ATLANTIC WOLFFISH
Anarhichas lupus

GENERAL INFORMATION

Atlantic wolffish is an elongate fish with 10-12 stripes on each side of the body. It has pronounced conical teeth in front of the mouth and large molariform teeth in back of the mouth used for grasping and crushing the prey. In the catch, common length range is 50-80 cm, but the largest one caught around Iceland was 125 cm. Atlantic wolffish is mainly found in the northwest part of the continental shelf of Iceland. At Atlantic wolffish feeding grounds, the substrate is commonly sand or clay at depth less than 100 m, but in its spawning grounds the substrate is usually coarser, with holes and crevices at depth larger than 100 meters.

THE FISHERY

LANDINGS TRENDS

The main fishing grounds for Atlantic wolffish are in the west and northwest part of the Icelandic shelf (Figure 1). From 2010, the proportion of the catch has been increasing in northwest of Iceland compared to west of Iceland (Figure 2). Catches at the main spawning ground (Látragrunn) west of Iceland have been decreasing since 2008 (Figures 1-2).

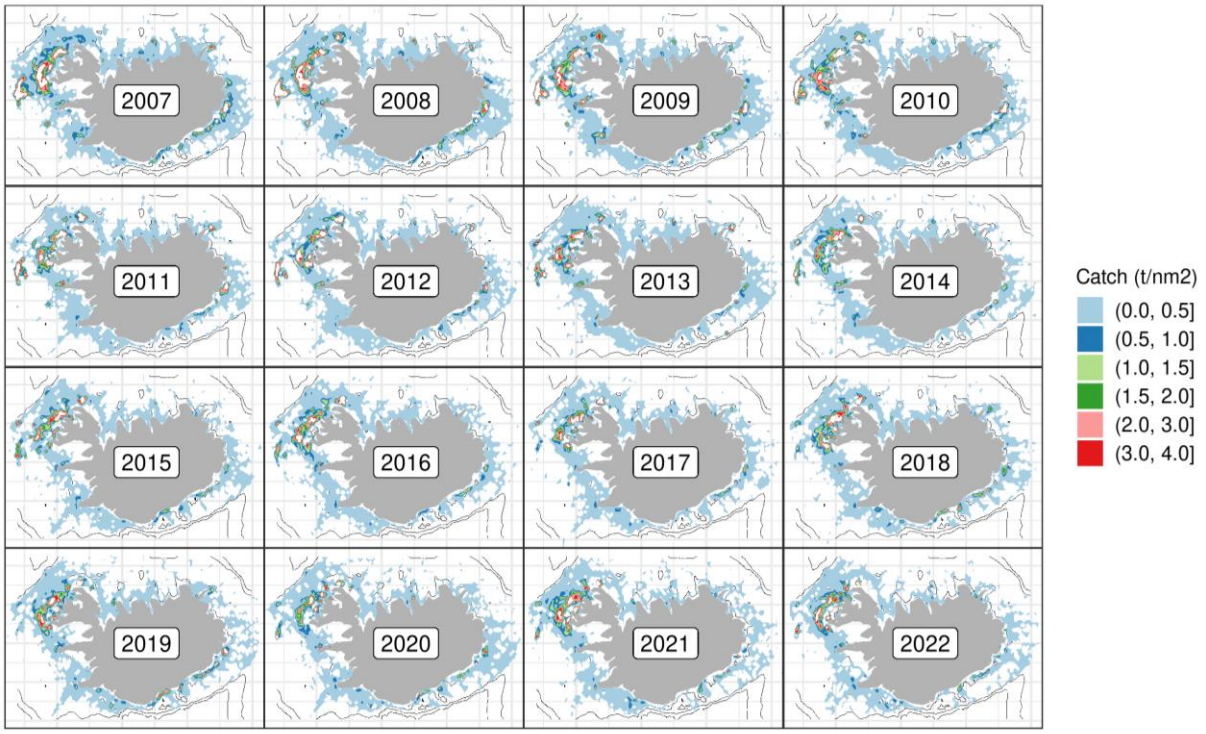

Figure 1. Atlantic wolffish. Geographical distribution of the Icelandic fishery since 2007. Reported catch from logbooks.

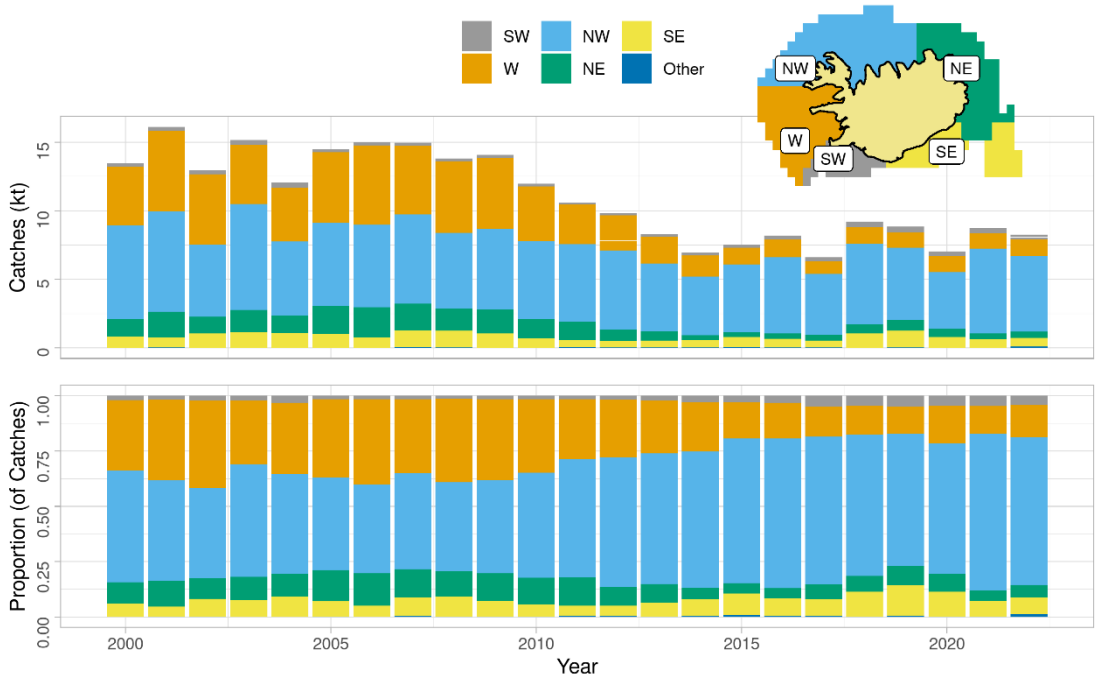

Figure 2. Atlantic wolffish. Spatial distribution of the Icelandic fishery by fishing area since 2000 according to logbooks. All gears combined.

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 range 61-120 m the proportion of the catch has been rather stable since 2000. At depths of 121-180 m, which includes the main spawning ground (Látragrunn), it increased in 2003-2008 but has decreased since then (Figure 3).

More than 97% of the Atlantic wolffish catch is taken by longline (40-70%), demersal trawl (20-50%) and demersal seine (5-30%) (Figure 4). These proportions have varied through the years and in recent years the proportion of the Atlantic wolffish caught in demersal seine has increased (Figure 4, Table 1).

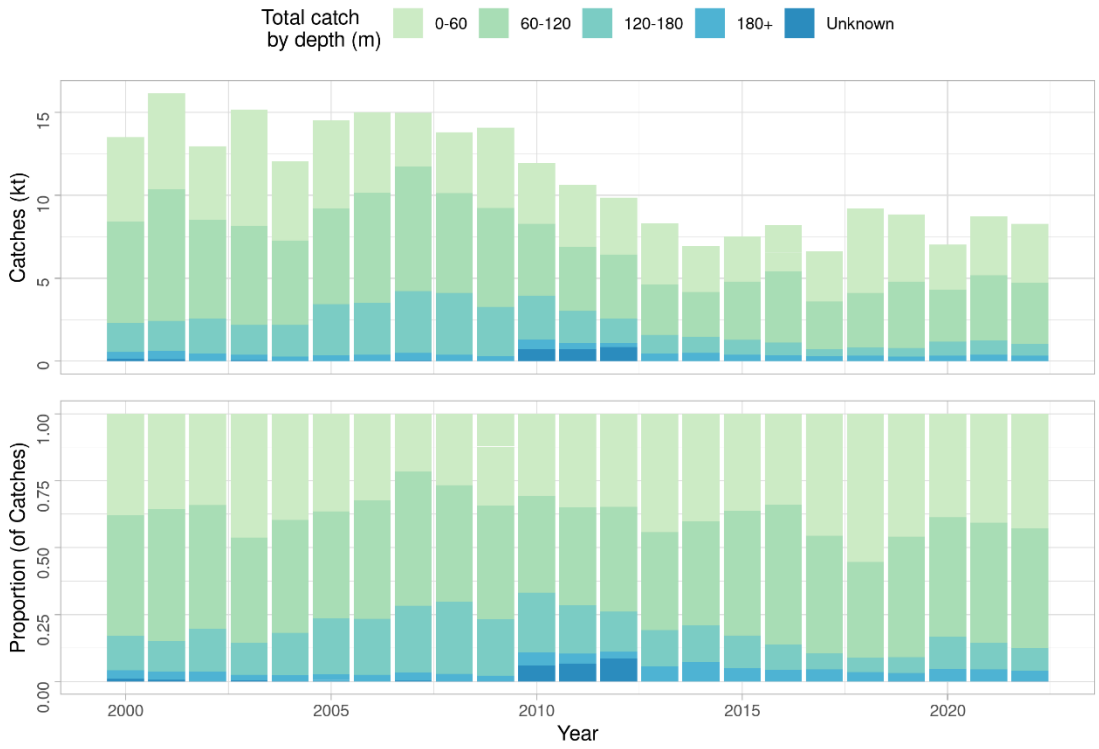

Figure 3. Atlantic wolffish. Depth distribution of demersal trawl, longline and demersal seine catches according to logbooks.

