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Distribution of pelagic redfish (*S. mentella* Travin), at depth below 500 m, in the Irminger Sea and adjacent waters in May 1998.

By

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Abstract

During recent years, fishery for oceanic redfish in the Irminger Sea has shifted towards greater depths while acoustic estimates of the stock only reach down to approximately 500 m depth. This paper describes the distribution of redfish, at depths below 500 m in the northern part of the Irminger Sea, based on a survey conducted during 7 to 23 May 1998. The main purpose of the survey was to map the deeper layer of oceanic redfish (at depth below 5-600 m) i.e. that part of the stock which is the target of commercial fishing during spring-early summer. The results indicate an even distribution with low density of redfish except for two small areas where the fishing fleet was concentrated, the wessels catching 2-3 tonnes of redfish per hour.

Keywords: Irminger Sea redfish, redfish distribution, redfish fishery.

Introduction

Since the fishery for oceanic redfish (*Sebastes. mentella*, Travin) started in 1982, several acoustic surveys have been conducted of the Irminger Sea and adjacent waters in order to measure the fishable stock size. The USSR and later Russia have carried out acoustic surveys nearly annually (e.g. Pedchenko et al. 1995). Iceland conducted a pilot survey in 1991 (Magnússon et al. 1992a) and in 1992 Iceland and Russia conducted an acoustic survey on the oceanic redfish in the Irminger Sea (Magnússon et al. 1992b). A joint Icelandic and Norwegian survey was carried out in 1994 (Magnússon et al. 1994) and in 1996, Iceland, Germany and Russia conducted a large acoustic survey (Magnússon et al. 1996).

During all of these surveys, oceanic redfish has been measured by acoustics down to approximately 500 m depth. Attempts have been made to measure below that depth, but without success. 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).

As mentioned, the fishery for oceanic redfish started in 1982 when vessels from the former USSR caught 60 000 tonnes. In the following years, the catches increased gradually to over 105 000 tonnes in 1986. Catches declined thereafter to only 25 000 tonnes in 1991, mainly due to a reduction in fishing effort. The main fishing period was from April-August and at depths shallower than 500 m. From 1992 the catch has increased substantially to over 150 000 tonnes in 1995 and 1996. The catch in 1997 is estimated to be around 140 000 tonnes. During the 1980s, almost the entire catch was taken above 500 m depth and the average length of the redfish was 35 - 36 cm. However, during the most recent years an increasing proportion of the fishing has taken place below 500 m and the mean length of redfish has increased with the trawling depth. Fishermen prefer to fish in the deeper layers as this generally yields larger fish with a lower incidence of parasites.

In the 1980s, a second type of *S. mentella*, resembling the deep-sea *S. mentella* caught at the shelves of E-Greenland, Iceland and the Faroes was found pelagically in the Irminger Sea at depths below 500 m (Magnússon 1983; Reinert 1987). The fishery in this deeper layer did not start until 1992, it usually takes place from the beginning of April until the second week of June in an area close to the Icelandic 200 miles EEZ, west of the Reykjanes Ridge. For practical reasons, this population has been treated as oceanic redfish (Anon 1998). However, it remains unclear whether redfish in the Irminger Sea constitute a single stock or whether two or more stocks may be involved. There are indications that redfish in the upper layer (< 500 m) differ in some respects from those in deeper layers (Anon 1997). Neither is it clear whether there is a relationship between the deep sea type in the Irminger Sea and the deep sea redfish caught at the shelves of E-Greenland, Iceland and Faroe Islands.

In summary, two hypotheses have been put forward to describe redfish in the Irminger Sea (Anon 1998):

A single-stock hypothesis, suggesting that the mature individuals of a single stock segregate according to age/size;

A two-stock hypothesis, suggesting that there is a distinct deep-sea stock, separate from the oceanic stock proper, and occupying deeper layers. Regarding this hypothesis, it is an open question whether or not the deep-sea stock in the Irminger Sea is separate from the deep-sea stock on the continental slope.

Discrimination between different redfish types in the Irminger Sea is very difficult and at present only Iceland divides the catch in the Irminger Sea between the two possible types. The discrimination is based on several but not well defined criteria (cf Anon 1998).

An attempt to map the distribution in the lower layer was made in the autumn of 1996 when the Marine Research Institute in Reykjavík (MRI) hired a commercial trawler for that purpose for two weeks. Due to spells of bad weather during the survey only 17 hauls were made. Redfish was caught in every haul, both west and east of the Reykjanes Ridge, but the catch rate was very low indicating a very low density and a nearly even distribution in the survey area (Sigurdsson 1997).

Preliminary results from a Russian trawl-acoustic survey, conducted in 1997, (unpublished) indicate a peak in abundance in the upper layer (above 500 m) far to the southwest of the highest concentration observed in the lower layer (below 500 m). The calculation of abundance is based on catch rates below 500 m and on correlation between catch and acoustic values in the upper layer. In general, the results corresponds to the horizontal and vertical distribution of the commercial catch.

As indicated above, many questions remains unanswered regarding stock identification and abundance of redfish in the Irminger Sea and adjacent waters and a great deal of effort is needed to resolve the problem. This paper describes an attempt to address one of these questions i.e. the distribution of pelagic redfish at depth below 5-600 m, which is subject to heavy commercial exploitation during spring and early summer.

Material and Methods

The survey was carried out with the research vessel "Bjarni Sæmundsson" during 7-23 May 1998.

A 38 kHz SIMRAD EK500 split-beam echo sounder and integrator were used for the acoustic data collection (Bodholt et al. 1989). In addition a BI500 post-processing system was used (Foote et al. 1991) for scrutinizing the echograms. Mean integrated values of redfish and from the "scattering layer" per 5 nm were recorded. The settings of the equipment used during the survey are given in Table 1. A few days prior to the survey, the acoustic equipment was calibrated using the standard sphere method (Foote et al. 1987).

The trawl used was a Gloria type 896 with a vertical opening of approximately 42 m and an horizontal opening of about 60-65 m. Trawling was standardized as far as possible. Each trawl haul was taken at three depth intervals, each of 50 min. duration. During the first, second and third part of the haul, the headline of the trawl was respectively at 500-570 m, 600-670 m and 700-800 m depth. Consequently, the duration of each haul was about 150 min.. In addition, one haul was taken above 500 m depth. A total of 33 pelagic hauls were taken and one haul with bottom trawl (Fig. 1).

A SIMRAD FS 3300 trawl sonar system was mounted on the headline of the trawl, recording the geometry of the trawl, temperature, depth and fish passing the mouth of the trawl.

Temperature and salinity measurements were made by a Seabird CTD down to 800-1200 m on two E-W sections (at about 62°35N and 60°N; see Fig. 1) and also in the fishing area of the commercial fleet during the survey, at about 61°40N.

Routine biological observations were made, including length, weight, and observations on external and, partly, internal abnormalities as well as on stomach contents. In addition, otoliths were collected.

Results

Acoustic measurements. Recordings definitely identifiable as redfish were rare during the survey, and then mostly in the uppermost 400 m. At depths below 400-500 m, dispersed recordings of fish were observed, but could not be directly identified as redfish. The mean integrated values (m^2/nm^2) within statistical rectangles are shown in Figure 2. Similarly, values deriving from the more or less continuous scattering layer are shown in Figure 3.

