Preliminary cruise report: Acoustic assessment of the Iceland–East Greenland–Jan Mayen capelin stock in autumn 2022

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1 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 on a r/v Tarajoq on 27 August–20 September and r/v Árni Friðriksson on 5–26 September on behalf of GINR and MFRI, respectively. The stock estimate was based on combined acoustic and trawl data from both vessels. Figure 1.1 shows the survey tracks and stations taken by the vessels.

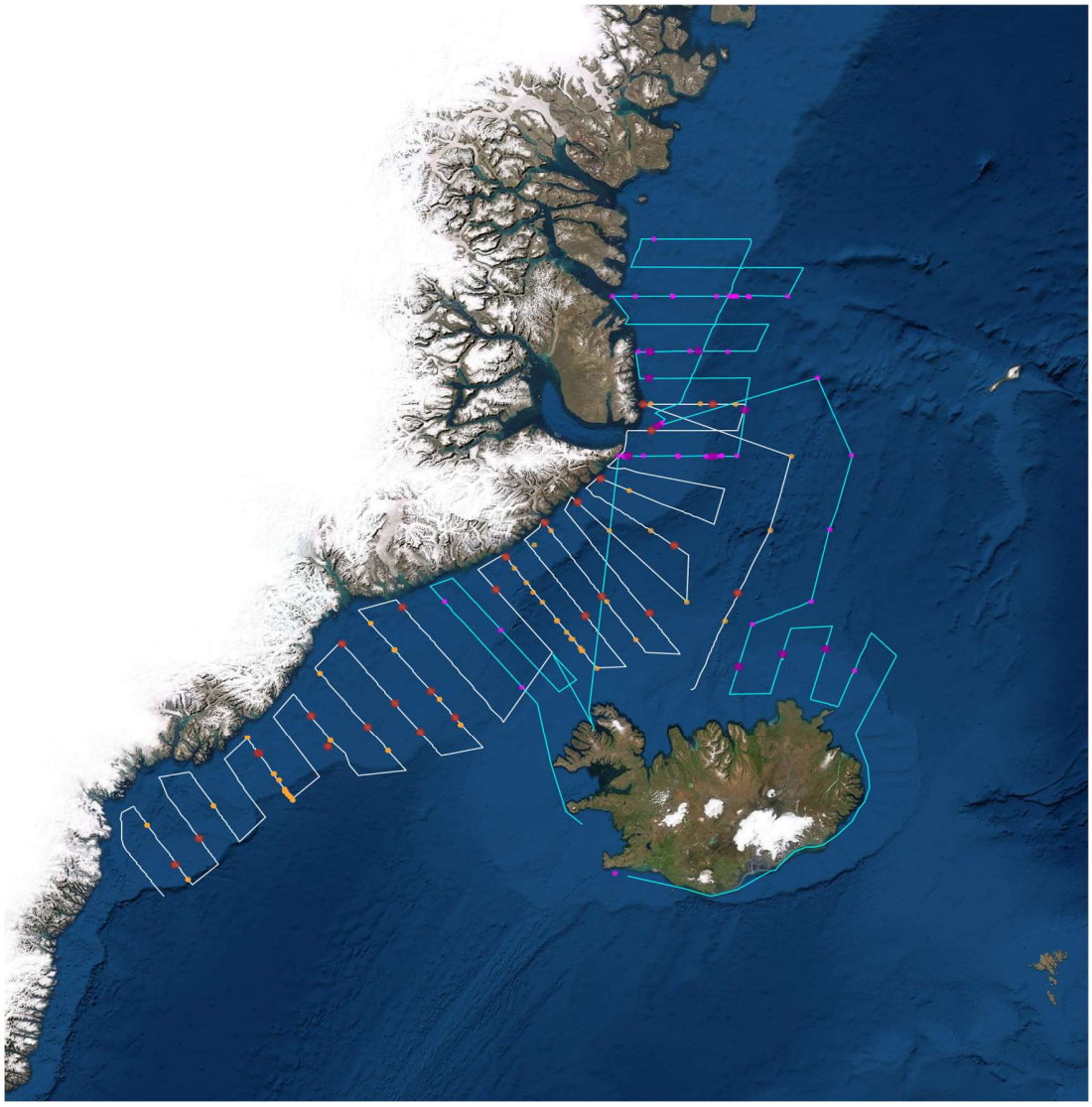

Figure 1.1: Survey track and stations of participating r/v-s in August–September 2022. Árni Friðriksson (track cyan, pelagic trawl stations large in dark magenta, other stations smaller in magenta), Tarajoq (track white, pelagic trawl stations large in brown, other stations smaller in orange). Zoom-able version on https://heima.hafro.is/~sigurdur/cap_aut_sur/2022/.

2 Methods

2.1 Survey area and conditions

The survey area was on the shelf and along the shelf edge of East Greenland from about 63°20'W towards about 72°40'N, also covering the Denmark Strait and the slope north west to north east of Iceland. The coverage was planned in 2018 and 2019 as a fixed transect layout with fixed stations for hydrography (CTD) and ecology (WPII and some Bongoes), with targeted pelagic trawl stations as capelin or other registrations are encountered. On Árni a WBT-tube was deployed to study in-situ TS of capelin.

