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Commercial Fishery Based Estimate of Pollock Abundance on the Scotian Shelf

by

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Abstract

The commercial landings data from 1987-1992 were used to produce abundance estimates for Scotian Shelf pollock stocks. The data used in the analysis were restricted to records from otter trawlers from all tonnage classes, where pollock represented at least fifty percent of the catch. Furthermore, this subset of the catch data was standardized to a common tonnage class, year, month and NAFO division.

The trends in abundance indicate that pollock numbers have declined since 1989 to an all time low for the series in 1992. The estimated effort increased over this time period, perhaps in an effort to maintain a constant 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 goberge du plateau néo-écossais. Les données en question provenaient uniquement de chalutiers à panneaux de toutes catégories de tonnage dont les prises se composaient d'au moins cinquante pour cent de goberge. En outre, on a standardisé ce sous-ensemble de données pour une même catégorie de tonnage, un même mois, une même année et une même division de l'OPANO.

Il ressort de l'analyse des tendances que le nombre de goberges a diminué depuis 1989 pour atteindre son niveau le plus bas de la série en 1992. L'effort éstimé a augmenté durant la période considérée, peut-être pour maintenir un niveau constant de prises ou de revenus.

Introduction

The Scotian Shelf, in the present context, refers to the North Atlantic Fisheries Organization (NAFO) divisions 4Vn, 4Vs, 4W, 4X, and the Canadian portion of 5Ze. In a given year this area is associated with thousands of records for pollock landings alone. These records are mainly used for catch monitoring purposes but potentially could help to answer abundance type questions. Typically, catch/effort records are generated by a large number and variety of vessels fishing in a number of different months and areas, and thus cannot be used for inter-year comparisons of abundance without first employing some standardization technique. The objectives of this report are to outline a method that reduces the quantity of the available data without affecting its quality and to estimate pollock abundance using standardized catch rate data.

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 (mobile and fixed) used to catch pollock complicates the estimation of abundance. Standardizing for gear type would not be satisfactory given the questionable definition of effort for fixed gears. Concentrating strictly on stern trawlers avoided this problem and helped to reduce the number of vessels to between 192-325 per year. Using a vessel's tonnage class designation (1-7) further reduced the dimensions of the data matrix.

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. The problem results from increasing amounts of detail in the catch recorded for a vessel's fishing trip. Prior to 1988 the catch from an entire trip would represent one record. By the late eighties, catch data for each day of the trip was recorded while in recent years set level information was included. Thus, the aggregated nature of the data from 1987-1989 dictated how the more recent data would be processed.

Estimates of catch rate were not consistent at the different levels of aggregation when all pollock landing were used but were when restricted to landings where pollock represented 50% or more of the catch. Thus, trip level estimates were proportional to set or day level estimates provided they were based on catches where pollock were targeted. Consequently, the trip-level-pollock-targeted data was used resulting in both a reduction in the number of records and the option of extending the time series into the earlier more aggregated years. Due to time restrictions only the 1987-1992 data could be considered.

The months fished were restricted to April through to November. This period corresponded to times when pollock were more abundant.

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 or 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 pollock may differ among different regions (NAFO divisions and/or areas for example), tonnage classes of 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 NAFO division, tonnage class, month and year. Each level of a main effect required a separate regressor to be estimated. These estimates were then used to predict the catch rate (abundance) for a standard vessel fishing in a standard month and division in each of the years in the time series. Changing the standard changes only the absolute estimate of catch rate and not the relative value among years (see Fig. 1)

Results

Figure 1 and Table 1 indicate a steady decline in catch rate and thus in pollock abundance since 1989. In each year, the relative abundance of pollock is highest in 4W followed by 4X, 5Ze, 4Vs and 4Vn. The multiplicative model ensures the proportionality of these abundance estimates among divisions. Significant interactions between divisions and some other factor, could change these uniform trends.

The nominal catch and estimated effort curves of Figure 2 show declining pollock landings coupled with increasing effort which supports the decline in abundance estimated in Figure 1.

An analysis of variation in pollock catch rate (Table 2) indicates that both tonnage class and year were important factors. Month and division account for lesser amounts of the total variation. Overall, only 20.6% of the total variation in catch rate can be attributed to regression. Interaction between factors may help to explain a sizeable portion of the remaining variation.

