# WORKING GROUP ON INTERNATIONAL DEEP PELAGIC ECOSYSTEM SURVEYS ( WGIDEEPS 2ND REPORT; outputs from 2021 meeting)

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

# Contents

# i Executive summary

The Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS) plans and reports on the international hydroacoustic-trawl surveys on pelagic redfish in the Irminger and Norwegian seas. During the 2021 meeting attended by Germany, Iceland, Norway, and Russia, the working group reported on the results from the pelagic redfish (*Sebastes mentella*) survey conducted in the Irminger Sea and adjacent waters in June-August 2021.

The trawl-acoustic survey on pelagic redfish in the Irminger Sea and adjacent waters was carried out by Russia only. In December 2020, the Marine and Freshwater Research Institute (MFRI) in Iceland informed the group that Iceland would not participate in the survey in June/July 2021. No specific reasons were given for the withdrawal. The participation of Germany was cancelled as well in the end of April due to technical problems. A bilateral agreement with financial compensation between Russia and Germany was reached, providing that Russia should take over the German part of the survey. Since the Russian and the German survey parts had to be carried out one after the other, the survey was extended from June to August 2021.

The survey area this year represented the minimum area required for perception of the state of redfish shallower and deeper than 500 m. About 242 000 $NM^2$ were covered, encompassing the northeastern (subarea A) and southeastern (subarea B) survey area and part of the southwestern (subarea E) survey area. As relative survey indices, a biomass of 490 000 t was estimated at depths shallower than deep scattering layer (DSL) by hydroacoustic measurements, about 352 000 t within the DSL, shallower than 500 m by a trawl method, and 154 000 t deeper than 500 m by the trawl method. For the redfish at depths shallower than 500 m, the observed biomass by of 842 000 t was the highest since 2005. The reason for this significant increase may be due to an incoming strong recruitment of *Sebastes mentella* most likely from the NAFO area, combined with favourable oceanographic conditions. The present results at depths shallower than 500 m show continuation of biomass increase which has been for the first time indicated in subarea A in 2018. For the redfish deeper than 500 m, the estimated biomass of 154 000 t is the lowest observed biomass since the beginning of the time-series. Concentrations of redfish deeper than 500 m were mostly distributed in the northeastern part of the survey area over Irminger Basin.

WGIDEEPS recommends that the survey should be continued with at least three vessels to cover the distribution area of redfish in the area. Additionally, the working group recommends that more nations should participate in the next surveys and that chartering of additional vessels and cost sharing should be considered as an alternative to direct participation.

# ii Expert group information

| | |
|---|---|
| **Expert group name** | Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS) |
| **Expert group cycle** | Multiannual fixed term |
| **Year cycle started** | 2020 |
| **Reporting year in cycle** | 2/3 |
| **Chair(s)** | Hannes Höffle, Norway |
| | Matthias Bernreuther, Germany |
| **Meeting venue(s) and dates** | 25-27 August 2020, Virtual meeting (4 participants) |
| | 16-19 February 2021, Virtual meeting (6 participants) |
| | 14-16 September 2021, Virtual meeting (5 participants) |

# 1 Report on the international trawl-acoustic survey on pelagic redfish in the Irminger Sea and adjacent waters in June-August 2021

## 1.1 Cancellation of the Icelandic and German participation and adaptation of the survey

In December 2020, the Marine and Freshwater Research Institute (MFRI) in Iceland informed the group that Iceland would not participate in the survey in June/July 2021. No specific reasons were given for 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 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.

In order to cover the planned survey area, a bilateral agreement with financial compensation between Russia and Germany was reached, providing that Russia should take over the German part of the survey. The Russian participant first covered the northern part of the survey area, then visited Reykjavik (Iceland) for bunkering and subsequently covered the part of the survey area in the south and west that was originally planned to be covered by Germany. By conducting both parts of the survey one after the other, the survey had to be extended into August 2021.

## 1.2 Participants

| | |
|---|---|
| Alexey Astakhov | Russia |
| Matthias Bernreuther (co-Chair) | Germany |
| Hannes Höffle (co-Chair) | Norway |
| Kristján Kristinsson | 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, International scientists and the Russian specialists on biology and hydroacoustics, which additionally have been deputy cruise leaders both, were present.

## 1.3 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 $NM^2$ (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, 1994).

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 $NM^2$ 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 $NM^2$ 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). Hydrographic 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, 2003). 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 redfish 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 conducted 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 inconsistency, is unknown (see ICES, 2003).

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 shallower 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 concentrations 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 distribution 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, 2007). 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, 2009a, b). The usual participation of Russia was cancelled. About 360 000 $NM^2$ 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 $NM^2$ 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 $NM^2$ 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 $NM^2$ 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 was 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.

The trawl-acoustic survey on pelagic redfish in the Irminger Sea and adjacent waters in June/July 2018 was carried out by Russia only (ICES, 2018). 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 was most certainly underestimated.

## 1.4 Material and methods

The planning of the survey was done during the WGIDEEPS online planning meeting (WebEx) from 16-19 February 2021 (ICES, 2021) according to the sampling methodology SISP (ICES 2015b).

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 in the northeastern and southeastern areas (main distribution of the deep pelagic *S. mentella*) and to additionally cover part of the southwestern area (subarea E) to get a better coverage of the distribution area of the shallow pelagic *S. mentella* compared to the International Deep Pelagic Ecosystem Surveys in 2015 and 2018. Since Germany was forced to cancel its participation due to technical problems with its research vessel, it was decided that Russia would take over the German part of the survey. To reach a better coverage of the redfish concentrations, the distances between transects were decreased as much as the timing allowed. Thus, the distance between 60% of transects was a 30 NM in areas with expected dense concentrations of redfish. The distances between the rest of transects were 45 NM and 60 NM (Figure 1). Additionally, the amount of trawls was increased up to 4 trawls (2 of Type 2 and 2 of Type T3) in 13% of the statistical rectangles.

### 1.4.1 Vessels, timing and survey area

The survey was carried out by the Atlantic branch ("AtlantNIRO") of the Russian Federal Research Institute of Fisheries and Oceanography "VNIRO", with the RV “Atlantida” from 5 June to 24 August 2021 with 57 days in the field (Russian part: 34, German part: 23; Table 1). Part of the scientific group of “Atlantida”consisted of sientists from Polar branch ("PINRO" named after N.M. Knipovich) of the Russian Federal Research Institute of Fisheries and Oceanography "VNIRO". The vessel covered an area of approximately 242 000 $NM^2$ within the boundaries of about 55°N to 65°N and 26°W to 50°W, on transects 30, 45 and 60 NM apart (Figure 1). The transects were covered as planned by the WGIDEEPS in February 2021 (ICES, 2021). Areas C, D and F (Figure 2) were not surveyed.

### 1.4.2 Acoustic assessment

A 38 kHz Simrad EK80 scientific echosounder was used for the acoustic data collection on RV “Atlantida”. Prior to the survey, the acoustic equipment was calibrated on two pulse lengths (1.0 and 2.0 ms) with the standard sphere method (Foote et al., 1987). The calibrated pulse length of 2.0 ms was used to reduce the noises appearing under bad weather conditions. 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 Echoview (V10.0, Myriax) was used for scrutinising the echograms. When determining the nautical area scattering coefficient $s_A$ ($m^2$/$mile^2$) for redfish and for the deep scattering layer (DSL), noises and echorecordings of the false bottom were excluded from the echograms. Mean integration values of redfish per 5 NM were used for the calculations.

Since many redfish became in subarea A, which very often assembled in schools, data from frequency 120 kHz were applied to distinguish redfish schools from the schools of Maurolicus spp. This new problem was valid for subarea A only, the main distribution area of Maurolicus within the IDEEPS survey area.

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 subareas A, B, E (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 each subarea.

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.

#### 1.4.2.1 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 analyzed 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).

### 1.4.3 Abundance estimation by the trawl method

As in the surveys in 1999–2018, 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, 2015b):

1 ) 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;

2 ) 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.

3 ) 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. The monitoring of the trawl depth, opening and width geometry was carried out by using the trawl sonar (also containing an echosounder). The stretched mesh size in the trawl codend was 16 mm.

During the survey, RV "Atlantida" employed a total of 11 Type 1 trawl hauls on redfish above the DSL which were acoustically identified, 80 Type 2 trawl hauls in the depth range from the top of the DSL down to 500 m and 79 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 (Fig. 7). Acoustic values for the Type 1 trawls were obtained from exactly the same position and depth range covered by the trawl.

Because a sufficient quantity of Type 1 trawls were taken in 2018 and 2021 on the same vessel (13 in 2018 and 11 in 2021), the Type 1 trawls data from these surveys 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:

$$s_A = \beta_0 + \beta_1 C$$

where $s_A$ is the surface density of fish distribution in the Type 1 trawl, $C$ is the catch (kg/NM) and $\beta_0$ and $\beta_1$ 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:

$$s_A = \beta_1 C$$

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:

$$\widehat{s_A} = \beta_1 * C$$

where $C$ is the catch of either Type 2 or Type 3 trawls in kg/NM and $\beta_1$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:

$$s_A = C * K * K_H$$

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.

### 1.4.4 Biological sampling of redfish

Standard biological observations of redfish needed for the acoustic assessment were carried out (ICES, 2015b). In addition, otoliths, scales and genetics samples were collected, and stomach fullness as well as parasite infestation were recorded according to an approved method (Bakay and Karasev, 2001). 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 as one category, but krill was reported in a separate category.

### 1.4.5 Hydrographic measurements

Temperature and salinity measurements were made with CTD probes down to 1000 m depth at the corners of each transects and at each trawl station (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.

## 1.5 Results

### 1.5.1 Acoustic measurements

The estimated biomass above the DSL (in the acoustic layer) in 2021 was 490 000 t which is almost 6 times higher compared to the last biomass estimation in 2013 (Figure 8; Table 5; 84 000 t for subareas A, B, E).

Figure 3 shows the average $s_A$ values by 5 NM sailed distance along the survey tracks, and the average values within the statistical rectangles are given in Figure 4. As shown in Figures 3 and

4, the boundary of the redfish was reached in all directions of subareas A and B and was not reached in the western and southwestern parts of subarea E which may lead to small underestimation of total biomass. However, this year a lot of redfish shallower than the DSL were observed in the main part of survey area. Hence, high and very high $s_A$ values have been registered on tracks at most part of survey time. Values up to 72 m²/NM² were observed (Figure 3). The abundance estimate of pelagic redfish within the covered area of 242 000 NM² shallower than the DSL amounts to about 949 million individuals or 490 000 t (Table 4). The abundance disaggregated by length groups is given in Table 13a.
In earlier years 1999-2007 (Table 5), the results of biomass estimates in the shallow layer were more or less stable (except the 2003 estimate) and started to decrease from 2009 on. The situation in 2021 demonstrates clear increase in abundance. Compared to the last estimates for subareas A, B, E (84 000 t) from 2013, the biomass in the acoustic layer is 406 000 t (5.8 times) higher than in 2013 (Table 5).

The average depth of the DSL and the corresponding confidence limits are presented in Figure 10. The depth of the layer above which redfish can be detected was, on average, around 140 m during the night-time but increased to its maximum of approximately 340 m between 12:00 and 15:00 UTC. As a consequence, the redfish were hard to detect and measure below those depths.

### 1.5.2 Abundance estimation by the trawl method

Figure 5 shows the redfish distribution within the DSL above 500 m, based on catches and the regression between catches and 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 35 m²/NM²) were observed in the northeast area, between latitudes 61°N and 62°35'N.

Figure 6 shows the redfish distribution at depths from 550 m to 900 m. The highest values ($s_A$ up to 7 m²/NM²) were observed in the central part of northeast area (above the Irminger basin).

The abundance estimation by subareas is given in Tables 6 and 8 for within the DSL and shallower than 500 m and deeper than 500 m, respectively, and disaggregated by length groups in Tables 13b and 13c.

The estimated numbers and biomass of redfish within the DSL and shallower than 500 m are 683 million individuals and 352 000 t, respectively. It is the highest estimate since 2001 (Table 7). The estimated value of 221 000 t for subarea A is the highest biomass computation for this subarea since the beginning of the time-series.

The assessment of the redfish distributed below 500 m constituted 154 000 t (0.27 billion individuals; Table 8; Figure 9).

For comparison, the results of the surveys 1999–2018 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 the biomass of redfish distributed below 500 m in subarea A has decreased by approximately 34% by 2021 compared to 2018 and for the subareas A, B, E combined, the value of 154 000 t is the lowest since the commence of the survey in 1999 (Table 9).

## 1.5.3 Biological data

### 1.5.3.1 Sex composition, length and weight

A summary of biological sampling in 2021 is given in Table 3. A total of 5 820 *S. mentella* was caught. Otoliths and scales were collected from 1 572 individuals (27%) and individual total length (5 142), weight, sex, maturity and parasites recorded. Samples from 432 specimens were taken for subsequent genetic analyses.

At depths shallower than 500 m, the percentage of females (53.7%) exceeded that of the males (46.3%). This is the first time since the beginning of this survey in 1999, that proportionally more females than males were observed shallower than 500 m. The proportion of females has more or less steadily increased from 35% in 2009 to reach the observed proportion of 53.7% in 2021 (Table 11). Deeper than 500 m, the sex ratio was different, compared to that of the shallow layer (51.5% males, 48.5% females) with a slightly higher proportion of males than females. However, even below 500 m we have observed a sharp increase in the relative proportion of females from 33.4-37.4% from 2013 to 2018, to 48.5% in 2021.