Tarajoq departed from Hafnarfjörður on Aug 27 and steamed west for ~400 nmi to the start of the coverage off Kong Fredrik Land where it started surveying on NW-SE oriented parallel transects along the East Greenland shelf. Capelin were not caught in the first two pelagic trawls taken on the first five transects. It should be noted that these were the first deployments of the pelagic trawl on Tarajoq an almost brand new research vessel, so there were some inital difficulties. A crew exchange scheduled for Sep 8 went ahead in Ísafjörður, surveying commenced after that at the position where Árni had to leave off due to engine trouble. Árni had then covered only 2 and a quarter of a transect starting slightly ahead of Tarajoq prior to halftime, close to the threshold in the Denmark Strait. Tarjoq then continued north to Kangertittivaq/Scoresby Sound where Árni rejoined the survey and interleaved with Tarajoq on a few transects before Tarajoq had to leave, covering a southward transect east of the transects on the shelf, on route to Hafnarfjörður where it finished the survey on the morning of Sep 20.

Árni left Hafnarfjööur on Sep 5 and started surveying on transects in Denmark Strait the morning after, but was interrupted in the afternoon of Sep 7 due to engine trouble and steamed in to Ísafjörður for repairs. On Sep 14 Árni was again ready for departure, steamed north to 70°N slightly ahead of Tarajoq and started on a transect south of the opening of Kangertittivaq/Scoresby Sound in the afternoon of Sep 15. After skipping ahead of the final two transects covered by Tarajoq to 71°N, Árni then continued on the fixed transect plan on the East Greenland shelf north to 72°40'N where sea ice had been encountered on the last two transects. Since no capelin had been observed on those transects and only small amount on the previous two, it was decided to skip the rest of the planned coverage (north to Shannon Island at ~75°N and a little bit higher). After taking an eastbound transect off Geographical Society Island Árni returned to the Kangertittivaq area where a WBT-tube station was taken outside the mouth of the Sound. In the early morning of Sep 21 Árni headed east of the southbound leg of Tarajoq and headed south to the shelf area north of Iceland and continued on transects there until late on Sep 24 when surveying finished. Only small amounts capelin were detected in the area and a severe storm was also putting a stop to the survey.

Mostly immature capelin were observed on the three southernmost trawl stations taken south of 67°N, while in the Denmark Strait area mature capelin predominated. Close to shore south of Kangertittivaq, the capelin samples consisted mostly of immatures, but further out the capelin were mostly or fully mature. Outside of the opening of the Sound and further north the same pattern of immature near shore and mature further out

continued, except on the northernmost transect were almost exclusively mature capelin were caught.

Strong registrations of capelin were encountered on two of Tarajoq's near-shore transverse transects and were included in the estimation. This has been done on occasion in previous IEGJM capelin survey estimates, even though it is not strictly in according to the survey design. Similarly on Árni, strong registrations, encountered on the transverse transect near the shelf edge between 70° and 71°N, were also included in the estimation. Árni added to the coverage east of these registrations before heading south.

Weather conditions were favorable for most of the survey, although both vessels were held up for a short period, Tarajoq at the start and Árni around on Sep 20. A severe storm prevented further work after Sep 24. Sea ice prevented Árni from progressing further north than 72°40'N.

2.2 Acoustic sampling

Acoustic data were collected with Simrad EK80 echosounders on both r/v-s, operating transducers on 18, 38, 70 120 and 200 kHz on both vessels, and 333 kHz in addition on Tarajoq. The data were scrutinized by a scientist onboard each vessel using LSSS (version 2.12.0) 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. Then, average NASC within rectangles of 30 minutes latitude and 15 minutes longitude was calculated. Abundance in numbers was estimated using a length dependent target strength (TS; in dB re $1m^2$)

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

from Vilhjálmsson (1994). Total length of the capelin was measured to nearest mm. For each length interval l within the length distribution of capelin the backscattering cross-section was calculated:

$$\sigma_l = 4 * \pi * 10^{TS_l/10}$$

The suvey area was split into strata based on a post-stratification based on proportion mature in the trawl samples. The echo abundance, EA_s allocated to capelin in each strata s consisting of rectangles r is the sum of the products of average NASC, rectangle area and proportion of rectangle area included p_r:

$$EA = \sum \overline{NASC}_r * A_r * p_r$$

. Echo abundance is converted to numbers by simple division:

$$N_s = EA_s / \overline{\sigma_s}$$

and weights, age and maturity proportions by strata are used to compile the stock in different ways.

As East-West and West-East transects are along parallels from 70˚N and northwards they coincide with rectangle boundaries in some cases. Therefore, 0.01 was added to the

latitude values north of 69.99N in order to ensure more even distribution of NASC values to rectangles.

2.3 Biological sampling

Number of stations taken by the two r/v-s by station type are given in the text table below:

Station type/Vessel	Tarajoq	Árni	Both
Pelagic trawl	26	10	36
CTD	75	34	109
WPII	74	30	104
Bongo	13	7	20
WBT-tube		3	3

2.3.1 Pelagic trawl

Total length and weight of up to 100 individual capelin fish was measured for a subsample from the catch at each pelagic trawl station. Also, sex and maturity were estimated visually and the gonads from maturing capelin were weighted. Age was estimated from otoliths. Stomachs of 10 capelin were preserved on each station. Also 50 individual capelin were sampled on every second station for genetic analysis and further on every station 100 individuals in two size categories (above and below 14 cm) were sampled for fat content analysis.

2.3.2 WP2 zooplankton net

Zooplankton was sampled by WP2 nets at depths down to 50 and 200 m at location where CTDs were taken if weather permitted.

2.3.3 Bongo

Bongo samples were sampled diagonally down to 200 m at chosen transects and at targeted depths based on acoustic observations. In total 20 bongo samples were collected.

