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SCIENTIFIC COUNCIL MEETING - JUNE 1990

Status of Subarea 1 Cod and the Fisheries

An Extract of the Report of the ICES Working Group on Cod Stocks off East Greenland, Hamburg, 21-27 February 1990

and

Revision of the 1989 trawl survey abundance estimate

by

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1 PARTICIPANTS

The Working Group on Cod Stocks off East Greenland met in Hamburg from 21-27 February 1990, with the following participants:

S. Christensen	Greenland
H.-P. Cornus	Federal Republic of Germany
H. Hovgård (Chairman)	Greenland
Sv.Aa. Horsted	Greenland
F.W. Koester	Federal Republic of Germany
J. Messtorff	Federal Republic of Germany
K. Nygård	Greenland
H.-J. Raetz	Federal Republic of Germany
H.H. Reinsch	Federal Republic of Germany
F.F. Riget	Greenland
S.A. Schopka (until 26 February)	Iceland

2 TERMS OF REFERENCE

At the 1989 Statutory Meeting, it was decided (C.Res.1989/2:4:2) that the Working Group on Cod Stocks off East Greenland should meet in Hamburg from 21-27 February 1990 to:

i) analyze the results of the latest groundfish survey;

ii) assess the status of and provide catch options for 1989 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 inter-relationships 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. 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 assessment, catch projections, and management advice.

3 THE COD STOCK COMPLEX IN GREENLAND AND ICELANDIC WATERS

The inter-relationship between the cod stocks at West and East Greenland and at Iceland (Figure 3.1) is well documented and has been known for many years. It is usually described as a one-way migration of (some of the) mature cod from West to East Greenland and from both West and East Greenland to Iceland. Also, immature cod may migrate from East Greenland to Icelandic waters as shown by tagging experiments in the Ammasalik area. The magnitude of emigration of mature cod from West Greenland to East Greenland and Iceland seems to vary from year to year and among 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. Results of the groundfish surveys of 1982-1989 indicate that the emigration varies considerably from year to year and in some years is much higher than 0.05.

The emigration rate from East Greenland to Iceland also varies from year to year. The North-Western Working Group concluded (Anon., 1971) that on average about 45% of the mature cod from East Greenland migrate to Iceland. However, the North-Western Working Group considered the East Greenland stock as combined with the southern part of the West Greenland stock (NAFO Div. 1E-1F) and estimated the emigration coefficient to be 0.29, which corresponds to an emigration of 25% per year.

The larval drift from East Greenland to West Greenland and from Iceland to East Greenland and possibly further to West Greenland is well documented but seems to vary much from year to year (see Table 3.1).A recent study of otolith types suggests that in some years even immature cod might migrate from East to West Greenland. The recruitment to the West Greenland stock may thus derive partly from its own larval production, partly from the well-known larval drift from Iceland and East Greenland to West Greenland, and also from immigration of immature fish.

The general stock distribution also varies between years and in some years (as in 1989; see Section 5.6) the stock is found very far south, at or across the border between the NAFO and ICES statistical areas.

The border line at Cap Farvel between the two management areas is thus not established on a biological basis but stems solely from the partitioning of Greenland waters between the ICNAF/NAFO and the NEAFC convention areas. The only biological reason to maintain a division between West and East Greenland would be to keep the spawning stock at East Greenland at a certain level.

4 SURVEYS AND RESEARCH

4.1 The Federal Republic of Germany Groundfish Survey Design

The standard bottom trawl used in all surveys remained the same as described in previous reports of the Working Group. 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 4.1. The survey areas are composed of statistical rectangles (30' lat. x 1°, long.), as used throughout the ICES area, which form the basis of the stratification schemes. However, for area-specific reasons, the construction of strata is different in the two survey areas.

The stratification scheme of the West Greenland survey area as well as the procedures for random selection of fishing stations remained the same as given in previous reports of the Working Group. Strata areas (nm^2) are given in Table 4.1.1.

Groundfish surveys conducted in Division XIVb by the Federal Republic of Germany from 1980-1986 have been fairly consistent in terms of area covered, method of selection of fishing stations, and analysis. In 1980-1982, and in 1987, a 4-depth zone stratification was used.

For the time period 1983-1986, stratification was done by previously observed density distribution. In 1988, stratification was adjusted to that used off West Greenland (i.e., by regional areas and depth zones, Table 4.1.2).

4.2 Greenland Surveys

4.2.1 West Greenland long-line survey

In October-November 1989, Greenland conducted a long-line survey in the inshore areas of NAFO divisions 1BCDE with the purpose of describing abundance and Distribution of cod outside the area covered by the German trawl survey. In total, 123 line settings, each of 400 hooks, were made.

Within the survey area fishing sites were selected using a random stratification scheme. Each NAFO division was divided into fjord and coastal areas and further subdivided into depth strata of 0-100 m, 100-200 m and 200-300 m. The coastal area was defined as the area between the 3-mile limit and straight lines drawn across the entrance of the fjords. The areas inside these lines were defined as fjords. The sizes of the inshore strata are given in Anon. (1988, Table 5.3.1.1).

The length distribution of long-line catches differs markedly from that seen in trawl catches, with long-line selecting the larger cod. However, based on results from concurrent long-line surveys by Greenland and trawl surveys by the Federal Republic of Germany in the same offshore areas in 1987 and 1988, it was possible to establish a key to convert long-line CPUE by size groups to swept area abundance (Hovgård and Riget, 1990). The long-line catches expressed in swept area abundance units were subsequently raised to total inshore area by stratum. Long-line catches of cod less than 36 cm were scarce and no attempt was therefore made to calculate abundance of these sizes of cod.

4.2.2 West Greenland young cod survey

During July 1989, Greenland carried out a survey on young cod in three inshore areas of West Greenland: Qaqortoq (Division 1F), Nuuk (Division 1D) and Sisimiut (Division 1B). Results of the survey were presented in a working paper at the meeting (Hovgård and Nygård, 1990). This survey using gill nets has been done

since 1985, and an index of abundance of 1- and 2-year olds has been calculated.

In 1989, a total of 2005 cod was caught in 208 settings in depths ranging from 0 to 35 m. In Division 1B catches were dominated by 2- and 3-year olds with a substantial amount of older fish as well. In Division 1D the 2-year olds dominated, and few older fish were caught, whereas catches of all age groups in Division 1F were very low. Only four 1-year olds were caught during the survey (Division 1B).

In 1985 and 1986, only three mesh sizes were used, whereas five mesh sizes have been used in recent years. For comparison, an index (mean number caught per hour) is computed for both three and five mesh sizes for the 1- and 2-year olds.

Index of year-class strength

	Survey year	Age 1	Age 2
Three mesh sizes	1985	0.74	+
(16, 24 and 33 mm)	1986	0.09	1.61
	1987	+	0.36
	1988	+	0.09
	1989	+	0.27
Five mesh sizes	1987	+	0.93
(16, 18, 24, 28 and 33 mm)	1988	+	0.25
	1989	+	0.61

The indices suggest that the 1987 year class is around 70% of the 1985 year class, whereas the 1988 year class seems to be poor. However, in 1988 the catch of 1-year olds (1987 year class) was also very small, and hence the gill nets might not reflect the abundance of 1-year olds properly.

4.3 Studies of Migrations of Cod by Otoliths Types

A paper on typing of otoliths as a mean for quantifying migration of cod between West and East Greenland was presented by H.J. Raetz (1989).

The method is based on the assumption that the structure of annuli in any otolith is influenced by the growth rate and thereby by the environmental conditions under which each growth zone in the otoliths was formed. Each growth zone in the otolith was classified using three structure types (called A, B and C).

Almost all young cod (1-3 years old) of East Grenland show type B and/or C growth zones, whereas most young cod off West Greenland show type A zones. Therefore, for East Greenland cod it seems fair to postulate that older cod showing type A in their inner growth zones are immigrants from West Greenland. It is less evident that the minor part of young cod at West Greenland which shows type B stems from East Greenland (as westbound young-fish emigrants).

The study shows that the proportion of A-types at East Greenland increases by age (about 15% by age 5 to about 70% by age 7). This indicates that cod at East Greenland of East Greenland origin are gradually being replaced by fish of West Greenland origin.

