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), the proportion of the catch increased in 2003-2008 but since then it has been decreasing (Figure 15.1.3).

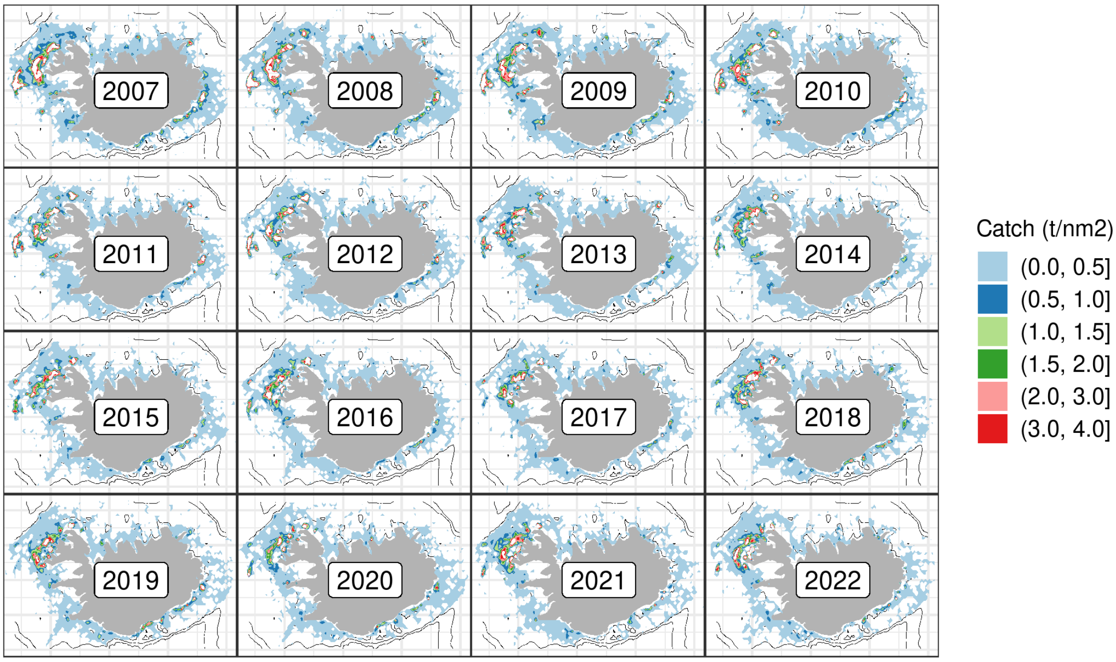

Figure 15.1.1 Atlantic wolffish in 5.a. Geographical distribution of the Icelandic fishery since 2007 as reported in logbooks. All gear types combined.

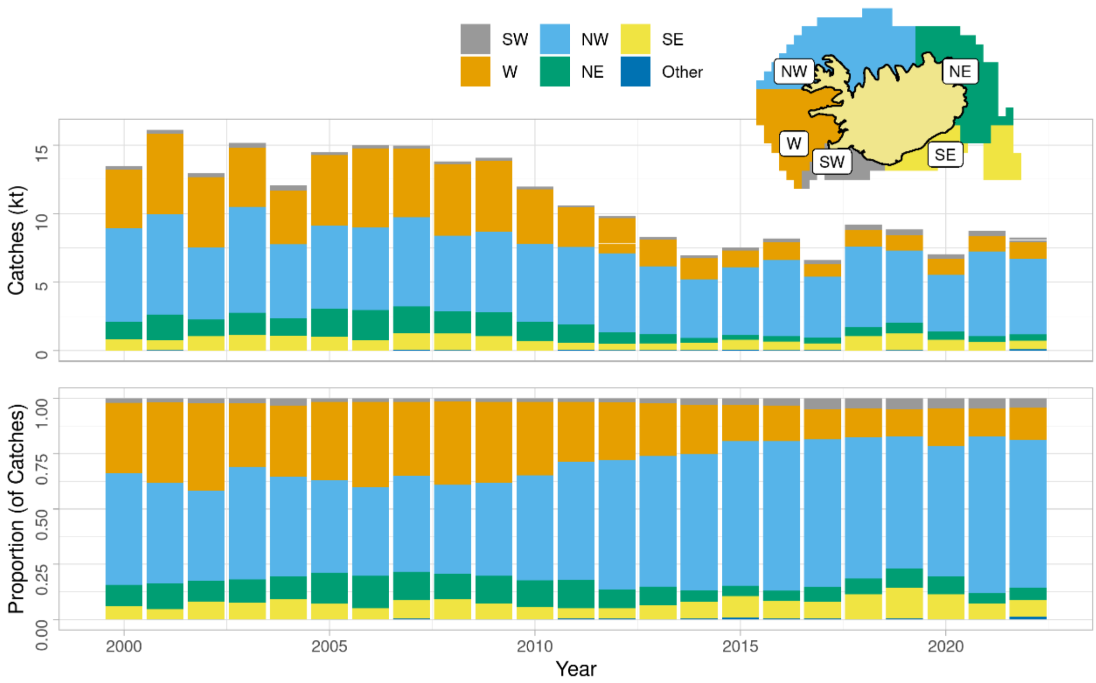

Figure 15.1.2: Atlantic wolffish in 5a. Spatial distribution of the Icelandic fishery by fishing area since 2000 according to logbooks. All gears combined.

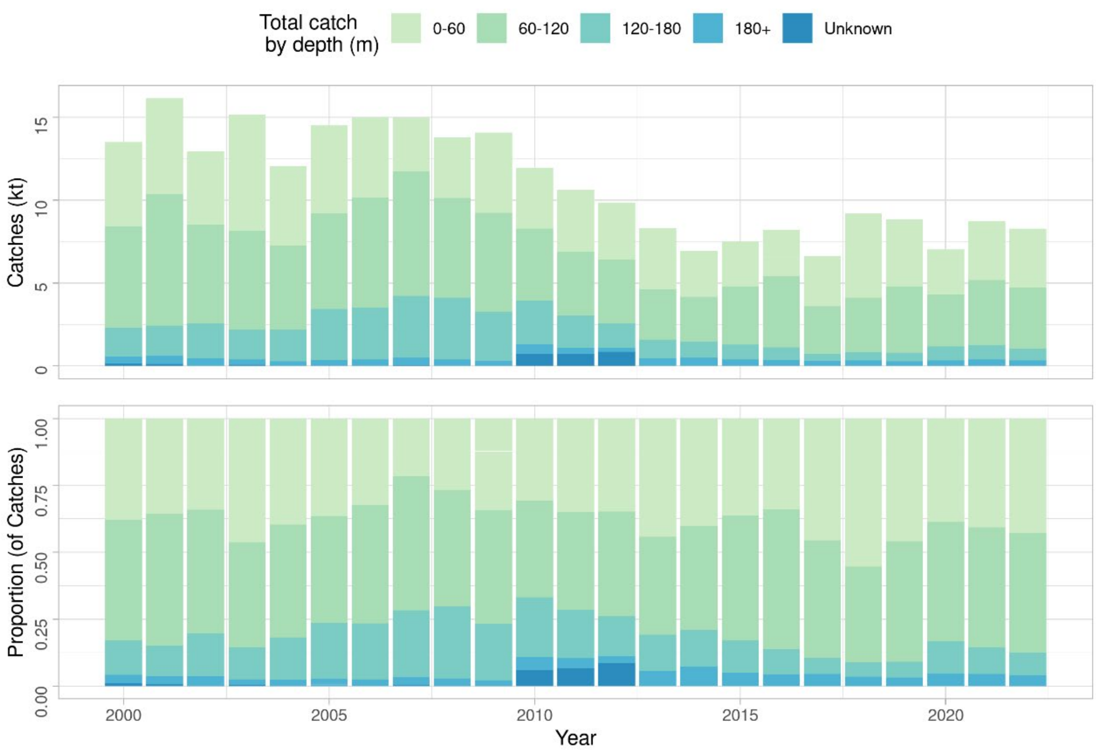

Figure 15.1.3. Atlantic wolffish in 5.a. Depth distribution of demersal trawl, longline and demersal seine catches according to logbooks.