2.4 Hydrography

Conductivity, temperature and depth (CTD) measurements were made at 109 locations and surface temperature and salinity were also measured continuously during the survey.

2.5 WBT tube

WBT-tube was cast two times on capelin registrations accompanied with a pelagic trawl and a CTD cast and once at the end of the survey to test out additional equipment on the tube platform.

3 Results

Maturing capelin were mainly observed along the East Greenlandic continental shelf and shelf edges in Denmark Strait and the Kangertittivaq/Scoresby Sund areas reaching north to 72˚N. In Denmark Strait maturing capelin were mixed with immature capelin, but mainly maturing capelin were found further north. No capelin were found by West Jan Mayen ridge or Kolbeinsey ridge. In general there were no signs of any important quantities of capelin east of Kolbeinsey ridge nor along Icelandic shelf edges. Pelagic trawls north of Iceland were dominated by blue whiting and Norwegian spring spawning herring, but in one trawl a few mature capelin were observed. Juveniles (0-group) of various species, including capelin (although not quantified) were observed in the south-western part of the surveyd area. Immature capelin were found in greatest quantity mixed with maturing capelin, nearshore close to and both south and north of the opening of Kangertittivaq/Scoresby Sound, , but also in the southwestern part of the survey area and western Denmark Strait with less mature capelin admixture. In general the gonad development of maturing capelin was such that it was not as challenging to distinguish between mature and immature developmental stages as in autumn 2022. Figures 1.1–3.3 show the cruise tracks, distribution and relative density of the capelin during the survey.

3.1 Distribution of capelin

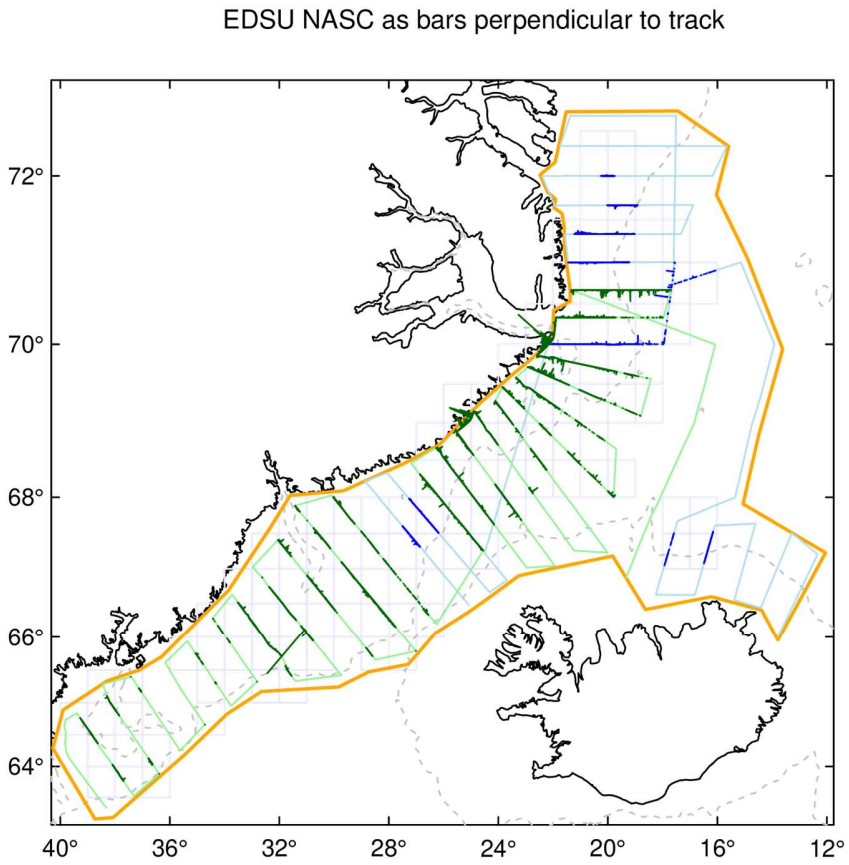

Figure 3.1: Capelin distribution as relative density of acoustic backscatter during the survey. Bars perpendicular to survey tracks show capelin acoustic backscatter as NASC per 0.1 nmi. Tarajoq track light green, NASC dark green, Árni Friðriksson track cyan, NASC blue.