From tagging experiments it is known that some cod of West Greenland origin as well as some of East Greenland origin migrate to Iceland. Also, this migration could influence the proportions of otolith types at East Greenland.

5 STOCK AT WEST GREENLAND (NAFO SUBAREA 1)

5.1 Trends in Catch and Effort

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

The estimated catch in 1989 was about 108,000 t (provisional figures), which is a 75% increase compared to the 1988 catch (Tables 5.1.1 - 5.1.2).

Greenland vessels landed about 89,000 t or 82% of the total catch; the remainder was taken by the Federal Republic of Germany and the UK. It was only possible to break down catches into trawlers and other gears (Table 5.1.2) because of problems within the Greenland statistics programme for vessels below 80 GRT. Trawl catches constituted 61% of the total Greenlandic catch.

Catch and effort data for Greenland trawlers in 1975-1989 have been carefully scrutinized and the earlier figures have been revised (Table 5.1.3). In 1989, the trawlers operated only in Divisions 1D, 1E, and 1F. During the second part of the year, effort had a more southerly distribution than in the first part of the year. The overall catch per unit effort (Table 5.1.3) increased by about 1 t/hour compared to 1988. The catch per unit effort in the second quarter of the year was the highest on record (Figure 5.1).

CPUE has been analyzed using a multiplicative model including effects of year, division and month (Riget et al., 1990). The data consist of logbooks from 6 sister trawlers owned by the Greenland Home Rule government, which account for about 90% of the total effort in the Greenlandic trawl fishery for cod.

The statistics and estimates from the multiplicative model are given in Table 5.1.4. The estimated yearly effects are shown in Figure 5.2.

5.2 Catch in Numbers at Age and Catch Composition

Catch statistics for the Greenlandic fishery are now collected on a gear-basis, but due to technical problems in Greenland, the data for 1989 were not ready for the meeting. However, catches could be split into trawl catches and catches by other gears (inshore catches) according to information from the factories. Comprehensive catch statistics should be ready for the NAFO meeting in June.

Greenland trawl catches were well sampled throughout the year. All samples from other gears regardless of month and division were pooled and used to convert the total inshore catch into numbers. Trawl catches of the Federal Republic of Germany and the United Kingdom were raised according to samples from the Federal Republic of Germany commercial fishery as their length frequency distributions differed from those of the Greenland trawl catches.

Greenland trawl catches were dominated by the age group 5 (96% by numbers) throughout the year and in all areas. The domination of age group 5 was also evident in the Federal Republic of Germany catches (80%) with age group 4 the next most abundant (18%). Some of this difference may have been due to discarding of age 4 fish by Greenlandic trawlers, as a part of this age group was still below minimum landing size of 44 cm in Greenland.

In the inshore catches, age groups 5 and 4 dominated with 77% and 21% by numbers, respectively.

Overall, the 1984 year class accounted for 86% by numbers (88% by weight) whereas the 1985 year class accounted for 12% (7% by weight) (Table 5.2).

5.3 Mean Weight at Age in the Catches

The mean-weights-at-age of cod in the Greenland and the Federal Republic of Germany trawl catches are listed in Table 5.3, together with the inshore catches. The weighted totals are shown for the Greenland fishery, the Federal Republic of Germany fishery and for both combined.

For all age groups, the mean weights are lower than in 1988, especially in the Federal Republic of Germany catches. However, these results must be considered as preliminary as it was discovered that age-length keys from Greenland and the Federal Republic of Germany differed significantly.

The Working Group agreed that the possibility of different interpretations of otoliths for age determination between readers in the two laboratories should be investigated using 1989 material before the NAFO Scientific Council meets in June 1990. The laboratories will exchange otoliths as soon as possible.

5.4 Groundfish Survey Results

The number of randomly distributed fishing stations occupied during the surveys from 1982-1988 amounted to:

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

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 the inclusion of stratum 4 in 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
1988	547,566 ± 42.1%	563,601 ± 42.3%	0.97
1989	349,812 ± 58.2%	368,388 ± 65.1%	0.95

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 and 1986-1989. 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 standard survey gears was used and towing speeds were the same.

From 1982 to 1984, the survey results reveal a major decline in cod biomass and abundance (Figure 5.4.1). The total survey biomass and abundance, however, have increased considerably since 1984, particularly between 1986 and 1987, due to increasing recruitment, especially from the outstanding 1984 year class (Table 5.4).

In 1988, the survey biomass of age 4 and younger cod increased by 122,000 t. The biomass of age 5 and older fish, however, decreased by 39,000 t. The resulting increase in total biomass of 83,000 t was less steep than previously. Despite increasing recruitment, mainly of the 1985 year class and younger cod, the total abundance started to decline in 1988.

The survey results of 1989 reveal a pronounced decrease, both in biomass and abundance by 198,000 t (36%) and 195 million fish (35%), respectively, together with an obvious southward displacement of the stock with 93% of the total survey biomass and 92% of the total survey abundance occuring on Divisions 1E and 1F. This decrease was mainly caused by a reduction in the abundance of the 1984 year class.

The changes in length-frequency distributions and age compositions of the West Greenland cod stock over the survey period from 1984-1989 are illustrated in Figure 5.4.2.

5.5 The Inshore Stock in Proportion to the Total Stock

Since 1987, Greenland has conducted annual inshore long-line surveys at the same time as the trawl surveys were undertaken by the Federal Republic of Germany. Inshore abundance of cod above 35 cm has then been calculated by converting long-line CPUE to swept area estimates (see Section 4.2.1). Trawl abundance for the same years was not available at the meeting on a length basis but assuming that 86.5%, 92.5% and 99% of the offshore cod were above 35 cm for the years 1987, 1988 and 1989, respectively, the offshore abundance of cod above 35 cm was derived from Table 5.4. The estimates of inshore and offshore cod abundance are given by year and area in Table 5.5.

By comparing the abundance found in divisions covered by both surveys, the inshore stock component was estimated to account for 20%, 38% and 23% of the total in 1987, 1988 and 1989, respectively. The high proportion found inshore in 1988 was caused by high inshore abundance of cod in Division 1C. This was probably due to the lines hitting a high local concentration of cod and the Working Group last year did not consider the result valid (Anon., 1989). On average, the long-line surveys indicate that approximately 20-25% of the total stock are not covered by the trawl surveys.

5.6 Distribution Pattern of the Stock

The important 1984 and 1985 year classes started recruiting to the fisheries in 1987 and 1988, respectively. In both these years, offshore fishing at West Greenland took place in the very southern part of Division 1C, and in Divisions 1D and 1E, with Division 1D the most important area. In 1989, Division 1E was by far the most important division, and it was furthermore noted that compared to 1988, catch and effort decreased in Division 1D but increased in Divisions 1E and 1F, thus indicating a southward displacement of the bulk of the fishable stock. Furthermore, the fishery at South East Greenland was relatively good, indicating that the displacement has also been from West Greenland to South East Greenland.

The survey results of the Federal Republic of Germany show the same trend. The survey biomass of Division 1D decreased dramatically from 453,000 t in 1988 to only 24,000 t in 1989, whereas there was a considerable increase for Divisions 1E and 1F from 41,000 and 53,000 t, respectively, in 1988 to 217,000 and 108,000 t, respectively, in 1989. Furthermore, the survey biomass at East Greenland increased from 42,000 t in 1988 to 140,000 t in 1989, and the major part (105,000 t) found south of 63°N lat.

During 1989, length compositions and mean weights were rather stable at West Greenland (mean weight of fish in the survey stock 0.97 kg in 1988, 0.95 kg in 1989) but they increased at East Greenland (mean weight of fish in the survey stock 2.21 kg in 1988, 2.55 kg in 1989). This indicates that the migration from West to East Greenland was mainly of large fish. Many of these migrants are likely to spawn there in 1990.

It does, therefore, seem reasonable to assume that, apart from the southward displacement of fish at West Greenland in 1989, there was a migration from West to East Greenland of the faster growing individuals, mainly of the 1984 year class. However, the Working Group found difficulties in quantifying the migration by age groups. Applying the age-length keys from the trawl survey to the survey stock leads to the following change in survey abundance estimates of the two important year classes (millions of fish) :

	West Greenland		East Greenland	
	1988	1989	1988	1989
1984 year class	461	173	9.6	36.8
1985 year class	92	188	6.2	9.8

Although these figures could explain the unchanged size composition and mean weight at West Greenland, and confirm that the increase at East Greenland was mainly due to the 1984 year class, the Working Group found it difficult to believe that the 1984 year class at West Greenland could have decreased to such an extent and especially that the abundance of the 1985 year class could have doubled. The above figure of 188 million fish by November 1989 would correspond to a year-class strength at age 3 of about 400 million fish (applying Z values of 0.3 for 1988 and 0.45 for 1989 up to November), whereas all former estimates of that year class have been at about the 100 million level.

