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Potential SLAs for West Greenland fin whales testing against the agreed evaluation trials

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ABSTRACT

This paper presents two *SLAs* for West Greenland fin whales which are variants of *SLAs* that have been previously reported. Candidate *SLAs* are presented ranging from providing complete satisfaction of the conservation performance criterion for all evaluation trials with $MSYR_{1+}$ of 1%, to an alternative that sacrifices performance on this count to increasing extents for improved need satisfaction. Need is satisfied over the first 20 years, but not over 100 years for the two *SLAs* in these trials.

INTRODUCTION

This paper provides results from the application of the software developed by Andre Punt for the West Greenland fin whale trials, as reported in IWC (2015) and with modifications to the conditioning of fin whale trials as reported in IWC (2016). The two potential *SLAs* considered are of the form previously proposed by Brandão and Butterworth (2015a, 2015b). Results for the interim *SLA* (*SLA1*) are also shown here.

The *SLAs* considered here are tuned to achieve the conservation performance criteria of one for trials with a $MSYR_{1+}$ of 1% and need envelopes B and C (see Appendix A). Results for the *SLAs* considered are shown for all evaluation trials, except for the GF08 trials as conditioning stills needs to be finalised for these trials.

SLAs CONSIDERED

Three *SLAs* are considered in this paper. One of these, the interim *SLA*, forms part of the ‘reference *SLAs*’ as given in IWC (2012).

SLA1: Interim *SLA* which sets the *Strike Limit* as the lesser of need and $0.02\hat{N}e^{-1.645CV}$ where \hat{N} is the most recent estimate of abundance and CV is the coefficient of variation of \hat{N} .

SLA2: Weighted-average *SLA* which uses all the abundance estimates and replaces \hat{N} and CV in *SLA1* by:

$$\hat{N} = \exp \left[\frac{\sum_i \frac{0.9^{t_i} \ln N_i}{CV_i^2}}{\sum_i \frac{0.9^{t_i}}{CV_i^2}} \right] \quad (1)$$

$$CV = \sqrt{\frac{\sum_i \frac{0.9^{2t_i}}{CV_i^2}}{\sum_i \frac{0.9^{t_i}}{CV_i^2}}} \quad (2)$$

where N_i is the i th estimate of abundance, CV_i is the coefficient of variation of N_i , and t_i is the time (in years) between when the i th estimate of abundance was obtained and the first year of the block for which a *Strike Limit* is needed. The 0.02 multiplier applied to \hat{N} as in *SLA1* is adjusted by a function of the observed trend of the abundance indices, so that the *Strike Limit* is set as the lesser of need and $\varphi f(\beta^*) \hat{N} e^{-1.645 CV}$, where

$$f(\beta^*) = \alpha + (1 - \alpha) \frac{1}{1 + e^{(\beta^* - \bar{\beta})/\delta}},$$

where

$\beta^* = \hat{\beta} - \lambda s_{\hat{\beta}}$, where $\hat{\beta}$ is the negative of the slope of the log-linear regression applied to the abundance indices, $s_{\hat{\beta}}$ is the standard error of the slope coefficient and λ is a control parameter, and

$\alpha, \bar{\beta}, \varphi$ and δ are further control parameters.

For this variant the following values are chosen for the control parameters:

$\alpha = 0.6, \bar{\beta} = 0.005, \delta = 0.008$ and $\lambda = 3$. For this *SLA*, the control parameter φ has been defined as

$$\varphi = \begin{cases} 0.02 & \text{on or before 2038} \\ 0.016 & \text{after 2038} \end{cases}.$$

The function $f(\beta^*)$ is calculated only if there are more than three abundance indices, otherwise it is set to 1.

SLA3: Variant of *SLA2* described above. In this variant the control parameters are set to:

$\alpha = 0.7, \bar{\beta} = 0.005, \delta = 0.008$ and $\lambda = 4$. For this *SLA*, the control parameter φ has been defined as $\varphi = 0.02$.

To take into account the possibility that in some years only a proportion of the population of West Greenland fin whales is present during surveys, unrealistically low abundance estimates were omitted from the computation of the *SLAs*. The criterion used was to omit any abundance estimate from surveys whose upper 95th percentile was lower than the lowest of the 5th percentile of the unbiased historical surveys.

