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Status of the West Greenland Cod Stock and Management Considerations

by

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1. Description of the Fishery

The fishery for cod in Subarea 1 is partly an offshore fishery, mainly by large trawlers using bottom otter trawls, and partly a coastal and fjord fishery in which the major part of the catch is taken by pound-nets. The pound-net season is generally from May-June to September, but in 1984 pound nets seem to have been used as late as in October.

In 1984 offshore fishing was conducted also by some vessels fishing with long-lines and bottom gill nets. Offshore catches by these gears accounted for approximately 7% of the total offshore catch, the remaining 93% being taken by trawl (Table 1).

The trawlers catch accounted for 59% of the total SA 1 catch of cod in 1984 as compared to about 67% in 1983 and 50% in 1982.

Division 1E was the most important division for the offshore fishery in 1984, closely followed by Division 1D, whereas for the inshore fishery Division 1D was the most important followed by Division 1C. The three northern divisions supplied about 1/3 of the inshore catch, whereas offshore virtually no cod fishing took place in these divisions.

About 1/3 of the total catch of cod in 1984 was caught in the period August-September (Table 2).

Fishing effort has been reported by some of the trawlers only. Their overall catch per unit effort decreased from 1981 (3.3 t/hour) through 1982 and 1983 to a level of just below 1 t/hour in 1984, the lowest since 1977 (Table 3).

In the past, catch per unit effort has generally been high in the first half of the year, then decreasing from June-July to September-October. However, after the usual decrease from June to September, catch per unit effort in 1983

did not increase but fluctuated at the low level from September 1983 through 1984, the only exception being August 1984. Information from the first months of 1985 does not indicate any improvement in the situation.

Not much information is available on discarding in 1984. The phenomenon is mainly occurring in the pound-net fishery. Apart from a record of 27% discards (by numbers), in a pound-net catch in Division 1B, the rate of discarding does not seem to have been high in 1984.

Fishing over the last 10 years has been regulated by total allowable catches (see Table 4) and by a minimum mesh size in trawls. A minimum size of 40cm for cod landed in Greenland is prescribed.

2. Nominal Catches

The catches over the last ten years are given in Table 4. During that period the catches varied between 30 000 and 99 000 tonnes. From the low level of 33 000 tonnes in 1976 the catches increased up to 99 000 tonnes in 1979. In 1980 to 1982 catches were at a level of about 50 000 tonnes annually, increasing to 63 000 tonnes in 1983 followed by a significant decrease to 30 000 tonnes in 1984, which is the lowest recorded in Subarea 1 since 1952.

The TAC's over the last ten years are also given in Table 4. In the period 1978-81 direct cod fishing was allowed only for Greenlandic vessels.

3. Catch in Numbers per Age Group

In 1984 there were some sampling problems and therefore, it was necessary to use samples also for other months, divisions and gears than they were sampled for. Especially the inshore catches taken by gears other than poundnets were poorly sampled.

Because of two very dominating year classes the bias introduced to the age composition of the total catch was less severe. The numbers per age group in 1984 by division and gear are given in Table 5.

4. Catch Composition

The age composition of the total catch is strongly dominated by the year-classes 1977 and 1979 which contribute 20% and 58% respectively to the total numbers (Table 5). The 1977 year class was predominantly caught in the offshore fishery whereas the 1979 year class was caught in equal numbers in in- and offshore waters. The 1980 year class which is almost lacking in the offshore fishery accounts for 22% by numbers in the inshore fishery.

The catches at age 1965-84 are summarised in Table 6.

5. Mean Weight at Age

The mean weight-at-age in the major Greenlandic fisheries (trawl, long line and pound net) fluctuates only little during the sampling period ($\pm 10\%$). The average mean weights for these fisheries together with mean weight from German samples (combined research and commercial data) are given in Table 7. The values from the German samples are considerably higher than in the Greenlandic

samples. This can be due to both geographical and temporal reasons as the German samples are based exclusively on data from the two southern divisions (1E and 1F) in the 4th quarter.

The mean weight-at-age used in the projection is based on the mean weights from the German trawl survey and from the Greenlandic trawl fishery. As little growth is expected during the winter the German data reflects the weight by 1 January 1985 (age shifted one year) whereas the Greenlandic data, which primarily are based on first-quarter catches, reflects mean weight 1 January 1984. The mean of these weight-at-age data is then used as weight 1 January. To account for the growth during the year the average weight of two successive age groups is used (i.e. the weight of a 7 year cod is the mean of the 7 and 8 year cod the 1 January). The resulting weight-at-age vector is given in Table 8.

6. Maturity at Age

Data on maturity at age based on catches from the German trawl survey are shown in Table 9 (classification criteria from Maier 1908). As the gonads at the time of the survey are not very developed there is doubt on whether the stage 2 fish are spawning in the following year. The authors decided to allocate the stage 2 fish proportionally to the distribution of stage 1 and 3+ (stage 1 to be immature, stage 3+ to be mature). A sample from West Greenland taken just before spawning in 1985 gave similar results.

Since the results are not significantly different from those obtained from the 1983 survey which were used in the 1984 assessment, the previous maturation ogive was used in the projection.

Further studies are envisaged particularly in relation to possible differences between the maturation rate of males and females.

7. Survey Results

Stratified-random bottom trawl surveys off West Greenland have been conducted in November/December 1982 and 1983 by RV "Walther Herwig" and in late October/November 1984 by RV "Anton Dohrn". The survey area includes the West Greenland shelf outside the 3-mile limit and the continental slope down to 600m depth, extending from the southern part of Division 1B (south of 67° southward as illustrated in Figure 2. The area consists of 7 main strata equal to Divisions 1B-F or parts thereof. The main strata are subdivided each by 100m depth zones between 0-600m into 6 substrata, except in Division 1F (stratum 7), where a substratification was only roughly possible by 200m depth zones due to the lack of suitable bathy-metric charts. Stratum 4, west of 55° mainly containing depths exceeding 600m has for the first time been covered down to 600m depth by the 1984 survey. Strata areas (nm²) are given in Table 10. The stratification is generally based on the scheme developed for Subarea 1 by Carlsson and Kanneworff and described in the NAFO Survey Manual (Doubleday, 1981).

Biomass and abundance estimates were obtained by applying the "swept area"

method with the following trawl parameters:

Towing time	30 minutes
Towing speed	4.5 knots (average)
Horizontal net opening	22 metres (standard survey trawl)

Lacking a reliable estimate of the catchability coefficient, it was taken as 1.0 to avoid overestimation of stock biomass and abundance.

During the surveys from 1982 to 1984 the number of randomly distributed fishing stations occupied amounted to 111, 153 and 162 respectively. The results were based on 98, 142 and 158 valid sets (see Table 11).

The coverage of the survey area accordingly improved from 203 nm² per set to 140 nm² and 127 nm² respectively.

Cod biomass and abundance estimates for the total survey area off West Greenland of 19 864 nm² in 1982 and 1983 and of 20 133 nm² in 1984 (including stratum 4) amounted to:

year	tonnes	nos ('000)
1982	179 934 ± 37 %	109 039 ± 36.1%
1983	98 843 ± 28.5%	59 375 ± 26.5%
1984	24 945 ± 39.7%	16 110 ± 39.1%

The confidence intervals are given at the 95% level of significance.

