Not to be cited without permission of the authors[1]

Ne pas citer sans autorisation des auteurs[1]

Canadian Atlantic Fisheries Scientific Advisory Committee

Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CAFSAC Research Document 92/ 100

CSCPCA Document de Recherche 92/ 100

Preliminary Analysis of Research Survey and Commercial Indices for 4TVn cod up to 1992

Alan Sinclair
Department of Fisheries and Oceans, Gulf Fisheries Center, P.O. Box 5030, Moncton, New Brunswick, E1C 9B6. Canada

[1]This series documents the scientific basis for fisheries management advice in Atlantic Canada. As such, it addresses the issues of the day in the time frames required and the Research Documents it contains are not intended as definitive statements on the subject addressed but rather as progress reports on ongoing investigations.

[1]Cette série documente les bases scientifiques des conseils de gestion des pêches sur la côte atlantique du Canada. Comme telle, elle couvre les problèmes actuels selon les échéanciers voulus et les documents de recherche qu'elle contient ne doivent pas être considerés comme des énoncés finals sur les sujets traités mais plutôt comme des rapports d'étape sur les études en cours.

Research Documents are produced in the official language in which they are provided to the Secretariat by the authors.

Les documents de recherche sont publiés dans la langue officielle utilisée par les auteurs dans le manuscrit envoyé au secrétariat.

Abstract

Preliminary results from the 1992 fall groundfish survey indicate a further decline in the abundance of the 4TVn(J-A) cod stock. Both mean number and biomass per tow were considerably less than those of previous years and also lower than predicted from the previous stock assessment. Separate analyses of the research survey and commercial catch rate indices indicated that recent fishing mortalities may be much higher than the estimates from SPA.

Sommaire

Les résultats préliminaires du relevé de poissons de fond de 1992 indiquent une baisse de l'abondance du stock de morue de 4TVn(j-a). La nombre et biomasse moyens par trait sont considérablement plus bas que l'année dernière et sont aussi plus bas que prédit par l'évaluation de stock la plus récente. Deux analyses indépendantes des indices d'abondance provenant des relevés de recherche et des prises par unité d'effort commerciales indiquent que le taux de mortalité par pêche pourrait être nettement plus élevé qu'estimé par l'ASP.

Introduction

This paper presents preliminary analyses of the results of the 1992 southern Gulf of St. Lawrence groundfish research vessel survey and commercial catch rates in support of scientific advice on the status of the 4TVn(J-A) cod stock. The analysis is preliminary because, at the time of writing, information on the age composition of the 1992 research vessel (RV) survey were not available. This analysis was undertaken because reports from the industry indicated that the advice presented in CAFSAC Adv. Doc. 92/7 may have been optimistic and because of lower than expected RV survey results.

It should be noted that the research vessel was changed in 1992 from the *Lady Hammond* to the *Alfred Needler*. A comparative fishing experiment was conducted prior to the 1992 survey and preliminary indications are that *Alfred Needler* may be more efficient at catching cod than *Lady Hammond*. The analysis of this experiment is ongoing and, for the purposes of this paper, no conversion factors were applied.

Methods

Research Survey Catches

The time trend in research survey catches were compared based on catch at length because the 1992 age composition data were not yet available. Annual research survey length compositions were calculated according to the stratified random survey design (Halliday and Koeller 1981). Tow by tow observations were adjusted to a standard distance of 1.75 nautical miles using the formula

$$\text{adjusted catch} = \frac{1.75 * \text{catch}}{\text{distance towed}}$$

Where the catches were subsampled, the catch in the tow was adjusted for the sampling ratio as

$$\text{catch} = \frac{\#\text{ in sample} * \text{catch weight}}{\text{sample weight}}$$

Stratified mean catch per tow at length was calculated using strata areas as weights.

The mean biomass per tow was estimated using the survey weight length relationships applied to the length frequencies. These are given below for the equation

$$W(kg) = aL(cm)^b$$

Year	a*10^{-6}	b
1988	6.169	3.0977
1989	5.956	3.1109
1990	6.659	3.086417
1991	7.149	3.064

The 1991 relationship was used for 1992 because the latter was not yet available.

