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Decrease in Fish Biomass off West Greenland (Subdivisions 1B-1F)

Continued

by

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Abstract

The results of the annual groundfish survey off West Greenland (Subdivisions 1B-1F) revealed a continuation in the drastic decline of total fish biomass. Compared to the last year's estimate (1990), the overall decrease amounted to -66% in 1991. The ecologically important fish species, *Gadus morhua* (-85%), *Hippoglossoides platessoides* (-27%), *Sebastes marinus* (-28%), *S. mentella* (-59%), *Anarhichas lupus* (-29%), *A. minor* (-46%) and the elasmobranch *Raja radiata* (-60%), contributed significantly to this negative trend. Fewer species showed a pronounced decrease in abundance, e.g. *G. morhua* (-86%), *S. mentella* (-74%) and *R. radiata* (-65%). The total fish abundance off West Greenland remained at a low level and increased slightly by 13%. These major events in the ichthyofauna were possibly caused by the increased fishing effort directed to cod.

Introduction

German survey data revealed that during the last decade the aggregate abundance and biomass of the demersal ichthyofauna off West Greenland have undergone dramatic changes in coherence with fundamental shifts in species dominance (Rätz, 1991 a). This paper represents the abundance and biomass indices for the ecologically most important fish species inhabiting the continental shelf and slope off West Greenland (0-600m depth, south of 67°N). The latest results of the groundfish surveys are compared with the trends in temperature and fishing effort.

Materials and Methods

The analyses are based on data derived from annual groundfish surveys established in 1982. The stratified-random surveys covered the shelf area and continental slope off West Greenland (NAFO Subdiv. 1B-1F) outside the 3-mile limit to the 600m isobath. Because of favourable weather and ice conditions and with the aim to avoid spawning concentrations, the autumn season was chosen for the survey. Figure 1 shows the area of investigation and the geographic stratification. The 4 geographic strata were subdivided into 3 depth strata covering the 0-200m, 201-400m and 401-600m zones, respectively. Thus, this stratification scheme produces 12 strata. Table 1 specifies strata boundaries, depth zones and strata areas.

The standard gear used was the 140-feet bottom trawl rigged with a heavy ground gear and equipped with a small mesh liner inside the cod end. Detailed information about the geometry of the trawl is given by Rätz (1990). Usually, the towing time was 30 minutes and 4.5 knots were aimed as towing speed. In case of any net damage of the trawl netting or hangup before 15 minutes towing time, the haul was rejected from the evaluation. In 1987 and 1988, some hauls were not excluded although their towing time was intentionally reduced to 10 minutes due to large catches which were to be expected from the traces of the echo sounder.

The survey was primarily designed for the assessment of cod (*Gadus morhua*). The strategy was to allocate the sampling effort proportionally to the cod abundance and to the area of the strata. Hauls were randomly distributed within the strata. During 1982-91, 1,168 successful sets were carried out. The numbers of valid hauls per stratum are listed in Table 2. The main feature of the effort distribution shown in Table 2 is the high number of tows allocated in the shallow strata 1.1, 2.1, 3.1 and 4.1 (0-200m). The strata 1.2, 2.2, 3.2 and 4.2 (201-400m) are distinguished by significantly lower numbers of hauls, especially the southern strata 3.2 and 4.2 which are characterized by extremely rough trawling grounds. Apart from the northern stratum 1.3, the remaining strata 2.3, 3.3 and 4.3 (401-600m) are covered inadequately with hauls. Therefore, the sampling effort of the very deep strata was stopped and shifted to the shallow strata in 1991.

Fishes were identified to species or the lowest taxonomic level as far as possible and numbers and weight was determined. Stratified abundance and biomass estimates were calculated using the "swept area" method (Cochran, 1953; Saville, 1977). The coefficient of catchability was set arbitrarily to 1.0 for all species. Consequently, the estimates can be considered only as indices of abundance and biomass (relative abundance and biomass). The trawl parameters are listed in Table 3. The respective confidence intervals are given at the 95% level of significance in per cent of the stratified mean. Strata including less than 5 hauls were excluded from the calculation of the stratified mean abundance and biomass. The variation in the survey area arising therefrom is negligible as the haul distribution was fairly consistent over the total time series.