An 18 kHz echo sounder was run concurrently with the 38 kHz. Usually, the scattering layer was more pronounced on the lower frequency. This was, however, not always the case and occasionally horizontal bands of the layer, at times the upper part, at times the lower, were more evident on the 38 kHz, indicating different organisms with frequency dependent back-scattering characteristics.

Trawl results. The distribution chart of redfish, caught in the pelagic trawl at depths below 500 m, is shown in Figure 4. There were two dense aggregations of redfish, approximately 200 miles southwest of Iceland, about 40-60 miles west of the Reykjanes Ridge. Apart from these concentrations, catches were mostly between 10-50 kg/standardized haul. The limit of the distribution area was not reached, neither west nor east of the Reykjanes Ridge. However, the highest catch rate was in the central part of the survey area, at latitudes close to 62°N.

During the survey, the redfish caught were separated into oceanic and deep-sea redfish. Figures 5 and 6 show the distribution of each stock component. Both components were most abundant in the area where the commercial fleet was fishing at the time. Outside this area of greater abundance, the distribution of oceanic type redfish showed an increase in density towards the southwest while in the northern or north-eastern part of the survey area, only deep sea redfish were caught.

Biological information. A total of 2926 redfish were caught in the pelagic trawl, of which 1481 were measured. Of the pelagic catch, 775 were determined as oceanic type redfish and 2151 as deep-sea type redfish. The proportion of males were 38% of the oceanic and 46 of the deep-sea type. The length-frequency distribution for each stock and the combined distribution for all redfish caught are shown in Figure 7, and the length-weight relationship in Figure 8.

Incidence of external and muscular abnormalities. A total of 22% of the redfish had external abnormalities originating from the ectoparasite *Sphirion lumpi* (Table 2), and 11% of the fish had abnormal pigmentation in the fillet (grey or black spots). The total incidence of both external and internal abnormalities was higher in fish classified as oceanic as compared with the fish classified as deep-sea redfish.

In addition to redfish, some 75 species were recorded and measured during the survey. A list of the most dominant ones is given in Table 3.

Hydrographic conditions. The main results of the hydrographic observations in the upper 1000 m of water column were the following (Figures 9-11): The Atlantic Water or more precisely Modified North Atlantic Water, observed at almost all stations, showed both high temperature (6-8°C) and salinity (up to and above 35.2‰). The highest temperatures and salinities were found to the east (in the Iceland Basin) and over the Reykjanes Ridge, with a general decrease, especially in salinity (~0.10 psu), towards the west in the Irminger Sea. Only very few stations showed water with temperature lower than 3.5°C and these were all situated below 600 m depth in the southern central part of the Irminger Sea (Figures 9-10). Two relatively weak frontal zones were observed on the section along 60°N. One was observed between stations 238 and 236, at the surface in the central part of the Irminger Sea, and the other between stations 233 and 231, in the depth range between 200 m to 1000 m, just west of the Reykjanes Ridge. In connection with the latter front, there was evidence of strong front in the depth range of 300 - 800 m.

Discussion

During earlier acoustic surveys of oceanic redfish in the Irminger Sea, which have been conducted in June/July and the MRI has participated in (Magnússon et al. 1992a, 1992b, 1994, 1996), conditions for acoustic assessment have been considered fairly good. During daylight hours, the oceanic redfish has been fairly evenly distributed, mainly between 100 and 400 m. Furthermore, the density has been low enough to allow a more or less continuous monitoring of the target strength distribution of the fish. The upper limit of the disturbing scattering layer of myctophids was well defined and usually at about 400-450 m. At night-time, the scattering layer generally ascended and mixed with the redfish, often to such a degree that the discrimination of redfish was impossible.

During the present survey, the conditions for acoustic estimates of oceanic and/or deep-sea redfish were very unfavourable. The upper limit of the scattering layer was for the most part higher up in the water column, often excluding the possibility of identifying the redfish in the uppermost 500 m. The situation is reflected in Figure 2, where the scarcity of definite redfish recordings is evident. Often, the scattering layer was divided in two parts, seemingly related to the time of day. As in the upper layer, the scattering layer was also dominant at lower layer, below 500 m depth. However, recordings of lesser concentrations (possibly larger fish) were observed near the lower border of the main layer.

From observations made during this and other surveys, conducted by the MRI in the Irminger Sea, it seems doubtful that redfish at depths below 500 m can generally be assessed by acoustic means with hull mounted transducers. The main obstacle is the ever present and rather dense scattering layer consisting of various species. However, the use of a towed body lowered to at least 300-400 m might clear the situation somewhat. The signal-to-noise ratio would be greatly improved and the horizontal resolution of the acoustic beam might be increased to such a degree that measurements of the target strength distribution at depths below 400 m become feasible. Then it might be possible to determine whether the main scatter has a distribution similar to redfish or stems from smaller fish (Dalen and Bodholt 1991).

The catch taken at depths below 500 m in pelagic trawl has been considered as oceanic redfish belonging to the same stock as that measured acoustically above the 500 m depth range. The length distribution in the stock below the acoustic scattering layer does differ from the length distribution of redfish above it, while the length/weight relationship and appearance are similar to those of the deep-sea *S.mentella,* stock which has been fished on the shelves of E-Greenland, Iceland and the Faeroe Islands during the last decades. As seen in Figures 4 and 5, the distribution of the redfish in the study area is continuous and consequently, there are no indications in the distribution data for the presence of more than one stock.

The size of the two small areas where the commerical fleet was operating was estimated to be around 10-20 nm^2 each. In the eastern part where the Icelandic fleet was fishing (about 25 vessels), the length of the area was approximately 15-18 nm in a N-S direction and the width between 0.4-1 nm. In the other area, where approximately 45 vessels of various nationalities were fishing the area was somewhat larger. Both fleets were fishing on schools or dense aggregations at depths between 600 and 800 m (Figure 12).

During all of the survey, a "scattering layer" or "cloud" which differed in size and shape, both throughout the day (diurnal variation) and between areas, was registered at depths from the surface down to 800 m. This layer consisted of a number of species and seemd to include redfish in varying degrees. The echo recordings in the area where the Icelandic fleet was fishing seemed not different (as judged by the eye) from registrations in other areas which gave much lower catches when trawling.

The high temperature and salinity measured in the survey area is in accordance with observations south and west of Iceland in 1997 and during the early part of 1998. When hydrographic observations are considered in the context of historical hydrographic data from the Irminger Sea (1955, 1958, 1959 and 1988) it appears that the westward extension of the 35.10 isohaline has never been so far to the west as at present (Dietrich 1957, Anon. 1960, Anon. 1961, Krauss 1995). Two relatively weak frontal zones were observed (more noticeable in salinity than temperature) both along the 60°N and 61°40'N sections (Figures 10 and 11). On the northern section, the fleet was fishing at a depth of 600-800 m, indicating that the redfish gather at these fronts. This in accordance to what has been observed earlier in the upper oceanic layer, above 500 m depth (i.e. Magnússon 1983, Pedchenko 1992).

Acknowledgments

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Table 1. Settings of the acoustic equipment during the survey.

