ICES WGIDEEPS REPORT 2016

SCICOM/ACOM STEERING GROUP ON INTEGRATED ECOSYSTEM OBSERVATION AND MONITORING

ICES CM 2016/SSGIEOM:02

REF. ACOM AND SCICOM

Final Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS)

By correspondence

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2016. Final Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS), By correspondence, ICES CM 2016/SSGIEOM:02. 39 pp.

https://doi.org/10.17895/ices.pub.8666

Contents

Executive summary

Over the reporting period 2014–2016, the ICES Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS) was chaired by Kristján Kristinsson (Iceland) and Benjamin Planque (Norway). WGIDEEP was active under the ToR approved by SCICOM between 2014 and 2016 and met in:

- Copenhagen, Denmark, 28–30 January 2014
- Tromsø, Norway, 3–5 February 2015
- Reykjavík, Iceland, 6–8 August 2015

In 2016 the group worked by correspondence.

The objective of the group is to plan and conduct international deep pelagic ecosystem surveys in the Irminger Sea and adjacent waters and in the Norwegian Sea. A major aim is to measure the abundance and map the distribution of beaked redfish (*Sebastes mentella*). The participating nations are Germany, Iceland, Norway, and Russia.

ToRs a and b were to set up a common format for trawl data (ToR a) and transfer all survey data from the Irminger Sea and adjacent waters (1999–2015, biennial) and the Barents and Norwegian Seas (2008, 2009, 2013, 2016, ToR b). During the meeting in January 2014, it was decided that the first step should be to transfer the trawl data into ICES DATRAS and start with the 2009 data (ToR a). At that meeting, which was also attended by personnel from ICES Data Centre, the DATRAS format was developed to be usable by the Norwegian and Irminger Sea IDEEPS. During the tenure of the group (2014–2016) several attempts were made by Iceland and Norway to transfer the 2009 trawl data but the work was not completed. This situation is in part due to the lack of a clear process and of a formal requirement on both parts to complete such work.

ToR c aimed at i) developing the group strategy towards redfish assessment and ecosystem approach, ii) evaluating and revising the data collection in the surveys and assessment methodologies used for the deep-water redfish stocks, and iii) publishing the results from the deep-water ecological surveys in the Irminger Sea and the Norwegian Sea in a peer-reviewed journal. The group strategy was outlined during the 2014 meeting. Data collection protocols were formalized in the Series of ICES Survey Protocols (SISP) report in 2015 and the Irminger Sea survey data formally included in the assessment model (GADGET) for the deep pelagic stock in 2016. Two article based on the WGIDEEPS surveys were published in peer-reviewed journals in 2016.

ToRs d, e, f and g were concerned with the preparation and reporting of the surveys in the Irminger Sea (ToRs d, e) and Norwegian Sea (ToRs f, g). The Irminger Sea survey was planned during the meeting in February 2015, was conducted in June/July 2015 and the outcome of the survey was published in the third interim report in August 2015. Not all nations who were intending to participate to the survey could conduct it. As a consequence, the scope of the survey had to be altered and the emphasis was on covering the deep pelagic stock found below 500 m. Important areas of redfish above 500 m could not be monitored.

The survey in the Norwegian Sea was conducted in August 2016. The outcome was published in the fourth interim report in September 2016. The survey showed that the biomass estimate of beaked redfish was far lower in 2016 than in earlier surveys. At the same time, cohorts of young adults appear to enter the population in the open Norwegian Sea. The report highlights the technical limitations to observational approaches

in this survey and formulate several recommendations to improve the survey performance in future.

1 Administrative details

Working Group name

Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS)

Year of Appointment within the current three-year cycle

3

Reporting year concluding the current three-year cycle

2016

Chair(s)

Kristján Kristinsson, Iceland

Benjamin Planque, Norway

Meeting venue(s) and dates

28–30 January 2014, Copenhagen, Denmark, (7)

3–5 February 2015, Tromsø, Norway, (6)

4–6 August 2015, Reykjavík, Iceland, (3)

2 Terms of Reference a) – g)

TOR	DESCRIPTION	BACKGROUND	SCIENCE PLAN TOPICS ADDRESSED	DURATION	EXPECTED DELIVERABLES
a	Transfer survey data from 2011 international redfish surveys coordinated by the group to ICES databases (January 2014 meeting)	Data are now stored by individual nations/participants. It is important to have the data within common database system for coordinated archiving and extraction.		Year 1 (2014)	WGIDEEPS 2104 report chapter database (various ICES databases) 15 March 2014 SSGESST
b	Transfer survey data from other years, when ICES data centre is ready			2015	
c	Develop the group strategy towards redfish assessment and ecosystem approach (January 2014 meeting). To evaluate and revise the data collection in the	The data collected during the surveys are used for assessment of the stocks in the areas and to map their horizontal and vertical distribution. No analytical assessment is conducted for the stocks in the Irminger Sea and their statuses are assessed from	112,113,121,123, 141,143,144,145, 152,153,161,162	Year 1 (2014) Year 3 (2016)	WGIDEEPS 2014 report chapter 15 March 2014 SSGESST Manuscript ready for

	surveys and assessment methodologies used for the deep-water redfish stocks (January 2014 meeting). To publish the results from the deep-water ecological surveys in the Irminger Sea and the Norwegian Sea in a peer-reviewed journal (2016).	biomass trends derived from the survey indices. Little additional data are collected to understand the trophic interaction in the areas. By broadening the work of the WG towards redfish assessment and the study of the meso-pelagic ecosystem of the North Atlantic will lead to increased knowledge of the multiple components in the deep-water ecosystem of the areas and provide better assessment data for deep-water redfish.			submission in 2016
d	Plan the international deep pelagic ecosystem survey with special emphasis on redfish to be carried out in the Irminger Sea and adjacent waters in June/July 2015 (January 2015 meeting)	The WG has been responsible for the planning of the international trawl/acoustic surveys on pelagic redfish (*Sebastes mentella*) in the Irminger Sea and adjacent waters since 1994 and corresponding reports on the survey results.	112,113,121,123, 141,143,144,145, 152,153,161,162	2015	WGIDEEPS 2015 – 1 report chapter 15 March 2015 SSGESST
e	Plan the international deep pelagic ecosystem survey with special emphasis on redfish to be carried out in the Norwegian Sea and adjacent waters in August 2015 (January 2015 meeting)	The WG has been responsible for the planning of the international trawl/acoustic surveys on pelagic redfish (*Sebastes mentella*) in the Norwegian Sea since 2008 and corresponding reports on the survey results.	112,113,121,123, 141,143,144,145, 152,153,161,162	Year 2 (2015)	WGIDEEPS 2015 – 1 report chapter 15 March 2015 SSGESST
f	Prepare the report on the outcome of the 2015 Irminger Sea survey (August 2015 meeting)	a) Provide sound, credible, timely, peer-reviewed, and integrated scientific advice on fishery management and the protection of the marine environment. b) Redfish indices are being used by assessment working groups.	112,113,121,123, 141,143,144,145, 152,153,161,162,	Year 2 (2015)	WGIDEEPS 2015 – 2 report 1 September 2015 SSGESST
g	Prepare the report on the outcome of the 2015	a) Provide sound, credible, timely, peer-reviewed, and integrated	112,113,121,123,	Year 2 (2015)	WGIDEEPS 2015 – 3 report

	Norwegian Sea survey (September 2015 meeting)	scientific advice on fishery management and the protection of the marine environment. b) Redfish indices are being used by assessment working groups.	141,143,144,145, 152,153,161,162	1 October 2015 SSGESST

3 Summary of Work plan

Year 1	Carry out ToR a, c
Year 2	Standard outputs for d-g.
Year 3	Carry out ToR b,c.

Year 1

Focus on the development of a database and common data format to store survey data within the ICES database system. Transfer of trawl data from the surveys conducted in 2009 to the ICES DATRAS database; development of the group strategy towards redfish assessment and ecosystem approach and to evaluation of the use of data collection in the surveys for the assessment of deep-water redfish stocks.

Year 2

Meet in February to plan the surveys in the Irminger Sea and adjacent waters in June/July 2015 and in the Norwegian Sea in August 2015. This includes the writing of survey manual to be published under the Series of ICES Survey Protocols (SISP) before the surveys. Conduct the surveys in the Irminger Sea and in the Norwegian Sea. After the survey to meet and prepare the reports on the outcome of the surveys. Furthermore, to continue the work on the IDEEPS database and transfer trawl data from other years into DATRAS.

Year 3

To publish the results from the deep-water ecological surveys in the Irminger Sea and the Norwegian Sea in a peer-reviewed journal.

4 Summary of Achievements of the WG during 3-year term

- Publication of ICES SISP manual for the Irminger Sea survey 2015.
- Planning and conduction of survey in the Irminger Sea and adjacent waters in June/July 2015
- Planning and conduction of survey in the Norwegian Sea in August 2016
- Development of a common data format compatible with DATRAS (2014), but transfer of the data is not finalized
- Use of survey data (index, length data) for the assessment of the deep pelagic stock in the Irminger (WKDEEPRED, 2016). Assessment model accepted and will be the basis for advice (Category 2 stock).

- Inclusion of survey data from the Norwegian Sea in assessment (in progress, AFWG).
- Publication of two peer reviewed articles based on WGIDEEPS surveys, Saha *et al.* (in press) and Siegelman-Charbit and Planque (2016).
- Publications:

ICES. 2014. First Interim Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS), 28-30 January 2014, ICES Headquarters, Copenhagen. ICES CM 2014/SSGESST:05. 20 pp.

ICES. 2015. Second Interim Report of the Working Group on International Deep Pe-agic Ecosystem Surveys (WGIDEEPS), 3-5 February 2015, Tromsø, Norway. ICES CM 2015/SSGIEOM:02. 13 pp.

ICES. 2015. Third Interim Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS), 4-6 August 2015, Marine Research Institute, Reykjavík (Iceland). ICES CM 2015/SSGIEOM:03. 49 pp.

ICES. 2015. Manual for the International Deep Pelagic Ecosystem Survey in the Irminger Sea and Adjacent Waters. Series of ICES Survey Protocols SISP 11 – IDEEPS VI. 49 pp.

ICES. 2016. Fourth Interim Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS). ICES CM 2016/SSGIEOM:02. 21 pp.

