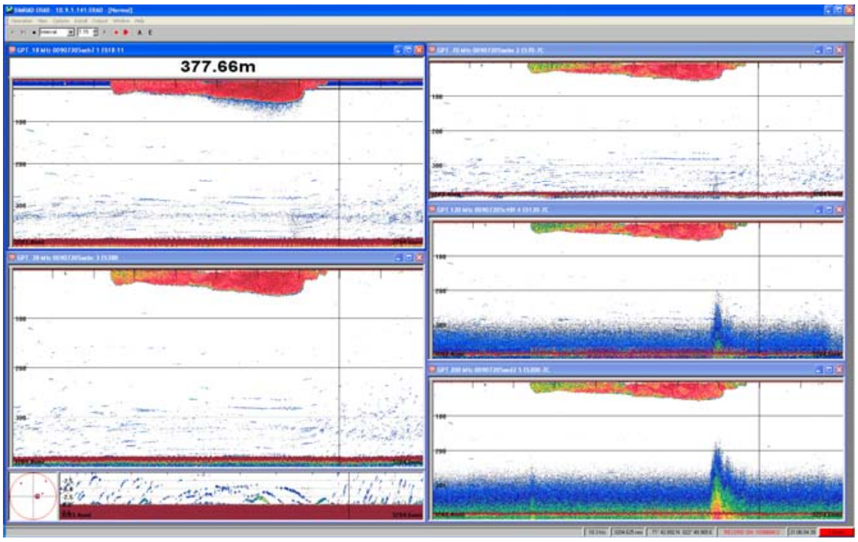
Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr.8 – 2008

Joint survey report: MS ”Eros” 02.02–02.03.2008 (survey nr: 2008803) and M/S “Libas” 15–29.02.2008 (survey nr: 2008804)

Methodology for assessment of the capelin spawning migration in the Barents Sea, spring 2008

Metodiske undersøkelser av loddens gyteinnsig langs Finnmarkskysten og i Russisk økonomisk sone våren 2008 (engelsk m/norsk sammendrag)



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Sammendrag (summary in Norwegian)

Denne rapporten oppsummerer resultatene fra et akustisk tokt for å teste ut metodikk for kartlegging og mengdeberegning av gyteinnsiget til lodde i Barentshavet våren 2008. Målsetningene for årets tokt var å estimere akustisk målstyrke for lodde i gyteperioden, kartlegge utbredelsen av ungsild med tanke på blanding av ungsild og lodde som problem for akustisk mengdeberegning, estimere vandringshastighet og retning for gytelodde med sonar som støtte for akustisk mengdeberegning og mengdeberegning av gytelodde. Toktet ble gjennomført av M/S ”Eros” (2/2 - 2/3.2008), M/S ”Libas” (15/2-29/2.2008) og M/S ”Smolensk” (25/1-12/2.2008). Resultater fra sistnevnte fartøy er gitt i egen rapport til ICES.

Toktet dekket et områd langs kysten av Norge, øst for 17˚ Ø, i to perioder (2 - 12/2 og 15/2 - 2/3) og en del av Russisk eksklusiv økonomisk sone (REØS) i perioden 13 - 19/2. Vanntemperaturen og saltholdighet ble målt med portabel CTD sonde. Biologiske prøver ble tatt med pelagisk trål. Akustiske registreringer med ekkolodd ble lagret og tolket kontinuerlig. De akustiske registreringene viste to hovedkonsentrasjoner av fisk: en i de øvre 10-50 m, hovedsakelig bestående av stimer og en ved bunnen (til ca 30-50 m over bunnen), bestående av flere arter blandet i et jevnt lag. Lodde ble observert ved bunnen sammen med andre fiskearter i de to første periodene, og i stim i den siste perioden. Tidlig vestlig innsig i vest ble observert fra 15. februar, og starten på et østlig innsig ble observert i slutten av toktperioden. Tette konsentrasjoner av lodde ble observert nær bunnen øst for Fugløybanken og det ble også funnet klumper av loddeegg i trålprøver ved bunnen. Dette tyder på at gytingen hadde startet i dette området. Biomassen av gytelodde ble beregnet til 432 000 tonn basert på akustiske data fra MS “Eros” og MS “Libas”.

Ungsild ble observert pelagisk i stim (2-5 åringer) og i blanding med andre fisk ved bunnen (2-4 åringer) langs Norskekysten. I REØS ble tette sildestimer bestående av yngre fisk (2-3 åringer) observert. Biomassen av ungsild ble beregnet til 342 000 tonn basert på akustiske data fra MS “Eros” og MS “Libas”. 2004 årsklassen dominerte de biologiske prøvene.

Det ble foretatt målinger av akustisk målstyrke (TS) for lodde med nedsenkbar TS sonde ombord på MS ”Libas”. Totalt 19 prøver fra det vestlige området ble samlet inn i dyp ned til 50 m. Forløpige resultater indikerer liten forskjell fra tidligere målstyrkemålingene, med unntak av større fisk. Målstyrken til lodde ble målt til -51.64 dB for 15.5 cm kroppslengde til -49.74 for 17.5 cm kroppslengde. Innsamling av målstyrkedata med tilsvarende metodikk om høsten anbefales for å verifisere de tidligere målstyrkemålingene, og få direkte sammenlignbare verdier.

Migrasjonsretning og fart hos lodde og ungsild stimer ble kvantifisert med lavfrekvent sonar Simrad SP70 (20-30 kHz) og høyfrekvent sonar Simrad SH80 (110-122 kHz). Gjennomsnittlig svømmehastighet for alle loddestimene ble målt til 0.98 knop. Stimer som ble observert i den vestlige delen av undersøkelsesområdet (20 - 32˚ E) hadde lavere fart (0.88 knop), enn stimer observert øst for 37˚E, hvor gjennomsnitts farten var 1.06 knop. Stimene i den vestlige delen beveget seg hovedsakelig i SØ retning, mens stimene i den østlige delen hovedsakelig beveget seg i VNV retning. Gjennomsnittsfarten for stimer av ungsild var ca 0.61 knop. Stimene beveget seg i NV og ØSØ retning mesteparten av tiden.

Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr.8 – 2008

Summary

This report presents the results from an acoustic survey to test methodology for mapping and abundance estimation of the capelin spawning stock during spawning migration in the Barents Sea in spring 2008. The objectives was to estimate acoustic target strength of capelin in the spawning period, map the distribution of juvenile herring to assess the mixture of capelin and juvenile herring as a problem for acoustic abundance estimation of capelin, estimate speed and direction of the spawning migration of capelin towards the coast with sonar, so that this can be implemented as a correction factor in the acoustic abundance estimation and acoustic abundance estimation of the spawning migration of capelin. The survey was conducted with MS "Eros" (2 February–2 March), MS "Libas" (15–29 February) and M/S "Smolensk" (25 January-12 February). Results from the last vessel are reported to the ICES working group.

The survey covered an area along the Norwegian coast, east of 17˚ E, in two periods (2.-12. Feb. and 15. Feb.-2. Mar.), and a part of the Russian Exclusive Economic Zone (REEZ) in the period 13.-19. Feb. Sea temperature and salinity were sampled with a portable CTD. Biological samples were taken with pelagic trawl. Acoustic registrations from echo sounders was saved and scrutinised continuously. The acoustic recordings showed two main concentrations of fish: one in the upper 10-50 m, dominated by schools, and one at the bottom (upwards to ca. 30-50 m above bottom) consisting of several species mixed in a layer. Capelin was observed along the bottom along with other fish species in the two first periods, and in schools in the last period. An early westerly spawning migration was observed from 15. Feb. and the start of an easterly migration was observed at the end of the survey period. Dense concentrations of capelin were observed close to the bottom East of Fugløybanken, and there was also occurrence of clumps of capelin eggs in trawl samples near bottom. This indicates that capelin spawning had started in this area. The spawning biomass of capelin was estimated to 432 000 tones based on acoustic data from MS "Eros" and MS "Libas".

Juvenile herring was observed in pelagic schools (2-5 years old) and in mixture with other fish species along the bottom (2-4 years old) along the Norwegian coast. In REEZ dense schools of younger herring (2-3 years old) were observed. The biomass of juvenile herring was estimated to 342 000 tones based on acoustic data from MS "Eros" and MS "Libas". The 2004 year class dominated the biological samples.

Acoustic target strength (TS) measurements were performed using a submersible "TS-probe" launched from MS "Libas". A total of 19 measurements of TS were obtained in the westernmost area down to a depth of 50 m. Preliminary results indicates small difference compared to earlier estimates, except from larger fish. The TS of capelin was measured to -51.64 dB for 15.5 cm body length to -49.74 for 17.5 cm body length. Sampling of TS data with identical methodology in autumn is recommended to verify earlier TS estimates and obtain directly comparable values.

Migration direction and speed in schools of capelin and juvenile herring was quantified using low frequency sonar Simrad SP70 (20-30 khz) and a high frequency Simrad SH80 (110-122 kHz). Mean speed of all the capelin schools was estimated to 0.98 knots. Schools in the western part of the survey area (20-32˚ E) showed a relatively lower speed, (0.88 knots) compared to schools east of 37˚E, where the mean speed was 1.06 knots. Schools in the western region migrated mainly in SE direction, while those in the eastern region migrated

mainly in the WNW direction. The mean speed of the herring schools was 0.61 knots, mainly migrating in the NW to the ESE direction.

Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr.8 – 2008

Table of Contents

Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr.8 – 2008

1 Introduction

This survey is part of an ongoing activity aiming at developing methodology for assessment and acoustic abundance estimation of the spawning migration of capelin in the Barents Sea. The specific objectives of the survey were:

- Obtain acoustic target strength (TS) estimates of capelin during the spawning migration.
- Map the distribution of juvenile herring to assess the mixture of capelin and juvenile herring as a problem for acoustic abundance estimation of capelin.
- Estimate speed and direction of the spawning migration of capelin towards the coast with sonar, so that this can be implemented as a correction factor in the acoustic abundance estimation.
- Acoustic abundance estimation of the spawning migration of capelin spring 2008.

The survey was organised as cooperation between two Norwegian vessels and one Russian Research vessel. Abundance indices were calculated based on acoustic registrations with echo sounder combined with biological samples. Note that the survey is aimed at development of methodology, so the abundance estimates are preliminary and not suited for assessment of the spawning stock in the Barents Sea. The coverage of the total spawning stock represents a major challenge for obtaining reliable stock estimates for assessment.

2 Execution and methodology

The survey was conducted in the period 2. February–2. March 2008 with the commercial vessel MS ”Eros” LIVA, M-60-HØ (survey number: 2008803, serial numbers: 72001-72044), starting in Tromsø and ending in Kirkenes, and in the period 15.–29. February 2008 with the commercial vessel MS ”Libas” LMQI, H-5-F (survey number: 2008804, serial numbers: 72117–72142), starting in Tromsø and ending in Hammerfest. Note that a survey of spawning migration of Norwegian spring-spawning herring in the period 1.–14. February 2008 with MS ”Libas” has identical survey number (2008804), but is reported in another IMR survey report. Results of the Russian research vessel are reported to the ICES working group. The survey was conducted in an area along the Norwegian coast covered by MS “Eros” during periods 1(2–12 February) and 3 (20 February–2 March), and by MS “Libas” during period 3 (15–28 February). Part of the Russian Exclusive Economic Zone (REEZ) was covered by MS “Eros” during period 2 (13–19 February) (Figure 1 and Table1).

