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Stock Abundance and Biomass, Distribution and Length Structure of American Plaice (*Hippoglossoides platessoides*, Fabricius 1780) off West Greenland (NAFO Divisions 1B-1F, 0-400 m), 1982-94

by

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ABSTRACT

During 1982-94, a dramatic decline of the American plaice stock off West Greenland in abundance and biomass by 85% and 94% was observed, respectively. Until 1987, the survey indices were found to vary at a high level. In 1988, the decline of both abundance and biomass was most pronounced and the following period until 1990 is characterized by nearly continuous and dramatic losses. Since 1990, the stock lacked any signs of recovery. The recently depleted status of the American plaice stock off West Greenland is reflected by significant fish size reductions from 28.1cm in 1982 to 20.3cm in 1990 remaining relatively constant at that low level since then. During 1990-94, small fish (15-18cm) have dominated the stock population while a regularely reappering peak around 30cm was not observed any longer. 81% of the abundance and 84% of the biomass were distributed in shallow strata (<200m). A trend of decreasing fish size with increasing latitude suggests the existence of nursery grounds in the northern area off West Greenland. A length-weight relation is given.

Based on a linear correlation and regression analysis between stock biomass and the abundance of small fish (<=16cm) three years later, a stock recovery in the near future seems unlikely because of low recruitment being expected from the extremely low stock biomass in 1992-1994.

INTRODUCTION

Based on annual groundfish surveys commenced in 1982 American plaice was found to be the second dominating species of the demersal fish assemblage off West Greenland and has undergone dramatic changes in abundance and biomass. There are controverse discussions about the effects of climatic conditions and fishing effort and their weight as controlling factors of population dynamics (Rätz 1994; Stein and Messtorff, 1990; Buch and Hansen, 1988).

Significant reductions of the abundance and biomass of some ecologically and economically important fish species off West Greenland, i.e. cod (*Gadus morhua*), golden and beaked redfish (*Sebastes marinus*, *S. mentella*), Atlantic and spotted wolffish (*Anarhichas lupus*, *A. minor*) and starry skate (*Raja radiata*), may be related to the same general causes. Furthermore, it is evident that other American plaice stocks in the Northwest Atlantic have collapsed recently, e.g. in Division 3M (Zamarro, 1991; Morozova, 1991; De Cárdenas and Godinho, 1994) and in Divisions 3LNO (Brodie, 1990; Brodie, Morgan and Power, 1994). For these two American plaice stocks, the existence of a distribution pattern has also been reported (Walsh, 1989, 1990, 1994; Walsh and Brodie, 1987; Brodie and Bowering, 1992). In this context, the paper presents changes in stock abundance, biomass, distribution and length structure for American plaice off West Greenland (NAFO Div. 1B-1F, 0-400m depth).

MATERIALS AND METHODS

Analysis of the stock abundance and biomass indices 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. The autumn season was chosen for the survey because of favourable weather and ice conditions.

The area of investigation is divided in 4 geographic strata, which are represented in Figure 1. Each of these 4 strata was subdivided into 2 strata according to the bathymetry: shallow strata (0-200m) and deep strata (201-400m). Table 1 specifies names of the 8 resulting strata, their boundaries, depth zones and areas.

The standard gear used was the 140-feet bottom trawl with 22m horizontal net opening. This trawl was 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 distribute the sampling effort according both to the stratum areas and to cod abundance. Consequently, fifty per cent of the hauls were allocated proportionally to strata by stratum area while the other fifty per cent were apportioned on the basis of review of the historical mean cod abundance/nm^2. Hauls were randomly distributed within trawlable areas of the strata. Numbers of valid hauls per stratum are listed in Table 2. The main feature of effort distribution shown in this table is the high number of tows allocated in shallow strata 1.1, 2.1, 3.1 and 4.1 (0-200m). The deep strata 1.2, 2.2, 3.2 and 4.2 (201-400m) 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.

Catch number and weight of American plaice (*Hippoglossoides platessoides* Fabricius, 1780) were recorded. Total lengths measurements were determined to the centimeter below. In 1994, 1,589 individual round fish weightings on board were conducted with a precision of 5g. A linear correlation and regression between log-transformed weight and length data was conducted.

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 "relative indices of total stock abundance and biomass". Strata including less than 5 hauls were excluded from calculations. The variation in survey area arising therefrom is negligible as the haul distribution was fairly consistent over the total time series.

Respective confidence intervals (CI) are given at the 95% level of significance in per cent of stratified mean abundance and biomass.

All linear correlation and regression analyses were conducted using CSS Statistical Software, 1991.

RESULTS

Trends in Stock Abundance and Biomass Indices and Spatial Distribution

Tables 3 and 4 list the abundance and biomass indices for American plaice by stratum and total, 1982-1994, with the accompanied confidence intervals. Figures 2 and 3 show the aggregate abundance and biomass indices over the last 13 years. From these tables and figures it can be concluded that:

1. The main feature of the aggregated abundance and biomass indices over the survey years for American plaice is the global decreasing trend in their values, with the latter years estimations being the lowest on record. Abundance and biomass decreased from 80 million in 1982 to 11 million individuals in 1994, i.e. a reduction by 85%, and from 17,000 tons in 1982 to 1,000 tons in 1994, i.e. a reduction by 94%. During 1982-87, abundance and biomass varied enormously among 56-115 million individuals and 8,000-22,000 tons, respectively. In 1988, the decline of both indices was most pronounced and continued since then.

