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On Population Structure of Redfish (*Sebastes* mentella Travin) in the North Atlantic

by

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Abstract

The materials collected in the process of researches and fishery in the Irminger Sea for 1982-1995 are summarized. The data on the "ocean" redfish distribution at the various stages of life cycle and seasonal cycles are analyzed. Local characteristics of length distributions and "maturation curves" are presented. The regularity of seasonal variations by lengths, sex ratio, mature fish population in different areas of the North Atlantic is revealed. Neither area is functionally complete population area. As a whole these areas may be considered as the single population area subdivided into reproductive and vegetative regions and enclosed into the common subarctic cyclonic circulation system. It is assumed that redfish of the North Atlantic is represented by a single population.

Introduction

The stock structure of redfish in the North Atlantic is a subject of intensive investigations including various individual methods.

The common problem is still to be interpretations of variations between samples, such variations may be of inter- and intra-population grade. Inter-sampling variations by themselves do not contain the criterion of rank. Their explanations as inter- and intra-population ones are usually based on the more general data on the life cycle, seasonal and ontogenetic spatial differentiation of the population specimens. A stock unit (population) may be only a local group, which is represented by all the ontogenetic stages and has a functionally complete range (including reproductive and feeding ground, etc.).

From this point of view it seems to be useful to analyze all the data given on distribution of redfish of various stages of life and seasonal cycles.

Material and Method

The data of mass measurements and biological analysis carried out at scouting vessels of Zaprybpromrazvedka in 1980-1984 were used to analyze redfish spatial differentiation by length and sex. Mean length was estimated based on summer measurements by months of a particular year and by two-degree rectangles of the open Irminger Sea between 40 and 28° W southwards up to 50° N. Long term average values by months and rectangles were estimated as arithmetic mean of average monthly values. The material has been pooled by 7 zones for subsequent analysis (Fig. 6). The data of catches from the depths of up to 450 m were used in the work. Total number of females measured was 405 thous. ind.

Results and Discussion

On the basis of materials collected during redfish fishery and researches in the Irminger Sea since 1982 it may be stated that commercial stock of this species in the open sea outside economical zones of Iseland, Greenland and Canada constitutes only a part of the population with a wider distribution area including coastal waters off Iseland, Greenland and, probably, Canada.

The open Irminger Sea is a reproductive region of the population distribution area where mass larvae hatching occurs from early April till late May - early June.

Larvae were observed during ichthyoplankton surveys over the entire Irminger Sea from 52° to 63° N. The highest larvae concentrations were observed in the western area over the western slope of Reykanes Ridge in 1982, over the western and eastern slopes between 53° and 59° N in 1983 and southwards of 57° N between 30° and 35° W in 1984. Differences in larvae distribution in 1982 (Noskov et al., 1985) and 1983 were observed at the background of significant SST differences during the survey period: in 1983 the 7°C isotherm was located more eastwards as compared to 1982 over the eastern slope of Reykanes Ridge. It should be noted that during all three surveys in 1982-1984 the decrease of larvae concentration to zero level was observed near the boundary of the Greenland economical zone. Distribution of the young-of-the-year during 24 August - 12 September 1984 was principally different. All fish was caught only westwards of Reykanes Ridge at the boundary of the Greenland economical zone while the maximum catches were obtained in the area of 62° N and 31° W (Noskov, Romanchenco, 1986).

During 1982-1995 the fishery in the Irminger Sea was based exclusively upon mature fish. Fish below 7 years old was actually absent in the catches. Evidently redfish larvae and fry are transported from the open Irminger Sea by autumn and juvenile contingent of the population distributes outside the latter area. Commercial aggregations mainly consist of females at VII-IX maturity stage, and the most efficient fishery is related to the period of larvae hatching in April-May. After mass larvae hatching from late May to early June the aggregations of spawned females migrate into the upper water layer under the thermocline and are gradually shifted westwards.

Echometric survey of redfish in July 1989 which covered the Greenland economical zone for the first time, revealed aggregations availability between 55° and 60° N near the economical zone and within the latter up to 45° W in the southern part of the area studied (27.06-29.07.1989, STM- 0782 “PINRO”)

Thus, the problem of the Irminger population juvenile contingent distribution and reserve fish and recruitment migration remains unclear. To clarify this problem all available publications as well as measurement and bioanalysis data obtained in 1980-1984 and 1995 (covering all months of the year) were studied. Measurements of about 500 ind. redfish caught in the open pelagic area at the depths up to 450 m were used.

In Fig. 1 the areas are shown where the data used in the analysis were obtained. Main characteristics of redfish from the above areas are presented in Table . According to Ni and Sandeman data (1984) the average fish length and mature fish (or firstly maturated) proportion increased from West Greenland to Newfoundland from area 1 to area 6.