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 have 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 42 in 2022. The number of trawlers has also decreased significantly from 76 in 2000 to 49 in the last year (Table 15.1.1).

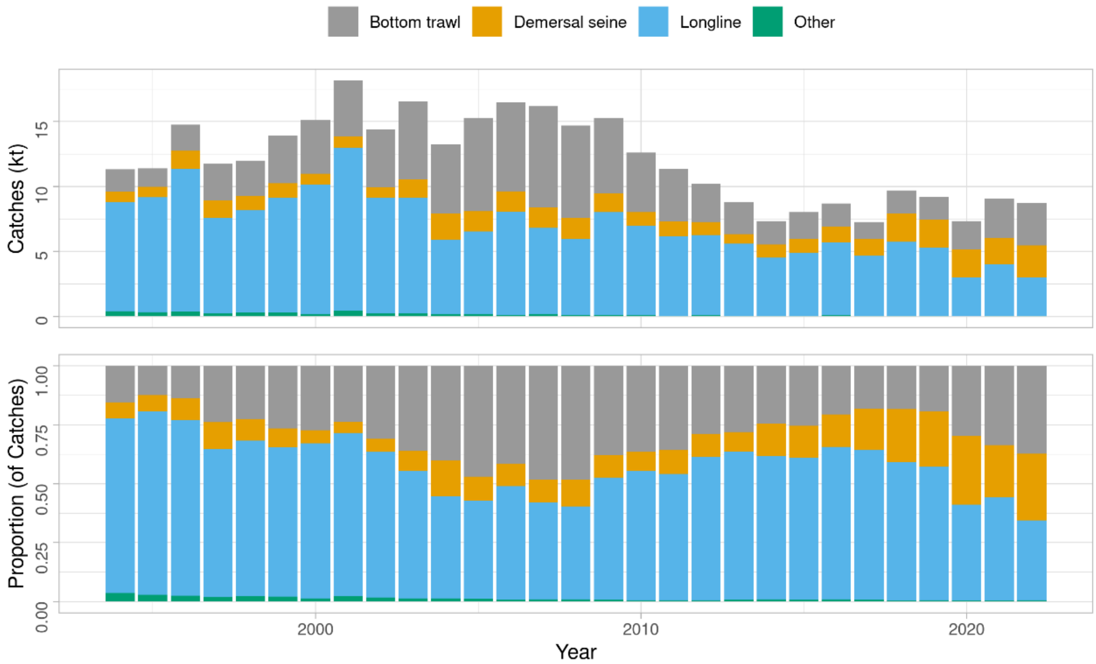

Figure 15.1.4. Atlantic wolffish in 5.a. Total catch (landings) by fishing gear since 1994, according to statistics from the Directorate of Fisheries.

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).

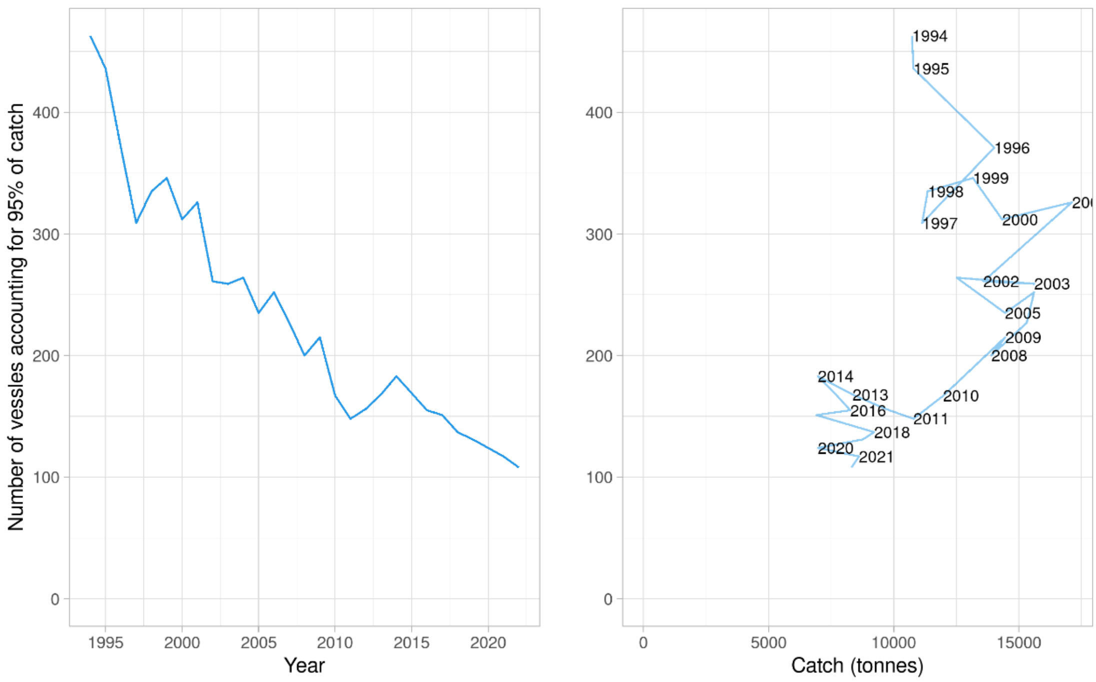

Figure 15.1.5. Atlantic wolffish in 5.a. Number of vessels (all gear types) accounting for 95% of the total catch annually since 1994. Left: Plotted against year. Right: Plotted against total catch. Data from the Directorate of Fisheries.

