TUSK - KEILA

Brosme brosme

GENERAL INFORMATION

Tusk, also commonly called cusk, is a slow-moving demersal species that lives solitarily or in small aggregations in offshore stony or pebbly habitats, mainly at depths less than 400 m. It feeds on crustaceans, shellfishes, and other demersal fishes. In Icelandic waters it grows to sizes close to 100 cm and may attain ages close to 20, but age determination of individuals over 10 years old is highly uncertain.

THE FISHERY

LANDINGS TRENDS

The total annual landings from ICES Division 5.a (Icelandic waters) were around 3444 tonnes in 2019 (Tables 1 and 2), signifying a continuous decrease in landings from 2010. This is contrary to the trend in landings from 2000 in which the annual landings gradually increased in Icelandic waters to around 9000 tonnes in 2010 (Figure 1).

The foreign catch (mostly from the Faroe Islands, but also from Norway) of tusk in Icelandic waters has always been considerable. Until 1990, between 40–70% of the total annual catch from ICES Division 5.a (Icelandic waters) was caught by foreign vessels, mainly vessels from the Faroe Islands. This proportion reduced to 15–25% until the most recent years in which it increased to closer to 50% due to a reduction in Icelandic catches (Table 1).

Landings in Greenlandic waters have always been low compared to those in Icelandic waters, rarely exceeding 100 t. However, around 900 tonnes were caught in 2015, after which catches have been consistently substantial. Catch data from ICES section 14 reported by the Greenland Institute of Natural Resources (WGDEEP, 2019:WD06) also reflect this trend. In total, 566 tonnes were caught in Greenlandic waters in 2019 mainly by Faroese and Greenlandic vessels (Table 2).

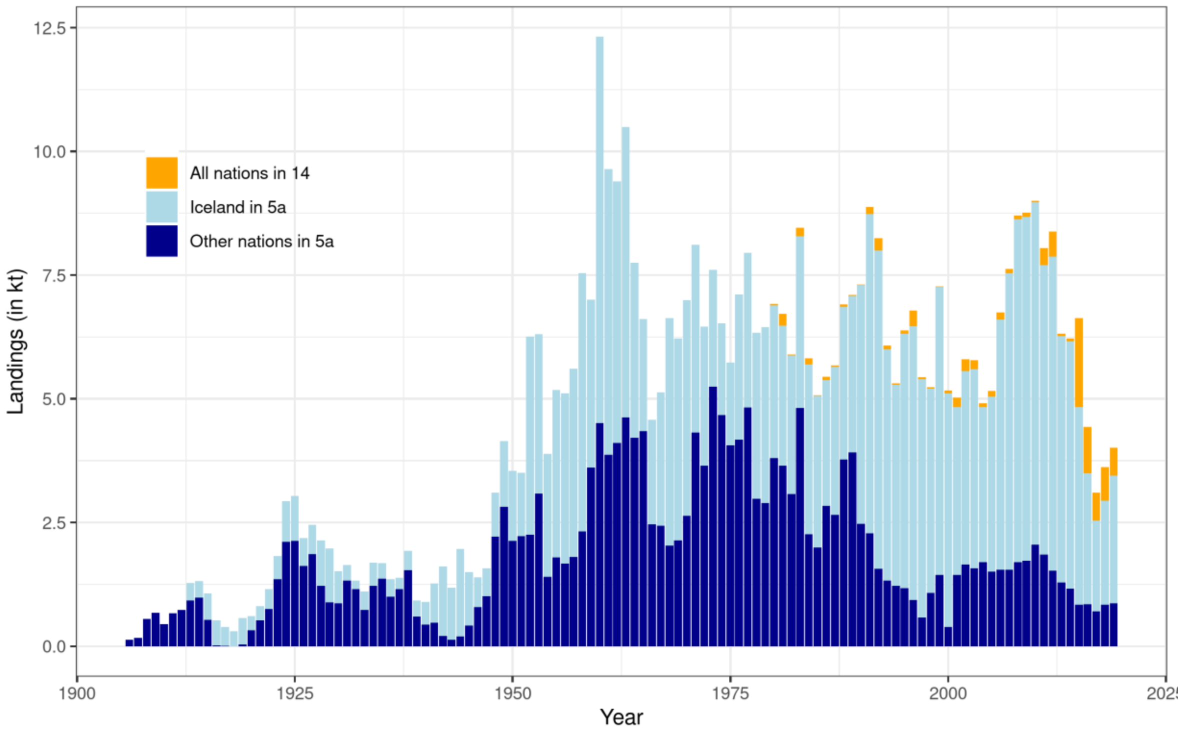

Figure 1. Tusk. Nominal landings within Icelandic waters by Icelandic vessels (light blue) or foreign vessels (dark blue), or within Greenlandic waters (orange).

Mynd 1. Keila. Landaður afli íslenskra skipa við Ísland (ljósblátt), erlendra skipa við Ísland (dökkblátt) og við Grænland (appelsínugult).

Tusk in Icelandic waters is caught in a mixed longline fishery, conducted in order of importance by Icelandic, Faroese and Norwegian boats. Between 150 and 240 Icelandic longliners report catches of tusk, but ~100 more vessels have small amounts of bycatch landings (Table 3). Far fewer gillnetters and trawlers participate in the fishery. The number of longliners reporting tusk catches decreased substantially from 308 in 2007 to 255 in 2008 (Table 3) and has continued to decrease since. Most of tusk in Icelandic waters, around 97% of catches in tonnes, is caught on longlines, and this had been relatively stable proportion since 1992 (Table 3).

Most of the tusk caught in Icelandic waters by Icelandic longliners is caught at depths less than 300 meters (Figure 1). The main fishing grounds for tusk in Icelandic waters as observed from logbooks are on the south, southwestern and western part of the Icelandic shelf (Figures 2 and 3).

The main trend in the spatial distribution of tusk catches in Icelandic waters according to logbook entries is the decreased proportion of catches caught in the southeast and increased catches on the western part of the shelf. Around 50–60% of tusk is caught on the southern and western parts of the shelf (Figure 3).

Tusk in Greenlandic waters is caught mainly as a bycatch by longliners and trawlers. The main area where tusk is caught in Greenlandic waters is 63°–66°N and 32°–40°W, well away from the Icelandic EEZ (Figure 4).

Table 1. Tusk. Catches by country (Source STATLANT) in Icelandic waters.

Tafla 1. Keila. Afli á Íslandsmiðum flokkað eftir þjóðum.

YEAR	FAROE	DENMARK	GERMANY	ICELAND	NORWAY	UK	TOTAL
1980	2873	0	0	3089	928	0	**6890**
1981	2624	0	0	2827	1025	0	**6476**
1982	2410	0	0	2804	666	0	**5880**
1983	4046	0	0	3469	772	0	**8287**
1984	2008	0	0	3430	254	0	**5692**
1985	1885	0	0	3068	111	0	**5064**
1986	2811	0	0	2549	21	0	**5381**
1987	2638	0	0	2984	19	0	**5641**
1988	3757	0	0	3078	20	0	**6855**
1989	3908	0	0	3131	10	0	**7049**
1990	2475	0	0	4813	0	0	**7288**
1991	2286	0	0	6439	0	0	**8725**
1992	1567	0	0	6437	0	0	**8004**
1993	1329	0	0	4746	0	0	**6075**
1994	1212	0	0	4612	0	0	**5824**
1995	979	0	1	5245	0	0	**6225**
1996	872	0	1	5226	3	0	**6102**
1997	575	0	0	4819	0	0	**5394**
1998	1052	0	1	4118	0	0	**5171**
1999	1035	0	2	5794	391	2	**7224**
2000	1154	0	0	4714	374	2	**6244**
2001	1125	0	1	3392	285	5	**4808**
2002	1269	0	0	3840	372	2	**5483**
2003	1163	0	1	4028	373	2	**5567**
2004	1478	0	1	3126	214	2	**4821**
2005	1157	0	3	3539	303	41	**5043**
2006	1239	0	2	5054	299	2	**6596**
2007	1250	0	0	5984	300	1	**7535**
2008	959	0	0	6932	284	0	**8175**
2009	997	0	0	6955	300	0	**8252**
2010	1794	0	0	6919	263	0	**8976**
2011	1347	0	0	5845	198	0	**7390**
2012	1203	0	0	6341	217	0	**7761**
2013	1092	0.12	0	4973	192	0	**6257**
2014	728	0	0	4995	306	0	**6029**
2015	625	0	0	4000	198	0	**4823**
2016	543	0	0	2649	302	0	**3494**
2017	492	0	0	1833	216	0	**2540**
2018	517	0	0	2097	326	0	**2940**
2019*	**549**	**0**	**0**	**2579**	**316**	**0**	**3445**

***Preliminary.**

Table 2. Catches by country (Source STATLANT) in Greenlandic waters.

Tafla 2. Afli á Grænlandsmiðum flokkað eftir þjóðum.

YEAR	FAROE	DENMARK	GREENLAND	GERMANY	ICELAND	NORWAY	RUSSIA	SPAIN	UK	TOTAL
1980	0	0	0	13	0	0	0	0	0	13
1981	110	0	0	10	0	0	0	0	0	120
1982	0	0	0	10	0	0	0	0	0	10
1983	74	0	0	11	0	0	0	0	0	85
1984	0	0	0	5	0	58	0	0	0	63
1985	0	0	0	4	0	0	0	0	0	4
1986	33	0	0	2	0	0	0	0	0	35
1987	13	0	0	2	0	0	0	0	0	15
1988	19	0	0	2	0	0	0	0	0	21
1989	13	0	0	1	0	0	0	0	0	14
1990	0	0	0	2	0	7	0	0	0	9
1991	0	0	0	2	0	68	0	0	1	71
1992	0	0	0	0	3	120	0	0	0	123
1993	0	0	0	0	1	39	0	0	0	40
1994	0	0	0	0	0	16	0	0	0	16
1995	0	0	0	0	0	30	0	0	0	30
1996	0	0	0	0	0	157	0	0	0	157
1997	0	0	0	0	10	9	0	0	0	19
1998	0	0	0	0	0	12	0	0	0	12
1999	0	0	0	0	0	8	0	0	0	8
2000	0	0	0	0	11	11	0	3	0	25
2001	3	0	0	0	20	69	0	0	0	92
2002	4	0	0	0	86	30	0	0	0	120
2003	0	0	0	0	2	88	0	0	0	90
2004	0	0	0	0	0	40	0	0	0	40
2005	7	0	0	0	0	41	8	0	0	56
2006	3	0	0	0	0	19	51	0	0	73
2007	0	0	0	0	0	40	6	0	0	46
2008	0	0	33	0	0	7	0	0	0	40
2009	12	0	15	0	0	5	11	0	0	43
2010	7	0	0	0	0	5	0	0	0	12
2011	20	0	0	0	131	24	0	0	0	175
2012	33	0	0	0	174	46	0	0	0	253
2013	1.9	0.3	0	0	0	23.8	0	0	0	26
2014	2	0	0	0	0	26	0	0	0	28
2015	670	0.1	166	0	0	62	0	0	0	898
2016	111	0	182	0	0	178	0	0	0	471
2017	83	0.38	335	0	0	141	0	0	0	559
2018	345	0	108	0	0	228	0	0	0	681
2019*	41	1	66	0	0	458	0	0	0	566

***Preliminary.**

Table 3. Tusk. Number of Icelandic boats participating in the fishery that land >100 kg tusk, and catches by fleet segment.

Tafla 3. Keila. Fjöldi íslenskra báta sem lönduðu >100 kg af keilu af Íslandsmiðum, og afli eftir veiðarfærum.

YEAR	NUMBER OF BOATS			CATCHES IN TONNES			SUM
	Trawlers	Gillnetters	Longliners	Trawlers	Longliners	Other	
2000	106	175	370	93	4564	37	4738
2001	83	224	350	73	3248	38	3422
2002	80	174	304	75	3722	30	3920
2003	78	148	305	56	3941	21	4059
2004	74	130	303	85	3007	15	3135
2005	77	101	324	108	3398	14	3540
2006	72	82	338	91	4912	16	5059
2007	64	65	308	95	5834	20	5987
2008	63	59	255	114	6762	19	6937
2009	66	65	239	107	6757	16	6953
2010	59	62	228	92	6761	14	6919
2011	51	54	221	69	5742	12	5847
2012	53	68	228	60	6255	16	6344
2013	53	43	233	74	4911	17	5016
2014	52	43	249	86	6045	14	6163
2015	47	32	228	69	4745	14	4835
2016	54	32	206	61	3420	8	3494
2017	50	31	180	48	2481	6	2540
2018	55	27	158	83	2840	17	2940
2019	48	22	155	102	3326	16	3444

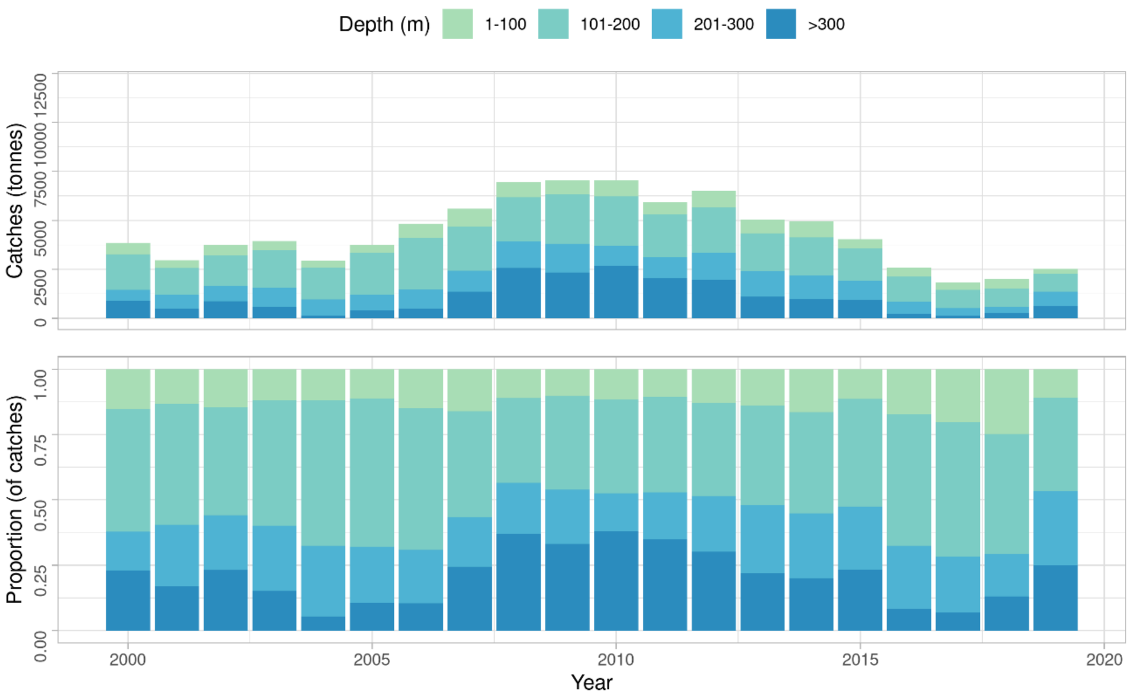

Figure 2. Tusk. Depth distribution of catches according to logbooks by the Icelandic fleet.

