TUSK

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, shellfish, and other demersal fish. In Icelandic waters it grows to sizes close to 100 cm and may attain ages close to 20 years, but age determination of individuals over 10 years old is highly uncertain.

THE FISHERY

Tusk in 5.a 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 1). Far fewer gillnetters and trawlers participate in the fishery. The number of longliners reporting tusk catches has been continually decreasing in the past few years (Table 1). Most of tusk in 5.a, around 95% of catch, is caught by longlines, and this proportion has been relatively stable since 1992 (Table 2).

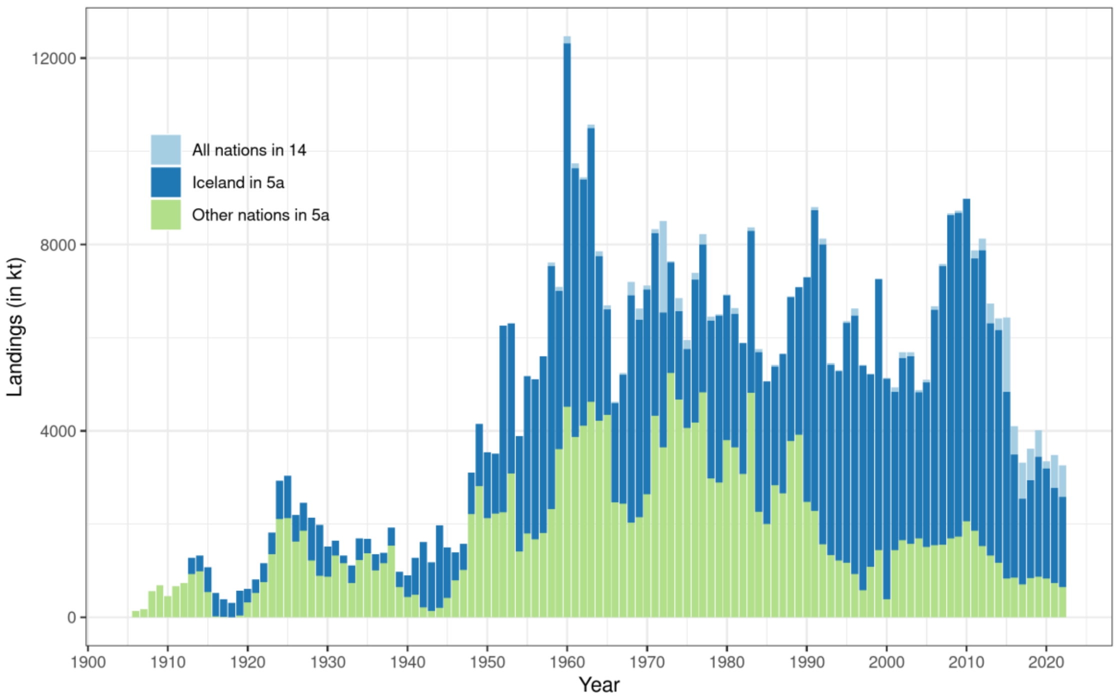

Figure 1. Tusk. Nominal landings within Icelandic waters (5a) by Icelandic vessels (dark blue) or foreign vessels (green), or within Greenlandic waters (14, light blue). (Source for 14: STATLANT).

Table 1. Tusk. Number of Icelandic boats with tusk landings, landings by gear and total catches.

	NUMBER OF BOATS			CATCH (TONNES)				
YEAR	Bottom trawl	Gill nets	Longlines	Bottom trawl	Gill nets	Longlines	Other	TOTAL CATCH
2001	108	224	348	87	63	3223	24	3397
2002	103	174	303	88	93	3712	17	3910
2003	97	148	304	65	41	3906	11	4024
2004	90	129	303	92	28	3007	8	3135
2005	87	101	324	115	19	3398	7	3539
2006	85	82	337	100	40	4907	7	5054
2007	74	65	308	104	38	5834	11	5987
2008	75	59	254	126	42	6758	7	6934
2009	75	65	239	115	72	6757	9	6953
2010	70	62	228	97	52	6761	9	6919
2011	63	54	221	72	24	5742	9	5847
2012	65	68	228	64	13	6255	13	6344
2013	66	43	230	76	15	4875	12	4979
2014	62	43	235	87	18	4878	12	4995
2015	55	32	214	71	7	3910	13	4001
2016	59	32	193	61	6	2575	7	2649
2017	52	31	166	48	5	1774	5	1833
2018	55	27	144	83	8	2002	4	2097
2019	49	23	142	103	7	2460	9	2579
2020	55	23	116	108	31	2209	9	2357
2021	51	18	111	112	12	1920	5	2049
2022	51	26	97	111	17	1801	4	1932

Most of the tusk caught in 5.a by Icelandic longliners is caught at depths less than 300 meters (Figure 2). The main fishing grounds for tusk in 5.a as observed from logbooks are on the southeast, southwestern and western part of the Icelandic shelf (Figure 3 and Figure 4). The spatial distribution of catches in 5.a according to logbook entries shows a decreasing trend in the southeast until 2015, but this proportion has been increasing in the last 5 years (Figure 3 and Figure 4). The proportional catch in the northwest has also increased over the years. Around 50–60% of tusk is caught on the southern and western parts of the shelf (Figure 3). Tusk in 14 is caught mainly as a bycatch by longliners and trawlers. The main area where tusk is caught in 14 is 63°–66°N and 32°–40°W, well away from the Icelandic EEZ.

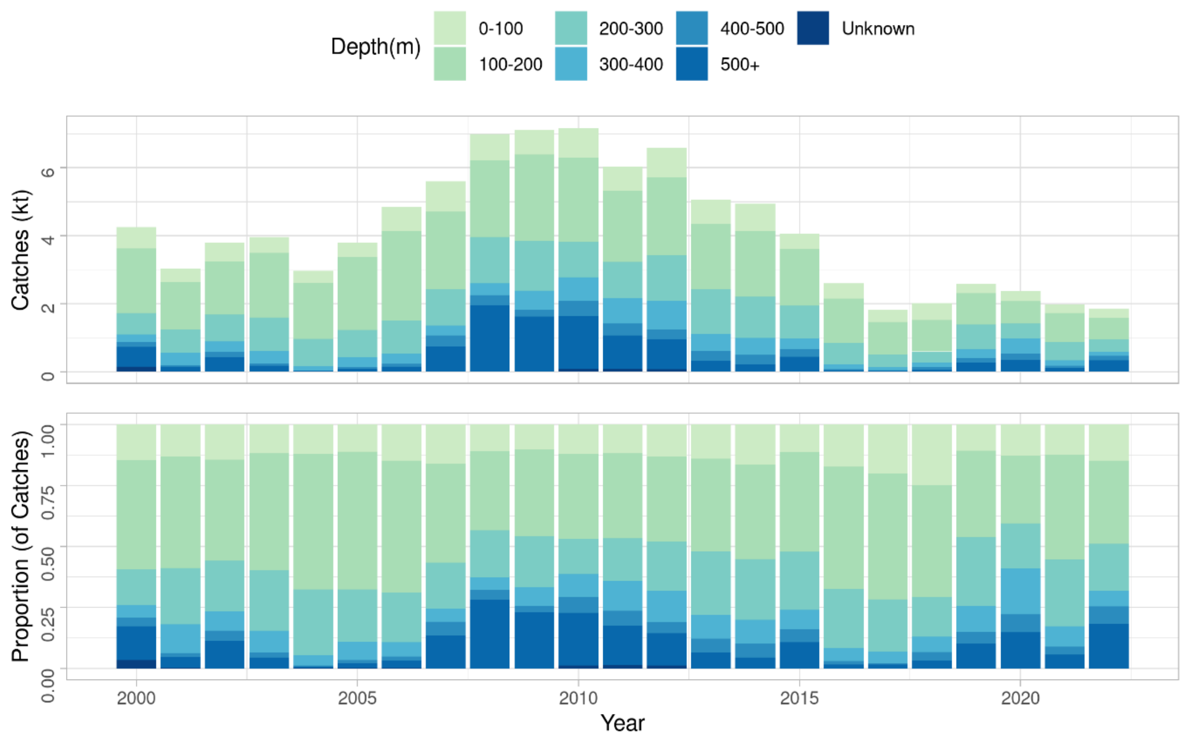

Figure 2. Tusk. Depth distribution of catches according to logbooks. All gears combined.

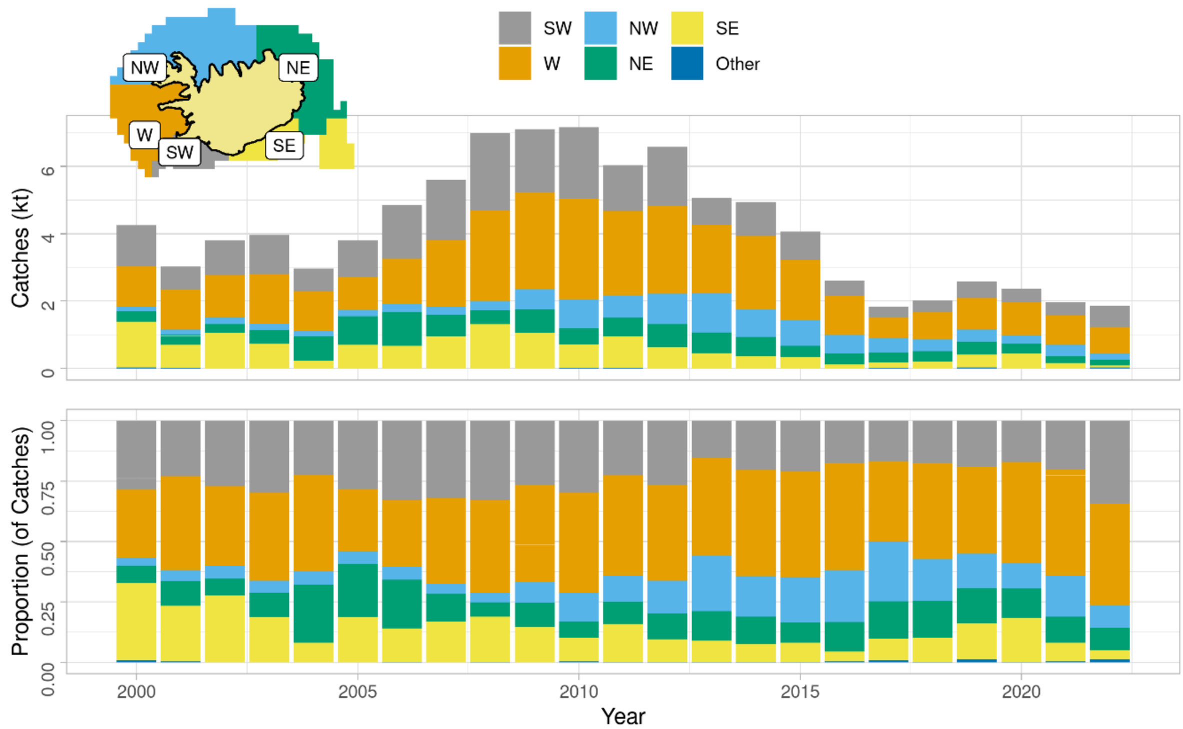

Figure 3. Tusk. Catch distribution and proportions by area according to logbooks. All gears combined.