Echo sounder/integrator	Simrad EK500/Bi500
Frequency	38 kHz
Transmisson power	2000 W
Absorption coefficient	10 dB/km
Pulselength	1.0 ms
Bandwidth	Wide
Transducer type	ES38-B
2-way beam angle	-20.6 dB
3 dB beamwidth	7.1
Integration threshold	-80 dB//1 m^2/m^3
Sound speed	1475 m/s

Table 2. Incidence of external and internal abnormalities in redfish caught in pelagic trawl. External abnormalities denote fish with the ectoparasite *Sphirion lumpi* and/or remains from the parasite. Internal abnormalities denote fish with muscular abnormailties.

	Oceanic			*Deep Sea*			
	male	*female*	*Total*	*male*	*female*	*Total*	*Total*
External	67	153	220	132	294	426	646
Internal	39	117	156	34	123	157	313
N	298	477	775	992	1159	2151	2926
% external	22%	32%	28%	13%	25%	20%	22%
% internal	13%	25%	20%	3%	11%	7%	11%

Table 3. List of most dominant species/groups caught in May 1998. The species is ranked according to total number caught during the whole survey.

Common name	
Myctophidae	*Myctophidae* (4 species)
Needle tooth, viperfish,Sloans viperfish	*Chauliodus sloani*
Shortnosed snipe eel,saw-tooth snipe eel	*Serrivomer beani*
Goitre blacksmelt	*Bathylagus euryops*
Boa dragonfish	*Stomias boa ferox*
Glacier lanternfish	*Benthosema glaciale*
Kroeyers lanternfish	*Notoscopelus Notoscopelus kroeyeri*
Lanternfishes	MYCTOPHIDAE
Anglemouths, lightfishes, bristlemouths	GONOSTOMATIDAE
White barracudina	*Arctozenus rissoi, Notolepis rissoi*
Squarenose helmetfish	*Scopelogadus beanii*
Squid	*Todarodes sagittatus*
Antarctic snaggletooth	*Borostomias antarcticus*
Greenland argentine, large eyed argentine	*Nasenia groenlandica*
Multipore searsid	*Normichthys operosus*
Loosejaw	*Malacosteus niger*
Snipe-eel	*Nemichthys scolopaceus*
Crested bigscale	*Poromitra crassiceps*
Atlantic gymnast,bluntsnout smooth-head	*Xenodermichthys copei*
Koefoeds skulderlysfish	*Searsia koefoedi*
Searsids, tubeholders	PLATYTROCTIDAE
Bighead searsid	*Holtbyrnia anomala*
Threelight dragonfish	*Trigonolampa miriceps*

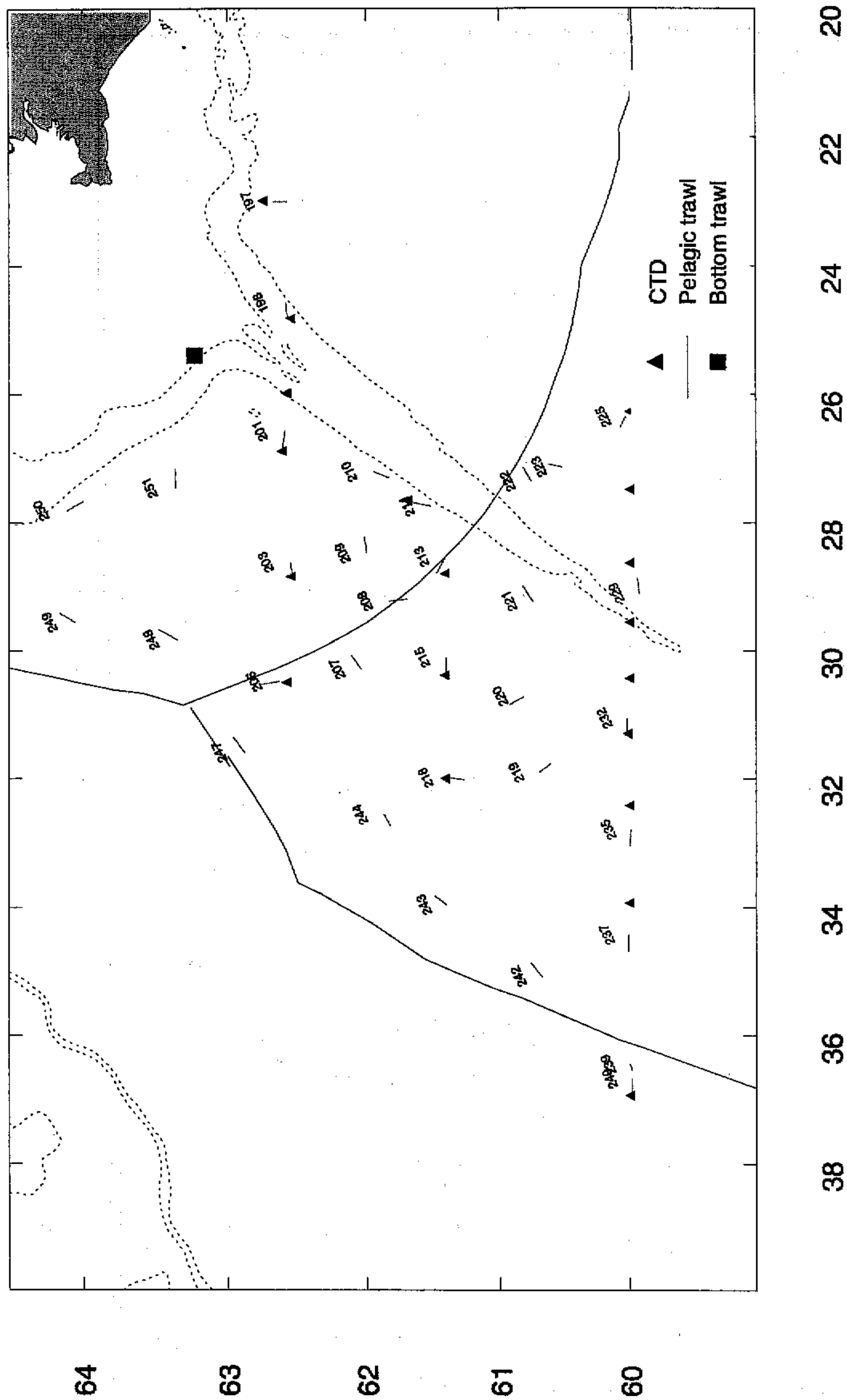


Figure 1. Stations taken during the redfish survey in May 1998.

