Northwest Atlantic Fisheries Organization

Serial No. N2090 NAFO SCS Doc. 92/16

SCIENTIFIC COUNCIL MEETING - JUNE 1992

REPORT OF AN EC GROUP OF EXPERTS

London, England, 17-19 March 1992

An Assessment of the Stock of Cod in NAFO Divisions 2J3KL

BACKGROUND

Following a scientific analysis (CAFSAC Working paper 92/7) and an advisory document (CAFSAC advisory document 92/2), the Canadian authorities undertook several management measures to protect the stock of cod in 2J3KL. They also requested foreign countries, EEC among them, to adopt similar approaches in their management of the fisheries outside 200 miles. The Commission, before taking any initiative on management, convened a Group of experts to examine the scientific background of the issue and to give a preliminar advice to the EC. The meeting took place in London, 17-19 March 1992

Participants.

A. Avila de Melo
P. Cornus
G. Kirkwood
Ph. Moguedet
K. Patterson
J. Shepherd (part time)
K. Stokes
A. Vazquez

Commission services:

A. Astudillo
A. Laurec (part time)

1. REVIEW OF THE EXISTING INFORMATION.

1.1. Community fisheries in 1991.

Fishing vessels from Germany, Spain and Portugal were fishing in international waters of division 3L in 1991. Estimates of catches were not available for all countries and therefore, officially reported figures were adopted as starting point for the assessment, as follows:

Germany:	6459
Spain:	8546
Portugal:	9459
Total EC:	24463

As regards non-contracting parties, the estimate of 5000 t made by Canada was adopted.

Large discrepancy occurs between these figures and those estimated by Canada. The Group wondered whether Canadian estimates were based on constant catch rates, when in fact they show a decreasing trend along the year. As Canadian estimation methods were unknown, no further discussions followed.

1.2. Sampling. Catch at age.

Germany had market samples in January and samples from a trawler thereafter. Length distributions by month were available, showing close agreement with the Spanish patterns (maximum catch on ages 5 and 6)

Spain has four observers in the pair trawler fleet, which accounts for a large majority of the catch. Length distributions by month and quarterly age-length keys (ALK's) were available. It was decided to use these ALK's to estimate catch at age by the German fleets. Portugal has four observers in its fleet of stern trawlers. Monthly length distributions and quarterly ALK's were available. Catches consisted in cod smaller than for other fleets.

The age composition of the catches by non-contracting parties was estimated to be the same as for EC fleets, since they operate in the same area (Table 1.2).

1.3. Catch rates.

Germany found in 1991 catch rates far higher than in 1990. In 1992 some hauls made in 3L showed very high catch rates, but only for a few days. As these high catch rates did not continued to appear, the fleet moved away.

Spanish catch rates in 1991 were at the same level or a little higher than in 1990. No information was available for 1992.

Portugal also found catch rates in 1991 to be much higher than in 1990. In 1992 the fishing vessels did not appear in 3L.

France also reported high catch rates in 3L inside 200 miles, but their quota is too small to develop a large fishery.

All these pieces of information show large discrepancies between Canadian and Community fisheries, the former having suffered a general decrease in catch rates in 1991. It was commented the difficulty of explaining to EC skippers that the stock could be in danger, whereas for them the fishery seemed healthy.

The reported high catch rates were found at waters deeper than in preceding years. This phenomenon, also described by Canadian scientists, appears to be gradual since some years ago (figure 1.3), and is also observed in other areas (3PS, 3NO). The Group discussed the possibility that the apparent decrease in the stock observed by the Canadians were only an artifact originated by a migration of cod to deeper waters. Further considerations are reported below.

1.4. Distribution in space and time.

Percent biomass by division was fairly stable for a period in the early 80's and averaged about one third in each division. However, since 1987 the percentages have became quite variable, with the abundance and biomass estimated from the Autumn R/V surveys in division 2J and in division 3L reaching respectively a minimum an a maximum in 1990.

During the first half of 1991 a reasonable part of the stock was still observed outside the Canadian EEZ. This is indicated by the high 1991 catch rates for the EEC fleets (equal to the ones observed in 1991 for the Spanish pair trawlers, higher for the Portuguese and German trawlers), most probably in relation to a high concentration of fish in the area. Higher catch rates in 1991 are also detected through all the age groups presented in the trawl catches.

1.5. Other biological evidences.

A steady increase in the size of seal populations has been quoted by CAFSAC in the past five years. In 1990 the seal population has been estimated in about 3.5 million individuals, with a rate of increase of about 0.5 million per year. The reason for this increase is not well known, but it seems related to environmental changes rather than the protection against seal hunting. The effect of this population increase on the natural mortality of cod or other associated species is very difficult to quantify, but taking into account that a seal probably consumes daily about 5 % of its biomass, it is difficult to avoid the association of the increase on seal populations to the difficulties experienced in some Newfounland fisheries.

Recent changes in food availability could also play a role in the decline of SSB. Fishing skippers are currently reporting catches of cod in poor condition, with individual weights abnormally low for the observed size. If cod have suffered from starvation, which could have increased natural mortality, it could be related to changes in growth pattern. Detailed data on individual length-weight relationship should be analysed after the meeting.

Since the same length-weight equations as in previous years were applied, the estimated weight at age do not include changes in condition coefficients, and only reflect changes in length at age. It is difficult to draw any conclusion. Portuguese data suggest an abnormally low growth in 1991, and the same pattern appears in the Canadian autumn survey, if not yet in the spring one.

