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Draft report on the Joint German/Icelandic/Norwegian/Russian Trawl-Acoustic Survey on Pelagic Redfish in the Irminger Sea and Adjacent Waters in June / July 2001

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Abstract

A trawl-acoustic survey on pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent was carried out by Germany, Iceland, Russia and Norway waters in June/July 2001. Approximately 420 000 n.m.^{2} were covered. The stock size measured with the acoustic instruments was assessed to be about 715 000 t at depths down to the deep-scattering layer or about 350 m, with redfish having a mean length of 34.6 cm. Highest concentrations of redfish were in the SW part of the area covered. In addition to the acoustic measurements, an attempt was made to estimate the redfish below the deep scattering layer. This was done by correlating catches and acoustic values at depths between 100 and 450 m. The obtained correlation was used to transfer the trawl data at greater depths to acoustic values and from there to abundance. A total of approximately 1075 thous. tonnes were estimated to be at depths between 0 and 500 m and about 1056 thous. tonnes below 500 m depth. Below 500 m, the densest concentrations were found in the NE part of the area. The average length of the fishes caught below 500 m was 39.5 cm. The estimated abundance derived from the trawl data should be treated with great caution.

Introduction

Several acoustic surveys have been conducted on the oceanic redfish in the Irminger Sea and adjacent waters. 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. Pedchenko *et al.*, 1995). The acoustic measurements were, however, not considered sufficient for stock assessment purposes (Anon. 1991).

In 1991, Iceland conducted a pilot acoustic survey (Magnússon *et al.*,1992a). The same year, Iceland and Russia decided to conduct an acoustic survey on the oceanic redfish in the Irminger Sea in 1992, in accordance with an agreement between the two countries. The results of the surveys were presented at the ICES Statutory Meeting 1992, (Magnússon *et al.*, 1992b) in a combined paper containing two separate survey reports. 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 (Anon. 1993).

In 1993, Russia conducted a survey in the Irminger Sea, in the summer time. Iceland carried out a short survey in September in the same year (Anon.1994a) with no reliable stock size estimate, since the area coverage was limited.

In 1994, Iceland and Norway carried out survey, with two vessels, covering the main distribution area down to 500 m depth (Magnússon *et al.*, 1994). Approximately 190 000 n.m.^{2} were covered, resulting in a stock size estimate of about 2.2 million tonnes 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 (Anon 1994b), that the entire area of distribution could not be covered sufficiently by only two vessels (Anon. 1993.) was supported.

In 1995, 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 tonnes and 4.1 billion individuals (Shibanov *et al*., 1996a). As the survey was only covered by one vessel, the NWWG meeting in 1996 (Anon, 1996), considered the results to be unreliable.

In 1996, 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 tonnes or 2.6 billions individuals 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, mainly within temperature range of 3.5°C to 5°C. The temperature recorded during the survey were somewhat higher than observed during previous acoustic surveys.

In 1997, Russia carried out a single vessel survey in June/July resulting in a stock estimate of 1.2 mill. tonnes down to 500 m depth (Melnikov *et al.,* 1998).

In 1999, an international acoustic survey on pelagic redfish was carried out in the Irminger Sea and adjacent waters in June/July, with participation of Iceland, Germany and Russia. The acoustically estimated biomass of the oceanic *S. mentella* in the upper 500 m of the water column was 0.6 mill. t (Anon., 1999a,b). The observed decrease in survey abundance compared with the years 1994-1996 was very drastic and exceeded the removed biomass by the fishing fleets. The area covered was the most extensive in the time series until then, but covered only a portion of the current horizontal distribution of the oceanic stock. Therefore, the estimate of 0.6 mill t was considered an underestimate. The stock above 500 m was observed more south-westerly and deeper than it has been during former acoustic surveys in this decade, and a gradual increase in temperature in the observation area has been observed. This may have influenced the distribution pattern of the redfish as the highest concentrations were found in the colder, i.e. south-western, part of the survey area.

During all of the surveys until 1999, oceanic redfish was only measured by acoustics down to approximately 500 m depth. Attempts have been made to measure below that depth, but basically without success in obtaining any stock size estimate. The reason is mainly due to a “scattering layer”, which is a mixture of many vertebrate and invertebrate species, mingled with the redfish (Magnússon, 1996).

Although several attempts have been made by Russia and Iceland to map the distribution of pelagic redfish at depths below 500 m (Anon, 1998; Anon 1999b; Sigurðsson and Reynisson, 1998), the 1999 survey provided for the first time an estimate on the abundance of the pelagic *S. mentella* (>500 m depth) in the order of 0.5 million tonnes. Hydrographic observations indicated that the highest concentrations of redfish below 500 were associated with eddies and fronts.

At the 88th ICES Statutory Meeting, it was decided (C.Res 2000/2D02) that the Planning Group on Redfish Stocks (PGRS) should meet to plan an international acoustic survey of oceanic redfish, to be carried out in the Irminger Sea and adjacent waters in June/July 2001 (ICES C.M. 2001/D:04). The main objective was a trawl-acoustic assessment of the oceanic redfish stock in the area. The basic area coverage was determined to be extended from what has previously been used and was defined in Anon (1995). As the results from the survey in 1999 indicated that the covered area did not reach the boundary of the distribution area of pelagic redfish in the acoustic layer, the PGRS felt it was necessary to expand the area both to south and west. As the fishery has also changed towards greater depths during the last years it is also considered important to continue expansion of the vertical coverage to assess the stock which is below the acoustic layer (below 500 m depth). The results of this survey are given here.

Along with the trawl and acoustic measurements since 1992, hydrographic data were obtained during all the surveys. The results indicate a relationship between the hydrography and distribution of redfish in the survey area. Shibanov *et al*. (1996b) found that the main concentration of redfish in the upper 500 m during June/July were found in the Subarctic Water mass (located in the central parts of the Irminger Sea).

During the last years, there has been a discussion on the stock structure of redfish in the Northwest Atlantic. In this report, no attempt was made to distinguish between different stocks of *S.mentella* in the survey area, as only one of the participating nations divided catches into different stocks. Therefore, reference is only made to depth.

Material and Methods

Acoustic assessment of redfish

The primary material consists of acoustic and biological data collected on pelagic redfish in the Irminger Sea. The Icelandic part of the survey was carried out by the Marine Research Institute (MRI), Reykjavík, with the research vessels Árni Friðriksson from 21 June to 12 July with 18 days in field and Bjarni Sæmundsson during the time period 18 June to 12 July with 19 days in the field. The German part was carried out by the Federal Research Centre for Fisheries, Institute for Sea Fisheries, Hamburg, with the research vessel Walther Herwig III during the time period 17 June to 10 July, with 12 days in the field. The Russian part was carried out by PINRO, the Marine Research Institute in Murmansk, with the research vessel Atlantniro in the field from 19 June to 11 July. The Norwegian research vessel G.O.Sars from the Institute of Marine Research, Bergen was in the field from 15 June-11 July for 10 days. The primary goal of the participation of G.O. Sars was to carry out special experimental work applying the upgraded and rebuilt deep towed vehicle system observing and estimating abundance of redfish deeper than 400 m (Anon 2001). Additionally, they were to acquire backscattering cross section (target strength) data at favourable redfish distributions both above and below the deep scattering layer. The data of the experimental work is not introduced here, but some of the trawl data along with the biological observation collected onboard G.O.Sars is used.

The vessels covered an area of approximately 420,000 square nautical miles within the boundaries of about 52° N to 64°30 N and 20° W to 54° W, mostly on transects 45 n.m. apart (Figure 1). The time schedule for the cruises, the distribution of the areas and the technical settings were discussed and agreed at a planning meeting in February 2001 in Bergen (Anon. 2001). However, some of the planned transects were altered and rescheduled during the survey due to different reasons.

A 38 kHz Simrad EK500 split-beam echo sounder and integrator was used for the acoustic data collection on all three ships (Bodholt *et al.*, 1989), and a BI500 post-processing system (Foote *et al.* 1991). Prior to or after the survey the acoustic equipment on all vessels was calibrated with the standard sphere method (Foote *et al.*, 1987). The settings of the acoustic equipment used during the survey are given in Table 1.

During the survey, the post-processing systems onboard all the vessels were used for scrutinising the echograms. Mean integrated values of redfish per 1 n.m. were recorded, but the average of 5 n.m. was used for the calculations.

Inter-calibration of acoustic equipment was planned between the participating vessels as circumstances would allow. On 23 June, an inter-calibration took place between Bjarni Sæmundsson and Atlantniro. The vessels sailed the same course with Atlantniro trailing Bjarni Sæmundsson at a distance of 0.5 n.m. and a 10 degrees offset. The vessel speed was 8 knots. The distance covered was 2 times 20 n.m. During the first half, a long transmitter pulse and a narrow bandwidth was used onboard Atlantniro but a medium pulse and medium bandwidth on the latter. The echo recording consisted mainly of a fairly strong layer of myctophids from about 350 m down to 650 m. In the uppermost 50 m, a layer of plankton and other small organisms was observed. Very scattered registrations of redfish were observed in the depth interval 225-350 m. The integrator values within the depth intervals 13-400 and 400-600 were used to establish a relationship between the two vessels (Figure 2). This was done according to the maximum likelihood as outlined by MacLennan and Pope (1983).

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 as well as changes in target strength. In order to compensate for these effects to some degree, it was decided to discard the acoustic data obtained during periods of the most pronounced mixing, *i.e.* during the darkest hours of the night, 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 were 45 n.m. in latitude and 1 degree in longitude. As the observed length range of the redfish in the 1999 acoustic survey had increased from previous years, a length base target strength formula of TS=20 lgL-71.3 dB was used instead of a constant TS of –40 dB (Reynisson, 1992) as has been used previously for all lengths. This equation gives same results as –40 dB does for 37 cm redfish and is also equal to a –38.3 dB /kg as has previously been used by Russia. The total number of fish within sub-areas was then obtained by summation of the individual rectangles. The sub-areas are as shown in Figure 3 (Anon. 1993), and are slightly changed from earlier years as the limits where shifted to fit the squares used and to fit the NAFO/NEAFC areas divisions. The acoustic results were further divided into numbers and biomass based on the biological samples representative for each sub-area.

For the entire survey area, single-fish echoes from redfish were expected to be detectable down to at least 200-250 m. In order to include all echoes of interest, a low integration threshold was chosen. As shown in Table 1, the integration threshold was set at -80 dB//1 m^2 / m^3 on all instruments. 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.

Earlier investigations on Walther Herwig III and on Atlantniro indicated that when using low integration threshold noise could possibly be a problem. In order to increase signal-to-noise ratio, it was decided to use the long pulse length and narrow bandwidth on the above mention vessels. The transducers was hull-mounted on all vessels

The net used on Bjarni Sæmundsson was a Gloria type #896 with a vertical opening of approximately 44 m. The net employed on Walther Herwig III was a Gloria type #1024, with a vertical opening of approximately 45 m. On Atlantniro, a Russian pelagic trawl (design PT 78.7/416) with a circumference of 416 m and a vertical opening of about 43 m was used. On Árni Friðriksson, a Gloria type #1024 with a vertical opening of about 42 m was used. There were however differences between the Gloria types used on Árni Friðriksson and Walther Herwig III as the type used by Árni Friðriksson was designed as a blue whiting type.

At the planning meeting in Bergen, in February 2001, it was decided to restrict trawling in the upper 500 m to the minimum needed for the acoustic assessment (type 1 hauls). It was also decided to take the hauls mainly during the hours of darkness when acoustic measurements are difficult (Reynisson, 1996). This was done although catches at night are generally poorer.

Experimental redfish abundance estimation

The classic method of continuous echo-integration beyond 500 m depth along survey tracks is applicable only under specific conditions, mainly because of the increased influence of the vessel's noise, as well as the mixing of redfish with various components of sound scattering layer. An additional difficulty is due to the decrease of the effective angle of the transducer beam, especially for single fish registration at high depths. This in particular, demands a lower Sv-threshold, down to (-85) – (-90) dB for correct echo-integration. For hull-mounted transducers this may cause problems with noise. Therefore, acoustic estimation of redfish with a hull mounted transducer is very difficult.

During the preparatory meeting, a Russian proposal on the experimental redfish abundance estimation at depths below 500 m was discussed (WD3 in Anon. 1999a). The method is based on a combination of standardised survey catches and the acoustic data, where the correlation between catch and acoustic values during trawling in the upper layer is used to obtain acoustic values for the lower layer, based on catches in the lower layer. To be able to make such trial, it was decided to make haul at different depth intervals, evenly distributed over the survey area.

During the survey, the vessels made a total of 88 deep trawl hauls (type 3) in the depths range 500–950 m which were relatively evenly distributed all over the survey area (Figure 1). Each trawl haul of 6 nautical miles (about 150 min duration) was taken at three depth intervals, 500-600 m, 600-750 m and 750-900 m, 2 n.m. at each depth. The catches were standardised to one nautical mile and converted into acoustic values using a linear relationship between catches and acoustic values at depth above 500 m. In addition, 44 hauls were taken inside the deep scattering layer in 2 steps, usually at around 300 m and 450 m (total of 4 n.m.- type 2 hauls).

Data for the correlation calculations were obtained during trawling only. In addition, scrutinised acoustic values were only taken from exactly the same position and depth range covered by the trawl. Acoustic data was both collected at depth range corresponding to the fishing depth and in the entire layer of redfish distribution in depth.

The regressions (geometric mean linear regressions of y=Ax+B, y=Kx and $y=Cx^D$) between acoustic values and catches recorded above 500 m, for each vessel are given in Figures 4-7.

The principle condition for the stock assessment by trawl method is to know the selectivity of each trawl used and algorithm of conversion of trawl data (catch per towed mile) to equivalent acoustic data (surface density of fish distribution in S_A units) to provide further estimation of abundance on the basis of both acoustic and trawl data using standard method for calculations of acoustic surveys.

The mean vertical opening of the trawl <dHtr> relative to which SA was estimated to be 45 m on Walther Herwig III (7 hauls), 44 m on Bjarni Sæmundson (8 tows of type 1), , 42 m on Árni Friðriksson (10 hauls) and 43 m and on Atlantniro (9 hauls).

When processing data from Atlantniro by analogy with similar works in 1999 for the convenience to estimate S_A, <dHtr> was taken equal to 50 m. Besides, when constructing the regression data were used not only from 9 tows of type 1 but also from 5 tows of type 2 and 9 tows of type 3 made on redfish concentrations against weak sound scattering layer where S_A was derived with the change of threshold at BI-500 during processing of echograms.

Calculated regression for trawls with 50 x 50 m^2 mouth, (based on calculations given in Anon 199a) is given for comparison:

$$SA=SA_{tr0} = 0.137*Catch \qquad (1),$$

corresponding to redfish target strength TS_{kg} = -38,3 dB/kg and effective trawl width L_{eff}=25 m (which is equivalent to coefficient of trawl efficiency relative to the area of trawl mouth – 50%). This is precisely the value of Leff for trawls of such type, which has been used for the most recent 15 years in trawl-acoustic surveys by PINRO vessels to estimate SA_{tr} and densities of fish concentrations by catches, to predict catches on the basis of acoustic estimates etc. by using formula as follows:

$$SA_{tr} = Catch\ (kilo/mile)*4p*(10^{0.1TSkg})*1852/L_{eff} \qquad (2).$$

As an algorithm to convert catches to the equivalent SA_{tr} it was accepted to use the linear regression SA = K* Catch or power regression $SA = C*(Catch)^D$, according to the correlation degree. These regressions are characterised by lower correlation compared to regression of Ax+B but give lesser relative error in estimation of SA_{tr} for small catches (below 10-20 kilos/mile), mainly taken during the survey.

Regression values of K for trawls of Walther Herwig-III" (Figure. 6) were very close to the theoretical K=0,137 with the satisfactory correlation:

$$SA_{WH} = 0.1322*Catch \quad (R^2 = 0.91 - 0.94) \qquad (3)$$
$$SA_{WH} = 0.4855*(Catch)^{0.6577} \quad (R^2 = 0.976) \qquad (4).$$

Data analysis from Atlantniro showed almost identical regressions between acoustic values and catches for both y=Ax+B and y=Kx types of regression (Figure. 7):

$$SA_{AT} = 0.2481*Catch +0.2201 \quad (R^2 = 0,757) \qquad (5)$$
$$SA_{AT} = 0.2568*Catch \quad (R^2 = 0,75) \qquad (6).$$

For Bjarni Sæmundsson it is possible to use both types of regression, linear or power one (Figure 5):

$$SA_{BS} = 0.2621*Catch \quad (R^2 = 0.6 - 0.8) \qquad (7)$$
$$SA_{BS} = 1.366*(Catch)^{0.5087} \quad (R^2 = 0.534) \qquad (8).$$

It is however, clear that the presence of only one haul with the catch exceeded 20 kilos per mile on Figure 5 brings essential uncertainty in the results.

