Northwest Atlantic Fisheries Organization

**Serial No. N4388** **NAFO SCR Doc. 01/20**

**SCIENTIFIC COUNCIL MEETING – JUNE 2001**

# Results from the Russian Investigations on Pelagic Redfish (*Sebastes mentella*, Travin) in the Irminger Sea and in NAFO Division 1F

by

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## Abstract

In the year 2000, the international catch of pelagic redfish taken in NAFO Div. 1F constituted above 8 thou. t. Increased pelagic redfish fisheries in the area, unclear status of the stock distributed in the zones of regulation of two adjacent regional fisheries organisations, and associated absence of common stock management measures, condition a necessity of settling this problem within the NAFO/NEAFC agreement.

The paper aims at studying the conditions for a formation of pelagic redfish aggregations in the Irminger Sea to the west of 42°W. Based on the results obtained the advice for management of pelagic redfish fishery in Div. 1F is provided.

Analysis was done for fisheries information, data on redfish biological status and on oceanographic regime in Div. 1F. Data were collected during 23 Russian research and scouting, research cruises, as well as during 3 international trawl-acoustic surveys. The pelagic redfish aggregations in NAFO Div.1F have been established to be a part of the total commercial stock of redfish in the Irminger Sea with common reproductive and feeding areas, common life and migration cycles and absence of spatial and temporal isolation. A formation of considerable fishing aggregations of pelagic redfish in Div. 1F has irregular pattern and occurs due to a seasonal redistribution of redfish aggregations from traditional feeding area into the Irminger Sea. The reason of the redistribution is a variation in the oceanographic conditions related to the enhanced Atlantic water advection and to an increase in heat content of waters in the upper layer. Based on the criterion of common redfish stock in Div. 1F and in the Irminger Sea, common measures for management and regulation, applied by NEAFC and NEAFC Contracting Parties in respect to the pelagic redfish stock in the Irminger Sea, are suggested.

## Introduction

Pelagic redfish *S.mentella* is a major fish object of commercial fisheries in the open North Atlantic. The Irminger Sea pelagial is mainly inhabited by a mature proportion of the redfish population. The international annual catch taken in the area varies within 100-180 thou. t. The fishery on pelagic redfish is regulated by NEAFC in the ICES Subareas XII, XIV, Va based on the criterion of common redfish stock from these Subareas. In 1980, aggregations of pelagic redfish were found by the USSR research and scouting vessels in the adjacent areas of the Irminger Sea in NAFO Div.1F. In total, 23 Russian comprehensive research and scouting cruises, as well as 2 international trawl-acoustic surveys, were carried out in Div. 1F during the subsequent two decades. In the course of the investigations a large body of data was collected on distribution of redfish, its biology and oceanographic conditions of the area. During the 1990, 1991 and 1999, redfish aggregations were fished off by Russian fishing trawlers in Div. 1F. In 2000, the international catch of pelagic redfish taken in the area made up above 8 thou. t, including 4550 t taken by Russia. Increased pelagic redfish fishery in Div. 1F, unclear status of the stock status and associated absence of common stock management measures condition a necessity of settling a number of problems within the NAFO/NEAFC agreement.

## Material and Methods

1. Bottom topography and oceanographical conditions of the area.

The Reykjanes Ridge and Iceland-Greenland Ridge, Basins of the Irminger and Labrador Seas, continental slopes of the southeastern Greenland, western and southwestern Iceland are the largest elements of the bottom topography of the area.

The Reykjanes Ridge stretches to the southwest of Iceland to 53°N where it is separated from the North Atlantic Ridge by a sublatitudinal Charlie-Gibbs Fracture Zone (Underwater mountain relief, 1984). The Ridge height, with regard to the bottom of the adjacent Basins, is 1100-2000 m (Kotenev, Nazimov, Rvachev, 1974). The Iceland-Greenland Ridge is at 66°N between Iceland and Greenland and separates the Irminger and Greenland Seas. To the south of it is the Irminger Sea Basin, the surface of the bottom of which represents an inclined plain, complicated by small mounts and hills on the edges. Depths in the Basin are gradually increase southwestward from 2400 to 3000m. To the south of the Irminger Sea Basin is the Labrador Sea Basin with sloping and hilly flat bottom and with 3000-4000m depths, gradually increasing in the western direction (Litvin, 1970).

The oceanographic regime of the area is formed by a system of the North Atlantic Currents (North-Atlantic, Irminger, East- and West- Greenland and Labrador Currents), which creates a cyclonic circulation over the Basins of the Irminger and Labrador Seas westward of the Reykjanes Ridge (Fig. 1). Its boundaries determine the bottom topography, i.e. the Reykjanes Ridge in the east, Iceland-Greenland Ridge in the north and the continental slope of East Greenland and North America in the west, and Subpolar front in the south. This gyre is pronounced in the surface, intermediate and bottom layers of the Irminger and Labrador Seas, as a steady circulation element (Bulatov, 1971).

In the central part of the Subpolar cyclonic gyre a zone of the Subpolar divergence creates (Burkov, 1980). Stable vertical circulation from the sea surface to 1000-1500 m depths provides a formation of zones of higher biological productivity within the Subpolar cyclonic gyre.

Currents intensity and movement of waters within the circulation depend on a pattern of atmospheric pressure. Enhanced western transport of air masses over the North Atlantic during winter results in an increase of velocity of the North Atlantic Current and in cooling of the Labrador Sea waters (Drinkwater, 1994; Dickson and Maincke, 1999). At the increased transport of the Atlantic water eastward a volume transport of water from the Irminger Current over Reykjanes Ridge to the north decreases, as well as a transport of the Atlantic water to the west along the southern extremity of Greenland. Under the influence of the atmospheric processes a considerable proportion of the Atlantic water deviates to the southwest off the Cape Farewell and intermingles with the slope waters from the Labrador Current, moving eastward along the North Atlantic Current northern periphery. In such cases, spatial dimensions of the subpolar cyclonic gyre decrease and the zone of water divergence shifts northeastward into the central Irminger Sea. In the years of attenuated air transport from the west an increase in the volume transport of water from the Irminger Current is noted and, hence, an inflow of the Atlantic water into the fishing areas of the North West Atlantic. Maintaining of such conditions during several years causes a gradual increase in dimensions of the subpolar cyclonic gyre in the western direction.

The temperature regime of the Irminger Sea, as in most areas of the open ocean, forms under the influence of the atmospheric processes and water advection (Stepanov, 1974; Yakovlev, 1977). Maximum water temperatures are noted in the streams of the Atlantic water in the peripheral cyclonic gyre and minimum - in its central part, in the Labrador Sea transformed waters. Seasonal minimum of the sea surface temperatures over the area (3.5-8.0°C) are registered in March-April and maximum (4.0-10.5°C) - in August-September. In summer, the temperature of water at 300-600 m depths varies from 3.8 to 9.0°C and from 3.5°C to 7.0°C, respectively.

2. History of the stock exploitation and brief review of the fishery.

Regular commercial fishery for oceanic redfish has been carried out in the Irminger Sea since the early-1980s, when its dense commercial aggregations were found in pelagial by the USSR research and scouting vessels. The international catch of redfish constituted about 1.8 mill. t for two decades. Total catch of redfish taken by the USSR/Russia makes up about 0.76 mill. t or 43% of the total world catch for a whole period of the fishery.

