Northwest Atlantic Fisheries Organization

Serial No. N2499

NAFO SCR Doc. 95/1
Revised

SCIENTIFIC COUNCIL MEETING - JUNE 1995

On the Population Structure of Beaked Redfish (*Sebastes Mentella* Travin) in the Irminger Sea as Related to the Hypothesis of the Latter Larvae Into the North-Western Atlantic

by

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Abstract

The biological features of adult beaked redfish (*Sebastes mentella* Travin) of the Irminger Sea, distributed within a pelagic depths (outside 200-mile zone) and on the slopes of Iceland and Eastern Greenland Shelf are discussed in the paper, as well as the data on the latter larvae and 0-group distribution. The results of comparison supposed the lack of close relation between adult redfish of the above areas.

Concerning the early stages, the redfish larvae, drifting towards Western Greenland, seems to originate from the spawning area, located at the shelf edge southwest off Iceland, while the larvae hatched in the central sea area are developing within the closed eddy, generated by surface currents. No facts were revealed to confirm the mass enter of larvae into the flow of Irminger Current. Young redfish, originated from the spawning area within pelagic depths also do not seem to recruit the stock of the Iceland and Eastern Greenland shelf slopes. In general all information available evidences the existence of two beaked redfish populations in the Irminger Sea. The first one inhabits the slopes of the Iceland and Eastern Greenland shelves, and the second one distributes within the pelagic depths and its life cycle is mainly restricted by the above-mentioned eddy. Therefore, management of the redfish fishery outside 200-mile zone should be performed independently of that, inhabiting the shelf slopes.

Introduction

As is known, the extensive redfish spawning ground (location of larvae hatching) is in the Irminger Sea center southwestward off Iceland. According to Troyanovsky (1992) part of the larvae from the above spawning ground drifts to Western Greenland and further to Labrador, reaching the Grand Newfoundland Bank, as is shown in the figure of the above-mentioned paper. Obviously, this hypothesis is very interesting both from the theoretical and practical points of view (the problems of population differentiation and fishery management). Therefore, NAFO and ICES agreed to convene the joint working group to study biological relation between the redfish stocks of the Western Greenland and Irminger Sea.

During the first half of the 1980s, the scientists of AtlantNIRO were intensively researching the so called "ocean stock" of redfish outside the 200-mile zone and collected extensive information which allows to derive some considerations on the structure of the redfish population from the Irminger Sea and possible relations of the latter with the same species from the North-Western Atlantic.

Materials and Methods

The biological materials, utilized in the work (area outside 200-mile zone between 55-62°N and 29-35°W) were collected in 1980-1985 and included the length measurements, weighting, age sampling, maturity stage estimation, revealing fish infection with parasitic Crustacea *Sphyrion lumpi* Krøyer. During the above-mentioned period, the total number of length measurements amounted to 568 thous. specimens and age was estimated in 4.6 thous. specimens.

Besides, in 1981-1985 the survey of redfish larvae and 0-group was carried out (757 stations). One hundred fish were sampled to perform the morphometric analysis. In total, 145 thous. specimens were analyzed. Biological data of the redfish from the slope of the Iceland and East Greenland shelf were obtained from Zakharov's dissertation (1969) by a kind consent of the author.

The materials had been treated with the methods, adopted in AtlantNIRO and PINRO. Age data were obtained from scales. Surveys of 0-group redfish larvae were carried out with the method, described in detail by Noskov and Romanchenko (1985, 1986).

History of the Problem

The first reference to the pelagic population of redfish was made by Nansen (1886). The hypothesis was supported later by Hjort (1901) on the base of repeated catches of redfish with long-lines at the depth of 100-200 m in the open Norwegian Sea. Schmidt (1904) and Jensen (1922) had found aggregations of redfish larvae southwestwards off Iceland hundreds of miles away from the nearest demersal stock of the latter. Based on that, Toning (1949) and Templeman (1959) assumed the existence of *Sebastes* spp. pelagic population in the Irminger Sea. However, the fact of abundant larvae occurrence may be interpreted in two ways. Thus, Zakharov (1963) supposes that larvae in the open ocean are spawned by redfish females which migrated from the Iceland shelf slope and 2-3 months later (in August-September) return back. His point of view is supported by Kotthaus (1965).

In general, by 1981 when extensive redfish fishery was performed outside the 200-mile zone the problem of *S. mentella* population structure had been yet uncertain in the Irminger Sea. The above hypotheses were equally acceptable.