2. During 1982-94, American plaice was found to be most abundant in northern and shallow strata, i.e. strata 1.1 and 2.1, the highest densities per square mile being observed in stratum 2.1. Although the fish decreased from all strata, the pronounced decline of the total estimates in 1988 was finally determined by the losses from the northern and shallow strata. 81% of the total abundance and 84% of the total biomass were found in shallow strata (1.1+2.1+3.1+4.1), thus only 19% and 16% being concentrated in deep strata (1.2+2.2+3.2+4.2), respectively. Comparing the abundance and biomass indices it must be considered, nevertheless, that the area of shallow strata contributes 75% of the total area surveyed. Consequently, American plaice shows no preference in depth distribution.

Length Structure and Size Distribution Pattern

Length disaggregated abundance is given in Table 5 and shown in Figures 4a and 4b for the entire survey period. Weighted mean length at aggregated shallow and deep strata can be taken from Table 6 and Figure 5 while Table 7 and Figure 6 show weighted mean length for strata aggregated by latitude.

1. A continuous decrease of the mean length is the main feature observed from 28.1cm in 1982 to 20.3cm in 1990 remaining relatively constant at that low level since then. During 1990-94, small fish (15-18cm) have dominated the stock population while a regularely reappering peak around 30cm was not observed any longer.

2. Comparing weighted mean length of shallow and deep strata, it is derivable that shallow and deep strata show a parallel declining trend from 28cm and 27cm in 1982 to 19cm and 21cm in 1994, respectively. Both trends are very similar lacking any pronounced differences. By contrast, when comparing the weighted mean length of the strata by latitude, a constant increase of fish size from northern areas, i.e. stratum 1, to southern areas, i.e. stratum 3, is evident. The highly variable estimates for stratum 4 are affected by the sample effort directed mainly to shallow areas but being extremely irregular in deeper soundings because of trawling problems arising from its rough ground.

Weight-Length Relationship

Figure 7 displays the length-weight relationhip for single fish data. With a regression analysis of these data, the equation $W(g)=0.0036105*L(cm)^{3.253315}$ is obtained, parameters of correlattion being $r^2=0.977$, $p<0.00000$.

Relationship Between Stock Biomass and Abundance of Small Fish (<=16cm)

In order to investigate the presence of a spawning stock biomass-recruitment relationship the stock biomass data and the abundance off small fish (<=16cm) were listed in Table 8 as substracted from Tables 4 and 5. The abundance indices of small fish were shifted by 3 years. The data which are shown in Figure 8 were analysed by a linear correlation and regression model, the resulting parameters and function being significant and n=10, $r^2=0.43$, p=0.04, f(x)=4950.4+0.302x. In contrast, insignificance was obtained in cases of time shifting amounting to 2 or 3 years (p=0.58 and 0.28). Based on the results shown in Figure 8 it seems evident, that the recruitment is low when the stock biomass is less than 5,000 tons.

DISCUSSION

During the survey years 1982-94, a dramatic decline of the American plaice stock off West Greenland in abundance and biomass by 85% and 94% was observed, respectively. Until 1987, the survey indices were found to vary at a high level. In 1988, the decline of both abundance and biomass was most pronounced and the following period until 1990 is characterized by nearly continuous and dramatic losses which coincide with a high fishing activity in the area. Although there was no fishing effort directed to groundfish since 1990, the stock lacked any signs of recovery but continued to decline. Although the fish decreased from all strata, the pronounced decline of the total estimates in 1988 was finally determined by the losses from the northern and shallow strata. Decreases have suffered the other main groundfish stocks in that area with a similar magnitude, i.e. cod, golden and beaked redfish, Atlantic and spotted wolffish, starry skate (Rätz, 1994). Furthermore, the stock collapse of the American plaice off West Greenland coincides with the recent depletion of other American plaice stocks in the Northwest Atlantic, e.g. in Division 3M (Zamarro, 1991; Morozova, 1991; De Cárdenas and Godinho, 1994) and in Divisions 3LNO (Brodie, 1990; Brodie, Morgan and Power, 1994).

The existence of a bathymetric pattern in stock distribution has been found for the Grand Bank by Walsh and Brodie (1987), who report that during the period 1984-1986, the shallower strata (55-183m) contained 80% of the American plaice biomass. The same characteristic is observed by Brodie and Bowering (1992) for American plaice in Flemish Cap. They realized from Canadian surveys carried out from 1978 to 1985, that American plaice on Flemish Cap were highest in abundance in shallow strata, generally less than 366m. Those observations do agree with the findings presented that 81% of the abundance and 84% of the American plaice biomass off West Greenland are distributed in shallow strata (<200m). Considering the fish density per square mile, no depth preference was derivable for the West Greenland stock. The occurrence of American plaice off West Greenland beyond 400m has not been determined because of survey strategy being designed for cod. However, there is some evidence from few deep trawls carried that American plaice is also distributed beyond 400m, corresponding with the depth range described for American plaice in the Northwest Atlantic by Scott and Scott (1989). Based on observations of Iglesias, De Cárdenas and Paz (1994) from catches of the Spanish fleet, the presence of American plaice at depths >800m was confirmed.

The recently depleted status of the American plaice stock off West Greenland is reflected by significant fish size reductions from 28.1cm in 1982 to 20.3cm in 1990 remaining relatively constant at that low level since then. During 1990-94, small fish (15-18cm) have dominated the stock population while a regularely reappering peak around 30cm was not observed any longer. Growth indications for single cohorts between successive years are hardly derivable from the length distributions, the only occurring in 1990-1991 with pronounced peaks at 14-15cm and 16-17cm, respectively. While there were no indications for depth dependent size distributions as has also been found for the Flemish Cape stock (Bowering and Brodie, 1994), the resulting trend of decreasing fish size with increasing latitude suggests the existence of nursery grounds in the northern area off West Greenland. The existence of nursery areas for other American plaice populations has been reported in the literature. From the papers published by Walsh (1989, 1990, 1994), it seems clear that three areas of highly concentrated juvenile American plaice are found on the Grand Bank, which might be the nursery areas of that population.

