IMR/PINRO
8
2022
Joint Report Series

JOINT



REPORT

Barents Sea Capelin - Report of the Joint Russian-Norwegian Working Group on Arctic Fisheries (JRN-AFWG) 2022

Institute of Marine Research – IMR

Polar branch of the FSBSI “VINRO” (“PINRO”)

Title (English and Norwegian):

Barents Sea Capelin - Report of the Joint Russian-Norwegian Working Group on Arctic Fisheries (JRN-AFWG) 2022

Report series:	Year - No.:	Date:	Distribution:
IMR-PINRO	2022-8	21.10.2022	Open

Number of pages:

30

Content

Barents Sea Capelin 4

Participants 4

Regulation of the Barents Sea Capelin Fishery 4

TAC and Catch Statistics (Table 10.1-10.2) 4

Stock assessment 5

Acoustic stock size estimates in 2022 (Table 10.3, Figure 10.1, 10.2 and 10.3) 5

Stock assessment in 2022 (Table 10.4-10.6, Figure 10.4-10.12) 5

Recruitment 9

Comments to the assessment 9

Further work on survey and assessment methodology 9

Reference points 10

References 10

Barents Sea Capelin

A bilateral Norwegian-Russian assessment working group met by correspondence 10-13 October 2022 to assess and give quota advice for the Barents Sea capelin stock.

Participants

- Bjarte Bogstad (Norway, Chair of meeting)
- Anatoly Chetyrkin (Russia)
- Harald Gjøsæter (Norway)
- Daniel Howell (Norway)
- Sondre Nedreås Hølleland (Norway)
- Stine Karlson (Norway)
- Yury Kovalev (Russia)
- Hector Pena (Norway)
- Dmitry Prozorkevich (Russia)
- Georg Skaret (Norway)

Regulation of the Barents Sea Capelin Fishery

Since 1979, the Barents Sea capelin fishery has been regulated by a bilateral fishery management agreement between Russia (former USSR) and Norway. A TAC has been set separately for the winter fishery and for the autumn fishery. From 1999, no autumn fishery has taken place, except for a small Russian experimental fishery in some years and small by-catch in the northern shrimp fishery. A minimum landing size of 11 cm has been in force since 1979. Scientific advice is to carry out capelin fishery only on mature fish during the period from January to April.

TAC and Catch Statistics (Table 10.1-10.2)

The Joint Russian-Norwegian Fishery Commission set a zero TAC for 2021 and a TAC of 70 000 tonnes for 2022. For both years, the quotas were in accordance with the ICES advice. The international historical catch by country and season in the years 1965–2022 is given in Table 10.1. The Norwegian catch in 2022 was 42 597 tonnes which was 647 tonnes above the national TAC. Russian catches were 22 646 tonnes which was 5 404 tonnes below the national TAC.

The age-length distribution of Norwegian and Russian catches in 2022 are summarized in Table 10.2a-b. The capelin sampling from the Barents Sea in 2022 is summarised below:

Investigation	No. of trawl hauls	Length measurements	Aged individuals
Sampling from fishing vessels in winter-spring 2022 (Norway)	23	2256	673
Sampling from fishing vessels in winter-spring 2022 (Russia)	43	13310	500
Winter capelin survey 2022 (Norway)	25	2383	978
Joint Winter survey 2022 (Norway)	292	10859	1059
Joint Winter survey 2022 (Russia)	97	5759	200
BESS 2022 (Norway) (included in estimation)	141	10640	4013
BESS 2022 (Russia)	0	0	0

Stock assessment

Acoustic stock size estimates in 2022 (Table 10.3, Figure 10.1, 10.2 and 10.3)

The geographical survey coverage of the Barents Sea capelin stock during the Barents Sea autumn Ecosystem Survey (BESS) in 2022 was incomplete (Fig 10.1), as the Russian Exclusive Economic Zone (EEZ) was not covered due to technical problems with the research vessel.

The geographical distribution of capelin in 2022 is shown in Fig 10.1, and the position and weighting of the trawl stations is shown in Fig. 10.2.

During the redfish survey west of Svalbard in early August 2022, large capelin was caught with the Gloria trawl in three trawl hauls (likely caught on the way up to the surface as trawling was done below about 200m depth). In these and adjacent areas high acoustic values were recorded in the upper 20-50 meters. Scrutiny of the echograms and trawl data from this survey and comparison with the trawl hauls and scrutiny done on the RV 'GO Sars' during the BESS survey west of Svalbard a few weeks later did, however, strongly indicate that the high acoustic recordings were of 0-group fish and not capelin. Consequently, no data from this survey were included in the stock estimate.

As decided during the 2016 assessment meeting, the capelin abundance was estimated using the software StoX (Johnsen et al. 2019), applying standard settings.

The stock estimate from the area covered by the 2022 survey was 2.174 million tonnes (Table 10.3). About 38% (0.817 million tonnes) of the estimated stock biomass consisted of maturing fish (>14.0 cm). The mean weight at age in the 2022 survey was the lowest since 1975 for age 2 and since 1987 for age 3 (Fig. 10.3).

A fixed sampling variance expressed as Coefficient of Variation (CV) of 0.2 per age group has been applied as input for the stock forecast in the capelin assessment and was also used this year (Tjelmeland 2002; Gjøsæter *et al.* 2002). The survey design and estimation software now allow for estimation of a direct CV by age group, and for the 2022 survey these were estimated:

for age group 1: 0.27; for age group 2: 0.20; and for age group 3: 0.20.

Relative sampling error based only on acoustic recordings (Nautical Area Scattering Coefficient (NASC; m^2nmi^{-2})) was estimated to 18.2%. Detailed information about previous CV estimates can be found in AFWG WD5, 2018. Future implementation of direct survey CV in the assessment is discussed under future work (10.4.6).

Stock assessment in 2022 (Table 10.4-10.6, Figure 10.4-10.12)

All projections described below were based on a maturation and predation model with parameters estimated by the model Bifrost and data on predicted cod abundance and size at age in 2023 from the 2022 Bilateral Norwegian-Russian Assessment Group (Anon. 2022).

The methodology is described in the 2009 WKSHORT report (ICES 2009) and the WKARCT 2015 report (ICES 2015a). The natural mortality M for the months October to December is drawn among a set of M-values estimated for different years based on historical data. The same set of M-values was used in 2022 as in 2021 (ICES 2011).

Due to incomplete survey coverage, two approaches were explored as alternatives to standard stock projection:

1. Compensation of maturing biomass using proportion of maturing capelin in the uncovered area in previous similar years
2. Stock projection 1.5 years ahead from the 2021 estimate

A similar situation occurred in 2014, when a large proportion of the traditional distribution area of capelin in the Norwegian EEZ was covered by ice and could not be surveyed. Then the working group applied approach 2, while ADGCAP that year preferred approach 1 which then became the basis for the advice (ICES 2015b). WKARCT (ICES 2015a) recommended that a pre-agreed procedure for adjusting for surveys with incomplete should be developed, but

that has not been done.

Before going into these two approaches, we investigated mean weight at age in NEEZ and REEZ for the years with high biomass of maturing capelin (Fig. 10.4; see below for background to the selection of years). Weight at age 2 in REEZ is higher than in NEEZ in the years 2007-2010, but there is no systematic difference in later years. For age 3 there were no systematic differences in weight at age. We concluded that the length distribution at age in NEEZ in 2022 could be taken to represent also the length distribution at age in REEZ in 2022.

For both approaches 1 and 2, probabilistic projections of the maturing stock to the time of spawning on 1 April 2023 were made using the R-Bifrost implementation which in 2021 was shown to give the same results as the Captool approach previously used. Some runs were also carried out in Captool this year and the results were the same as the results from R-Bifrost. 50 000 simulations were run.

1: Adjustment using proportion maturing capelin biomass in uncovered area in previous similar years

The approach taken here was to scale the biomass of maturing fish estimated from the survey. The scaling was based on the proportion of maturing capelin in the covered area in previous years with good survey coverage and high biomass of maturing capelin. Fig. 10.5 shows the proportion of maturing biomass in NEEZ for the years 2004-2021 for which StoX estimates are available, as well as the biomass of maturing capelin in those years. The years 2014 and 2018 were excluded due to incomplete survey coverage (partly ice covered survey area in 2014, and incomplete coverage in the SE Barents Sea in 2018). 2016 was also excluded since the survey results from that year contradict with the results from both the years before and after (Skaret et al. 2018). If we also exclude years with lower biomass of maturing capelin than what was measured in 2022 in the Norwegian EEZ (straight line in Fig 10.5), the following years are relevant to draw from: 2007-2013, 2017 and 2021. If we further select only years where the proportion of age 3 fish was high in the maturing stock, only the years 2009-2013 were selected. Table 10.4 shows the proportion of age 3 fish for the years 2007-2013, 2017 and 2021, and clearly the years 2007, 2008, 2017 and 2021 has a much lower proportion of age 3 fish than the years 2009-2013. We investigated both selection of years: 2007-2013, 2017 and 2021 as well as 2009-2013.

The scaling factor was drawn randomly among the relevant years. This approach gave median biomasses at October 1 2022 of 1.68 million tonnes when selecting only 2009-2013 and 1.26 million tonnes when selecting the years 2007-2013, 2017 and 2021. The first approach resulted in a catch advice of 62 thousand tons, while the second resulted in an advice of 21 thousand tons.

