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# Does the Rebuilding Plan for Greenland Halibut in Subarea 2 and Divisions 3KLMNO have a Scientific Basis and is it on Track?

by

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## Abstract

NAFO Subarea 2 + Divisions 3KLMNO Greenland halibut stock is one of the last remaining commercially significant groundfish stocks in the Northwest Atlantic. Exploitable biomass is estimated to be at the lowest level ever and fishing mortality is estimated to be extremely high. The situation is strikingly similar to that of northern cod in the late 1980s. Although NAFO adopted a Precautionary Approach framework in 2004, it plans to first test the framework on two relatively healthy stocks before proceeding with actual implementation. Subarea 2 + Divisions 3KLMNO Greenland halibut is therefore not afforded the protection that should occur under the Precautionary Approach at the present time. Instead, NAFO has implemented a rebuilding plan for this stock aimed at restoring the exploitable biomass over a period of time. This plan is considerably less cautious than one which would be specified under a precautionary approach. In addition, the rebuilding of the stock is not robust to retrospective error in estimates of recruitment nor is it robust to alternative assessment methods applied in the 2004 assessment. Based on the production model estimates from the 2004 assessment and an approach accepted by NAFO Scientific Council for setting Precautionary approach reference points, the stock is below $B_{lim}$ and $F$ is more than 2X $F_{lim}$.

## Introduction

With the depletion of many fish stocks to lowest observed levels, there has been a growing emphasis on rebuilding plans which have as their objective the restoration of a depleted stock to a biomass level from which greater sustainable yields can eventually be achieved. Additional objectives may also include restoring ecosystem "health" in terms of the ecological role of the depleted species. Rebuilding plans are built into the US Magnusson-Stevens Act and in the northwest Atlantic attempts have been made to limit fishing mortality on cod and American plaice stocks to promote rebuilding both by NAFO and by Canada (DFO). Experience has shown (e.g. Shelton and Morgan, 2005) that once stocks are depleted to very low levels, small amounts of by-catch may be sufficient to nullify any surplus production (the so-called "by-catch trap"). Clearly instituting stock rebuilding before such levels are reached is important. When the rebuilding plan includes a moratorium on directed fishing and minimum possible by-catch, it can be argued that all possible measures have been taken and a "wait-and-see" approach can be adopted. Additional putative measures such as "stock-enhancement" and "predator control" are sometimes considered but there is little evidence that such measures can have any impact on open ocean fish populations embedded in complex ecosystems.

Where rebuilding measures rely on a reduction in TAC rather than a complete cessation of directed fishing, some analysis is generally considered advisable in order to evaluate the expected rebuilding rates associated with different levels of TAC reduction. This invariably requires medium to long-term projections based on population model estimates and some assumptions about future stock productivity levels (growth rate, reproductive rate and mortality

rate). While the precision and accuracy of estimate of current population size dominates short-term projections used for TAC adjustments, and are generally within useful bounds, model uncertainty and uncertainty regarding appropriate assumptions dominate longer-term projections and are less easily specified, leading to wide uncertainty bounds. Nevertheless, it is important for rebuilding plans to have a scientific basis for demonstrating a reasonably high probability of success under acceptable assumptions and for regular reviews of the progress of the rebuilding plan and adjustments of the projections to be carried out. Without a good scientific basis, there is the danger of the classic "too little too late" step-wise reduction in TAC with concomitant continuing increase in *F* scenario that epitomized management efforts on the northern cod stock in the late 1980s and early 1990s.

**Greenland halibut rebuilding plan**

*XSA based projections*

Advice from NAFO Scientific Council (SC) in June 2003 on the Greenland halibut stock in 2+3KLMNO was that exploitable biomass had declined to the lowest estimated level, recruitment in the recent period had been poor and that the stock was projected to decline further at current catch levels (SCS Doc. 03/19). This prompted NAFO Fisheries Commission (FC) in September 2003 to put in place a fifteen year rebuilding plan with the objective of attaining a 140 000 tons exploitable biomass (FC Doc. 03/13). TAC levels were set for 2004-2007 at 20 kt, 19 kt, 18.5 kt and 16 kt, respectively. The intention was that subsequent TACs would depend on rebuilding progress, but with a 15% cap on any change. SC was not requested by FC to evaluate alternative rebuilding plans in 2003, but calculations were carried out by members of delegations to inform the decision. As an example, calculations provided by a member of the Canadian delegation (D.B. Atkinson) in fact show the 5+ biomass declining to 2006, the 10+ biomass declining to 2008 and *F* increasing to 2005 under the "rebuilding" plan (Fig. 1), suggesting that the term was, in fact, a misnomer. A slight increase in 5+ biomass in 2007 and 2008 in these projections was the consequence of the entry into this age group of the assumed recruitment at age 1 in 2003 and 2004, set at a value substantially higher than recent recruitment levels.

