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Status of the Demersal Fish Assemblage and Near Bottom Temperature off West Greenland, 1982-95 (Divisions 1B-1F, 0-400 m)

by

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Abstract

During 1982-94, survey results indicated fundamental shifts in species composition of the demersal fish assemblage inhabiting the shelf and continental slope off West Greenland in Divisions 1B-1F down to 400m depth. These observations happened in coherence with dramatic changes in stock abundance, biomass and size structure for ecologically and economically important species. Recent decreases of biomass estimates for demersal stocks of cod, American plaice, golden redfish, Atlantic and spotted wolffish and starry skates vary between 73% and almost 100%, losses in abundance being less pronounced. Length distributions revealed that these stocks are mainly composed of small and juvenile fish at present. For 1995, the estimates do not indicate any significant changes from this assessment considering the incomplete coverage of the survey area (50%). The status of the demersal fish assemblage stagnates at that low level since 1990 lacking any signs of recovery. Considering the dominance of juvenile fish and the poor abundance of the stocks, the continuation of their severely depleted status seems logical. In addition, the shrimp fishery on traditional fishing grounds is suspected to have a negative effect on survival rates of recruits. Consequently, short term recovery of the demersal stocks must be considered as unlikely and the present situation does not allow to formulate any long term prediction.

Almost all strata showed the same trend in near bottom temperature close to the swept area of the fishing stations. The findings of a very cold event in 1983-84, warmer conditions in 1985-86, a decreasing trend in 1987-89 and warming since then are in agreement with the knowledge about the climatic conditions around Greenland. However, near bottom temperatures were found to differ between strata, the difference ranging around 3 °C. In general, deeper and southern strata were warmer throughout the time series. Correlation analyses indicated that the high temperature variation between and within strata seems not to determine directly the cod distribution at the bottom. The three significant variables depth, latitude, and log-transformed cod abundance are combined by a multiple regression model explaining 34% of the observed variation in near bottom temperature.

Introduction

Since 1982, the demersal fish assemblage off West Greenland has been monitored annually by German groundfish surveys. The surveys were conducted during fall and represent the only source of information about the status of the groundfish stocks inhabiting the shelf and continental slope in Divisions 1B-1F outside the 3 mile zone down to 400m depth. This paper describes the most recent status and trends in stock abundance, biomass and structure for ecologically and economically important species as derived from survey catches. In contrast to earlier publications an evaluation of near bottom temperatures observed directly at trawl stations is included for the first time.

Materials and Methods

Abundance, biomass estimates and length structures have been derived using annual groundfish surveys covering shelf areas and the continental slope off West Greenland. Surveys commenced in 1982 and were primarily designed for the assessment of cod. Because of favourable weather and ice conditions and to avoid spawning concentrations, autumn was chosen for the time of the surveys. These were carried out by the research vessel (R/V) WALTHER HERWIG (II) throughout most of the time period, except in 1984 and since 1994, when R/V ANTON DOHRN was used and she was replaced by the new R/V WALTHER HERWIG III, respectively. In 1995, the coverage of the survey area was incomplete for the first time due to technical problems. Only 50% of the strata were covered with hauls according to the strategy.

The fishing gear used was a standardized 140-feet bottom trawl, its net frame rigged with heavy ground gear because of the rough nature of the fishing grounds. A small mesh liner (10 mm) was used inside the cod end. The horizontal distance between wing-ends was 25 m at 300 m depth, the vertical net opening being 4 m. Since 1994, smaller Polyvalent doors (4.5 m^2, 1,500 kg) were used to reduce net damages due to overspread caused by bigger doors (6 m^2, 1,700 kg) which have been used previously. All calculations of abundance and biomass indices are based on the 'swept area' method using 22 m horizontal net opening as trawl parameter, i. e. the constructional width specified by the manufacturer. The towing time was normally 30 min. at a speed of 4.5 knots. Trawl parameters are listed in Table 1. Hauls which received net damage or became hangup after less than 15 minutes were rejected. Some hauls of the 1987 and 1988 surveys were also included although their towing time had been intentionally reduced to 10 minutes because of the expected large cod catches as observed from echo sounder traces.

Fish were identified to species or lowest taxonomic level and the catch in number and weight was recorded. Redfish (>=17 cm) were separated to golden (*Sebastes marinus* L.) or beaked redfish (*Sebastes mentella* Travin), whereas juvenile redfish (<17 cm) were classified as *Sebastes spp.* due to time-consuming and difficult species identification.Total fish lengths were measured to cm below.

The surveys were primarily designed for the assessment of cod. In order to reduce the error of abundance estimates, the subdivision of shelf areas and the continental slope into different geographic and depth strata was required due to a pronounced heterogeneity of cod distribution. The survey area was thus split into four geographic strata. Each stratum was itself subdivided into two depth strata covering the 0-200m and 201-400m zones. Figure 1 and Table 2 indicate the names of the 8 strata, their geographic boundaries, depth ranges and areas in nautical square miles (nm^2). All strata were limited at the 3 mile offshore line.

