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An Update on the Canadian Re-aging Effort for Building Age-length Keys for Yellowtail Flounder on the Grand Bank

by

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Abstract

A long term goal in the assessment of yellowtail flounder (*Limanda ferruginea*) is to supplement the current stock-production model with an age-structured model. Before this goal can be achieved, and given the inaccuracies in the old whole-otolith ageing method, a significant part of the historical otolith archive will have to be re-aged. Therefore, a first step is to determine how many otoliths actually need to be re-aged in order to produce age-length keys from sub-samples of the complete collection with a minimum loss of information. A preliminary analysis carried out using 1998 survey otolith data indicated that sub-sampling sizes around 60% of the total sample size can produce adequate age-length matrices (Dwyer *et al.*, 2004). However, this result relied on data from a single year, and hence, potential differences between years could not be evaluated. To address this issue, we repeated these analyses for a different year. The year 1991 was selected because it provides good contrast with 1998, mainly due to the differences between years in the survey trawls employed (Engels trawl in 1991 and Campelen trawl in 1998), and the trends of the yellowtail flounder stock (decreasing in 1991and increasing in 1998). Despite these differences, the results for 1991 were highly consistent with the findings already obtained for 1998. The spring and fall age-length matrices differed significantly (2D Kolmogorov-Smirnov test *p*-value = 0.0017), and sub-sampling sizes of 60% allow building sub-sampled age-length matrices (SSALMs) that are similar enough to the full data age-length matrices (FDALMs) to be considered adequate for building age-length keys from survey otoliths with a minimum loss of information.

Introduction

Yellowtail flounder (*Limanda ferruginea*) is a pleuronectid found on the Grand Bank off Newfoundland (Div. 3LNO) where it sustains an important commercial fishery. In recent years it was discovered that the ageing method being used for this species was underestimating the age of the older fish (Dwyer *et al.*, 2003). Since then, research efforts have been made towards correcting this aging problem (Dwyer *et al.*, 2003, 2004).

It was determined that thin-sectioned otoliths were the most accurate method for ageing yellowtail flounder, while the old whole otolith reading method underestimated the age of fish 25cm in length and larger (Dwyer *et al.*, 2003, 2004). These results posed the challenge of re-ageing a significant amount of otoliths from the historical archive (around 46 000), if an age-based model is to be used for providing the management advice.

In this context, a computer-intensive method was implemented to assess what is the minimum number of otoliths needed to be re-aged to produce age-length keys without great loss of information (Dwyer *et al.*, 2004). This preliminary exploration was done using the otolith collection from the RV surveys conducted in 1998. The results indicated that age-length matrices (ALMs) built with 60% or more of the otoliths of the full sample allow building

ALMs similar enough to the full sample to be considered adequate (Dwyer *et al.*, 2004). Hence, a re-ageing of 60% should ensure a minimum loss of information with a significant reduction of re-aging effort.

However, this result was based on RV surveys from a single year. It is necessary to verify if this figure holds over time. For this reason, the objective of this work is to repeat the analyses using the otolith collection from the RV surveys of 1991.

Materials and Methods

Year selection

The previous analysis was done using 1998 data because that year was the last one where ages were originally obtained using the old whole otolith method (Dwyer *et al.*, 2004). Since many factors can affect the age-length composition of the RV sampling, we decided for this second evaluation of the minimum number of otoliths needed, to choose a year that differs as much as possible from 1998. Although this practice will not ensure certainty of the overall results, if will certainly add to the robustness (or lack thereof) of the re-ageing minimum sample size determined from the 1998 data.

In this case, the year chosen was 1991. This year was selected because the overall design of the survey was still similar to 1998 and meets current standards for DFO RV surveys, but the survey trawl employed was different (Engels trawl in 1991 versus Campelen trawl in 1998). The year 1991 is also previous to the lowest stock level for the yellowtail flounder in 1994, and hence, 1991 is part of a downward trend in the stock size, while 1998 is part of an upward trend in the stock, during the recovery from the 1994 minimum.

Age determination

Ages were obtained from all otoliths of yellowtail flounder (Div. 3LNO) from spring (n = 501) and fall (n = 584) 1991 DFO RV surveys. The ages were obtained from the thin-sectioned method and were used to build seasonal full data age-length matrices (FDALMs) (Fig. 1), which were considered "target keys" for the computer-intensive simulation analysis. Differences between spring and fall FDALMs were evaluated using the 2D Kolmogorov-Smirnov test (Peacock, 1983; Fasano and Franceschini, 1987) as implemented in ks2d2s Fortran 77 subroutine (Press *et al*., 1992).

Computer-intensive resampling scheme

We started by assuming that the data used to build an ALM is a random sample from an underlying and unknown age-length bivariate distribution. In the case of comparing two ALMs, we want to know if both ALMs could have been obtained from the same underlying bivariate distribution. This hypothesis can be tested using the 2D version of the Kolmogorov-Smirnov (2D K-S) test (Peacock, 1983; Fasano and Franceschini, 1987; Press *et al*., 1992).

