Northwest Atlantic Fisheries Organization

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SCIENTIFIC COUNCIL MEETING - FEBRUARY 1994

Report of Scientific Council, Special Meeting, 13-15 February 1994

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REPORT OF SCIENTIFIC COUNCIL

Special Meeting, 13-15 February 1994

Chairman: H. Lassen Rapporteur: T. Amaratunga

I. PLENARY SESSIONS

The Scientific Council met at the European Union DG XIV Building, at 99 Rue Joseph II, Brussels, Belgium, on 13 February 1994 and at the Albert Borschette Conference Centre on 14 and 15 February 1994.

Representatives attended from Canada, European Union (Denmark, Federal Republic of Germany, Portugal, Spain and United Kingdom), Japan, Republic of Korea and the Russian Federation. The Executive Secretary and Assistant Executive Secretary were in attendance.

The opening session of the Council was called to order at 0915 hr on 13 February 1994.

The Chairman extended a special welcome to the representatives of the Republic of Korea, the new Contracting Party of NAFO, to this their first meeting of the Scientific Council.

The Chairman welcomed everyone to this special meeting to conduct an updated stock assessment of cod in Div. 3NO and to provide catch options for 1994. The Assistant Executive Secretary was appointed rapporteur.

The plan of work was reviewed. With respect to the Fisheries Commission provisional agenda for the 15-17 February 1994 Meeting, the Council noted that there were no new data available since the Scientific Council meeting of 19-23 November 1993, to reconsider items on the experimental redfish fishery or the minimum fish size for witch, redfish and Greenland halibut. The provisional agenda of this Scientific Council Meeting (see Appendix I) was accordingly **adopted** as presented, and the scientific considerations of the assessment of cod in Div. 3NO was assigned to the Standing Committee on Fishery Science (STACFIS). The session was adjourned at 0935 hr.

At a brief meeting on 14 February 1994, the Council agreed to convene its closing session on 15 February 1994.

The concluding session of the Council was convened at 0900 hr on 15 February 1994. The Council then considered the report of the Standing Committee on Fishery Science, and **adopted** it with the proposed modifications.

The Council then considered and **adopted** the Report of the Scientific Council of the 13-15 February 1994 Meeting.

The meeting was adjourned at 1130 hr on 15 February 1994.

The Report of the Standing Committee on Fishery Science (STACFIS) is at Appendix I.

Brief summary of the STACFIS Report and other matters considered are given below in Sections II-IV. The Agenda, List of Research (SCR) and Summary (SCS) Documents and the List of Participants of this meeting are given in Appendix II, III and IV, respectively.

II. FISHERY SCIENCE (see STACFIS report, App. I)

1. Stock Assessment

a) Cod in Divisions 3N and 3O

The Council noted that the assessment of cod in Div. 3NO as requested by Canada was completed, and endorsed the assessment as presented in the STACFIS report. The Summary Sheet as prepared for the assessment is given below.

SUMMARY SHEET - Cod in Divisions 3N and 3O

Source of Information: SCR Doc. 94/1, 2, 3

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994
Recommended TAC				Same as agreed					
Agreed TAC	33	33	40	25	18.6	13.6	13.6	10.2	6
Reported catches	51	42	43	33	18	17[1]	10.1[1]	9[1]	
Non-reported catches	-	-	-	-	11	12	2.5	0.7	
Total landings	51	42	43	33	29	29[1]	12.6[1]	9.7[1]	
Sp. stock biomass from maturity ogive									
Dome	240	240	170	140	120	110	90	60	
Flat-topped	105	104	81	63	51	43	29	20	
Recruitment (age 3)									
Dome	8	7	15	16	7	10	57	40	
Flat-topped	9	7	14	14	6	8	47	33	
Mean F (ages 7-10)									
Dome	0.16	0.17	0.22	0.19	0.18	0.29	0.13	0.09	
Flat-topped	0.32	0.37	0.46	0.37	0.37	0.64	0.31	0.19	

[1] Provisional. Weights in '000 tons

Catches: Catches declined from a peak of 227 000 tons in 1967 to lows of 12 600 tons in 1992 and 9 728 tons in 1993. TACs were introduced for this stock in 1973. Until 1978 catches were substantially lower than TACs. From 1981 to 1991, catches exceeded the TACs. However, in 1992 and 1993 catches were slightly below the TACs.

Data and Assessment: An analytical assessment was conducted using three Canadian survey indices and one Russian survey index in a formulation of the adaptive framework. Analyses were conducted using two estimates of partial recruitment (PR), domed and flat topped. The resulting interpretations of stock status and stock trends over time were substantially different but STACFIS considered that the analysis and data were not sufficient to determine the most appropriate PR. It was noted, however, that the analysis using the dome PR indicated that the SSB in the mid-1980s was far greater than that during the 1960s. This was considered to be unrealistic.

Fishing Mortality: For both options of PR, the mean fishing mortalities were high in the 1960s and early-1970s, and during some years were in excess of 1.0. They decreased in the late-1970s to levels at or below $F_{0.1}$. Since the early-1980s, Fs gradually increased but declined in 1992 and 1993. Fishing mortalities in recent years have been particularly high on the younger immature ages.

Recruitment: The 1983 to 1988 year-classes are extremely weak. The 1989 and possibly the 1990 year-classes are, however, above the average of the 1974-88 year-classes.

State of Stock: The stock is comprised mainly of young, immature fish. The number of older mature, fish continues to decline. Rebuilding of the spawning stock biomass (SSB) in the short term is dependant on the 1989 and the 1990 year-classes surviving to maturity. It will be another one to two years before the majority of these fish are sexually mature.

Forecast for 1994:

Option Basis	Predicted Catch (1994) (tons)	Predicted SSB (1.1.1995) (tons)
	Domed PR	
$F_{0.1}$ = 0.25	18 871	61 649
F_{max} = 0.40	28 622	55 486
No Fishing	0	72 747
F_{94} = 0.07	6 000	69 878
	Flat-topped PR	
$F_{0.1}$ = 0.20	10 609	37 709
F_{max} = 0.30	15 336	34 663
No Fishing	0	44 644
F_{94} = 0.11	6 000	40 767

Recommendation: Exploitation rates targeting on younger immature fish remain high. STACFIS therefore reiterated its advice of June 1993 that all necessary steps should be taken to eliminate the catch of small fish from this stock.

The 1989 year-class is estimated to be somewhat stronger than estimated in June 1993. There are indications that the 1990 year-class is also strong. However, high variability in the 1993 Canadian and Russian spring RV survey data, as well as conflicting evidence between spring and autumn surveys, dictate caution in the interpretation of the strength of these year-classes. Therefore STACFIS also reiterated its June 1993 advice that any catch in 1994 should not exceed 6 000 tons. STACFIS emphasizes that this catch level is an upper limit and should not be interpreted as a recommended TAC.