Applying an age-length key drived from Greenland offshore fisheries and research in August and October of 1989 to the German survey stock of November, results in figures at West Greenland of 128 and 226 million fish of the 1985 and 1984 year classes, respectively. These figures are in better conformity with previous observations and with estimates of the proportions of the two year classes than are the figures in the text table above.

It was observed that the 1989 survey stock has a bimodal length distribution. However, the Working Group did not find a clear means for splitting the length distribution into corresponding age groups of normal distribution, possibly because both may be skewed.

The Working Group was not able to solve the question of the proportional size of the 1984 and 1985 year classes at present in the West Greenland stock although it was observed that the sum of the two year classes in both analyses correspond well with the sum in 1988.

5.7 Possible Causes for the Recent Displacement of the Stock

The Working Group had a lenghty discussion of the displacement which took place during 1989 and made a number of observations and suggestions.

Environmental conditions

As stated in last year's report of the Working Group, air temperatures and sea surface layer temperatures at West Greenland were below normal in 1988. The strong inflow of warm Irminger water at depths deeper than 200 m in September - November 1988 does not seem to have persisted through 1989. Rather, 1989 was somewhat colder than 1988 for air temperatures (negative anomaly of 8C° at Nuuk/Godthab in March) as well as for sea surface layer temperatures (negative anomalies of about 1C° in summer). Negative anomalies down to 400 m indicate strong inflow of East Greenland Polar Water in 1989. These cold conditions may have induced the displacement of the stock.

Prey supply

It was suggested that food supply for cod may have changed. A study on cod stomach content analysis (Koester and Schover, 1990) showed that crustaceans, including large specimens of Pandalus borealis, were the major food items, whereas few fish were found in the stomachs. However, this material only covered a 24-hour period in July at Fylla Bank (50-100 m). Analyzing cod stomach from the 1989 survey with previous findings (Tiedtke, 1988) did not show clear signs of changes in the amount of prey.

A suggestion that food supply of small fish had decreased from 1988 to 1989 was not confirmed by a rough analysis of data from the autumn trawl surveys.

The Working Group was, therefore, not able to judge whether changes in prey composition and abundance have been a contributing factor to the recent displacement of cod. However, important prey species such as sandeels and capelin do not seem to occur in quantities in this material.

The condition factor of cod at West Greenland for the years 1983-1989 was examined for fish above 40 cm from all age-length samples (except small samples of less than 50 fish) taken by the Greenland Fisheries Research Institute in that period. The condition factor was lower than normal in 1989 and this was also found in 1984, another cold year.

5.8 Future Recruitment

1986 year class

Both in the trawl survey and the young cod survey this year class shows a northernly distribution (Division 1D and north thereof). The abundance is low in all surveys.

1987 year class

This year class shows a very low abundance in the south (Division 1F) in both surveys, and higher abundance in the northern divisions. The young-cod index shows values around 70% of the 1985 year class, and according to this, the year class might account for some 70 million fish at age 3. This is in contrast to the trawl survey results which only give an estimate of 7% of the 1985 year class. It is the first time that the two surveys have shown such disagreement, and it might reflect differences in abundance between inshore and offshore areas.

1988 year class

Very few fish of the 1988 year class were caught in the two surveys, and then only in Division 1B. This indicates that the year class is poor.

1989 year class

Few 0-group fish were caught in the trawl survey in Division 1F, and little inflow of larvae from Iceland can be expected as the Iceland 0-group survey (Table 3.1) gives an index value of almost zero for the East Greenland area. This year class is, therefore expected to be small.

5.9 **Assessment Results**

The Working Group decided to assess the West Greenland cod stock by a VPA incorporating the period 1975-1989 and age groups 3-12+.

Natural mortality was assumed to be 0.2 for age 5 and older. For age groups 3 and 4, the natural mortality was increased to 0.3 to account for discarding. An emigration coefficient of 0.15 was applied for the age groups 5 and older to account for emigration to East Greenland. This value was chosen because it produces the number of emigrants which on average over the years is nessesary to account for the immigrants to East Greenland as calculated by the Working Group in its previous reports.

In previous reports, the Working Group has usually applied migration coefficients for the cod age 6+ of 0.05 based on interpretations of former tagging experiments. However, in some years higher values have been applied, e.g., 0.30 for 1986. The stock distribution in 1989 indicates that the 5-year-old cod (1984 year class) have shown a considerable migration from West Greenland to East Greenland. Therefore, it was decided to apply an emigration coefficient of 0.15 to age 5 fish.

A terminal F value of 0.35 was applied to age groups 5 and older. This gives a Z of 0.70, which is in accordance with the Z value calculated from the survey abundance of the 1984 year class between the 1988 and 1989 surveys when the latter is broken down by the Greenland age-length key. The 3- and 4-year-old cod were assumed to have only partly recruited to the fishery, and terminal Fs of 0.18 and 0.03, respectively, were applied. The results from the VPA are shown in Tables 5.9.1 and 5.9.2.

The biomass of the 4+ group for the years 1975 to 1989 has been plotted against the annual indices derived from the multiplicative analysis of CPUE in Figure 5.9 and a reasonable linear relation is apparent.

However, the abundance of the stock from the VPA is only about 50% of what is found by the survey in November, indicating that the survey in 1989 may have overestimated stock abundance. If age 5+ abundance from the VPA is compared with the abundance of the same year classes in the preceding November surveys from 1983 to 1990, similar deviations are seen in 1983, 1988, and 1989, whereas the survey underestimates abundance relative to VPA in 1985 and 1986:

Abundance (million) of age 5 cod and older

Year	1983	1984	1985	1986	1987	1988	1989	1990
Survey	71	54	14	15	13	31	468	363
VPA	41	52	32	23	16	14	305	197
Ratio	1.76	1.05	0.43	0.65	0.80	2.28	1.54	1.85

Using a Z of 0.70 and an emigration coefficient of 0.15 and applying the equation:

Nos. of Emigrants = E/Z * (Total deaths)

leads to an estimated emigration of 33 million cod from West Greenland during 1989.

Assuming similar Z and E values for West Greenland in 1990 leads to the folowing numbers ('000) of emigrants in that year:

	Age								Total
	5	6	7	8	9	10	11	12+	
Emigrants	4,876	15,953	147	21	41	42	104	15	21,199

Table 1.1 Abundance indices of 0-group cod from the international and Icelandic 0-group survey in the East Greenland/Iceland area, 1971-1989 (except 1972).

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

Table 4.1.1 Strata areas in square nautical miles off West Greenland (NAFO Subarea 1).

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

Strata areas only available by 200-m depth zones.

Table 4.1.2 Strata areas in square nautical miles off East Greenland (ICES Division XIVb).

Stratum	Substrata = depth zones (m) 0-200	201-400	401-600	601-800	Total
1	25	3,073	998	345	4,441
2	322	5,160	1,826	334	7,642
3	1,562	2,495	1,011	226	5,294
Total	1,909	10,728	3,835	905	17,377

Table 5.1.1 Nominal catches of cod in NAFO Subarea 1 (1980-1989).

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

Country	1985	1986	1987[1]	1988[1]	1989[1]
Faroe Islands	-	-	-	-	-
Germany, Fed. Rep.	2,170	37	68	6,352	12,763
France - M	-	-	-	-	-
Greenland	12,319	6,546	18,477	51,237	88,526
Japan	-	-	9	2	-
Norway	-	-	-	-	-
United Kingdom	-	-	-	1,027	3,987
Total	14,544	6,583	18,554	58,618	105,276
Working Group estimate	-	-	-	61,618	108,017

[1] Provisional data.

Table 5.1.2 Nominal catches of NAFO Subarea 1 cod for 1978-1989 ('000 t).

