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SPECIAL MEETING OF SCIENTIFIC COUNCIL - FEBRUARY 1981

Provisional Report of Scientific Council

Dartmouth, Canada, 17-20 February 1981

CONTENTS

PROVISIONAL REPORT OF SCIENTIFIC COUNCIL

Special Meeting, February 1981

Chairman: R. H. Letaconnoux Rapporteur: V. M. Hodder

The Scientific Council met at NAFO Headquarters, Dartmouth, Canada, during 17-20 February 1981 to provide advice for 1981 on the conservation of the cod stocks in Div. 3M and 3NO and the capelin stocks in Subareas 2 and 3, for which management measures had been deferred from the 1980 Annual Meeting (*NAFO Sci. Coun. Rep.* 1979-80, pages 70 and 117). Representatives attended from Canada, European Economic Community (EEC) and Union of Soviet Socialist Republics (USSR), and an observer attended from Spain.

The stock assessments were undertaken by the Standing Committee on Fishery Science (STACFIS), whose report as approved by the Council is given in Appendix I. The agenda is given in Appendix II, the participants are listed in Appendix III and the research and summary documents are listed in Appendix IV. Brief summaries of the assessments and other matters considered by the Council are given below.

I. STOCK ASSESSMENTS (APP. I)

1. Fishery Trends

For the stocks considered at this meeting of the Council, the nominal catches and total allowable catches (TACs) since 1973 were as follows:

Species	Stock area		TACs and Catches (000 tons) 1973	1974	1975	1976	1977	1978	1979	1980[1]
Cod	3M	TAC	-	40	40	40	25	40	40	13
		Catch	23	25	22	22	27	33	30	10
	3NO	TAC	103	101	88	43	30	15	25	26
		Catch	80	73	44	24	18	15	28	19
Capelin	2+3K	TAC	-	110[2]	160[2]	160[2]	212[2]	212	75	5
		Catch	136	127	199	216	152	55	12	6
	3LNO	TAC	-	148[3]	180[3]	180[3]	200[3]	200	10	16
		Catch	132	158	166	144	74	30	12	14

[1] Catches for 1980 are provisional.
[2] Countries without specific allocations could each take up to 10,000 tons.
[3] Countries without specific allocations could each take up to 5,000 tons.

2. Cod in Division 3M

The provisional nominal catch in 1980 was 10,000 tons from a TAC of 13,000 tons. Except in 1977 when the TAC was reduced, the catches have been less than the TACs since their introduction in 1974. Commercial catch rates in 1979 continued at the low level of recent years. USSR research vessel survey data for 1978-80 indicated a decline in biomass from 75,000 tons in 1978 to 48,400 tons in 1980. A similar decline was observed in data from Canadian research vessel surveys during the same period.

A non-equilibrium general production model, utilizing catch and effort data for 1960-79, indicated a yield at 2/3 F_{MSY} of 1,000 tons in 1981 and an equilibrium maximum sustainable yield of 29,000 tons.

Cohort analyses, with fishing mortality in 1980 derived from Canadian survey data, indicated that the mean biomass (age 3+) had declined from a high of 92,000 tons in 1976 to 41,000 tons in 1980. The biomass is projected to increase slightly to 46,000 tons in 1981, and a catch of 5,000 tons is projected for 1981 with fishing mortality at $F_{0.1} = 0.20$. The Council emphasizes that the projected catch for 1981 is well below the equilibrium maximum sustainable yield (29,000 tons) and that a gain in yield per recruit could be achieved by reducing fishing mortality in 1981, because the stock is now dominated by young fish whose growth potential is substantial up to ages 6 and 7. Such a reduction in fishing mortality below the $F_{0.1}$ level in 1981 would also increase the rate of recovery of this depleted cod stock.

3. Cod in Divisions 3N and 3O

The provisional nominal catch in 1980 was 19,000 tons from a TAC of 25,000 tons. Catches have declined from a high of 227,000 tons in 1967 to a low of 15,000 tons in 1978. Catch rates have declined greatly from the mid-1960's to 1978, with some slight improvement in 1979 and 1980.

A non-equilibrium general production model, utilizing catch and effort data for 1959-80, indicated an equilibrium maximum sustainable yield of about 125,000 tons and a yield at 2/3 F_{MSY} of 22,000 tons in 1981. A symmetrical general production model fitted to two series of catch-effort data (1960's and 1970's) showed maximum but different yields at the same level of effort. The difference in the two curves was hypothesized to have resulted from reduced recruitment in the 1970's because of some undefined ecological change affecting the survival of cod larvae in Div. 3NO. An alternative explanation of reduced recruitment during the 1970's is that heavy fishing on the stock in the late 1960's and early 1970's substantially reduced the stock, thereby causing the fishery to concentrate on fish of smaller size with possible enhanced discarding of undersized fish. Data were not available to distinguish between the two hypotheses.

Correlations between commercial catch rates and biomass estimates from preliminary cohort analyses indicated a fishing mortality of 0.25 in 1980. Recruitment of age 3 cod in 1980 was estimated from research vessel survey data to be about 60 million fish, about 50% more than the mean recruitment level for the 1971-79 period. The results of the final cohort analysis indicated that the mean biomass (age 3+) had declined from a level of 335,000 tons during 1966-70 to 72,000 tons in 1976-80. The mean biomass is projected to be 132,000 tons in 1981, and an optimal yield of 15,000 tons is projected for 1981 with fishing mortality at $F_{0.1} = 0.18$. The Council emphasizes that the stock is in a depleted state, consisting mainly of young fish, and that low fishing mortality in the next few years would provide a gain in yield per recruit. The Council therefore advises that a cautious approach to the exploitation of cod in Div. 3NO should be maintained.

The Council noted the reservation of USSR scientists who felt that the increase in biomass levels estimated from USSR surveys in 1978 to 1980 justified an increase in catch in 1981 to 30,000 tons.