Saha, A., Johansen, T., Hedeholm, R., Nielsen, E. E., Westgaard, J.-I., Hauser, L., Planque, B., *et al*. accepted. Geographic extent of introgression in *Sebastes mentella* and its effect on genetic population structure. Evolutionary Applications.

Siegelman-Charbit, L., and Planque, B. 2016. Abundant mesopelagic fauna at oceanic high latitudes. Marine Ecology Progress Series, 546: 277-282.

5 Final report on ToRs, workplan and Science Implementation Plan

ToR A Transfer survey data from 2009 international redfish surveys coordinated by the group to ICES databases.

In 2014 WGIDEEPS met with database experts from the ICES secretariat. A common data format was agreed on, to transfer the WGIDEEPS trawl data into the DATRAS system and a prototype set of files was produced. Several attempts were made by Iceland and Norway to transfer the 2009 trawl data but the work was not completed. This situation is in part due to the lack of a clear process and of a formal requirement on both parts to complete this work. As a way forward, ICES could request relevant nations or institutions involved in the surveys to export the data collected into the ICES DATRAS format. It is important that ICES data centre requests survey data from the expert group in due time and regularly updates data structure and qualification procedures.

ICES open access data policy may in some cases conflict with national data policy. These nations should, however, produce the data in DATRAS format even if it is not possible to transfer the data to ICES for archive. By this, data from all countries will exist in a compatible format.

ToR B Transfer survey data from other years, when ICES data centre is ready.

This ToR is pending on the completion of ToR a and was not achieved during the 3-year term.

ToR C

- Develop the group strategy towards redfish assessment and ecosystem approach;
- To evaluate and revise the data collection in the surveys and assessment methodologies used for the deep-water redfish stocks;
- To publish the results from the deep-water ecological surveys in the Irminger Sea and the Norwegian Sea in a peer-reviewed journal.

The group strategy was prepared during the meeting in 2014 and is outlined in the 2014 report. The strategy has three main pillars: 1) promote the use of WGIDEEPS survey data in assessment, 2) harmonize the age reading procedure and 3) shift from monitoring of single species (beaked redfish) to monitoring of the pelagic ecosystems. Research proposals to conduct ecosystem studies in the mesopelagic zone of the Norwegian Sea were submitted to the Norwegian Research Council in 2014 and 2015 but did not receive funding.

Data collection protocols were formalized in the Series of ICES Survey Protocols (SISP) report in 2015 and the Irminger Sea survey data formally included in the assessment model (GADGET) for the deep pelagic stock in 2016. The SISP for the Norwegian Sea survey is still pending.

Two articles based on WGIDEEPS surveys were published: Saha *et al.* (in press) and Siegelman-Charbit and Planque (2016). A synthesis article with results from both surveys combined is still pending.

ToR D Plan the international deep pelagic ecosystem survey with special emphasis on redfish to be carried out in the Irminger Sea and adjacent waters in June/July 2015

The survey was planned and conducted in 2015. The original plan was that Germany, Iceland and Russia would carry out the survey but in May 2015 Russia cancelled its participation with no reason given. The scope of the survey had to be altered and the emphasis was on covering the deep pelagic stock situated deeper than 500 m. Important areas of redfish distribution shallower than 500 m were omitted.

The survey results showed that the total biomass was the lowest in the time-series and less than 20% of what was measured highest in 2001. The acoustic measurement results for 2015 are considered highly uncertain. This is because of mixing with smaller scatter over a large area and the intermixing of redfish and jellyfish, especially in the south part of the research area, making it difficult to distinguish between redfish and other scatters.

ToR E Plan the international deep pelagic ecosystem survey with special emphasis on redfish to be carried out in the Norwegian Sea and adjacent waters in August 2015.

The survey was planned and conducted in 2016, one year later than originally planned. Only Norway conducting the survey, which limited the extent of the geographical area covered. The survey showed that the biomass estimate of beaked redfish was far lower in 2016 than in earlier surveys. At the same time, cohorts of young adults appear to enter the population in the open Norwegian Sea. The report highlight the technical limitations to observational approaches in this survey and formulate several recommendations to improve the survey performance in the future.

ToR F Prepare the report on the outcome of the 2015 Irminger Sea survey

The report was prepared during the Reykjavik meeting in 2015 and published as interim group report.

ToR G Prepare the report on the outcome of the 2015 Norwegian Sea survey.

The report was prepared during the Norwegian Sea survey in 2016 and published as interim group report.

6 Cooperation

Cooperation with other WG

WGIDEEPS cooperates with the following stock assessment groups:

- North Western Working Group (NWWG)
- Arctic Fisheries Working Group (AFWG).

WGIDEEPS has contributed to the following workshops:

- Workshop on redfish management plan evaluation (WKREDMP, 2014)
- Workshop on the review of the ICES acoustic-trawl survey database design (WKIACTDB, 2015)
- Workshop on Assessment and Catch Advice for Deep Pelagic Redfish in the Irminger Sea (WKDEEPRED, 2016)

Cooperation with Advisory structures

WGIDEEPS reports to the Scientific Committee (SCICOM) and the Steering Group on Integrated Ecosystem Observation and Monitoring (SSGIEOM, previously SSGESST) of ICES.

Cooperation with other IGOs

WGIDEEPS cooperates with the North East Atlantic Fisheries Commission (NEAFC)

7 Summary of Working Group self-evaluation and conclusions

A copy of the Working Group self-evaluation is included in Annex 4.

The objective of WGIDEEPS is to provide sound, credible, timely, peer-reviewed, and integrated scientific data and information to support fishery management advice. The surveys planned and conducted by the group are a primary data basis for the advice on the stock status of beaked redfish in the ICES areas.

This report summarizes the achievements of the group in the last 3 years, the details of which are documented in four interim reports and one manual published under SISP covering the three meetings in 2014–2016 and work by correspondence.

The self-evaluation form highlights the capacity of the group to plan, conduct and report on regular observation surveys in the deep pelagic Irminger and Norwegian Seas. It also highlights serious limitations in the group capacity to develop its work towards a more robust data collection and delivery, primarily as a result of the limited participation from ICES Member Countries and due to specific technological constraints related to deep-sea (> 400 m) observations into the deep scattering layer.

The Group expresses severe concerns about the insufficient survey participation of ICES countries involved in the pelagic redfish fisheries in the Irminger Sea and adjacent waters and in the Norwegian Sea. The Group is particularly concerned with the decreased data quality and higher uncertainty (on top of the methodological drawbacks) in the derived dataseries and corresponding low credibility in the Group's work and consequently the advice on the stock status.

8 Deep pelagic survey in the Norwegian Sea in 2016

The WGIDEEPS survey was conducted in the Norwegian Sea in August 2016, to monitor the abundance and distribution of beaked redfish, mesopelagic fauna, and hydrological conditions. The survey was conducted by the Institute of Marine Research, Norway, on board the Icelandic RV Árni Fridriksson. The survey used the standard observation strategy based on i) hydroacoustic registrations at 38 kHz ii) sampling with the large pelagic trawl Gloria 1024, and iii) hydrographic measurements during trawling.

The key results from the Norwegian Sea deep pelagic ecosystem in 2016 are:

- There is a higher acoustic energy in the mesopelagic layer and lower acoustic energy in the epipelagic layer than in earlier surveys (2008, 2009, 2013),
- the beaked redfish distribution extends beyond the area covered by the survey,
- densities of redfish are highest between 1 and 4°C and between 300 m and 600 m depth,
- the biomass estimate of beaked redfish is highly uncertain, due to limitations in the observation methodologies employed,
- the biomass estimate of beaked redfish is far lower than those from earlier surveys even when uncertainties are taken into consideration,
- the length structure of the beaked redfish population indicates that cohorts of young adults that were detected earlier in the Barents Sea surveys, are beginning to enter the Norwegian Sea.

The past and current surveys of the deep pelagic ecosystem in the Norwegian Sea suffer from serious limitations that forbid a robust assessment of the abundance of beaked redfish and a comprehensive description of the deep ecosystem fauna. A series of recommendations are made to improve observations in future. These include redfish trawl standardization, the use of deep-towed transducers, optical systems (DeepVision) and macroplankton trawl. It is also recommended that WGIDEEPS pursue its efforts towards multinational participation to the Norwegian Sea survey.

8.1 Introduction

The Working group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS) acts to strategically plan, coordinate and report on the monitoring of deep pelagic ecosystems in the Irminger and Norwegian Seas, with a particular emphasis on the stocks of beaked redfish (*Sebastes mentella*).

In 2016, the Working Group did not hold a physical meeting since Norway was the only country to conduct the survey in the Norwegian Sea in August 2016. The survey was conducted on board the Icelandic RV Árni Fridriksson. This report presents the technical information on the design and conduction of the survey and key results at the time of the survey completion.

8.2 Material and methods

Vessel, timing, survey area, survey design

The IDEEPS survey was conducted on board the Icelandic Research Vessel Àrni Fridriksson in the Norwegian Sea during August 2016. The survey started and terminated in Reykjavik, Iceland. Details about the research vessel (Table 8.2.1), extent and coverage of the survey (Table 8.2.2), the cruise track (Figure 8.2.1) and the list of scientists participating to the cruise (Table 8.2.3) are provided further below. The cruise track follows a randomized zigzag design that optimizes sailing distance over conventional parallel transects designs when performing acoustic-based abundance estimation.