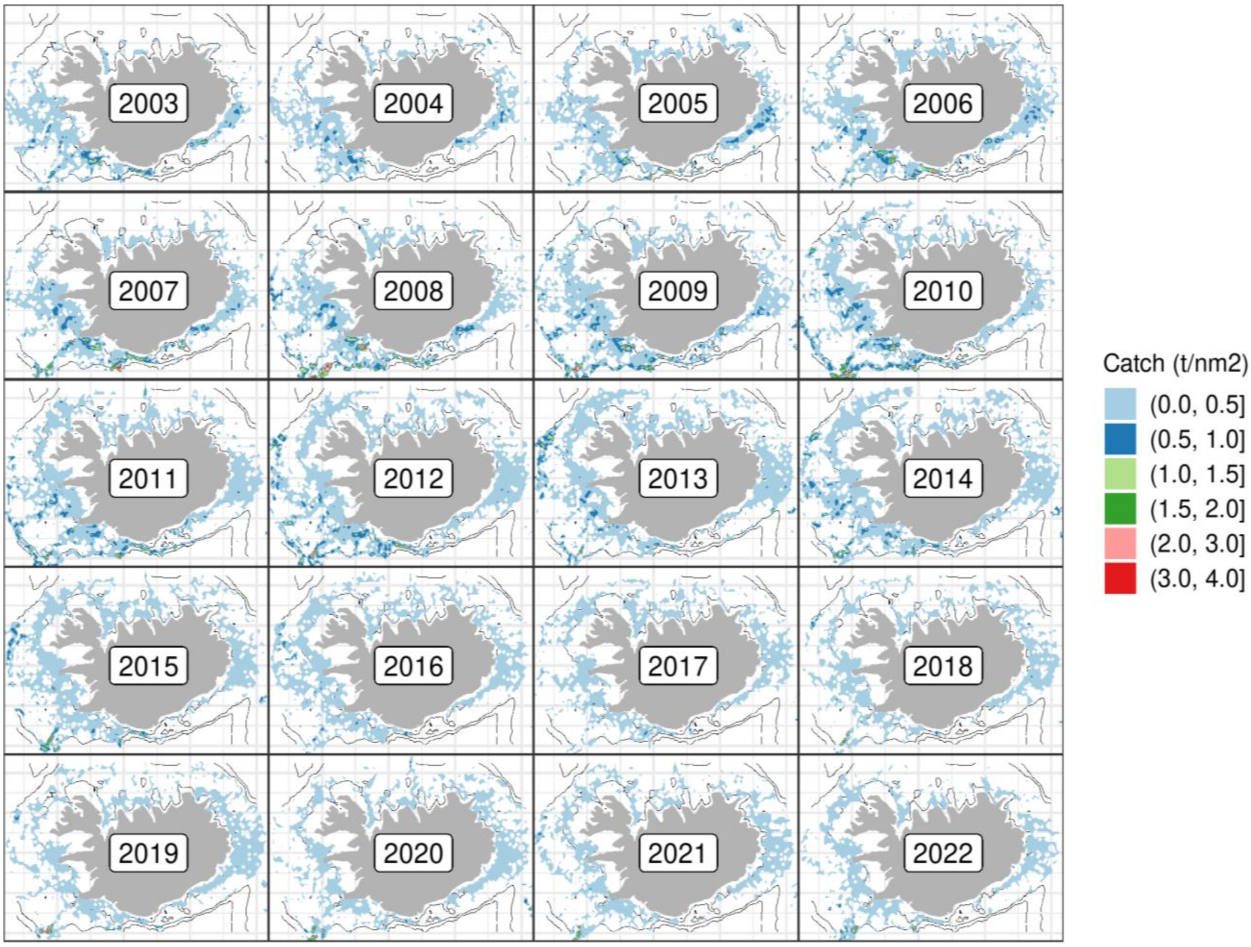

Figure 4. Tusk. Geographical distribution (tonnes) of the Icelandic longline fishery since 2003, as reported in logbooks by the Icelandic fleet.

LANDING AND DISCARDS

Total annual landings from ICES Division 5.a were 2577 tonnes in 2022 (Table 2), signifying a continuous decrease in landings from 2010. This is contrary to the trend in landings from year 2000 in which the annual landings gradually increased in 5.a to around 9000 tonnes in 2010 (Figure 1). The foreign catch (mostly vessels 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 was caught by foreign vessels, mainly vessels from the Faroe Islands. This proportion has reduced since and has been 10-30% since 1991 (Table 2).

Landings in area 14 have always been low compared to 5.a, rarely exceeding 100 t (Table 3). However, around 1600 tonnes were caught in 2015, after which catches have been consistently substantial. Catch data from section 14 reported by the Greenland Institute of Natural Resources (WGDEEP, 2019:WD06) also reflect this trend. Around 566 tonnes in 2019 were caught in the 14.b mainly by Faroese and Greenlandic vessels (Table 3). This has however increased in 2022 to about 680 tonnes. As the Icelandic TACs were relatively low during this period, this constituted over 20% of the annual catch.

Discarding is banned in the Icelandic fishery. There is no available information on discarding of tusk.

Table 2. Tusk. Nominal landings by nations in 5.a.

YEAR	USSR/RUSSIA	FAROE	GERMANY	ICELAND	NORWAY	UK	TOTAL
1980	0	2873	0	3109	928	0	6910
1981	0	2624	0	2864	1025	0	6513
1982	0	2410	0	2801	666	0	5877
1983	0	4046	0	3468	772	0	8286
1984	0	2008	0	3430	254	0	5692
1985	0	1885	0	3064	111	0	5060
1986	0	2811	0	2549	21	0	5381
1987	0	2638	0	2987	19	0	5644
1988	0	3757	0	3087	20	0	6864
1989	0	3908	0	3158	10	0	7076
1990	0	2475	0	4821	0	0	7296
1991	0	2286	0	6449	0	0	8735
1992	0	1567	0	6432	0	0	7999
1993	0	1333	0	4086	0	0	5419
1994	0	1217	0	4065	0	0	5282
1995	0	1168	1	5151	0	0	6320
1996	11	916	1	5540	3	0	6471
1997	0	579	0	4816	0	0	5395
1998	0	1080	1	4130	0	0	5211
1999	0	1041	2	5821	391	2	7257
2000	0	10	0	4727	374	2	5114
2001	0	1150	1	3397	285	5	4838
2002	0	1279	0	3910	372	2	5563
2003	0	1198	1	4024	373	2	5598
2004	0	1478	1	3135	214	2	4830
2005	0	1157	4	3539	303	41	5044
2006	0	1244	2	5054	299	2	6601
2007	0	1250	0	5987	300	1	7538
2008	0	1398	0	6934	298	0	8629
2009	0	1516	0	6953	210	0	8679
2010	0	1794	0	6919	263	0	8976
2011	0	1655	0	5847	198	0	7701
2012	0	1310	0	6344	217	0	7872
2013	0	1132	0	4979	192	0	6302
2014	0	742	0	4995	425	0	6163
2015	0	637	0	4001	198	0	4836
2016	0	543	0	2649	302	0	3494
2017	0	492	0	1833	216	0	2541
2018	0	517	0	2097	326	0	2940
2019	0	549	0	2579	316	0	3445
2020	0	558	0	2358	271	0	3187
2021	0	342	0	2049	388	0	2779
2022	0	288	0	1932	357	0	2577

Table 3. Tusk. Nominal landings by nations in 14.

Year	Faroe	Germany	Greenland	Iceland	Norway	Ussr/ Russia	Spain	UK	Total
1980	0	13	0	0	0	0	0	0	13
1981	110	10	0	0	0	0	0	0	120
1982	0	10	0	0	0	0	0	0	10
1983	74	11	0	0	0	0	0	0	85
1984	0	5	0	0	58	0	0	0	63
1985	0	4	0	0	0	0	0	0	4
1986	33	2	0	0	0	0	0	0	35
1987	13	2	0	0	0	0	0	0	15
1988	19	2	0	0	0	0	0	0	21
1989	13	1	0	0	0	0	0	0	14
1990	0	2	0	0	7	0	0	0	9
1991	0	2	0	0	68	0	0	1	71
1992	0	0	0	3	120	0	0	0	123
1993	0	0	0	1	39	0	0	0	40
1994	0	0	0	0	17	0	0	0	17
1995	0	0	0	0	30	0	0	0	30
1996	0	0	0	0	158	0	0	0	158
1997	0	0	0	10	9	0	0	0	19
1998	0	0	0	0	12	0	0	0	12
1999	0	0	0	0	8	0	0	0	8
2000	0	0	0	11	11	0	3	0	25
2001	3	0	0	20	69	0	0	0	92
2002	4	0	0	86	30	0	0	0	120
2003	0	0	0	2	88	0	0	0	90
2004	0	0	0	0	40	0	0	0	40
2005	7	0	0	0	41	8	0	0	56
2006	3	0	0	0	19	51	0	0	73
2007	0	0	0	0	40	6	0	0	46
2008	0	0	33	0	7	0	0	0	40
2009	12	0	15	0	5	11	0	0	43
2010	7	0	0	0	5	0	0	0	12
2011	20	0	0	131	24	0	0	0	175
2012	33	0	0	174	46	0	0	0	253
2013	2	0	0	401	24	0	0	0	427
2014	145	0	74	0	35	0	0	0	254
2015	759	0	785	0	55	0	0	0	1599
2016	243	3	182	0	178	0	0	0	606
2017	281	0	358	0	141	0	0	0	781
2018	345	0	108	0	228	0	0	0	681
2019	41	1	66	0	458	0	0	0	566
2020	0	2	41	0	114	0	0	0	158
2021	260	2	59	0	380	0	0	0	701
2022	35	1	87	0	558	0	0	0	680

SAMPLING FROM COMMERCIAL CATCHES

In general sampling is considered appropriate from commercial catches from the main gear (longlines), although the quantity of samples has decreased substantially in recent years. The sampling does seem to cover the spatial distribution of catches for longlines and trawls. Similarly, sampling does seem to follow the temporal distribution of catches (ICES (2012)). The sampling coverage in 2022 is shown in Figure 5.