In Baffin Island area (area 2) no adult females (up to maximum length 42 cm) were observed, in West Greenland and North Labrador areas the proportion of mature females amounted to 3.5-11.7% while in Newfoundland area adult females predominated (more than 65%).

Evidently, that the group of area 2, where no mature females were observed, should not be considered as the independent unit. In area 1 individual mature females occurred among the largest fishes (Fig. 2), the same was observed in area 3 (Fig. 2).

However, in both areas no 50% maturation of female was attained at maximum fish length observed. In area 4 (Fig. 2) the 100% maturation occurred only at maximum length of females constituting no less than 1%. Neither groups of areas 1-4 may be considered independent. They represented the part of the population from the area inhabited by juvenile contingent. Besides, in areas 1-3 and 4-6 juvenile fish of 8 cm in length was commonly observed, while in the areas where mature fish actually absent juvenile fish may only come from outside.

From area 1 to area 6 the increase of average fish length and mature fish proportion occurred (from total absence in area 2 to predominance in area 6). Recruitment in areas 1-4 occurred only at the account of juvenile fish, while in area 6 both juvenile and maturating fish constituted recruitment. As moving from area 1-2 to area 6 the shift of “maturation curves” to the left, i.e. to the origin of length distribution, and decrease of the 50% and 100% maturation length was observed.

However, even in area 6 the 100% maturation was attained at the maximum length which corresponded to the right side of the length distribution. If we consider “maturation curve” in the area 6 as an objective characteristic of females maturation rate, we should assume that most fish never attained maturity.

“Maturation curve” for the Irminger Sea group (Fig.3) drawn on the basis of data from STM “Atlantida” for 1995 is of different pattern. Actually entire curve locations above poorly represented left side of females length distribution while the 100% maturation is a characteristic of females 33 cm in length. Besides, juvenile females constituted about 5% in 1983 and 1984, and 2.1% in 1995. Comparison of length distribution and “maturation curve” shows that the Irminger contingent is recruited exclusively by females.

In general the analysis of length composition and mature fish proportion distribution by length in areas 1-7 allows to conclude that populations of these areas represent there components of one population with evident spatial ontogenetic differentiation. Areas 1-4 are recruited only by juvenile fish, area 7 - only by mature fish. While growing, redfish migrates from the areas 1 and 2 towards the area 6, and individuals attaining sexual maturity enter the reproductive zone of the Irminger Sea.

All the areas under consideration area within the unique circulation system that is formed by the following currents: Irminger Current, East Greenland Current, West-Greenland Current and Labrador Current. Redfish inhabits the Atlantic transformed waters of the whole system that are circulating along the continental slopes of Greenland and Labrador below colder and diluted waters of inshore components of East Greenland Current, West Greenland Current and Labrador Current.

The integrating factor for the Northwestern Atlantic population is a drift of larvae and fry from the vast water area of practically entire high seas of the Irminger where the larvae hatching takes place. Westerly drift of fry towards the continental slopes of Greenland and Labrador happens due to a centrifugal component characteristic of cyclonic circulation systems. It is quite natural that with a vast water area of larvae hatching fry transportation covers the whole west periphery of circulation system for the Irminger Sea and the Labrador Sea. It is also evident that a powerful integrating factor of fry drift excludes the fractional populational differentiation of species in the North-West Atlantic Ocean. Although populational unity of redfish from the high Irminger Sea and continental slopes of Greenland, Labrador and Newfoundland may hardly raise doubts, a number of aspects of life cycle is left to be discussed. This, first of all, concerns a possibility for matured individuals to migrate from the offshore waters of the Irminger Sea to the areas of the continental slope in autumn-winter period.

The data on size composition and sex ratio within the whole water area under investigation during 1980-1984 have been used to analyze redfish migration within the offshore Irminger Sea. Female mean lengths and their quantity in catches have been served as specific indices.

Both female lengths and their quantities in catches have substantially been changed over the year (Fig. 4). Maximum mean length of 38.4 cm in February has been sharply decreasing to minimum values in April-May (35.2 cm), being somewhat increased from May to August, and then being decreased in September-October to be reincreased towards December. Female share in catches increases up to 70% in March-July, being decreased to

45% in September-December. Mean length decrease has clearly been related to a season of massive larvae hatching (Fig. 5). Female largest share in catches has also been observed during the same season.

