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Executive summary

In August 2008, Norway, the Russian Federation and the Faroe Islands conducted a joint survey on beaked redfish (*Sebastes mentella*) in the Norwegian Sea. The objectives of the survey, as set by NEAFC-AM 2007/58 were to measure the horizontal and vertical stock distribution and provide an abundance estimate. During the two weeks of investigation, the distribution, abundance and biology of *S. mentella* in the Norwegian Sea were studied by means of hydroacoustics and pelagic trawling on board three commercial vessels: Atlantic Star (Norway), Osveyskoe (Russia) and Skálaberg (Faroes).

S. mentella was observed between 100 and 800 m, with maximum concentrations in the 350–550 m depth layer. This depth corresponds to the Deep Scattering Layer (DSL), were high concentration of small preys occur (myctophids, shrimps, cephalopods,…). *S. mentella* was observed in more than 90% of the trawls, over most of the area covered by the survey. The geographical distribution of the stock extended beyond the survey coverage, so only a fraction of the population could be studied by the survey. Generally larger and older individuals were found in the southern area of the study. More than 90% of individuals were older than 15 years, supporting the observed very low recruitment in the recent decades.

Not all hydroacoustic data could be analysed by the group. In addition there are still important methodological difficulties and discrepancies which will require additional work to be resolved. For these reasons, a joint robust estimate of distribution and abundance of *S. mentella* in the Norwegian Sea can not be produced at the time of revising this report.

A series of recommendations are proposed to converge towards common methodologies in future surveys.

1 Introduction

The meeting opened on 16 September 2008 at 9:00 at ICES headquarters in Copenhagen. Christoph Stransky (Germany) was elected Chair for the meeting. There was a brief introduction by the Chair on security issues in the ICES building and the use of the ICES SharePoint system. Although the meeting is not a formal ICES meeting, it was agreed that the documents and report of the meeting would be placed on the ICES/SGRS SharePoint.

1.1 Objective of the meeting

Following the request from NEAFC (AM 2007/58), Norway, Russia and the Faroe Islands conducted a joint survey on redfish in the Norwegian Sea during August 2008. The objective of the meeting was to report on the international survey on *Sebastes mentella* in the Norwegian Sea in August 2008 and to provide relevant information on horizontal and vertical distribution and abundance.

1.2 Adoption of the Agenda

The agenda (Annex 2) was adopted.

1.3 Participants

There were seven participants from 5 countries:

Eckhard Bethke (Germany), Kristján Kristinsson (Iceland), Andrey Pedchenko (Russia), Benjamin Planque (Norway), Jákup Reinert (Faroes), Fróði Skúvadal (Faroes), Christoph Stransky (Germany).

The detailed contacts for participants are given in Annex 1.

The group missed the expertise of some of the survey participants who had been collecting and scrutinizing the hydroacoustic data. This resulted in difficulties in resolving important issues linked to the analysis of hydroacoustic data. This is further discussed in the report and a recommendation is provided to address the issue (Annex 3, Rec. 7).

1.4 Structure of the report

The report is divided into three main sections. The first section presents the sampling methodology used by the three vessels for hydroacoustics and biological sampling. The second section reports the results available at the time of the group meeting. The third section discusses the results with regards to methodological aspects and provides a series of recommendations for improved planning, coordination and harmonization of the survey protocols in future. This report is an updated version of the AGRED report 2008. Main changes from the previous report include revised hydroacoutics analyses for Norway and Russia as well as data on age structure of redfish population for Norway and the Faroes.

2 International survey on beaked redfish (*S. mentella*) in the Norwegian Sea in August 2008

2.1 Material and method

2.1.1 Vessels timing and survey area (Table 1, Figure 1)

Norway: the survey was conducted on board the commercial trawler Atlantic Star. The survey extent and sampling plan was done according to the survey planning document (Annex 5) except for the following:

- Transect 10 was sampled before Transect 9 (this was done so that the Atlantic Star could still meet with F/T Osveyskoe, because of the late departure of the latter, see below),
- The total number of trawl hauls was reduced to 24, to fit with available time during the survey. This resulted in 72 biological samples (3 samples per trawl haul when using the multisampler codend),
- Transects 13 and 14 were shifted slightly westward to cover a larger fraction of the international waters and less of the shelf break area.

Russia: the Russian part of survey was carried out by PINRO, the Knipovich Polar Research Institute of Marine Fisheries and Oceanography in Murmansk, with the commercial trawler "Osveyskoe" according to the survey planning document (Annex 5). However, some of the planned researches were altered and rescheduled prior to and during the survey:

- The survey started later than planned, on 15 August after calibration of acoustic equipment near Tromsø. The survey ended on 28 August (14 days in total).
- On some parts of the transects, trawling was not possible and only hydroacoustics registrations were performed. This was because of the vessel awaiting the permission by Russian authorities to fish in Norwegian waters (Tracks 7 and 8) or adverse weather conditions (Tracks 5 and 7).

Faroe Islands: the survey was conducted on board the commercial trawler Skálaberg. The survey extent and sampling plan was done according to the survey planning (Annex 5) except for the following:

- Late start (14 August) because of preparation of vessel and fishing gear. This was the reason for why only 23 trawl stations were conducted in contrast to the 32 originally planned.
- Tracks were followed according to the original planning except for a slight shortening of transects 1, 3, 4 and 5 in order to meet up with the Russian vessel Osveyskoe.
- Intercomparison of the hydroacoustic registrations between Skálaberg and Osveyskoe were not performed as a consequence of bad weather conditions. Instead two parallel trawl hauls were done, on 300 and 400 m headrope depth, respectively.

The extent of the survey and the sampling locations (trawls and acoustics) of the tree vessels is provided in Figure 1 and Table 1.

2.1.2 Biological sampling (Tables 2 and 3)

Norway: biological sampling on board the Atlantic was carried out using the Gloria Trawl 2048/HO (100 m x 100 m opening) fitted with a multiple codend sampling device: the multisampler. This allowed for successive sampling at three distinct depth within one trawl haul and without contamination from one depth to the next and no sampling during shooting or heaving of the trawl. The sampling was carried out following the agreed recommendations set in the survey planning document. However, some adjustments were made for practical reasons. These are listed below:

- When the total number of fish of a given species was too large, the total number of fish was estimated from the total catch weight and the mean individual weight from a subsample (typically 100 fish).
- If the catch was so large that not all fish from one species could be weighed on the small scale, the total quantity was assessed by multiplying the number of fish baskets by the average weight of a basket (from a subsample).
- When using the multisampler, each trawl haul results in three biological catches. Each catch was treated separately. Otoliths were sampled from the first 10 individuals. Weight, sex, and maturity were determined for the first 33 individuals. Length and parasite infestation were recorded for the first 100 individuals. There was no recording of pigmentation or stomach content.
- Genetics sampling was only performed on 5 catches. Up to 100 individuals were sampled (fin clips, otoliths, length, weight, sex and maturity).

Russia: biological sampling on board "Osveyskoe" was carried out using the Gloria Trawl 2048 (Table 2). The sampling was carried out following the agreed recommendations set in the survey planning document (Annex 5). The following adjustments were made:

- Total catch was weighted in each trawl, even when large quantities of fish were caught.
- Stomach fullness as well as parasite infestation, pigment patches and muscular melanosis were recorded according to the method described in Bakay and Karasev (2001). Analysis on the stomach contents were done for 576 individuals (mostly within DSL) and parasite for 1575 individuals.
- The fin clips and otoliths were sampled according PINRO method of biological sampling.
- Genetics sampling was performed on 11 catches (585 individuals).

Faroe Islands: the biological sampling on board the Skálaberg was conducted using the Red Lion trawl 3072/HO (130 m x 170 m) for the first 18 stations and the Gloria 4096/HO (200 m x 200 m) for the remaining 5 stations. Both codends were fitted with a 40 mm mesh 12 m long piece of netting in the hind most part. The biological sampling was followed performed according to the agreed recommendations. However there were some deviations from the plan for practical reasons and these are listed below:

- When the catch of redfish was too large to be weighted on the small-scale weight, the total catch was calculated from processed weight + sampled weight. The trawlers make use of a conversion factor of 1.7 to calculate the round weight from the processed fish. This factor was used to calculate the weight of round fish processed.

- On average, 100 *Sebastes mentella* were randomly sampled for weight, length, sex and maturity except from station 5 where 205 fish were sampled.
- Due to lack of personnel the genetic sampling was limited to 30 fish per station on fifteen stations scattered over the survey area..
- Parasite and pigment recordings was done on the fish that were sampled for otoliths, i.e. up to 30 *Sebastes mentella* per station were sampled.
- All species other than *S. mentella* were recorded as random subsamples taken from the total catch. The proportion of other species than *S. mentella* in the total catch was calculated as the proportion in the in the subsample relative to the total catch.

All length measurements were done at the cm below.

The trawl characteristics and biological sampling for the three vessels are summarized in Tables 2 and 3.

2.1.3 Hydroacoustic sampling (Table 4)

Norway: hydroacoustics was conducted following the recommendations from the survey planning document (Annex 5). The hydroacoustics calibration was conducted on the first day of the survey. Results were highly consistent with previous calibrations conducted in May 2008 and August 2007 suggesting very minor drift in the instrument. Vessel noise measurements were conducted on the last day of the survey in calm weather conditions. The max recorded noise did not exceed -132dB for vessel speed between 7 and 13 knots. Overall the weather conditions during the survey were calm, allowing for 'clean' hydroacoustic registrations throughout the area surveyed. The registrations were recorded down to 1000 m depth (instead of the 750 m originally planned).

Scrutinizing of the acoustics data was done by echo-integration using the LSSS software. Contrary to the Irminger Sea, redfish in the Norwegian Sea is found mostly within the DSL, and in smaller quantities above (mixed with other fish species) and below (almost pure). The echo-integration was therefore performed with S_V thresholding to remove low-energy echoes which results from smaller targets in the DSL. Integration was done in a series of depth layers selected on the basis of vertical structures visible on the echogram and the information for the nearest trawl catches. In each layer, the threshold was raised up to a level where the DSL (or other 'background' layer) could not be seen. This was often around -72dB. The s_A was then allocated to fish targets and divided between fish species according to s_A proportions in the nearest trawl hauls (s_A proportions are directly provided by the 'trawl module' of LSSS on the basis of species quantities and length distribution in the catch). The threshold was then brought back to -82dB and the additional s_A was allocated to the category 'plankton'. In the upper 100m there was no trawl sampling so all energy was allocated to 'plankton' and 'other'. The data were not scrutinized below 800 m. The scrutinizing was performed by 5 nautical miles (NM) blocks and the data exported into report files with a resolution of 1 NM and 10 m depth. As fish below 600 m had a significantly greater length than those above, two different target strength (TS) values were used in the abundance estimate: one for the layer 100–600 m and one for the layer 600–800 m.

Russia: before carrying out of shooting calibration on reference sphere about island Vannøya (Troms) on depth of 25 m has been executed.

Hydroacoustic sampling was carried out using echosounder ER60 (version 2.1.2) on frequency 38 kHz and systems of post-processor processing FAMAS and BI60. Echo-integration during trawling about 750 m was conducted. The method consists in calculation of amount of individual fish on echograms (for an interval of 1 nautical mile), average force of the purpose <TS> which exceeds certain value TS_{min} with the further estimation S_{Aac} for these fish or under classical formulas of hydroacoustics, or on the algorithms received experimentally. For example, special measurements have demonstrated, that for the redfish in length 36–40 cm (<TS> = - (40–39) dB) on depth of 600–700 m the amount of fish on mile of a way n=4 is approximately equivalent S_{Aac} = 1 m^2 / nm^2.

Identification by acoustic way of the redfish settling down below edge of DSL, had experimental character and was possible only in case of satisfactory "noise" conditions of environment (for example, at sweeps or at favourable weather).

For a trawl Gloria the coefficient of trawl efficiency has been accepted equal K=0.250 and the formula of calculation s_A for the redfish for the period sweep in DSL and under it looked like s_A = K*Catch (Results from observations in the Irminger Sea in 2007).

Calculation of number and a biomass of *S. mentella* have been averaged over 5 nm intervals. Acoustic backscattering coefficients (s_A) of *S. mentella* in each 5 nm block were estimated separately above the DSL (as a rule, is higher 300–400 м), and within/below the DSL.

Faroe Islands: hydroacoustics was conducted following the agreed recommendations from the planning document. The Skálaberg had recently installed the EK 60 and split-beam transducer. The hydroacoustic calibration was conducted on 13 August. The results from the calibration demonstrated satisfying results and were done according to the EK 60 manual. Vessel noise measurements were done on 15 August. Some scrutinizing of the acoustic data was done on board. The energy was allocated to species according to the nearest trawl haul.

2.1.4 Hydrographic measurements (Table 5)

Norway: hydrographic measurements were done using a CTD probe SAIV AS/SD204 calibrated prior to the survey. The probe was attached to the multisampler and recorded temperature and salinity every 10 seconds. The maximum depth of hydrographic measures was set by the maximum trawling depth. During trawling, the mutlisampler-CTD was usually 40 to 70 m below the headline depth.

Russia: hydrographic measurements were done using the Simrad temperature sensor of FS20 attached on trawl headrope. During the survey in a few different points the data of sensor was calibrated against data from a CTD probe FSI NXIC. After the survey, temperature data from the FS20 sensor was corrected and used for analyse. The maximum depth of temperature measures was set by the maximum trawling depth (headrope) and was about 600 m.

Faroe Islands: hydrographic measurements were done using Star-Oddi CTD Data Storage Tags attached to the trawl. Two tags were attached to the trawl at each station, one on the headline and one on the groundline. The tags were set to measure temperature, depth and salinity every second. The results were then after each haul read from the tags and an average temperature derived from the data.

2.2 Results

2.2.1 Species composition (Table 6)

Sebastes mentella was the most common species found and occurred on average in 93% of the trawl samples (note that most trawls were performed around the depth of maximum density of *S. mentella*).

Blue whiting (*Micromesistius poutassou*) was also commonly found (83% occurrence) above and within the DSL. The non-commercial species 'ribbon barracudina' (*Arctozenus risso*) also occurred throughout the sampling region (74% occurrence).

Catches of other species included small individuals, mostly in the DSL, such as shrimps and myctophids (30%). Cornish blackfish was also commonly found in the middle and southern regions (23% occurrence).

Other fish species included saithe (29%), herring (24%), greater argentine (13%), golden redfish (6%), mackerel (8%), cod (7%), Greenland halibut (5%), and haddock (1%).

