15 Atlantic wolffish (*Anarcichas lupus*) in Division 5.a (Icelandic grounds)

15.1 Atlantic wolffish in 5a

15.1.1 Fishery

The main fishing grounds for Atlantic wolffish are in the west and northwest part of the Icelandic shelf. From 2010, the proportion of the catch has been increasing in northwest of Iceland compared to west of Iceland. Catches at the main spawning ground (Látragrunn) west of Iceland have been decreasing since 2008 (Figures 15.1.1 and Figure 15.1.2). About 80% of the catch of Atlantic wolffish is caught at depths less than 120 m. Proportion of the catch taken at depth range 0-60 m decreased from 2003 to 2007, but since then it has been increasing. At the depth range 61-120 m the proportion of the catch has been rather stable since 2000. At depths from 121 to 180 m, which includes the main spawning ground (Látragrunn), it the proportion of the catch increased in 2003-2008 but since then it has been decreasing (Figure 15.1.3).

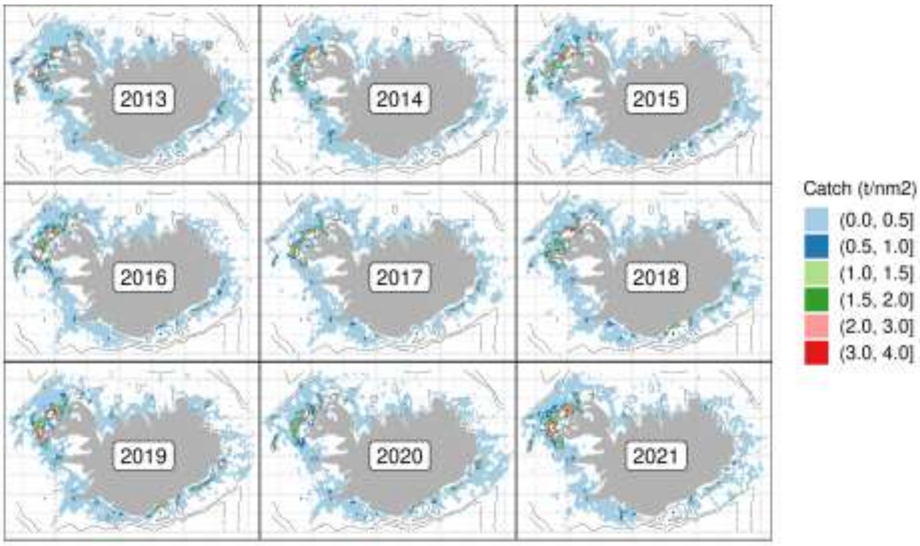

Figure 15.1.1 Atlantic wolffish in 5.a. Geographical distribution of the Icelandic fishery since 2013 as reported in logbooks. All gear types combined.

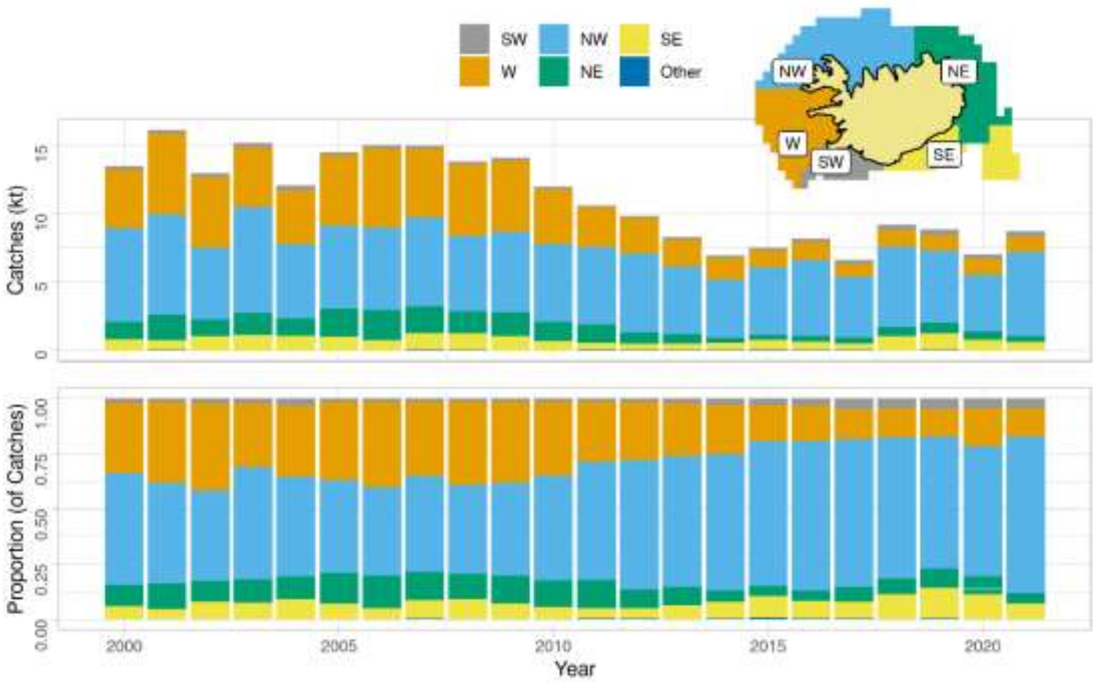

Figure 15.1.2: Atlantic wolffish in 5a. Spatial distribution of the Icelandic fishery by fishing area since 2000 according to logbooks. All gears combined.

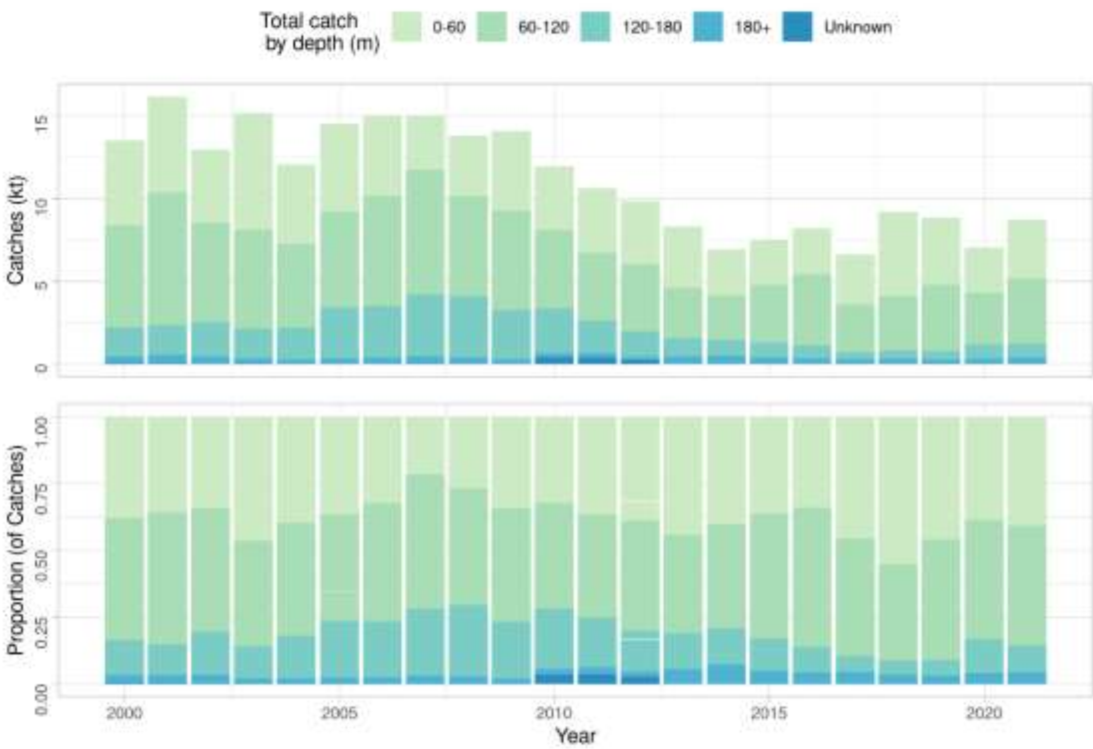

Figure 15.1.3. Atlantic wolffish in 5.a. Depth distribution of demersal trawl, longline and demersal seine catches according to logbooks.