Results and Discussion

Let us compare first some biological characteristics of adult beaked redfish in the central part of the Irminger Sea (outside 200-mile zone) and on the Iceland shelf slopes. Apparently data on the length composition, presented in Table 1, are the most abundant. The data presented shows that an average length of fish, caught in pelagic zone and at the shelf edge, differs significantly and the difference is observed throughout the year, i.e. there are no reasons to assume migration of various size redfish from one area to another. Age composition differs to the lesser extent. Thus, in the catches from the open sea areas the dominating age was 13-19 years for females and 12-17 for males, while in the shelf zone the dominating age was 16-22 and 16-21 years, respectively. Taking into account the above-mentioned facts, it is reasonable to pay attention to a growth rate of redfish from the areas considered (Table 2). The data presented apparently evidence the higher growth rate of fish, caught within the Iceland shelf slopes . Magnússon (1972, 1983) also observed the lower growth rate of the ocean redfish as compared to that from the shelf areas. Table 3 shows the data on *S. mentella* maturity rate. Significant differences are observed for this characteristic also. Thus, while 90-95% of fish caught from pelagic area are mature at the length of 32 cm, redfish from the coastal areas approach the above percent maturity only at the length of 42 and 44 cm for males and females, respectively. Therefore, the conclusion could be made on correlation between *S. mentella* growth rate and maturity in the Irminger Sea. The redfish maturity dynamics research throughout a year shows that in pelagic area the major mating occurs in August-September while in the shelf area if occurs in September-December. As to sex ratio, females amount up to 90% of catches outside 200-mile zone in April-May. Later on the male proportion increases and approaches 50% and over by winter.

The results of meristic characteristics of the beaked redfish caught outside 200-mile zone (our data) and on the Iceland shelf slopes (Barsukov, Zakharov, 1972), presented in Table 4, evidence statistically significant variations for three characteristics of four considered.

Parasitic Crustacea *Sphyrion lumpi* is also a good indicator of the redfish (*Sebastes*) population differentiation (Templeman and Squires, 1960; Sinderman, 1961; Yanulov, 1962). It is not surprising that the problem of fish infection with this parasite in the central Irminger Sea had been carefully studied (Gaevskaya, 1984). The results show that the average infection level is 16.8% for females, 8.5% for males, and 14.3% for both sexes. Besides, during some months the infection level exceeded 35% at some sites. We refer to other data on the beaked redfish infection in some other areas of the Northern Atlantic to compare. Thus, for comparison, in the Barents Sea an average infection amounts to about 1.0% off the Bear Iceland - 2.9%, in the Iceland shelf - 1.4% (Williams, 1963). In the North Western Atlantic the peak redfish infection (6.6%) is observed in the Southern Labrador Bank. No *S. lumpi* is found in the north-eastern area of the Grand Newfoundland Bank, at the Flemish Cap Bank and Scotian Shelf (Templeman and

Squires, 1960). Based on the results obtained, Gaevskaya (1984) concluded that no other area of the Northern Atlantic shows so high level of the deep-sea redfish infection, as the open Irminger Sea; and the *S. lumpi* invasion center is likely to locate there. Poor interrelation of redfish from the latter area and that from other areas contributes to maintenance of the high infection level.

To conclude the comparison of adult redfish biological characteristics it seems useful to consider data on distribution and occurrence of the latter outside 200-mile zone which has been based on the results of the long-term fishery of the former Soviet Union fishermen. Briefly we may assume that *S. mentella* occurs in the above area throughout a year, concentrating in the most dense aggregations during larva hatching (April-May), feeding period (June-July) and, sometimes, during mating (August-September). During the rest of the year adult redfish also permanently occur over the vast sea areas outside 200-mile zone, though no dense aggregations are found. The information presented supplemented by sex ratio data (see above) makes questionable the hypothesis on the seasonal migration of females above into the central Irminger Sea, followed by their return after spawning into the shelf area.

In general, the facts discussed above evidence the lack of close interrelation between adult beaked redfish, inhabiting a pelagic zone and the slopes of the Iceland and Eastern Greenland Shelves. The assumption of adult pelagic redfish migration into the North-Western Atlantic and return seems unlikely also. Magnússon (1981) clearly suppose the existence of the ocean spawning stock of redfish *S. mentella*.