2.2.2 Horizontal and vertical distribution

Norway: because trawls were performed at different depths, sometimes at the depth of maximum density of redfish and sometimes in much shallower or deeper waters, it is not possible to derive a reliable horizontal distribution from the trawl data alone. Therefore, the horizontal distribution is described here on the basis of hydroacoustics registrations. *S. mentella* was registered in almost all the area covered (Figure 9), except for the northwesternmost part where water temperature was the lowest (Figure 11). The highest densities were found in international waters and close to the shelf break around the 600 m isobaths.

The vertical distribution of *S. mentella* was studied from the trawl catch and the hydracoustic registrations. The vertical distribution of catch rates (Figure 10) indicates that *S. mentella* was found at all depths. 90% of the catches were distributed between 200 and 600 m and 50% of the catches were taken from the layer 400–550 m, mostly within the DSL (see Figure 8 for examples of DSL in acoustic registrations). Although hydroacoustics is limited at depth because of energy spreading (and consequent loss of signal from individual fish targets), the vertical distribution of area backscattering coefficients (s_A) is very close to that of trawl catch rates. The shift between cumulated distributions of catch rate and s_A against depth indicate that hydroacoustic registrations are biased toward higher abundances in shallower waters (which is to be expected). However, the difference between the distribution obtains from trawling and hydroacoustics is small which indicate that hydroacoustics registrations are probably valid throughout the water column, down to 800 m. There are two main sources of bias associated with echo-integration in the DSL and at depth. The first is related to the misallocation of DSL targets to redfish (which results in an overestimate of redfish abundance in the DSL). This can be partly resolved by s_V thresholding in order to remove low energy targets (i.e. plankton and small fish) and retain high energy ones (e.g. redfish). This may lead to the second type of bias which is because of the reduction in the effective beam angle as a result of s_V thresholding (which results in an underestimate of redfish abundance at great depths). These are further discussed in Section 3.3.

Russia: The analysis of echograms has demonstrated, that in the daytime rarefied concentrations of *S. mentella* as of 200–350 m were usually distributed on the depths, mixing up with DSL, blue whiting, ribbon barracudina (*Arctozenus risso*). With approach of darkness the top border of DSL rose up to depths of 50–100 m and identification of concentrations of *S. mentella* by acoustic way became inconvenient and to allocate values s_A for the redfish on background of DSL somewhat it was possible to allocate with change of a threshold at post-processor processing on BI60 or FAMAS. Control sweep in the daytime demonstrated catches from 9 to 550 kg per hour trawling.

Faroe Islands: in the western-most part of the survey area there were no *S. mentella* catches. This was particular evident when getting near the Icelandic continental shelf. In this area there was also a cold front with temperatures as low as 1°C at 400 m depth (Figure 11). Apart from these stations *S. mentella* was caught on all stations with the highest catches in the Northern part of the Faroese EEZ and in the Southern part of the International waters. The highest catches were in the DSL at 350 m at temperatures of 3–4°C.

2.2.3 Assessment by trawl and acoustics method

Under certain assumptions, and following specific methodologies, it is possible to estimate the total abundance of redfish in the surveyed area using trawl catches and/or hydroacoustic registrations. The group tried the two methods but this was done with limited success because of uncertainties in some assumptions and lack of common agreed methodologies. The results from these calculations are presented below.

2.2.3.1 Trawl abundance estimates

The trawl method is the simplest. The 2 most important assumptions are 1) that the trawl samples are representative of the population in the area (i.e. sufficient trawl hauls in different subareas and depth strata and sufficient sampling volume) and 2) that catchability of redfish in the trawl is known. Assumption 2 is unknown and the group only perform calculations with an assumed catchability of 100%. If a catchability of 25% was applied (as is commonly accepted by Russian scientists), the biomass estimates should be raised by a factor of 4. Furthermore, 3 different types of trawls were used during the survey and the degree to which data from different trawls can be compared is unknown.

The trawl based calculations are therefore done in an indicative manner but can not provide a robust abundance estimate at the present time.

The procedure for trawl based abundance estimates is as follows: all trawl samples are grouped by depth strata (50 m for Norwegian data and 100 m for Russian and Faroese data) ranging from 100 to 800 m. For each stratum the mean catch rate (by NM^2 and 100 m depth) is calculated. The sum of the catch rate (i.e. catchrate per NM^2 for the whole water column) is then multiplied by the survey area to provide a total abundance.

For the north part of the survey (Norway) the total area sampled is 53 720 NM^2. The mean catch rate is 3.8 tonnes/NM^2. The estimated total abundance is 203 000 tonnes.

For the middle part of the survey (Russia) the total area sampled is 97 865 NM^2. The mean catch rate is 2.8 tonnes/NM^2. The estimated total abundance is 276 000 tonnes.

For the southern part of the survey (Faroes), the total area sampled is 73 140 NM^2. The mean catch rate is 0.9 tonnes/NM^2. The estimated total abundance is 65 000 tonnes.

2.2.3.2 Hydroacoustics abundance estimates

The hydroacoustics estimates were performed differently for the three parts of the survey and the individual procedures are detailed below.

Norway: the procedure for hydroacoustics abundance estimate is described in Section 3.1.3. On average, the depth integrated backscattering coefficient (s_A) value was 33 m^2/NM^2. The TS value used for *S. mentella* was based on the length dependent equation TS=20log*L*-*k*, with *k*=68. This value is based on recent estimates (Gauthier and Rose, 2001, 2002) and measurements based on individual fish (Kang and Hwang, 2003). However, there is still an ongoing debate on whether *k* should be set to 68 or 71.3 (as currently used in the Irminger Sea). The effect of setting k to 71.3 instead of 68 is to raise the hydroacoustics abundance estimate by a factor of 2. Further investigations on the *in situ* target strength of *S. mentella* need to be conducted to resolve this issue.

The total abundance estimate, over the 53 720 nm^2 area is estimated to 395 000 tonnes. This abundance estimate is significantly larger than the value obtained from the trawl estimate (203 000 tonnes). This may result primarily from underestimation in the trawl estimates as a consequence of the true catchability being less than 100%. It may also result from misallocation of acoustic energy from small targets in the DSL to *S. mentella*. These issues would need to be further investigated.

Russia: the estimation of redfish density distribution was carried out via the trawling method by means of recalculation of sizes the redfish catches in acoustic units s_{Atr} with application of the program "Severer".

Calculation of number and biomass of the redfish was carried out by the stratified method, i.e. breakdown of all research area on spatial strata, the size 2° longitude on 1° latitude. The equation for the redfish TS=20LgL-71.3, recommended SGRS for estimation stock abundance of the redfish in the Irminger Sea in 2007, was used, in addition to the equation TS=20LgL-68 recommended in the survey planning. According to calculations, the biomass of the redfish in the Russin part of Norwegian Sea was at 2.14 times less when using the second equation. The total biomass of fish over the area was calculated as sum of biomass in each individual rectangle (2° longitude by 1° latitude).

The total abundance estimate of the redfish on the area 97 865 nm^2 is estimated at 246 900 tonnes (equation 1) or 115 600 tonnes (equation 2).

Faroe Islands: the analysis of hydroacoutics data from the Faroese part was not completed at the time of the group meeting (Section 3.1.3). The final scrutinizing and allocation of the acoustic energy to different organisms was planned to be done before the hydroacoustic scrutinizing workshop held in Tromsø in late November 2008. Unfortunately, at the time of writing this revised report, it has yet not been possible to fully process the hydroacoustics data because of unavailability of hydroacoustics specialist from Iceland. There is no hydroacousitc abundance estimate for the southern area of the survey.

2.2.4 Biological data

Length, sex, maturity, parasites and pigmentation data were compiled for the three areas. For length, sex, and age the data were also analysed by depth strata in the northern part of the survey (Norway).

The lengths of individuals sampled ranged from 29 to 46 cm (Figure 3). The mean length increased towards southern areas with 36.6 cm in the north (Norway), 37.0 cm in the middle (Russia) and 37.7 cm in the south (Faroes). The mean length of females was greater than that of males by one cm or more in all areas.

The length distribution also varied with depth of sampling (Figure 4, northern area). Individuals collected in the layer 100–300 m were slightly longer (mean 36.8 cm) than those found in the layer 300–600 m (mean 36.3 cm). Below 600 m, the mean recorded length was much greater: 38.7 cm.

The age distribution was determined for the Norwegian and Faroes data, from otolith reading carried out at the Institute of Marine Research (Norway) following the protocol recommended by the ICES Workshop on Age determination of Redfish (Nanaimo, Canada, September 2008). In the Northern area, 90% of the population is composed of fish older than 15 years and there were no individuals younger than 10 years (Figure 5). The age distribution of males and females is almost identical. On the other hand, there are important differences in age structure in different depth strata. The layer 300–600 m where most fish are found is dominated by individuals around 18 years. In the above layer (100–300 m) maximum densities are found for fish of 19 and 27 years. In the deeper layer (600–800 m) maximum densities are found for fish of 17 and 27–31 years. Overall the proportion of older individuals is greater in the deep layer. The length-at-age for females is significantly greater than for males (Figure 6).

In the southern area, the proportion of old individuals is much higher with 90% of the individuals older than 19 years and 50% older than 33 years. The maximum density is at 39 years (Figure 7). Age reading from the Norwegian and Faroese samples reveal that: 1) population age structure is depth dependent and region dependent, 2) that most fish are older than 15 years, confirming the existing evidence of low recruitment in the past 15 years, 3) that females are larger than males, as a consequence of differential growth rates.

The sex ratio was in favour of females in the northern part of the survey area, but males dominated in the middle and southern areas (Table 7). An analysis of sex ratio by depth strata in the northern part demonstrates that the proportion of females is greater in the layer 100–300 m (61%) and even greater in waters deeper than 600 m (72%) than in the DSL (52%).

Norway and Faroes recorded most individuals at a maturity stage of 2 (ICES scale for Norway and closely related Faroese scale for the Faroes). Russian maturity reading reported a majority of male stage 2 and female stage 3 (according to the ICES scale). Some discrepancies remain in the maturity scales used and in the reading of maturity by the different participants. These will need to be further investigated.

The stomach contents were analysed only for the central part of the survey area (Russia). In both the shallower and deeper layer, the majority of the redfish stomachs (98.6% shallow, 93.7% deep layer) were everted. The data of redfish catch within the DSL demonstrate that in stomach content was mostly constituted by small plankton (62%), shrimps (21%) and fish items (15%).

2.2.5 Hydrography

The oceanographic regime in the investigation area depends on inflow of warm and saline Atlantic water into Norwegian Sea from the North Atlantic Ocean (Figure 12). The Atlantic current transports warm water northwards, with results that are important for fish resources distribution in the Norwegian Sea.

While warm Atlantic water flows north along the coast of Norway, cold Arctic water flows southwards along the east coast of Greenland. Cold water from the Polar Basin flows through the Fram Strait. A part of it continues south through the Denmark Strait, while some passes into the Greenland Sea, the Icelandic Sea and the Norwegian Sea, producing a front between a warm eastern side and a cold western side. This front plays a central role in the distribution of species in the sea.

The peculiarities of temperature condition on the research area in August 2008 are illustrated by the horizontal distributions of temperature on 200 and 400 m depth (Figure 8). The main redfish concentrations were recorded along the gradient zone between Atlantic and Arctic waters southeasterly of the Mohn Ridge and in the central part of area. The temperature in the place of the greatest catch of redfish was: in the northern part within depth 350–600 m about 2.5–4.5 °C; in the central part within depth 400–600 m about 2.1–5.0°C; in the southern part area within depth 300–450 m from 0.5 to 4.5°C.

2.3 Discussion

2.3.1 General aspects

It is the first year that an international survey on *S. mentella* in the Norwegian Sea is conducted. The planning and coordination have been done within a limited time frame and without a proper planning structure (such as an ICES planning group). Five parties originally agreed for this survey to be conducted, but in 2008, it was only possible for three of them to conduct the survey (Norway, Russia and the Faroe Islands). Due to funding constraints, the survey was run from commercial trawlers rather than research vessels. All these factors resulted in non-optimal conditions for conducting the planned scientific research on redfish distribution and abundance. In addition, observation and data processing methodologies were not always harmonized to a sufficient level, making it difficult to combine the results from the three parties. All these limitations will need to be carefully considered and the necessary adjustment be made for future surveys. This task will be devoted to the newly established planning group on redfish surveys (ICES-PGRS).

2.3.2 Distribution and acoustic abundance estimate

The survey did not reach the boundaries of the spatial distribution of *S. mentella*. Future surveys will need to consider spatial expansion at least in the northern and western area. This will require at least one additional vessel, given a similar density of acoustic tracks and trawls as in the 2008 survey.

In the eastern and northeastern part of the survey, the open-ocean component of the population overlaps with the demersal component. In particular over the shelf break area between the Barents Sea and the Norwegian Sea. This ‘mixed’ component needs to be considered. This will require dedicated observation and sampling methodologies, as the method used for the open-ocean (acoustics and pelagic trawling) is not adequate in this area. In addition, the stock identity of *S. mentella* in the North-east Arctic needs to be investigated further.

The *in situ* target strength of *S. mentella* is still a matter of debate. Recent bibliography and rapid calculations based on individual target counting and s_A estimates during the survey suggest that length dependent TS coefficient is about -68. However, in the Irminger Sea, this coefficient is usually set to -71.3. Such difference in the coefficient can alter abundance estimates by a factor of 2. It is therefore critical that dedicated research is conducted to determine unambiguously the in-situ target strength of redfish in the Norwegian Sea.

The vertical distribution of *S. mentella* in the Norwegian Sea is different from the one generally observed in the Irminger Sea. A dominant feature is the presence of highest densities of *S. mentella* within the Deep Scattering Layer (DSL). Above the DSL, *S. mentella* is often found mixed with other fish species (blue whiting, herring,...) while it is found 'pure' below the DSL. The vertical distribution extends down to 800 m. For these reasons, the methods to assess the distribution and abundance of *S. mentella* in the Norwegian Sea can not be transposed directly from those developed and used in the Irminger Sea. In particular, the hydroacoustics scrutinizing procedures and the trawl-acoustic regression models will need to be evaluated carefully.

The important discrepancies between s_A values from the Russian and Norwegian vessels can not result only from differences in abundance of *S. mentella*. The vessels acoustic performance and the methods used by the two parties to scrutinize the hydroacoustic registrations are different. How this affects the abundance estimate needs to be addressed and resolved. There is an urgent need for harmonized methodology and on-board scrutinizing of the data, if a consensus view on horizontal distribution and abundance is to be reached. A first attempt to explore the discrepancies in scrutinizing methodologies was carried out during the hydroacoustic scrutinizing workshop held in Tromsø, Norway in November 2008. Much work remains to be done for robust hydroacoustic estimates to be obtained for the Norwegian Sea area.

