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Preliminary SLA runs for West Greenland fin whales

Lars Witting

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

ABSTRACT
In this paper I run four initial SLA variants on the evaluation trials for West Greenland fin whales. They are all simple data procedures that take a growth rate fraction of a lower percentile of an abundance measure, covering the growth rates of 1% (SLA p2r1), 2% (p2r2), 3% (p2r3) and 4% (p2r4), with the latter being the accepted SLA for West Greenland humpback whales. The msyr of the current evaluation trials are 1%, 2.5%, 4% and 7%, and it is only p2r1 that ensures an increasing lower 5th percentile on the 1% trials. This procedure has an average need satisfaction of 80%, while the other procedures ensures an average need satisfaction above 93%.

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. For this I let the growth rate parameter of the SLA cover a range from one to four percent, with the latter being the SLA that was accepted for humpback whales.

The model of the SLAs is described in the Appendix. The only differences between the four SLAs is the value of the growth rate parameter (Table 1), and the trend modifier function is not applied for the SLAs in this paper (r_Δ parameter).

RESULTS AND DISCUSSION

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

Relating to conservation we note the expected trade-off with more exploitation from SLAs with higher growth rate parameters. If we set as a conservation criterion that the lower 5th percentile should increase over the simulation period (except for the 7% trials, that are allowed to decline from recovered states), we note that this is only ensured by p2r1. The failures of the other SLAs are on the 1% trials, and almost exclusively with increasing need. Apart from this, the SLAs will generally allow for an increase in the lower 5th percentile.

While these conservation failures might be taken as a failure of the SLAs, we note that it is a result of implausible trials as there is approximately a 95% probability that the

Name	r	p	r_Δ	s	n_u	n_l	s_u
p2r1	0.01	2	-	0.8	1200	600	6
p2r2	0.02	2	-	0.8	1200	600	6
p2r3	0.03	2	-	0.8	1200	600	6
p2r4	0.04	2	-	0.8	1200	600	6

Table 1: Names and parameters of SLAs. r:production; p:percentile; r_Δ:max r change; s:snap to need level; n_u:upper protection abundance; n_l:lower protection abundance; s_u:strike limit at n_u.

msyr in North Atlantic fin whales is above 2% (Witting 2015b). A more plausible trial structure would have a lower bound of 2% on the msyr in the evaluation trials, and some robustness trials based on a 1% msyr.

Turning to need satisfaction (Table 2) there is a clear difference between p2r1 on one side, and the other SLAs on the other. The average need satisfaction over the 20 and 100 year simulation period across all the evaluation trials is 80% for p2r1, while it is above 93% in the remaining SLAs.

	Need	Inte	p2r1	p2r2	p2r3	p2r4
Avg	1.00	0.95	0.80	0.93	0.96	0.97
50%	1.00	0.99	0.93	0.99	1.00	1.00
5%	1.00	0.94	0.73	0.92	0.96	0.97

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

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

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

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

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

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

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

Given $\epsilon = 4/3$ and $\gamma = 10$, the SLA has 7 additional parameters (r, r_Δ, p, s, n_u, n_l, s_u) that need to be specified (Table 1).

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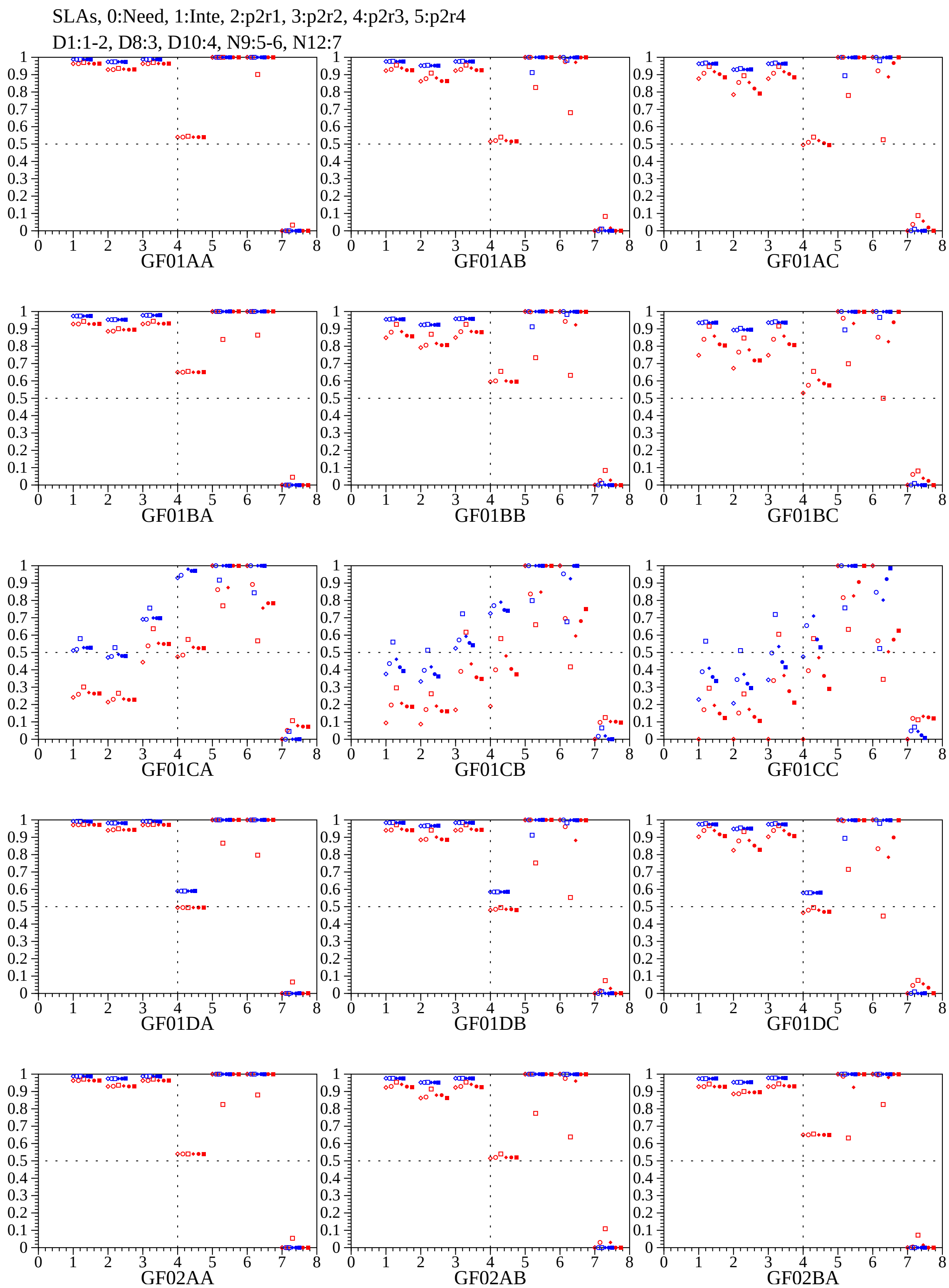