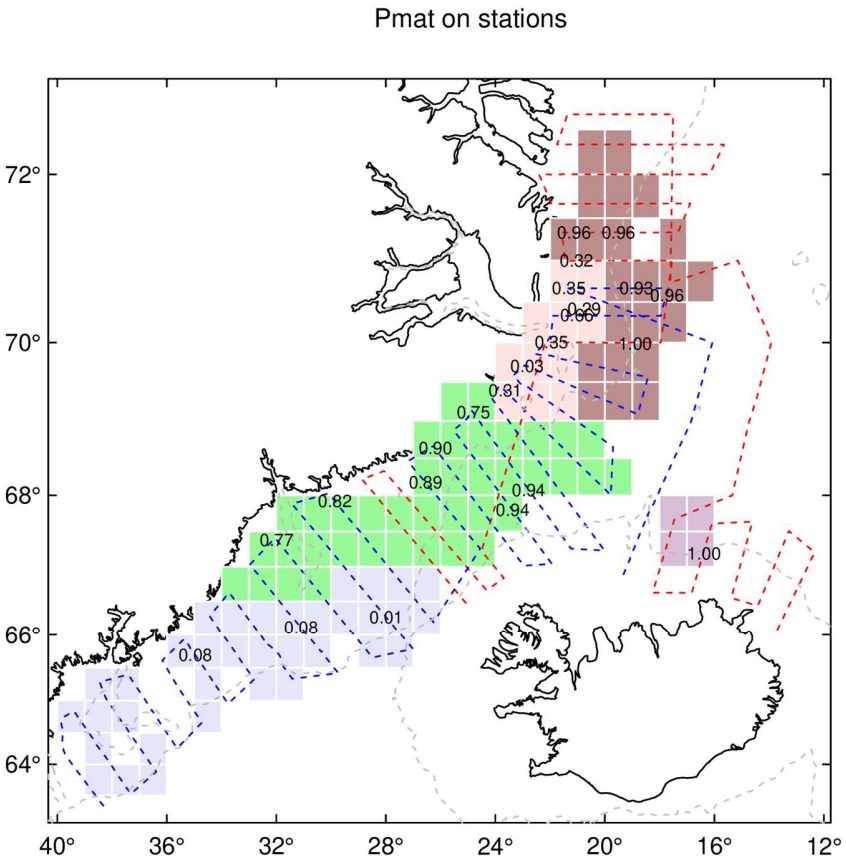

Figure 3.2: Maturity proportion at each trawl station

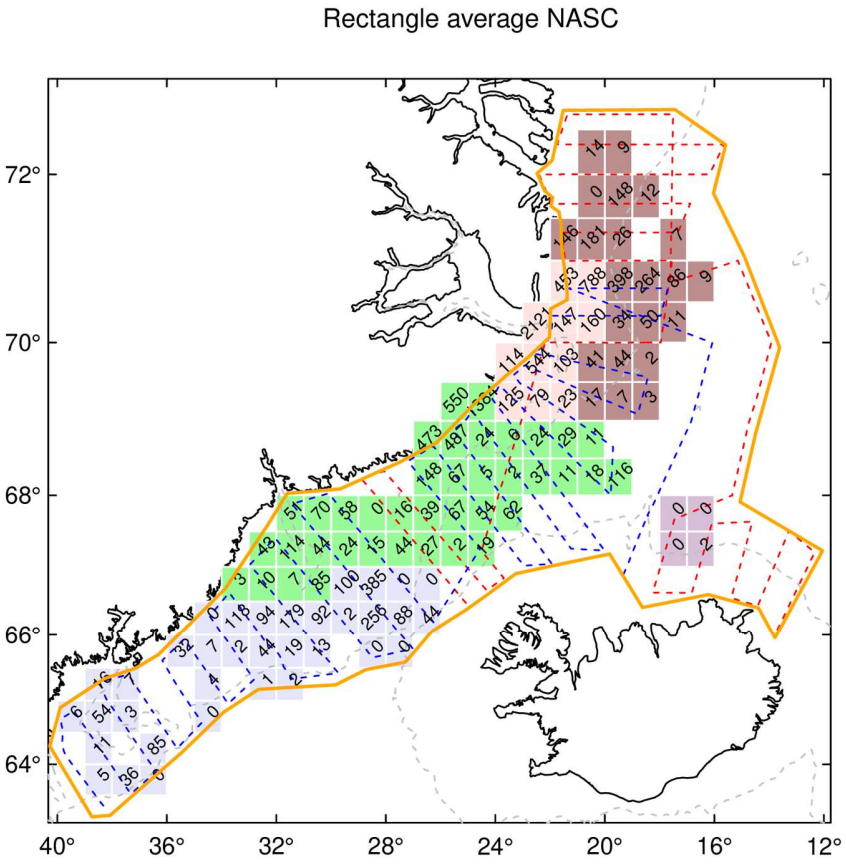

Figure 3.3: Average NASC within each rectangle

3.2 Biomass and age composition of capelin

Age and length disaggregated biomass is shown in Tables 3.1–3.3 and tables 3.4–@ref(tab:imm give breakdown of total, maturing and immature stock by length and age. The total number of capelin amounted to 75.3 billions whereof the 1-group was about 28.7 billions. The total estimate of 2 group capelin was about 34 billions. The total biomass estimate was 1097 200 tonnes of which about 944 100 tonnes were 2 years and older. About 67.1 % of the 2 year old, 92.9 % of the 3 year old and 'all' (only 43 million) the 4 year old capelin appeared to be maturing. This gives about 762 600 tonnes of maturing 2 - 4 year old capelin. According to this estimation a third of the abundance and 43% oft the biomass of maturing capelin belonged to age group 3, destined to spawn as 4 year olds next winter/spring. This is among the higher proportions of the older age group in the spawning stock [Vilhjálmsson (1994); see Fig. 14.9.]

3.2.1 Age-disaggregated summaries by stock components

*Table 3.1: Age dis-aggregated **total** stock summary, N: Numbers (billions), B: Biomass (thous. tonnes), ml: Mean length (cm), mw: Mean weight (g), percent: % abundance by age.*

parameter/age	1	2	3	4	All
N	28.7	34	12.6	0	75.3
B	153.1	600.7	341.6	1.8	1097.2
ml	11.2	15.3	17.1	19.3	14.9
mw	5.8	18	27.7	39.6	17.8
percent	38.1	45.1	16.7	0.1	100