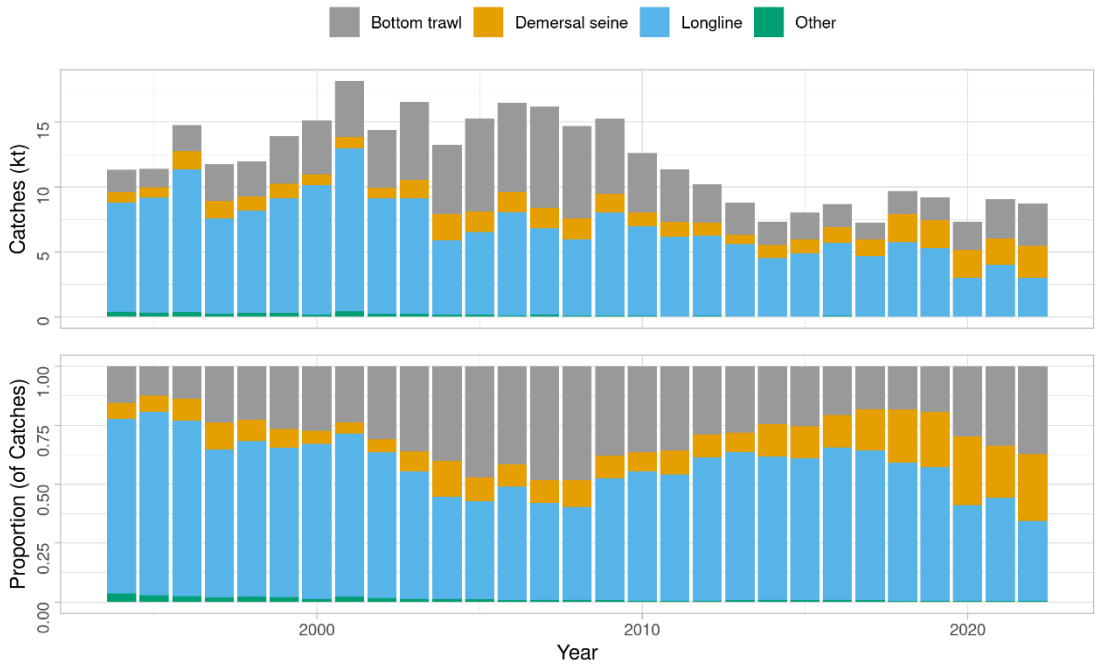

Figure 4. Atlantic wolffish. Total catch (landings) by fishing gear since 1994, according to statistics from the Directorate of Fisheries.

Since 2001, the number of longliners and trawlers reporting catches of 10 tonnes/year or more of Atlantic wolffish has decreased, but the number of demersal seiners has fluctuated between 14 and 40. In the longliners fleet the number has dropped from 198 vessels in 2001, down to 42 in 2022. The number of trawlers has also decreased significantly; from 76 in 2000 to 49 last year (Table 1).

Table 1. Atlantic wolffish. 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				CATCHES (TONNES)				
YEAR	Longliners	Trawlers	Seiners	Other	Longline	Demersal trawl	Demersal 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	2145	54	7340
2021	51	48	22	1	3941	3047	2012	45	9046
2022	42	49	23	0	2951	3261	2459	55	8728

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 148 vessels in 2011 despite higher catches (Figure 5). The number increased to 186 in 2014, although the catch decreased but since then the number has been decreasing in 2022 a total of 108 vessels landed 95% of the catch.

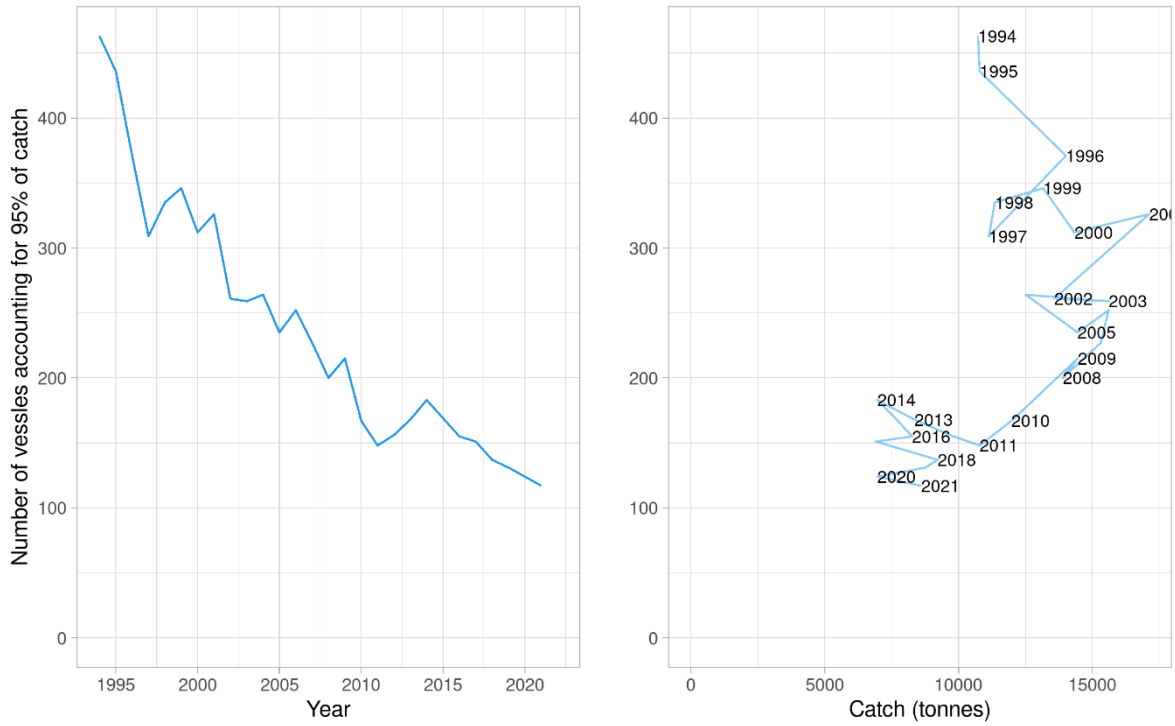

Figure 5. Atlantic wolffish. Number of vessels (all gear types) accounting for 95% of the total catch annually since 1994. Left: Plotted against year. Right: Plotted against total catch. Data from the Directorate of Fisheries.

CATCH PER UNIT OF EFFORT AND EFFORT

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.

Estimates of CPUE in demersal trawl (kg/hour), and longline (kg/1000 hooks), are calculated as the total weight in sets or tows in which Atlantic wolffish was more than 10% of the catch, or that Atlantic wolffish was part of the catch according to logbook records. Here, CPUE is calculated for each fishing trip and the median CPUE of all fishing trips in each year is presented (Figure 6).

CPUE of demersal trawl were catch was >10% of the total catch increased from about 138 to 300 kg/h in 2001-2005, and since then it has been between 138-278 kg/h (Figure 6). Where the Atlantic wolffish catch was >0, CPUE increased from its lowest value in 2001 (48 kg/h) to its highest value in 2003 (98 kg/h). Since then, it has oscillated between 68-96 kg/h with no clear trend. CPUE in longline vessels were catch was >10% of the total catch has oscillated between 51-96 kg/1000 hooks (Figure 6). Where the catch was >0, CPUE was highest in 2001 (25 kg/ 1000 hooks), but has been decreasing since then and was lowest in 2022 (3 kg/1000 hooks).

