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SCIENTIFIC COUNCIL MEETING - JUNE 1992

Report of The Special Meeting Scientific Council, 1-4 June 1992

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REPORT OF THE SPECIAL MEETING SCIENTIFIC COUNCIL

1-4 June 1992

Chairman: V. P. Serebryakov Rapporteur: T. Amaratunga

I. PLENARY SESSIONS

The Scientific Council met at the NAFO Headquarters at 192 Wyse Road, Dartmouth, Nova Scotia, Canada, during 1-4 June 1992, upon the request from Canada as a Coastal State for advice on the status of the cod stock in Div. 2J and 3KL. Representatives attended from Canada, Cuba, European Economic Community (EC-France, Germany, Portugal, Spain and United Kingdom), Japan, Russia and an observer from the United States of America (USA). The NAFO Executive Secretary and Assistant Executive Secretary were in attendance.

The Chairman noted that this special meeting was requested on 24 April 1992 with less than 60-day advance notice to call the meeting on 1-2 June 1992 in accordance with Rule 4.3 of the Rules of Procedure. However, a mail vote was taken to waive this requirement.

The meeting was called to order at 1000 hr on 1 June 1992.

As was the usual practise, the Council appointed the Assistant Executive Secretary as rapporteur.

The Assistant Executive Secretary informed the Council that a request had been received from a Non-Governmental Organization to attend the meeting as observers. The Council unanimously agreed not to extend an invitation at this time.

The provisional agenda was then adopted. Noting Canada's request for the report of this meeting by 4 June 1992, the Chairman hoped that the work be concluded before the end of the meeting on 2 June 1992. Requesting STACFIS to undertake the stock assessments, the session was concluded at 1025 hr.

The Council reviewed the progress of STACFIS deliberations on the evening of 2 June 1992, and agreed to meet when possible during 3-4 June 1992.

The concluding session was convened at 0945 hr on 4 June 1992. The meeting was adjourned at 1415 hr on 4 June 1992.

The adopted Report of the Standing Committee on Fisheries Science (STACFIS) is given in Appendix I.

The Agenda, List of Research Documents and List of Participants are given in Appendix II, III and IV respectively.

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

1. Stock Assessments

The Scientific Council acknowledged that STACFIS had reviewed available documentation pertaining to the status of cod in Div. 2J+3KL as requested by Canada pursuant to Article VII of the Convention. The Council concurred with the conclusion of STACFIS that this cod stock has recently declined rapidly and is currently at or near the lowest level observed. In addition, the Council agreed that the low spawning stock biomass, as approximated by the age 7+ biomass, is caused for concern although there will be some short-term increase related to growth of the relatively strong 1986 and 1987 year-classes . Longer term recovery will depend on the actual strength of the 1988-1991 year-classes, and the level of harvest of the 1986-1987 year-classes will be critical as well. The Council concurred that the cause(s) of the decline is not clear at present, and agreed that it would not be prudent to provide projections beyond 1992 until the processes taking place are better understood and additional commercial and research data collected during 1992 are available and can be analyzed. The Council endorsed the recommendation of STACFIS that *fishing mortality should be reduced in 1992 from the level of recent years and supports their comment that it would be wise to consider* $F_{0.1}$ *catch to be 50 000 tons, the lowest of the range of estimated* $F_{0.1}$ *values.* It was noted that the 1992 catch (to the end of May) was estimated to be about 25 000 tons.

The Council endorsed the research recommendations of STACFIS detailed as follows:

- *further investigations into the relationships between the areal extent of the cold intermediate layer, and recruitment of cod in Div. 2J+3KL be carried out,*
- *further investigations of the linkage between ocean conditions at West Greenland and Labrador be carried out, and*
- *all data on cod relative to the commercial fisheries and research vessel surveys in Div. 2J+3KL during 1992, should be made available at the earliest possible date in 1993, to facilitate the next assessment of this stock.*

SUMMARY SHEET - Cod in Divisions 2J, 3K and 3L

Source of information:

Year		1985	1986	1987	1988	1989	1990	1991	1992
TAC		266	266	256	266	235	199	190	120
Catch		231	252	235	269	253[a]	219[a]	150[a]	
Offshore catch		151	179	156	168	151[a]	106[a]	90[a,b]	
Fixed gear catch		80	72	79	101	103[a]	113[a]	60[a]	
SSB ADAPT		303	290	299	332	299	181	110	
Laurec/Shepherd (L/S)		302	287	295	324	282	155	72	
Recruitment (age 3)	ADAPT	353	173	154	217	385	520	193	
	L/S	340	161	139	184	297	452	165	
Mean F (ages 7-9)	ADAPT	.55	.52	.56	.72	.91	.96	.68	
	L/S	.55	.53	.57	.75	.99	1.3	1.4	

[a] Provisional
[b] Canadian surveillance estimated 111. *See details under catches below.*

Catches: Catches declined from a high of 810 000 tons in 1968 to a low of 139 000 tons in 1978. During 1982-90 catches ranged between 219 000 and 270 000 tons. Preliminary data reported to NAFO indicated a catch in 1991 of about 150 000 tons, although Canadian surveillance estimates along with reported catches put the 1991 catch at about 171 000 tons. The Canadian fixed gear catch declined from 113 000 tons in 1990 to 60 000 tons in 1991.

Data and assessment: An analytical assessment of catch-at-age data was conducted using Canadian RV survey data included in ADAPT and Laurec-Shepherd analyses. The 1991 Canadian RV estimate is about half the 1990 estimate. (See Special Comment 1)

Fishing Mortality: Analyses using both assessment techniques indicated that fishing mortalities have increased from levels of about 0.5 in the mid-1980s to values between 0.7 and 1.4 in recent years.

Recruitment: The 1986 year-class is estimated to be above average and the 1987 *year-class* is estimated to be strong from analyses using both assessment methods. The 1986 year-class estimates were 385 and 300 million fish while those for the 1987 year-class were 520 and 450 million fish from ADAPT and Laurec-Shepherd respectively. Estimates, from both techniques, indicate that the 1988 year-class is below average. Similarities noted between the cold intermediate layer (CIL) of the Labrador current and SPA age 3 abundance suggest that the 1989 year-class may be about average while the 1990 and 1991 year-classes may be weak.

State of the stock: There is little doubt that the stock is currently at a low level. The age 3+ biomass, between 520 000 tons and 640 000 tons, and the age 7+ biomass (approximately the SSB) between 72 000 tons and 110 000 tons are presently at or approaching the lowest levels ever observed for this stock.

Forecast for 1993: With the uncertainty regarding the causes of the large decline in biomass between 1990 and 1991 and given ancillary information suggesting a lack of fish in early-1992, it was concluded that it would not be prudent to conduct quantitative projections beyond 1992. Before advice for 1993 could be provided, data from the 1992 commercial fisheries and research surveys should be evaluated.

Option basis	predicted catch (1992)	predicted SSB (1.1.1993)
$F_{0.1}$ F_{91} F_{MAX}	No Information Available	

Recommendations: (see Council Report)

Special comments:

1. The fishing mortalities derived from the models used were not consistent with research survey and commercial fishing data during recent years, nor with declining trends in fishing effort of Canadian otter trawl fleet. This could be related to assuming constant annual levels of natural mortality for the assessment, which does not account for a possible increase of natural mortality or emigration in 1991.

2. Given the size of the weak 1988 year-class and the similarities between the extent of the CIL and recruitment suggesting below average year-classes for the early-1990s, the 1986 and 1987 year-classes will be the main contributors to the SSB in the immediate future. The actual size of the 1988-91 year-classes and the level of harvesting of cod of the 1986-87 year-classes will be critical to the future levels of both 3+ and spawning biomasses.

2. <u>Other Matters</u>

There were no other matters addressed.

III. ADOPTION OF REPORTS

The Scientific Council adopted the report of STACFIS as presented.

IV. ADJOURNMENT

There being no further business, the Chairman thanked all of the participants for their long hours of work and the excellent scientific contributions. He also thanked scientists who submitted high standard papers in the short time available, the Chairman of STACFIS for conducting the meeting so efficiently, the Executive Secretary and Assistant Executive Secretary for the arrangements of the meeting, and the Secretariat staff for their very excellent support.

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

Chairman: D. B. Atkinson Rapporteur: Various

The Committee met at *NAFO Headquarters, 192 Wyse Road, Dartmouth, Nova Scotia, Canada*, during 1-3 June 1992 to consider and report on the matters pertaining to cod in Div. 2J+3KL referred to it by the Scientific Council (see Agenda, Appendix I). Representatives from Canada, Cuba, Denmark (Greenland), European Economic Community (EC-France, Germany, Portugal, Spain and United Kingdom), Japan, Russia and United States of America (USA) were in attendance. The Chairman welcomed the national representatives to NAFO Headquarters and Canada.

I. STOCK ASSESSMENTS

1. Cod in Divisions 2J, 3K and 3L (SCR Doc. 92/6, 13, 14, 15, 18, 19, SCS Doc. 92/1, 9, 10, 12, 13, 14, 16)

   a) Introduction

      i) Description of the fishery

         Nominal catches for this stock increased during the late-1950s and early-1960s and peaked at just over 800 000 tons in 1968 (Fig. 1). Catches rapidly declined thereafter and were at a low of 139 000 tons in 1978. From 1982 to 1990 catches were in the range of 219 000 to 270 000 tons . However, based on preliminary data reported to NAFO, a reduction to approximately 150 000 tons occurred during 1991, mainly because of reduced catches in the Canadian fixed and mobile gear fisheries. The total Canadian catch increased from a low of about 36 000 tons in 1974 to 214 000 tons in 1983. Catches then declined to 190 000 tons in 1986 but increased to a high of 242 000 tons in 1988. Since 1988 catches have again declined and in 1991 the Canadian catch was approximately 120 000 tons.