Results

The resulting abundance and biomass estimates for cod (*Gadus morhua*), long rough dab (*Hippoglossoides platessoides*), golden and beaked redfish (*Sebastes marinus, S. mentella*), atlantic and spotted wolffish (*Anarhichas lupus, A. minor*), starry skate (*Raja radiata*), others and total are illustrated in the Figures 2 and 3 and listed in the Tables 4 and 5, respectively. The precision of these estimates is low. Usually, the confidence intervals vary among 30-60% of the stratified mean and exceed even 100%.

Pronounced negative trends in total fish biomass were observed during the periods 1982-84 and 1988-91. The maximum value amounted to 691,488 tonnes in 1987. Compared to 1990, total fish biomass decreased by -66% to 18,771 tonnes in 1991. The trend in total abundance is very similar, although the value in 1991 increased slightly by 13% to 275 million compared to the last year's estimate (1990).

During 1982-84, the cod (*G. morhua*) showed a declining trend both in abundance and biomass. The high values in total fish abundance and biomass in 1986-89 were mainly caused by the occurrence of cod. Since 1988, this species decreased in abundance and biomass from 786 million to 5 million individuals and from 638,622 tonnes to 5,150 tonnes in 1991. The last year's decreases amounted to -86% and -85%, respectively.

The long rough dab (*H. platessoides*) is the second predominating species. During the early years of the last decade, the abundance and biomass indices varied between 57 million and 115 million individuals and 8,354 and 22,246 tonnes. Since 1987, both estimates decreased to 24 million and 2,246 tonnes in 1991. The last year's estimates showed a decrease by -19% in abundance and -27% in biomass.

Both redfish species, the golden redfish (*S. marinus*) and the beaked redfish (*S. mentella*) showed an extremely low precision in the abundance and biomass indices. During the period 1982-84, the golden redfish decreased in abundance and biomass. The last 4 years showed a strong decline from 65 million to 6 million individuals and from 7,420 tonnes to 1,806 tonnes, too. The last year's decrease in biomass amounted to -28% whereas the abundance was found to remain constant. Although the beaked redfish showed pronounced maximum values in 1987, the abundance and biomass indices decreased significantly by -74% and -59% during 1990-91.

The abundance indices of both wolffish species (*A. lupus* and *A. minor*) remained relatively unchanged since 1983 and varied among 10-12 million and 628,000-1,052,000 individuals, respectively. During 1982-85, the trends of the biomass estimates were negative for both species. Since 1989, these indices decreased again to 2,229 and 1,227 tonnes. The last year's declines amounted to -29% and -46%.

The only elasmobranch species taken into consideration is the starry skate (*Raja radiata*). In 1982-84, the occurrence of the starry skate diminished. Subsequently to high abundance and biomass estimates in 1989, both indices decreased from 20 million to 5 million and from 4,081 tonnes to 908 tonnes in 1991. The last year's estimates decreased by -65% and -60%, respectively.

Discussion

During 1982-84 and in recent years (1988-91), the ecologically important fish species cod (*G. morhua*), long rough dab (*H. platessoides*), golden and beaked redfish (*S. marinus, S. mentella*), atlantic and spotted wolffish (*A. lupus, A. minor*) and the starry skate (*R. radiata*) inhabiting the shelf and the continental slope off West Greenland (0-600m) contributed to the dramatic decline in total fish abundance and biomass. Compared to the last year's estimates (1990), the overall decrease in biomass amounted to -66% in 1991, whereas the total fish abundance remained at a low level and increased slightly by 13%. It should be noted that the precision of the indices is low and could be considerably in error (Rätz, 1991 b).

