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Status of Subarea 1 Cod and the Fisheries

An Extract of the Report of the ICES Working Group on Cod Stocks off East Greenland, Copenhagen, 11-23 February 1988

compiled by

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1 PARTICIPANTS

The Working Group on Cod Stocks off East Greenland met in Copenhagen from 17-23 February 1988, with the following participants:

C. Bishop	Canada
H.P. Cornus	Fed. Rep. of Germany
H. Hovgård	Denmark
Sv.Aa. Horsted	Denmark
H. Lassen	Denmark
K. Lehmann	Denmark
J. Messtorff	Fed. Rep. of Germany
K. Nygård	Denmark
S.A. Schopka (Acting Chairman)	Iceland
A. Schumacher	Fed. Rep. of Germany

Since the Chairman of the Working Group, Mr K. Hoydal, could not attend the meeting, Dr S.A. Schopka agreed to serve as chairman. Dr E.D. Anderson, ICES Statistician, attended part of the meeting.

2 TERMS OF REFERENCE

At the 1987 Statutory Meeting, it was decided (C.Res.1987/2:3:2) that the Working Group on Cod Stocks off East Greenland should meet at ICES Headquarters from 17-23 February 1988 to:

i) analyze the results of the latest groundfish survey;

ii) assess the status of and provide catch options for 1988 within safe biological limits for East Greenland cod.

Due to the interrelationship between the West Greenland and East Greenland cod stocks, it is necessary to use data derived from the assessment of the West Greenland cod stock in order to make a proper assessment of the East Greenland cod stock. In Section 3, the interrelationships of these two cod stocks are discussed, and it is obvious that there are sound scientific reasons for carrying out the two assessments simultaneously and presenting them in one report. There are also practical reasons for this.

The assessments in the two areas are based on data from a groundfish survey which is designed in almost the same way for both areas, and the scientists involved are the same.

Management advice on the two areas is given by two different international organizations. In the case of West Greenland, the Scientific Council of NAFO scrutinizes the assessment and formulates the advice; in the case of East Greenland, the ACFM of ICES handles the advice.

As in the 1987 Working Group report, both assessments are presented in this report. The West Greenland part of the report will be presented by participants of the meeting as a working document to the NAFO Scientific Council for its further discussion and for catch projections and management advice.

3 THE COD STOCK COMPLEX IN GREENLAND AND ICELANDIC WATERS (Table 3.1, Figure 3.1)

It has been known for several decades that there is an interrelationship between the cod stocks at West and East Greenland and at Iceland (Figure 3.1). Tagging experiments carried out at Greenland and Iceland show that a part of the mature cod at West Greenland migrates to East Greenland and some of them further to Iceland. Results of tagging experiments carried out in East Greenland waters also show that mature cod from that area migrate to Iceland. This may also sometimes be the case for immature cod found in the East Greenland area closest to Iceland. On the other hand, in some years, immature cod seem to migrate from East Greenland to West Greenland. At Iceland, tagging experiments show that migration of cod from Icelandic to Greenland waters hardly occurs and, therefore, the migrations from Greenland waters to Iceland can be regarded as one-way emigration.

However, the interrelationship between the stocks is not only a matter of adult and immature cod migrating and mixing, but also a matter of recruitment to one area originating from spawning in another area. As far as this question is concerned, larval drift with currents from East to West Greenland and from Iceland via East Greenland waters to the banks off West Greenland seems evident.

The magnitude of this drift and the survival rate of the larvae seem to vary much from year to year. In some years, the drift seems negligible, while in other years (e.g., in 1963, 1973, and 1984), considerable numbers of cod larvae seem to have drifted from Iceland to East Greenland and to the southern part of West Greenland. This variation is reflected by the abundance indices of cod from the Icelandic 0-group surveys in East Greenland waters (Table 3.1).

As haddock do not spawn in Greenland waters, the occurrence of the 1984 and 1985 hadddock year classes at Greenland, therefore, documents that a similar larval/0-group drift has taken place for haddock in these latter years. This further supports the hypothesis that, under the hydrographical conditions for larval/0-group drift in 1984 and 1985, these two year classes of cod at Greenland may be largely of Icelandic origin (Hovgård and Messtorff, 1987).

The magnitude of emigration from West Greenland to East Greenland and Iceland also seems to vary from year to year and between year classes. Up to 1984, the Working Group used an emigration coefficient of E = 0.05 for the West Greenland stock as a whole, which was based on results from tagging experiments carried out mainly in the period 1945-1970. Information from the groundfish surveys from 1982 to 1987 indicates that the emigration varies considerably from year to year and between year classes.

Also at East Greenland, the emigration to Iceland varies from year to year. From Danish tagging experiments, the North-Western Working Group concluded (Anon., 1971) that about 45% of the mature cod from East Greenland migrate to Iceland. However, the North-Western Working Group considered the East Greenland stock and the cod in NAFO Divisions 1E-F at West Greenland as being combined and estimated the coefficient of emigration as 0.29, which corresponds to an emigration of 25% per year.

Another attempt to estimate the migration from Greenland to Iceland was made by the Joint ICES/ICNAF Working Group on Cod Stocks in the North Atlantic in 1972 (Anon., 1973). The result of that exercise confirmed previous findings (24%).

4 ENVIRONMENTAL CONDITIONS IN 1987

The air temperatures over the West Greenland area have been fluctuating around the long-term average in 1987, but the period February-May experienced relatively strong negative anomalies (-3.2^{0}C in April). The temperatures of the surface layer were, therefore, slightly below normal throughout the year. Also the deeper layers west of the fishing banks showed temperatures slightly below the mean conditions, indicating a relatively weak inflow of Irminger water in 1987.

5 SURVEYS AND RESEARCH (Table 5.1, Figure 5.1)

5.1 The Federal Republic of Germany Groundfish Survey Design

The surveys were designed according to the stratified random sampling method by applying the "swept-area" method to the survey results. The parameters of the standard bottom trawl used in all surveys are as follows:

Gear:	140' bottom trawl equipped with a small mesh (30-mm) liner inside the codend
Horizontal net opening:	22-m wing spread
Vertical net opening:	3.5-m headline height (not considered in the calculations)
Trawling speed:	4.5 knots
Towing time:	30 minutes

The true catchability coefficient is unknown. For the calculation of survey estimates, it was, however, taken as 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.

The survey areas off East Greenland (ICES Division XIVb) and off West Greenland (NAFO Subarea 1) are shown in Figure 5.1. Trial surveys during different seasons proved that cod in both areas were most evenly distributed in the autumn and, therefore, give smaller variances of the survey estimates than at other times of the year.

The survey areas are composed of statistical rectangles (30' lat. x 1^0 long.), as used throughout the ICES area, which form the basis of the stratification schemes. However, according to area-specific reasons, the construction of strata is different in the two survey areas.

Groundfish surveys conducted in Division XIVb by the Federal Republic of Germany from 1980 to 1986 have been fairly consistent in terms of area covered, method of selection of fishing stations, and analysis. In 1980 to 1982, a 4-depth zone stratification was used.

Since no substantial changes in the relative density distribution were observed in these surveys, for the 1983-1986 surveys, the stratification of the East Greenland area has been based on mean densities of cod per statistical rectangle derived from the previous surveys. A set of five strata was constructed for five increasing ranges of density distribution. Each stratum is composed of statistical rectangles for which the same range of mean relative density distributions has been computed. Consequently, the strata are different in size depending on how many of the whole survey area's 36 statistical rectangles are allocated to them.

The survey in 1987 was conducted somewhat different in that the stratification was done by depth zone as in the period 1980-1982 except that the depth zones were further divided into a northern, middle, and southern part. The change was instituted because it was felt by some researchers that the results of the 1985 and 1986 surveys had indicated that areas of higher cod densities had changed geographically and, as such, the method of stratification on the basis of previous density distribution might be inappropriate.

In addition, the survey area was enlarged (a) to the north (Strede Bank) and (b) to include the shelf region between 64^0 and 66^0 N latitude, since from hydroacoustic observations cod are known to be present in the respective areas. However, trawling in the latter area is almost impossible due to some ice coverage and the rough bottom conditions. Inclusion of this area would lead to extrapolation of density values to large areas which were not fished and for which, therefore, no density estimates are available.

The Working Group did not consider this approach to be satisfactory on the grounds that, under the prevailing complicated and highly variable current and hence temperature regime, extrapolation of density estimates into this large area would lead to biased results.

For the purpose of comparison, the Working Group decided to use the result from calculations with a 4-depth zone stratification (0-200 m, 200-400 m, 400-600 m, and 600-800 m), based on the survey area used in all previous years. This is in fact the stratification which was used in the surveys in 1980-1982. However, the depth zone 600-800 m was not fished in 1987, but the contribution from this zone was taken as zero based on past experience. The strata areas are given in Figure 5.1.

The West Greenland survey area lies within 51 statistical rectangles containing the shelf outside the 3-mile limit and the continental slope down to 600-m depth extending from the southern part of NAFO Division 1B (south of 67^0N latitude) southward as illustrated in Figure 5.1. The area consists of seven main strata equal to NAFO Divisions 1B-F or parts thereof. The main strata are each sub-divided by 100-m depth zones between 0-600 m into six sub-strata, except in Division 1F (stratum 7) where, due to

the lack of suitable bathymetric charts, a sub-stratification was possible only by 200-m depth zones. Strata areas (nm^2) are given in Table 5.1.

For the purpose of random selection of fishing stations, each statistical rectangle is divided into unit areas equivalent to 7.5' latitude x 15' longitude rectangles, with each of these further sub-divided into nine smaller random units (2.5' x 5' rectangles). The random units are numbered consecutively but separately inside each main stratum. Of the total number of fishing stations planned for each survey, 50% are allocated proportionally to the stratum sizes and correspondingly inside each stratum to the sub-strata areas. The remaining half is allocated proportionally to the mean relative densities within each stratum and sub-stratum as derived from previous surveys.

