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REPORT ON THE JOINT ICELANDIC/NORWEGIAN SURVEY ON OCEANIC REDFISH IN THE IRMINGER SEA AND ADJACENT WATERS, IN JUNE/JULY 1994

by

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Abstract

An acoustic survey on oceanic redfish (oceanic *Sebastes mentella*) in the Irminger Sea, in June/July 1994 was carried out by Iceland and Norway. Approximately 190 000 n.m.^{2} were covered. The stock size in the area surveyed was assessed to be about 2.2 million tonnes or 3.5 million individuals. Only depths shallower than 500 meters were included. The oceanic redfish concentrations were densest in the 100-250 m depth layer, mainly within a temperature range of 3° to 4°C.

Males were in majority in all areas (55-61%). The average length of oceanic *S. mentella* was 36,7 cm, and the average weight 640 g. Females were on the average larger and heavier than males. The percentage of fish with external abnormalities (i.e. *Sphyrion lumpi* and spots) was much higher for females than for males. The average was 43.5% and the average for fish with abnormal muscular pigmentation, 47.1%, resp. The maturity stages and the stomach contents were recorded.

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. 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 oceanographical conditions of the area surveyed. The acoustic measurements were, however, not considered sufficient for stock assessment purposes (Anon., 1991).

Iceland conducted a pilot study survey, in 1991 (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. One of the main aims of the ICES Study Group on Redfish Stocks (SGRS) in May, 1992, was therefore to coordinate the ongoing research on the stock (Anon.,1992). The Icelandic and Russian acoustic surveys were carried out in the time period May/July, 1992. The planned cooperation did not work out as anticipated. Therefore, the results of these 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 extensive area of distribution within a reasonable time period.

In 1993, Russia conducted a survey in the Irminger Sea, in the summer time and Iceland, a short survey in September, the same year. Working papers on the Russian and on the Icelandic surveys were presented at the ICES North Western Working Group in May, 1994. (Anon.,1994a). The meeting of the SGRS at Copenhagen, May 1993 was used to prepare an international survey, in 1994. The main survey plan was worked out at the meeting and presented at the ICES Statutory Meeting,1993 (Anon.,1993). The terms of reference were:" To assess the total stock size, if possible, of the oceanic *S. mentella* in the Irminger Sea and adjacent waters by trawl-acoustic methods. In addition, to sample biological data of oceanic *S. mentella* and to provide hydrographic information from the investigated area".

Russia, Iceland and Norway announced their readiness to participate in the combined survey. Some other nations considered participation but were not able to provide vessel time in June-July, 1994.

Representatives - i.e. the three cruise leaders - from the participating countries met in Bergen, Norway, on 6 - 7 April, 1994, to work out a detailed survey plan and presented it to the SGRS on its meeting in Copenhagen, 2-3 May,1994 (Anon.,1994b).

According to this plan, the Russian vessel "Pinro" was to start the acoustic survey south of Cape Farewell, on June 20th. The Icelandic vessel "Bjarni Sæmundsson" would leave Reykjavík on June 24th, the Norwegian vessel "Michael Sars" would leave Bergen for Reykjavík on June 22nd, and Reykjavík, on June 25th. Both these vessels should start the acoustic survey in the northern part of the planned survey area.

On June 23rd, Russia announced its withdrawal from the survey because of financial difficulties,i.e. after they should have started the work and after the Norwegian vessel had left Norway. This sudden and unexpected withdrawal called for a hurried re-planning and had considerable influence on the performance of the survey. The cruise leaders of the two remaining vessels decided to cover as much of the area as possible but rather curtail some other planned activities such as the deep-sea hauls, cut down on the number of hauls and besides, re-arrange the cruise tracks. Iceland was able to provide for three additional survey days. The Icelandic and the Norwegian vessels started the survey at the planned time.

The two parties met in Reykjavík immediately after the survey to prepare this report.

Material and methods

The primary material consists of acoustic and biological data collected on oceanic redfish in the Irminger Sea.

The Icelandic part of the survey was carried out by the Marine Research Institute (MRI), Reykjavík, with the research vessel "Bjarni Sæmundsson" during the time period June 24 to July 17. The Norwegian part was carried out by the Institute of Marine Research (IMR), Bergen with the research vessel "Michael Sars", during the time period June 26 to July 15, though interrupted by a change of crew in Reykjavík at 8 July. The vessels sailed 4744 miles (Iceland) and 3500 miles (Norway) and covered an area of approximately 190 000 square nautical miles within the area between 54° N and 64° N and 28° W and 48°W, mostly on sections 30 and 45 n.m. apart (Fig. 1). As said before, the planned sections had to be altered in some cases. A few sections had to be curtailed because of ice.

A 38 kHz Simrad EK500 split-beam echo sounder and a BI500 postprocessing system was used for the acoustic data collection on both ships (Bodholt et al. 1989 and Foote et al. 1991). Just prior to and after the survey the equipment on Bjarni Sæmundsson was calibrated by the standard sphere method (Foote et al. 1987). A difference of 5 % was observed in the sensitivity of the equipment beetween calibrations. This was accounted for in the processing of the acoustic data by using the mean sensitivity. In order to verify that the acoustic data from the ships were comparable, an intercalibration was carried out during the survey. During the intercalibration the ships sailed side by side with a distance of 0.3 nautical miles between them at a speed of 8 knots. The echo recordings consisted mainly of redfish and to some extent of myctophids. The distance sailed was 30 nm. The settings of the equipment were mainly the same as used during the survey and are given in Table 1. Since echo recordings in the depth interval 50-250 m were the most representative ones of the echoes of interest during the survey, the integrator values within this depth interval were used to establish a relationship between the two vessels. This was done according to the method of maximum likelihood as outlined by MacLennan and Pope (1983). The accepted data are shown in Figure 2. The relationship obtained is the following

$$SA_{BS} = 0.66 \cdot SA_{MS}$$

where SA_{BS} and SA_{MS} are the integrator values from Bjarni Sæmundsson and Michael

Sars respectively.

During the survey, the postprocessing systems were used for scrutinizing the echograms and mean integrated values of redfish per 1 nm were recorded for every 5 nm sailed. The integration threshold used was set at -80 dB//1 m^2/m^3, except on M. Sars, where it was from time to time adjusted upwards in order to minimize contribution from smaller scatterers. All integrator values were referred to the "Bjarni Sæmundsson" using the results from the intercalibration. In further processing of the data the number of fish were calculated within statistical rectangles, the size of which were 30 nm in latitude and 1 degree in longitude. A single fish target strength of -40.0 dB (Reynisson, 1992) was used for the whole area. The total number of fish within subareas was then obtained by summation of the individual rectangles. The subareas are the ones agreed upon in the SGRS Report as shown in Figure 3 (Anon, 1993), except that the limits in latitude were shifted 15 degrees south in order to be better suited to the cruise tracks. In addition, subarea B was divided into two areas i.e. east and west of 39° W due to differences in length distributions and subarea A was extended to the east. The results were further divided into numbers and biomass of males and females based on the biological samples representative for each subarea. The fish were only observed in very scattered condition, and an effort was made to investigate the effect of the thresholding of the integrated echo energy.

In the course of the survey, a considerable systematic difference was observed in the integrator-values obtained at different times of the day. The redfish integrator-values obtained on "Bjarni Sæmundsson" during the survey were used to give an indication of this diurnal cycle. This was not taken into account in the calculation of the redfish biomass.

A specially designed pelagic trawl (Gloria type, Hampiðjan, with maximum circumference 1024 m and stretched mesh size of 32 m) with vertical opening of 62-72 m in operation was used on "Bjarni Sæmundsson". The codend was lined with fine-meshed net (40 mm). The duration of the hauls was 1 hour with few exceptions when it was prolonged to 1.5 hours. On "Michael Sars" a smaller and different pelagic trawl (Aakratrawl, with circumference 486 m) with vertical opening of 27-35 m in operation was used as the standard trawl for redfish. The mesh size ranges from 3200 mm in front to 40 mm in the codend. In the beginning the duration of the hauls was 1-1.5 hours, but as the trawl showed low efficiency in catching the redfish (e.g. 6 kg versus 100 kg redfish on "Bjarni Sæmundsson" during the intercalibration, 1.5 hrs trawling) the towing time was prolonged to 2 hours at the end of the survey. On "Michael Sars" a total of 15 hauls were taken in 130-500 metres depth. In addition, 3 hauls were taken by an even smaller pelagic trawl (Fourclover trawl, with vertical opening of 15 m and 8 mm mesh size in the codend) to investigate the dense echo-layer in the upper 50-70 metres. On "Bjarni Sæmundsson" a total of 18 hauls were taken, of which 2 were deep-sea hauls (>500 m. depth). Most of the hauls were taken in 150-250 m depth.

The biological sampling on both vessels was carried out according to the plan agreed to at the meeting of the SGRS in Copenhagen in May 1994 (Anon 1994b).

On "Bjarni Sæmundsson" temperature measurements were recorded by means of CTD sonde down to 800 m and bathythermograph (XBT) down to 400 m depth alternating 30 n.m. apart. Only XBT, however, was used during the 3 last days of the survey. Zooplankton sampling was regularly carried out by means of bongo net (100 and 50 m depth oblique) mostly 60 n.m. apart. In vivo, chlorophyll **a** was recorded during the survey by a Model 10 Fluormeter Turner Design. Sampling for Chl. **a** extraction measurements were carried out twice a day.

On "Michael Sars", temperature measurements were recorded by CTD sonde down to 800 m except for the standard 3K-section where the sonde was lowered down to 1000 m. Only the six most westerly stations of the 3K-section were taken, but with an addition of two stations within the Greenland EEZ. A smaller genetic analysis was conducted by electrophoresis of blood to look for variation in the haemoglobin-molecule among the fishes.

During the cruise the vessels exchanged data, usually twice a day. On board "Bjarni Sæmundsson" the acoustic data from both vessels were compiled and processed.