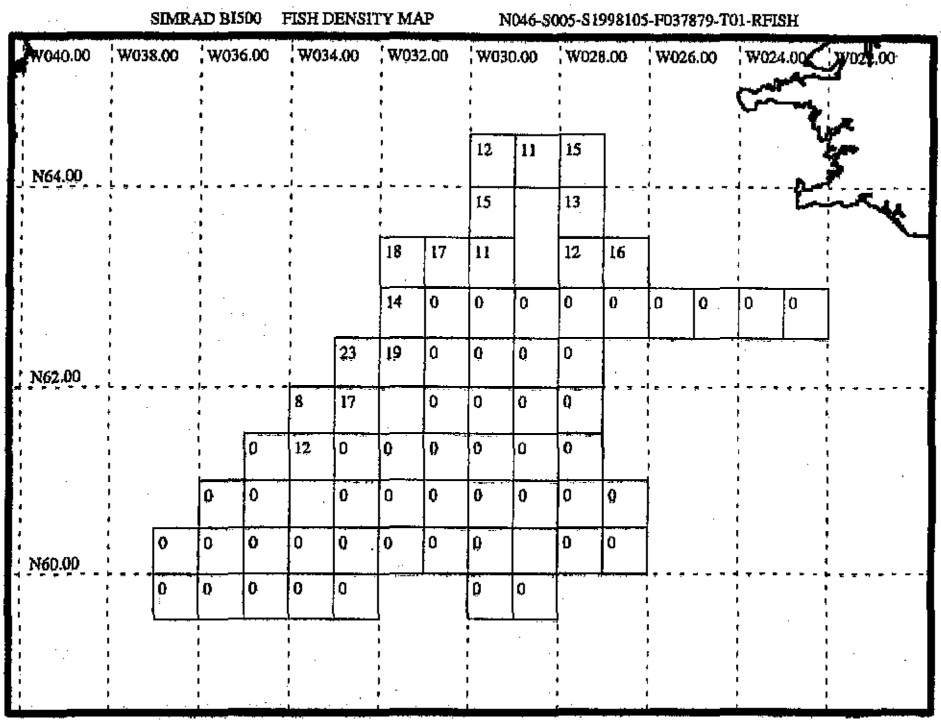


Figure 2. Area back scattering values (S_A m^2/nm^2) of redfish in May 1998 from BI500 post-processing system.

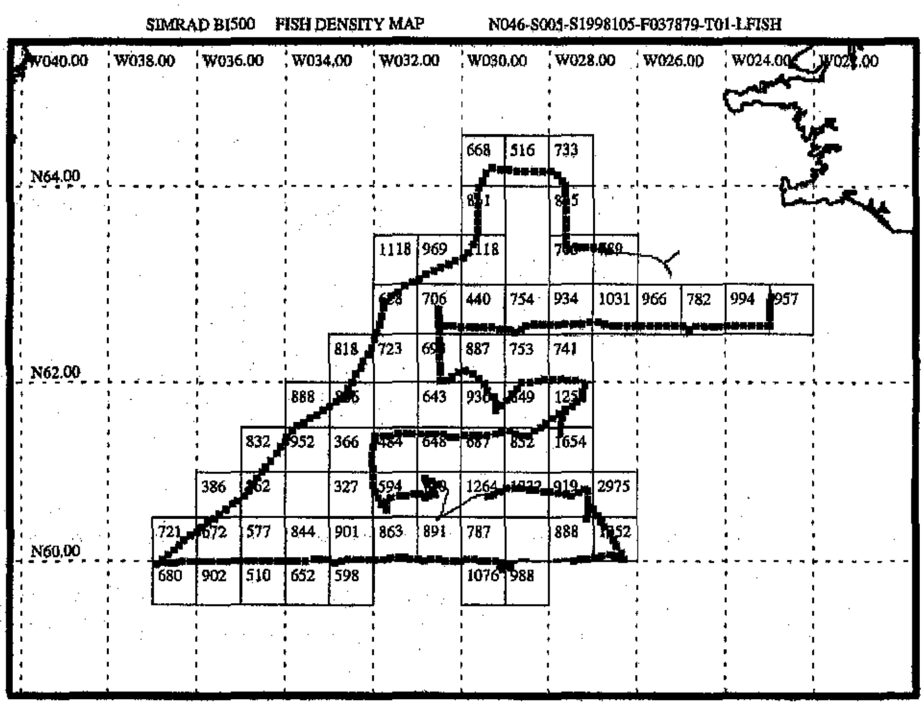


Figure 3. Area back scattering values (S_A m^2/nm^2) of the "scattering layer" in May 1998 from BI500 post-processing system.

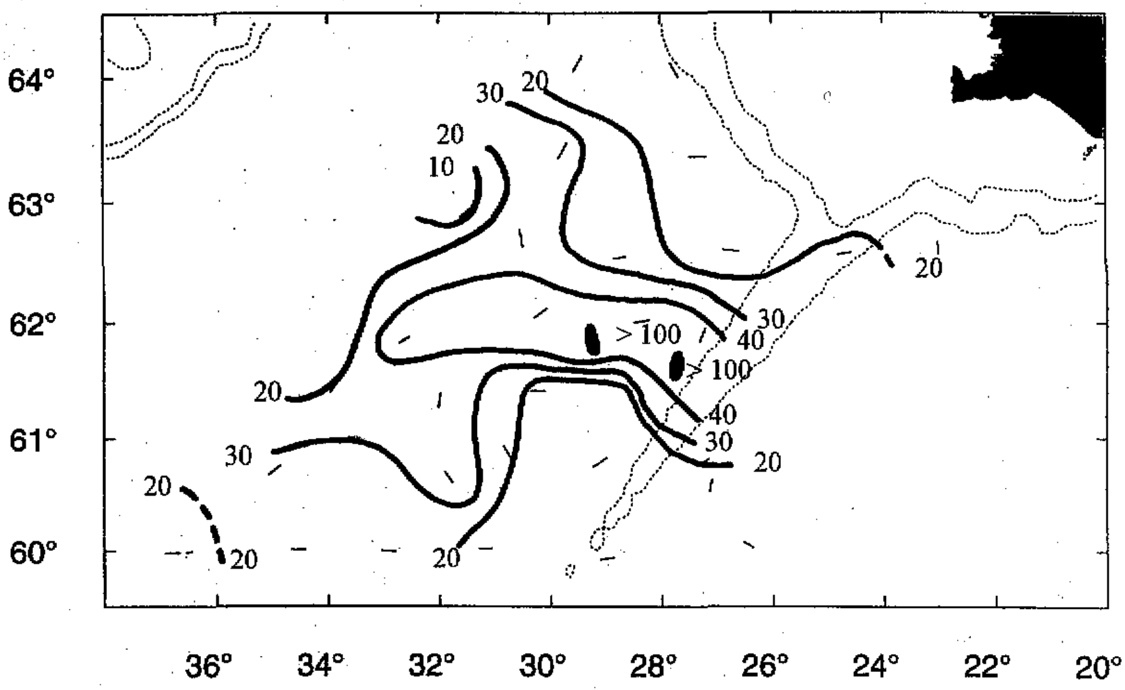


Figure 4. Distribution of redfish caught below 500 m in May 1998 (kg/standardized haul (150 min.)).

