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# Commercial Fishery Based Estimate of Cod Abundance in NAFO Division 4X

by

A.R. Hanke
Department of Fisheries and Oceans
Biological Station
St. Andrews, New Brunswick E0G 2X0

## Abstract

The commercial landings data from 1987-1992 were used to produce abundance estimates for the 4X cod stocks. The data used in the analysis were restricted to records from otter trawlers that were allocated quotas for this species in 1992, and had records in at least three years of the time series. Furthermore, this subset of the catch data was standardized to a common vessel, year, month and NAFO area.

The trends in abundance indicate a steady decline in cod numbers since 1989. The estimated effort increased over this time period, perhaps in an effort to maintain a constant level of catch or income.



## Résumé

On s'est servi des données sur les débarquements commerciaux de 1987 à 1992 pour produire des estimations d'abondance des stocks de morue de 4X. Les données en question provenaient uniquement de chalutiers à panneaux qui avaient reçu des quotas de morue en 1992 et à propos desquels on disposait de statistiques sur au moins trois années de la série chronologique. En outre, on a standardisé ce sous-ensemble de données pour un même bateau, un même mois, une même année et une même zone de l'OPANO.

Il ressort de l'analyse des tendances que l'abondance de la morue a constamment diminué depuis 1989. L'effort éstimé a augmenté durant la période considérée, peut-être pour maintenir un niveau constant de prises ou de revenus.

## Introduction

A substantial groundfish fishery occurs in division 4X every year, with cod being one of the more commercially important species. A record of this fishery is maintained in a commercial landings data base for catch monitoring purposes. An alternative use for these data is the estimation of cod abundance. However, two factors prevent the abundance estimation from being a straightforward task. Firstly, there are a vast number of records to be considered in a given year and secondly, the catch and effort data are not directly comparable for different vessels fishing in different years and/or months. This document describes the methodology for reducing the data set's size and for standardizing the catch rate so that cod abundance could be estimated.

## Methods

### Data selection

The commercial landings data base thoroughly characterizes a vessel's catch on either a set, day or trip level. Variables include vessel characteristics (eg. tonnage, horsepower), gear type (eg. handline, purse seine), species, weight, date, effort and location. From this list, variables thought to introduce the most variation in the catch rate were considered.

#### Vessel/Gear

The variety of gear types used to catch cod complicate the estimation of abundance. Gear type cannot be easily standardized because the definition of effort for the fixed gears (eg. gillnets, longlines) is not a straightforward one. Thus, the abundance estimates were based on cod caught by mobile gear (eg. trawlers). The ITQ listings for the 1992 mobile gear sector identified the vessels with a history in the 4X cod fishery, and those allocated a quota greater than 5 t were selected. These vessels were primarily tonnage class 2 and 3 with a few being tonnage class 1 and were stern otter trawlers. From a possible 280 vessels with ITQ's, 243 passed the initial selection.

#### Years/Months

Every effort was made to make the time series as long as possible. However, changes in the format of the commercial landings data set in the recent past made it difficult to extend the series earlier than 1987. In recent years, a greater level of detail has been associated with a vessel's catch on a given fishing trip; set level information is now recorded. The late 1980s have mostly day level data while 1987 and older are aggregated to the trip level. Thus, the aggregated nature of the early data dictates how the more recent data would be processed.

Estimates of catch rate were consistent at the different levels of aggregation for all cod landings data. Consequently, trip level values were used, resulting in both a reduction in the number of records and the possibility of extending the time series into the earlier more aggregated years. Landings data earlier than 1987 were not available for this report but will be considered in future analyses.

All months fished were considered because the fishery in 4X is always open.

Landed weight/Effort hours

All records, where either the landed weight or effort hours equalled zero, were excluded. An inconspicuous feature of the data was that the weight for a catch was often partitioned according to the form in which it was landed (round, gutted), whereas the corresponding effort was not. If this situation were not remedied, many invalid occurrences of low catch rate would be evident, biasing abundance estimates downwards. Consequently, these split records were summed for values of landed weight only, not effort hours.

The trip level aggregation of the data left two alternatives for representing the catch rate of a vessel's trip. Catch rate in this study was represented by the ratio of the sum of the catch to the sum of the effort rather than the average catch rate for a trip. The former method tends to dampen the effect of extreme values.

Catch rate standardization

The ability to catch cod may differ among different regions (NAFO divisions and/or areas for example), vessels, years and months of the year. In fact, there are probably interactions among these factors which contribute to variation in catch rate. The importance of these interactions will be the topic of further study. The present analysis addressed the significance of the main effects only.

A multiplicative model (as outlined by Gavaris 1980) was used to describe the relationship between catch rate and area, vessel, month and year. Each level of a main effect required a separate regressor to be estimated. Incorporating individual vessels in the model rather than tonnage classes meant 243 regressors would have to be estimated for the vessel category alone. Therefore, the number of vessels in the model was reduced to 139 by eliminating those vessels missing three or more years of data in the six years of the time series, 1987-1992 (A similar data reduction of the Georges Bank fishery's data improved the precision of catch rate estimates without dramatically altering their relative value across years). NAFO area 4XI was also eliminated due to missing data in many years.