The exploitation of the fish stocks off West Greenland was mainly directed to cod and redfish. Additionally, a considerable shrimp fishery affected the demersal fish community by unknown by-catches (Carlsson, 1991). The remaining fish species were taken more or less as by-catches. Figure 4 illustrates the annual catches of cod, redfishes and wolffishes during 1982-90. In 1983-84 and 1989-90, the catches showed analogous declines to the abundance and biomass indices. Unfortunately, no complete statistic of the fishing effort was documented. However, very high figures of the fishing effort for Greenland trawlers were noted by Hovgård (1991) in 1982-84 and 1988-90 concurrently to the observed decreases in abundance and biomass indices. Hovgård postulated that the loss of cod was mainly due to an emigration. Following the assessment carried out by Schopka (1991), the contribution of migrating cod from Greenland to the Icelandic stock amounted to 100 million individuals during the last decade.

There was a very cold anomaly observed from 1981 until 1984, which possibly affected the negative course in fish abundance and

biomass, especially as the following increase of the indices coincided with the higher temperature in 1985-87. The trend in the temperature of the upper 200 m at the Fyllas Bank (Fig. 1, stratum 2) from 1963 until 1991 is illustrated in Figure 5 (Stein, 1992). Hansen (1949) described the periodical occurrence of cod in Greenland waters and the ichthyofauna was found to be mainly composed of boreal species (Rätz, 1991 a). However, the second period of decreasing abundance and biomass estimates from 1987 until 1991 was lacking a distinct indication of a cooling as the respective temperatures returned to normal.

Comparing the data, the changes in fish abundance and biomass correspond both with changes in fishing effort and temperature for the period 1982-87. Contrarily, the decreasing trend in abundance and biomass since 1988 is reflected inversily by an increased fishing effort only. Thus, the most recent negative events in the ichthyofauna off Greenland were possibly caused by the fishing activities comprising a variety of species.

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Table 1 Specification of the strata.

64°15'N - 67°00'N 50°00'W - 57°00'W
Stratum 1.1 depth 1-200m, area 6,805 nm²
Stratum 1.2 depth 201-400m, area 1,881 nm²
Stratum 1.3 depth 401-600m, area 1,191 nm²

62°30'N - 64°15'N 50°00'W - 55°00'W
Stratum 2.1 depth 1-200m, area 2,350 nm²
Stratum 2.2 depth 201-400m, area 1,018 nm²
Stratum 2.3 depth 401-600m, area 259 nm²

60°45'N - 62°30'N 48°00'W - 53°00'W
Stratum 3.1 depth 1-200m, area 1,938 nm²
Stratum 3.2 depth 201-400m, area 742 nm²
Stratum 3.3 depth 401-600m, area 57 nm²

59°00'N - 60°45'N 44°00'W - 50°00'W
Stratum 4.1 depth 1-200m, area 2,568 nm²
Stratum 4.2 depth 201-400m, area 971 nm²
Stratum 4.3 depth 401-600m, area 353 nm²

Table 2 Number of valid hauls per stratum, 1982-91

Stratum	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	total
Year													
1982	20	11	4	16	7	2	9	6	0	13	2	0	90
1983	26	11	4	25	11	0	17	5	0	18	4	0	121
1984	25	13	13	26	8	2	18	6	1	21	4	1	138
1985	10	8	3	26	10	1	17	5	0	21	4	0	105
1986	27	9	7	21	9	3	16	7	1	18	3	0	121
1987	25	11	8	21	4	1	18	3	0	21	3	2	117
1988	34	21	9	28	5	1	18	5	2	18	2	1	144
1989	26	14	5	30	9	1	8	3	0	25	3	0	124
1990	19	7	7	23	8	0	16	3	0	21	6	1	111
1991	19	11	0	23	7	0	12	6	0	14	5	0	97
total	231	116	60	239	78	11	149	49	4	190	36	5	1,168

Table 3 Trawl parameters of the survey.

Gear	140-feet bottom trawl
Horizontal net opening	22 m
Standard trawling speed	4.5 kn
Towing time	30 minutes
Coefficient of catchability	1.0

Table 4 Survey abundance indices (* 1,000) for the listed fish species, others and total, 1982-1991. The confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean.

