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Subarea 1 cod: data for 1977-78 and early 1979, and estimates of biomass and yield, 1979-81[1]

by

Sv. Aa. Horsted
Grønlands Fiskeriundersøgelser
Charlottenlund, Denmark

1. Nominal catch 1977 and 1978

TAC for Subarea 1 cod was 31 000 tons for 1977 but although fishing by non-Greenlandic vessels and by the large Greenland trawlers was stopped by May-June the TAC was exceeded by about 7000 tons (Table 1).

In 1978 only Greenland vessels were allowed direct cod fishing at West as well as at East Greenland. Although, as in 1977, the large trawlers had their direct cod fishing stopped by May the total Greenland catch for Subarea 1 is about 35 700 tons and about 1900 tons for Southeast Greenland. Bycatch of cod in other fisheries, primarily in the fishery for redfish by the Fed.Rep.of Germany, was reported by the vessels engaged as about 1500 tons at West and 500 tons at East Greenland, but these figures may probably be regarded as provisional minimum estimates. The total catch of cod in 1978 is thus 37 000 tons or more for Subarea 1 and 2300 tons or more for Southeast Greenland (ICES XIVb). 1978 catches by divisions and gear are given in Table 2.

The local, inshore fishing (included in the figures given above) which for Subarea 1 was as low as 5200 tons in 1976 increased to 14 000 tons in 1977 and to about 18 000 tons in 1978. The increase occurs mainly in the pound-net fishery in Div. 1E-1F.

The trawlers' proportion of the total catch in Subarea 1 increased from about 37% in 1977 to about 52% in 1978. Inshore catches were caught mainly by pound nets, but inshore catches are not reported by gear in the statistics.

2. Trends in catch per unit effort and total effort

Greenland vessels were the only ones allowed direct cod fishing in 1978 and, thus, the only ones for which comparison of catch per unit effort can be made between 1977 and 1978.

Table 3 gives their effort and catch of cod by divisions for the years 1976-78. The figures show about a doubling of cpue for Subarea 1 as a whole from 1976 to 1977 and a very significant increase (by about 160%)

[1] Appendices 1 and 2 were prepared subsequent to the writing of the initial manuscript.

from 1977 to 1978. However, since distribution of effort on divisions and months was not the same for all three years a better comparison may be obtained by considering figures for shorter periods of the year.

Table 4 gives effort and catch per unit effort by divisions and quarter of the year for the years 1976-78 and for January 1979.

For 1977 as well as for 1978 there is a remarkable change in cpue between divisions from first to second quarter of the year. In the first quarter, especially in 1978 (when for Div. 1C the figures given for the second quarter are from the first part of April) fishing concentrated in Div. 1C, but in the second quarter catch rates were better in Div. 1E and vessels fished relatively more in this division in the second quarter. The restrictions on fishing unfortunately mean that data for the third and fourth quarter are sparse, but the 1977 data suggest that the seasonal southward shift of fishing (to obtain best possible catch rate) might have continued in the third quarter had fishing been free. By the end of the year the more northerly areas again seem to become more attractive. This is also illustrated in Fig.1. For 1979 the January figures indicate that Div. 1C again is the most important.

Assuming that the Greenland trawlers' catch rate can be taken as an index of cpue for the total catch in Subarea 1 then the figures in Tables 3 and 4 suggest that total effort decreased by about 45% from 1976 to 1977 and by about 62% from 1977 to 1978 (about 79% from 1976 to 1978), see Table 5. However, in terms of fishing mortality the situation is not that simple. To assume that effort as measured in Tables 3-5 is and index of fishing mortality requires the assumption of cpue being a direct measurement of the overall stock abundance. This assumption is not likely to hold. The shoaling behaviour of cod, e.g. at time of spawning or due to hydrographic conditions, makes it very difficult to adopt the said assumption. Rather it occurs that catchability varies considerably not only between seasons of the year but also, for any given season, between years. This variation between years is likely to be most pronounced for the first and second quarter of the year (spawning time and extreme temperature conditions). In fact, in the 1950-60s the author used the month of August as the best month for between-years comparison of stock abundance, measured by cpue (Horsted, 1965). This is not possible at present with the very limited amount of effort data for that month.

It may, however, be important to note that in terms of number of fish caught the catch dropped by about 24% from 1977 to 1978 (Table 12). Furthermore, for both years the 1973 yera-class was by far the major one (77% by numbers of the 1977 catch, 81% in 1978). Part of, but not all, the increase in cpue between 1977 and 1978 is, therefore, simply the effect of the growth of the individuals of this year class between the two years, especially as fishing in the first part of 1978 seems to have been on the mature (fastest growing) part of the year class (see Section 4 of this paper). Table 5 illustrates the changes in catch and effort between 1977 and 1978 when catch is expressed by numbers rather than by weight. From this table it will occur that overall effort might have dropped by

about 46% from 1977 to 1978 when considering numbers caught. However, considering again the fact that catches in the two years were made up mainly of the same year class (the 1973 year-class) it seems likely that the increase in cpue from 1977 to 1978 is to a great extent due to an increase in catchability rather than to an increase in overall stock abundance.

3. The stock by January-February 1979

As in January-February of 1978 the Greenland trawlers did again experience good catch rates in the first part of 1979 (see Table 4 and observe that catches registered in fourth quarter of 1978 were taken in late December). Their activity was, however, concentrated in a very narrow area. The major part of the effort was exercised in the southern part of Div. 1C at the western slopes of the Tovqussaq (Banana) Bank and the south-western part of the Sukkertoppen Bank between $64^{o}15'N$ and $64^{o}45'N$. A minor part of the activity took place in Div. 1D, either at the borderline between Div. 1C and 1D directly connected with the afore mentioned fishing area, or at the southeastern slope of the Fylla Bank.

Samples of the landings from this fishing are shown in Table 6. For Div. 1C it will be seen that in terms of numbers as well as of weight the age-group 5 (year-class 1974) was the major contributor to the catch, whereas for Div. 1D the samples indicate that the 1973 year-class was the major contributor. The research sample was taken in the southernmost part of Div. 1D just north of the borderline between Div. 1D and 1F. In this sample the 1973 year-class is of the same relative importance as it was in the majority of the samples in 1978. The commercial sample from Div 1D is from the southern part of the Fylla Bank.

When comparing the mean weight of age groups in the 1979 samples (Table 6) to those in the 1978 samples (Table 9) one finds a good correspondence for age-group 6 and older. Age-group 5 in 1978 evidently had a higher mean weight than age-group 5 in January-February 1979. The explanation may be found in the possibility that the fastest growing individuals of the 1973 year-class joined the exploited spawning shoals in 1978. Some research sampling was made in March-April 1978 and maturity of cod was studied on a limited material. Whereas the samples indicated that the theory of an early maturation of the 1973 year-class could be valid so far as males are concerned very few 5 year-olds females were found to be mature. However, the sampling actually came too late to demonstrate the January-March situation in Div. 1C., Table 13.

The 1979 samples (Table 6) indicate that the role of the 1973 year-class in the fishery is still very important although decreasing. Forecasts made last year (Table 16 in Res.Doc. 78/VI/44) predicted that the 1973 year-class would make up about 1/3 - 1/2 (by weight) of the 1979 catch. The data for January-February 1979 seem to be in conformaty with the prediction. In fact, for the January catch of 2508 tons in Div. 1C and 1619 tons in Div. 1D calculations show the 1973 year-class to make up 38% of the combined 1C-1D catch (see also Appendix 1).

The occurrence of the 1975 year-class in the 1979 samples was expected. The samples seem to confirm this year class to be relatively more important in Div. 1C than in Div. 1D.

The fact that the trawlers cluster in a narrow area makes it very difficult to use their activity and catch per effort in a judgment of the overall abundance of cod in the subarea. However, some acoustic surveys were made in January-February 1979 by the R/V ADOLF JENSEN to investigate the distribution of cod.

On 29-30 January the western slopes of Fiskenæs, Danas, Ravns and Frederikshåb Banks (Div. 1D-1E) and of the south and east slopes of the latter bank were surveyed. Bottom depth range was 100-600 m. Only on the southern part of Danas Bank on 300-400 m and on the northeastern part of Frederikshåb Bank on 240-250 m were fish seen, in the former place possibly redfish, in the latter mainly single fish supposed to be cod. On 31 January shoals of cod were observed in the deep east of Ravns Bank at about 250 m. Two bottom trawl hauls were made resulting in 311 cod caught in about 40 minutes (the research sample in Table 6, Fig.3).

On the 20-23 February 1979 another survey covered the eastern slopes of the Fylla Bank and the eastern and western slopes of the Fiskenæs, Danas, Ravns, Frederikshåb and Narssalik Banks (Div. 1D-1E). Only at the south eastern slope of the Fylla Bank were noteworthy shoals of cod observed; relatively large and dense shoals at 200-300 m. This is where the trawlers had part of their fishing in January-February and the 1D commercial sample of Table 6 is from this area.(Fig. 4-5).

In summary, dense shoals occurred in very limited areas giving good catch rate in these areas, but cod was not considered abundant in the overall area surveyed. It should also be noted that an extensive survey for sandeel by three commercial vessels in June-September 1978 in Div. 1A-1D (to be reported in the Danish Research Report for 1978) found few cod in their extensive acoustic survey.

4. Mean length and weight of age groups in 1978 and first part of 1979

Age and length samples of cod in Subarea 1 and off East Greenland (ICES XIVb) for 1978 were provided by Denmark (G) and by the Fed.Rep. of Germany (Dr. J.Messtorff kindly provided the author with these).

The FRG samples give figures for mean length and weight of each total sample while some of the Danish samples have been used to achieve mean length and weight for each individual age group. These samples are listed in Table 7, while Table 8 gives the overall mean length and weight for the FRG samples.

As will be seen from Table 7 the material for age groups older than 8 years or in most cases older than 7 years is very limited. Likewise weight data for age-group 3 and younger age groups are limited. For age-groups 3 to 8 the quarterly mean weights from the Greenland samples are given in Table 9 for the offshore and inshore samples separately. The weighted annual mean has been obtained by weighting with the quarterly inshore and offshore catches in Table 10.

As will be seen from Table 9, for age-groups 4 and older the 1978 mean weight turns out to be significantly higher than for 1977, most remarkable for age-group 5 (the important 1973 year-class). This phenomenon seems to be related to the first quarter of the year especially. As was suggested by the author in Res.Doc. 78/VI/44 (Horsted, 1978) the rather sudden increase in mean length and weight of the 1973 year-class by January-February 1978 may be due to the fact that the very good fishing at that time was on shoals likely to be pre-spawners and the possibility that the fastest growing individuals of the 1973 year-class matured in the winter of 1977/78 and joined the spawning concentrations.

Studies of this phenomenon are mentioned in Chapter 3, page 4 of this paper. As mentioned the sampling did occur too late to cover the peak period of the good fishing in Div. 1C. In fact, trawlers left this area in April, and the effort and good catch rate listed under the second quarter of 1978 for Div. 1C in Table 4 is occurring in the beginning of April.

The theory of a separation of the 1973 year-class (and probably also the 1972 year-class) in a mature and an immature component in the first part of the year 1978 seems confirmed by the fact that in the second to fourth quarter of the year the mean length and weight of the age groups returned to a lower, less "abnormal" level.

It should be mentioned that, although the tables refer to samples and thereby include the inevitable possibility of bias, the observations made through the samples correspond very well with those generally reported by the commercial fleet. The fleet exploited good, but scattered concentrations of unexpected large cod in January to mid April, especially in the southern part of Div. 1C, but thereafter catches again had inflow of smaller sized cod, and samples confirm that these were also mainly five years old.

The above described phenomenon seems necessary to take into account when samples are used to calculate numbers landed by age groups in 1978. Whereas in former years' calculations the weighted annual mean weight of each age group was used, for the 1978 catch the monthly or quarterly mean weights have been used to calculate numbers landed by age groups. This refers to catches by Greenland vessels. For the FRG catches the mean weight of the total sample, or of combined samples, was used to convert catches to numbers.

The variation between years in weight by age makes it difficult to estimate mean weights to be used in forecasts of catches. The fisheries trend in 1977-79 will, however, suggest that offshore fishing will continue to take the major part of any allowed catch in the first part of the year so that a figure between the weighted annual mean weight found for 1978 and the mean weight for January-February 1979 may be a proper value. These figures are set out in Table 11 together with figures found for the inshore fishery in 1978. In order to achieve an overall mean annual figure for each age group it has been supposed that for the forecast years offshore catches will make up about 60% of the total TAC. It may occur that the figure for age-group 7 is too low. Anyway, to the extent that trawlers' proportion of

the total catch may exceed the assumed 60% the predicted catches will tend to be underestimates.

5. Numbers landed by age groups in 1977 and 1978

Numbers landed per age group for the years 1965-76 are found in the following Res.Doc. 75/31, 76/VI/17, 77/VI/8 and 78/VI/44. The latter also contains provisional figures for 1977.