Fish total length in the catches ranged from 29 to 45 cm. The mean length of redfish in the shallower layer was 34.4 cm, 1.2 cm larger than in 2018, and the mean individual weight was 503 g compared to 468 g in 2018 (in 2018 only subarea A (Northeastern area) was covered)). The mean length of *S. mentella* in the shallow layer was similar in all areas (34.3-34.5 cm), females were in all areas slightly longer and heavier than the males (Tables 12a-f). In the deeper layer, the mean length was 35.4 cm, which was 0.7 cm smaller than in 2018, and the mean weight was with 567 g, 46 g lighter compared to 613 g in 2018. Deeper than 500 m, the largest *S. mentella* were observed in the Northeastern area (subarea A) with a mean of 35.8 cm and 579 g, whereas the smallest fish were observed in the southwestern area with a mean of 34.7 cm and 540 g (Tables 12a-f).

The length frequencies from the trawl stations are illustrated in Figures 11 to 14 and length-disaggregated abundance data are given Tables 13a-c. In comparison to the previous years, the peaks of the length distributions above and below 500 m are similar to 2018, where only subarea A was covered.

### 1.5.3.2 Feeding

An overview on the stomach fullness is given in Table 14. In both the shallower and deeper layer, the majority of the redfish stomachs (75% shallow layer, 80% deep layer) were everted. In the shallow layer, 18.7% of the investigated redfish had empty stomachs, and 6.6% had food items in their stomachs, while in the deeper layer 14.9% had empty stomachs and 5.3% contained food. 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 euphausids (35%), cephalopods (24%), amphipoda (19%), mesopelagic fish (7%) and jellyfish (5%).

### 1.5.3.3 Parasite infestation

Tables 15 and 16 contain 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 infestation rates (in %) were: 28.1 (A), 25.0 (B), 30.9 (E) and the corresponding abundance indices were 0.5, 0.4 and 0.6. Below 500 m these values were: 24.5 (A), 26.2 (B), 52.1 (E) with corresponding abundance indices of 0.5, 0.5 and 1.1.

#### 1.5.3.4 Maturity

The great majority of the males were identified as maturing (96%), whereas most of the females were in the post-spawning stage (81%), as expected from earlier investigations. The percentage of immature fish, observed in the samples, was 0.4% for males and 1.5% for females above 500 m and 0.3 and 1.9 below 500 m correspondingly. 14 females (mean total length: 37.6 cm) were ascribed to nonreproductive fish (maturity stage X, Filina et al., 2017). Similar to immature fish, their gonads had thin transparent non-pigmented walls and were visually identified as immature.

### 1.5.4 Species composition

*S. mentella* was found in 83% of all trawl samples (Table 17). In the southwestern area, *S. mentella* was observed in almost all hauls (97%), in the northeastern area in 89% of the hauls and only in 64% of the hauls in the southeastern area. 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* = 76%), *Serrivomer beanii* (*FO* = 95%), *Stomias boa ferox (FO = 92%)*, *Chauliodus sloani* (*FO* = 96%) and the myctophids *Lampanyctus macdonaldi* (*FO* = 89%), *Myctophum punctatum* (*FO* = 86%) and *Notoscopelus kroeyeri* (*FO* = 99%). The *FO*s of the most frequent species were estimated for all trawls with no differentiation between the trawl types (Table 17).

### 1.5.5 Hydrography

During the survey 132 oceanographic stations, including observations in the long-term hydrographical Russian 3K section, were carried out. Oceanographic investigations were conducted in the area between 56°30'N and 64° 20'N and from the Reykjanes Ridge to 49°10' W. Temperature data from a similar survey in 2013 were also used for the analysis. The results are shown in Figures 15-19.

The surface layer temperature decreased gradually from the Reykjanes Ridge to the coasts of Greenland. The temperature varied from 6°C on the southern slope of Greenland to 11.7°C in the relatively warmer waters of the Irminger Current over the Reykjanes Ridge (Figure 15).

A characteristic feature of thermal regime in surface waters is an abnormally high temperature deviation from the climatic norm (survey data 1982-2003). The average deviation throughout the area was +2.3°C, maximum values were noted in the southeast, in the area of the Irminger Current (Figure 16). Compared to the previous survey in 2018, the surface layer temperature was also significantly higher (+1.3°C, Figure 17).

At 400 m, the temperature ranged from 3.4°C in the area of the Subpolar Gyre to 7.4°C in the area of the Irminger Current. A high-gradient zone in the temperature and salinity field, associated with the Subpolar Front, is clearly distinguishable between these areas. The temperature in the specified layer, as well as in the surface layer, was mostly above normal. The greatest temperature deviations from the norm are associated with the Irminger Current and were observed to reach +1.3°C. In the central part of the Irminger basin and the waters associated with the Subpolar Gyre, the temperature also increased by 0.2–0.4°C relative to the norm. Compared to 2018, the temperature also increased by an average of 0.3°C (Figure 17).

At a depth of 600 meters, the temperature varied from 3.4°C in the waters associated with the Subpolar Gyre to 6.7°C in the area of the Irminger Current (Figure 15). In respect of the climatic norm, positive values were observed in the entire survey area. The tendency to the increase in the thermal content in the waters of the Irminger Current (up to +0.8°C) appears to continue. The water temperature in the central part of the Subpolar Gyre is also 0.2°C higher than normal (Figure 16). In relation to the 2018 survey, an increase in temperature is noted in the waters of the Irminger Current; the temperature in the central part of the gyre was within the normal range (Figure 17).

The data from the section 3K suggested that there was also an increase in temperature relative to the climatic norm and the survey in 2018 (Figures 18-19). On average, for stations located from the Subpolar Gyre to the Irminger Current (stations 1-9), the temperature increase was + 1.4 °C for the entire water column in comparison to the same period in 2018. In climatic terms, the deviation from the norm in the same area was + 0.8 °C. Directly in the area of the Irminger Current (stations 7–10), the temperature increase affected the upper 150-m layer, in the deeper layers the temperature was the same as in 2018.

## 1.6 Discussion

### 1.6.1 Acoustic assessment

The survey covered 242 000 NM², which is less than in previous years where around 340 000 NM² were covered. The reason for less area coverage in 2021 was the withdrawal of Iceland and Germany (due to technical reasons). Despite these circumstances, the survey area was covered as planned because the Russian vessel took over the German part of the survey. The German part was conducted after the Russian one. The survey area this year represented the minimum area required for an assessment of the redfish abundance in the Irminger Sea and adjacent waters.

Results of biomass estimate show a significant increase of redfish above the DSL. The estimated biomass of 490 000 t was the highest since 2005. The reason for this significant increase may be due to an incoming strong recruitment most likely from the NAFO area combined with ongoing north-eastward displacement of cold Labrador Sea Water (LSW). The possible effect of north-eastward displacement on distribution of redfish above 500 m was described in Nunez-Riboni et al. 2013. Highest concentrations of redfish above DSL were found in the area of activity of the LSW (Figures 3, 15 (depth 200 m)).

A decreasing trend in water temperature in the upper layers of the Irminger Sea has been observed since 2015. Since the estimation of the redfish biomass above the DSL was not possible in 2015 (ICES, 2015a), the increase in biomass was first observed in 2018, when the estimated biomass for subarea A (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 survey in 2018 was conducted in subarea A only (ICES, 2018a), but the observed high $s_A$ values on the southernmost transects were promising for subarea B. That assumption was confirmed in this year´s survey, with partly high $s_A$ and, hence, biomass values in subarea B and also in subarea E (Figure 3, Table 5). Regarding subarea A, the biomass was estimated to be almost 1.8 times the estimated biomass in 2018.

### 1.6.2 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 of redfish deeper than 500 m from the biennial (from 2015 on, the temporal distance between surveys was changed to three years) surveys in 1999-2021 (in 2018 only subarea A was covered). 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 1.5.2 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 9 are based on the outcome of these recalculations (ICES, 2014).

The survey area this year represented the minimum area required for an assessment of the redfish abundance shallower and deeper than 500 m (i.e. subareas A, B, E). The estimated biomass above 500 m and within the DSL of 352 000 t was the highest since 2001 (Surveys in 2005 and 2007 were not comparable; Table 7). The potential explanation for this significant increase is the same as for redfish in the acoustic layer (see 1.6.1). Highest concentrations of redfish within the DSL and shallower than 500 m were also found in the area of activity of LSW (Figures 5, 15 (depth 400 m). The estimated biomass below 500 m of 154 000 t was the lowest in the time-series (Table 9). Concentrations of redfish below 500 m were mostly distributed in the northeastern part of the survey area over Irminger basin (Figure 6).

### 1.6.3 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 was interpreted as an indication of recruitment of juvenile fish into the adult populations in the Irminger Sea. In 2021, the observed mean total length was lower (0.7 cm) in the deep pelagic *S. mentella* compared to 2018, whereas the observed mean total length in the shallow pelagic *S. mentella* was higher (1.2 cm) compared to 2018 (where only subarea A was covered). The observed increase in average length in the shallow layer may be accounted to the expected growth of the individuals but may also give an indication of "new" adult fish moving into the area of the Irminger Sea from Canadian waters. In Quebec, Newfoundland and Labrador regions, some strong cohorts of beaked redfish have been observed in the last decade and calculations show a drastic increase in the biomass in the NAFO areas 2, 3 and parts of 4 (DFO 2020a, 2020b), which may spread into the Irminger Sea. The next scheduled IDEEPS in 2024 will give us more insight into this potential migration.

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 (Dolgov et al., 2011).

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* (Bogovski and Bakay, 1989; Bakay and Melnikov, 2008).

### 1.6.4 Hydrography

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, 2001), 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, 2005). 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.

In 2021, the main feature of the oceanographic situation was an increase in the thermal background of water masses almost throughout studied water column (down to 1000 m) to the level of warm years. In comparison with the previous survey in 2018, a significant increase in thermal content of the waters was also observed. The greatest warming affected the waters of the Irminger Current. Water volume, associated with the the Subpolar Gyre (SPG), decreased.

The distribution area of the Irminger Current Water (ICW) over the Reykjanes Ridge increased. The LSW to Irminger basin, on the contrary, decreased and the SPG, where dense concentrations of beaked redfish occur at this time of year, occupied a smaller area. The abundance and distribution of pelagic *S. mentella* in relation to oceanographic conditions were analyzed 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 ICW temperature changes, linked to the SPG circulation and the North Atlantic Oscillation. The fish avoid increasing volumes of ICW (>4.5ºC and >34.94) in the north-eastern Irminger Sea due to an intensification of the SPG by displacing towards the southwest, to fresher, colder waters. A weakening of the SPG has the opposite effect (ICES, 2012).

# 2 Future of the survey and participation

During the February meeting in Tromsø, Norway in 2015, the participant from Iceland informed the group on the decision that the Marine Research Institute in Iceland would from 2015 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. Also in 2021, the working group participant from Iceland informed the group that Iceland will not participate in the survey in June/July 2021. Again, no specific reason was 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 area of the Irminger Sea and adjacent waters. The Group is particularly concerned 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 again. To compensate this failure, the Russian vessel took over the German part of the survey, so that the survey area was covered as planned. Despite the fact that the survey did not cover the entire distribution area of *S. mentella*, the results are promising. The results may indicate an incoming recruitment of juvenile/adult fish from the NAFO area into the adult stocks in the Irminger Sea.

In the light of this result, the Group confirms its recommendations (e.g. ICES, 2015b, 2018) 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 four of the last seven surveys (2007, 2009, 2015 and 2021), the redfish distribution area was only covered with a partly relatively low density of hydroacoustic tracks and trawl hauls by two (or one) vessel(s), 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 data series and corresponding low credibility in the Group's work and consequently the advice on the stock status.