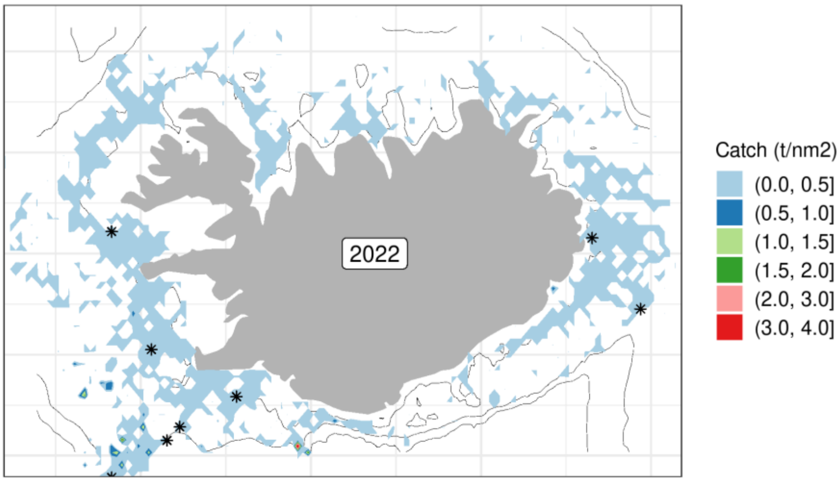

Figure 5. Tusk. Fishing grounds in 2022 as reported by catch in logbooks (tiles) and positions of samples taken from landings (asterisks) by longliners.

Table 4. Tusk. Number of available length measurements from Icelandic (5.a) commercial catches.

YEAR	BOTTOM TRAWL	DEMERSAL SEINE	GILL NET	LONGLINE	OTHER
2004	150	0	0	3809	0
2005	21	0	0	5820	0
2006	472	0	0	4861	0
2007	150	0	167	11936	0
2008	0	0	0	20963	0
2009	0	0	0	21451	0
2010	0	0	0	9084	0
2011	0	0	0	8158	0
2012	150	0	0	11867	0
2013	0	150	0	6469	0
2014	0	0	0	11748	0
2015	0	0	0	4821	0
2016	0	0	0	4844	0
2017	0	0	0	1710	0
2018	0	0	0	2781	0
2019	0	0	0	2952	0
2020	1	0	0	2336	0
2021	0	0	0	1499	26
2022	83	0	0	1023	120

LENGTH COMPOSITIONS

An overview of available length measurements from 5.a is given in Table 4. Most of the measurements are from longlines; number of available length measurements increased in 2007 from around 5000 to around 12000 and were close to that until 2016 when they decreased to around 1700 fish and have remained roughly at that level. Length distributions from the longline fishery is shown in figure 6.

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

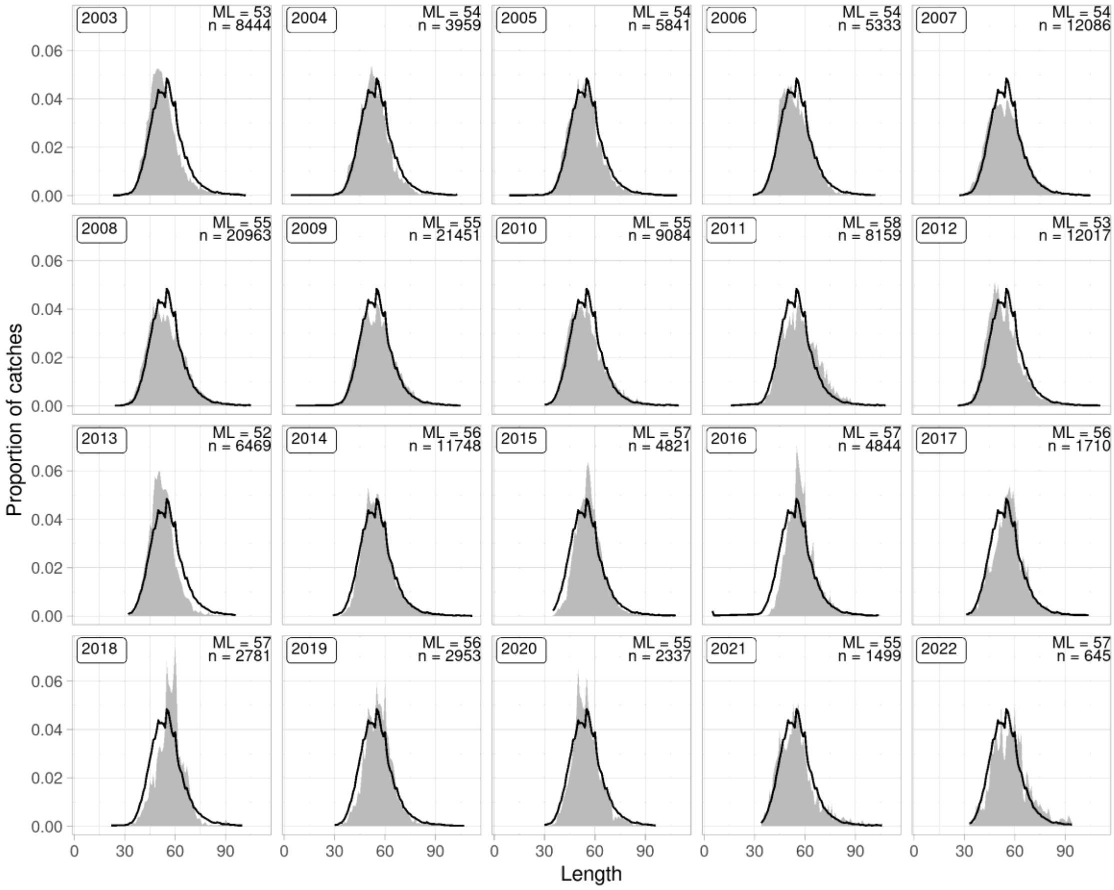

Figure 6. Tusk. Length distributions from Icelandic commercial longline catches.

ICELANDIC SURVEY DATA

Information on abundance and biological parameters from tusk in Icelandic waters is available from two surveys, the Icelandic groundfish survey in the spring (SMB) and the Icelandic autumn survey (SMH). 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 in the estimation of survey indices. In addition, the autumn survey 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 (ICES (2017b)). Figure 7 shows a recruitment index and the trends in various biomass indices. No substantial change in spatial distribution is seen in general although there are spatial gradients in size distribution (Figure 20).

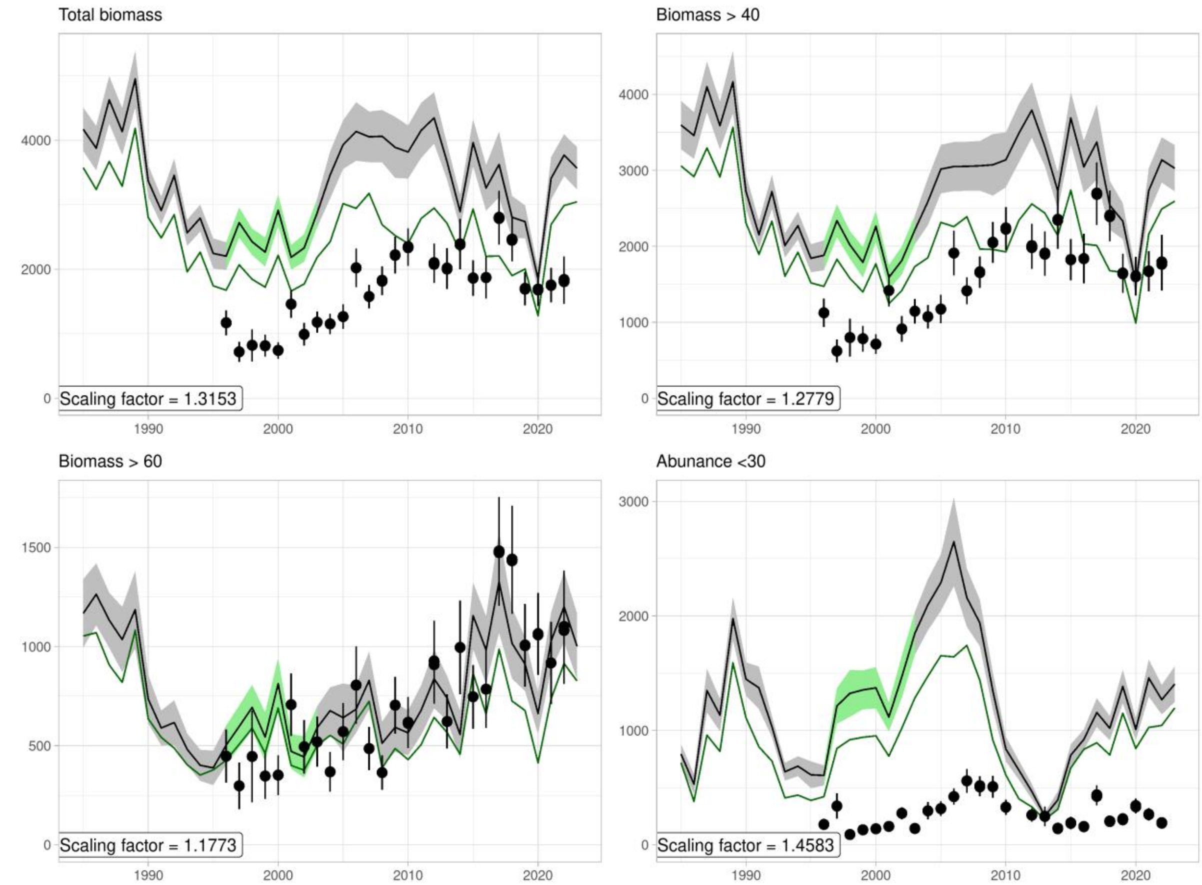

Figure 7. Tusk. a) Total biomass indices, b) biomass indices larger than and including 40 cm, c) biomass indices larger than and including 60 cm and d) abundance indices smaller than and including 30 cm. The lines with shaded areas show the spring survey index from 1985 and the points with the vertical lines show the autumn survey from 1997. The shaded area and vertical lines indicate +/- standard error. The dark green line without a shaded area is the index excluding the Iceland-Faroe Ridge.