2: Predicting 1.5 years ahead from the 2021 estimate

Fig 10.7 shows the natural mortality estimated from survey mortality from age 1-2 and 2-3, assuming total spawning mortality for capelin >14 cm. The mortality from age 1 to 2 of the 2020 year class is quite plausible, while the mortality for age 2 to 3 for the 2019 year class is unusually high. In view of the incomplete survey coverage, we investigated upscaling the abundance of capelin at age 3 in 2022 based on a regression between age 3 and immature age 2 fish for all cohorts in the time series. This regression is shown in Fig 10.7. Using this regression and inserting the observed value of 259.7 billion immature fish in 2021, the predicted value of this cohort is 105.2 billion, compared to the survey estimate of 57.7 billion. A similar regression between age 1 and age 2 estimates (only cohorts 1980-2019 due to incomplete survey coverage of age 1 fish in the 1970s) is shown in Fig 10.8 and gives 129.73 billion age 2 fish in 2022 which is very close to the observed value of 135.79. This supports the decision of not applying any scaling to the abundance of age 2 fish in 2022.

Uncertainty in the prediction of age 3 from immature age 2 fish was calculated as the standard deviation of the regression residuals, and indicated a CV of 0.222. Thus we implemented the abundance of the 2019 year class at 1 October 2022 as 105.2±23.4 billion individuals, (corresponding formula: *105.2*RiskNormal(0.2)*RiskNormal(0.222))* instead of *57.7*RiskNormal(0.2)* as the survey estimate indicates. This approach (run 3) gave a catch advice of 31 kt.

Summary and discussion of results

A summary of the results of the runs mentioned above are shown in the text table below. The table also includes, for illustrative purposes, a 1.5 year prediction run with scaling of abundance at age 3 in 2022 and no additional uncertainty as well as a run with no scaling or adjustment at all.

Basis	Total catch (2023)	Median biomass of maturing capelin on 1 October 2022	Median of SSB on 1 April 2023, no catch	5% percentile of SSB on 1 April 2023, no catch
Compensation for incomplete survey coverage based on proportion maturing capelin in the covered area drawn from the 5 years 2009-2013, years with high biomass of maturing capelin and high proportion of age 3 fish in the maturing stock	62 000	1 628 000	586 000	250 000
Compensation for incomplete survey coverage based on proportion maturing capelin in the covered area drawn from 9 years (2007-2013, 2017, 2021) instead of 5 years, i.e. including years with high biomass of maturing capelin but various proportions of age 3 fish in the maturing stock	21 000	1 260 000	455 000	215 000
Predicting from 2021 survey with added uncertainty	31 000	1 350 000	464 000	225 000
Predicting from 2021 survey without added uncertainty	72 000	1 380 000	471 000	256 000
No compensation for incomplete area coverage (survey estimate from Norwegian zone only used)	0	833 000	278 000	148 000

The approach using historical distribution of maturing capelin as compensation for incomplete survey coverage and only the years 2009-2013 was found to be the most appropriate as basis for the assessment and advice. In 2014, a large part of the core capelin area was covered with ice, and the distribution in comparable years with complete survey coverage was used to compensate for the incomplete coverage. The approach chosen here is consistent with the 2014 compensation approach.

The compensations based on 5 and 9 historical years correspond to on average of 53% and 64%, respectively, of the stock biomass of maturing capelin being in the surveyed area in 2022. The results of the 1.5 year prediction as applied here imply that a 60% proportion of the maturing stock biomass is in the area covered by the survey.

The development of biomass of maturing capelin from 1 October 2022 to 1 April 2023 based on the area correction method using the years 2009-2013, is shown with no catch and a catch of 62 kt in Fig 10.9. The risk of SSB being below 200 000 tonnes by 1 April 2023 as a function of catch is shown in Fig 10.10.

Stock abundance estimates by age group and total biomass for the historical period are shown in Table 10.6. Other data which describe the stock development are shown in Table 10.7. Information about spawning surveys going back to the 1980s are given in Gjøsæter and Prozorkevitch (WD05, 2020). Summary plots are given in Figure 10.11.

Additional information for the assessment

Historically, similar stock status and abundance of age groups (especially age 2) as in 2022 were observed only in 1973, 1975, 1978 and 1979. In these years, average mortality from age 2 to age 3 was about 58%, compared to about 82% in 2022. But using these years as analogues seems incorrect, because in recent years there have been significant changes both in the environment in the Barents Sea and the biology of key species, primarily cod and capelin.

As an alternative, the working group considered calculations by the Capstock model (Gjøsæter, 1998). This model resembles a VPA type of model but based on annual stock size estimates. The model keeps track of the stock history, giving estimates of stock abundance and production through the year as well as of fishing and natural mortality (including postspawning). This model gives 135 billion individuals at age 3 in 2022 when using average capelin mortality for the last 2 years. However, since this approach has not been used before, it was decided to include it only as additional information.

The distribution of capelin taken as bycatch in the Russian shrimp fishery in 2022, as well as the distribution of capelin

in bottom trawl catches in BESS in 2019-2022, is shown in Fig 10.12. It was noted that in 2022 there was bycatch of maturing capelin in the shrimp fishery close to the boundary between international waters (Loophole) and REEZ, which is unusual. This may indicate that the distribution of mature capelin in REEZ stretches farther south than usual.

Recruitment

The 0-group series was recalculated by WGIBAR in 2022. Table 10.5 shows the number of fish in the various year classes from surveys at age 0-2. A 0-group estimate was not available for 2022.

The 1-group abundance in 2022 in the area covered by the survey was 75.5 billion which is about half the long-term average (Table 10.5). The most recent evaluation of the spawning stock and recruitment time series was made by Gjøsæter *et al.* (2016).

Future recruitment conditions: High abundance of young herring (mainly age groups 1 and 2) has been suggested to be a necessary but not a single factor causing recruitment failure in the capelin stock (Hjermann *et al.,* 2010; Gjøsæter *et al.* 2016). In 2022, high abundances of 0-group herring were observed during BESS.

Comments to the assessment

Ecological considerations

The number of young herring in the Barents Sea can be an important factor that affects the capelin recruitment. It is not currently taken into account in the assessment model. The benchmark for capelin stocks in the Barents Sea (ICES 2015a) noted the need for further study of this effect as well as better monitoring of the young herring abundance.

The amount of other food than capelin for cod and other predators may also have changed in recent years. This may also indirectly have affected the predation pressure on capelin. A more detailed discussion of interactions between capelin and other species is given in the 2016-2022 ICES WGIBAR reports.

Further work on survey and assessment methodology

Spawning survey

On 27 February–13 March 2022, IMR carried out a trawl-acoustic monitoring and stock estimation of spawning capelin (Skaret et al. 2022). The survey is the fourth in a series to evaluate whether such a monitoring can be used in the assessment to improve the advice. The initiative and funding come from the Norwegian industry, and the idea in the long term is that monitoring closer to when fishery and spawning happens, can reduce uncertainty in stock advice. Monitoring during spawning has been attempted before, last time in 2007–2009, and has proven to be methodologically challenging due to unpredictable timing and location of the spawning migration.

The survey was carried out using two fishing vessels ‘Vendla’ and ‘Eros’. A stratified design using zig-zag transects with randomized starting points was used and the effort was allocated based on historical and recent information about capelin distribution. The fishery sonar was used actively during the whole survey to estimate size distribution of capelin schools, migration speed and direction. In addition, target strength measurements were carried out using submersible TS-probes on both vessels. The coverage of the capelin spawning migration was successful and the estimate of ca. 427 000 tonnes with a CV of 0.42 was within the expected range from the predictions made in the autumn 2021.

Despite the methodological challenges due to timing and distribution of capelin as well as acoustic target strength, the survey results from all four test years have fallen within the uncertainty range of the autumn prediction. This consistency is promising for the use of the survey in an advisory process. An evaluation of the four-year series will be carried out as part of the ICES benchmark for this stock which is planned for November 2022.

Assessment model

In the present capelin assessment model, the only species interaction in the Barents Sea taken explicitly into account is predation by cod on mature capelin. The model does not take into account possible changes in capelin stock dynamics (e.g. maturation), the current state of the environment and stock status of other fish species and mammals in the Barents Sea. The ICES working group of Integrated Assessment of the Barents Sea (WGIBAR) has addressed some of these issues.

Consumption of pre-spawning capelin by mature cod in the winter-spring season and autumn season is still not included in the assessment model. It may have a significant impact on capelin SSB calculations.

Gjøsæter *et al*. (2015) calculated what the quota advice and spawning stock would have been in the period 1991—2013, given the present assessment model and updated knowledge about the cod stock. They exchanged the cod abundance from prognoses which was originally used in the capelin assessment, with updated cod abundance estimates from the cod assessment model run later in time. When rerunning the capelin assessment model, they showed that considerably smaller annual capelin quotas would have been advised with the updated cod abundance estimates. Following this work, a retrospective analysis of the capelin assessment as well as of the assessment performance should be included annually. This is a feature which so far has been missing from the capelin assessment.

There is ongoing work to address specific points related to modelling for the benchmark meeting in November 2022. These include implementation of survey CV in the capelin assessment model, incorporating the assessment model in Template Model Builder (R-package), validating both the cod consumption part of the model, and the capelin maturation part and updating consumption parameters to reflect recent state in the Barents Sea. As mentioned above, the Excel based platform (Captool) used for running simulations for half-year stock predictions has already been implemented in R. Historical CVs of SSB estimates will be calculated back to 2004.

Reference points

A B_{lim} (SSB_{lim}) management approach has been suggested for this stock (Gjøsæter *et al.,* 2002). In 2002, the JRNFC agreed to adopt a management strategy based on the rule that, with 95% probability, at least 200 000 tonnes of capelin should be allowed to spawn. Consequently, 200 000 tonnes was used as a B_{lim}. Alternative harvest control rules of 80, 85 and 90% probability of SSB > B_{lim} were suggested by JNRFC and evaluated by ICES (ICES 2016). ICES considers these rules not to be precautionary. At its 2016 meeting, JNRFC decided not to change the adopted management strategy.

References

Anon. 2022. Report of the Joint Russian-Norwegian Working Group on Arctic Fisheries (JRN-AFWG) 2022. IMR-PINRO report series 6-2022, 213 pp.