4. Capelin in Subareas 2 and 3

a) Fishery trends

Nominal catches of capelin in Subareas 2 and 3 increased from 2,800 tons in 1971 to 366,000 tons in 1975 and then declined to 24,000 tons in 1979. Provisional data for 1980 indicate a further decline to 20,000 tons. Commercial catch and effort data for Subarea 2 and Div. 3K indicate a decline from 6.47 tons per hour in 1975 to 1.34 tons per hour in 1979. Catch rates for the special experimental fishery in 1980 by USSR vessels showed an increase to 4.57 tons per hour, but this was considered to be biased upwards and not indicative of stock status due to the seasonal and spatial distribution of fishing activity.

b) Subarea 2 and Division 3K

Acoustic surveys by Canada and USSR in the autumn of 1980 indicated very low levels of abundance. Since the near-shore areas were not surveyed, the resultant biomass estimate is considered to be an under-estimate, but the degree of under-estimation cannot be quantified. The age composition of catches from the USSR experimental fishery indicated that the 1976 and 1977 year-classes predominated, whereas the 1977 and 1978 year-class were dominant in the Canadian survey. A sequential capelin abundance model (SCAM) calibrated with 1972-79 commercial catch rates indicate that the biomass of age 2+ capelin was highest in 1975 and declined to about 10% of that level in 1978 and 1979, with some increase estimated for 1980. This increase in 1980 was largely the result of the recruitment of the 1978 year-class which was estimated by SCAM to be the third largest in the time series of data. The Council noted, however, that evidence from the two acoustic surveys conducted in 1980 did not support the observation that the 1978 year-class was as large as calculated from the model. Nevertheless, using the results of the SCAM model and assuming that the 1979 year-class at age 2 is equal to the geometric mean of the 1970-78 year-classes, projections to 1981 indicate that the total biomass (age 2+) of this stock will be lower than estimates for all years from 1972-77. In addition, the biomass of mature capelin, although higher than in 1980, will be relatively low in 1981. In view of the conflicting evidence available and the uncertainty about the size of the 1978 year-class which comprises a large proportion of the projected biomass in 1981, the Council advises the continued closure of the autumn fishery for capelin in Div. 2J+3K in 1981 or a small nominal TAC. A small fishery of 10,000-15,000 tons in 1981 would provide scientists with comparable data to those collected previously and would allow them to better assess the status of the stock in 1981 and to quantify their advice for 1982.

c) Capelin in Divisions 3L, 3N and 3O

Acoustic surveys by Canada and USSR in 1980 indicate that this stock is substantially below historical levels of abundance. Although juvenile capelin of the 1979 year-class were found over a large area, the surveys indicated very low abundance of mature fish in Div. 3NO, particularly in the spawning area of the Southeast Shoal. A sequential capelin abundance model (SCAM), using both inshore and offshore catch data, provided biomass estimates (age 3+) for Div. 3L in the 1967-80 period. The age structure of the population in 1980 was derived from correlations between year-class strength of capelin in Div. 2J+3K and Div. 3L. The results indicated a decline in biomass from over 500,000 tons in 1976 to 170,000 and 160,000 tons in 1979 and 1980 respective-

ly. The biomass is projected to increase to 300,000 tons in 1981, but this value depends largely on the strength of the 1978 year-class which was derived from the estimate of the size of that year-class in Div. 2J+3K. Therefore, taking into account these uncertainties, the Council advises that an exploitation rate of 10% should be maintained for 1981, implying a TAC of 30,000 tons of capelin for Div. 3L. The Council noted the continued depressed state of the spawning stock in Div. 3NO and advises that there should be no fishery for capelin in these divisions in 1981, in order to allow a further increase in the spawning stock in Div. 3N and to protect this stock during its migration through Div. 3O to Div. 3N.

5. Biological Studies

Information presented on changes in capelin abundance in relation to variations in cod growth and the success of the inshore cod fishery indicated no significant relationship between the growth rate of cod and capelin abundance, but positive correlations were found between inshore catches (both poundnet and all gears) and abundance indices for mature capelin. However, because of the short time series of historical data and some uncertainty about the data, it was concluded that the present analysis does not constitute an adequate test of the postulated dependency of cod on capelin. Likewise, the estimates of the quantity of capelin (1.2-4.4 million tons) that might be consumed by cod in 1981, were considered to be uncertain due to data limitations.

6. Future Research Requirements

The Council endorsed the recommendations for future research listed in the Report of STACFIS (Appendix I), concerning the need for intensified research on cod-capelin interaction, for expanded pre-recruit capelin surveys, and for better coordination of capelin acoustic surveys such that maximum areal coverage be achieved.

II. OTHER MATTERS

1. Agenda and Timetable for the June 1981 Meeting

The Council reviewed a tentative timetable and agenda for its June 1981 Meeting and requested the Secretariat to circulate the information as soon as possible. It was noted that a special session on squid biology and distribution would be held during 3-6 June 1981, followed by meetings of the Scientific Council and its Standing Committees (STACFIS, STACREC and STACPUB) during 8-20 June 1981.

2. Assessment of Redfish Stocks at Greenland

The Council was informed of the positive reaction of ICES (International Council for the Exploration of the Sea) regarding the proposal for cooperation between NAFO and ICES on assessment of the redfish stocks at West and East Greenland. It was noted that ICES had invited the Council to participate in a meeting of the ICES Working Group on redfish in the East Greenland area during 11-19 March 1981 when the interaction of the redfish stocks at East and West Greenland will be assessed. Dr W. D. McKone and Mr W. R. Bowering were nominated to participate on behalf of the Scientific Council.

III. ADJOURNMENT

The Chairman expressed his appreciation for the excellent meeting facilities provided for the meeting. He thanked the Chairman of STACFIS, Dr G. H. Winters, and all participants for their interest and cooperation in dealing with the assessment matters, and the Secretariat staff for their efficiency in servicing the meeting. The meeting adjourned at 1930 hours on 20 February 1981.