Table 8.2.1: Research Vessel Árni Fridriksson

IMO No: 919204	MMSI No: 251507000	Call Sign: TFNA	ICES shipcode: 46FR
Flag: Icelandic	Homeport: Reykjavik	Building Year: 2000	
Tel.: +354 8512085	Immarsat: 000 871/000 874-325 150 711		

Table 8.2.2: Extent and coverage of the survey

NUMBER OF DAYS IN THE FIELD (START/END DATES):	21 DAYS, 11TH AUGUST – 1ST SEPTEMBER 2016
Distance travelled:	
Distance with hydroacoustic registrations:	2200 nmi
Distance with valid scrutinized registrations:	1883 nmi
Area surveyed:	67,150 nmi^2
Number of trawl hauls	30 hauls (89 samples)
Number of successful trawl samples	86
Number of successful CTD casts	31

Table 8.2.3: Scientific crew

FIRST NAME	LAST NAME	ROLE
Erik	Berg	Fish sampling and hydroacoustics
Lia	Charbit	Fish sampling and hydroacoustics (student)
Alf	Harbitz	Fish sampling and hydroacoustics
Ronald	Pedersen	Hydroacoustics and multisampler
Benjamin	Planque	Cruise leader
Anne	Sveistrup	Fish sampling
Tone	Vollen	Fish sampling
Rupert	Wienerroither	Fish sampling

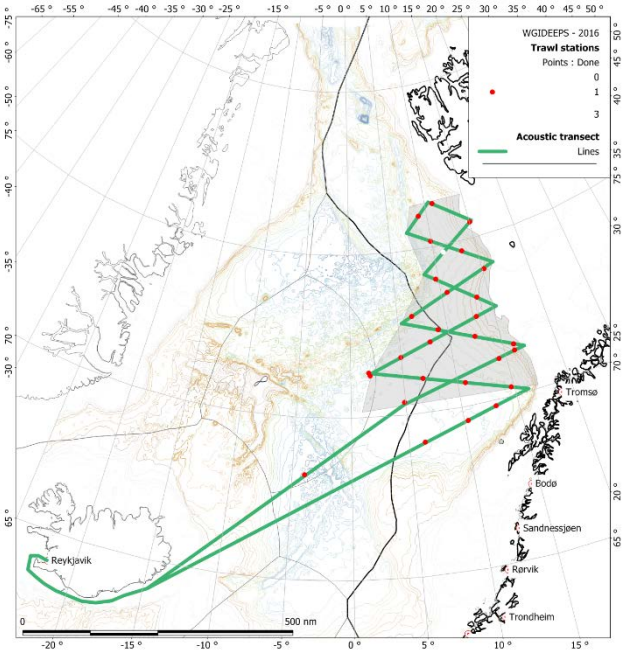

Figure 8.2.1: Survey route and extent. Sailed route (green line) trawl hauls with CTD (red points) and the geographical area considered for biomass estimations (grey polygon).

8.2.1 Trawling

Trawl hauls were used for the determination of species composition and of individual size composition in conjunction with hydroacoustics. Trawling was performed using a Gloria trawl 1024 (Table 8.2.1.1).

The trawl was equipped with a multisampler with 3 codends fitted with 24 mm inner net. The multisampler was programmed for fixed sampling durations (30' or 40') at prespecified depth horizons (i.e. horizontal trawling). Each codend was analysed separately and was given an individual serial (i.e. sample) number.

In total, trawling was conducted at 30 stations, resulting in 89 samples, which were numbered from 74001 to 74089, following the IMR serial numbering system.

The location, depth, time, duration, speed, opening, and door spread of each sample was recorded onboard using the 'toktlogger' system and archived using Sea2Data.

The geographical and vertical distributions of the trawl hauls is shown in Figure 8.2.1.

Table 8.2.1.1: Trawl specifications

MANUFACTURER/REF	HAMPIDJAN / GLORIA 1024
Vertical opening	50 m
Horizontal spread	70 m
Codend	Multisampler with 3 codends fitted with 24mm inner net
IMR Gear code	3575

8.2.2 Biological sampling

Biological sampling was conducted in accordance with the IMR 'Manual for sampling of fish and crustaceans'. Biological records were digitally archived using the Sea2Data

platform. The whole catch was sorted and identified to species or genus level. The sampling protocol for the WGIDEEPS-2016 survey is provided below:

Non-target species

All fish, cephalopod, crustaceans, and jellyfish were identified to species level. For every species, total catch in weight and numbers was recorded. Lengths were measured for all fish and cephalopods, with an upward limit of 30 individuals per species and serial number.

Beaked redfish

Lengths were measured for up to 100 individuals representative of the catch, and biological sampling (weight, sex, maturity stage, special stage (ICES scale), otoliths) was taken for the first 33 individuals. Otoliths for age determination were stored in envelopes, with no indication of individual data (i.e. length, weight, sex, stage). The two maturity scales used are the standard IMR scale and the ICES scale.

Mesopelagic fish (except target and commercial species)

Samples of glacier lanternfish (*Benthosema glaciale*) were frozen for analyses of pollutants and nutrients by NIFES (National Institute of Nutrition and Seafood Research). Less abundant species were frozen for use as voucher specimens and for education.

8.2.3 Additional biological sampling of beaked redfish

Genetics

Gill filaments of the first 10 individuals were preserved in 96% ethanol without additives.

Imaging

For the same 10 individuals photos were taken of the whole fish, head pointing left (Figure 8.2.3.1 left), and later of both sides of the otoliths (Figure 8.2.3.1 right) for future analyses. For each image, labels were put on the background to fully identify survey, haul, net, and individual number. The camera was set up with fixed parameters to ensure consistency. Settings for imaging of whole individual fish are reported in Table 8.2.3.1.

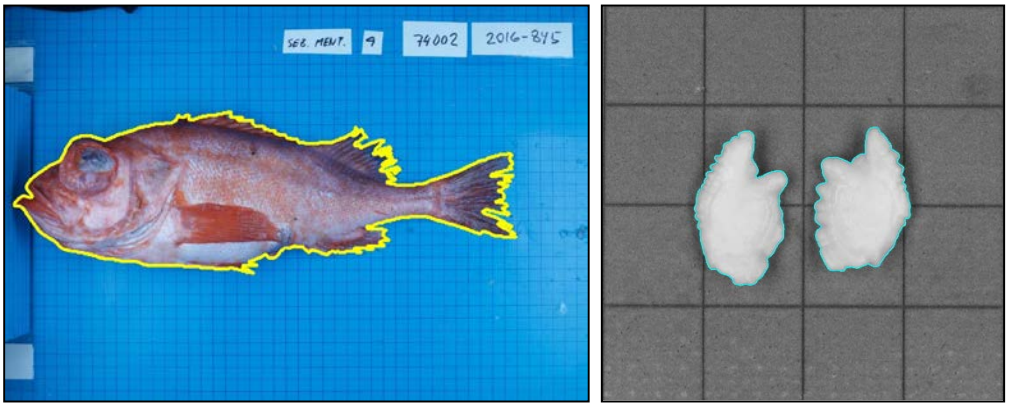

Figure 8.2.3.1: Left: Imaged *S. mentella* with automatically fitted contour (yellow). Right: image of *S. mentella* otolith with automatically fitted contours (cyan).

Table 8.2.3.1: Camera specifications for imaging of whole individual fish

CAMERA MODEL	CANON EOS 70D
Lens	35 mm
Focal / shutter speed	f/22 1/30s
ISO	320 ASA
File format	RAW
Image size	5427 x 3648 x 3
Distance from lens to imaging board	75 cm

8.2.4 Hydroacoustic sampling

The echosounders were calibrated at the beginning of the survey for the 18, 38, 120, and 200 kHz frequencies. 38 kHz was used as the primary frequency for hydroacoustics analyses.

The technical specifications for hydroacoustics are provided in Table 8.2.4.1. The sampling rate was set to 1.34 s intervals. This allowed covering the depth range 0–1000 m. In cases where ghost bottom echoes were detected, the sampling rate was adjusted to greater intervals.

Hydroacoustics was registered and stored for the entire duration of the cruise down to 1000 m (or bottom depth when less than 1000 m). Typical echograms registered during the survey are illustrated in Figure 8.2.4.1.

Echogram interpretation (scrutinizing) was conducted following the protocol described in the report of the workshop on hydroacoustic scrutinizing in the Norwegian Sea (Planque *et al.*, 2009) and adopted by the Working Group on Redfish Surveys (WGRS; ICES, 2013). The main steps are summarized below:

Echointegration is performed using LSSS software with Sv thresholding to remove low-energy echoes which results from smaller targets in the Deep Scattering Layer (DSL). Integration is 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 is raised to a level where the DSL (or other 'background' layer) can no longer be seen. The s_A is then allocated to fish targets and divided between fish species according to s_A proportions in the nearest trawl hauls (s_A proportions are provided by the 'trawl module' of LSSS on the basis of species quantities and length distribution in the catch). The threshold is then brought back to -82dB and the additional s_A is allocated to the category 'plankton'.

The following acoustic categories were used: redfish (S. mentella), blue whiting, herring, plankton, other, cod, greater argentine, and saithe. The 'plankton' category comprises all small targets (e.g. myctophids, shrimps), including ribbon barracudina (Arctozenus risso). The category 'other' comprises all other large targets which are not identified (i.e. other fish species).

Possible sources of error such as ghost bottom echoes or 'noisy pings' are removed either by 'schooling them out' (i.e. by drawing a school object which is removed from the layer analysis) or by adapting the layer contour. The mean s_A surrounding a 'schooled-out-region' is then assigned to the region.

Scrutinized sections are stored to the LSSS database with a resolution of 10 m (vertical) by 1 NM (horizontal).

The target strength (TS) for *S. mentella* was defined using the following size-dependent relationship:

TS = 20logL - 69.6.

This corresponds to the recommended TS equation with fixed slope from the workshop on the Determination of Acoustic Target Strength of Redfish (WKTAR, ICES 2010). This is different from the equation used in earlier surveys (20logL-68.0).

The target strength (TS) for blue whiting (*Micromesistius poutassou*) was defined using the following size-dependent relationship:

TS = 21.8logL - 72.8

Target strengths for other fish categories were based on fixed slope equations (20logL) with the following intercept: herring: -67.3, cod: -68.0, greater argentine: -67.5, saithe: -68.0. Typical echograms registered during the survey are presented in Figure 8.2.1.1.