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# 5 Tables

**Table 1. Extent, coverage and trawl specification of the international redfish survey in the Irminger Sea and adjacent waters in June-August 2021.**

| Country | Russia |
|---|---|
| Vessel | RV Atlantida |
| Call sign/ICES country code | UALU / 90 |
| Days in field | 57 (Russian part: 34, German part: 23) |
| Type of trawl | Russian pelagic trawl (design 78.7/416) |
| Number of hauls | 11 T1; 80 T2; 79 T3 = 170 |
| Opening / Width | 50 m / 50 m |
| Codend | 16 mm codend |
| Distance for acoustic registrations | 6240 NM |
| Area surveyed | 242 148.3 $NM^2$ |
| Number of CTD casts | 132 |

**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<br>Integrator | Simrad EK80<br>Echoview 10.0 (Myriax) | |
| Frequency | 38 kHz | |
| Transmission power | 2000 W | |
| Absorption coefficient | 9.6 dB/km | |
| Pulse length | 1.0 ms | 2.0 ms |
| Bandwidth | 2.43 kHz | 1.45 kHz |
| Transducer type | ES38-B | |
| Two-way beam angle | -20.7 | |
| Integration Threshold | -80 dB/m3 | |
| Sound speed | 1475 m/s | |
| Transducer Gain<br>$s_A$ correction | 26.15 dB<br>-0.66 dB | 26.30 dB<br>-0.43 dB |

**Table 3. Summary of biological sampling in the international redfish survey in the Irminger Sea and adjacent waters in June-August 2021.**

| Country | Russia |
|---|---|
| Total number / biomass of redfish caught | 5 142 ind. / 2 627 kg |
| Number of length measurements | 5 142 |
| Number of pairs of otoliths collected | 1572 |
| Number of feeding analysis | 5 142 |
| Number of parasites analysis | 5 142 |
| Individuals for genetics | 432 |

**Table 4. Results of the acoustic abundance and biomass computation and area coverage for redfish shallower than the DSL in June-August 2021. Areas C, D and F (see Figure 2) were not surveyed.**

| Subarea | A | B | E | Total |
|---|---|---|---|---|
| Area ($NM^2$) | 95 158.9 | 88 127.6 | 58 861.8 | 242 148.3 |
| No. fish ('000) | 286 138 | 289 400 | 373 622 | 949 160 |
| **Biomass (t)** | **143 773** | **149 956** | **196 341** | **490 070** |

**Table 5. Results (biomass in ´000 t) for the international surveys conducted 1994–2021, for redfish shallower than the DSL for each subarea and total along with the area coverage. No estimate was available in 2015 and in 2018 only subarea A was covered.**

| SUBAREA | | | | | | | | Area covered (´000 NM²) |
|---|---|---|---|---|---|---|---|---|
| Year | A | B | C | D | E | F | Total | |
| 1994 | 673 | 1228 | - | 63 | 226 | | 2190 | 190 |
| 1996 | 639 | 749 | - | 33 | 155 | | 1576 | 253 |
| 1999 | 72 | 317 | 16 | 42 | 167 | | 614 | 296 |
| 2001 | 88 | 220 | 30 | 267 | 103 | 7 | 716 | 420 |
| 2003 | 32 | 46 | 1 | 2 | 10 | 0 | 89 | 405 |
| 2005 | 121 | 123 | 0 | 87 | 204 | 17 | 551 | 386 |
| 2007 | 80 | 95 | 0 | 53 | 142 | 3 | 372 | 349 |
| 2009 | 39 | 48 | 4 | 1 | 15 | 1 | 108 | 360 |
| 2011 | 5 | 74 | 0 | 3 | 40 | 1 | 123 | 343 |
| 2013 | 9 | 33 | 2 | 5 | 42 | 0 | 91 | 340 |
| 2015 | - | - | - | - | - | - | - | - |
| 2018 | 82 | - | - | - | - | - | 82 | 103 |
| 2021 | 144 | 150 | - | - | 196 | - | 490 | 242 |

**Table 6. Results from estimation of redfish within the DSL and shallower than 500 m in June-August 2021. Subareas C, D and F (see Figure 2) were not surveyed.**

| | **A** | **B** | **E** | **Total** |
|---|---|---|---|---|
| Area (NM²) | 95 158.9 | 88 127.6 | 58 861.8 | 242 148.3 |
| Mean length (cm) | 34.4 | 34.4 | 34.5 | 34.4 |
| Mean weight (g) | 508 | 527 | 525 | 520 |
| No. fish ('000) | 433 493 | 76 631 | 172 646 | 682 770 |
| **Biomass (t)** | **220 502** | **40 438** | **90 727** | **351 667** |

**Table 7. Results (biomass in ´000 t) for the international surveys conducted since 2001, 2009, 2011, 2013, 2015, 2018 and 2021 for redfish within the DSL layer and shallower than 500 m for each subarea and the total along with the area coverage. Subareas C-F were not surveyed in 2015. Subareas B-F were not surveyed in 2018 and subareas C, D and F were not surveyed in 2021 (see Figure 2).**

| | Subarea | | | | | | | Area covered (´000 NM$^2$) |
|---|---|---|---|---|---|---|---|---|
| Year | A | B | C | D | E | F | Total | |
| 2001 | 23 | 40 | 45 | 399 | 54 | 5 | 565 | 420 |
| 2009 | 136 | 68 | 0 | 25 | 48 | 0 | 278 | 360 |
| 2011 | 69 | 185 | 1 | 30 | 76 | 0 | 309 | 343 |
| 2013 | 71 | 94 | 0 | 9 | 26 | 1 | 201 | 340 |
| 2015 | 31 | 38 | - | - | - | - | 69 | 201 |
| 2018 | 171 | - | - | - | - | - | 171 | 103 |
| 2021 | 221 | 40 | - | - | 91 | - | 352 | 242 |

**Table 8. Results from trawl estimation of redfish deeper than 500 m in June-August 2021. Subareas C, D and F (see Figure 2) were not surveyed.**

| | **A** | **B** | **E** | **Total** |
|---|---|---|---|---|
| Area (NM$^2$) | 95 158.9 | 88 127.6 | 58 861.8 | 242 148.3 |
| Mean length (cm) | 35.7 | 34.9 | 34.6 | 35.0 |
| Mean weight (g) | 584 | 555 | 538 | 559 |
| No. fish ('000) | 147 141 | 69 039 | 54 277 | 270 457 |
| **Biomass (t)** | **85 929** | **38 377** | **29 221** | **153 527** |

**Table 9. Results (biomass in ´000 t) for the international surveys conducted since 1999, for redfish deeper than 500 m (1999–2003 and 2009–2021), deeper than 350 m (2005 and 2007) for each subarea, and total, and the depth range covered along with the area coverage. (+) 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). Subareas C-F were not surveyed in 2015. Subareas B-F were not surveyed in 2018 and subareas C, D and F were not surveyed in 2021(see Figure 2).**

| | Subarea | | | | | | | | Area covered (´000 NM²) |
|---|---|---|---|---|---|---|---|---|---|
| Year | A | B | C | D | E | F | Total | Depth (m) | |
| 1999+ | 277 | 568 | 12 | 27 | 52 | 0 | 935 | 500–950 | 296 |
| 2001 | 497 | 316 | 28 | 79 | 64 | 18 | 1001 | 500–950 | 420 |
| 2003 | 476 | 142 | 20 | 13 | 27 | 0 | 678 | 500–950 | 405 |
| 2005* | 221 | 95 | 0 | 8 | 65 | 3 | 392 | (350–950) | 386 |
| 2007* | 276 | 166 | 1 | 5 | 92 | 11 | 522 | (350–950) | 349 |
| 2009 | 291 | 121 | 0 | 8 | 37 | 1 | 458 | 550-900 | 360 |
| 2011 | 342 | 112 | 0 | 1 | 18 | 0 | 474 | 550–900 | 343 |
| 2013 | 193 | 75 | 0 | 2 | 10 | 0 | 280 | 550-900 | 340 |
| 2015 | 153 | 43 | - | - | - | - | 196 | 550-900 | 201 |
| 2018 | 130 | - | - | - | - | - | 130 | 550-900 | 103 |
| 2021 | 86 | 38 | - | - | 29 | - | 154 | 550-900 | 242 |

**Table 10. Division of redfish biomass within NEAFC and NAFO areas in June-August 2021**

| | **NEAFC** | | **NAFO** | |
|---|---|---|---|---|
| | ´000 t | % | ´000 t | % |
| Acoustic <DSL | 294 | 60 | 196 | 40 |
| Trawl < 500 m (within the DSL) | 261 | 74 | 91 | 26 |
| Trawl > 500 m | 124 | 81 | 29 | 19 |

**Table 11. Sex ratio of redfish above and below 500 m from the international redfish surveys 1999–2021.**

| | <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 |
| 2021 | 46.3 | 53.7 | 51.5 | 48.5 |

**Table 12a. Redfish trawl data < 500 m. Northeast area. Mean weight and individuals by length (cm below).**

| | F | | M | | Total | |
|---|---|---|---|---|---|---|
| Total length (cm) | **Weight (g)** | **Numbers** | **Weight (g)** | **Numbers** | **Weight (g)** | **Numbers** |
| 29 | 362 | 1 | 320 | 1 | 341 | 2 |
| 30 | 343 | 8 | 351 | 27 | 349 | 35 |
| 31 | 377 | 34 | 374 | 131 | 374 | 165 |
| 32 | 405 | 130 | 404 | 272 | 404 | 402 |
| 33 | 442 | 294 | 441 | 335 | 441 | 629 |
| 34 | 476 | 409 | 476 | 322 | 476 | 731 |
| 35 | 516 | 371 | 524 | 240 | 519 | 611 |
| 36 | 561 | 328 | 566 | 152 | 563 | 480 |
| 37 | 608 | 202 | 618 | 62 | 611 | 264 |
| 38 | 657 | 117 | 679 | 16 | 659 | 133 |
| 39 | 712 | 40 | 734 | 6 | 715 | 46 |
| 40 | 754 | 17 | 756 | 4 | 755 | 21 |
| 41 | 798 | 5 | 843 | 2 | 811 | 7 |
| 42 | | | | | | |
| Total number | | **1956** | | **1570** | | **3526** |
| Mean weight (g) | **518** | | **471** | | **497** | |
| Mean total length (cm) | | **34.9** | | **33.7** | | **34.3** |

**Table 12b. Redfish trawl data > 500 m. Northeast area. Mean weight and individuals by length (cm below).**

| | **F** | | **M** | | **Total** | |
|---|---|---|---|---|---|---|
| Total length (cm) | **Weight (g)** | **Numbers** | **Weight (g)** | **Numbers** | **Weight (g)** | **Numbers** |
| 29 | | | | | | |
| 30 | | | 353 | 7 | 353 | 7 |
| 31 | 393 | 4 | 382 | 13 | 385 | 17 |
| 32 | 401 | 12 | 413 | 23 | 409 | 35 |
| 33 | 433 | 22 | 450 | 28 | 442 | 50 |
| 34 | 491 | 32 | 471 | 21 | 483 | 53 |
| 35 | 538 | 31 | 527 | 27 | 533 | 58 |
| 36 | 578 | 23 | 587 | 24 | 582 | 47 |
| 37 | 631 | 22 | 613 | 19 | 623 | 41 |
| 38 | 678 | 12 | 678 | 18 | 678 | 30 |
| 39 | 740 | 13 | 740 | 13 | 740 | 26 |
| 40 | 758 | 12 | 783 | 15 | 772 | 27 |
| 41 | 854 | 6 | 838 | 8 | 845 | 14 |
| 42 | 925 | 3 | 943 | 8 | 938 | 11 |
| 43 | | | 1022 | 5 | 1022 | 5 |
| 44 | 1058 | 2 | | | 1058 | 2 |
| 45 | | | 992 | 1 | 992 | 1 |
| Total number | | **194** | | **230** | | **424** |
| Mean weight (g) | **579** | | **579** | | **579** | |
| Mean total length (cm) | | **35.8** | | **35.7** | | **35.8** |

**Table 12c. Redfish trawl data < 500 m. Southeast area. Mean weight and individuals by length (cm below).**

| | F | | M | | Total | |
|---|---|---|---|---|---|---|
| Total length (cm) | **Weight (g)** | **Numbers** | **Weight (g)** | **Numbers** | **Weight (g)** | **Numbers** |
| 29 | 348 | 1 | 297 | 2 | 314 | 3 |
| 30 | 326 | 1 | 359 | 6 | 355 | 7 |
| 31 | 410 | 9 | 389 | 15 | 397 | 24 |
| 32 | 420 | 13 | 417 | 49 | 417 | 62 |
| 33 | 463 | 25 | 445 | 49 | 451 | 74 |
| 34 | 502 | 46 | 493 | 47 | 497 | 93 |
| 35 | 529 | 42 | 542 | 34 | 534 | 76 |
| 36 | 588 | 47 | 587 | 31 | 588 | 78 |
| 37 | 634 | 27 | 618 | 20 | 627 | 47 |
| 38 | 696 | 13 | 687 | 6 | 693 | 19 |
| 39 | 722 | 14 | 746 | 1 | 724 | 15 |
| 40 | 684 | 2 | 752 | 1 | 707 | 3 |
| 41 | | | | | | |
| 42 | | | 988 | 1 | 988 | 1 |
| Total number | | **240** | | **262** | | **502** |
| Mean weight (g) | **550** | | **495** | | **521** | |
| Mean total length (cm) | | **35.1** | | **33.9** | | **34.5** |

**Table 12d. Redfish trawl data > 500 m. Southeast area. Mean weight and individuals by length (cm below).**

| | F | | M | | Total | |
|---|---|---|---|---|---|---|
| Total length (cm) | **Weight (g)** | **Numbers** | **Weight (g)** | **Numbers** | **Weight (g)** | **Numbers** |
| 29 | | | | | | |
| 30 | | | 334 | 1 | 334 | 1 |
| 31 | | | 429 | 2 | 429 | 2 |
| 32 | 435 | 6 | 425 | 8 | 429 | 14 |
| 33 | 469 | 11 | 451 | 11 | 460 | 22 |
| 34 | 486 | 14 | 488 | 7 | 486 | 21 |
| 35 | 547 | 5 | 554 | 6 | 551 | 11 |
| 36 | 571 | 17 | 588 | 11 | 578 | 28 |
| 37 | 616 | 8 | 624 | 2 | 618 | 10 |
| 38 | 698 | 4 | 680 | 1 | 694 | 5 |
| 39 | 741 | 4 | 742 | 1 | 741 | 5 |
| 40 | | | 912 | 1 | 912 | 1 |
| 41 | | | 886 | 1 | 886 | 1 |
| 42 | 908 | 1 | | | 908 | 1 |
| 43 | | | 996 | 1 | 996 | 1 |
| 44 | | | | | | |
| 45 | | | | | | |
| Total number | | **70** | | **53** | | **123** |
| Mean weight (g) | **552** | | **533** | | **543** | |
| Mean total length (cm) | | **35.2** | | **34.5** | | **34.9** |