5.2 Japanese Groundfish Survey

In 1987, a groundfish survey was carried out by the Japanese research trawler "Shinkai Maru" in a joint programme between the Japanese Marine Resources Research Center (JAMARC) and the Greenland Home Rule Trawling Company (GHT).

The survey covered both East and West Greenland waters. The West Greenland survey was carried out in July and August covering the areas south of 70^0N latitude, i.e., the southern part of NAFO Division 1A and Divisions 1B-1F. Stratification was done by NAFO division and depths zones. Stations were allocated to strata in proportion to the area.

In East Greenland, the area south of 67^0N latitude was covered in October-November. The area was divided into a northern, central, and southern part, and these were further sub-divided into depth zones. Stations were then allocated according to area. However, due to the extremely difficult bottom conditions off East Greenland, only two-thirds of the stations could be fished and many had to be moved to areas more favourable than the pre-selected sites.

The distribution pattern of the cod stocks found in the Japanese surveys was, in general, in accordance with the German (F.R.) findings, as the stocks at both East and West Greenland were concentrated in shallow areas (0-200 m) and rather southerly. Both surveys also showed a dominance of the 1984 and 1985 year classes. However, abundance estimates and confidence intervals differed between surveys. In West Greenland, the two estimates were in the same order of size, but the confidence interval calculated from the Japanese survey is much wider. This is to be expected as the stations in the Japanese survey were allocated proportional to areas, whereas the Federal Republic of Germany survey is designed specifically for cod and, hence, more effort is distributed in areas where cod are usually caught (shallow areas in the south). In East Greenland, the estimated abundance accounted only for 40% of the total abundance estimates by the Federal Republic of Germany survey. This difference can be caused by many factors: differences in vessels, gear, and towing speed; differences in experience of the crew; and differences in the survey designs (allocation of stations proportional to area on the one hand and proportional to area and density on the other hand).

As the Federal Republic of Germany survey uses gears that have been trimmed to Greenland conditions, and the crew has experience in fishing in the area and uses a design especially aiming at estimating cod abundance, and in view of the lack of time series, the Working Group decided to base the assessment on East Greenland cod stocks on the results of the Federal Republic of Germany survey only.

5.3 Greenland Surveys and Research

5.3.1 West Greenland longline survey (Tables 5.3.1.1-5.3.1.3)

Description

In October-November 1987, Greenland conducted a longline survey off West Greenland. The results were discussed in a working paper presented at the meeting (Hovgård *et al.*, 1988). The survey was carried out in inshore and offshore areas of NAFO Divisions 1C, 1D, and 1E, with the purpose of describing the relative distribution and abundance of cod inside and outside the area covered by the concurrent Federal Republic of Germany trawl survey.

The survey was carried out from R/V "Adolf Jensen" and R/V "Misiliisoq" with longlines of equal type on both vessels. At most of the stations, 400 hooks were used, but in a few cases, 200 hooks were used. Lines were baited with capelin. Fishing took place only during the light hours, and average fishing time was 4.8 h (range 3.7-7.8 h). Results are expressed in catch in numbers per 100 hooks disregarding any difference in fishing time.

Within the survey area, which included fjords, coast, and banks (offshore), fishing was conducted using a random stratification method of fishing site selection. Strata were selected within the depth range 0-300 m and at 100-m depth intervals. There were some restrictions on the randomization of stations in that they had to be fished on a daily basis and be permitted sufficient fishing time on the bottom. This restricted the number of stations to 4-5 per day as well as the distance between stations.

The offshore area was defined as the area outside a line 3 nautical miles off the baseline (area covered by the Federal Republic of Germany trawl survey), the coastal area between the 3-mile zone to straight lines drawn across the entrance of the fjords. The area inside these lines was defined as fjords. The survey covered only areas between 0- and 300-m depth.

The size of the offshore strata was taken from Anon. (1987), and coastal areas were recorded by planimeter measurements. In fjord areas, the depth information is generally poor, and the areas cannot be directly measured. However, bathygraphic lines were subjectively drawn according to information available for 13 fjords, and areas of depth strata were hereafter recorded by planimeter. The mean depth distribution found was then raised to cover the total fjord area of each division. Areas of all strata are given in Table 5.3.1.1.

Results

The low catchability of smaller cod by the longline fishery causes problems when interpreting results, and, to avoid bias, small and large cod were treated separately. The division of the two groups was made at 54 cm, as this length best separates the outstanding 1984 year class from the older cod.

Mean density (catch per 100 hooks) is given by all strata in Tables 5.3.1.2 and 5.3.1.3 for small and large cod, respectively.

Based on the stratified random survey scheme, the results of the mean density calculations in the three areas, i.e, banks, coast, and fjords, are shown in the following text table:

	Relative distribution of cod in Div. 1C-E (%)	
Area	Small (< 54 cm)	Large (> 54 cm)
Bank	79	78
Coast	19	21
Fjord	2	1

From this survey it may be concluded that, when estimating the stock size in Divisions 1C-1E solely by the offshore component, only 78% of the total stock abundance is included.

5.3.2 West Greenland young cod survey

During July and August 1987, Greenland carried out a survey on young cod in three inshore areas of West Greenland: Quaqortoq (Division 1F), Nuuk (Division 1D), and Sisimiut (Division 1B). The results of the survey were presented in a working document at the meeting (Hovgård and Nygård, 1988).

Links of gillnets containing separate sections with 5 mesh sizes (16-39 mm, bar length) arranged in random order were used. With these mesh sizes, fish between 15 and 35 cm are efficiently caught, whereas the catchability of larger and smaller fish is substantially lower.

A total of 223 net settings was made. Nets were set (floating or at the bottom) at depths ranging from 2 to 35 m. Average fishing time was 8.2 h (range 5.1-13.1 h) and the catch rate (number caught per hour) for each age group was used as an index of abundance.

During the survey, a total of 3,991 cod was caught. Catches were dominated by 3- and 2-year-old cod, i.e., the 1984 and 1985 year classes. Only two 1-year-old cod were taken. As 1-year-old cod (13-20 cm) have previously been caught efficiently by this method (Hansen and Lehmann, 1986), the present results indicate a very low abundance for the 1986 year class in the West Greenland area.

The 1985 year class was found primarily in Divisions 1F and 1B, whereas the catch in Division 1D was significantly lower. As 3-year-old cod (1984 year class) are too big to be caught effectively, formal analysis of their distribution was not carried

out. However, as survey effort has been distributed evenly between areas, it could be deduced that 3-year-old cod were relatively evenly distributed in West Greenland, although with a somewhat higher abundance in the northern area (Division 1B).

Based on the stratified sampling techniques, indices of year-class strength were calculated. Due to the almost non-existence of the 1-year-old cod, the index for that age group was set at zero.

By comparing the abundance index of cod at age 2 in this survey with the value of the 1986 survey, the size of the 1985 year class is estimated to be 22% of the 1984 year class, as shown in the text table below:

	Index of year-class strength	
Survey	Age 1	Age 2
1986	0.09	1.61
1987	0.00	0.36

6 STOCK AT WEST GREENLAND (NAFO SUBAREA 1)(Tables 6.1.1-6.1.6)

6.1 Trends in Catch and Effort

The fishery for cod in NAFO Subarea 1 is partly an offshore fishery carried out by large trawlers, and partly a coastal and fjord fishery, of which the main part of the landings usually is taken by pound net.

In 1987, no directed trawl fishery by vessels greater than 80 GRT was allowed in the first 10 months. The pound net fishery was restricted to places where, based on experience, at least 30% of the catch by weight would be above 40 cm. Similar regulations were introduced in 1986 in order to protect small cod, especially the 1984 year class.

The nominal catch in 1987 was 18,554 t (provisional figures) (Tables 6.1.1-6.1.5), which is more than 3 times greater than the 1986 landings, but still at a low level compared with the landings in the last decade.

Greenland vessels landed 18,477 t or 99% of the total; the remainder (77 t) was taken by the Federal Republic of Germany (68 t) and Japan (9 t).

Of the 3,300 t taken by trawlers greater than 80 GRT, 800 t resulted from a directed cod fishery in the last two month of the year; the remaining 2,500 t were caught as by-catch in the fishery directed for redfish. In 1987, a new statistics programme was introduced for vessels below 80 GRT. This programme supplied statistics of the landings by division, gear, month, and size group for cod whether above or below 55 cm. In 1987, this programme covered 75% of the landings from those vessels. The remaining part was only broken down by division and month. The

breakdown by gear given in Table 6.1.2 refers to the total reported landings of small vessels raised according to the data from the detailed, new programme. Of the landings from vessels below 80 GRT, 2,500 t were reported to be taken by trawls. The landings from these small trawlers were concentrated in NAFO Division 1D in the first months, while the large trawlers operated in NAFO Divisions 1D, 1E, and 1F. Pound nets caught 5,300 t with 900 of these being reported from Division 1B in the first 4 months. The latter may be misreported as normally the pound net fishery does not start before May. The remaining catches were taken in June, July, and August, and were concentrated in Division 1D.

The next prominent fishery, the handline fishery, took place in June, July, and August and was concentrated in Divisions 1E and 1B. This fishery amounted to 4,220 t. Landings from gillnets and longlines were 1,600 and 1,700 t, respectively. The gillnet fishery started in June and continued for the rest of the year mainly in Divisions 1F, 1D, and 1E. The main part of the longline fishery took place in January to July and was concentrated in Divisions 1B and 1D.

A directed cod fishery was carried out by only two large vessels in November-December, mainly in Division 1D. The overall catch per unit effort has more than doubled, compared to the low value of 1985, to 1.7 t per hour in 1987 (Table 6.1.6).