In 1982-1988, the annual catch of redfish constituted 106-151 thou. t, including 55-85 thou. t taken by the USSR (Fig. 2). The fishery duration was 4-4,5 months.

An intensive fishery conducted during the first years resulted in a reduction of the redfish stock. The international catch reduced, due to different reasons, to 30.2 thou. t, including that of the USSR - to 18 thou. t. Fishing efficiency of STM-type vessels was 10-15 t per a vessel/fishing day.

In 1994, with a shifting of the fishery to the depths below 500 m, and owing to a use of large-sized trawls, a somewhat increase in fishing efficiency occurred. The reduction in redfish catches from the depths below 500 m has been observed since 1997. The extension of fishing period to 8 months and extension of areas due to the increased fishery within the 200-mile zone of Greenland and adjacent areas of the Labrador Sea occurred simultaneously.

3. Basic stages of redfish life cycle, its biological peculiarities and migrations.

*S.mentella* refers to viviparous fish species with an inner fertilization. Its sexual cycle comprises the peculiarity that is typical of all the redfish species from *Sebastes* genus, i.e. time of ripenning of reproductive products in males and females does not coincide, therefore the coupling and fertilization of eggs do not occur simultaneously. Redfish couple in August-November and sperm is retained in the ovaries of females in an inactive state until February-March, when the resting spermatozoids are more active and fertilize eggs. Soon after that, in April-May, occurs an extrusion of larvae. Thus, the annual cycle of mature redfish consists of the following stages, i.e. overwintering (December-March); extrusion of larvae (April-May); feeding (June-mid-August); coupling (late August-November).

In the Irminger Sea pelagial and in thalassobathyal of the Reykjanes Ridge redfish occur to 1100 m depths. Aggregations of redfish in catches are represented by specimens of 22-51 cm long at age 5-25, with the weight being 115-1500 g. A proportion of fish at age 5-9 is minor; no specimens from junior length-age groups are found over the oceanic depths. Abundant representatives of mesopelagic complex, i.e. zooplankton, mesopelagic fish and molluscs, constitute the bulk of the redfish feeding. In total, 15 species of parasites are known to be in redfish. The most frequent of them are *Sphyrion lumpi* and *Anisakis* sp., localizing in fish muscles.

The Irminger Sea oceanic pelagial is inhabited by mature proportion of the redfish population. Seasonal migrations of mature redfish are determined by the basic stages of yearly cycle. Pattern of seasonal migrations of males and females is different. Seasonal migrations of females are conditioned by the larval extrusion, feeding and overwintering and those of males - by feeding and coupling. Females, mainly from the 200-mile zones of East Greenland and Iceland, start to approach the sites of larval extrusion in February-March. From mid-May, with a termination of the larval extrusion peak, a feeding migration of fish starts in the direction of the 200-mile zones of East Greenland and Iceland. During autumn-winter, major redfish aggregations are distributed in the economic zones and in the vicinity of them. Young redfish are distributed in a neretic part of the sea on the shelf and slopes of East Greenland. Linkage between mature and immature proportions of the population is maintained by means of prolonged returned migrations of mature fish from the sites of nursery area of juveniles to the area of reproduction, i.e. from the shelf and slopes into the open sea.

Daily vertical migrations of redfish during spring-summer represent aggregation of fish in the upper layers in the daytime and vertical dispersion - at dark. During the autumn-winter period, because of a dark period of time, redfish are scattered at low fish densities.

4. Extrusion of larvae.

By the results from the ichthyoplankton investigations carried out by PINRO during 1982-1995, boundaries of the reproductive area of the redfish population from the Irminger Sea were established. The extrusion of larvae occurs in pelagial at 250-800 m depths over the vast area from 64°30' to 52°45'N between 22°00' and 40°30'W in April-May (Pavlov, Shibanov, 1991; Shibanov and Melnikov, 1994; Pedchenko et al., 1995) (Fig. 3). Period and duration of larval extrusion vary by years depending on hydrographic conditions (Alexeeva, Svetlov, Balabanova, 1989). Locations of the densest aggregations of spawning redfish and extruded larvae vary in different years by latitude, however, their occurrence and orientation along the western slope of the Reykjanes Ridge remain to be invariable (Shibanov, Pedchenko, Melnikov, 1995) (Fig. 4). After the extrusion the main bulk of larvae is distributed in the upper 50-meter layer of pelagial. The Irminger Current contributes to transporting of juveniles outside the reproductive zone. In August-September, a proportion of juveniles, drifting in its stream, reaches the shelf of East Greenland and there probably settles. Another proportion of the juveniles is transported by the Irminger Current to the west of Greenland, continues drifting in the West Greenland Current water and in October-December settles on the Baffin Land shelf and in the adjacent areas (Troyanovsky, 1992).

5. Spread and peculiarities of seasonal distribution of redfish in the Irminger Sea.

The region of redfish occurrence in the Irminger Sea covers both the shelf areas and continental slopes of the East Greenland and Iceland, as well as the oceanic pelagial. In the area of Iceland, redfish inhabit the southwestern slope and the Reykjanes Ridge at 400-700 m depth (Travin, 1951; 1952; Barsukov, 1968) and occur in the trough crossing the Iceland-Greenland Ridge to 67°N. Redfish of 5-32 cm predominant lengths are distributed on the East Greenland shelf and along the continental slope at 150-500 m depths. Outside the slope redfish pass to a bathypelagic mode of life (Zakharov, 1969; Magnusson, 1983). No ecological barriers are available for migrations of fish from the continental slope into the open Irminger Sea (Zakharov, 1969). More stable conditions are created for redfish in pelagial, compared to the zones of a narrow slope of Greenland with the contrasting and unsteady environmental conditions (Konstantinov, 1959). By the data from Russian trawl-acoustic surveys carried out in the open waters, redfish are distributed to 1100 m depth (Shibanov et al.1996; Melnikov et al.1998). Analysis for the length-age composition of redfish over its vertical distribution indicates the mean lengths of fish first to decrease smoothly with a depth to 400-600m and then to increase (Melnikov, 1998). The upper 500-meter layer is inhabited by the redfish at age 5-18, and at age 5-25 - below 500 m (Melnikov, 1999).

A number of peculiarities of seasonal distribution of redfish aggregations in the Irminger Sea exists. In spring (April-May), the major aggregations of spawning redfish are always in the open sea over the western slopes of the underwater Reykjanes Ridge at 250-850 m depths (Pedchenko, 1992; Shibanov, Pedchenko, Melnikov, 1995). Most part of the fish aggregations is distributed in the peripheral subpolar cyclonic gyre, along the streams of the Irminger Current in the subarctic intermediate waters (Pedchenko, 2000). Redfish aggregations are observed in the sites with maximum horizontal gradients of temperatures from 0.08 to 0.12°C/mile. An intensive vertical exchange of waters in these sites contributes to transport of larvae to the sea surface into a photic layer rich in phytoplankton. During spawning the densest aggregations of redfish occur at different depths at equal thermohaline conditions. The temperatures from 3.7 to 6.2°C and salinity 34.84-35.08 are optimum for the redfish spawning (Pedchenko et al.,1995).