As for Árni Friðriksson, the regression analysis showed almost no correlation between catches per mile and acoustic values in the fishing layer (R^2<0.1). The efficiency of tows of type 1 was also estimated very low (catches did not exceed 3,3 kilos per mile even in the southern part of the area where maximum density of redfish distribution was observed). More or less satisfactory correlation (R^2 = 0.35) was, however, found between catches and mean SA per tow for redfish distributed throughout the entire "acoustic layer", i.e. in the depth range 150-400 m:

$$SA_{TOTAL} = 5.685*Catch \qquad (9).$$

To convert the estimated SA to the thickness of fishing layer, the mean for all tows of Árni Friðriksson ratio between density of redfish distribution in the whole water column and in the fishing layer was used ($<SA_{TOTAL}/SA>=2.23$). As a result, estimated regression was accepted as follows:

$$SA_{AF} = 2.5493*Catch \qquad (10),$$

from which it is seen that trawl efficiency (at least as resulted from the studied tows of type 1) is estimated to be 20 times lower than for instance on Walther Herwig-III (equation (3), which had similar trawl).

Correlation analysis of acoustic values and catches showed that the best correlation, as a rule, is reached if acoustic values is taken for the whole water column where redfish could be detected. This could be related to fish behaviour (avoidance) in the area of trawl operation. In most tows in depth less than 500m, redfish seem to move down in front of the trawl mouth by 30-50 m. Therefore, it could be more correct to consider correlation between catches and SA_{TOTAL} (i.e. by all depths) and subsequently to choose an optimum algorithm to convert SA_{TOTAL} to acoustic SA values corresponding to the vertical opening of the trawl.

Biological and hydrographic measurements

Standard biological observations needed for the acoustic assessment were carried out, as decided at the preparatory meeting in Bergen (Anon, 2001a).

In addition, otoliths were collected and observations on external and partly muscular melanosis, parasite infestation as well as on stomach contents were recorded. Samples for studies within the EU Project REDFISH (QLK5-CT1999-01222) were also collected onboard all vessels.

On all vessels, temperature and salinity measurements were made with CTD probes, usually after each haul and at the turning points of the cruise down to 1000m depth (Figure 1). During the survey, 155 CTD stations were taken, whereof 52 were made by Atlantniro, 36 by Bjarni Sæmundsson, 25 by Árni Friðriksson and 28 by Walther Herwig III. The Russian oceanographic section (so-called 3 -K section -9 standard stations) in the Irminger Sea was included in the Joint survey programme and taken in June by G.O.Sars down to the bottom.

Results

Acoustic assessment of redfish.

The means of integrated values (m^2/nm^2) within the statistical rectangles are given in Figure 8. The average S_A value of all rectangles was about 3.2 with a standard deviation of the mean of 1.27. As can been seen in Figure 8, it is only in the SW part that the distribution area was not covered. The stock abundance estimate of oceanic redfish within the covered area of 420,000 nm^2 amounts to about 1.4 billion individuals or 715 000 tonnes. Details are given in Table 2 and Tables 4-9 where the number of fish is divided according to the proportion of males and females and the corresponding mean weight obtained from the biological samples within sub-areas.

The average depth of the deep scattering layer (DSL) and standard deviation is shown in Figure 9, combined for all vessels. As seen, the depth of the layer that redfish can be detected is, on average, only between 150 and 220 m during the nighttime but increases to its maximum of about 330 m around noon. As a consequence, the redfish is hard to detect and measure below those depths. The depth distribution of the redfish observed on Bjarni Sæmundsson and Árni Friðriksson is shown on Figure 10. With the threshold used (-80dB), the expected underestimate in the depth intervals indicated in the figure ranges from 0-28% with a weighted mean of 7%. The diurnal distribution of the acoustic values is shown in Figure 11.

The results of the acoustic inter-calibration (Figure 2) are highly dependent on the depth interval chosen and it is questionable whether the data are representative for redfish since the main scatters within the two depth intervals are either plankton or myctophids. The observed differences in the relationships between depth intervals could indicate either the variation of the local abundance of scatters or instrumental threshold effects. Our choice was therefore to depend on individual calibration of the acoustic equipment onboard each vessel.

Experimental redfish abundance estimation

Estimation of redfish distribution by the trawl method both inside and outside the sound scattering layer for all three types of tows was done by conversion of catches (Catch, kilo per mile) to equivalent acoustic estimates of density SA_{tr} with the account for regression coefficients of trawl efficiency and coefficient K_H allowing for the width of the entire depth range of redfish distribution relative to vertical opening of the trawl in each particular tow:

$$SA_{tr} = Catch*K*K_H \qquad (12),$$

In case of “layer by layer” tows in the sound scattering layer (DSL) and below (tows of type 2 and 3), K_H was defined by towing depth:

$$K_H = (H_{MAX} – H_{MIN} + dH_{TR}) / dH_{TR} \qquad (14),$$

where H_{MAX} and H_{MIN} are maximum and minimum depth of headline way during tow, and dH_{TR} is the mean vertical opening of the trawl relative to which regression coefficients K were calculated. In tows of type 3, H_{MIN} in most cases was taken 500 m, and H_{MAX} varied from 650 to 950 m. In tows of type 2 with H_{MAX} = 450 m, H_{MIN} varied from 50 to 300 m in dependence on depth of the uppermost edge of the DSL.

For “target” tows of type 1, in each of them K_H was taken as a ratio between SA for redfish in the entire “acoustic layer” above 500m (SA_{TOTAL}) and SA just in the fishing layer.

According to the results of the regression analysis, the coefficients K (formula 12) for each vessel were used:

Wather Herwig-III	: K =0.132	(tows of type 1, 2, 3)
Atlantniro	: K = 0.2568	(tows of type 1, 2, 3)
Bjarni Sæmundsson	: K = 0.2621	(tows of type 1, 2, 3)
Árni Friðriksson	: K_1= 2.5493	(tows of type 1)
Árni Friðriksson	: K_2= 0.2621	(tows of type 2 and 3)

The reason we chose two different K-coefficients for Árni Friðriksson is the following. The use of the regression coefficient K_1 for tows of type 2 and 3 leads to unreasonably high estimates of SA_{tr} (up to 200-300) which is in contradiction to the results obtained from other vessels at adjacent tracks (stations). Therefore, we make the assumption that the efficiency of the trawl used by Árni Friðriksson is likely to increase with increase in depth. For example, a comparison of results of tows by Árni Friðriksson and Bjarni Sæmundsson in the same area (in the eastern part of Subarea A) shows that catches in tows of type 3 were similar for both vessels (within 10-15 kg per mile). In this relation for tows of type 3 and 2 by Árni Friðriksson, a coefficient K_2 was taken equal to the regression coefficient of Bjarni Sæmundsson.

Figures 12 and 13 shows the redfish distribution both above and below 500 m as derived from the above mentioned method. The circles indicate units of SA_{tr}. It is clearly seen that having “normalised” the size of catches to K and K_H coefficients using formulas (12), the distribution in SA_{tr} above 500 m reflects fairly adequately the distribution of redfish obtained with the acoustic instruments. The highest catch rates below 500 m depth were in the north-eastern part of the area and decreased towards the south-western part.

Estimates of SA_{tr} by subareas were defined as arithmetical mean. Estimates of SA_{tr} for trawl stations located on “borders” of the Subareas when averaging were taken with the statistical weight of 0,5 each. Totally, there were 9 such “border” tows (1 of type 1, 3 of type 2, 5 of type 3). Tows of G.O. Sars, (except for 4 trawls of type 1 and 2), were not used when estimating the total abundance as G.O. Sars used a small mid-water trawl, which considerably differed in parameters from the trawls of the other four vessels. The four above mentioned tows in Subarea A with

0-catches of redfish were, nevertheless, included into the estimation, as they allowed to some extent to compensate for bad coverage of tows above 500 m in the north-eastern area.

After obtaining the SA_{tr} per each subarea A-F, the estimation number and biomass was calculated using the same target strength (20Log length – 71.3) as for the acoustically observed SA values. The results are given in Tables 10a and 10b, based on the data obtained when using a linear relationship between catch and acoustics. It was considered impossible to only include the data in the scattering layer as most of the hauls of type 2 were taken during dark hours, when acoustic measurements were not usable. Therefore a part of the biomass obtained with acoustic method is involved in the assessment obtained by the trawl method for the redfish inside the sound scattering layer above 500 m.

In order to obtain total redfish biomass in layers above 500 m, tows of type 1 and 2 were combined in one category. As a result, assessment of the redfish stock distributed above 500 m obtained by the trawl method constituted 1075 thou. tonnes (2 billion individuals; Table 9a). About 1060 thou. tonnes (1.4 billion individuals) were estimated to be at depths below 500m (Table 9b).

By applying a power regression between the catches and the SA values of the Icelandic vessels, the abundance above 500 m is calculated to be about 10% higher or about 1234 thou. tonnes. The abundance below 500 m is calculated to be 2177 thou. tonnes using the power regression, which is almost twice as the value obtained when using the linear relationship.

Biology and hydrographic measurements

Length and weight. In the layers shallower than 500 m, the percentage of males exceeded the females and compiled 65.9%. The proportion of females has decreased steadily within the past decade. In the layer deeper than 500 m, the sex ratio was similar (59.5% males, 40.5% females). Fish length in catches ranged from 20 to 56 cm. The mean length of redfish in the upper layer (< 500 m) was 34.4 cm and the mean weight was 546 g. In the lower layer (> 500 m), the mean length was 39.4 cm and the mean weight was 781 g. In sub-areas A and B, the mean length of redfish caught in the deeper layer was 4-5 cm higher than for redfish in the upper layer, whereas in sub-areas C, D, E and F, the sizes of redfish were similar in both layers (Tables 4-9).

The length frequencies from all trawl stations were aggregated by area and depth and scaled to abundance, both using the acoustic data as well as the trawl method. Those values are listed in Table 11 and illustrated in Figures 14-15. The peak at 35 cm of the length frequency above 500 m (Table 11a) has also been observed in previous surveys. However, there are indications of recruitment of fish smaller than 30 cm, as observed in 1999. In sub-area F, about 40% of the fish were <30cm. In the layer >500 m (Table 11b), two peaks are visible at 35 and 43cm.

Food and feeding. Analysis on feeding and food composition is given in Table 12. In both the shallower and deeper layer, a great proportion of the redfish stomachs was everted. Of those which were not everted, 83% of the investigated redfish from the upper layer had food items in the stomachs, as the proportion in the lower layer was 42%. In the upper layer, the redfish fed mostly on Amphipods, Euphausids and small squid. In the lower layer, the redfish were also eating the above mentioned prey organisms, but in addition, shrimp and small fishes were also rather dominant (Table 12).

Maturity stages. Table 13 lists the maturity stages by sex and sub-areas A-F above and below 500 m. The stages are described in the Report of the Study Group on Redfish Stocks (ICES CM 2001/D:04). The great majority of both males and females were identified as maturing (39-82 %, Stage 2 for males, Stage M for females), as expected from earlier investigations. In comparison with the 1994, 1996 and 1999 surveys, the proportion of juveniles was considerably lower for males and slightly higher for females in both depth zones. Males and females in the shallower layer were predominantly in the recovery stage, whereas in the deeper layer, males were mostly maturing and females mostly in the postspawning stage. Since some inconsistencies were observed in the maturity staging, a reliable analysis of geographical effects was not possible. Further research and training is necessary to distinguish between the different stages. Figure 16 displays the maturity ogive by sex and depth zones. In general, all fish at 39 cm length were identified as being mature. 50 % maturity is reached at around 33 cm length for both sexes. Females caught in the lower layer mature larger.

Parasite infestation. Table 14 gives results of the parasitological investigation of redfish infested by *Sphyrion lumpi*, the occurrence of pigmented patches (of red and black colour) on the fish skin, as well as of melanin in muscular tissue, implemented according to Bakay and Karasev, 2001. Preliminary analysis of the data obtained in combination with those from studying the parasite fauna of redfish indicate a single reproductive part of this species population to inhabit the Irminger Sea pelagial and adjacent area of the Labrador Sea. As in previous years, the infestation by *S. lumpi* and occurrence of pigmented patches on redfish skin was higher in females than in males throughout the whole area investigated.

On the whole, infestation by *S. lumpi* in redfish males made up 17.6% and 31.2% in females in the layer shallower than 500m. The occurrence of pigmented patches was 14.7% and 24.1%, respectively. The data derived in 2001, indicate a relatively stable occurrence of pigmented patches and melanin in muscles in fish from the upper layer of the pelagial, compared to 1999 (Anon., 1999; Sigurdsson *et al*., 1999), while the infestation by *S. lumpi* decreased to about half of the percentage observed in 1999. As for the fish inhabiting the layer below 500 m, a similar pattern is observed for them. Variability of the data characterising the occurrence of lesions in redfish is noted for the subareas surveyed. As a result of the preliminary analysis, these differences are conditioned by peculiarities of the length-age composition of catches (samples) and vertical age stratification of redfish aggregations (Table 14).

Age readings. The text table below shows the number of age determined *S. mentella*, collected on G.O.Sars in the northern part of the area. Lowest and highest age, and mean age ±1 standard error are shown. The material was grouped in two depth groups, i.e. shallower and deeper than 500 meters. It is worth noticing that the mean age of the *S. mentella* currently fished upon in the area deeper than 500 meters was 30 years. The age-length relationship is shown in Figure 17. Otoliths were collected on all vessels, but the results are not available yet.

Depth interval	Number fish age determined	Lowest age [year]	Highest age [year]	Mean age [year]	St. error [year]
Shallower than 500 m	26	8	38	22	9
Deeper than 500 m	682	8	65	30	10

Hydrographic data. A total number of 155 CTD-stations were carried out during the survey (Figure 2) measuring temperature and salinity against depth mostly down to depths of ca. 1000 m. Due to the early stage of processing of the CTD data, only temperature is included here.

The survey covers the area from the eastern side of the Reykjanes Ridge in the Iceland Basin westwards into the Irminger Sea, the eastern and central parts of the Labrador Sea south to 51°N. The oceanographic conditions of the area depend on cyclone current systems bound usually called as Subpolar Gyre (Dickson *et al.* , 1988) to the basins involved - Irminger and Labrador Seas. This current system includes the "warm" Irminger Current along the Reykjanes Ridge and west of Iceland around the Irminger Sea, the cold East and West Greenland Currents along Greenland, the cold Labrador Current in the western part of the Labrador Sea along the Canadian coast, and at last the southern boundary of the overall current system at the "warm" northern boundaries of the North Atlantic (Bersch *et al.*, 1999).

The main water masses in the upper 1000m layer in this area are :

- the warm , saline and less dense Subpolar Mode Water (SPMW), also referred to as Modified North Atlantic Water (MNAW) in the Irminger Current found at the eastern and northern boundaries of the Irminger Sea;
- the colder, fresher or less saline and denser Subarctic Water (SAW) occupying the upper layers of the central parts of Subpolar Gyre in the Irminger and Labrador Seas.
- the cold and low saline Labrador Sea Water (LSW) found in the intermediate layers within the Subpolar Gyre far to the southeast and southwest of Cape Farewell. It spreads at 600-2000m depth both eastwards and southwards into the Irminger Sea as well as into the Iceland Basin east of the Reykjanes Ridge.
- the warmer, saline and less dense North Atlantic Central Water (NACW) which is associated with the North Atlantic Current, in the south of the study area.

The present oceanographic conditions observed during the survey are illustrated by the horizontal distribution (Figures 18-20) and vertical sections (Figures 21-26) of temperature. The general temperature distribution in July

2001 in the Irminger and Labrador Seas at 200m depth are from 7-8 °C in the East over the Reykjanes Ridge to 5 °C east of Greenland and below 3.5 °C in the Labrador Sea. Also the horizontal temperature distribution reveals the presence of a number of eddies in the survey area. Furthermore, a general heating-up at the surface to 9-11 °C was observed.

During the survey, the highest concentrations of acoustically measured pelagic redfish at depths less than 500 m were found in the Subarctic Water, south of Cape Farewell between 52 and 58° N and associated with temperatures of around 3.3 to 5.4°C (see Figures 18 and 19).

Below 500 m depth, the conditions were more complex. However, the hydrographic observations indicated that the highest concentrations of redfish were associated with eddy activity and fronts in the northern part of the area with temperatures around 3.1-5.8°C (see Figure 20).

Discussion

Acoustic assessment of redfish

The survey seems to cover horizontally most of the distribution area, but over 420,000 square nautical miles were covered, which is the most extensive acoustic estimation of redfish in the Irminger Sea and adjacent waters so far. The boundaries of the horizontal distribution were more or less reached in all directions except in the southwestern part. Compared with earlier investigations at this time of year (Magnusson *et al.*, 1994, 1996; Anon 1999a), the redfish were more westerly (and south-westerly) distributed.

