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

Cruise: A02-2018
Period: 16.01.-31.01. 2018.

Cruise: PA01-2018
Period: 18.01-31.01. 2018.

Cruise: B02-2018
Period: 16.01.-31.01. 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 stock components. The capelin spawningstock had been estimated as 954 000 tonnes in autumn survey conducted in September-October 2017.

Vessels

The survey was conducted by the r/s Arni Fridriksson, r/s Bjarni Saemundsson and the Greenlandic pelagic fishing vessel Polar Amaroq.

There were 5 Scientist based on board each vessel from the Marine Research Institute of Iceland and one scientist from IMR Norway. Polar Amaroq had facilities for observations of acoustic measurements and for processing and analysis of fish samples. Further, the vessel was equipped with a scientific echosounder (Simrad EK80 38kHz).

Calibration

In December the echosounder of Polar Amaroq was successfully calibrated in Nordfjordur. Echosounders of the research vessels were calibrated just before the cruise.

Coverage and procedures

The vessels were planned to be stand by in the period 10th – 25th January, waiting for promising weather forecasts.

The vessels were standby from late January waiting for promising weather conditions for acoustic measurements. Polar Amaroq left harbour from Neskaupstadur the 11. January with 5 scientists on-board. This way the vessel could go fishing while at the same time the eastern (foremost) location of the capelin migration would be observed. Following fishing and biological sampling in the area, Polar Amaroq started acoustic sampling the 18. January along transects east of Iceland.

Outlooks in the east and northeast of Iceland were promising for a few days period following the 17th of January although forecasts still predicted heavy winds in Denmark Strait during coming days. Hence, Arni Fridriksson and Bjarni Saemundsson left Reykjavik harbour the 16th of January to start acoustic measurements east of Iceland in the hope to get continuous measurements westwards from off Eastfjords towards Denmark Strait.

The 3 vessels managed to get conditions for a continuous coverage of acoustic measurements from east to west until just off Hornall, north of the Westfjords peninsula.

Capelin was observed along the continental slopes while also in some areas further off the shelf or further up on the continental shelf (Fig. 1). Immature capelin predominated in the western part of the survey area, mainly west of Kolbeinsey-ridge, while larger maturing capelin dominated further east (Fig. 2).

The vessels finished the acoustic measurements the 30th of January east of Iceland.