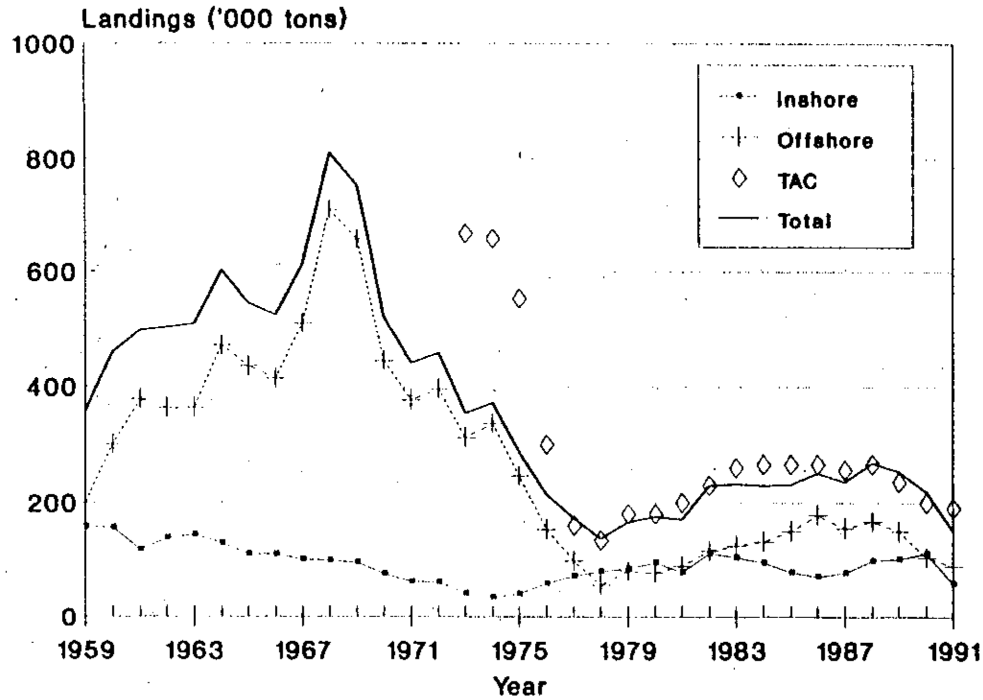

Figure 1. Cod in Divisions 2J3KL: Inshore and offshore landings and TAC's.

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Fixed Gear Catch	113	106	98	80	72	79	101	103[a]	113[a]	60[a]	
Offshore Catch	117	126	135	151	179	156	168	151[a]	106[a]	90[a,b]	
Total Catch	230	232	232	231	252	235	269	253[a]	219[a]	150[a]	
TAC	230	260	266	266	266	256	266	235	199	190	120

[a] Provisional.
[b] Canadian surveillance estimated 111.

Total allowable catches (TAC) were first introduced for this stock in 1973 but during the 1973-76 period did not result in the catches by any fleet sector being restricted. During 1977 Canada extended its fisheries jurisdiction to 200 nautical miles and TACs were reduced to more restrictive levels.

Canada estimates the catches of all fishing vessels that operate in the Regulatory Area using information collected from fishing logbooks and sighting obtained from surveillance platforms. Catch rates observed from vessel boardings are used to determine total catch by fleet in the area. These estimates indicated that the catch of cod by non-Canadian fleets in the Regulatory Area in Div. 3L was about 48 900 tons in 1991. Of the total, 41 900 tons was estimated to have been taken by EC vessels and the remaining 7 000 tons taken by non-

Contracting Parties. The officially reported provisional EC catch of 24 464 tons (Portugal - 9 459 tons; Spain - 8 546 tons; and Germany - 6 459 tons) for 1991 was about 40% lower than that estimated by Canadian surveillance. Prior surveillance estimates of the EC cod catch for Div. 3L have been consistent with those reported. The catch by non-Canadian fleets in the Regulatory Area was taken primarily during the first six months of 1991.

Catch and allocation/allowance data from recent years indicated that Canadian catches have been less than allocations for each year with major discrepancies occurring mainly for the fixed gears. In 1991 the fixed gear catch was lower than the allowance by about 50%, the largest discrepancy since an allowance was first introduced in 1978.

During the 1960s, when the fishery was dominated by non-Canadian fleets, most of the catch occurred in Div. 2J and 3L with 2J generally predominating (Fig. 2). Since that time catches have been mainly from Div. 3K and 3L. Canadian landings by TC-5 otter trawlers have shown considerable fluctuation between these divisions during the 1977-86 period.

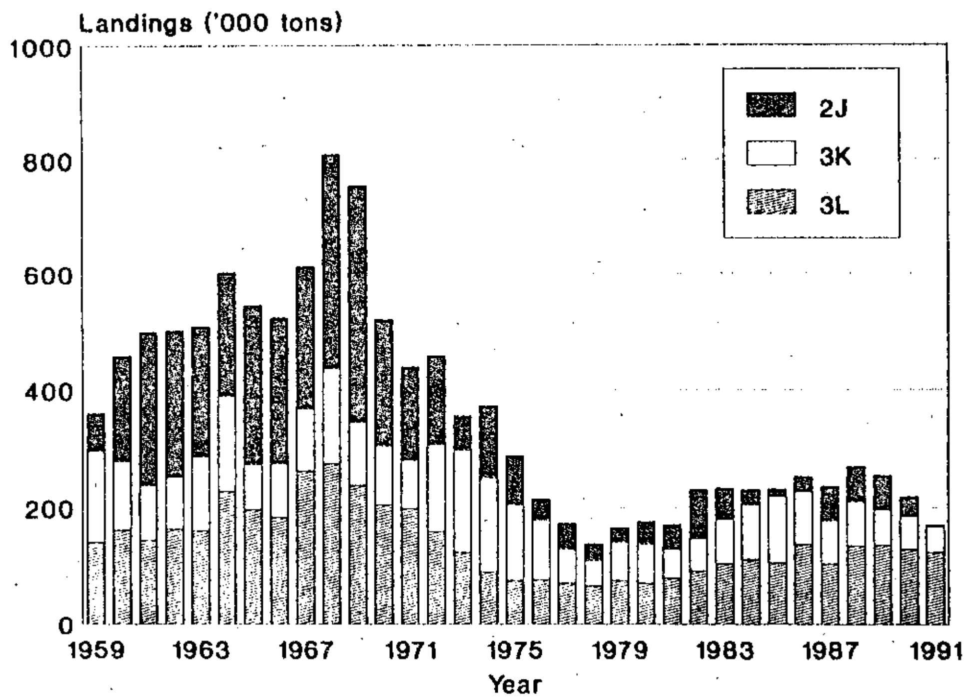

Figure 2. Cod in Divisions 2J3KL:
Landings by Division.

In 1987 a Canadian management plan was put in place to distribute Canadian otter trawl catches equally among all 3 Divisions. As a result catches were more evenly distributed during 1987-89.

In 1990 and 1991 severe ice conditions prohibited the otter trawl fleet from fishing in Div. 2J during the winter months and during other months catch rates were low. This resulted in a shortfall in the offshore allocation in this division. The Canadian catch distribution for large otter trawlers by division during 1990 was 23% in Div. 2J, 34% in Div. 3K, and 43% in Div. 3L, while for 1991 the distribution was 1%, 50% and 49%, respectively.

The catch by fixed gears (traps, gillnets, handlines and longlines) increased from a low of 35 000 tons in 1974 to 113 000 tons in 1982. Catches subsequently decreased to about 75 000 tons between 1985 and 1987 but increased to about 112 500 tons in 1990. In 1991 the fixed gear catch declined by almost half the 1990 level to about 60 000 tons. The catch in 1990 was the highest since 1982 while that for 1991 was the lowest since 1976.

The predominant gears in the fixed gear fishery are traps and gillnets (Fig. 3). The decline in catch from 1990 to 1991 was observed for all gears but was most pronounced for gillnets with a decrease of over 70% from the 1990 level. Trap catches declined slightly from 1990 to 1991 but were comparable to those obtained in the 1986-89 period. In recent years a gillnet fishery has developed in the offshore area of Div. 3L primarily in the area of the Virgin Rocks. In 1990 this fishery contributed about 20 000 tons of the total 27 000 tons gillnet catch for Div. 3L but in 1991 the catch by this gear component declined to about 7 900 tons of a total gillnet catch in Div. 3L of 10 400 tons. During 1991 an estimated 4 000 tons (Canadian Dept. of Fisheries and Oceans surveillance) of offshore gillnet catch, actually taken in Div. 3NO, was

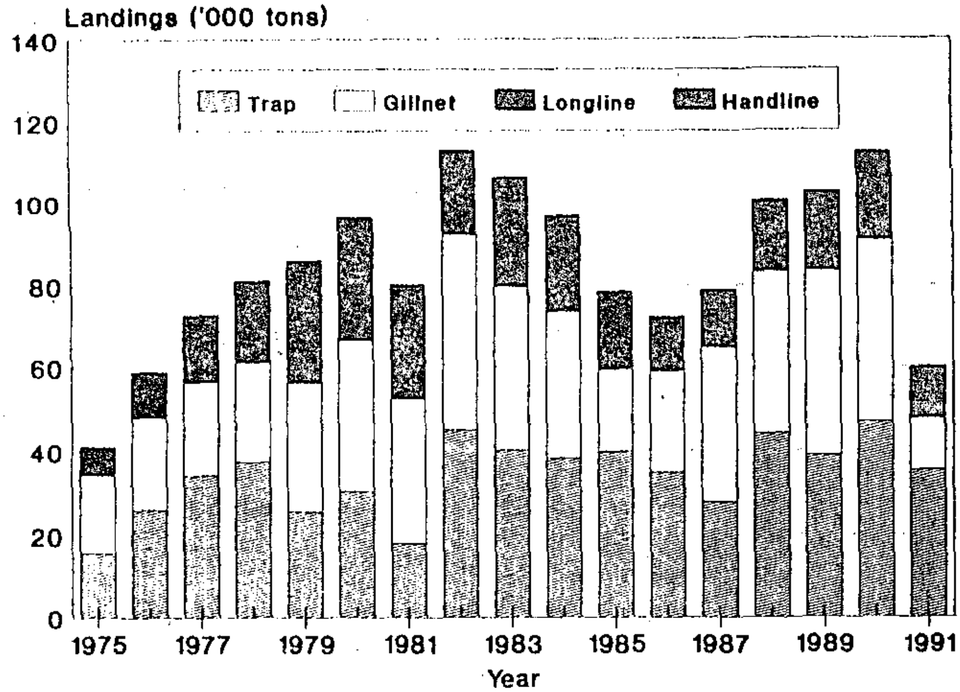

Figure 3. Cod in Divisions 2J3KL:
Inshore landings by gear.

reported for Div. 3L and was not included in the Div. 3L catch. Some of the decline in gillnet catch could have resulted from the presence of poor to average year-classes in the population at ages 6-8, ages which generally have been most abundant in Div. 2J+3KL gillnet catches.

