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Preliminary Assessment of Subarea 1 Cod

by

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1. Introduction

The cod in West Greenland can be considered as being composed of four components spawning in different areas. The West Greenland offshore component spawns off Southwest Greenland (Div. 1DEF) and the eggs and larvae are carried northwards towards the Great Hellefiske bank (Div. 1B). Inshore cod stock components are found in various fiord areas and their offspring probably remains and settles within the coastal area. Moreover, larvae and o-group cod are carried by the Irminger current from spawning areas off East Greenland and from Iceland (Fig 1). The inflow of larvae from Iceland varies from year to year (Table 1) but is for some year-classes, as the 1984 and 1973 year-classes, very important. The nursery areas for these cod are found in southeast and southwest Greenland.

Tagging of cod in west Greenland have shown migration patterns which can be associated with the different stock components. Inshore cod mainly remains within the area where they were tagged whereas West Greenland offshore cod migrates between summer areas in Div. 1BCD and wintering areas in Div. 1DE (Hovgård and Christensen, 1990). Recaptures in Iceland comes primarily from cod tagged in southwest Greenland. The migration from Greenland is observed from almost all year-classes (Riget and Hovgård, 1989) but is most evident for year-classes which were earlier as o-groups observed drifting from Iceland to Greenland.

The contribution of the four stock components to the West Greenland population is believed to have changed significantly during the last century. The year-classes of 1984 and 1985 which have completely dominated the fisheries in recent years are both believed to be mainly of Icelandic origin.

For more information on the stock structure and migration patterns see Harden Jones, 1967, and Anon., 1991.

2. Commercial fishery

2.1 Trends in Catch and Effort

The fishery for cod in NAFO Subarea 1 is partly an offshore fishery mainly carried out by trawlers, and partly a coastal and fjord fishery, dominated by pound nets.

Following low catches during WW-2 catches rose to an annual level of 300-400,000 tons in the 1950-1968 period (Fig. 2) with the major part taken by non-greenland vessels in the offshore areas. Due to recruitment failures for a number of years catches declined significantly after 1968 to a low of 33,000 tons in 1976. With the recruitment of the strong 1973 year-class catches increased to 99,000 tons in 1979. During 1980-83, catches stabilized at a level of 55,000 tons but decreased thereafter by about 50% annually to the low level of only 6,600 tons in 1976, the lowest catch on record since the start of the fishery in the 1920s. From 1987 catches increased significantly due to the recruitment of the very strong 1984 year-class reaching a high of 108,000 tons in 1989. Catches by nations since 1980 are given in Table 2.

2.2 Catch and Effort in 1990

The reported catch in 1990 was about 60,000 t (provisional figures), which is a 42% decrease compared to the 1989 catch. The TAC for 1990 was set to 110,000 tons.

Greenland vessels landed about 51,000 t or 86% of the total catch; the remainder was taken by trawlers from the Federal Republic of Germany and the United Kingdom (Table 2). Trawl catches constituted 65% of the total catch.
Effort and CPUE for Greenland trawlers in 1975-1990 are shown by area in Table 3. In 1990, 98% of the effort was exerted in Div. 1EF and this is the most southerly effort distribution seen in the time series. Within the year there was a shift to the more southern banks. CPUE decreased from second to third and further in the fourth quarter of 1990 (Fig. 2). The overall catch per unit effort decreased from 4.3 t/hour in 1989 to 1.7 t/hour in 1990, i.e. a reduction of 60%.

CPUE from the state owned fresh fish trawlers were analyzed by a multiplicative model (Riget and Hovgård, 1991). The statistics are given in Table 4. The index for 1990 indicates a reduction in the CPUE of approximately 66% compared to 1989.

2.3 Catch in Numbers at Age and Catch Composition

Greenland catches were split into trawl catches and catches by other gears (inshore catches mostly from pound nets) according to information from the fish processing plants.

Greenland trawl and pound net catches were well sampled throughout the year, and samples from pound net were used to convert the total inshore catch into numbers. Trawl catches of the Federal Republic of Germany were raised according to samples from the German commercial fishery as their length frequency distributions differed from those of the Greenland trawl catches. No samples were available from the UK fishery, and the catch in numbers from this fishery were derived by applying German samples.

During the first half of the year age group 6 cod was dominant (80% by numbers) in Greenland trawl catches. This was also observed in the Federal Republic of Germany catches (60% age group 6, age 5 cod accounting for the rest). From August there was a change in age composition with age group 6 and age group 5 respectively accounting for approx. 40% and 60% by numbers in the Greenlandic trawl catches and 20% and 50% in the Federal Republic of Germany trawl fishery. Some of this difference between countries is due to differences in minimum landing size (40 cm set by NAFO; 44 cm bering enforced on Greenlandic landings).

The inshore catches were dominated by age groups 5 (50-90% by numbers) the remaining part being mostly of age 6. In the northern part (Div. 1B) however some age 4 cod (22% by numbers) were caught.

Overall, the 1984, 85 and 86 year-classes accounted for 52, 42 and 6% by numbers (Table 5).

2.4 Discards

Observations on the discarding rates in poundnets and trawl catches were made in the Greenland fisheries (Riget and Hovgård, 1991). The discarding rates in poundnets were 100% for age 3, 73% for age 4 , 34 % for age 5 and 4 % for age 6. However, cod is not damaged by the pound net and if sorted immediately after caching only a small fraction is killed. In the trawl fishery in March 30 % age 5 cod and 1 % age 6 cod were discarded. No cod of younger age groups were caught and the discarding of these age groups could therefore not be estimated.

2.5 Mean Weight at Age in the Catches

Mean weights are based on sample mean-weight raised by the proportion of the catch they cover. UK trawlers were raised by the German statistics. The overall mean-weight at age for 1990 are given by fleet and aggregated in Table 6.

For the age groups of importance (5 and 6 years old cod) the weight at age is low compared to earlier years (Table 7) In a work by Riget and Hovgård (1990) on less aggregated data, and only analyzing fully recruited age groups (5-8 year cod) a significant and large reduction in mean-length at age is observed in the last decade. The same rate of decline in size at age is observed for all age groups. The reason for the decline is not well understood.

2.6 Maturity ogive

In March, 1990, the maturity of cod was observed aboard a commercial trawler in Div. 1F. Only 8% of the 1984 year-class and 6% of the 1985 year-class were found in spawning condition. These two year-classes together accounted for 99% of the total catch in numbers. The maturity ogives are given in Table 8.

3. Surveys and Research

3.1 The German Ground fish Survey off West Greenland

The German trawl survey has been carried out in autumn since 1982. The survey period was November-December in 1982, 1983 and 1985 and October-November in 1984 and 1986-1990. The R/V "Walther Herwig" was used each year except in 1984 when she had to be replaced by R/V "Anton Dohrn". However, experience from a 13-year time series of bottom trawl surveys off Labrador has confirmed that the fishing power of both vessels did not differ significantly.

The standard bottom trawl used in all surveys remained the same in all years. Survey abundance and biomass were calculated by the swept area method, i.e. by assuming a catchability coefficient of 1.0. Therefore, the results are expressed in terms of "trawlable biomass or abundance" and refer to the part of the offshore population available to the gear at the time of the survey.

Approximately half of the survey trawl hauls are distributed proportional to survey area (Table 9). The remaining effort is distributed onto strata with expected high densities of cod, i.e. the upper 200 meters in Div. 1DEF. Actual trawling positions is determined by random selection. The number of fishing stations covered annually is given in the text table below.

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990
Total	111	153	162	133	155	150	176	140	127
Valid sets	98	142	158	114	142	140	162	130	111

From 1982 until 1984, the revealed a major decline in cod biomass and abundance (Fig. 4, and Table 10). The total survey biomass and abundance have increased considerably since 1986 due to increasing recruitment from the outstanding 1984 year-class (Table 11). In spite of additional recruitment, mainly of the 1985 year-class and younger cod, the total abundance started to decline in 1988, whereas the estimate of the total biomass still increased in 1988 due to individual growth.

