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

6-8 August 2018

Bremerhaven, Germany

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

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Executive summary

The Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS) met in Bremerhaven, Germany, 6-8 August 2018. The meeting, remotely chaired by Kristján Kristinsson, was attended by four participants from Germany and Russia. During the meeting, the group prepared the report on the results from the pelagic redfish (*Sebastes mentella*) survey conducted in the Irminger Sea and adjacent waters in June/July 2018.

The trawl-acoustic survey on pelagic redfish in the Irminger Sea and adjacent waters was carried out by Russia only. In November 2017, the Marine and Freshwater Research Institute (MFRI) in Iceland informed the group that Iceland would not participate in the survey in June/July 2018. No specific reasons were given for the withdrawal. The participation of Germany was cancelled as well at the beginning of June due to technical problems. Accordingly, the scope of the survey had to be altered and the emphasis was on the detailed coverage of the pelagic redfish above and below 500 m depth in Subarea A.

About 103 000 NM^2 were covered, covering the northeastern part of the survey area (Subarea A). As relative survey indices, a biomass of 82 000 t was estimated at depths shallower than DSL by hydroacoustic measurements, about 171 000 t within the DSL, shallower than 500 m by a trawl method, and 130 000 t deeper than 500 m by the trawl method. Since the survey only covered Subarea A, the total biomass is most certainly underestimated. The highest concentrations of redfish above 500 m were found in the southwestern area of Subarea A, whereas the highest concentrations of redfish below 500 m were found in the central part of Subarea A. Since only Subarea A was covered, the comparison of the estimated biomass in previous surveys should be based on this subarea.

WGIDEEPS recommends that the survey should be continued with at least three vessels to cover the distribution area of redfish in the area. The Group recommends that further nations should participate in the next surveys and that chartering of additional vessels and cost share should be considered as alternative to direct participation.

1 Administrative details

Working Group name

Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS)

Year of Appointment within the current cycle

2

Reporting year within the current cycle (1, 2 or 3)

2

Chair(s)

Kristján Kristinsson, Iceland

Meeting venue

Bremerhaven, Germany

Meeting dates

6-8 August 2018

2 Terms of Reference

According to 2016/MA2/SSGIOM04 "The Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS) chaired by Kristján Kristinsson, Iceland, will meet in Bremerhaven, Germany, 6-8 August 2018.

The Terms of Reference applicable for the August meeting are:

- prepare the report of the outcome of the 2018 Irminger Sea survey.

WGIDEEPS will report by 19 September 2018 (August meeting via SSGIEOM/EOSG) for the attention of SCICOM and ACOM.

3 Summary of work plan

	Meeting dates	Venue	Reporting details	ToRs
Year 2017	25-27 April	ICES HQ, Denmark	Interim report by 29 May to SSGIEOM	a, b, c
Year 2018	13-15 February	ICES HQ, Denmark	Interim report by 1 March to SSGIEOM	d
Year 2018	6-8 August	Bremerhaven, Germany	Interim report by 1 September to SSGIEOM	e
Year 2019	TBD January	Town, Country	Interim report by 1 March to SSGIEOM	f
Year 2019	TBD September	Town, Country	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

4 Report on the international trawl-acoustic survey on pelagic redfish in the Irminger Sea and adjacent waters in June/july 2018

4.1 Cancellation of the Icelandic and German participation

In November 2017, the Marine and Freshwater Research Institute (MFRI) in Iceland informed the group that Iceland would not participate in the survey in June/July 2018. No specific reasons were given for the withdrawal. It is the implication of the group that the priority of the MFRI on pelagic redfish research is not high which could explain the withdrawal.

It is the view of the Group that the withdrawal of Iceland from the international redfish survey in the Irminger Sea and adjacent waters is very unfortunate. No alternatives that could be arranged for compensating the corresponding loss of survey coverage at the time being. Additionally, the German participation had to be cancelled due to technical problems in the dockyard.

For this reason, the scope of the survey had to be altered and the emphasis was on the detailed coverage of the pelagic redfish above and below 500 m depth in Subarea A. This means that the geographical distribution of pelagic redfish in the remaining area was not covered.

With only one vessel participating in the 2018 survey, the quality of the survey is seriously hampered and it will also undermine any scientific advice that ICES may provide to national and international management bodies.

4.2 Participants

Alexey Astakhov	Russia
Matthias Bernreuther	Germany
Eckhard Bethke (part-time)	Germany
Kristján Kristinsson (Chair,	
part-time by correspondence)	Iceland
Aleksei Rolskii	Russia

Detailed contact information of the participants is given in Annex 1.

The attendance and expertise in the Group was adequate for addressing the Terms of Reference, the cruise leader and specialists on biology and hydroacoustic were present.

4.3 Historical development of the survey in the Irminger Sea and adjacent waters

Several acoustic surveys have been conducted on pelagic redfish in the Irminger Sea and adjacent waters. This chapter describes the surveys that have been conducted in the area since 1991 and the main outcome.

During the period of commercial fishery in the area, which commenced in 1982, the former Soviet Union, and later Russia, carried out acoustic surveys annually until 1993. These surveys provided valuable information on the distribution and relative abundance of oceanic redfish and on the biology of the species as well as on the oceanographic conditions of the area surveyed (e.g. Shibanov et al., 1996b). The acoustic measurements were, however, not considered sufficient for stock assessment purposes (ICES, 1991).

In 1991, Iceland (6–26 June in the field) conducted a national survey on pelagic redfish with a very limited area coverage of 60 000 NM2 (Magnússon et al., 1992a).

In 1992, Iceland and Russia conducted a joint acoustic survey on oceanic redfish from 26 May-11 July in the field (Magnússon et al. 1992b). It became obvious from the surveys in 1992 that for an acoustic assessment, two vessels were hardly sufficient to cover the whole area of distribution within a reasonable time period (ICES, 1993).

In 1993, Russia conducted a survey from 7 June–8 July (Shibanov et al., 1994). Iceland carried out a short survey in September in the same year with no reliable stock size estimate, since the area coverage was limited (ICES, 1994a).

In 1994, Iceland and Norway carried out a survey with two vessels, covering the main distribution area of pelagic redfish down to 500 m depth (Magnússon et al., 1994). The vessels were in the field from 24 June-17 July. Approximately 190 000 NM2 were covered, resulting in a stock size estimate of about 2.2 million t or 3.5 billion individuals. Most of the fish was measured in the area east of Cape Farewell. In the report from the survey, the view of the ICES Study Group on Redfish Stocks (ICES, 1994) that the entire area of distribution could not be covered sufficiently by only two vessels was supported.

In 1995 (25 June - 30 July in the field), Russia carried out a single vessel survey for redfish, covering the main distribution area down to 500 m depth. The stock was estimated to be 2.5 million t and 4.1 billion individuals (Shibanov et al., 1996a). As the survey was only covered by one vessel, the NWWG meeting in 1996 (ICES, 1996), considered the results to be unreliable.

In 1996 (19 June – 22 July in the field), Iceland, Germany and Russia carried out the survey in June/July. Approximately 250 000 NM2 were covered. The acoustic assessment yielded a stock size of about 1.6 million t at depths down to 500 m (Magnússon et al., 1996). This estimate was considered to be an underestimation of the stock due to mixture of the redfish towards depths below 500 m. The oceanic redfish concentrations were densest between 200 and 300 m depth and mainly within a temperature range of 3.5°C to 5°C. Temperatures recorded during the survey were somewhat higher than observed in previous surveys.

In 1997 (21 June-21 July in the field), Russia carried out a single vessel survey in June/July, resulting in a stock estimate of 1.2 million t down to 500 m depth (Melnikov et al., 1998).

In 1999 (18 June-10 July in the field), an international acoustic survey on pelagic redfish was carried out in the Irminger Sea and adjacent waters, with participation of Iceland, Germany and Russia. The biomass of oceanic S. mentella at 0-500 m depth was 600 thousand t (Sigurðsson et al., 1999), a sharp decreased compared to previous surveys . The observed decrease in survey biomass compared with the years 1994–1996 exceeded the removed biomass by the fishing fleets. The stock above 500 m was observed to be more southwesterly and deeper than observed in previous acoustic surveys. A gradual increase in temperature in the observation area was observed. This was considered to have influenced the distribution pattern of the redfish, as the highest concentrations were found in the colder waters, i.e. southwestern part of the survey area.

During the surveys prior to the 1999 one, pelagic redfish was only measured by acoustics down to approximately 500 m depth. Attempts have been made to measure below that depth (see Section 2.2.3), but without success. The reason is mainly due to the deep scattering layer (DSL), which is a mixture of many vertebrate and invertebrate species (Magnússon, 1996) mixed with redfish and hampers acoustic registrations. Although several attempts have been made by Russia and Iceland to map the distribution of pelagic redfish at depths below 500 m (Shibanov et al., 1996a; ICES, 1998; Sigurðsson and Reynisson, 1998), the 1999 survey provided for the first time an estimate on the biomass of the pelagic S. mentella >500 m depth in the order of 500 000 t. This estimate was revised in 2014 where the biomass was estimated to be 935 000 t (ICES, 2014). Hydro-graphic observations indicated that the highest concentrations of redfish below 500 were associated with eddies and fronts.

In 2001 (19 June-14 July in the field), the trawl-acoustic survey was carried out by Germany, Iceland, Russia and Norway with five vessels in the field. Approximately 420 000 NM2 were covered. The stock size measured with acoustic instruments was assessed to be about 715 000 t at depths down to the DSL (about 350 m). Highest concentrations of redfish were found in the SW part of the covered survey area. In addition to the acoustic measurements, pelagic redfish within and below the deep scattering layer was estimated with a trawl method (see Section 2.2.3). A total biomass of approximately 1.3 million t was estimated to be at depths between 0 and 500 m and 1 million t deeper than 500 m depth. The densest concentrations of redfish deeper than 500 m were found in the NE part of the area.

Germany, Iceland and Russia participated in the international survey in May/June 2003 (28 May-30 June in the field). Approximately 405 000 NM2 were covered (ICES, 2003b). A total biomass of less than 100 000 t was estimated at depths between 0 and 500 m and about 700 000 t deeper than 500 m by the use of the trawl method. The red-fish biomass estimated acoustically down to the deep-scattering layer or about 350 m was the lowest ever obtained since the beginning of the joint measurements. The highest concentrations of redfish were found around 60°N, east of Cape Farewell. Deeper than 500 m, the densest concentrations were found in the NE part of the area. The results of the 2003 survey were regarded as inconsistent because the survey was con-ducted a month earlier than in previous years and thus did hardly indicate the actual stock status of pelagic redfish. To which extent seasonal effects contributed to this in-consistency, is unknown (see ICES, 2003b).

The international trawl-acoustic survey on pelagic redfish in June/July 2005 (18 June-18 July in the field) was carried out by Germany, Iceland and Russia (ICES, 2005). Nearly 400 000 NM2 were covered. A total biomass of 551 000 t was estimated at depths shal-lower than the DSL by hydroacoustic measurements, and about 674 000 t within and deeper than the DSL by the trawl method. In both depth layers, the highest concentra-tions of redfish were found in the western and southwestern part of the survey area. Although the estimates divided by depth layers were not comparable between years due to changes in the depth range covered in the deeper layer in the 2005 survey, the total estimates of the shallower and deeper layer combined can be compared between years. The total biomass estimate of 1.2 million t, encompassing the shallower and the deeper layer, represented a value within the range of the 1999 and 2001 estimates. Along with the trawl and acoustic measurements since 1992, hydrographic data had been obtained. The results indicated a relationship between the hydrography and dis-tribution of redfish in the survey area.