Changes in mean lengths and in sex ratio can theoretically been related both to inflow and outflow of smaller or larger females, as well as to inflow or outflow of females and males. However, since in the period of female maximum prevalence in catches and their minimum mean lengths maximum catch per effort has been observed which was 10-20 times less in the period of male prevalence, one can suppose that variations in sex ratio are attributed to exclusively or mainly female inflows for larvae hatching and their outflows from sea deep waters by September-December. Availability of substantial variations in fish mean lengths and in sex ratio clearly evidences that the Irminger Sea contingent is not constant over the year, and so the problem of migrations of population reproductive part is urgent.

Distribution area of redfish is confined in the east by warm waters of the Irminger Current. Therefore, possible migration of reproductive contingent to be in the south-east direction. To observe possible westerly, southerly and south-west migrations the data on mean length and sex ratio have been combined for two degree blocks of western (I, II, IV, VI) and eastern (III, V, VII) zones (Fig. 6).

Variations of female length composition and proportion in catches as shown in Fig. 4, are characteristics to the entire Irminger Sea area. However, seasonal trends of both indices variability and their values in specific time and point of the sea significantly differ.

Variations in female share and in their mean lengths in II and IV (eastern) blocks and III and V (western) blocks are given in Fig. 7 . In the beginning of 80-ths fishing was carried out in the eastern zone during March-May over female concentrations shedding larvae, being the same shifted towards the western zone late in June-August where post-spawned females were fished on their supposed way of migration towards the Exclusive Economical Zone of Greenland. Female share sharply increased just by the beginning of reproductive season, attaining its maximum in April and then sharply decreasing from August to September. At the same time, maximum female proportion in the western blocks was observed in July-August, just during the season of their migration towards the west. However, female share in catches at the end of winter and in the beginning of spring was not observed in the western blocks. Hence, one can suggest that female spring inflow into the eastern III and IV blocks took place from the west. Female mean length is considerably larger in the eastern blocks than that in the western zone from October till March after the finish of larvae hatching.

Variations in female mean lengths over the year in the western I, II, IV and VI blocks (Fig. 8) allow for observing a supposed migration of females in the north-south direction. In September-January fish mean length is the least in the VI southern block. It is increasing from January to April to the maximum value for the whole western zone against a background of a sharp decrease of mean length for the most northern I block. During the season of post-spawning migration the values of mean length become closer within all of four western blocks (June-August) and in September a reverse distribution is observed as compared to the spring one, being considerably decreased female mean length from the north to the south. Correlated trend of seasonal variations in female spatial distribution of reproductive contingent from the Irminger Sea in the direction of east-west (II, IV-III, V blocks) and north-south (I, II, IV, blocks) confirms a suggestion of recruitment migration from the south-west to the north-east, from the continental slopes to the offshore Irminger Sea. On having hatched the larvae, females migrate towards the west and south -west along Greenland eastern coast. However, active migration of matured fish does not repeat passive drift of young fish in warm components of East Greenland Current, West Greenland Current and Labrador Current. Mature redfish from the Irminger Sea does not attained continental slopes of West Greenland, Baffin Land and Labrador.

Younger age groups of a mature contingent mainly undertake seasonal migrations to the South-West Irminger Sea and backwards. Larger individuals migrate to the slopes of Iceland, Iceland-Greenland Ridge, attaining Rosengarten Bank and Northern Reykanes Ridge. In addition, individuals of older and middle age groups are observed all over the year in the offshore Irminger Sea.

As a whole, the scheme of the range functional structure of the North Atlantic population of redfishis shown on the Fig. 9.

Conclusion

Nowhere in areas considered (1-10) redfish is presented by all the ontogenetic stages.

As a whole these areas may be considered as a range of the one entire population subdivided by spatially isolated reproductive and feeding grounds, locked in entire Circular System of Subarctic Cyclonic Gyre.

Life cycle includes drift of larvae and juveniles, ontogenetic active migration of immature and primary maturing fish and seasonal migrations of reproductive part of population. The extensive drift of planktonic ontogenetic stages is the factor of integration.

The deepwater redfish in North Atlantic is presented, most probable, by one entire population.

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Noskov A.S., Romanchenko A.N. 1986. Abundance and distribution of juveniles of 0-age group of redfish (*Sebastes mentella* Travin) in Irminger Sea in 1984. In: Life Cycles, Distribution and migrations of commercial fishes of Atlantic and Pacific Oceans. Kaliningrad, AtlantNIRO, 1986, pp. 68-76. (In Russian).

Table

Size composition, share of adult fishes and length at which 50% specimens reach maturity, by areas; S.mentella.