The present results show that in sub-area A, where the highest concentration of redfish was observed prior to 1999, the biomass recorded was similar as in 1999 which is only about 10% of measured abundance in 1994 and 1996. In sub-area B, also as in 1999, less than 30% of the 1994 and 1996 value is measured. In sub-area E, south-west of Cape Farewell, the abundance was lower than in previous years and was only about 45% of the maximum in 1994. In areas C, D and F, the coverage has never been as extensive as now and the acoustic abundance is higher than ever observed. In sub-area D, the abundance now is more than 4 times the value in 1994 and 5-6 times the abundance in 1996 and 1999.

Even though discarding the acoustic data obtained during the times of the most pronounced mixing with the scattering layer, the diurnal variation of the integration values was evident. In Figure 11 the mean normalised redfish integrator values during this survey, averaged over every two hours of the day are shown. During night time (*i.e.* from about 22:00-08:00 GMT), the integration values usually decrease. Compared with the surveys in 1994-1996 (Magnússon *et al.,* 1994, Magnússon *et al.,* 1996) this is, however, not as pronounced now as it has been.

The mixing with the deep scattering layer will certainly affect the results. The observed depth distribution of the redfish in this survey was similar to the observed distribution in 1996 and in 1999 (Magnússon *et al.*, 1996, Anon 1999). However, the last surveys do show a deeper distribution compared with the international surveys conducted in 1992, and 1994 (Magnússon *et al.*, 1992a,b and Magnússon *et al*., 1994, 1996). Whether this indicates that the acoustic measurements of the oceanic redfish were in general more affected by mixing with the scattering layer this year as compared to earlier surveys is difficult to reveal. When trawling within the deep scattering layer down to 500 m, i.e. in the layer where redfish could not be distinguished from other scatters (type 2 hauls on Figure 1), the catches were often relatively high in areas where acoustically measured abundance was relatively high (Figures 8 and 13). Furthermore, in areas of low acoustic values, i.e. in the north-eastern part the catches were low. This supports the idea of the pelagic redfish mixing with the scattering layer. It is however difficult to speculate whether this was also the case or not in the former surveys, as in previous years hauls were infrequently taken in the scattering layer.

Since 1994, the results of the acoustic estimate indicate a drastic decreasing trend (Table 3). In the same period, the total catch has been about 800 000 tonnes, at the same time as the acoustically measured abundance estimate has decreased by about 1.5 million tonnes. However, it should not be excluded that the results form earlier years might have been an overestimation of the abundance. During the same period, the fishery has also developed towards greater depth and towards bigger fish and in recent years the majority of the catch has been caught at depths below 500 m. (Anon. 2001b).

During the survey, the acoustic data obtained was scrutinised down to 800-1000 m. Redfish was detected with the acoustic equipment down to about 900 m, but the density was very low and it was often very difficult to distinguish the redfish from other scatterers. During this survey, the redfish occurred in and below the deep scattering layer of meso-pelagic organisms. Due to the uncertainty in distinguishing between redfish and other organism below 500 m, as well as a poor S/N-ratio, a reliable estimate of redfish abundance below 500 m by acoustic means has been considered impossible with the equipment used. The preliminary results using the towed transducer (G.O.Sars) indicate that using a transducer lowered into the scattering layer might improve the technique of measuring redfish acoustically. The results are, however, not worked up yet.

Experimental redfish abundance estimation

During Russian trawl – acoustic surveys in 1995 and 1997 attempts were made to assess the redfish stock at depth lower than 500 m. According to an expert estimation in 1995 the stock constituted nearly 800 000 tonnes (unpublished data) and in 1997 it was estimated to be 500,000 tonnes (unpublished data). In the joint survey in 1999 (Anon, 1999) attempt was made to estimate the abundance below 500 based on similar method as presented here. It was estimated that about 500 000 could be below 500 m depth with a high degree of uncertainty. The estimate given here (Tables 9 and 10) based on the experimental calculations both above and below 500 m depth, must just be considered as an attempt to measure the abundance in and below the acoustic layer as the applicability of the applied method can only be verified after replicate measurements. The uncertainty in the results are great and for instance by changing the regression type used for converting the catch to acoustic values changes the results below 500 m by a factor of 2.

Based on the trawl data below 500 m, one can see that although the catch rates are usually low, the distribution area of the redfish at those depths is very large and exceeds the distribution area of the redfish above 500 m. It is clear, and should be kept in mind, that all the assumptions made in the calculation of the abundance make the calculations unreliable.

Furthermore, the relatively poor fit between the observed catches and acoustic values above 500 m (type 1 hauls) for some vessels (on which the trawl estimation is based), decreases the reliability of the results given. There might be several reasons for this poor fit, but for Árni Friðriksson, which gave the worst fit, investigations are taking place to verify if the trawl used is suitable for redfish investigations. It is therefore strongly recommended to interpret the magnitude of the redfish abundance obtained with the trawl method with great care.

The way the total biomass estimate by the trawl method above 500 m is derived, it is not possible to combine the acoustic results with the trawl results, both due to behavioural factors such as avoidance, but also due to the design of the trawl hauls. SA estimates for redfish obtained at night time, when the major part of fish is “disguised” in the sound scattering layer, which is rising almost up to the surface, are essentially underestimated. Therefore, night estimates of acoustic values are interpolated to the nearby estimates obtained in the morning and evening hours. At the same time, this portion of the redfish biomass is estimated by the trawl method based on tows of type 2 conducted at night.

Biology and hydrographic measurements

The observed length distribution pattern of pelagic redfish in the shallower layer (150-450m) of the surveyed area is similar to previous surveys. As in 1999, a considerable proportion of fish <30cm was found, mainly in the western and southwestern part of the area (sub-areas E & F). In sub-area E, a small peak around 30-31cm indicates further recruitment of redfish, probably belonging to the recruiting redfish observed in 1999 around 28-29 cm which are thought to have migrated from the East Greenland shelf (Stransky, 2000). This would also imply slower growth of these redfish (around 1cm/year) in the pelagic environment, compared to the growth observed for demersal *S. mentella* (around 2cm/year; *e.g.* Magnússon *et al.* 1988). This might also be due to reaching maturity. In sub-area F, representing the southwest corner of the survey area, about one fourth of the fish were 27-29 cm. It is unclear, from which area these fish recruit. In the layer >500 m, the observed two peaks in the length distribution is due to an area effect, since a large proportion of smaller fish was found in sub-areas D and E.

The overall picture from the maturity, stomach and parasite data is that redfish inhabiting the layer shallower than 500m do not differ significantly from redfish found deeper than 500m. The results are similar to earlier observations

(Bakay, 1999; Bogovski and Bakay, 1989; Magnusson *et al*., 1992; Magnusson *et al*., 1996).

As stated in the report from 1999 (Anon 1999b), hydrographic conditions in the survey area had undergone pronounced changes (e.g. Pedchenko 1997, Bersch *et al*. 1999, Mortensen and Valdimarsson 1999; Pedchenko, 2000). These changes were revealed in reports from joint surveys in 1994, 1996 to 1999 and consisted in a gradual warming over the most part of the Irminger Sea. The progress of the heating can be followed at 200m depth as a southwestwards gradual withdrawal of the 3.5 and 4.0 °C isotherms out of the Irminger Sea between 1996 and 1999 (see Figure 26). The heating tendency was also reflected in the vertical temperature distribution (Figures 21-25). The conditions in July 2001 survey were quite similar to the situation in 1999, but with slightly higher temperatures in the eastern and central parts of the Irminger Sea.

Analysis of the results from the surveys in last decade and oceanographic conditions during the same period, allows following conclusions:

Strong positive anomalies of temperature observed in the upper layer of the Irminger Sea with a maximum in 1998, are related to an overall warming of North Atlantic waters in 1994-1999. These changes were also observed in the Irminger Current off Iceland (Malmberg *et al*., 2000) and in the Labrador Sea (Mortensen, 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 WGOH STATUS REPORT 2001).

Warming-up of the 0-200m layer also had an effect on the distribution of redfish aggregations. With a temperature rise, major aggregations shifted to the south and southwest and the distribution depth increased from year to year, which probably was the main reason for a considerable underestimation of the redfish stock in the upper 500m layer in 1999 in comparison with TAS results in 1994 and 1996.

The results of the survey in June-July 2001 proved the conclusions (Pedchenko *et al*., 1997; Pedchenko, 2000) that feeding aggregations of mature redfish were distributed within the Subpolar Gyre and their location depended on the dynamics and structure of waters.

Temperature conditions in the upper layers of the Irminger Sea in July 2001 were similar to or even slightly warmer than those observed in July 1999, being thus the warmest for the period 1994-2001. That indicates a relatively strong Irminger Current ("warm and high saline") and a weak input of Labrador Sea Water ("cold and low saline") in the Irminger Sea.

Concluding Remarks

A total of about 715.000 t redfish was measured acoustically above 500 m. It is clear that there has been a significant downward trend in the acoustically measured stock size estimate since 1994. Of the observed abundance, 47% was within NEAFC area and 53% in the NAFO area (Table 15).

The observed decrease in acoustic abundance since 1994 is very drastic and exceeds the removed biomass by a factor of 2.

Redfish is mixed with the scattering layer.

The stock above 500 m is now observed more south-westerly and deeper than it was prior to 1999. Gradual increase in temperature in the survey area has been observed from 1994-1999 and the temperature in 2001is similar to the situation in 1999. This may have influenced the distribution pattern of the redfish in June -July 2001 as the highest concentration was found in the colder part of the survey area.

Based on the trawl method, About 1 057 thous. t were estimated below 500 m using a linear relationship between catch and acoustic values. Using power relationship, the abundance is double. Based on the results given in this report the authors want to stress that the abundance estimate given, must be considered as highly uncertain, and is only given here as a very rough indicator of the abundance. Of the estimated abundance, 84% was within NEAFC area and 16% in the NAFO area (Table 15).

Based on the trawl method, About 1 075 thous. t were estimated above 500 m using a linear relationship between catch and acoustic values. Based on the results given in this report the authors want to stress that the abundance estimate given, must be considered as highly uncertain, and is only given here as a very rough indicator of the abundance. Furthermore, it is not possible to combine these results with the results obtained with the acoustic instruments. Of the estimated abundance, 36% was within NEAFC area and 64% in the NAFO area (Table 15).

It is not possible to combine the results from the acoustics and the results from the trawl method.

Below 500 m depth, the hydrographic observations indicate that the highest concentrations of redfish are associated with eddies and fronts.

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Table 1. Instrument settings of the acoustic equipment onboard the participating vessels. The sound speed value is approximate for the prevailing hydrographic condition in the survey area.

Vessel	Bjarni Sæmundsson	Atlantniro	Árni Friðriksson	G.O. Sars	Walther Herwig III
Echo sounder/ integrator	Simrad EK500 /BI500	Simrad EK500 /BI500	Simrad EK500 /BI500	Simrad EK60 /BEI500	Simrad EK500 /BI500
Frequency	38 kHz	38 kHz	38 kHz	multi	38kHz
Transmission power	2000 W	2000 W	2000 W	1000 W	2000 W
Absorption coefficient	10 dB/km	10dB/km	10 dB/km	10 dB/km	10dB/km
Pulselength	1.0 ms	1.0 ms (3.0 ms)	1.0 ms	multi	3.0 ms
Bandwidth	Wide	Wide (Narrow)	Wide	multi	Narrow
Transducer type	ES38-B	ES 38-B	ES38-B	multi	ES38-B
2-way beam angle	-20.6 dB	-21.2	-20.9 dB	multi	-20.9
Integration threshold	-80 dB//m3	-80 dB//m3(-84)	-80 dB//m3		-80 dB//m3
Sound speed	1470m/s	1470m/s	1470m/s	1470m/s	1470m/s

Table 2. Results of the acoustic abundance computation (in numbers *1000 and in ´000 tonnes) and area coverage for redfish at depths down to 500 m for each sub-area.

	Sub-Area							
	A	B	C	D	E	F	Total	Unit
Area coverage	126179	106502	25616	76052	52840	34481	421671	nm^2
No of fishes	168068	402917	49947	511538	220545	17383	1370399	´000
Abundance	88	220	30	267	103	7	716	Thous.tonnes

Table 3. Results (biomass in ´000 t) for the international surveys conducted in 1994, 1996 and 1999.

	Sub-area					
Year	A	B	C	D	E	Total
1994	673	1228	-	63	226	2190
1996	639	749	-	33	155	1576
1999	72	317	16	42	167	614

Table 4a. Redfish trawl data < 500m. Sub-Area A. Mean weight by length.

Length (cm)	Males		Females		Total	
	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
25	187	4	199	2	191	6
26	235	2			235	2
27	241	3	222	5	229	8
28	236	4	258	5	248	9
29	283	6	303	1	286	7
30	316	8	324	9	321	17
31	348	19	331	5	344	24
32	397	15	392	7	396	22
33	438	16	425	13	432	29
34	493	32	455	6	487	38
35	542	37	491	10	531	47
36	569	45	563	16	567	61
37	631	24	545	15	598	39
38	681	25	659	14	673	39
39	734	12	722	16	727	28
40	775	5	744	9	755	14
41	838	4	723	1	815	5
42			872	1	872	1
43			965	1	965	1
Total number		261		136		397
Avg. weight	522		521		522	
Avg. length	34.6		35.0		34.7	

Table 4b. Redfish trawl data > 500m. Sub-Area A. Mean weight by length.

Length (cm)	Males		Females		Total	
	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
22	130	1			130	1
23	134	1			134	1
24	167	2	152	1	162	3
25	183	2	184	7	184	9
26	199	1	209	6	207	7
27	238	3	232	5	235	8
28	272	4	251	6	259	10
29	276	9	278	9	277	18
30	307	12	319	13	313	25
31	366	16	334	13	352	29
32	375	21	377	20	376	41
33	423	35	430	20	425	55
34	460	42	462	16	460	58
35	507	60	513	23	509	83
36	545	60	546	35	545	95
37	600	70	599	40	600	110
38	664	66	666	49	665	115
39	720	105	704	32	716	137
40	798	108	784	48	794	156
41	839	132	864	85	849	217
42	914	112	920	82	916	194
43	971	112	987	99	978	211
44	1026	97	1058	98	1042	195
45	1107	85	1126	91	1117	176
46	1126	44	1198	45	1162	89
47	1214	26	1246	21	1228	47
48	1294	10	1316	15	1307	25
49	1313	1	1363	3	1350	4
50			1327	1	1327	1
56	1250	1			1250	1
Total number		1238		883		2121
Avg. weight	791		844		813	
Avg. length	39.9		40.4		40.1	

Table 5a. Redfish trawl data < 500m. Sub-Area B. Mean weight by length.

Length (cm)	Males		Females		Total	
	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
23	165	1	135	1	150	2
24	168	1			168	1
25	187	2			187	2
26	210	1			210	1
27	228	1	245	6	243	7
28	271	6	275	2	272	8
29	307	6	311	5	309	11
30	333	5	326	6	329	11
31	368	9	383	4	373	13
32	401	11	387	8	395	19
33	447	12	412	3	440	15
34	501	60	508	5	502	65
35	540	47	526	18	536	65
36	596	56	578	19	591	75
37	640	38	627	32	634	70
38	661	19	667	28	665	47
39	713	9	730	21	725	30
40	756	5	780	9	771	14
41	806	1	863	4	851	5
42			751	1	751	1
43			960	2	960	2
Total number		290		174		464
Avg. weight	538		585		555	
Avg. length	34.8		35.9		35.2	

Table 5b. Redfish trawl data > 500m. Sub-Area B. Mean weight by length.

Length (cm)	Males		Females		Total	
	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
23	145	1			145	1
24	158	1			158	1
25						
26			190	2	190	2
27	244	2	235	3	238	5
28	268	5	236	2	259	7
29	292	4	259	1	286	5
30	301	5	319	7	312	12
31	344	10	368	13	358	23
32	394	9	379	11	386	20
33	432	11	430	10	431	21
34	474	30	451	7	469	37
35	513	33	519	15	515	48
36	563	40	555	13	561	53
37	606	30	595	17	602	47
38	673	23	666	18	670	41
39	722	36	691	10	715	46
40	797	28	797	17	797	45
41	838	34	852	14	842	48
42	924	44	944	24	931	68
43	990	39	992	32	991	71
44	1083	31	1094	25	1088	56
45	1145	18	1209	17	1176	35
46	1200	13	1206	16	1203	29
47	1202	8	1244	5	1218	13
48	1261	1	1338	4	1323	5
49	1321	1			1321	1
Total number		457		283		740
Avg. weight	748		788		764	
Avg. length	38.9		39.3		39.0	

Table 6a. Redfish trawl data < 500m. Sub-Area C. Mean weight by length.