Gjøsæter, H. 1998. The population biology and exploitation of capelin (*Mallotus villosus*) in the Barents Sea. February 1998, Sarsia 83:453-496 DOI: 10.1080/00364827.1998.10420445

Gjøsæter, H., B. Bogstad, and S. Tjelmeland. 2002. Assessment methodology for Barents Sea capelin, *Mallotus villosus* (Müller). ICES Journal of Marine Science **59** :1086-1095.

Gjøsæter, H., B. Bogstad, S. Tjelmeland, and S. Subbey. 2015. A retrospective evaluation of the Barents Sea capelin management advice. Marine Biology Research **11** :135-143.

Gjøsæter, H., Hallfredsson, E. H., Mikkelsen, N., Bogstad, B., and Pedersen, T. 2016. Predation on early life stages is decisive for year class strength in the Barents Sea capelin (*Mallotus villosus*) stock. ICES Journal of Marine Science 73(2):182-195. doi: 10.1093/icesjms/fsv177

Table 10.1 Barents Sea CAPELIN. International catch ('000 t) as used by the Working Group.

Year	Winter-Spring				Summer-Autumn			Total
	Norway	Russia	Others	Total	Norway	Russia	Total	
1965	217	7	0	224	0	0	0	224
1966	380	9	0	389	0	0	0	389
1967	403	6	0	409	0	0	0	409
1968	460	15	0	475	62	0	62	537
1969	436	1	0	437	243	0	243	680
1970	955	8	0	963	346	5	351	1314
1971	1300	14	0	1314	71	7	78	1392
1972	1208	24	0	1232	347	13	360	1591
1973	1078	34	0	1112	213	12	225	1337
1974	749	63	0	812	237	99	336	1148
1975	559	301	43	903	407	131	538	1441
1976	1252	228	0	1480	739	368	1107	2587
1977	1441	317	2	1760	722	504	1226	2986
1978	784	429	25	1238	360	318	678	1916
1979	539	342	5	886	570	326	896	1782
1980	539	253	9	801	459	388	847	1648
1981	784	429	28	1241	454	292	746	1986
1982	568	260	5	833	591	336	927	1760
1983	751	373	36	1160	758	439	1197	2357
1984	330	257	42	629	481	368	849	1477
1985	340	234	17	591	113	164	277	868
1986	72	51	0	123	0	0	0	123
1987-1990	0	0	0	0	0	0	0	0
1991	528	159	20	707	31	195	226	933
1992	620	247	24	891	73	159	232	1123
1993	402	170	14	586	0	0	0	586
1994-1996	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	1	1	1
1998	0	2	0	2	0	1	1	3
1999	50	33	0	83	0	22	22	105
2000	279	94	8	381	0	29	29	410
2001	376	180	8	564	0	14	14	578
2002	398	228	17	643	0	16	16	659
2003	180	93	9	282	0	0	0	282
2004	0	0	0	0	0	0	0	0
2005	1	0	0	1	0	0	0	1
2006	0	0	0	0	0	0	0	0
2007	2	2	0	4	0	0	0	4
2008	5	5	0	10	0	2	0	12
2009	233	73	0	306	0	1	1	307
2010	246	77	0	323	0	0	0	323
2011	273	87	0	360	0	0	0	360
2012	228	68	0	296	0	0	0	296
2013	116	60	0	177	0	0	0	177
2014	40	26	0	66	0	0	0	66
2015	71	44	0	115	0	0	0	115
2016-2017	0	0	0	0	0	0	0	0
2018	129	66	0	195	0	0	0	195
2019-2021	0	0	0	0	0	0	0	0
2022	42	23	0	65	0	0	0	65

Table 10.2a. Barents Sea capelin, age-length distribution of Norwegian catch in 2022 (million individuals).

Length (cm)	Age 3	Age 4	Age 5	Age 6	Sum	%
12.5	12.143	0	0	0	12.143	0.5
13.0	18.768	0	0	0	18.768	0.8
13.5	153.387	8.718	0	0	162.105	6.9
14.0	152.613	31.794	0	0	184.407	7.8
14.5	248.012	19.987	0	0	267.999	11.4
15.0	365.148	29.998	3.871	0	399.017	17.0
15.5	257.369	30.209	8.728	0	296.306	12.6
16.0	293.49	53.235	0	3.809	350.534	14.9
16.5	261.853	29.155	0	3.577	294.585	12.5
17.0	100.867	16.288	0	0	117.155	5.0
17.5	142.664	20.152	10.545	1.908	175.269	7.5
18.0	38.014	6.709	0	4.471	49.194	2.1
18.5	21.594	0	0	0	21.594	0.9
19.0	0	0	0	0	0	0.0
19.5	0	0.707	0	0	0.707	0.0
Sum	2065.922	246.952	23.144	13.765	2349.783	
%	87.9	10.5	1.0	0.6		100.0

Table 10.2b. Barents Sea capelin, age-length distribution of Russian catch in 2022.

Length (cm)	Age 2	Age 3	Age 4	Age 5	N 10^6
	%	%	%	%	
10	50	50	0	0	5.2
11	0	100	0	0	5.2
12	0	100	0	0	23.6
13	0	98	2	0	128.4
14	0	100	0	0	319.6
15	0	90.1	9.9	0	317.0
16	0	82.2	16.8	0.9	280.3
17	0	80.4	17.9	1.8	146.7
18	0	65.4	34.6	0	68.1
19	0	100	0	0	13.1
20	0	0	100	0	2.6
sum					1309.8

Table 10.3. Barents Sea CAPELIN. Stock size estimation table. Estimated stock size (10^9) by age and length, and biomass (1000 tonnes) from the acoustic survey in August-October 2022. TSN: Total stock number. TSB: Total stock biomass. MSN: Maturing stock number. MSB: Maturing stock biomass.

	Age/year class							
Length (cm)	**1**	**2**	**3**	**4**	**5**	**Sum (10^9)**	**Biomass (10^3 t)**	**Mean weight (g)**
	2021	**2020**	**2019**	**2018**	**2017**			
7.0-7.5	0.275	0	0	0	0	0.275	0.347	1.26
7.5-8.0	0.448	0	0	0	0	0.448	0.982	2.19
8.0-8.5	1.851	0	0	0	0	1.851	4.324	2.34
8.5-9.0	3.240	0	0	0	0	3.240	9.512	2.94
9.0-9.5	11.849	0.367	0	0	0	12.216	41.061	3.36
9.5-10.0	16.198	0.643	0	0	0	16.841	64.576	3.83
10.0-10.5	18.004	3.259	0.234	0	0	21.498	92.273	4.29
10.5-11.0	15.478	22.005	0.997	0	0	38.481	191.589	4.98
11.0-11.5	4.450	28.864	1.244	0	0	34.558	193.871	5.61
11.5-12.0	2.061	28.342	2.699	0	0	33.102	211.645	6.39
12.0-12.5	1.194	20.241	4.766	0	0	26.201	190.108	7.26
12.5-13.0	0.270	11.627	3.362	0.016	0	15.275	128.200	8.39
13.0-13.5	0.141	8.034	4.325	0.081	0	12.581	122.333	9.72
13.5-14.0	0	4.171	5.232	0.068	0	9.470	105.374	11.13
14.0-14.5	0	2.936	5.955	0.040	0	8.932	114.229	12.79
14.5-15.0	0	1.788	5.060	0.046	0	6.894	101.479	14.72
15.0-15.5	0	1.294	5.544	0.262	0	7.100	119.397	16.82
15.5-16.0	0	0.832	5.340	0.184	0	6.356	122.091	19.21
16.0-16.5	0	0.933	5.625	0.447	0	7.006	148.635	21.22
16.5-17.0	0	0.290	3.518	0.005	0	3.814	91.257	23.93
17.0-17.5	0	0.079	1.988	0.077	0	2.143	59.219	27.63
17.5-18.0	0	0.078	1.019	0.025	0.008	1.129	34.809	30.82
18.0-18.5	0	0.004	0.679	0	0	0.683	22.707	33.24
18.5-19.0	0	0	0.103	0	0	0.103	3.620	35.2
19.0-19.5	0	0	0.001	0	0	0.001	0.033	39
TSN(10^9)	75.460	135.787	57.692	1.250	0.008	270.197		
TSB(10^3 t)	324.674	964.078	860.680	24.052	0.188		2173.671	
Mean length (cm)	9.85	11.69	14.22	15.32	17.5			
Mean weight (g)	4.3	7.1	14.92	19.25	24			8.04
MSN(10^9)	0	12.405	40.064	1.153	0.008	53.630		
MSB (10^3 t)	0	133.063	662.616	21.613	0.188		817.480	

Table 10.4. Biomass of maturing capelin at age for selected years and proportion biomass of age 3 capelin to total mature biomass.

Year	Biomass maturing age 1	Biomass maturing age 2	Biomass maturing age 3	Biomass maturing age 4	Biomass maturing age 5	Proportion biomass age 3 to total maturing biomass
2007	28.44	710.28	101.15	3.82	0.00	0.12
2008	1.30	1804.10	610.70	51.40	0.00	0.25
2009	0.91	809.00	1505.70	7.20	0.00	0.65
2010	0.28	610.68	1415.75	25.03	0.23	0.69
2011	0.01	697.25	1183.82	233.74	0.00	0.56
2012	3.30	397.44	1540.95	56.74	0.00	0.77
2013	3.00	523.06	785.33	159.60	0.12	0.53
2017	26.23	1267.63	417.63	11.60	0.00	0.24
2021	0.93	1287.85	147.96	1.22	0.00	0.10

Table 10.5 Barents Sea CAPELIN. Recruitment and natural mortality table. Larval abundance estimate in June, 0-group indices and acoustic estimate in August-September, total survey mortality from age 1 to age 2.

