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Status of the Demersal Fish Assemblage off West Greenland and a Simple Production Model, 1982-93 (Divisions 1B-1F, 0-400 m)

by

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Abstract

During the periods 1982-84 and 1988-93, pronounced negative trends in aggregate fish abundance and biomass were observed. Since 1988, overall decrease in aggregate abundance and biomass amounted to 88% and 99%, respectively. Ecologically important fish species cod (*G. morhua*), American plaice (*H. platessoides*), golden and beaked redfish (*S. marinus*, *S. mentella*), Atlantic and spotted wolffish (*A. lupus*, *A. minor*) and starry skate (*R. radiata*) contributed to the dramatic decline in total fish abundance and biomass. Length distributions revealed that at present very small individuals dominate demersal stocks. Overall mean individual weight decreased by 94% from 0.738 kg in 1988 to 0.044 kg in 1993.

No significant correlations between annual cod or aggregate fish production indices (biomass) and temperature were found. A positive and a negative correlation between annual aggregate fish production (dependent) and number of cod recruits at age 3 (independent) and fishing effort (independent) were combined by a multiple regression. The production model based on these two correlations explains 87% of the observed variability in aggregate fish production identifying cod recruitment and fishing effort as probable main factors. On the basis of minor fishing effort and poor recruitment, the model prognosticates stagnant fish biomass at lowest level for 1994.

Introduction

Regular German survey data revealed that during the period 1982-93 the demersal fish assemblage off West Greenland changed significantly in terms of abundance, biomass, fundamental shifts in species dominance and in size of specimens (Rätz, 1991, 1992 and 1993). For this time, the present paper compiles changes of abundance and biomass indices as well as length structure of the ecologically important fish stocks inhabiting the continental shelf and slope off West Greenland (0-400m depth, south of 67°N). Annual changes in production of aggregate fish biomass are compared with trends in temperature, cod recruitment indices and fishing effort.

Materials and Methods

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 Div. 1B-1F, south of 67°N) outside the 3-mile limit to the 400m isobath. Because of favourable weather and ice conditions and to avoid spawning concentrations, the autumn season was chosen for the survey.

Figure 1 shows the area of investigation and the geographic stratification. 4 geographic strata were subdivided into 2 depth strata covering the 0-200m and 201-400m zones, respectively. Thus, this stratification scheme produces 8 strata. Table 1 specifies names of strata, boundaries, depth zones and stratum 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. Standard towing required 30 minutes and 4.5 knots were aimed as the towing speed. In case of net damage or hangup before 15 minutes towing time, the haul was rejected from evaluation. In 1987 and 1988, some hauls were not excluded although their towing time was intentionally reduced to 10 minutes due to large catches being expected from traces of the echo sounder.

The surveys were primarily designed for the assessment of cod (*Gadus morhua*). The applied strategy was to allocate sampling effort proportionally to cod abundance and to area of the strata. Hauls were randomly distributed within trawlable areas of the strata. During 1982-93, 1,190 successful sets were carried out. Numbers of valid hauls per stratum are listed in Table 2. The main feature of effort distribution shown in Table 2 is the high number of tows allocated in 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 lower numbers of hauls, especially the southern strata 3.2 and 4.2 which are characterized by extremely rough trawling grounds. Since 1992, the effort has been reduced significantly (50%) due to technical reasons and a combination of West and East Greenland surveys.

Fishes were identified to species or lowest taxonomic level and catch number and weight was recorded. Redfish >=16 cm were separated to golden or beaked redfish, whereas redfish <16 cm were classified as *Sebastes spec.* Total length measurements were determined to the centimeter below.

Stratified abundance and biomass estimates were calculated using the "swept area" method (Cochran, 1953; Saville, 1977). Coefficient of catchability was set arbitrarily to 1.0 for all species. Consequently, estimates can be considered only as trawlable abundance and biomass defined as indices of total stock abundance and biomass (relative). Trawl parameters are listed in Table 3. 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 calculation of stratified mean abundance and biomass. The variation in survey area arising therefrom is negligible as the haul distribution was fairly consistent over the total time series. Before summing up, length distributions were standardized, pooled by stratum and weighted by stratum abundance.

Linear correlation and regression analyses between annual changes in cod and aggregate fish biomass indices (indices of annual production), trends in effort and temperature and cod recruitment indices for year classes 1980-83 and 1986-91 were calculated using statistical software (CSS Statsoft, Inc.). Production indices were computed by subtraction of respective estimates of the preceding year. Annual fishing effort (hours fished) directed to groundfish (Greenland halibut and shrimp excluded) for otter-trawls>500 GRT were adopted from the report of the ICES North-Western Working Group (Anon. 1992) and the NAFO

Statistical Bulletin (Vol. 32-39, Anon. 1982-89). Due to extremely low catch rates, fishing effort in 1992 and 1993 was low. For the period 1992-94, 1,000 hours were speculatively inserted for calculations. This value is lower than in 1986 and 1987 when offshore trawling was banned for the whole year and the first 10 months, respectively. Mean water temperatures of Fyllas Bank Station 4 (63°48'N, 53°56'W; 0-200m, November) were obtained by oceanographic standard measurements except for 1992 (Stein, 1992). These data sets are listed in Table 6.

Results

Abundance and biomass estimates for cod (*Gadus morhua*), American plaice (*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 Figures 2 and 3 and listed in Tables 4 and 5, respectively. Precision of these estimates is low, especially for the period 1987-89 with high abundance and biomass. Usually, confidence intervals (CI) vary among 30-60% of the stratified mean and some cases exceed 100%.

Pronounced negative trends in aggregate fish biomass were observed during the periods 1982-84 and 1988-93. Maximum biomass was calculated to amount to 686,000 tonnes in 1987. Since 1988, total fish biomass decreased by 99% to 6,600 tonnes in 1993. The trend in total abundance is very similar. Maximum abundance amounted to 1,300 million fish in 1987. The index of 150 million individuals in 1993 represents a decline by 88%. Mean individual weight decreased simltaneously from 0.738 kg in 1988 to 0.044 kg in 1993.

Both trends in aggregate abundance and biomass were determined by the occurrence of cod (*G. morhua*). During 1982-84, cod showed a declining trend both in abundance and biomass. The following enormous increase until 1987 was caused by recruitment of the strong 1984 and 1985 year classes. Since 1988, this species decreased in abundance and biomass from 786 million to 1.4 million individuals and from 640,000 tonnes to 360 tonnes in 1993 (Fig. 2 and 3, Tab. 4 and 5). Significant changes in length structure were also detected (Fig.4). Strong year classes 1984 and 1985 were found to be absent from the stock while present structure is dominated by 1-3 year old and pre-recruiting fish (19-40 cm).