Revised figures for 1977 and provisional figures for 1978 are given in Table 12. The table also includes figures for Southeast Greenland (ICES XIVb).

Since no new sampling data were available for the 1977 catches as compared to those used to obtain provisional figures last year (Res.Doc. 78/VI/44) the revision is simply a raising of the provisional figures to take into account a higher total catch (37 993 tons) than the provisional one (35 644 tons).

For 1978 the offshore catch by otter trawl is fairly well sampled, especially in the important first quarter of the year, both by Denmark(G) and by the FRG. There is a very good correspondence between the samples representing this fishery, all samples showing the high predominance of the 1973 year-class and, with the exception of one sample, very few cod of age 9 or older occur. The inflow of such old cod seems to occur more common off East Greenland, but also here the 1973 year-class was the major one in 1978. Inshore catches are not well sampled, except in Div. 1D and partly Div. 1E, but the samples do not allow to judge differences in age composition between divisions. It seems likely, however, that if sampling had occurred in Div. 1C and 1B the inflow of the 1975 year-class might have been higher than indicated by Table 12.

Year-class 1974 (age-group 4) has partly recruited to the fishery in 1978 while the 1975 year-class, expected to be better than the 1974 year-class, has been landed only in small quantities and mainly in the northern divisions, but - as mentioned in the preceding paragraph - the figures for this year class are probably biassed (underestimated).

6. Information on future recruitment

Recruitment of Subarea 1 cod to the fishery normally starts at an age of 3-4 years. Local Greenland regulations prescribe a minimum size of 40 cm total length of cod in landings. Smaller cod may be caught, but generally only in the inshore pound-net fishery from where they can be discarded alive. Unfortunately, as stated in Section 5, the pound-net fishery was not very well sampled in 1978 and information on discard is rather sparse.

The year classes in question for recruitment in 1979-81 are the year-classes 1975-78.

The strength of the 1978 year-class can at present be made only on hydrographic and plankton observations in 1978. These will be described in details in the Danish Research Report for 1978. In brief, water temperatures in the spring and summer of 1978 were relatively low over the fishing banks

in Div. 1B-1D, and the hydrographic observations indicate that the year class may be rather poor.

The number of cod larvae in the plankton was extremely low, and it must, therefore, be a provisional judgment that the 1978 cod year-class will be ranged amongst the very poor ones.

Individuals of the 1977 year-class have not yet reached a size where they could be expected to occur in commercial catches. However, in research catches (cod-end mesh size 30 mm) of the Fed.Rep. of Germany in December some samples contain 1-year old cod, most noteworthy in Div. 1E, where as much as 13% (by number) of the samples (four length samples combined) consisted of this year class. Here it was more frequent than the 1975 year-class (7.5%). Apart from this sample (samples) the 1977 year-class has not yet shown up in any noteworthy amount in research samples. It is, however, yet too early to make more firm conclusions on the strength of the year class. It should be remenbered, however, that temperatures were relatively favourable in 1977. The 1979 pound-net fishery and research hauls with fine meshed trawls will hopefully allow a better judgment of the year class at the end of 1979. Anyway, the recent information seems to confirm last year's judgment of a year-class strength below that of the 1973 year-class but probably above that of the 1976 year-class.

The 1976 year-class did not have the same good environmental condition in its larval stage as the 1977 year-class. Its individuals do now have a size when they could be expected to occur in pound net catches and in research hauls. Danish offshore research hauls at standard stations in Div. 1D and 1E have not shown noteworthy amounts of 2-years old cod, nor do we have information pointing to a high discard rate of such small cod in the pound-net fishery.

The research hauls by the Fed.Rep. of Germany did show occurrence of this year class, but only in the same sample(s) as mentioned above for the 1977 year-class did the 1976 year-class occur as a relatively important one, viz. by 28.7% (by numbers). In the 1977 research hauls the year class was found only in Div 1E. It is thus likely to have a limited distribution, mainly in Div. 1E, and the new data do not lead to a revision of the view that year class is a relatively poor one for Subarea 1 as a whole.

On the basis of the information by the end of 1977 the 1975 year-class was considered a relatively good year class and with its main occurrence in Div. 1B-1D. It has to some extent recruited to the fishery in 1978, and commercial samples seem to confirm its main occurrence in the northern divisions.

The year class occurs in the FRG research hauls in December in Div. 1C-1F, most common in Div. 1D (10.2%), and it is also observed in most Danish research samples. Unfortunately information on discard from the pound-net fishery is rather limited in 1978, but a good part of the individuals of the 1975 year-class would have been discarded if they were caught in this fishery. A pound-net sample from the southern part of Div.1D, inshore in July shows about 30% (by number) of this year class. A length sample from the Godthåb Fiord (Div. 1D) in July is illustrated in Fig.2.

The fish round modal length 63 cm are most certainly of the 1973 year-class, while those round modal length 36 cm are likely to be 3- and 4-years old fish, i.e. year-classes 1975 and 1974, respectively.

The captain of one of the large Greenland trawlers reported that in late March some of the concentrations seen on the echo sounder on the Tovqussaq (Banana) Bank, Div. 1C, consisted of small cod around 25 cm. The trawlers evidently tried to avoid such small fish, but the observation confirms the general impression, that the 1975 year-class will be the main substitute for the 1973 year-class although it is still considered to be less abundant than the latter.

In summary, for the year-classes 1975-77 there is at present no such new information which seems to require a revision of the estimates made last year. The 1978 year-class is tentatively regarded as poor as the 1976 year-class. Consequently, the following estimates of recruitment (thousands of 3-years old fish) have been used in the forecasts:

Number x 10^{-3} at age 3 (beginning of the year)

Year class	1A - 1D	1E - 1F	Subarea 1
1975	50 000	25 000	75 000
1976	10 000	10 000	20 000
1977	25 000	25 000	50 000
1978	10 000	10 000	20 000

7. Values of instantaneous fishing mortality rate (F) for virtual population analyses

On the basis of catch and effort figures it was concluded last year that effective effort ($\sim$F) had decreased from 1976 to 1977 by about 1/3 in the offshore fisheries but probably increased inshore, so that a range of F values of 0.16-0.20 was suggested for 1977 as compared to a value of 0.25 in 1976.

From 1977 to 1978 it has already been stated (Chapter 2, page 1) that data in Tables 3, 4 and 5 would suggest a further decrease in overall effort by about 45% from 1977 to 1978 when catches are considered by numbers instead of by weight. However, bearing in mind that the 1973 year-class made up about 80% of the catch (by number) in both years, so that the age composition of the stock was roughly the same in the two years, it seems reasonable to make the consideration that a drop in catch of about 23% from 24.4 mill fish to 18.7 mill fish (Table 12) is less than would be expected as a function of total mortality in the stock during 1977-78 (Z = 0.36-0.40 corresponds to a decrease of 30-33%). However, it should also be taken into consideration that the 1973 year-class was not fully recruited to the fishery by 1977 and that the further recruitment in 1978 has to some extent compensated the decrease caused by fishing and natural mortality. It occurs, therefore, that fishing mortality may have been of the same scale in 1978 as in 1977, i.e. in the range 0.16-0.20. Figures in Tables 3-5 would then suggest that catchability was considerably (about 80%) higher in 1978 than in 1977.

8. Partial recruitment

A review of all the age samples available for 1978 shows that so to say all 5-years old cod in the samples are above 40 cm long, also in cases where smaller cod are present in the sample. It is, therefore, likely that the 1973 year-class was nearly fully recruited to at least the trawl and the pound-net fisheries in 1978, although probably not to the gill-net and long-line fisheries. Unfortunately the ratio of catch between gears is not known, but considering that trawls and pound nets caught the major part of the catch it may be proper to assume a partial recruitment of 5-year olds of about 90% in 1978 and of 100% for fish of age 6 years or older. For fish of 3 and 4 years the same figures as last year, i.e. 60% and 72%, respectively, are used again.

9. Other parameters for VPA and prognoses

As previously the natural mortality is set at M = 0.20. A coefficient of emigration for Div. 1E-1F cod of age 7 or older has earlier been assumed to have a value of 0.15, and there is no new information to suggest a change in this parameter. For Subarea 1 as a whole the coefficient is again set at a value of 0.05.

Weight-by-age figures for prognoses are found in Table 11.

Recruitment figures for prognoses are given in Chapter 6, page 6. The model further requires an input for recruitment in 1977, i.e. of the year-class 1974. This has initially been set at values corresponding to last years' astimates, i.e. 25 mill.fish in Div. 1A-1D and 15 mill.fish in Div. 1E-1F.

The set of F values used in the VPA for the years 1965-76 is as previously. i.e.

	1965	1966	1967	1968	1969	1970-75	1976	1977-78
Subarea 1	0.46	0.54	0.62	0.80	0.55	0.35	0.25	see
Div.1A-1D	0.45	0.52	0.68	1.00	0.59	0.35	0.25	Table 14
Div.1E-1F	0.49	0.61	0.55	0.50	0.50	0.35	0.25	

10. Results and discussion

i) The virtual population analyses (VPA)

Having seen the results of the first VPA-runs (with input values as given in the preceding chapters) several more runs were made as background material for the discussion. For all runs the numbers caught of each age group was in accordance with the figures given in Table 12, but values of M, F, and emigration coefficient were varied, Table 14 lists the inputs for the various runs. Some were made for Subarea 1 as a whole as well as for Div. 1A-1D and 1E-1F separately. Since the present situation in the stock and fisheries indicates that the offshore fishing is limited to the area from the southern part of Div. 1C and southwards only runs for Subarea 1 as a whole will be illustrated and discussed.

Runs Sub 1-1 and Sub 1-2 (given as Tables 15-18) are, in fact, similar to the runs presented last year except for the updating by one year. One would, therefore, hope to find similar results for years prior to 1977 as

were found last year. There is a reasonable good correspondence so far as stock in numbers in the various years is concerned except for the years 1974-75, where the present runs lead to figures ¼-½ below those found last year. Also for 1976 the present runs indicate a stock about 25% below that found by last year's analyses. So far as the important 1973 year-class is concerned the present analyses are in very good agreement with those of last year, pointing to the year class as being in the order of 200 mill fish at age 3.

When comparing resultant F-values obtained last year and in the present analyses there is, however, a great discrepancy between the two years for age groups 6 years or older in the years 1975-77. Most noteworthy are the high F-values for age-group 8-13 in 1977 (Tables 15 and 17). However, looking at the numbers caught by age groups in 1977 and 1978 (Table 12) it is clear that such input data must lead to high F-values for older age groups (when M is kept at the same level as for younger age groups). Age groups older than 7 years were evidently fished in relatively much lesser scale than previously. The samples may, of course, be biassed. However, it should also be born in mind that the previous offshore fishery by gill nets and long lines practically vanished by 1978. Thereby the older cod may be relatively less exploited.

The unexpected high fishing mortality occurring for older age groups in previous years in the present analyses would, however, also occur by wrong assumptions of some other input parameters. If, for instance, the emigration of older age groups has been relatively high in 1977-78, as supposed in run Sub 1-4 (Tables 19-20), then the F-values of 1977 will decrease somewhat (compare Table 19 to Table 17). Another consideration could be that if not all catches of cod are actually reported then there is - in terms of the present analyses - a higher natural mortality than assumed. In runs Sub 1-5 and Sub 1-6 such assumptions are made, and also this leads to lower F-values in 1977 than in the initial runs (run Sub 1-6 is found in Tables 21-22. Compare Table 21 with Tables 19 and 17). Anyway, it seems clear from the data for the first part of 1979 (see Chapter 3 and **Appendix 1**), that the 1973 year-class is not as abundant now as initial analyses would suggest. The assumed fishing mortality corresponding to the 1978 catch could be too low (which would lead to too high estimates of the stock and the year class) or there might have been other "mortalities" (emigration and/or non-reported catches such as discards due to regulations prescribing a maximum allowance of cod in fisheries for species other than cod). Whether one or the other (or a combination of) the considerations is proper, the uncertainties also influence the prognoses.

ii) Forecasts

Forecasts of catches, stock size and spawning biomass will, of course, differ between the various assumptions made. The catches in 1978 were higher than expected, but illustrated that Greenland may well catch about 35 000 tons again in 1979. All forecasts made in this paper suppose that this will be the case. A number of strategies are set up as shown in Table 23. Spawning stock is defined as all cod 6 years or older.

Strategy 1 operates with a constant catch level of 35 000 tons annually while strategy 2 operates with a constant F equal to that required to obtain 35 000 tons in 1979. There is practically no difference between these two strategies but both will, of course, like the other strategies, result in higher stock levels by assuming F in 1978 = 0.16 instead of 0.20.