The SSB continued to decline in 1993. STACFIS advised that the stock should be allowed to rebuild.

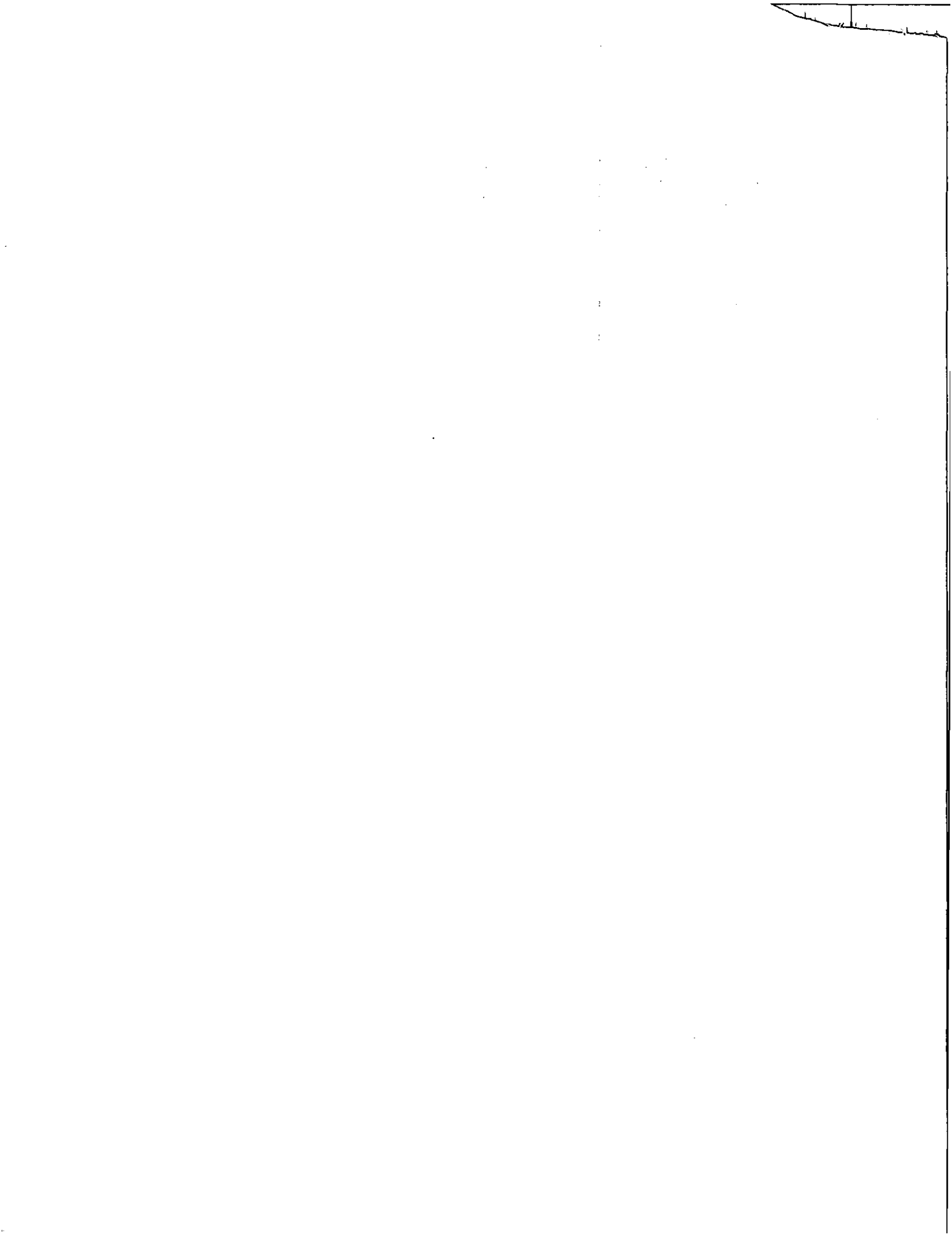
Special Comments: The SSB cannot begin to recover unless the 1989 and 1990 year-classes survive to maturity. This will not happen if fisheries on immature ages continue at current high levels. Any harvesting of this stock will reduce the rebuilding potential. Recovery will occur most rapidly in the absence of a fishery.

III. ADOPTION OF REPORTS

At its concluding session on 15 February 1994, the Council reviewed and **adopted** the Report of the Standing Committee on Fishery Science and the Report of the 13-15 February 1994 Meeting of the Scientific Council, noting that discussions of the Council's concluding session and editorial modifications will be reflected in the Report.

IV. ADJOURNMENT

There being no other business, the Chairman extended a special thanks to the Executive Secretary, the Assistant Executive Secretary and to the staff of the Secretariat for exceptional efficiency and support. Thanks were extended to all participants for their valuable contributions. He adjourned the meeting, looking forward to seeing most of the participants at the June Meeting.



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

Chairman: H. P. Cornus Rapporteur: Various

The Committee met at the European Union DG XIV Building, at 99 Rue Joseph II, Brussels, Belgium on 13 February 1994, and at Albert Borschette Conference Centre on 14 February 1994 to consider and report on the assessment of cod in Div. 3NO as referred to it by the Scientific Council. Representatives attended from Canada, European Union (EU) (Denmark, Germany, Portugal, Spain and United Kingdom), Japan, Republic of Korea and the Russian Federation.

The Chairman was pleased to note the attendance of representatives from the Republic of Korea, and extended a cordial welcome to them.

During its meeting on 14 February 1994, the Committee noted that the Chairman, H. P. Cornus (EU-Germany) would be leaving before the completion of STACFIS deliberations. The Committee agreed that H. Lassen (EU-Denmark) would chair the meeting to its completion.

I. STOCK ASSESSMENTS

1. Cod in Divisions 3N and 3O (SCR Doc. 94/1, 2, 3)

a) Introduction

i) Description of fishery

Nominal catches increased during the late-1950s and early-1960s, reaching a peak of about 227 000 tons in 1967, and subsequently declined to lows of 12 561 tons in 1992 and 9 728 tons in 1993 (Fig. 1).

Recent TACs and catches ('000 tons) are as follows:

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
TAC	26	33	33	33	40	25	18.6	13.6	13.6	10.2	6
Catch	27	37	51	42	43	33	29[2]	29[1,2]	13[1]	10[1]	

[1] Provisional.
[2] Includes estimates of non-reported catches.

TACs were first introduced for this stock in 1973 at a level of 103 000 tons. Until 1978, catches were substantially lower than the TACs but from 1981 to 1991, they exceeded those recommended. In 1992 and 1993, the catches were slightly under the recommended TAC.

