

TUSK - KEILA

Brosme brosme

GENERAL INFORMATION

Tusk, also commonly called cusk, is a gadiform species with variable brown coloration with red or green tones on the dorsal side that fade to a yellow or pale colour on the belly. It 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

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 1). Far fewer gillnetters and trawlers participate in the fishery. The number of longliners reporting tusk catches in 2016 decreased to 138 from 163 the previous year (Table 1) 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 1).

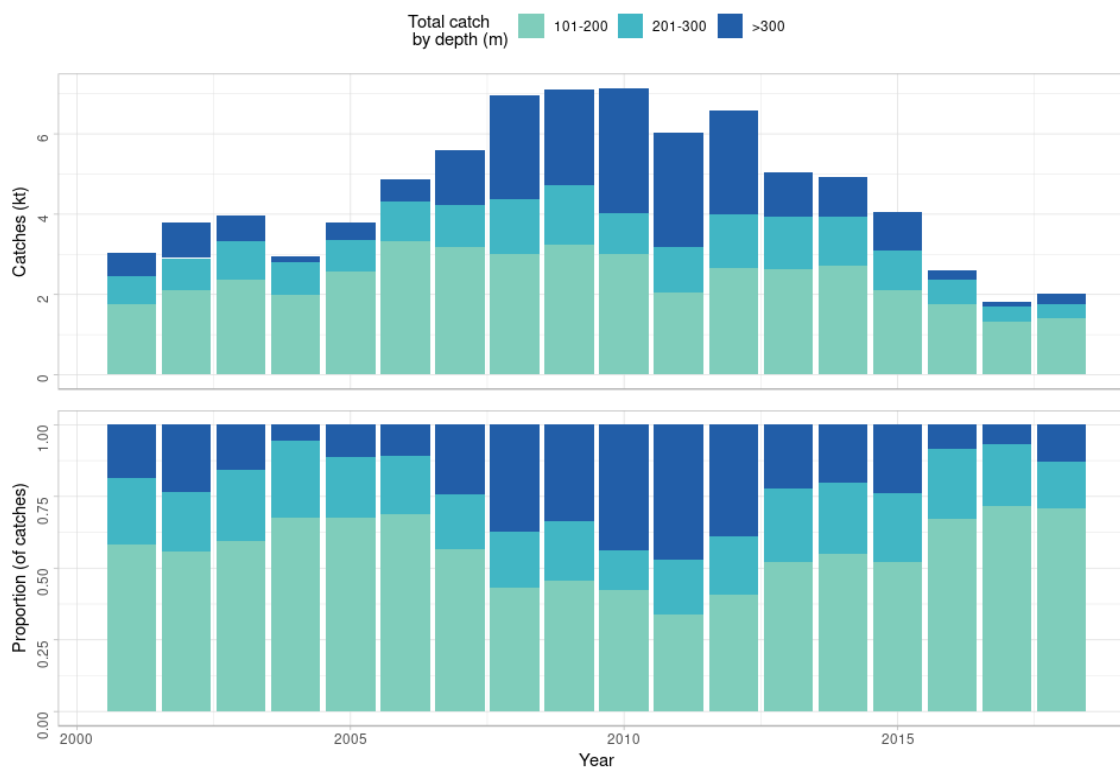
Most of the tusk caught in Icelandic waters by Icelandic longliners is caught at depths less than 300 meters (Figure 1). The main fishing grounds for tusk in Icelandic waters as observed from logbooks are on the south, southwestern and western part of the Icelandic shelf (Figures 2 and 3).

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. Number of Icelandic boats participating in the fishery that land >100 kg tusk, and catches by fleet segment.*Tafla 1. Keila. Fjöldi íslenskra báta sem lönduðu >100 kg af keilu af Íslandsmiðum, og aflri eftir flota.*

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

**Figure 1. Tusk. Depth distribution of catches according to logbooks by the Icelandic fleet.***Mynd 1. Keila. Dýpi samkvæmt afladagbókum íslenskra skipa.*

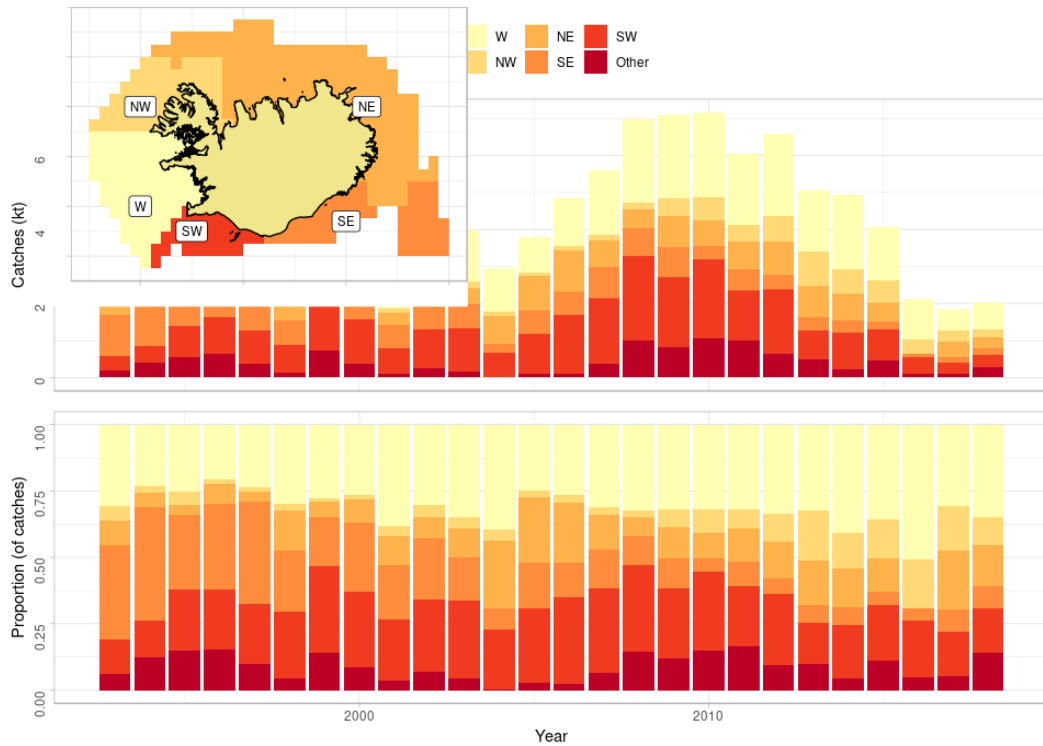


Figure 2. Tusk. Catch distribution and proportions by area according to logbooks.

Mynd 2. Keila. Afli eftir svæðum ásamt hlutfalli innan hvers svæðis samkvæmt afladagbókum.