Temperature measurements from both vessels were combined to produce both the vertical temperature distribution sections and the horizontal distribution charts.

Contact with the fishing fleet was made during the survey to be orientated about changes in fish distribution and concentrations.

Results

Acoustic measurements. The means of integrated values (m2/nm2) within the statistical rectangles are given in Figure 4. The relative distribution based on the echo values in

Figure 4 is shown in Figure 5. The stock abundance estimate of oceanic redfish within the area covered amounts to about 3.5 million individuals or 2.2 million tonnes. Details are given in Table 2, where the number of fish are divided according to the proportion of males and females and the corresponding mean weight obtained from the biological samples within subareas. The area covered within each subarea during the survey is indicated.

The effect of threshold on the integrator values obtained from pure redfish registrations within different depth intervals is shown in Figure 6. Calculations based on these investigations and the depth distribution of the redfish observed during the survey (Figure 7) indicate that with a threshold of -80 dB, an underestimate of about 6% may be expected. The results from the biomass estimates were corrected accordingly.

In Figure 8 are shown the mean normalized redfish integrator-values obtained on Bjarni Sæmundsson from the 26th of June until the 14th of July, averaged over every 2 hours of the day.

Temperature conditions and distribution of oceanic *S. mentella.* The horizontal distribution of the temperature at 150 m depth is shown in Fig. 9 and at 200 m depth, in Fig. 10, resp. The horizontal temperature distribution is characterized by a tongue of relatively cold water penetrating from southwest into the survey area causing temperature fronts on the western and eastern borders. The movement of these fronts apparently have an impact on the concentration of oceanic redfish. The temperature range in which the species was most abundant, i.e. 3° to 4°C was somewhat lower than the one observed in 1991 and in 1992. These conditions are also reflected in the vertical temperature distribution (Figs. 11 and 12). In general the thermocline is pronounced in the uppermost 70 meters. The concentrations of oceanic redfish were mainly observed in depths below the thermocline, i.e. in 100 to 250 m (Fig. 7). While this survey was carried out the main commercial fishing took place in an area between 57°N and 58°N and between 35°W to 37°W, i.e. within the eastern temperature frontal zone (see Fig. 12). There was also a noticeable influx of colder water (3°C) deriving from deeper waters.

Biological information. A total of 4960 oceanic redfish were measured of which 2965 (60%) were males and 1995 (40%) females. The length range was 24-46 cm, av. 36,65 cm. For males, the average was 36,17 cm and for females, 37,65 cm resp. (see

Appendix). A total of 3101 fish in a length range of 25-46 cm were weighed individually. The average overall weight was 640 g while it was 620 g for males and 668 g for females (Tables 3-7). The maturity stages were 91% stage II for males, i.e. ripening according to the agreed upon scale of maturity (Anon., 1993) and 66,4% stage IV for females i.e. spent. Females were also observed in stage II (29,5%) and a few ones in stage I, i.e. immature (Table 8).

Like in the 1991 and 1992 surveys, deep-sea *S. mentella* was observed in hauls taken in depths greater than 500 m. This *S. mentella* differs from the oceanic *S. mentella* by a different colour, a larger weight and size, much less external and muscular abnormalities and a different stomach content.

Jellyfish was very common in the trawl catches and frequently exceeded those of oceanic redfish.

A pronounced scattering layer was observed during the entire survey between 400-700 meters at day which to some extent ascended to shallower waters during the night time. The most common fish species or groups were e.g. *Myctophidae, Chauliodus sloani, Paralepididae, Stomias boa ferox* and *Serrivomer beani.*

The three hauls which were taken in the upper 50 to 70 metres in different areas caught only the squid *Gonatus fabricii.*

Incidence of external and muscular abnormalities. According to the sampling procedure agreed upon (Anon., 1993), observations on the general appearance of the fish were carried out. About 31% of the males and 61% of the females carried external abnormalities (*Spyrion lumpi* and various spots). These percentages were very similar in the different Sub-Areas. (Table 9).

Abnormal muscular pigmentation, i.e. gray or black spots in the fillets showed up in 47,9% of the 3278 investigated fish, but most of them were only slightly pigmented. The percentage of these abnormal muscular pigmentations were slightly higher for males than for females. A connection between external and muscular abnormalities could not be established.

Observations on stomach contents. Most of the investigated specimens (Table 10) had everted (48%) or empty stomachs (21%). About 31% of the stomachs were with content, but very few of them were with full stomach. Amphipods were the most prominent food group. This year, however, the squids (fully dominated by *Gonatus fabricii*) were the second most common prey group. Their frequency of occurrence was highest in the northernmost area (Sub-Area A). Fish remnants were only observed in some few cases. It should be noted that offal from the fish-processing were found in some stomachs in the area where the fleet was fishing.

Discussion

In almost all the area surveyed, single-fish echoes from redfish were resolved in the water column down to 200-250 m. In such conditions the volume backscattering strength is very sensitive to the threshold used as well as the backscattering cross section of the fish and the depth of the fish. As can be inferred from Fig. 6, a threshold of at least -82 dB//1 m^2/m^3 is required in order to incorporate all redfish echoes down to 300 m.

One drawback in using such a low threshold is that echoes from smaller organism e.g. myctophids cannot be excluded. During the night the ever present scattering layer of myctophids and other creatures ascends and mixes with the redfish to such an extent that the integration limits have to be reduced in order to avoid notable overestimation of the redfish. This and possibly behaviour related factors result in often considerably lower integrator values during the night as compared to daytime values. In Figure 13a-b are shown typical echograms obtained during different times of the day. Using values obtained from Figure 8 to compensate for the diurnal cycle of the integrator data from Bjarni Sæmundsson results in about 37% higher echo abundance. Compensating values obtained within 00:00-06:00 GMT by 70%, but otherwise leaving the data unchanged, increases the echo abundance by 12%. The biological sampling showed some mixing with other species. Of these the jellyfish was the most prominent. In general the redfish-catch was in good agreement with the registrations on the echo sounder. In earlier surveys experimental tows verified that the jellyfish did not contribute to the acoustic data (Reynisson, 1992).

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Table 1.
Instrument settings in the joint Icelandic/Norwegian redfish survey in June/July 1994.

Vessel	Bjarni Sæmundsson	Michael Sars
Echo sounder/integrator	Simrad EK500/BI500	Simrad EK500/BEI500
Frequency	38 kHz	38 kHz
Transmitter power	2000 W	2000 W
Absorbtion coefficient	10dB/km	10dB/km
Pulselength	1.0 ms	1.0 ms
Bandwidth	3.8 kHz	3.8 kHz
Transducer type	ES38-B	ES38-S
2 way beam angle	-20.6 dB	-21.0
Sv-transducer gain	26.5 dB	27.6 dB
TS-transducer gain	26.7 dB	27.5 dB
Angle sensitivity	21.2	21.9
3 db beamwidt	7.1 dg	6.7 dg
Alongship offset	0.02 dg	-0.09 dg
Athw. ship offset	-0.01 dg	-0.04 dg
Integration treshold	-80 dB	-80 dB
Sound speed	1467-1472 m/s	1472 m/s

Table 2. Biomass computation for Oceanic redfish. The number of fish are given in thousands and the biomass in thousands of tonnes.

Subarea	Area (nm^2)	Number of males	Biomass of males	Number of feamales	Biomass of females	Total number of fish	Total biomass
A	75307	609.9	359.2	499.5	314.2	1109.4	673.4
B-west	48672	822.7	519.1	526.0	363.4	1348.6	882.5
B-east	40066	336.3	182.9	279.2	162.5	615.4	345.4
D	7342	55.7	36.7	39.0	26.5	94.6	63.2
E	18348	195.2	129.6	132.9	95.9	328.1	225.5
Total	189735	2021.1	1226.1	1475.2	960.2	3496.1	2190.0

Table 3. Oceanic redfish
Sub-Area A. Mean weight (g) by length (cm)

	Males		Females		Total	
cm	g	no	g	no	g	no
26			197	1	197	1
27	218	1			218	1
28	265	4	274	3	269	7
29			284	3	284	3
30	299	3	309	6	306	9
31	357	8	361	2	358	10
32	432	19	396	2	429	21
33	467	58	462	7	466	65
34	499	66	277	19	449	85
35	544	75	534	42	540	117
36	593	84	582	54	589	138
37	647	69	626	72	636	141
38	707	52	686	78	694	130
39	774	36	763	40	768	76
40	810	21	796	36	801	57
41	880	2	862	11	865	13
42	862	1	851	4	853	5
43	894	1	930	2	918	3
46	1340	1			1340	1
Total		501		382		883
Av. g	589		629		606	
Av. cm		35,68		36,98		36,25

Table 4. Oceanic redfish
Sub-Area B-west. Mean weight(g) by length(cm)

	Males		Females		Total	
cm	g	no	g	no	g	no
26	0	0	211	1	211	1
27	252	1	231	3	237	4
28	237	1	262	1	250	2
29	0	0	331	1	330	1
30	0	0	307	1	307	1
31	385	4	0	0	385	4
32	407	13	378	4	400	17
33	446	47	449	4	446	51
34	498	89	494	17	498	106
35	545	89	526	28	540	117
36	603	105	590	55	599	160
37	655	119	636	78	647	197
38	713	105	697	90	705	195
39	757	109	752	85	754	194
40	817	35	810	67	812	102
41	841	16	886	34	872	50
42	0	0	890	10	890	10
43	897	2	931	2	914	4
44	0	0	0	0	0	0
45	0	0	1185	1	1185	1
Total		735		482		1217
Av.g	631		691		655	
Av.cm		36,54		37,84		37,05

Table 3. Oceanic redfish
Sub-Area A. Mean weight (g) by length (cm)

	Males		Females		Total	
cm	g	no	g	no	g	no
26			197	1	197	1
27	218	1			218	1
28	265	4	274	3	269	7
29			284	3	284	3
30	299	3	309	6	306	9
31	357	8	361	2	358	10
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34	499	66	277	19	449	85
35	544	75	534	42	540	117
36	593	84	582	54	589	138
37	647	69	626	72	636	141
38	707	52	686	78	694	130
39	774	36	763	40	768	76
40	810	21	796	36	801	57
41	880	2	862	11	865	13
42	862	1	851	4	853	5
43	894	1	930	2	918	3
46	1340	1			1340	1
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29	0	0	331	1	330	1
30	0	0	307	1	307	1
31	385	4	0	0	385	4
32	407	13	378	4	400	17
33	446	47	449	4	446	51
34	498	89	494	17	498	106
35	545	89	526	28	540	117
36	603	105	590	55	599	160
37	655	119	636	78	647	197
38	713	105	697	90	705	195
39	757	109	752	85	754	194
40	817	35	810	67	812	102
41	841	16	886	34	872	50
42	0	0	890	10	890	10
43	897	2	931	2	914	4
44	0	0	0	0	0	0
45	0	0	1185	1	1185	1
Total		735		482		1217
Av.g	631		691		655	
Av.cm		36,54		37,84		37,05

Table 5. Oceanic redfish
Sub-area B-east. Mean weight(g) by length(cm).