In late May, with the beginning of a seasonal heating of waters over the Reykjanes Ridge, the thermic gradient zone shifts to the west, that serves as a signal of a commencement of fish feeding migration. According to the results from TAS, the feeding aggregations of redfish are registered from 53° to 64°N between 28° and 50°W in the area over 250 thou. $mile_2$ (Report on the Joint ..., 1996; Report on the Joint ..., 1999) (Fig. 3). In the feeding area redfish are distributed irregularly. The boundaries, location and density of aggregations in a 0-500-meter layer vary from year to year depending on distribution of water masses (Shibanov, Melnikov, Pedchenko, 1996). The main bulk of redfish aggregations is distributed in the subarctic water mass within the subpolar cyclonic gyre at 150-850 m depths. Maximum depth of fish distribution were registered off the Reykjanes Ridge. Increase of density of fish aggregations is noted in the areas rich in feeding meso- and macro-plankton with a well pronounced horizontal gradient of temperature both in the peripheral subpolar cyclonic gyre and in its central part. Interannual variability of the Atlantic water advection influences the location, area of redfish aggregation and density of aggregations during feeding. Conditions of fish occurrence at different depths during the feeding are similar. Temperatures from 2.1 to 6.4°C and salinity 34.72-35.08 are optimum for the distribution of feeding redfish (Pedchenko, Shibanov, Melnikov, 1998). Distribution of linear lengths of redfish in a 0-500-meter layer is non-uniform during feeding.

As a rule, specimens from older length-age groups are distributed in the central part of the area and those from different length-age groups - in the peripheral feeding area (Pedchenko et al., 1997). In September, the main redfish aggregations shift to the 200-mile zone of East Greenland. In October-March, redfish do not aggregate in the open sea area.

6. Dynamics of commercial stock.

To study the redfish commercial stock in the Irminger Sea, regular trawl-acoustic surveys were initiated by Russian scientists in 1982. The results from the surveys indicate this species to be widely distributed in the Irminger Sea open waters, adjacent areas of the Labrador Sea, within the 200-mile zones of Iceland and East Greenland. By the data from the trawl-acoustic surveys for 1982-1997, the biomass of redfish in the upper 500-meter layer varied from 0.4 to 2.6 mill. t (Pavlov et al., 1989; Shibanov et al., 1996; Melnikov et al., 1998) (Table 1). More complete estimate for the redfish stock was derived and the boundaries of feeding area were determined during the international trawl-acoustic surveys performed in 1996 and 1999 (Report of Joint ..., 1996; Report of Joint ..., 1999). An attempt to assess the biomass of redfish in the layers below 500 m over the entire area was for the first time undertaken during the international trawl-acoustic survey for 1999. Presently, a trend of reduction in the redfish commercial stock of the Irminger Sea became visible. Verified data on the redfish stock status will be derived during the next international trawl-acoustic survey planned to be in the summer 2001.

7. Redfish in NAFO Div.1F.

Pelagic redfish aggregations in NAFO Div. 1F were for the first time found by the USSR research and scouting vessels in 1980. For the period 1980-2000, 23 comprehensive fisheries cruises were done by research and scouting, research and fishing vessels to Div. 1F, during which a large body of data was obtained on redfish, its biology and oceanography of the area. In 1990-1991, the fishery on redfish was carried out by Russian vessels in the area to the south from the 200-mile zone of Greenland from 53°00' to 55°20'N between 42°00' and 45°00'W (Fig. 5 and 6); fishing efficiency was 13.9-14.5 t per vessel/fishing day (Table 2). In 1999, the Russian fleet operated in the area from 54°47' to 56°25'N between 42°00' and 46°11'W (Fig. 7) with fishing efficiency being 6.2 t per vessel/fishing day. In July-October 2000, a successful fishery was carried out by Russian vessels from 54°46' to 56°25'N between 42°00' and 45°55'W at 280-350 m depths (Fig. 8). Fishing efficiency was 19.0 per vessel/fishing day.

During the investigations a lot of data on redfish biology was obtained by Russian scientists (Table 3). The redfish caught to the west of 42°W did not differ, by all parameters, from the pelagic redfish of the Irminger Sea open waters. Redfish of 22-45 cm long (predominant length -33-38 cm) were fished off in Div. 1F. The catches were dominated by males (58%). Most of the fish examined (58.2%) were mature with the gonads at the stage of restoration. Plankton crustaceans (*Themisto, Calanus*, euphausiids, shrimps), fish objects, molluscs were predominant in the redfish feeding.

Distribution of the redfish aggregations in Div.1F was studied during the summer trawl-acoustic surveys for the stock assessment of pelagic redfish in the Irminger Sea. In specific years (1992, 1995-1997 and 1999) the surveys covered the area to 53°N, 48°W (Magnusson 1992; Pedchenko et al., 1995; Report on the Joint ..., 1996; Melnikov et al., 1998; Report on the Joint ..., 1999). During the trawl-acoustic surveys not always it was managed to find zero boundaries redfish distribution in the southwestern feeding area, as far as a position of major redfish aggregations varied over the area surveyed. According to the data from the surveys for 1982-1991, maximum densities of feeding redfish were noted within the 200-mile zone of East Greenland and eastwards 42°W (Shibanov, Melnikov, Pedchenko, 1996; Pedchenko, Melnikov, Shibanov 1996). Shifting of major redfish aggregations westwards, off the Labrador Sea, has been noted by us since 1994 (Fig. 9). The main reason of that was a variation in the oceanographic conditions in the Irminger Sea on traditional feeding area, initiated in the mid-1990s (Fig. 9a).

By the data from the TAS for 1994-1999, an enhanced advection of the Atlantic water and increase in the heat content of waters in the upper 200-meter layer resulted in a considerable redistribution of fish aggregations by area and depth (Report on the Joint ..., 1994; Results of the Russian ..., 1995; Report on the Joint ..., 1996; Results of the Russian..., 1997; Report of the Joint ..., 1999). Further development of abnormal conditions in a sea surface layer during 1997-1999 resulted in the redistribution of water masses over the area and in essential shifting of major fish aggregations southwestward from the traditional feeding area (Fig. 9).

These peculiarities of the redfish distribution were also observed earlier, however, the feeding area boundaries always remained to be within the ICES Subareas. Thus, until 1989, the redfish commercial aggregations were mainly distributed in the northern area, however an attenuation in transporting of the Atlantic waters during the subsequent years (1990, 1992 and 1993) resulted in a decline in temperature and salinity in a layer of redfish distribution and in redistribution of major fish aggregations to the south (Results of the USSR ..., 1989; Results of Icelandic and Russian ..., 1992; Results of the Russian trawl ..., 1994). Large-scale investigations on the distribution of redfish in Div. 1F were undertaken during the international trawl-acoustic surveys in 1996 and 1999 (Fig.10 and 11). By the results from the 1999 trawl-acoustic survey, the densities of redfish aggregations much increased in the southwestern direction. Having surveyed the area up to 54°N, 48°30'W, zero boundaries of redfish distribution were not found.

