6 Greater silver smelt (*Argentina 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.

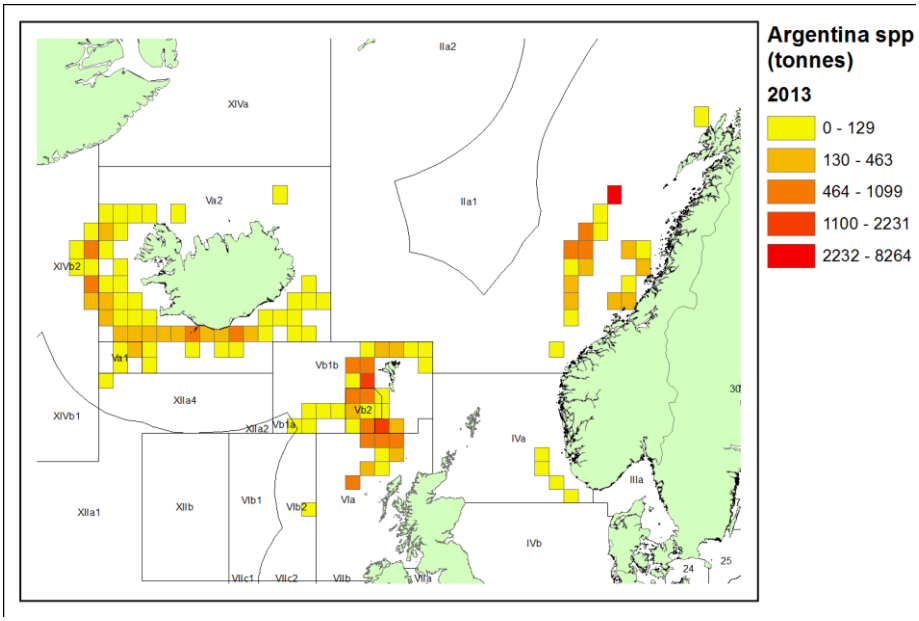

Figure 6.1.1. Catches of greater silver smelt by Iceland, Norway, Faroes and the Netherlands in 2013. Some catches of *A. sphyraena* and *Argentina* unidentified may be included in the Norwegian and Dutch landings.

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.

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. Since 2012 the landings increased from 351 t to reaching the highest landings so far in 2018 with 8071 t, and then a slight reduction to become 7215 t in 2020.

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, now amounting close to half 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.

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. 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.

6.2.3 ICES Advice

In 2019 ICES advised that, when the precautionary approach is applied, catches should be no more than 10 270 tonnes in each of the years 2020 and 2021. 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 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. TAC for 2021 is not agreed yet between EU and UK.

This management unit is not distributed in international waters, hence the 2020 TACs described above totalling 9033 t (Norway) and 90 (EU; subareas 1 and 2) + 1234 t (EU; subareas 3 and 4) apply to Norwegian and EU waters, respectively.

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 2014–2020 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 2009–2020 and for bycatches by Norwegian vessels in Division 4.a for the years 2011, 2013, 2014 and 2016-2020 (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, 1984–2020 (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).

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 1984–2020. 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 nine 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 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 survey shows upward trend (Figure 6.2.7).

In Division 3.a the length distributions throughout the 1984–2020 shrimp survey time-series are bimodal since 2014, as the age distribution in 2020, 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 bimodal in later years and suggest that the catches comprise rather variable but smaller fish than those in the target fishery landings in Division 2.a. 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, while the 2020 estimate is higher (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 with updated data. The results show that $L_{mean}/L_{F=M}$ = 1.05 (Figure 6.2.15), which indicates that the exploitation status is within precautionary levels.

SPiCT results are shown in Figure 6.2.16-6.2.20. The average of the relative biomass index from SPiCT (Figure 6.2.21) for the last two years was 1.16235, and 1.6223 for the three years before that. Thus, the ratio to be used in the ICES two-over-three rule for advice is 1.16235/ 1.6223 = 1.0001. The precautionary buffer was last used in 2019 and is thus not applied in the 2021 assessment.

6.2.8 Comments on the assessment

The assessment is in accordance to the WKGSS 2020 benchmark workshop (ICES 2021).

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.

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 2021 advice applies for 2022 and 2023.

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*	0	0	0	0	222	15534	21	8	0	0	0	35	0	15820

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
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

Year	Germany	Netherlands	Norway	Poland	Russia/USSR	Scotland	France	Faroes	Iceland	TOTAL
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
2019			12493		8					12501
2020*			8697		8					8705

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*					0

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						5669
2017					5508	(388)					5508(388)
2018	17(1)		67	152	7786	(38)		6			8028(39)
2019			143	349	6679	(39)					7171(39)
2020*				222	6837	(100)			35	21	7115(100)

6.2.12 Figures

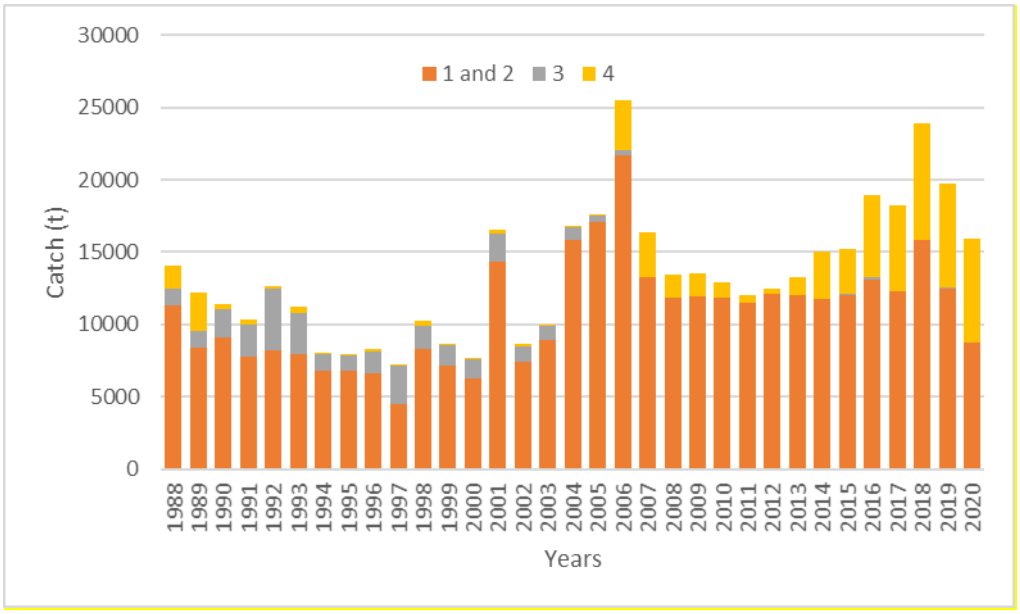


Figure 6.2.1. Total catch of greater silver smelt in subareas 1, 2, 3 and 4.

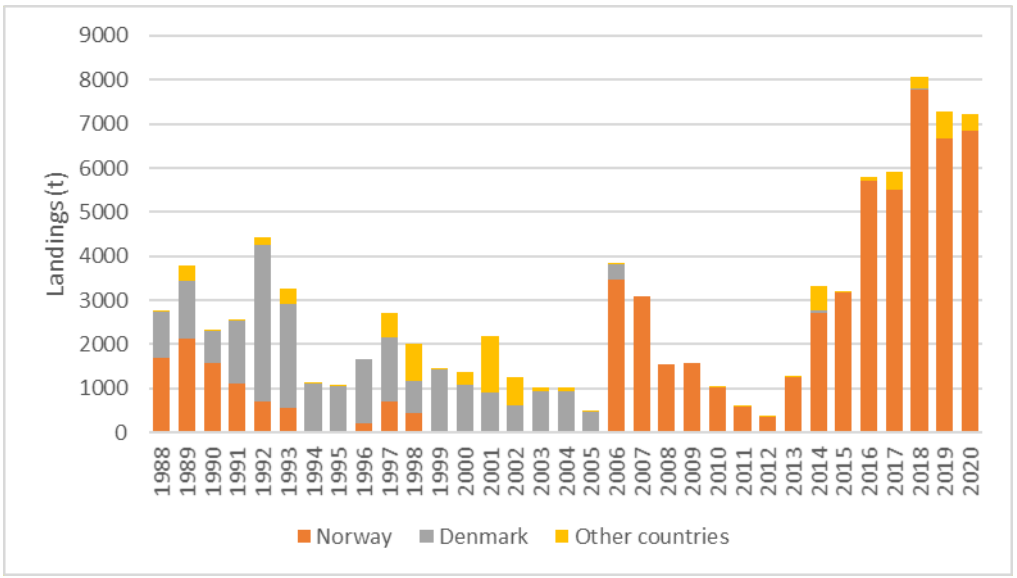


Figure 6.2.2. Total catch of greater silver smelt in subareas 3 and 4, by countries.

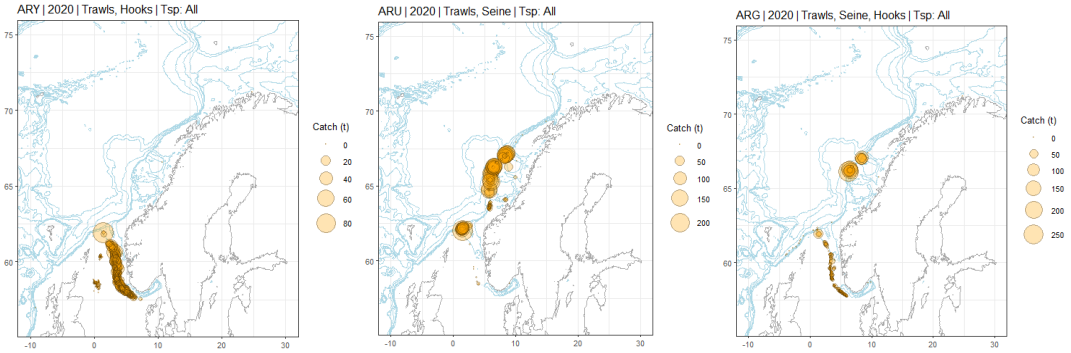


Figure 6.2.3. Norwegian catches in 2020 based on logbooks, including bycatch. Left, middle and right panels show catches registered as lesser silver smelt, greater silver smelt and mix of both species, respectively. Bubble sizes reflect sizes of single catches. NB: Catch representing max bubble size varies between panels.

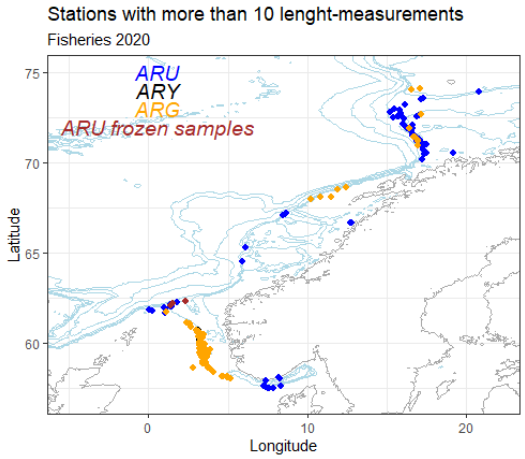


Figure 6.2.4. Positions from the fisheries for 2020 with length measurement landed as GSS, LSS, GSS/LSS and frozen samples.

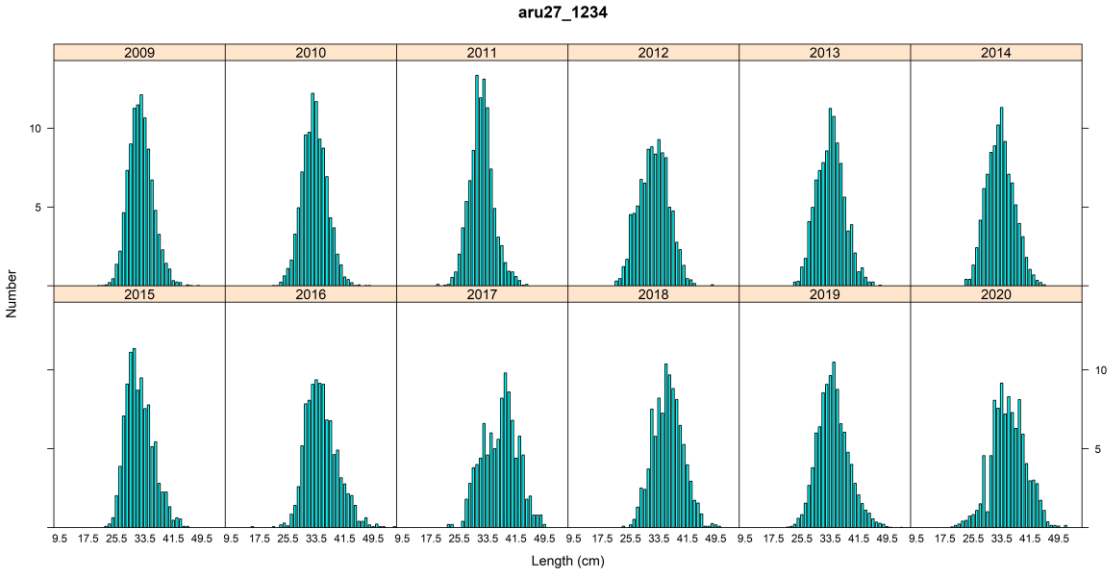


Figure 6.2.5. Greater silver smelt in subareas 1, 2, and 4 and Division 3.a. Length distributions (% numbers) from the target fisheries in 2009–2020 north of 62°N (approximately subareas 1 and 2).

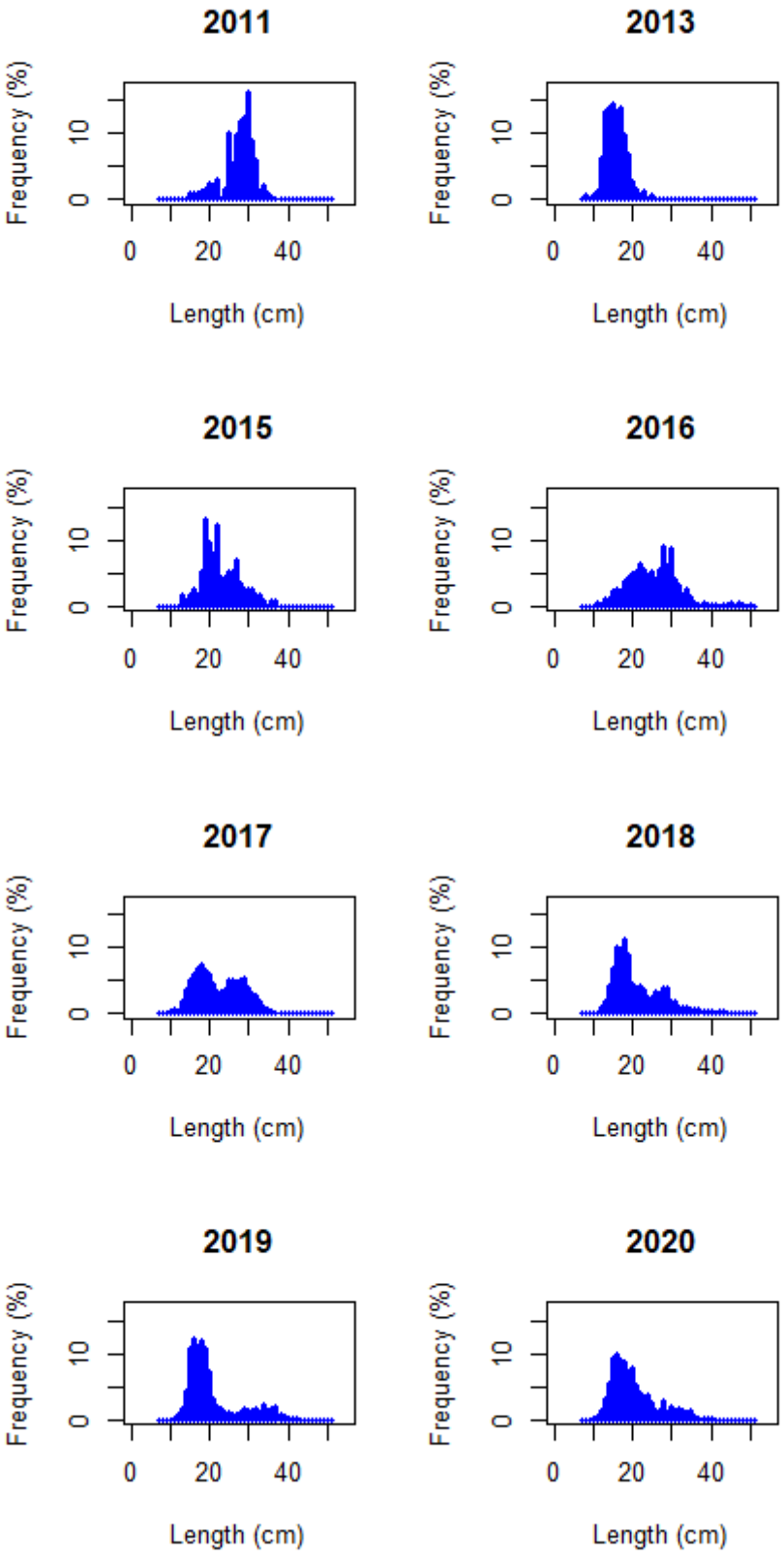


Figure 6.2.6. Greater silver smelt in 1, 2, 3.a and 4. Length distributions in annual samples from Norwegian bycatches south of 62°N (approximately subareas 3 and 4).

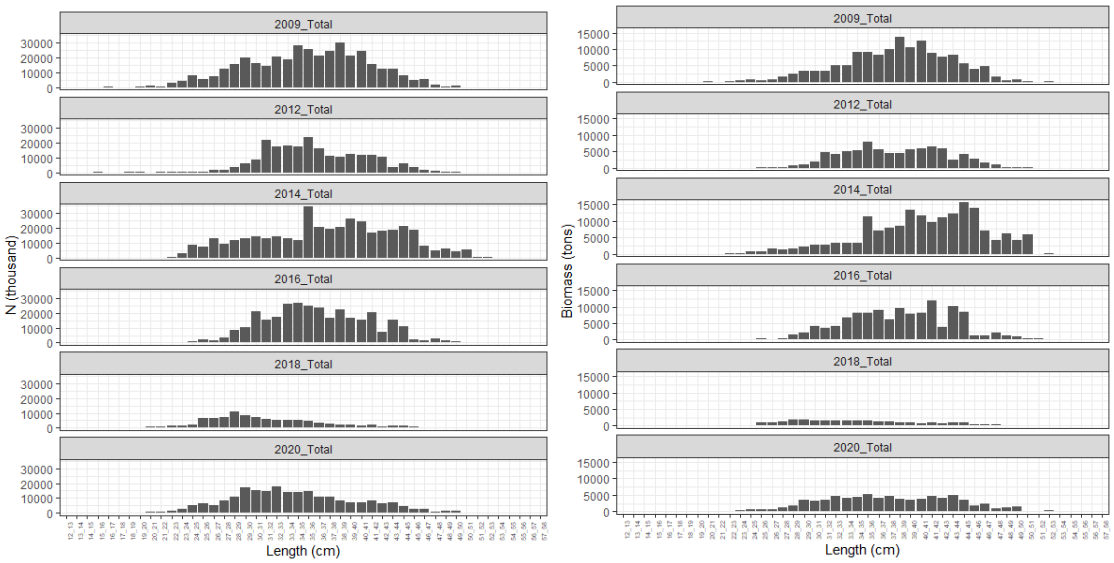


Figure 6.2.7. Length distributions in numbers (left panels) and biomass (tons) (right panels) for greater silver smelt in the Norwegian Sea south-east slope survey in 2009, 2012, 2014, 2016, 2018 and 2020. Swept area estimates from StoX.

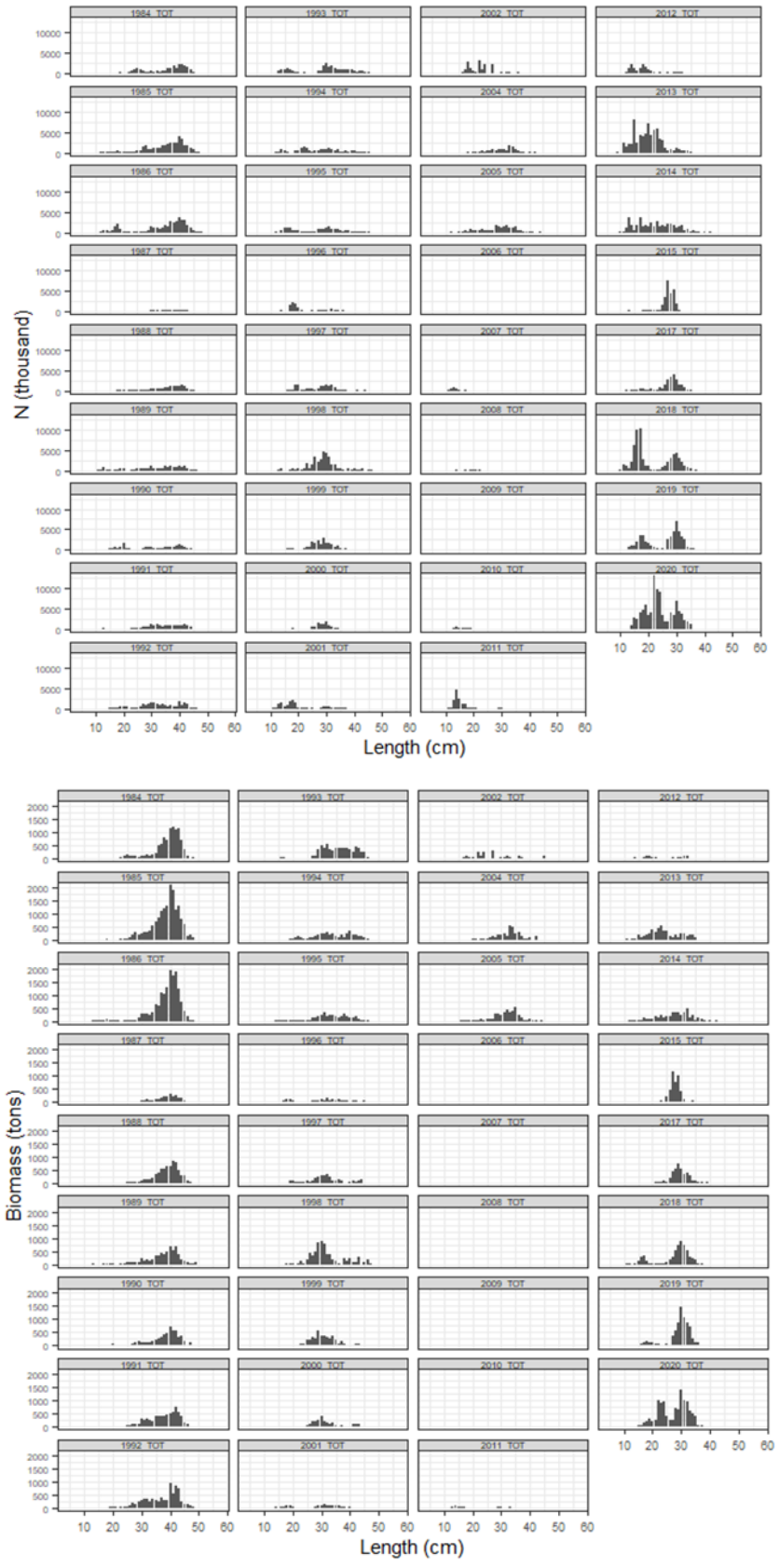


Figure 6.2.8. Length distributions in numbers (upper panels) and biomass (lower panels) for greater silver smelt in the North Sea/Skagerrak survey.

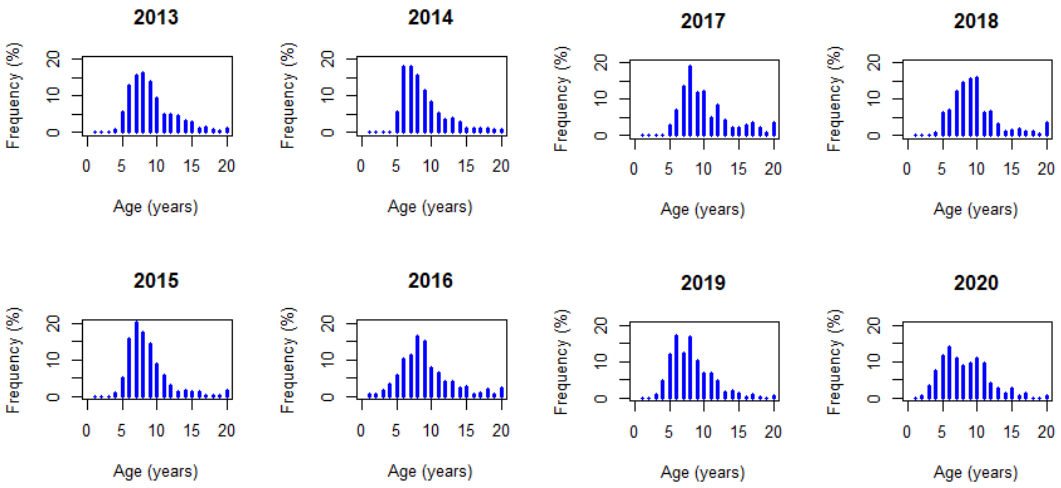


Figure 6.2.9. Greater silver smelt in 1, 2, 3, and 4. Age composition of Norwegian landings samples, 2013-2020.

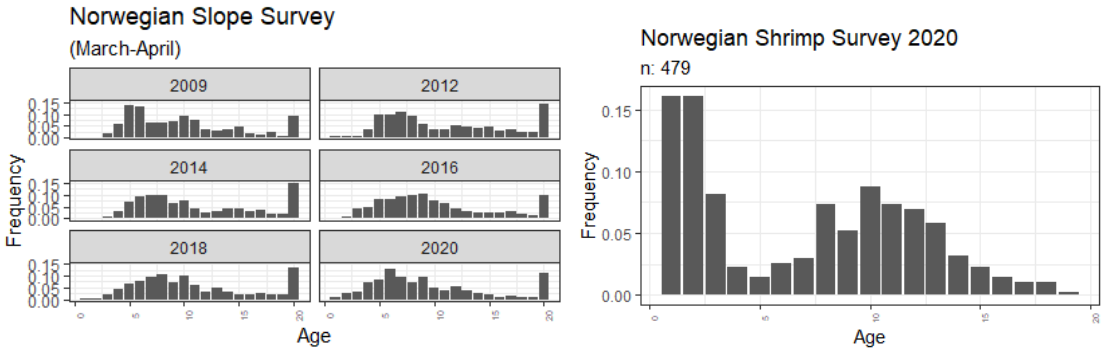


Figure 6.2.10. Age distributions of greater silver smelt from the Norwegian slope survey 2009-2020 (left panels) and the Norwegian Shrimp survey in North Sea/Skagerrak 2020 (right panel). Age 20 is a plus group.