Table 8.2.4.1: Hydroacoustic specifications

Echosounder/Integrator	Simrad EK60/LSSS
Frequency	38 kHz
Transmission Power	2000 W
Absorption coefficient	9.65 dB/km
Pulse length	1.024
Bandwidth	2.43 kHz
Transducer type	ES38B
Two-way beam angle	-20.6 dB
Integration threshold	-82 dB
Sound speed	1490 m/s
Transducer gain Sv	24.44 dB
s_A correction	-0.63 dB

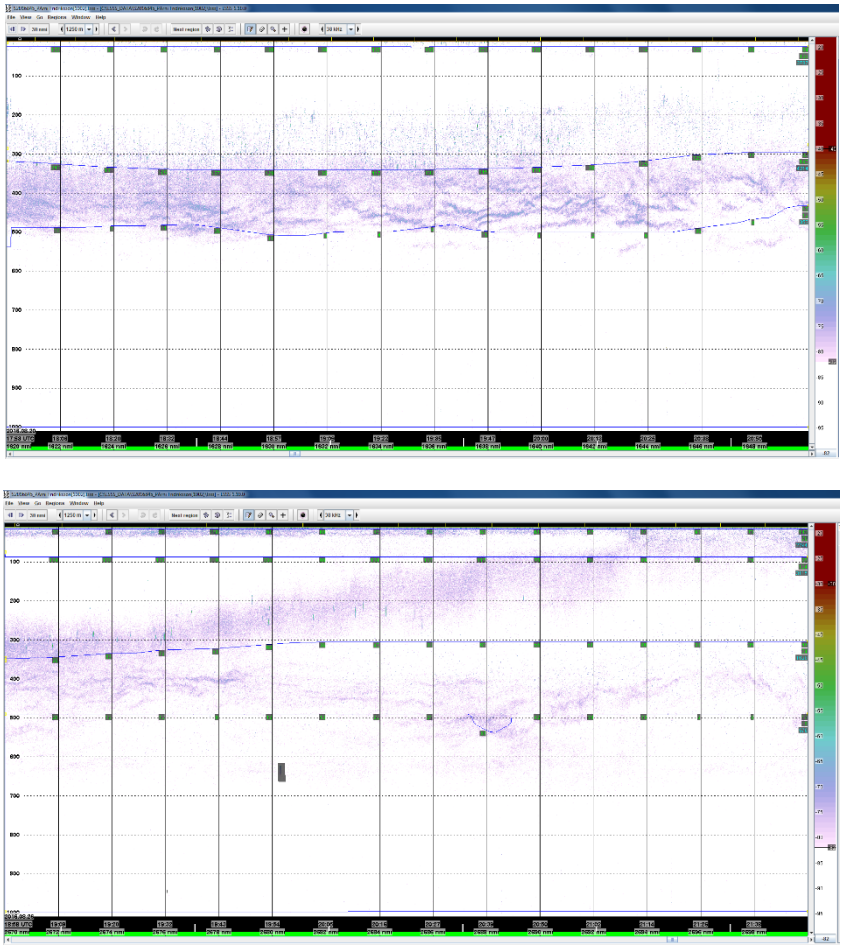

Figure 8.2.4.1 examples of echograms registered during the survey (38 kHz), before (top) and during (bottom) the upward vertical migration of organisms in the deep scattering layer.

Hydrographic measurements

A Conductivity Temperature Depth (CTD) sensor was attached to the multisampler and used to register temperature and salinity at depth during trawling. The technical specifications of the sensor are provided in Table 8.2.5.1. The CTD probe was encaged in a metallic frame to protect it from shocks and to ensure a minimal distance between the probe and the metallic frame of the multisampler (which could result in magnetic interferences).

Table 8.2.5.1: CTD specification

MANUFACTURER/REF	SAIV AS/SD204 – INSTRUMENT NUM: 749
sampling rate	1 Hz
Pressure resolution/accuracy	0.01 dbar / 0.1dbar
Temperature precision/accuracy	0.001°C / 0.01°C
Salinity precision/accuracy	0.01 /0 .015

8.3 Results

8.3.1 Extent of the deep scattering layer

The open Norwegian Sea is characterized by the presence of a dense layer of organisms, the Deep Scattering Layer (DSL). During daytime, this layer is located in the mesopelagic zone, below 200 m. At night, many organisms migrate towards the surface and enter the epipelagic zone. During the survey, daily migrations were more marked in the southern area where the daily light cycling was more pronounced. The acoustic energy reflected by organisms in the epipelagic and mesopelagic layers was registered as an integrated measure of abundance in the two depth zones, following the method in (Siegelman-Charbit and Planque, 2016). The mean s_A for the mesopelagic layer is 184 m^2/nmi^2 and for the epipelagic layer is 53 m^2/nmi^2. This indicate higher acoustic energy in the mesopelagic zone and lower acoustic energy in the epipelagic zone than observed in earlier surveys (Table 8.3.1.1).

Table 8.3.1.1: s_A recorded in the epipelagic and mesopelagic layers (m^2/nmi^2) and the ratio between the two layers.

	2008	2009	2013	2016
Epipelagic	116	71	NA	53
Mesopelagic	133	140	NA	184
Meso:Epi	1.2	2.0	NA	3.5

8.3.2 Species composition

The survey targeted primarily species present in the mesopelagic layer and its vicinity. However, the Gloria trawl used in the survey does not quantitatively sample all species present in this layer and is most suited for larger fish specimens (more than ~15 cm). Blue whiting and beaked redfish were encountered in most of the trawl samples (~80%). This figure is, however, lower for beaked redfish than was observed in previous surveys (95, 100, and 96% in 2008, 2009, and 2013, table D10 in ICES, 2014). Glacier lanternfish, jellyfish (*Periphylla periphylla*), northern krill, and boreoatlantic armhook squid were found in more than half of the trawl samples. Ribbon barracudina, several species of prawn/shrimp, amphipods, and saithe were also found relatively frequently throughout the survey. The details of species occurrence, catch and sampling are provided in Table 8.3.2.1. More specific results on the distribution and abundance of beaked redfish and blue whiting are provided below.

Table 8.3.2.1: Species occurrence, catch and sampling.

Latin name	Common English name	Common Norwegian Name	Occur.	Catch (number)	Catch weight (kg)	Length samples	Biological samples
Micromesistius poutassou	Blue whiting	Kolmule	73	7868	886.392	1353	-
Sebastes mentella	Beaked redfish	Snabeluer	71	1099	704.821	1096	949
Benthosema glaciale	Glacier lanternfish	Nordlig lysprikkfisk	68	16804	27.429	1710	-
Periphylla periphylla		Kronemanet	65	-	132.483*	-	-

Latin name	Common English name	Common Norwegian Name	Occur.	Catch (number)	Catch weight (kg)	Length samples	Biological samples
Meganyctiphanes norvegica	Northern krill	Norsk storkrill	59	-	15.092	-	-
Gonatus fabricii	Boreoatlantic armhook squid		53	1356	11.719*	778	-
Arctozenus risso	Ribbon barracudina	Liten laksetobis	34	108	2.300	108	-
Pasiphaea tarda	Crimson pasiphaeid	Rødglassreke	33	-	3.704	-	-
Sergestes arcticus	Panaeid prawn	Rødflekkglassreke	26	-	6.357	-	-
Lampanyctus macdonaldi	Rakery beaconlamp	Brun lysprikkfisk	20	80	0.269	80	-
Chaetognatha	Arrow worms	Pilormer	15	-	0.514	-	-
Themisto spp.			15	-	2.680	-	-
Pasiphaea multidentata	Pink glass shrimp	Rosenglassreke	12	-	0.542	-	-
Pollachius virens	Saithe	Sei	10	32	42.580	-	
Hymenodora glacialis	Northern ambereye		4	-	0.005	-	-
Gadus morhua	Atlantic cod	Torsk	4	6	16.626	6	-
Pasiphaea spp.		Glassreker	3	-	0.050	-	-
Maurolicus muelleri	Pearlside	Laksesild	3	3	0.004	3	-
Notoscopelus kroyeri	Kroyers lanternfish	Stor lysprikkfisk	3	3	0.061	3	-
Argentina silus	Greater argentine	Vassild	3	4	1.569	4	-
Cirroteuthis muelleri			2	2	0.794	2	-
Pasiphaea sivado	White glass shrimp	Glassreke	2	2	0.002	-	-
Reinhardtius hippoglossoides	Greenland halibut	Blåkveite	1	2	1.564	2	-
Anarhichas denticulatus	Northern wolffish	Blåsteinbit	1	1	0.286	1	-
Melanogrammus aeglefinus	Haddock	Hyse	1	2	0.007	2	-
Isopoda	Isopods	Isopoder	1	1	0.002	-	-
Cyclopterus lumpus	Lumpsucker	Rognkjeks	1	1	1.181	1	-
Clupea harengus	Atlantic herring	Sild	1	1	0.204	1	-
Paraliparis bathybius	Black sea snail	Svart ringbuk	1	1	0.062	1	-
Sebastes sp.	Redfish	Uerslekten	1	3	0.002	3	-

***weight missing from 1 sample.**

8.3.3 Vertical and thermal distributions of redfish and blue whiting

Trawl hauls were performed at headrope depth ranging from 200 m to 700 m. For each trawl sample, the catch rates of beaked redfish and blue whiting were calculated (in number of individuals per hour of towing) and associated with the mean depth of towing (depth of the codend) and the mean temperature during sampling. The catch rates of redfish were highest between 1 and 4°C and between 300 m and 600 m depth. Outside these limits, catch rates were always small (Figure 8.3.3.1). For blue whiting, the catch rates were higher above 3°C and at depths shallower than 400 m (Figure 8.3.3.2).

Hydroacoustic profiles also suggest high densities of beaked redfish between 330 m and 600 m. It is not possible to assess the density of redfish adequately with acoustics below 600 m, the number reported at these depths being underestimated due to limitation in target detection (Dalen *et al.*, 2003).