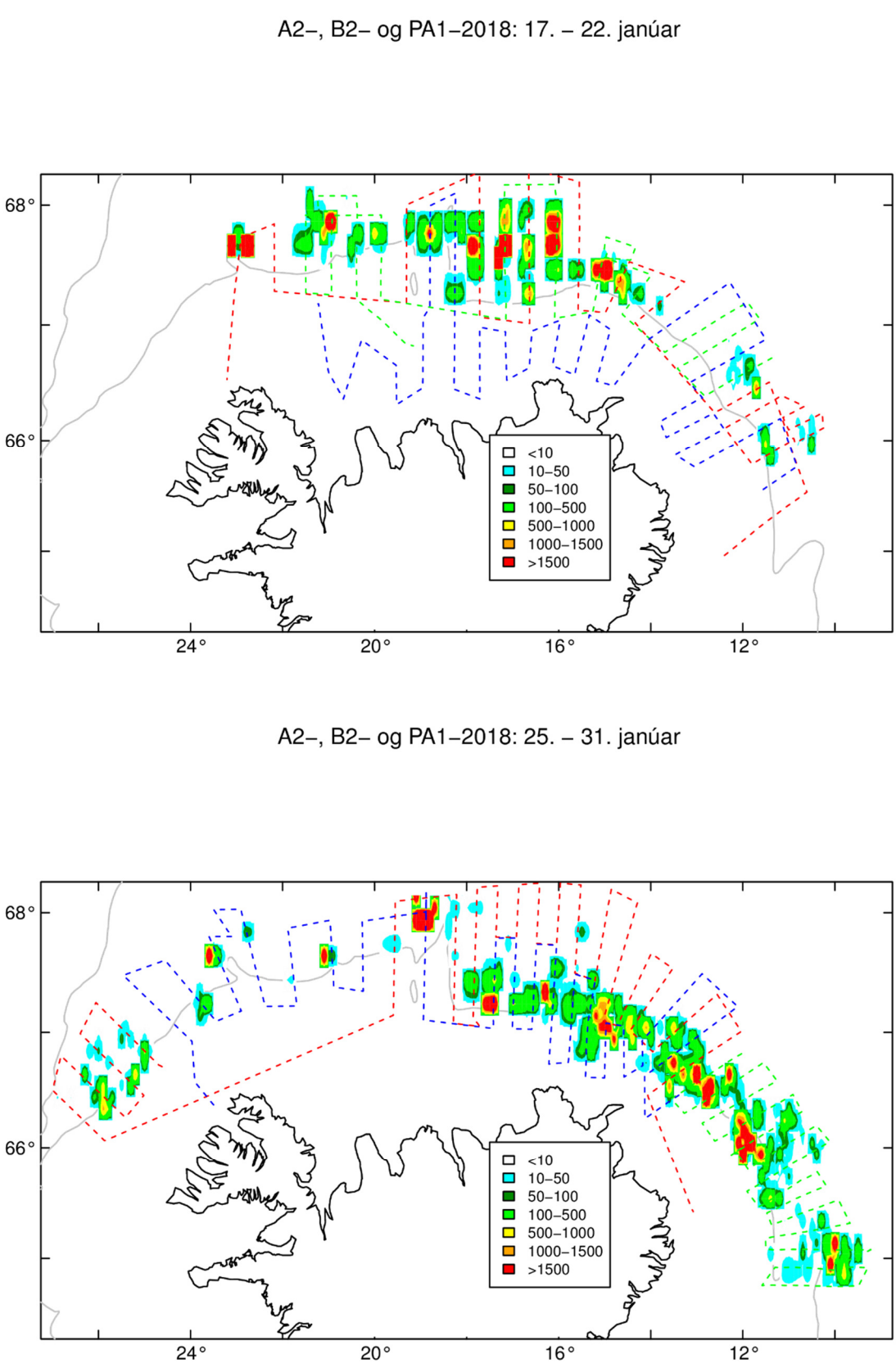

Figure 1. *Distribution and density of capelin backscatter. Black lines indicate vessel tracks.*