APPENDIX I. REPORT OF STANDING COMMITTEE ON FISHERY SCIENCE (STACRES)

Chairman: G. H. Winters Rapporteurs: Various

The Committee met at NAFO Headquarters, Dartmouth, Canada, during 17-20 February 1981 to assess the status of the cod stocks in Divisions 3M and 3NO and the capelin stocks in Subareas 2 and 3, as requested by the Scientific Council (see Appendix II). Advice on conservation measures for these stocks in 1981 was deferred from the June 1980 Meeting of the Council (*NAFO Sci. Coun. Rep.* 1979-80, pages 70 and 117). Instead of appointing a single rapporteur to record the results of the discussions, the Chairman designated scientists to prepare draft summaries of the various topics for approval and incorporation into the STACFIS report. Scientists attended from Canada, European Economic Community (EEC), Spain, and Union of Soviet Socialist Republics (USSR).

I. STOCK ASSESSMENTS

1. Cod in Division 3M (SCR Doc. 81/II/6, 9, 12, 13, 15)

a) Fishery trends

Nominal catches from this stock were as high as 60,000 tons in 1965 and 58,000 tons in 1972. Total allowable catches (TACs) have been in effect since 1974, but actual catches have generally been less than the TACs. Recent TACs, catches and catch rates were as follows:

	1974	1975	1976	1977	1978	1979	1980
TAC (000 tons)	40	40	40	25	40	40	13
Catch (000 tons)	25	22	22	27	33	30	10[1]
Tons/hour	1.16	0.90	0.73	0.68	0.45	0.50	...

[1] Preliminary data.

b) General production model

The Committee reviewed a series of standardized catch rates for the 1960-79 period, derived from all available catch and effort data for otter trawlers of tonnage class 6 of Portugal and tonnage class 7 of USSR in January, February and October (SCR Doc. 81/II/12). The standardized catch rate declined from 2.0 tons per hour fished in 1969 to 0.78 tons per hour in 1973. There was some improvement in 1974 and 1975 followed by a steady decline to a low level of 0.45-0.50 tons per hour in 1978 and 1979. Data are presently insufficient to estimate a standardized catch rate for 1980. It was noted that the catch rates for the 1960-72 period were at a level distinctly higher than those for 1973-79. A discussion of the interpretation of this phenomenon is given below in the section on cod in Div. 3NO.

A non-equilibrium multiplicative model, based on the standardized catch rates for 1960-79, indicated a yield in 1981 at 2/3 F_{MSY} effort of about 1,000 tons. The equilibrium maximum sustainable yield of about 29,000 tons was estimated from the model.

c) Estimates of stock biomass from research vessel surveys

From the distribution of catches by USSR research vessels at standard fixed stations in the area, and with the application of an experimentally derived catchability coefficient (6.2%), estimates of biomass in 1978-80 were 75,000, 67,200 and 48,200 tons respectively. From the Canadian surveys in the same period, the catch rate (number per 30-minute tow) declined substantially from 1978 to 1979 and either remained stable (from arithmetic means) or continued to decline (from logarithmic means) in 1980.

The Committee noted a discrepancy in the age compositions of catches from the Canadian and USSR surveys, although the length compositions were quite similar.

d) Cohort analysis parameters

Age compositions. Sampling data for the Polish and Portuguese fisheries in 1980 were obtained by observers operating under the NAFO Scientific Observer Program. The samples were small, were taken in the autumn, and were not necessarily representative of total removals over the whole year.

Partial recruitment. Partial recruitment factors were derived from a comparison of age composi-

tions of the commercial catch and the Canadian survey. Values for the older age-groups fluctuated widely, but age 5 and older cod were considered fully recruited after examining the historical fishing mortality rates from preliminary cohort analyses. The partial recruitment values used were 0.05 for age 3, 0.50 for age 4, and 1.00 for age 5+.

Recruitment. Evidence from the Canadian research surveys (from the arithmetic index) indicated that the 1978 year-class was about the same size as the 1975 year-class. Consequently, a recruitment of 10 million fish was used for the projection to 1981.

Terminal F. A series of cohort analysis were examined over a range of terminal F from 0.3 to 1.2. The terminal F value of 0.74, computed for ages 4-11 from Canadian research survey data (using a log transformation to estimate total abundance), was considered representative for the stock in 1980.

Yield per recruit. A yield-per-recruit calculation, using average weights at age from Canadian surveys in 1978-80 and the above partial recruitment pattern implied an $F_{0.1}$ value of 0.13. However, the Committee agreed to use the previous estimate of $F_{0.1} = 0.20$, which was considered to be more representative of the long-term situation.

e) Results of cohort analysis and projections

Utilizing the catch-at-age matrix for 1972-80 and the relevant parameters outlined above, including a recruitment value of 34 million fish as the size of the 1977 year-class at age 3 in 1980 (based on the indication from survey data that the 1977 year-class was about 4 times the size of the 1975 year-class at age 3), the cohort analysis indicates the following estimates of mean biomass (average biomass during the year) (000 tons):

Year	1972	1973	1974	1975	1976	1977	1978	1979	1980
Mean biomass	51	32	26	40	92	62	35	29	41

Projections of catch in 1981 and mean biomass in 1981 and 1982 with $F_{0.1} = 0.20$ are as follows:

Year	Recruitment at age 3 (10^6)	F for fully recruited ages	Projected catch (tons)	Mean biomass (000 tons)		
				Age 3+	Age 4+	Age 6+
1981	10	0.20	5,000	46	38	9
1982	-	-	-	-	50	11

It was noted that the projected catch for 1981 is well below the estimated maximum equilibrium yield (29,000 tons). It is further noted that a possible gain in yield per recruit from the relatively strong 1977 year-class could occur by reducing the fishing mortality in 1981 since growth up to ages 6 and 7 is substantial.

f) Conclusions

The low level of catch projected for 1981 at the $F_{0.1}$ level is a clear indication that the stock is severely depleted. The rate of recovery would increase if fishing mortality were maintained below the $F_{0.1}$ level for the immediate future. The Committee further noted that the present low level of spawning biomass may be such as to impair potential recruitment, and accordingly

recommends

that the Scientific Council at its June 1981 Meeting consider specific measures to ensure maximum spawning potential for the cod stock in Div. 3M.