American plaice (*H. platessoides*) is the second dominating species. During early years of the last decade, abundance and biomass indices varied between 56 million and 115 million individuals and 8,000 and 22,000 tonnes, respectively (Fig. 2 and 3, Tab. 4 and 5). Since 1987, these values decreased to 13 million and 894 tonnes in 1993. Figure 5 illustrates, that the 45% decline in stock abundance from 1992 to 1993 is due to a loss of individuals >14cm.

During the period 1982-84, golden redfish (*S. marinus*, >16 cm) decreased in abundance and biomass and varied until 1986 among 24 million and 132 million individuals and 11,000 and 56,000 tonnes. Since 1986, golden redfish showed a strong decline from 43 million to 1 million individuals and from 18,000 to 384 tonnes in 1993 (Fig. 2 and 3, Tab. 4 and 5). Last year's decline (1992-93) affected mainly the larger fish (>26cm, Fig. 6).

Beaked redfish (*S. mentella*, >16 cm) showed extremely low precision in abundance and biomass indices (Fig. 2 and 3, Tab. 4 and 5). This effect may be caused by the survey area limited at 400m depth which therefore covered only a small part of the total distribution. In 1987, beaked redfish showed pronounced maxima with 15 million individuals and 2,500 tonnes. Abundance and biomass indices decreased significantly to minimum estimates amounting to 190,000 individuals and 29 tonnes in 1993, respectively. The length frequency distribution illustrates that adult beaked redfish (<30 cm) are almost absent from the area at present (Fig. 7).

Juvenile redfish (*Sebastes spec.*, <16cm) dominated abundance and biomass of species summarized under the category "others". Both length distributions in 1992 and 1993 showed less pronounced peaks at the range between 9.5-13.5 cm while numerous juvenile redfish at 6.5-7.5 cm length as observed in 1992 were absent in 1993 (Fig. 8).

During the period 1982-88, abundance and biomass indices of spotted wolffish (*A. minor*) varied among 628,000 and 1.5 million individuals and 1,800 and 8,000 tonnes, respectively (Fig. 2 and 3, Tab. 4 and 5). Since 1988, these indices decreased to minima of 313,000 and 126 tonnes in 1992. Last year's (1993) increase to 530,000 individuals and 415 tonnes is insignificant because both values represent the second lowest indices of abundance and biomass over the total time series. Juvenile spotted wolffish (<34.5 cm) dominated the stock structure in 1992 and 1993 (Fig. 9).

Biomass indices of Atlantic wolffish (*A. lupus*) decreased continuously since 1982 from 26,000 to 1,400 tonnes in 1993 while abundance estimates varied among 8.8 million in 1993 and 23 million in 1982 without any significant trend (Fig. 2 and 3, Tab. 4 and 5). Both values for 1993 represent the minimum of the time series. Comparing the length distributions in 1992 and 1993, a shift to smaller individuals seems evident (Fig. 10).

The only elasmobranch species taken into consideration is the starry skate (*Raja radiata*). In 1982-84, occurrence of starry skate diminished (Fig. 2 and 3, Tab. 4 and 5). Subsequently to high abundance and biomass estimates in 1989, both indices decreased from 19 million to 4 million and from 4,000 tonnes to 600 tonnes in 1993. Last year's estimates (1993) are again record minima. Although the number of juvenile skates decreased in 1992-93, the occurrence of fish <20.5 cm domimates the length structure (Fig 11).

Correlation and regression analyses were applied to annual changes in cod and aggregate fish biomass indices (production) as dependent and temperature fishing effort and indices of cod recruits at an age of 3 years as independent variables. Significant results ($p<0.05$) were calculated for the relation between aggregate biomass production, effort and number of 3 years old recruits. Aggregate fish production is positively affected by increasing numbers of cod recruits at an age of 3 years, whereas annual production decreases with increasing effort. Parameters of these correlations are listed in Table 7. Both correlations were combined by means of a multiple linear regression. This multiple regression resulted in a highly significant function explaining 87% of the observed variability in fish production (Tab.7). The similarity between observed and calculated production is illustrated in Figure 12. Respective values are listed in Table 6. In order to foresee the strength of the recruits at age 3 in 1994 (year class 1991) a regression was calculated between the strength of the cohorts 1980-83 and 1986-90 at age 2 and 3. Year classes 1984 and 1985 are disregarded because of their immense strength. This significant regression and the prognosis for year class 1991 in 1994 is shown in Figure 13 and respective parameters are listed in Table 7. On the basis of 1,000 fishing hours and a calculated number of 1.4 million cod at age 3, no significant change from the low level status of the fish assemblage is prognosticated for 1994 by the multiple function of aggregate biomass production.

Discussion

During 1982-84 and in recent years (1988-93), ecologically important fish species cod (*G. morhua*), American plaice (*H. platessoides*), golden and beaked redfish (*S. marinus*, *S. mentella*), Atlantic and spotted wolffish (*A. lupus*, *A. minor*) and starry skate (*R. radiata*) inhabiting the shelf and the continental slope off West Greenland (0-400m) contributed to the dramatic decline in total fish abundance and biomass (Tab. 4 and 5, Fig. 2 and 3). Since 1987, overall decrease in aggregate abundance and biomass amounted to 88% and 99%, respectively. Apart from the spotted wolffish showing the second lowest value, minimum biomass indices have been determined in 1993 for the remaining 6 species examined. Although sampling effort of the groundfish survey varies both in coverage of survey area and time and precision of resulting abundance and biomass indices is low, these trends must be regarded as significant. Similar declines in fish abundance and biomass without any indication of biomass compensation for other species of the demersal fish community have been observed in NAFO Divisions 2J3KL (Atkinson, D. B., 1993).

Length distributions revealed that at present very small individuals dominate demersal stocks (Fig. 4-11). Overall mean individual weight decreased by 94% from 0.738 kg in 1988 to 0.044 kg in 1993. Pronounced peaks of length distributions of juvenile redfish at 6.5-7.5 cm and 9.5-13.5 cm might correspond to age groups 0 and 1 year as smallest individuals were still silvery coloured without any red gleam (Fig. 8).

Mean temperature in November at Station 4 (0-200m) of the Fyllas Bank oceanograpic standard section was taken as representative of hydrographic conditions off West Greenland. Stein and Buch (1991) tested the hypothesis that subsurface ocean temperatures are predictable from air temperature data sampled at Nuuk. It appeared that late summer air temperature conditions steer upper ocean layer temperatures that are observed in November. Especially anomalous cold conditions in climate during early-1980s are thus reflected by mean temperature at Fyllas Bank.