6.2 Catch in Numbers at Age and Catch Composition (Tables 6.1.4, 6.2.1, and 6.2.2)

The catch statistics from the fisheries by Greenland now supply information on the gears used. Furthermore, landings of cod in 1987 were recorded in two size categories (below 55 cm, and 55 cm or larger). The split into two size categories seems to be either a direct sorting of the fish before or when landed (this goes for small-boat catches mainly) or a judgement of the proportion of the categories through a sample taken at the fish plant after landing. In most cases, the biological samples in 1987 were taken randomly from unsorted landings. However, in some cases, the two size categories were sampled separately. The breakdown of catches by gears and in two size categories should allow improved accuracy when converting catch by weight into catch by number, but would require more samples than taken in 1987 to achieve the full benefit of that information.

Whereas in 1986, fisheries regulations influenced the catches so that trawls and pound nets caught a minor part of the total catch, these two gears took the major catch component (28% and 31%, respectively) in 1987. Catches by these gears, especially those by pound nets, were relatively well sampled. The catch by longlines (9%) was sampled mainly through fishing by research vessel, gillnet catches (9%) were represented by one sample only, whereas the handline component (22%) had to be judged through pound net samples lacking direct sampling.

Trawl catches in the first quarter of the year were dominated by age groups 8, 7, and 6 (1979, 1980, and 1981 year classes), whereas the large catch in the last quarter (see Table 6.1.4) was heavily dominated by the recruiting 1984 year class (82% by number).

Longline catches were dominated by the 1979 year class (about 40%), although by the end of the year, cod of the 1984 year class became more frequent.

Pound net catches (and supposedly those by handlines) were heavily dominated by the recruiting 1984 year class (some samples by about 90% by number) and, in some cases, there seems to have been a high rate of discard of fish below the Greenland minimum landing size (40 cm), mainly fish of the 1984 year class.

In total, the 1984 year class seems to have accounted for about 60% (by number) of the total nominal catch in 1987. In terms of catch by weight, the year class accounted for about 42% of the landings.

The estimate of a rather high amount of 4-year-old fish (1983 year class) is based on one of the samples of pound net catches (Division 1D in July) taken as representing a catch of nearly 3,000 t. However, the overlap in length distribution of the 3-and the 4-year-old fish in that sample seems to call for a test of the ageing of its otoliths. This was not possible during the present meeting of the Working Group.

Among the older year classes, the 1979 year class is still a significant contributor to the total catch (18% by weight).

6.3 Mean Weight at Age in the Catches (Table 6.3)

The mean weights at age of cod in the major Greenlandic fisheries in 1987 are listed in Table 6.3. For each gear, the mean weights were calculated by weighting the observed mean weights at age by the numbers in each age group in the catch represented by the individual samples. Mean weight of the total was likewise calculated by weighting by the numbers caught in each gear and age group. This is a different weighting procedure than used formerly when total catch by gear was used as the weighting factor for all age groups. Mean weights in landings were highest for those from longlines and gillnets and lowest for those from pound nets.

The mean weights found in 1987 generally exceed the values of last year, especially for the 3-year-olds.

6.4 Maturity Ogives

Data from the 1987 Greenland longline survey suggest that the proportion of maturity at age in 1987 is different from the 1986 ogive but very similar to the 1983 and 1985 maturity pattern. It was, therefore, agreed to use the same maturity ogive as used in the 1985 assessment. The maturity rates for the period 1983-1987 are given in the text table below:

Age	Maturity at age (%)			
	1983	1985	1986	1987[1]
3	1	-	<1	-
4	3	2	3	<1
4	15	11	27	13
6	48	42	81	77
7	83	82	98	67
8	96	96	100	94
9	99	99	100	97
10+	100	100	100	98

[1] Not smoothed by a sigmoid curve.

6.5 Groundfish Survey Results (Tables 6.5.1-6.5.3, Figures 6.5.1-6.5.2)

The number of randomly distributed fishing stations occupied during the surveys from 1982-1987 amounted to 111, 153, 162, 133, 155, and 150, respectively. The results were based on 98, 142, 158, 114, 142,and 140 valid sets.

Cod biomass and abundance estimates for the total survey area off West Greenland of 19,864 nm^2 in 1982 and 1983 and of 20,133 nm^2 after inclusion of stratum 4 since 1984 amounted to:

Year	Tonnes	Number ('000)	w kg
1982	189,934 ± 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

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

The surveys were carried out in November-December in 1982, 1983, and 1985 and in October-November in 1984, 1986, and 1987. The R/V "Walther Herwig" was used each year except in 1984 when, for technical reasons, she had to be replaced by R/V "Anton Dohrn". However, experience from a 13-year time series of bottom trawl surveys in Division 2J (Labrador) 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.

From 1982-1984, the survey results reveal a drastic decline in cod biomass and abundance which was observed not only for the whole survey area (Figure 6.5.1), but for all divisions, as shown in detail in Table 6.5.1. Confirmation of the reduced stock size in 1983 and 1984 was also obtained by continuous echosounder recordings throughout the survey area and by the trends in commercial catch and effort. The survey results of 1985-1987 indicated a stabilization of the 4+ biomass slightly above the low level of 1984 until 1986 around 30,000 t, but an increase to 55,000 t in 1987. The total survey biomass and abundance, however, increased

considerably since 1984 and very steeply in 1987 by factors of 18 and 36, respectively, due to increasing recruitment, mainly of the outstanding 1984 year class which amounted to 86% of the total survey biomass and 88% of the abundance in 1987. Cod of age 4 and older accounted for only 12% of the total biomass and 5% of the abundance, and the predominating year classes were those of 1983, 1981, and 1979.

The changes in length frequency distributions and age compositions of the West Greenland cod stock over the survey period from 1982-1987 are illustrated in Figure 6.5.2.

Estimates for the inshore stock components by division were derived from longline surveys conducted by Greenland in inshore and offshore areas of Divisions 1C-E in 1987 at the same time as the trawl survey of the Federal Republic of Germany.

The results revealed that the offshore cod biomass and abundance, as estimated from the trawl survey, accounted for only about 75% of the total stock size. The trawl survey estimates for Divisions 1B-F (Table 6.5.1) were, therefore, raised by respective factors to correct for the stock proportions outside the trawlable areas. The results are given in Table 6.5.2 and the respective raising factors are given in Table 6.5.3.

6.6 Future Recruitment

1984 year class

The 1987 survey results confirmed the 1984 year class as being the strongest since the occurrence of the 1973 year class. Survey abundance estimates increased from 108 million fish in 1986 to 514 million in 1987. The total abundance off West Greenland, including the inshore areas, was estimated at 680 million fish in the autumn of 1987.

1985 year class

The abundance index of 0-group cod off East Greenland from the Icelandic 0-group survey in August 1985 was the third highest observed since 1973, but considerably lower than those of 1973 and 1984 (Table 3.1). From inshore young cod surveys, as well as from the offshore trawl surveys, the 1985 year class was estimated to be approximately one-fourth of the size of the 1984 year class.

1986 year class

The abundance index obtained from the Icelandic 0-group survey off East Greenland in August 1986 was extremely low. The survey abundance estimate at age 1 in 1987 was only 1% of the age 1 abundance of the 1984 year class. In the Greenland gillnet survey, this year class was found as almost non existing.

1987 year class

The abundance index obtained from the Icelandic 0-group survey off East Greenland in August 1987 was relatively low. A small number of 0-group cod was, however, observed in the bottom trawl survey catches off West Greenland in the autumn of 1987.

6.7 Assessment Results (Tables 6.7.1-6.7.5)

The assessment method used by the Working Group for all years is explained below.

The stock in numbers at age at the end of the survey year has been calculated from the abundance estimate of the autumn survey with the appropriate fraction of the natural mortality and deducting the post-survey catch in numbers at age. Total mortality (Z) was calculated from this estimate and the corresponding one from the preceding survey for each age group.

The total mortality estimates were apportioned to:

i) Natural mortality (0.2)

ii) Fishing mortality

iii) Emigration coefficient.

As explained in Section 6.5, the stock abundance estimates from the Federal Republic of Germany survey have been raised to account for the portion of the stock which is present in the inshore and fjord region and, therefore, not included in the groundfish survey results. Since the inshore/offshore proportions are different for the divisions with an increasing gradient from north to south (see Table 6.5.3), the calculation was done separately for each division using the respective factors for all survey results since the series began. With this revision of the basis for the assessments, it was necessary to revise the previous assessments. This procedure did not affect the trends shown previously, but the absolute values of stock size estimates increased between 30% and 40% while fishing mortality estimates decreased correspondingly.

The results of the assessments are given in Tables 6.7.1-6.7.5 and are summarized in the text table below.

West Greenland Cod, Summary of the Assessments

Year	Total stock no. (3+)	Total stock biom. (3+)	Spawn. stock no.	Spawn. stock biom.	$F_{(6-9)}$	Catch no.	Catch weight
1983	143	274	53	147	0.36	35	58
1984	79	147	30	75	0.32	18	31
1985	20	35	9	20	0.42	8	15
1986	23	51	14	37	0.22	3	7
1987	163	175	10	29	0.30	14	19
1988[1]	698	801	33	73	-	-	-

[1] Preliminary estimates, not including age group 3. Maturity ogive and mean weights at age in 1986.
Estimates of stock size refer to 1 January.
Weights in '000 t, numbers in millions.

The average fishing mortality in 1987 over age groups 6-9 was estimated as 0.30, i.e., only slighly below the 1983-1985 level, but about 40% above that of the previous year (0.22).

For almost all age groups up to age 8, the emigration coefficients as well as the Z values are negative. This can be interpreted for the younger age groups as additional recruitment to the stock covered by the survey from other areas or from mid-water. For the older age groups immigration from East Greenland cannot be excluded as a possible reason since the assessment of that stock results in negative immigration rates indicating emigration out of the East Greenland area in addition to the already incorporated emigration to Iceland.