A linear correlation and regression analysis between the abundance of small fish (<=16cm) and stock biomass was carried out in order to assess the recent stock status in relation to future development. Significant results were found for a 3 year time shifting of the abundance of small fish assuming that the stock biomass in a given year is a controlling factor of their abundance 3 year later. These underlying assumptions are made because direct estimations of recruitment and spawning stock biomass are impossible due to unavailability of age determinations and maturity ogives. However, the significance of the model indicates the presence of a recruitment-spawning stock relation and the mean age of the small fish (<=16cm) amounting to 3 years. The tested variation of both variables were found to be insignificant applying a 2 and 4 years time shifting. It should be pointed out, that the significant relation is based only on 10 data points. Consequently, the reduced recruitment in case of a stock biomass amounting to less than 5,000 tons should be taken as a rough estimate. However, a stock recovery in the near future seems unlikely because of low recruitment being expected from the extremely low stock biomass in 1992-1994.

In relation to American plaice in Divisions 3LNO, Brodie (1990) speculates on the factors that could have caused the severe stock decline observed in the mid-1980's arguing that for such a stock not subject to large variations in recruitment, containing fish of about 15 year-classes in the commercial catches, the sudden decreases observed in the indices were difficult to comprehend, as one would expect to see much more gradual changes. According to him, although the recruitment was lower, and catches were higher than the $F_{0.1}$ reference level, neither of these factors fully explain the decreases, and theorises on the fact that very cold water found on the Grand Bank throughout the mid-1980's could have influenced the abundance estimates of that stock, either through changing availability, natural mortality or some other factor. After 1986, and until 1993, biomass and abundance indices of the American plaice stock in Divisions 3LNO continued their decreasing trend, as assessed by Brodie, Morgan and Power (1994). More curious is the case of the American plaice stock in Division 3M. Zamarro (1991) reported for the American plaice stock of the Flamish Cap (Div. 3M), relatively stable biomass from 1983 to 1987 (except a peak in 1986) with a reduction from 1988 to 1990 as observed from Soviet Union and EEC surveys, which really differed in magnitude. Morozova (1991) reported a great decline of both abundance and biomass from 1986 to 1990 in accordance with the results from trawl-acoustic surveys conducted by the USSR. Finally, De Cárdenas and Godinho (1994) report that, despite of the estimated biomass and abundance differences existing between Russian and EEC surveys, it appeared that the stock had steadily declined from 1986 to 1993. When comparing the trend of American plaice abundance and biomass indices in Division 3M with the trend that is presented for American plaice off West Greenland, it is surprising to realize that both show a great decline in the same period 1986-1993, with the same peak in 1986.

Strong conclusions about the factors which led to the actual situation of the American plaice stock off West Greenland and future predictions are hardly to derive from the presented data. Fishing activities directed to groundfish in former years could be a responsible factor of the major observed decline in both abundance and biomass indices. It might also be possible to speculate on the fact that marked changes which has undergone the climate at West Greenland (Stein and Messtorf, 1990) could have had a negative effect on the recruitment process of the stock. It could be argued too that shrimp fisheries taking place nowadays in the area do not allow the stock to rebuild. However, there is good evidence that the stock is at present in a poor status compared to former years, and that it has difficulties to rebuild. In this context further studies, like assessing the population dynamics, accompanied by the consideration of other parameters that could influence the dynamics of that stock and which unfortunately are unknown, e.g. the effect of the by-catches by the shrimp fisheries, would probably help to answer some of the questions arised.

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Table 1 Specification of strata.

Stratum		geographic boundaries			depth	area
	south	north	east	west	(m)	(nm2)
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 2 Numbers of valid hauls by stratum and total, 1982-94.

YEAR	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	TOTAL
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

Table 3 Abundance indices (n*1,000) by stratum and total, 1982-94. Confidence intervals (CI) are given in per cent of the stratified mean at 95% level of significance.

YEAR	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	TOTAL	CI
1982	31584.0	5092.6	29597.3	5734.8	2843.8	2133.1	1041.6		78027.5	31.8
1983	46602.0	6481.0	55493.6	2870.4	2725.4	460.8	811.0		115443.3	53.8
1984	18249.6	6257.9	53764.9	4365.7	2928.5	2244.0	1793.2		89603.5	46.6
1985	21386.8	5973.1	22819.7	6185.6	2631.6	238.6	3161.5		62396.8	29.5
1986	22038.0	11392.8	58740.8	9555.6	2936.7	2387.5	4462.2		111512.8	44.6
1987	23322.1	3314.3	26226.2		2356.4		1029.5		56247.9	33.5
1988	10962.9	3475.1	8026.0	5697.7	3564.6	799.4	1035.7		33562.0	25.0
1989	9371.2	4454.0	11362.7	3774.7	8764.2		1445.0		39171.8	34.0
1990	8616.5	6464.4	8226.6	2613.6	1083.0		1491.5	605.4	29101.6	36.3
1991	7825.7	4536.1	5168.4	1898.9	1516.6	638.5	1249.0	951.8	23785.0	25.1
1992	8529.2	4996.7	3018.7	2704.2	1232.6	1707.3	1743.2	174.4	24106.3	29.4
1993	5855.9	3284.2	1201.6	1212.5	630.8	694.0	398.0		13277.0	19.7
1994	2211.6	3524.2	1488.0	1514.1	623.6	282.2	1660.5	188.8	11493.7	23.9

Table 4 Biomass indices (tons) by stratum and total, 1982-94. Confidence intervals (CI) are given in per cent of the stratified mean at 95% level of significance.

