Cruise: A11-2018
Period: 06.09.-27.09. 2018.

Cruise: B12-2018
Period: 10.09.-26.09. 2018.

Cruise: EROS1-2018
Period: 07.09.-23.09. 2018.

Preliminary cruise report: Acoustic assessment of the Iceland-East Greenland-Jan Mayen capelin stock in autumn 2018.

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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 Bjarni Saemundsson 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 59° 20´N to about 75°00´ N, also covering the Denmark Strait and the slope off west and north Iceland. Western regions of the Iceland Sea, West Jan Mayen and Greenland basin were also surveyed.

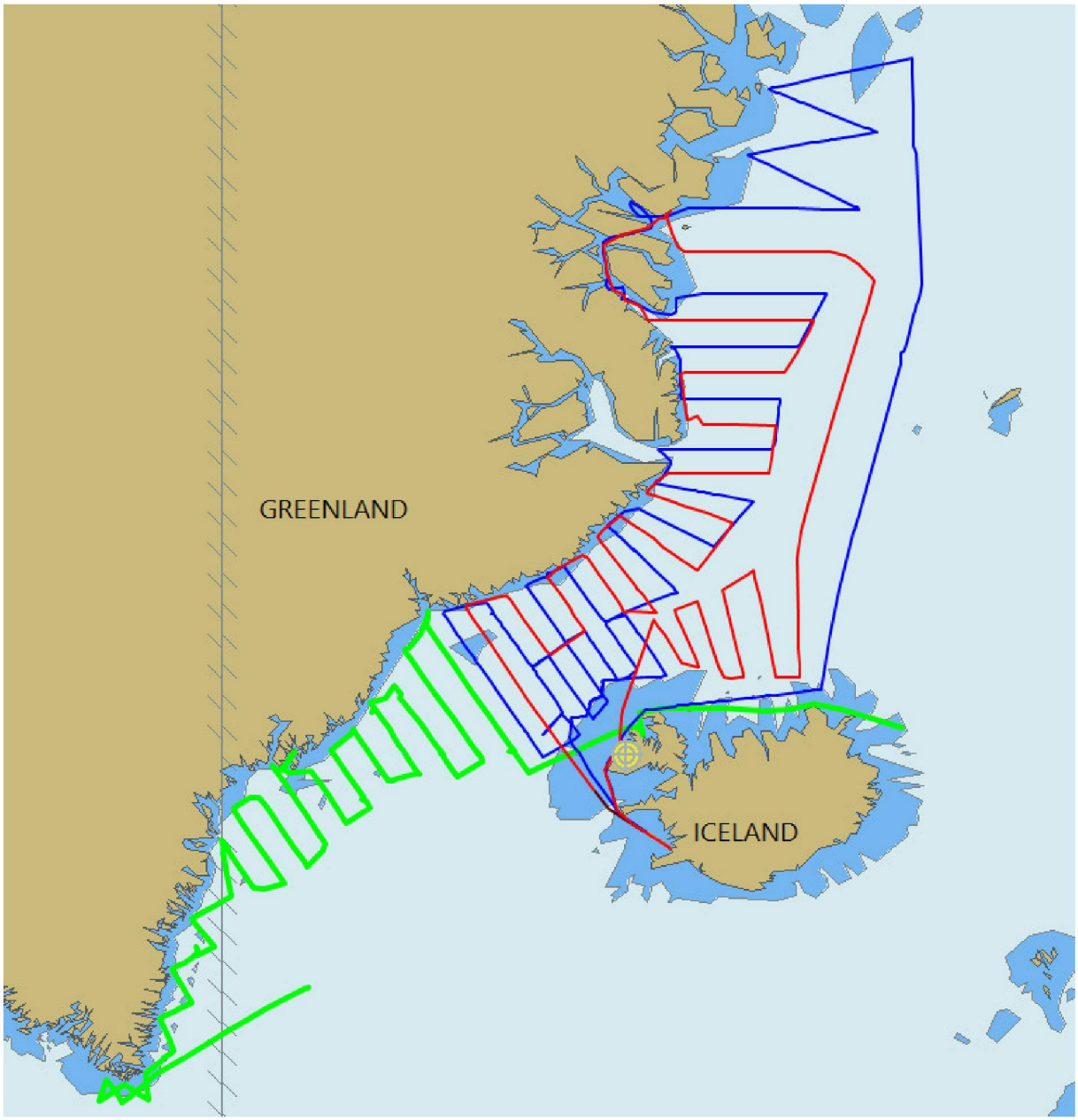

Figure 1 Routes of the research vessels; Arni Fridriksson (blue), Bjarni Saemundsson (red) and Eros (green).

Eros left Alesund harbour the 0 4th of September and sailed to Isafjordur in Iceland to pick up scientists and for calibration of the echosounders. Eros was on first transect the 08th of September and in continuance covered the southwestern parts of the survey region (Figure 1) with intentions to study further some of the Greenlandic fjords in the area. The 06th of September the research vessel Arni Fridriksson started the survey from Reykjavik. Due to weather conditions Arni started by measuring the southern part of Denmark Strait. The 10th of September Bjarni left harbour in Reykjavik and joined Arni as both vessels covered the northern part of Denmark Strait. The two vessels just managed to reach north of Denmark Strait before it became inaccessible for several days due to heavy winds. In continuance, they managed to reach 72°20'N before having to seek shelter the 18th (Bjarni) and 19th (Arni) September in Kong Oscar fjord due to bad weather. Both vessels used the shelter of the fjords to sail through Sofia sound and gain 60 nmi northward shift during the bad weather. Hence, as soon as conditions were more promising both vessels started measuring early in the morning

of 21. September, east of Keiser Frans Joseph fjord. Bjarni then sailed southwards and surveyed shelf areas north of Iceland and ended the survey by calibrating the echosounders in Arnarfjordur before harbouring in Reykjavik the 26th September. Arni surveyed northwards by the Greenlandic shelf areas until reaching 75°N and then sailed south to Thistilfjardardjup on the Icelandic shelf and also ended the survey by calibrating echosounders in Arnarfjordur before harbouring in Reykjavik the 27th September. Sea ice did not hinder the survey extent in open water areas although most of the Greenlandic fjords could not be entered by Eros due to sea ice. In areas near the Greenlandic coast the captains of all vessels often had concerns because of limited bathymetric information on available nautical charts.