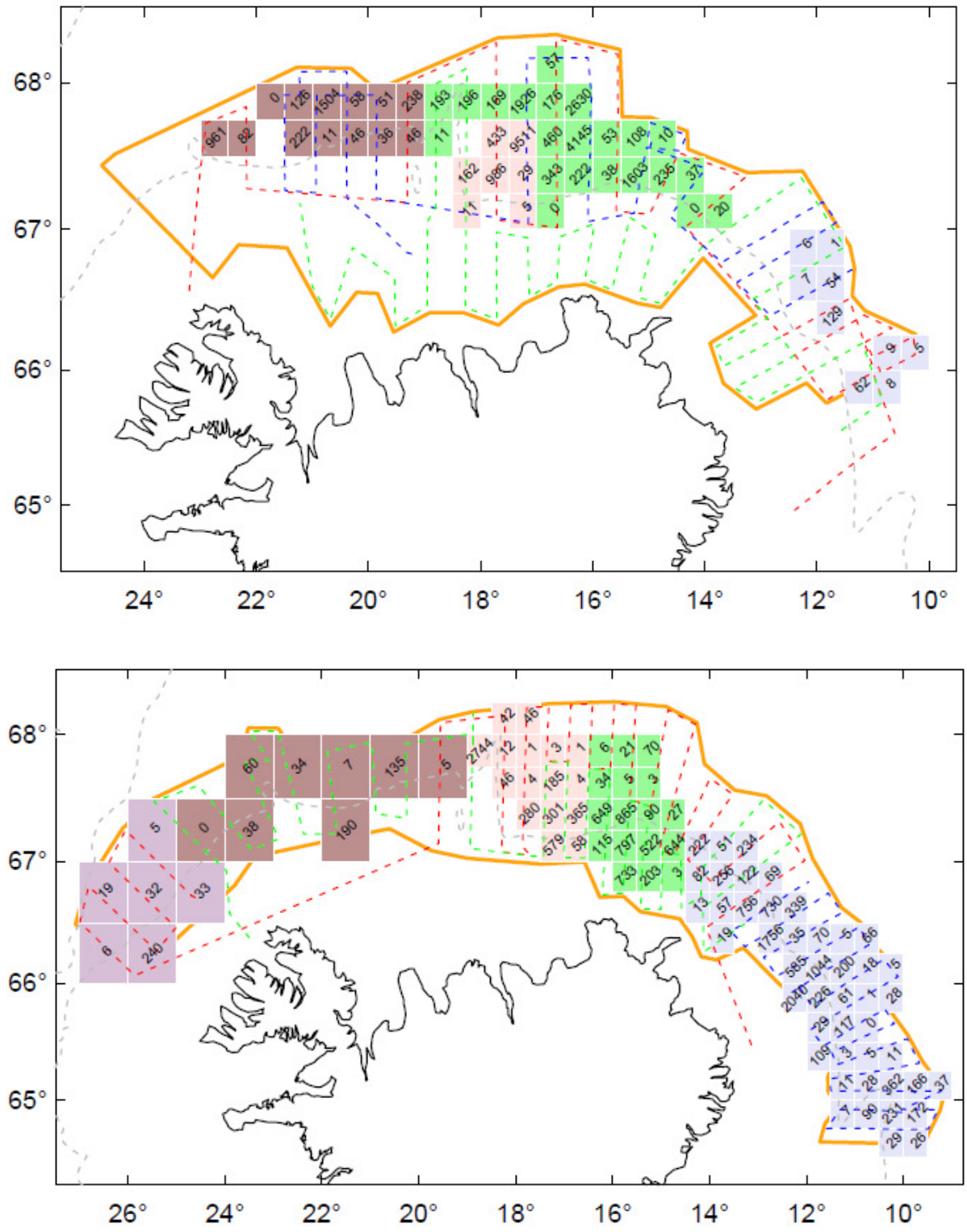

Figure 2. *Map showing statistical squares and average NASC within each square, filled colors indicate seperation into subareas based on sample compositions. Dashed lines show vessel tracks.*

Acoustic sampling

Arni Fridriksson and Bjarni Saemundsson were equipped with Simrad EK60 transducers sampling at four frequencies (18, 38, 120 and 200 kHz) and three frequencies (18, 38 and 120) respectively while Polar Amaroq was equipped with Simrad EK80 transducer sampling at 38 kHz. The 38 kHz data were scrutinized using LSSS (version 2.2.0 for both EK60 dataand EK80 data) 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. The acoustic data was scrutinized continuously during the survey by onboard scientists. Then, average NASC within quadrangles of 15 minutes latitude and 30 minutes longitude was calculated in the first coverage, and a mix of 15' x 30' and 30' x 60' lat and lon quadrangles for the second coverage.

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). 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

Total length and weight of up to 100 individual capelin fish was measured for a subsample from the catch of each of 50 pelagic trawl stations. Also, sex and maturity were estimated visually and the roe from maturing females were weighted. Age was estimated from otoliths.

Capelin abundance and age composition

Age and length disaggregated abundance is shown in table 1 based on the average of the two coverages. The total number of capelin amounted to 46.9 billions whereof 12 billions were immature. About 7.3 % of the maturing stock was 2 years old while 85.0 % were 3 years old and 7.7 % were 4 years old. In total about 801 000 tonnes of capelin (at age 2-5) are estimated to be maturing to spawn this spring. In Table 1 is shown the age disaggregated biomass, numbers and weights of the capelin.