Catches by month for 1991 indicate that Canadian otter trawl landings were mainly in the autumn in Div. 2J, in the winter in Div. 3K and more widespread in Div. 3L with some preponderance toward the late autumn and winter periods. As in the past, fixed gear catches were mainly during the summer period. During 1991 the inshore fishery, relative to other years, was late starting, by about two to four weeks, in virtually all areas in the management unit. Drifting ice was a threat to fixed gear well into the month of July and grounded icebergs blocked some trap berths until about the same time. The cod-trap fishery continued for some two to six weeks longer than usual.

ii) The fishery in 1992

The Canadian offshore catch of cod in 1992 to date was virtually all taken by March. Reduced catch rates, the presence of small fish and reduced allocations lead to reduction in fishing activity throughout the area. Cod were found mainly in southern 3K and northern 3L and predominantly in deeper waters. The total catch of cod to the middle of May in 1992 from Div. 2J+3KL was approximately 14 400 tons compared to 41 700 tons for the same months of 1991, a decline of about 65%. Virtually all the Canadian catch during these months, for both years, was taken by large (>100 ft) otter trawlers fishing in Div. 3KL.

The non-Canadian fleet fishing in the Regulatory Area on the Nose of the Grand Bank had also experienced lower catch rates along with catches of small fish during the early months of 1992. Low catch rates caused vessels from Germany to leave the Regulatory Area early. The catch of cod by EC vessels in Div. 3L for January to April of 1992, as estimated by Canadian surveillance, was approximately 6 900 tons, down from 21 600 tons estimated for the same months of 1991. This represents a decline of almost 70%. EC statistics so far reported to NAFO (1991 - 13 800 tons, 1992 - 2 411 tons) indicate a larger proportionate decline in catch between 1991 and 1992 for these months. This appears to reflect low abundance because numbers of vessels engaged in the fisheries in the Regulatory Area in 1991 and 1992 remained at similar levels.

iii) <u>Environmental conditions in 1991</u>

Environmental observations for the waters off northern and eastern Newfoundland indicated that water temperatures were below normal in 1991. The areal extent of ice coverage was greater than normal and persisted for a longer period of time. Ice was present in inshore waters well into the summer and records were set for last presence of ice. Low ocean temperatures persisted throughout the summer and early autumn and negative anomalies extended from the Labrador Shelf to southern Newfoundland with the largest occurring on the Grand Banks. Temperatures in the bottom water layers (75-175 m) continued a declining trend that commenced in the mid-1980s. The areal extent of the cold intermediate layer (CIL) of the Labrador Current (waters <0°C) was at or near its long term maximum. Bottom temperatures for 1992 are expected to be slightly higher than in 1991 but will remain below normal. The extent of the CIL is expected to remain large in 1992 as well.

Data were also presented which link the climate scenarios in Greenland and Labrador. Evidence was provided of a salinity anomaly during 1988 which was clearly documented off south Iceland, later off East Greenland and off Cape Farewell, but did not reach as far north as the Fylla Bank section. This anomaly of about -0.05 PSU (practical salinity units) found in the Irminger component, might have travelled from West Greenland to Labrador. During 1991 water temperatures off West Greenland, during autumn, in both the surface layers and in the Irminger layer were near normal in contrast to the cold conditions off Labrador and Newfoundland. Temperature was about 1°K above the 1990 autumn conditions, and 0.4°K above the 30-year mean at Fylla Bank. This confirms that the cooling in 1991 off Labrador and Newfoundland did not extend to the eastern side of the Labrador Sea. Data from 1880 to 1990 were presented which revealed a general cooling trend in the West Greenland area since 1969. A similar trend has been observed off southern Labrador.

The influence of these conditions on cod distribution and the fisheries in Div. 2J+3KL has not been fully determined. Evidence from February hydroacoustic surveys and the commercial offshore fisheries suggests that cod have been moving to deeper water on the slopes of offshore banks during winter and early spring. Surveys conducted during autumn also indicate higher proportions of biomass in deep water strata, however this appears to reflect both a reduction of biomass in shallow water strata as well as some movement to deeper water (Fig. 4-6). Length frequencies from research vessel surveys and the Portuguese trawl fishery indicate that similar ranges of lengths were observed in both shallow and deep water areas. The low inshore catches in the northern areas were coincidental with colder than normal water masses although other factors (e.g. stock abundance) might have played a role either by themselves or in concert with the environment. The declining trend in survey biomass is most pronounced in the north.

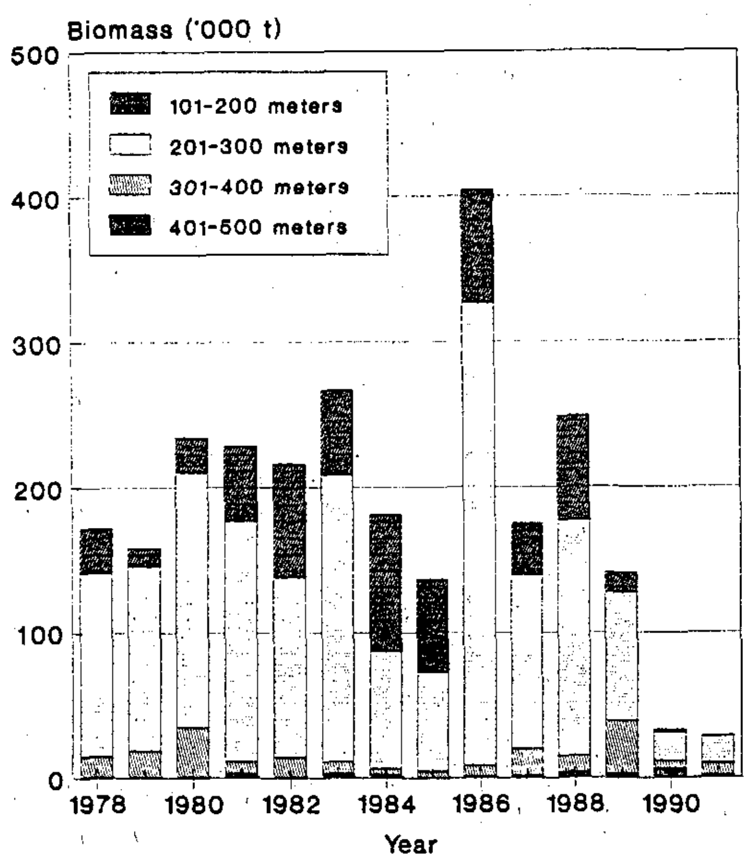

Figure 4. Cod in Divisions 2J3KL:
RV biomass in Division 2J by depth.

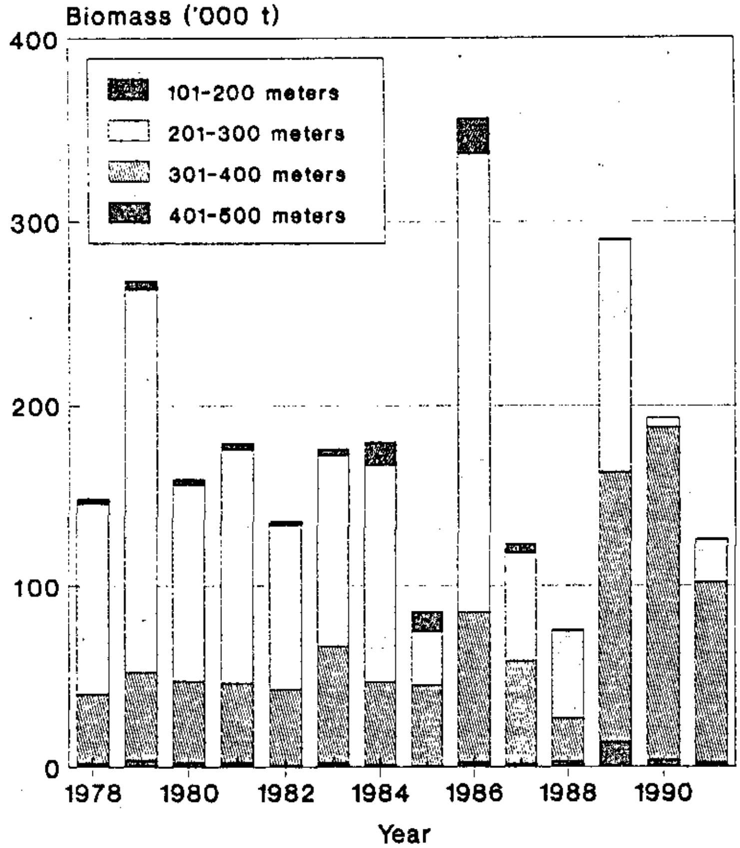

Figure 5. Cod in Divisions 2J3KL:
RV biomass in Division 3K by depth.