Mynd 2. Keila. Dýpi samkvæmt afladagbókum íslenskra skipa.

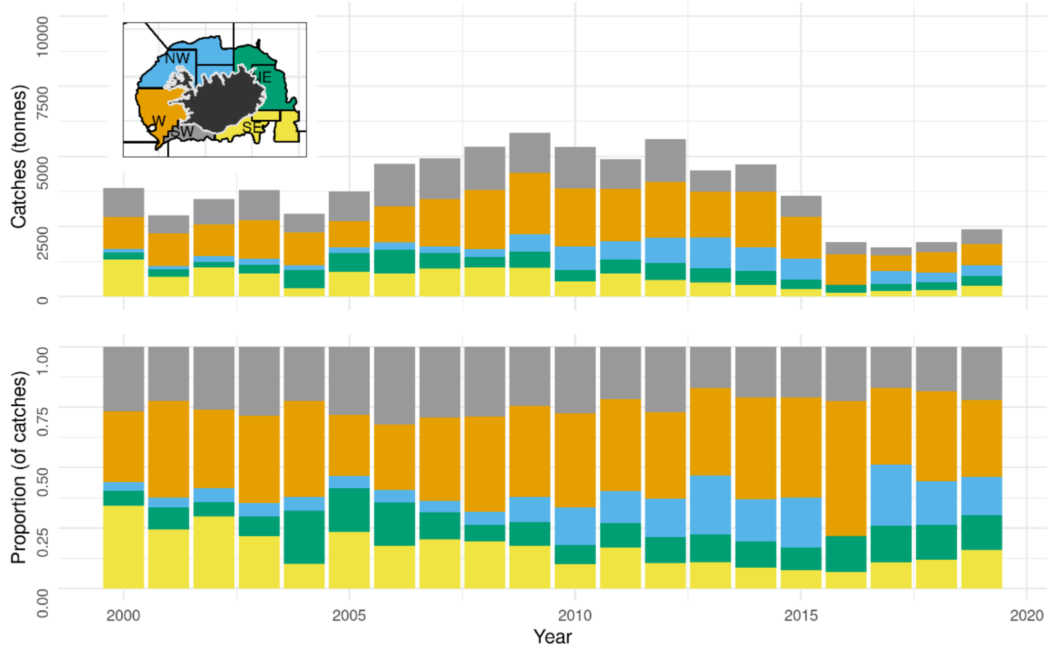

Figure 3. Tusk. Catch distribution and proportions by area according to logbooks.

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

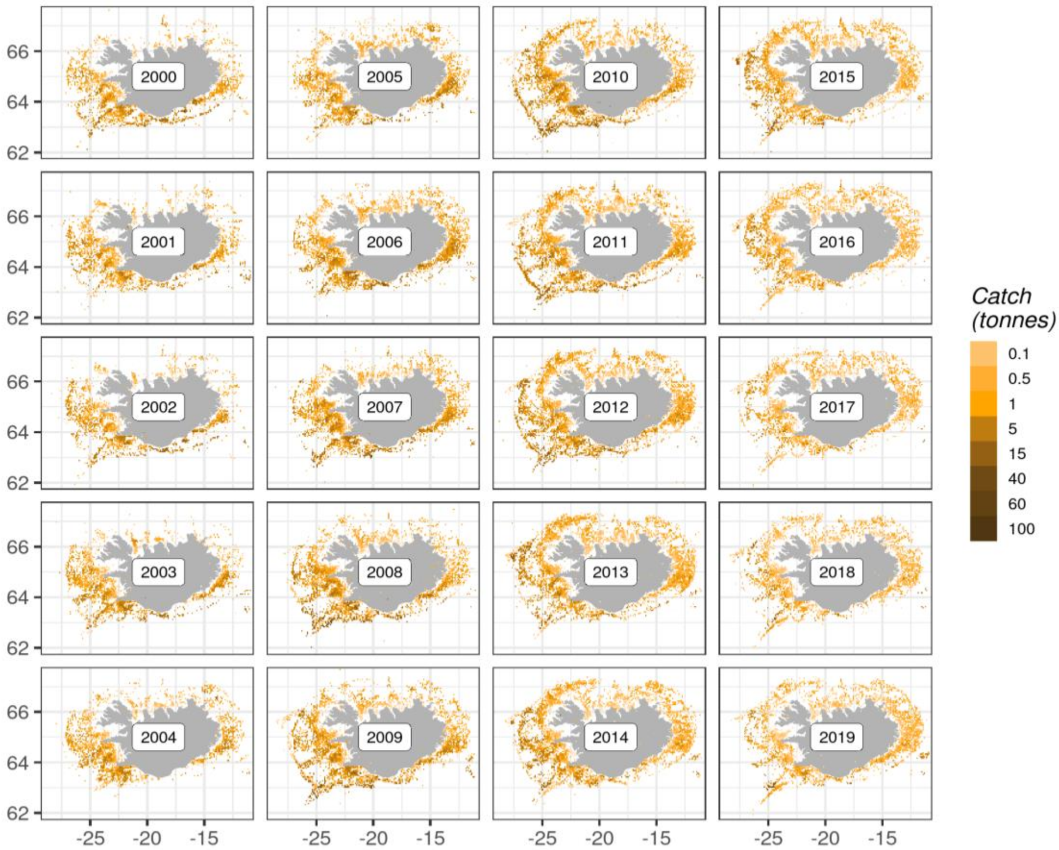

Figure 4. Tusk. Geographical distribution (tonnes) of the Icelandic longline fishery since 2000, as reported in logbooks by the Icelandic fleet.

Mynd 4. Keila. Útbreiðsla (tonn) á Íslandsmiðum frá 2000 samkvæmt afladagbókum.

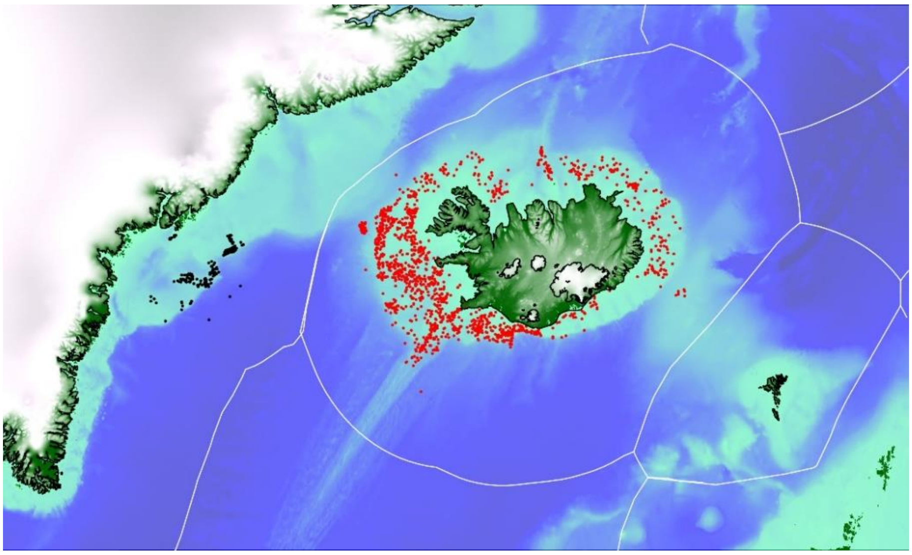

Figure 5. Tusk. Position of longline operations in 14.b (Greenlandic waters) and 5.a (Icelandic waters) where tusk was recorded in 2015.

Mynd 5. Keila. Staðsetningar línulagna við Ísland og á Grænland árið 2015 þar sem keila var skráð sem afli.

DATA AVAILABLE

In general sampling is considered appropriate from commercial catches from the main gear (longlines). The sampling does seem to cover the spatial distribution of catches for longlines and trawls but less so for gillnets. Similarly, sampling does seem to follow the temporal distribution of catches (WGDEEP, 2012). The sampling coverage by gear in 2019 is shown in Figure 6.

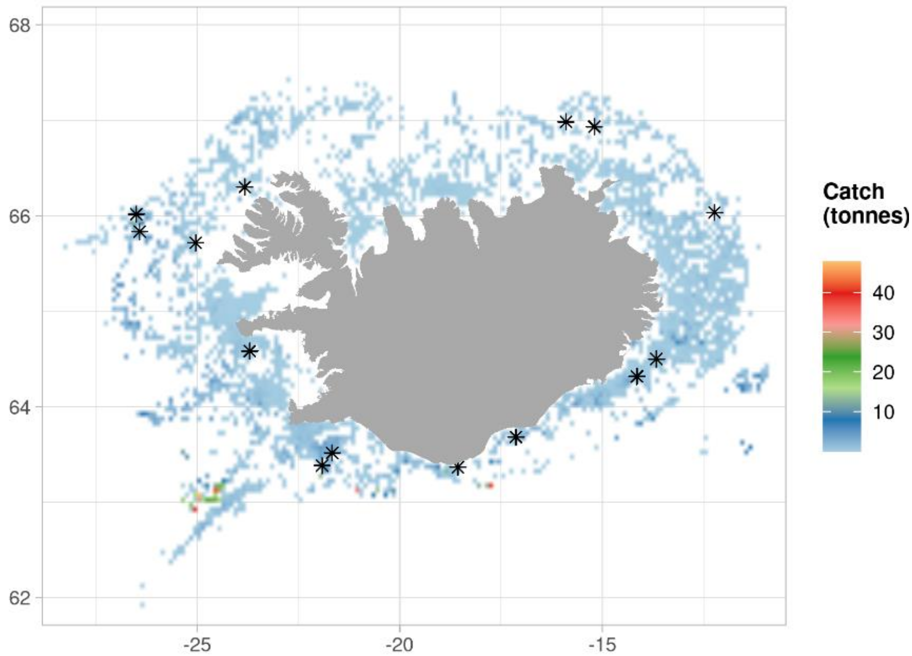

Figure 6. Tusk. Fishing grounds in 2019 as reported in logbooks and positions of samples taken from landings (asterisks).

Mynd 6. Keila. Veiðisvæði við Ísland árið 2019 samkvæmt afladagbókum og staðsetningar sýna úr lönduðum afla (stjörnur).

LANDINGS AND DISCARDS

Landings by Icelandic vessels are given by the Icelandic Directorate of Fisheries. 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. Based on limited data, discard rates in the Icelandic longline fishery for tusk are estimated very low (<1% in either numbers or weight) (WGDEEP, 2011:WD02). 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. A description of the management system is given in the stock annex for tusk in Icelandic waters (WGDEEP 2019).

Landings for tusk in Greenlandic waters are obtained from the STATLANT database. Figures reported by the Greenland Institute of Natural Resources (WGDEEP 2019:WD06) are in agreement. No information is available on discards in Greenlandic waters.

LENGTH COMPOSITIONS

An overview of available length measurements from 5.a is given in Table 2. Most of the measurements are from longlines; number of available length measurements increased in 2007 from around 2500 to around 4000 and were close to that until 2016 when they decreased to around 1700 and have remained roughly at that level.

Length distributions from the spring survey data and longline fishery are shown in Figures 7 and 8 respectively. In the figures, numbers-at-length are multiplied by the expected proportion mature at that length to split catch numbers into mature and immature components.

No length composition data from commercial catches in Greenlandic waters are available.

Table 2. Tusk. Number of available length measurements from Icelandic commercial catches.

Tafla 2. Keila. Fjöldi lengdarmælinga úr afla við Ísland.

YEAR	LONGLINE		GILLNETS		TRAWLS	
	Samples	Measured	Samples	Measured	Samples	Measured
2005	34	5820	0	0	1	21
2006	30	4861	0	0	4	472
2007	68	11936	2	167	1	150
2008	110	20963	0	0	0	0
2009	108	21451	0	0	0	0
2010	58	9084	0	0	0	0
2011	43	8158	0	0	0	0
2012	70	11867	0	0	1	150
2013	35	6469	0	0	0	0
2014	62	11748	0	0	0	0
2015	35	4821	0	0	0	0
2016	28	4844	0	0	0	0
2017	14	1710	0	0	0	0
2018	23	2781	0	0	0	0
2019	29	2952	0	0	0	0

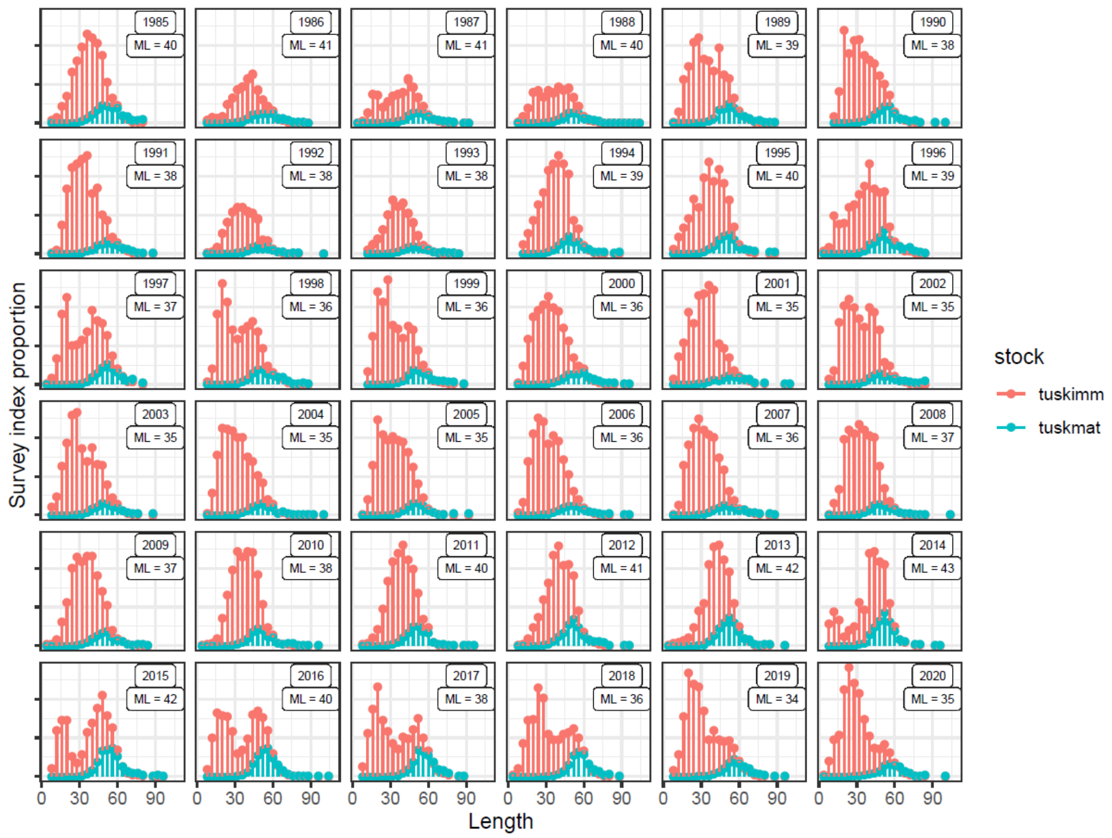

Figure 7. Tusk. Length distributions (4-cm grouping) from the spring survey since 1985. Red areas are immature tusk and green represent mature tusk. Small numbers to the right refer to mean length (ML).

