Candidate SLAs for the hunt of bowhead whales in West Greenland

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ABSTRACT
This paper describes candidates SLAs for the West Greenland hunt on bowhead whales. Two candidates based on the current interim SLA are proposed; they are both simple data based procedures with no internal population model, and they have been selected from a total set of 29 examined procedures.

INTRODUCTION

In this paper I proposed two candidate SLAs for bowhead whales in West Greenland. The candidates were selected from a set of 29 possible SLAs including the interim procedure. All procedures were simple data based procedures based on different percentiles of different measures of abundance with some procedures having protection levels and/or snap to need features.

All procedures were tested on selected sets of evaluation trials, and here they were set to pass a test of acceptable conservation performance before they could be included in sets of conservation acceptable procedures from which the two final candidates could be chosen.

TRIALS, CONSERVATION, AND SELECTION

A candidate SLA was said to perform adequately in terms of conservation on the selected set of evaluation trials when the 5th percentile of the $D10$ statistics of relative increase (P_T/P_0) was larger than one, i.e., when the population at the end of the hundred year simulation period was larger than at the beginning of the period for the 5th percentile.

However, none of the 29 SLAs that were tried out were able to pass the conservation criterion for the low production trials of the two alternative B and C scenarios for future Canadian catches, where annual Canadian catches are assumed to increase from 5 to 10, and from 5 to 15 over the simulation period. Not even a zero-SLA, which assumed zero Greenlandic catches for the whole period, was able to pass the conservation criterion from the Canadian alternative C, where catches increased from 5 to 15. So instead of aiming for an SLA that performed adequately in terms of conservation of these trials, it is instead considered that the underlying assumption, where Canadians can take whales for free while Greenlanders can only be allocated a quota according to what remains, is maybe not the most optimal way forward. While a solution to this problem may require additional considerations by the AWMP group, for now I restricted my SLA development to trials where the annual Canadian catches were assumed to be no higher than five in the future.

The trials that were used in the SLA-selection process were then B01AA, B01AB, B01AC, B01BA, B01BB, B01BC, B03BA, B03BC, B05BA, B05BC, B06BA and B06BC. These include all the low production evaluation trials except those with five year survey intervals (B02BA/C) and those with negatively biased surveys (B04BA/C). A procedure that passed the conservation criterion on these trials should be useful for all Greenlandic need envelopes given that the Canadian catches from the stock do not exceed 30 over a six year quota block. From the original set of 29 procedures, 8 passed the conservation criterion on these trials, and one SLA candidate was selected from this set of procedures.

Looking at the simulation results it was evident that the need satisfaction conservation trade-off was stronger for the West Greenland bowhead case, than for the West Greenland humpback case. This implies that the conservation performance on the high need envelope, where need increased to 15 whales per year, was limiting need satisfaction for the low need envelope, where need did not exceed five whales per year. Hence, I made a second selection, where the conservation criterion was applied only for the low need envelope trials. A procedure that passed the conservation criterion on these trials should be useful for the lowest Greenlandic need envelope given that the Canadian catches from the stock do not exceed 30 over a six year quota block. From the original set of 29 procedures, 17 passed the conservation criterion on these trials, and one SLA candidate was selected from this set of procedures.

A third alternative, that was selected to pass the conservation criterion for the low and median Greenlandic need envelopes, where need do not exceed 10 bowhead whales per year, would also be an obvious SLA to consider. However, low production median need envelope evaluation trials were not set up for trials B02 to B06 and hence this selection was not possible.

Table 1 list the average need satisfaction performance of the interim and four of the best performing procedure among the 17 that passed the conservation criterion for the low need envelope. Among these I chose the best performing procedure ($r_1N_{2.5}P_a$) to be a candidate SLA.

Table 2 list the average need satisfaction performance of the interim and the four best performing procedure among the 8 that passed the conservation criterion for the low to high need envelopes. Among these I chose the best performing procedure ($r_{.5}N_{2.5}PS$) to be a candidate SLA.

The summary statistics for the two best performing procedures on the two sets of trials are plotted in Figure 1, together with the statistics of the interim procedure. While candidate $r_1N_{2.5}P_a$ did not pass the conservation criterion for the high need envelopes, we note that it failed only because of a marginal decline in the 5th percentile of $D10$ in trial B03BC.