15.1.2 Landings trend

More than 97% of the Atlantic wolffish catch is taken by longliners (50-65%), demersal trawlers (20-30%) and demersal seiners (about 10%) (Figure 15.1.4). These proportions have been relatively stable through the years. However, in 2004-2008 longline and demersal trawl catches were similar (40-50%) and in the last three years catches by demersal seiners hasve been increasing and are now greater than in demersal trawlers (Figure 15.1.4). Since 2001, the number of longliners and trawlers reporting Atlantic wolffish catches of 10 tonnes/year or more has decreased. In the longline fleet, the number of vessels has dropped from 198 in 2001, down to 67 in 2018. The number of trawlers has also decreased significantly from 76 in 2000 to 40 in the last year (Table 1).

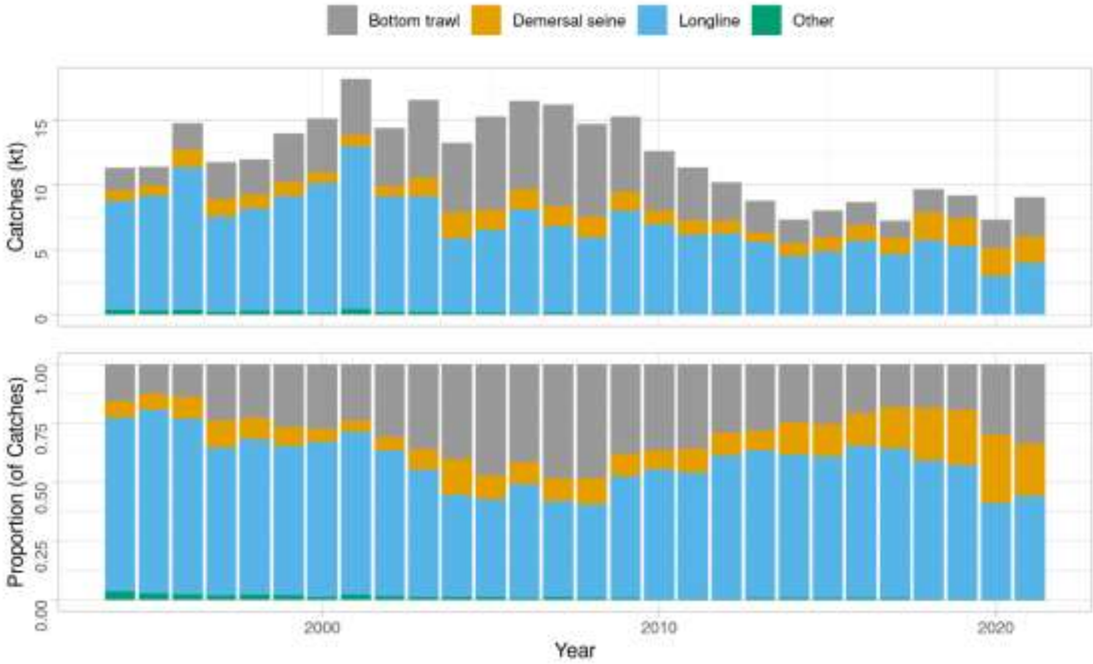

Figure 15.1.4. Atlantic wolffish in 5.a. Total catch (landings) by fishing gear since 1994, according to statistics from the Directorate of Fisheries.

In 1994 and 1995, more than 500 vessels accounted for 95% of the annual catch of Atlantic wolffish in Icelandic waters, but this number had dropped to 200 vessels in 2008 despite higher catches. Since 2010 the number of vessels accounting for 95% of the annual catch has remained relatively constant (about 150-200 vessels), despite catch reductions (Figure 15.1.5).

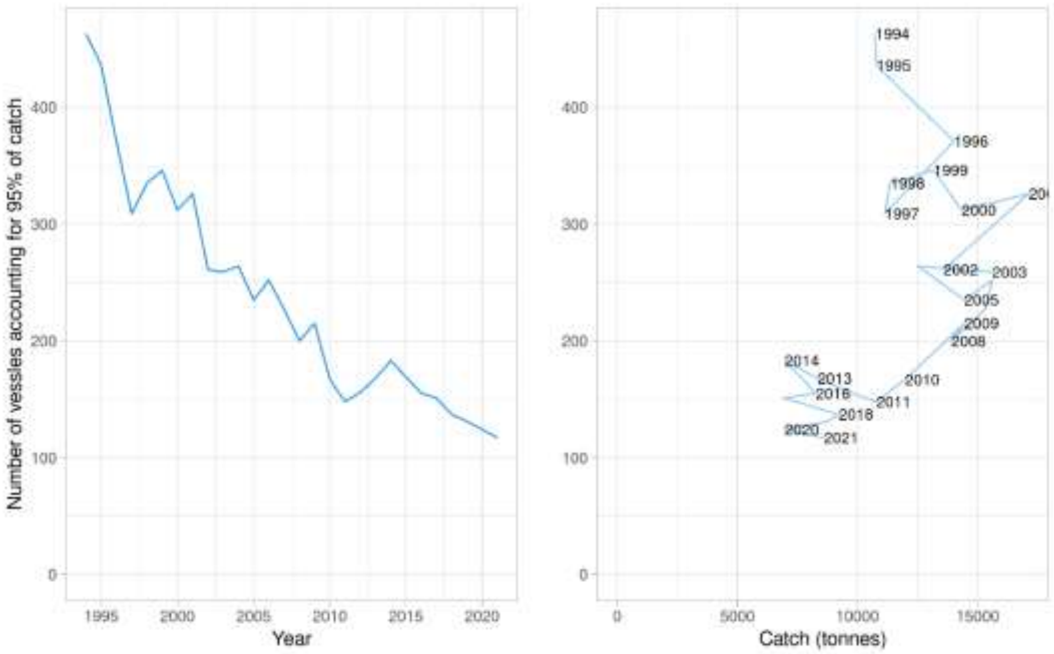

Figure 15.1.5. Atlantic wolffish in 5.a. Number of vessels (all gear types) accounting for 95% of the total catch annually since 1994. Left: Plotted against year. Right: Plotted against total catch. Data from the Directorate of Fisheries.

15.1.3 Data available

The commercial catch samples taken are normally representative of the landings with most number of samples taken in areas of high catch intensity (Figure 15.1.7).

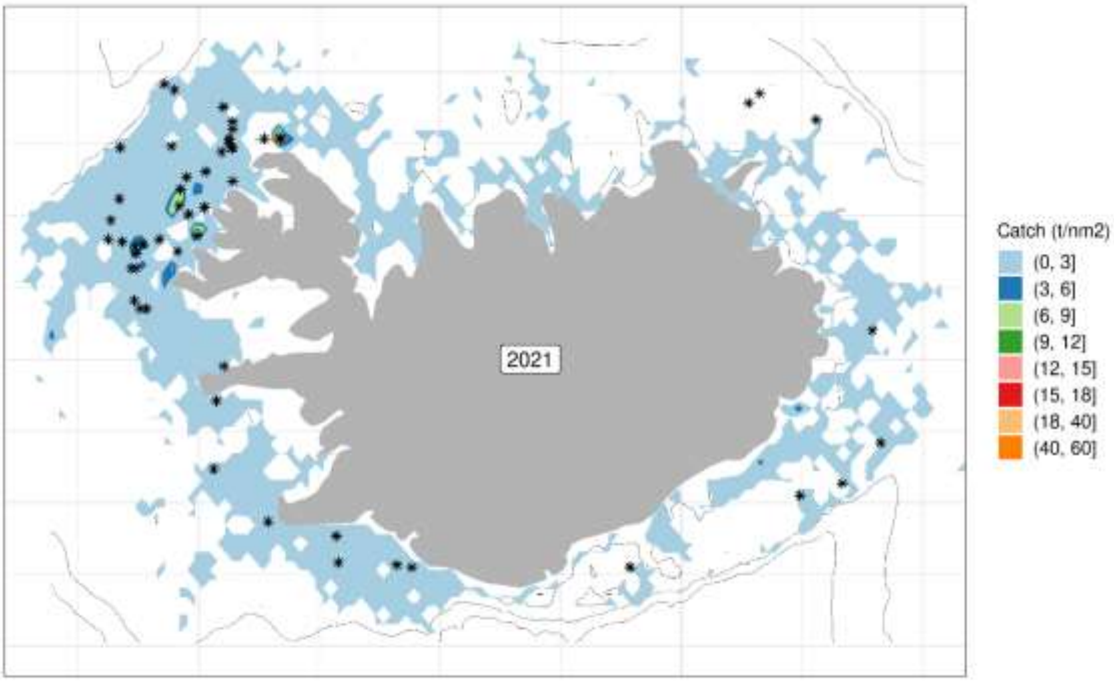

Figure 15.1.7. Atlantic wolffish in 5.a. Fishing grounds in 2021 as reported in logbooks and positions of samples taken from landings (asterisks).

