explored further for next assessment.

6.4.7 Short term forecast

A short-term forecast was carried out using the forecast options on stockassessment.org. Recruitment was based on a 10-year geometric mean recruitment (2010-2019) and mean weights was based on 5 year averages. Stock numbers and selectivity were taken from the final year.

A particular challenge in the forecast of this stock is the way to deal with the discrepancy between the SAM estimates of catch and the InterCatch estimated catch. At the 2022 assessment several forecast options were explored and a catch constraint based on the ratio of TAC to catch since 2010 on the intermediate year was introduced. The working group developed a method to estimate uptake of the quota in the interim year. The process calculates the uptake of the TAC as a ratio of ICES landings over summed TAC of the Faroes, EU and UK TACs for the years since 2010. It then fits a linear model on the ΣTAC-uptake datapoints and uses this relationship to predict the expected uptake given the agreed TAC in the interim year. This results in an expected catch in the interim year. Results are shown in figure 6.4.21 and table 6.4.21.

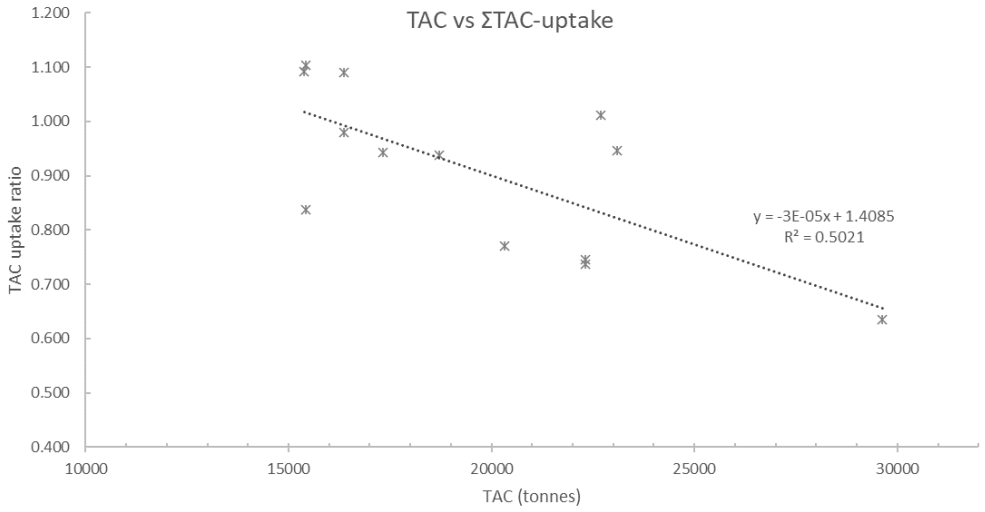

Figure 6.4.21. Greater silver smelt in 5.b and 6.a. Estimated F-at-age in the WGDEEP 2022 and 2023 final assessments as well as the ratio between these F estimates.

6.4.8 Reference points

Reference points for this stock were estimated at the benchmark meeting WKGSS 2020 (ICES, 2021). Two types of reference points are referred to when giving advice for Category 1 stocks: precautionary approach (PA) reference points and maximum sustainable yield (MSY) reference points.

With the updated technical guidelines on reference points (ICES (2021). 16.4.3.1. ICES fisheries management reference points for category 1 and 2 stocks. ICES Advice Technical Guidelines.), the procedure for estimating fishing mortality reference points have changed. F_{pa} is now set at $F_{p0.5} = 0.33$. The previously estimated F_{lim} (=0.29) is no longer considered relevant, as it is lower than the new F_{pa}. F_{MSY} is estimated at F=0.24 (Table 6.4.18).

6.4.8.1 Impact of changes in stock assessment configuration on the reference points

Due to the changes made in the assessment model, one could argue that reference points need to be updates as well. The working group suggests to retain the current reference points as these are still considered precautionary.

The working group considered two aspects of the model to justify this approach. (1) the change in selection at age and (2) the change in productivity of the stock.

The selection pattern of the fleet under the 2023 adjusted assessment settings results in a decline in selection of older ages and increase in a selection of younger individuals (Figure 6.4.22). This change has a positive impact on the estimate of F_{msy} and hence leaves the current estimate of F_{msy} to be more precautionary compared to an updated value. It should furthermore be noted that this assessment has substantial retrospective patterns in F and therefore will estimations of F reference points vary based on the most recent assessment anyhow.

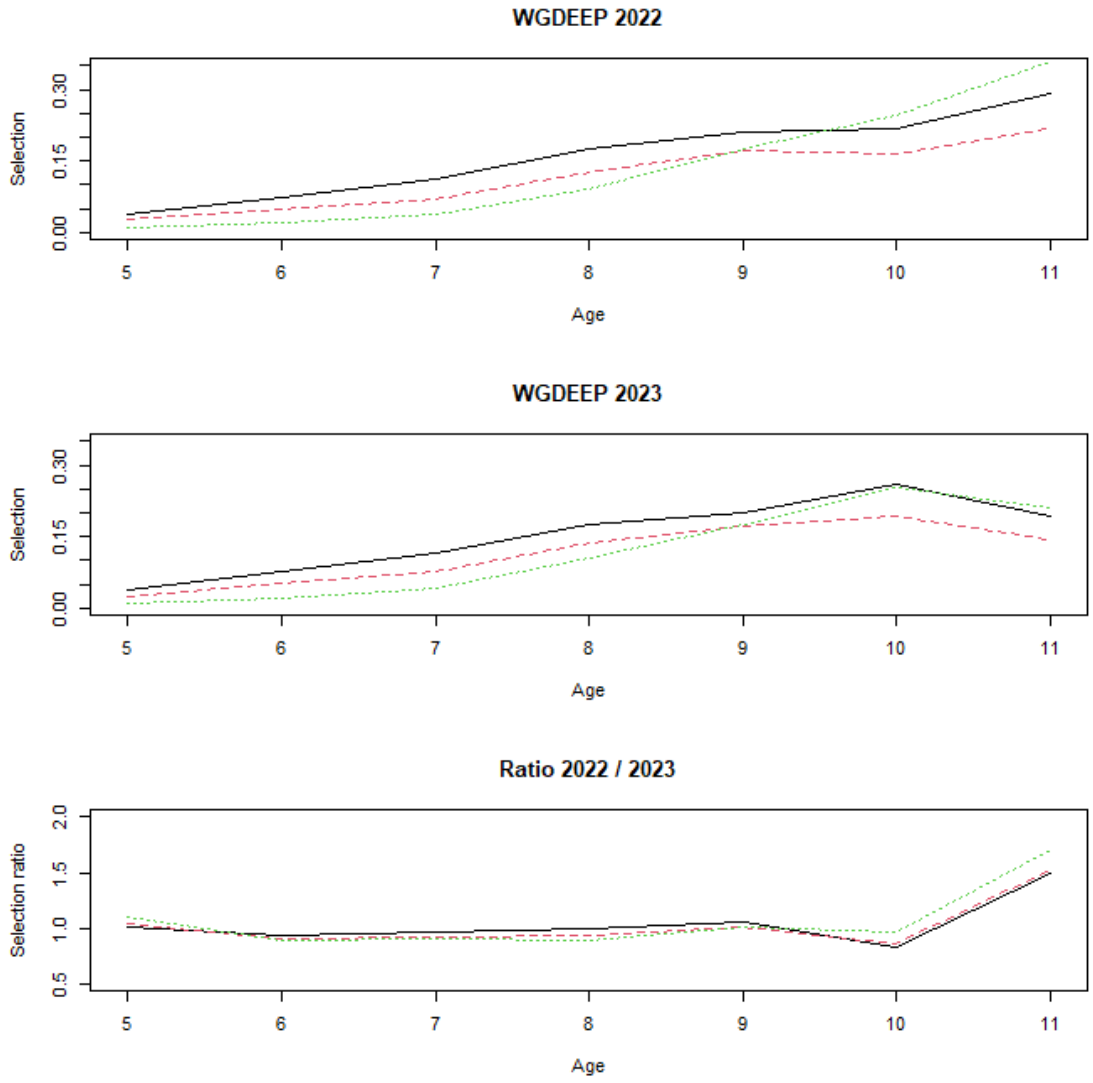

Figure 6.4.22. Greater silver smelt in 5.b and 6.a. Estimated F-at-age in the WGDEEP 2022 and 2023 final assessments as well as the ratio between these F estimates. Lines represent the estimates for the years 2019-2021 (black, red and green respectively).