The survey results in 1989 showed a decrease by 35%, both in biomass and abundance as compared to 1988. Also a pronounced southward displacement of the stock was observed (93% of the total survey biomass and abundance occurring in Division 1EF (Table 11). This decrease was mainly caused by a reduction in the abundance of the 1984 year-class.

In 1990, the survey abundance and biomass declined dramatically as compared to 1989. In numbers from 361 mill. to 35 mill.; in weight from 350.000 tones to 34.000 tones (Table 11).

The decrease is seen especially by nearly complete disappearance of the 1984 year-class, but also by a significant reduction in abundance of the now dominating 1985 year-class.

The reduction in the abundance of the 1984 and 1985 year-classes is observed in all areas. The stock is still southerly distributed with 88% of the survey biomass and 82% of the survey abundance found in Div. 1EF.

The changes in length and age composition as observed by the survey since 1988 are illustrated in Figure 5.

In 1990 a few 0-group cod were caught in Div. 1F. 0-group size cod are never taken in high numbers, and their survey abundance do not give a good reflection of later year-class size.

3.2 West Greenland young cod survey

Since 1985 Greenland has carried out a survey on young cod in inshore areas of West Greenland(Nygård & Pedersen, 1991). The survey covers three inshore areas in Div. 1B, 1D and 1F. Strings of gillnets with different mesh sizes is used as survey gear. The mesh sizes used efficiently catch the age 2 cod whereas only the larger cod of age 1 is taken. Catch per hour is used as an index of year-class size.

The overall catch per hour has been used as an index of year-class strength. Up to 1988 this index correlated well with the abundance estimate of age 2 cod found in the ground fish survey. However, the correspondence between the two indexes was poor in 1989 and 1990.

Index of 2-year old: 1984 year-class set to 100.

year		1986	1987	1988	1989	1990
trawl	(offshore)	100	35	3	2	1
gillnet	(inshore)	100	22	6	17	9

The inshore catch rates is quite different in the three areas over the years (Table 12). In 1986 the catch rate was high in all areas. In later years it has generally been high in Div. 1B whereas the catch rates in Div. 1D and 1F has varied considerable with the trend in Div. 1F closely resembling the offshore abundance as seen in the ground fish survey.

It therefore seems misleading to use the overall gillnet index as a measure of year-class strength. The high catch rates taken inshore since 1988 in Div. 1B and in 1989 in 1D probably merely reflects good year-classes from the local fiord populations.

3.3 Tagging off West Greenland

In august 1989 Greenland conducted a cod tagging experiment off South West Greenland. A total of 2500 cod were tagged, almost exclusively belonging to the 1984 year-class. At present only year 1 recoveries are complete (Hovgård and Riget, 1991).

In total 39 tags were returned in 1990 of which 14 (36%) were caught off Iceland. Historically, recoveries at Iceland shows up with largest numbers 2 to 3 years after tagging at West Greenland. From previous tagging experiments covering the same tagging locations only 6.1% of the first year returns were from Iceland. Moreover, the previous tagged cod were much larger than the ones tagged in 1989. Analyzing previous tagging experiments including only cod tagged within the size range tagged in 1989 leads to a first year proportion of returns from Iceland of only 1.8%. The results of the tagging experiment therefore indicates a substantial migration from West Greenland to Iceland.

3.4 Other research information

Surveys in deeper waters after Greenland halibut by Japan (covering depths between 400-1500 m) and shrimp by Greenland (150-600 m) have been carried out in Div. 1ABCD since 1987 and 1988, respectively. In both surveys stations are randomly selected and distributed according to sizes of strata.

In 1990 two Greenland halibut surveys were made (June and September), with almost no cod caught. The shrimp survey in 1990 also showed very few cod. These findings in the deep water surveys is in accordance with the normal distribution pattern as cod is rarely found in the deeper waters. However, the observed changes in cod abundance and distribution seen in 1990 can not be explained by a migration of cod into deep water areas.

A survey by the Federal Republic of Germany, with the objective to collect cod stomachs, were carried out in July-August in Div

1B, 1D and 1F. Even when searching for cod by acoustics, the numbers caught in Div. 1B and 1D were very low. In Div 1F the fishing was concentrated in areas with a concurrent commercial trawl fishery, and catches amounted to 1,320 cod in 4 hauls. This distribution pattern is in accordance with the distribution of the commercial fisheries and with the distribution in autumn as seen in the German ground fish survey.

Searching for cod for tagging in coastal and bank regions in Div. 1DEF showed only quantities of cod in one area (coast in Div. 1D), and abundance was low compared to the tagging survey of the previous year.

4. Information on Cod off East Greenland

German ground fish surveys has been carried out in September-October off East Greenland since 1980 (Table 13 , Fig. 6). The survey abundance declined from 19 mill. in 1981 to 6 mill. in 1982. The stock remained at this level until 1985 after which the abundance increased to 17 mill. due to the recruitment of the 1984 year-class. This stock size was maintained until 1989 where the abundance increased to 54 mill. cod. In 1990 the abundance decreased to 17 mill. The stock has since 1987 been dominated by the 1984 and 1985 year-classes with an increasing dominance of the 1984 year-class since 1988.

Due to the recommendations by the ICES Working Group on cod stocks off East Greenland (Anon., 1990) the TAC of West and East Greenland were combined to a single TAC for the entire area. This allowed the trawl fishery to move to East Greenland. As a consequence landings in 1990 increased by 100% compared to 1989 (Table 14).

5. Information on the Cod Fisheries in Early 1991

Catch rates off West Greenland has been poor in spring which is usually the period with the best fishing. Monthly averages for the Home Rule trawler has been between 700 and 1,100 kg pr. hour (cf. Fig. 3). Total trawl catches by the end of April amounted to 1,963 tons compared to 16,402 tons in the same period in 1990. The fishery takes place in Div. 1F. Age samples from January and February show that 78% belongs to the 1985 year-class and only 17% to the 1984 year-class and 5% to the 1986 and 1987 year-classes. In East Greenland catches amounted to 7,761 tons by the end of April compared to 11,089 in the same period of 1989.

6. Assessment

During 1989 a large displacement of the cod stock from West to South Greenland was observed. It could not be concluded whether this was due to environmental changes or whether it was a spawning migration to East Greenland or Iceland (Anon.,1990).

In 1990 the offshore trawl fishery off West Greenland took place even more southerly with almost no catches taken north of division 1E. During 1990 catch rates declined and the offshore fishery has almost stopped in spring 1991 with catches taken until May being 88% lower than the same period last year. The decrease is most apparent for the 1984 year-class which in spring 1991 account for 17% of the catches as opposed 80% last spring. For this age group catches is thus down by more than 95%.

Catches in East Greenland doubled in 1990. In 1991 catches from January to April is down by 30% compared to last year.

1990 survey abundance and biomass decreased in all areas of West Greenland compared to the 1989 survey. The 1984 and 1985 year-classes which accounted for about 90% of the stock according to the surveys was reduced from 327 mill.in 1989 to 30 mill. in 1990. The survey also showed that the stock was concentrated in division 1EF. The 1. year tag returns, from tagging experiments conducted in 1989, showed an unusual high proportion of returns from Iceland.

Altogether the available information indicate a significant migration from West to East Greenland and further to Iceland in 1990, especially for the 1984 year-class.

It is likely that the migration from West Greenland to Iceland is a return migration to where the cod were initially spawned. In this case the proportion migrating is related to the stock composition in West

Greenland. For year-classes where the cod of Icelandic origin are abundant relative to the true West Greenland stock the proportion migrating will be high. The migration rate was estimated to 0.05 (mortality units) from tagging experiments carried out in the 1950s and 1960s (Anon. 1971). In this period the West Greenland stock component was abundant. In recent assessments a migration rate between 0.05 and 0.30 have been used. Values higher than 0.05 is justified as the West Greenland stock component have been weak for the last 20 years. In last years assessment a value of 0.15 were used (Riget, 1990) as this level could on average account for the migration to East Greenland in the 1983 to 1989 period (Anon., 1990). However the 1984 year-class were subjected to a migration of 0.25 in 1989 to account for a considerable migration to Iceland (op cit). With the dramatic decline observed in 1990 for the 1984 year-class a much higher migration must be expected in that year. Total mortality of this year-class observed in the surveys is estimated to 3.3.