YEAR	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	TOTAL	CI
1982	6048.3	946.9	7797.1	1151	919.2	376.2	155.9		17394.1	33.7
1983	7450.1	1154.2	11772.3	606.9	1008.3	87.7	166.1		22245.6	47.3
1984	1704.0	761.1	8663.0	807.0	606.6	387.2	364.9		13293.6	51.0
1985	1940.1	600.8	3861.8	1061.6	520.0	48.7	321.3		8354.4	30.1
1986	2149.0	1147.2	8429.2	1385.1	703.3	452.1	459.7		14726.2	40.6
1987	3128.9	338.2	5469.6		645.4		227.5		9808.9	39.9
1988	918.7	292.9	1698.8	807.5	814.3	136.6	236.3		4904.5	29.0
1989	519.9	296.3	1476.7	370.5	2120.2		287.6		5070.8	54.7
1990	393.3	396.7	1219.9	313.6	212.8		286.8	221.3	3044.3	35.2
1991	348.9	398.6	487.3	259.7	265.3	125.4	188.4	172.4	2246.0	27.9
1992	581.8	419.3	228.5	183.4	150.9	250.3	151.7	25.1	1991.0	28.1
1993	324.2	221.7	83.1	101.8	66.6	70.7	25.5		893.6	20.6
1994	144.9	415.7	133.7	142.8	64.3	33.8	109.1	28.4	1072.6	32.9

Table 5 Length disaggregated abundance indices, mean length and standard deviation, 1982-1994

Length (cm)	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	10	0	0	0	0	0	0	0
4.5	0	0	0	0	0	10	7	0	5	10	0	0	7
5.5	0	0	0	127	19	0	22	0	0	27	0	0	0
6.5	0	0	0	9	19	41	33	10	0	87	14	0	0
7.5	13	0	10	74	9	58	52	19	32	251	68	0	14
8.5	7	20	36	57	43	84	103	43	44	170	123	7	93
9.5	20	14	53	142	64	90	181	36	161	253	163	136	34
10.5	20	29	86	403	154	359	235	212	370	273	505	251	57
11.5	59	46	148	364	333	367	473	514	569	620	618	430	74
12.5	150	228	368	381	751	540	749	813	1060	1087	846	913	353
13.5	302	404	940	610	1187	668	873	1275	1875	1106	731	904	576
14.5	420	978	1283	1067	2197	1142	1060	1742	2629	1291	1024	654	835
15.5	793	1976	2023	1674	3597	1177	1130	2215	2556	1399	1627	977	1276
16.5	814	2232	2567	2443	6220	1047	1365	2093	2259	1863	1663	1110	1204
17.5	1340	3336	3768	3631	7906	1625	1159	2007	1883	1771	1901	1109	882
18.5	1661	3934	4833	4281	8122	2132	1715	1778	1658	1593	1788	1079	634
19.5	2054	5257	4170	3890	8619	2716	1658	1905	1407	1320	1851	705	488
20.5	2839	8731	5896	4259	9066	3088	1984	2012	1414	1317	1254	827	587
21.5	2737	8334	5740	3752	9715	3140	1802	1866	1008	1218	1292	593	463
22.5	3541	7697	5159	3992	9279	3253	1803	1537	937	942	1342	476	439
23.5	2976	7502	7171	3398	7120	3593	1654	1685	900	1052	1217	442	428
24.5	3802	6773	4220	3281	6310	3085	1431	1878	807	934	857	409	415
25.5	4532	6553	4913	3029	4428	2976	1711	2005	811	919	1086	481	566
26.5	4872	8563	4609	2408	3495	2580	1722	1886	889	735	1050	335	430
27.5	5366	7078	5200	2450	3485	3308	1233	2129	1035	687	552	324	367
28.5	5300	6700	6410	2546	2934	2547	1189	1386	914	600	671	335	247
29.5	5035	4102	4824	2949	3145	2868	1342	1866	1238	454	597	206	259
30.5	5532	5194	4645	2974	3235	3332	1687	1644	967	484	427	199	237
31.5	4302	3381	2769	2243	2910	2714	1369	1251	479	365	215	113	231
32.5	3799	3120	2114	1580	2173	2298	1306	1042	285	312	337	141	133
33.5	2655	2328	2099	1669	1803	1993	841	770	447	182	119	9	60
34.5	2421	2278	1176	1093	1307	1158	592	628	202	167	67	77	60
35.5	2516	2012	749	552	781	851	410	325	121	144	86	17	32
36.5	2043	1818	500	355	358	637	318	200	67	57	21	12	11
37.5	1655	1352	375	244	264	351	198	195	32	19	0	12	5
38.5	1143	1051	291	135	184	135	67	77	37	31	5	0	5
39.5	915	512	210	128	101	132	61	46	5	18	0	0	0
40.5	940	754	84	79	55	73	4	49	4	5	0	0	0
41.5	473	446	69	34	17	33	15	21	0	0	0	0	0
42.5	279	216	48	62	16	21	0	4	0	0	0	0	0
43.5	170	183	19	3	22	0	0	0	0	0	0	0	0
44.5	219	55	8	7	7	4	0	0	0	0	0	0	0
45.5	54	125	15	4	7	4	0	3	0	0	0	0	0
46.5	89	42	0	0	53	0	8	0	0	0	0	0	0
47.5	49	14	0	17	5	8	3	0	0	0	0	0	0
48.5	0	25	0	0	0	0	0	0	0	0	0	0	0
49.5	30	39	0	4	0	0	0	0	0	0	0	0	0
50.5	31	0	0	0	0	0	0	0	0	0	0	0	0
51.5	24	0	0	0	0	0	0	0	0	0	0	0	0
52.5	13	4	0	0	0	0	0	0	0	0	0	0	0
53.5	18	13	0	0	0	0	0	0	0	0	0	0	0
54.5	0	0	0	0	0	0	0	0	0	0	0	0	0
mean	28.1	25.6	24.5	23.7	22.6	25.0	23.5	22.9	20.3	20.0	20.2	19.1	20.1
st.dev.	6.2	5.9	5.5	6.1	5.4	6.2	6.7	6.5	6.3	6.2	5.6	5.5	5.7