These results were taken as an indication that, at present, the tendency of West Greenland cod to migrate to East Greenland is not very strong. Therefore, the traditional emigration rate of 0.05 derived from earlier tagging experiments was used to estimate the contribution in 1988 to the East Greenland stock from West Greenland compared to a value of 0.30 used in last year's assessment.

The historic development shows a declining spawning stock biomass from the high level at the beginning of the 1960s to very low levels in the mid-1970s. This trend has reverted after 1976 when the very abundant 1973 year class reached spawning size. However, the slight recovery of the spawning stock was terminated due to exploitation and emigration, particularly during 1983 and 1984. The spawning stock size was at its lowest level on record in 1985 followed by some improvement in 1987 due to the contribution of the 1981 year class and possibly immigration from East Greenland.

The assessment results show significant improvement in stock size in 1987-1988 as a result of the abundant 1984 and 1985 year classes now making up the outstanding part of the estimated biomass. These year classes are now joining the exploitable biomass at West Greenland, and careful management of the fishery would make best use of their growth potential and increase their contribution to the spawning stock.

Throughout the period when random stratified trawl surveys have been conducted in Greenland waters, i.e., since 1980, the Working Group has used the results of the surveys at their face value and explained variation between years and between East and West Greenland by migration.

The Working Group noted that the estimate of the 1984 year class from the 1987 survey results points to this year class as being higher than any other year class over the period when VPA has been used to estimate year-class strength. However, the bigger year classes seen (1953, 1957, and 1961) did have a much wider area of distribution along the coast line and were observed there as much more abundant than has so far been the case for the 1984 year class. Further analysis of the situation, including analysis of estimates of previous year classes, does, therefore, seem necessary before the results are used in prognosis of the West Greenland fisheries.

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Table 3.1 Abundance indices of 0-group cod from the international and Icelandic 0-group survey in the East Greenland/Iceland area, 1971-1987 (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

Table 5.1 Strata areas in square nautical miles off West Greenland (NAFO Subarea 1).

Depth zone (meters)	Division/Stratum number							Total (nm^2)
	1B	1C	1C	1 C/D	1D	1E	1F	
	1	2	3	4	5	6	7	
0-100	865	593	598	0	1,475	276	+	3,807+
101-200	1,256	1,574	1,902	17	875	1,662	+	7,268+
0-200	2,121	2,167	2,500	17	2,350	1,938	2,568	13,661
201-300	297	259	708	29	628	464	+	2,385+
301-400	209	54	280	45	390	278	+	1,256+
201-400	506	313	988	74	1,018	742	971	4,612
401-500	149	122	156	60	176	33	+	696+
501-600	215	293	78	118	83	24	+	811+
401-600	364	415	234	178	259	57	353	1,860
Total	2,991	2,895	3,722	269	3,627	2,737	3,892	20,133

Table 5.3.1.1 Longline survey at West Greenland. Stratum area by division (square nautical miles).

Division		0-100 m	100-200 m	200-300 m	Total
1B	Fjord	78	50	43	171
	Coast	380	176	40	596
	Bank	865	1,256	297	2,418
	Total	1,323	1,482	380	3,185
1C	Fjord	269	131	121	521
	Coast	962	135	34	1,131
	Bank	1,191	3,493	996	5,680
	Total	2,422	3,759	1,151	7,332
1D	Fjord	381	185	134	700
	Coast	1,093	85	86	1,264
	Bank	1,475	875	628	2,978
	Total	2,949	1,145	848	4,942
1E	Fjord	258	102	63	423
	Coast	963	184	21	1,168
	Bank	276	1,662	464	2,402
	Total	1,497	1,948	548	3,993
1F	Fjord	485	291	255	1,031
	Coast	844	742	52	1,638
	Bank[1]	366	2,202	607	3,175
	Total	1,695	3,235	914	5,844

[1] Estimated from area distribution in Division 1E (Anon., 1987) (Table 5.1.2).
Bank areas from Anon.(1987).

Table 5.3.1.2 NAFO Subarea 1 cod.
Mean catch per unit of effort (100 hooks) for smaller cod (<54 cm). Number of valid sets in brackets.

Division		0-100 m	100-200 m	200-300 m
1C	Bank	0.86 (3)	0.45 (7)	0.09 (3)
	Coast	1.78 (7)	0.67 (7)	0.00 (2)
	Fjord	1.32 (3)	0.00 (1)	- (0)
1D	Bank	5.01 (11)	1.38 (6)	0.63 (5)
	Coast	0.83 (8)	1.17 (4)	0.56 (3)
	Fjord	0.12 (5)	0.00 (3)	0.09 (6)
1E	Bank	0.52 (1)	1.48 (7)	0.00 (2)
	Coast	0.59 (7)	0.00 (7)	0.28 (1)
	Fjord	0.00 (2)	0.00 (2)	0.00 (2)

Table 5.3.1.3 NAFO Subarea 1. Cod.
Mean catch per unit of effort (100 hooks) for larger cod (> 54 cm). Number of valid sets in brackets.

Division		0-100 m	100-200 m	200-300 m
1C	Bank	0.10 (3)	0.08 (7)	0.00 (3)
	Coast	0.84 (7)	0.16 (7)	0.00 (2)
	Fjord	0.28 (3)	0.00 (1)	- (0)
1D	Bank	7.97 (11)	7.08 (6)	1.85 (5)
	Coast	5.09 (8)	2.62 (4)	1.13 (3)
	Fjord	0.94 (5)	0.10 (3)	0.09 (6)
1E	Bank	25.45 (1)	12.91 (7)	2.07 (2)
	Coast	6.14 (7)	1.50 (7)	1.11 (1)
	Fjord	0.39 (2)	0.14 (2)	0.26 (2)

Table 6.1.1 Nominal catches of cod in NAFO Subarea 1 (1978-1987).

Country	1978	1979	1980	1981	1982
Faroe Islands	-	38	-	-	-
Fed.Rep. of Germany	1,057	1,344	1,024	417	8,139
France - M	-	139	-	-	-
Greenland	37,420	46,384	45,838	53,039	47,693
Japan	-	-	-	-	-
Norway	4	-	-	-	-
United Kingdom	-	-	-	-	-
Total	38,531[1]	47,905[1]	46,862[1]	53,456[1]	55,832[1]
Estimate of the Working Group	73,000	99,000	54,000	-	-

Country	1983	1984	1985	1986[4]	1987[4]
Faroe Islands	1,339	-	-	-	-
Fed.Rep. of Germany	10,158	8,941	2,170	37	68
France - M	-	-	-	-	-
Greenland	44,970	22,041	12,319	6,546	18,477
Japan	-	13	-	-	9
Norway	-	5	-	-	-
United Kingdom	1,174	-	-	-	-
Total	57,641	31,000[2]	14,544[3]	6,583	18,554

[1] ICNAF/NAFO Statistical Bulletin.
[2] NAFO SCS Doc. 85/22.
[3] NAFO SCS Doc. 86/22.
[4] Provisional data.

Table 6.1.2 NAFO Subarea 1 Cod. Nominal catch by division and gear in 1987 (provisional figures in tonnes).

Division	Pound net	Longlines	Handlines	Gillnet	Otter trawl	Total
1A	9	32	2	54	-	97
1B	1,477	688	645	125	60	2,995
1C	321	66	49	68	32	536
1D	2,795	523	143	549	4,100	8,110
1E	37	1	3,191	169	1,162	4,560
1F	618	121	121	767	51	1,678
1NK	-	218	-	-	360	578
Total	5,257	1,649	4,151	1,732	5,765	18,554

Table 6.1.3 NAFO Subarea 1 Cod. Nominal catches 1987 (provisional figures in tonnes) per month and division.

Month	1A	1B	1C	1D	1E	1F	1NK	Total
Jan	-	44	1	291	-	2	-	338
Feb	1	153	3	788	192	2	-	1,139
Mar	10	57	1	1,156	643	3	-	1,870
Apr	5	37	-	495	182	4	-	723
May	2	46	9	442	342	74	-	915
Jun	2	1,011	150	782	734	402	-	3,081
Jul	3	764	244	785	980	491	-	3,267
Aug	11	179	58	439	547	282	-	1,516
Sep	19	195	9	155	176	175	-	729
Oct	10	158	48	493	441	85	-	1,235
Nov	10	190	4	1,623	190	69	-	2,086
Dec	25	159	9	659	134	76	-	1,062
NK	-	-	-	-	-	-	593	593
Total	98	2,993	536	8,108	45,61	1,665	593	18,554

Table 6.1.4 NAFO Subarea 1 Cod. Nominal catches 1987 (provisional figures in tonnes) by gear per month.

Month	Pound net	Longlines	Handlines	Gillnet	Otter trawl	Total
Jan	-	123	-	2	213	338
Feb	157	231	1	4	745	1,138
Mar	616	206	3	5	1,043	1,873
Apr	122	210	2	15	376	725
May	41	15	274	77	509	916
Jun	1,815	196	749	275	45	3,080
Jul	1,813	120	1,150	151	31	3,265
Aug	553	52	737	156	18	1,516
Sep	89	41	382	140	89	741
Oct	9	99	542	125	462	1,237
Nov	30	74	236	102	1,644	2,086
Dec	12	65	75	680	228	1,060
NK	-	217	-	-	362	579
Total	5,257	1,649	4,151	1,732	5,765	18,554

Table 6.1.5 Nominal catches of NAFO Subarea 1 cod for 1976-1987 ('000 t).