In this situation where the migration rate far exceeds the fishing mortality there is no basis for conducting an analytical assessment. Previous assessments have, however, shown that the survey and VPA estimates of stock size are of the same magnitude (Anon., 1990).

7. Future Recruitment

1987 year-class

This year-class shows low abundance in all Divisions in the trawl survey, whereas the gillnet survey reveals higher abundance in the northern divisions. Based on the trawl survey abundance as age 3 cod, the year-class size is estimated to 3% of the 1985 year-class.

1988 year-class

This year-class shows a very low abundance in the south in both gillnet and trawl surveys. The gillnet survey gives an index value around 35 to 40% of the 1985 year-class, whereas the trawl survey only gives an abundance of 3%. The gillnet index is an average of catch-rates in three inshore areas and high abundance was only observed in one area (Div. 1B). This might merely reflect the recruitment from a local fjord population. The overall abundance of the 1988 year-class is therefore estimated to be low.

1989 year-class

No cod larvae were taken by R/V Poseidon off West Greenland in 1989 (Wieland, 1991) and very few 1-year old were caught in the bottom trawl survey in 1990, and only in the southern areas. No 1-year old cod were caught in the gillnet survey. Significant numbers of age 1 cod are seen in the gillnet survey, when the year-class is very strong, e.g. in 1985. The size of the year-class must therefore be expected to be low.

1990 year-class

Some 0-group fish were caught in the trawl survey in Div. 1F. No significant inflow of larvae from Iceland should be expected (Table 1). The expected year-class size is at present difficult to assess, however there are no signs indicating a big year-class.

8. Forecast

The cod stock measured as age 3+ cod by the German survey in November 1990 is about double that observed in the period 1983 to 1986, i.e the years prior to the recruitment of the 1984 year-class. Catches in this period in the year succeeding the surveys were between 7 and 15 thousand tons. Catches of cod could therefore be expected to reach levels between 15 and 25 thousand tons in 1991.

The stock is now dominated by the 1985 year-class of which a significant proportion is probably of Icelandic origin and an above average migration of this year-class could therefore be expected. It might be that the 1985 year-class will disappear in 1991 as did the 1984 year-class in 1990. Cod of the 1986 year-class and younger are scarcely represented in as well surveys or offshore trawl catches. However in some inshore areas these year-classes are relative abundant. Under these circumstances it is fruitless to try to estimate stock development in the coming years from the latest survey abundances.

Based on the present weight at age, the historical fishery pattern and migration rates and natural mortalities as used in recent assessments (Table 15) a yield per recruit curve is constructed (Fig. 7). F(0.1) is found at F=0.43 whereas F(max) is not defined.

The year-classes of 1987 to 1990 are all expected to be small. Conventionally a recruitment size of 20 mill cod age 3 has been used in projections for small year-classes. Assuming a fishing mortality of 0.43 and the associated yield per recruit a steady recruitment of 20 mill cod leads to a annual catch of approximately 9000 tons. This catch level must of several reasons only be taken as indicative. Size at age has shown considerable decrease in the 1980s and this trend might be reversed. Also the fishery pattern might change if a larger proportion of the fishery is carried out by poundnet fishing on the local fiord stock components. Finally the migration rate might differ from the value of 0.15 used. However, a catch level of 9,000 tons agrees with the levels taken in the years just prior to the recruitment of the 1984 year-class.

The prospects for the fishery are poor at least until 1995 where the 1991 year-class, which size is still unknown, is recruited. Catches in 1991 and 1992 where some cod of the 1985 year-class is still available should be expected in the range between 15 and 25 thousand tons annually. In 1993 and 1994 catches is not expected to exceed 15 thousand tons. The inshore summer fishery will be effected to a lesser degree than the offshore trawl fishery as the relative importance of the local fiord stock will increase.

As has been the case in later years the expected development in length distribution of stock and catches have been requested by Greenland. Previous attempts to estimate size distributions has generally not been successful due to unexpected low growth of the 1984 and 1985 year-classes. Under the present uncertainties it is even more difficult to estimate the future size distributions. However, catches in the inshore areas are dominated by younger cod and as this fishery is expected to be the most important in the coming years only a small proportion of the catch is expected to exceed the size of 55 cm.

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Table 1. Abundance indices of O-group cod from the international and Icelandic O-group survey in the East Greenland/Iceland area, 1971-1989 (except 1972).

Year-class	Dohrn Bank East Greenland	SE Iceland	SW Iceland	W Iceland	N Iceland	E Iceland	Total
1971	+	-	-	60	214	-	283
1973	135	10	107	96	757	86	1,191
1974	2	-	-	22	30	+	54
1975	+	-	2	50	73	5	130
1976	5	9	30	102	2,015	584	2,743
1977	7	2	+	26	305	94	435
1978	2	-	+	169	335	47	552
1979	2	+	1	22	345	+	370
1980	1	2	+	38	507	10	557
1981	19	-	-	41	19	-	78
1982	+	-	+	7	4	-	11
1983	+	-	+	85	66	2	153
1984	372	5	+	200	826	369	1,772
1985	32	+	+	581	197	2	812
1986	+	1	2	15	32	+	50
1987	7	-	1	2	61	10	81
1988	0	-	1	7	12	+	20
1989	1	-	3	7	30	+	41
1990	3	-	+	2	30	2	37

Table 2. : Nominal catches of cod in NAFO Subarea 1 (1980-1990).

Country	1980	1981	1982	1983	1984
Faroe Islands	-	-	-	1,139	-
Germany, Fed. Rep.	1,024	417	8,139	10,158	8,941
France - M	-	-	-	-	-
Greenland	45,838	53,039	47,693	44,970	22,041
Japan	-	-	-	-	13
Norway	-	-	-	-	5
United Kingdom	-	-	-	1,174	-
Total	46,862	53,456	55,832	57,641	31,000
Working Group estimate	54,000	-	-	-	-

Country	1985	1986	1987!	1988!	1989!
Faroe Islands	-	-	-	-	-
Germany, Fed. Rep.	2,170	37	68	6,352	12,763
France - M	-	-	-	-	-
Greenland	12,319	6,546	12,283	52,166	88,526
Japan	-	-	9	2	-
Norway	-	-	-	-	-
United Kingdom	-	-	-	1,027	3,987
Total	14,544	6,583	12,360	59,166	105,276
Working Group estimate	-	-	-	62,166	108,017

Country	1990!
Faroe Islands	-
Germany, Fed. Rep.	6,512
France - M	-
Greenland	51,405
Japan	-
Norway	-
United Kingdom	2,127
Total	60,044
Working Group estimate	-

Table 3. NAFO Subarea 1 cod: effort (hours fished) and catch per unit effort (kg/hour) for Greenland trawlers in 1975-1990. Only figures for directed cod fishing area used.

	1B		1C		1D		1E		1F		Total	
Year	Hours	CPUE	Hours	CPUE	Hours	CPUE	Hours	CPUE	Hours	CPUE	Hours	CPUE
1975	392	69	6,789	1,448	4,486	325	2,489	502	248	359	14,404	878
1976	170	50	4,430	637	5,044	601	5,831	882	23	112	15,498	710
1977	-	-	2,434	919	1,675	871	3,471	1,486	122	2,175	7,702	1,184
1978	-	-	3,634	3,039	679	3,053	891	3,410	62	2,563	5,266	3,098
1979	27	20	2,991	1,941	1,226	2,583	396	1,598	11	2,007	4,651	2,070
1980	791	2,033	1,804	987	2,401	792	1,156	1,183	36	715	6,188	1,080
1981	-	-	1,279	2,910	1,856	2,292	953	4,064	5	30	4,093	2,895
1982	100	1,091	1,938	1,878	4,398	1,545	3,362	2,497	17	575	9,815	1,931
1983	927	296	625	817	4,107	876	6,323	1,645	120	882	12,102	1,230
1984	71	24	22	27	1,891	903	2,285	960	318	551	4,587	889
1985	-	-	-	-	328	434	1,942	779	101	1,105	2,371	746
1986[1)]	-	-	-	-	-	-	321	1,452	111	637	432	1,243
1987[1)]	-	-	3	1,848	497	1,633	11	804	-	-	511	1,617
1988	-	-	213	4,209	5,811	2,656	2,439	3,062	356	4,134	8,819	2,866
1989	-	-	9	44	2,519	4,026	6,847	4,729	1,471	3,126	10,846	4,344
1990	-	-	8	121	191	1,900	7,276	2,079	4,224	1,166	11,699	1,745

1) No directed trawl fishery for cod allowed in 1986, and in the first 10 month of 1987

Table 4 : Statistics and parameter estimates from the multiplicative analysis of CPUE from 6 Home Rule trawlers off West Greenland, 1975-1990.

