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Biomass and Abundance of Greenland Halibut (*Reinhardtius hippoglossoides*) and Redfish (*Sebastes* spp.) from a Bottom Trawl Survey in NAFO Subarea 1 in 1993

by

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Introduction

A stratified-random survey was performed with a shrimp trawl off West Greenland and in the Disko Bay during July to September 1993. This paper presents estimates of biomass, abundance indices and length distributions of Greenland halibut and redfish based on data collected during the survey. Catch-per-unit effort indices are calculated for the years 1991 to 1993.

Materials and Methods

The survey covered the offshore areas at West Greenland between 59°00'N to 72°30'N from the 3-mile limit to the 600 m depth contour line (Fig. 1) and the inshore area Disko Bay.

The survey was conducted with the commercial stern trawler M/Tr PAAMIUT (722 GRT) equipped with a Skjervoy 3000/20 trawl with bobbin gear and a double-bag with 20 mm mesh size in the codend. The trawl doors used were of the type 'Perfect' and wingspread was estimated by use of SCANMAR to an average of 20.7 m.

Standard trawling time was 60 minutes at a mean towing speed of 2.5 knots. Trawl operations were only performed during daytime.

The survey area was divided into NAFO Divisions which were further subdivided into three depth strata (0-200, 201-400 and 401-600 m). Areas of depth strata (km^2) per Division are given in Table 1 and the survey area is shown in Fig.1.

The areas of depth strata (Table 1.) have been recalculated in 1993 by the use of digitalized maps in the Spline survey designer software system (Stolyarenko, 1993).

Hauls were allocated to strata proportionally to their size, with a minimum of two planned hauls per stratum. Within each stratum the trawl positions were chosen at random (Doubleday, 1981).

In Subarea 1AN it is not possible to make a depth stratification due to lack of information on the bottom topography. This Subarea and the Disko Bay (DISKO) are treated as two single strata.

The catch from each haul was sorted by species and weighed. Samples of Greenland halibut and redfish were length measured to centimetre below. Biomass and abundance indices with standard deviations were calculated by means of the swept area method as described by Cochran (1977), assuming a catchability factor of 1.0.

Hauls taken outside Greenland areas are not included in these calculations.

The codend used in previous years surveys, with a mesh size on 44 mm, was in 1993 replaced by a codend with 20 mm stretched mesh. To investigate the effect of this change, a series of 60 parallel hauls were performed during the survey (Andersen *et al*, 1993). Thirty (30) hauls were conducted with a 20 mm mesh, and keeping the starting and ending positions the same, 30 hauls were conducted with the same towing direction, using a 44 mm mesh in the codend. The catch in numbers per cm group of Greenland halibut and redfish, were tested for significant differences between the two mesh sizes. By assuming a log-normal distribution of the fish caught per cm-group the number of fish caught in each mesh size was tested by using a general linear model in SAS. No significant differences ($P>0.05$) were found for Greenland halibut, but the numbers of redfish <= 10 cm were significantly higher in the 20 mm mesh size codend than in the 44 mm mesh ($P<0.02$). The estimated ratios between the catch numbers in the 20 and 44 mm meshes, were used to calibrate the numbers of redfish caught in every cm-group below 11 cm in 1993, in order to make catch-per-unit effort (CPUE) data comparable. The total catch weights in the two mesh sizes were compared for both species but no significant differences were found.

The redfish CPUE data from 1993 are adjusted by the following equations to make them comparable to the 1991-1992 data:

$$n\ (6\ cm) = N/2.53$$
$$n\ (7\ cm) = N/7.69$$
$$n\ (8\ cm) = N/7.38$$
$$n\ (9\ cm) = N/4.60$$
$$n\ (10\ cm) = N/2.93$$

where n = numbers of fish in 44 mm mesh and N = numbers of fish in 20 mm mesh of the given length group.

CPUE values (catch in numbers per standardized trawling hour) are calculated for the surveys in 1991, 1992 and 1993. Because the offshore survey area in 1991 only covered Divisions 1AS to 1D, only these Divisions are included in this analysis. Data from Disko Bay are only available from the surveys in 1992 and 1993.

Results

A total of 155 valid hauls were taken off West Greenland (Table 1). A single haul is representing 1 069 km^2 as an overall mean. In Disko Bay a total of 32 hauls were taken, one haul representing 293 km^2.

The estimates are given with 95% confidence limits.

Greenland Halibut (*Reinhardtius hippoglossoides*)

The total abundance was 239 mill. +/- 82 mill. in the West Greenland offshore waters corresponding to a mean abundance of 1441 +/- 492 fish/km^2. 73% and 12% of the fish were located in 1BN and 1AN respectively and highest abundance was found in Division 1BN in depth stratum 201-400 m (91 mill.) and 401-600 m (83 mill.) (Table 2).

The total biomass off West Greenland was estimated to 9596 tons +/- 3009 tons, corresponding to a mean density of 0.0579 +/- 0.0181 tons/km^2. 49% and 27% of the biomass was found in 1BN and 1AN respectively. The largest biomass was found in the same Division (1BN) as the highest abundance, in the same two depth strata, with a maximum of 2682 tons in 401-600 m, while 2013 tons were found in 201-400 m (Table 3).

In Disko Bay the total abundance was estimated to 30 mill. +/- 12 mill. corresponding to a mean abundance of 3244 +/- 1238 fish/km^2. The biomass was 2368 tons +/- 902 tons corresponding to a mean density of 0.2529 +/- 0.0963 tons/km^2. (Tables 2 and 3).