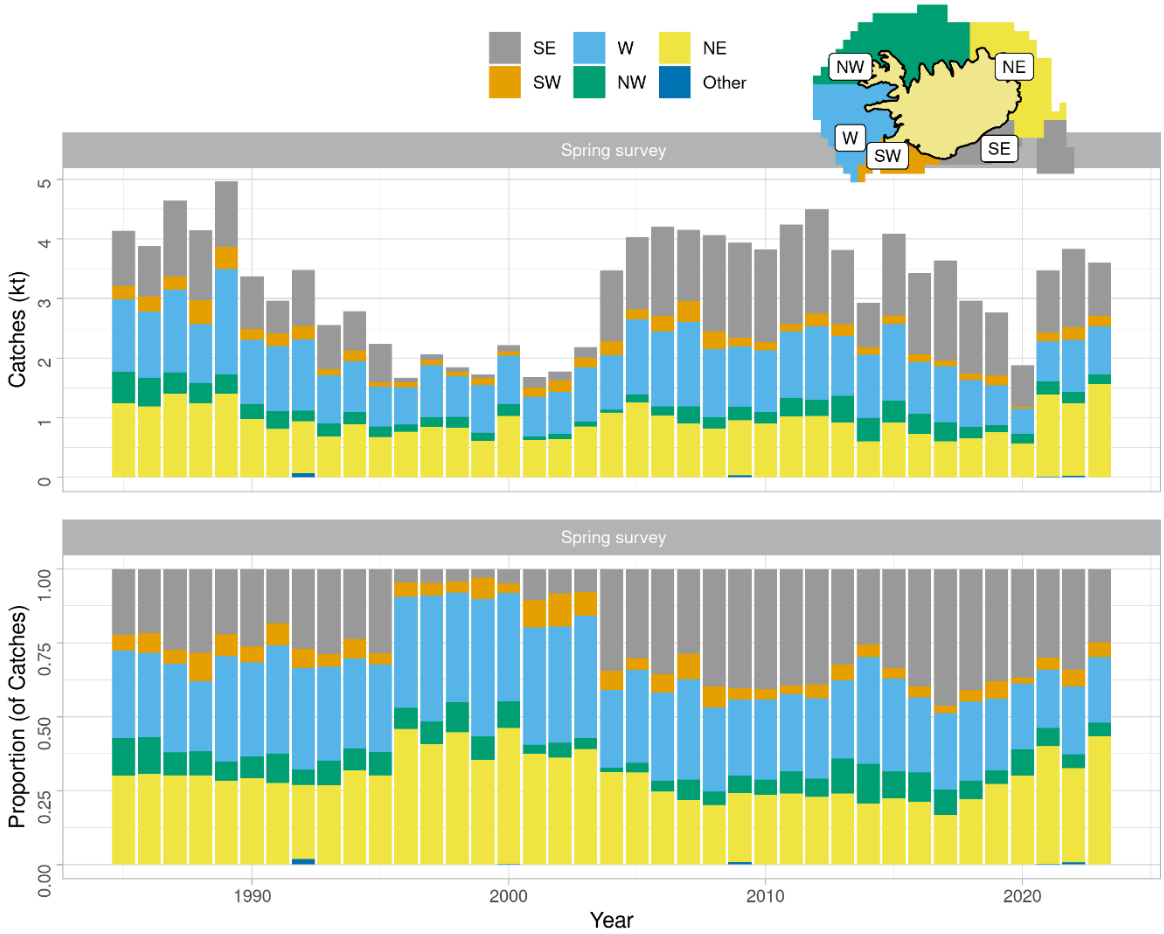

Figure 8. Tusk. Estimated survey biomass in the spring survey by year from different parts of the continental shelf (upper figure) and as proportions of the total (lower figure).

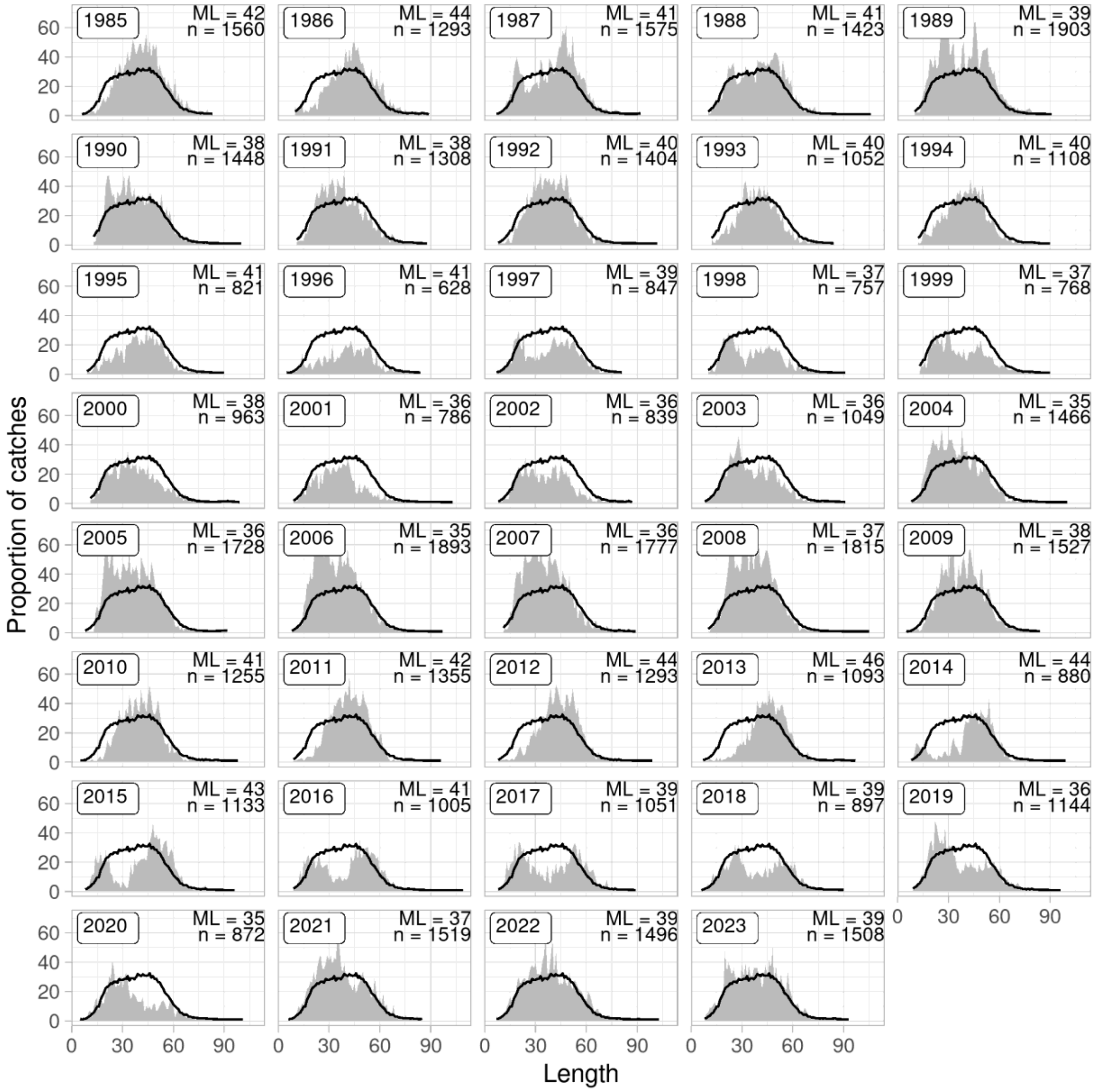

Figure 9. Tusk. Length distributions from the spring survey (SMB) since 1985. Mean length (ML) and sample sizes (n) are shown.

OTHER SURVEYS

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 14 were available at the meeting up to 2015. The trend in the German survey catches is similar to those observed in surveys in 5.a. It should, however, be noted that the data presented in Figure 10 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 11.

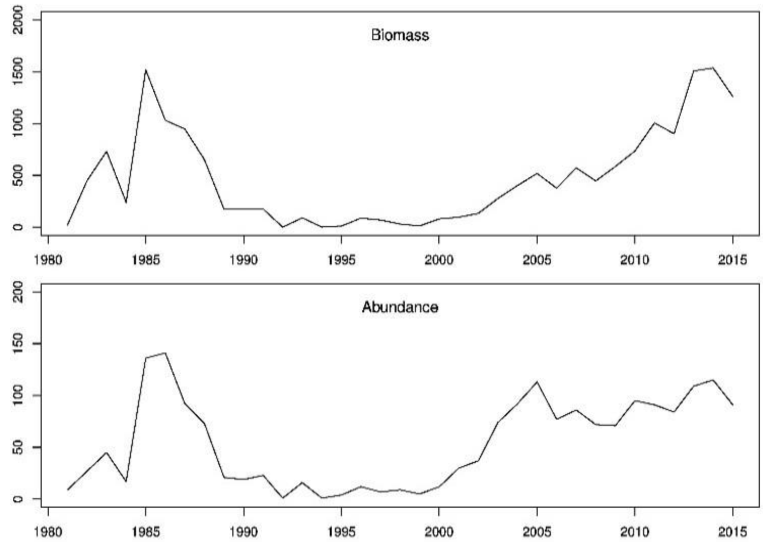

Figure 10. Tusk. Biomass and abundance estimates from the Walter Herwig survey in 14. The data are just the total number caught and then converted to weight.