## Conclusion

The pelagic redfish aggregations in NAFO Div. 1F in the Irminger Sea adjacent areas westward of 42°W were found by the Russian research and scouting vessels in 1980. The pelagic fishery on redfish in Div. 1F was carried out by the Russian and foreign vessels during specific years. During the investigations conducted by Russia it was established that the redfish caught in Div. 1F did not differ by biological characteristics from the pelagic redfish from the open Irminger Sea. The data from the Russian and international trawl-acoustic surveys conducted in the Irminger Sea allowed to reveal a variation in the geographical position of major redfish aggregations over the area surveyed in different years of the investigations. In 1982-1991, maximum densities of feeding redfish were registered within the 200-mile zone of East Greenland eastward of 42°W. Shifting of redfish aggregations to the west, off the Labrador Sea, has been noted since 1994. The main reason of redfish redistribution over the feeding area was an enhanced advection of the Atlantic waters by the Irminger Current, as well as increase in the heat content of waters in the upper layer. As a result of such redistribution, in 1999 the major redfish aggregations shifted to the west of 42° up to 48°30'W; the density of aggregations increased essentially in the southwestern direction.

Based on the results from the Russian and international trawl-acoustic surveys, we believe that the pelagic redfish from Div. 1F is a part of the total commercial stock of redfish from the Irminger Sea with common reproductive and feeding areas, common life and migration cycles, without spatial and temporal isolation. Formation of considerable commercial aggregations of the pelagic redfish in Div. 1F has irregular pattern and occurs due to the redistribution of redfish aggregations from traditional feeding area to the Irminger Sea. Based on the criterion of common redfish stock in Div. 1F and in the Irminger Sea, common measures for management and regulation, developed by NEAFC in respect to the pelagic redfish stock of the Irminger Sea, are suggested.

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**Table 1**. Biomass of pelagic redfish in a 0-500 m layer by results from the Russian trawl-acoustic surveys carried out during the summer 1982-2000.

| Year | Survey area, thou.mile$^2$ | Abundance, mill. indiv. | Biomass, thou. t |
|---|---|---|---|
| 1982 | 40 | 790 | 560 |
| 1983 | 50 | 960 | 700 |
| 1984 | 55 | 660 | 526 |
| 1985 | 71 | 1122 | 700 |
| 1986 | 117 | 1912 | 1180 |
| 1987 | 215 | 1903 | 1220 |
| 1988 | 163 | 1510 | 956 |
| 1989 | 148 | 1610 | 918 |
| 1990 | 73 | 1495 | 848 |
| 1991 | 105 | 661 | 396 |
| 1992 | 190 | 2550 | 1600 |
| 1993 | 121 | 4186 | 2556 |
| 1994 | | No investigations were carried out | |
| 1995 | 168 | 4091 | 2481 |
| 1996 | 250 | 2600 | 1600 |
| 1997 | 158 | 2380 | 1225 |
| 1998 | | No investigations were carried out | |
| 1999 | 296 | 1165 | 614 |
| 2000 | | No investigations were carried out | |

**Table 2.** Results from the Russian fishery conducted in NAFO Div. 1F, 1980-2000.

| Year | Month | Total catch, t | No. of vessel/ fishing days | Catch per vessel/fish-ing day, t | Catch per trawling hour, t | No. of vessels |
|---|---|---|---|---|---|---|
| 1980* | Jun, Nov | 4,5 | 7 | 0,6 | 0,1 | 2 |
| 1982* | May-Dec | 29.2 | 3,2 | 9,1 | 0,7 | 3 |
| 1983* | Jul | 0,6 | 0,4 | 0,6 | 0,5 | 1 |
| 1989* | May-Jun | 7,4 | 2 | 3,7 | 0,4 | 2 |
| 1990 | Jun-Jul | 384,9 | 27,7 | 13,9 | 1,2 | 6 |
| 1991 | Jun-Jul | 458,3 | 31 | 14,5 | 0,9 | 2 |
| 1992* | Jun-July | 15,4 | 4 | 3,9 | 0,3 | 2 |
| 1999* | Jul-Sep | 446,0 | 73 | 6,2 | 0,5 | 9 |
| 2000* | Jul-Oct | 5259,0 | 239 | 19,0 | 0,9 | 10 |
| ***Total*** | | ***6605,3*** | | | | |

* Results from the operations by research and research/scouting vessels.

**Table 3.** Inventory of data on pelagic redfish collected in NAFO Div. 1F during 1980-2000.

| Type of research | Number |
|---|---|
| Valid and sampling trawling | 156 |
| Hydrographic stations, including those with hydrochemistry | 356/63 |
| Fish measured, indiv. | 27859 |
| Determination of maturity, indiv. | 2569 |
| Analysis for feeding, indiv. | 2032 |
| Fish aged, indiv. | 1694 |

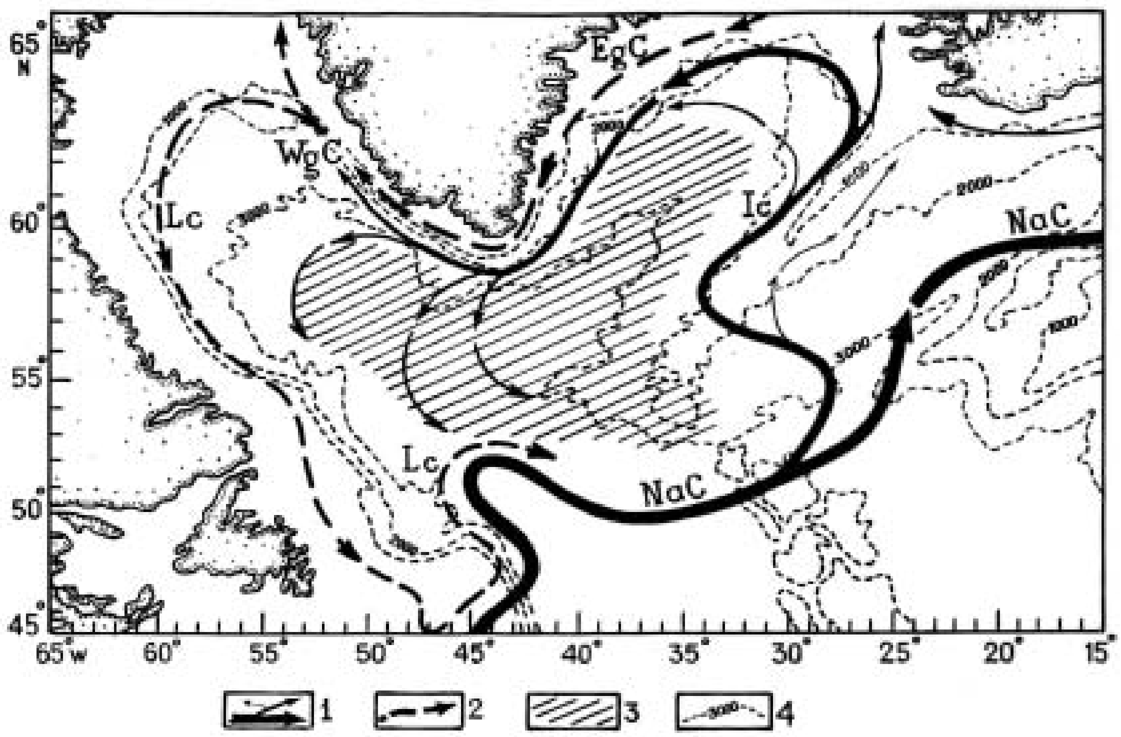


**Fig. 1**. Scheme of the North Atlantic Currents:

*Warm currents* (1): NaC - North Atlantic; IC - Irminger;
*Cold currents* (2): EgC - East Greenland; WgC - West Greenland;
LC - Labrador; boundary of subpolar cyclonic gyre (3); isobathes (4).