15.1.3.1 Landings and discards

Landings by Icelandic vessels are given by the Icelandic Directorate of Fisheries. Landings of Norwegian and Faroese vessels are given by the Icelandic Coast Guard. Discarding is banned by law in the Icelandic demersal fishery, as well as in Norway. Measures in the Icelandic management system such as converting quota share from one species to another are used by the Icelandic fleet to a large extent, and this is thought to discourage discards in mixed fisheries.

15.1.3.2 Length composition

The length distribution of landed Atlantic wolffish has been relatively stable since 2004 (Figure 15.7.8). The average length in the commercial catch increased from about 65 cm in 2003 to about 70 cm in 2011 where from it has been similar.

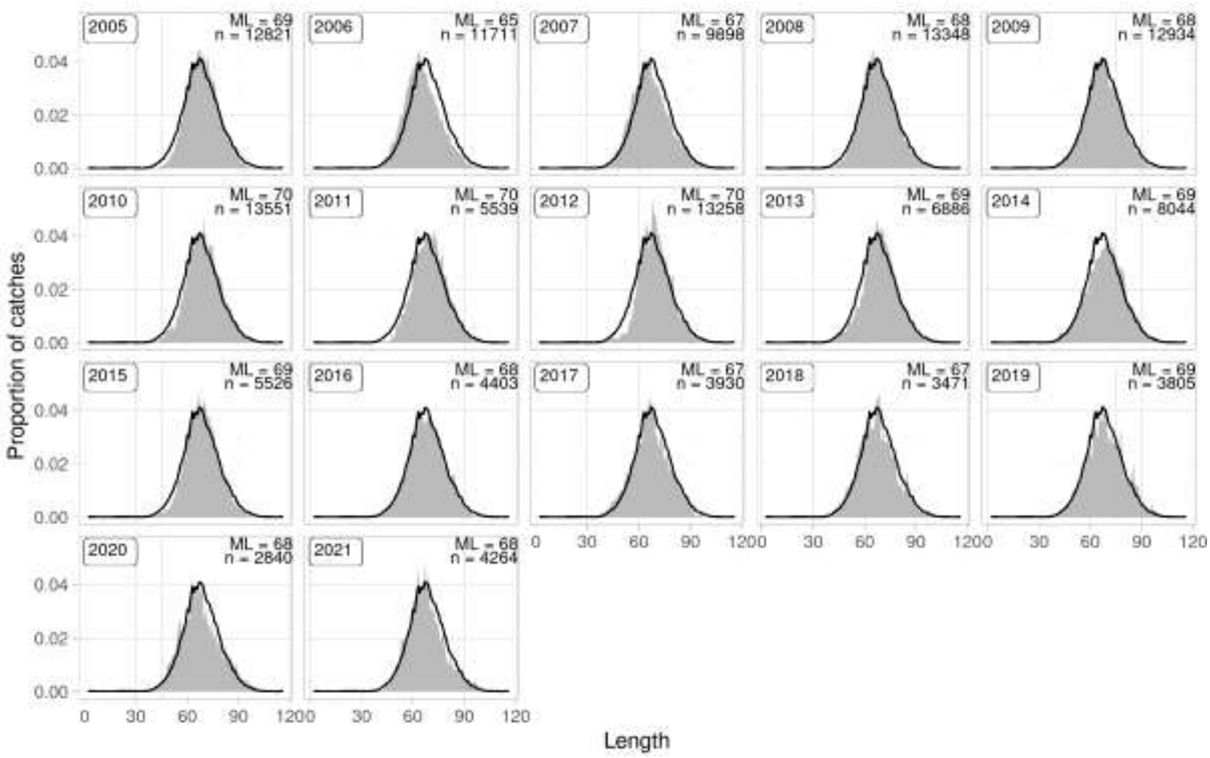

Figure 15.7.8. Atlantic wolffish in 5.a. Length distribution of fish sampled from landed catch. The black line represents the mean length distribution for the period.

Since 2004, the length frequency distribution in the spring survey has been bimodal because of a relatively greater decrease in number of fish at 40-60 cm (Figure 15.7.9). The mean length of Atlantic wolffish has been about 39 cm on average. It was, however, lowest in 1994-2004, about 37 cm, but in these years the recruitment index was high. Due to decreasing recruitment beginning 2004 (Figure 15.7.9), the mean length increased and was on the average about 42 cm in 2007-2021 (Figure 15.7.9). Mean length in the autumn survey oscillated from 34-40 cm in 1996-2021, with no clear trend (Figure 15.7.10).

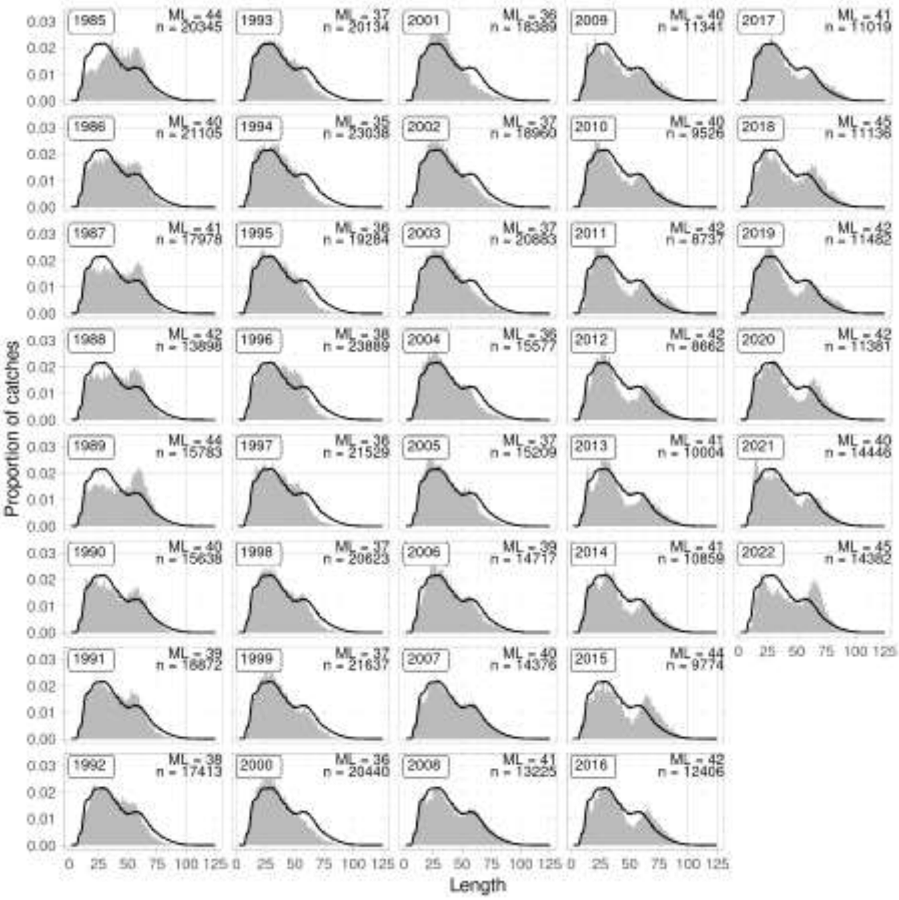

Figure 15.7.9. Atlantic wolffish in 5.a. Length distribution from the spring survey. The black line shows the mean for all years.