For technical reasons RV "Walther Herwig" had to be replaced for the 1984 survey by RV "Anton Dohrn". However, experience from a 12 years time series of bottom trawl surveys in Division 2J has confirmed that the fishing power of both vessels did not differ significantly provided that equal standard survey gears as well as towing speeds were used.

Since 1982 the survey results reveal a drastic decline in cod biomass and abundance which was observed not only for the overall survey area (Figure 4) but for all divisions as shown in detail in Table 11. Indications of the reduced stock size in 1983 and 1984 were also confirmed by continuous echosounder recordings between stations.

The age composition of the West Greenland cod stock since 1982 as obtained from survey data (Table 11) shows predominance of the younger ages of which year-classes 1977 and 1979 are clearly outstanding although drastically declining in numbers over the 3-year period. Cod of age 8 and older amount to only 2-3% in numbers. The former good year-class 1973 was already reduced to 2% of the total stock abundance in 1982 and practically absent in 1984. The consequence of this development is a drastically reduced stock size in 1984 with year-class 1979 (age 5) predominating (51% by numbers). Cod of age 6 and older made up only 20% including year class 1977 (13%). The same trend is seen when comparing the length frequencies by Division and for the whole area (Figures 3) for 1984 with those for the preceding years as given SCR Doc. 84/VI/93. Mean lengths at age as obtained from survey results are given by Division and for the whole survey area in Table 12.

It is noteworthy that for the first time in the three years bottom trawl survey

practice off West Greenland few specimen of 0-Group cod (year class 1984) were obtained in all divisions. It should be remembered that the 0-group cod is not quantitatively represented in the catch due to selectivity.

The inclusion of stratum 4 in the area surveyed in 1984 did not show any substantial number of cod in the deeper waters of the continental slope.

8. Correlation between Survey Results and Catch Rates (Figure 4)

Catch rates in the Greenlandic trawl fishery in Divisions 1D and 1E show a declining trend very similar to what is found in the German survey Biomass estimates.

Data on catch-rates in the inshore fishery are not available (effort presently not recorded) but no substantial change in effort is expected in the 4th quarter over the last years, where the catches mainly come from hook and gillnet fishery. The trend in catches in this fishery also shows a significant decline.

9. Future Recruitment

Year-class 1981

Initially the strength of that year-class was estimated as rather poor based on unfavourable hydrographic conditions and very low larval abundance. Therefore recruitment at age 3 of 20 million fish was used. The relative low abundance of that year-class at ages 1 to 3 in the subsequent German trawl surveys give no reason to change the initial estimate.

Year-class 1982

Based mainly on the high abundance of cod larvae in plankton catches the 1982 year-class was supposed to be a relatively good one and was estimated as 200 million recruits at age 3. However, in the German trawl surveys the 1982 year-class was observed for the first time at age 2 in only very small numbers. Also Danish research vessel catches with small meshed gear (shrimp trawl) conducted on standard stations during 1983 and 1984 did not contain cod of that year-class. The recruitment estimate has therefore been reduced to 20 million fish.

Year-class 1983

The strength of the 1983 year-class was initially estimated as poor based mainly on observations of relatively cold water over the banks during 1983. A tentative figure of 20 million fish at age 3 was proposed for its abundance. There is no reason to change the previous assumption since that year-class was virtually absent in subsequent surveys.

Year-class 1984

It is known that 0-group fish drift with the current from East Greenland waters to West Greenland. It is therefore interesting to note that the Icelandic 1984 0-group survey (ICES C.M. 1985/Assess:6) in East Greenlandic waters gave a very high abundance index of 0-group cod about 3 times that for the 1973 yearclass.

0-group cod were caught at West Greenland in the R.V. "Anton Dohrn" trawl survey late October/November 1984. This is the first time that these surveys (carried out since 1982) show occurrence of 0-group fish.

The extremely cold winters of 1982/83 and 1983/84 cooled the upper water masses in the Davis Strait resulting in negative temperature anomalies of 1° to 2° C throughout the following year (Stein, M. and Buch, E. 1985). This low temperature may have already influenced the survival of the 1984 yearclass.

It will be highly interesting and necessary to follow the 1984 year-class closely in the following year to see whether it is more abundant than is to be expected from temperature observations.

Bearing in mind the revision of the first estimate of the 1982 year-class the authors do suggest not to use an estimate higher than 20 million fish unless subsequent observations in 1985 support a more optimistic estimate. The projection is only marginally affected by the assumption about that year-class.

10. Assessment results (Table 13)

The stock in number-at-age at the end of 1984 has been calculated from the abundance estimate of the October/November survey with 1/12 of the natural mortality and deducting the December catch in numbers-at-age.

Total mortality (Z) was calculated from this estimate and the corresponding one from the 1983 survey as 1.6 on age 5 and older cod. This value was apportioned to:

- i) Natural mortality (0.20)
- ii) Fishing mortality (0.57; about the same level as last year)
- iii) Emigration coefficient (0.83; compared to 0.47 in 1983)

The ICES Working Group on Cod Stocks off East Greenland (Anon., 1985) provided an estimate of immigrants from West Greenland of about 4 million cod (age 5+) in 1984, based on trawl surveys in that area.

Of the possible total loss due to emigration of about 23 million fish, as estimated from the present West Greenland assessment, about 19 million are thus still unexplained, compared to 13 million in 1983.

This lends some support to the hypothesis that the present reduction in the West Greenland cod stock is due to vast migrations. Earlier tagging experiments show considerable migration of West Greenland cod to Iceland which might account for the rest of the estimated losses. Compared to the Icelandic cod stock, the number in question is very low making such a migration difficult to detect in the Icelandic assessment (Schopka, pers. comm.).

The only biological explanation at hand is that on the way to Iceland the emigrants from West Greenland have passed through the East Greenland region outside the survey area or during the period between the survey. Previous tagging experiments have shown that it is possible for large cod to travel such a distance within the time period required for this hypothesis.

11. Emigration rate used in Projections

Previous estimates of emigration coefficients are much lower than the present ones. The ICES North-Western WG (Anon. 1971) found an emigration coefficient

of 0.29 combining the migration from Divisions 1E-F and Eastgreenland. With only little migration from the northern divisions this led to a emigration coefficient of 0.05 for the total West Greenland stock when weighted by the catch distribution by division at that time.

As will be known much of the variation in the Greenlandic cod stock size and distribution can be attributed to the overall temperature regime (Hermann et al. 1964). The water temperature in both 1983 and 1984 showed significant negative anomalies and it is thus tempting to relate the recent mass migrations to the temperature conditions.

If migration is temperature dependent the setting of a reliable emigration coefficient for the projection period is very difficult as mean temperatures show great and unpredictable variations (Stein and Buch, 1985). A value of 0.3 which lays between the historical average and the high values for the last years, was used for the projection period.

12. Projection of catches and stock sizes 1986-1987

The parameters used to project catches and the size of the biomass of the cod stock at age 3 and older as well as the spawning stock biomass are discussed in the preceeding sections and are given in Table 14. The numbers at age at the beginning of 1985 are taken from Table 13 (stock size 31 December, ages shifted by one year). Projections were carried out for two different levels of catch in 1985:

- A. Assuming a catch of 28 300 tonnes. This level is derived from the TAC of 25 000 tonnes for Greenlandic vessels and the allowance for German trawlers to fish the unused part (3 300 tonnes) of their 1984 quota in early 1985.
This level of catch is, however, associated with a very high fishing mortality of 1.844 at the present very low level of the exploitable biomass. Therefore, it seems unlikely that a catch of that magnitude can be taken in 1985.
- B. Assuming a catch of 13 100 tonnes. This level of catch is associated with the fishing mortality of 0.568 estimated for 1984.