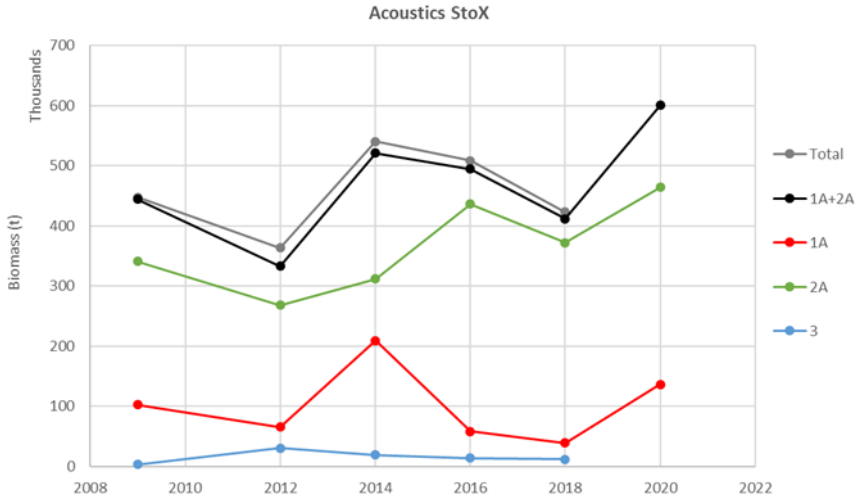


Figure 6.2.11. Acoustic index from the Norwegian Slope survey in subareas 1 and 2. Biomass estimates for different strata (1A, 2A and 3) in the survey are shown, as well as summed estimates for 1A and 2A and total for all strata. Stratum 3 was not covered in 2020 due to covid19 complications in the conduct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

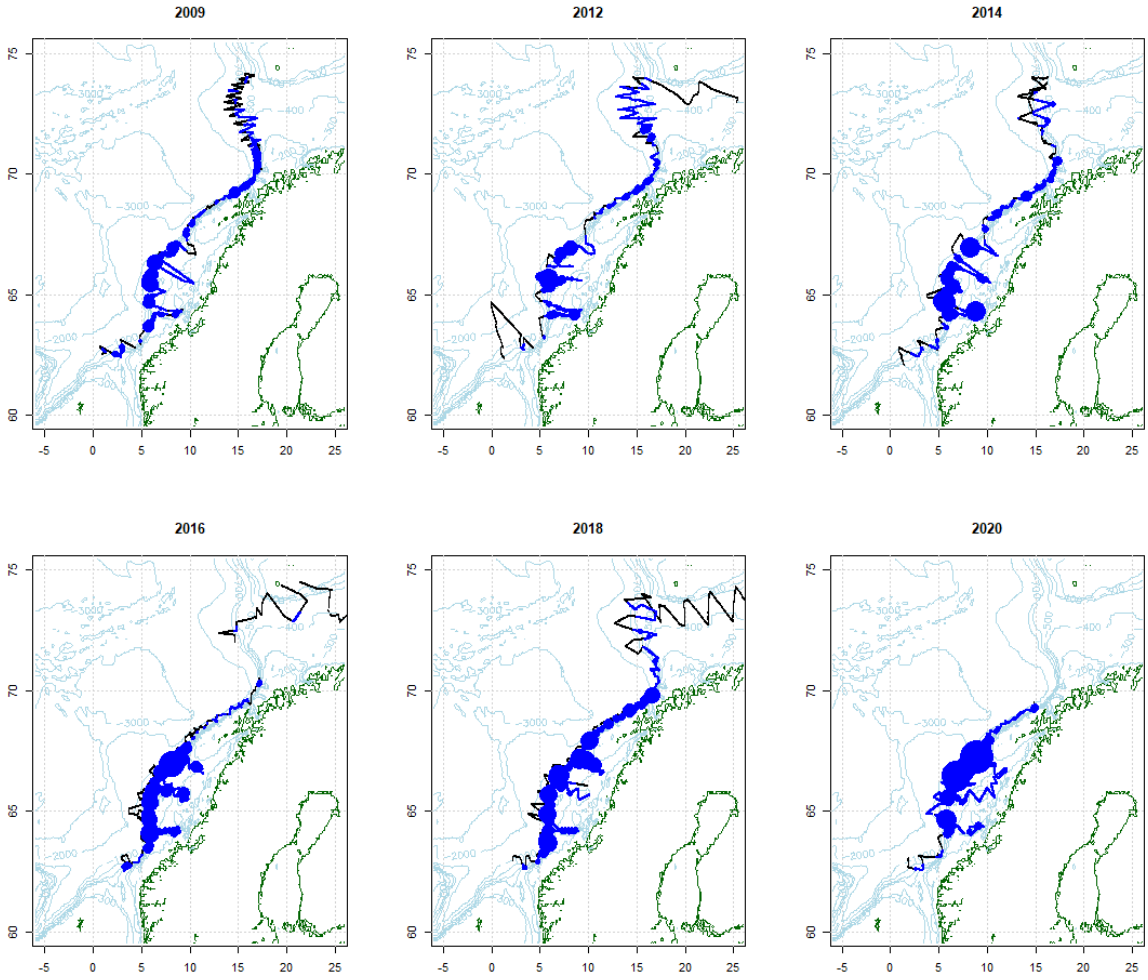


Figure 6.2.12. Greater silver smelt in Division 2.a. Acoustic backscattering strength estimates (SA-values) in Norwegian continental shelf and slope surveys March–April 2009, 2012, 2014, 2016, 2018 and 2020.

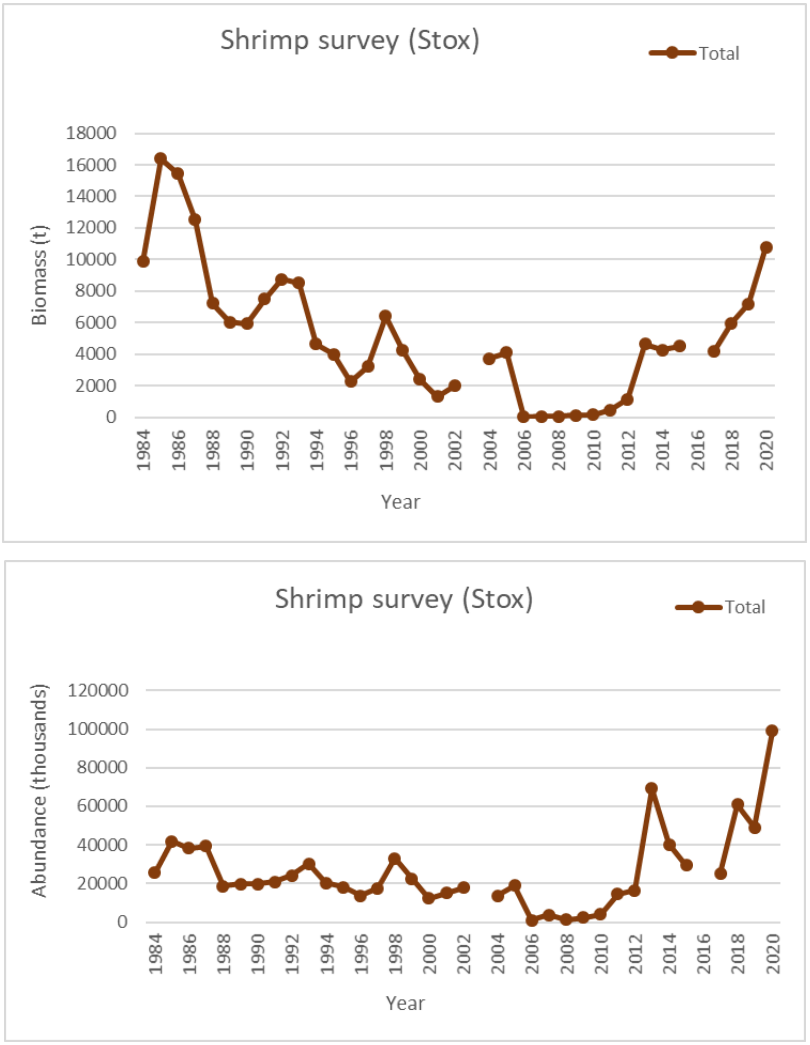


Figure 6.2.13. Swept area total biomass index (upper panel) and swept area total abundance index (lower panel) for greater silver smelt in the shrimp survey in North Sea/Skagerrak. Seasonality of the survey has varied through the years. It was conducted in October 1984-2002, May 2004-2005, February 2006-2007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

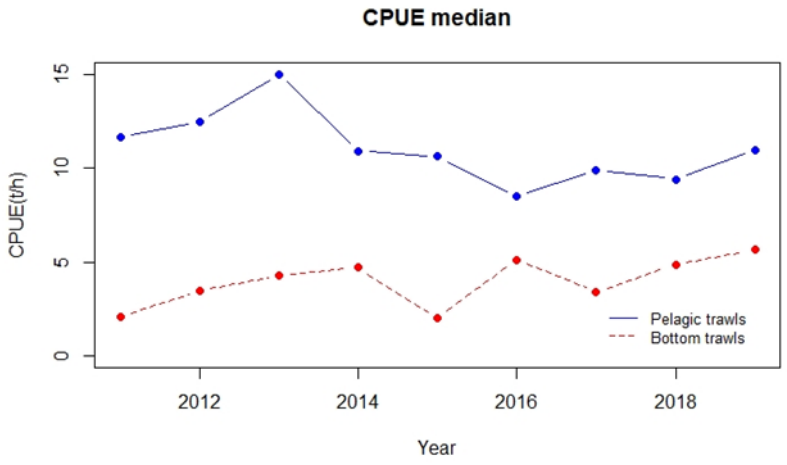
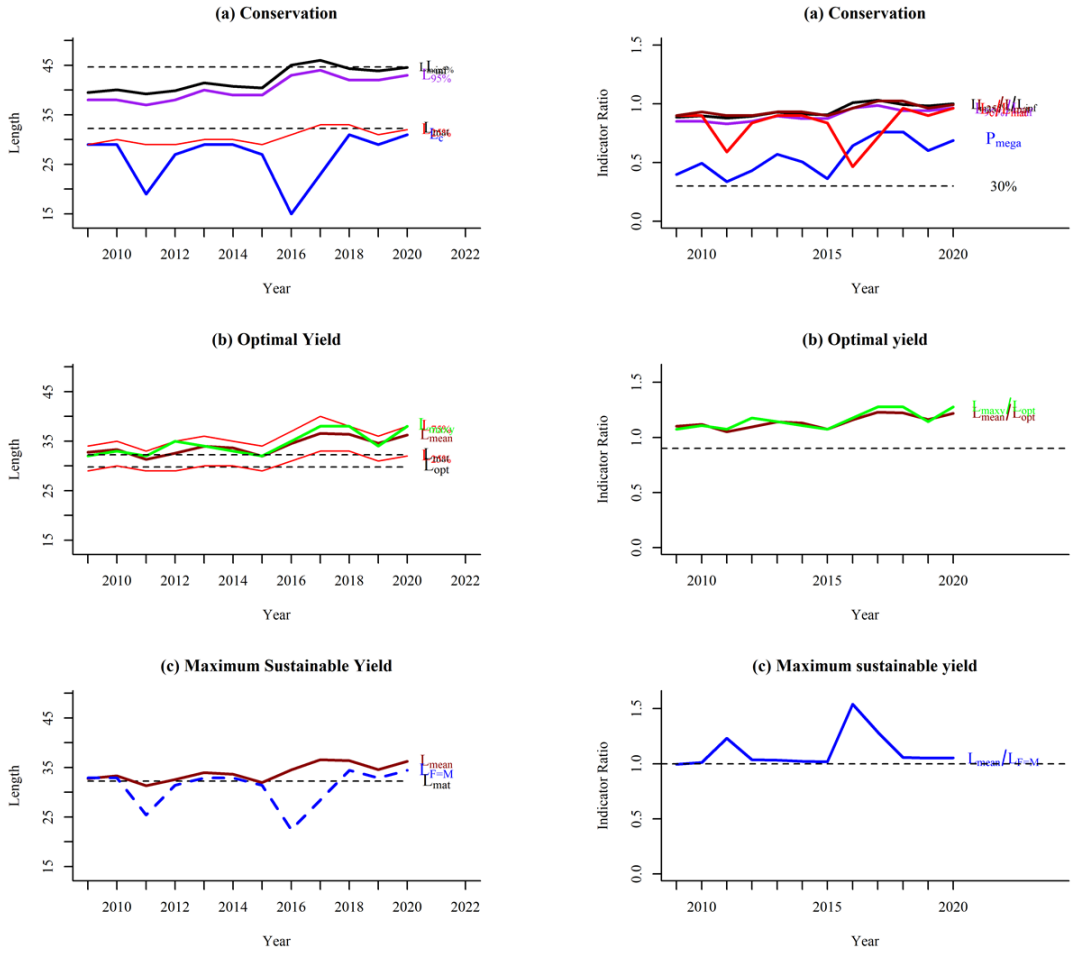


Figure 6.2.14. CPUE from the Norwegian direct fisheries on greater silver smelt in Division 2.a, based on electronic log-books 2011-2019.



Traffic light indicators

	Conservation				Optimizing Yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/$L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2018	0.96	1.02	0.99	0.76	1.22	1.06
2019	0.90	0.96	0.98	0.60	1.16	1.05
2020	0.96	0.99	1.00	0.69	1.22	1.05

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. The exploitation status is below $F_{MSYproxy}$ when the index ratio $L_{mean}/L_{F=M}$ value for the maximum sustainable yield (c) is higher than 1.

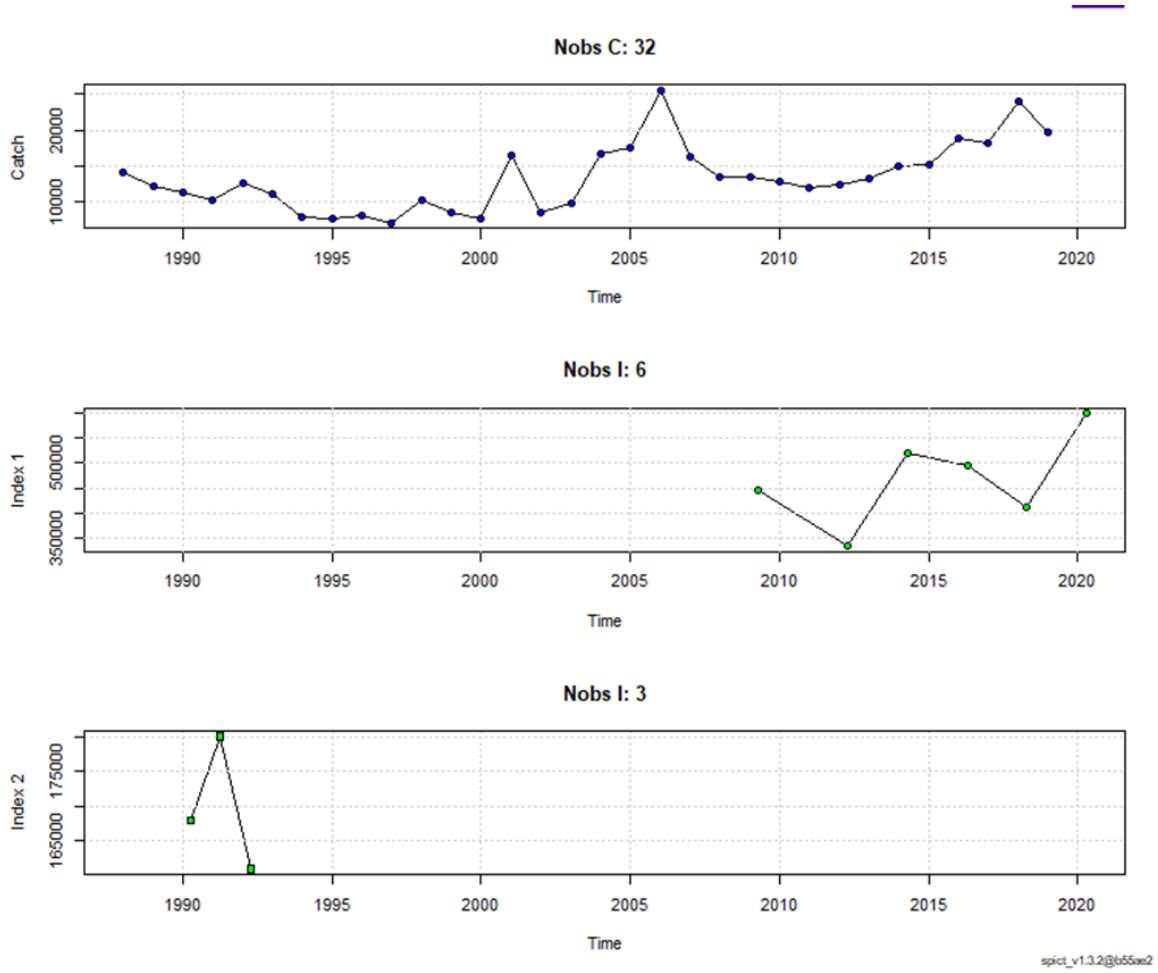


Figure 6.2.16. Input data to the SPiCT analysis. Uppermost panel is catch in tonnes, midpanel is acoustic index from the Norwegian slope survey and lowest panel is acoustic index from surveys at the slope in the 1990s.

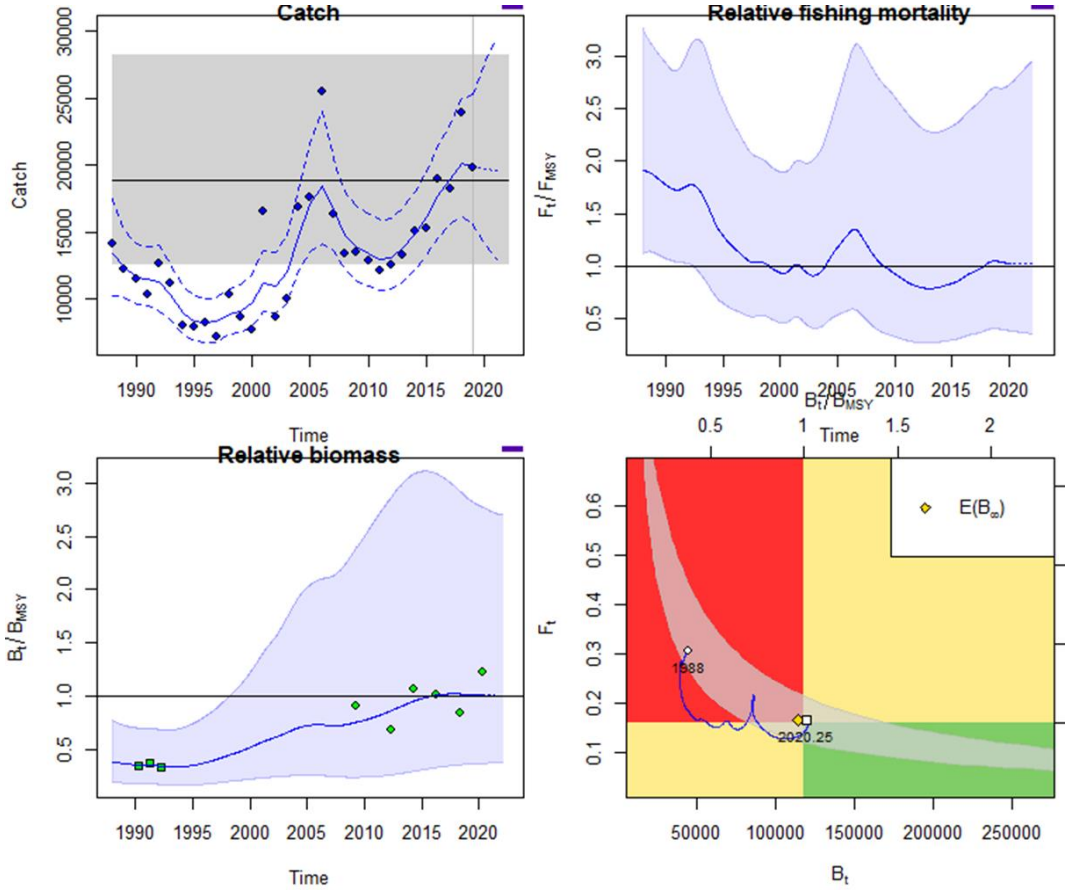


Figure 6.2.17. Results from the SPiCT analysis

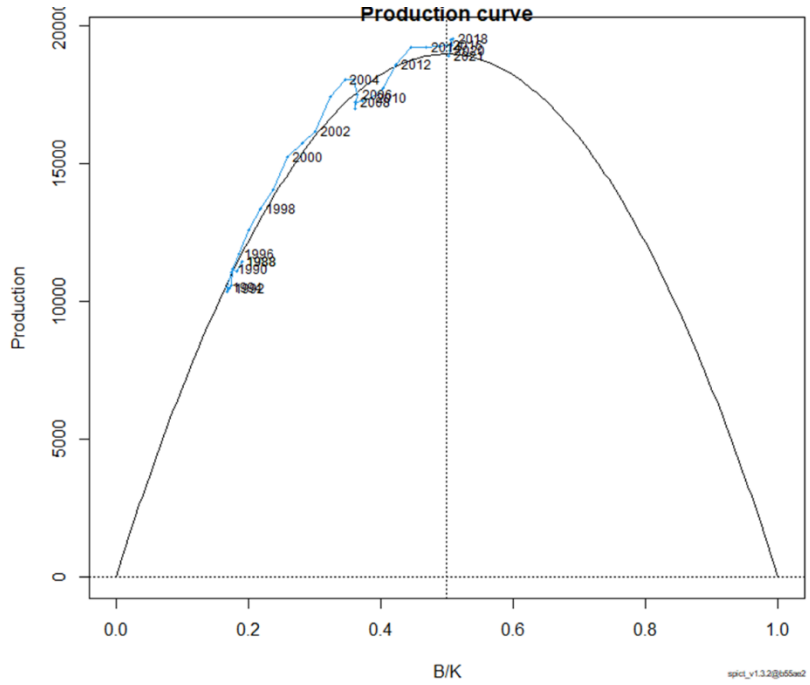


Figure 6.2.18 Production curve from the SPiCT analysis.

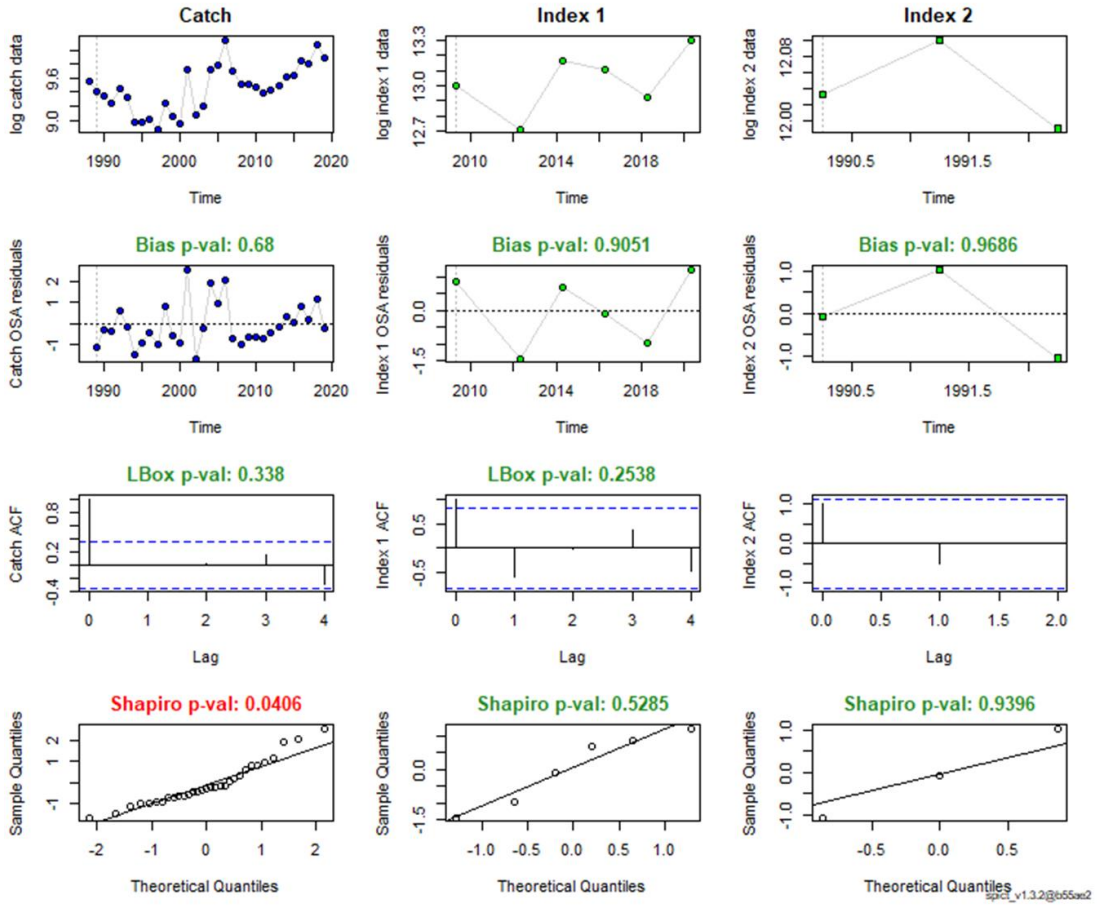


Figure 6.2.19. Diagnostics from the SPiCT analysis.

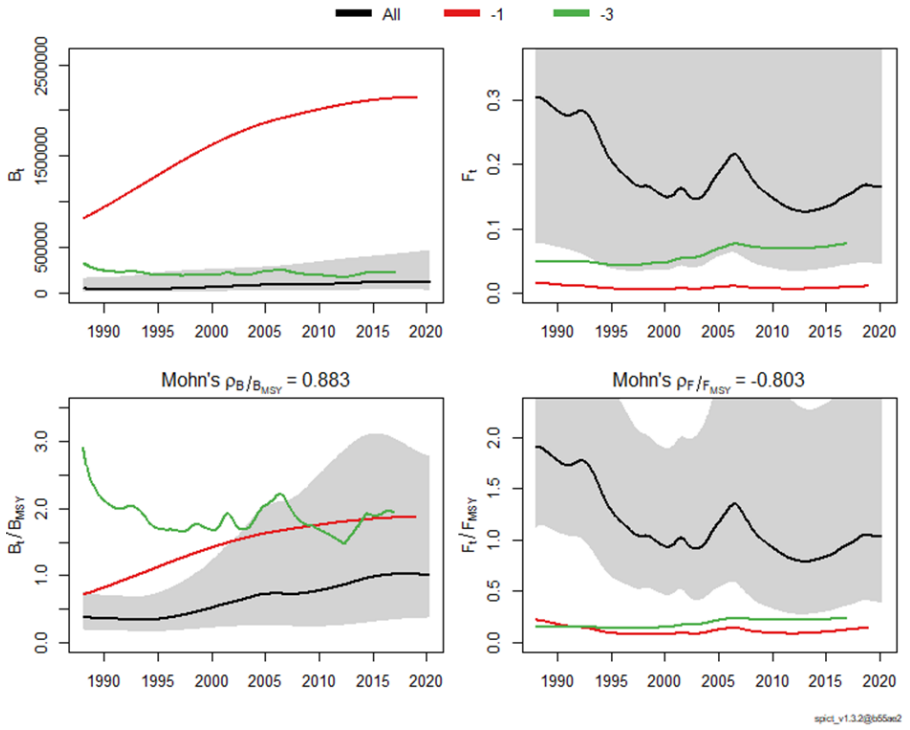


Figure 6.2.20. Retrospective analysis from the SPiCT analysis.

