SPOTTED WOLFFISH
Anarhichas minor

GENERAL INFORMATION

Spotted wolffish has been exploited for many years in Icelandic waters. It is an oblong fish with characteristic dark spots in its skin and sharp, protruding teeth. In catches, a common length range is 60-90 cm, but the largest spotted wolffish caught around Iceland was 144 cm. Spotted wolffish is mainly found at the north parts of the continental shelf of Iceland, at sandy or muddy substrate and depths of 100-400 m. In Icelandic waters, female spotted wolffish mature at the average length of 83 cm and age of 9 years. Before maturity, annual growth is on the average 6.5 cm.

THE FISHERY

The main fishing grounds for spotted wolffish are northwest off Iceland (Figure 1). In 2000, most of the catches were taken in the NE area but the proportion of catches in the NW area has been gradually increasing in the period. In 2020, catches in NE and NW accounted 85% of all catches (Figures 1 and 2).

About 6% of the catch of spotted wolffish is caught at depths less than 100 m, and about 20-30% between 100 and 200 m (Figure 3). In 2000-2004 about 50% of the catch of spotted wolffish was caught at depths between 200 and 300 m, decreasing to about 40% in following years. However, this proportion increased again to approximately 42% in 2020. The catch taken at more than 300 m has been relatively stable between 20-25% since 2000 (Figure 3).

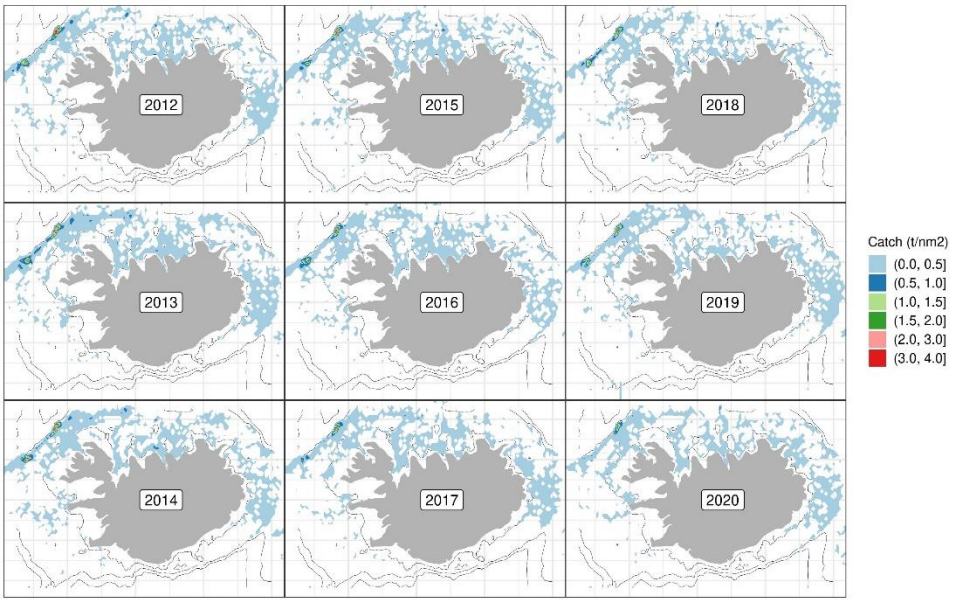

Figure 1. Spotted wolffish. Geographical distribution of the Icelandic fishery since 2012. Reported catch from logbooks.

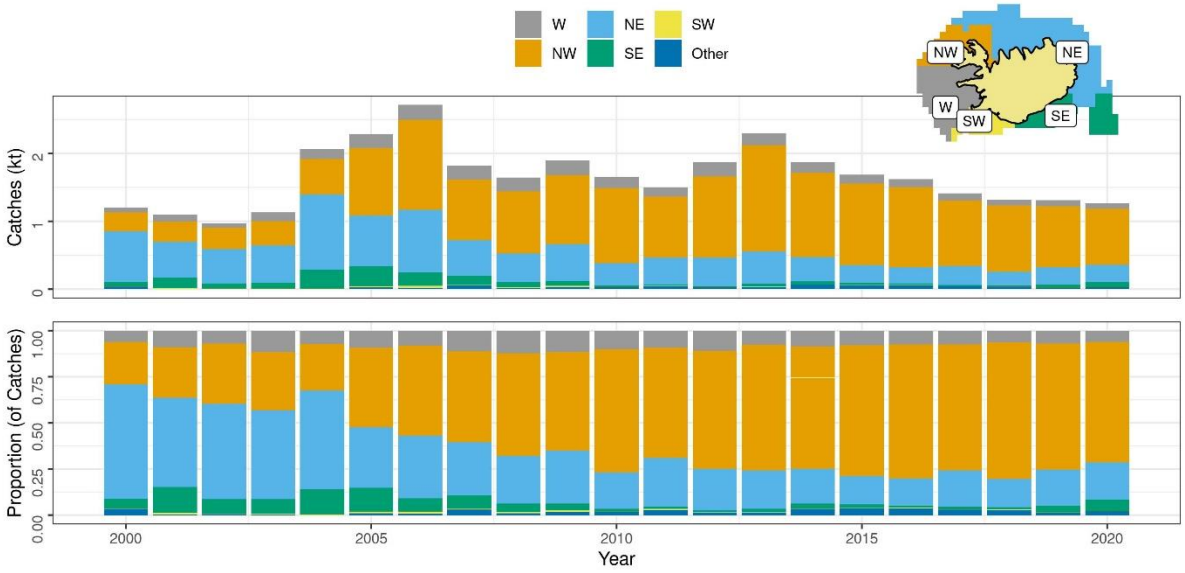

Figure 2. Spotted wolffish. Spatial distribution of the Icelandic fishery by fishing areas from year 2000 according to logbooks. All gears combined.