The results of the calculations are given in Tables 15 and 16 covering various management options. Catches in 1986 and resulting stock sizes at the beginning of 1987 are shown in Figure 5 for the range of fishing mortality between $F=0$ and F_{MAX} .

13. Management considerations

No detailed calculations of projected catches are in fact, necessary for describing the extreme bad situation for the cod stock in Subarea 1 as it has developed over the last few years. The evidences of a disaster are brought readily forward by trends in catches both inshore and offshore and by the results of trawl surveys. Total nominal catch decreased from about 63 thousand tons in 1983 to about 30 thousand tons in 1984 leaving more than 50% of the TAC unused. Trawlable biomass/stock abundance estimated from the trawl surveys by the end of the two years were 99 thousand tons/59 million fish and 25

thousand tons/16 million fish, respectively (95% confidence intervals ranging from 26-40%).

The inshore stock component is not included in the estimate from the trawl surveys. However, this component does not seem to account for any surprise of an increase in catch since in the fourth quarter of the year (i.e. at the time of the trawl surveys) the inshore catches were about 8,2 thousand tons in 1982 but decreased to 3,9 and 2,4 thousand tons in 1983 and 1984, respectively.

Clearly, therefore, there seems no hope of the 1985-86 catches being higher than that in 1984, unless some unexpected recruitment or immigration takes place. However, as already explained in Section 9, it has not been possible to maintain the initial expectation of some improvement by the recruitment of the 1982 year-class.

The authors also regard it unlikely that the TAC of 28,300 tons set for 1985 will be taken, but regard catches of about 10-15 thousand tons more realistic.

Although detailed catch projections do not seem necessary, the authors have presented projections in accordance with the request to NAFO by Denmark on behalf of Greenland (Tables 15 and 16, Fig. 5). However, the authors do not feel that present knowledge on future recruitment allows for catch and stock projections beyond 1986 and 1987 respectively, because for 1985 51% of the stock biomass (age 3+) by the beginning of the year and about 29% of the expected catch for the year are based on the recruiting year-classes 1981 and 1982, which were set at the conventional level (20 million cod at age 3) of poor yearclasses (see Section 9).

The calculations show that the fishing mortality coefficient (F) corresponding to the catch of 30 thousand tons in 1984 was about 0.57 which is between the $F_{0.1}$ and F_{max} estimates from last year. However, in order to maintain that catch level in 1985, F would have to be more than three times as high, and to increase to the very unrealistic level of above 8 to maintain such a catch level in 1986 (by the assumed low recruitment). In other words: not even catches of the 1984-level are likely to occur until such a time that recruitment improves considerably.

The spawning stock biomass left after the 1984 fishery is as low as about 18 thousand tons. This is the lowest estimate over more than 25 years. Estimates of the spawning biomass for the period 1962-83 were presented in Redbook 1983, p. 32, and show that the present low level was approached only for the period 1975-78. For the remainder of the period the estimates were considerably higher, although decreasing from the high level of 700 thousand tons by 1962. Under the present circumstances only a catch level of less than 10 thousand tons in 1986 seems to give a chance of maintaining the recent level of spawning stock by 1987.

Under such conditions catch rates may well be so low that the fishery regulates itself. However, the authors recommend that the fishery remains under strict management, both in order to preserve a spawning potential and to take the specific circumstances explained below into account, should an improvement in stock situation occur due to an abundant recruiting yearclass.

Unless the now 65-year-long cod period at West Greenland really has come to an end, the occurrence of a relatively good year class is to be expected at some time. A situation somewhat similar to that in 1976-77, when the good yearclass 1973 suddenly came into the stock after a series of years with poor recruitment, would then occur. However, since present stock level is well below that before the 1973 year-class recruited, a future improvement is likely to be relatively much more drastic. In a situation where the major part of the fishable stock would consist of three years old fish substantial discarding will occur and landings will consist almost entirely of fish just above the minimum landing size of 40 cm. Although the amount of fish below 40 cm would have decreased the following year (unless two consecutive good year classes were recruiting) there could still be a considerable proportion of discards. Both from the point of view of harvesting a year class to give maximum yield per recruit, and from the point of view of rebuilding a spawning stock, such a situation would call for strict measures with a great potential benefit some years later.

An improvement may occur by the 1984 year-class (see Section 9). Bearing in mind, however, that the estimate of the strength of the 1982 year-class has had to be reduced from the initial 200 million fish at age 3 to a poor level of 20 million fish, a revision of a hitherto unseen magnitude (possibly due to extreme environmental condition 1982-84), the authors feel that further information of the 1984 year-class, at least through 1985, has to become available before any quantitative estimate can be given. Therefore the year-class has been incorporated in the projections by a conservative figure of 20 million fish at age 3.

However, for the reasons given above the authors advice to maintain very strict catch regulations (TAC below 10 thousand tonnes) and to introduce management measures to specifically protect young fish (such as a temporary ban on directed cod fishing) if an abundant year-class is expected to enter the exploitable stock since even a low catch of fish of marketable size can be taken only by sacrificing great amounts of small fish in such a situation.

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TABLE 1 SUBAREA 1 COD, NOMINAL CATCH IN 1984 (PROVISIONAL FIGURES)
----- IN TONNES. POUND NET CATCHES ARE ESTIMATED FOR DIVISION 1B AS BEING 3/4 OF THE TOTAL MISCELLANEOUS GEAR CATCHES JUNE TO SEPTEMBER. FOR DIVISION 1C - 1F THE POUND NET CATCHES ARE ESTIMATED AS BEING 3/4 OF THE MISCELLANEOUS GEAR CATCHES JUNE - SEPTEMBER PLUS 3/8 OF THE OCTOBER CATCHES. A PART OF THE OTTER TRAWL CATCHES (4 035 TONNES) ARE ONLY REPORTED BY MONTH AND ARE THEREFORE ALLOCATED TO DIVISIONS IN PROPORTION TO THE REST OF THE OTTER TRAWL CATCHES.

DIV.	OTTER TRAWL OFFSHORE	LONG LINES OFFSHORE	GILL NET OFFSHORE	POUND NET INSHORE	MISC. GEAR INSHORE	TOTAL
1A	-	-	-	-	141	141
1B	1	-	-	947	747	1 695
1C	-	-	-	812	979	1 791
1D	6 407	19	8	3 452	1 484	11 370
1E	6 792	959	413	475	523	9 162
1F	4 274	269	159	442	313	5 457
TOTAL	17 474	1 247	580	6 128	4 187	29 616

TABLE 2 SUBAREA 1 COD, NOMINAL CATCHES 1984 (PROVISIONAL FIGURES)
----- IN TONNES PER MONTH AND DIVISION.