Undoubtedly, the great difference of the data compared by the time of sampling (up to 20 years) is a disadvantage of the analysis discussed above. However, if we accept the hypothesis of a single beaked redfish population in the Irminger Sea, it is hard to suppose, that in the period from the 1960s to 1980s the biological characteristics of the species researched may change so significantly due to some unknown reasons. In any case, as far as known, the proportion of fish, infected by *S. lumpi* is different areas of the North Atlantic remains at present approximately the same as some decades ago.

Now we shall consider the data on early stages (larvae and 0-group) of the beaked redfish in the Irminger Sea. Figure 1 (Noskov *et al.*, 1985) shows larvae distribution and abundance on the basis of the ichthyoplankton survey, performed from 27 April to 6 June 1982. The most striking is almost entire absence of the latter stages at peripheral stations, adjacent to the boundary of 200-mile zone. Similar results were obtained in the survey of 1983. Therefore, it can be assumed that during the period discussed there was no larvae drift westwards and northwards. Otherwise, the latter seems to occur near the above boundary much frequently. The trawl survey of 0-group redfish in August-September 1984 revealed that even in September considerable number of young fish still remains within the central part of the sea (Fig. 2) (Noskov and Romanchenko, 1986), approaching the length of 4-6 cm by this time. In that case it seems appropriate to assume an active movement of young fish which undoubtedly extend its area, as it has grown up, and went outside the survey area. It should be noted that the authors of the latter two papers refer to the results obtained and conclude definitely larvae and young fish penetration from the spawning area in the central part of the sea into the Irminger Current with further drift to the Eastern and Western Greenland. Evidently that the above conclusion should be verified with reference to the data on the surface current system in the area of study. Figure 3 shows the large closed eddy in the area, within which the spawning area of the "ocean" redfish stock distributes. It seems unlikely that larvae are able to escape the eddy actively and enter the Irminger Current. Young fish of 0-group also "do not hurry" to do it (Noskov and Romanchenko, 1986).

Interesting information relevant to the problem discussed, is presented in the work by Zakharov (1966). Research of 0-group redfish distribution in July-October 1964 permits the author to reveal large amount of young fish in the Irminger Current zone (Eastern and Western Greenland shelf slopes). The latter was essentially represented by *S. marinus* while *S. mentella* occurred rarely. The above information supports the conclusion that the bulk of beaked redfish larvae, hatched outside the 200-mile zone do not penetrate the Irminger Current flow. Young fish, occurred in the area originate from the spawning ground at the shelf edge southward off Iceland (Magnússon, 1961; Zakharov, 1966). In the above-mentioned area both larvae of golden and beaked redfish are observed. The latter may easily enter the Irminger Current flow and drift further towards Eastern and then to Western Greenland.

In general, the results of the analysis performed leave no doubt concerning the structure of *S. mentella* population in the Irminger Sea. However, the location of the major distribution area of 1-7 year old fish hatched in the pelagic layer remains uncertain. The above-mentioned age groups actually absent in commercial catches from outside the 200-mile zone. However, the Report of the Joint Working Group ICES/NAFO (Anon., 1984) notes that the beaked redfish stock of the Iceland shelf slopes and the Eastern Greenland seems only slightly recruited from the pelagic stock of the species. Data, presented in the work, supports the above conclusion. The grown up youth of the above-mentioned ages seem essentially to distribute within the eddy approximately between 55-62°N and 32-38°W. However, the latter is likely to penetrate in small amounts into the Eastern Greenland shelf, where it mixes with the local population and never returns into the open sea. Concerning the particular areas of distribution of 1-7 age-groups redfish pelagic population, the abundance of which seems to be very high, they will undoubtedly be found if specific researches are performed.

Conclusion

The events discussed in the paper seem, to my opinion, evidence the existence of 2 beaked redfish populations in the Irminger Sea, the first one (coastal) inhabits the Iceland and Eastern Greenland shelf slopes, and another (pelagic) occurs in the open sea and spends almost all its life cycle within the eddy, developed from surface currents. Therefore, the redfish fishery management outside the 200-mile zone should be, performed independently of the population, fished on the shelf slopes. Concerning the relation to the North-Western Atlantic, *S. mentella* larvae, drifting towards Western Greenland and further, seem originate from the spawning grounds, located at the shelf edge south-westwards off Iceland (coastal population), while larvae hatched in a central area of the Irminger Sea develop entirely with the closed eddy.