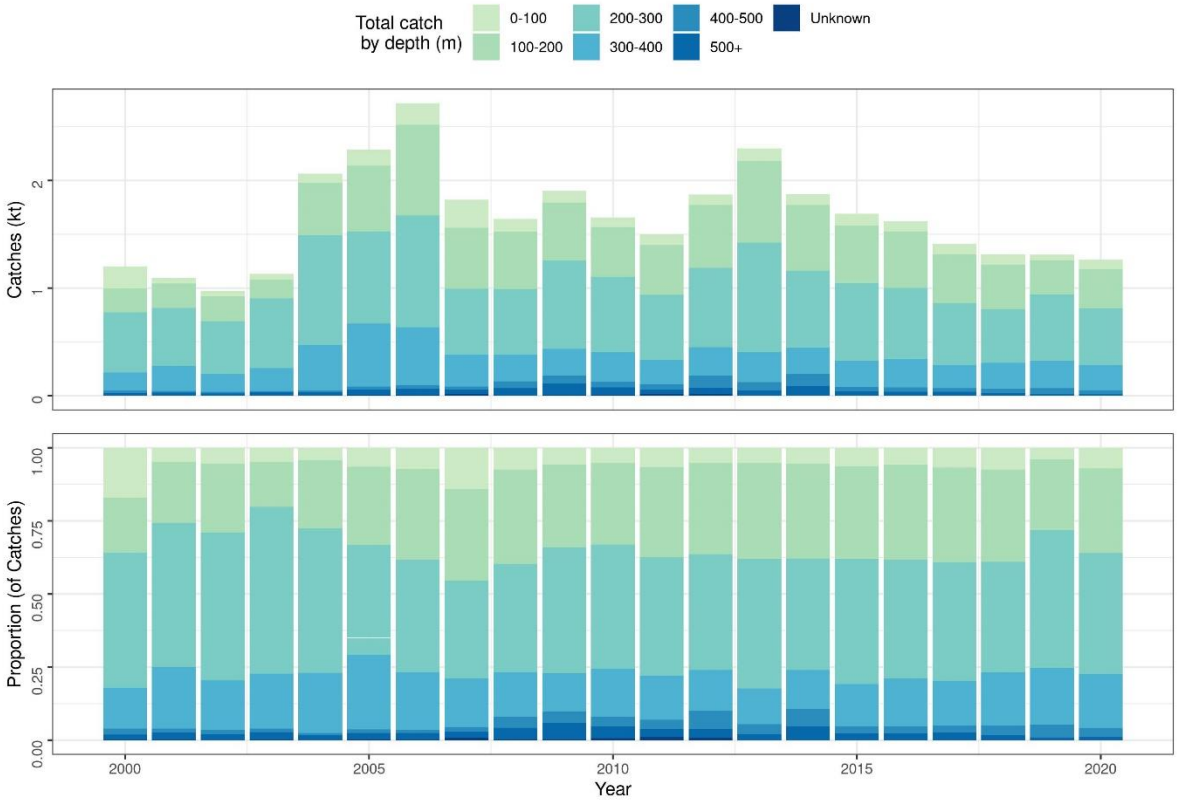

Figure 3. Spotted wolffish. Depth distribution of catches according to logbooks.

Around 98% of landed spotted wolffish is caught on longline and in demersal trawl. In 2000-2003, the longline catch was less than 40% of the total catch, and in demersal trawl little more than 60%. From 2002, the catch on longline has been increasing relative to that taken in demersal trawl. In 2020, longline catch was 50% of the total catch (Figure 4).

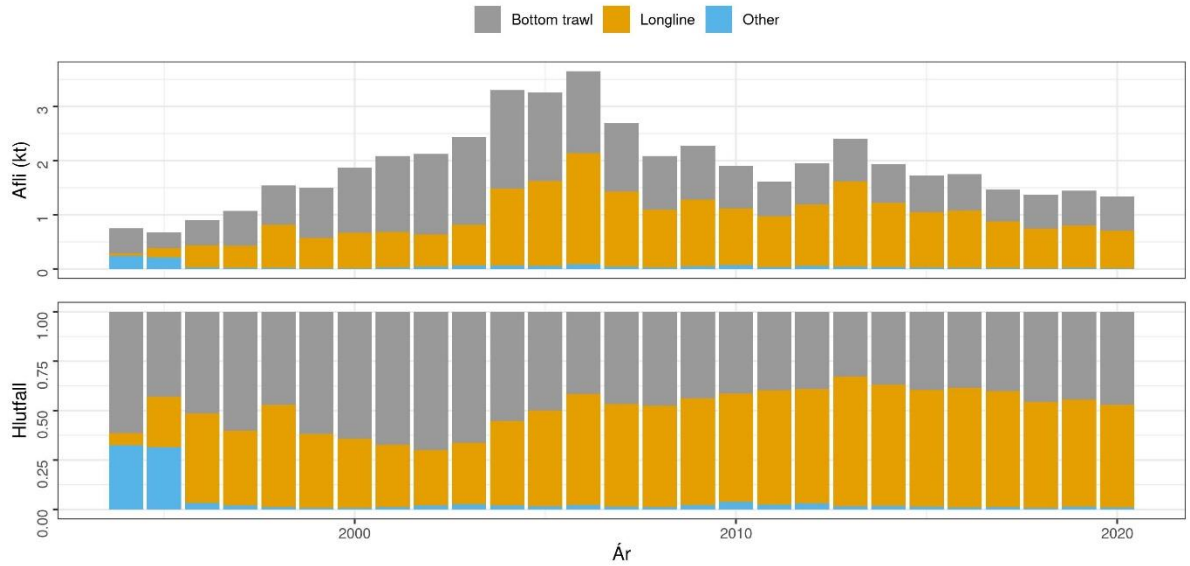

Figure 4. Spotted wolffish. Total catch (landings) by fishing gear since 1994, according to statistics from the Directorate of Fisheries.

In 2000-2006, the number of longliners reporting catches of 1000 kg/year or more of spotted wolffish increased from 24 to 87 (Table 1). At the same time catches on longline increased from 700 to 2000 tonnes. Since then, the number of longliners reporting spotted wolffish catches decreased to around 60 vessels from 2008-2020, with an annual longline catch of around 1000 tonnes on average. The number of trawlers was 40-60 in 2000-2020 with no trend observed. However, catches in demersal trawl from 2008 have been only about half of what they were in 2000-2007 (Table 1).

The increased targeting of spotted wolffish by longliners began in 1996 with a catch over 400 tonnes, but before that it was usually less than 100 tonnes annually. This increased effort could be related to the fact that in the fishing year 1996/97 its closely related species, Atlantic wolffish, was for the first time included in ITQ system.

Table 1. Spotted wolffish. Number of Icelandic vessels reporting catch of 1000 kg/year or more, and all landed catch divided by gear type according to statistics from the Directorate of Fisheries.

	NUMBER OF VESSELS			CATCHES (TONNES)			
YEAR	Longline	Trawlers	Other	Longline	Demersal trawl	Other	Sum
2000	24	39	2	693	1149	10	1852
2001	32	42	0	673	1399	15	2087
2002	29	42	2	610	1463	35	2108
2003	29	41	3	748	1618	58	2424
2004	53	53	1	1409	1813	59	3281
2005	71	45	3	1571	1631	48	3250
2006	87	51	3	2041	1565	35	3641
2007	84	44	1	1391	1258	38	2687
2008	60	50	2	1069	990	25	2084
2009	63	55	8	1243	1000	49	2292
2010	56	54	8	1042	808	51	1901
2011	63	49	6	934	642	38	1614
2012	63	56	5	1124	761	38	1923
2013	77	61	8	1575	788	35	2398
2014	72	55	6	1180	714	34	1928
2015	67	50	7	1005	740	29	1774
2016	56	49	8	1031	727	17	1775
2017	59	54	4	818	589	18	1424
2018	62	50	2	718	625	10	1353
2019	47	50	6	729	640	20	1389
2020	56	52	4	658	629	14	1302

The number of vessels accounting for 95% of the annual catch of spotted wolffish has been in the range of 75-150 (Figure 5). The number of vessels was relatively stable in 1996-2003, despite increased catches, but increased in 2004-2006 when annual catches exceeded 3000 tonnes. Since 2007, a drop in the number of vessels accounting for 95% of the catches has coincided with catch reductions (Figure 5).

