GREATER SILVER SMELT

Argentina silus

GENERAL INFORMATION

Greater silver smelt is a rather small (<60 cm) silvery bathypelagic species that can form large schools close to the seafloor mainly at depths >500 m. In Icelandic waters it can live to around 26 years old. Juveniles tend to aggregate in shallower depths. Greater silver smelt mainly feed on zooplankton (e.g., euphausiids, amphipods, and copepods) or small nekton (e.g., squids, jellyfish, or fish).

THE FISHERY

LANDINGS TRENDS

Landings of greater silver smelt are presented in Table 1 and Figure 1. 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 2600 to 6700 t. Since 2008 landings have increased substantially, from 4200 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 Greenlandic and Icelandic waters. 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.

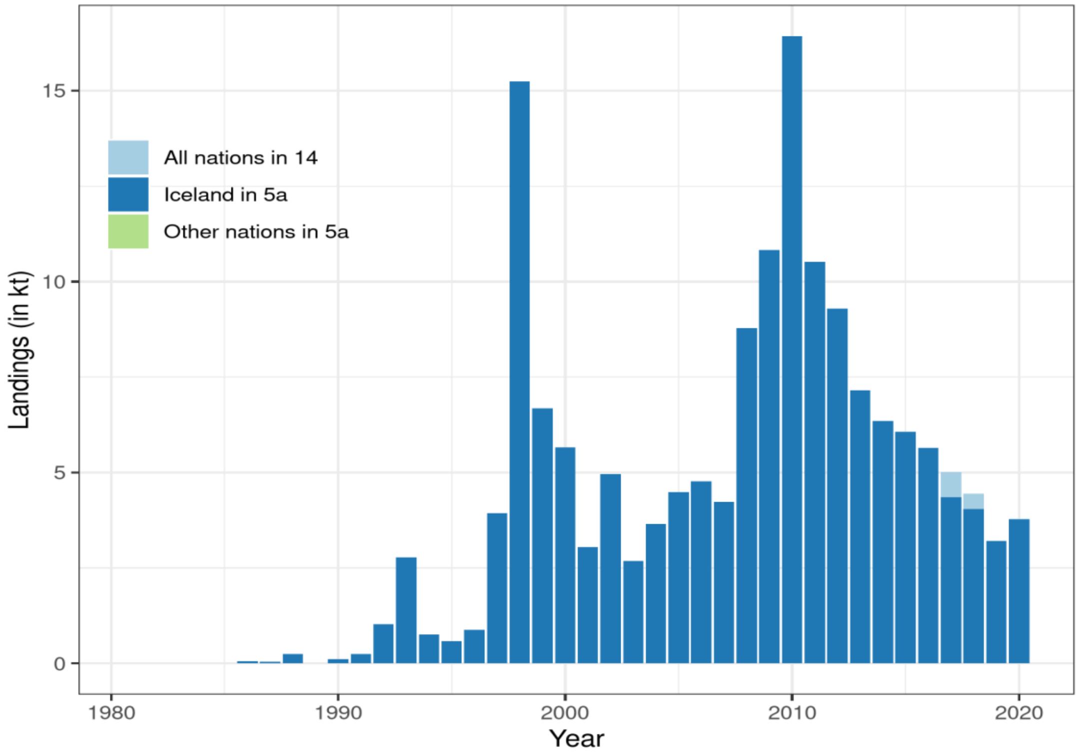

Figure 1. Greater silver smelt in Icelandic waters. Nominal landings. 23 tonnes were landed by foreign vessels (England and Wales) in 1999, which is the only year of catch reported by foreign vessels.

Table 1. Greater silver smelt in Icelandic waters. Information on the fleet reporting catches of greater silver smelt.

YEAR	NUMBER TRAWLERS	NUMBER HAULS	REPORTED CATCH (KG)	NO. HAULS WHICH GSS >50% OF CATCH	PROPORTION OF REPORTED CATCH IN HAULS WERE GSS >50%
1997	26	854	2257	384	**0,846**
1998	39	2587	11132	1968	**0,955**
1999	24	1451	4456	824	**0,865**
2000	23	1263	3491	643	**0,827**
2001	26	767	1577	255	**0,715**
2002	32	1134	3127	504	**0,777**
2003	30	1127	1965	253	**0,538**
2004	27	1017	2688	340	**0,705**
2005	30	1368	3520	361	**0,732**
2006	31	1542	3725	395	**0,715**
2007	26	1259	3440	461	**0,759**
2008	31	3143	8428	863	**0,663**
2009	34	3434	10233	1010	**0,694**
2010	36	4724	16280	1836	**0,740**
2011	34	3244	10155	973	**0,723**
2012	31	3334	9732	985	**0,713**
2013	31	2704	7192	618	**0,651**
2014	24	2336	6157	487	**0,614**
2015	24	1836	5312	334	**0,600**
2016	26	2090	5708	387	**0,596**
2017	21	1347	4344	241	**0.593**
2018	20	1424	3876	216	**0,481**
2019	28	1169	2570	143	**0,560**
2020	**25**	**1170**	**2968**	**174**	**0,475**

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 2). Greater silver smelt has been caught in bottom trawls for years as a bycatch in the redfish fishery. Only small amounts were reported prior to 1996 as most of the greater silver smelt was discarded. However, discarding is not considered significant because of the relatively large mesh size used in the redfish fishery. Since 1997, a directed fishery for greater silver smelt has been ongoing. This caused the landings to increase significantly in the past with the highest amount recorded in 2010, after which it has been gradually decreasing. ~~and the landings have increased significantly in the past~~ (Table 1).

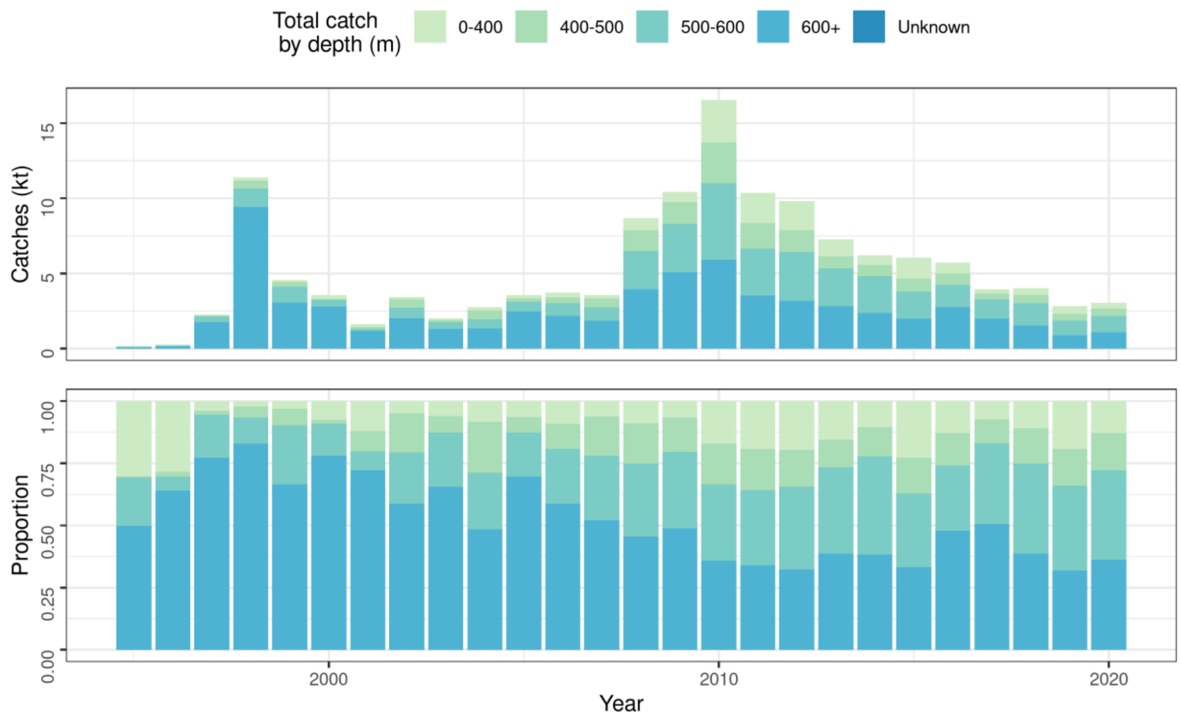

Figure 2. Greater silver smelt. Depth distribution of catches according to logbooks by the Icelandic fleet. All gears combined.

FLEETS

Since 1996 between 20 and 39 trawlers have annually reported catches of greater silver smelt in Icelandic waters (Table 1). The trawlers participating in the greater silver smelt fishery also target redfish (*Sebastes marinus* and *S. mentella*) and to lesser extent Greenland halibut and blue ling. Number of hauls peaked in 2010, but the number of hauls has decreased since then in line with lower total catches. In most years over 50% of the greater silver smelt catches are taken in hauls where the species is more than 50% of the catch (Table 1).

TARGETING AND MIXED FISHERIES ISSUES IN THE GREATER SILVER SMELT FISHERY IN ICELANDIC WATERS

MIXED FISHERIES ISSUES: SPECIES COMPOSITION IN THE FISHERY

Redfish spp. (*Sebastes 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 Icelandic waters (Table 2).

Table 2. Greater silver smelt in Icelandic waters. Proportional bycatch species composition where greater silver smelt was more than 50% of the total catch in a haul.