No significant correlations between annual change in cod and aggregate biomass indices and temperature were found (Tab. 6 and 7). The very cold anomaly observed from 1981 until 1984 possibly contributed to the negative trend in fish abundance and biomass, especially as the following increase of indices coincided with higher temperature in 1985-87. Hansen (1949) described periodical occurrence of cod in Greenland waters and the ichthyofauna was found to be mainly composed of boreal species (Rätz, 1991). Therefore, a correlation between fish abundance and temperature might be expected. However, the second period of decreasing fish abundance and biomass estimates from 1987 until 1991 was lacking any distinct indication of cooling as respective temperatures at Fyllas Bank Station 4 (0-200m) returned to normal. Contrarily, Buch (1993) defines the oceanographic conditions off West Greenland throughout the past 3-4 years as cold on the basis of temperature measurements taken on top of the Fyllas Bank in June (Station 2, 0-44m, 63°58'N, 52°44'W).

The exploitation of fish stocks off West Greenland is mainly directed to cod and redfish. Other fish species are taken more or less as by-catches. Unfortunately, no statistic of fishing effort by depth is documented. To obtain reliable figures, annual fishing effort (hours fished) directed to groundfish (Greenland halibut and shrimp excluded) for otter-trawls>500 GRT was summarized. The considerable shrimp fishery, which affects the demersal fish community by unknown by-catches is not considered due to lack of information. However, the shrimp fishery changed its geographic distribution. In 1992, about 50% of the catches reported in logbooks were taken in Divisions 1C-1F while Divisions 1A and 1B have been most important in the past (Carlsson and Kanneworff, 1993)

A positive and a negative correlation between annual aggregate fish production (dependent) and number of cod recruits at age 3 (independent) and fishing effort (independent) were found to be significant (Tab. 6 and 7). The positive effect of cod recruits to overall fish production is explained by the high number of recruiting cod year class 1984 in 1987 and its growth. Contrarily, years with high fishing activities are characterized by negative changes whereas periods of low effort conincide with steady conditions or positive values. Although the majority of fishing effort is directed to cod, the relationship between cod production (dependent) and fishing effort resulted in a higher p-level and was determined to be statistically insignificant. This might indicate multi species effects of fishing activities comprising a variety of species. Insignificance might also be explained by loss of cod due to an emigration as postulated by Hovgård (1991) and Schopka (1991). The production model based on these two correlations explains 87% of the observed variability in aggregate fish production (Tab. 6 and 7, Fig.12) identifying cod recruitment and fishing effort as probable main factors. In the case that the presented model reflects reality, the management of the demersal fish stocks off West Greenland (Divisions 1B-1F, 0-400m) must be considered as failed. On the basis of minor fishing effort and poor recruitment, the model prognosticates stagnant fish biomass at lowest level for 1994.

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Table 1 Specification of Strata.

stratum	geographic boundaries south	north	east	west	depth (m)	area (nm^2)
1.1	64°15'N	67°00'N	50°00'W	57°00'W	1-200	6,805
1.2	64°15'N	67°00'N	50°00'W	57°00'W	201-400	1,881
2.1	62°30'N	64°15'N	50°00'W	55°00'W	1-200	2,350
2.2	62°30'N	64°15'N	50°00'W	55°00'W	201-400	1,018
3.1	60°45'N	62°30'N	48°00'W	53°00'W	1-200	1,938
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	2,568
4.2	59°00'N	60°45'N	44°00'W	50°00'W	201-400	971
sum						18,273

Table 2 Number of valid hauls by stratum, 1982-93.

stratum year	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	sum
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
sum	246	128	254	89	165	63	204	41	1,190

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 listed fish species, others and total, 1982-1993. Confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean.

Year	G.morhua	CI	H.plates.	CI	S.marinus	CI	S.mentella	CI	A.lupus	CI	A.minor	CI	R.radiata	CI	Others	Total
1982	92,276	29	77,970	32	132,357	111	3,116	105	23,069	25	1,508	33	9,697	39	12,565	352,558
1983	50,203	29	115,415	54	28,714	35	8,884	66	15,427	28	873	42	6,999	88	17,705	244,220
1984	16,684	38	86,227	47	24,091	39	5,405	82	11,023	24	787	27	6,314	45	26,496	177,027
1985	59,343	39	62,397	30	45,471	45	810	115	12,741	33	628	51	7,878	46	50,065	239,333
1986	145,680	35	111,514	45	43,314	43	3,333	76	12,090	31	1,033	31	6,706	48	277,199	600,869
1987	786,392	63	56,248	34	13,157	57	14,765	79	9,568	27	946	42	3,337	33	417,074	1,301,487
1988	626,494	50	33,562	25	14,290	40	8,819	79	10,497	31	935	35	7,148	40	182,560	884,305
1989	358,726	73	38,448	35	9,160	62	303	59	10,560	33	843	42	19,419	39	53,078	490,537
1990	34,524	71	28,876	36	4,996	34	4,649	112	10,414	27	622	35	13,325	54	125,465	222,871
1991	4,805	52	23,785	25	3,724	61	2,425	106	9,863	31	721	34	4,832	27	225,294	275,449
1992	2,042	61	24,106	29	2,193	43	157	94	13,164	29	313	55	10,710	51	142,071	194,756
1993	1,437	32	13,277	20	1,188	53	190	160	8,849	47	530	44	4,126	43	120,464	150,061

Table 5 Survey biomass indices (t) for listed fish species, others and total, 1982-93. Confidence intervals (CI) are given at the 95% level of significance in per cent of the stratified mean.

Year	G.morhua	CI	H.plates.	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	55,682	100	1,109	116	26,002	33	7,950	47	6,091	37	23,428	266,146
1983	82,375	32	22,246	48	14,178	37	4,270	77	12,788	36	5,693	45	2,413	34	16,366	160,329
1984	25,565	39	13,298	51	11,225	47	1,771	89	6,998	26	3,956	33	1,920	37	7,256	71,989
1985	35,672	73	8,354	30	19,634	58	260	108	5,959	26	1,822	44	2,166	24	12,894	86,761
1986	86,717	35	14,726	41	18,068	46	574	65	6,767	25	3,501	38	1,774	32	14,997	147,124
1987	638,589	69	9,810	40	6,553	63	1,307	62	4,950	26	4,178	41	1,067	34	19,759	686,213
1988	607,988	50	4,905	29	5,902	41	2,549	92	4,504	21	4,755	59	1,744	30	20,429	652,776
1989	333,850	66	5,057	55	3,669	64	46	50	4,563	25	2,841	50	3,996	32	5,717	359,739
1990	34,432	70	3,036	36	2,438	46	643	109	3,130	23	2,255	49	2,229	48	4,717	52,880
1991	5,150	76	2,246	28	1,778	74	598	104	2,229	31	1,227	69	908	31	4,633	18,769
1992	607	64	1,991	28	947	49	33	105	2,969	23	126	87	1,054	31	3,428	11,155
1993	359	38	894	21	384	47	29	130	1,448	37	415	84	601	34	2,425	6,555

Table 6 Annual fishing effort (hours fished) directed to groundfish (Greenland halibut and shrimp excluded) for otter-trawls>500GRT, mean water temperature at Fyllas Bank (Station 4, 63°48'N, 53°56'W, 0-200m), indices of cod year class strength 1980-91 at an age of 2 and 3 years, survey indices of annual production in cod and aggregate fish biomass, 1982-93. Values of effort in 1992-94 are speculative and temperature in 1992 is missing (s. text). Values of recruits at an age of 3 years and aggregate production (model) in 1994 are based on prognosis!