The international trawl-acoustic survey in June/July 2007 (23 June–24 July in the field) was carried out by Iceland and Russia (ICES, 2007b). The usual participation of Germany had to be cancelled due to short-term technical problems of their vessel. The German participant, however, compensated the Russian participant by funding additional days in the field, in order to ensure the complete survey area coverage. Nearly 350 000 NM2 were covered, with only slightly increased distances between hydroacoustic tracks and trawl hauls, compared to previous surveys. As relative survey indices, a total biomass of 372 000 t was estimated at depths shallower than the DSL by hydroacoustic measurements, and about 854 000 t within and deeper than the DSL by the trawl method (350-900 m). In the shallower layer, the highest concentrations of redfish were found southeast of Cape Farewell and in the southwestern survey area. In the deeper layer, high concentrations were also found southeast of Greenland, but as well in the northeastern survey area. As in 2005 the estimates divided by depth layers are not comparable between years due to changes in the depth range covered in the deeper layer, the total estimates of the shallower and deeper layer combined can be compared between years. The total relative biomass value of 1.2 million t derived in 2005 and 2007, encompassing the shallower and the deeper layer, represents a value within the range of the 1999 and 2001 estimates.

The international trawl-acoustic survey in June/July 2009 (11 June – 19 July in the field) was carried out by Iceland and Germany (ICES, 2009cb). The usual participation of Russia was cancelled. About 360 000 NM2 were covered, with increased distances between hydroacoustic tracks and trawl hauls, compared to previous surveys. As relative survey indices, a total biomass of 108 000 t was estimated at depths shallower than the DSL by hydroacoustic measurements, the lowest in the time-series (excluding the 2003 estimate). About 278 000 t were estimated within the DSL shallower than 500 m by a trawl method and 458 000 t deeper than 500 m by the trawl method. In the shallower layer (both acoustic and trawl method), the highest concentrations of redfish were found southeast of Cape Farewell. In the layer deeper than 500 m, highest concentrations were found in the northeastern survey area and southeast of Cape Farewell. The total relative biomass value of 845 000 t derived in 2009 (to make the 2005 and 2007 estimates comparable with other years), encompassing the shallower and the deeper layer, was the lowest value recorded excluding the 2003 estimate.

The international trawl-acoustic survey in June/July 2011 (6 June – 18 July in the field) was carried out by Iceland, Germany and Russia (ICES, 2011a). About 343 000 NM2 were covered. As relative survey indices, a total biomass of 123 000 t was estimated at depths shallower than the DSL by hydroacoustic measurements, about 309 000 t within the DSL shallower than 500 m by a trawl method, and 475 000 t deeper than 500 m by the trawl method. In the shallower layer (both acoustic and trawl method), the highest concentrations of redfish were found southeast and south of Cape Farewell. In the layer deeper than 500 m, highest concentrations were found in the northeastern survey area. The total relative biomass value of 907,000 t was 62,000 t higher than in 2009.

The international trawl-acoustic survey in June/July 2013 was carried out by Iceland, Germany and Russia (ICES, 2013). About 340 000 NM2 were covered. As relative survey indices, a total biomass of 91 000 t was estimated at depths shallower than the DSL by hydroacoustic measurements, about 201 000 t within the DSL shallower than 500 m by a trawl method, and 280 000 t deeper than 500 m by the trawl method. In the shallower layer (both acoustic and trawl method), the highest concentrations of redfish were found southeast and south of Cape Farewell. In the layer deeper than 500 m, highest concentrations were found in the northeastern survey area.

The international trawl-acoustic survey in June/July 2015 was carried out by Iceland and Germany (ICES, 2015a). The usual participation of Russia was cancelled. About 200 000 NM2 were covered, covering the main distribution area of the deep pelagic stock found deeper than 500 m. As relative survey indices, a total biomass of 196 000 t was estimated deeper than 500 m by the trawl method. This is about 80 000 t less than recorded in 2013. Although much less area was covered in 2015 compared to previous year the biomass estimation is considered to be adequate, but is likely to be underestimated by 5–10%. The highest concentrations of redfish were found in the northeast survey area as observed in previous surveys. No biomass estimates of redfish were derived at depths shallower than the DSL by hydroacoustic measurements or within the DSL shallower than 500 m by a trawl method. The reason is that the geographical distribution were omitted. Furthermore, 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.

4.4 Material and methods

The planning of the survey was done during the WGIDEEPS planning meeting in Copenhagen, Denmark, from 13-15 February 2018 (ICES, 2018a) according to the sampling methodology SISP (ICES 2015).

Since Iceland cancelled its participation the area coverage and planned cruise tracks were changed. It was decided by Germany and Russia to survey the shallow and deep pelagic redfish (mainly in the northeast and southeast areas) and leave out important areas where the shallow pelagic stock is found (mainly south and southwest of Cape Farwell, Greenland). The geographical area covered was therefore smaller than in the surveys 1999–2013. However, since Germany was forced to cancel its participation due to technical problems with its research vessel, the spatial coverage was altered again. It was decided that the Russian vessel should conduct a detailed coverage of the pelagic redfish above and below 500 m depth in subarea A. To reach a better coverage of the redfish concentrations, the distances between transects were decreased from 45 NM to 30 NM and partly 20 NM (Figure 1) in areas with expected dense concentrations of redfish. Additionally, the amount of trawls was increased up to 4 trawls (2 of Type 2 and 2 of Type T3) in 90% of the statistical rectangles, resulting in 108 trawls and totally 121 trawls including Type 1 tows.

4.4.1 Vessels, timing and survey area

Table 1 describes the extent, coverage and the trawl specification of the survey. The Russian survey was carried out by the Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO) and the Atlantic Research Institute of Marine Fisheries and Oceanography (AtlantNIRO), with the RV "Atlantida" from 5 June–27 July with 35 days in the field. The vessel covered an area of approximately 103 000 NM2 within the boundaries of about 60°N to 65°N and 26°W to 42°W, on transects 20–30 NM apart (Figure 1). The planned transects (ICES, 2018a) were altered and rescheduled prior to the survey, mainly due to cancellation of Germany. Areas B-F (Figure 2) were not surveyed.

4.4.2 Acoustic assessment

A 38 kHz Simrad EK60 split-beam echosounder was used for the acoustic data collection on RV "Atlantida". Prior to the survey, the acoustic equipment was calibrated with the standard sphere method (Foote et al., 1987) according to SISP manual (ICES, 2015b). The settings of the acoustic equipment used during the survey are given in Table 2. During the survey on board RV "Atlantida" the post-processing system (FAMAS) was used for scrutinising the echograms. Mean integration values of redfish per 5 NM were used for the calculations.

Earlier investigations (Magnússon et al., 1994; Magnússon et al., 1996; Reynisson and Sigurðsson, 1996) have shown that the acoustic values obtained from oceanic redfish exhibit a clear diurnal variation, due to a different degree of mixing with smaller scatter. In order to compensate for these effects to some degree, the acoustic data obtained during periods of the most pronounced mixing, i.e. during the darkest hours of the night, were discarded and to estimate the values within the missing sections by interpolation.

In further data processing, the number of fish was calculated for statistical rectangles, the size of which was 1 degree in latitude and 2 degrees in longitude. A length based target strength (TS) model was used for all length groups for the estimation of the number of pelagic redfish in the survey area: TS = 20 × lg(L) -71.3 dB.

The total number of fish within Subarea A (Figure 2) was then obtained by summation of the individual rectangles. The acoustic results were further divided into the number of individuals and biomass based on the biological samples representative for Subarea A.

For the entire survey area, single-fish echoes from redfish were expected to be detectable down to 350 m. In order to include all echoes of interest, a low integration threshold was chosen. As shown in Table 2, the integration threshold was set at -80 dB/m3 for echo integration. Based on the depth distribution of redfish observed during the survey and the expected target strength distribution, the method outlined by Reynisson (1996) was used to estimate the expected bias due to thresholding. The results of the biomass calculations were adjusted accordingly.

4.4.2.1 Noise measurements

The measurements of echosounders can be disturbed by noise and reverberation. Reverberation consists of echoes reflected from unwanted targets and cannot be avoided. For noise, we distinguish between ambient noise (rain, wind-induced noise, thermal noise) and vessel noise (propeller noise, turbulent flow noise). Ambient noise cannot be avoided, whereas vessel noise can be minimized by constructive measures. The results of the measurements show that the Russian RV “Atlantida”, optimized for acoustic measurements, can detect redfish echoes down to 1000 m under good weather condition.

Whereas noise is always present and influences the echo integration results, echoes of redfish are much more seldom. Therefore, already very small noise can prevent the measurements. For the improvement of the signal to noise ratio, a threshold is usually applied. The amplitude of the signal decreases with depth whereas the amplitude of noise increases due to time varied gain. Accurate results can only be obtained by applying a threshold adapted to the analysed depth range. Even if redfish are still visible on the echogram, an accurate measurement may be not possible. The applied threshold preventing the influence of noise is optimized for a depth of 250 m (Bethke, 2004).

4.4.3 Abundance estimation by the trawl method

As in the surveys in 1999–2015, a trawl method was used to calculate abundance of redfish within and deeper than DSL where it cannot be acoustically identified. The method is based on a combination of standardized survey catches and the acoustic data, where the correlation between catch and acoustic values during trawling in the shallower layer is used to obtain acoustic values for the deeper layer, based on catches in the deeper layer. To be able to make the calculations, hauls were carried out at different depth intervals, evenly distributed over the survey area.

The sampling was carried out as follows (ICES, 2015):

a) Type 1 tow: Trawling takes place at depths shallower than the DSL where and when redfish has been acoustically identified. Trawling distance is 4 NM calculated with GPS;

b) Type 2 tow: Trawling takes place at depths shallower than 500 m and within the DSL. The trawling distance is 4 NM, calculated with GPS. The haul is divided into two parts of equal distance of 2 NM each. First, the headrope is at the top of the DSL and the second stage is at depth of 450 m.

c) Type 3 tow: Trawling takes place at depths deeper than 500 m depth. The deep identification hauls should cover the following 3 depth layers (headline): 550 m, 700 m, and 850 m. The total trawling distance is 6 NM calculated with GPS and the trawling distance at each depth layer is 2 nautical miles.

The towing speed of all trawls was 3.0–3.5 knots.

The net used on RV "Atlantida" was a Russian pelagic trawl (design 78,7/416), with a passport opening/width of 50 m but actual mean value of 58 m was measured by the trawl acoustic sounder (Table 1). More wider opening and width were due to exploitation onboard of RV "Atlantida" of more heavy weights (sinkers) on the bridles and setting for trawl doors. Actual value of opening has been used in biomass estimates particularly during determination of values K and K_H (see below) whereas methods take into account possible deviation of trawl opening. The stretched mesh size in the codend was 16 mm.

During the survey, RV "Atlantida" employed a total of 13 Type 1 trawl hauls on redfish above the DSL which were acoustically identified, 52 Type 2 trawl hauls in the depth range from the top of the DSL down to 500 m and 56 Type 3 trawls hauls in the depth range from 550–900 m, which were relatively evenly distributed over the survey area (Figure 1). The catches were standardized by 1 NM and converted into acoustic values using a linear regression model between catches and acoustic values at depths shallower than the DSL.

A linear regression model between the acoustic values and catches (in kg/NM) of Type 1 trawls (shallower than the DSL) was applied to predict the acoustic values for each Type 2 and Type 3 trawls (Figure 7). Acoustic values for the Type 1 trawls were obtained from exactly the same position and depth range covered by the trawl.

Because few Type 1 trawls were taken in 2018 (13 for RV "Atlantida", Table 1), the Type 1 trawls from the surveys in 2007, 2011, 2013 and 2018 were used in the regression analysis. The result of the geometric mean linear regression between the acoustic values and the catches recorded shallower than the DSL is given in Figure 7.

