GREATER SILVER SMELT – GULLLAX

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 greater than 500 m. In Icelandic waters greater silver smelt 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 2019 amounted to approximately 3210 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.

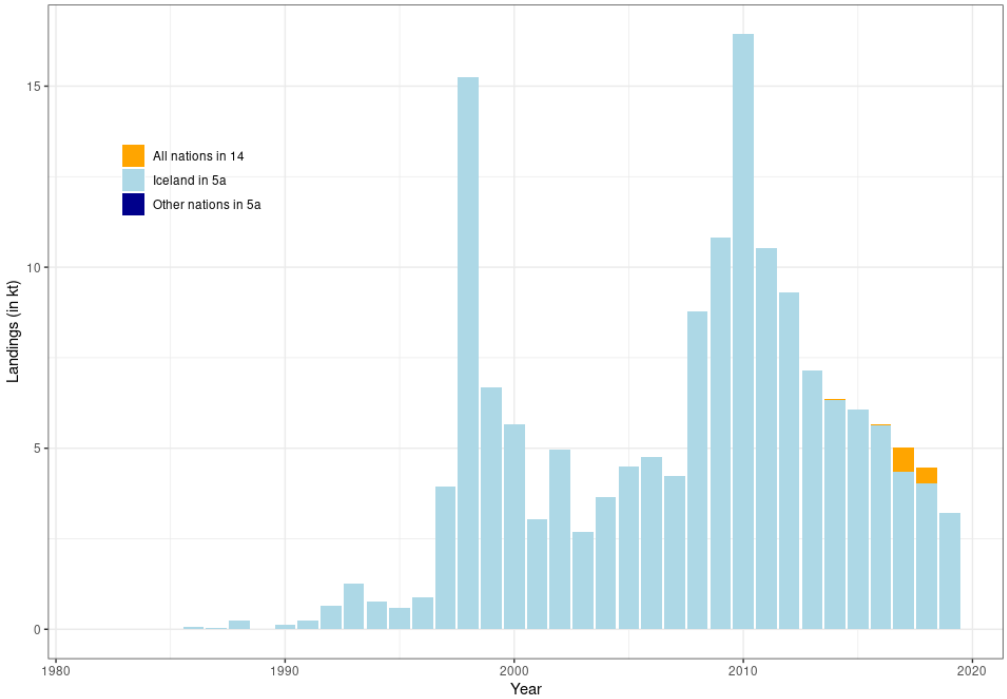

Figure 1. Greater silver smelt in Icelandic waters. Nominal landings. 23 tonnes were landed by foreign vessels (England and Wales) in 1999, which is the only year of catch reported by foreign vessels.

Mynd 1. Gulllax. Landaður afli á Íslandsmiðum. Einungis 23 tonnum var landað af erlendum skipum (England og Wales árið 1999).

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

Tafla 1. Gulllax. Fjöldi íslenskra skipa sem veitt hafa gulllax ásamt lönduðum afla í botnvörpu.

YEAR	NUMBER TRAWLERS	NUMBER HAULS	REPORTED CATCH	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**

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 and the landings have increased significantly in the past (Table 1).

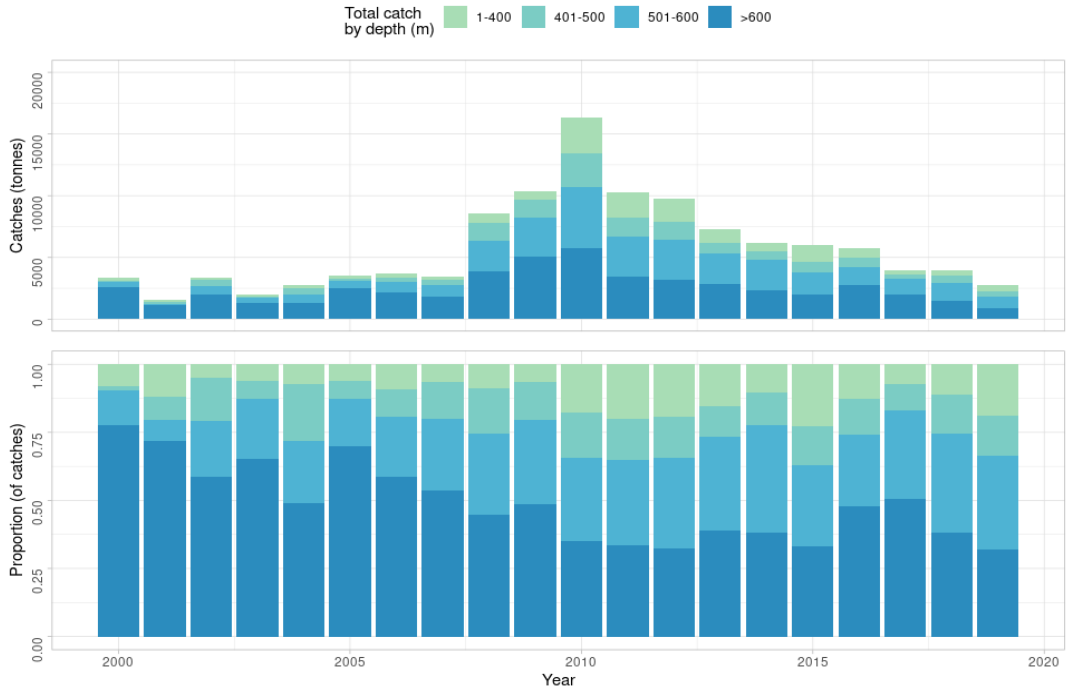

Figure 2. Greater silver smelt. Depth distribution of catches according to logbooks by the Icelandic fleet.

Mynd 2. Gulllax. Dýpi samkvæmt afladagbókum íslenskra skipa.

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 have decreased since then in line with lower total catches. In most years over 50% of the greater silver smelt catches are taken in hauls were 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.

Tafla 2. Gulllax. Hlutfall meðafla í botnvörpuveiðum þar sem meira en 50% aflans var gulllax.

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	1,84	0,2	0,6	7,0

SPATIAL DISTRIBUTION OF CATCHES THROUGH TIME

Spatial distribution of catches in 1996–2018 is presented in Figures 3 and 4. With the exception of 1996, most of the catches have been from the southern edge of the Icelandic shelf. However, in recent years 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 (Figures 3 and 4).

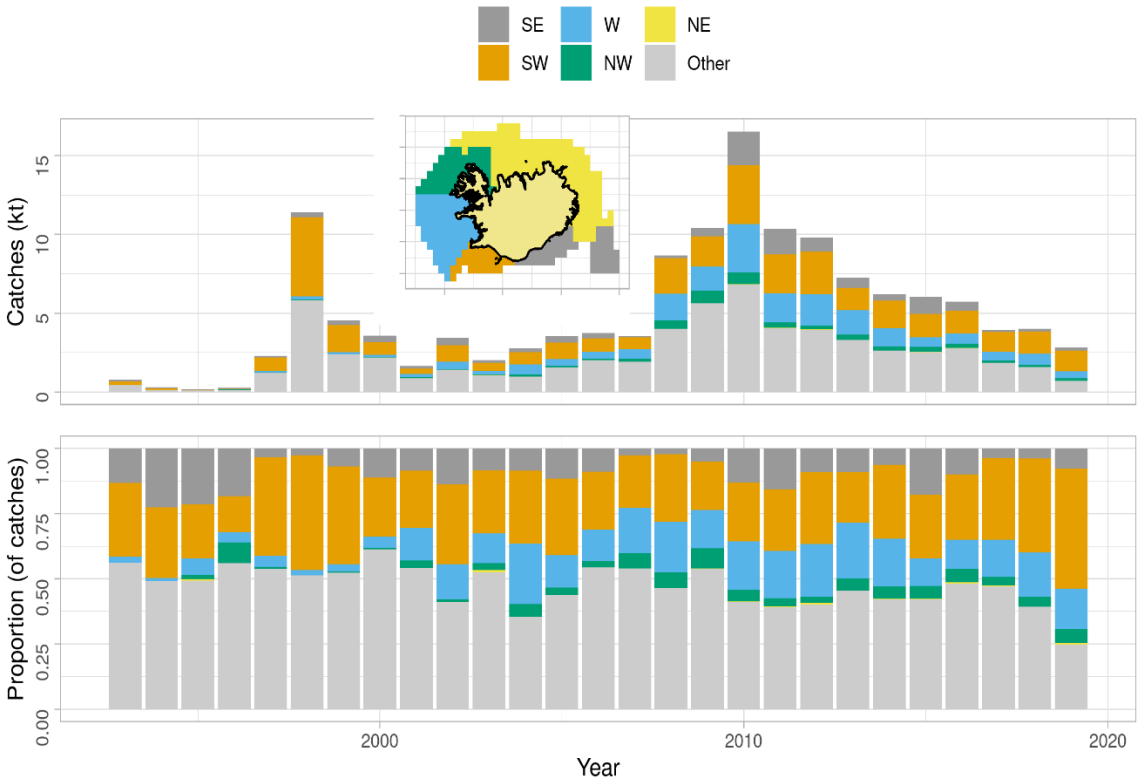

Figure 3. Greater silver smelt in Icelandic waters.. Catch distribution and proportions by area according to logbooks..