Year	Effort	Temp.	Rekruits (1,000)		Annual Production (t)		
	(h)	(°C)	Age 2	Age 3	Cod	Aggregate	Model
1982			884				
1983	21,419	0.68	1,469	2,815	-46,115	-105,817	-244,090
1984	12,862	2.01	38	2,094	-56,810	-88,340	-139,540
1985	3,712	3.14	1,531	898	10,107	14,772	-28,075
1986	1,714	3.34	114,823	4,374	51,045	60,363	-820
1987	1,334	3.26	45,474	692,566	551,872	539,089	540,844
1988	12,012	2.53	3,290	101,820	-30,601	-33,437	-51,282
1989	14,447	2.20	2,583	7,618	-274,138	-293,037	-154,699
1990	16,637	2.60	1,014	2,900	-299,418	-306,859	-185,283
1991	1,909	2.99	208	435	-29,282	-34,111	-6,289
1992	1,000		1,473	227	-4,543	-7,614	4,715
1993	1,000	2.65	832	546	-248	-4,600	4,964
1994	1,000			1,427			5,652

Table 7 Single linear correlation and regression functions between variables as listed in Table 6. Only significant (p<0.05) regressions are given!

Variable dependent	/independent	n	p	coeff. corr.	const. a(x/y)	coeff.regr. b(x/y)
prod. cod	/temperature	10	0.278			
prod. aggrega.	/temperature	10	0.185			
prod. cod	/effort	11	0.076			
prod. aggrega.	/effort	11	0.045	-0.613	119,693.2	-17.9023
prod. aggrega.	/recruits 3y.	11	0.001	0.841	-90,262.9	0.8983
recruits 3y.	/recruits 2y.	9	0.012	0.788	-79.8799	1.8115
(year classes 1984 and 1985 disregarded!)						
prod. aggrega.	/effort	11	0.001	0.934	16,821.9	-12.2839
	recruits 3y.					0.7803

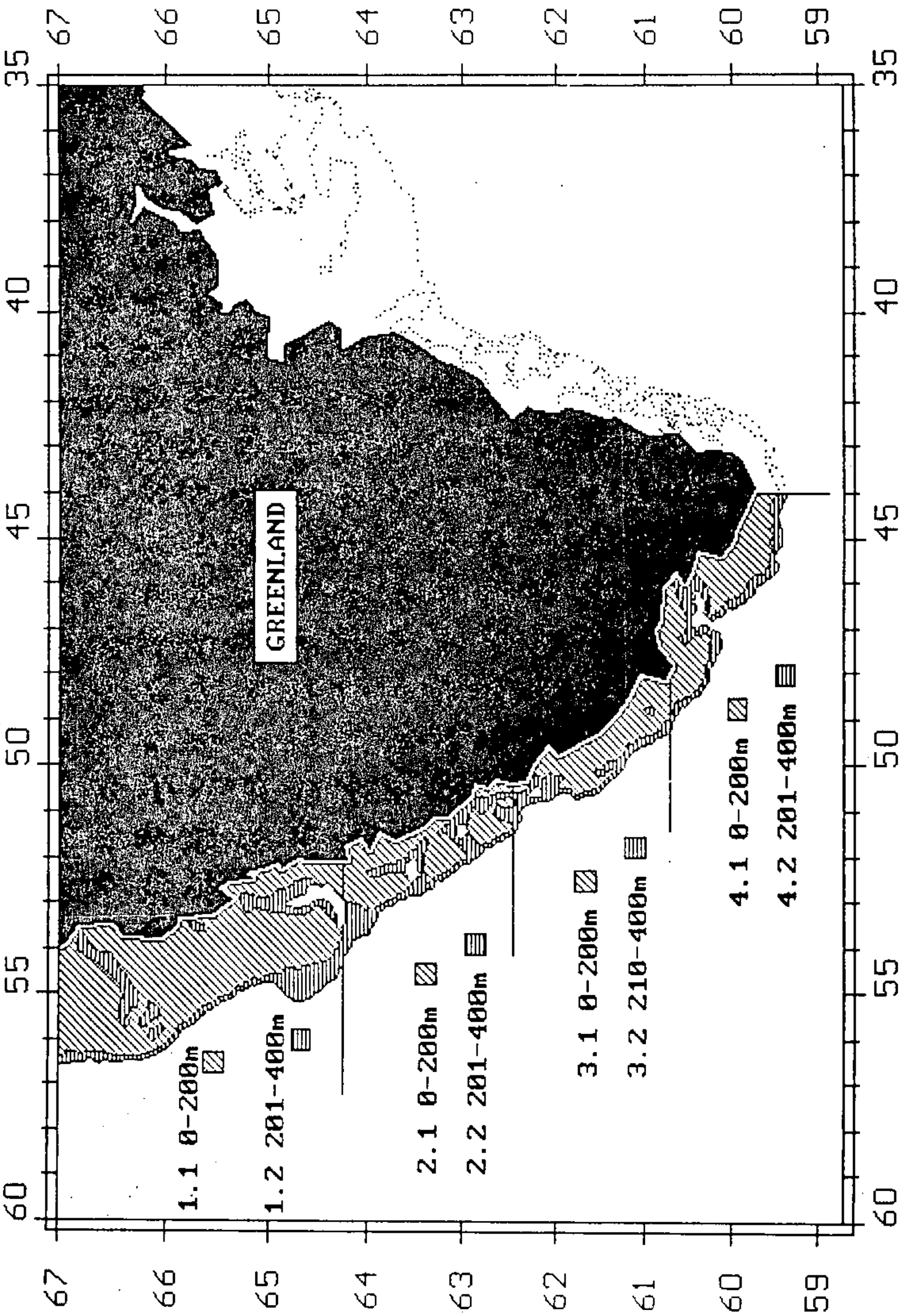

Fig. 1 Survey area and stratification scheme as specified in Table 1.