If a growth anomally has really occurred, it could be related to the decrease in the capelin populations. An examination of the mean weights at age reported from research vessels did not give any clue. A drastic decline in catch at age is only observed in the 3L autumn surveys, and only in ages 5 and above. If starvation were the origin, it should be observed for all ages, everywhere and at all times.

2. STOCK ASSESSMENT

2.1. Review of CAFSAC Working Paper 92/7.

2.1.1. Catch statistics.

1991 catches by EC vessels were reviewed (see 1.1). As for 1991, similar discrepancies could have occurred in former years, but the Group was not in a position to revise the whole series. It is believed that foreign catches were systematically overestimated by the Canadian scientists.

Small discrepancies were found between the data submited to the Group in floppy disk and the tables in the report. It was believed that the figures given in the report were the correct ones, and corrections were made accordingly.

2.1.2. Catch and weight at age.

The mean weights at age in division 3L reported from autumn surveys show a marked decrease in growth compared to 1990 for ages 5 and onwards. This seems in relation to the migration of large adult cod to deeper waters.

On theother hand, given the differences in the length structure of the catches by Portugal as regards other EC fleets, the extrapolation of this information to the total foreign catch seems very little justified from the scientific point of view.

2.1.3. Research vessel survey data.

The Canadian trawl surveys during spring and autumn 1991 in division 3L covered only the area down to round about 750 m of depth. From the commercial fishery during the first half of the year there are informations that cod was cught below 750 m and even deeper. This implies that the Canadian surveys might not have covered the actual area of distribution of cod in 3L. In addition it has to be specially considered that survey gears (which should be rigged in a standard way) perform less effectively in deeper waters. This is due to a longer warp length which reduces the spread of the net by the doors and cannot be compensated using greater doors because of standard rigging. This induces an underestimation of the stock in 3L.

It was also noted that the survey design was changed in 1991. Whereas this had the objective of minimizing variance, in cases when changes in distribution and environmental conditions could largely influence catchability, any change in survey design can have very adverse consequences on the standardisation of the results (ICES Methods Working Group, 1990). 2.1.4. Stock parameters and assessment.

The Group examined and commented on the assumptions made in the assessment. It was found that the further research should be done as regards the sensitivity of the assessment to errors in catch at age, alternative hypothesis on natural mortality, shape of the curve of partial recruitment and to the use of separate or combined research vessel indices. But generally speaking, it was found that the assessment relied too much in the results of the surveys in the last year to accurately determine the stock status at the end of the period and, hence, to advice alternative TAC figures based on a catch forecast.

2.4 Alternative Stock Assessments

The group had a version of ADAPT available but preferred to proceed using a familiar assessment package and 'standard' ICES methods. A Laurec/Shepherd tuned VPA was, therefore, run with the Canadian data and all assumptions as close as possible to those in the Canadian assessment. The only difference was that the Canadian assessment forced a domed selection pattern from 1978 onwards (using F(91)=0.5*Fbar(7-9)) whereas the Laurec/Shepherd run utilised a dome from 1962 set as F(91)=0.5*Fbar(8-12). This led to high biomasses in the early years but very similar results, qualitatively and quantitatively, from 1978 onwards. The similarity of the two assessmnets gave confidence to base further deliberations on runs made using Laurec/Shepherd assessments. The F, SSB and biomass estimates from ADAPT and Laurec/Shepherd are shown in Fig. 2.4. Section 3 describes the sensitivity runs that were conducted and the choice of a 'baseline' assessment for retrospective analysis and projections.

3 SENSITIVITY OF ASSESSMENTS.

3.1. The canadian assessments were carried out using an assumed EC (plus others) catch of 47,000 tonnes in 1991. The official EC statistics for that year were, however, about 24,463 tonnes and this figure was adopted, together with a revised age distribution. A Laurec/Shepherd analysis was conducted using this figure (plus 5,000 tonnes for other non-EC fisheries). A further analysis was conducted using the Canadian estimate of 47,000 tonnes but with the revised EC age distribution. Both of these analyses were compared to the analysis using the original Canadian estimates for foreign catches.

The analysis using *47,000 tonnes foreign catch*, with revised EC age distribution, was essentially identical to the Canadian counterpart. The analysis using the revised catch numbers and age distribution also gave very similar results. The group concluded that the analysis was not sensitive to the precise details of the EC catches and decided to proceed further using the revised catches and age distribution.

3.2. The canadian assessments were conducted with the assumption of domed selectivity from 1978 onwards. The group were not, however, convinced that this was either justified or necessary. An analysis was therefore performed in which the selection pattern was assumed to be flat for older fish. Compared to the domed selection pattern analysis, this resulted in slightly higher F values in all years but insignificant differences in SSB or 3+ Biomass estimates.

The group concluded that there was no necessity to force a dome shaped selection pattern and that further analyses could assume a flat selection pattern.

3.3. The canadian anaysis used a combined RV survey index. The group tested the sensitivity of the analysis to *using separated RV indices* and to the inclusion or excusion of the area 3L Spring survey. This latter survey was not included in the combined survey series. Combining survey indices smooths spatial differences, which results in lower F estimates and consequently higher biomass and SSB estimates. This result was borne out by the analyses. The inclusion of the area 3L Spring survey made little difference to the analysis.

The group concluded that further investigations could proceed using the combined survey series (as was done in the Canadian assessment).