Acknowledgements

I am very grateful to the scientists of AtlantNIRO and Zaprybpromrazvedka (Fishing Scouting Service) participated in biological sampling of beaked redfish in the Irminger Sea during the 1980s. I would like also to thank sincerely Dr. G. P. Zakharov for his kind permission to use materials from his dissertation.

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TABLE 1. Average length (cm) of redfish caught outside the 200-mile zone of the Irminger Sea and on the Iceland shelf slopes.

Area	Year	Sex	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Month											
Outside 200-mile zone	1981	♂	-	-	-	33.1	33.2	33.8	34.5	34.9	33.6	33.9	-	-
		♀	-	-	-	35.6	35.6	35.8	36.6	36.6	35.3	35.5	-	-
	1982	♂	35.6	34.6	34.6	32.9	32.8	33.3	33.6	35.3	35.1	35.2	-	-
		♀	38.4	39.2	37.1	35.7	35.2	35.6	35.8	37.0	37.7	36.9	-	-
	1983	♂	-	-	33.5	32.7	33.4	33.6	34.3	34.8	-	-	-	35.1
		♀	-	-	36.4	35.2	35.3	35.5	36.3	36.7	-	-	-	37.1
Shelf slopes	1960s	♂	41.8	40.9	41.6	41.2	42.0	42.1	41.3	42.0	42.0	40.2	41.9	43.0
		♀	43.9	43.4	43.7	42.5	42.3	42.8	42.7	43.2	43.6	42.0	43.0	44.8

TABLE 2. Average length by age (cm) of redfish caught outside the 200-mile zone of the Irminger Sea (1981-1982) and on the Iceland shelf slopes (1960s).

Age	Outside 200-mile zone ♂	Outside 200-mile zone ♀	Shelf slopes ♂	Shelf slopes ♀
9	27.2	27.6	-	-
10	28.8	28.5	-	-
11	29.7	29.4	-	-
12	30.9	30.5	-	-
13	32.0	32.8	38.0	37.0
14	33.1	33.9	39.5	41.5
15	34.6	35.2	41.0	42.2
16	36.1	36.2	42.5	42.5
17	38.0	37.8	43.4	44.7
18	37.9	38.7	43.6	45.2
19	39.0	39.6	44.3	45.2
20	-	40.3	45.0	45.8
21	-	41.1	45.2	46.2
22	-	41.9	45.8	46.5
23	-	42.7	-	-

TABLE 3. Percent of mature redfish by age-groups caught outside the 200-mile zone (1981-1982) and on the Iceland shelf slopes (1960s).

Length (cm)	Outside 200-mile zone ♂ June-July	Outside 200-mile zone ♀ March-April	Shelf slopes ♂	Shelf slopes ♀
25				
26	0	8		
27	5	12		
28	25	33		
29	71	25		
30	88	55		
31	86	87		
32	92	95	12	
33	96	97	20	
34	97	99	15	
35	99	99	21	1
36	99	99	27	3
37	99	99	33	4
38	98	99	44	6
39	96	99	68	10
40	100	98	80	33
41		97	86	52
42		97	92	69
43		88	95	84
44		86	97	92
45		100	98	94
46			96	98
47			98	98
48			97	98
49			95	98
50			100	99
51				100

TABLE 4. Comparison of four measurement characteristics for redfish caught outside the 200-mile zone of the Irminger Sea and on the Iceland shelf slopes (number of specimen is shown in brackets).

Characteristics	Average values: Outside 200-mile zone	Average values: Shelf slopes	t%	$t_s t$ at P = 0.01
Vertebrae number	31.00 (81)	31.17 (253)	12.14	2.58
Number of rays in anal fin	8.76 (78)	8.49 (282)	4.03	2.58
Number of rays in dorsal fin	14.49 (75)	14.65 (34)	1.14	2.62
Number of rays in pectoral fin	18.05 (81)	19.33 (60)	17.07	2.58