Year class	Larval abundance (10^{12})	0-group swept area numbers (10^9 ind.)	Acoustic estimate (10^9 ind.)		Mortality survey (1-2)
	0 (Y)	0+(Y)	1(Y+1)	2(Y+2)	%
1980	-	740	402.6	147.6	63
1981	9.7	477	528.3	200.2	62
1982	9.9	600	514.9	186.5	64
1983	9.9	340	154.8	48.3	69
1984	8.2	275	38.7	4.7	88
1985	8.6	64	6.0	1.7	72
1986	0.0	42	37.6	28.7	24
1987	0.3	4	21.0	17.7	16
1988	0.3	65	189.2	177.6	6
1989	7.3	862	700.4	580.2	17
1990	13.0	116	402.1	196.3	51
1991	3.0	169	351.3	53.4	85
1992	7.3	2	2.2	3.4	--
1993	3.3	1	19.8	8.1	59
1994	0.1	14	7.1	11.5	--
1995	0.0	3	81.9	39.1	52
1996	2.4	137	98.9	72.6	27
1997	6.9	189	179.0	101.5	43
1998	14.1	113	156.0	110.6	29
1999	36.5	288	449.2	218.7	51
2000	19.1	141	113.6	90.8	20
2001	10.7	90	59.7	9.6	84
2002	22.4	67	82.4	24.8	70
2003	11.9	341	51.2	13.0	75
2004	2.5	54	26.9	21.7	19
2005	8.8	148	60.1	54.7	9
2006	17.1	516	221.7	231.4	--
2007	-	480	313.0	166.4	46
2008	-	995	124.0	127.6	--
2009	-	673	248.2	181.1	27
2010	-	319	209.6	156.4	25
2011	-	594	145.9	216.2	-
2012	-	989	324.5	106.6	67
2013	-	316	105.1	40.5	62
2014	-	164	39.5	8.1	79
2015	-	457	31.6	123.7	-
2016	-	779	86.4	59.6	31
2017	-	214	58.6	7.0	88
2018	-	680	17.5	31.1	-
2019	-	1465	366.4	330.0	10
2020	-	1077	220.9	135.8	39
2021	-	325	75.5		
2022					
Average	9.0	372	174.4	106.0	

Table 10.6 Barents Sea CAPELIN. Stock size in numbers by age, total stock biomass, biomass of the maturing component (MSB) at 1. October.

Year	Stock in numbers (10^9)						Biomass (10^3 tonnes)	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	MSB
1973	528	375	40	17	0	961	5144	1350
1974	305	547	173	3	0	1029	5733	907
1975	190	348	296	86	0	921	7806	2916
1976	211	233	163	77	12	696	6417	3200
1977	360	175	99	40	7	681	4796	2676
1978	84	392	76	9	1	561	4247	1402
1979	12	333	114	5	0	464	4162	1227
1980	270	196	155	33	0	654	6715	3913
1981	403	195	48	14	0	660	3895	1551
1982	528	148	57	2	0	735	3779	1591
1983	515	200	38	0	0	754	4230	1329
1984	155	187	48	3	0	393	2964	1208
1985	39	48	21	1	0	109	860	285
1986	6	5	3	0	0	14	120	65
1987	38	2	0	0	0	39	101	17
1988	21	29	0	0	0	50	428	200
1989	189	18	3	0	0	209	864	175
1990	700	178	16	0	0	894	5831	2617
1991	402	580	33	1	0	1016	7287	2248
1992	351	196	129	1	0	678	5150	2228
1993	2	53	17	2	2	75	796	330
1994	20	3	4	0	0	28	200	94
1995	7	8	2	0	0	17	193	118
1996	82	12	2	0	0	96	503	248
1997	99	39	2	0	0	140	911	312
1998	179	73	11	1	0	263	2056	931
1999	156	101	27	1	0	285	2776	1718
2000	449	111	34	1	0	595	4273	2099
2001	114	219	31	1	0	364	3630	2019
2002	60	91	50	1	0	201	2210	1290
2003	82	10	11	1	0	104	533	280
2004	51	25	6	1	0	82	628	294
2005	27	13	2	0	0	42	324	174
2006	60	22	6	0	0	88	787	437
2007	222	55	4	0	0	280	1882	844
2008	313	231	25	2	0	571	4427	2468
2009	124	166	61	0	0	352	3756	2323
2010	248	128	61	1	0	438	3500	2051
2011	209	181	55	8	0	454	3707	2115
2012	146	156	88	2	0	392	3586	1997
2013	324	216	59	7	0	610	3956	1471
2014	105	107	39	2	0	253	1949	873
2015	40	40	13	1	0	94	842	375
2016	32	8	3	0	0	43	328	181
2017	86	124	17	0	0	227	2506	1723
2018	59	60	21	0	0	140	1597	1056
2019	17	9	7	1	0	35	411	302
2020	366	31	4	1	0	403	1884	533
2021	221	330	7	0	0	558	3998	1438
2022	75	136	58	1	0	270	2174	817

*Table 10.7 Barents Sea CAPELIN. Summary stock and data for prognoses table. Recruitment and total biomass (TSB) are survey estimates back-calculated to 1 August (before the autumn fishing season) for 1985 and earlier; for 1986 and later it is the survey estimate. Maturing biomass (MSB) is the survey estimate of fish above length of maturity (14.0 cm). SSB is the median value of the modelled stochastic spawning-stock biomass (after the winter/spring fishery). * - indicates a very small spawning stock. Estimates from spawning surveys going back to the 1980s are given in Gjøsæter and Prozorkevitch (WD05, AFWG 2021) and are not included here.*

Year	Estimated stock by autumn acoustic survey (10^3 t) 1 October		SSB, assessment model, April 1 year+1 (10^3 t)	Recruitment Age 1, survey assessment 1 October 10^9 sp.	Young herring biomass age 1+2 (10^3 t) source: WGIBAR 2022	Herring 0-group swept area index (10^9 ind.p) source: WGIBAR 2022	Capelin landing (10^3 t)
	TSB	MSB					
1972	6600	2727		152	2		1591
1973	5144	1350	33	529	2		1337
1974	5733	907	*	305	48		1148
1975	7806	2916	*	190	74		1441
1976	6417	3200	253	211	39		2587
1977	4796	2676	22	360	46		2986
1978	4247	1402	*	84	52		1916
1979	4162	1227	*	12	39		1782
1980	6715	3913	*	270	66	0	1648
1981	3895	1551	316	403	47	0	1986
1982	3779	1591	106	528	9	3	1760
1983	4230	1329	100	515	12	195	2357
1984	2964	1208	109	155	1467	27	1477
1985	860	285	*	39	2638	20	868
1986	120	65	*	6	191	0	123
1987	101	17	34	38	288	0	0
1988	428	200	*	21	77	61	0
1989	864	175	84	189	277	18	0
1990	5831	2617	92	700	434	15	0
1991	7287	2248	643	402	929	268	933
1992	5150	2228	302	351	1329	84	1123
1993	796	330	293	2	2432	291	586
1994	200	94	139	20	1887	104	0
1995	193	118	60	7	647	11	0
1996	503	248	60	82	238	550	0
1997	909	312	85	99	537	463	1
1998	2056	932	94	179	560	476	3
1999	2775	1718	382	156	1616	36	105
2000	4273	2098	599	449	2109	470	410
2001	3630	2019	626	114	1233	10	578
2002	2210	1291	496	60	428	152	659
2003	533	280	427	82	1794	178	282
2004	628	294	94	51	3790	774	0

2005	324	174	122	27	2191	126	1
2006	787	437	72	60	2115	295	0
2007	2119	844	189	222	876	144	4
2008	4428	2468	330	313	958	201	12
2009	3765	2323	517	124	440	104	307
2010	3500	2051	504	248	605	117	323
2011	3707	2115	487	209	816	83	360
2012	3586	1997	504	146	445	177	296
2013	3956	1471	479	324	492	289	177
2014	1949	873	504	105	673	136	66
2015	842	375	82	40	963	83	115
2016	328	181	37	32	498	79	0
2017	2506	1723	462	124	1106	154	0
2018	1597	1056	317	59	2034	55	195
2019	411	302	85	17	389	50	0
2020	1884	533	154	366	359	12	0
2021	3998	1438	420	221	152	209	0
2022	2174	817		75			65