<table>
<tr><th rowspan="3">Area (According to Fig. 5)</th><th rowspan="3">NAFO Div.</th><th colspan="4">Length, L, cm</th><th colspan="2">Share of adults</th><th colspan="2">L - 50</th></tr>
<tr><th colspan="2">Males</th><th colspan="2">Females</th><th rowspan="2">males</th><th rowspan="2">females</th><th rowspan="2">males</th><th rowspan="2">females</th></tr>
<tr><th>from - to</th><th>mean</th><th>from - to</th><th>mean</th></tr>
<tr><td>1</td><td>1</td><td>8-44</td><td>20,8</td><td>8-48</td><td>21,4</td><td>17,9</td><td>3,5</td><td>29,4</td><td>(45,1)</td></tr>
<tr><td>2</td><td>0</td><td>8-42</td><td>24,3</td><td>8-45</td><td>23,7</td><td>31,3</td><td>0,0</td><td>29,1</td><td>-</td></tr>
<tr><td>3</td><td>2</td><td>24-50</td><td>35,5</td><td>22-48</td><td>37,0</td><td>89,3</td><td>11,7</td><td>29,0</td><td>(59,69)</td></tr>
<tr><td>4</td><td>2H</td><td>8-48</td><td>30,8</td><td>10-52</td><td>32,8</td><td>68,1</td><td>21,8</td><td>27,7</td><td>43,1</td></tr>
<tr><td>5</td><td>2</td><td>10-48</td><td>34,7</td><td>8-48</td><td>35,6</td><td>90,8</td><td>38,8</td><td>24,9</td><td>40,6</td></tr>
<tr><td>6</td><td>3</td><td>8-50</td><td>33,1</td><td>8-54</td><td>35,7</td><td>92,6</td><td>65,2</td><td>21,8</td><td>34,6</td></tr>
<tr><td>7</td><td></td><td>22-47</td><td>34,0</td><td>22-50</td><td>36,3</td><td>~96</td><td>~95</td><td>(28,4)</td><td>(30,5)</td></tr>
<tr><td>8</td><td></td><td>27-52</td><td>38-40*</td><td>32-52</td><td>36-40*</td><td rowspan="2">~85</td><td rowspan="2">~70</td><td rowspan="2">(38,4)</td><td rowspan="2">(41,0)</td></tr>
<tr><td>9</td><td></td><td>34-50</td><td>42*</td><td>37-52</td><td>43-45*</td></tr>
<tr><td>10</td><td></td><td>37-56</td><td>45*</td><td>42-52</td><td>46-48*</td><td>>90</td><td>90</td><td></td><td></td></tr>
</table>

* Instead of the mean length the modes of size distributions are presented. In brackets are given values of L_{50} obtained from inadequate material (share of immature or mature fish is less then 10%).

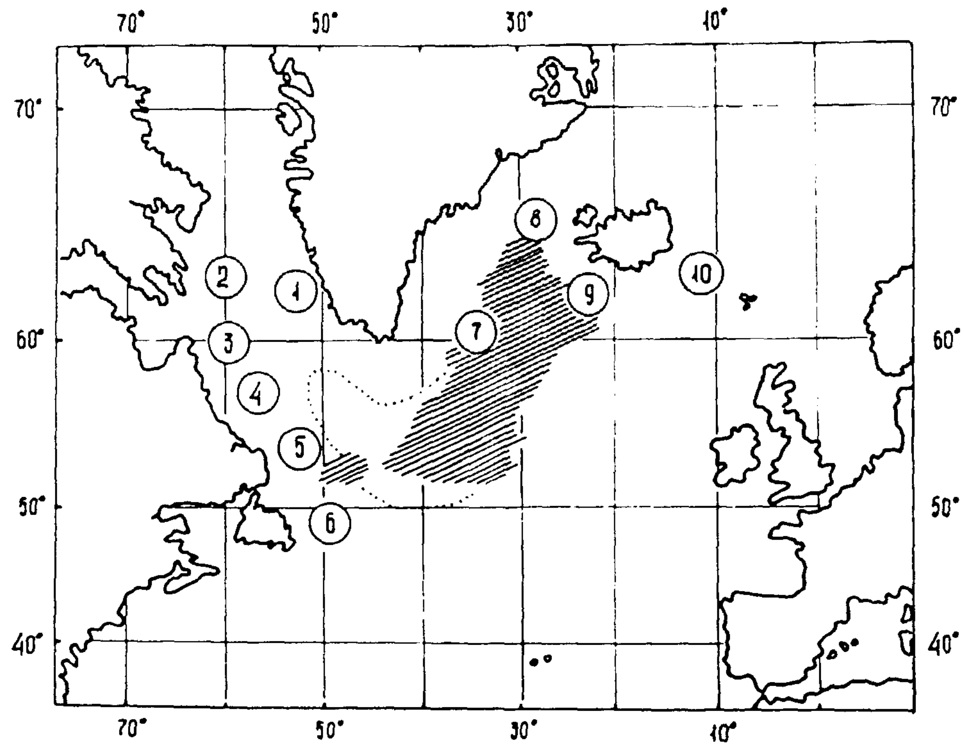

Figure 1. Areas where length composition and mature and juvenile redfish proportions were estimated
Reveival areas of mass larvae hatching are shadowed, probable areas are shown in dotted line

