

Preliminary cruise report: Acoustic assessment of the Iceland-East Greenland-Jan Mayen capelin stock in autumn 2019.

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Objective

The main objective of the survey was acoustic assessment of the capelin stock in the Iceland, East Greenland and Jan Mayen area, measuring mature and immature stock components at age 1 and older. The survey was conducted by the research vessels Arni Fridriksson and the fishing vessel Eros.

Methods

Survey area and conditions

The survey area was on and along the shelf edge off East Greenland from about 63° 50' N towards about 75°00' N, also covering the Denmark Strait and the slope off west and north Iceland. The Iceland Sea, Jan Mayen ridges and Greenland basin were also surveyed but with less transect density.

Eros departed from Helgúvík harbour on 12 September and sailed westwards over Irminger Sea to start surveying from the southwest end of the survey area. Eros followed preset transects covering the Greenlandic shelf areas until Tasilaq region. There, the Angmakssalik fjord was surveyed towards Kungmiut. Then Eros continued covering the East-Greenland shelf areas to northeast but could not cover the shallower end of transects south of four transects southwest of Kangerdlugssuaq fjord. Eros had to depart the shelf areas the 19. September and sail to Helgúvík harbour due to bad weather and for personnel change. Eros was back on the research area on 22 September and continued measuring in rather difficult weather conditions and had to stop measuring during the night before 23 September. In continuance, Eros surveyed the preset transect through Denmark Strait mostly in good conditions until finishing his last transect on 30 September and arriving to Akureyri harbour on 1 October.

Arni departed from Reykjavík harbour on 21 September and sailed north of the Westfjords peninsula starting first transect, just off Strandagrunn bank and crossing Denmark Strait. Then, continuing from the coverage of Eros, Arni surveyed to northeast out of Denmark Strait, covering northwards along the East-Greenland shelf and shelf edges. While in the Scoresby region Arni picked up a communication cable for whaletags from Constable Punt airport. Arni followed preset transects until reaching the edge of drift ice at 73°30N, and then sailing by zikk-zakk transects northeastwards along the ice edge until reaching 74°50N. From there, Arni sailed south to survey roughly the Jan Mayen ridges and then Iceland sea from east to west until the coverage was finished just west of Kolbeinsey ridge. Arni measured in relatively good weather conditions the whole survey. Arni arrived to Reykjavík harbour on 21 October.

Acoustic sampling

Acoustic data was sampled with Simrad EK60 transducer at five frequencies in Arni Fridriksson (18, 38, 70, 120 and 200 kHz) and five frequencies in Eros (18, 38, 70, 120 and 200 kHz). The 38 kHz data were scrutinized using LSSS (version 2.7.0) software where capelin backscatter was defined and its Nautical Area Scattering Coefficient (NASC) in SA units (m^2/nmi^2) calculated at 0.1 nmi integration intervals. EchoView live viewing was run simultaneously for an alternative view of the recordings. The acoustic data was scrutinized by a scientist on-board each vessel. Then, average NASC within squares of 30 minutes latitude and 1 degree longitude was calculated. Abundance in numbers was estimated using a length dependent target strength (TS; in dB re $1m^2$)

$$TS = 19.1 * \log(L) - 74.5$$

Total length of the capelin was measured to nearest mm. For each length interval within the length distribution of capelin in the samples the following parameters were calculated: backscattering proportion, number and weight.