Mynd 7. Keila. Lengdardreifing úr stofnmælingu botnfiska að vori (4 cm lengdarhópar) frá árinu 1985 (rautt = ókynþroska, grænt = kynþroska).

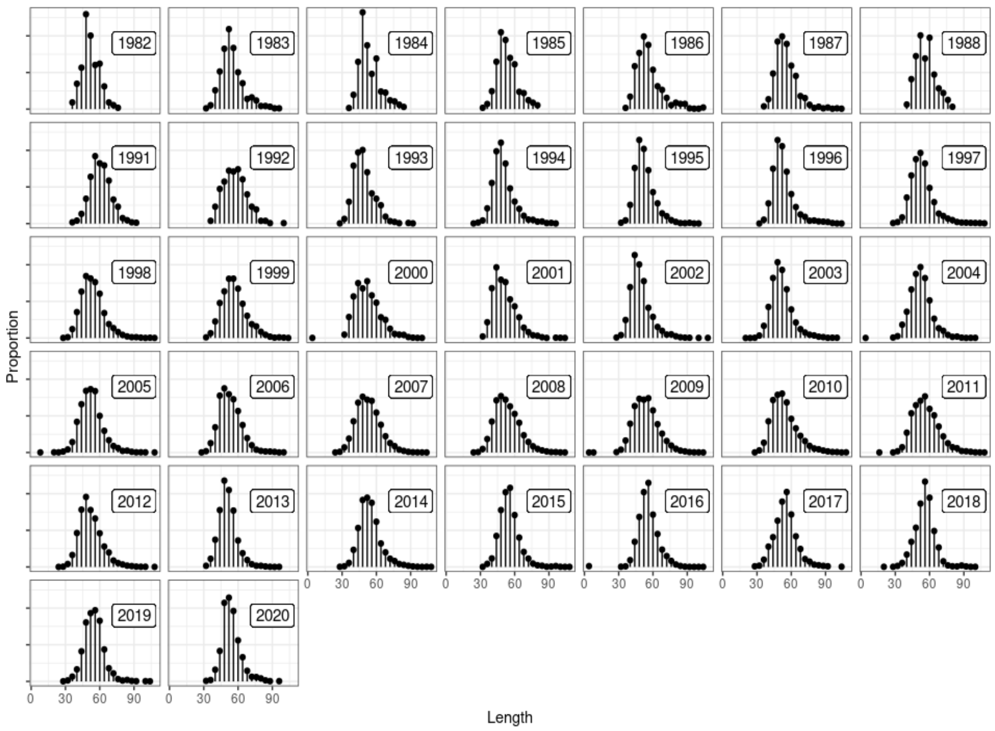

Figure 8. Tusk. Length distributions from Icelandic commercial longline catches.

Mynd 8. Keila. Lengdardreifing úr línuveiðum Íslendinga.

AGE COMPOSITIONS

Table 3 gives an overview of otolith sampling intensity by gear types from 2004 to 2019 in Icelandic waters. Since 2010, considerable effort has been put into ageing tusk otoliths, so now aged otoliths are available from the most recent decades. The age data are used as input for the Gadget assessment. It is expected that the effort in ageing of tusk will continue. Age distributions are shown from the spring survey and commercial longline samples in Figures 9 and 10, respectively. No data are available from Greenlandic waters.

Table 3. Tusk. Number of available aged otoliths from the commercial catches.
Tafla 3. Keila. Fjöldi aldurslesinna kvarna úr afla.

YEAR	LONGLINE			SURVEY		
	Samples	Otoliths	Aged	Samples	Otoliths	Aged
2004	10	500	0	225	422	**399**
2005	12	600	0	263	488	**148**
2006	15	750	0	281	499	**457**
2007	22	1100	0	290	483	**381**
2008	32	1600	600	282	489	**475**
2009	27	1350	1090	277	453	**434**
2010	29	1449	1373	241	378	**363**
2011	28	1400	1306	270	738	**728**
2012	34	1700	1112	285	771	**750**
2013	22	1100	490	275	744	**517**
2014	28	620	587	241	585	**560**
2015	26	555	505	260	614	**573**
2016	14	290	290	259	689	**676**
2017	8	160	160	245	579	**570**
2018	9	180	179	247	560	**549**
2019	**15**	**330**	**321**	**251**	**721**	**704**

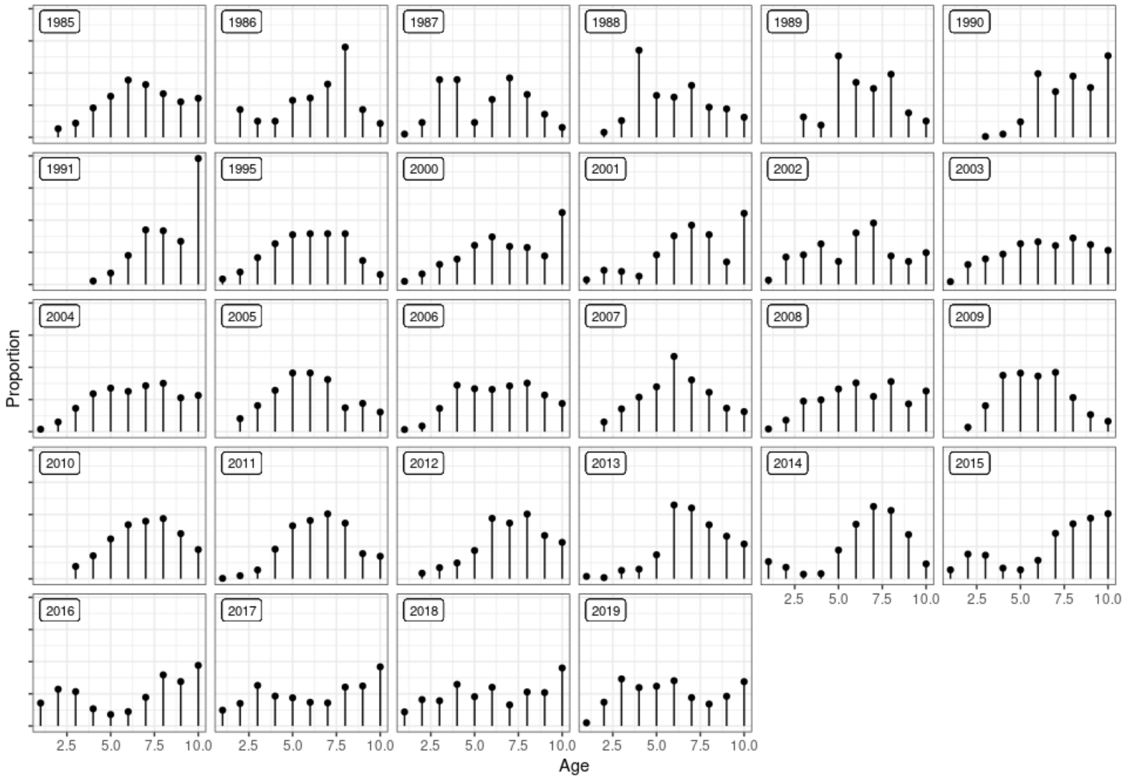

Figure 9. Tusk. Age distributions in proportions in Icelandic waters from the Iceland spring survey.

Mynd 9. Keila. Aldursdreifing (hlutfall) úr stofnmælingu botnfiska að vori.

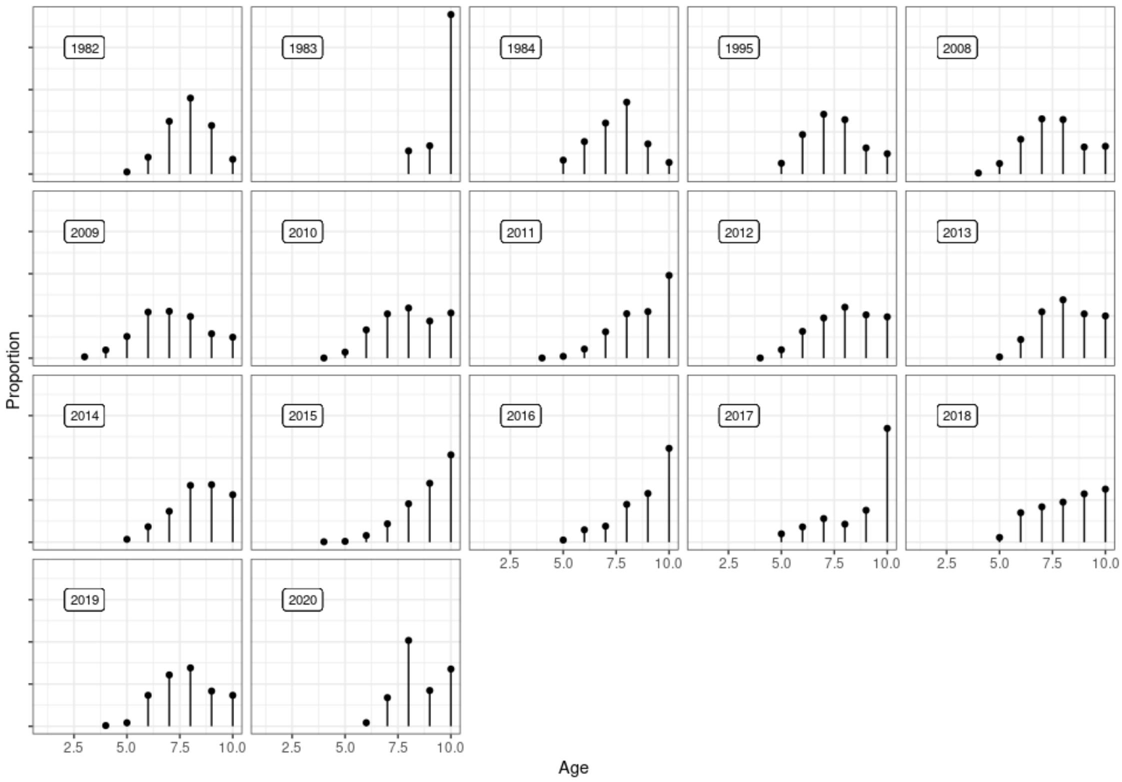

Figure 10. Tusk. Age distributions from Icelandic commercial longline catches.

Mynd 10. Keila. Aldursdreifing (hlutfall) úr línuveiðum Íslendinga.

WEIGHT AT AGE

Weight-at-age data from Icelandic waters are limited to 2008–2019. No data are available from 14.

MATURITY AT AGE

At 54 cm around 25% of tusk in Icelandic waters is mature, at 62 cm 50% of tusk is mature and at 70 cm 75% of tusk is mature based on the spring survey data.

No data are available for 14.

NATURAL MORTALITY

No information is available on natural mortality of tusk in Icelandic or Greenlandic waters. For assessment and advisory purpose, natural mortality is set to 0.15 for all age groups.

CATCH, EFFORT AND RESEARCH VESSEL DATA

CATCH PER UNIT OF EFFORT AND EFFORT DATA FROM COMMERCIAL FISHERIES

The CPUE estimates of tusk in Icelandic waters are not considered representative of stock abundance.

CPUE estimations have not been attempted on available data from Greenlandic waters.

ICELANDIC SURVEY DATA (ICES DIVISION 27.5.A)

Information on abundance and biological parameters from tusk in Icelandic waters is available from two surveys, the Icelandic groundfish survey in the spring and the Icelandic autumn survey. The Icelandic spring groundfish survey, which has been conducted annually in March since 1985, covers the most important distribution area of the tusk fishery. In 2011 the 'Faroe Ridge' survey area was included into the estimation of survey indices. In addition, the autumn survey was commenced in 1996 and expanded in 2000; however, a full autumn survey was not conducted in 2011 and therefore the results for 2011 are not presented. A detailed description of the Icelandic spring and autumn groundfish surveys is given in the Stock Annex (WGDEEP, 2019). Figure 11 shows both a recruitment index and the trends in various biomass indices. No substantial changes in spatial distribution are seen in general although there are spatial gradients in size distribution (Figure 12).

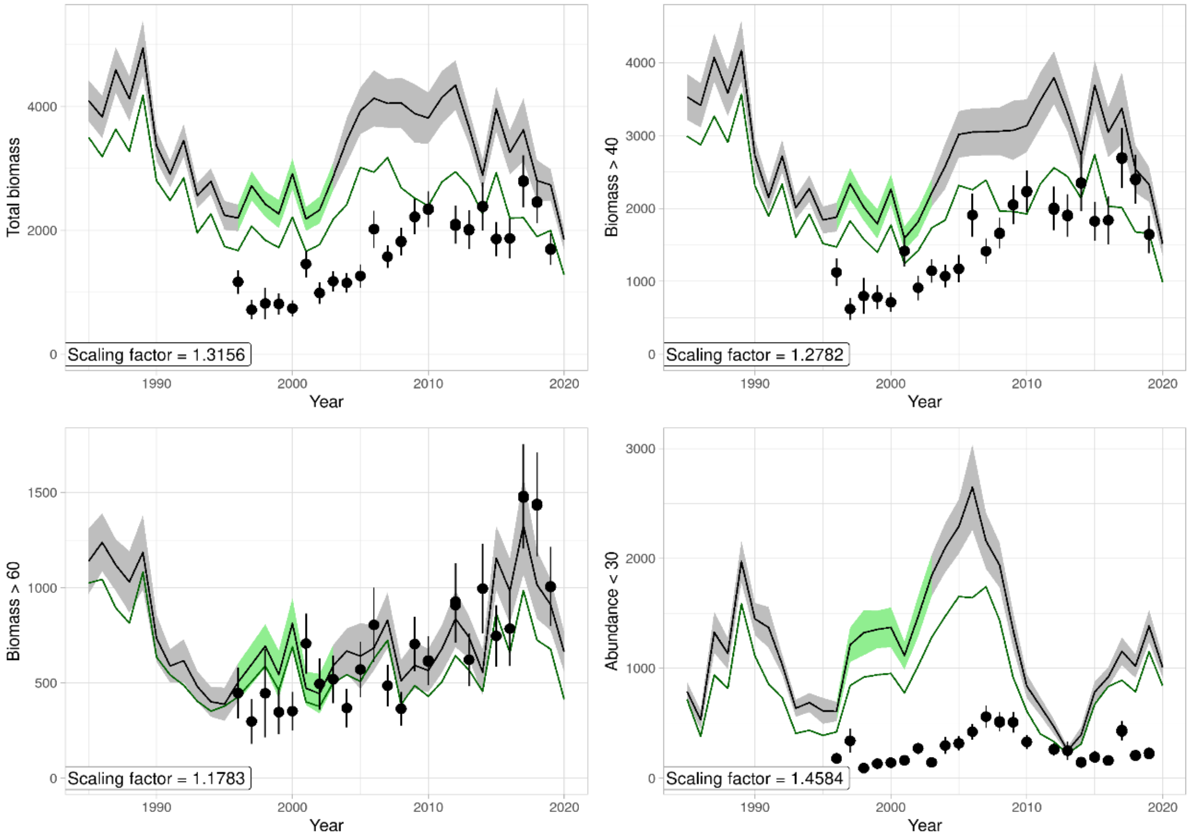

Figure 11. Tusk. a) Total biomass indices, b) biomass indices ≥40 cm, c) biomass indices ≥60 cm and d) abundance indices ≤30 cm. The lines with shaded areas show the spring survey index from 1985 and the points with the vertical lines show the autumn survey from 1997. The shaded area and vertical lines indicate ± standard error. Green line is the index excluding the Iceland-Faroe Ridge.