Figure 1: Performance of p2r1, p2r2, p2r3 and p2r4 (relative to Need and Inte) over trials GF01AA to GF02BA, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

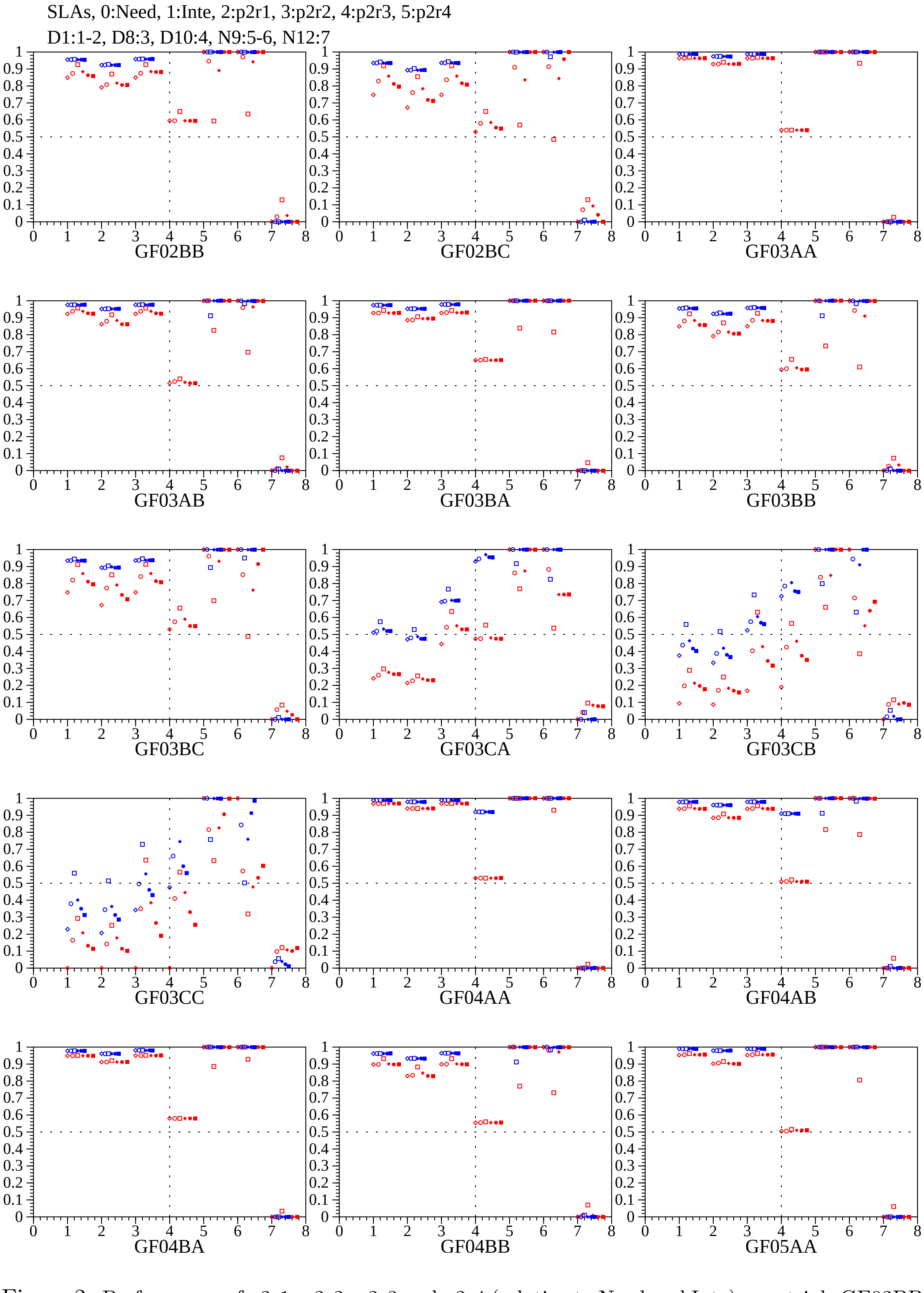

Figure 2: Performance of p2r1, p2r2, p2r3 and p2r4 (relative to Need and Inte) over