We used the p-values of the 2D K-S test as a measure of the degree of similarity between two ALMs. Larger *p*-values indicate a high degree of similarity, while small values indicate poor agreement, or even statistical differences (p-value<0.05).

For each season, random sub-samples of different sizes (without replication) were taken from the full collection of fish with known length (FDALM). Each of these sub-sampled age-length matrices (SSALM) was compared with the FDALM using the 2D K-S test. For each (sub)sample size, we generated 400 independent random samples, and we plotted the median and 95th percentile range of the corresponding p-values as a function of sample size. Logically, as sample size increases, the *p*-value will approach to 1 because the sub-samples approach to the full collection, and its variability will also be reduced. However, the shape of this plot and the p-value variability at each sample size provide a simple way of visualizing the trade-offs implied when selecting a given sample size. Most numerical procedures (i.e. resampling and 2D K-S tests) were implemented in Fortran 77. We used plots of the median *p*-values against subsample size to determine the size that produces the desired similarity with the full sample (i.e. a *p*-value close to one with small variability).

Results and Discussion

Figure 1 shows the consensus ages determined by the two age readers from samples taken in the 1991 spring and fall surveys. Unlike the 1998 age readings by the same two age readers, both readers reported difficulties in aging some fish less than 26 cm and as a result some small fish were aged older than expected. These anomalies were not deleted from the analysis and the observed dispersion is simply part of the expected error within the bounds of the methodology.

As it happened for 1998, the 1991 age-length matrices from spring and fall differed significantly (2D K-S test d = 0.136 *p*-value = 0.0017). Based on this result, the computer-intensive resampling scheme was performed separately for each season.

The analyses indicated a high level of consistency between 1991 and 1998 results. For both years, small sub-sampling sizes (~10%) produce ALMs that do not differ significantly from their corresponding FDALMs (Fig. 2 and 3). As it also happened for 1998, the results for spring and fall of 1991 indicated that sub-sampling sizes of 60% or more produce ALMs which are highly similar to the FDALMs. These new results indicate that the cut-off point of 60% appears to be fairly robust, suggesting that it can be considered adequate for the re-ageing effort.

Based on all these results, new and old, a sub-sampling size of *circa* 60% of the full data sample size can be considered adequate for building RV-based age-length keys for yellowtail flounder. Now, the work will focused on age-length matrices from the commercial catches to determine their appropriate sub-sampling level using the same methodology. Once these analyses are finished we will be ready to determine the total re-ageing effort required to properly implement age-based management models for yellowtail flounder.

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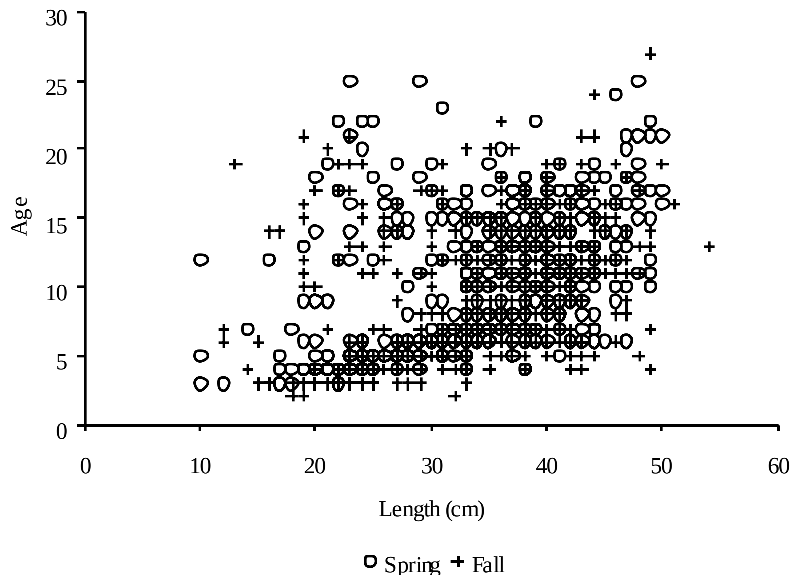

Fig. 1. Age-length data for the spring and fall of 1991 used in this paper.