YEAR	REDFISH		GREENLAND HALIBUT	LING	BLUE LING	OTHER
	S. marinus	*S. mentella*				
1997	1,4	79	0,0	6,9	7,2	5,5
1998	5,3	77,9	0,0	3,6	6,4	6,8
1999	4	79,9	0,0	2,5	5,9	7,6
2000	4,8	71	0,2	0,3	9,7	14,1
2001	22,4	55,4	4,5	0,5	0,9	16,3
2002	16,9	74,2	0,4	1,2	4,0	3,2
2003	37,7	52	0,4	0,1	5,1	4,7
2004	25,1	68,4	0,7	0,1	0,9	4,8
2005	15,6	69,5	4,3	1,4	3,0	6,2
2006	28,8	59,8	1,4	0,9	1,0	8,1
2007	12,1	70,9	5,9	0,3	6,1	4,6
2008	26,7	60,8	2,8	1,2	5,0	3,4
2009	20,9	63,7	3,3	0,2	7,9	4,1
2010	16	63,7	2,0	0,9	6,4	11,1
2011	13,4	66,3	2,2	0,4	4,8	12,9
2012	8,9	67,5	1,3	0,2	7,5	14,5
2013	9,6	63,8	4,7	0,2	9	12,8
2014	2,4	78,3	2,8	0,3	5,5	10,7
2015	13,8	67,1	3,1	0,3	4,2	11,7
2016	10,9	73,5	5,5	0,2	2,8	7,1
2017	2,9	85,6	1.6	0,2	2,9	6,8
2018	4,7	87,7	2,1	0,1	1,6	4,0
2019	7,8	81,1	1,8	0,2	0,6	7,0
2020	5,6	87,5	1,7	0,1	0,9	4,2

SPATIAL DISTRIBUTION OF CATCHES THROUGH TIME

Spatial distribution of catches in 1995–2020 is presented in Figures 3 and 4. In the period, a gradual relative increase is seen in the southwestern area and a gradual decrease in the southeastern area.

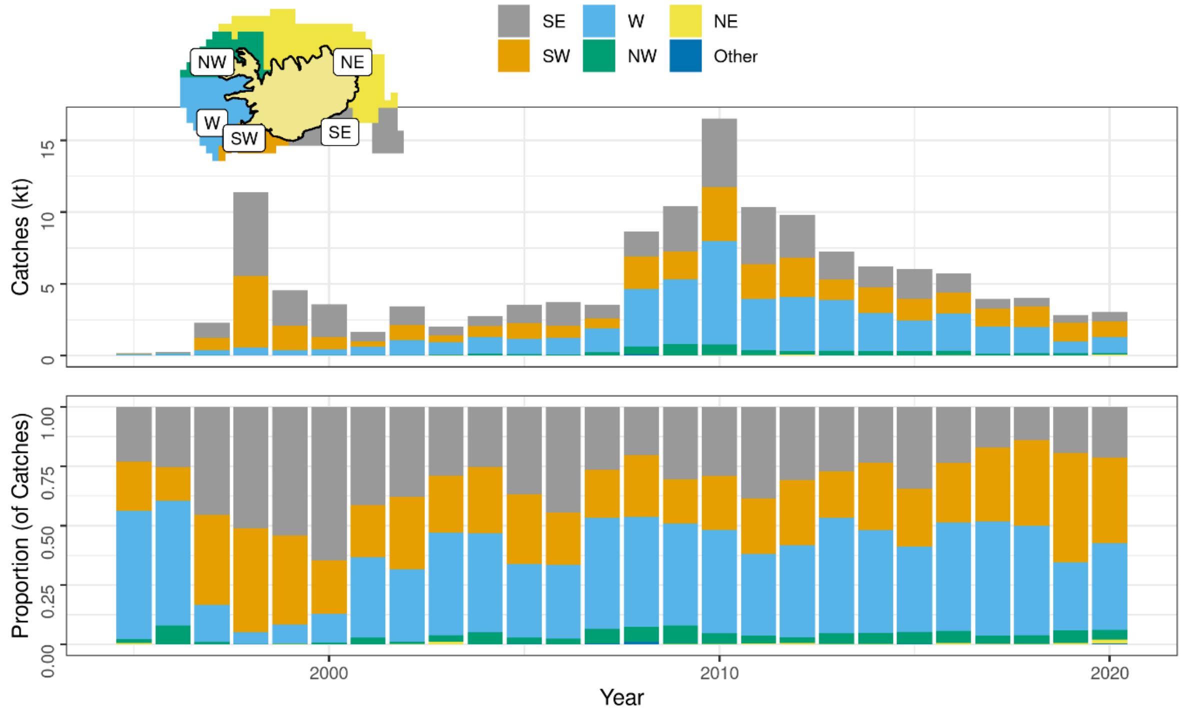

Figure 3. Greater silver smelt in Icelandic waters. Catch distribution and proportions by area according to logbooks.

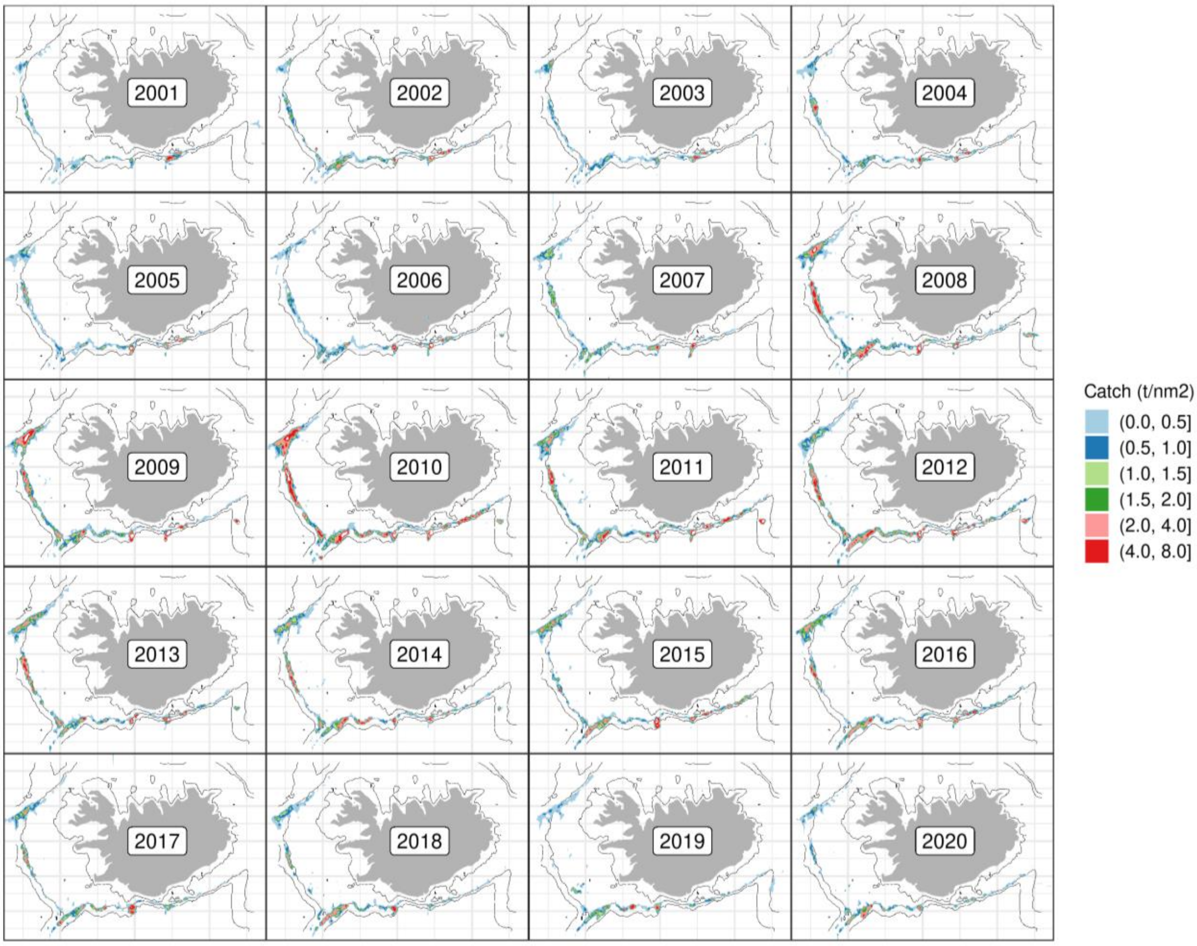

Figure 4. Greater silver smelt in Icelandic waters. Spatial distribution of catches as reported in logbooks.

Table 3. Greater silver smelt. Landings (tonnes) records from the Icelandic directorate of Fisheries and Greenland (WGDEEP:WD05).

YEAR	INSIDE THE NEAFC RA	OUTSIDE THE NEAFC RA		CATCHES
		Section 5.a	Section 14.b	
1988				**206**
1989				**8**
1990				**112**
1991				**247**
1992				**657**
1993				**1255**
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**

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 4). 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 5. However, recent years have experienced a large decline in sampling.

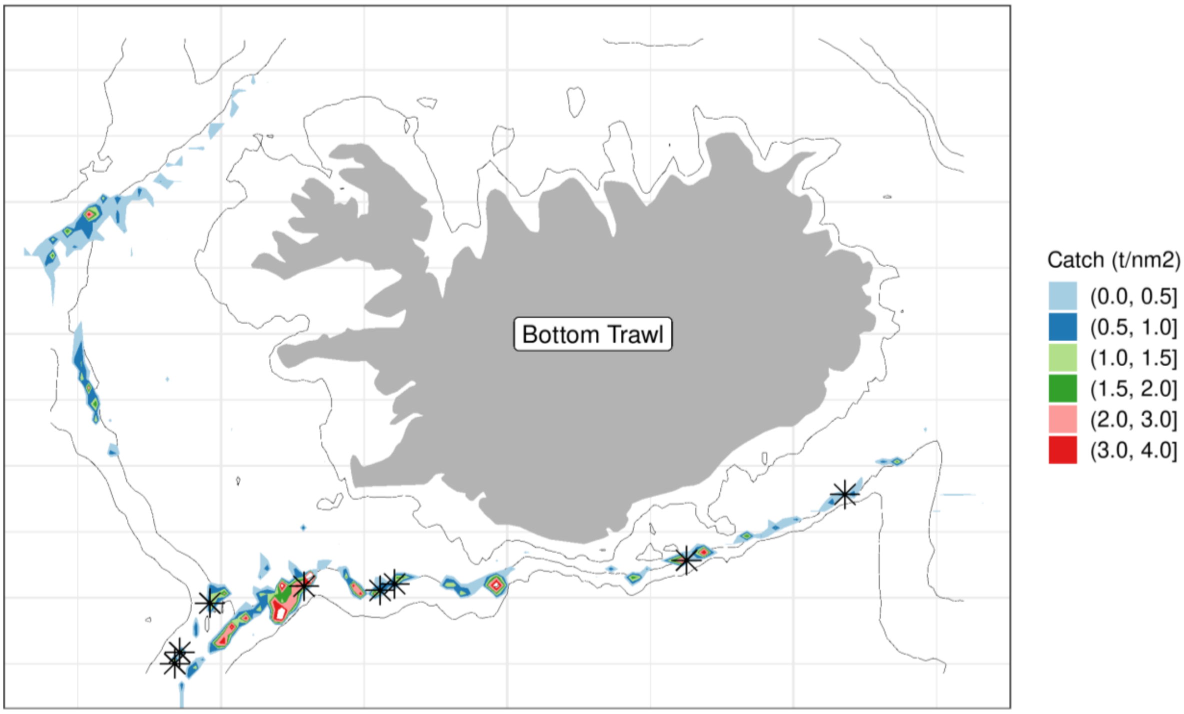

Figure 5: Greater silver smelt. Fishing grounds in 2020 as reported in logbooks and positions of samples taken from landings (asterisks).