Year	G.morhua	CI	H.platessoides	CI	S. marinus	CI	S.mentella	CI	A. lupus	CI	A.minor	CI	R. radiata	CI	Others	Total
1982	92,276	30	77,970	32	133,598	110	3,115	106	23,068	25	1,508	33	9,697	39	10,949	352,181
1983	50,203	29	115,415	54	33,340	34	8,927	67	15,427	28	872	42	6,999	88	13,078	244,261
1984	16,694	38	86,700	47	31,506	37	12,010	50	11,050	24	804	26	6,455	44	22,683	187,902
1985	59,343	39	62,397	30	59,636	44	3,934	96	12,741	33	628	51	7,878	46	32,779	239,336
1986	145,706	35	111,851	45	58,203	38	21,131	46	12,116	31	1,052	30	6,859	47	262,470	619,388
1987	786,453	62	56,961	33	14,622	52	152,101	105	9,607	27	957	41	3,387	32	294,650	1,318,738
1988	626,558	50	33,973	25	64,873	53	33,645	55	10,532	31	940	35	7,247	39	124,383	902,151
1989	359,011	73	39,152	34	32,886	44	16,453	40	10,560	33	843	42	19,820	38	26,084	504,809
1990	34,658	71	29,360	36	6,036	30	33,369	45	10,414	27	641	35	13,643	52	115,308	243,429
1991	4,805	52	23,758	25	6,032	55	8,521	74	9,849	31	721	34	4,832	27	216,856	275,374

Table 5 Survey biomass indices (t) for the listed fish species, others and total, 1982-91. The confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean.

Year	G.morhua	CI	H.platessoides	CI	S. marinus	CI	S.mentella	CI	A. lupus	CI	A.minor	CI	R. radiata	CI	Others	Total
1982	128,490	26	17,394	34	55,704	101	1,109	117	26,002	33	7,950	47	6,090	37	23,367	266,106
1983	82,375	32	22,246	48	14,310	37	4,273	78	12,788	36	5,693	45	2,413	34	16,233	160,331
1984	25,575	39	13,378	51	11,646	45	3,023	56	7,026	26	4,022	32	1,986	36	9,992	76,648
1985	35,672	73	8,354	30	19,726	59	687	78	5,959	26	1,822	44	2,166	24	12,386	86,772
1986	86,778	35	14,806	41	18,647	45	3,224	50	6,774	25	3,536	38	1,864	31	16,605	152,234
1987	638,622	68	9,894	40	6,794	61	10,521	89	4,967	26	4,182	41	1,100	33	15,408	691,488
1988	608,028	50	4,956	29	7,420	37	3,793	66	4,512	21	4,766	59	1,767	30	19,425	654,667
1989	333,989	66	5,128	54	3,947	59	975	34	4,563	25	2,841	50	4,081	31	6,599	362,123
1990	34,499	70	3,087	35	2,500	45	1,956	45	3,130	23	2,262	49	2,295	47	5,190	54,919
1991	5,150	76	2,246	28	1,806	73	798	85	2,229	31	1,227	69	908	31	4,407	18,771