Mynd 3. Gulllax. Afli eftir svæðum ásamt hlutfalli innan hvers svæðis samkvæmt afladagbókum..

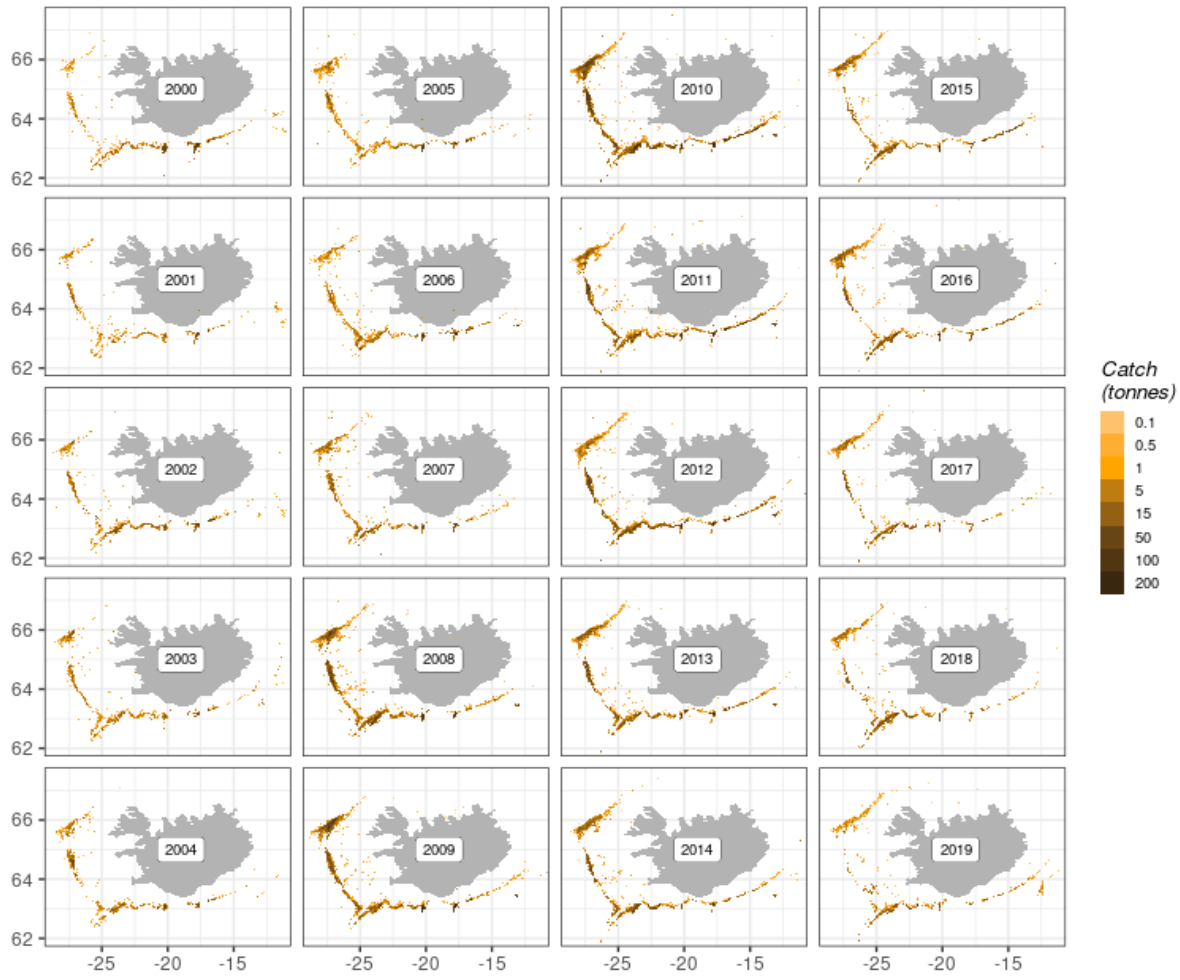

Figure 4. Greater silver smelt in Icelandic waters. Spatial distribution of catches as reported in logbooks.

Mynd 4. Gulllax. Afli eftir svæðum samkvæmt afladagbókum.

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

Tafla 3. Gulllax. Landaður afli af Íslandsmiðum (5.a) og Grænlandsmiðum (14.b).

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**

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). The sampling does seem to cover the spatial and temporal distribution of catches. The sampling coverage by gear in 2019 is shown in Figure 5. However, recent years have experienced a large decline in sampling. No age data were collected in 2019.

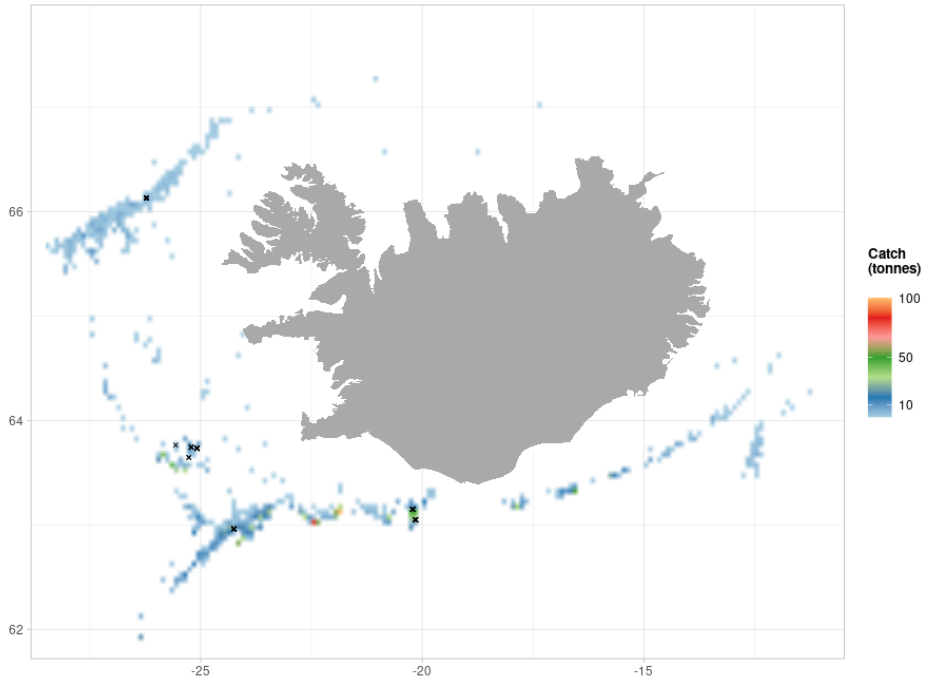

Figure 5: Greater silver smelt. Fishing grounds in 2019 as reported in logbooks and positions of samples taken from landings (asteriks).*Mynd 5. Gulllax. Veiðisvæði við Ísland árið 2019 samkvæmt afladagbókum og staðsetningar sýna úr lönduðum afla (*stjörnur*)*

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.