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.

LENGTH COMPOSITIONS

Table 4 gives the number of samples and measurements available for calculations of catch in numbers of greater silver smelt in Icelandic waters. Length distributions from autumn survey and commercial samples are presented in Figures 6 and 7, respectively. Length distributions from the autumns survey are rather stable, with 2020 being close to the long-term average (Figure 6).

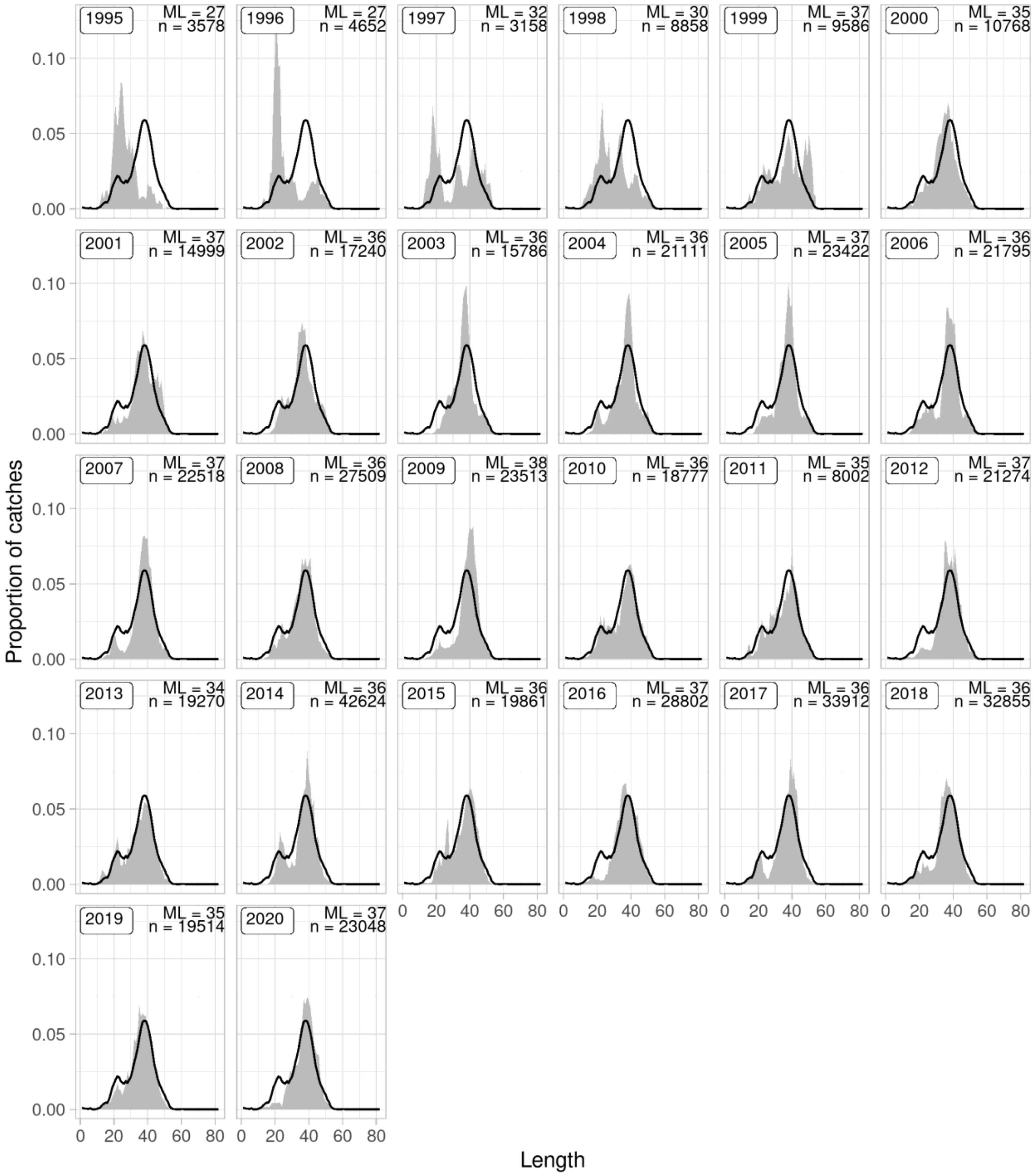

Figure 6. Greater silver smelt. Length distribution from the autumn survey (grey area) and mean length distribution (black line).

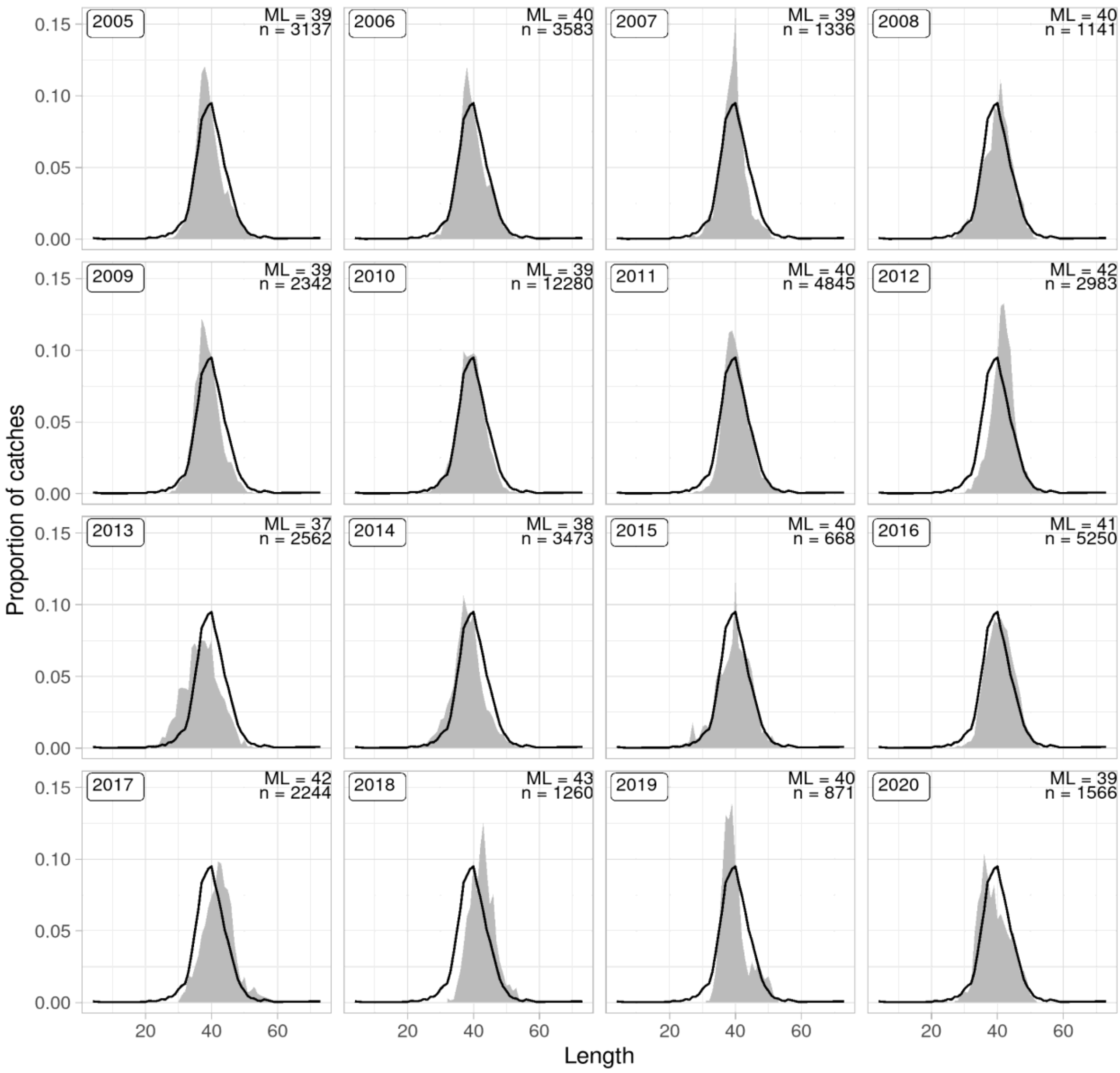

Figure 7. Greater silver smelt. Length distributions from Icelandic commercial bottom trawl catches.

AGE COMPOSITIONS

Table 4 gives the number of samples and measurements available for calculations of catch in numbers of greater silver smelt in Icelandic waters. Age distributions from the autumn survey in Figure 8 and estimated as catch in numbers are given in Figure 9.

Table 4. Greater silver smelt in Icelandic waters. Summary of sampling intensity and overview of available data.