Mynd 11. Keila. a) Heildarlífmassi, b) lífmassi ≥40 cm, c) lífmassi ≥60 cm og d) nýliðun (fjöldi ≤30 cm). Línur sýna niðurstöður úr stofnmælingu botnfiska að vori og punktar niðurstöður úr stofnmælingu að hausti. Skyggð svæði og lóðréttar línur sýna staðalskekkju. Græn lína sýnir vísitölur þar sem stöðvar á Íslands-Færeyjahrygg eru ekki teknar með.

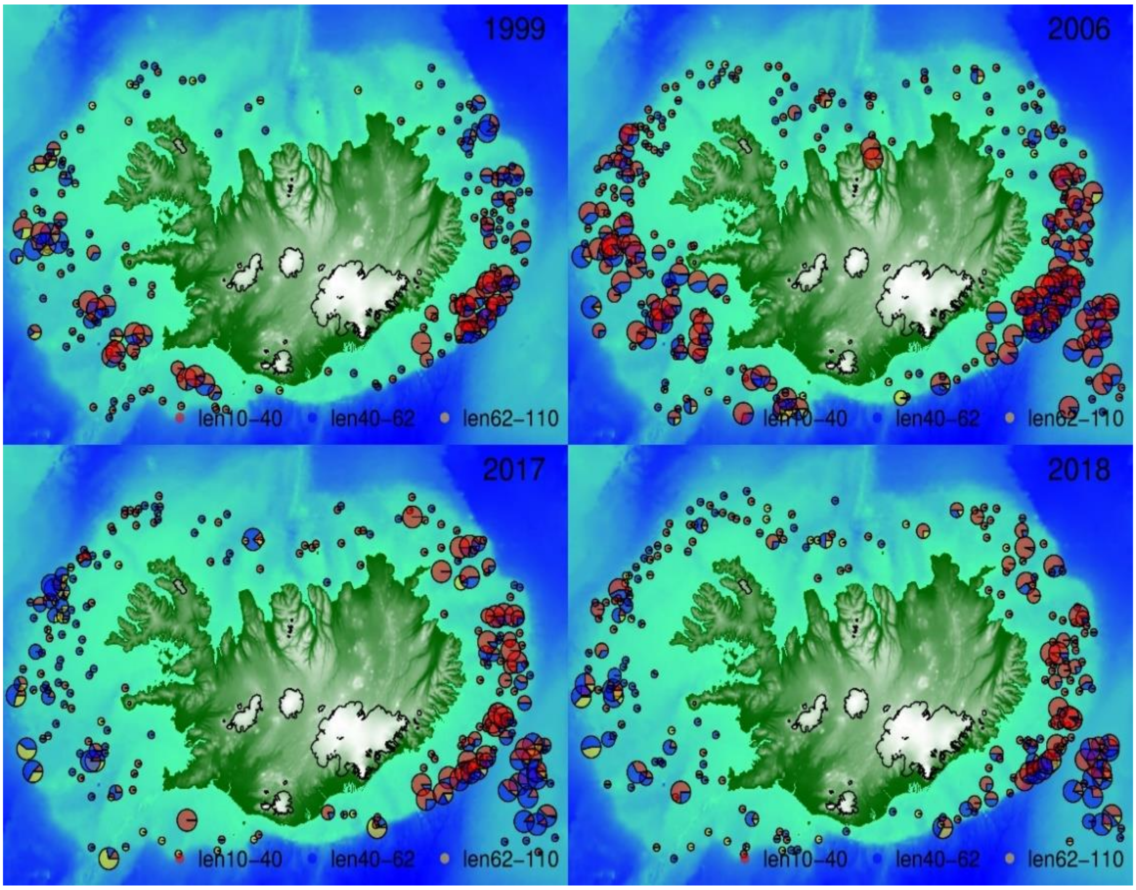

Figure 12. Tusk. Changes in spatial distribution divided by size. Size of pie is indicative of numbers of specimens caught at the tow-station.

Mynd 12. Keila. Breytingar á útbreiðslu keilu í stofnmælingu botnfiska að vori, skipt eftir lengdarflokkum. Stærð hringja fer eftir fjölda einstaklinga á hverri togstöð.

GERMAN SURVEY DATA (ICES SUBAREA 27.14)

The German groundfish survey was started in 1982 and is conducted in autumn. It is primarily designed for cod but covers the entire groundfish fauna down to 400 m. The survey is designed as a stratified random survey; the hauls are allocated to strata off West and East Greenland both according to the area and the mean historical cod abundance at equal weights. Towing time was 30 minutes at 4.5 kn. (Ratz, 1999). Data from the German survey in Greenlandic waters were available at the meeting up to 2015. The trend in the German survey catches is similar to those observed in surveys in Icelandic waters. It should, however, be noted that the data presented in Figure 13 is based on total number caught each year so it can't be used directly as an index from East Greenland. Length distributions from the survey in recent years are shown in Figure 14.

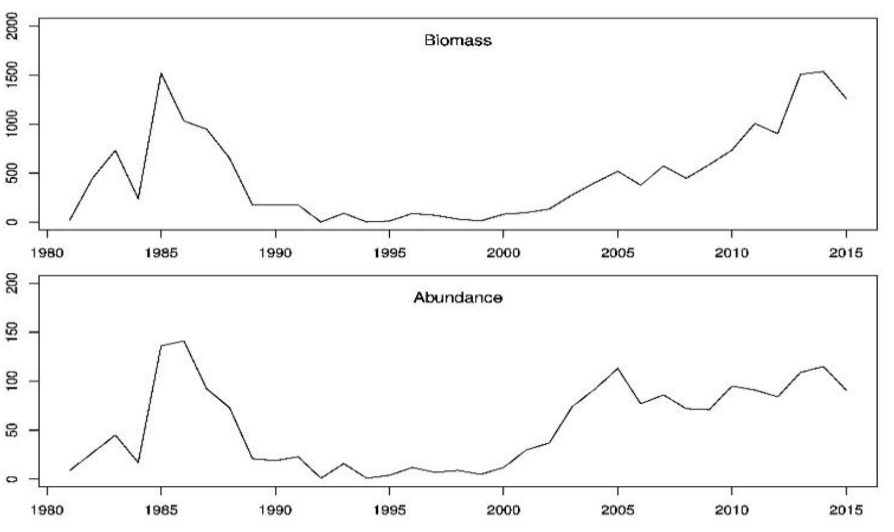

Figure 13. Tusk. Biomass and abundance estimates from the Walter Herwig survey in Greenlandic waters. The data are the total number caught (abundance), converted to weight to calculate biomass.

Mynd 13. Keila. Vísitölur lífmassa og fjölda úr stofnmælingum Þjóðverja við Grænland.

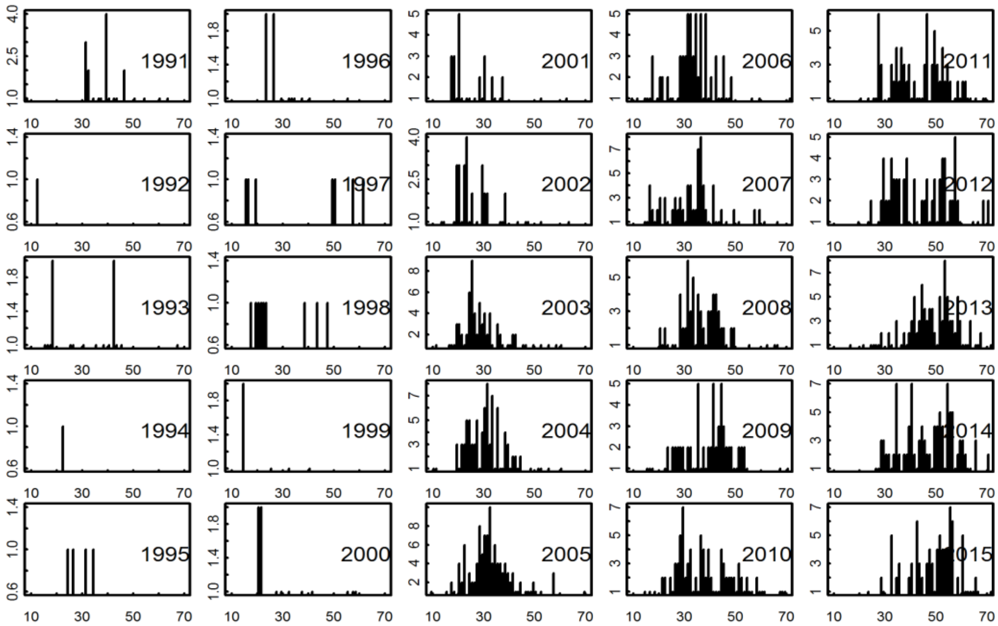

Figure 14. Tusk. Length distributions from the Walter Herwig survey in Greenlandic waters.

Mynd 14. Keila. Lengdardreifingar frá stofnmælingu Þjóðverja við Grænland.

GREENLAND SURVEY DATA (ICES SUBAREA 27.14)

The Greenland Institute of Natural Resources conducted a stratified bottom trawl survey in East Greenland (ICES 14b) from 1998 to 2016 at depths between 400 to 1500 m (WGDEEP2019:WD05). Survey results for tusk show a highly variable but increasing trend over recent years, so results from this survey will be monitored after it resumes in the future as a potential biomass index to be included in the tusk assessment.

DATA ANALYSES

There have been no marked changes in the number of boats nor the composition of the fleet participating in the tusk fishery in Icelandic waters (Table 1). Catches decreased from around 9000 tonnes in 2010 to 3444 tonnes in 2019. This decrease is mainly because of reductions in landings by the Icelandic longline fleet and to a lesser extent Faroese and Norwegian landings (Tables 6 and 7). This has resulted in less overshoot of landings relative to set TAC (see Management section). Species conversions in the ITQ system show that other species were converted to tusk last year rather than vice versa.

There are no marked changes in the length compositions since 2004, mean length in the catches ranges between 52.7 and 54.1 (Figures 7 and 8). According to the available length distributions and information on maturity only around 29% of catches in abundance and 44% in biomass are mature. There does seem to be a gradual increase in mean age of the age distribution from commercial catches from roughly 7 to 9 (Figure 10). The reason for this is unknown but given the lack of distinctive cohort structure in the data the first explanation might be a lack of consistency in ageing. Also, tusk have experienced a reduction in fishing mortality over the latter half of this range. Reasons such as difference in sampling, temporal or spatial are unlikely.

At WGDEEP 2011 the Faroe-Iceland Ridge was included in the survey index when presenting the results from the Icelandic spring survey for tusk in Icelandic waters. The total biomass index and the biomass index for tusk larger than or equal to 40 cm (reference biomass) was stable since 2011 until a few years ago but has decreased in recent years (Figure 11). The same holds for the index of tusk larger than or equal to 60 cm (spawning–stock biomass index). The index of juvenile abundance (≤30 cm) decreased by a factor of six between the 2005 survey when it peaked and the 2013 survey when it was at its lowest observed value. Since 2013 juvenile index has increased year on year in the 2014–2017 surveys and currently remains stable. The index excluding the Faroe-Iceland Ridge shows similar trends as described above. The result from the shorter autumn survey are by and large similar to those observed from the spring survey except for the juvenile abundance index that is more or less at a constant level compared to the spring survey juvenile index. Due to a labor strike, the autumn survey did not take place in 2011.

When looking at the spatial distribution from the spring survey around half of the index is from the SE area. However only around 20 to 25% of the catches are caught in this area (Figures 2 and 3). The change in juvenile abundance between 2006 and recent years can be clearly seen in Figures 11 and 12 where in 2006 juveniles (<40 cm) were all over the southwestern part of the shelf but can hardly be seen in recent years.

ANALYTICAL ASSESSMENT ON TUSK IN ICELANDIC WATERS USING GADGET

Since 2010 the Gadget model (**G**lobally applicable **A**rea **D**isaggregated **G**eneral **E**cosystem **T**oolbox, see www.hafro.is/gadget) has been used for the assessment of tusk in Icelandic waters (See stock annex for details, WGDEEP2019). As part of a Harvest Control Evaluation requested by Iceland this stock was benchmarked in 2017 (WKICEMSE 2017). Several changes were made to the model setup and settings which are described in the stock annex.

DATA USED BY THE ASSESSMENT AND MODEL SETTINGS

Data used for tuning are given in the stock annex. Model settings used in the Gadget model for tusk in Icelandic waters are described in more detail in the stock annex.

DIAGNOSTICS

OBSERVED AND PREDICTED PROPORTIONS BY FLEETS

Overall, the fit of the predicted proportional length distributions is close to the observed distributions (Figures 15 and 16). In general, for the commercial catch distributions the fit is better at the end of the time-series (Figure 15). The reason for this is there are few data at the beginning of the time-series and the model may be constrained by the initial values. In contrast, the fit of the survey data is not as good toward the end of the time series, mainly due to an absence of fish in the middle size ranges 2015 – 2018 (Figure 16). The survey age distributions are relatively well-fit (Figure 17); however, commercial age distributions show some misfits especially toward the end of the time series (Figure 18).