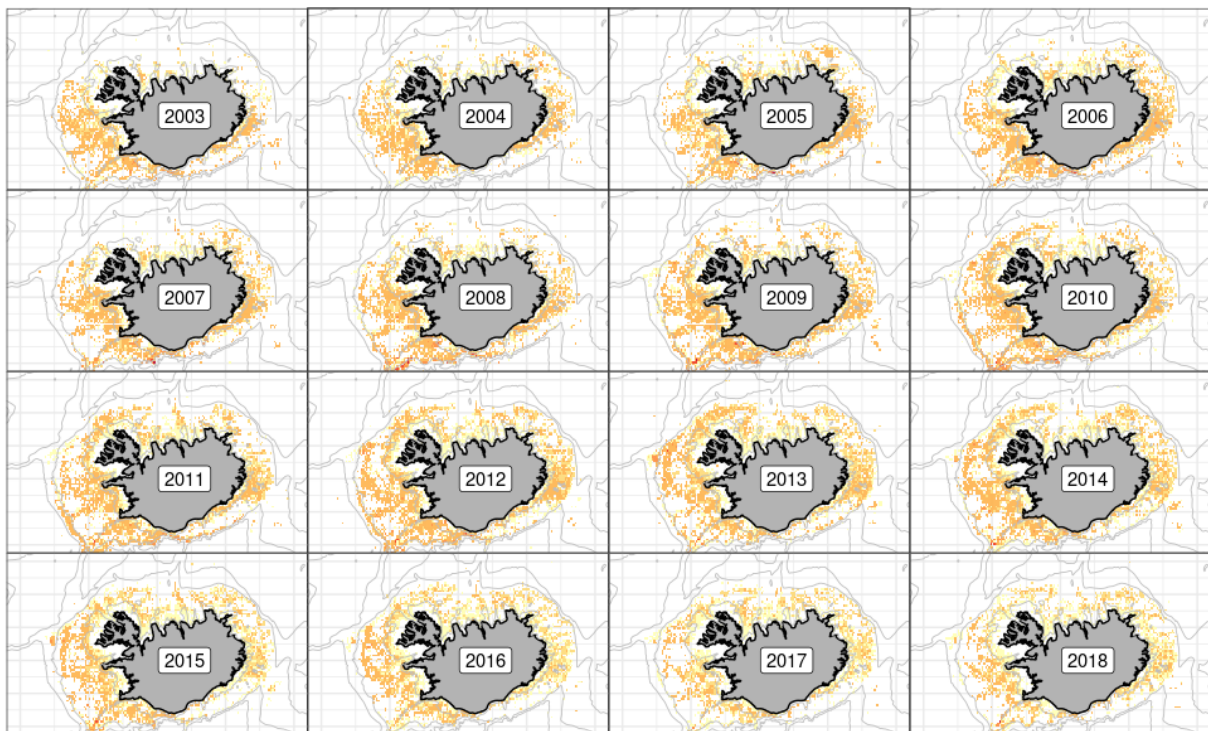


Figure 3. Tusk. Geographical distribution (tonnes/square mile) of the Icelandic longline fishery since 2003, as reported in logbooks by the Icelandic fleet.

Mynd 3. Keila. Útbreiðsla (tonn/sjómílu²) á Íslandsmiðum frá 2002 samkvæmt afladagbókum.

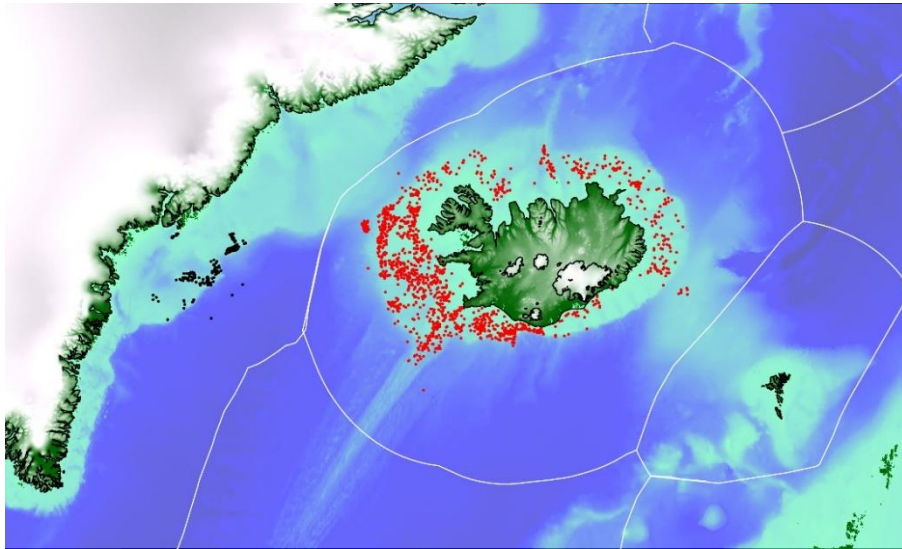


Figure 4. Tusk. Position of longline operations in 14.b (Greenlandic waters) and 5.a (Icelandic waters) where tusk was recorded in 2015.

Mynd 4. Keila. Staðsetningar línulagna við Ísland og á Grænland árið 2015 þar sem keila var skráð sem afli.

LANDINGS TRENDS

The total annual landings from ICES Division 5.a (Icelandic waters) were around 2940 tonnes in 2018 (Table 7), 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 5).

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 7).

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. Around 682 tonnes in 2018 were caught in Greenlandic waters mainly by Faroese and Greenlandic vessels (Table 8).

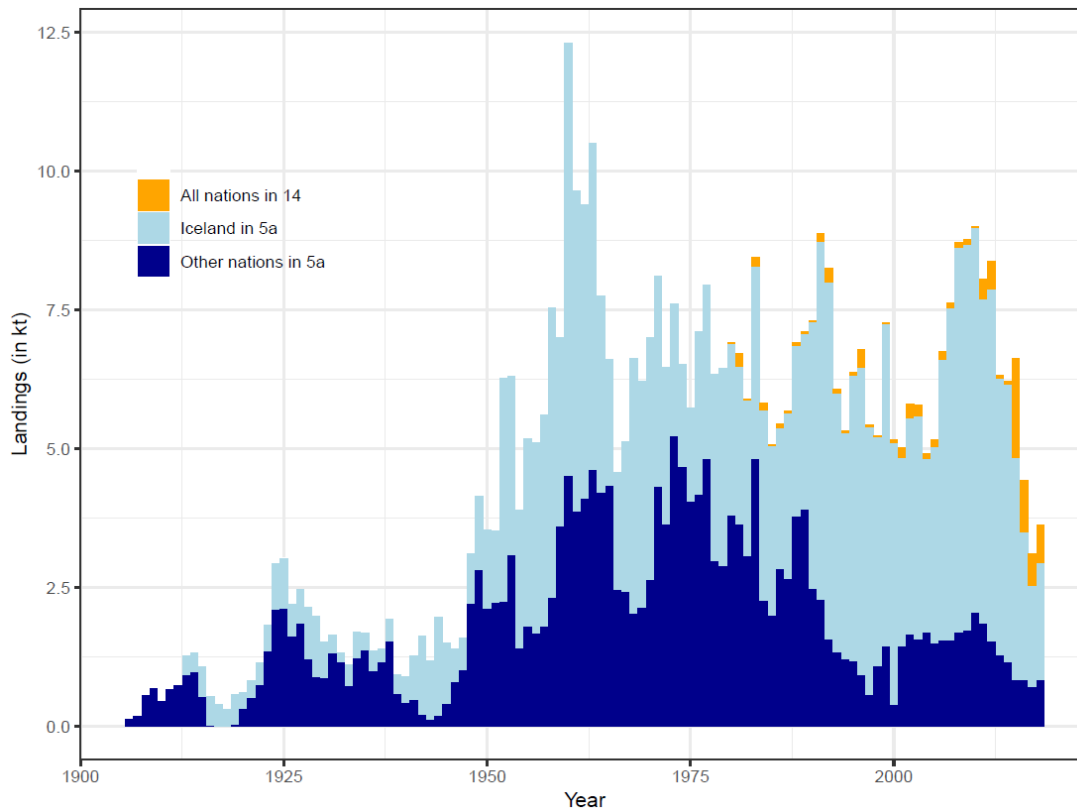


Figure 5. Tusk. Nominal landings within Icelandic waters by Icelandic vessels (light blue) or foreign vessels (dark blue), or within Greenlandic waters (orange).

Mynd 5. Keila. Landaður afli íslenskra skipa við Ísland (ljósblátt), erlendra skipa við Ísland (dökkblátt) og við Grænland (appelsínugult).

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 2018 is shown in Figure 6.

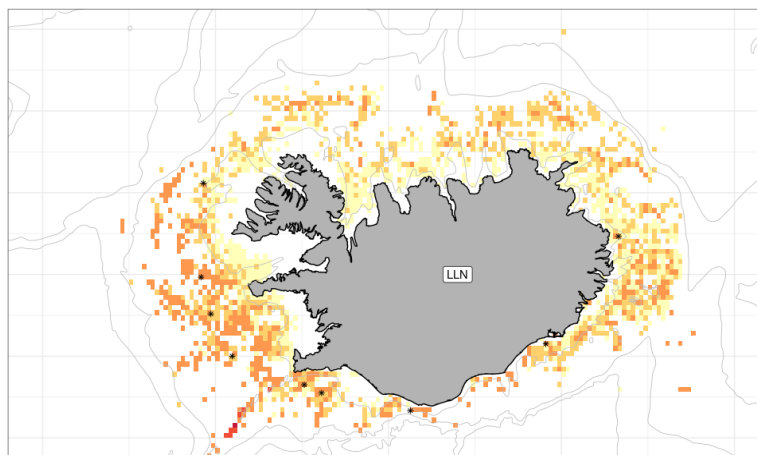


Figure 6. Tusk. Spatial distribution of length samples (black) from commercial catches (red) in Icelandic waters in 2018.