DIVISION :	1A :	1B :	1C :	1D :	1E :	1F :	NK :	TOTAL :
MONTH :	:	:	:	:	:	:	:	MONTH :
JAN :	- :	23 :	1 :	115 :	1128 :	234 :	233 :	1734 :
FEB :	- :	33 :	1 :	2 :	431 :	191 :	- :	658 :
MAR :	- :	26 :	3 :	12 :	339 :	829 :	167 :	1376 :
APR :	1 :	59 :	34 :	9 :	943 :	1160 :	544 :	2750 :
MAY :	1 :	133 :	47 :	144 :	239 :	336 :	795 :	1695 :
JUN :	+	567 :	407 :	525 :	200 :	114 :	174 :	1987 :
JUL :	7 :	404 :	372 :	630 :	44 :	109 :	681 :	2247 :
AUG :	12 :	167 :	101 :	4099 :	1107 :	66 :	825 :	6377 :
SEP :	27 :	127 :	87 :	2831 :	1074 :	160 :	143 :	4449 :
OCT :	56 :	52 :	230 :	431 :	470 :	612 :	103 :	1954 :
NOV :	28 :	73 :	506 :	209 :	956 :	169 :	314 :	2255 :
DEC :	9 :	31 :	2 :	865 :	893 :	278 :	56 :	2134 :
TOTAL :	141 :	1695 :	1791 :	9872 :	7824 :	4258 :	4035 :	29616 :
DIV. :	:	:	:	:	:	:	:	:

TABLE 5 SUBAREA 1 COD, CATCH IN NUMBERS PER AGE GROUP (THOUSANDS) IN 1984, GROUPED BY DIVISIONS
 FOR OFFSHORE AND INSHORE CATCHES, THE LATTER BEING A MAXIMUM FIGURE IN WHICH SOME
 OFFSHORE CATCHES BY GEARS OTHER THAN OTTER TRAWL MAY OCCUR.

AGE GROUP	TRAWL			OFFSHORE CATCH			TOTAL			INSHORE CATCH			TOTAL		
	1A-1D	1E-1F	1A-1D	1A-1D	1E-1F	1A-1D	1E-1F	1A-1D	1E-1F	1A-1D	1E-1F	1A-1D	1E-1F	1A-1D	1E-1F
III	115	246	-	-	-	115	246	361	227	227	7	234	253	342	595
IV	93	228	-	14	14	93	242	335	1630	1630	53	1683	295	1723	2018
V	1506	3511	2	433	433	1506	3944	5450	4123	4123	811	4934	4755	5629	10384
VI	199	291	+	28	28	199	319	518	91	91	79	170	398	290	688
VII	1047	1877	4	255	255	1051	2132	3183	304	304	169	473	2301	1355	3656
VIII	33	49	+	9	9	33	58	91	8	8	7	15	65	41	106
IX	120	138	2	42	42	131	180	311	44	44	10	54	190	175	365
X	42	29	1	13	13	43	42	85	10	10	2	12	44	53	99
XI	29	20	-	8	8	29	28	57	11	11	1	12	29	40	69
XII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
XIII	2	1	-	-	-	2	1	3	-	-	-	-	1	2	3
TOTAL	3193	6390	9	802	802	3202	7192	10394	6448	6448	1139	7587	8331	9650	17981

TABLE 6 SURAPEA 1 COD. CATCH IN NUMBERS AT AGE, 1965 - 1984

AGE :	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
3 :	14163	1530	1727	3764	662	49	272	51	131	334
4 :	56928	7672	15091	7976	12399	2768	2519	10039	2302	1079
5 :	52451	62130	30457	36670	8709	10342	10172	9786	16378	2384
6 :	9055	36941	61848	29824	27433	6465	9283	12020	3065	6938
7 :	9890	5915	24562	34591	14664	13985	5237	4081	2605	1135
8 :	15395	4955	2700	10005	12411	4365	9158	2550	1406	1806
9 :	2849	4912	1996	1725	4784	2810	2077	2660	1203	800
10 :	566	1289	5237	833	513	1280	1841	624	552	194
11 :	488	283	352	2348	237	149	953	954	165	177
12 :	1911	130	93	187	704	85	78	709	237	152
13 :	75	981	166	37	41	201	51	130	93	272
14 :	37	139	453	42	62	27	134	57	37	147
15+ :	276	247	85	303	8	41	56	122	44	11
TOTAL :	164084	132324	144767	128305	82627	42567	41831	43747	28218	15438

AGE :	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
3 :	275	10760	634	287	286	2999	12	1204	77	595
4 :	3595	4026	46649	5494	10656	4513	16864	1210	12356	2018
5 :	2677	2243	6053	30039	12505	4580	6374	17960	2011	10384
6 :	1803	1216	1515	1004	18970	1978	2391	2965	17228	688
7 :	5855	302	618	509	709	8014	1053	2078	1581	3656
8 :	1388	1594	425	83	400	125	3382	807	995	106
9 :	610	139	445	41	78	60	45	610	364	365
10 :	291	148	168	13	52	24	65	45	343	97
11 :	84	53	79	7	55	1	1	88	3	69
12 :	38	27	88	7	80	16	1	9	22	0
13 :	0	17	22	7	5	3	0	4	0	3
14 :	12	14	1	1	5	1	0	1	2	0
15+ :	10	26	1	1	16	2	7	13	19	0
TOTAL :	16656	20565	56690	37493	43817	22316	30195	26994	34981	17981

TABLE 7 MEAN WEIGHT AT AGE IN THE MAIN FISHERIES OFF WEST
GREENLAND 1984 (KG).
ONLY FISH ABOVE THE MINIMUM LANDING SIZE (40 CM) ARE
INCLUDED. THE WEIGHT OF THE 3 AND 4 YEARS OLD COD
GIVEN IN THE TABLE WILL THUS BE SOMEWHAT HIGHER THAN
THE AVERAGE IN THE POPULATION.

AGE	GREENL. TRAWL JAN-APR +AUG	GERMAN TRAWL OCT-NOV	GREENL. LONG LINE APR-DEC	GREENL. POUND NET MAY-SEP
3		0.64		
4	0.85	0.86	1.11	0.98
5	1.28	1.42	1.44	1.49
6	1.92	2.34	1.97	2.19
7	2.39	3.63	2.68	2.84
8	3.01	4.67	3.58	3.00
9	3.86	6.40	4.40	4.00
10	4.95	7.69	5.35	
11+	4.17		6.06	

TABLE 8 MEAN WEIGHT AT AGE USED IN THE PROJECTION

AGE	1 JAN 1984	1 JAN 1985	MEAN OF 1 JAN WEIGHTS	MEAN WEIGHTS USED IN PROJECT.
4	0.85	0.64*	0.75	0.91
5	1.28	0.86*	1.07	1.37
6	1.92	1.41	1.67	2.00
7	2.39	2.27	2.33	2.75
8	3.01	3.30	3.16	3.50
9	3.86	3.79	3.83	3.94
10	4.95	5.12	4.04	4.92
11	4.17	7.42	5.80	5.80

* CORRECTED FOR DIFFERENCE BETWEEN MEAN WEIGHT IN THE
POPULATION AND MEAN WEIGHT IN THE CATCH.

TABLE 9 SUBAREA 1 COD, MATURITY AT AGE FROM 1984 SURVEY

AGE	STAGE 1	STAGE 2	STAGE 3+	NUMBER IMMAT.	NUMBER MATURE	% * MATURE	% MAT. 1984 ASSESS.
1	1			1			
2	9			9			
3	353	13		366			1
4	122	91	9	207	15	7	3
5	143	737	283	390	773	66	15
6	1	64	45	1	109	99	48
7	1	56	329	1	385	100	83
8		2	16		18	100	96
9		5	44		49	100	99
10		-	7		7	100	100
11		1			1	100	100

* FOR COMPARISON WITH THE FOLLOWING COLUMN AGES HAVE TO BE SHIFTED UP BY ONE YEAR.