Table 6 Weighted mean length (cm, by abundance) for strata aggregated by depth, 1982-94.

YEAR	SHALLOW STRATA 1.1, 2.1, 3.1, 4.1	DEEP STRATA 1.2, 2.2, 3.2, 4.2
1982	28.24	27.40
1983	25.54	26.17
1984	24.53	24.25
1985	23.62	23.97
1986	22.68	22.15
1987	25.24	21.60
1988	23.71	22.91
1989	23.55	20.43
1990	20.46	19.99
1991	18.99	21.89
1992	19.97	20.61
1993	18.42	20.20
1994	19.20	20.98

Table 7 Weighted mean length (cm, by abundance) for strata aggregated by latitude, 1982-94.

YEAR	STRATA 1.1 and 1.2	STRATA 2.1 and 2.2	STRATA 3.1 and 3.2	STRATA 4.1 and 4.2
1982	26.56	29.63	29.74	23.00
1983	24.21	26.53	31.19	26.40
1984	21.31	25.57	26.65	26.80
1985	21.37	25.86	27.46	20.50
1986	20.70	23.33	26.60	20.20
1987	22.48	27.20	29.00	26.60
1988	19.56	25.97	27.69	27.20
1989	18.29	23.28	28.80	27.10
1990	17.10	22.84	26.00	27.29
1991	17.88	20.79	25.80	23.29
1992	19.52	20.47	23.34	19.64
1993	18.51	20.40	21.81	16.20
1994	19.89	20.70	22.45	18.32

Table 8 Stock biomass (tons) and abundance of small fish (<=16cm, n*1,000) three years later as listed in Tables 4 and 5, 1982-91.

YEAR	BIOMASS	ABUNDANCE
1982	17394	7351
1983	22246	14593
1984	13293	5593
1985	8354	6283
1986	14726	8972
1987	9809	11560
1988	4905	8437
1989	5071	7382
1990	3044	5382
1991	2246	4523

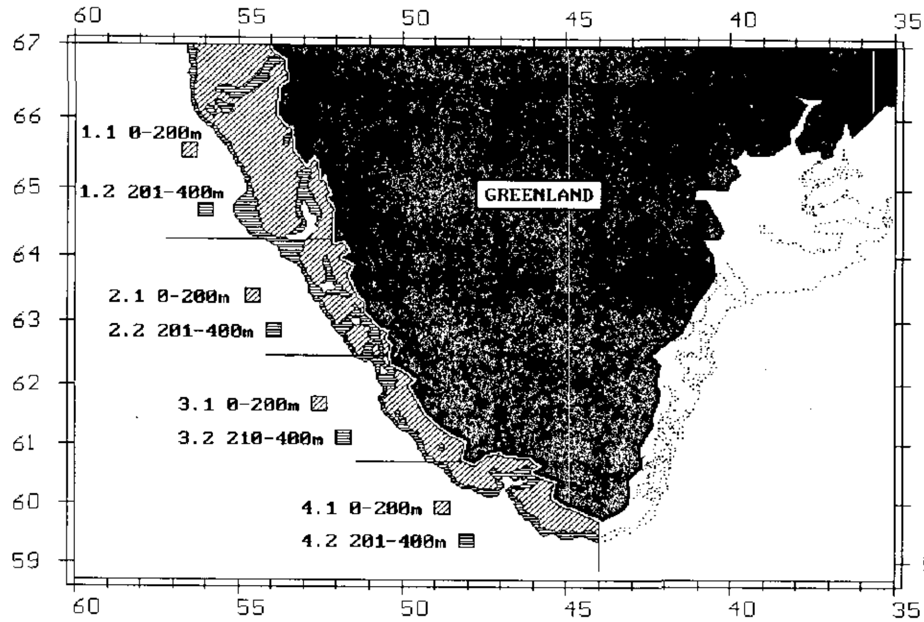

Fig. 1 Survey area and stratification as specified in Table 1.