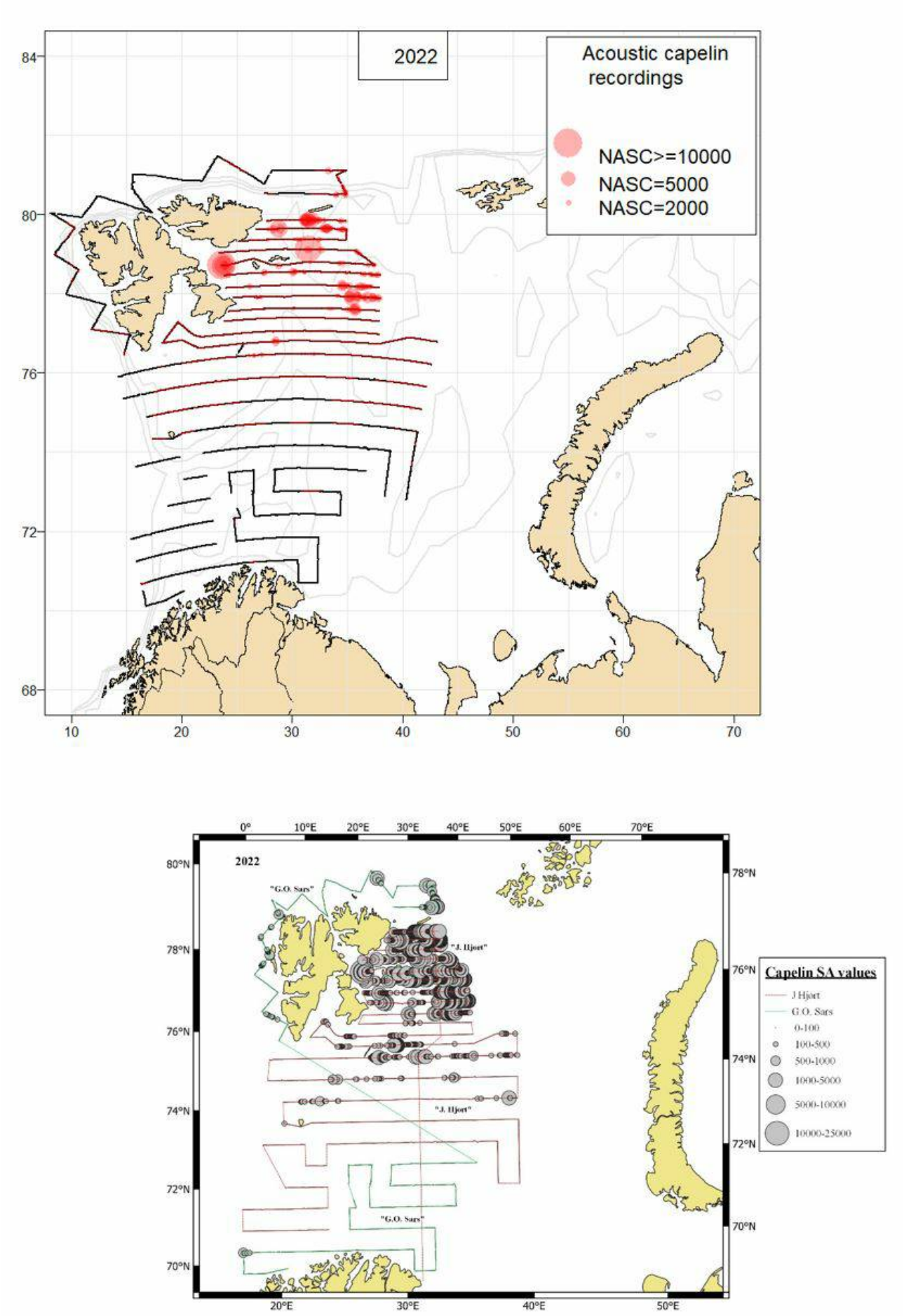

2022
Acoustic capelin recordings
NASC>=10000
NASC=5000
NASC=2000
84
80
76
72
68
10
20
30
40
50
60
70
2022
"G.O. Sars"
"J. Hjort"
"J. Hjort"
"G.O. Sars"
0°
10°E
20°E
30°E
40°E
50°E
60°E
70°E
80°N
78°N
76°N
74°N
72°N
70°N
Capelin SA values
J Hjort
G.O. Sars
0-100
100-500
500-1000
1000-5000
5000-10000
10000-25000

Figure 10.1. Survey coverage and geographical distribution of acoustic abundance of capelin in autumn 2022, using two different options for scaling of the circles indicating acoustic abundance.

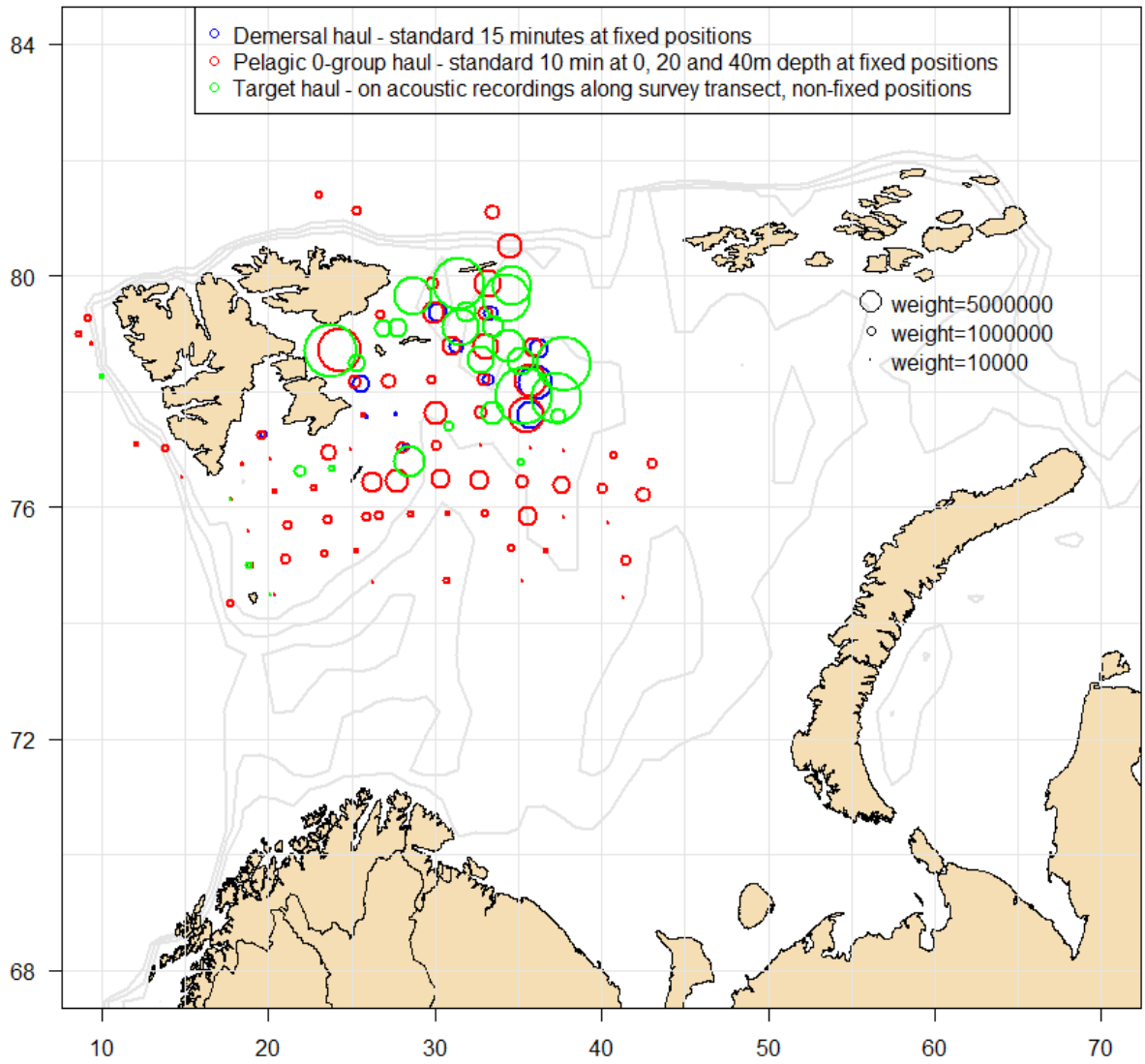


Figure 10.2. Position of trawl hauls and weighting of the corresponding capelin length distributions applied in the acoustic estimate in 2022. The weighting is proportional to NASC within a 10 nautical mile radius.

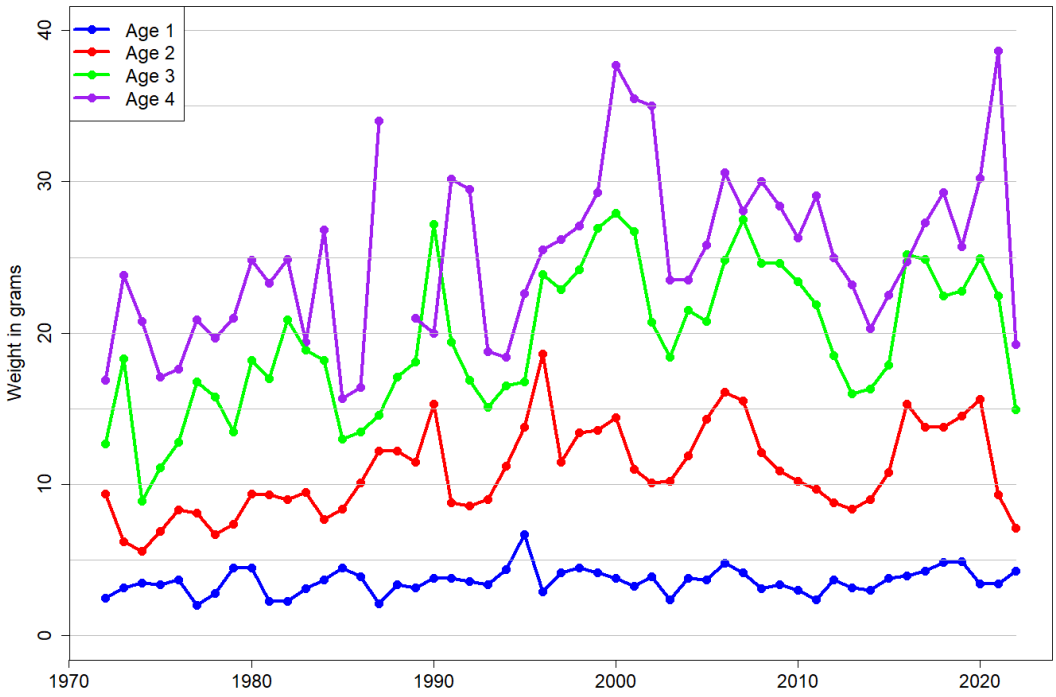


Figure 10.3 Weight at age (grams) for capelin from the autumn survey.