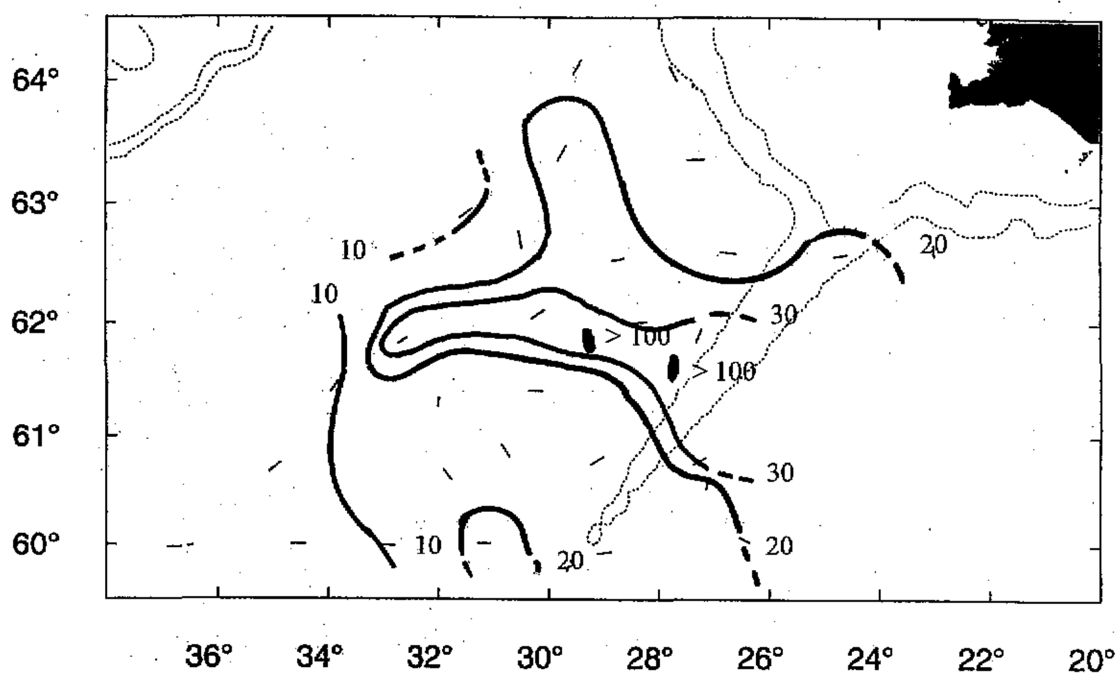


Figure 5. Distribution of deep sea redfish caught below 500 m in May 1998 (kg/standardized haul (150 min.)).

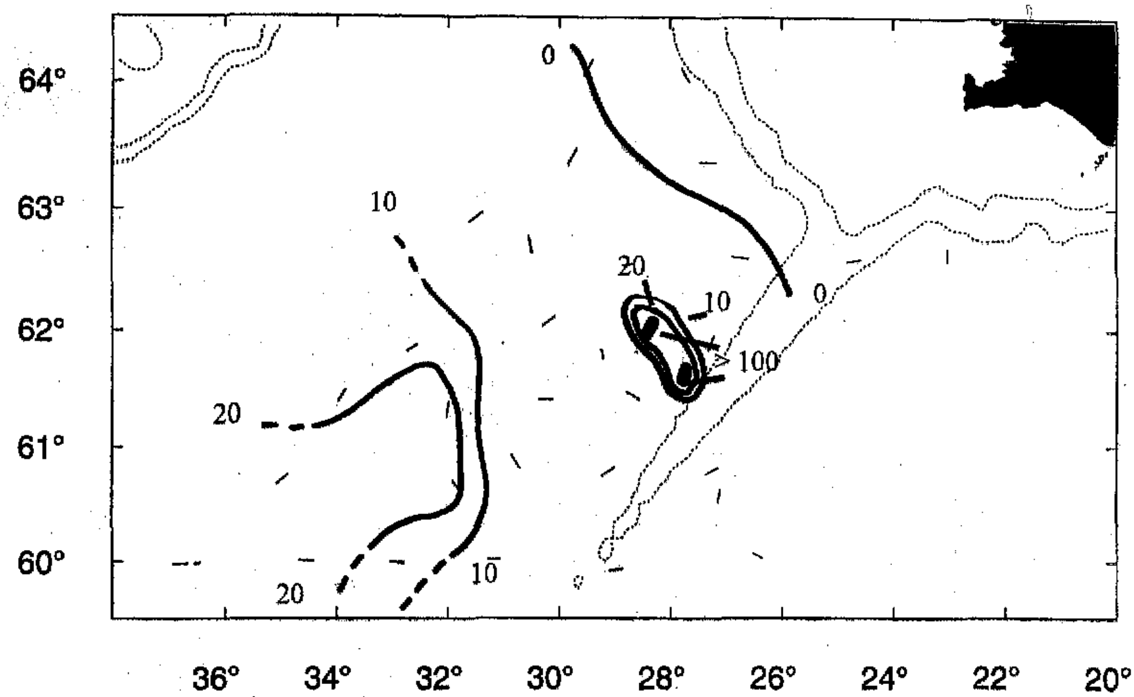


Figure 6. Distribution of oceanic redfish caught below 500 m in May 1998 (kg/standardized haul (150 min.)).

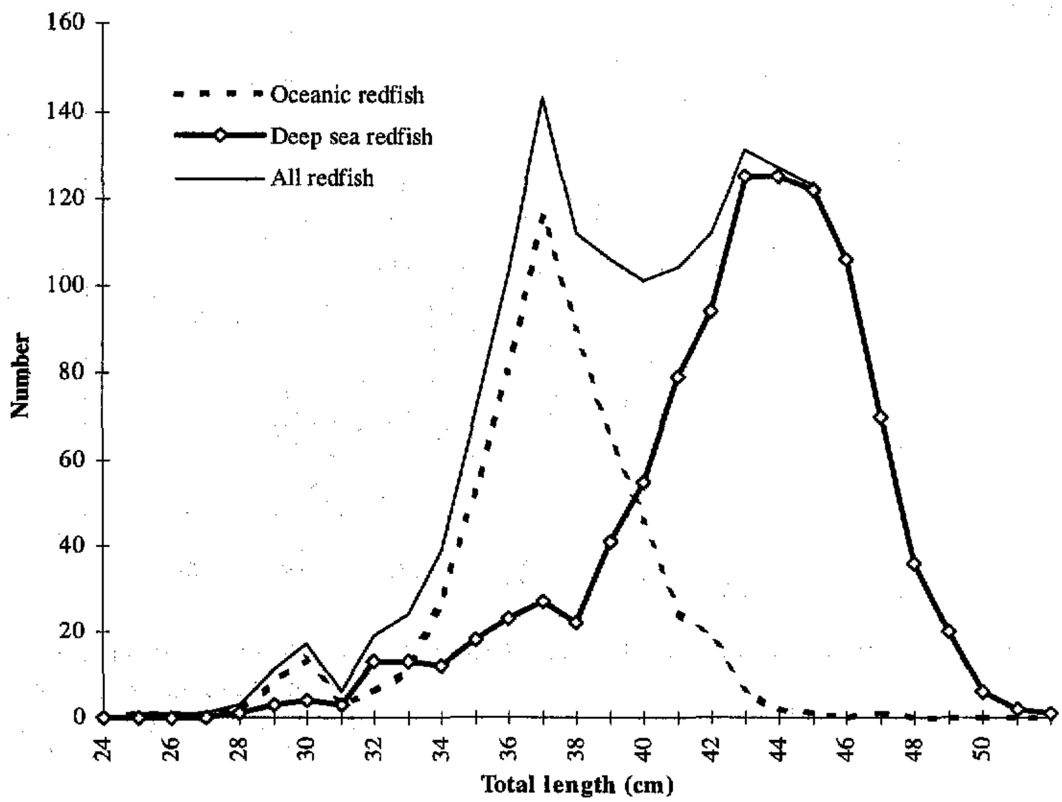


Figure 7. Length distribution of redfish caught below 500 m in May 1998.