The results are divided into different periods and an area along the Norwegian coast is divided into two subareas (west and east) according to Table 1.

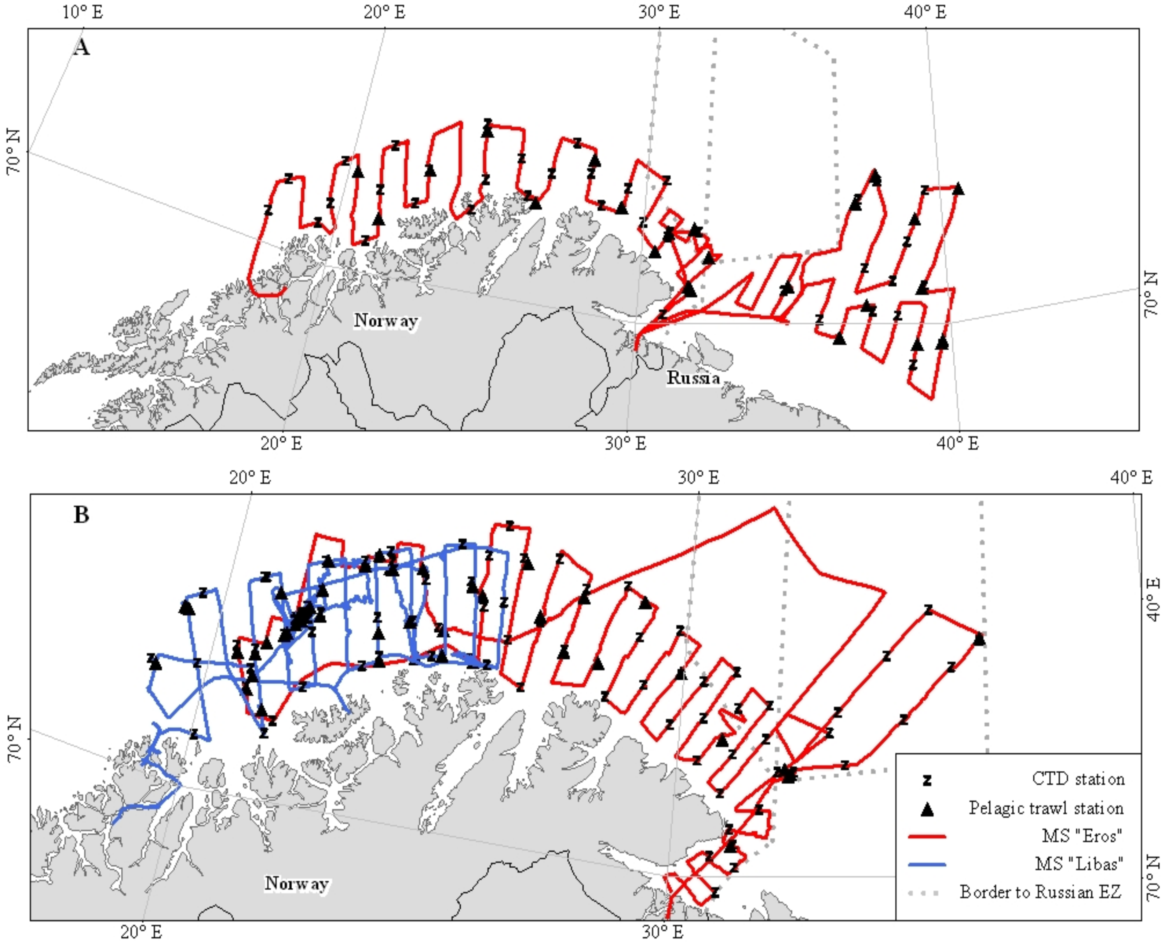

Figure 1 Course lines, CTD stations and pelagic trawl hauls for MS "Eros" (red line) and MS "Libas" (blue line). A corresponds to period 1 and 2, and B corresponds to period 3.

Table 1. Timing and coverage of the capelin spawning survey 2008. Reference log numbers represents sailed nautical miles, and are given for future reference.

Covered area	**Vessel**	**Date**	**Period**	**Number of trawl stations**	**Number of CTD stations**	**Reference log**
Norwegian coast, west (18°E - 26°30'E)	Eros	2.–7. February	**1**	5	15	2460 - 7204
Norwegian cost, east (26°30'°E - 32°E)	Eros	7.-12. February	**1**	7	11	7945 – 2513
Russian Exclusive Economic Zone	Eros	13.-19. February	**2**	10	13	5876 – 6021
Norwegian coast, west (17°E - 26°30'E)	Libas	15.–28. February	**3**	26	35	1910 - 8755
Norwegian coast, west (21°E - 26°30'E)	Eros	20.-25. February	**3**	12	22	7085 - 5149

Norwegian cost, east (26°30'E - 36°E)	Eros	25. February-2. March	**3**	10	27	5749 - 4211

2.1 Physical oceanography

Salinity (‰) and temperature (ºC) was measured with a transportable STD/CTD probe SD204 (SAIV A/S, Bergen). The probe was lowered and heaved with a mechanical winch and the interval for data registration was set to 1 per 2 sec. Data from the upcast was used, as the probe seemed to need some time in the water to stabilize. Samples were taken at regular intervals, and in combination with biological samples. At MS "Libas" a total of 35 stations were sampled, of which 4 was unsuccessful due to malfunction of the probe. At MS "Eros" a total of 88 stations were sampled, of which 3 was unsuccessful due to malfunction of the probe.

2.2 Biological samples

Biological samples were taken with a pelagic capelin trawl with opening circumference of 952 m at MS "Libas" and with small herring pelagic trawl with opening circumference of 608 m at MS "Eros". To avoid excessive catch, the trawl was cut with a 3 m incision in the longitudinal direction, about 3 m from the end of codend. A total of 44 hauls were taken at MS "Eros", and 26 hauls at MS "Libas" (Table 1).

Length (down to nearest ½ cm), weight (down to nearest 1 g) and sex were recorded for maximum 100 individuals of capelin and young herring from each trawl sample. In addition individual measures of age and special maturation stadium was taken from 30 randomly selected individuals of capelin onboard both vessels and herring onboard MS "Eros". Relative gonad weight (gonad %) for the individually measured female capelin was measured as (total gonad weight/total individual weight) × 100. Some samples of about 100 capelin individuals were frozen for genetic studies.

2.3 Echo sounder registrations

Acoustic data was recorded continuously by both vessels acoustic systems. Data was recorded at 5 frequencies (18, 38, 70, 120 and 200 kHz) with SIMRAD split-beam transducers. The range of the echosounder was set to 500 m, and pulse length was 1024 µs. Calibration of all frequencies was done prior to the survey. Acoustic abundance of fish was recorded as nautical area scattering coefficient (s_A) ($m^2/n.mi.^2$), and stored as ER60 raw files (*.raw). The acoustic data recorded at 38 kHz was scrutinised in the Large Scale Survey

System[1]. The following acoustic categories were used (priority in parentheses): capelin (1), herring (1), bottom fish (3), and others (3). The results were stored for each nautical mile with a vertical resolution of 10 m. Echo integration stopped at 0.5 m above the acoustic bottom registration, threshold for volume backscattering strength (S_v) was set to -82 dB. Acoustic recordings from the other frequencies were stored for multi-frequency analysis of capelin and herring. The results of these analyses will be presented at the ICES Symposium on the Ecosystem Approach with Fisheries Acoustics and Complementary Technologies (SEAFACTS) in Bergen, 16-20 June 2008.

2.4 Acoustic abundance estimation of capelin and herring

Nautical area scattering coefficient (s_A) ($m^2/n.mi.^2$) from the scrutinised echosounder data along acoustic transects is used as input to the acoustic abundance estimation of capelin and herring. The relation between acoustic target strength (TS), individual length in cm (L) and back scattering cross section (σ) is given as:

$TS = 10\log(\frac{\sigma}{4\pi}) = 19.1\log L - 74.0$, which gives: $\sigma = 5 \cdot 10^{-7} \cdot L^{1.91}$. The number of fish is calculated for standard 1 by 2 degrees WMO squares as:

$N(L) = \frac{\overline{s_A} A n(L)}{\sum_{Min.length}^{Max.length} n(L)\sigma(L)}$, where $\overline{s_A}$ is the mean s_A-value in the square, A is the area of the square in square nautical miles and n(L) the observed length distribution from samples in the square.

The TS-relation used is the same as the one used during surveys in the autumn. However, conditions during the winter (swimming behavior, fatness, sexual development, depth of registrations) are different in the winter from the conditions in the autumn. This may constitute a major source of error in the estimate, which makes it impossible to compare winter and autumn results without performing TS measurements in both periods at various depths, which has not been accomplished yet. The abundance estimation has been performed

[1] Korneliussen, R. J., Ona, E., Eliassen, I., Heggelund, Y., Patel, R., Godø, O.R., Giertsen, C., Patel, D., Nornes, E., Bekkvik, T., Knudsen, H. P., Lien, G. 2006. The Large Scale Survey System - LSSS. Proceedings of the 29th Scandinavian Symposium on Physical Acoustics, Ustaoset 29 January – 1 February 2006.).

with the program Recap, see www.assessment.imr.no/Bifrost/capelinResampling.htm for a description of the program. Here, also a comparison between the present abundance estimate and autumn estimates is given.

Migration during the survey poses a problem for abundance estimation of capelin, especially during the pre-spawning period. The current state of survey methodology makes it possible only to handle this problem very crudely. In the beginning of the survey MS "Eros" had only low recordings of capelin west of Nordkapp, while by the end of the survey she had sizeable recordings in this area, as did MS "Libas". It is quite likely that there was a migration from the north to this area after MS "Eros" had surveyed it for the first time. Therefore, the recordings from the first period have been deleted from the estimation.

Note that the abundance estimates under no circumstance are absolute measures, but must be treated as indices for the spawning stock.

2.5 Acoustic target strength measurements

The TS measurements were performed using a submersible "TS-probe" launched from MS "Libas". The structure of the probe consists of a frame and pressure housing. The probe contains a Simrad EK60 echosounder with a Simrad ES38-DD pressure stabilized transducer mounted on a gyro stabilized platform on the bottom of the probe. Additional instruments carried by the probe includes pitch/roll sensor, compass and temperature and depth sensor. The probe is connected to a PC aboard the vessel through a fibre optic cable.

The TS-probe was calibrated in accordance with recommended procedures[2] on the 16th of February outside Tromsø. A Cu60 copper sphere, with theoretical TS of -32.7 dB at the measured sound speed at the site, was suspended 7 meters below the TS-probe, using a monofilament line. The transducer platform was moved so that the entire beam could be mapped. The echosounder was also calibrated after the last measurement 28th of February, under much better conditions than the first calibration, and a gain adjustment was applied to the TS measurements in post-processing (Table 2 displays calibration results and echosounder settings during measurements). A calibration sphere was suspended beneath the transducer in some of the experiments in order to monitor the performance of the echosounder.

[2] Foote, K. G., Knudsen, H. P., Vestnes, G., Maclennan, D. N. and Simmonds, E. J. 1987. Calibration of acoustic instruments for fish-density estimation: a practical guide. ICES Cooperative Research Report.