RESULTS AND DISCUSSION

Table 1 gives a summary of the results in terms of conservation performance (defined by the D10 statistic: relative increase of 1+ population size: P_T/P_0 , where P is the size of the total 1+ population) and need satisfaction criteria (defined by the N9 statistic: Average need satisfaction given by $\frac{1}{T} \sum_{t=0}^{T-1} \frac{C_t}{Q_t}$, where C is catch and Q is the need) in the same manner as reported in IWC (2014) for the evaluation trials for

the *SLAs* considered. A further statistic is reported in Table 1 that was not given previously: the proportion of times that each *SLA* achieves need satisfaction (N9 over 20 and 100 years) above 0.75 at the lower 5%-ile for these fin whale evaluation trials. Note that Appendix A gives details of all the trials and need envelopes considered.

Of the range of *SLAs* that were tested, trying to meet the perfect conservation performance was only achieved at the expense of meeting need satisfaction, with a worse performance for need satisfaction over a 100 year period. *SLA2* was selected to achieve the D10 criterion for all $MSYR_{1+} = 1\%$ trials. The D10 criterion is not achieved for some of the other trials, however the lower 5%-ile values for these trials are mostly very close to 1. Need satisfaction over 20 years is met except for one trial with the highest need envelop. The need satisfaction over 100 years failed to be met by most trials. *SLA3* was selected to improve need satisfaction without sacrificing conservation performance too much. Although for this *SLA* the number of occasion the D10 criterion is not met increases because of the trade-off with need satisfaction, the D10 values are mostly very close to 1. *SLA 3* meets need satisfaction over a 20 year period.

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Table 1. Proportion of times that each *SLA* meets the conservation performance and need satisfaction (over 20 and 100 years) criteria for various subsets of the 51 evaluation trials for West Greenland bowhead whales, and the mean of the lower 5%-ile need satisfaction (over 20 and 100 years).

(a) Results by MSY rate

	Interim	SLA 2	SLA 3
MSYR1+ = 1% (9 trials)			
Conservation performance	0.56	1.00	0.78
Mean Need satisfaction 20 yrs	0.84	0.83	0.85
Mean Need satisfaction 100 yrs	0.67	0.52	0.62
Proportion Need satisfaction 20 yrs	1.00	1.00	1.00
Porportion Need satisfaction 100 yrs	0.33	0.00	0.22
MSYR1+=2.5% (24 trials)			
Conservation performance	0.46	0.92	0.50
Mean Need satisfaction 20 yrs	0.85	0.83	0.85
Mean Need satisfaction 100 yrs	0.75	0.60	0.72
Proportion Need satisfaction 20 yrs	1.00	0.96	1.00
Porportion Need satisfaction 100 yrs	0.46	0.13	0.42
MSYR1+=4% (15 trials)			
Conservation performance	0.33	0.53	0.27
Mean Need satisfaction 20 yrs	0.87	0.84	0.87
Mean Need satisfaction 100 yrs	0.75	0.61	0.73
Proportion Need satisfaction 20 yrs	1.00	1.00	1.00
Porportion Need satisfaction 100 yrs	0.47	0.07	0.47
MSYR1+ = 7% (3 trials)			
Conservation performance	0.00	0.00	0.00
Mean Need satisfaction 20 yrs	0.85	0.84	0.85
Mean Need satisfaction 100 yrs	0.67	0.51	0.62
Proportion Need satisfaction 20 yrs	1.00	1.00	1.00
Porportion Need satisfaction 100 yrs	0.33	0.00	0.33

(b) Results by need envelope

	Interim	SLA 2	SLA 3
Need Scenario A (20 trials)			
Conservation performance	0.75	0.85	0.70
Mean Need satisfaction 20 yrs	0.87	0.85	0.87
Mean Need satisfaction 100 yrs	0.83	0.71	0.83
Proportion Need satisfaction 20 yrs	1.00	1.00	1.00
Porportion Need satisfaction 100 yrs	1.00	0.20	0.95
Need Scenario B (20 trials)			
Conservation performance	0.20	0.65	0.35
Mean Need satisfaction 20 yrs	0.85	0.83	0.85
Mean Need satisfaction 100 yrs	0.70	0.54	0.66
Proportion Need satisfaction 20 yrs	1.00	1.00	1.00
Porportion Need satisfaction 100 yrs	0.10	0.00	0.05
Need Scenario C (11 trials)			
Conservation performance	0.18	0.82	0.18
Mean Need satisfaction 20 yrs	0.83	0.82	0.83
Mean Need satisfaction 100 yrs	0.60	0.44	0.54
Proportion Need satisfaction 20 yrs	1.00	0.91	1.00
Porportion Need satisfaction 100 yrs	0.00	0.00	0.00

APPENDIX A

List of evaluation trials (see IWC, 2016, Table 2a)