	Males		Females		Total	
cm	g	nos.	g	nos.	g	nos.
25	180	1			180	1
26	195	2	215	2	205	4
27	235	1	232	3	233	4
28	270	4	269	4	270	8
29	280	1	298	2	292	3
30	320	3	263	2	297	5
31	345	1	393	2	377	3
32	411	8	485	1	419	9
33	454	11	0	0	454	11
34	486	33	477	12	484	45
35	536	22	515	16	527	38
36	612	19	586	13	601	32
37	641	14	631	24	635	38
38	716	13	663	19	685	32
39	733	5	716	7	723	12
40	891	1	800	11	808	12
41	914	2	775	3	831	5
42	880	1	951	1	916	2
43	1000	1			1000	1
Total		143		122		265
Av. g	544		582		561	
Av.cm		34,79		35,91		35,31

Table 6 Oceanic redfish
Sub-Area D **Mean weight(g) by length(cm)**

	Males		Females		Total	
cm	g	no	g	no	g	no
33	475	4	397	1	459	5
34	507	4	481	1	502	5
35	540	17	530	4	538	21
36	606	8	575	11	588	19
37	680	10	659	10	670	20
38	703	16	682	10	695	26
39	761	11	777	13	770	24
40	808	7	819	3	812	10
41	819	1	902	3	882	4
42	968	2	0	0	968	2
Total		80		56		136
Av.g	660		679		668	
Av.cm		37,04		37,55		37,25

Table 5. Oceanic redfish
Sub-area B-east. Mean weight(g) by length(cm).

	Males		Females		Total	
cm	g	nos.	g	nos.	g	nos.
25	180	1			180	1
26	195	2	215	2	205	4
27	235	1	232	3	233	4
28	270	4	269	4	270	8
29	280	1	298	2	292	3
30	320	3	263	2	297	5
31	345	1	393	2	377	3
32	411	8	485	1	419	9
33	454	11	0	0	454	11
34	486	33	477	12	484	45
35	536	22	515	16	527	38
36	612	19	586	13	601	32
37	641	14	631	24	635	38
38	716	13	663	19	685	32
39	733	5	716	7	723	12
40	891	1	800	11	808	12
41	914	2	775	3	831	5
42	880	1	951	1	916	2
43	1000	1			1000	1
Total		143		122		265
Av. g	544		582		561	
Av.cm		34,79		35,91		35,31

Table 6 Oceanic redfish
Sub-Area D Mean weight(g) by length(cm)

	Males		Females		Total	
cm	g	no	g	no	g	no
33	475	4	397	1	459	5
34	507	4	481	1	502	5
35	540	17	530	4	538	21
36	606	8	575	11	588	19
37	680	10	659	10	670	20
38	703	16	682	10	695	26
39	761	11	777	13	770	24
40	808	7	819	3	812	10
41	819	1	902	3	882	4
42	968	2	0	0	968	2
Total		80		56		136
Av.g	660		679		668	
Av.cm		37,04		37,55		37,25

Table 7 Oceanic redfish
Sub-Area E. **Mean weight (g) by length (cm)**

cm	Males g	Males no	Females g	Females no	Total g	Total no
28	0	0	254	2	254	2
29	275	1	0	0	275	1
30	327	3	339	2	332	5
31	386	2	0	0	386	2
32	424	6	0	0	424	6
33	443	24	453	5	445	29
34	494	22	488	4	492	26
35	548	45	523	17	541	62
36	595	36	586	30	591	66
37	667	47	629	27	653	74
38	723	60	689	29	712	89
39	769	50	755	28	764	78
40	824	39	815	41	820	80
41	872	16	875	37	874	53
42	901	5	915	16	911	21
43	985	1	958	2	967	3
44		0	1024	3	1024	3
Total		357		243		600
Av.g	664		722		687	
Av.cm		37,04		38,40		37,59

Table 8 Oceanic redfish 1994.
Maturity stages by Sub-Area

Sub-Area	Mat.st.	Males 1	Males 2	Males 3	Males 4	Males Total	Females 1	Females 2	Females 4	Females Total	Gr.Total
A	No.	12	716	2	16	746	23	110	428	561	1307
	%	1,6	96,0	0,3	2,1	100,0	4,1	19,6	76,3	100,0	
B	No.	20	1329	0	207	1556	47	327	583	957	2513
	%	1,3	85,4	0,0	13,3	100,0	4,9	34,2	60,9	100,0	
D	No.		80			80	1	29	26	56	136
	%		100,0			100,0	1,8	51,8	46,4	100,0	
E	No.	6	546	0	1	553	10	117	274	401	954
	%	1,1	98,7		0,2	100,0	2,5	29,2	68,3	100,0	
Gr.Total	No.	38	2671	2	224	2935	81	583	1311	1975	4910
	%	1,3	91,0	0,1	7,6	100,0	4,1	29,5	66,4	100,0	

Table 9 Oceanic redfish1994

Incidence of external and muscular abnormalities

External abnormalities	Sub-Area A			Sub-Area B			Sub-Area D			Sub-Area E			Total		
	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total
No. of fish examined	502	382	884	1003	680	1683	80	56	136	357	243	600	1942	1361	3303
No. of fish with ext. abnorm.	161	235	396	306	407	713	26	30	56	109	162	271	602	834	1436
% with ext. abnorm.	32,07	61,5	44,8	30,5	59,9	42,36	32,5	53,6	41,2	30,5	66,7	45,2	31,0	61,3	43,5
No. with ext. spots	66	127	193	144	210	354	5	15	20	41	69	110	256	421	677
% w.spots	13,15	33,2	21,83	14,4	30,9	21,0	6,3	26,8	14,7	11,5	28,4	18,3	13,2	30,9	20,5
No. w. Sph.l. and/or remn.	108	164	272	198	289	487	17	25	42	70	133	203	393	611	1004
% w.Sph.l. and/or remn.	21,51	42,9	30,77	19,7	42,5	28,94	21,3	44,6	30,9	19,6	54,7	33,8	20,2	44,9	30,4
Muscular abnormalities															
	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total
No. of fish examined	502	382	884	989	669	1658	80	56	136	357	243	600	1928	1350	3278
No. of fish w. musc. abnorm.	258	171	429	488	303	791	42	26	68	164	93	257	952	593	1545
% w. musc. abnorm.	51,4	44,8	48,5	49,3	45,3	47,7	52,5	46,4	50,0	45,9	38,3	42,8	49,4	43,9	47,1

Table 10 Oceanic redfish 1994

Observations on the stomach content

	Sub-Area A		Sub-Area B		Sub-Area D		Sub-Area E		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Total	884		1657		136		600		3277	
everted	465	52,6	773	46,7	49	36,0	284	47,3	1571	47,9
empty	180	20,4	358	21,6	13	9,6	151	25,2	702	21,4
w.content	239	27,0	526	31,7	74	54,4	165	27,5	1004	30,6
little	136	15,4	362	21,8	38	27,9	82	13,7	618	18,9
medium	82	9,3	125	7,5	21	15,4	45	7,5	273	8,3
much	21	2,4	39	2,4	15	11,0	38	6,3	113	3,4
	frequ.	%	frequ.	%	frequ.	%	frequ.	%	frequ.	%
Amphip.	93	27,8	379	50,7	71	70,3	121	42,3	664	45,2
Copepod.	36	10,8	31	4,1	2	2,0	2	0,7	71	4,8
Euphaus.	57	17,1	53	7,1	6	5,9	10	3,5	126	8,6
Squids	127	38,0	132	17,7	14	13,9	30	10,5	303	20,6
Gastrop.	1	0,3	4	0,5	0	0,0	0	0,0	5	0,3
Medusae	4	1,2	47	6,3	2	2,0	40	14,0	93	6,3
Chaetogn.	8	2,4	26	3,5	1	1,0	69	24,1	104	7,1
Fish remn.	1	0,3	22	2,9	5	5,0	12	4,2	40	2,7
Other	7	2,1	53	7,1	0	0,0	2	0,7	62	4,2