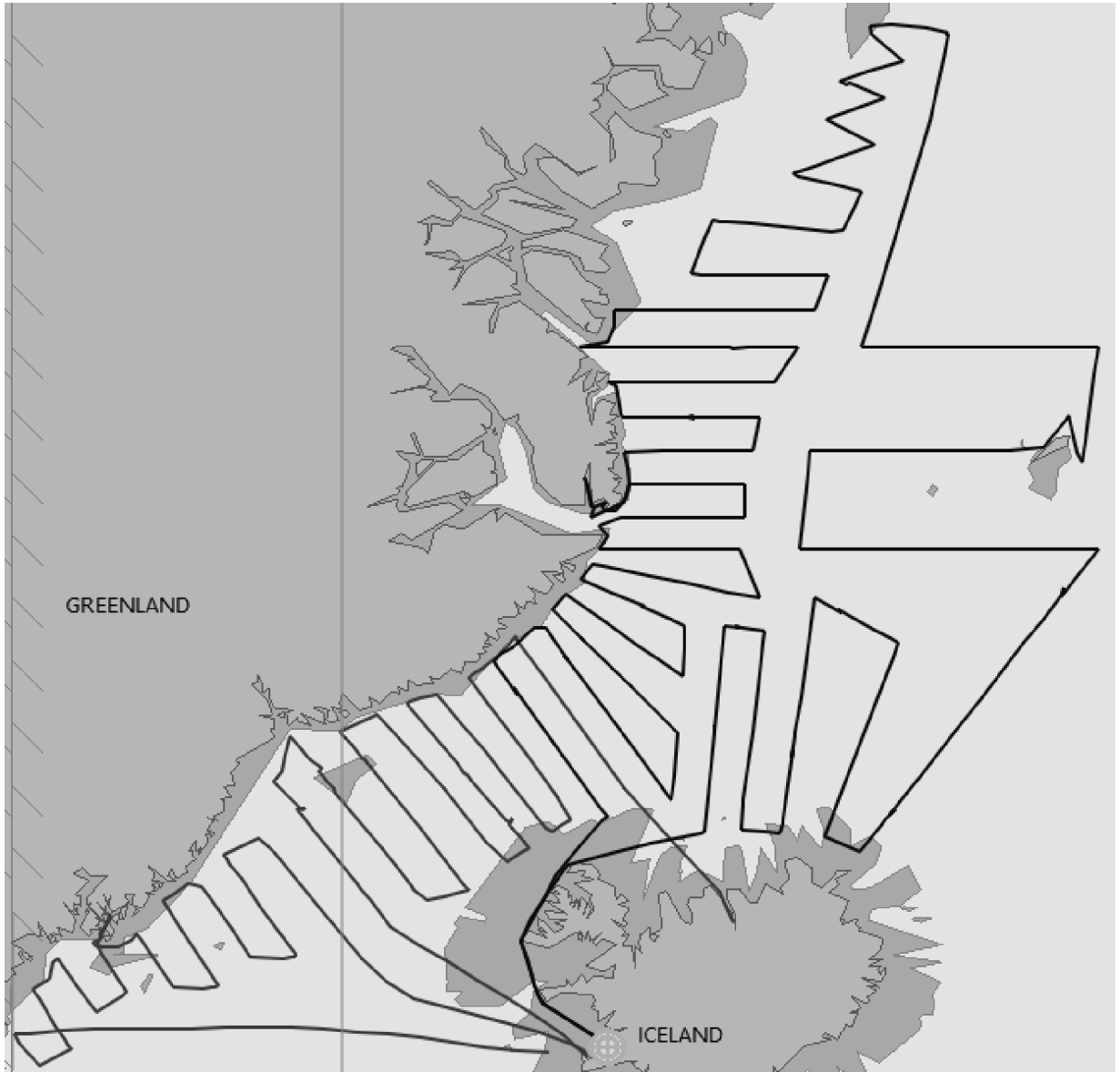


Figure 1: Routes of the research vessels; Arni Fridriksson (blue) and Eros (green).

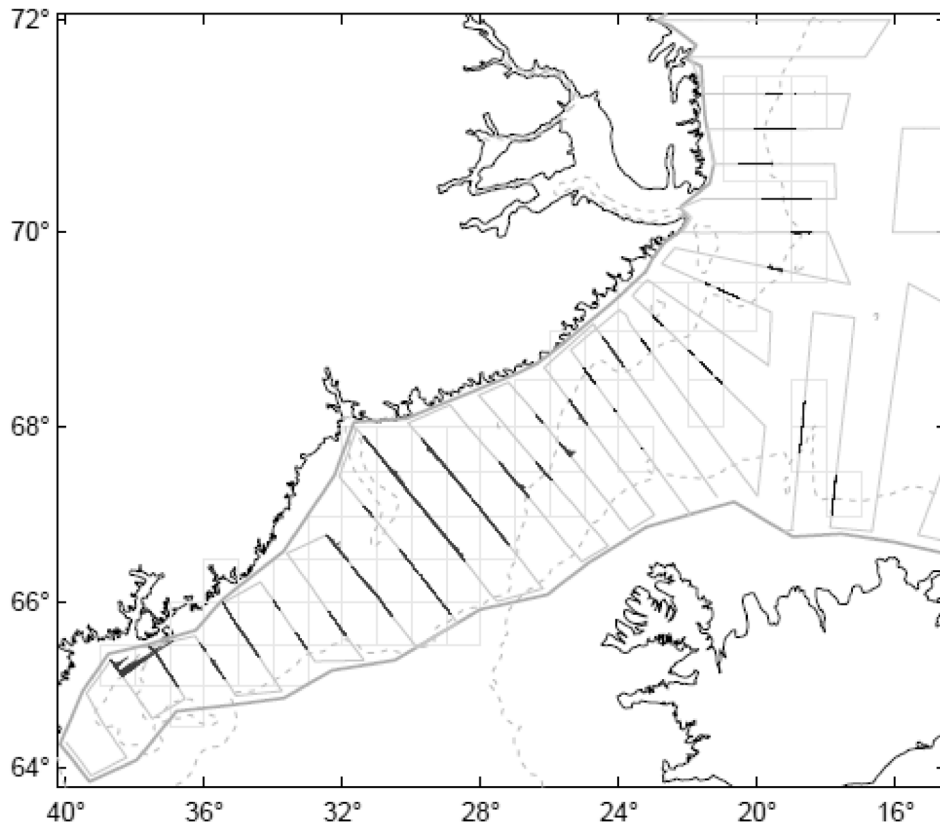


Figure 2: Capelin distribution as relative density of acoustic backscatter during the survey. Bars perpendicular to survey tracks show capelin acoustic backscatter as NASC per 0.1 nmi.