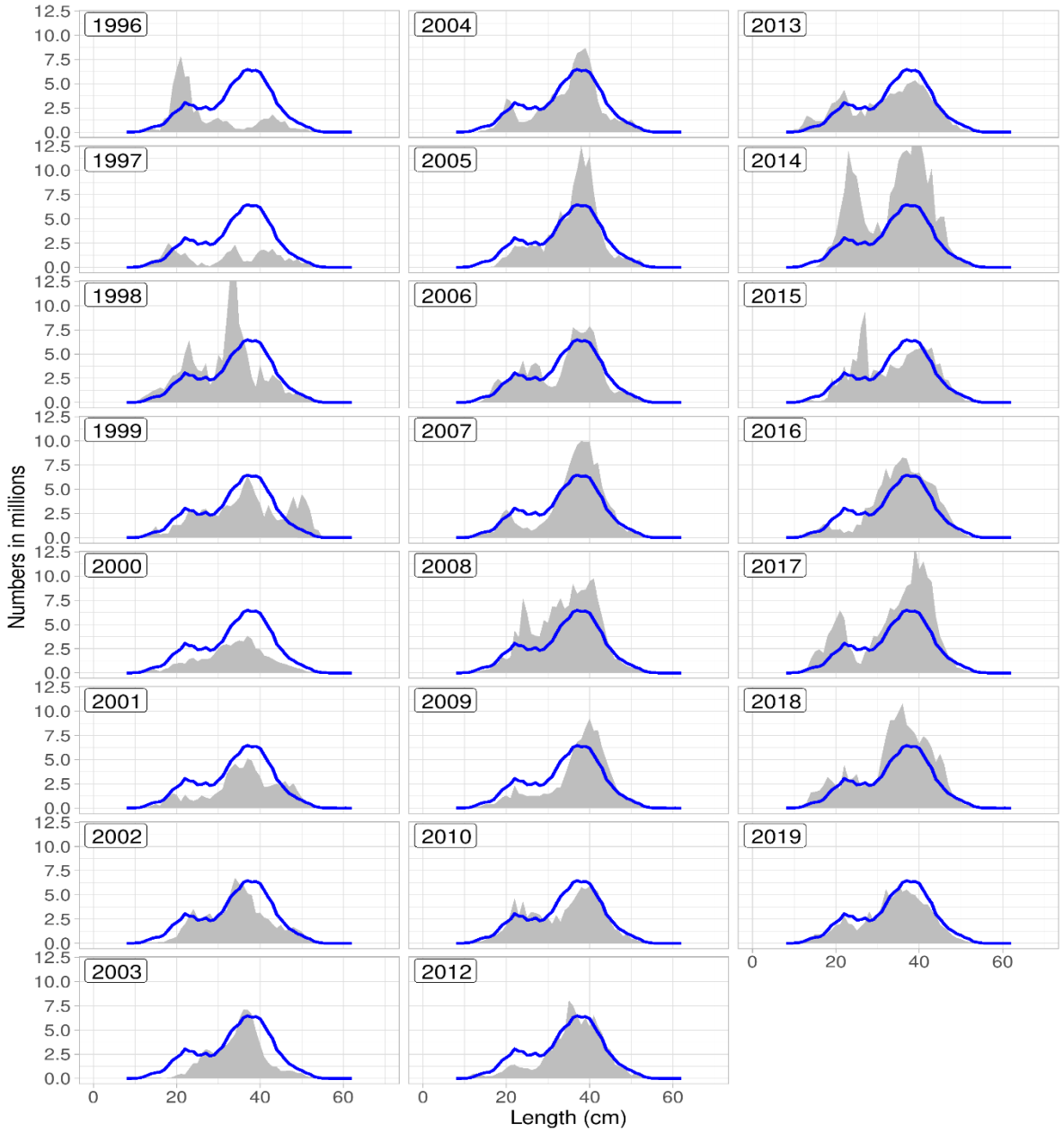

Figure 6. Greater silver smelt. Length disaggregated abundance indices from the autumn survey. The blue line shows the mean for all years.

Mynd 6. Gulllax. Lengdarskiptar vísitölur úr stofnmælingu botnfiska að hausti ásamt meðaltali allra ára (blá lína).

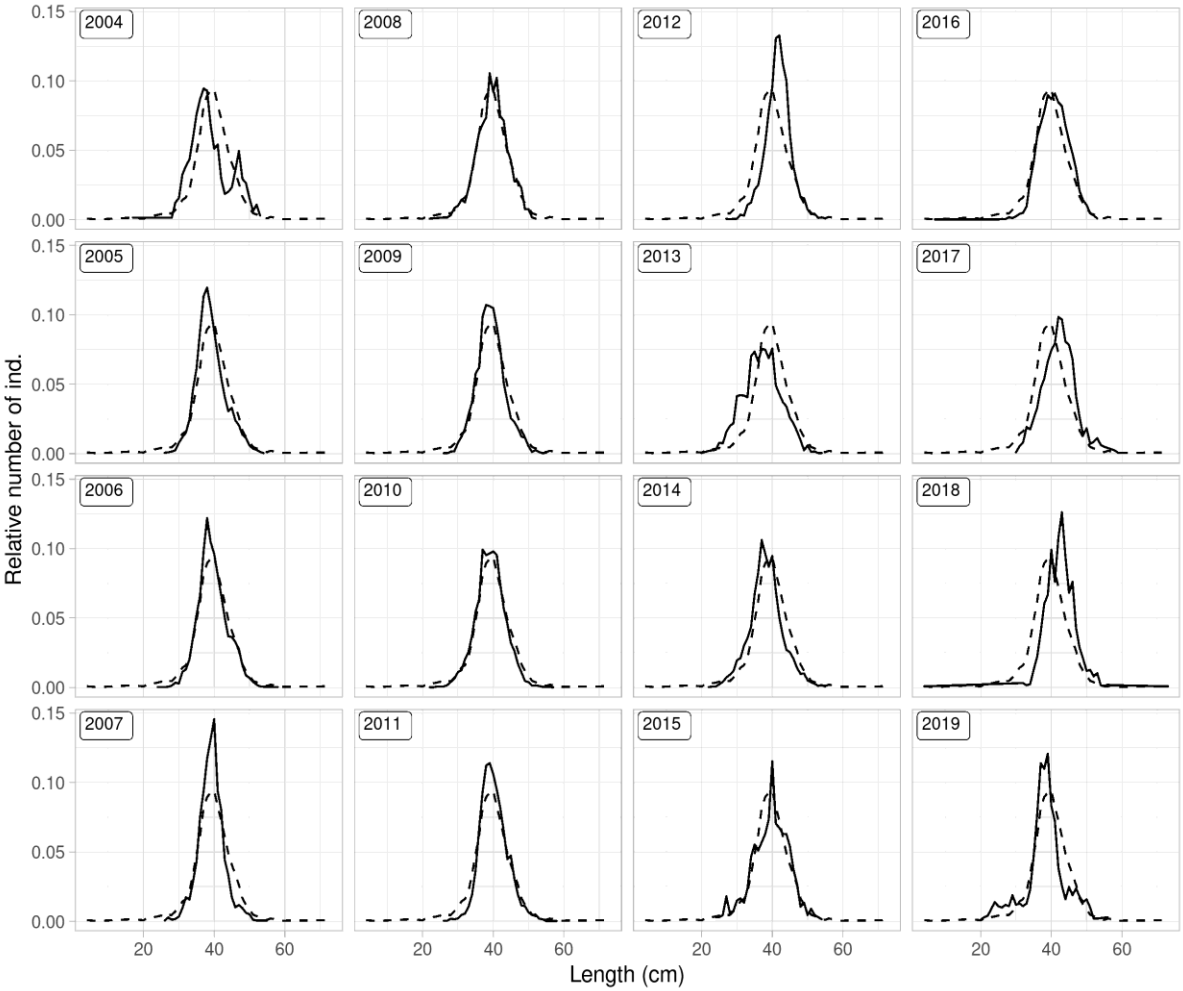

Figure 7. Greater silver smelt. Length distributions from Icelandic commercial bottom trawl catches.

Mynd 7. Gulllax. Lengdardreifing úr botnvörpuveiðum Íslendinga.

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.

Tafla 4. Gulllax. Samantekt á lengdar og aldursgagnasöfnun ásamt fjölda aldursgreininga.