Category	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Trawlers	53	57	16	14	29	42	18	7	1	6[3]	42[3]	73[3]
Other	20[2]	42[2]	38[2]	39	26	16	12	8	4	13[3]	20[3]	35[3]
Total	73[2]	99[2]	54[2]	53	55	58	30	15	5	19[3]	62[3]	108[3]
TAC	-[1]	-[1]	20[1]	50[1]	62	62	68	28.5	12.5	12.5	53	90

[1] Catches limited to Greenlanders' fishery and to by-catches.
[2] Estimates used for stock assessments.
[3] Provisional data.

Table 5.1.3 NAFO Subarea 1 cod. Effort (hours fished) and catch per unit effort (kg/hour) for Greenland trawlers (500-999 GRT class) in 1975-1989. Only figures for directed cod fishing are used.

	1B		1C		1D		1E		1F		Total	
Year	Hours	CPUE	Hours	CPUE	Hours	CPUE	Hours	CPUE	Hours	CPUE	Hours	CPUE
1975	392	69	6,789	1,448	4,486	325	2,489	502	248	359	14,404	878
1976	170	50	4,430	637	5,044	601	5,831	882	23	112	15,498	710
1977	-	-	2,434	919	1,675	871	3,471	1,486	122	2,175	7,702	1,184
1978	-	-	3,634	3,039	679	3,053	891	3,410	62	2,563	5,266	3,098
1979	27	20	2,991	1,941	1,226	2,583	396	1,598	11	2,007	4,651	2,070
1980	791	2,033	1,804	987	2,401	792	1,156	1,183	36	715	6,188	1,080
1981	-	-	1,279	2,910	1,856	2,292	953	4,064	5	30	4,093	2,895
1982	100	1,091	1,938	1,878	4,398	1,545	3,362	2,497	17	575	9,815	1,931
1983	927	296	625	817	4,107	876	6,323	1,645	120	882	12,102	1,230
1984	71	24	22	27	1,891	903	2,285	960	318	551	4,587	889
1985	-	-	-	-	328	434	1,942	779	101	1,105	2,371	746
1986[1]	-	-	-	-	-	-	321	1,452	111	637	432	1,243
1987	-	-	3	1,848	497	1,633	11	804	-	-	511	1,617
1988	-	-	213	4,209	5,811	2,656	2,439	3,062	356	4,134	8,819	2,866
1989	-	-	9	44	2,519	4,026	6,847	4,729	1,443	3,027	10,818	4,334

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

Table 5.1.4 Statistics and parameter estimates from the multiplicative analysis of CPUE data for cod off West Grenland, 1975-1989.

Source of variation	Df	Sum of squares	Mean squares	F value	R-square
Model	29	377.829	13.029	16.69	0.590
Year	14	184.690	13.192	16.90	
Division	4	37.321	9.330	11.95	
Month	11	78.317	7.120	9.12	
Error	337	263.056	0.781		

Parameter Estimates

Year	Estimate	Std error	Month	Estimate	Std error
1975	-2.181	0.213	Jan	0.391	0.212
1976	-2.027	0.223	Feb	0.505	0.220
1977	-1.429	0.246	Mar	0.174	0.209
1978	-0.364	0.261	Apr	0.553	0.213
1979	-0.972	0.264	May	0.552	0.216
1980	-1.188	0.239	Jun	0.707	0.228
1981	-0.397	0.255	Jul	0.031	0.237
1982	-0.469	0.226	Aug	-0.183	0.241
1983	-1.296	0.226	Sep	-0.770	0.213
1984	-1.819	0.271	Oct	-0.833	0.225
1985	-2.117	0.291	Nov	-0.259	0.213
1986	-1.540	0.360	Dec	0	-
1987	-0.766	0.547			
1988	-0.507	0.252			
1989	0	-			

Division	Estimate	Std error
1B	-1.158	0.260
1C	-0.074	0.205
1D	0.133	0.187
1E	0.299	0.184
1F	0	-

Table 5.2 COD OFF WEST GREENLAND - CATEGORY: TOTAL.

CATCH IN NUMBERS UNIT: thousands

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
3	1530	1727	3764	662	49	272	51	131	343	275	10760	634
4	7872	15091	7976	12399	2768	2519	10039	2302	1079	3595	4026	46649
5	62130	30457	36670	8709	10342	10172	9786	16378	2384	2677	2243	6053
6	26941	61848	29824	27433	6465	9283	12020	3065	6938	1803	1216	1515
7	5915	24562	34591	14664	13985	5237	4081	2605	1135	5855	302	618
8	4955	2700	10005	12411	4365	9158	2550	1406	1806	1388	1594	425
9	6912	1996	1725	4784	2810	2077	2660	1203	800	619	139	446
10	1289	5237	833	513	1280	1841	624	552	194	291	148	168
11	283	352	2348	237	149	953	954	165	177	84	53	79
12	130	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	139	453	42	62	27	134	57	37	147	12	14	1
15+	247	85	303	8	41	56	122	44	11	10	26	1
TOTAL	119324	144767	128305	82627	42567	41831	43783	28218	15438	16656	20565	56699

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989[1]
3	287	286	2999	12	1204	77	595	456	12	8626	832	40
4	5494	10656	4513	16864	1210	12356	2018	1266	113	2474	49766	10,442
5	30039	12505	4580	6374	17960	2011	10384	1303	706	415	1060	74,960
6	1004	18970	1978	2391	2965	17228	688	4915	318	1001	497	689
7	509	709	8014	1053	2078	1581	3656	161	1193	641	646	101
8	83	400	125	3382	807	995	106	750	12	1037	519	191
9	41	78	60	45	610	344	365	42	332	11	744	195
10	13	52	24	65	45	343	97	140	80	45	21	489
11	7	55	1	1	88	3	69	15	13	2	83	0
12	7	80	16	1	9	22	0	8	35	3	0	67
13	7	5	3	0	4	0	3	0	0	0	0	0
14	1	5	1	0	1	2	0	0	0	1	0	0
15+	1	16	2	7	13	19	0	14	0	17	0	0
TOTAL	37493	43817	22316	30195	26994	34981	17981	9070	2814	14273	54168	87,174

[1] Preliminary.

Table 5.3 Mean weight at age in the main fisheries at West Greenland in 1989 (kg whole, round fish).

Age	Greenland trawl	Greenland inshore	Greenland total	German trawl	Weighted total[1]
3	-	0.56	0.56	0.42	0.52
4	0.98	0.84	0.86	0.48	0.72
5	1.38	1.32	1.35	0.99	1.27
6	1.80	1.86	1.83	1.28	1.67
7	1.94	3.00	2.25	3.32	2.31
8	3.76	-	3.76	3.58	3.71
9	3.90	4.58	4.22	4.01	4.21
10	3.94	6.34	4.99	3.47	4.67
11	-	-	-	-	-
12	2.98	-	2.98	4.28	3.12
Weighted mean	1.40	1.26	1.34	0.93	1.24

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

Table 5.4 West Greenland cod. Autumn survey abundance estimates (no. x 10^3) by age and division, 1984-1989. The respective survey biomass estimates (tonnes) and mean weights are below.