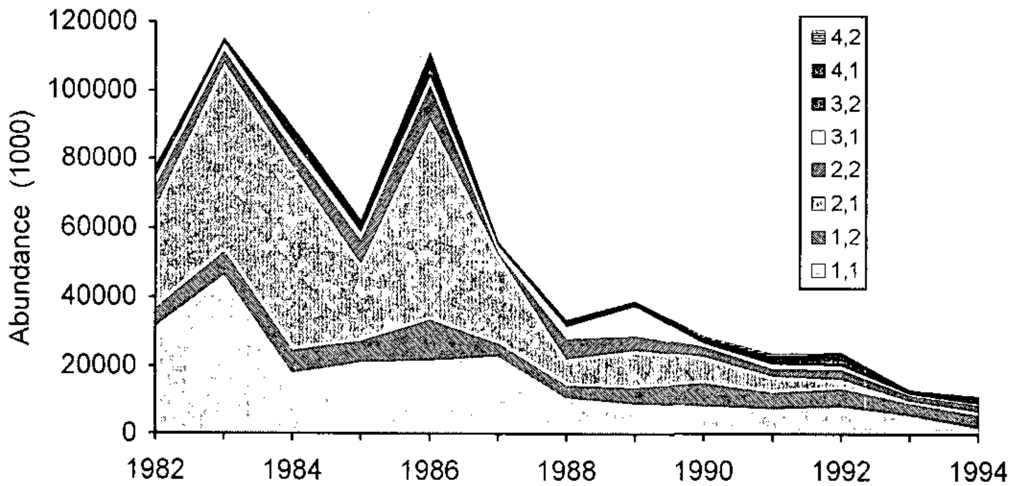

Fig. 2 Aggregate abundance indices by stratum, 1982-94.

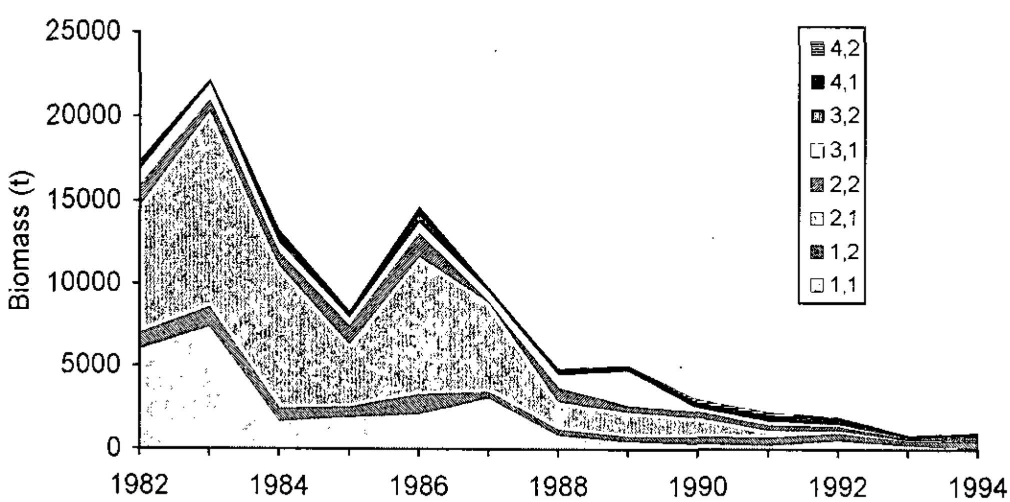

Fig. 3 Aggregate biomass indices by stratum, 1982-94.