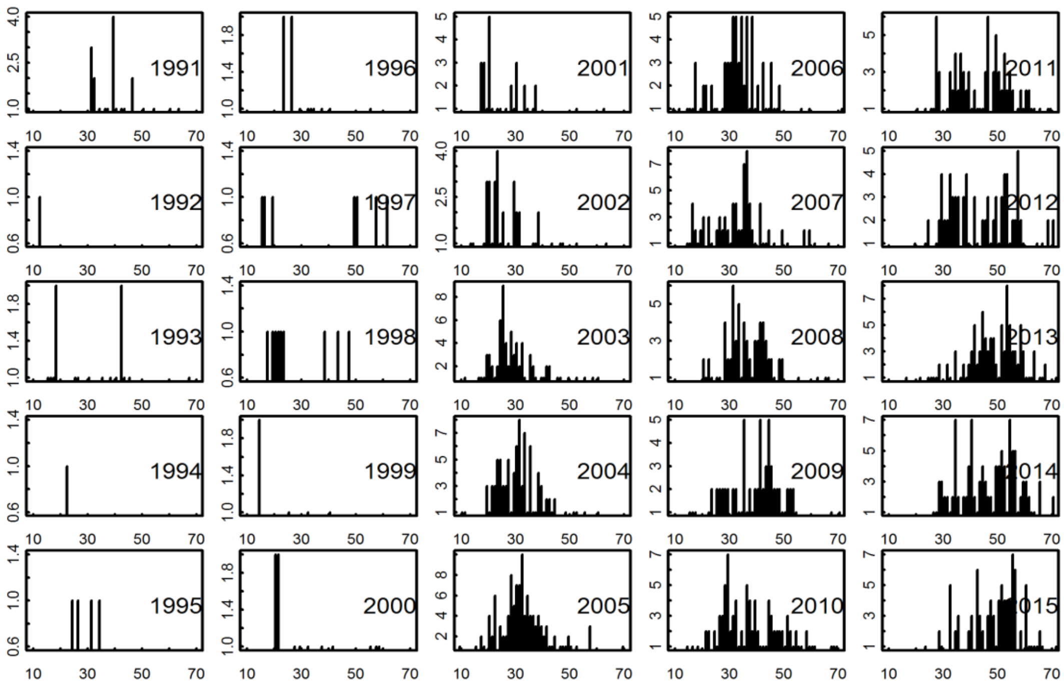

Figure 11. Tusk. Length distributions from the Walter Herwig survey in 14.

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 (ICES 2019: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 or the composition of the fleet participating in the tusk fishery in 5.a (Table 1). Catches decreased from around 9000 tons in 2010 to 2577 tons in 2022. This decrease is mainly because of reductions in landings by the Icelandic longline fleet and to a lesser extent Faroese and Norwegian landings (Table 2 and Table 3). This has resulted in less overshoot of landings relative to set TAC, except in the last two years when the stock has experienced an all-time low. As this all-time low is more likely due to the low recruitment during 2010–2011 rather than overexploitation, so is expected to increase as subsequent higher recruitment levels grow to fishable sizes.

There are no marked changes in the length compositions since 2004, mean length in the catch ranges between 52 and 58 (Figure 6). Length distributions from the spring survey show a distinct large cohort, or series of consecutive cohorts, appearing in 2014, growing through time, and just beginning to reach fished sizes approximately this year 6. This recruitment peak appears to follow a recruitment low that can also be traced through the length distribution from 2014 and can still be observed this year as slightly lower-than-average frequencies of tusk in the 45-50 cm range. According to the available length distributions and information on maturity only around 29% of catches in abundance and 44% in biomass are mature. 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 highly unlikely.

At WGDEEP 2011 the Iceland-Faroe Ridge was included in the survey index when presenting the results from the Icelandic spring survey for tusk in 5.a. The total biomass index and the biomass index for tusk larger than 40 cm (reference biomass) decreased substantially but increased again and has remained at relatively high similar level as in 2011 (Figure 7). The same holds for the index of tusk larger than 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. The index excluding the Iceland-Faroe Ridge shows similar trends as described above. The results from the shorter autumn survey are 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 labour strike, the autumn survey did not take place in 2011.

When looking at the spatial distribution from the spring survey, around 25% of the index is from the SE area. However only around 4% of the catches are caught in this area (Figure 3 and Figure 4). The change in juvenile abundance between 2006 and recent years can be seen in Figure 7.

AGE COMPOSITIONS

Table 5 gives an overview of otolith sampling intensity by gear types from 2006-2022 in 5.a. Since 2010, considerable effort has been put into ageing tusk otoliths, so now aged otoliths are available from 1984, 1995, 2008–2022. The age data are used as input for the SAM assessment. It is expected that the effort in ageing of tusk will continue.

Table 5. Tusk. Number of available otoliths from Icelandic (5.a) commercial catches and the Icelandic spring survey (SMB) and the number of aged otoliths.

Year	Samples (catch)	Otoliths (catch)	Aged (Catch)	Samples (survey)	Aged (survey)
2006	18	900	-	282	475
2007	25	1217	-	290	466
2008	32	1600	600	282	475
2009	27	1350	1090	277	434
2010	29	1449	1373	241	363
2011	28	1400	1306	270	728
2012	35	1750	1160	285	750
2013	23	1150	510	275	536
2014	28	620	587	241	559
2015	26	555	505	260	573
2016	14	290	290	259	676
2017	8	160	152	245	571
2018	9	180	179	247	549
2019	15	330	321	251	704
2020	14	290	261	250	647
2021	15	291	278	278	811
2022	14	287	261	313	897

WEIGHT AT AGE

Weight-at-age data from 5.a are limited to 2008–2022. No data is available from 14.

MATURITY AT AGE

In recent years, at 54 cm around 34% of tusk in 5.a is mature, at 62 cm 54% of tusk is mature and at 70 cm 50% 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 5.a or 14. For assessment and advisory purposes the natural mortality is set to 0.15 for all age groups.

CATCH, EFFORT AND RESEARCH VESSEL DATA

The CPUE estimates of tusk in 5.a are not considered representative of stock abundance.

CPUE estimations have not been attempted on available data from 14.

ANALYTICAL ASSESSMENT USING SAM

Since 2010 the Gadget model (Globally applicable Area Disaggregated General Ecosystem Toolbox, see www.hafro.is/gadget) had been used for the assessment of tusk in 5.a (See stock annex for details). As part of a Harvest Control Evaluation requested by Iceland this stock was benchmarked in 2017 (WKICEMSE 2017) and a Gadget model was used for category 1 assessment through 2021. In 2022, Tusk was re-assessed as the previously benchmarked Gadget model had begun to show great instability in retrospective patterns in recent years. As a part of a Harvest Control Evaluation requested by Iceland (ICES 2022a), the stock was benchmarked (WKICEMSE, ICES 2022c) which resulted in changes in the assessment method and updated reference points. Model setup and settings are described in the Stock Annex (ICES 2022b).

DATA USED BY THE ASSESSMENT AND MODEL SETTINGS

Data used for tuning and the model configuration are given in the stock annex (ICES 2022b).

MODEL FIT

Model results are shown in table 8. The model fit to survey indices are shown in Figures 12 and 13. Generally, the model closely follows the spring survey data, which are in good agreeance. The autumn survey is noisier but generally follows the same pattern. Fits to the April gillnet survey (age 10 abundance) are much noisier.

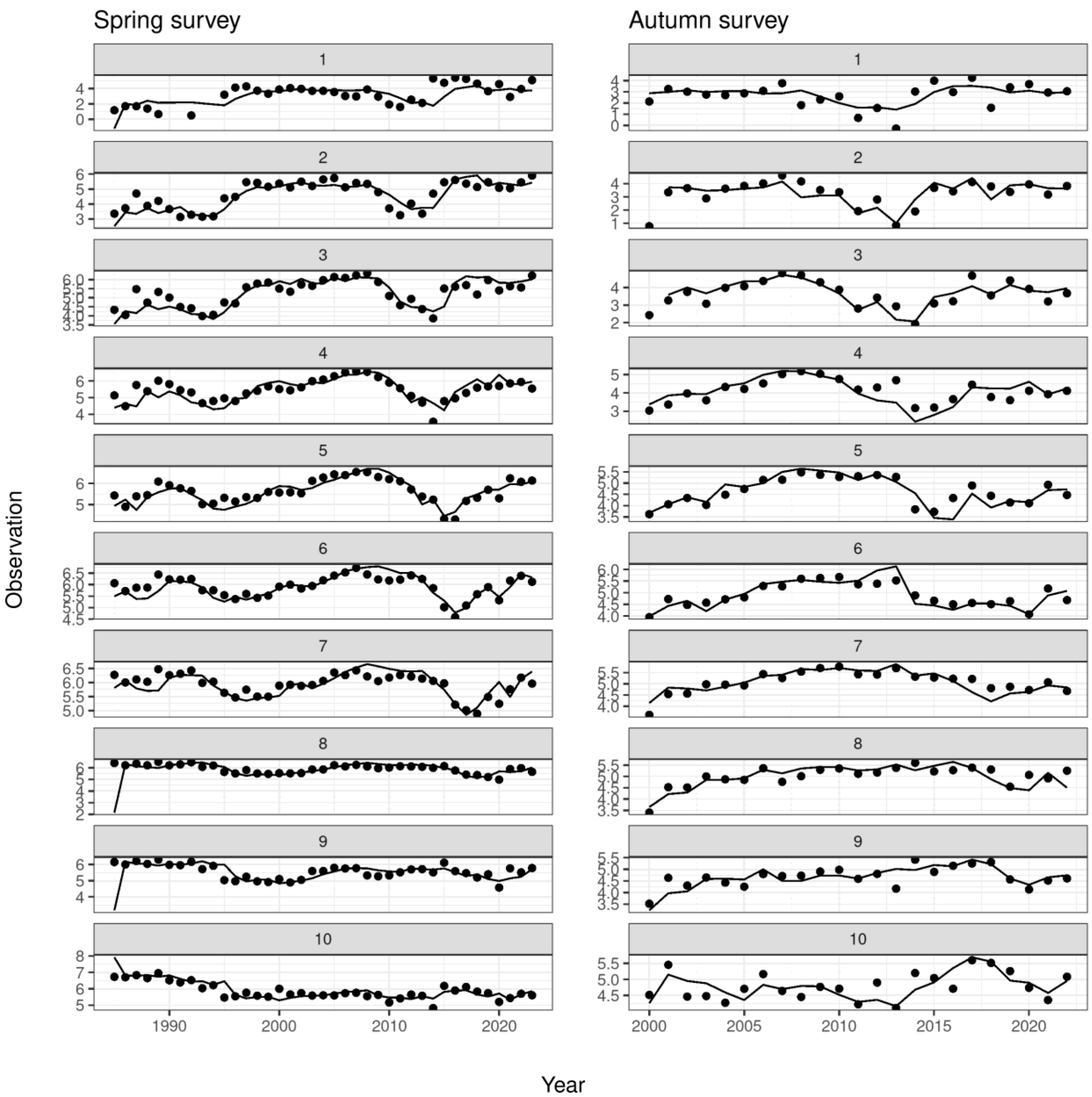

Figure 12. Tusk. Model fit to spring survey and autumn survey indices.