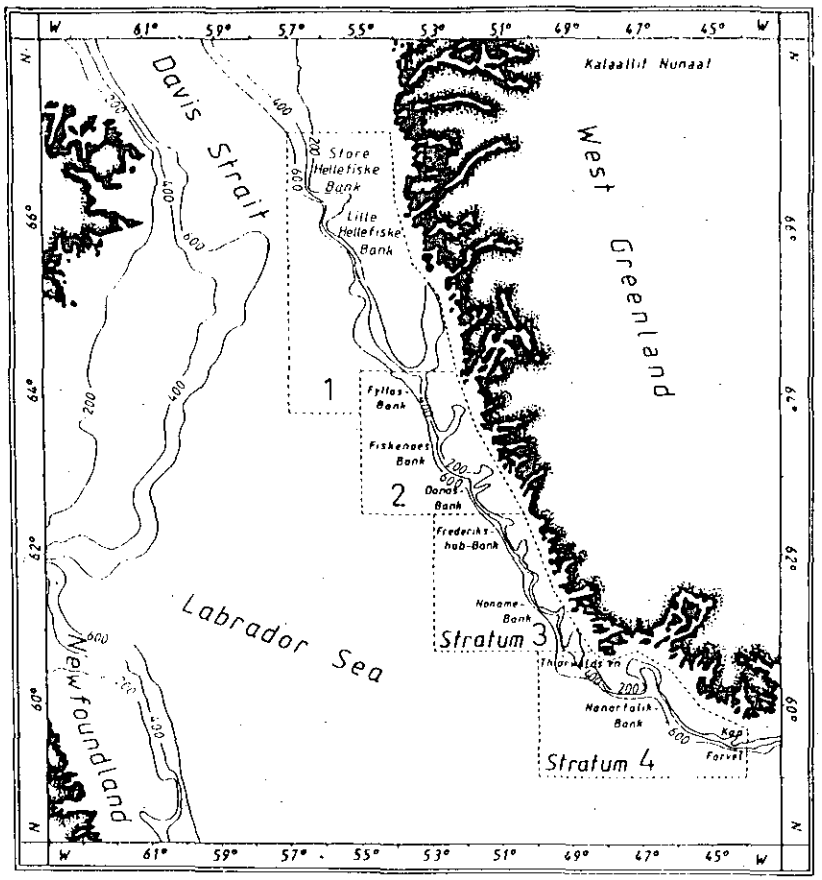

Figure 1 Survey area and stratification scheme as specified in Table 1.

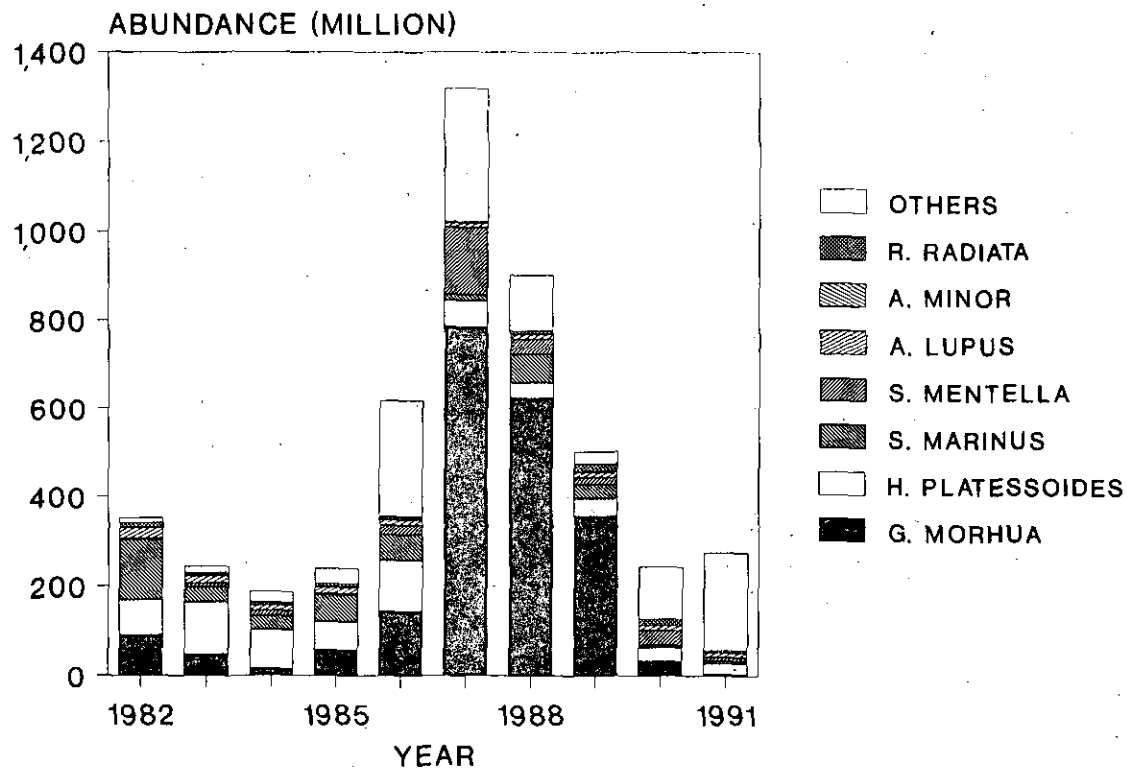

Figure 2 Aggregate fish abundance indices as listed in Table 4.