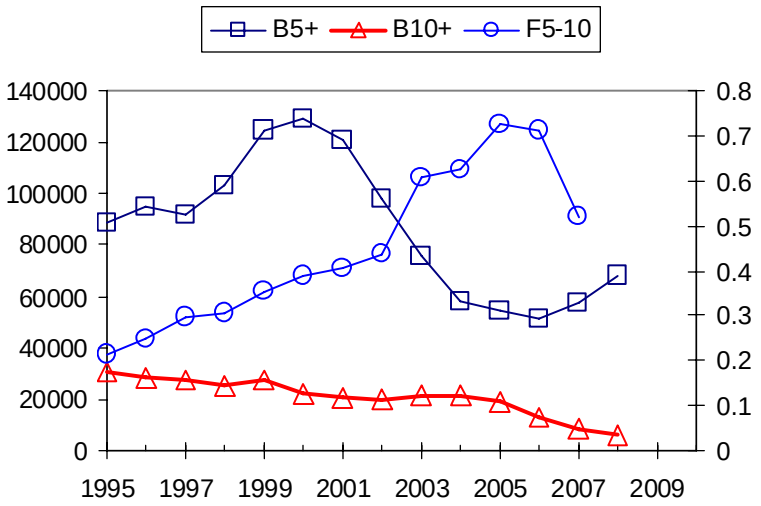


**Fig. 1.** Trajectories of 5+ and 10+ biomass, as well as the average *F* on ages 5-10 conducted outside Scientific Council in September 2003 and used by Fisheries Commission as the basis for the rebuilding plan. Input data are from the 2003 XSA assessment (Darby *et al*. 2003).

While quota reductions that were achieved by FC at the September 2003 meeting under the rebuilding plan were impressive, it appeared, based on XSA estimates from the 2003 assessment and the above projection (or other projections undertaken by the author on the same data), that they were insufficient to arrest the decline in the stock. This could be considered analogous to the northern cod situation where the quota reduction steps at the time of the collapse were too small to arrest the decline in that stock (Shelton, 1998).

The 2004 XSA-based assessment (Darby *et al*., 2004) was more optimistic regarding the size of recruiting year-classes for the more recent period than the 2003 assessment (Fig. 2), although the size of the 1994 year-class was revised downward somewhat.

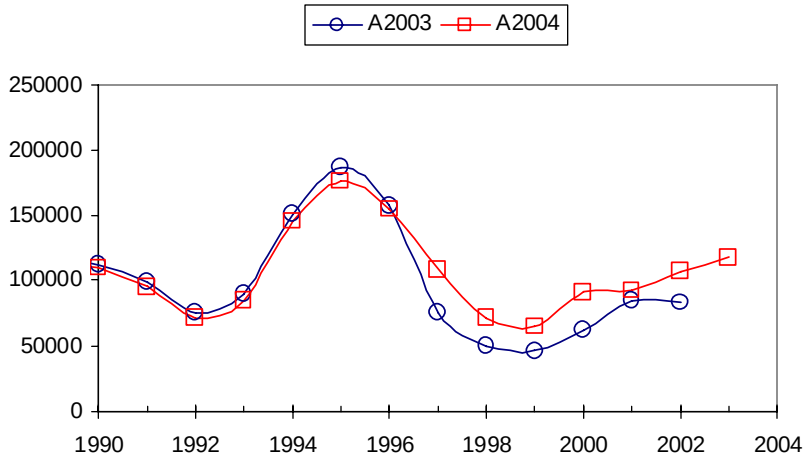


**Fig. 2.** Estimates of numbers of numbers of 1 year olds (thousands) by year (not cohort) from the 2003 and 2004 XSA assessments.