When a suitable capelin school was found, the probe was lowered from the vessel to the desired depth using one of the vessels winches. Data were collected continuously, and monitored on-line. Raw data from the echosounder as well as depth and tilt/roll of transducer was stored for post processing. After each measurement session, a trawl sample was collected from the school. Biological parameters measured including length, weight, maturity and age.
Single target detection was performed using Simrad ER60 software. These data were then imported to Matlab® where a target tracking algorithm[3] was used to assign the detections to individual fish. The mean TS was calculated for each experiment found to be of sufficiently high quality.

Table 2. Echosounder settings for the TS probe.

Simrad EK60 – 38 kHz	**Value**			**Units**
Transducer Type	ES38DD	ES38DD	ES38DD	-
Absorption coefficient	10.1	10.1	10.1	dB km^{-1}
Pulse duration	0.256	0.512	0.512	ms
Bandwidth	3.68	3.28	3.28	kHz
Transmitting power	1000	2000	1000	W
Two-way beam angle	-20.6	-20.6	-20.6	dB
Along ship angle sensitivity	21.9	21.9	21.9	deg
Athwart ship angle sensitivity	21.9	21.9	21.9	deg
Transducer gain	24.54	24.7	24.54	dB
Along ship 3 dB beam width	6.98	7.05	6.98	deg
Athwart ship 3 dB beam width	6.94	7.01	6.94	deg
Along ship offset angle	-0.13	-0.12	-0.13	deg
Athwart sip offset angle	0.01	-0.05	0.01	deg
s_A-correction	-0.83	-0.88	-0.83	dB

[3] Handegard, N. O., Patel, R. and Hjellvik, V. 2005. Tracking individual fish from a moving-platform using a split-beam transducer. Journal of the Acoustical Society of America, 118: 2210-2223

2.6 Sonar measurements of migration

Onboard MS "Eros" and MS "Libas", the school tracking was realized using a low frequency sonar Simrad SP70 (20-30 kHz) and a high frequency Simrad SH80 (110-122 kHz). Both sonars have the same capabilities regarding school tracking, including the simultaneous tracking of 5 schools. The following data was obtained from each tracked school: date and time, school identification, geographical position, horizontal range, direction to the target relative to north, school depth, school speed, school course, and school area and volume.

The target tracking data was exported in real time from the sonar PC by a special serial communication to the working station. The data was retrieved as an Ascii file using the Hyperterminal software available in the windows operating system.

The sonar raw data from both sonars was retrieved by using the available scientific output function. The data collection was also done in the IMR working station using an ad-hoc network communication and using the Simrad software Sonar Data Logger.

For the school track sampling, the first stage was to detect the schools, which was done primarily with the SP70 sonar using more frequently a range 2500 and 3000 m. The tilt was also aimed to keep it at the same level without changes, fluctuating between 3 to 5 degrees. This range and tilt angle were the standard settings used during surveying along transects at an average speed of 10 knots. When the school was detected outside the cruise track, in most cases the ship changed course in order to sample the school with the echosounder. The school detection was complemented with the data from the SH80, which was operating during cruising in a fix range of 600 m, with a tilt angle between 6 to 8 deg.

From the echosounder frequency response together with the school migration information available during the survey transect, the decision of tracking the school was made. Also the size of the school was used as criteria to track a school; in general small schools (relatively below 50 ton) were rejected.

The selected school for tracking was marked using a Target marker, a tool available in the sonar operation which creates a marker in the geographical position on top of the school. This marker helps the later tracking and also gives a very good reference to see the general displacement of the school.

Up to 5 schools were tracked simultaneously. The target tracking automatically follows the centre of gravity of the school. However in many cases it was necessary to stop and restart the tracking of a school due to interference with the ship propeller, bottom echo or beam bending. Also, during the tracking the sonar tilt angle is automatically following the stronger echo from one of the schools (priority school) and if the other schools which are tracked simultaneously are not at the same depth, the quality of the tracking is poor. The solution for this problem was to manually change the tilt angle in order to have visible in the beam all the schools that were tracked.

In an area were several schools were present, one school was selected as a priority school. The SH80 was used as a primarily sonar for school tracking, but also SP70 sonar was used. The SH80 sonar was set to a range between 600 and 750 m, and SP70 to a range between 900 to 1500 m. When tracking started, the vessel speed was reduced to below 3 knots, aiming to keep a constant distance between 200 and 300 m from the school. Usually the priority school was encircled by the ship, and in some occasions was crossed again to get another acoustic sampling with the multi-frequency echosounder.

For larger school sizes, the range between the vessel and the school was increased to 400-500 m, with the consequent increase in the sonar total range. At a short distance in the large schools the centre of gravity is moving inside the school, giving a bad indication of the school movement. With the increased range the area of the large school became smaller in the sonar and therefore the tracking data more reliable.

Although the tracking conditions were variable during the survey, the time period estimated for an acceptable quality tracking was between 10 to 15 minutes.

During all the school tracking period, screen dumps from each of the sonars were stored every 10 pings. These sonar images will be used for the analysis of the school tracking, helping to identify wrong tracks.

During cruising along transects also screen-dumps were collected at longer time periods, for the SH80 each 2 minutes and for the SP70 each minute. The time interval for SP70 was the maximum available, because the option for longer time period was not available.

A set of parameters for each ping for every school was obtained from the resulting tracked data, for each sampling period. Previous work with this type of data have analyzed the single ping school track parameters (i.e. speed, course and depth) to obtain a value representative for each of the school tracks[4]. Exploratory examination of these data was done, and the data

[4] Godø, O. R., Hjellvik, V., Iversen, S. A., Slotte, A., Tenningen, E., and Torkelsen, T. 2004. Behaviour of mackerel schools during summer feeding migration in the Norwegian Sea, as observed from fishing vessel sonars. ICES Journal of Marine Science, 61: 1093-1099.

showed very high variability that needed to be analysed and reduced, this analysis was betond the scope of this cruise report. Therefore, a manual procedure was designed to extract the school track parameters, using a Geographical Information System (GIS) Arcmap software as working platform.

The data for each sampling was plotted in Arcmap, displaying for each track position the school identification label, as seen in Figure 2.

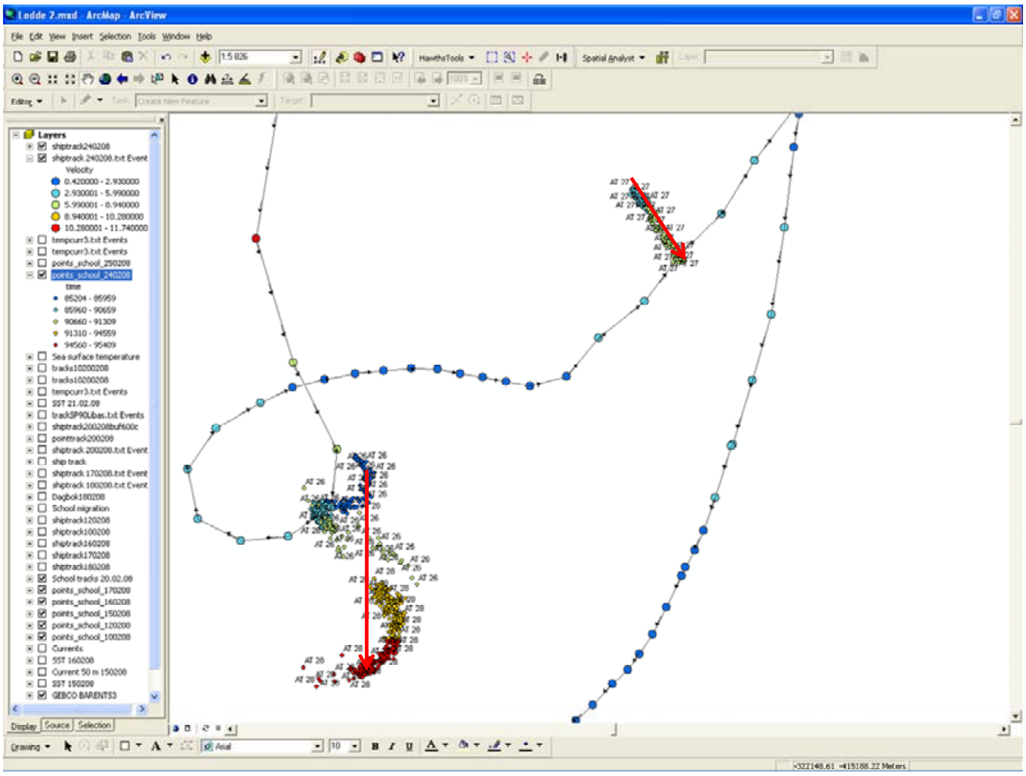

Figure 2. Example of tracked data from 2 schools in Arcmap. Each school position is labelled with the school identification label (i.e. AT26 and AT27). The colours of the symbols indicate time, with an increasing range between blue to red. Also the track of the vessel is plotted as a continuous black line, with arrows showing the vessel direction and round symbols showing the vessel speed (from blue < 3 knots to red >10 knots). Big red arrows indicate the general swimming direction of the schools.

To verify the quality of the tracked data and identify possible errors in the tracking, the sonar screen-dump of the correspondent time period was replayed. This information was crucial for determine the period in which the track data is representing a real track and avoid wrong

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Hafsteinsson, M. T. and Misund, O. A. 1995. Recording the migration behaviour of fish schools by multi-beam sonar during conventional acoustic surveys. ICES Journal of Marine Science, 52: 915–924.

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tracks due to bottom, other schools or acoustic noise. The time of each school detection was used as an indicator of the direction of the displacement of the school (Figure 2).

Together with the tracked data, the vessel position was plotted in order to relate the trajectory of the vessel to the relative position of the tracked school. This analysis was very useful to identify wrong detection due to propeller water after the school was crossed with the vessel.

The direction and speed of the school migration was determined by measuring the net displacement of the school during the tracking. Therefore, the geographical positions of the start, middle and end of the track were obtained, together with the time in each of these locations. The net displacement was measured using a ruler tool available in the software, and an angle tool was used to measure the course. The time interval was obtained by subtracting the start time from the end times of the track.

In order to have a better understanding about the school migration, the ocean currents were measured onboard MS “Eros” using a Furuno current indicator model CI-35 (fishery doppler current meter) available in the vessel. The current meter measured the current mean direction and speed in three layers: surface (10 m), middle (50 m) and bottom (150 m). The vessel position, direction and speed of the three layers were manually recorded by the officer in duty in the wheelhouse.

All data from the survey are stored in external hard discs (Sigurd Tjelmeland, Research group pelagic fish, Institute of Marine Research, Bergen, Norway). Biological data and Acoustic data from the echosounders are also stored in databases at Institute of Marine Research.

3 Results and discussion

3.1 Physical oceanography

The average temperature in the upper 50 m of the water column decreased gradually from west to east within the survey area, with maximum 6.38 °C in the western area and minimum 1.87 °C in the eastern area. There was small difference in the geographical temperature distribution between early and late February, with a tendency to lower temperatures along the coast in the latter period (Figure 3).