The research survey mean biomass per tow ($\overline{W}$)for fish of commercial size (> 40 cm) were converted to absolute population biomass estimates (B) using the following formula. The research survey catchability (q) was taken as the average for ages 5-10 from Hanson et al. (1992).

$$B = \frac{\overline{W}}{q}$$

Comparison of 1992 Research Survey Results and Predictions from Last Assessment

RV mean numbers per tow at ages 3-10 are used along with commercial CPUE at ages 5-12 to calibrate the sequential population analysis (SPA) for this stock. The age 3+ numbers from the 1992 survey were estimated by taking the numbers ≥ 30 cm in length. 30 cm is roughly mid-way between mean lengths at ages 2 and 3. The predicted 1992 survey was estimated from the projected 1992 beginning of year population, fished to the end of September (as is done in the SPA calibration), assuming a 1992 total catch of 39,000 t. The population numbers were then multiplied by the appropriate survey catchabilities from ADAPT and summed from ages 3-10 (Hanson et al. 1992).

Comparison of Calibration Indices

The RV and CPUE calibration indices were analyzed separately to investigate whether they gave comparable indications of total mortality and year-class strength. A multiplicative model was used to analyse each index for two separate time periods. The multiplicative model included the index at age a for year-class y as a function of year class (Y) and age (A);

$$\ln(I_{ay}) = A + Y + \varepsilon$$

The year class terms were taken as relative indices of year-class size and the age terms were used for catch curves, normalized for variation in year class strength (Shepherd and Nicholson 1991, Sinclair and Chouinard 1992). The two time periods were 1980-85 and 1986-91, and were chosen to compare the estimates of total mortality and year-classes.

Results

Research Survey Catches

The 1987 year-class has been estimated to be above average in abundance and to be more abundant than those adjacent (1984-86, 1988-89) (Hanson et al. 1992). This year-class is apparent in the RV length frequencies from ages 2-5, its modes at 25, 34, 37, and 40 cm respectively (Figure 1). However, by 1992, the abundance of the year-class has been reduced and the overall abundance of cod > 40 cm was substantially lower than in the previous years. It appears that the 1988-89 year-classes are less abundant than the 1987. While still early, there is little to suggest that the 1990 year-class is more abundant than the 1988-89.

There has been a steady decline of numbers of commercial sized cod (> 40 cm) since 1988 (Figure 2). The mean biomass per tow for commercial sized cod has also decreased substantially, from 122 kg in 1988 to 22 kg in 1992.

The RV estimate of population biomass for fish >40 cm in length declined from 260,000 t in 1988 to 48,000 t in 1992 (Figure 3). The annual catch from the stock declined from 55,000 t in 1988 to 44,000 t in 1991 (Hanson et al. 1992). The 1992 catch is predicted to be in the order of 39,000 t. The decline in fishable biomass estimated by the research survey has been much faster than the decline in catch, indicating that exploitation rate may be increasing to a potentially very high level.

Comparison of 1992 Research Survey Results to Predictions from Last Assessment

Based on the assessment presented by Hanson et al. (1992), the predicted 1992 RV mean numbers per tow for ages 3-10 was 91 fish per tow (Table 1). The observed 30+ cm catch was 47 fish per tow, approximately half the predicted value. If a conversion factor for *Alfred Needler/Lady Hammond* catch per tow is required, the observed 1992 RV mean catch would be lower.

The CAFSAC Groundfish Subcommittee recommended calibration of the assessment with a short RV time series, from 1979-91, to account for an apparent change in RV catchability. The predictions described above were repeated using the results from the short time series calibration (G. A. Chouinard, DFO Moncton, pers. comm.). The shorter time series gave lower population numbers and higher RV catchabilities (Table1). Consequently, a 1992 catch of 39,000 t would generate a higher fishing mortality in1992. The predicted 1992 RV mean numbers per tow for ages 3-10 from the short series calibration was 93 fish per tow.

The comparison of observed and predicted research survey results for the long and short series calibration were similar. The lower population estimates and higher survey catchabilities from the short series approximately cancelled each other.

Comparison of Calibration Indices

Model fit for the four multiplicative analyses was good as indicated by the R^2 below and examination of normal probability plots of residuals.