3.4. CAFSAC advisory document 92/2, which constituted the basis for the changes in management regime decided by Canada, included SSB estimates calculated using knife-edge maturity at age 7. The group had available maturity at age estimates for area 2J3KL (Baird et al., 1986, NAFO SCR Doc 86/122) which spread maturity over a range of ages. There was concern that the sharp changes in estimated SSB might be sensitive to knife-edge maturity (as only 8% of the stock is greater than age 8). In fact, the use of the maturity ogive made little difference to the estimated SSB using the knife-edge assumption. The group decided to base further runs on the maturity ogive but noted that the SSB estimates in the Canadian report *would be comparable.*

3.5. The Canadian analyis assumes natural mortality (M) of 0.2 on all ages. Two sensitivity tests were made to this assumption. Firstly, because of the suggestion of a major impact/environmental effect in 1991, M on all ages in this year were doubled to 0.4. the effects of such a change were barely discernible. A second test was to implement an age structured M 'borrowed' from the North sea. the group recognised that the predation structure of the Northern Cod was quite different to the North Sea but nevertheless desired to test an increased M on younger ages as might be expected. The Ms at age from the North Sea were converted to Ms at length which were then applied to the Northern Cod. This gave an M at age vector from ages 3 to 11 of [.8, .8, .35, .3, .25, .25, .25, .25, .2] with all older ages having an M of 0.2. The F and SSB estimates using this approach were similar to those obtained uing M = 0.2 on all ages. The total biomass estimates were, however, higher. This is because the only effects on the results are on ages 3-5 which are below the age of maturity. All further runs were made using the M = 0.2 assumption, as in the Canadian report.

4. RETROSPECTIVE ANALYSES

Retrospective analyses were conducted for 1990, 1989 and 1988. The results of the analysis are shown in Fig. 4. For years prior to 1987 the 1988 and 1991 analyses give similar results. The 1989 and 1990 analyses, similarly, give comparable results prior to 1987. The major feature of the retrospective analyses is, as pointed out in the Canadian report, that the 1990 assessment gave a relatively optimistic result whereas the 1991 assessment produced a picture of very high Fs and precariously low SSB and biomass.

The discrepancies in the pictures created by the sequential assessments are due to the effects of highly variable RV survey indices. Any assessment taking account of these indices will result in the same changing picture. The Canadian assessments did not result in quite such large changes in F as seen in the Laurec/Shepherd assessments because of the different dependency of the two methods on terminal year data differences.

The 1991 assessment shown in Fig. 4 used the revised EC data, a flat selection pattern, combined survey indices, a maturity ogive and a constant M of 0.2. This assessment was considered to be based on the most reasonable set of assumptions that could be made and as such, despite the problems identified by retrospective analysis, was chosen to form a basis for the study of fleet interactions in section 5. The diagnostic outputs from the asessment, however, were not encouraging (!) The catchabilities through time for both the commercial and RV fleets did seem to be fairly constant with the commercial data generally having smaller standard errors at age and therefore receiving a higher weighting in the calculation of terminal Fs. The ratios of between and within variances, however, were highly variable and mostly very low. This, as has been generally recognised, indicates that the two series are not very compatible.

5. ANALYSIS OF FLEET INTERACTIONS.

The effects on SSB per recruit and yield per recruit of the Canadian fleet and the EEC fleet are presented in fig 5 a) and 5 b) respectively. It can be stated that a change in the fishing effort of the EEC fleet (X-axis) results in a far lesser change of SSB per recruit as a change in fishing effort of the Canadian fleet (Y-axis). The same is true on a yield per recruit basis. This is also confirmed by the yield/biomass ratio of the Canadian fleet in comparison to the other fleets fishing outside the 200 miles zone (table 5). For the years 1986 to 1991 the Y/B ratio shows a quite constant behaviour as well as for the Canadian and the other fleets. In 1991 the slight shift to lower Y/b for the Canadian fleet and higher Y/B for the other fleets reflects the change in the distribution of the stock, which was more available outside the 200 mile zone. Therefore it can be concluded that the major decline in the stock is not related to increased fishing effort.

6. CONCLUSIONS AND RECOMMENDATIONS FOR MANAGEMENT.

Sensitivity of the assessment to differences in method or in input parameters were small. Nevertheless, as shown by the retrospective analyses, the results are extremely dependent on the noise in research vessel survey data.

The Group found that none of the current assessment methods is able to produce a definitive picture of the current situation. The extreme dependence of the assessment on the noise of the input data makes it nearly impossible to definitively diagnose the current situation and establish the necessary basis for a catch forecast. Therefore, the Group is not in a position to recommend any change in the management strategy adopted so far.

It seems unlikely that the decrease in abundance of fish in the traditional area of distribution observed in the Canadian surveys could have been caused by overfishing by either fleet. Changes in distribution and in natural mortality could also have played an important role.

On the other hand, as the possibility of real biological problems in the stock still remains open, the most sensible initiative for managers to adopt should be the ad hoc approach: to closely monitor catch rates during the season and to adopt measures accordingly.

The origin of the noise in the data for the assessment could be in environmental changes affecting the distribution and the availability of cod. The magnitude of such changes could have also effects on the structure of the stocks in the area. A comprehensive review of this structure is urgently needed.

The Group was requested to comment on the utility of management actions such as the ban on fishing on spawning populations. The Group felt that conservation of the stocks depend on the pattern and intensity of the removal of fish, regardless the time of the year at which this is done. Unless the occurrence of adverse effects of fishing on reproductive success and resulting recruitments is clearly demonstrated, the utility of such closures is dubious.