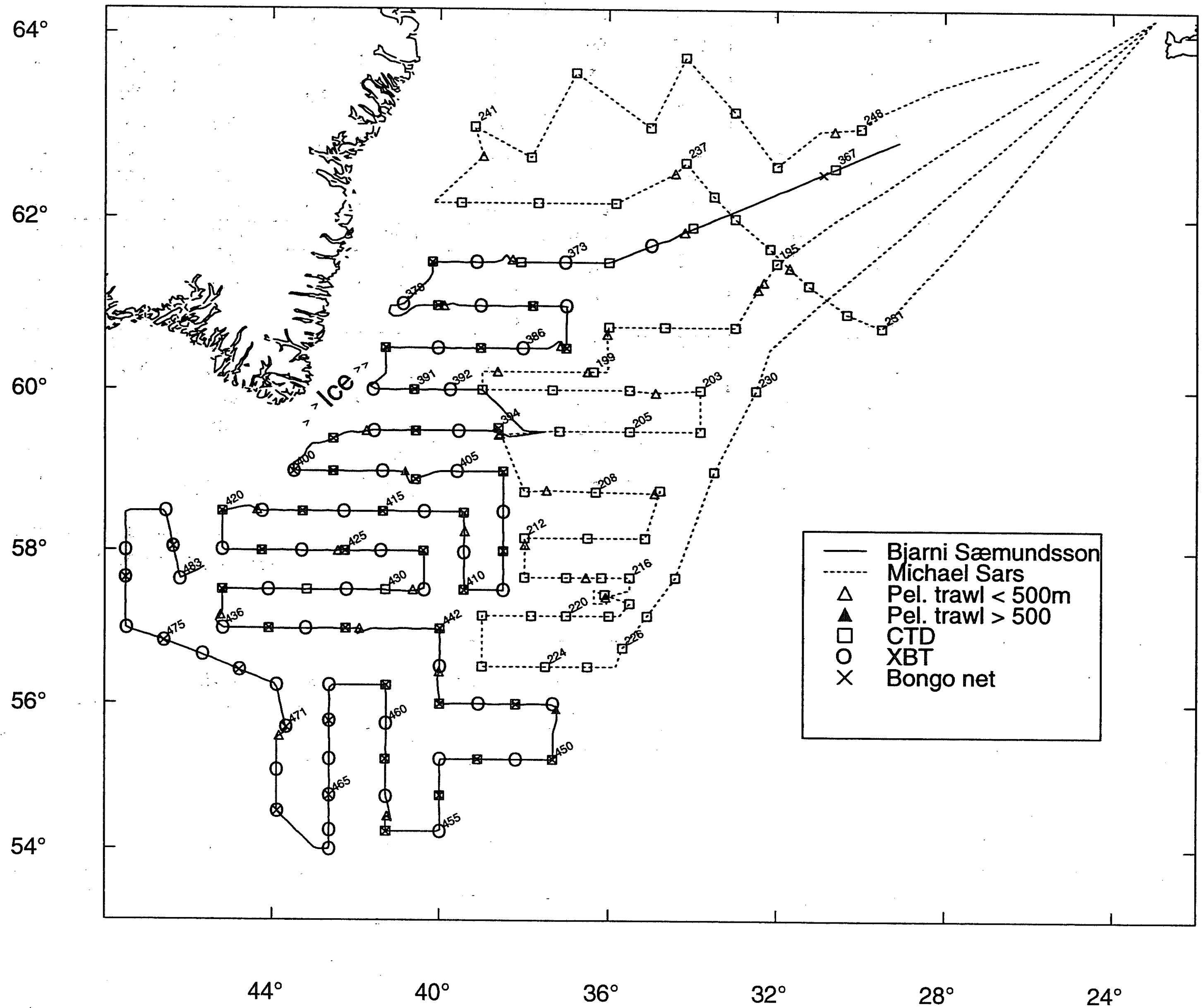
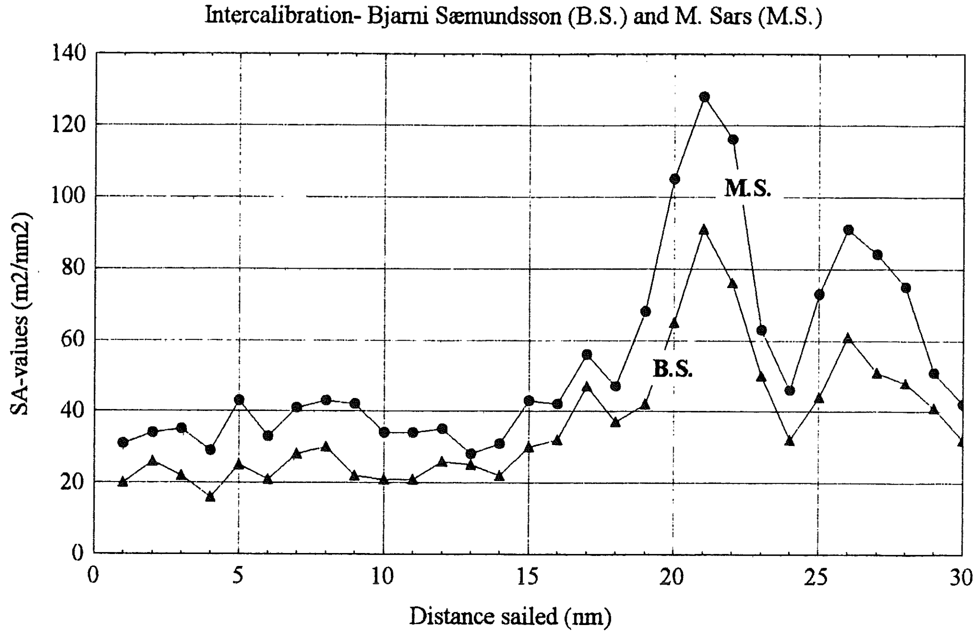


Fig. 1
Cruise tracks and stations.



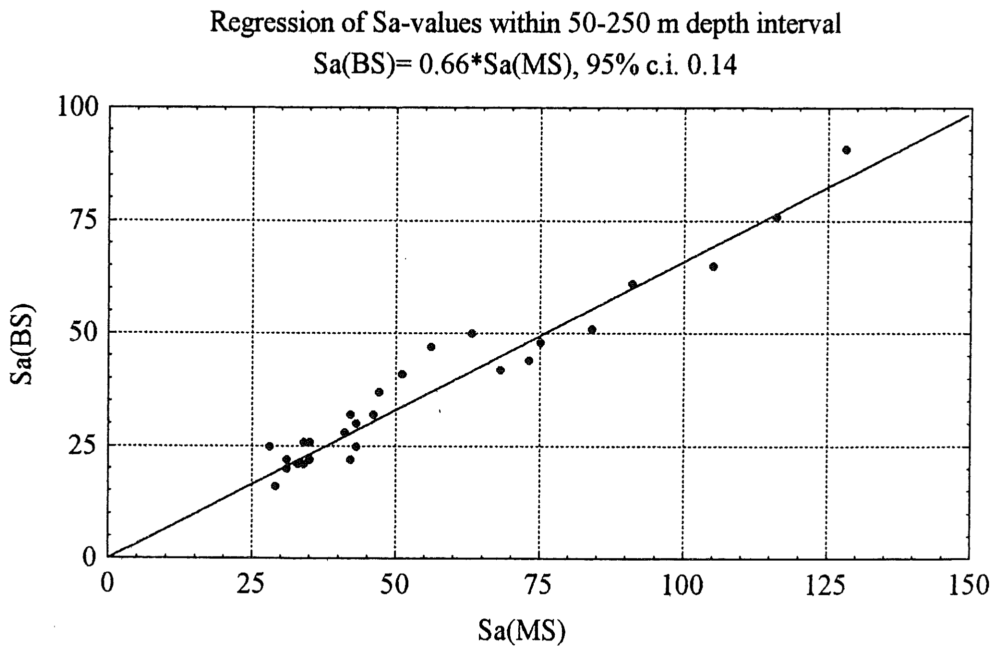


Fig. 2
Results of the inter-ship comparison between "Bjarni Sæmundsson" and "Michael Sars".

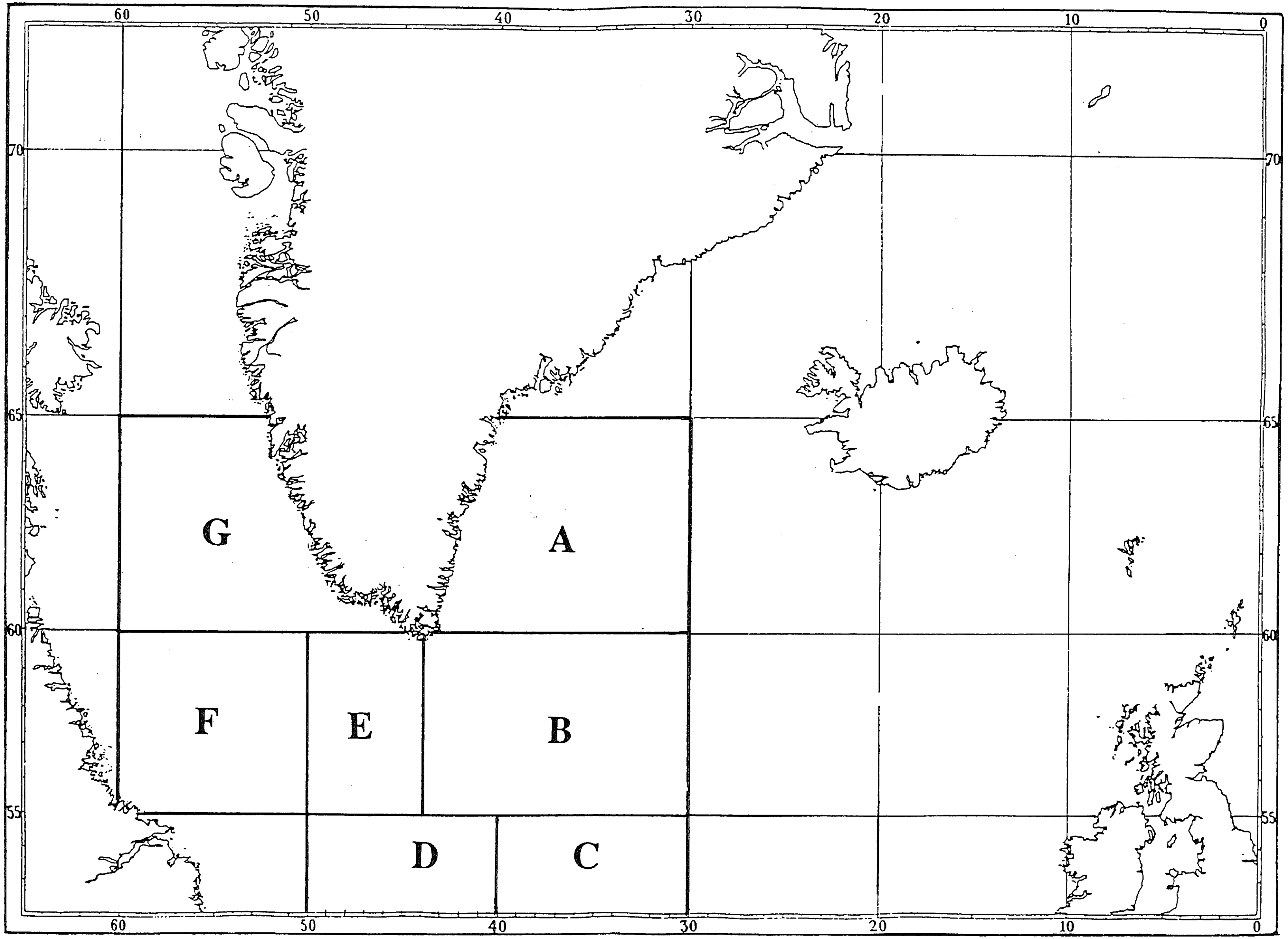


Fig. 3.
Map showing the agreed sub-areas to be used on international surveys for oceanic *S. mentella* in the Irminger Sea and adjacent waters.