R^2 from multiplicative models

Index	Time Period 80-85	86-91
RV	0.94	0.93
CPUE	0.98	0.97

The catch curves from the four multiplicative analyses are given in Figure 4. The CPUE index indicated full recruitment to the fishery at age 6 in both time periods. A linear regression of the age effects (in ln scale) was calculated for ages 7-12 and the estimated slope was taken as an estimate of average total mortality during the time period. The slopes indicated total mortalities of 0.63 and 0.71 for the 1980-85 and 1986-91 periods respectively. The RV index indicated full recruitment to the surveys at age 3 in the earlier period and age 4-5 in the later period. Total mortality was estimated to be 0.62 for ages 6-10 for 1980-85 and 0.73 for ages 5-10 for 1986-91.

The year-class estimates from the two indices are compared in Figure 5. The trends for the RV and CPUE data were very similar, both peaking for the 1979-80 year-classes and showing decreases in year class size since. Correlations within time periods were highly significant ($p<.01$); however, the correlations between time periods were not significant ($p>.05$).

R^2 for year class estimates between indices

	CPUE 80-85	RV86-91
RV 80-85	0.96	0.20
CPUE 86-91	0.16	0.80

Stock Status

The research survey indicates a declining trend in population size since 1988. The poor year-classes of the mid 1980's recruited to the commercial fishery during this time. The 1987 year-class appears to be above average in size, however, the 1988-90 year-classes may be well below average. It is difficult to interpret the 1992 RV estimate due to uncertainties regarding the fishing powers of the *Alfred Needler* and *Lady Hammond.* Preliminary indications are that the *Alfred Needler* may be more efficient and thus the unconverted 1992 estimates may be too high.

The 1992 survey mean numbers per tow for ages 3-10 were less than half that predicted from the last assessment. With this stock, there is a tendency for the SPA estimates of fishing mortality in the terminal year to be lower than those estimated for the same year in subsequent assessments (Hanson et al. 1992). This has been referred to as a retrospective pattern (Sinclair et al. 1991). Catch curves from the two independent indices indicate an average fully recruited fishing mortality for the 1986-91 period of about 0.5. The latest assessment indicated a much lower 1991 F of 0.26. The SPA over predicted the 1992 survey by at least 50% thus indicating the calibrated SPA estimates of population size in the terminal year must be interpreted with caution until the retrospective problem is solved.

The RV population biomass estimates indicate that the current population abundance is only slightly higher than in the mid 1970's. Fishable population biomass may be in the order of 40,000-50,000 t. A catch of 33,000 t in 1993 could result in an extremely high exploitation rate. Stock status is made more perilous by poor recruitment for several years to come; the 1988 to 1990 year classes may be well below average.

References

Halliday, R. G., and P. A. Koeller. 1981. A history of Canadian groundfish trawling surveys and data usage in ICNAF Divisions 4TVWX, p. 27-41. In W.G. Doubleday and D. Rivard [ed.] Bottom trawl surveys. Can. Spec. Pub. Fish. Aqua. Sci. 58.

Hanson, J. M., G. A. Chouinard, G. A. Nielsen, and L. J. Currie. 1992. Stock status of the southern Gulf of St. Lawrence cod stock (4T and 4Vn (Jan.- Apr.) in 1992. CAFSAC Res. Doc.92/55.

Shepherd, J. G., and M. D. Nicholson. 1991. Multiplicative modelling of catch-at-age data, and its application to catch forcasts. J. Cons. int. Explor. Mer 47: 284-294.

Sinclair, A., D. Gascon, R. O'Boyle, D. Rivard, S. Gavaris. 1991. Consistency of some Northwest Atlantic groundfish stock assessments. NAFO Sci. Coun. Studies 16: 59-77.

Sinclair, A. and G. Chouinard. 1992. Application of a Multiplicative Model to Research Survey Data from Two Cod Stocks. CAFSAC Res. Doc. 92/66.

Table 1: 1992 RV predictions from SPA.