YEAR	NO. LENGTH SAMPLES	NO. LENGTH MEASUREMENTS	NO. OTOLITH SAMPLES	NO. OTOLITHS	NO. AGED OTOLITHS
1997	45	4863	28	1319	985
1998	141	14911	102	6018	890
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	0
2004	34	996	7	225	84
2005	49	3708	14	772	0
2006	29	4186	13	616	465
2007	14	2158	8	285	272
2008	44	3726	39	1768	1387
2009	53	5701	36	1746	1387
2010	134	16351	68	3370	3120
2011	63	6866	40	1953	1774
2012	35	3891	23	1094	405
2013	47	4925	34	710	704
2014	32	4709	16	350	340
2015	11	1275	8	221	217
2016	45	5880	13	285	184
2017	20	2927	12	250	206
2018	12	1437	9	185	181
2019	8	1010	0	0	0
2020	8	1566	2	50	25

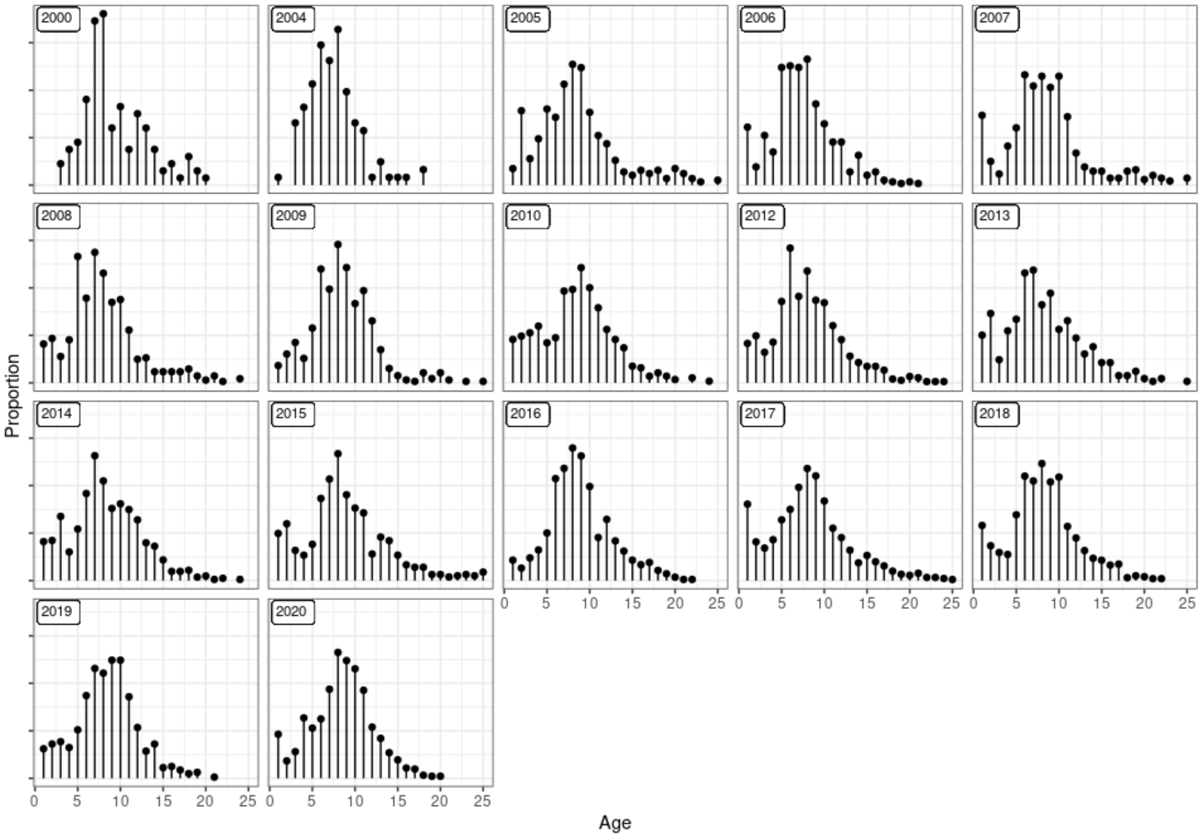

Figure 8: Greater silver smelt. Age distributions in proportions from the Icelandic autumn survey.

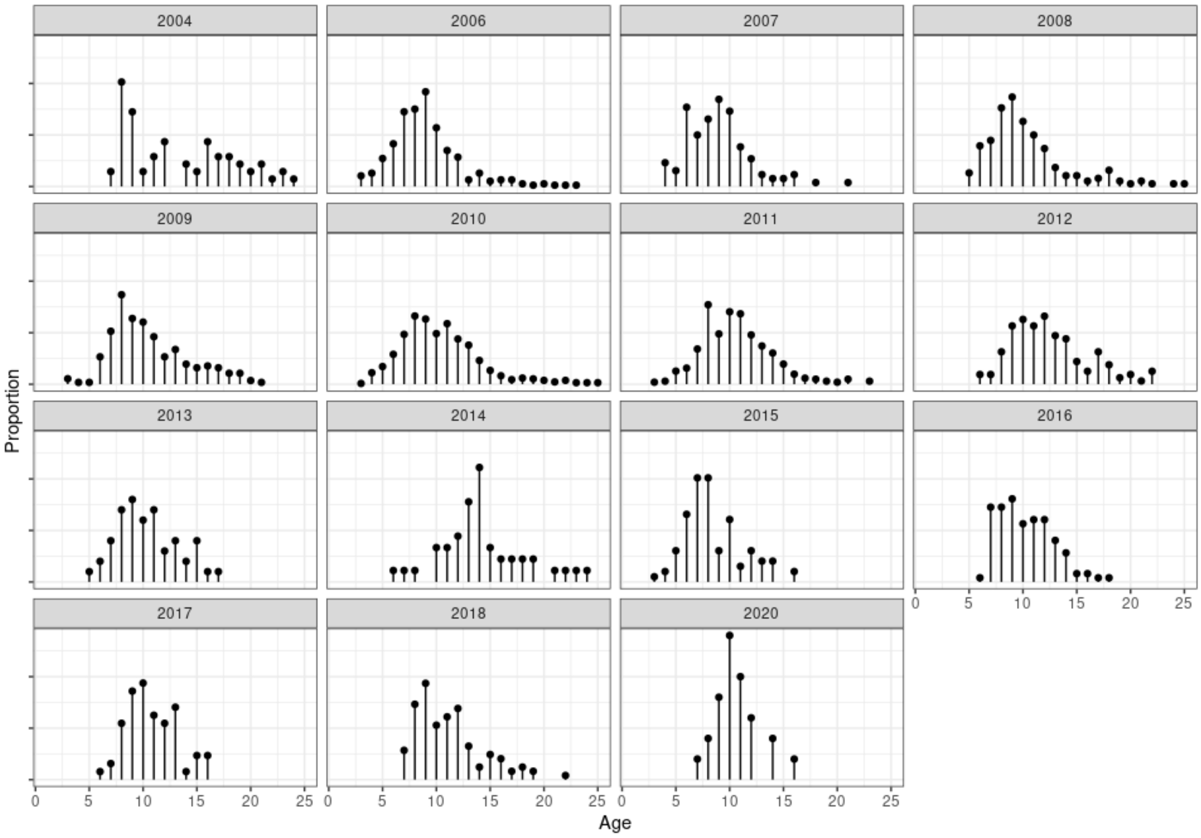

Figure 9. Greater silver smelt. Catch in numbers. No age data available in 2019 from commercial catches.

WEIGHT AT AGE

Biological data from the spring survey, autumn survey, and commercial catches 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 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 Icelandic waters are mature.

No information exists on natural mortality of greater silver smelt in Icelandic waters.

CATCH, EFFORT AND SURVEY DATA

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.

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 Icelandic waters 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.

The Icelandic groundfish autumn survey was commenced in 1996 and expanded in 2000. A detailed description of the autumn groundfish survey is given in the stock annex (ICES 2020) for greater silver smelt in Icelandic waters. The survey is considered representative of stock biomass of greater silver smelt since it was expanded in 2000. Figure 9 gives trends in biomass density and juvenile density (numbers) for the spring survey in 1985-2021 and for the autumn survey in 2000-2020. These values represent simple mean densities over stations; no stratification was used in these as the standard spring and autumn stratification schemes are inappropriate (Figure 10). Due to a strike 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 spatial distribution are seen in general in Figure 11.

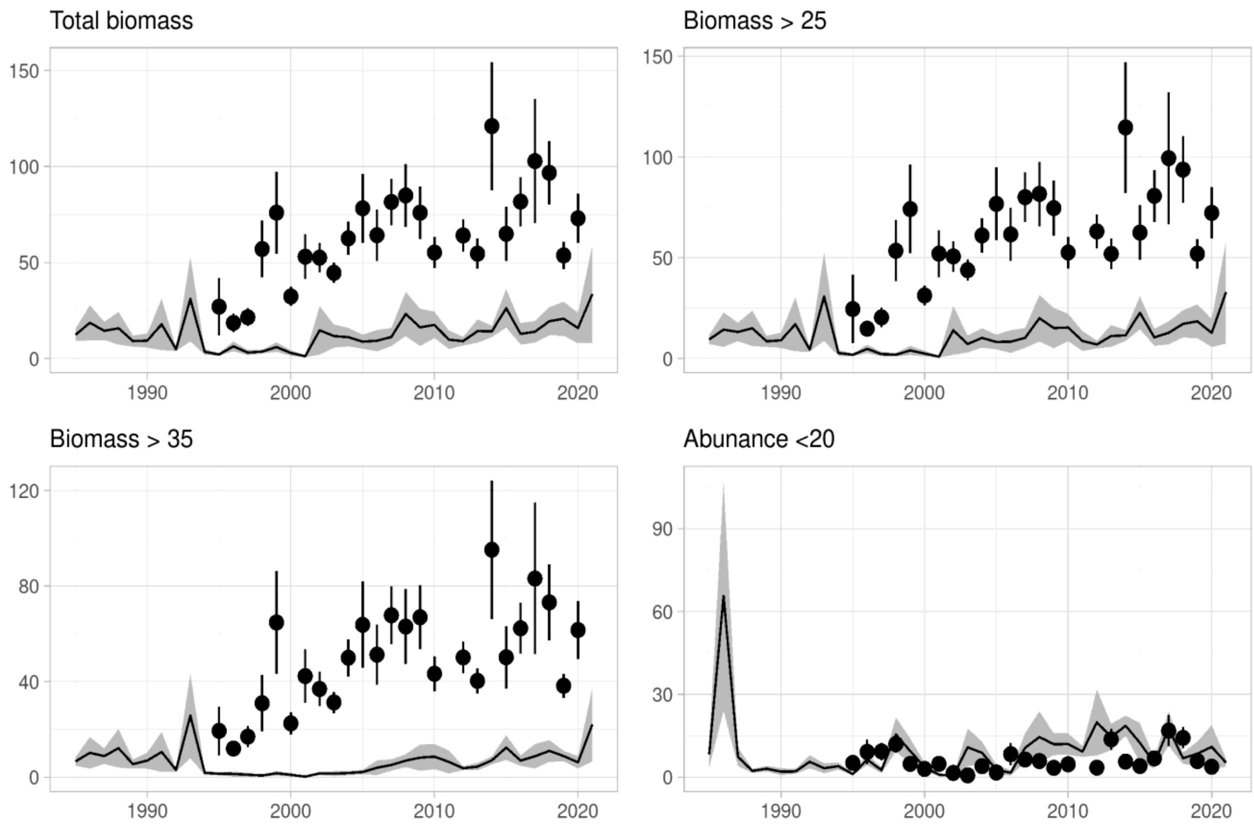

Figure 10. Greater silver smelt. Indices calculated from the Icelandic spring survey (lines and shaded area) and from the autumn survey (dots). Vertical lines and shaded area represent +/- 1 standard error.