When considering the second (2) point, the working group noticed only a marginal change in recruitment over SSB (Figure 6.4.22). There is however a shift visible in the SR-pairs with a shift to lower SSB values. As B_{lim} and B_{pa} are derived from the lowest observed biomass levels, retaining the current biomass reference points will be considered to be more precautionary than when these values would be updated. It should furthermore be noted that this assessment has substantial retrospective patterns in SSB and therefore estimates of biomass reference points will vary based on the most recent assessment regardless.

6.4.9 Management considerations

The quota of greater silver smelt in the Faroese EEZ has been reduced from 16 000 tonnes (2014) to 11 700 in 2018 and 2019 (Table 6.4.3). The reason for this was the decrease in the spawning–stock biomass index from the exploratory assessment in 2018.

The TACs by the European Union for areas 5, 6 and 7 are set for the European fisheries only. This TAC mostly applies to the fishery in Divisions 5.b and 6.a where the bulk of the catches are taken.

No bilateral agreement between the UK, EU and the Faroe Islands exists to set an overall TAC of greater silver smelt in 5.b and 6a. The sum of quotas of the Faroe Islands, UK and EU has exceeded the scientific ICES advice since 2016, except for in 2022 (Table 6.4.3).

6.4.10 Future research and data requirements

The WG recommends that work be done to further explore the assessment and forecast issues that have been identified for this stock. Based upon the new ICES Benchmark guidelines and outcome of these analyses, potential solutions could be presented for the working group at next WGDEEP. The most pressing issues are:

- Revisit the whole time series of catch at age and weight at age in order to resolve the discrepancy between modelled catch and observed catch. Special attention should be devoted to the allocation criteria for assigning catch at age proportions to unsampled strata. Furthermore, the catch weight at age estimates need attention as the lack of samples of fish older than 15 years, in some years, highlights the need to combine catch at age and weight at age samples in the allocation process that is currently handled separately in Division 5b and 6a.
- Review the short-term forecast assumptions and method in the light of the discrepancy between the SAM estimates of catch and the InterCatch estimated catch and revisiting the catch at age and weight at age matrices.
- Revisit, if needed, the biological reference points in the light of the new guidelines from ACOM.
- Investigate the model's sensitivity to catches in the most recent years which is showing quite a large variability in the selectivity at age over the years. The change in the selectivity estimated in the model driving the difference in the forecast (Figure 6.4.20) should be investigated too.

6.4.11 Tables

Table 6.4.1. Greater Silver Smelt 5.b and 6.a. WG estimates of landings in tonnes. *preliminary data

Division 5.b															TOTAL
Year	Den-mark	Faroes	France	Germany	Greenland	Iceland	Ireland	Netherlands	Norway	Poland	UK(E&W)	UK (Scot)	Russia		
1988		287													287
1989		111											116		227
1990		2885											3		2888
1991		59										1			60
1992		1439											4		1443
1993		1063													1063
1994		960													960
1995		5534											6752		12286
1996		9495										3			9498
1997		8433													8433
1998		17570													17570
1999		8186	5								23	15			8229
2000		3713	64									247	1185		5209
2001		9572					1					94	414		10081
2002		7058						5				144	264		7471
2003		6261						51				1	245		6558
2004		3441						1125				42	702		5310
2005		6939						15					59		7013
2006		12554											35		12589
2007		14085						441	32				8		14566
2008		14930							3				19		14952
2009		14200											28		14228
2010		15567										40	2		15609
2011		15578											8		15586
2012		9744											110		9854
2013		11109											114		11223

Division 5.b Year	Den-mark	Faroes	France	Germany	Greenland	Iceland	Ireland	Netherlands	Norway	Poland	UK(E&W)	UK (Scot)	Russia	TOTAL
2014		9747		110									339	10196
2015		13025	0	40		132							115	13312
2016		11129		38		345		31				0	13	11557
2017		9424		1		63		2					6	9496
2018		10114	0							1			150	10265
2019	0	9194		2		6				4			87	9292
2020	0	8416								0			22	8438
2021	0	5411												5411
2022*		6368												6368

Table 6.4.1 (Continued).

Division 6.a Year	Den-mark	Faroes	France	Germany	Ireland	Lithuania	Netherlands	Norway	Poland	UK (E&W)	UK (Scot)	Russia	Spain	Total
1988					3040			4884						7924
1989		188			1325		3715	11984			3369			20581
1990		689		14	110		5870				112			6795
1991			7				4709				10			4726
1992			1		100		4964				466			5531
1993							663				406			1069
1994				43			6217				1375			7635
1995		483		284			3706				465			4938
1996				1384	295		3953							5632
1997				1496	1089		4309							6894
1998				464	405		4696							5565
1999				24	168		8188			5				8385
2000			19	403	3178		3436							7036
2001			7	189	5838		3654				4777			14465
2002			1	150	3035		4009			424	4136			11755
2003				26	1		1958				80			2065

Division 6.a															Total
Year	Den-mark	Faroes	France	Germany	Ireland	Lithuania	Netherlands	Norway	Poland	UK (E&W)	UK (Scot)	Russia	Spain		
2004			147	652	46		4335				507				5687
2005		103	10	125	18		5276				61				5593
2006		52		213			4841				3		1		5110
2007		254		589			7621	3					2		8469
2008		991		10			4186	3							5190
2009		3923		115			2616	83			6	36			6779
2010		3060					3139	7			20	11			6237
2011		3655					3724			2	2				7383
2012		2781		538			3248			5	5	1			6578
2013	388	3197		417	0		1380					13			5395
2014	711	1495		908			2332					21			5467
2015		1055		1027			2154	0							4236
2016		2050	0	228			2495								4773
2017		2304		599			4405	2							7310
2018		1974	8	1001			2763	5				18			5769
2019		2980	4	953	6		4540		29			28	0		8538
2020		3629	8	384	0	114	4330		111				0		8576
2021		3141	17	336	0		4019		1		3		0		7514
2022*	4	3040	1	728	4		8664	0	21						12461

Table 6.4.2. Greater silver smelt (*Argentina silus*) (5.b and 6.a). *preliminary data

Year	5.b	6.a	Total Landings	Discard 5.b	Discard 6.a	Total catches
1988	287	7924	8211			8211
1989	227	20581	20808			20808
1990	2888	6795	9683			9683
1991	60	4726	4786			4786
1992	1443	5531	6974			6974
1993	1063	1069	2132			2132
1994	960	7635	8595			8595

Year	5.b	6.a	Total Landings	Discard 5.b	Discard 6.a	Total catches
1995	12286	4938	17224			17224
1996	9498	5632	15130			15130
1997	8433	6894	15327			15327
1998	17570	5565	23135			23135
1999	8229	8385	16614			16614
2000	5209	7036	12245			12245
2001	10081	14465	24546			24546
2002	7471	11755	19226			19226
2003	6558	2065	8623			8623
2004	5310	5687	10997			10997
2005	7013	5593	12606			12606
2006	12589	5110	17699			17699
2007	14566	8469	23035			23035
2008	14952	5190	20142			20142
2009	14228	6779	21007			21007
2010	15609	6237	21846			21846
2011	15586	7383	22969			22969
2012	9854	6578	16432			16432
2013	11223	5395	16618			16618
2014	10196	5467	15663	28	1553	17244
2015	13312	4236	17548		270	17818
2016	11557	4773	16330	12	1651	17993
2017	9496	7310	16806	31	239	17076
2018	10265	5769	16033	2	185	16220
2019	9292	8538	17830		86	17916
2020	8438	8576	17014	0	127	17141
2021	5411	7514	12925		157	13081
2022*	6368	12461	18829		243	19071

Table 6.4.3. Greater silver smelt in 5.b and 6.a. Overview of ICES advice and TACs set by the Faroese authorities and the European Union for greater silver smelt in area 5.b and 6.a.