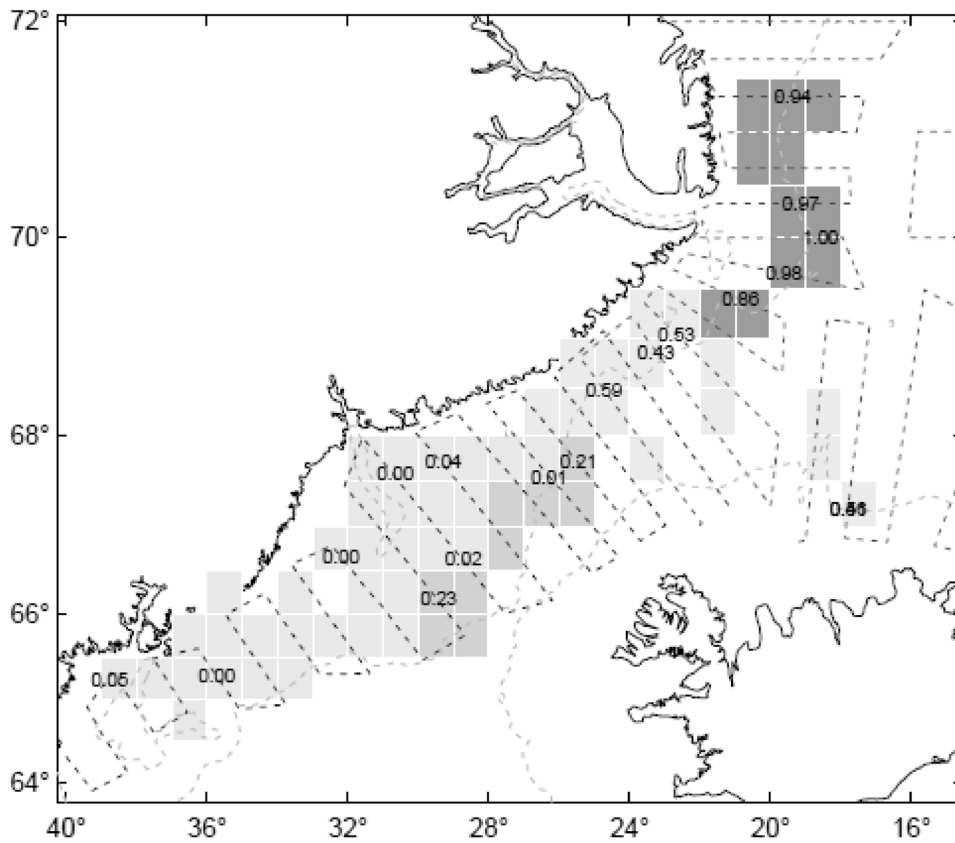


Figure 3: Maturity proportion at each trawl station.

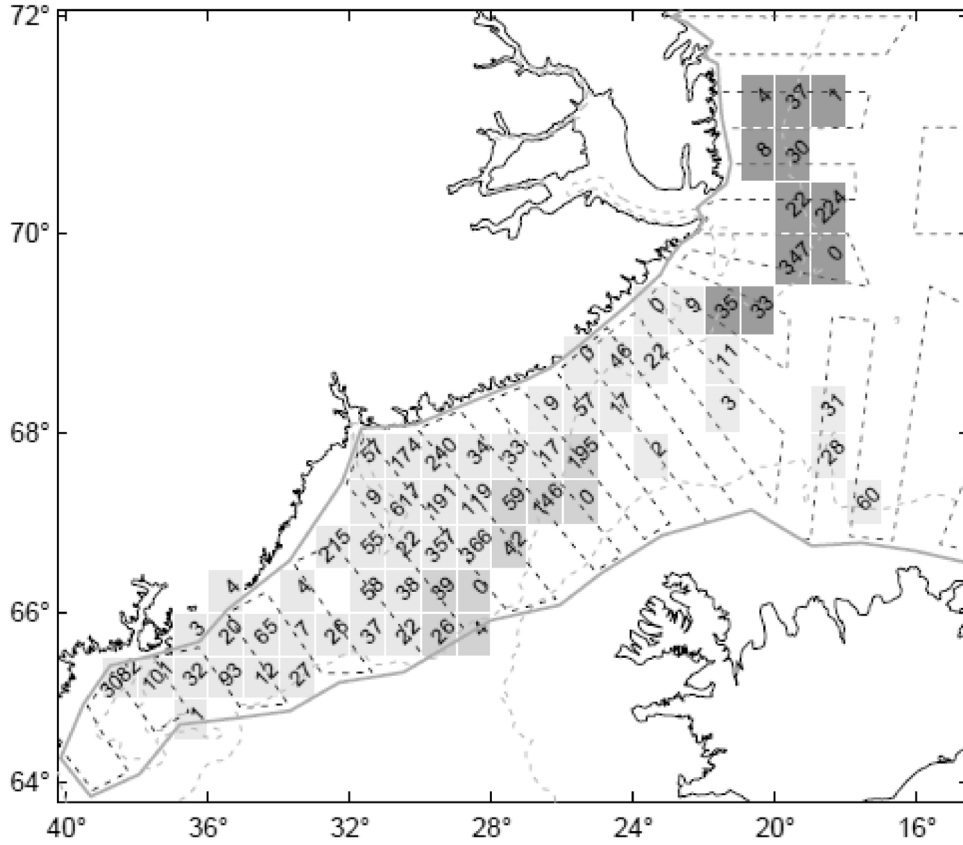


Figure 4: Average NASC within each rectangle.

$$\sigma_L = 4 * \pi * 10^{TSL/10}$$

$$C_L = \frac{\sum_L (C_L * \sigma_L)}{\sigma_L}$$

$$W_L = C_L * \overline{W_{sL}}$$

Where L is measured length, σ is backscattering cross-section, C is total number, Cs is number in sample, A is surface area and Ws is average weight in sample.