Age	Divisions 1B+C						Division 1D					
	1984	1985	1986	1987	1988	1989	1984	1985	1986	1987	1988	1989
0	104	124	-	32	-	-	68	131	-	13	-	-
1	-	18,148	1,193	363	200	149	4	7,765	2,752	23	11	-
2	78	725	35,014	6,774	2,126	2,000	11	349	33,830	8,237	964	545
3	29	249	737	142,759	1,356	666	282	300	1,582	227,042	67,112	1,745
4	36	133	43	2,745	442	541	847	898	197	4,012	386,465	9,729
5	107	64	51	1,267	5	345	3,203	1,340	482	1,903	2,972	13,854
6	7	74	31	1,811	+	10	151	2,766	363	3,801	466	322
7	80	3	85	222	2	-	625	81	512	501	790	-
8	-	13	1	330	+	-	20	155	8	1,431	405	15
9	36	-	20	-	2	-	97	-	25	-	728	2
10	-	-	1	30	-	7	7	-	2	150	14	12
11	-	-	-	-	-	-	-	-	-	-	16	-
12	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-
NK	-	-	-	-	-	-	-	-	-	-	-	-
Total	477	19,533	37,176	156,333	4,133	3,718	5,315	13,785	39,753	247,113	459,943	26,224
Tonnes	789	2,378	13,333	131,909	1,188	1,076	8,383	11,447	19,483	198,252	452,870	23,653
w (kg)	1.654	0.122	0.359	0.844	0.287	0.289	1.577	0.830	0.490	0.802	0.985	0.902

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 5.4 (cont'd)

Age	Division 1E						Division 1F					
	1984	1985	1986	1987	1988	1988	1984	1985	1986	1987	1988	1989
0	10	149	-	3	-	-	40	438	-	-	-	12
1	-	4,622	3,488	-	10	-	-	3,856	2,797	-	14	-
2	5	195	26,096	10,072	6	22	4	146	13,056	12,582	23	88
3	826	37	768	108,967	8,903	-	850	11	580	34,754	14,637	30
4	333	3,503	188	4,377	33,491	144,695	241	1,195	146	1,597	40,639	33,219
5	3,172	599	4,037	707	215	98,082	2,635	195	3,051	328	396	60,506
6	299	2,510	256	2,342	32	802	350	945	270	1,424	61	541
7	586	122	1,062	307	189	-	768	145	1,429	197	177	-
8	30	180	27	955	72	112	36	260	68	651	73	120
9	49	4	91	-	265	23	59	18	316	-	272	36
10	4	5	3	50	13	40	11	13	14	86	8	113
11	2	-	6	23	18	-	2	-	17	-	11	-
12	-	-	-	-	-	-	-	-	-	-	-	5
13	-	-	-	-	-	-	-	-	21	-	5	-
14	-	-	-	-	-	-	-	-	-	-	-	-
NK	-	-	-	-	-	-	-	-	-	-	-	-
Total	5,316	11,926	36,022	127,803	43,214	243,776	4,996	7,222	21,765	51,619	56,311	94,670
Tonnes	7,526	11,934	23,675	96,433	40,698	217,096	8,247	6,101	19,729	37,692	52,810	107,987
w (kg)	1.416	1.001	0.657	0.755	0.942	0.891	1.651	0.845	0.906	0.730	0.938	1.141

(cont'd.)

Table 5.4 (cont'd)

Age	Total					
	1984	1985	1986	1987	1988	1989
0	222	842	-	48	-	12
1	4	34,391	10,230	386	235	149
2	98	1,415	107,996	37,665	3,119	2,655
3	1,987	597	3,667	513,522	92,008	2,441
4	1,457	5,729	574	12,731	461,037	188,184
5	9,117	2,198	7,621	4,205	3,588	172,787
6	807	6,295	920	9,378	559	1,675
7	2,059	351	3,088	1,227	1,158	-
8	86	608	104	3,367	550	247
9	241	22	452	-	1,267	61
10	22	18	20	316	35	172
11	4	-	23	23	45	-
12	-	-	-	-	-	5
13	-	-	21	-	-	-
14	-	-	-	-	-	-
Total	16,104	52,466	134,716	582,868	563,601	368,388
Tonnes	24,945	31,860	76,220	464,286	547,566	349,812
w (kg)	1.549	0.607	0.566	0.797	0.972	0.950

Table 5.5 Swept area estimates of offshore and inshore cod above 35 cm. Inshore abundance is based on long-line fishery converted to swept area units as decribed in section 4.2.1. Abundance given in millions.

Year	1987		1988		1989	
Div.	insh.	offs.	insh.	offs.	insh.	offs.
1B	nc.	+	nc.	+	8	+
1C	67	135	199	4	18	4
1D	32	214	68	425	22	26
1E	17	111	16	40	31	241
1F	nc.	45	nc.	52	nc.	94

nc: no survey coverage
+ : less than 0.5 mill. cod

Table 5.9.1 Fishing mortality from VPA.

AGE	1975	1976	1977	1978	1979	1980	1981	1982
3	.012	.047	.013	.006	.009	.024	.001	.015
4	.263	.266	.326	.169	.352	.203	.203	.217
5	.550	.299	.968	.419	.836	.289	.570	.400
6	.751	.638	.406	.493	.622	.353	.285	.704
7	.957	.314	1.012	.274	.996	.725	.385	.518
8	1.201	.967	1.263	.415	.430	.566	1.003	.704
9	.828	.412	1.037	.439	1.116	.123	.493	.592
10	1.032	.580	1.840	.081	2.750	2.074	.223	2.035
11	.970	.639	.893	.394	.683	.548	.558	.643
12+	.970	.639	.893	.394	.683	.548	.558	.643
F 6- 8	.970	.639	.894	.394	.683	.548	.558	.642

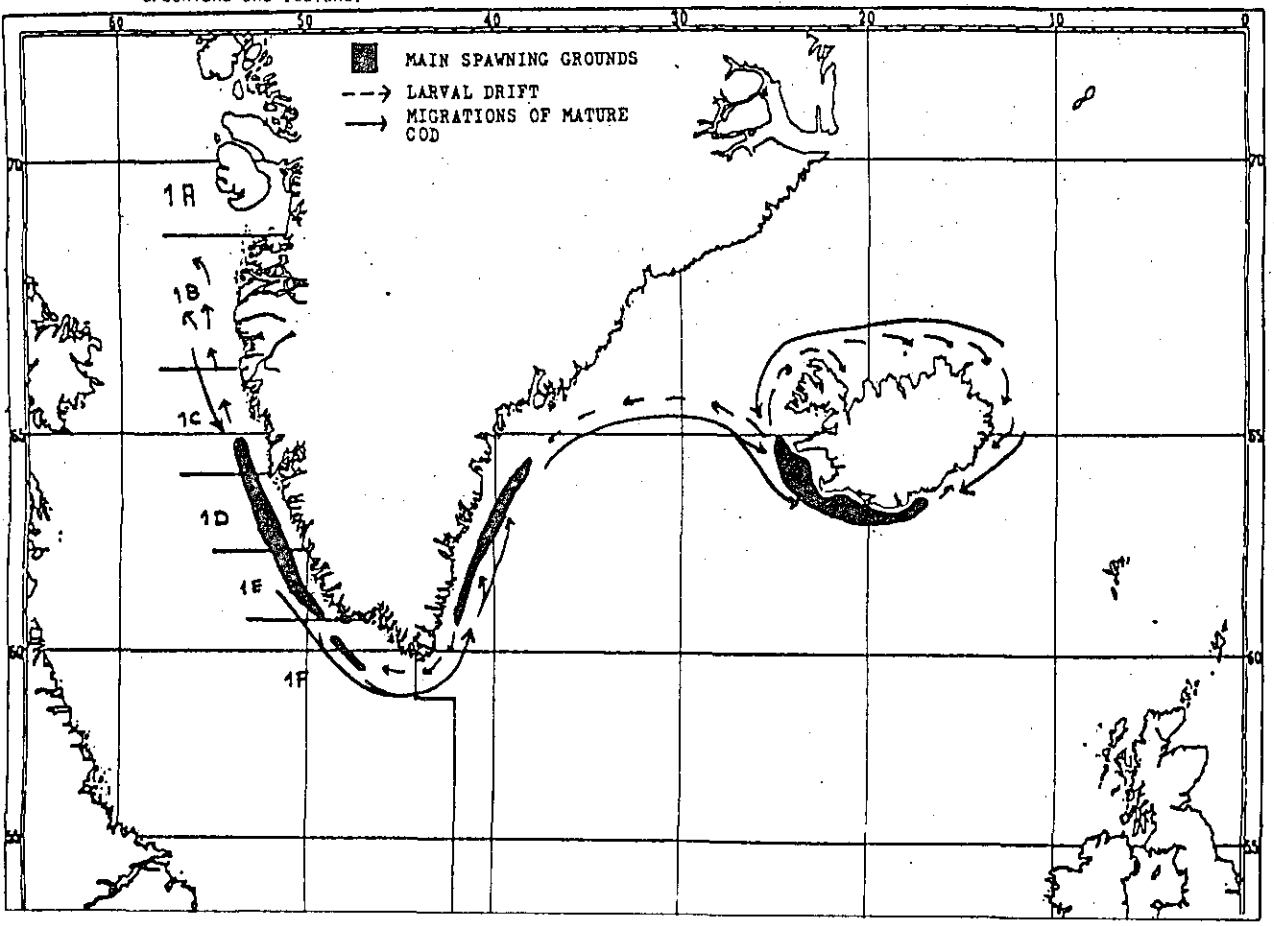
AGE	1983	1984	1985	1986	1987	1988	1989
3	.005	.051	.123	.001	.016	.010	.030
4	.227	.185	.161	.045	.344	.133	.180
5	.792	.348	.200	.145	.262	.278	.350
6	1.067	.880	.329	.080	.373	.700	.350
7	1.425	.862	.637	.145	.271	.531	.350
8	.616	.370	.514	.101	.213	.440	.350
9	.953	.586	.290	.547	.148	.276	.350
10	1.014	1.011	.569	2.038	.153	.557	.350
11	1.037	.704	.493	.108	.285	.557	.000
12+	1.037	.704	.493	.108	.285	.000	.350
F 6- 8	1.036	.704	.493	.108	.285	.557	.350

Table 5.9.2 Stock size from VPA.