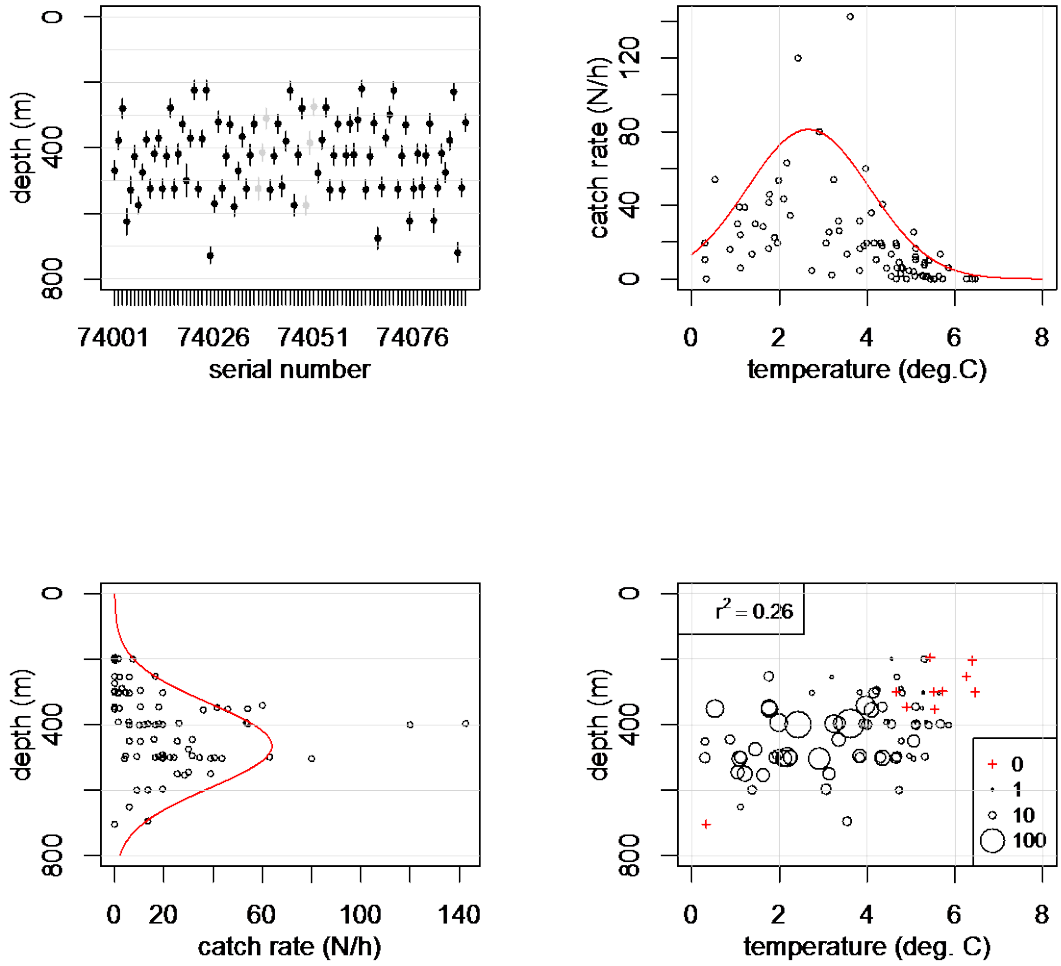

Figure 8.3.3.1: Top left: vertical distribution of trawling. Dots mark the mean depth of the codend and vertical bars show the trawl opening. Top right: catch rates of *S. mentella* as a function of temperature. The red line shows the upper envelope encompassing 80% of observations. Bottom left: catch rates of *S. mentella* as a function of trawling depth. Bottom right: depth and temperature recorded at each trawl sample. Size of circles is proportional to catch rates.

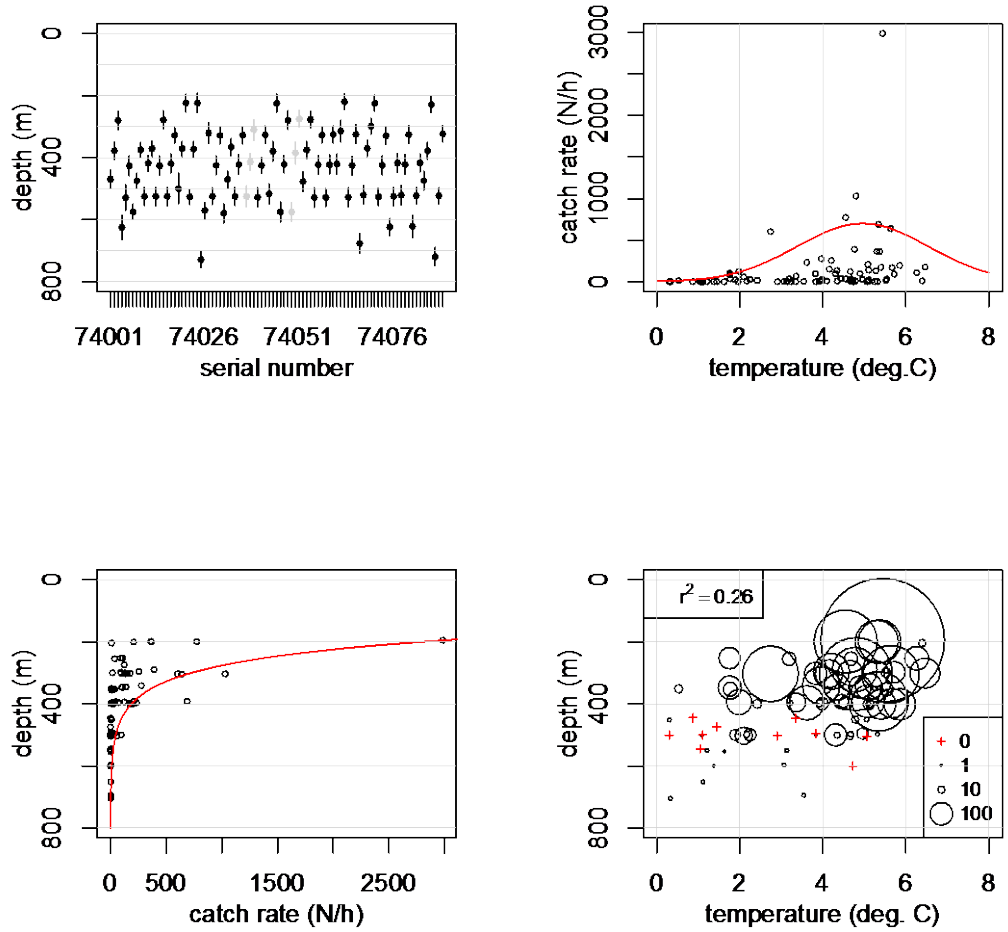

Figure 8.3.3.2: Top left: vertical distribution of trawling. Dots mark the mean depth of the codend and vertical bars show the trawl opening. Top right: catch rates of *M. Poutassou* as a function of temperature. The red line shows the upper envelope encompassing 80% of observations. Bottom left: catch rates of *M. Poutassou* as a function of trawling depth. Bottom right: depth and temperature recorded at each trawl sample. Size of circles is proportional to catch rates.

8.3.4 Length distribution of beaked redfish

Individual measurements of beaked redfish show that individuals sampled in 2016 are on average slightly longer than those sampled in previous surveys (Figure 8.3.4.1), with a mean length of 37.7 cm compared to 37.0, 36.6, and 37.5 cm in 2008, 2009, and 2013 respectively.

The length distribution is characterized by an increase in the length of the large individuals and the appearance of individuals of smaller length. The shift of the length distribution to greater lengths suggest ageing of the existing cohorts. The small increase in the proportion of the smallest length groups can be interpreted as a sign of the new cohorts recruiting into the Norwegian Sea mature stock. Length distributions split by sex (Figure 8.3.4.2 left) confirm the larger size-at-age for females beaked redfish and seem to indicate two new cohorts entering the Norwegian Sea population unit at 28 and 32 cm for females and 27 and 31 cm for males. These will need to be confirmed by age readings.

As observed in earlier years, individual found outside the deep scattering layer are generally larger than those found within the DSL. The average length of individual found above and below the DSL are similar (respectively 38.1 cm and 38.4 cm) but their length composition differs, with the few largest individuals (> 42 cm) in the deepest

layer compared with a large proportion of 39–40 cm individuals in the shallower layer (Figure 8.3.4.2 right).

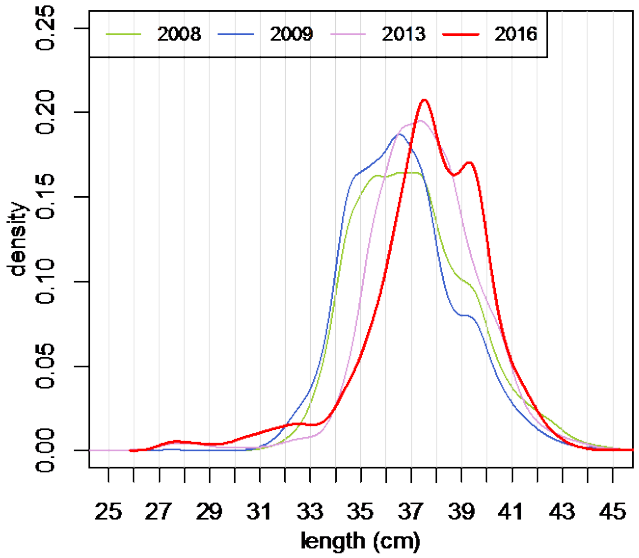

Figure 8.3.4.1: estimated mean length distribution of *S. mentella*, males and females combined for the surveys conducted in the Norwegian Sea in 2008, 2009, 2013 and 2016.

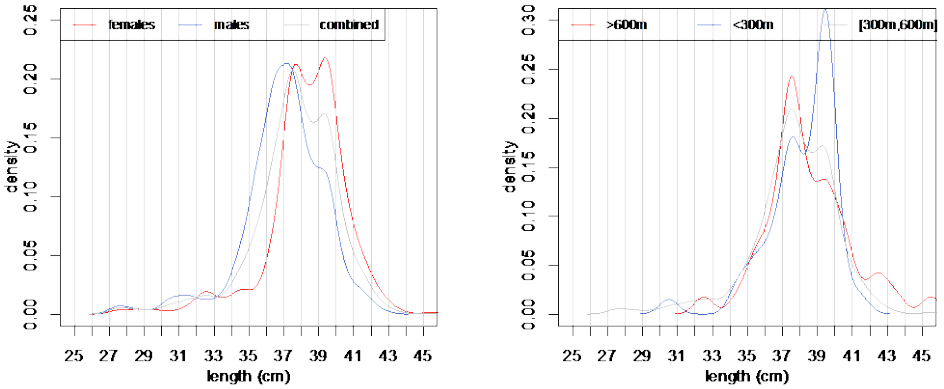

Figure 8.3.4.2: estimated mean length distribution of *S. mentella* in 2016 split by sex (left) and by depth (right).

8.3.5 Sex ratio and maturity

The sex ratio of sampled individuals is close to 50/50 with 478 female and 471 male fish sampled. The vast majority of individuals were of maturity stage 2. These findings are consistent with observations from earlier surveys (Table 8.3.5.1).

Table 8.3.5.1: Number of individuals sampled for each sex x maturity category. The overall sex ratio is indicated.