Strategy 4 operates with a higher fishing mortality (F = 0.30) from 1980 and onwards. This will, of course, result in higher catches in 1980 and 1981, but will also lead to a spawning stock by 1983 which is about 40% below that obtained through strategies 1 and 2. Strategy 5 operates with an even higher fishing mortality from 1980 (F = 0.40, estimated to be the $F_{0.1}$-value) and leads to a spawning stock by 1983 about 55% below that in strategies 1 and 2.

Run 7.3 illustrates what would happen if in 1979 and the following years catches were kept at an absolute minimum (allowing for small bycatches). Spawning biomass by 1983 would increase considerably (40% above the one in strategies 1 and 2).

For run A 1.1 the assumption was made that the emigration and/or non reported catches has functioned as if natural mortality was higher (M = 0.35) than assumed in other runs, but (reported) catch level has been maintained at the 35 000 tons as in strategy 1. It will be seen that the assumption of a higher M leads to a significantly lower spawning biomass, by 1982-83 about 50-60% below that occurring by M = 0.20. It does, therefore, seem very important to obtain further information on migration and on discards, to improve the prognoses.

It should be strongly stressed that the 1979 data so far indicate that the 1973 year-class is not likely to achieve the relatively high importance as suggested by the forecast analyses. If the 1973 year-class has been overestimated and/or fished more rapidly than in the model used then the resultant catches and spawning biomasses in Table 23 are significantly overestimated.

11. Cod at East Greenland

Samples by Demnmark(G) and the Fed.Rep. of Germany made it possible to estimate numbers by age in the reported landings from Southeast Greenland (Table 12). The figures for 1977 confirmed that the stock in this area normally contains relatively more older cod than the West Greenland stock. The 1978 samples also have relatively higher frequency of older age groups but nevertheless considerably below that of 1977. There is, therefore, not much support to be found for a theory of an increased emigration of old cod from West to East Greenland waters.

It seems difficult to estimate fishing mortality in this region and no VPA runs have been made. If all fishing is occurring in the Kap Farvel region (as most of the Greenlandic effort) then figures might simply be added to the figures for West Greenland and the area regarded as a unity.

Attention is again drawn to the conclusions based upon the report of the ICES North-Western Working Group, 1976, that a catch for the Greenland

area as a whole would be about 25% greater than that in Subarea 1 for the same levels of F.

The importance of the East Greenland area as a potential spawning area for the West Greenland stock should be born in mind.

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Table 1. Nominal catch (metric tons x 10^{-3}) of cod in Subarea 1 and off East Greenland, 1977. Figures for Greenland (SA 1 24220 tons, East Greenland 1833 tons) taken from STATLANT 21 B as supplied to ICNAF. Figures for other countries from Summ.Doc. 78/VI/28 (15 June 1978) and thereby still provisional figures. Catches listed under gill net may contain some catches taken by otter trawl or long line.

Division	Otter trawl	Set gill net	Long line	Gear Unknown	TOTAL
1A	-	127	-	216	343
1B	3	298	-	580	881
1C	3546	935	-	2505	6986
1D	3066	5013	19	2946	11044
1E	6208	2025	573	3521	12327
1F	1090	-	1091	4231	6412
Total SA 1	13913	8398	1683	13999	37993
East Greenland	4253	0	0	965	5218
Grand total	18166	10081	1683	14964	43211

Table 2. Provisional nominal catch (metric tons x 10^{-3}) of cod in Subarea 1 and off East Greenland, 1978. Figures for Greenland (SA 1 35651 tons, East Greenland 1860 tons) taken from internal reports(final figures for trawlers) while figures for other countries (SA 1 1488 tons, East Greenland 463 tons) taken from radio reports by vessels to the Greenland administrative offices as requested in the management scheme. Figures for Norway (3 tons) supplied as provisional figures for the 1979 Assessment Meeting.

Division	Otte trawl	Set gill net	Long line	Gear unknown	TOTAL
1A	-	-	-	326	326
1B	2	-	-	1319	1321
1C	11804	-	-	2943	14747
1D	2716	-	2	2094	4812
1E	4053	-	1	4078	8132
1F	702	-	-	7099	7801
Total SA 1	19277	-	3	17859	37139
East Greenland	1194	-	30	1129	2353
Grand total	20471	-	33	18988	39492

Table 3. Effort (hours fished), catch of cod and catch per unit effort for the Greenland trawlers in 1976-78. Only figures for direct cod fishing are included for 1977-78 while for 1976 part of the effort may be for groundfish unspecified, especially in the last half of the year.

Division	1976			1977			1978		
	hours	tons	kg/hour	hours	tons	kg/hour	hours	tons	kg/hour
1B	236	9	38	0	0	-	0	0	-
1C	5071	3013	594	2432	2478	1019	3562	11803	3314
1D	5912	3197	541	1531	1510	986	465	1148	3759
1E	6319	4756	753	3446	5459	1584	648[1)]	2684[1)]	4142
1F	0	0	-	121	293	2421	5	13	2600
Total SA 1	17538	10975	626	7530	9740	1293	4680[1)]	15648[1)]	3344
East Greenland	98	109	1020	428	868	2028	386	727	1883

[1)] Figures include 35 hours and 148 tons of cod registered in fisheries for wolffish in May but most likely to be direct cod fishing.

Table 4.

Effort (hours fished) and catch per unit effort by quarter of the year for the Greenland trawlers in 1976-78 and first month of 1979. Only figures for direct cod fishing are included for 1977-78 while for 1976 part of the effort may be ground fish unspecified, especially in the last part of the year.

Division	Year / Quarter	1976 I		1976 II		1976 III		1976 IV	
		hours	kg/hour	hours	kg/hour	hours	kg/hour	hours	kg/hour
1B		-	-	136	22	100	60	-	-
1C		3582	736	610	367	600	25	279	498
1D		1406	575	1713	180	1202	428	1591	984
1E		744	942	2672	631	1091	267	1812	1147
1F		-	-	-	-	-	-	-	-
Total Subarea 1		5732	723	5131	433	2993	276	3682	1027
East Greenland		-	-	96	1031	2	1000	-	-

	1977 I		1977 II		1977 III		1977 IV	
1B	-	-	-	-	-	-	-	-
1C	2258	1066	129	341	-	-	45	600
1D	919	693	566	1498	14	571	32	531
1E	1383	1277	1876	1846	141	1113	46	1565
1F	-	-	33	3364	88	2068	-	-
Total Subarea 1	4560	1055	2604	1715	243	1428	123	943
East Greenland	-	-	-	-	268	2213	160	1719

	1978 I		1978 II		1978 III		1978 IV		1979 January	
1B	-	-	-	-	-	-	-	-	-	-
1C	3030	3225	487	3398	-	-	45	8333	938	2674
1D	261	2877	162	3679	-	-	42	9548	388	4173
1E	260	988	388	6255	-	-	-	-	-	-
1F	-	-	-	-	5	2600	-	-	-	-
Total Subarea 1	3551	3035	1037	4511	5	2600	87	8920	1326	3112
East Greenland	-	-	-	-	359	1975	27	667	-	-

Table 5. Effort (hours fished), catch of cod (by weight as well as by number) and catch per unit effort for the Greenland trawlers, and total effort (trawlers' effort raised to correspond to total catch) for Subarea 1, 1977-78 (see Table 3 for trawlers' effort and Table 12 for number landed).

		Trawlers' effort	Trawlers' catch	Trawlers cpue	Total catch	Total effort (trawlers' effort raised to cover total catch)
Catch in tons	1977	7530	9740	1.293	37993	29372
	1978	4680	15648	3.344	37139	11108
Catch x 10^{-3}	1977	7530	8706	1.156	24454	21151
	1978	4680	7734	1.653	18709	11321

Table 6.

Age distribution and, for age groups representing 1% or more of the samples, mean length and weight of age groups in samples from January and February, 1979 of the Greenland trawlers' landings. Weight has been converted by factor 1.22 from gutted, head-on iced fish to round, fresh weight. + indicates occurrence below 0.5%

		Age frequency %				Mean length (cm)				Mean weight (kg, round fresh)			
Age group	Division Month	1C JAN	1C FEB	1D JAN	1D(research) JAN	1C JAN	1C FEB	1D JAN	1D(res.) JAN	1C JAN	1C FEB	1D JAN	1D(res.) JAN
III		-	-	+	+	-	-	-	-	-	-	-	-
IV		43	25	12	+	48.1	48.6	48.7	-	1.10	1.13	1.16	-
V		44	49	32	26	56.7	58.3	58.0	62.2	1.81	1.94	2.04	2.44
VI		12	22	53	73	67.4	68.7	67.8	67.8	2.92	3.05	3.24	3.10
VII		+	+	1	1	-	-	78.4	74.5	-	-	4.80	4.00
VIII		+	1	2	+	-	86.4	87.5	-	-	6.46	6.81	-
IX-XIII		+	+	+	-	-	-	-	-	-	-	-	-
Overall mean length and weight						54.6	58.9	63.8	66.3	1.68	2.11	2.70	2.93

Table 7. Subarea 1 cod, 1978. Danish samples. Only fish which were aged and weighted are given here and since these were sampled stratified the table does not give the length nor the age frequency. Overall mean lengths and weights are, however, calculated on basis of the total (random) length sample. Information on discard obtained through vessels' logbooks is indicated by x) whereas information obtained through direct observation is indicated by xx). Samples are from offshore areas unless otherwise indicated.

cm = uncorrected mean total length in cm (below) ± standard deviation.

kg = mean weight in kg round, fresh weight ± standard deviation. Most fish from commercial samples were actually weighted as gutted iced fish and were converted to round, fresh weight by a conversion factor of 1.22.

(Table 7 continued on next 4 pages)

Table 7. (Cont'd)

1.

Age group	Div. Month Gear	1C January OTB	1C January comm.	1C February OTB	1C February comm.	1C March OTB	1C March comm.	1C May OTB	1C May comm.	1D April OTB	1D April res.
II	no.	-		-		-		-		-	
	cm										
	kg										
III	no.	-		-		2		-		-	
	cm					40.8	-				
	kg					0.60					
IV	no.	76		76		100		28		16	
	cm	53.0	4.2	53.2	4.1	51.0	4.1	52.7	5.0	46.9	4.8
	kg	1.47	0.30	1.48	0.28	1.27	0.32	1.33	0.34	0.89	0.29
V	no.	187		187		222		258		138	
	cm	66.9	4.9	66.6	5.0	66.1	5.5	60.5	6.1	61.8	6.8
	kg	2.99	0.54	2.95	0.55	2.88	0.72	1.96	0.50	2.15	0.72
VI	no.	23		23		24		5		4	
	cm	68.6	5.3	68.5	5.5	68.7	6.1	65.6	2.5	75.3	5.3
	kg	3.22	0.64	3.20	0.66	3.25	0.92	2.41	0.24	3.59	0.77
VII	no.	38		38		40		2		4	
	cm	78.7	9.1	77.7	9.5	72.7	9.4	79.0	-	76.8	4.3
	kg	5.08	1.30	4.92	1.34	4.00	1.42	4.02	-	3.63	0.46
VIII	no.	16		16		16		1		-	
	cm	87.0	4.9	86.3	6.0	80.2	4.0	95.0	-		
	kg	6.88	0.95	6.64	1.07	5.29	0.72	6.47	-		
IX	no.	1		1		-		-		-	
	cm	92.0	-	92.0	-						
	kg	7.50	-	7.50	-						
X	no.	2		1		3		1		4	
	cm	92.3	-	77.0	-	91.4	20.0	87.0	-	83.0	4.5
	kg	8.10	-	4.59	-	7.49	4.37	4.64	-	4.23	0.98
XI	no.		-		-		-		-	3	
	cm									81.0	9.0
	kg									4.33	1.37
XII	no.		-		-		-		-	2	
	cm									76.5	-
	kg									3.59	-
XIII	no.		-		-		-		-	1	
	cm									91.0	-
	kg									4.50	-
XIV	no.		-		-		-		-	-	
	cm										
	kg										
XV +	no.		-		-		-		-	1	
	cm									109.0	-
	kg									10.0	
Overall mean length		66.6		66.1		62.1		60.2		62.5	
Overall mean weight		3.04		2.95		2.49		1.90		2.27	
Discard, cod		none x)		none x)		none x)		none x)		none (res.)	
No. aged and weighted		343		342		407		295		173	
Ref. no.		2722		2723		2725		2732		5553	

Table 7. (Cont'd)

2.