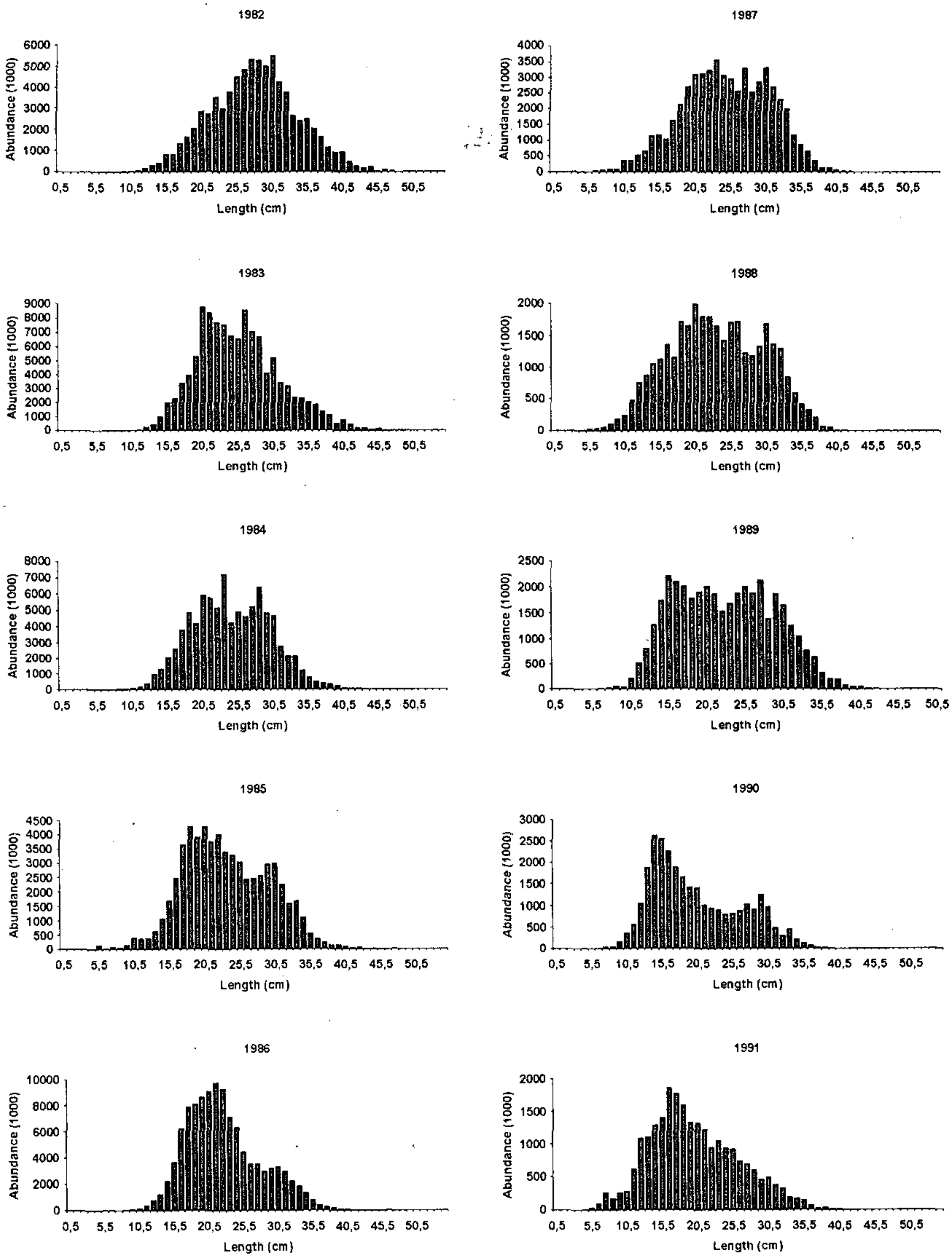

Fig. 4a Length frequencies, 1982-91.

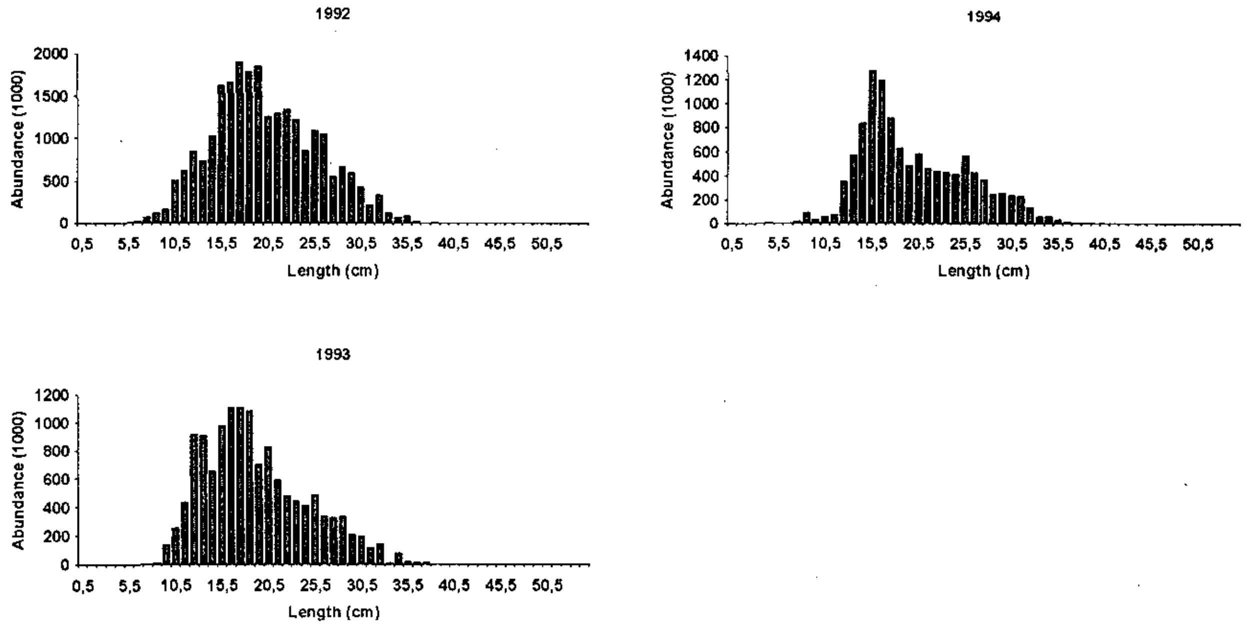

Fig 4b Length frequencies, 1992-94.

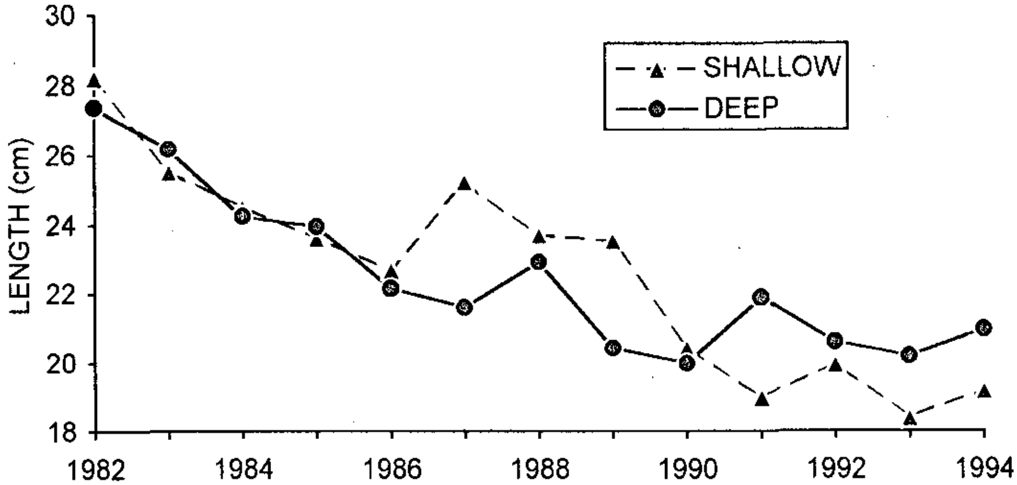

Fig. 5 Weighted mean length (by abundance) for strata aggregated by depth.