Long series

	Age	Population	F	q	Pred. RV
	3	96000	0.00	2.12E-04	17.49
	4	47473	0.02	3.20E-04	12.84
	5	80810	0.09	4.16E-04	26.96
	6	46157	0.22	4.70E-04	15.85
	7	24302	0.30	4.70E-04	7.87
	8	15144	0.34	4.81E-04	4.87
	9	10280	0.36	4.27E-04	2.88
	10	6573	0.36	5.39E-04	2.32
	11	3567	0.36		
	12	4918	0.36		
	13	2654	0.36		
	14	265	0.36		
Total					91.09

Short Series

	Age	Population	F	q	Pred. RV
	3	93000	0.00	2.78E-04	22.21
	4	37230	0.04	4.21E-04	13.13
	5	62062	0.14	5.47E-04	26.34
	6	39581	0.32	6.14E-04	16.44
	7	20233	0.44	6.11E-04	7.67
	8	11147	0.50	6.35E-04	4.20
	9	6734	0.53	5.79E-04	2.25
	10	3688	0.53	7.22E-04	1.54
	11	1762	0.53		
	12	2369	0.53		
	13	1105	0.53		
	14	145	0.53		
Total					93.78

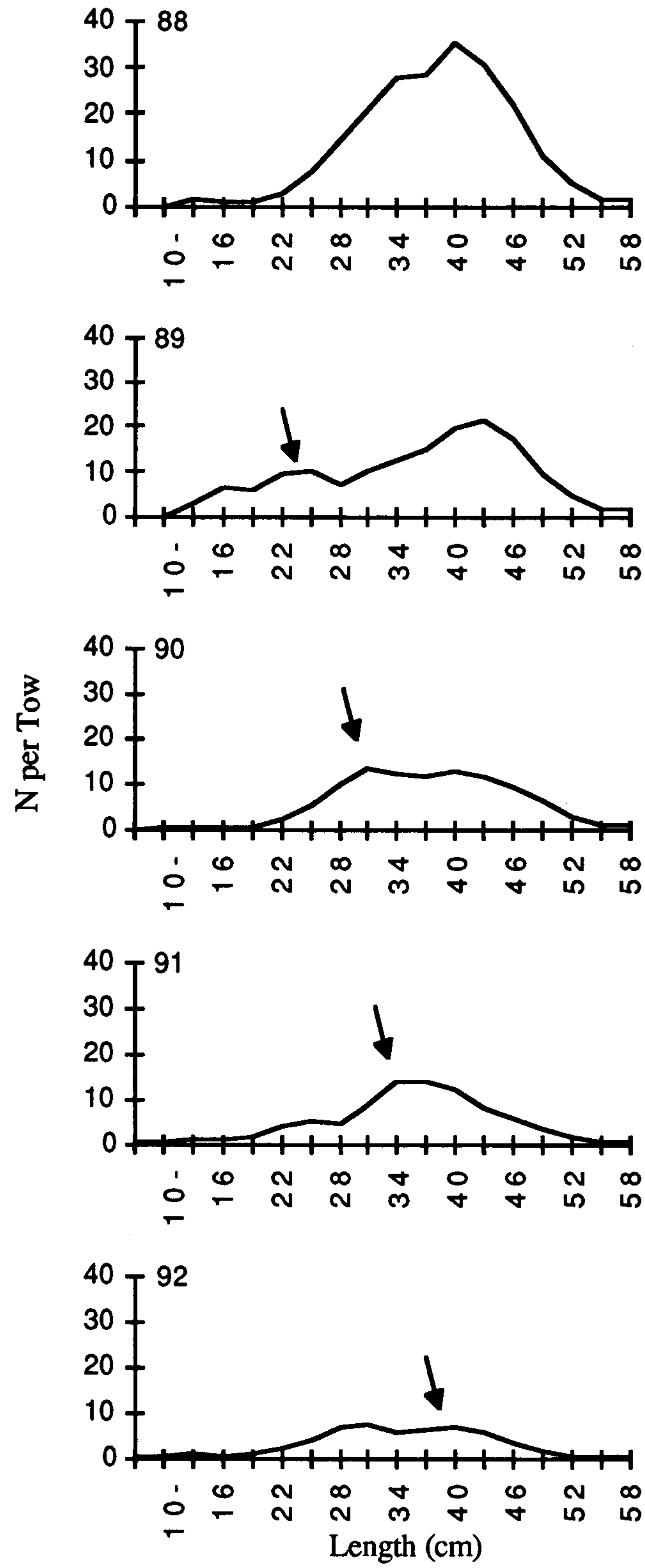
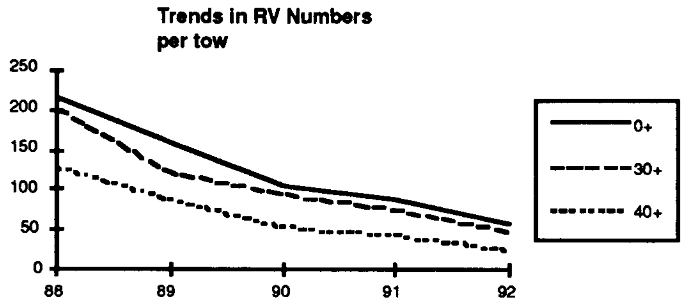