2. Cod in Divisions 3N and 3O (SCR Doc. 81/II/6, 9, 11)

a) Fishery trends

Nominal catches from this stock declined from a high of 227,000 tons in 1967 to a low of 15,000 tons in 1978. Total allowable catches have been in effect since 1973, but the actual catches were substantially less than the TACs during 1973-77. Recent catches and TACs were as follows:

	1974	1975	1976	1977	1978	1979	1980
TAC (000 tons)	101	88	43	30	15	25	26
Catch (000 tons)	73	44	24	18	15	28	19[1]

[1] Provisional.

The Committee reviewed a series of standardized catch rates for the 1959-79 period, equivalent to catch per hour fished in February, May and August by Canadian (M) and Spanish trawlers. In 1967, when the highest catch in the entire series occurred, the standardized catch rate was 2.1 tons per hour. A fairly consistent decline in catch rate occurred with values falling below 1.0 tons per hour for the first time in 1973. The standardized catch rates for 1973-80 were as follows:

Year	1973	1974	1975	1976	1977	1978	1979	1980
Catch/hour	0.81	0.76	0.71	1.03	0.45	0.30	1.28	0.68

It was noted that the Committee in its report of the February 1980 Meeting (*Sci. Coun. Rep.* 1979-80, page 45) implied that the standardized catch rate for 1979 might in fact be somewhat overestimated.

b) General production model

A non-equilibrium version of the surplus production model, based on the standardized catch rates for 1959-80, indicated an equilibrium maximum sustainable yield of about 125,000 tons. The yield in 1981, if the standardized catch rate is at the estimated 1980 level of 0.68 tons per hour, would be about 22,000 tons. The catch rates for 1963-71 were distinctly higher than those for 1973-79. The 1972 catch rate was intermediate between the two levels, and the 1978 rate was clearly anomalously low.

The Committee reviewed SCR Doc. 81/II/6 which hypothesized that the observed difference in catch rates between the two periods noted above was due to reduced recruitment during the 1970's, which could be explained by the influence of large-scale oceanographic events upon, for example, the food supply of cod larvae and hence upon cod recruitment. Symmetrical general production curves fitted to the two series of catch/effort data showed different maximum yields at the same effort level, and it was suggested that fishing effort could appropriately be maintained at a relatively high level, recognizing that the yield would be at a substantially lower level than in the 1960's because of ecological changes.

An alternative explanation of the trend in catch rates was that fishing effort had been at or above the level corresponding to F_{MSY} during the 1967-74 period with a consequent reduction in stock biomass. Furthermore, because of the absence of older and larger cod, the fishery in the 1970's had concentrated on younger and smaller fish with possible enhanced discarding of undersized specimens. However, data were not available to distinguish whether this hypothesis or the hypothesis of an ecological change is the more reasonable.

c) Estimates of stock biomass from research vessel surveys

From the distribution of catches by USSR research vessels at standard fixed stations in the area, and with the application of an experimentally derived catchability coefficient (6.2%), estimates of biomass in 1978-80 were 76,400, 96,900 and 135,900 tons respectively. From the Canadian random-stratified surveys in 1977-79, the catch rate (mean number per 30-minute tow) was fairly constant at 23.3, 19.6 and 22.6 specimens. In 1980, the mean number per tow was only 4.3 specimens, but this anomalous result may be due to the difference in the time of the 1980 survey.

The Committee noted that, although the length compositions of cod taken in the Canadian and USSR surveys were similar, there was a discrepancy in identification of the dominant year-class.

d) Cohort analysis parameters

Age compositions. Sampling data for the Portuguese and Spanish fleets obtained through the NAFO Scientific Observer Program and for the Canadian fleet amounted to 56,000 length measurements and 3,200 age determinations, which were used to construct an age composition of overall removals in 1980. With some adjustment to the previous 1979 age composition due to the availability of final catch statistics and the inclusion of an estimated age composition for 1971, a matrix of catch-at-age for the 1959-80 period was available for use in the cohort analysis.

Partial recruitment. Partial recruitment factors for 1980 were derived from a comparison of age compositions of the commercial catch and the Canadian survey. Although the ratios indicated declining availability after age 6, full recruitment at age 6 and older was considered more reasonable. Consequently, the partial recruitment values used were 0.05 for age 3, 0.36 for age 4, 0.77 for age 5, and 1.00 for age 6+.

Recruitment. From a rather poor relationship ($r^2 = 0.38$) between abundance at age 3 in the cohort analysis (with terminal F = 0.25) and the catch per tow of age 2 fish in the Canadian survey, the 1978 year-class was estimated to consist of about 60 million fish at the beginning of 1981. The geometric mean abundance of age 3 cod during 1971-80 was about 40 million, and this value was used to represent the sizes of recruiting year-classes at age 3 in 1982 and 1983.