The applied strategy was to distribute the sampling effort according both to the stratum areas and to cod abundance. Consequently, fifty percent of the hauls were allocated proportionally to strata by stratum area while the other fifty percent were apportioned on the basis of a review of the historical mean cod abundance/nm^2, all hauls being randomly distributed within trawlable areas of the various strata. Non-trawlable areas are mainly located inshore. During 1982-95, 1,303 successful sets were carried out, the numbers of valid sets by year and stratum being listed in Table 3. In 1995, only the four southern strata were covered.

Stratified abundance estimates were calculated from catch-per-tow data using the stratum areas as weighting factor (Cochran, 1953; Saville, 1977). Strata with less than five valid sets were rejected from the calculation. The coefficient of catchability was set arbitrarily at 1.0, implying that estimates are merely indices of abundance and biomass. Respective confidence intervals (CI) were set at the 95% level of significance of the stratified mean.

As a standard procedure, near bottom temperatures were measured directy before or after trawling in the vicinity of the swept area by a CTD-sonde with a precision of a hundredth °C. Table 7 lists the available numbers of temperature values by stratum and year. During the 14 year time series, a total of 1,207 measurements were conducted.

Results

Table 4 and 5 list abundance and biomass estimates for cod (*Gadus morhua*). American plaice (*Hipplogossoides platessoides*), golden and beaked redfish (*Sebastes marinus* and *S. mentella*), Atlantic and spotted wolffish (*Anarhichas lupus* and *A. minor*), starry skate (*Raja radiata*), others and all species aggregated to total. Trends in abundance and biomass are illustrated in Figures 2 and 3 for cod and others. Both aggregated abundance and biomass estimates are dominated by the occurrence of cod. After a decrease from 350 million individuals and 270,000 tons in 1982 to 180 million individuals and 70,000 tons in 1984, the total indices increased to the maximum values amounting to 1,300 million individuals and 690,000 tons in 1987. The following 3 years are characterized by dramatic declines to 220 million individuals and 50,000 tons in 1990. Since then, the demersal fish fauna stagnated at this low level and the most recent indices amounted to 130 million and 8,000 tons in 1994 representing an overall reduction of

90% and 99% in abundance and biomass, respectively. The mean individual weight of all specimens is given in Table 6 and illustrated in Figure 5 as a bold line. There is a significant decreasing trend over the entire survey period from 800 gr. to less than 70 gr. per individual with the exception of the years 1987-89 when cod dominated and caused values exceeding 250 gr. The estimates of the covered strata in 1995 do not indicate any significant changes from this assessment.

During 1982-94, cod was found to be the dominant fish species. The trends in stock abundance and biomass controlled the aggretated values of the entire demersal fish assemblage. The increase in stock abundance and biomass during 1984-87 to 790 million individuals and 640,000 tons was due to the recruiting process of the year classes 1984 and 1987. Thereafter, the stock abundance and biomass collapsed by nearly 100% to indices amounting to 0.5 million and 140 tons in 1994. The most recent length structure was dominated by recruits ranging at 13-22 cm and 34-40 cm, representing both poor year classes 1991 and 1993 (Fig. 4). In 1994 and 1995, no mature cod were caught. In 1995, the cod caught in the four southern strata were almost exclusively two years old. During the four most recent years, the mean individual weight was extremly low and did not exceed 300 gr. (Fig. 5).

During 1982-1986, American plaice fluctuated at high levels of 62-115 million individuals and 8,000-22,000 tons, but continued to decrease since then by 90% and 93%, respectively. In 1994, stock estimates amounted to 11 million individuals and 1,100 tons. Length structures in 1993 and 1994 were dominated by small fish varying from 13-18 cm (Fig. 4). The results for 1995 do not indicate significant changes for the southern strata covered. Juvenile fish <16 cm missing in 1995 are mainly distributed in northern strata which were not covered (Lloret, 1995). The mean weight of the specimens decreased almost constantly from 220 gr. in 1982 to 100 gr. in the most recent years (Fig. 5).

Since 1982, golden redfish (>=17 cm) decreased continuously from 130 million and 60,000 tons by 99% to 1.3 million individuals and 500 tons in 1994. During 1993 and 1994, the length structure of this stock was composed mainly by juvenile fish being smaller than 30 cm (Fig. 4). Reappearing peaks around 20 cm and 25 cm migth indicate annual growth increment. Golden redfish showed a significant reduction in body weight from an average of 450 gr. during 1982-92 to less than 350 gr. during 1993-95 (Fig. 5).