Table 1: The relative need satisfaction performance of different SLA candidates on the selected set of evaluation trials with low need envelopes, with the selected SLA marked with *. The procedure to the right is the selected procedure for the low to high need envelope trials. Performance is shown as the average of $N9$ across trials over the 20 and 100 year period for the median ($\bar{N}9$) and 5th percentile ($\bar{N}9_{5\%}$).

SLA	interim	$r_{.5}N_5PS$	r_1N_5PS	r_1N_5P	$r_1N_{2.5}P_a^*$	$r_{.5}N_{2.5}PS$
$\bar{N}9$	1.000	0.797	0.824	0.824	0.955	0.786
$\bar{N}9_{5\%}$	0.936	0.679	0.688	0.688	0.773	0.670

Table 2: The relative need satisfaction performance of different SLA candidates on the selected set of evaluation trials with low to high need envelopes, with the selected SLA marked with *. The SLA to the right is the selected SLA on the low need envelope trials. Performance is shown as the average of $N9$ across trials over the 20 and 100 year period for the median ($\bar{N}9$) and 5th percentile ($\bar{N}9_{5\%}$).

SLA	interim	$r_{.5}N_5P_a$	$r_{.5}N_5P_aS$	$r_{.5}N_{2.5}P$	$r_{.5}N_{2.5}PS^*$	$r_1N_{2.5}P_a$
$\bar{N}9$	0.993	0.696	0.700	0.709	0.711	0.893
$\bar{N}9_{5\%}$	0.902	0.577	0.578	0.593	0.595	0.713

SLA DESCRIPTION

With τ being the year of a strike limit calculation, the two chosen candidate procedures make an interim-SLA-like calculation based on an estimate of abundance (N_τ) and an associated coefficient of variation (cv_τ).

If there are three, or less than three, abundance estimates from surveys available, the measure of abundance is calculated as

$$N_\tau = \frac{\sum_t N_t e^{-0.07(\hat{t}-t)}}{\sum_t e^{-0.07(\hat{t}-t)}} \tag{1}$$

where N_t is the point estimate of abundance in year t and $\hat{t} \leq \tau$ is the year of the last estimate. If instead there are four or more surveys estimates available, the measure of abundance is obtained by fitting a straight line

$$n_t = a + bt \tag{2}$$

to the point estimates of the last four abundance estimates, using the Chi-Squares fitting routine *fitab.h* of Press et al. (2007). The abundance estimate that is provided to the SLA is then

$$N_\tau = a + b\hat{t} \tag{3}$$

Independently of the number of survey estimates available, the estimate of uncertainty in the abundance estimate was always given as

$$cv_\tau = \frac{\sum_t cv_t e^{-0.07(\hat{t}-t)}}{\sum_t e^{-0.07(\hat{t}-t)}} \tag{4}$$

where cv_t is the coefficient of variation of the survey estimate in year t. This measure of abundance was chosen because the use of the last estimate only, as done in the interim procedure, was considered too sensitive to statistical variation in the estimate, and because alternative measures that provide some average over a larger set of abundance estimates do not take the trend in the estimates into account.

The strike limit S_τ for $r_1 N_{2.5} P_a$ is then calculated as

$$\tilde{S}_\tau = \min\left[\text{need}_\tau, \text{round}\left(0.01 N_\tau e^{-1.96 cv_\tau}\right)\right] \tag{5}$$

$$S_\tau = \begin{cases} \tilde{S}_\tau & \text{if} \quad 800 \le N_\tau \\ 2 & \text{if} \quad 400 \le N_\tau < 800 \\ 0 & \text{if} \quad N_\tau < 400 \end{cases} \tag{6}$$

And the strike limit S_τ for $r_{.5} N_{2.5} PS$ is calculated as

$$\tilde{S}_\tau = \min\left[\text{need}_\tau, \text{round}\left(0.005 N_\tau e^{-1.96 cv_\tau}\right)\right] \tag{7}$$

$$\dot{S}_\tau = \begin{cases} \tilde{S}_\tau & \text{if} \quad \tilde{S}_\tau < 0.8\ \text{need}_\tau \\ \text{need}_\tau & \text{if} \quad \tilde{S}_\tau \ge 0.8\ \text{need}_\tau \end{cases} \tag{8}$$

$$S_\tau = \begin{cases} \dot{S}_\tau & \text{if} \quad 1200 \le N_\tau \\ 3 & \text{if} \quad 900 \le N_\tau < 1200 \\ 2 & \text{if} \quad 600 \le N_\tau < 900 \\ 1 & \text{if} \quad 300 \le N_\tau < 600 \\ 0 & \text{if} \quad N_\tau < 300 \end{cases} \tag{9}$$

REFERENCES

Press, W. H., S. A. Teukolsky, W. T. Vetterling and B. P. Flannery 2007. *Numerical recipes. The art of scientific computing.* 3rd ed. Cambridge University Press, Cambridge.