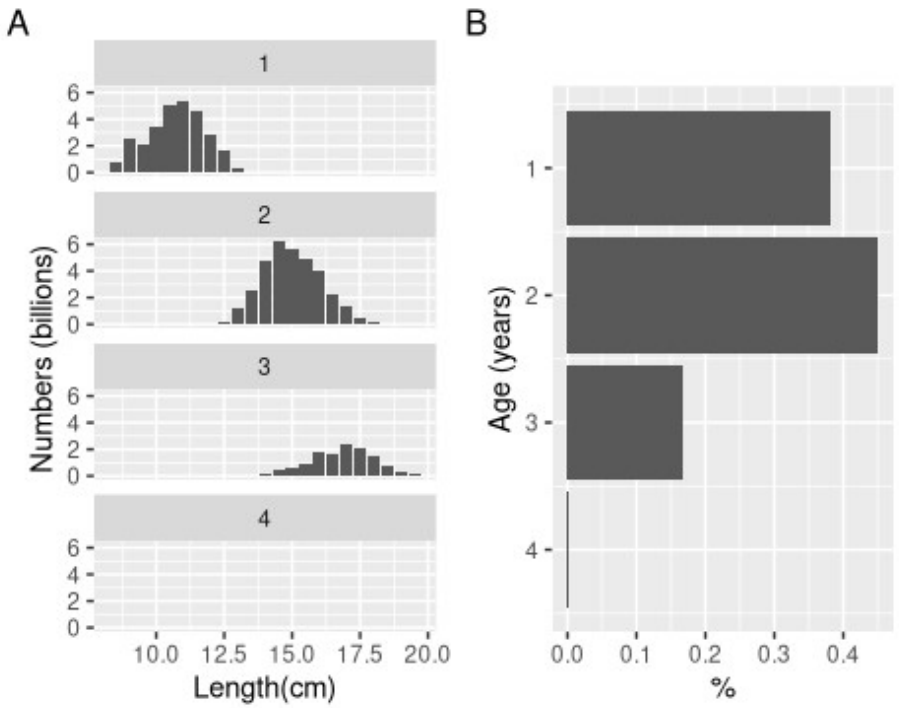

*Figure 3.4: Length and age (A) and age (B) distribution of **total** stock*

*Table 3.2: Age dis-aggregated **maturing** stock summary, N: Numbers (billions), B: Biomass (thous. tonnes), ml: Mean length (cm), mw: Mean weight (g), percent: % abundance by age.*

parameter/age	2	3	4	All
N	22.8	11.7	0	34.5
B	436.7	324.2	1.8	762.6
ml	15.6	17.2	19.3	16.2
mw	19.5	28	39.6	22.8
percent	65.9	33.9	0.1	100

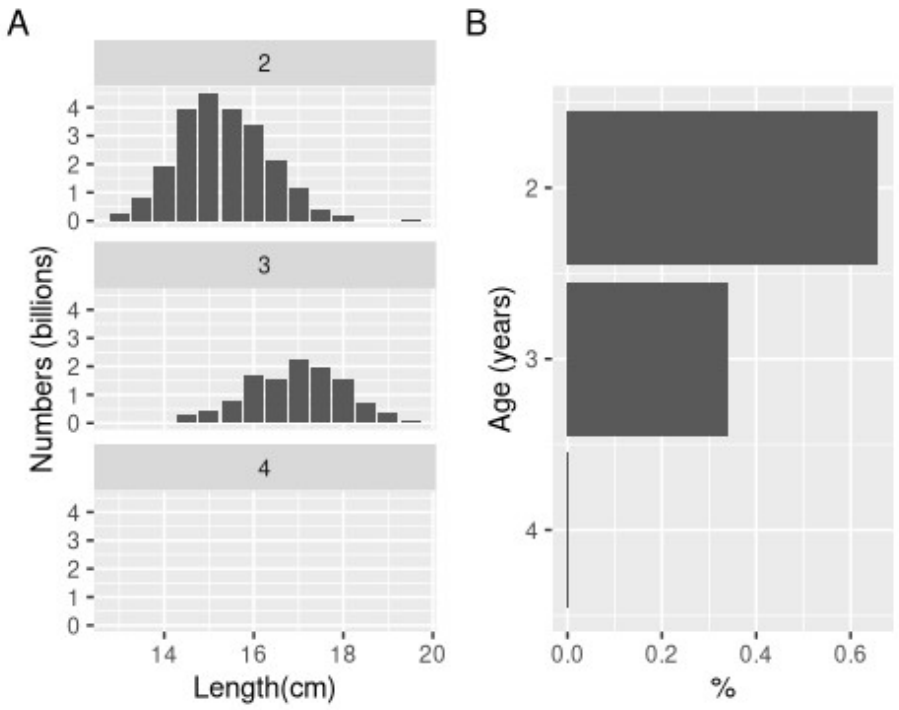

*Figure 3.5: Length and age (A) and age (B) distribution of **maturing** stock*

*Table 3.3: Age dis-aggregated **immature** stock summary, N: Numbers (billions), B: Biomass (thous. tonnes), ml: Mean length (cm), mw: Mean weight (g), percent: % abundance by age.*

parameter/age	1	2	3	All
N	28.7	11.2	0.9	40.7
B	153.1	164	17.4	334.6
ml	11.2	14.5	16.1	12.9
mw	5.8	14.7	21.9	10.4
percent	70.4	27.5	2.1	100