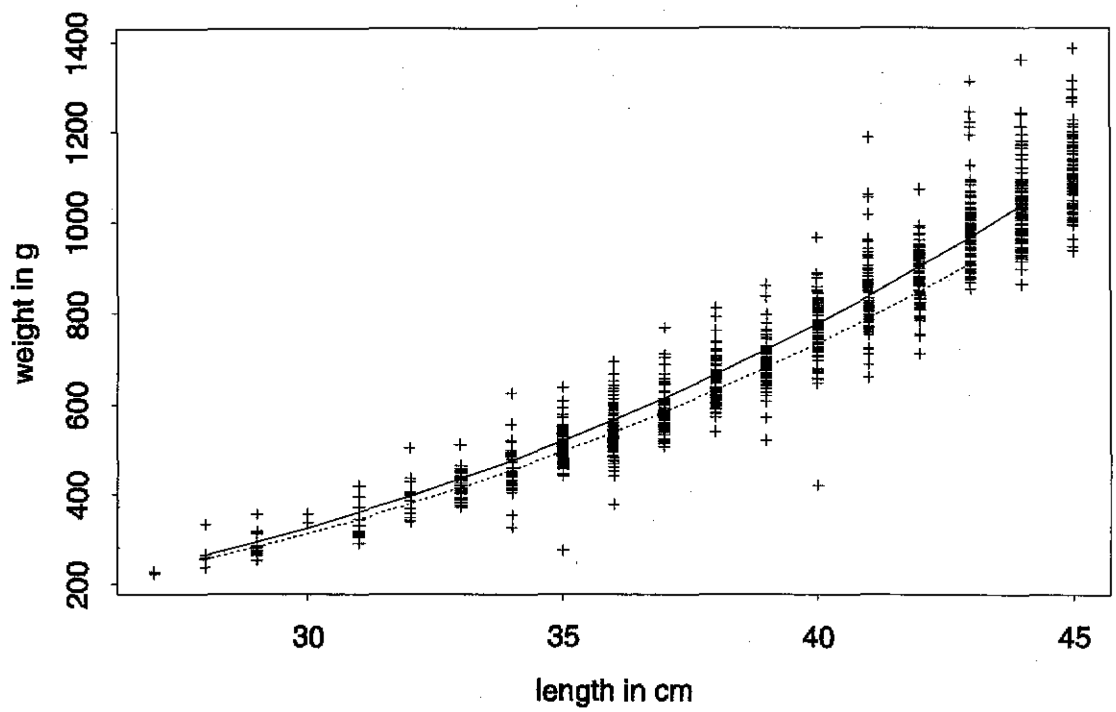
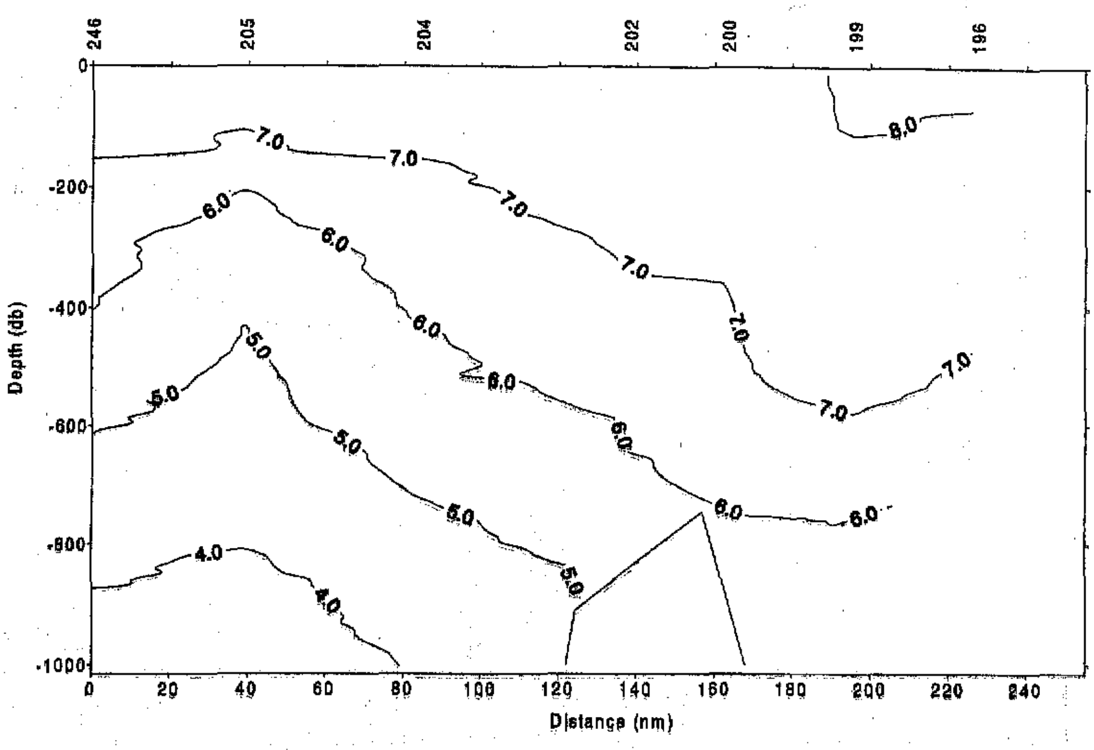
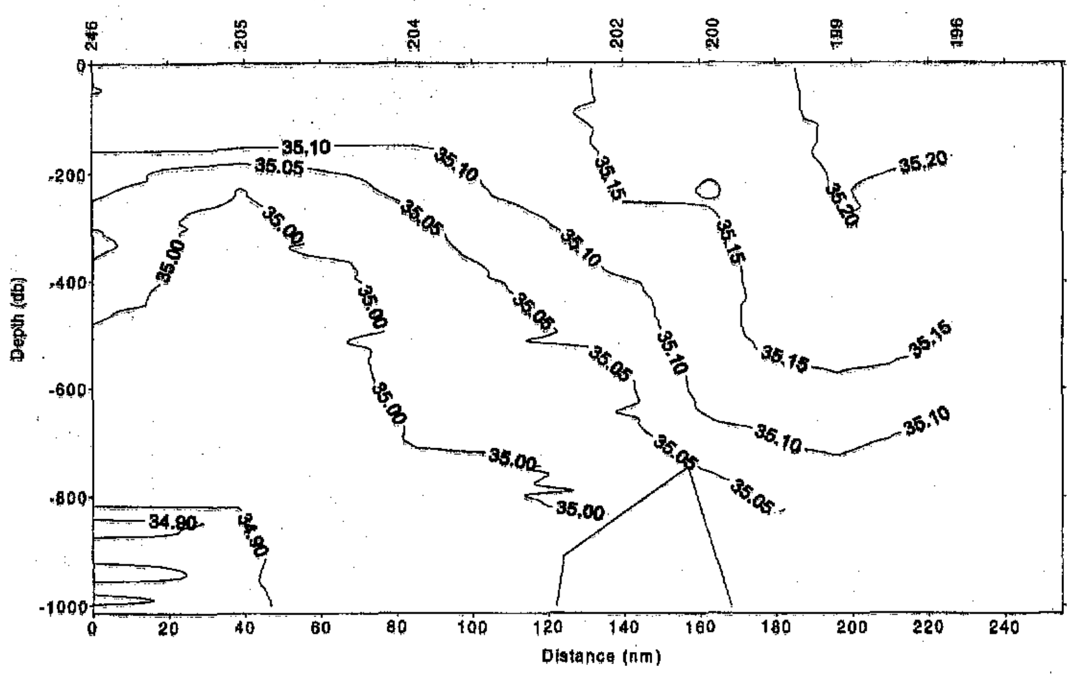


Figure 8. Length-weight relationship from a general linear model (glm(w~log(l), family=Gamma (link=log)); solid line = deep sea redfish (intercept=-4.511; log(l) = 3.027); dashed line = oceanic redfish (intercept=-4.339; log(l) = 3.280).