Category	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Trawlers	19	46[3]	53[3]	57[3]	16	14	29	42	18	7	1[4]	6[4]
Other	14	27	20	42	38	39	26	16	12	8	4[4]	13[4]
Total	33	73[3]	73[3]	99[3]	54[3]	53	55	58	30	15	5[4]	19[4]
TAC	45[2]	31[2]	-[1]	-[1]	20[1]	50[1]	62	62	68	28.5	12.5[5]	40

[1] Catches limited to Greenlander's fishery and to by-catches.
[2] Quota for offshore fishery only.
[3] Estimates used for stock assessments.
[4] Provisional data.
[5] Direct trawling prohibited. Ban on pound net fishing (with some exemptions) from mid-July.

Table 6.1.6 NAFO Subarea 1 cod. Effort (hours fished) and catch per unit effort (CPUE = kg/hour) for Greenland trawlers (500-999 GRT class) in 1975-1987. Only figures for directed cod fishing are used.

Year	1B		1C		1D		1E		1F		Total	
	Hours	CPUE	Hours	CPUE	Hours	CPUE	Hours	CPUE	Hours	CPUE	Hours	CPUE
1975	1,132	57	6,666	1,467	4,896	293	3,154	422	243	346	16,091	789
1976	236	38	5,071	594	5,912	541	6,319	753	-	-	17,538	626
1977	-	-	2,432	1,019	1,531	986	3,446	1,584	121	2,421	7,530	1,293
1978	-	-	3,562	3,314	815	2,962	873	3,743	70	3,029	5,320	3,327
1979	-	-	2,983	2,155	1,163	3,083	365	1,948	9	2,667	4,520	2,378
1980	727	2,461	1,513	1,088	1,983	892	1,092	1,277	31	613	5,346	1,238
1981	-	-	1,279	3,326	1,856	2,533	952	4,602	5	-	4,092	3,259
1982	100	1,330	1,937	2,077	4,084	1,760	3,221	2,903	17	647	9,359	2,212
1983	927	315	593	948	4,039	984	6,295	1,808	114	982	11,968	1,364
1984	51	20	19	+	1,926	1,004	2,248	1,055	317	584	4,561	985
1985	10	-	-	-	378	370	2,050	760	113	982	2,551	709
1986[1]	-	-	-	-	-	-	-	-	-	-	-	-
1987	4	1,549	1	5,794	457	1,704	11	804	-	-	473	1,690

[1] No directed trawl fishery for cod allowed in 1986.

Table 6.2.1 Sum of Products check.

COD OFF WEST GREENLAND
CATEGORY: TOTAL

CATCH IN NUMBERS UNIT: thousands

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
3	1550	1727	3764	662	49	272	51	131	545	275	10760	654
4	78?2	15391	7970	12399	2768	2519	10039	2302	1079	5595	4024	46649
5	62150	30457	36670	8709	10342	10172	9786	10378	2384	2677	2243	6055
6	20941	61448	29324	27435	6465	9283	12020	5065	6938	1803	1216	1515
7	5915	24562	34591	14664	13985	5237	4081	2605	1135	5855	302	618
8	4953	2700	10005	12411	4365	9158	2550	1406	1806	1388	1594	425
9	0912	1996	1725	4784	2810	2077	2660	1203	800	619	139	446
10	1239	5237	855	515	1280	1841	624	552	194	291	148	168
11	2853	352	2348	257	149	953	954	165	177	84	53	79
12	150	93	187	704	85	78	709	237	152	38	27	88
13	981	166	37	41	201	51	130	93	272	9	17	22
14	159	455	42	62	27	134	57	37	147	12	14	1
15+	247	85	503	8	41	56	122	44	11	10	26	1
TOTAL	119524	144767	128305	82627	42567	41831	43783	28218	15438	16556	20565	56699

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
3	237	236	2999	12	1204	77	595	456	12	8626
4	5474	10556	4515	16864	1210	12356	2018	1266	113	2474
5	30059	12505	4580	6374	17960	2011	10384	1303	206	415
6	1084	16970	1978	2391	2965	17224	688	4915	513	1001
7	509	709	8014	1055	2078	1581	5056	161	1193	641
8	65	400	125	5582	807	995	105	750	12	1037
9	41	78	60	45	610	544	565	42	332	11
10	15	52	24	65	45	545	97	140	80	45
11	7	55	1	1	88	5	69	15	15	2
12	7	80	16	1	9	22	0	8	55	3
13	7	5	5	0	4	0	5	0	0	0
14	1	5	1	0	1	2	0	0	0	1
15+	1	16	2	7	13	19	0	14	0	7
TOTAL	37475	43317	22516	30195	26994	34981	17981	9070	2814	14263

Table 6.2.2 West Greenland Cod, NAFO Subarea 1. Total international catches by age groups. Jan-Oct and Nov-Dec 1987. Numbers in '000.

Age	Jan-Oct	Nov-Dec	Total
3	6,961	1,665	8,626
4	2,304	170	2,474
5	299	116	415
6	871	130	1,001
7	571	70	641
8	853	184	1,037
9	10	1	11
10	38	7	45
11	1	1	2
12	2	1	3
13	-	-	-
14	1	-	1
15+	-	-	-
Non-aged (large fish)	9	8	17
Total	11,920	2,353	14,273

Table 6.3 Mean weight at age in the main Greenlandic fisheries at West Greenland in 1987 (kg whole, round fish).

Age	Trawl	Longline	Gillnet	Pound net	Handline	Weighted total[1]
3	0.97	0.86	0.88	0.87	0.89	0.90
4	1.25	1.38	1.02	1.05	1.10	1.07
5	1.44	2.11	1.36	2.10	2.15	1.80
6	2.01	2.41	2.52	2.62	2.04	2.12
7	2.35	2.94	3.43	3.04	2.69	2.61
8	2.95	3.22	3.72	4.19	3.38	3.24
9	-	4.30	-	-	-	4.30
10+	4.28	4.91	3.46	3.93	3.93	4.70
Non-aged (large fish)	-	-	8.38	-	-	incl. in 10+
Weighted mean[1]	1.55	2.46	2.18	0.99	1.08	1.30

[1]Weighted by catch in numbers in each age group and gear category.

Table 6.5.1 West Greenland cod. Autumn survey abundance estimates (no. x 10^3) by age and division, 1982-1987. The respective survey biomass estimates (tonnes) and mean weights are below.

Age	Divisions 1B+C						Division 1D					
	1982	1983	1984	1985	1986	1987	1982	1983	1984	1985	1986	1987
0	-	-	104	124	-	32	-	-	68	131	-	13
1	60	-	-	18,148	1,193	363	16	-	4	7,765	2,752	23
2	610	166	78	725	35,014	6,774	90	395	11	349	33,830	8,237
3	3,686	228	29	249	737	142,759	18,862	2,915	282	300	1,582	227,042
4	292	352	36	133	43	2,745	4,151	15,059	847	898	197	4,012
5	96	4	107	64	51	1,267	21,238	683	3,203	1,340	482	1,903
6	11	13	7	74	31	1,811	3,903	2,779	151	2,766	363	3,801
7	2	-	80	3	85	222	1,082	203	625	81	512	501
8	-	-	-	13	1	330	270	271	20	155	8	1,431
9	-	-	36	-	20	-	335	60	97	-	25	-
10	-	-	-	-	1	30	30	52	7	-	2	150
11	-	-	-	-	-	-	75	-	-	-	-	-
12	-	-	-	-	-	-	70	-	-	-	-	-
13	-	-	-	-	-	-	-	15	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-
NK	-	-	-	-	-	-	39	27	-	-	-	-
Total	4,757	763	477	19,533	37,176	156,333	50,161	22,459	5,315	13,785	39,753	247,113
Tonnes	2,387	393	789	2,378	13,333	131,909	60,757	29,666	8,383	11,447	19,483	198,252
$\bar{w}$ (kg)	0.502	0.515	1.654	0.122	0.359	0.844	1.211	1.321	1.577	0.830	0.490	0.802

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 groups of divisions.

cont'd.

Table 6.5.1 cont'd.

Age	Division 1E						Division 1F					
	1982	1983	1984	1985	1986	1987	1982	1983	1984	1985	1986	1987
0	-	-	10	149	-	3	-	-	40	438	-	-
1	65	-	-	4,622	3,488	-	19	-	-	3,856	2,797	-
2	15	658	5	195	26,096	10,072	7	516	4	146	13,056	12,582
3	8,951	111	826	37	768	108,967	5,191	72	850	11	580	34,754
4	2,854	9,302	333	3,503	188	4,377	3,523	6,733	241	1,195	146	1,597
5	6,214	2,463	3,172	599	4,037	707	11,241	2,709	2,635	195	3,051	328
6	2,613	3,718	299	2,510	256	2,342	7,091	6,448	350	945	270	1,424
7	627	752	586	122	1,062	307	3,046	1,268	768	145	1,429	197
8	115	393	30	180	27	955	661	508	36	260	68	651
9	227	157	49	4	91	-	1,443	158	59	18	316	-
10	22	84	4	5	3	50	74	62	11	13	14	86
11	5	-	2	-	6	23	5	-	2	-	17	-
12	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	21	-
14	-	-	-	-	-	-	13	-	-	-	-	-
NK	67	8	-	-	-	-	32	20	-	-	-	-
Total	21,775	17,646	5,316	11,926	36,022	127,803	32,346	18,494	4,996	7,222	21,765	51,619
Tonnes	29,599	31,056	7,526	11,934	23,675	96,433	87,191	37,728	8,247	6,101	19,729	37,692
W (kg)	1.359	1.760	1.416	1.001	0.657	0.755	2.696	2.040	1.651	0.845	0.906	0.730

cont'd

Table 6.5.1 : cont'd.