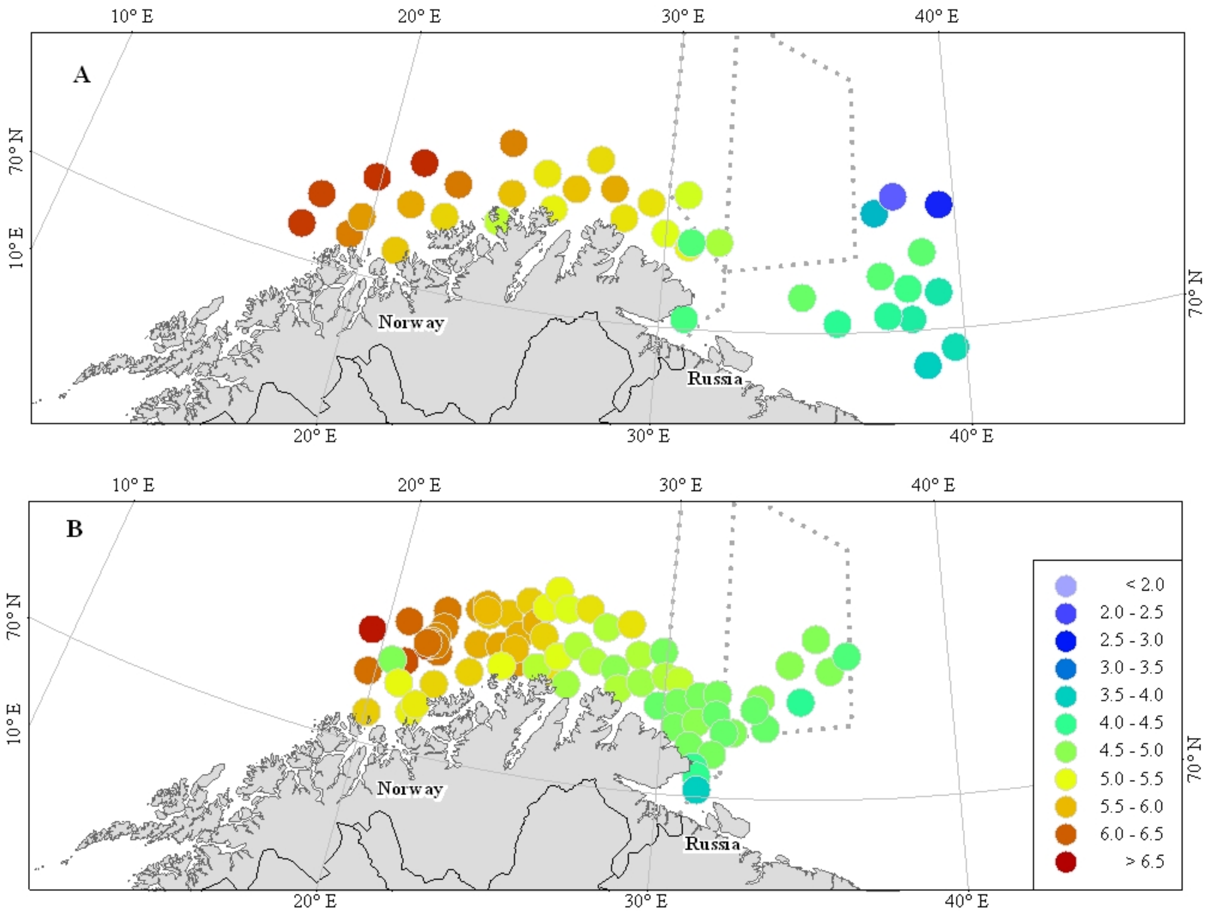


Figure 3. Average temperature (°C) in 0-50 m depth at the CTD stations from MS "Eros" 2-19 February (A) 20 February-2 March (B) and from MS "Libas" 15-28 February 8 (B).

3.2 Biology, distribution and abundance indices of the capelin spawning stock

Capelin was distributed near the bottom in mix with other fish species in a wide area along the Norwegian and Russian coasts during period 1 and 2. While during period 3, capelin was mainly observed in schools, particularly in the western area along the Norwegian coast

(Figure 4). The general pattern of the capelin spawning migration during the survey period was an early western approach of pre-spawning capelin (15-25/2) and western spawning, and only start of eastern approach (1/03) of pre-spawning capelin (Figure 4). Dense concentrations of capelin were observed close to the bottom East for Fugløybanken, and bottom trawl sample contained clumps of capelin egg, indicating spawning of capelin in this area.

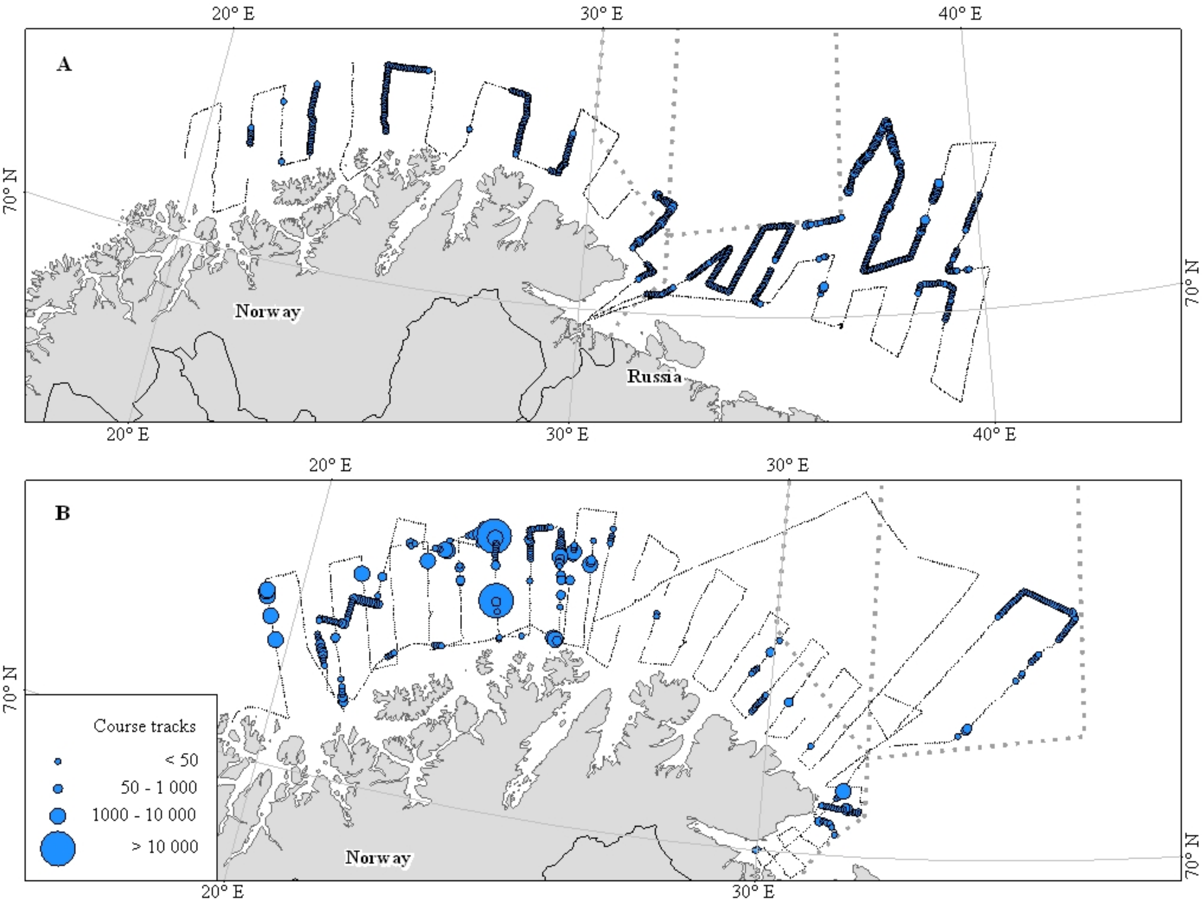


Figure 4. Acoustic recordings of capelin from MS "Eros" 2-19 February (A) 20 February-2 March (B) and from MS "Libas" 15-28 February 8 (B). Course tracks included in the acoustic abundance estimation are indicated. Size of circles indicates level of nautical area scattering coefficient (s_A) ($m^2/n.mi.^2$).

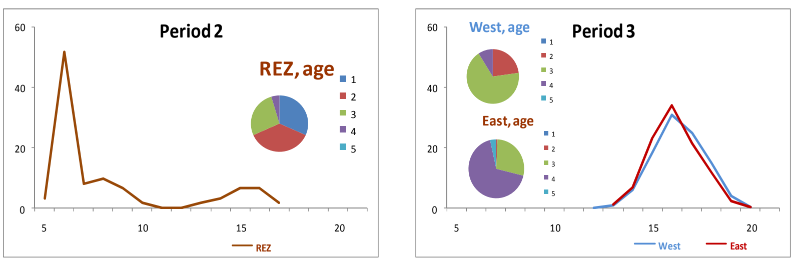
Trawl catches of capelin were divided into two groups: the first is schools in the upper water layer (10-50 m), the second was the mix registration of capelin and other fish near the bottom (~30-50m from the bottom). These observations were considered when scrutinising the acoustic registrations. The length of capelin varied between 14 and 20 cm, and capelin were 2 and 5 years old. Mean length, weight and special maturation stadium by different age group is presented in Table 3. The length and age composition of capelin varied between periods and areas (Figure 5).

Table 3. Biological parameters of capelin in different periods and areas; mean length in cm ($\bar{L}$), mean weight in g ($\bar{w}$), special stadium for capelin (Ss), and mean gonad percent (Gonad %).

Age/ periods	$\bar{L}$				$\bar{w}$				Ss				Gonad %
	2	**3**	**4**	**5**	**2**	**3**	**4**	**5**	**2**	**3**	**4**	**5**	
1		16.4	17.7	18.2		19.9	25.5	30.0		4	4	3.8	13
2	11.8	16.0	17.8		4.7	17.8	26.5		1.5	3.3	3.7		10
3	9.5	16.1	17.1	18.0	3.0	18.1	22.5	28.2	2.0	4.9	5.2	5.2	16

Capelin was observed near the bottom in mix with other fish during 1.period. In the western and eastern parts the capelin dominated by 3 years old individuals (Figure 5). In REEZ the capelin schools (2 stations) were observed in the northern part of surveyed area and schools dominated by 1 and 2 years old fish. While capelin near the bottom in mix was observed regularly through all surveyed area in REEZ, and catches dominated by 3 years old individuals. During 3.period capelin were observed generally in schools, and western schools were dominated by 3 years old fish, while eastern schools were dominated by 4 years old fish. Capelin near the bottom in mix were observed at two station, and capelin dominated by 3 years old fish. Trawl catches indicated that the capelin near the bottom has almost similar age composition during early and late February. Early spawning was observed during survey, and capelin schools dominated by 3years old fish. Only start of eastern approach was observed during the survey, and capelin schools dominated by 4 years old fish (Figure 5).