The overall size distributions for West Greenland and Disko Bay showed two modes at 11-12 cm and at 17-18 cm representing year-classes 1 and 2 respectively (Fig. 2). From Figure 3 it is seen that the mode at 11-12

cm almost exclusively originates from areas north of 1BS. The catches in the southern areas were small and the size distribution without any clear modes. The length distribution in Disko Bay is resembling the distribution found in the northern part of the offshore area (Fig. 2 + 3) but the catches were dominated by 20 cm fishes, supposedly representing year-class 2.

In the CPUE data from the offshore areas (Fig. 6) a high appearance of two-year old fish (18 cm) in 1993 is seen. These are the remnants of a big year-class 1 (12 cm) in 1992. In Disko Bay (Fig. 7) CPUE values are low for 1 year old fish (12 cm) and 2 year old fish (18 cm), and there seems to be a significant drop in the recruitment.

Redfish (Sebastes spp.)

The total abundance off West Greenland was estimated to 1148 mill. +/- 670 mill. corresponding to a mean abundance of 6926 +/- 4043 fish/km^2. The highest abundance (408 mill.) was found in Division 1BN with a maximum in stratum 201-400 m (Table 4). The high abundance in Division 1F in depth stratum 0-200 m should also be noticed. In Disko Bay the total abundance was estimated to 5.9 mill. +/- 4.1 mill. which gives a mean abundance of 624 +/- 439 fish/km^2 (Table 4).

The total biomass in the offshore survey area was estimated to 17745 tons +/- 9013 tons corresponding to a mean density of 0.1071 +/- 0.0544 tons/km^2. The largest biomass was found in Division 1BN (8116 tons) with a maximum in depth stratum 401-600 m (Table 5). In Disko Bay the biomass was estimated to 270 tons +/- 141 tons which gives a mean density of 0.2289 +/- 0.0151 tons/km^2 (Table 5).

The length distribution of redfish for the offshore area showed three distinct modes at 5 cm, 8 cm and 11 cm (Fig. 4). In Disko Bay distinct modes were present at 12 and 20 cm.

Small redfish (5-8 cm) dominates the catches in the areas south of 67°N while the 10 and 12 cm groups are dominating in the catches from the northern areas (Fig. 5).

CPUE data are dominated by the strong 1+ group (6 to 8 cm) from 1991 but a falling tendency is seen in CPUE values throughout the years (Fig. 8). In Disko Bay (Fig. 9) the CPUE of 6 to 10 cm fish in 1993 is low compared to 1992 values, while the catch of 12 cm fish is remarkably high.

Discussion

As recalculation of the strata areas has caused changes in certain strata (Bech, 1993) the biomass and abundance estimates for previous years have been recalculated, using the new areas. The recalculation did not reveal any significant changes in the indices reported earlier (Kanneworff and Pedersen, 1992; Pedersen and Kanneworff, 1992; Pedersen and Nygård, 1992; Bech, 1993). Previous years results are given in brackets.

Greenland Halibut

The change of mesh size in the codend did not affect the biomass and abundance estimates of Greenland halibut, so these indices can readily be compared to the previous years.

The biomass estimates have increased since 1991 from 3900 tons +/- 1600 tons [5000 tons] over 8800 tons +/- 3600 tons [8800 tons] in 1992 to 9600 tons +/- 3400 tons in 1993. The abundance index increased from 84 mill. +/- 40 mill. [70 mill.] in 1991 to 283 mill. +/- 138 mill. [290 mill.] in 1992 but then the abundance is decreasing to 240 mill. +/- 83 mill. in 1993. The 1993 value is not significantly different from the value of 1992. The reason for the increase in biomass and decrease in abundance is due to the relative large amount of 2 year fishes caught in 1993 (Fig. 6). These 2 year fishes are the remnants of a big year-class 1 in 1992 (Bech, 1993).

In Disko Bay the biomass of Greenland halibut is decreasing to the level of 1991 (2100 tons +/- 1600 tons in 1991, 4000 tons +/- 1300 tons in 1992 and 2400 tons +/- 900 tons in 1993). The abundance is also declining from 69 mill. +/- 27 mill. in 1992 to 30 mill. +/- 12 mill. in 1993. The 1993-catches in Disko Bay were dominated by 2-year old fish, the remnants of the year-class 1 in 1992 (Fig. 7). CPUE values are low compared to 1992 values.

Earlier works (Smidt, 1969; Riget and Boje, 1988) have pointed out the importance of the northern areas (1AN-1BN) as nursery grounds for Greenland halibut. The results of more recent surveys underlines the importance by the fact that the year-class 1 mainly is located in the northern areas (Fig. 3 and 6). The little mode seen in Fig. 3 at 8 cm is caused by juvenile fish caught in Division 1F.

The recruitment stage of the stock, as indicated by the survey results, seems to be at a relative stable point in the Greenland offshore areas. In the inshore area there is a decreasing tendency in abundance of the year-classes 1 and 2.

Redfish

The 1993-catches of redfish were dominated by large catches of small individuals, a result of the change in mesh size of the codend. These small redfish are seen as a mode at 5 cm in Fig. 4 and 5. Juvenile individuals are solely found south of 67°N. This peak was not revealed in the catches of a 44 mm mesh (Bech, 1993).

The abundance estimate was significantly influenced by the change in mesh size, but even without correcting the overall result to 44 mm mesh size, the estimate is the lowest since 1991 (3100 mill.+/- 3600 mill. [2100 mill.] in 1991, 1400 mill. +/- 1100 mill. [1400 mill.] in 1992 to 1100 mill. +/- 700 mill. in 1993). The same picture is seen by comparing the biomass estimates (25000 tons +/- 21000 tons [25000 tons] in 1991, 21000 +/- 15700 tons [21000 tons] in 1992 and 18000 tons +/- 9000 tons in 1993) which apparently not is influenced by the mesh change.