**Table 12e. Redfish trawl data < 500 m. Southwest area. Mean weight and individuals by length (cm below).**

| | F | | M | | Total | |
|---|---|---|---|---|---|---|
| Total length (cm) | **Weight (g)** | **Numbers** | **Weight (g)** | **Numbers** | **Weight (g)** | **Numbers** |
| 29 | | | | | | |
| 30 | | | 352 | 2 | 352 | 2 |
| 31 | 369 | 5 | 380 | 15 | 377 | 20 |
| 32 | 424 | 14 | 416 | 38 | 418 | 52 |
| 33 | 451 | 38 | 451 | 38 | 451 | 76 |
| 34 | 499 | 39 | 497 | 44 | 498 | 83 |
| 35 | 545 | 41 | 548 | 49 | 547 | 90 |
| 36 | 592 | 34 | 598 | 43 | 595 | 77 |
| 37 | 642 | 26 | 632 | 19 | 638 | 45 |
| 38 | 681 | 18 | 673 | 6 | 679 | 24 |
| 39 | 751 | 5 | | | 751 | 5 |
| 40 | 740 | 1 | | | 740 | 1 |
| 41 | | | | | | |
| 42 | | | | | | |
| Total number | | **221** | | **254** | | **475** |
| Mean weight (g) | **544** | | **511** | | **527** | |
| Mean total length (cm) | | **34.9** | | **34.2** | | **34.5** |

**Table 12f. Redfish trawl data > 500 m. Southwest area. Mean weight and individuals by length (cm below).**

| | **F** | | **M** | | **Total** | |
|---|---|---|---|---|---|---|
| Total length (cm) | **Weight (g)** | **Numbers** | **Weight (g)** | **Numbers** | **Weight (g)** | **Numbers** |
| 29 | | | 308 | 1 | 308 | 1 |
| 30 | 365 | 2 | | | 365 | 2 |
| 31 | 404 | 1 | | | 404 | 1 |
| 32 | 431 | 4 | 402 | 4 | 416 | 8 |
| 33 | 462 | 6 | 431 | 3 | 452 | 9 |
| 34 | 506 | 8 | 501 | 13 | 503 | 21 |
| 35 | 577 | 12 | 560 | 9 | 570 | 21 |
| 36 | 570 | 6 | 593 | 8 | 583 | 14 |
| 37 | 656 | 4 | 672 | 4 | 664 | 8 |
| 38 | 668 | 3 | 694 | 2 | 678 | 5 |
| 39 | | | 718 | 2 | 718 | 2 |
| 40 | | | | | | |
| 41 | | | | | | |
| 42 | | | | | | |
| 43 | | | | | | |
| 44 | | | | | | |
| 45 | | | | | | |
| Total number | | **46** | | **46** | | **92** |
| Mean weight (g) | **536** | | **544** | | **540** | |
| Mean total length (cm) | | **34.5** | | **34.8** | | **34.7** |

**Table 13a. Length distribution (numbers of fish in '000 per cm class) of redfish by area, derived from the acoustic estimate <DSL.**

| Length (cm) | A | B | E | Total |
|---|---|---|---|---|
| 29 | 159 | 0 | 0 | 159 |
| 30 | 188 | 6 493 | 1 573 | 8 254 |
| 31 | 14 984 | 11 131 | 15 731 | 41 846 |
| 32 | 31 403 | 33 392 | 40 902 | 105 697 |
| 33 | 52 605 | 50 089 | 59 780 | 162 474 |
| 34 | 65 357 | 54 726 | 65 286 | 185 369 |
| 35 | 49 098 | 45 451 | 70 792 | 165 341 |
| 36 | 36 823 | 36 175 | 60 566 | 133 564 |
| 37 | 19 288 | 27 827 | 35 396 | 82 511 |
| 38 | 9 246 | 12 986 | 18 878 | 41 110 |
| 39 | 2 710 | 9 276 | 3 933 | 15 919 |
| 40 | 1 116 | 1 855 | 787 | 3 758 |
| 41 | 159 | 0 | 0 | 159 |
| Total | 286 138 | 289 400 | 373 622 | 949 160 |
| Mean length | 34.2 | 34.4 | 34.5 | 34.3 |
| Mean weight (g) | 502 | 518 | 525 | 515 |

**Table 13b. Length distribution (numbers of fish in '000 per cm class) of redfish by subarea, derived from the trawl within the DSL and shallower than 500 m.**

| Length (cm) | A | B | E | Total |
|---|---|---|---|---|
| 29 | 250 | 1 210 | 0 | 1 460 |
| 30 | 3 756 | 0 | 727 | 4 483 |
| 31 | 17 780 | 4 840 | 7 269 | 29 889 |
| 32 | 51 338 | 10 486 | 18 900 | 80 724 |
| 33 | 74 878 | 8 066 | 27 623 | 110 567 |
| 34 | 80 388 | 13 713 | 30 168 | 124 269 |
| 35 | 75 880 | 10 890 | 32 712 | 119 482 |
| 36 | 62 357 | 15 730 | 27 987 | 106 074 |
| 37 | 35 811 | 6 856 | 16 356 | 59 023 |
| 38 | 18 782 | 2 017 | 8 723 | 29 522 |
| 39 | 7 262 | 2 017 | 1 817 | 11 096 |
| 40 | 3 506 | 403 | 363 | 4 272 |
| 41 | 1 503 | 0 | 0 | 1 503 |
| 42 | 0 | 403 | 0 | 0 |
| Total | 433 493 | 76 631 | 172 646 | 682 770 |
| Mean length | 34.4 | 34.4 | 34.5 | 34.4 |
| Mean weight (g) | 508 | 527 | 525 | 520 |

**Table 13c. Length distribution (numbers of fish in '000 per cm class) of redfish by subarea, derived from the trawl estimate ≥500 m.**

| Length (cm) | A | B | E | Total |
|---|---|---|---|---|
| 29 | 0 | 0 | 590 | 590 |
| 30 | 2 429 | 561 | 1 180 | 4 170 |
| 31 | 5 900 | 1 123 | 590 | 7 613 |
| 32 | 12 146 | 7 858 | 4 720 | 24 724 |
| 33 | 17 351 | 12 348 | 5 310 | 35 009 |
| 34 | 18 393 | 11 787 | 12 389 | 42 569 |
| 35 | 20 128 | 6 174 | 12 389 | 38 691 |
| 36 | 16 310 | 15 716 | 8 260 | 40 286 |
| 37 | 14 228 | 5 613 | 4 720 | 24 561 |
| 38 | 10 411 | 2 806 | 2 950 | 16 167 |
| 39 | 9 023 | 2 806 | 1 180 | 13 009 |
| 40 | 9 370 | 561 | 0 | 9 931 |
| 41 | 4 858 | 561 | 0 | 5 419 |
| 42 | 3 817 | 561 | 0 | 4 378 |
| 43 | 1 735 | 561 | 0 | 2 296 |
| 44 | 694 | 0 | 0 | 694 |
| 45 | 347 | 0 | 0 | 347 |
| Total | 147 141 | 69 039 | 54 277 | 270 457 |
| Mean length | 35.7 | 34.9 | 34.6 | 35.0 |
| Mean weight (g) | 584 | 555 | 538 | 559 |

**Table 14. Redfish trawl data. Observations on stomach fullness index, from fish caught shallower (upper panel) and deeper (lower panel) than 500 m by Area. 0 corresponds to an empty stomach, 5 to an everted stomach and the values for 1 to 4 reach from little (stomach filled 1-20%) to full (stomach filled 100%).**

| < 500 m | Area | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Northeast | | Southeast | | Southwest | | Total | |
| | No. | % | No. | % | No. | % | No. | % |
| 0 | 660 | 18.7 | 70 | 13.9 | 91 | 19.2 | 821 | 18.2 |
| 1 | 55 | 1.6 | 15 | 3.0 | 7 | 1.5 | 77 | 1.7 |
| 2 | 98 | 2.8 | 23 | 4.6 | 7 | 1.5 | 128 | 2.8 |
| 3 | 51 | 1.4 | 4 | 0.8 | 1 | 0.2 | 56 | 1.2 |
| 4 | 33 | 0.9 | 3 | 0.6 | 1 | 0.2 | 37 | 0.8 |
| 5 | 2629 | 74.6 | 387 | 77.1 | 368 | 77.5 | 3384 | 75.1 |
| Total | 3526 | 100 | 502 | 100 | 475 | 100 | 4503 | 100 |
| With content | 237 | 6.7 | 45 | 9.0 | 16 | 3.4 | 298 | 6.6 |

| > 500 m | Area | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Northeast | | Southeast | | Southwest | | Total | |
| | No. | % | No. | % | No. | % | No. | % |
| 0 | 59 | 13.9 | 19 | 15.4 | 17 | 18.5 | 95 | 14.9 |
| 1 | 3 | 0.7 | 2 | 1.6 | | 0.0 | 5 | 0.8 |
| 2 | 4 | 0.9 | 6 | 4.9 | 2 | 2.2 | 12 | 1.9 |
| 3 | 7 | 1.7 | 3 | 2.4 | 2 | 2.2 | 12 | 1.9 |
| 4 | 5 | 1.2 | | 0.0 | | 0.0 | 5 | 0.8 |
| 5 | 346 | 81.6 | 93 | 75.6 | 71 | 77.2 | 510 | 79.8 |
| Total | 424 | 100 | 123 | 100 | 92 | 100 | 639 | 100 |
| With content | 19 | 4.5 | 11 | 8.9 | 4 | 4.3 | 34 | 5.3 |

**Table 15. Redfish trawl data. Infestation with the copepod *Sphyrion lumpi* (according to remains of the parasite present) above 500 m**

| | A | | | B | | | E | | |
|---|---|---|---|---|---|---|---|---|---|
| | males | females | total | males | females | total | males | females | total |
| No. of fish examined | 1570 | 1956 | 3526 | 262 | 240 | 502 | 254 | 221 | 475 |
| % of fish with *S. lumpi* and/or remnants | 22.4 | 32.7 | 28.1 | 19.0 | 31.2 | 25.0 | 25.2 | 37.6 | 30.9 |
| Abundance index of *S. lumpi* invasion | 0.4 | 0.6 | 0.5 | 0.3 | 0.6 | 0.4 | 0.4 | 0.7 | 0.6 |

**Table 16. Redfish trawl data. Infestation with the copepod *Sphyrion lumpi* (according to remains of the parasite present) below 500 m**

| | A | | | B | | | E | | |
|---|---|---|---|---|---|---|---|---|---|
| | males | females | total | males | females | total | males | females | total |
| No. of fish examined | 230 | 194 | 424 | 53 | 70 | 123 | 46 | 46 | 92 |
| % of fish with *S. lumpi* and/or remnants | 18.3 | 31.9 | 24.5 | 15.0 | 34.3 | 26.2 | 36.9 | 37.6 | 52.1 |
| Abundance index of *S. lumpi* invasion | 0.3 | 0.6 | 0.5 | 0.2 | 0.6 | 0.5 | 0.8 | 0.7 | 1.1 |

**Table 17. Trawl data. The most frequent species/genera in the survey conducted in the Irminger Sea by area in June-August 2021. #: Tows with species/genera present. *FO* (%): Frequency of occurrence. NE = Northeastern area (subarea A); SE = Southeastern area (subarea B); SW = Southwestern area (subarea E).**

| **Vessel** | **RV "Atlantida"** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Number of Tows | **90** | **50** | **30** | **170** | | | | |
| Area | **NE** | **SE** | **SW** | **All areas** | **NE** | **SE** | **SW** | **All areas** |
| Species/Genus | **#** | **#** | **#** | **#** | **FO (%)** | **FO (%)** | **FO (%)** | **FO (%)** |
| *Notoscopelus elongatus kroyeri* | 88 | 50 | 30 | 169 | 98 | 100 | 100 | 99 |
| *Benthosema glaciale* | 84 | 49 | 30 | 163 | 93 | 98 | 100 | 96 |
| *Chauliodus sloani* | 84 | 49 | 30 | 163 | 93 | 98 | 100 | 96 |
| *Serrivomer beanii* | 84 | 48 | 29 | 161 | 93 | 96 | 97 | 95 |
| *Stomias boa* | 79 | 49 | 29 | 157 | 88 | 98 | 97 | 92 |
| *Lampanyctus macdonaldi* | 74 | 48 | 29 | 151 | 82 | 96 | 97 | 89 |
| *Myctophum punctatum* | 67 | 49 | 30 | 146 | 74 | 98 | 100 | 86 |
| *Sebastes mentella* | **80** | **32** | **29** | **141** | **89** | **64** | **97** | **83** |
| *Arctozenus risso* | 59 | 46 | 30 | 135 | 66 | 92 | 100 | 79 |
| *Borostomias* | 61 | 44 | 27 | 132 | 68 | 88 | 90 | 78 |
| *Malacosteus niger* | 68 | 40 | 24 | 132 | 76 | 80 | 80 | 78 |
| *Bathylagus euryops* | 61 | 42 | 26 | 129 | 68 | 84 | 87 | 76 |
| *Normichthys operosus* | 57 | 38 | 24 | 119 | 63 | 76 | 80 | 70 |
| *Holtbyrnia anomala* | 52 | 38 | 20 | 110 | 58 | 76 | 67 | 65 |
| *Scopelogadus beanii* | 54 | 30 | 20 | 104 | 60 | 60 | 67 | 61 |
| *Cyclothone braueri* | 42 | 33 | 17 | 92 | 47 | 66 | 57 | 54 |
| *Holtbyrnia macrops* | 49 | 27 | 15 | 91 | 54 | 54 | 50 | 54 |
| *Eurypharynx pelecanoides* | 32 | 28 | 17 | 77 | 36 | 56 | 57 | 45 |
| *Xenodermichthys copei* | 43 | 18 | 12 | 73 | 48 | 36 | 40 | 43 |
| *Melanolagus bericoides* | 35 | 23 | 14 | 72 | 39 | 46 | 47 | 42 |
| *Lampanyctus intricarius* | 40 | 20 | 9 | 69 | 44 | 40 | 30 | 41 |
| *Chiasmodon niger* | 27 | 23 | 14 | 64 | 30 | 46 | 47 | 38 |
| *Lampadena speculigera* | 35 | 20 | 9 | 64 | 39 | 40 | 30 | 38 |
| *Poromitra megalops* | 31 | 22 | 11 | 64 | 34 | 44 | 37 | 38 |
| *Coryphaenoides rupestris* | 29 | 16 | 13 | 58 | 32 | 32 | 43 | 34 |