2.3.3 Abundance estimate from trawl

The survey plan specifically stated that the abundance and spatial distribution would be studied by hydroacoustics, but because of the current difficulties and uncertainties with hydroacoustics estimates, a trawl based abundance estimate was attempted. However, there are large differences in gear (three different trawls) and depth zones between vessels, so only data by individual vessels can be presented. A robust abundance estimate from trawl would require standardization of trawl equipment, standardization of vertical distribution of trawl hauls and known catchability. This will be difficult to achieve with commercial vessels and would require dedicated research on pelagic trawl catchability of *S. mentella*.

2.3.4 Biological sampling and data processing

The vertical distribution of *S. mentella* is difficult to study with standard pelagic trawls which have a wide opening and require substantial time for shooting and hauling. The use of the mutlisampler by Norway proved to be an efficient way to assess the depth distribution of *S. mentella* without increase in the sampling time. The generalization of the use of the mutlisampler should be thought of.

The sampling protocols for genetics and otoliths need to be better harmonized:

- The sampling for genetics was carried out differently onboard the three vessels. Whilst Norway collected up to 100 fish in only 5 stations, Russia collected 585 individuals in 11 stations and the Faroes collected up to 30 fish in 15 stations. Harmonisation of genetics sampling protocols in critical for the subsequent analysis of samples with micro-satellites or other methods.
- At present, Norway and the Faroe Islands have followed a random sampling protocol for otoliths, while Russia is sampling following a length stratified sampling scheme. The two approaches yield slightly different results in age-structure estimates. They will need to be assessed and a common sampling procedure selected.

In Norway, otolith reading is currently performed using the most recently internationally agreed protocols (ICES, 2008). The Faroe Islands do not hold the technical capacity to analyse the otoliths collected in 2008. However, Faroese otoliths were sent to Norway and age reading performed in the same way. Cross-comparison of reading between Norway and Russia should be carried out. Training of Faroese and Russian readers to internationally agreed methods is also needed.

The analysis of parasites and pigmentation was fully carried out by Russia but only partially by Norway and the Faroe Islands. Harmonisation of the sampling protocols and observation methods should be done through a common training workshop.

2.3.5 Hydrography

During 2008, hydrography measurements were done on an ad hoc basis, considering the constraints of individual commercial vessels (winches), available hydrographic equipment and time. The three vessels used instrument attached to the trawl (headline or multisampler) but with different precision, accuracy and data acquisition frequencies. Temperature and salinity measurements made to acceptable hydrographical standards can only be achieved with high precision instruments, calibration, water sampling and vertical stations. This will require additional time and equipment if conducted in future. Alternatively, measurements taken from trawl attached instruments may provide acceptable data for redfish habitat identification and water masses characterization at the scale of the survey. The precision, accuracy and measurement protocols for temperature and salinity will need to be discussed ad harmonized for future surveys.

3 Future surveys, 2009 and beyond

In September 2008, the group agreed that a second international survey on *S. mentella* in the Norwegian Sea should be conducted in 2009. Many of the sampling and data processing methodological issues should be clarified during the planning of this second survey. This can be achieved through a series of workshops (see Recommendations 3, 7, 8, 9 in Annex 3) and by the constitution of a dedicated planning group under the auspices of ICES. The newly established Planning Group on Redfish Surveys (PGRS) which held its first meeting at ICES HQ in January 2009 is now working specifically on these issues.

The current survey effort is not sufficient to cover the geographical distribution of *S. mentella* and an increase in the number of vessels and/or survey duration will be needed. Optimally, the survey should be conducted from research vessels.

From 2010 onwards, a regular international Norwegian Sea survey could be conducted. The PGRS is currently developing a strategy for the international coordination and long-term planning of the Irminger and Norwegian Sea surveys on redfish.

4 Acknowledgements

The group expresses their thanks to the International Council for the Exploration of the Sea for hosting the meeting in its headquarters in Copenhagen and providing all necessary help for the conduction of the meeting.

5 References

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6 Tables

Table 1. Extent and coverage of the survey.

Country	Norway	Russia	Faroe Islands
Vessel	Atlantic Star	Osveyskoe	Skálaberg
Days in the field	14	13	12
Number of hauls	24 (x3)	28	23
Min/max trawling depth	100 m / 800 m	100/600 m	200 m / 600 m
Distance for acoustics registration	1350 nm	2110 nm	1219 nm
Area surveyed	53 720 nm2	97 865 nm2	73 140 nm2
Number of CTD casts	24	28	18

Table 2. Trawl specifications.

Country	Norway	Russia	Faroe Islands
Manufacturer/ref	Hampidjan / Gloria 2048 HO	Hampidjan / Gloria 2048 HO	Vónin/Red Lion 3072 Hampidjan / Gloria 4096 H20
Opening	100m	100m	130/195
Width	100m	110m	168 /196
Cod end	Multisampler (3 bags) / inner net 40 mm	12-m inner net 40 mm	12-m inner net 40 mm

Table 3. Summary of the biological sampling.

Country	Norway	Russia	Faroe Islands
Total number / biomass of redfish caught	6378 ind./3892 kg	9673 ind./6105 kg	9344 ind./6401 kg
Number of length measurements	2914	6116	1848
Number of pairs of otoliths collected	940	1225	584
Number of feeding analyses	-	576	-
Number of parasites analyses	-	1175	-
Number of stations/individuals with genetics	5 / 410	11/585	15/ 431

Table 4. Instrument settings of the acoustic equipment on board the participating vessels.

COUNTRY	NORWAY	RUSSIA	FAROE ISLANDS
Vessel	Atlantic Star	Osveyskoe	Skálaberg
Echo/sounder/Integrator	Simrad EK60/LSSS	Simrad EK60/BI60/Famas	Simrad EK60/EchoView
Frequency	38 kHz	38 kHz	38 kHz
Transmission Power	2000 W	4000 W	2000 W
Absorption coefficient	9.65 dB/km	9.8 dB/km	9.8 dB/km
Pulse length	1.024	1.024	1.024
Bandwidth	2.43 kHz	2.43 kHz	2.43 kHz
Transducer type	ES 38-B	ES 38-B	ES 38 B
Two-way beam angle	-20.6 dB	-20.6 dB	-21.0 dB
Integration threshold	-82 dB	-70 bB	-70 dB
Sound speed	1493 m/s	1494 m/s	1494 m/s
Transducer gain Sv	25.59 dB	25.01 dB	
Transducer gain TS			25.41 dB

Table 5. Temperature and salinity sensor specifications.

COUNTRY	NORWAY	RUSSIA	FAROE ISLANDS
Manufacturer / ref	SAIV AS / SD204	Simrad/ temperature sensor of FS20	Star-Oddi/DST CTD and DST milli
Pressure resolution / accuracy	0.01 dbar / 0.1dbar	0.1dbar / ±1%	0.03%/+/-0.4 %
Temperature resolution/accuracy	0.001°C / 0.01°C	0,05 °C / 0,5 °C	0.032°C/0.1°C
Salinity resolution/accuracy	0.01 /0 .015	-	0.02 (PSU)/ +/- 0.75 (PSU)
Data acquisition frequency	0.1 Hz	-	1 Hz
Type of profiling	CTD attached to the multisampler (codend)	Attached to headrope	CTD DST attached to the head line and fishing line

Table 6. Species occurrence.

TRAWLS WITH SPECIES PRESENT, COUNTRY (TOTAL NO. OF TRAWLS)							
COUNTRY	NORWAY (72)		RUSSIA (28)		FAROE ISLANDS (23)		
Species (Latin name)	Number	Percentage	Number	Percentage	Number	Percentage	(Avg. % for ranking)
Beaked redfish (Sebastes mentella)	69	96%	27	96%	20	87%	93%
Blue whiting (Micromesistius poutassou)	48	67%	27	96%	20	87%	83%

Trawls with species present, Country (total no. of trawls)							
Country	Norway (72)		Russia (28)		Faroe Islands (23)		
Ribbon barracudina (Arctozenus risso)	45	63%	25	89%	16	70%	74%
Squid (Gonatus spp.)	29	40%	21	75%	-	-	38%
Myctophids (Myctophidae)	31	43%	6	21%	6	26%	30%
Saithe (Pollachius virens)	4	6%	12	43%	9	39%	29%
Herring (Clupea harengus)	20	28%	5	18%	6	26%	24%
Cornish blackfish (Schedophilus medusophagus)	2	3%	11	39%	6	26%	23%
Shrimp	1	1%	10	36%	2	9%	15%
Glass shrimp (Palaemonetes spp.)	28	39%	-	-	-	-	13%
Sagittal squid (Ommastrephes sagittatus)	-	-	-	-	3	13%	13%
Greater argentine (Argentina silus)	6	8%	7	25%	1	4%	13%
Mackerel (Scomber scombrus)	2	3%	1	4%	4	17%	8%
Cod (Gadus morhua)	4	6%	1	4%	3	13%	7%
Golden redfish (Sebastes marinus)	-	-	4	14%	1	4%	6%
Greenland halibut (Reinhardtius hippoglossoides)	10	14%	-	-	-	-	5%
Krill (Euphausiacea)	8	11%	-	-	-	-	4%
Atlantic pomfret (Brama brama)	-	-	-	-	2	9%	3%
Lumpsucker (Cyclopterus lumpus)	6	8%	-	-	-	-	3%
Northern Wolffish (Anarhichas denticulatus)	-	-	-	-	1	4%	1%
Haddock (Melanogrammus aeglefinus)	-	-	1	4%	-	-	1%

Trawls with species present, Country (total no. of trawls)							
Country	Norway (72)		Russia (28)		Faroe Islands (23)		
Octopus (Octopus spp.)	1	1%	-	-	-	-	<1%
Northern Rockling (Ciliata septentrionalis)	1	1%	-	-	-	-	<1%

Table 7. Sex ratios for *S. mentella*.

Country	Norway	Russia	Faroe Islands
%Males	45.5%	63.2%	61.6%
%Females	54.5%	36.8%	38.4%

Table 8. Infestation by parasites (copepod *S. lumpi*) and pigmentation for trawls above the DSL (top) and trawls within and below the DSL (below).

	Norway			Russia			Faroe Islands		
Trawls above DSL	males	females	total	males	females	total	males	females	total
External damages									
No. of fish examined	185	308	493	203	152	355	102	92	194
No. of fish with S.lumpi and/or remnants	37	63	100	128	97	225	9	5	14
% of fish with S.lumpi and/or remnants	20,0	20,4	20,3	63,1	63,8	63,4	8,8	5,4	7,2
No. of S.lumpi and/or remnants	54	108	162	301	278	579	10	6	16
Abundance index of S.lumpi invasion	0,29	0,35	0,33	1,5	1,8	1,6	0.09	0.07	0.08
No. of fish with external pigment spots				6	4	10			
% of fish with external pigment spots				3,0	2,6	2,8			
Muscular melanosis									
No. of fish examined				203	152	355			
No. of fish with muscular melanosis				1	2	3			
% of fish with muscular melanosis				0,5	1,3	0,9			
Trawls within and below DSL	Norway			Russia			Faroe Islands		
	males	females	total	males	females	total	males	females	total
External damages									
No. of fish examined	639	855	1494	514	306	820	198	192	390

No. of fish with S.lumpi and/or remnants	109	170	279	307	197	504	13	10	23
% of fish with S.lumpi and/or remnants	17,1	19,9	18,7	59,7	64,4	61,5	6,6	5,2	5,9
No. of S.lumpi and/or remnants	152	248	400	688	504	1192	18	12	30
Abundance index of S.lumpi invasion	0,24	0,29	0,27	1,3	1,6	1,5	0,09	0,06	0,08
No. of fish with external pigment spots				9	16	25			
% of fish with external pigment spots				1,8	5,2	3,0			
Muscular melanosis									
No. of fish examined				514	306	820			
No. of fish with muscular melanosis				5	4	9			
% of fish with muscular melanosis				1,0	1,3	1,1			

7 Figures

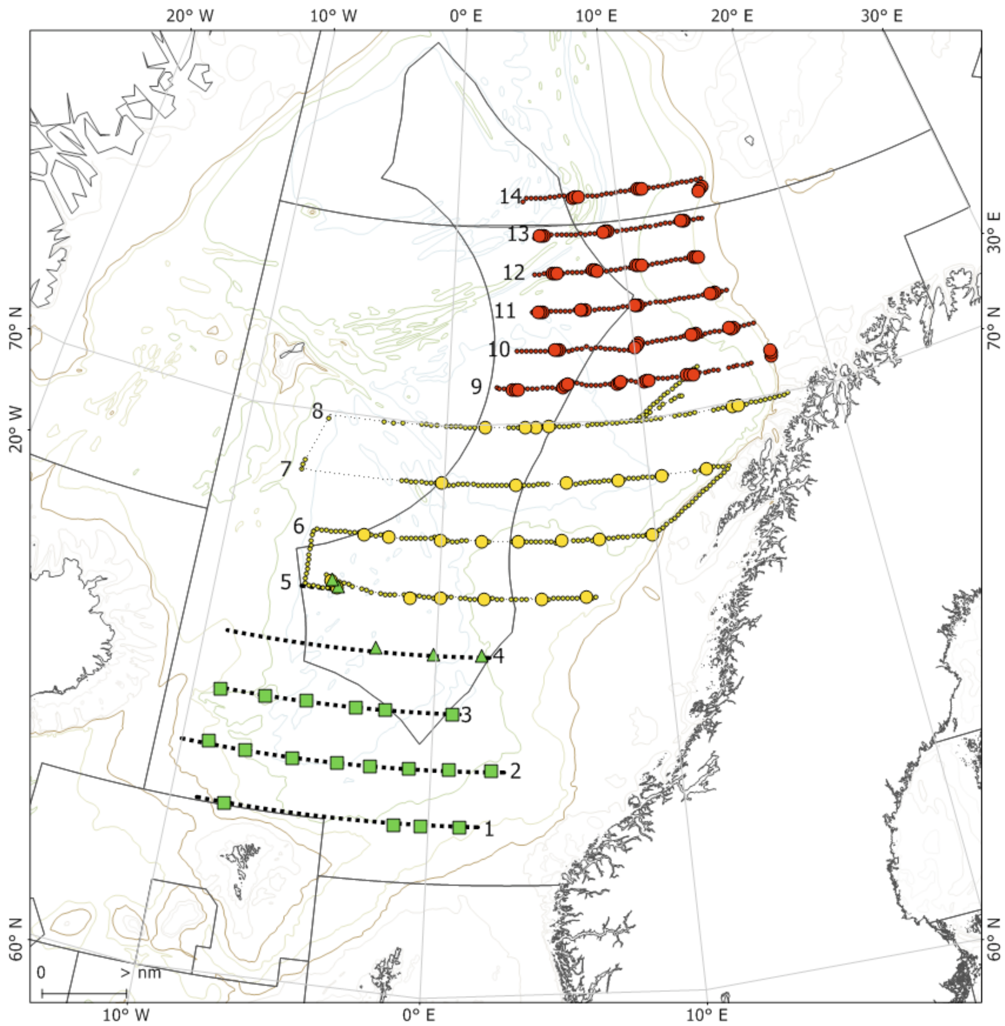

Figure 1. Geographical extent and sampling activity during the *S. mentella* survey in August 2008. Small dots show the location of 5 nm sections retained for acoustic scrutinizing. Lager dots indicate the location of biological sampling (trawling) for Norway (red), Russia (yellow) and the Faroe Islands (green). Circles: Trawl Gloria 2048, triangle: Trawl Gloria 4096, squares: Trawl Red Lion. The acoustic data for the Faroese part is not available at the time of the report; acoustics tracks are thus shown as dotted lines.