Figure 1: Cod length frequencies for southern Gulf research Surveys 1988-1992. Units are mean numbers per tow. The arrows indicate the mode corresponding to the 1987 year-class.



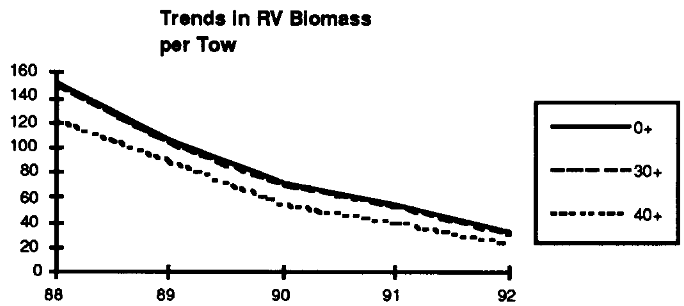


Figure 2: Trends in RV mean numbers and biomass per tow for 4TVn cod.

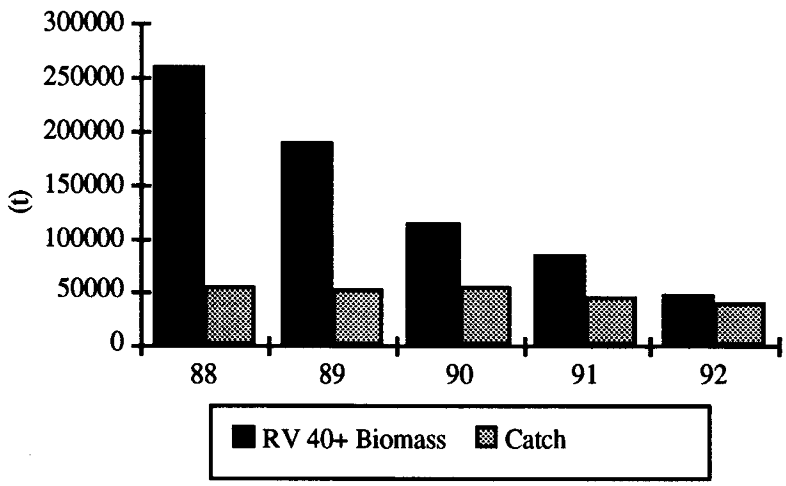
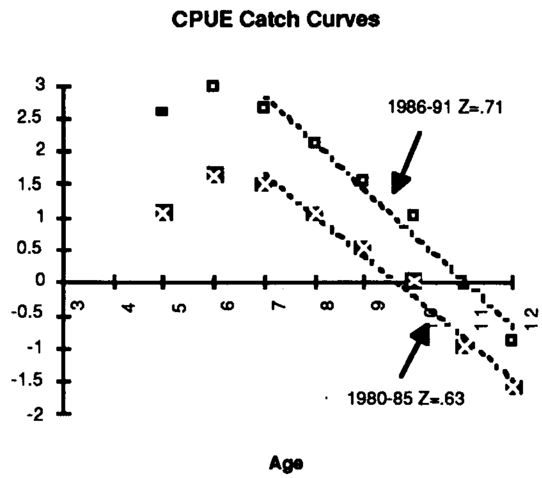


Figure 3: Comparison of RV estimated 40 + cm population biomass and commercial catch.