The abundance estimate was adjusted to 44 mm mesh catches by using the equations given above, in order to compare directly with the earlier estimates. This resulted in a decrease of the 1993 estimate to 608 mill. +/- 350 mill. individuals, about one half of the 20 mm catches.

The high abundance in Division 1F in depth stratum 0-200 m is due to the presence of juvenile redfish (0-group) which are caught in large amounts by the 20 mm meshes (5 cm peak in Fig. 4 and 5).

The large 1990 year-class (Pedersen and Kanneworff, 1992) is seen in 1991 as 6 to 8 cm fish (Fig. 8). This year-class can be seen as 10 cm fish in 1992 and the remnants are seen in 1993 as 12 cm fish. Even though the picture is completely dominated by the 1990 year-class, it can be seen that the CPUE-indices as a whole are decreasing in the offshore waters.

In Disko Bay the abundance estimates are at the same level as in 1992 (6 mill. +/- 3 mill.), even when the abundance is adjusted to 44 mm mesh catches (5.6 mill. +/- 3.9 mill.). The biomass estimates are not significantly different from previous reported values (1991: 215 tons +/- 200 tons. 1992: 330 tons +/- 130 tons. 1993: 270 tons +/- 140 tons.). The catches are completely dominated by 12 cm fish, presumedly 3-year old fish and remnants of the 1990 year-class (Fig. 4 and 9). Except for the dominance of 3-year old fish there is a general decrease of the CPUE values in the Disko Bay.

The total recruitment to the West Greenland redfish stock is decreasing, and a huge variation is seen in the results of these surveys.

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TABLE 1. Size of depth strata (km^2) and distribution of valid hauls in Greenland trawl survey 1993.

AREA/AREAL	DEPTHSTR. 0-200 m	km^2 201-400 m	401-600 m	TOTAL
1AN				41129
Nos. hauls	-	-	-	23
1AS	4681	7474	640	12795
Nos. hauls	4	7	2	13
1BN	16093	17370	4133	37596
Nos. hauls	12	27	5	44
1BS	7722	1682	1243	10647
Nos. hauls	5	3	2	10
1C	17916	5314	3366	26596
Nos. hauls	12	6	3	21
1D	8921	3562	903	13386
Nos. hauls	9	6	1	16
1E	7871	2000	329	10200
Nos. hauls	7	4	3	14
1F	8808	3330	1211	13349
Nos. hauls	7	3	4	14
TOTAL WEST				165698
Tot.hauls	56	56	20	155
DISKO				9364
Tot.hauls	-	-	-	32

TABLE 2. Abundance of Greenland halibut (mill.) by Divisions and depth strata in Greenland trawl survey 1993.

AREA/DEPTH	0-200 m	201-400 m	401-600 m	TOTAL
1AN	-	-	-	28.25
1AS	0.16	13.37	0.75	14.28
1BN	0.07	90.82	82.88	173.77
1BS	0.06	2.93	7.25	10.24
1C	0.24	0.08	3.98	4.30
1D	0.14	0.24	3.53	3.91
1E	0.08	3.44	0	3.52
1F	0.24	0	0.19	0.43
TOTAL WEST				238.70
DISKO	-	-	-	30.37

TABLE 3. Biomass estimates (tons) of Greenland halibut by depth and Division in Greenland trawl survey 1993.

AREA/DEPTH	0-200 m	201-400 m	401-600 m	TOTAL
1AN	-	-	-	2564
1AS	2	180	84	266
1BN	2	2013	2682	4697
1BS	2	96	659	757
1C	8	11	568	587
1D	0	13	439	452
1E	0	229	0	229
1F	0	0	44	44
TOTAL WEST				9596
DISKO	-	-	-	2368

TABLE 4. Abundance (mill.) of redfish by Division and depth in Greenland trawl survey 1993.

AREA/DEPTH	0-200 m	201-400 m	401-600 m	TOTAL
1AN	-	-	-	9.22
1AS	0.01	2.12	26.16	28.29
1BN	1.43	250.90	155.80	408.13
1BS	0.96	17.15	4.31	22.42
1C	2.00	155.90	15.50	173.40
1D	0.17	174.30	16.90	191.37
1E	0.54	65.42	0.06	66.02
1F	240.10	4.54	4.15	248.79
TOTAL WEST				1147.64
DISKO	-	-	-	5.85

TABLE 5. Biomass estimates (tons) of *Sebastes* spp. by depth and Division in Greenland trawl survey 1993.

AREA/DEPTH	0-200 m	201-400 m	401-600 m	TOTAL
1AN	-	-	-	309
1AS	1	36	663	700
1BN	9	3549	4558	8116
1BS	11	152	167	330
1C	12	965	664	1641
1D	0	3538	468	4006
1E	47	1271	7	1325
1F	395	493	429	1317
TOTAL WEST				17744
DISKO	-	-	-	270

