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Sudden Changes in the Perception of Stock Size and Reference Catch Levels for Cod in Northeastern Newfoundland Shelves

J. W. Baird, C. A. Bishop, and E. F. Murphy
Department of Fisheries and Oceans, Science Branch
P. O. Box 5667, St. John's, Newfoundland, Canada A1C 5X1

Abstract

A brief description of the fishery since the late-1950s as well as a summary of the management and assessment of the cod stock in NAFO Divisions 2J+3KL since the early-1970s is presented. During the spring of 1987 the status of this stock was assessed at Canadian Atlantic Fisheries Scientific Advisory Committee. At that time the projected $F_{0.1}$ catch for 1988 was 266,000 tons. At the autumn 1988 assessment it became apparent that the stock size had been previously overestimated. In an early-1989 assessment which incorporated all commercial and research data for 1988 along with the use of an analytical calibration model for this stock (ADAPT), the estimated size of the resource was revised which implied an $F_{0.1}$ catch for 1989 of 125,000 tons. The actual TAC for 1989 was set at 235,000 tons, a catch level at which the size of the stock at the beginning of 1990 would be approximately the same as it was at the beginning of 1989. A review is made from the data which led to the original estimate as well as the changes which eventually resulted in the current perception of stock.

History of the Fishery

Total nominal catches of cod increased quite rapidly in the late-1950s and into the 1960s (Fig. 1). The peak catch, reported to be about 800,000 tons, occurred during 1968. While the Canadian catch remained relatively stable throughout this period, increases in fishing effort by non-Canadian countries caused the increase in catch. As an example, countries other than Canada that participated in the Div. 2J+3KL cod fishery during 1968 are as follows (NAFO, MS 1986).

Country	Reported catch (tons)
Portugal	152,473
Spain	130,972
USSR	117,559
France	81,966
Poland	68,987
Federal Republic of Germany	47,868
United Kingdom	32,598
German Democratic Republic	27,393
Norway	16,057
Faroes	10,227
Japan	526
Iceland	68
Total	686,694

The total non-Canadian catch during 1968 was approximately 690,000 tons, compared to about 120,000 tons reported by Canada.

After the peak in 1968, catches declined steadily, as the stock declined, to a low of about 140,000 tons in 1978. Catches gradually increased in the late-1970s and early-1980s and have ranged between 230,000 and 266,000 tons since 1982. The total reported catch for 1989 was approximately 250,000 tons (NAFO, MS 1990).

There are two major components in the Div. 2J+3KL cod fishery. The offshore component, mainly otter trawl, usually occurs on pre-spawning and spawning concentrations during winter. The inshore segment, which takes place mainly during summer months, is prosecuted by fixed gears (traps, gillnets, longlines and handlines) closer to shore. During the 1960s the inshore gears caught a relatively small percentage of the total (between 10-30%), but catches have increased considerably (between 30-60%) since 1977 (Fig. 2).

Early Management and Assessment

The earliest management of this stock, through the International Commission for the Northwest Atlantic Fisheries (ICNAF), consisted mainly of mesh regulation. It was thought, at the time, that stocks would sustain themselves if a sufficient number of young fish could escape and eventually contribute to the spawning stock and to the fishable biomass.