The linear regression model for the Type 1 trawls is:

$$s_{A_{tr}}=\beta_0+\beta_1 C$$

where $s_{A_{tr}}$ is the surface density of fish distribution in the Type 1 trawl, C is the catch (kg/NM) and β_0 and β_1 are the intercept and slope respectively. To ensure that zero catch of the Type 2 and Type 3 trawls will be with zero s_A value, the intercept of 0 is forced ($\beta_0 = 0$) which gives:

$$s_{A_{tr}}=\beta_1 C$$

Estimation of redfish distribution by the trawl method for Type 2 and Type 3 trawls is done by conversion of catches (catch in kg per NM) to equivalent acoustic estimates by predicting the s_A values using the obtained correlation for each vessel:

$$\widehat{s_{A_T}} = \beta_1 * C_T$$

where C_T is the catch of either Type 2 or Type 3 trawls in kg/NM and β_1 is the coefficient from the regression.

The obtained s_A values were then adjusted for the vertical coverage of the trawls and the depth range of each haul ($\Delta D/H_{tr}$ where ΔD is the difference between maximum and minimum depth of each haul and H_{tr} is the vertical opening during each tow). The s_A value for each trawl is:

$$s_{A_T} = C * K * K_H$$

where C is the catch in kg per NM of each Type 2 and Type 3 trawls, K is the coefficient of the trawl obtained from the linear regression and K_H is the width of the depth range towed defined as:

$$K_H = (H_{MAX} - H_{MIN} + \mathrm{d}H_T)/\mathrm{d}H_T$$

where H_{MAX} and H_{MIN} are the maximum and minimum depths of the headline of a trawl type during a tow and $\mathrm{d}H_T$ is the mean vertical opening of the trawl. For all trawls $\mathrm{d}H_T$ is 50 m. For Type 3 hauls H_{MIN} was 550 m and H_{MAX} was 850 m. For Type 2 H_{MAX} trawls is either 400 or 450 m but H_{MIN} varies and depends on the minimum depth of the DSL layer.

Based on the linear regressions, confidence limits for the estimates were also calculated.

After having calculated the s_A values from the catches of each haul, the estimation of the abundance and biomass was calculated using the same target strength equation for redfish (20log (L) – 71.3) and the same algorithm as used for the acoustic estimation. The area coverage was considered to be the same as for the acoustic results and applied to all subareas.

4.4.4 Biological sampling of redfish

Standard biological observations of redfish needed for the acoustic assessment were carried out (ICES, 2015b). In addition, otoliths were collected, and stomach fullness as well as parasite infestation were recorded according to an approved method (Bakay and Karasev, 2001). A summary of biological sampling in 2018 is given in Table 3. A total of 4 323 S. mentella was caught. Otoliths were collected from 545 individuals (13%) and individual length (3 887), weight, sex, maturity and parasites recorded. Samples from 1918 specimens were taken for subsequent genetic analyses.

4.4.5 Species composition in the trawls

The total catch was split into species or appropriate taxonomic group. Catch weight and number of all species was recorded for each haul. The weight of jelly fish was recorded. Shrimps were reported in one group, but krill were reported in a separate category.

4.4.6 Hydrographic measurements

Temperature and salinity measurements were made with CTD probes at the corners of each transects and at each trawl station down to 1000 m depth (Figure 1). The hydrographic data at depths of 0, 10, 20, 30, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 m from each CTD station were used in the data analysis.

4.5 Results

Only Subarea A was surveyed in 2018 and hence covered only part of the pelagic redfish distribution area in the Irminger Sea and adjacent waters.

The estimated biomass above the DSL (in the acoustic layer) in 2018 was 82 000 t which is approximately 9 times higher compared to the last biomass estimation in 2013 and similar as it was in 2007 (Table 5). The highest concentration of redfish was observed in the southwestern part of Subarea A (Figures 3 and 4).

The average depth of the DSL is shown in Figure 8. The depth of the layer in which redfish can be detected is, on average, around 170 m during the night-time but increases to its maximum approximately 320 m around noon. As a consequence, the redfish is hard to detect and measure below those depths.

4.5.1 Abundance estimation by the trawl method

Figure 5 shows the redfish distribution within the DSL above 500 m, based on the regression between the catches and the measured s_A values in the layer shallower than the DSL. The circles indicate converted units of s_A. The highest values (s_A up to 30 m^2/NM^2) were observed in the northeast area of Subarea A, between latitudes 60°N and 61°30′N.

Figure 6 shows the redfish distribution at depths from 550 m to 900 m. The highest values (s_A up to 7 m^2/NM^2) were observed at latitude of between 61°N and 63°N in the northeast area.

The abundance estimation by subareas is given in Tables 5 and 7 for within the DSL and shallower than 500 m and deeper than 500 m, respectively, and disaggregated by length groups in Tables 12b and 12c.

The estimated biomass of redfish within the DSL and shallower than 500 m is 171 000 t and is the highest biomass estimation since the beginning of the time-series (Table 7).

The assessment of the redfish distributed below 500 m constituted 130 000 t (0.21 billion individuals; Table 8).

For comparison, the results of the surveys 1999–2015 are given in Table 9. The depth coverage of the deep trawls was changed to 350–950 m in 2005 (ICES, 2005a) and again in 2009 to 550–900. The survey estimates are therefore not strictly comparable between years, but attempt was made in 2014 to get estimates for the stock below 500 m for 2005 and 2007 (ICES, 2014). The estimates for 1999 and 2013 were also revised in 2014 (ICES, 2014).

The results show that biomass of the redfish distributed below 500 m in Subarea A decreased by approximately 15% in 2018 compared to 2015 and is the lowest since the commence of the survey in 1999 (Table 9).

4.5.2 Biological data

4.5.2.1 Sex composition, length and weight

At depths shallower than 500 m, the percentage of males (53.4%) exceeded that of the females (46.6%). The proportion of females increased compared to 2013 and 2015 and was the highest in the time-series (Table 10). In the layer deeper than 500 m, the sex ratio was different, compared to that of the shallow layer (62.6% males, 37.4% females), and the proportion of females increased compared to 2015.

Fish total length in the catches ranged from 27 to 45 cm. The mean length of redfish in the shallower layer was 33.2 cm, 1.7 cm smaller than in 2015, and the mean individual weight was 468 g compared to 529 g in 2015 (Table 11a). In the deeper layer, the mean length was 36.1 ,which was 2.4 cm smaller than in 2015, and the mean weight was with 613 g, 59 g lighter compared to 672 g in 2015 (Table 11b).

The length frequencies from the trawl stations are illustrated in Figures 9 and 10 and length-disaggregated abundance data are given Tables 12a, 12b and 12c. Compared with the previous years, the peaks of the length distributions above and below 500 m show smaller sizes. In depths shallower than 500 m (Figure 9), the peak n in the north-eastern area is around 33 cm, whereas the peak in depths deeper than 500 m is around 35/36 cm.

4.5.2.2 Feeding

An overview on the stomach fullness is given in Table 13. In both the shallower and deeper layer, the majority of the redfish stomachs (76% shallow layer, 74% deep layer) were everted. In total 15% of the investigated redfish from the shallower layer and 9% in the deeper layer had food items in their stomachs. The most important prey items (frequency of occurrence, %, a percent of stomachs with the prey from the total number of stomachs with food) of redfish were copepods (21%), amphipods (19%), euphausiids (16%), cephalopods (12%) and mesopelagic fish (7%).

4.5.2.3 Parasite infestation

Table 14 contains the results of the analysis of the infestation of the beaked redfish S. mentella by parasitic copepod Sphyrion lumpi. As in previous years, the infestation by copepod S. lumpi was higher in females than in males of S. mentella throughout the whole survey area and at all depths. Above 500 m 38.7% of the females were infested with S. lumpi or were carrying remnants, while the percentage in males was 27.6. Below 500 m the difference in the values of infestation between females and males were 36.2% and 31.4%, respectively. The highest abundance index (No. S. lumpi and/or remnants / No. fish examined) was observed in females above 500 m with 0.8. The index was equal to 0.5-0.6 for females and males below 500 m.

4.5.2.4 Maturity

The great majority of the males were identified as maturing (86%), whereas most of the females were in the post-spawning stage (69%), as expected from earlier investigations. The percentage of immature fish, observed in the samples, were 6% for males and 3% for females.

4.5.3 Species composition

S. mentella was found in 93% of all trawl samples. Other species were mainly small non-commercial species belonging to the mesopelagic fauna, mainly myctophids. Numerous species were commonly observed throughout the sampling area i.e. Bathylagus euryops (frequency of occurrence, FO = 75%), Serrivomer lanceolatoides (FO = 89%), Stomias boa ferox, Chauliodus sloani (FO = 93%) and the myctophids Lampanyctus macdon-aldi (FO = 85%) and Notoscopelus kroeyeri (FO = 98%). The FOs of the most frequent spe-cies were estimated for all trawls with no differentiation between the trawl types (Table 15).

4.5.4 Hydrography

During the survey 72 oceanographic stations, including observations in the long term hydrographical Russian 3K section, were carried out. Oceanographic investigations were conducted in the area between 60° 25'N and 64° 35'N and from the Reykjanes Ridge to Greenland. Temperature data from a similar survey in 2013 were also used for the analysis. The results are shown in Figures 11-16.

Temperature in the surface layer varied from 6.9 °C in the northeast to 9.7°C in the east and south (Figure 11). Negative temperature anomalies (0.5-1.0 °C) in the surface layer were observed in the central part of the surveyed area. Local areas with positive anomalies of up to 1.0-2.0°C were found in the southwest and 1.0-1.5°C above the Reykjanes Ridge (Figure 12). Negative temperature anomalies (0.2-0.8°C) were observed almost over the entire area and of up to -1.0-1.3°C in the central part compared to 2013 (Figure 13).

At 200 m and 400 m, the temperature ranged from 3.7°C to 4.0°C above Irminger basin and was 7.3°C - 7.6°C in the eastern part of the Reykjanes Ridge. In the central part temperature was lower by 0.1-0.4°C, in the west and east exceed the normal up to 0.5-0.9°C (Figures 11, 12). The temperature at depths 200 m and 400 m decreased by 0.3-0.9°C compared to 2013. (Figure 13). The temperature at 600 m was slightly lower than in 2013 by 0.2-0.5°C (Figures 11 - 13).

The data from the section 3K suggested that there was a decrease in temperature compared to 2013. The highest negative temperature anomalies were observed in upper 500 m layer, excluding surface layer. The average temperature for the whole layers along the entire section was slightly below the normal by 0.1-1.0°C. The largest negative anomalies were registered in the surface layer (Figures 14-16).

Similar temperature conditions in the Irminger Current (stations 7-9) were observed for the 0, 0-50, 0-200 m layers in 1999 and 2013, 50-200, 200-500, 0-500, 500-1000, 0-1000 m in 2011 and 1999.

4.6 Discussion

4.6.1 Acoustic assessment

The survey covered 103 000 NM^2, which is much less than in previous years where around 340 000 NM^2 were covered. The reason for less area coverage in 2018 was the withdrawal of Iceland from the survey in November 2017 and the cancellation of Germany due to technical problems in June 2018. It was not possible to cover the distribution area of pelagic redfish in the Irminger Sea and adjacent waters with only one vessel in the scheduled time interval. Therefore, it was decided to conduct a detailed coverage of the pelagic redfish above and below 500 m depth in Subarea A.

The present results show that in Subarea A, the highest concentration of redfish was observed in the southwestern part of the subarea. The estimated biomass above the DSL in 2018 with 82 000 t was approximately 9 times higher compared to the last biomass estimation in 2013 and similar to what was estimated in 2007. The reason for this significant increase may be due to incoming recruitment of juvenile fish. Additionally, observed decreasing trend in water temperature in the upper layers of the Irminger Sea compared with 2013, might also affect the distribution of redfish concentrations above 500 m (i.e. northeastward displacement) (Nunez-Riboni et al. 2013).

4.6.2 Abundance estimation by the trawl method

During Russian trawl-acoustic surveys in 1995 and 1997, attempts were made to assess the redfish deeper than 500 m by acoustic methods. According to an expert estimation in 1995, the stock constituted nearly 900 000 t (Shibanov et al., 1996a), and in 1997, it was estimated to be 500 000 t (Melnikov et al., 1998). In the joint survey in 1999, an attempt was made to estimate the abundance deeper than 500 m based on a similar method as presented here.