Terminal F. A series of cohort analyses were examined for a range of terminal F values with M = 0.2. With a terminal F of 0.25, the age 3+ biomass of 101,000 tons in 1980 was equal to that predicted from the application of the 1980 catch rate to the regression ($r^2 = 0.85$) of age 3+ biomass against catch rate for the 1959-75 period (excluding the 1963 point). Also, the predicted age 4+ biomass from a regression of age 4+ biomass against catch rate for the 1959-78 period (excluding the 1976 point) was intermediate between the age 4+ biomasses from cohort analyses with terminal F values of 0.20 and 0.30, the correlation coefficients (r^2) being 0.79 and 0.80 respectively. Furthermore, there was a good correlation ($r^2 = 0.80$) between the cohort numbers of age 3 and older cod (terminal F = 0.25) and the numbers per tow of the same age-groups in the Canadian surveys for the 1971-79 period (excluding the 1973 point). The terminal F value of 0.25 was therefore accepted as reasonable for use in the assessment.

Yield per recruit. A yield-per-recruit calculation, using average weights at age up to age 20 for the 1978-80 period and the above partial recruitment pattern implied an $F_{0.1}$ value of 0.14. However, the Committee noted that $F_{0.1}$ values may fluctuate from year to year depending on the input parameters and agreed to use the previous estimate of $F_{0.1} = 0.18$ which was considered to be a reasonable approximation of the average situation.

e) Results of cohort analysis and projections

Utilizing the catch-at-age matrix for 1959-80 and the relevant parameters outlined above, the results of the cohort analysis indicate the following historical trend in mean biomass of age 3 and older cod:

Period	Mean biomass
1961-65	231,000 tons
1966-70	335,000 tons
1971-75	155,000 tons
1976-80	72,000 tons

Projections of catch and stock size in 1981, 1982 and 1983, with recruitment at age 3 assumed to be 60 million fish in 1981 and 40 million fish in 1982 and 1983 and $F_{0.1} = 0.18$, are as follows:

Year	Recruitment at age 3 (10^6)	F for fully recruited ages	Projected catch (tons)	Mean biomass (000 tons)		
				Age 3+	Age 4+	Age 6+
1980	25	0.25	19,000	101	85	39
1981	60	0.18	15,000	132	96	64
1982	40	0.18	20,000	164	140	96
1983	40	0.18	25,000	193	170	92

f) Conclusions

It is evident that the biomass has declined substantially over the period. The biomass of age 3+ cod in 1980 was estimated to be about 100,000 tons. The Committee noted that the stock is composed mainly of young and small fish, primarily of the 1978 year-class, and that low fishing mortality in the next few years would provide a gain in yield per recruit and a return to a more broadly based age structure in the stock. The Committee reiterates the concerns expressed at the February 1980 Meeting (*Sci. Coun. Rep.* 1979-80, page 47) and advises that a cautious approach to the exploitation of the cod stock in Div. 3NO should be maintained.

g) Reservation by USSR scientists

On the basis of the increase in biomass levels obtained from USSR research surveys in 1978 to 1980, USSR scientists felt that levels of catch up to 30,000 tons in 1981 may be considered appropriate for this cod stock.

3. Capelin in Subareas 2 and 3 (SCR Doc. 81/II/3, 4, 5, 10, 14)

a) Fishery trends

Nominal catches of capelin in Subareas 2 and 3 increased from 2,800 tons in 1971 to 366,000 tons in 1975 and declined to 24,000 tons in 1979. Preliminary statistics indicate a catch of 20,000 tons in 1980. No offshore fishing was allowed in Div. 3LNO during 1979 and 1980 and only a small experimental offshore fishery was allowed in Subarea 2 and Div. 3K. Recent TACs and catches were as follows:

		1974	1975	1976	1977	1978	1979	1980
2+3K	TAC (000 tons)	110[1]	160[1]	160[1]	212[1]	212	75	5
	Catch (000 tons)	127	199	216	152	55	12	6
3LNO	TAC (000 tons)	148[2]	180[2]	180[2]	200[2]	200	10	16
	Catch (000 tons)	158	166	144	74	30	12	14

[1] Countries without allocations could each take up to 10,000 tons.
[2] Countries without allocations could each take up to 5,000 tons.

b) Subarea 2 and Division 3K

i) Commercial catch-effort analysis

The series of catch rates of USSR BMRT-type trawlers has been considered as a useful index of abundance (*ICNAF Redbook* 1979, page 34; *Sci. Coun. Rep.* 1979-80, page 49). However, the 1972-80 series is composed of estimates from two different classes of trawler, the 1972-78 estimates being for the larger and more powerful BMRT-A class and the 1979 and 1980 estimates being for the smaller BMRT class. During periods of high stock abundance, catch rates are likely to be similar for both types of trawler, but in periods of low abundance, as in recent years, the catch rates of the BMRT trawler are likely to be underestimates relative to previous years. The catch rates peaked in 1975 at 6.47 tons per hour and declined to 1.34 tons per hour in 1979 (SCR Doc. 80/II/13).

The results from an experimental capelin fishery by USSR BMRT-type trawlers in 1980 indicated a catch rate of 4.57 tons per hour. The fishery in 1980 was concentrated in a small area with fewer vessels (3) for a shorter period than in previous years and was therefore able to sustain a relatively high catch rate. As the results of both the Canadian and USSR acoustic surveys indicated that capelin abundance was low in 1980, the Committee concluded that the catch rate for 1980 was not a reliable indicator of stock abundance.

ii) Research vessel surveys

An acoustic survey conducted by USSR in late October and early November 1980 resulted in a biomass estimate of 20,200 tons of capelin in Div. 2J. No capelin were found in Div. 3K. The area inside the 12-mile limit was not surveyed and the indicated biomass estimate should be considered a minimum. The experimental capelin fishery by USSR commercial vessels was conducted on capelin concentrations in a limited area on the southwest part of Hamilton Bank from mid September to early November. The catch rate declined throughout the period such that it was not efficient to fish by early November. The age composition of catches indicated a predominance of ages 3 and 4 capelin (1977 and 1976 year-classes).