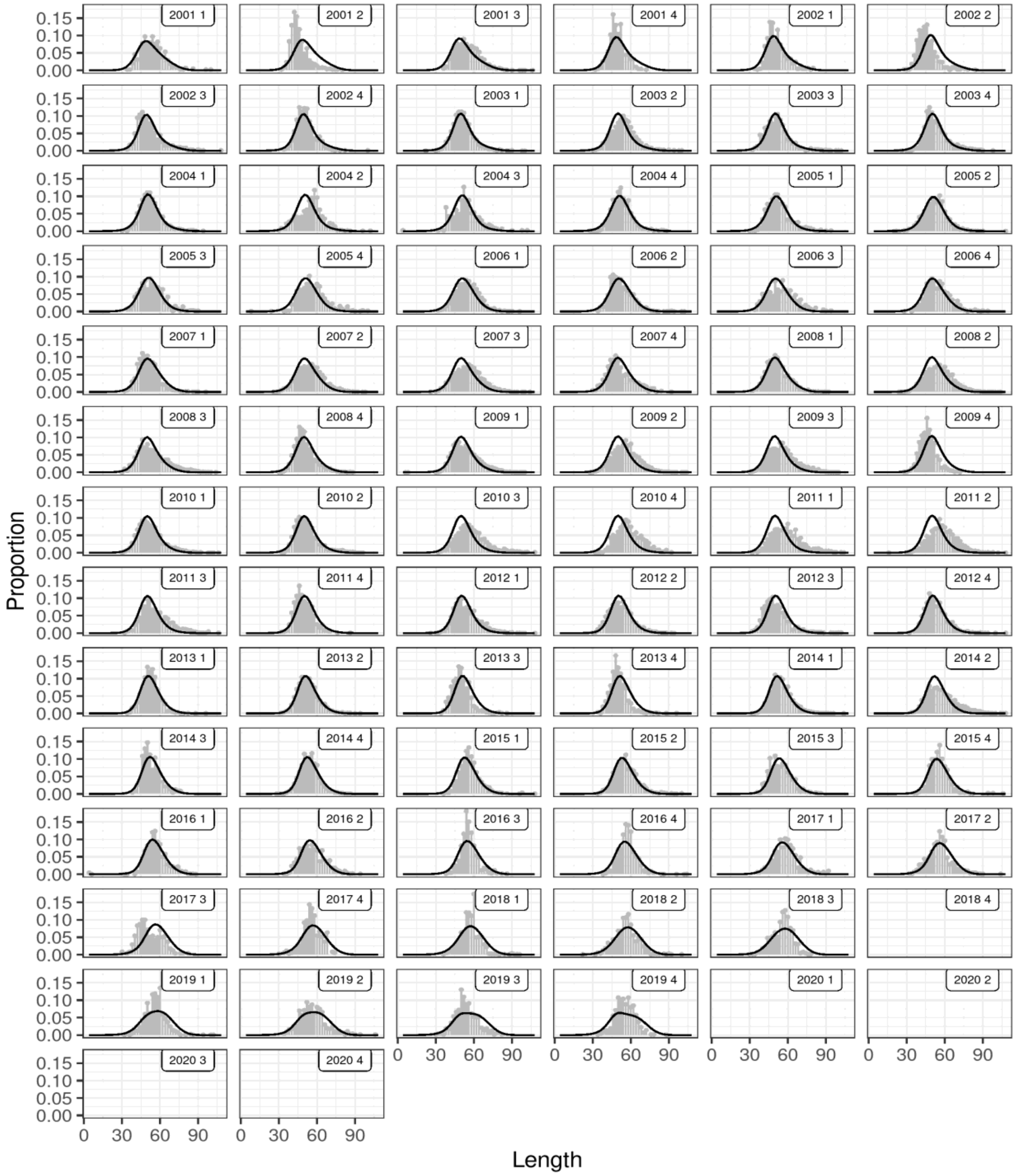

Figure 15. Tusk. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from longline catches (grey lines and dots).

Mynd 15. Keila. Hlutföll eftir lengdarflokkum úr Gadget líkani (svartar línur) samanborið við fengin hlutföll úr línuveiðum (gráar línur og punktar).

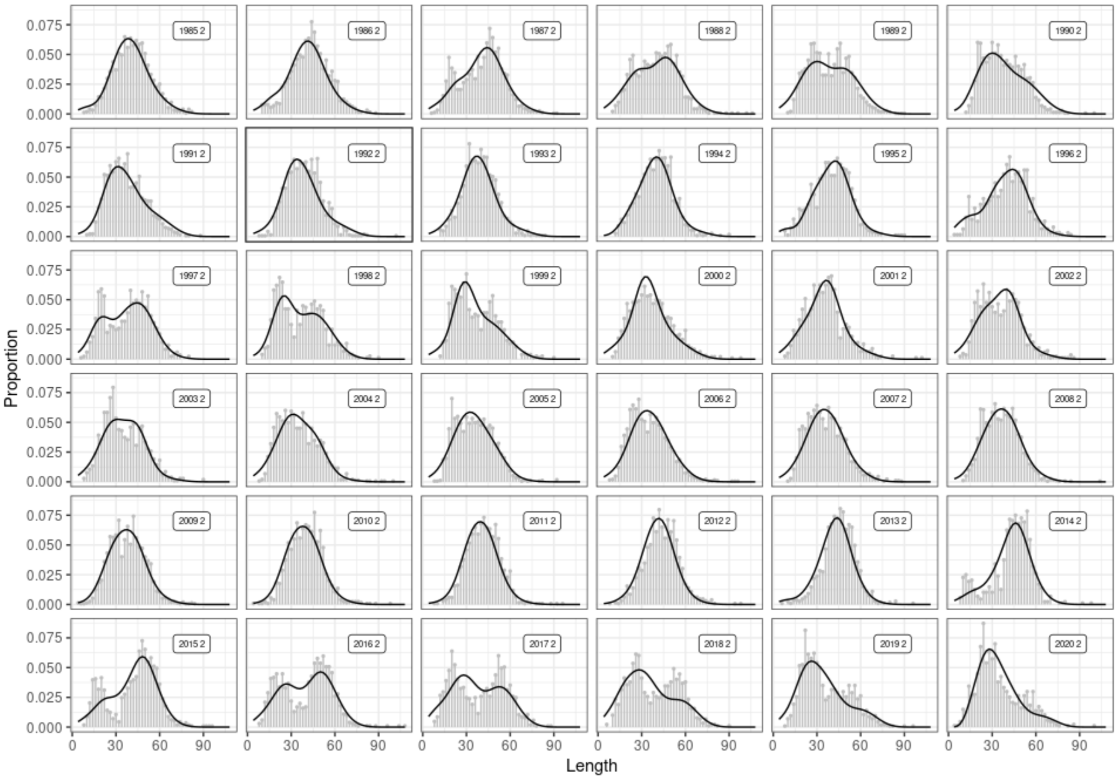

Figure 16. Tusk. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the spring survey (grey lines *and* points).

Mynd 16. Keila. Hlutfall eftir lengdarflokkum úr Gadget líkani (svartar línur) samanborið við fengin hlutföll í vorralli (gráar línur og punktar).

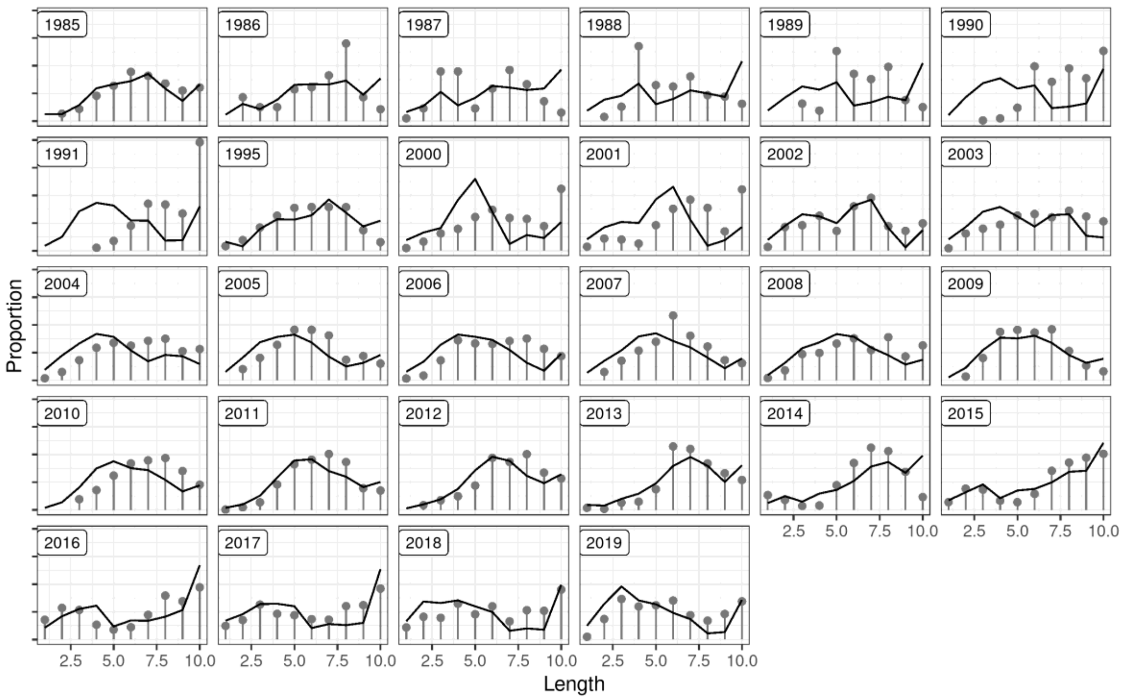

Figure 17. Tusk. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the spring survey catches (grey lines and points).

Mynd 17. Keila. Hlutfall eftir aldursflokkum úr Gadget líkani (svartar línur) samanborið við fengin hlutföll í vorralli (gráar línur og punktar).

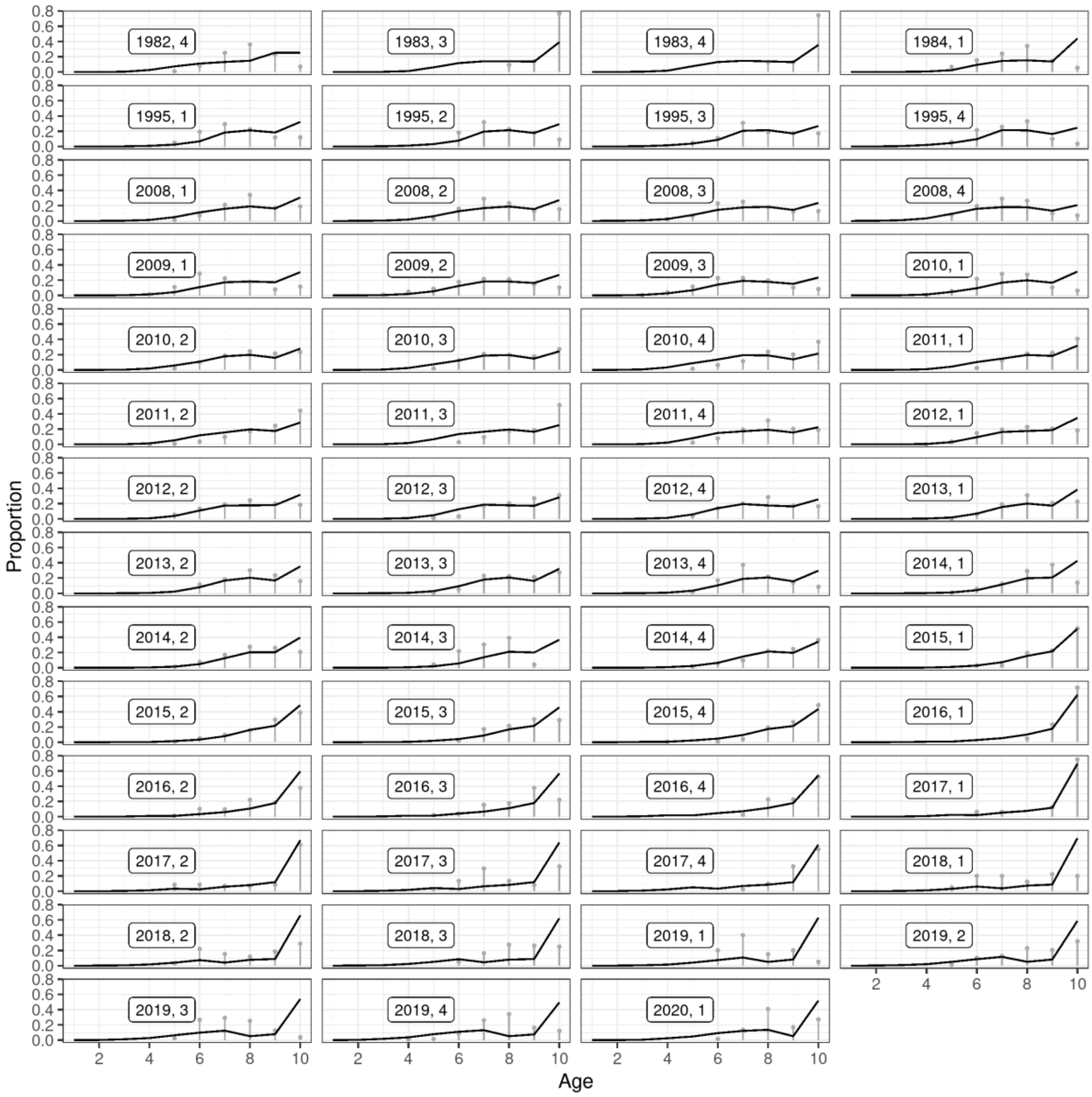

Figure 18. Ling. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from longline catches (vertical lines and points).

Mynd 18. Langa. Hlutföll eftir lengdarflokkum úr Gadget líkani (svartar línur) samanborið við fengin hlutföll úr línuveiðum (lóðréttar línur og punktar).

MODEL FIT

In Figure 19 the length disaggregated indices are plotted against the predicted numbers in the stock as a time-series. The correlation between observed and predicted is good for the first five length groups (10–19, 20–29, 30–39, 40–49, 50–59 and 60–69), of which the first three to four are the main length groups of tusk caught in the spring survey. In the two larger length groups the fit gets progressively worse.

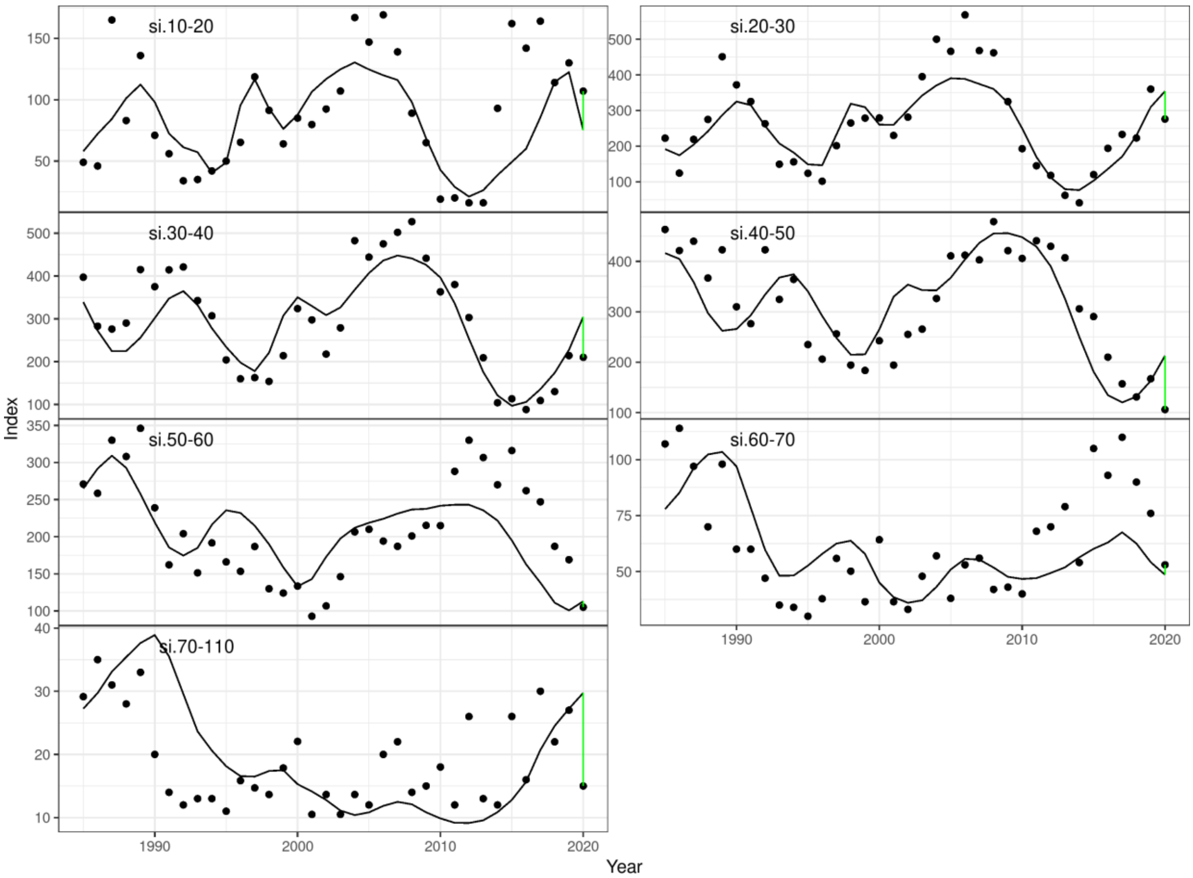

Figure 19. Tusk. Fitted spring survey index by length group from the Gadget model (black line) and the observed number of ling caught in the survey (points). The green line indicates the difference between the terminal fit and the observations.