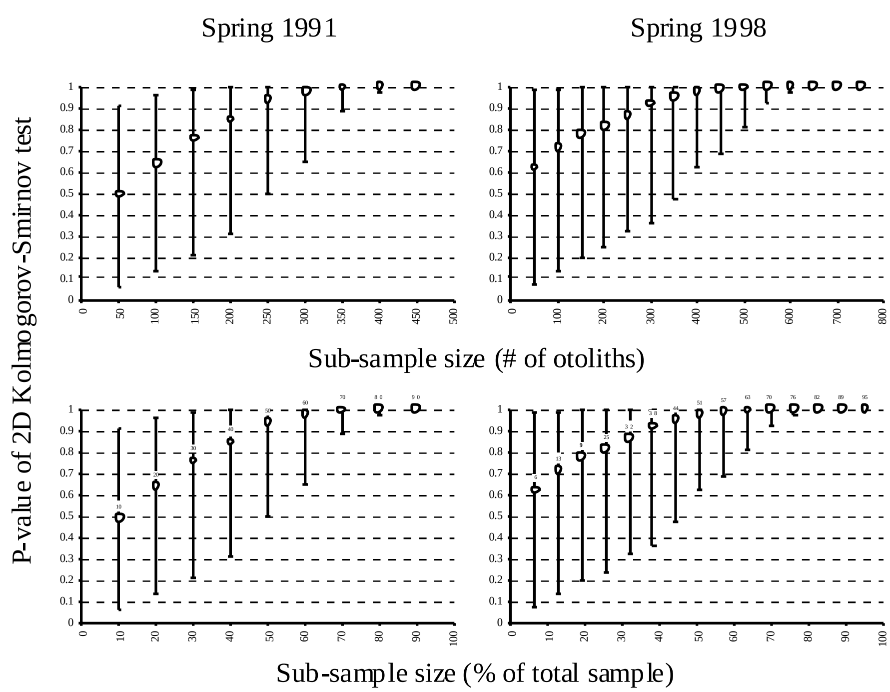

Fig. 2. Comparisons of the full data age-length matrices (FDALMs) with the sub-sampled age-length matrices (SSALMs) for the springs of 1991 and 1998 using 2D Kolmogorov-Smirnov Tests. Circles and bars correspond to the median and 95^{th} percentile ranges at each sub-sample size. Sample replicates = 400 in all cases. The small figures at each sample size indicate the exact percentage of the corresponding full sample. The data for 1998 are from Dwyer *et al.* (2004).

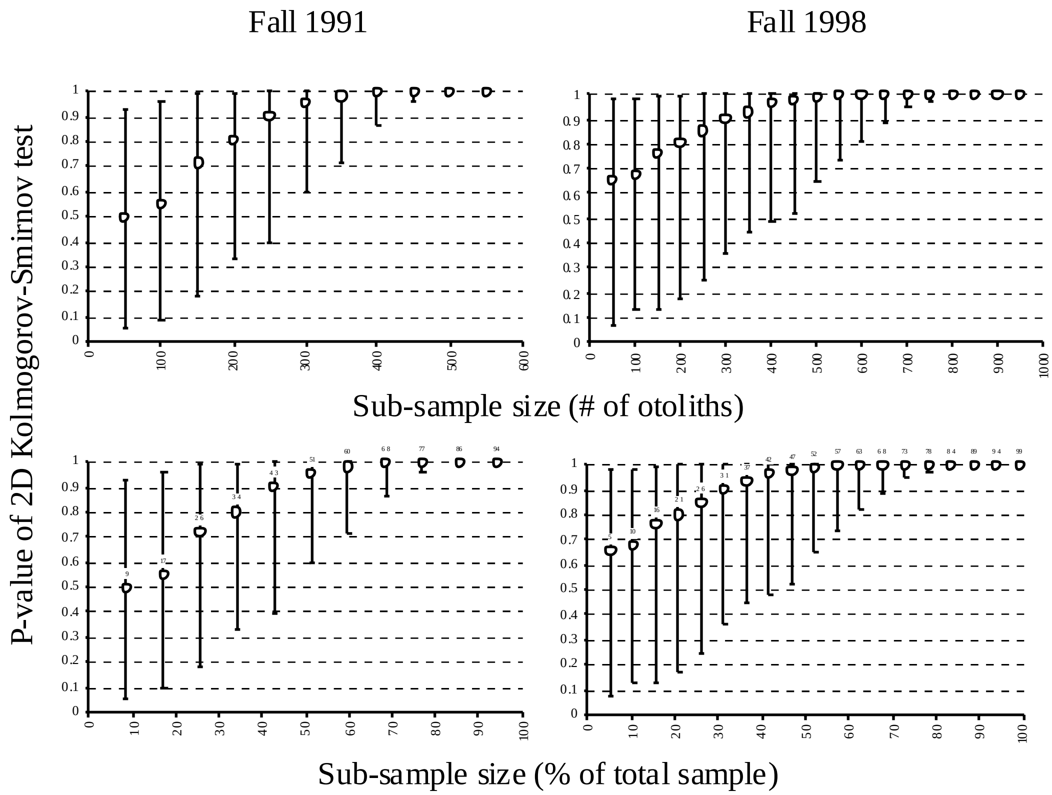

Fig. 3. Comparisons of the full data age-length matrices (FDALMs) with the sub-sampled age-length matrices (SSALMs) for the falls of 1991 and 1998 using 2D Kolmogorov-Smirnov Tests. Circles and bars correspond to the median and 95th percentile ranges at each sub-sample size. Sample replicates = 400 in all cases. The small figures at each sample size indicate the exact percentage of the corresponding full sample. The data for 1998 are from Dwyer *et al*. (2004).