Mynd 6. Keila. Dreifing lengdarmælinga (svart) og afla (rautt) á Íslandsmiðum árið 2018.

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 aflu 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

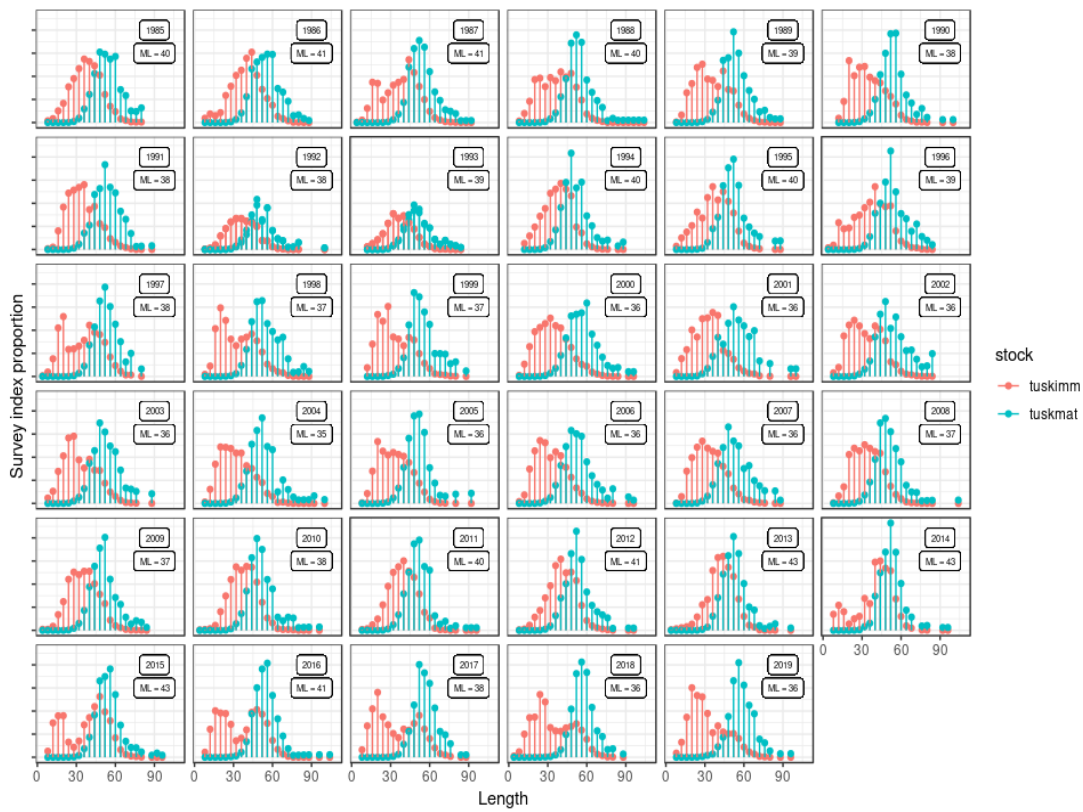


Figure 7. Tusk. Length distributions (4 cm grouping) from the spring survey since 1985. Red areas are immature tusk and green represent mature tusk. Small numbers to the right refer to mean length (ML).

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

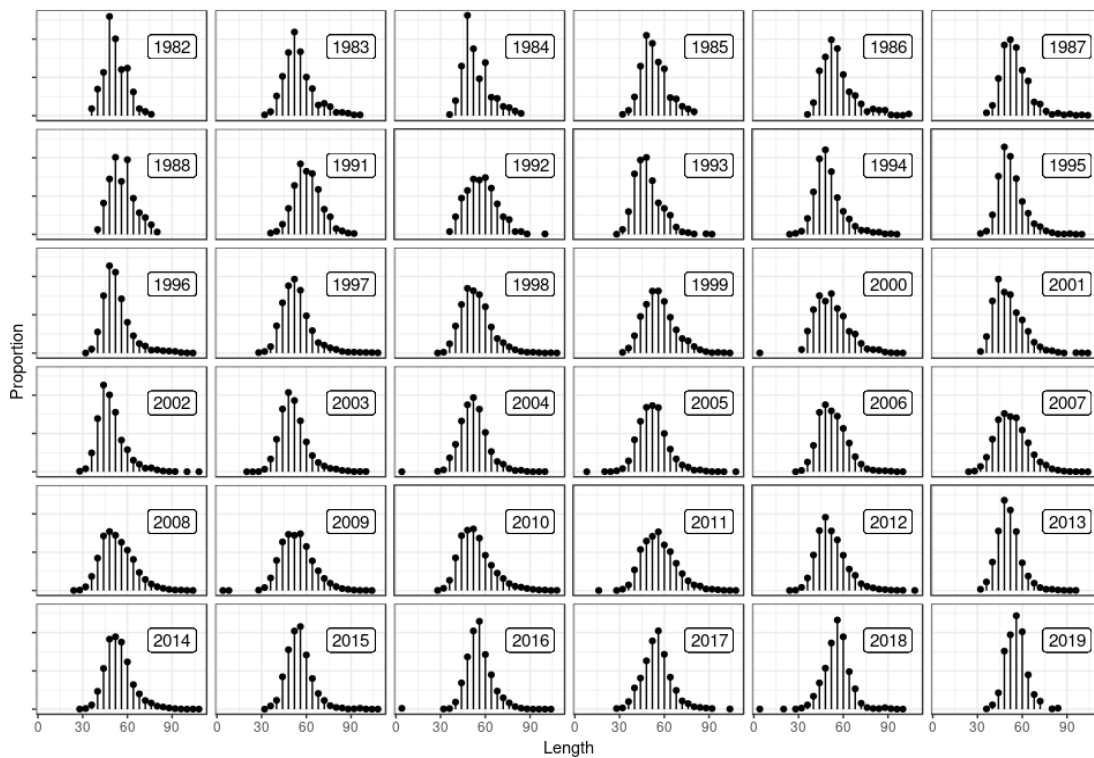


Figure 8. Tusk. Length distributions from Icelandic commercial longline catches.

Mynd 8. Keila. Lengdardreifing úr línuveiðum Íslendinga.

AGE COMPOSITIONS

Table 3 gives an overview of otolith sampling intensity by gear types from 2000 to 2018 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 aldursgreindra 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