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**

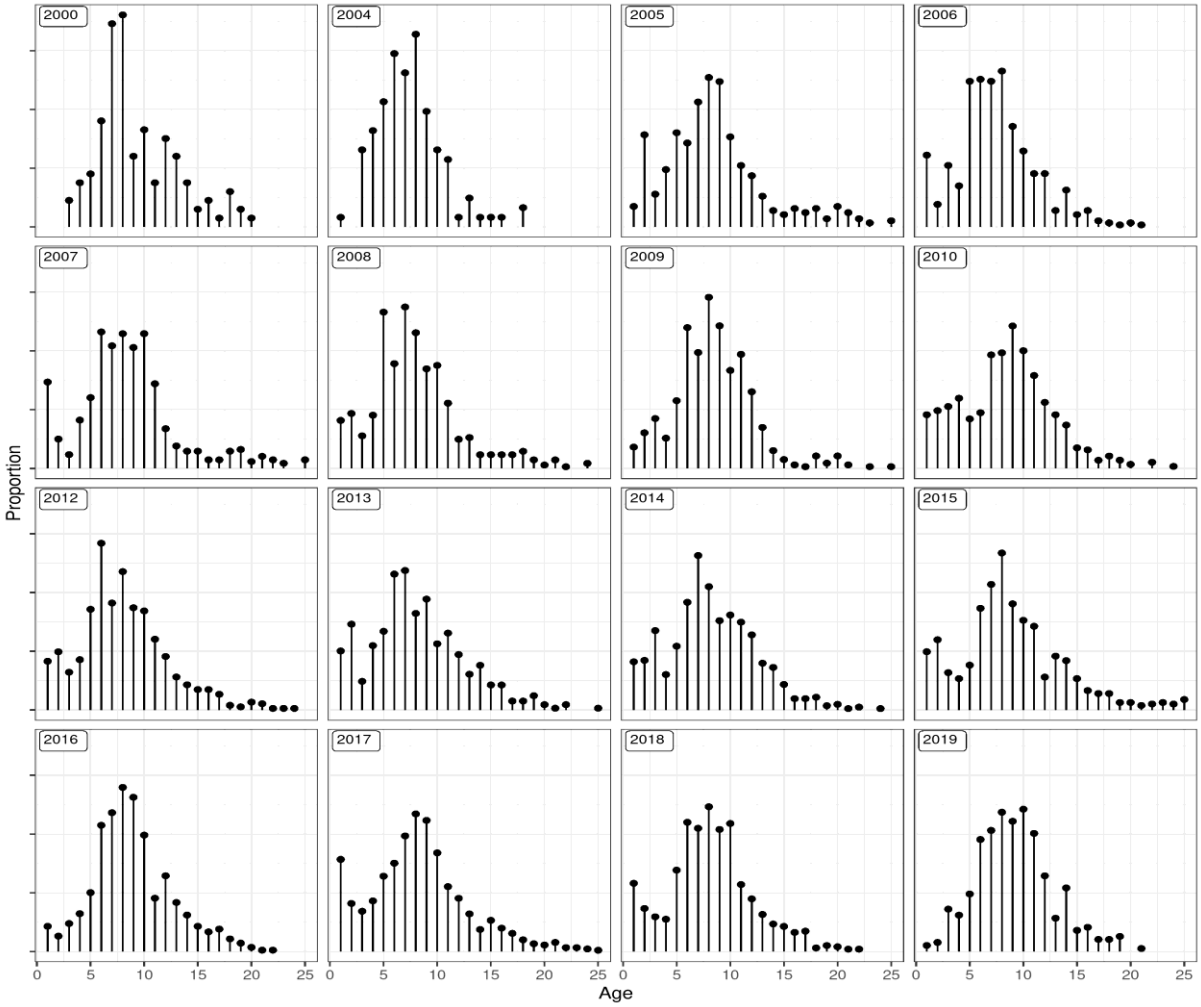

Figure 8: Greater silver smelt. Age distributions in proportions from the Icelandic autumn survey.

Mynd 8. Gulllax. Fjöldi einstaklinga í afla eftir aldri.

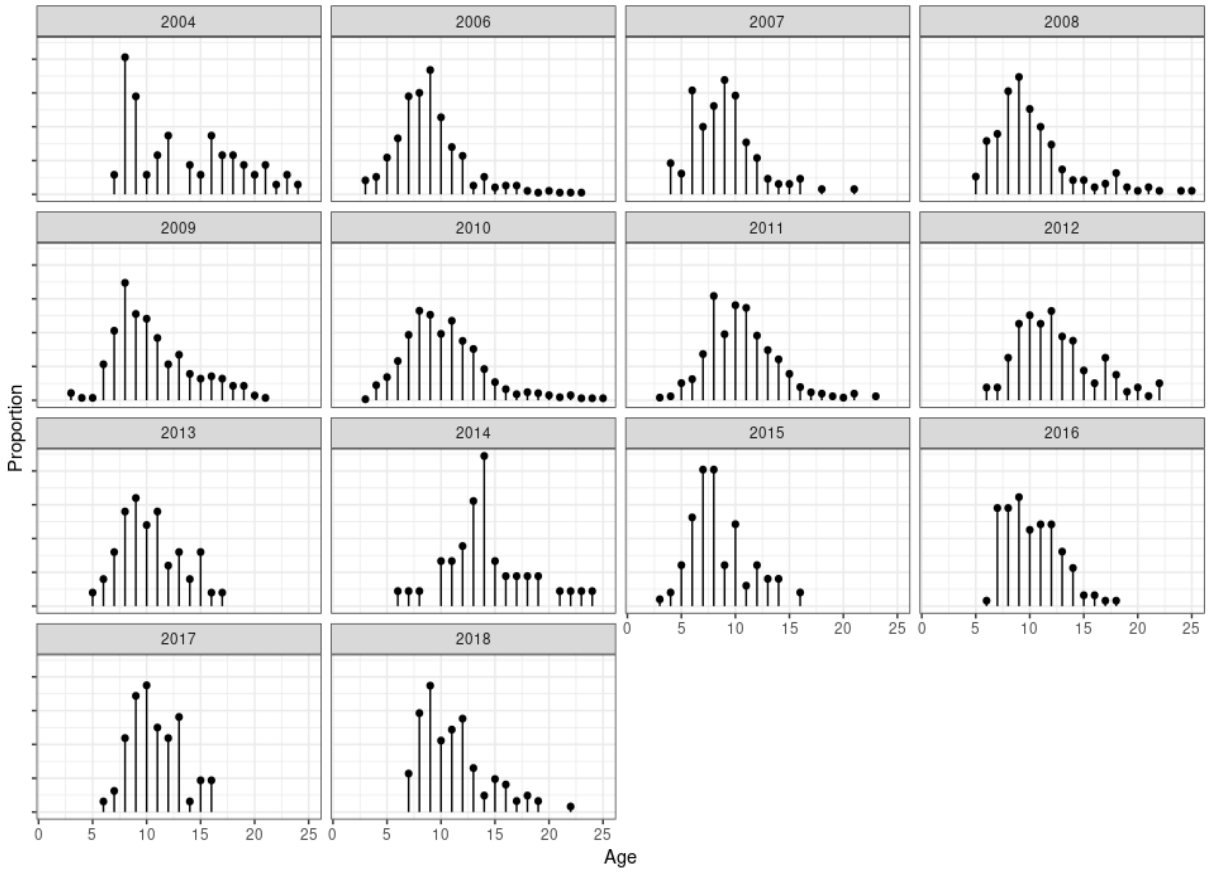

Figure 9. Greater silver smelt. Catch in numbers. No age data available in 2019 from commercial catches

Mynd 9. Gulllax. Fjöldi einstaklinga í afla eftir aldri. Engin aldursgögn eru úr lönduðum afla frá árinu 2019..

WEIGHT AT AGE

No marked changes can be observed in mean weight-at-age from commercial catches.

MATURITY AT AGE AND NATURAL MORTALITY

Estimates of maturity ogives of greater silver smelt in Icelandic waters were presented at the WKDEEP 2010 meeting for both age and length (ICES 2010, GSS-04) 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 RESEARCH VESSEL 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 1985-2020 and for the autumn survey in 2000-2019. 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 an 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 due to the fact that 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.

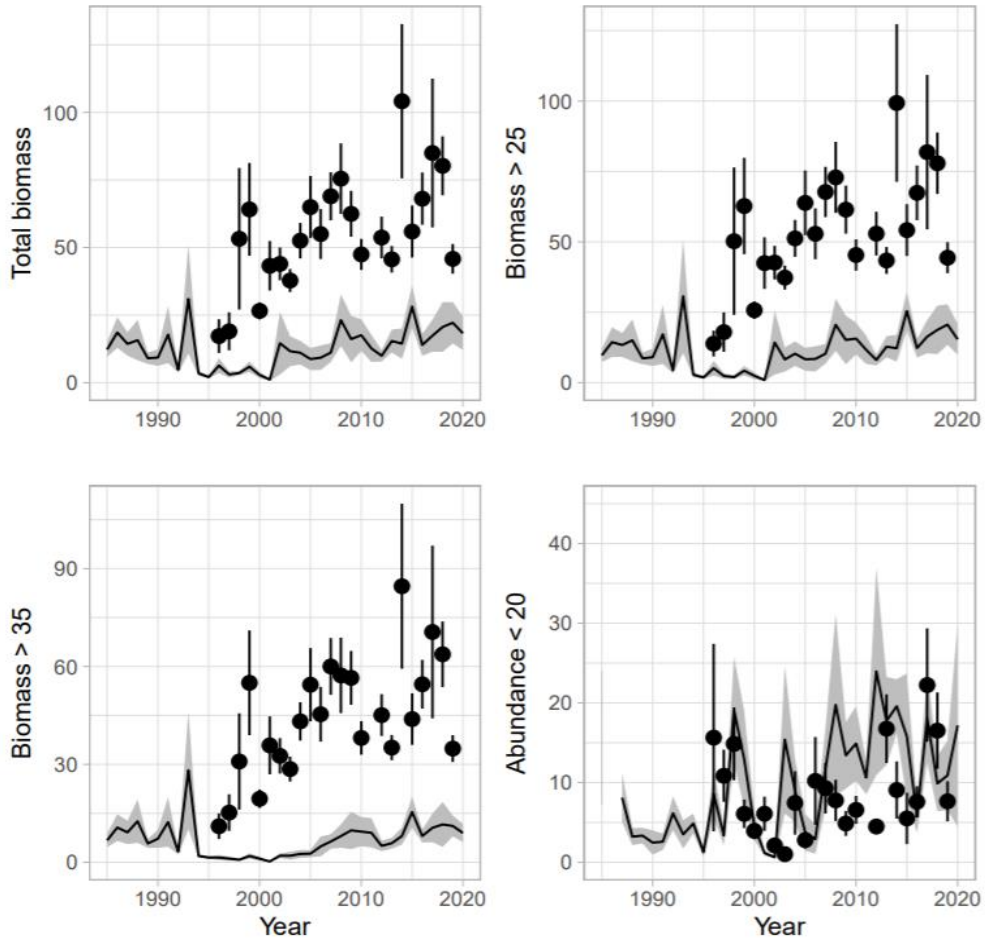

Figure 10. Greater silver smelt. Indices calculated without stratification (mean density) from the Icelandic spring survey (lines and shaded area) and from the autumn survey (dots). Vertical lines and shaded area represent +/- 1 standard error.