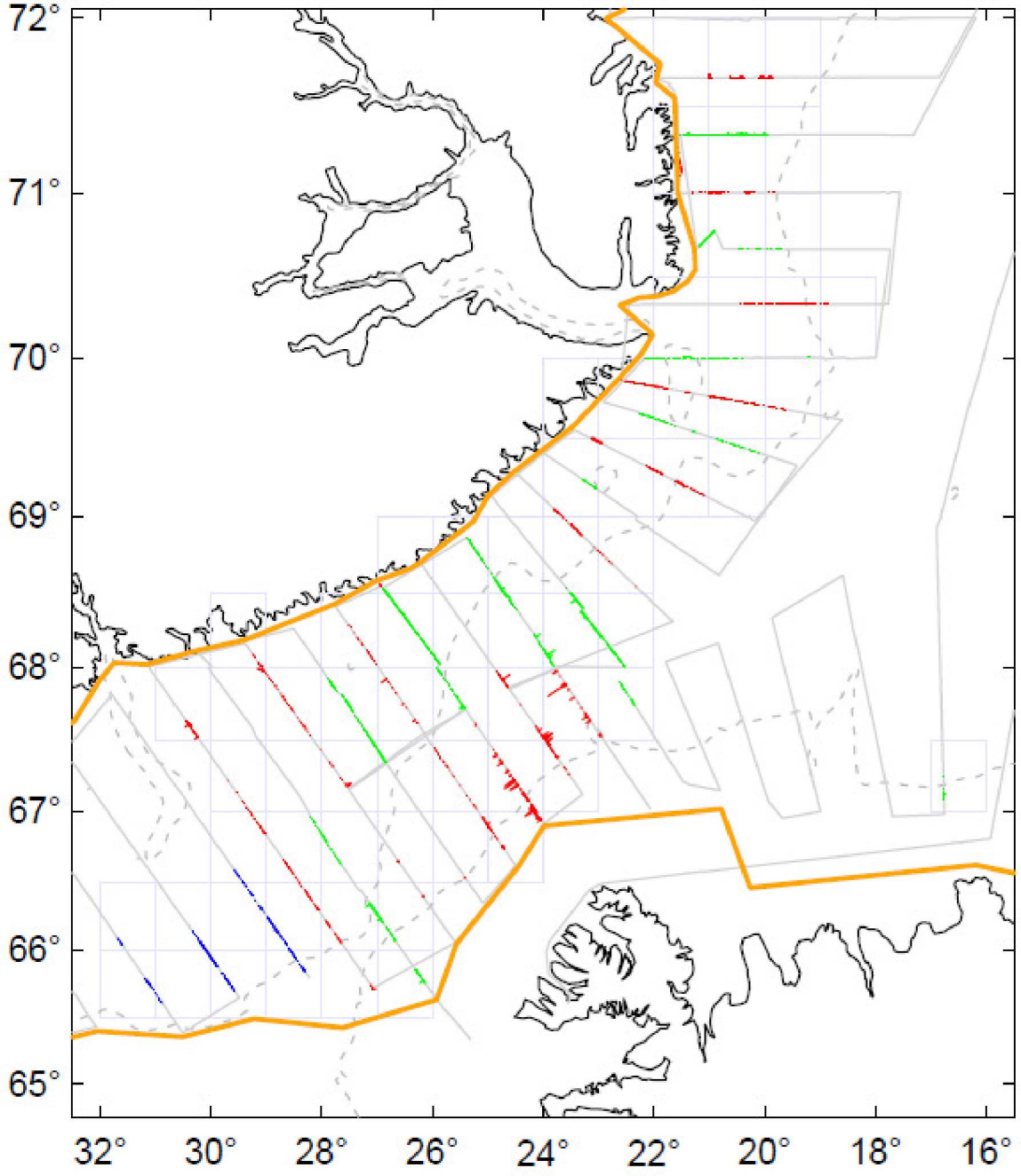

Figure 2 Capelin distribution as relative density of acoustic backscatter during the survey. Survey tracks of R/V Arni Fridriksson and R/V Bjarni Saemundsson and F/V Eros are shown as black transect lines.

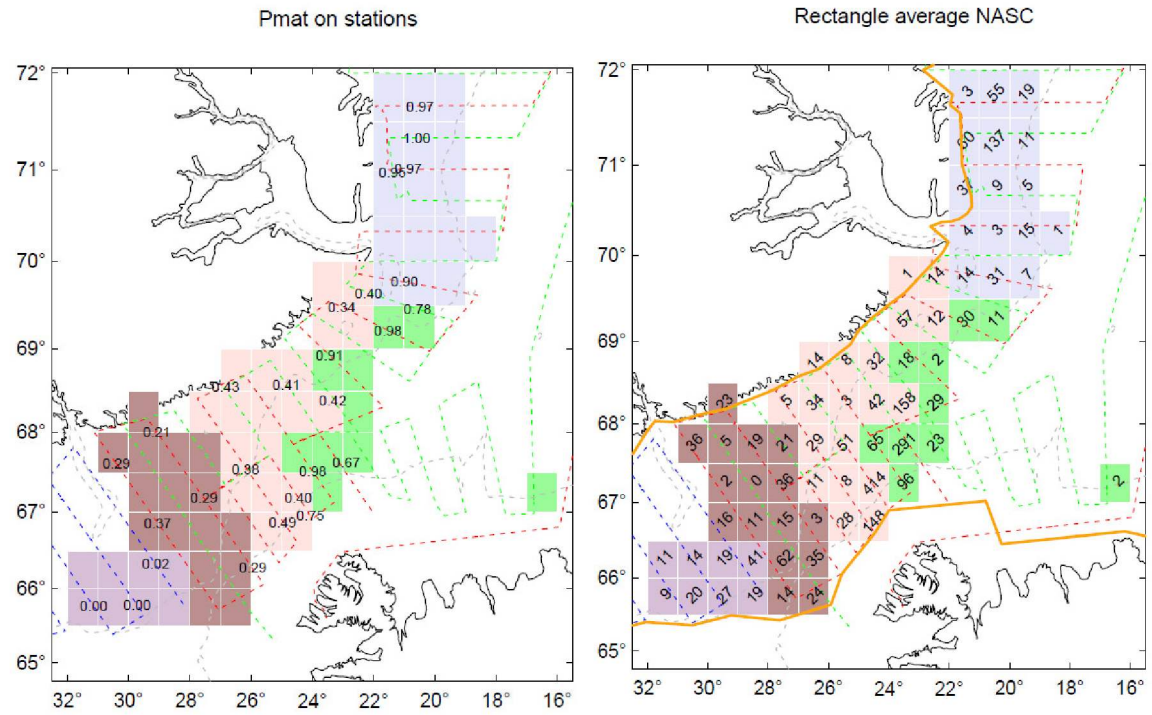

Figure 3 Region allocations by color. Maturity proportion at each trawl station and average NASC within each rectangle.

Acoustic sampling:

Acoustic data was sampled with Simrad EK60 transducer at four frequencies in Arni Fridriksson (18, 38, 120 and 200 kHz), three frequencies (18, 38 and 120 kHz) in Bjarni Saemundsson and five frequencies in Eros (18, 38, 70, 120 and 200 kHz). The 38 kHz data were scrutinized using LSSS (version 2.3.0) software where capelin backscatter was defined and its Nautical Area Scattering Coefficient (NASC) in S_A 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 $1m^2$)

$$TS = 19.1 \log(L_{+0.25}) - 74.5$$

Where $L_{+0.25}$ is total length (cm) added by 0.25 cm because of the design of the measuring board (0.5 cm interval in front of the grid) used onboard Arni and Bjarni. Onboard Eros the total length of the capelin was measured to nearest mm and afterwards adapted to the Icelandic data. For each length interval within the length distribution of capelin in the samples the following parameters were calculated: backscattering proportion, number and weight.

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

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

$$W_L = C_L * \overline{Ws_L}$$

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

Biological sampling:

Pelagic trawl:

Total length and weight of up to 100 (50 onboard Eros) individual capelin fish was measured for a subsample from the catch at each of 43 pelagic trawl stationsl. Also, sex and maturity were estimated visually and the roe from maturing females were weighted. Age was estimated from otoliths. Stomachs of 10 capelin were preserved on each station and on Árni Friðriksson the contents of 10 additional stomachs were analsyesed coarsly. Also tissue samples were taken from 10 indivuals at each sation for isotope and genetics analysis (???).

MIK net:

Capelin juveniles (0-group) were sampled at 40 station with MIK nets onbard all vessels.