The rebuilding plan was evaluated for the first time by SC in the June 2004 meeting. Projections were more optimistic than calculations based on the 2003 assessment because of the increase in the estimated size of the recruiting year-classes. Based on the 2004 XSA, 5+ biomass was projected to increase from 2005 onwards and the average *F* on ages 5-10 was expected to decline from a peak in 2003 (Fig. 3). The 10+ biomass however was projected to decline to 2008, consistent with projections carried out in 2003. Note that the estimates in Fig. 3 are recomputed by the author from the population point estimates and other projection inputs provided in Darby *et al*. (2004) because the assessment document does not provide this information.

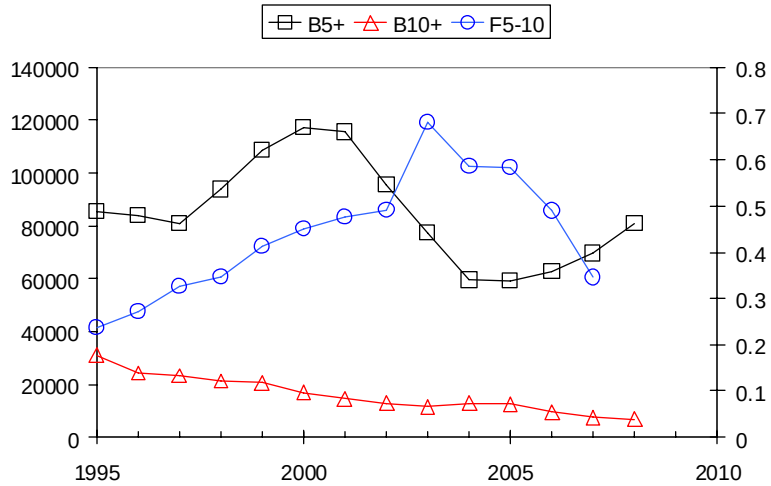


**Fig. 3.** Trajectories of 5+ and 10+biomass, as well as the average *F* on ages 5-10 for the rebuilding plan from the 2004 XSA assessment (recomputed from the population estimates and other projection inputs in Darby *et al*. 2004).

The limited growth in 5+biomass and the decrease in *F* from this projection could be taken as scientific validation that the rebuilding plan is working. There are however a number of concerns. Firstly, the change in stock projections from 2003 to 2004 is based on the upward revision of the estimates of recruiting year-classes driven by recent surveys. This variability in the estimates for recent years is cause for concern – the indication of improved recruitment could be real, an artifact of model constrains (such as *F*- shrinkage), or a consequence of noise in the

data. If the estimates are revised downward in subsequent assessments, as was the case for the 1994 year-class, the current projection may be over-optimistic. This is pointed out in Darby *et al*. (2004) and is examined here. To account for possible over-estimation in the most recent assessment, the numbers at ages 1-3 for 2004 were reduced by 30% in the projection. Note that the number for age 1 applied in the projections in the 2004 assessment is the geometric mean number of age 1 fish for the period 1975-2003 and is considerable higher than recent estimates (i.e. 1998-2001). The more pessimistic estimates for ages 1-3 in 2004 results in virtually no increase in the exploitable biomass to 2008 under the present rebuilding plan (Fig. 4).

Irrespective of whether or not the 5+ biomass will increase under the rebuilding plan, the 10+ biomass is projected to decline below current levels to 2008. This must have implications for spawner biomass (maturation occurs within this plus group) and therefore there should be concerns regarding potential recruitment-overfishing.