	Males		Females		Total	
Length (cm)	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
32	405	2	383	1	397	3
33						
34	458	6	442	1	455	7
35	527	6	538	3	530	9
36	416	4	554	5	492	9
37	634	3	632	5	633	8
38	670	3	651	6	657	9
39	740	1	685	2	703	3
40	757	1	762	3	761	4
41			824	2	824	2
Total number		26		28		54
Avg. weight	530		628		581	
Avg. length	35.6		37.3		36.5	

Table 6b. Redfish trawl data > 500m. Sub-Area C. Mean weight by length.

	Males		Females		Total	
Length (cm)	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
26			286	1		
27						
28						
29						
30	434	1			434	1
31						
32						
33	429	1			429	1
34	490	4			490	4
35	524	2	594	1	547	3
36	612	2	565	3	584	5
37			629	4	629	4
38	676	1	612	1	644	2
39	679	2	746	2	713	4
40			826	1	826	1
41	854	1			854	1
42	887	1			887	1
43						
44	1078	3			1078	3
45						
46						
47			1346	2	1346	2
Total number		18		15		33
Avg. weight	672		714		691	
Avg. length	37.3		37.8		37.5	

Table 7a. Redfish trawl data < 500m. Sub-Area D. Mean weight by length.

Length (cm)	Males		Females		Total	
	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
23						
24	195	1	216	1	206	2
25						
26	260	1			260	1
27	288	5	275	3	283	8
28	303	4	323	3	312	7
29	335	15	328	17	332	32
30	374	28	362	14	370	42
31	415	40	405	25	411	65
32	457	75	459	21	457	96
33	497	176	520	26	500	202
34	540	238	565	60	545	298
35	582	239	608	81	588	320
36	634	151	641	99	637	250
37	689	96	687	84	688	180
38	745	57	741	54	743	111
39	782	20	792	31	788	51
40	870	9	900	12	887	21
41	893	1	964	3	946	4
Total number		1156		534		1690
Avg. weight	565		615		581	
Avg. length	34.4		35.2		34.7	

Table 7b. Redfish trawl data > 500m. Sub-Area D. Mean weight by length.

Length (cm)	Males		Females		Total	
	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
25			202	1	202	1
26	244	1			244	1
27						
28						
29	323	1			323	1
30	366	2			366	2
31	372	1	440	1	406	2
32	477	2	498	1	484	3
33	493	2	481	2	487	4
34	516	4	526	1	518	5
35	583	7	588	4	585	11
36	640	2	656	3	649	5
37	709	2	670	3	686	5
38	736	2	707	2	721	4
39	767	1			767	1
40	795	1			795	1
41			909	2	909	2
42						
43						
44	959	1			959	1
Total number		29		20		49
Avg. weight	567		609		584	
Avg. length	34.6		35.3		34.8	

Table 8a. Redfish trawl data < 500m. Sub-Area E. Mean weight by length.

Length (cm)	Males		Females		Total	
	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
21			116	1	116	1
22						
23	162	3	163	1	162	4
24	192	3	176	6	181	9
25	193	2	210	3	203	5
26	221	6	219	11	220	17
27	251	10	237	10	244	20
28	280	15	280	12	280	27
29	308	26	297	19	303	45
30	347	26	343	34	345	60
31	383	33	384	27	383	60
32	427	42	410	15	422	57
33	482	70	474	21	480	91
34	522	93	527	36	524	129
35	555	81	588	39	565	120
36	615	74	610	40	613	114
37	690	37	673	20	684	57
38	707	28	697	14	704	42
39	773	10	741	10	757	20
40			801	5	801	5
41			903	2	903	2
Total number		559		326		885
Avg. weight	506		480		497	
Avg. length	33.5		32.9		33.3	

Table 8b. Redfish trawl data > 500m. Sub-Area E. Mean weight by length.

Length (cm)	Males		Females		Total	
	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
22	120	1	133	1	127	2
23	171	1			171	1
24	170	1	212	1	191	2
25	204	1	202	2	202	3
26	207	2			207	2
27	226	1	239	1	232	2
28	260	3			260	3
29	299	8	312	2	302	10
30	328	3	348	3	338	6
31			352	3	352	3
32	426	4	391	3	411	7
33	481	5	469	2	478	7
34	517	8	514	2	516	10
35	537	9	586	2	546	11
36	613	7	593	2	608	9
37	648	6	579	1	638	7
38	697	3	666	4	679	7
39			764	1	764	1
40	855	1	790	2	811	3
41						
42						
43						
44	1092	1			1092	1
45	1360	1			1360	1
Total number		66		32		98
Avg. weight	487		462		479	
Avg. length	33.0		32.6		32.9	

Table 9a. Redfish trawl data < 500m. Sub-Area F. Mean weight by length.

Length (cm)	Males		Females		Total	
	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
20			92	1	92	1
21			121	1	121	1
22						
23	165	1	147	2	153	3
24	165	2			165	2
25	188	3			188	3
26	221	3			221	3
27	242	5	230	3	238	8
28	261	3	271	1	264	4
29	297	5	291	2	295	7
30	330	1	340	1	335	2
31	356	3	376	1	361	4
32	380	2	410	2	395	4
33	468	3	402	2	441	5
34	515	10			515	10
35	542	3	515	1	535	4
36	575	5	555	1	572	6
37	681	5	658	2	674	7
38	665	1			665	1
39	695	2			695	2
40	860	3			860	3
Total number		60		20		80
Avg. weight	441		339		415	
Avg. length	32.0		29.5		31.4	

Table 9b. Redfish trawl data > 500m. Sub-Area F. Mean weight by length.

Length (cm)	Males		Females		Total	
	Weight (g)	Numbers	Weight (g)	Numbers	Weight (g)	Numbers
24	151	1	171	1	161	2
25			175	1	175	1
26	228	2	253	1	236	3
27	238	2			238	2
28	265	2	263	2	264	4
29	300	1	283	2	289	3
30	305	1			305	1
31	363	3	393	1	370	4
32						
33	473	2	490	1	479	3
34	528	1	503	1	516	2
35	572	2			572	2
36	593	1			593	1
37	665	2			665	2
38			744	2	744	2
39	734	1			734	1
40						
41						
42						
43	952	1			952	1
44						
45						
46						
47						
48						
49	1068	1			1068	1
Total number		23		12		35
Avg. weight	461		380		433	
Avg. length	32.6		30.3		31.8	

Table 10a. Results from experimental estimation of redfish between 0 and 500 m.

The Redfish Abundance Estimation Results by the Trawl Method at the Depthes above 500 m (Trawlings type 1 and 2).
(TS = 20LgL - 71.3)

Subarea	Area, sq.nm	Number of Trawlings	Mean SAtr, sq.m/sq.nm	Mean Length, cm	Mean Weight, g	Abundance, 10^6 sp	Biomass, 10^3 tonn
A	80982	20	2.17	34.57	530.4	157.61	83.59
B	103579	23	5.63	35.26	555.5	503.24	279.54
C	8464	2	6.60	36.54	591.7	44.92	26.58
D	62897	13	14.44	34.74	580.9	807.92	469.30
E	69000	15	6.17	33.32	496.6	411.48	204.33
F	32470	5	0.83	31.11	405.6	29.93	12.14
Total	**357392**	**78**	6.09	34.55	550.1	**1955.10**	**1075.48**

Table 10b. Results from experimental estimation of redfish at depths below 500m.

The Redfish Abundance Estimation Results by the Trawl Method at the Depthes below 500 m (Trawlings type 3).
(TS = 20LgL - 71.3)

Subarea	Area, sq.nm	Number of Trawlings	Mean SAtr, sq.m/sq.nm	Mean Length, cm	Mean Weight, g	Abundance, 10^6 sp	Biomass, 10^3 tonn
A	125975	40	7.80	39.72	805.5	668.57	538.54
B	127125	27	4.75	39.12	767.8	423.97	325.54
C	28934	4	1.82	37.60	691.5	39.97	27.64
D	62897	6	2.49	35.20	602.7	135.42	81.62
E	69000	9	1.97	32.91	478.7	134.50	64.38
F	32470	5	1.28	31.82	433.2	43.97	19.05
Total	**446401**	**91**	4.42	38.19	730.6	**1446.40**	**1056.77**

Table 11a. Length distribution (numbers of fish in '000 per cm class) of redfish by area, derived from the acoustic estimate <500m.

	Sub-Area						
Length (cm)	A	B	C	D	E	F	Total
20	0	0	0	0	0	203078	203078
21	0	0	0	0	232900	203078	435978
22	0		00	0	0	0	0
23	0	1623096	0	0	931601	609233	3163930
24	0	811548	0	565767	2096103	406156	3879573
25	2373893	1623096	0	0	1164501	609233	5770724
26	791298	811548	0	282884	3959305	609233	6454268
27	3165191	5680836	0	2263069	4658006	1624622	17391724
28	3560840	6492384	0	1980185	6288308	812311	19134028
29	2769542	8927028	0	9052276	10480513	1421544	32650904
30	6726031	8927028	0	11881113	13974017	406156	41914344
31	9495573	10550124	0	18387437	13974017	812311	53219462
32	8704275	15419412	2593311	27156829	13275316	812311	67961455
33	11473817	12173220	0	57142495	21193926	1015389	102998847
34	15034657	52750621	6051059	84299325	30044137	2030778	190210576
35	18595497	52750621	7779934	90522765	27948034	812311	198409161
36	24134581	60866101	7779934	70720910	26550633	1218467	191270624
37	15430306	56808361	6915496	50919055	13275316	1421544	144770079
38	15430306	38142757	7779934	31400084	9781812	203078	102737970
39	11078168	24346440	2593311	14427066	4658006	406156	57509147
40	5539084	11361672	3457748	5940556	1164501	609233	28072796
41	1978244	4057740	1728874	1131535	465801	0	9362194
42	395649	811548	0	0	0	0	1207197
43	395649	1623096	0	0	0	0	2018745
Total	168068	402917	49947	511538	220545	17383	1370399
Mean L	34.7	35.2	36.5	34.7	33.3	31.4	34.6

Table 11b. Length distribution (numbers of fish in '000 per cm class) of redfish by area, derived from the trawl data >500m.

	Sub-Area						
Length (cm)	A	B	C	D	E	F	Total
22	300	0	0	0	2745	0	3045
23	300	571	0	0	1372	0	2244
24	900	571	0	0	2745	2513	6729
25	2701	0	0	2764	4117	1256	10838
26	2101	1143	1211	2764	2745	3769	13732
27	2401	2857	0	0	2745	2513	10515
28	3001	4000	0	0	4117	5025	16143
29	5401	2857	0	2764	13724	3769	28515
30	7802	6857	1211	5527	8235	1256	30888
31	8702	13142	0	5527	4117	5025	36514
32	12603	11428	0	8291	9607	0	41929
33	16804	11999	1211	11055	9607	3769	54445
34	17705	21141	4845	13818	13724	2513	73746
35	25506	27427	3634	30400	15097	2513	104577
36	29407	30284	6056	13818	12352	1256	93174
37	34209	26855	4845	13818	9607	2513	91847
38	34809	23427	2422	11055	9607	2513	83833
39	42311	26284	4845	2764	1372	1256	78832
40	48012	25712	1211	2764	4117	0	81817
41	67217	27998	1211	5527	0	0	101954
42	60315	38854	1211	0	0	0	100381
43	70818	40569	0	0	0	1256	112643
44	62116	31998	3634	2764	1372	0	101883
45	59115	19999	0	0	1372	0	80486
46	29708	17142	0	0	0	0	46849
47	14704	7428	2422	0	0	0	24554
48	7502	2857	0	0	0	0	10359
49	1500	571	0	0	0	1256	3328
50	300	0	0	0	0	0	300
56	300	0	0	0	0	0	300
	668570	423970	39970	135420	134500	43970	1446400
Mean L	40.2	39.0	37.5	34.8	32.9	31.8	38.3

Table 12. Redfish trawl data. Observations on stomach contents, from fish caught shallower and deeper than 500m.

	Sub-Area													
<500m	A		B		C		D		E		F		***Total***	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	141		333		49		1029		717		14		2283	
everted	73	51.8	83	24.9	5	10.2	581	56.5	337	47.0	8	57.1	1087	47.6
empty	36	25.5	29	8.7	0.0	0.0	89	8.6	51	7.1	1	7.1	206	9.0
with content	32	17.0	221	66.4	44	89.8	359	34.9	329	45.9	5	35.7	990	43.4
little	8	9.9	27	8.1	3	6.1	87	8.5	64	8.9	1	7.1	190	8.3
medium	14	7.1	38	11.4	0	0.0	243	23.6	204	28.5	3	21.4	502	22.0
high	10	0.0	156	46.8	41	83.7	29	2.8	61	8.5	1	7.1	298	13.1
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Amphipoda	11	20.8	-	0.0			55	45.5	28	50.0			94	39.2
Euphausiacea	21	39.6	5	50.0			8	6.6	13	23.2			47	19.6
Cephalopoda	12	22.6	-	0.0			4	3.3	1	1.8			17	7.1
Shrimp	4	7.5	1	10.0			1	0.8	2	3.6			8	3.3
Jellyfish	-	0.0	2	20.0			2	1.7	1	1.8			5	2.1
Fish	-	0.0	1	10.0			5	4.1	-	0.0			6	2.5
Other	5	9.4	1	10.0			46	38.0	11	19.6			63	26.3

	Sub-Area													
>500m	A		B		C		D		E		F		***Total***	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	942		433		31		48		98		26		1578	
everted	525	55.7	211	48.7	5	16.1	27	56.3	63	64.3	17	65.4	848	53.7
empty	277	29.4	124	28.6	1	3.2	1	2.1	14	14.3	4	15.4	421	26.7
with content	140	14.9	98	22.6	25	80.6	20	41.7	21	21.4	5	19.2	309	19.6
little	25	2.7	19	4.4	1	3.2	5	10.4	11	11.2	2	7.7	63	4.0
medium	21	2.2	13	3.0	2	6.5	11	22.9	8	8.2	3	11.5	58	3.7
high	94	10.0	66	15.2	22	71.0	4	8.3	2	2.0	0	0.0	188	11.9
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Amphipoda	2	3.8	-				4	40.0	5	35.7	1	50.0	12	11.3
Euphausiacea	9	17.0	3	11.1			-		3	21.4	-		15	14.2
Cephalopoda	14	26.4	13	48.1			3	30.0	-		-		30	28.3
Shrimp	9	17.0	7	25.9			2	20.0	1	7.1	-		19	17.9
Jellyfish	1	1.9	1	3.7			-		-		-		2	1.9
Fish	8	15.1	1	3.7			1	10.0	-		-		10	9.4
Other	10	18.9	2	7.4			-		5	35.7	1	50.0	18	17.0

Table 13. Redfish trawl data. Maturity stages by sex and Sub-area, shallower and deeper than 500m.