Biological sampling:

Pelagic trawl:

Total length and weight of up to 100 individual capelin fish was measured for a subsample from the catch at each of 27 pelagic trawl stations. Also, sex and maturity were estimated visually and the roe from maturing capelin were weighted. Age was estimated from otoliths. Stomachs of 10 capelin were preserved on each station. Also tissue samples were taken from 10 individuals at each station for isotope and genetics analysis.

MIK net:

Capelin juveniles (0-group) were sampled at 7 stations with MIK nets onboard all vessels.

WP2 zooplankton net:

Zooplankton was sampled by WP2 nets at depths down to 50 and 200 m at 92 stations at same location as CTD measurements

Bongo nets:

Macro-zooplankton was sampled by Bongo nets at towdepths of the trawl at every second trawl station when conditions allowed. Further Bongo samples were sampled diagonally down to 150 m at chosen transects and at targeted depths based on acoustic observations. In total 41 bongo samples were collected.

eDNA:

Onboard Arni, eDNA samples were filtered from seawater at various depths at 58 locations to facilitate the development of methods for screening for capelin DNA in the seawater samples.

Marine mammal observation and tagging:

One marine mammal observer was on-board Arni. Two humpback whales were tagged with satellite tags with simultaneous biopsy sampling.

Environmental measurements:

Conductivity, Temperature and depth (CTD) measurements were made at 94 locations and on Árni surface temperature and salinity were also measured continuously during the survey.

Results**Distribution of capelin**

Maturing capelin was mainly observed along the East Greenlandic continental shelf and shelf edges in Denmark Strait and the Scoresby areas. In Denmark Strait maturing capelin was mixed with immature capelin, but mainly maturing capelin was found further north. No capelin was found by Jan Mayen ridges but in Iceland Sea small quantities of both maturing and immature capelin were found in the proximity of Kolbeinsey ridge. Considerable quantities of 0-group capelin (although not quantified) were observed along the continental shelf north of Iceland. Immature capelin was found along the Greenlandic shelf, dominating in southwestern part of the survey area and western Denmark Strait. High abundances of immature capelin were found near Inigsalik, west of Angmagssalik fjord. The distribution of capelin was westerly as in recent years. Figures 1 and 2 show the cruise tracks, distribution and relative density of the capelin during the survey.

Biomass and age composition of capelin

Age and length disaggregated biomass is shown in tables 1-6. The total number of capelin amounted to 91 billion whereof the 1-group was about 83.3 billion. The total estimate of 2 group capelin was about 7.2 billions. The total biomass estimate was 795 000 tonnes of which about 179 000 tonnes were 2 years and older. About 2.1 % in numbers of the 1-group was estimated to be maturing to spawn, about 84.4 % of the 2 year old and 99.1 % of the 3 year old capelin appeared to be maturing. This gives about 186 000 tonnes of maturing 1 - 4 year old capelin. Tables 1-6 give the age disaggregate biomass, numbers and weights of the capelin stock components.

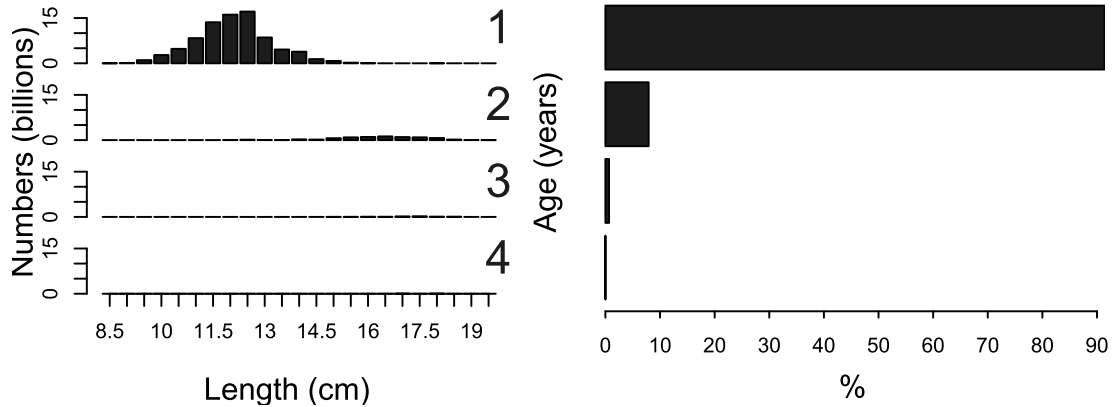
Total stock

Table 1: Estimated stock size of Iceland-Greenland-Jan Mayen capelin total stock in numbers (millions) by age (years) and length (cm), and biomass (thous. tonnes) from the acoustic survey in 12. September – 21. October 2019. Mean weight is in grams