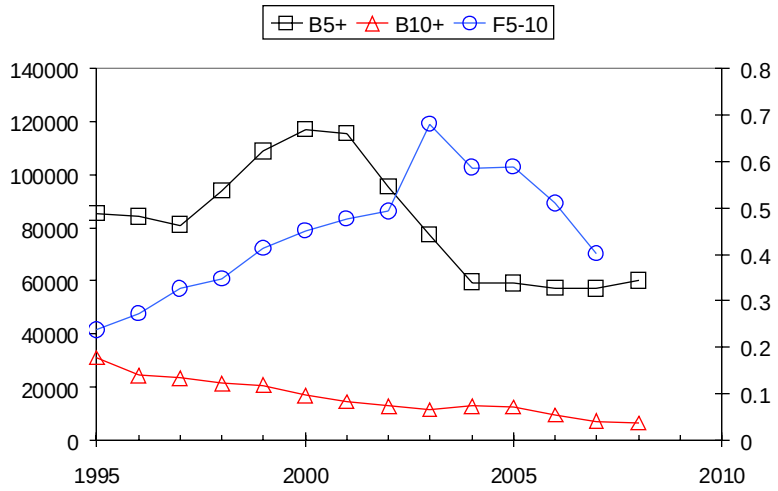


**Fig. 4.** Trajectories of 5+ and 10+ biomass, as well as the average *F* on ages 5-10 for the rebuilding plan from the 2004 XSA assessment using estimates of ages 1-3 that were 30% lower than the estimates used in the projection by Darby *et al*. (2004).

*Alternative assessments*

Two alternative assessment were presented by Darby *et al*. (2004), one based on ADAPT (Gavaris, 1988) and another on a non-equilibrium surplus production model using ASPIC (Prager, 1994). Estimates of population size and fishing mortality from these models were found to be reasonably consistent with the XSA results and were therefore interpreted as support for the XSA-based advice. However, both ADAPT and ASPIC provide a basis for evaluating the rebuilding plan, and the results from these projections should be considered to see if they support the XSA projections.

*ADAPT-based projections*

The ADAPT analysis presented in the June SC meeting was conducted using the same input data as the XSA analysis and structured to follow the XSA setup as closely as possible (Darby *et al*., 2004). A projection was carried out using the ADAPT bias-adjusted estimates applying the same basic projection framework as the XSA projections.

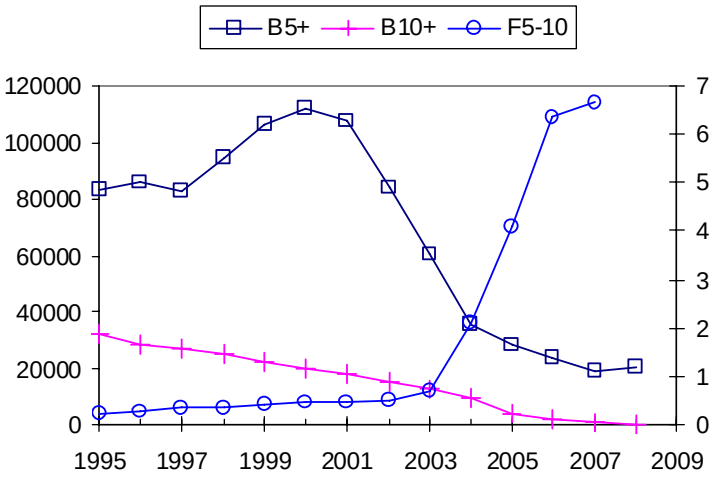


**Fig. 5.** Trajectories of 5+ and 10+ biomass, as well as the average *F* on ages 5-10 for the rebuilding plan based on the population estimates from ADAPT assessment presented in Darby *et al*. (2004).

Results are considerably more pessimistic than those based on XSA (Fig. 5). The 5+ biomass is projected to decline to 2007, *F* rises to a very high level and the 10+ biomass is wiped out. The slight increase in the 5+ biomass in 2008 is a consequence of the entry of the long-term geometric mean recruitment for age 1 in 2004 into the 5+ age group – the value is higher than recent levels of recruitment. The greater degree of pessimism in ADAPT *versus* XSA projections is a consequence of lower estimates of recruiting fish for the recent period from the ADAPT (Fig. 6) and as a consequence, lower estimates of survivors in 2004 (Fig. 7). The 2004 ADAPT estimates of recent recruits are very similar to those obtained in the 2003 XSA and substantially lower than those obtained in the 2004 XSA.