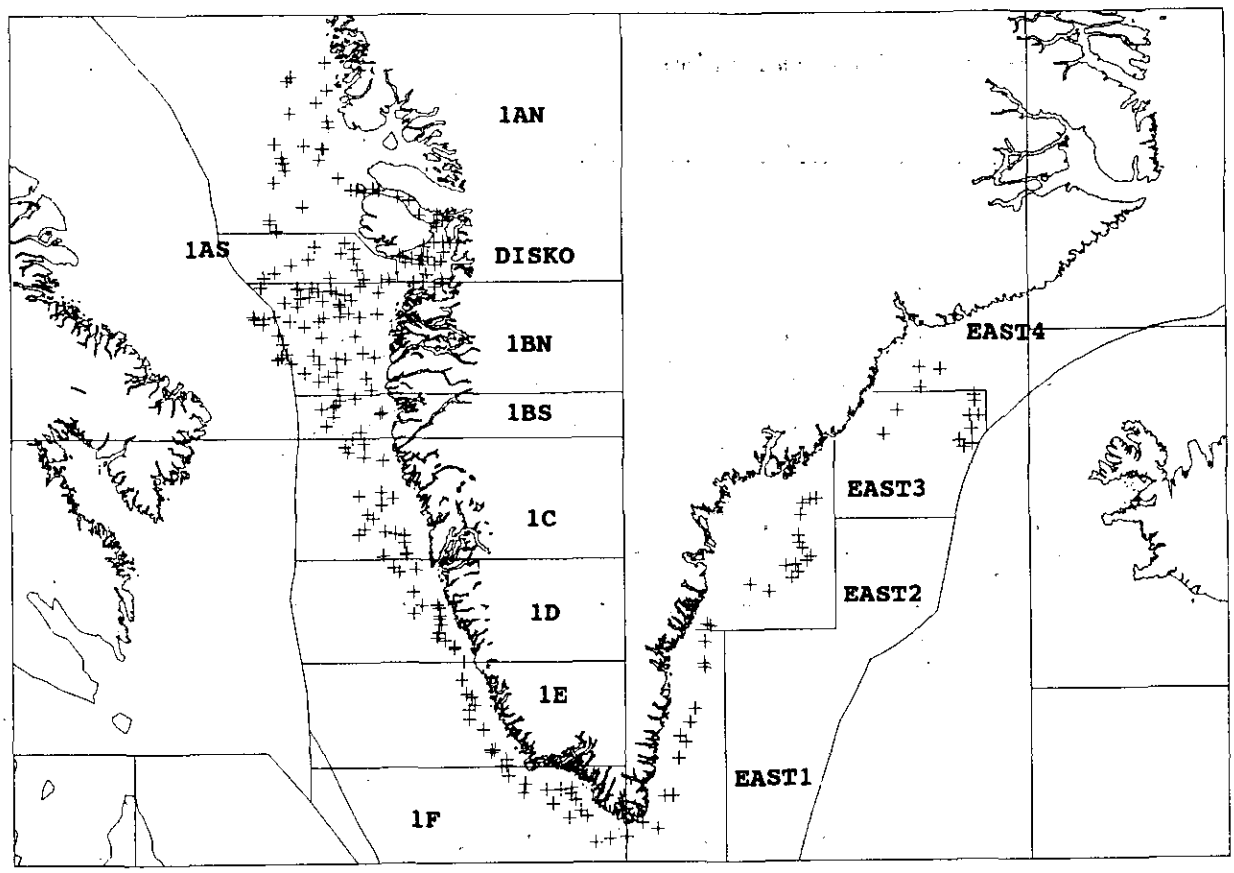

Fig. 1. Location of Subareas and hauls in Greenland trawl survey 1993.

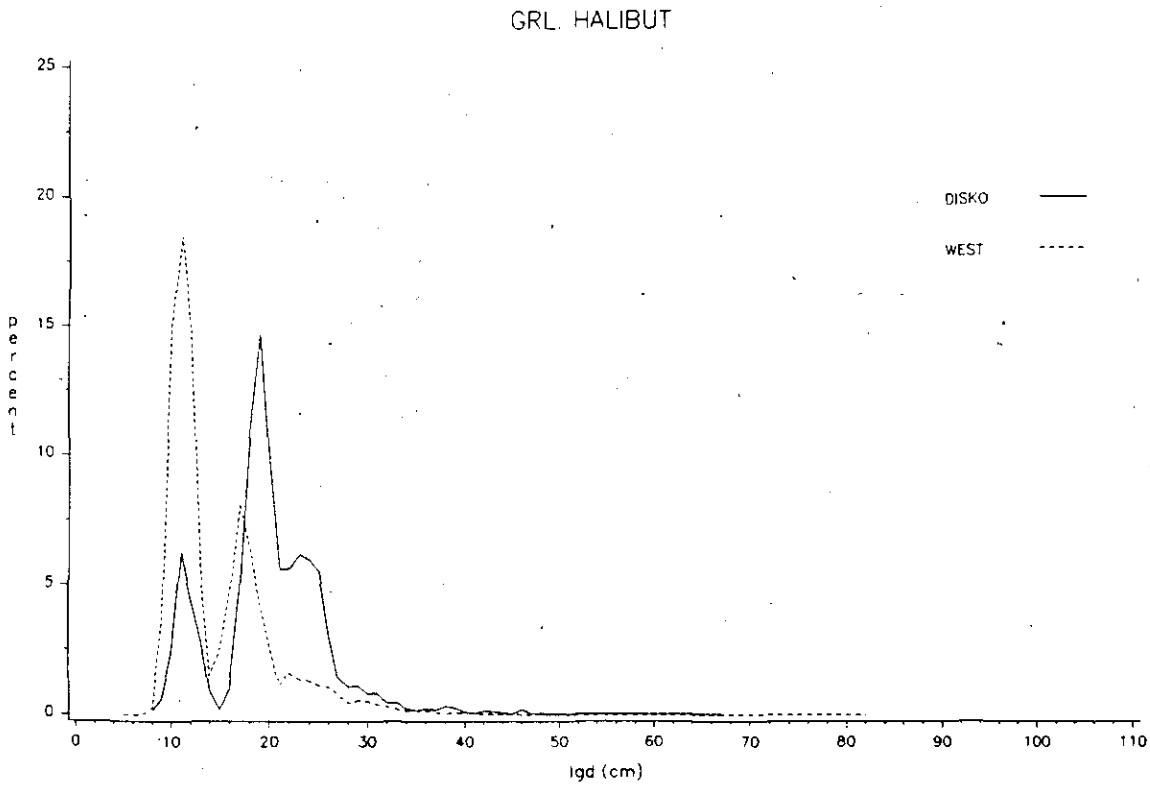

Fig. 2. Relative length frequency distribution (1 cm groups) of Greenland halibut in West Greenland waters and Disko Bay, 1993.