| Vessel | RV "Atlantida" | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Protomyctophum arcticum* | 23 | 22 | 6 | 51 | 26 | 44 | 20 | 30 |
| *Sternoptyx diaphana* | 16 | 18 | 6 | 40 | 18 | 36 | 20 | 24 |
| *Anoplogaster cornuta* | 20 | 10 | 6 | 36 | 22 | 20 | 20 | 21 |
| *Dolopichthys longicornis* | 16 | 12 | 7 | 35 | 18 | 24 | 23 | 21 |
| *Nansenia groenlandica* | 29 | 6 | | 35 | 32 | 12 | 0 | 21 |
| *Caristius groenlandicus* | 17 | 10 | 5 | 32 | 19 | 20 | 17 | 19 |
| *Ceratias holboelli* | 15 | 11 | 5 | 31 | 17 | 22 | 17 | 18 |
| *Lampanyctus crocodilus* | 25 | 4 | 1 | 30 | 28 | 8 | 3 | 18 |
| *Maulisia mauli* | 10 | 12 | 6 | 28 | 11 | 24 | 20 | 16 |
| *Cryptopsaras couesii* | 13 | 9 | 2 | 24 | 14 | 18 | 7 | 14 |
| *Searsia koefoedi* | 17 | 5 | 2 | 24 | 19 | 10 | 7 | 14 |
| *Melanostigma atlanticum* | 10 | 7 | 4 | 21 | 11 | 14 | 13 | 12 |
| *Nemichthys scolopaceus* | 8 | 11 | 1 | 20 | 9 | 22 | 3 | 12 |

# 6 Figures

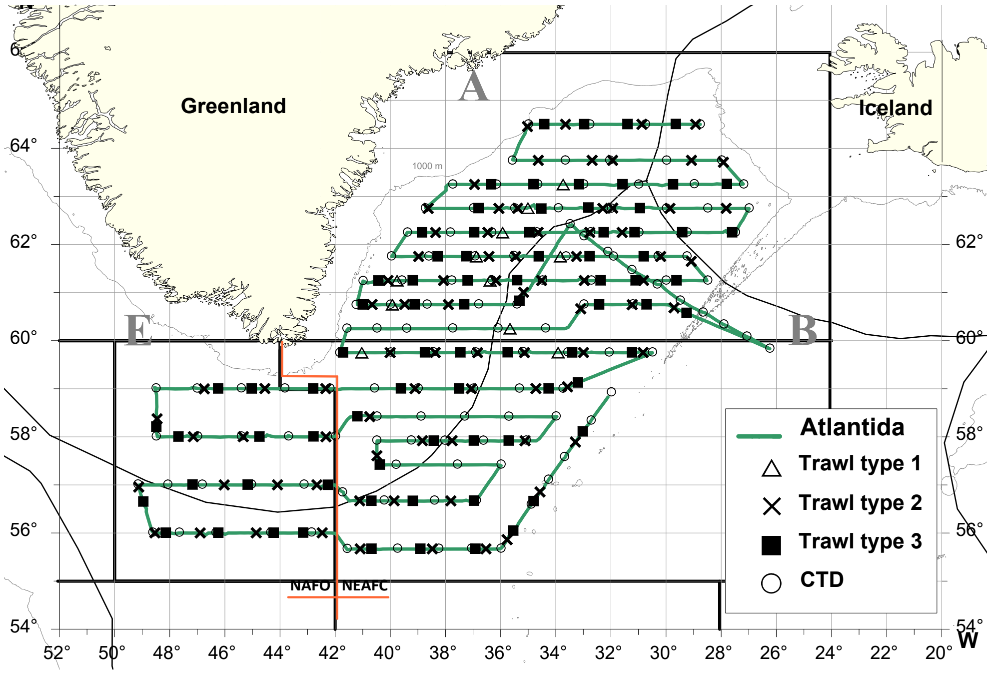


**Figure 1. Cruise tracks and stations conducted in the joint international redfish survey in June-August 2021.**

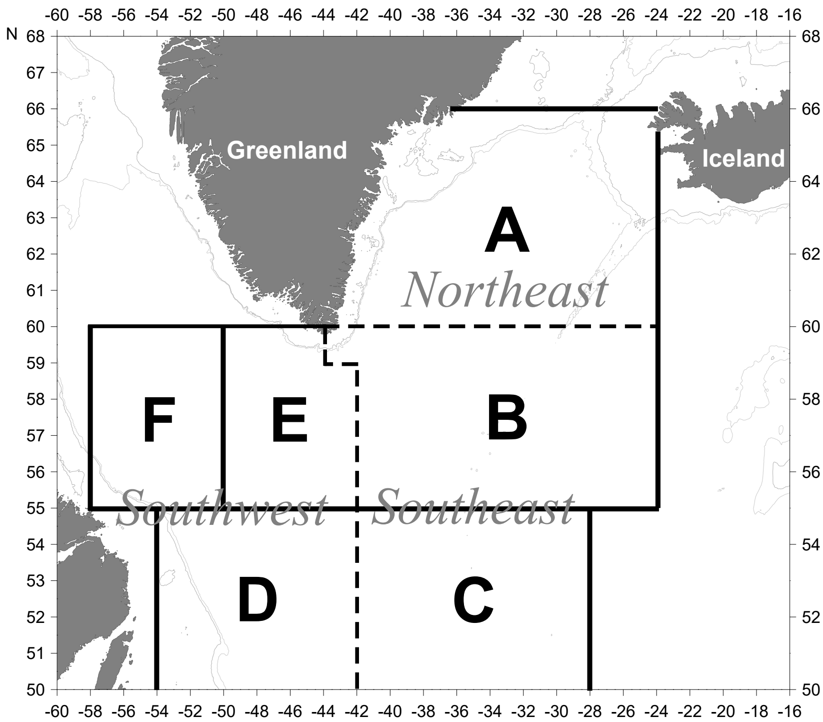


**Figure 2. Subareas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines).**

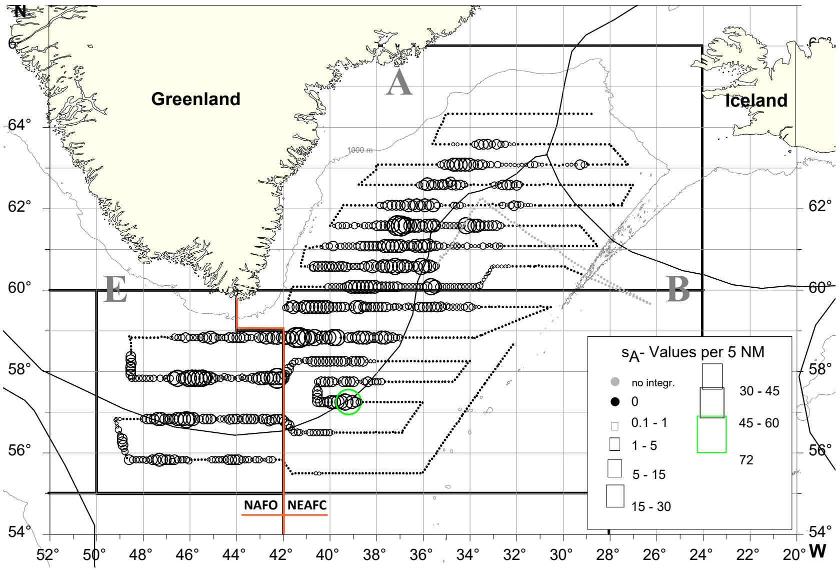


**Figure 3. Redfish acoustic estimates shallower than the DSL. Average $s_A$ values by 5 NM of sailed distance. Route in subarea A and small part of B marked by grey dots was not integrated because of too long duplicate proceeding (in comparison with survey 2018) during sailing to/conducting of 3K hydrographic section.**

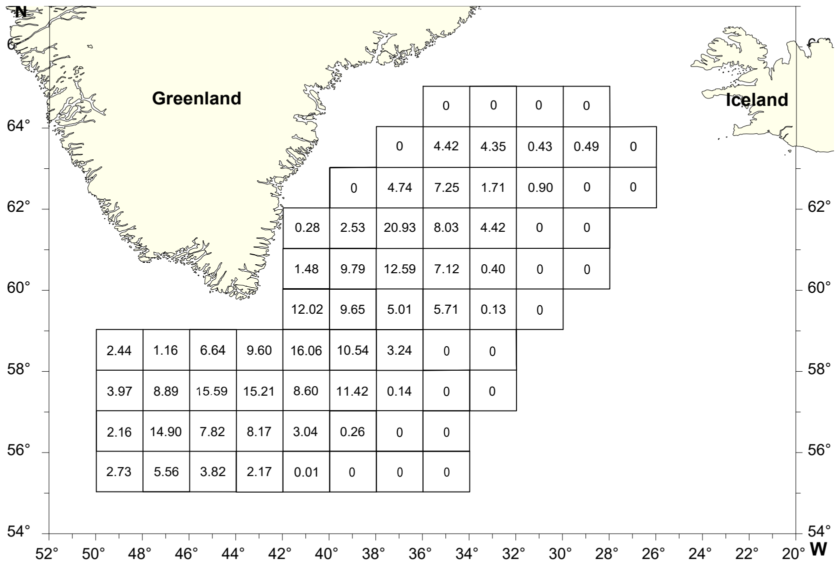


**Figure 4. Redfish acoustic estimates shallower than the DSL. Average sA values by 5 NM within statistical rectangles during the joint international redfish survey in June-August 2021.**

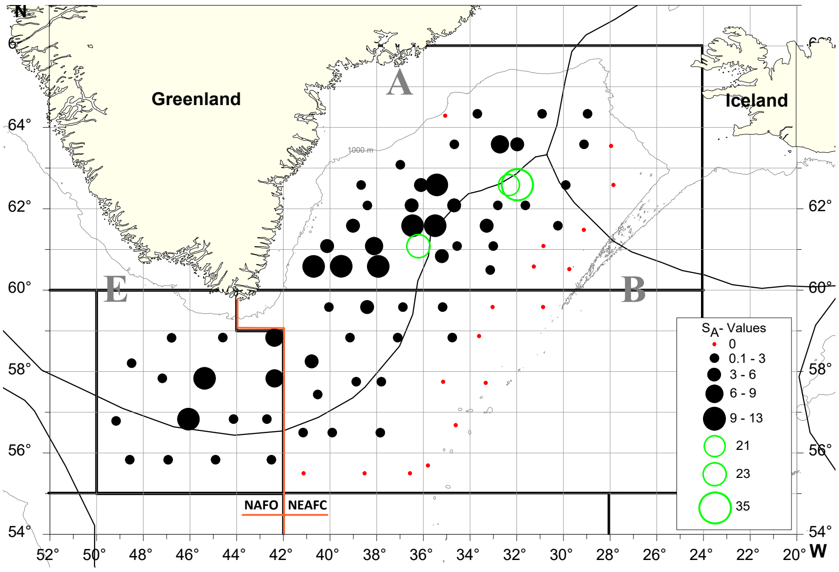


**Figure 5. Redfish trawl estimates within the DSL and shallower than 500 m (Type 2 trawls). $s_A$ values calculated by the trawl method (Section 1.4.3) during the joint international redfish survey in June-August 2021.**

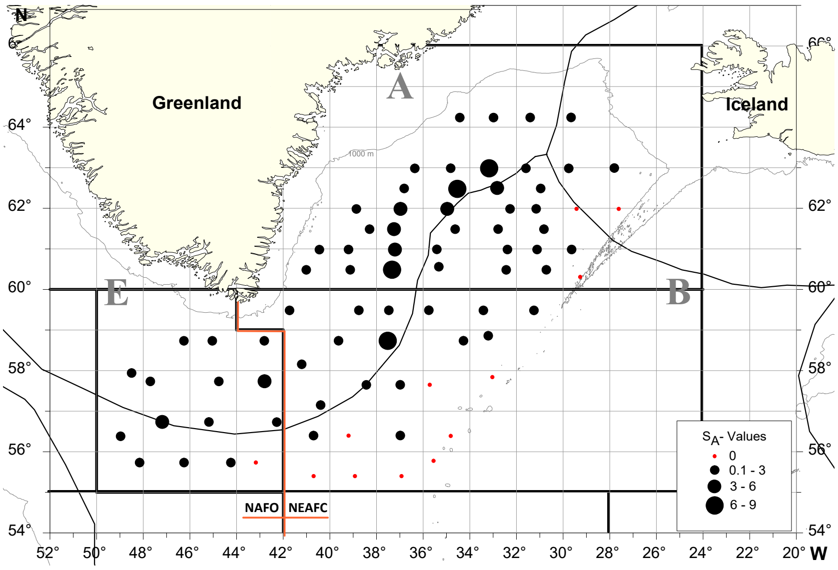


**Figure 6. Redfish trawl estimates deeper than 500 m (Type 3 trawls). $s_A$ values calculated by the trawl method (Section 1.4.3) during the joint international redfish survey in June-August 2021.**