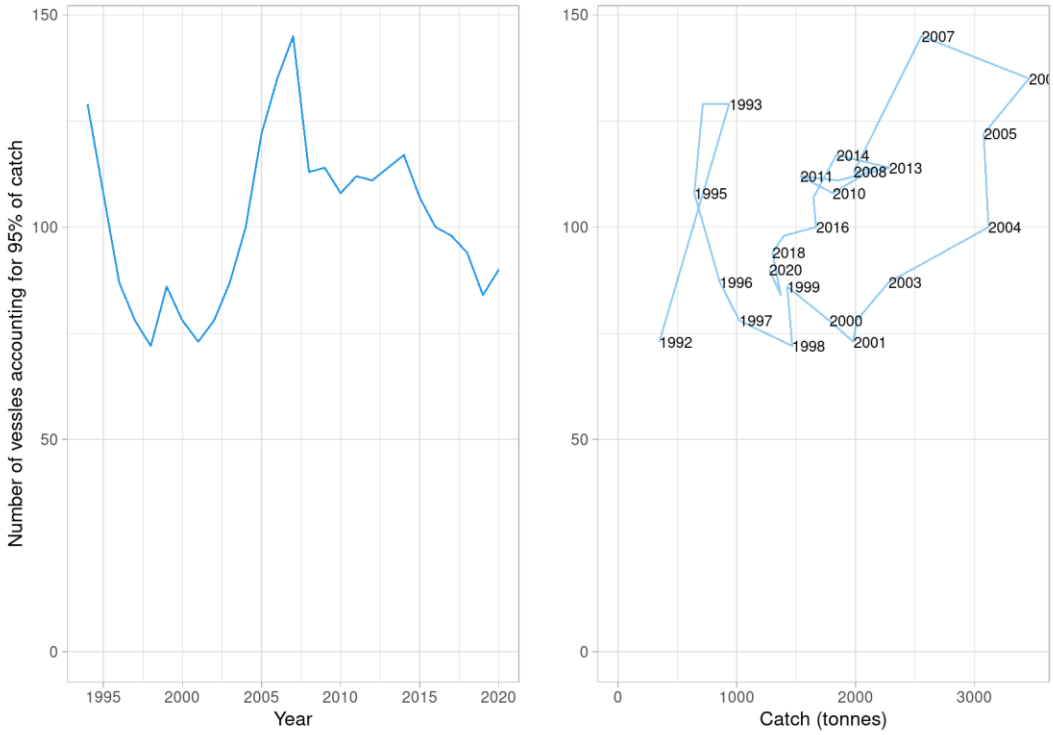

Figure 5. Spotted wolffish. Number of vessels (all gear types) accounting for 95% of the total catch annually since 1994. Left: Plotted against year. Right: Plotted against total catch. Data from the Directorate of Fisheries.

CATCH PER UNIT EFFORT (CPUE) AND EFFORT.

CPUE estimates of spotted 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.

None-standardised estimates of CPUE of longline (kg/1000 hooks), and demersal trawl (kg/tow-hour), were calculated as the total weight in sets or tows in which spotted wolffish was more than 10% of the catch, according to logbooks. Similarly, effort of demersal trawl was the number of tow-hours and for longline number of hooks, in both cases data in which spotted wolffish was more than 10% of the catch.

The estimated longline CPUE has no clear trend; it was highest in 2003 (94 kg/1000 hooks) and lowest in 2011 and 2020 (41 kg/1000 hooks). Estimates of CPUE from demersal trawl fluctuated between 93 and 150 kg/h in 2000-2010 also with no clear trend. From 2011 (111 kg/h) to 2020 (119 kg/h) CPUE has generally increased with highest value of 156 kg/h in 2017 (Figure 6).

Longline effort increased from 6 million hooks in 2000 to around 11 million hooks in 2006, but since then it has been decreasing and was around 2.1 million hooks in 2020. Fishing effort of demersal trawl was in the range of 1500-2350 tow-hours in 2000-2006. Since 2006 the effort has been decreasing and was around 500 tow-hours in 2020 (Figure 6).

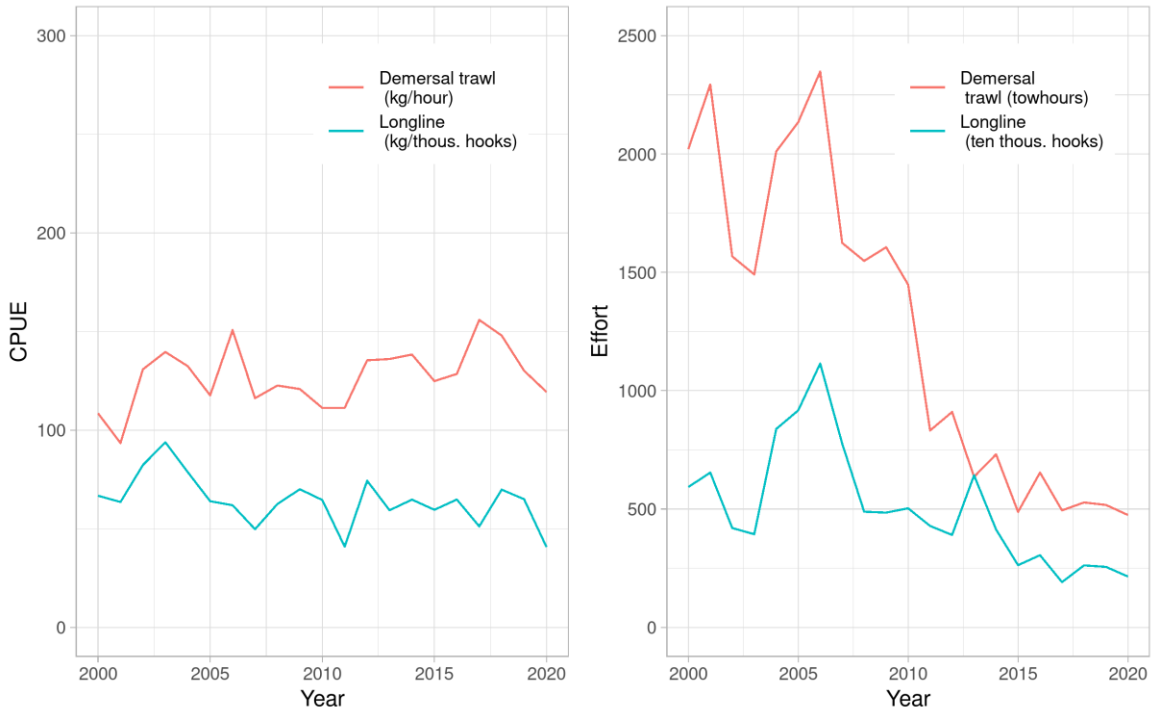

Figure 6. Spotted wolffish. Non-standardised estimates of CPUE (left) from demersal trawl (kg/h, red) and longline (kg/1000 hooks, blue). Fishing effort (right) for demersal trawl (tows hours, red) and longline (10000 hooks, blue).