A Canadian acoustic survey in Div. 2J and 3K during 24 October-18 November 1980 indicated low pelagic fish abundance throughout the area. Since capelin made up a small proportion of the total pelagic biomass sampled with the midwater trawl, it was not possible to provide an estimate of the capelin biomass from the acoustic data. The 1977 and 1978 year-classes predominated in the catches.

Results from Canadian groundfish surveys in the autumns of 1977-80, immediately after the Canadian acoustic surveys, indicated higher proportions of catches with capelin in 1979 and 1980. In these years, more catches with capelin were reported from deepwater stations although the numbers per set were very low. The larger catches of capelin in 1979 and 1980

were reported from the Hamilton Bank area. The Canadian acoustic surveys for capelin are conducted in an area more shoreward than the groundfish surveys, but, considering the results of both types of surveys, the acoustic surveys appear to have covered the area of capelin distribution reasonably well. Neither type of survey covers the extreme inshore area.

iii) Numerical population models

A sequential capelin abundance model (SCAM) was used to estimate abundance of capelin in 1972-80. Estimates of the population mature at age in 1980, calculated from catch-per-unit-effort data, were considered unreliable because of the suspected bias in the 1980 catch rate. Consequently, mean values of the population mature at age, calculated from 1973-78 values, were used for 1980. Partial recruitment factors were estimated by comparing research and commercial age compositions. Exploitable biomass, defined as the biomass of capelin available to the fishery in each year, was compared with commercial catch rate data to determine terminal F. Exploitable biomass was considered better than total biomass, used in previous assessments (*Sci. Coun. Rep.* 1979-80, page 49), because the fishery mainly exploits maturing fish. Because the 1980 catch rate was considered unreliable, only catch rates for 1972-79 were used, and the results of the analysis at terminal F - 0.03 was accepted as the best assessment of the status of the stock.

The assessment indicated that the biomass of capelin on 1 September was highest in 1975, declined to about 10% of the 1975 biomass in 1978 and 1979 and increased in 1980. This increase was largely a result of the 1978 year-class which at age 2 was estimated to comprise 51 $\times$ 10^9 fish, the third highest year-class in the 1972-79 data series and about one-third of the size of the largest (1973 year-class consisting of 184 $\times$ 10^9 individuals at age 2). However, the Committee noted that evidence from the two acoustic surveys in 1980 do not support the observation that the 1978 year-class was as large as calculated from the model.

iv) Recruitment estimation and prognosis for 1981

Estimates of year-class size from the sequential abundance model were used as the basis of the projection for 1981. The geometric mean of the 1970-78 year-classes at age 2 was taken as the estimate of the size of the 1979 year-class on 1 January 1981 (31.7 $\times$ 10^9 individuals). The estimated stock size on 1 September 1980 and projected stock sizes in 1981 are as follows:

Age	Stock size in numbers (10^6)		
	1 Sep 1980	1 Jan 1981	1 Sep 1981
2	51,200	31,700	25,900
3	9,200	46,200	32,700
4	1,100	8,200	3,000
5	130	970	200
6	87	100	21
Total biomass (tons)	1,180	1,420	1,320
Mature biomass (tons)		325	

The total biomass projected for 1 January 1981 is lower than estimates for all years in the 1972-77 period. Because a large proportion of this total stock consists of age 2 fish, which are not mature, and age 3 fish, some of which are immature, the biomass of mature capelin on 1 January 1981 is projected to be relatively low although higher than in January 1980. The projection indicates that the biomass on 1 September 1981 will be higher than in 1979 and 1980 but only about one-third of the peak biomass level in 1975. Although the catch rate from the experimental fishery in Div. 2J in 1980 was higher than that for 1979, the results of two independent acoustic surveys indicated a relatively low level of abundance. Because of the conflicting evidence from the numerical analysis, the catch rate data and the acoustic surveys concerning the status of the stock, the estimate of the size of the 1978 year-class and consequently the biomass projected for 1981 may be subject to substantial error and be optimistic. Because of these uncertainties, the Committee advises the continued closure of the autumn fishery for capelin in Div. 2J+3K or a small nominal TAC. A small fishery of 10,000-15,000 tons in 1981 would provide scientists with information comparable to that collected previously and would allow them to better assess the status of the stock in 1981 and to quantify their advice for conservation in 1982.

c) Divisions 3L, 3N and 3O

i) Commercial catch-effort analysis

There was no offshore commercial fishery in these divisions in 1979 and 1980. However, the variation in catch rates for USSR trawlers (>2000 GRT) in Div. 3L during 1973-78 was not great, the range being from 2.27 tons per hour fishing in 1973 to 3.88 tons per hour in 1976.

ii) Research vessel surveys

An acoustic survey by USSR during 26 May-14 June 1980 indicated a mixture of mature and juvenile capelin in Div. 3L, the latter belonging to the 1977 year-class. The biomass of mature capelin in Div. 3L could not be estimated from the acoustic data, as only small quantities of capelin were observed and it was not possible to separate the acoustic counts of mature capelin, juvenile capelin and sand lance. It is possible that, at the time of the survey, most of the mature stock was in inshore Newfoundland waters. Age-groups 3 and 4 (1977 and 1976 year-classes) predominated in the catches of mature capelin. No mature capelin were found in Div. 3NO, but juvenile capelin of the 1979 year-class were found over a large area.

Canadian acoustic surveys of Div. 3LNO were carried out during 12 June-7 July 1980. From a large-scale survey in Div. 3L, the biomass was estimated to be 16,700 tons, consisting of 2,600 tons of mature capelin and 14,100 tons of juveniles mostly of the 1979 year-class. This survey did not cover inshore areas where mature capelin were congregating prior to beach spawning. In the survey of Div. 3NO, mature capelin were detected only on the South-east Shoal (Div. 3N). Of the estimated biomass of 9,900 tons in Div. 3NO, 1,300 tons were mature fish mostly of the 1977 year-class and the remainder were juveniles mostly of the 1979 year-class.