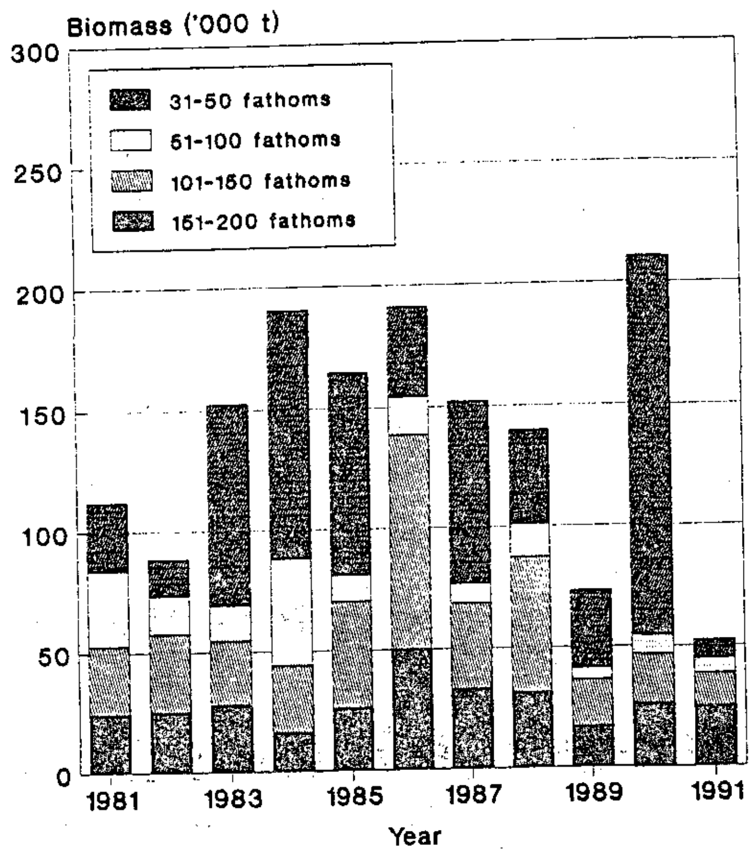

Figure 6. Cod in Divisions 2J3KL:
RV biomass in Division 3L by depth.

Similarities were noted between the time series of areal extent of the CIL and of cod recruitment. A regression analysis was undertaken and a negative relationship was found (r = -0.83) between the area of the CIL waters along the Bonavista transect and the numbers of age 3 cod from VPA in Div. 2J+3KL for the years 1978 to 1988. The area of the CIL in 1990 and 1991 would suggest weak year-classes in those years.

This initiated an investigation of the relationship between CIL area at Bonavista and Fylla Bank/West Greenland temperature and salinity anomalies averaged over the top 200 m. Negative relationships (r = -0.82 for temperature and -0.87 for salinity) were found if the Fylla Bank data were lagged by 7 months. This suggests a coupling of the West Greenland and Labrador current systems.

iv) Interrelationships with other species

Available information on population size, distribution and diet of harp seal in the Northwest Atlantic was briefly reviewed. Previous studies estimated the population at about 1.8 million animals in the mid-1980s. Based on a 1990 aerial survey, the population was estimated to be in the range of 3 to 4 million animals (likely not more than 3.2 million) in that year. Data on seal diet is presently in the form of frequency of occurrence and it is therefore not possible to estimate the consumption of various prey items. However, it was noted that cod were present in a small percentage of the stomachs examined. STACFIS concluded that the increase in the seal population probably had an effect on cod either directly by predation or indirectly by competition and could contribute to, but not account for the decrease in population size.

Studies were reviewed on the trophic relationships between cod and capelin in the Div. 3KL area. It was accepted that capelin is relatively important to the cod diet, however, it could be possible that capelin consumption by cod may be limited at certain times of the year because of spatial separation of the areas of distribution.

b) Input Data

i) Commercial fishery data

Catch and weight at age. Catch and weight at age of the Canadian and French catches inside the Canadian zone was estimated using sampling spread spatially and temporally over all gears and area. Coefficients of variation on the estimated catch were less than 10% for most ages. The 1985 to 1987 year-classes were the most abundant in the commercial catch in 1991. The 1986 and 1987 year-classes dominated the fixed gear fishery in 1991 while the 1985 and 1986 year-classes were dominant in the offshore mobile gear fishery.

The age composition of the catch by non-Canadian fleets fishing in the Regulatory area in 1991 was estimated by applying age/length keys from the Canadian 3L offshore fishery or spring RV surveys to length frequencies provided by Spain, Portugal and Germany. Ages 5 and 6 dominated in the fisheries in the Canadian zone while ages 4 to 6 dominated in the Regulatory Area.

Age compositions of the 1990 catch by Spain and Portugal outside of 200 miles were available and were included in a revision of the 1990 catch at age. A comparison of the original and revised age compositions indicated that more fish at younger ages were taken in 1990 than had previously been estimated.

At the 1991 assessment of this stock the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) recommended that the age compositions from Canadian spring RV surveys be evaluated for their potential use in adjusting non-Canadian catches outside 200 miles. It was previously determined that autumn surveys were not appropriate for this purpose. Results for years with sufficient information to make comparisons indicate that spring RV surveys include proportionately more fish at younger ages than either Canadian or non-Canadian sampling. Consequently it was considered more appropriate to use Canadian offshore sampling if non-Canadian sampling was not available.

The total catch at age for 1991 indicates that the 1986 year-class was most abundant with the highest catch at that age since 1974. The relatively high catch at age 4 and low catches at age 7 and 8 are consistent with the population age structure from the most recent assessment of this stock that shows strong 1987 and weak 1983 and 84 year-classes.

Average weights increased from the early-1970s to the early-1980s and subsequently declined. The 1991 average weights at age compared with those from recent years are marginally lower at ages 4 and 5 but slightly higher for ages 7 and older. In general, no trend in commercial fishery mean weights has been observed in more recent years. Average weights in the Portuguese trawl fisheries decreased for the most abundant year-classes in 1991.

ii) <u>Research survey data</u>

<u>Canadian surveys</u>. Research vessel surveys have been conducted by Canada during autumn in Div. 2J, 3K, and 3L since 1977, 1978, and 1981, respectively. Divisional survey estimates of biomass and abundance have shown large fluctuations in recent years. The values observed in 1991 in Div. 2J were similar to those from the 1990 survey and were the lowest observed in the 14 year time series. Biomass has declined since 1988, and a similar trend was observed for abundance to 1990 with a slight increase in 1991. Both biomass and abundance declined substantially in Div. 3K and 3L from 1990 to 1991. The 1990 estimate of biomass for Div. 3L was the highest in the time series whereas the estimate for 1991 was the lowest. The total biomass estimated from the autumn surveys in Div. 2J+3KL during 1991 was about one-half that estimated in the 1990

survey. In the 1991 autumn survey cod abundance and biomass were low in the shallow water strata. This was particularly true for Div. 3L where in contrast to previous years, cod were found in low numbers in large strata in the 31-50 fathom depth range. Trends in total Div. 2J+3KL biomass (Fig. 7) indicate declines in Div. 2J since 1989 are coincident with increased biomass in the more southern divisions (Div. 3KL) in 1989 and

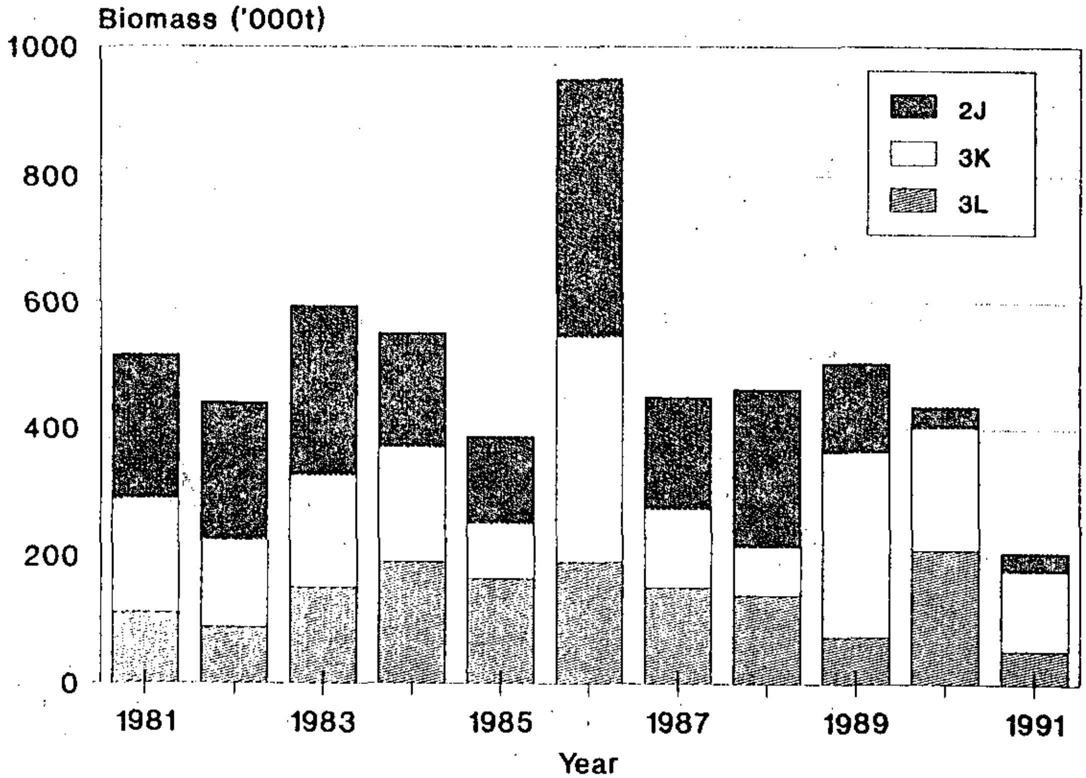

Figure. 7. Cod in Divisions 2J3KL:
Research vessel biomass.