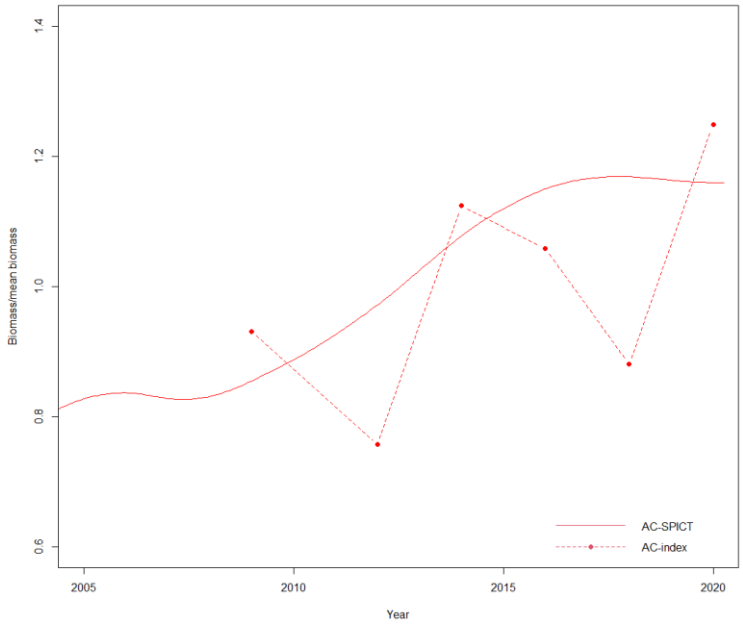


Figure 6.2.21. Relative biomass (estimated biomass/mean) from the SPiCT analysis with the acoustic index from the Norwegian slope survey.

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 and the landings have increased significantly in the past (Table 6.3.1).

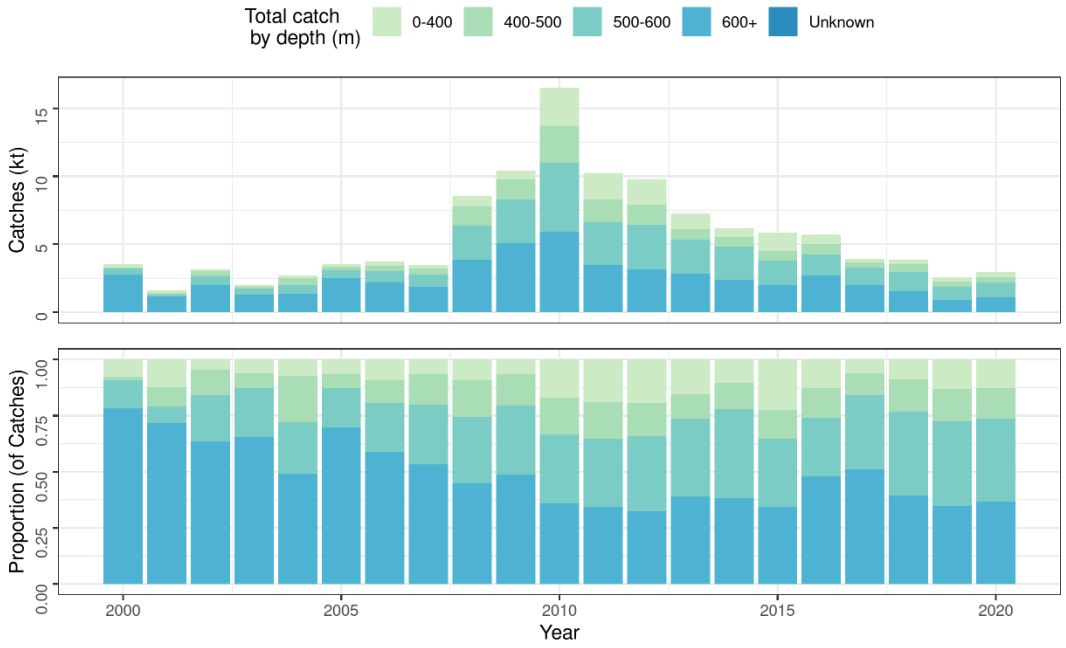


Figure 6.3.1: Greater silver smelt in 5.a and 14. Depth distribution of catches in 5.a according to Icelandic logbooks. All gear combined.

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				206
1989				8
1990				112
1991				247
1992				657
1993				1255

Year	Inside the NEAFC RA	Outside the NEAFC RA		Landings (tonnes)
1994				613
1995				492
1996				808
1997				3367
1998				13387
1999				6704
2000				5657
2001				3043
2002				4960
2003				2686
2004				3637
2005				4481
2006				4775
2007				4226
2008				8778
2009				10829
2010				16428
2011				10515
2012				9290
2013	0	7154		7154
2014	0	7241	4	7245
2015	0	6056	12	6068
2016	0	5646	16	5662
2017	0	3946	666	4612
2018	0	4035	425	4460
2019	0	3208	0.5	3209
2020	0	3775	22	3797

6.3.2 Fleets

Since 1996 between 20 and 39 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
2013	31	2743	7246715	609	0.6418890

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%
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

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 2014).

6.3.3.2 Spatial distribution of catches through time

Spatial distribution of catches (5.a and 14) in 2000– 2020 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 northwestern 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).

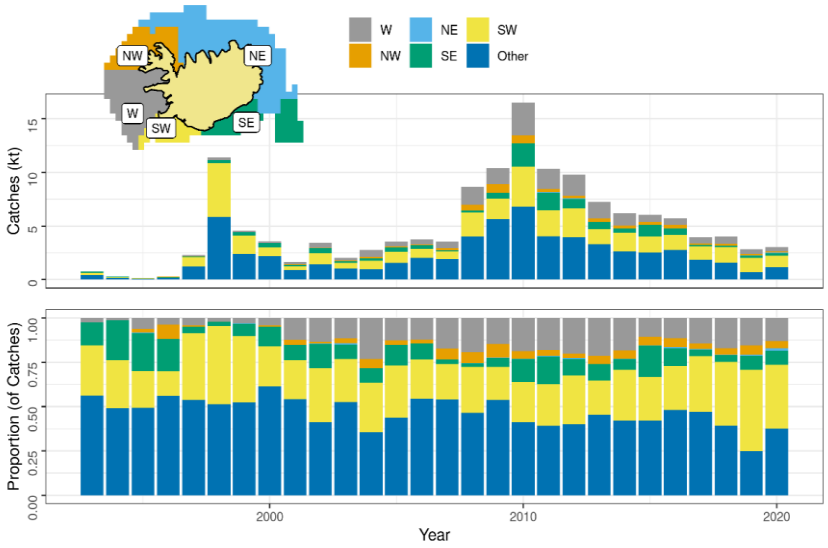


Figure 6.3.2: Greater silver smelt in 5.a and 14. Spatial distribution of catches defined by regions deeper than 400 m by year (See stock annex for details). Above are the catches on absolute scale and below in proportions. All gears combined.

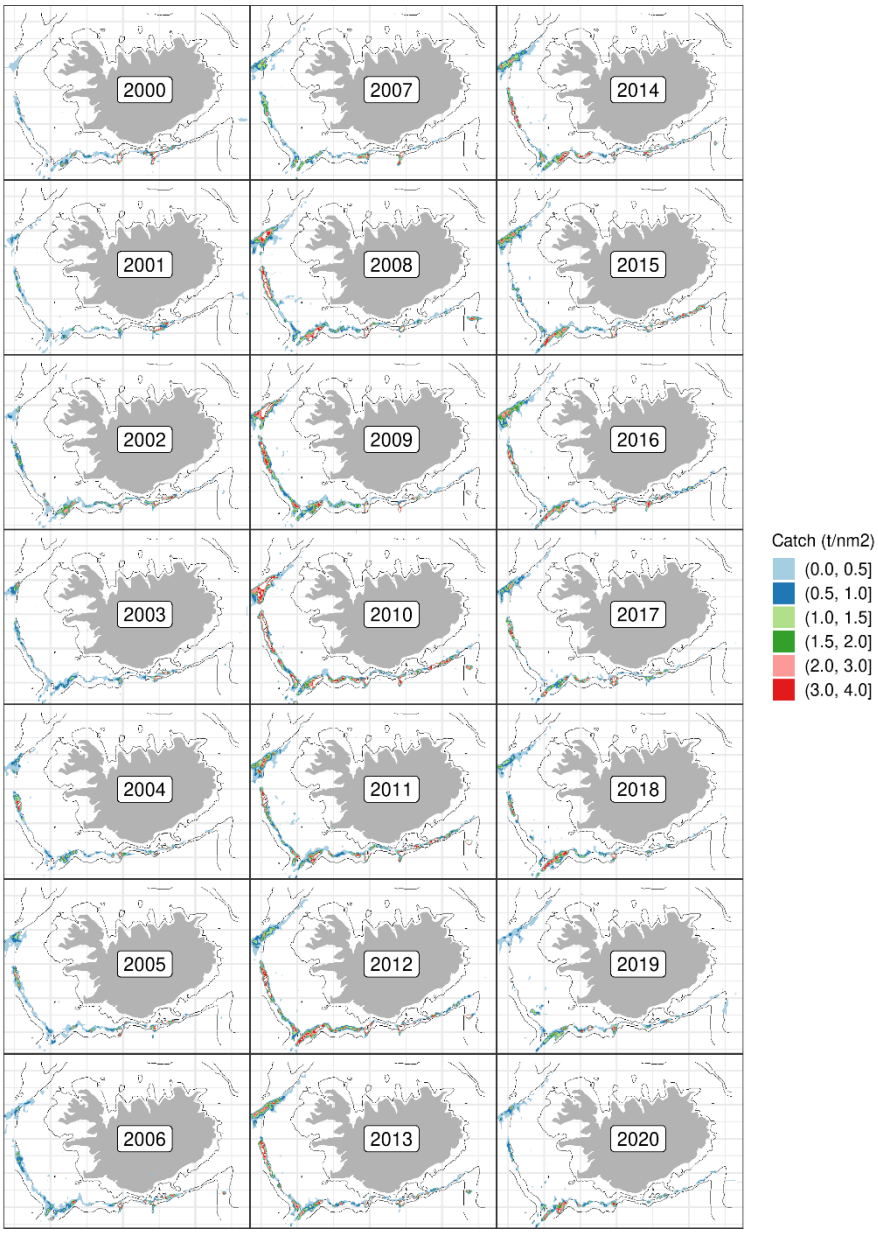


Figure 6.3.3: Greater silver smelt in 5.a and 14. Spatial distribution of the Icelandic fishery catches as reported in logbooks. All gears combined.

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. Since 2008 landings have 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 2020 amounted to approximately 3797 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.

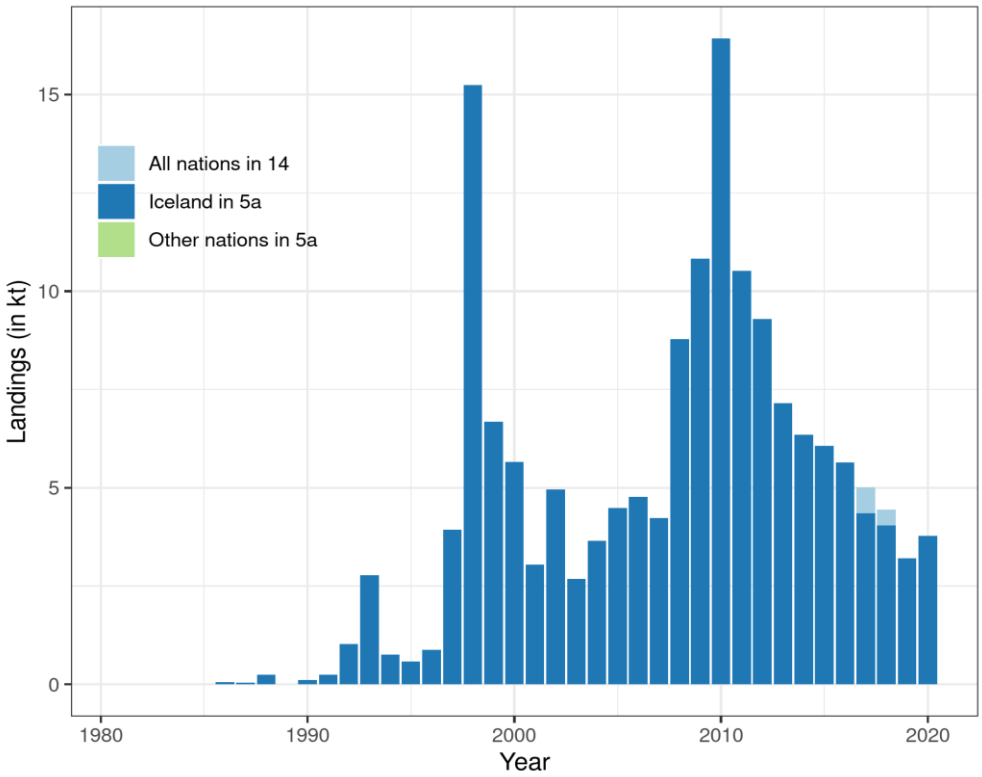


Figure 6.3.4: Greater silver smelt in 5.a and 14. Nominal landings. 23 tonnes were landed by foreign vessels (England and Wales) in 1999, which is the only year of catches reported by foreign vessels.

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	

Year	No. length samples	No. length measurements	No. otolith samples	No. otoliths	No. otoliths aged
2006	29	4186	13	616	525
2007	14	2158	8	285	272
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	0	0
2020	8	1566	2	50	25

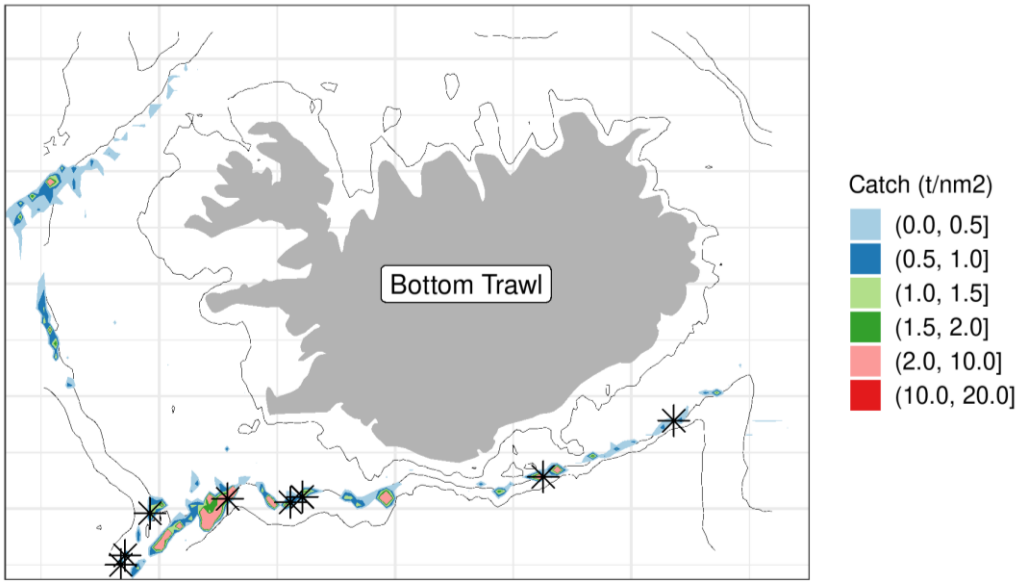


Figure 6.3.5: Greater silver smelt in 5.a and 14. Fishing grounds in 2020 as catches reported in logbooks (tiles) and positions of samples taken from landings (asterisks).

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. Figure 6.3.6 gives trends in biomass density and juvenile density (numbers) for the spring survey in 1985 to 2021 and for the autumn survey in 2000 to 2020. 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. No substantial changes in proportional catch by area is seen in general (Figure 6.3.7).

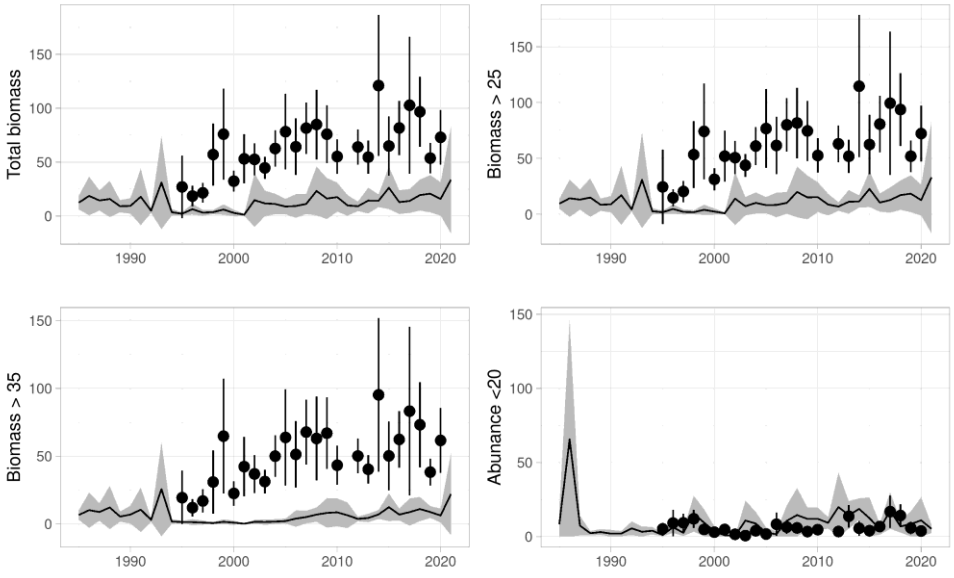


Figure 6.3.6. Greater silver smelt in 5.a and 14. Indices calculated from the Icelandic spring survey (black lines and shaded area) and from the autumn survey (dots and vertical lines). Vertical lines and shaded area represent +/- 1 standard error.

Figure 6.3.7: Greater silver smelt in 5.a and 14. 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 6.3.8 and Figure 6.3.9 respectively. Length distribution from the autumn survey are rather stable, with 202 being close to the long-term average (Figure 6.3.8).

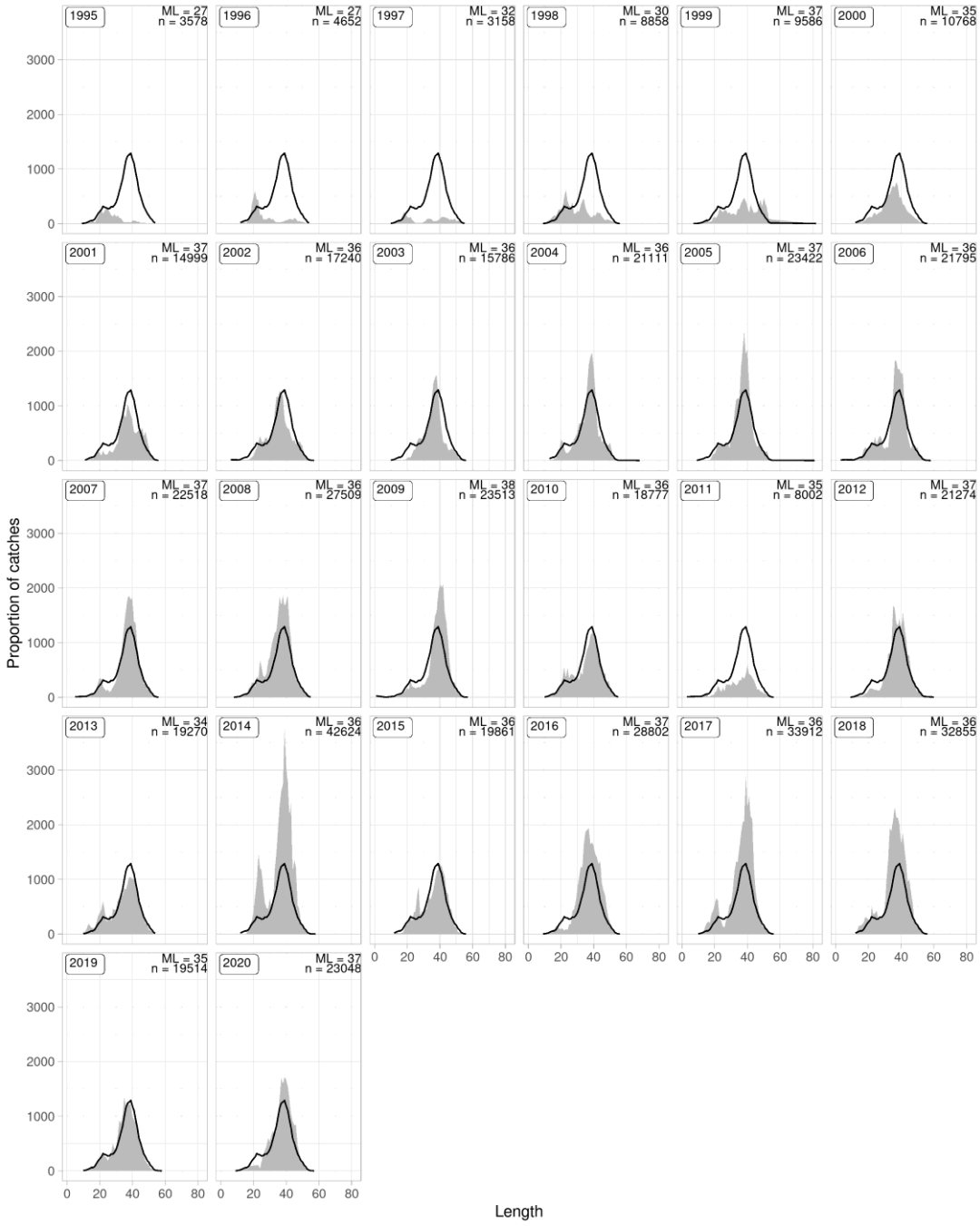


Figure 6.3.8: Greater silver smelt in 5.a and 14. Length distribution from the autumn survey. The black line shows the mean for all years.

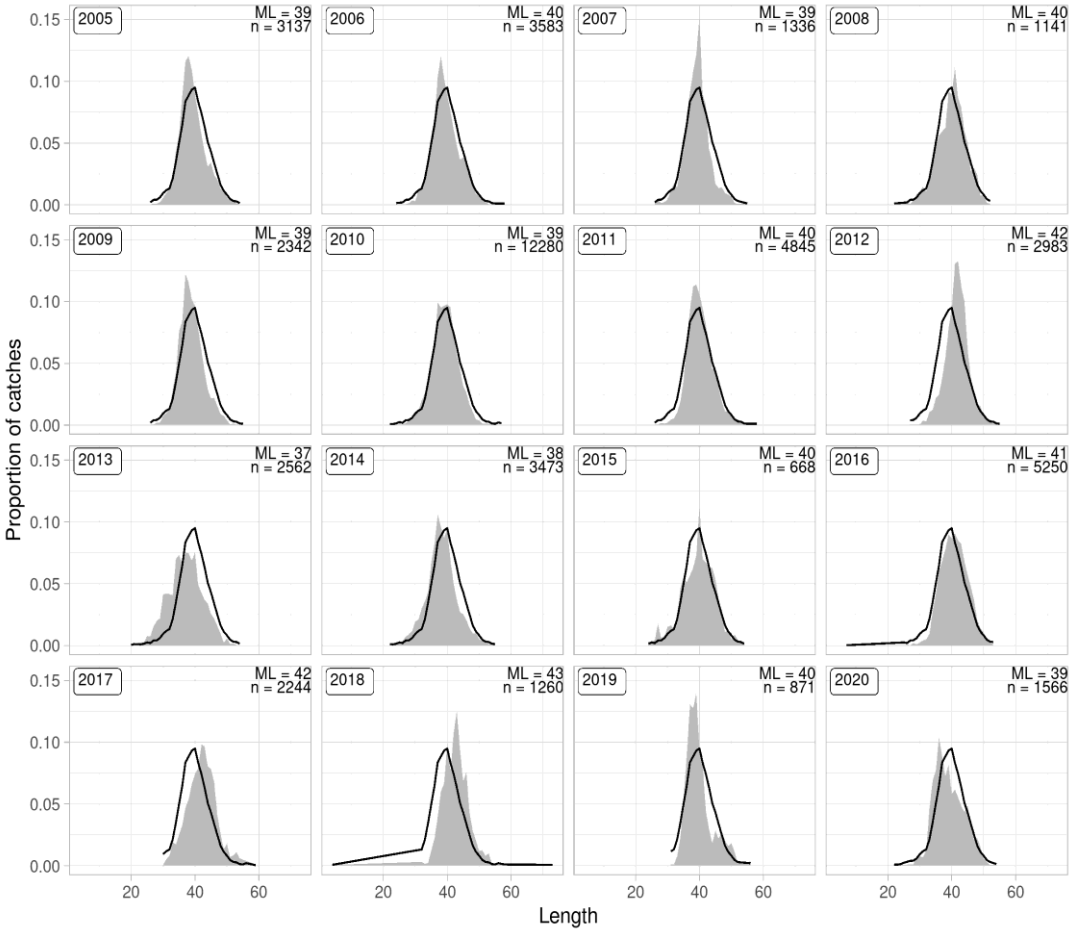


Figure 6.3.9: Greater silver smelt in 5.a and 14. Length distributions from commercial catches.

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 6.3.10 & 6.3.11.

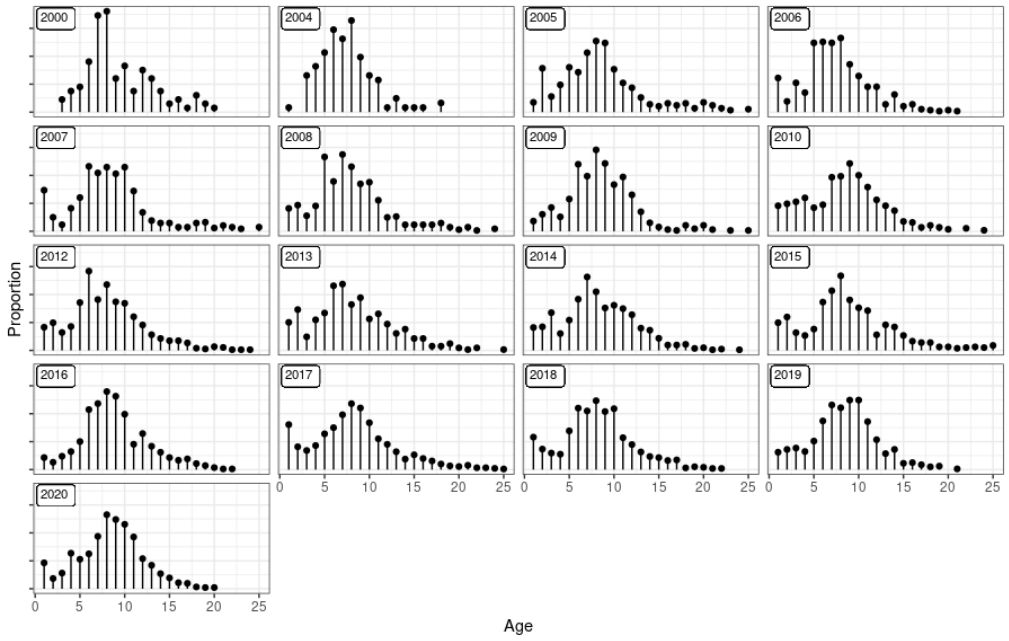


Figure 6.3.10: Greater silver smelt in 5.a and 14. Age distributions in proportions in 5.a from the Icelandic autumn survey.