WP2 zooplankton net:

Zooplankton was sampled by WP2 nets at depths down to 50 and 200 m at 108 stations at same location as CTD measurements

Bongo nets:

Onboard Arni and Bjarni macro-zooplankton was sampled by Bongo nets at towdepths of the trawl at each trawl stations when conditions allowed. Further 6 Bongo samples were sampled diagonally down to 150 m at chosen transects.

Capelin gonad samples:

Gonads of 12 capelin were sampled in formaldehyde and imaged for gonad development study, stomachs of 50 capelin were sampled in ethanol for a trophic study.

eDNA:

eDNA samples were filtered from seawater at various depths at 20 locations to facilitate the development of methods for screening for capelin DNA in the seawater samples.

Marine mammal observation and tagging:

Four marine mammal and seabird observers were on-board Arni and Eros while there were 2 onboard Bjarni. Two humpback whales were tagged with satellite tags.

Environmental measurements:

Conductivity, Temperature and depth (CTD) measurements were made at 111 locations and surface temperature and salinity were also measured continuously during the survey on Árni and Bjarni.

Results

Distribution of capelin

Capelin schools were observed mainly north off the continental shelf edge north of the Vestfirðir peninsula and along the East Greenlandic continental shelf in Denmark Strait and the Scoresby areas. No capelin was found by western Jan Mayen ridge or Iceland Sea. Considerable quantities of 0-group capelin (although not quantified) were observed along the continental shelf north of Iceland while no older capelin was found in the areas east of the Vestfirdir peninsula with the exception of very limited quantities north of Axarfjordur (Fig. 1). Immature capelin was found in low numbers, or 10.8 billion whereof 10.3 billion belonged to capelin at age 1. Immature capelin was generally found in the southwestern part of the surveyed area but further east by the Vestfirdir peninsula and north along the Greenland shelf older, maturing capelin predominated. The distribution of capelin was westerly as in recent years although there was increased proportion of mature capelin by the Vestfirdir peninsula. Further, mature capelin was found very close to the Greenlandic coast. Figure 2 shows 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 table 1. The total number of capelin amounted to 22 billion whereof the 1-group was about 11.9 billion. The total estimate of 2-group capelin was about 9.2 billions. The total biomass estimate was 337 000 tonnes of which about 225 000 tonnes were 2 years and older. About 13.0 % in numbers of the 1- group was estimated to be maturing to spawn, about 95.4 % of the 2 year old and 98.5 % of the 3 year old capelin appeared to be maturing. This gives 238 000 tonnes of maturing 1 - 4 year old capelin. Table 1 gives the age disaggregate biomass, numbers and weights of the capelin.

Environment

Only environment variables from selected transects are shown.

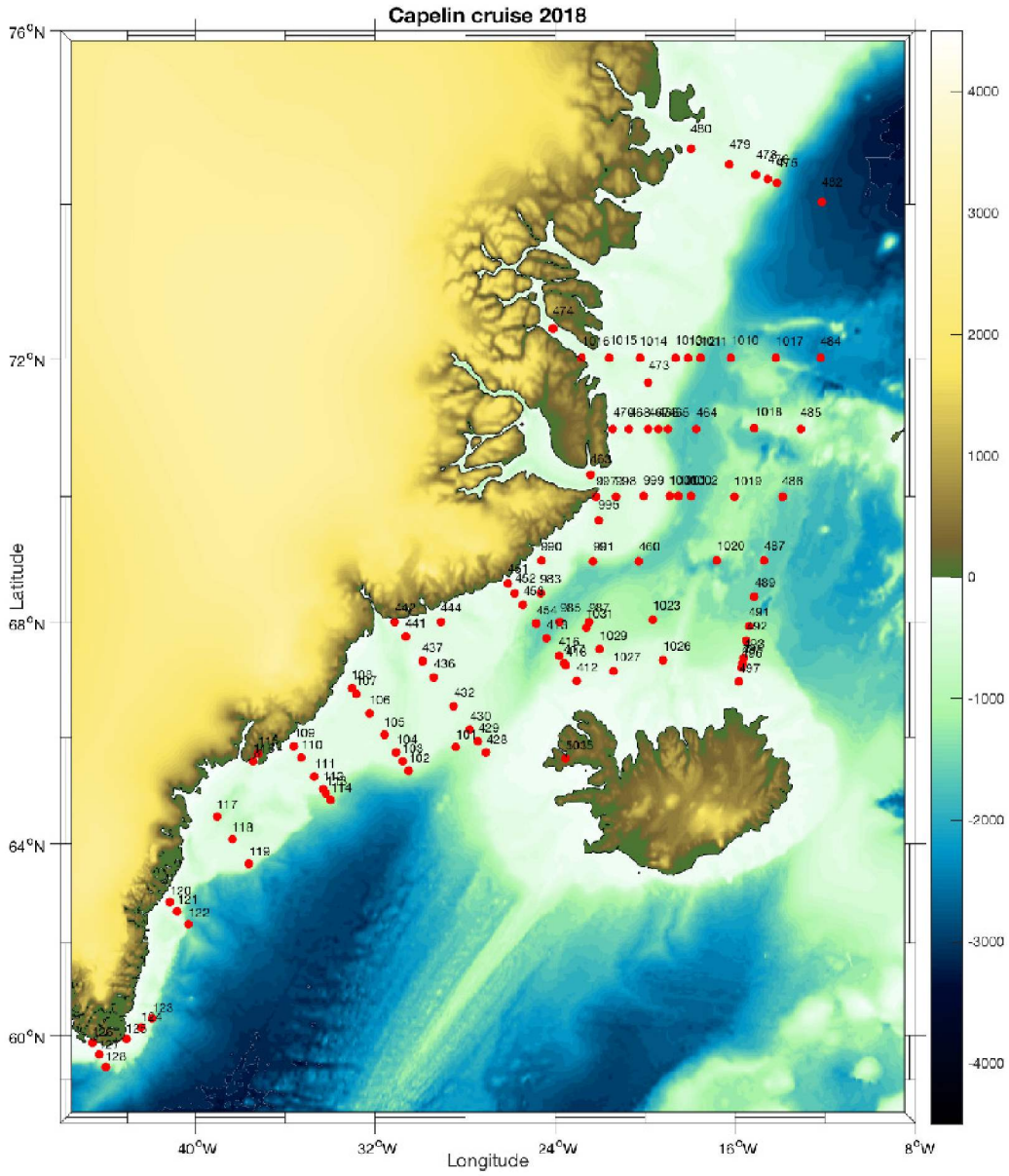

Figure 4 Overview of CTD stations.