1990. During 1991 low estimates were observed in both Div. 2J and 3L.

The 1991 estimate for the Div. 3L spring survey also declined substantially and was the lowest in the time series since 1977. However, several strata, which previously had high abundance estimates, particularly in 1990, could not be fished in 1991 because of ice coverage.

The total stock area index at age from the autumn survey indicated that although the total abundance had declined substantially, the 1987 year-class, age 3 in 1990, was still above average while the 1986 year-class was near average. The abundance at age observed during the autumn surveys was lower at all ages than that predicted from the 1991 assessment. This was more pronounced at ages 6+.

The 1991 autumn survey biomass and abundance estimates were substantially lower (about 50% by weight and 33% by number) than those observed in 1990 with the difference observed mainly at the older (age 6+) age groups (Fig. 8). The reasons for this decline are not known. The 1991 survey was conducted using gear and methodologies similar to those of previous

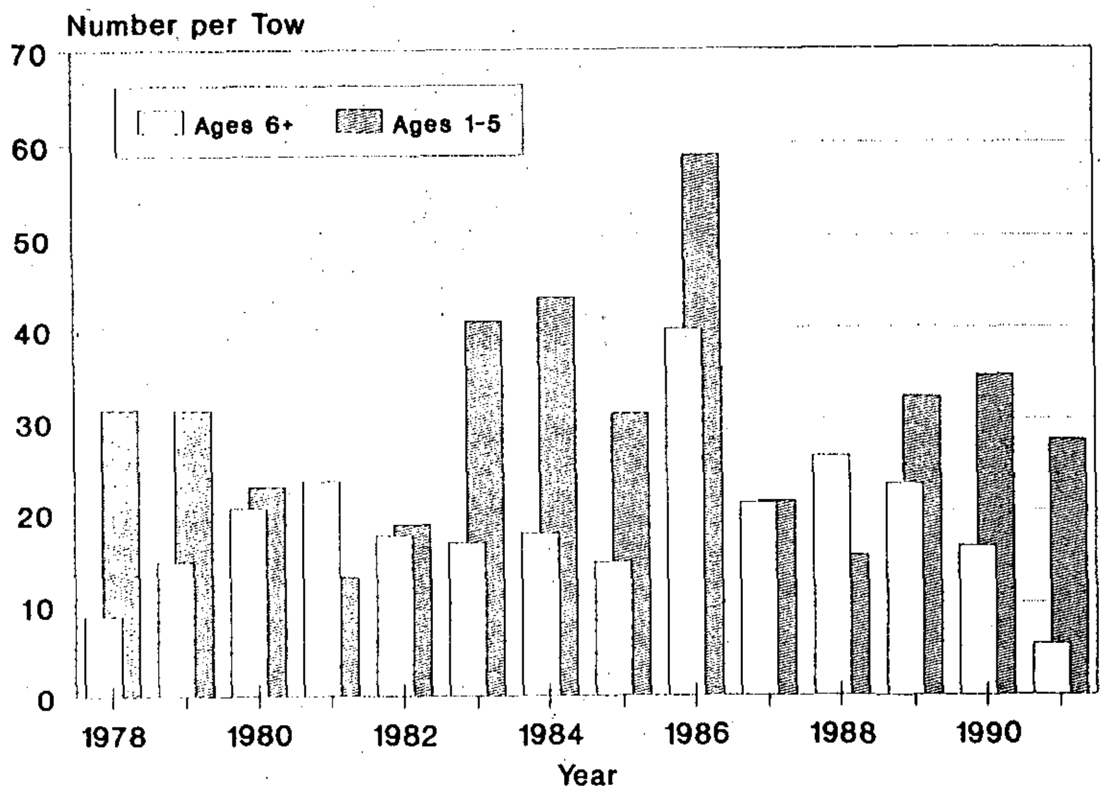

Figure. 8. Cod in Divisions 2J3KL:
Research vessel survey numbers.

years to ensure no systematic change in catchability, though variation may occur. An autumn survey in 1991 in Div. 2GH did not suggest migrations of cod to this area, as the biomass in Div. 2GH was very low. A comparison of age structure and biomass distribution of cod from 1991 spring and autumn RV surveys in Div. 3L and 3NO indicated that there may have been some movement from Div. 3L to 3NO in 1991 but the increase in Div. 3NO biomass in 1991 is insufficient to explain the decline in Div. 3L, let alone in the whole stock area. The Div. 3NO autumn survey has only been conducted during 1990 and 1991 and the differences observed could be the result of annual survey variation.

There was no information to suggest that vertical migration above the area swept by the trawl was a factor. At the beginning of the 1991 autumn survey a hydroacoustic experiment was conducted in a small area in Div. 2J and 3K. The results indicated that densities were low in the area and very few cod were observed in the water column above the standard bottom trawl. In addition, sounder watches maintained throughout the survey did not indicate concentrations of cod in the water column above the trawl.

As reported previously, the inshore fishery was later in 1991 and in some areas good catches persisted until late in the autumn. This might suggest that a higher proportion of the stock remained in inshore areas at the time of the autumn surveys. However, it was noted that abundance in strata close to inshore areas was low.

Survey average weights at age indicated that there was a decline in average weights at ages 4 to 6 since 1989 in Div. 2J and 3K and since 1990 in Div. 3L, while remaining stable or showing some increase at older ages. Recent average weights for all divisions are substantially lower than those observed in the early- to mid-1980s.

Russian surveys. Russia has conducted stratified random surveys in Div. 3KL since 1983. In 1991, Div. 3K was not surveyed due to severe ice conditions. From 1987 onward, the surveys also incorporated an acoustic phase to determine the amount of cod distributed in the water column above the trawl.

In Div. 3K, biomass and abundance estimates in 1988 to 1990 were at the highest level in the time series. In Div. 3L estimates were generally lower in 1987-90 than in the mid-1980s. The trawl survey indicated an increase in biomass in Div. 3L by about 35% in 1991, although the total biomass (trawl and acoustic) showed a decline of about 15% from 1990. With no survey in Div. 3K in 1991 it is not known if the increase in the trawl estimate was caused by movements of cod at the time of the survey from Div. 3K to Div. 3L. The 1991 survey was conducted with a different vessel than previous years and the effects of this change, and of earlier changes in vessels, were not quantified.

The 1986 and 1987 year-classes dominated survey catches in Div. 3L in 1991, comprising about 66% of the total abundance. This compared to 57% of the abundance for the same year-classes from results of the Canadian spring survey in this Division.

Winter hydroacoustic surveys. An annual winter hydroacoustic survey series for cod in Div. 2J+3KL was started by Canada in 1987. Several years were involved in developing the appropriate acoustic hardware and vessel technology that would permit the acquisition of data necessary to estimate the abundance of cod from electronic records. The purpose of these surveys is to determine the abundance and distribution of cod on the seaward slopes of the offshore banks within the management unit. Only in 1991 and 1992 were sufficient electronic data collected to produce such estimates. Similar information for years prior to 1991 could not be obtained because of problems encountered with hydroacoustic hardware and operation of vessel and gear particularly with respect to ice conditions. During years prior to 1991, however, information was obtained on the general distribution of cod in the area surveyed from a combination of visual echogram records and trawling.

In the initial survey (1987) a large concentration was observed in the southern part of Div. 2J and the northern part of Div. 3K at depths ranging from 300 to 500 m. In 1988 and 1989 the major concentration was found slightly further south but in the same depth zone. In the 1990 survey commercial concentrations of cod were found still further south in Div. 3K and mainly at 550 m, about 150 m deeper than in previous years. The general distribution and size range of cod encountered throughout the survey area during 1991 and 1992 were similar to those determined from the trawl surveys conducted during the previous respective autumns. Mean densities in Div. 2J were lower, about the same in Div. 3K, and about 75% lower in Div. 3L in 1992, compared to 1991. In general the 1992 acoustic data obtained from surveys conducted during February indicated that cod densities were lower in 1992 than in 1991, and that fish were smaller and more dispersed. The results for Div. 3K and 3L indicated levels of reduction from 1991 to 1992 similar to those observed from the autumn trawl surveys during these years. In 1991 a large concentration of commercial sized cod was found in the southernmost area of Div. 3K between the depths of 600 and 850 m. This concentration was most dense at 700-800 m, and extended into the northern part of Div. 3L. In 1992 cod were generally dispersed throughout Div. 3K and 3L in depths from 350 to 550 m, with some fairly dense aggregations observed in the northern part of Div. 3L. Length frequencies indicated that most of the cod were between 37 and 43 cm in length.

Migration Research - Summer Hydroacoustics. Research by Canadian scientists on the movement and distribution of Div. 2J+3KL cod during the post spawning onshore migration in the spring of 1990 and 1991 has indicated that during both years, cod migrated onshore in large size-structured aggregations through a "pathway" defined by the bathometry and temperature (2°C). The timing of the passage through the "pathway" was approximately two weeks later in 1991 than in 1990. However, the 1990 inshore catch was itself two weeks later than average. The size distributions differed markedly between years. Large fish (>60 cm) observed in quantity in 1990 could not be found in 1991 despite widespread search patterns in the northern part of Div. 3L and 3K using 2 vessels equipped with dual-beam echosounders and bottom trawls. Average densities within the aggregations recorded in 1991 were well below those recorded for 1990 based on acoustic integration and counting methods and trawl catches.