SAMPLING AND AGE DISTRIBUTION OF LANDED SPOTTED WOLFFISH

Around 400-1900 otoliths have been sampled annually for age reading by the MFRI, and in the last nine years 4-45 samples from longliners and 4-29 samples from demersal trawl were collected (Table 2, Figure 7). Samples were not taken from other gear, as they represent small proportion (~2%) of the total catch.

In samples from commercial catches in 2015 about 400 specimens were aged. The estimated age range was 5-16 years, age 8 and 9 years were most common or about 40%. Age has not been determined for spotted wolffish landed since 2016, but recently age determination for spotted wolffish from the spring groundfish survey began.

Table 2. Spotted wolffish. Number of samples and otoliths sampled from landed catch.

Year	Longline		Demersal trawl	
	Samples	Otoliths	Samples	Otoliths
2010	7	295	8	355
2011	7	329	5	246
2012	9	432	10	451
2013	16	789	4	200
2014	45	1101	29	775
2015	19	475	20	500
2016	14	350	12	300
2017	8	200	9	225
2018	8	200	9	225
2019	12	300	12	300
2020	4	100	12	300

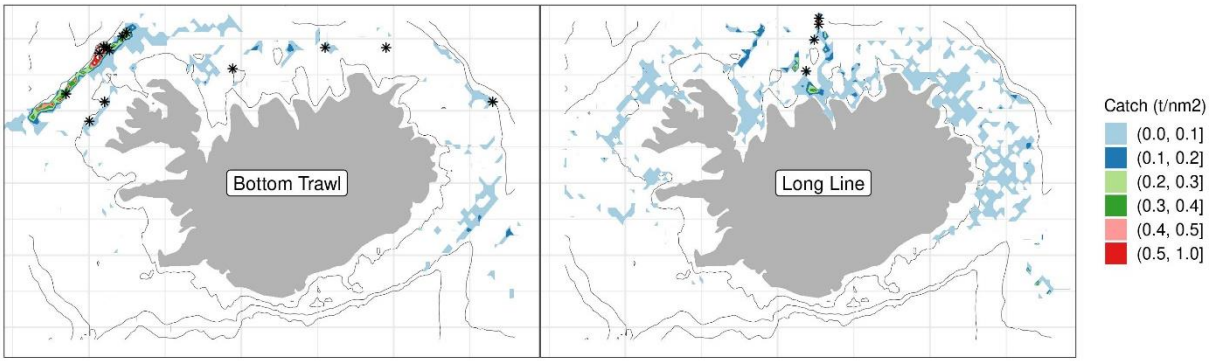

Figure 7. Spotted wolffish. Fishing grounds in 2020 as reported in logbooks and positions of samples taken from landings (asterisks).

LENGTH DISTRIBUTION OF LANDED SPOTTED WOLFFISH

The mean length of spotted wolffish sampled from commercial catches has generally been increasing from 2005 (72 cm) to 2018 (79 cm), since then it has decreased and was it 75 cm in 2020 (Figure 8).