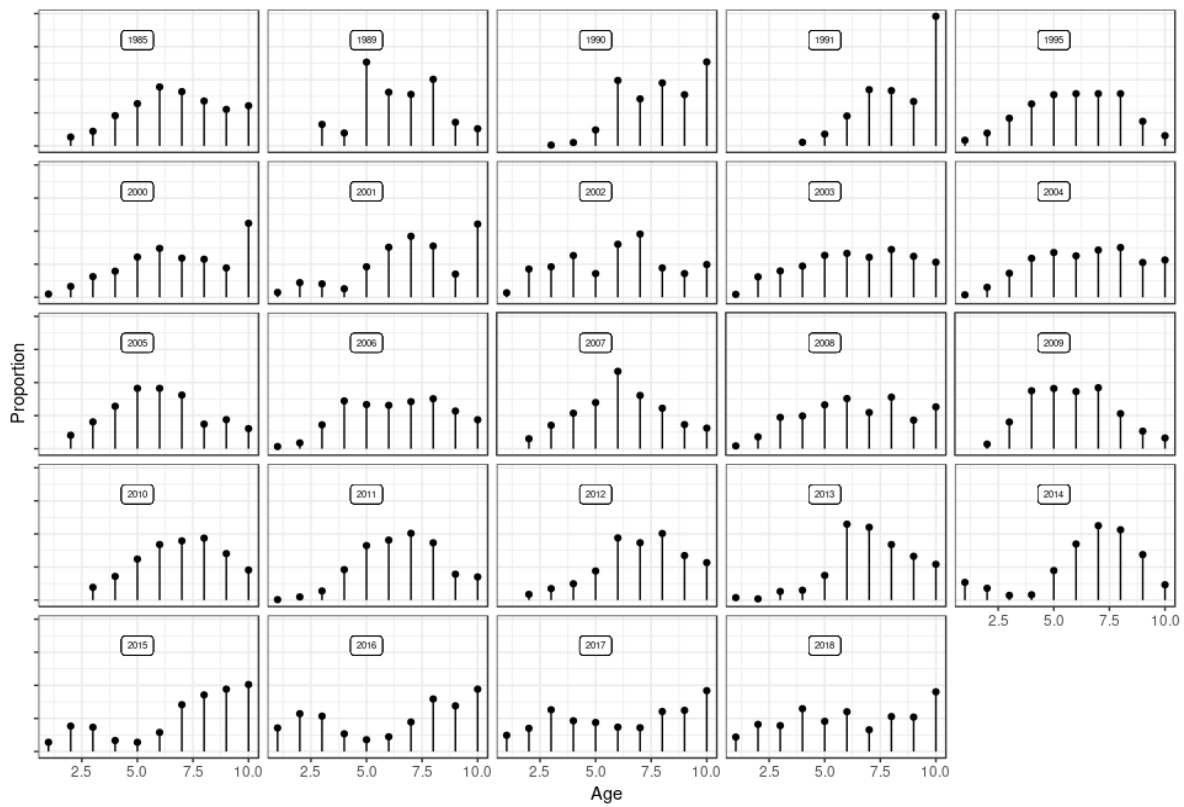


Figure 9. Tusk. Age distributions in proportions in Icelandic waters from the Iceland spring survey.

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

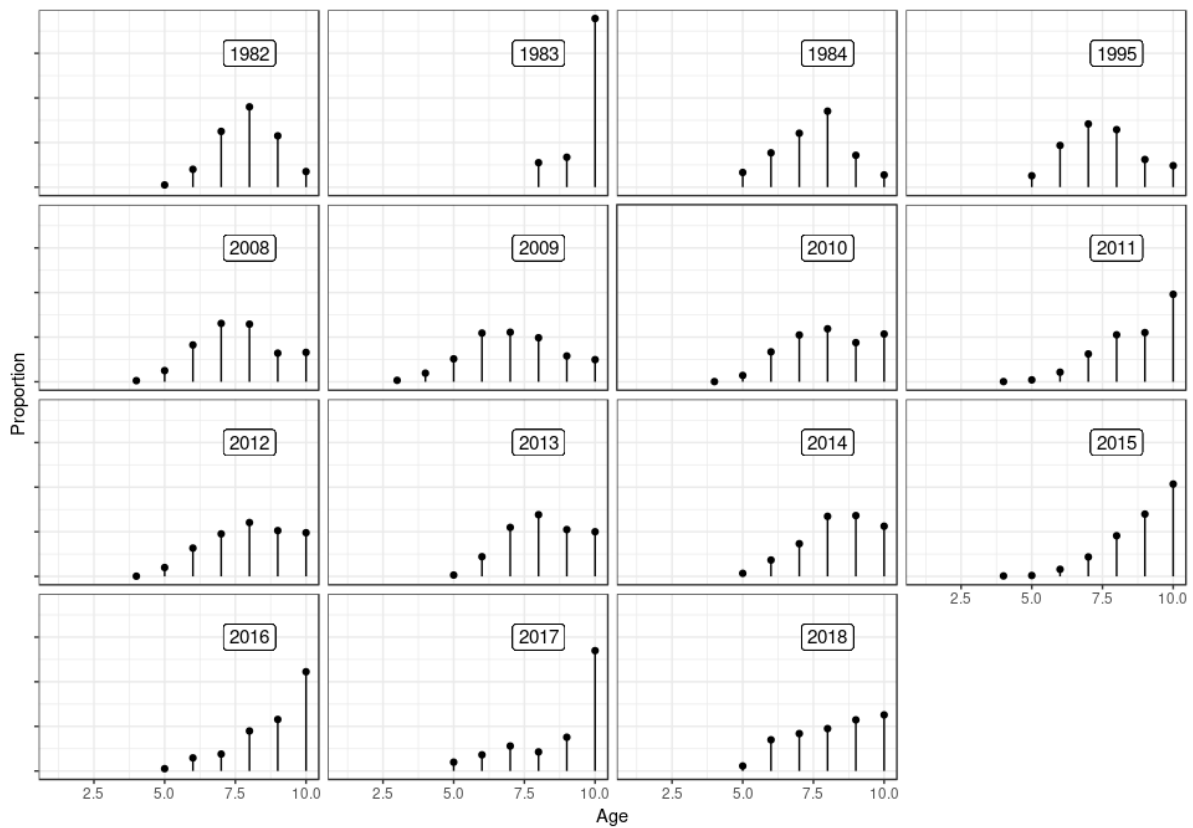


Figure 10. Tusk. Age distributions from Icelandic commercial longline catches.

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 the natural mortality is set to 0.1 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 due to labor strikes 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).

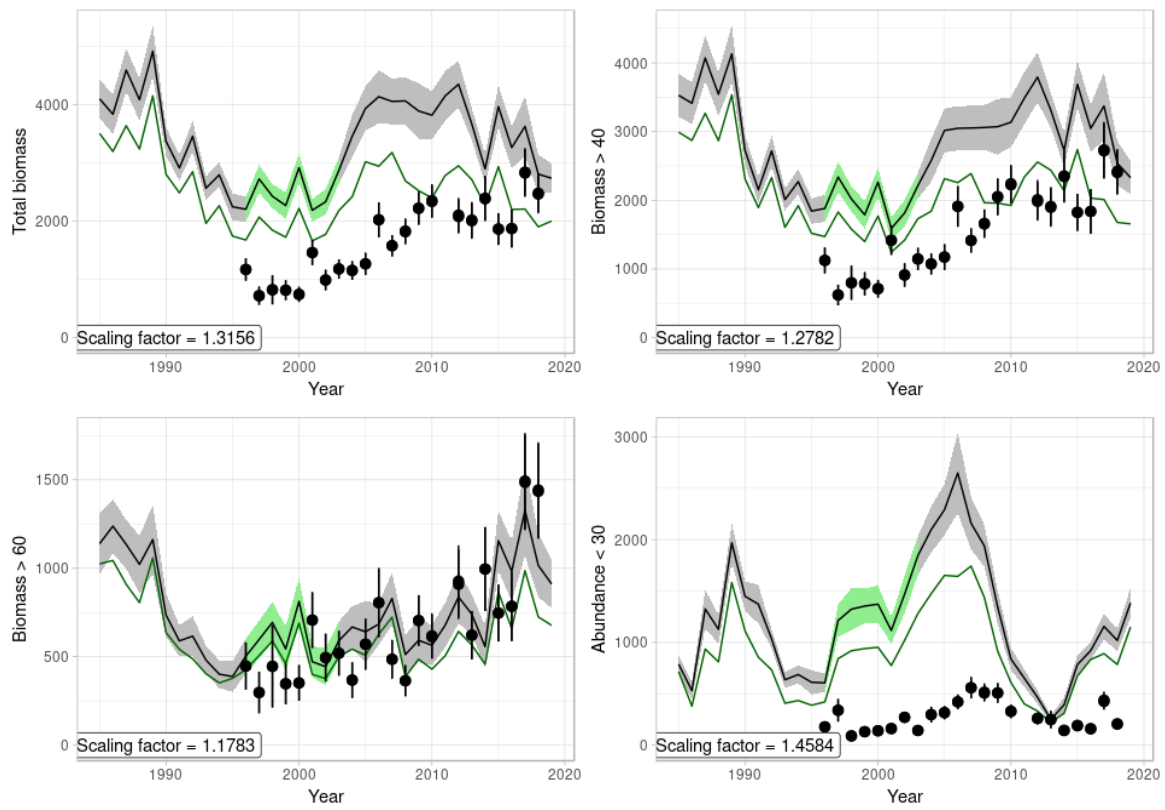


Figure 11. Tusk. a) Total biomass indices, b) biomass indices larger than and including 40 cm, c) biomass indices larger than and including 60 cm and d) abundance indices smaller than and including 30 cm. The lines with shaded areas show the spring survey index from 1985 and the points with the vertical lines show the autumn survey from 1997. The shaded area and vertical lines indicate +/- standard error. 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.