Year/Area	ICES advise (5.b and 6.a)	Faroe Islands Quota (5.b and 6.a)	EU Quota ˆ (5, 6, 7)	UK Quota (5, 6, 7)	TACs Summed
2014	-	16000	4316	-	20316
2015	-	14400	4316	-	18716
2016	10030	13000	4316	-	17316
2017	10030	11500	3884	-	15384
2018	12036	11700	4661	-	16361
2019	12036	11700	4661	-	16361
2020	7703	11700	3729	-	15429
2021	7703	11700	3521	208	15429
2022	24493	18000	10976	650	29626
2023	17078	12700	7670	454	20824

ˆ **The EU TAC applies to all of areas 5, 6 and 7. However, only minor catches have been taken outside of divisions 5.b and 6.a.**

Table 6.4.4. Greater silver smelt in 5.b and 6.a. Discards of greater silver smelt in tons per country per area from 2014 to last data year along with discard percentage of combined annual catch. *preliminary data

Year	Area 5.b				Area 6.a					Areas combined 5.b and 6.a	
	France	Germany	Netherlands	UK(Scotland)	France	Germany	Netherlands	Spain	UK(Scotland)	Total	% of catches
2014		28			808	92			653	1581	9.2
2015					161				109	270	1.5
2016	12				200				1451	1663	9.2
2017	31		0		217		9		14	270	1.6
2018	2				118				67	187	1.2
2019					13			9	64	86	0.5
2020				0				2	124	127	0.7
2021								0	156	157	1.2
2022*								83	159	243	1.3

6.5 Greater silver smelt (*Argentina silus*) in 6.b, 7, 8, 9,10 and 12

6.5.1 The fishery

The fisheries in this area are very minor and there are no directed fisheries.

6.5.2 Landing trends

Landings from this area are reported from 1966–2022. Landings increased until 2002 to 4662 tons then declined again to low levels of less than a ton in 2016. Landings from 2006 until 2022 have been less than 50 tons, except for 76 t in 2020. The main landings have been from Division 6b and Subarea 7 where Ireland was fishing for some years between 2000 and 2003.

Landings in Division 6.b and subareas 7–10 and 12 are small. Considerable discarding is known to occur in some fisheries in the Porcupine Bank outer shelf and upper slope fisheries for demersal and deep-water fish. These fisheries do not land greater silver smelt. Targeted fisheries for greater silver smelt that existed prior to 2006 have not operated significantly in these areas since then. It is considered more likely that variations in landings over time reflect market opportunities rather than fish abundance.

6.5.3 ICES Advice

Advice is given every other year. The 2021 advice for area 6b, 7, 8, 9, 10 and 12, stated "ICES advises that catches should be no more than 124 tonnes in each of the years **2022 and 2023**. The precautionary approach was applied for the advice given in 2021. ICES previously gave advice on landings for this stock. Because discard data are now available, the present advice is provided for catch.

6.5.4 Management

The EU introduced TAC management in 2003. For 2023 and 2024, the EU TAC is 7670 t whilst the UK TAC is 454 t in Subareas 5, 6 and 7 [4]. Catches of blue whiting may include unavoidable by-catches of greater silver smelt in the area.

6.5.5 Data available

6.5.5.1 Landings and discards

Landings data are presented by area and countries (Tables 6.5.1–6.5.5, Figure 6.5.1). Discards data from the eight last years are presented in Table 6.5.6. Discards from 2015 to 2019 and from 2021 to 2022 are mainly from the Spanish fishery and from Subarea 7 while for 2020 the discards were around 50 t from both the Spanish fishery and the Scottish fishery. For previous years, the discards were very high compared to the landings. In 2020 this shifted, with Dutch landings of 62 t from Subarea 7. However, for the last two years the landings have declined again and are now, respectively, approximately 35 and 14 percent of the total catch.

Argentina silus can be a very significant discard of the trawl fisheries of the continental slope of Subareas 6 and 7 particularly at depths 300–700 m (e.g. Girard and Biseau, WD 2004) (Table 6.5.7). Information have been available on discards in 2009 and 2012 in Basque country and Spanish fisheries in Subareas 6–7 and Divisions 5.3.abcd and northern 9.a. These estimates have been in the range 1000–4000 t since

[4] EU-UK for 2023 (europa.eu)

2003. In 2010 and 2011, they were around 2000 t. New calculation of the estimates for 2012 and 2013 reduce strongly the discards reported by Spain. Same applies for discards registered by the Netherlands. Based upon on-board observations from DCF sampling, the catch composition of the French mixed trawl fisheries in 5.b, 6 and 7 include 5.3% of greater silver smelt, based upon data for year 2011 (Dubé *et al*., 2012). This species is discarded in that fishery; it represents 25.3% of the discards. Raised to the total landings from that fishery, an estimated 280 t of discarded greater silver smelt was estimated for 2011. It should be noted that after redefinition of stock structure in 2015 area 6.a is not included in this stock.

ICES considers that the high landings of silver smelt seen in the early 2000s (Table 6.5.1 and 6.5.2, and Figure 6.5.1.) may have resulted from misreporting of fish species other than silver smelt. There is currently no directed fishery and bycatches of greater silver smelt are discarded in fisheries for other species (primarily hake, monkfish, and megrim).

6.5.5.2 Length compositions

The size compositions of *Argentina* spp. from Porcupine survey since 2012 is presented in Figure 6.5.2.

Length distribution from discards is available in InterCatch for 2015 (Scotland), 2016 (Scotland and Spain), 2017 (Spain and Scotland), 2018 (Spain and Scotland), 2019 (Spain), 2020 (Scotland and Spain), 2021 (Spain) and 2022 (Spain). Length distributions from discards is presented in Figure 6.5.7. For landings, length distributions are available from 2020 (Netherland). Comparison of length distributions from landings and discards from 2020 is shown in Figure 6.5.8.

6.5.5.3 Age compositions

No new data on age composition were presented.

6.5.5.4 Weight-at-age

No new data on weight-at-age were presented.

6.5.5.5 Maturity and natural mortality

No new data on maturity and natural mortality were presented.

6.5.5.6 Catch, effort and research vessel data

Spanish bottom-trawl surveys have been carried out in Subarea 7 (Porcupine) since 2001. Recent investigations have revealed that survey catches from the Spanish Porcupine survey contain both *A. Silus* and *A. Sphyraena* (Table 6.5.8 and Figures 6.5.2 - 6.5.6). Abundance and biomass indices from survey catches of mixed *A. silus* and *A. sphyraena* is presented in Figure 6.5.4. The Spanish survey only covers depths to 400 m and is unlikely to fully cover the depth range of greater silver smelt.