TABLE 10 STRATA AREAS IN SQUARE NAUTICAL MILES OFF WEST GREENLAND.
(NAFO SUBAREA 1, TERRITORIAL WATERS EXCLUDED)

DEPTH ZONE (METERS)	DIVISTON/STRATUM NUMBER							TOTAL
	1B	1C	1C	1C/D	1D	1E	1F	
	1	2	3	4	5	6	7	
0 - 200	2121	2167	2500	17	2350	1938	2568	13661
201 - 400	506	313	988	74	1018	742	971	4612
401 - 600	364	415	234	178	259	57	353	1860
TOTAL	2991	2895	3722	269	3627	2737	3892	20133

STRATA BOUNDARIES:

LATITUDES (N)

LONGITUDES (W)

STRATUM DIVISTON

1	1B	66°15' - 67°00'	57°00'
2	1C	65°30' - 66°15'	57°00'
3	1C	64°15' - 65°30'	55°00'
4	1C/1D	63°45' - 65°30'	55°00' - 57°00'
5	1D	62°40' - 64°15'	55°00'
6	1E	60°45' - 62°30'	53°00'
7	1F	59°00' - 60°45'	44°00' - 50°00'

Table: 11 Cod in Subarea 1, Survey abundance estimates (Nos. $\times 10^{-3}$) by age and Division in 1982-1984

Age	Div. Strat.	1B+C 1-4	1D 5	1E 6	1F 7	Total 1B-F Σ of Strat 1-7	Total SA 1 based on combined age/length key		
							1982	83	84
0	1982	83	84	84	83	84	1982	83	84
1	60	104	16	68	19	40	160	222	148
2	610	78	90	4	7	4	722	98	4
3	686	29	18 862	11	5	4	36 181	1 735	1 595
4	292	36	4 151	282	5 191	850	3 326	1 987	3 498
5	96	4	15 059	847	3 523	241	10 821	1 457	2 028
6	11	107	683	2 463	11 241	2 635	38 789	9 117	1 479
7	2	7	2 779	3 718	7 091	350	13 618	5 859	9 268
8		80	203	752	3 046	768	4 754	12 958	14 488
9		36	271	393	661	36	1 047	2 223	5 002
10			60	157	1 443	59	2 006	1 172	1 245
11			52	84	74	11	126	375	2 071
12			75	5	5	2	85	198	22
13			70				70	4	159
14							13	15	57
NK							137	55	16
TOTAL	4 757	763	22 459	17 646	32 346	4 996	109 039	59 362	59 375
	477	50 161	5 321	21 775	32 346	4 996	115 685	16 110	16 110

TABLE 12 SUBAREA 1 COD, MEAN LENGTH AT AGE BY DIVISIONS AND
SUBAREA 1 COMBINED FROM 1984 SURVEY RESULTS.

DIVIS./STRATUM	1B+C	1D	1E	1F	1B-F	1 SA 1
I 1-4	5	6	7	Σ 1-7	IOVERALL	I
YEARCL.	AGE I					ALK
1984	0 I 7.50	9.22	10.50	9.90	8.59	I 9.22
1983	1 I -	19.50	-	-	19.50	I 19.50
1982	2 I 25.04	27.14	30.30	30.00	25.74	I 26.58
1981	3 I 29.12	36.74	34.45	34.21	34.58	I 34.79
1980	4 I 44.42	43.77	44.67	44.15	44.05	I 44.09
1979	5 I 57.21	52.58	52.55	53.53	53.14	I 52.81
1978	6 I 52.50	57.91	60.31	61.66	60.36	I 60.22
1977	7 I 71.96	68.15	67.50	67.66	67.93	I 67.70
1976	8 I -	68.55	74.40	74.58	73.12	I 72.79
1975	9 I 79.17	78.11	80.48	79.91	79.19	I 78.88
1974	10 I -	87.21	88.50	87.68	87.68	I 88.40
1973	11 I -	-	79.50	79.50	79.50	I 79.50

TABLE 13 SUBAREA 1 COD, ASSESSMENT TABLE 1984 (NUMBERS IN THOUSANDS OF FISH)

AGE	YEARCL.	STOCK SIZE	Z	F	1984 CATCH	M	E	LOSSES DUE TO	EMIGR.	UNEXPL.
		1 JAN**	31 DEC*					E	**	LOSSES
5	1979	33245	7994	0.586	10384	0.2	0.639	11323	1255	10068
6	1978	4895	716	0.316	688	0.2	1.406	3056	552	2504
7	1977	12413	1901	0.653	3656	0.2	1.024	5735	2352	3383
8	1976	1094	80	0.178	106	0.2	2.839	1691	144	1547
9	1975	1121	224	0.655	365	0.2	0.756	421	134	287
10	1974	350	14	0.912	97	0.2	2.134	227	-68	295
11	≤1973	254	4	1.195	72	0.2	2.756	166	-406	572
TOTAL 5+		54283	10933	0.568	15368	0.2	0.836	22619	3963	18656
TOTAL 6+		21038	2939	0.542	4984	0.2	1.228	11296	2708	8588

* FROM 1984 SURVEY AND DECEMBER CATCHES

** FROM 1983 SURVEY

*** FROM EAST GREENLAND ASSESSMENT

AGE	YEARCL.	SURVEY STOCK	CATCH DEC
		OCT-NOV	
5	1979	9117	981
6	1978	813	84
7	1977	2050	125
8	1976	86	5
9	1975	241	13
10	1974	22	8
11+	≤1973	4	-

TABLE 14 SUBAREA 1 COD, PARAMETERS USED IN CATCH
 PROJECTIONS WITH $M = 0.2$ AND RECRUITMENT
 AT AGE 3 AS 20 MILLION FOR YEARCLASSES
 1981 TO 1984. THE EMIGRATION COEFFICIENT
 OF 0.3 IS ADDED TO M FROM AGE 6 ONWARDS.