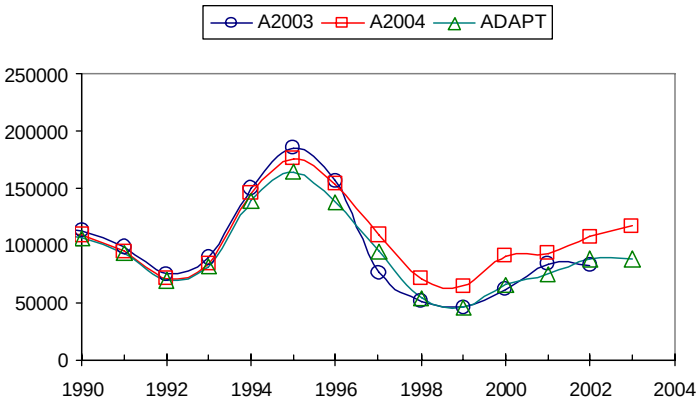


**Fig. 6.** Comparison of the estimates of the age 1 recruits from the 2003 XSA, 2004 XSA and 2004 ADAPT (bias-adjusted).

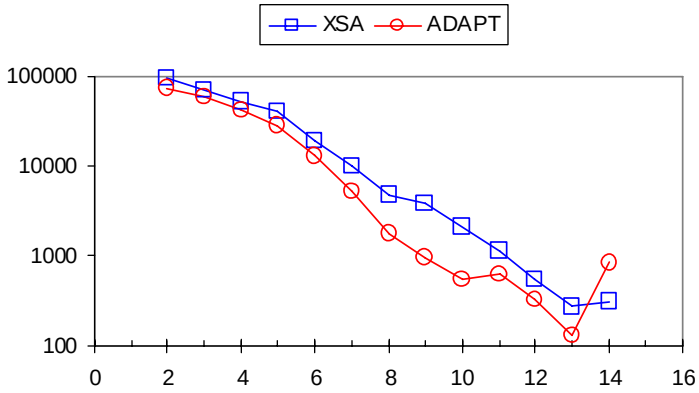


**Fig. 7.** Plot of logarithm of survivors for ages 2 to 14+ for 2004 from ADAPT and XSA showing the difference in the estimates of abundance, especially at older ages.

*ASPIC-based projections*

The ASPIC production model applied in the June 2004 assessment used the same tuning indices and total catch as those applied in the final XSA (Darby *et al*., 2004). Based on

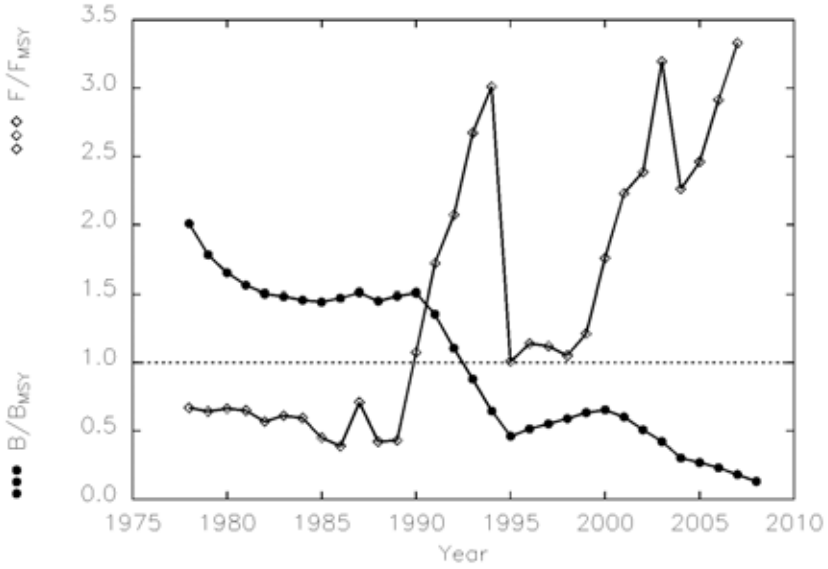


**Fig. 8.** Relative biomass and fishing mortality trajectories for the rebuilding plan based on the ASPIC model from Darby *et al*. (2004).

ASPIC estimates, it is projected that exploitable biomass will fall below a definition of $B_{lim}$ endorsed by SC for production model-based assessments (30% $B_{msy}$) by 2005, reaching 0.13 $B_{msy}$ by 2005 under the TACs specified by the current rebuilding plan (Fig. 8). $F$ is estimated to have been above $F_{lim}$ since 1990 and will remain at above 2x $F_{lim}$ under the TACs specified under the rebuilding plan.

