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Candidate SLA for West Greenland fin whales

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INTERNATIONAL
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ABSTRACT
In this paper I illustrate three, and propose one, candidate SLA/s for West Greenland fin whales. The procedures are slight variants of what has been proposed earlier for humpback, bowhead and fin whales in West Greenland. They are all simple data procedures that take a growth rate fraction of a lower percentile of an abundance measure, with a trend modifier included as something new. The three candidate SLAs are tuned (with the growth rate parameters) to produce a stable population over the 100 year simulation period for the maximal need envelope (C) on the base case trial with a msyr of 1%. The proposed procedure (d05g1) was chosen as the best performing procedure from a total of 22 tested SLAs, and it has an average need satisfaction of 92.4% across all the evaluation trials.

INTRODUCTION

In this paper I use the SLA program that I developed for West Greenland humpback whales (Witting 2014) and bowhead whales (Witting 2015a) to investigate the catch-conservation trade-off space of the evaluation trials for fin whales in West Greenland.

The model of the SLAs is described in the Appendix. Relative to my earlier procedures, it has a slightly simpler formulation of the protection level, and it includes also a trend modifier that attempts to adjust the strike limit relative to the trend information in the abundance data over time.

I tested a total of 22 SLA candidates, of which three of the best performing are included in this paper. All the SLAs were tuned with the growth rate parameter to ensure a stable population (D10 ≥ 1.00) over the 100 year simulation period for the maximal need envelope (C) on the base case trial with a msyr of 1% (trial GF01CC). One of the included procedures (d0g0) does not include the trend modifier, and two (d05g1 and d1g1) do.

RESULTS AND DISCUSSION

Figures 1 to 4 illustrate the performance of the SLAs in relation to the interim SLA and strikes equals need.

Relating to conservation we note that there are a few low msyr cases [trials GF01CB and GF03C] where the lower 5th percentile of D10 is slightly smaller than one for some of the SLAs.

Name	r	p	r_Δ	s	n
d0g0	0.015	1.65	-	0.8	600
d05g1*	0.014	1.65	0.005	0.8	600
d1g1	0.0105	1.65	0.01	0.8	600

Table 1: Names and parameters of SLAs. r:production; p:percentile; r_Δ:max r change; s:snap to need level; n:protection abundance.

The SLA d05g1 is proposed as the candidate for West Greenland fin whales as it has the highest need satisfaction, with an overall average of 92.4% across all the evaluation trials.

	Need	Inte	d0g0	d05g1*	d1g1
50%	1.000	0.993	0.986	0.989	0.989
5%	1.000	0.941	0.894	0.911	0.897
Avg	1.000	0.953	0.911	0.924	0.915

Table 2: Need satisfaction (N9) of SLA candidates across all evaluation trials. N9 is given as the average (Avg), median (50%), and 5th percentile (5%), of the average between the 20 and 100 year period across the trials.

APPENDIX: SLA DESCRIPTION

With τ being the year of a strike limit calculation, the SLA makes an interim-SLA-like calculation based on an estimate of abundance (N_τ) with an associated coefficient of variation (cv_τ).

Abundance

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

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

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.

Independently of the number of survey estimates available, the estimate of uncertainty in the abundance estimate is

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

where cv_t is the coefficient of variation of the survey estimate in year t.

Trend modifier

Let r be an assumed standard production for the population, and Δr a change in production as a function of a possible trend. Let r_Δ be the allowed maximum to the absolute change, with $-r_\Delta \leq \Delta r \leq r_\Delta$.

If there are three, or less than three, abundance estimates from surveys available the Δr change in production is set to zero. Given at least four abundance estimates, the Δr-function is based on a fitted a straight line

$$\ln n_t = \alpha + \beta t \tag{5}$$

to the natural logarithm of the point estimates of the last four abundance estimates, using the Chi-Squares fitting routine *fitab.h* of Press et al. (2007). A maximum production estimate is then obtained as

$$r_{max} = \beta + 2\sigma_\beta \tag{6}$$

and a minimum as

$$r_{min} = \beta - 2\sigma_\beta \tag{7}$$

where σ_β is the *fitab.h* estimate of the standard error on β. A probability of an increasing population is then given as