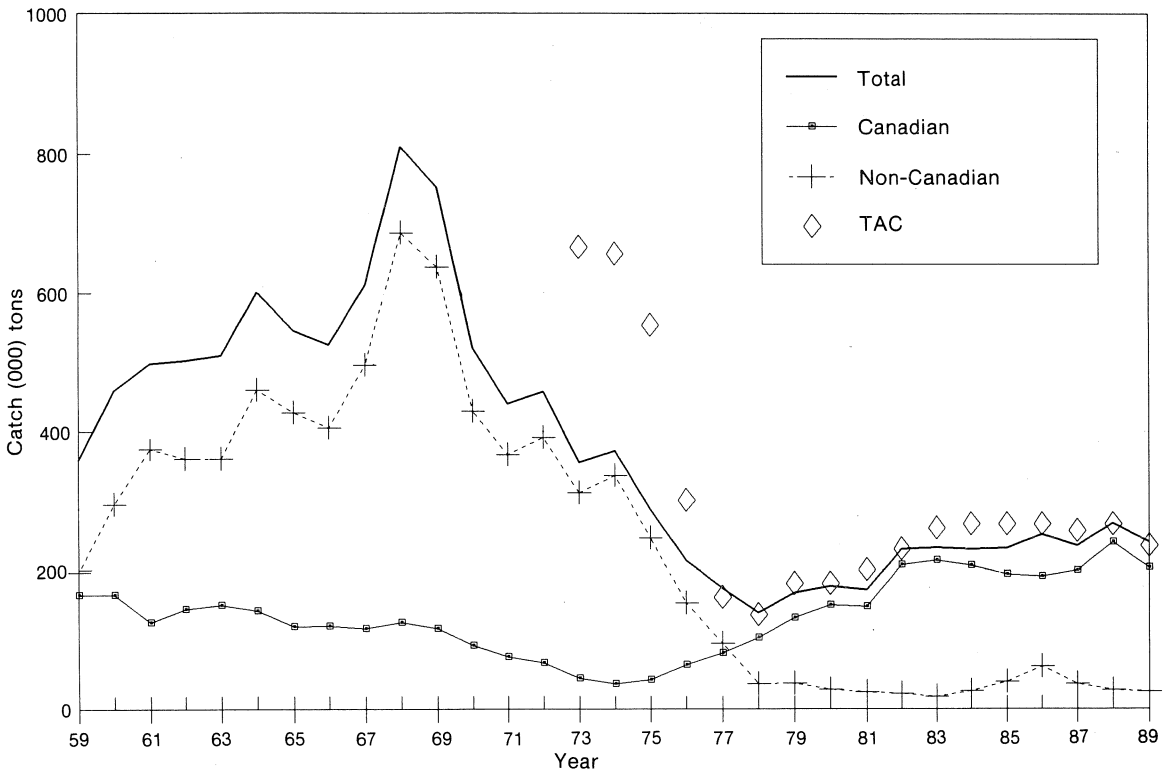

Fig. 1. Cod catches in Div. 2J+3KL by Canadian and Non-Canadian vessels from 1959 to 1989.

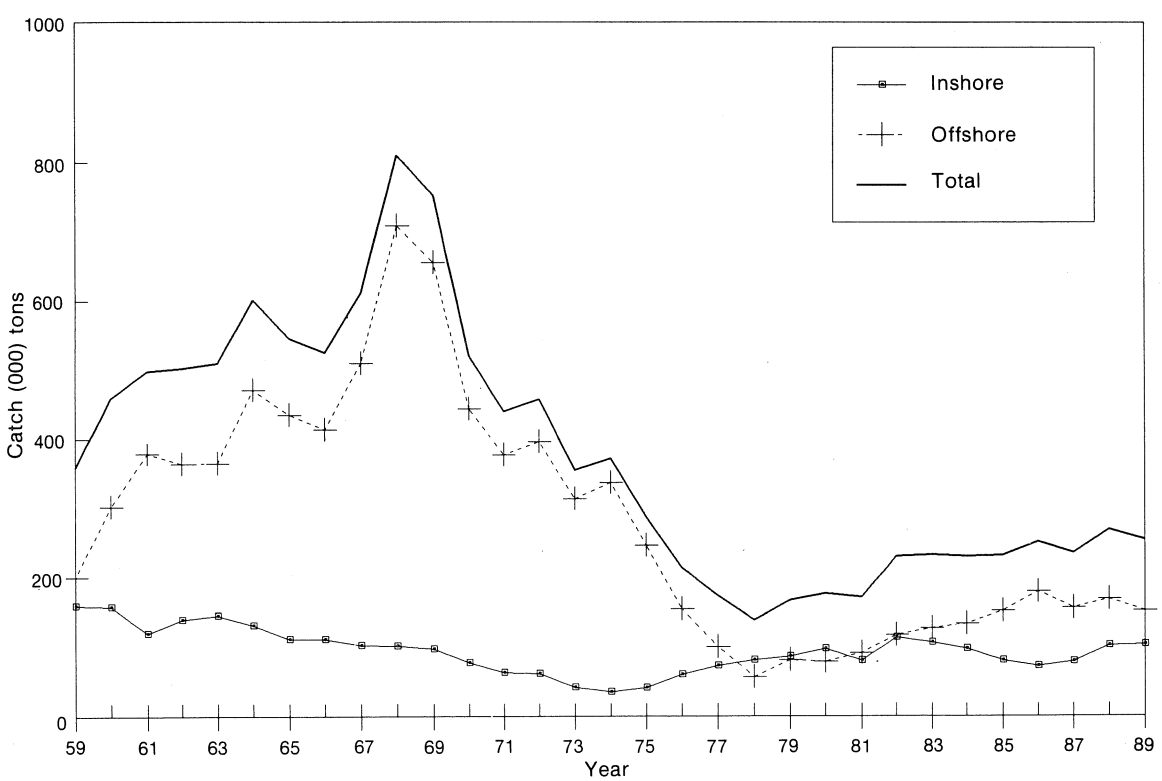

Fig. 2. Cod catches in Div. 2J+3KL by inshore and offshore vessels from 1959 to 1989.

Total allowable catches (TACs) were first implemented during the early-1970s and were based on fishing mortalities that would give the maximum yield (F_{max}). These early TACs (1973–76) were ineffective and during that time period nominal catches were well below TACs with fully recruited fishing mortalities approaching 1.0. Had these TACs been taken, the fishing mortalities generated would have been well in excess of 1.0.

Throughout the period the stock continued a decline that had started about the time peak catches were taken (late-1960s). During 1975 the Standing Committee on Research and Statistics of ICNAF advised that $F_{0.1}$ level of fishing mortality was preferable over F_{max} as a management strategy (ICNAF, 1975). This advice was accepted by ICNAF and during 1976 it was advised that the 1977 TAC be set at the $F_{0.1}$ level.

Attempts at calibration of sequential population analysis in these early years were at best tenuous, because of the lack of adequate research survey or commercial catch-rate data. Research vessel surveys, conducted by the Federal Republic of Germany (FRG), Canada and the USSR were used as indicators of year-class strength, although the time series were short. In some cases, ratios of fishing mortality to catch, with the assumption of approximate constant fishing effort, were used to determine fishing mortalities in the terminal year.