Abundance and biomass estimates for beaked redfish (>=17 cm) varied without any distinct trend, but were extremely low during the most recent four years (Tab. 4 and 5). High confidence intervals resulting from extreme varation in catch per tow data indicate that the estimates are very inprecise. In 1994 and 1995, the length frequency was dominated by small fish around 19 cm (Fig. 4). Individual sizes varied from 90 gr. to 481 gr. but amounted to less than 300 gr. since 1986 and to less than 200 gr. since 1993 (Fig. 5).

Juvenile and unspecified redfish (<17 cm) dominated the category of other finfish. In 1993 and 1994, the length distributions peaked at 6, 9, 12 and 15 cm (Fig. 4).

The abundance of Atlantic wolffish varied without a clear trend between 9 million and 23 million individuals, whereas the biomass decreased continuously by 91% from 26,000 tons in 1982 to 2,200 tons in 1994, pointing to a pronounced reduction in fish size. This is reflected by the mean body weight decreasing from 1.1 kg in 1982 to less than 200 gr. since 1993 (Fig. 5). The analysis of the length distributions in 1993, 1994 and 1995 reveal the dominance of small fish <30 cm (Fig. 4).

Spotted wolffish were caught rarely during the whole survey period, but abundance and biomass estimates decreased significantly. Since 1982, these indices are reduced by 76% and 96% to 360,000 individuals and 311 tons in 1994, respectively. Recently, the majority of the fish are very small, displaying pronounced peaks at 16 cm and 22-25 cm (Fig. 4). The mean individual weight varied without a clear trend (Fig. 5).

During 1982-92, starry skates varied in abundance and biomass without a clear trend. However, the most recent values in 1993 and 1994 amounted to 4 million and 5 million individuals and 600 tons, respectively. Compared to the mean of the previous 11 years, these estimates reflect a reduction by 49% in abundance and 73% in biomass. Figure 4 reveals the frequent occurrence of individuals <15 cm and the dominance of fish <25 cm. Apart from the year 1995 with an incomplete coverage of the survey area, the individual weight did not exceed 200 gr. since 1990 (Fig. 5).

Table 8 lists mean near bottom temperatures by stratum and weighted by stratum area to total, 1982-95. Respective values are illustrated in Figure 6. All years are characterized by high differences in mean temperatures ranging around 3 °C between strata. Most of the strata show the same trend during the survey period. The weighted mean temperature is illustrated as a bold solid line in Figure 6. A very cold event around 2°C is identifiable for the period 1983-84 followed by a warming of 2 °C to an overall mean of 4 °C. During 1987-89, a cooling by 2.5 °C was observed. Subsequently, there was an increasing trend exceeding 3.5 °C in the most recent years. Figure 6 reveals that the mean near bottom temperatures of the strata show clear positive depth and negative latitude effects. The shallow strata (1-200 m) indicated by solid lines were regularely colder than deep strata (201-400 m) indicated by dashed lines. The northern strata at higher latitudes are found to be colder than southern strata. Linear correlation and regression

analyses based on individual values explained 28% and 2% of the observed variation in near bottom temperature, parameters being listed in Table 9. Furthermore, log-transformed cod abundance values were found to be highly significant correlated with the near bottom temperature. However, this relation has a very low weight since it explains a negligible part of temperature variation ($r^2<0.005$). Statstical insignificance was determined in the cases when temperature versus longitude and untransformed cod abundance as dependent variables were tested. The three significant variables depth, latitude, and log-transformed cod abundance are combined by a multiple linear regression. This model explains 34% of the observed variation in near bottom temperature (Tab.9).

Discussion

During 1982-94, survey results indicated fundamental shifts in species composition of the demersal fish assemblage inhabiting the shelf and continental slope off West Greenland in Divisions 1B-1F down to 400m depth (Tab. 4 and 5, Fig. 2 and 3). These observations happened in coherence with dramatic changes in stock abundance, biomass and size structure for ecologically and economically important species. Recent decreases of biomass estimates for demersal stocks of cod, American plaice, golden redfish, Atlantic and spotted wolffish and starry skates vary between 73% and almost 100%, losses in abundance being less pronounced. Length distributions revealed that these stocks are mainly composed of small and juvenile fish at present (Tab. 6, Fig. 4 and 5). For 1995, the estimates do not indicate any significant changes from this assessment considering the incomplete coverage of the survey area (50%). Annual changes in aggregate fish biomass (production) have been related significantly to the occurrence of cod recruits at age 3 and fishing effort directed to groundfish (Rätz, 1994) explaining 87% of the observed variation. Similar stock collapses without any clear indication for biomass compensation have been described for Divisions 2J3KL (Atkinson, 1993).