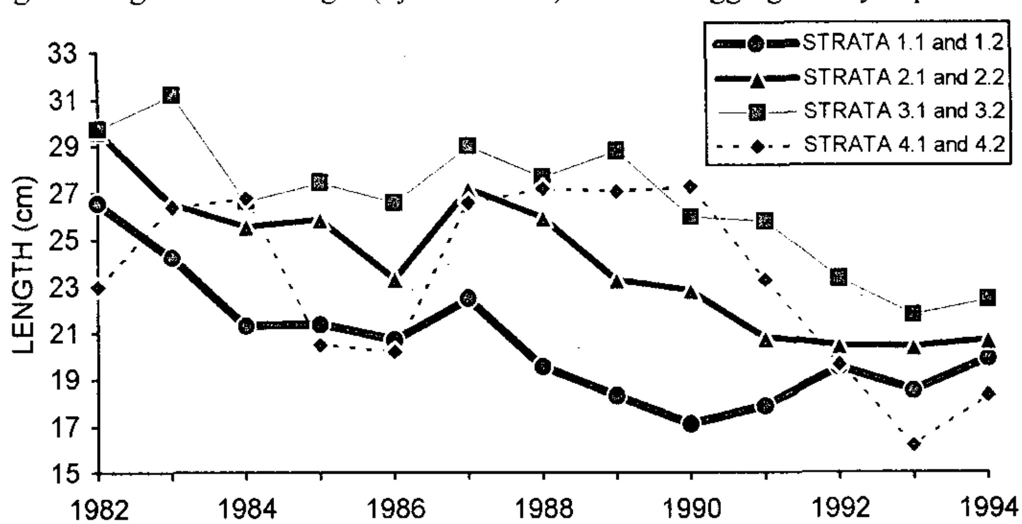

Fig. 6 Weighted mean length (by abundance) for strata aggregated by latitude.

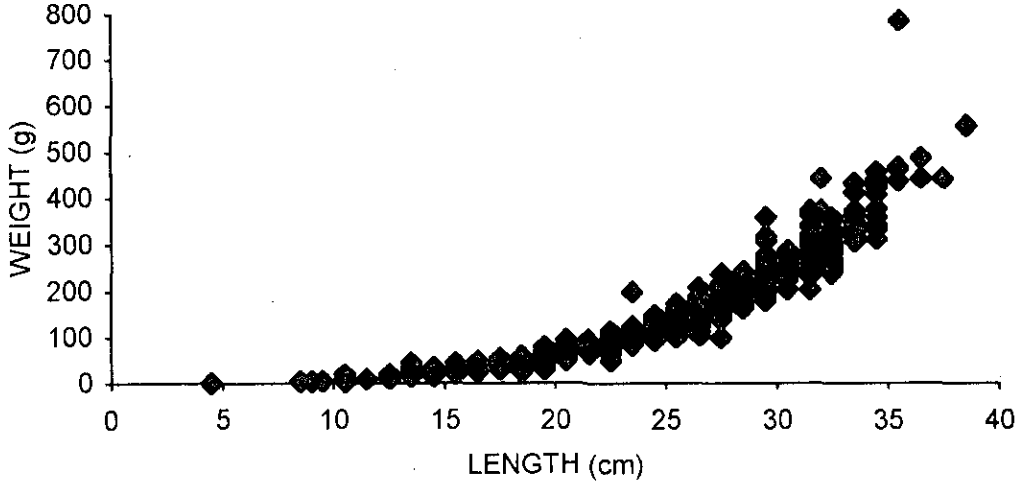

Fig. 7 Length-weight relation : $W(g)=0.0036105*L(cm)^{3.253315}$, $r^2=0.977$, $p<0.00000$.

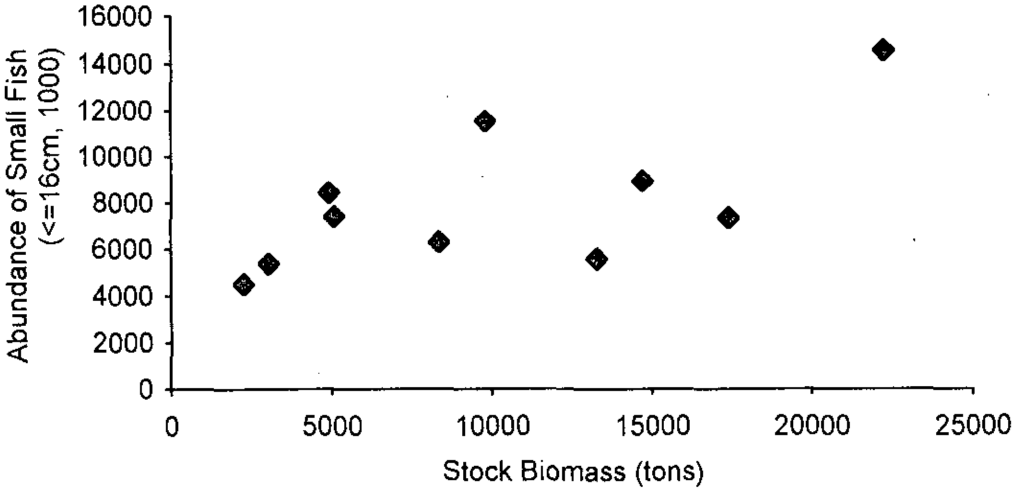

Fig. 8 Stock biomass (tons) and abundance of small fish (<=16cm, n*1,000) three years later, 1982-91.