A



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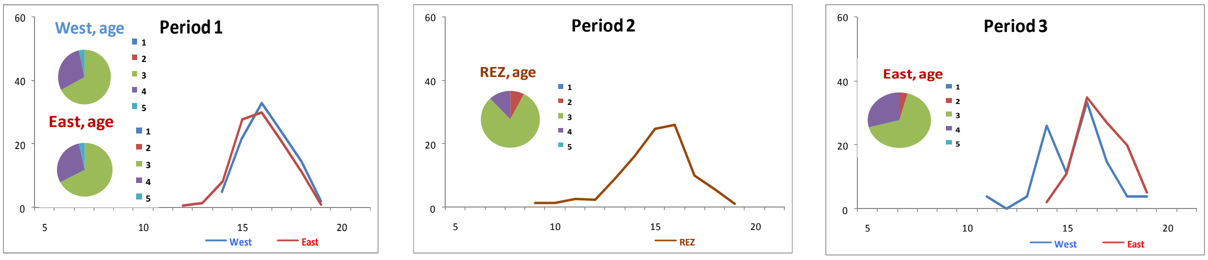


Figure 5. Length and age distribution of capelin in schools in periods 2 and 3 (A), and near the bottom in periods 1-3 (B).

Sex and length composition varied between periods and areas and presented in Figure 6. During period 1 and 3, along the Norwegian coast, proportion of females and male in catches was almost similar. During period 2, REEZ, samples were generally presented by 3 years males and 4 years females. Males were generally l-2cm larger than females, and were 15.5 and 17cm, respectively. Gonad percent varied between period, and capelin observed during periods 1 and 2 represented pre-spawners, while capelin observed during period 3 were dominated by spawners (Table 3).

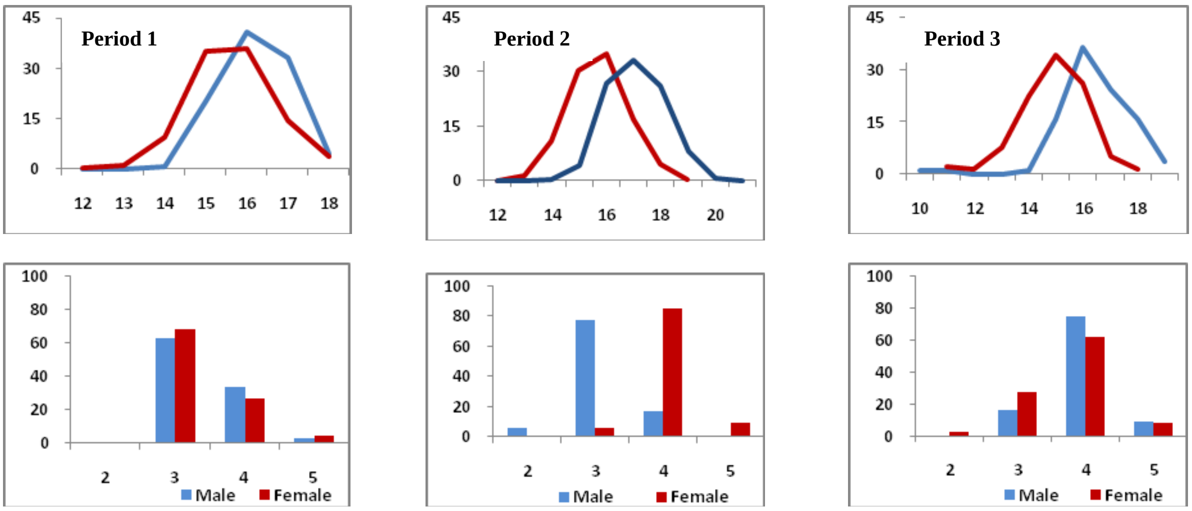


Figure 6. Length and age distribution of capelin during period 1 (2-12/2), period 2 (13-19/2) and period 3 (15/2-2/3).

The point estimate of mature (> 14.0 cm) capelin using only s_A-values from MS “Eros” and MS “Libas” is 432 000 tones. The point estimate by age is given in the text table below:

	Age 1	Age 2	Age 3	Age 4	Age 5	Sum	
Total	0	2.19	9.29	5.97	0.56	18.0339	Billion
Mature	0	2.18	9.29	5.97	0.56	18.0207	Billion
Total biomass	0	44.76	208.96	160.69	17.21	431.63	Thousand tonnes
Mature biomass	0	44.7	208.91	160.69	17.21	431.521	Thousand tonnes

Calculating the uncertainty by re-sampling Sa-values and biological data yielded the following mean values and CVs by age:

Age	1	2	3	4	5
Mean numbers	0	2.47	9.04	5.95	0.63
CV numbers	0	0.7	0.25	0.3	0.5
Mean mature numbers	0	1.78	8.95	5.95	0.63
CV mature numbers	0	0.36	0.25	0.3	0.5
Mean biomass	0	41.44	206.92	161.26	19.32
CV biomass	0	0.34	0.26	0.32	0.54
Mean mature biomass	0	40.11	206.19	161.26	19.32
CV mature biomass	0	0.35	0.26	0.32	0.54

The CV of the total mature stock was found to be 0.28. Figure 7 shows the histogram of the mature biomass with the 5% quantile marked as a red line. The 5% quantile is about 50 000 tonnes above the precautionary limit of 200 000 tonnes. However, the measurement is made one month and a half before the spawning time of April 1 assumed in the harvesting control rule. Taking into account the reduction because of predation by cod during one month the present estimate – if it could have been used – would not allow for any fishery in 2008.
It is interesting to note, however, that the spawning in 2008 seemed to start about one month earlier than assumed in the harvesting control rule.

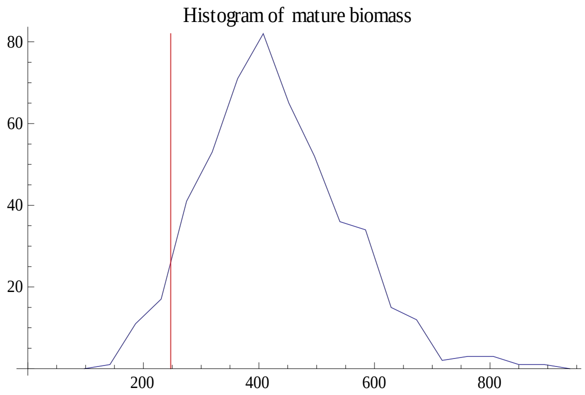


Figure 7. Histogram of mature (> 14 cm) capelin biomass. The 5% quantile is shown as a red line.

3.3 Biology, distribution and abundance indices of herring

Herring was observed both in schools, and mixed with several fish species near the bottom along the Norwegian coast in periods 1 and 2 (Figure 8). Young herring was found together with young haddock, redfish, Norway pout, blue whiting, pre-spawned capelin and other fish species, and species composition varied along the coast. In the western area along the

Norwegian coast the herring was smaller, compared to in the eastern area, where larger herring was observed.

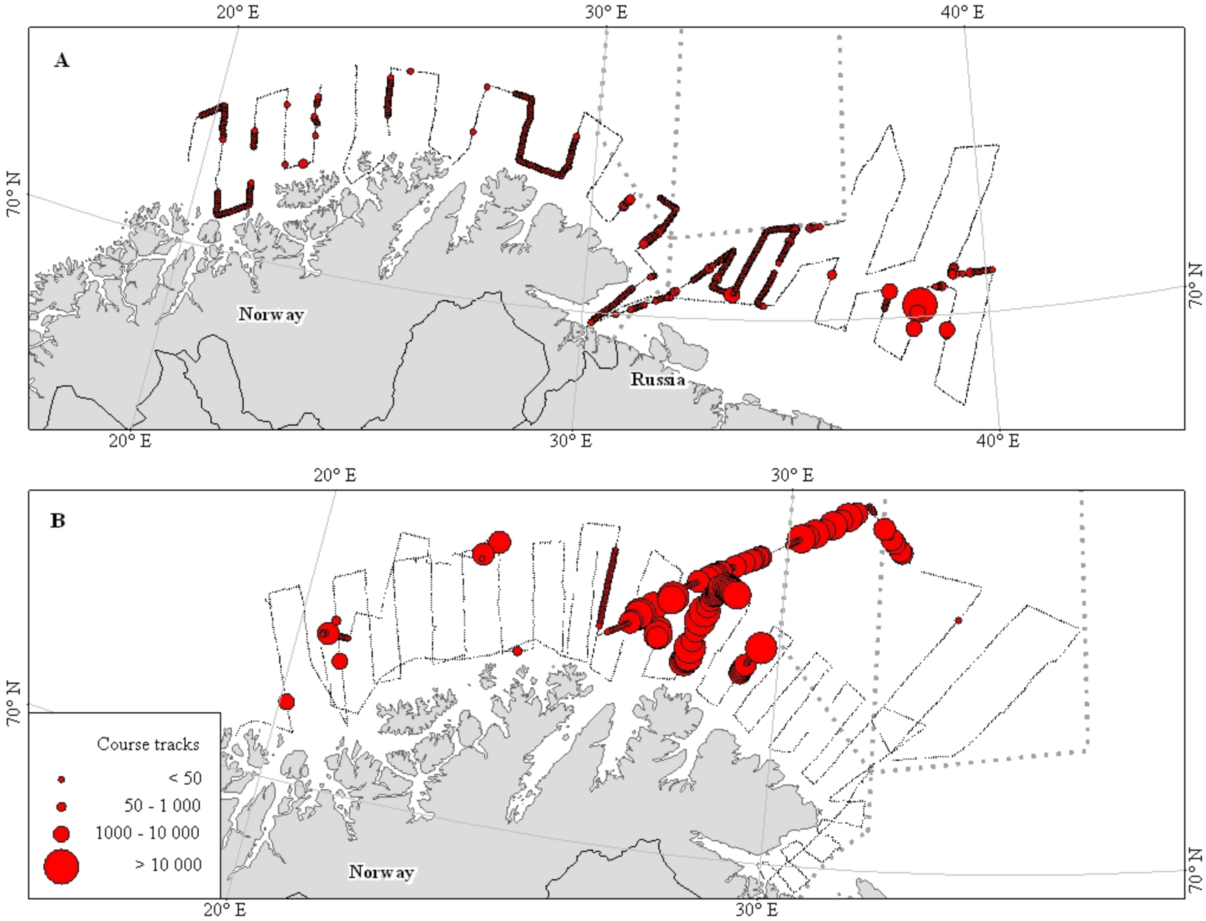


Figure 8. Acoustic recordings of herring from MS "Eros" 2-19 February (A) 20 February-2 March (B) and from MS "Libas" 15-28 February 8 (B). Course tracks included in the acoustic abundance estimation are indicated. Size of circles indicates level of nautical area scattering coefficient (s_A) (m^2/n.mi.^{2}).

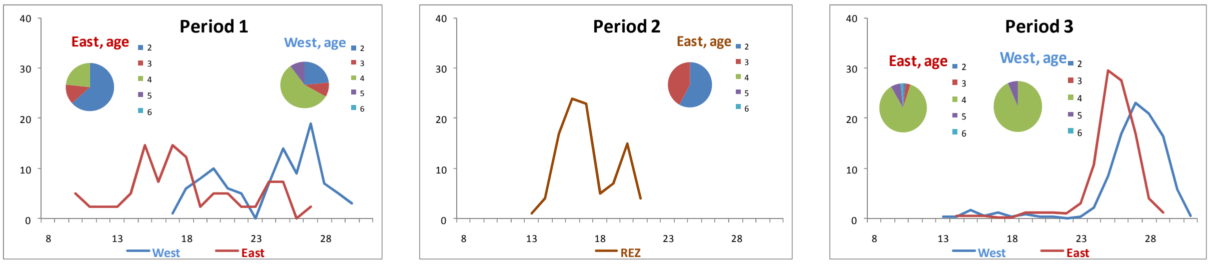
Trawl catches of herring were divided into the two groups: the first one was school of herring in the upper water layer (10-150 m), the second was mixed registrations of herring and other fish species near the bottom (~30-50m from the bottom). These observations were considered when scrutinising the acoustic registrations.