Mynd 19. Keila. Lífmassavísitala úr Gadget líkani (svartar línur) eftir stærðarflokkum borin saman við fenginn fjölda langa í vorralli (punktar). Grænar línur sýna muninn á samsvörun gagna og líkans við lok tímabilsins.

MODEL RESULTS

The results are presented in Table 7 and Figure 20. In comparison with last year, there has been a small downward correction of the whole time series of biomass levels as well as a large downward revision of biomass trends estimated over the last decade. Total biomass is shown to be decreasing, and spawning–stock biomass has been stable but only slightly above Bpa since 2005 (Figure 21).

Although this year's advice shows a large downward revision, the analytical retrospective analysis (next section) shows that large downward revisions should have instead occurred more incrementally during previous assessments: the 2018 biomass levels should have been decreased in relation to 2017 estimates, and the 2019 biomass levels should have decreased in relation to 2018. These revisions would have caused decreases in the advice given during these years. Errors in the survey index used for model tuning and possibly insufficient criteria for model optimization are the likely reasons that these downward revisions were not detected until this year.

However, the main cause of the downward revisions in biomass is that the fit to survey index and length distribution data worsens after the addition of data after 2017 (see Analytical Retrospective Analysis). Additionally, survey indices of larger fish have experienced a large decrease in biomass levels that cannot be fully explained by the model. In comparison to previous assessments, the model is increasingly relying on the three survey indices reflecting the smallest sized tusk, and therefore do not follow the recent peaks in large-sized fish indices (especially since 2010 in indices for 50-60 and 60-70 cm tusk (Figure 23 and see Analytical Retrospective Analysis section).

The same trend can also be seen in length distribution data from surveys beginning 2016 (Figure 15). Many years prior to 2018 appear bimodal, whereas each year since then has shown a large decrease in the right lobe of the length distribution. Previous years have shown a better fit in the bimodal length distributions observed 2015-2018. However, in this year’s assessment, a distinct trough between the two modes of the length distribution can be tracked from 2015 but cannot be fitted by the model. This trough appears to have reached roughly 40 cm this year, thereby contributing to the decrease in reference and spawning stock biomass values in a more catchable length range. This suggests that the best model fit to the data this year includes an underestimation of the right lobe of this distribution during the years 2017-2019 in order to reconcile these data with the patterns found in 2015-2016 and 2020.

There are a few possible explanations for the change in the view of biomass levels. The first is that growth estimated by the model using age data conflicts with growth patterns reflected in cohort structure of length distribution data. If this is the case, then more detailed studies of growth and reparameterization of the model is needed. Second, the underestimation of 40+ cm tusk in 2017-2019 is due to unusually high true catchability during this period. Conversely, unusually low catchability could be currently experienced by the largest sized tusk. However, a shift in catchability by the survey has not been observed in other species, and assuming this is the case could lead to overestimation of the reference biomass and advice. Similarly, time-variable changes in selectivity from the current assumed logistic shape to a dome-shaped curve could effect such a discrepancy. However, further investigations of model fits including time-invariant dome-shaped selectivity did not improve the model fit in these last years, while implementing dome-shaped selectivity for only the last few years could also introduce overestimation of biomass with little grounds for suspecting such a selectivity shift. Finally, unaccounted for changes in mortality, such as higher natural or discard mortality, or outmigration either in the size range of the trough or in 40+cm fish could explain this discrepancy.

In any case, the management strategy evaluation that informed the management plan for this stock was completed with high assessment uncertainty and autocorrelation (CV = 0.3, rho = 0.8, WKICESMSE 2017), so it is unlikely that this downward correction has an effect on reference point calculation or the derived management plan.

Recruitment peaked in 2005 to 2006 but decreased and is estimated in 2013 to have been the lowest observed. Recruitment in 2014–2019 is estimated to be considerably higher than in 2013. Harvest rate has decreased from 0.35 in 2010 to 0.12 in 2016 and remains close to Fpa. Estimates of reference biomass (B40+) have also been stable for the last several years.

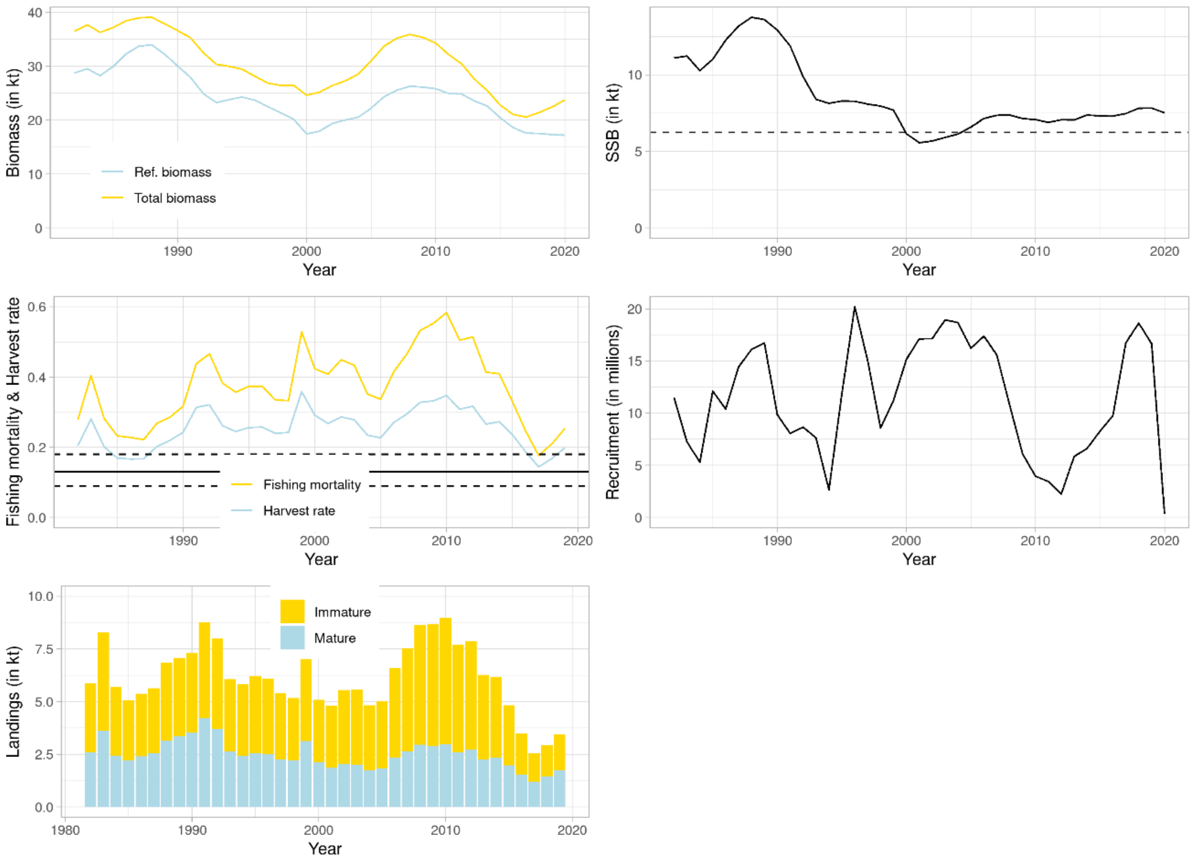

Figure 20. Tusk. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fish and harvest rate, recruitment, and total catches. The dashed line in the SSB plot represents Bpa. The solid line in the harvest rate plot indicates the target harvest rate used in the harvest control rule, whereas the dashed lines indicate the bounds of the realized harvest rates resulting from the harvest control rule given the uncertainty in the assessment.

Mynd 20. Keila. Áætlaður heildarlífmassi, lífmassi hrygningarstofns, dánartala og veiðidánartala, nýliðun og heildarafli. Brotin lína við lífmassa hrygningarstofns sýnir gátmörk (Bpa). Heil lína við veiðihlutfall sýnir það gildi sem stefnt er að með aflareglu, en brotnar línur sýna þau mörk sem búast má við vegna óvissu í stofnmati.

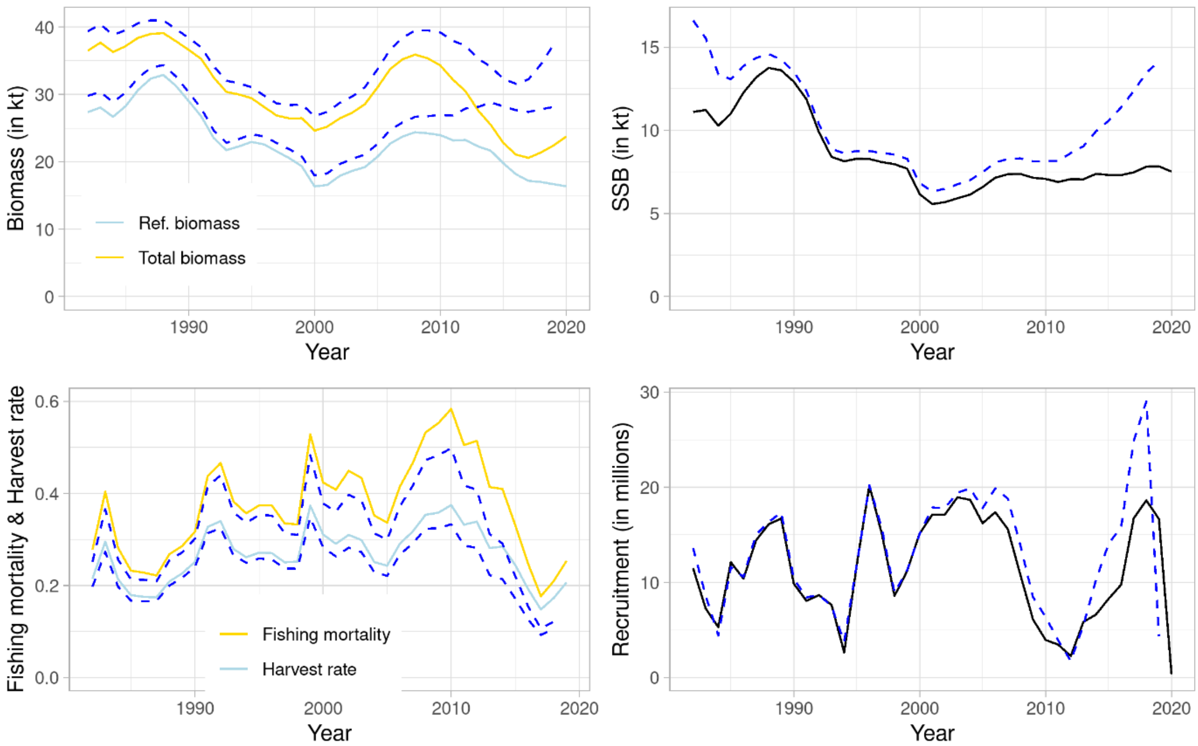

Figure 21. Ling. This year's assessment (blue and yellow lines) compared with the previous year's assessment (dashed lines). Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fishes and harvest rate and recruitment.

Mynd 21. Langa. Stofnmat ársins í ár (blá og gul lína) borið saman við stofnmatið fyrir ári síðan (punktalína). Áætlaður heildarlífmassi, lífmassi hrygningarstofns, dánartala og veiðidánartala, og nýliðun.

ANALYTICAL RETROSPECTIVE ANALYSIS

The results of an analytical retrospective analysis are presented (Figure 22). Additional plots are provided due to the large downward revision detected this year. The analysis indicates that estimates of biomass were stable over the first 3 years of the 5-year peel followed by two larger downward revisions of biomass (SSB) in subsequent years of the peel, and consequently an upward revision of F. Estimates of recruitment are mostly stable except for largest overestimates in 2016 and 2017 leading to a strong retrospective pattern. Growth parameter estimates are very stable, across all peels and the current model, except for a slight increase in recruitment standard deviation, which has the effect of increasing the mean length at recruitment in predictions slightly over time. Recruitment indices generally tend to be uncertain as there are few repeated observations at larger sizes to help reduce uncertainty. However, the good fit to survey indices in the age 3 recruitment length range (20-30 cm, (Figure 23), suggest that at least recruitment estimates from this peak are reliable. In addition, a peak in these sizes of tusk followed by a sharp decline in 2020 are reflected in length distribution data as a rather large but steep peak in proportions of fish that have begun to shift right (to larger sizes) with no obvious new peaks of small sizes taking its place (Figure 24). Therefore, it is likely that reference biomass may increase once these cohorts reach 40+ cm sizes.

The cause of the large revision in biomass estimates can also be observed in these plots as progressively worse fits to survey indices of larger sized tusk, as well as underestimation of the right peak of the bimodal length distributions observed in the last 5 years (Figure 24). It is possible that these misfits reflect an underestimation of the current true spawning stock biomass levels. However, this is difficult to conclude as these misfits generally represent an inconsistency between the model being able to reconcile length distribution and survey data collected after 2018 with the relatively good fits to these data observed in the earliest assessment periods. Trends in catchability estimates across peels indicate that changes to the catchability of the largest two indices, to which the fit of the model has changed, are likely to cause the overall shifts in biomass levels (Figure 25).

Mohn's rho was estimated to be 0.182 for SSB, -0.144 for F, and -0.418 for recruitment.