Table 9 shows the total biomass estimates from the biennial surveys in 1999-2015 and biomass for Subarea A in 2018. Note that the biomass estimates for 1999 and 2013 were revised in 2014 (ICES, 2014). Furthermore, attempts were made to estimate the total biomass of redfish below 500 m from the 2005 and 2007 surveys (ICES, 2014). As described in Section 2.1 the trawling was conducted differently in 2005 and 2007 than in 2001–2003 and 2009-2015. The difference is that in the 2005 and 2007 the trawling was from 350–950 m in a single tow. In the other surveys the trawling was in two separate tows, i.e. one tow from 350-500 m and one tow from 550 m down to 950 m. This means that in 2005 and 2007 both pelagic stocks were sampled simultaneously. The biomass estimates for 2005 and 2007 shown in Table 8 are based on the outcome of these recalculations (ICES, 2014).

Since we were only able to cover Subarea A, the biomass in previous years are not comparable to the estimation of the redfish biomass in 2018. The estimated biomass above 500 m and within the DSL with 171 000 t was the highest since 2001 (Table 7). The estimated biomass below 500 m with 130 000 t was the lowest in the time-series for Subarea A (Table 9). The reason for the biomass increase of the redfish above 500 m may be due to incoming recruitment of juvenile fish into the adult stock in the Irminger Sea.

4.6.3 Biology

Due to the difference in depth layers observed, compared to 2005 and 2007 when the layers were 'shallower than' and 'within and deeper than the DSL', the length distribution data are not comparable to some of the previous surveys. The differences in mean length between the layers <500 m and >500 m in all areas, however, display the pattern observed in the commercial fisheries and in surveys prior to 2005, especially in the northeastern area. The relatively high amount of redfish of 33–37 cm length (peak at 35 cm) in the shallow layer of the NE and SE areas have been observed in the survey 2009 and 2011 and coincide with recently observed large numbers of demersal S. mentella on the East Greenland shelf (ICES, 2011b) that are probably partly migrating eastwards into the pelagic waters at that size. In 2018, we observed a marked decrease in the average total length in both S. mentella below and above 500 m. Despite no indication of young juvenile redfish on the Greenlandic or Icelandic shelf in the last 5 – 10 years (ICES, 2018b) this may give an indication of recruitment of juvenile fish into the adult populations in the Irminger Sea.

As in previous years, the majority of the fish caught had everted stomachs, and only few stomach content data could be collected, thus the feeding condition and food composition could not be fully evaluated. From the observations made so far, redfish are opportunistic feeders that graze within the DSL (Magnússon, 1996) and feed on invertebrate species and small fish in the layers shallower and deeper than the DSL.

The obtained results show year-to-year value stability for parameters of S. mentella infestation by copepod S. lumpi. Some differences in redfish infestation between depths were observed. These differences in occurrence of the above characteristics in S. mentella between specific areas may be associated with the peculiarities of size structure and sex composition of the catch and the ecology of the mesopelagic parasite S. lumpi (Bo-govski and Bakay, 1989; Bakay and Melnikov, 2002, 2008).

4.6.4 Hydrography

Analysis of oceanographic situation during the survey and long-term data allows following conclusions:

Strong, positive anomalies of temperature observed in the upper layer of the Irminger Sea with a maximum in 1998 are related to an overall warming of water Irminger Sea and adjacent areas in 1994-2003. These changes were also observed in the Irminger Current above the Reykjanes Ridge (Pedchenko, 2000), off Iceland (Malmberg et al., 2001) and in the Labrador Sea water (Mortensen and Valdimarsson, 1999). Thus an increase in temperature and salinity has been found in the Irminger Current since 1997 to higher values than for decades, as well as a withdrawal of the Labrador Sea water due to a slow-down of its formation by winter convection since the extreme year 1988 (ICES, 2001).

The results of the survey in 2003 were confirmed by the presented high water temperature anomalies of the 0-200 m layer in the Irminger Sea and adjacent waters. In 200-500 m depth and deeper, positive anomalies in most parts of the observation area were observed, but increasing temperature as compared to the survey in June-July 2001 was obtained only north of 60° N in the flow of the Irminger Current above the Reykjanes Ridge and the northwestern part of the Irminger Sea.

In June/July 2005, the temperature of the water in the shallower layer (0-500 m) of the Irminger Sea was higher than normal (ICES, 2005b). As in the surveys 1999-2003, the redfish were aggregating in the southwestern part of the survey area, partly influenced by these hydrographic conditions. In connection with the continuation of positive anomalies of temperature in the survey area, the redfish concentrations were distributed mainly in depths of 450-800 m, within and deeper than the DSL. Favourable conditions for aggregation of redfish in an acoustic layer have been marked only in the southwestern part of the survey area with temperatures between 3.6-4.5°C.

In June/July 2007, again a higher temperature in the shallower layer was observed, as seen since 1996.

Hydrography surveys of June/July 2011 show that the increased temperature background is still in place in the survey area on the level specific for warm and moderately warm years. However as compared to the 2007 and 2009 surveys the heat capacity reduction trend is observed.

Hydrography results of the 2013 survey show that the increased temperature situation in previous years was still persisting in upper 600 m depth layer of the survey area indicating warm and moderately warm years. However, compared to the 2011 survey the temperature decreased by 0.3-0.7°C in most of the survey area, with exception of the Irminger current's waters where the temperature increased up to 0.2-0.4°C.

Decreasing trend of water temperature by 0.3-0.9°C compared to 2013 at depths 200 m and 400 m and increasing volumes of Labrador Sea Water (LSW) to Irminger basin were observed during the survey 2018. The temperature at 600 m was slightly lower than in 2013 by 0.2-0.5°C.

Decreasing water temperature since 2009 may affect spatial distribution of major concentrations of the beaked redfish both in horizontal and vertical planes (Pedchenko, 2005). The abundance and distribution of pelagic S. mentella in relation to oceanograph-ic conditions were analysed in a special multistage workshop (WKREDOCE1-3). It was established that the spatial distribution of S. mentella in the Irminger Sea mainly in waters < 500 m appears to be influenced by the Irminger Current Water (ICW) tempera-ture changes, linked to the Subpolar Gyre (SPG) circulation and the North Atlantic Oscillation (NAO). The fish avoid increasing volumes of ICW (>4.5ºC and >34.94) in the northeastern Irminger Sea due to an intensification of the SPG by displacing towards the southwest, to more fresher, colder waters. A weakening of the SPG has the opposite effect (ICES, 2012).

5 Future of the survey and participation

During the February meeting in Tromsø, Norway in 2015, the participant from Iceland informed the group the decision that Marine Research Institute in Iceland will from now on only participate in the survey conducted in the Irminger Sea every third year, and not biennially as has been the practise since 1999. This adjustment was followed by the notification of the Marine and Freshwater Research Institute (MFRI) in Iceland in November 2017 that Iceland will not participate in the survey in June/July 2018. No specific reasons were given for the withdrawal.

The objective of the group is to provide sound, credible, timely, peer-reviewed, and integrated scientific advice on fishery management. The surveys are primary basis for the advice on the stock status of pelagic redfish in the areas. The Group is particularly con-cerned with the decreased data quality and higher uncertainty in the derived data series and consequently the advice on the stock status. Regardless of these concerns, both Germany and Russia will continue their participation in the International Deep Pelagic Ecosystem Survey in the Irminger Sea. Unfortunately, Germany had to cancel its participation in this year's survey due to technical problems. Despite the fact that only one vessel was conducting the IDEEP survey, and therefore only the northeastern area was covered, the results are promising. The results may indicate an incoming recruitment of juvenile fish into the adult stocks in the Irminger Sea.

In the light of this result, the Group confirms its 2005 recommendations (ICES, 2005a: 2005b) that the survey should be continued, that it should be carried out with as many vessels as possible to improve the quality of the derived estimates, and that the timing of the survey should be kept in June/July.

On three of the last five surveys (2007, 2009 and 2015), the redfish distribution area was only covered with a relatively low density of hydroacoustic tracks and trawl hauls by two vessels, due to the cancellation of the German part in 2007 and the Russian part in 2009 and 2015. The coverage of the distribution area in 2018 was even lower due to the cancellation of the German participation. The Group would like to express its severe worries about the insufficient survey participation of ICES countries involved in the pelagic redfish fisheries in the Irminger Sea and adjacent waters. 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.

6 Acknowledgements

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7 Recommendations

Recommendation	Action
Continue international trawl-acoustic survey on pelagic redfish in the Irminger Sea and adjacent waters; keep survey frequency at every third year; participation of as many vessels as possible; keep timing of the survey (June/July)	ICES Secretariat
Involve more countries in the Irminger and Norwegian Seas surveys	ICES Secretariat
Secure appropriate funding to support the WGIDEEPS in the Norwegian and Irminger Seas	NEAFC Coastal States
To transfer survey data from 1999 to 2018 to ICES DATRAS	ICES DATRAS

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9 Tables

Table 1. Extent, coverage and trawl specification of the international redfish survey in the Irminger Sea and adjacent waters in June/July 2018.

Country	**Russia**
Vessel	RV Atlantida
Call sign/ICES country code	UALU / 90
Days in field	35
Type of trawl	Russian pelagic trawl (design 78,7/416)
Number of hauls	13 T1; 52 T2; 56 T3 = 121
Opening / Width	58 m / 58 m
Codend	16 mm codend
Distance for acoustic registrations	4,025 NM
Area surveyed	103,075 NM^2
Number of CTD casts	72

Table 2. Instrument settings of the acoustic equipment on board the participating vessel. The sound speed value is approximate for the prevailing hydrographic condition in the survey area.

Vessel	**Atlantida**	
Echosounder	Simrad EK60	
Integrator	FAMAS	
Frequency	38 kHz	
Transmission power	2000 W	
Absorption coefficient	8.05 dB/km	
Pulse length	1.0 ms	2.0 ms
Bandwidth	2.43 kHz	1.45 kHz
Transducer type	ES38-B	ES38-B
Two-way beam angle	-20.7	-20.7
Integration Threshold	-80 dB/m3	-80 dB/m3
Sound speed	1470 m/s	1470 m/s
Transducer Gain	26.57 dB	26.48 dB
s_A correction	-0.61 dB	-0.40 dB

Table 3. Summary of biological sampling in the international redfish survey in the Irminger Sea and adjacent waters in June/July 2018.

Country	**Russia**
Total number / biomass of redfish caught	4 323 ind. / 2 157 kg
Number of length measurements	3887
Number of pairs of otoliths collected	545

Number of feeding analysis	3887
Number of parasites analysis	3887
Individuals with genetics	1918

Table 4. Results of the acoustic abundance and biomass computation and area coverage for redfish shallower than the DSL in June/July 2018. Areas B-F (see Figure 2) were not surveyed.

Sub-area	A	Total
Area (NM^2)	103,075	103,075
No. fish ('000)	178,279	178,279
Biomass (t)	81,624	81,624

Table 5. Results (biomass in ´000 t) for the international surveys conducted 1994–2018, for redfish shallower than the DSL for each subarea and total. No estimate was available in 2015 and in 2018 only subarea A was covered.

	Subarea						
Year	A	B	C	D	E	F	Total
1994	673	1228	-	63	226		2190
1996	639	749	-	33	155		1576
1999	72	317	16	42	167		614
2001	88	220	30	267	103	7	716
2003	32	46	1	2	10	0	89
2005	121	123	0	87	204	17	551
2007	80	95	0	53	142	3	372
2009	39	48	4	1	15	1	108
2011	5	74	0	3	40	1	123
2013	9	33	2	5	42	0	91
2015	-	-	-	-	-	-	-
2018	82	-	-	-	-	-	82

Table 6. Results from estimation of redfish within the DSL and shallower than 500 m in June/July 2018. Areas B-F (see Figure 2) were not surveyed.