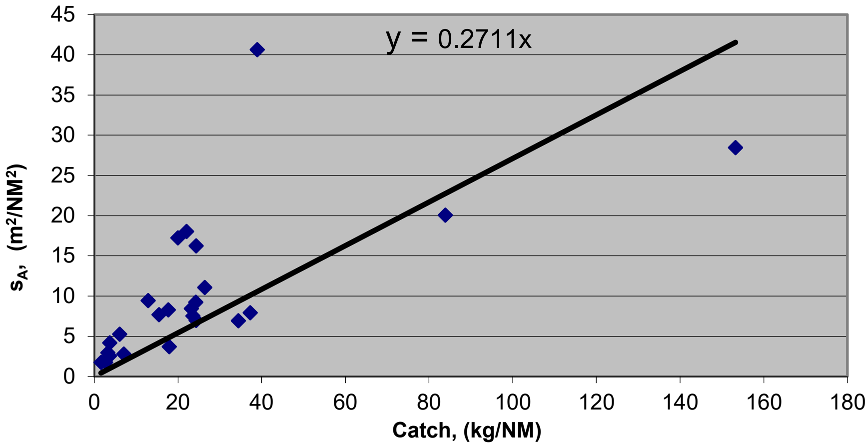


**Figure 7. Regression between catches and observed hydroacoustic sA values, obtained on the Russian vessel shallower than the DSL and used in the biomass calculations. Trawl Types 1 for the years 2018 and 2021 were used for the regression.**

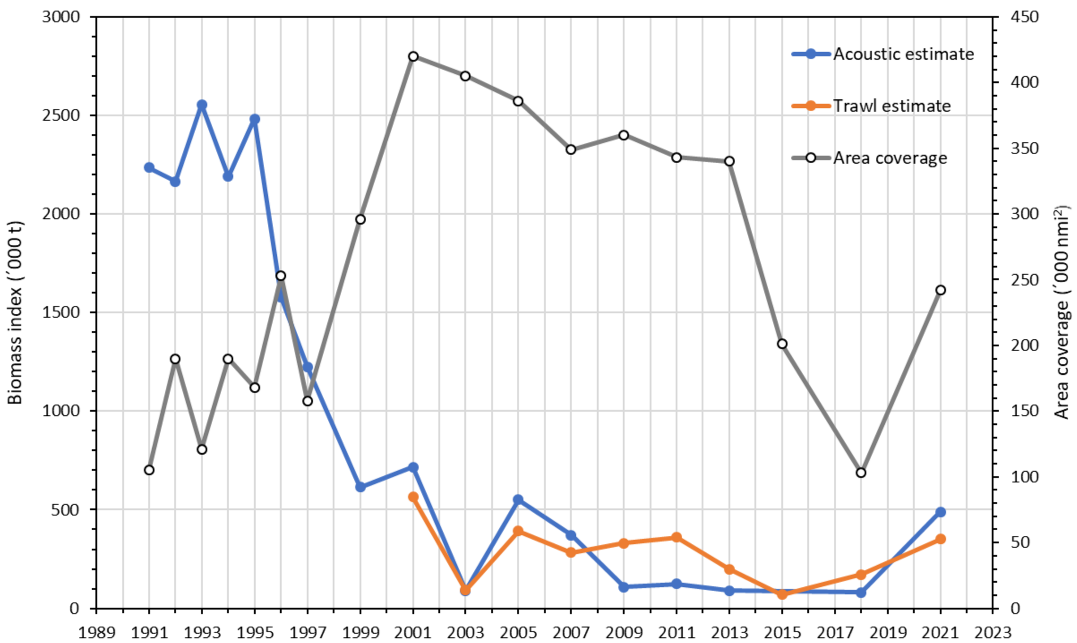


**Figure 8. Biomass indices for the shallow pelagic Sebastes mentella from 1991 to 2021: Acoustic survey indices (in thousand tonnes) from above the deep scattering layer (blue line), trawl estimates within the deep scattering layer and shallower than 500 m (orange line), and area coverage (nmi2; grey line with white circles).**

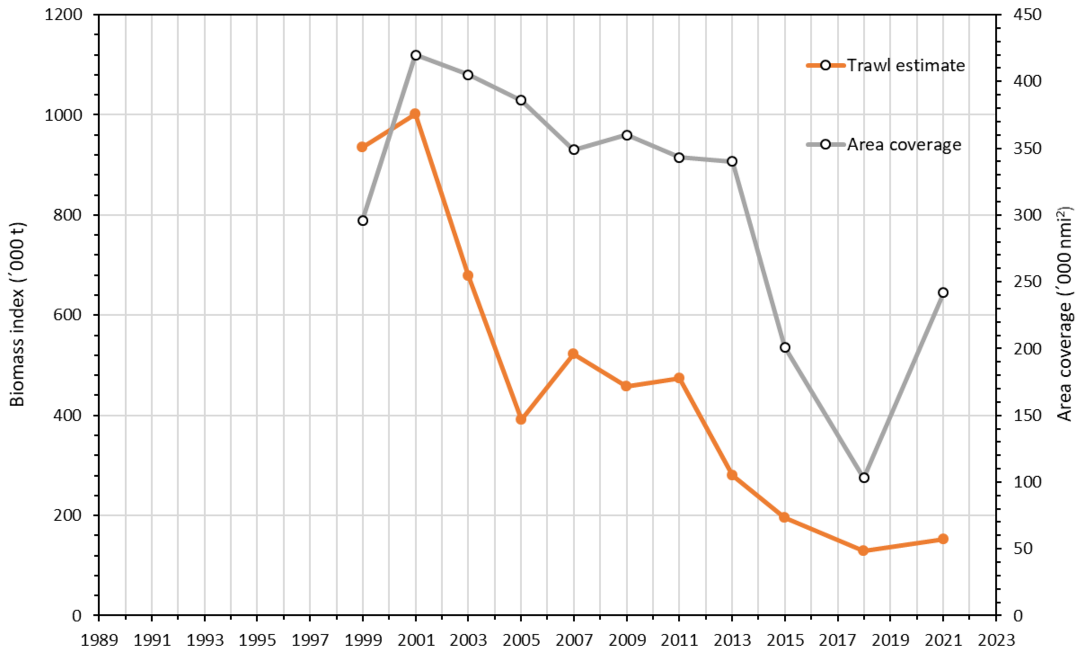


**Figure 9. Biomass index (in thousand tonnes) for the deep pelagic Sebastes mentella (deeper than 500 m) and the area coverage (nmi2; grey line with white circles) from 1999 to 2021.**

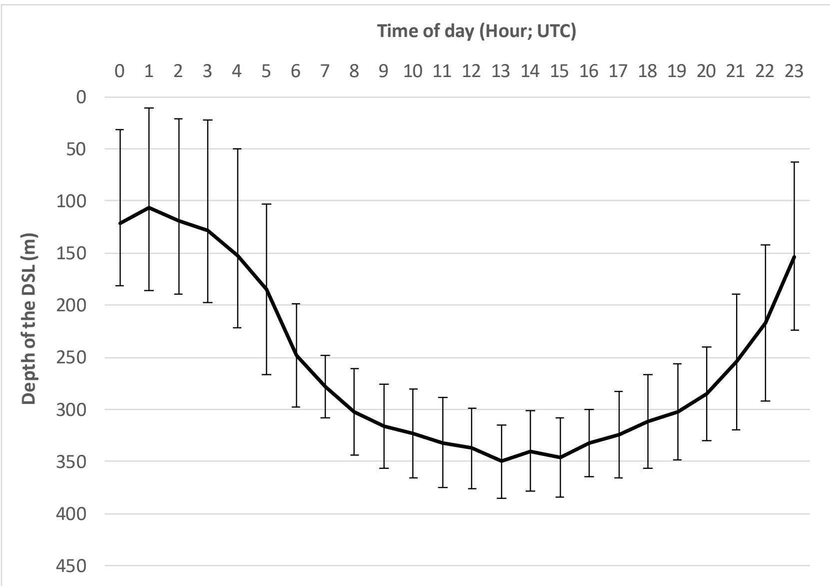


**Figure 10. Average depth and standard deviation of the DSL during the survey in June-August 2021.**

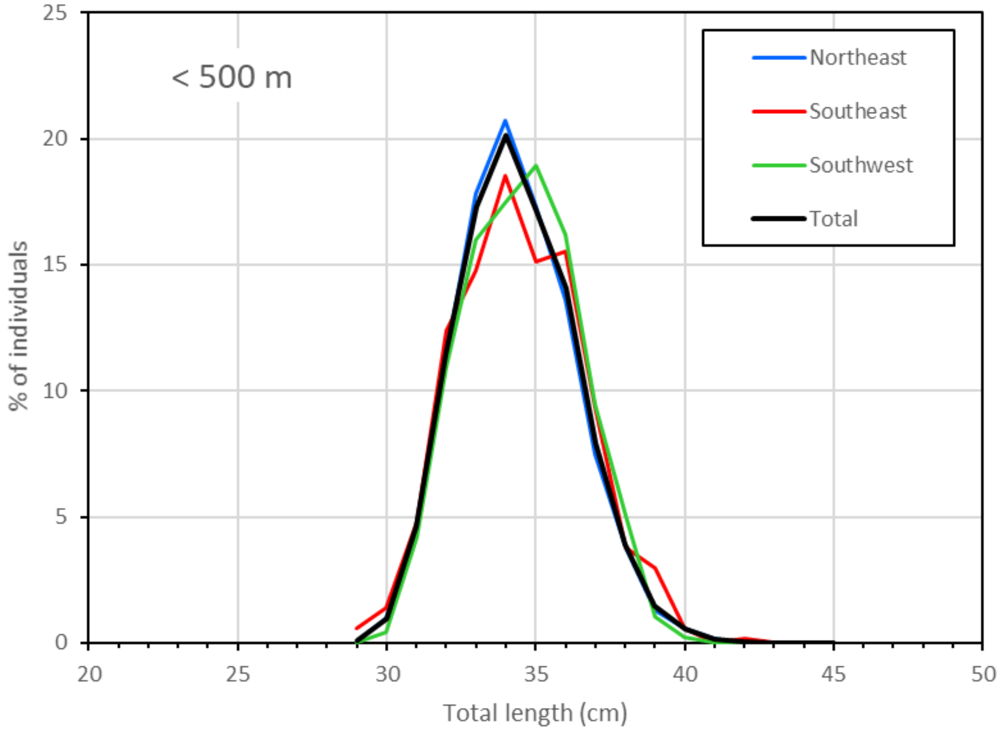


**Figure 11. Length distribution of redfish in the trawls (in % of individuals), by geographical areas (see Figure 2) and total, from fish caught shallower (<) than 500 m in 2021.**

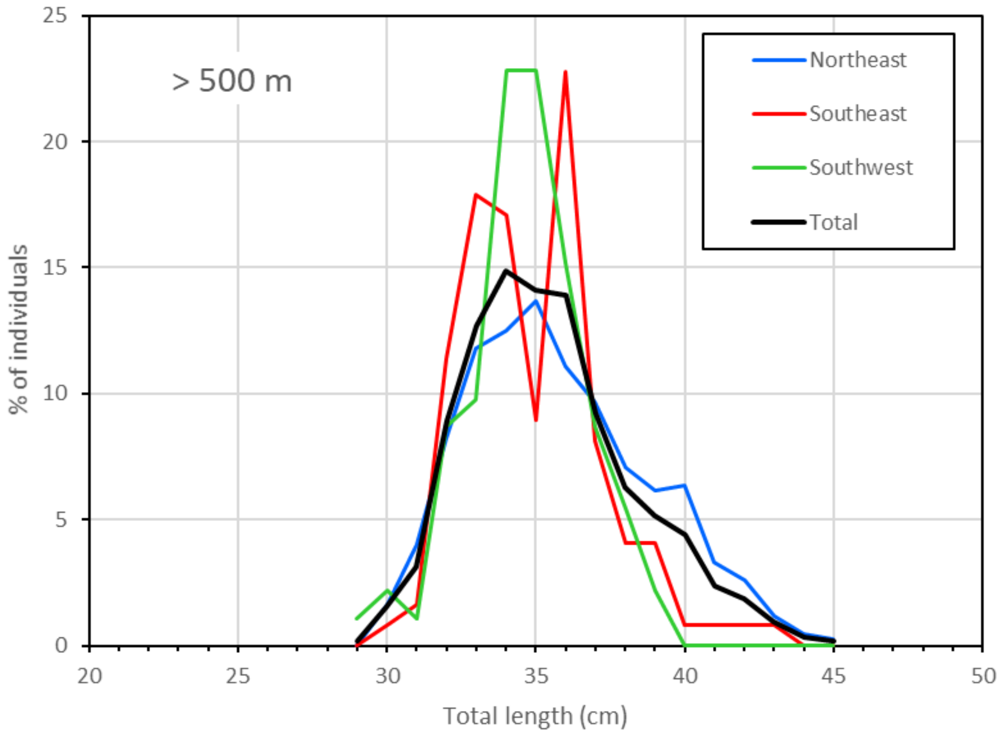


**Figure 12. Length distribution of redfish in the trawls (in % of individuals), by geographical areas (see Figure 2) and total, from fish caught deeper (>) than 500 m in 2021.**

