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Estimating Trends in F from Length Frequency Data

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Abstract

A method is described for estimating trends in fishing mortality at length using commercial and research vessel survey length frequency data. An example is presented for two haddock stocks on the Scotian Shelf. The method may be used to estimate absolute fishing mortalities if the research vessel survey catchability is known.

Résumé

On décrit ici une méthode d'estimation des tendances de la mortalité par pêche selon la longueur qui fait appel aux données sur la fréquence des longueurs provenant de la pêche commerciale et des relevés de recherche. Un exemple portant sur deux stocks d'aiglefin du plateau néo-écossais est présenté. La méthode en question peut être utilisée pour estimer les mortalités par pêche absolues si l'on connaît le potentiel de capture propre au relevé de recherche.

Introduction

Sequential population analyses (SPA) have not been used for Scotian Shelf haddock stocks for several years due to difficulties with catch-at-age data and the calibration process for the SPA (Zwanenburg 1989; Zwanenburg 1990). As an alternative, total mortality (Z) along cohorts was estimated from research vessel survey (RV) estimates of population size (A) in successive years.

$$Z_{i+.5} = \ln\left(\frac{A_i}{A_{i+1}}\right)$$

Fishing mortalities were estimated by subtracting M=0.2 from the estimated Z's. These estimates were extremely variable and sometimes negative because of variability in RV data.

Difficulties with age determinations precluded the use of age-composition data for estimating mortality rates for these stocks in 1993. As an alternative, length-frequencies from the commercial fishery and the research surveys were assembled and analyzed (Hurley 1993, Zwanenburg 1993).

This paper presents a relatively simple method for estimating relative F directly from research survey and commercial length frequency data. The basic approach uses the following relationship between F, catch (C) and mean population abundance ($\overline{N}$) described by Ricker 1975.

$$F = \frac{C}{\overline{N}}$$

Assuming that annual RV surveys provide a consistent relative index of mean population abundance (A) then equation 1 may be modified to provide an estimate of relative F (R).

$$R = \frac{C}{A}$$

Estimates of C and A may be length-based thus producing length-based estimates of R.

Methods

Length frequencies of the commercial catches and the research surveys for the 4TVW and 4X haddock stocks were used in this study. The research survey length frequencies were expressed as population numbers at length. The frequencies were grouped in 2 cm length intervals. The interval mid points were on the half cm of even numbered lengths (e.g. interval 20.5 included 19.5 <= L <21.5)

The RV surveys for the Scotian Shelf haddock stocks are conducted in July and, for the purposes of this paper, they are taken to represent mid-year estimates of population size. The ratio of catch at length (C_l) to the RV estimate (A_l) were used as a direct estimate of relative fishing mortality at length (R_l).

$$R_l = \frac{C_l}{\overline{A}_l}$$

Preliminary examination indicated that $\ln(R_l)$ could be cast as a quadratic function of length, and the annual curves were estimated using the analysis of covariance described below.

$$\ln(R_l) = \beta_0 + \beta_1 L + \beta_2 L^2 + \beta_3 Y + \beta_4 Y * L + \beta_5 Y * L^2 + \varepsilon$$

where L = the mid-point of the length interval
Y = a matrix of 0 and 1 indicating the years
the coefficients β_3 β_4 β_5 are vectors.

Residuals were tested for normality and the main effects were tested for significance using type III sums of squares. Trends in fitted annual R at selected length intervals were examined.

<u>Results</u>

The regression results for both stocks indicated that the full model given in equation 2 is adequate; there was significant variation in both slope and intercept among the years (Tables 1 and 2). The model explained over 86% of the variation in $\ln(R_l)$. The residual distribution appeared to be normal.

The results indicate increasing R with length for both stocks (Figure 1). The estimated R at successive selected length intervals increased consistently with length in all years. There was a decline in R from the early 1980's until 1987 for 4TVW haddock. Since then, R increased for the lengths > 40.5, and were extremely high in 1992. For 4X haddock, the R's declined from 1987-1991 and increased slightly in 1992.

<u>Discussion</u>

This paper presents a method for estimating trends in F over time from length frequency data. Temporal change in R would indicate relative changes in fishing mortality at length. We believe that it is a useful way of examining commercial and research vessel data when aged estimates of abundance are unavailable or when SPA is not possible.

The method may be used to estimate absolute fishing mortalities at length if reliable estimates of the RV catchability (k) are available. The ratio between F and R would be equal to the catchability of the RV survey. If the RV catchability is known, then estimates of F may be obtained as

$$F = \frac{kC}{A}$$

It would be useful to compare the results of this type of length-based analysis to those obtained from an SPA for the same stock.

References

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Table 1: Regression results for 4TVW haddock F at length analysis.