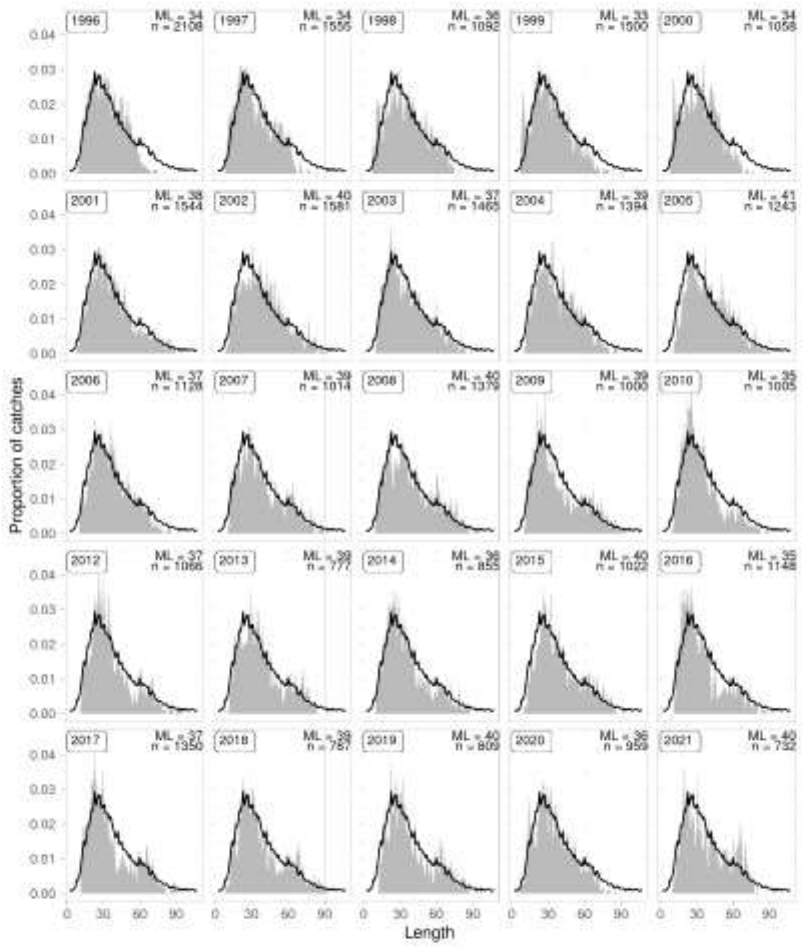

Figure 15.7.10. Atlantic wolffish in 5.a. Length distribution from the autumn survey. The black line shows the mean for all years.

15.1.3.3 Age composition

Age composition data are available from surveys. Commercial age data are available from earlier periods (1978). In samples from commercial landings, the mean age of Atlantic wolffish was around 10.7 years in 1999. Since then, mean age in samples from commercial catches has generally been increasing to around 12 years in recent years.

15.1.3.4 Weight-at-age

Weight-at-age data in Icelandic waters are available from 1996.

15.1.3.5 Maturity and natural mortality

Females have the most reliable maturity designations; a maturation scale for males is unavailable. Therefore, maturity analysis is based on females caught during the autumn survey and in commercial catches from June – December. From these data, maturation occurs close to 60 cm and around age 10 but is highly variable and difficult to measure. No information is available on natural mortality. For assessment and advisory purposes, the natural mortality is set to 0.15 for all age groups.

15.1.3.6 Catch, effort and survey data

CPUE estimates of Atlantic wolffish in Icelandic waters are not considered representative of stock abundance, as changes in fleet composition, technical improvements and differences in gear setup among other things have not been accounted for when estimating CPUE. Effort of demersal trawl was defined as the number hours towed, and for longline number of hooks. Non-standardised estimates of CPUE in longline (kg/1000 hooks), and demersal trawl (kg/hour), are calculated as the total weight in a set or tow per effort measure. For both effort and CPUE meadsures, only sets or tows in which Atlantic wolffish was more than 10% of the catch, according to logbooks, were included. CPUE in longline vessels has been similar among years prior to 2018, around 100-150 kg/1000 hooks. CPUE of demersal trawl increased from about 230 to 400 kg/h in 2000-2005, but since 2006 it has fluctuated at around 250-300 kg/h (Figure 15.7.11). Fishing effort in longline increased from 66 million hooks in 2000 to 97 million hooks in 2001. Since then it has been generally decreasing and was around 22 million hooks in 2018. In demersal trawl, fishing effort increased from about 14 thousand tow-hours in 2004 to 23 thousand tow-hours in 2008, followed by a sharp decrease to 4.8 thousand tow-hours in 2014. Since then it has been at a similar level, but with a notable decrease in 2017 (Figure 15.7.11).

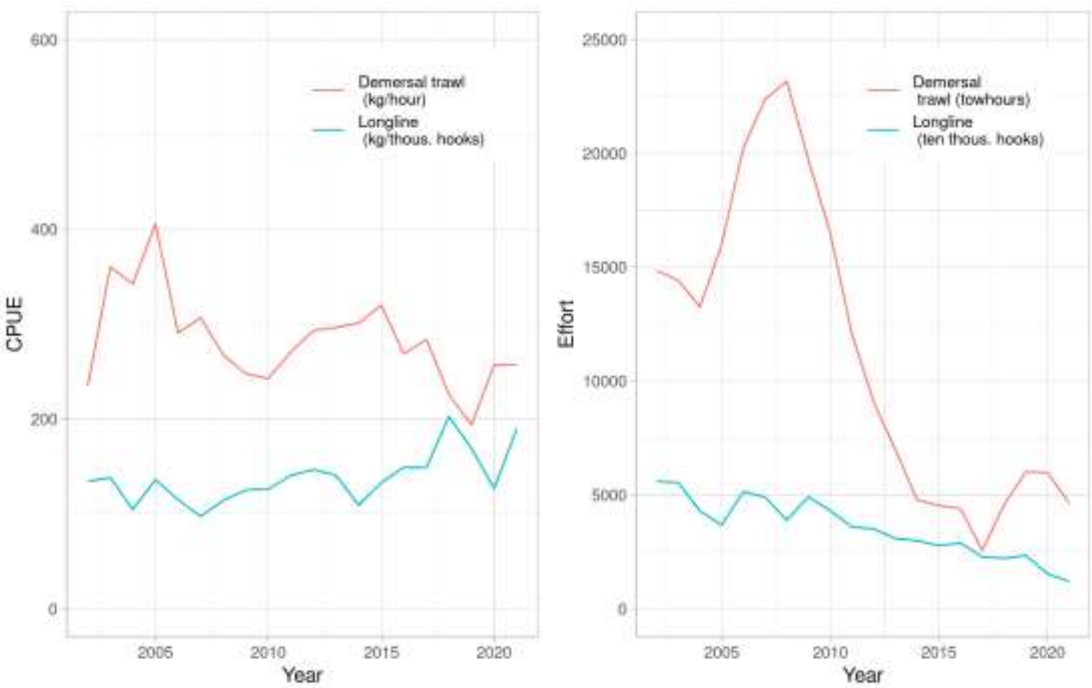

Figure 15.7.11. Atlantic wolffish in 5.a. Non-standardized estimates of CPUE (left) from demersal trawl (kg/h) and long-line (kg/1000 hooks). Fishing effort (right) for longline (10000 hooks) for demersal trawl (tow-hours).

Total biomass and harvestable biomass indices decreased from 1985-1995. In 1996, the biomass index increased to 1998, then decreased to a historical low level in 2010-2012, but since then it has been increasing (Figure 15.7.12). The harvestable biomass has generally been increasing from 1995 with considerable oscillators. The recruitment index was high in the years 1992-2003, since 1999 it has been decreasing, which coincides with increasing effort and catch of trawlers at the main spawning ground west of Iceland (Látragrunn) during the spawning and incubation time. The recruitment index reached a historical low level in 2011, but since then it has been rather stable or increased slightly. This coincides with that the closed spawning/incubation area on Látragrunn was enlarged from 500 km^2 (from 2002) to 1000 km^2 in October 2010.