length	a1	a2	a3	a4	num.sampled	numbers	biomass	weight.mean
8.5	10.49	0.00	0.00	0.00	2	10.49	22.86	2.18
9.0	117.00	0.00	0.00	0.00	2	117.00	253.73	2.17
9.5	1042.50	0.00	0.00	0.00	16	1042.50	3082.64	2.96
10.0	2736.09	0.00	0.00	0.00	30	2736.09	9652.12	3.53
10.5	4777.60	0.00	0.00	0.00	58	4777.60	20126.06	4.21
11.0	8334.99	0.00	0.00	0.00	97	8334.99	41954.13	5.03
11.5	13604.66	0.00	0.00	0.00	161	13604.66	81772.72	6.01
12.0	16123.26	27.75	0.00	0.00	190	16151.01	111537.80	6.91
12.5	17144.45	139.51	0.00	0.00	229	17283.95	138371.07	8.01
13.0	8559.52	27.75	0.00	0.00	134	8587.27	78343.47	9.12
13.5	4569.23	14.91	0.00	0.00	95	4584.15	49060.51	10.70
14.0	3841.22	238.42	0.00	0.00	68	4079.64	49651.36	12.17
14.5	1380.40	169.18	0.00	0.00	48	1549.58	21607.75	13.94
15.0	778.15	622.92	5.24	0.00	58	1406.31	22672.78	16.12
15.5	207.57	901.13	20.97	0.00	90	1129.67	20303.46	17.97
16.0	32.99	1037.60	49.98	0.00	116	1120.57	22989.31	20.52
16.5	0.00	1219.12	41.13	0.00	143	1260.24	28710.70	22.78
17.0	0.00	1005.05	151.03	5.24	123	1161.32	29048.95	25.01
17.5	0.00	911.31	193.79	0.00	126	1105.10	30835.93	27.90
18.0	27.75	686.25	80.62	5.24	78	799.86	25436.40	31.80
18.5	0.00	181.74	64.89	0.00	31	246.63	8446.22	34.25
19.0	0.00	24.58	0.00	0.00	3	24.58	917.35	37.32
19.5	0.00	9.67	0.00	0.00	1	9.67	403.00	41.68

Table 2: Age (years) aggregated total stock summary. T = Total, S = Stock, N = Numbers(billions), W = Weight(grams), L = Length(Cm), p = %

parameter	a1	a2	a3	a4	All
TSN	83.29	7.22	0.61	0.01	91.12
TSB	616.29	162.22	16.40	0.30	795.20
MeanW	7.40	22.48	26.98	28.41	8.73
MeanL	12.09	16.33	17.27	17.50	12.46
TSNp	91.40	7.92	0.67	0.01	100.00



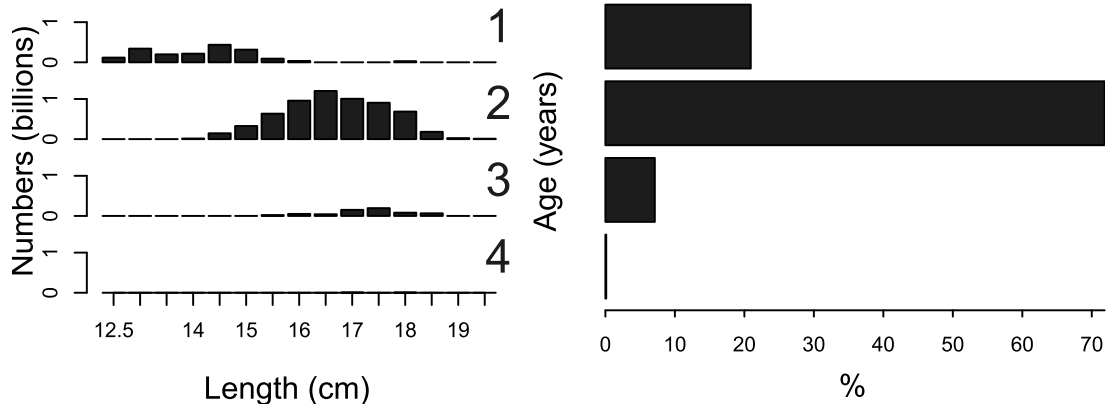
Spawning stock

Table 3: Estimated stock size of the Iceland-Greenland-Jan Mayen capelin spawning stock component in numbers (millions) by age (years) and length (cm), and biomass (thous. tonnes) from the acoustic survey in 12. September – 21. October 2019. Mean weight is in grams

length	a1	a2	a3	a4	num.sampled	numbers	biomass	weight.mean
12.5	117.00	0.00	0.00	0.00	36	117.00	947.78	8.10
13.0	340.51	0.00	0.00	0.00	48	340.51	3079.98	9.05
13.5	197.90	0.00	0.00	0.00	33	197.90	2216.11	11.20
14.0	214.34	14.91	0.00	0.00	14	229.26	2967.48	12.94
14.5	436.32	144.60	0.00	0.00	44	580.91	8346.90	14.37
15.0	315.40	326.11	0.00	0.00	53	641.51	10649.18	16.60
15.5	90.57	634.14	20.97	0.00	86	745.68	13681.19	18.35
16.0	32.99	957.52	49.98	0.00	116	1040.49	21263.83	20.44
16.5	0.00	1199.78	41.13	0.00	143	1240.91	28335.35	22.83
17.0	0.00	1005.05	151.03	5.24	123	1161.32	29048.95	25.01
17.5	0.00	906.07	193.79	0.00	126	1099.86	30689.86	27.90
18.0	27.75	686.25	80.62	5.24	78	799.86	25436.40	31.80
18.5	0.00	181.74	64.89	0.00	31	246.63	8446.22	34.25
19.0	0.00	24.58	0.00	0.00	3	24.58	917.35	37.32
19.5	0.00	9.67	0.00	0.00	1	9.67	403.00	41.68