6.5.6 Data analyses

Length and age distributions

In previous years, the size compositions from Porcupine Bank in Subarea 7 have not shown any obvious trend towards smaller fish, but these data may be disturbed by the relative species composition of *A. silus* and *A. sphyreana* (Figure 6.5.2 and 6.5.5). In 2019, however, despite the low abundance per size of *A. silus* from the last survey, small specimens (around 17 cm) were found. For *A. silus*, this shows the highest amount of small specimens in the last ten years. A second small mode was found around 28 cm. For 2020, the length composition from the survey for *A. silus* shows that the mode around 22 cm increased greatly. The survey conducted in 2021 did not show any trends regarding the length composition as the amount of *A. silus* was low. For 2022, the length composition still shows a bi-modal

distribution. However, the number of specimens is considerably lower than showed in 2020. For, *A. sphyraena,* a single mode is showed around 22 cm since 2017 (Figure 6.5.2).

Commercial and survey cpue series

For Subarea 7, abundance and biomass indices from the Spanish porcupine survey showed a decreasing trend from 2002 until 2011, were rising from 2012 until 2016 but have had a downward trend since then (Figure 6.5.4). The index has decreased for *A. silus* since 2016 with the exception of relatively high estimates in 2020 (Figure 6.5.3). However, the survey is unlikely to cover all the exploitable biomass of the stock as it only covers depth down to 400 meters. In 2019, the biomass of both species of *Argentina* continued decreasing whereas the abundance increased slightly (Table 6.5.8 and Figure 6.5.4). *A. silus*, the most contributing species in the overall percentage of silver smelt, followed the downward trend of the previous years whereas *A. sphyraena* increased abruptly both regarding biomass and abundance (Table 6.5.8 and Figure 6.5.3). However, the index from the survey conducted in 2020 shows that both the biomass and the number of *A. silus* increased considerably, breaking the downward trend of recent years, and staying in the medium-high values of historical series. *A. sphyraena*, by contrast, decreased sharply, getting medium-low values of the time series. For 2021 the trend for *A. sphyraena* continued at 2020 values, while both the biomass and abundance of *A. silus* declined to a historical low level. For 2022 the trend for both species, considering biomass and abundance, increased.

Exploratory assessment

No exploratory assessment was presented.

Biological reference points

SPiCT was run on the landings dataseries (1973–2016) and the biomass index series from Porcupine bank (2001–2016) at WGDEEP 2017, but it did not converge. SPiCT was also run before WGDEEP 2023 on the catch dataseries (1966-2022) and the biomass index series from Porcupine Bank (2001-2022), but either this time did SPiCT converge.

6.5.7 Assessment

According to the recommendations from WKLIFE X, the ICES-rfb rule was applied for a trend-based advice (ICES, 2023). The Spanish Porcupine bank survey greater silver smelt index (Table 6.5.8 and Figure 6.5.3) was used for the stock development. The advice is based on the recent advised catches (2023), multiplied by the ratio of the mean of the last two index values (index A) and the mean of the three preceding values (index B), a ratio of observed mean length in the catch relative to the target mean length, a biomass safeguard, and a precautionary multiplier. The stability clause was considered and applied to limit the decrease in catch advice to 30%. The discard rate (mean 2015–2022) was 82%. The biomass index, index A and index B is shown in Figure 6.5.9. The pooled lengths from years 2015-2022 is shown in Figure 6.5.10. Note that the pooled lengths are from discards, hence the Lc, length at first capture, is not representative for landings. Age data were not available for this stock and growth parameters from the nearby greater silver smelt stock in Faroes waters and west of Scotland (ICES areas 5b and 6a) were applied. The parameters from von Bertalanffys growth function used in the rfb calculations were L_∞ = 48 cm and k = 0.225 yr^{-1}. $L_{trigger}$ is 40 kg $haul^{-1}$. The stock size is above MSY $B_{trigger\ proxy}$ ($I_{trigger}$) (Figure 6.5.9), and the fishing pressure is above $F_{MSY\ proxy}$ (Figure 6.5.11).

6.5.8 Comments on the assessment

Advice is given every other year for this stock and last advice applies for 2024 and 2025.

It should be noted that lesser silver smelt (*A. sphyraena*) may in some southerly areas have been included in the landing figures. According to research on the Spanish Porcupine survey where both species appear, lesser silver smelt are smaller and occupies shallower areas than greater silver smelt (Figures 6.5.2, and 6.5.6). The proportion of lesser silver smelt in the fisheries is not believed to be large but further investigations should be undertaken.

The biomass index is only from the Porcupine bank and is therefore not covering the total stock area.

A SPiCT model with the Spanish Porcupine survey as a biomass index was explored before the meeting but did not converge. This indicates that a production model is not appliable to the stock with the currently available data. Thus, in accordance with ICES guidelines (ICES, 2023) a trend-based rfb rule assessment is applied.

6.5.9 Management considerations

The trends for Porcupine bank survey biomass indices for *Argentina* species have increased in 2015 and 2016, declined in 2017, 2018 and 2019, increasing again in 2020 before declining to a historical low level in 2021 before increasing again in 2022.

6.5.10 References

Dubé, B., J. Dimeet, M.-J. Rochet, A. Tétard, O. Gaudou, C. Messannot, L. Fauconnet, Y. Morizur, A. Biseau, and M. Salaun. 2012. Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2011.

Girard, Marine & Alain Biseau. 2004. Preliminary results concerning spatial variability of the catch in the ICES Subarea VI: Composition and importance of the discard fraction. 8 p. WD WGDEEP 2004

ICES. 2023. Advice on fishing opportunities. In Report of the ICES Advisory Committee, 2023. ICES Advice 2023, section 1.1.1. https://doi.org/10.17895/ices.advice.22240624

6.5.11 Tables

Table 6.5.1. Greater Silver Smelt in 6.b. WG estimates of landings in tonnes. *landings in 2022 are preliminary.

Year	Faroes	Germany	Ireland	Netherlands	Scotland	Russia	Spain	TOTAL
1979								
1980		13						13
1981		525						525
1982								
1983		4						4
1984								
1985								
1986								
1987								
1988								
1989								
1990			300					300
1991				5				5
1992			220		1			221
1993					3			3
1994					20			20
1995	1114							1114
1996								
1997								
1998								
1999			178					178
2000			1355			29		1384
2001					62	68		130
2002					1	29		30
2003					6	120		126
2004				11		12		23
2005						4		4

Year	Faroes	Germany	Ireland	Netherlands	Scotland	Russia	Spain	TOTAL
2006								
2007								
2008						1	8	9
2009								
2010								
2011								
2012								
2013								
2014						20.5		20.5
2015								0
2016								0
2017								0
2018								0
2019						1		1
2020						11		11
2021								0
2022*								0

Table 6.5.2. Greater Silver Smelt in 7. WG estimates of landings in tonnes. *landings in 2022 are preliminary.