Trial	Description	Conditioning
GF01-1A	MSYR ₁₊ = 1%; need scenario A; survey frequency = 12; historic survey bias = 1	Yes [1-1]
GF01-1B	MSYR ₁₊ = 1%; need scenario B; survey frequency = 12; historic survey bias = 1	1-1
GF01-1C	MSYR ₁₊ = 1%; need scenario C; survey frequency = 12; historic survey bias = 1	1-1
GF01-2A	MSYR ₁₊ = 2.5%; need scenario A; survey frequency = 12; historic survey bias = 1	Yes [1-2]
GF01-2B	MSYR ₁₊ = 2.5%; need scenario B; survey frequency = 12; historic survey bias = 1	1-2
GF01-2C	MSYR ₁₊ = 2.5%; need scenario C; survey frequency = 12; historic survey bias = 1	1-2
GF01-4A	MSYR ₁₊ = 4%; need scenario A; survey frequency = 12; historic survey bias = 1	Yes [1-4]
GF01-4B	MSYR ₁₊ = 4%; need scenario B; survey frequency = 12; historic survey bias = 1	1-4
GF01-4C	MSYR ₁₊ = 4%; need scenario C; survey frequency = 12; historic survey bias = 1	1-4
GF01-7A	MSYR ₁₊ = 7%; need scenario A; survey frequency = 12; historic survey bias = 1	Yes [1-7]
GF01-7B	MSYR ₁₊ = 7%; need scenario B; survey frequency = 12; historic survey bias = 1	1-7
GF01-7C	MSYR ₁₊ = 7%; need scenario C; survey frequency = 12; historic survey bias = 1	1-7
GF02-2A	MSYR ₁₊ = 2.5%; need scenario A; survey frequency = 6; historic survey bias = 1	1-2
GF02-2B	MSYR ₁₊ = 2.5%; need scenario B; survey frequency = 6; historic survey bias = 1	1-2
GF02-2C	MSYR ₁₊ = 2.5%; need scenario C; survey frequency = 6; historic survey bias = 1	1-2
GF02-4A	MSYR ₁₊ = 4%; need scenario A; survey frequency = 6; historic survey bias = 1	1-4
GF02-4B	MSYR ₁₊ = 4%; need scenario B; survey frequency = 6; historic survey bias = 1	1-4
GF03-1A	MSYR ₁₊ = 1%; need scenario A; survey frequency = 18; historic survey bias = 1	1-1
GF03-1B	MSYR ₁₊ = 1%; need scenario B; survey frequency = 18; historic survey bias = 1	1-1
GF03-1C	MSYR ₁₊ = 1%; need scenario C; survey frequency = 18; historic survey bias = 1	1-1
GF03-2A	MSYR ₁₊ = 2.5%; need scenario A; survey frequency = 18; historic survey bias = 1	1-2
GF03-2B	MSYR ₁₊ = 2.5%; need scenario B; survey frequency = 18; historic survey bias = 1	1-2
GF03-2C	MSYR ₁₊ = 2.5%; need scenario C; survey frequency = 18; historic survey bias = 1	1-2
GF03-4A	MSYR ₁₊ = 4%; need scenario A; survey frequency = 18; historic survey bias = 1	1-4
GF03-4B	MSYR ₁₊ = 4%; need scenario B; survey frequency = 18; historic survey bias = 1	1-4
GF04-2A	MSYR ₁₊ = 2.5%; need scenario A; survey frequency = 12; historic survey bias = 0.8	Yes [4-2]
GF04-2B	MSYR ₁₊ = 2.5%; need scenario B; survey frequency = 12; historic survey bias = 0.8	4-2
GF04-4A	MSYR ₁₊ = 4%; need scenario A; survey frequency = 12; historic survey bias = 0.8	Yes [4-4]
GF04-4B	MSYR ₁₊ = 4%; need scenario B; survey frequency = 12; historic survey bias = 0.8	4-4
GF05-2A	MSYR ₁₊ = 2.5%; need scenario A; survey frequency = 12; historic survey bias = 1.2	Yes [5-2]
GF05-2B	MSYR ₁₊ = 2.5%; need scenario B; survey frequency = 12; historic survey bias = 1.2	5-2
GF05-4A	MSYR ₁₊ = 4%; need scenario A; survey frequency = 12; historic survey bias = 1.2	Yes [5-4]
GF05-4B	MSYR ₁₊ = 4%; need scenario B; survey frequency = 12; historic survey bias = 1.2	5-4
GF06-1A	MSYR ₁₊ = 1%; need scenario A; survey frequency = 12; historic survey bias = 1; 3 episodic events	1-1
GF06-1B	MSYR ₁₊ = 1%; need scenario B; survey frequency = 12; historic survey bias = 1; 3 episodic events	1-1
GF06-1C	MSYR ₁₊ = 1%; need scenario C; survey frequency = 12; historic survey bias = 1; 3 episodic events	1-1
GF06-2A	MSYR ₁₊ = 2.5%; need scenario A; survey frequency = 12; historic survey bias = 1; 3 episodic events	1-2
GF06-2B	MSYR ₁₊ = 2.5%; need scenario B; survey frequency = 12; historic survey bias = 1; 3 episodic events	1-2
GF06-2C	MSYR ₁₊ = 2.5%; need scenario C; survey frequency = 12; historic survey bias = 1; 3	1-2