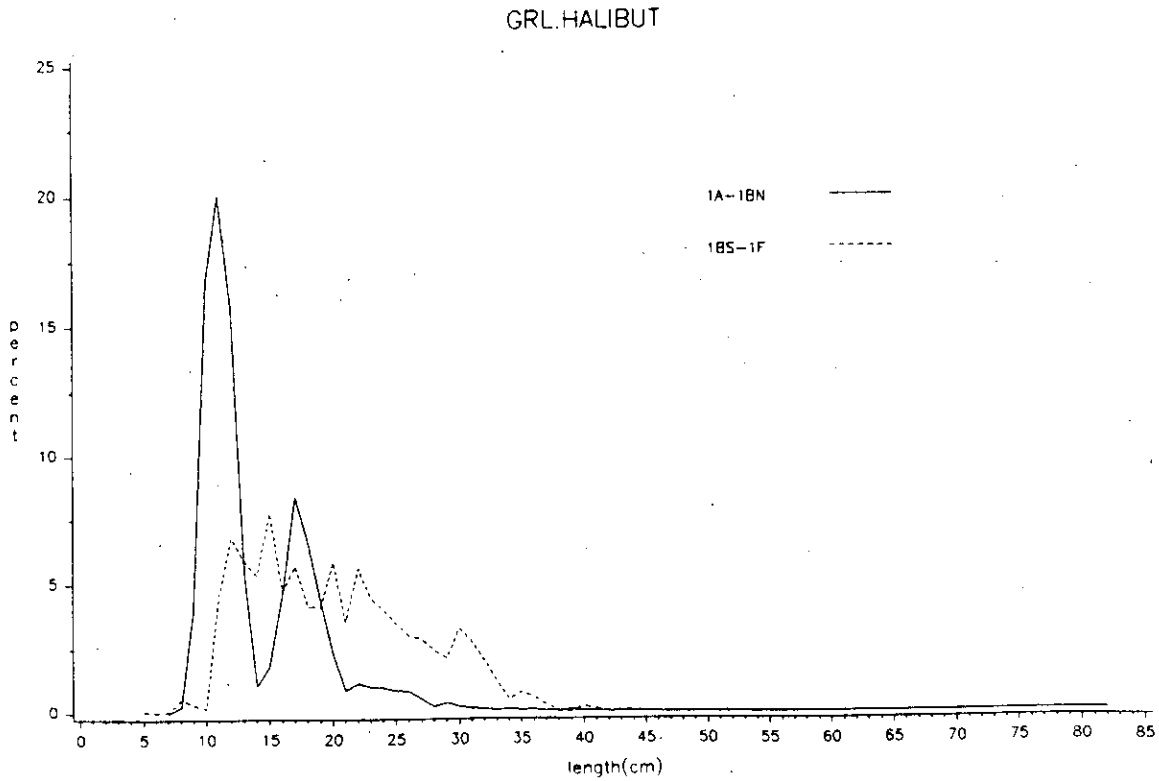

Fig. 3. Relative length frequency of Greenland halibut in northern (1AN-1BN) and southern (1BS-1F) Subareas, 1993.