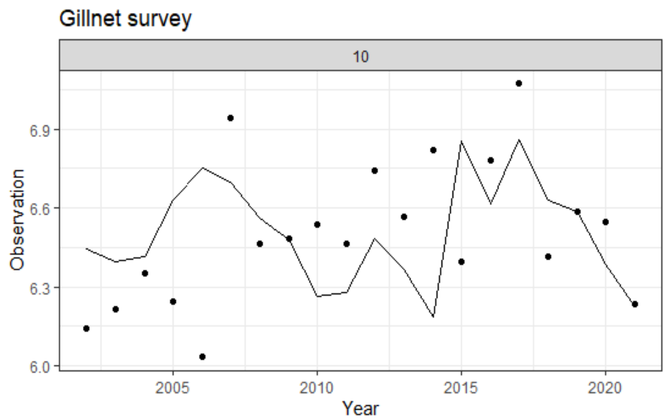

Figure 13. Tusk. Model fit to gillnet survey indices.

MODEL RESULTS

Spawning stock biomass has shown a gradual decline prior to 1995, although prior to 1985 the model is informed by very little data, so uncertainty is high. The period 1995-2015 was steady, with a gradual decline thereafter that continued until 2022, when biomass levels have started to increase again. This pattern is likely due to a distinctive low point in recruitment in 2011-2012, which has since then increased to relatively high levels. Therefore, given moderate fishing levels, spawning stock biomass is expected to increase over the next several years as the newest higher recruitment levels grow into the fishable population. The previous peak in recruitment (2004-2005) likely did not increase spawning stock biomass levels substantially during this period due to higher fishing rates and catch values during 2008-2010, when these fish would have been entering the fishery (Figure 14).

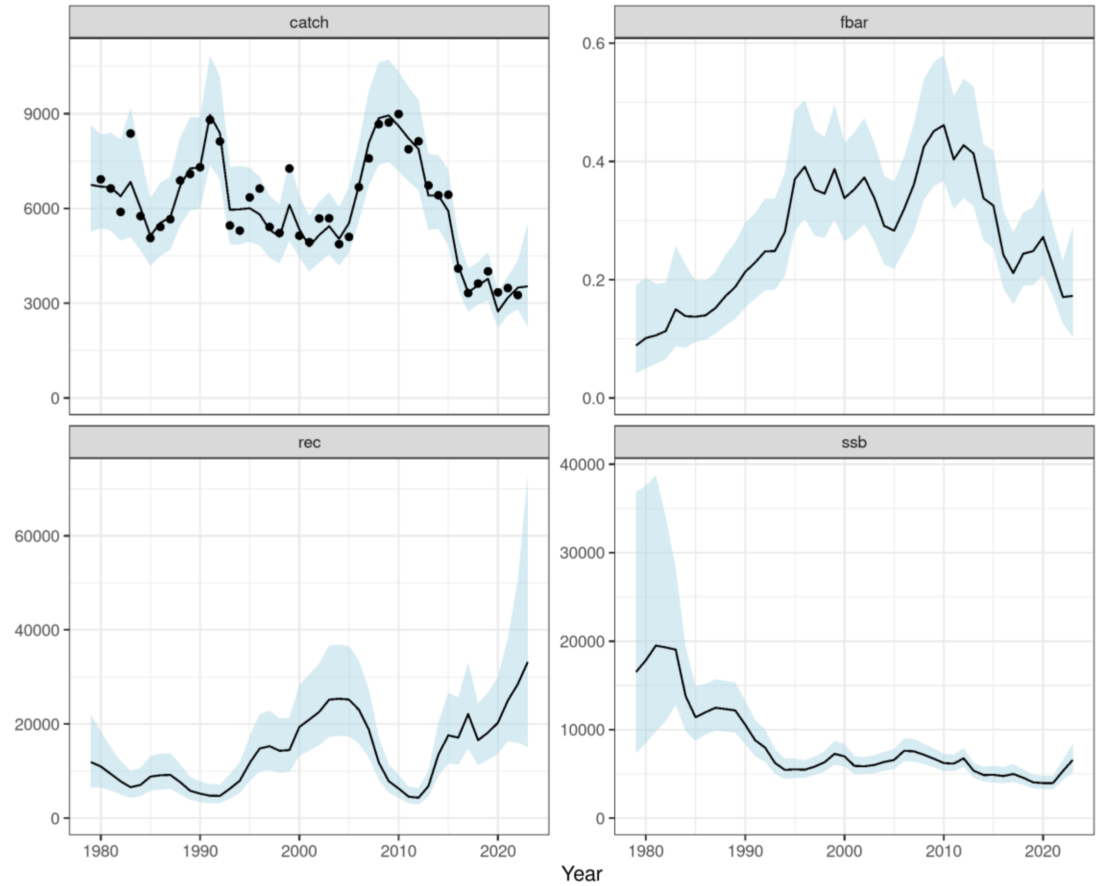

Figure 14. Tusk. Model results of population dynamics overview: estimated catch, average fishing mortality over ages 7 - 10 (Fbar), recruitment (age 1), and spawning stock biomass (SSB). Catch and Fbar in 2022 are projections.

RETROSPECTIVE ANALYSIS

The results of an analytical retrospective analysis are presented (Figure 15). The analysis indicates generally consistent model results over the 5-year peel. Mohn's ρ was estimated to be 0.0327 for SSB, -0.0327 for F, and 0.177 for recruitment. Recruitment indices generally tend to be uncertain as there are few repeated observations at larger sizes with which this influence can be tempered. However, the good fit to survey indices at age 1, Figure 12), suggests that recent 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 7). Therefore, it is likely that the increase in biomass observed this year will continue in the next year or so.

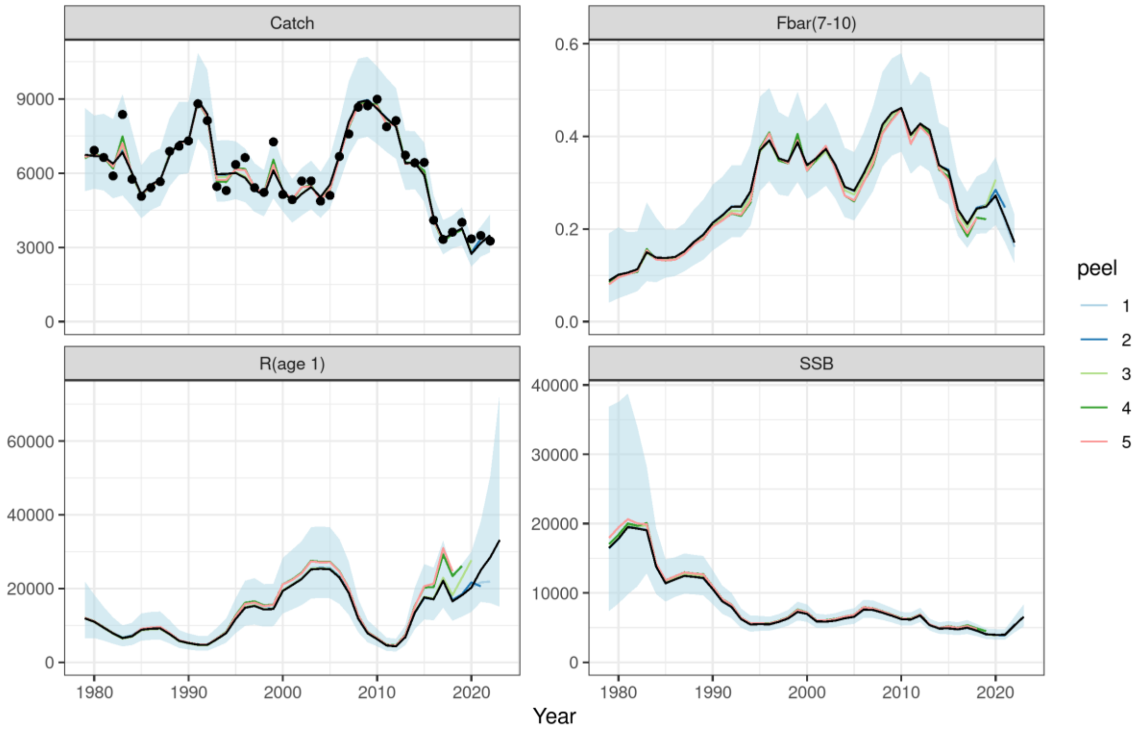

Figure 15. Tusk. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 3) are shown.

Observation nor process residuals show slight trends in autocorrelation and some blocks of time where the model was consistently over- or underestimating the model. (Figures 16 and 17). However, a better model configuration could not be found in the benchmark that would remove these patterns, and similar model configurations gave similar model results (WKICEMP, ICES 2022c). Process variance is therefore rather high in this model, indicating high uncertainty in true population dynamics, due to greater uncertainty in input data (Figure 18).