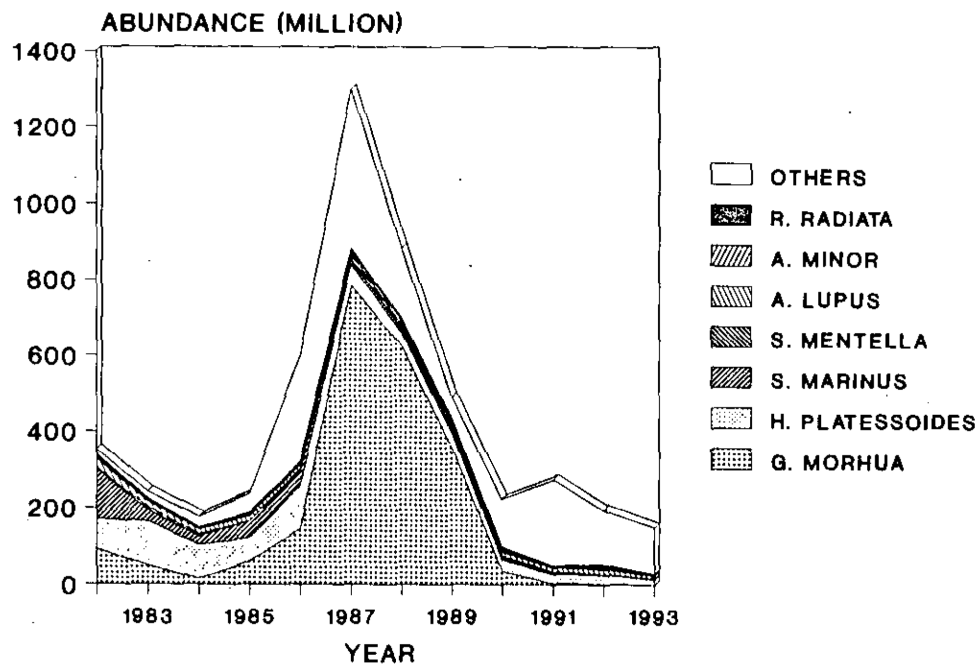

Fig. 2 Aggregate fish abundance indices as listed in Table 4, 1982-93.

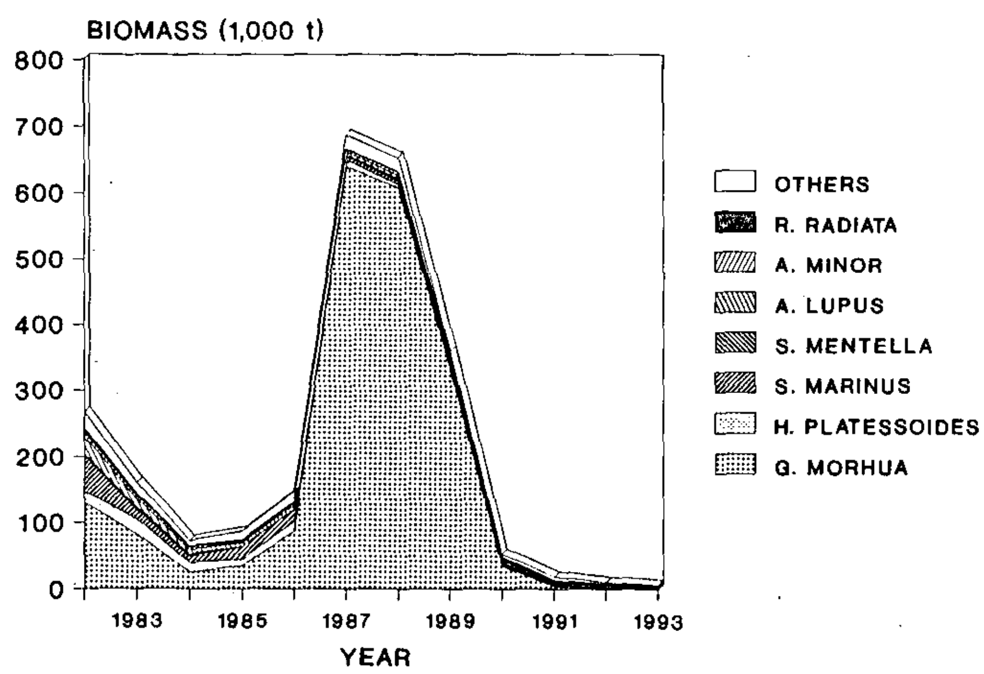

Fig. 3 Aggregate fish biomass indices as listed in Table 5, 1982-93

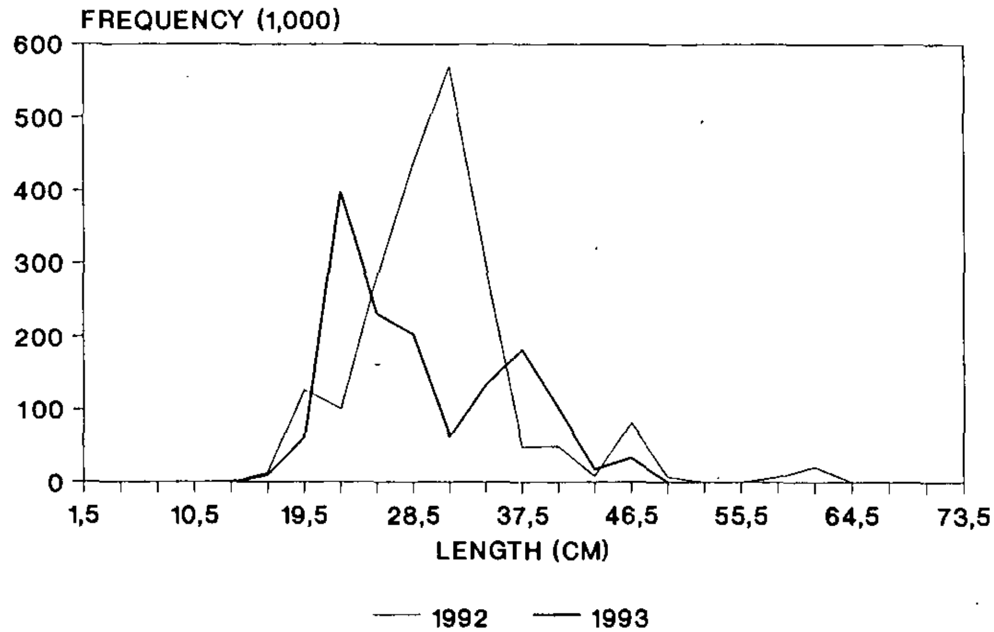

Fig. 4 Cod (*Gadus morhua*), length structure of the stock off West Greenland in 1992 (2,049,000) and 1993 (1,439,000).