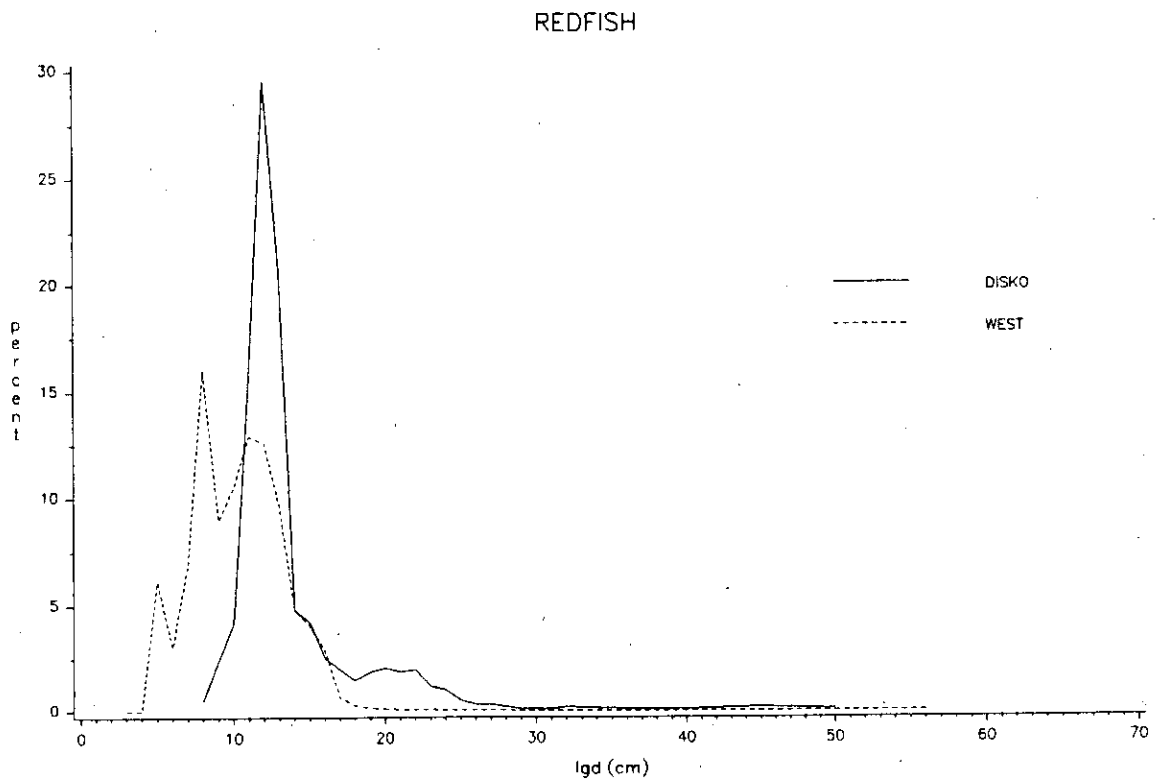

Fig. 4. Relative length frequency (1 cm groups) of *Sebastes* spp. in West Greenland waters and Disko Bay, 1993.

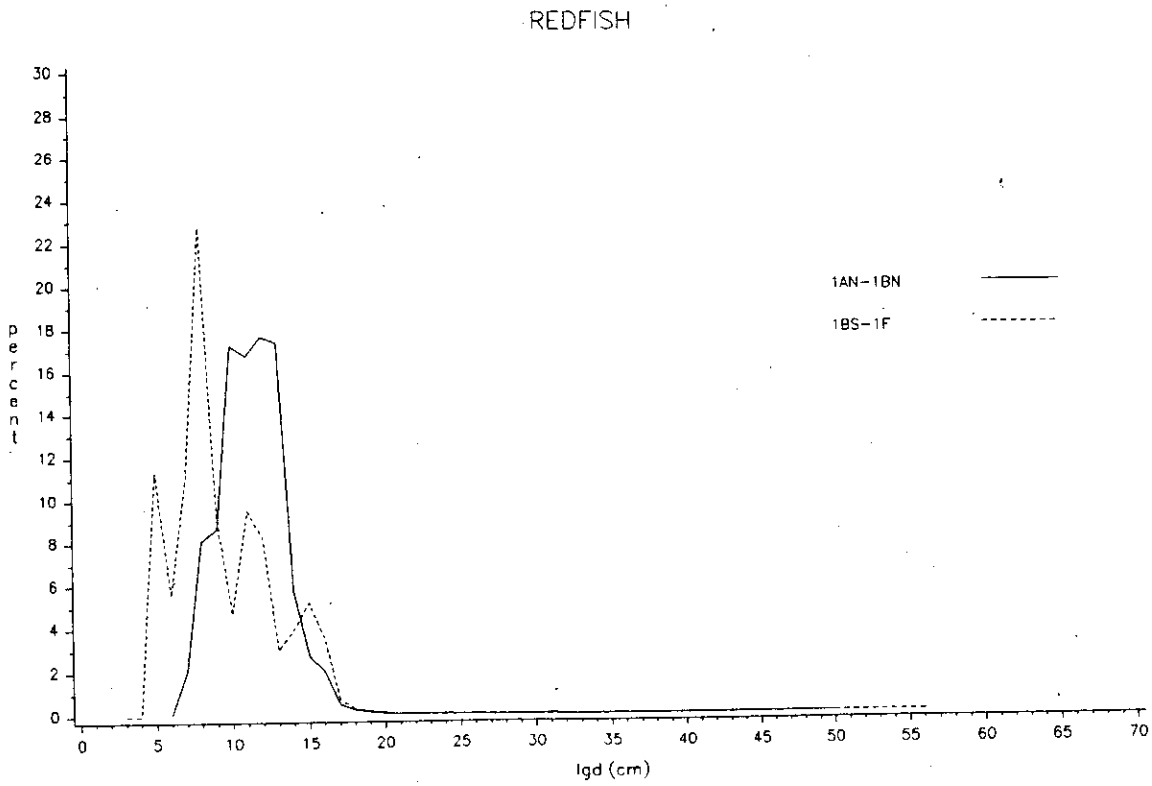

Fig. 5. Relative length frequency of *Sebastes* spp. in northern (1AN-1BN) and southern (1BS-1F) Subareas, 1993.