## Results

Figure 1 and Table 1 indicate a steady decline in catch rate and thus in cod abundance since 1989. However, abundance is still above the low of 1987. While the actual landings for the tonnage class 1,2 and 3 vessels have been fairly consistent over the six year period, the effort expended has increased since the high of 1989. Significant differences in catch rate were detected among years, months, unit areas and vessels (Table 2), however only 28% of the total sum of squares of catch rate can be attributed to the regression. A better fit may be achieved with the inclusion of interaction terms.

The regression parameter estimates associated with months and areas, termed powers, represent the conversion ratio of category types relative to a standard category. These powers are a useful tool for comparing categories. For example, the relative fishing powers for areas ranks 4Xs and 4Xr as two of the best places to catch cod followed by 4Xp, 4Xo, 4Xq, 4Xm and 4Xn. The best months were June and March (Fig. 2) while the worst were May and August. The low value for May may have resulted from fishing in unproductive areas due to closures in high abundance unit areas and therefore does not reflect true cod abundance at that time.

## References

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37:2272-2275.

Table 1. Estimated catch rate (t/hr) and effort (hr) using one vessel, area 4Xn and October as the standard. The observed catch (t) for cod is by tonnage class 1-3 trawlers.

| Year | CPUE | S.E. | Catch | Effort |
|---|---|---|---|---|
| 1987 | 0.097 | 0.012 | 6446 | 66327 |
| 1988 | 0.137 | 0.018 | 7580 | 55137 |
| 1989 | 0.191 | 0.024 | 8526 | 44602 |
| 1990 | 0.181 | 0.023 | 7730 | 42699 |
| 1991 | 0.148 | 0.018 | 10744 | 72662 |
| 1992 | 0.121 | 0.015 | 10438 | 86427 |

Table 2. Analysis of variance for a main effects multiplicative model, for catch rate of cod in NAFO division 4X.

| Source of variation | Degrees of freedom | Sum of squares | Mean squares | F-value |
|---|---|---|---|---|
| Intercept | 1 | 1.183E5 | 1.183E5 | |
| Regression | 160 | 6.536E3 | 4.085E1 | 32.355* |
| Vessel | 138 | 3.663E3 | 2.654E1 | 21.025* |
| Area[1] | 6 | 3.822E2 | 6.370E1 | 50.453* |
| Month | 11 | 8.145E2 | 7.404E1 | 58.645* |
| Year | 5 | 4.334E2 | 8.669E1 | 68.662* |
| Residuals | 13561 | 1.712E4 | 1.263E0 | |
| Total | 13722 | 1.420E5 | | |

[1]Unit area 4Xl not included due to low numbers.
*P<0.01.
Multiple R=0.526 Multiple R squared=0.276

Fig. 1. Standardized CPUE generated for an otter trawler fishing for cod in 4Xn in October.

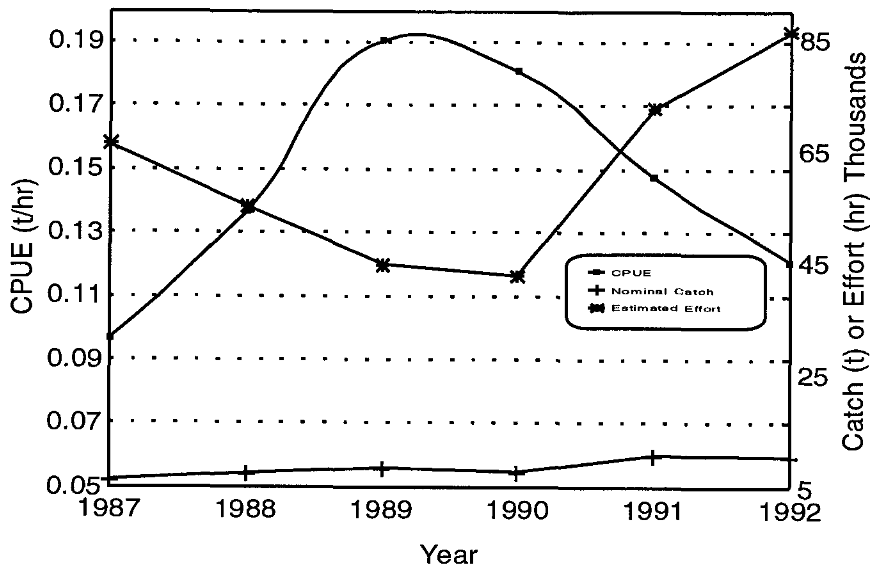


Fig. 2. Fishing power of months for cod in 4X between 1987-92.