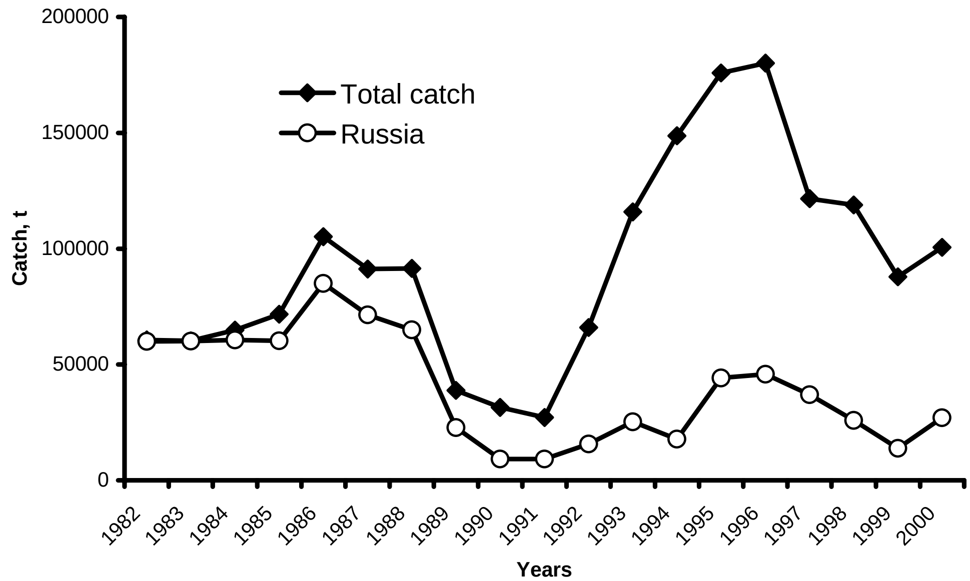


**Fig. 2.** Catch of pelagic redfish taken from the Irminger Sea, 1982-2000.

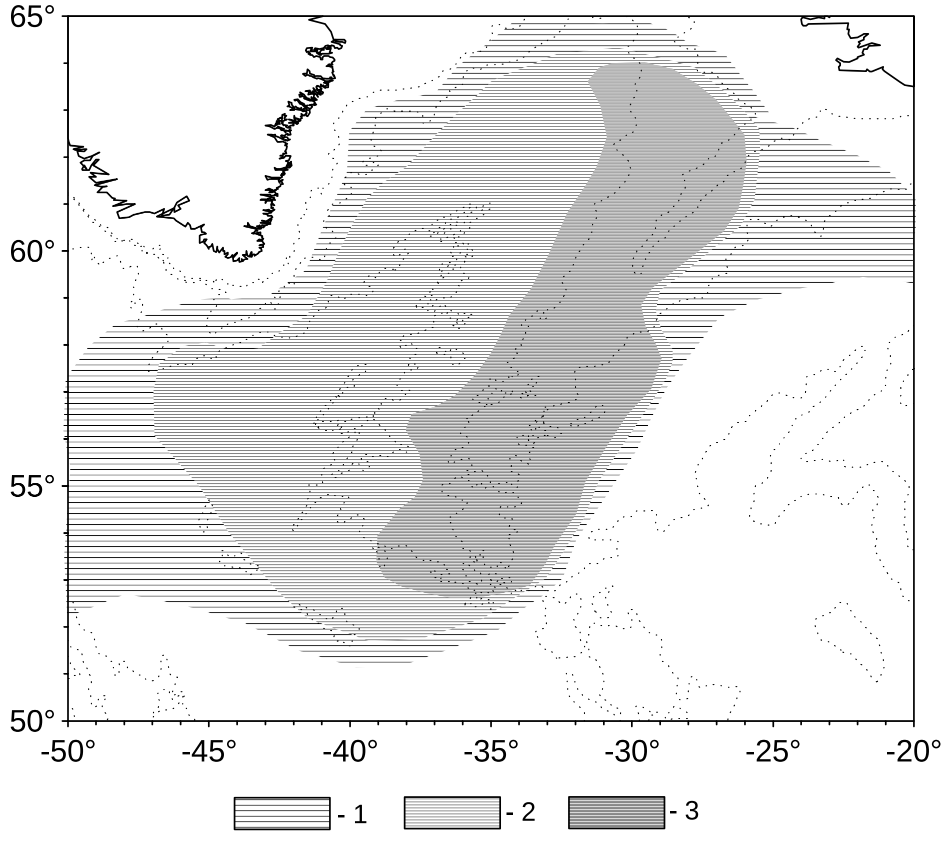


**Fig. 3.** Area of redfish, its distribution during feeding (2) and extrusion of larvae (3).

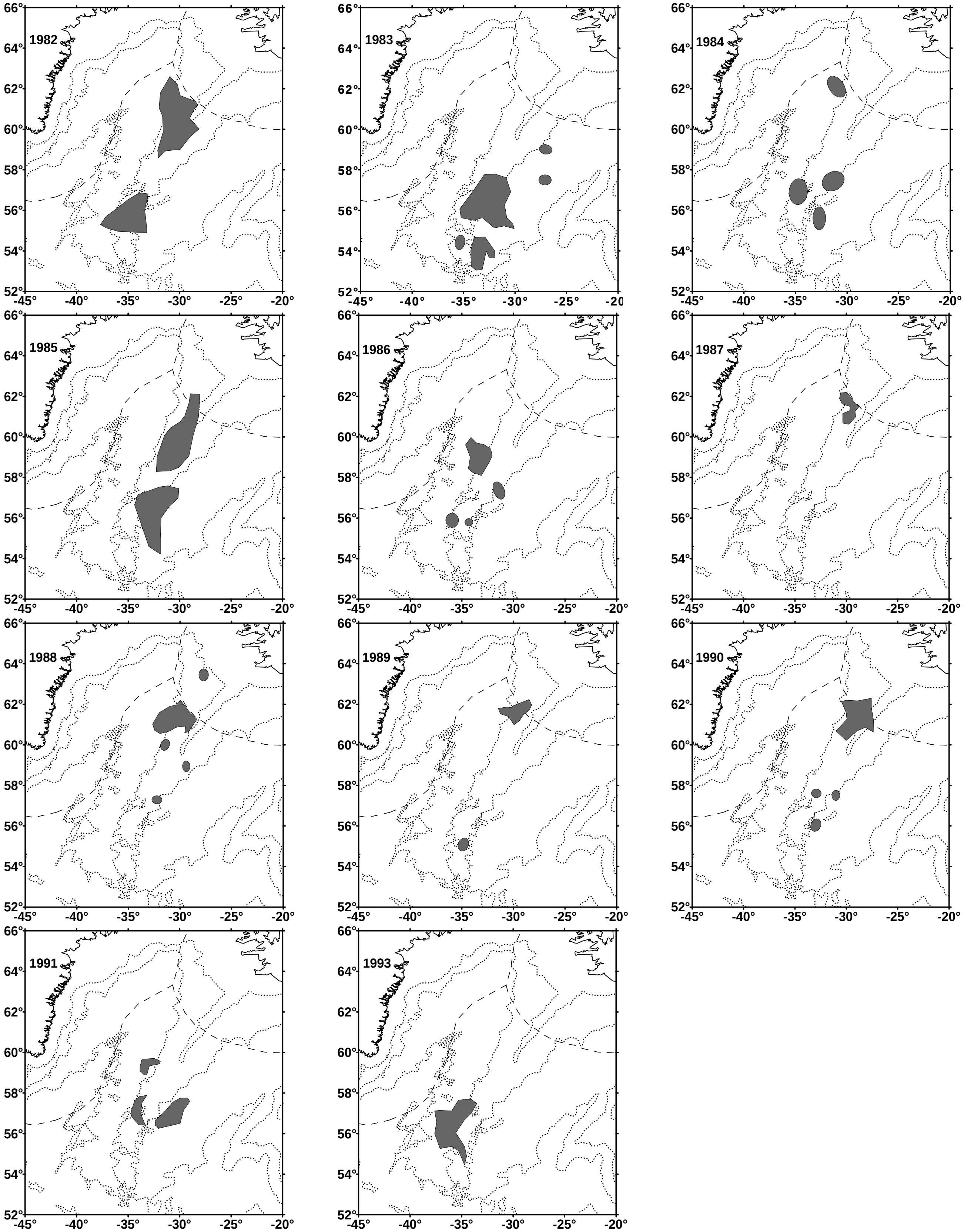


**Fig. 4**. Sites of the most abundant extrusion of redfish larvae in the Irminger Sea during the spring ichthyoplankton surveys.