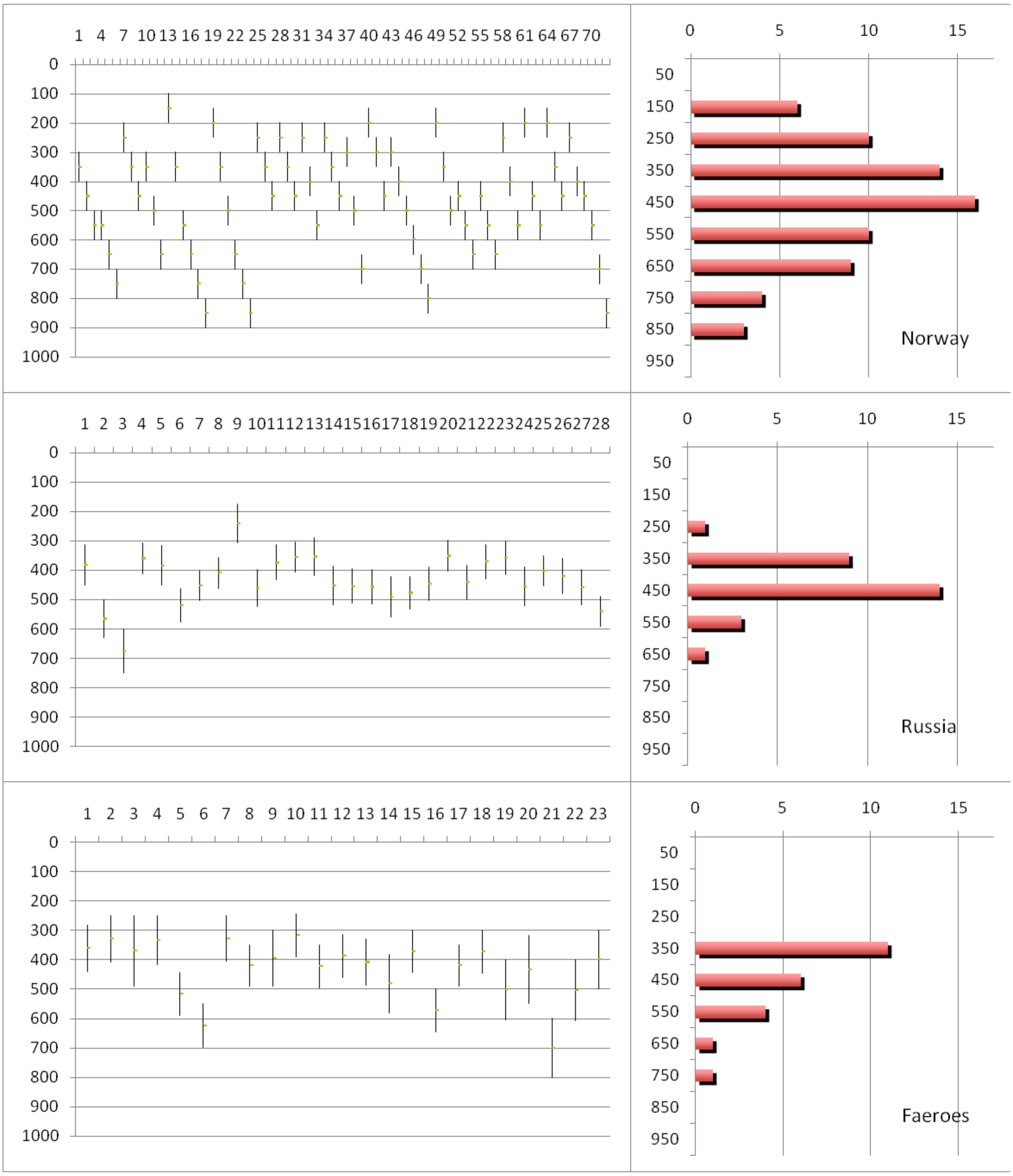

Figure 2. Vertical extent of trawling during the *S. mentella* survey in August 2008 for Norway (top), Russia (middle) and the Faroe Islands (bottom). The left panels display the sequence of trawls with vertical bars placed at the upper and lower limits of the trawl opening. The right panels display the frequency of trawls in 50 m depth layers. The depth is calculated as the mean depth of trawling (not headrope depth, but depth between the depth of the headrope and the depth of headrope + opening).

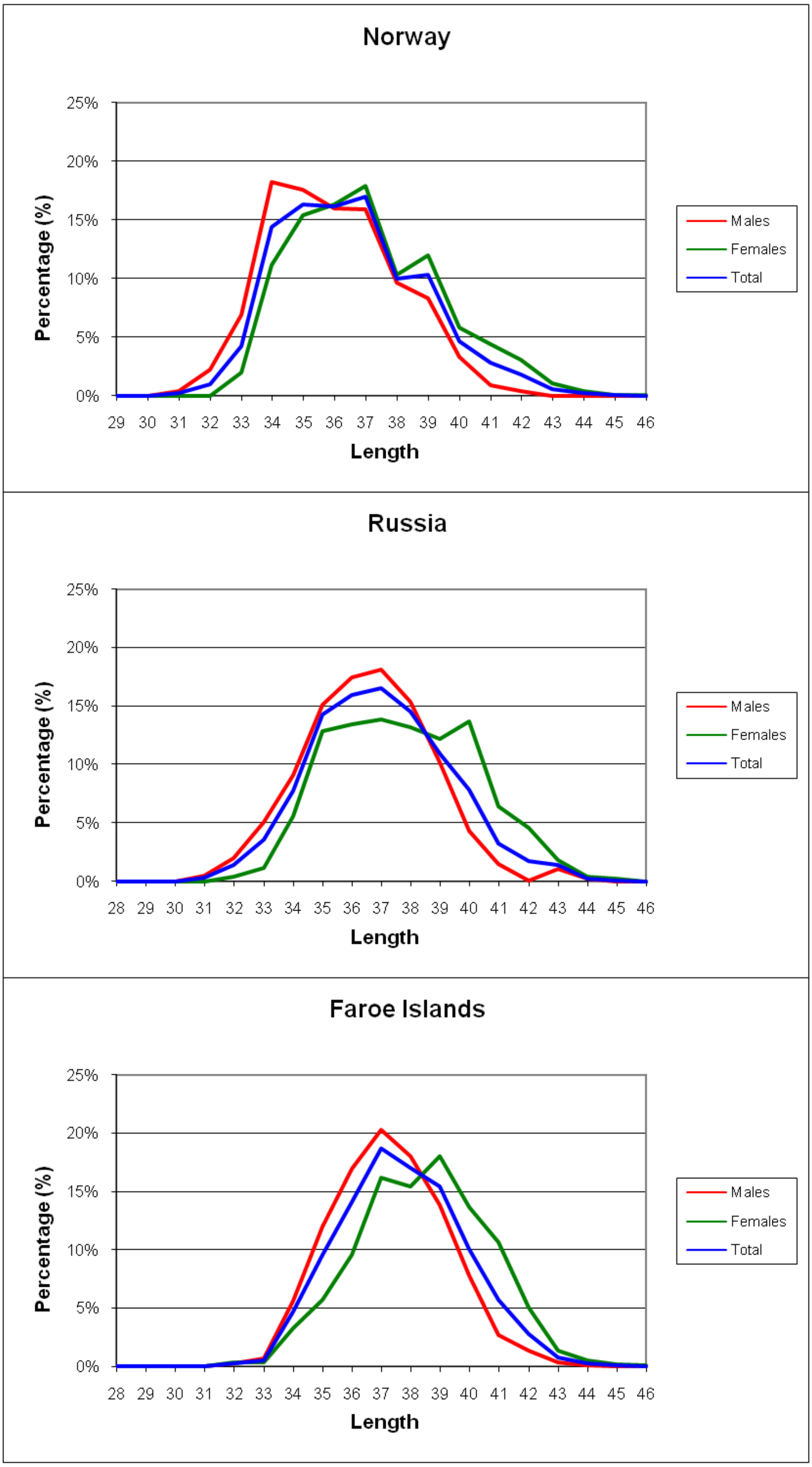

Figure 3. Body length distribution of *S. mentella* for the Norwegian (top), Russian (middle) and Faroese (bottom) parts of the survey, split by sex: males (red), females (green) and combined (blue).

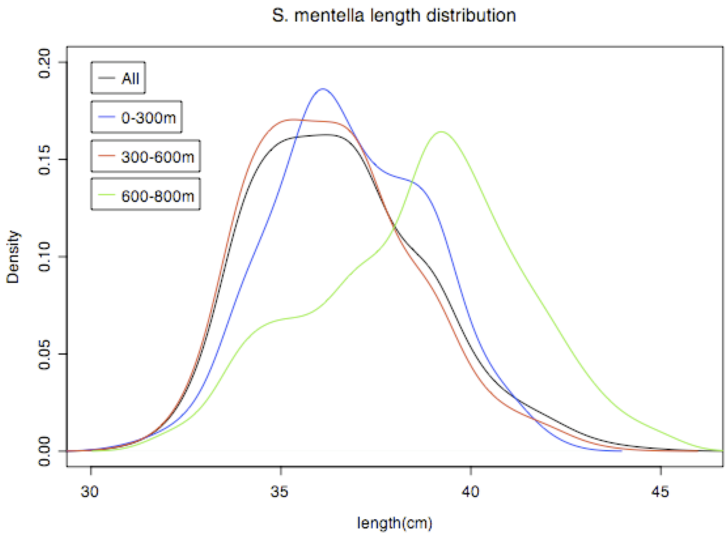

Figure 4. Body length distributions of *S. mentella* for three depth layers for the Northern part of the survey (Norwegian data only): layer 0–300 m (blue), 300–600 m (red) and 600–800 m (green).

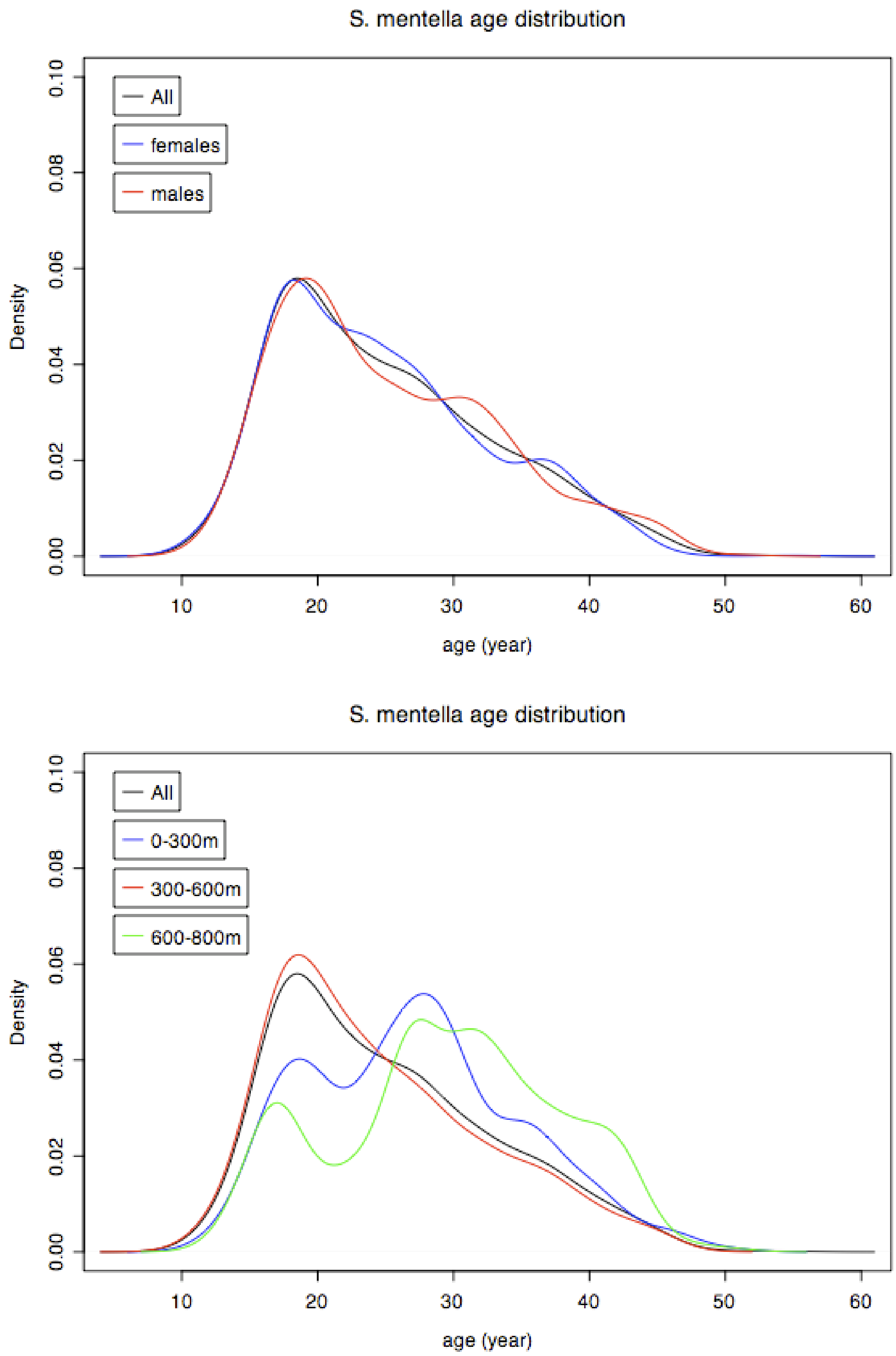

Figure 5. Age distribution of S. mentella in the northern part of the survey (Norway). Top: age distribution for females (blue), males (red) and sex-combined (black). Bottom: age distribution for the shallow (blue), middle (red), deep (green) or all depth-combined (black).