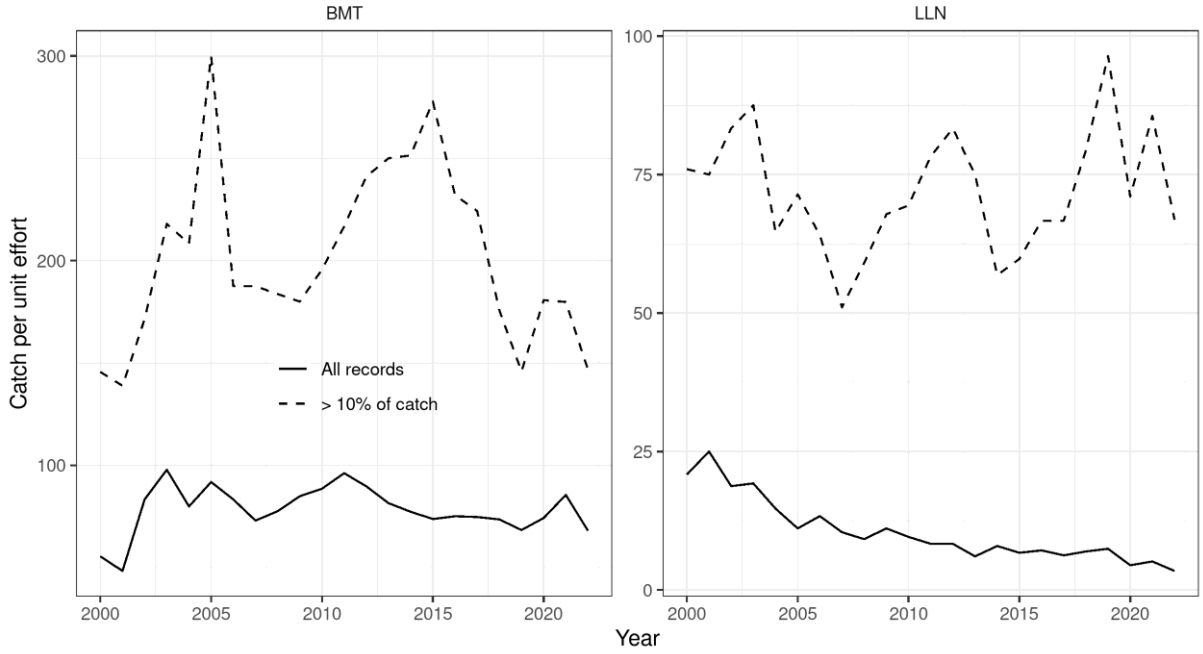

Figure 6. Atlantic wolffish. Non-standardized estimates of CPUE for demersal trawl (left, kg/h) and longline (right, kg/1000 hooks).

LANDINGS AND DISCARDS

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

SAMPLING FROM COMMERCIAL CATCH

In 1969-1997, on average 500 otoliths were sampled annually, except in 1970, 1973, and 1974 when no otoliths were sampled. In 1999, the effort of sampling Atlantic wolffish from commercial catch was

increased. In the years 1999-2014 annual sampling of aged fish was 1600-3000 or on average 2200, but since 2015 this average has been around 1200 fish. In 2022, a total of 3, 26 and 17 samples were collected from longline, demersal trawl and demersal seine catches, respectively (Table 2, Figure 7).

Table 2. Atlantic wolffish. Number of samples and aged fish from landed catch of Atlantic wolffish.

YEAR	LONGLINE		DEMERSAL TRAWL		DEMERSAL SEINE	
	Samples	Fish	Samples	Fish	Samples	Fish
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	3	60	26	525	17	338

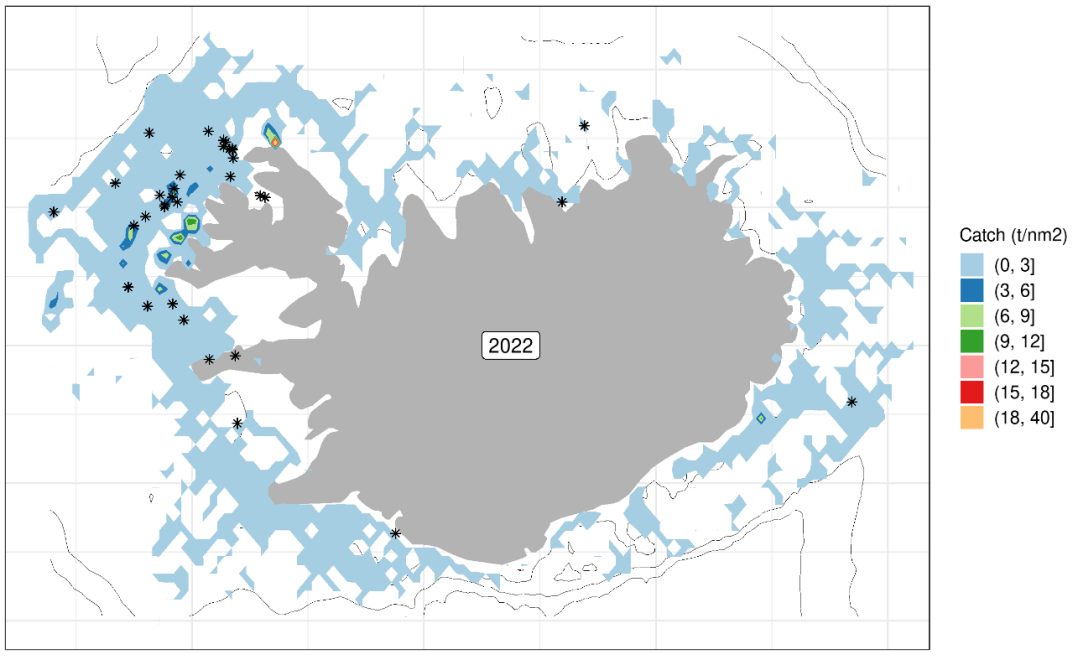

Figure 7. Atlantic wolffish. Fishing grounds in 2022 as reported in logbooks and positions of samples taken from landings (asterisks).

LENGTH COMPOSITIONS

The length distribution of landed Atlantic wolffish catch has been relatively stable since 2000 (Figure 8).

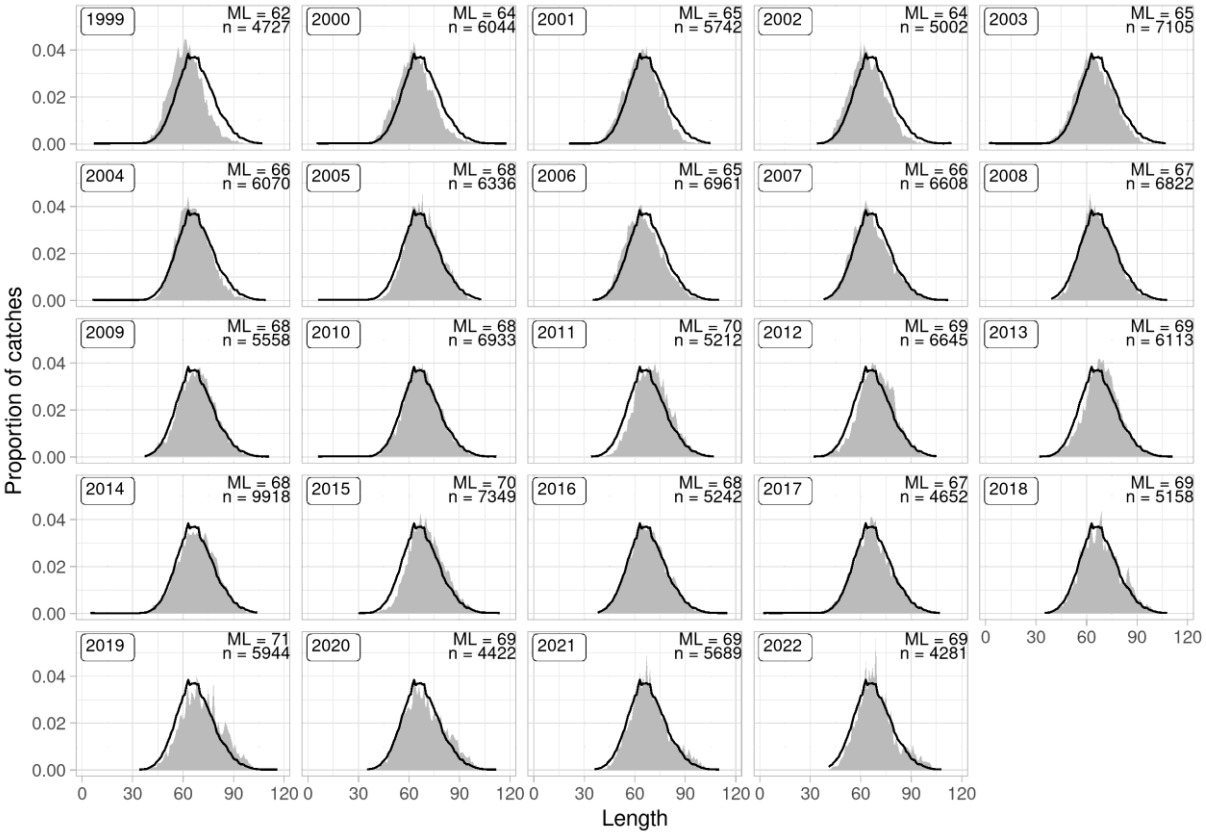

Figure 8. Atlantic wolffish. Length distribution of fish sampled from landed catch. The black line represents the mean length distribution for all years.

ICELANDIC SURVEY DATA

The Icelandic spring groundfish survey (hereafter IS-SMB), which has been conducted annually in March since 1985, covers the most important distribution area of Atlantic wolffish in Icelandic waters. In addition, the Icelandic autumn groundfish survey (hereafter IS-SMH) was commenced in 1996 and expanded in 2000. However, a full autumn survey was not conducted in 2011. The spring survey is considered to measure changes in abundance/biomass of Atlantic wolffish better than the autumn survey.