For the period since 1978, catches have been taken predominantly by Canada and EU-Spain. All non-Canadian catches in 1993 were from the Regulatory Area. Canadian catches have been taken mainly within the Canadian 200-mile fishery zone by otter-trawlers, with an increasing proportion by other gears, especially gillnet and longline. Canadian catches were stable at approximately 19 000 tons from 1985 to 1988 but have since declined to about 5 300 tons in 1993.

Catches by EU-Spain, mainly by pair-trawlers, averaged approximately 17 000 tons from 1986 to 1989. Since 1989, catches have decreased to a low of approximately 1 900 tons in 1992 but rose in 1993 to approximately 3 000 tons. Catches by EU-Portugal decreased from about 7 000 tons in 1986 to 1 000 tons in 1989, but increased again to 2 000 tons in 1990 but dropped to 450 tons in 1992. The reported catch in 1993 was about 525 tons. The latter was taken by gillnet and otter-trawl fleets.

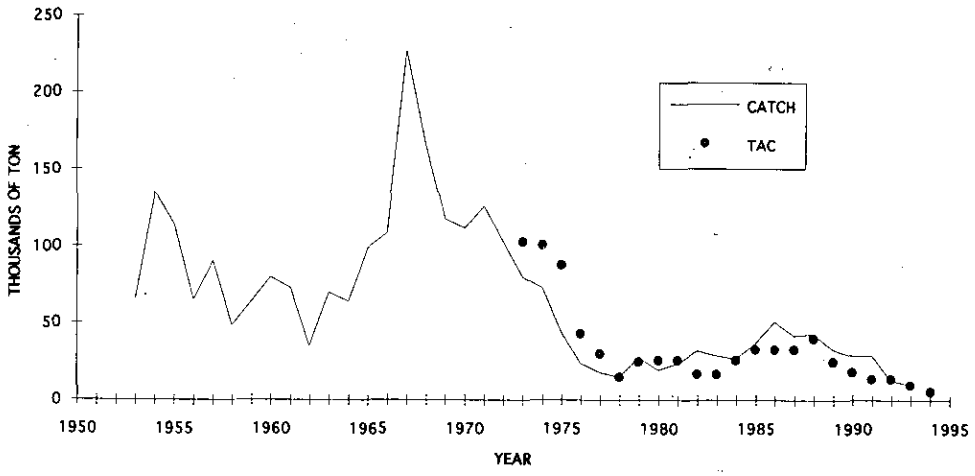


Fig. 1. Cod in Div. 3NO: catches and TACs.

In recent years additional unreported catches have been estimated for countries fishing in the Regulatory Area, and in 1993 this amounted to about 700 tons.

b) **Input Data**

i) **Commercial fishery data**

Catch rates. Catch-rate indices for Canadian otter-trawl and Spanish pair-trawl fleets have not been incorporated into the assessment calibration models in recent years because they are not considered reflective of stock abundance. They were only considered useful as indicators of general trends. Otter-trawl catch rates for EU-Portugal were up in 1993 after having been low during the 1990-92 period. Gillnet catch rates were higher in 1991-92, down in 1989-90 and declined in 1993. It is difficult to determine if these changes are different from previous years due to the associated high standard errors. Pair-trawl catch rates for EU-Spain were higher in 1993 in comparison to 1991 and earlier year. In 1992 data were not available.

Catch-at-age. Biological sampling data from the Canadian otter-trawl, longline and gillnet fisheries and Spanish pair-trawl fisheries were used to estimate the age composition of the commercial catch in 1993. The 1988 and 1989 year-classes (ages 4 and 5) were most numerous in the Canadian catch and landings. The 1989 and 1990 year-classes (age 4 and 3) were the most abundant in the pair-trawl fishery of EU-Spain in 1993. Sampling from the Spanish fleet was used to derive age compositions for all cod catches in the Regulatory Area. Sampling data from the Canadian gillnet fishery were used to estimate catch-at-age for the Portuguese gillnet fishery. This indicated that about 3.7 million age 3 and 4 cod were caught in 1993.

There do not appear to be any discernable trends in mean weights-at-age although those for most ages have shown an increase from 1992 to 1993.

ii) **Research survey data**

Stratified-random research vessel surveys have been conducted by Canada in Div. 3N for

the 1971-93 period, with the exception of 1983, and in Div. 3O for the years 1973-93 with the exception of 1974 and 1983. Biomass for Div. 3N and 3O combined, gradually increased from the early-1970s to the early-1980s and increased considerably between 1982 and 1984 (Fig. 2a). Another sharp increase occurred in 1987 but survey biomass then declined until 1992 when it was the lowest observed since 1982. Estimates of the Div. 3NO biomass in 1993 increased to about 74 000 tons.

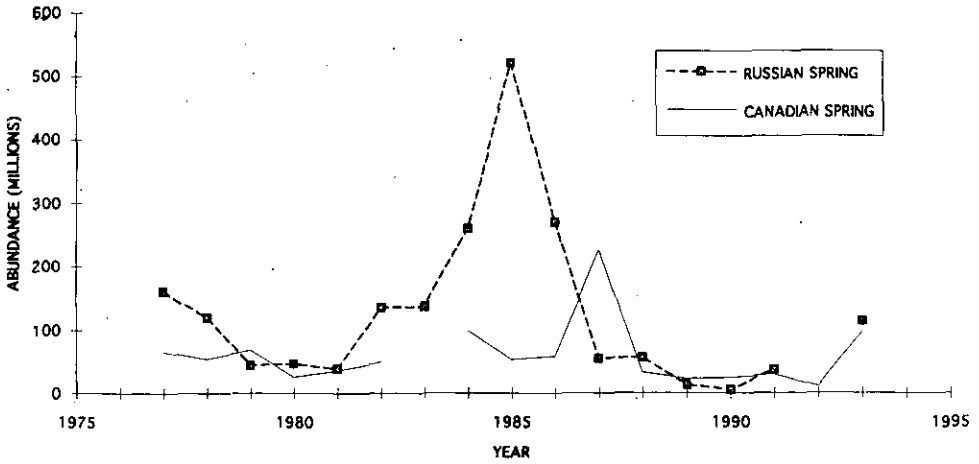


Fig. 2a. Cod in Div. 3NO: abundance from spring Canadian and Russian research vessel surveys.

Abundance estimates for Div. 3NO suggested similar trends to those observed for biomass with a large value occurring in 1987 resulting mainly from a high estimate for Div. 3O. The abundance estimates for the 1988-91 period were low but stable. The 1992 estimate dropped and was the lowest observed in the time series. The 1993 estimate is considerably higher, reflecting the strength of the 1989 and 1990 year-classes.

The low levels of biomass and abundance in recent years has been attributed to a succession of very weak year-classes as measured at age 3. Abundance estimates-at-age indicated that the 1983 to 1988 year-classes (ages 5 to 10 in 1993) were among the lowest observed in the time series. The dominant age in the 1993 survey was 3 and 4 (the 1990 and 1989 year-classes) which comprised about 90% of the total abundance.