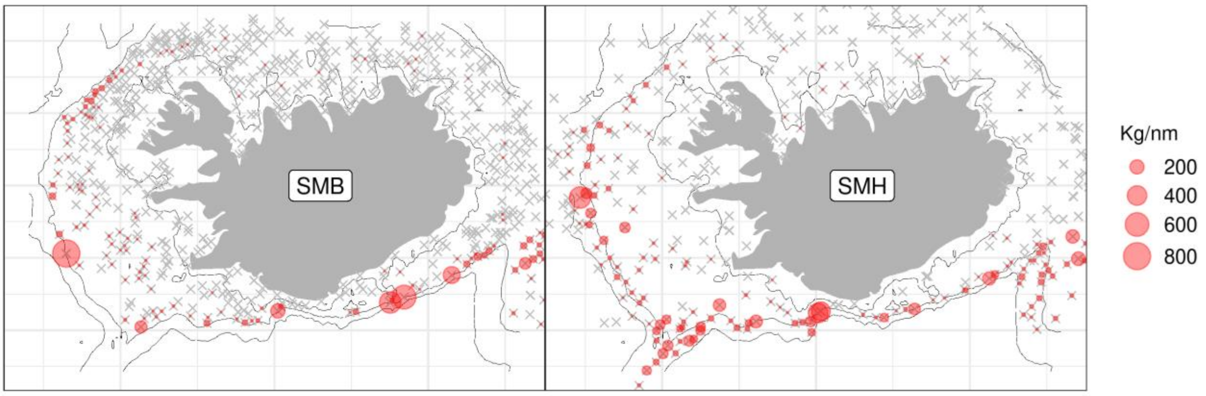

Figure 10. Greater silver smelt. Abundance and distribution of greater silver smelt in the spring survey (SMB) in 2021 and in the autumn survey (SMH) in 2020.

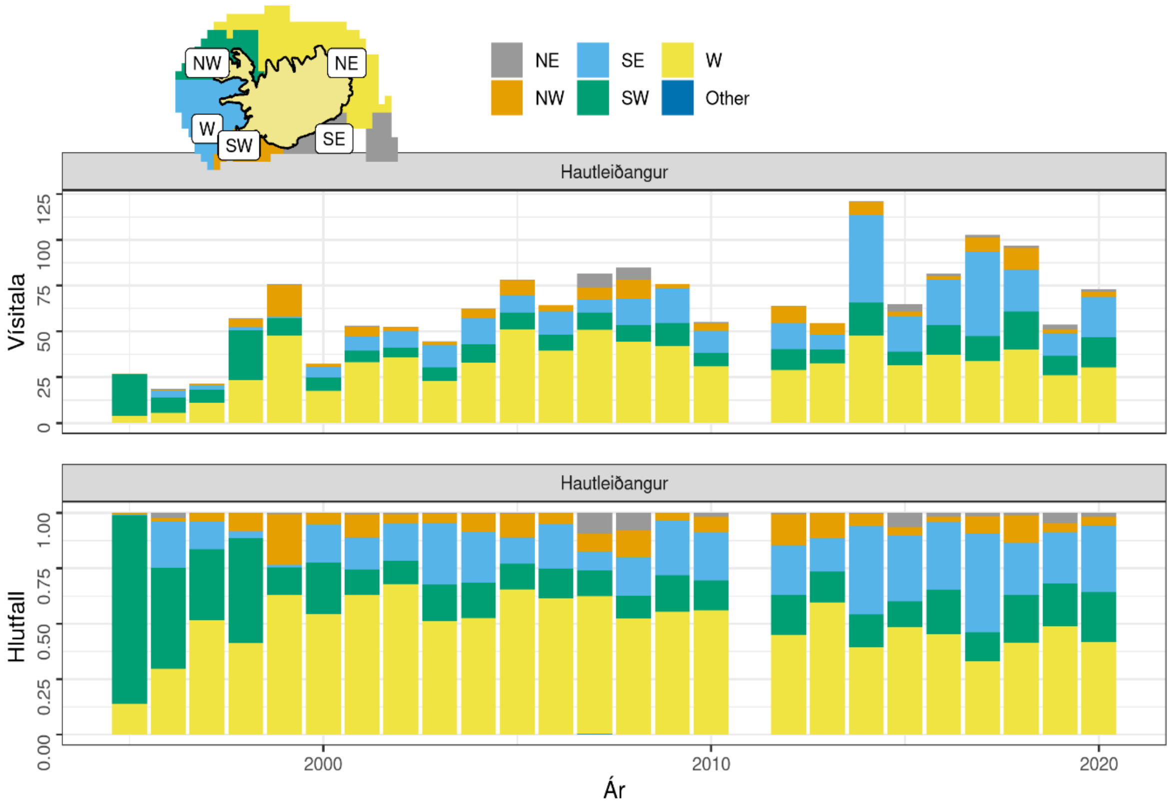

Figure 11. Greater silver smelt. Estimated survey biomass in the autumn survey by year from different areas (upper figure) and as proportions of the total (lower figure).

DATA ANALYSES

LANDINGS AND SAMPLING

Spatial distribution of catches in Icelandic waters has not changed markedly in recent years and fishing for greater silver smelt in the NW area seems to have reduced (Figures 2 and 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 3775 tonnes in 2020 (Figure 4 and Table 3). 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 was a slight increase in mean length in 2012 which can also be seen in recent years (Figures 7 and 8). 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 years in 2006 to 2011. 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 9). 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.

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 2021 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 10).

The observed trends in the biomass indices from the autumn survey have a considerably different trend than those observed in the spring survey (Figure 10). 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 the spring survey, which is conducted at shallower depths, is not considered representative of the stock.

ANALYTICAL ASSESSMENT

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).

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).

DIAGNOSTICS

OBSERVED AND PREDICTED PROPORTIONS BY FLEET

Overall fit to the predicted proportional length and age–length distributions is close to the observed distributions, except for a small peak of small-sized fish (Figures 12-15). This peak does not shift from year to year and therefore is considered due to 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.

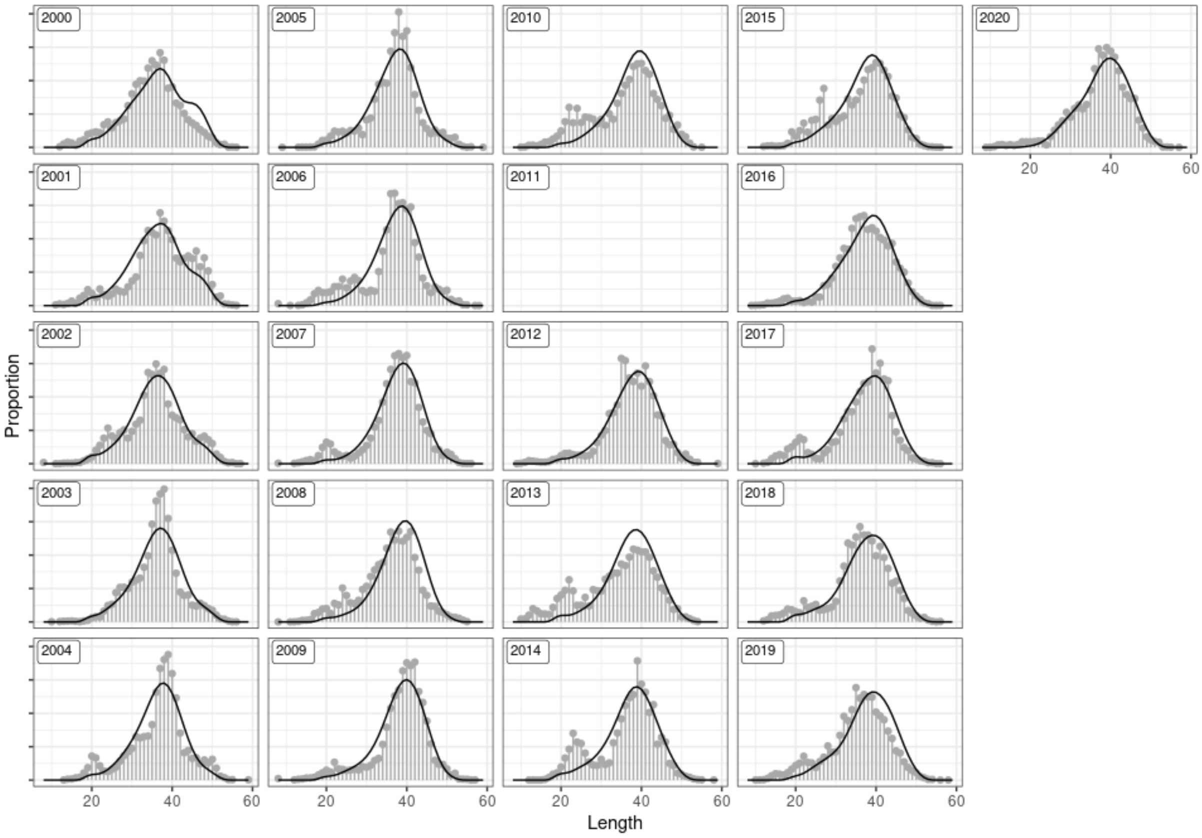

Figure 12: Greater silver smelt. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the autumn survey (vertical lines and points).