Sub-area (<500m)		Maturity stages males						Maturity stages females					
		1	2	3	4	5	6	I (1)	M (2)	F (3)	P (4)	S (5)	R (6)
A	No.	19	134	3	1	0	1	20	27	0	0	15	10
	%	12.0	84.8	1.9	0.6	0.0	0.6	27.8	37.5	0.0	0.0	20.8	13.9
B	No.	2	31	17	0	2	140	18	11	1	0	65	27
	%	1.0	16.1	8.9	0.0	1.0	72.9	14.8	9.0	0.8	0.0	53.3	22.1
C	No.	0	0	20	0	0	5	0	0	0	0	21	0
	%	0.0	0.0	80.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	100.0	0.0
D	No.		254	66	0	0	386	67	71	18	0	56	202
	%	0.0	36.0	9.3	0.0	0.0	54.7	16.2	17.1	4.3	0.0	13.5	48.8
E	No.		191	43	0	0	241	104	33	11	0	64	97
	%	0.0	40.2	9.1	0.0	0.0	50.7	33.7	10.7	3.6	0.0	20.7	31.4
F	No.		10	16	0	0	6	4	6	5	0	0	0
	%	0.0	31.3	50.0	0.0	0.0	18.8	26.7	40.0	33.3	0.0	0.0	0.0
Total	No.	21	620	165	1	2	779	213	148	35	0	221	336
	%	1.3	39.0	10.4	0.1	0.1	49.1	22.4	15.5	3.7	0.0	23.2	35.3

Sub-area (>500m)		Maturity stages males						Maturity stages females					
		1	2	3	4	5	6	I (1)	M (2)	F (3)	P (4)	S (5)	R (6)
A	No.	28	874	33	7	0	21	76	203	0	0	349	94
	%	2.9	90.8	3.4	0.7	0.0	2.2	10.5	28.1	0.0	0.0	48.3	13.0
B	No.	6	187	7	0	2	85	27	68	0	0	33	62
	%	2.1	65.2	2.4	0.0	0.7	29.6	14.2	35.8	0.0	0.0	17.4	32.6
C	No.	0	0	5	0	0	11	0	0	0	0	14	1
	%	0.0	0.0	31.3	0.0	0.0	68.8	0.0	0.0	0.0	0.0	93.3	6.7
D	No.	0	13	0	0	0	15	2	7	0	0	2	9
	%	0.0	46.4	0.0	0.0	0.0	53.6	10.0	35.0	0.0	0.0	10.0	45.0
E	No.	1	45	0	0	0	20	15	13	0	0	2	2
	%	1.5	68.2	0.0	0.0	0.0	30.3	46.9	40.6	0.0	0.0	6.3	6.3
F	No.	0	10	0	0	0	7	5	3	0	0	0	1
	%	0.0	58.8	0.0	0.0	0.0	41.2	55.6	33.3	0.0	0.0	0.0	11.1
Total	No.	35	1129	45	7	2	159	125	294	0	0	400	169
	%	2.5	82.0	3.3	0.5	0.1	11.5	12.7	29.8	0.0	0.0	40.5	17.1

Table 14a. Incidence of *Sphyrion lumpi* and pigment abnormalites (depth < 500 m).

	sub-area A			sub-area B			sub-area C			sub-area D			sub-area E			sub-area F			total		
	males	females	total	males	females	total	males	females	total	males	females	total	males	females	total	males	females	total	males	females	total
External abnormalities																					
No. of fish examined	138	74	212	257	156	413	38	40	78	423	221	644	388	231	619	9	5	14	1253	727	1980
No. of fish with ext. pigment spots	3	1	4	49	49	98	4	15	19	64	60	124	64	50	113	0	0	0	184	175	358
% with ext. pigment spots	2.2	1.4	1.9	19.1	31.4	23.7	10.5	37.5	24.4	15.1	27.1	19.3	16.5	21.6	18.3	0.0	0.0	0.0	14.7	24.1	18.1
No. with *S.lumpi* and/or remnants	4	7	11	63	75	138	17	22	39	62	58	120	73	64	137	1	1	2	220	227	447
% with *S.lumpi* and/or remnants	2.9	9.5	5.2	24.5	48.1	33.4	44.7	55.0	50.0	14.7	26.2	18.6	18.8	27.7	22.1	11.1	20.0	14.3	17.6	31.2	22.6
Muscular melanosis																					
No. of fish examined	41	19	60	179	107	286	38	40	78	423	221	644	333	198	531	9	5	14	1023	590	1613
No. of fish w. musc. melanosis	22	11	33	55	25	80	12	8	20	161	60	221	120	64	184	3	2	5	373	170	543
% w. musc. melanosis	53.7	57.9	55.0	30.7	23.4	28.0	31.6	20.0	25.6	38.1	27.1	34.3	36.0	32.3	34.7	33.3	40.0	35.7	36.5	28.8	33.7

Table 14b. Incidence of *Sphyrion lumpi* and pigment abnormalites (depth > 500 m)

	sub-area A			sub-area B			sub-area C			sub-area D			sub-area E			sub-area F			total		
	males	females	total	males	females	total	males	females	total	males	females	total	males	females	total	males	females	total	males	females	total
External abnormalities																					
No. of fish examined	907	560	1467	409	260	669	17	13	30	42	28	70	52	24	76	17	9	26	1444	894	2338
No. of fish with ext. pigment spots	31	38	69	32	32	64	1	3	4	4	6	10	6	3	9	2	1	3	76	83	159
% with ext. pigment spots	3.4	6.8	4.7	7.8	12.3	9.6	5.9	23.1	13.3	9.5	21.4	14.3	11.5	12.5	11.8	11.8	11.1	11.5	5.3	9.3	6.8
No. with *S.lumpi* and/or remnants	99	135	234	63	58	121	7	5	12	8	6	14	8	6	14	4	2	6	189	212	401
% with *S.lumpi* and/or remnants	10.9	24.1	16.0	15.4	22.3	18.1	41.2	38.5	40.0	19.0	21.4	20.0	15.4	25.0	18.4	23.5	22.2	23.1	13.1	23.7	17.2
Muscular melanosis																					
No. of fish examined	634	400	1034	237	151	388	17	13	30	42	28	70	54	25	79	17	9	26	1001	626	1627
No. of fish w. musc. melanosis	130	63	193	14	12	26	6	7	13	13	3	16	18	5	23	5	2	7	186	92	278
% w. musc. melanosis	20.5	15.8	18.7	5.9	7.9	6.7	35.3	53.8	43.3	31.0	10.7	22.9	33.3	20.0	29.1	29.4	22.2	26.9	18.6	14.7	17.1

Table 15. Division of redfish abundace within NAFO and NEAFC areas.

	NEAFC		NAFO	
	´000 tonnes	%	´000 tonnes	%
Acoustic 0-500 m	338	47%	377	53%
Trawl method				
above 500 m	390	36%	686	64%
below 500 m	892	84%	165	16%

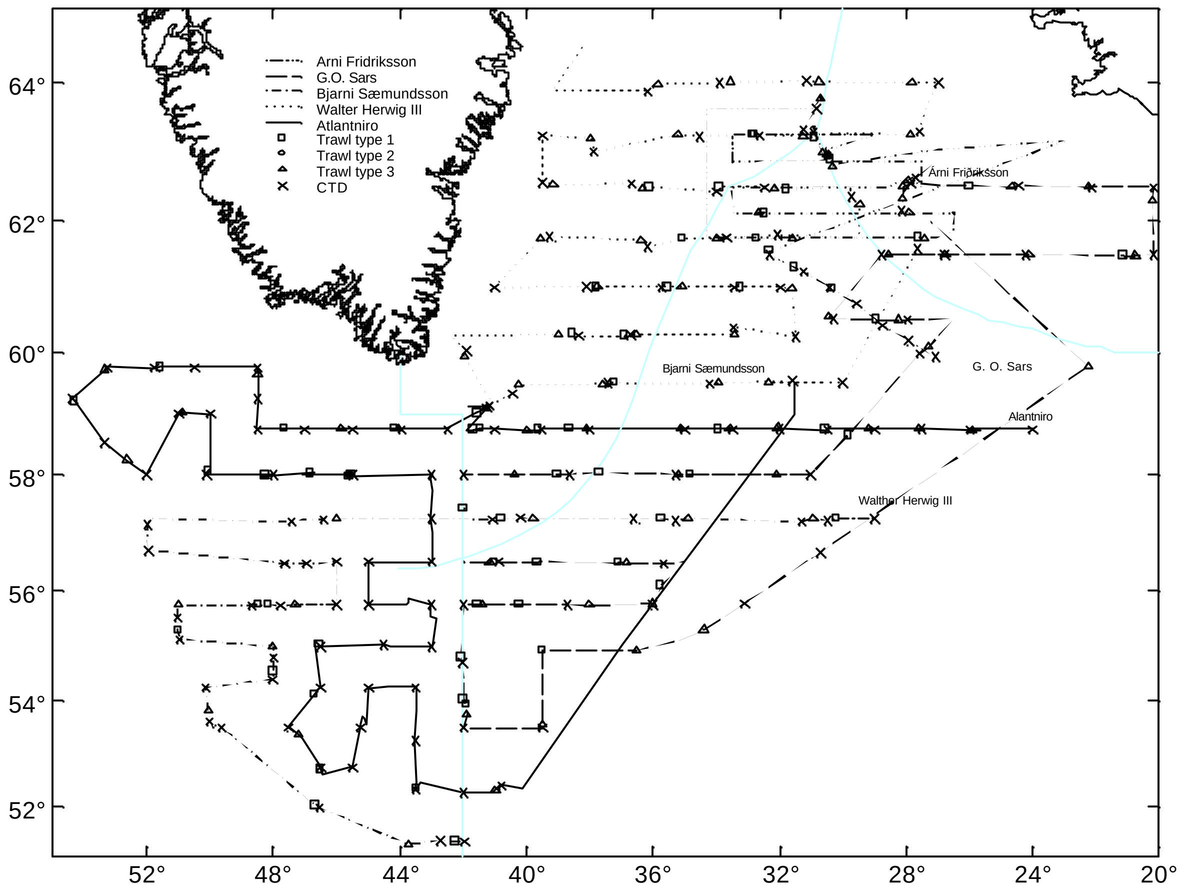
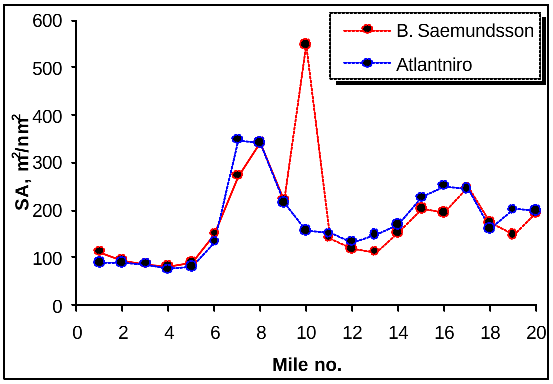


Figure 1. Cruise tracks and stations taken in the joint international redfish survey in June/July 2001.



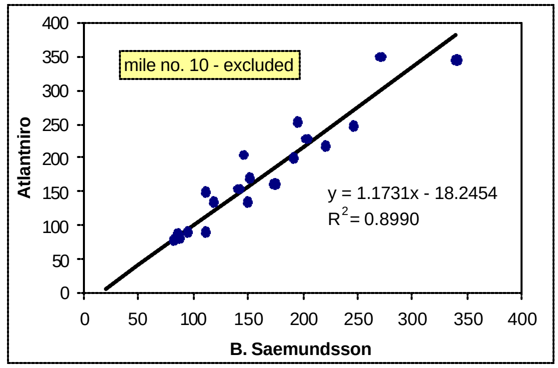


Figure 2. Hydroacoustic SA-values from the two research vessels, Atlantniro and Bjarni Sæmundsson, measured during the intercalibration excercise at the depth range 13-400 m (?? -500 mode: MEDIUM / WIDE for Bjarni Sæmundsson; LONG / NARROW for Atlantniro).

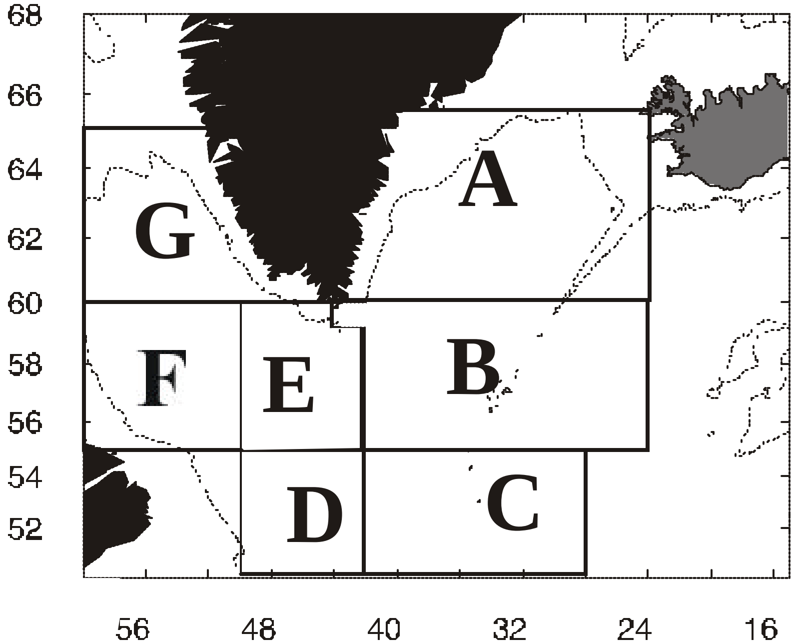


Figure 3. Sub-areas used on international surveys for redfish in the Irminger Sea and adjacent waters.

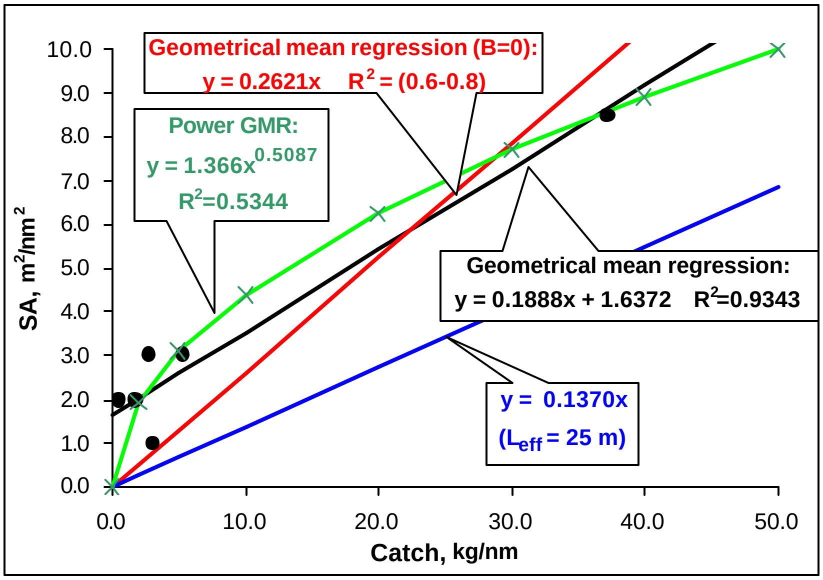


Figure 4. Data from Bjarni Sæmundsson. Different regression between catches and observed hydroacoustic values SA above 500 m depth.

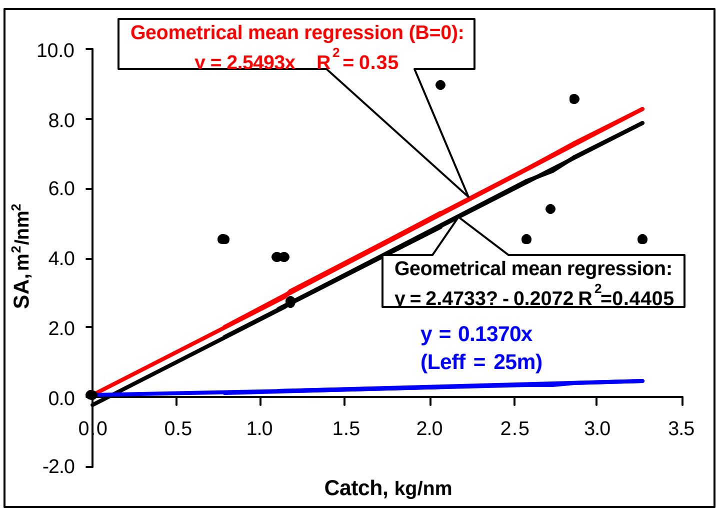


Figure 5. Data from Árni Friðriksson. Different regression between catches and observed hydroacoustic values SA above 500 m depth.

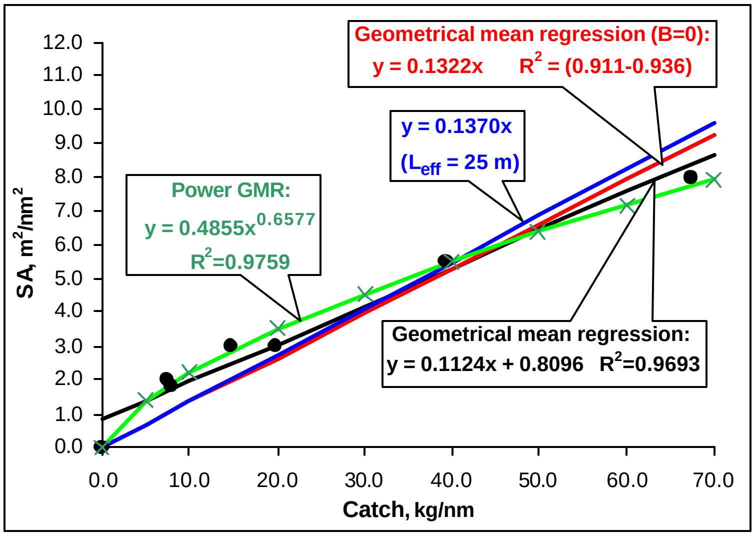


Figure 6. Data from Walther Herwig III. Different regression between catches and observed hydroacoustic values SA above 500 m depth.

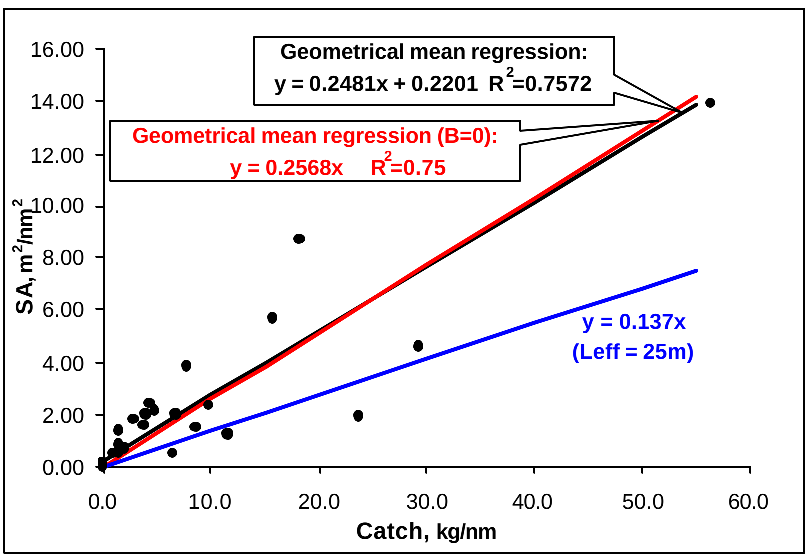


Figure 7. Data from Atlantniro. Different regression between catches and observed hydroacoustic values SA above 500 m depth.