As in 1991 and 1992, the 1993 spring survey also covered the deeper water strata (366-732 m) not surveyed in previous years. Biomass in the depth range (366-545 m) was substantial in Div. 3O in 1991 but was considerably lower in 1992 and 1993. Abundance estimates for this depth zone were also low in 1993. Biomass and abundance for these depth zones in Div. 3N were not substantial. Information was not available to determine whether the 1991-93 distributions were similar to previous years when this depth had not been covered.

Additional stratified-random surveys have been conducted by Canada during autumn in 1990-93. Biomass and abundance estimates were at similar levels in 1990-91 in Div. 3O but were considerably lower in 1992 and 1993. Biomass estimates in Div. 3N have fallen in 1992 and 1993. Abundance in Div. 3N was much lower than in 1991 or 1992. The age composition from the 1993 survey indicated that the 1989 year-class which had been strong in 1991 and 1992 surveys had declined substantially.

Canada has conducted stratified-random surveys during the August-September period in Div. 3NO since 1980 for the purpose of estimating abundance of juvenile as well as adult groundfish. The surveys since 1988 have covered depths to 150 fathoms. The results of these surveys indicate that Div. 3NO cod biomass and abundance (Fig. 2b) increased from 1989-91 but have since decreased. The 1989 and 1990 year-classes were both strong in this series.

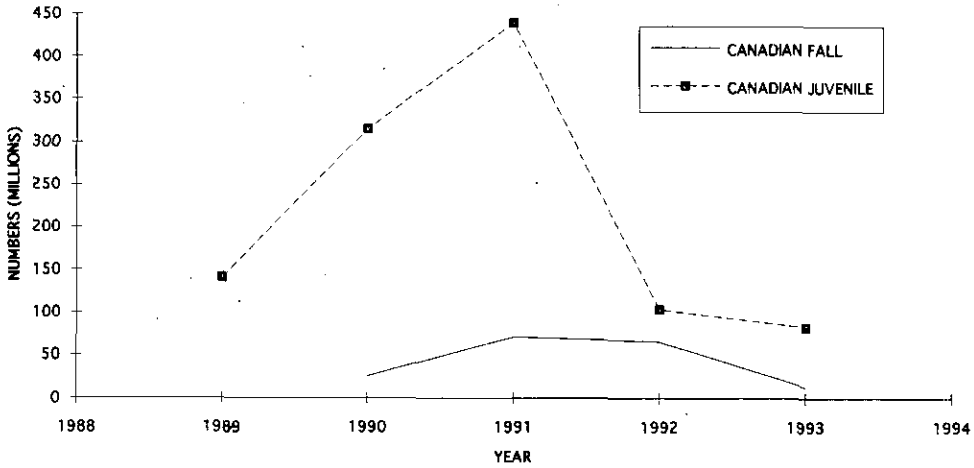


Fig. 2b. Cod in Div. 3NO: abundance from Canadian autumn and juvenile research vessel surveys.

The 1993 Russian survey indicates an upward trend in the cod stock in Div. 3NO (Fig.2a). Although the biomass estimates for 1993 are lower than for 1991 when the last Russian survey was conducted, abundance of the stock was reported to be increasing. Fish at ages 2-6 were observed to be especially numerous with individuals at ages 3 and 4 predominating.

c) Estimation of Parameters

i) Sequential population analysis

Formulations of the adaptive framework (ADAPT) and the Laurec-Shepherd (L/S) technique, including Canadian spring, autumn and juvenile groundfish surveys and Russian RV survey data (for the ADAPT analysis only), were used for the determination of stock size for 1993. Results from ADAPT indicated that coefficients of variation (Cvs) on the age 4 to 11 abundance estimates were in the range of 30% to 37%, while that on the age 3 estimate was higher at approximately 49%. All research vessel catchabilities were estimated with Cvs between 23 and 50%. Residuals indicated no obvious trends but all survey indices contained several year effects, both positive and negative. The Cvs on all abundance estimates and the patterns of residuals described above suggest some uncertainty with the results of this calibration analysis. Similar comments regarding uncertainty were also made during the previous four assessments of this stock (NAFO Scientific Council Reports, 1990, 1991, 1992, 1993) and were attributed to large year-to-year variation in survey estimates as well as poorly estimated removals-at-age.

An analysis using the L/S technique was also conducted using Canadian spring RV data only from 1984 to 1993 as well as Canadian autumn and juvenile groundfish data from 1990 to 1993. Most of the structure and data were the same as included in the ADAPT

analysis except that the oldest age Fs were set to the mean of the previous five ages (7-11) instead of ages 7-10. Autumn survey estimates were used without adjustments to the beginning of the following year. Standard errors of F were large at the young ages for the Canadian spring and juvenile groundfish surveys. Those for the autumn survey were generally larger than the other survey indices. As with ADAPT, no trends were evident in log catchability residuals.

ii) **Estimation of Partial Recruitment**

Assessments of this stock for the years 1990 to 1993 have included a formulation of ADAPT for which PR was estimated to be 'dome' shaped; the F on the oldest age group was estimated at 40% of the fully recruited F (mean of ages 7-10). During the June 1993 assessment, analyses were presented indicating that different interpretations of stock status were produced depending on the option of PR that was considered most appropriate. In June 1993 it was recommended that additional analysis be conducted to assess the impact of PR on the interpretation of stock status and determine the most appropriate approach.

The basis for adoption of a 40% dome on the oldest age group was related to patterns observed in the ADAPT RV catchability estimates (K) (NAFO Scientific Council Report, 1990). Earlier assessments suggested that Ks should be at least stable, if not declining, through older ages. Catchabilities obtained assuming a 'flat-topped' PR indicated increasing values at age for both Canadian and Russian RV indices. When fishing mortalities on oldest ages were set at 40% of those at fully recruited ages, more stable catchabilities for older ages in the RV indices were produced.

For the current assessment, similar analyses were conducted. A formulation of ADAPT was used assuming flat-topped PR and a dome of 40%. In this analysis, additional indices were included (Canadian autumn RV and juvenile groundfish). The catchabilities produced showed similar patterns with those in earlier analyses. As the dome approached a flat-topped PR, K values for the spring Canadian RV index showed an increasing trend, mainly at ages 9 and older. Russian RV data showed a similar but less pronounced effect. With the exception of values for the oldest age in the calibration (age 11), the Canadian autumn K values decreased at all ages older than 6, with the effect becoming more pronounced with an increasing dome. Juvenile groundfish survey K estimates were high at age 3 and declined at all subsequent ages with the exception of a high value at age 11.