	A	Total
Area (NM^2)	103,075	103,075
Mean length (cm)	33.2	33.2
Mean weight (g)	468	468
No. fish ('000)	354,796	354,796
Biomass (t)	**170,987**	**170,987**

Table 7. Results (biomass in ´000 t) for the international surveys conducted since 2001, 2009, 2011, 2013, 2015 and 2018 for redfish within the DSL layer and shallower than 500 m for each subarea and the total. Areas C-F were not surveyed in 2015. Areas B-F (see Figure 2) were not surveyed in 2018.

	Subarea						
Year	A	B	C	D	E	F	Total
2001	23	40	45	399	54	5	565
2009	136	68	0	25	48	0	278
2011	69	185	1	30	76	0	309
2013	71	94	0	9	26	1	201
2015	31	38					69
2018	171						171

Table 8. Results from trawl estimation of redfish deeper than 500 m in June/July 2018. Areas B-F (see Figure 2) were not surveyed.

	A	Total
Area (NM^2)	103,075	103,075
Mean length (cm)	36.1	36.1
Mean weight (g)	613	613
No. fish ('000)	212,841	212,841
Biomass (t)	**130,221**	**130,221**

Table 9. Results (biomass in ´000 t) for the international surveys conducted since 1999, for redfish deeper than 500 m (1999–2003 and 2009–20189), deeper than 350 m (2005 and 2007) for each subarea, and total, and the depth range covered. (+) Estimates for 1999 and 2013 were revised in 2014 (ICES, 2014). (*) Attempts were made to estimate biomass below 500 m for the surveys conducted in 2005 and 2007 (ICES, 2014). Areas C-F were not surveyed in 2015. Areas B-F (see Figure 2) were not surveyed in 2018.

	Subarea							
Year	A	B	C	D	E	F	Total	Depth (m)
1999+	277	568	12	27	52	0	935	500–950
2001	497	316	28	79	64	18	1001	500–950
2003	476	142	20	13	27	0	678	500–950
2005*	221	95	0	8	65	3	392	(350–950)
2007*	276	166	1	5	92	11	522	(350–950)
2009	291	121	0	8	37	1	458	550-900
2011	342	112	0	1	18	0	474	550–900
2013	193	75	0	2	10	0	280	550-900
2015	153	43					196	550-900
2018	130						130	550-900

Table 10. Sex ratio of redfish above and below 500 m from the international redfish surveys 1999–2018.

	<500m		>500 m	
Year	Males	Females	Males	Females
1999	61.8	38.2	59.7	40.3
2001	64.8	35.2	59.5	40.5
2003	63.1	36.9	61.7	38.3
2005	64.9	35.1		
2007	60.1	39.9		
2009	65.0	35.0	67.0	33.0
2011	61.0	39.0	58.0	42.0
2013	61.5	38.5	66.6	33.4
2015	58.6	41.4	68.7	31.3
2018	53.4	46.6	62.6	37.4

Table 11a. Redfish trawl data < 500 m. Northeast area. Mean weight and individuals by length (cm below).

	Males		Females		Total	
Length (cm)	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
27	250	1	254	3	253	4
28	286	9	292	8	289	17
29	320	57	316	38	318	95
30	346	172	342	80	344	252
31	373	214	373	163	373	377
32	413	227	413	186	413	413
33	454	290	447	195	451	485
34	500	246	489	210	495	456
35	540	191	539	189	539	380
36	595	110	581	146	587	256
37	629	55	625	94	627	149
38	680	17	679	54	679	71
39	772	6	707	15	726	21
40			726	7	726	7
41			710	2	710	2
42	1087	1	830	1	959	2
43						
Total number		**1596**		**1391**		**2987**
Avg. weight	**457**		**482**		**468**	
Avg. length		**32,9**		**33,6**		**33,2**

Table 11b. Redfish trawl data > 500 m. Northeast area. Mean weight and individuals by length (cm below).

	Males		Females		Total	
Length (cm)	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
27						
28			289	3	289	3
29	281	9	315	5	293	14
30	337	25	343	10	339	35
31	373	33	379	13	375	46
32	410	32	411	25	410	57
33	454	41	448	26	452	67
34	494	47	502	25	497	72
35	543	54	545	45	544	99
36	598	56	586	41	593	97
37	645	50	625	39	636	89
38	694	51	690	31	693	82
39	765	39	726	28	749	67
40	808	36	803	24	806	60
41	887	35	864	11	882	46
42	931	32	915	8	928	40
43	1018	17	1014	3	1017	20
44	1061	4			1061	4
45	1088	2			1088	2
46						
Total number		**563**		**337**		**900**
Avg. weight	**625**		**591**		**613**	
Avg. length		**36,3**		**35,8**		**36,1**

Table 12a. Length distribution (numbers of fish in '000 per cm class) of redfish by area, derived from the acoustic estimate <DSL.

LENGTH (CM)	A	TOTAL
27	0,297	0,297
28	1,487	1,487
29	5,850	5,850
30	15,865	15,865
31	22,805	22,805
32	27,168	27,168
33	29,052	29,052
34	27,962	27,962
35	21,318	21,318
36	14,477	14,477
37	7,536	7,536
38	3,570	3,570
39	0,793	0,793
40	0,099	0,099
Total	**178,279**	**178,279**
Mean length	**33.0**	**33.0**
Mean weight (g)	**459**	**459**

Table 12b. Length distribution (numbers of fish in '000 per cm class) of redfish in subarea A, derived from the trawl within the DSL and shallower than 500 m.

LENGTH (CM)	A	TOTAL
27	0,298	0,298
28	0,597	0,597
29	10,742	10,742
30	27,453	27,453
31	43,865	43,865
32	41,477	41,477
33	57,293	57,293
34	51,921	51,921
35	49,236	49,236
36	32,824	32,824
37	21,783	21,783
38	10,444	10,444
39	3,879	3,879
40	1,790	1,790
41	0,597	0,597
42	0,597	0,597
Total	**354,796**	**354,796**
Mean length	**33.2**	**33.2**
Mean weight (g)	**468**	**468**

Table 12c. Length distribution (numbers of fish in '000 per cm class) of redfish in subarea A, derived from the trawl estimate ≥500 m.

Length (cm)	A	Total
28	0,709	0,709
29	3,311	3,311
30	8,277	8,277
31	10,879	10,879
32	13,480	13,480
33	15,845	15,845
34	17,027	17,027
35	23,412	23,412
36	22,939	22,939
37	21,048	21,048
38	19,392	19,392
39	15,845	15,845
40	14,189	14,189
41	10,879	10,879
42	9,460	9,460
43	4,730	4,730
44	0,946	0,946
45	0,473	0,473
Total	**212,841**	**212,841**
Mean length	**36.1**	**36.1**
Mean weight (g)	**613**	**613**

Table 13. Redfish trawl data. Observations on stomach contents, from fish caught shallower and deeper than 500 m Subarea A.

Stomach fullness index	< 500 m		> 500 m	
	No.	%	No.	%
0	252	8,4	152	16,9
1	99	3,3	30	3,3
2	132	4,4	21	2,3
3	113	3,8	12	1,3
4	110	3,7	15	1,7
5	2281	76,4	670	74,4
With content	454		78	
Total	2987		900	

Table 14. Redfish trawl data. Infestation with the copepod *Sphyrion lumpi* (according to remains of the parasite present)

	Above 500 m			Below 500 m		
	males	females	total	males	females	total
No. of fish examined	1596	1391	2987	563	337	900
% of fish with *S. lumpi* and/or remnants	27.6	38.7	32.8	31.4	36.2	33.2
Abundance index of *S. lumpi* invasion	0.6	0.8	0.6	0.5	0.6	0.6

Table 15. Trawl data. The most frequent species/genera in the survey conducted in the Irminger Sea (Northeastern area) in June/July 2018. #: Tows with species present. *FO* (%): Frequency of occurrence.

Vessel	**RV "Atlantida"**	
Number of Tows	**121**	
Species / Genus	**#**	**FO (%)**
Notoscopelus elongatus kroyeri	118	98
Chauliodus sloani	113	93
Sebastes mentella	**113**	**93**
Serrivomer lanceolatoides	108	89
Arctozenus risso	105	87
Benthosema glaciale	104	86
Lampanyctus macdonaldi	103	85
Stomias boa	102	84
Borostomias	94	78
Myctophum punctatum	92	76
Bathylagus euryops	91	75
Malacosteus niger	91	75
Normichthys operosus	72	60
Cyclothone braueri	70	58
Scopelogadus beanii	55	45
Xenodermichthys copei	55	45
Maulisia mauli	49	40
Holtbyrnia anomala	44	36
Holtbyrnia macrops	43	36
Lampadena speculigera	40	33
Lampanyctus intricarius	40	33
Nansenia groenlandica	40	33
Symbolophorus veranyi	39	32
Nemichthys scolopaceus	36	30
Borostomia arcticus	27	22
Anoplogaster cornuta	25	21
Chiasmodon niger	25	21
Ceratias holboelli	23	19
Cryptopsaras couesii	23	19
Melanolagus bericoides	21	17
Melanostigma atlanticum	21	17
Sternoptyx diaphana	20	17
Coryphaenoides rupestris	18	15
Sagamichthys schnakenbecki	18	15
Caristius groenlandicus	17	14
Electrona	16	13
Poromitra megalops	14	12
Dolopichthys longicornis	13	11
Eurypharynx pelecanoides	13	11

10 Figures

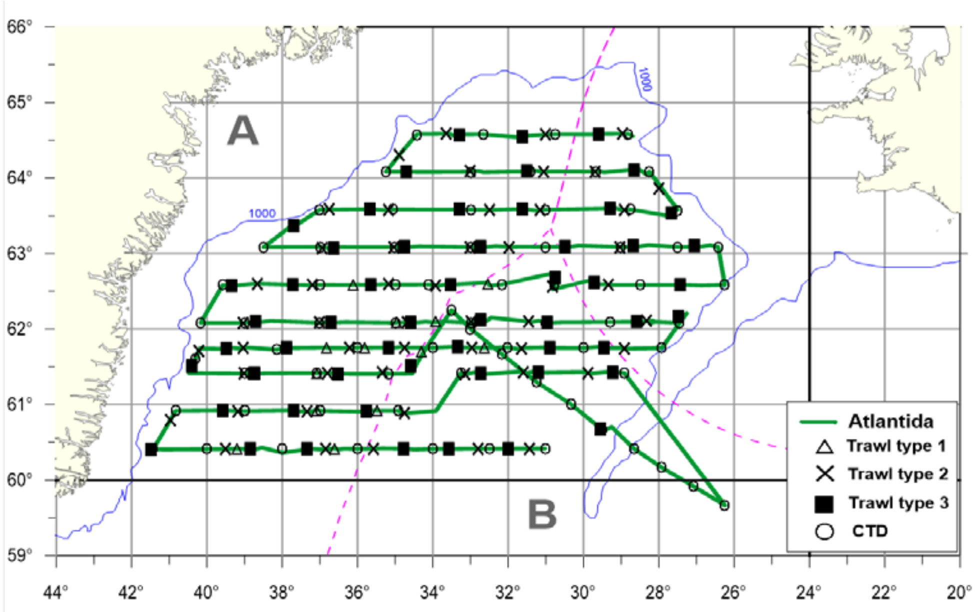

Figure 1. Cruise tracks and stations taken in the joint international redfish survey in June/July 2018.