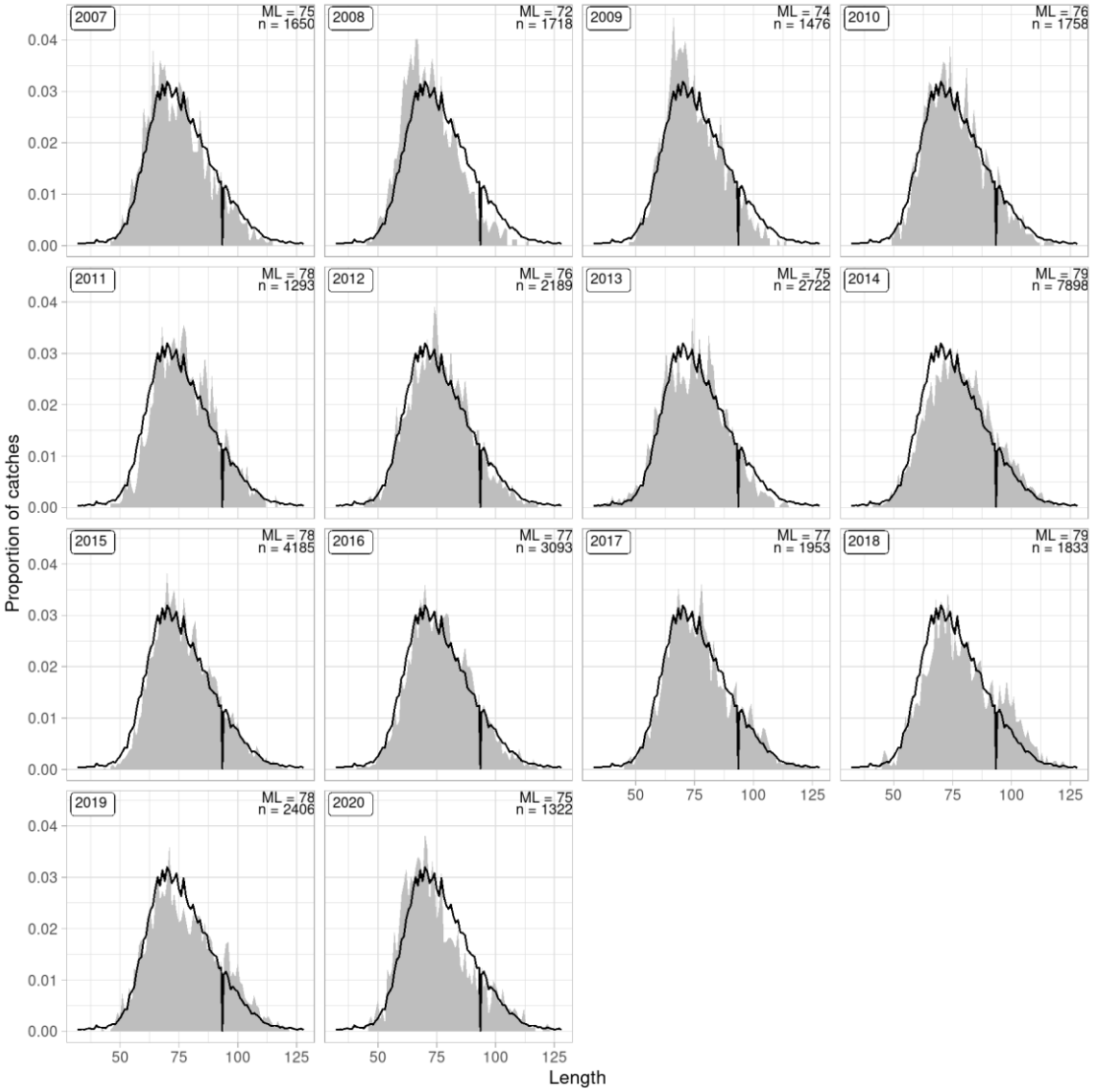

Figure 8. Spotted wolffish. Length distribution of spotted wolffish sampled from landed catch. The black line represents the mean length distribution for all years.

SURVEY DATA

The Icelandic spring groundfish survey (hereafter spring survey, IS-SMB), which has been conducted annually in March since 1985, covers the most important distribution area of the spotted wolffish fishery. In addition, the Icelandic autumn groundfish survey (hereafter autumn survey, IS-SMH) was commenced in 1996 and expanded in 2000. However, a full autumn survey was not conducted in 2011 due to a labour dispute. For spotted wolffish, the spring survey is considered to measure changes in abundance/biomass better than the autumn survey, although in 1996-2003 the Iceland-Faroe ridge was not sampled in the spring survey.

Indices of total biomass and harvestable biomass have been decreasing since 1996, except in the years 2003-2006 (but note that in 2004, stations at the Iceland-Faroe ridge were reintroduced in IS-SMB). Last year, the indices were at a historically low level but an upward revision was observed in the most recent survey (Figure 9).

The recruitment index was high in the years 1992-2000. Since then, it decreased almost every year to a historically low level in 2012. Recruitment index from spring survey has increased in 2021, as well as other biomass indices and is now similar as it was in 2011 (Figure 9).

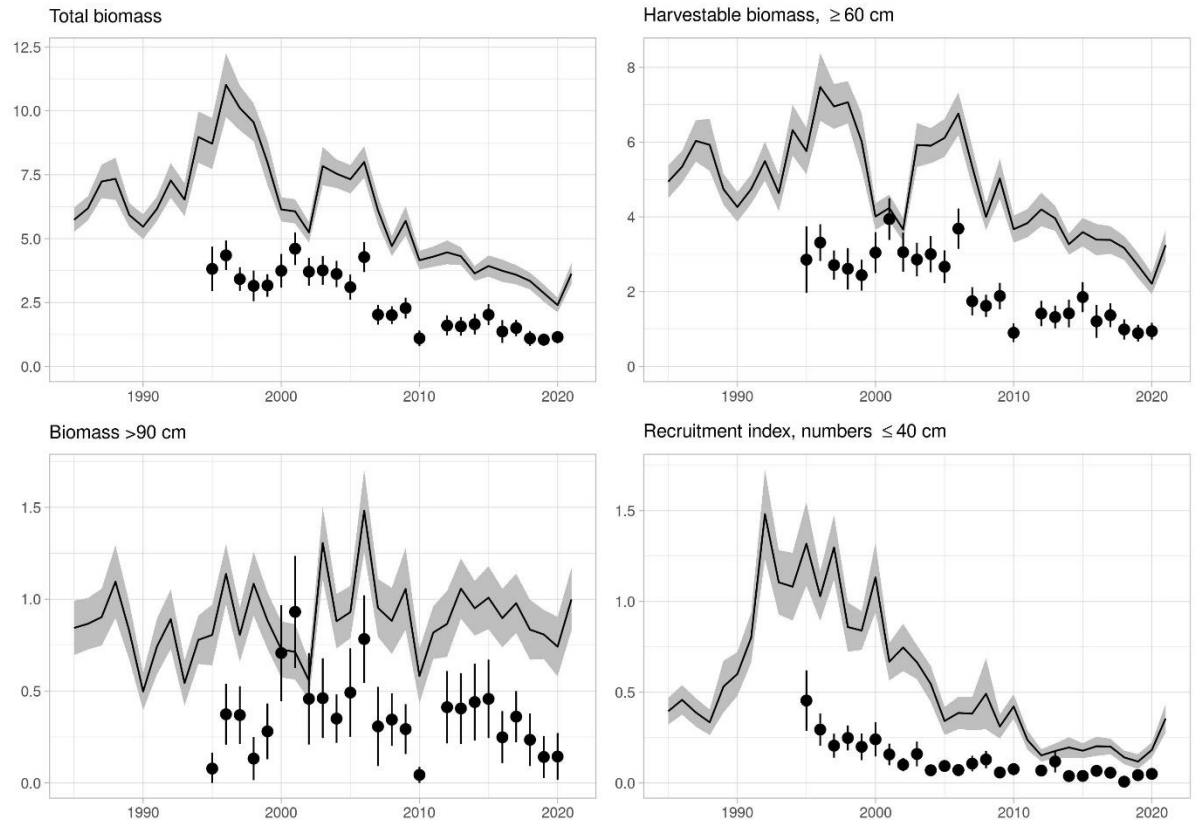

Figure 9. Spotted wolffish. Total biomass indices (upper left) and harvestable biomass indices (≥60 cm, upper, right), large fish biomass indices (≥90 cm, lower left) and juvenile abundance indices (≤40 cm, lower right) from the spring survey (blue) from 1985 and autumn survey (red) from 1996, along with the standard deviation.

Since 2012, spotted wolffish has mostly been caught in the slope areas northwest and north of Iceland in the spring survey (Figures 10 and 11). Biomass indices from the NW area have been relatively stable throughout the survey period. Greater changes have taken place in the NE area, where biomass increased in 1985-1996 but have decreased significantly since then (Figure 11). In 1996-2003 the Iceland-Faroe

ridge was not sampled in the spring survey, which seems to have resulted in 15-20% underestimation of the total biomass index for spotted wolffish.

Spotted wolffish spawn in late summer or autumn and the distribution of the catch is similar in the autumn and spring surveys, which may suggest a proximity between spawning and feeding grounds. (Figures 10 and 11). However, in 1996-2003, a lower proportion of the autumn survey biomass was measured in the NE area as compared to the spring survey. Most spotted wolffish in the autumn survey in 2020 were caught at the slope areas northwest of Iceland, but the biomass there has been decreasing since 2006. The biomass index in the NE area has been decreasing from 1996, in accordance with the spring survey (Figures 10 and 11).