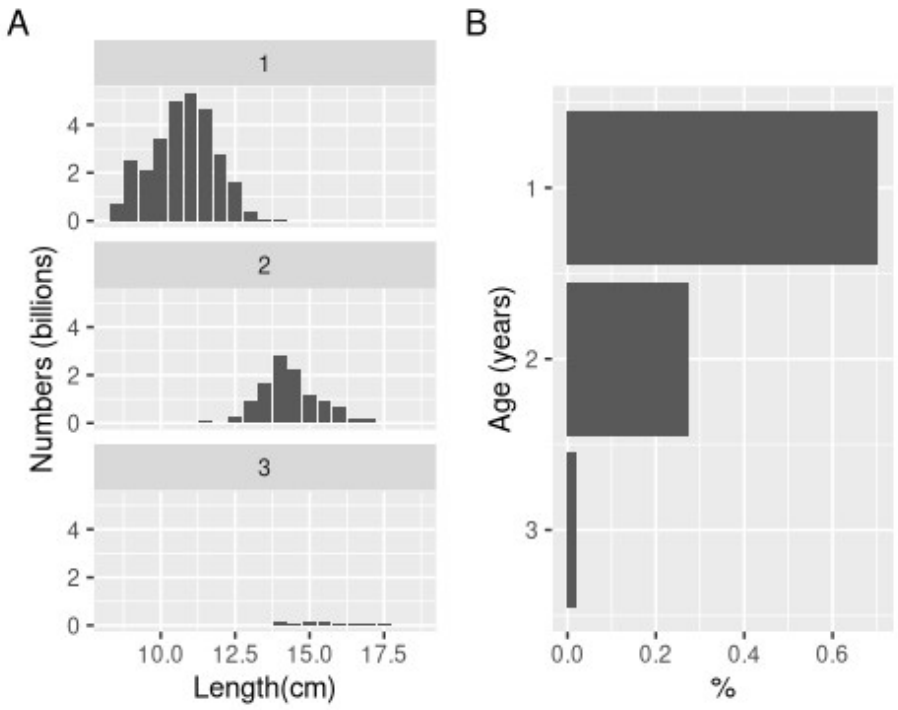

*Figure 3.6: Length and age (A) and age (B) distribution of **immature** stock*

3.2.2 Length and age composition by stock components

*Table 3.4: Estimated size of Iceland-East Greenland-Jan Mayen capelin **total** stock in numbers (millions) by age and length (cm), and biomass (thous. tonnes) from acoustic survey in August 27–September 26 2022. Mean weight in grams.*

	1	2	3	4	Total N	Total B	Mean weight (g)
8.5	724.7				724.7	1630.6	2.2
9	2536.5				2536.5	6830.4	2.7
9.5	2118.1				2118.1	7248.4	3.4
10	3432.2				3432.2	14281.0	4.2
10.5	4997.2				4997.2	23778.4	4.8
11	5346.5	25.5			5372.0	29615.7	5.5
11.5	4646.8	76.5			4723.3	30207.2	6.4
12	2781.8	25.5			2807.3	21207.3	7.6
12.5	1636.8	236.1			1872.9	16513.5	8.8
13	354.5	1186.6			1541.1	15792.5	10.2
13.5	51.0	2514.4	34.5		2599.9	30562.7	11.8
14	51.0	4762.8	176.1		4989.8	66697.7	13.4
14.5		6183.9	390.6		6574.5	99207.0	15.1
15		5666.8	588.1		6254.9	107797.3	17.2
15.5		4833.2	885.5		5718.7	112920.0	19.7
16		4044.5	1750.5		5795.0	127108.9	21.9
16.5		2304.6	1577.5		3882.1	95641.5	24.6
17		1383.2	2365.0		3748.2	102354.1	27.3
17.5		467.6	2053.2		2520.8	76026.8	30.2
18		233.0	1542.9		1775.9	61443.9	34.6
18.5			705.3	17.5	722.8	27386.9	37.9
19			382.6		382.6	15376.9	40.2
19.5		17.5	122.0	25.5	165.0	7577.4	45.9
Total N	28677.0	33961.6	12573.9	43.0	75255.5	1097206.1	
Percentage (%)	38.1	45.1	16.7	0.1			
Total B	153116.3	600728.1	341610.6	1751.2			
Mean weight (g)	5.3	17.7	27.2	40.7	14.6		
Mean length (cm)	10.7	15.0	16.8	19.1	13.7		

*Table 3.5. Estimated size of Iceland-East Greenland-Jan Mayen capelin **maturing** stock in numbers (millions) by age and length (cm), and biomass (thous. tonnes) from acoustic survey in August 27–September 26 2022. Mean weight in grams.*

	2	3	4	Total N	Total B	Mean weight (g)
13	284.7			284.7	2900.0	10.2
13.5	820.8	34.5		855.3	10352.7	12.1
14	1948.9	34.5		1983.4	27663.9	13.9
14.5	3962.4	279.6		4242.1	65409.9	15.4
15	4530.7	446.6		4977.3	86526.0	17.4
15.5	3934.6	758.1		4692.7	93309.7	19.9
16	3371.8	1674.1		5045.9	111001.8	22.0
16.5	2100.7	1534.5		3635.2	89677.1	24.7
17	1179.3	2271.1		3450.4	94200.2	27.3
17.5	416.7	1976.7		2393.4	72144.0	30.1
18	207.5	1517.4		1724.9	59733.4	34.6
18.5		687.8	17.5	705.3	26748.0	37.9
19		382.6		382.6	15376.9	40.2
19.5	17.5	122.0	25.5	165.0	7577.4	45.9
Total N	22775.7	11719.5	43.0	34538.2	762621.0	
Percentage (%)	65.9	33.9	0.1			
Total B	436700.9	324168.9	1751.2			
Mean weight (g)	19.2	27.7	40.7	22.1		
Mean length (cm)	15.3	16.9	19.1	15.9		