Age group	Div. Month Gear	1D April OTB	1D April res.	1E April OTB	1E April comm.	1E November OTB	1E November res.	1F/East Greenl August OTB	1F/East Greenl August comm.	1F/East Greenl September OTB	1F/East Greenl September comm.
II	no.	-		-		-		-		-	
	cm										
	kg										
III	no.	5		1		1		-		-	
	cm	38.6	3.4	40.0	-	42.0	-				
	kg	0.50	0.16	0.49	-	0.80	-				
IV	no.	18		17		6		-		-	
	cm	46.4	4.2	52.5	4.2	47.7	7.0				
	kg	0.89	0.27	1.26	0.24	1.11	0.51				
V	no.	43		228		93		315		315	
	cm	54.3	6.8	55.9	5.1	63.2	5.4	58.2	6.0	55.8	5.8
	kg	1.39	0.53	1.58	0.35	2.35	0.68	2.03	0.4	1.82	0.4
VI	no.	-		6		3		10		10	
	cm			62.8	7.2	60.3	12.7	64.0	6.9	62.1	7.6
	kg			2.21	0.63	2.22	1.54	2.59	0.5	2.41	0.6
VII	no.	2		2		-		4		-	
	cm	79.5	7.8	73.5	-			76.5	5.2		
	kg	4.40	1.13	3.54	-			3.81	0.4		
VIII	no.	-		-		-		1			
	cm							80.0	-		
	kg							4.00	-		
IX	no.	-		-		1		-		-	
	cm					95.0	-				
	kg					7.50	-				
X	no.	-		1		1		-		-	
	cm			73.0	-	84.0	-				
	kg			3.23	-	4.60	-				
XI	no.	-		-		-		-		-	
	cm										
	kg										
XII	no.	-		-		-		-		-	
	cm										
	kg										
XIII	no.	-		-		-		-		-	
	cm										
	kg										
XIV	no.	-		-		-		-		-	
	cm										
	kg										
XV +	no.	-		-		-		-		-	
	cm										
	kg										
Overall mean length		51.8		55.8		62.5		58.4		56.0	
Overall mean weight		1.28		1.59		2.35		2.07		1.83	
Discard, cod		none (res.)		none[x)]		none (res.)		none[x)]		none[x)]	
No. aged and weighted		68		255		105		330		325	
Ref. no.		5562		2729		5636		2750		2762	

Table 7. (Cont'd)

3.

Age group	Div. Month Gear	1D August Hand l.	comm.	1D inshore September Hand l.	res.	1D inshore May Pound n.	comm.	1D inshore July Pound n.	comm.	1D inshore August Pound n.	comm.
II	no.	-		-		-		-		-	
	cm										
	kg										
III	no.	10		-		-		-		-	
	cm	40.2	11.8								
	kg	0.73	0.52								
IV	no.	78				51		78		78	
	cm	50.2	3.8	49.9	5.3	45.5	4.1	45.9	4.2	45.5	4.5
	kg	1.18	0.22	1.16	0.32	1.06	0.2	0.89	0.18	1.09	0.17
V	no.	402				127		402		402	
	cm	62.9	5.1	62.6	5.0	51.7	6.8	64.7	6.4	58.8	5.3
	kg	2.31	0.45	2.27	0.41	1.54	0.6	2.53	0.57	1.89	0.42
VI	no.	15				-		15		15	
	cm	68.8	5.3	68.0	7.1			70.7	5.2	71.8	12.5
	kg	2.92	0.56	2.38	0.72			3.19	0.52	3.07	1.88
VII	no.	8				-		9		9	
	cm	66.7	9.3	62.0	-			73.7	14.8	67.8	15.2
	kg	2.29	1.27	1.78	-			3.57	1.44	2.90	1.49
VIII	no.	-		Preceding age/length key and weights used for length sample of 61 specimens		-		-		-	
	cm										
	kg										
IX	no.	2				-		-		-	
	cm	83.0	-								
	kg	4.80	-								
X	no.	-				-		-		-	
	cm										
	kg										
XI	no.	-				-		-		-	
	cm										
	kg										
XII	no.	-				-		-		-	
	cm										
	kg										
XIII	no.	-				-		-		-	
	cm										
	kg										
XIV	no.	-				-		-		-	
	cm										
	kg										
XV +	no.	-				-		-		-	
	cm										
	kg										
Overall mean length		62.8		62.2		49.3		59.7(landing)		55.7	
Overall mean weight		2.31		2.17		1.39		2.35		1.72	
Discard, cod		none[xx)]		none (res.)		25% by no.[xx)]		44% by no.[xx)]		4% by no.[xx)]	
No. aged and weighted		515		61		178		504		504	
Ref. no.		2746, 2754		2760		5570		2745		2747	

Table 7. (Cont'd)

4.

Age group	Div. Month Gear	1E inshore September Pound n.	comm.	1D inshore May Gill net	comm.	1D inshore June Gill net	comm.		
II	no.	-		-		-			
	cm								
	kg								
III	no.	-		4		6			
	cm			41.8	0.9	40.0	2.4		
	kg			0.81	0.03	0.81	0.11		
IV	no.	54		57		58			
	cm	44.0	2.7	47.4	6.3	45.9	4.5		
	kg	0.92	0.1	1.25	0.42	1.10	0.28		
V	no.	218		127		127			
	cm	56.5	5.1	59.7	4.8	56.6	7.5		
	kg	1.81	0.4	2.23	0.47	1.97	0.72		
VI	no.	2		2		2			
	cm	56.7	9.8	72.0	-	63.2	5.1		
	kg	1.91	0.9	3.96	-	2.58	0.56		
VII	no.	1		4		4			
	cm	65.0	-	62.6	7.4	73.1	3.3		
	kg	2.62	-	2.73	1.44	not weighted			
VIII	no.	-		2		2			
	cm			71.0	-	70.8	5.2		
	kg			3.90	-	not weighted			
IX	no.	-		-		-			
	cm								
	kg								
X	no.	-		-		-			
	cm								
	kg								
XI	no.	-		-		-			
	cm								
	kg								
XII	no.	-		-		-			
	cm								
	kg								
XIII	no.	-		-		-			
	cm								
	kg								
XIV	no.	-		-		-			
	cm								
	kg								
XV +	no.	-		-		-			
	cm								
	kg								
Overall mean length		55.7		58.2		53.4			
Overall mean weight		1.75		2.13		-			
Discard, cod		less than 20% by no. x)		1-2% by no. xx)		3% by no. xx)			
No. aged and weighted		215		196		199			
Ref. no.		2758, 2759		5567		5577, 5578			

Table 8. Overall mean length and weight of samples from Fed.Rep.of Germany fisheries and research in 1978. All catches taken by bottom otter trawl. Research hauls 30 mm codend mesh size, commercial 130 mm.

Division	Month	Type of fishing and sample	Mean length cm	Mean weight kg
1C	FEB/MAR	commercial,catch	61.2	2.14
1C	DEC	research, catch	65.4	2.83
1D	MAR	commercial,catch	62.4	2.14
1D	DEC	research, catch	60.5	2.45
1E	MAR	commercial,catch	60.3	2.14
1E	DEC	research, catch	47.3	1.43
1F	JAN	commercial,landing	54.4	1.24
1F	DEC	research, catch	60.0	1.87
East Greenl.	JAN	commercial,landing	54.4	1.33
" "	FEB	" "	69.7	2.64
" "	MAY	" "	62.2	1.96
" "	JUN	" "	62.1	1.80
" "	JUL	" "	82.9	3.58
" "	AUG	" "	69.9	2.26

Table 9. Subarea 1 cod, 1978. Mean weight (kg round, fresh) by age as obtained from samples as listed in Table 6. Inshore 1977 unweighted mean.

	Age group	Unweighted mean by quarter 1	2	3	4	Weighted mean 1978	Weighted mean 1977
Offshore	III	(0.60)	0.49	0.73	(0.80)	0.59	0.66
	IV	1.41	1.09	1.18	1.11	1.29	1.03
	V	2.94	1.77	2.05	2.35	2.54	1.43
	VI	3.22	2.74	2.64	(2.22)	2.98	1.87
	VII	4.67	3.90	3.05	-	4.40	3.39
	VIII	6.27	(6.47)	(4.00)	-	6.29	-
Inshore	III	no samples	-	0.73	no samples	0.73	0.86
	IV		1.06	1.05		1.06	1.55
	V		1.54	2.16		1.99	2.14
	VI		-	2.69		2.69	2.49
	VII		-	2.63		2.63	4.44
	VIII		-	-		-	-

Table 10.

Nominal catch of Subarea 1 cod in 1978 by quarter of the year.

	Quarter	1	2	3	4	Total specified catch in % of total nominal catch.
offshore	Tons	10782	5093	293	1624	92.3
	%	60.6	28.6	1.6	9.1	
inshore	Tons	230	4213	11269	2145	100
	%	1.3	23.6	63.1	12.0	

Table 11.

Weight (kg round, fresh) used in the forecast for catches in 1979-80. For age groups older than 7 years recent material is very limited, and for these age groups mean weights from previous years' assessment are used.

Age group	Basic weight data				Figures used in forecast assuming 60% offshore, 40% inshore fishing.
	1 Offshore 1978 (Table 9)	2 Offshore Jan-Feb. 1979 (Table 6)	3 Mean of 1 and 2	4 Inshore 1978 (Table 9)	
III	0.59	-	0.59	0.73	0.65
IV	1.29	1.13	1.21	1.06	1.15
V	2.54	2.06	2.30	1.99	2.18
VI	2.98	3.08	3.03	2.69	2.89
VII	4.40	4.40	4.40	2.63	3.69
VIII	4.58				
IX	5.06				
X	5.60				
XI	6.00	as in previous years' assessment.			
XII	6.60				
XII	7.70				
XIV	9.00				
XV	10.50				

Table 12. Number of cod (in thousands) per age group in nominal catches 1977 and provisional figures for 1978.

Age group	1977				1978			
	Div. 1A-1D	1E-1F	Subarea 1	SE Greenl.	1A-1D	1E-1F	Subarea 1	SE Greenl.
III	225	39	264	1	214	2	216	-
IV	8850	9873	18723	1407	1810	799	2609	6
V	1265	1433	2698	344	6709	8381	15090	1064
VI	678	546	1224	157	388	81	469	67
VII	287	210	497	200	214	33	247	9
VIII	247	151	398	65	47	1	48	7
IX	229	148	377	132	13	1	14	4
X	75	44	119	53	11	2	13	8
XI	40	23	63	25	1	-	1	3
XII	45	24	69	9	1	-	1	2
XIII	13	9	22	3	1	-	1	2
XIV	-	-	-	-	-	-	-	1
XV+	-	-	-	-	-	-	-	1
Total	11954	12500	24454	2397	9409	9300	18709	1114
Nominal catch (tons)	19254	18739	37993	5218	21206	15933	37139	2353
Calculated mean weight (kg)	1.61	1.50	1.55	2.18	2.25	1.71	1.99	2.00

Table 13.

Maturity stages of cod caught offshore in Div. 1C-1E between 21 March and 25 April, 1978. Stage I immatures, II maturing but not yet ready to spawn, III just before spawning or spawning, IV post-spawners. Figures are number of fish analyzed.

Length group cm	Males				Females			
	I	II	III	IV	I	II	III	IV
33-35	2	-	-	-	-	-	-	-
36-38	1	-	-	-	-	-	-	-
39-41	3	1	-	-	7	-	-	-
42-44	11	1	-	-	8	-	-	-
45-47	13	2	-	-	16	-	-	-
48-50	11	7	-	2	17	1	-	-
51-53	13	10	1	2	12	4	-	-
54-56	3	11	1	-	20	4	-	-
57-59	3	9	-	4	10	4	-	-
60-62	2	5	2	8	12	2	-	1
63-65	4	5	2	3	17	-	-	-
66-68	1	10	1	8	16	2	-	1
69-71	-	1	1	8	13	2	-	-
72-74	-	4	1	3	5	2	-	-
75-77	-	1	-	3	-	2	-	4
78-80	-	1	-	2	-	-	-	-
81-83	1	2	-	1	2	1	-	1
84-86	-	-	1	-	-	-	-	-
87-89	-	1	-	-	-	-	-	-
90-92	-	-	-	2	-	-	-	-
108-110	-	-	-	1	-	-	-	-
Total nos.	68	71	10	47	155	24	0	7
% (by sex)	34.7	36.2	5.1	24.0	83.3	12.9	0	3.8

Table 14.

Input values of M and F for the various VPA- runs available at the 1979 March-April Meeting of the ICNAF Subcommittee on Assessments. Values of M include emigration coefficient. In the notation N indicates that the run was made for Div. 1A-1D, S stands for Div. 1E-1F, and Sub.1 for Subarea 1 as a whole. F-values for years prior to 1977 are found in the text, page 10.

Reference notation of the run	Sub 1 - 1		Sub 1 - 2		Sub 1 - 3		Sub 1 - 4		Sub 1 - 5		Sub 1 - 6	
Age-group	M	F	M	F	M	F	M	F	M	F	M	F
3	.20	.096	.20	.120	.20	.18	.20	.12	.30	.12	.32	.12
4	.20	.115	.20	.144	.20	.22	.20	.144	.30	.144	.34	.144
5	.20	.144	.20	.180	.20	.27	.20	.18	.30	.18	.38	.18
6	.20	.16	.20	.20	.20	.30	.30	.20	.30	.20	.40	.20
7+	.25	.16	.25	.20	.25	.30	.50	.20	.35	.20	.45	.20
F for oldest age-group in 1977		.16		.20		.30		.20		.20		.20

cont.