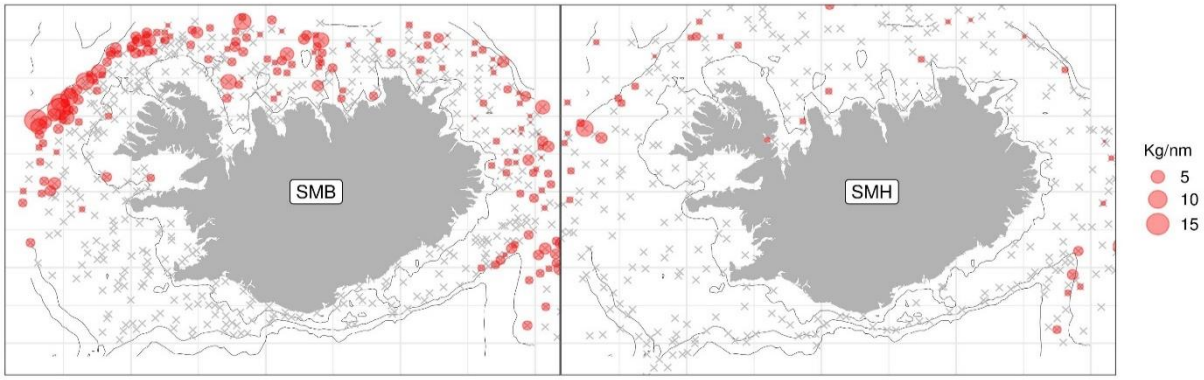

Figure 10. Spotted wolffish. Spatial distribution and abundance in the spring survey (SMB) and autumn survey (SMH) in 2020.

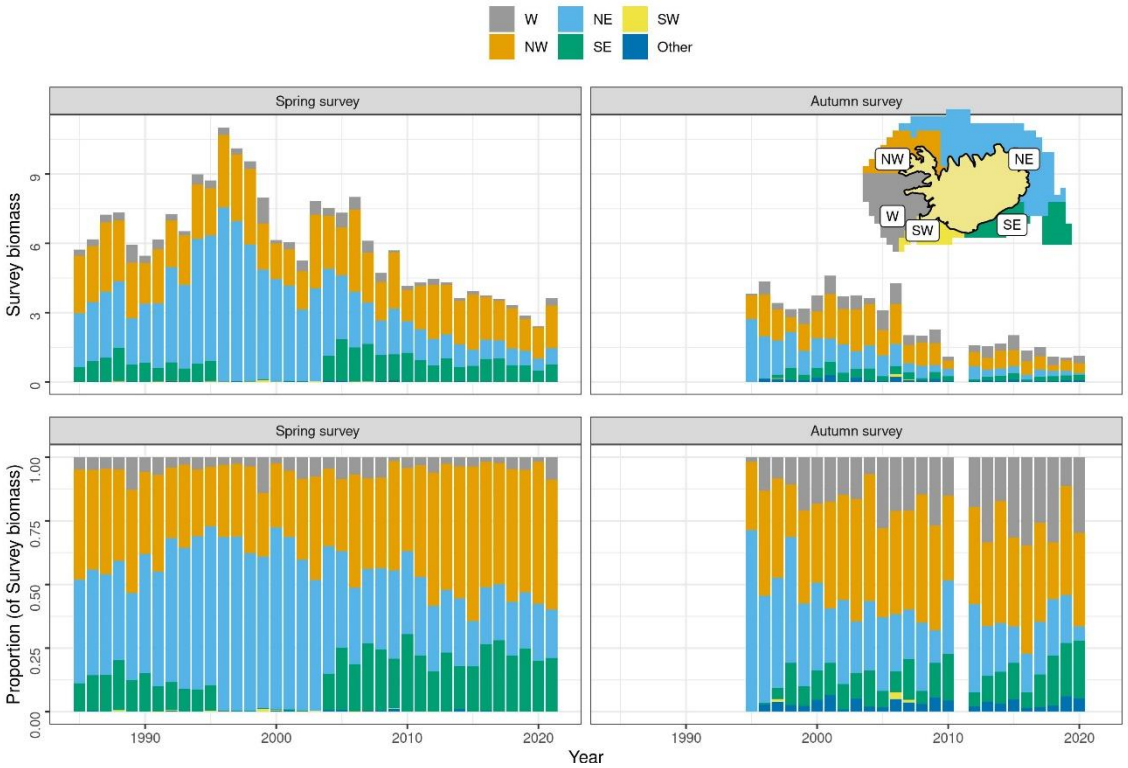

Figure 11. Spotted wolffish. Spatial distribution of the index from the spring survey and autumn survey. Note that the Iceland-Faroe ridge was not sampled in 1996-2003.

The mean length in spring survey decreased from 1986 (62.9 cm) to 1995 (52.1 cm) due to increased abundance of smaller fish (<60 cm) (Figure 12). Thereafter, the mean length increased to 69.4 cm in 2019, due to lower abundance of fish smaller than 60 cm. The mean length has decreased since. The number of spotted wolffish caught in the spring survey increased from 1273 fish in 1990 to 2744 fish in 1997. Since then, the number has been declining and reached the lowest level last year or 353. In 2021, the number of observed fish was slightly higher, or 550 individuals.

In the year 2020 it was beginning to age determine spotted wolffish from IS-SMB and is it done for the years 2015-2020 or 1070 fishes. The age range was 1-16 years, but about 70% were at the ages 7-12 years and the weighted mean was 8.8 years old. The main purpose with this age determination is to provide data for stock assessment with the Gadget model.