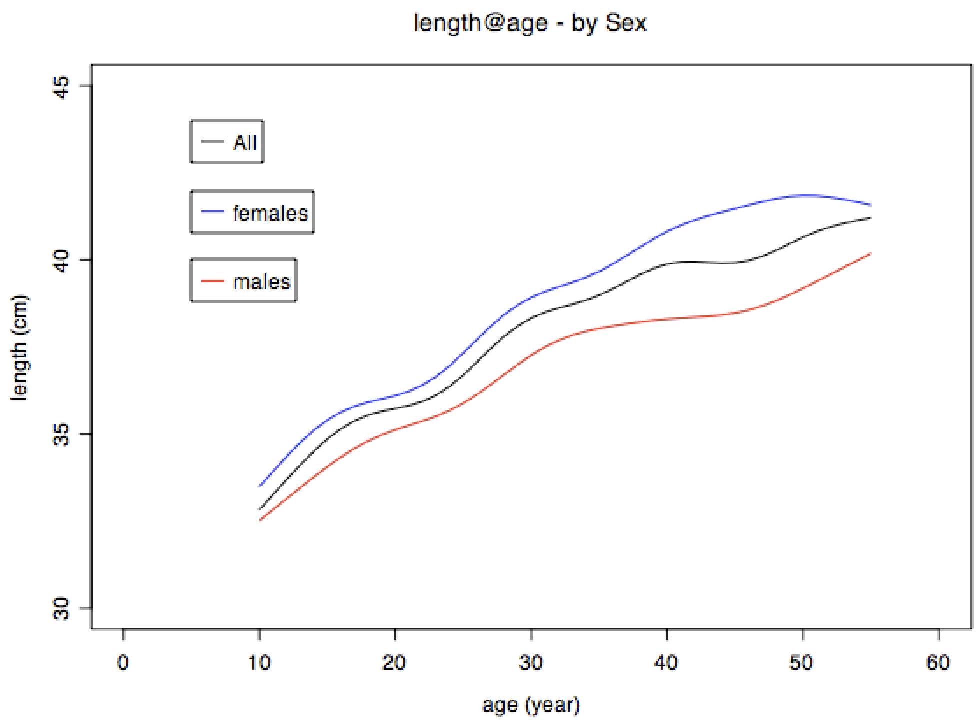

Figure 6. Length-at-age of *S. mentella* in the northern part of the survey (Norway) for females (blue), males (red) and sex-combined (black).

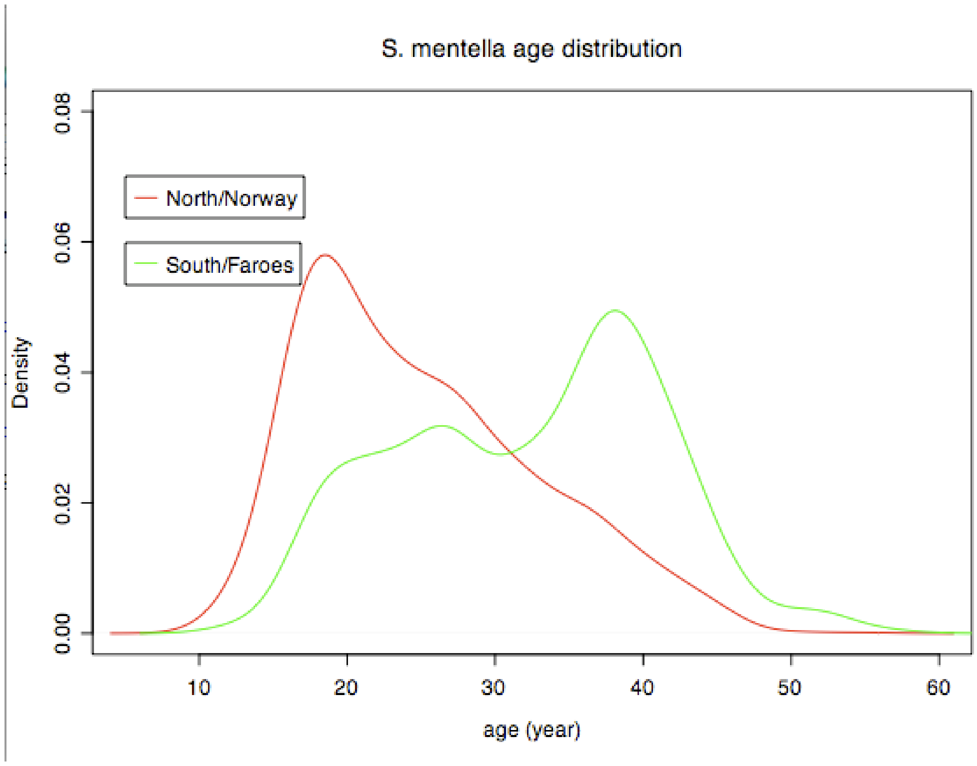

Figure 7. Age distribution of *S. mentella* for the northern (Norway, red) and southern (Faroes, green) areas.

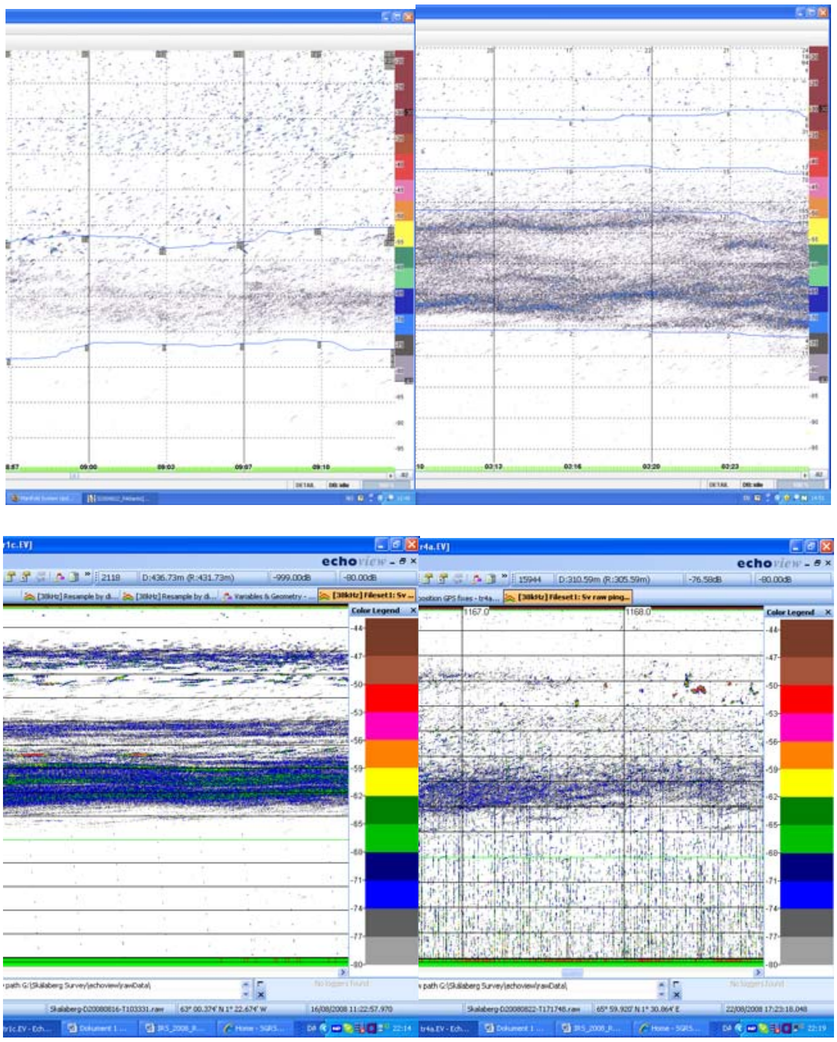

Figure 8. Examples of echograms recorded during the survey (top: Atlantic Star 100–800 m, bottom: Skálaberg 0–700 m). Common features include the Deep Scattering Layer (DSL) in diffuse (top-left) or dense (top-right and bottom-left) state and detection of individual targets (mostly redfish) above, within and below the DSL. Bottom-right echograms demonstrates the effect of poor weather conditions on the background noise (most likely bubble attenuation).

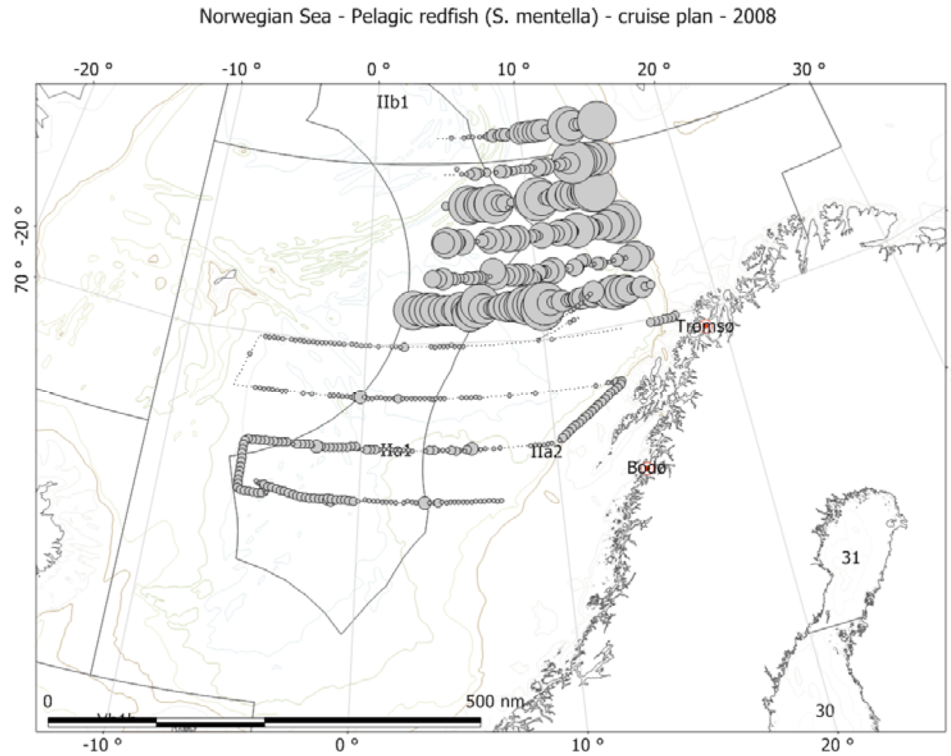

Figure 9. Spatial distribution of area backscattering coefficient (s_A) of *S. mentella* estimated for the Norwegian (north) and Russian (middle) part of the survey.

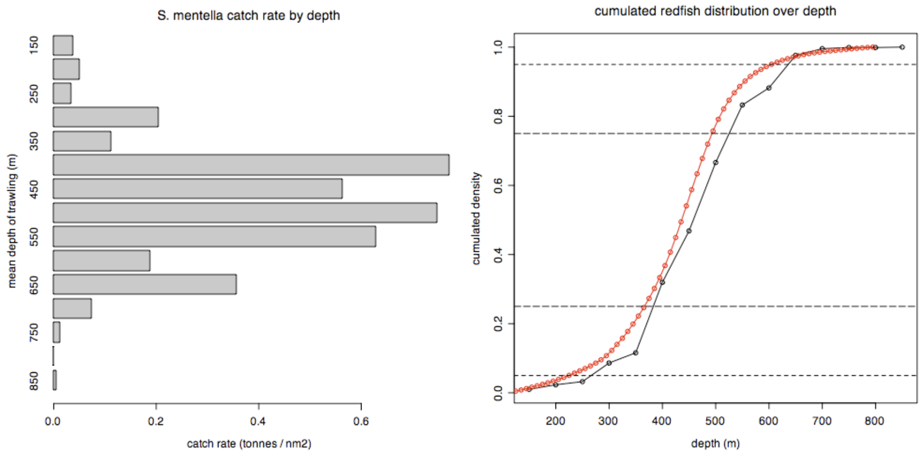

Figure 10. Left: Vertical distribution of catch rates. Right: cumulated density distribution of catch rates (black) and area backscattering coefficient (s_A, red) as a function of depth. Dotted lines indicate the 5 and 95% probability levels. Dashed lines indicate the 25% and 75% probability levels. Data are from the northern part of the survey only (F/T Atlantic Star).