An analysis of sampling variation and survey design for the Canadian acoustic survey in Div. 3LNO in 1980 indicated a 95% confidence interval of ±61.9% for the large-scale survey in the whole area and intervals from ±16.5% to ±18.6% for the concentrated surveys of the spawning population in Div. 3N. These confidence intervals are comparable to those reported for acoustic surveys on other species of fish. It was emphasized that this source of variation is related only to sampling design and that other sources of variation in acoustic surveys also exist. However, the present analysis will allow future surveys to be planned in such a way that variance due to sampling design can be reduced.

iii) Numerical population models

A sequential capelin population model (SCAM) was used to estimate abundance of capelin in Div. 3L during 1967-80. Catches from both the inshore fishery and the offshore fishery (1972-78) were used in the analysis. Estimates of the proportions mature at age were calculated from catch rate data when available (1972-78), and averages were used when such data were not available. The relationship between catch rate (1974-78) and total biomass was used to determine a terminal F of 0.10 for 1980. The results of the analysis with this terminal F value was considered to provide the best assessment of status of the stock during 1972-78.

There was a statistically significant relationship between the estimates of year-class strength of age 2 capelin in Div. 2J+3K and age 3 capelin in Div. 3L for the 1968 to 1974 year-classes. This relationship was used to refine the estimates of year-class strength in the early years and the more recent years of the series. The results of this analysis indicated that the 1973, 1969 and 1964 year-classes were large, and that the 1975, 1976 and 1977 year-classes were relatively small, about one-fifth the size of the large 1973 year-class (24×10^9 individuals). These small year-classes resulted in rather low biomass estimates of 170,000 and 150,000 tons in 1979 and 1980 respectively.

iv) Recruitment estimation and prognosis for 1981

Stock size projections for capelin in Div. 3L were made, using estimates of year-class strength based on the relationship between capelin year-class size in Div. 3L and Div. 2J+3K. These projections indicated that the 1978 year-class, which will form the bulk of the stock in 1981, is larger than the 1977 and 1976 year-classes but still below the long-term average. The projected stock size of capelin (age 3 and older) in Div. 3L on 1 January 1981 indicates a total biomass of 300,000 tons.

Stock size (10^6), 1 Jan 1981			Biomass
Age 3	Age 4	Age 5+	(tons)
9,900	2,800	500	300,000

The Committee emphasizes that the estimated size of the 1978 year-class in Div. 3L may be subject to substantial error because of the method of estimation noted above. The Committee also recognizes that capelin are an important source of food for predators, especially cod. In view of these factors, the Committee advises that an exploitation rate of 10% should be maintained for 1981, resulting in a TAC of 30,000 tons for capelin in Div. 3L.

No stock projections were made for capelin in Div. 3NO in 1981, because no estimates of year-class size were available. However, it was noted that the spawning stock was at a very low level in 1980 and would still be at a low level in 1981 if estimates of year-class strength in these divisions followed the pattern of other areas. Consequently, in order to allow further increase in the spawning stock in Div. 3N and to protect this stock during its migration through Div. 3O to Div. 3N, the Committee advises that there should be no fishery for capelin in Divisions 3N and 3O during 1981.

4. Cod predation on capelin (SCR Doc. 81/II/1, 7, 8)

The Committee reviewed three papers dealing with the geographical and seasonal patterns of predation by cod on capelin in Div. 2J+3KL and 3NO, the association of capelin with the cold inshore branch of the Labrador Current for much of the year, and the influence of this distribution on the cod-capelin interaction.

The possibility that changes in capelin abundance might influence the growth rate of cod and the success of the inshore fishery was examined by correlation analysis, using 1970-79 data for the capelin stock in Div. 2J+3K and the cod stock in Div. 2J+3KL (SCR Doc. 81/II/1). No significant relationship between cod growth rate and capelin abundance was demonstrated. However, significant positive correlations were found between the proportion of available cod biomass taken by poundnet in inshore waters and one of the two available indices of mature capelin abundance, and between the proportion of available cod biomass taken by the total inshore fishery and the same index of mature capelin biomass and water temperature. Because of uncertainties in the data and the shortness of the time series, it was considered that the analysis did not constitute an adequate test of the postulated dependency of cod on capelin. It was noted, however, that, particularly for cod in Div. 2J+3KL, there may be no alternative prey of comparable size which could provide adequate forage for cod on a sustained basis.

Estimates of the quantity of capelin which might be consumed by cod in Div. 2J, 3K, 3L, 3N and 3O in 1981 were in the range of 1.2-4.4 million tons (SCR Doc. 81/II/8). These estimates were considered to be very tenuous, because the cod-feeding studies on which they were based suffered from inadequate spatial and seasonal sampling and were conducted during a period (1973-76) when capelin abundance was high and cod abundance was low.

II. FUTURE RESEARCH REQUIREMENTS

1. Cod predation on capelin

The Committee, noting with concern that estimates of the consumption of capelin by cod in Subareas 2 and 3 approached the projected biomass, and considering the need for studies on the trophic interaction between cod and capelin,

recommends

that extensive sampling of cod stomachs should be continued both inshore and offshore in Subareas 2 and 3, with emphasis on providing more reliable estimates of capelin consumption by cod and on establishing whether lowered levels of capelin biomass can detrimentally affect production of the cod stocks and success of the cod fishery.

2. Pre-recuit capelin surveys

In view of the potentially high contribution of recruiting year-classes of capelin to the total biomass, the Committee

recommends

that the 0-group and 1-group capelin surveys be expanded to provide better estimates of recruitment.

3. Acoustic surveys for capelin

The Committee, noting the desirability of achieving maximum coverage,

recommends

that the acoustic sruveys for capelin should be coordinated between countries and that inshore surveys should be conducted concurrently with offshore surveys.