STAGE (ICES SCALE)	FEMALES	MALES
1	12	5
2	461	466
3	0	0
4	0	0
5	3	0
6	1	0
7	1	0
all	478	471

8.3.6 Abundance estimate based on trawls only

The sampling scheme is not strictly designed to derive abundance estimates from trawls only. However, the relatively regular distribution of trawl hauls in the horizontal and the vertical dimensions, the decision of trawling being mostly independent of registration and the rather continuous distribution of redfish over the entire area of study, make it possible to estimate abundance from trawls only. The method used here is identical with the one used in earlier survey. For each 50 m depth layers, the mean catch rates (kg.nmi^{-1}) is calculated for the entire survey area (CR_{layer}). The total biomass in each depth layer is calculated as $B_{layer} = CR_{layer}$ x 1852/70 x Total survey area (1852/70 is the ratio between the volume of 1 nmi^2 by 50 m and the volume sampled by the trawl in 1 nmi distance). The total biomass over the survey area is then calculated by summing the biomass in each individual layers.

The mean catch rates in each 50 m layer are presented in Figure 8.3.6.1. Assuming that the catchability of the Gloria 1024 is similar the Gloria 2048, that is 50% (Bethke *et al.*, 2010) and considering an area of 67 150 nmi^2, the total abundance of beaked redfish in the surveyed area is estimated to:

136 000 tonnes.

This is substantially lower that abundance estimates obtained with similar calculations in earlier years: 482 000 t (2013), 548 000 t (2009), 406 000 t (2008).

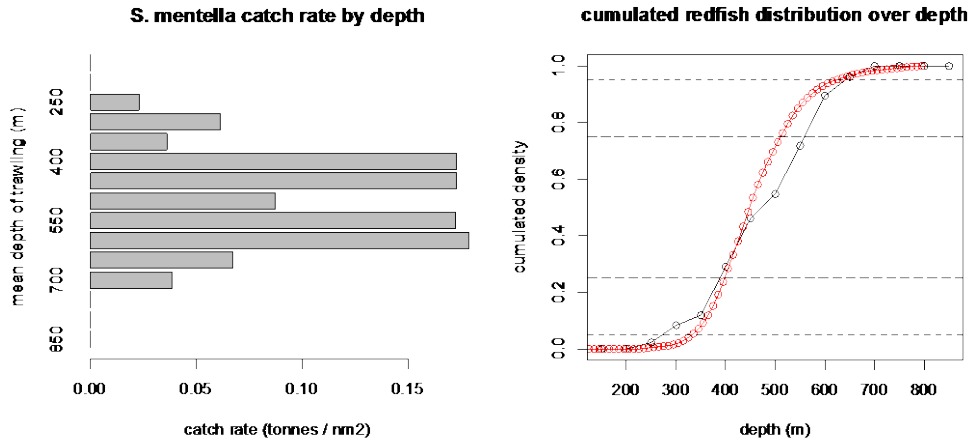

Figure 8.3.6.1: Left: mean catch rate (tonnes/nmi²) of beaked redfish by 50 m depth layers, as used for the calculation of total biomass base on trawl samples. Right: cumulated distribution of beaked redfish biomass over depth derived from trawl catches (black) and hydroacoustic registrations (red).

8.3.7 Abundance estimate based on hydroacoustics

The acoustic energy registered at 38 kHz and allocated to beaked redfish was used to derive biomass estimate over the surveyed area. As in previous surveys, the registrations were divided in 2 layers, above and below 600 m depth where the mean length are slightly different (mean(L^2)$^{1/2}$: 37.7 cm in shallow and 38.5 cm in deep waters). For each layer, the biomass of fish per nmi² was calculated as:

$$Biomass = N \times w$$
$$N = SA/\sigma$$
$$\sigma = 4\pi 10^{\frac{TS}{10}}$$

with TS = 20log(L)-69.6, w = 654 g (< 600 m) and w = 674 g (> 600 m), and SA the mean recorded s_A times the total area of the survey: 67 150 nmi². The biomasses in the two layers were then added to obtain the total biomass in the area.

The resulting total abundance of beaked redfish is estimated to:

116 000 tonnes.

This is substantially lower that abundance estimates obtained in earlier years: 297 000 t (2013), 532 000 t (2009), 395 000 t (2008). In addition, the change in the TS equation coefficient, from -68.0 to -69.6 leads to an increase in the estimated biomass by about 45% for the same amount of s_A. This makes the difference between the estimate in 2016 and those in earlier years even greater. The horizontal distribution of the s_A allocated to beaked redfish is illustrated in Figure 8.3.7.1.

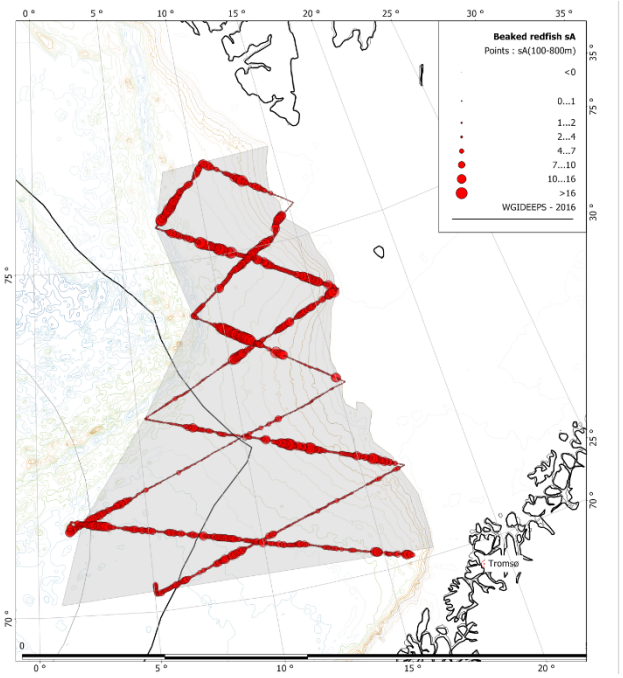

Figure 8.3.7.1: Hydroacoustics registered and allocated to beaked redfish in the survey area.

8.3.8 Imaging of redfish

During the survey, methodologies were developed to automatically contour (i.e. isolate the outer shape of) individuals and otoliths and to measure fish length from images. The measurements of length derived from images are highly consistent with those obtained with the standard fishmeter system (Figure 8.3.8.1). The contouring algorithm used for whole fish was built on the *ratio* of red to green colours for the anterior part of the fish and on the *difference* between red and green colours for the posterior part of the fish (Figure 8.2.3.1 left).

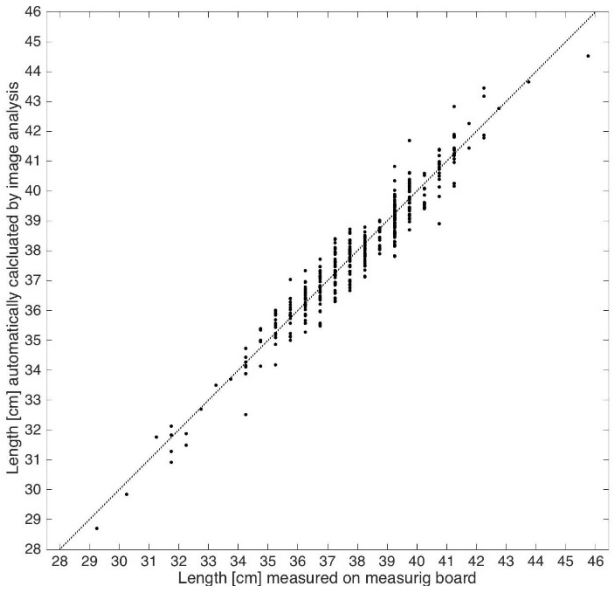

Figure 8.3.8.1: length measured with the fishmeter against length automatically derived from image analysis.

8.3.9 Hydrography

Records of temperature and salinity were performed at each trawl station providing 30 hydrological 'profiles' over the investigation area. Temperatures ranged from 7 to 11°C at the surface, 4°C to 7°C at 200 m depth and < 1°C to 6 at 400 m. The westward intrusions of water masses of Arctic origin into the Lofoten basin in the south and into the Norwegian basin in the North are clearly visible at 400 m depth (Figure 8.3.9.1). The presence of Atlantic water masses and the relatively high catch rates of beaked redfish in the northernmost part of the investigated area suggest that the suitable habitat for beaked redfish extends further north.

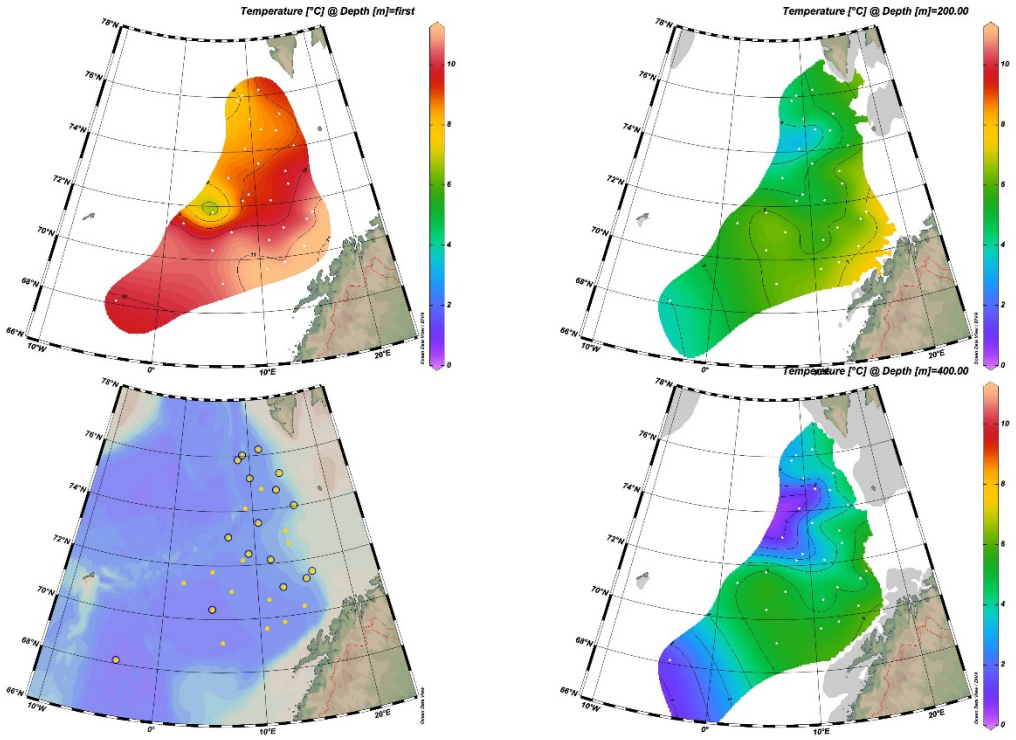

Figure 8.3.9.1: horizontal distribution of sea temperature at the surface, 200 m and 400 m depths.