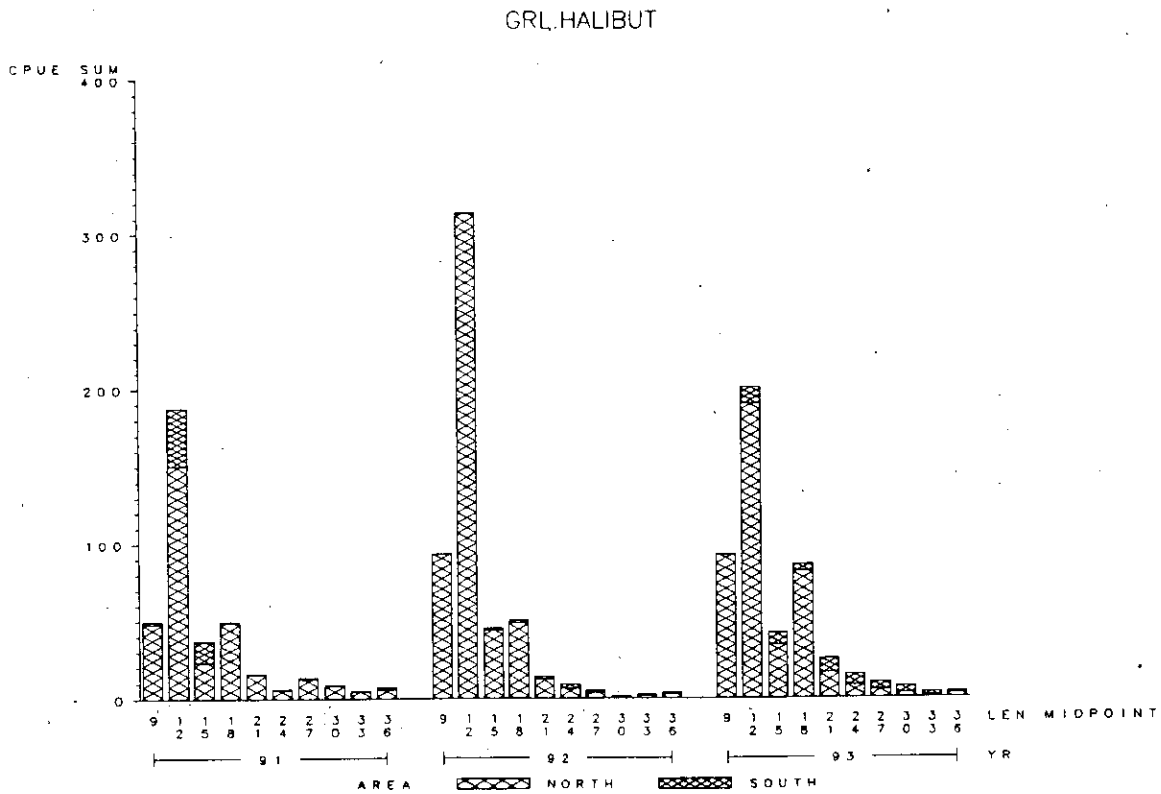

Fig. 6. Greenland halibut catch in numbers by 3 cm length groups (LEN) per trawl hour in Divisions 1AS-1BN (NORTH) and 1BS-1D (SOUTH) in the 1991-1993 surveys.

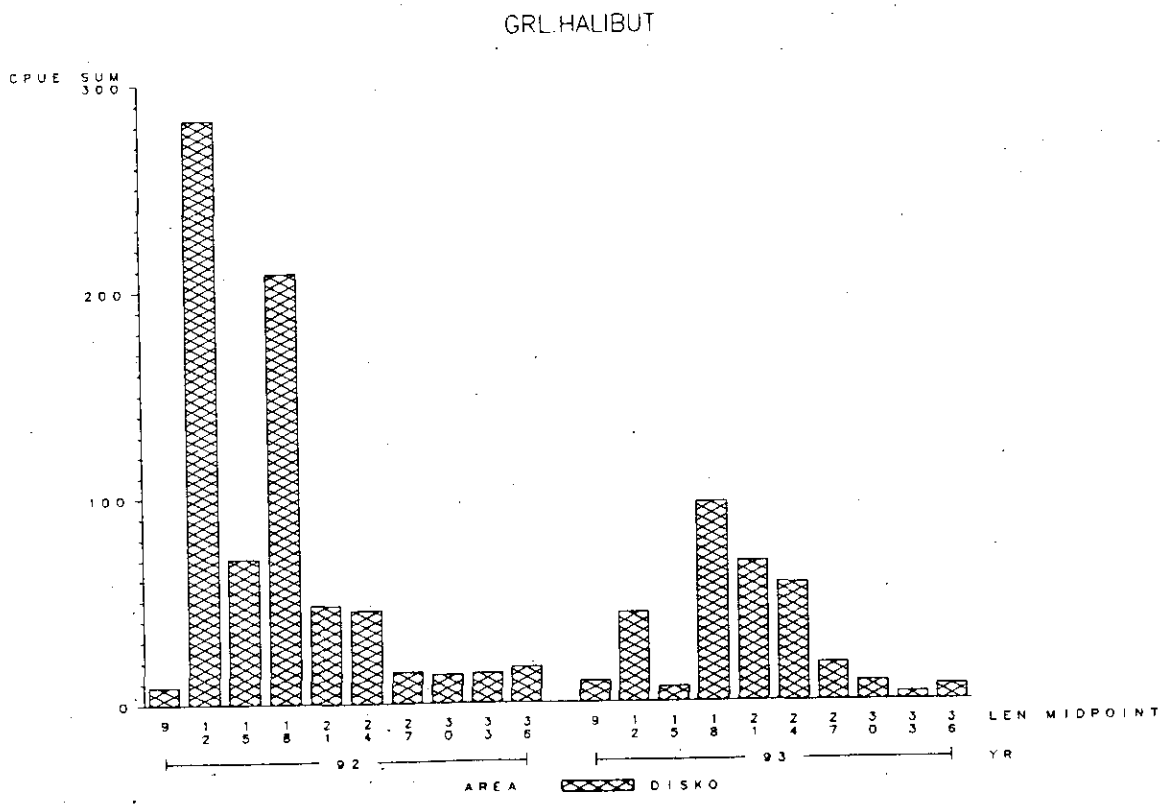

Fig. 7. Greenland halibut catch in numbers in 3 cm length groups (LEN) per trawl hour in the inshore area Disko Bay in 1992-1993 surveys.