The status of the demersal fish assemblage stagnates at that low level since 1990 lacking any signs of recovery, although no fishing effort was recently directed towards groundfish. Considering the dominance of juvenile fish and the poor abundance of the stocks, being unable to ensure normal recruitment, the continuation of their severely depleted status seems logical. In addition, the increased effort of the shrimp fishery on traditional fishing grounds is suspected to select efficiently small sized fish and thus to have a negative effect on survival rates of recruits. The finfish by-catch of a standard survey haul side by side with a shrimp trawler in 1994 amounted to 28% in weight, although the different catch procedure of the shrimp fishery (different nets and lower towing speed) prevented direct estimation (Rätz, 1995). However, there is still no information available to quantify the impact of the shrimp fishery off West Greenland on the recruitment of demersal fish stocks. In view of their poor status and unreliable catch figures, short term recovery of the demersal stocks must be considered as unlikely and the present situation does not allow to formulate any long term prediction.

Almost all strata showed the same trend in near bottom temperature close to the swept area of the fishing stations. This trend is characterized by a very cold event in 1983-84, warmer conditions in 1985-86, a decreasing trend in 1987-89 and warming since then. The findings are in agreement with the description of the climatic conditions around Greenland as derived from air tempertures and oceanographic standard sections (Stein, 1995). However, near bottom temperatures were found to differ between strata, the difference ranging around 3 °C. In general, deeper and southern strata were warmer throughout the time series. Contrarily, a direct impact of near bottom temperature on cod distribution could not be proved but was found to be statistically significant for log-transformed values by very low regression weight ($r^2<0.005$). The high temperature variation between and within strata seems not to determine directly the cod distribution at the bottom. The three significant variables depth, latitude, and log-transformed cod abundance are combined by a multiple regression model explaining 34% of the observed variation in near bottom temperature.

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Table 1 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 2 Specification of strata.

Stratum	geographic boundaries				depth	area
	south	north	east	west	(m)	(nm^2)
1.1	64°15'N	67°00'N	50°00'W	57°00'W	1-200	6805
1.2	64°15'N	67°00'N	50°00'W	57°00'W	201-400	1881
2.1	62°30'N	64°15'N	50°00'W	55°00'W	1-200	2350
2.2	62°30'N	64°15'N	50°00'W	55°00'W	201-400	1018
3.1	60°45'N	62°30'N	48°00'W	53°00'W	1-200	1938
3.2	60°45'N	62°30'N	48°00'W	53°00'W	201-400	742
4.1	59°00'N	60°45'N	44°00'W	50°00'W	1-200	2568
4.2	59°00'N	60°45'N	44°00'W	50°00'W	201-400	971
Sum						18273

Table 3 Numbers of valid hauls by stratum and total, 1982-95.

Year	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	Σ
1982	20	11	16	7	9	6	13	2	84
1983	26	11	25	11	17	5	18	4	117
1984	25	13	26	8	18	6	21	4	121
1985	10	8	26	10	17	5	21	4	101
1986	27	9	21	9	16	7	18	3	110
1987	25	11	21	4	18	3	21	3	106
1988	34	21	28	5	18	5	18	2	131
1989	26	14	30	9	8	3	25	3	118
1990	19	7	23	8	16	3	21	6	103
1991	19	11	23	7	12	6	14	5	97
1992	6	6	6	5	6	6	7	5	47
1993	9	6	9	6	10	8	7	0	55
1994	16	13	13	8	10	6	7	5	78
1995	0	0	3	0	10	7	10	5	35
Σ	262	141	270	97	185	76	221	51	1303

Table 4 Abundance indices (1,000) of specified fish stocks, others and total off West Greenland, 1982-95. Confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean. *) only 50 % coverage of the survey area.

year	cod	CI	American plaice	CI	golden redfish	CI	beaked redfish	CI	Atlantic wolffish	CI	spotted wolffish	CI	starry skate	CI	others	total
1982	92276	29	78028	32	132357	111	3116	105	23069	25	1508	33	9697	39	12565	352616
1983	50203	29	115443	54	28714	35	8884	66	15427	28	873	42	6999	88	17705	244248
1984	16684	38	89604	47	24091	39	5405	82	11023	24	787	27	6314	45	26496	180404
1985	59343	39	62397	30	45471	45	810	115	12741	33	628	51	7878	46	50065	239333
1986	145680	35	111513	45	43314	43	3333	76	12090	31	1033	31	6706	48	277199	600868
1987	786392	63	56248	34	13157	57	14765	79	9568	27	946	42	3337	33	417074	1301487
1988	626494	50	33562	25	14290	40	8819	79	10497	31	935	35	7148	40	182560	884305
1989	358726	73	39172	34	9160	62	303	59	10560	33	843	42	19419	39	53078	491261
1990	34524	71	29102	36	4996	34	4649	112	10414	27	622	35	13325	54	125465	223097
1991	4805	52	23785	25	3724	61	2425	106	9863	31	721	34	4832	27	225294	275449
1992	2042	61	24106	29	2193	43	157	94	13164	29	313	55	10710	51	142071	194756
1993	1437	32	13277	20	1188	53	190	160	8849	47	530	44	4126	43	120464	150061
1994	575	36	11493	24	1268	42	679	55	11971	67	359	36	4775	48	95557	126677
*1995	277	48	3885	53	302	68	1826	120	3145	34	37	122	612	82	117198	127282