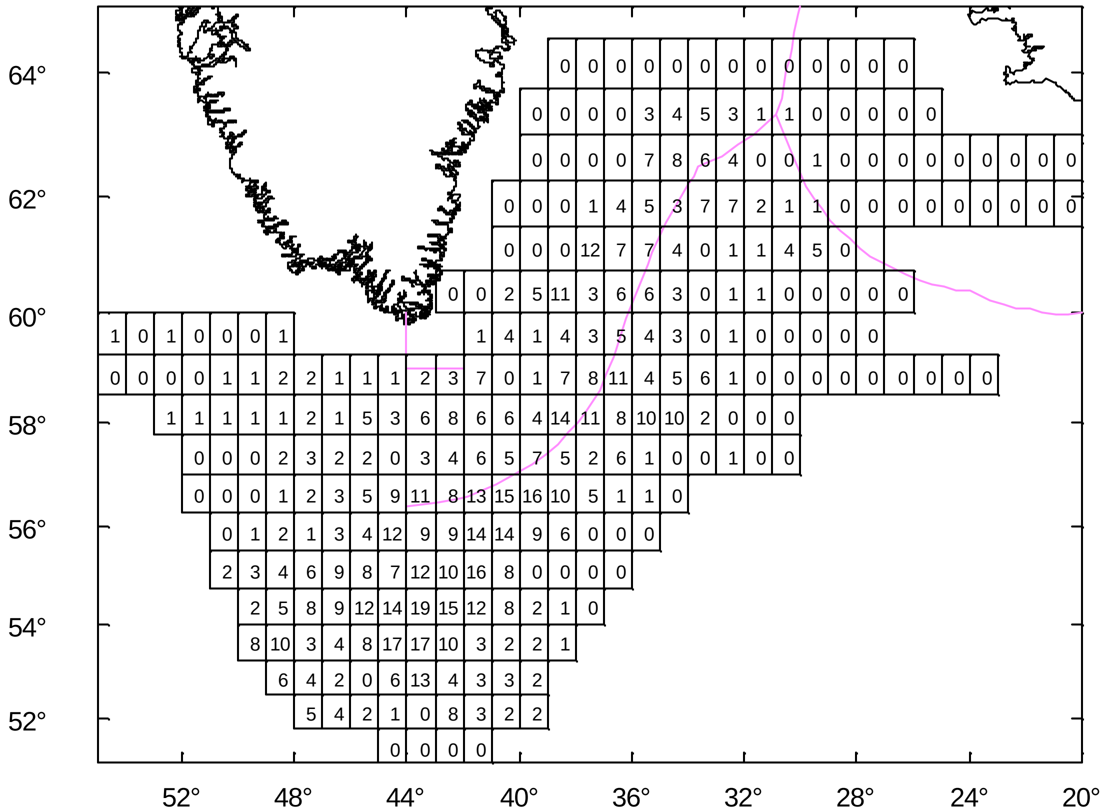


Figure 8. Mean values of area back scattering strength (m^2/nm^2) in June/July 2001 at depths between 0-500 m within statistical rectangles.

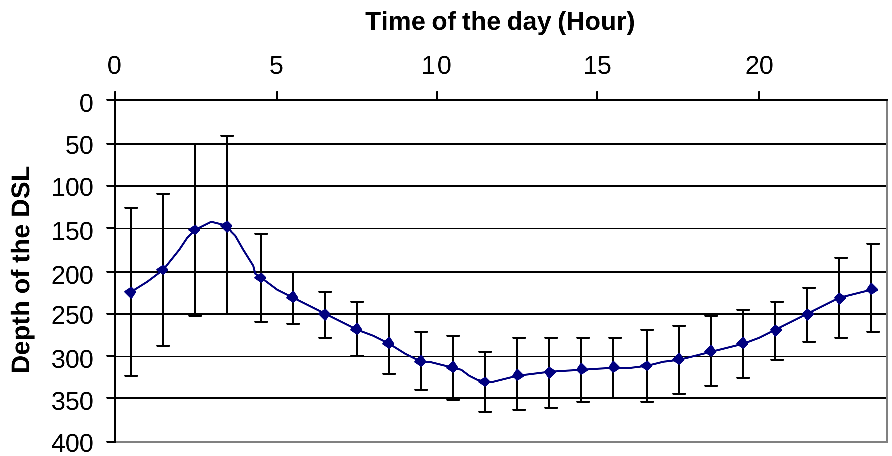


Figure 9. Average depth and standard deviation of the deep-scattering layer during the survey in June/July 2001.

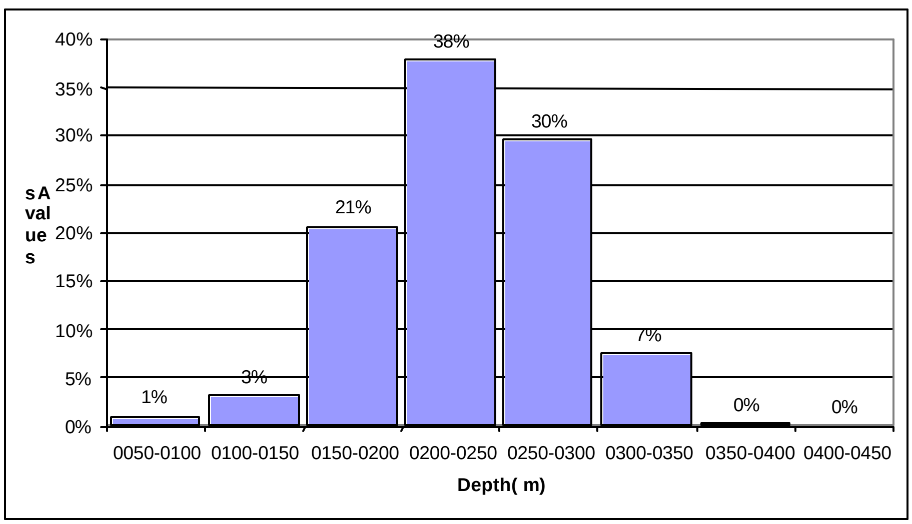


Figure 10. Depth distribution of redfish measured acoustically in the Irminger Sea in June/July 2001.

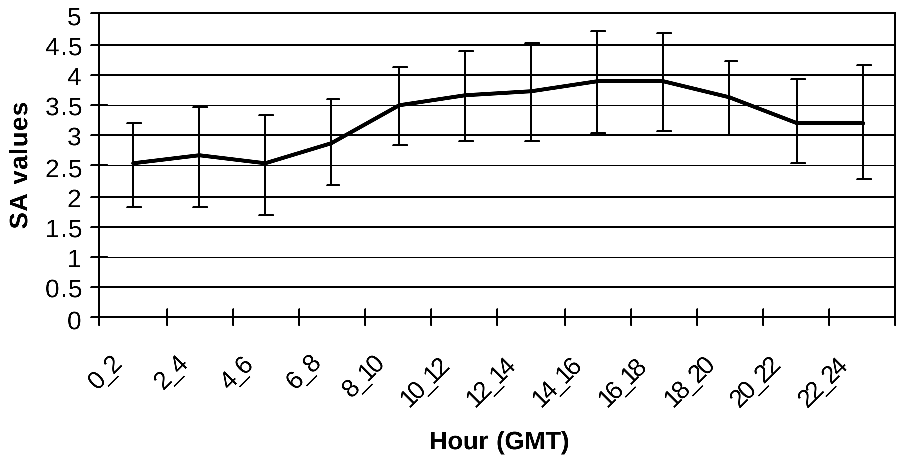


Figure 11. Diurnal variations of integrator values of redfish in June/July 2001, along with 95% confidence limits. Data combined for German, Icelandic and Russian vessels.

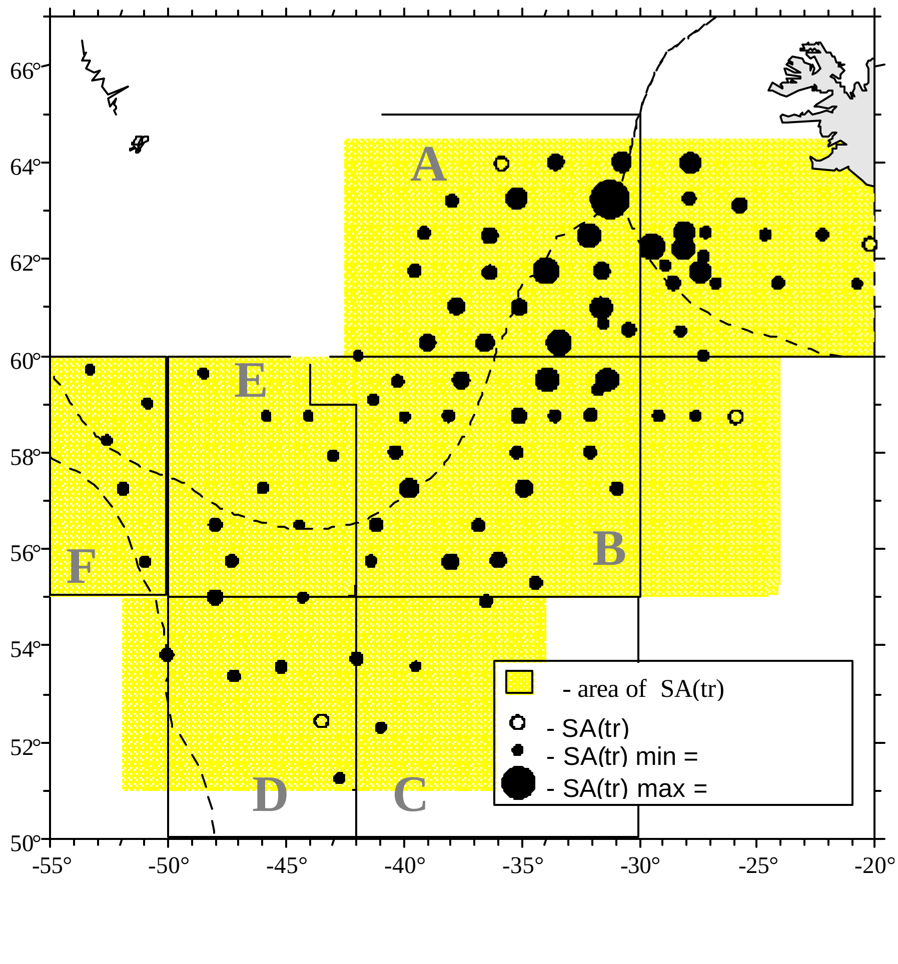


Figure 12. Geographical distribution patterns of standardised redfish catches below 500m depth.

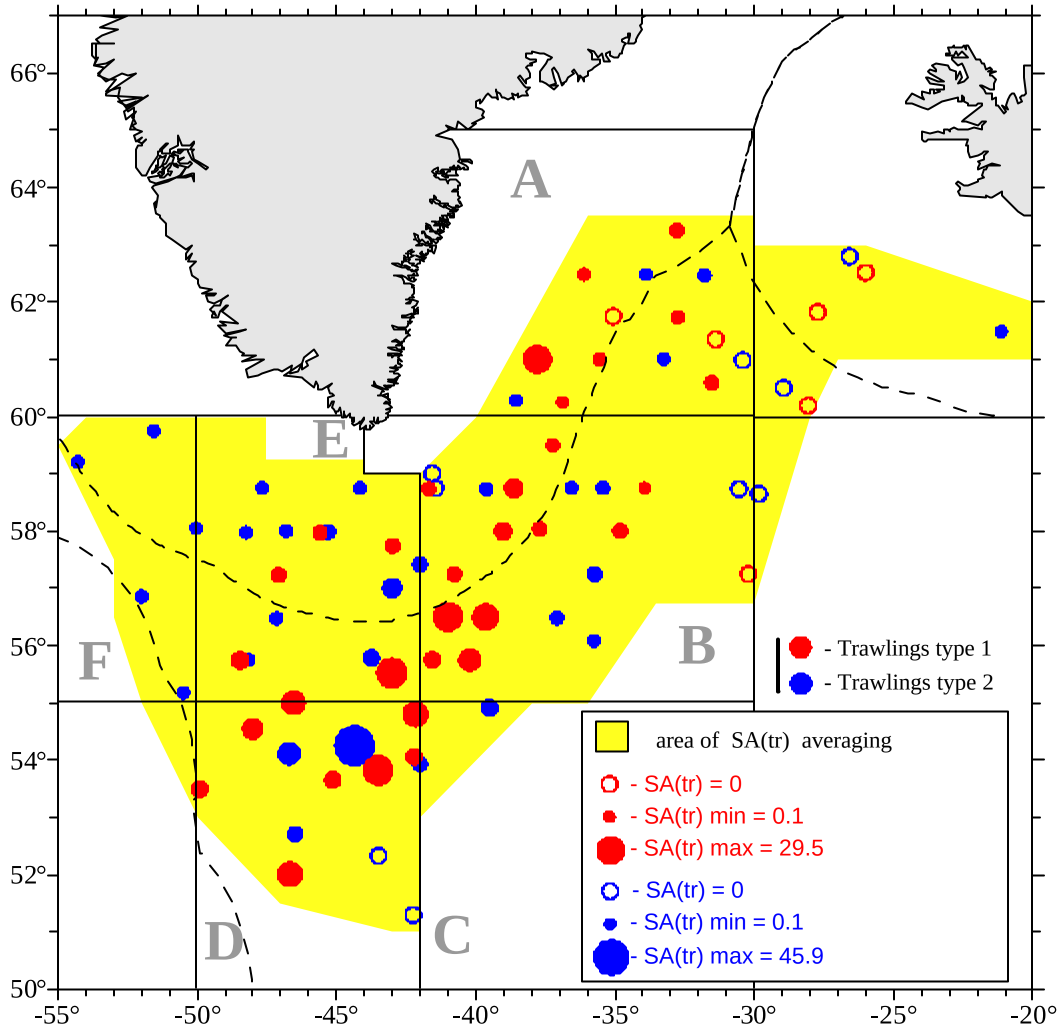


Figure 13. Calculated SA values above 500 m, obtained from correlation between catch and SA values. See text for further explanation.

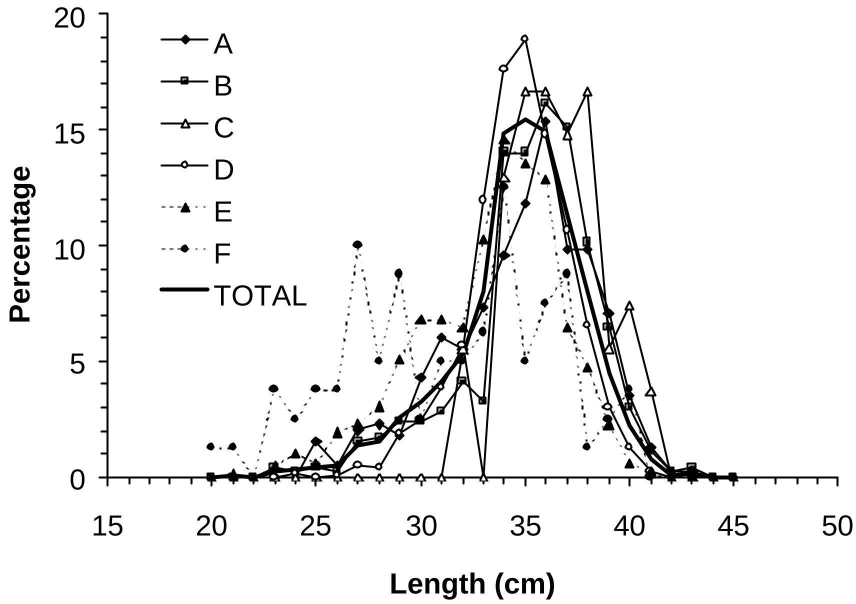
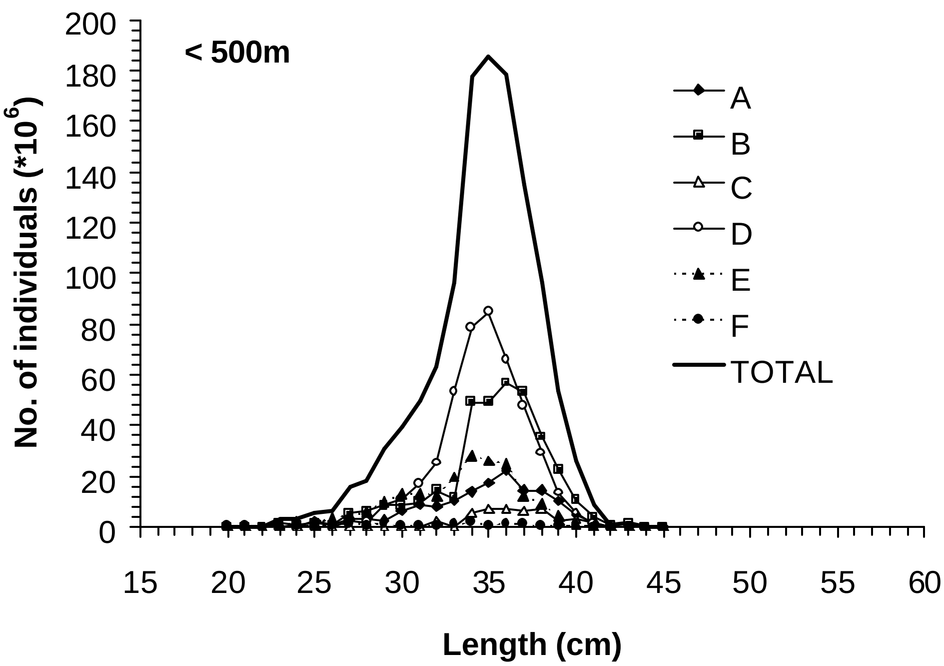


Figure 14. Length distribution of redfish in 150-450m depth, by sub-area and total. The values are derived from the acoustic abundance estimation.