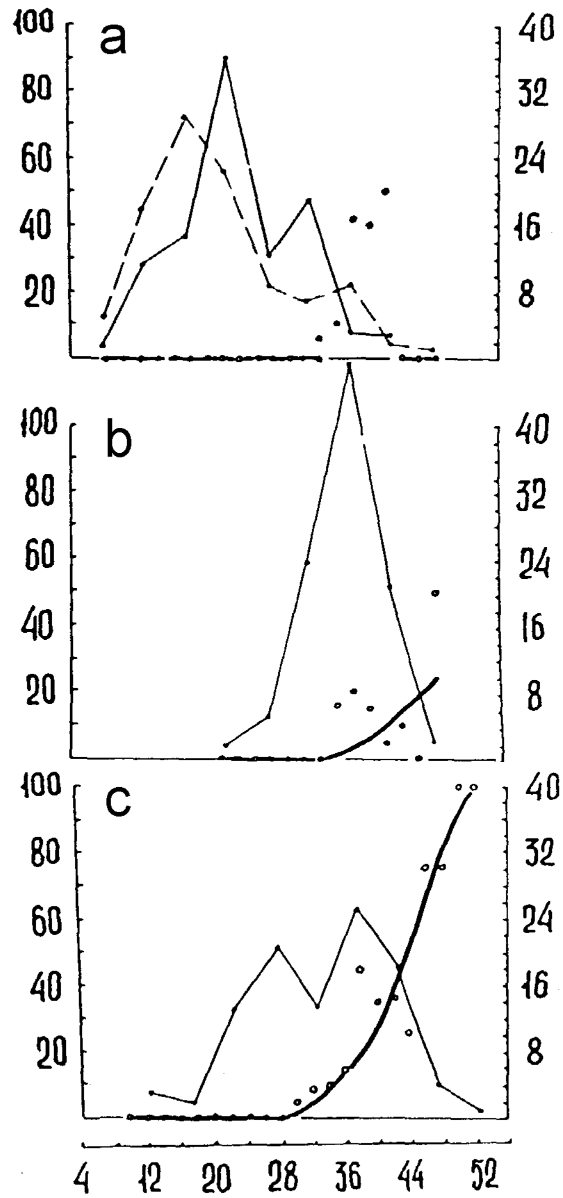

Figure 2. Length composition and relative number of juvenile females by length classes of redfish
a - areas 1 and 2 (dotted line), b - area 3, c area 4
Areas location is shown in Fig. 1

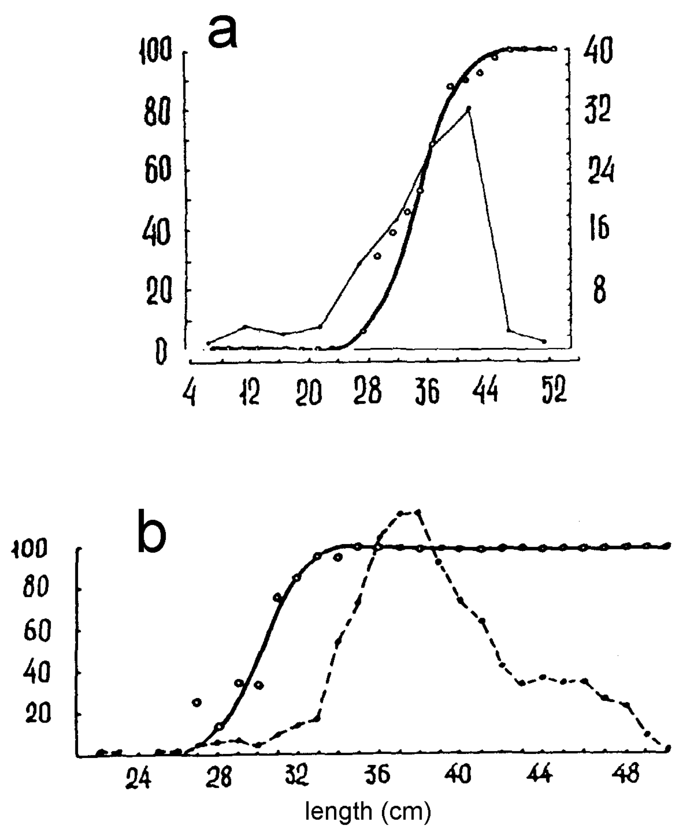

Figure 3. Length composition and relative number of mature females by length classes
a - in area 6; b - in area 7