Table 5 Biomass indices (tons) of specified fish stocks, others and total off West Greenland, 1982-95. Confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean. *) only 50 % coverage of the survey area.

year	cod	CI	American plaice	CI	golden redfish	CI	beaked redfish	CI	Atlantic wolffish	CI	spotted wolffish	CI	starry skate	CI	others	total
1982	128490	26	17394	34	55682	100	1109	116	26002	33	7950	47	6091	37	23428	266146
1983	82375	32	22246	47	14178	37	4270	77	12788	36	5693	45	2413	34	16366	160329
1984	25565	39	13294	51	11225	47	1771	89	6998	26	3956	33	1920	37	7256	71985
1985	35672	73	8354	30	19634	58	260	108	5959	26	1822	44	2166	24	12894	86761
1986	86717	35	14726	41	18068	46	574	65	6767	25	3501	38	1774	32	14997	147124
1987	638589	69	9809	40	6553	63	1307	62	4950	26	4178	41	1067	34	19759	686212
1988	607988	50	4905	29	5902	41	2549	92	4504	21	4755	59	1744	30	20429	652776
1989	333850	66	5071	55	3669	64	46	50	4563	25	2841	50	3996	32	5717	359753
1990	34432	70	3044	35	2438	46	643	109	3130	23	2255	49	2229	48	4717	52888
1991	5150	76	2246	28	1778	74	598	104	2229	31	1227	69	908	31	4633	18769
1992	607	64	1991	28	947	49	33	105	2969	23	126	87	1054	31	3428	11155
1993	359	38	894	21	384	47	29	130	1448	37	415	84	601	34	2425	6555
1994	138	37	1072	33	473	43	85	51	2242	64	312	101	643	28	3231	8196
*)1995	57	50	405	55	101	59	200	125	561	36	325	148	147	56	2074	3870

Table 6 Mean individual weight (gr.) for specified fish stocks and total off West Greenland, 1982-95. *) only 50 % coverage of the survey area.

year	cod	American plaice	golden redfish	beaked redfish	Atlantic wolffish	spotted wolffish	starry skate	total
1982	1392	223	421	356	1127	17243	628	755
1983	1641	193	494	481	829	14648	345	656
1984	1532	148	466	328	635	8892	304	399
1985	601	134	432	321	468	9489	275	363
1986	595	132	417	172	560	6551	265	245
1987	812	174	498	89	517	5233	320	527
1988	970	146	413	289	429	4817	244	738
1989	931	129	401	152	432	5413	206	732
1990	997	105	488	138	301	5032	167	237
1991	1072	94	477	247	226	3092	188	68
1992	297	83	432	210	226	9486	98	57
1993	250	67	323	153	164	2732	146	44
1994	240	93	373	125	187	6245	135	65
*) 1995	206	104	334	110	178	15162	240	30

Table 7 Number of temperature measurements by stratum and total, 1982-95.

Year	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	Σ
1982	20	11	16	7	9	6	13	2	84
1983	26	11	25	11	17	5	18	4	117
1984	23	10	18	7	13	4	16	4	95
1985	10	8	26	10	17	5	21	4	101
1986	27	9	16	7	16	7	18	3	103
1987	25	11	21	4	18	3	21	3	106
1988	34	20	28	5	18	5	16	2	128
1989	23	10	23	8	3	2	22	3	94
1990	15	6	23	7	14	3	17	4	89
1991	16	9	21	5	12	4	13	1	81
1992	6	6	6	5	6	5	6	4	44
1993	9	6	8	6	10	8	7	0	54
1994	16	13	12	8	10	6	7	4	76
1995	0	0	3	0	10	7	10	5	35
Σ	250	130	246	90	173	70	205	43	1207

Table 8 Mean near bottom temperature (°C) by stratum and weighted total (by stratum area), 1982-95. Confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean. *) only 50 % coverage of the survey area.

Year	1.1	CI	1.2	CI	2.1	CI	2.2	CI	3.1	CI	3.2	CI	4.1	CI	4.2	CI	Mean	CI
1982	2.5	24	3.6	36	2	33	3.1	57	3.3	29	3.6	51	2.6	15			2.8	11
1983	2	17	3.7	13	1.4	26	3.8	14	2.1	25	4.8	1	2.2	26			2.4	7
1984	1.4	21	2.8	36	1.6	22	3.9	10	2.5	25			2.5	23			2	9
1985	4.2	11	5.2	6	3.1	8	4.6	11	2.6	11	4.3	14	4.4	4			4	4
1986	3.7	8	4.4	12	4	7	5.1	8	4.2	11	5.1	4	4.1	8			4.1	3
1987	3.1	12	4.9	6	3.4	7			3.5	10			3.5	9			3.5	5
1988	2.5	11	4.3	11	3	10	5	13	4.2	11	5.2	4	4.3	12			3.5	4
1989	2.3	25	4	17	2.7	18	4.5	8					2.6	24			2.8	11
1990	2.5	28	3.9	21	3	13	4.8	6	3.4	21			2.5	14			3	10
1991	3.5	14	4.7	7	3.5	11	4.2	22	3	22			3	20			3.6	7
1992	3.9	14	4.4	9	2.9	51	4.5	11	3	22	4.7	4	1.9	31			3.5	7
1993	3	31	4	17	2.4	15	3.4	21	4.7	20	5	15	2.8	15			3.3	10
1994	2.9	20	4.4	8	3.7	10	4.6	4	3.8	8	5.1	5	3.8	25			3.6	7
*) 1995									4.2	3	4.6	3	3.5	12	4.2	6	4	4
Mean	2.9		4.2		2.8		4.3		3.4		4.7		3.1		4.2		3.3	