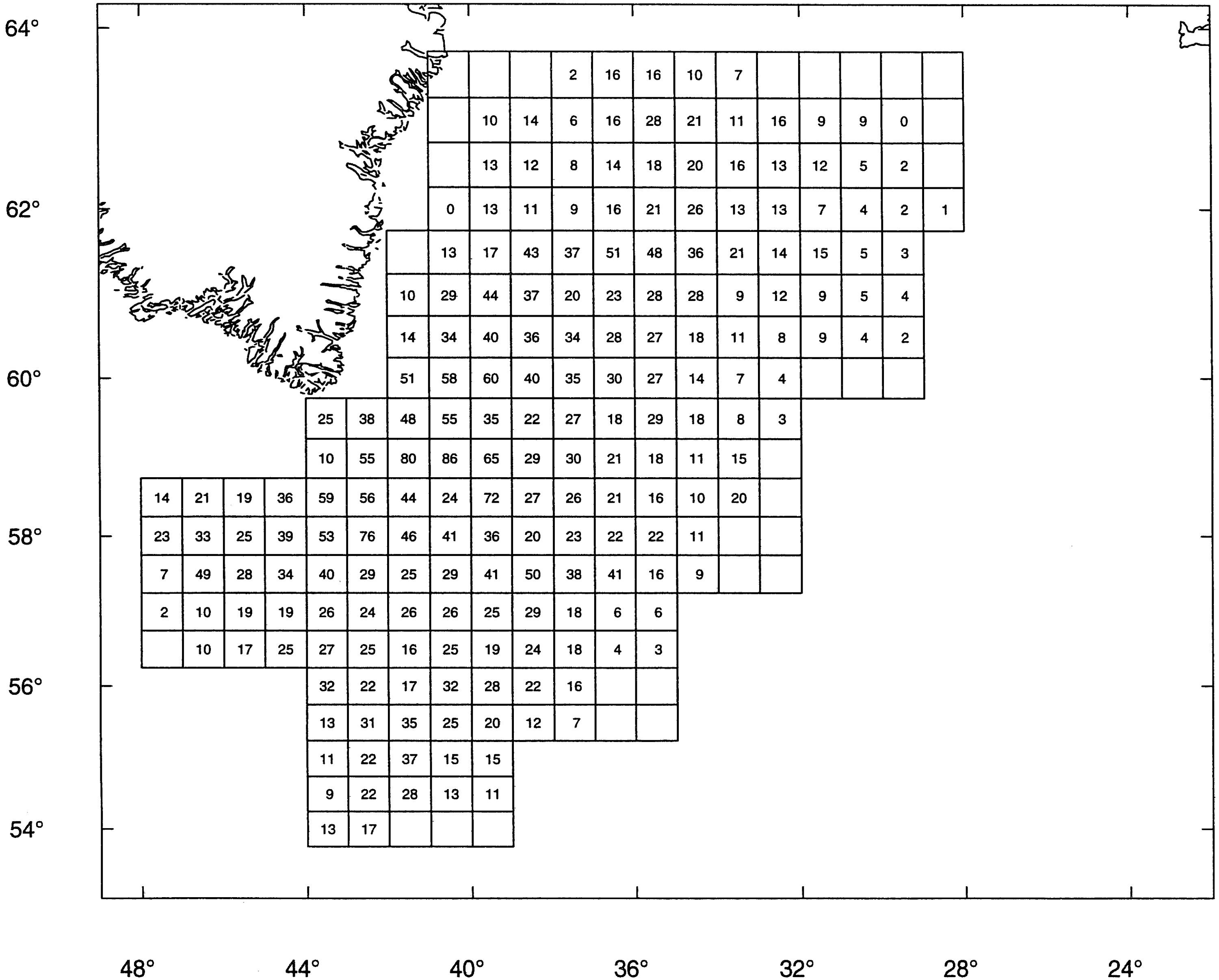


Fig. 4
Mean values of area back scattering strength (m^2/ nm^2/) within statistical rectangles.

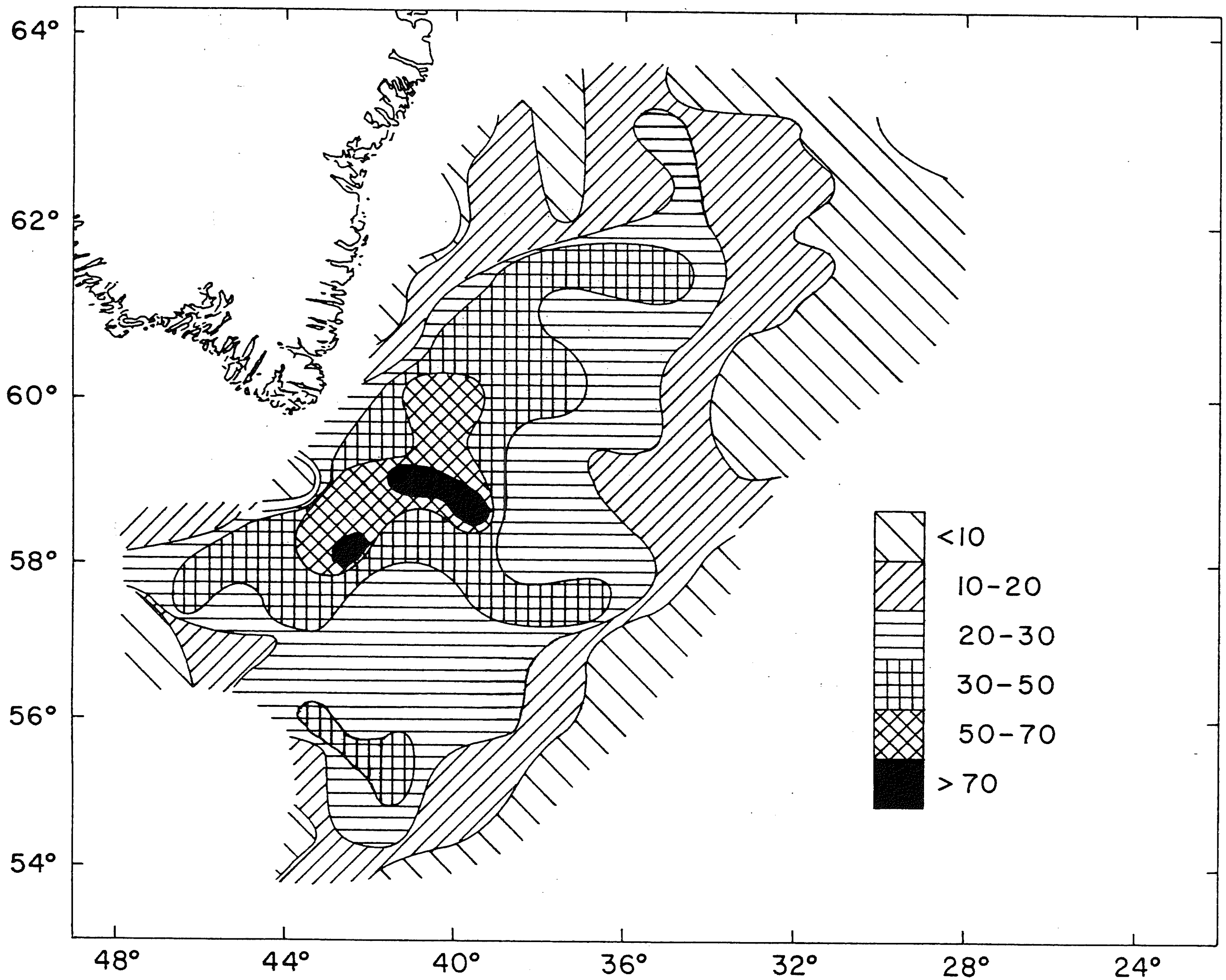


Fig. 5
Distribution and relative density of Oceanic redfish in June/July 1994. The contours are based on the values shown in Figure 4.