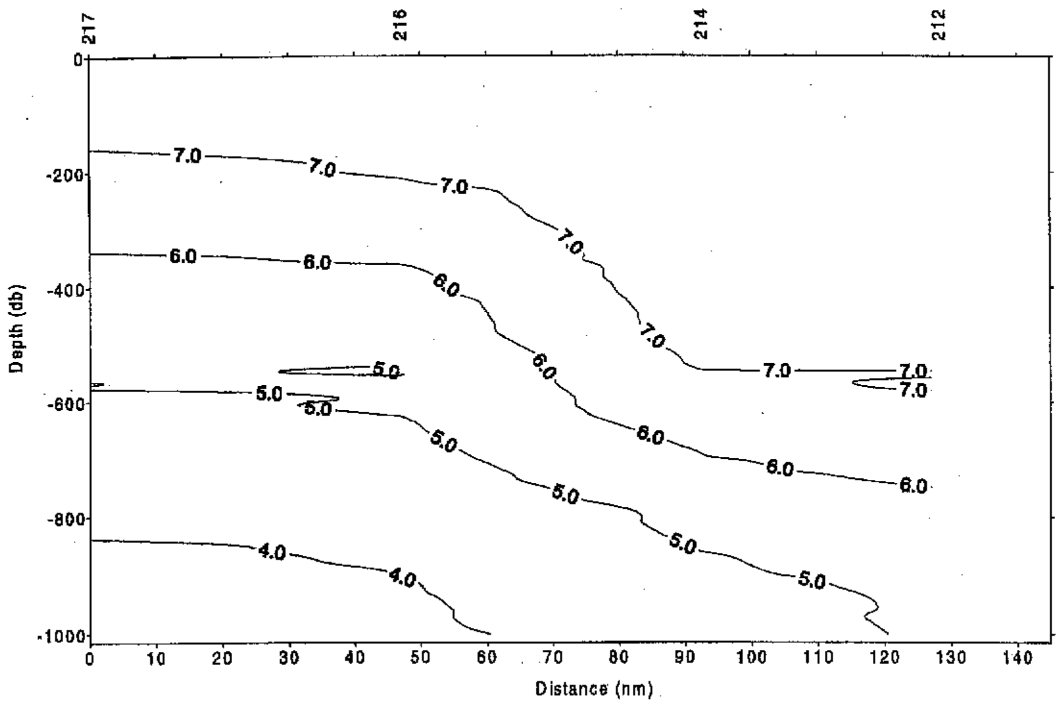


a)



b)

Figure 9. Temperature (a) and salinity (b) on a section in an E-W directon at about 62°35' N.



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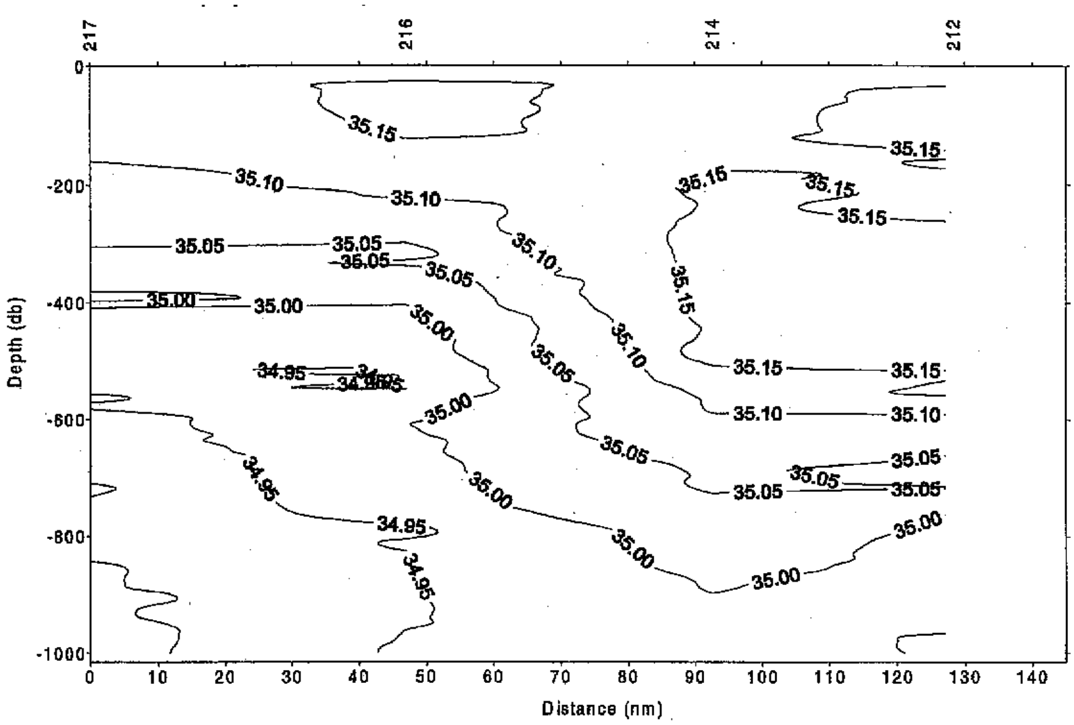
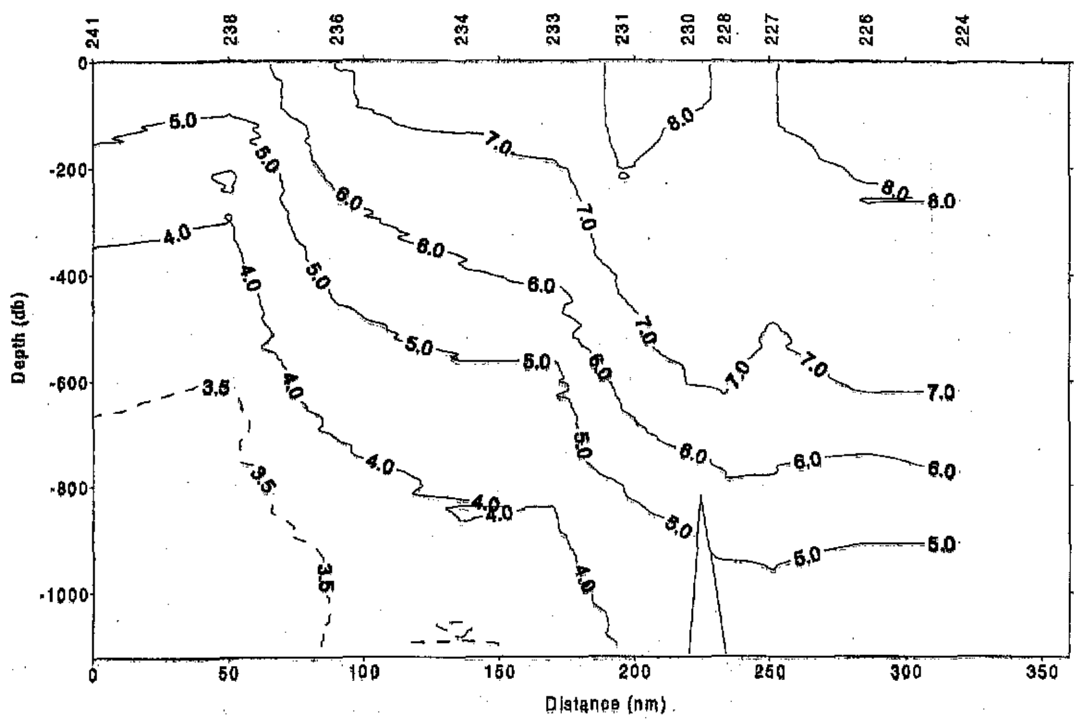