Age	Total					
	1982	1983	1984	1985	1986	1987
0	-	-	222	842	-	48
1	160	-	4	34,391	10,230	386
2	722	1,735	98	1,415	107,996	37,665
3	36,690	3,326	1,987	597	3,667	513,522
4	10,820	31,446	1,457	5,729	574	12,731
5	38,789	5,859	9,117	2,198	7,621	4,205
6	13,618	12,958	807	6,295	920	9,378
7	4,757	2,223	2,059	351	3,088	1,227
8	1,046	1,172	86	608	104	3,367
9	2,005	375	241	22	452	-
10	126	198	22	18	20	316
11	85	-	4	-	23	23
12	70	-	-	-	-	-
13	-	15	-	-	21	-
14	13	-	-	-	-	-
NK	138	55	-	-	-	-
Total	109,039	59,362	16,104	52,466	134,716	582,868
Tonnes	179,934	98,843	24,945	31,860	76,220	464,286
$\bar{w}$ (kg)	1.650	1.665	1.549	0.607	0.566	0.797

Table 6.5.2 West Greenland Cod. Autumn survey abundance estimates (no. x 10^3) by age and division raised to account for the inshore stock components according to the proportions given in Table 6.5.3. The respective biomass estimates (tonnes) are given below.

Age	Divisions 1B+C						Division 1D						Division 1E					
	1982	1983	1984	1985	1986	1987	1982	1983	1984	1985	1986	1987	1982	1983	1984	1985	1986	1987
0	-	-	124	148	-	39	-	-	91	175	-	17	-	-	14	210	-	4
1	71	-	-	21,596	1,420	440	21	-	5	10,405	3,688	31	92	-	-	6,517	4,918	-
2	726	198	93	863	41,666	8,216	121	529	15	468	45,332	11,038	21	928	7	275	36,795	14,202
3	4,387	271	35	296	877	173,143	25,275	3,906	378	402	2,120	304,240	12,621	157	1,165	52	1,083	153,645
4	348	419	43	158	51	3,329	5,562	20,179	1,135	1,203	264	5,376	4,024	13,116	469	4,939	265	6,172
5	114	5	127	76	61	1,537	28,459	915	4,292	1,796	646	2,550	8,762	3,473	4,473	845	5,692	997
6	13	15	8	88	37	2,197	5,230	3,724	202	3,706	486	5,093	3,684	5,243	422	3,539	361	3,302
7	2	-	95	4	101	269	1,450	272	838	109	686	671	884	1,060	826	172	1,498	433
8	-	-	-	15	1	400	362	363	27	208	11	1,918	162	554	42	254	38	1,347
9	-	-	43	-	24	-	449	81	130	-	33	-	320	221	69	6	128	-
10	-	-	-	-	1	36	40	70	9	-	3	201	31	118	6	7	4	70
11	-	-	-	-	-	-	101	-	-	-	-	-	7	-	3	-	9	32
12	-	-	-	-	-	-	94	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NK	-	-	-	-	-	-	52	36	-	-	-	-	95	11	-	-	-	-
Total	5,661	908	568	23,244	44,239	189,606	67,216	30,075	7,122	18,472	53,269	331,135	30,703	24,881	7,496	16,816	50,791	180,204
Tonnes	2,841	468	939	2,830	15,866	156,972	81,414	39,752	11,233	15,239	26,107	265,658	41,735	43,789	10,612	16,827	33,382	135,971

cont'd.

Table 6.5.2 cont'd.

Age	Division 1F						Total survey area (Divisions 1B-F)					
	1982	1983	1984	1985	1986	1987	1982	1983	1984	1985	1986	1987
0	-	-	58	635	-	-	-	-	287	1,168	-	60
1	28	-	-	5,591	4,056	-	212	-	5	44,109	14,082	471
2	10	748	6	212	18,931	18,244	878	2,403	121	1,818	142,724	51,700
3	7,527	104	1,232	16	841	50,393	49,810	4,438	2,810	766	4,921	681,421
4	5,108	9,763	349	1,733	212	2,316	15,042	43,477	1,996	8,033	792	17,193
5	16,300	3,928	3,821	283	4,424	475	53,635	8,321	12,713	3,000	10,823	5,559
6	10,282	9,349	507	1,370	391	2,065	19,209	18,331	1,139	8,703	1,275	12,657
7	4,417	1,839	1,114	210	2,072	286	6,753	3,171	2,873	495	4,357	1,659
8	959	737	52	377	99	944	1,483	1,654	121	854	149	4,609
9	2,092	229	86	26	458	-	2,861	531	328	32	643	-
10	107	90	16	19	20	125	178	278	31	26	28	432
11	7	-	3	-	25	-	115	-	6	-	34	32
12	-	-	-	-	-	-	94	-	-	-	-	-
13	-	-	-	-	30	-	-	20	-	-	30	-
14	19	-	-	-	-	-	19	-	-	-	-	-
NK	46	29	-	-	-	-	193	76	-	-	-	-
Total	46,902	26,816	7,244	10,472	31,559	74,848	150,482	82,700	22,430	69,004	179,858	775,793
Tonnes	126,427	54,706	11,950	8,846	28,607	54,653	252,417	138,715	34,742	43,842	103,962	613,254

Table 6.5.3 West Greenland cod. Offshore and inshore stock components derived from Greenland longline surveys in autumn 1987.

Division	Offshore %	Inshore %	Raising factor
1B+C	84	16	1.19
1D	73	27	1.34
1E	71	29	1.41
1F	69	31	1.45

Table 6.7.1 NAFO Subarea 1 Cod, Assessment table 1983.

			A	B	C	D	E	F	G	H	I
Age	Year class	Survey stock Oct-Nov	Catch after survey	Stock size 1 Jan[1]	Stock size 31 Dec	1983 catch	Z	F	M	E	Losses due to M	Losses due to E
3	1980	4,438	13	863	4,352	77	-1.618	0.036	0.2	-1.854	431	-3,997
4	1979	43,477	694	48,039	42,070	12,356	0.133	0.275	0.2	-0.342	8,998	-15,385
5	1978	8,321	114	14,441	8,070	2,011	0.582	0.184	0.2	0.198	2,190	2,170
6	1977	18,331	1,130	49,936	16,908	17,228	1.083	0.565	0.2	0.318	6,100	9,700
7	1976	3,171	105	18,467	3,014	1,581	1.813	0.185	0.2	1.427	1,705	12,167
8	1975	1,654	67	6,348	1,560	995	1.403	0.292	0.2	0.912	682	3,111
9	1974	531	17	1,365	505	344	0.994	0.398	0.2	0.397	173	343
10+	<1974	298	29	3,095	264	389	2.462	0.338	0.2	1.923	230	2,212
Total 3+		-	-	142,554	76,743	34,981	0.619	0.324	0.2	0.096	20,509	10,321
Total 6+		-	-	79,211	22,251	20,537	1.270	0.457	0.2	0.613	8,890	27,533

[1] From previous year's survey.
Catch and stock numbers in thousands.

STEPS IN THE CALCULATIONS

1. Calculation of col.B from autumn survey estimate.
2. Calculation of Z: [ln(col.A / col.B)].
3. Calculation of col.H: [col.A * 0.2/Z(1-exp-Z)].
4. Calculation of col.I: [col.A - (col.B + col.C + col.H)].
5. Calculation of col.E and G: Allocation of Z proportionally to cols. C, H, and I.

Table 6.7.2 NAFO Subarea 1 Cod, Assessment table 1984.

				A	B	C	D	E	F	G	H	I
				Stock size							Losses due to	
Age	Year class	Survey stock Oct-Nov	Catch after survey	1 Jan[1]	31 Dec	1984 catch	Z	F	M	E	M	E
3	1981	2,810	47	2,324	2,717	595	-0.156	0.237	0.2	-0.593	503	-1,491
4	1980	1,996	160	4,352	1,804	2,018	0.881	0.697	0.2	-0.017	579	-49
5	1979	12,713	981	42,070	11,530	10,384	1.294	0.440	0.2	0.654	4,719	15,437
6	1978	1,139	84	8,070	1,037	688	2.052	0.201	0.2	1.651	686	5,659
7	1977	2,873	125	16,905	2,702	3,656	1.834	0.472	0.2	1.162	1,549	8,998
8	1976	121	5	3,014	114	106	3.275	0.120	0.2	2.955	177	2,617
9	1975	328	13	1,560	310	365	1.616	0.472	0.2	0.944	155	730
10+	<1975	37	8	769	28	169	3.313	0.756	0.2	2.357	45	527
Total 3+		-	-	79,064	20,242	17,981	1.362	0.414	0.2	0.748	8,413	32,428
Total 6+		-	-	30,318	4,191	4,984	1.979	0.377	0.2	1.402	2,612	18,531

[1] From previous year's survey.
Catch and stock numbers in thousands.

STEPS IN THE CALCULATIONS

1. Calculation of col.B from autumn survey estimate.
2. Calculation of Z: [ln(col.A / col.B)].
3. Calculation of col.H: [col.A * 0.2/Z(1-exp-Z)].
4. Calculation of col.I: [col.A - (col.B + col.C + col.H)].
5. Calculation of col.E and G: Allocation of Z proportionally

Table 6.7.3 NAFO Subarea 1 Cod, Assessment table 1985.