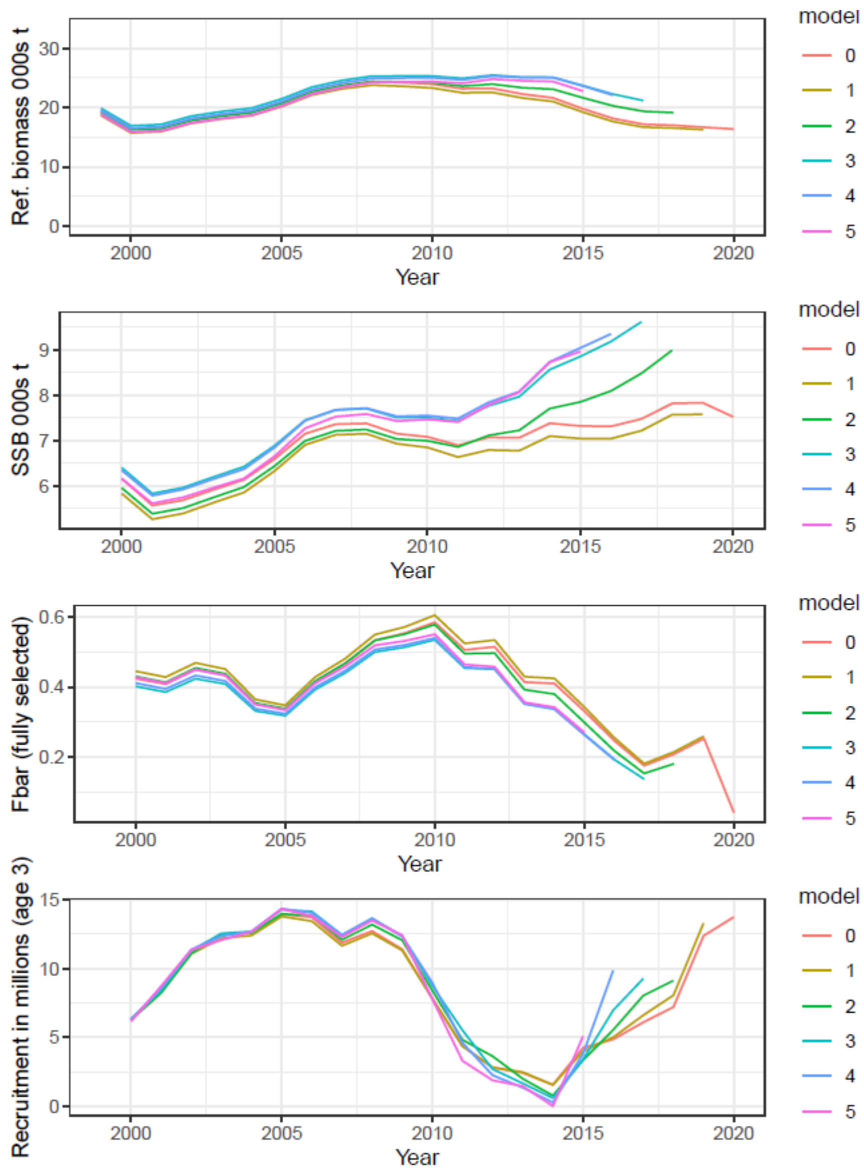

Figure 22: Tusk. Analytical retrospective analysis of the assessment of tusk with a 5 year peel. Results of reference biomass, spawning stock biomass (SSB), fishing mortality Fbar, and recruitment (age 3) are shown.

Mynd 22. Keila. Endurlitsgreining sem sýnir stöðuleika í mati líkansins fimm ár aftur í tímann. Niðurstöður eru sýndar fyrir hrygningarstofn (SSB), fiskveiðidánartölu, Fbar og nýliðun (3 ára).

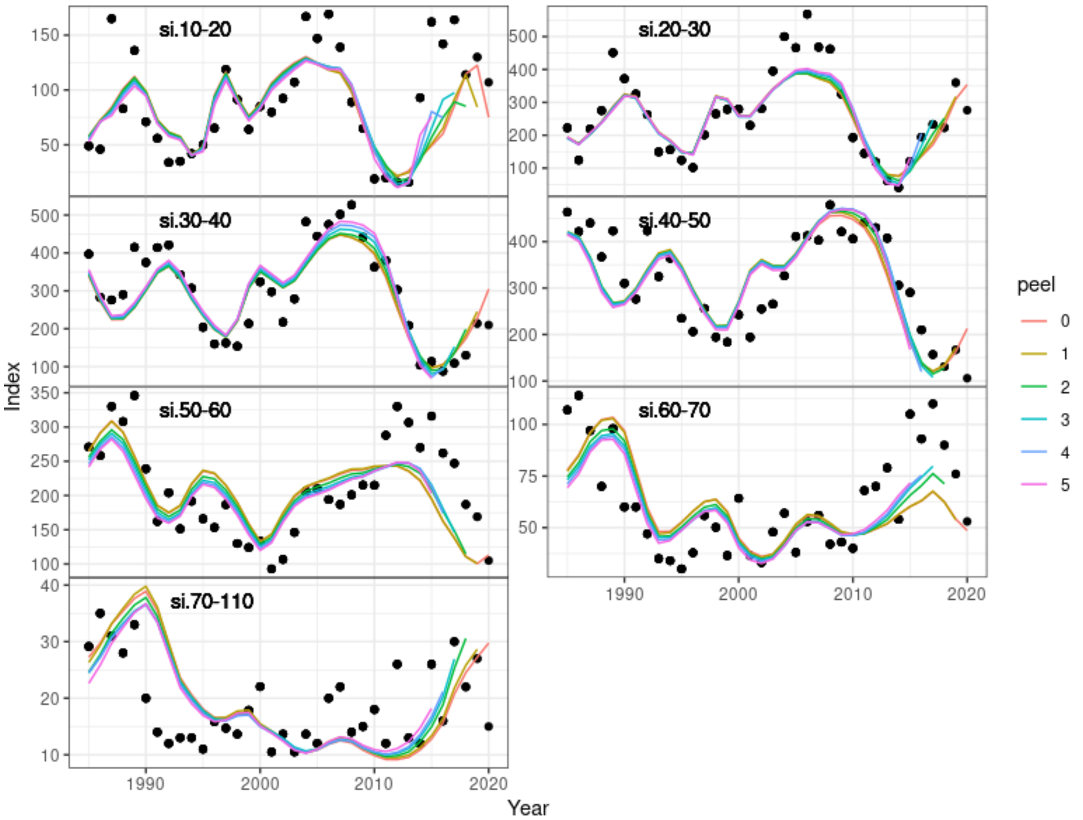

Figure 23: Tusk. Retrospective plots illustrating stability in model fits to survey indices over a 5-year 'peel' in data.

Mynd 23. Keila. Endurlitsgreining sem sýnir stöðugleika líkans við stofnvísitölur fimm ár aftur í tímann.

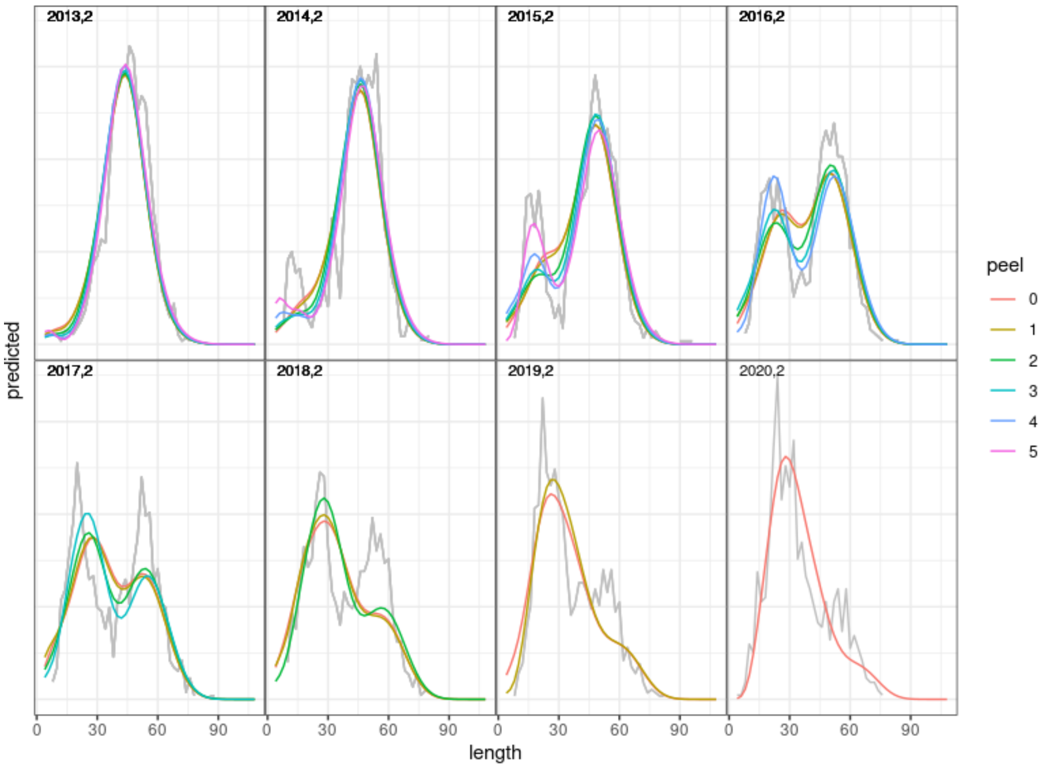

Figure 24. Tusk. Retrospective plots illustrating stability in fit length distribution data from the spring survey over a 5-year 'peel' in data.

Mynd 24. Keila. Endurlitsgreining sem sýnir stöðugleika líkans við lengdardreifingar úr stofnmælingu að vori fimm ár aftur í tímann.

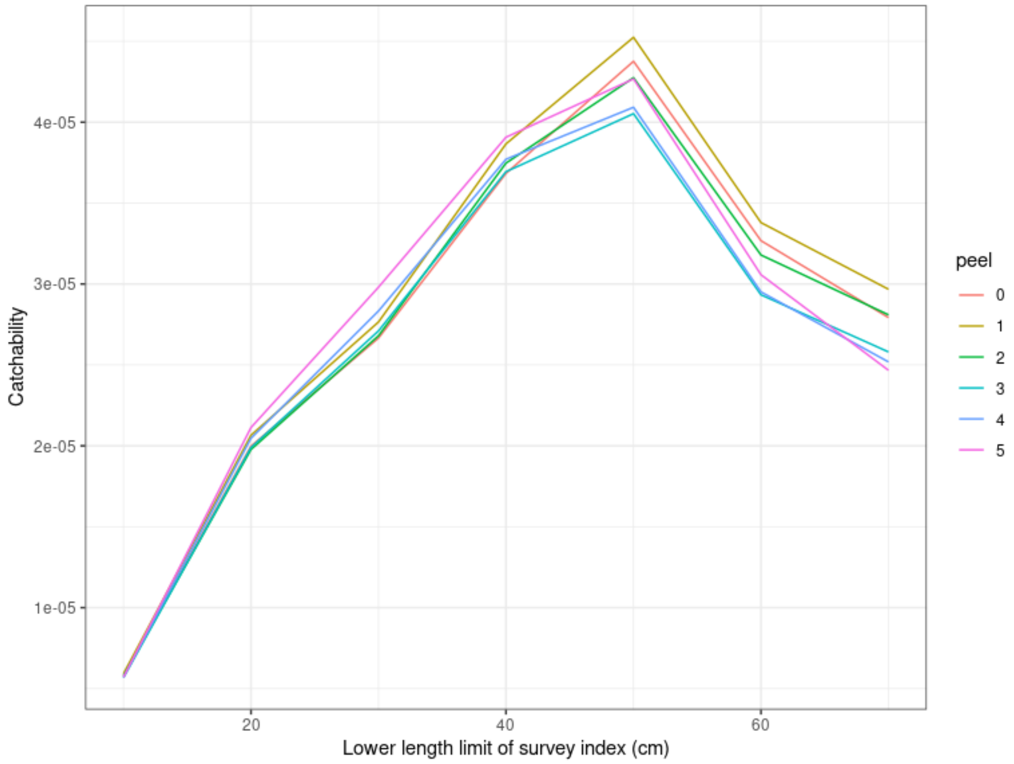

Figure 25. Tusk. Retrospective plots illustrating stability in catchability estimates over a 5-year 'peel' in data.

Mynd 25. Keila. Endurlitsgreining sem sýnir stöðugleika líkans við veiðanleika fimm ár aftur í tímann.

REFERENCE POINTS

In the past, yield-per-recruit-based reference points, estimated as described in the stock annex, were used as proxies for Fmsy. Fmsy from a Y/R analysis is 0.24 and F0.1 is 0.15. WGDEEP 2014 recommended using Fmsy=0.2 as the target fishing mortality rather than Fmax. This was subsequently used as the basis for the advice in 2014 by ICES. (See stock annex for details, WGDEEP2019). As part of the WKICEMSE 2017, HCR evaluations requested by Iceland the following reference points were defined for the stock.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	6.24 kt	B_{pa}
	H_{msy}	0.17	The harvest rate that maximises the median long-term catch in stochastic simulations with recruitment drawn from a block bootstrap of historical recruitment scaled according to a hockey stick recruitment function with B_{lim} as defined below.
	F_{msy}	0.226	The median fishing mortality when an harvest rate of H_{msy} is applied.
	$H_{p.05}$	0.371	The harvest rate that has an annual probability of 5% of SSB < B_lim.
	$F_{p.05}$	0.356	The median fishing mortality when an harvest rate of $H_{p.05}$ is applied.
Precautionary approach	B_{lim}	4.46 kt	$B_{pa}/e^{1.645\sigma}$ where $\sigma = 0.2$
	B_{pa}	6.24 kt	SSB(2001), corresponding to B_{loss}
	H_{lim}	0.27	H corresponding to 50% long-term probability of SSB > B_{lim}
	F_{lim}	0.41	F corresponding to H_{lim}
	F_{pa}	0.27	$F_{lim}/e^{1.645\sigma}$ where $\sigma = 0.25$
	H_{pa}	0.20	H corresponding to F_{pa}
Management plan	H_{mp}	0.13	

The management plan proposed by Iceland is:

The spawning–stock biomass trigger (MGT Btrigger) is defined as 6.24 kt, the reference biomass is defined as the biomass of tusk 40+ cm and the target harvest rate (HRmgt) is set to 0.13. In the assessment year (y) the TAC for the next fishing year (September 1 of year Y to August 31 of year y+1) is calculated as follows:

When SSBy is equal or above MGT Btrigger:

TACy/y+1 = HRmgt*BRef,y

When SSBY is below MGT Btrigger:

TACy/y+1 = HRmgt* (SSBy/MGT Btrigger) * Bref,y

WKICEMSE 2017 concluded that the HCR was precautionary and in conformity with the ICES MSY approach.