$$p = \frac{\max(r_{max}, 0)}{\max(r_{max}, 0) - \min(r_{min}, 0)} \tag{8}$$

Relative measures of increase ($m_\uparrow$), and decrease ($m_\downarrow$), that takes values of one when an increase or decrease is certain, and values of zero when an increase or decrease is highly uncertain, is then obtained as

$$\begin{aligned} m_\uparrow &= e^{-\gamma \max\left(\frac{1}{1-p}-\epsilon,0\right)} \\ m_\downarrow &= e^{-\gamma \max\left(\frac{1}{p}-\epsilon,0\right)} \end{aligned} \tag{9}$$

with the estimated change in the production rate given as

$$\Delta r = r_\Delta (m_\uparrow - m_\downarrow) \tag{10}$$

where γ and ϵ are tuning parameters that determine the shape of the increase in Δr from $-r_\Delta$ to r_Δ as the probability of a positive trend (p) increases from zero to one.

SLA

The strike limit S_τ is then calculated as

$$\tilde{S}_\tau = (r + \Delta r) N_\tau e^{-p\, cv_\tau} \tag{11}$$

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

$$S_\tau = \begin{cases} \dot{S}_\tau & \text{if} \quad N_\tau > 2n \\ \frac{N_\tau - n}{n} \dot{S}_\tau & \text{if} \quad n < N_\tau \leq 2n \\ 0 & \text{if} \quad N_\tau \leq n \end{cases}$$

with the total number of strikes for the six year block period being $\min[\text{round}(6S_\tau), 6\text{need}_\tau]$.

Given $\epsilon = 1$ and $\gamma = 1$, the SLA has 5 additional parameters (r, r_Δ, p, s, n) that need to be specified (Table 1).

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Witting, L. 2015. Candidate SLAs for the hunt of bowhead whales in West Greenland. *IWC/SC/66a/xx. Available from the International Whaling Commission (http://www.iwcoffice.org/)* .