**Greenland halibut rebuilding plan in the context of the Precautionary Approach**

Reference points for this stock were not determined in the 2004 assessment. This apparently stemmed from difficulty in obtaining an estimate of spawning stock biomass to apply in SR-based LRP derivations and considerations that recruitment may come in part from outside the assessed stock area.

The NAFO LRP Study Group provided approaches for determining LRPs for a number of life-history and data availability situations (SCS Doc. 04/12). Where SR estimates are not possible or not considered useful, one course

of action suggested in the SG report is to base LRPs on production model estimates. In these cases, the SG recommended that 30%$B_{msy}$ and $F_{msy}$ be used as LRPs. This recommendation was accepted by NAFO SC in June 2004. If applied to 2+3KLMNO Greenland halibut stock using the production model estimates in Darby *et al*. (2004), and a projection is carried out based on the rebuilding plan as above, the stock is projected to fall below $B_{lim}$ in 2005 and to remain below until the end of the projection period. $F$ is estimated to have been above $F_{lim}$ from 1990 onwards, and to remain at 2x $F_{lim}$ throughout the projection period.

Scientific Council recommended in 2004 that its Framework for a Precautionary Approach (PA) (SCS Doc. 03/23 – now FC Doc. 04/18) be adopted and implemented by the Fisheries Commission. This found general agreement among Contracting Parties and the SC Framework was adopted by NAFO in 2004 (FC Doc. 04/18). However, a proposal for first testing the SC Framework on two stocks (yellowtail flounder in Div. 3LNO and shrimp in Div. 3M) before moving forward on any actual implementation (FC WP 04/10, Rev.) was also adopted by FC. Both of the suggested "test" stocks are in relatively healthy condition and it is not clear how the pre-implementation testing is be performed or the time period that will be involved. Given the deteriorated state of the 2+3KLMNO Greenland halibut stock, implementation of the PA framework on this stock could be considered an urgent priority. PA implementation, given current stock status, would almost certainly result in more drastic reductions in TACs than those contained under the current rebuilding plan.

Although 2+3KLMNO Greenland halibut has not been selected as a "test" stock for implementation of the PA, FC has made a general request to SC to inform on how to rebuild all stocks that are below any reasonable level of $B_{lim}$ or $B_{buf}$. They request the evaluation of various scenarios corresponding to recovery plans with timeframes of 5 to 10 years, or longer, as appropriate. They require that this evaluation provide the information necessary for FC to consider the balance between risks and yield levels. A re-evaluation of the current 2+3KLMNO Greenland halibut rebuilding plan would be consistent with this request.

Although there is some tentative evidence based on the 2004 XSA assessment that the FC rebuilding plan for Greenland halibut could result in slow rebuilding of the exploitable biomass, this outcome is not robust to uncertainty in the strength of recent year-classes nor to the assessment approach that is taken. Analyses based on ADAPT and ASPIC assessments are more pessimistic. It is not clear whether the more optimistic view based on the 2004 XSA relative to the 2003 XSA, 2004 ADAPT or 2004 ASPIC is real or an artifact of model constraints (such as shrinkage) or noise in the data. Given that the 5+ biomass is at the lowest observed level and that current $F$ is very high, any rebuilding plan should be robust to alternative interpretations of the available data. It is clear that the current rebuilding plan does not meet these requirements. When rebuilding plans are developed, it is desirable that there be a scientific, analytical basis for demonstrating the likelihood of the plan achieving the desired objectives. This has not been the approach taken with the current 2+3KLMNO Greenland halibut rebuilding plan. One of the lessons from the northern cod disaster, and from other stock collapses, is that TAC reductions on a declining stock may appear to be impressive in magnitude, but may be insufficient to arrest the population decline and $F$s may continue to increase. If this happens to 2+3KLMNO Greenland halibut, then one of the last remaining significant commercial groundfish stocks in the NAFO Convention area will be destroyed.

## Acknowledgements

Brian Healey provided access to the estimates from the June 2004 NAFO assessment and both Brian and Ray Bowering generously shared their knowledge of the stock and the most recent assessment.

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