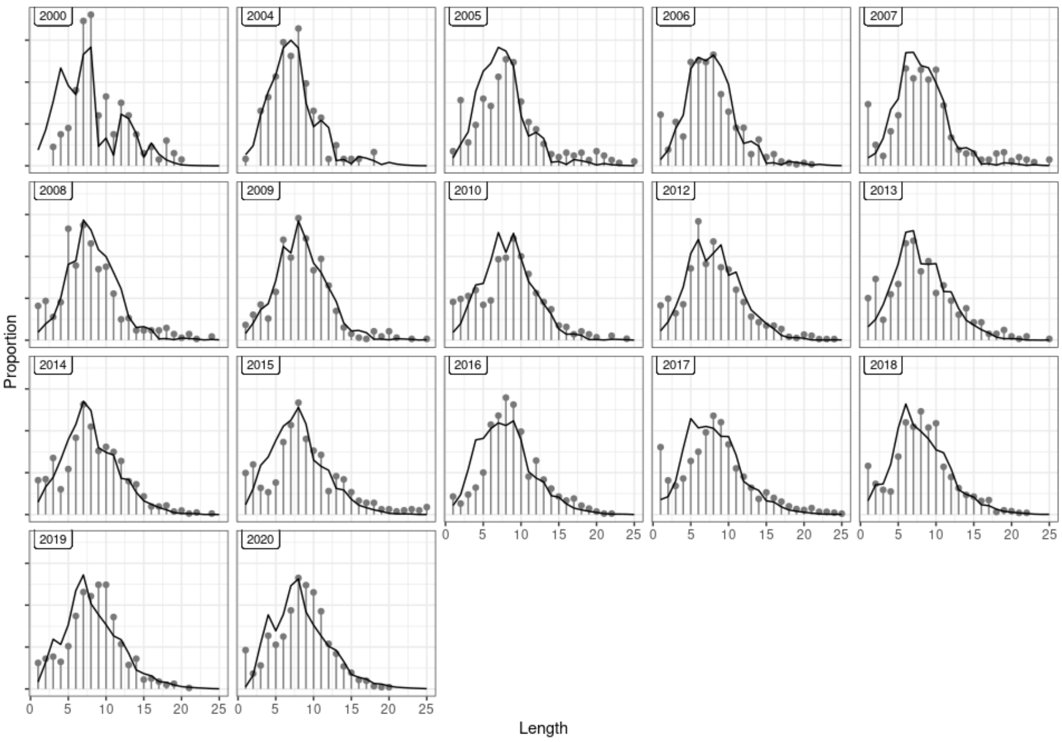

Figure 13: Greater silver smelt. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the autumn survey catches.

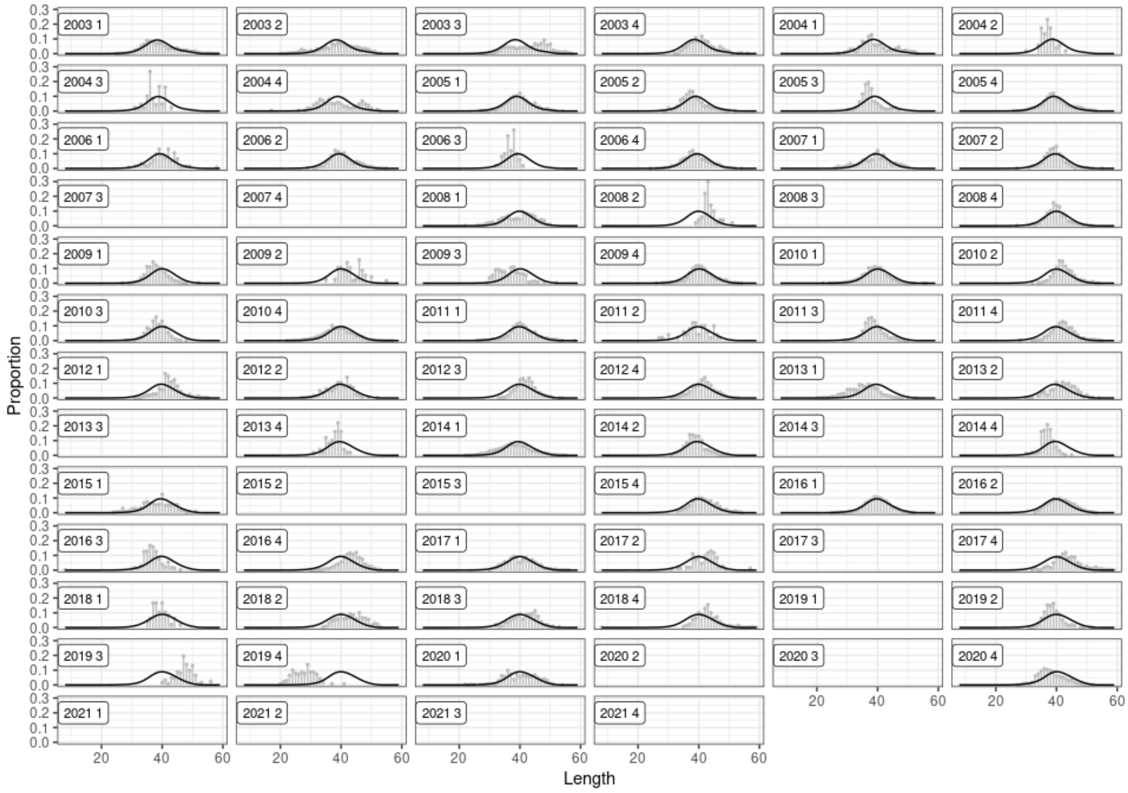

Figure 14: Greater silver smelt. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from commercial catches.

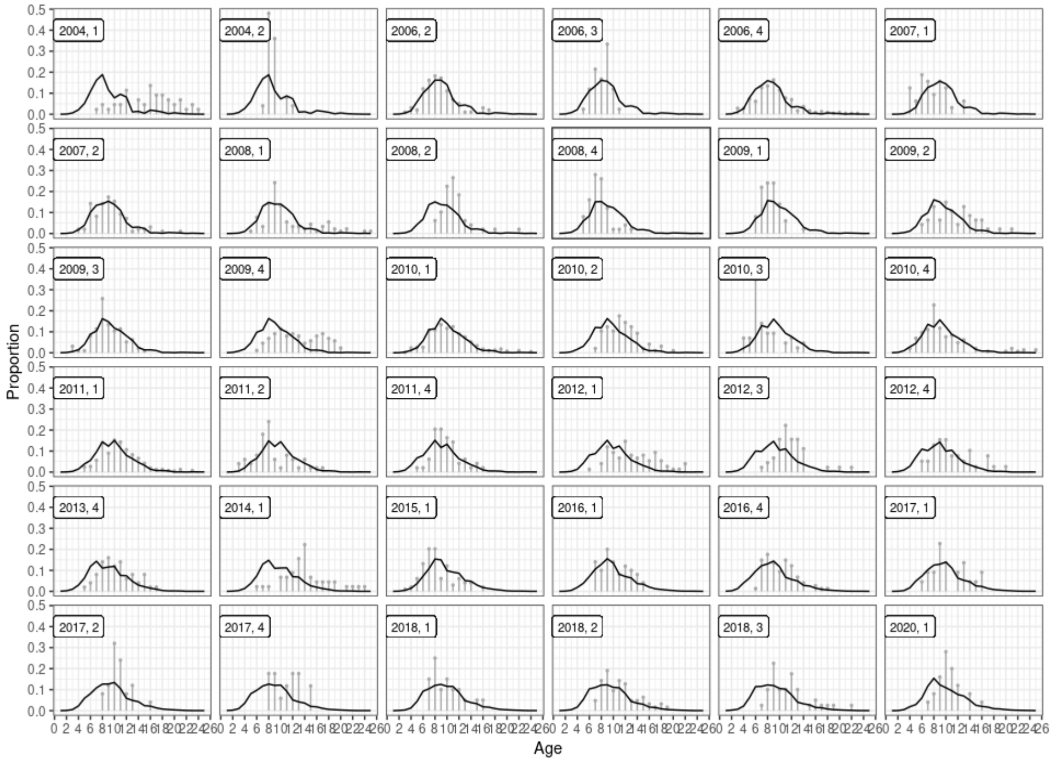

Figure 15: Greater silver smelt. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in commercial catches.

MODEL FIT

Figure 14 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 survey indices for the smallest tow size classes (10-25 and 25-30 cm) due to generally low selectivity the peak on small-sized fish that likely results from aggregation rather than cohort dynamics (see previous section). Last year, the terminal estimate had a large overestimation due to very low survey indices that year, indicating the potential for overestimation of biomass last year. This year's results support this overestimation, and a slight downward revision occurred this year. As overestimations are still apparent, there will likely be more downward revisions in the upcoming years, if this trend continues.