In early February the herring schools were dominated by 2 years old fish in the east, and 4 years old fish in west. During late February the proportion of larger herring increased and some fish was close to spawning. The schools with pre-spawning herring were also observed by RV "Johan Hjort" (Joint Norwegian-Russian winter survey). The schools consist of larger and older (4-6 years old) herring, probably migrating west or south-westwards into the

Norwegian Sea or towards the spawning grounds. In REEZ herring schools were denser and composed of 2 and 3 years fish.

Age sample was taken only in the eastern area, and dominated by 2 years old fish (Figure 9). During late February herring between13-18 cm dominated in trawl catches. In REEZ herring in mix was dominated by 3 years old fish.

A



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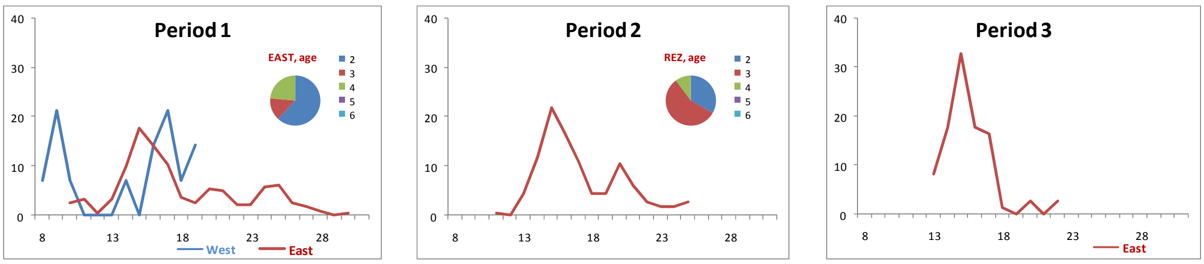

Figure 9. Length and age distribution of schooling juvenile herring during periods 1-3 (A) and of juvenile herring observed near the bottom during periods 1-3 (B).

Sex and length composition of herring varied between different periods (1 and 3), and presented in Figure 10.

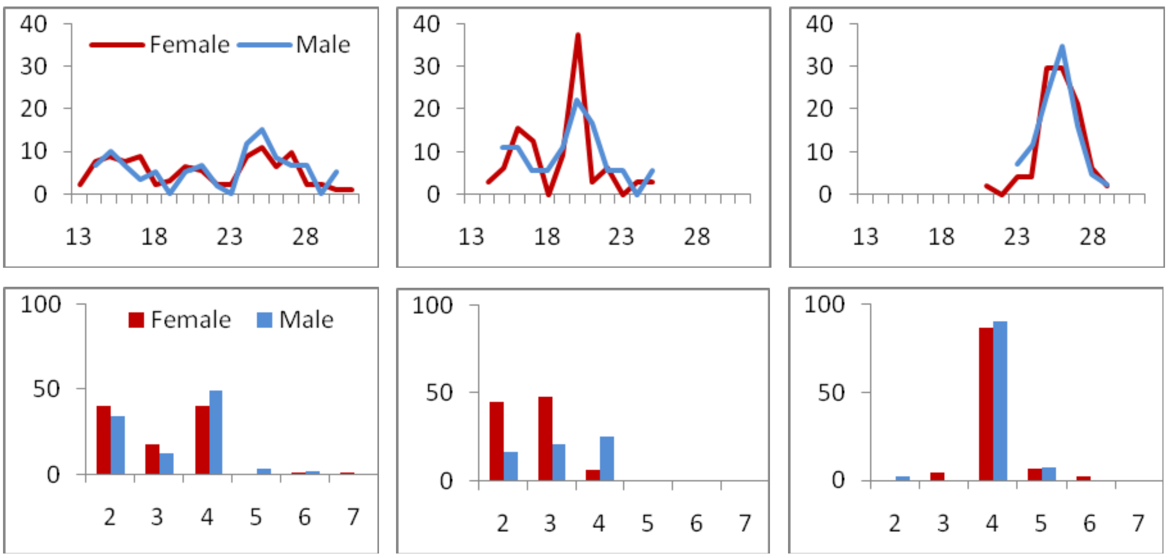

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Figure 10. Length and age distribution of herring during period 1and 2 and 3, where the Norwegian coast was covered during period 1 and 3, while Russian Economic Zone during period 2.

During early February females and males of herring were almost equally represented in the trawl catches, and dominated by 2 and 4 years old fish. During period 2 in REEZ herring was dominated by females of 2, 3 and 4 years old fish. In late February females and males of herring were again almost equally represented.

The point estimate of the total biomass of herring is 342 thousand tones, most of which from the 2004 year class. The age distribution is given in the text table below:

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Sum	
Total	0	1.06	1.25	2.28	0.15	0.02	0	4.78369	Billion
Mature	0	0	0	0	0	0	0	0	Billion
Total biomass	0	24.41	47.23	244.12	22.1	4.5	0	342.388	Thousand tonnes
Mature biomass	0	0	0	0	0	0	0	0	Thousand tonnes

The uncertainty of the estimate is calculated by resampling the acoustic values inside each WMO square, and the biological data. The expectation values and CVs by age is shown in the text table below:

Age	1	2	3	4	5	6	7
Mean numbers	0	3.04	0.95	1.75	0.13	0.02	0
CV numbers	0	0.85	0.6	0.5	0.9	2.15	4.07
Mean mature numbers	0	0	0	0	0	0	0
CV mature numbers	0	13.5	0	6.09	4.13	3.99	4.07
Mean biomass	0	64.14	35.96	196.06	19.63	4.01	0.45
CV biomass	0	0.73	0.64	0.51	0.92	2.2	4.05
Mean mature biomass	0	0.01	0	0.04	0.13	0.18	0.45
CV mature biomass	0	13.53	0	5.01	4.6	5.26	4.05

The CV of the total biomass of herring is 0.32 Figure 11 shows the histogram of the total biomass.

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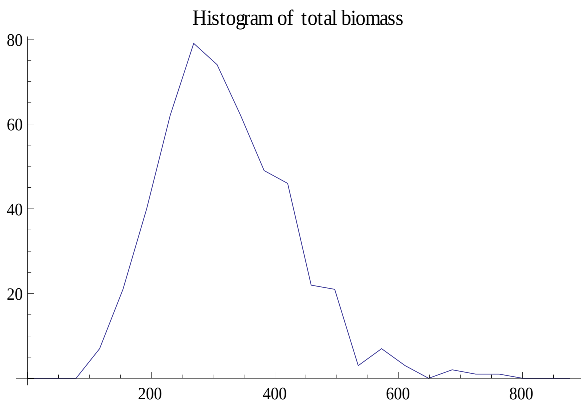

Figure 11. Histogram of total biomass of herring surveyed by MS "Eros" and MS "Libas".

3.4 Acoustic target strength measurements of capelin

A total of 19 measurements of TS were obtained, all taken in the westernmost area (Table 4). Results from the initial analysis are presented in Table 5. A more detailed paper will be published at a later date.

Table 4. Summary of TS measurements taken by MS "Libas". Latitude and longitude are given as degrees and decimal minutes. TS station number, trawl station number used for validation, and transducer depth are given.

Date	Time [UTC]	Lat (N)	Lon (E)	TS-st. no	Trawl st. no	Transd.depth	Quality	Comment
20.02.2008	740	71 24.5	24 03.0	1	25	15 - 18 m	High	
20.02.2008	1350	71 24.5	24 03.0	2	No trawl	15 m	Low	Too dense
20.02.2008	1830	71 43.5	23 26.0	3	26	25 m	High	
21.02.2008	110	71 45.0	24 04.0	4	27	-	Med/Low	Few traces
21.02.2008	1930	71 51.0	24 25.0	5	No trawl	25 m	Low	Dense school. Few traces.
22.02.2008	1330	71 33.3	25 56.5	6	No trawl	150 m	?	No capelin
23.02.2008				7				**Cancelled**. No data available
24.02.2008	110	71 42.6	22 46.4	8	33	10 - 22 m	Med	Dense. Few single fish traces
24.02.2008	442	71 43.7	22 50.0	9	33	20 - 40 m	Med	Partly too dense
24.02.2008	805	71.42.0	21 41.0	10	No trawl	30 - 50 m	Low	Bad weather. Strong heave.

25.02.2008	1300	71 23.7	21 46.5	11	No trawl	35 - 50 m	Low	Few detections. Bad weather
25.02.2008	1917	71 21.9	21 51.8	12	35	10 - 15 m	High	
25.02.2008	2027	71 22.0	21 43.0	13	35	10 - 16 m	Low	Didn't hit school. Fish too shallow
26.02.2008	2332	71 17.4	21 43.2	14	36	10 - 25 m	High	
26.02.2008	532	71 15.0	21 31.0	15	37	20 - 60 m	Low	Fish diving.
26.02.2008	1511	71 16.8	21 34.9	16	38	15 m	Med	Few single traces.
26.02.2008	1910	71 15.0	21 43.0	17	39	12 - 25 m	High	
26.02.2008	2325	71 16.7	21 50.5	18	39	7 - 10 m	Med	Few fish
27.02.2008	2008	71 32.2	18 59.9	19	No trawl	140 m	High	Not capelin. Mean TS -45dB

Table 5. Initial results from target strength measurements.

Date (D.M.Y)	Time (UTC) (HH:MM)	Mean TS (dB re 1m^2)	Mean fish length (cm)
20.02.2008	08:07-09:15	-50.63	16.94 ± 1.26
21.02.2008	19:30-20:05	-50.67	16.73 ± 1.26
24.02.2008	01:10-02:22	-50.43	16.68 ± 1.36
25.02.2008	19:17-19:38	-51.28	16.02 ± 1.08
25.02.2008	23:32-00:20	-51.64	15.70 ± 1.14
26.02.2008	05:31-06:35	-50.46	16.21 ± 1.18
26.02.2008	15:11-16:23	-50.64	16.69 ± 1.33
26.02.2008	23:25-02:02	-49.74	17.45 ± 1.06

3.5 Migration towards the spawning grounds

The results on migration studies with sonar are based on the data from MS "Eros". Similar sonar data from MS "Libas" are stored for future analyses.

From the processing of the tracked schools some general comments can be noted:

Only the tracking data from one or two schools was finally accepted in each sampling period. When multiple schools were present, they were located at different depth, therefore the tracking data of not prioritised schools was of bad quality.

Problems with propeller water caused errors following of the school track. This problem was common for both SH80 and SP70 sonar.

In SP70 sonar a ring with very strong scattering was present in the range between 100 and 150 m. This noise masked the signal coming from the tracked school, which eventually disappears in this ring. The solution was to increase the sonar RCG filter to a maximum, filtering the noise ring, and leaving the school signal. However, this filter was returned to normal settings when cruising because it decreases the capabilities for school detection in the long range.