Cod and seal scouting survey, 1992. A cod and seal scouting survey was conducted in Div. 2J+3KL by two Canadian commercial trawlers charted to the Department of Fisheries and Oceans during April 1992. Using a line survey design these vessels covered an area similar to that surveyed during the February hydroacoustic survey. The results indicated the distribution and size range of cod observed was consistent with that observed in the hydroacoustic survey as well as with other surveys (cod tagging in January, 1992 and fall 1991 groundfish) and the commercial fishery.

c) Commercial Catch Rates

A C/E index at age for 1983-91 was derived using the catch at age from the offshore fleet along with the calculated fishing effort from the C/E standardization. This index indicates that the 1986 year-class is relatively strong while the 1985 year-class appears to be about average. The 1983 and 1984 year-classes are weak. Although this index indicates that the numbers of age 3-5 cod are at a level similar to previous years, the numbers of cod ages 6 and older have declined and are at their lowest level in the series. A comparison of observed and predicted C/E at age for the 1991 offshore catch indicated that fewer fish were caught at older ages than was expected.

A spatial analysis technique (SPANS) was used to convert estimates of catch rate and area fished from observer data collected in January to April over the period 1980-91 into a biomass index. An index at age was derived by adjusting the Canadian otter trawl age composition by the ratio of the SPANS biomass index to otter trawl landings for each year. This index was judged to be preliminary by its authors who advised against its use in its present form.

Catch at age from cod traps for the 1978-91 period was also examined as a potential index of abundance. The trap index was also considered to be preliminary. Before this index can be used for calibration purposes, additional analysis should be conducted to determine the internal consistency of year-class strength. In addition, the impact of the assumption of constant cod-trap fishing effort should be evaluated.

d) Estimation of Stock Parameters

Several formulations of the adaptive framework (ADAPT) and the Laurec-Shepherd (L/S) calibration analysis were examined in an effort to evaluate the abundance indices and for the determination of stock size. With the uncertainties with the SPANS and cod-trap indices and because of the lack of fit with the commercial C/E to SPA, STACFIS concluded it was appropriate to conduct calibrations with the RV index only.

To determine the effect of the amount of catch in the terminal year on the results of calibration, ADAPT and L/S analyses were conducted using both 31 400 tons (reported EC catch of 24 400 tons and Canadian estimate of 7 000 tons for non-Contracting Parties) and 48 900 tons (Canadian estimate) as the size of the catch in the Regulatory Area during 1991. The results of these analyses indicate that there is little impact on the beginning of the year population estimates for 1991 and previous years of a change in total catch in 1991 by about 12%, however, there is a marginal change in the estimated fishing mortalities in the terminal year to accommodate the different catch. The impact of a different catch will be more obvious when making comparisons of projected catch for 1992.

The model formulation used with ADAPT, including RV data only, indicated Cvs on the estimated population abundance at age were in the range of 18% to 44%, while those on the estimated catchabilities were all about 12%. The positive year effect for 1986 identified during previous assessments was again realized in this calibration. The 1991 RV residuals were all negative while those for 1989 and 1990 were all positive. It was suggested that this pattern could have been caused by: the occurrence of positive year effects for 1989 and 1990 combined with a negative year effect for 1991 or effective natural mortality (fish death or migrations) in 1991 being higher than that assumed in the model (0.2). Additional commercial fishery and RV survey information collected during the early months of 1992 indicate that the large decline in RV biomass, which resulted in the disturbing residual pattern for 1989-91, may be more attributed to natural mortality than availability. This situation should become clearer after data from the commercial fisheries and autumn RV surveys for 1992 are evaluated.

The only difference between the structure of the L/S formulation and that of ADAPT was that for L/S the F on the oldest age group (13) was set to 50% of the mean of the 5 previous ages (8-12) while for ADAPT the mean for ages 7-9 was used. Age specific catchabilities did not exhibit any discernable trends over the 14 year time series.

Impact of assumptions about natural mortality/availability. The models which have been explored are not consistent with the data and suggest an increase in natural mortality or emigration. As a consequence, the resulting patterns of population abundance and fishing mortality as derived from the models are distorted for the recent years and interpretation requires care. An illustrative ADAPT analysis was conducted which assumed natural mortality on older ages in the terminal year to be higher than the originally assumed 0.2 to account for the unexplained absence of older cod. It was agreed that these types of models more adequately represent the situation that occurred during the recent few years because trends in fishing mortality are more realistic and are more coherent with other information that indicates no increase in fishing effort. However, it is currently impossible to quantify the age specific natural mortalities that should be assumed.

Fishing mortality and stock abundance (Fig. 9 and 10). The ADAPT assessment indicated that the 1991 age 7-9 unweighted mean F is about 0.7 with the age 3+ population numbering about 940 million cod. The age 3+ population biomass is about 640 000 tons and the age 7+ (approximately the SSB) is 110 000 tons. The analysis conducted using the L/S technique gave a somewhat more pessimistic view of total abundance (780 million fish), 3+ biomass (520 000 tons

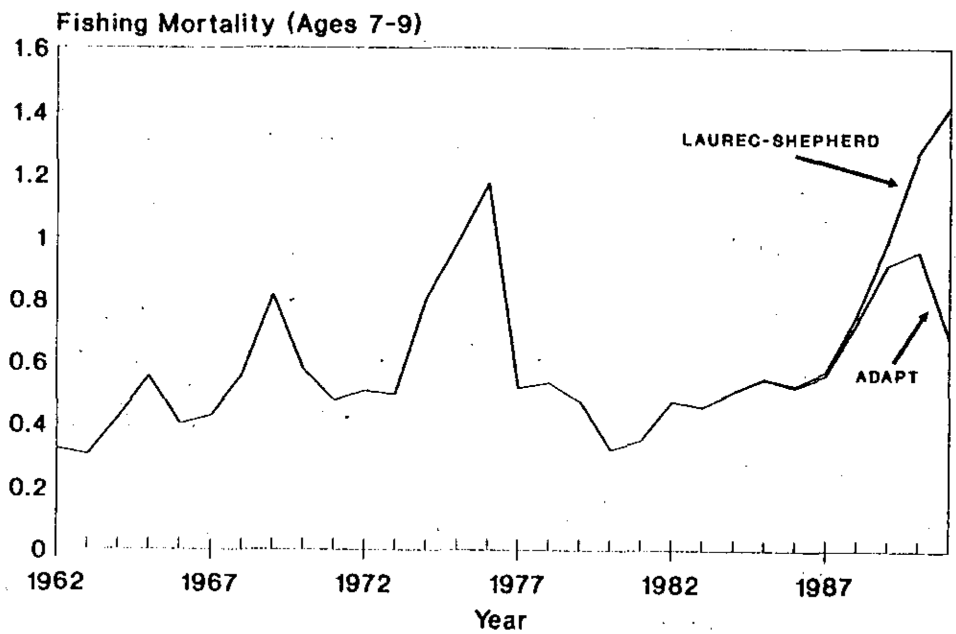

Figure 9. Cod in Divisions 2J3KL:
Mean fishing mortality.

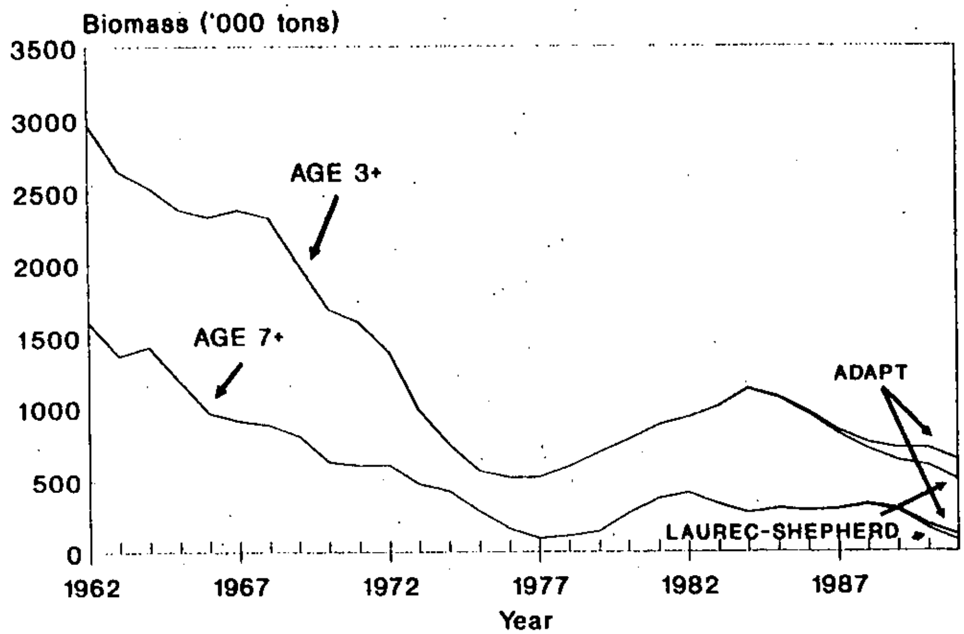

Figure 10. Cod in Divisions 2J3KL: January 1 population biomass.

in 1991), and SSB (72 000 tons) than the ADAPT analysis. The age 7-9 fishing mortality is also considerably higher at about 1.4. Both analyses indicated a sharp increase in fishing mortality from levels in the mid-1980s of around 0.5 to values between 0.7 and 1.0 (ADAPT) or greater than 1.0 (L/S) in 1989-91. It was noted that the increase in fishing mortality in the recent years is inconsistent with the trends in fishing effort by Canadian fleets. The total number of hours fished by the Canadian otter trawl fleet in Div. 2J+3KL declined consistently from 63 000 tons in 1988 to 43 500 tons in 1991.

ADAPT calibration shows a decline in F in 1991, while the L/S indicated a continued increase in F to 1991. STACFIS noted that both calibrations gave a radically different view of the recent trends in F compared to that observed in recent assessments of this stock, but as seen above, the estimates of fishing mortality must be interpreted with care.