Management and Assessment 1977-87

During the period 1977–87, ICNAF/NAFO continued the assessments of cod in Div. 2J+3KL, however, during 1977 Canada extended fishing jurisdiction to 200 nautical miles from the coastline (Fig. 3). At this

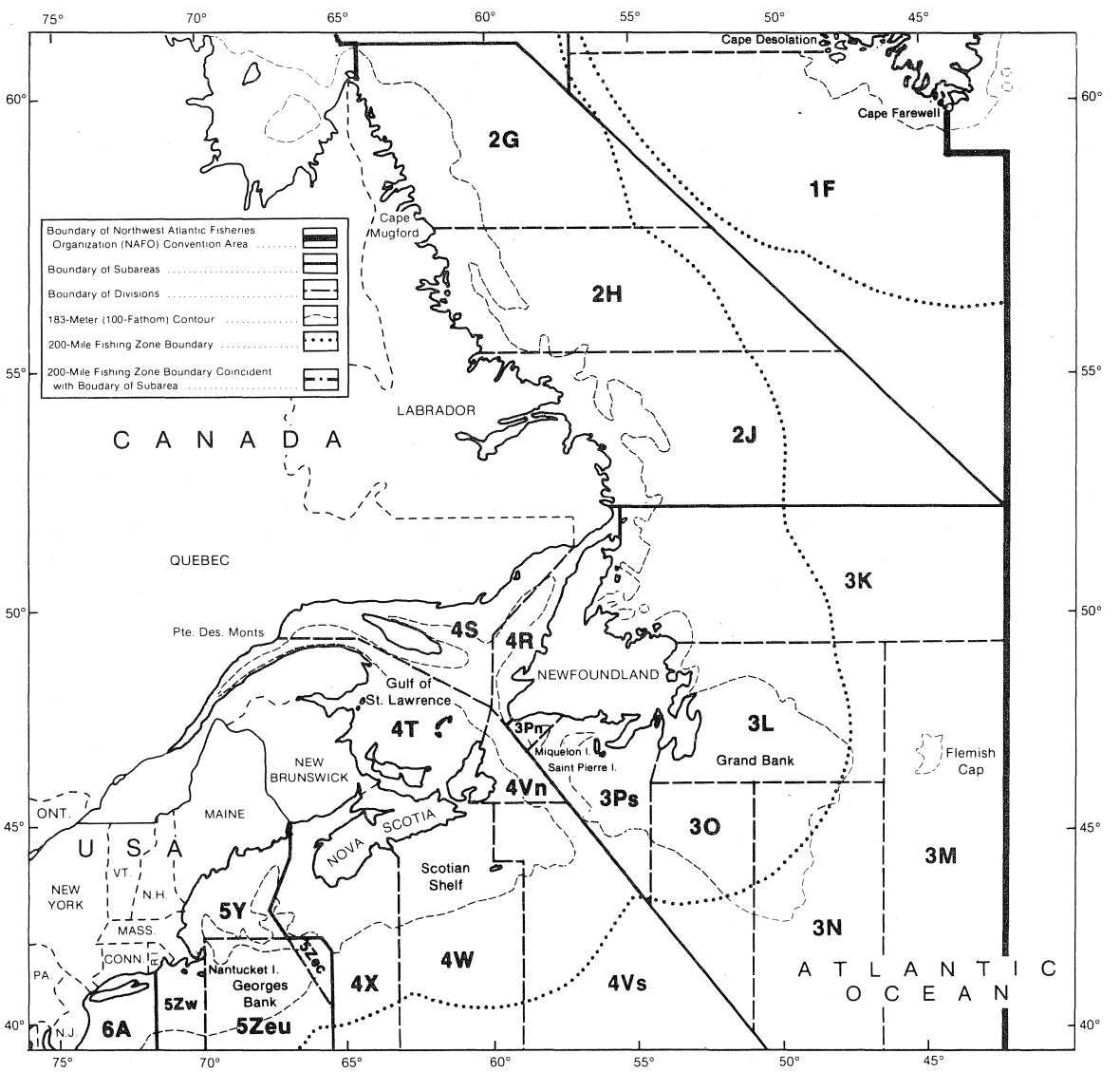

Fig. 3. NAFO Div. 2J, 3K, and 3L showing the Canadian 200-mile fishing zone.

time the allocations of cod in Div. 2J+3KL to countries other than Canada were reduced, which meant a significant reduction in the amount of total fishing mortality. It was also decided that because fishing mortalities had been high and the stock was at a very low level, that a reference fishing mortality lower than $F_{0.1}$ would be appropriate to allow the stock to rebuild. With the objective of reaching a target spawning stock biomass in the range of 1.2 to 1.8 million tons, catches were projected at a fishing mortality of 0.16, 80% of the $F_{0.1}$ level. This management strategy was used until 1983 when it was thought the target spawning biomass had been reached. During the 1983 assessment the 1984 catch was advised at the $F_{0.1}$ level. This management practice was used until 1987.

For the period 1977–79 fully recruited fishing mortality was estimated from the relationship obtained between fishing effort and fishing mortality (F). Research vessel surveys conducted by the USSR and the FRG were used to determine the year-class size.

During 1980 a multiplicative model (Gavaris, 1980) was used for the first time to standardize catch rates. For the period 1980 to 1987 various combinations of these total standardized catch rates and some aggregate research vessel abundance were used to calibrate sequential population analysis. The criteria for selecting fully-recruited fishing mortality in the terminal year using this type of calibration method was some combination of the following:

i) highest correlation (R^2);

ii) pattern of residuals in the most recent years;

iii) closeness of the intercept to the origin.