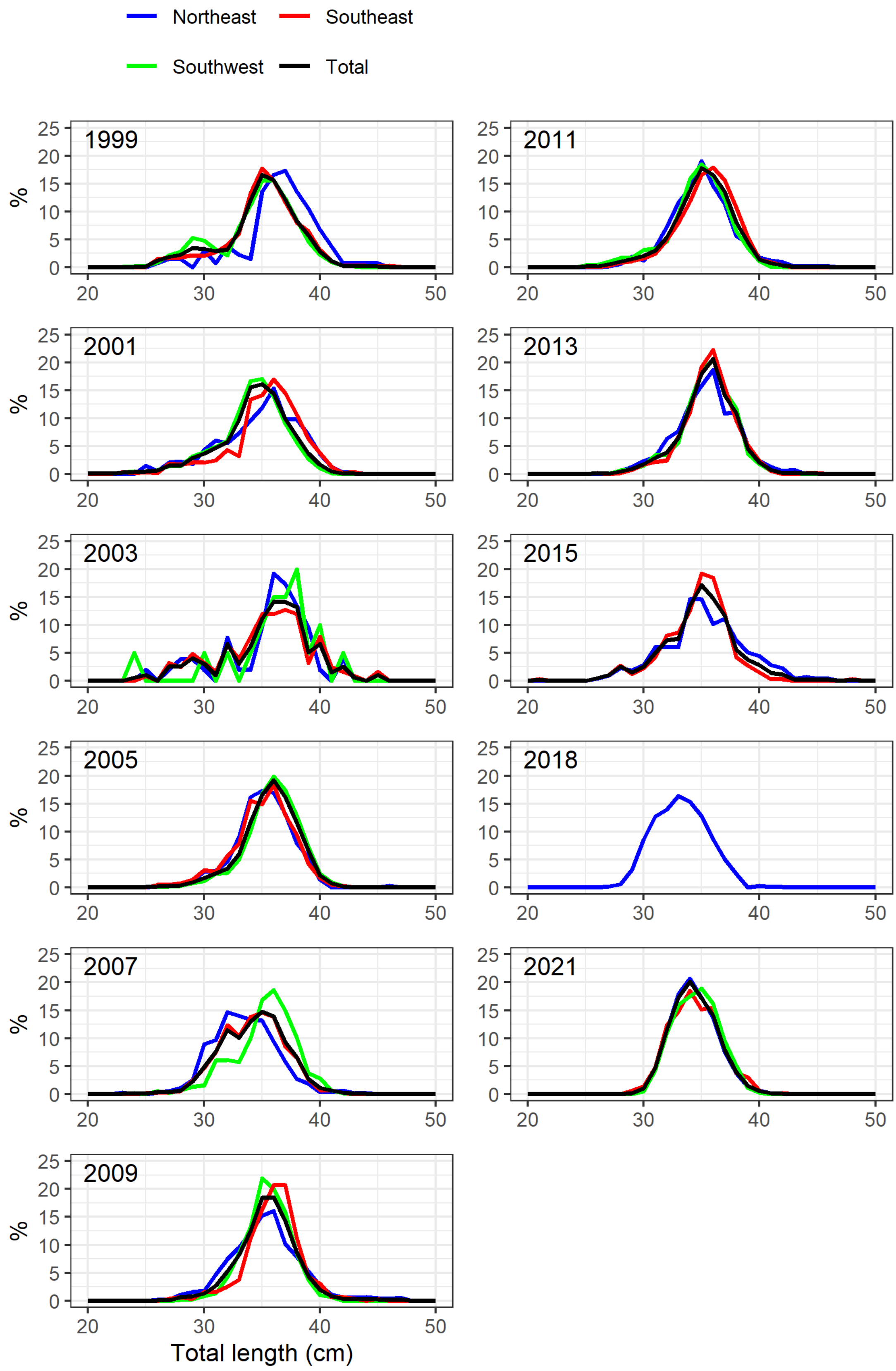


**Figure 13. Length distribution of redfish in the trawls (in % of individuals), by geographical areas (see Figure 2) and total, from fish caught shallower than 500 m 1999–2021 (in 2018, the survey only covered the northeastern area).**

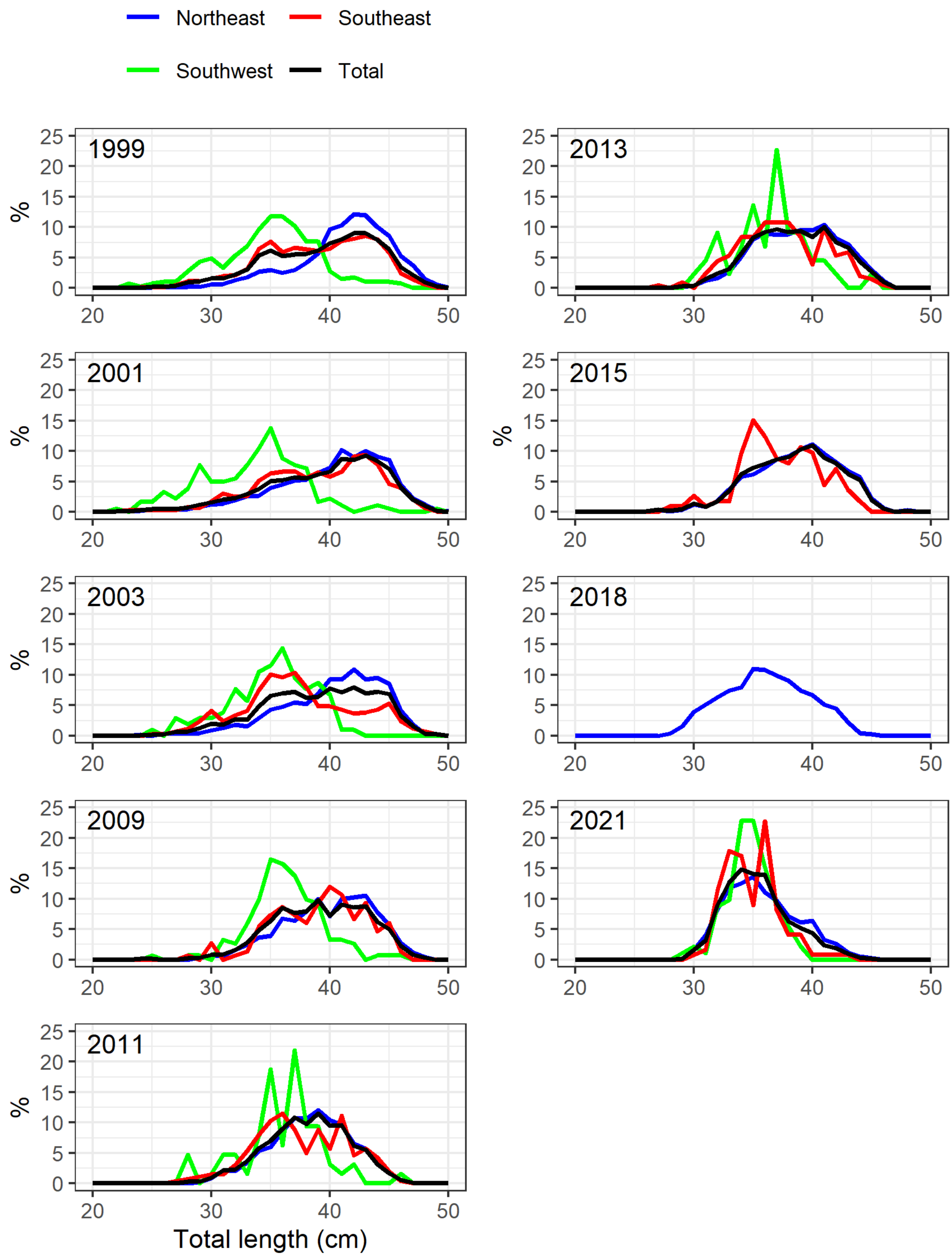


**Figure 14. Length distribution of redfish in the trawls (in % of individuals), by geographical areas (see Figure 2) and total, from fish caught deeper than 500 m 1999–2003 and 2009–2021 (in 2018, the survey only covered the northeastern area).**

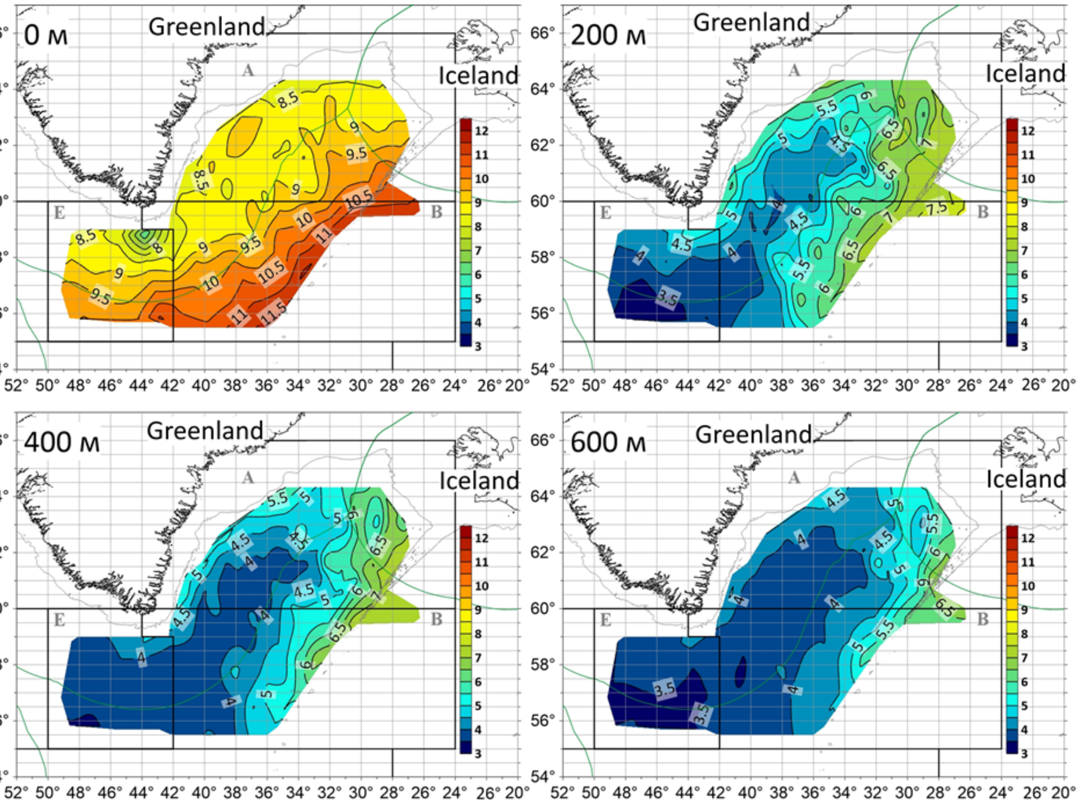


**Figure 15. Temperature distribution (°C) at different depths in the survey area of the international hydroacoustic-trawl survey on redfish in the Irminger Sea and adjacent waters in June-August 2021.**

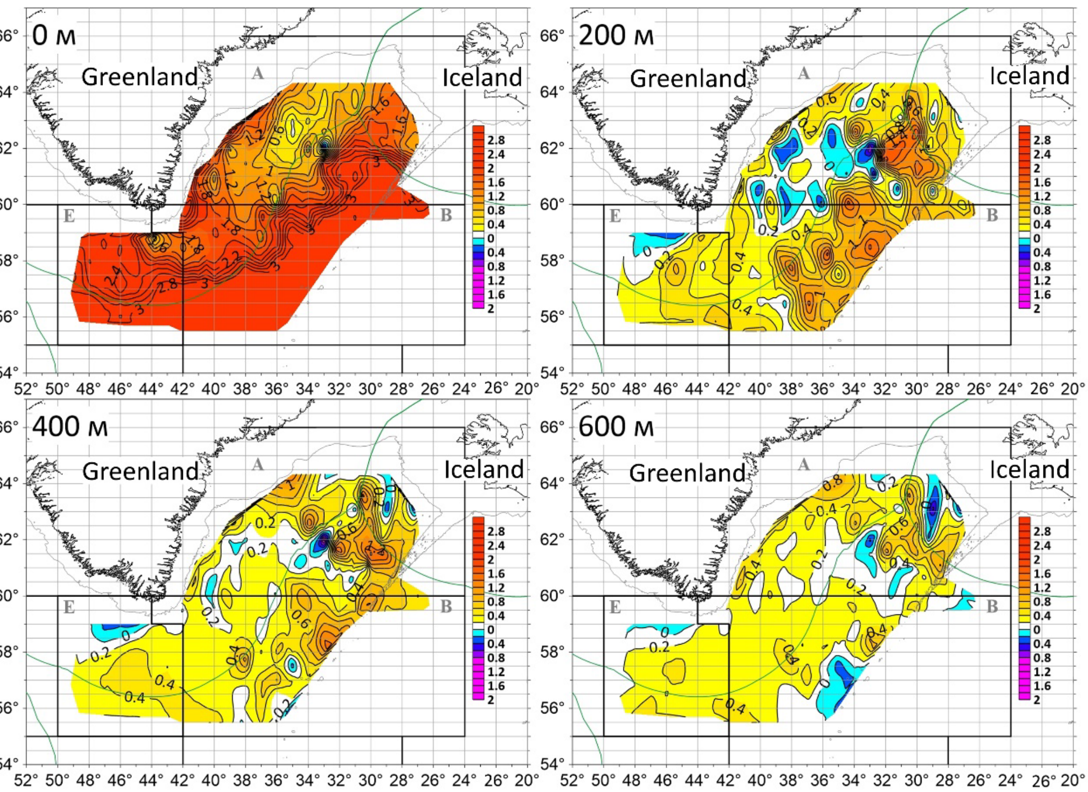


**Figure 16. Temperature (°C) anomaly at different depths in the survey area of the international hydroacoustic-trawl redfish survey on redfish in the Irminger Sea and adjacent waters in June-August 2021.**