Source of variation	Df	Sum of Squares	Mean	F value	P
Model	30	391.480	13.049	16.74	<0.0001
Year	15	248.847	16.590	21.28	<0.0001
Division	4	54.251	13.563	17.40	<0.0001
Month	11	88.382	8.035	10.31	<0.0001

Year	Estimate	Std error
1975	-1.128	0.231
1976	-0.969	0.242
1977	-0.384	0.263
1978	0.700	0.278
1979	0.009	0.282
1980	-0.117	0.258
1981	0.671	0.273
1982	0.595	0.246
1983	-0.241	0.245
1984	-0.758	0.287
1985	-1.086	0.303
1986	-0.512	0.367
1987	0.324	0.556
1988	0.570	0.270
1989	1.079	0.244
1990	0	-

Inter cept	Estimate	Std. error
	6.756	0.247

Month	Estimate	Std. error
Jan	0.416	0.206
Feb	0.526	0.213
Mar	0.197	0.204
Apr	0.550	0.207
May	0.575	0.212
Jun	0.714	0.223
Jul	0.155	0.226
Aug	-0.157	0.232
Sep	-0.715	0.207
Oct	-0.928	0.216
Nov	-0.267	0.207
Dec	0	-

Div.	Estimate	Std. error
1B	-1.245	0.250
1C	-0.152	0.192
1D	0.031	0.173
1E	0.233	0.165
1F	0	-

Table 5 : Catches in numbers ('000) at age for West Greenland cod,1976-1990.

YEAR		1976	1977	1978	1979	1980
Age	3	10760.0	634.0	287.0	286.0	2999.0
	4	4026.0	46649.0	5494.0	10656.0	4513.0
	5	2243.0	6053.0	30039.0	12505.0	4580.0
	6	1216.0	1515.0	1004.0	18970.0	1978.0
	7	302.0	618.0	509.0	709.0	8014.0
	8	1594.0	425.0	83.0	400.0	125.0
	9	139.0	446.0	41.0	78.0	60.0
	10	148.0	168.0	13.0	52.0	24.0
	11	53.0	79.0	7.0	55.0	1.0
	12+	84.0	112.0	16.0	106.0	22.0
Catch (tons)		33286.00	73000.00	73000.00	99000.00	54000.00

YEAR		1981	1982	1983	1984	1985
Age	3	12.0	1204.4	77.0	595.0	456.0
	4	16864.0	1210.0	12356.0	2018.0	1266.0
	5	6374.0	17960.0	2011.0	10384.0	1303.0
	6	2391.0	2965.0	17228.0	688.0	4915.0
	7	1053.0	2078.0	1581.0	3656.0	161.0
	8	3382.0	807.0	995.0	106.0	750.0
	9	45.0	610.0	344.0	365.0	42.0
	10	65.0	45.0	343.0	97.0	140.0
	11	1.0	88.0	3.0	69.0	15.0
	12+	8.0	27.0	43.0	3.0	22.0
Catch (tons)		53456.00	55832.00	57641.00	31000.00	14544.00

YEAR		1986	1987	1988	1989	1990
Age	3	12.0	5705.0	839.0	36.0	66.0
	4	113.0	1636.0	50214.0	9540.0	2912.0
	5	706.0	274.0	1070.0	71645.0	21859.0
	6	318.0	662.0	501.0	655.0	26589.0
	7	1193.0	424.0	652.0	97.0	66.0
	8	12.0	686.0	524.0	191.0	.0
	9	332.0	7.0	751.0	182.0	8.0
	10	80.0	30.0	21.0	463.0	2.0
	11	13.0	1.0	85.0	.0	39.0
	12+	35.0	14.0	.0	67.0	6.0
Catch (tons)		6583.00	12360.00	62166.00	108017.00	60044.00

Table 6. Mean weight at age in the main fisheries at West Greenland in 1990 (kg, whole, round fish).

Age	Greenland trawl	Greenland inshore	Greenland total	German trawl	Weighted total[1)]
3	0.72	0.90	0.86	-	0.86
4	0.88	0.91	0.91	0.91	0.91
5	1.05	1.06	1.06	0.85	1.02
6	1.34	1.47	1.37	1.28	1.36
7	1.94	2.55	2.04	-	2.04
8	-	-	-	-	-
9	2.20	-	2.20	-	2.20
10	2.89	-	2.89	-	2.89
11	3.60	4.06	3.79	-	3.79
12	-	-	-	-	-
13	3.66	-	3.66	-	3.66
14	-	-	-	-	-
15+	-	12.23	12.23	-	12.23
Weighted mean[1)]	1.25	1.17	1.22	0.97	1.19

1) Weighted by catch in numbers in each age group and gear catagory.

Table 7 : Mean weight (kg.) at age for West Greenland cod, 1976-1990

YEAR	1976	1977	1978	1979	1980
Age 3	.8500	.7400	.6500	.7200	.8700
4	1.2100	1.2400	1.1500	1.2300	1.3300
5	2.0300	1.7100	2.1800	2.0200	2.0600
6	2.7100	2.1200	2.8900	2.7100	3.0000
7	3.4200	3.6100	3.6900	3.7800	4.2800
8	4.5800	4.5800	4.5800	4.9000	5.8400
9	4.4900	4.8100	5.0600	6.4000	6.4000
10	5.8800	5.6000	5.6000	7.8000	7.8000
11	7.0200	6.0000	6.0000	9.0000	9.0000
12+	6.4600	6.6000	6.6000	9.7000	9.7000

YEAR	1981	1982	1983	1984	1985
Age 3	.8300	.8300	.7800	.7800	.5000
4	1.1100	1.1000	.9800	.9100	.8200
5	1.7000	1.7000	1.3800	1.3700	1.0800
6	2.3500	2.3500	2.0800	2.0000	1.6200
7	3.2000	3.2000	2.9500	2.7500	2.2500
8	4.3000	4.3000	3.8500	3.5000	3.0000
9	6.5000	6.5000	4.7800	3.9400	3.9900
10	9.0200	9.0200	5.5800	4.9200	4.3700
11	9.3200	9.3200	6.0000	5.8000	5.8000
12+	9.3200	9.3200	6.7000	5.8000	6.5000

YEAR	1986	1987	1988	1989	1990
Age 3	.6500	.9000	.5500	.5200	.8600
4	1.0400	1.0700	1.0800	.7200	.9100
5	1.8600	1.8000	1.3700	1.2700	1.0200
6	2.0900	2.1200	2.0000	1.6700	1.3600
7	2.7100	2.6100	2.7500	2.3100	2.0400
8	3.1600	3.2400	3.5000	3.7100	.0000
9	4.5900	4.3000	3.9400	4.2100	2.2000
10	4.7100	4.7000	4.9200	4.6700	2.8900
11	4.7100	4.7000	4.9200	4.0700	3.7900
12+	4.7100	4.7000	4.9200	3.1200	5.3600

Table 8 : Proportion mature at age, West Greenland cod, 1976-1990.