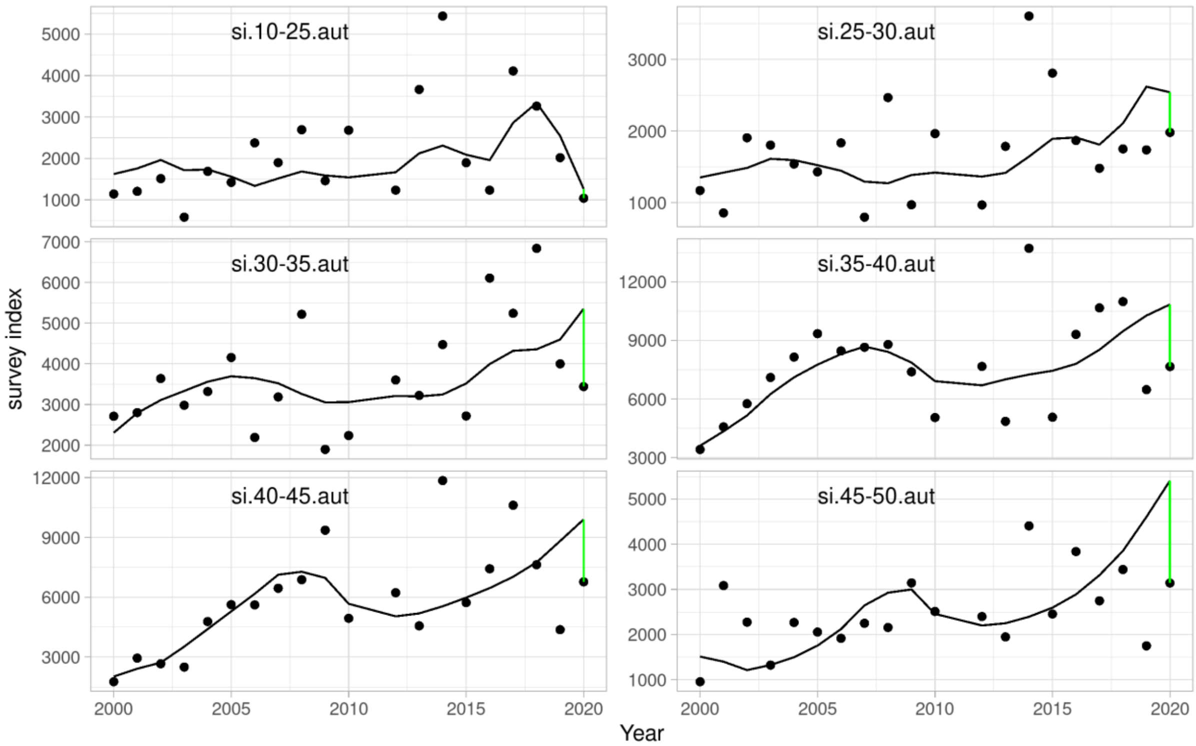

Figure 16: Greater silver smelt. Fitted autumn survey index by length group from the Gadget model (black line) and the observed number of greater silver smelt caught in the survey (points). The green line indicates the difference between the terminal fit and the observations.

RESULTS

The results are presented in Table 5 and Figure 17. 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 the time-series in 2019 with a slight decrease in 2020. Fishing mortality for greater silver smelt (age 6–14) has decreased from 0.3 in 2010 to less than 0.05 over the past several years, due to greater regulation of the fishery as well as reduced commercial interest.

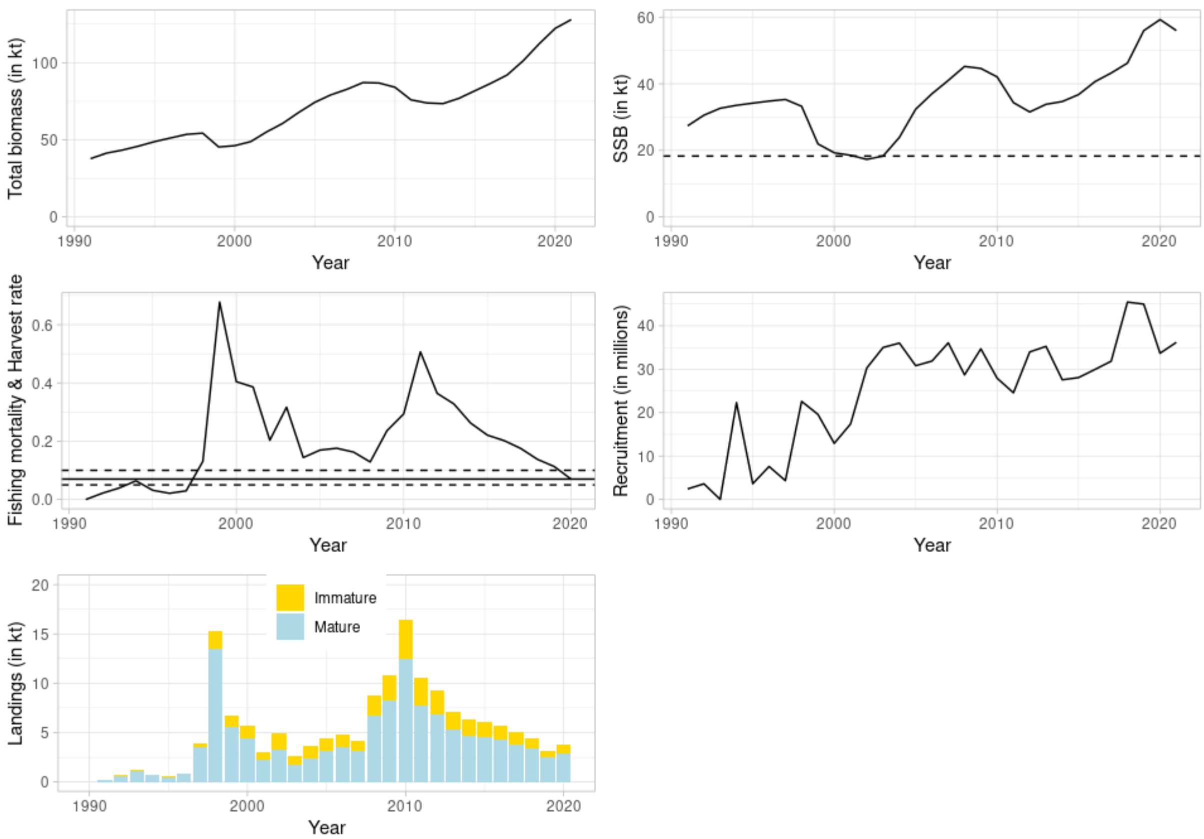

Figure 17: Greater silver smelt. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fishes and harvest rate, recruitment, and total catches. The dashed line in the SSB plot represents Bpa. The solid line in the fishing mortality plot indicates the fishing mortality 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.

In comparison with last year's assessment (Figure 18), there has been a slight downward revision of biomass levels and upward revision of fishing mortality, but within the range expected according to benchmark uncertainty estimates (WKGSS 2020).

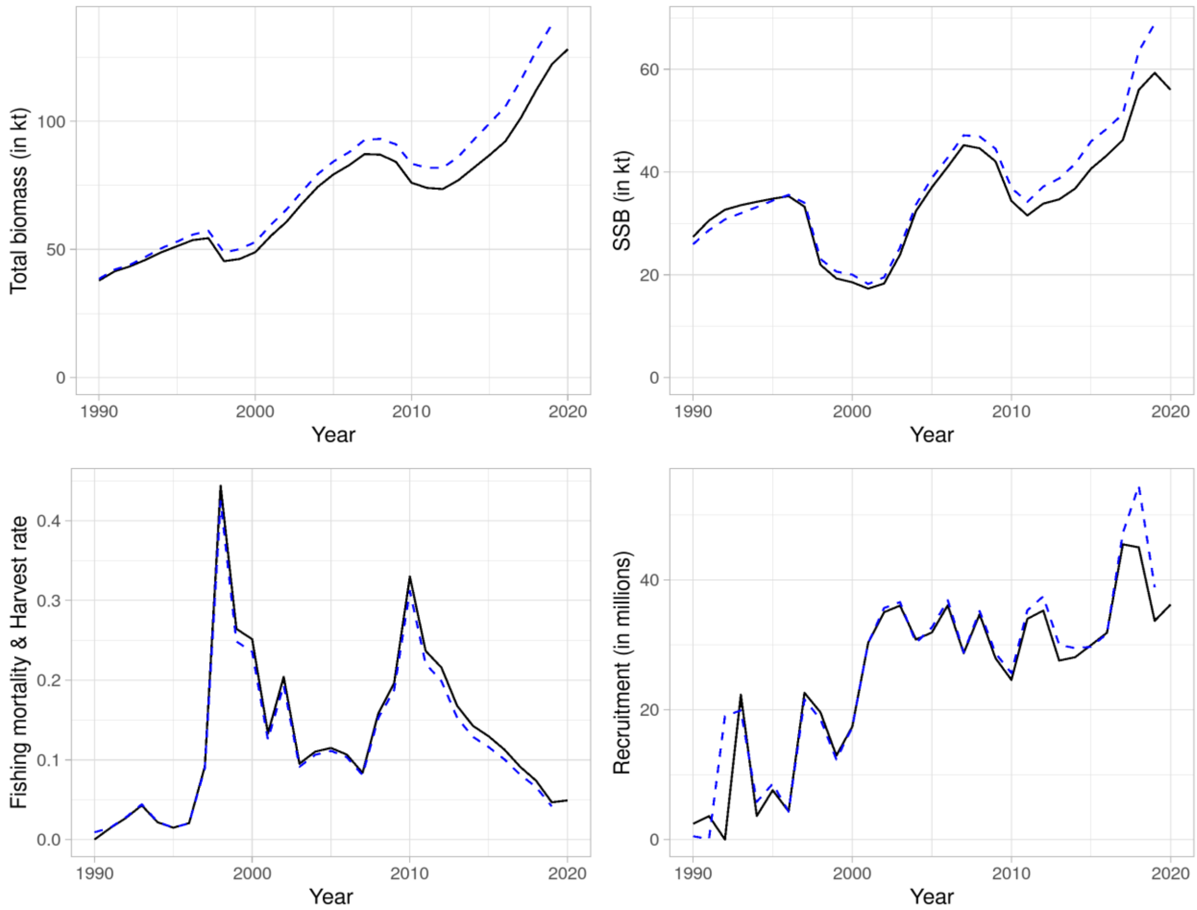

Figure 18: Greater silver smelt. This year's assessment (black line) compared with the previous year's assessment (dashed blue lines). Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fishes and recruitment.

Table 5. Greater silver smelt. 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. Projections (years after 2020) reflect filling the current TAC and fishing at F_{MSY} in the fourth quarter of 2020; catches in 2020 reflect fishing at F_{MSY}.