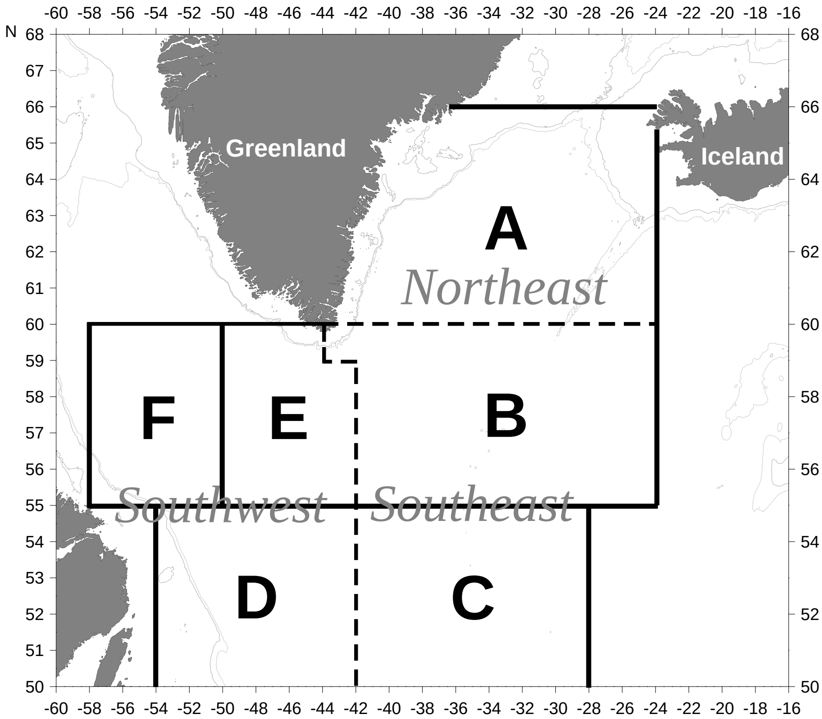

Figure 2. Sub-areas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines).

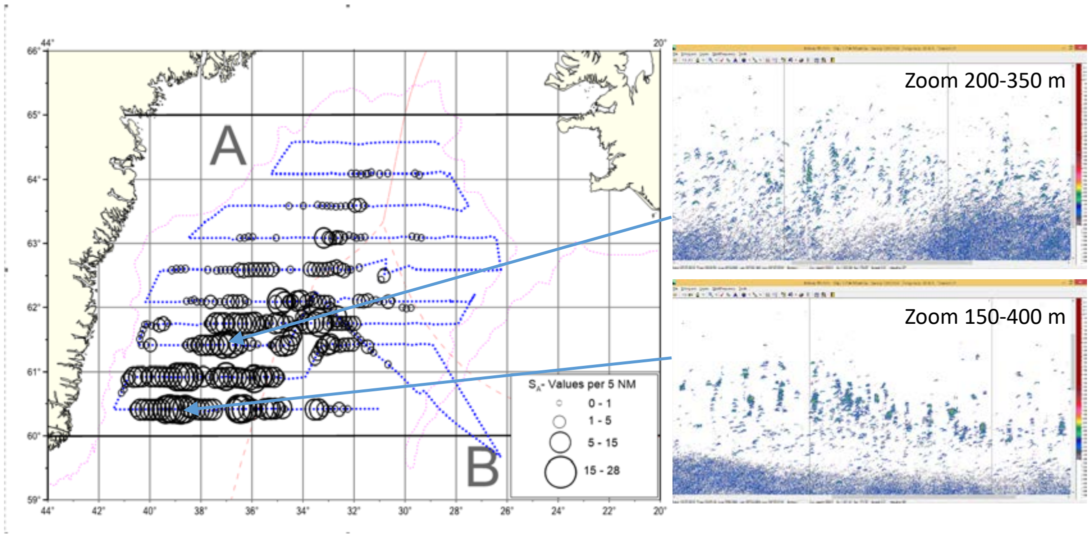

Figure 3. Redfish acoustic estimates shallower than the DSL and echogram examples. Average sA values by 5 NM of sailed distance (left) and two zoomed echograms with dense redfish concentrations (right). Example (right, bottom) when multiple single targets of redfish have been assembled in schools.

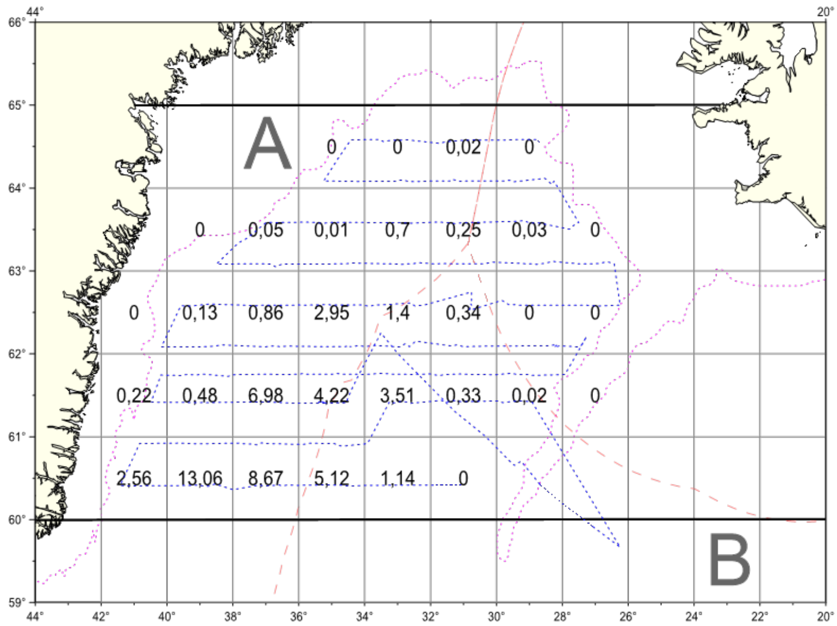

Figure 4. Redfish acoustic estimates shallower than the DSL. Average sA values by 5 NM within statistical rectangles during the joint international redfish survey in June/July 2018.

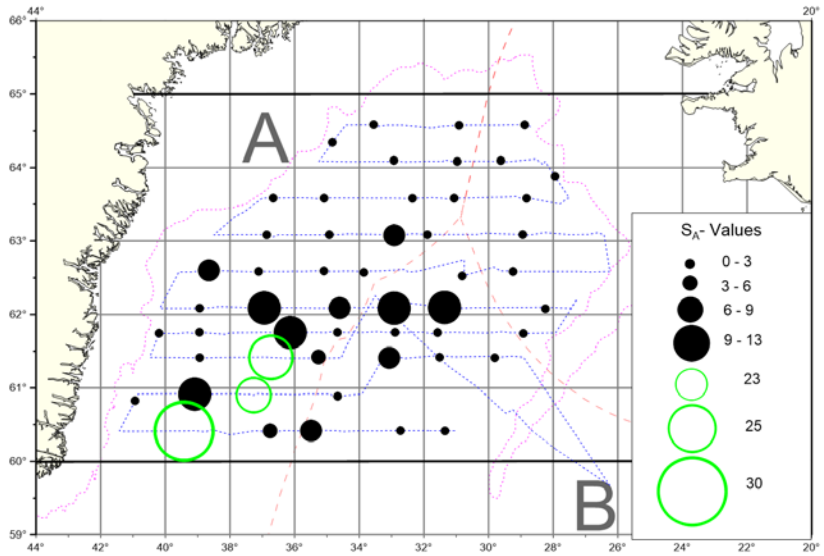

Figure 5. Redfish trawl estimates within the DSL and shallower than 500 m (Type 2 trawls). sA values calculated by the trawl method (Section 4.4.3) during the joint international redfish survey in June/July 2018.

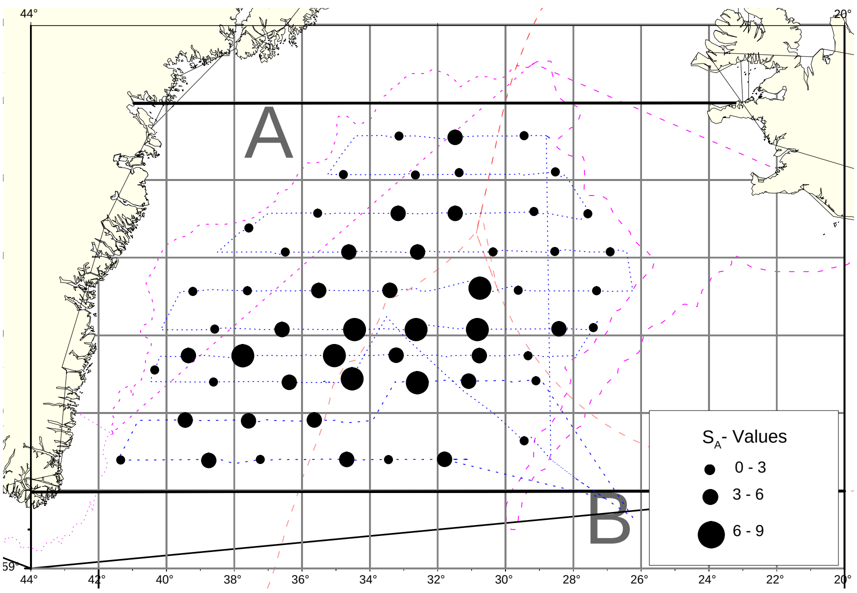

Figure 6. Redfish trawl estimates deeper than 500 m (Type 3 trawls). sA values calculated by the trawl method (Section 4.4.3) during the joint international redfish survey in June/July 2018.

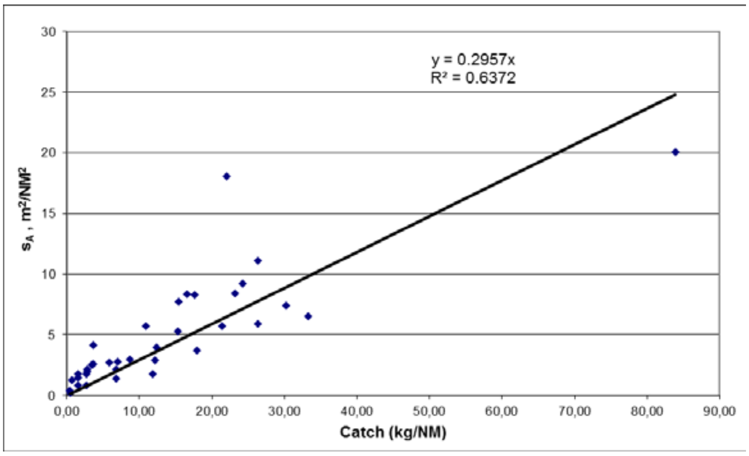

Figure 7. Regression between catches and observed hydroacoustic sA values, obtained on the Russian vessel shallower than the DSL and used in the biomass calculations. Trawl Types 1 for the years 2007, 2011, 2013 and 2018 were used for the regression.

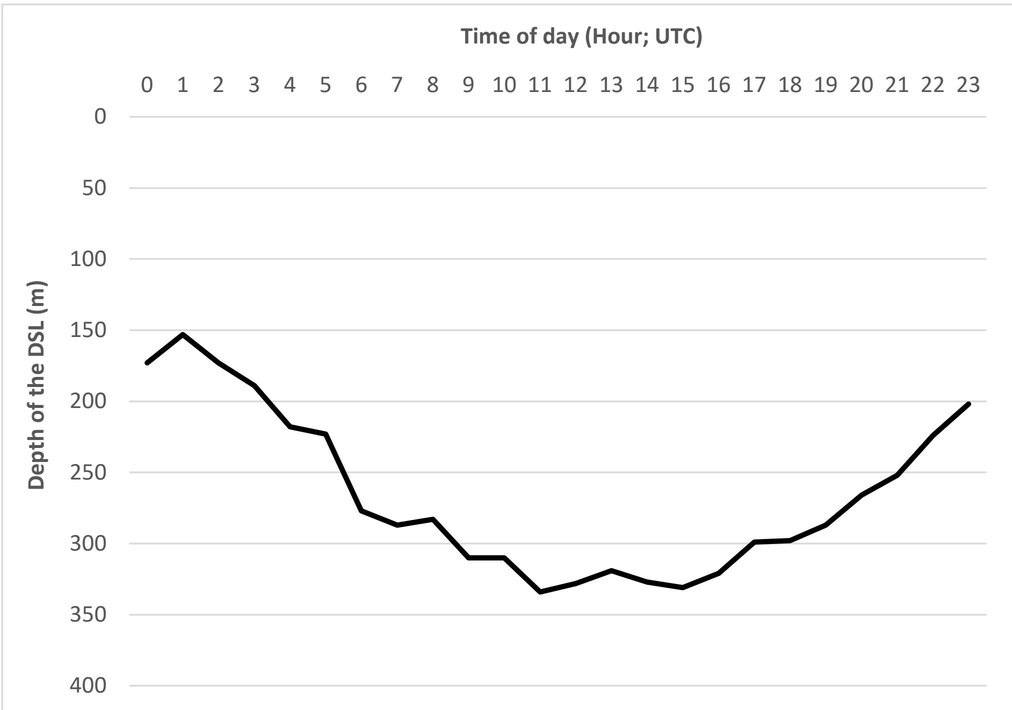

Figure 8. Average depth of the DSL during the survey in June/July 2018.

