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Distribution of Greenland Halibut (Reinhardtius hippoglossoides Walb.) of the Canadian-West Greenland Stock in Dependence on the Temperature Level

by

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The distribution area of Greenland halibut within the region of investigations (47°N-65°N) is limited by the range of temperature from -1 °C to +5 °C. The limits of distribution conditioned by temperature are determined by the physiological state.

Since 1970 the variations of the hydrographical regime in the Northwest Atlantic have been the reason for changes of the limits of horizontal and vertical distribution of the main species roundnose grenadier (Macrourus rupestris GUNN.) and Greenland halibut in the deepsea fishery during the period of investigations from 1968 to 1983. Because of the negative development of the temperature regime the main depths in the fishery on roundnose grenadier and Greenland halibut shifted from fishing depths of 600-800 m during the period from 1968 to 1971 to fishing depths of 800-1500 m during the period from 1975 to 1983. At the same time the composition of the catches displaced in favour of Greenland halibut.

Introduction

According to TOMPSON (17) the main distribution areas of Greenland halibut are situated within the Arctic convergence zones, according to MILINSKY (12) they are limited by a range of bottom water temperatures from +3 °C up to +8 °C.

Investigations in the Barents Sea showed, that mature Greenland halibut only concentrates for spawning in the deep water area providing temperatures not below +5 °C. (13). Spawning places are suggested to be generally in vast depths (8).

Our own investigations (5) concerning the dependence of Greenland halibut on water temperature relations in the sea area Iceland proved, that within the investigation period April - May 1969 and May - July 1971, respectively Greenland halibut

depends on the development of the temperature level and forms concentrations within the range of the near bottom convergence. During the postepawning period (April/May) the Greenland halibut occurs on the warm water side of the convergence (concentration density within the temperature range from +2,0 °C to +2,5 °C). When the feeding migration starts (May-July) the Greenland halibut occurs on the cold water side (concentration density within the temperature range from -0,2 °C to +0,2 °C).

In the course of investigations in June and July 1968 CHUMAKOV (2) too ascertained, that Greenland halibut generally concentrates in the Icelandic fishing area attemperatures from +0,8 °C up to +3,0 °C and that densiest concentrations were fished at bottom temperatures from -0,2 °C to +0,5 °C.

Material and methods

Within the distribution area of the Greenlandic-Canadian stocks 3288 fishing hols have been analysed concerning the results of catch per unit effort (catch per hour/kg), bottom temperature and fishing depths. In this case data of the GDR groundfish and stock assessment and Canadian data of the summer fishery (1) during the period from 1968 to 1982 had to be combined for judging coherently the period of feeding migrations (July-September) and the prespawning period (Fig. 1).

Analysis of hols during the period from September to December represent exclusively values obtained by the Institut für Hochseefischerei und Fischverarbeitung Rostock during stock assessment and commercial fisheries. Values obtained during the period from July to September represent Canadian (1) and GDR data.

Hols have not been taken into consideration when their results were impaired by damage of netting or machines as well as hols without any result at all.

Results and discussion

This investigation shows, that feeding concentrations occur in areas of shallow waters up to a depth of around 600 m with temperature boundaries from -0,5 °C up to +4,5 °C at an optimum between +1,5 °C and +3,5 °C (highest concentration density). During the saison of the Canadian summer fishery the depth of distribution increases along with the concentration density.

The temperature boundaries during the Canadian summer fishery on feeding concentrations in the shallow water region find their continuation in the results of the GDR fisheries on occurrences during the transition phase when changing from feeding to prespawning concentrations (September/October) and from feeding to overwintering concentrations (October-December), respectively.

Along with the increasing depth and increasing maturity (6), respectively the range of temperature preferences grow narrower (Fig. 1). In addition the concentration density increases and so does the catch of unit effort (Fig. 2).

When at the end of the feeding period (September up to a depth of around 600 m) temperature boundaries of the Greenland halibut are between +2,0 °C and +4,5 °C with an optimum around +2.5 °C up to +3,5 °C these parameters are even more restricted during the prespawning period. Within the prespawning period these temperature optima are in the range of spawning temperatures from +3,2 °C to +3,5 °C (3).