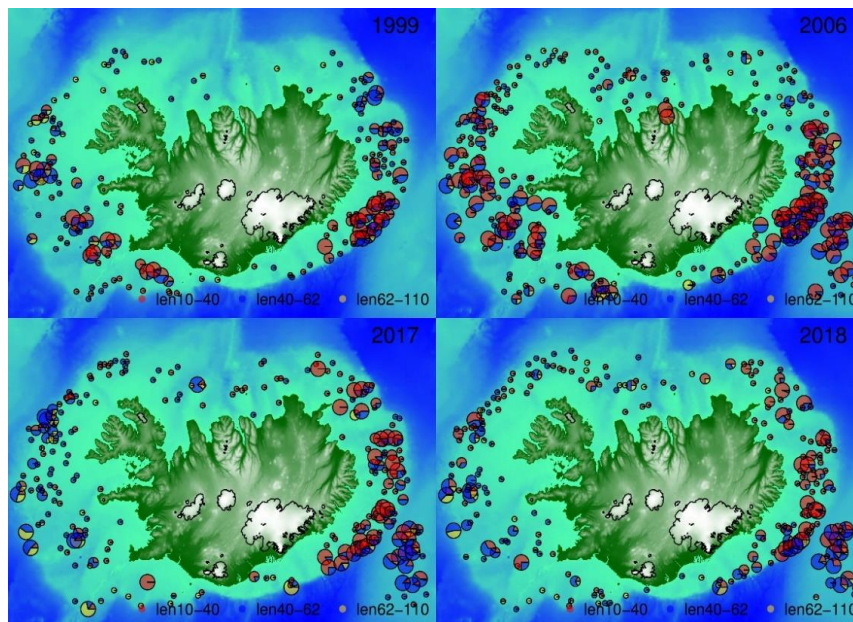


Figure 12. Tusk. Changes in spatial distribution divided by size. Size of pie is indicative of numbers of specimens caught at the tow-station.

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.

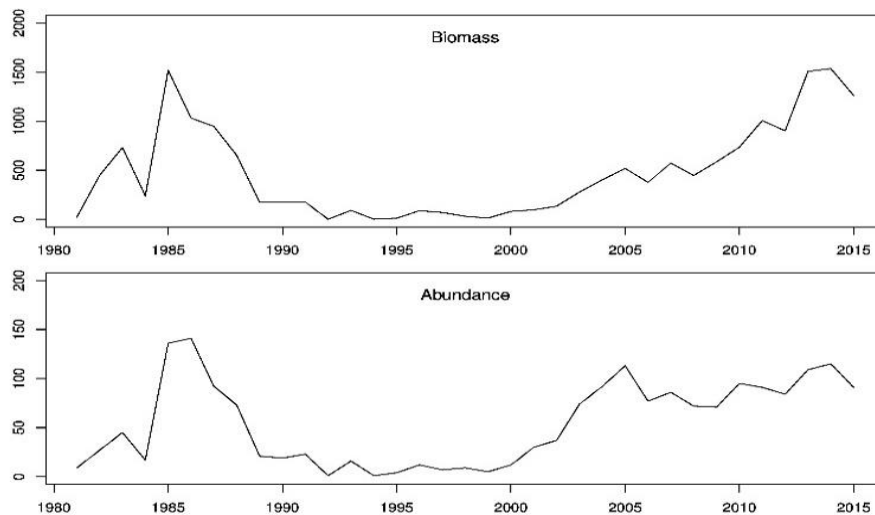


Figure 13. Tusk. Biomass and abundance estimates from the Walter Herwig survey in Greenlandic waters. The data are the total number caught converted to weight.

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

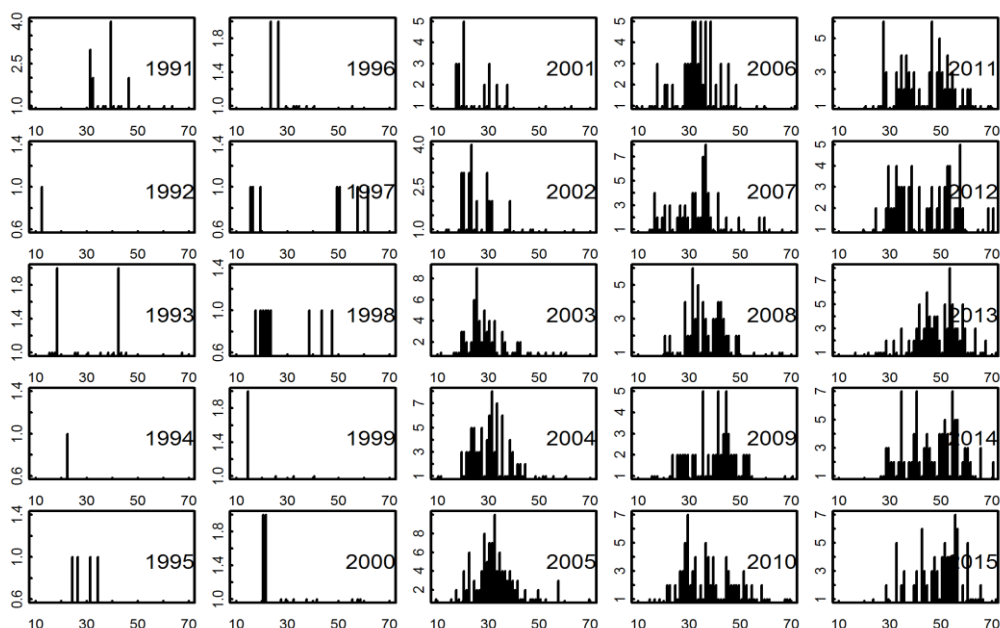


Figure 14. Tusk. Length distributions from the Walter Herwig survey in Greenlandic waters.

Mynd 14. Keila. Lengdardreifingar frá stofnmælingum 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 2940 tonnes in 2018. 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) has remained at similar level as in since 2011 at a relatively high level (Figure 11). The same holds for the index of tusk larger than or equal to 60 cm (spawning–stock biomass index) but that index didn't increase by similar factors as the other two biomass indices. 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 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 labor strikes in the fishing industry, 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.