YEAR	1976	1977	1978	1979	1980
Age 3	.010	.010	.010	.010	.010
4	.040	.030	.030	.040	.040
5	.130	.120	.130	.140	.150
6	.350	.360	.390	.430	.460
7	.670	.690	.720	.760	.790
8	.880	.900	.910	.930	.940
9	.960	.970	.980	.980	.990
10	.990	.990	.990	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000
12+	1.000	1.000	1.000	1.000	1.000

YEAR	1981	1982	1983	1984	1985
Age 3	.010	.010	.010	.010	.010
4	.040	.030	.030	.030	.030
5	.160	.160	.150	.150	.150
6	.480	.500	.480	.480	.480
7	.810	.840	.830	.830	.830
8	.950	.960	.960	.960	.960
9	.990	.990	.990	.990	.990
10	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000
12+	1.000	1.000	1.000	1.000	1.000

YEAR	1986	1987	1988	1989	1990
Age 3	.000	.000	.020	.020	.010
4	.030	.000	.080	.080	.030
5	.270	.130	.230	.230	.060
6	.810	.770	.520	.520	.080
7	.980	.670	.790	.790	.650
8	1.000	.940	.930	.930	.900
9	1.000	.970	.980	.980	.980
10	1.000	.980	.990	.990	1.000
11	1.000	1.000	1.000	1.000	1.000
12+	1.000	1.000	1.000	1.000	1.000

Table 9: Strata areas in square nautical miles off West Greenland (NAFO Subarea 1).

Depth zone (meters)	Division/stratum number 1B 1	1C 2	1C 3+4	1D 5	1E 6	1F 7	Total (nm")
0-100	865	593	598	1,475	276	+	3,807+
101-200	1,256	1,574	1,919	875	1,662	+	7,268+
0-200	2,121	2,167	2,517	2,350	1,938	2,568	13,661
201-300	297	259	737	628	464	+	2,385+
301-400	209	54	325	390	278	+	1,256+
201-400	506	313	1,062	1,018	742	971	4,612
401-500	149	122	216	176	33	+	696+
501-600	215	293	196	83	24	+	811+
401-600	364	415	412	259	57	353	1,860
Total	2,991	2,895	3,991	3,627	2,737	3,892	20,133

In Div. 1F strata areas are only available by 200-m depth zones.

Table 10 Survey abundance and biomass as found by the German ground fish survey, 1982-1990. The confidence intervals are given at the 95% level of significance. Weight refers to mean weight in kg. in survey catches.

Year	Tonnes		Number ('000)		weight
1982	198,934	37.0%	109,039	36.1%	1.65
1983	98,843	28.5%	59,362	26.5%	1.67
1984	24,945	39.7%	16,104	39.1%	1.55
1985	31,860	60.1%	52,466	33.3%	0.61
1986	76,220	30.8%	134,716	31.8%	0.57
1987	464,286	47.0%	582,868	42.6%	0.80
1988	547,566	42.1%	563,601	42.3%	0.97
1989	349,812	58.2%	368,388	65.1%	0.95
1990	34,495	69.8%	34,657	70.6%	1.00

Table 11. West Greenland cod. Autumn survey abundance estimates (no. x 10^3) by age and division, 1985-1990. The respective survey biomass estimates (tonnes and mean weights are below.

Age	Divisions 1B+C 1985	1986	1987	1988	1989	1990	Division 1D 1985	1986	1987	1988	1989	1990
0	124	-	32	-	-	13	13	-	13	-	-	8
1	10,148	1,193	363	200	149	4	7,765	2,752	23	11	-	8
2	725	35,014	6,774	2,000	349	349	349	33,830	8,237	964	545	117
3	249	737	142,759	1,356	666	744	300	1,582	227,042	67,112	1,745	744
4	133	43	2,745	442	541	55	898	197	4,012	386,465	9,729	314
5	64	51	1,267	5	345	202	1,340	482	1,903	2,972	13,854	2,493
6	74	31	1,811	+	10	41	2,766	363	3,801	466	322	782
7	3	85	222	2	-		81	512	501	790	-	11
8	13	1	330	+	-	-	155	8	1,431	405	15	-
9	-	20	-	2	-	-	-	25	-	728	2	-
10	-	1	30	-	7	-	-	2	150	14	12	-
11	-	-	-	-	-	-	-	-	-	16	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-
NK	-	-	-	-	-	-	-	-	-	-	-	-
Total	19,533	37,176	156,333	4,133	3,718	1,696	13,785	39,753	247,113	459,943	26,224	4,477
Tonnes	2,678	13,333	131,909	1,188	1,076	423	11,447	19,483	198,252	452,870	23,653	3,721
w (kg)	0.122	0.359	0.844	0.287	0.289	0.249	0.830	0.490	0.802	0.985	0.902	0.831

Table 11. (continued)

Age	Division 1E						Division 1F					
	1985	1986	1987	1988	1989	1990	1985	1986	1987	1988	1989	1990
0	149	-	-	-	-	-	438	-	-	-	12	137
1	4,622	3,488	-	10	-	-	3,856	2,797	-	14	-	32
2	195	26,096	10,072	6	22??	20	146	13,056	12,582	23	88	8
3	37	768	108,967	8,903	6,263	820	11	580	34,754	14,637	30	808
4	3,503	188	4,377	33,491	86,974	162	1,195	146	1,597	40,639	33,219	288
5	599	4,037	707	215	121,931	3,958	195	3,051	328	396	60,506	16,284
6	2,510	256	2,342	32	2,256	1,044	945	270	1,424	61	541	4,874
7	122	1,062	307	189	178	4	145	1,429	197	177	-	20
8	180	27	955	72	41	-	260	68	651	73	120	-
9	4	91	-	265	41	-	18	316	-	272	36	-
10	5	3	50	13	-	-	13	14	86	8	113	-
11	-	6	23	18	-	5	-	17	-	11	-	-
12	-	-	-	-	-	-	-	-	-	-	5	-
13	-	-	-	-	-	-	-	21	-	5	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-
NK	-	-	-	-	-	-	-	-	-	-	-	-
Total	11,926	36,022	127,803	43,214	217,840	6,013	7,222	21,765	51,619	56,311	94,670	22,471
Tonnes	11,934	23,675	96,433	40,698	217,096	5,778	6,101	19,719	37,691	52,810	107,987	24,573
w (kg)	1.001	0.657	0.755	0.942	0.997	0.961	0.845	0.906	0.730	0.938	1.141	1.094

Age	Total					
	1985	1986	1987	1988	1989	1990
0	842	-	48	-	12	158
1	34,391	10,230	386	235	149	40
2	1,415	107,996	37,665	3,119	2,789	1,080
3	597	3,667	513,522	92,008	8,704	2,821
4	5,729	574	12,731	461,037	130,463	819
5	2,198	7,621	4,205	3,588	196,636	22,937
6	6,295	920	9,378	559	3,129	6,761
7	351	3,088	1,227	1,158	-	36
8	608	104	3,367	550	313	-
9	22	452	-	1,267	79	-
10	18	20	316	35	173	-
11	-	23	23	45	-	5
12	-	-	-	-	5	-
13	-	21	-	-	-	-
14	-	-	-	-	-	-
Total	52,466	134,716	582,868	563,601	342,452	34,657
Tonnes	31,860	76,220	464,286	547,566	349,812	34,495
w (kg)	0.607	0.566	0.797	0.972	1.021	0.995

Note: The age compositions for the northern Divisions 1B+C and 1D and for the southern Divisions 1E and 1F are based on separate age/length keys comprising ageing material from the respective areas.

Table 12 : Indices of year-class strength by division and year based on CPUE from three mesh sizes.

Year-class	NAFO division 1B	1D	1F	Total
1984	3.19	0.74	0.92	1.61
1985	0.58	0.11	0.49	0.36
1986	0.19	0.07	0.005	0.09
1987	0.37	0.42	0.02	0.27
1988	0.36	0.07	0.002	0.14

Table 13. East Greenland cod. Estimates of trawlable biomass, based on the Federal Republic of Germany trawl surveys from 1980-1990.

Year	Season	Ship	Biomass		Stock numbers	
			Tonnes	+%	No.(1000)	+%
1980	Oct-Nov	"Karlsburg"	62,944	33	15,425	34
1981	Nov-Dec	"W. Herwig"	88,336	43	19,448	35
1982	Sep-Oct	"W. Herwig"	19,782	35	6,106	52
1983	Sep-Oct	"W. Herwig"	26,980	38	6,730	33
1984[1]	Oct	"A. Dohrn"	21,151	42	6,488	51
1985	Oct	"W. Herwig"	21,842	26	7,815	27
1986	Sep-Oct	"W. Herwig"	44,288	34	17,554	32
1987	Sep-Oct	"W. Herwig"	33,929	36	25,296	37
1988	Sep-Oct	"W. Herwig"	41,817	47	18,859	40
1989	Sep-Oct	"W. Herwig"	139,967	61	53,857	45
1990	Sep-Oct	"W. Herwig"	45,302	33	17,342	30

Confidence intervals are given at the 95% significance level.
1) Only 36 valid hauls.