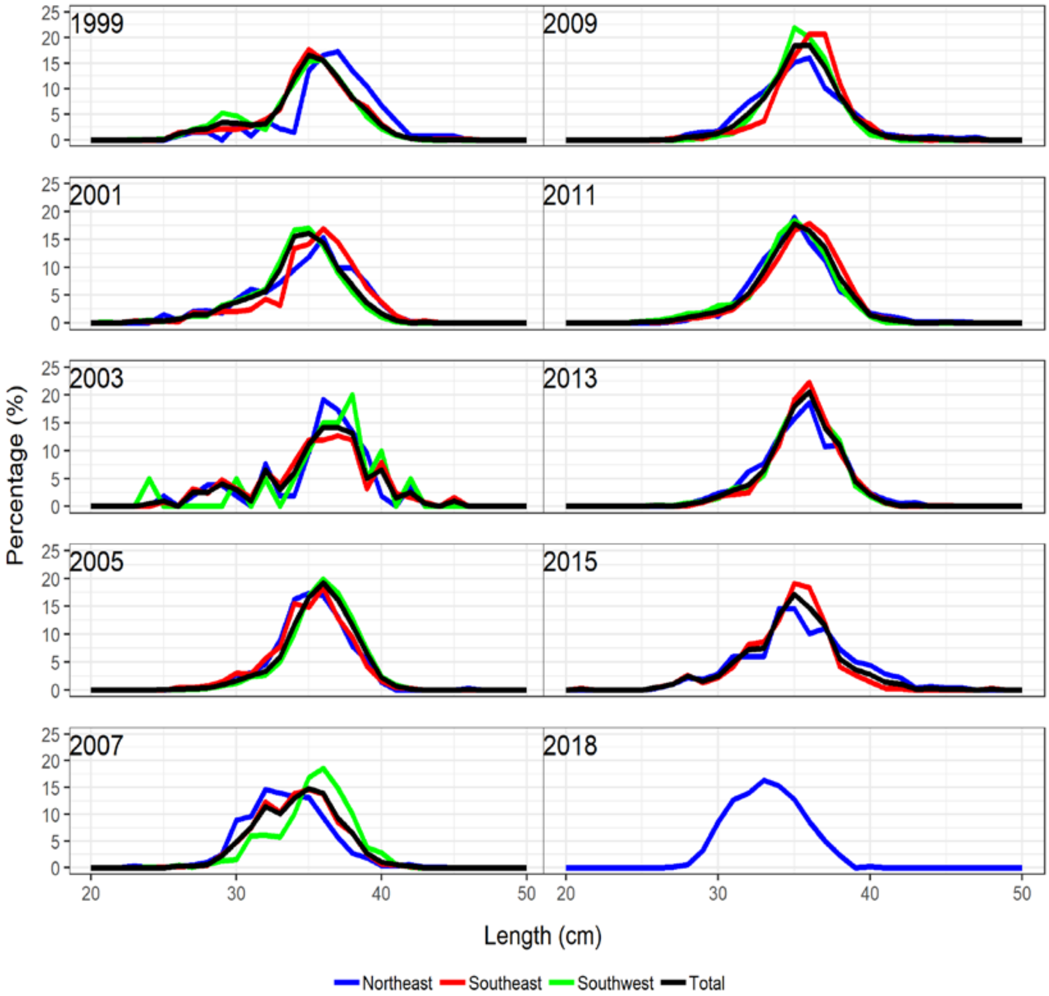

Figure 9. Length distribution of redfish in the trawls, by geographical areas (see Figure 2) and total, from fish caught shallower than 500 m 1999–2018 (in 2018, the survey only covered the northeastern area).

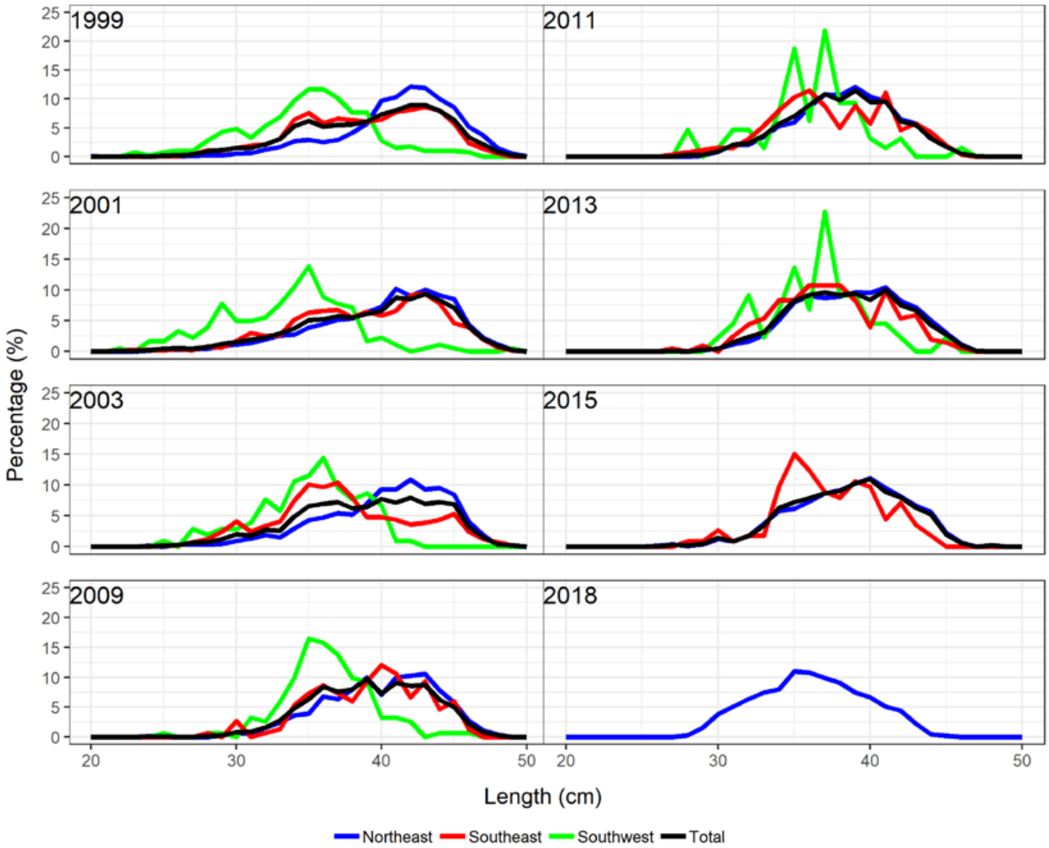

Figure 10. Length distribution of redfish in the trawls, by geographical areas (see Figure 2) and total, from fish caught deeper than 500 m 1999–2003 and 2009–2018 (in 2018, the survey only covered the northeastern area).

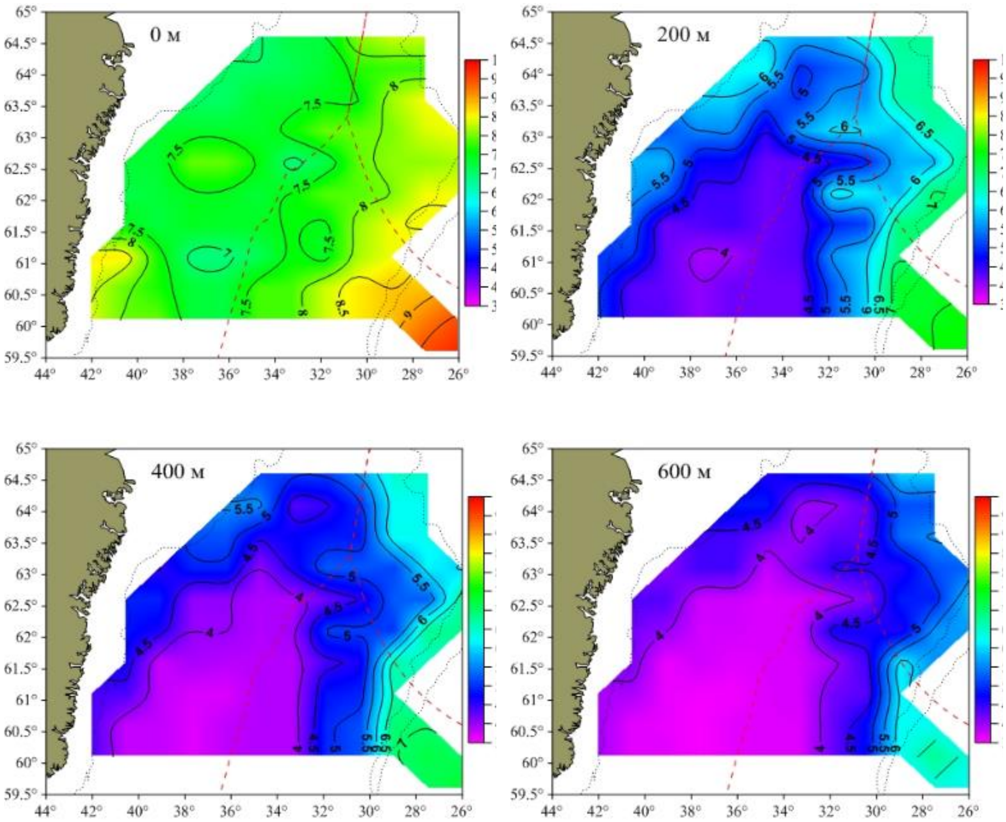

Figure 11. Temperature distribution (°C) at different depths in the survey area of the international hydroacoustic-trawl survey on redfish in the Irminger Sea and adjacent waters in June/July 2018.