AGE	CANADA + FRANCE(SPM)	SPAIN	PORTUGAL	GERMANY	EC TOTAL	UNALL.	TOTAL
2	12	9	175	1	185	38	234
3	1002	366	2189	160	2714	555	4271
4	23856	1639	4229	2377	8245	1685	33787
5	40252	2219	4482	1901	8602	1758	50612
6	21962	590	1597	324	2511	513	24986
7	7340	226	173	136	536	109	7985
8	4931	23	108	35	166	34	5131
9	3859	6	120	9	135	28	4022
10	1380	2	75	5	82	17	1479
11	436	0	54	1	55	11	503
12	179	0	5	0	5	0	184
13	65	0	0	0	0	0	65
14	23	0	0	0	0	0	23
15	10	0	3	0	3	1	14
16	9	0	0	0	0	0	9
17	3	0	0	0	0	0	3
18	0	0	0	0	0	0	0
19	2	0	0	0	0	0	2
WEIGHT (t)	126558	8546	9459	6459	24464	5000	156022

Table 1.2. Estimated catches at age in 1991. Thousands.

YEAR	3+ BIOMASS 2J3KL(1)	LANDINGS(2)			Y/B(3)		
		TOTAL	CANADA	EEC+OTHERS	TOTAL	CANADA	EEC+OTHERS
1986	1151449	251506	190352	61154	22	17	5
1987	993302	235010	199388	35622	24	20	4
1988	964732	268677	241870	26807	28	25	3
1989	931843	253424	214676	38748	27	23	4
1990	885258	218688	190660	28028	25	22	3
1991	717954	174651	126558	48093	24	18	7

Table 5. Recent trends in biomass, landings and landings/biomass ratio.
(1) From VPA results in CAFSAC Working Paper 92/7
(2) Canadian figures, same source as above.
(3) Yield/biomass ratio expressed in percentage.

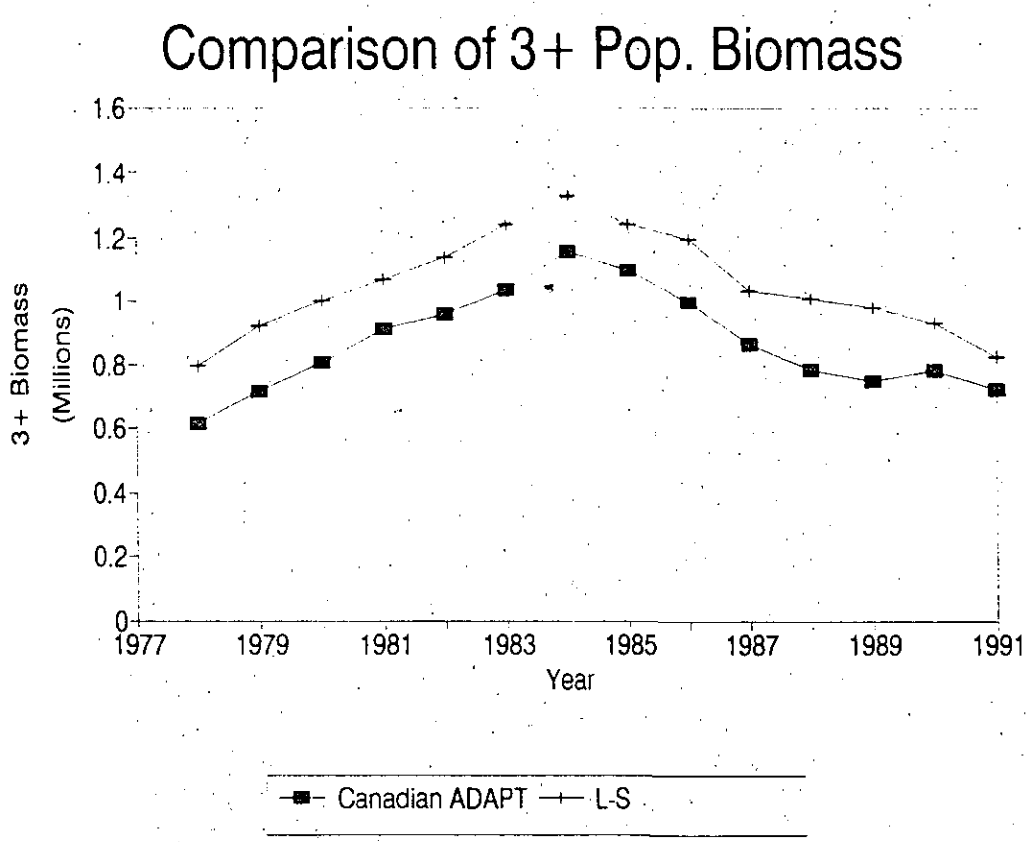


Fig. 2.4.a). Comparison of results using Canadian ADAPT and baseline run using Laurec-Shepherd tunning method. Biomass.