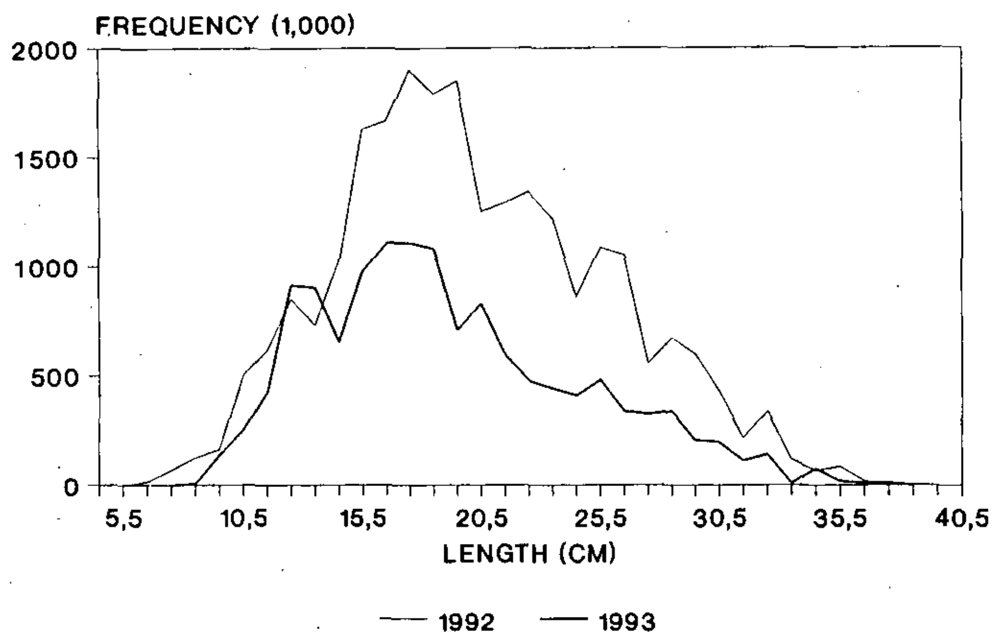

Fig. 5 American plaice (*Hippoglossoides platessoides*), length structure of the stock off West Greenland in 1992 (24,117,000) and 1993 (13,283,000).

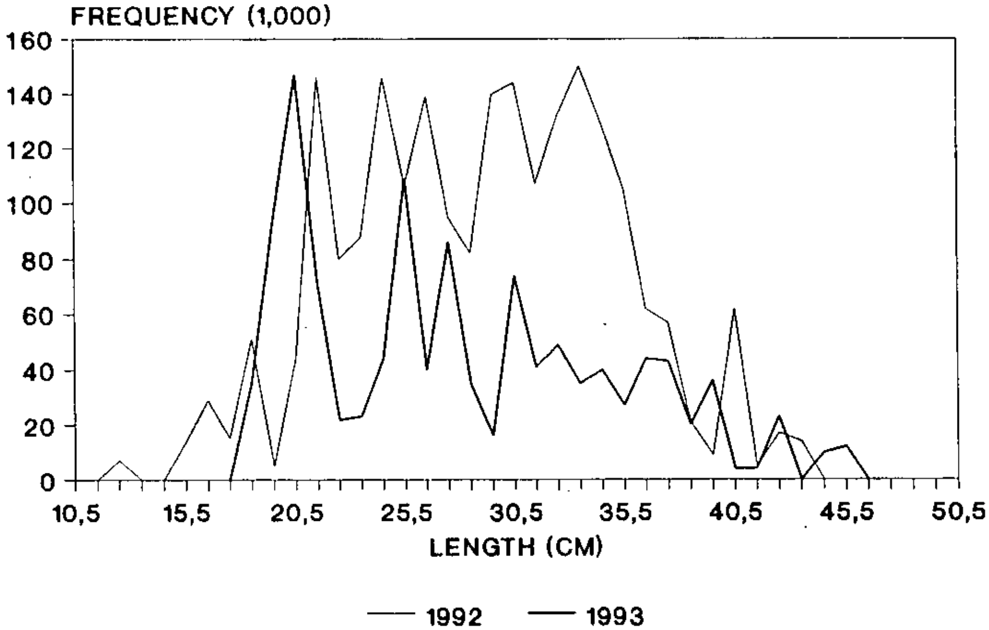

Fig. 6 Golden redfish (*Sebastes marinus*), length structure of the stock off West Greenland in 1992 (2,201,000) and 1993 (1,190,000).

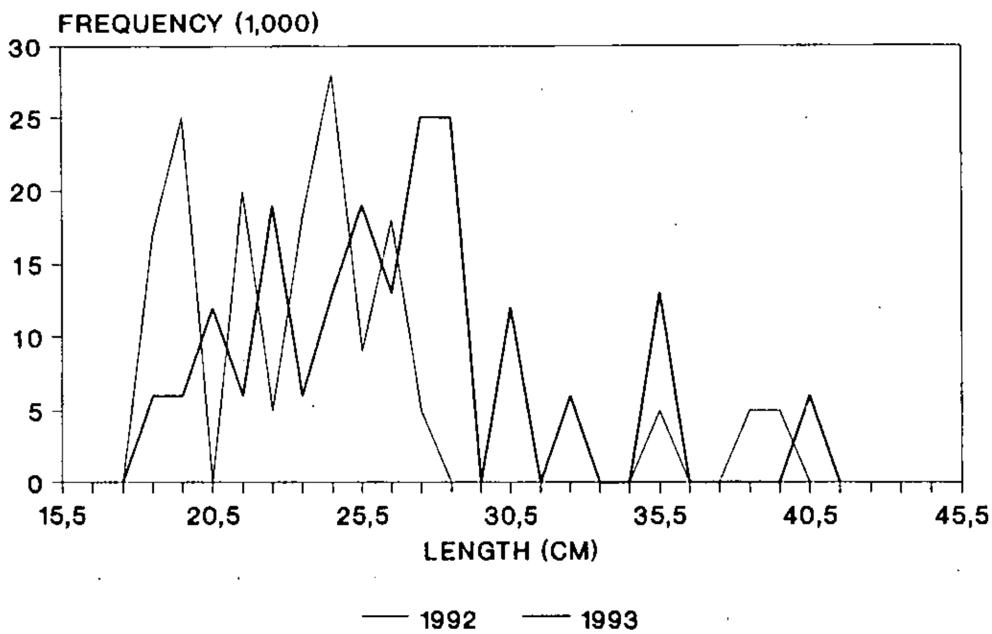

Fig. 7 Beaked redfish (*Sebastes metella*), length structure of the stock off West Greenland in 1992 (160,000) and 1993 (187,000).