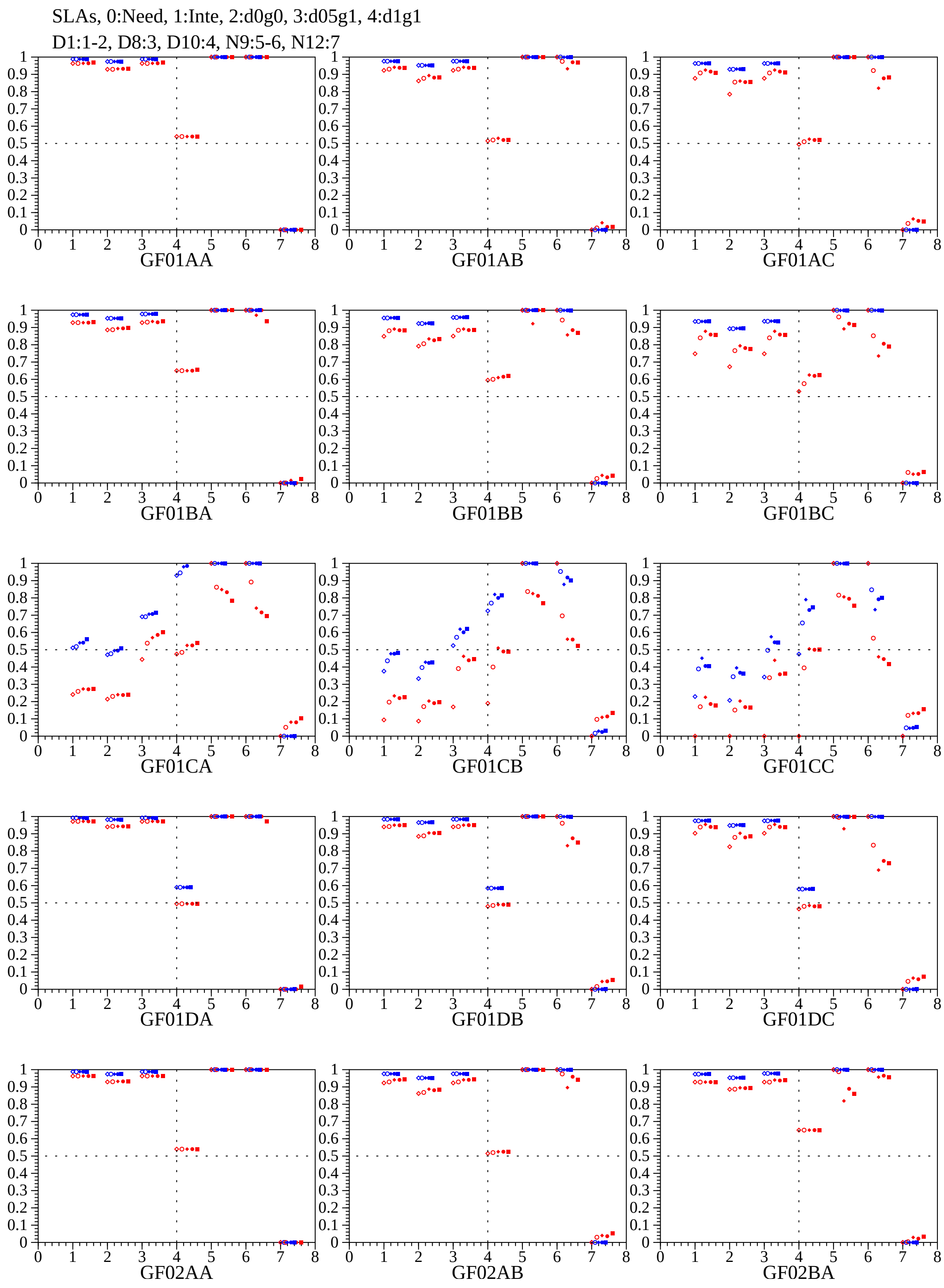

Figure 1: Performance of the different SLAs relative to Need and Inte over trials GF01AA to GF02BA, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