INDICES AND DISTRIBUTION OF ATLANTIC WOLFFISH IN IS-SMB AND IS-SMH

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 9). 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 coincide with increasing effort and catch of trawlers at its main spawning ground west of Iceland (Látragrunn) during its 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.

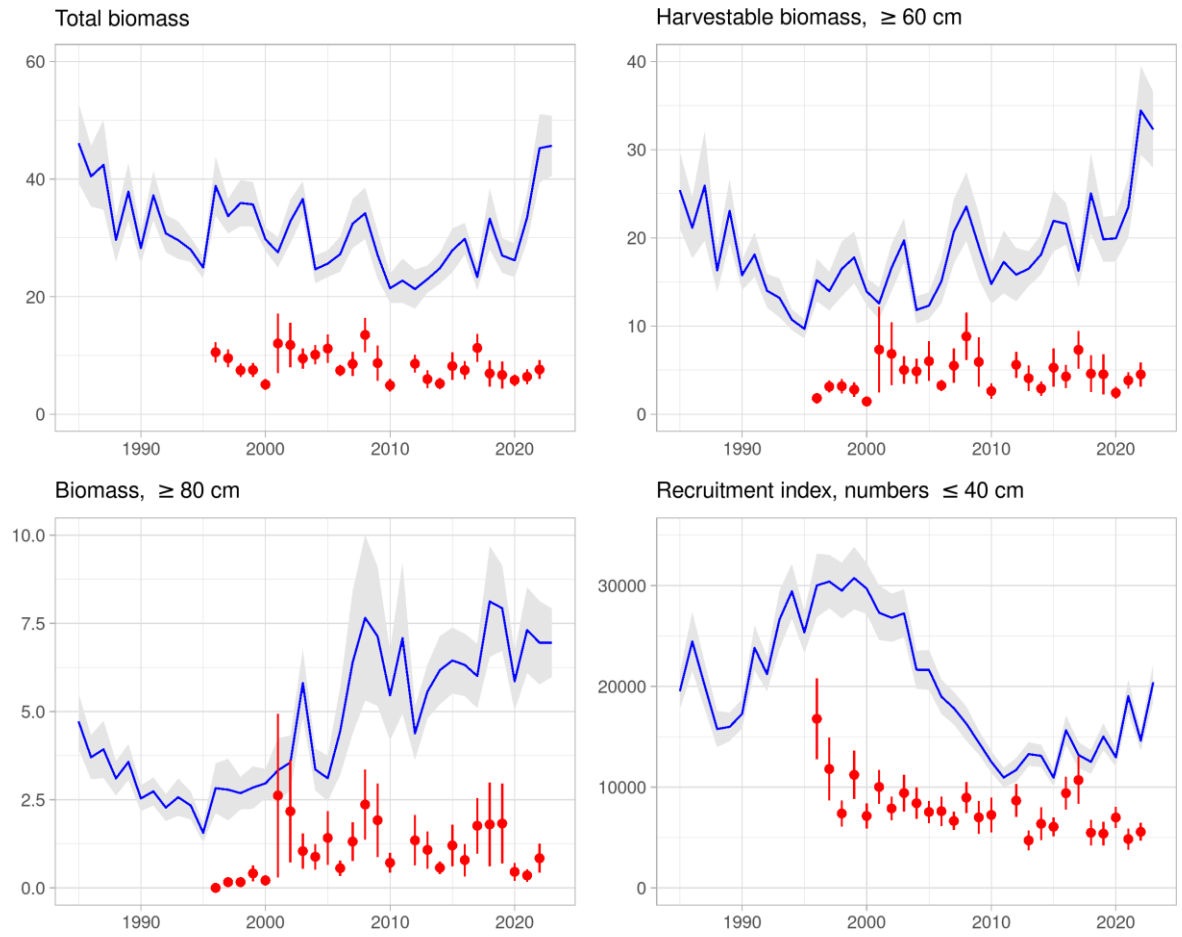

Figure 9. Atlantic wolffish. Total biomass indices (upper left) and harvestable biomass indices (≥60 cm, upper right), large fish biomass indices (≥80 cm, lower left) and juvenile abundance indices (≤40 cm, lower right), from the spring survey (blue) and the autumn survey (red), along with the standard deviation.

When the spring survey is conducted, Atlantic wolffish are on their feeding grounds which are commonly in relatively shallow waters (Figure 10). In the spring survey (SMB), the highest abundance has always been measured in the NW area (Figure 11).

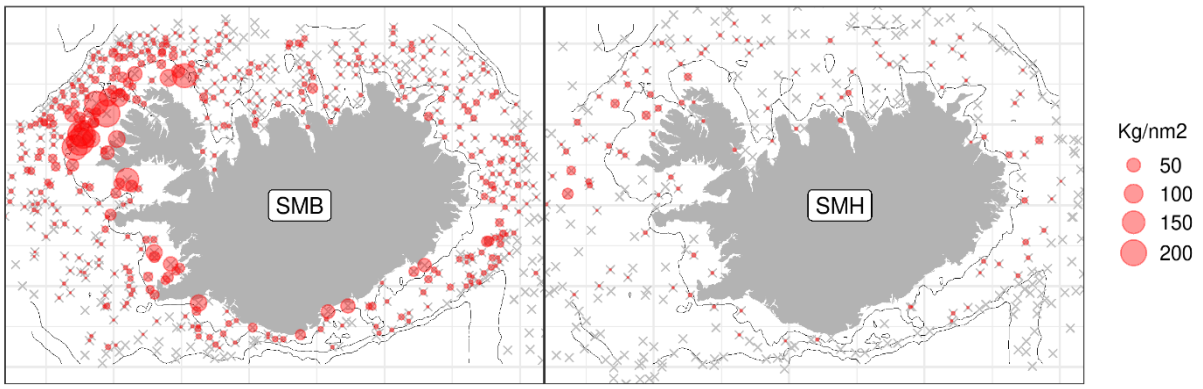

Figure 10. Atlantic wolffish. Spatial distribution and abundance in the spring survey (SMB) in 2023 and the autumn survey (SMH) in 2022.

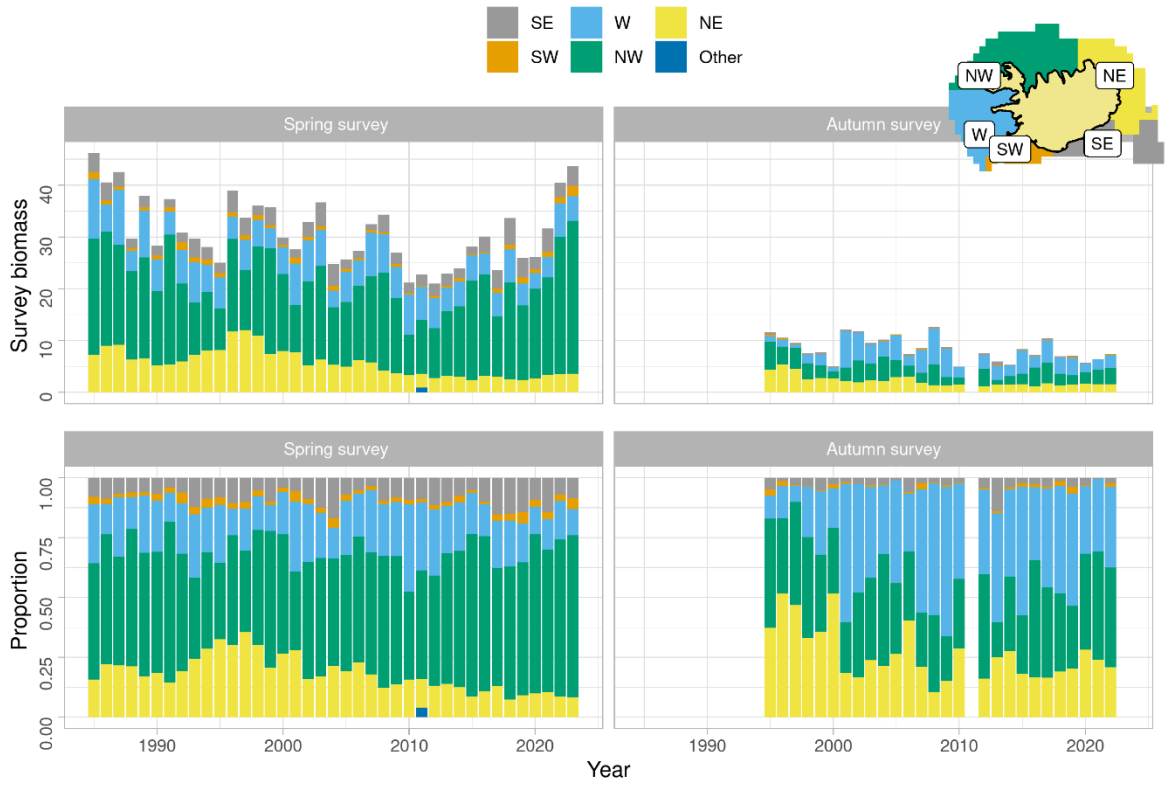

Figure 11. Atlantic wolffish. Spatial distribution of biomass index from the spring survey and autumn survey.