This technique provided little discrimination because in virtually all instances each of the criteria were met at different terminal Fs. This led to some degree of subjectivity in the choice of F and in some cases inconsistency in the criteria used from one year to the next.

Commercial catch-rate series originally used were those from 1962 to the assessment year. It was eventually determined that, because of unreliability of data collected prior to 1977 as well as the uncertainty in the total time series of catch rates caused by the change in fleet composition around 1977–78, the most appropriate time series of commercial catch rates was that from 1978 to the present. This was also the time period of the Canadian research vessel survey index.

When catch rate and research vessel data were used for calibration in the assessments, each index gave a different estimate of fishing mortality and population estimates in the terminal year. The research vessel series always gave more pessimistic indications of stock size than the catch-rate series. The assessment usually resulted in the selection of a population size midway between the values suggested by the indices, however there was no justification for assigning more weight to one data set than another.

The 1987 Assessment Compared to Those of 1989-90

The assessment conducted by the Canadian Atlantic Fisheries Science Advisory Committee during 1987 (Baird and Bishop, MS 1987) indicated that the age 4+ average population biomass was about 1.5 million tons with a fully-recruited terminal fishing mortality of 0.21. This resulted in an $F_{0.1}$ calculation for 1988 of about 290,000 tons, which represented about a 10% increase over the TACs of the previous 4 or 5 years. During subsequent assessments (Baird and Bishop, MS 1989; Baird *et al.*, MS 1990) it was determined that population estimates of 1987 and in fact of previous assessments, were much too high. For example the current assessment (Baird *et al.*, MS 1990) indicated that the 1986 age 4+ average population biomass was only about 60% of that estimated from the 1987 assessment. How could such an error have been made?

The commercial catch-rate index used for the 1987 assessment (Fig. 4) indicated a steadily increasing trend over the entire period. It was felt that the slight decline in the index in 1986 was about the same as that of 1982 and was not attributable to a decline in the stock.

The 1986 research survey gave a much higher value for the abundance than in previous surveys (Fig. 5), making the difference between estimates of population size obtained from the two indices (catch rate and research vessel) much less than it had been in previous assessments. The large increase in survey abundance between 1984–85 and 1986 could not have been attributed completely to an increase in population abundance, but there was some evidence to suspect the 1984 and 1985 research vessel survey points.

Bottom water temperatures in the survey area (Fig. 6) during 1984 and 1985 were the coldest observed for the time period the surveys were conducted. This led to the belief that the survey population size for 1984 and 1985 may have been underestimated because of reduced availability caused by the lower than usual water temperatures. In addition, survey biomass for some flatfish species (Fig. 7), for which fishing pressure was low, had also declined during 1984 and 1985. With some suspicion cast on the 1984 and 1985 survey points the large increase between 1985 and 1986 was much easier to rationalize, and the high 1986 research vessel point was influential in determining the size of the stock during the 1987 assessment.

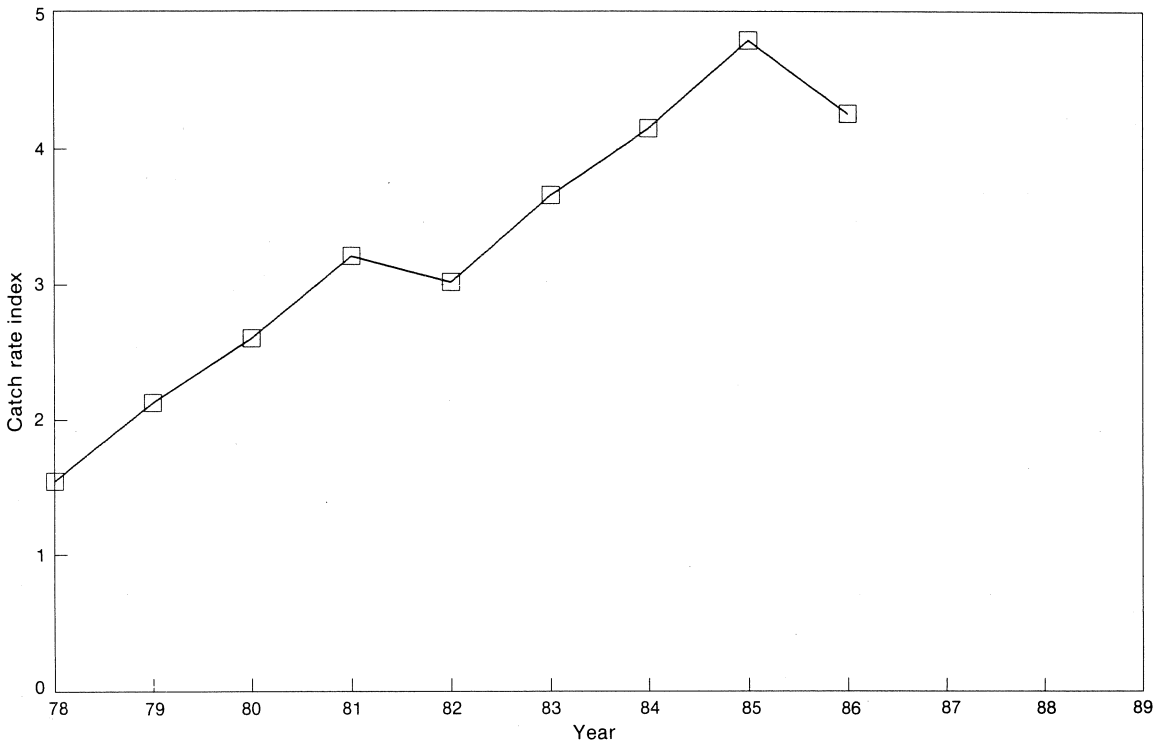

Fig. 4. Commercial catch rate index for cod in Div. 2J+3KL for 1978–86.