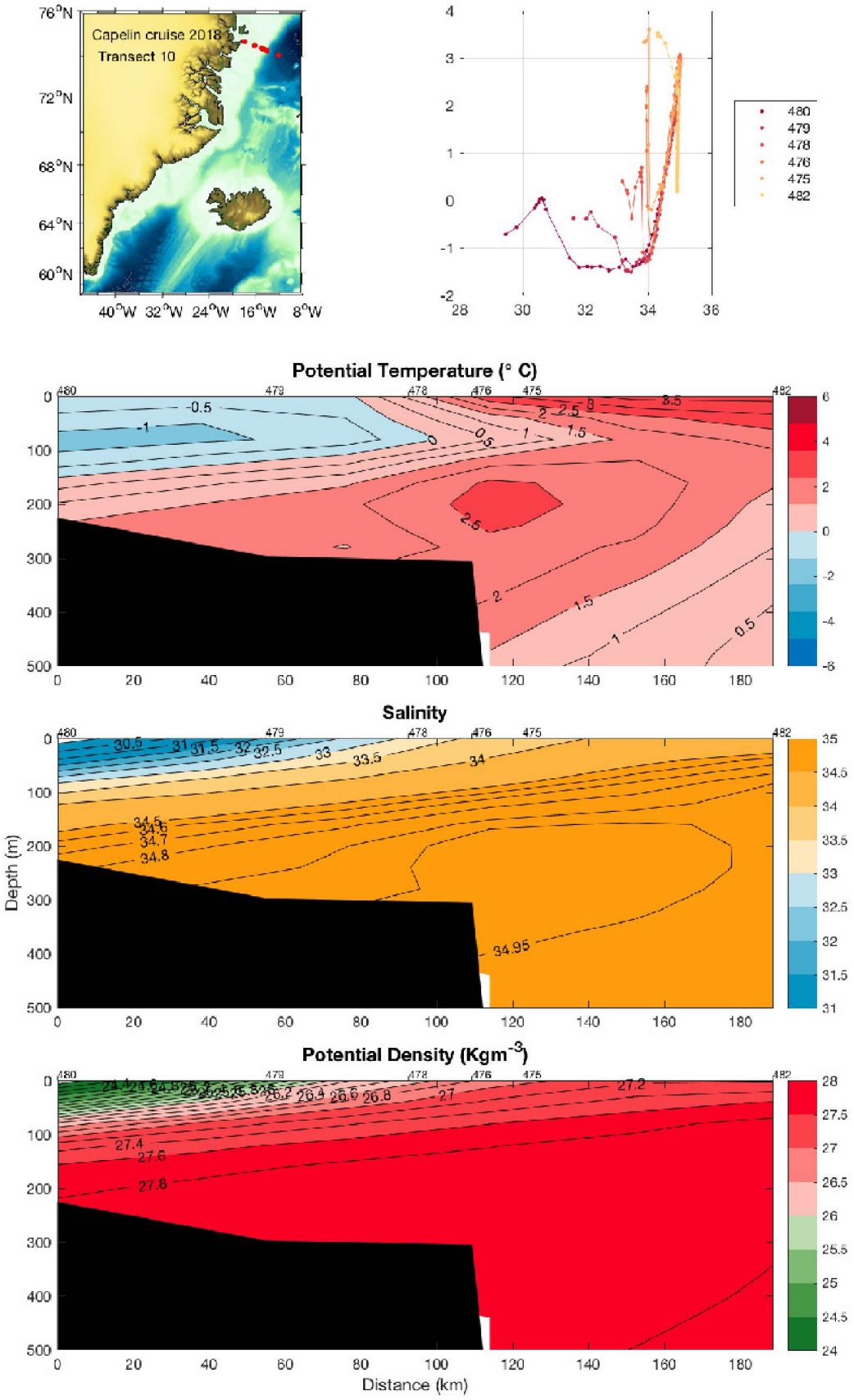

Figure 5 Transect east of Pendulum Islands. Transect direction: East.

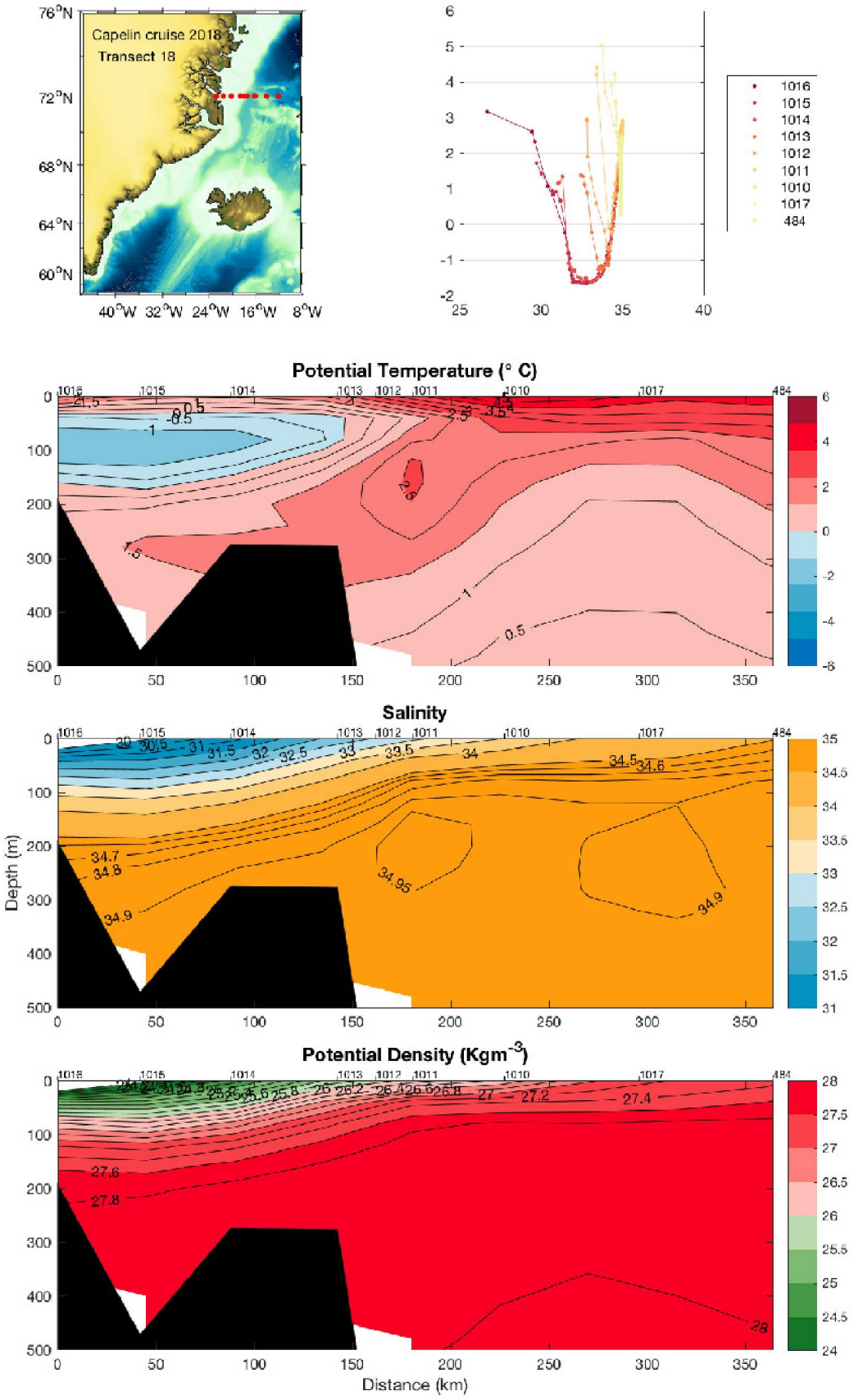

Figure 6 Transect east of Kong Oscar fjord. Transect direction: East.