Refernce notation	N-1		N-2		S-1		S-2	
Age group	M	F	M	F	M	F	M	F
3	.20	.096	.20	.12	.20	.096	.20	.12
4	.20	.115	.20	.144	.20	.115	.20	.144
5	.20	.144	.20	.18	.20	.144	.20	.18
6	.20	.16	.20	.20	.30	.16	.20	.20
7+	.20	.16	.20	.20	.35	.16	.35	.20
F for oldest age-group in 1977		.16		.20		.16		.20

FISHING MORTALITIES

age	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	0.081	0.008	0.028	0.056	0.012	0.002	0.004	0.001	0.014	0.025	0.019
4	0.182	0.059	0.100	0.177	0.261	0.064	0.106	0.197	0.273	0.149	0.384
5	0.336	0.308	0.338	0.370	0.298	0.361	0.350	0.741	0.564	0.502	0.657
6	0.397	0.463	0.574	0.651	0.525	0.378	0.644	0.913	0.546	0.499	0.914
7	0.553	0.506	0.600	0.775	0.823	0.579	0.620	0.685	0.521	0.411	1.117
8	0.455	0.642	0.488	0.563	0.774	0.673	1.058	0.767	0.573	0.926	1.519
9	0.633	0.404	0.628	0.721	0.623	0.419	0.878	1.201	1.180	0.827	1.104
10	0.455	0.718	0.659	0.631	0.520	0.354	0.574	0.784	0.972	0.639	0.915
11	0.631	0.461	0.463	0.766	0.390	0.295	0.520	0.722	0.521	1.123	0.686
12	0.527	0.361	0.285	0.512	0.589	0.249	0.262	1.034	0.415	1.573	0.855
13	0.193	0.610	1.204	0.185	0.210	0.350	0.245	1.001	0.370	1.361	0.353
14	0.086	0.699	0.687	1.408	0.569	0.220	0.444	0.506	0.991	2.110	0.184
15	0.460	0.540	0.620	0.800	0.550	0.350	0.350	0.350	0.350	0.350	0.350
Mean	0.474	0.478	0.583	0.692	0.637	0.499	0.741	0.864	0.606	0.590	1.104

age	1976	1977	1978
3	0.055	0.009	0.096
4	0.406	0.128	0.115
5	0.440	0.526	0.144
6	0.724	0.459	0.160
7	0.378	0.778	0.160
8	1.261	1.433	0.160
9	0.629	1.448	0.160
10	0.968	2.646	0.160
11	0.436	2.079	0.160
12	0.525	2.158	0.160
13	1.457	1.247	0.160
14	1.731	0.294	0.160
15	0.250	0.160	0.160
Mean	0.855	0.789	0.160

Table 15. Subarea 1 cod: fishing mortalities from VPA run Sub 1-1.

STOCK IN NUMBERS

age	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	200023	215764	67945	76580	60871	33860	75728	12961	10645	15487	16455
4	376800	150988	175271	54070	59302	49239	27678	61755	10598	8597	12370
5	261604	257226	116515	129890	37085	37400	37616	20390	41522	6607	6066
6	30270	117943	154763	68035	73423	22534	21334	21826	7961	19338	3274
7	26023	16657	60759	71367	29049	35547	12646	9170	7172	3774	9617
8	47141	11660	7820	25965	25614	9932	15520	5297	3600	3317	1948
9	6776	23290	4777	3738	11517	9196	3946	4198	1916	1580	1024
10	1735	2802	12105	1986	1415	4812	4710	1277	984	458	539
11	1163	857	1064	4880	623	655	2629	2066	454	290	188
12	5216	482	421	522	1766	434	380	1218	782	210	73
13	480	2399	262	246	243	763	264	226	337	402	34
14	506	308	1015	61	160	154	419	161	65	182	80
15	426	361	119	596	12	70	96	209	75	19	17
sum1	898162	800739	602836	437738	301279	204597	203166	140756	86112	60262	51686
sum2	119736	176759	243105	177198	144021	84097	61944	45650	23347	29571	16794

age	1976	1977	1978
3	221797	32594	2599
4	13224	171881	26447
5	6901	7214	123847
6	2575	3639	3490
7	1076	1022	1882
8	2451	574	366
9	332	541	107
10	264	138	99
11	168	76	8
12	74	85	8
13	24	34	8
14	19	4	8
15	52	3	3
sum1	248957	217807	158871
sum2	7035	6118	5977

Table 16. Subarea 1 cod: stock size in numbers from VPA run Sub 1-1.

sum1 : sum of stock age 3 to 15
sum2 : sum of stock age 6 to 15

Run identification: SUB1-1

ISHING MORTALITIES

age	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	0.081	0.008	0.028	0.056	0.012	0.002	0.004	0.001	0.014	0.026	0.020
4	0.182	0.059	0.100	0.177	0.261	0.064	0.106	0.197	0.274	0.152	0.409
5	0.336	0.308	0.336	0.370	0.298	0.361	0.350	0.741	0.565	0.507	0.678
6	0.397	0.463	0.574	0.651	0.525	0.378	0.645	0.913	0.547	0.500	0.932
7	0.553	0.506	0.600	0.775	0.823	0.579	0.621	0.686	0.522	0.412	1.126
8	0.455	0.642	0.488	0.563	0.774	0.673	1.058	0.768	0.574	0.928	1.526
9	0.633	0.404	0.628	0.721	0.623	0.419	0.878	1.202	1.186	0.830	1.110
10	0.455	0.718	0.659	0.631	0.520	0.354	0.574	0.785	0.974	0.647	0.924
11	0.631	0.461	0.463	0.766	0.390	0.295	0.520	0.722	0.522	1.129	0.703
12	0.527	0.361	0.285	0.512	0.589	0.249	0.262	1.034	0.415	1.585	0.868
13	0.193	0.610	1.204	0.185	0.210	0.350	0.245	1.001	0.370	1.361	0.360
14	0.086	0.699	0.687	1.408	0.569	0.220	0.444	0.506	0.991	2.110	0.184
15	0.460	0.540	0.620	0.800	0.550	0.350	0.350	0.350	0.350	0.350	0.350
Mean	0.474	0.478	0.583	0.692	0.637	0.499	0.742	0.865	0.607	0.592	1.115

age	1976	1977	1978
3	0.065	0.011	0.120
4	0.446	0.155	0.144
5	0.486	0.614	0.180
6	0.771	0.539	0.200
7	0.393	0.893	0.200
8	1.294	1.590	0.200
9	0.636	1.606	0.200
10	0.984	2.834	0.200
11	0.444	2.257	0.200
12	0.549	2.338	0.200
13	1.530	1.394	0.200
14	1.838	0.328	0.200
15	0.250	0.200	0.200
Mean	0.891	0.913	0.200

Table 17. Subarea 1 cod: fishing mortalities from VAP run Sub 1-2.

STOCK IN NUMBERS

age	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	200616	215758	67925	76564	60858	33849	65631	12884	10445	14705	15269
4	376800	150983	175266	54053	59288	49229	27669	61676	10535	8434	11729
5	201604	257226	116510	129886	37071	37389	37607	20382	41457	6555	5933
6	30270	117943	154763	68032	73420	22525	21325	21818	7955	19285	3231
7	26023	16657	60759	71367	29046	35544	12637	9163	7166	3769	9573
8	47141	11660	7620	25965	25614	9930	15518	5290	3594	3313	1945
9	6776	23290	4777	3736	11517	9196	3944	4196	1911	1576	1020
10	1735	2802	12105	1986	1415	4812	4710	1276	985	454	535
11	1163	857	1064	4680	823	655	2629	2066	453	289	185
12	5216	482	421	522	1766	434	380	1218	782	209	73
13	480	2399	262	246	243	765	264	228	337	402	33
14	506	308	1015	61	160	154	419	161	65	182	80
15	426	361	119	398	12	70	96	209	75	19	17
sum1	898156	800727	602807	437698	301232	204548	203029	140567	85759	59191	49625
sum2	119736	176754	243105	177195	144015	84081	61922	45625	23322	29498	16694

age	1976	1977	1978
3	187354	26445	2103
4	12253	143683	21413
5	6378	6422	100768
6	2466	3212	2845
7	1042	934	1534
8	2418	547	298
9	329	516	87
10	262	136	81
11	165	76	6
12	71	83	6
13	24	32	6
14	18	4	6
15	52	2	2
sum1	212832	182092	129156
sum2	6848	5543	4872

Table 18. Subarea 1 cod: stock size in numbers from VPA run Sub 1-2.

sum1 : sum of stock age 3 to 15
sum2 : sum of stock age 6 to 15

Run identification: SUB1-2

FISHING MORTALITIES

age	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	0.067	0.006	0.022	0.047	0.010	0.001	0.004	0.001	0.013	0.024	0.020
4	0.140	0.048	0.081	0.135	0.212	0.054	0.091	0.174	0.244	0.139	0.379
5	0.226	0.224	0.262	0.285	0.214	0.275	0.285	0.597	0.475	0.430	0.593
6	0.225	0.283	0.383	0.468	0.378	0.257	0.448	0.678	0.398	0.399	0.723
7	0.306	0.279	0.351	0.483	0.561	0.422	0.427	0.456	0.374	0.311	0.910
8	0.250	0.349	0.277	0.332	0.459	0.464	0.815	0.554	0.398	0.716	1.233
9	0.352	0.237	0.325	0.407	0.372	0.248	0.616	0.919	0.843	0.607	0.886
10	0.220	0.378	0.402	0.308	0.284	0.223	0.360	0.549	0.732	0.443	0.691
11	0.421	0.226	0.233	0.455	0.186	0.172	0.363	0.459	0.388	0.839	0.505
12	0.348	0.264	0.148	0.261	0.337	0.129	0.177	0.754	0.275	1.193	0.633
13	0.127	0.432	0.961	0.111	0.115	0.210	0.147	0.734	0.285	0.878	0.265
14	0.058	0.521	0.527	1.108	0.387	0.142	0.296	0.340	0.711	1.681	0.112
15	0.460	0.540	0.620	0.800	0.550	0.350	0.350	0.350	0.350	0.350	0.350
Mean	0.266	0.285	0.370	0.447	0.426	0.341	0.525	0.619	0.433	0.460	0.888

age	1976	1977	1978
3	0.065	0.011	0.120
4	0.437	0.155	0.144
5	0.432	0.593	0.180
6	0.633	0.473	0.200
7	0.307	0.748	0.200
8	1.083	1.382	0.200
9	0.532	1.397	0.200
10	0.828	2.566	0.200
11	0.361	2.011	0.200
12	0.430	2.088	0.200
13	1.025	1.201	0.200
14	1.366	0.198	0.200
15	0.250	0.200	0.200
Mean	0.726	0.792	0.200

Table 19. Subarea 1 cod: fishing mortalitites from VPA run Sub 1-4.

STOCK IN NUMBERS

age	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	242581	264238	86728	91323	71742	38904	84554	14262	11343	15633	15517
4	478261	185829	214958	69447	71371	58140	31808	68982	11664	9169	12490
5	284963	340262	145039	162379	49670	47273	45103	23770	47435	7478	6534
6	51659	186105	222668	91354	99976	32827	29404	27781	10708	24158	3984
7	47140	30549	103862	112425	42398	50766	18811	13911	10445	5330	12006
8	87413	21065	14022	44336	42053	14671	20194	7443	5350	4358	2369
9	12015	41275	9012	6447	19285	16119	5597	5420	2593	2179	1291
10	3615	5123	19759	3948	2603	8066	7633	1834	1312	677	720
11	1772	1760	2129	8014	1761	1188	3915	3232	642	383	264
12	8151	705	852	1023	3085	887	607	1651	1239	264	100
13	797	3492	329	445	478	1336	473	308	471	571	49
14	831	426	1375	76	242	258	657	248	90	215	144
15	576	476	154	492	15	100	136	296	107	27	24
sum1	1219777	1081307	820886	591712	404679	270529	248691	169139	103400	70445	55494
sum2	213971	290977	374161	268563	211695	126212	87426	62124	32957	38162	20952

age	1976	1977	1978
3	187354	26445	2103
4	12456	143683	21413
5	6999	6587	100768
6	2955	3718	2980
7	1433	1163	1717
8	2932	639	334
9	419	602	97
10	323	149	90
11	219	86	7
12	97	92	7
13	32	38	7
14	23	7	7
15	78	4	4
sum1	215319	183214	129534
sum2	8511	6499	5250

sum1 : sum of stock age 3 to 15
sum2 : sum of stock age 6 to 15

Table 20. Subarea 1 cod: stock sizes in numbers from VPA run Sub 1-4.