In the autumn survey, Atlantic wolffish are more often caught in deeper waters than in the spring survey. The autumn survey is conducted when Atlantic wolffish is spawning, and the spawning grounds are usually deeper than the feeding grounds. Since 2000, the highest biomass has been measured in the northwest and west areas (Figures 10-11). The main spawning area of Atlantic wolffish is located at the northern part of the west area.

LENGTH DISAGGREGATED ABUNDANCE INDICES IN IS-SMB AND IS-SMH

Since 2004, the length distribution in the spring survey has been bimodal because of a relatively lower number of fish at 40-60 cm. The mean length of Atlantic wolffish has been similar between years or on the average about 39 cm. It was, however, the lowest in 1994-2004, about 37 cm, but in these years the recruitment index was high. Due to decreasing recruitment since 1999 (Figure 9 and 12), the mean length increased and was on the average about 41.8 cm in 2007-2023 (Figure 12). Mean length in the autumn survey varied from 33-41 cm, with no clear trend (Figure 13).

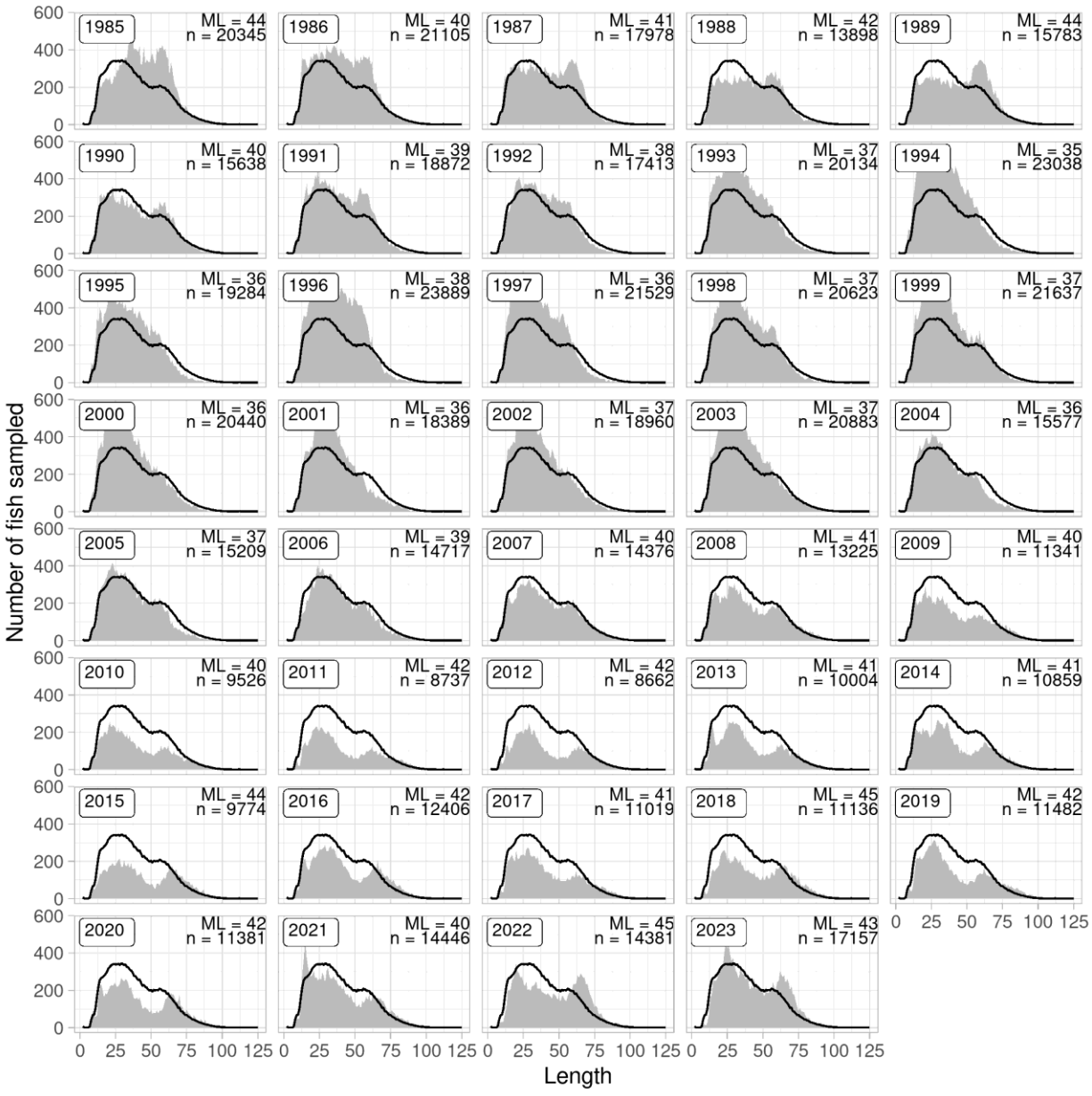

Figure 12. Atlantic wolffish. Length-disaggregated abundance indices from the spring survey. The black line shows the mean for all years.

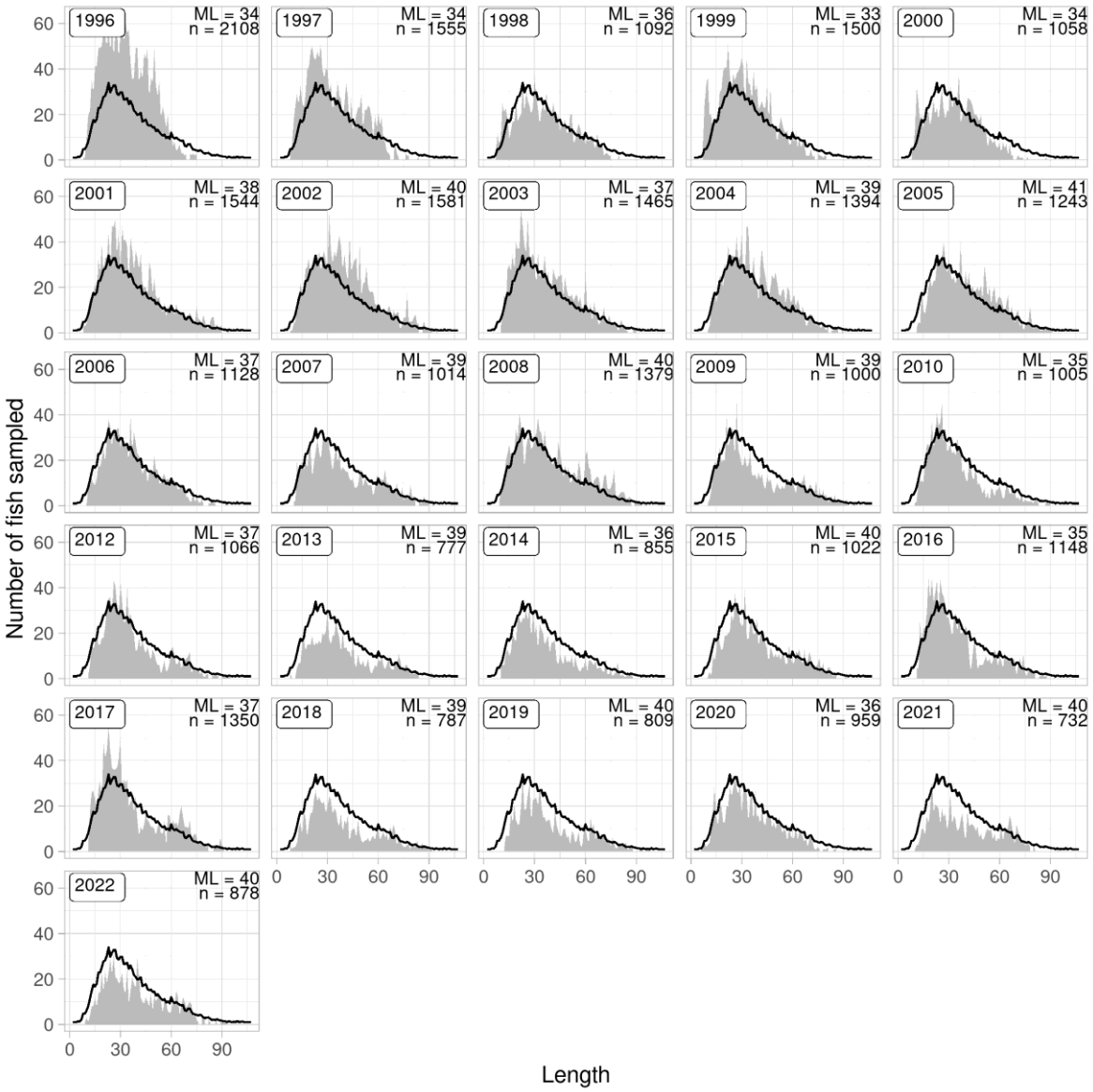

Figure 13. Atlantic wolffish. Length-disaggregated abundance indices from the autumn survey. The black line shows the mean for all years.