Table 9 Linear correlation and regression parameters between near bottom temperatures, mean depth, latitude and log-transformed cod abundance

dependent variable: f()=near bottom temperure (°C)
independent variables: x=depth (m)
y=latitude (positive decimal)
z=cod abundance (log-transformed n+1 per nm^2)

$f(x)=1.901559+0.008782x$, n=1207, p=0.00, r=0.53, $r^2=0.28$
$f(y)=8.601220-0.082900y$, n=1207, p=0.00, r=0.13, $r^2=0.02$
$f(z)=3.230825+0.025247z$, n=1207, p=0.03, r=0.06, $r^2=0.00$

multiple linear regression:
$f(x,y,z)=9.088733+0.009425x+0.036272y-0.119019z$, n=1207, p=0.00, r=0.58, $r^2=0.34$

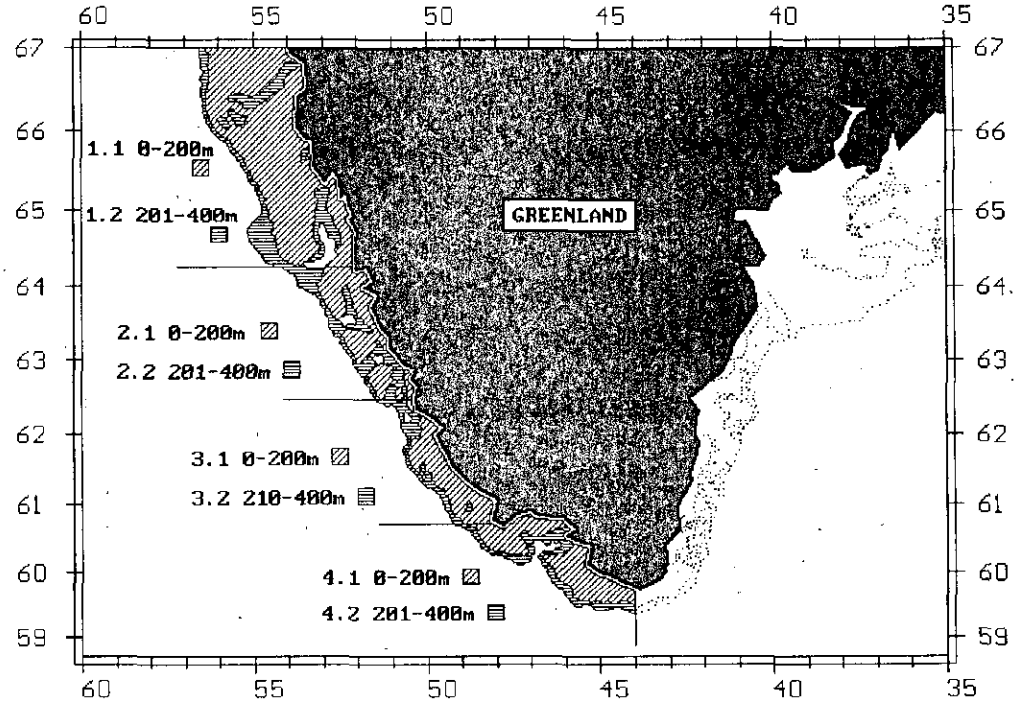

Fig. 1 Survey area and stratification scheme as specified in Table 2.

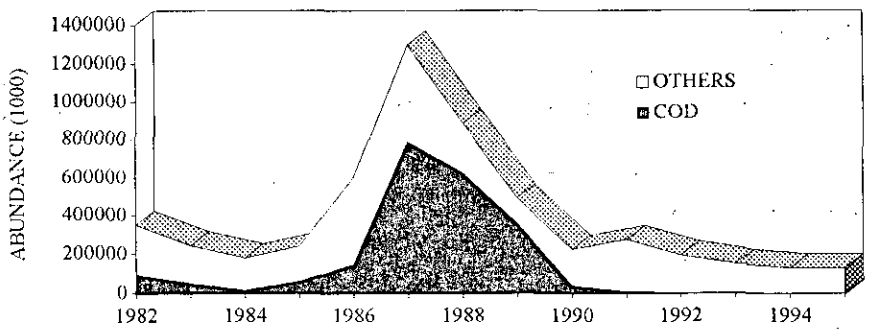

Fig. 2 Aggregate fish abundance indices for cod and others as listed in Table 4, 1982-95. Only 50 % coverage of the survey area in 1995.