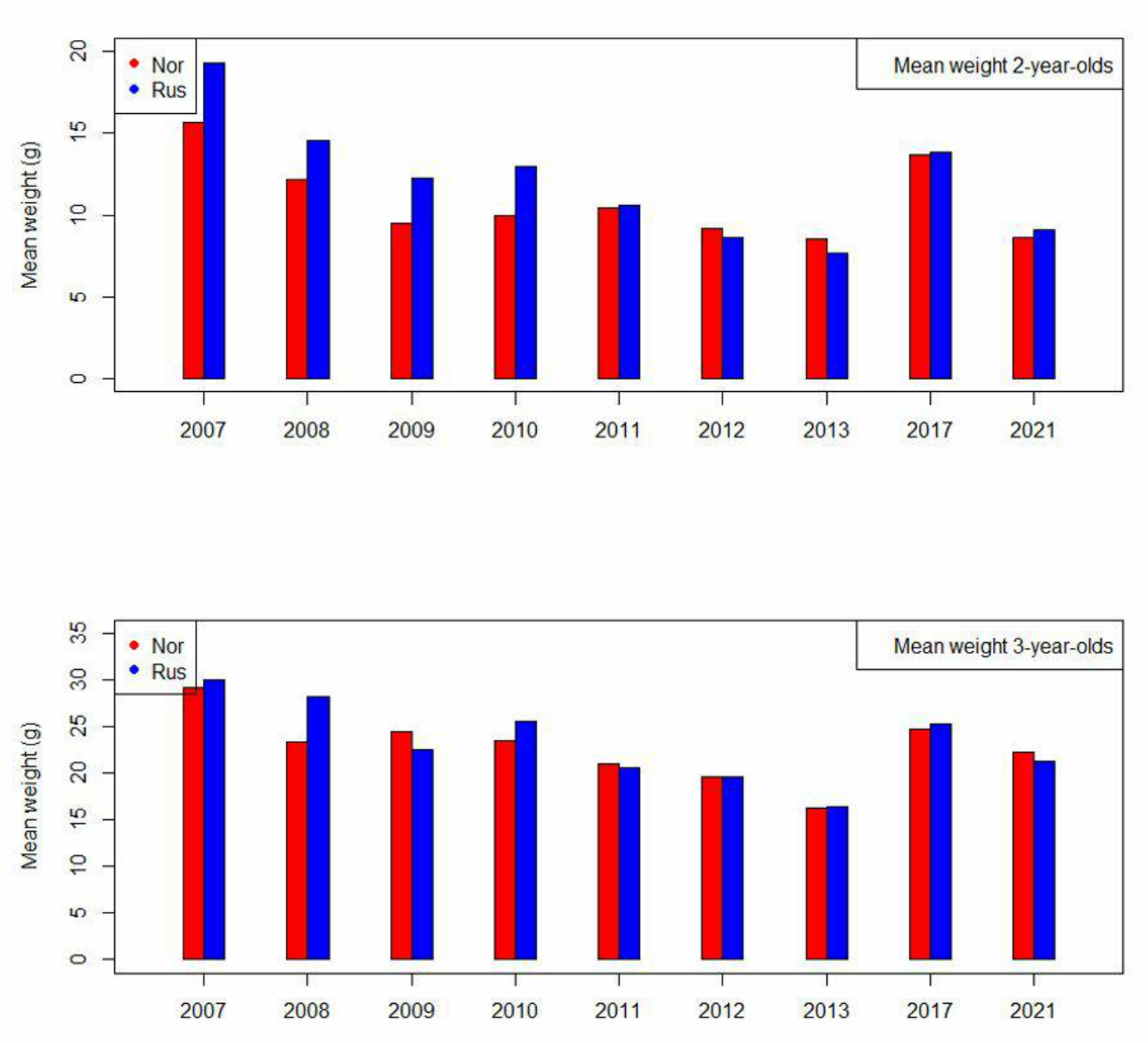


Fig 10.4. Mean weight at age 2 and 3 for BESS years (2004-2021) with high biomass of maturing capelin.

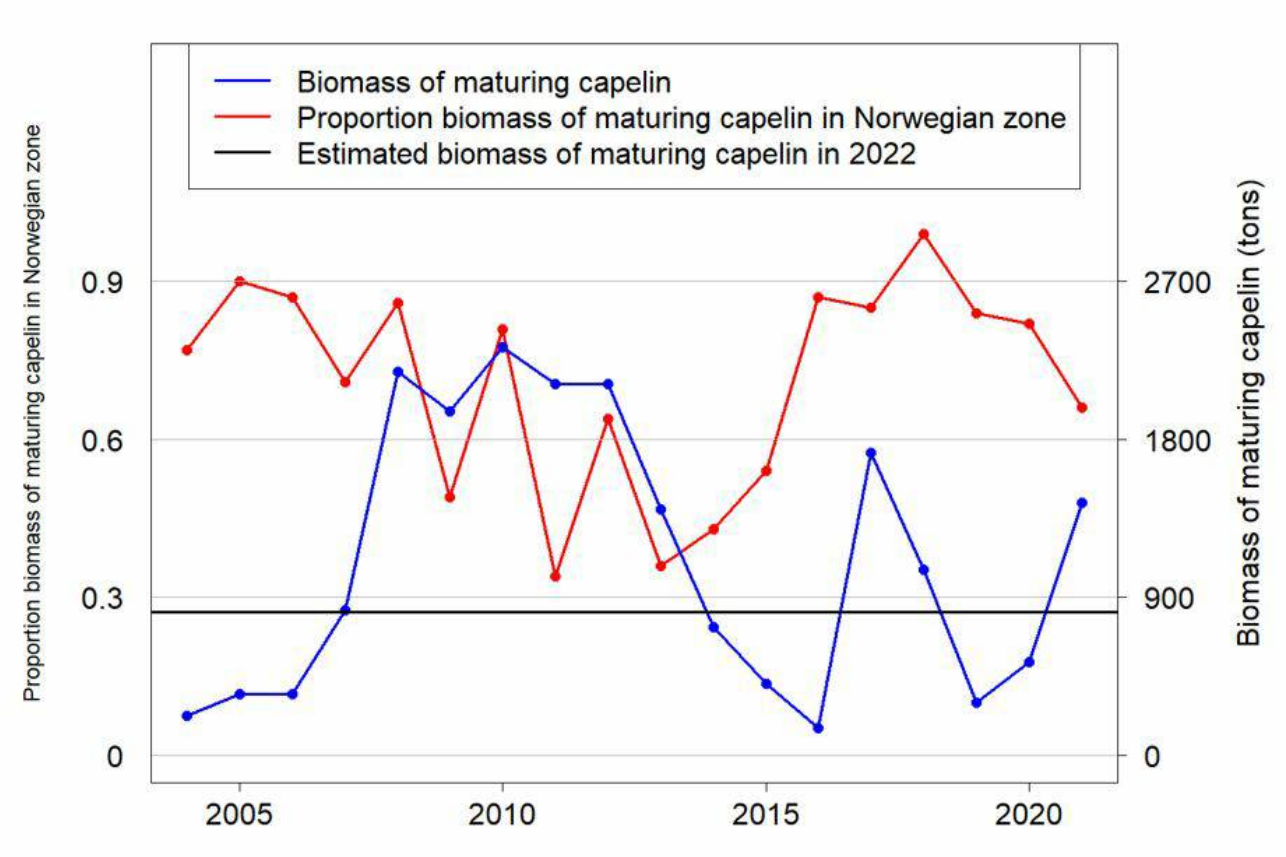


Fig 10.5. Proportion biomass of maturing capelin in Norwegian EEZ vs total biomass of maturing capelin for 2004-2021 (red line) and total biomass of maturing capelin (blue line). For the years 2007-2013, 2017 and 2021 biomass of maturing capelin was higher than want was estimated for 2022. The estimated biomass of maturing capelin based on the 2022 survey is indicated by the black horizontal line.

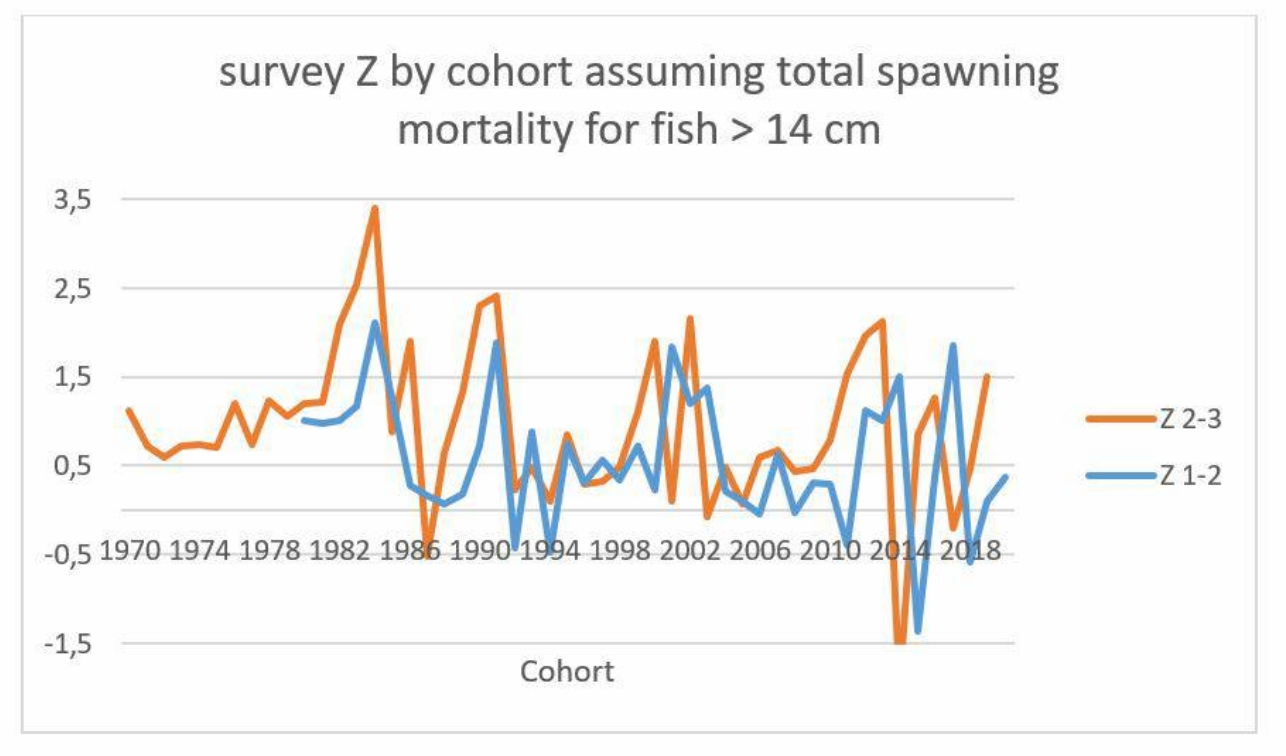


Figure 10.6. Capelin survey mortality per year class from age 1-2 and 2-3 (survey data), assuming total spawning mortality for fish > 14 cm.