Table 4: Age (years) aggregated spawning stock component summary. T = Total, S = Stock, N = Numbers(billions), W = Weight(grams), L = Length(Cm), p = %

parameter	a1	a2	a3	a4	All
SSN	1.77	6.09	0.60	0.01	8.48
SSB	23.74	146.07	16.32	0.30	186.43
MeanW	13.39	23.98	27.09	28.41	21.99
MeanL	14.13	16.66	17.29	17.50	16.18
SSNp	20.92	71.85	7.11	0.12	100.00



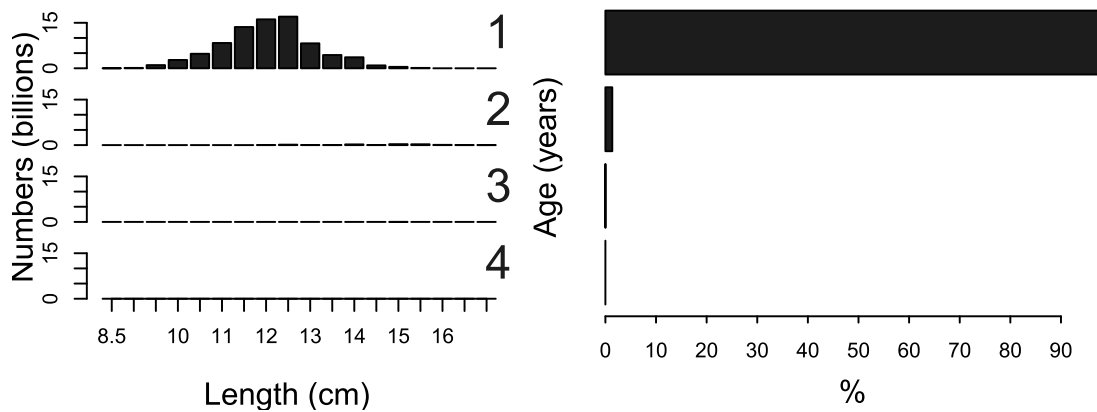
Immature stock

Table 5: Estimated stock size of the Iceland-Greenland-Jan Mayen capelin immature stock component in numbers (millions) by age (years) and length (cm), and biomass (thous. tonnes) from the acoustic survey in 12. September – 21. October 2019. Mean weight is in grams

length	a1	a2	a3	a4	num.sampled	numbers	biomass	weight.mean
8.5	10.49	0.00	0.00	0	2	10.49	22.86	2.18
9.0	117.00	0.00	0.00	0	2	117.00	253.73	2.17
9.5	1042.50	0.00	0.00	0	16	1042.50	3082.64	2.96
10.0	2736.09	0.00	0.00	0	30	2736.09	9652.12	3.53
10.5	4777.60	0.00	0.00	0	58	4777.60	20126.06	4.21
11.0	8334.99	0.00	0.00	0	97	8334.99	41954.13	5.03
11.5	13604.66	0.00	0.00	0	161	13604.66	81772.72	6.01
12.0	16123.26	27.75	0.00	0	190	16151.01	111537.80	6.91
12.5	17027.45	139.51	0.00	0	229	17166.95	137423.29	8.01
13.0	8219.01	27.75	0.00	0	134	8246.76	75263.49	9.13
13.5	4371.34	14.91	0.00	0	94	4386.25	46844.40	10.68
14.0	3626.87	223.51	0.00	0	67	3850.38	46683.88	12.12
14.5	944.08	24.58	0.00	0	44	968.66	13260.84	13.69
15.0	462.75	296.81	5.24	0	43	764.81	12023.60	15.72
15.5	117.00	266.99	0.00	0	26	383.99	6622.26	17.25
16.0	0.00	80.08	0.00	0	63	80.08	1725.48	21.55
16.5	0.00	19.34	0.00	0	9	19.34	375.35	19.41
17.5	0.00	5.24	0.00	0	7	5.24	146.07	27.86

Table 6: Age (years) aggregated immature stock component summary. T = Total, S = Stock, N = Numbers(billions), W = Weight(grams), L = Length(Cm), p = %

parameter	a1	a2	a3	a4	All
ISN	81.52	1.13	0.01	0	82.65
ISB	592.40	16.29	0.08	0	608.77
MeanW	7.27	14.46	15.72	0	7.37
MeanL	12.05	14.57	15.00	0	12.08
ISNp	98.63	1.36	0.01	0	100.00



**Advice for Intermediate TAC of
Capelin in the Iceland-East Greenland-Jan Mayen area
for
the 2019/2020 fishing season
based on
Autumn survey (12. September – 21. October 2019).**

Marine & Freshwater Research Institute, Iceland.