Mynd 10. Gulllax. Vísitala úr vorralli (lína með skyggðum svæðum) og haustralli (punktar). Skyggð svæði og lóðréttar línur tákna +/- staðalfrávik.

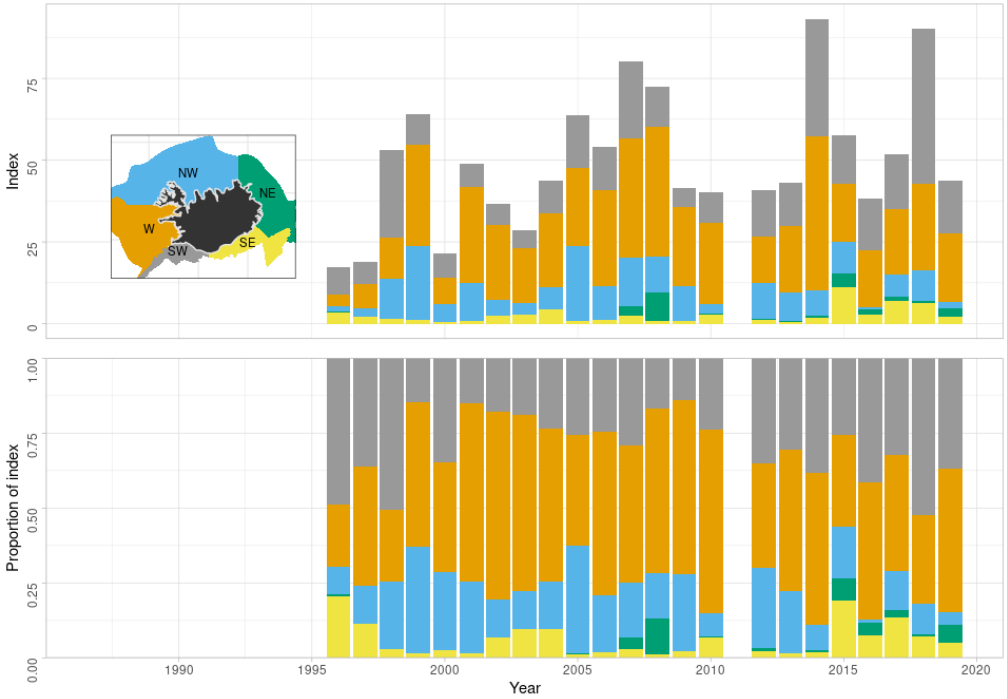

Figure 11. Greater silver smelt. Estimated survey biomass in the autumn survey by year from different areas (upper figure) and as proportions of the total (lower figure).

Mynd 11. Gulllax. Áætluð vísitala úr stofnmælingu botnfiska að hausti eftir árum og svæðum (efri mynd) og hlutfall milli svæða (neðri mynd).

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 3200 tonnes in 2019 (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. 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 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 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 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 .

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, with the exception of 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.

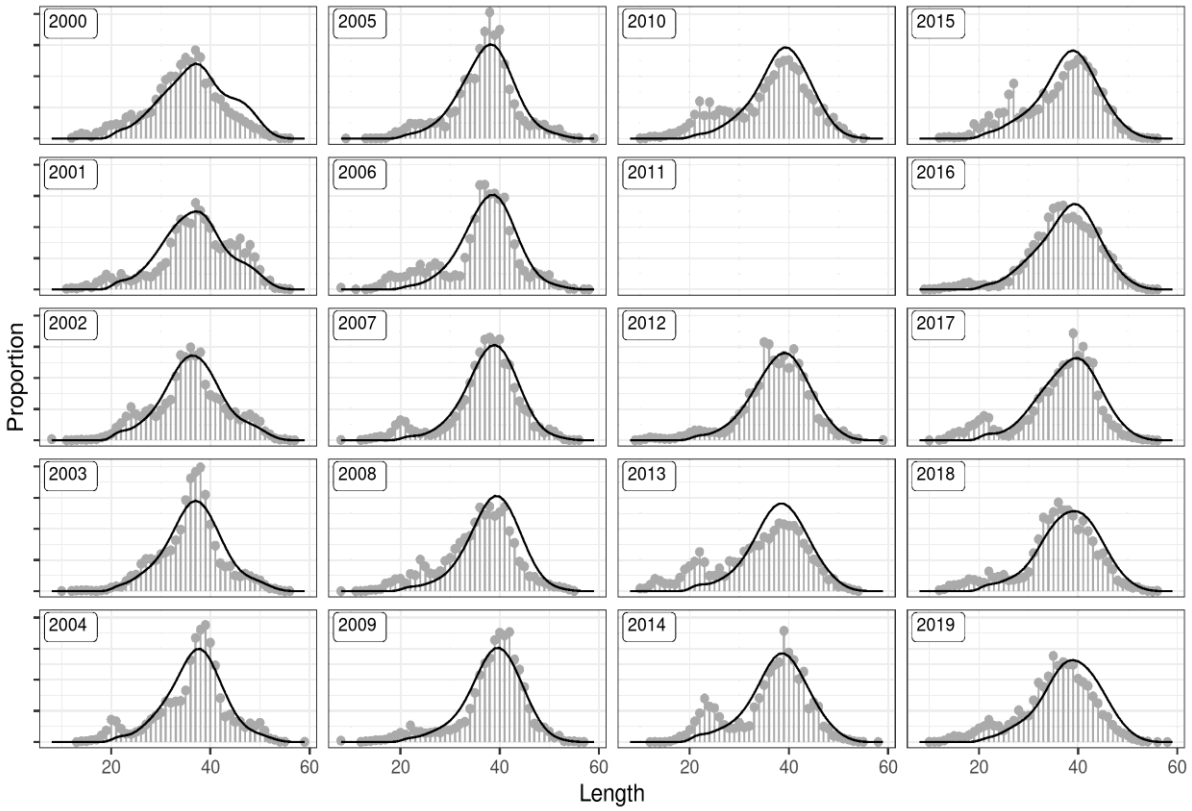

Figure 12: Greater silver smelt. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the autumn survey (vertical lines and points).

Mynd 12. Gulllax. Hlutföll eftir lengdarflokkum úr Gadget líkani (svartar línur) samanborið við fengin hlutföll úr stofnmælingu botnfiska að hausti (lóðréttar línur og punktar).