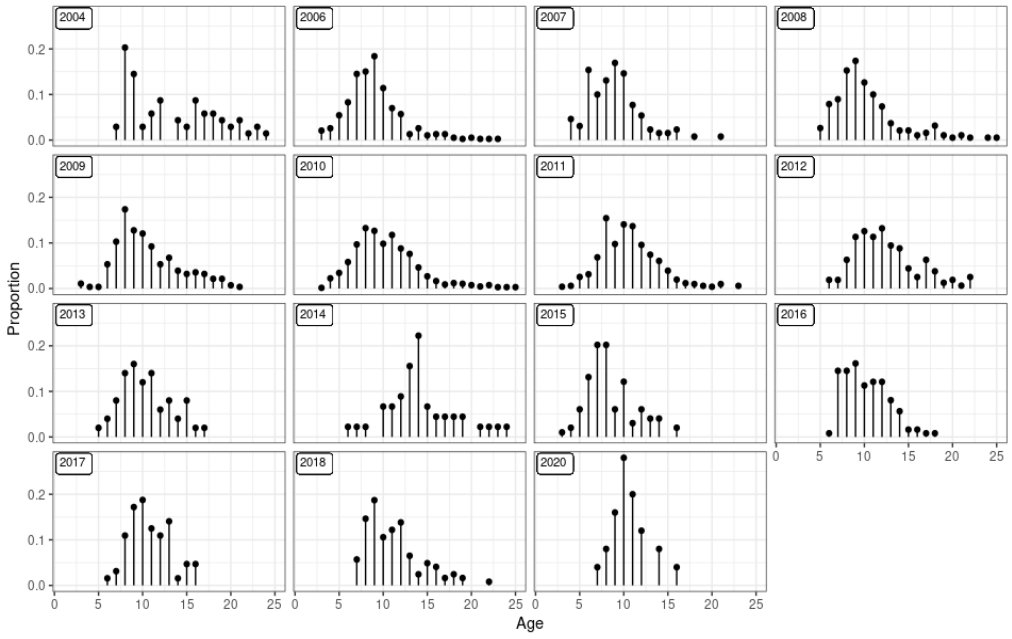


Figure 6.3.11: Greater silver smelt in 5.a and 14. Catch in numbers at age. Estimates for 2002 are based on limited number of aged otoliths. No age data are available for 2019.

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. 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.

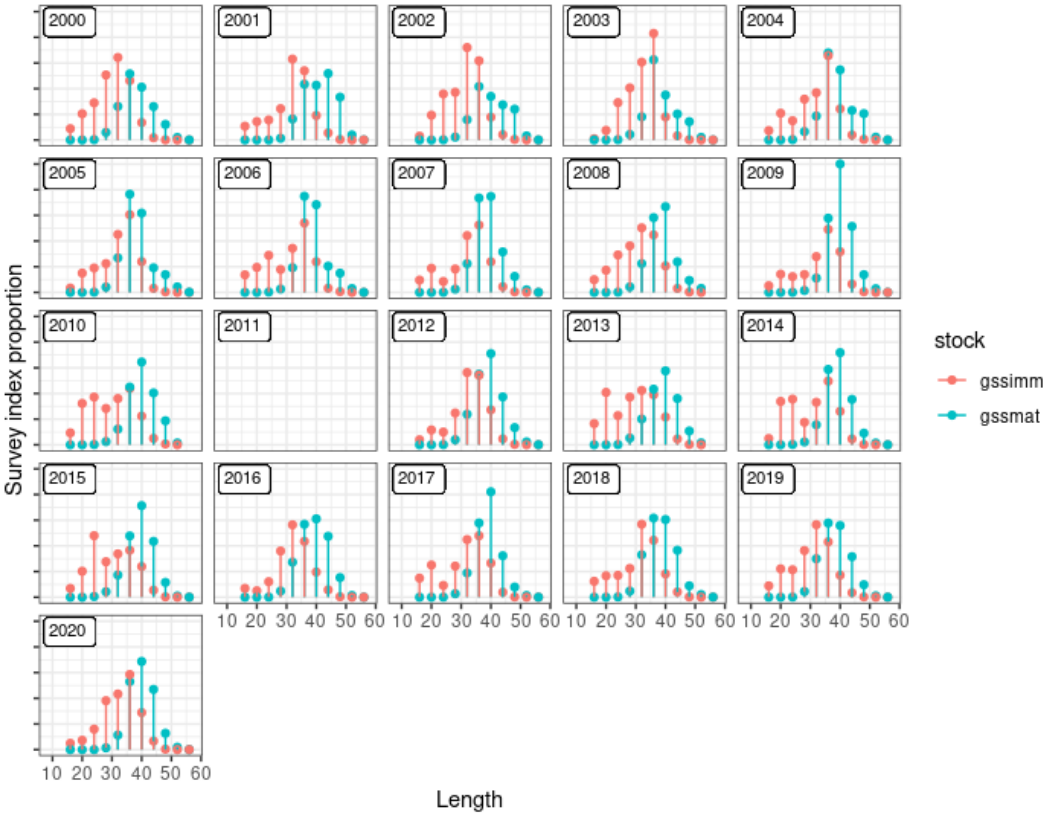


Figure 6.3.12: Greater silver smelt in 5.a and 14. Length distributions from the autumn survey since 2000. Red areas are immature greater silver smelt and green represent mature greater silver smelt.

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 around 3209 tonnes in 2020 (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 6.3.9). 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 6.3.11). 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 2020 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 the highest value observed, and thereafter has been relatively stable but with high variability.

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).

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 (Figure 6.3.13, Figure 6.3.14 Figure 6.3.15, Figure 6.3.16). 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.

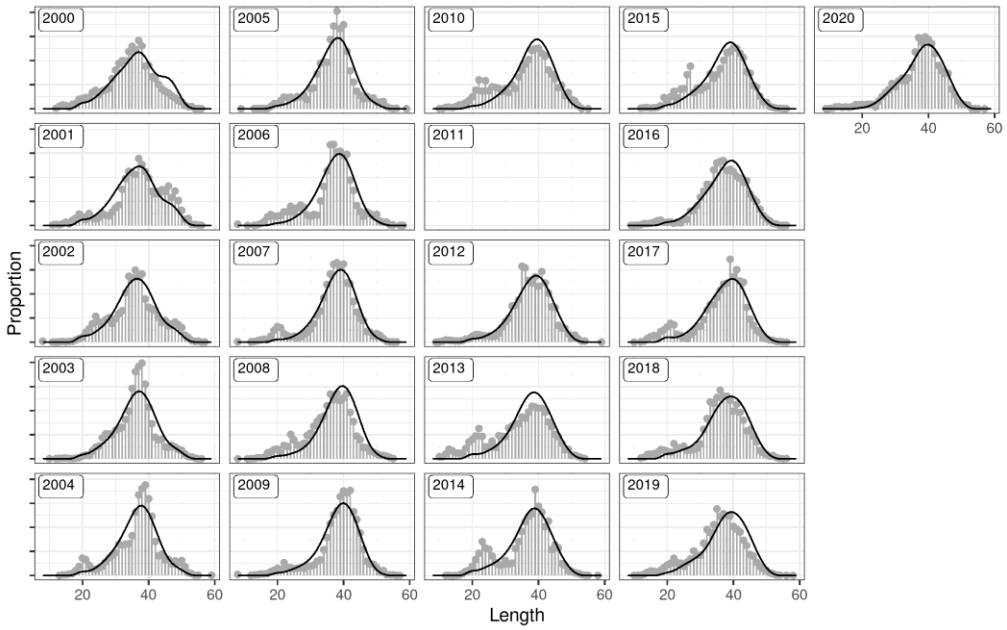


Figure 6.3.13: Greater silver smelt in 5.a. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the autumn survey (green lines and points)

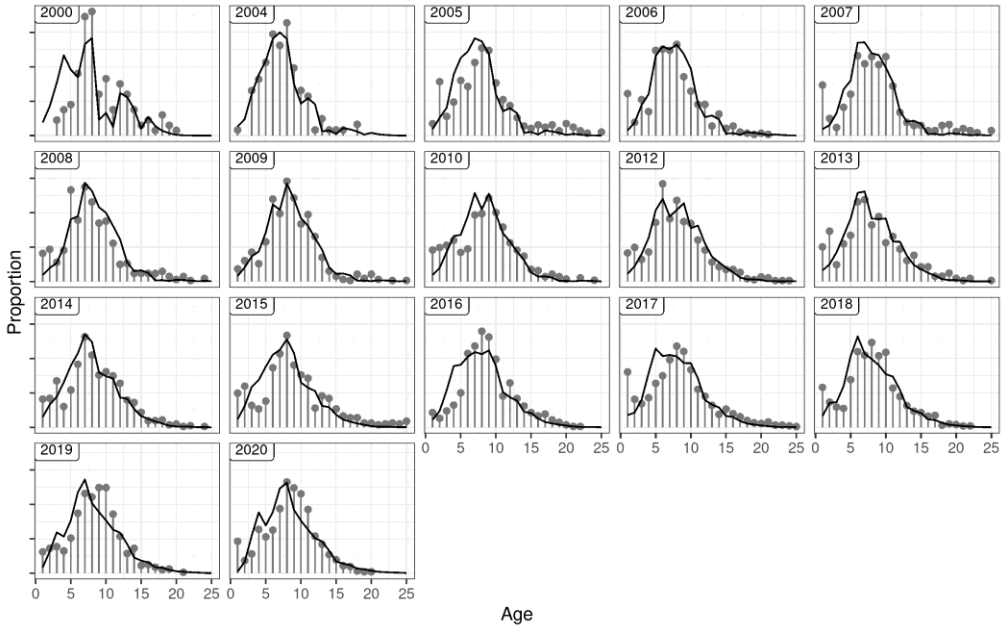


Figure 6.3.14: Greater silver smelt in 5.a. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the autumn survey catches (grey lines and points).

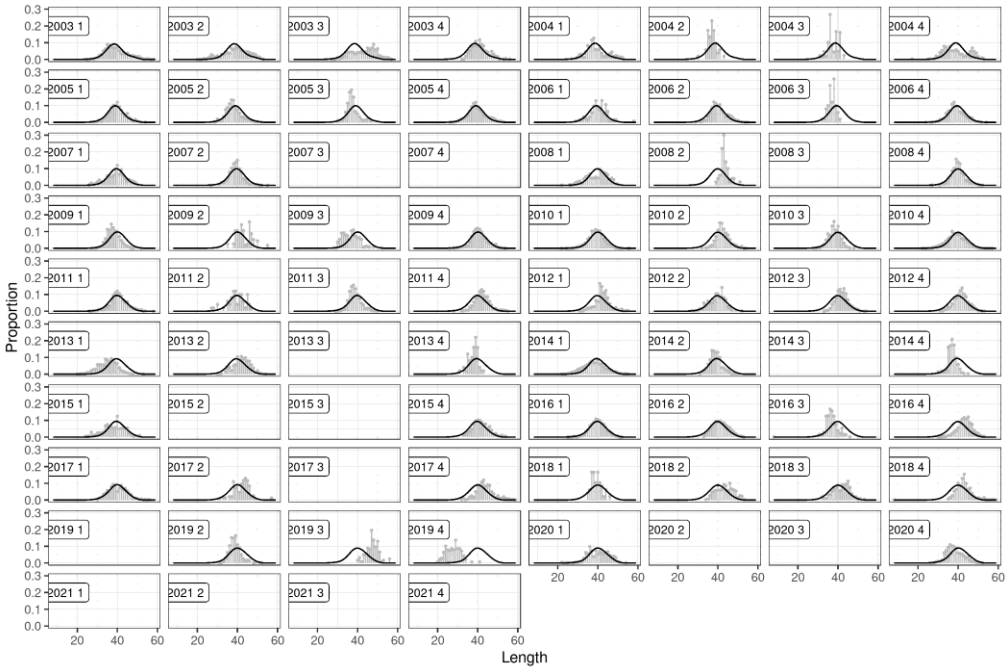


Figure 6.3.15: Greater silver smelt in 5.a. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from commercial catches (grey lines and points).

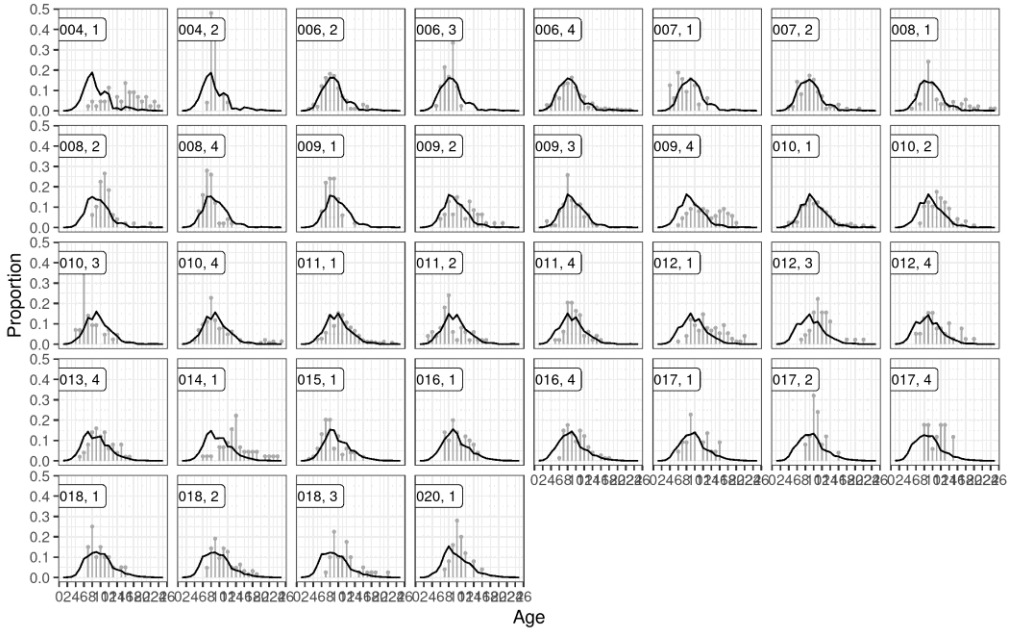


Figure 6.3.16: Greater silver smelt in 5.a. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in commercial catches (grey lines and points).

6.3.9.5 Model fit

Figure 6.3.17 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 this year and downward revisions in coming years, if this trend continues.

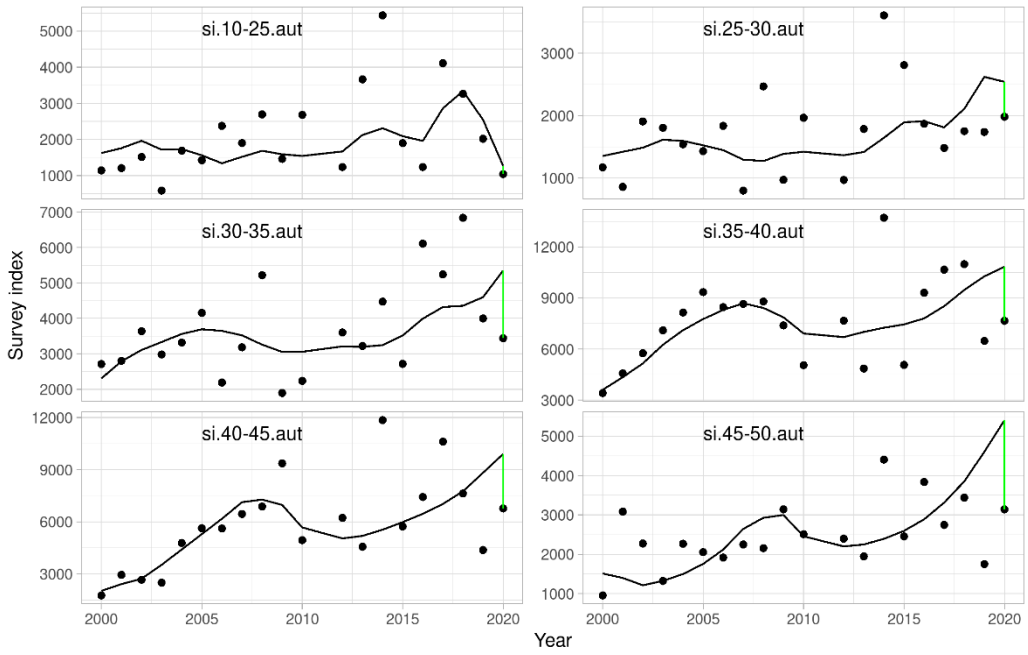


Figure 6.3.17: Greater silver smelt in 5.a. Fitted autumn survey index by length group from the Gadget model (black line) and the observed number of greater silver smelt caught in the survey (points). The green line indicates the difference between the terminal fit and the observations.

6.3.10 Results

The results are presented in Table 6.3.4 and Figure 6.3.18. Recruitment has been increasing over the past decade, but the most recent very high estimates of age 1 recruitment in 2017 - 2019 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 2019 with a slight decrease in 2020. Fishing mortality for greater silver smelt (age 6–14) has decreased from around 0.2 in 2010 to 0.05 over the past several years, due to greater regulation of the fishery as well as reduced commercial interest.

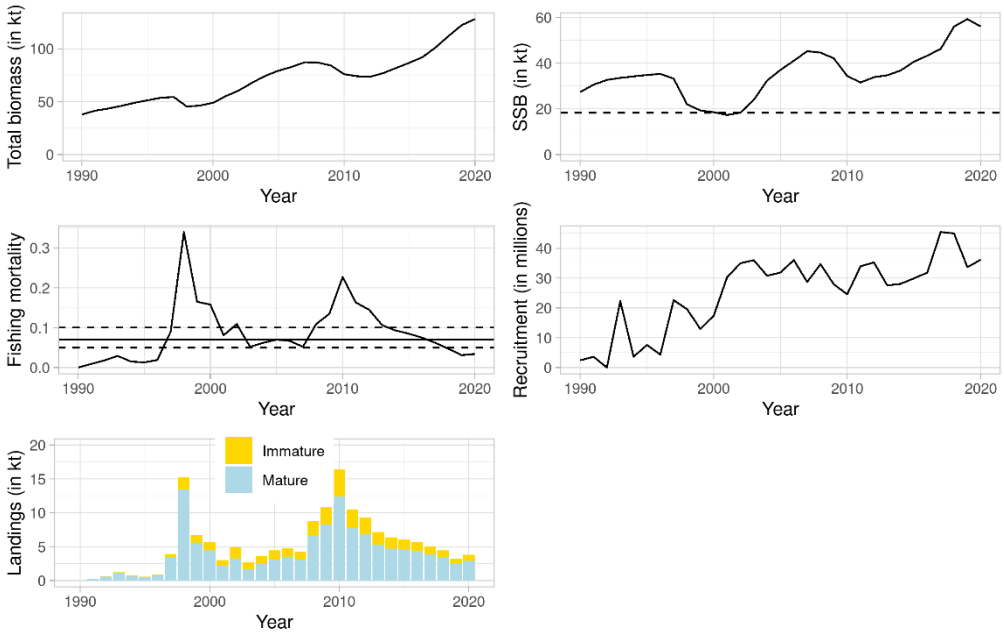


Figure 6.3.18: Greater silver smelt in 5.a and 14. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fishes, recruitment and total catches. The dashed line in the SSB plot represents Bpa. The solid line in the fishing mortality plot indicates the fishing mortality used in the ICES MSY advice rule, whereas the dashed lines indicate the bounds of the realized fishing mortality resulting from the advice rule given the uncertainty in the assessment.

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.

Year	Total Biomass	Catch	SSB	Rec.	F
2000	46249.11	5.657	19298.27	17.38056	0.158
2001	48895.48	3.043	18545.38	30.28578	0.081
2002	55261.09	4.961	17296.34	35.00796	0.109
2003	60763.54	2.680	18419.44	36.02414	0.052
2004	67871.64	3.645	23931.51	30.80830	0.062
2005	74388.48	4.482	32418.07	31.87912	0.070
2006	79222.95	4.769	37040.10	36.07259	0.067
2007	82814.22	4.227	41196.46	28.70044	0.052
2008	87171.57	8.778	45386.04	34.69130	0.109
2009	86918.64	10.828	44726.62	27.92182	0.135
2010	84134.24	16.428	42206.14	24.57031	0.227
2011	75966.08	10.516	34539.26	33.97954	0.163
2012	73956.18	9.289	31698.93	35.25951	0.145
2013	73520.22	7.155	33986.69	27.56153	0.106
2014	76981.45	6.348	34801.72	28.07747	0.093

Year	Total Biomass	Catch	SSB	Rec.	F
2015	81911.83	6.070	36913.52	29.94022	0.085
2016	86801.96	5.662	40824.24	31.84774	0.075
2017	92113.52	5.011	43405.92	45.46419	0.062
2018	101318.33	4.460	46453.89	44.98915	0.047
2019	112322.33	3.209	56170.72	33.67367	0.031
2020	122340.89	3.775	59500.52	36.19197	0.034
2021	128040.96	9.824	56362.38	81.86833	0.085
2022	129260.89	8.838	49051.34	85.78528	0.067

6.3.10.1 Retrospective analysis

An analytical retrospective analysis is presented. The analysis indicates that there was an upward revision of biomass from the first to the second year of the peel followed by a downward revision of biomass (SSB) over the last 3 years. The F shows a downward revision over the years. Estimates of recruitment show an increase in the first two years of the peel, followed by a downward revision with an apparent peak in 2017-2018. As explained in reference to the survey indices, this is likely the influence of highly variable survey indices that, for the smallest sizes in the most recent years, have no repeated observations at larger sizes. Therefore, it is expected that these recruitment peaks may simply be the result of uncertainty in survey indices and are likely to disappear in the coming assessment years.

Mohn's rho was estimated to be 0.293 for SSB, -0.188 for F, and 0.245 for recruitment.

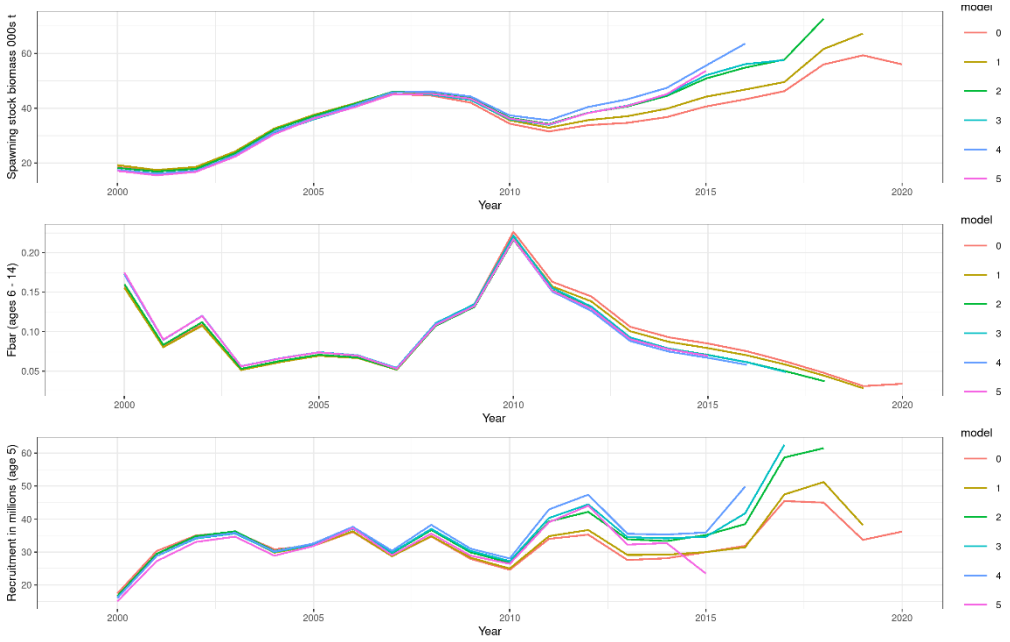


Figure 6.3.19: Greater silver smelt in 5.a and 14. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 5) are shown.

6.3.11 ICES advice

No advice from ICES wad requested by Iceland in 2020 due to the Covid 19 disruption.

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. 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 $SSBy > B_{trigger}$, scaled by $(SSBy)/B_{trigger}$ while $Blim \leq SSBy < B_{trigger}$, and set to 0 while $SSBy \leq B_{lim}$.

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 and 8 729 for 2020/21(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		8 497
2012/13	8 000		11 217
2013/14	8 000	8 000	7 242
2014/15	8 000	8 000	6 848
2015/16	8 000	8 000	5 991
2016/17	7 885	7 885	3 570
2017/18	9 310	9 310	5 159
2018/19	7 603	7 603	2 818
2019/20	9 124	9124	3775
2020/21	8729	8729	2395
2021/22	8717		

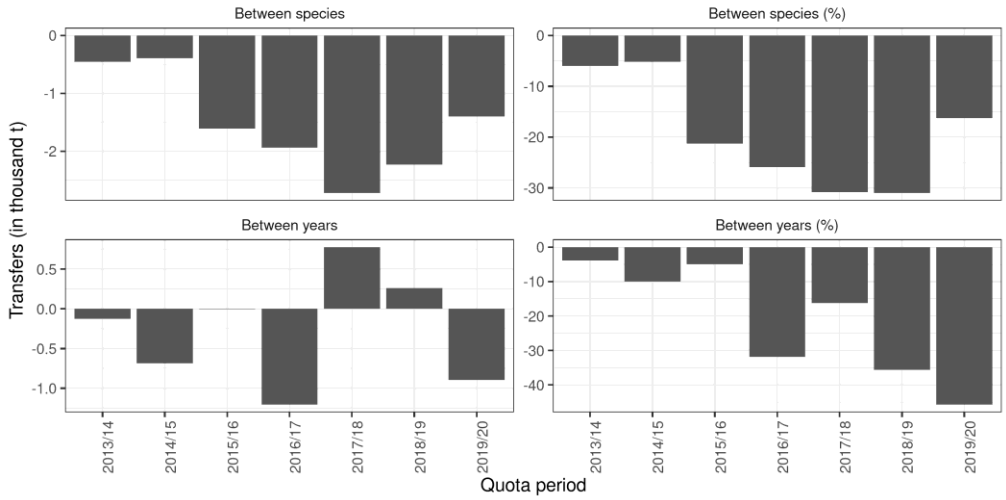


Figure 6.3.20: Greater silver smelt in 5.a and 14. An overview of the net transfers of quota between years and species transformations in the fishery in 5.a.

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.

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. Based on a crude assumption of fishing year landings being approximately half of the recommended TAC for 2020/2021, the TAC for the fishing year 2021/2022 was estimated to be 9200 tonnes instead of 8717 tonnes. A reduction in total catch removals will lead to a higher estimated TAC.

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 2020, this would be the geometric mean of age 1 recruitment estimates from years 2014–2016). 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.

2016. "Stock Annex: Greater silver smelt (Argentina silus) in Subarea 14 and Division 5.a (East Greenland and Iceland grounds)." International Council for the Exploration of the Seas; ICES publishing.

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

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

6.4.1 The fishery

The target fisheries on greater silver smelt in Divisions 5.b and 6.a are mainly conducted by Faroese and European trawlers. In 2020, the catches in 5.b were mainly taken by three pairs of Faroese pair trawlers deploying bentho-pelagic trawls (99%) while the catches in 6.a were mostly taken by European trawlers (58%) and the remainder mainly by previously mentioned Faroese trawlers (42%, inside the Faroese EEZ) (Table 6.4.1 and Figure 6.4.1).