15.1.3 Data available

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

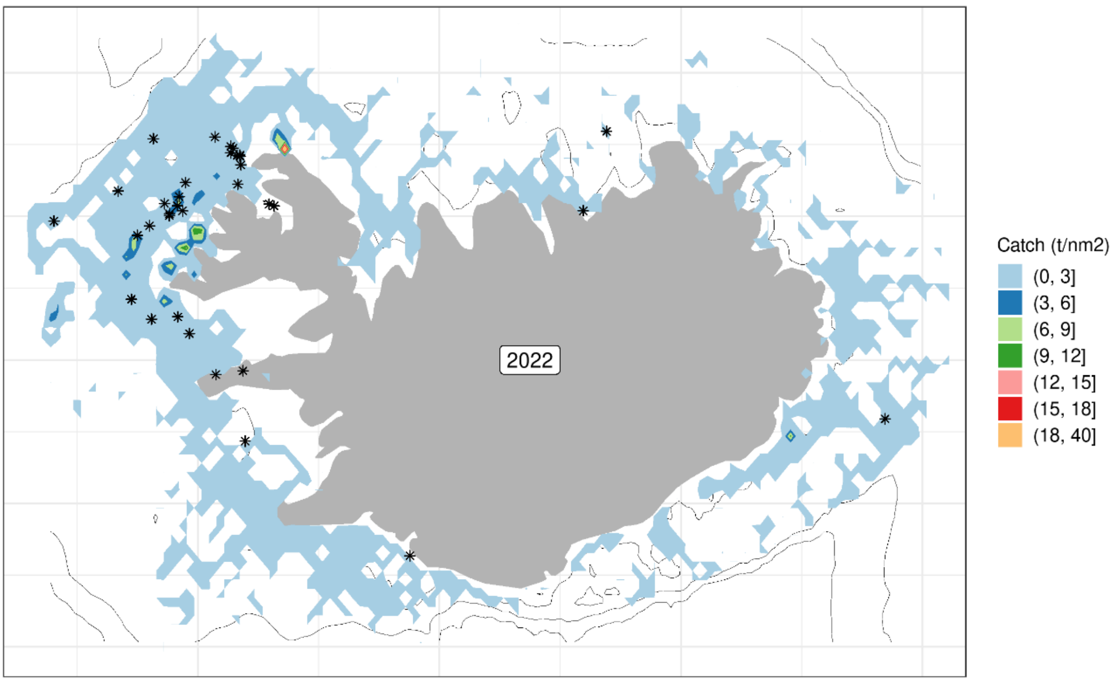

Figure 15.1.7. Atlantic wolffish in 5.a. Fishing grounds in 2022 as reported in logbooks and positions of samples taken from landings (asterisks).

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 63 cm in 1998 to about 70 cm in 2011 where from it has been similar.

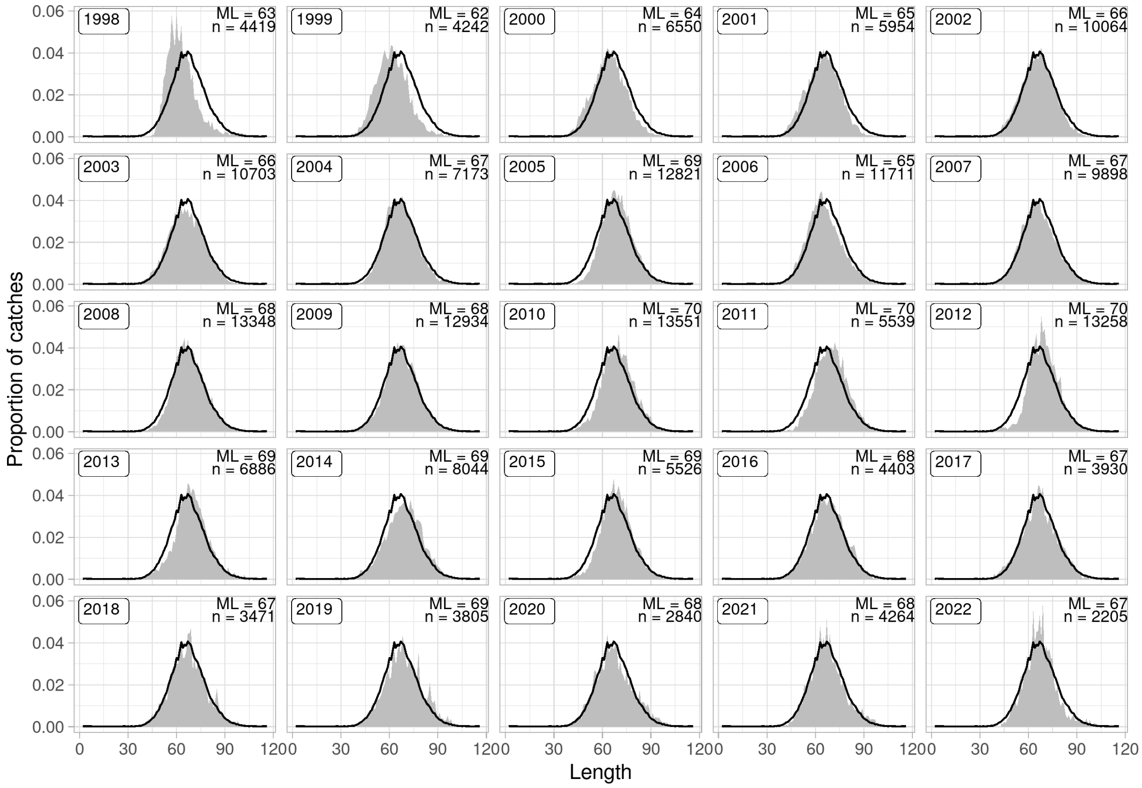

Figure 15.7.8. Atlantic wolffish in 5.a. Length distribution of fish sampled from landed catch. The black line represents the mean length distribution for the period.

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 average about 42 cm in 2007-2023 (Figure 15.7.9). Mean length in the autumn survey oscillated from 34-40 cm in 1996-2022, with no clear trend (Figure 15.7.10).