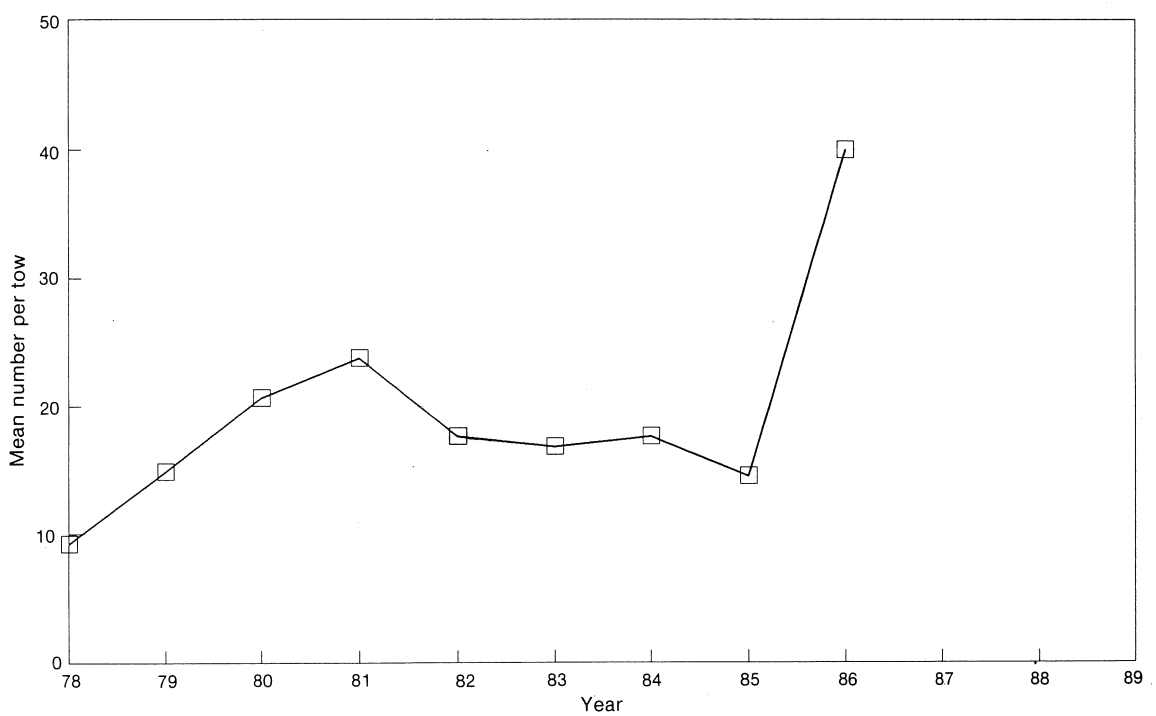

Fig. 5. Mean number of cod per tow at ages 6 and older in Div. 2J+3KL as estimated from research vessel surveys from 1978 to 1986.