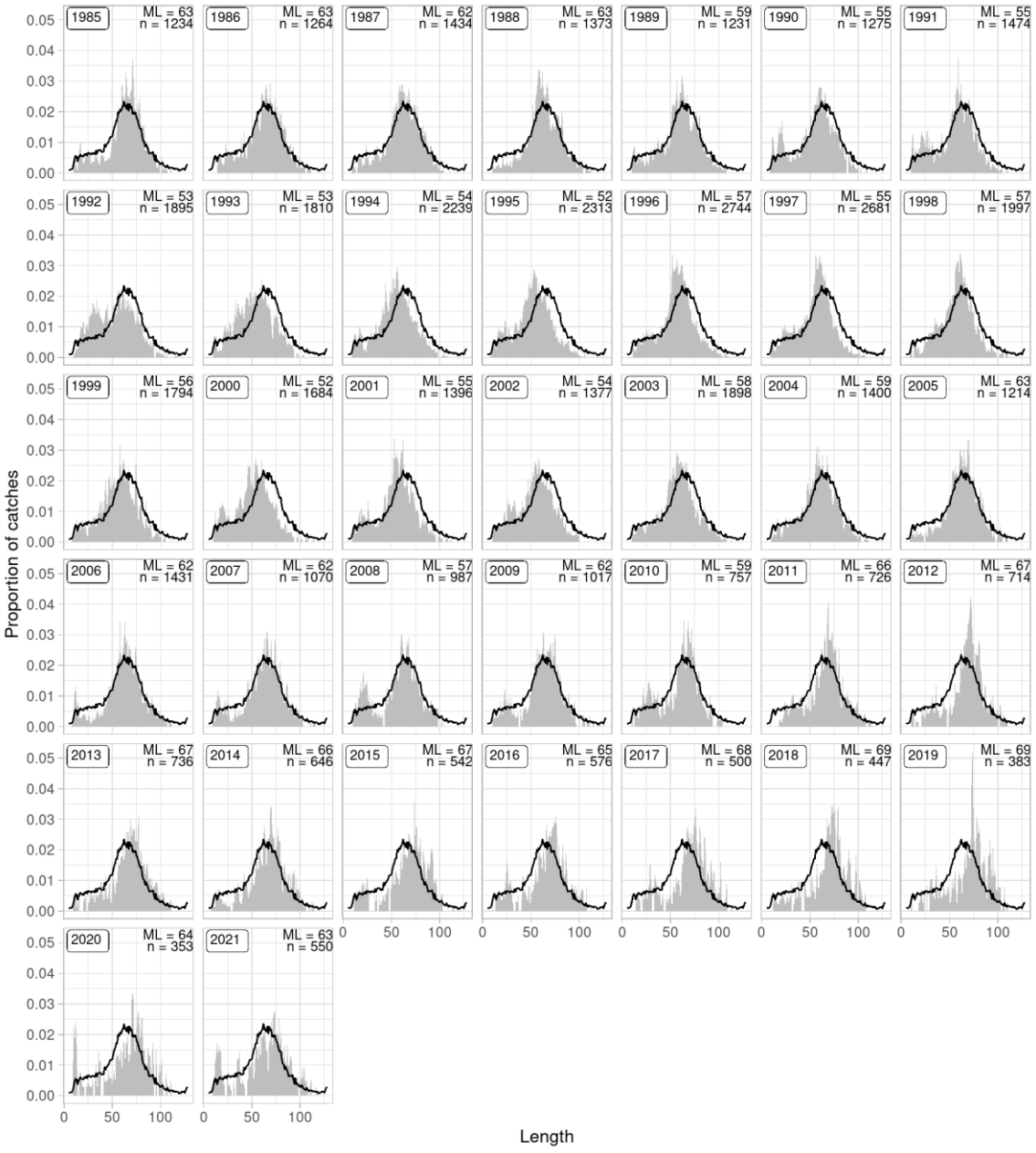

Figure 12. Spotted wolffish. Length abundance indices from the spring survey. The black line shows the mean for all years.

The mean length of spotted wolffish in the autumn survey has increased from 1996 (58.8 cm) to 2020 (63 cm). This is in accordance with the spring survey and the reason is decreased abundance of fish smaller than 60 cm (Figure 13). Number of spotted wolffish caught in the autumn survey was on the average 250 fish in the years 1996-2006. Since then, the number has been decreasing and was on average 90 fish in the years 2010-2017, but 75 fish were caught in the 2020 survey.

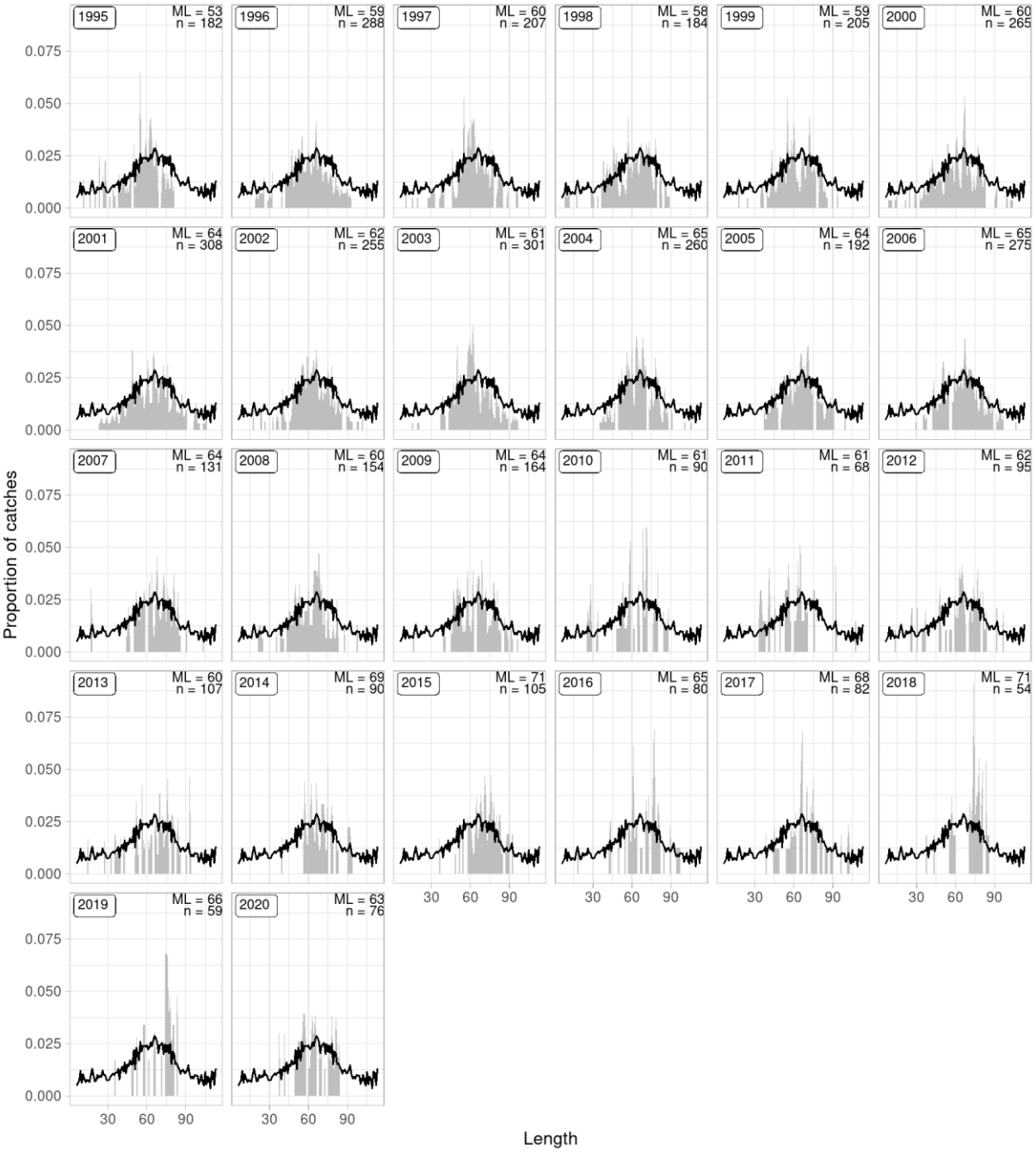

Figure 13. Spotted wolffish. Length distribution from the autumn survey. The black line shows the mean for all years.