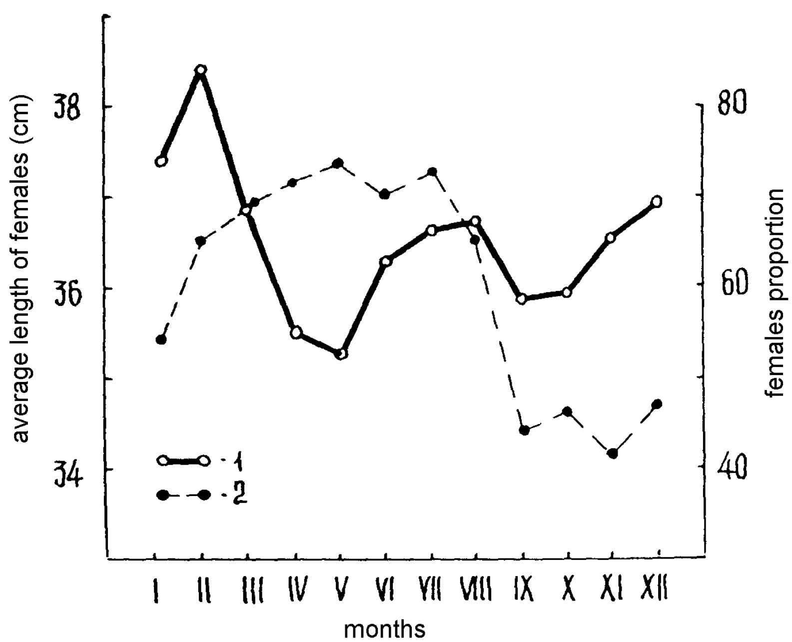

Figure 4. Average length and proportion
1 - average length, 2 - females proportion in catches

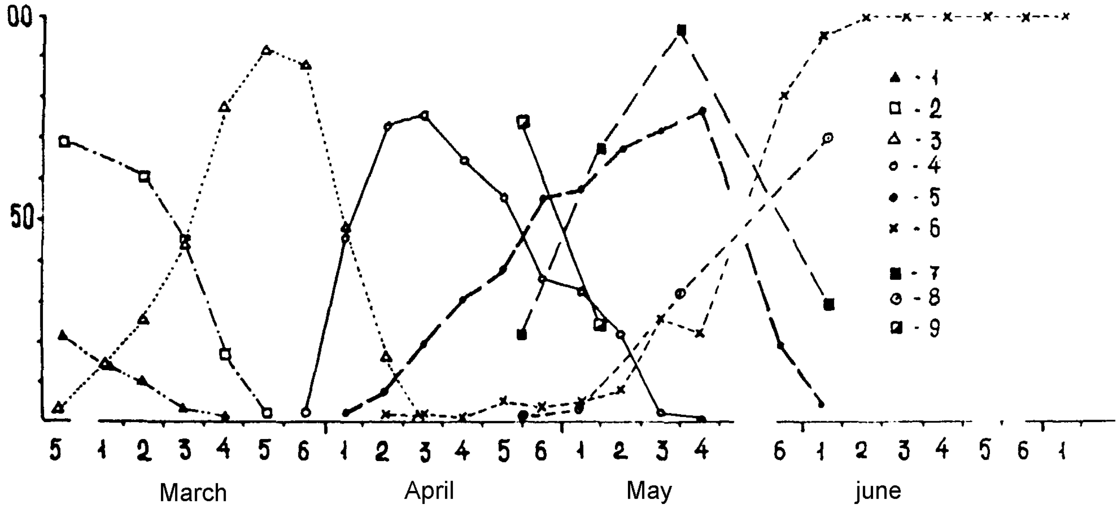

Figure 5. Redfish females maturity stages in the Irminger Sea in February - June 1983 and May - June 1995
1 - V, 2 - VI, 3 - VII, 4 - VIII, 5 - IX, 6 - IX-III and III stages in 1983;
7 - VIII, 8 - IX, 9 - III stages in 1995