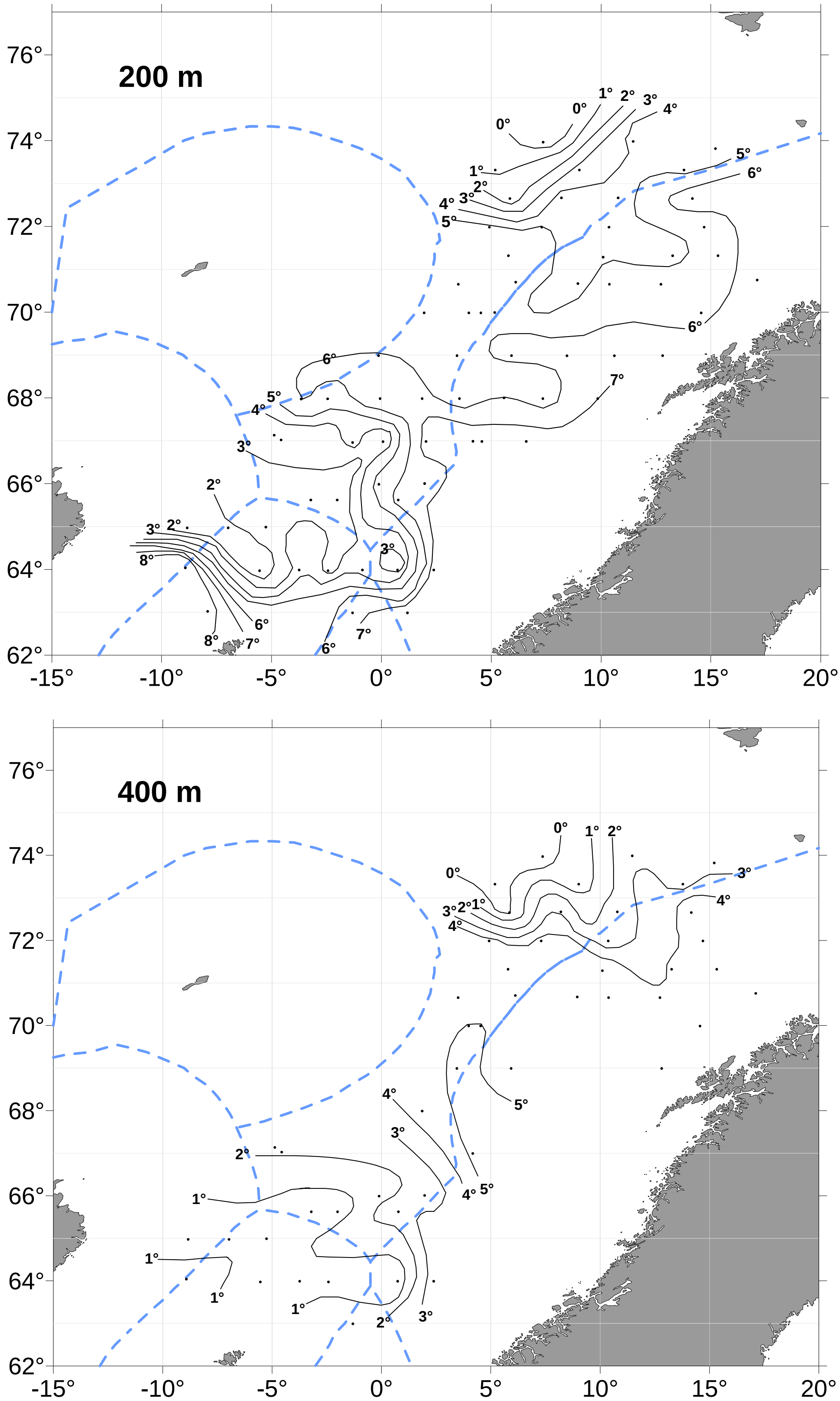

Figure 11. Horizontal distribution of temperature (°C) at 200 m (top) and 400 m (bottom). Black dots indicate the position of temperature measurements.

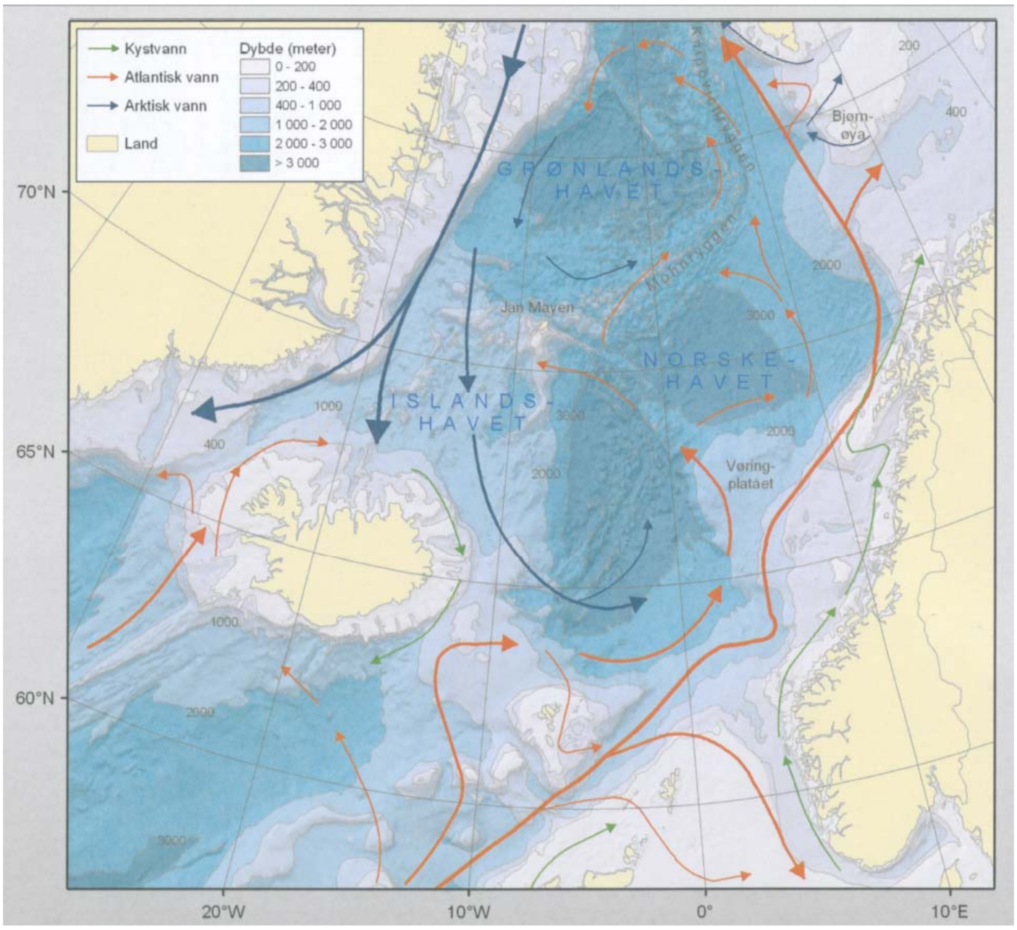

Figure 12. Horizontal distribution of the main currents in the Norwegian Sea. Red arrows: Atlantic waters. Blue arrows: Arctic waters. Green arrows: Coastal waters.

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Annex 2 Agenda

Tuesday 16 September 2008

9:00–9:30 Start of the meeting

- Housekeeping, network access
- Suggestions for venues of lunch breaks and dinner
- Adoption of the Agenda
- Election of the Chair

9:30–12:00 Review of logistics and sampling protocols (plenary)

- Area covered, duration of the survey, deviation form survey planning
- Trawling: gear, number and duration of trawls, trawling depths
- Biological sampling: review of the protocol and possible deviations from it.
- Hydroacoustics: transducer, calibration, noise measurements, inter-vessel comparisons
- Hydrography: equipment, precision, sampling protocol
- Daily reporting protocol

12:00–13:00 Lunch break

13:00–17:00 Review of data analysis protocols (plenary)

- Species composition
- Length frequency distribution, sex-ratio, age distribution
- Parasites
- Acoustics scrutinizing, s_A allocation, DSL, TS, echo-counting,
- Abundance estimates above DSL, within DSL and below DSL
- Data formats

Wednesday 17 September 2008

9:00–12:00 Data and figures preparation (subgroups)

- Trawl data table
- Survey plot: cruise track, location of trawls, CTDs, …
- Population structure: length distribution (by depth/area/sex), sex-ratio (by depth/area)
- Plot of s_A by 5nm, trawl catch rates
- Hydrography tables, maps and sections
- Abundance estimates by region and depths

12:00–13:00 Lunch break

13:00–15:00 Data and figures preparation continues (subgroups)

15:00–17:00 Report on results (plenary)

Thursday 18 September 2008

9:00–12:00 Report drafting (subgroups)

12:00–13:00 Lunch break

13:00–17:00 Plenary final

- Main results / Executive summary
- Recommendations for future surveys
- Recommendations to ICES/SGRS

17:00 end of the meeting

Annex 3 Recommendations

1) Expansion of survey area

In 2008, not all the geographical distribution of *S. mentella* could be covered by the survey. The group has identified the need to increase the geographical extension of the survey, and in particular to increase the number of vessels by including at least one further participating vessel (EU, Iceland)

2) **Research notifications**: The requests for permission to fish in different EEZ by different vessels have to be sent to the relevant authorities well in advance (at least 6–9 months before the start of the survey). The omission of survey effort in a particular EEZ because of missing approval of research activities in an EEZ has lead to unnecessary gaps in survey data in the past and must be avoided by any means. As a way forward, the group recommends that the requesting country stays in regular communication with a contact person in the authorizing country about the request and reports problems with the research notification to the authorizing country and the survey co-ordinator as soon as possible.

3) Need for harmonization of methodology and protocols:

The work of the group was hampered by insufficient harmonization of instrumentation (hyroacoustics, hydrography), trawl gear and biological sampling. There is an urgent need for workshops dedicated to the harmonization of scrutinisation of hydroacoustic raw data; survey gear; depth zones to be covered by gear; hydrographic equipment; biological sampling.

4) Next surveys

The group recommended that the next survey should take place in August 2009. The following survey will take place in August 2010 then every two years in alternance with the international survey in the Irminger Sea.

5) Planning of surveys 2009 and 2010 to be conducted by a new Expert Group (cf. PGRS Draft Resolution)

The planning and reporting of the redfish surveys in the Norwegian Sea should be carried out by a specific planning group. For that purpose, it is recommended that a new ICES expert planning group: the Planning Group on Redfish Survey(PGRS), be set up rapidly. A draft resolution is given in Annex 4.

6) More research on *in-situ* target strength needed

The true value of *S. mentella* target strength (TS) is still debated. Current uncertainty on the true TS value can lead to overestimates (or underestimates) of stock abundance by a factor of 2. The group recommended that effort should be put on in situ measurement of redfish target strength.

7) Scrutinisation workshop

Variations in the acoustic performances of the three vessels used in 2008 and in the acoustic scrutinizing methods led to important differences in mean abundance. To resolve the issue, it was proposed that a workshop on the analysis of hydroacoustics raw data be hosted rapidly. The workshop was help in Tromsø, Norway in November 2008.

8) Maturity staging workshop

The maturity data from Russia, Norway and the Faroes revealed some inconsistency. The group recommended that a workshop on maturity reading be hosted to resolve methodological differences. This workshop will be proposed to ICES PGCCDBS (Planning Group on Commercial Catch, Discards and Biological Sampling) in 2009 and if approved it will be conducted in 2010.

9) Otolith exchange and mini-workshop

The group recommended that harmonization of otolith age readings should be carefully considered. Exchange of otoliths and the setting up of a mini-workshop on otolith reading are proposed, within the existing bilateral collaboration programme between Russia and Norway. Countries other than Norway and Russia will be invited.

Annex 4 Recommendation for a new planning group

The Planning Group on Redfish Surveys [PGRS] (Chair: Benjamin Planque, Norway) will be established and takes place at ICES Headquarters, Copenhagen, from 28–30 January 2009, and in Bergen, Norway, from 1–3 September 2009 to:

a) plan the international trawl/acoustic survey on redfish in the Norwegian Sea and adjacent waters in August 2009 (January meeting);

b) prepare the report on the outcome of the 2009 survey (September meeting);

c) consider the establishment of an international database for redfish surveys in the Norwegian Sea.

d) PGRS will report by 15 March 2009 (January meeting) and 15 October 2009 (September meeting) for the attention of the Resource Management Committee, Arctic Fisheries Working Group, Study Group on Redfish Stocks and ACOM.

Supporting Information

PRIORITY:	ESSENTIAL
Scientific justification and relation to action plan:	PGRS will be responsible for the planning and reporting of the international hydroacoustic-trawl survey on pelagic redfish (Sebastes mentella) in the Norwegian Sea and adjacent waters. Redfish in this area have been fished in an olympic fishery by an international fleet since 2005. Since 2007, ICES has advised a protection of juveniles, no directed trawl fishery and low bycatch limits for S. mentella in Sub-areas I and II. NEAFC has recently set a TAC for pelagic S. mentella in this area of 14 500 t. The unknown stock size and its relations to other S. mentella stocks on the shelves have evoked the immediate need for an international survey on redfish in the Norwegian Sea and adjacent waters. The first international survey, carried out in August 2008, was hampered by insufficient harmonization of instrumentation (hyroacoustics, hydrography), trawl gear and biological sampling. The need for a planning group on redfish surveys in the Norwegian Sea, with close linkage to the Study Group on Redfish Stocks (SGRS) was clearly identified in the post-survey meeting of the 2008 survey. Moreover, the expansion of the survey area and participation of more than three vessels has been recommended. From the early stages of the survey, it is highly advisable to build up an international database for redfish surveys in the Norwegian Sea, including scrutinised hydroacoustic data, biological data and hydrographic data. Relation to Strategic Plan: Provide sound, credible, timely, peer-reviewed, and integrated scientific advice on fishery management and the protection of the marine environment in response to requests from regulatory commissions, Member Countries, and partner organizations.
Resource requirements:	N/A
Participants:	<10 (incl. the cruise leaders of each vessel and the principle experts involved in abundance and biomass calculations). Participation of SGRS members is highly recommended because of the expected synergistic effects in the planning of the survey and analysis of hydroacoustic, biological and hydrographic data.
Secretariat facilities:	N/A
Financial:	Travel costs will be eligible for participants from Member States of the European Union throgh the EU Data Collection Regulation (Reg. 199/2008).
Linkages to advisory committees:	ACOM
Linkages to other Committees or Groups:	RMC, AFWG, SGRS, PGNAPES
Linkages to other Organisations:	NEAFC

Annex 5 Planning document for the *Sebastes mentella* survey in the Norwegian Sea in August 2008

Objective of the survey

The objective of the survey is defined in the NEAFC document AM 2007/58 which states that the Contracting Parties agreed to conduct a scientific survey for pelagic *Sebastes mentella* in ICES Subareas I and II during August-September 2008 to measure the horizontal and vertical stock distribution and provide an abundance estimate. The survey planning (below) has been designed to fulfil these objectives.

Spatial and temporal extent of the survey

To conform to NEAFC request, the proposed survey design covers the known distribution area of *S. mentella* in the Norwegian Sea (as observed through past scientific surveys and commercial catches). Originally, the survey plan involved five vessels (one by contracting parties: Russia, Iceland, Faroes, EU and Norway) for a duration of 15 days. The survey is planned to start on 11 August (Monday). Soon after the start of the survey the vessels will be located in the central part of the survey area. A cross-vessel calibration exercise will then be conducted. Map of the planned cruise tracks are given in Appendix 1.

It has been planned that the survey will be funded by research quotas. Possibly up to 2000 tons, i.e. 400 tons per participating parties. However, the attribution of research quotas in international waters and the use of these quotas by contracting parties is still to be clarified. Norway will guarantee that the remaining tons after the scientific survey may be caught in a directed fishery within the Norwegian Economic Zone (incl. Jan Mayen) or the Svalbard Fishery Protection Zone. All participating parties that will depend on such a guarantee should as soon as possible apply the Norwegian authorities for permission to enter the NEZ and/or Svalbard as part of the research survey, incl. permission to fish up to 400 t in these zones together. Vessels participating to the survey will communicate daily. The procedure for communication will be defined when the participating vessels have been identified.