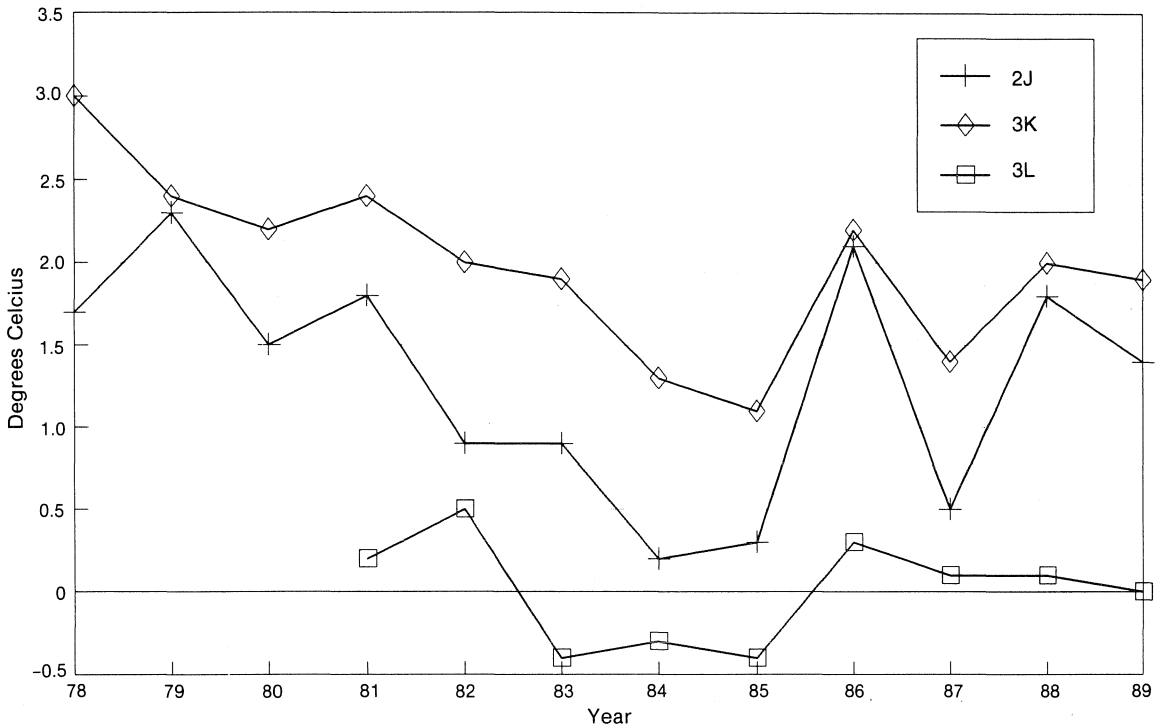

Fig. 6. Average bottom temperatures for Div. 2J, 3K and 3L at depths from 100 to 400 m for 1978–89.

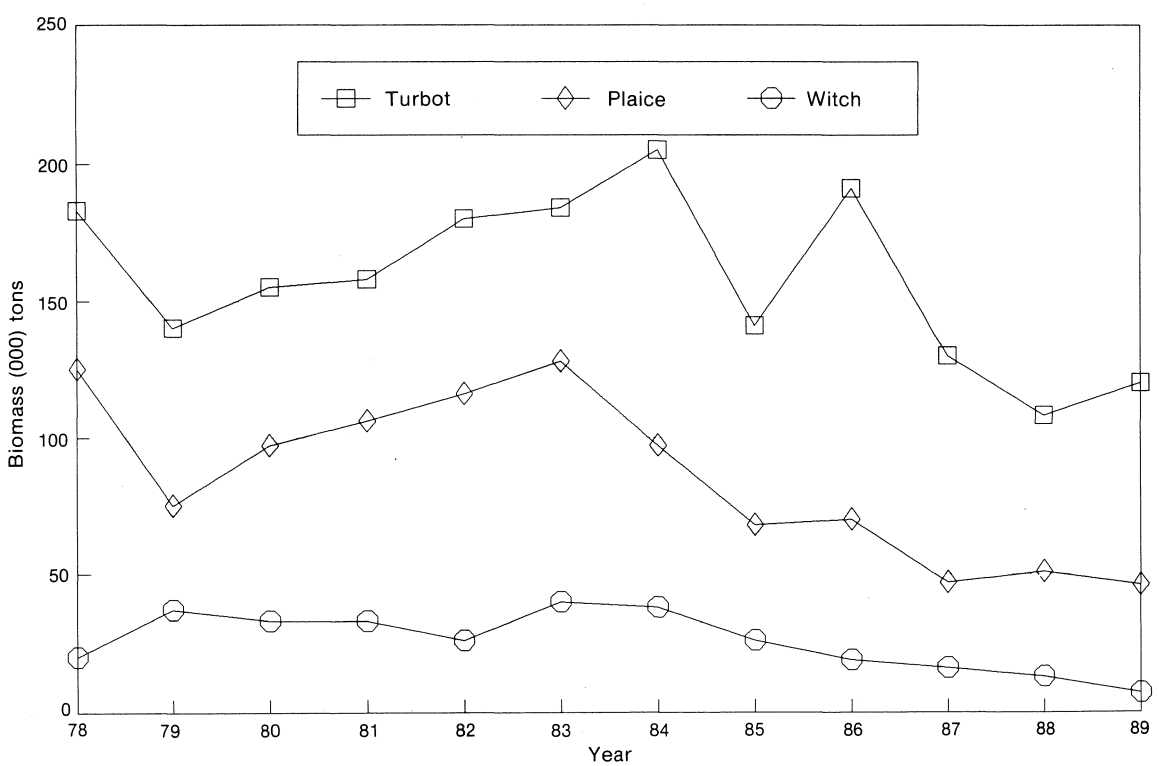

Fig. 7. Flatfish biomass estimated from research vessel surveys for Div. 2J and 3K combined for 1978–79.

At an autumn 1988 assessment it became apparent that the stock size had previously been overestimated. During this assessment the slight decline in the commercial catch rate observed in the previous year continued and there was some doubt as to the validity of the high 1986 research vessel value. It was at this assessment that a more objective calibration tool, the Adaptive Framework (ADAPT) (Gavaris, MS 1988), was first used for this stock.

As the 1988 assessment was conducted during autumn, it would only take a few months to incorporate all the available 1988 data (both research vessel and commercial) into a revised assessment to confirm or refute the conclusions of the 1988 assessment. An early 1989 assessment which incorporated all commercial and research data for 1988 confirmed the conclusions of the 1988 assessment. The commercial catch-rate index remained lower than previous years (Fig. 8), and there was now little doubt that the 1986 survey estimate was anomalous (Fig. 9). While the results of ADAPT indicated that the 1984 and 1985 survey indices were anomalously low (all negative residuals), as had been previously suspected, the 1986 survey index was associated with all large positive residuals and was most certainly an overestimate. The size of the resource was now revised to be much lower than that indicated by previous assessments and the implied $F_{0.1}$ catch for 1989 was 125,000 tons, less than half the previous TAC. The actual TAC for 1989 was set at 235,000 tons, a catch at which the size of the biomass at the beginning of 1990 would be approximately the same as it was at the beginning of 1989.