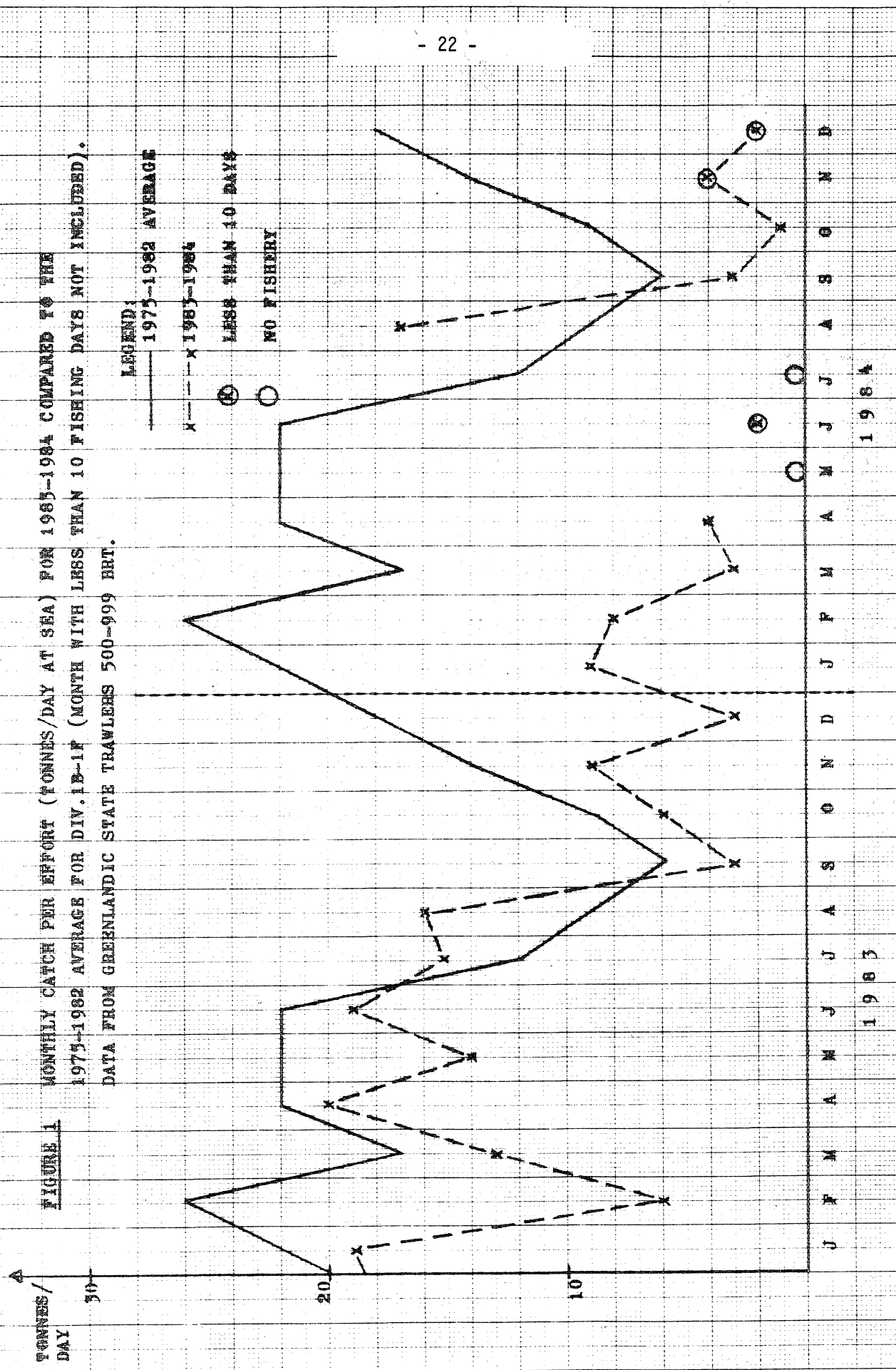
AGE	STOCK SIZE 1 JAN 1985 (1000)	RELATIVE M	MEAN WEIGHT (KG)	% MATURITY	RELATIVE F
3	20 000	1.5	0.78	1	0.039
4	14 307	1.0	0.91	3	0.52
5	1 286	1.0	1.37	15	1.0
6	7 994	2.5	2.00	48	1.0
7	716	2.5	2.75	83	1.0
8	1 901	2.5	3.50	96	1.0
9	80	2.5	3.94	99	1.0
10	224	2.5	4.92	100	1.0
11	14	2.5	5.80	100	1.0
12+	4	2.5	6.50	100	1.0

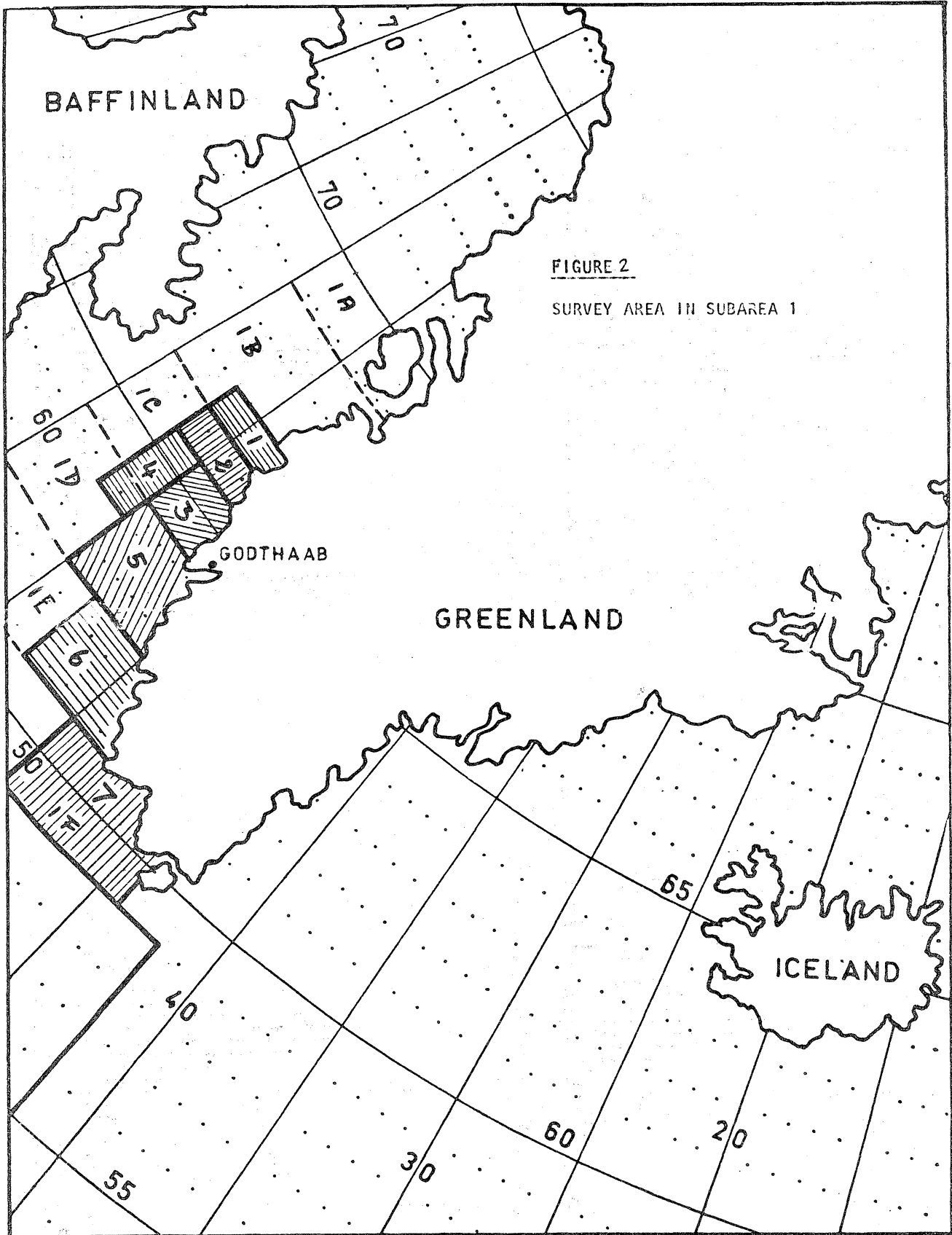
TABLE 15 SUBAREA 1 COD, PROJECTION OF BIOMASS OF COD AT AGE 3 AND OLDER (BIOM. 3+), SPawning STOCK BIOMASS (SSB) AT THE BEGINNING OF EACH YEAR AND CATCH DURING THE YEAR FOR DIFFERENT MANAGEMENT STRATEGIES. THE ASSUMED CATCH IN 1985 OF 28 300 TONNES CORRESPONDS TO THE TAC. WEIGHTS IN THOUSANDS OF TONNES