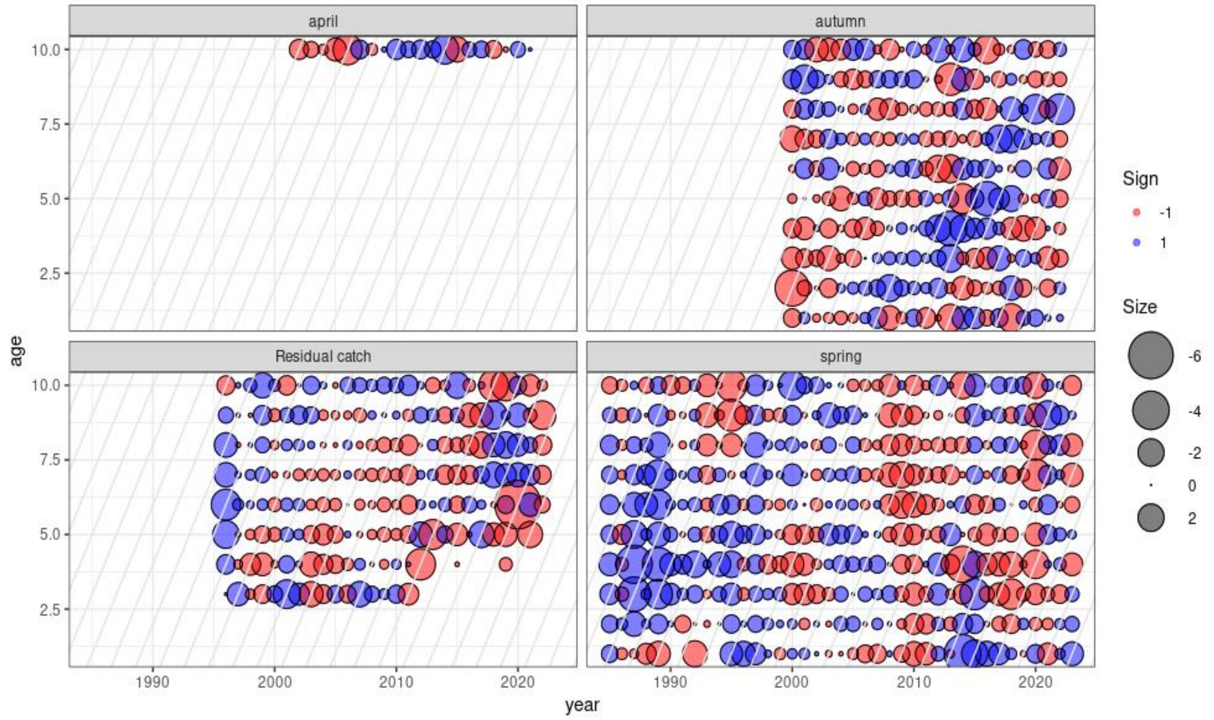

Figure 16. Tusk. Observation error residuals of the SAM model.

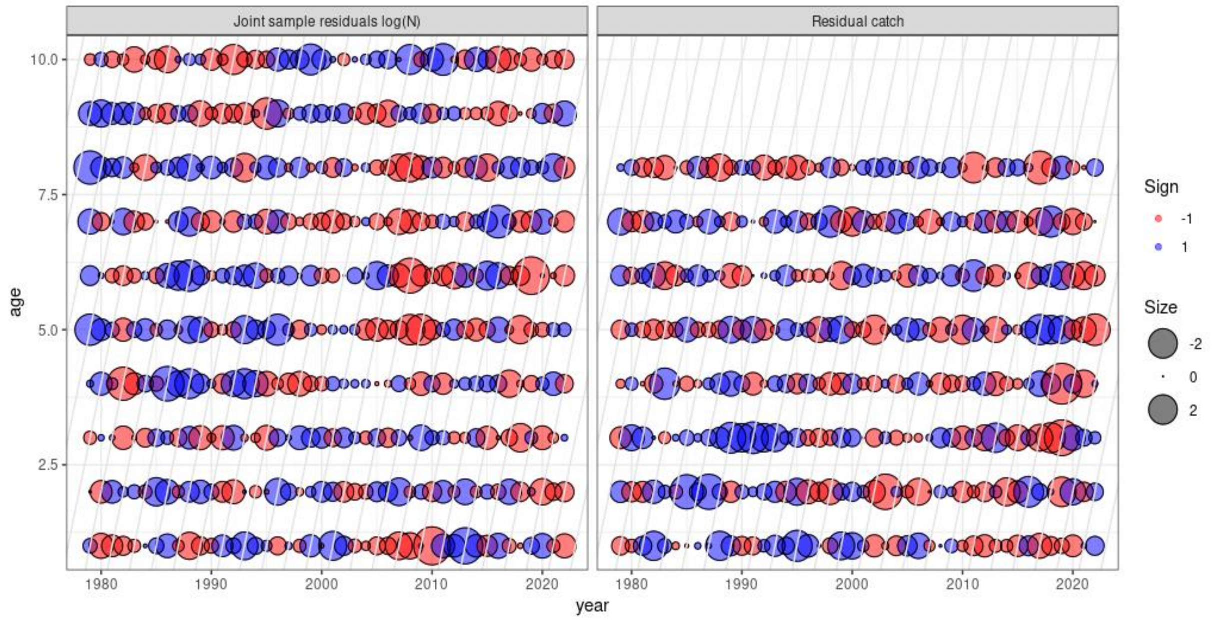

Figure 17. Tusk. Process error residuals of the SAM model.

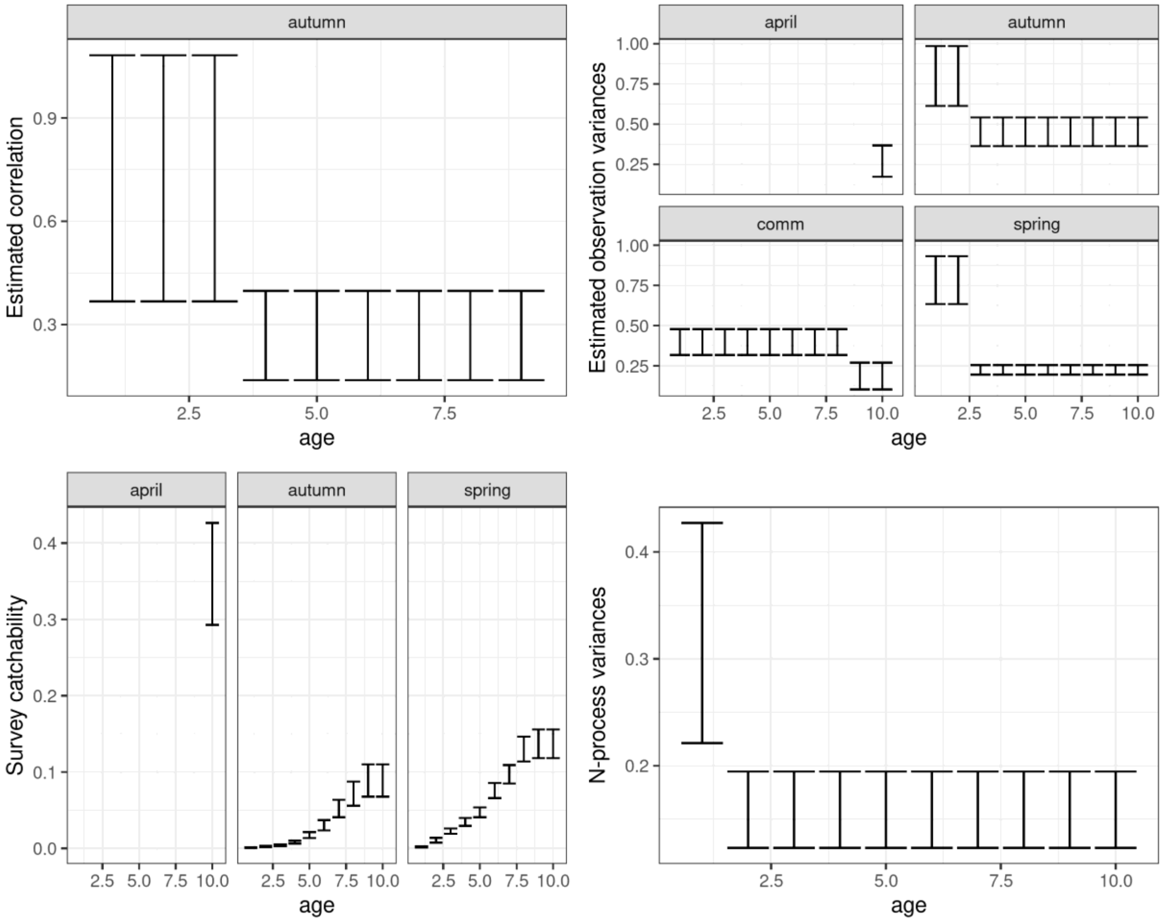

Figure 18. Tusk. Overview of the SAM model parameter estimates. Error bars indicate 95% confidence intervals.

REFERENCE POINTS

In the past, yield-per-recruit-based reference points, estimated as described in the stock annex, were used as proxies for F_{msy}. F_{msy} from a Y/R analysis is 0.24 and F0.1 is 0.15. WGDEEP 2014 recommended using F_{msy}=0.2 as the target fishing mortality rather than F_{max}. This was subsequently used as the basis for the advice in 2014 by ICES. (See stock annex for details). As part of the WKICEMSE 2017 HCR evaluations (ICES (2017a)), the following reference points were defined for the stock. The management plan accepted at that time was: The spawning–stock biomass trigger (MGT $B_{trigger}$) 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 SSB_y is equal or above MGT $B_{trigger}$:

$TAC_{y/y+1} = HR_{mgt} * B_{Ref,y}$

When SSB_Y is below MGT $B_{trigger}$:

$TAC_{y/y+1} = HR_{mgt} * (SSB_y/MGT\ B_{trigger}) * B_{ref,y}$

WKICEMSE 2017 concluded that the HCR was precautionary and in conformity with the ICES MSY approach, but the model started to show instability in retrospective patterns. As part of the WKICEMP

(ICES, 2022c), harvest control rule (HCR) evaluations requested by Iceland, stock assessment methods were evaluated, and the following reference points were defined for the stock.

The HCR for the Icelandic Tusk fishery, which sets a TAC for the fishing year y/y+1 (September 1 of year y to August 31 of year y+1) is based on a fishing mortality F_{mgt} of 0.23 applied to ages 7 to 10 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. WKICEMSE (ICES 2022c) concluded that the HCR was precautionary and in conformity with the ICES MSY approach.

Table 6. Tusk. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	4800	B_{pa}
	F_{MSY}	0.23	Limited by F_{pa}, maximum F at which the probability of SSB falling below B_{lim} is <5%
Precautionary approach	B_{lim}	3400	B_{pa} x $e^{-1.645 * \sigma B}$
	B_{pa}	4800	B_{loss} (SSB in 2016)
	F_{lim}	0.44	Fishing mortality that in stochastic equilibrium will result in median SSB at B_{lim}.
	F_{pa}	0.23	Maximum F at which the probability of SSB falling below B_{lim} is <5%
Management plan	MGT $B_{trigger}$	4800	According to the management plan
	F_{MGT}	0.23	According to the management plan

MANAGEMENT

The Icelandic Ministry of Food, Agriculture and Fisheries 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 TACs were not filled, until the past two years when the TAC has been exceptionally low (Table 7).