8.4 Summary of key findings

The key results from the survey are as follows:

- The geographical distribution of beaked redfish covers and goes beyond the area of the survey,
- The biomass estimates of beaked redfish are (as previously) very uncertain, given the limitations in the observation methodologies employed,
- The absolute biomass estimates are far lower than those derived in earlier survey. This is believed to reflect a decline in the biomass of redfish in the area,
- Length structure of the redfish population indicates that i) the cohorts of old adults present earlier in the Norwegian Sea are seen ageing and growing and ii) cohorts of young adults of beaked redfish, that were detected earlier in the Barents Sea surveys, are beginning to enter the Norwegian Sea.
- The total energy recorded in the mesopelagic zone is greater than observed earlier, while the energy recorded in the epipelagic layer is lower.

- Comparison of results from the 2016 survey and from earlier surveys are summarized in Table 8.4.1.

Table 8.4.1: Comparison of results on *Sebastes mentella* from the Norwegian Sea pelagic surveys in 2008, 2009, 2013 and 2016.

	2008	2009	2013	2016
mean length (cm) All/M/F[1]	37.0 / 36.4 / 37.5	36.6 / 36.0 / 37.1	37.5 / 37.0 / 38.1	37.7 / 37.0 / 38.3
mean length (cm) S/DSL/D[2]	37.2 / 36.8 / 39.1	37.2 / 36.5 / 38.3	37.1 / 37.4 / 38.9	38.1 / 37.6 / 38.4
mean weight (g) All/M/F	619 / 585 / 648	625 / 609 / 666	659 / 625 / 706	656 / 619 / 694
Mean age (y) All/M/F	25 / 25 / 25	25 / 25 / 24	- / - / -	- / - / -
Sex ratio	45% (M) / 55% (F)	45% (M) / 55% (F)	59% (M) / 41% (F)	50% (M) / 50% (F)
Occurrence	96%	100%	95%	80%
Catch rates	3.80 t/nmi^2	3.94 t/nmi^2	3.47 t/nmi^2	1.01 t/nmi^2
mean s_A	33 m^2/nmi^2	34 m^2/nmi^2	19 m^2/nmi^2	5.2 m^2/nmi^2
Total Area	53 720 nmi^2	69 520 nmi^2	69 520 nmi^2	67 150 nmi^2
Abundance (Acoustics)[3]	395 000 t	532 000 t	297 000 t	136 000 t
Abundance (Trawl)[4]	406 000 t	548 000 t	482 000 t	116 000 t

[1] M = males only, F = females only

[2] S = shallower than DSL, DSL = deep scattering layer, D = deeper than DSL

[3]The abundance derived from hydroacoustics is calculated assuming a Length-dependent target strength equation of TS=20log(L)-68.0. In 2016, the TS equation used was TS=20log(L)-69.6, following recommendation from ICES-WKTAR (2010).

[4]Trawls: Gloria 2048 in 2008 and 2009, Gloria 2560 HO helix in 2013 and Gloria 1024 in 2016. Trawl catchability for redfish set to 0.5 for all trawls, based on results from Bethke et al (2010).

8.5 Request, recommendations, technical issues

The past and current surveys of the deep pelagic ecosystem in the Norwegian Sea suffer from limitations that forbid a robust assessment of the abundance of beaked redfish and a comprehensive description of the deep ecosystem fauna. The following are recommended to correct these limitations:

- There is an absolute necessity to use a standardized trawl in order to build a time-series useful for assessment purposes. It is recommended that IMR purchase a Gloria 2048 trawl to be used on IMR vessels or on rented vessels.
- Hull mounted echosounder cannot be used to assess reliably the density of fish below 500 m. A large fraction of the redfish population is situated below this depth. It is recommended that a deep-towed transducer, operating at 10 knots, be used in future surveys.
- Many of the organisms present in the deep scattering layer are too small or too fragile to be efficiently sampled by the Gloria trawl, and the vertical resolution of species distribution cannot be monitored precisely with preprogramed tows at fixed depth. It is recommended that the DeepVision system

be embarked and used on some tows to reveal the vertical structure of species composition in the deep scattering layer.

- For the reasons presented above it is also recommended that the use of alternative sampling gears (e.g. macroplankton trawl) be investigated and tested.
- The distribution area of beaked redfish vastly extends the region covered by the survey, in the North and South. It is recommended that WGIDEEPS pursue its efforts towards multinational participation to the survey.

8.6 Acknowledgements

The WGIDEEPS group would like to express its thanks to the research cruise participants: Erik Berg, Lia Charbit, Alf Harbitz, Ronald Pedersen, Benjamin Planque, Anne Sveistrup, Tone Vollen, Rupert Wienerroither; to the Captain Ingvi Fridriksson, and to the crew of the RV Fridriksson, who have made this survey so efficient and pleasant: Hilmar Sigursson, Kristján H Kristinsson, Gudmundur Erlingsson, Ævar Rafn Thrastarson, Alexander Oddson, Sigurdur K Gudmindsson, Rakel Jóhannsdóttir, Hafthor Júlíusson, Vidir Gudmundsson, Bjarni Sveinsson, Gudmundur Meyvantsson, Thorsteinn Búi Hardarson, Haukur Ingólfsson, Frímann Gudmundsson, and Björn Sigurddsson.

8.7 References

Bethke, E., Götze, E., and Planque, B. 2010. Estimation of the catchability of redfish and blue whiting for survey trawls in the Norwegian Sea. Journal of Applied Ichthyology, 26 (Suppl. 1): 47-53.

Dalen, J., Nedreaas, K., and Pedersen, R. 2003. A comparative acoustic-abundance estimation of pelagic redfish (Sebastes mentella) from hull-mounted and deep-towed acoustic systems. ICES Journal of Marine Science, 60: 472-479.

ICES 2010. Report of workshop on the Determination of Acoustic Target Strength of Redfish (WKTAR). ICES CM, 2010/SSGESST:15: 29pp.

ICES 2013. Report of the working group on redfish surveys (WGRS-3). ICES CM, 2013/SSGESST: 15: 35pp.

ICES 2014. Report of the arctic fisheries working group (AFWG). ICES CM, 2014/ACOM:05: 656pp.

Planque, B., Bethke, E., Drevetnyak, K., Harbitz, A., Nedreaas, K., Pedchenko, A. P., Pedersen, R., et al. 2009. Workshop on hydro-acoustic scrutinizing in the Norwegian Sea. . 3/2009. 39 pp.

Siegelman-Charbit, L., and Planque, B. 2016. Abundant mesopelagic fauna at oceanic high latitudes. Marine Ecology Progress Series, 546: 277-282.

Annex 1: List of participants

Name	Address	E-mail
Alexey Astakhov	Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO) 6 Knipovich Street 183038 Murmansk Russian Federation	aleks_a@pinro.ru
Matthias Bernreuther	Thünen Institute of Sea Fisheries Palmaille 9 D-22767Hamburg Germany	matthias.bernreuther@thuenen.de
Eckhard Bethke	Thünen Institute of Sea Fisheries Palmaille 9 D-22767Hamburg Germany	eckhard.bethke@thuenen.de
Klara Björg Jakobsdóttir	Marine Research Institute Skúlagata 4 PO Box 1390 121Reykjavík Iceland	klara@hafro.is
Kristjan Kristinsson (Chair)	Marine Research Institute Skúlagata 4 PO Box 1390 121Reykjavík Iceland	krik@hafro.is
Anna Osypchuk	International Council for the Exploration of the Sea H. C. Andersens Boulevard 44-46 1553 Copenhagen V Denmark	anna.osypchuk@ices.dk
Benjamin Planque (Chair)	Institute of Marine Research Tromsø PO Box 6404 9294Tromsø Norway	benjamin.planque@imr.no
Alexey Rolskiy	Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO) 6 Knipovich Street 183038 Murmansk Russian Federation	rolskiy@pinro.ru
Vaishav Soni	International Council for the Exploration of the Sea H. C. Andersens Boulevard 44-46 1553 Copenhagen V Denmark	vaishav.soni@ices.dk

Annex 2: Recommendations

RECOMMENDATION	ADRESSED TO
1. Involve more countries in the Irminger and Norwegian Seas surveys	ICES Secretariat
2. Secure appropriate international support to the WGIDEEPS surveys in the Norwegian and Irminger Seas	NEAFC
3. Set up a workshop to evaluate and propose new observational approach to the deep pelagic ecosystems in the Irminger and Norwegian Seas (WKMESO)	SSGIEOM

Annex 3: WGIDEEPS meetings and terms of reference

The **Working Group on International Deep Pelagic Ecosystem Surveys** [WGIDEEPS] chaired by Kristján Kristinsson, Iceland and Benjamin Planque, Norway , will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	ToRs
Year 2017	XX-XX June	Town, Country, tbd	Interim report by 1 September to SSGIEOM	a, b, c
Year 2018	XX-XX January	Town, Country, tbd	Interim report by 1 March to SSGIEOM	d
Year 2018	XX-XX August	Town, Country, tbd	Interim report by 1 September to SSGIEOM	e
Year 2019	XX-XX January	Town, Country, tbd	Interim report by 1 March to SSGIEOM	f
Year 2019	xx-xx September	Town, Country, tbd	Interim report by 10 September to SSGIEOM	g
Year 2019	By correspondence	-	Final report by 15 September to SSGIEOM	a, b, c, d, e, f, g