Historically, greater silver smelt were only taken as bycatch in the shelf-edge deep-water fisheries and either discarded or landed in small quantities. Targeted fisheries 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.

From the mid-1990s to 2007 the greater silver smelt fishing grounds 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. Since 2008 the Faroese fishery has extended the fishing grounds to include the area on the Wyville-Thomson Ridge south of the Faroe Plateau. Since 2012 around 50% of the Faroese catches were caught on the Wyville-Thomson Ridge (in Divisions 5.b and 6.a, inside the Faroese EEZ).

The European fisheries on silver smelt mostly takes place on the shelf edge within Divisions 6a, 5.b and 4.a. New information from the self-sampling program carried out by the European fisheries (Pelagic Freezer-trawler Association, PFA) was presented to the Working Group in 2018 and been updated in (Pastoors, WD 2021). 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.

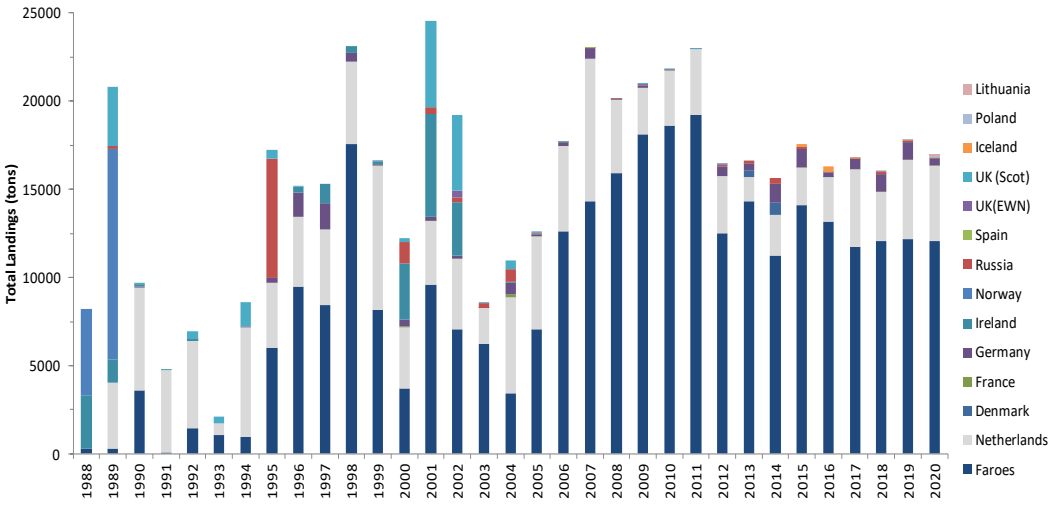


Figure 6.4.1. Greater silver smelt in 5.b and 6.a. Total landings per year of greater silver smelt in 5.b and 6.a by countries from 1988-present.

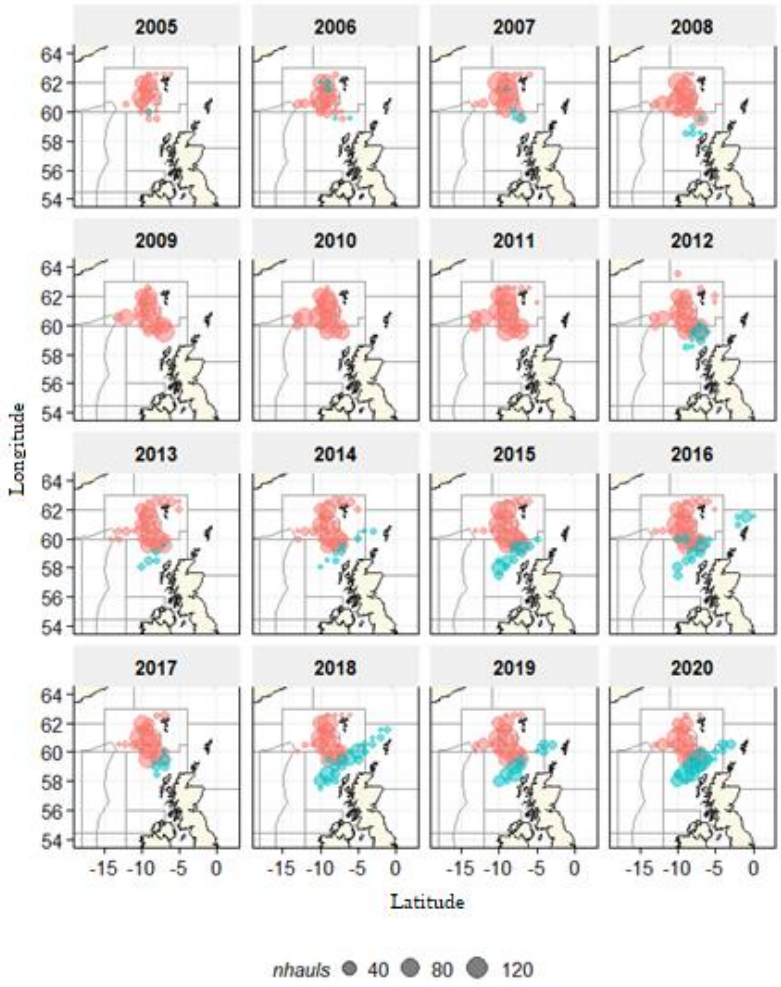


Figure 6.4.2. Greater silver smelt in 5.b and 6.a. Number of hauls of commercial fisheries available for standardized CPUE calculation in Faroese fishery (red circles) and PFA fishery (blue circles) from 2005-present (WGDEEP 2021, WD02).

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). Since then landings have been around 10 000 – 13 000 tonnes. The reduction in greater silver smelt catches in 5.b in 2012 was probably a combination of the introduction of quotas for greater silver smelt in Faroese waters, the effect that the fishery was targeting mackerel rather than greater silver smelt and also a shift in fishing area moving into Division 6.a within the Faroese EEZ towards the Wyville-Thomson Ridge.

Landings in Division 6.a have been fairly stable at around six to eight thousand tonnes since the fishery started excluding two peaks in 1989 and in 2001 with landings comprising of 20581 and 14 466 respectively. Since 2004 landings varied between 5000 and 7500 tonnes.

In 2020 the preliminary catch is 8438 tonnes in Division 5.b and 8576 tonnes in Division 6.a.

6.4.2 ICES Advice

ICES advises that when the precautionary approach is applied, landings should be no more than 7703 tonnes in each of the years 2020 and 2021. ICES cannot quantify the corresponding catches.

6.4.3 Management

The EU introduced total allowable catch (TAC) management for greater silver smelt in 2003 and has since then set 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 3a and 4). TAC quotas for the EU fishery in Subareas 5, 6 and 7 for the period 2014 - present are presented in the Table 6.4.3.

In the period from 2010 to 2013, the Faroese greater silver smelt fishery was managed by an agreement between the Faroese fleet with licences to conduct direct greater silver smelt fishery and the Faroese authorities. This management was guided by the stock assessment and scientific advice of Faroe Marine Research Institute (FAMRI). With this agreement, total annual landings should not exceed 18 000 tonnes in the Faroese EEZ. There was no advice from ICES that was specific for the Faroese greater silver smelt component. Regulation was through a general regulation of fishing days for the trawler group. There were also limitations in e.g. minimum size, bycatch, mesh size and fishing area restrictions.

In 2014, the Faroese authorities introduced species-specific TAC quota for greater silver smelt applicable for Faroese trawlers fishing inside the Faroese EEZ. Six trawlers had licences to target greater silver smelt at this point in time and the technical measures continued to apply. The Faroese TAC quotas are also presented in the Table 6.4.3. A decrease in the biomass index as estimated by the age-based exploratory assessment of greater silver smelt in Faroese waters has resulted in the decreasing TAC from 2014 to 2017.

ICES advice for greater silver smelt and the TACs that have been set by the Faroese authorities and the European Union are also summarised in Table 6.4.3.

6.4.4 Data available

Commercial data on length, round weight and age were available for greater silver smelt from samples taken from Faroese and European landings. There were also catch and effort data from logbooks for the Faroese trawlers and from the PFA fisheries in the Northeast Atlantic (WGDEEP 2021, WD02).

From the annual ground fish summer survey on the Faroe Plateau, biological data (mainly length and round weight) as well as catch and effort data are available for greater silver smelt from 1995 - present. This survey is targeting cod, haddock and saithe, but entire catch is examined and quantified. In addition, a Faroese deepwater survey has been conducted since 2014 which covers the greater silver smelt fishery areas in inside the Faroese EEZ.

The Scottish deepwater survey is also included in the SAM assessment as a biomass index. This survey covers the European fisheries in 6a (Campell 2020, WD01 WKGSS). This survey includes catch and effort data.

6.4.4.1 Landings and discards

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

Discard is banned inside the Faroese EEZ and all catches are assumed to be landed. In the European Union, the landing obligation for pelagic fisheries was implemented in 2015. Catches of all species caught during pelagic fisheries are to be landed, except for protected species which need to be immediately released after capture. In 2019 the EU landing obligation was applied to demersal fisheries.

For this stock unit, information on discards from non-Faroese fisheries is reported to ICES (Table 6.4.4). It is assumed that bycatch is landed.

In Subareas 6 and 7 greater silver smelt can represent a significant discard of the trawl fisheries on the continental slope particularly at depths of 300 to 700 m (e.g. Girard and Biseau, WD 2004). New calculation of the estimates for 2012 and 2013 reduced strongly the discards reported by Spain. In 2014–2015 there appears to have been no Spanish discards of this species in Subarea 6 (only in 7).

Based upon on-board observations from EU data collection framework (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 was discarded in that fishery; representing 25.3% of the discards. The discards in 2015 - present were mainly in Division 6.a reported from the French and Scottish deep-water fisheries (data from ICES) (Table 6.4.4). Discard data reported to ICES from 2014 - present comprise 3.4% of the total catches.

6.4.4.2 Length compositions

Length frequency distributions of commercial catches are from Faroese commercial trawl catches in 5.b and 6.a (Figure 6.4.3) and from PFA fisheries in Divisions 4a, 5b and 6a (Pastoors, WD06 2020) (Figure 6.4.4).

Length distributions 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.

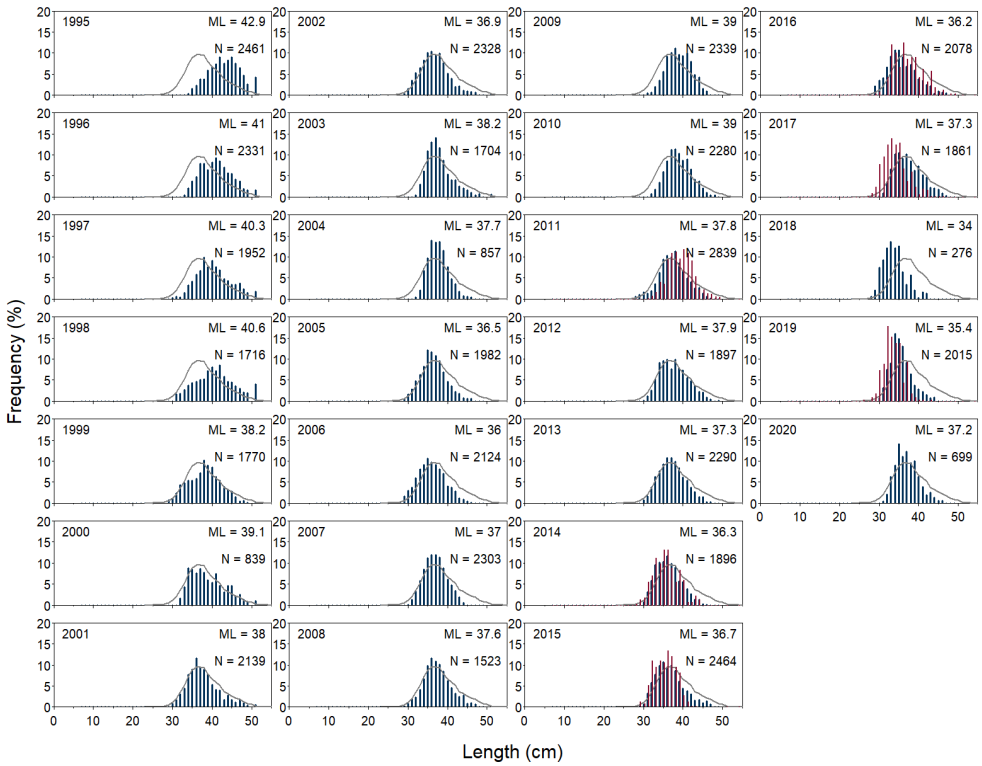


Figure 6.4.3. Greater silver smelt in 5.b. Length frequencies of greater silver smelt in the Faroese catches from 1995-present. Blue bars are catches within area 5b and red bars are catches within area 6a. Curves are the average over whole time frame. ML= mean length (cm) and N= number of length measurements.

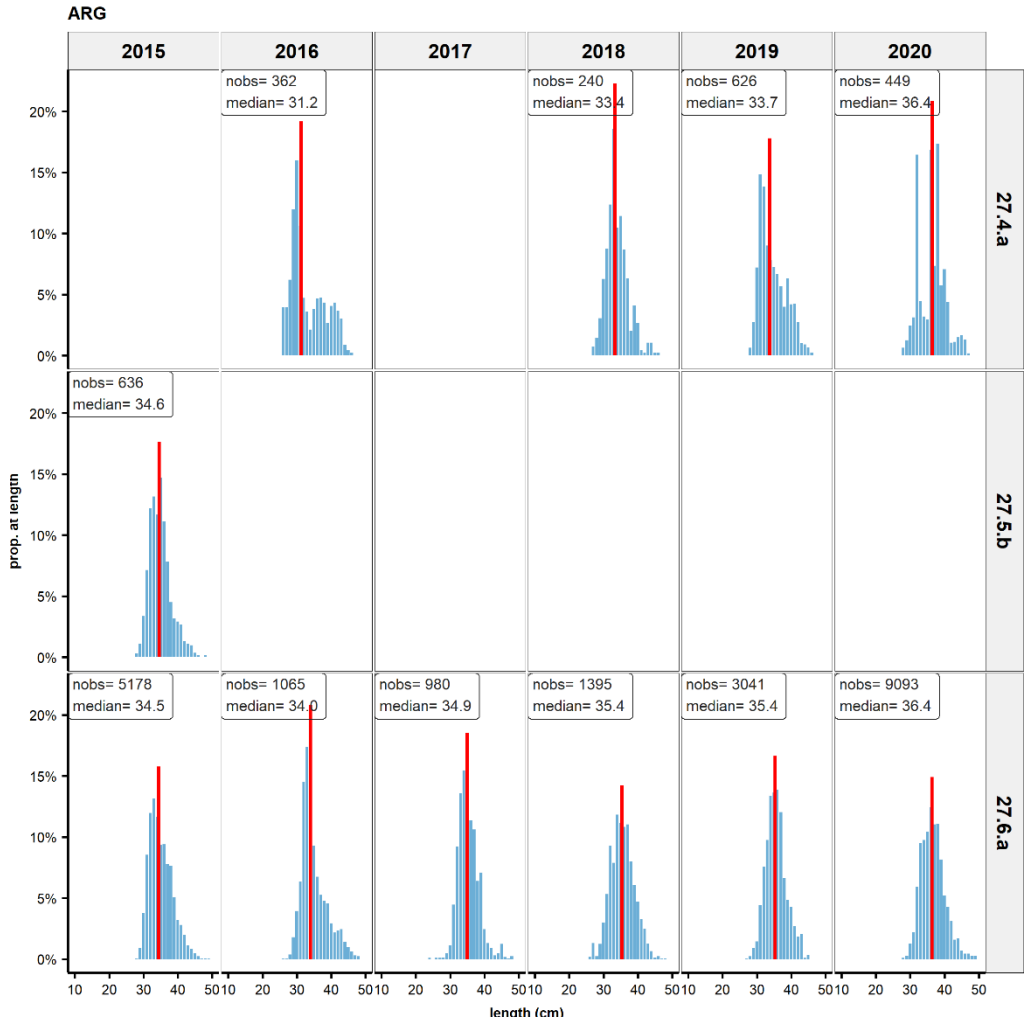


Figure 6.4.4. Silver smelt (*Argentine spp.)* in 5.b and 6.a. Relative length frequencies in PFA self-sampled fisheries in division 4a, 5b and 6a. Median length in red. Number of length measurement in top left (WGDEEP 2021, WD02).

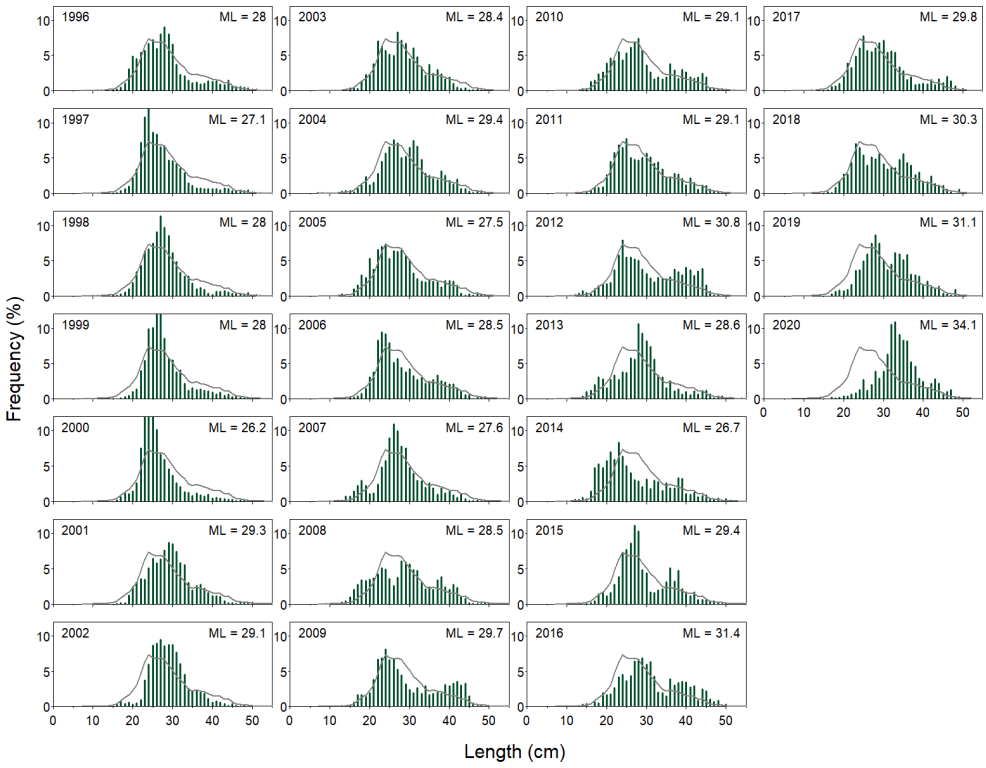


Figure 6.4.5. Greater silver smelt in 5.b. Length frequencies from Faroese ground fish summer survey from 1996-present. Greater silver smelt is sub sampled of the total catch i.e. the values of greater silver smelt are scaled to reflect total catch. ML= mean length.

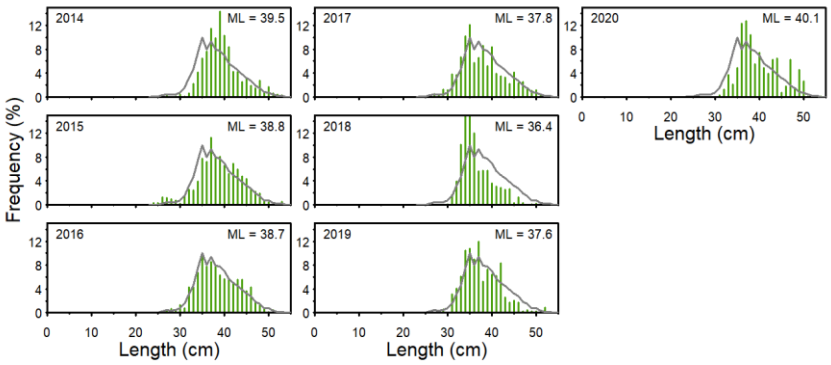


Figure 6.4.6. Greater silver smelt in 5.b. Length frequencies from the Faroese deep water survey from 2014 r. ML = mean length.

6.4.4.3 Catch at age (CAA)

Age frequency distributions from the combined catch at age (CAA) matrix compiled in InterCatch are presented in Figure 6.4.7 and Table 6.4.5. These data are used in the age based SAM assessment. In addition, for some years age data are available from Netherland and Scottish fishery in Division 6.a. The calculation of catch at age is described in detail in stock annex.

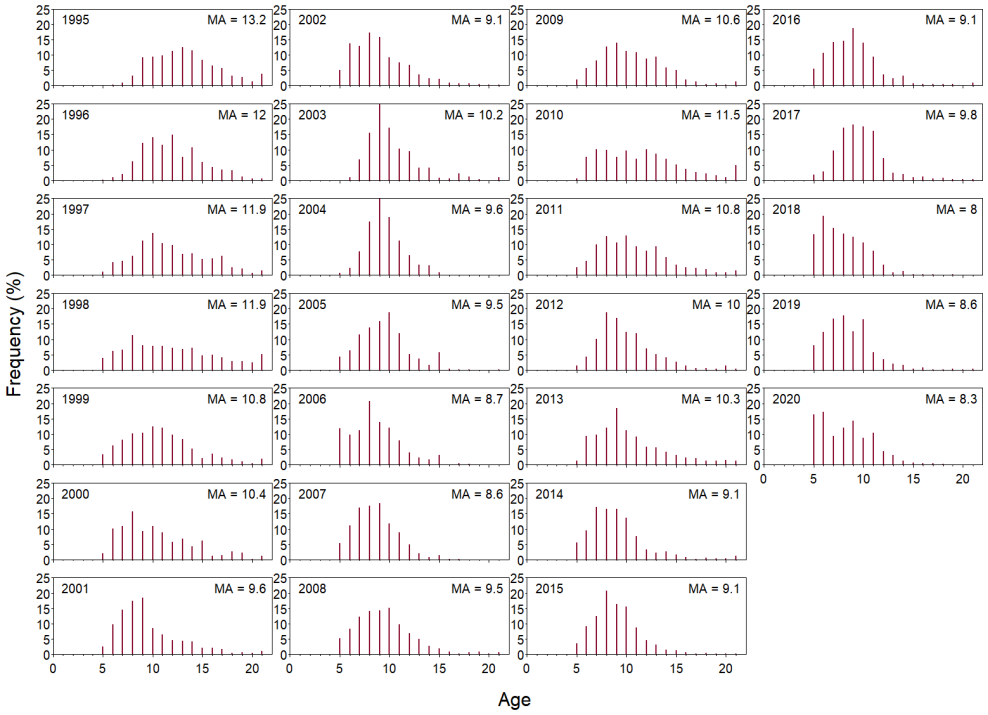


Figure 6.4.7. Greater silver smelt in 5.b and 6.a. Catch at Age (CAA) used in the SAM assessment in 1995-present. Prior to 2005 only CAA from the Faroese data has been used. From 2005 to present the combined CAA from Faroese and EU data have been used (compiled in InterCatch). MA= mean age.

6.4.4.4 Weight-at-age

Catch weight at age data used in the assessment is compiled in InterCatch (Figure 6.4.8 and Table 6.4.6). Data from 1995 to 2005 is only available from Faroese fishery in Division 5.b. Stock weights at age are set to the same values as catch weight at age (1995 - present, ages 5 to 21+). The low 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).

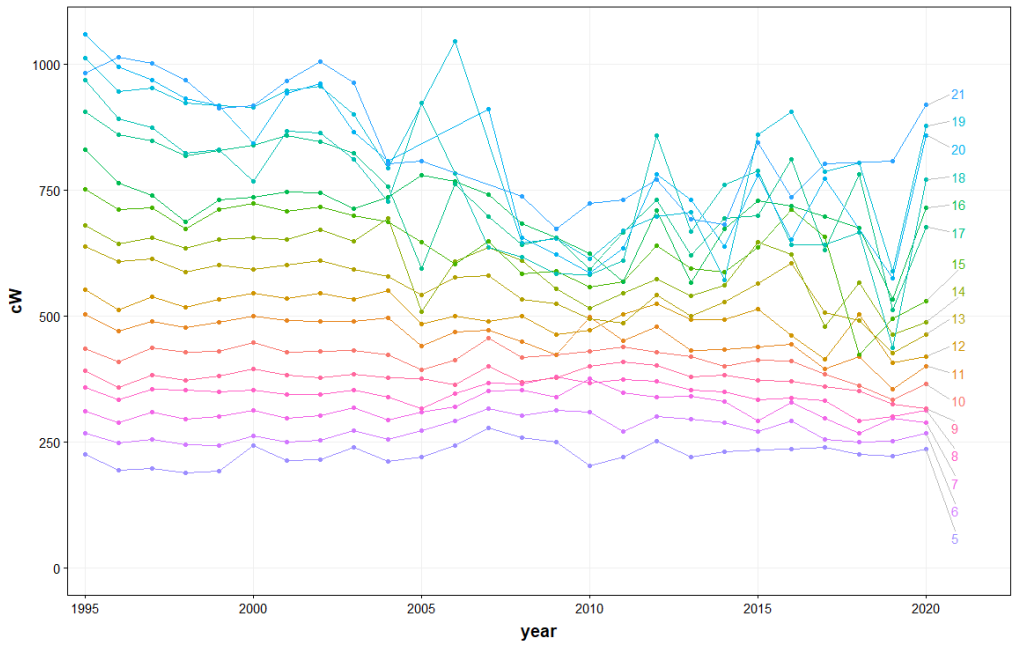


Figure 6.4.8. Greater silver smelt 5.b and 6a. Mean weight-at-age of greater silver smelt in the commercial catch within 5.b and 6.a.

6.4.4.5 Maturity and natural mortality

Most of the greater silver smelt caught in commercial catches in Division 5.b is mature (ICES, 2021).

Proportion mature is time invariant. The background data are from different Faroese surveys in the period 2000-2019, see Table 6.4.7. There is no maturity data available from the Scottish deep-water survey.

The natural mortality was set to 0.15 (ICES, 2021).

6.4.4.6 Catch, effort and research vessel data

Catch and effort data by haul for the commercial Faroese (1995 - present) and PFA fishery (2005-2008, 2012 - present) are available from Faroese logbooks and the PFA self sampling program. The catch from the Faroese trawlers logbook data accounts for more than 80% of the Faroese landings from 2005 and onwards. Therefore this period was chosen for calculating 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.

At the benchmark meeting in 2020, a 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 (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 WD01, WGDEEP 2021.

Commercial CPUE may be influenced by changes greater silver smelt quotas and fishing season/marked factors, but these influences were regarded as minor in comparison to variations in stock biomass.