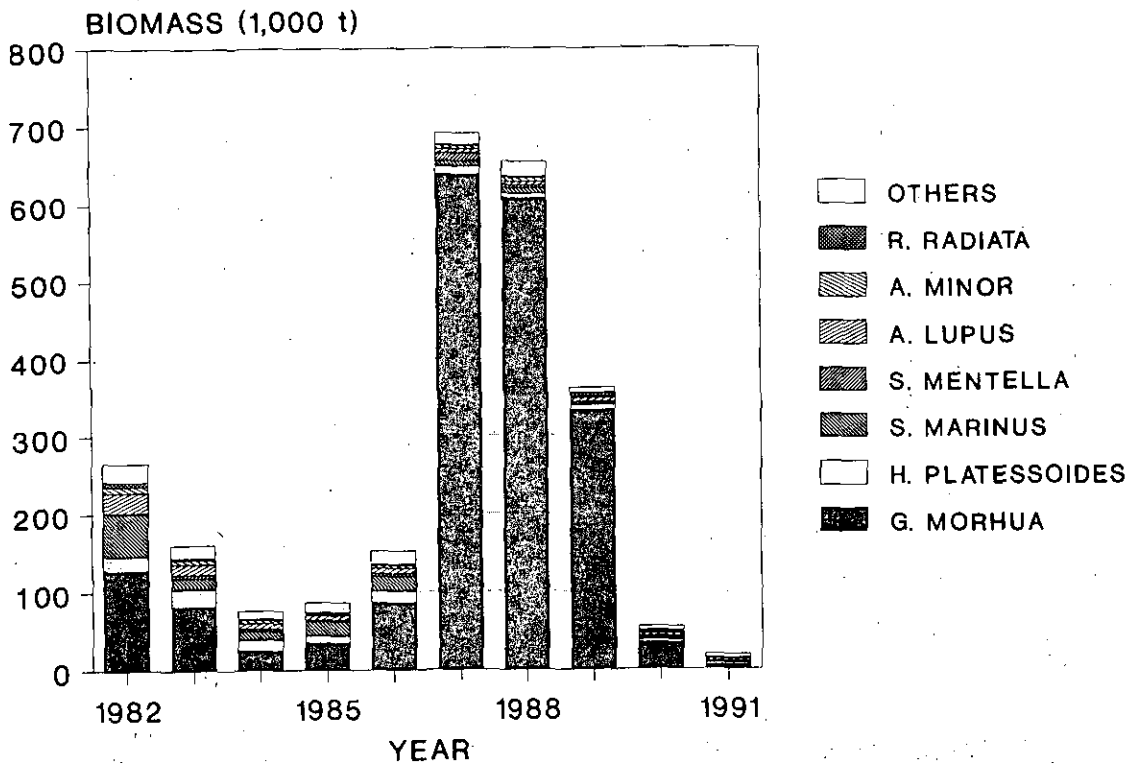

Figure 3 Aggregate fish biomass indices as listed in Table 5.