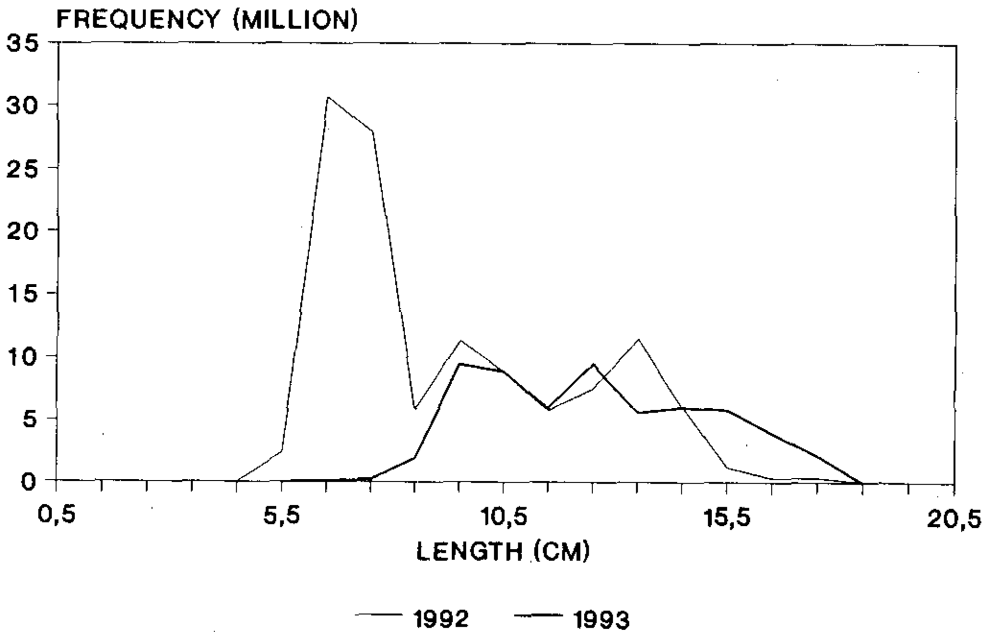

Fig. 8 Juvenile redfish (*Sebastes spec.*), length structure of the stock off West Greenland in 1992 (119,966,000) and 1993 (59,632,000).

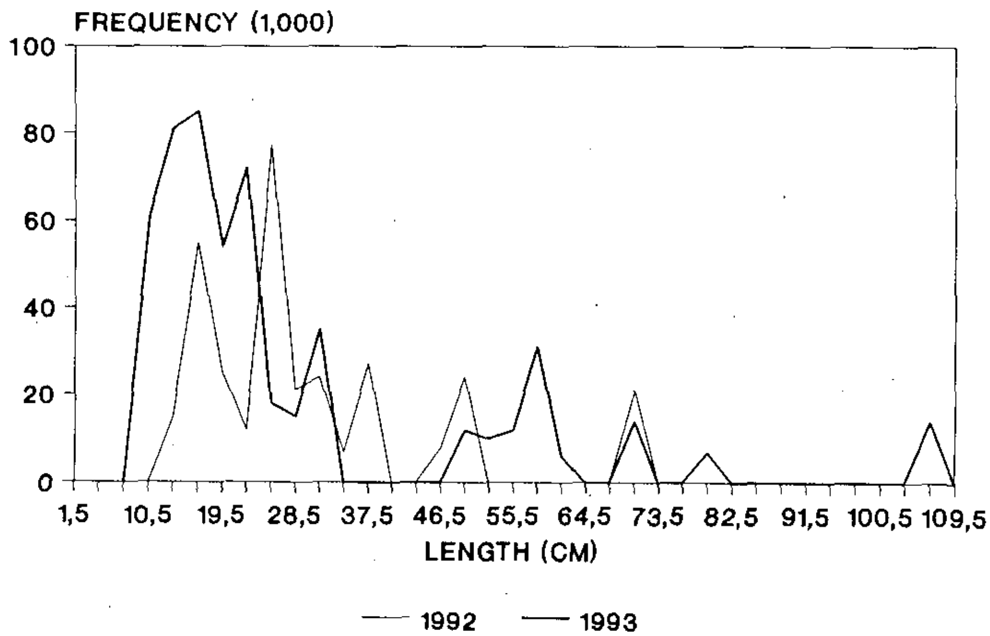

Fig. 9 Spotted wolffish (*Anarhichas minor*), length structure of the stock off West Greenland in 1992 (316,000) and 1993 (527,000).

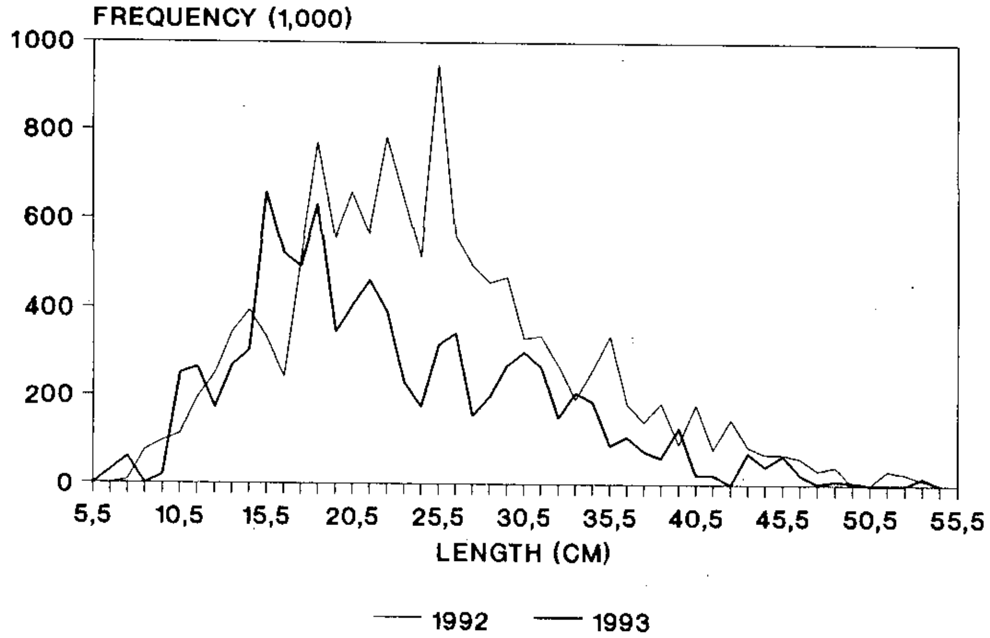

Fig. 10 Atlantic wolffish (*Anarhichas lupus*), length structure of the stock off West Greenland in 1992 (13,167,000) and 1993 (8,853,000).