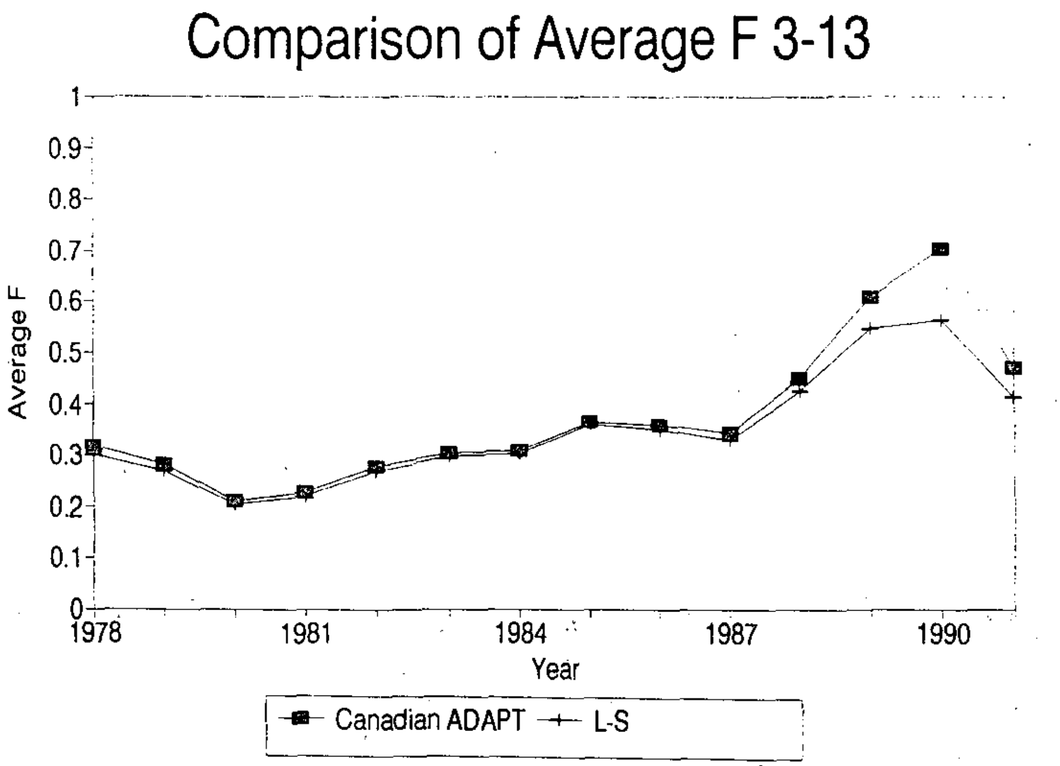


Fig. 2.4.b). Comparison between results using Canadian ADAPT and baseline run using Laurec-Shepherd tunning method. Fishing mortality.

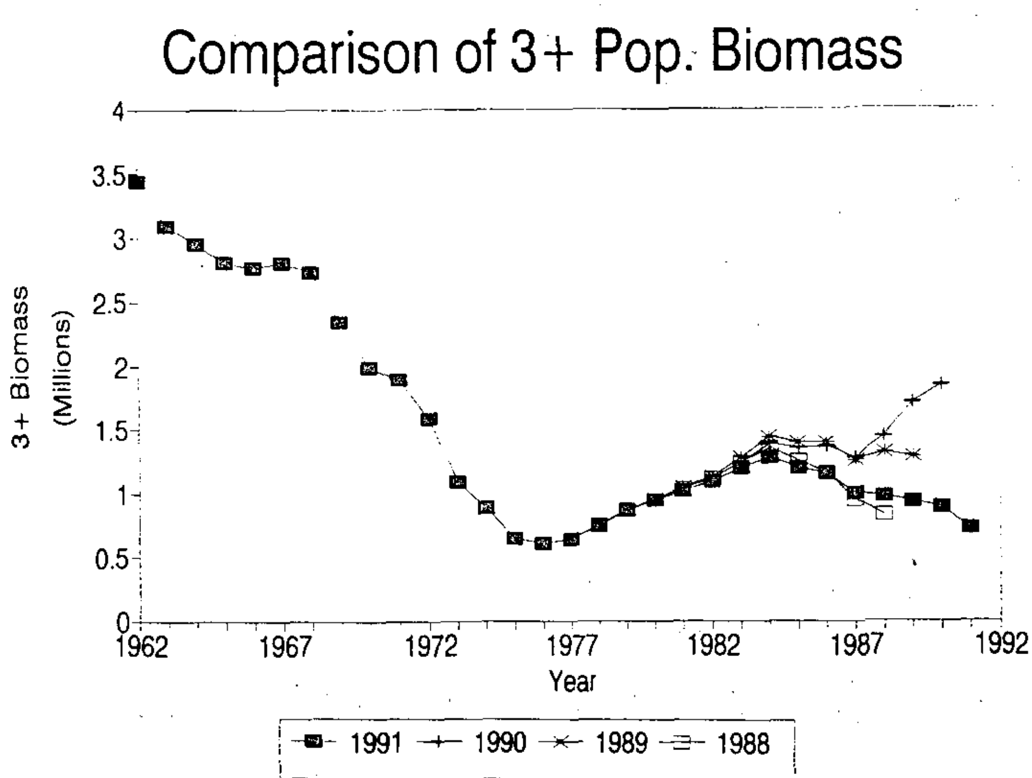


Fig. 4.b). Retrospective analysis. 3 + biomass values.