The decrease of the catch of unit effort within the range of the prespawning concentrations in fishing depths below 700 m (Fig. 2) is the concequence of the emigration of mature specimens into spawning grounds which are not accessible for fishing operations (ice covering, fishing depth).

Since the end of November the basis of the GDR fishery are overwintering concentrations of firstspawnings of the next year within a temperature spectrum from +2.5 °C to +4,5 °C and fishing depths from 700 to 900 m together with mature specimens which are migrating more and more northward.

Observations during the Canadian summer fishery (July-September) within the area of the Grand Newfoundland Bank show only small and sporadic occurrences of halibut, respectively (1). Temperatures within the distribution area were at -1 °C or below. This range of temperature indicates the inferior limit of the distribution (5) during the feeding period.

Observations by TEMPLEMAN (15) are of special interest; he describes mass dyings of Greenland halibut within the area of the Trinity Bay (Southeast Newfoundland) during the pelagic fishery on capelin (Mallotus villosus MÜLLER).

According to the opinion of the author feeding concentrations of Greenland halibut get into medium water layers when chasing capelin for prey. Here the temperatures of the water proved to be below -1 °C. These temperatures seem to be below the subsistence level of the Greenland halibut during the feeding phase and mass dyings occurred as a result.

BOWERING (1) ascertained +3.0 °C to +5.0 °C for an optimum temperature range. Within this temperature spectrum of the range of depths from 400 to 600 m catches of unit effort increased significantly above 100 kg/h, partially even up to 600 kg/h (Fig. 1).

These data refer to results of the Canadian summer fishery on prevailing juvenile feeding concentrations within the sea areas East and Northeast Newfoundland.

LEAR and PITT (11) report on the most extensive fishing results within the area of the eastern coast of Newfoundland at bottom temperatures of +3 °C and less without references to the period of fishing and the character of concentration (possibly feeding concentration?).

According to TEMPLEMAN (16) Greenland halibut disperses in the NW Atlantic in vast depths within ranges of bottom temperatures from -1,0 °C up to +3 °C. In the deep water areas with higher temperatures spawning concentrations are supposed to occur. This was still more exactly defined by CHUMAKOV and SEREBRYAKOV (3) concerning the presumed spawning areas of the Greenlandic-Canadian stock between 62°N and 64°N in depths of 1000 m to 1500 m at a temperature optimum between +3,2 °C and 3,4 °C.

When summarizing all internationally presented data concerning Greenland halibut a spectrum of temperatures from -1,0 °C (1,15) to +8,0 °C (12) can be established as the limitation of distribution concerning the occurrence of Greenland halibut. Concerning the area Newfoundland/Labrador/Baffinland these limitations can be fixed on the range of -1,0 °C (15) up to +5,0 °C (1).

Own results concerning the dependence of the Icelandic Greenland halibut on water temperatures in connection with the physiological state (5) correspond with present international results of investigations within the distribution area of the Canadian and Greenlandic occurrences as well as with our results.

Feeding concentrations are found within a broad spectrum of temperatures, which is supposed to be within the limits of -1 °C and +4 °C. During the prespawning phase however the optimum level of temperatures has to be restricted to an interval from +2.5 °C up to +5.0 °C.

The results show that during a year's time with increasing maturing the preference temperature is restricted in a way, that the range of spawning temperatures from +3.2 °C to +3.4 °C given by CHUMAKOV and SEREBRIAKOV (3) also stands critical consideration on the basis of these results.

Summarizing HELA and LAEVASTU (7) refer to the dependence of temperature limits and herewith of distribution limits of fish on their physiological condition as it is the case with gadids, clupeids and Pleuronectes platessa.

The dependence of distribution and concentration density,

respectively of Greenland halibut on the temperature level and the degree of maturing (Tab. 2) as well as the correlation of these components are reflected by the results of fishing (Fig. 1 and 2).