Date: 30th October 2019

Advice for the mature/maturing part of the stock (for current season)

Based on current HCR the Marine Research Institute advises **0** catch of capelin during the fishing year 2019/2020. This is an intermediate TAC advice set at catch giving $p(\text{SSB} < \text{Blim} = 150\text{kt}) < 0.05$, that should be re-evaluated following measurements of the maturing stock in January-February 2020. Further, abundance of immature capelin was estimated as 82.6 billions.

Summary of results

Below are results for the advice on TAC for the maturing part in current season. This methodology is in accordance with the Stock Annex for the capelin stock in the Iceland-East Greenland- Jan Mayen area (WKICE2015).

Inputs: Bootstrap replications of survey estimates of SSB, brought forward from autumn to winter through the use of assumptions about growth, mortality etc. Additional uncertainty included due to variable mortality. Fed into the predation model starting at 15 Jan 2020.

Bootstrap model:

Acoustic data from the A13-2019 and EROS1-2019 acoustic surveys was used. Nautical area backscattering coefficients (NASC) were averaged within squares of 30 x 60 minutes latitude and longitude. The stock size estimate was based on one coverage of the survey area where the surveyed area was split into 4 subareas for appropriate allocation of biological samples (See survey report).

The squares, trawl stations, and biological samples within each subarea (strata) were bootstrapped with 10 000 replications to estimate the coefficient of variation (CV) as an estimate of uncertainty (Table 1). This methodology is in accordance with the Stock Annex for the capelin stock in the Iceland-East Greenland- Jan Mayen area (WKICE2015).

Table 1 Quantiles of stock assessment. Where, EA = Echo Abundance (NASC*Area, millions m²), N = Number of individuals (Billions), B = Biomass (Thous. tonnes), SS. = mature, imm. = immature.

	<i>Mean</i>	<i>CV</i>	<i>5%</i>	<i>25%</i>	<i>50%</i>	<i>75%</i>	<i>95%</i>
EA	5.14	0.37	2.59	3.58	4.93	6.33	8.72
N	91.73	0.4	43.83	61.7	87.69	114.6	159.99
B	797.7	0.34	425.18	582.79	765.68	964.79	1304.14
SSN	8.43	0.3	4.63	6.62	8.22	10.03	12.83
SSB	185.16	0.31	99.35	144.15	180.33	221.76	285.73
ImmN	83.29	0.43	36.62	53.66	79.42	105.87	150.65
ImmN1	82.17	0.43	35.88	52.87	78.29	104.4	149.07
ImmN2	1.12	0.65	0.31	0.62	0.94	1.42	2.53
ImmB	612.54	0.42	274.01	398.06	583.35	775.78	1102.51
Prop. N3 in SSB	0.07	0.34	0.04	0.06	0.07	0.09	0.12
Prop. B3 in SSB	0.09	0.32	0.05	0.07	0.08	0.1	0.14

Predation model results:

Harvest control rule for this stock was adopted by managers in spring 2015. The HCR is based on leaving 150 thous. tonnes of capelin to spawn with 95% probability. The HCR incorporates uncertainty in stock size estimates and model estimation of predation by cod, haddock and saithe on capelin.

The model predictions give, when catch is 0 tonnes, less than 95% probability that there will be 150 000 tonnes (Blim) left for spawning at assumed spawning time the 15. March 2020 (Figure 1 & 2 and Table 2).

Table 2 Quantiles and mean of SSB at time of spawning (15. March) and total predator consumption in thous. tonnes based on the predation model.

	<i>Mean</i>	<i>5%</i>	<i>25%</i>	<i>50%</i>	<i>75%</i>	<i>95%</i>
SSB	88.66	33.22	59.20	82.79	112.23	161.48
Predation	97.89	54.67	76.63	95.14	115.74	151.97