Table 1. *Estimated stock size of Iceland-Greenland-Jan Mayen capelin stock in numbers by age and length, and biomass from the* ***acoustic survey in 16. – 31. January*** *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	4	5	(10^9)	(10^3 t)	weight (g)
8.5	0.01	0.00	0.00	0.00	0.00	0.01	0.03	2.8
9	0.01	0.00	0.00	0.00	0.00	0.01	0.01	2.3
9.5	0.02	0.03	0.00	0.00	0.00	0.05	0.16	3.0
10	0.01	0.06	0.00	0.00	0.00	0.07	0.24	3.5
10.5	0.01	0.17	0.00	0.00	0.00	0.18	0.72	3.9
11	0.01	0.29	0.00	0.00	0.00	0.30	1.44	4.8
11.5	0.00	0.62	0.00	0.00	0.00	0.62	3.60	5.8
12	0.00	1.55	0.00	0.00	0.00	1.55	10.11	6.5
12.5	0.00	2.09	0.04	0.00	0.00	2.13	16.26	7.6
13	0.00	2.31	0.04	0.00	0.00	2.35	20.62	8.8
13.5	0.00	2.49	0.15	0.00	0.00	2.64	26.43	10.0
14	0.00	1.67	0.34	0.00	0.00	2.00	22.82	11.4
14.5	0.00	1.19	0.68	0.00	0.00	1.88	24.26	12.9
15	0.00	0.46	1.62	0.00	0.00	2.08	31.57	15.2
15.5	0.00	0.41	3.05	0.02	0.00	3.48	59.05	17.0
16	0.00	0.12	4.48	0.08	0.00	4.68	91.14	19.5
16.5	0.00	0.01	4.86	0.33	0.00	5.20	111.72	21.5
17	0.00	0.10	5.31	0.39	0.00	5.80	139.07	24.0
17.5	0.00	0.00	4.59	0.53	0.00	5.12	136.53	26.7
18	0.00	0.00	3.08	0.81	0.00	3.90	113.20	29.1
18.35	0.00	0.00	0.01	0.00	0.00	0.01	0.29	31.7
18.5	0.00	0.00	1.66	0.35	0.00	2.00	64.89	32.4
19	0.00	0.00	0.64	0.16	0.00	0.80	27.44	34.3
19.5	0.00	0.00	0.21	0.07	0.00	0.28	10.43	37.0
21	0.00	0.00	0.00	0.02	0.00	0.02	0.87	52.1
TSN (10^9)	0.07	13.57	30.77	2.75	0.00	47.2		
TSB (10^3 t)	0	130	706	76.2	0.1		912.89	
Mean W (g)	0	9.6	22.9	27.7	29.1			19.4
Mean L (cm) 11.1	0	13.2	16.7	17.7	18.0			
%TSN	0.1	28.8	65.2	5.8	0.0			
SSN (10^9)	0.0	2.6	29.8	2.70	0.00	35.1		
SSB (10^3 t)	0.0	34.5	692.0	74.4	0.1		801.0	
SMean W (g)	0.0	13.5	23.2	27.6	29.1			22.8
SMean L (cm) 16.7	0.0	14.4	16.8	17.7	18.0			
%SSN	0.0	7.3	85.0	7.7	0.0			
ISN (10^9)	0.1	11.0	0.8	0.0		12.0		
ISB (10^3 t)	0.2	95.3	11.7	0.5			107.8	
IMean W (g)	3.3	8.6	13.9	23.1				9.0
IMean L (cm) 13.0	9.6	12.9	14.9	17.0				
%ISN	0.6	92.2	7.0	0.2				

T= Total, S=Spawning stock, I=Immature stock, N=Abundance in numbers, B=Abundance in biomass, L=Length, W=Weight.

Advice for TAC of

Capelin in the Iceland-Greenland-Jan Mayen area

for

2017/2018 fishing season

based on

Winter survey (16. – 31. January 2018).

Marine Research Institute, Iceland.

Date: 2nd February 2018

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

Based on the adopted HCR for capelin the Marine Research Institute advices catches of **285 000 tonnes** of capelin during the fishing year 2017/2018. This TAC advice, set at catch giving p(SSB < Blim = 150kt) < 0.05, is an update of earlier advice (of 208 000 tonnes) regarding this stock for the current fishing year.

Summary of results

Below are the results of the model used for estimating the adviced TAC based on the stochastic HCR described in the Stock Annex (WKICE, ICES 2015) for the capelin stock in the Iceland-East Greenland-Jan Mayen area.

Inputs: Bootstrap replications of survey estimates of capelin SSB and abundance of predators.

Bootstrap model:

Acoustic and biological data from the A2-2018, PA1-2017 and B2-2012 collaborative acoustic surveys were used. The capelin stock was covered twice during the surveys. Stock estimates were made based on average nautical area backscattering coefficient (NASC) within quadrangles of 15 x 30 minutes latitude and longitude, split into 4 subareas during the first coverage. For estimation based on the second coverage the area was split into 5 subareas, two of which had quadrangles of 30 x 60 minutes latitude and longitude, while the rest were of the same size as in the first coverage (See survey report).

The quadrangles, 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, given for the two coverages in **Table 1 and 2**. This methodology is in accordance with the Stock Annex for the capelin stock in the Iceland-East Greenland- Jan Mayen area (WKICE2015).