Iceland and EU will not be able to operate a survey vessel in 2008. The survey design presented in Appendix 1 is based on participation from three vessels: Norway, Russia and the Faroes.

Acoustic and trawling

To fulfil the primary objective of the survey (above) the sampling protocol will be based on acoustics transects combined with pelagic trawl hauls. This methodology is adapted to resolve the horizontal and vertical distribution of redfish within the first 500 m and possibly deeper. It is currently believed that off-shelf, most of the *S. mentella* population in the Norwegian Sea, is located in the 300–500 m depth layer. The combined acoustics-trawl survey should therefore form the basis of stock assessment in the area.

However, as the presence of *S. mentella* in deeper layers cannot be excluded, additional deep 'blind' fishing will be conducted during the survey. This will consists of trawl hauls performed at depth greater than 500 m and possibly down to 1000 m.

Although Faroes has expressed some difficulties to operate an acoustics survey, it is willing to achieve such protocol. Iceland has offered personnel and expertise for the Faroese component of the survey, if needed. For each participant, the cruise track approximates 2000 nautical miles and 37 trawl hauls, cruise tracks are provided in Appendix 1. The first day of the survey should be used for acoustics calibration. Acoustics cross-calibration between vessels is planned at the beginning of the survey between Russian and Norwegian vessels and at the end of the survey, between Russian and Faroese vessels. Due to the geographical configuration of the cruise track, there will be no direct calibration between Faroese and Norwegian vessels.

Technical specifications for acoustics

The specifications for acoustics are provided in Appendix 2. There is consensus on using split-beam transducer and 38 KHz as the primary frequency. Particular attention should be paid to vessel acoustics characteristics when selecting the operating fishing vessels.

Technical specifications for trawls

The fishing activity during the time of the survey will be restricted to direct contributions to the primary objective (i.e. measure the horizontal and vertical stock distribution and provide an abundance estimate), whether participating vessels are allocated specific research quotas or not.

Trawl hauls will be used for species and size composition in conjunction with acoustics so there is no need for an exact match of fishing gears between vessels. However, to limit possible discrepancies in catch characteristics between vessels it was decided to favour the common use on board all vessels of a Gloria trawl 2048 of not less than 100 mm mesh size, with a 12 m codend fitted with an inner net of 40 mm mesh size, or an equivalent trawl (see Appendix 3). The Norwegian survey will use a multisampler codend in order to resolve fish depth distribution with more accuracy. As this equipment is not available to other countries, the trawls should be integrated over sufficient depth. Trawl hauls will be set to last approximately 2 hours (+1h handling).

Calibration and inter-calibration

The first day of the cruise will be required to perform acoustics calibration. This will be done using a standard sphere calibration procedure. This calibration is essential to ensure the quality of the acoustics data collected. The calibration should be repeated (e.g. at the end of the survey) in case of any doubt. At the beginning of the survey all vessels will be heading for the same geographical area and close to the area of greater density of *S. mentella*. Acoustics cross-calibration between vessels will then be conducted, i.e. with vessels steaming in parallel and acquiring acoustics data simultaneously[1,2].

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[1] Monstad T, Borkin L, Ermolchev V. 1992. Report of the joint Norwegian-Russian acoustic survey on blue whiting, spring 1992. ICES CM 1992/H:6.

[2] Section 8.9.2 in Simmonds J, MacLennan. 2005. Fisheries Acoustics, theory and practice. 2nd edition. Blackwell Publ. 437pp.

Biological sampling

Biological sampling should be conducted with the objective of: (i) quantifying species composition in the catch, (ii) resolving sex, age, length, maturity, and parasite infestation of *S. mentella*, and (iii) collecting biological material for subsequent genetic analysis of *S. mentella*.

Key points for sampling:

1) Sub-sampling: For subsampling, the ratio of the subsample to total catch should be noted as "conversion factor" in the data recording sheet. Subsampling should be done from the top middle and bottom part of the codend.

2) Catch composition: Taxonomic identification, length and weight will be recorded for all individual fish from the (sub) sample.

3) Redfish individual data: The total length (cm below), individual weight, sex and stage of maturity should be measured on at least 100 redfish from each haul. The maturity scale given in Appendix 6 will be used for data exchange. The Russian participants will use the maturity scale given in Appendix 7 that will be converted to the one given in Appendix 6. When using multiple codends (Norway) the individual sampling procedure should be carried on each codend.

4) Redfish otolith sampling: A pair of otolith will be collected from randomly selected individual fish sampled for weight, sex and stage, up to a maximum of 30 fish per station. The otolith envelope should carry the station no. and fish ID no. given in the database to allow for allocation to the individual biological data.

5) Redfish genetic sampling: Fin clips will be randomly sampled from 100 *S. mentella* from each haul and from all fish on which ageing is performed. Collected samples will be preserved in ethanol for subsequent microsatellite analysis.

6) Redfish parasite and pigments: Presence of parasites (*S. lumpi*) and location of pigment spots will be recorded on individual fish (as in Point 3). Parasite recording sheet is given in Appendix 8.

Hydrological data collection

Hydrological data will be collected in addition to acoustics and biological data. CTD casts may be the optimal way of acquiring vertical hydrological profiles. However, this would require a specific winch and will take some extra time to deploy during the survey. This may not be achievable. Instead hydrological measurements will be performed using a CTD probe attached to the trawl, and recording depth, temperature and conductivity while trawling. The recommended settings for CTD measurements are: maximum depth range of 1000 m, sampling frequency 1Hz or more, temperature accuracy 0.01°C, salinity accuracy 0.02, pressure accuracy 0.02% fullscale (i.e. 0.2 m for 1000 m depth range). Instruments should be calibrated before the start of the survey.

Data format and exchange

Two possible data formats have been proposed, originating in the Irminger Sea surveys (ICES SGRS) or from the Norwegian Sea pelagic surveys (ICES-PGNAPES). The data from SGRS will be used for the survey. The data exchange forms used for the

Irminger Sea survey will be used to exchange information between vessels once a day.

Other considerations

Time synchronization of all instruments used for data collection should be performed at the beginning of the survey and regularly checked. UTC will be the time reference for all data collected.

Geographical positioning of the vessels should be monitored and recorded using a GPS system. Data should be transmitted from the GPS to the echosounder software.

If equipment is available to measure ship angular motion, this should be recorded.

When trawling available data on altitude, depth and geometry of the trawl should be recorded.

Application to fish in national waters

Following the cruise tracks proposed prior to the London meeting, Russia will have to request permission to enter Norwegian waters for the purpose of the survey. Because Iceland will not take part directly to the survey, Faroes may wish to extend its survey tracks into Icelandic waters for detectable redfish presence. Faroes should therefore seek permission to enter Icelandic waters for the purpose of the survey.

Scientists in charge

Benjamin Planque (IMR-Tromsø, benjamin.planque@imr.no) will be responsible for the coordination of the survey and will be in charge of the Norwegian part of the survey.

Andrey Pedchenko (PINRO-Murmansk, andy@pinro.ru) will be in charge of the Russian part of the survey. Dmitriy Aleksandrov (mitja@pinro.ru) will be cruise leader for the Russian part of the survey.

Jákup Reinert (FRS-Tórshavn, jakup@frs.fo) will be in charge of the Faroese part of the survey.

A group composed of the leading scientists from each party should meet after the survey to exchange on aspects concerning the survey design, data exchange and data processing. This meeting will be held under the auspices of ICES, at ICES headquarters in Copenhagen from 16 to 18 September. The group will report to the ICES Study Group on Redfish Stocks (SGRS).

Vessels

The Russian part of the survey will take part on board F/V Osveiskoe. Registration K-2165, call sign UDXD. Email: osveisko@plitfor.koenig.ru

The Norwegian part of the survey will take part on board F/V Atlantic Star. Registration F-111-BD, call sign LMBG. Email: atlantic.star@seamail.no

The Faroese par of the survey will take part on board F/V Skálaberg. Registration KG118, call sign XTPI.

Annex 5 Appendix 1

Acoustic survey tracks

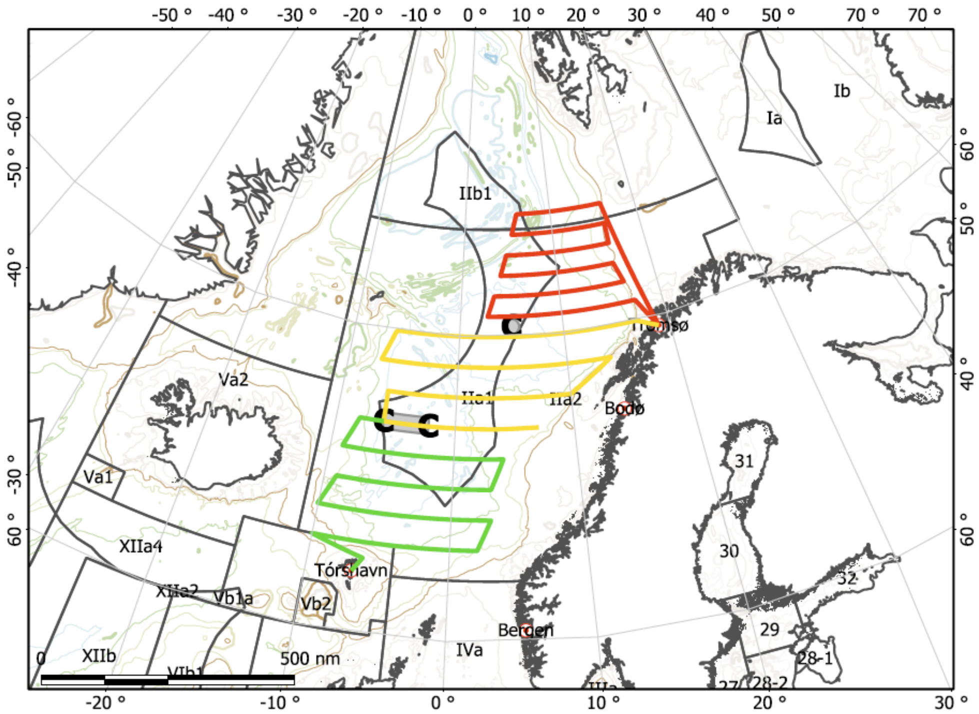

Figure 1. Norwegian Sea redfish acoustic survey sampling plan for 2008. ICES areas are delimited with black lines. Coloured lines indicate bathymetry. Green Track: Faroes, Red track: Norway, Yellow track: Russia. Grey areas labelled with "C" indicate location of inter-vessel calibration.

Table 1. Total distance, track length and number of trawls estimated for each participating country. The total number of hours required is estimated with vessel steaming at 10 knots, each trawl haul lasting 3 h and 8 h additional time (for acoustic calibration). Inter-vessel calibration is accounted for.

Country	Total distance	Sampling distance	hauls	Total hours required
Faroes	1842 nm	1345 nm	32	297
Russia	2001 nm	1595 nm	40	337
Norway	2008 nm	1332 nm	39	335
EU	-	-	-	-
Iceland	-	-	-	-

Annex 5 Appendix 2

Acoustics specifications

Survey vessels should be equipped with an echosounder Simrad EK60 or similar. The parameters settings should follow the following specifications:

Transducer: ES38B or equivalent (split-beam)

Primary frequency: 38kHz

Pulse length: 1ms

Beam angle: 7 degrees

Transmit Power: 2kW

Sampling rate ~ 1Hz. This may lead to seabed ghost echoes in areas deeper than ~ 750 m, in such case, this should be slightly adjusted in a ad hoc fashion to remove ghost echoes from the layer containing redfish. This sampling rate also implies that fish echoes will be only recorded at depth of less than ~ 750 m.

Vessel acoustic performance: Each institute should follow the recommendations from ICES[3] when selecting the fisheries vessel which will participate to the survey.

The recommended echosounder is EK60/EK500 or equivalent. If possible it is recommended that a scientific echosounder is brought on board the vessel and serves as the master echosounder. If several acoustic systems coexist on board the vessel, these should be synchronized and the echosounder used for scientific purpose should be configured as master and other equipment as slaves.

Calibration should be performed at the beginning of the survey using a standard calibration sphere, following recommendations from Foote *et al.* [4]. Each party should ensure that calibration sphere as well as associated equipment and software for the calibration are brought on board.

The target strength (TS) for *S. mentella* is defined using the following size-dependent relationship: TS = 20logL -68. This corresponds to the most recent TS estimate based on measurements performed at close vicinity of individual fish[5],[6],[7]. There is still on-

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[3] ICES 2007. Collection of acoustic data from fishing vessel. ICES Coop. Res. Rep. 287, 84pp.

[4] Foote, K.G., Knudsen, H.P., Vestnes, G., MacLennan, D.N. and Simmonds, E.J. 1987. Calibration of acoustics instruments for fish density estimation: a practical guide. ICES Coop. Res. Rep. 144, 57pp.

[5] Gauthier, S. and G. A. Rose. 2001. Target Strength of encaged Atlantic redfish (*Sebastes spp.*). ICES Journal of Marine Science 58(3): 562–568.

[6] Gauthier, S. and G. A. Rose (2002) In situ target strength studies on Atlantic redfish (*Sebastes spp.*). ICES Journal of Marine Science 59(4): 805–815.

going debate on the most appropriate value of TS to be used for *S. mentella*. This will be further discussed, likely within ICES, and the TS equation will be revised if necessary.