Table 14. Nominal catches (in tonnes) of cod in ICES Subarea XIV, 1981-1990. (Data for 1981-1987 broken down by countries are from Bulletin Statistique.)

Country	1981	1982	1983	1984	1985
Faroe Islands	292	-	368	-	-
Germany, Fed. Rep.	7,367	8,940	8,238	7,035	2,006
Greenland	890	898	438	1,051	106
Iceland	1	-	-	-	-
Norway	-	-	-	794	-
USSR	-	-	-	-	-
Total	8,550	9,838	9,044	8,880	2,112
Working Group estimate	16,000	27,000	13,377	8,068	2,112

Country	1986	1987	1988[1)]	1989[1)]	1990[1)]
Faroe Islands	86	-	-	2	-
Germany, Fed. Rep.	4,063	5,358	11,702	10,700	23,365
Greenland	606	1,476	380	3,790	4,187
Iceland	-	1	-	-	-
USSR	-	-	65	-	-
UK	-	-	-	1,860	2,822
Japan	-	-	-	94	129
Total	4,755	6,835	12,147	16,446	30,243
Working Group estimate	4,668	6,658	9,147[2)]	15,151[3)]	30,243

1) Preliminary.
2) Excluding 3,000 t assumed to be from NAFO Division 1F.
3) Excluding 2,741 t assumed to be from NAFO Division 1F and including 1,500 t reported from other areas assumed to be from Sub-area XIV.

Table 15 : Parameters used to calculate Yield per Recruit for West Greenland cod, 1991.

Age	Mean Weight	M+E	Rel. F
3	0.86	0.3	0.039
4	0.91	0.3	0.52
5	1.02	0.35	1
6	1.36	0.35	1
7	2.04	0.35	1
8	2.12	0.35	1
9	2.20	0.35	1
10	2.89	0.35	1
11	3.79	0.35	1
12+	5.36	0.35	1

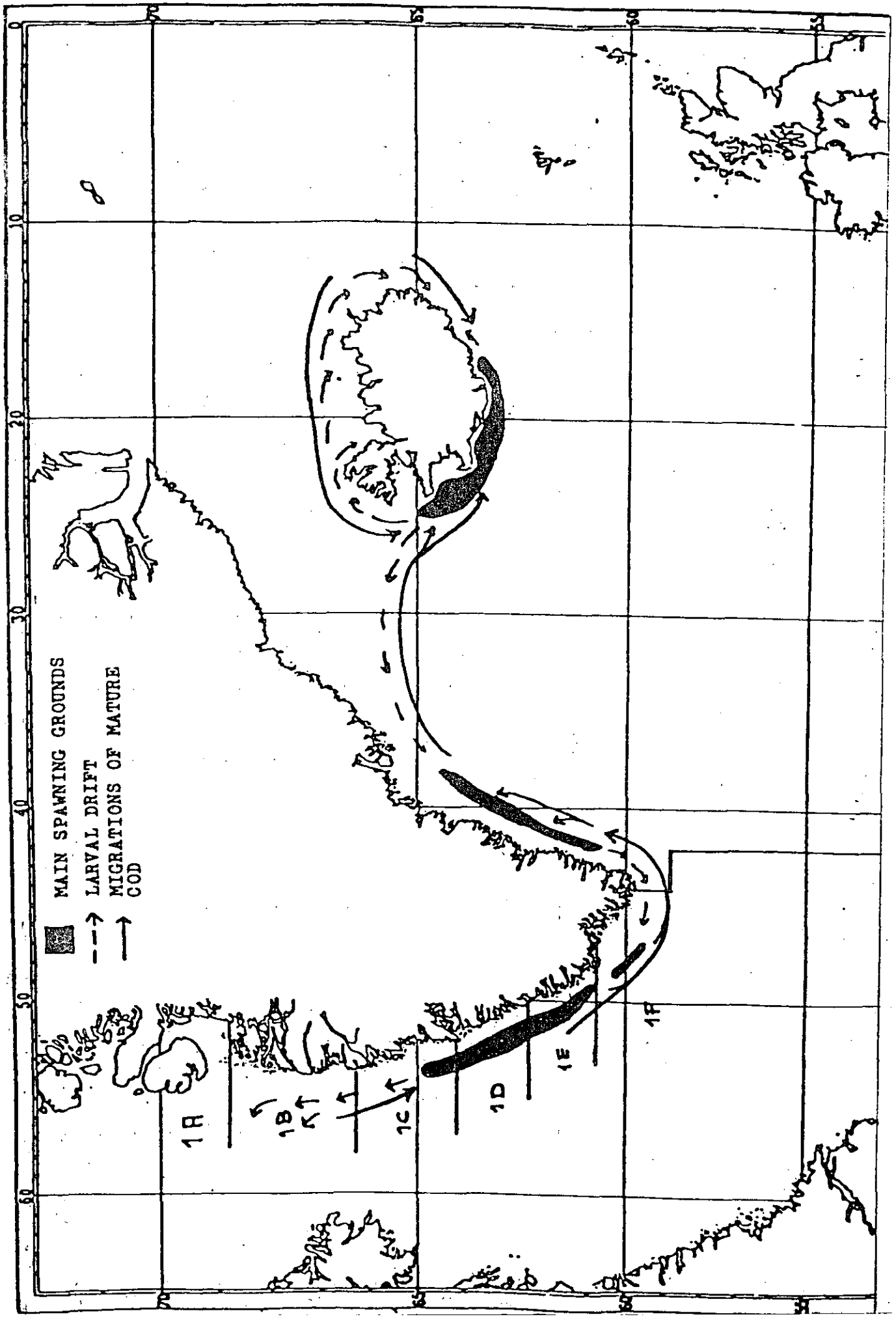

Fig. 1. Main spawning grounds, migrations on mature fish and larval drift of the cod stocks at West Greenland, East Greenland and Iceland.

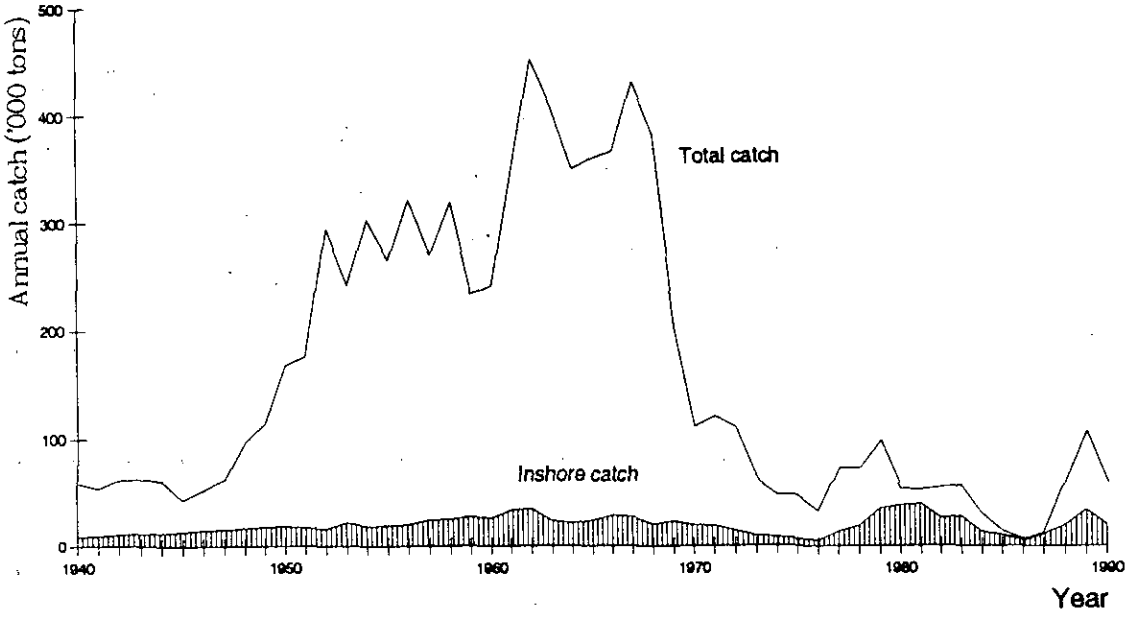

Fig. 2. Total catch and the inshore catch of cod off West Greenland, 1940 to 1990.