AGE	1975	1976	1977	1978	1979	1980	1981	1982
3	27072.	272175.	55854.	55939.	38500.	146157.	9656.	96080.
4	17890.	19820.	192407.	40834.	41194.	28276.	105705.	7143.
5	7383.	10191.	11253.	102856.	25559.	21458.	17097.	63920.
6	3960.	3002.	5324.	3012.	47678.	7807.	11328.	6812.
7	10963.	1317.	1118.	2500.	1296.	18035.	3866.	6002.
8	2275.	2966.	678.	286.	1340.	337.	6153.	1854.
9	1273.	482.	795.	135.	133.	614.	135.	1591.
10	520.	392.	225.	199.	61.	31.	383.	58.
11	156.	131.	155.	25.	129.	3.	3.	216.
12+	128.	207.	219.	58.	249.	61.	22.	66.
B.Tot.	131779.	308966.	325047.	329115.	275598.	316335.	224421.	252946.
SSB	54762.	30397.	26855.	44455.	79812.	87759.	61908.	63599.
B 6- 8	64392.	26224.	18428.	19242.	140671.	102582.	65449.	43186.

AGE	1983	1984	1985	1986	1987	1988	1989	1990
3	18653.	13930.	4557.	13196.	630120.	99561.	1565.	0.
4	70146.	13753.	9810.	2986.	9765.	459409.	73043.	1125.
5	4260.	41429.	8466.	6186.	2116.	5131.	297806.	45198.
6	30208.	1359.	20607.	4884.	3772.	1147.	2737.	147886.
7	2373.	7326.	398.	10455.	3177.	1831.	401.	1359.
8	2520.	402.	2180.	148.	6375.	1707.	759.	199.
9	646.	959.	196.	919.	94.	3632.	775.	377.
10	620.	176.	376.	103.	375.	57.	1943.	385.
11	5.	159.	45.	150.	9.	227.	0.	965.
12+	77.	7.	66.	404.	52.	0.	274.	136.
B.Tot.	175797.	110018.	63400.	69511.	620765.	581025.	453122.	
SSB	55435.	33945.	27789.	47016.	34033.	63373.	109974.	
B 6- 8	79533.	24272.	40818.	39007.	36943.	11066.	8313.	

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



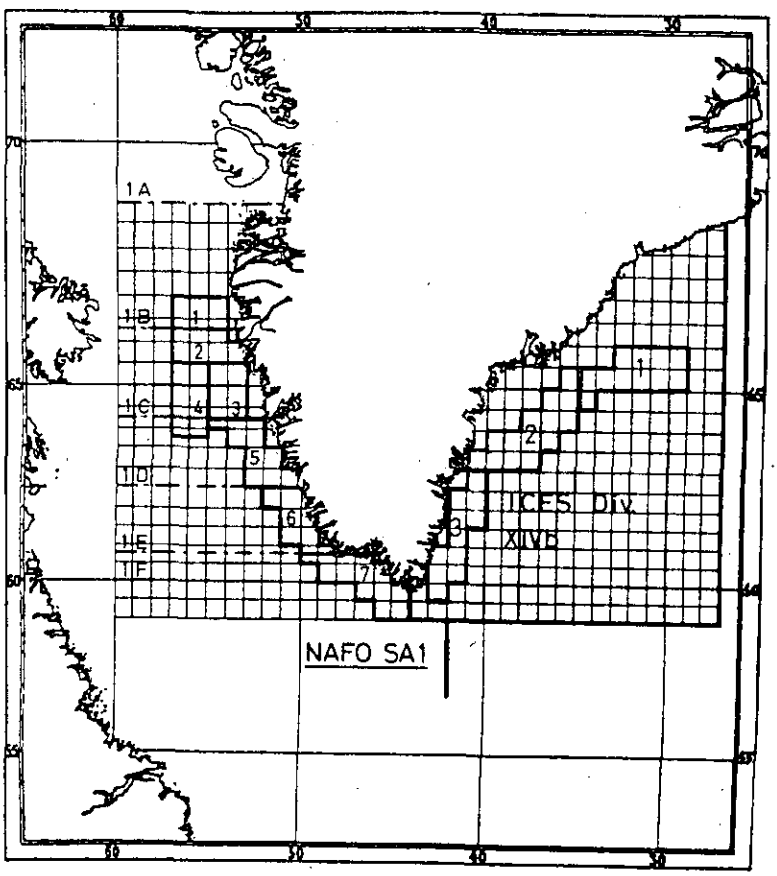


Figure 4.1 Survey areas and stratification off East and West Greenland.

Figure 5.1 Catch (kg) per unit effort (hours) given by quarter for West Greenland, 1975-1989.