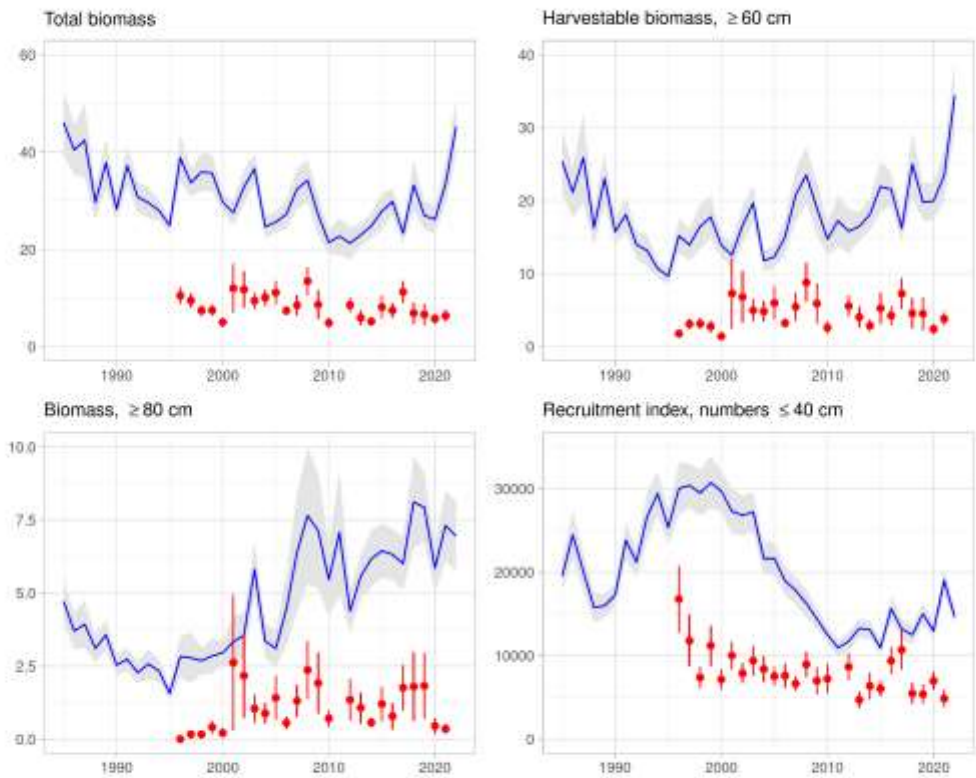

Figure 15.7.12. Atlantic wolffish. Total biomass indices (upper left) and harvestable biomass indices (≥60 cm, upper right), large fish biomass indices (≥80 cm, lower left) and juvenile abundance indices (≤40 cm, lower right), from the spring survey (blue) and the autumn survey (red), along with the standard deviation.

When the spring survey is conducted, Atlantic wolffish are on their feeding grounds which are commonly in relatively shallow waters. In the spring survey, the highest abundance has always been measured in the NW area (Figure 15.7.13).

Figure 15.7.13. Atlantic wolffish in 5.a. Spatial distribution of biomass index from the spring and autumn survey.

15.1.4 Data analysis

15.1.4.1 Assessment on Atlantic wolffish in Icelandic waters using SAM

Atlantic wolffish in 5.a is new to ICES where it became a part of the ICES assessment process after an MoU between Iceland and ICES was signed on December 1st, 2019.

During the benchmark in April 2022, a SAM model (State-space stock assessment model) was agreed upon for use in the assessment.

15.1.4.2 Data used by the assessment and model settings

The new assessment model is a statistical catch at age model based on:

- commercial catch-at-age and landings data from 1979 onwards
- the Icelandic spring groundfish survey from 1985
- the autumn groundfish survey in Iceland from 2000.Recruitment at age 1 every year

The maximum age of the model is 16, which is considered a plus group. The assessment showed that SSB has been rather stable over the time period, while fishing mortality has gradually decreased, and recruitment has slightly decreased after 2001 but remained stable.

Natural mortality of 0.15 was chosen for all age groups. During the workshop, a wide range of estimates for natural mortality were tested and none showed a significant improvement in terms of model fit. It was therefore decided to use a M of 0.15.

15.1.4.3 Diagnostics

Fits to the catch-at-age data and survey numbers-at-age indices can be found in Figure 15.1.14). The fit to total catch and landings data can be found in figures 15.5.15) and 15.1.16). Catch and spring survey data are followed the closest by the model, whereas fits to the autumn survey series are slightly noisier but follow a similar pattern. Fits to landings data are quite variable, but more recent fits catch at age data are better.

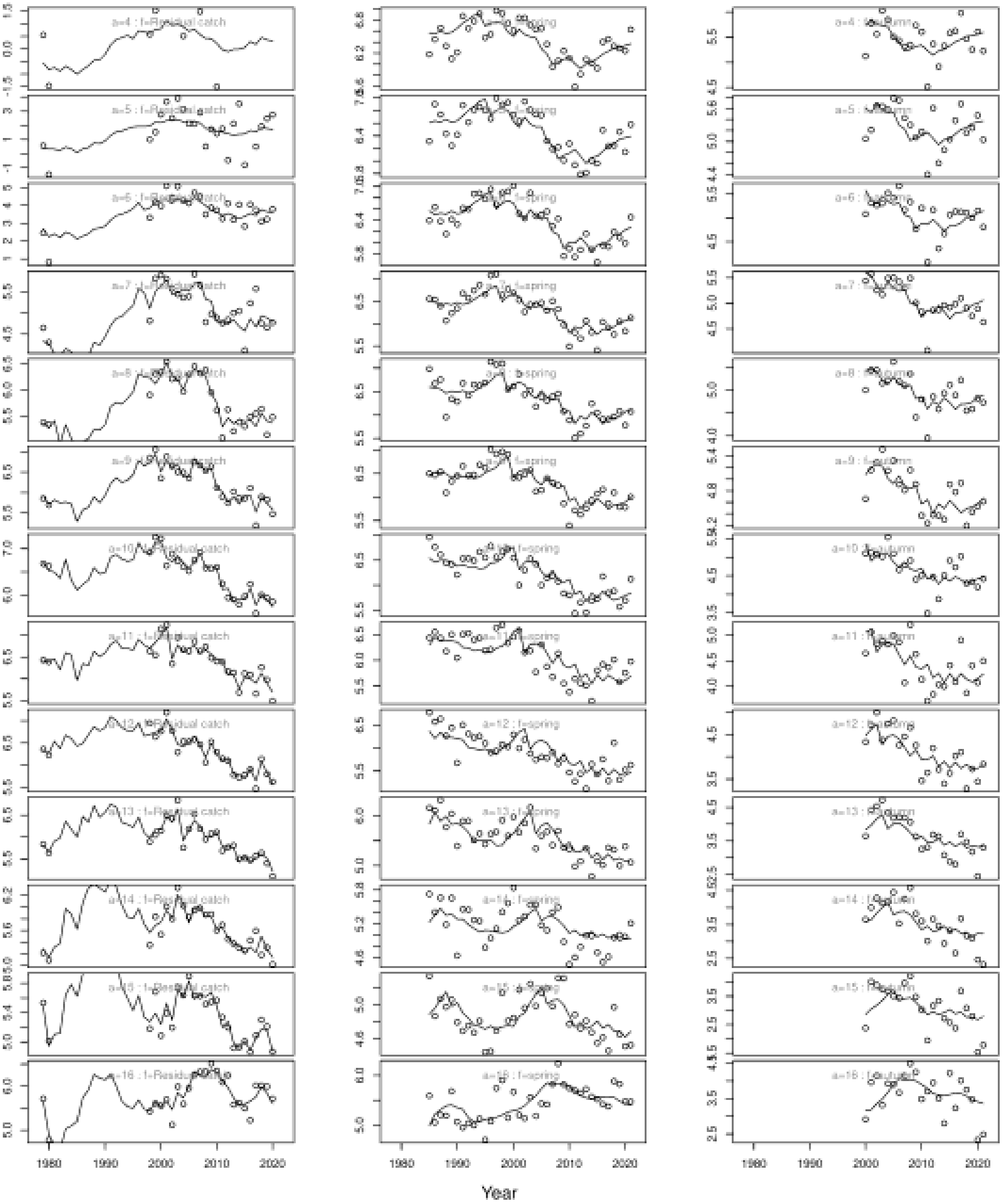

Figure 15.1.14 Atlantic wolffish in 5.a. Fit to the numbers at age input data to the proposed SAM model (columns left to right: catch, spring survey, and autumn survey.