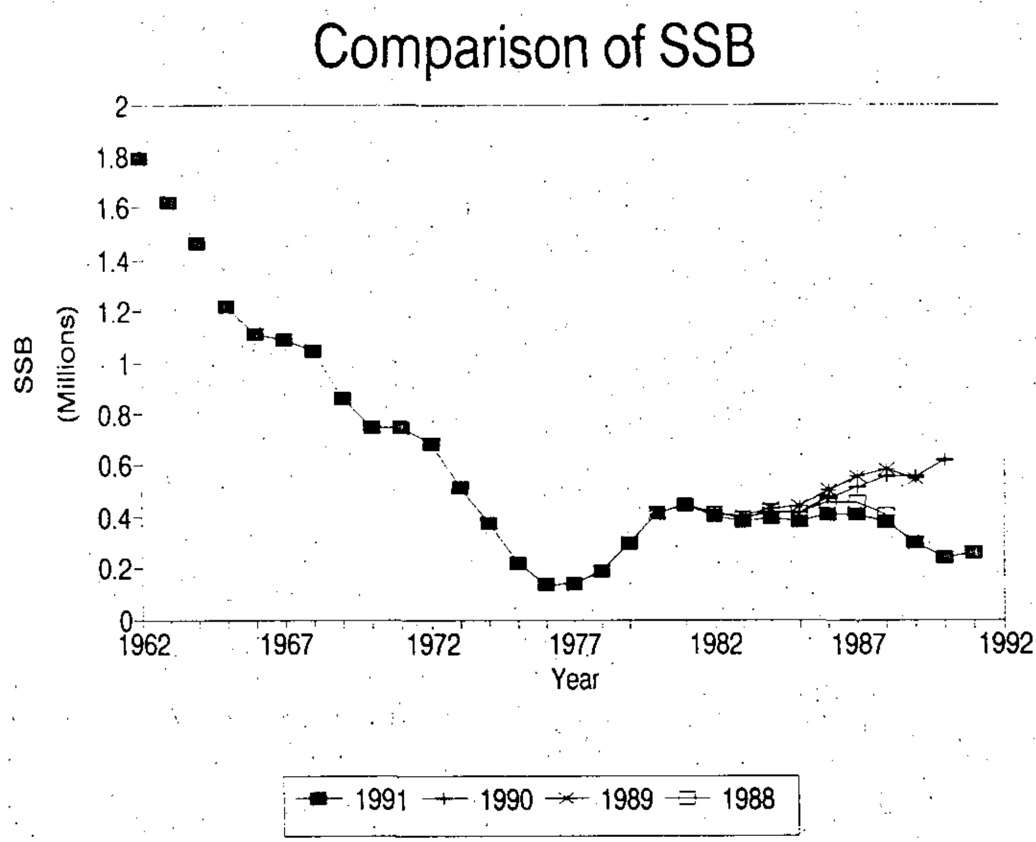


Fig. 4.c). Retrospective analysis. SSB values.

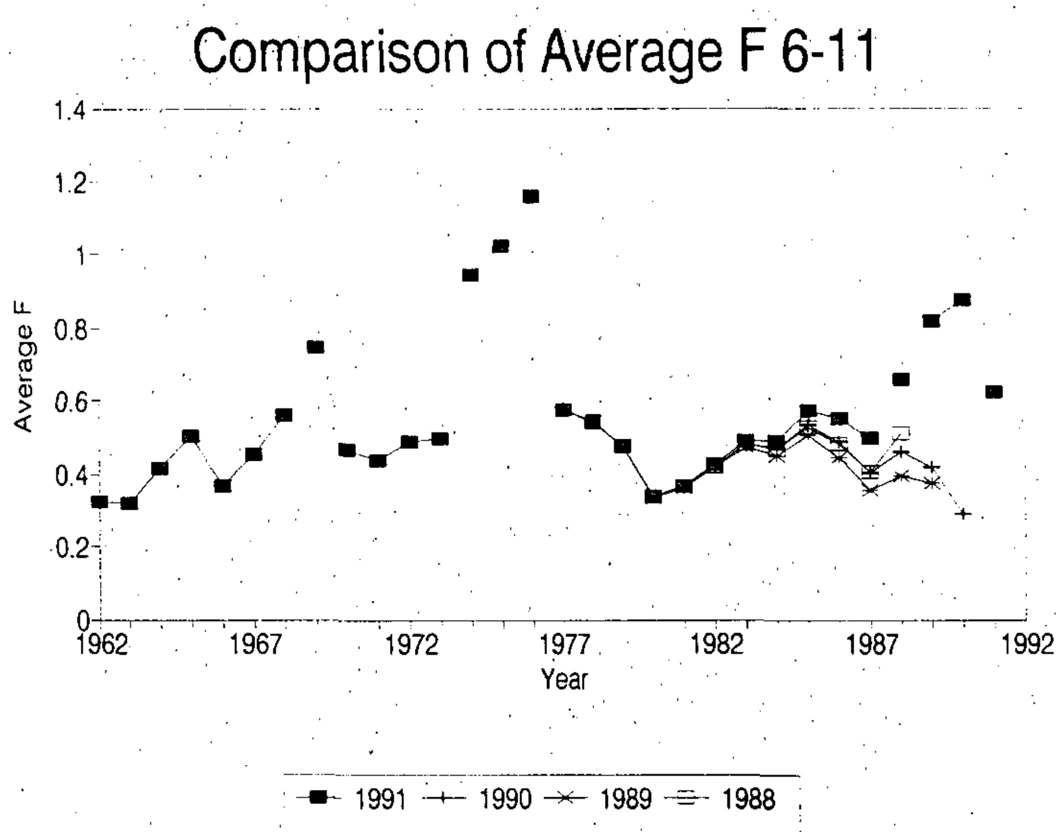


Fig. 4.a). Retrospective analysis. F(6-11) values.