Year	France	Germany	Ireland	Netherlands	Scotland	Norway	Poland	Spain	UK E/W	TOTAL
1972										
1973	40									103
1974							63			
1975										
1976										
1977			1							1
1978		404					5			409
1979		103								103
1980										
1981										

Year	France	Germany	Ireland	Netherlands	Scotland	Norway	Poland	Spain	UK E/W	TOTAL
1982						666				666
1983						595				595
1984						163				163
1985										
1986						258				258
1987						50				50
1988						100				100
1989						200				200
1990		23		1						24
1991				9						9
1992				254						254
1993				505						505
1994				39						39
1995		73	6	431						510
1996		10								10
1997				12						12
1998										
1999			50							50
2000		79	166	244				34		523
2001	5		1592	2	2782			34		4415
2002			4433		2			2		4437
2003			95	19				5		119
2004				13	19			15		47
2005		26	1		14			17		58
2006								40		40
2007								35		35
2008										
2009	13		1					6		20
2010	10			8				2	3	23

Year	France	Germany	Ireland	Netherlands	Scotland	Norway	Poland	Spain	UK E/W	TOTAL
2011		4			8					12
2012		2			1					3
2013				1						1
2014				1						1
2015				5						5
2016	0			0				0		0
2017				8						8
2018				31				1		32
2019			0	5						5
2020			1	62						63
2021				34						34
2022*				16						16

Table 6.5.3. Greater Silver Smelt in 8. WG estimates of landings in tonnes. *landings in 2022 are preliminary.

Year	Netherlands	Spain	Ireland	TOTAL
2002	195			194.61
2003	43			42.525
2004	23			22.722
2005	202			202.29
2006				0
2007				0
2008		10		10
2009				0
2010				0
2011	1			1
2012				0
2013				0
2014	1.1			1.1
2015				0
2016		0		0

Year	Netherlands	Spain	Ireland	TOTAL
2017		0		0
2018		3.9		3.9
2019		1.6	0.5	2.1
2020		1.6		1.6
2021		0.3		0.3
2022*	1.5			1.5

Table 6.5.4. Greater Silver Smelt 9. WG estimates of landings in tonnes. *landings in 2022 are preliminary.

Year	Netherlands	Spain	Portugal	TOTAL
2006				0
2007	1			1
2008			0.5	0.5
2009			1.9	1.9
2010			1.9	1.9
2011			0.9	0.9
2012			1.9	1.9
2013				0
2014				0
2015				0
2016				0
2017				0
2018		0.1		0.1
2019				0
2020				0
2021				0
2022*		0.06		0.06

Table 6.5.5. Greater Silver Smelt 12. WG estimates of landings in tonnes. *landings in 2022 are preliminary.

Year	Faroes	Iceland	Russia	Netherlands	TOTAL
1988					0
1989					0
1990					0
1991					0
1992					0
1993	6				6
1994					0
1995					0
1996	1				1
1997					0
1998					0
1999					0
2000		2			2
2001					0
2002					0
2003					0
2004			4	625	629
2005				362	362
2006					0
2007					0
2008					0
2009					0
2010					0
2011					0
2012		31			31
2013					0
2014					0
2015					0

Year	Faroes	Iceland	Russia	Netherlands	TOTAL
2016					0
2017					0
2018					0
2019					0
2020					0
2021					0
2022*					0

Table 6.5.6. Discard data from 2015-2021 from Subarea 6b, 7-1012. *discards in 2022 are preliminary

Year	Spain				UK (Scotland)	TOTAL
	6b	7	8	9	6b	
2015	0.7	28			0.5	29.2
2016		237	2	1		240
2017	1.82	148.8			0.3	151
2018	2.3	97.9	1.8	0.8	10	112.8
2019	5	146	0.2	0.1	0.29	152
2020	2	44.6	7.4	2.9	50	107
2021	2	59.1	0.4	0.2	0.033	62
2022*	2.1	98.7	5.5	2.3	0.2	108.8

Table 6.5.7. Discards by Spain and Netherlands from before the redefinition of the stock area (Subarea 6,7 and 8) from 2003–2014.

Year	Spain	Denmark	Germany	Sweden	Netherland	Total
2003	2807				1247	4053
2004	3075				300	3375
2005	2438				0	2438
2006	1250				149	1399
2007	2038				45	2083
2008	3060				58	3118
2009	4109				74	4183
2010	2006				23	2029
2011	2050				6	2056
2012	177				26	203
2013	91			21	20	133
2014	160	6	120	1	111	398

Table 6.5.8. Greater silver smelt in subareas 7–10 and 12, and in Division 6.b. Assessment summary. Biomass index from the Spanish Porcupine Bank survey for both greater and lesser silver smelt. Also given is the biomass index for *A. silus* only and the proportion between the two species. High and low refer to standard errors.

Year	*Argentina sp.*			*Argentina silus*			Proportion of *A. silus*/*A. sphyrena* in the survey
	kg haul^{-1}	Low	High	kg haul^{-1}	Low	High	
2001	133.17	72.76	193.57				
2002	143.72	62.36	225.08				
2003	141.33	82.19	200.47				
2004	142.76	68.42	217.09				
2005	111.15	59.60	162.69				
2006	98.05	36.29	159.81				
2007	79.03	43.71	114.35				
2008	82.16	32.93	131.40				
2009	79.74	43.65	115.83	72.95	37.69	108.21	0.91
2010	97.39	41.19	153.59	89.97	34.02	145.91	0.92
2011	57.57	32.38	82.75	50.32	25.85	74.78	0.87
2012	93.52	51.51	135.53	83.02	42.52	123.53	0.89
2013	135.63	76.35	194.91	121.50	66.25	176.75	0.90
2014	75.59	48.41	102.77	59.57	35.53	83.61	0.79
2015	92.80	53.82	131.79	72.56	41.95	103.18	0.78
2016	199.00	109.49	288.51	172.94	92.32	253.55	0.87
2017	159.31	89.22	229.41	129.63	73.41	185.86	0.81
2018	112.36	38.57	186.16	98.72	25.44	172.00	0.88
2019	92.59	70.69	114.49	67.60	48.07	87.13	0.73
2020	125.34	87.95	162.72	109.81	75.28	144.34	0.88
2021	43.40	33.05	53.75	28.59	22.39	34.78	0.66
2022	96.54	74.66	118.42	71.04	54.58	87.51	0.74

6.5.12 Figures

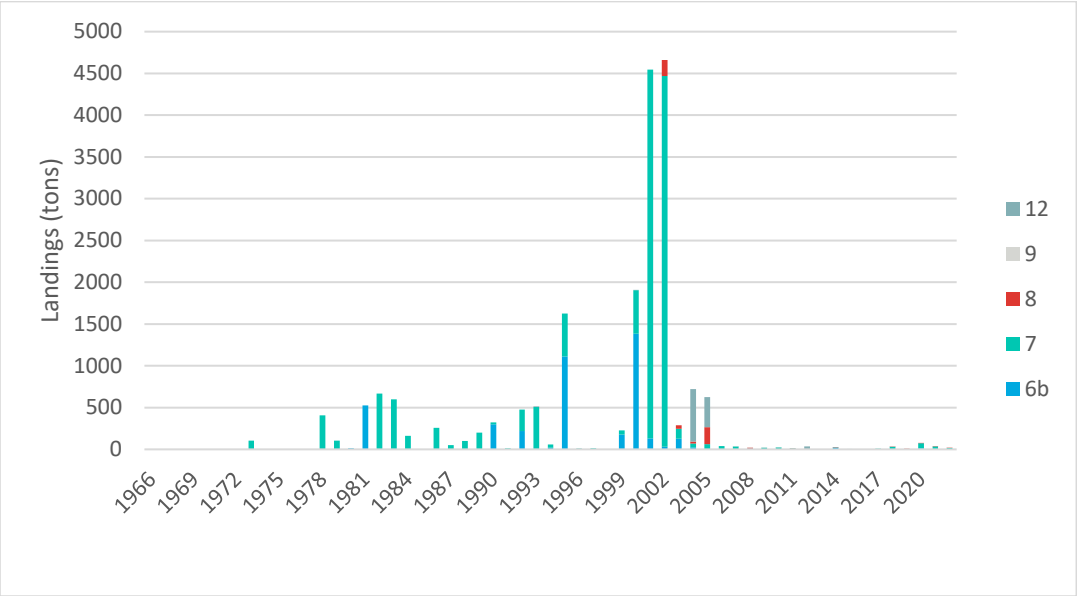

Figure 6.5.1. Total landings from 1966–2022 of greater silver smelt in 6.b, 7, 8, 9, 10 and 12.

