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# SC WG ON GREENLAND HALIBUT ASSESSMENT METHODS - JUNE 2009

## FLEDA and SURBA analysis of the 2+3KLMNO Greenland halibut data

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### Abstract

Survey and commercial catch data were examined using an exploratory data analysis tool in FLR (FLEDA) and a survey based assessment (SURBA, surrey data only). Older fish are poorly represented in both commercial catch and survey data. Correlations between successive ages in a cohort become poor in all surveys at ages lower than those used in the calibration in the 2008 assessment. Both FLEDA and SURBA show lower mortality in recent years based on the survey data. SURBA estimates an increase in total biomass although estimates are still below those of 1998-2000. SURBA estimates of recruitment show decreasing trend.

# Introduction

In this paper we examine the fishery and survey data used in the 2008 assessment of Greenland halibut in SA2+Div.3KLMNO (Healey and Mahé MS 2008). The purpose of these analyses was to examine the data consistency within and between data sets and to explore basic information content without resorting to more elaborate models.

## Methods

Survey and catch at age data were examined using the FLEDA procedure of FLR (Kell et al. 2007) available at flrproject.org. The data examined are Canadian fall 2J3K survey ages 1-13, years 1996-2007, Canadian spring 3LNO survey ages 1-8, years 1996-2007 (except 2006), EU 3M survey ages 1-12, years 1995-2007 and commercial catch at age data from 1975-2007.

SURBA is a survey based separable model of total mortality (Beare et al. 2005). The separable model used in SURBA assumes that total mortality Za; y in age a and year y can be expressed as  $Z_{a,y}=S_a*f_y$ 

Where: *sa* and *fy* are respectively the *age* and *year* effects of mortality. Then, given *Za*; *y*, abundance *Na*, *y* can be derived as

$$N_{a,y} = N_{a_0,y_0} \exp\left(-\sum_{m=a_0}^{a-1} \sum_{n=y_0}^{y-1} Z_{m,n}\right)$$
$$= r_{y_0} \exp\left(-\sum_{m=a_0}^{a-1} \sum_{n=y_0}^{y-1} Z_{m,n}\right)$$

where  $a_0$  and  $y_0$  are the age and year in which the fish measured as  $N_{a,y}$  first recruit to the observed population or survey. Thus the abundance at each age and year of a cohort is given by the recruiting abundance of the cohort modified by the cumulative effect of mortality during its lifetime.

The SURBA analysis of 2+3KLMNO Greenland halibut used the Canadian fall 2J3K survey ages 1-13, years 1996-2007, Canadian spring 3LNO survey ages 1-8, years 1996-2007 (except 2006) and the EU 3M survey ages 1-12, years 1995-2007 data.

#### **Results and Discussion**

Catches over the period 1975 to present have ranged from 15 to 65 kt and averaged about 30 kt (Fig 1). Catches are mostly of ages 5 to 10 with ages 7 and 8 predominating (Fig 2). Cohort effects are not evident in the catch data (Fig 3). The dearth of older fish in the catch after about 1995 is evident. Given the longevity of Greenland halibut one would expect that if the stock was abundant that, even with low selectivity, there would be a higher proportion of older fish in the population than shown in the commercial catch in recent years.

Data from the three surveys show a reasonably good correspondence over time for most of the period and for most ages (Fig. 4). There is some divergence between surveys in recent years for ages 6, 8 and 9. Year-class progression with respect to the 1995 year-class is evident up to about age 8. The appearance of older fish in the EU and Canadian fall surveys in the recent period does not appear to be a result of cohort progression.

In the EU survey (Fig. 5), the 1995 year-class clearly tracks through the data until about age 7 after which it was subject to heavy fishing mortality. Recent year-classes in the survey have been relatively weak. Appearance of older fish in recent years was not a consequence of younger fish in earlier years.

The 1995 year-class is also evident in the Canadian fall survey, in this case up to age 5, otherwise there is little evidence of cohorts in the data (Fig. 6). There is an appearance of older fish in 2007 at ages 6 to 12. Year-classes at ages 1-3 in recent years appear weak.

The 1994 year-class is evident in the Canadian spring survey, rather than the 1995 year-class seen in the other two surveys (Fig. 7). Older fish have appeared at ages 7 and 8 in the most recent year. The catch at age 1 in the 2007 survey was relatively large.

Correlations between successive ages in a cohort become weak or nonexistent in all surveys at older ages. In the EU survey this happens after age 7 (Fig. 8). In the Canadian fall survey correlations break down after age 6 or 7 (Fig. 9) and for the Canadian spring survey correlations are poor after age 6 (Fig. 10). Consideration should be given to limiting the use of these surveys as tuning indices to younger ages than those currently used in the assessment model.

There have also been biological changes that have occurred in the Greenland halibut stock. Commercial weights at age have decreased (Fig. 11) and proportion mature at age (Fig. 12) has increased in the population. Increases in the proportions mature at age since the mid-1990s is reminiscent of changes in other groundfish stocks on the Grand Banks that have been subject to heavy fishing pressure and which have severely decline or collapsed.