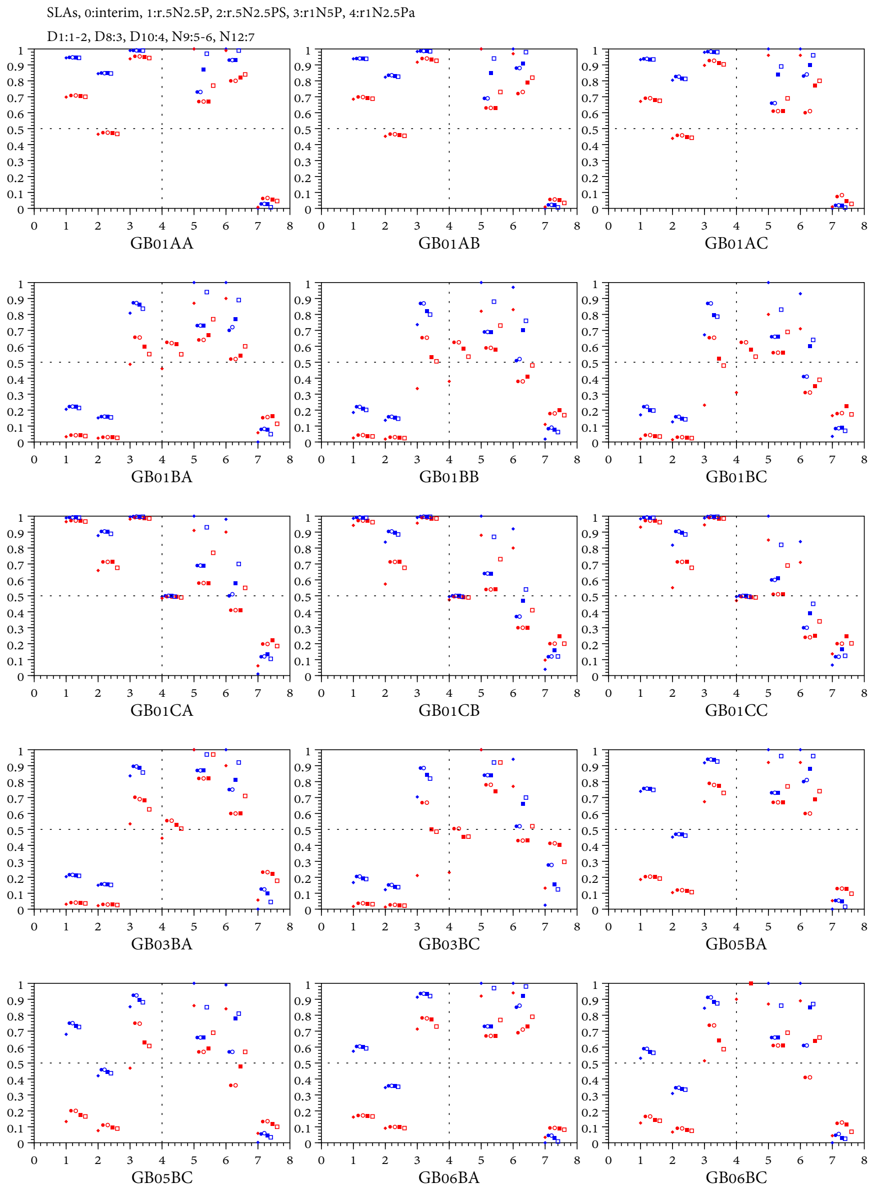

Figure 1: Overall performance of the two best performing procedures in both Table 1 and 2, given by the median (blue) and the 5th percentile (red) for different statistics over different trials (Note that $D10$ is rescaled here as $D10/2$, and that red gives the 95% percentile for $N12$).