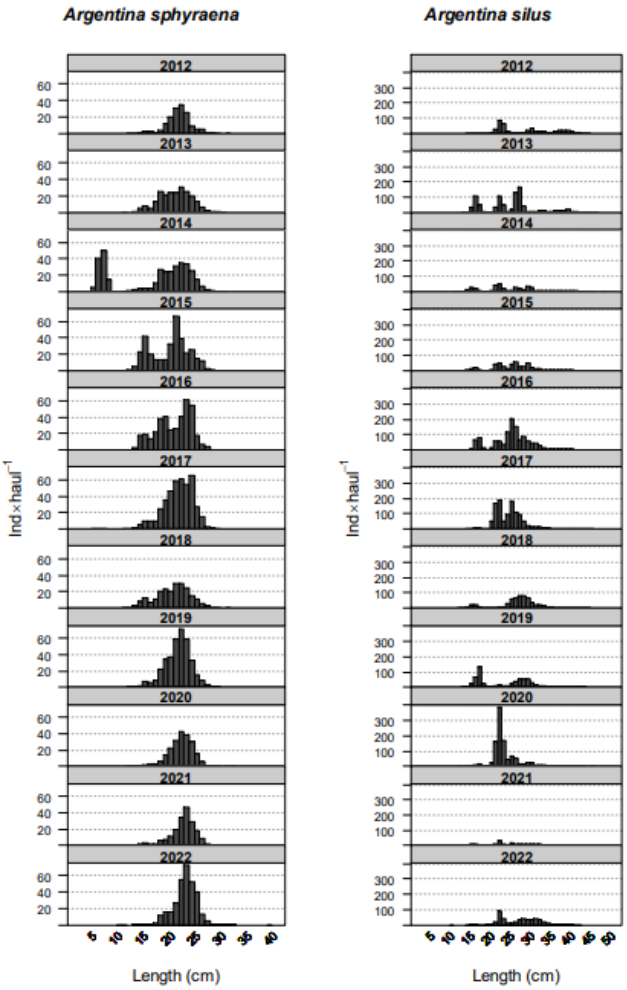

Figure 6.5.2. Mean stratified length distributions of *Argentina* spp. in Spanish Porcupine surveys from 2012–2022. Note different range in the y-axis values between species.

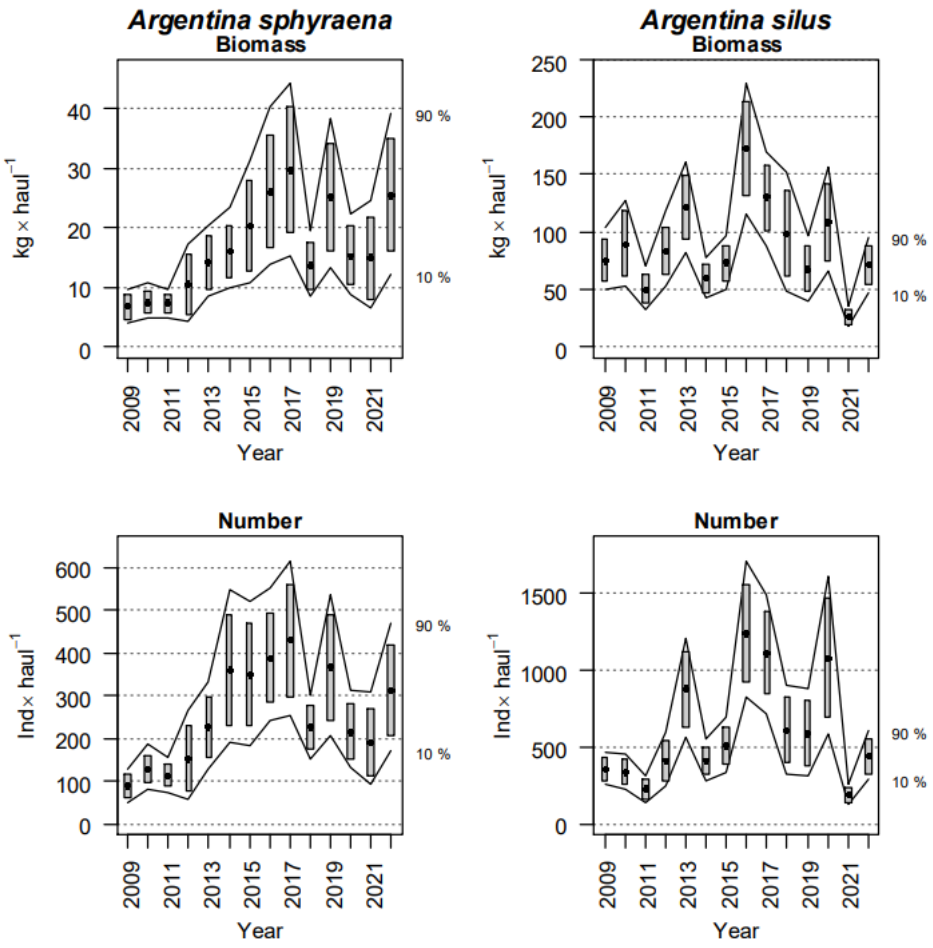

Figure 6.5.3. ***Argentina sphyraena*** **and** ***Argentina silus*** **biomass and abundance indices in Porcupine surveys (2009–2022). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a=0.80, bootstrap iterations=1000).**