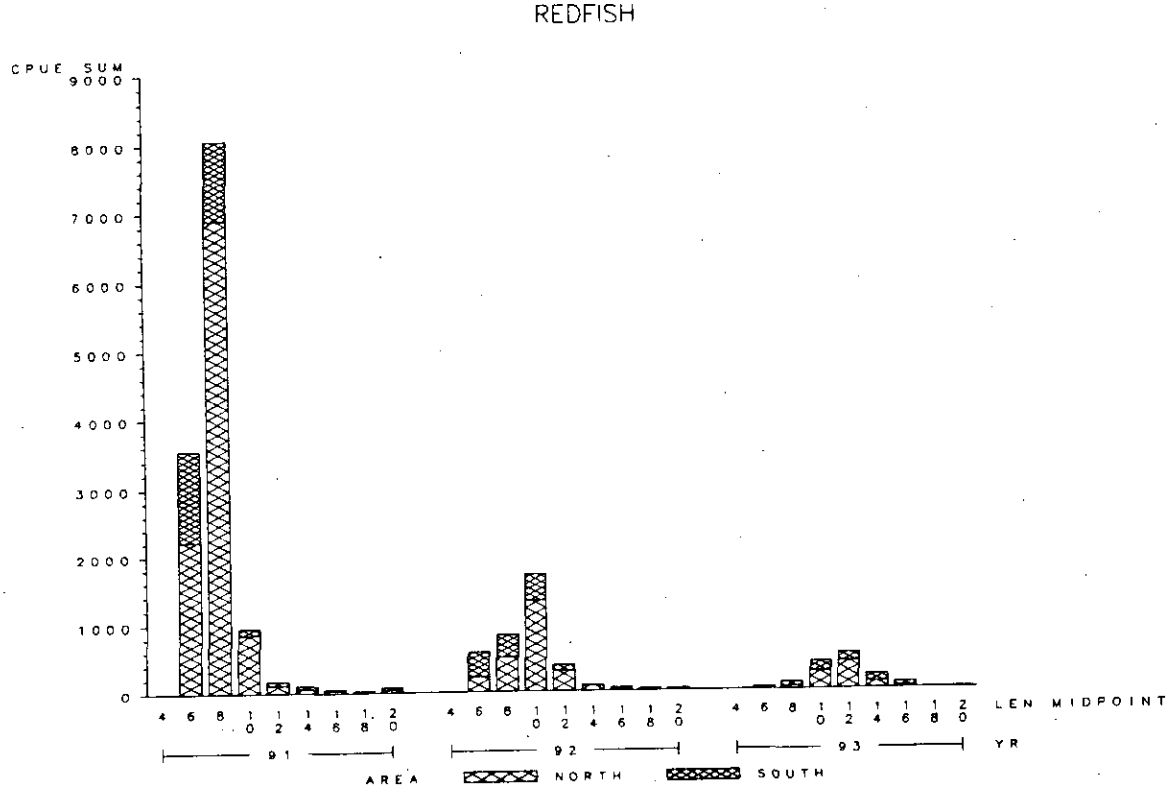

Fig. 8. Redfish catch in numbers in 2 cm length groups (LEN) per trawl hour in Divisions 1AS-1BN (NORTH) and 1BS-1D (SOUTH) in the 1991-1993 surveys.

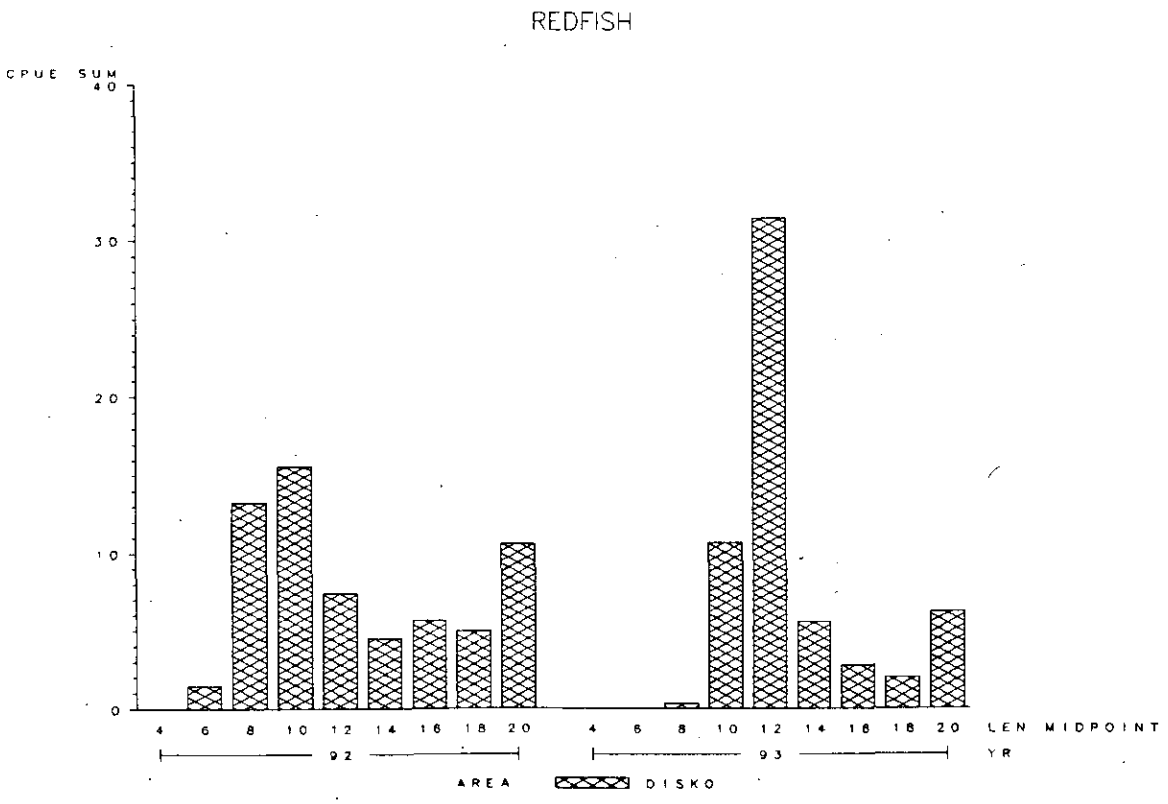

Fig. 9. Redfish catch in numbers in 2 cm length groups (LEN) per trawl hour in the inshore area Disko Bay in 1992-1993 surveys.