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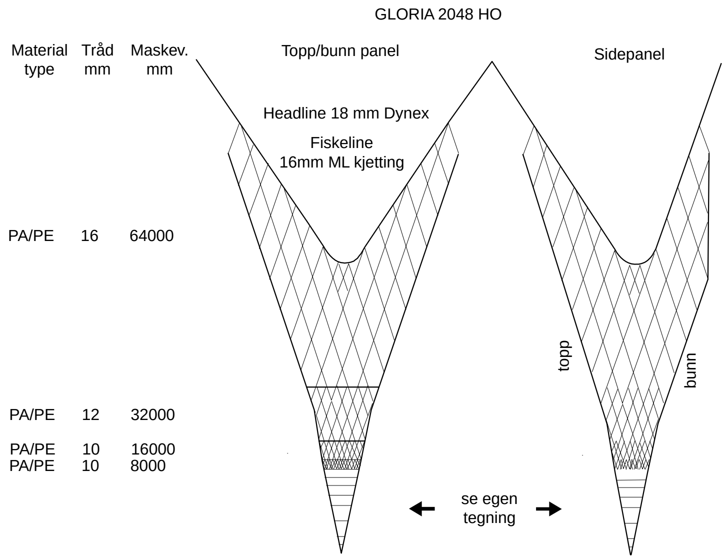
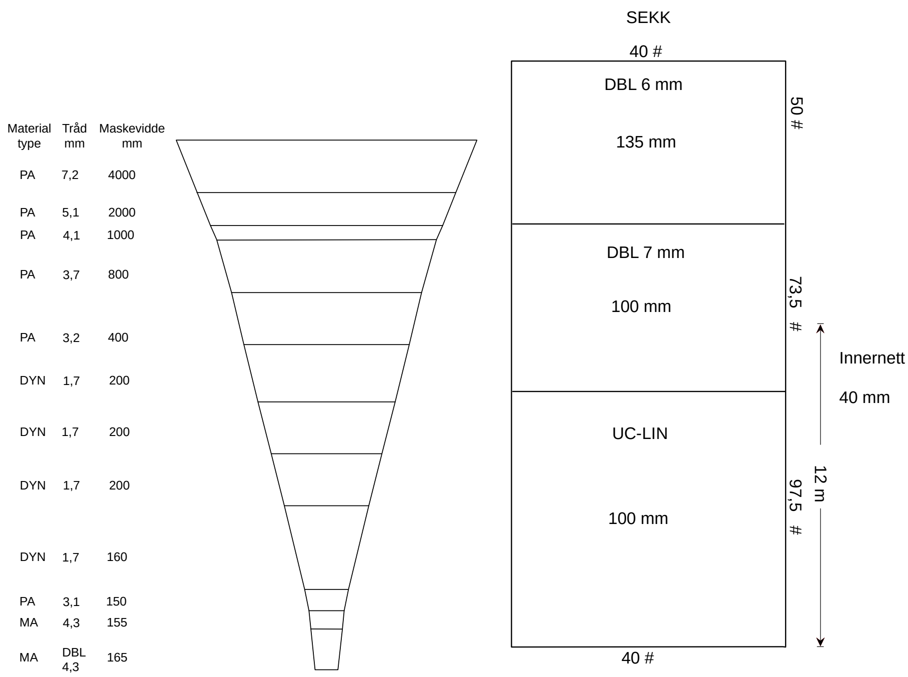
[7] Kang, D. and D. Hwang. 2003. Ex situ target strength of rockfish (*Sebastes schlegeli*) and red sea bream (*Pagrus major*) in the Northwest Pacific. ICES Journal of Marine Science 60(3): 538–543.

Annex 5 Appendix 3

Trawl specifications





Annex 5 Appendix 4

Data format and exchange:

As in SGRS

Annex 5 Appendix 5

Horizontal and vertical distribution of redfish *S. mentella* during the Norwegian Sea survey conducted by IMR-Norway in 2007.

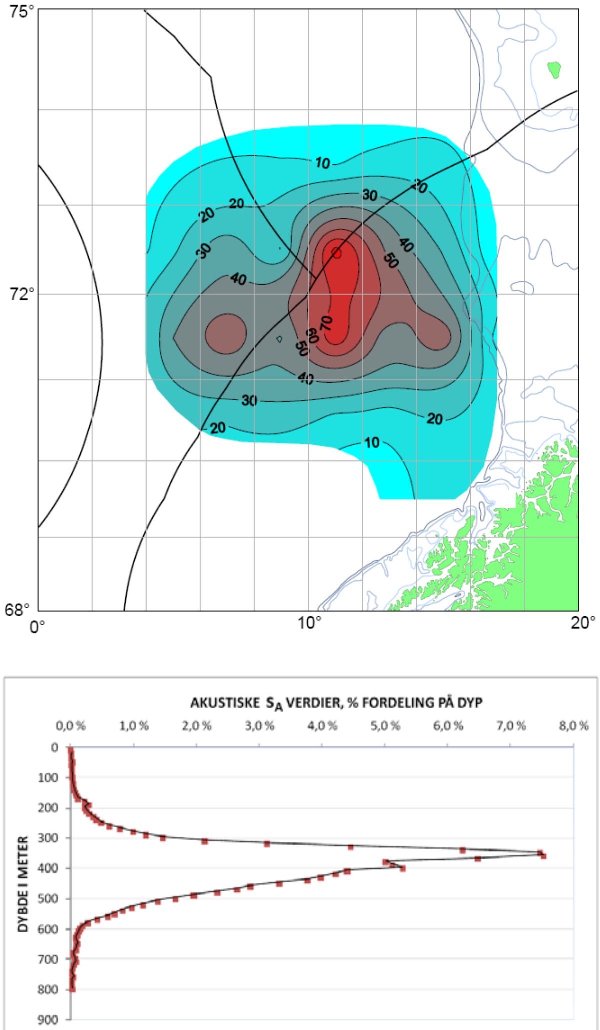


Figure 2. Top: Horizontal distribution of redfish area backscattering coefficient (sA, m²/nmi²) in the area surveyed in 2007. Bottom: vertical distribution of redfish observed by acoustics during the Norwegian Sea survey in August 2007. Vertical axis: depth in meter. Horizontal axis: relative frequency of redfish area backscattering coefficient (sA) per 10 m depth layers. Highest redfish densities where observed between 300 and 500 m.

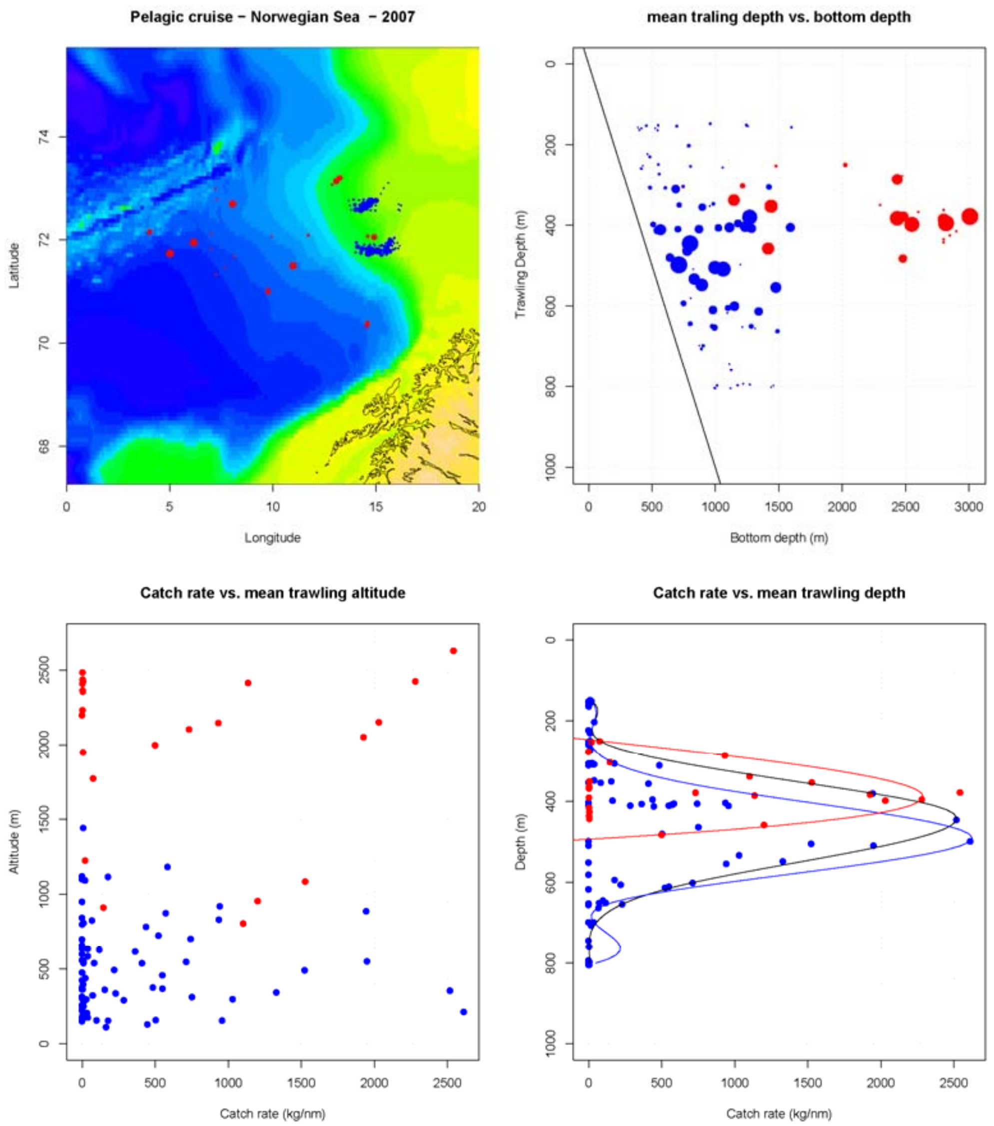


Figure 3. Top-left: spatial distribution of survey trawl hauls in summer 2007. Blue: first period, red: second period. Size of dots is proportional to *S. mentella* catch rate. Background colour indicates bathymetry. Top-right depth of trawling vs. Bottom depth . Size of dots is proportional to *S. mentella* catch rate. Bottom-left: vertical distribution of catch rates against trawling altitude. Bottom-right: vertical distribution of catch rates against trawling depth. Lines are the maximum catch rates for the first (blue), second (red) or both (black) periods, fitted using quantile regression splines (τ=0.9).

Annex 5 Appendix 6

Maturity scale agreed to be used in the international survey in June/July 2007 for redfish in the Irminger Sea and adjacent waters (reproduced from the report of the ICES Study Group on redfish stocks, ICES CM 2007/RMC:01.

MATURITY STAGES OF FEMALE REDFISH

Stage	Code	Ovaries description
Immature	1 (I)	Ovaries tubular, thin and small. Ovarian wall whitish and delicate. Without conspicuous blood vessels. If visible eggs occur, they are very small, whitish or pale yellowish. Pigmented eye larvae are never observed in the ovary.
Maturing/ Mature	2 (M)	The ovary has increased in size considerably and it is easy to distinguish in the body cavity. The ovary wall and eggs inside the ovary are clearly visible. Eggs are yellow and opaque.
Mature/ Fertilized	3 (F)	Ovaries are considerably bigger and occupy most of the body cavity. Colour is bright yellow. Many eggs are transparent (approx. 50%) because of yolk re-absorption the eye pigment of the larvae becomes visible.
Parturition	4 (P)	Ovary occupy practically the whole body cavity, it is delicate and the wall transparent and thin. The colour shift to a green-yellowish due to larval developing, the eyes are evident and there is little yolk. Larvae are easily released from the ovary when it is manipulated.
Post spawning	5 (S)	Ovary is flaccid, but still big. No visible larvae inside or just a remainder of them. The colour is purple or blackish, sometimes confused with the body cavity wall (peritoneum).
Recovery	6 (R)	Size is reduced to stage 3 or smaller, but no visible eggs, colour yellow to purple.

MATURITY STAGES OF MALE REDFISH

Stage	Code	Testes and genital papilla description
Immature	1 (I)	Testes are translucent, very thin and sometimes even difficult to detect, because it is confused with the mesentery. Width less than 1 mm. The penis is difficult to distinguish and easy to confuse with female genital papilla.
Maturing/ Mature	2 (M)	The testes are more easily distinguishable because of increasing size. They are white. Width more than 1,1–1,5 mm. There is no running sperm when the testes are cut. Penis is visible, and it is easy to identify sex externally.
Mature/ Fertilized	3 (F)	Testes are bright white. The sperm is observed inside the testes, but only when they are cut, i.e. sperm doesn't run out of the testes when they are pressed. Penis is thick, but no sperm is observed on it.
Parturition	4 (P)	Testes are big and with a cream colour. The sperm run out of the fish when belly is pressed. Penis is very conspicuous, with a purple tip and there are remains of sperm on it.
Post spawning	5 (S)	Testes are flaccid. The colour is still cream but with obvious dark (brown) patches. Practically no sperm inside the testes.
Recovery	6 (R)	Size of the testes has been reduced to stage 3, but the sperm is not visible. The colour is whitish.

Annex 5 Appendix 7

Maturity scale used by Russia in the international survey in June/July 2007 for redfish in the Irminger Sea and adjacent waters (reproduced from the report of the ICES Study Group on redfish stocks, ICES CM 2007/RMC:01).

	MALES
Juvenile stage	Gonads are poorly developed, sex is indistinguishable. Specimens at this stage occur throughout a year.
Stage 1	Sex is distinguishable. Testicles are as thin long colourless bends and occur throughout a year.
Stage 2	Testicles are as thick long bends, on a cross section they are of irregular triangular shape of brownish colouring. Remnants of non-extruded sperm are available in repetitive-maturing specimens. December-March.
Stage 3	Testicles are large, elastic, coloured brown, in some cases they are of violet shade. Along a cross section they are of triangular shape with smoothed angles. March-June.
Stage 4	Testicles are large, of light-brown colouring, with a white colour being irregular in some areas. At the end of the stage the testicles are white due to the sperm formed. Along the cross section the sperm does not run. June-September.
Stage 5	Mating period. Testicles are of milky-white colour. When dissecting the external sides flow down and drops of sperm are released from spermatic duct. September-November.
Stage 6	Extrusion (after mating). Testicles are of brownish colour with white patches. Two zones are visible along a cross section, i.e. brown marginal and white middle zones. October-December.

	FEMALES
Juvenile stage	Gonads are poorly developed, sex is indistinguishable. Specimens at this stage occur all the year round.
Stage 1	Ovaries are poorly developed, of light-yellowish colour, eggs are indistinguishable during a whole year.
Stage 2	(for repetitive-spawning fish - stage 9–2). Eggs are with 0.2–0.5mm diameter. In immature fish a membrane of ovaries is transparent, in repetitive-spawning specimens it is covered with black pigment. May-August.
Stage 3	Ovaries are bright-orange, egg diameter is about 1mm. August-September.
Stage 4	Ovaries occupy above a half of the body cavity, egg diameter is up to 1.5mm. September-December.
Stage 5	Ovaries are muddy-greenish, eggs are transparent. December-March.
Stage 6	Ovary membrane is strongly prolonged. The stage lasts from the moment of cleavage to the beginning of eye pigmentation in embryo. December-March.
Stage 7	Eye pigmentation begins in embryos owing to which ovaries gradually acquire black colouring. February-March.
Stage 8	Eyes acquire bright metallic shade. Embryos are well developed and mobile. The stage lasts until larvae extrusion.
Stage 9	Ovaries have fallen off, of bloody colouring. Single unextruded larvae occur. April-June.

Annex 5 Appendix 8

Sheet for the recording of fish individual data on board, including parasites and pigmentation.