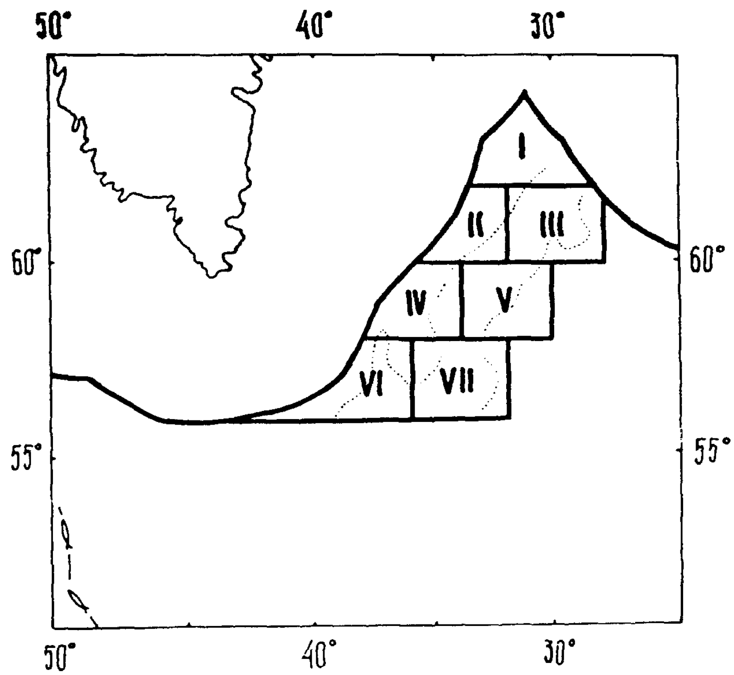

Figure 6. Sampling area
Roman numerals indicate rectangles of the eastern (I, III, V, VII) and western (II, IV, VI) zones. The area with redfish larvae density above 25 ind. under 1 sq. m. is marked with a dotted line

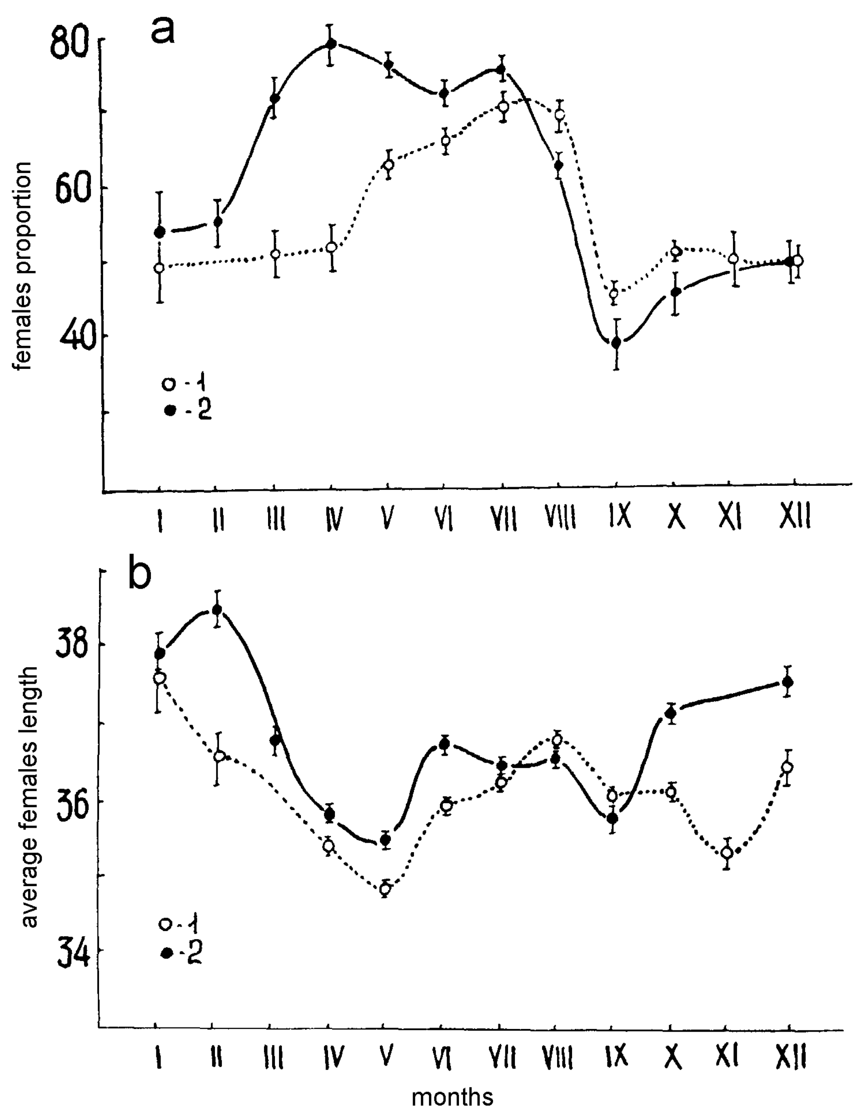

Figure 7. Females proportion (a) and average length in the western and eastern parts of the fishing ground in January - December
1 - rectangles II, IV (west); 2 - III, V (east)