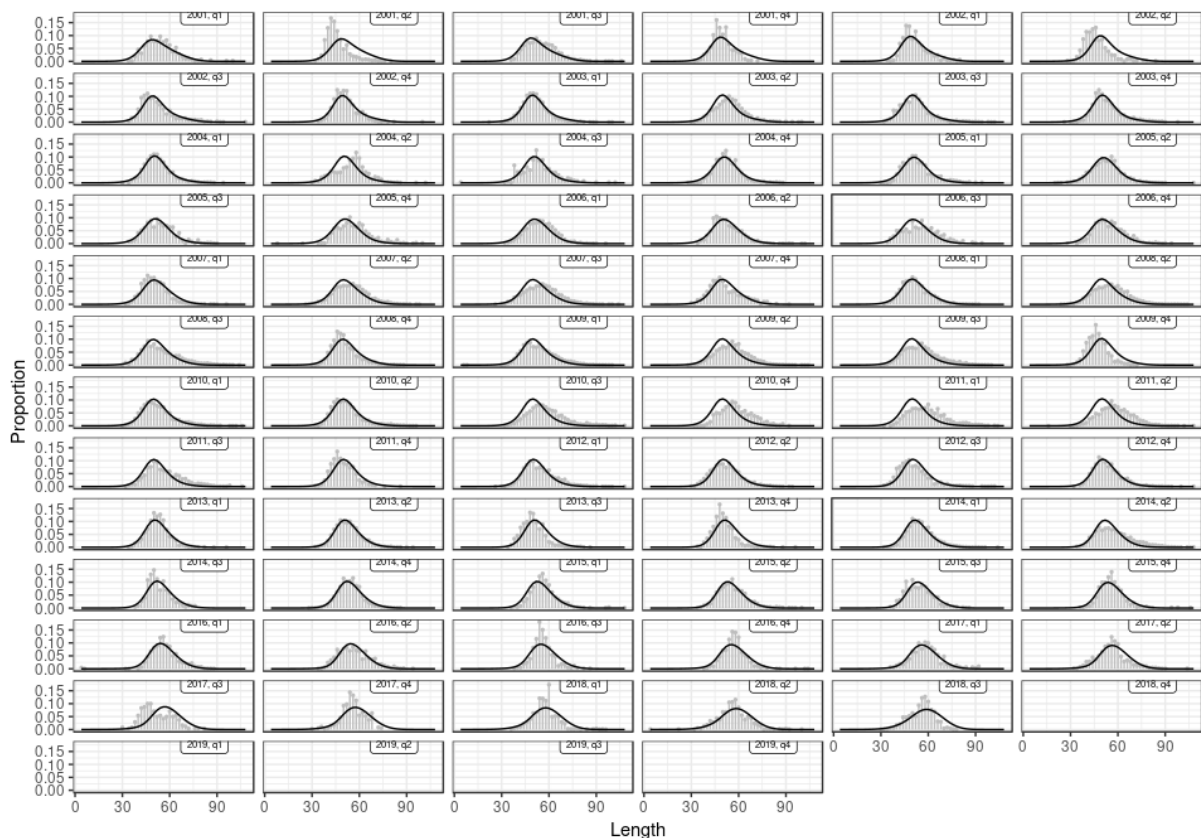


Figure 15. Tusk. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from longline catches (grey lines and dots).

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

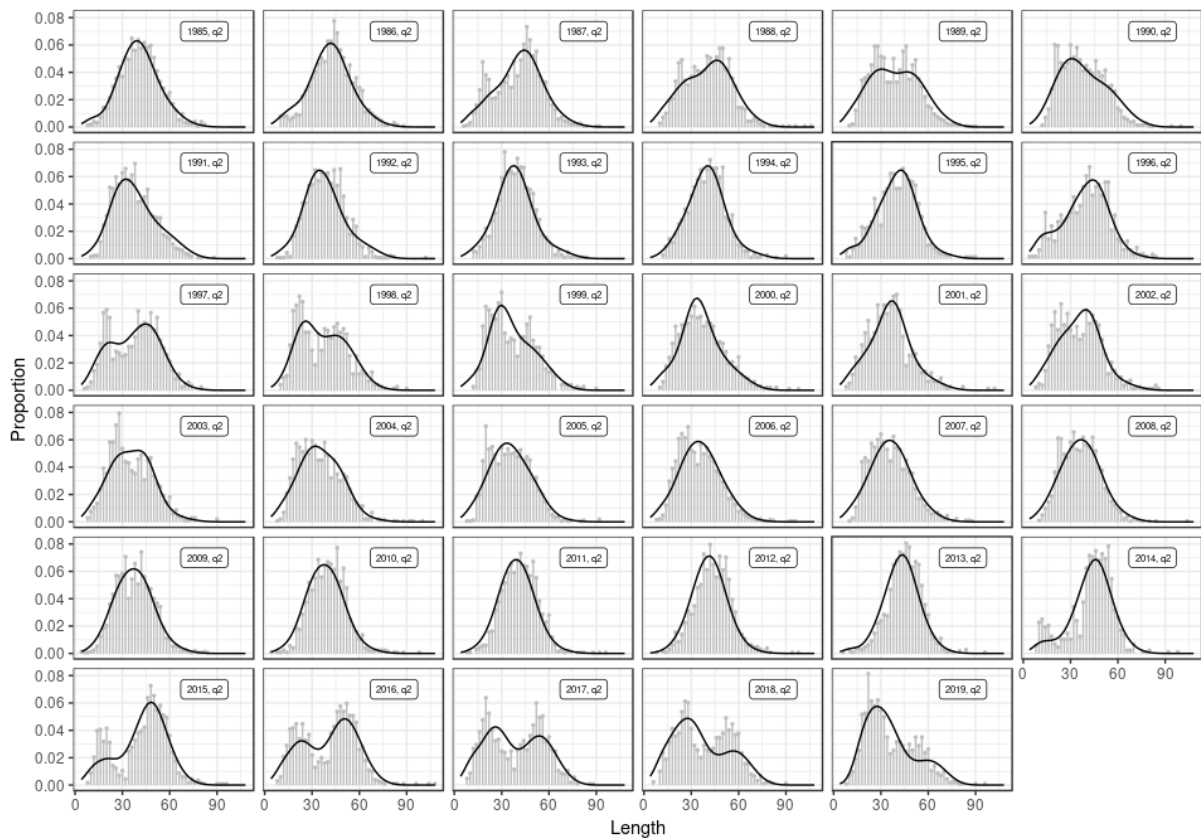


Figure 16. Tusk. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the spring survey (grey lines and points).

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

MODEL FIT

In Figure 17 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.

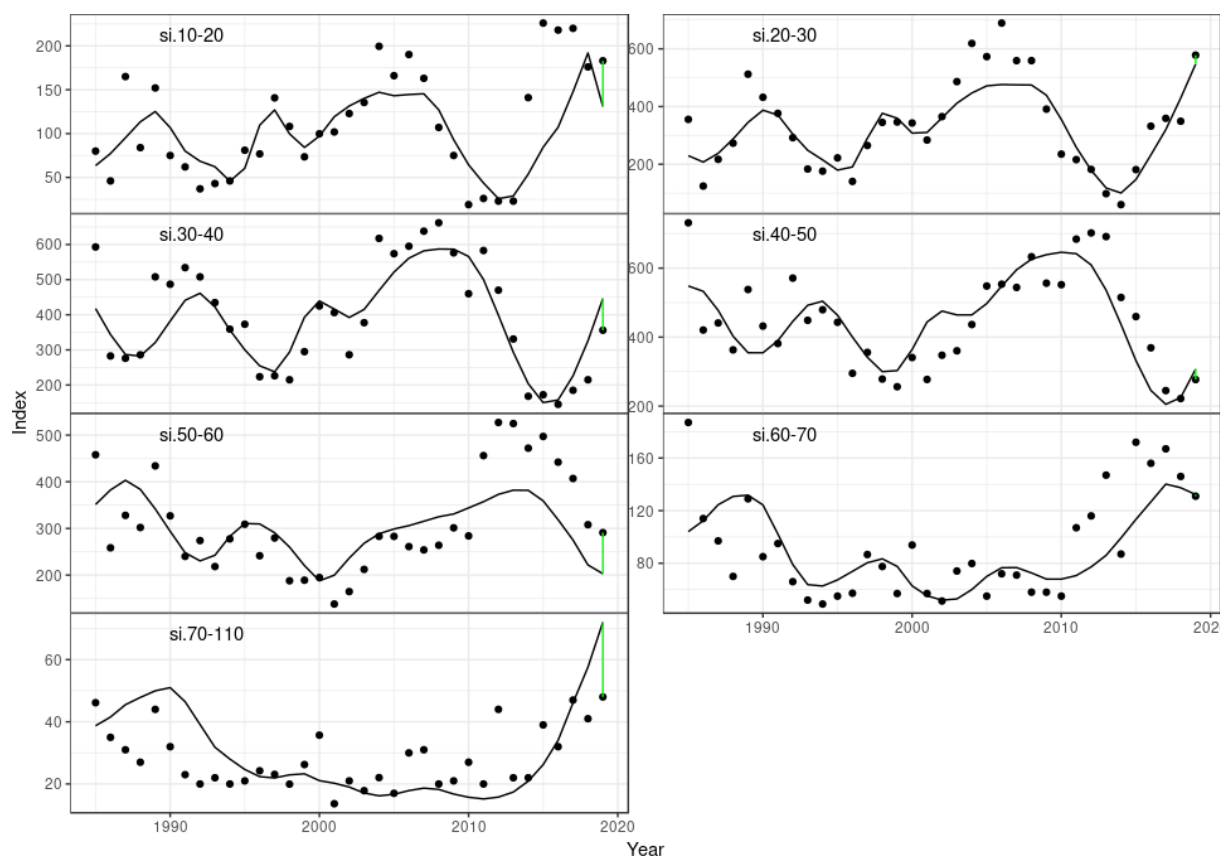


Figure 17. Tusk. Fitted spring survey index by length group from the Gadget model (black line) and the observed number of ling caught in the survey (points). The green line indicates the difference between the terminal fit and the observations.