Within the period of November/December 1982 and 1983 investigations within the fishing area (NAFO 2 H) have shown, that the situation of fishing is determined by spatial separation of the fishing areas and by fishing depths concerning the main species Greenland halibut and grenadier (Coryphaenoides rupestris GUNN.) (6).

According to empirical results of the GDR during the preceding years about 1970 and 1978/79 a horizontal and a vertical partition of these both main species could be observed continually up to 1983.

The reason for the changes of the horizontal and vertical distribution limits of grenadier and Greenland halibut has to be traced in the development of changes of the hydrological regime (cooling) in the NW Atlantic.

KUDLO et al. (10) and KONSTANTINOV (9) proved the dynamic longterm variation of the hydrographical regime by a present cooling phase since 1970, which has been already discussed by ELIZAROV (4) who referred to annual fluctuations and periodical rhythmus in general. In 1982 and 1983 temperatures were below the long-term average (Tab. 1, Fig. 3). This anomaly was significant for all investigated layers (0-50 m, 0-200 m, and 50-200 m water depths) of the shelf area of Labrador between the positions 53°40'N; 50°44'W and 50°40'N; 53°32'W. This part of the standard section 8A intersects the polar component of the Labrador current. In 1982 a negative anomaly had been observed within the range of the total section. The range of 0-50 m water depth within the shelf area was extremely cold as well (9).

TRITES (18) and STEIN (14) independently from each other proved by their findings the cooling of the NW Atlantic since 1970. TRITES demonstrates the space of time from 1970 to 1979 as period of temperature anomalies showing a negative tendency and refers to the results of the Grand Newfoundland Bank as an index for the condition of the NAFO Subareas 2 and 3.

STEIN also draws attention to the general decrease of temperature during the period from 1969 to 1980. According to his findings deviations are possible within this tendency. Temperatures of the Polar component and the Irminger component of the Labrador current increased during the period from 1974 to 1977 but in 1979 they again decreased. In 1979/1980 an increase of the Polar component had been proved along with a decrreasing of the Irminger component at the same time and herewith the cooling of the offshore component in the late 70s and in the early 80s was confirmed.

In consequence of the negative development of the temperature regime the main depths concerning fisheries on grenadier and Greenland halibut shifted from depths of 600 to 800 m to depths of 800 to 1500 m during the period from 1968 to 1971 within the time of investigations from 1975 to 1983 (6). At the same time a shifting of the assortment in favour of Greenland halibut took place. Within the quarter IV of the years 1968-1970 the share of Greenland halibut during the fisheries on grenadier and Greenland halibut performed by the GDR within the Labrador area amounted to 15 % on the average. Within the same period of investigations in the years 1981-1984 this share increased to values between 50 and 75 % (about 20 % in early November, about 85 % in late December) (Fishing statistics of the GDR for the years 1981-1984).

The shifting of the assortment in favour of Greenland halibut during the fisheries on grenadier and Greenland halibut within the period from 1968 to 1983 confirms the immigration of Greenland halibut into the fishing area (2, 6) on one hand but verifies the result of changes of temperatures favouring concentrations on the other.

Summary

The range of temperatures from -1 ^{o}C up to +5 ^{o}C limitates the area of distribution of Greenland halibut within the area of investigations (47^{o}N to 65^{o}N). The limits of distribution conditioned by temperatures are determined by physiological state (Tab. 2).

Since 1970 the variations of the hydrographical regime in the Northwest Atlantic have been the reason for changes of the limits of horizontal and vertical distribution of the main species roundnose grenadier (C. rupestris) and Greenland halibut in the deepsea fishery during the period of investigations from 1968 to 1983. Because of the negative development of the temperature regime the main depths in the fishery on roundnose grenadier and Greenland halibut shifted from fishing depths of 600-800 m during the period from 1968 to 1971 to fishing depths of 800-1500 m during the period from 1975 to 1983. At the same time the composition of the catches displaced in favour of Greenland halibut.