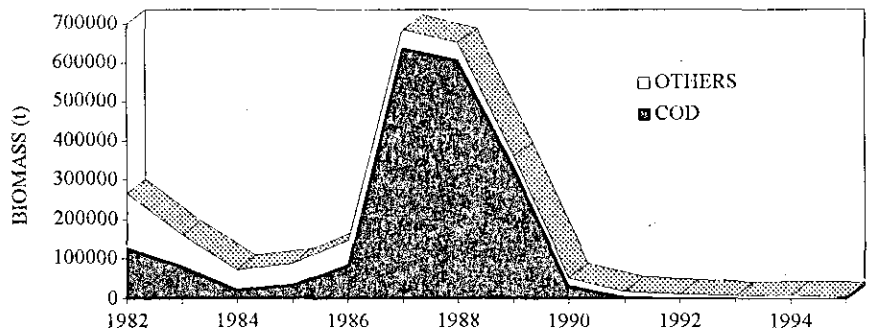

Fig. 3 Aggregate fish biomass indices for cod and others as listed in Table 5, 1982-95. Only 50 % coverage of the survey area in 1995.

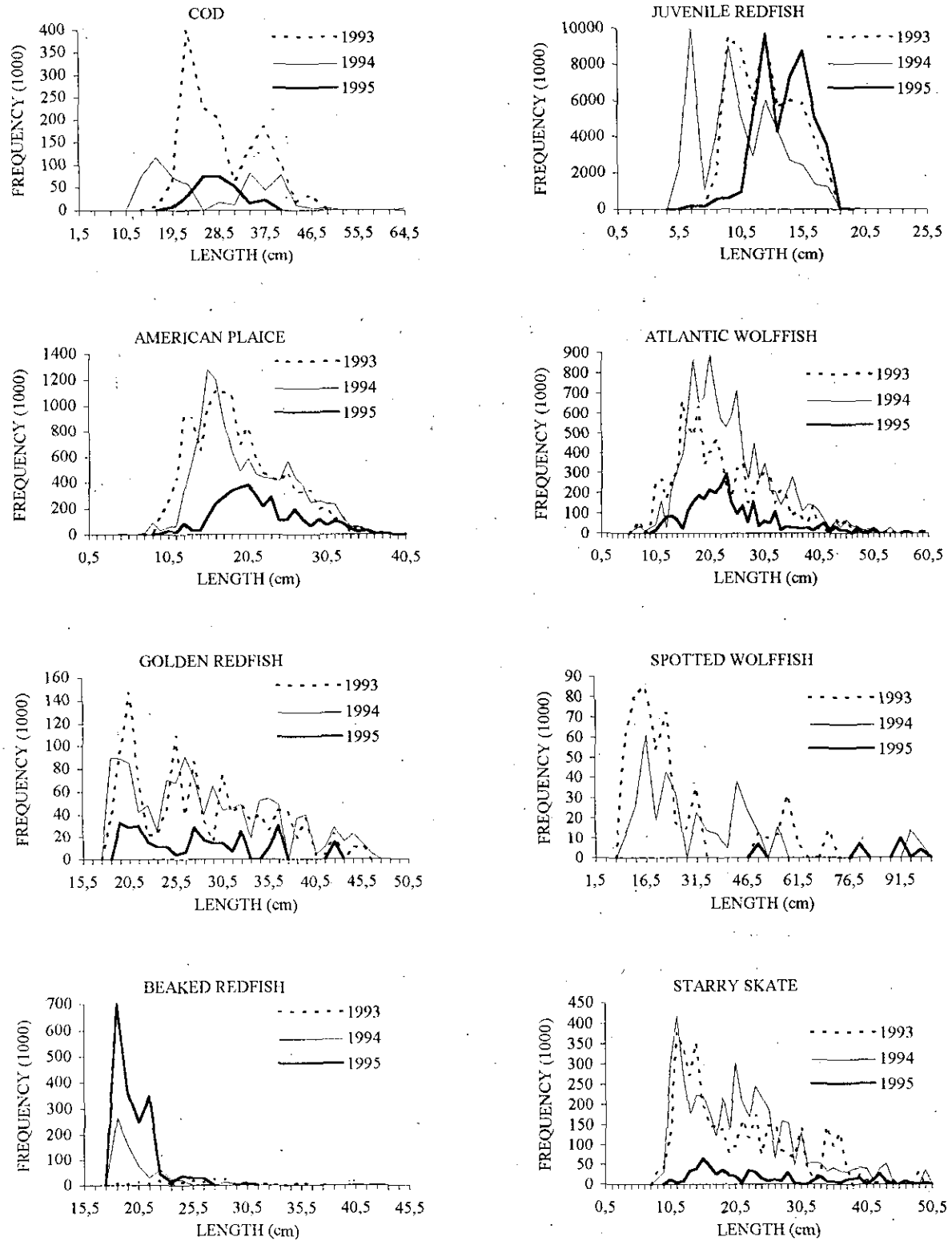

Fig. 4 Length structure of specified fish stocks in 1993-95. Only 50 % coverage of the survey area in 1995.