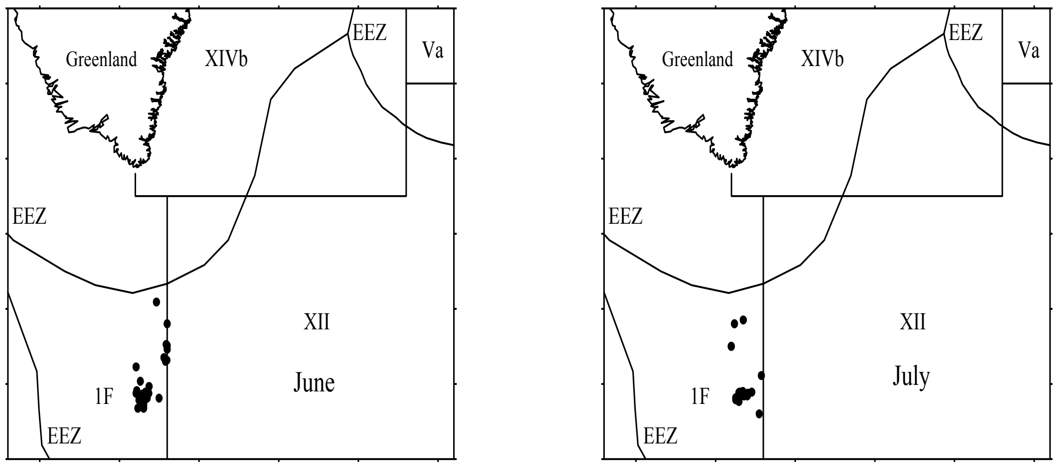


**Fig. 5**. Location of the Russian fleet during the fishery for pelagic *Sebastes mentella* in the NAFO Div.1F in June/July 1990.

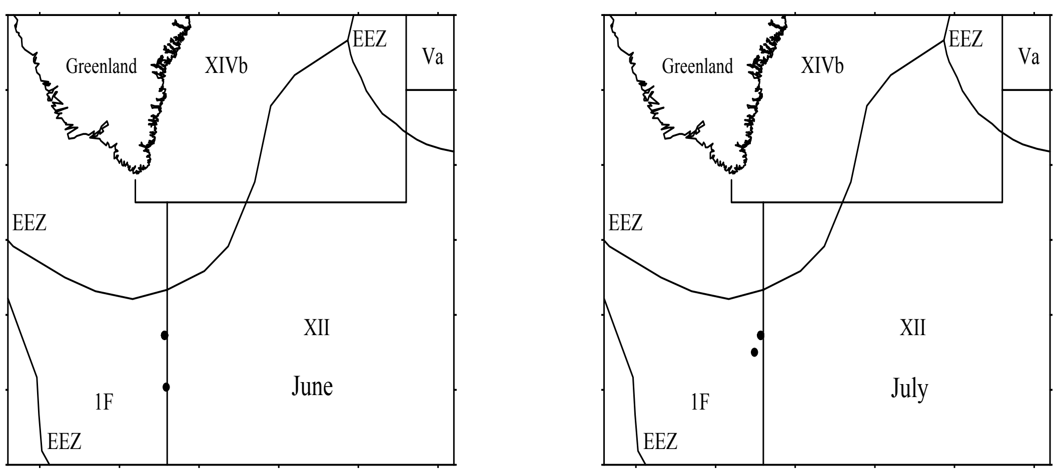


**Fig. 6**. Location of the Russian fleet during the fishery for pelagic *Sebastes mentella* in the NAFO Div.1F in June/July 1991.