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Table 1: Water temperature of the hydrological section 8A on 1st November 1964-1982 in °C (according to KONSTANTINOV 1983)

Year	Layer (m)			
	0-50	50-200	0-200	200-500
1964	1.04	0.04	0,32	4,08
1965	1,49	1,76	1,66	4,37
1966	2,41	1,44	1,72	4,60
1967	2,00	0,89	1,19	4,04
1068	2,29	-0,18	0,50	3,95
1969	0,89	9,36	0,50	4,38
1970	1,29	0,32	0,60	4,49
1971	0,88	0.43	0,57	4,08
1972	0,35	-0,39	-0,17	4,07
1973	1,00	0,59	0,72	3,91
1974	0,96	-0,02	0,27	3,54
1975	1,14	0,51	0,70	3,72
1976	0,74	0,20	0,36	3,46
1977	1,76	2,52	2,32	3,68
1978	0,94	0,78	0,82	3,92
1979	1,42	0,79	0,99	3,82
1980	1,32	0,62	0,82	3,65
1981	2,76	0,70	1,28	3,68
mean values of the years 1964-1981	1,37	0,63	0,84	3,97
1982	0,45	0,38	0,41	3,58
anomaly (mean value 1964-1981 in relation to 1982	-0,92	-0,25	-0,43	-0,39

Table 2: Distribution limits of the Canadian-West-Greenland stock Greenland halibut conditioned by temperature in depence on the physiological state

	Spectrum of temperature (°C)	Optimum of temperature (°C)	Period of time (month)	Depth of distribution (m)	Author
total occurrence	-1,0 to +5,0	-	-	200 to>1200	TEMPLEMAN (1965) BOWERING (1984)
feeding phase	-1,0 to +4,5	+1,5 to 3,5	VI/VII to VIII	200 to 600	TEMPLEMAN (1965) BOWERING (1984) ERNST (1986)
late feeding phase	+2,5 to +4,5	+2,5 to 3,5	IX	600 to 700	ERNST 1986
prespawning phase	+2,5 to +5,0	+3,0 to 4,0	IX/X to XII	700 to 1200	ERNST (1986)
spawning phase	+3,2 to +3,4	-	I - III	deep water up to ~ 1500	CHUMAKOV and SEREBRYAKOV (1982)
overwintering phase (first-spawnings of the next year and juveniles)	+3,0 to +4,5 (?)	?	XII to ?	> 700	ERNST (1986)