Total mortality from catch curve analysis applied to commercial catch data for ages 5-10

shows an increasing trend in mortality since the mid-1990s (Fig. 13). In contrast, survey indices, although noisy, tend to show lower mortality in recent years (Figs. 14-16). This decrease in mortality in the surveys is also seen in the plots of log index by cohort from SURBA (Figs. 17-19. Estimates of mean total mortality over ages 5-9 from SURBA also show somewhat lower mortality in the last 4-5 years (Fig. 20).

Relative spawning stock biomass is estimated to have increased in the last few years (Fig. 21). Relative total stock biomass is also estimated to have increased in the last few years but is still lower than 1998-2000 (Fig. 22). Recruitment estimated from SURBA shows a declining trend over the time series (Fig. 23).

Residuals from the fits of the model to the data seem to indicate a relatively good fit with little patterning (Fig. 24-26). However, standard errors on the estimates of mortality and recruitment were relatively high with many CVs above 0.5. Retrospective analyses (Fig. 27-30) also indicate a relatively good fit to the data with little pattern and for recruitment and mortality all estimates retrospective runs were within 2 standard errors around the means from the run including the final year of data.

The combined results from the application of FLEDA and SURBA provide considerable insights into the data and the stock and could be considered standard tools to be applied before resorting to more sophisticated modelling approaches. They can show potential problems with the data, can provide guidance on what ages to use in the analyses, and give a preliminary indication of relative stock dynamics. The analyses presented here appear to be reasonably consistent with the 2008 XSA assessment of the stock (Healey and Mahé MS 2008).

#### References

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Figure 1. Commercial catch series for Greenland halibut.



Figure 2. Proportions at age in the commercial catch. Values within a year sum to 1.

Proportion at age in commercial catch for Ghal



Standardized proportion at age in the commercial catch for Ghal

Figure 3. Standardized proportions at age in the commercial catch.



Figure 4. Standardized indices by age plotted over time.



EU survey standardized proportions at age for Ghal

Figure 5. Standardized proportions at age and year for the EU survey (SPAY).



Canadian Fall Survey standardized proportions at age for Ghal

Figure 6. Standardized proportions at age and year for the Canadian fall survey (SPAY).

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Canadian Spring Survey standardized proportions at age for Ghal

Figure 7. Standardized proportions at age and year for the Canadian spring survey (SPAY).



Pairwise plot of age by cohort (EU\_Survey\_MNPT)

Figure 8. Cross-correlation matrix for the EU survey. Plots are on the log scale.



Pairwise plot of age by cohort (CAN\_2J3K\_Fall\_MNPT)

Figure 9. Cross-correlation matrix for the Canadian fall survey. Plots are on the log scale.



Pairwise plot of age by cohort (CAN\_3LNO\_Spr\_MNPT)

Figure 10. Cross-correlation matrix for the Canadian spring survey. Plots are on the log scale.



Catch weight at age by year for Ghal

Figure 11. Weights at age from commercial catch samples.

1.0 0.8 0.6 Proportion 0.4 -0.2 0.0 1990 1980 2000 year

Figure 12 Estimates of proportions mature at age.

Maturity at age by year for Ghal



Total mortality (Z) for Ghal ages 5-10 - commerical data

Figure 13. Total mortality from catch curve analysis applied to commercial catch data for ages 5-10.



Total mortality (Z) for Ghal ages 6-10 - EU Survey data

Figure 14. Total mortality from catch curve analysis applied to the EU survey for near fully recruited ages.



Figure 15. Total mortality from catch curve analysis applied to the Canadian fall survey for near fully recruited ages.



Total mortality (Z) for Ghal ages 5-7 - Can Spring Survey data

Figure 16. Total mortality from catch curve analysis applied to the Canadian spring survey for near fully recruited ages.



EU Survey\_MNPT: log cohort abundance

Figure 17. log abundance along a cohort for EU survey.



CAN 2J3K Fall\_MNPT: log cohort abundance

Figure 18. log abundance along a cohort for Canadian fall survey.



CAN 3LNO Spr\_MNPT: log cohort abundance

Figure 19. log abundance along a cohort for Canadian spring survey.



Mean total mortality

Figure 20. Mean estimated total mortality on ages 5-9 from SURBA.



Spawning stock biomass

Figure 21. Estimated spawning stock biomass from SURBA.



Figure 22. Estimated total stock biomass from SURBA.

Total stock biomass

Recruitment



Figure 23. Estimated recruitment from SURBA with (top) and without (bottom) 2 standard errors.





Figure 24. Log residuals for EU survey.

CAN 2J3K Fall\_MNPT



Figure 25. Log residuals for Canadian fall survey.

CAN 3LNO Spr\_MNPT



Figure 26. Log residuals for Canadian spring survey.

Mean total mortality



Figure 27. Six year retrospective on estimates of total mortality.

Spawning stock biomass



Figure 28. Six year retrospective on estimates of spawning stock biomass.

Total stock biomass



Figure 29. Six year retrospective on estimates of total stock biomass.

Recruitment



Figure 30. Six year retrospective on estimates of recruitment, with (top) and without (bottom) standard error of the final year run.