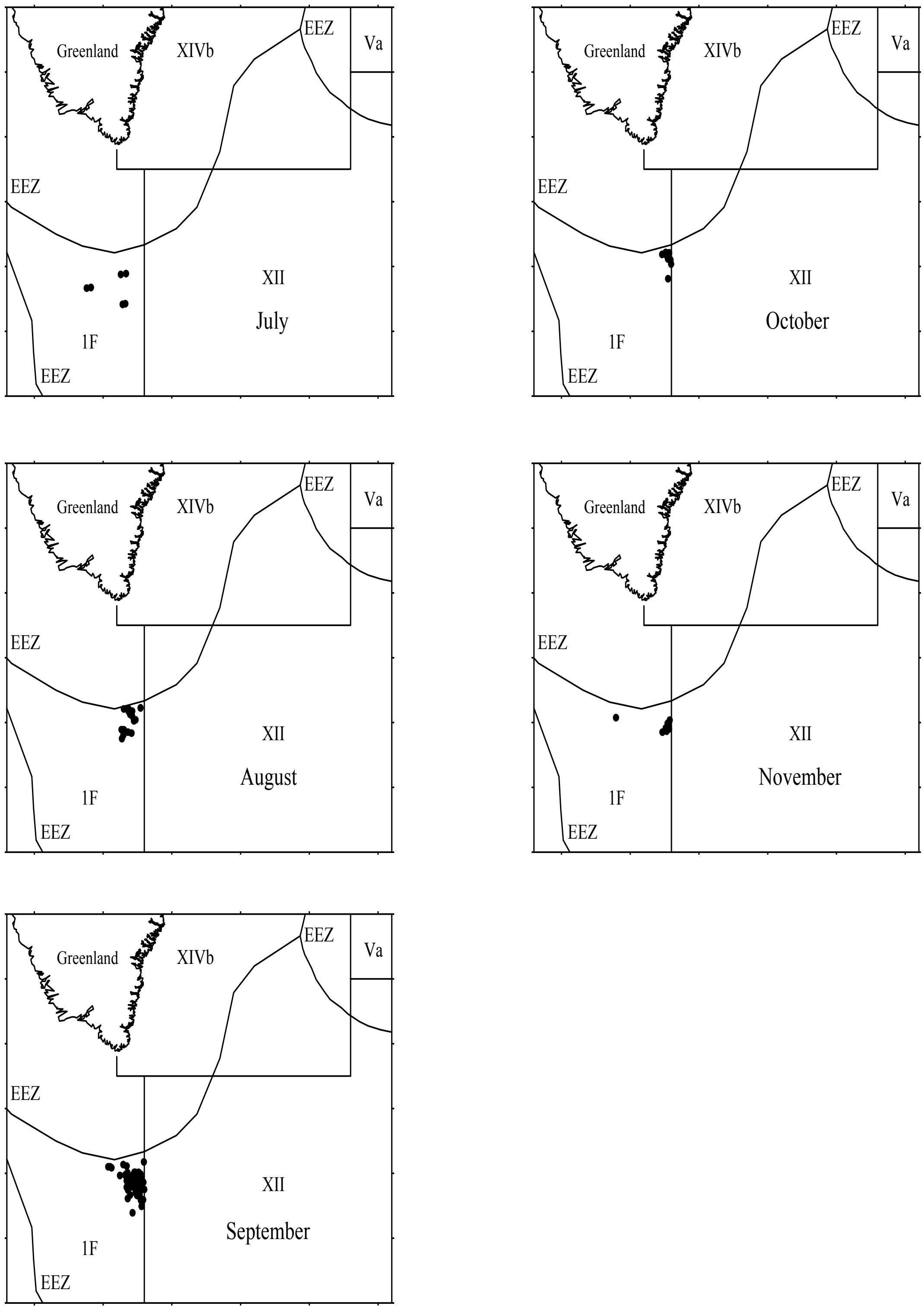


**Fig. 7.** Location of the Russian fleet during the fishery for pelagic *Sebastes mentella* in the NAFO Div.1F in July-November 1999.

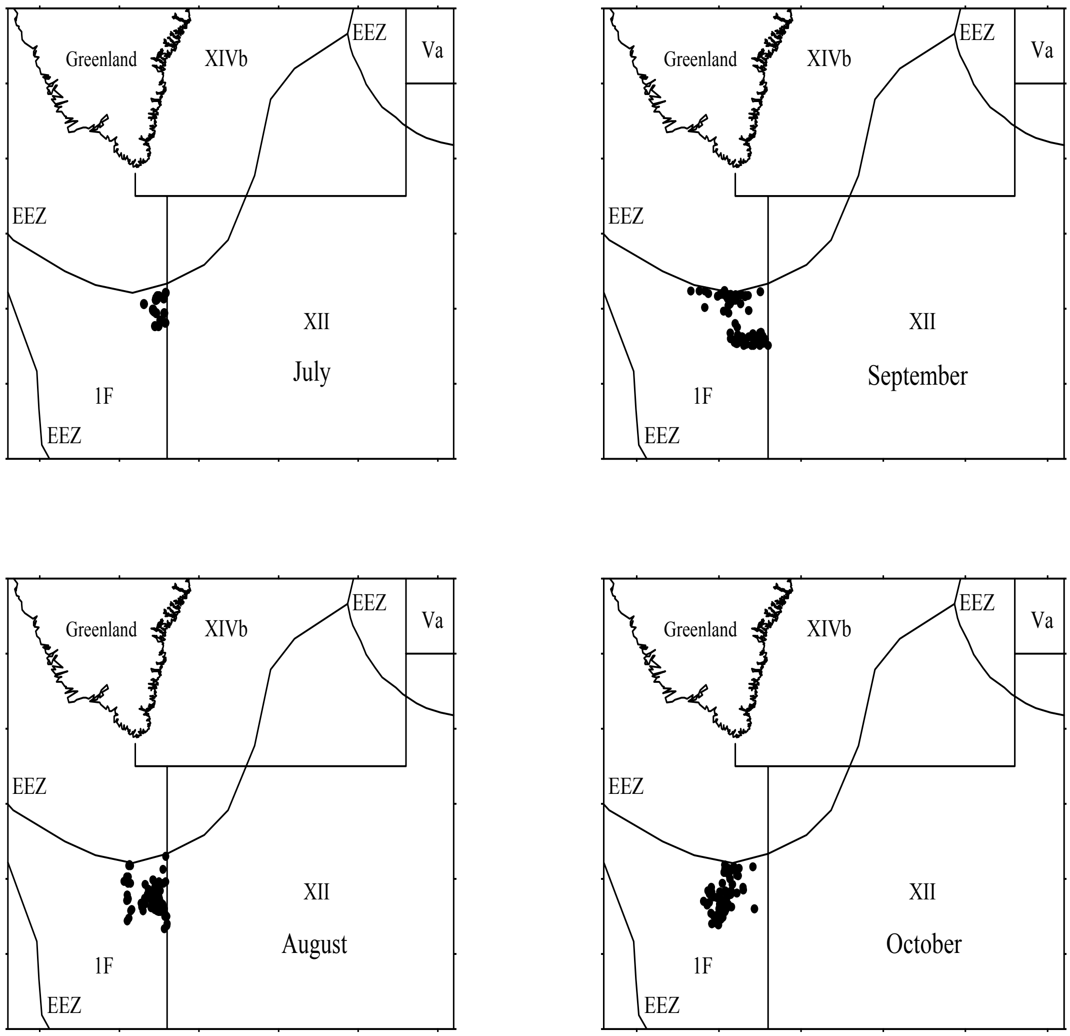


**Fig. 8.** Location of the Russian fleet during the fishery for pelagic *Sebastes mentella* in the NAFO Div.1F in July-October 2000.