While there was some refinement of the formulation of ADAPT for the 1990 assessment, the results were very similar to those of the 1989 assessment. The trends in stock biomass from the most recent assessment are shown in Fig. 10. The biomass was at its lowest level during the mid-1970s, then increased by a factor of about 2.5 times up until 1984. The decline in biomass in the most recent years was due to the recruitment of the weak 1983 and 1984 year-classes. These year-classes were estimated to be among the lowest observed in the 28 year time series of age 3 population estimates.

Summary

A number of reasons are attributed to the overestimation of stock size during the period prior to 1988:

Inappropriate weight was given to the commercial catch-rate index in assessments in the mid-1980s. It is currently believed that the increase in commercial catch rates from 1978 to 1985 (a factor of over 3) was partly due to changes in fleet efficiency during the early years of the catch-rate time series.

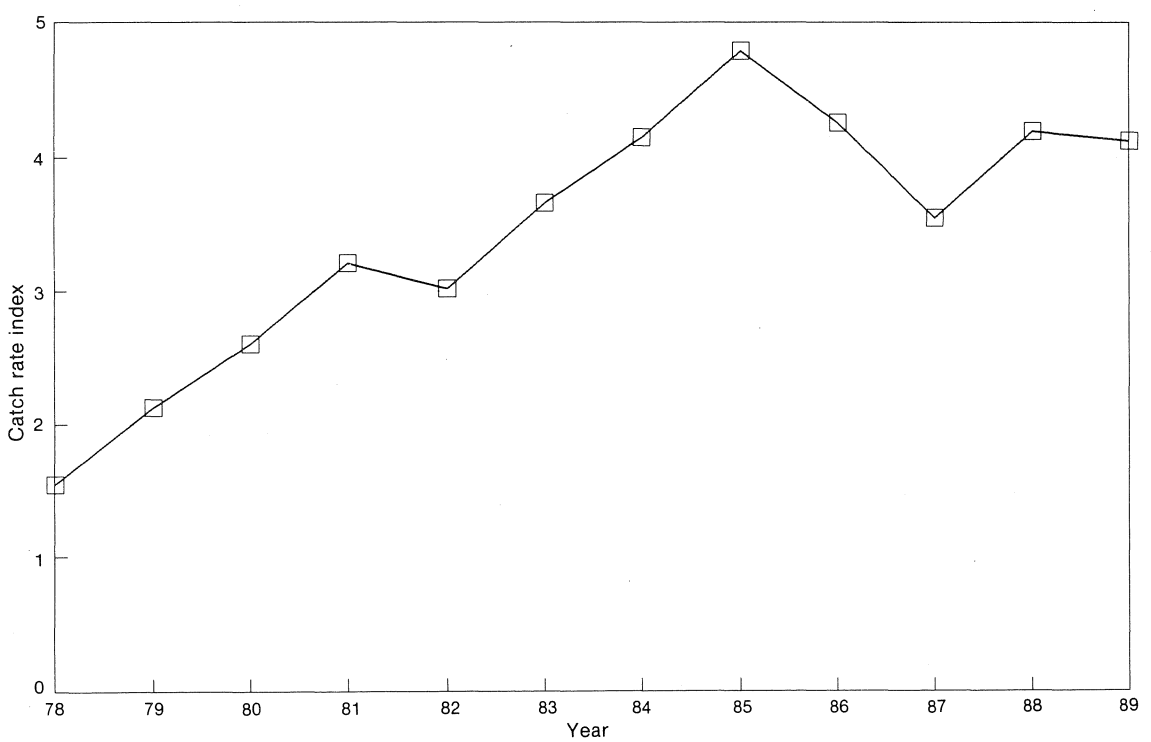

Fig. 8. Commercial catch rate index for cod in Div. 2J+3KL for 1978–89.