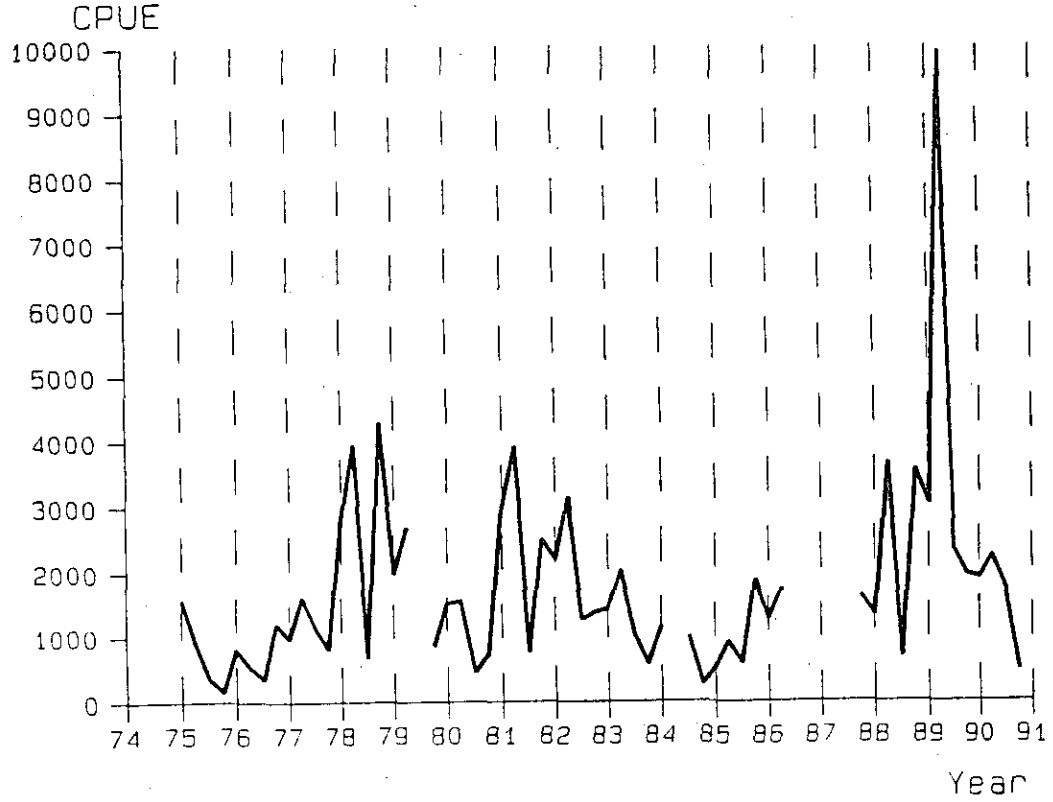

Fig. 3. CPUE from Subarea 1 by quarter for six sister trawlers owned by the Greenland Home Rule.

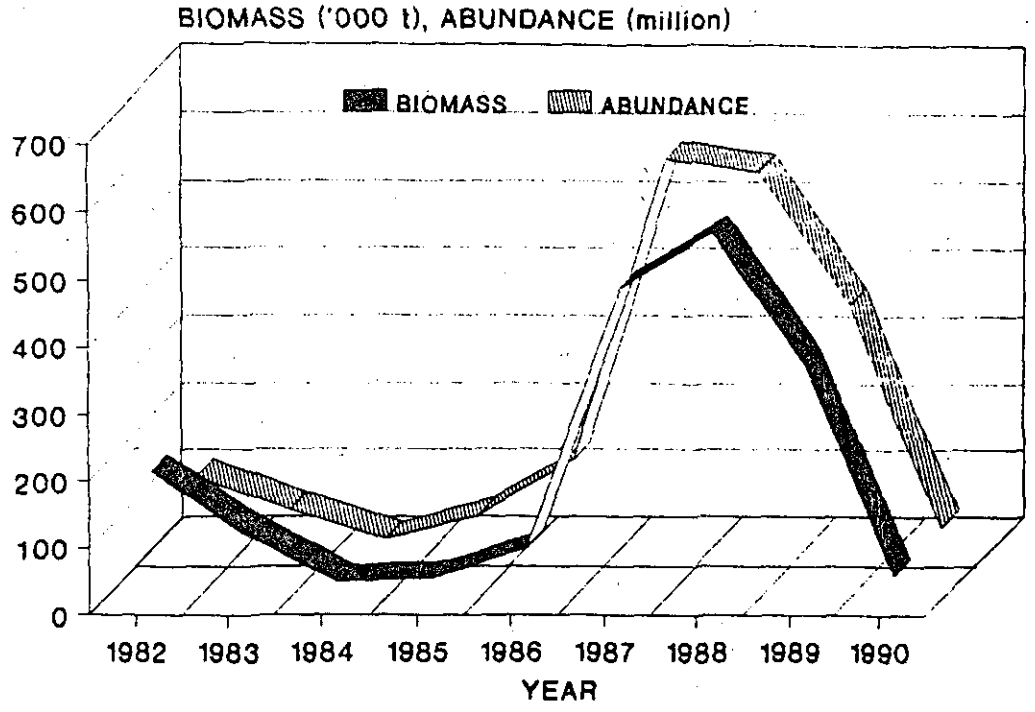

Fig. 4. West Greenland cod. Trends in survey biomass and abundance estimates, 1982-1990.