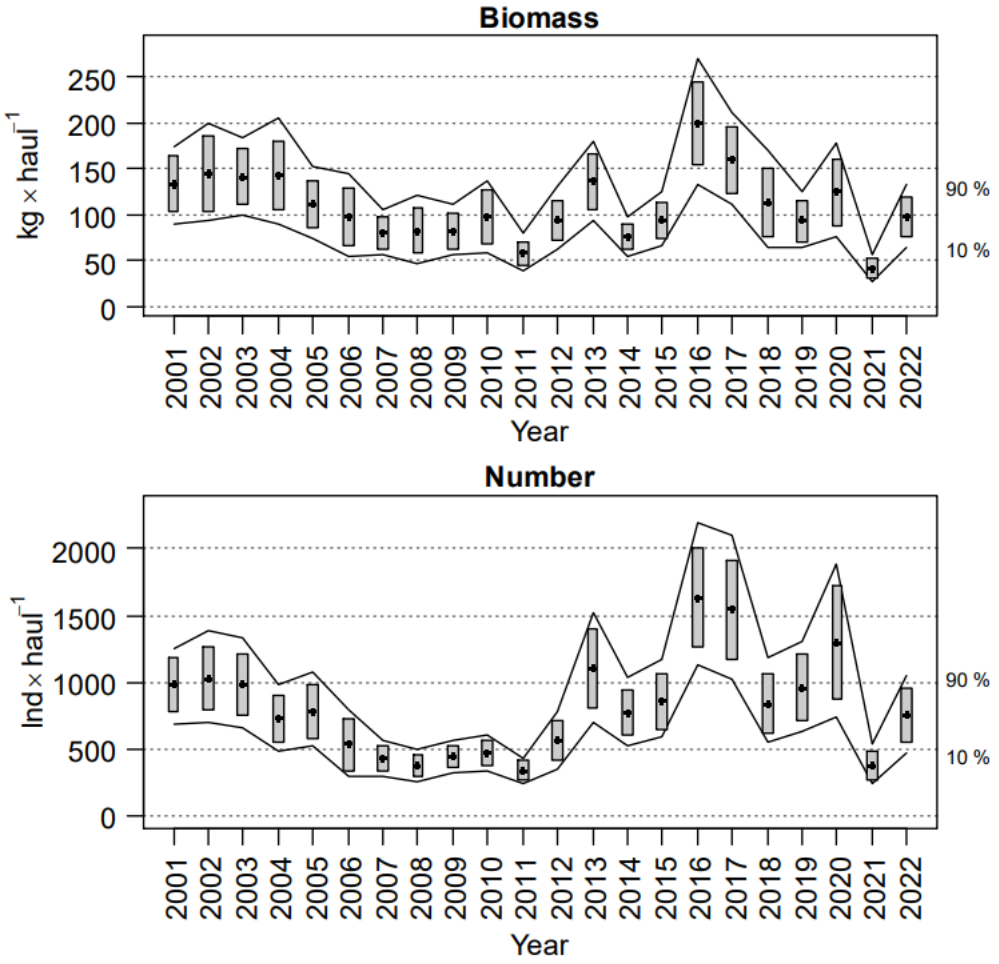

Figure 6.5.4. Argentina spp. (mainly Argentina silus) biomass and abundance indices in Porcupine surveys (2001-2022). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000)

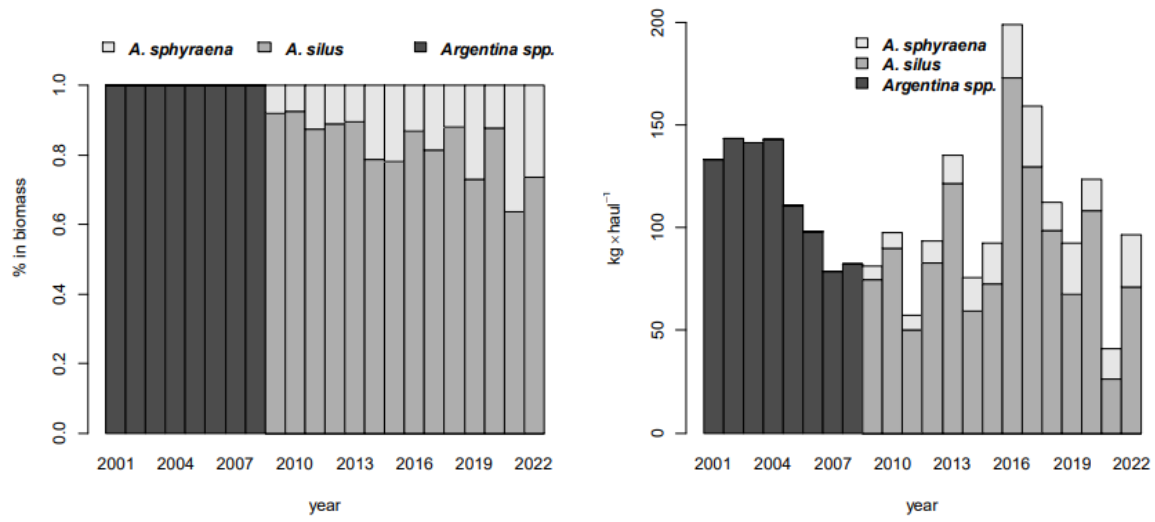

Figure 6.5.5. Share and abundance of Argentine species in Porcupine Bank surveys (2001–2022).

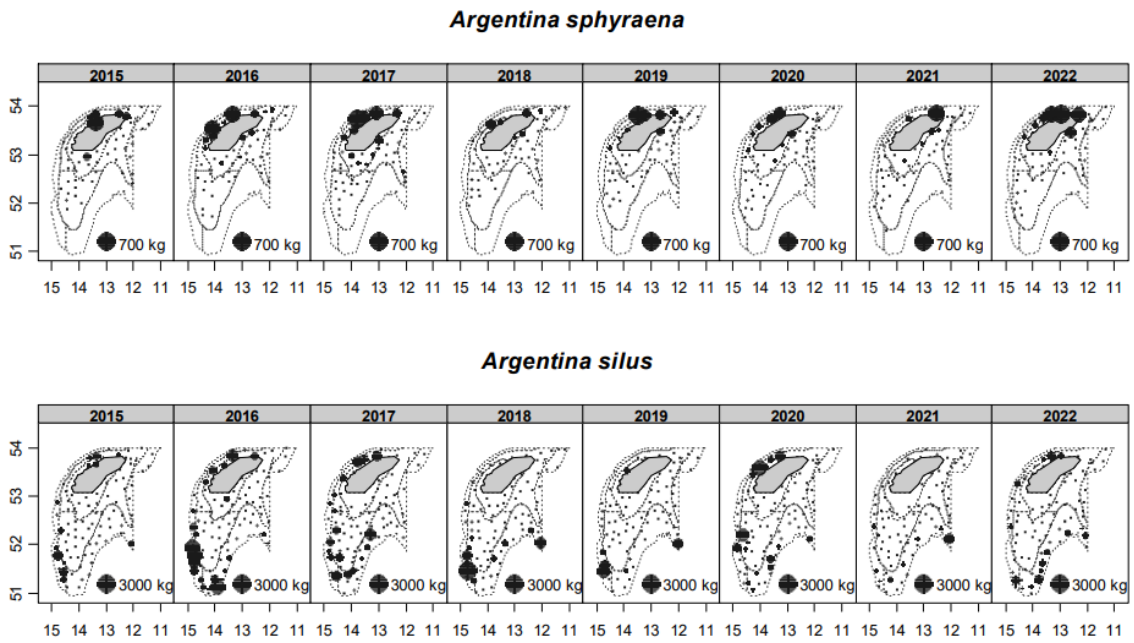

Figure 6.5.6. Geographic distribution of *Argentina sphyraena* and *Argentina silus* catches (kg/30 min haul) in Porcupine surveys (2015 - 2022)

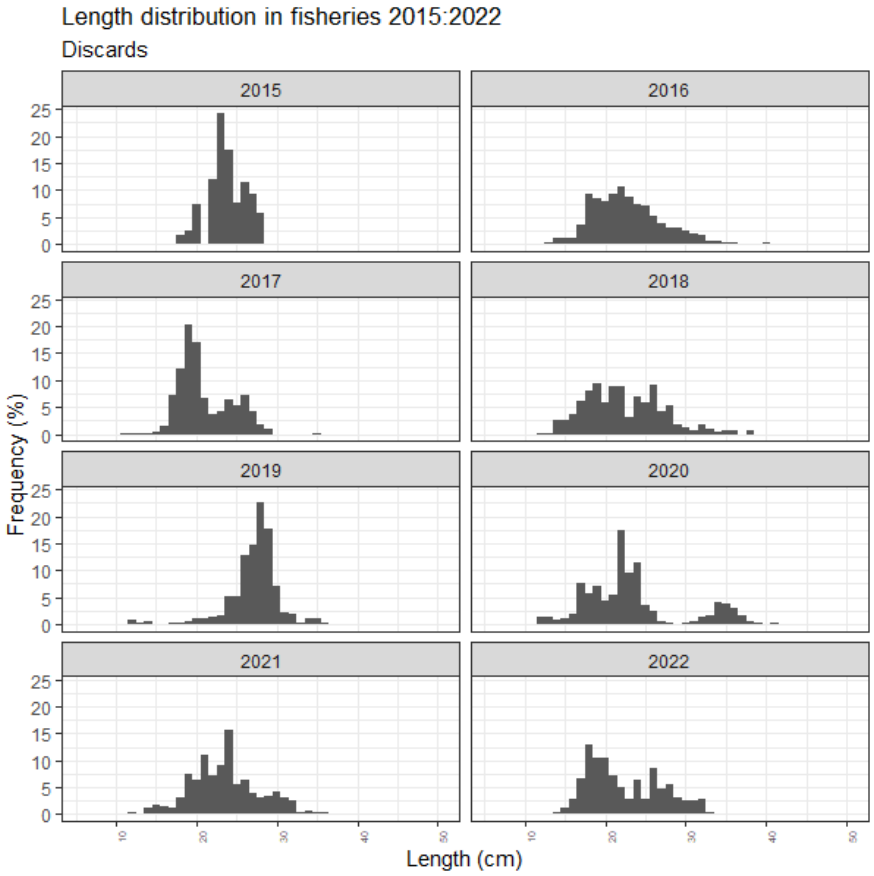

Figure 6.5.7. Length distribution from discard 2015-2022, all areas **combined.**