*Table 3.6: Estimated size of Iceland-East Greenland-Jan Mayen capelin **immature** stock in numbers (millions) by age and length (cm), and biomass (thous. tonnes) from acoustic survey in August 27–September 26 2022. Mean weight in grams.*

	1	2	3	Total N	Total B	Mean weight (g)
8.5	724.7			724.7	1630.6	2.2
9	2536.5			2536.5	6830.4	2.7
9.5	2118.1			2118.1	7248.4	3.4
10	3432.2			3432.2	14281.0	4.2
10.5	4997.2			4997.2	23778.4	4.8
11	5346.5	25.5		5372.0	29615.7	5.5
11.5	4646.8	76.5		4723.3	30207.2	6.4
12	2781.8	25.5		2807.3	21207.3	7.6
12.5	1636.8	236.1		1872.9	16513.5	8.8
13	354.5	901.9		1256.4	12892.6	10.3
13.5	51.0	1693.5		1744.5	20210.0	11.6
14	51.0	2813.9	141.6	3006.5	39033.8	13.0
14.5		2221.5	111.0	2332.5	33797.1	14.5
15		1136.1	141.6	1277.7	21271.3	16.6
15.5		898.6	127.4	1026.0	19610.3	19.1
16		672.7	76.5	749.1	16107.0	21.5
16.5		203.9	43.0	246.9	5964.4	24.2
17		203.9	94.0	297.8	8153.9	27.4
17.5		51.0	76.5	127.4	3882.8	30.5
18		25.5	25.5	51.0	1710.5	33.6
18.5			17.5	17.5	638.9	36.5
Total N	28677.0	11185.9	854.3	40717.3	334585.1	
Percentage (%)	70.4	27.5	2.1			
Total B	153116.3	164027.2	17441.7			
Mean weight (g)	5.3	14.7	20.4	8.2		
Mean length (cm)	10.7	14.4	15.6	11.8		

3.3 Survey bootstrap uncertainty estimation

Uncertainty of estimates of stock parameters was estimated using bootstrap according to ICES (2015). Table 3.7 gives the bootstrap mean, CV and standard quantiles of selected stock parameters.

*Table 3.7: Mean and quantiles of stock assessment. EA: echo abundance (NASC*Area, millions m^2), N: number of individuals (billions), B: biomass (thous. tonnes), SS: mature, Imm: immature.*

para	mean	CV	pt5	pt25	pt50	pt75	pt95
EA	5.25	0.16	3.94	4.65	5.20	5.79	6.73
N	75.56	0.17	56.35	66.75	74.82	83.62	97.25
B	1094.67	0.17	810.26	963.01	1081.83	1212.59	1422.47
SSN	34.50	0.20	24.23	29.56	33.90	38.82	46.84
SSB	760.84	0.20	531.78	651.15	747.32	857.00	1035.66
ImmN	41.06	0.22	27.43	34.61	40.34	46.70	57.09
ImmN1	29.13	0.28	17.11	23.21	28.30	34.10	44.06
ImmN2	11.10	0.27	6.62	8.91	10.82	12.99	16.51
ImmB	333.83	0.21	228.82	284.43	328.82	377.79	455.98
Prop. N3 in SSN	0.34	0.14	0.26	0.31	0.34	0.37	0.42
Prop. B3 in SSB	0.42	0.13	0.33	0.39	0.42	0.46	0.51

3.4 Predation model results

After the survey and upon completion survey estimation of stock parameters and their uncertainty 100 thous. bootstrap replicates were used as starting values for predation model runs (Höskuldur Björnsson and Kristinn Guðnason, pers. comm) results from the autumn 2033 predation runs are given in Table 3.8 and shown in Figures 3.7–3.8.

Table 3.8: Quantiles and mean of SSB at time of spawning (15. March) and total predator consumption in thous. tonnes based on the predation model.

	Mean	5%	25%	50%	75%	95%
SSB	708.99	150.00	436.30	671.31	942.43	1395.63
Predation	226.61	147.98	188.09	221.79	259.64	322.23