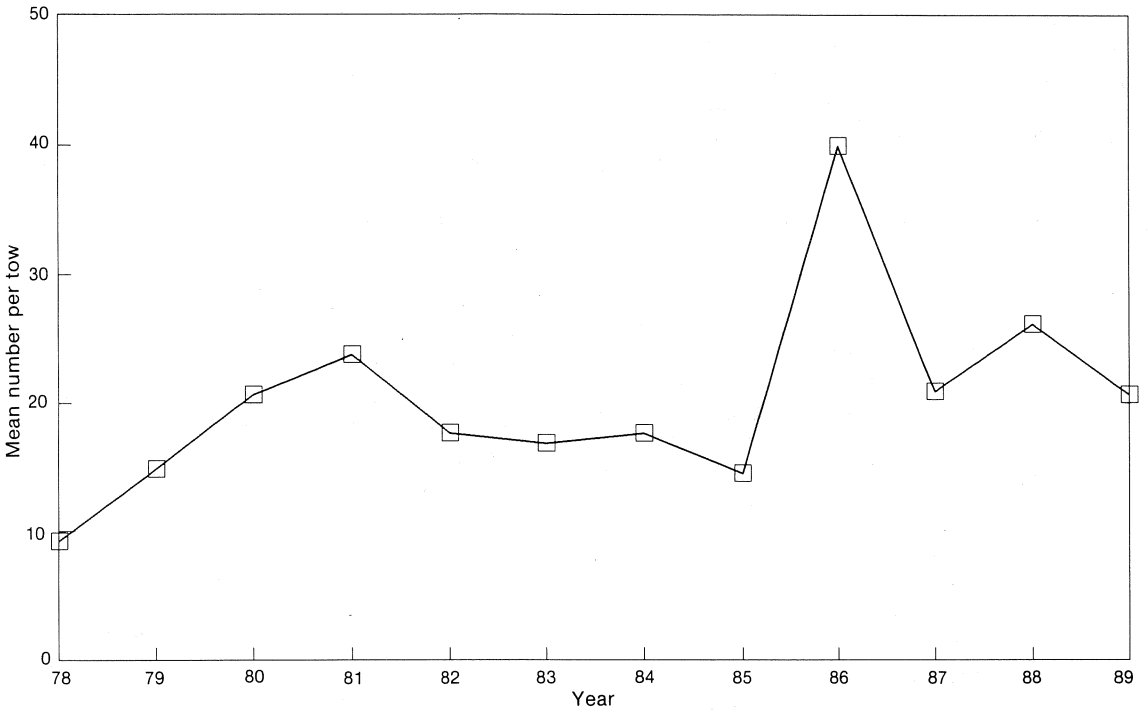

Fig. 9. Mean number of cod per tow at ages 6 and older in Div. 2J+3KL as estimated from research vessel surveys from 1978 to 1989.

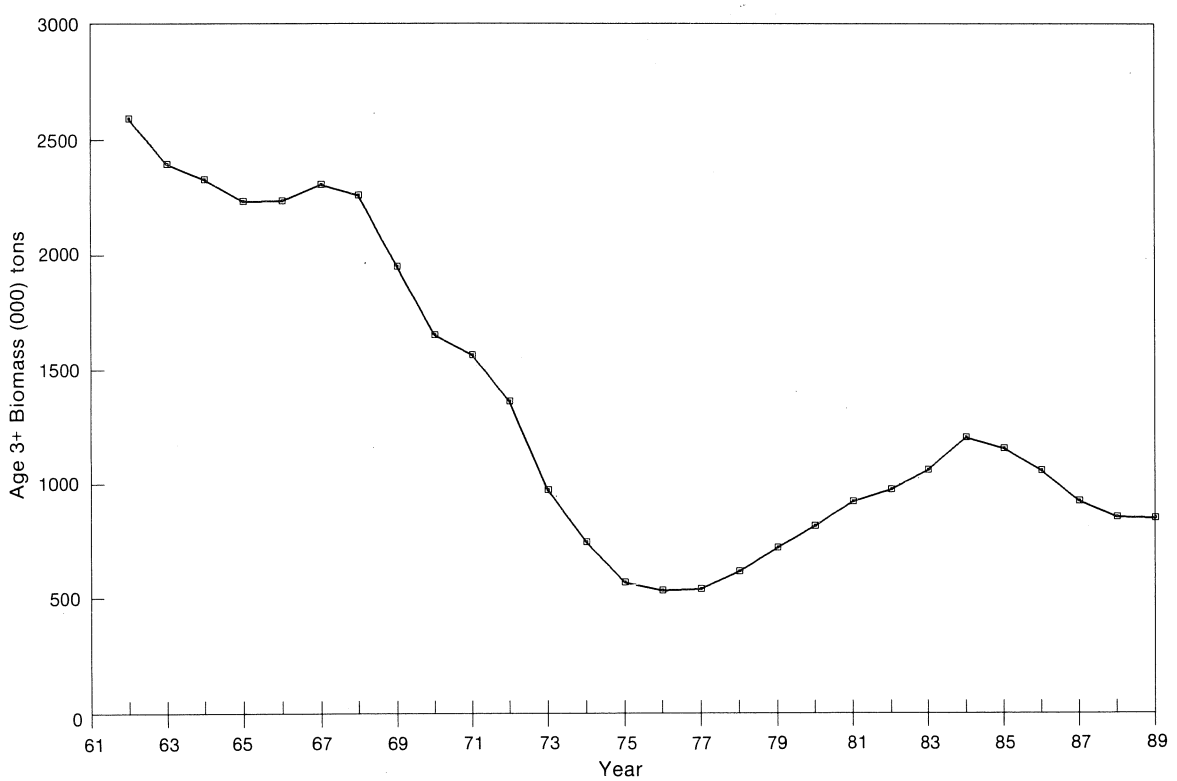

Fig. 10. Age 3+ cod biomass in Div. 2J+3KL.

In the most recent assessment (Baird *et al.*, MS 1990) the earliest years (1978–82) of the catch-rate index were excluded from the calibration because of this.

In years prior to 1988, the time series for calibration were short and the value of a single year in the index could have been extremely influential on the assessment (note — the 1986 research vessel index). The time series used are still short, but, as each year passes and additional points are added to existing indices there is less chance that anomalous values for a single year will influence the outcome of an entire assessment.

Lastly, the calibration method used prior to 1988 was too subjective. Current assessments employ a more objective calibration tool in ADAPT. This has been the case for the most recent assessments (1989 and 1990) and will continue to be the case into the future.

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