Mynd 17. Keila. Lífmassavísitala úr Gadget líkani (svartar línur) eftir stærðarflokkum borin saman við fenginn fjölda langa í vorralli (punktar). Grænar línur sýna muninn á samsvörum gagna og líkans við lok tímabilsins.

MODEL RESULTS

The results are presented in Table 3 and Figure 18. In comparison with last year, there has been a slight downward revision of biomass levels. Recruitment peaked in 2005 to 2006 but has decreased and is estimated in 2013 to have been the lowest observed. Recruitment in 2014–2018 is estimated to be considerably higher than in 2013. Spawning–stock biomass has increased slowly since 2005. Harvestable biomass is estimated at a fairly high level compared to the rest of the time-series. Harvest rate has decreased from 0.29 in 2008 to 0.12 in 2016 and remains close to the target 0.13. Estimates of reference biomass (B40+) have also been stable for the last several years.

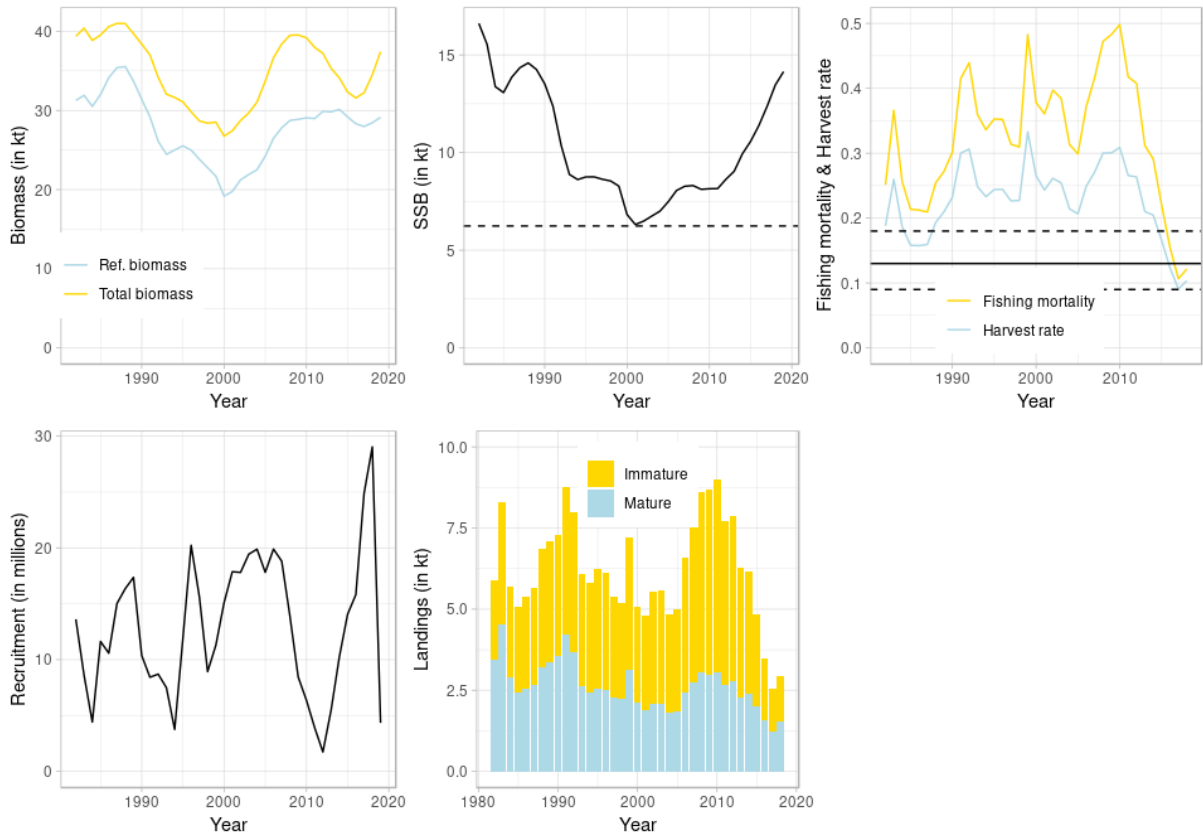


Figure 18. Tusk. Estimated biomass, spawning stock biomass (SSB), fishing mortality for fully selected fish and harvest rate, recruitment and total catches. The dashed line in the SSB plot represents Bpa. The solid line in the harvest rate plot indicates the target harvest rate used in the harvest control 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 18. 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.

ANALYTICAL RETROSPECTIVE ANALYSIS

An analytical retrospective analysis was completed with a 5-year peel, which shows some a gradual downward revision as biomass decreased but has stabilised as bio-mass started to increase again. It does not exhibit bias (Figure 19), as Mohn's rho was calculated as -0.077283327 for F, 0.029 for recruitment, 0.109 for spawning stock biomass and 0.036 for total biomass.

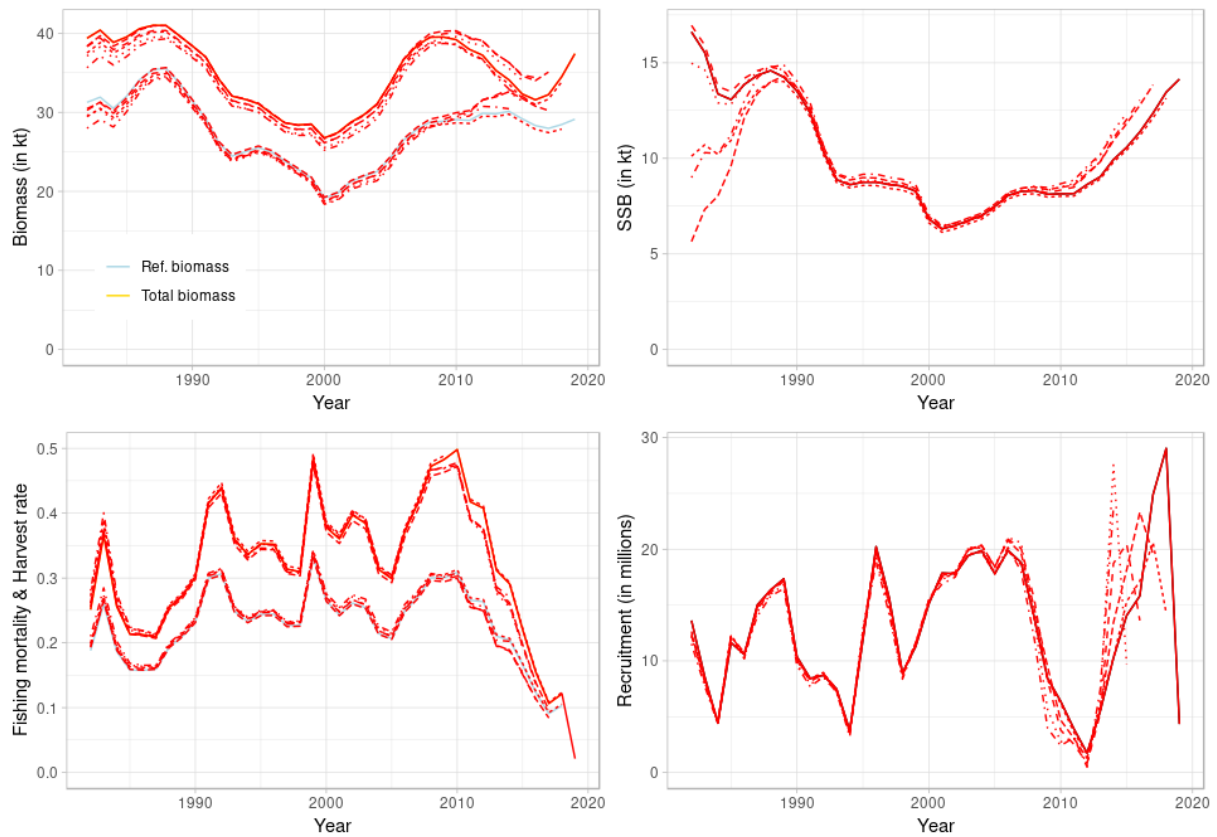


Figure 19: Tusk. Analytical retrospective analysis of the assessment of tusk with a 5 year peel.