Table 1 *Summary statistics from bootstrap of stock assessment based on first survey coverage 17-22 January. Where, EA = Echo Abundance (NASC*Area, millions m^2), N = Number of individuals (Billions), B = Biomass (Thous. tonnes), SS. = mature, imm. = immature*

	Mean	CV	5%	25%	50%	75%	95%
EA	4.72	0.37	2.19	3.43	4.54	5.82	7.84
N	53.79	0.36	25.64	39.28	51.63	66.12	88.84
B	981.67	0.37	452.02	713.44	944	1210.52	1634.77
SSN	38.1	0.39	16.47	27.12	36.56	47.45	64.91
SSB	845.64	0.38	371.42	607.68	813.18	1049.97	1428.55
ImmN	15.69	0.42	6.32	10.97	14.95	19.53	27.62
ImmN2	15.11	0.42	6.05	10.57	14.42	18.86	26.61
ImmB	136.03	0.43	54.4	93.46	129.01	169.56	243.94
Prop. N3 in SSN	0.85	0.03	0.8	0.84	0.86	0.87	0.9
Prop. B3 in SSB	0.87	0.03	0.83	0.86	0.87	0.89	0.91

Table 2 *Summary statistics from bootstrap of stock assessment based on second survey coverage 25-31 January. Table headings same as in Table 1.*

	Mean	CV	5%	25%	50%	75%	95%
EA	3.77	0.18	2.74	3.3	3.73	4.19	4.94
N	40.24	0.18	29.11	35.21	39.77	44.72	53.03
B	842.8	0.18	610.37	737.09	835.43	937.42	1103.37
SSN	31.51	0.18	22.65	27.45	31.26	35.12	41.55
SSB	755.07	0.18	542.16	658.2	748.98	841.46	997.93
ImmN	8.73	0.37	4.65	6.5	8.18	10.31	14.63
ImmN2	7.12	0.36	3.67	5.33	6.7	8.46	11.88
ImmB	87.72	0.36	47.23	65.49	82.5	103.43	146.45
Prop. N3 in SSN	0.86	0.02	0.82	0.85	0.86	0.87	0.89
Prop. B3 in SSB	0.86	0.02	0.83	0.85	0.86	0.88	0.89

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 the catch is **285 000** tonnes, a 95% probability that there will be 150 000 tonnes (Blim) left for spawning at assumed spawning time the 15. March 2018 (**Figures 1 and 3, and Table 3**). **Figure 2** shows the predicted development with no catch.

Table 3 Input and results from predation model: Quantiles and mean of starting SSB input into the predation model (linear combination of autumn, and two winter measurements, accounting for catch prior to winter survey and in between coverages) and SSB at time of spawning (15. March) assuming catch of 285 000 tonnes. SSB = Spawning Stock Biomass (thous. tonnes).

	Mean	***5%***	***50%***	***95%***
SSB(15 January)	**849**	**609**	**838**	**1119**
SSB (15 March)	364	150	352	614