The reason for the differences in the results from both calibration techniques is the treatment of the terminal year values of the abundance indices. The model formulation used with ADAPT considers all RV estimates of a cohort to determine year-class strength, whereas the L/S method uses only the RV indices for the last data year. The difference in results therefore, can be attributed to differences in the degree of influence placed on each survey year. In this particular case, some of the disparity occurred because of different assumptions regarding the timing of the survey. The ADAPT formulation assumed that the survey index corresponded to the population fished until November (autumn RV) while the L/S assumed that the survey corresponded to mid-year.

Recruitment (Fig. 11). The ADAPT calibration indicated the 1986 and 1987 year-classes to be above average at 385 and 520 million cod, respectively while the 1988 year-class, age 3 in 1991, is well below average at approximately 175 million fish. The 1978-91 geometric mean recruitment for this stock is now estimated to be about 270 million fish. The corresponding results from the L/S analysis were 300 and 450 million for the 1986 and 1987 year-classes respectively. The 1988 year-class was also estimated to be below average at about 165 million. The L/S geometric mean recruitment was 250 million.

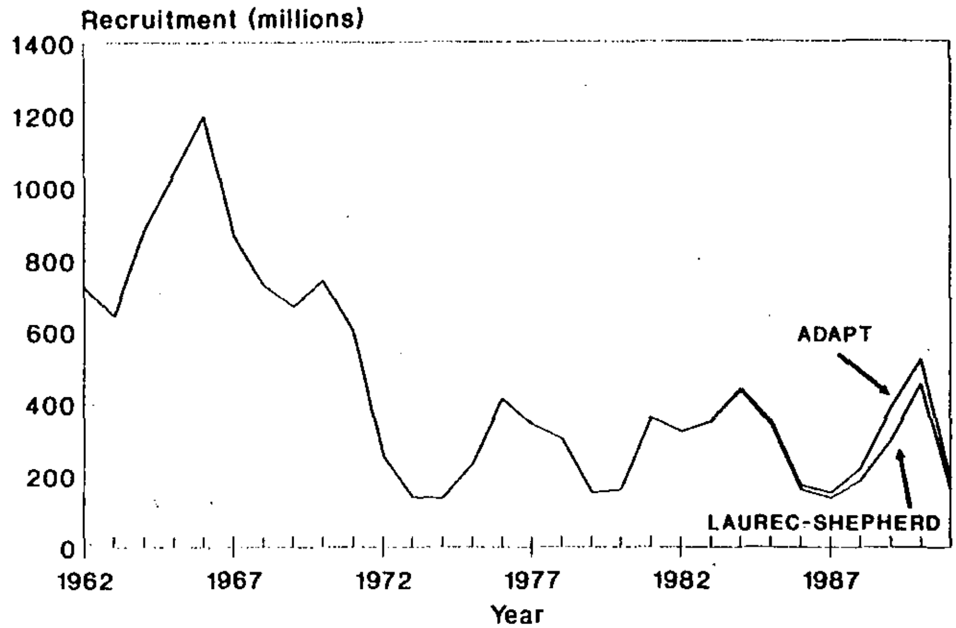

Figure 11. Cod in Divisions 2J3KL: Age 3 population numbers.

<u>Retrospective analysis (Fig. 12)</u>. Retrospective analyses were conducted using both calibration techniques. Trends in mean F, population biomass, and catch, projected at an arbitrary F of 0.40 were examined for retrospective patterns. Such patterns were present in some but not all years and it is quite clear that the

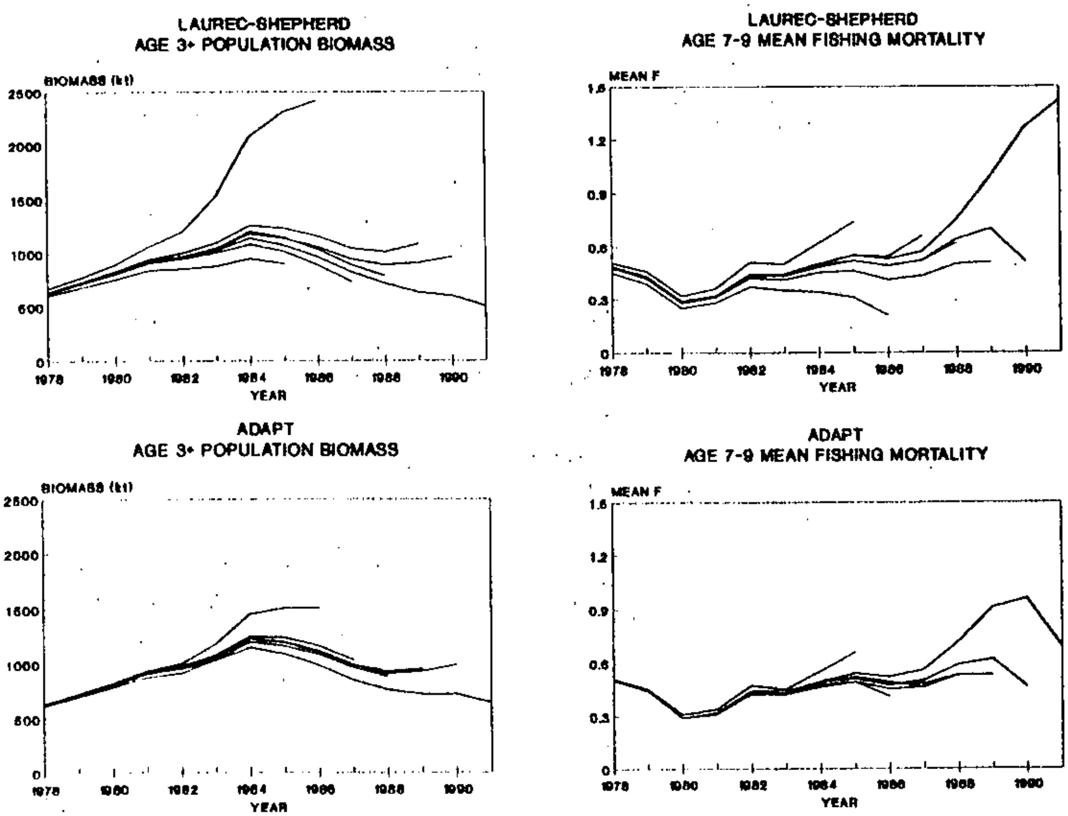

Figure 12. Cod in Divisions 2J3KL: Retrospective analysis.

terminal year population estimates, fishing mortalities and subsequent projected catches are very sensitive to changes in the abundance index used in calibration. In general, the ADAPT results are a little more optimistic than the L/S results. However, the ADAPT estimates were not adjusted for bias for this comparison. The L/S calibration gives more variable results when the index in the terminal year shows major changes from previous years, as seen in the 1986 and 1991 RV estimates.

The retrospective analysis from both methods indicates a sharp discontinuity between the 1990 and 1991 assessments. The analysis confirms that both models have not adequately captured the dynamics which occurred during 1990 and 1991. Estimates of mean F were similar with both methods, around 0.5, until 1989. The L/S shows a continual increase in F to 1991 while the F for the ADAPT analysis shows an increase in F followed by a decline. This difference is consistent with the different weighting of surveys in the terminal year by the two approaches.

e) Prognosis

It was concluded by STACFIS that the stock has recently declined rapidly and is currently at or approaching its lowest observed level. The exact cause(s) of this decline is unclear. In the face of uncertainty regarding which model formulation is most reliable, and the ancillary information suggesting a lack of fish in early 1992, STACFIS concluded that it would not be prudent to conduct quantitative catch projections beyond 1992 at this time. In addition, if the illustrative SPA, assuming an increase in natural mortality in 1991, approximates the actual events then meaningful predictions with respect to stock status will not be possible until it is determined if this situation will continue. Before advice for 1993 is provided, data from the 1992 commercial fisheries and research vessel surveys should be reviewed. Therefore, only projections for 1992 are provided.

With the uncertainty associated with the treatment of the terminal year in the calibration index, it was thought appropriate to conduct the standard suite of projections of catch, biomass and F for 1992 using the results of both ADAPT and L/S calibrations. These projections were done using the SPA results from calibration analyses with the upper and lower levels of 1991 catch in the Regulatory Area.

Input parameters for projections are as follows:

A) Catch in Regulatory Area of 48 900 tons

Age	Jan. 1 1992 Population Nos.(000) ADAPT	L/S	Weight at age (kg)	Partial Recruitment ADAPT	L/S
3	270,000	250,000	0.42	.017	.012
4	141,310	132,375	0.68	.14	.12
5	315,586	268,601	1.02	.40	.35
6	132,035	83,953	1.45	.70	.63
7	32,065	17,164	1.88	1.0	1.0
8	10,766	5,326	2.19	1.0	1.0
9	5,182	1,500	2.57	1.0	1.0
10	3,787	827	3.07	1.0	1.0
11	1,676	450	3.78	1.0	1.0
12	404	116	5.02	1.0	1.0
13	273	36	6.41	.50	.50
14	190	58	8.45	.50	.50
15	0	0	10.47	.50	.50

B) Catch in Regulatory of 31 400 tons

Age	Jan. 1 1992 Population Nos.(000) ADAPT	L/S	Weight at age (kg)	Partial Recruitment ADAPT	L/S
3	270,000	250,000	0.42	.016	.013
4	140,807	128,180	0.68	.15	.12
5	316,838	267,157	1.02	.44	.34
6	136,356	86,571	1.45	.77	.72
7	34,143	18,442	1.88	1.0	1.0
8	11,361	5,678	2.19	1.0	1.0
9	5,629	1,660	2.57	1.0	1.0
10	4,145	890	3.07	1.0	1.0
11	1,813	504	3.78	1.0	1.0
12	457	137	5.02	1.0	1.0
13	300	71	6.41	.55	.64
14	197	65	8.45	.50	.50
15	0	0	10.47	.50	.50

The weights at age were averages of values from the commercial fishery from 1989 to 1991. Partial recruitment values were determined for each analysis and were averages from fishing mortalities assuming full recruitment at ages 7-9 for the same period. Natural mortality was assumed to be 0.2. The 1989 and 1990 year-classes at age 3 were set at 270 million for the ADAPT and 250 million for the L/S, each being the geometric mean recruitment from 1978 to 1991 from the respective analyses.