Biomass estimates were obtained from cohort analyses using the options of PR described above in ADAPT analyses. A 40% dome produced biomass estimates that were about 80% higher in the mid-1980s, than with the flat-topped PR. This would also imply that biomass in the mid-1980s was as large or larger than that in the late-1960s when landings were consistently in excess of 100 000 tons. Research vessel biomass estimates peaked in the mid-1980s, but there were no survey estimates in the late-1960s for similar comparisons. Particularly the SSB estimates obtained with the dome shaped PR in the mid-1980s are well above what have been estimated for other periods in the time series. Comparing the catches taken in mid-1960s and mid-1980s, these SSB of mid-1980s appear unrealistic.

The data presented indicated that the validity of procedure previously used for estimation of an appropriate level of PR for the fully recruited ages is not clear, and that the consequent influence on the interpretation of stock status is substantial. STACFIS finds that the flat-topped assessment better reflects the stock trends than the dome-shaped assessment. STACFIS, however, considered that the data and analysis provided was not sufficient to determine the most appropriate PR. Consequently stock status was considered using population estimates derived from both flat-topped and dome shaped PR for the 1977-93 period.

d) **Assessment Results**

As for the 1993 assessment, results from ADAPT were used as the best estimate of stock status (Fig. 3-5a,b). Population (age 3+) biomass estimates from both options of PR indicated declines

from recent highs in the mid-1980s but at substantially different levels. The 1993 beginning of year biomass from a domed PR (95 000 tons) was almost twice as large as that from a flat-topped PR (48 000 tons). This difference was also observed in the mid-1980s. Population numbers (age 3+) from both options of PR indicated declines from recent highs in the mid-1980s. Estimates increased after 1991 for both as the result of relatively large estimates for the 1989 and 1990 year-classes (respectively, 47 and 33 million flat-topped; 57 and 40 million domed). The 1993 assessment estimated the 1989 year-class at about 38 million at age 3, but for projection purposes, was set at 20 million, the geometric-mean for recent years (*NAFO Scientific Council Reports, 1993*).

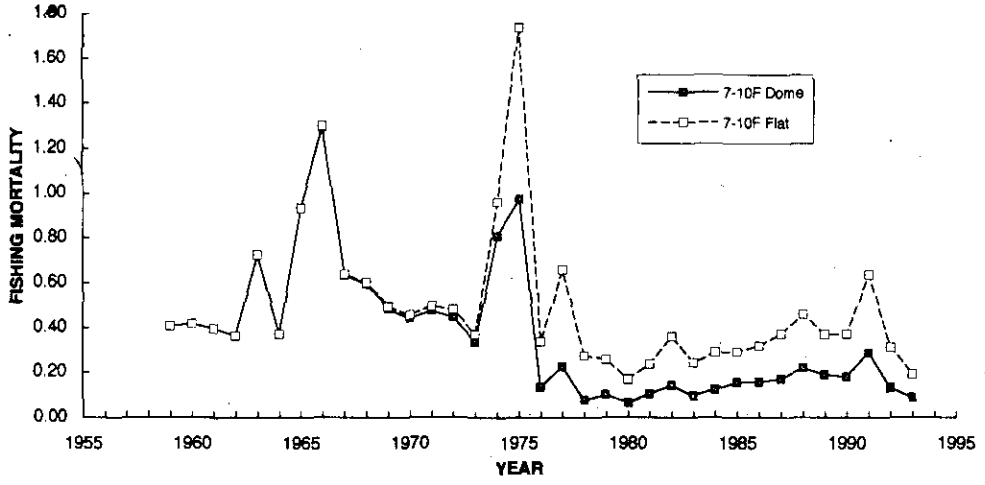


Fig. 3. Cod in Div. 3NO: age 7-10 mean fishing mortalities from SPA with domed and flat-topped PR.

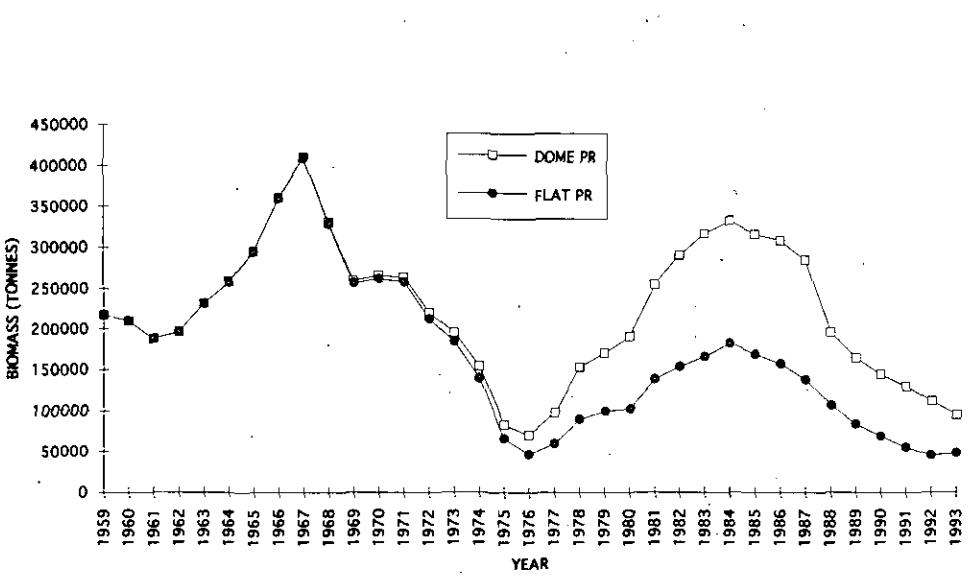


Fig. 4. Cod in Div. 3NO: age 3+ biomass (SSB) from SPA with domed and flat-topped PR.

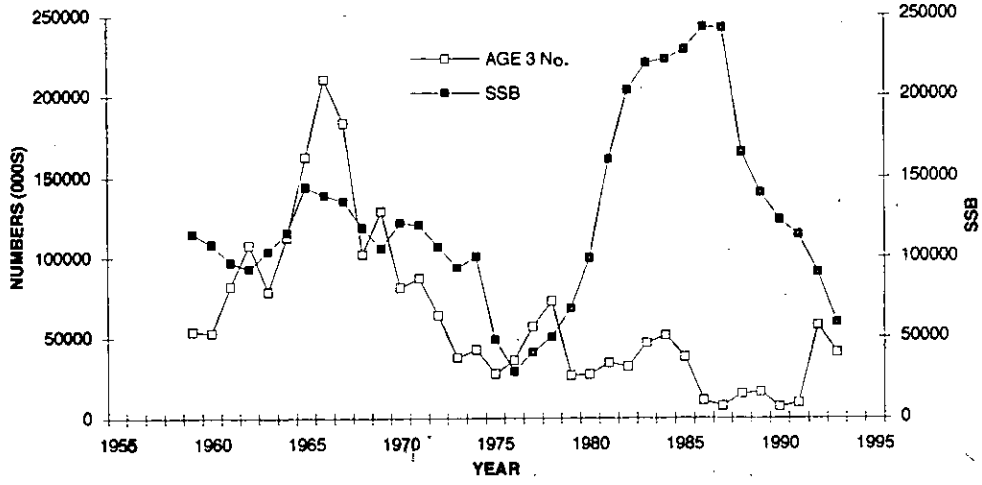


Fig. 5a. Cod in Div. 3NO: SPA age 3 numbers and SSB by year with domed shape recruitment.