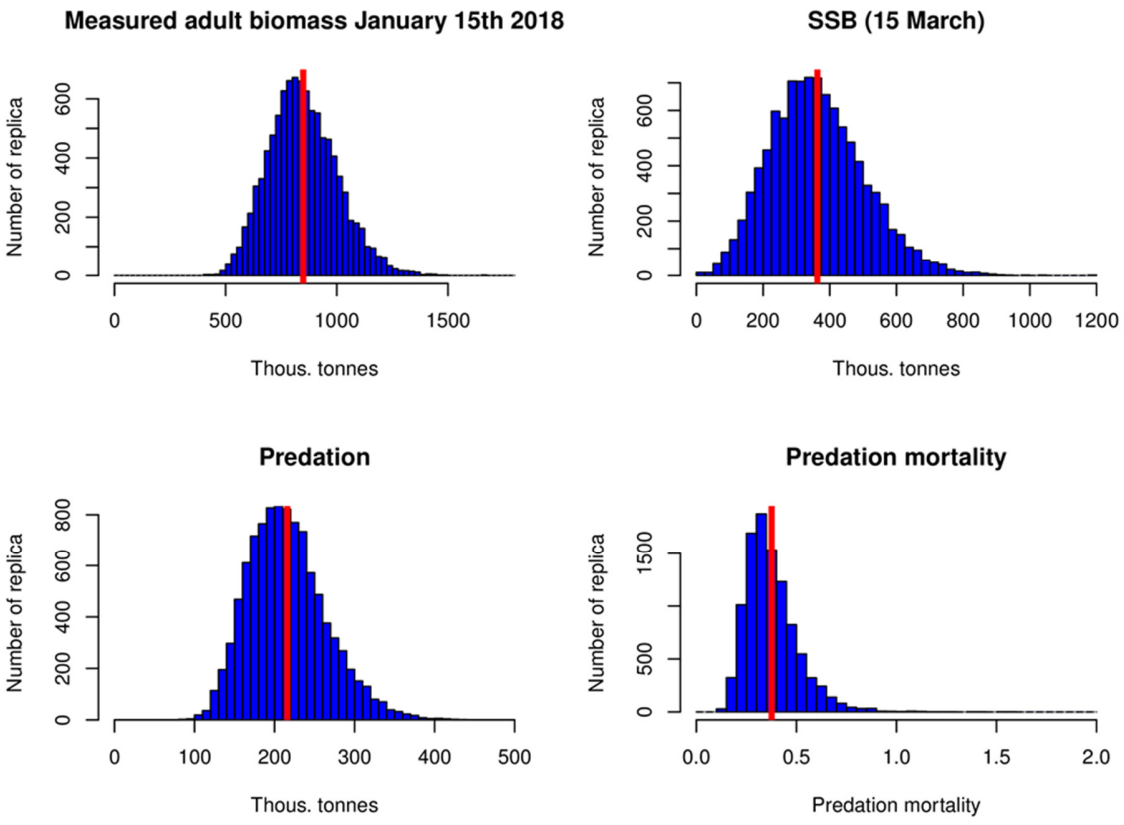

Figure 1 *Summary of results from predation model, based on the autumn survey 2017, two coverages of the stock during the winter survey in January 2018 and 1985-2017 predator distribution data, and predicted predator abundance in 2018.*