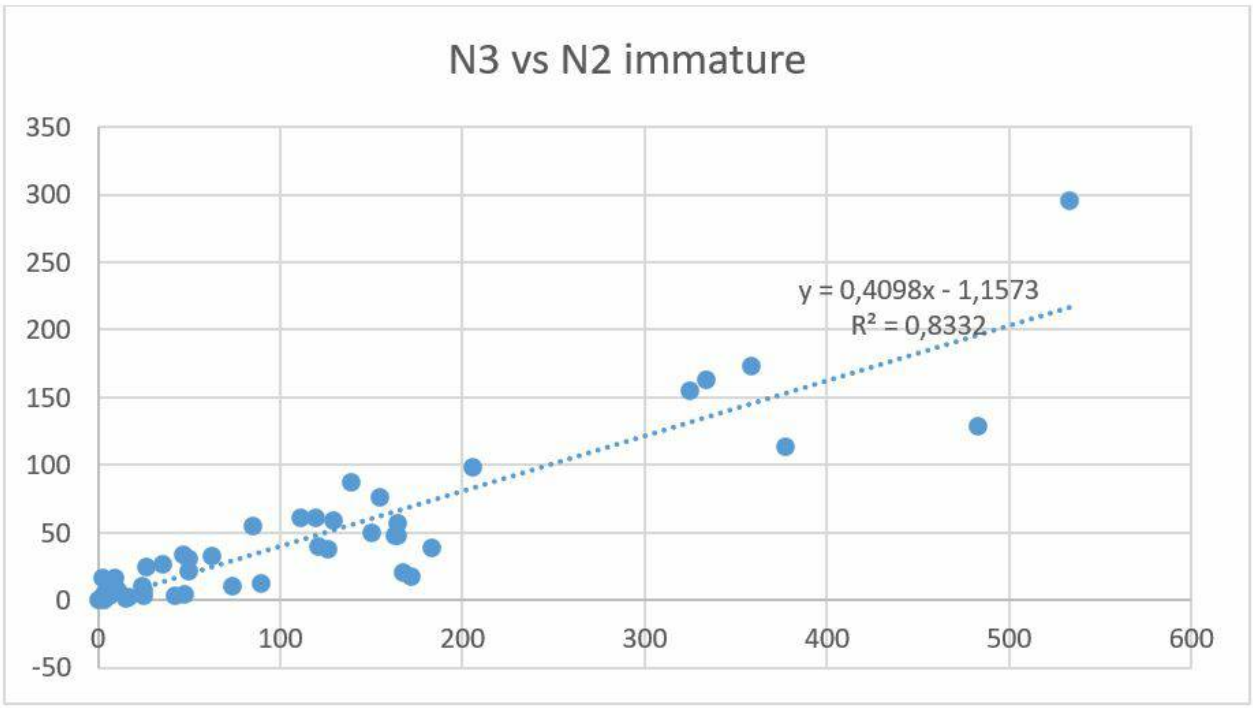


Fig 10.7. Regression of survey estimates of number of age 3 vs age 2 (immature fish only) for cohorts 1970-2018.

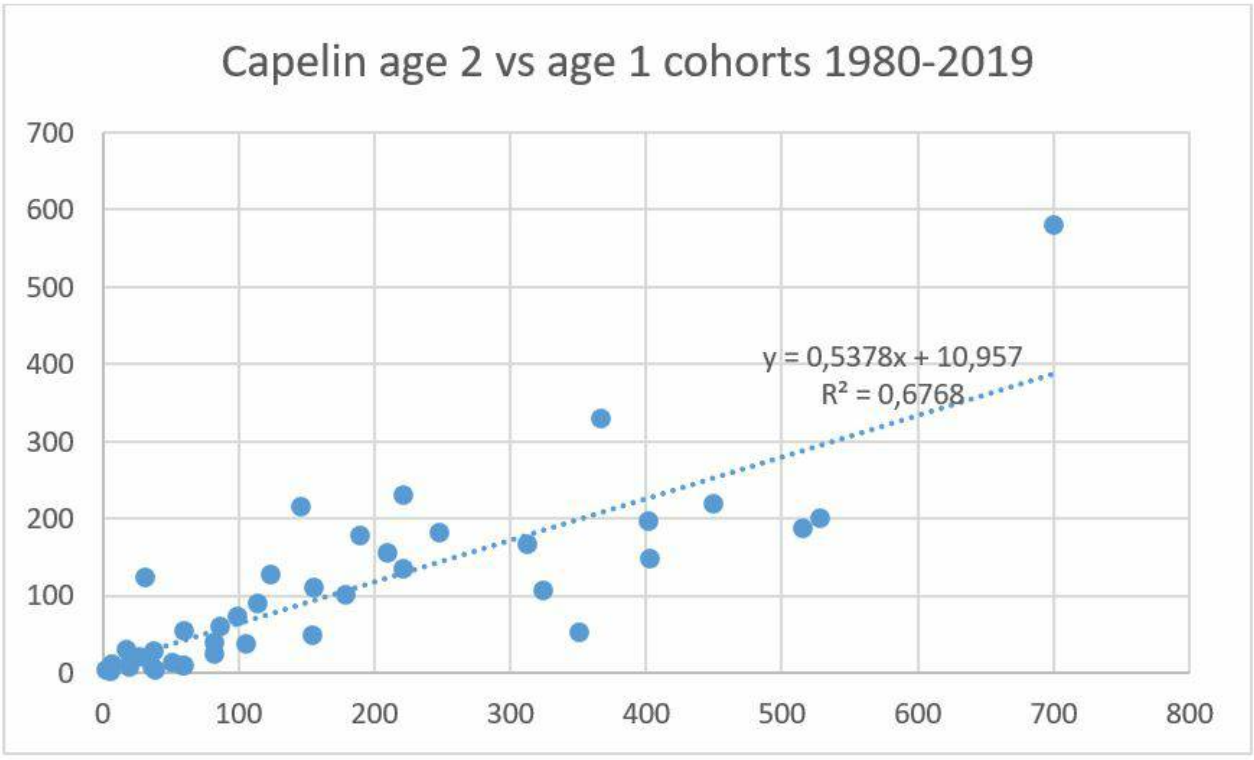


Figure 10.8. Regression of survey estimates of number of age 2 vs age 1 fish for cohorts 1980-2019.



Figure 10.9. Probabilistic prognosis 1 October 2022—1 April 2023 for Barents Sea capelin maturing stock, with a catch of 62 000 tonnes (upper panel) and 0 tonnes (lower panel).