R^2	0.86
Observations	306

Effect Test

Source	Nparm	DF	SS	F Ratio	Prob>F
Length	1	1	165.6	358.7	0.0000
$Length^2$	1	1	109.5	237.1	0.0000
Year	14	14	22.3	3.4	0.0000
Year*Length	14	14	19.4	3.0	0.0003
$Year*Length^2$	14	14	16.7	2.6	0.0016

Analysis of Variance

Source	DF	SS	MS	F Ratio
Model	44	718.2	16.3	35.3
Error	261	120.51	0.46	Prob>F
C Total	305	838.7		0.0000

Shapiro-Wilk W Test for Normality

W	Prob<W
0.98	0.32

Table 2: Regression results for 4X haddock F at length analysis.

R^2	0.87
Observations	316

Effect Test

Source	Nparm	DF	SS	F Ratio	Prob>F
Length	1	1	129.8	812.5	0.0000
Length^2	1	1	106.7	667.5	0.0000
Year	14	14	6.5	3.0	0.0004
Year*Length	14	14	6.7	3.0	0.0003
Year*Length^2	14	14	7.4	3.3	0.0001

Analysis of Variance

Source	DF	SS	MS	F Ratio
Model	44	290.6	6.6	41.3
Error	271	43.3	0.2	Prob>F
C Total	315	333.9		0.0000

Shapiro-Wilk W Test for Normality

W	Prob<W
0.99	0.96

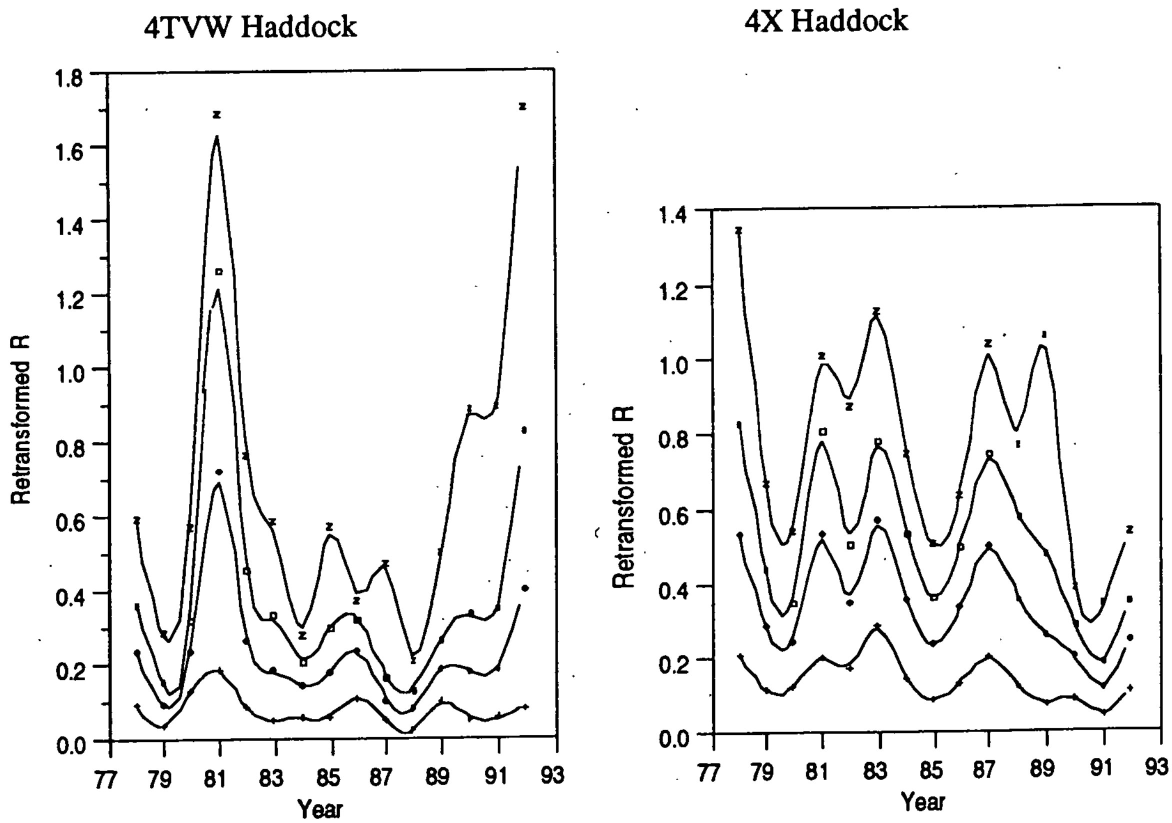

Figure 1: Estimates of R at length for 4TVW and 4X haddock. In both panels, the lengths represented by the smother lines are 60.5, 50.5, 46.5, and 40.5 cm from top to bottom respectively. The F estimates were bias-corrected in retransforming from the ln estimates.