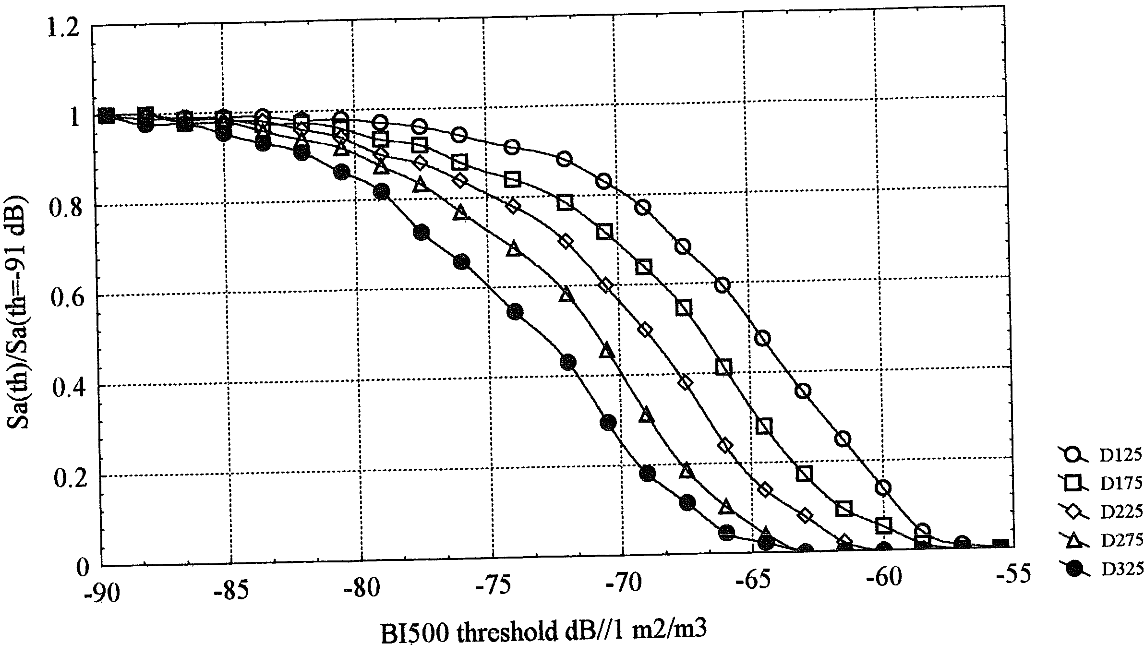


Fig. 6
The effect of integration threshold on Oceanic redfish within 50 m depth intervals from 100 m down to 350 m.

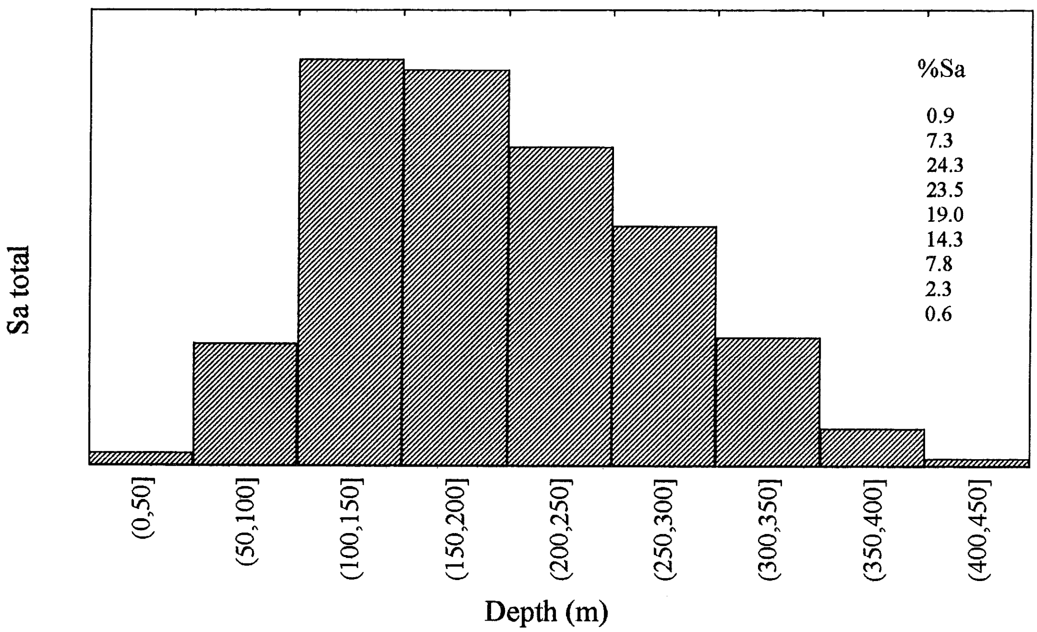


Fig. 7
Depth distribution of Oceanic redfish in the Irminger Sea in June/July 1994.

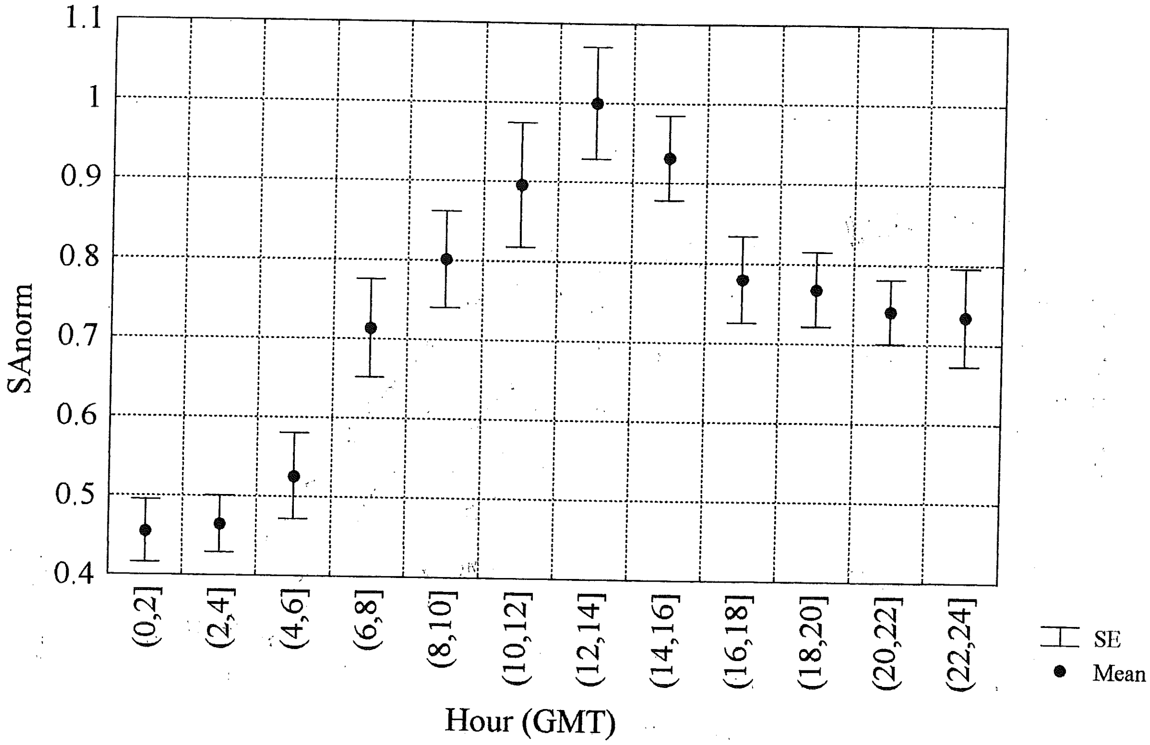


Fig. 8
Diurnal variations of integrator values of oceanic redfish from "Bjarni Sæmundsson" in June/July 1994.

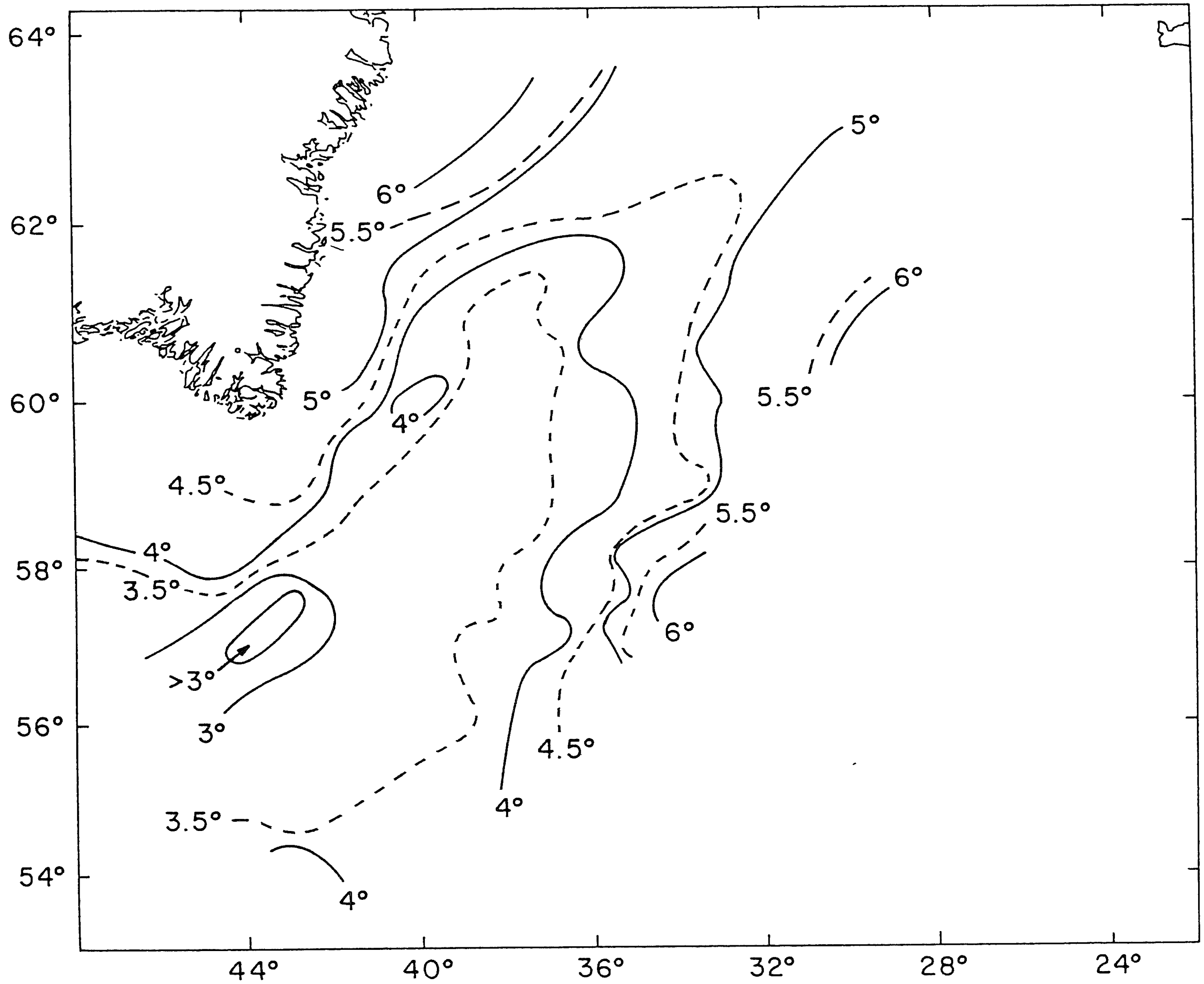


Fig. 9
Horizontal temperature (t°C) distribution at 150 m. depth.