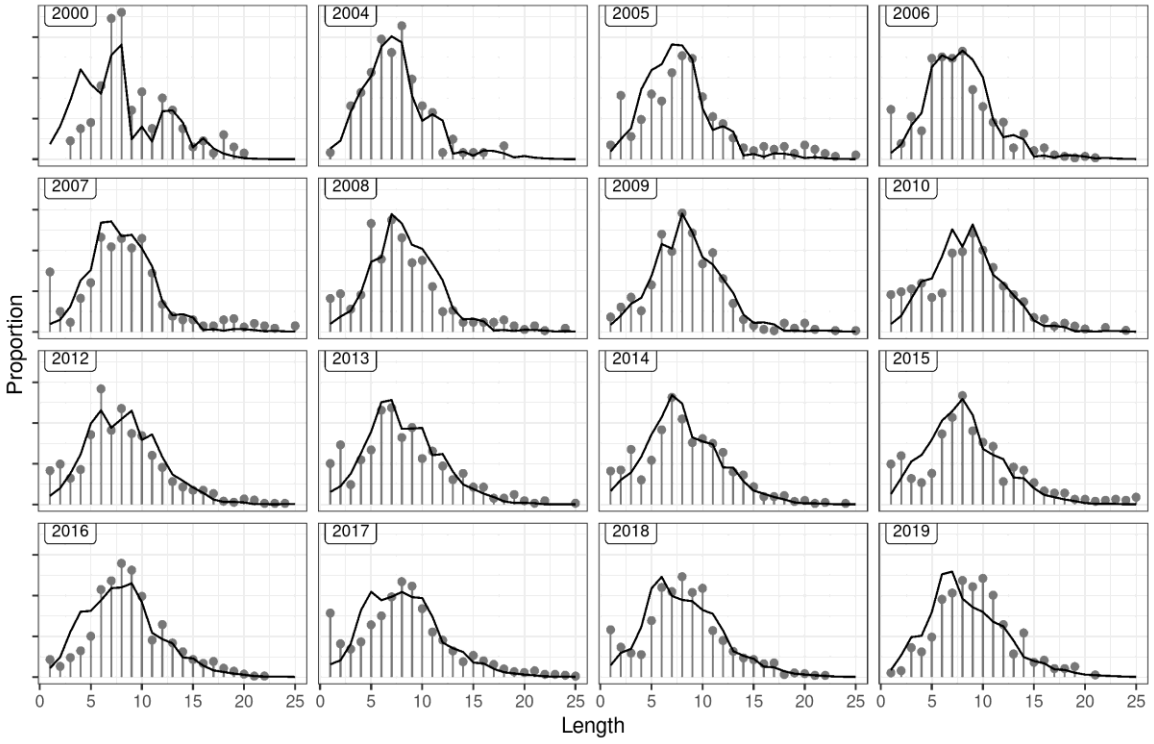

Figure 13: Greater silver smelt. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the autumn survey catches.

Mynd 13. Gulllax. Hlutfall eftir aldursflokkum úr Gadget líkani (svartar línur) samanborið við fengin hlutföll úr stofnmælingu botnfiska að hausti (lóðréttar línur og punktar).

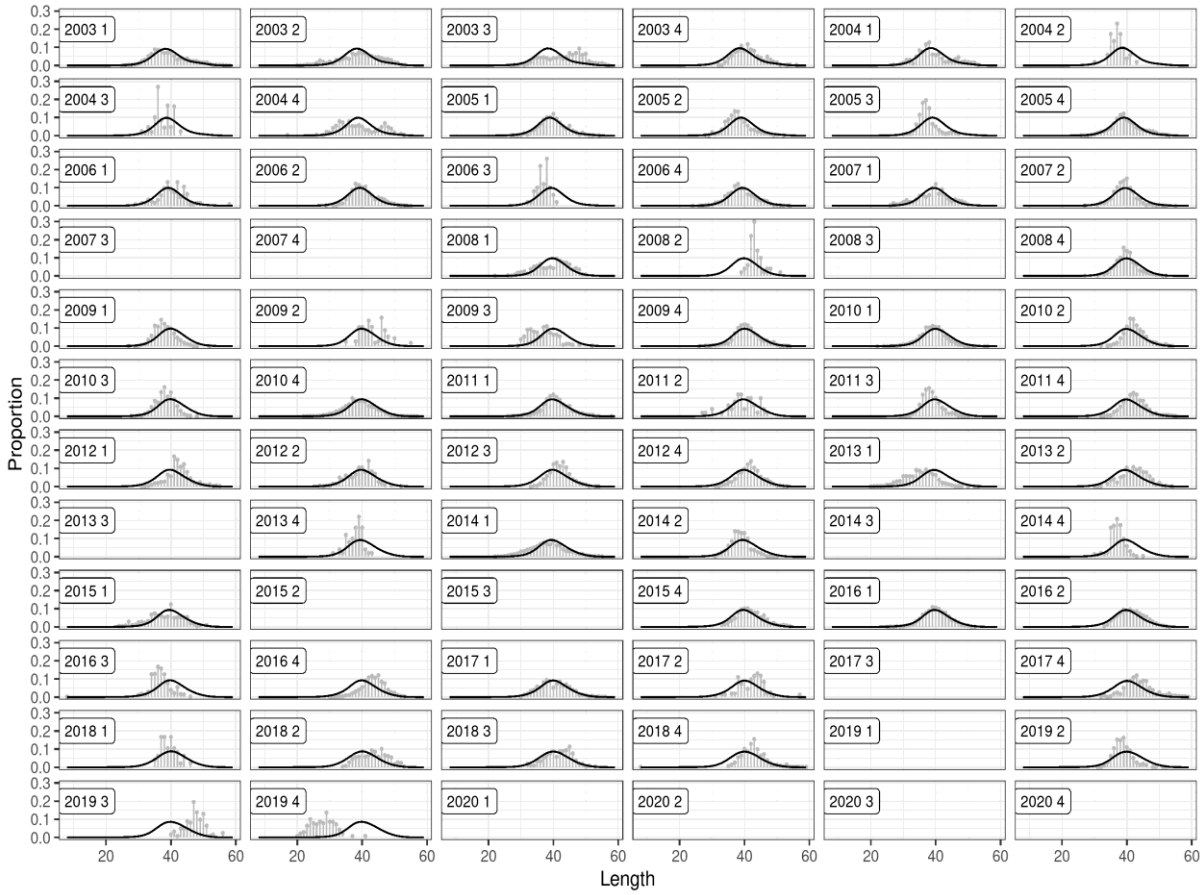

Figure 14: Greater silver smelt. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from commercial catches.

Mynd 14. Gulllax. Hlutföll eftir lengdarflokkum úr Gadget líkani (svartar línur) samanborið við fengin hlutföll úr afla (lóðréttar línur og punktar).

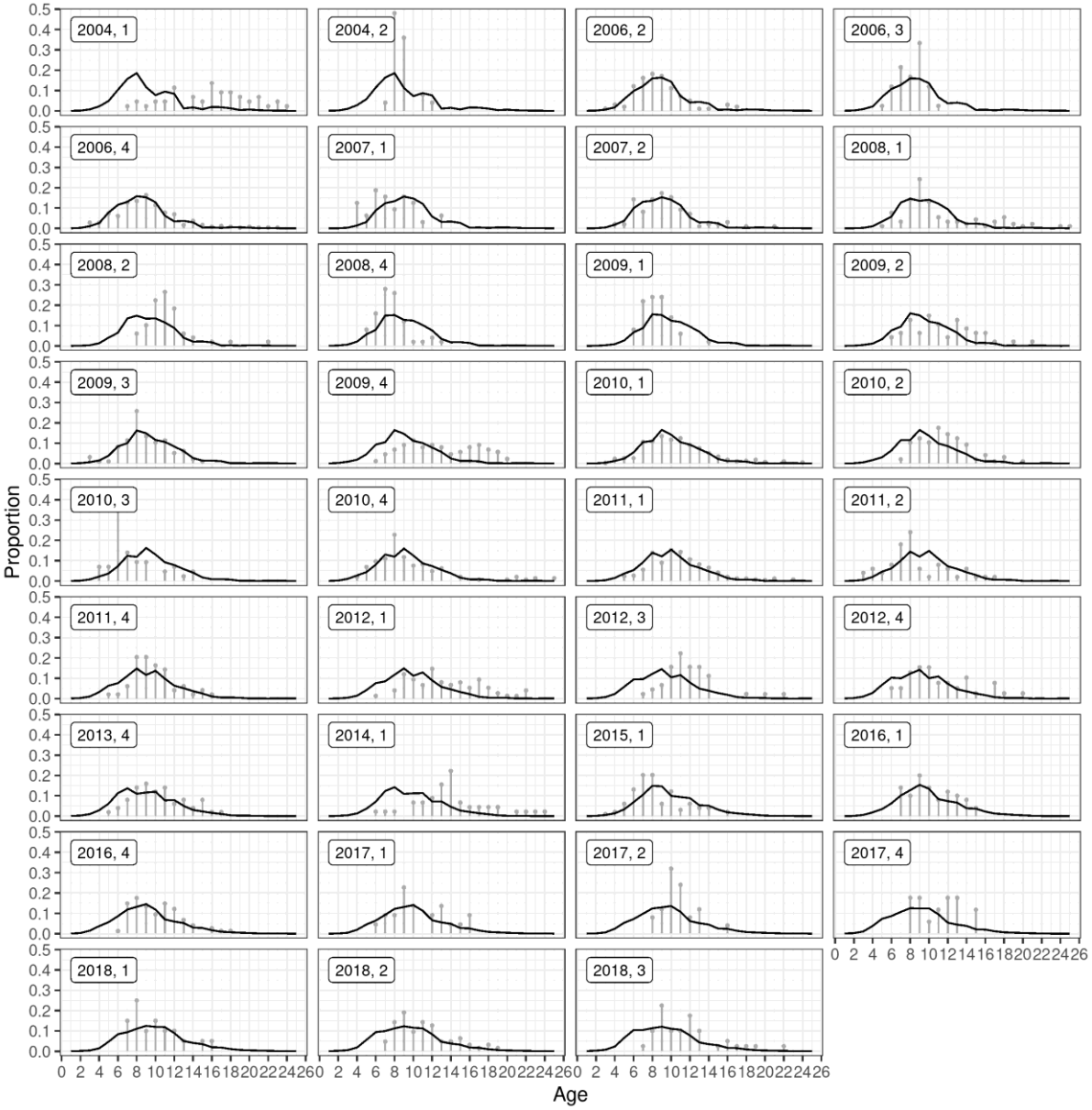

Figure 15: Greater silver smelt. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in commercial catches.