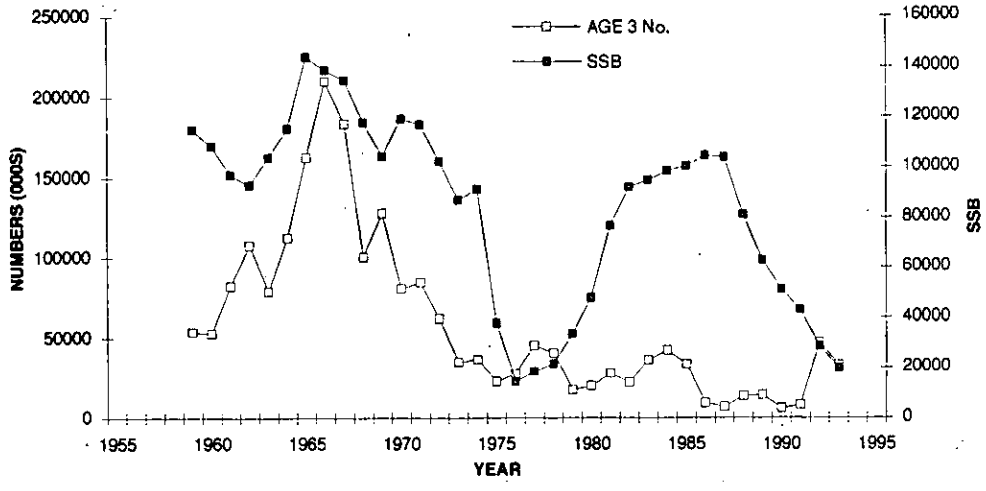


Fig. 5b. Cod in Div. 3NO: SPA age 3 numbers and SSB by year with flat-topped shape recruitment.

The increased abundance estimate for the 1989 and 1990 year-classes results mainly from their strong appearance in the Canadian spring and Russian surveys during 1993. The confidence limits about the 1993 estimates were large for both of these surveys. In the Canadian survey, most cod were found in 2 strata in Div. 3O. The Canadian autumn surveys in 1991 and 1992 also indicated a relatively strong 1989 year-class while the autumn 1993 survey suggested a much smaller year-class size. Estimates from the juvenile groundfish survey in 1993 also indicated a decline in abundance for the 1989 and 1990 year-classes.

The stock in 1993 is represented mainly by the younger age groups (85-90% of the abundance and 40-60% of the biomass at ages 3 and 4 depending on the PR option).

These year-classes (1989 and 1990) have been in commercial catches since age 2 and have dominated the catch numbers at age since 1991. These year-classes will not contribute significantly to the spawning stock until age 6 (50% mature between ages 5 and 6), i.e. 1995 for the 1989 year-class and 1996 for the 1990 year-class.

e) **Consideration of Spawning Stock Biomass**

STACFIS reviewed two documents (SCR Doc. 94/1, 2) pertaining to cod in Div. 3NO which addressed the issue of spawner stock replacement and population sustainability. Both analyses were based on the assessment conducted in June, 1993.

In the first paper, spawning stock biomass was calculated based on annual estimates of the proportion mature at age from 1972 to 1992, and the past recruitments compared with the amount necessary to replace the spawner stock. Three techniques for determining the threshold replacement were examined. These were: F_{rep} which was defined as the level of fishing pressure above which the spawning biomass of a year-class over its lifetime falls below the spawning biomass of its parents on average, %SPR which was defined as the amount of spawner biomass from a single recruit at the average prevailing levels of fishing mortality, fish weights and proportions mature at age relative to that obtained at F = 0 expressed as a percent, and annual replacement which was the amount of recruitment required to replace the spawner stock that gave rise to it at the age specific fishing mortalities, fish weights and proportions mature that pertain to that year. The first two were average estimates, while the third was year specific.

All three techniques indicated that fishing mortality had been above levels to allow replacement in recent years. Recruitment was considered to be below replacement threshold from 1983 to 1989. STACFIS noted that current estimates placed the 1989 year-class very close to the replacement threshold.

One interesting observation was that during the period 1983 to 1987, there was low recruitment (measured as numbers at age 3) from relatively high estimates of spawner stock biomass. The reasons for this were unclear, but a number of possible explanations were discussed. It may be that fecundity or survival during the egg and larval stages was low during that period, or there could have been higher total mortality on the fish before they reached age 3 caused by fishing (discards) and/or environment. The assumption of a dome shaped partial recruitment (which increases the numbers of older mature fish in the population) may be incorrect, and the spawner stock size was not as great as estimated. It was also considered that the observations could have resulted from a combination of these factors. STACFIS commented that it would be interesting to carry out a similar analysis examining fecundity and the numbers of eggs produced to look at changes over time in overall survival to age 3.

The second paper, utilized fecundity information to estimate the sustainability of the stock. A population was described as sustainable when over the lifetime of an individual, survivorship and fecundity allow it to replace itself. Such a population was, in theory, in equilibrium and did not change in abundance over time. The analysis involved the calculation of *r*, the intrinsic rate of natural increase which is '0' for a population in equilibrium, positive for an increasing population, and negative for a decreasing one. Temporal changes in estimates of *r* for Div. 3NO cod were in broad agreement with observed changes in abundance. The paper concluded that it is necessary to lower fishing mortality in order to improve the chances of stock sustainability.

STACFIS considered that these types of analyses are valuable in the provision of scientific advice. Steps should be taken to enable a closer linkage between the analyses and the most current assessment results.

f) **Prognosis**

Stock projections were conducted to the beginning of 1997 to determine $F_{0.1}$ catch in 1994 as well as the impact on spawning stock of both $F_{0.1}$ catch and fishery closure with respect to the 1989 and

1990 year-classes. The parameters which were used to project stock size and SSB are given in Table 1. Population numbers in 1993 were obtained from ADAPT formulations with both flat-topped and domed Prs. Mean weights-at-age were averages of values from 1990 to 1993. Partial recruitment patterns were recalculated based on average Fs for 1991-93. In the June 1993 assessment the 1990 estimates were included in the average PR but these now appeared anomalous and were therefore discarded.

Table 1. Cod in Div. 3NO: parameters used in projections of catch and stock biomass, partial recruitment values were averages for the 1991-93 periods from the two analyses.