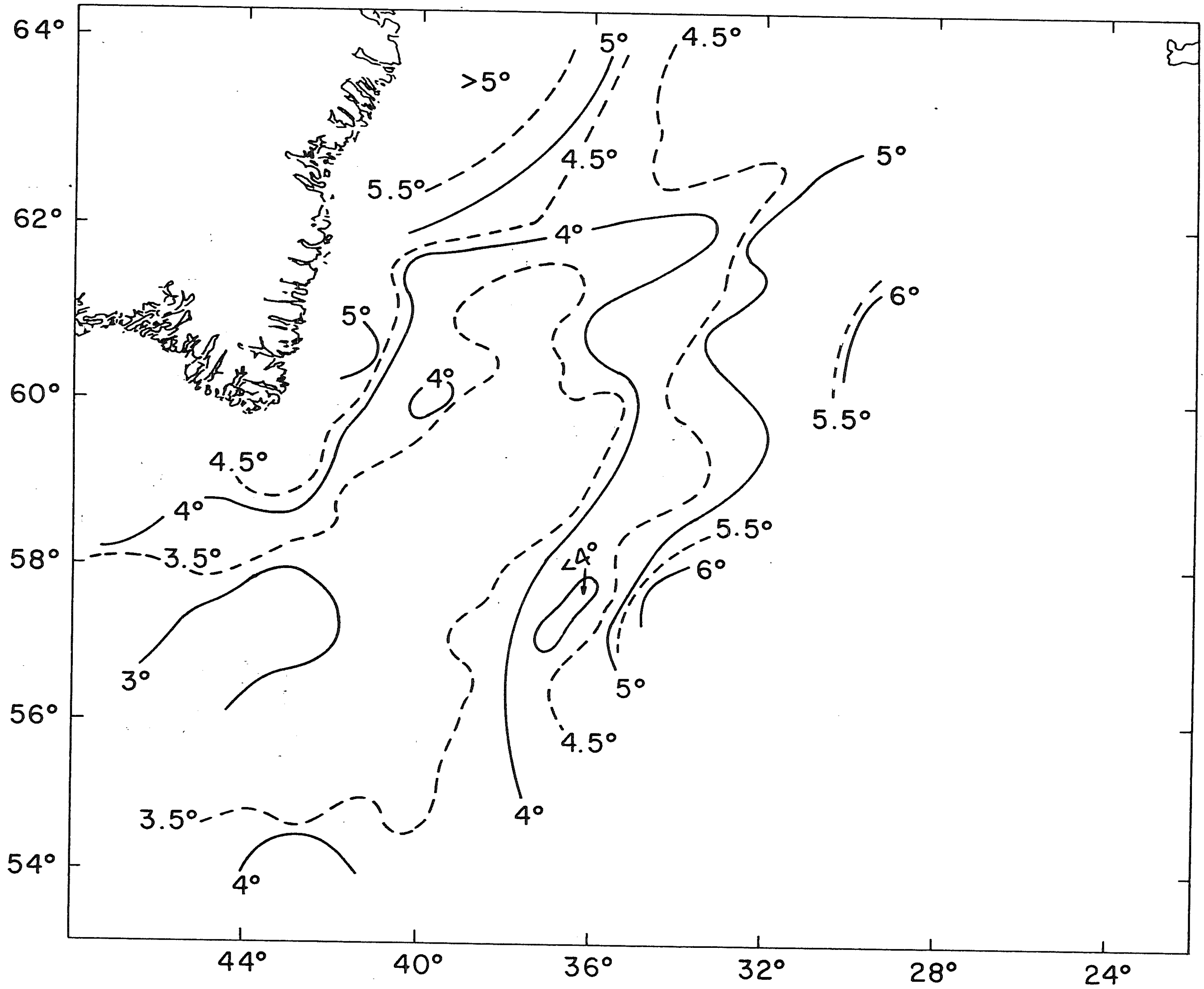


Fig. 10
Horizontal temperature (t°C) distribution at 200 m. depth.

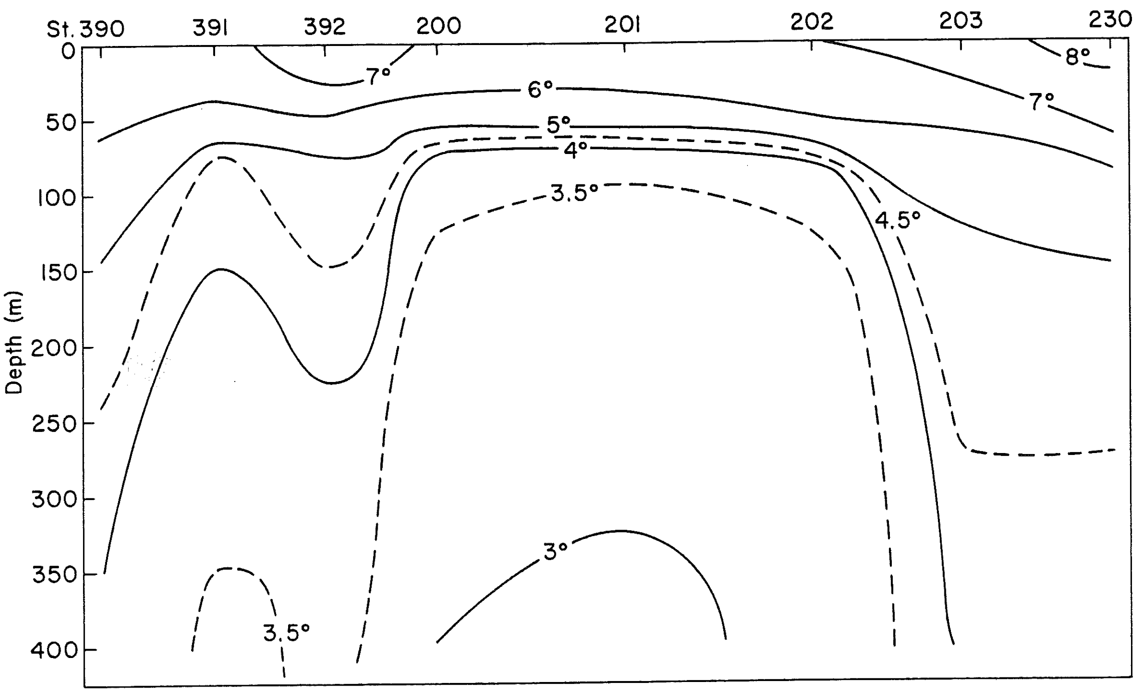


Fig. 11
Vertical temperature distribution (t°C) on a section along the 60°N latitude between 41°38'W to 32°30'W longitude taken by "Bjarni Sæmundsson" stations 390-392 and Michael Sars (stations 200-203 and 230).