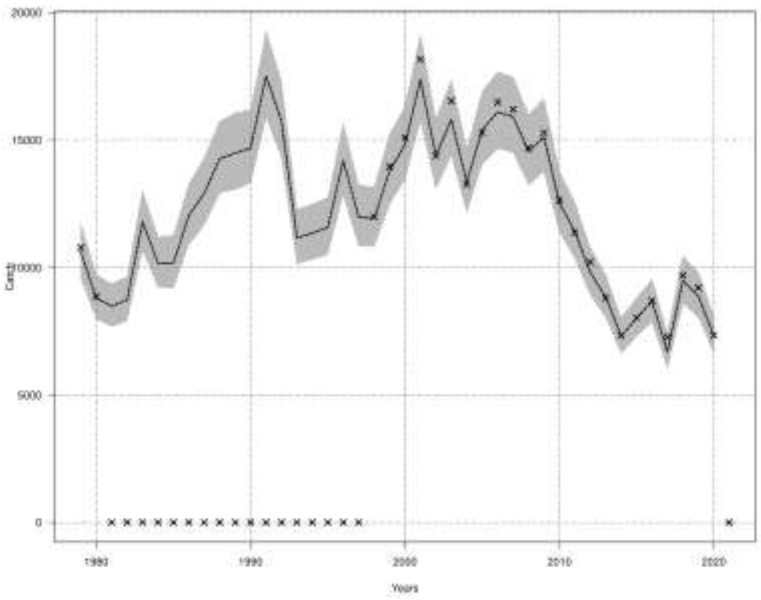

Figure 15.1.15. Atlantic wolffish in 5.a. Atlantic wolffish in 5.a. Fit to the total catch in the proposed SAM model.

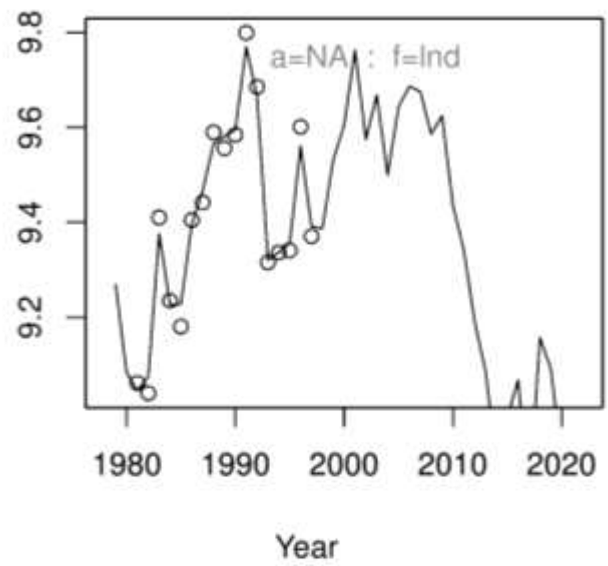

Figure 15.1.16. Atlantic wolffish in 5.a. Fit to the landings input data to the proposed SAM model.

15.1.5 Model results

Model results show that Atlantic wolffish total biomass levels decreased from high levels in 2000 – 2006 to current levels. Excluding biomass values earlier than 1985, which are highly uncertain because spring survey data begin in 1985, current total biomass levels are on par with those in 2013, which represent a minimum in the more reliable post-1985 portion of the time series. This pattern contrasts with that of a higher value for harvestable biomass, which represents larger fish. This decrease in total biomass therefore indicates a smaller proportion of smaller fish contribution to total biomass and appears to be due to a halving of recruitment levels from roughly 20 million prior to 2000 to roughly 10 million after 2000. However, following a step decrease in landings and fishing mortality from high levels in 2009 to current levels, total biomass levels have been relatively stable after 2010 (Figure 15.1.18).

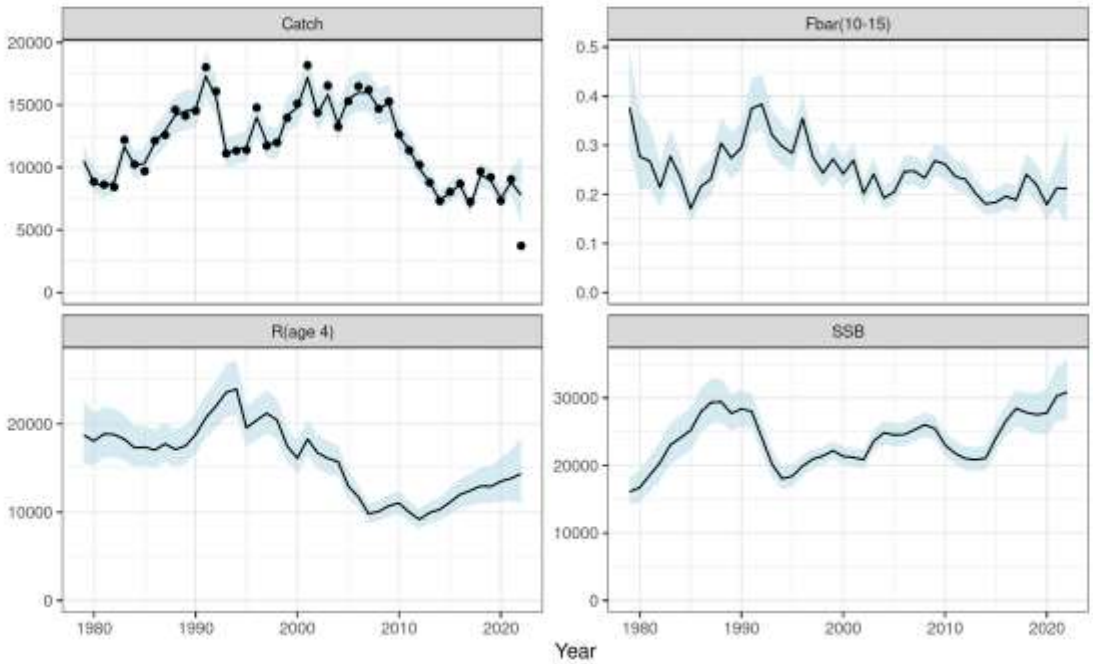

Figure 15.1.18. Atlantic wolffish in 5.a. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fish and harvest rate, recruitment and total catches.

3.4.10.1 Retrospective analysis

The results of an analytical retrospective analysis are presented. The analysis indicates relatively stable estimation, except in the earliest peel. Mohn's rho was estimated to be -0.0278 for SSB, 0.0385 for F, and 0.0368 for recruitment.