DATA ANALYSES

ANALYTICAL ASSESSMENT ON ATLANTIC WOLFFISH IN ICELANDIC WATERS USING SAM

In 2022, Atlantic wolffish in 5.a became a part of the ICES assessment benchmarking process after an MoU between Iceland and ICES was signed on 1 December 2019 that requested evaluation of harvest control rules for ling, tusk, Atlantic wolffish, and plaice.

During the harvest control rule evaluation in April 2022, a SAM model (State-space stock assessment model) was agreed upon for use in the assessment (ICES 2022).

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 estimated at age 4 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 M=0.15.

DIAGNOSTICS

Model results are shown in Table 5. Fits to the catch-at-age data, survey numbers-at-age indices and fit to total catch can be found in Figure 14. 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.

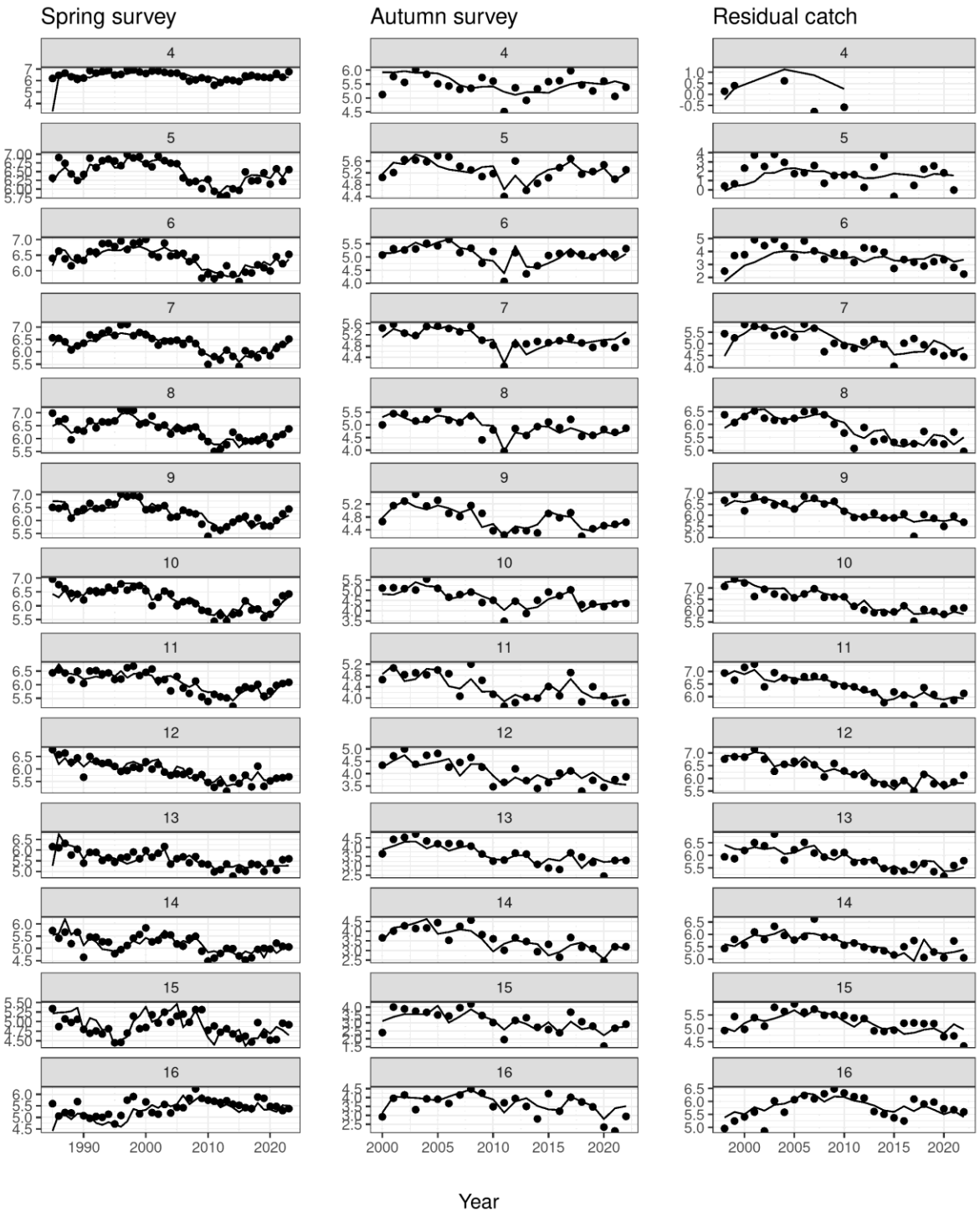

Figure 14. Atlantic wolffish. Fit of the proposed SAM model to numbers at age (4-16 years) input data to spring survey, autumn survey and catch. Points indicate input data; lines indicate model predictions.

MODEL RESULTS

Model results show that Atlantic wolffish recruitment levels decreased from high levels in 1990-2000 to current levels. Excluding values earlier than 1985, which are highly uncertain because spring survey data began in 1985, current spawning stock biomass levels are on par with those in 1985-1990, which represent a maximum in the more reliable post-1985 portion of the time series. A smaller proportion of smaller fish currently contribute to the total stock, because of lower recruitment, which halved from roughly 20 million prior to 2000 to roughly 10 million after in 2008-2012. However, following a decrease in landings and fishing mortality from high levels in 2009 to current levels, both spawning stock biomass and recruitment levels appear stable or slowly increasing after 2012 (Figure 15).

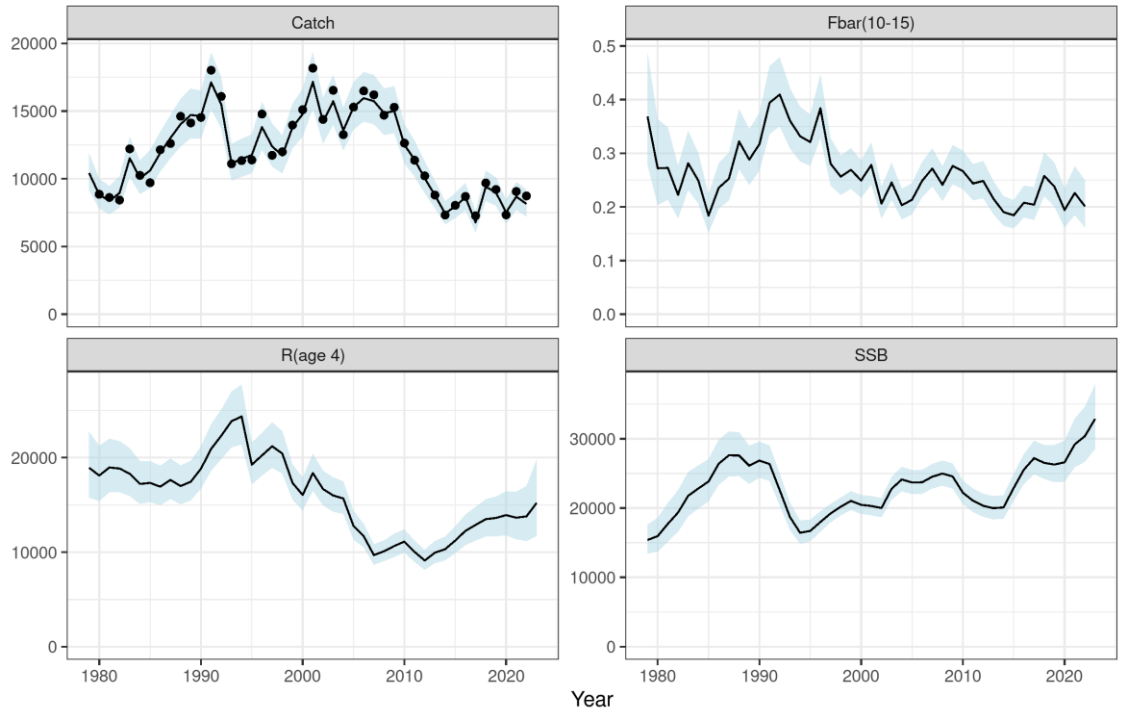

Figure 15. Atlantic wolffish. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fish and harvest rate, recruitment, and total catches.

RETROSPECTIVE ANALYSIS

The results of an analytical retrospective analysis are presented in Figure 16. The analysis indicates relatively stable estimation, except in the earliest peel. Mohn's rho was estimated to be -0.00879 for SSB, -0.02095 for F, and 0.-0.03788 for recruitment.

Neither observation nor process residuals show obvious trends (Figure 17 and 18).