Run identification: SUB1-4

FISHING MORTALITIES

age	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	0.046	0.004	0.016	0.034	0.007	0.001	0.003	0.001	0.009	0.018	0.015
4	0.112	0.037	0.063	0.107	0.169	0.042	0.073	0.138	0.196	0.111	0.303
5	0.209	0.204	0.235	0.255	0.193	0.248	0.254	0.540	0.421	0.384	0.529
6	0.244	0.301	0.401	0.479	0.385	0.265	0.462	0.689	0.403	0.397	0.726
7	0.355	0.322	0.398	0.542	0.613	0.452	0.465	0.499	0.402	0.330	0.952
8	0.288	0.406	0.317	0.375	0.519	0.505	0.864	0.597	0.432	0.757	1.290
9	0.407	0.268	0.381	0.465	0.417	0.279	0.667	0.976	0.911	0.650	0.929
10	0.259	0.439	0.452	0.363	0.325	0.247	0.400	0.595	0.780	0.481	0.735
11	0.460	0.264	0.271	0.512	0.218	0.193	0.393	0.508	0.414	0.897	0.542
12	0.380	0.282	0.170	0.300	0.379	0.148	0.193	0.806	0.301	1.269	0.679
13	0.138	0.464	1.008	0.125	0.129	0.233	0.162	0.783	0.301	0.960	0.282
14	0.063	0.551	0.555	1.161	0.416	0.154	0.319	0.367	0.758	1.756	0.122
15	0.460	0.540	0.620	0.800	0.550	0.350	0.350	0.350	0.350	0.350	0.350
Mean	0.301	0.311	0.400	0.487	0.453	0.365	0.555	0.652	0.457	0.467	0.921

age	1976	1977	1978
3	0.051	0.010	0.120
4	0.359	0.134	0.144
5	0.378	0.530	0.180
6	0.627	0.460	0.200
7	0.323	0.776	0.200
8	1.124	1.422	0.200
9	0.552	1.437	0.200
10	0.658	2.618	0.200
11	0.377	2.059	0.200
12	0.452	2.137	0.200
13	1.113	1.238	0.200
14	1.445	0.216	0.200
15	0.250	0.200	0.200
Mean	0.743	0.782	0.200

Table 21. Subarea 1 cod: fishing mortalities from VPA run Sub 1-6.

STOCK IN NUMBERS

age	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	364408	401966	129645	133131	109709	57806	125936	20920	16805	22573	21790
4	631826	252612	290590	92677	93482	79103	41935	91218	15178	12092	16101
5	332268	402068	173199	194185	59288	56177	53982	27737	56530	8881	7704
6	50256	184393	224215	93593	102894	33430	29982	28622	11059	25373	4138
7	40583	26382	91441	100657	38862	46943	17196	12662	9628	4953	11439
8	75525	18148	12194	39142	37335	13428	19042	6889	4901	4107	2271
9	10432	56097	7707	5663	17146	14165	5169	5116	2417	2030	1228
10	3048	4430	17598	3356	2268	7203	6830	1692	1229	620	676
11	1616	1500	1820	7143	1489	1045	3588	2919	595	359	244
12	7400	651	734	885	2730	763	549	1544	1120	251	93
13	719	3226	313	395	418	1191	420	289	440	528	45
14	756	399	1294	73	226	234	602	228	84	208	129
15	546	453	147	473	15	94	128	279	101	25	23
sum1	1519382	1332325	950898	671374	465858	311582	305361	200114	120089	82001	65879
sum2	190881	275679	357463	251380	203379	118495	83508	60239	31575	38454	20285

age	1976	1977	1978
3	254690	31783	2225
4	15589	175825	22855
5	8467	7750	109486
6	3104	3968	3118
7	1342	1112	1680
8	2816	619	326
9	398	583	95
10	309	146	88
11	207	84	7
12	91	90	7
13	30	37	7
14	22	6	7
15	73	3	3
sum1	287137	222006	139904
sum2	8391	6649	5338

sum1 : sum of stock age 3 to 15
sum2 : sum of stock age 6 to 15

Table 22. Subarea 1 cod: stock sizes in numbers from VPA run Sub 1-6.

Run identification: SUB1-6

Table 23. Predicted catches and spawning biomass (at the beginning of the year) by various fishing strategies and by various assumptions of F in 1978. Catches and biomass given in thousands of tons. Run A 1.1 based on an M-value of 0.35, the other runs on a value of 0.20. Figures in brackets show the percentage which the 1973 year-class makes up of the catches and biomass in the analyses.

Strategy (Ref.no. for computer out-prints)			1	2	4	5	7.3 for F_{78}=0.16 / A 1.1 for F_{78}=0.20
F in 1978 = 0.16	1979	F	0.11	0.11	0.11	0.11	0.01
		catch	35 (69)	35 (69)	35 (69)	35 (69)	3 (69)
		sp. stock	271 (94)	271 (94)	271 (94)	271 (94)	271 (94)
	1980	F	0.10	0.11	0.30	0.40	0.01
		catch	35 (57)	39 (57)	97 (57)	124 (57)	4 (58)
		sp.stock	298 (80)	298 (80)	298 (80)	298 (80)	329 (80)
	1981	F	0.10	0.11	0.30	0.40	0.01
		catch	35 (49)	39 (49)	81 (48)	95 (48)	4 (51)
		sp.stock	354 (59)	349 (59)	291 (58)	264 (58)	423 (59)
	1982	F	0.10	0.11	0.30	0.40	0.01
		sp.stock	321 (51)	313 (50)	217 (50)	179 (50)	417 (51)
	1983	sp.stock	325 (39)	314 (39)	186 (37)	141 (36)	450 (41)
F in 1978 = 0.20	1979	F	0.13	0.13	0.13	0.13	0.164
		catch	35 (65)	35 (65)	35 (65)	35 (65)	35 (67)
		sp.stock	212 (94)	212 (94)	212 (94)	212 (94)	196 (94)
	1980	F	0.12	0.13	0.30	0.40	0.173
		catch	35 (52)	39 (52)	82 (51)	104 (51)	35 (53)
		sp.stock	236 (77)	236 (77)	236 (77)	236(77)	175 (80)
	1981	F	0.12	0.13	0.30	0.40	0.205
		catch	35 (44)	39 (44)	70 (43)	82 (42)	35 (43)
		sp.stock	290 (54)	286 (54)	244 (54)	221 (53)	175 (56)
	1982	F	0.12	0.13	0.30	0.40	0.25
		sp.stock	264 (45)	256 (45)	186 (45)	153 (44)	127 (47)
	1983	sp.stock	274 (33)	262 (33)	166 (32)	126 (31)	110 (31)

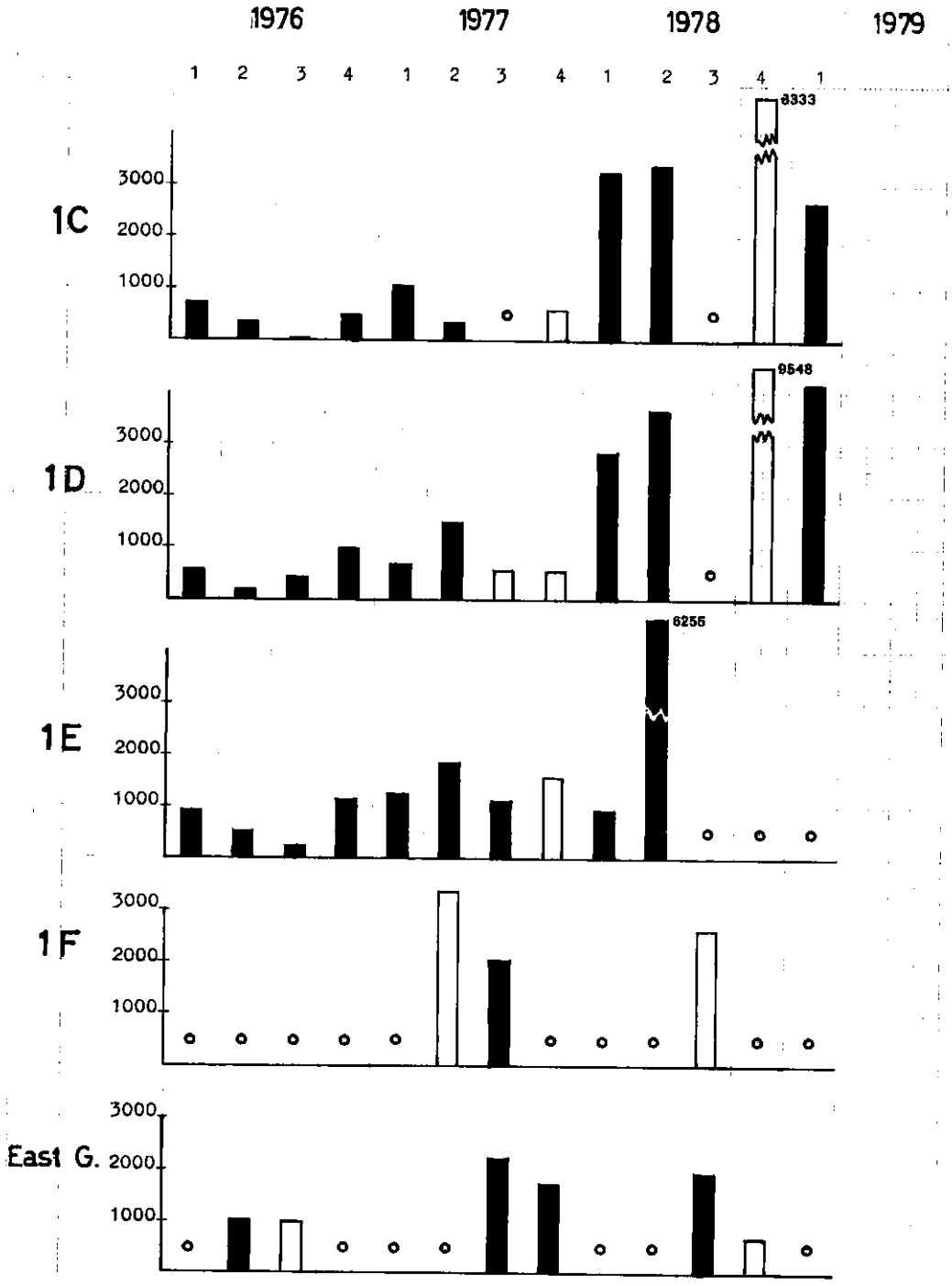

Fig. 1. Greenland trawlers' catch of cod per unit effort (kg/hr) by division and quarter of the year (see Table 4). Open columns based on less than 50 hours trawling. Small circles indicate nil effort.

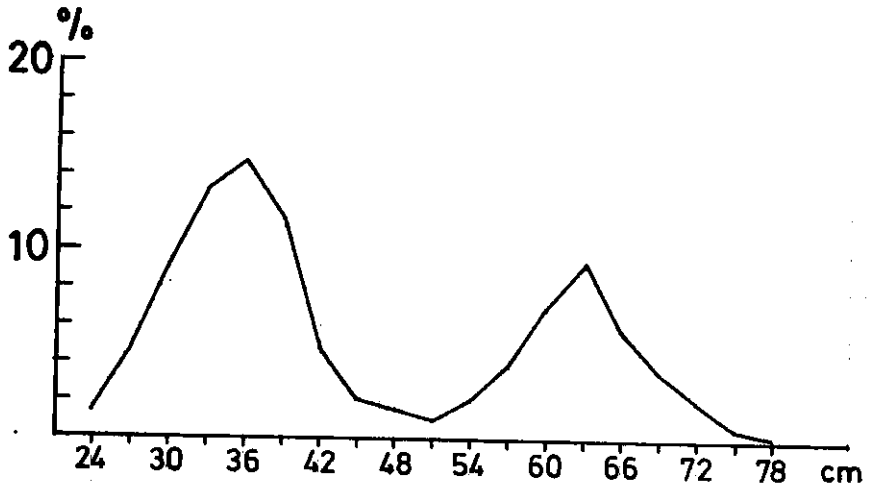

Figure 2. Length-frequency diagram of cod caught by pound net in the Godthåb Fiord (Div. 1D), July 1978. A total of 2075 cod was measured.