Age	Stock Size 1.1.1993 ('000 tons) Dome	Flat	Average Weights (kg) Start of year	Mean annual	Percent Mature	Partial Recruitment Flat	Dome
3	40 279	32 853	0.36	0.46	0.00	0.26	0.32
4	42 899	34 430	0.63	0.83	0.04	0.61	0.75
5	3 967	2 983	1.09	1.37	0.22	0.83	0.94
6	1 967	1 417	1.73	2.13	0.64	0.99	1.00
7	2 371	1 433	2.59	3.07	0.94	1.00	0.90
8	1 107	577	3.82	4.69	0.99	0.84	0.65
9	397	177	5.33	6.07	1.00	0.98	0.60
10	663	240	7.07	8.23	1.00	0.92	0.42
11	1 178	283	8.93	9.65	1.00	0.96	0.34
12	1 800	330	10.44	11.17	1.00	0.94	0.25
13	1 172	337	13.99	12.83	1.00	0.94	0.25

The results of these projections (Table 2; Fig. 2) indicate that an $F_{0.1}$ catch in 1994 could range from 10 600 tons to 18 900 tons depending on the option of PR.

About 66% of this catch biomass would be derived from the 1989 and 1990 year-classes. The beginning of the year SSB in 1995 could be 37 700 or 61 600 tons with fishing in 1994 and 44 600 or 73 700 tons with no fishing in 1994. The 1989 and 1990 year-classes would contribute between 45 and 60% of these SSBs.

The rate at which SSB might recover is indicated in Figure 6a,b. The request for advice on Div. 3NO cod specifies that the SSB development should be set against a reference level calculated as the SSB in the mid-1980s. Figure 6a,b shows the average 1982-87 SSB along with the 1989-90 SSB average for comparison. STACFIS could not determine an appropriate SSB reference but noted that recruitment was low during the mid-1980s.

Table 2. Cod in Div. 3NO: projections of 1994 catch and spawning stock biomass (SSB), reference fishing mortality levels assumed a domed and flat-topped PR in obtaining ADAPT population numbers for 1993.

Reference Fishing Mortality Levels	Catch (1994) (tons)	SSB (1.1.1995) (tons)
	Domed PR	
$F_{0.1}$ = 0.25	18 871	61 649
F_{max} = 0.40	28 622	55 486
No Fishing	0	72 747
F_{94} = 0.07	6 000	69 878
	Flat-topped PR	
$F_{0.1}$ = 0.20	10 609	37 709
F_{max} = 0.30	15 336	34 663
No Fishing	0	44 644
F_{94} = 0.11	6 000	40 767

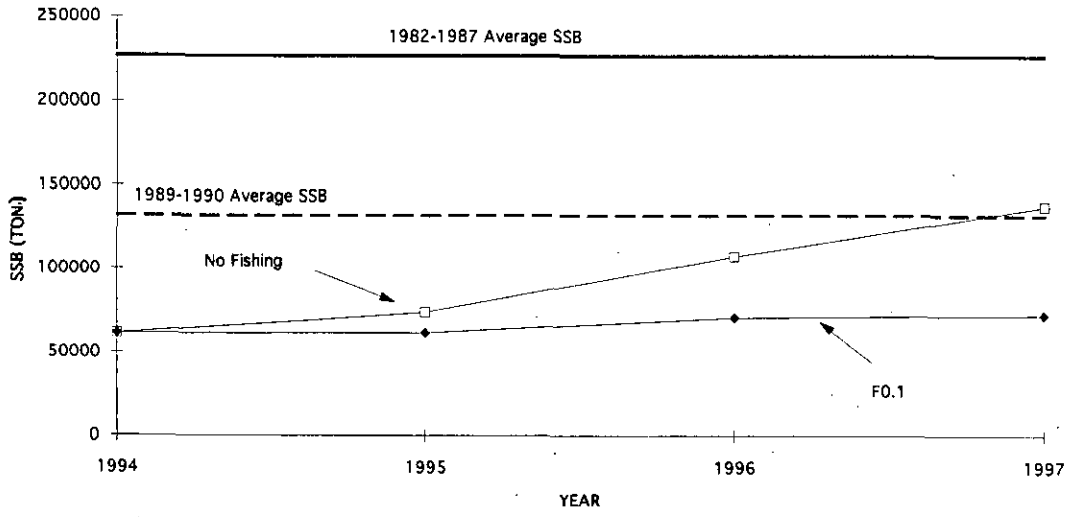


Fig. 6a. Cod in Div. 3NO: projected beginning of year SSB (1994-1997) with domed PR and fishing options in relation to two average SSB levels.

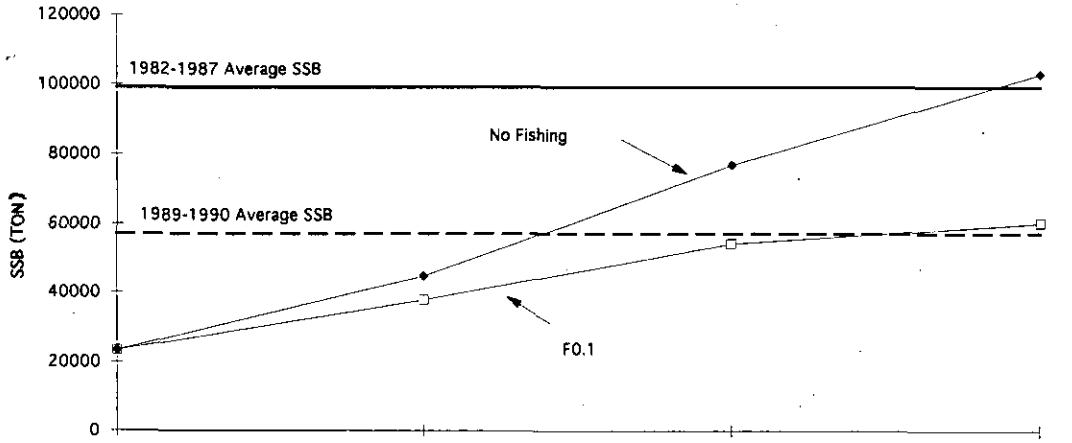


Fig. 6b. Cod in Div. 3NO: projected beginning of year SSB (1994-1997) with flat-topped PR and fishing options in relation to two average SSB levels.

The calculated mid-1980s SSB averages were substantially different depending on the PR (227 000 tons with domed PR and 99 000 tons with flat-topped PR). With flat-topped PR, recovery to mid-1980s level would be achieved by 1997 only in the absence of a fishery, while with a domed PR option, the target would not be reached. The uncertainty of the appropriate PR, as discussed above in section on Estimation of Partial Recruitment, resulted in the inconclusive nature of the assessment at this meeting.