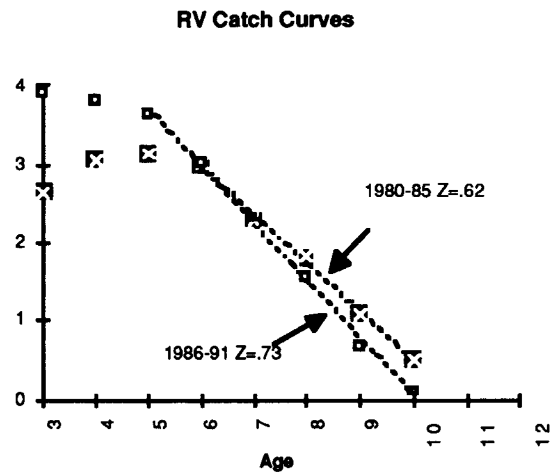


Figure 4: Catch curves for 4TVn cod from RV and CPUE data. The slope is an estimate of total mortality.

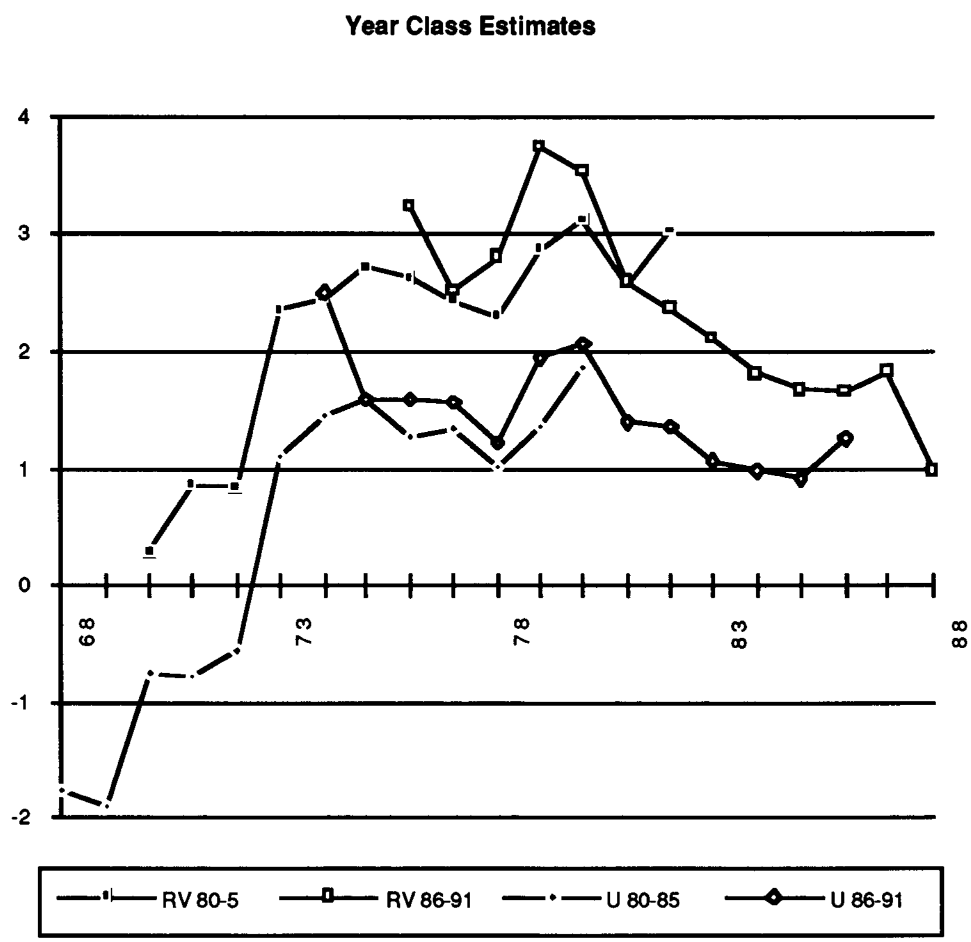


Figure 5: Year class estimates from multiplicative analyses of 4TVn cod RV and CPUE data.