Candidate SLAs for West Greenland humpback whales

Lars Witting
Greenland Institute of Natural Resources
P. O. Box 570, DK-3900 Nuuk, Greenland

ABSTRACT
This paper describes candidates SLAs for the West Greenland hunt on humpback 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 48 examined procedures.

INTRODUCTION

In this paper I propose two candidate SLAs for humpback whales in West Greenland. They are both based on the current interim SLA, which is a simple data based procedure with no internal population dynamic model. This approach is taken here because it keeps the procedures very simple and easy to understand, and as long as this approach provides acceptable conservation performance and a high need satisfaction there seems to be no real reason to extend to larger and more complicated models based procedures.

The two candidates have been selected from a set of 48 SLAs including the interim procedure. All candidates were simple data based procedures based on different percentiles of different measures of abundance, with some procedures having simple trend responses and/or protection levels and/or snap to need features.

All procedures were tested on a selected set of evaluation trials, and here they were set to pass a test of acceptable conservation performance before they could be included in a set of conservation acceptable procedures from which the two candidates could be chosen; dependent upon their need satisfaction performance and other features.

TRIALS, CONSERVATION, AND SELECTION

The trials that were used in the SLA-selection process were H01AB, H01AC, H01AD, H01BB, H01BC, H01BD, H01CB, H01CC, H01CD, H03BB, H03BD, H05BB, H05BD, H06BB, and H06BD. These include all the low production evaluation trials except those with five year survey intervals (H02BA/C), those with negatively biased surveys (H04BA/C), and stochastic events every 5 years (H07BA/C).

A candidate SLA was said to perform adequately in terms of conservation 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

Table 1: The relative need satisfaction performance of different SLA candidates on the selected set of evaluation trials, with the selected SLAs marked with *. 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_2N_5	$r_3N_{2.5}P^*$	$r_3N_{2.5}P_a$	$r_3N_{2.5}P_b$	$r_3N_{2.5}PS^*$
$\bar{N}9$	0.999	0.999	1.000	1.000	1.000	1.000
$\bar{N}9_{5\%}$	0.818	0.856	0.885	0.892	0.893	0.896

at the beginning of the period for the 5th percentile. Of the original 48 procedures, 26 performed adequately by this measure of conservation.

From the set of 26 I chose five procedures and the interim procedure for a closer examination, with their overall need performance shown in Table 1. When overall need satisfaction was measured as the average of $N9$ over the 20 and 100 year period for the median, all five procedures had a need satisfaction between 0.999 and 1.000. Relative performance was therefore best described by the average of $N9$ over both the 20 and 100 year period for the 5th percentile, where the chosen procedures were the third to sixth best performing SLAs and a base-case SLA (named r_2N_5) that represented only a slight modification from the current interim SLA.

The first and second best $N9$ performing procedures, with $\bar{N}9_{5\%}$ statistics of 0.910 and 0.908, were not chosen for the set for further consideration. This was because these procedures included protection level functions that were not considered to be the most desirable in terms of practical application compared with the protection level functions in the chosen procedures.

The summary statistics for the set of five was then plotted in Figure 1, together with the statistics of the interim procedure. Based on the results in the figure, it was decided to include the $r_3N_{2.5}P$ and the $r_3N_{2.5}PS$ procedures as the proposed candidate procedures, with $r_3N_{2.5}PS$ being considered to have the best overall performance. $r_3N_{2.5}P_a$, $r_3N_{2.5}P_b$ and $r_3N_{2.5}PS$ have almost identical performance, however, $r_3N_{2.5}PS$ performs better in terms of relative increase ($D10$) on trial H05BD and was therefore considered the best procedure. $r_3N_{2.5}P$ was selected as a slightly less aggressive second variant, with the only difference between $r_3N_{2.5}P$ and $r_3N_{2.5}PS$ being that $r_3N_{2.5}PS$ has the additional feature of snap to need for initial suggested strikes limits above 80% of need.