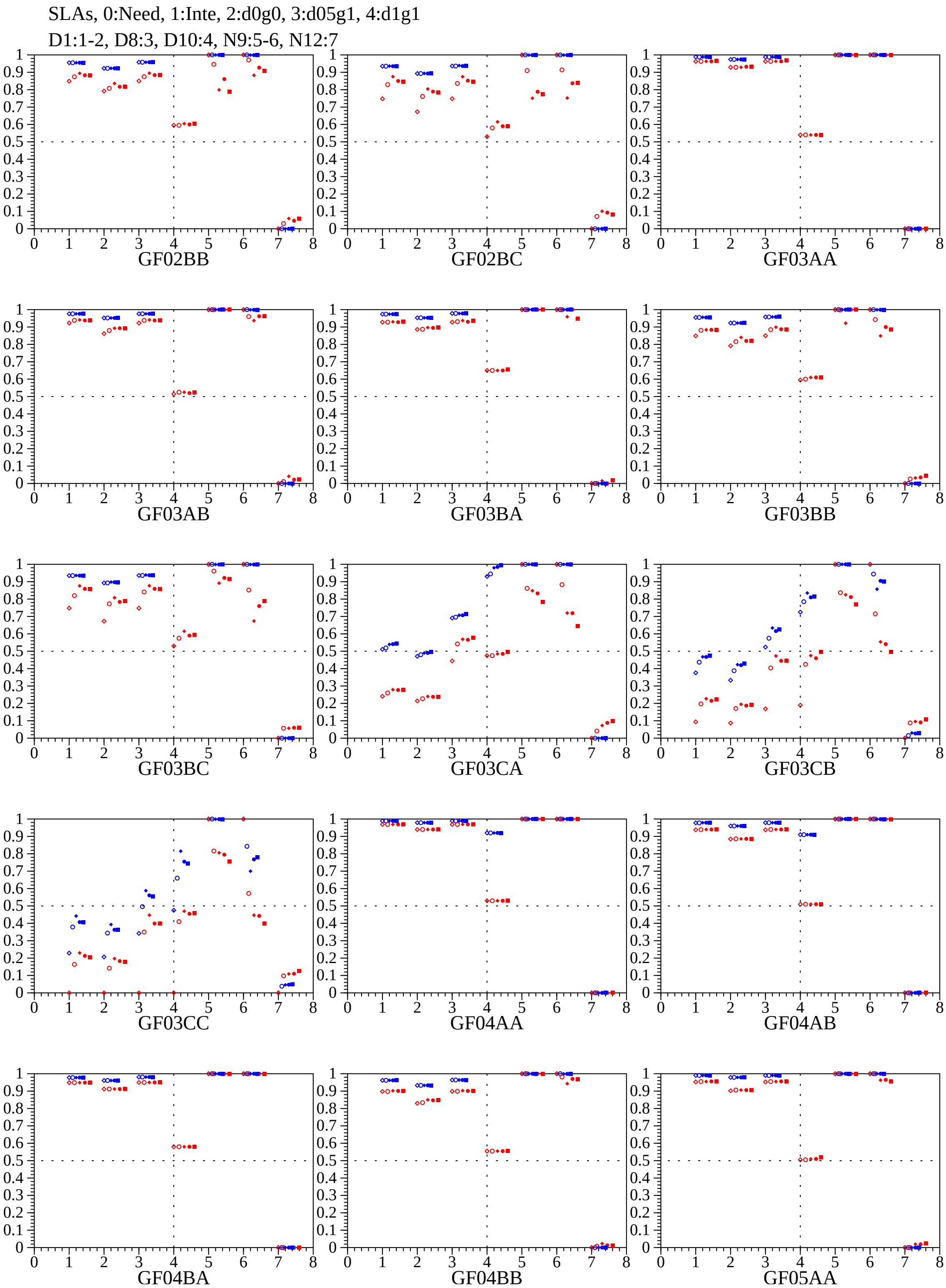

Figure 2: Performance of the different SLAs relative to Need and Inte over trials GF02BB to GF05AA, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