YEAR	F(86)= F 0.1	F(86)= F MAX	F(86)= F(84)	CATCH 25000 T	CATCH 15000 T	CATCH 0	F(85-86)= F 0.1	F(85-86)= F MAX	CATCH(85)= 86)15000T
1985	BIOM. 3+ SSB F CATCH	56.5 18.0 1.844 28.3	56.5 18.0 1.844 28.3	56.5 18.0 1.844 28.3	56.5 18.0 1.844 28.3	56.5 18.0 1.844 28.3	56.5 18.0 0.392 9.7	56.5 18.0 1.000 19.9	56.5 18.0 0.674 15.0
1986	BIOM. 3+ SSB F CATCH	37.9 4.5 0.392 5.1	37.9 4.5 0.568 6.9	37.9 4.5 8.300 25.0	37.9 4.5 1.750 15.0	37.9 4.5 0 0	37.9 4.5 0.392 10.3	37.9 4.5 1.000 15.2	37.9 4.5 0.775 15.0
1987	BIOM. 3+ SSB	48.3 6.6	41.5 4.2	25.6 0.5	36.2 2.5	54.6 9.0	60.7 15.2	44.6 6.2	51.6 9.0

TABLE 16 SUBAREA 1 COD, PROJECTION OF BIOMASS OF COD AT AGE 3 AND OLDER (BIOM. 3+), SPawning STOCK BIOMASS (SSB) AT THE BEGINNING OF EACH YEAR AND CATCH DURING THE YEAR FOR DIFFERENT MANAGEMENT STRATEGIES. THE ASSUMED CATCH IN 1985 OF 13 100 TONNES CORRESPONDS TO A FISHING MORTALITY OF 0.568, THE SAME AS IN 1984. WEIGHTS IN THOUSANDS OF TONNES.

YEAR	F(86)= F 0.1	F(86)= F MAX	F(86)= F(84)	CATCH(86)= 15000 T	CATCH(86)= 0
1985	BIOM. 3+ SSB F CATCH	56.5 18.0 0.568 13.1	56.5 18.0 0.568 13.1	56.5 18.0 0.568 13.1	56.5 18.0 0.568 13.1
1986	BIOM. 3+ SSB F CATCH	53.5 13.2 0.392 9.3	53.5 13.2 0.568 12.6	53.5 13.2 0.715 15.0	53.5 13.2 0 0
1987	BIOM. 3+ SSB	58.4 13.5	47.1 8.0	51.7 10.2	69.4 19.2