COMMENTS ON THE ASSESSMENT

A benchmark was completed in 2017, which was done as part of the Harvest Control Rule evaluation request to ICES from Iceland. WKICEMSE 2017 noted: "Catches of tusk in Greenland, within ICES Subarea 14, were discussed. Minor catches (representing <5% of the total catch of tusk in Icelandic waters+14) have always occurred in the Greenland area and were never included in the stock assessment of tusk. However, these catches increased in 2015 and 2016, representing around 10%–15% of the total catches in those years. None of the work presented to WKICEMSE included these catches, which seem to occur well away from the area where the catches included in the stock assessment take place (i.e. in or around ICES Division 5.a). Information about these catches in the Greenland area is somewhat limited and no biological samples are available; doubts related to population structure, movement and connectivity were also noted during the discussion. It was then decided to conduct a stock assessment run incorporating those catches (just the tonnage), to gain understanding on their potential impact on stock assessment results. Their inclusion in the assessment resulted in minor revisions upwards of the estimated stock biomass (around 1%–4% revision, on average throughout the years in the stock assessment) and downwards of the estimated harvest rate (around 0%–3% revision, on average throughout the years in the stock assessment, although with an increase of the harvest rates estimated for 2015 and 2016); the results of this run are available at the end of Section 2.2. As there are some doubts in relation to these catch data and population structure of tusk in the area, WKICEMSE did not feel that a decision to include these catches in the stock assessment at this point was appropriate before conducting additional explorations and having a better understanding. It is recommended that appropriate stock experts in WGDEEP should explore this issue further." This was discussed at WGDEEP-2017 and the following points were raised:

- Stock structure is generally unclear when it comes to deep-water stocks and many of the stock units assessed by WGDEEP are defined based on very limited scientific knowledge.
- The current advice units of tusk are not based on genetic studies except for tusk in Rockall and on the Mid Atlantic Ridge.
- The fishing areas for tusk in Icelandic waters and 14 are widely separated. However, survey data do show continuous distribution between Greenland, Iceland, and the Faroe Islands.
- Genetic studies do not detect difference in tusk populations from the Barents Sea down to the Faroe Islands and over to Iceland and Greenland (Knutsen et al., 2009).
- Knutsen et al. (2009) proposed that the bathymetry over the NE-Atlantic could form a "bridge" between Norway and Greenland. However, they point out that tusk is not believed make extensive migrations and actually to be a sedentary species. Larval dispersal could account for the lack of genetic difference in tusk.
- It is highly plausible that the increased abundance of tusk seen in the Walter Herwig survey is of Icelandic origin that might have been dispersed as larvae to Greenland, similar as has been reported for cod in Icelandic waters. However, unlike cod it is unlikely that tusk would migrate back to Iceland.
- The tusk population in Greenland is likely to be a "sink" from the Icelandic population and as such should not affect the productivity of tusk in Iceland.

Based on this, WGDEEP 2017 concluded that the catches in Greenlandic waters should not be included in the assessment of tusk in Icelandic waters. Additionally, the EG concluded that the division of tusk into different advice units should be reviewed, not only in Icelandic waters and Greenlandic waters, but for all the tusk stocks.

MANAGEMENT

The Icelandic Ministry of Industries and Innovation (MII) is responsible for management of the Icelandic fisheries and implementation of legislation. Tusk was included in the ITQ system in the 2001/2002 quota year and as such subjected to TAC limitations. At the beginning, the TAC was set as recommended by MFRI but thereafter had often been set higher than the advice. One reason is that no formal harvest advisory rule existed for this stock. Up until the fishing year 2011/2012, the landings, by quota year, had always exceeded the advised and set TAC by 30-40%. However, since then the overshoot in landings has decreased substantially, apart from 2014/2015 when the overshoot was 34%. In recent years the TAC has not been filled. (Table 4).

The reasons for the large difference between annual landings and both advised and set TACs are threefold: 1) It is possible to transfer unfished quota between fishing years; 2) It is possible to convert quota shares in one species to another; 3) The national TAC is only allocated to Icelandic vessels. All foreign catches are therefore outside the quota system. [However, in recent years managers have to some extent taken into account the foreign catches when setting the national TAC (see below)].

There are bilateral agreements between Iceland, Norway and the Faroe Islands related to fishing activity of foreign vessels in restricted areas within the Icelandic EEZ. Faroese vessels are allowed to fish 5600 t of demersal fish species in Icelandic waters which includes a maximum 1200 tonnes of cod and 40 t of Atlantic halibut. The rest of the Faroese demersal fishery in Icelandic waters is mainly directed at tusk, ling, and blue ling. The tusk advice given by MFRI and ICES for each quota year is, however, for all catches, including foreign catches. Further description of the Icelandic management system can be found in the stock annex.

Figure 20 shows the net transfers in the Icelandic ITQ-system. During the 2005/2006–2010/2011 fishing years there was a net transfer of other species quota being converted to tusk quota, this however reversed during the following three fishing years. In the 2015/2016 and 2016/2017 fishing years there was again a small net transfer of other species being changed to tusk quota.

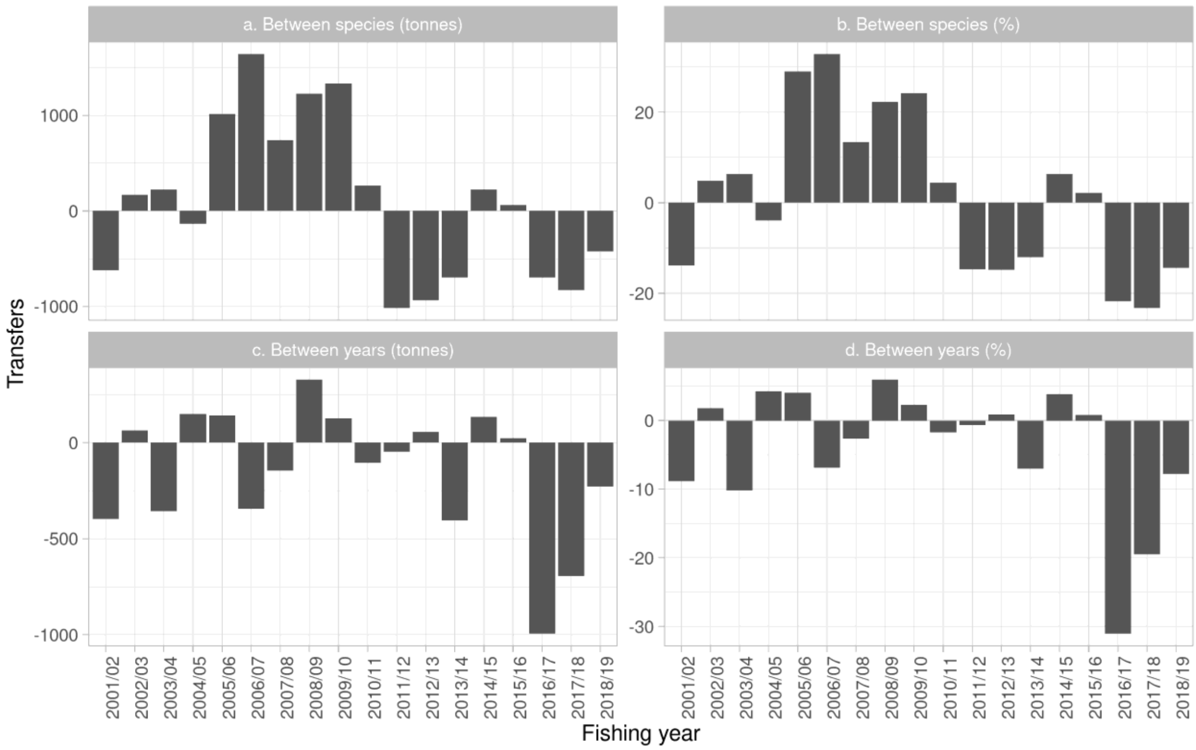

Figure 20. Tusk. Net transfer of quota in the Icelandic ITQ system by fishing year. Between species (upper): Positive values indicate a transfer of other species to tusk, but negative values indicate a transfer of tusk quota to other species. Between years (lower): Net transfer of quota for a given fishing year (may include unused quota).

Mynd 20. Keila. Nettó tilfærsla á kvóta eftir fiskveiðiárum. Tilfærsla á milli tegunda (efri mynd): jákvæð gildi tákna tilfærslu á kvóta annarra tegunda yfir á keilu en neikvæð gildi tilfærslu keilukvóta á aðrar tegundir. Tilfærsla milli ára (neðri mynd): Nettó tilfærsla kvóta á viðkomandi fiskveiðiári (gæti innihaldið ónotaðar aflaheimildir).

Table 4. Tusk. Advice given by MRI/MFRI, set national TAC by the Ministry of Fisheries and Agriculture and landings by fishing year (1 September–31 August).

Tafla 4. Keila. Ráðgjöf Hafrannsóknastofnunar, ákvörðun stjórnvalda um aflamark Íslendinga og landaður afli eftir fiskveiðiárum.

FISHING YEAR	ADVICE	NATIONAL-TAC	LANDINGS
2001/02		4500	**4876**
2002/03	3500	3500	**5046**
2003/04	3500	3500	**4958**
2004/05	3500	3500	**4901**
2005/06	3500	3500	**5928**
2006/07	5000	5000	**7942**
2007/08	5000	5500	**7279**
2008/09	5000	5500	**8162**
2009/10	5000	5500	**8382**
2010/11	6000	6000	**7777**
2011/12	6900	7000	**7401**
2012/13	6700	6400	**6833**
2013/14	6200	5900	**5881**
2014/15	4000	3700	**4958**
2015/16	3440	3000	**3494**
2016/17	3780	3380	**2407**
2017/18	4370	3770	**3139**
2018/19	3776	3100	**3651**
2019/20	3856	2906	
2020/21	**2289**		

MANAGEMENT CONSIDERATIONS

Increased catches in Greenlandic waters from less than 100 tonnes in previous years to 900 tonnes in 2015, and about 682 tonnes in 2018 are of concern. However, the signs from commercial catch data and surveys indicate that the total biomass of tusk in Icelandic waters is stable. This is confirmed in the Gadget assessment. Recruitment in Icelandic waters is on the increase again after a low in 2013. A reduction in fishing mortality has also led to harvestable biomass and SSB that seem to be either stable or slowly increasing. Due to the selectivity of the longline fleet catching tusk in Icelandic waters and the species relatively slow maturation rate, a large proportion of the catches is immature (60% in biomass, 70% in abundance). The spatial distribution of the fishery in relation to the spatial distribution of tusk in Icelandic waters as observed in the Icelandic spring survey may result in decreased catch rates and local depletions of tusk in the main fishing areas. Tusk is a slow growing late maturing species, therefore closures of known spawning areas should be maintained and expanded if needed. Similarly, closed areas to longline fishing where there is high juvenile abundance should also be maintained and expanded if needed.

ECOSYSTEM CONSIDERATIONS

Tusk has recently exhibited spatial changes in length distributions (Figure 12), however, there have been no obvious changes in maturity patterns or growth through time. Demo-graphic patterns of tusk should be monitored as other Icelandic demersal species have exhibited recent changes (e.g., haddock). Biomass levels of large-sized tusk have recently decreased, possibly as a result of increased natural mortality and environmental factors. However, the causes for this, such as multispecies interactions, are unknown and not currently considered in the assessment.

Table 7. Results from the Gadget assessment. Estimates of biomass, biomass 40+ cm, spawning–stock biomass (SSB) in thousands of tonnes and recruitment (millions), harvest rate (HR) and fully selected fishing mortality (F). Values from projections include fishing amounts and values for 2020, and all values after 2020, and result from assuming the current TAC is filled and that fishing occurs according to the HCR.

Tafla 7. Niðurstöður úr Gadget stofnmati. Áætlaður heildarlífmassi, lífmassi 40 cm og stærri, hrygningarstofns (SSB) í þúsundum tonna og nýliðun (milljónir), veiðihlutfall og veiðidánartala.

YEAR	BIOMASS	B40+	SSB	REC3	CATCH	HR	F
1982	36494	28927	11176	10297	5877	0.20	0.28
1983	37690	28796	10850	9135	8286	0.29	0.40
1984	36302	28217	10203	8396	5692	0.20	0.28
1985	37177	30120	11043	5232	5061	0.17	0.23
1986	38415	32196	12209	3765	5381	0.17	0.23
1987	38990	33580	13191	8858	5644	0.17	0.22
1988	39095	33108	13476	7591	6864	0.21	0.27
1989	37900	31778	13449	10590	7076	0.22	0.29
1990	36635	29620	12679	11867	7296	0.25	0.32
1991	35291	27171	11349	12348	8762	0.32	0.44
1992	32503	24606	9514	7202	7999	0.33	0.47
1993	30390	23498	8300	5883	6074	0.26	0.38
1994	29996	24279	8256	6294	5828	0.24	0.36
1995	29451	24317	8306	5518	6225	0.26	0.37
1996	28146	23536	8259	1819	6101	0.26	0.37
1997	26871	22652	8235	8688	5399	0.24	0.33
1998	26454	21406	8069	14892	5171	0.24	0.33
1999	26471	19444	7341	11071	7225	0.37	0.53
2000	24628	17708	6094	6290	5087	0.29	0.42
2001	25208	18100	5473	8284	4809	0.27	0.41
2002	26435	19921	5841	11127	5551	0.28	0.45
2003	27296	20243	5984	12517	5571	0.28	0.43
2004	28545	20645	6140	12566	4822	0.23	0.35
2005	31029	22598	6697	13958	5041	0.22	0.34
2006	33744	24451	7150	13739	6598	0.27	0.42
2007	35230	25714	7377	11887	7540	0.29	0.47
2008	35908	26647	7493	12729	8626	0.32	0.53
2009	35365	26074	7153	11405	8680	0.33	0.55
2010	34293	25864	7128	7822	8978	0.35	0.58
2011	32191	25187	7026	4365	7702	0.31	0.51
2012	30482	24911	7203	2799	7873	0.32	0.51
2013	27615	23317	7122	2415	6265	0.27	0.41
2014	25489	22147	7391	1548	6163	0.28	0.41
2015	22804	20295	7433	4245	4836	0.24	0.33
2016	21069	18206	7266	4853	3494	0.19	0.25
2017	20591	17778	7633	6097	2541	0.14	0.18
2018	21410	17316	7712	7202	2940	0.17	0.21
2019	22441	17575	7868	12385	3445	0.20	0.25

YEAR	BIOMASS	B40+	SSB	REC3	CATCH	HR	F
2020	23715	17609	7546	13748	3856	0.22	0.30
2021	25359	17596	7120180	11111	2334	0.13	0.17
2022	29283	20800	7741561	11111	2494	0.12	0.16

REFERENCES

ICES. 2011. "Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (Wgdeep), 2 March–8 March, 2011, Copenhagen, Denmark. ICES Cm 2011/Acom:17." International Council for the Exploration of the Seas; ICES publishing.

———. 2012. "Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (Wgdeep), 28 March–5 April, 2012, Copenhagen, Denmark. ICES Cm 2012/Acom:17." International Council for the Exploration of the Seas; ICES publishing.

———. 2014. "Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (Wgdeep). ICES Scientific Reports. 1:21., Copenhagen, Denmark. ICES Cm 2014/Acom:17." International Council for the Exploration of the Seas; ICES publishing. https://doi.org/10.17895/ices.pub.5262.

———. 2017a. "Report of the Workshop on Evaluation of the Adopted Harvest Control Rules for Icelandic Summer Spawning Herring, Ling and Tusk (WKICEMSE), 21–25 April 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:45." International Council for the Exploration of the Seas; ICES publishing. https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2017/WKICEMSE/wkicemse_2017.pdf

———. 2017b. "Tusk in ICES Subarea 14 and Division 5.a." International Council for the Exploration of the Seas; ICES publishing. http://ices.dk/sites/pub/Publication%20Reports/Stock%20Annexes/2016/usk-icel_SA.pdf

———. 2019. "11.2 Icelandic Waters ecoregion – Fisheries overview." International Council for the Exploration of the Seas; ICES publishing. https://doi.org/10.17895/ices.advice.5706.