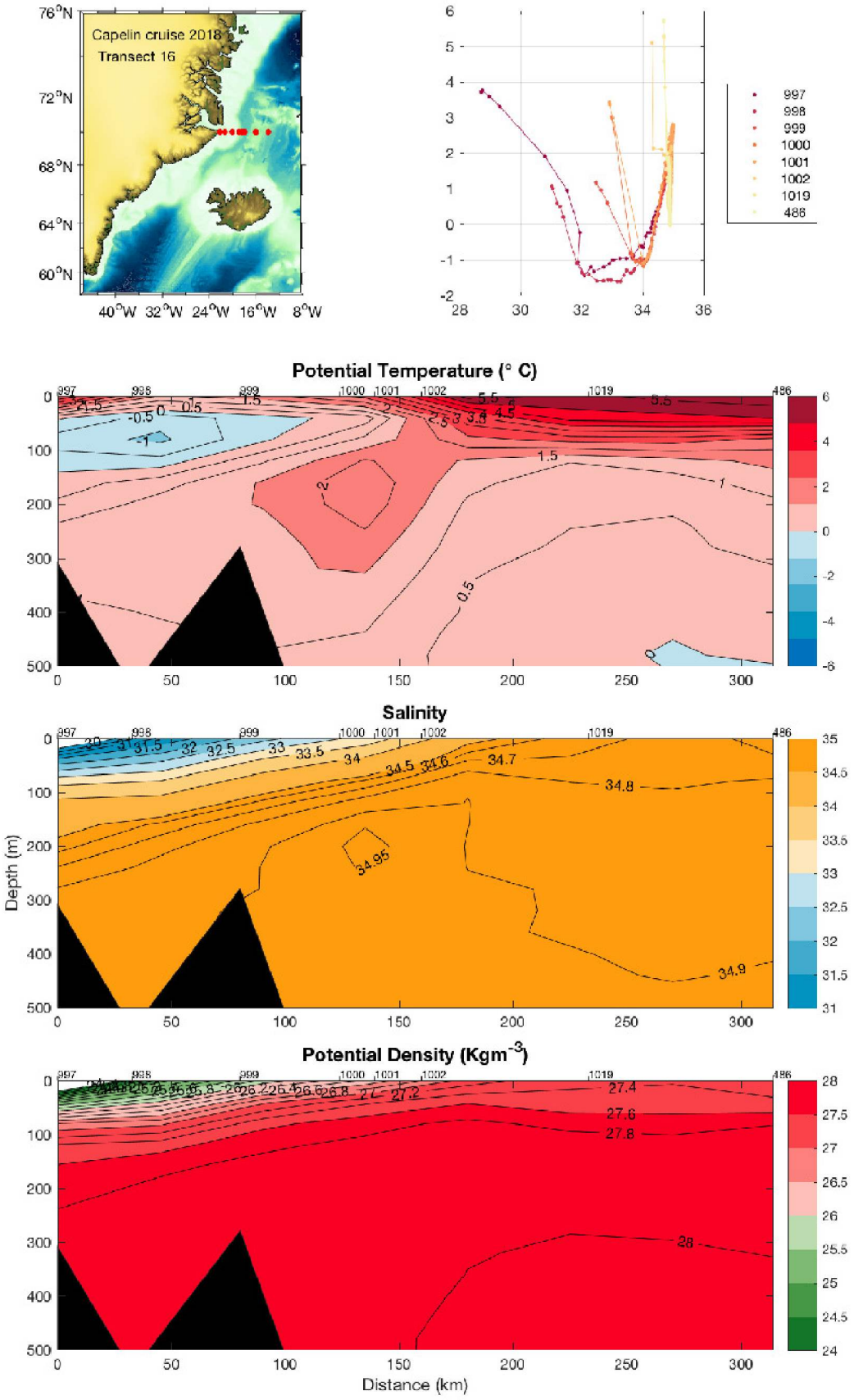

Figure 7 Transect east of Scoresby. Transect direction: East.

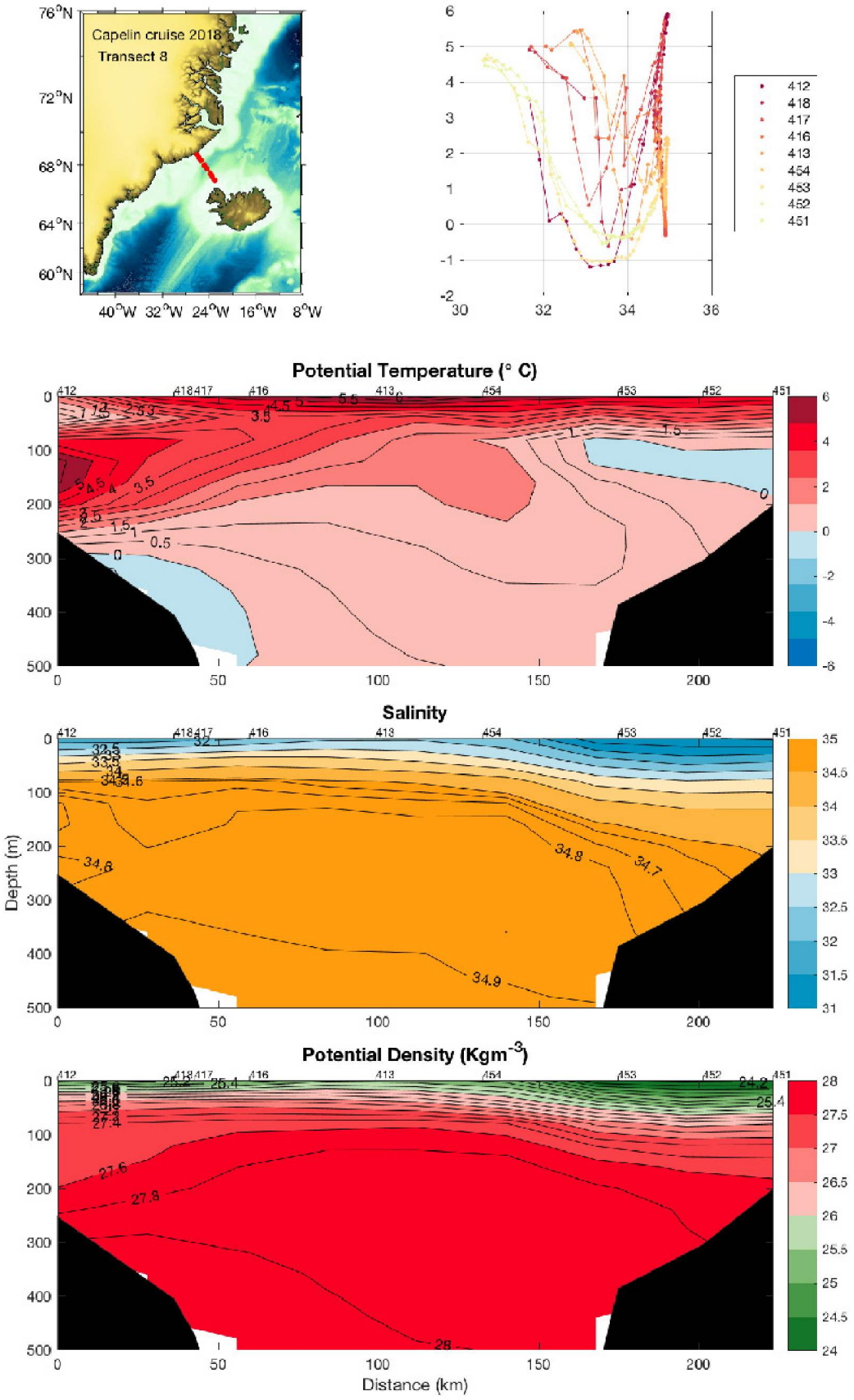

Figure 8 Transect in Denmark Strait. Transect direction: Northwest.