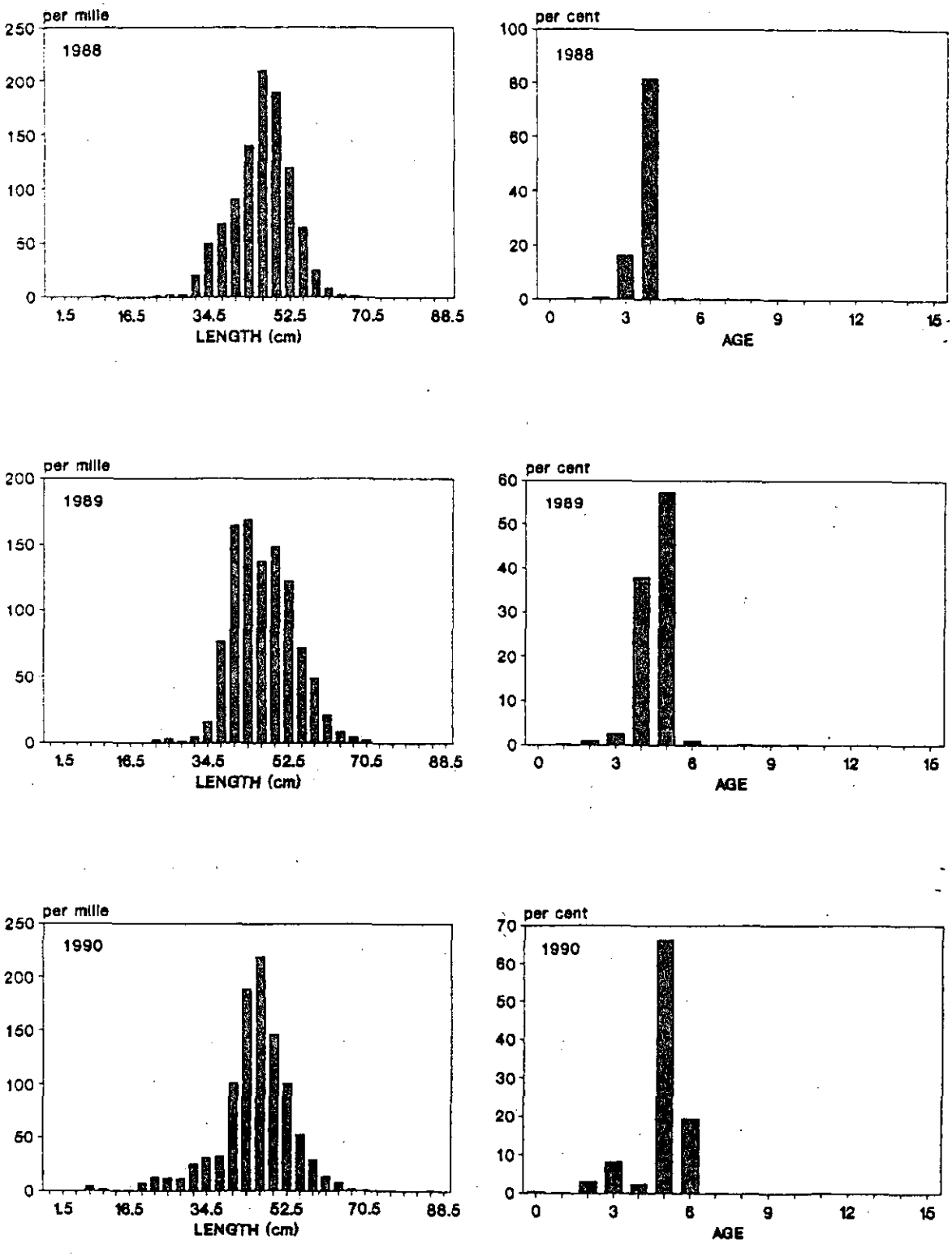

Fig. 5. West greenland cod. Length frequencies and age compositions from survey results, 1988-1990.

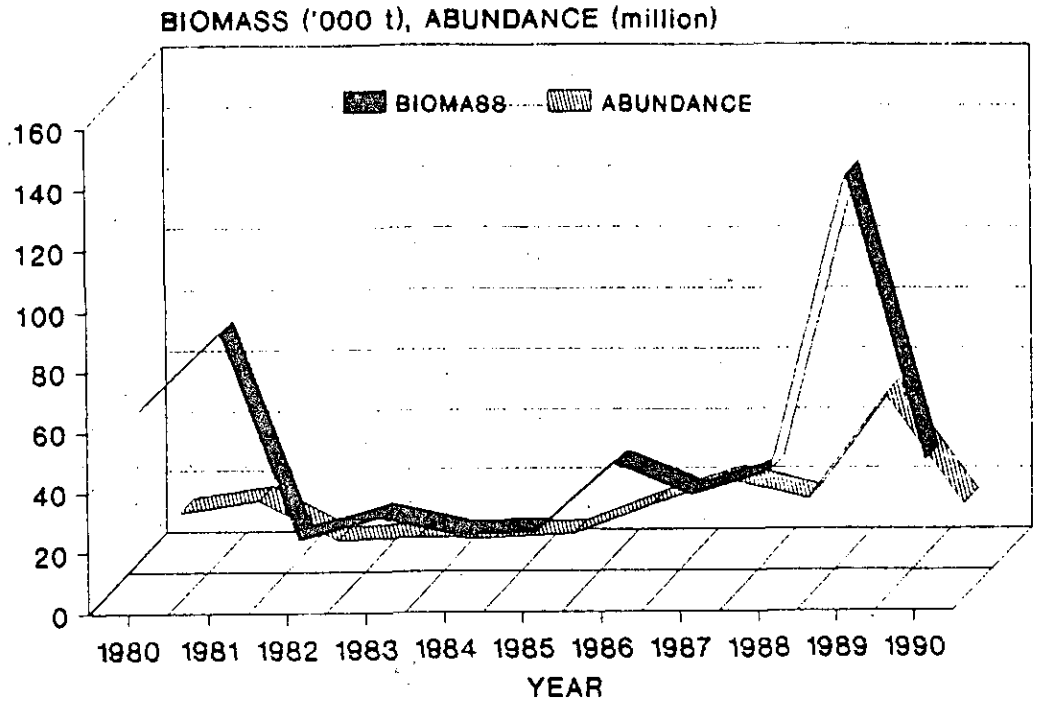

Fig. 6. East Greenland cod. Trends in survey biomass and abundance estimates, 1980-1990.

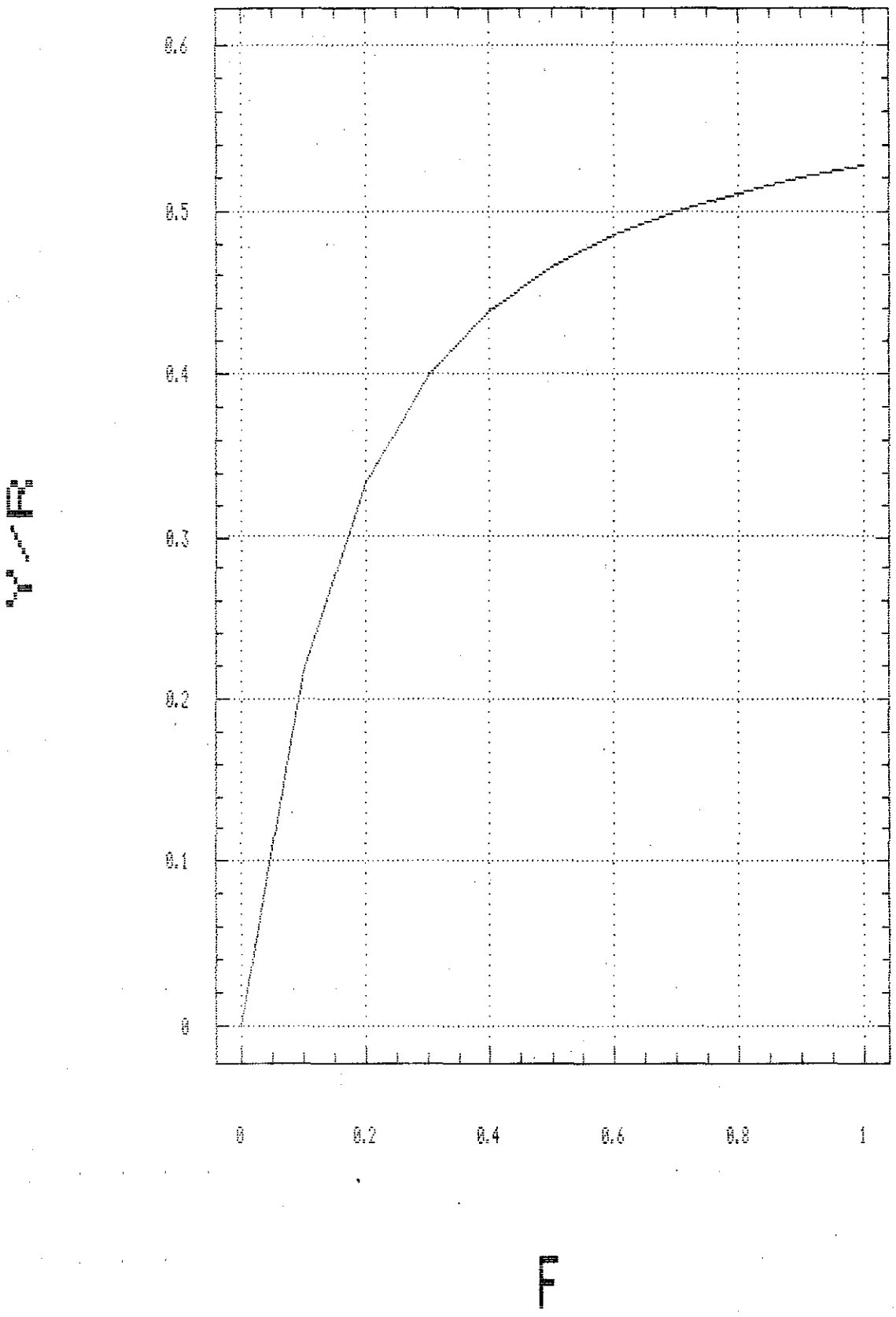

Fig. 7. Yield-per-recruit, cod in Subarea 1.