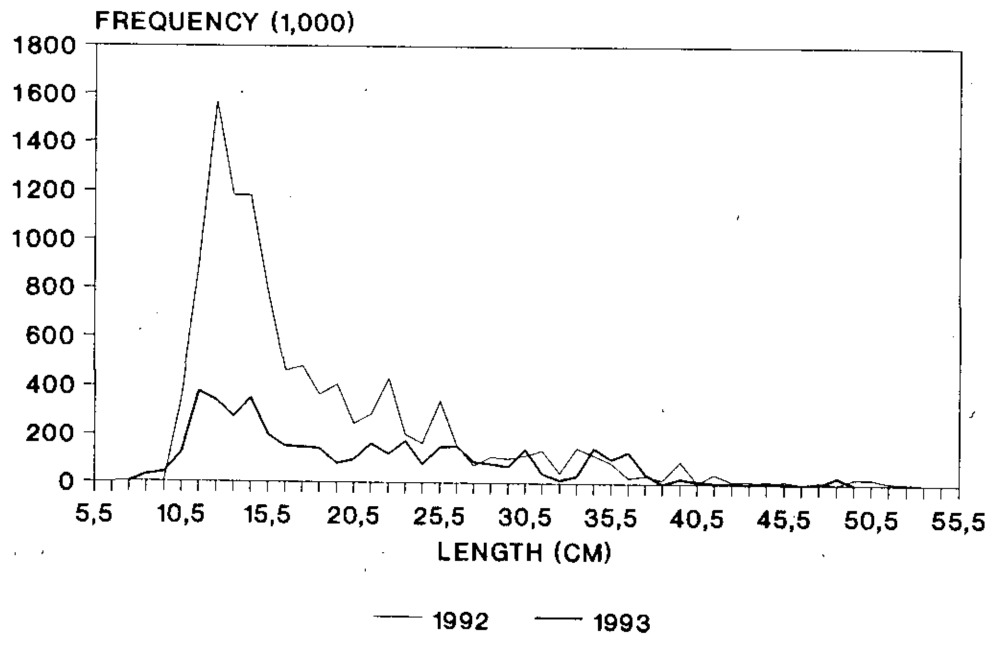

Fig. 11 Starry skate (*Raja radiata*), length structure of the stock off West Greenland in 1992 (10,713,000) and 1993 (4,132,000).

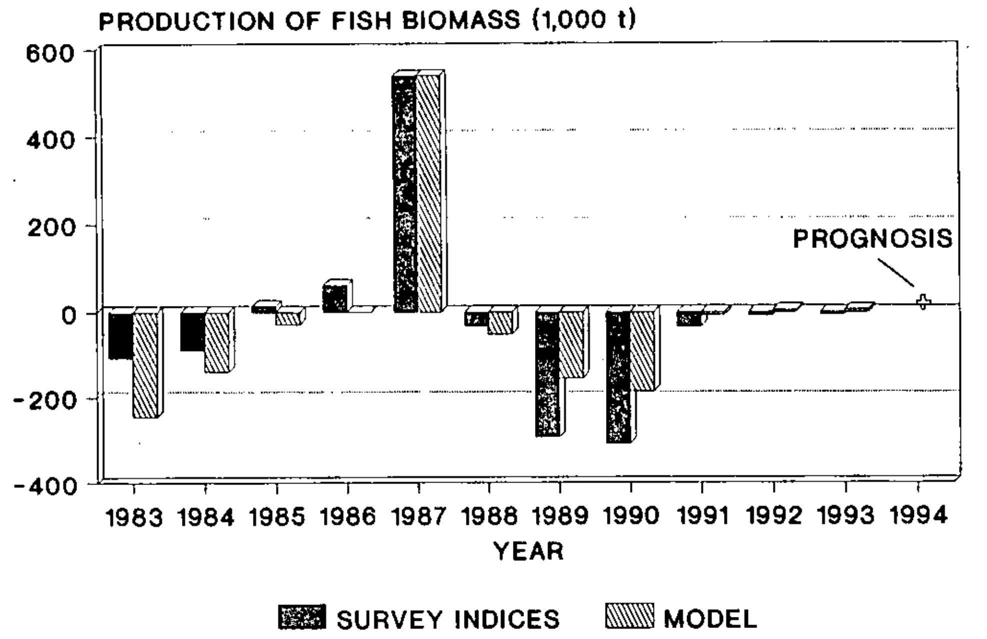

Fig. 12 Production model for aggregate fish biomass based on survey indices for cod recruits at age 3 and fishing effort as listed and specified in Tables 6 and 7. The 1994 value is based on prognosis! p=0.001, r^2=8.87, f(x,y)=16,821.9+0.7803x-12.2839y, x=cod recruits at age 3 (1,000), y=fishing effort (h).

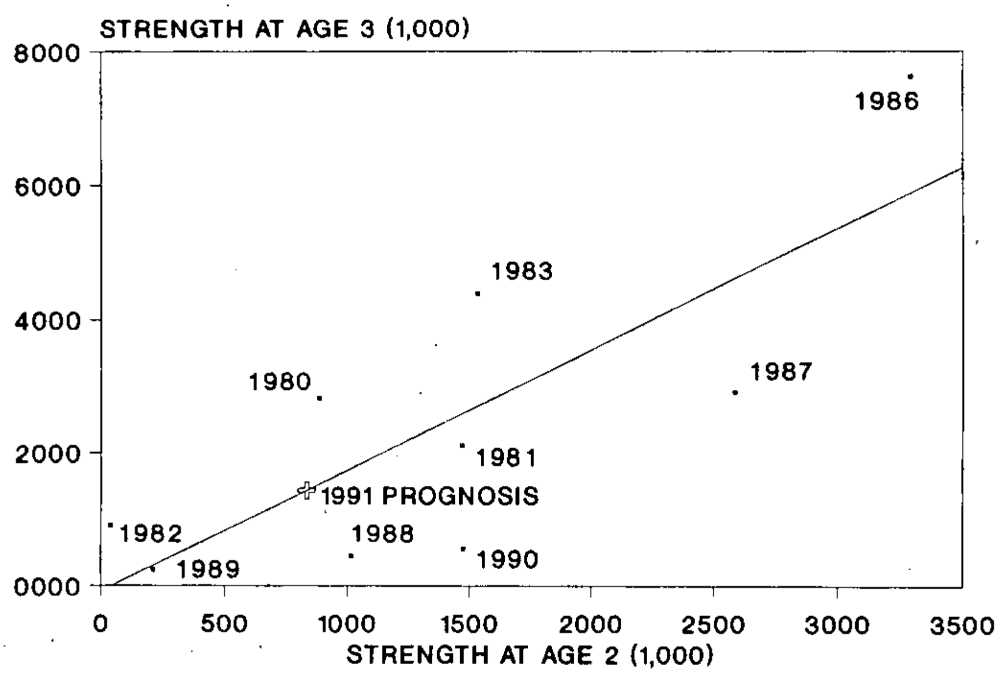

Fig. 13 Regression between survey abundance indices of cod year classes 1980-83 and 1986-91 at an age of 2 and 3 years as listed and specified in Tables 6 and 7. The 1994 value for the 1991 year class is based on prognosis! p=0.012, r^2=0.62, f(x)=-79.9*1.81x, x=cod recruits at age 2 (1,000).