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) with 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

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

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 is then calculated as

$$\tilde{S}_\tau = \min\left[\text{need}_\tau, \text{round}\left(0.03 N_\tau e^{-1.96 cv_\tau}\right)\right] \tag{5}$$

$$\dot{S}_\tau = \begin{cases} \tilde{S}_\tau & \text{if} \quad \tilde{S}_\tau < 0.8\ \text{need}_\tau \\ \text{need}_\tau & \text{if} \quad \tilde{S}_\tau \geq 0.8\ \text{need}_\tau \end{cases} \tag{6}$$

$$S_\tau = \begin{cases} \dot{S}_\tau & \text{if} \quad 1200 \leq N_\tau \\ 6 & \text{if} \quad 900 \leq N_\tau < 1200 \\ 3 & \text{if} \quad 600 \leq N_\tau < 900 \\ 0 & \text{if} \quad N_\tau < 600 \end{cases} \tag{7}$$

for $r_3 N_{2.5} PS$, and $r_3 N_{2.5} P$ performs the same calculation except that equation (6) is replaced with $\dot{S}_\tau = \tilde{S}_\tau$.

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.

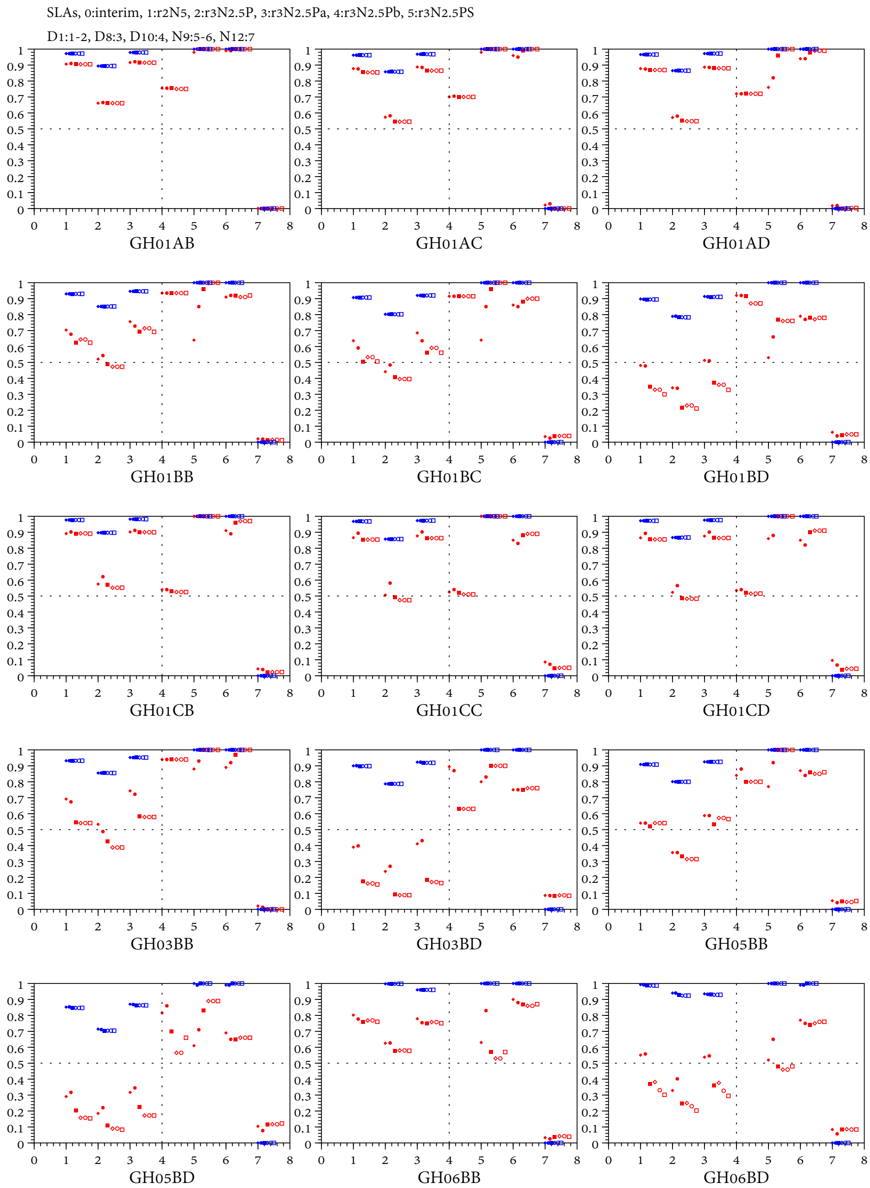

Figure 1: Overall performance of the five procedures in Table 1, given by the median (blue) and the 5th percentile (red) for different statistics over different trials (Note that $D10$ is rescaled here as $D10/2$, and that red gives the 95% percentile for $N12$).