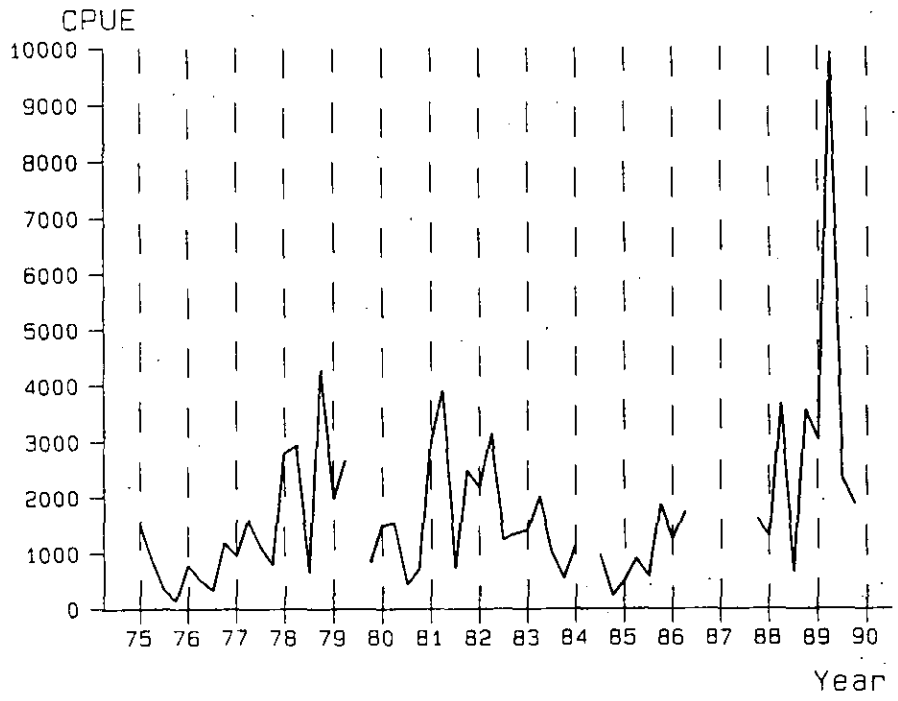
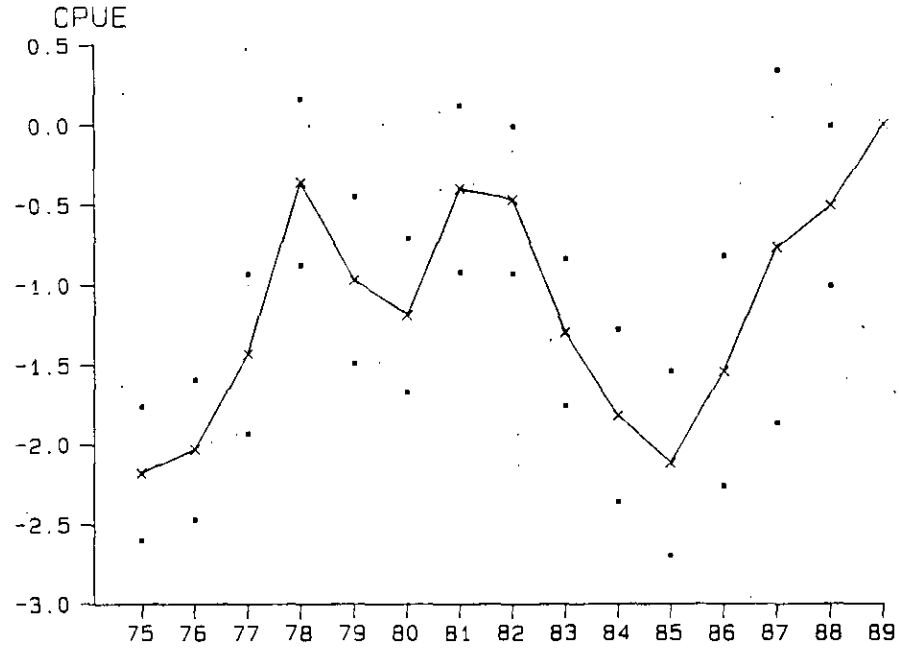
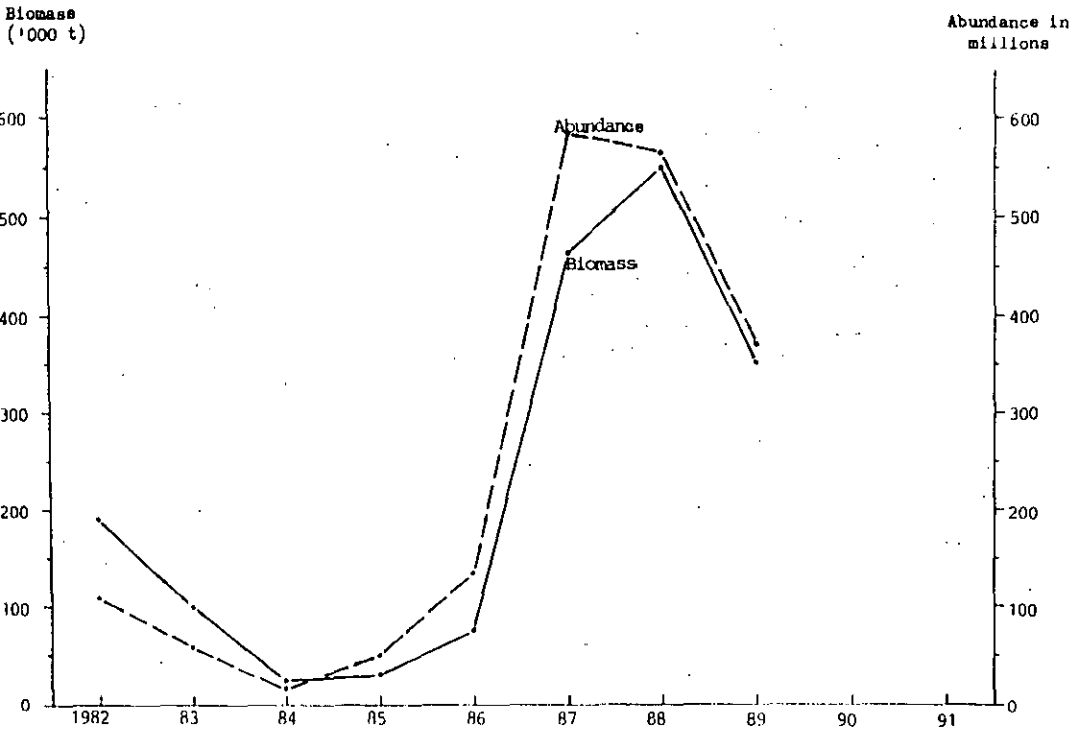


Figure 5.2 Estimates of annual CPUE index from a multiplicative analysis of CPUE data from West Greenland, 1975-1989. The 95% confidence intervals of the estimates are shown by the dots.





- Figure 5.4.1 West Greenland cod. Trends in survey biomass and abundance estimates, 1982-1989.

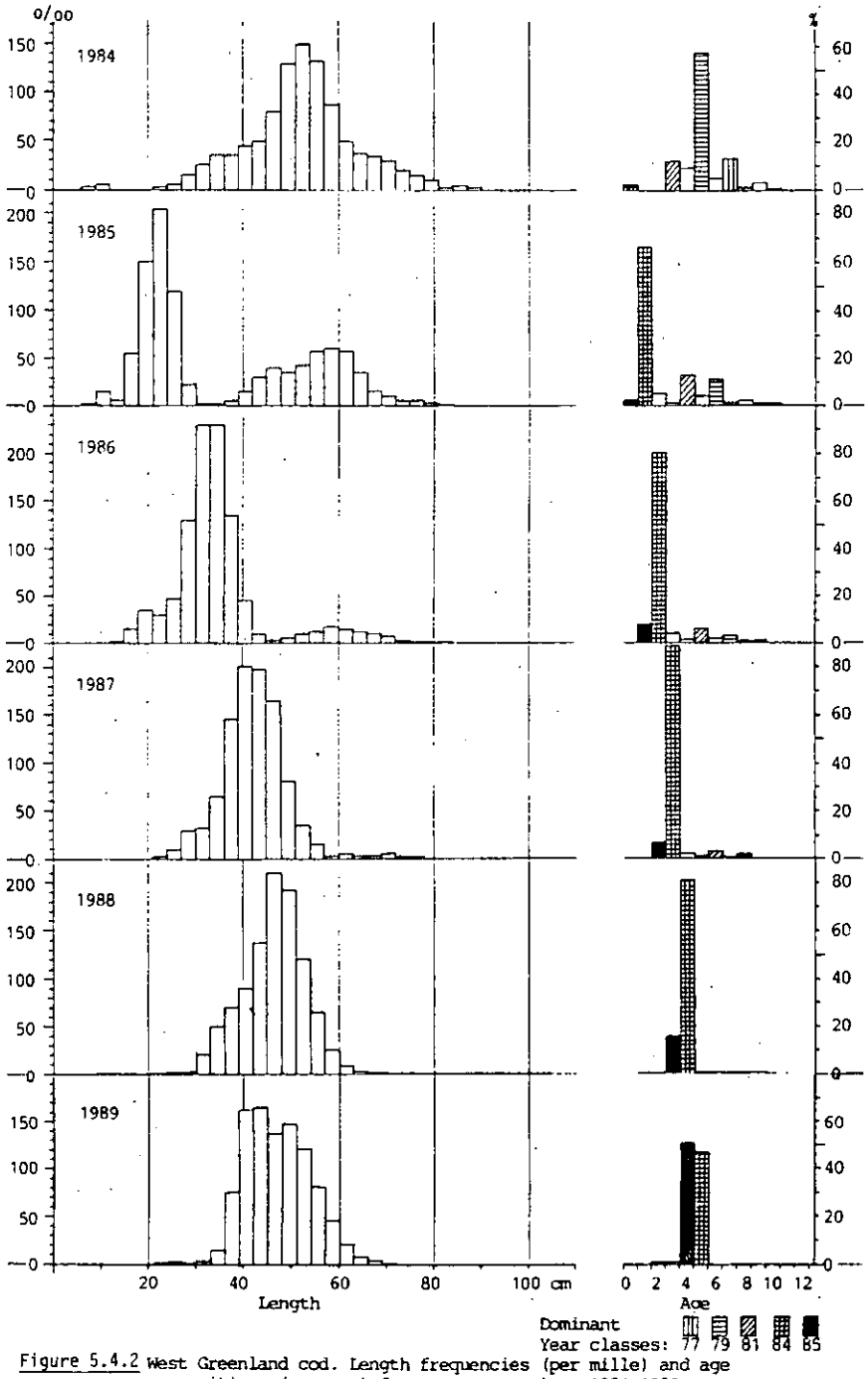
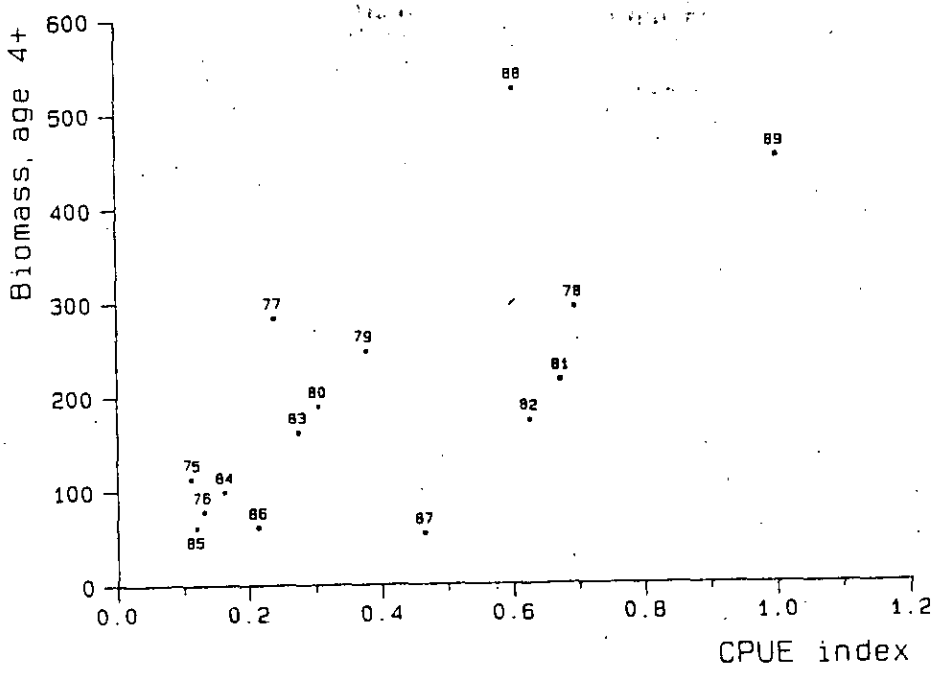