				A	B	C	D	E	F	G	H	I
Age	Years class	Survey stock Nov-Dec	Catch after survey	Stock size 1 Jan[1]	Stock size 31 Dec	1985 catch	Z	F	M	E	Losses due to M	Losses due to E
3	1982	766	-	119	753	-	-1.845	-	0.2	-2.045	69	-703
4	1981	8,033	15	2,717	7,885	652	-1.065	0.134	0.2	-1.400	970	-6,790
5	1980	3,000	27	1,804	2,924	1,155	-0.483	0.498	0.2	-1.181	464	-2,739
6	1979	8,703	114	11,530	8,446	4,899	0.311	0.494	0.2	-0.383	1,982	-3,797
7	1978	495	5	1,037	482	225	0.766	0.311	0.2	0.256	145	185
8	1977	854	15	2,702	825	665	1.186	0.420	0.2	0.566	316	896
9	1976	32	1	114	30	28	1.335	0.445	0.2	0.690	13	43
10+	<1976	26	2	338	24	126	2.645	1.061	0.2	1.384	24	164
Total 3+		-	-	20,361	21,369	7,750	-0.048	0.385	0.2	-0.633	3,983	-12,741
Total 6+		-	-	15,721	9,807	5,943	0.472	0.471	0.2	-0.199	2,480	-2,509

[1] From previous year's survey.
Catch and stock numbers in thousands.

STEPS IN THE CALCULATIONS

1. Calculation of col.B from autumn survey estimate.
2. Calculation of Z: [ln(col.A / col.B)].
3. Calculation of col.H: [col.A * 0.2/2(1-exp-Z)].
4. Calculation of col.I: [col.A - (col.B + col.C + col.H)].
5. Calculation of col.E and G: Allocation of Z proportionally to cols. C, H, and I.

Table 6.7.4 NAFO Subarea 1 Cod, Assessment table 1986.

				A	B	C	D	E	F	G	H	I
Age	Year class	Survey stock Oct-Nov	Catch after survey	Stock size 1 Jan[1]	Stock size 31 Dec	1986 catch	Z	F	M	E	Losses due to M	Losses due to E
3	1983	4,921	3	1,788	4,837	12	-0.995	0.004	0.2	-1.199	613	-3,674
4	1982	792	19	753	760	113	-0.009	0.149	0.2	-0.359	151	-271
5	1981	10,823	113	7,885	10,532	706	-0.289	0.077	0.2	-0.567	1,829	-5,182
6	1980	1,275	51	2,924	1,203	318	0.888	0.164	0.2	0.524	388	1,015
7	1979	4,357	189	8,446	4,098	1,193	0.723	0.198	0.2	0.325	1,202	1,953
8	1978	149	2	482	145	12	1.201	0.043	0.2	0.958	56	269
9	1977	643	53	825	580	332	0.352	0.477	0.2	-0.325	139	-226
10+	(1977	92	18	54	73	118	-0.301	1.872	0.2	-2.374	13	-150
Total 3+		-	-	23,157	22,228	2,804	0.041	0.129	0.2	-0.288	4,391	-6,266
Total 6+		-	-	12,731	6,099	1,973	0.736	0.219	0.2	0.317	1,798	2,861

[1] From previous year's survey.
Catch and stock numbers in thousands.

STEPS IN THE CALCULATIONS

1. Calculation of col.B from autumn survey estimate.
2. Calculation of Z: [ln(col.A / col.B)].
3. Calculation of col.H: [col.A * 0.2/Z(1-exp-Z)].
4. Calculation of col.I: [col.A - (col.B + col.C + col.H)].
5. Calculation of col.E and G: Allocation of Z proportionally to cols. C, H, and I.

Table 6.7.5 NAFO Subarea 1 Cod, Assessment table 1987.

				A	B	C	D	E	F	G	H	I
Age	Year class	Survey stock Sep-Oct	Catch after survey	Stock size 1 Jan[1]	31 Dec	1987 catch	Z	F	M	Losses due to E	M	E
3	1984	681,421	1,665	140,365	657,449	8,626	-1.544	0.026	0.2	-1.770	66,975	-592,685
4	1983	17,193	170	4,837	16,462	2,474	-1.225	0.261	0.2	-1.685	1,898	-15,997
5	1982	5,559	116	10,760	5,263	415	-1.935	0.178	0.2	-2.513	467	-5,379
6	1981	12,657	130	10,532	12,114	1,001	-0.140	0.089	0.2	-0.428	2,261	-4,844
7	1980	1,659	70	1,203	1,536	641	-0.244	0.470	0.2	-0.915	273	-1,247
8	1979	4,609	184	4,098	4,277	1,037	-0.043	0.248	0.2	-0.490	837	-2,053
9	1978	(2)	1	145	1	11	4.977	0.380	0.2	4.397	6	127
10+	<1978	462	9	653	438	68	0.399	0.126	0.2	0.073	108	39
Total 3+		-	-	162,593	695,540	14,273	-1.453	0.039	0.2	-1.692	72,825	-622,039
Total 6+		-	-	16,631	18,366	2,758	-0.095	0.156	0.2	-0.451	3,485	-7,978

[1] From previous year's survey.
Catch and stock numbers in thousands.

STEPS IN THE CALCULATIONS

1. Calculation of col.B from autumn survey estimate.
2. Calculation of Z: [ln(col.A / col.B)].
3. Calculation of col.H: [col.A * 0.2/Z(1-exp-Z)].
4. Calculation of col.I: [col.A - (col.B + col.C + col.H)].
5. Calculation of col.E and G: Allocation of Z proportionally to cols. C, H, and I.

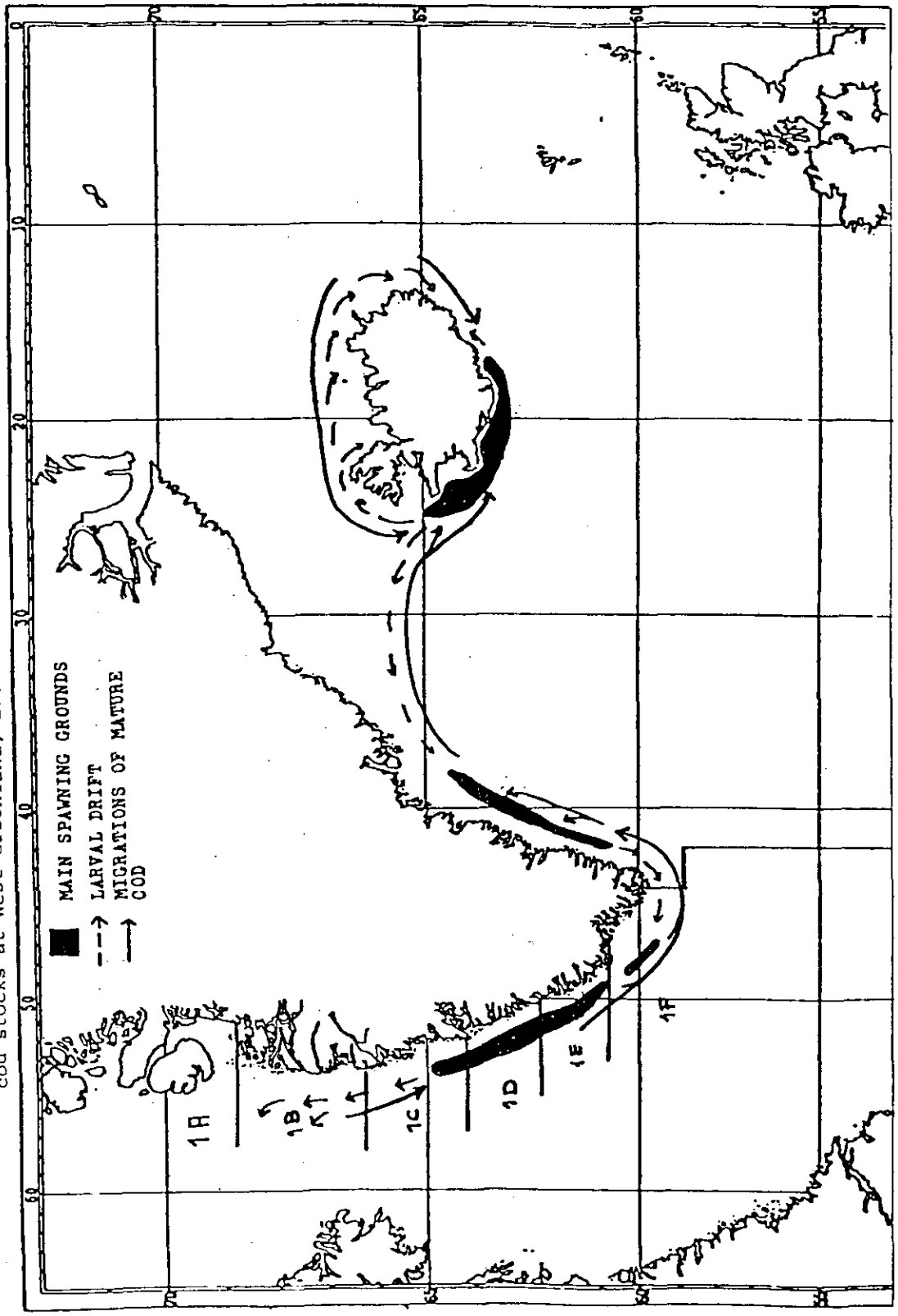

Figure 3.1 Main spawning grounds, migrations of mature fish and larval drift of the cod stocks at West Greenland, East Greenland and Iceland.