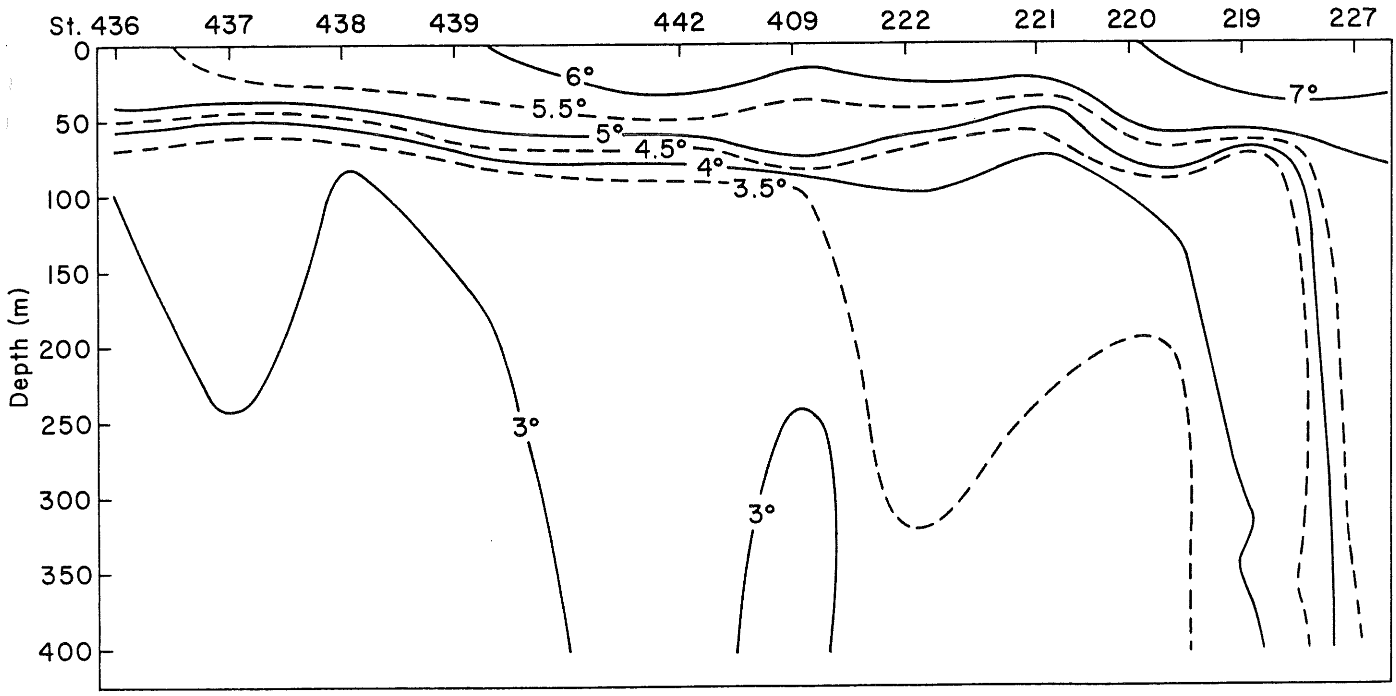
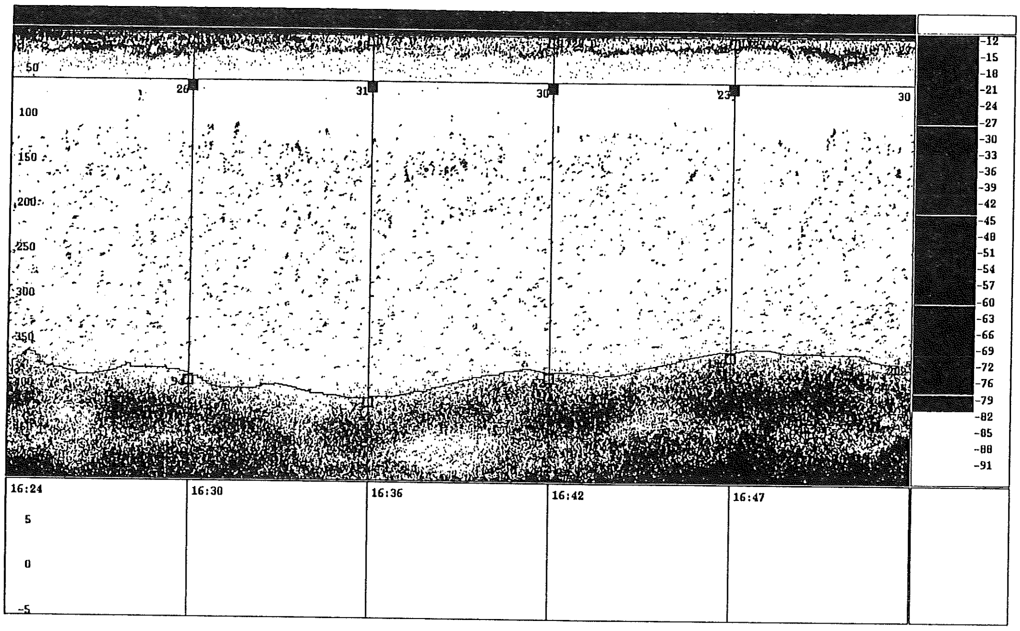


Fig. 12
Vertical temperature (t°C) distribution on a section between 57°00'N and 45°12'W and 57°10'N and 35°05'W taken by Bjarni Sæmundsson (No 436 to 439 and 442 and 409) and Michael Sars (222-220 and 219 and 227).

a)



b)

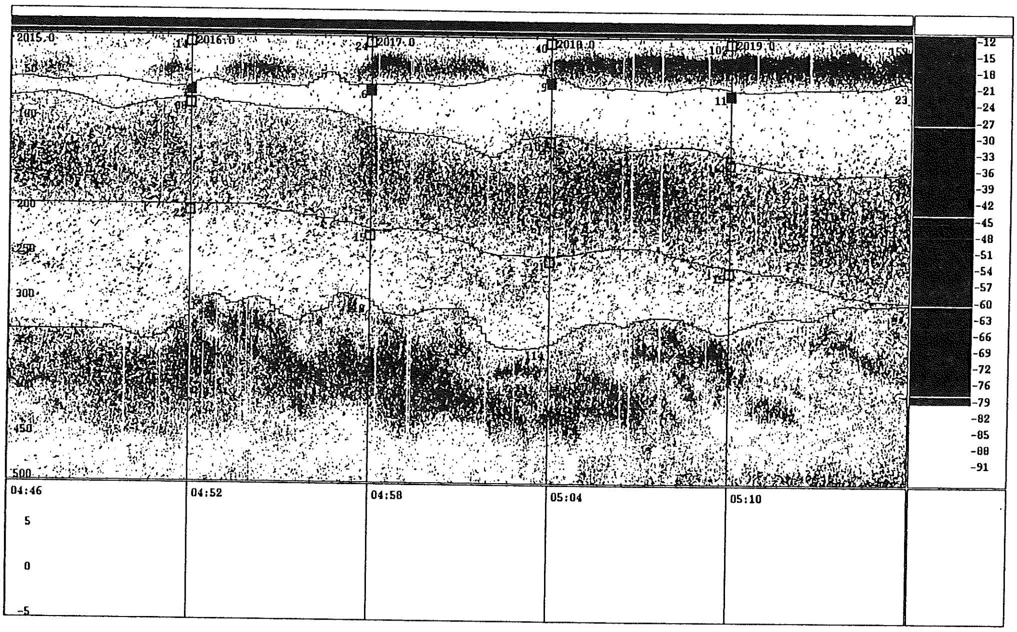


Fig. 13

Typical echograms obtained during the survey. a) Dayligth conditions (16:24-16:57 GMT). Pure redfish registrations are observed from 100 m down to 350-400 m. Below 400 m, a rather dense scattering layer of smaller organism is observed. b) Conditions at dawn (045:46-05:20 GMT). During nighttime, a part of the scattering layer ascends (shortly after midnight) to a depth of about 100 m, making separation of redfish echoes difficult, and descends at dawn.

Appendix Oceanic redfish
Length distribution by Sub-Area and sex

A)Males **B)Females**

cm	Sub-A	%	Sub.-B	%	Sub-D	%	Sub-E	%	Total	%	Sub-A	%	Sub-B	%	Sub-D	%	Sub-E	%	Total	%	Gr.Total	%
24			1	0,1					1	0,0											1	0,0
25			1	0,1					1	0,0											1	0,0
26	1	0,1	3	0,2			1	0,2	5	0,2	2	0,3	4	0,4					6	0,3	11	0,2
27	2	0,3	5	0,3			1	0,2	8	0,3	0	0,0	8	0,8					8	0,4	16	0,3
28	6	0,8	7	0,5			0	0,0	13	0,4	5	0,9	12	1,3			2	0,5	19	1,0	32	0,6
29	3	0,4	4	0,3			1	0,2	8	0,3	4	0,7	6	0,6			0	0,0	10	0,5	18	0,4
30	4	0,5	7	0,5			3	0,5	14	0,5	7	1,2	10	1,0			2	0,5	19	1,0	33	0,7
31	10	1,3	9	0,6			3	0,5	22	0,7	4	0,7	3	0,3			1	0,2	8	0,4	30	0,6
32	28	3,6	40	2,6			10	1,8	78	2,6	4	0,7	11	1,2			1	0,2	16	0,8	94	1,9
33	87	11,1	111	7,2	4	5,0	32	5,8	234	7,9	13	2,2	8	0,8	1	1,8	8	2,0	30	1,5	264	5,3
34	117	14,9	238	15,4	4	5,0	40	7,2	399	13,5	28	4,8	48	5,0	1	1,8	11	2,7	88	4,4	487	9,8
35	126	16,1	208	13,4	17	21,3	69	12,5	420	14,2	72	12,4	92	9,6	4	7,1	26	6,5	194	9,7	614	12,4
36	108	13,8	208	13,4	8	10,0	57	10,3	381	12,8	90	15,5	110	11,5	11	19,6	42	10,5	253	12,7	634	12,8
37	102	13,0	244	15,8	10	12,5	80	14,5	436	14,7	105	18,0	154	16,1	10	17,9	55	13,7	324	16,2	760	15,3
38	88	11,2	186	12,0	16	20,0	91	16,5	381	12,8	112	19,2	162	16,9	10	17,9	50	12,5	334	16,7	715	14,4
39	58	7,4	179	11,6	11	13,8	77	13,9	325	11,0	57	9,8	139	14,5	13	23,2	60	15,0	269	13,5	594	12,0
40	32	4,1	64	4,1	7	8,8	55	9,9	158	5,3	53	9,1	116	12,1	3	5,4	70	17,5	242	12,1	400	8,1
41	3	0,4	28	1,8	1	1,3	25	4,5	57	1,9	13	2,2	52	5,4	3	5,4	49	12,2	117	5,9	174	3,5
42	5	0,6	2	0,1	2	2,5	7	1,3	16	0,5	9	1,5	15	1,6	0	0,0	19	4,7	43	2,2	59	1,2
43	3	0,4	3	0,2	0	0,0	1	0,2	7	0,2	4	0,7	4	0,4	0	0,0	2	0,5	10	0,5	17	0,3
44	0	0,0	0	0,0	0	0,0	0	0,0	0	0,0	0	0,0	1	0,1	0	0,0	3	0,7	4	0,2	4	0,1
45	0	0,0	0	0,0	0	0,0	0	0,0	0	0,0	0	0,0	1	0,1	0	0,0	0	0,0	1	0,1	1	0,0
46	1	0,1	0	0,0	0	0,0	0	0,0	1	0,0	0	0,0	0	0,0	0	0,0	0	0,0	0	0,0	1	0,0
Tot.	784		1548		80		553		2965		582		956		56		401		1995		4960	
Av.l.	35,68		36,09		37,04		36,98		36,17		36,90		37,23		37,55		38,25		37,35		36,65	