b)

Figure 10. Temperature (a) and salinity (b) on a section in an E-W direction at about 61°40'N.



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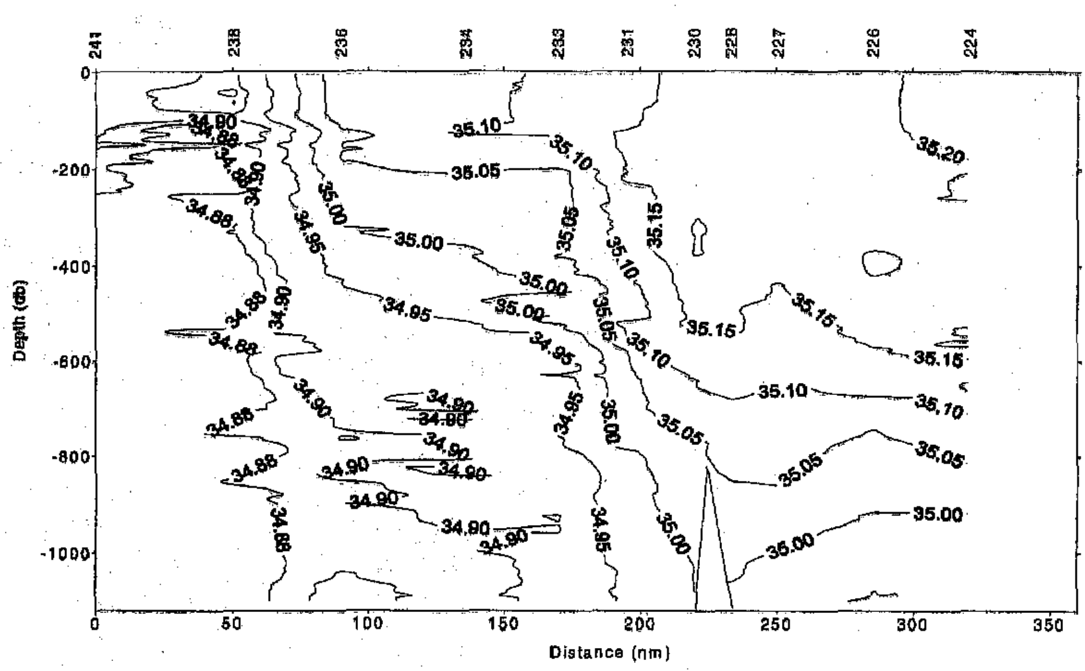

b)

Figure 11. Temperature (a) and salinity (b) on a section in an E-W direction at about 60°N.

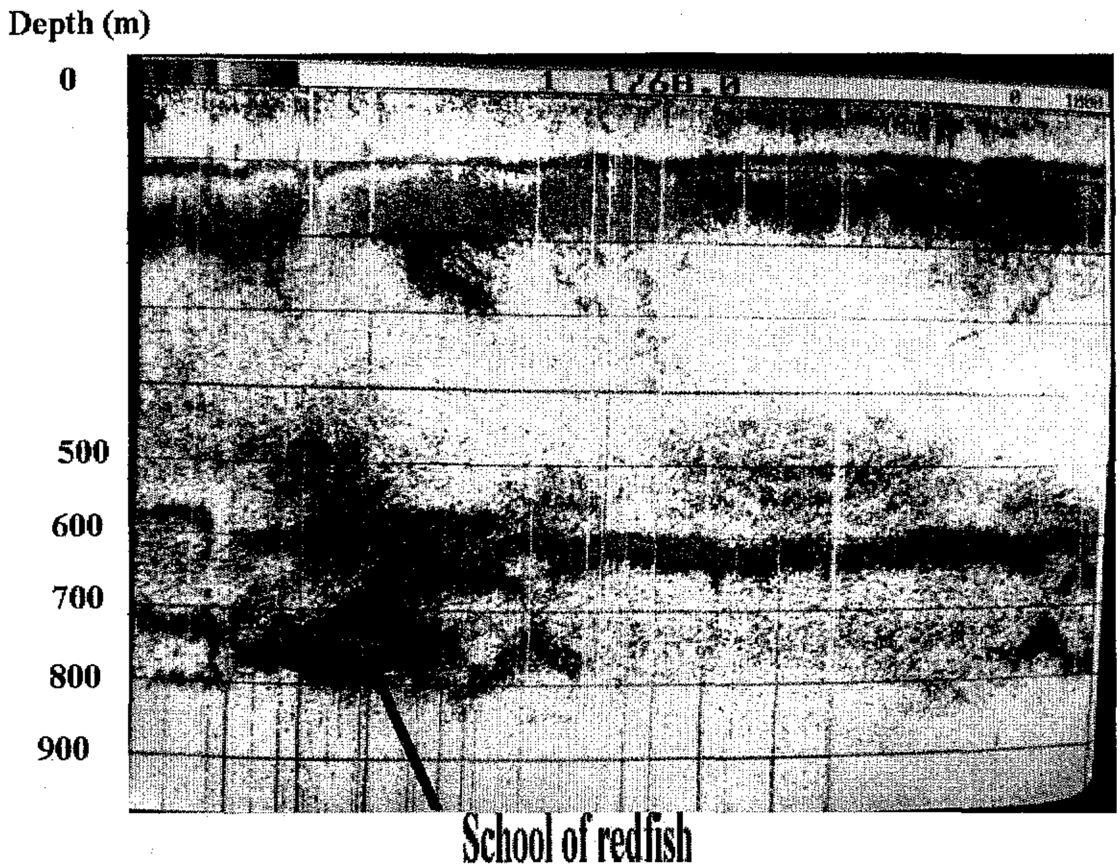

Figure 12. Photograph of echogram in the area where the Icelandic fishing fleet was operating (with an average catch per hour between 3 and 4 tonnes) at approximately 61°30' N-27°45' V. The distance from left to right on the figure (from north to south in the area) is approximately 5 nautical miles.