The results of projections for 1992 over a range of fishing mortalities are presented in Fig. 13 with the catches for 1992 for all evaluated scenarios, projected at the $F_{0.1}$ reference level, as follows:

	1991 Catch (tons) in the Regulatory Area	
	48,900	31 400
ADAPT	79 000	91 000
Laurec-Shepherd	50 000	57 000

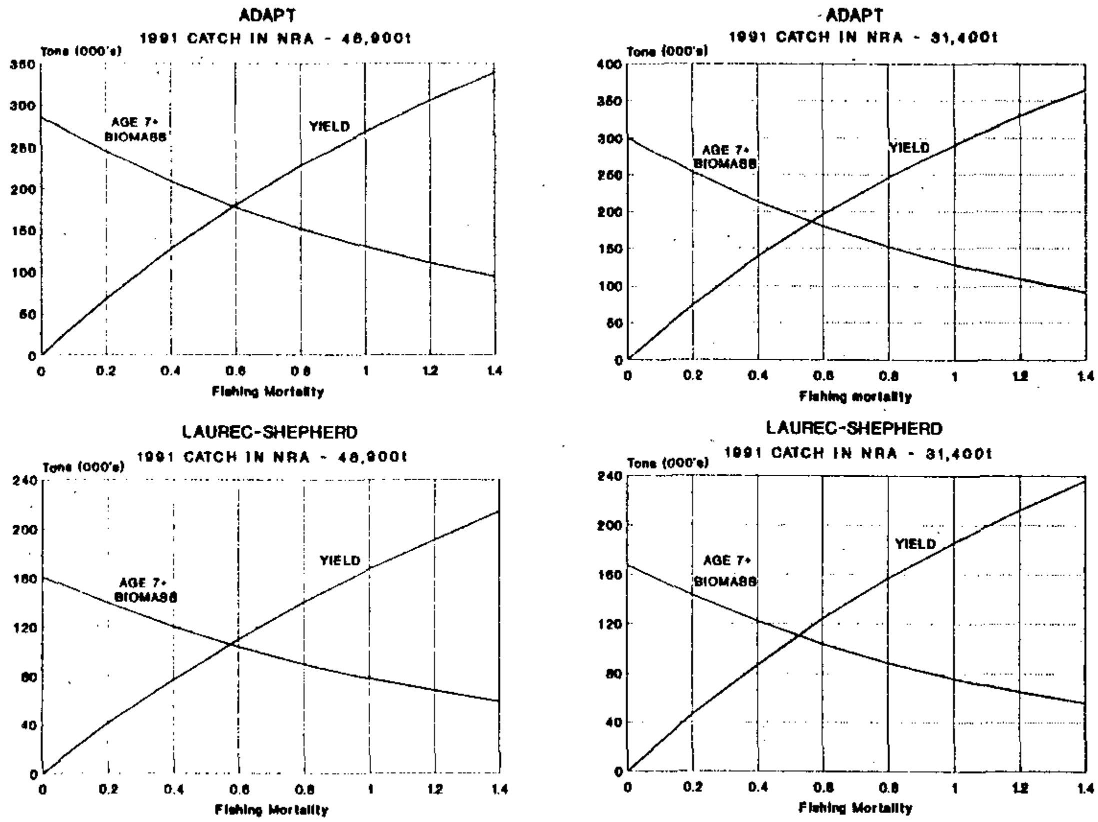

Figure 13. Cod in Divisions 2J3KL:
Projections of catch and age 7+ biomass for 1992.

There is little doubt that the stock is at a low level regardless of which calibration technique is used. The age 3+ biomass, between 520 000 and 640 000 tons, and even more disturbing, the age 7+ biomass (approximately the SSB), between 72 000 and 110 000 tons, are currently at or near the lowest levels ever observed for this stock. The fishery in 1992 will be dominated by only two year-classes, those of 1986 and 1987. The limited information available indicates that the 1988 year-class is below average, and is currently estimated to be about the level of the weak 1983 and 1984 year-classes. Comparisons between the extent of the CIL of the Labrador current and year-class strength also suggest the 1990 and

1991 year-classes may be weak, with the 1989 year-class close to average. With the current status of the resource and the lack of potential recruitment STACFIS therefore recommends that *fishing mortality should be reduced in 1992 from the levels of recent years.*

Under the most optimistic option, to achieve a fishing mortality rate of 0.25 ($F_{0.1}$) in 1992 the total catch should not exceed 91 000 tons. Given the uncertainties in the assessments and the obvious requirement for caution, it would be wise to consider the $F_{0.1}$ catch to be at the lower value of 50 000 tons. It should not be forgotten that at least 20 000 to 25 000 tons appears to have been already caught in 1992.

The present level of the spawning stock is such as to cause concern. It is noted however, that the spawning stock biomass is expected to increase in 1992 and 1993, but remain at a low level, with the contribution of the above-average 1986 and 1987 year-classes. Given the possible relationship between the extent of the CIL and the success of recruitment, there is concern that the year-classes 1988-91 may be among lower values observed during 1978-87. Under this scenario the 1986 and 1987 year-classes could be the main component of the SSB until the mid to late-1990s. Thus the actual size of the 1988-91 year-classes and the level of harvesting of cod of the 1986-87 year-classes will be critical.

f) Recommendations

STACFIS recommends that:

- *further investigations into the relationships between the areal extent of the cold intermediate layer, and recruitment of cod in Div. 2J+3KL be carried out,*
- *further investigations of the linkage between ocean conditions at West Greenland and Labrador be carried out, and*
- *all data on cod relative to the commercial fisheries and research vessel surveys in Div. 2J+3KL during 1992, should be made available at the earliest possible date in 1993, to facilitate the next assessment of this stock.*

2. Other Matters

There being no other business, the Chairman expressed gratitude to the NAFO Secretariat for their continued support throughout the meeting. Thanks was also extended to all of the participants for their valuable contributions during the discussions. The meeting was then adjourned.

APPENDIX II. AGENDA FOR SPECIAL SCIENTIFIC COUNCIL MEETING - 1-2 JUNE 1992

I. Opening (Chairman: V. P. Serebryakov)

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

II. Fishery Science (STACFIS Chairman: D. B. Atkinson)

1. Stock assessments of cod in 2J-3KL (Annex 1)

   - historical stock levels
   - present stock size
   - interrelation with other species and its possible influence of the stock size
   - environmental conditions and their possible influence on the stock size and distribution
   - evaluation of the present spawning stock size in relation to the continuing productive potential of the stock
   - status of the stock and the implications of fishing at F0.1 in 1993 and subsequent years
   - projection of catch rate and TACs for 1993 and the long term

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 requests the Scientific Council to consider the following in assessing and projecting future stock levels for 2J-3KL cod:

- As this stock is subject to an analytical assessment (dynamic-pool type), the status of the stock should be reviewed and the implications of fishing at $F_{0.1}$ in 1993 and subsequent years should be evaluated. The present stock size should be reviewed and should be described in relation to historical stock levels and to the levels to be expected at $F_{0.1}$ in both the short and long term. The Scientific Council should also evaluate the present spawning stock in relation to the continuing productive potential of the stock. All results should be expressed in terms of stock sizes, catch rates and TACs implied for 1993 and the long term.

APPENDIX III. LIST OF SCIENTIFIC COUNCIL RESEARCH AND SUMMARY DOCUMENTS

RESEARCH DOCUMENTS (SCR)

SCR #	Ser. #	
92/6	N2039	Narayanan, S., S. Prinsenberg, and E. B. Colbourne. Overview of environmental conditions in NAFO Divisions 2J+3KL in 1991.
92/13	N2055	Kuzmin, S. A. Stock assessment of cod from NAFO Subarea 3 by the data from 1991 trawl-acoustic survey.
92/14	N2056	Albikovskaya, L. K., and O. V. Gerasimova. Feeding and trophic relations between cod and capelin of the northeastern Newfoundland (3K) in spring-summer.
92/15	N2057	Gerasimova, O. V., L. K. Albikovskaya, and S. A. Kuzmin. A study of trophic interrelations between cod (*Gadus morhua*) and capelin (*Mallotus villosus*) on the Newfoundland Shelf in spring and summer seasons of 1985-1991.
92/18	N2063	Baird, J. W., C. A. Bishop, and E. F. Murphy. An assessment of cod stock in NAFO Divisions 2J3KL.
92/19	N2064	Stein, M. Variability of climate - impact on cod recruitment off West Greenland.

SUMMARY DOCUMENTS (SCS)

SCS #	Ser. #	
92/1	N2042	NAFO. Reports of Scientific Council, March 1992 Meeting.
92/9	N2058	Koeller, P., J. S. Loch. Canadian research report for 1991. SECTION I - Scotia Fundy Region SECTION II - Gulf Region
92/10	N2060	NAFO Secretariat. Report of the Joint ICES/NAFO Working Group on harp and hooded seals, Copenhagen, 14-18 October 1991.
92/12	N2066	Borovkov, V., S. Kovalev, and P. Savvatimsky. PINRO research in the NAFO Area in 1991.
92/13	N2067	Vazquez, A., G. Perez-Gandaras, J. Paz, J. Zamarro, and S. Junquera. Spanish research report for 1991.
92/14	N2082	Alpoim, R., M. Carneiro, L. Godinho, and A. Avila de Melo. Portuguese research report for 1991.
92/16	N2090	EC Group. Report of an EC Group of Experts. An assessment of the stock of cod in NAFO Divisions 2J3KL.

APPENDIX IV. LIST OF PARTICIPANTS

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