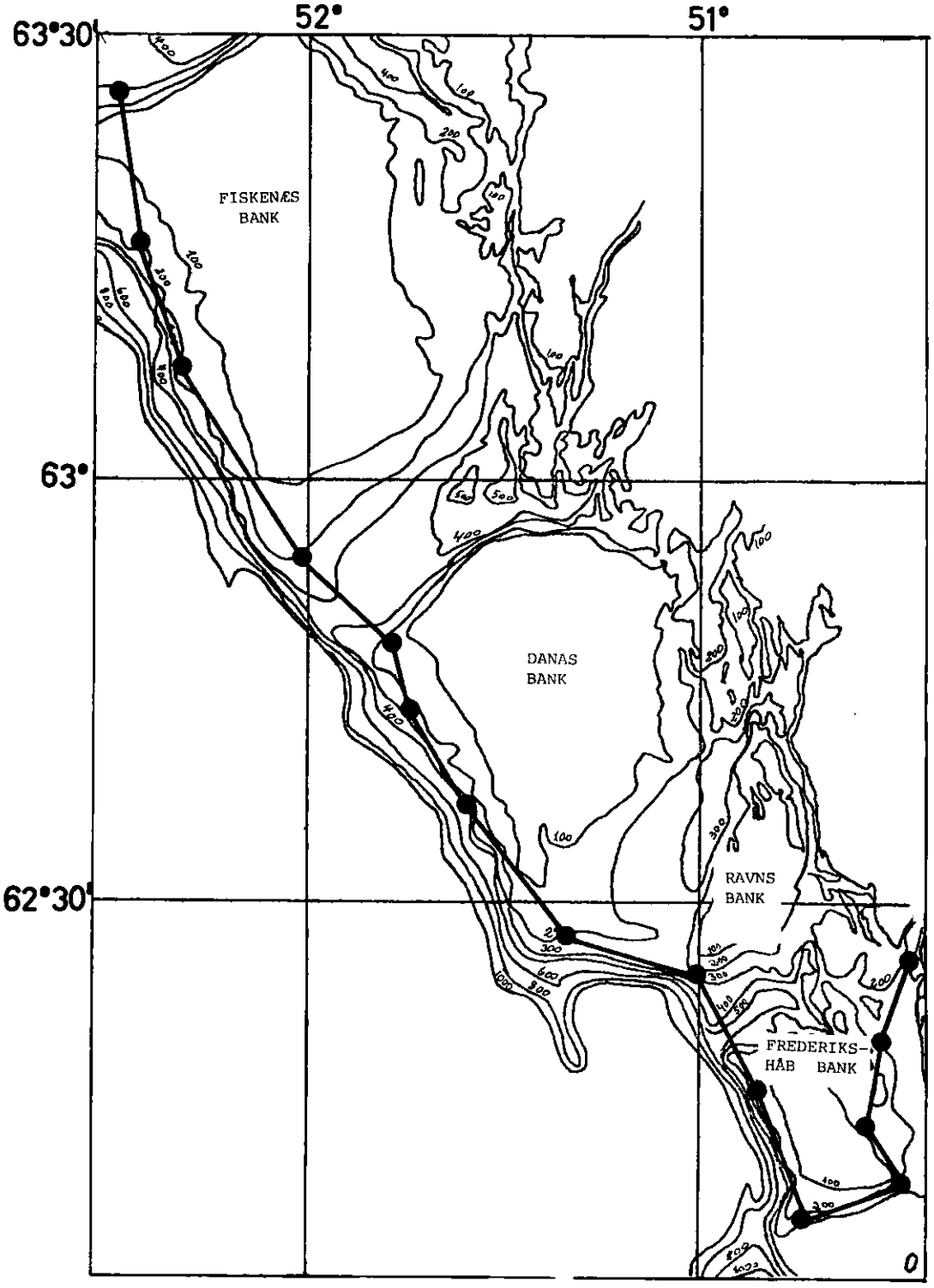

Fig. 3. Acoustic survey by *RV Adolf Jensen*, 29-30 January 1979. Black dots are reference positions. Only at the zig-zag lines west of Ravns Bank and northeast of Frederikshaab Bank were shoals of fish seen.

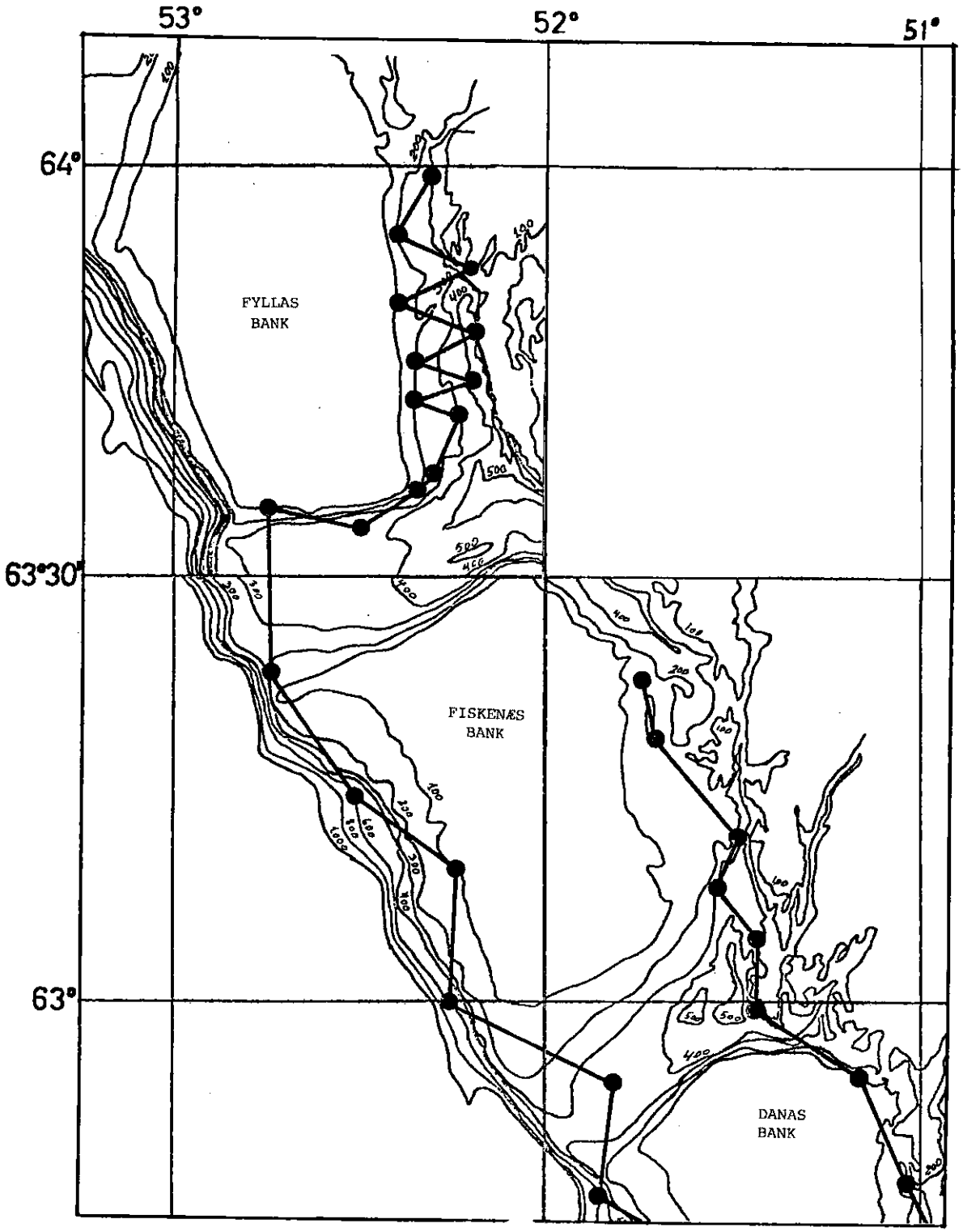

Fig. 4. Acoustic survey by *RV Adolf Jensen*, 20-23 February 1979. Black dots are reference positions. The remainder of the survey is shown in Fig. 5.

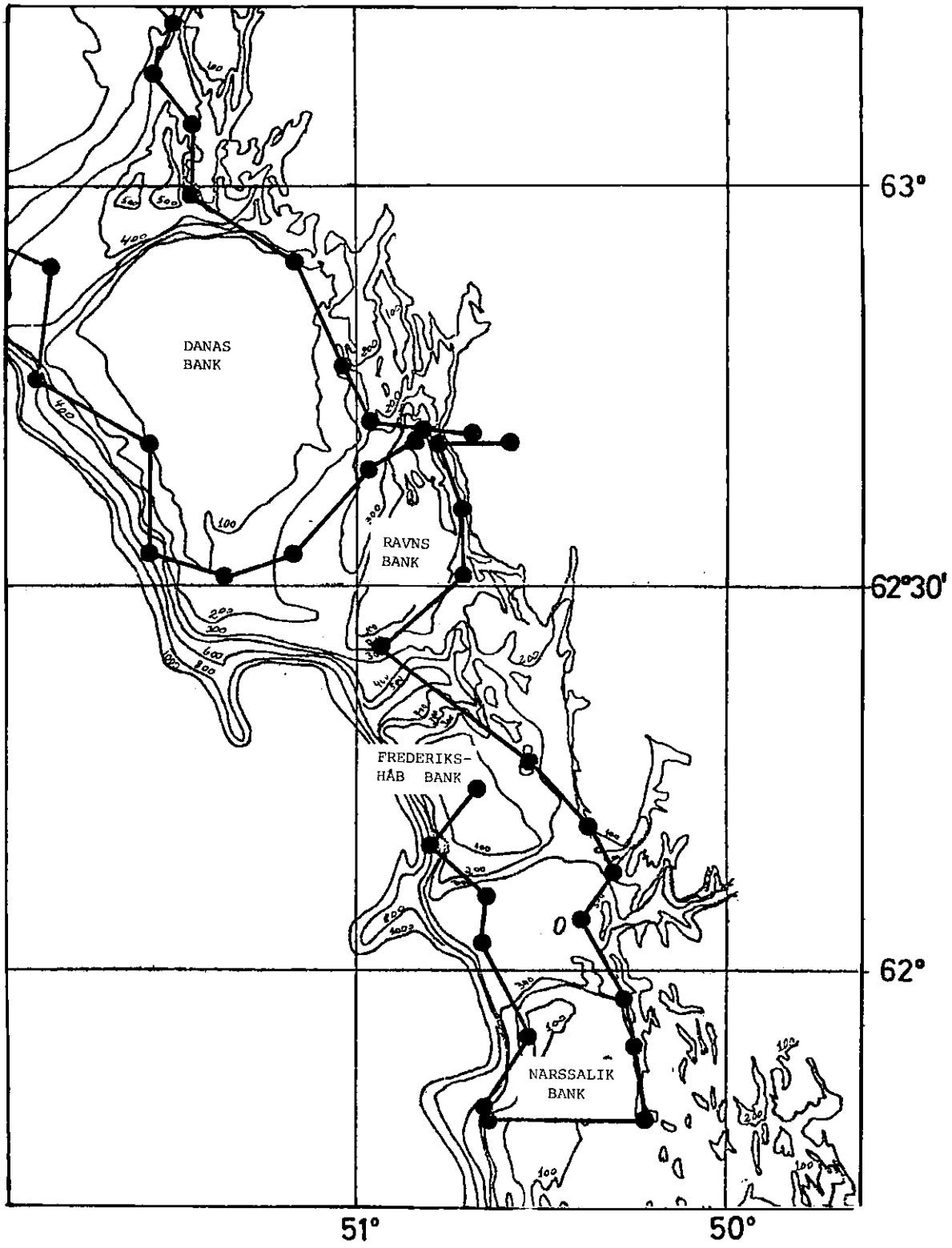

Fig. 5. Acoustic survey by *RV Adolf Jensen*, 20-23 February 1979. Black dots are reference positions. The other part of the survey is shown in Fig. 4.

APPENDIX 1

Additional Information for February-March 1979

After the main paper and the tables had been produced two more samples of the commercial landings by Greenland trawlers in February and in March, 1979, were received. One of the samples was worked up with otoliths from other samples from January-February (the same as those used for sample in Table 6 of the main paper). Time did not permit this for the second sample.

The age distribution of the February sample is shown in App. Table 1, while the length distribution of both the February and the March samples is given in App. Table 2.

It will be seen that age-group 4, the 1975 year-class, is now the predominating one accounting for close to half the landing (by number). The relative importance of the 1973 year-class has decreased to about 20% by number and about 35% by weight (applying weight figures from App. Table 1). Although this latter figure is still inside the range found in the forecasts made last year, it is at the low end of the range and below that expected from the analyses.

The fishery is at the same time reporting decreasing catch rate (verbal information) so unless catch rate improves again and the 1973 year-class again becomes the predominating one (which may happen closer to the spawning time) the catches of 1979 would seem to be dominated by small cod of the 1974 and 1975 year-classes. Catches by gill net and long line, if any, would be supposed to consist mainly of individuals of the 1973 year-class.

Appendix, Table 1. Age distribution and mean length and weight of age groups in a sample of a commercial landing from ICNAF Div. 1 C, 23-28 February ,1979. Gear is bottom otter trawl, 130 mm cod-end mesh size.

Age-group	Age frequency %	Mean length cm	Mean weight kg, round, fresh
III	+	33.0	0.43
IV	47	47.0	1.02
V	32	56.0	1.82
VI	20	67.4	3.05
VII	+	76.7	4.40
VIII	1	87.2	6.65
IX-XIII	+	-	-
Overall mean length and weight		54.5	1.75

Appendix, Table 2. Length frequency ($^{o}/_{oo}$) of samples of landings by Greenland commercial trawlers, February and March, 1979, ICNAF Div. 1C and 1D. Gear is bottom otter trawl as for Table 1. The age distribution in the sample from February is given in App. Table 1. Otoliths for the March sample not yet read at the time when the paper was produced.