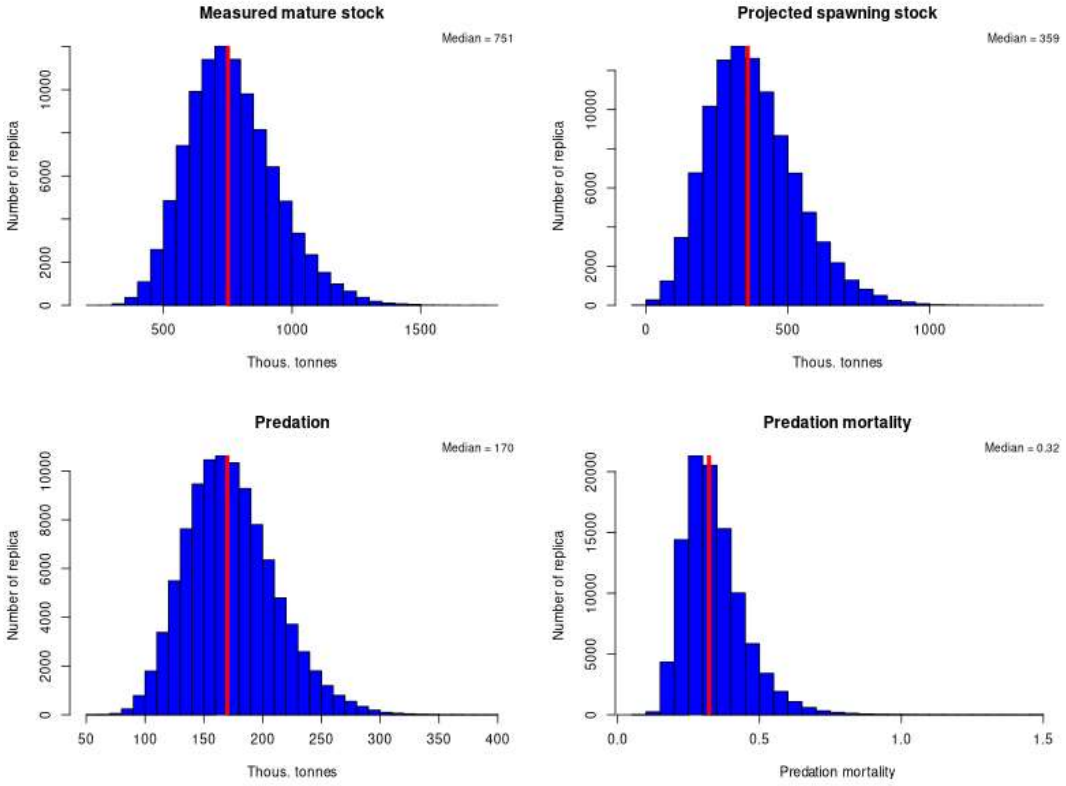

Figure 3.7: Summary of results from the 2022 autumn acoustic survey and predation model predictions. Biomass survey estimates of mature capelin (top-left), the projected spawning stock biomass left for spawning based on the predation model (top-right), predicted predation 15 January – 15 March (bottom-left) and the applied predation mortality (bottom-right)

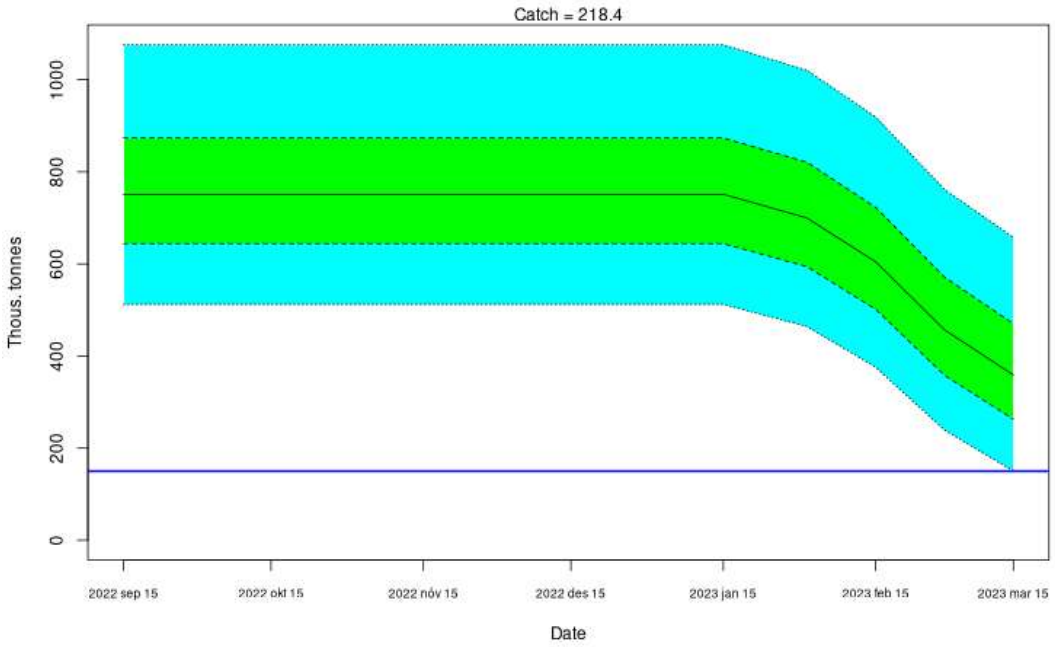

Figure 3.8: Predicted development of the SSB with 218 400 t catch based on the predation model

4 Appendix

4.1 Personnel

4.1.1 A10-2022 — r/v Árni Friðriksson 5–26 September

Role	Name
Chief scientist	Sigurður Þór Jónsson
Acoustics	Thassya Christina dos Santos Schmidt
Acoustics/technichian	Arnþór Bragi Kristjánsson
Biological sampling	Ragnhildur Ólafsdóttir
Biological sampling	Gunnhildur Vigdís Bogadóttir
Biological sampling	Sverrir Daniel Halldórsson
Captain	Heimir Örn Hafsteinsson

4.1.2 TARA6-2022 — r/v Tarajoq 27 August–20 September

Role	Name
Chief scientist	Lars Heilman
Acoustics / Co-chief scientist	Kristinn Guðnason (until 8 September)
Acoustics / Co-chief scientist	Sigurvin Bjarnason (from 8 September)
Acoustics / technician	Rune Garmund
Acoustics / Biological sampling	Eva Maria Pedersen (until 8 September)
Acoustics / Biological sampling	Maria Krüger-Johnsen (from 8 September)
Biological sampling	Jørgen Sethsen
Biological sampling / zooplankton	Hildur Pétursdóttir (until 8 September)
Biological sampling	Malthe Kjølhede Ahlmann Olesen (from 8 September)

References

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Vilhjálmsson, Hjálmar. 1994. “The Icelandic Capelin Stock: Capelin, Mallotus villosus (Müller) in the Iceland–Greenland–Jan Mayen Area.” *Rit Fiskideildar* 13: 1–281.