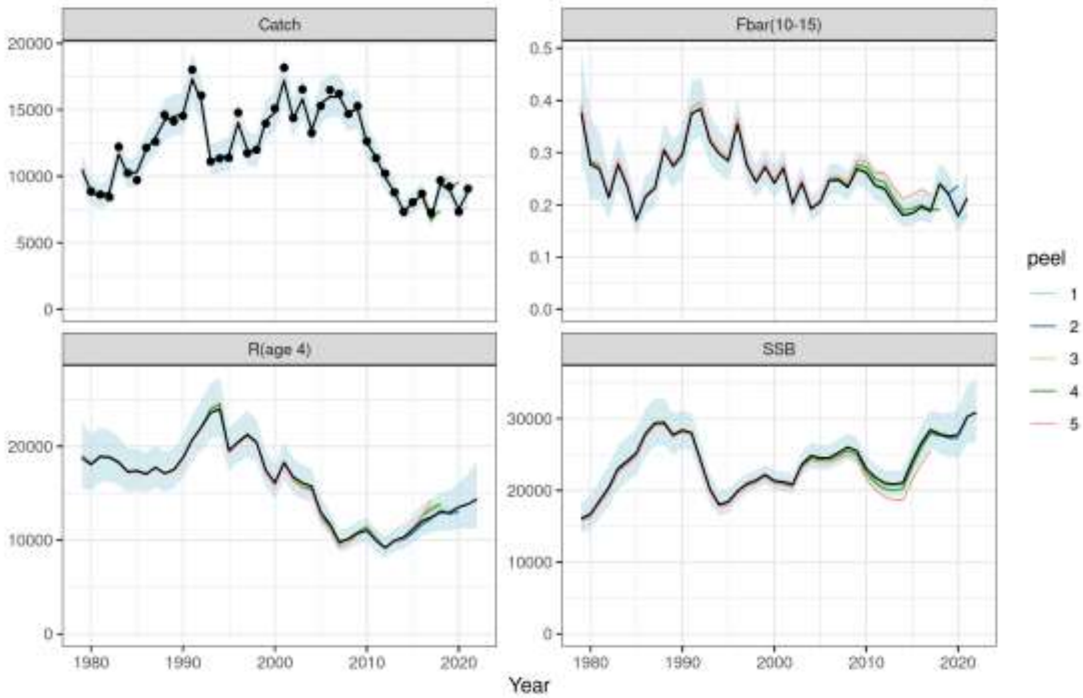

Figure 15.1.19. Atlantic wolffish in 5.a. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 4) are shown.

Neither observation nor process residuals show obvious trends (Figs. 3.4.15 and 3.4.16).

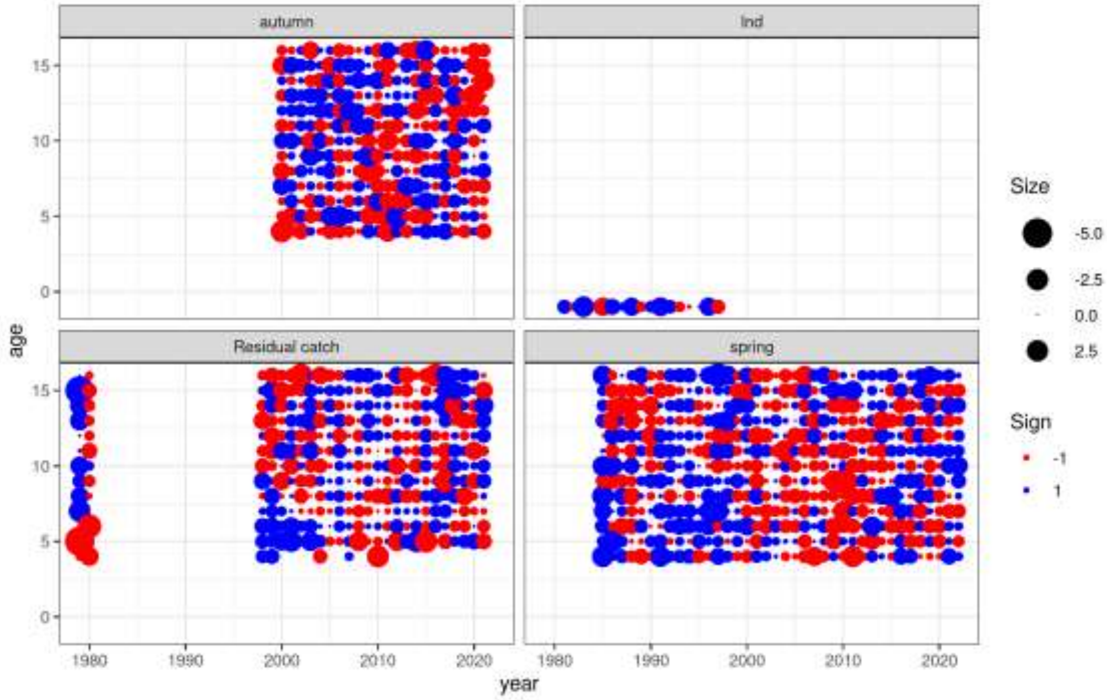

Figure 15.1.20. Atlantic wolffish in 5.a. Observation error residuals of the SAM model.

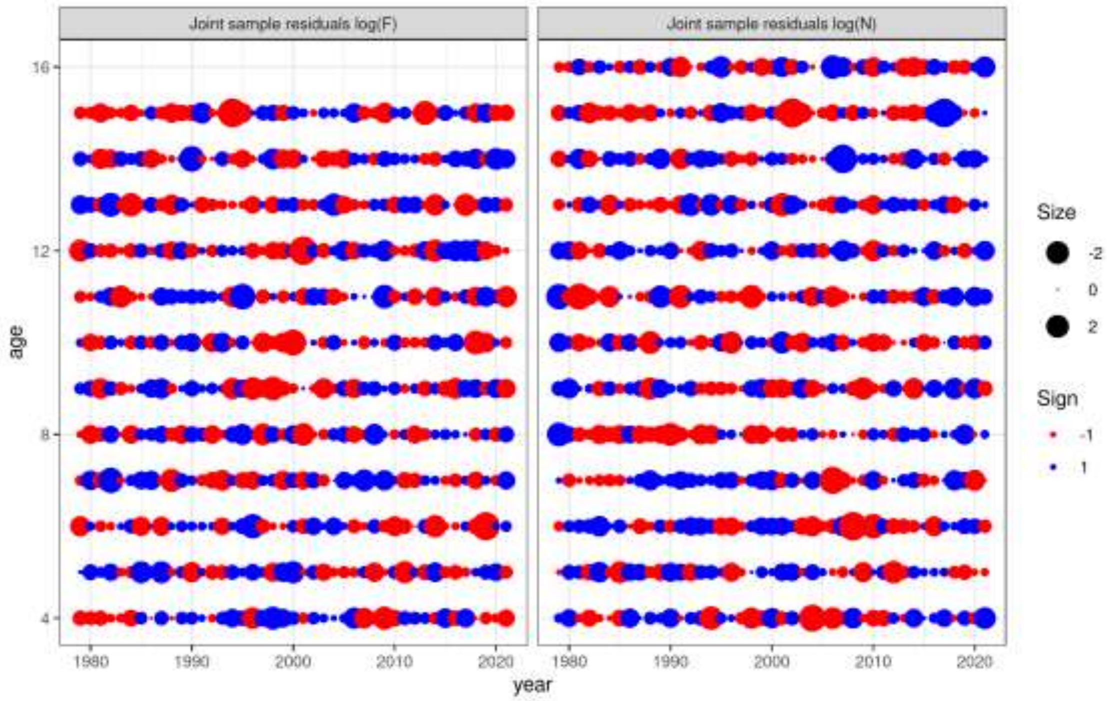

Figure 15.1.21. Atlantic wolffish in 5.a. Process error residuals of the SAM model.

15.1.6 Management

The Ministry of Industries and Innovation is responsible for management of the Icelandic fisheries and implementation of legislation. Atlantic wolffish was included in the ITQ system in the 1996/1997 quota year and as such subjected to TAC limitations. From that time to the fishing year

2004/2005, the catch was on average 5% more than recommended by the MRI, although in some years it was lower than advised TAC. In the fishing years 2005/2006 to 2011/2012, the catch was on average around 34% above the advised TAC. The main reasons were that national TAC was set higher than the advised TAC, and quota of other species were being transferred to Atlantic wolffish quota (Table 15.1.2, Figure 15.1.6). Net transfer of Atlantic wolffish quota for each fishing year is usually less than 10%.