3cm length group	Div. 1C + 1D 23-28 Feb.	Div.1C 7-12 March
39-41	20	4
42-	96	49
45-	154	147
48-	172	171
51-	124	135
54-	89	92
57-	77	95
60-	70	97
63-	52	64
66-	34	38
69-	44	42
72-	23	18
75-	20	23
78-	8	13
81-	5	3
84-	3	3
87-	2	-
90-	2	3
93-	1	2
96-	2	-
99-	1	3
Total nos.measured.	1548	1180
Total landing sampled	99 tOns	66 tons

APPENDIX 2

Further Analysis at the April 1979 Meeting of the Assessments Subcommittee

Having discussed the status and recruitment prospects for Subarea 1 cod based upon Res. Doc. 79/VI/59, the ICNAF Assessments Subcommittee felt that some further analyses should be carried out based upon the likely trend in the fishery (also occurring in other cod stocks considered at the April 1979 Meeting of the Subcommittee) towards a higher concentration on effort with increasing fishing mortality on newly-recruited age-groups, and with a decreasing effort on older age-groups.

The analyses presented here are based upon estimates of the 1979 catch composition as evidenced by catches and sampling in January-March 1979, and on estimates on fishing mortality created by effort concentrating on newly-recruited year-classes assuming that offshore fishing by gillnet and longline will be negligible in 1979-82. The following two sets of assumptions were made.

Assumption A. The 1979 catch will be about 36,000 tons. Catch composition by age-groups and estimates of F for 1979:

Age	3	4	5	6	7	8	9	10	11	12-15+
Nos. x 10^{-3}	200	9000	6000	4000	200	20	20	10	5	1 each
F	0.05	0.30	0.30	0.30	0.15	0.10	0.05	0.03	0.02	0.01

Assumption B. The 1979 catch will be of the same order as in Assumption A (the inputs of F and stock composition resulted in 39,000 tons). Catch composition and estimates of F as follows:

Age	3	4	5	6	7	8	9	10	11	12-15+
Nos. x 10^{-3}	200	5000	3000	9000	200	20	20	10	5	1 each
F	0.05	0.20	0.30	0.30	0.15	0.10	0.05	0.03	0.02	0.01

The actual 1979 situation is very likely to be in between the two sets of assumptions, possibly closer to assumption A than to B. For both sets of assumptions, it was further regarded that the relatively high exploitation of younger age-groups is likely to result in a relatively higher degree of discard of especially age-group 3. Consequently, the natural mortality rate for this age-group has been raised from 0.20 to 0.30 in the present analyses.

The resultant population numbers by age and fishing mortalities are presented in Tables 1 and 2 for assumptions A and B, respectively.

It will be seen that the results are much more reasonable than those in the first runs of Res. Doc. 79/VI/59. For example, the extremely high fishing mortalities for old age-groups in recent years resulting from the former assumptions are now at a level much closer to that assumed by trends in effort. Furthermore, the relative strength of year-classes is in good agreement with that judged by direct observations. The 1973 year-class seems to be in the range of 100-145 million fish at age 3, the 1974 year-class 25-46 million, as compared to the initial estimate of 40 million. The size of the 1975 year-class in the analyses is extremely dependent upon the rather arbitrary choice of F for age-group 4 in 1979. By the chosen F values the year-class turns out with figures of 41-51 million fish. This is, however, estimated to be too low a figure, and in the projections for 1980-83 the figure has been increased to the initial estimate of 75 million fish at age 3.

Projections of catch and spawning biomass have been made under the same two sets of assumptions as mentioned above. Clearly, for the immediate future (1980), there is a rather great difference between the results for the two sets of assumptions. Assumption A implies that the important year-class 1973 was initially about 100 million fish at age 3 and that it has been fished relatively more than by

assumption B, where the initial size was about 145 million fish. Consequently, the residuals by 1980 of this year-class is rather much higher by assumption B than by assumption A (38 and 17 million fish, respectively, by the beginning of 1980). The projections are presented in Table 3. Strategy 1 assumes that the 1979 estimated catch level be maintained through 1980-82. Strategy 2 operates at the $F_{0.1}$ level from 1980. Stragegy 3 illustrates the changes in catch and spawning biomass occurring if the 1980 catch is kept very low (at the by-catch-only level), but thereafter raised to a level corresponding to F by 1979 (0.30 for most exploited age-groups). Strategy 4 illustrates the development by a catch level corresponding to half the present level.

It will be seen from the analyses that the 1973 year-class is the major one in the spawning stock by 1979 (74-87% by weight). It will decrease rapidly thereafter and, by 1983, it is expected to make up no more than 14-28% of the spawning biomass. The degree to which the following year-classes will be exploited is highly decisive for the resultant spawning stock.

The figures for spawning stock can, of course, not be very accurate. They do, however, demonstrate the relation between the various strategies in terms of the rate by which the spawning stock will change. The potential of the 1973 year-class was not utilized very much to rebuild the spawning stock, but some possibilities seem to exist in the following 1974 and especially 1975 year-class. It will, however, require a lower exploitation of these year-classes than that faced by the 1973 year-class if the spawning stock is going to be rebuilt.

The absolute figures for spawning stock do, as mentioned, vary by the various assumptions made. However, the level of spawning stock was no doubt extremely low in 1976-78. Table 4 illustrates, for the same two sets of assumptions and same mean weight of age-groups as by 1979, the relative changes in spawning stock in the years 1971-78 in relation to the one estimated by the beginning of 1971. It is pointed out that the overall level for this period is much below that in the 1950-60's.

Acknowledgement

Dr W. G. Doubleday (Canada) kindly undertook the computer work of the analyses for this addendum.

Table 1. Population (nos. x 10^{-3}) and fishing mortality (F) by assumption A.

	POPULATION NUMBERS								3/ 4/79
	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	86315	16129	12780	14010	16264	102048	46101	51711	4741
4	28791	63710	11935	9355	10083	11812	66338	33925	38122
5	39100	21293	43077	7689	6683	5003	6028	37372	25415
6	22421	22809	8579	20449	4138	3049	2066	2494	16943
7	13680	9958	7798	4250	10465	1757	1396	584	1618
8	16026	6033	4153	3774	2308	2983	1101	649	237
9	4045	4399	2448	1994	1346	573	916	507	463
10	5068	1318	1079	845	847	502	324	381	382
11	2741	2322	475	353	487	403	260	147	285
12	435	1294	967	225	119	305	267	147	114
13	416	270	382	544	41	59	214	147	114
14	747	279	96	215	183	24	31	147	114
15	213	464	167	42	38	132	6	23	114
	220000	150276	93936	63745	53002	128649	125049	128234	88661

Table 1. (Cont'd)

FISHING MORTALITY 3/ 4/79

	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	0.004	0.001	0.012	0.029	0.020	0.131	0.007	0.005	0.050
4	0.102	0.191	0.240	0.136	0.501	0.473	0.374	0.089	0.300
5	0.339	0.709	0.545	0.420	0.585	0.684	0.682	0.591	0.300
6	0.612	0.873	0.502	0.470	0.657	0.581	1.063	0.233	0.300
7	0.569	0.624	0.476	0.360	1.005	0.217	0.516	0.652	0.150
8	1.043	0.652	0.484	0.781	1.144	0.930	0.527	0.088	0.100
9	0.872	1.156	0.814	0.606	0.737	0.321	0.628	0.032	0.050
10	0.530	0.769	0.867	0.301	0.493	0.407	0.539	0.039	0.030
11	0.501	0.627	0.500	0.840	0.218	0.161	0.321	0.008	0.020
12	0.227	0.970	0.326	1.456	0.451	0.106	0.347	0.008	0.010
13	0.149	0.789	0.323	0.837	0.288	0.396	0.124	0.008	0.010
14	0.227	0.263	0.577	1.485	0.077	1.095	0.037	0.008	0.010
15	**0.350**	**0.350**	**0.350**	**0.350**	**0.350**	**0.250**	**0.200**	**0.050**	0.010

Table 2. Population (nos. x 10^{-3}) and fishing mortality (F) by assumption B.

POPULATION NUMBERS 3/ 4/79

	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	86315	16129	12780	14010	16264	144698	25150	41195	4741
4	28791	63710	11935	9355	10083	11812	97933	18404	30332
5	39100	21293	43077	7689	6683	5003	6028	63240	12707
6	22421	22809	8579	20449	4138	3049	2066	2494	38122
7	13680	9958	7798	4250	10465	1757	1396	584	1618
8	16026	6033	4153	3774	2308	2983	1101	649	237
9	4045	4399	2448	1994	1346	573	916	507	463
10	5068	1318	1079	845	847	502	324	381	382
11	2741	2322	475	353	487	403	260	147	285
12	435	1294	967	225	119	305	267	147	114
13	416	270	382	544	41	59	214	147	114
14	747	279	96	215	183	24	31	147	114
15	213	464	167	42	38	132	6	23	114
	220000	150276	93936	63745	53002	171299	135693	128066	89343

FISHING MORTALITY 3/ 4/79

	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	0.004	0.001	0.012	0.029	0.020	0.090	0.012	0.006	0.050
4	0.102	0.191	0.240	0.136	0.501	0.473	0.237	0.170	0.200
5	0.339	0.709	0.545	0.420	0.585	0.684	0.682	0.306	0.300
6	0.612	0.873	0.502	0.470	0.657	0.581	1.063	0.233	0.300
7	0.569	0.624	0.476	0.360	1.005	0.217	0.516	0.652	0.150
8	1.043	0.652	0.484	0.781	1.144	0.930	0.527	0.088	0.100
9	0.872	1.156	0.814	0.606	0.737	0.321	0.628	0.032	0.050
10	0.530	0.769	0.867	0.301	0.493	0.407	0.539	0.039	0.030
11	0.501	0.627	0.500	0.840	0.218	0.161	0.321	0.008	0.020
12	0.227	0.970	0.326	1.456	0.451	0.106	0.347	0.008	0.010
13	0.149	0.789	0.323	0.837	0.288	0.396	0.124	0.008	0.010
14	0.227	0.263	0.577	1.485	0.077	1.095	0.037	0.008	0.010
15	**0.350**	**0.350**	**0.350**	**0.350**	**0.350**	**0.250**	**0.200**	**0.050**	0.010

Table 3. Subarea 1 cod: projected catch and spawning biomass (Nos. x 10^{-3}) by various fishing strategies and estimates (A and B) of the 1979 catch and stock composition. Figures in brackets show the percentage which the 1973 year-class makes up of the catch and spawning biomass. For assumptions see text.

			Strategy No.			
			1	2	3	4
A	1979	Spawning biomass	66 (74)	66 (74)	66 (74)	66 (74)
		F	0.30	0.30	0.30	0.11
		Catch	36 (32)	36 (32)	36 (32)	15 (32)
	1980	Spawning biomass	96 (40)	96 (40)	96 (40)	113 (40)
		F	0.27	0.40	0.05	0.09
		Catch	35 (12)	49 (12)	7 (12)	15 (12)
	1981	Spawning biomass	145 (22)	131 (23)	174 (21)	194 (22)
		F	0.28	0.40	0.30	0.09
		Catch	35 (7)	43 (8)	43 (7)	15 (7)
	1982	Spawning biomass	133 (19)	110 (21)	158 (18)	202 (17)
		F	0.36	0.40	0.30	0.11
		Catch	35 (4)	34 (4)	33 (4)	15 (4)
	1983	Spawning biomass	144 (14)	126 (14)	169 (13)	238 (13)
B	1979	Spawning biomass	127 (87)	127 (87)	127 (87)	127 (87)
		F	0.30	0.30	0.30	0.10
		Catch	39 (66)	39 (66)	39 (66)	15 (66)
	1980	Spawning biomass	121 (71)	121 (71)	121 (71)	145 (72)
		F	0.25	0.40	0.05	0.09
		Catch	35 (26)	53 (26)	8 (25)	15 (27)
	1981	Spawning biomass	176 (41)	158 (43)	205 (39)	227 (42)
		F	0.26	0.40	0.30	0.09
		Catch	35 (15)	46 (16)	46 (15)	15 (16)
	1982	Spawning biomass	159 (36)	130 (39)	181 (35)	228 (35)
		F	0.34	0.40	0.30	0.10
		Catch	35 (8)	35 (8)	34 (8)	15 (8)
	1983	Spawning biomass	169 (28)	136 (30)	190 (27)	262 (26)

Table 4. Spawning biomass (age 6+ in tons x 10^{-3}) in relation to that by 1971 and by two sets of assumptions for the 1979 situation.

Assumption	1971	1972	1973	1974	1975	1976	1977	1978	1979
A	100	71	39	44	29	15	10	8	25
B	100	71	39	44	29	15	10	8	47