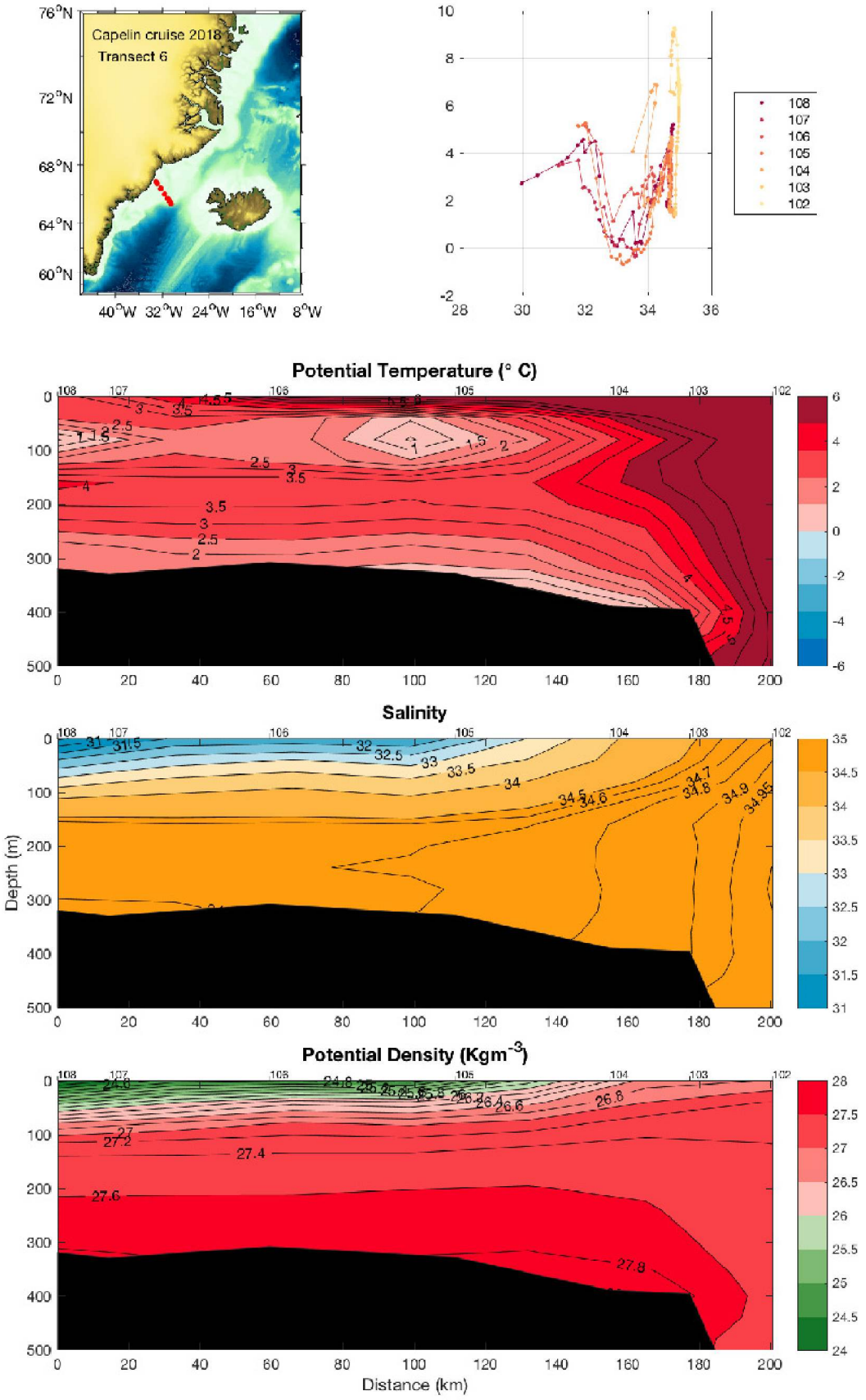

Figure 9 Transect on Greenland shelf. Transect direction: Southeast.

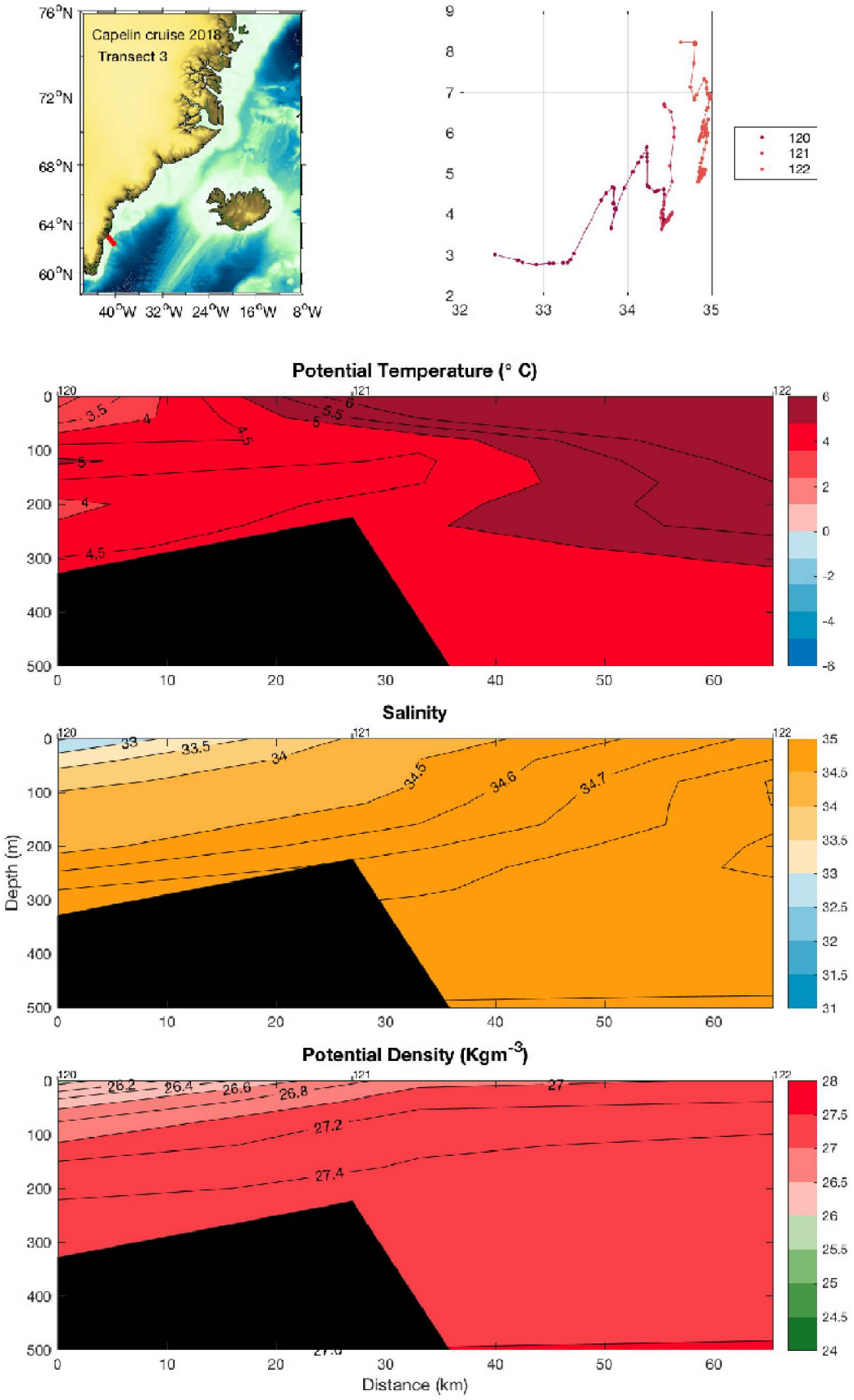

Figure 10 Transect in the southern region of East Greenland shelf. Transect direction: Southeast.