III. OTHER MATTERS

1. Working Group on Flemish Cap Project

The Committee, noting that Mr R. Wells has previously resigned as convener of the Working Group, agreed that Canada be asked to appoint a Canadian scientist as Convener. Dr G. Nizovtsev, Deputy Director of the Polar Institute of Marine Fisheries and Oceanography (PINRO) kindly agreed to act as the USSR coordinator.

2. Mesh assessment of cod and redfish in Div. 3M

The Committee noted that this item would be dealt with at the June 1981 Meeting and agreed to defer consideration of SCR Doc. 81/II/2, "Effects of changes in mesh size upon yield per recruit of cod in Division 3M", to that meeting.

3. Acknowledgements

The Chairman expressed his thanks to all participants for their interest and cooperation during the meeting, especially to those scientists who contributed to the report by summarizing the results of the discussions on particular topics, and to the Secretariat staff for their usual efficient work.

APPENDIX II. AGENDA

Special Meeting of Scientific Council - February 1981

1. Opening (Chairman: R. H. Letaconnoux)

   a) Appointment of rapporteur
   b) Adoption of agenda
   c) Plan of work

2. Fishery Science (Chairman of STACFIS: G. H. Winters)

   a) Stock assessments (see Annex 1 overleaf)
      i) Cod (3M, 3NO)
      ii) Capelin (2+3K, 3LNO)
   b) Research requirements
   c) Other matters

3. Review of Agenda and Timetable for June 1981 Meeting of the Council

4. Other Matters

5. Adjournment

ANNEX 1

Extract from

Canadian Request for Advice on the Scientific Basis for Management in 1981 of Certain Stocks in Subareas 0 to 4

Canada requests the Scientific Council to consider the following options in assessing and projecting future stock levels:

a) For those stocks subject to analytical dynamic-pool type assessments, the status of the stock should be reviewed and management options evaluated in terms of their implications of fishable stock size in both the short and the long term. In those cases where present spawning stock size is a matter of scientific concern in relation to the continuing productive potential of the stock, management options should be evaluated in relation to spawning stock size. As a general reference point, the implications of continuing to fish at $F_{0.1}$ in 1981 and subsequent years should be evaluated. The present stock size should be described in relation to those observed historically and to those to be expected at the $F_{0.1}$ level. Management options for arriving at the latter stock size on a shorter time scale should be developed. Opinions of the Scientific Cpuncil should be expressed in regard to stock sizes, catch rates, and TACs implied by these management strategies for 1981 and the long term.

b) For those stocks subject to general production-type assessments, the status of the stock should be reviewed and management options evaluated in the way described above to the extent possible. In this case, the general reference point should be the level of fishing effort ($\equiv F$) which is two-thirds that calculated to be required to take the MSY catch in the long term.

c) For those resources on which only general biological and/or catch data are available, no standard criteria on which to base advice can be established. The evidence on stock status should, however, be weighed against a strategy of optimum yield management and maintenance of stock biomass at levels of about two-thirds that of the virgin stock.

(NAFO Sci. Counc. Rep. 1979-80, page 170)

APPENDIX III. LIST OF PARTICIPANTS

Special Meeting of Scientific Council - February 1981

CANADA

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APPENDIX IV. LIST OF DOCUMENTS

Special Meeting of Scientific Council - February 1981

RESEARCH DOCUMENTS

SCR Doc.	Serial	
81/II/1	N264	AKENHEAD, S. A., J. CARSCADDEN, H. LEAR, G. R. LILLY, and R. WELLS. On the cod-capelin interaction of northeast Newfoundland and Labrador
81/II/2	N265	WELLS, R. Effects of changes in mesh size upon yield per recruit of cod in Division 3M
81/II/3	N267	CARSCADDEN, J., G. H. WINTERS, and D. S. MILLER. Assessment of the Division 3L capelin stock, 1967-1980, using SCAM
81/II/4	N268	CARSCADDEN, J., and D. S. MILLER. Analytical assessment of the capelin stock in Subarea 2 + Division 3K using SCAM
81/II/5	N269	MILLER, D. S., and J. E. CARSCADDEN. Acoustic survey results for capelin (*Mallotus villosus*) in Divisions 2J3K and 3LNO, 1980
81/II/6	N270	LARRANETA, M. Ecology and fishing of cod stocks in Divisions 3M and 3NO
81/II/7	N271	LILLY, G. R. Influence of the Labrador Current on predation by cod on capelin and sand lance off eastern Newfoundland
81/II/8	N272	LILLY, G. R., R. WELLS, and J. CARSCADDEN. Estimates of the possible consumption of capelin by the cod stocks in Divisions 2J+3KL and 3NO
81/II/9	N273	CHEKHOVA, V. A., and A. I. POSTOLAKY. Abundance and biomass of cod on the Grand Bank (Divisions 3NO) and Flemish Cap (Division 3M)
81/II/10	N274	BAKANEV, V. S. Results of soviet investigations on capelin in Northwest Atlantic in 1980
81/II/11	N275	BISHOP, C. A., and S. GAVARIS. Stock assessment of cod in Divisions 3NO (+ 3 Adden.)
81/II/12	N276	GAVARIS, S. Assessment of the cod stock in Division 3M (+ Corr.)
81/II/13	N277	WELLS, R. Distribution and abundance of cod on the Flemish Cap in January 1981 and mortality in 1980
81/II/14	N278	NAKASHIMA, B. S. Sampling variation and survey design for capelin (*Mallotus villosus*) densities from an acoustic survey in Divisions 3LNO 1980
81/II/15	N279	WELLS, R. The number of research vessel tows on the Flemish Cap is never enough

SUMMARY DOCUMENTS

SCS Doc.	Serial	
81/II/1	N266	NAFO Secretariat. Report to Scientific Council on inadequate response to specified data requirements for stock assessments
81/II/2	N280	NAFO. Provisional report of Scientific Council, Dartmouth, Canada, 17-20 February 1981