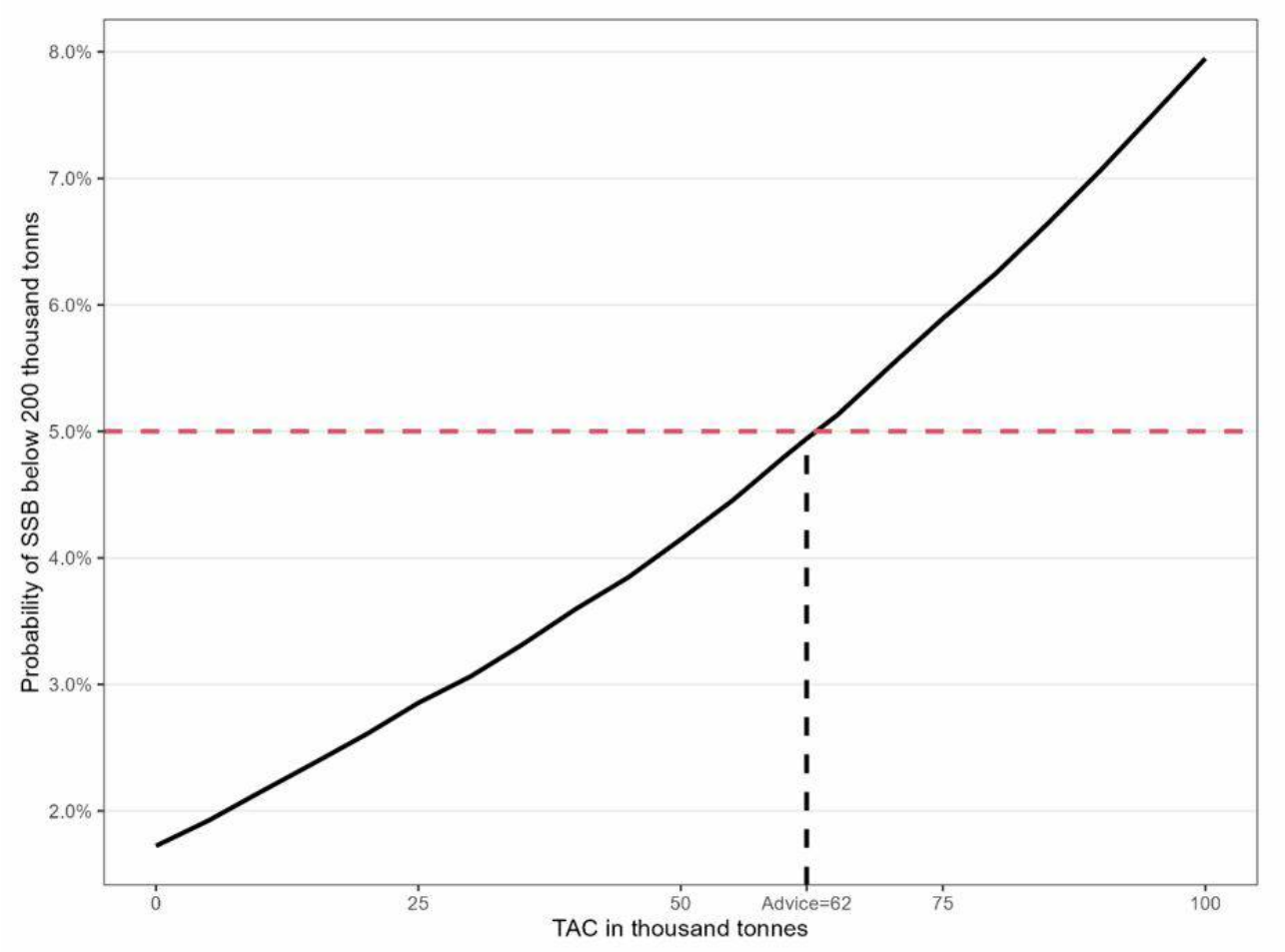


Figure 10.10. Probability of SSB 2023 < Blim as a function of the catch.

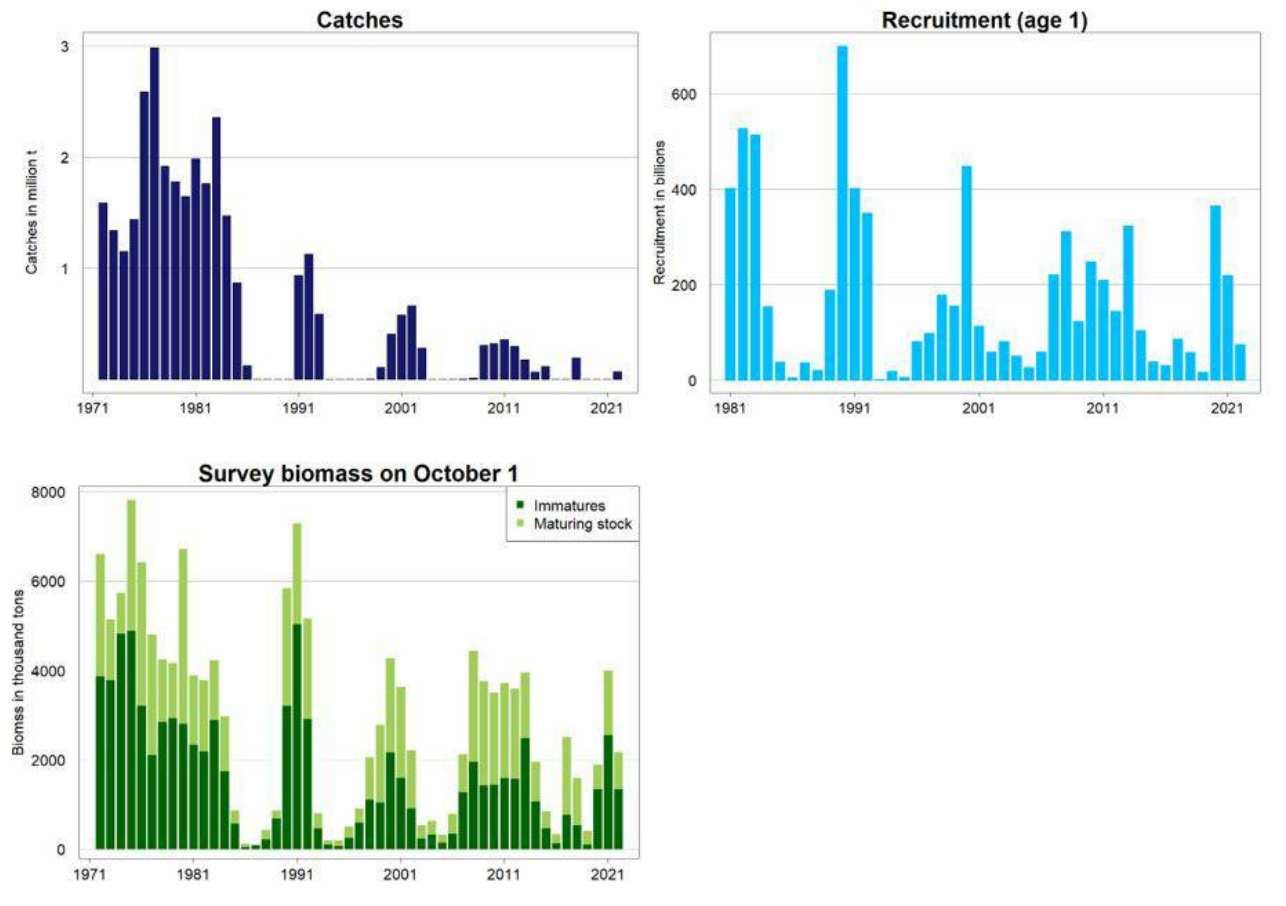


Figure 10.11. Capelin in subareas 1 and 2, excluding Division 2a west of 5°W (Barents Sea capelin). Landings, recruitment and summary of stock assessment (Biomass of maturing (>14 cm) and immature (<14 cm) stock in tonnes). The 2022 estimate is not corrected for incomplete survey coverage.

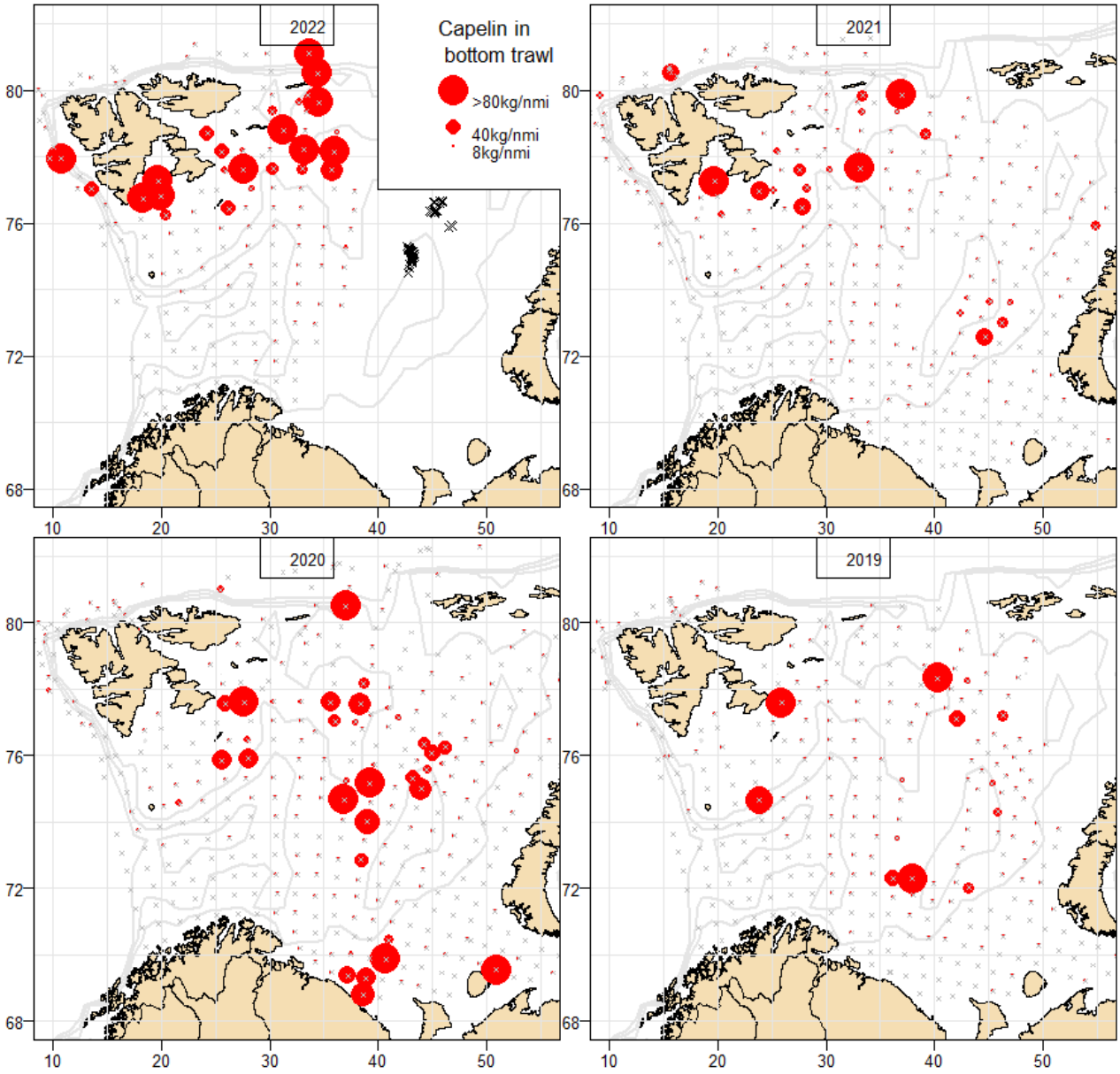


Fig. 10.12. CPUE of capelin from the bottom trawl for BESS in 2019-2022. The black crosses for 2022 are positions with reported capelin bycatch in the Russian shrimp fishery.



Institute of Marine Research – IMR

Polar branch of the FSBSI “VINRO” (“PINRO”)