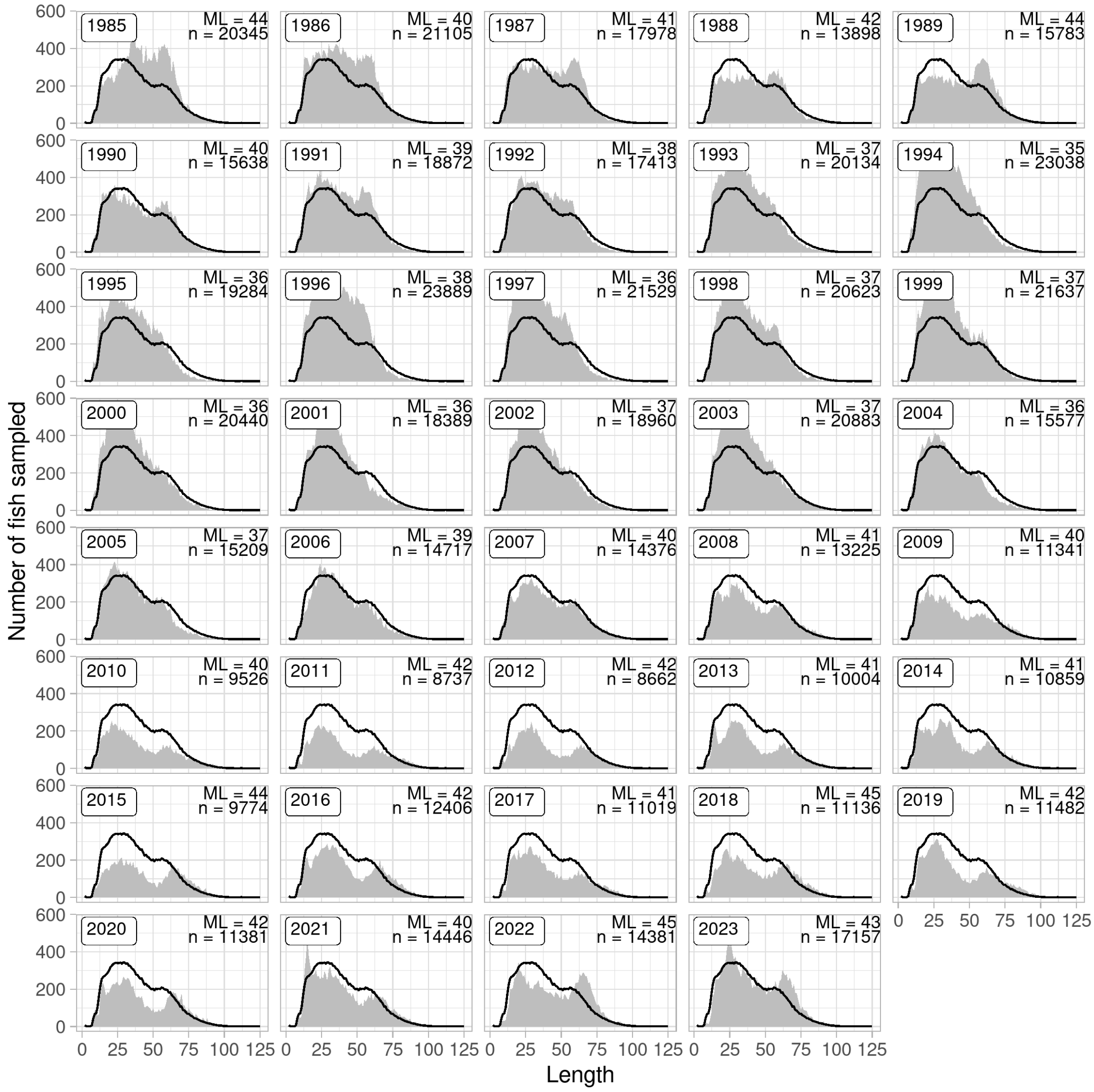

Figure 15.7.9. Atlantic wolffish in 5.a. Length distribution from the spring survey. The black line shows the mean for all years.

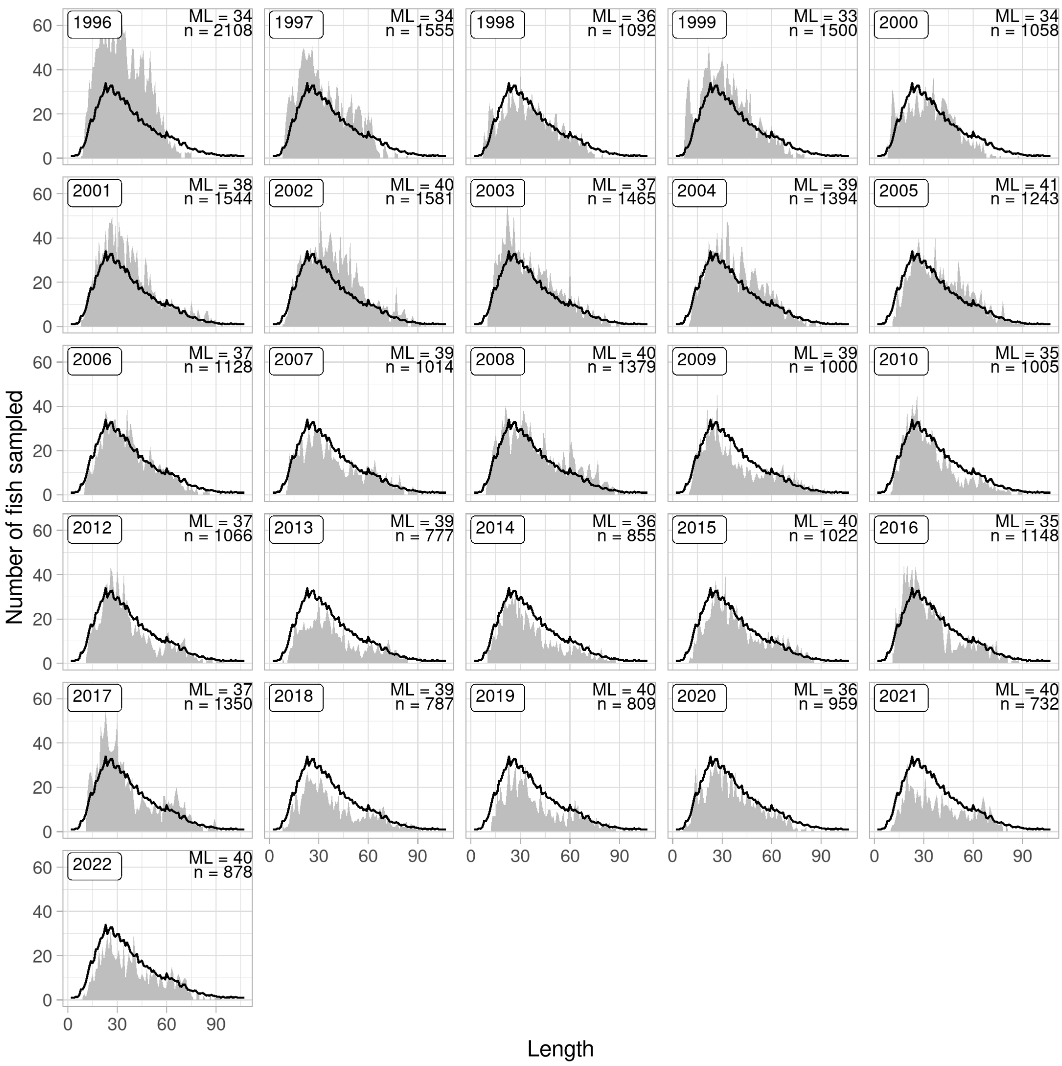

Figure 15.7.10. Atlantic wolffish in 5.a. Length distribution from the autumn survey. The black line shows the mean for all years.

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-standardized 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 measures, 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 increased. Note that tow-hours are missing in 2022 (Figure 15.7.11).

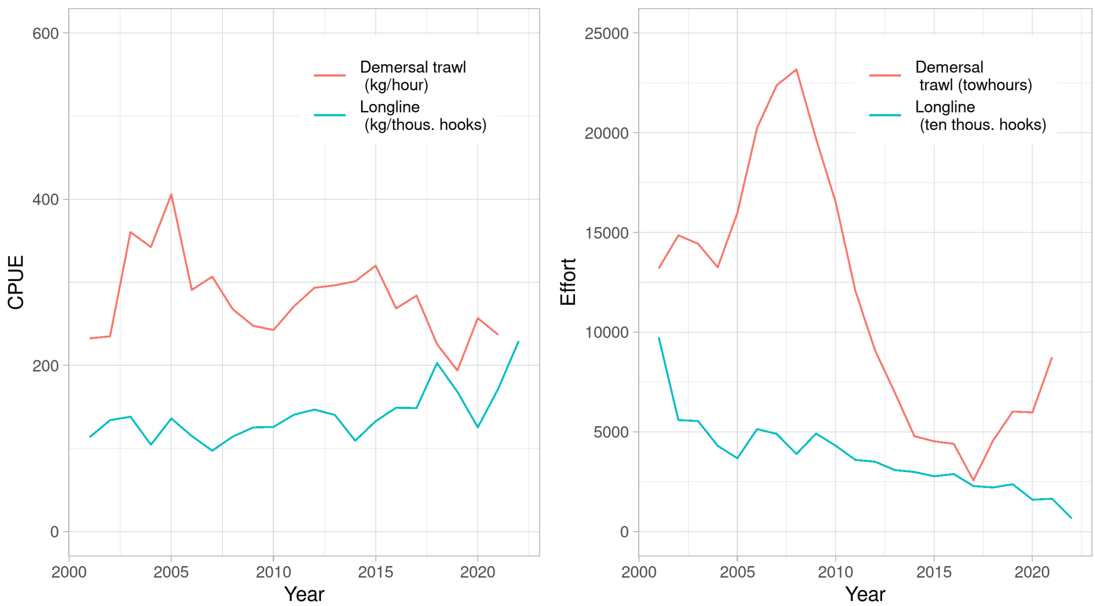

Figure 15.7.11. Atlantic wolffish in 5.a. Non-standardized estimates of CPUE (left) from demersal trawl (kg/h) and longline (kg/1000 hooks). Fishing effort (right) for longline (10000 hooks) for demersal trawl (tow-hours).