The tracked data collected from short sampling periods (< 5 minutes) was not suitable for obtaining high quality data for determining school direction and speed.

Examples of school tracking with the high and low frequency sonar are showed in Figure 12.

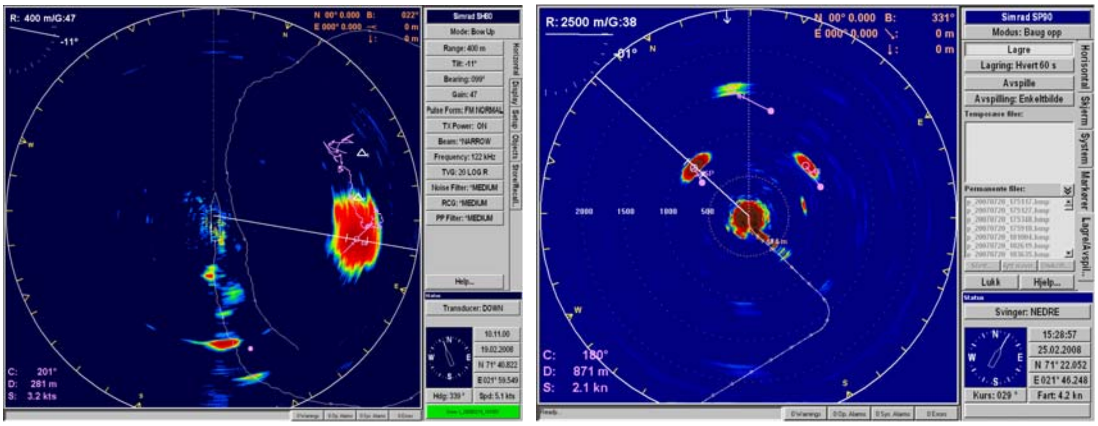

Figure 12. Examples of school tracking. Single school tracking using the high frequency sonar SH80 in a short range, which school track is displayed as a continuous purple line (a). Multiple school tracking at a long range using the low frequency sonar SP90 (b).

Suitable tracking data was obtained from 18 schools of capelin, from the 15 to 25 of February 2008 (Table 6).

Table 6. Results of tracked data for herring and Capelin schools onboard M/V Eros, during February 2008. IDT is a label for date and school number. Latitude and longitude are the geographical coordinates of the central

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position of the track (decimal deg), Time UTC, School course (deg), distance travelled during the track (m), elapsed time in the tracking (min) and school speed (knots).

IDT	Latitude	Longitude	Time	Date	Course	Distance	Elapsed time	Speed
1501	71.563	37.840	13:18:03	15.02.2008	188	245	4.2	1.90
1503	71.525	37.863	14:07:56	15.02.2008	120	95	4.2	0.74
1504	71.513	37.881	14:45:12	15.02.2008	135	114	1.7	2.19
1505	71.445	37.906	15:20:52	15.02.2008	260	197	20.8	0.31
1506	71.444	37.898	15:19:04	15.02.2008	270	140	13.4	0.34
1507	71.444	37.896	15:23:27	15.02.2008	293	82	10.0	0.27
2001	70.715	32.365	21:35:49	20.02.2008	297	79	5.6	0.46
2002	70.728	32.441	22:27:27	20.02.2008	279	318	12.6	0.82
2401	71.249	21.580	05:22:26	24.02.2008	294	131	3.5	1.20
2402	71.230	21.659	06:44:17	24.02.2008	270	722	11.9	1.97
2403	71.064	21.084	09:03:49	24.02.2008	146	188	16.2	0.38
2404	71.056	21.072	09:38:54	24.02.2008	179	459	41.0	0.36
2405	70.725	20.894	15:40:12	24.02.2008	93	122	6.8	0.58
2406	70.735	20.872	15:55:25	24.02.2008	122	304	16.0	0.62
2407	70.722	20.926	16:20:42	24.02.2008	209	254	4.1	2.03
2408	70.731	20.892	16:29:40	24.02.2008	132	133	5.0	0.87
2501	71.227	25.546	07:24:23	25.02.2008	88	477	13.6	1.14
2501	71.665	25.482	10:43:36	25.02.2008	270	1139	25.4	1.45

The tracked data came from schools in a wide geographical extension from 20˚ to 38˚E in Longitude, and also from the coastal to off shore regions. The mean speed of the capelin schools for all the surveyed area was 0.98 knots with a standard deviation (SD) of 0.66. For an arbitrary separation in space, the schools in the eastern region (32 - 20˚ E) showed a relatively lower speed, with a mean of 0.88 knots and a SD of 0.76. In contrary, the schools in the western region (*ca*. 37˚E) showed a relatively higher speed with mean value of 1.06 knots and also lower SD of 0.61.

The course of the schools was different, for the entire region, the course ranged from 93˚ to 294˚, i.e. from E to NW (Figure 13a). For the schools in the eastern region, the course ranged from SE to NW, but with a relatively higher number of schools between W to NW (Figure 13b). In the western region, the range was from E to NW, but a higher predominance in the quadrant from E to S (Figure 13c).

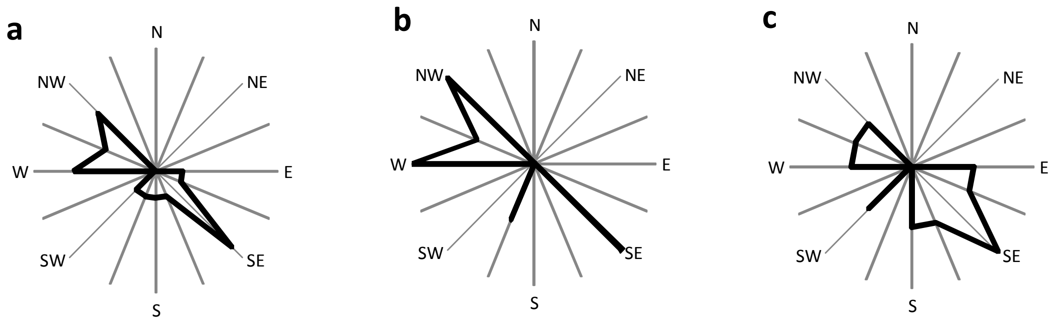

Figure 13. Capelin school course (in percentage), in all the study area (a), in the eastern region, from 32 a 20˚E (b) and from the western region, *ca*. 37˚E (c).

The compiled information of the tracked capelin schools, including the geographical location of each school, speed and course is showed in Figure 14. From the figure it is evident that most of the capelin schools had a course either east or west, with only a few with a mean direction to the south, towards the coast. In the western region, the schools located more offshore were swimming mostly towards the west, in contrary, the schools more close to the coast where swimming towards east.

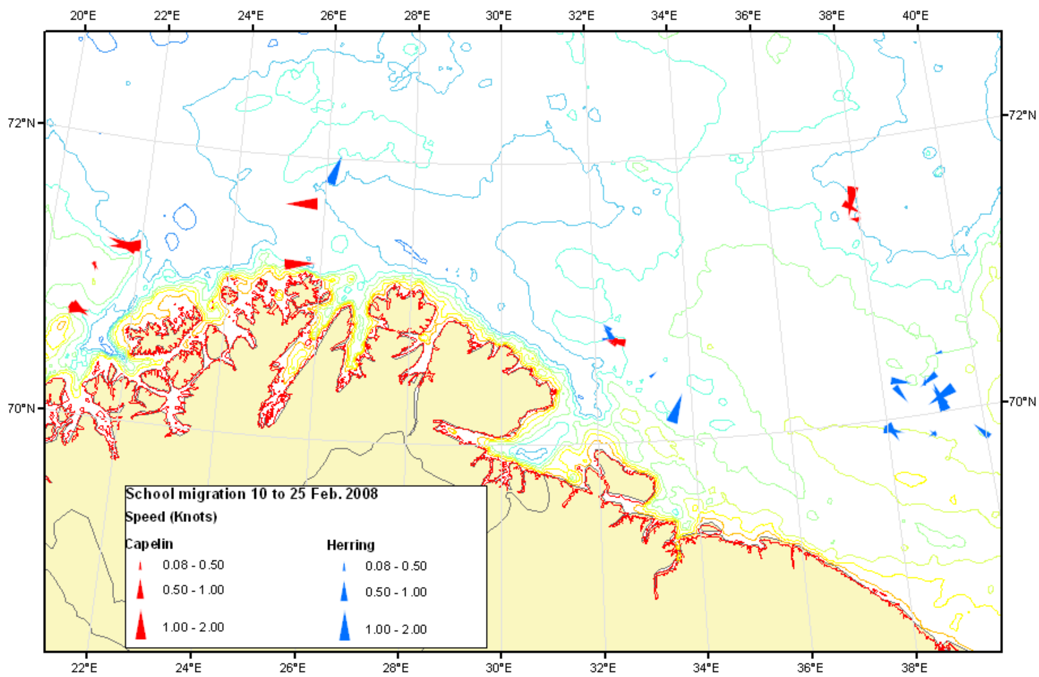

Figure 14. Geographical position, course and speed (knots) of capelin (red arrows) and herring (blue arrows) for the period from 10 to 25 February 2008.

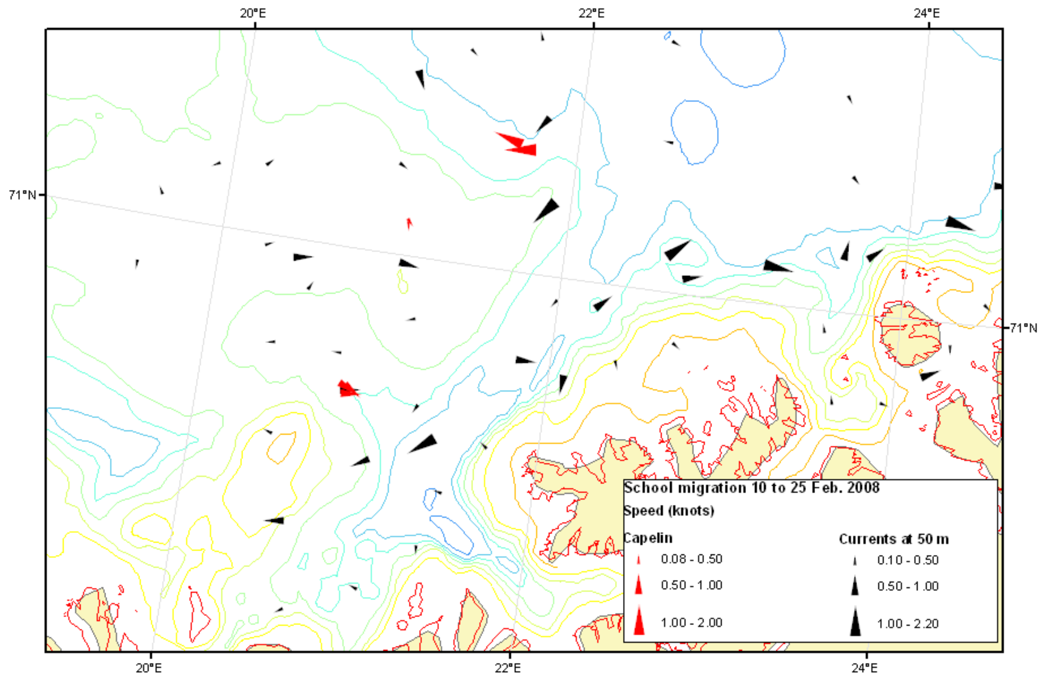

Figure 15. Detail of capelin school direction and speed migration (red arrows) and ocean currents direction and speed at 50 m (black arrows).