Mynd 19. Keila. Samanburður á stofnmati undanfarinna ára.

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 $F_{0.1}$ 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, 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} 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. The median fishing mortality when an harvest rate of H_{msy} is applied. The harvest rate that has an annual probability of 5% of $SSB < B_{lim}$. The median fishing mortality when an harvest rate of $H_{p,05}$ is applied.
	H_{msy}	0.17	
	F_{msy}	0.226	
	$H_{p,05}$	0.371	
Precautionary approach	$F_{p,05}$	0.356	
	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 $\sigma = 0.25$
Management plan	H_{pa}	0.20	H corresponding to F_{pa}
	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 SSB_y is equal or above MGT Btrigger:

$$TAC_{y/y+1} = HRmgt * B_{ref,y}$$

When SSB_y is below MGT Btrigger:

$$TAC_{y/y+1} = HRmgt * (SSB_y / MGT Btrigger) * B_{ref,y}$$

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.

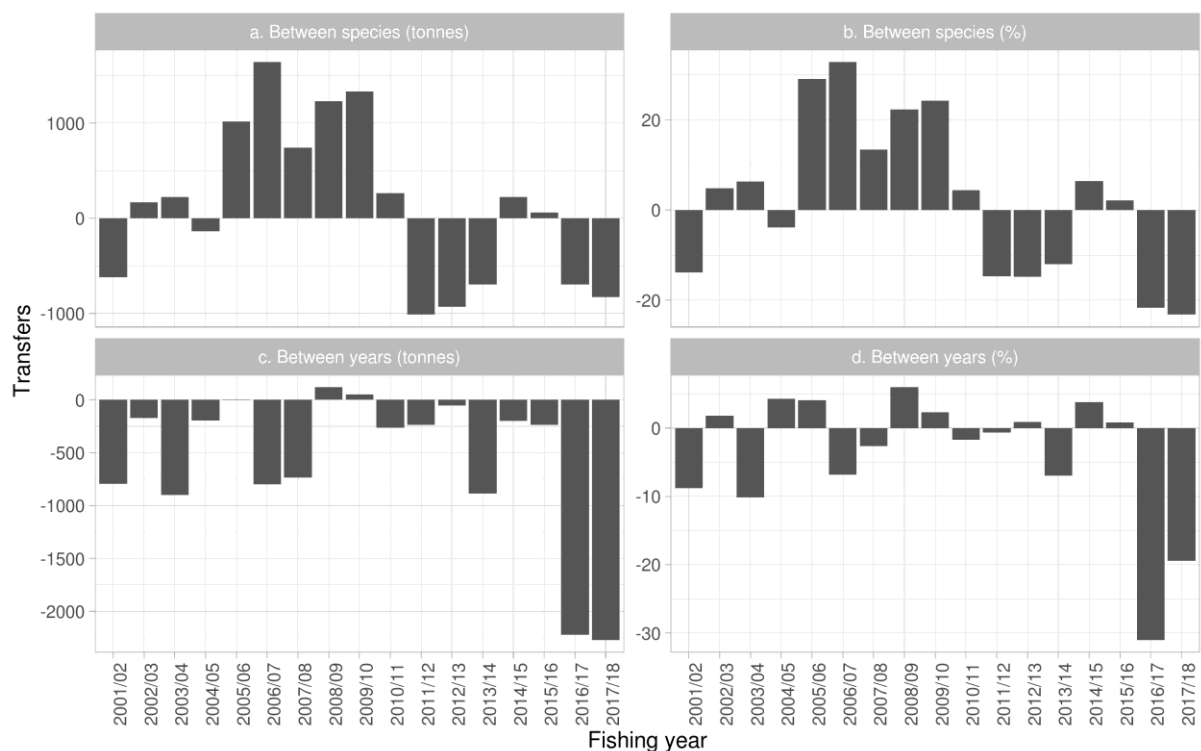


Figure 20. Tusk. Net transfer of quota in the Icelandic ITQ system by fishing year. Between species (upper): Positive values indicate a transfer of other species to tusk, but negative values indicate a transfer of tusk quota to other species. Between years (lower): Net transfer of quota for a given fishing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

Mynd 20. Keila. Nettó tilfærsla á kvóta eftir fiskveiðiarum. 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 fiskveiðiarí (gæti innihaldið ónotaðar aflaheimildir).

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

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

FISHING YEAR	MFRI-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	

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. Demographic patterns of tusk should be monitored as other Icelandic demersal species have exhibited recent changes (e.g., haddock). However, as tusk biomass levels and indices appears stable or increasing, environmental factors and multispecies interactions are not currently considered to be a concern for the assessment.

Table 5. Tusk. Catches by country (Source STATLANT) in Icelandic waters.*Tafla 5. 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

*Preliminary.

Table 6. Catches by country (Source STATLANT) in Greenlandic waters.*Tafla 6. Afli á Grænlandsmiðum flokkað eftir löndum.*

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

*Preliminary.

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.

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

YEAR	BIOMASS	B40	SSB	REC3	CATCH	HR	F
1982	39.37	31.40	16.37	9.84	5.88	0.19	0.25
1983	40.40	31.14	14.79	9.52	8.29	0.26	0.37
1984	38.85	30.42	13.07	10.13	5.69	0.19	0.26
1985	39.53	32.15	12.96	6.37	5.06	0.16	0.21
1986	40.60	34.01	13.69	3.27	5.38	0.16	0.21
1987	41.00	35.22	14.29	8.61	5.64	0.16	0.21
1988	40.98	34.64	14.27	7.83	6.86	0.19	0.25
1989	39.70	33.21	14.08	11.13	7.08	0.21	0.27
1990	38.39	30.93	13.26	12.11	7.30	0.23	0.30
1991	37.01	28.39	11.84	12.85	8.76	0.30	0.42
1992	34.19	25.80	10.00	7.68	8.00	0.31	0.44
1993	32.05	24.69	8.78	6.24	6.07	0.25	0.36
1994	31.64	25.48	8.73	6.45	5.83	0.23	0.34
1995	31.09	25.56	8.77	5.54	6.23	0.24	0.35
1996	29.83	24.83	8.74	2.78	6.10	0.24	0.35
1997	28.68	23.99	8.78	8.81	5.40	0.23	0.31
1998	28.40	22.84	8.66	14.98	5.17	0.23	0.31
1999	28.52	21.04	7.94	11.57	7.23	0.33	0.48
2000	26.76	19.45	6.78	6.61	6.24	0.27	0.38
2001	27.42	19.91	6.23	8.35	4.81	0.24	0.36
2002	28.74	21.76	6.65	11.18	5.55	0.26	0.40
2003	29.70	22.14	6.82	13.23	5.57	0.25	0.38
2004	31.07	22.60	7.00	13.18	4.82	0.21	0.31
2005	33.71	24.63	7.59	14.39	5.01	0.21	0.30
2006	36.64	26.60	8.05	14.72	6.60	0.25	0.37
2007	38.41	28.00	8.29	13.19	7.54	0.27	0.42
2008	39.50	29.14	8.44	14.73	8.63	0.30	0.47
2009	39.53	28.91	8.14	13.93	8.68	0.30	0.48
2010	39.19	29.27	8.23	10.27	8.98	0.31	0.50
2011	37.97	29.43	8.35	6.25	7.70	0.27	0.42
2012	37.22	30.23	8.86	4.72	7.87	0.26	0.41
2013	35.32	29.88	9.24	2.89	6.26	0.21	0.31
2014	34.11	29.99	10.11	1.29	6.16	0.21	0.29
2015	32.33	29.30	10.87	4.08	4.84	0.17	0.22
2016	31.58	28.09	11.52	7.60	3.49	0.12	0.16
2017	32.24	28.28	12.68	10.41	2.54	0.09	0.11
2018	34.51	28.42	13.47	11.72	2.94	0.10	0.12
2019	37.09	29.66	14.29	18.43			