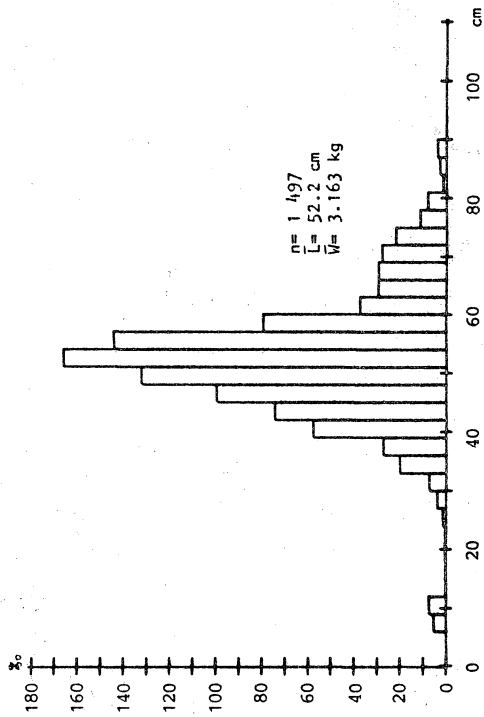


Figure 3a : *Gadus morhua*, West Greenland, Division 1 D,

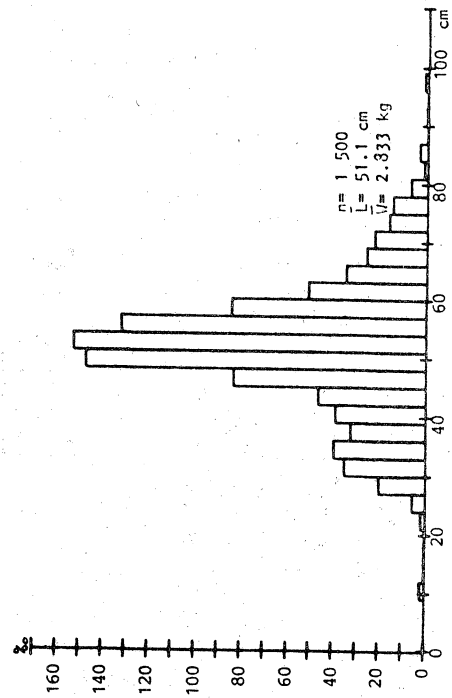


Figure 3b : *Gadus morhua*, West Greenland, Division 1 E,

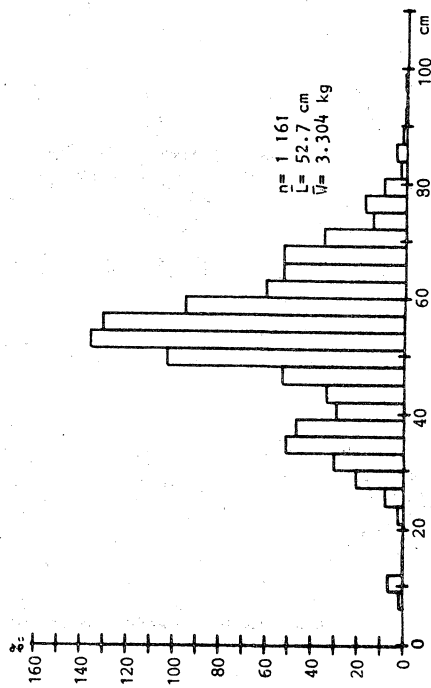


Figure 3c : *Gadus morhua*, West Greenland, Division 1 F,

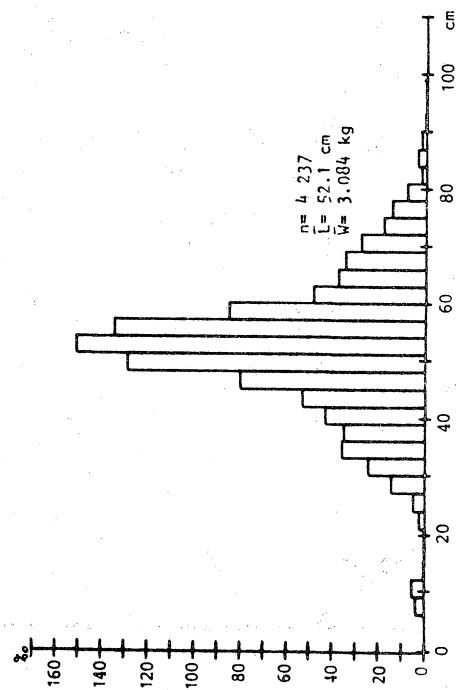


Figure 3d : *Gadus morhua*, West Greenland (Div. 1 B-F) TOTAL,

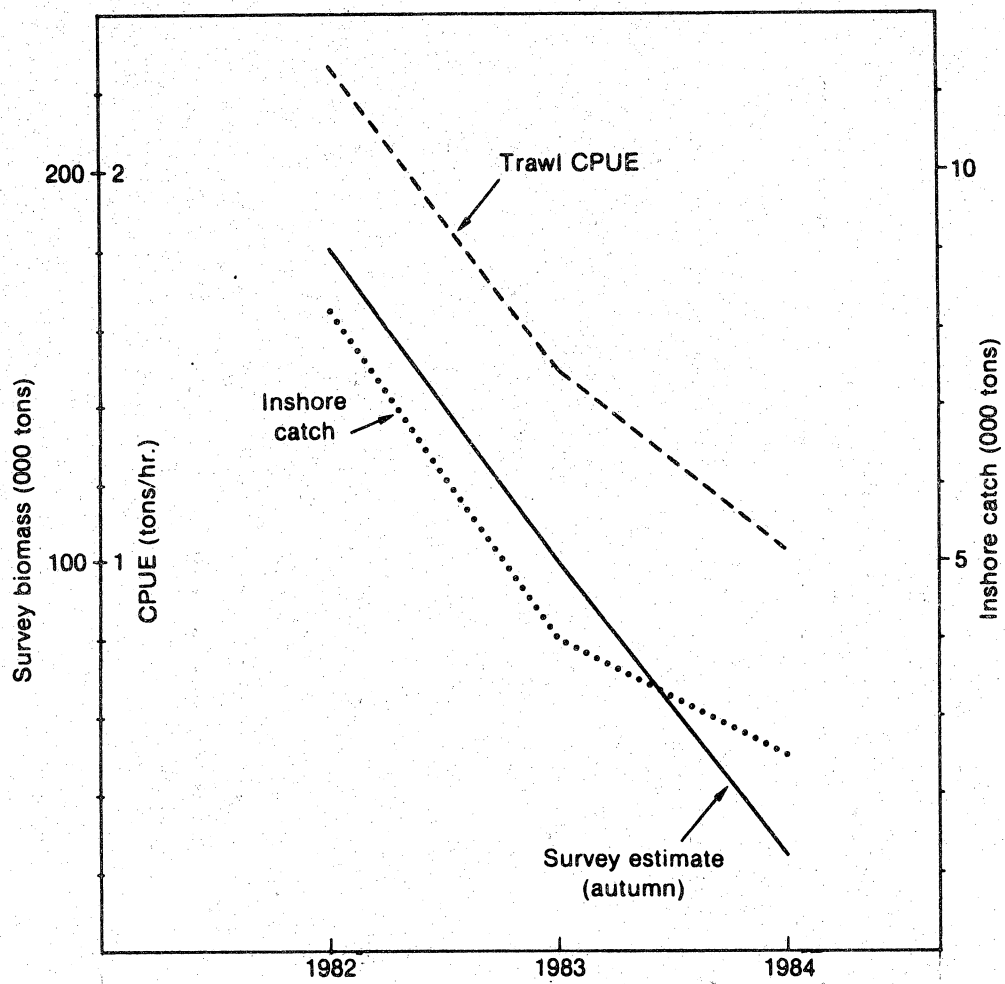


Fig. 4. Subarea 1 cod: trends in survey biomass estimates, CPUE of Greenlandic trawlers and inshore catches, 1982-1984.

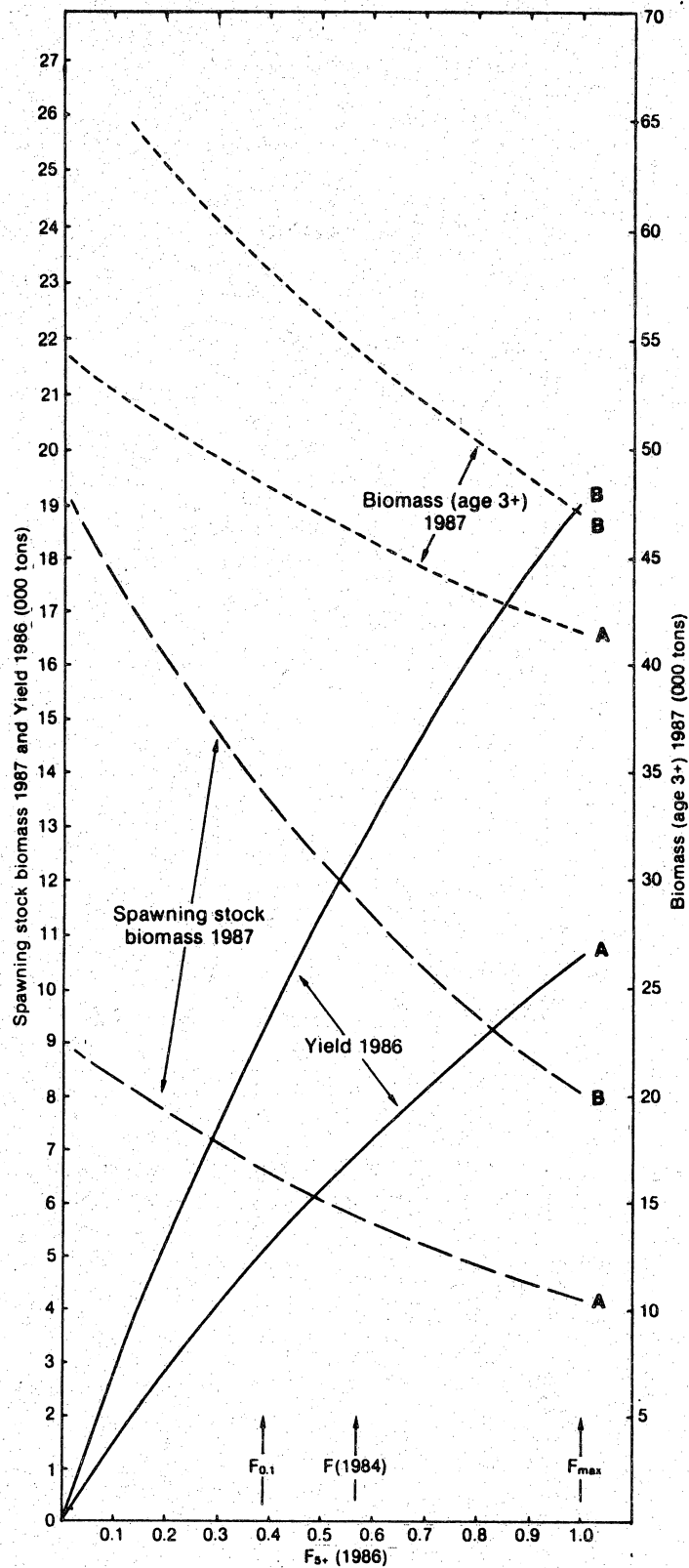


Fig. 5. Cod in Subarea 1: calculated yield in 1986, biomass (age 3+) and spawning stock biomass in January 1987 for various levels of fishing mortality in 1986, assuming (A) the 1985 catch to be 28,300 tons, and (B) the 1985 catch to be 13,200 tons.