A very strong correlation was found when graphically combining the data from the school migration and the currents. In most cases the schools were swimming following the direction of the prevailing currents at the depth they were located. Also a good agreement was observed with the speed of the schools and the currents (Figure 15). The same correlation was observed during the school tracking by the scientist and officers in the wheelhouse.

Together with the tracking of capelin schools, a sampling of herring schools was done during the survey. The results of the tracking of herring school are resuming in Table 7. The mean speed of the herring schools was 0.61 knots with a standard deviation of 0.35. The course of the school was predominant from the NW to the ESE (Figure 16).

Table 7. Results of tracked data for herring schools onboard M/V Eros, during 10 to 25 February 2008. Column explanation same as in Table 6.

IDT	Latitude	Longitude	Time	Date	Course	Distance	Time	Speed	Specie
1001	70.741	32.274	20:16:11	10.02.2008	86	443	31.5	0.46	Herring
1002	70.783	32.310	22:17:10	10.02.2008	329	303	15.1	0.65	Herring
1003	70.796	32.282	22:30:22	10.02.2008	300	121	8.7	0.45	Herring
1004	70.829	32.271	22:56:08	10.02.2008	307	190	15.1	0.41	Herring
1201	70.224	33.704	23:07:04	12.02.2008	20	658	21.1	1.01	Herring
1202	70.470	33.243	17:32:17	12.02.2008	50	230	41.6	0.18	Herring
1601	70.417	39.260	23:21:16	16.02.2008	252	209	26.5	0.26	Herring
1701	69.829	39.930	17:22:04	17.02.2008	309	125	7.2	0.56	Herring
1702	69.846	38.912	17:46:45	17.02.2008	237	64	8.0	0.26	Herring
1703	69.864	38.915	18:03:04	17.02.2008	310	49	19.6	0.08	Herring
1704	70.115	39.171	19:55:50	17.02.2008	340	136	11.1	0.40	Herring
1705	70.117	39.172	19:57:30	17.02.2008	320	246	14.3	0.56	Herring
1706	70.117	39.182	20:01:34	17.02.2008	235	159	4.3	1.21	Herring
1707	70.117	39.170	20:03:26	17.02.2008	336	64	1.8	1.17	Herring
1709	70.240	38.945	21:35:45	17.02.2008	230	369	18.1	0.66	Herring
1710	70.242	38.931	21:35:13	17.02.2008	4	140	11.1	0.41	Herring
1711	70.246	38.431	23:16:15	17.02.2008	96	250	15.2	0.54	Herring
1712	70.154	38.374	00:04:03	17.02.2008	140	209	12.1	0.56	Herring
1713	69.912	38.128	21:07:55	17.02.2008	99	276	13.2	0.68	Herring
1714	69.908	38.125	21:07:55	17.02.2008	145	115	7.1	0.52	Herring
2503	71.924	26.243	18:15:35	25.02.2008	23	353	12.8	0.89	Herring
2504	71.924	26.246	18:20:04	25.02.2008	23	902	19.2	1.52	Herring

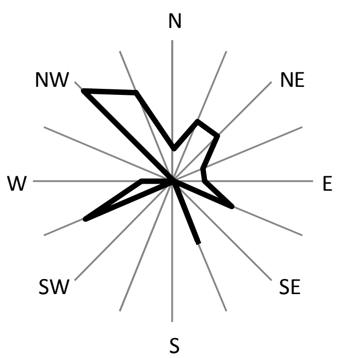

Figure 16. Herring school course (in percentage), in all the study area, during 10 to 25 February 2008.

3.6 Conclusions and future recommendations

Research vessels are equipped with advanced instruments with effective internal communication between the different units. IMR has now developed a suite of equipment making the system at rental commercial vessels similar to the one at the research vessels. This setup was used on both MS "Eros" and MS "Libas", and the experience was that the rental commercial vessels fitted perfectly to the task of acoustic abundance estimation and other acoustic sampling. With the acoustic technology currently found on commercial vessels combined with the IMR survey suit the commercial vessels are well equipped for mapping and abundance estimation of the spawning migration of capelin.

The spawning migration of capelin appears to be very dynamic in time and space. This is illustrated by the differences in acoustic abundance between period 1 and 3 in the western area. It is important to realise that the survey design for abundance estimation in the whole area was not optimal due to other objectives than abundance estimation. TS measurements onboard MS "Libas" probably resulted in slightly insufficient coverage of the outer limits of the capelin distribution. In addition MS "Eros" needed capelin recordings to obtain good migration data with sonar. We therefore made the decision that MS "Eros" should diverge from the course tracks in east and go westwards to cover the distribution limits and get data for migration studies. For abundance estimation purposes, it is recommended that a vessel aims at conducting a synoptic coverage of a limited area in one period. However, the coverage of the western spawning migration in period 3 seems to have been sufficient for obtaining reasonable abundance estimates, both with respect to area coverage and density of the course lines.

Reasonable abundance estimation of the capelin spawning migration depends on being at the right place at the right time. It is difficult to predict were the main spawning concentrations will hit the coast based on experience from earlier. However, the occurrence of capelin in the mixed species layer at the bottom early in the survey period poses some interesting questions about how the capelin approach the coast. If this is a general trait early in the spawning period, more attention should be directed towards the mapping of this mixed layer along the coast. Bathymetry and temperature conditions should also be studied to test if migration is limited or guided by these physical factors. A combination of early signs of migration timing and distribution would simplify the design of future surveys for estimating the spawning stock of capelin in the winter.

The area covered by the survey is important as parts of the feeding area of juvenile herring in the Barents Sea. The acoustic recordings of capelin and herring are quite similar, and difficult to separate. The main herring concentrations were found in the eastern part along the

Norwegian coast, an area with sparse capelin registrations. The abundance estimates of the main spawning migration in the western area is therefore less likely confounded by erroneous scrutinising due to mixture of herring and capelin. During this survey, simultaneous sampling of multi-frequency acoustic data was done and the preliminary analyses of this data is promising with respect to separate schools of capelin and herring based on acoustic properties. The results of these analyses should be followed up with further data sampling to strengthen the procedures of school identification. Using vessels with several echosounder frequencies in the future is crucial for using the current results and continuation of data sampling for improving the method.

The acoustic target strength (TS) depends on fish tilt angle, and may depend on depth distribution of the fish, as well as biological parameters such as gonad size and fat percentage. The swimbladder of fish, giving the most important contribution to backscattered sound, is influenced by pressure leading to compression with increasing depth. The current acoustic target strength (TS) used for capelin is developed for use during the autumn survey situation in the feeding areas along the polar front. Capelin on spawning migration has a different vertical distribution than in the feeding areas. This was observed in the capelin survey performed during winter 2007, where the depth distribution of capelin was found to be different than at the survey in autumn 2006. This indicates that the situation during spawning migration might lead to a different TS than the one used in the autumn biomass estimate. Preliminary TS estimations based on samples from the survey reported here indicates that the TS is similar to the one used in the autumn surveys for smaller capelin, while it differs more for larger capelin. For a mean length of 15.5 cm we estimated the TS to -51.64 dB, the corresponding TS for the autumn survey is -51.26 dB. For a mean length of 17.5 cm we estimated the TS to -49.74 dB, the corresponding TS for the autumn survey is -50.26 dB. The TS probe and calculation methods used here gives more reliable estimates of TS than earlier. Further sampling using the same methods is recommended at the autumn survey 2008 to get comparable estimates from the two periods.

A method for sonar estimation of migration speed and direction is now established, and similar studies as the one presented here can be done in the future. The data sampled at this cruise are valuable as a first approach towards describing the small scale migration patterns in spawning capelin. A general impression of the migration speed and direction of capelin is obtained. One important result is the correlation between current direction and migration direction. This relationship should be further studied to improve the potential of sonar registrations to aid the establishing of survey areas based identification of probable migration routes.

Currently, the capelin quota is determined by forward modelling of a multispecies model taking into account the autumn survey abundance estimate and estimated predation by cod during winter. This survey is part of a series of surveys from 2005 and 2007-2009, exploring the potential of obtaining abundance estimates of the spawning stock of capelin as a basis for setting fishing quotas. To fulfil this aim, we need to obtain reliable estimates early in the spawning season, so the fishermen can get the catches before the capelin is spent. The dynamic properties of the spawning migration make this task difficult. Two possible strategies are proposed to fulfil this task:

1. Instead of aiming at abundance estimates of the total spawning stock, we can estimate the stock in a predefined geographical area and time, suggested in cooperation with the fishermen. The quota based on the model described above can be adjusted if the abundance in this area is above a certain limit. For the time being, it is not clear if this strategy is compatible with the current exploitation rules.
2. If a quota based is recommended based on the modelling, this can be viewed as preliminary. Then several commercial vessels are used to assess the spawning stock before the quota is set, and fishing can commence.

We thank the technical staff onboard MS “Eros” and MS “Libas” for their invaluable assistance during the survey. We also like to send our sincere gratitude to the skippers and crews onboard MS “Eros” and MS “Libas” for their goodwill and effort during the survey. Their contribution to the excellent working conditions for the scientific staff was immense and much appreciated. The cooperation between them and the scientific staff was flawless, and their expertise and experience was an important success factor for the survey. The exchange of experience between fishermen and researchers experienced at such surveys is educating and inspiring, and represents a valuable asset from surveys with rental commercial vessels.

Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr.8 – 2008

4 Participants

Participants	**Research group**	**Time**	**Vessel**	**Responsibility**
Sigurd Tjelmeland	433 Pelagic fish	-	-	Cruise coordinator
Elena Eriksen	439 Trophic interactions	2/2-2/3	MS ”Eros”	Cruise leader
Geir Odd Johansen	439 Trophic interactions	15-29/2	MS ”Libas”	Cruise leader
Hector Pena	431 Observation methodology	2/2-2/3	MS ”Eros”	Sonar and CTD
Geir Pedersen	431 Observation methodology	15-29/2	MS ”Libas”	TS measurements
Ingvald Svellingen	431 Observation methodology	15-29/2	MS ”Libas”	TS measurements
Lage Drivenes	620 Electronic equipment	2/2-2/3	MS ”Eros”	Equipment and data storage
Magnar Mjanger	620 Electronic equipment	15-29/2	MS ”Libas”	Equipment and data storage
Jan Henrik Nilsen	433 Pelagic fish	2-20./2	MS ”Eros”	Biological sampling
Bjørn Vidar Svendsen	433 Pelagic fish	2-20./2	MS ”Eros”	Biological sampling
Valentin Anthonypillai	433 Pelagic fish	20/2-2/3	MS ”Eros”	Biological sampling
Meland Elna	433 Pelagic fish	20/2-2/3	MS ”Eros”	Biological sampling
Silje Elisabeth Seim	Unestablished	15-29/2	MS ”Libas”	Biological sampling
Anne Christine Knag	Unestablished	15-29/2	MS ”Libas”	Biological sampling