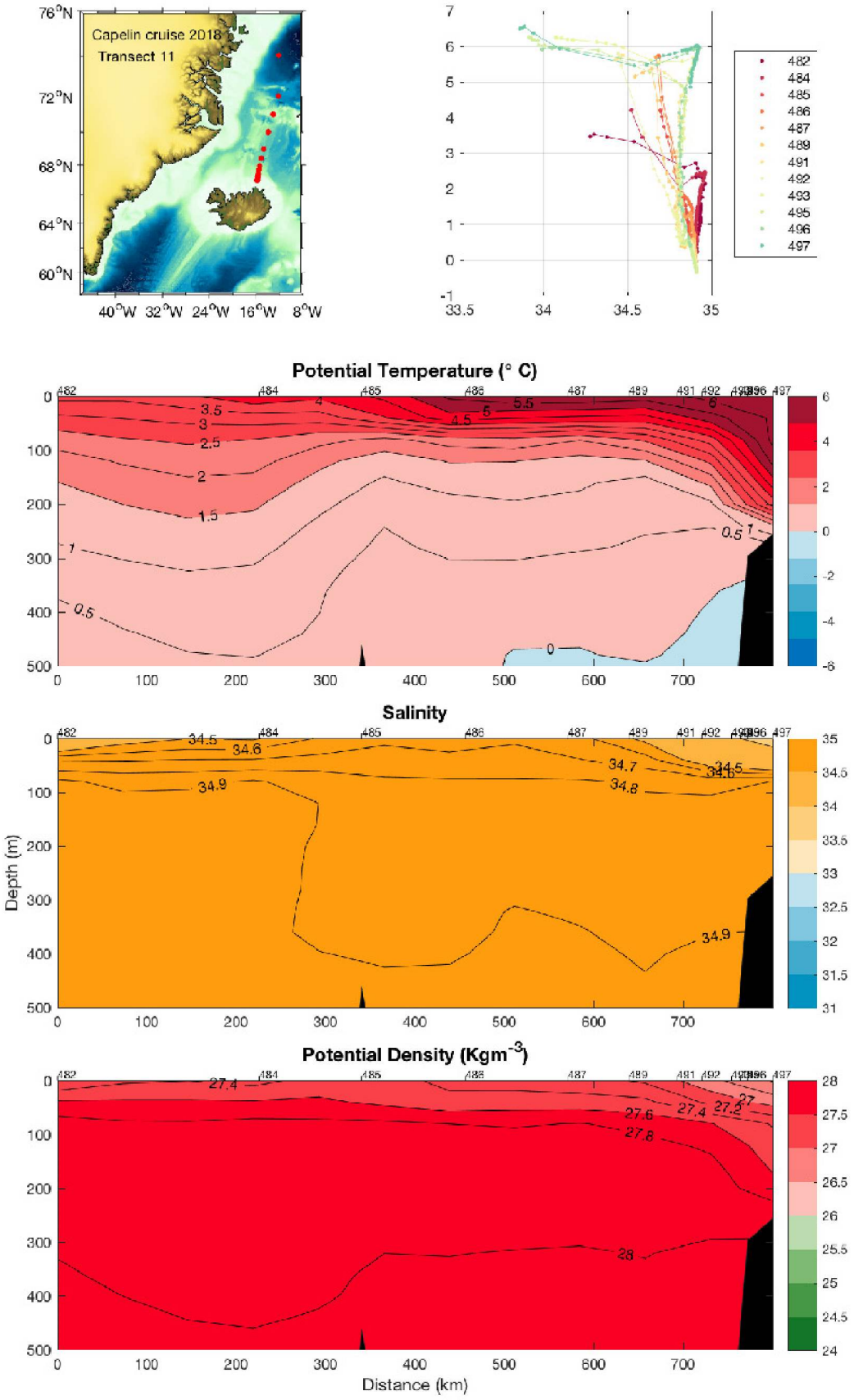

Figure 11 North – south transect through Greenland basin, over West Jan Mayen ridge and through Iceland sea. Transect direction: South.

Tables

Table 1 *Overview of sampling stations.*

		Number of stations			
Sampling target	Gear	Arni	Bjarni	Eros	Total
Fish	Pelagic trawl	21	10	12	43
Zooplankton	Bongo	18	10		28
Zooplankton	WP2	44	37	27	108
Capelin larvae/juveniles	MIK	7	14	19	40
Environment	CTD	45	38	28	111

Table 2 Estimated stock size of Iceland-Greenland-Jan Mayen capelin stock in numbers by age and length, and biomass from the acoustic survey in 06. – 28. September 2018. Summary statistics for the total stock and the maturing and immature part of stock are given at the bottom of the table.

	Length	Numbers at Age (10^9)			Numbers	Biomass	Mean
	(cm)	1	2	3	(10^9)	(10^3 t)	weight (g)
	9.5	0.08	0.00	0.00	0.08	0.27	3.6
	10	0.12	0.00	0.00	0.12	0.54	4.3
	10.5	0.53	0.00	0.00	0.53	2.68	5.1
	11	0.95	0.00	0.00	0.95	5.70	6.0
	11.5	1.29	0.00	0.00	1.29	8.82	6.8
	12	1.86	0.01	0.00	1.87	14.66	7.9
	12.5	2.16	0.02	0.00	2.18	19.53	9.0
	13	1.90	0.03	0.00	1.92	20.02	10.4
	13.5	1.37	0.08	0.00	1.45	17.11	11.8
	14	0.97	0.28	0.00	1.25	16.60	13.3
	14.5	0.43	0.52	0.00	0.96	14.51	15.2
	15	0.17	1.08	0.01	1.27	21.56	17.0
	15.5	0.05	1.73	0.05	1.84	34.93	19.0
	16	0.01	1.69	0.11	1.81	38.10	21.1
	16.5	0.00	1.75	0.15	1.90	45.01	23.7
	17	0.00	1.30	0.20	1.50	39.90	26.6
	17.5	0.00	0.51	0.24	0.75	21.72	28.9
	18	0.00	0.18	0.17	0.34	10.86	31.6
	18.5	0.00	0.04	0.05	0.09	3.03	33.4
	19	0.00	0.01	0.02	0.03	1.02	40.9
	0	0.00	0.00	0.00	0.00	0.00	0.0
	0	0.00	0.00	0.00	0.00	0.00	0.0
	0	0.00	0.00	0.00	0.00	0.00	0.0
	0	0.00	0.00	0.00	0.00	0.00	0.0
	0	0.00	0.00	0.00	0.00	0.00	0.0
TSN (10^9)		11.89	9.21	1.01	22.1		
TSB (10^3 t)		177	198	27		336.60	
Mean W (g)		14.9	21.5	27.0			15.2
Mean L (cm)	14.1	12.5	16.0	17.1			
%TSN		53.8	41.7	4.6			
SSN (10^9)		1.5	8.8	1.0	11.3		
SSB (10^3 t)		20.0	191.0	27.0		238.0	
SMean W (g)		12.9	21.7	27.1			21.0
SMean L (cm)	15.8	13.7	16.0	17.1			
%SSN		13.6	77.6	8.8			
ISN (10^9)		10.3	0.4	0.0	10.8		
ISB (10^3 t)		91.3	7.0	0.3		98.6	
IMean W (g)		8.8	16.5	21.2			9.1
IMean L (cm)	12.4	12.3	14.8	16.0			
%ISN		95.9	3.9	0.1			

Advice for Intermediate TAC of

Capelin in the Iceland-East Greenland-Jan Mayen area

for

the 2018/2019 fishing season

based on

Autumn survey (06. – 27. September 2018).