Of cursory interest are the powers associated with months and tonnage classes. The powers are simply the regression parameter estimates and they represent the conversion ratio of category types relative to a standard category. For example, fishing power increased with vessel tonnage class indicating that larger vessels do in fact catch more fish per hour than smaller vessels. The plot of powers for months is sinusoidal with obvious peak fishing times corresponding to June-July and September-October (Fig. 3).

The significant trends in powers for both tonnage class and month justify their inclusion in the model.

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 tonnage class 2, division 4X and June as the standard. Observed catch (t) for pollock is by all tonnage class trawlers.

Year	CPUE	S.E.	Catch	Effort
1987	0.568	0.036	31123	52010
1988	0.388	0.024	29246	71515
1989	0.743	0.044	27428	35060
1990	0.557	0.032	21582	36764
1991	0.399	0.020	26101	62143
1992	0.243	0.012	21909	85496

Table 2. Analysis of variance for a main effects multiplicative model, for catch rate of pollock on the Scotian Shelf.

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-value
Intercept	1	9.857E3	9.857E3	
Regression	23	2.921E3	1.270E2	84.424*
Division[1]	4	1.151E2	2.876E1	19.121*
Tonnage	6	1.330E3	2.217E2	147.393*
Month	8	6.822E1	8.527E0	5.669*
Year	5	9.684E2	1.937E2	128.751*
Residuals	7471	1.124E4	1.504E0	
Total	7495	2.402E4		

[1]Divisions 5Ze, 4W, 4Vs, 4Vn and 4X.
*$P<0.01$.
Multiple R=0.454 Multiple R squared=0.206

Fig. 1. Standardized CPUE generated for tonnage class 2 otter trawlers fishing for pollock in NAFO Division 4X. Only catches with at least 50% pollock were used.

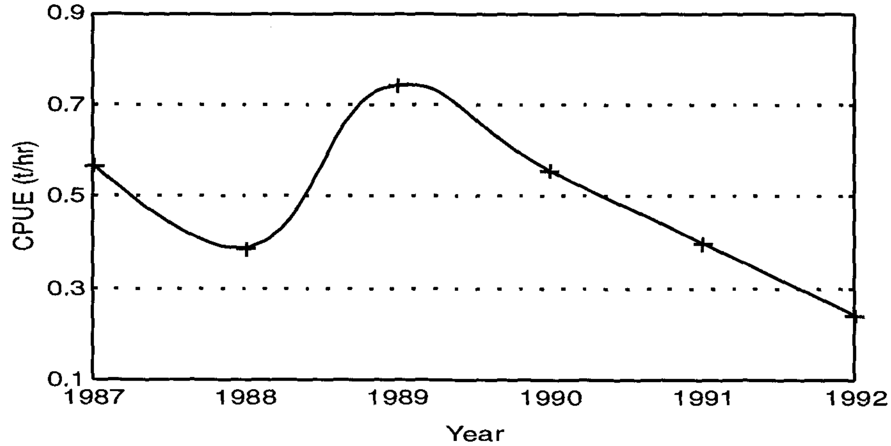

Fig. 2. Nominal catch and estimated effort for all tonnage class otter trawlers taking pollock on the Scotian Shelf.

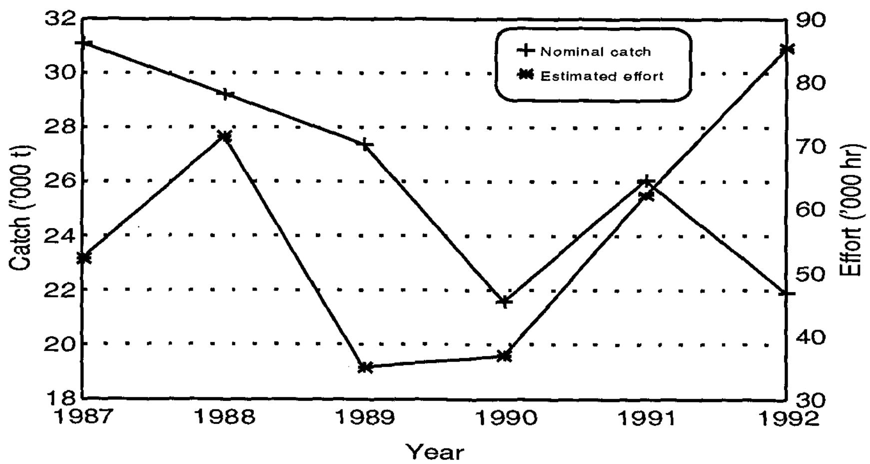

Fig. 3. Fishing powers for months.