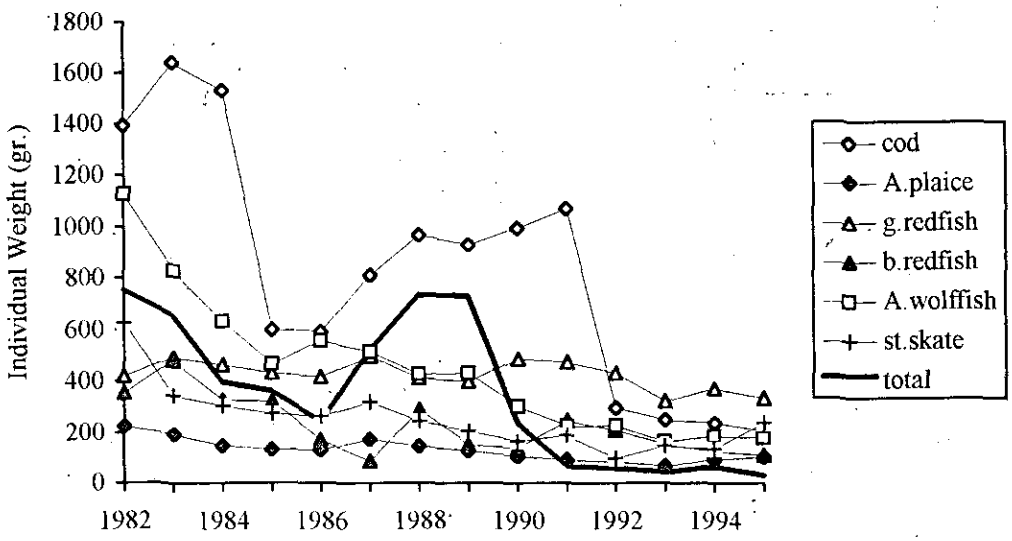

Fig. 5 Mean individual weight (gr.) for specified fish stocks and total off West Greenland, 1982-95. Only 50 % coverage of the survey area in 1995.

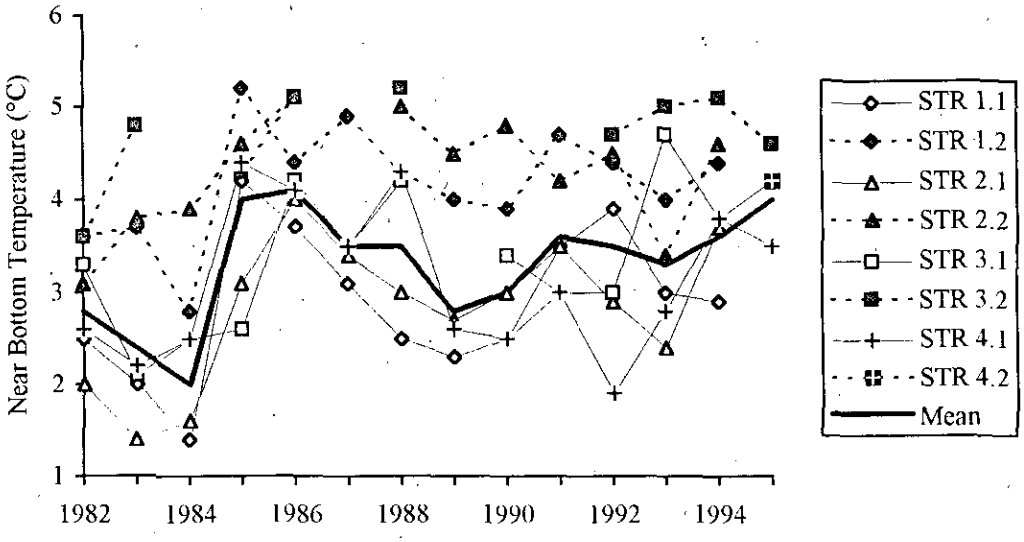

Fig. 6 Mean near bottom temperature by stratum off West Greenland as listed in Table 7, 1982-95. Solid lines indicate trends for shallow strata (1-200 m), dashed lines indicate deep strata (201-400 m), mean temperature weighted by stratum area is illustrated as a bold line. Only 50 % coverage of the survey area in 1995.