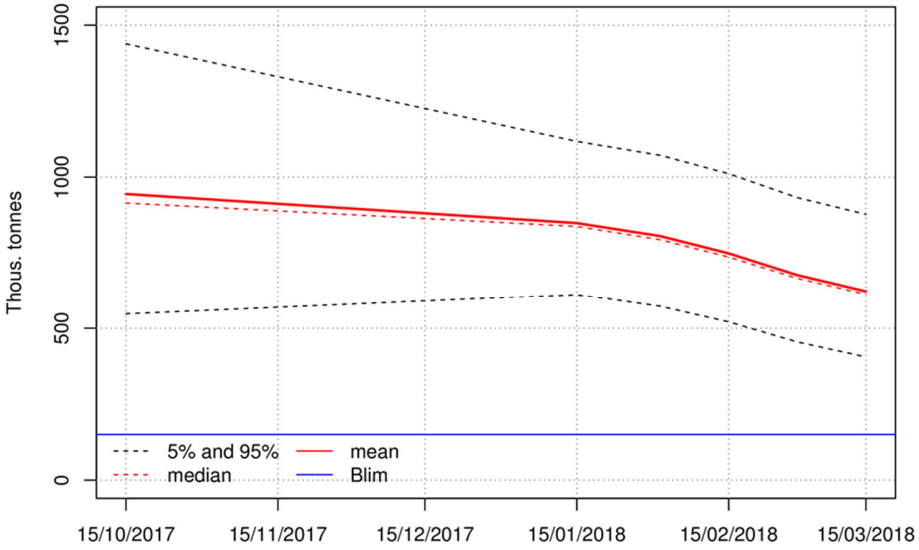

Figure 2 *Development of the SSB with 0 catch.*

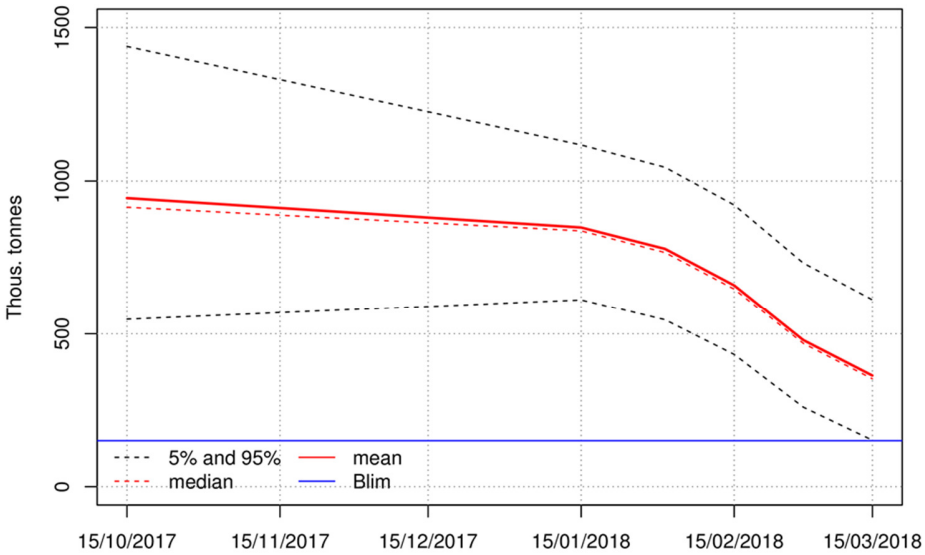

Figure 3 *Development of the SSB with catch of 285 000 tonnes.*

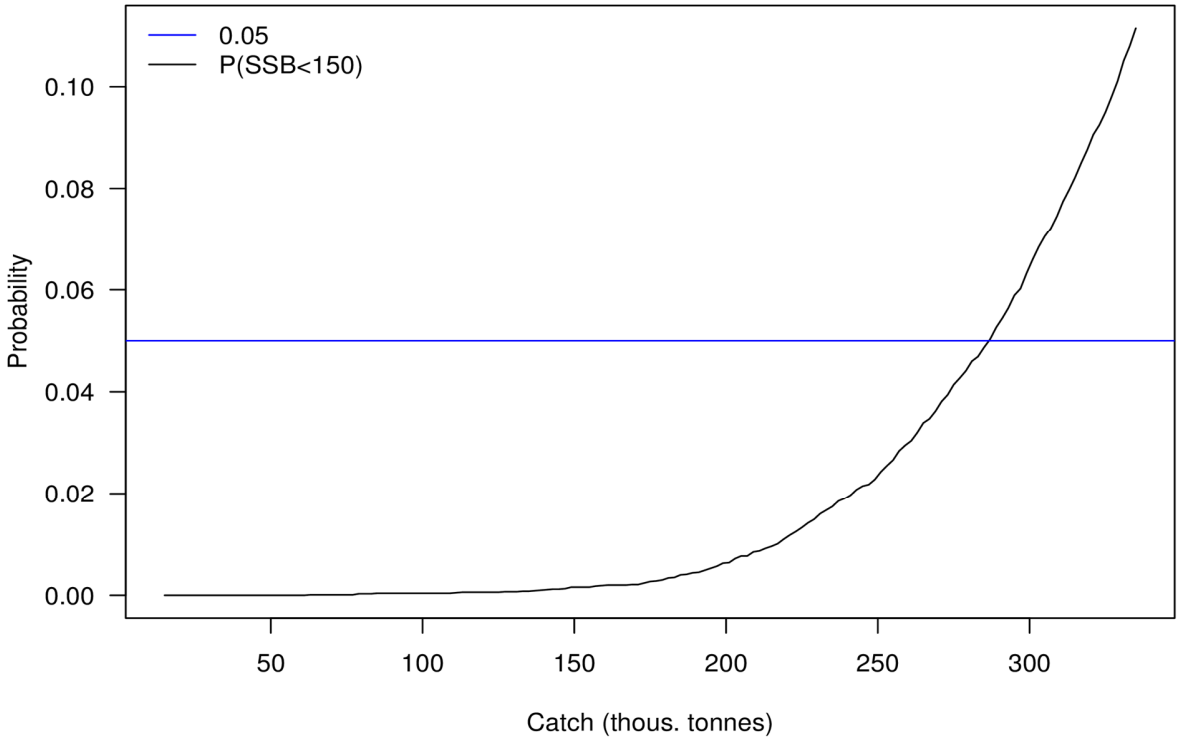

Figure 4 *Probability of SSB being below Blim = 150 000 t (on March 15) as a function of TAC for the season.*