	episodic events	
GF06-4A	MSYR ₁₊ = 4%; need scenario A; survey frequency = 12; historic survey bias = 1; 3 episodic events	1-4
GF06-4B	MSYR ₁₊ = 4%; need scenario B; survey frequency = 12; historic survey bias = 1; 3 episodic events	1-4
GF07-2A	MSYR ₁₊ = 2.5%; need scenario A; survey frequency = 12; historic survey bias = 1; stochastic events every 5 years	1-2
GF07-2B	MSYR ₁₊ = 2.5%; need scenario B; survey frequency = 12; historic survey bias = 1; stochastic events every 5 years	1-2
GF07-4A	MSYR ₁₊ = 4%; need scenario A; survey frequency = 12; historic survey bias = 1; stochastic events every 5 years	1-4
GF07-4B	MSYR ₁₊ = 4%; need scenario B; survey frequency = 12; historic survey bias = 1; stochastic events every 5 years	1-4
GF08-1A	MSYR ₁₊ = 1%; need scenario A; survey frequency = 12; historic survey bias = 1; asymmetric environmental stochasticity (depletion = 0.3)	Yes [1-1,8-1]
GF08-1B	MSYR ₁₊ = 1%; need scenario B; survey frequency = 12; historic survey bias = 1; asymmetric environmental stochasticity (depletion = 0.3)	8-1
GF08-1C	MSYR ₁₊ = 1%; need scenario C; survey frequency = 12; historic survey bias = 1; asymmetric environmental stochasticity (depletion = 0.3)	8-1
GF08-2A	MSYR ₁₊ = 2.5%; need scenario A; survey frequency = 12; historic survey bias = 1; asymmetric environmental stochasticity (depletion = 0.3)	Yes [1-2,8-2]
GF08-2B	MSYR ₁₊ = 2.5%; need scenario B; survey frequency = 12; historic survey bias = 1; asymmetric environmental stochasticity (depletion = 0.3)	8-2
GF08-2C	MSYR ₁₊ = 2.5%; need scenario C; survey frequency = 12; historic survey bias = 1; asymmetric environmental stochasticity (depletion = 0.3)	8-2
GF08-4A	MSYR ₁₊ = 4%; need scenario A; survey frequency = 12; historic survey bias = 1; asymmetric environmental stochasticity (depletion = 0.3)	Yes [1-4,8-4]
GF08-4B	MSYR ₁₊ = 4%; need scenario B; survey frequency = 12; historic survey bias = 1; asymmetric environmental stochasticity (depletion = 0.3)	8-4
GF09-2A	MSYR ₁₊ = 2.5%; need scenario A; survey frequency = 12; historic survey bias = 1; future survey CV = 0.35	1-2
GF09-2B	MSYR ₁₊ = 2.5%; need scenario B; survey frequency = 12; historic survey bias = 1; future survey CV = 0.35	1-2
GF09-2C	MSYR ₁₊ = 2.5%; need scenario C; survey frequency = 12; historic survey bias = 1; future survey CV = 0.35	1-2
GF10-2A	MSYR ₁₊ = 2.5%; need scenario A; survey frequency = 12; historic survey bias = 1; future survey CV = 0.45	1-2
GF10-2B	MSYR ₁₊ = 2.5%; need scenario B; survey frequency = 12; historic survey bias = 1; future survey CV = 0.45	1-2
GF10-2C	MSYR ₁₊ = 2.5%; need scenario C; survey frequency = 12; historic survey bias = 1; future survey CV = 0.45	1-2

Description of the different need scenarios (see IWC, 2015b, Table 5) for fin whales off West Greenland.

Need scenario	Description
A	19 -> 19 over 100 years
B	19 -> 38 over 100 years
C	19 -> 57 over 100 years