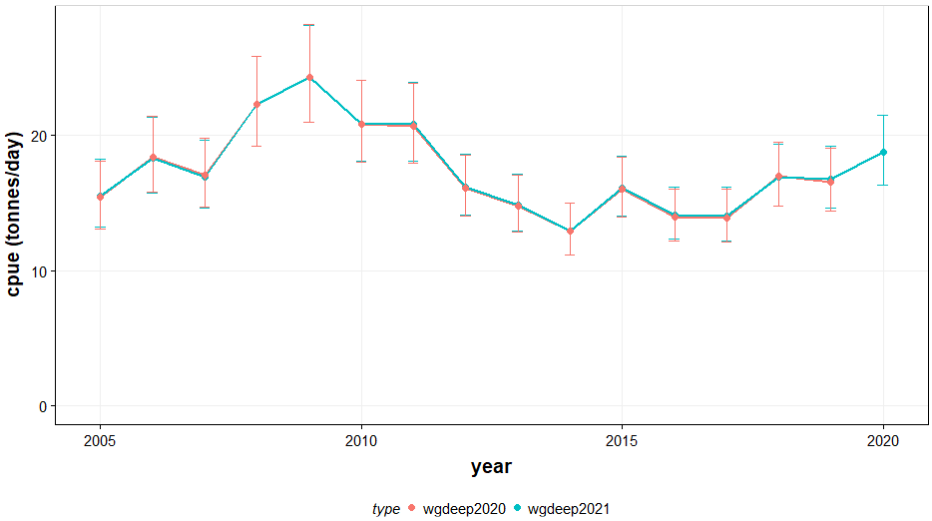


Figure 6.4.9. Greater silver smelt in 5b and 6a. Combined standardized CPUE with confidence intervals from Faroese and EU fisheries from 2005 to last data year (blue line) compared to last year's assessment (red line) (Pastoors *et al*. 2021, WD01).

Standardised catch index from the Faroese summer groundfish survey, conducted in August since 1996, is used to tune the assessment of greater silver smelt in 5.b and 6.a (Figure 6.4.10, ICES, 2021, stock annex). It has to be noted that the survey have very few stations deeper than 500 m and are therefore likely to only cover the juveniles adequately. The adult part of the population is not fully covered by these surveys and they may not necessarily reflect correctly the temporal variation of the biomass of the stock that is better covered by the 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 for greater silver smelt, because of large variation.

A Faroese deep-water trawl survey has been conducted in September since 2014, covering the slope and banks including the fishing area for greater silver smelt in the Faroese EEZ (5.b and 6.a)(ICES, 2021, Stock annex). The standardized index is presented in Figure 6.4.10. The Faroese surveys are conducted by R/V Magnus Heinason.

No Scottish deep water survey was conducted in 2020. The Scottish deepwater trawl survey (6.a) was explored at the benchmark in 2020 (ICES, 2021). A regular trawl survey of the fish community in the deep waters to the northwest of Scotland has been undertaken irregularly since 1998, using the MRV Scotia and showed that greater silver smelt are found at depths between 400m and 750m (Campbell, WD Nov. 2019). The CPUE was standardized (Figure 6.4.10) and the number of hauls per year where greater silver smelt is encountered is generally around 10 (ICES, 2021, stock annex).

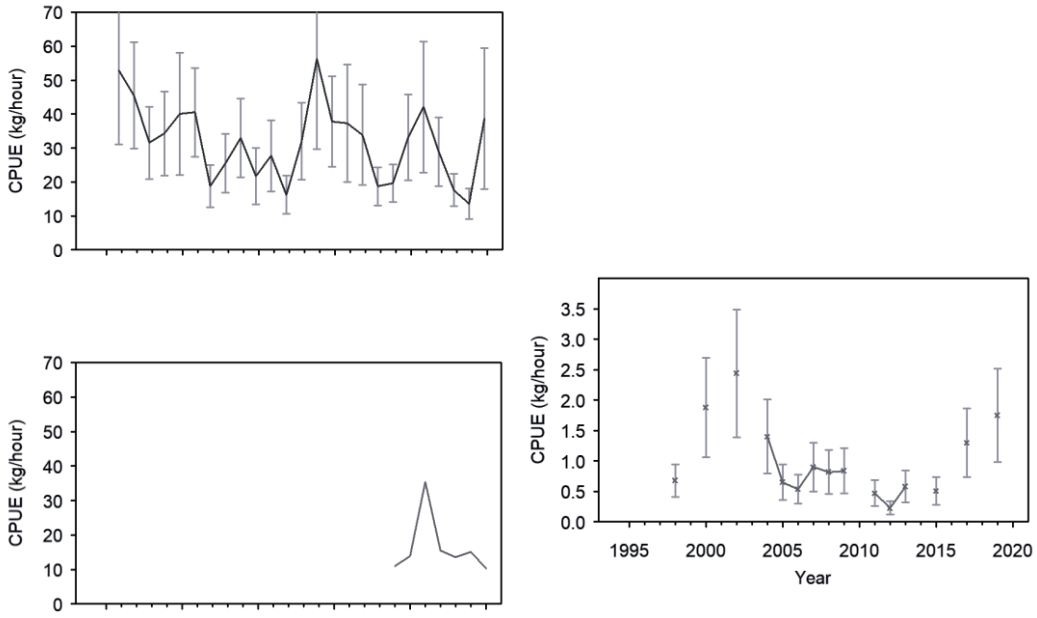


Figure 6.4.10. Survey indices (kg/hour) with confidence intervals from the Faroese summer survey (1995-present) top, Faroese deepwater survey (2014-present) centre and Scottish deepwater survey (1998-2019, irregularly) bottom.

6.4.5 Data analyses

6.4.5.1 Length and age distributions

In Division 5.b the mean length and age in the Faroese landings decreased from 1994 to 2000 and have been stable since then (Figures 6.4.3, 6.4.11). 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 the latest 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.

For the whole period 1995 - present, mean lengths in landings from Netherland were mainly between 34 to 38 cm (Figure 6.4.11).

After 2003, the mean length of greater silver smelt from Faroese and Netherland trawlers landings was very similar, around 36–39 cm (Figure 6.4.11). 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 fished in shallower waters these particular years compared to other years. Another probability is that the data are from discard not landings.

The mean length in the catch from the fisheries 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 6.4.11). However, this survey covers distribution of juveniles which the other indices do not.

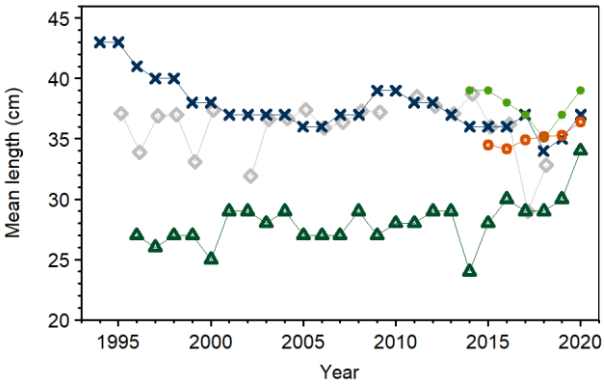


Figure 6.4.11. Greater silver smelt in 5.b and 6.a. Comparison of median lengths at year from Faroese (Blue crosses), PFA (open orange circles) and Netherland (grey diamonds) catches and from the Faroese summer (dark green triangles) and deepwater surveys (green filled circles).

6.4.5.2 Stock assessment

In the benchmark workshop on greater silver smelts (ICES, 2021), a Category 1 approach has been agreed for the stock in divisions 5b and 6a. The SAM model is used with catch at age from ages 5 to 21+ and years starting in 1995 (Table 6.4.5). Catch at age data for 1995 to 2004 is derived from the Faroese sampling raised to the international catches. Catch at age data for 2005 until present is derived from InterCatch whereby the age-based data is only contributed by Faroe Islands and the Netherlands. Only catch at age data from age 5 and upwards is used in the assessment, while in InterCatch, also information is available on (small) catches at ages 2-4.

Maturity at age is based on Faroese survey data and used as time-invariant variable.

Natural mortality was 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 (1997-present, Table 6.4.8) and the Faroese deepwater survey, ages 5 to 14 years (2014-present, Table 6.4.9).

The Scottish deepwater survey (1998-2019, irregular, Table 6.4.10) and the combined commercial Faroese and EU trawlers catch per unit effort (2005-present, 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 SAM stock assessment can be found in the Stock annex.

Diagnostics and results of the SAM model ARU _27.5b6a_WGDEEP2021 @ stockassessment.org are shown in the Figures and Tables below:

- Model fits to the data (Figures 6.4.12-6.4.15)
- Standardized one-step-ahead residuals (Figure 6.4.16)
- Leave-one-out analysis (Figure 6.4.17)
- Retrospective analysis (Figure 6.4.18)
- Estimated correlations between age groups for each fleet (Figure 6.4.19)
- SSB, Fbar, Recruitment and Catch (Figure 6.4.20 and Table 6.4.13)
- Parameter estimates (Table 6.4.12, Figure 6.4.21)

A closer look to the leave one out analysis showed that the model is very sensitive to exclusion of the Faroese summer survey from the model fit (Figure 6.4.17), especially for the estimation of recruitment.

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. All the retrospective runs falls within the confidence intervals of the final assessment. Mohn's rho parameters are estimated at 0%, -13% and -13% for the spawning stock biomass, F and recruitment, respectively.

The results from SAM shows that the spawning stock biomass (SSB) currently around 86 000 tonnes (Figure 6.4.20, Tables 6.4.13, 6.4.15), which is above B_{pa}. The fishing mortality ($F_{6\text{-}14}$) has varied but has been below F_{MSY} since 2018 (Figure 6.4.20, Tables 6.4.13, 6.4.14). The model-estimated catch in the years since 2014 has been lower than the observed catch.

Parameter estimates of the model are in the Table 6.4.5 and compared with the WGDEEP 2020 assessment in the Figure 6.4.21. Overall, parameter estimates are comparable between years, although some differences are observed in the observation variance of the Faroese Deepwater survey (LogSdLogObs - 2) and the correlation in observations of the Faroese Deepwater survey (transflRAR_dist - 1).

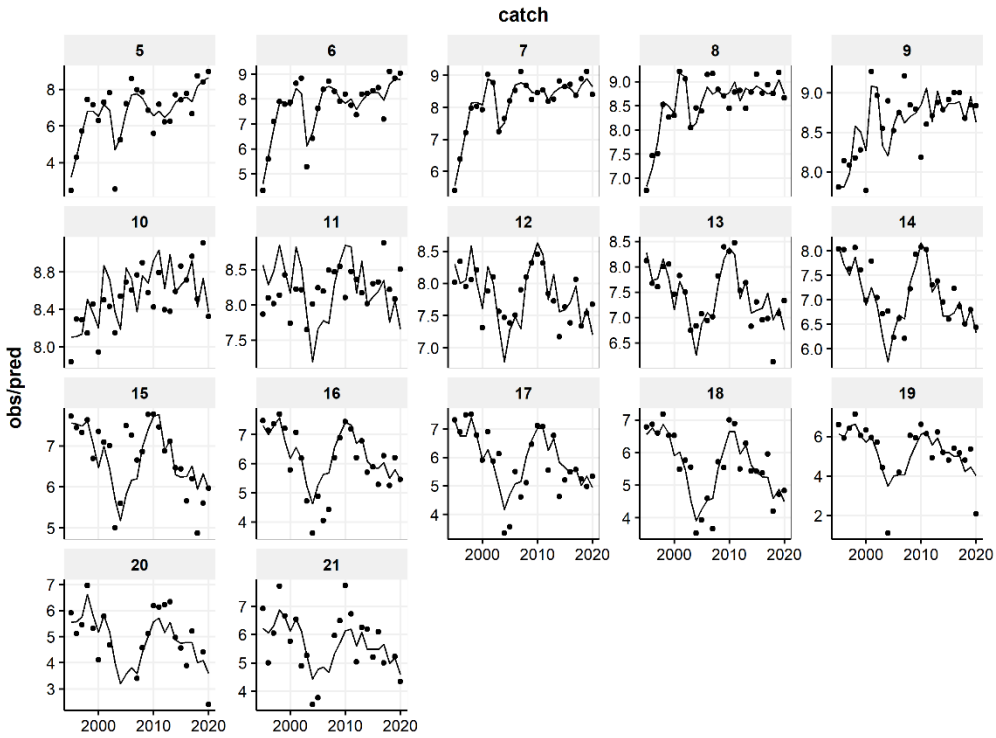


Figure 6.4.12. Greater silver smelt in 5.b and 6.a. Fit of the assessment model to the catches at age.

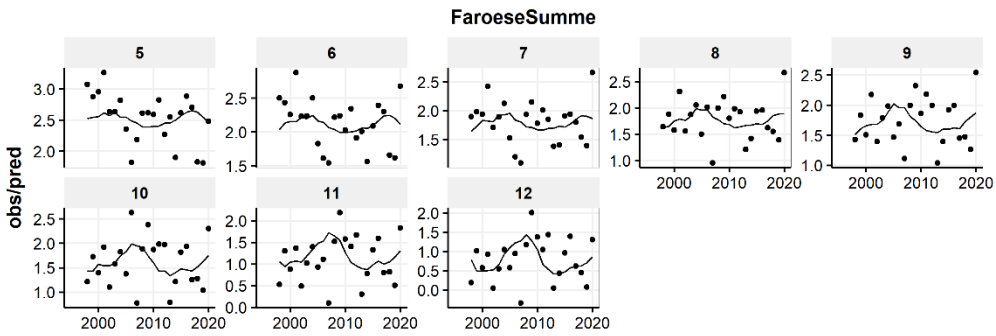


Figure 6.4.13. Greater silver smelt in 5.b and 6.a. Fit of the assessment model to the Faroese summer survey.

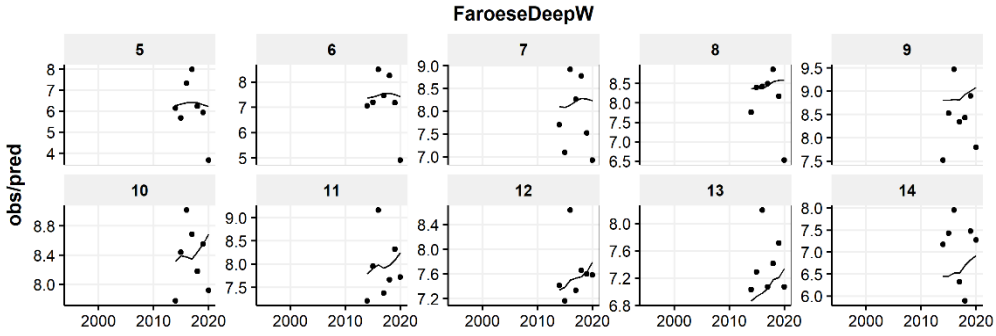


Figure 6.4.14. Greater silver smelt in 5.b and 6.a. Greater silver smelt in 5b and 6a. Fit of the assessment model to the Faroese deepwater survey

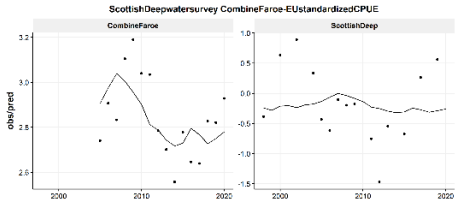


Figure 6.4.15. Greater silver smelt in 5b and 6a. Fit of the assessment model to the combined Faroese/EU CPUE (left) and the Scottish deepwater survey (right).

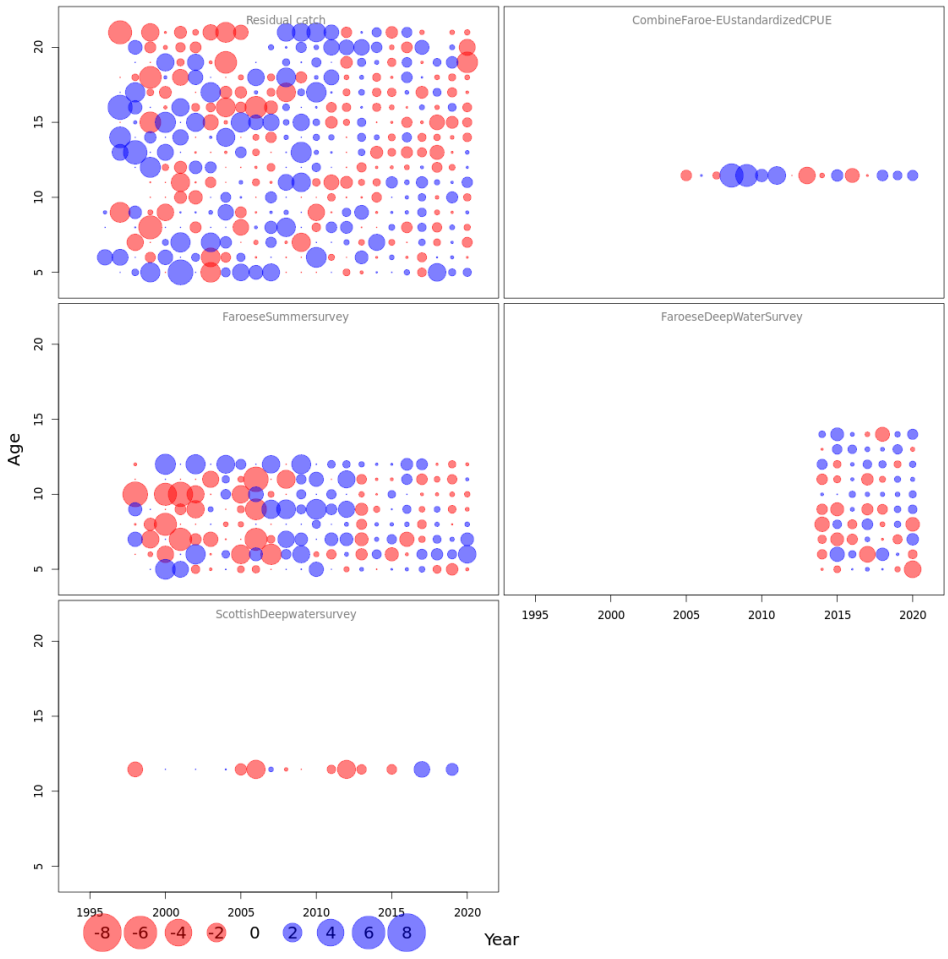


Figure 6.4.16. Greater silver smelt in 5b and 6a. Standardized one-step-ahead residuals from the SAM model.

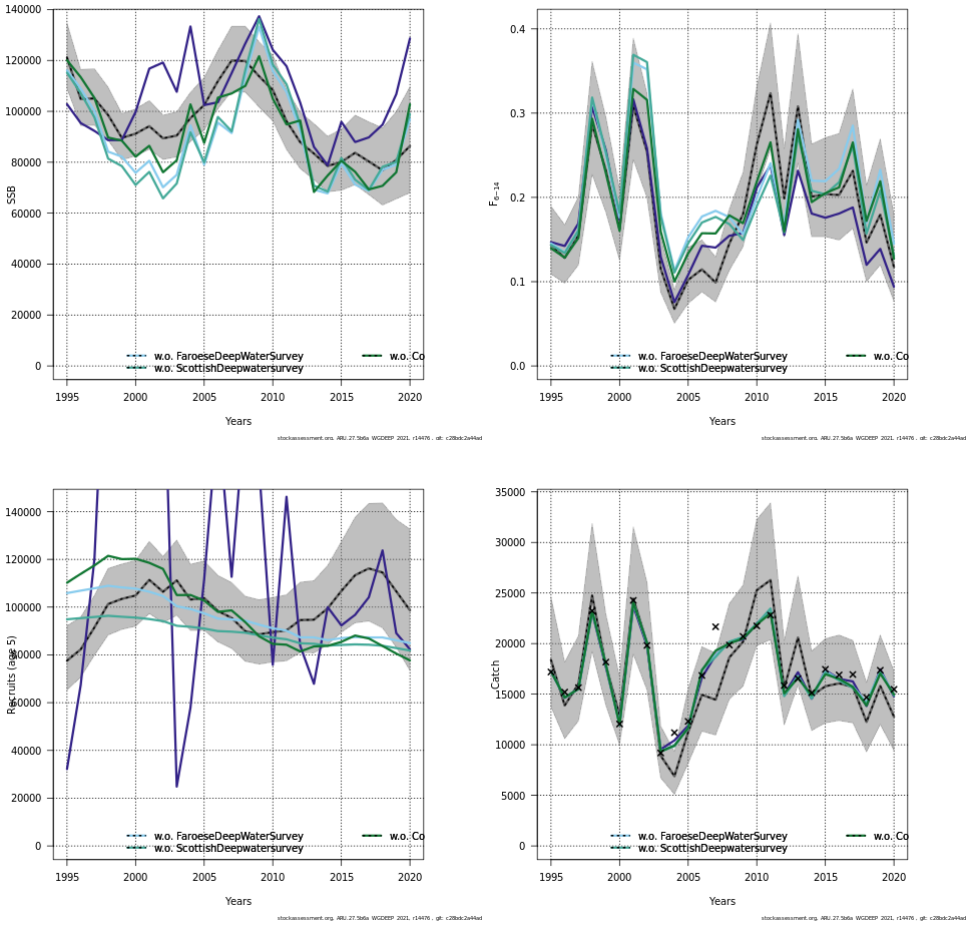
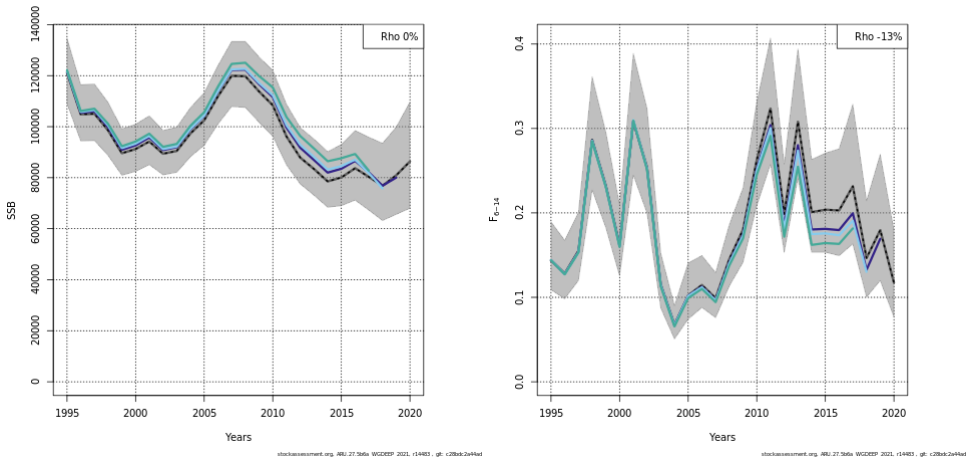


Figure 6.4.17. Greater silver smelt in 5b and 6a. Leave-one-out analysis of SSB (upper left), fishing mortality (upper right), recruitment (lower left) and catch (lower right).



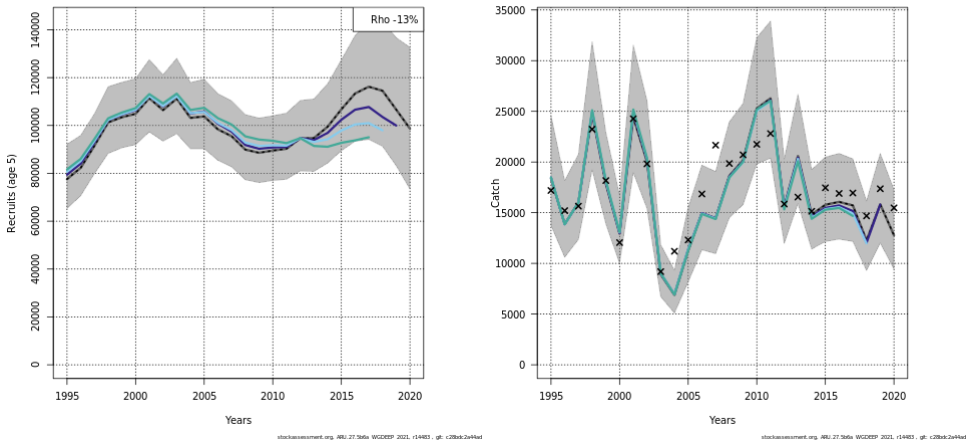


Figure 6.4.18. Greater silver smelt in 5b and 6a. Retrospective analysis with 3 peels in SSB (upper left), fishing mortality (upper right), recruitment (lower left) and catch (lower right).

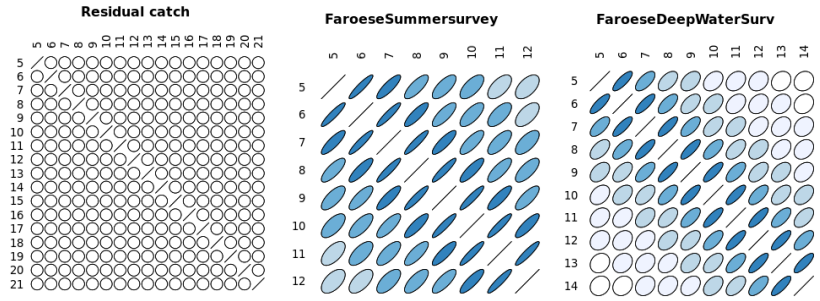


Figure 6.4.19. Greater silver smelt in 5b and 6a. Estimated correlations between age groups for each fleet.

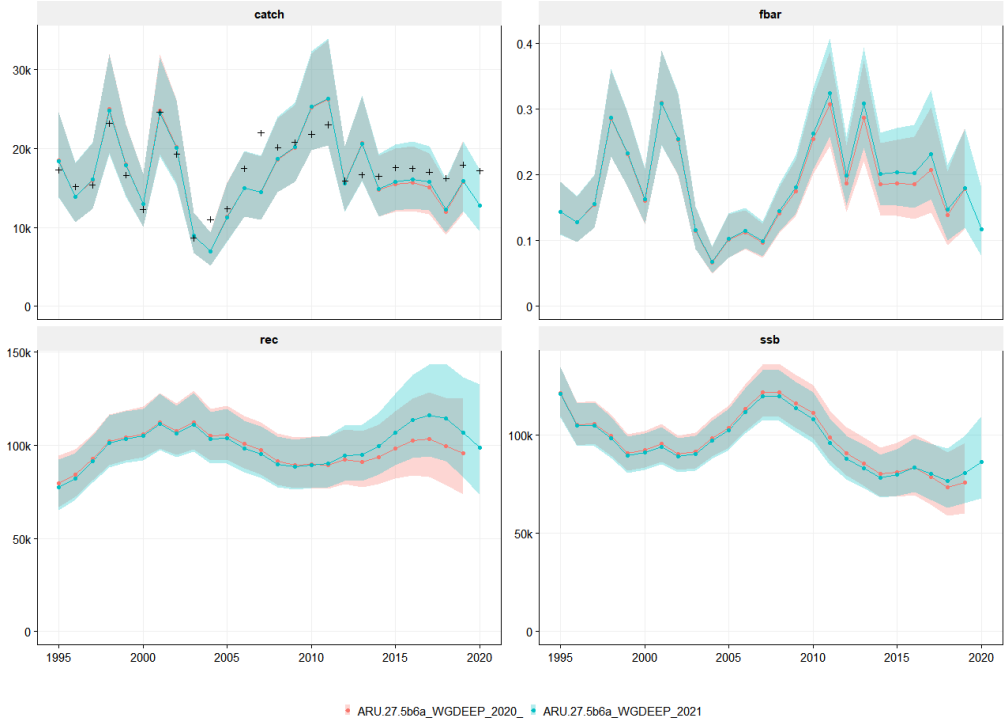


Figure 6.4.20. Greater silver smelt in 5.b and 6.a. Results from the SAM assessment. Catch, tonnes (upper left), fishing mortality (upper right), recruitment (lower left) and SSB (lower right).