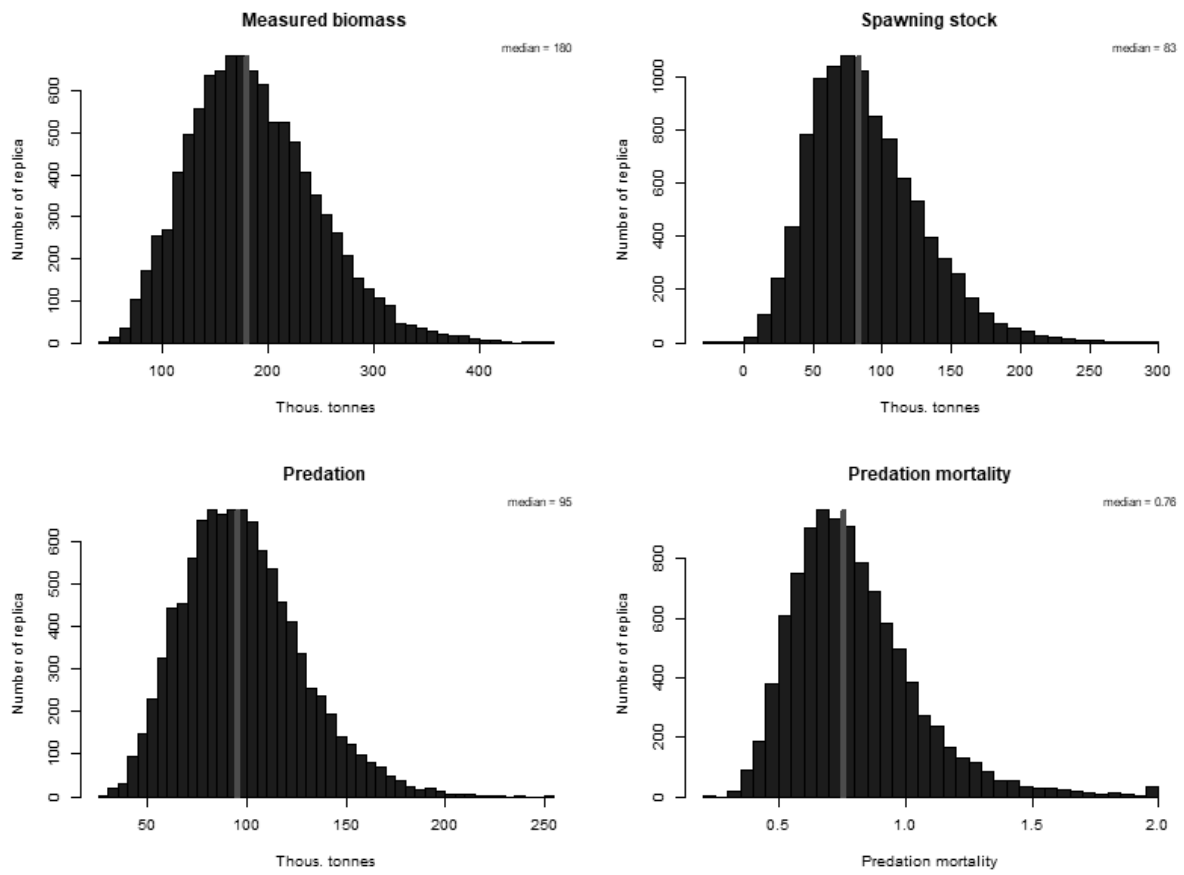


Figure 1 Summary of results from the 2019 autumn survey and 1985-2019 predator data.

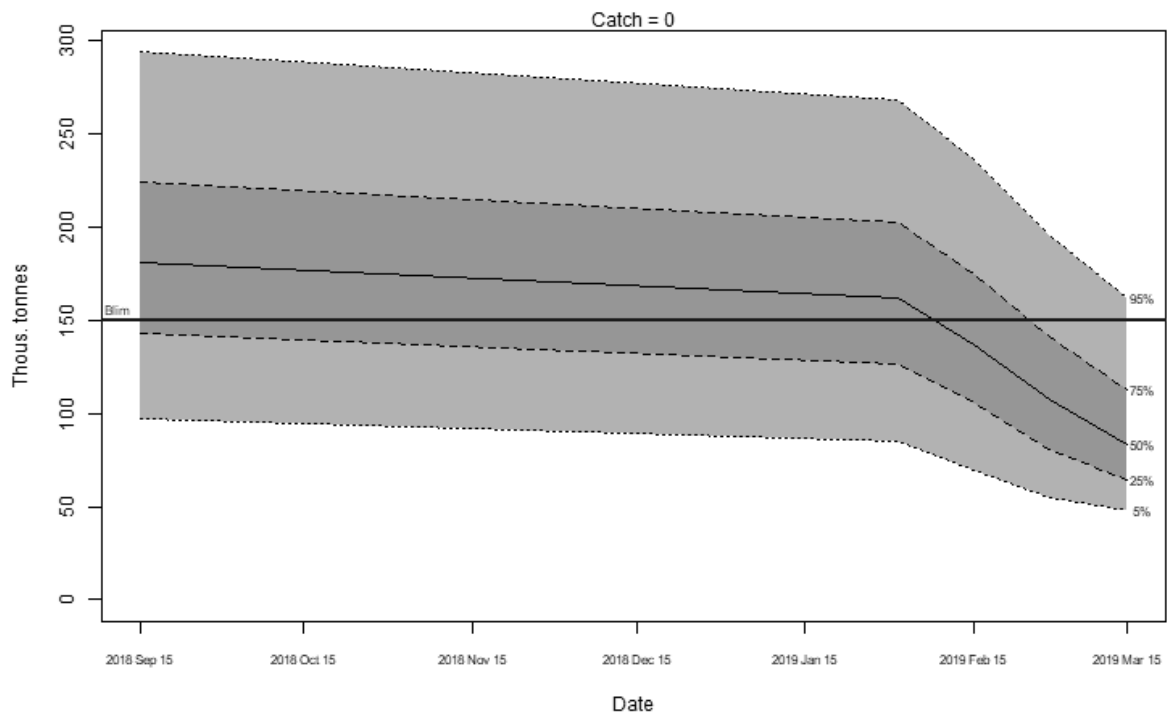


Figure 2 Development of the SSB with no catch.