1)



2)

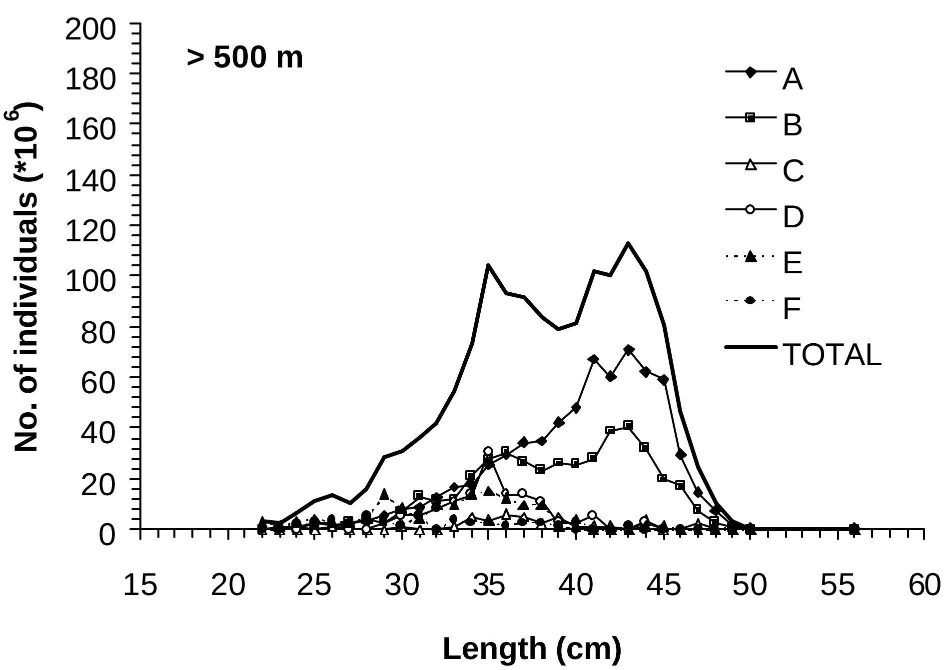


Figure 15. Length distribution of the redfish derived from the trawl method 1) =0-500 m depth, 2) = 500-950 m depth.

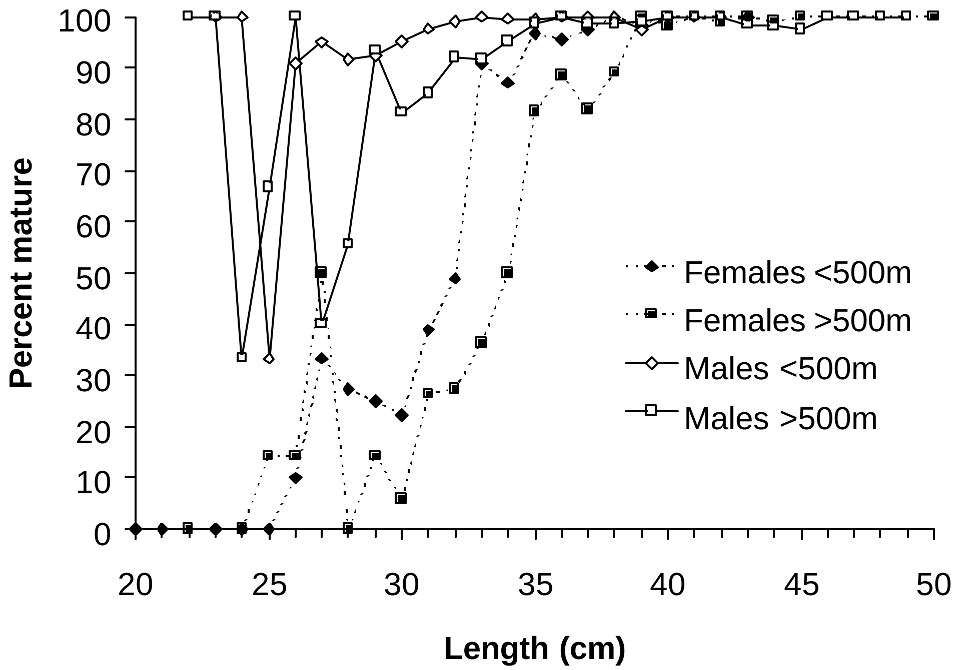


Figure 16. Redfish trawl data. Maturity ogives by sex, shallower and deeper than 500 m.

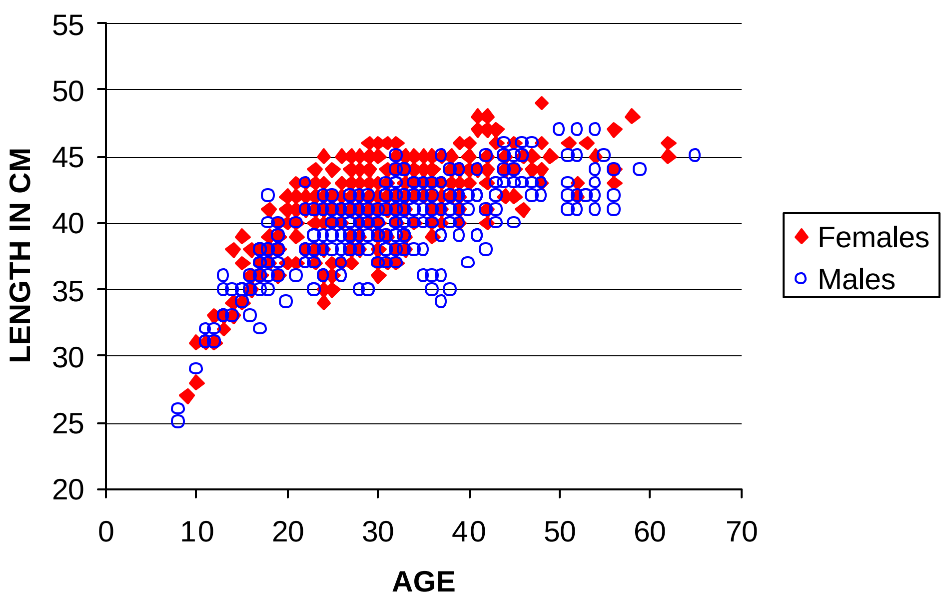


Figure 17. Data collected onboard G.O.Sars. Age-length composition of female and male *S. mentella*. The age material from depths shallower and deeper than 500 meters has been combined.

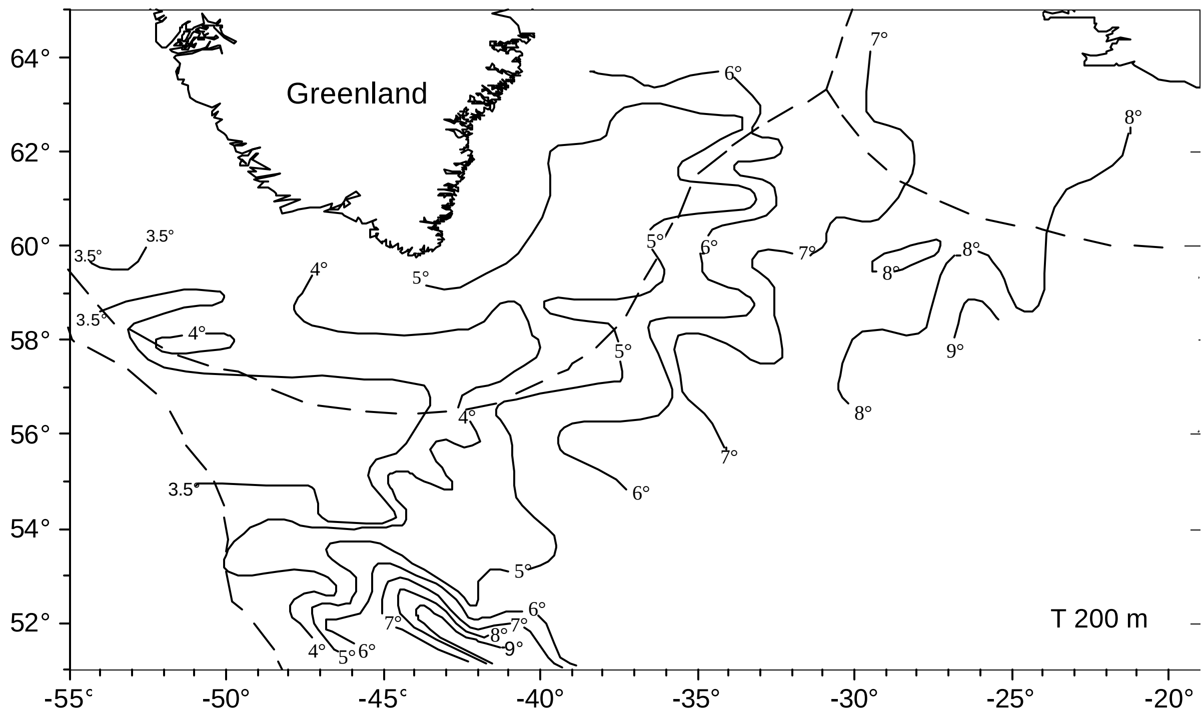


Figure 18. Horizontal temperature (tºC) distribution at 200 m depth in June/July 2001.

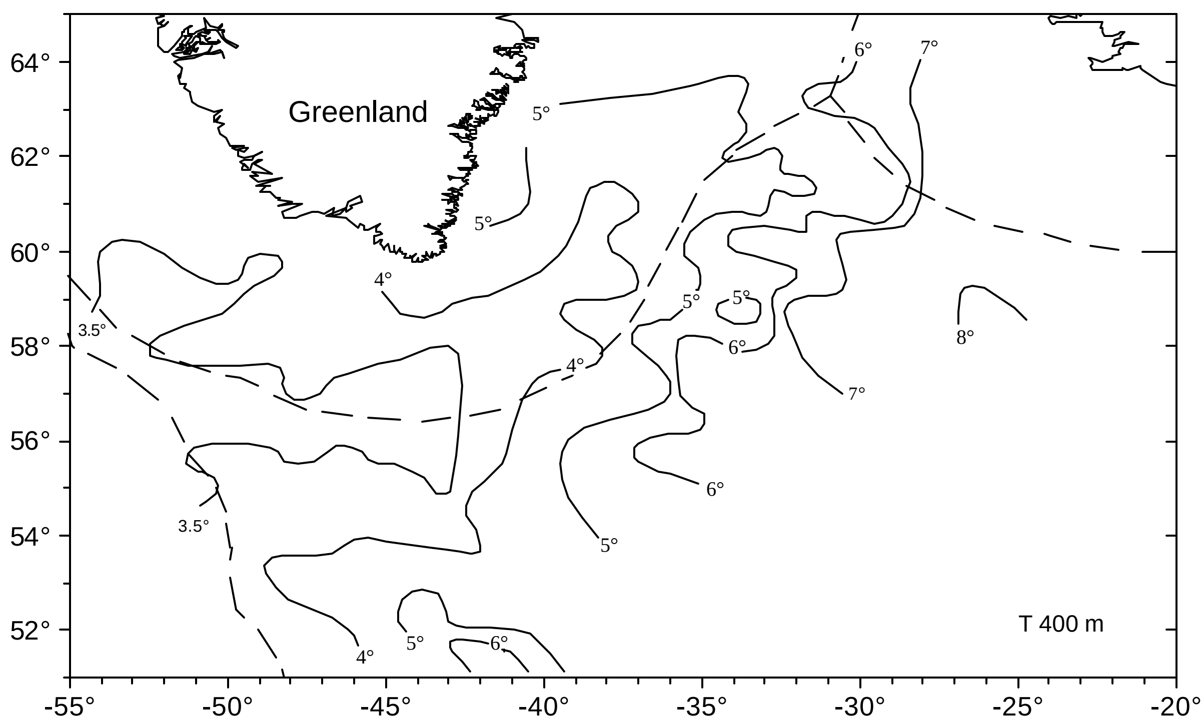


Figure 19. Horizontal temperature (tºC) distribution at 400 m depth in June/July 2001.

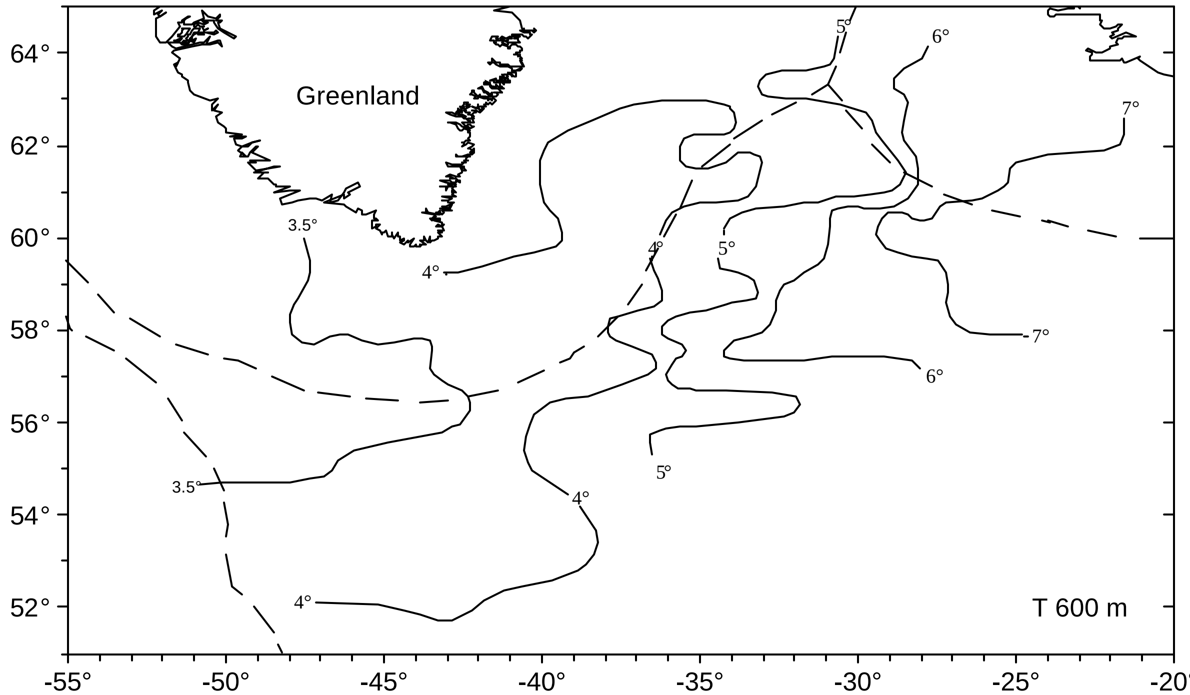


Figure 20. Horizontal temperature (tºC) distribution at 600 m depth in June/July 2001

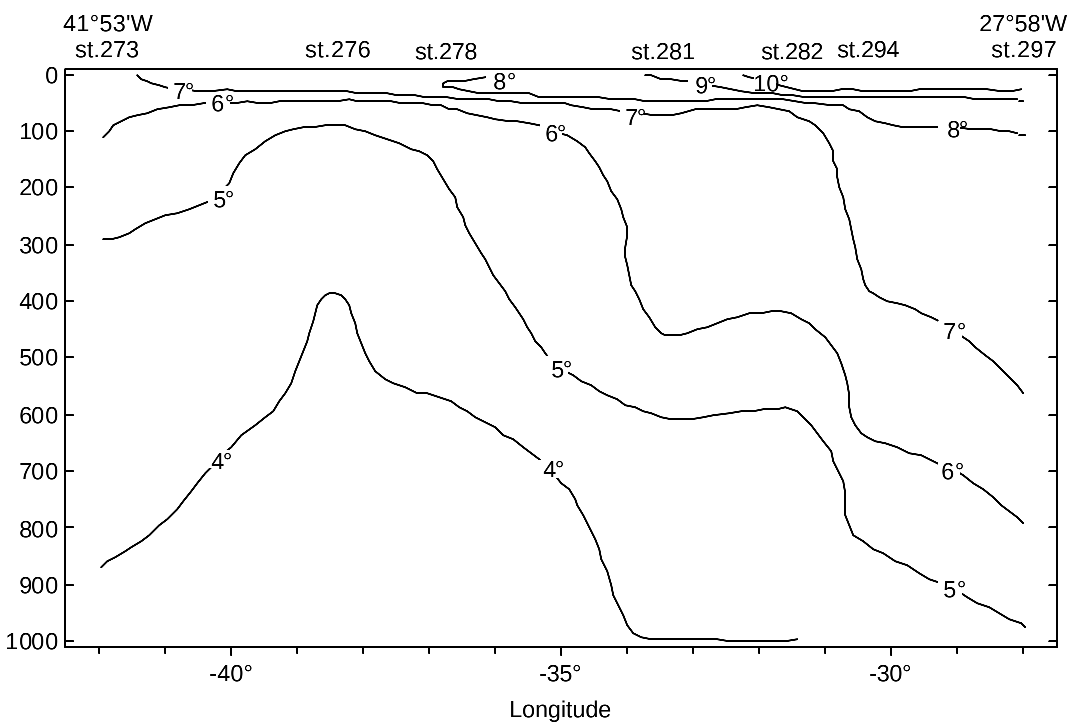


Figure 21 Vertical temperature distribution (tºC) on a section along the 60º15ºN latitude between 41º50W and 28ºW.