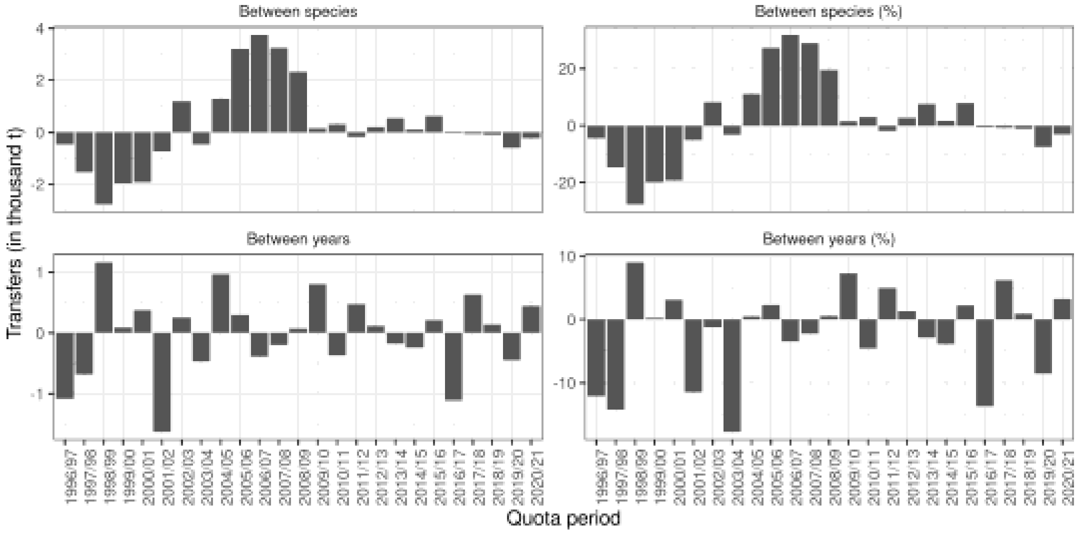

Figure 15.1.22: Atlantic Wolffish in 5.a. Net transfer of quota, from Atlantic Wolffish to other species, in the Icelandic ITQ system by fishing year.

15.1.7 Current Advisory Framework

Reference points were calculated for the stock. This resulted in B_{pa} of 21 000 t, based on the lowest estimate of SSB observed after the 2001 shift in recruitment had been observed (2002), and Blim of 18 500 t. The fishing pressure estimates, defined in terms of fishing mortality applied to ages from 10 to 15, were estimated in accordance with the ICES guidelines. This resulted in an estimate of F_{lim} of 0.33, F_{p05} of 0.20 and F_{MSY} of 0.20. The MSY $B_{trigger}$ was set as B_{pa}

The proposed HCR for the Icelandic Atlantic wolffish fishery, which sets a TAC for the fishing year y/y+1 (September 1 of year y to August 31 of year y+1) based on a fishing mortality F_{mgt} of 0.20 applied to ages 10 to 15 modified by the ratio SSB_y/MGT $B_{trigger}$ when SSB_y < MGT $B_{trigger}$, maintains a high yield while being precautionary as it results in lower than 5% probability of SSB < B_{lim} in the medium and long term.

15.1.8 Management considerations

A reduction in fishing mortality has led to harvestable biomass and SSB that seem to be stable. Atlantic wolffish is a slow-growing late-maturing species, therefore closures of known spawning areas should be maintained and expanded if needed. Similarly, closed areas fishing where there is high juvenile abundance should also be maintained and expanded if needed.

15.1.9 Ecosystem considerations

Most fishing for Atlantic wolffish occurs in the northwest and west of Iceland, where the fastest growing Atlantic wolffish are found. A likely cause for differences in growth is environmental differences between the relatively warm southwestern waters versus colder northeaster waters.

However, Atlantic wolffish are also highly sedentary, especially while guarding nests during spawning and rearing season, and therefore additional metapopulation structure cannot be excluded. Therefore, it is possible that local depletion may occur in more heavily fished areas despite a stable overall biomass level.

Table 15.1.1. Atlantic wolffish in 5.a. Number of Icelandic vessels reporting catch of Atlantic wolffish, and all landed catch divided by gear type.

Number of vessels				Catch (tonnes)				
Year	Long liners	Trawls	Seiners	Longline	Trawl	D. seine	Other	Sum
2000	483	155	106	9979	4173	834	241	15227
2001	451	141	90	12595	4319	862	394	18170
2002	406	137	87	8897	4423	800	304	14424
2003	417	129	93	8943	5960	1402	263	16568
2004	420	129	91	5746	5349	2010	216	13321
2005	436	122	87	6370	7247	1552	177	15346
2006	424	109	83	7962	6885	1569	144	16560
2007	387	106	74	6655	7857	1551	171	16234
2008	336	99	72	5810	7026	1642	152	14630
2009	309	89	68	7896	5709	1462	143	15210
2010	265	88	59	6923	4531	1033	175	12662
2011	258	86	52	6094	4062	1138	97	11391
2012	283	91	53	6209	2910	992	103	10214
2013	268	91	53	5537	2424	721	110	8792
2014	264	86	45	4463	1722	1006	138	7329
2015	242	78	47	4828	1926	1097	137	7988
2016	220	74	44	5563	1713	1201	148	8625
2017	201	75	46	4586	1243	1286	128	7243
2018	174	67	45	5657	1689	2185	125	9656
2019	173	63	42	5223	1748	2154	90	9215
2020	143	67	41	2984	2147	2147	54	7340
2021	131	66	41	3941	3047	2012	45	9046

Table 15.1.2: Atlantic wolffish in 5.a. Advised TAC, national TAC and total landings since the quota year 2013/2014.

Fishing Year	MFRI Advice	National TAC	Landings
2013/14	7500	7500	7531
2014/15	7500	7500	7862
2015/16	8200	8200	8982
2016/17	8811	8811	7545
2017/18	8540	8540	9515
2018/19	9020	9020	9355
2019/20	8344	8344	7166
2020/21	8761	8761	8974
2021/22	8933	8933	-

Table 15.1.3. Atlantic wolffish. Number of samples and aged otoliths from landed catch of Atlantic wolffish.

Year	Longline		Demersal trawl		Demersal seine	
	Samples	Otoliths	Samples	Otoliths	Samples	Otoliths
2010	29	1669	18	1040	5	285
2011	14	750	15	778	9	550
2012	26	1300	14	700	7	350
2013	25	1249	14	692	5	249
2014	30	800	26	675	28	700
2015	25	625	19	479	19	474
2016	25	625	13	325	9	225
2017	23	575	9	220	6	150
2018	22	550	9	225	17	425
2019	22	537	10	245	20	480
2020	9	223	12	294	16	386
2021	14	350	25	625	15	400

Table 15.1.4. Atlantic wolffish in 5.a. Estimates of spawning–stock biomass (SSB) in thousands of tonnes, recruitment at age 4 (thousands), fishing mortality over ages 10 - 15 (Fbar) and catch from SAM.

Year	SSB	Recruitment	Fbar	Catch
1979	16103	18739	0.377	10530
1980	16720	18062	0.277	8816
1981	18584	18875	0.267	8438
1982	20413	18795	0.214	8834
1983	23030	18272	0.277	11677

Year	SSB	Recruitment	Fbar	Catch
1984	24086	17289	0.235	10134
1985	25195	17375	0.171	10343
1986	27920	17042	0.216	12012
1987	29324	17741	0.232	12924
1988	29416	17119	0.304	14174
1989	27712	17508	0.274	14510
1990	28385	18792	0.295	14650
1991	27996	20696	0.375	17309
1992	24097	22026	0.383	15612
1993	20179	23559	0.321	11175
1994	18032	23950	0.298	11380
1995	18414	19559	0.284	11646
1996	19897	20436	0.355	14009
1997	20930	21211	0.277	12000
1998	21405	20428	0.243	11816
1999	22191	17483	0.272	14169
2000	21340	16115	0.242	14802
2001	21186	18285	0.270	17189
2002	20842	16715	0.202	14320
2003	23612	16098	0.241	15823
2004	24846	15728	0.192	13464
2005	24517	12957	0.205	15483
2006	24566	11720	0.246	15976
2007	25269	9822	0.247	15979
2008	26022	10081	0.233	14742
2009	25488	10714	0.268	15084
2010	23045	11030	0.262	12496
2011	21790	9979	0.237	11444
2012	21022	9170	0.231	9916

Year	SSB	Recruitment	Fbar	Catch
2013	20841	9953	0.202	8818
2014	21063	10299	0.180	7381
2015	24034	11124	0.184	7971
2016	26601	12010	0.196	8629
2017	28439	12441	0.188	6855
2018	27836	12952	0.241	9392
2019	27529	12913	0.220	8990
2020	27749	13493	0.179	7511
2021	30278	13821	0.213	8813
2022	30872	14364		