YEAR	TOTAL BIOMASS	CATCH	SSB	REC.	F
2000	46249.11	5.657	19298.27	17.38056	0.165
2001	48895.48	3.043	18545.38	30.28578	0.076
2002	55261.09	4.961	17296.34	35.00796	0.090
2003	60763.54	2.680	18419.44	36.02414	0.045
2004	67871.64	3.645	23931.51	30.80830	0.069
2005	74388.48	4.482	32418.07	31.87912	0.070
2006	79222.95	4.769	37040.10	36.07259	0.063
2007	82814.22	4.227	41196.46	28.70044	0.042
2008	87171.57	8.778	45386.04	34.69130	0.089
2009	86918.64	10.828	44726.62	27.92182	0.089
2010	84134.24	16.428	42206.14	24.57031	0.208
2011	75966.08	10.516	34539.26	33.97954	0.159
2012	73956.18	9.289	31698.93	35.25951	0.071
2013	73520.22	7.155	33986.69	27.56153	0.111
2014	76981.45	6.348	34801.72	28.07747	0.102
2015	81911.83	6.070	36913.52	29.94022	0.095
2016	86801.96	5.662	40824.24	31.84774	0.073
2017	92113.52	5.011	43405.92	45.46419	0.062
2018	101318.33	4.460	46453.89	44.98915	0.043
2019	112322.33	3.209	56170.72	33.67367	0.028
2020	122340.89	3.775	59500.52	36.19197	0.036
2021	128040.96	9.824	56362.38	81.86833	0.103
2022	129260.89	8.838	49051.34	85.78528	0.066

RETROSPECTIVE ANALYSIS

An analytical retrospective analysis is presented (Figure 19). The analysis indicates that there was an upward revision of biomass over the first year of the 5-year peel followed by a downward revision of biomass (SSB) over the last 4 years, and subsequently a downward then upward revision of F. Estimates of recruitment are decently stable except for the 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 with which this influence can be tempered. 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.

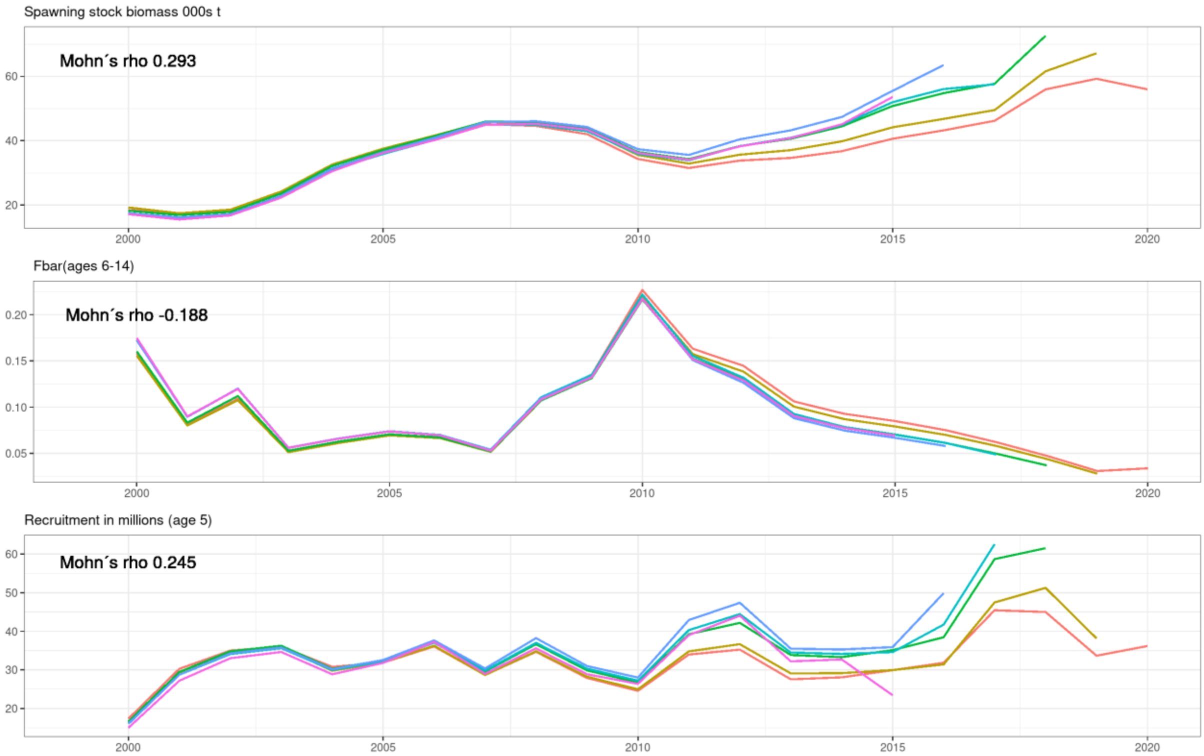

Figure 19: Greater silver smelt. Retrospective plots illustrating stability in mod-el estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 5) are shown.

COMMENTS ON THE ASSESSMENT

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 Fmsy to determine the expected catch from fishing at this level. Advised catch is set to this value while SSBy>Btrigger, scaled by (SSBy)/Btrigger while Blim≤SSBy<Btrigger, and set to 0 while SSBy≤Blim.

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 Icelandic waters is given in the stock annex (ICES 2020). Fishing for greater silver smelt is banned at depths less than 400 m to avoid catching younger fish.

The TAC for the 2013/2014 fishing year was set at 8000 t 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 8000 t. For the fishing year 2015/2016 it was also maintained at 8000 t, but was 7885 t for 2016/2017, 9310 t for 2017/2018, 7603 t for 2018/2019, 9124 for 2019/2020, and 8729 for 2020/21 (Table 6).

Figure 19 illustrates the difference between national TAC and landed catch in Icelandic waters. The difference can be attributed to species transformation (in both directions, Figure 19).

Table 6. Greater silver smelt in 6. TAC recommended by the Marine and Freshwater Research Institute, national TAC set by the Ministry, and total landings (tonnes).

FISHING YEAR	MFRI ADVICE	NATIONAL TAC	LANDINGS
2010/11	8000		**12091**
2011/12	8000		**8497**
2012/13	8000		**11217**
2013/14	8000	8000	**7242**
2014/15	8000	8000	**6848**
2015/16	8000	8000	**5991**
2016/17	7885	7885	**3570**
2017/18	9310	9310	**5159**
2018/19	7603	7603	**2818**
2019/20	9124	9124	**3775**
2020/21	**8729**	**8729**	**2395**

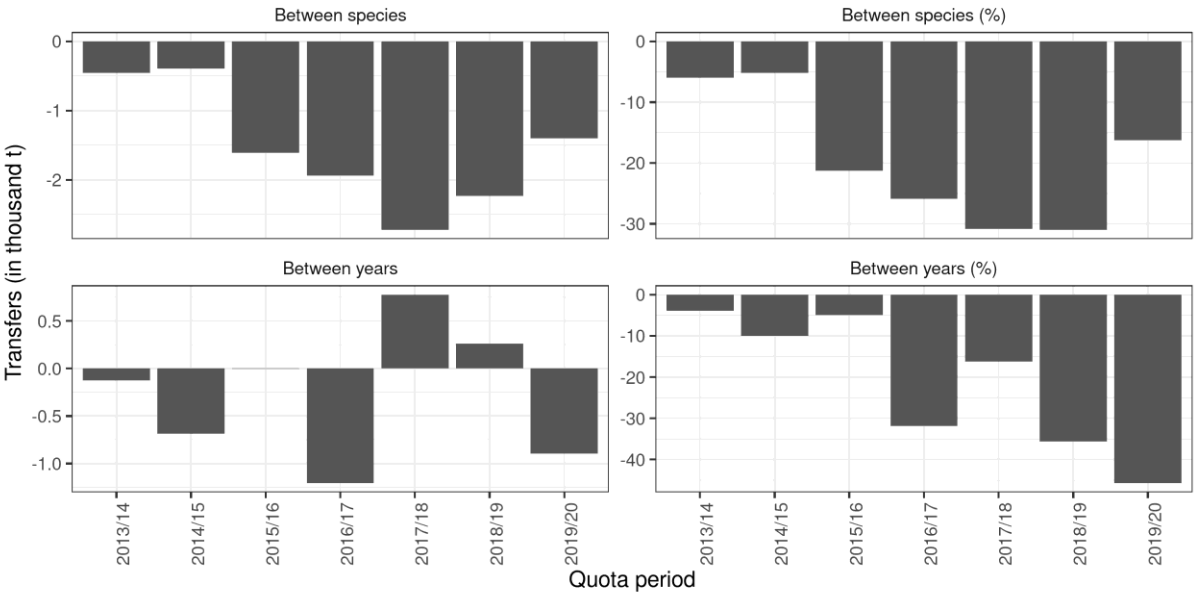

Figure 19. Greater silver smelt. Net transfer of quota in the Icelandic ITQ system by fishing year. Between species (upper): Positive values indicate a transfer of other species to greater silver smelt, but negative values indicate a transfer of greater silver smelt quota to other species. Between years (lower): Net transfer of quota from a given fishing year (may include unused quota).

CURRENT ADVISORY FRAMEWORK

Reference points defined for the stock is shown in Table 7.

Table 7: Greater silver smelt. Reference points.

Framework	*Reference point*	*Value*	*Basis*
MSY	MSY $B_{trigger}$	25 440 t	B_{pa}
	F_{MSY}	0.07	F that leads to long-term MSY and a <5% risk of SSB < B_{lim} in equilibrium in stochastic projections. Realized F can range from 0.050–0.10
Precautionary approach	B_{lim}	18 308 t	B_{loss}
	B_{pa}	25 440 t	B_{lim}*1.4
	F_{lim}	0.24	Equilibrium F which will maintain the stock above B_{lim} with a 50% probability
	F_{pa}	0.07	F that leads to a <5% risk of SSB < B_{lim} in equilibrium

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 before 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.

MANAGEMENT CONSIDERATIONS

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

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.

REFERENCES

ICES 2010. Report of the Benchmark Workshop on Deep-water Species (WKDEEP), 17–24 February 2010, Copenhagen, Denmark. ICESCM2010/ACOM: 38. 247pp. http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2010/WKDEEP/wkdeep_final_2010.pdf

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.

———. 2020. "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).