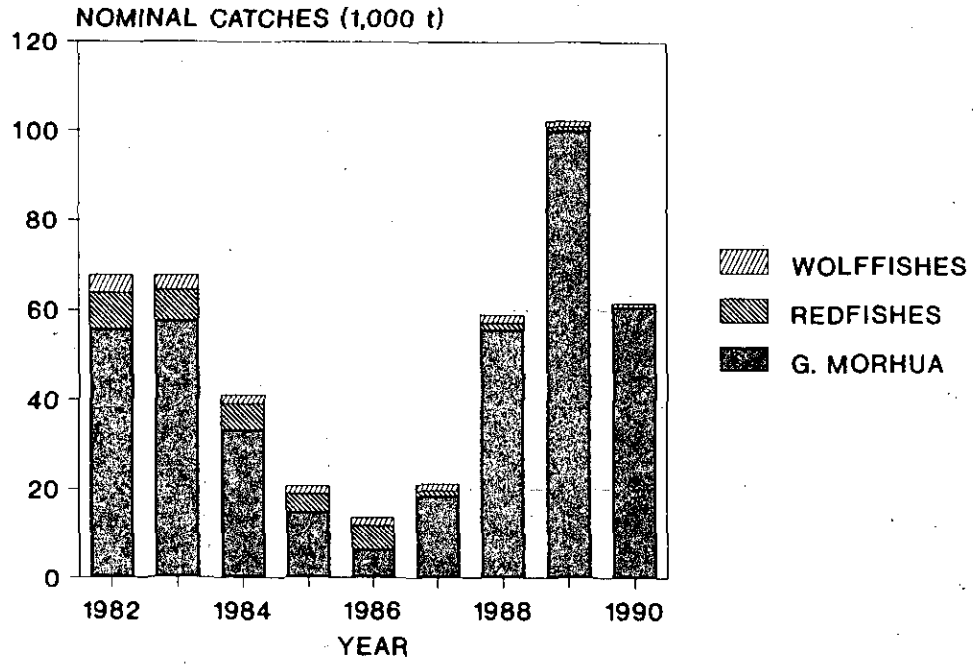

Figure 4 Nominal catches summarized for cod, redfishes and wolffishes (Anon., 1991), 1982-90.

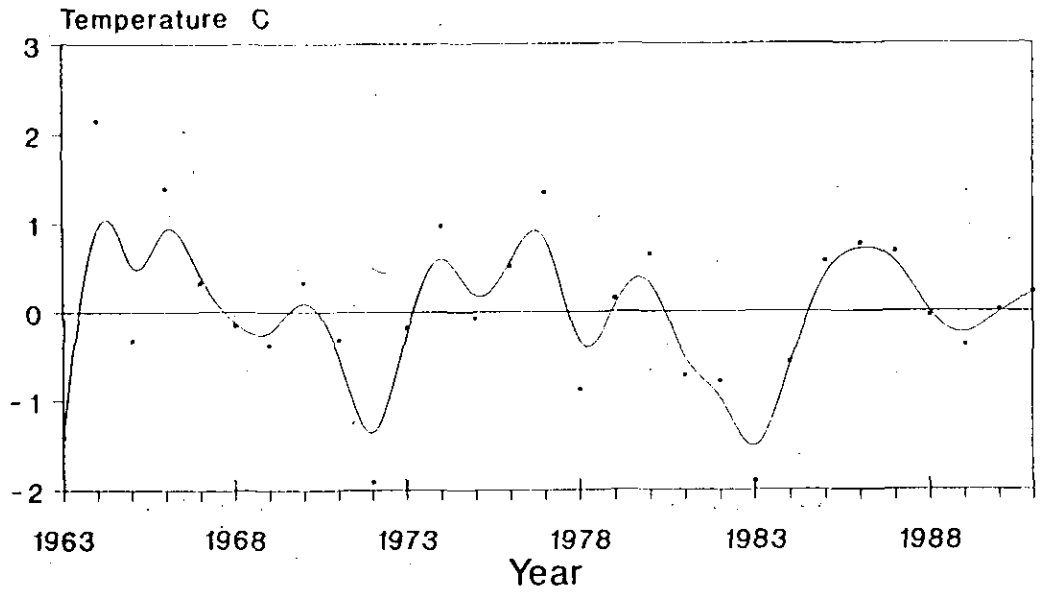

Figure 5 Interannual variability of temperature anomaly of the upper 200m of the ocean on Fylla Bank/West Grenland between 1963 and 1991 (Stein, 1992).