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 has increased since (Figure 15.7.12). The harvestable biomass has generally been increasing from 1995 with considerable oscillations. 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 but slightly increasing. This coincides with the enlarging of the area closure of the spawning/incubation area on Látragrunn from 500 km^2 (in 2002) to 1000 km^2 in October 2010.

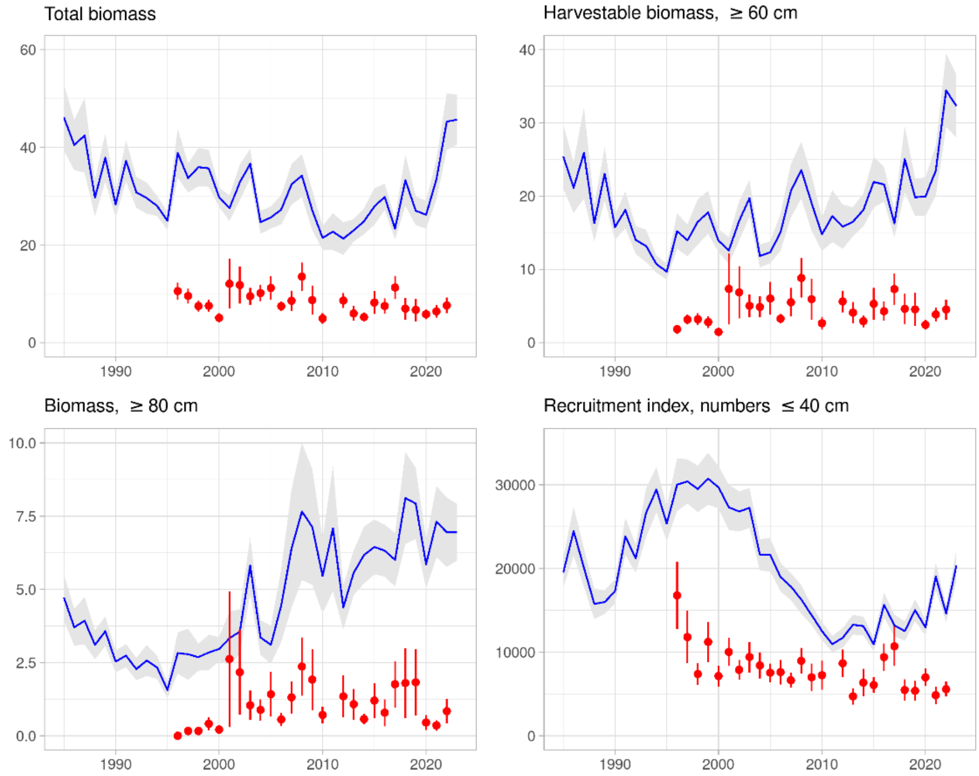

Figure 15.7.12. Atlantic wolffish. Total biomass indices (upper left) and harvestable biomass indices (≥60 cm, upper right), large fish biomass indices (≥80 cm, lower left) and juvenile abundance indices (≤40 cm, lower right), from the spring survey (blue) and the autumn survey (red), along with the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

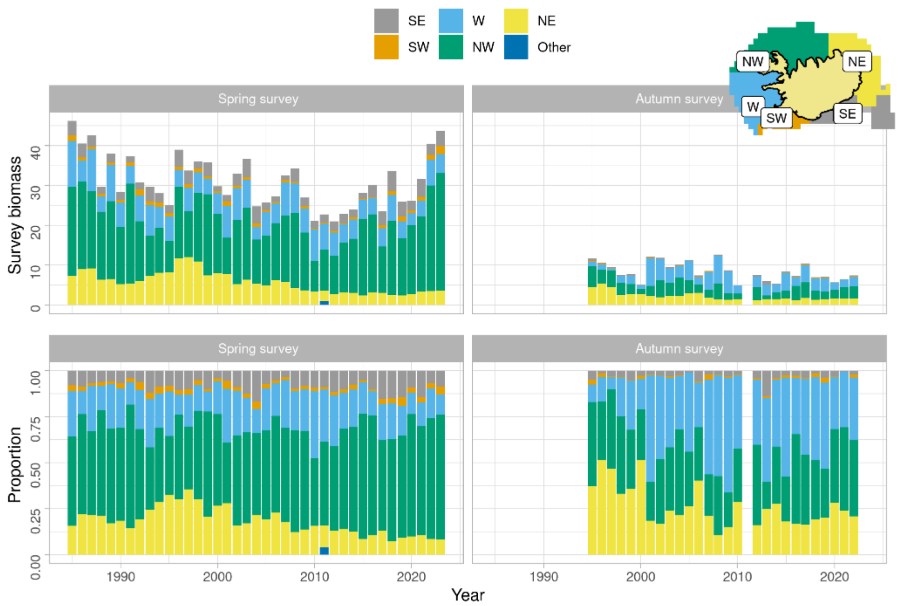

Figure 15.7.13. Atlantic wolffish in 5.a. Spatial distribution of biomass index from the spring and autumn survey.

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 catch at age data show a better fit.

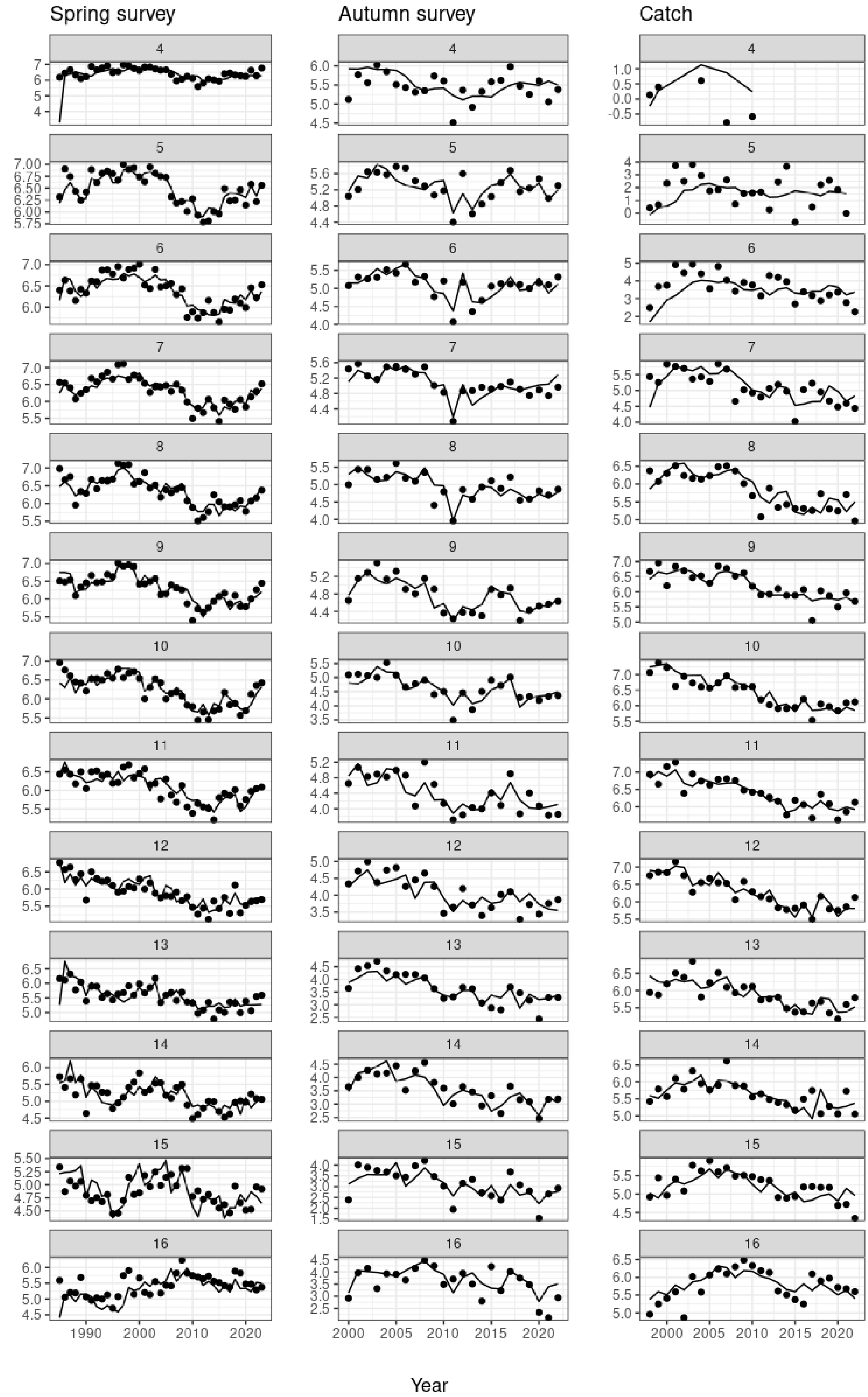

Figure 15.1.14 Atlantic wolffish in 5.a. Fit to the numbers at age input data to the proposed SAM model (columns left to right: spring survey, autumn survey, and catch.

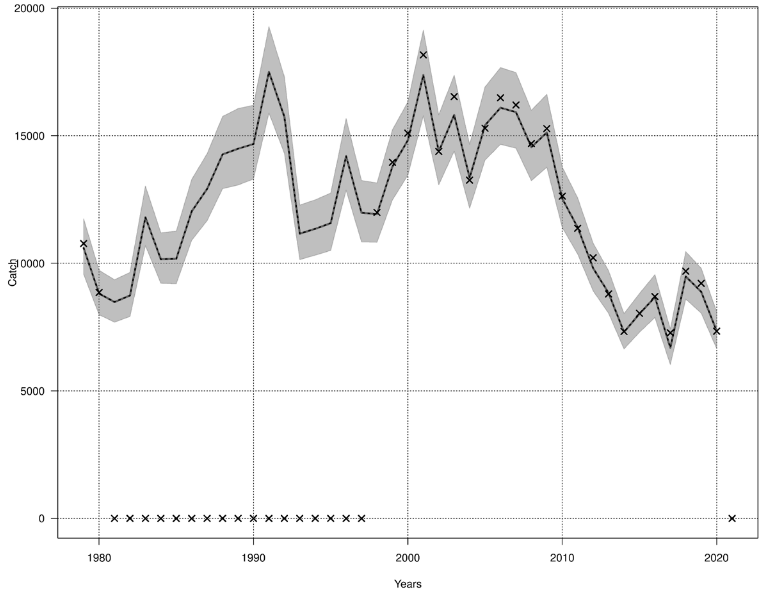

Figure 15.1.15. Atlantic wolffish in 5.a. Atlantic wolffish in 5.a. Fit to the total catch in the proposed SAM model.

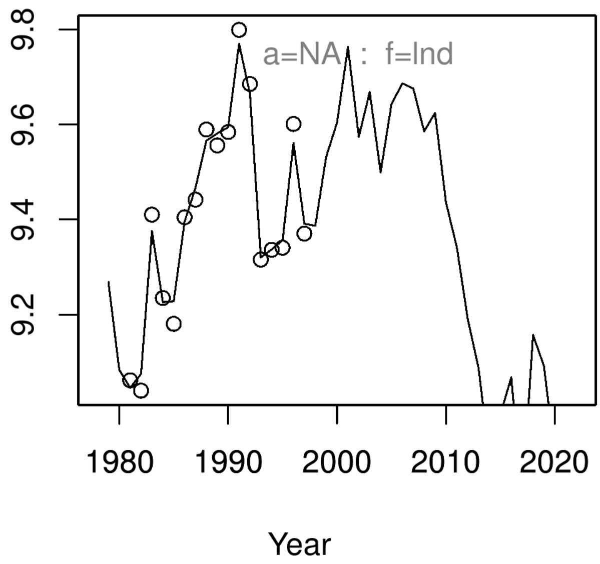

Figure 15.1.16. Atlantic wolffish in 5.a. Fit to the landings input data to the proposed SAM model.

15.1.5 Model results

Model results show that Atlantic wolffish total biomass levels decreased from high levels in 2000 – 2012 but have increased since then and are now at its highest level. Recruitment levels have also increased after being at the lowest level in 2011. Spawning stock biomass has also shown a steady increase since 1992 (Figure 15.1.18).

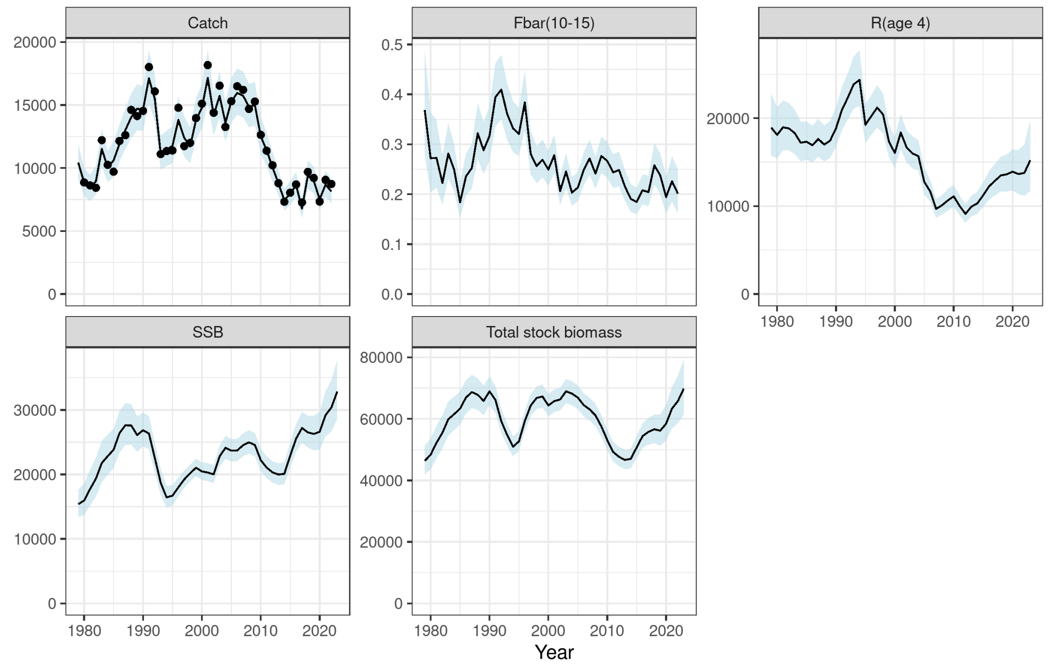

Figure 15.1.18. Atlantic wolffish in 5.a. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fish and harvest rate, recruitment, total stock biomass and total catches.

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.

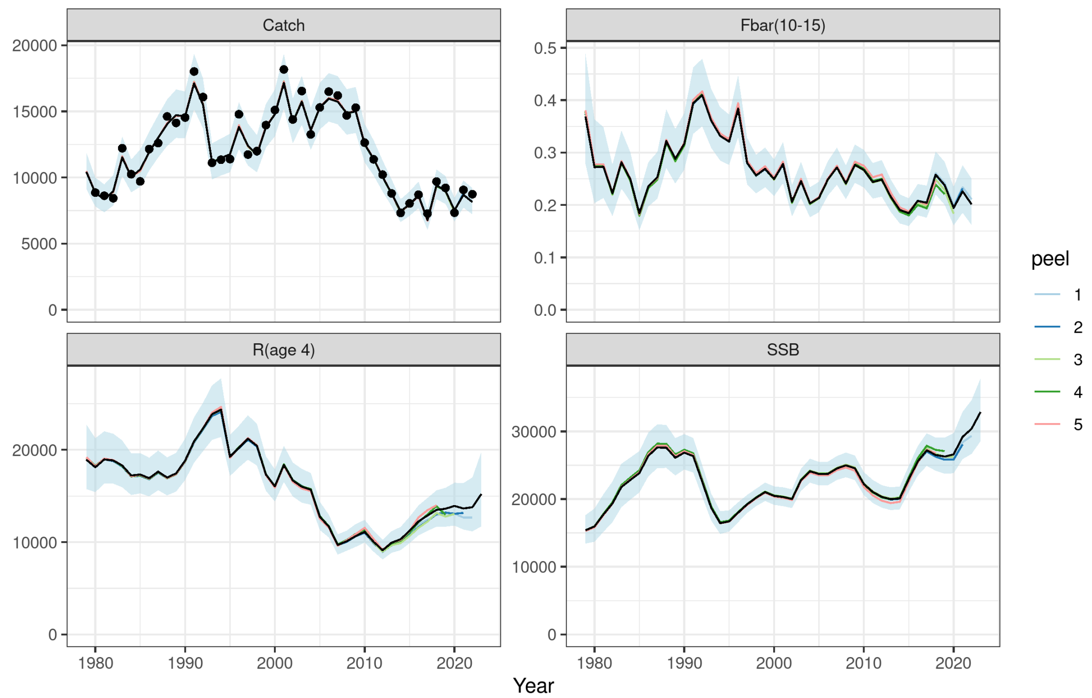

Figure 15.1.19. Atlantic wolffish in 5.a. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 4) are shown.

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

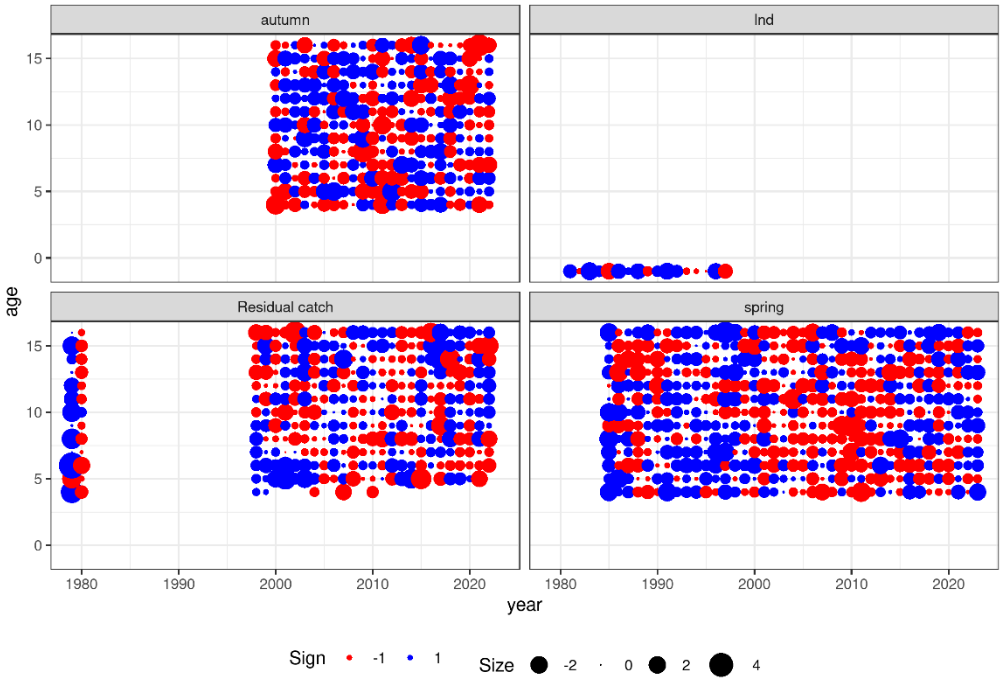

Figure 15.1.20. Atlantic wolffish in 5.a. Observation error residuals of the SAM model.

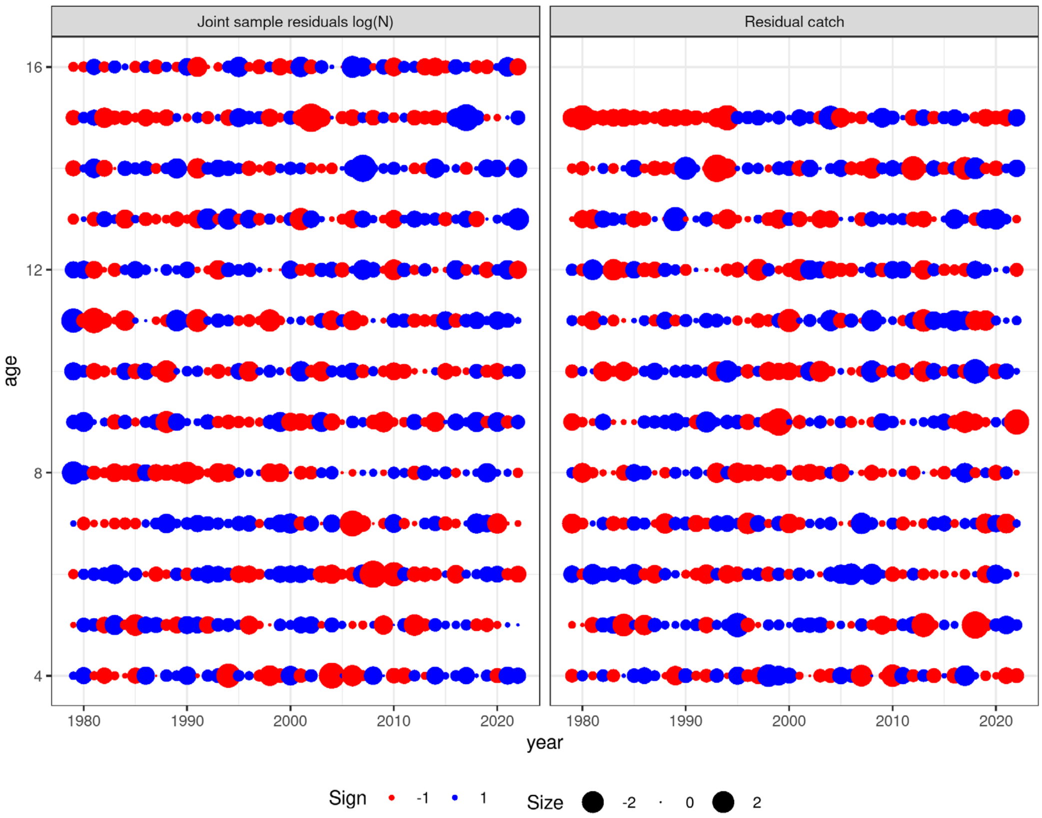

Figure 15.1.21. Atlantic wolffish in 5.a. Process error residuals of the SAM model.

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%.

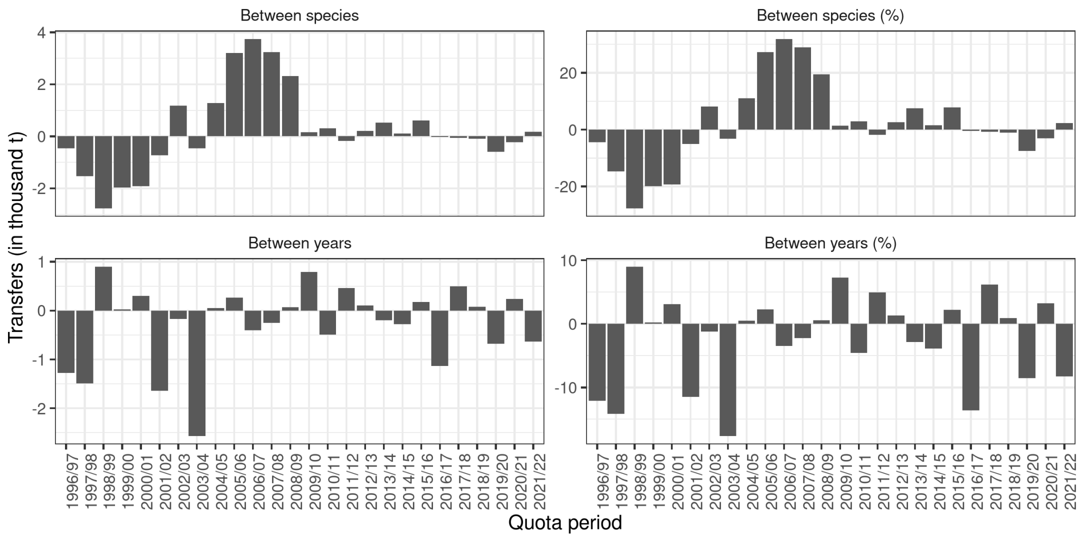

Figure 15.1.22: Atlantic Wolffish in 5.a. Net transfer of quota, from Atlantic Wolffish to other species, in the Icelandic ITQ system by fishing year.

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 B_{lim} 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 10 tonnes/year or more of Atlantic wolffish, and all landed catch divided by gear type.

Number of vessels					Catch (tonnes)				
Year	Long liners	Trawls	Seiners	Other	Longline	Trawl	D. seine	Other	Sum
2000	172	76	20	1	9979	4173	834	241	15227
2001	198	76	19	4	12595	4319	862	394	18170
2002	151	65	14	3	8897	4423	800	304	14424
2003	142	63	25	1	8943	5960	1402	263	16568
2004	109	60	40	2	5746	5349	2010	216	13321
2005	96	64	34	0	6370	7247	1552	177	15346
2006	136	66	32	1	7962	6885	1569	144	16560
2007	124	65	27	1	6655	7857	1551	171	16234
2008	100	60	25	2	5810	7026	1642	152	14630
2009	124	58	34	1	7896	5709	1462	143	15210
2010	82	46	23	2	6923	4531	1033	175	12662
2011	68	36	18	0	6094	4062	1138	97	11391
2012	80	28	21	0	6209	2910	992	103	10214
2013	77	29	19	2	5537	2424	721	110	8792
2014	77	22	17	1	4463	1722	1006	138	7329
2015	68	34	18	2	4828	1926	1097	137	7988
2016	65	37	19	3	5563	1713	1201	148	8625
2017	65	26	19	1	4586	1243	1286	128	7243
2018	67	40	26	4	5657	1689	2185	125	9656
2019	66	36	22	1	5223	1748	2154	90	9215

2020	50	38	25	1	2984	2147	2147	54	7340
2021	51	48	22	1	3941	3047	2012	45	9046
2022	42	49	23	0	2951	3262	2460	55	8728

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	8561
2022/23	8107	8107	

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	1090	5	285
2011	14	750	15	778	9	550
2012	26	1300	14	700	7	350
2013	25	1249	14	691	5	200
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	550	10	276	20	500
2020	9	225	12	350	16	400
2021	14	350	25	625	15	375
2022	14	110	17	330	14	273

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	15388	18931	0.368	10429
1980	15957	18103	0.272	8837
1981	17724	18958	0.273	8357
1982	19349	18842	0.222	8960
1983	21773	18298	0.281	11520
1984	22827	17214	0.249	10043
1985	23829	17324	0.184	10610
1986	26396	16923	0.236	11909
1987	27618	17637	0.253	13015
1988	27588	16996	0.322	14035
1989	26103	17448	0.288	14712
1990	26854	18828	0.317	14626
1991	26346	20919	0.394	17115
1992	22560	22320	0.409	15485
1993	18709	23846	0.361	11136
1994	16439	24354	0.332	11467
1995	16700	19254	0.321	11757
1996	17992	20232	0.384	13817
1997	19222	21202	0.280	12389
1998	20196	20425	0.256	11719
1999	21031	17326	0.269	13808
2000	20467	16043	0.249	14778
2001	20296	18367	0.278	17150
2002	20007	16676	0.206	14185
2003	22787	15995	0.245	15729
2004	24124	15675	0.203	13582

Year	SSB	Recruitment	Fbar	Catch
2005	23690	12758	0.213	15289
2006	23720	11684	0.249	15955
2007	24525	9685	0.272	15734
2008	24978	10093	0.241	14860
2009	24554	10649	0.276	15001
2010	22215	11114	0.267	12512
2011	21053	10024	0.244	11405
2012	20320	9116	0.248	10043
2013	19979	9945	0.216	8792
2014	20096	10308	0.191	7441
2015	22907	11227	0.184	7970
2016	25545	12251	0.208	8634
2017	27198	12881	0.204	6787
2018	26521	13490	0.258	9418
2019	26274	13617	0.238	8993
2020	26604	13918	0.194	7518
2021	29188	13644	0.226	8688
2022	30383	13783	0.201	8143
2023	32864	15214		