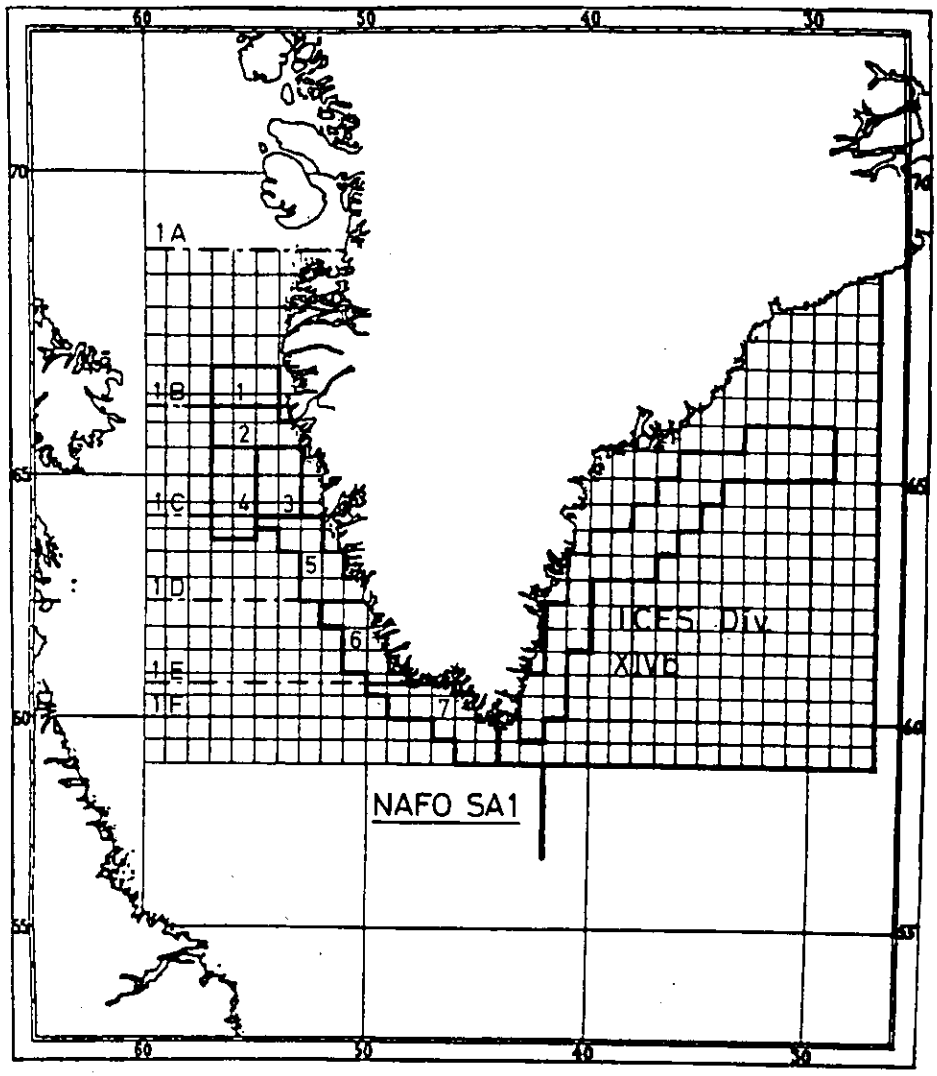

Figure 5.1 Survey areas and stratification off East and West Greenland.

Stratification East Greenland:

Stratum	Depth	nm^2
1	0 - 200 m	1,909
2	200 - 400 m	10,728
3	400 - 600 m	3,835
4	600 - 800 m	905
Total		17,377

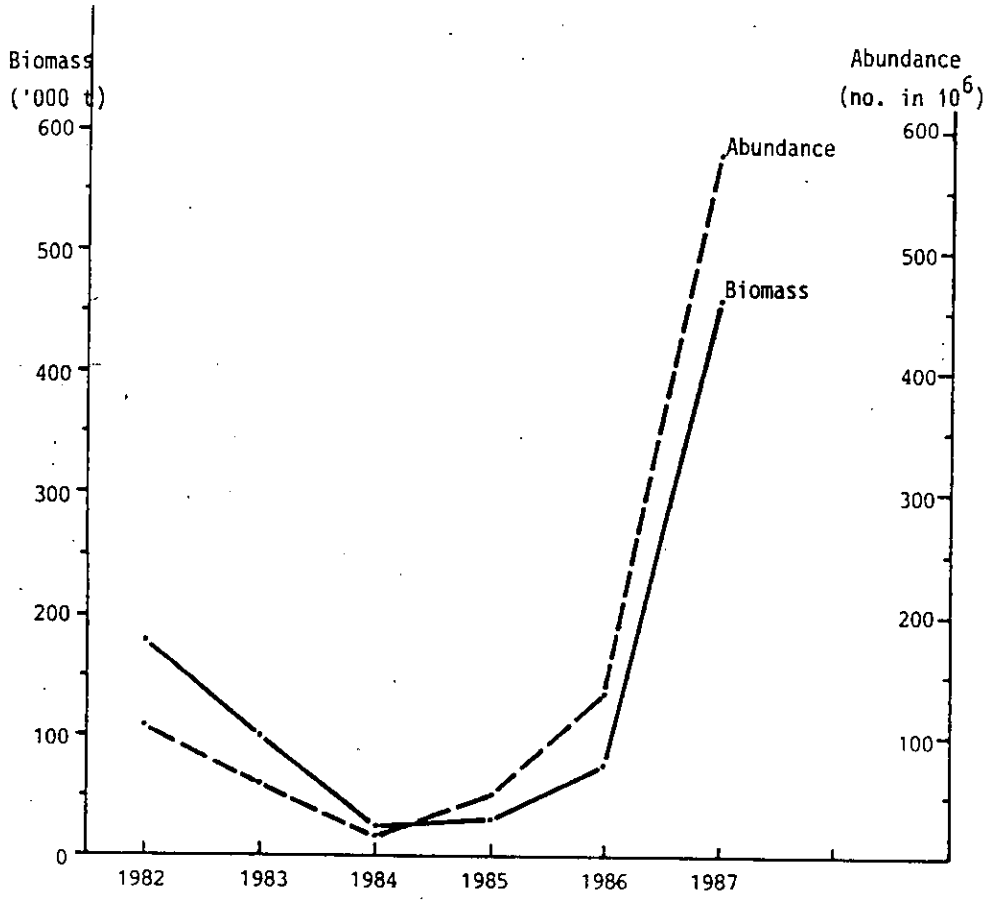

Figure 6.5.1 West Greenland cod. Trends in survey biomass and abundance, 1982-1987.

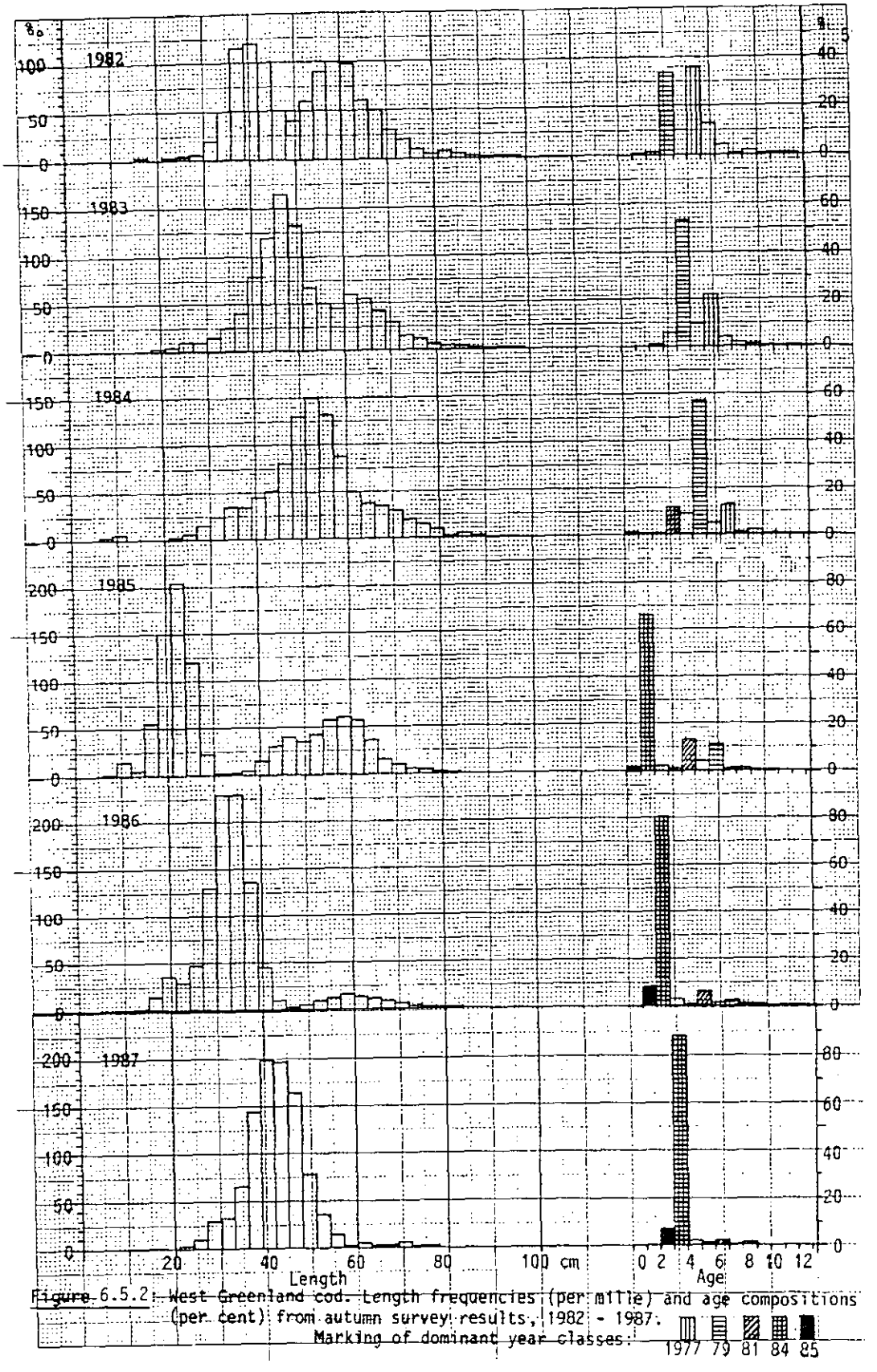

Figure 6.5.2. West Greenland cod. Length frequencies (per mille) and age compositions (per cent) from autumn survey results, 1982 - 1987.
Marking of dominant year classes: