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Potential Indicators of Pollock Productivity

Indicateurs potentiels de la productivité de la goberge

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ABSTRACT

As part of the Framework Assessment of pollock conducted in 2003, potential indicators of the current status or productivity of the pollock resource in Divs. 4VWX5Zc were presented. The indicators of condition, survey mean weight at age, age composition and spatial measures were described. It was recommended that as part of the preparations for the final stage of the pollock Framework Assessment, that time series of these potential indicators be made available to scientists participating in the review.

RÉSUMÉ

Des indicateurs potentiels de l'état actuel ou de la productivité de la ressource en goberge des divisions 4VWX5Zc ont été présentés lors de l'examen du cadre d'évaluation de l'espèce effectué en 2003. Ceux-ci incluaient la condition, le poids moyen selon l'âge établi par relevé, la composition par âge et des mesures spatiales. On a recommandé que des séries chronologiques de ces indicateurs potentiels soient mises à la disposition des scientifiques participant à cet examen pour qu'ils puissent se préparer en vue de la dernière étape du processus.

INTRODUCTION

There has been considerable recent interest in augmenting traditional indicators of stock productivity, such as survey abundance indices or commercial CPUE. The motivation for this appears to be related to improving the stability and reliability of models of stock condition, and to include types of information which are not usually included in the population model. Methods for incorporation of such indicators into stock assessments are still under development, but have included the so-called Traffic Light Approach (Halliday 2001) that attempts to summarize time series of various indicators of stock and ecosystem health, and integrate them into population characteristics of production, abundance, and mortality. It has been noted that indicators of stock condition were often included on intuitive grounds only, and the functional form of the relationship between the indicator and the characteristic of the population was poorly understood or unknown.

In this document, I document trends in potential indicators of stock productivity for pollock in Div. 4X, and when possible, attempt to relate them to trends in abundance as indicated by population model for pollock. As part of the pollock Framework Assessment in 2003, I present these indices as candidates for further investigation including possible incorporation in population models to be assessed during the final meeting.

TRENDS IN WEIGHTS AT AGE

On first principles of competition theory, growth rates of individual fish are expected to decline as the abundance of the population increases, unless the food supply also increases or was not limiting. Thus, growth rate may offer some potential as a measure of stock performance. A review of the literature, however, suggests that most of the empirical data supporting a negative correlation between growth rate and abundance are from freshwater ecosystems. For marine fish stocks in Canadian Maritimes Region, temperature accounts for a considerably larger fraction of variation in growth rate than does density dependence (Brander, 1997; Swain et al, 2002).

As a component of production, however, consideration of growth and growth rates is obligatory. Unusual recent observations of growth rate must, of course, be included in the assessment and the resulting projections of population growth and potential harvest.

Survey (Fig. 1) and commercial fishery pollock weights at age in NAFO Div. 4X have followed a decreasing trend that reached a minimum in the mid-1990s. Since then, weights at age have followed an increasing trend. The trends in weights at age in the Canadian surveys also appear to be reflected in USA surveys

conducted in NAFO Subarea 5, indicating that these patterns of growth of pollock are wide-spread through the range of the fish.

To contrast the trends in weight at age with population abundance, I updated the population model presented in the last full assessment for pollock (Neilson et al. 1999). This provided estimates of total biomass from 1982 to 2002, which are compared with the trends in weights at age in Fig. 2. As can be seen, there is some correspondence between population biomass and weights at age, but the relation is a positive one: higher weights at age appear to be associated with greater levels of population biomass. The causal agent for such a relationship is not known. Of course, it is also possible that the apparent relationship is coincidental.

CONDITION

I show the trend in condition (as indicated by the predicted weight of a 40 cm pollock and the traditional Fulton's K measure of condition, based on observations of length and weight from surveys in NAFO Div. 4X) in Fig. 3. Both measures of condition track each other well from year to year, but the decline in predicted weights is more pronounced. Condition declined to a minimum in 1994, and has not recovered appreciably. The updated relationship between recruitment and parental stock is shown in Fig 4 (included ages 3 to 8 from the VPA, Fig. 4), and appears to indicate promise for exploration of relationships between residuals and condition, following a similar approach to that of Neilson et al. 2002.

AGE COMPOSITION

An often-noted feature of recent assessments has been the considerable reduction in the occurrence of older fish in the commercial fishery and the RV surveys (Fig. 5) that has been noted across the Scotian Shelf and the Gulf of Maine. The abundance of fish age 7 and older appears to have declined in the 1990s and has not recovered. Older ages were similarly depleted in the 1970s on the Scotian Shelf. Given published reports for other gadids that there is a positive relationship between female size and egg survival (Solemdal et al. 1995), the loss of these larger, older pollock may be a concern. However, evidence for such an effect is not clear from Fig. 4, as years of reduced abundance of older fish (post 1988 years) are sometimes associated with higher than anticipated numbers of recruits.

SPATIAL MEASURES

Several authors have noted that area occupied and abundance are positively correlated for a number of demersal fish populations (Winters and Wheeler 1985; Creco and Overholtz 1990; Rose and Leggett 1991; Swain and

Wade 1993, 1994; Marshall and Frank 1994). Using examples from the Gulf of St. Lawrence cod (Swain and Sinclair 1994) and eastern Scotian Shelf cod stocks (Zwanenburg MS 2000), workers have illustrated how area occupied was positively correlated with abundance.

However, when I plotted two measures of resource distribution (proportion of nonzero sets, and stratified area occupied (Fig. 6), I observed an increasing trend that bore no obvious relationship to the abundance of pollock as indicated in the VPA. The interpretation appears to be that pollock are more widespread now than was the case when they were relatively abundant.

It may be that a measure of the spatial concentration of the fishery would be more informative than indicators from the survey for this species. Clark et al. (1998) documented changes in the spatial distribution of the fishery that could be related to changes in resource distribution, but they noted the interpretation was confounded by fishery management actions that have influenced the distribution of effort.

CONCLUSIONS AND RECOMMENDATIONS

The trend in weight at age and condition is striking and widespread among pollock in NAFO Div. 4X and Subarea 5. Unfortunately, we lack experimental studies such as those of Lambert and Dutil (see references below) for cod in the northern Gulf of St. Lawrence, where condition levels were linked with reduced reproductive success or increased mortality. Nonetheless, It may be appropriate to consider ways to reflect the current low condition of the pollock resource in population models to be developed during the next step of the pollock Framework Assessment. Comparison of residuals from stock-recruitment relationships with the condition index in a given year would seem an appropriate matter for further investigation.

While there are complications in attempting to describe the spatial extent of the fishery, I believe this still may be a useful indicator to pursue. As indicated in the Working Paper of Clark et al. 2003 (this meeting) the spatial distribution has changed with a localization of the fishery in western Div. 4X and extent of the pollock fishery appears to be much reduced. There have been concerns that for schooling species, catch rates can remain misleadingly high even when the overall abundance of the stock is depleted. Given that the pollock assessment relies upon catch rate information to a considerable extent, it would seem appropriate to consider an indicator of abundance that reflects the area over which the fishery operates and experiences good catch rates.

The impact of the reduced age range on the productivity of the population could be explored using approaches similar to Marteinsdottir and Thorarinsson (1998). Those authors concluded that for Icelandic cod, the stock recruitment relationship could be improved by inclusion of a measure of spawner age diversity

such as Shannon's Diversity Index. This possibility could be investigated as part of the preparations for the third meeting of the Framework Assessment, however the preliminary results presented here suggest no obvious relationship between the presence of older spawners and improved recruitment.

The distinction between indicators of the state of a resource and indicators of the productivity of a resource is important to recognize. The state of the resource pertains to the magnitude of abundance, biomass and rates of mortality for the resource. Of the indicators I discuss here, spatial measures potentially has the clearest relationship with abundance. The productivity of a resource is related to its capacity to generate new growth in biomass. The processes associated with productivity, body growth, mortality and recruitment determine the harvest strategy reference points. Indicators of the productivity of the resource can be used to adjust or qualify the decision rules that use those reference points. In this context, the indicators of weight at age, condition and age composition appear to warrant further investigation.

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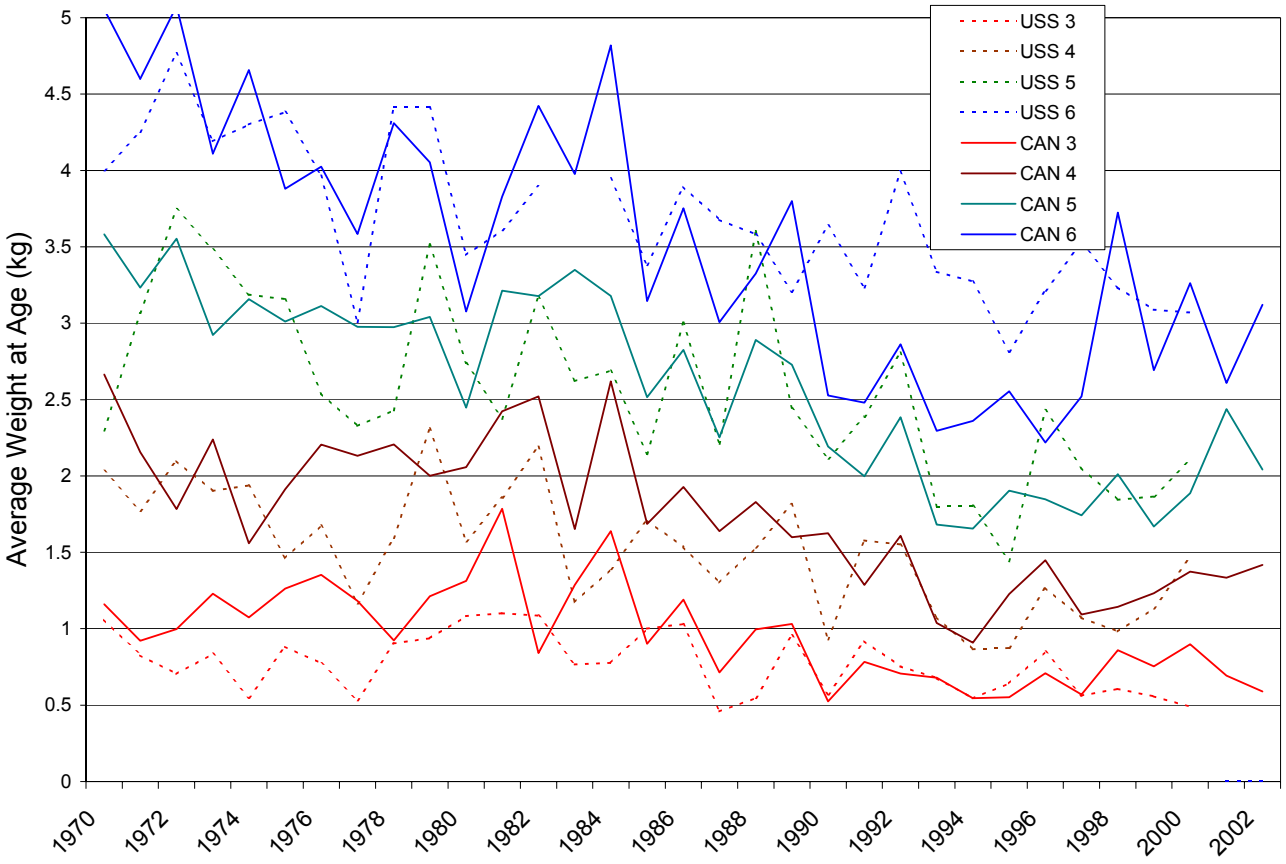

Fig. 1. Trends in weight at age for Canadian summer surveys (solid lines) in NAFO Divisions 4VWX, compared with trends in weight at age from USA spring surveys (dashed lines) in NAFO Subarea 5.

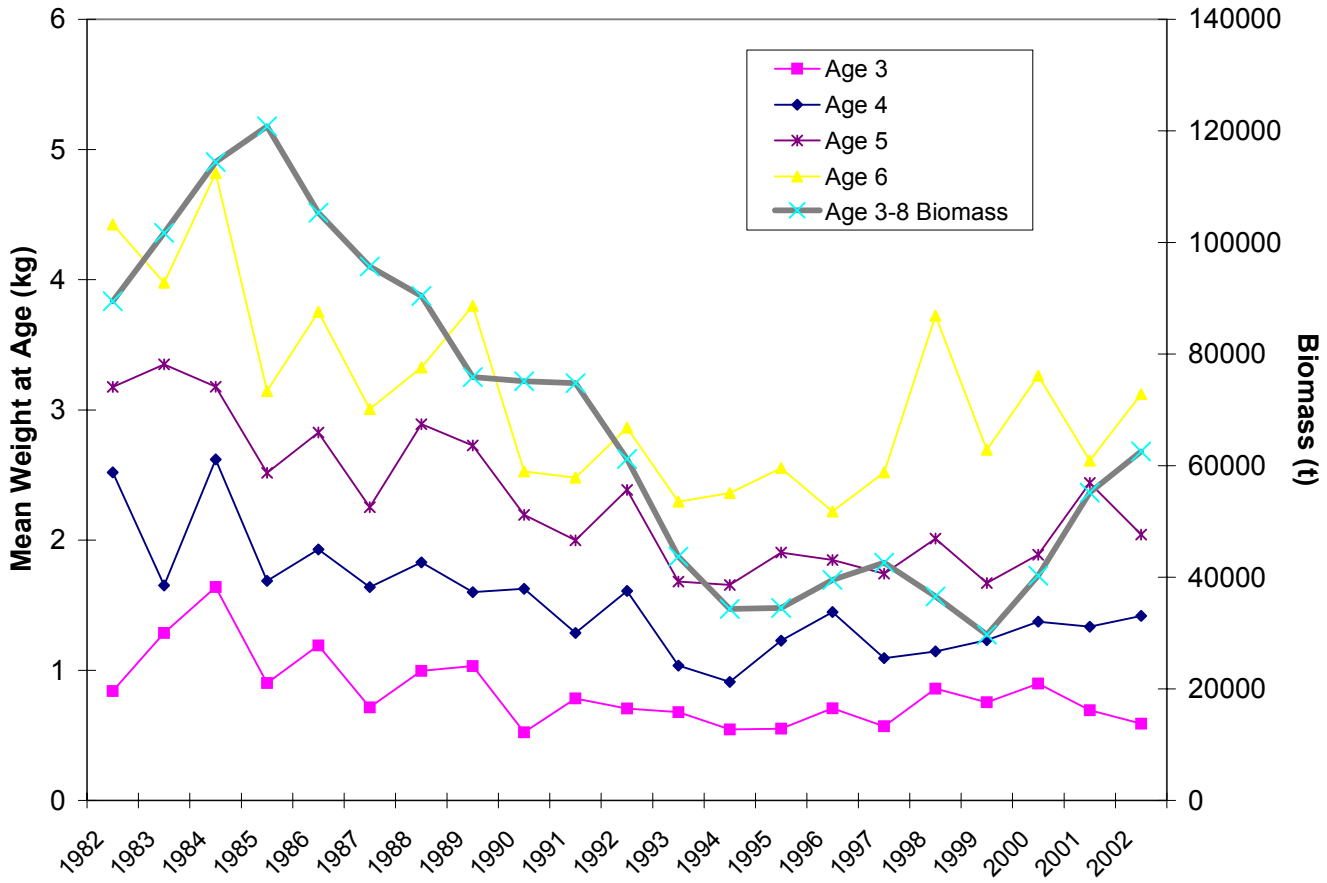

Fig. 2. Trends in weight at age for Canadian summer surveys in NAFO Div. 4X, compared with VPA population biomass (ages 3-8) in NAFO Divisions 4X and 5Zc.

Fig. 3. Trend in condition (shown as the predicted weight of a 40 cm fish from the survey) for pollock in Division 4X.

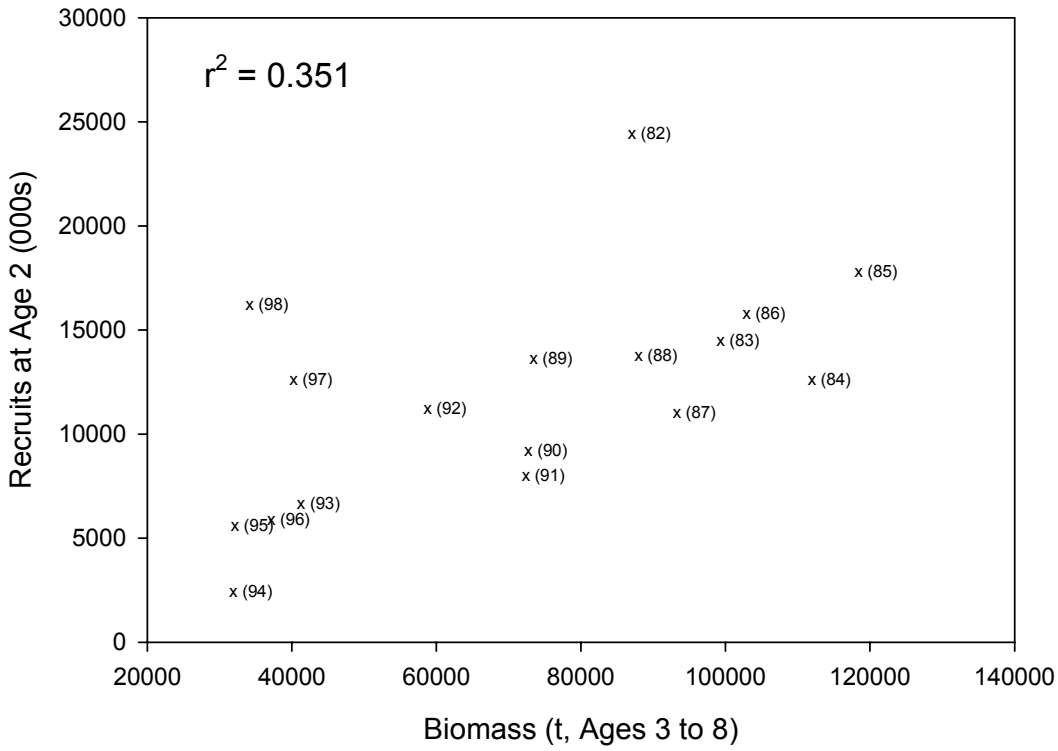

Fig. 4. Relationship between recruitment (age 2) and parental stock (ages 3 to 8) for pollock in Div 4X. and 5Zc.

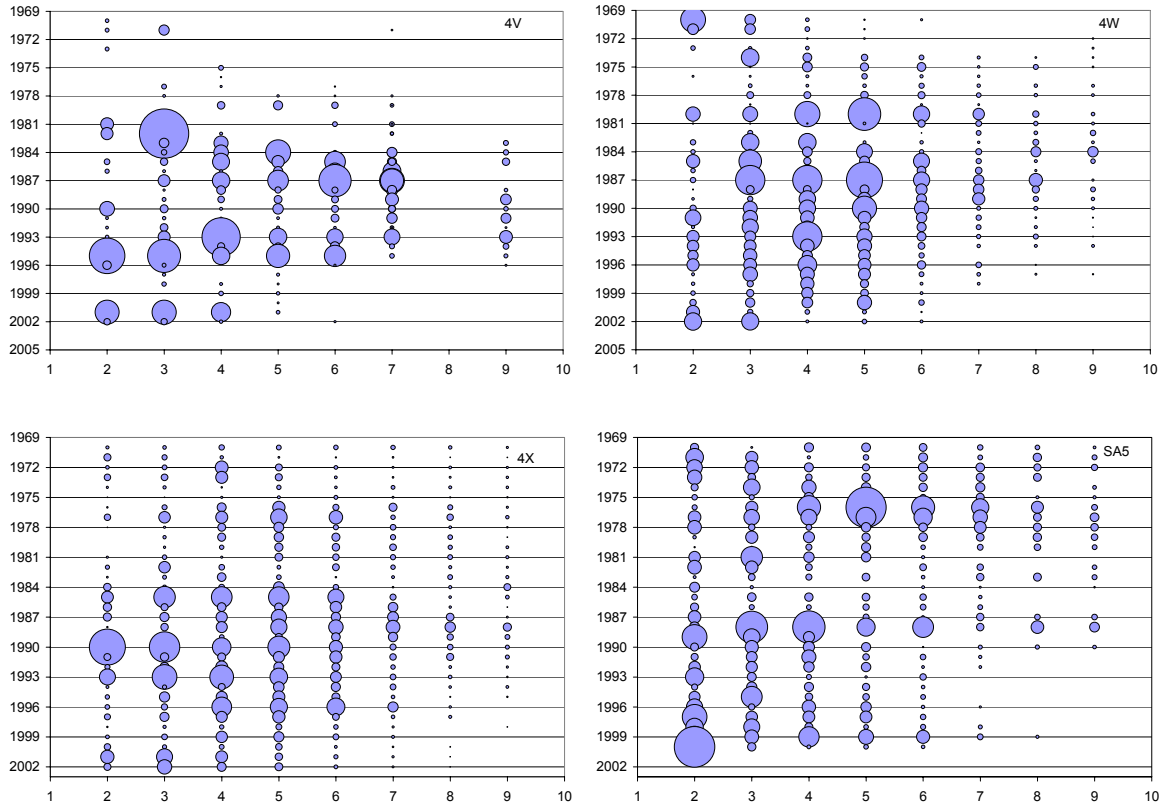

Fig. 5. Age composition of pollock caught in Canadian summer surveys in Divs. 4X, 4W and 4V, and in USA spring surveys in Subarea 5.

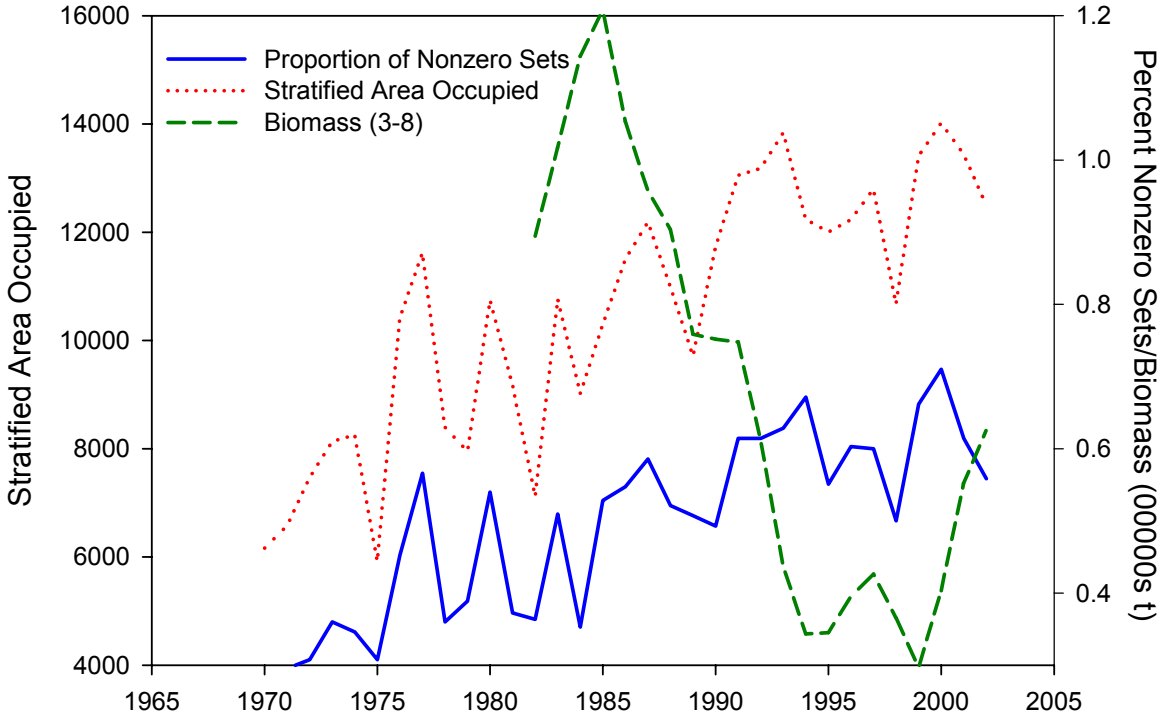

Fig.6. Trends in measures of pollock resource distribution from surveys in NAFO Div. 4X. 1970-2002.