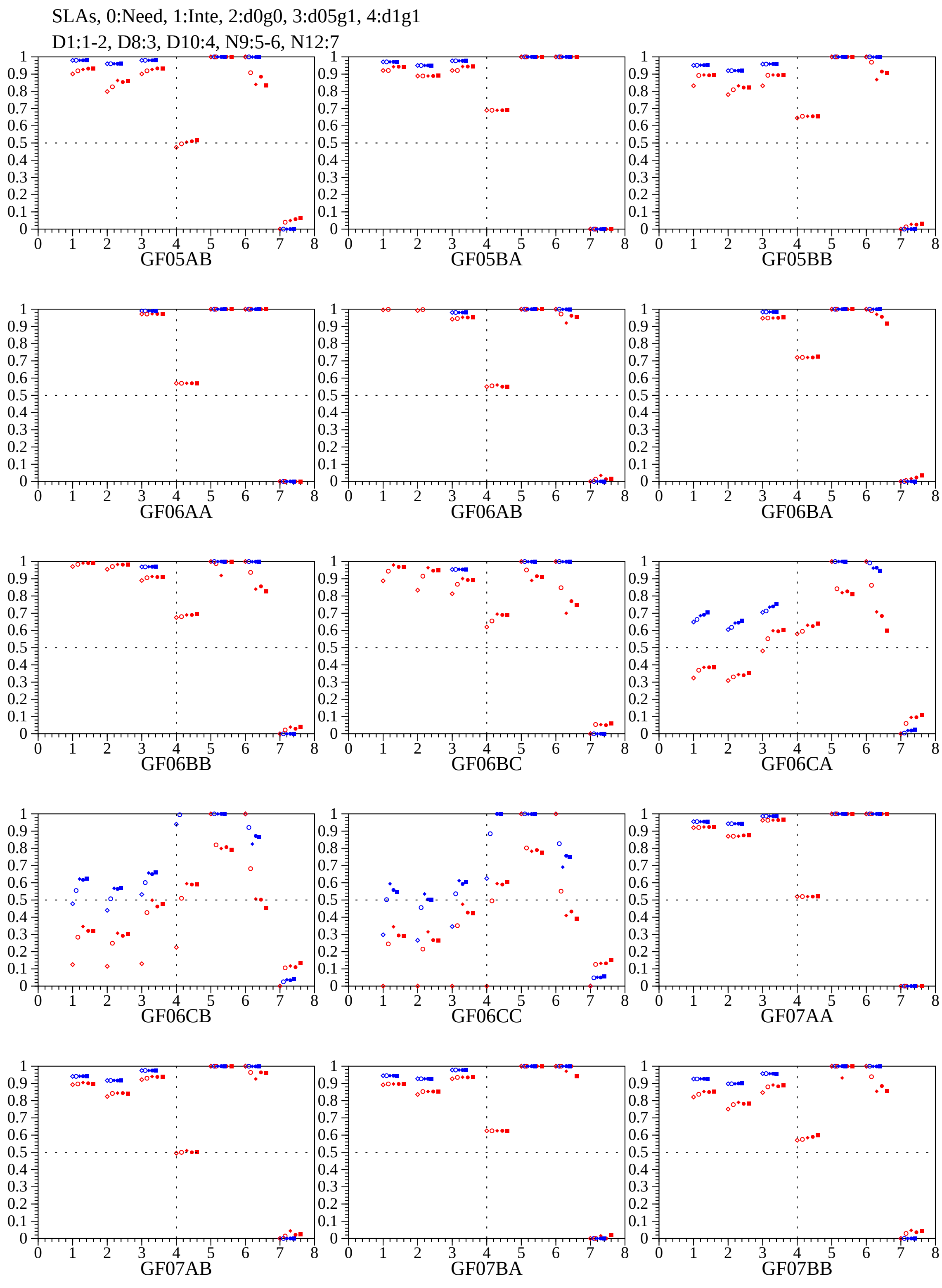

Figure 3: Performance of the different SLAs relative to Need and Inte over trials GF05AB to GF07BB, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

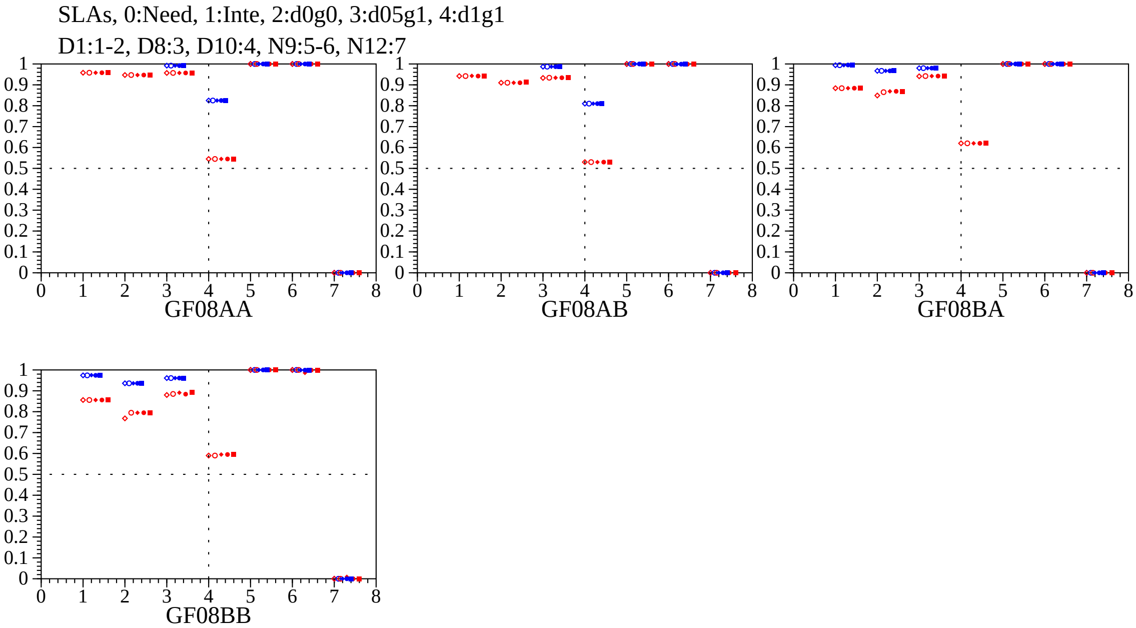

Figure 4: Performance of the different SLAs relative to Need and Inte over trials GF08AA to GF08BB, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).