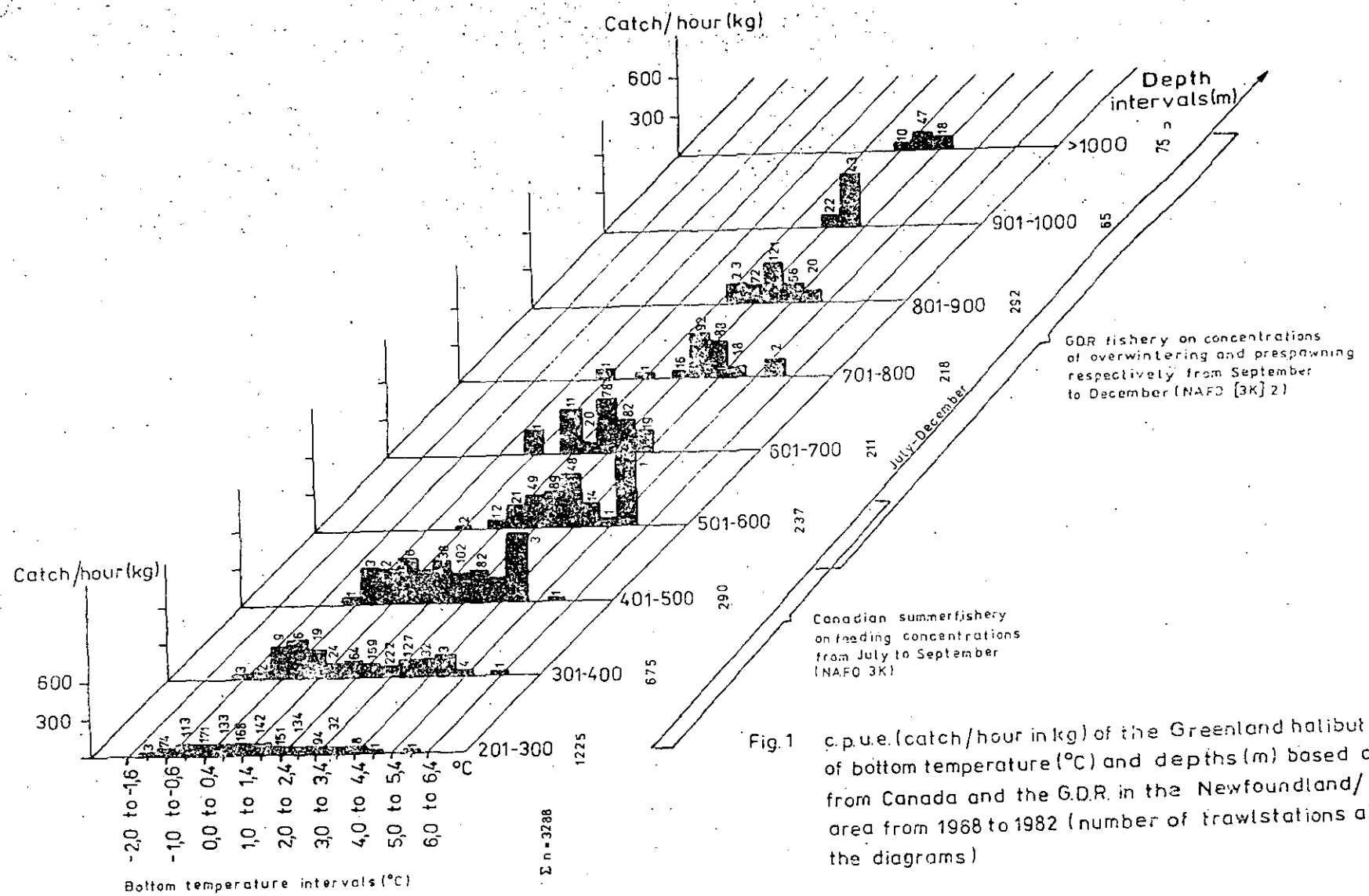

Fig. 1 c.p.u.e. (catch/hour in kg) of the Greenland halibut by intervals of bottom temperature (°C) and depths (m) based on data from Canada and the G.D.R. in the Newfoundland/Labrador area from 1968 to 1982 (number of trawlstations above the diagrams)