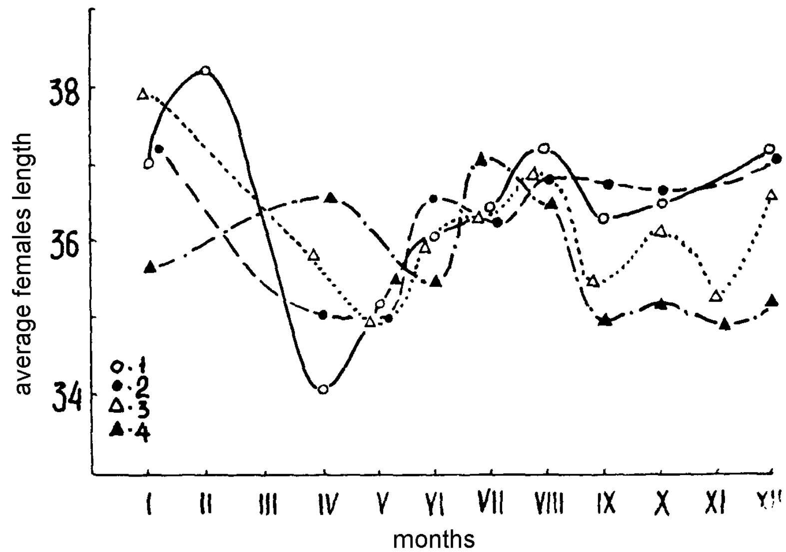

Figure 8. Females average length in January - December
Rectangles: 1 - I, 2 - II, 3 - IV, 4 - VI

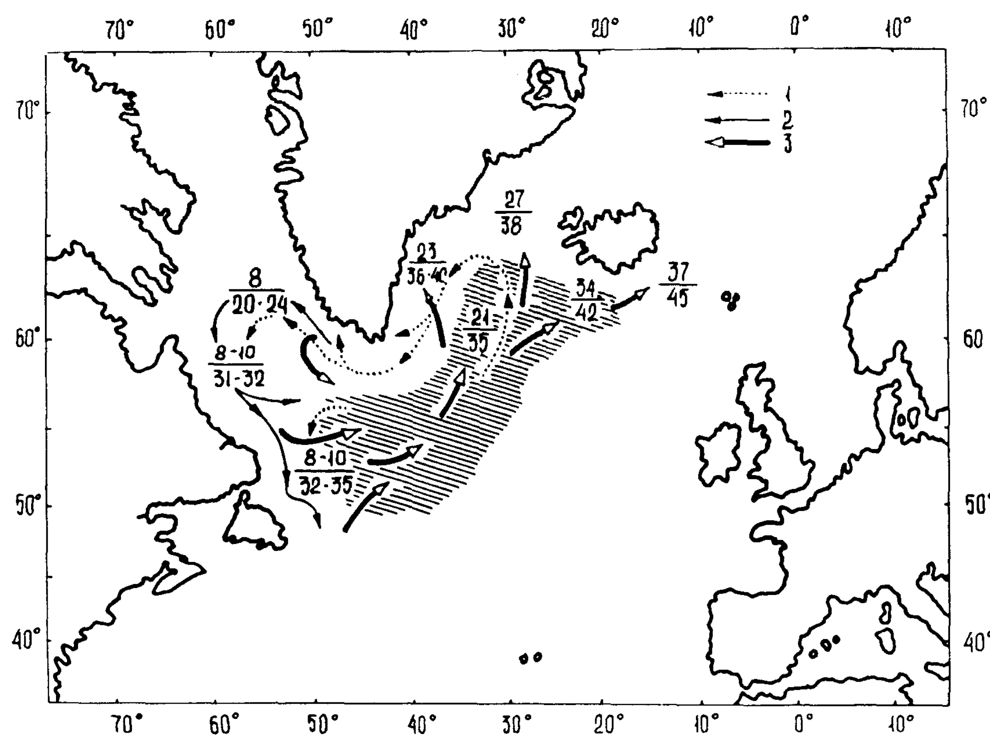

Figure 9. Functional structure of redfish distribution area in the North Atlantic Ocean
1 - larvae and fry drift direction;
2 - juvenile fish migration direction;
3 - direction of first matirating and mature females migration;
The area of larvae hatching is shadowed
Figures indicate minimum fish length or mode by areas.