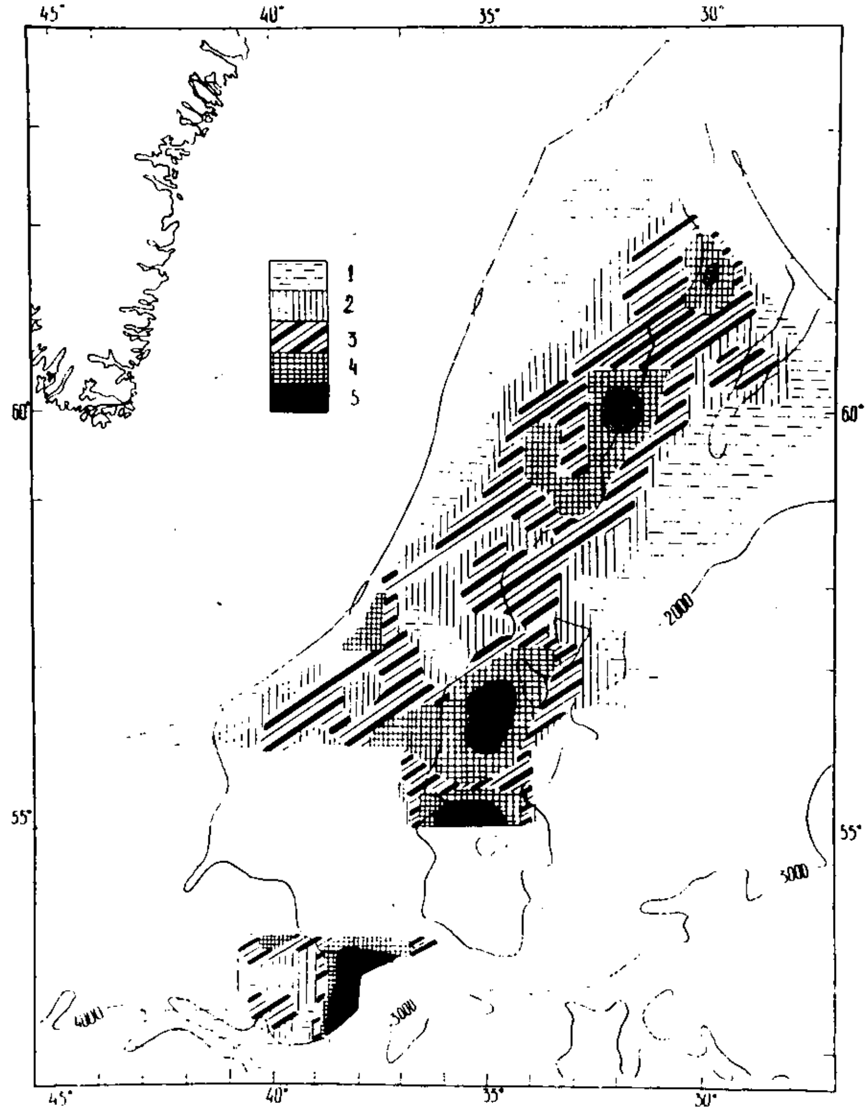

Fig. 1. Distribution and abundance of *S. mentella* larvae in spring 1982 (from Noskov *et al.*)
1 = 10, 2 = 11-25, 3 = 26-50, 4 = 51-100, 5 = 101 and more specimen under m^2.