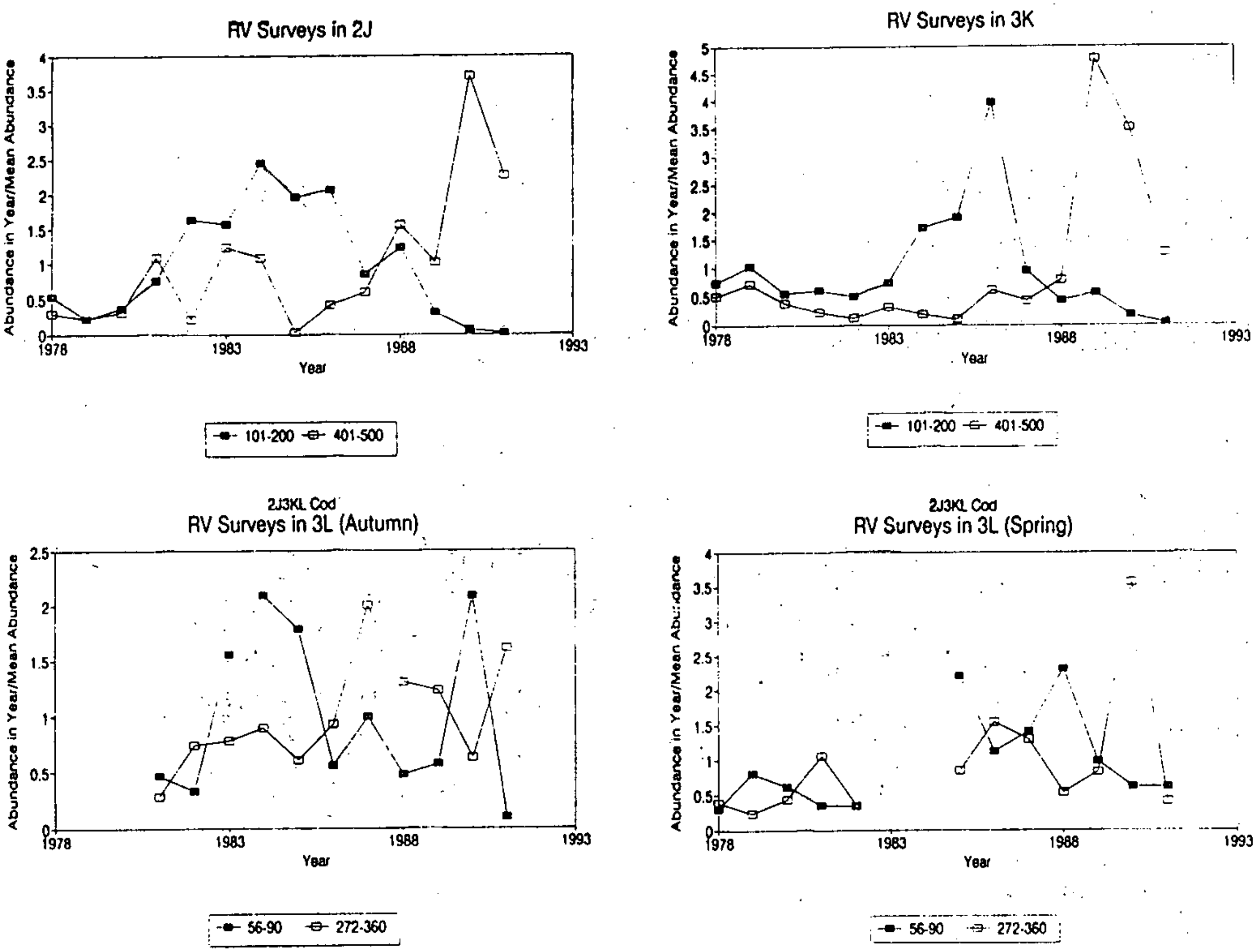


Fig. 1.3. Abundance indices of cod, relative to the mean abundance in the period, for shallow and deep strata.