The determination of stock levels present and past is greatly influenced by the option of PR adopted. This issue could not be resolved at this meeting. STACFIS **recommended** that *the estimation of partial recruitment be addressed before the next assessment to include analysis to determine the most appropriate approach for determination of partial recruitment.*

Regardless of the option used in the current assessment, the analyses indicated that the stock has declined since the mid-1980s to levels at or approaching those in the mid-1970s. Projected stock increases in the near future are heavily dependant on the current size of the relatively large 1989 and 1990 year-classes, as the preceding 6 year-classes (1983-88) have been well below average. The current assessment estimates the 1989 year-class to be larger than estimated in the previous assessment.

The survey indices used in the present assessment gave somewhat different interpretations as to the abundance of these year-classes. Two new indices (Canadian autumn and juvenile groundfish surveys) although representing a relatively short time series (4 and 5 years, respectively) indicated a reduction in these year-classes in 1993, while the indices that cover a longer time series and that have been used in most previous assessments (Canadian and Russian spring surveys) suggest a very large increase in the abundance of the 1989 and 1990 year-classes. Distributions of the catches of these ages (3 and 4) in the Canadian survey were from two strata on the slope of the bank and the results from both surveys indicated wide confidence limits about the 1993 abundance and biomass estimates. Large year effects have been observed in the indices in previous years (e.g. 1987), and consequently the results from the 1993 spring surveys should be treated with some caution until the results can be evaluated by further surveys.

The present assessment of the state of the Div. 3NO cod confirmed that the population, and hence a fishery in 1994, would depend mainly on the 1989 and the 1990 year-classes, older year-classes are at a low level.

The assessment confirmed the undesirable PR pattern - the relative high exploitation rate of immature fish are in excess of what is considered prudent. This catch of immature cod represents a sub-optimal use of the resource in yield-per-recruit terms as noted in June 1993. The catch of small cod also decreases future SSB compared to the SSB possible under a better PR. STACFIS therefore reiterates its advice from June 1993:

> "All necessary steps should be taken to eliminate the catch of small fish from this stock".

The precision of the estimate of strength of the 1989 year-class has been improved by including the 1993 survey results in the analysis. The 1993 Canadian and Russian spring surveys both found the 1989 and 1990 year-classes to be abundant. However, the two autumn surveys gave a less optimistic view of these year-classes. Weighing the estimates together provided an estimate of 47 million fish compared with the estimate obtained in June 1993 of 38 million for the 1989 year-class and an initial estimate of the 1990 year-class in the range of 30-40 million depending on the PR. However, the Canadian spring survey found the 1989 year-class predominantly in two strata only and both spring survey estimates have very larger confidence limits. Given the conflicting evidence from the fall surveys STACFIS **advised** that the advice for 1994 as given in June 1993 be left unchanged:

> "The 1994 catch should not exceed 6 000 tons".

STACFIS emphasizes that this catch level is an upper limit and should not be interpreted as a recommended TAC.

STACFIS recognized that the fishery on the year-classes 1982-88 did not allow the stock to replace itself. The low recruitment of the year-classes 1983-88 and the fishery have depleted the SSB and STACFIS **advised** that the stock be allowed to rebuild. The first chance of such a rebuilding is the 1989 and perhaps the 1990 year-classes which will only add substantially to the spawning stock at age 6 in 1995 and 1996, respectively. STACFIS noted that any harvesting would reduce the rebuilding potential.

2. **Other Matters**

There being no other business, the Chairman thanked the Committee members for their good cooperation and adjourned the meeting.

APPENDIX II. AGENDA FOR SPECIAL SCIENTIFIC COUNCIL MEETING, 13-15 FEBRUARY 1994

I. Opening (Chairman: H. Lassen)

1. Appointment of Rapporteur
2. Adoption of Agenda
3. Work Plan

II. Fishery Science (STACFIS Chairman: H. P. Cornus)

1. Stock assessment of cod in Div. 3NO (see Annex 1)

   - catch options for 1994 of cod in Div. 3NO

2. Other matters

III. Adoption of Report

IV. Adjournment

ANNEX 1

The terms of reference presented by Canada pursuant to Article VII of the NAFO Convention

"Canada has received new and most disturbing research information on the state of the 3NO cod stock. This information is of direct concern to other Contracting Parties, and we wish to bring it to their attention. We also request consideration of this information by the NAFO Scientific Council and by the Fisheries Commission and therefore we propose to add under Part III of the draft agenda [for Special Meeting of Fisheries Commission] an additional item Review of Management Measures in 1994 for Fish Stocks Straddling National Fishing Limits - Cod in Division 3NO.

In order to provide the Fisheries Commission with an updated analysis of the status of the 3NO cod population, I would be grateful if you would request the Chairman of the Scientific Council to call a special meeting of the Scientific Council for February 14 in conjunction with the planned special Fisheries Commission meeting of February 15-17.

We propose the following reference to the NAFO Scientific Council on 3NO cod:

> In June 1993, the Scientific Council reported on 3NO cod that the spawning stock biomass is declining and may not begin to rebuild until the 1989 and later, year-classes begin to make a contribution. A Canadian survey in the spring of 1993 and the 1992 fishery showed some encouraging signs of increased abundance of small fish. However, a more recent survey, completed in December 1993, showed a sharp decline in the biomass estimate from 1992. This information suggests a need to reassess the stock status as quickly as possible before the 1994 fishery, given the very low and declining level of the spawning stock.
>
> The Council is asked to review its response to the Fisheries Commission's request for scientific advice in 1993, in light of the most recent information, and particularly review the question referring to spawning stock levels that might be considered necessary for maintenance of sustained recruitment.
>
> In presenting its analyses, the Council is asked:
>
> - to review present (total and spawning) stock size in relation to historical stock levels, and to levels to be expected in both the short term and the long term under various harvest levels;
> - to evaluate the productive potential in relation to these estimated future trends in spawning stock size; and,
> - to provide options for rebuilding the spawning stock to the levels seen in the mid-1980s.

Canada has consulted with European Commission officials who concur with this reference to the NAFO Scientific Council as well as with the consideration of the additional question by the Fisheries Commission."

APPENDIX III. LIST OF RESEARCH AND SUMMARY DOCUMENTS

RESEARCH DOCUMENTS (SCR)

SCR #	Ser. #	Author(s) and Title
94/1	N2354	SHELTON, P. A., and M. J. MORGAN. NAFO Divisions 3NO cod stock - spawner stock biomass and recruitment required for replacement.
94/2	N2355	HUTCHINGS, J. A. Temporal variability in estimates of population sustainability for 3NO Atlantic cod from 1959-94.
94/3	N2356	DAVIS, M. B., C. A. BISHOP, D. STANSBURY, and E. F. MURPHY. An assessment of the cod stock in NAFO Divisions 3NO.

SUMMARY DOCUMENTS (SCS)

SCS #	Ser. #	Author(s) and Title
94/2	N2352	NAFO. Report of Scientific Council, Special Meeting, 13-15 February 1994.

APPENDIX IV. LIST OF PARTICIPANTS

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