MANAGEMENT

The Ministry of Industries and Innovation is responsible for management of the Icelandic fisheries and implementation of legislation. Spotted wolffish was included in the ITQ system in 2018. The MFRI advised catch based on F_{proxy} for the first time in the fishing year 2012/2013. For the first four fishing years, the advice was based on average catch in the years 1985-1997 which was around 900 tonnes, and the stock size was rather stable during these years. When advising catch for the fishing year 2016/2017, it was decided to use 70% of the average F_{proxy} of the years 2001-2015 as target F_{proxy}, but the biomass index from the spring survey decreased about 20% at this time. For the fishing year 2019/2020 it was decided, due to low spawning stock biomass and poor recruitment, to set target F_{proxy} on a more precautionary basis than the years before. The mean F_{proxy} for the years 1985-1998 was chosen, because then fishing pressure did not have any observed detrimental effects on the stock biomass (Figure 14). Catches of spotted wolffish in the fishing years 2012/2013-2015/2016 were around 100% higher than recommended by the MRI and around 40% higher in each of the next three fishing years and in last fishing year it was about 240% higher (Table 3).

The spotted wolffish stock is now at a historically low level, in 2020 index values was measured lower than any points observed in the IS-SMB time series. The size of the spawning stock is likely to be below any candidate value of B_{lim}. Managements of spotted wolffish fishing effort is difficult as most of its catch is bycatch. Therefore, the advised catch levels are expected to decline in coming years or potentially an advised landing ban of spotted wolffish. Another possibility is that fishermen release spotted wolffish beyond quota. When MFRI was advising catch of spotted wolffish for ongoing fishing year it proposed that fishermen were granted license to released spotted wolffish. This licence was granted by the Ministry of Industries and Innovation on 14. December. 2021.

Table 3. Spotted wolffish. Recommended TAC, national TAC, and landings (tonnes).

FISHING YEAR	REC. TAC	NATIONAL TAC	CATCH
2012/13	900	-	2041
2013/14	900	-	2241
2014/15	900	-	1636
2015/16	900	-	1886
2016/17	1128	-	1548
2017/18	1080	-	1553
2018/19	1001	1001	1425
2019/20	375	375	1310
2020/21	314	314	

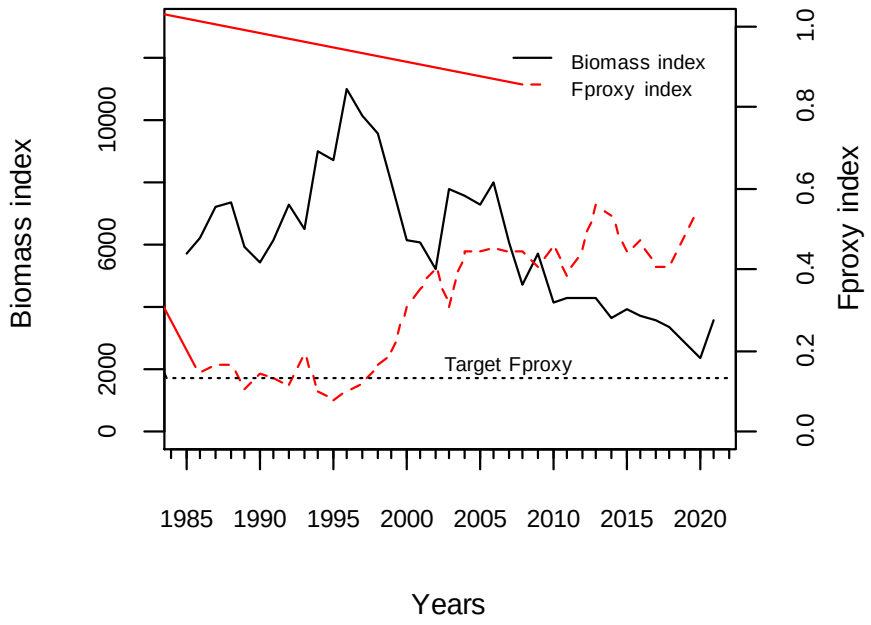

Figure 16. Spotted wolffish. F_{proxy} (catch/survey biomass). The target F_{proxy} is set as the mean of the reference period of 1985-1998.

SURVIVAL OF RELEASED SPOTTED WOLFFISH AFTER CATCH

In the years 2001-2006 there was a fish farming of spotted wolffish in Iceland. The fish that was used to produce larvae was collected in a conventional bottom trawl fishing. After the fish from the catch had been put into a container with seawater flowing to it. Virtually no mortality was observed neither in the fishing vessel or the farming station where the fish were moved to after landing. Same applied for spotted wolffish sampled on handliners for the fish farming.

In the years 2015-2017 102 spotted wolffish were tagged thereof 43 also with DST tag in IS-SMB and IS-SMH. Recapture from this tagging has been good, indicating that spotted wolffish tolerate well to be released after catch in bottom trawl. In this tagging it was a surprise that some of the spotted wolffish seemed to survive up to one hour in the fishing ramp. Most of these fish seemed lifeless when it was put into a container with seawater flowing to it, but after c. 5-10 minutes it begin swimming lively in the container. In 2021 150 spotted wolffish were tagged with T-bar anchor tag in IS-SMB to among other things to investigate its survival after being released after catch in bottom trawl, it is scheduled to continue this research in next years.

Grant and Hiscock, 2014 showed that 90% of Atlantic wolffish survived if it were released two hours after catch in bottom trawl i.e., the fish could survive two hours in the fishing ramp or the conveyor belt after catch. The authors of this research assumed that same applied to spotted wolffish, because that these two species are so related. In the year 2020 MRFI did a preliminary research on how long spotted can survive in fishing ramp and conveyor belt in IS-SMH. The result indicate that spotted wolffish can survive up to two hours after catch in fishing ramp and conveyor belt. Research have shown that spotted wolffish and Atlantic wolffish can tolerate sea with low oxygen content, which support the result of the two before mention studies (Foss *et al.*, 2002).

In 2020 when MRFI recommended that fishermen were able to release spotted wolffish beyond quota, it was known that its survival was high when released after capture in bottom trawl. However, no studies

or observation had been done on survival of released spotted wolffish after longline catch. Therefore, the MFRI begin to investigate it in the autumn 2020. Preliminary results suggest that survival of spotted wolffish is high after being released after capture in longline, it is schedule to continue this research in this year.

REFERENCE

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