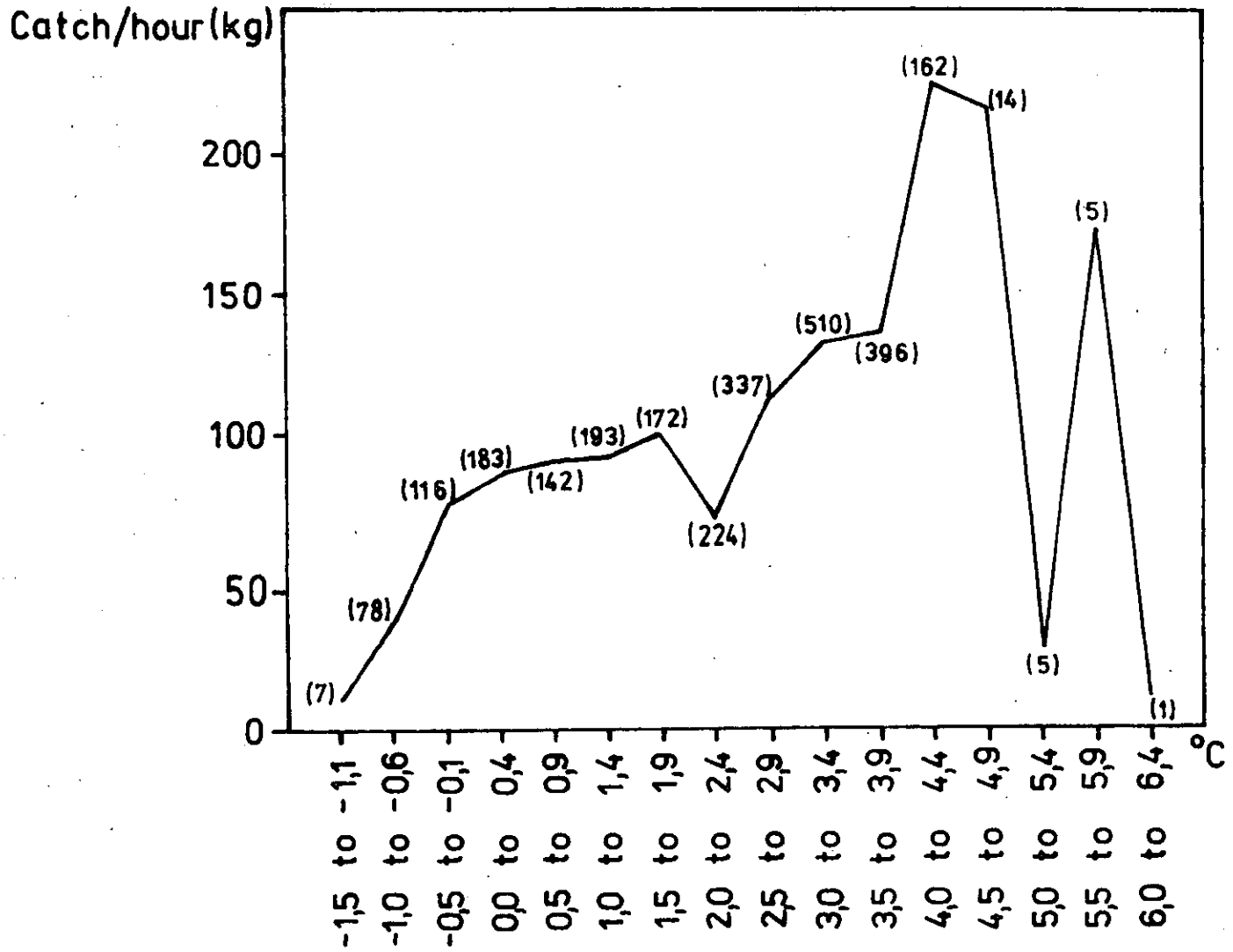

Fig. 2 Average c.p.u.e. (catch/hour in kg) of Greenland halibut by temperature intervals based on G.D.R. investigations 1975-1983 (4th quarter), NAFO 3K and 2. Number of hauls in brackets.

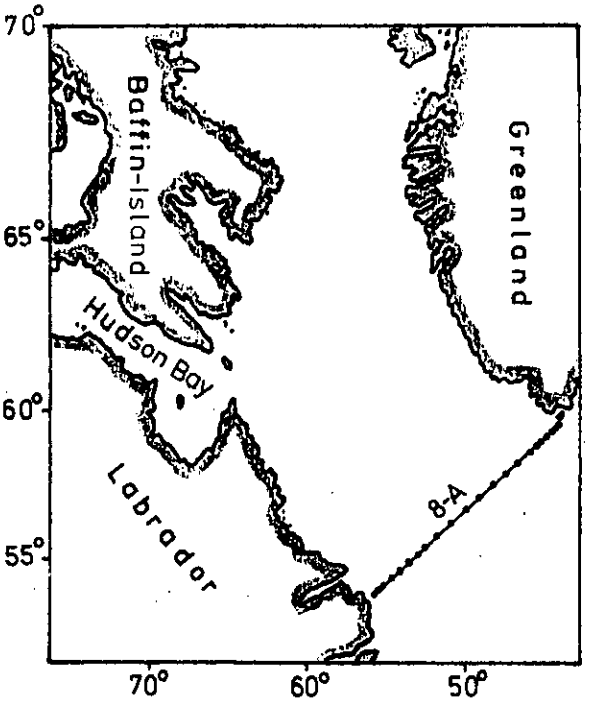

Fig. 3 Hydrological standard section 8 A
(Seal Island - Cape Farewell)