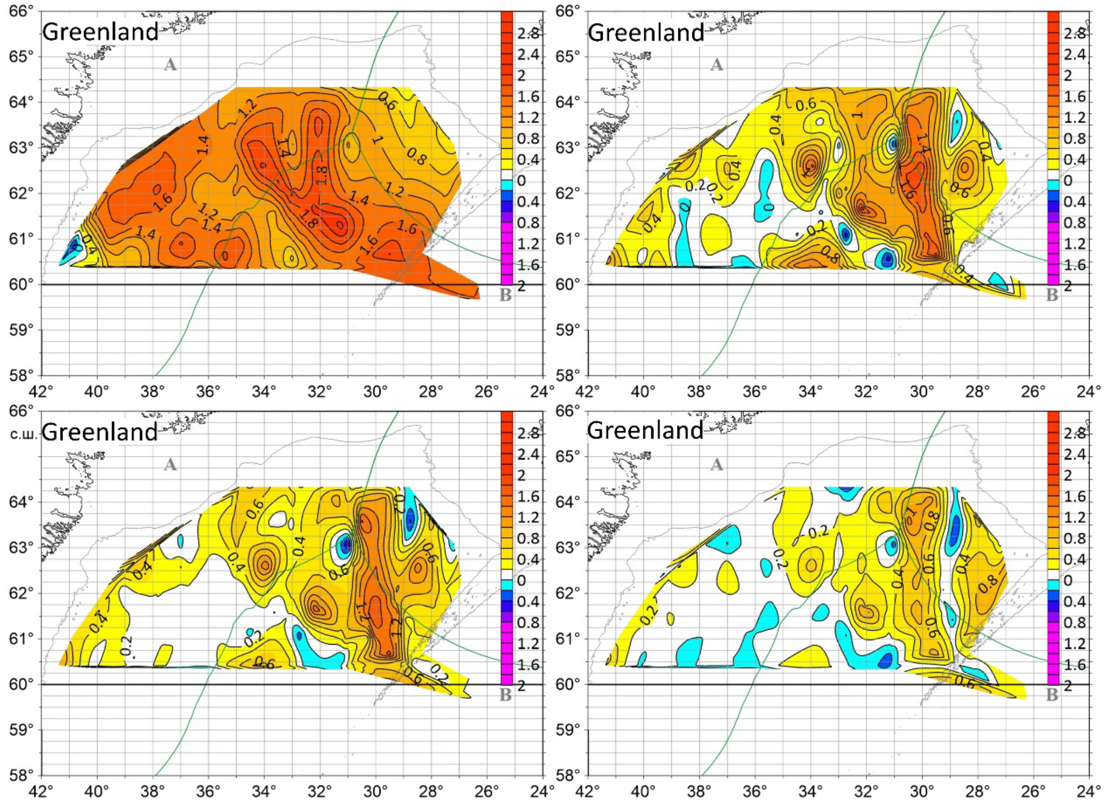


**Figure 17. Temperature (°C) anomaly between 2018 and 2021 at 0 m, 200 m, 400m, and 600 m depth in the survey area of the international hydroacoustic-trawl redfish survey on redfish in the Irminger Sea and adjacent waters in June-August 2021.**

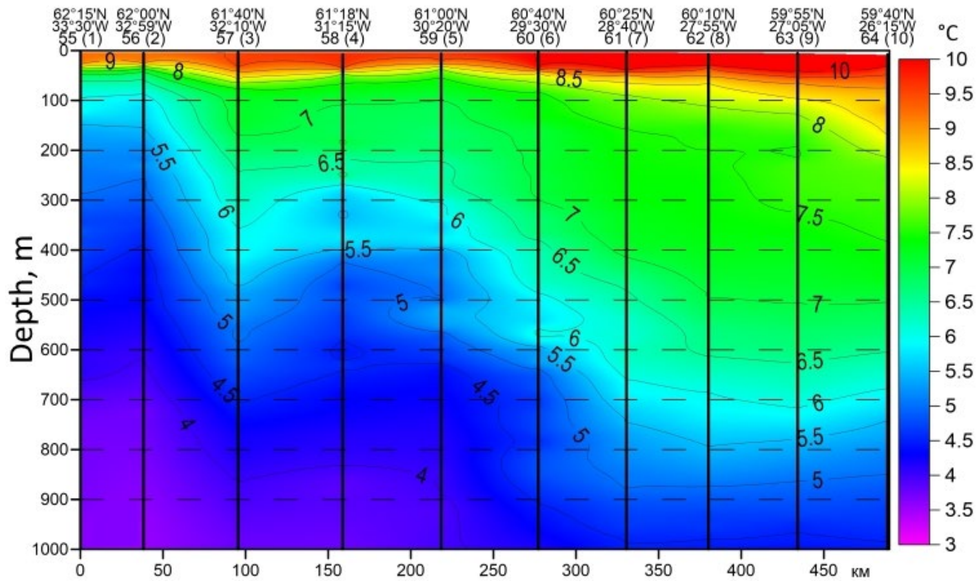


**Figure 18. Vertical temperature (°C) distribution on the 3K oceanographic section in the international hydroacoustic-trawl redfish survey on redfish in the Irminger Sea and adjacent waters in June-August 2021.**

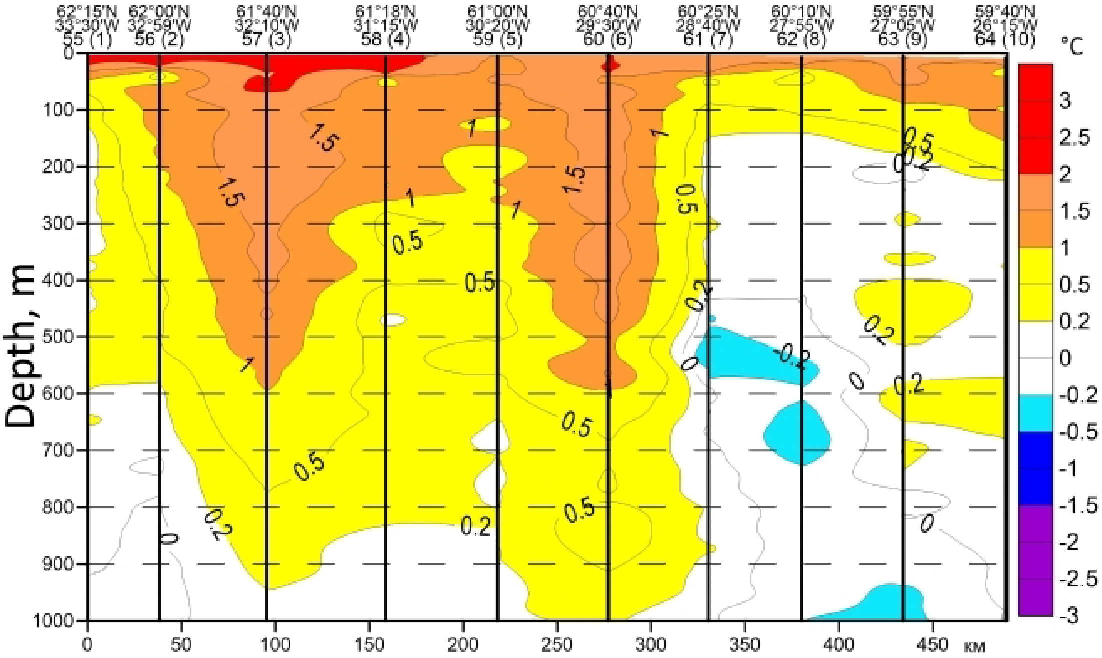


**Figure 19. Temperature (°C) anomaly between 2018 and 2021 along the section 3K in the international hydroacoustic-trawl redfish survey on redfish in the Irminger Sea and adjacent waters in June-August 2021.**

# Annex 1: List of participants

| Name | Institute | Country (of institute) |
|---|---|---|
| Alexey Astakhov | Atlantic branch ("AtlantNIRO") of the Russian Federal Research Institute of Fisheries and Oceanography "VNIRO" | Russian Federation |
| Matthias Bernreuther (co-chair) | Thünen Institute of Sea Fisheries | Germany |
| Hannes Höffle (co-chair) | Institute of Marine Research | Norway |
| Kristján Kristinsson | Marine and Freshwater Research Institute | Iceland |
| Aleksei Rolskii | Polar branch ("PINRO" named after N.M. Knipovich) of the Russian Federal Research Institute of Fisheries and Oceanography "VNIRO" | Russian Federation |

# Annex 2: Resolutions

**WGIDEEPS - Working Group on International Deep Pelagic Ecosystem Survey**

**2019/FT/EOSG04** A **Working Group on International Deep Pelagic Ecosystem Surveys** (WGIDEEPS), chaired by Hannes Höffle, Norway, and Matthias Bernreuther, Germany, will work on ToRs and generate deliverables as listed in the Table below.

| | Meeting dates | Venue | Reporting details | Comments (change in Chair, etc.) |
|---|---|---|---|---|
| Year 2020 | 25-27 August | Online Meeting | E-evaluation by 24 September 2020 to ACOM-SCICOM | Kristján Kristinsson as outgoing chair. |
| Year 2021 | 16-19 February | Online Meeting | Interim report by 15 March 2021 to ACOM-SCICOM | |
| Year 2021 | 14-16 September | Online Meeting | Interim report by 14 October 2021 to ACOM-SCICOM | |
| Year 2022 | TBD January | To be decided | Interim report by 1 March 2022 to ACOM-SCICOM | |
| Year 2022 | By correspondence | | Final report by 15 September 2022 to ACOM-SCICOM | |

**ToR descriptors**[1]

| ToR | Description | Background | Science plan codes | Duration | Expected Deliverables |
|---|---|---|---|---|---|
| a | 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. | 3.2 | Year 1 (2020) | Datras data product developed in cooperation with Data Centre and TAF |

[1] Avoid generic terms such as "Discuss" or "Consider". Aim at drafting specific and clear ToR, the delivery of which can be assessed

| | | | | | |
|---|---|---|---|---|---|
| b | Finalise transfer of trawl survey data from international deep pelagic ecosystem surveys coordinated by the group to ICES DATRAS databases | Data is now stored by individual nations/participants. ICES has committed to a fully transparent and documented quality assurance framework for all data products and assessment results derived from data collated within the ICES working groups, this un-derpins agreements with all the recipients of ICES advice. | 3.2 | Year 1 (2020) | Inclusion of data in datras |
| c | Set up a formal procedure for the use and transfer of Norwegian Sea 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. | 3.1, 3.2 | Year 1 (2020) | TAF proceedure for formally including survey data in assessments. |
| d | Coordinate 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 2021 | 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 producing reports on the survey results and outcomes. | 3.1, 3.2 | Year 2 (January meeting) | |
| e | Report on the outcome of the Irminger Sea survey | a) Support sound, credible, timely, peer-reviewed, and integrated scientific advice on fishery management and the protection of the marine environment.<br>b) Redfish indices are being used by assessment working groups. | 3.1, 3.2 | Year 2 (August meeting) | WGIDEEPS 2021 – 2 report chapter<br>1 September 2021 SCICOM |

| | | | | | |
|---|---|---|---|---|---|
| f | Coordinate the international deep pelagic ecosystem survey with special emphasis on redfish to be carried out in the Norwegian Sea and adjacent waters in August 2022 | 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. | 3.1, 3.2 | Year 3 (January meeting) | WGIDEEPS 2022 – 1 report<br>1 March 2022<br>SCICOM |
| g | Report on the outcome of the 2022 Norwegian Sea survey | a) Support sound, credible, timely, peer-reviewed, and integrated scientific advice on fishery management and the protection of the marine environment.<br>b) Redfish indices are being used by assessment working groups. | 3.1, 3.2 | Year 3 | WGIDEEPS 2022 – 2 report chapter<br>15 September 2022<br>SCICOM |

**Summary of the Work Plan**

| Year 1 | CARRY OUT TOR A-C |
|---|---|
| Year 2 | Carry out ToR d-e |
| Year 3 | Carry out ToR f-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 | Less than 12 participants (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 |
| Linkages to other committees or groups | SCICOM, WGOH, WGBIODIV, WKFAST, WGISDAA, ICES data centre |
| Linkages to other organizations | NAFO, NEAFC |