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Finalize transfer of trawl survey data from international deep pelagic ecosystem surveys coordinated by the group to ICES DATRAS databases September/2017)	Data are now stored by individual nations/participants. It is important to have the data within common database system for coordinated archiving and extraction.	25	Year 1 (2017)	WGIDEEPS 2017 – 1 report chapter database (ICES DATRAS) 15 September 2017
b	Evaluate calculation of biomass and abundance indices derived from the trawl method in the Irminger Sea.	The mehtod of calculating biomass and abundance indices from the trawl data has been based on convertion of the trawl data into acoustic values. This method needs to be evaluated and other methods to be explored.	25, 30	Year 1 (2017)	WGIDEEPS 2017 – 1 report chapter 15 September 2017 SSGESST
c	Set up a formal procedure for the use and transfer of Norwegian survey data to AFWG and WGINOR expert groups	There is currently no agreed format and standard on how the data collected by WGIDEEPS should be transfered to relevant assessment EGs.	25, 30	Year 1 (2017)	WGIDEEPS 2017 – 1 report chapter 15th September 2017

d	Plan the international deep pelagic ecosystem survey with special emphasis on redfish to be carried out in the Irminger Sea and adjacent waters in June/July 2018 (January 2018 meeting)	The WG has been responsible for the planning of the international trawl/acoustic surveys on pelagic redfish (Sebastes mentella) in the Irminger Sea and adjacent waters since 1994 and corresponding reports on the survey results.	1, 9, 27, 30, 31	Year 2 (2018)	WGIDEEPS 2018 – 2 report chapter 15 March 2018
e	Prepare the report on the outcome of the 2018 Irminger Sea survey (August 2018 meeting)	a) Provide sound, credible, timely, peer-reviewed, and integrated scientific advice on fishery management and the protection of the marine environment. b) Redfish indices are being used by assessment working groups. c) Prepare survey data in the ICES format and deliver to ICES.	1, 9, 30, 31	Year 2 (2018)	WGIDEEPS 2018 – 3 report 1 September 2018
f	Plan the international deep pelagic ecosystem survey with special emphasis on redfish to be carried out in the Norwegian Sea and adjacent waters in August 2019 and write SISP (January 2019 meeting)	The WG has been responsible for the planning of the international trawl/acoustic surveys on pelagic redfish (Sebastes mentella) in the Norwegian Sea since 2008 and corresponding reports on the survey results.	1, 9, 27, 30, 31	Year 3 (2019)	WGIDEEPS 2018 – 4 report chapter SISP document 15 March 2019
g	Prepare the report on the outcome of the 2019 Norwegian Sea survey (September 2019 meeting)	a) Provide sound, credible, timely, peer-reviewed, and integrated scientific advice on fishery management and the protection of the marine environment. b) Redfish indices are being used by assessment working groups. c) Prepare survey data in the ICES format and deliver to ICES.	1, 9, 30, 31	Year 3 (2019)	WGIDEEPS 2019 – 5 report 1 October 2019 SSGESST

Summary of the Work Plan

Year 1	Carry out ToR a-c.
Year 2	Standard outputs for d and e.
Year 3	Carry out ToR f and g.

Supporting information

Priority	Essential, primary basis for the advice on the stock status of pelagic redfish in the Irminger Sea and adjacent waters and in the Norwegian Sea.
Resource requirements	N/A
Participants	< 12 (incl. the cruise leaders of each vessel and the principle experts involved in abundance and biomass calculations and deep-sea ecology).
Secretariat facilities	N/A
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	NWWG, AFWG, WGDEC, WKFAST, WGOH, WGISDAA, WGBIODIV
Linkages to other committees or groups	SSGESST, SSGIEOM
Linkages to other organizations	NAFO, NEAFC.

Annex 4: Copy of Working Group self-evaluation

1) Working Group name:

Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS)

2) Year of appointment:

As Working Group: 2014, for three year period 2014-2015-2016.

Formerly as Working Group on Redfish Surveys (WGRS, 2010-2013), Planning Group on Redfish Surveys (2008-2009) and either as Planning Group or Study Group on Redfish Stock (PGRS/SGRS, 1998-2007).

3) Current Chairs:

Kristján Kristinsson (MRI, Iceland)

Benjamin Planque (IMR, Norway)

4) Venues, dates and number of participants per meeting:

1. **Copenhagen, Denmark, ICES HQ: 28-30 January 2014,** 7 participants (of which 2 participants were from ICES Data Centre), see 2014 report for details.
2. **Tromsø, Norway, 3-5 February 2015,** 6 participants, see 2015a report for details.
3. **Reykjavík, Iceland, 4-6 August 2015,** 3 participants, see 2015a report for details.
4. **No meeting in 2016**. Work by correspondence.

WG Evaluation

5) If applicable, please indicate the research priorities (and sub priorities) of the Science Plan to which the WG make a significant contribution.

WGIDEEPS focuses on planning and coordination of observation and monitoring of the deep pelagic ecosystems and redfish stocks. The group provides data and information to appropriate stock assessment and integrated assessment expert groups. The group contributes mainly to the second and fourth goal of ICES Strategic Plan 2015-2018, i.e. Ecosystem Pressures and Impacts (EPI) and Integrated Ecosystem Observation and Monitoring Programme (IEOM).

6) In bullet form, highlight the main outcomes and achievements of the WG since their last evaluation. Outcomes including publications, advisory products, modelling outputs, methodological developments, etc.

- Collection of hydrological and biological data in the open Irminger and Norwegian Seas, with particular emphasis on the mesopelagic layer and the stocks of beaked redfish (*Sebastes mentella*) in these waters.
- Compilation and evaluation of relevant survey independent data on beaked redfish for stock assessment expert groups (NWWG and AFWG) and integrated assessment expert group (WGINOR).
- Preparation of a common data format to store survey data within the ICES database system (DATRAS).

- Develop appropriate methods for data collection and publish under the Series of ICES Survey Protocols (SISP).
- Publications:

ICES. 2014. First Interim Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS), 28-30 January 2014, ICES Headquarters, Copenhagen. ICES CM 2014/SSGESST:05. 20 pp.

ICES. 2015. Second Interim Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS), 3-5 February 2015, Tromsø, Norway. ICES CM 2015/SSGIEOM:02. 13 pp.

ICES. 2015. Third Interim Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS), 4-6 August 2015, Marine Research Institute, Reykjavík (Iceland). ICES CM 2015/SSGIEOM:03. 49 pp.

ICES. 2015. Manual for the International Deep Pelagic Ecosystem Survey in the Irminger Sea and Adjacent Waters. Series of ICES Survey Protocols SISP 11 – IDEEPS VI. 49 pp.

ICES. 2016. Fourth Interim Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS). ICES CM 2016/SSGIEOM:02. 21 pp.

Saha, A., Johansen, T., Hedeholm, R., Nielsen, E. E., Westgaard, J.-I., Hauser, L., Planque, B., et al. accepted. Geographic extent of introgression in Sebastes mentella and its effect on genetic population structure. Evolutionary Applications.

Siegelman-Charbit, L., and Planque, B. 2016. Abundant mesopelagic fauna at oceanic high latitudes. Marine Ecology Progress Series, 546: 277-282.

7) Has the WG contributed to Advisory needs? If so, please list when, to whom, and what was the essence of the advice.

WGIDEEPS's Terms of Reference (ToR) do not focus directly on the delivery of specific advice. The outcome of the surveys conducted by WGIDEEPS has been used as basis/part of advice for pelagic beaked redfish in the Irminger Sea and adjacent waters (NWWG) and in the Barents and Norwegian Seas (AFWG).

8) Please list any specific outreach activities of the WG outside the ICES network (unless listed in question 6). For example, EC projects directly emanating from the WG discussions, representation of the WG in meetings of outside organizations, contributions to other agencies' activities.

Results from the surveys conducted in the Norwegian Sea are reported to the North East Atlantic Fisheries Commission (NEAFC) in support for the management of beaked redfish in international waters.

9) Please indicate what difficulties, if any, have been encountered in achieving the workplan.

- The group suffers from a lack of strong commitment of participating nations to the surveys.
- The group lacks participation from several countries that participate to the fishery.
- The ocean areas to be covered are very large (>300,000NM^2) and are not adequately covered with current shiptime capacity.
- The common data format and database have been difficult to establish.

- The methodology used to monitor fish stocks and other fauna are poorly adapted to depths greater than 400m at which most of the observations must be conducted.

Future plans

10) Does the group think that a continuation of the WG beyond its current term is required? (If yes, please list the reasons)

Yes.

- Data from the WGIDEEPS surveys are essential support for the advice on beaked redfish stocks in the Irminger Sea and adjacent waters and in the Barents and Norwegian Seas. The deep pelagic beaked redfish stock in the Irminger Sea and adjacent waters was benchmarked in late August 2016, where assessment model was accepted and advice based on this model. Data collected in the Norwegian Sea survey constitute the only fisheries independent data source for the adult component of the stock.
- Data from the WGIDEEPS surveys constitute the only regular information source about deep-sea ecosystem status in these regions (open waters of Irminger Sea and adjacent waters and Barents and Norwegian Seas). None of the other surveys conducted in these regions provide information at mesopelagic depths.
- What do we want to do for the next three years (2017-2019)?
    - Plan and coordinate surveys scheduled in 2018 (Irminger Sea) and 2019 (Norwegian Sea).
    - Evaluate current abundance indices derived from the survey and their use in analytical assessment (NWWG and AFWG).
    - Finalize the transfer of trawl data from present and past surveys into DATRAS
    - Develop the group strategy towards support to ecosystem integrated assessment (WGINOR).
    - Use the surveys as platforms to test alternative observation methodologies for better monitoring of beaked redfish and ecosystems in the mesopelagic zone.

11) If you are not requesting an extension, does the group consider that a new WG is required to further develop the science previously addressed by the existing WG.

Not relevant.

12) What additional expertise would improve the ability of the new (or in case of renewal, existing) WG to fulfil its ToR?

- Need support from ICES secretariat to finalize the archival and management of data collected within WGIDEEPS surveys,
- Need support and input from SSGIEOM, WGFAST and other observational groups in order to develop or adapt observation methodologies for the monitoring of mesopelagic resources (i.e. deep, scattered and not always acoustically detectable).

13) Which conclusions/or knowledge acquired of the WG do you think should be used in the Advisory process, if not already used? (please be specific)

- Data on the adult fraction of the beaked redfish population from the Norwegian Sea survey are not currently integrated in the analytical assessment for this stock. This can and should be done (work in progress).
- Knowledge of interannual changes in the geographical extent (horizontal and vertical) and intensity of the mesopelagic layer should be reported to the relevant integrated assessment working groups (WGINOR).