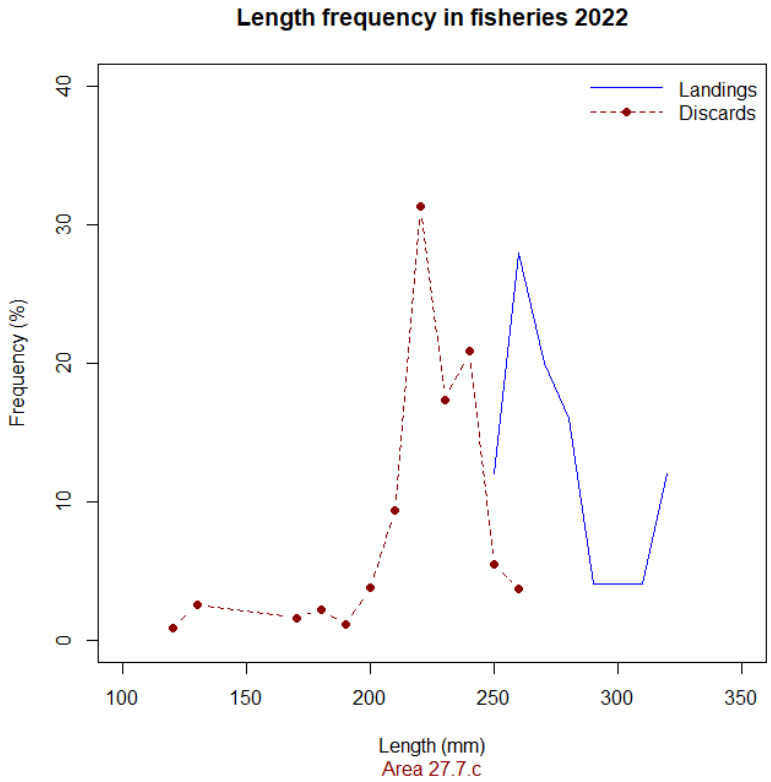

Figure 6.5.8. Length distribution from discard and landings from area 27.7.c in 2020.

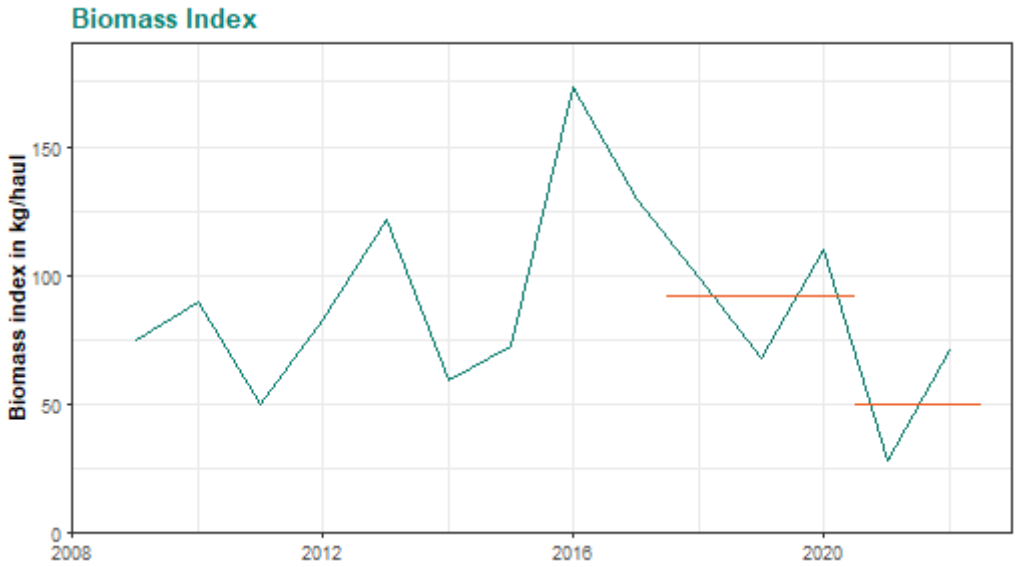

Figure 6.5.9. Biomass index year 2009-2022. Red horizontally lines indicating Index A (2021 and 2022) and index B (2018-2020).

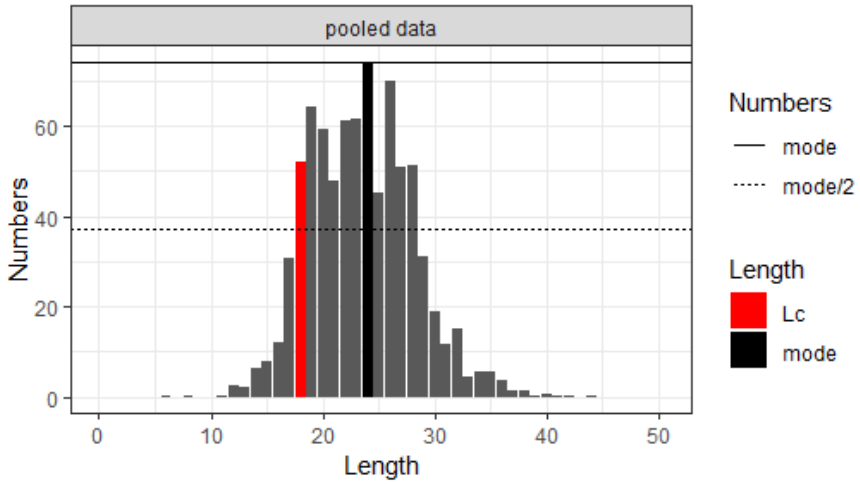

Figure 6.5.10. Pooled length distribution (years 2015-2022), including Lc and mode length.

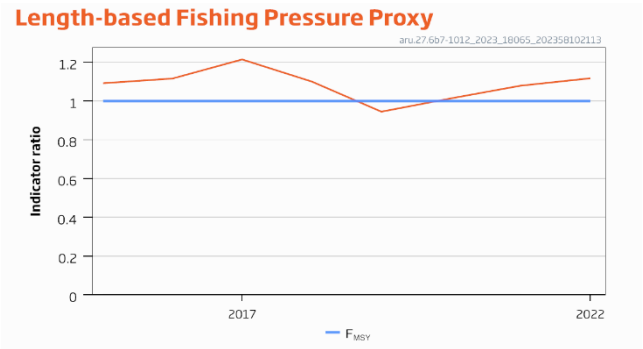

Figure 6.5.11. Length-based fishing pressure proxy. Indicator ratio LF= M/Lmean (inverse of the indicator ratio, f) from the length-based indicator (LBI) method is used for the evaluation of the exploitation status. The proxy fishing pressure is less than that corresponding to the FMSY proxy (LF= M) when the indicator ratio value is lower than 1 (shown by the horizontal blue line).