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.

Figure 19 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. In the last four out of five fishing years, 2017/2018-2019/2020, net transfers have been negative again with tusk quota being converted to other species, while 2020/2021 shows an overshoot of the quota.

Table 7. Tusk. Recommended TAC, national TAC, and catches (tonnes).

FISHING YEAR	RECOMMENDED TAC	NATIONAL TAC	CATCHES ICELAND	CATCHES OTHER	TOTAL CATCH
2010/2011	6000	6000	6235	1545	7768
2011/2012	6900	7000	5983	1420	7401
2012/2013	6700	6700	5555	1284	6833
2013/2014	6300	6300	4850	588	5438
2014/2015	4000	4000	4136	1304	5440
2015/2016	3440	3440	3221	900	4121
2016/2017	3780	3780	1689	729	2418
2017/2018	4370[1)]	4370	2200	885	3085
2018/2019	3776[1)]	3776	2454	778	3232
2019/2020	3856[1)]	3856	2460	781	3241
2020/2021	2289[1)]	2289	2192	757	2949
2021/2022	2172[1)]	2172	1918	503	2421
2022/2023	4464[2)]				

[1)] *13% harvest control rule*

[2)] *F_{MGT}: 0.23*

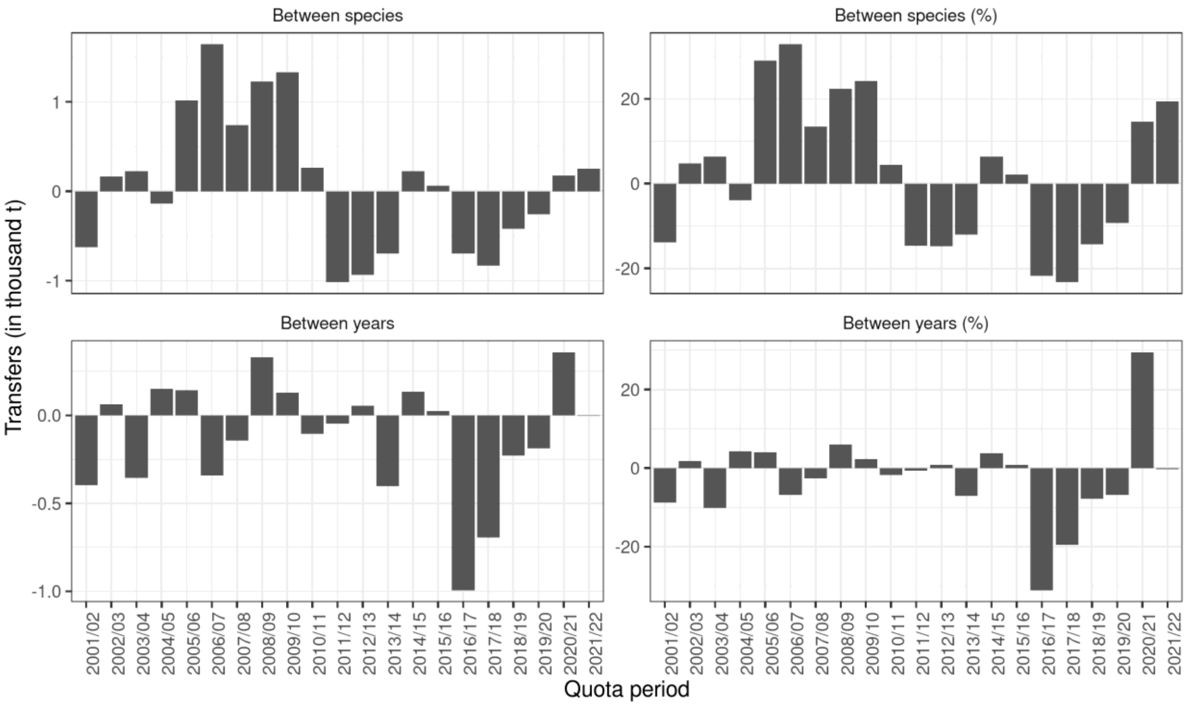

Figure 19. Tusk. Net transfer of quota in the Icelandic ITQ system by fishing year. Between species (upper): Positive values indicate a transfer of other species to tusk, but negative values indicate a transfer of tusk quota to other species. Between years (lower): Net transfer of quota for a given fishing year (may include unused quota).

MANAGEMENT CONSIDERATIONS

Increased catches in 14.b, and now 14.a also, from less than 100 tons in previous years to around 1600 tons in 2015 are of concern. Catches reduced after but have been around 150-800 tons since. In 2021 and 2022, catches were also substantial, close to 700 tons, roughly 200 tons of which were recorded as originating in 14.a. However, the signs from commercial catch data and surveys indicate that the total biomass of tusk in 5.a is stable. This is confirmed in the assessment. Recruitment in 5.a shown high levels after a low in 2011. 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 5.a 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 5.a 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 considered. Similarly, closed areas to longline fishing where there is high juvenile abundance should also be maintained and expanded if needed.

Table 8. Tusk. Estimates of biomass, biomass spawning–stock biomass (SSB) in thousands of tonnes and recruitment at age 1 (millions) and fishing mortality from the SAM model.

	Recruitment			SSB			Catches	F		
	2.5%	Age 1	97.5%	2.5%	SSB	97.5%	tonnes	2.5%	Ages 7-10	97.5%
1979	6458	11911	21969	7391	16512	36890	6502	0.041	0.089	0.191
1980	6570	10981	18353	8481	17845	37546	6923	0.051	0.101	0.20
1981	5872	9403	15056	9811	19499	38752	6633	0.058	0.106	0.193
1982	5035	7835	12192	10954	19293	33980	5887	0.066	0.113	0.195
1983	4312	6569	10007	12838	19043	28246	8371	0.087	0.150	0.26
1984	4657	7057	10693	9837	13792	19336	5755	0.085	0.138	0.22
1985	5863	8815	13254	8743	11400	14863	5065	0.095	0.138	0.199
1986	6078	9107	13645	9440	11958	15146	5416	0.098	0.140	0.198
1987	6130	9193	13786	9900	12472	15712	5659	0.109	0.152	0.21
1988	5112	7640	11418	9801	12327	15504	6885	0.122	0.172	0.24
1989	3884	5821	8725	9646	12166	15344	7090	0.134	0.188	0.26
1990	3456	5202	7830	8393	10560	13285	7305	0.154	0.21	0.30
1991	3155	4764	7195	6996	8807	11087	8806	0.168	0.23	0.31
1992	3134	4724	7122	6362	7977	10001	8122	0.182	0.25	0.34
1993	4174	6253	9367	4995	6235	7782	5459	0.183	0.25	0.34
1994	5316	7938	11854	4410	5451	6739	5298	0.21	0.28	0.38
1995	7896	11719	17393	4531	5510	6702	6351	0.28	0.37	0.49
1996	9891	14791	22119	4556	5471	6570	6628	0.30	0.39	0.50
1997	10232	15281	22821	4874	5823	6958	5413	0.27	0.35	0.45
1998	9663	14311	21194	5284	6320	7557	5223	0.27	0.35	0.44
1999	9804	14461	21330	6042	7267	8741	7265	0.30	0.39	0.50
2000	13239	19360	28310	5831	6981	8358	5139	0.26	0.34	0.43
2001	14350	20943	30566	4960	5902	7024	4930	0.28	0.35	0.45
2002	15520	22577	32844	4985	5861	6890	5683	0.29	0.37	0.47
2003	17286	25173	36659	5088	6006	7088	5688	0.27	0.34	0.43
2004	17461	25368	36856	5369	6350	7509	4870	0.23	0.29	0.38
2005	17348	25198	36600	5537	6575	7806	5100	0.22	0.28	0.37
2006	15820	22998	33433	6416	7603	9009	6674	0.25	0.32	0.41
2007	12885	18761	27316	6385	7551	8930	7584	0.28	0.36	0.46
2008	8147	11820	17149	6105	7159	8396	8669	0.34	0.43	0.54
2009	5410	7857	11409	5742	6716	7855	8722	0.36	0.45	0.57
2010	4337	6295	9136	5321	6222	7275	8988	0.37	0.46	0.58
2011	3120	4567	6685	5277	6158	7186	7876	0.32	0.40	0.51
2012	2915	4324	6415	5795	6756	7877	8125	0.34	0.43	0.54
2013	4627	6803	10000	4585	5363	6272	6729	0.32	0.41	0.53
2014	8986	13481	20224	4121	4872	5758	6417	0.27	0.34	0.43
2015	11615	17595	26654	4029	4891	5937	6434	0.25	0.33	0.42
2016	11396	17093	25637	3924	4754	5758	4100	0.185	0.24	0.32
2017	14789	22114	33066	4084	4990	6097	3321	0.159	0.21	0.28
2018	11259	16562	24363	3776	4565	5519	3621	0.190	0.24	0.31
2019	12404	18176	26636	3350	4045	4884	4011	0.191	0.25	0.32
2020	13703	20279	30011	3276	3961	4790	3344	0.21	0.27	0.36
2021	16364	24995	38178	3285	3965	4786	3480	0.171	0.22	0.29
2022	16054	28476	50512	4313	5325	6574	3258	0.126	0.171	0.23
2023	15104	33172	72856	5173	6589	8392				

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.

———. 2017b. "Tusk in ICES Subarea 14 and Division 5.a." International Council for the Exploration of the Seas; ICES publishing.

———. 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.

———. 2022a. Iceland request for evaluation of a harvest control rule for tusk in Icelandic waters. In Report of the ICES Advisory Committee, 2022. ICES Advice 2022, sr.2022.6d, https://doi.org/10.17895/ices.advice.19625823

———. 2022b. "Stock Annex: Tusk (*Brosme brosme*) in Division 5.a (Iceland grounds)." International Council for the Exploration of the Seas; ICES publishing. Unpublished

———. 2022c. Workshop on the evaluation of assessments and management plans for ling, tusk, plaice and Atlantic wolffish in Icelandic waters (WKICEMP). ICES Scientific Reports. Report. https://doi.org/10.17895/ices.pub.19663971.v1