Mynd 15. Gulllax. Hlutfall eftir aldursflokkum úr Gadget líkani (svartar línur) samanborið við fengin hlutföll úr afla (lóðréttar línur og punktar).

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). The terminal estimate has a large overestimation due to very low survey indices this year, indicating the potential for overestimation of biomass this year and downward revisions in coming years, if this trend continues.

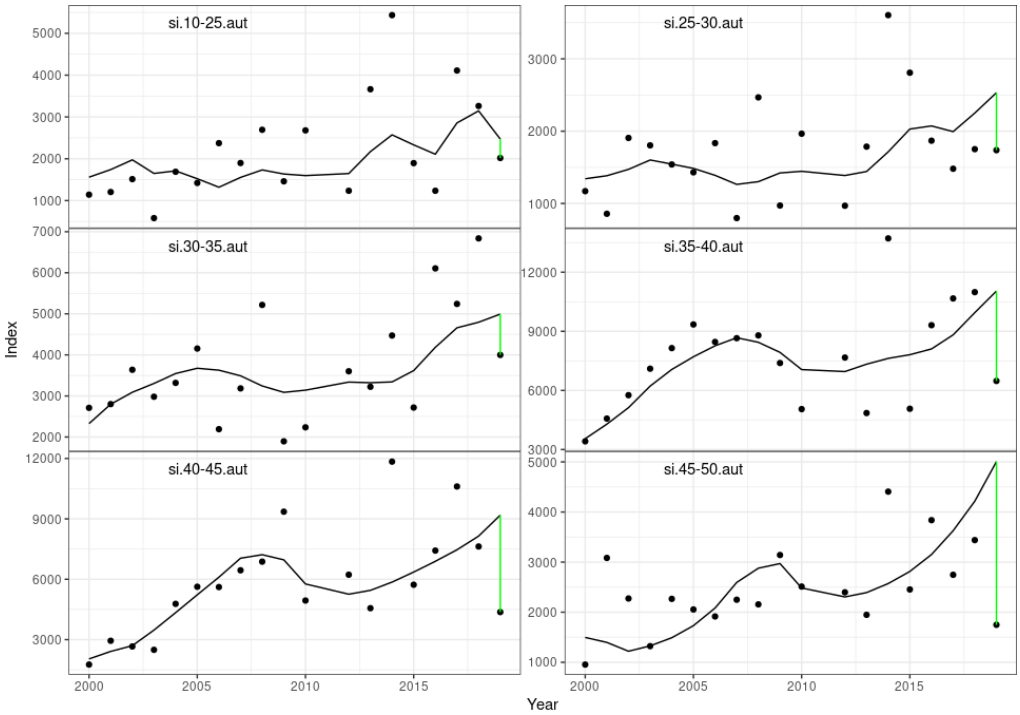

Figure 16: Greater silver smelt. Fitted autumn survey index by length group from the Gadget model (black line) and the observed number of greater silver smelt caught in the survey (points). The green line indicates the difference between the terminal fit and the observations.

Mynd 16. Gulllax. Lífmassavísitala úr Gadget líkani (svartar línur) eftir stærðarflokkum borin saman við fenginn fjölda gulllax í stofnmælingu botfiska að hausti (punktar). Grænar línur sýna muninn á samsvörun gagna og líkans við lok tímabilsins.

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 the terminal year. Fishing mortality for greater silver smelt (age 6–14) has decreased from 0.3 in 2010 to 0.05 over the past several years, due to greater regulation of the fishery as well as reduced commercial interest.

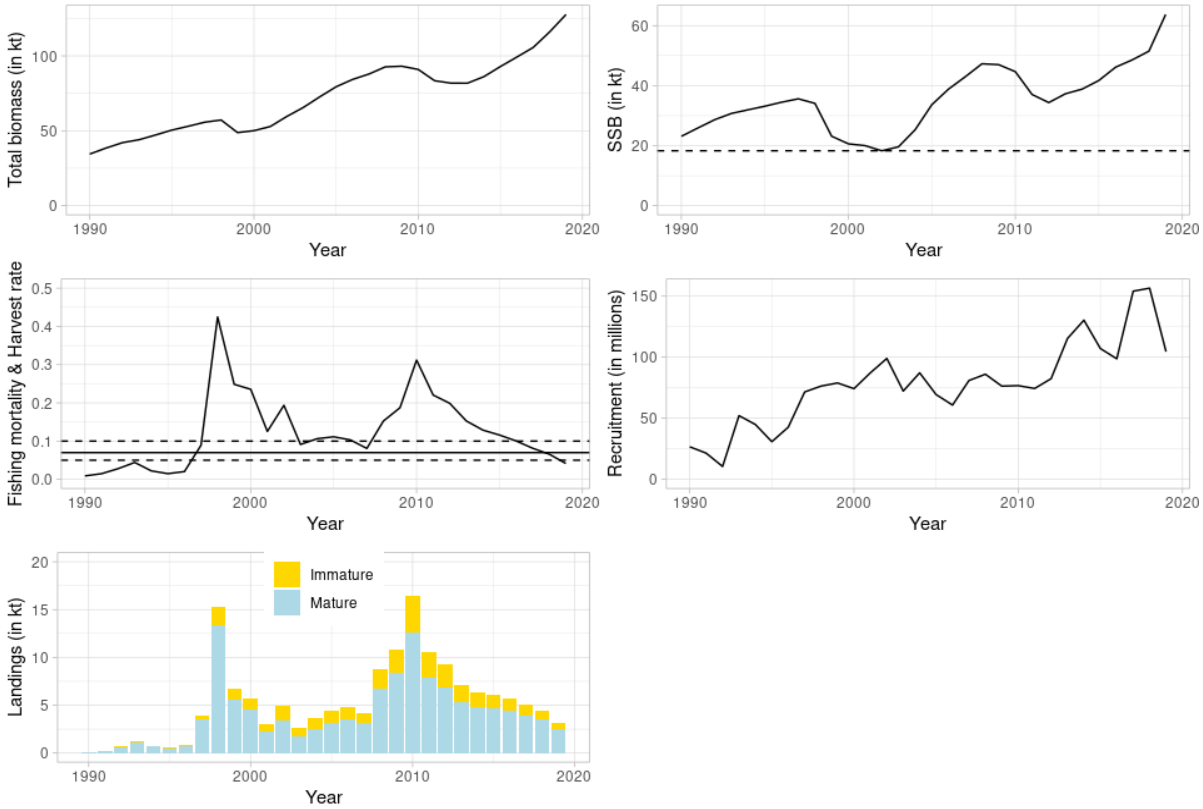

Figure 17: Greater silver smelt. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fishes and harvest rate, recruitment, and total catches. The dashed line in the SSB plot represents Bpa. The solid line in the fishing mortality plot indicates the fishing mortality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

Mynd 17. Gulllax. Áætlaður lífmassi hrygningarstofns, veiðidánartala, nýliðun og heildarafli. Brotin lína við lífmassa hrygningarstofns sýnir gátmörk (Bpa). Heil lína við veiðihlutfall sýnir það gildi sem stefnt er að með aflareglu, en brotnar línur sýna þau mörk sem búast má við vegna óvissu í stofnmati.

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}.

Tafla 5. Gulllax. Niðurstöður úr Gadget líkani (metin stærð hrygningarstofns (SSB, tonn), nýliðun (Rec., 5 ára í milljónum fiska) og fiskveiðidánarstuðull (F)) auk afla (tonn). Framreikningar eru gefnir síðasta árið.