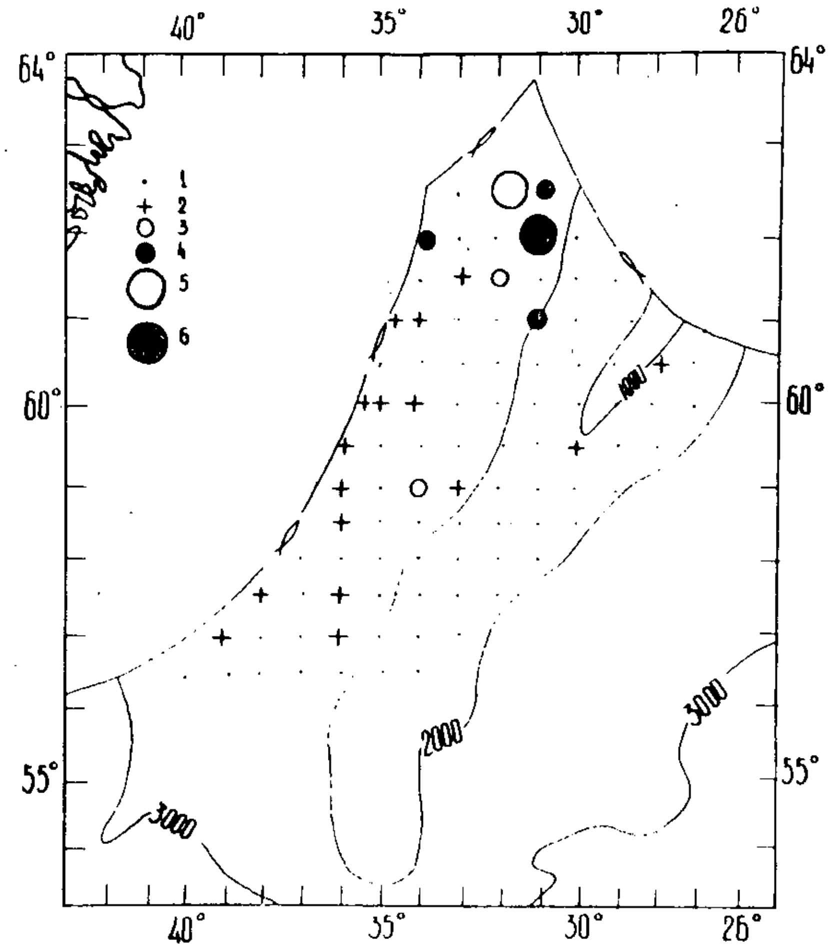

Fig. 2. Distribution and abundance of 0-group *S. mentella* in August-September 1984 (from Noskov and Romanchenko)
1 = 1, 2 = 1-50, 3 = 50-100, 4 = 101-500, 5 = 501-1 000, 6 = 1 001 and more specimen per haul.

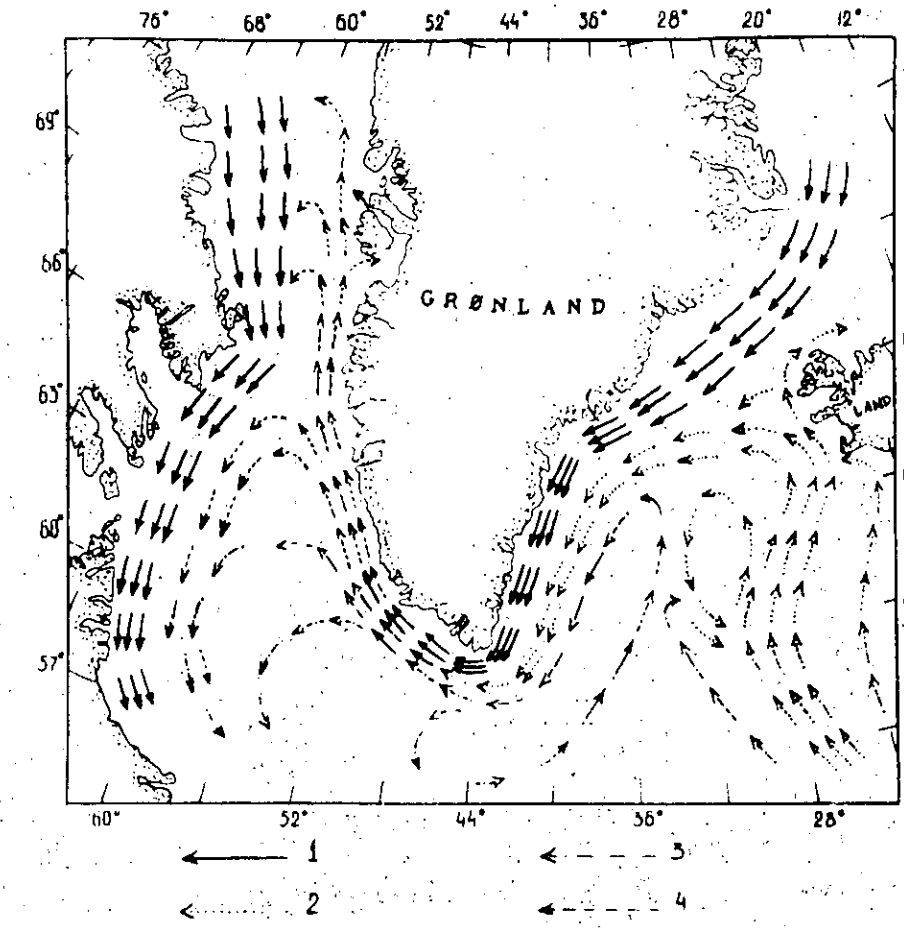

Fig. 3. Surface current system in the Iceland-Greenland area (from Hansen and Germann).
(1 = Polar current, 2 = Irminger current, 3 = Subarctic water mass, and 4 = West Greenland current).