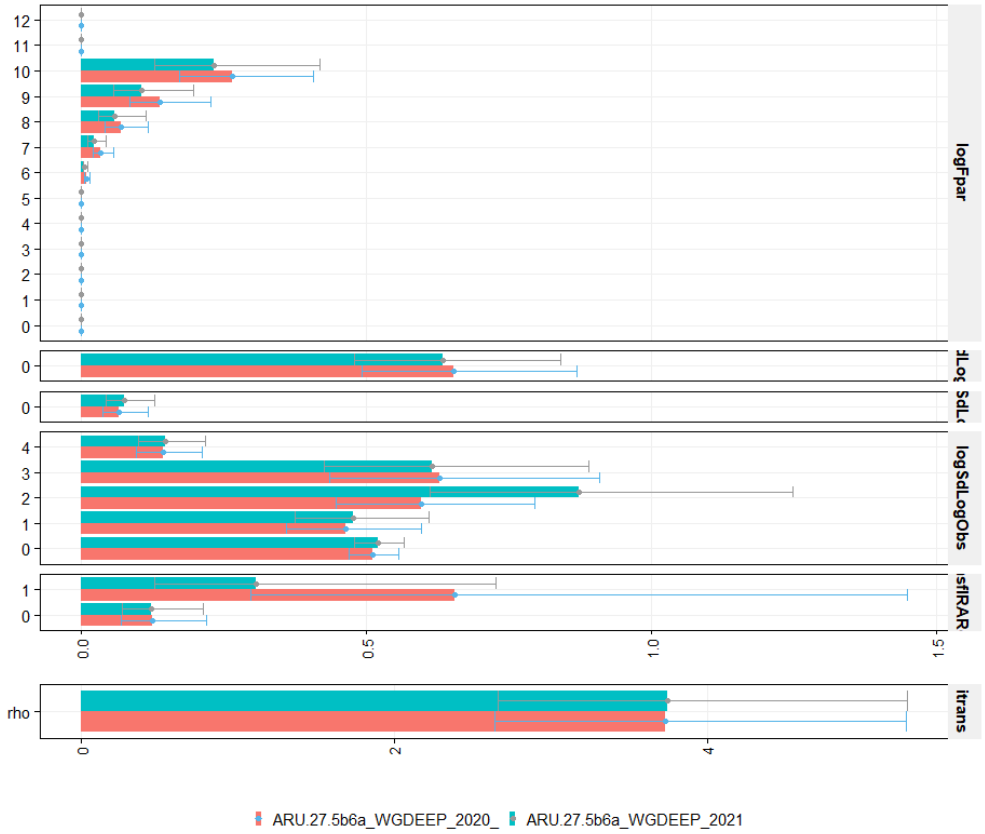


Figure 6.4.21. Greater silver smelt in 5.b and 6.a. Comparison of parameter estimates of WGDEEP 2020 (red) and WGDEEP 2021 (green).

6.4.6 Quality of the assessment

The assessment of greater silver smelt was benchmarked in 2020 (ICES, 2021), where the assessment was moved from a trend-based assessment derived from the Faroese summer survey to a SAM state-space assessment using catch at age information and four indices. A comparison between the assessments of WGDEEP 2020 and WGDEEP 2021 indicates that the model results are largely comparable, although both F and recruitment are estimated somewhat higher than in the 2021 assessment (Figure 6.4.20).

Catch at age information from the period 1995-2004 is derived from the Faroese catch at age sampling raised to the total catch, while the catch at age 2005 to present is derived from InterCatch raising based on Faroese and Netherland catch at age data.

During the 2021 assessment of this stock, we noticed that there was a substantial discrepancy between the calculated catch in tonnes from InterCatch and the SAM estimated catch in tonnes. The discrepancy mostly occurred in the period 2015 to present. 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 is shown in Figure 6.4.22 (both in tonnes and in proportion). This explains part of the discrepancy between observed catch and modelled catch, but still a noticeable discrepancy remains. This could potentially be due to a mis-match between the catch at age information from InterCatch and the SAM model configuration which should be further explored before next WGDEEP.

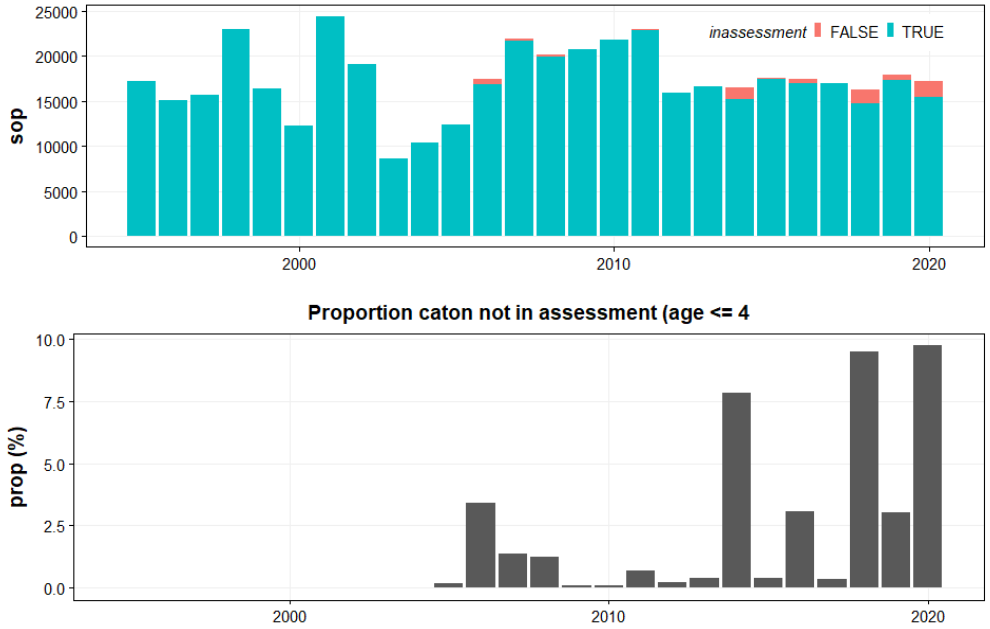


Figure 6.4.22. Greater silver smelt in 5.b and 6.a. Proportion of catch in tonnes available in InterCatch (ages 2-4) that is not included in the assessment.

During the benchmark of greater silver smelt, the method for deriving the survey index at age in the Faroese deepwater survey was based on a GLM approach that involves re-estimating all values for all years every time that the GLM is being run. In the meantime, a new ALK program has been developed and tested by the Faroe Marine Research Institute that allows for annual estimates of abundance at age, without the need to re-estimate all previous years. A comparison between the abundance at age from the GLM and the ALK approach has been carried out during WGDEEP 2021 (Figure 6.4.23, stockassessment.org: ARU.27.5b6a_WGDEEP_2021 and ARU.27.5b6a_WGDEEP_2021_DWalk) and found that there was no discernible difference. Therefore, the WGDEEP 2021 approved that the ALK method will be used to generate catch number at age from the Faroese deepwater survey from WGDEEP 2022 onwards, and the stock annex will be updated correspondingly.

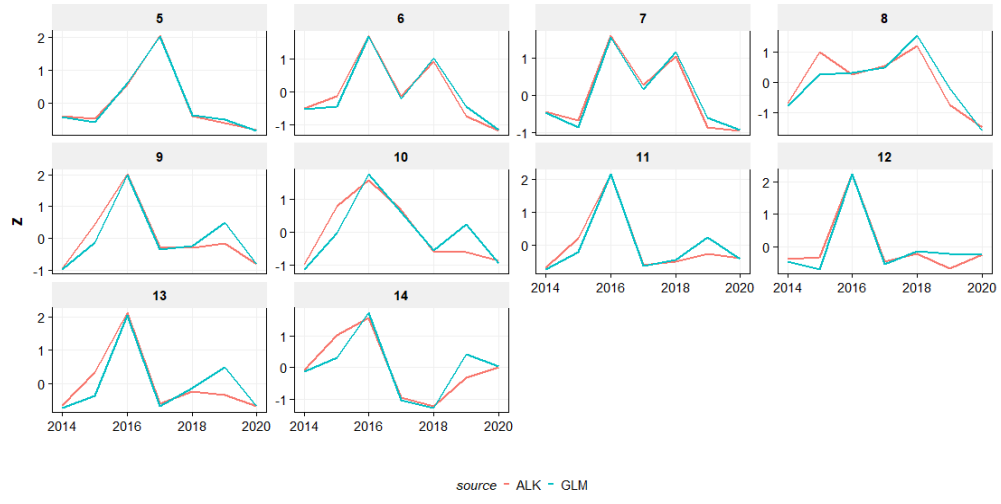


Figure 6.4.23. Greater silver smelt in 5.b and 6.a. Comparison between the estimated catch number of age from the Faroese deepwater survey. Red line- numbers from ALK-program and blue line- numbers when using GLM.

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. Ideally, this discrepancy would have been resolved prior to the provision of advice, but because this is not feasible in a very short time, the WG decided to put forward two different short term forecasts, based on either:

- A status quo fishing mortality at F = 0.117, which results in a catch of 13 337 tonnes in 2021 (as agreed on WKGSS, ICES, 2021).
- A catch constraint of 17 141 tonnes in 2021, which results in a F = 0.16.

Both options are presented on the final run on Stockassessment.org (SAO) (ARU.27.5b6a_WGDEEP_2021) and in Tables 6.4.16, 6.4.17.

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 maintained at F=0.20 (Table 6.4.18).

6.4.9 Management considerations

In Faroese waters, the greater silver smelt fishery is managed by Faroese authorities. The quota of greater silver smelt in the Faroese EEZ has been reduced from 16 000 tonnes (for 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. After the entering into effect of the EU-UK separation agreement ("Brexit"), no agreement has been reached so far (April 2021) between EU and UK on the 2021 quota for shared stocks, including the greater silver smelt stock.

There has never been an agreement between the Faroe Islands and EU on the setting of an overall TAC for greater silver smelt in 5.b and 6.a. The sum of the quotas of the Faroe Islands and EU has exceeded the scientific ICES advice from 2016 onwards (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. Pending the outcome of these analyses, an Interbenchmark could be carried out for this stock to implement potentially identified solutions after a

thorough discussion during WGDEEP 2022 but prior to final advice in 2022. 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.

6.4.11 Tables

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

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

Division 5.b														TOTAL
Year	**Den-mark**	**Faroes**	**France**	**Germany**	**Greenland**	**Iceland**	**Ireland**	**Netherlands**	**Norway**	**Poland**	**UK(E&W)**	**UK (Scot)**	**Russia**	
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
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

***preliminary data**

Table 6.4.1 (Continued).

Division 6.a														Total
Year	**Den-mark**	**Faroes**	**France**	**Germany**	**Ireland**	**Lithuania**	**Netherlands**	**Norway**	**Poland**	**UK (E&W)**	**UK (Scot)**	**Russia**	**Spain**	
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

Division 6.a Year	Den-mark	Faroes	France	Germany	Ireland	Lithuania	Netherlands	Norway	Poland	UK (E&W)	UK (Scot)	Russia	Spain	Total
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
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

***preliminary data**

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

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
1995	12286	4938	17224			17224
1996	9498	5632	15130			15130
1997	8433	7269	15702			15327
1998	17570	5556	23126			23135
1999	8229	8223	16452			16614
2000	5209	6989	12198			12245
2001	10081	14466	24547			24546
2002	7471	11766	19237			19226
2003	6558	2039	8597			8623
2004	5310	5059	10369			10997
2005	7013	5634	12647			12606
2006	12559	4897	17456			17699
2007	14126	7817	21943			23035
2008	14952	5160	20112			20142
2009	14228	6651	20879			21007
2010	15609	6237	21846			21846
2011	15586	6709	22295			22969
2012	9854	5115	14969			16432
2013	11223	5445	16668			16618
2014	10196	5467	15663	28	1553	17244
2015	13312	4236	17548		270	17818
2016	11547	4773	16320	12	1651	17993

Year	5.b	6.a	Total Landings	Discard 5.b	Discard 6.a	Total catches
2017	9496	7310	16806	31	239	17076
2018	10265	5769	16033	2	185	16220
2019	9287	8626	17913		86	17916
2020*	8438	8576	17014	0	127	17141

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	*	*	

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.

*** No current agreement on quotas available between EU and UK (April2021).**

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.

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

Table 6.4.5. Greater silver smelt in 5.b and 6.a. Catch numbers at age (*1000) used in the assessment (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
1995	12	76	222	851	2459	2534	2610	3036	3361	3086	2264	1765	1502	880	728	370	1005
1996	73	267	593	1747	3435	3999	3278	4201	2145	3055	1708	1258	986	952	373	167	148
1997	306	1205	1358	1828	3246	3969	3023	2843	2010	2058	1524	1569	1803	725	603	233	423
1998	1696	2688	2911	5015	3542	3443	3418	3155	2996	3174	2065	2212	1853	1303	1251	1053	2228
1999	1282	2416	3070	3891	3932	4710	4551	3674	3144	2021	802	1351	883	681	425	203	772
2000	544	2603	2780	4026	2355	2819	2293	1499	1736	1086	1562	324	368	679	557	61	317
2001	1472	5606	8333	9983	10595	4920	3714	2646	2498	2420	1196	1178	1001	241	383	323	692
2002	2468	6843	6436	8571	7810	4590	3682	3302	1802	1144	1102	487	355	318	299	107	132
2003	13	195	1397	3127	5149	3458	2093	1924	849	822	148	112	458	255	83	-1	193
2004	189	614	2097	4678	7288	5109	3016	1750	925	869	268	37	28	34	3	-1	34
2005	1369	2042	3643	4388	5007	5959	3795	1608	1180	506	1795	131	35	51	-1	-1	43
2006	5299	4377	5040	9345	6286	5454	3613	1819	1030	747	1425	57	244	99	66	-1	-1
2007	2896	6064	9147	9561	10031	6435	4865	2695	1110	495	771	84	100	39	-1	30	-1
2008	2571	4011	5955	6882	6928	7314	4738	3294	2475	1370	951	493	166	302	427	97	387
2009	948	2722	3810	6031	6586	5334	5115	4101	4409	2767	2345	974	642	254	375	168	657
2010	272	3599	4722	4665	3586	4561	3293	4695	4037	3234	2375	1719	1235	1095	752	484	2275
2011	1328	2319	5104	6500	5439	6604	4779	4092	4776	3041	1740	1328	1196	972	461	458	836

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
2012	503	1576	3595	6732	6044	4432	4266	2547	1862	1491	962	492	255	242	138	504	154
2013	526	3631	3846	4651	7141	4342	3533	2263	2174	1610	1227	884	876	532	501	563	517
2014	2225	3731	6778	6517	6540	5390	3023	1298	919	1046	637	301	101	229	180	143	487
2015	1666	4151	5676	9401	7438	7057	4023	2064	1483	736	624	362	182	227	121	96	181
2016	2360	4656	6133	6351	8134	6084	4118	1609	1042	1376	286	198	243	215	220	49	441
2017	781	1331	4326	7605	8074	7851	7174	3177	1070	955	491	528	263	382	175	184	148
2018	6161	8981	7209	6314	5866	4968	3709	1540	457	667	130	190	189	67	122	-1	-1
2019	4470	6850	9164	9783	6932	9077	3233	1881	1189	894	270	492	145	112	212	82	186
2020	7904	8313	4481	5775	6887	4119	4942	2146	1524	624	389	235	208	125	8	11	77

Table 6.4.6. Greater silver smelt in 5.b and 6.a. Mean weight at age used in the assessment (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
1995	0.225	0.268	0.312	0.358	0.392	0.435	0.503	0.553	0.638	0.681	0.751	0.830	0.906	0.968	1.013	1.060	0.982
1996	0.194	0.249	0.289	0.334	0.359	0.409	0.470	0.512	0.608	0.643	0.711	0.764	0.860	0.891	0.946	0.994	1.015
1997	0.198	0.256	0.309	0.355	0.383	0.438	0.489	0.538	0.614	0.656	0.715	0.739	0.848	0.875	0.952	0.969	1.003
1998	0.189	0.245	0.295	0.354	0.373	0.428	0.477	0.517	0.588	0.634	0.674	0.687	0.818	0.824	0.923	0.932	0.968
1999	0.192	0.244	0.301	0.350	0.382	0.431	0.488	0.533	0.601	0.652	0.712	0.730	0.829	0.830	0.917	0.917	0.912
2000	0.243	0.262	0.313	0.353	0.395	0.448	0.501	0.546	0.592	0.655	0.724	0.736	0.839	0.767	0.915	0.843	0.918
2001	0.214	0.250	0.298	0.345	0.383	0.429	0.492	0.535	0.602	0.653	0.709	0.746	0.858	0.867	0.948	0.943	0.966

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
2002	0.215	0.254	0.303	0.344	0.378	0.431	0.490	0.545	0.610	0.672	0.717	0.744	0.847	0.863	0.957	0.962	1.007
2003	0.239	0.273	0.318	0.353	0.384	0.432	0.490	0.533	0.592	0.649	0.700	0.713	0.823	0.812	0.900	0.866	0.963
2004	0.212	0.255	0.294	0.339	0.378	0.423	0.496	0.550	0.579	0.694	0.687	0.736	0.757	0.728	0.793	0.807	0.802
2005	0.221	0.273	0.309	0.316	0.376	0.394	0.440	0.484	0.542	0.509	0.647	0.780	0.595	0.923	-1	-1	0.808
2006	0.244	0.293	0.321	0.346	0.364	0.412	0.469	0.500	0.577	0.609	0.604	0.768	0.762	0.784	1.046	-1	-1
2007	0.279	0.317	0.351	0.367	0.400	0.457	0.473	0.489	0.581	0.637	0.648	0.741	0.698	0.636	-1	0.910	-1
2008	0.259	0.303	0.353	0.365	0.370	0.418	0.449	0.500	0.533	0.611	0.584	0.683	0.642	0.617	0.646	0.655	0.738
2009	0.251	0.314	0.339	0.379	0.378	0.423	0.423	0.464	0.524	0.555	0.589	0.656	0.656	0.584	0.654	0.622	0.674
2010	0.203	0.309	0.377	0.368	0.401	0.430	0.499	0.473	0.495	0.516	0.558	0.624	0.592	0.582	0.613	0.586	0.724
2011	0.220	0.272	0.348	0.375	0.410	0.439	0.452	0.503	0.486	0.546	0.568	0.569	0.667	0.610	0.670	0.634	0.730
2012	0.252	0.301	0.339	0.371	0.402	0.428	0.480	0.524	0.542	0.574	0.640	0.710	0.731	0.859	0.697	0.781	0.771
2013	0.221	0.296	0.342	0.354	0.380	0.420	0.432	0.493	0.500	0.541	0.595	0.567	0.620	0.668	0.706	0.731	0.693
2014	0.231	0.289	0.330	0.350	0.383	0.400	0.434	0.493	0.528	0.562	0.588	0.673	0.694	0.761	0.571	0.639	0.682
2015	0.235	0.271	0.293	0.335	0.373	0.413	0.439	0.515	0.565	0.647	0.636	0.729	0.700	0.788	0.861	0.779	0.845
2016	0.236	0.293	0.329	0.338	0.371	0.411	0.445	0.461	0.605	0.622	0.711	0.719	0.811	0.642	0.905	0.652	0.736
2017	0.239	0.256	0.298	0.333	0.361	0.385	0.396	0.415	0.507	0.479	0.657	0.697	0.632	0.641	0.787	0.773	0.802
2018	0.226	0.250	0.267	0.292	0.352	0.363	0.420	0.503	0.492	0.566	0.424	0.675	0.781	0.666	0.804	-1	-1
2019	0.222	0.252	0.297	0.301	0.326	0.335	0.355	0.407	0.427	0.464	0.495	0.534	0.512	0.438	0.589	0.576	0.808

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
2020	0.237	0.267	0.288	0.314	0.317	0.366	0.401	0.420	0.463	0.488	0.530	0.715	0.677	0.771	0.877	0.859	0.919

Table 6.4.7. Greater silver smelt 5.b and 6a. Maturity proportion by age used in the assessment for greater silver smelt .

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
Prop mature	0.13	0.29	0.52	0.75	0.89	0.96	0.98	0.99	1	1	1	1	1	1	1	1	1

Table 6.4.8. Greater silver smelt in 5.b and 6.a. Summer survey input to tuning series in the assessment (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year	Effort/Age	5	6	7	8	9	10	11	12
1998	0.2	4.317	2.435	1.336	1.033	0.832	0.672	0.339	0.242
1999	0.2	3.556	2.281	1.446	1.310	1.250	1.120	0.735	0.551
2000	0.2	3.828	1.909	1.393	0.969	0.902	0.805	0.483	0.354
2001	0.2	5.236	3.559	2.256	2.024	1.758	1.367	0.782	0.504
2002	0.2	2.778	1.863	1.107	0.951	0.806	0.603	0.325	0.209
2003	0.2	2.795	1.875	1.323	1.303	1.192	0.970	0.555	0.346
2004	0.2	3.352	2.446	1.680	1.556	1.453	1.234	0.806	0.569
2005	0.2	2.103	1.245	0.919	0.894	0.866	0.786	0.507	0.354
2006	0.2	1.234	1.002	0.664	1.500	1.080	2.775	0.607	0.515
2007	0.2	1.779	0.933	0.595	0.516	0.607	0.433	0.220	0.142
2008	0.2	2.713	1.834	1.378	1.475	1.469	1.318	0.914	0.645
2009	0.2	2.727	1.869	1.717	1.838	2.040	2.160	1.783	1.495

Year	Effort/Age	5	6	7	8	9	10	11	12
2010	0.2	2.662	1.521	1.183	1.216	1.288	1.298	0.965	0.789
2011	0.2	3.370	2.084	1.492	1.451	1.777	1.455	0.811	0.570
2012	0.2	1.927	1.355	1.269	1.370	1.469	1.437	1.064	0.843
2013	0.2	2.559	1.489	0.795	0.669	0.564	0.440	0.271	0.209
2014	0.2	1.336	0.952	0.816	0.821	0.806	0.671	0.436	0.310
2015	0.2	2.727	1.614	1.353	1.387	1.370	1.228	0.752	0.524
2016	0.2	3.571	2.184	1.387	1.416	1.470	1.379	0.983	0.805
2017	0.2	2.990	2.001	1.207	1.010	0.853	0.699	0.446	0.372
2018	0.2	1.245	1.046	0.934	0.943	0.870	0.717	0.452	0.314
2019	0.2	1.220	1.007	0.805	0.803	0.708	0.566	0.332	0.215
2020	0.2	2.380	2.910	2.870	2.909	2.548	1.996	1.246	0.738

Table 6.4.9. Greater silver smelt in 5.b and 6.a. Deepwater survey input to tuning series in the assessment (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year	Effort/Age	5	6	7	8	9	10	11	12	13	14
2014	0.110	50.90	128.50	243.10	258.50	202.40	260.80	148.10	181.50	124.40	142.80
2015	0.078	22.80	103.70	94.00	346.00	391.90	360.40	222.20	100.40	114.20	131.00
2016	0.073	110.80	358.00	547.20	332.90	943.60	601.80	697.30	412.30	265.50	208.10
2017	0.073	216.40	126.80	282.50	357.20	307.40	430.80	116.80	111.80	85.70	40.70
2018	0.038	19.40	144.70	245.80	268.50	174.70	135.10	80.50	80.60	63.10	13.70

Year	Effort/Age	5	6	7	8	9	10	11	12	13	14
2019	0.052	19.70	68.20	96.10	182.70	380.20	268.10	213.20	103.90	116.60	91.40
2020	0.031	1.20	4.20	31.40	21.10	75.20	84.90	69.90	60.70	36.40	44.50

Table 6.4.10. Greater silver smelt in 5.b and 6.a. Index from the Scottish deepwater survey and CPUE from the combined Faroe- EU standardized CPUE used as input to tuning series in the assessment (ARU _27.5b6a_WGDEEP2021 @ stock-assessment.org).

Year	Scottish deepwater survey	Combined Faroe-EU CPUE
1998	0.68	
1999	-1	
2000	1.88	
2001	-1	
2002	2.44	
2003	-1	
2004	1.4	
2005	0.65	15.5
2006	0.54	18.3
2007	0.9	17
2008	0.82	22.3
2009	0.84	24.3
2010	-1	20.9
2011	0.47	20.8
2012	0.23	16.2
2013	0.58	14.9
2014	-1	12.9
2015	0.51	16.1
2016	-1	14.1
2017	1.3	14
2018	-1	16.9
2019	1.75	16.8
2020	-1	18.7

Table 6.4.11. Greater silver smelt in 5.b and 6.a. Model configuration with 23 parameters.