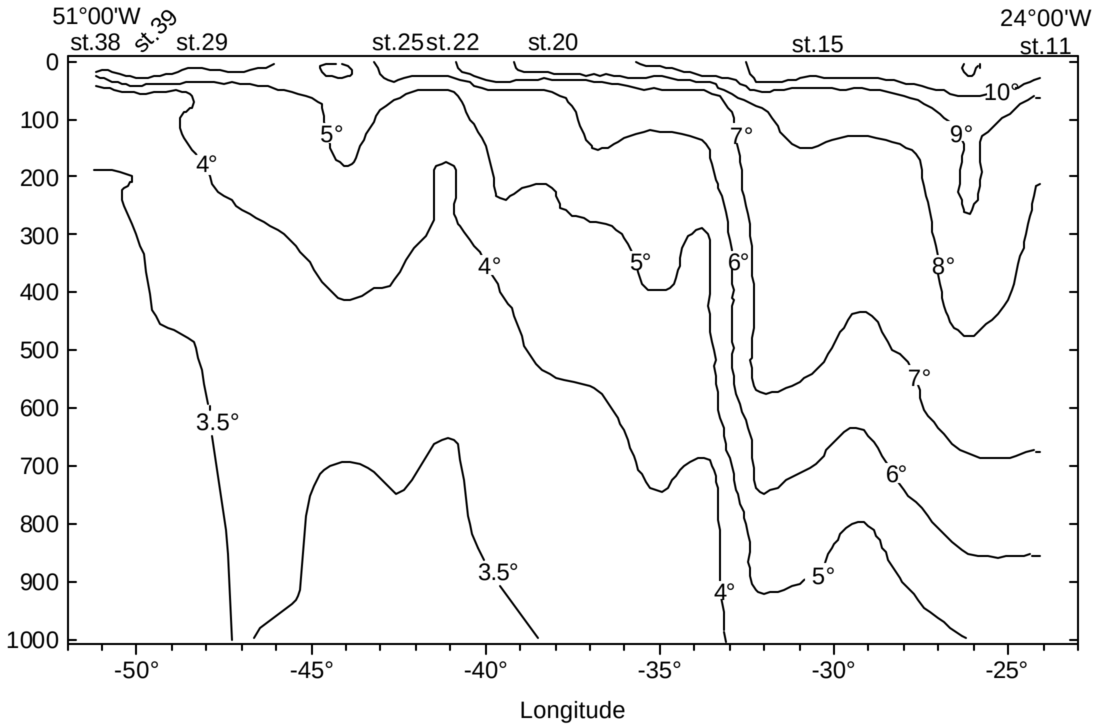


Figure 22. Vertical temperature distribution (tºC) on a section along the 58º45N latitude between 51ºW and 24ºW.

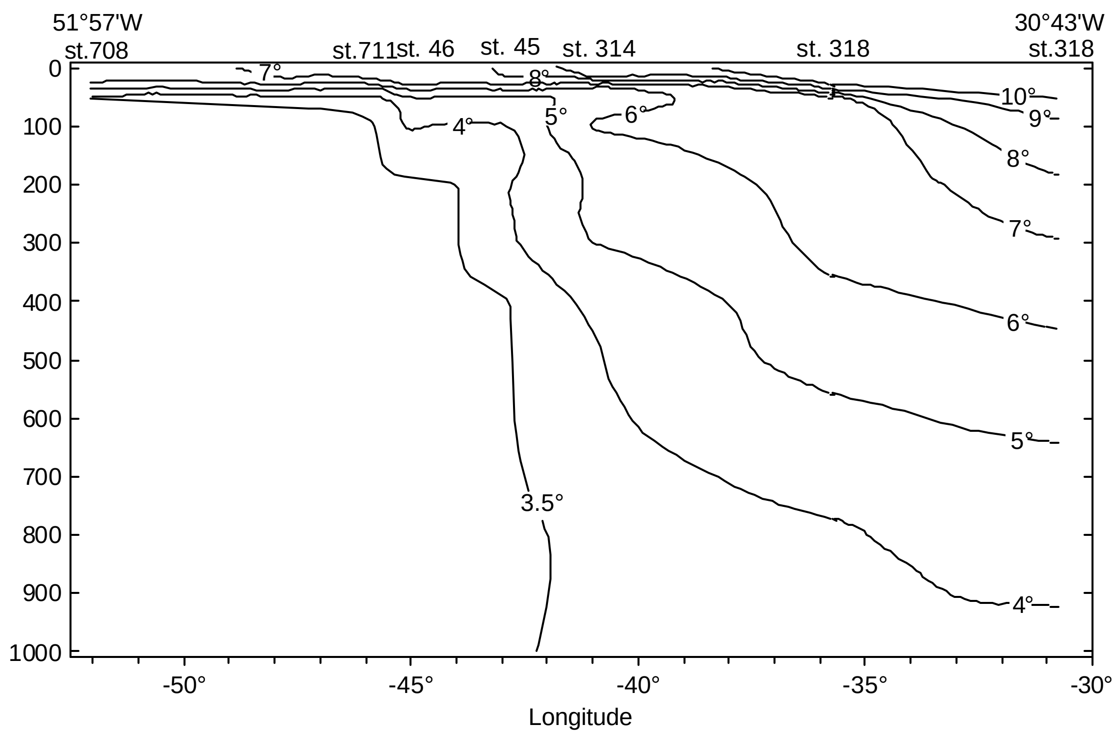


Figure 23. Vertical temperature distribution (tºC) on a section along the 56º30N latitude between 52ºW and 30º45W.

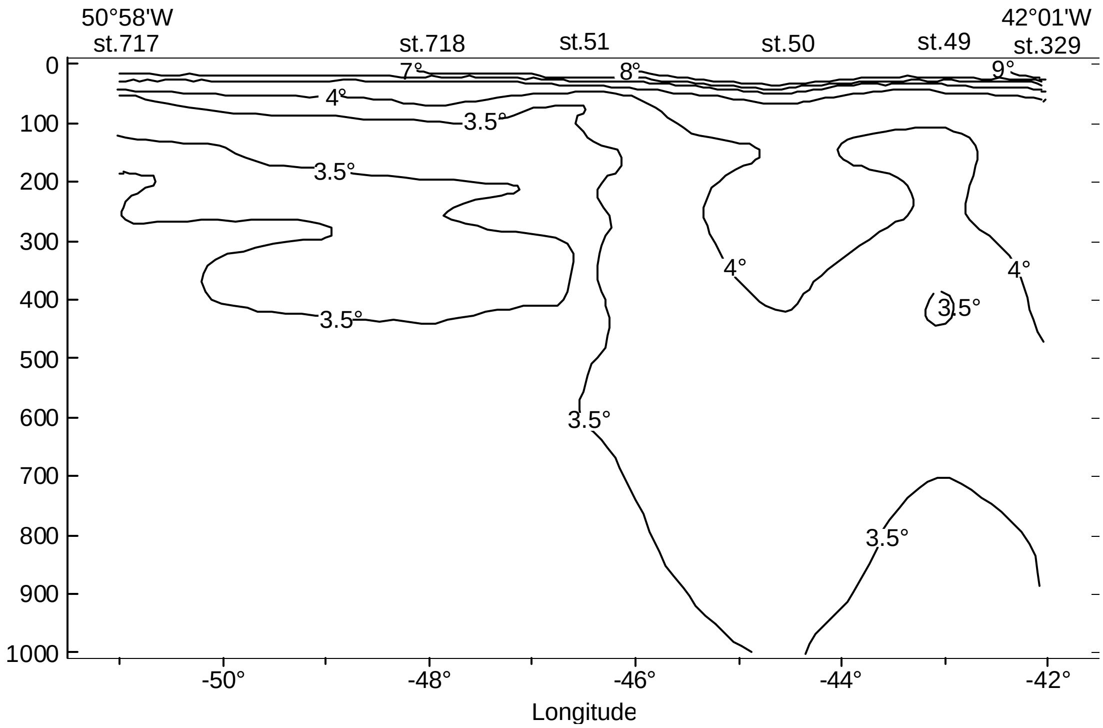


Figure 24. Vertical temperature distribution (tºC) on a section along the 55ºN latitude between 51ºW and 42ºW.

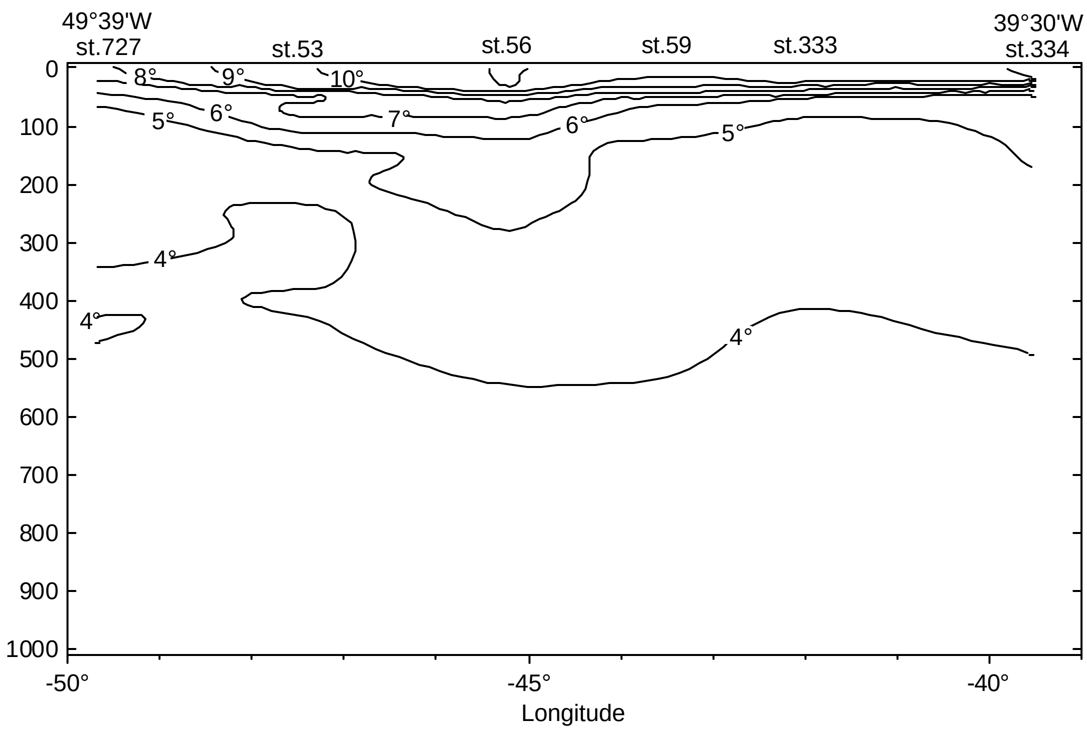


Figure 25. Vertical temperature distribution (tºC) on a section along the 53º30N latitude between 49º45W and 39º30W.

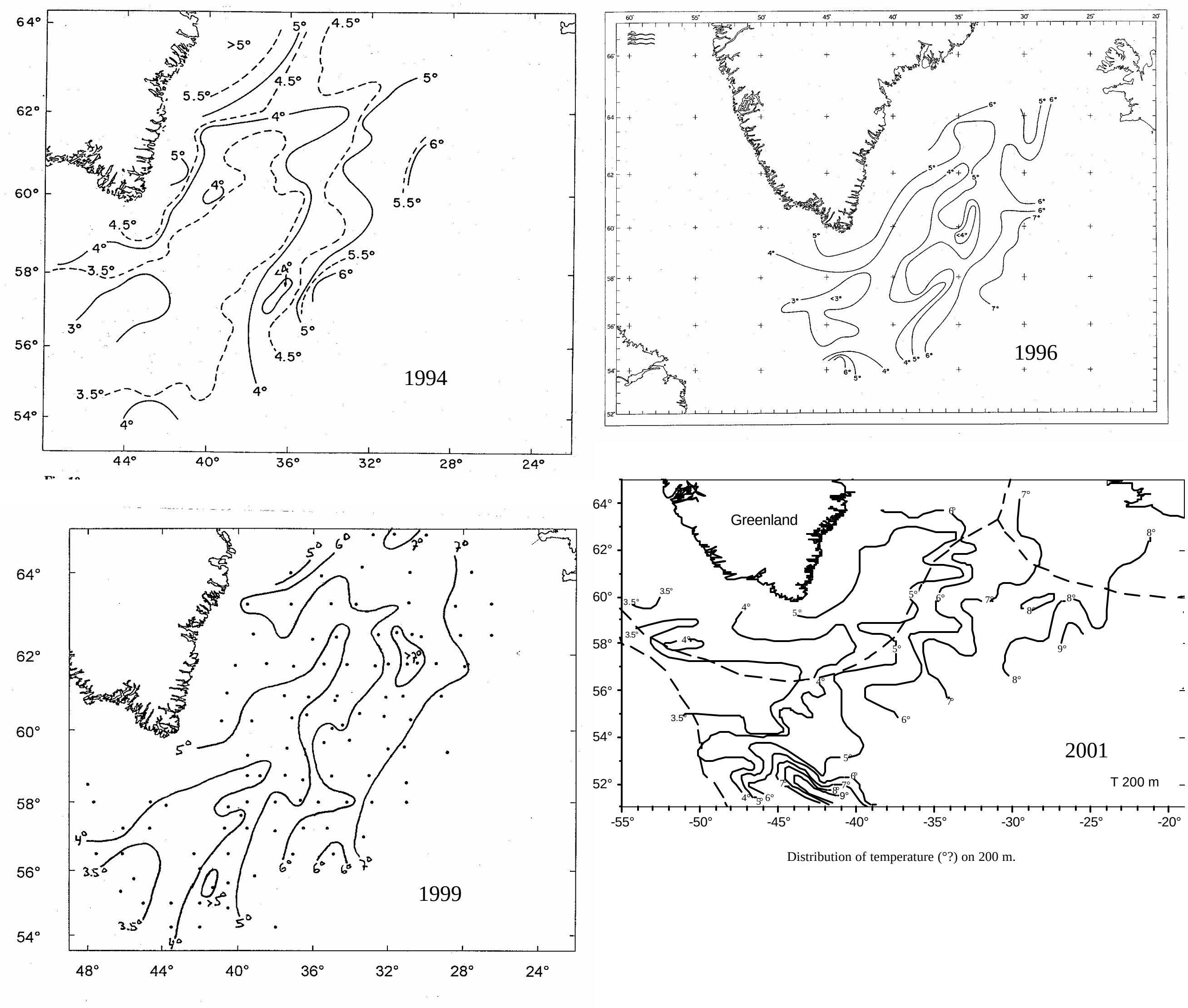


Figure 26. Temperature at 200 m depth in June/July 1994 (ICES C.M 1994/G:44), in June/July 1996 (ICES C.M 1996/G:8), June/July 1999 (ICES C.M 1999/ACFM:17) and June/July 2001.