Marine & Freshwater Research Institute, Iceland.

Date: 15th October 2018

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

Based on current HCR the Marine Research Institute advices **0** catch of capelin during the fishing year 2018/2019. This is an intermediate TAC advice set at catch giving p(SSB < Blim = 150kt) < 0.05, that should be re-evaluated following measurements of the maturing stock in January-February 2019. Further, abundance of immature capelin was estimated as 10 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 2019.

Bootstrap model:

Acoustic data from the A11-2018, B12-2017 and EROS1-2018 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 5 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 m^2), N = Number of individals (Billions), B = Biomass (Thous. tonnes), SS. = mature, imm. = immature.*

	Mean	*CV*	*5%*	*25%*	*50%*	*75%*	*95%*
EA	1.64	0.21	1.11	1.38	1.61	1.86	2.25
N	22.13	0.21	15.1	18.67	21.7	25.12	30.58
B	336.08	0.21	228.02	283.62	330.75	382.29	462.86
SSN	11.31	0.23	7.35	9.4	11.09	13.02	15.9
SSB	237.2	0.23	153.57	197.12	233.21	273.1	334.84
ImmN	10.82	0.23	7.24	8.98	10.55	12.37	15.36
ImmN1	10.38	0.24	6.89	8.6	10.12	11.91	14.82
ImmN2	0.42	0.3	0.24	0.33	0.41	0.5	0.65
ImmB	98.88	0.23	66.7	82.28	96.42	112.79	139.48
Prop. N3 in SSB	0.09	0.21	0.06	0.07	0.09	0.1	0.12
Prop. B3 in SSB	0.11	0.2	0.08	0.1	0.11	0.13	0.15

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 2019 (Figure 1 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.

	Mean	*5%*	*25%*	*50%*	*75%*	*95%*
SSB	113.58	51.40	82.33	108.18	138.70	194.81
Predation	125.56	78.55	102.43	122.54	145.68	182.27

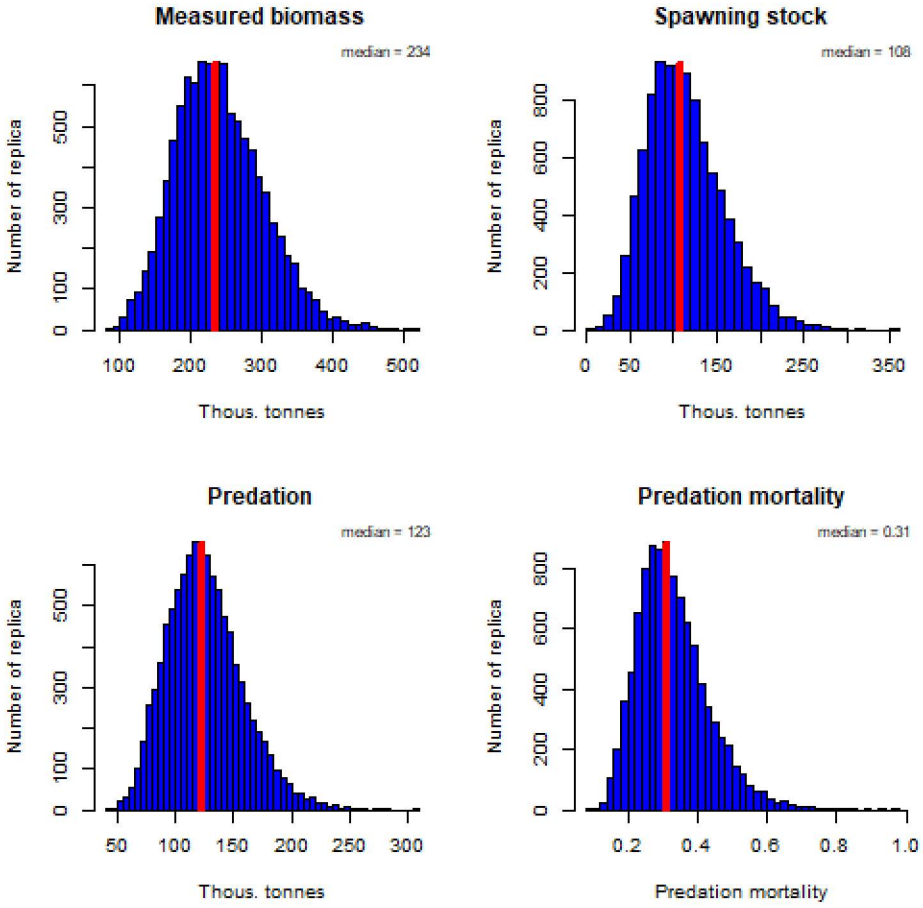

Figure 1 Summary of results from the 2018 autumn survey and 1985-2018 predator data.

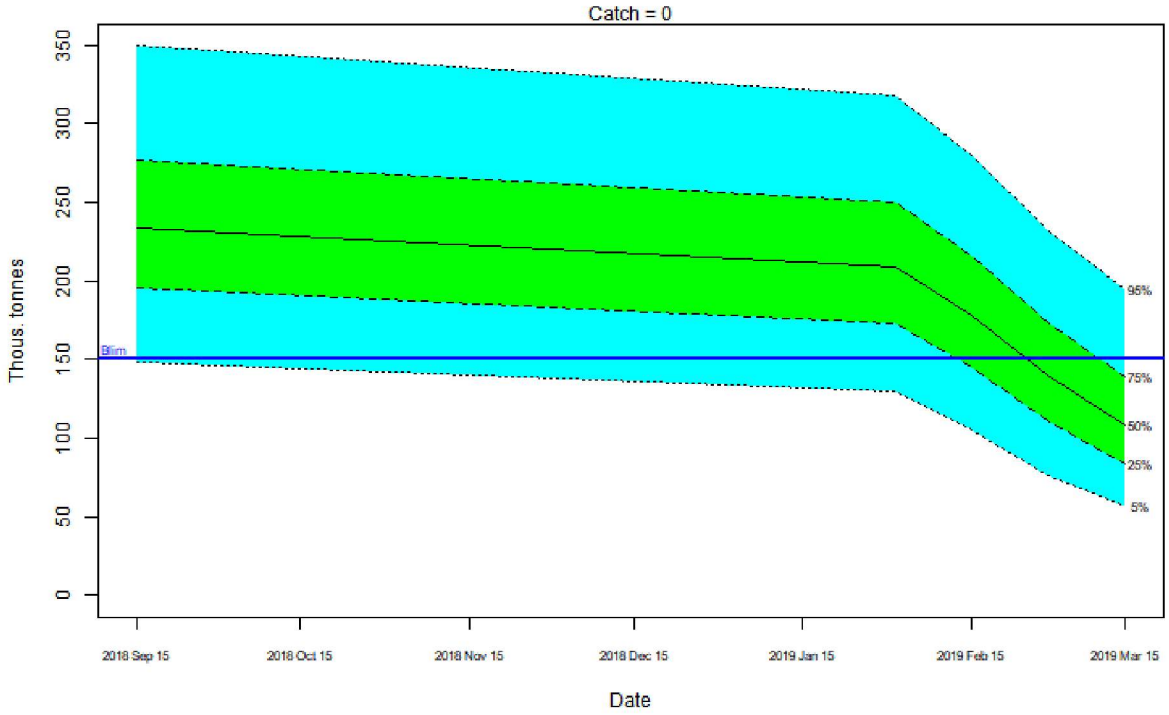

Figure 2 Developement of the SSB with no catch.