$minAge	5
$maxAge	21
$maxAgePlusGroup	1 0 0 0 0
$keyLogFsta	
catch	0 1 2 3 4 6 5 5 5 5 5 5 5 5 5 5 5
Faroese summer surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese deepw surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Scottish deepw surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese/EU CPUE	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$corFlag	2
$keyLogFpar	
catch	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese summer surv	0 1 2 3 4 5 5 5 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese deepw surv	6 7 8 9 10 10 10 10 10 10 -1 -1 -1 -1 -1 -1 -1
Scottish deepw surv	11 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese/EU CPUE	12 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyQpow	All -1
$keyVarF	
catch	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Faroese summer surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese deepw surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Scottish deepw surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese/EU CPUE	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyVarLogN	0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
$keyVarObs	
catch	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Faroese summer surv	1 1 1 1 1 1 1 1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese deepw surv	2 2 2 2 2 2 2 2 2 2 2 -1 -1 -1 -1 -1 -1
Scottish deepw surv	3 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese/EU CPUE	4 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$obsCorStruct	"ID" "AR" "AR" "ID" "ID"
$keyCorObs	
catch	NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
Faroese summer surv	0 0 0 0 0 0 0 0 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese deepw surv	1 1 1 1 1 1 1 1 1 -1 -1 -1 -1 -1 -1 -1 -1
Scottish deepw surv	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
Faroese/EU CPUE	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$stockRecruitmentModelCode	0
$noScaledYears	0
$keyScaledYears	
$keyParScaledYA	
$fbarRange	6-14
$keyBiomassTreat	-1 -1 -1 5 5
$obsLikelihoodFlag	"LN" "LN" "LN" "LN" "LN"
$fixVarToWeight	0
$fracMixF	0
$fracMixN	0
$fracMixObs	0 0 0 0 0
$constRecBreaks	

Table 6.4.12. Greater silver smelt in 5.b and 6.a. Model parameter estimates (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_0	-8.901	0.111	0	0	0
logFpar_1	-9.116	0.11	0	0	0
logFpar_2	-9.221	0.11	0	0	0
logFpar_3	-8.968	0.11	0	0	0
logFpar_4	-8.693	0.111	0	0	0
logFpar_5	-8.419	0.112	0	0	0

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_6	-5.117	0.34	0.006	0.003	0.012
logFpar_7	-3.788	0.333	0.023	0.012	0.044
logFpar_8	-2.829	0.324	0.059	0.031	0.113
logFpar_9	-2.25	0.31	0.105	0.057	0.196
logFpar_10	-1.458	0.294	0.233	0.129	0.419
logFpar_11	-12.115	0.165	0	0	0
logFpar_12	-9.076	0.069	0	0	0
logSdLogFsta_0	-0.455	0.14	0.635	0.479	0.84
logSdLogN_0	-2.59	0.273	0.075	0.043	0.129
logSdLogObs_0	-0.652	0.042	0.521	0.48	0.567
logSdLogObs_1	-0.74	0.122	0.477	0.374	0.609
logSdLogObs_2	-0.135	0.178	0.873	0.612	1.247
logSdLogObs_3	-0.485	0.184	0.615	0.426	0.889
logSdLogObs_4	-1.912	0.194	0.148	0.1	0.218
transfIRARdist_0	-2.093	0.277	0.123	0.071	0.214
transfIRARdist_1	-1.181	0.432	0.307	0.13	0.728
itrans_rho_0	1.322	0.171	3.75	2.663	5.28

Table 6.4.13. Greater silver smelt in 5.b and 6.a. Assessment summary. Weights are in tonnes, recruitment in thousands (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year	$R_{(age\ 5)}$	Low	High	SSB	Low	High	$Fbar_{(6-14)}$	Low	High	TSB	Low	High
1995	77583	65291	92189	121184	109013	134715	0.144	0.109	0.19	159874	145163	176076
1996	82306	70641	95897	104863	94417	116466	0.128	0.098	0.167	142610	129506	157039
1997	91525	79870	104880	105074	94561	116755	0.155	0.12	0.201	147965	134315	163003
1998	101307	88310	116216	98523	88671	109471	0.287	0.227	0.361	143650	130508	158115
1999	103466	90680	118054	89603	80943	99191	0.232	0.182	0.296	137673	125262	151313
2000	104892	92011	119575	91237	82452	100957	0.162	0.126	0.21	147604	134243	162294
2001	111408	97320	127535	94185	85094	104247	0.309	0.245	0.389	148969	135441	163849
2002	106435	93456	121217	89408	81111	98554	0.254	0.2	0.324	144337	131336	158625
2003	111213	96565	128083	90504	82080	99794	0.115	0.087	0.152	150554	136575	165965
2004	103186	90245	117983	97360	88205	107465	0.068	0.051	0.09	152946	138775	168564
2005	103800	90278	119349	102479	92689	113304	0.102	0.074	0.141	159922	144852	176559
2006	98387	85440	113297	111861	100962	123937	0.115	0.088	0.15	171446	155111	189501
2007	95527	82717	110321	119958	107872	133399	0.099	0.076	0.129	182548	164655	202385
2008	89926	77329	104574	119777	107547	133398	0.145	0.113	0.186	176489	158916	196005
2009	88597	76125	103113	113796	101691	127343	0.18	0.142	0.23	168098	150635	187585
2010	89528	77006	104087	108392	96262	122049	0.263	0.209	0.331	159293	141912	178802
2011	90303	77528	105182	96152	84993	108776	0.324	0.257	0.407	145706	129252	164254

Year	$R_{(age\ 5)}$	Low	High	SSB	Low	High	$Fbar_{(6-14)}$	Low	High	TSB	Low	High
2012	94593	81003	110463	87900	77538	99647	0.199	0.153	0.258	142020	125625	160555
2013	94749	80790	111121	83431	73136	95177	0.308	0.241	0.394	135851	119481	154464
2014	99501	84285	117464	78567	68406	90238	0.201	0.153	0.263	132324	115571	151505
2015	106770	89461	127429	80111	69002	93009	0.204	0.153	0.271	134039	116052	154813
2016	113376	93405	137617	83731	71190	98481	0.203	0.149	0.276	143218	122580	167332
2017	116219	94177	143419	80323	67281	95893	0.232	0.163	0.329	139124	117509	164715
2018	114505	91295	143616	76855	63169	93507	0.147	0.1	0.214	133613	111100	160689
2019	106631	83169	136713	80955	65611	99887	0.18	0.12	0.269	136950	112283	167036
2020	98685	73419	132645	86361	68001	109679	0.117	0.077	0.18	140914	112800	176036

Table 6.4.14. Greater silver smelt in 5.b and 6.a. Estimated fishing mortality at age (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
1995	0.000	0.002	0.006	0.025	0.073	0.133	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263	0.263
1996	0.001	0.005	0.013	0.039	0.083	0.127	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
1997	0.003	0.014	0.027	0.062	0.105	0.150	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259
1998	0.010	0.036	0.063	0.128	0.186	0.246	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480
1999	0.009	0.034	0.059	0.114	0.158	0.211	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379
2000	0.007	0.028	0.050	0.089	0.119	0.159	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254
2001	0.013	0.056	0.111	0.193	0.257	0.312	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462	0.462

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
2002	0.010	0.043	0.104	0.185	0.251	0.270	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359
2003	0.001	0.005	0.021	0.060	0.116	0.182	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
2004	0.002	0.009	0.026	0.058	0.089	0.132	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074
2005	0.009	0.025	0.050	0.090	0.115	0.231	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102
2006	0.024	0.057	0.090	0.123	0.146	0.176	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
2007	0.027	0.066	0.101	0.122	0.125	0.130	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087
2008	0.022	0.061	0.102	0.138	0.157	0.196	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163
2009	0.013	0.043	0.083	0.133	0.175	0.215	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
2010	0.009	0.036	0.082	0.145	0.213	0.309	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395
2011	0.011	0.043	0.100	0.191	0.276	0.403	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475
2012	0.007	0.028	0.065	0.128	0.189	0.272	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277
2013	0.010	0.038	0.083	0.162	0.275	0.421	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448	0.448
2014	0.016	0.049	0.092	0.150	0.206	0.272	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260
2015	0.018	0.052	0.099	0.164	0.225	0.271	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256
2016	0.019	0.046	0.088	0.153	0.220	0.293	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256
2017	0.014	0.032	0.066	0.133	0.229	0.360	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316
2018	0.034	0.060	0.084	0.124	0.161	0.209	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
2019	0.050	0.079	0.104	0.154	0.202	0.251	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
2020	0.063	0.083	0.084	0.114	0.138	0.157	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120

Table 6.4.15. Greater silver smelt in 5.b and 6.a. Estimated stock numbers at age (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
1995	77583	56980	44508	39597	37333	28411	24284	18629	18294	15184	8840	7001	6925	3251	2140	1191	2303
1996	82306	66754	48951	38072	33224	29860	21402	16064	12323	12101	10044	5848	4631	4581	2150	1416	2312
1997	91525	70770	57179	41606	31506	26307	22628	14758	11076	8497	8344	6926	4032	3193	3159	1483	2570
1998	101307	78519	60089	47906	33652	24405	19481	15027	9800	7356	5643	5541	4599	2678	2121	2098	2692
1999	103466	86363	65215	48551	36271	24053	16427	10375	8003	5219	3917	3005	2951	2449	1426	1129	2550
2000	104892	88218	71844	52900	37297	26661	16770	9682	6115	4717	3076	2309	1771	1739	1444	840	2169
2001	111408	89635	73823	58849	41663	28496	19570	11194	6463	4082	3148	2053	1541	1182	1161	964	2009
2002	106435	94675	72938	56853	41782	27729	17953	10613	6071	3505	2214	1707	1114	836	641	630	1612
2003	111213	90723	78041	56551	40689	27969	18211	10795	6381	3650	2107	1331	1027	670	503	385	1348
2004	103186	95621	77667	65800	45834	31196	20077	13306	7887	4662	2667	1540	972	750	489	367	1266
2005	103800	88604	81581	65152	53442	36083	23528	16052	10638	6306	3728	2132	1231	777	600	391	1306
2006	98387	88530	74362	66760	51231	41008	24650	18290	12478	8270	4902	2898	1657	957	604	466	1319
2007	95527	82644	72012	58472	50789	38086	29606	19011	14105	9623	6378	3780	2235	1278	738	466	1377
2008	89926	80062	66581	56003	44534	38596	28776	23365	15003	11132	7595	5033	2983	1764	1009	582	1455
2009	88597	75702	64811	51746	41982	32775	27308	21034	17079	10967	8137	5551	3679	2181	1289	737	1489

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+
2010	89528	75301	62395	51333	38985	30333	22761	18426	14193	11524	7400	5490	3746	2482	1471	870	1502
2011	90303	76402	62492	49468	38209	27127	19161	13201	10687	8231	6683	4292	3184	2172	1440	853	1376
2012	94593	76876	63007	48668	35158	24965	15597	10256	7066	5720	4406	3577	2297	1704	1163	771	1193
2013	94749	80825	64352	50830	36869	25052	16366	10176	6691	4610	3732	2875	2334	1499	1112	759	1281
2014	99501	80737	67006	50971	37194	24099	14160	8996	5593	3678	2534	2051	1580	1283	824	611	1121
2015	106770	84280	66180	52623	37775	26066	15796	9395	5969	3711	2440	1681	1361	1048	851	547	1150
2016	113376	90237	68898	51598	38458	25968	17101	10524	6260	3977	2473	1626	1120	907	699	567	1130
2017	116219	95777	74140	54300	38104	26568	16667	11389	7009	4169	2649	1647	1083	746	604	465	1130
2018	114505	98604	79825	59749	40917	26093	15946	10458	7146	4398	2616	1662	1033	679	468	379	1001
2019	106631	95275	79923	63163	45429	29975	18228	11576	7592	5188	3193	1899	1207	750	493	340	1002
2020	98685	87317	75788	62000	46629	31957	20065	12756	8101	5313	3630	2234	1329	844	525	345	939

Table 6.4.16. Greater silver smelt in 5.b and 6.a. Short term forecast with F_{sq} constraint in 2021 (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Intermediate year assumptions						
		Value	low	high		
TAC	2021	13337				
Advice	2021	7703				
F_{bar}	2021	0.117	0.077	0.178		
Catch	2021	13337	10132	16921		
Recruitment	2021-2023	106631	89528	116219		
SSB	2021	93047	72522	119450		
SSB	2022	95864	73681	123191		

Forecast options						
Scenario	**Catch**	**Fbar**	**SSB**	**%SSB change**	**% TAC change**	**%Advice change**
	2022	**2022**	**2023**			
F_{MSY}	22224	0.2	90010	-6	67	189
F=0	0	0	109016	14	-100	-100
F_{sq}	13581	0.117	97503	2	2	76
F_{lim}	30874	0.29	82978	-13	131	301
$F_{p0.5}$	34461	0.33	80007	-17	158	347
F=0.16	18146	0.16	93497	-2	36	136
F=0.241	26288	0.241	86780	-9	97	241

Table 6.4.17. Greater silver smelt in 5.b and 6.a. Short term forecast with catch constraint in (ARU _27.5b6a_WGDEEP2021 @ stockassessment.org).

Intermediate year assumptions				
		Value	low	high
TAC	2021	17141		
Advice	2021	7703		
F_{bar}	2021	0.16	0.105	0.242
Catch	2021	17141	13263	21415
Recruitment	2021-2023	106631	89528	116219
SSB	2021	89337	68527	115597
SSB	2022	88854	66383	116356

Forecast options						
Scenario	**Catch**	**Fbar**	**SSB**	**%SSB change**	**% TAC change**	**%Advice change**
	2022	**2022**	**2023**			
F_{MSY}	20811	0.2	84323	-5	21	170
F=0	0	0	101816	15	-100	-100
F_{sq}	12725	0.117	91012	2	-26	65
F_{lim}	28866	0.29	77692	-13	68	275
$F_{p0.5}$	32262	0.33	75000	-16	88	319
F=0.16	16997	0.16	87456	-2	-1	121
F=0.241	24585	0.241	81323	-8	43	219

Table 6.4.18. Greater silver smelt in 5.b and 6.a. Reference points, values, their technical basis and source.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	82 999	B_{pa}; in tonnes	(ICES, 2021a)
	F_{MSY}	0.2	Stochastic simulations (EqSim) with segmented regression fixed at B_{lim}	(ICES, 2021a)
Precautionary approach	B_{lim}	59 730	$B_{lim}=B_{pa}/(\exp(\sigma\times SSB\times 1.645),\sigma=0.2)$; in tonnes	(ICES, 2021a)
	B_{pa}	82 999	B_{loss}, lowest observed SSB (2014) from 2020 benchmark; in tonnes	(ICES, 2021a)
	F_{lim}	Not defined	F_{lim} was set to 0.29 at WKGSS which is below new F_{pa} based on F_{p05}. F_{pa} in WKGSS was set to 0.2.	
	F_{pa}	0.33	The F that provides a 95% probability for SSB to be above B_{lim} (F_{P05}).	(ICES, 2021a)

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

6.5.1 The fishery

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

6.5.2 Landing trends

Landings from this area are reported from 1966–2020. Landings increased until 2002 to 4662 tons then declined again to low levels of less than a ton in 2016. Landings from 2006 until 2019 have been less than 50 tons. However, the landings of 76 t in 2020 was the highest since 2005. The main landings have been from Subareas 6b and 7 where Ireland were 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 2019 advice for area 6b, 7, 8, 9, 10 and 12, stated "ICES advises that catches should be no more than 193 tonnes in each of the years 2020 and 2021. The precautionary approach is not applied for the advice given in 2019. 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 2020 and 2021 the EU TAC in Subareas 5, 6 and 7 are 3521 t and 881 t, respectively. 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 six last years are presented in Table 6.5.6. Discards from 2015 to 2019 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 has shifted, with Dutch landings of 62 t from Subarea 7.

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 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 *Argentinas* spp. from Porcupine survey since 2009 is presented in Figure 6.5.2.

Length distribution from discards are available in InterCatch for 2015 (Scotland), 2016 (Spain), 2017 (Spain and Scotland), 2018 (Spain and Scotland), 2019 (Spain) and 2020 (Scotland and Spain). For landings, length distributions are available from 2020 (Netherland). These length distributions have, for the time being, not been analysed.

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. However, *A.sphyraena* showed a single mode around 22 cm (Figure 6.5.2).

Commercial and survey cpue series

For Subarea 7, abundances and biomass indices from the Spanish porcupine survey have been showing a decreasing trend from 2002 until 2011 but have been rising since then until 2016 (Figure 6.5.4). The index has decreased for *A.silus* the last three years compared to 2016. 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 he 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.

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.

6.5.7 Assessment

The ICES framework for category 3 stocks was applied (ICES, 2012). 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 a comparison of the two latest index values (index A) with the three preceding values (index B), multiplied by recent advice and divided by the retention rate (1 – discard rate). The index is estimated to have decreased by 66% and thus the uncertainty cap was applied. The stock status relative to candidate reference points is unknown.

6.5.8 Comments on the assessment

Advice is given every second year for this stock and last advice applies for 2022 and 2023.

It should be noted that lesser silver smelt (*Argentina 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.

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 before increasing again in 2020.

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

6.5.11 Tables

Table 6.5.1. Greater Silver Smelt in 6.b. WG estimates of landings in tonnes. *landings in 2020 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

Year	Faroes	Germany	Ireland	Netherlands	Scotland	Russia	Spain	TOTAL
2001					62	68		130
2002					1	29		30
2003					6	120		126
2004				11		12		23
2005						4		4
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

Table 6.5.2. Greater Silver Smelt in 7. WG estimates of landings in tonnes. *landings in 2020 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

Year	France	Germany	Ireland	Netherlands	Scotland	Norway	Poland	Spain	UK E/W	TOTAL
1979		103								103
1980										
1981										
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

Year	France	Germany	Ireland	Netherlands	Scotland	Norway	Poland	Spain	UK E/W	TOTAL
2008										
2009	13		1					6		20
2010	10			8				2	3	23
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

Table 6.5.3. Greater Silver Smelt in 8. WG estimates of landings in tonnes. *landings in 2020 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

Year	Netherlands	Spain	Ireland	TOTAL
2016		0		0
2017		0		0
2018		3.9		3.9
2019		1.6	0.5	2.1
2020*		1.6		1.6

Table 6.5.4. Greater Silver Smelt 9. WG estimates of landings in tonnes. *landings in 2020 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

Table 6.5.5. Greater Silver Smelt 12. WG estimates of landings in tonnes. *landings in 2020 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
2016					0

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

Table 6.5.6. Discard data from 2015-2020 from Subarea 6b, 7-1012. *discards in 2020 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	2.9	97.9	1.8	0.8	10.3	114
2019	5	146	0.2	0.1	0.29	152
2020*	2	44.6	7.4	2.9	50	107

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

6.5.12 Figures

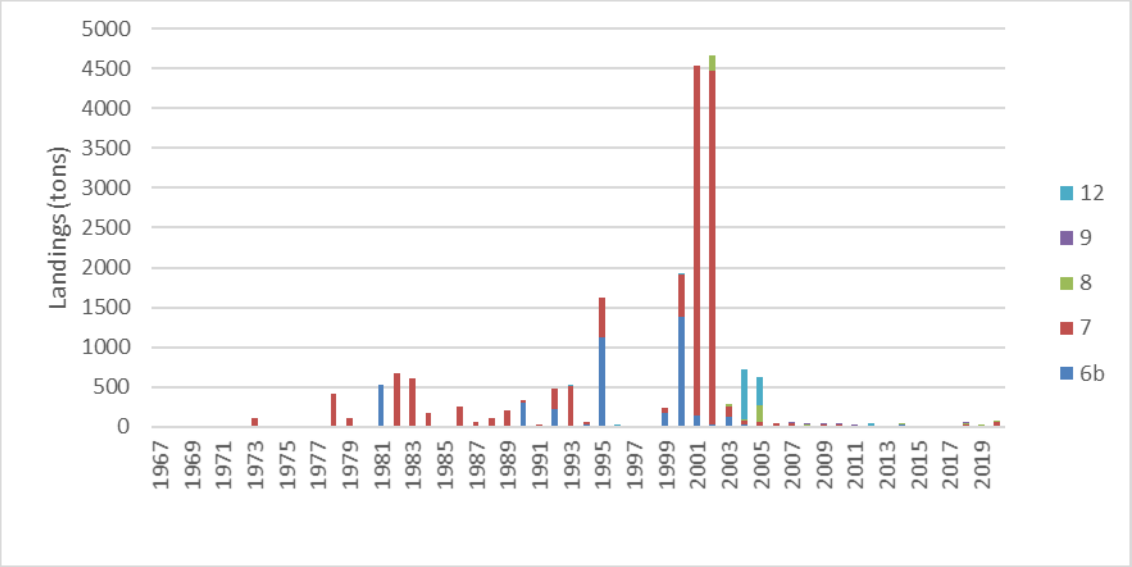


Figure 6.5.1. Total landings from 1966–2020 of greater silver smelt in 6.b, 7, 8, 9, 10 and 12.

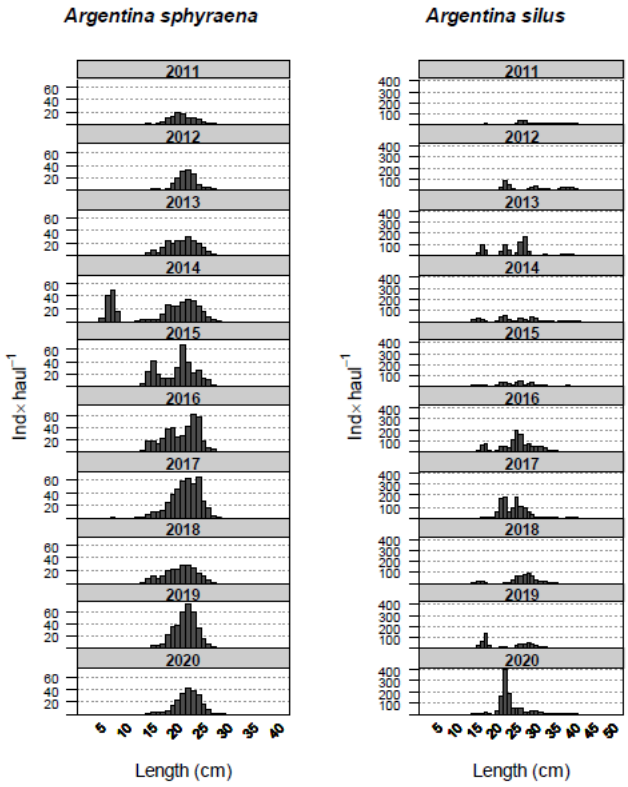


Figure 6.5.2. Mean stratified length distributions of *Argentina* spp. in Spanish Porcupine surveys from 2009–2020. Note different range in the y-axis values between species.

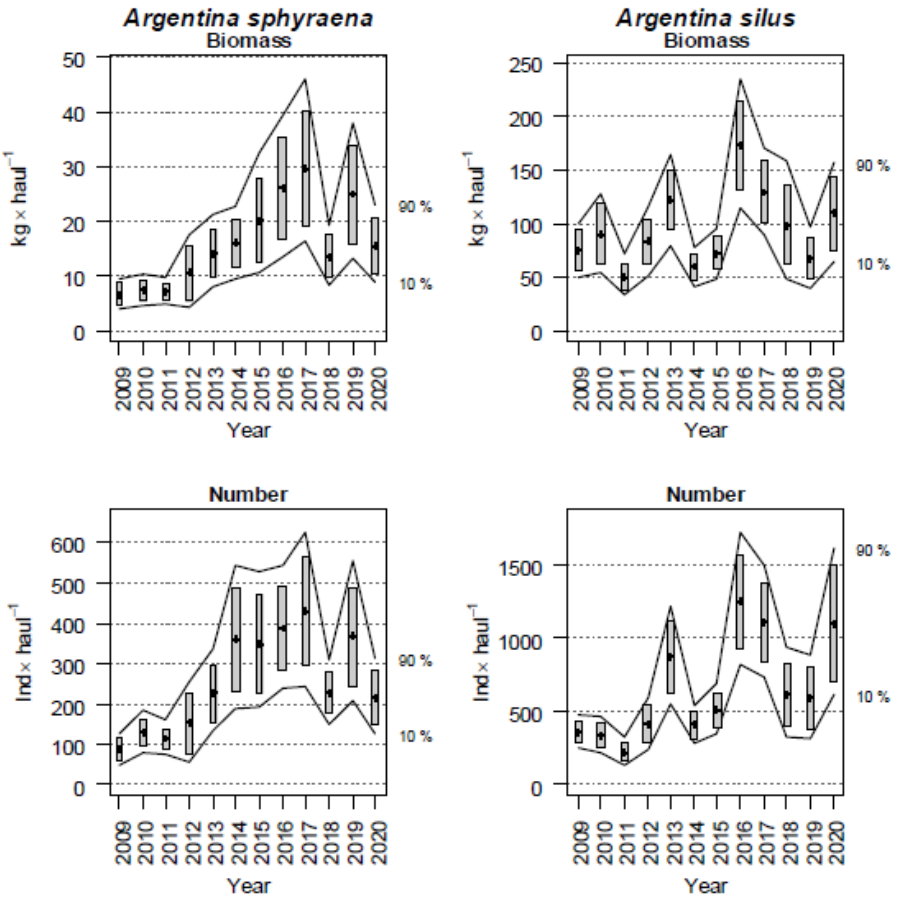


Figure 6.5.3. Evolution of *Argentina sphyraena* and *Argentina silus* biomass and abundance indices in Porcupine surveys (2009–2020). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a=0.80, bootstrap iterations=1000).

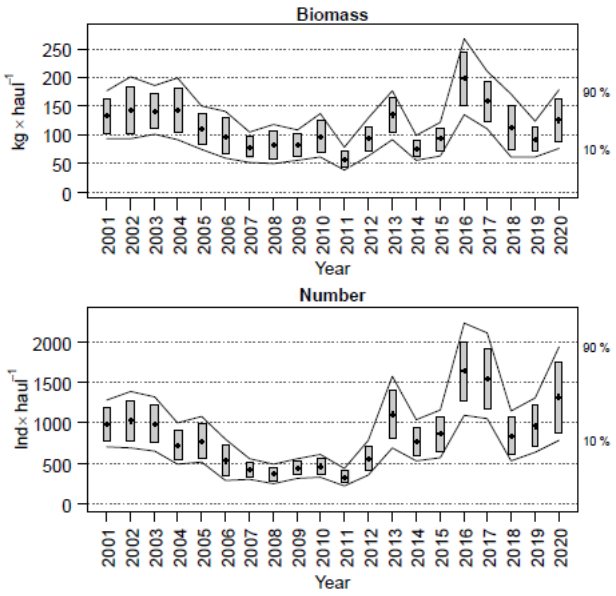


Figure 6.5.4. Evolution of *Argentina* spp. (mainly *Argentina silus*) biomass and abundance indices in Porcupine surveys (2001-2020). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000)

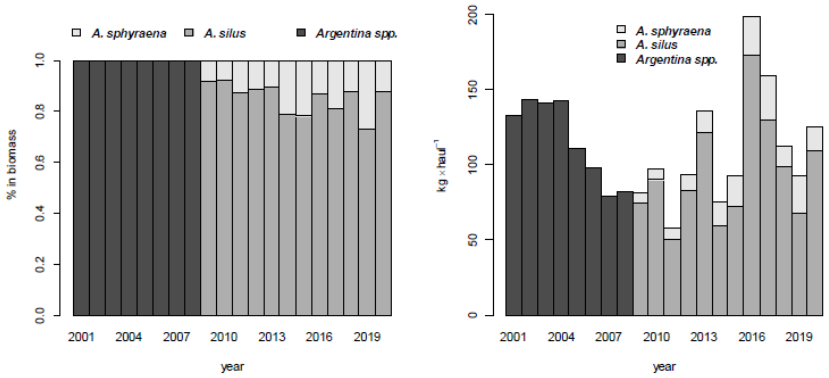


Figure 6.5.5. Share and abundance of *Argentine* species in Porcupine Bank surveys (2001–2020).

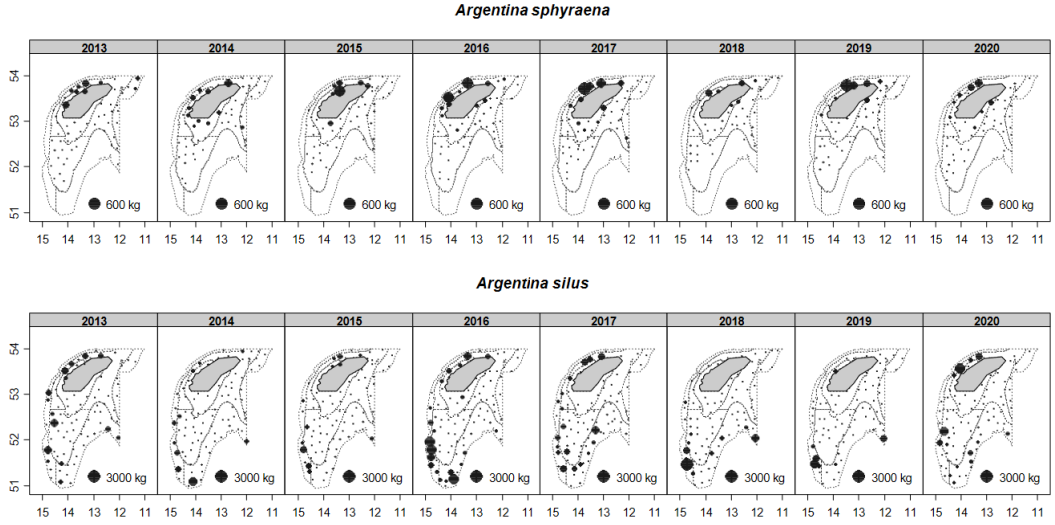


Figure 6.5.6. Geographic distribution of *Argentina sphyraena* and *Argentina silus* catches (kg/30 min haul) in Porcupine surveys (2013 - 2020)