YEAR	TOTAL BIOMASS	CATCH	SSB	REC.	F
1990	34469	113	23134	26613	**0.009**
1991	38514	246	25934	21417	**0.015**
1992	42100	657	28678	10525	**0.028**
1993	44034	1254	30753	52063	**0.044**
1994	47163	756	31970	44792	**0.022**
1995	50477	586	33158	30781	**0.015**
1996	53033	881	34489	42667	**0.020**
1997	55735	3935	35620	71436	**0.089**
1998	57202	15242	34100	76240	**0.425**
1999	48793	6681	23138	78770	**0.249**
2000	50091	5657	20618	74119	**0.235**
2001	52880	3043	20024	87090	**0.125**
2002	59575	4961	18300	98811	**0.194**
2003	65557	2680	19617	72166	**0.091**
2004	72644	3645	25325	87053	**0.106**
2005	79385	4482	33667	69299	**0.111**
2006	84260	4769	38867	60704	**0.103**
2007	87891	4227	42971	80769	**0.081**
2008	92695	8778	47299	85945	**0.153**
2009	93107	10828	47006	76198	**0.187**
2010	90958	16428	44661	76598	**0.312**
2011	83416	10516	37060	74266	**0.220**
2012	81806	9289	34368	82276	**0.199**
2013	81789	7155	37305	115138	**0.153**
2014	86143	6348	38863	130104	**0.129**
2015	92865	6070	41734	106951	**0.116**
2016	99197	5662	46151	98526	**0.101**
2017	105640	5011	48601	153784	**0.081**
2018	115989	4460	51516	156267	**0.066**

2019	127640	3208	63729	104364	**0.042**
2020	138010	10073	69073	109.327	**0.083**
2021	141409	8861	69779	109.327	**0.07**
2022	**145624**	**9397**	**71972**	**109.327**	**0.066**

RETROSPECTIVE ANALYSIS

An analytical retrospective analysis are presented. The analysis indicates that there was an upward revision of biomass over the first 3 years of the 5-year peel followed by a downward revision of biomass (SSB) over the last 2 years, and subsequently an 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 0.097 for SSB, -0.083 for F, and -0.667 for recruitment.

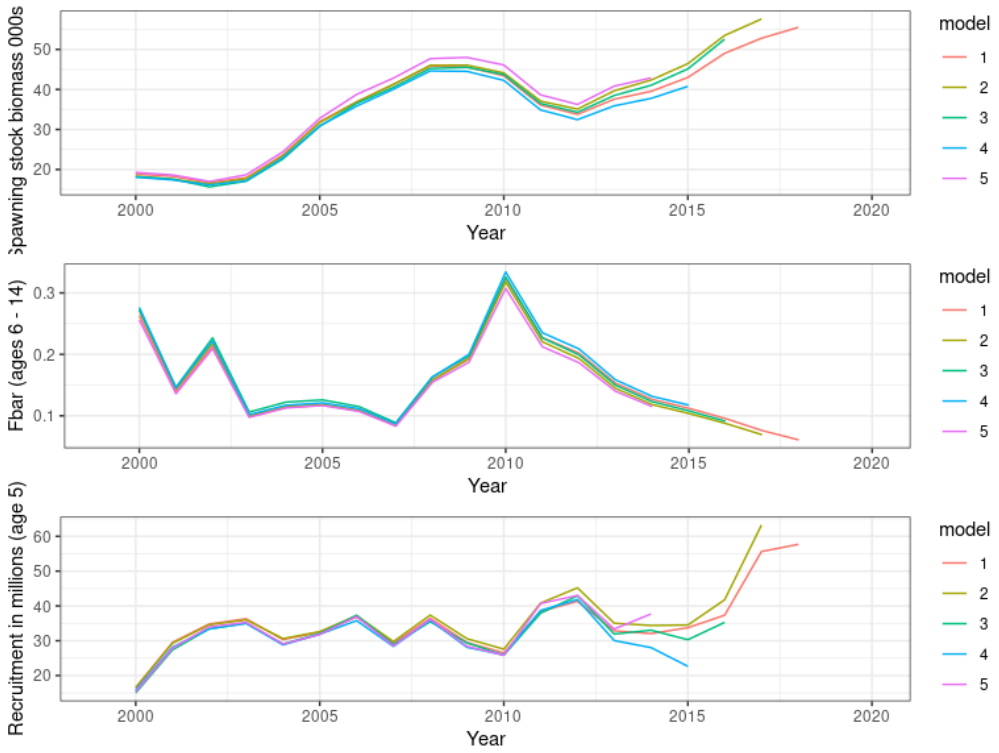

Figure 18: Greater silver smelt. Retrospective plots illustrating stability in mod-el estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 5) are shown.

Mynd 18. Gulllax. Endurlitsgreining sem sýnir stöðuleika í mati líkansins fimm ár aftur í tímann. Niðurstöður eru sýndar fyrir hrygningarstofn (SSB), fiskveiðidánartölu, F og nýliðun (5 ára).

COMMENTS ON THE ASSESSMENT

The assessment was conducted according to the stock annex (ICES 2020).

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, and 7603 t for 2018/2019 (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).

Tafla 6. Gulllax. Tillögur Hafrannsóknastofnunar um hámarksafla, ákvörðun stjórnvalda um aflamark og landaður afli (tonn).

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**	

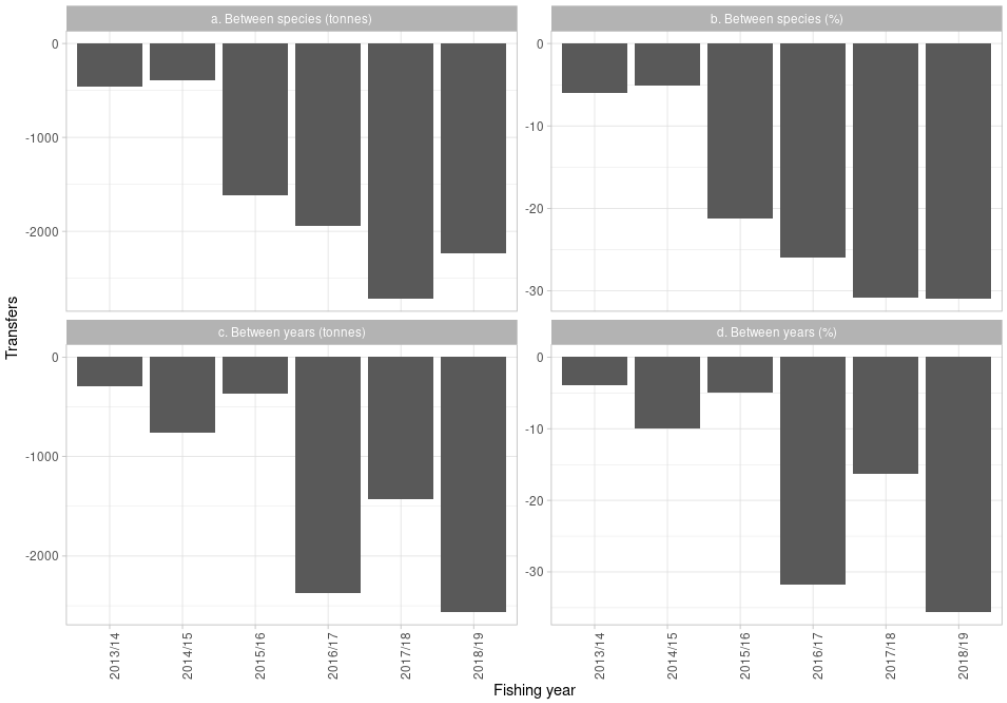

Figure 19. Greater silver smelt. Net transfer of quota in the Icelandic ITQ system by fishing year. Between species (upper): Positive values indicate a transfer of other species to greater silver smelt, but negative values indicate a transfer of greater silver smelt quota to other species. Between years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

Mynd 19. Gulllax. Nettó tilfærsla á kvóta eftir fiskveiðiárum. Tilfærsla á milli tegunda (efri mynd): jákvæð gildi tákna tilfærslu á kvóta annarra tegunda yfir á gulllax en neikvæð gildi tilfærslu gulllaxkvóta á aðrar tegundir. Tilfærsla milli ára (neðri mynd): Nettó tilfærsla kvóta frá viðkomandi fiskveiðiári (gæti innihaldið ónotaðan kvóta).

CURRENT ADVISORY FRAMEWORK

In past years, an Fproxy of 0.171 was applied under an ICES Category 3 framework as a factor to a winsorized autumn survey index. The current advisory framework is currently under consideration as part of the WKGSS 2020 benchmark proceedings. Pending results of this benchmark, the following reference points were defined for the stock:

Table 7: Greater silver smelt. Reference points.

Tafla 7. Gulllax. Viðmiðunarmörk.

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}

The ICES MSY advice rule is applied for this stock. The decision which allocates catches to the fleets requires 1) an expected quantity of catch to be removed that will complete total catch removals for the current fishing season, 2) a 1-year projection to determine the amount of biomass available to fish, and 3) application of projected fishing effort according to 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 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 favorable environmental conditions have led to high recruitment levels over the past decade.

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