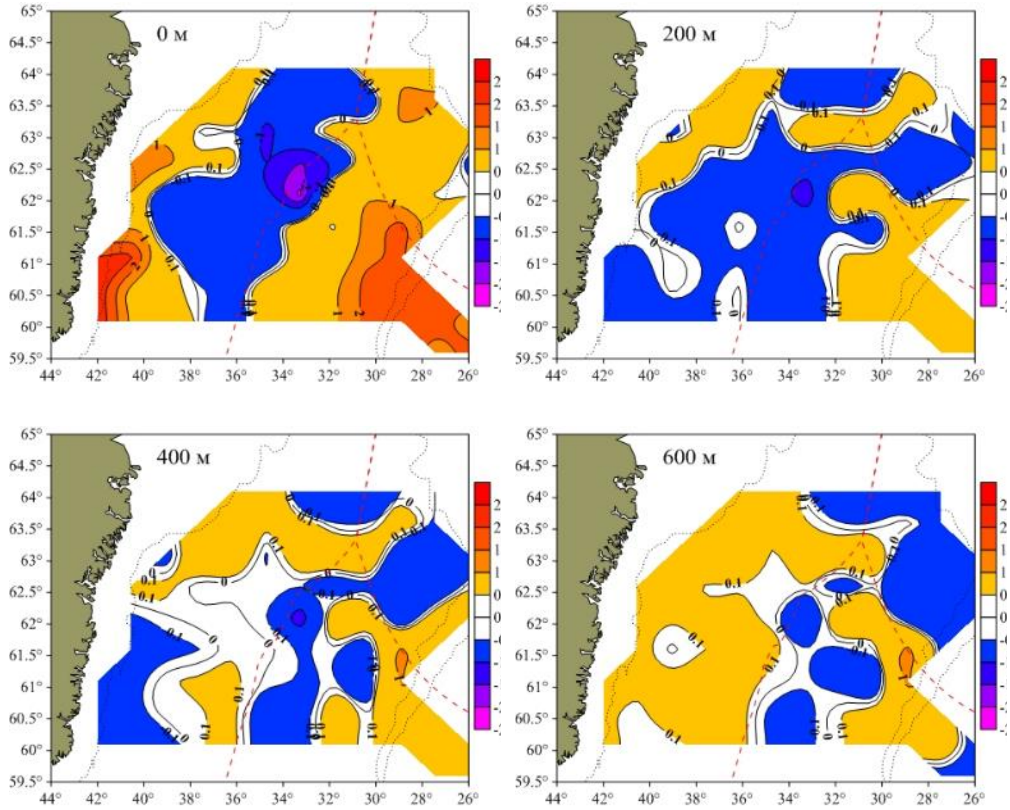

Figure 12. Temperature (°C) anomaly at different depths in the survey area of the international hydroacoustic-trawl redfish survey on redfish in the Irminger Sea and adjacent waters in June/July 2018.

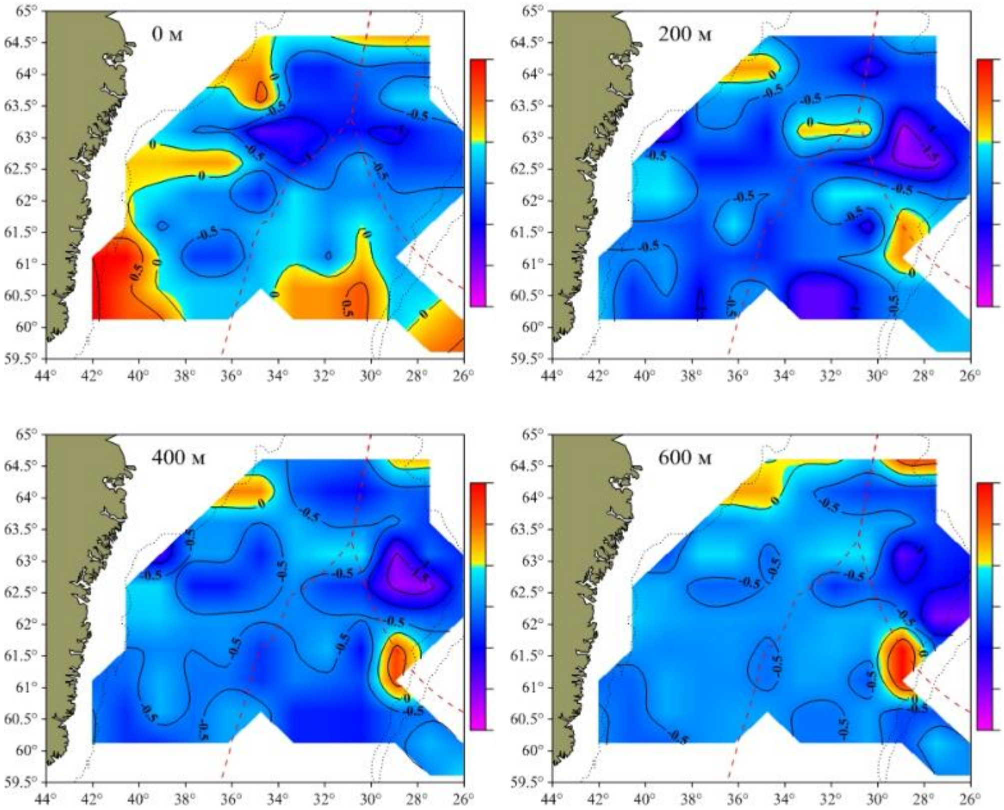

Figure 13. Temperature (°C) anomaly between 2013 and 2018 at 0 m, 200 m, 400m, and 600 m depth in the survey area of the international hydroacoustic-trawl redfish survey on redfish in the Irminger Sea and adjacent waters in June/July 2018.

Figure 14. Vertical temperature (°C) distribution on the 3K oceanographic section in the international hydroacoustic-trawl redfish survey on redfish in the Irminger Sea and adjacent waters in June/July 2018.

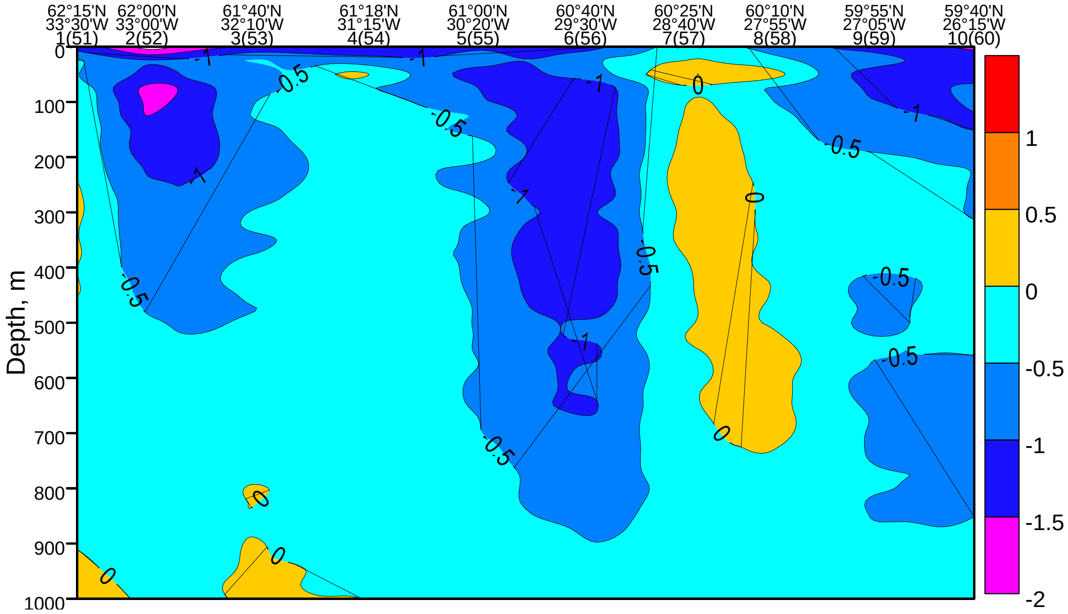

Figure 15. Vertical temperature (°C) deviation on the 3K oceanographic section in the international hydroacoustic-trawl redfish survey on redfish in the Irminger Sea and adjacent waters in June/July 2018.

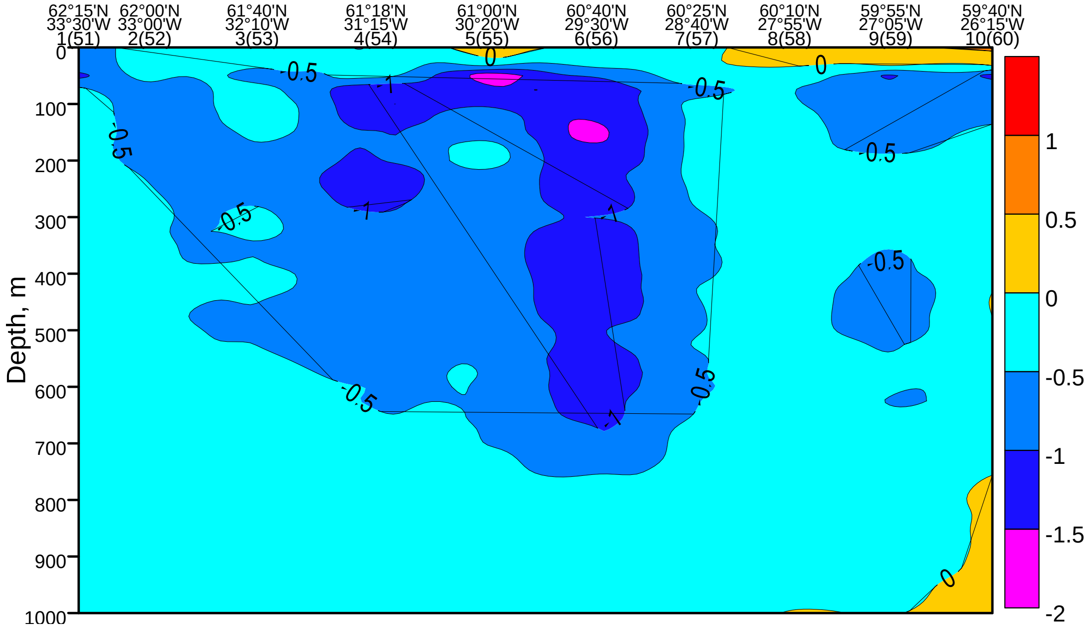

Figure 16. Temperature (°C) anomaly between 2013 and 2018 along the section 3K in the international hydroacoustic-trawl redfish survey on redfish in the Irminger Sea and adjacent waters in June/July 2018.

Annex 1: List of participants

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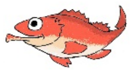
Annex 2: Agenda of the meeting



ICES Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS) meeting

Bremerhaven, Germany, 6-8 August 2018

Chair: Kristjan Kristinsson, Iceland

Provisional Agenda

ToR (Recommendation 2016/MA2/SSGIOM04):
e. at the 6-8 August meeting prepare the report of the outcome of the 2018 Irminger Sea survey.

Monday, 6 August 2018

10:00 Start of the meeting

- Housekeeping, network access
- Suggestions for venues of lunch breaks and dinner
- Adoption of the agenda

10:30 Plenary:

- Discussion of logistic and technical issues during the survey
  - Coverage deficiencies due to damages, bad weather, lack of time etc.
  - Deviations from survey planning (tracks, depth and duration of trawling)
  - Biological sampling; unusual observations
  - Hydrography: short description of the situation during the survey
- Other relevant observations during the survey (e.g. intensity of fishery activities, reports on catch rates of the fleet, targeted areas, depth zones etc.)
  - Genetic sampling
  - Echosounder comparison
- Preliminary biomass and abundance estimates, draft of main tables and figures

13:00–14:00 Lunch break

14:00–18:00 Individual/subgroup work:

- *Alexey:*
    - cruise track plot
    - biomass and abundance estimation from acoustic method (shallower than DSL) and from trawl-acoustic method (within and below DSL)
    - regression analyses
    - report drafting for hydroacoustics section
- *Aleksei:*
    - environmental conditions, temperature contour plots at 200/400/600 m depth
    - parasite infestation
    - report drafting for hydrography and biological sections
- *Matthias*:
    - biological results
    - report drafting for biological and general sections
    - report drafting for hydroacoustics section

Tuesday, 7 August 2018

09:00 Plenary:

- Drafts of tables and figures for hydroacoustic estimation, trawl estimation, biology, environmental conditions
- Description of uncertainties of the survey index

10:30 Continue individual/subgroup work (report drafting)

12:00–13:00 Lunch break

13:00 Plenary: General issues:

- Participation of further countries
- Future of the survey, assessment relevance, financing, national interests/constraints
- Other issues

15:00 Continue individual/subgroup work (report drafting)

17:00 Start discussion on first draft of report

18:00 End of working day and start of barbecue!

Wednesday, 8 August 2018

09:00–11:00 Finish first draft of report

11:00 Plenary:

- Perception of the state of the stock and discuss the suitability of the survey results for the corresponding advice (advice in October)
- Recommendations

12:00–13:00 Lunch break

13:00 Discuss draft report, clarify outstanding issues,

14:00

☞ Deadline for report: 19 September 2018

☞ Leave all material (data, tables, figures, text parts etc.) on the server. 16:00 End of the meeting.