Figure 5.4.2 West Greenland cod. Length frequencies (per mille) and age compositions (percent) from survey results, 1984-1989.

Figure 5.9 Cod biomass ('000 t) as calculated from VPA vs annual CPUE index from Greenland Home Rule government trawlers. West Greenland, 1975-1989.



Revision of the 1989 trawl survey abundance estimate

In 1989 about 2/3 of the survey abundance estimate obtained for the total survey area accounted for Div. 1E (66% by number). Div. 1E was covered in two periods during the survey, which were separated both by time and by location. The catch and the length distributions in these two periods were quite different. (Fig.1). In the first period the length distribution peaked ar about 50 cm with the 1984 year-class probably dominating the survey catches, while in the second period the length distribution peaked at about 41 cm with a likely domination of the 1985 year-class.

On the background it was decided to divide Div. 1E into two parts according to the length distributions and applying age-length key from Div. 1B-D to the northern part and the age-length key from Div. 1E-F to the southern part. The respective strata areas were estimated as follows :

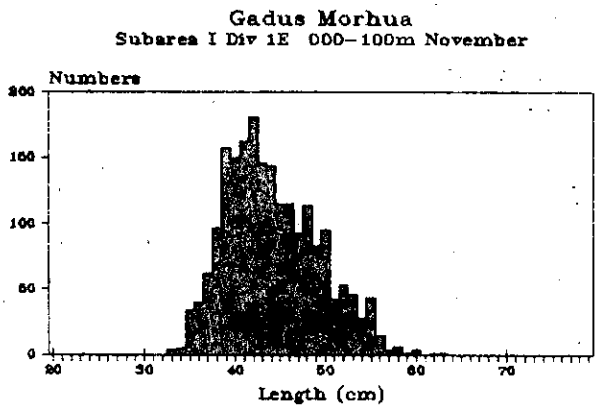
Division 1E.

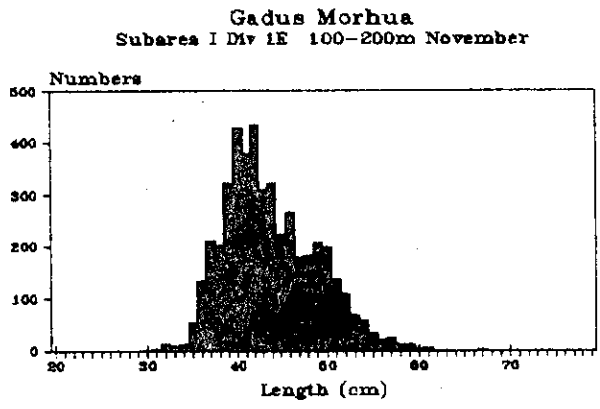
Depth zone	north	south	total
0-100 m	276	0	276
100-200 m	554 (1/3)	1108 (2/3)	1662
200-300 m	232 (1/2)	232 (1/2)	464
0-300 m	1062	1340	2402

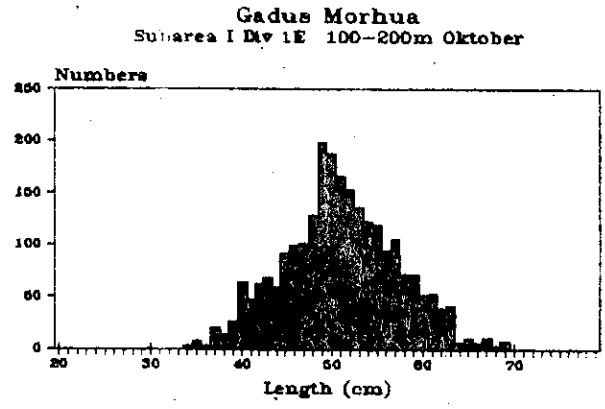
Based on this approach the age composition as it stands in the report from the ICES Working Group should be reviced according to Table 1.

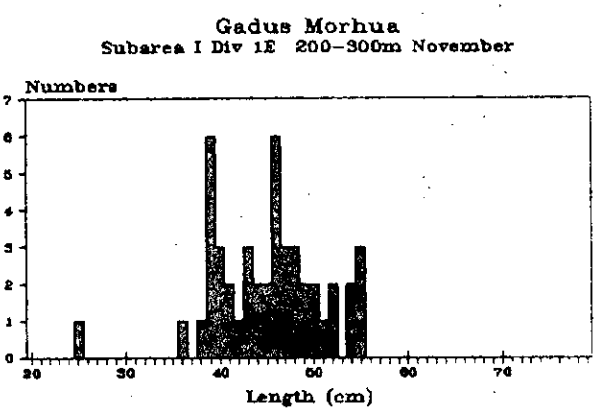
Table 1. West Greenland cod. Autumn survey abundance estimates ('000) by age and division, 1989, (revised).

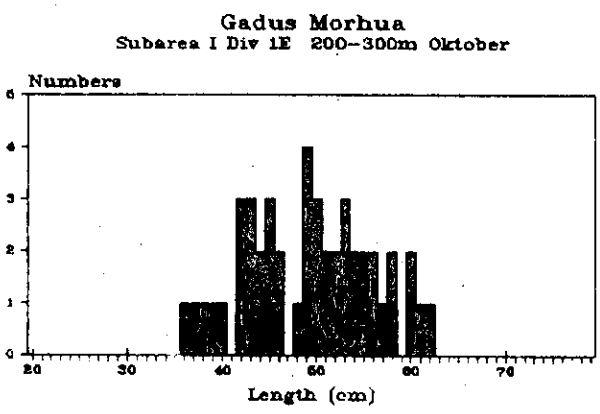
Age	1B+C	1D	1E	1F	Total
0	-	-	-	12	12
1	149	-	-	-	149
2	2000	545	156	88	2784
3	666	1745	6263	30	8704
4	541	9729	86974	33219	130463
5	345	13854	121931	60506	196636
6	10	322	2256	541	3129
7	-	-	-	-	-
8	-	15	178	120	313
9	-	2	41	36	79
10	7	12	41	113	173
11				-	-
12				5	5
13					
14					
NK					
Total	3718	26224	217840	94670	342452
Tonnes	1076	23653		107987	
w (kg)	0.289	0.902		1.141	











Figur 1. Mean number by 30 min hauls in November in the northern part of Division 1E and in October in the southern part of Division 1E.