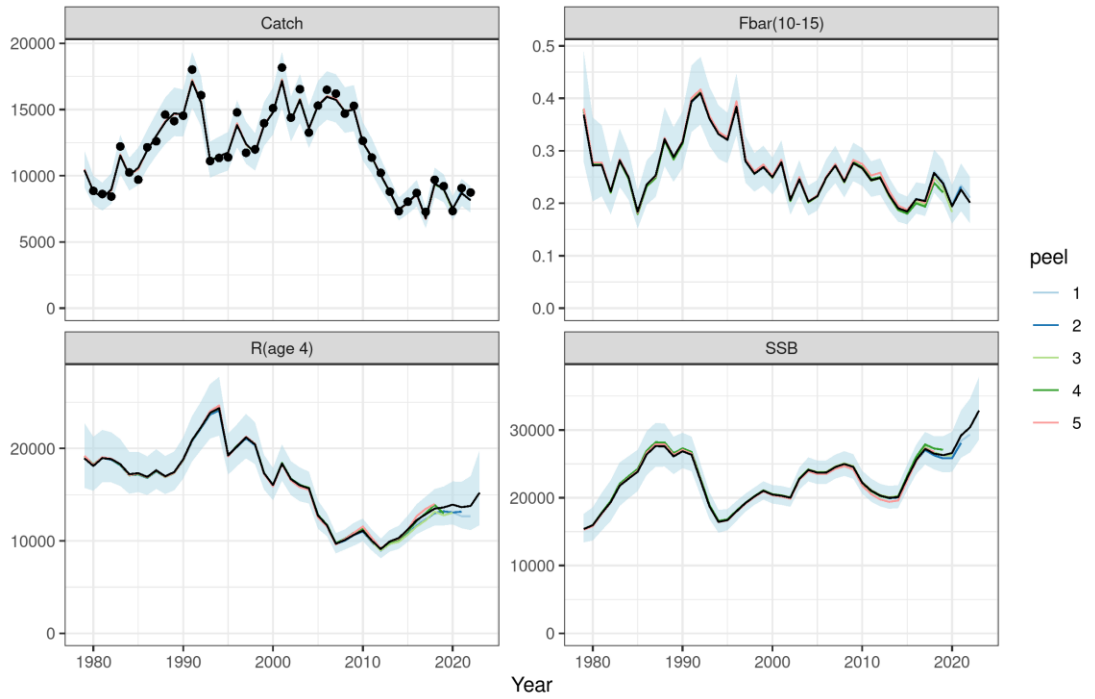

Figure 16. Atlantic wolffish. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 4) are shown.

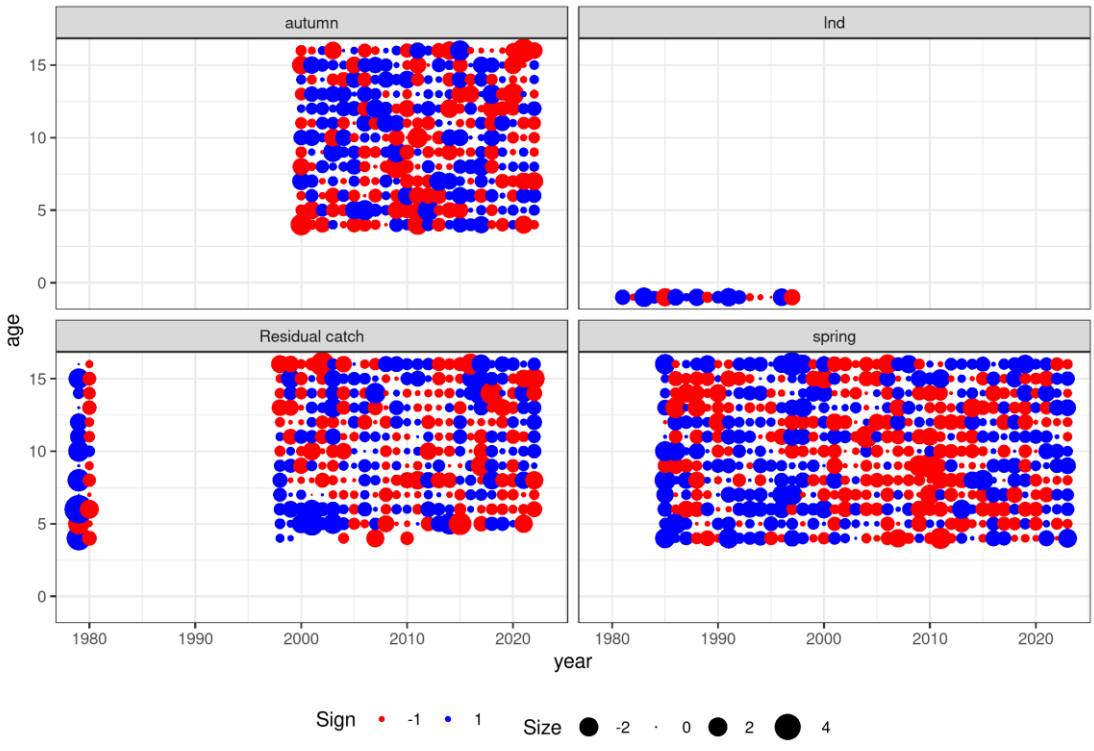

Figure 17. Atlantic wolffish. Observation error residuals of the SAM model.

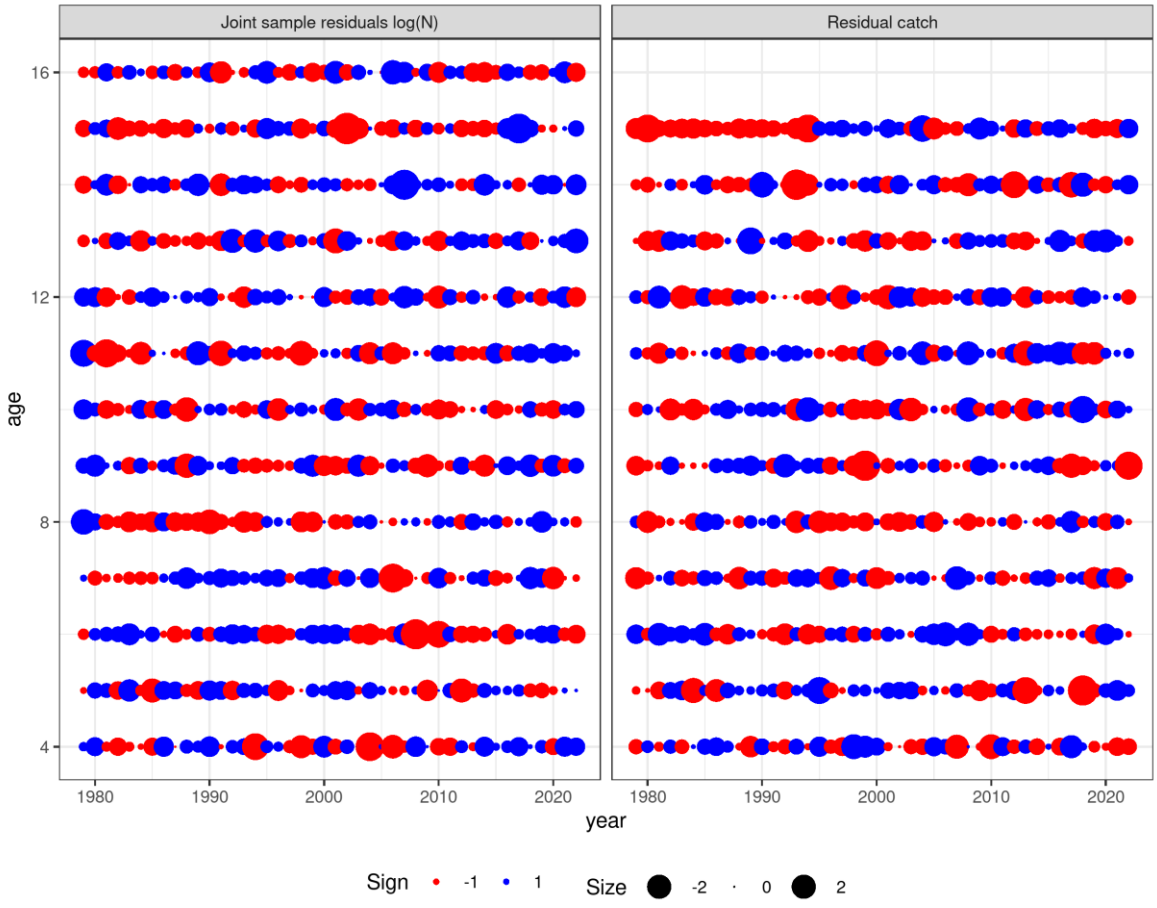

Figure 18. Atlantic wolffish. Process error residuals of the SAM model.

REFERENCE POINTS

As part of the WKICEMP 2022 HCR evaluations, the following reference points were defined for the stock.

Table 3. Atlantic wolffish. Reference points adopted from ICES WKICEMP 2022.

Framework	Reference point	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	21 000	B_{pa}
	F_{msy}	0.20	Based on F_{pa}, maximum F at which the probability of SSB falling below B_{lim} is <5%
Precautionary approach	B_{lim}	18 500	B_{lim} x $e^{1.645 * \sigma B}$
	B_{pa}	21 000	B_{loss} (SSB in 2002).
	F_{lim}	0.33	Fishing mortality that in stochastic equilibrium will result in median SSB at Blim.
	F_{pa}	0.20	Based on F_{pa}, maximum F at which the probability of SSB falling below B_{lim} is <5%
Harvest control rule	MGT $B_{trigger}$	21 000	According to the harvest control rule
	F_{MGT}	0.20	According to the harvest control rule

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.

SUMMARY OF THE ASSESSMENT

Table 4. Atlantic wolffish. Assessment summary by calendar year. Catches are ICES estimates.

Year	Recruitment Age 4 (thousands)			SSB Tonnes			Catches Tonnes	F Age 10-15		
	Value	97.5%	2.5%	Value	97.5%	2.5%		Value	97.5%	2.5%
1979	18931	22750	15753	15388	17627	13433	10429	0.37	0.49	0.28
1980	18103	21257	15417	15957	18600	13689	8837	0.27	0.36	0.20
1981	18958	22008	16331	17724	20718	15162	8357	0.27	0.35	0.21
1982	18842	21737	16333	19349	22576	16583	8960	0.22	0.28	0.18
1983	18298	21007	15938	21773	25217	18800	11520	0.28	0.34	0.23
1984	17214	19628	15097	22827	26144	19930	10043	0.25	0.30	0.21
1985	17324	19641	15281	23829	27079	20970	10610	0.18	0.22	0.15
1986	16923	19142	14962	26396	29829	23357	11909	0.24	0.28	0.20
1987	17637	19912	15622	27618	31055	24561	13015	0.25	0.30	0.21
1988	16996	19178	15062	27588	30934	24605	14035	0.32	0.38	0.27
1989	17448	19669	15478	26103	29010	23487	14712	0.29	0.34	0.24
1990	18828	21201	16720	26854	29591	24369	14626	0.32	0.38	0.27
1991	20919	23525	18602	26346	29029	23912	17115	0.39	0.46	0.34
1992	22320	25099	19849	22560	25002	20357	15485	0.41	0.48	0.35
1993	23846	26979	21077	18709	20809	16820	11136	0.36	0.42	0.31
1994	24354	27734	21385	16439	18210	14840	11467	0.33	0.39	0.28
1995	19254	21604	17159	16700	18336	15209	11757	0.32	0.37	0.28
1996	20232	22609	18105	17992	19528	16577	13817	0.38	0.45	0.33
1997	21202	23745	18932	19222	20602	17935	12389	0.28	0.33	0.24
1998	20425	22806	18293	20196	21521	18952	11719	0.26	0.30	0.22
1999	17326	19299	15555	21031	22438	19713	13808	0.27	0.31	0.23
2000	16043	17881	14394	20467	21876	19149	14778	0.25	0.29	0.22
2001	18367	20431	16512	20296	21741	18946	17150	0.28	0.32	0.24
2002	16676	18617	14937	20007	21435	18674	14185	0.21	0.24	0.18
2003	15995	17926	14271	22787	24472	21218	15729	0.25	0.28	0.21
2004	15675	17488	14049	24124	25959	22419	13582	0.20	0.23	0.18
2005	12758	14383	11317	23690	25490	22018	15289	0.21	0.24	0.19
2006	11684	12987	10513	23720	25530	22039	15955	0.25	0.28	0.22
2007	9685	10843	8651	24525	26354	22822	15734	0.27	0.31	0.24
2008	10093	11240	9064	24978	26867	23221	14860	0.24	0.28	0.21
2009	10649	11953	9487	24554	26435	22807	15001	0.28	0.32	0.24
2010	11114	12411	9952	22215	23975	20585	12512	0.27	0.31	0.23
2011	10024	11217	8958	21053	22824	19418	11405	0.24	0.28	0.21
2012	9116	10243	8113	20320	22051	18726	10043	0.25	0.29	0.22
2013	9945	11188	8840	19979	21730	18370	8792	0.22	0.25	0.19
2014	10308	11640	9129	20096	21863	18472	7441	0.19	0.22	0.16
2015	11227	12740	9893	22907	24916	21059	7970	0.18	0.21	0.16
2016	12251	13978	10736	25545	27810	23465	8634	0.21	0.24	0.18
2017	12881	14789	11219	27198	29710	24897	6787	0.20	0.24	0.18
2018	13490	15603	11662	26521	29089	24179	9418	0.26	0.30	0.22
2019	13617	15882	11674	26274	29087	23734	8993	0.24	0.28	0.20
2020	13918	16431	11789	26604	29721	23815	7518	0.19	0.23	0.16
2021	13644	16395	11356	29188	32895	25899	8688	0.23	0.28	0.19
2022	13783	17008	11170	30383	34608	26674	8143	0.20	0.25	0.16
2023	15214	19782	11701	32864	37825	28554	7490			

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.

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.

MANAGEMENT

The Ministry of Food, Agriculture and Fisheries 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 (Table 5). 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 (Figure 19). Net transfer of Atlantic wolffish quota for each fishing year is usually less than 10%.

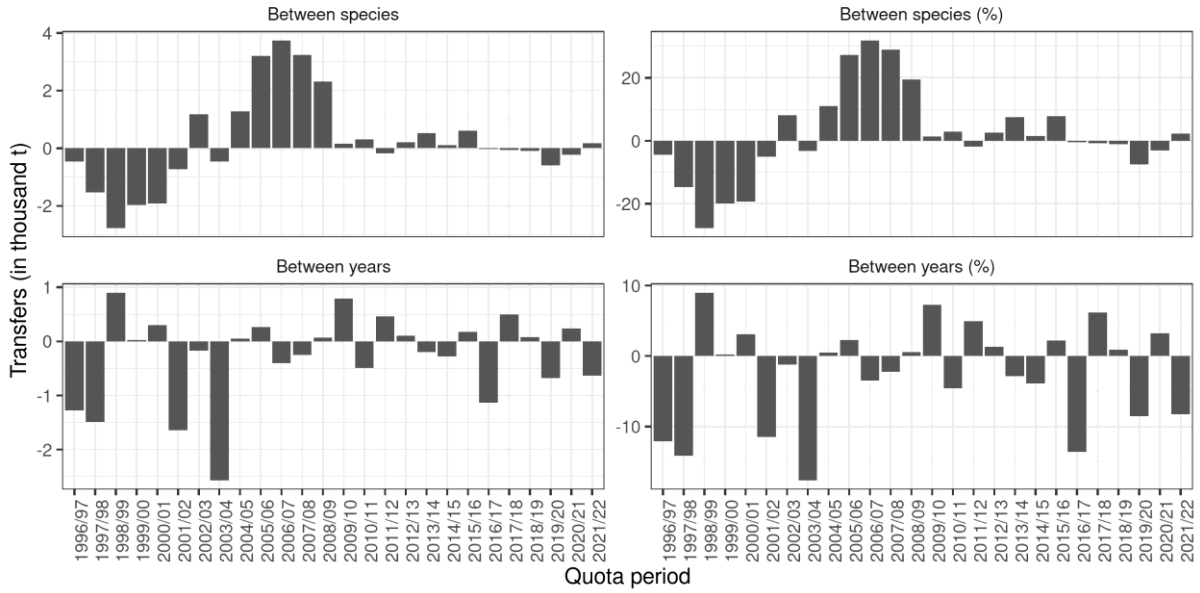

Figure 19. Atlantic Wolffish. Net transfer of quota, from Atlantic Wolffish to other species, in the Icelandic ITQ system by fishing year.

Table 5. Atlantic wolffish. Recommended TAC, national TAC, and catches (tonnes).

Fishing year	Recommended TAC	National TAC	Catches
1998/1999	13 000	13 000	13 139
1999/2000	13 000	13 000	14 913
2000/2001	13 000	13 000	18 084
2001/2002	13 000	16 100	13 682
2002/2003	15 000	15 000	16 943
2003/2004	15 000	16 000	13 255
2004/2005	13 000	16 000	14 201
2005/2006	13 000	13 000	16 461
2006/2007	12 000	13 000	15 817
2007/2008	11 000	12 500	15 098
2008/2009	12 000	13 000	15 428
2009/2010	10 000	12 000	13 090
2010/2011	8 500	12 000	12 078
2011/2012	7 500	10 500	10 582
2012/2013	7 500	8 500	8 940
2013/2014	7 500	7 500	7 530
2014/2015	7 500	7 500	7 862
2015/2016	8 200	8 200	8 982
2016/2017	8 811	8 811	7 542
2017/2018	8 540	8 540	9 553
2018/2019	9 020	9 020	9 355
2019/2020	8 344	8 344	7 166
2020/2021	8 761	8 761	8 974
2021/2022	8 933	8 933	8 561
2022/2023	8 107	8 107	

REFERENCES

Gunnarsson, Á., Hjörleifsson, E., Thórarinsson, K., Marteinsdóttir, G., 2006. Growth, maturity and fecundity of wolffish *Anarhichas lupus* L. in Icelandic waters. Journal of Fish Biology, 68, 1158-1176. doi: 10.1111/j.1095-8649.2006.00990.

Gunnarsson, Á., Sólmundsson, J., Björnsson, H., Sigurðsson, G., Pampoulie, C., 2019. Migration pattern and evidence of homing in Atlantic wolffish (*Anarhichas lupus*). Fisheries Research, 215. https://doi.org/10.1016/j.fishres.2019.03.001

ICES. 2022. Workshop on the evaluation of assessments and management plans for ling, tusk, plaice and Atlantic wolffish in Icelandic waters (WKICEMP). ICES Scientific Reports. 4:37. 271 pp. http://doi.org/10.17895/ices.pub.19663971