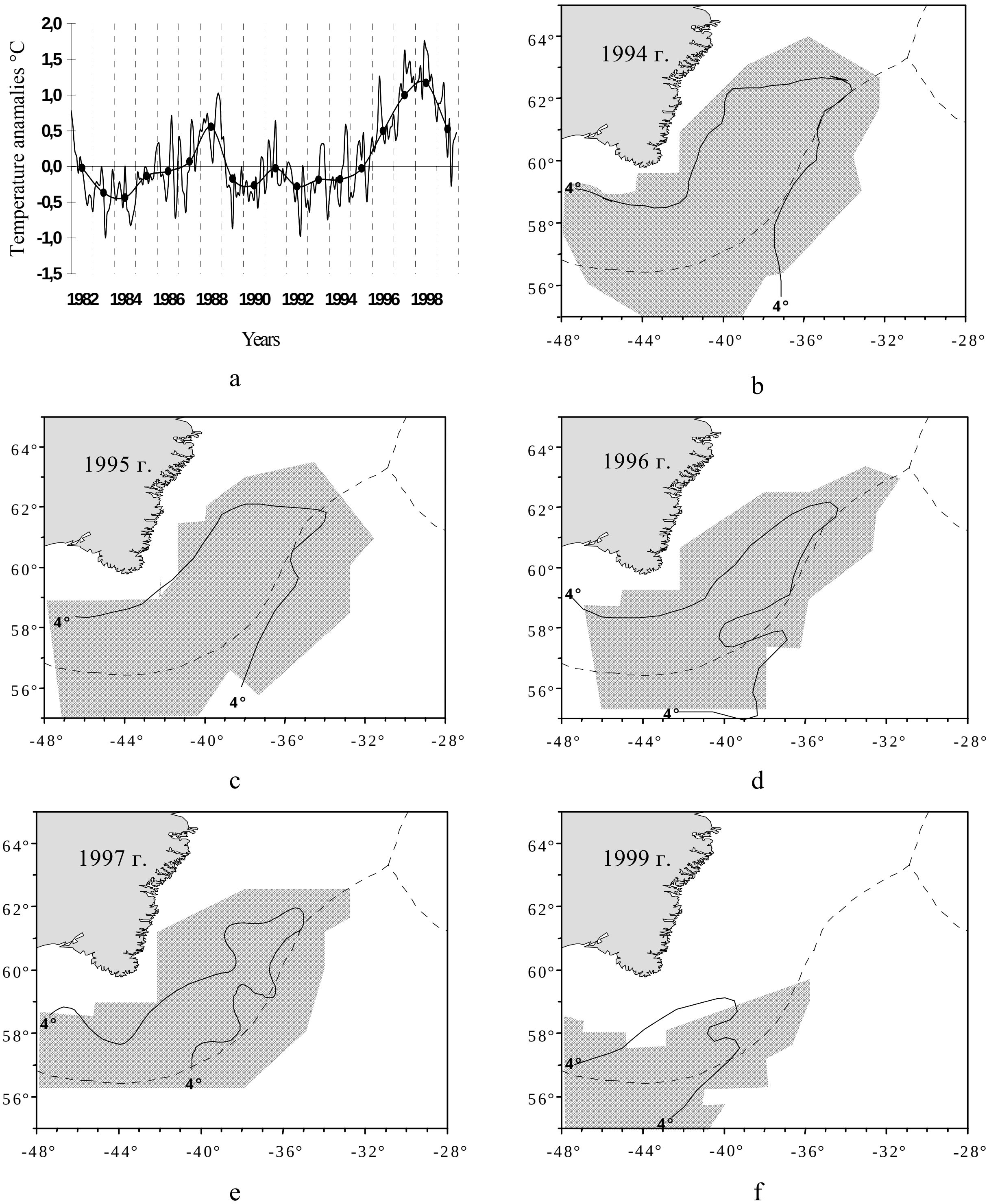


**Fig. 9**. Mean monthly and mean yearly (marked) anomalies of the sea surface temperatures over the feeding area (a). Aggregations of feeding redfish Sa>10m$^2$/nm$_2$ at 0-500m (shading) and 4°C isotherms at 200m in the Irminger Sea, June-July 1994-1999 (b-f).

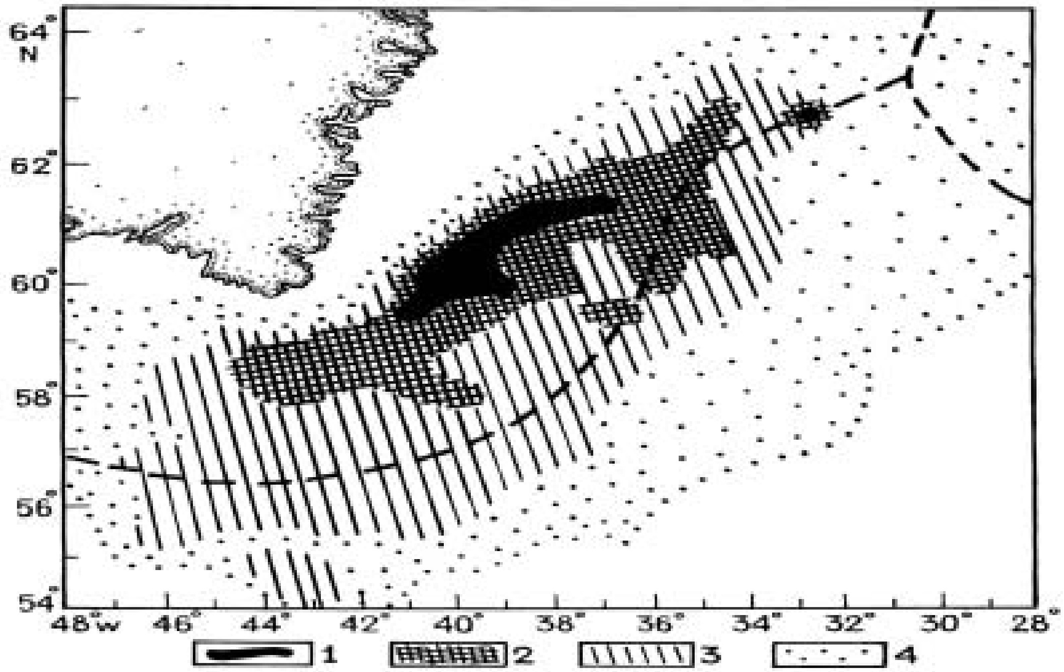


**Fig. 10**. Distribution of redfish aggregation density (Sa ($m^2$/$mile^2$)) in June-July 1996: **1** - above 50; **2** - 25-50; **3** - 10-25; **4** - 0-10.

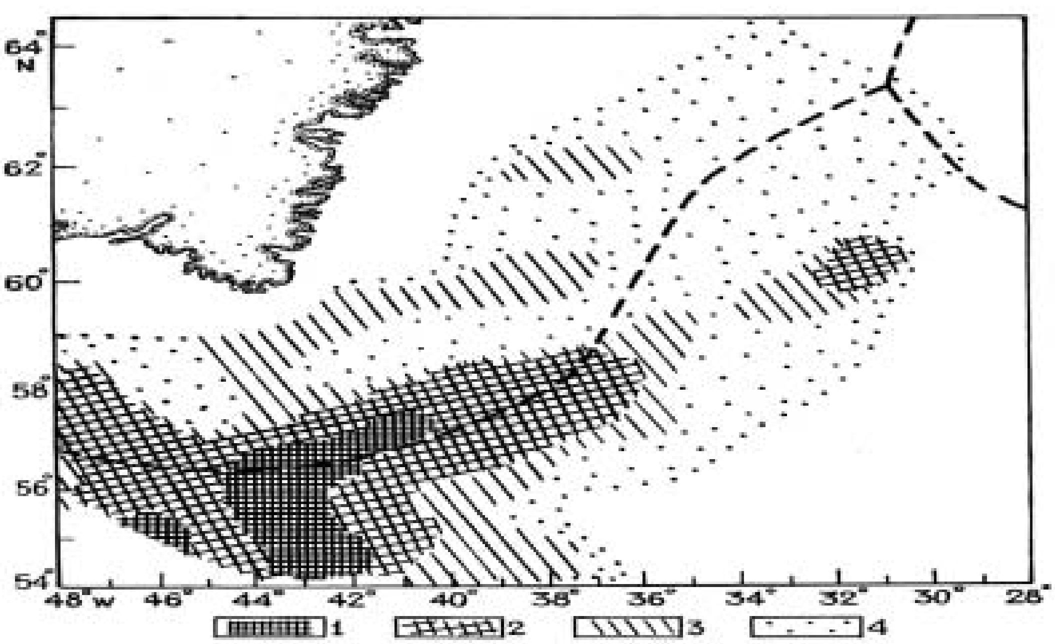


**Fig. 11.** Distribution of redfish aggregation density (Sa ($m^2$/$mile^2$)) in June-July 1999: **1** - above 25; **2** - 10-25; **3** - 5-10; **4** - 0-5.