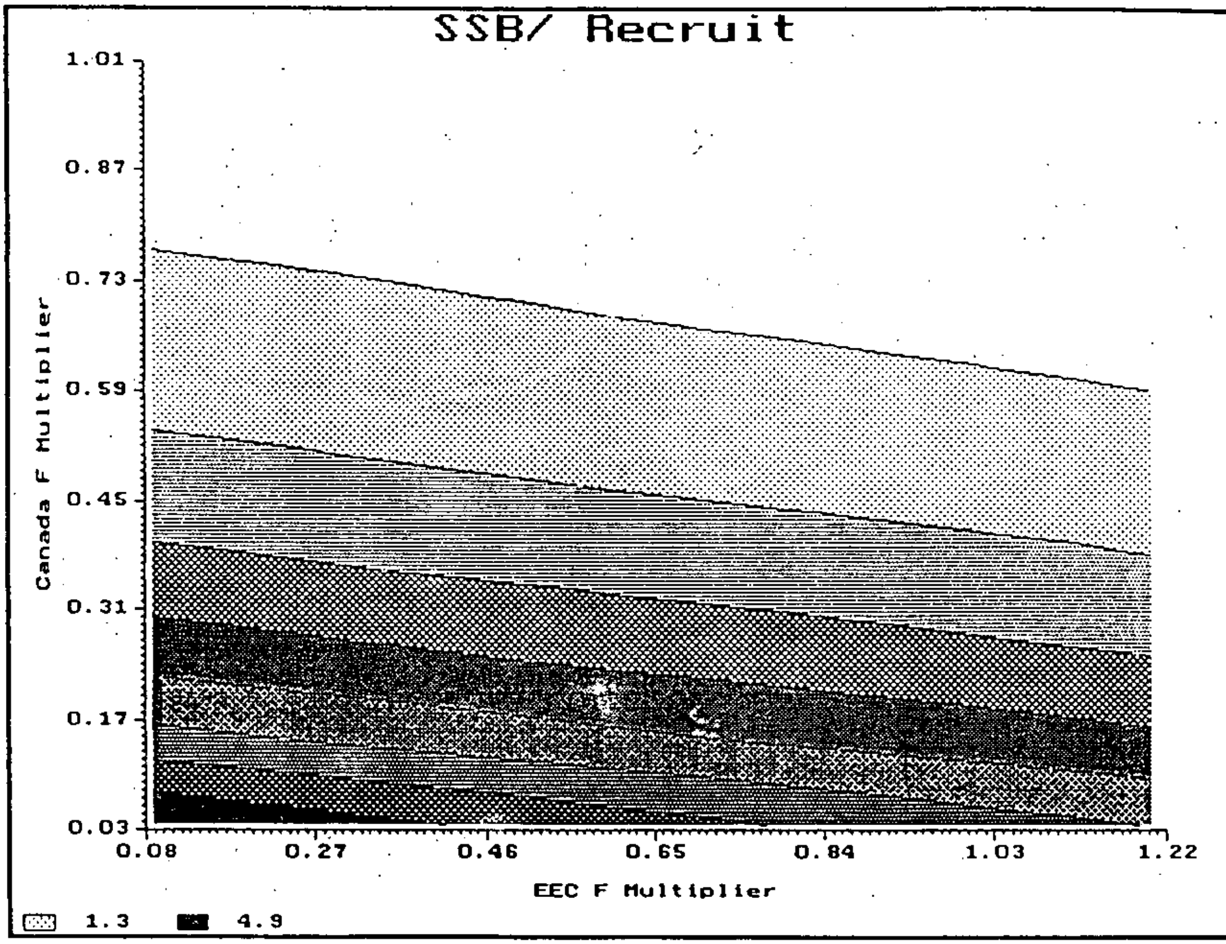
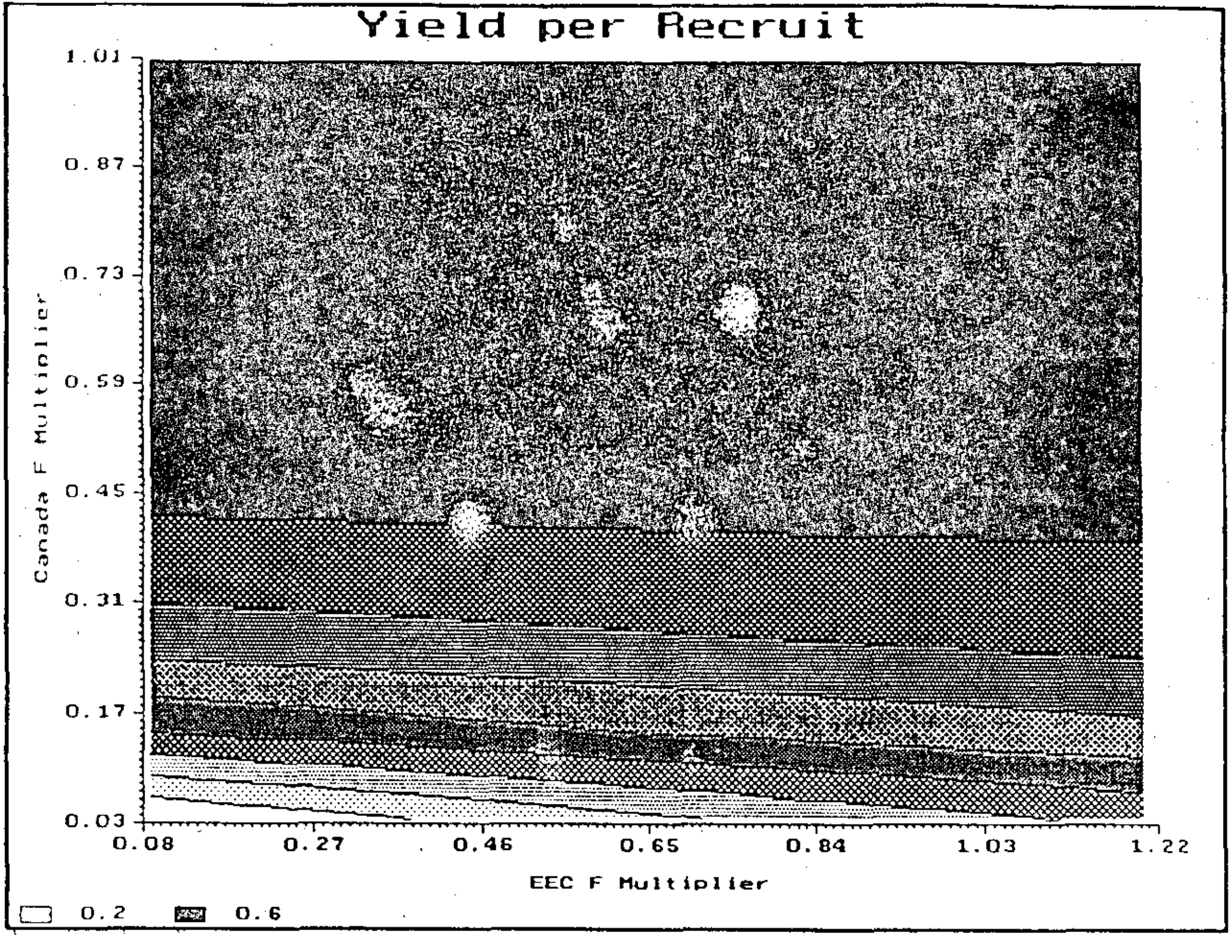


Fig. 5.a). Spawning biomass per recruit as a function of variations in Canadian and EC fishing effort. Separation of line contours : 8Kg/recruit.



'ig. 5.b). Yield per recruit as a function of variations in Canadian and EC fishing effort. Separation of line contours : 8 Kg/recruit.