trials GF02BB to GF05AA, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

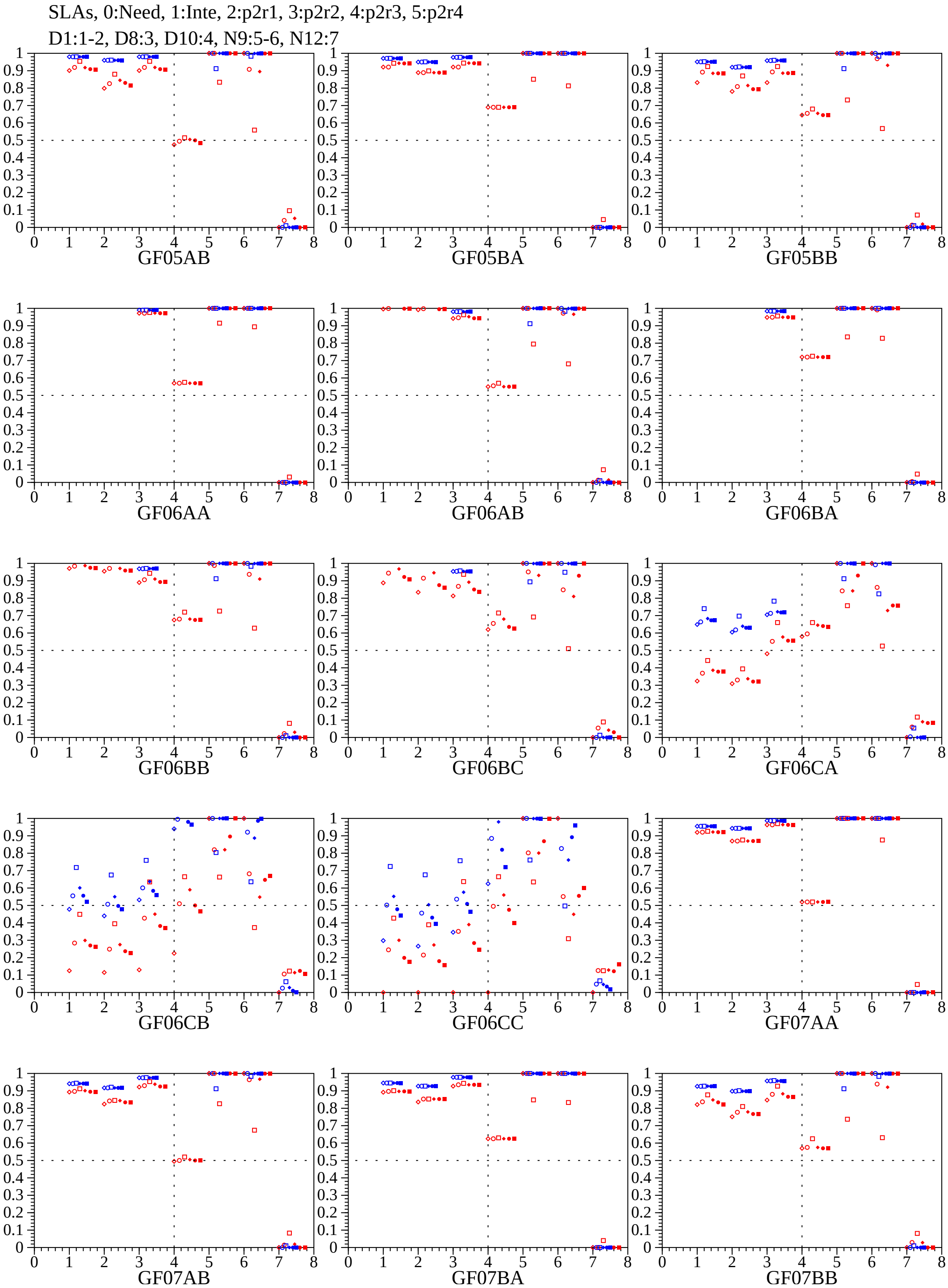

Figure 3: Performance of p2r1, p2r2, p2r3 and p2r4 (relative to Need and Inte) over trials GF05AB to GF07BB, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

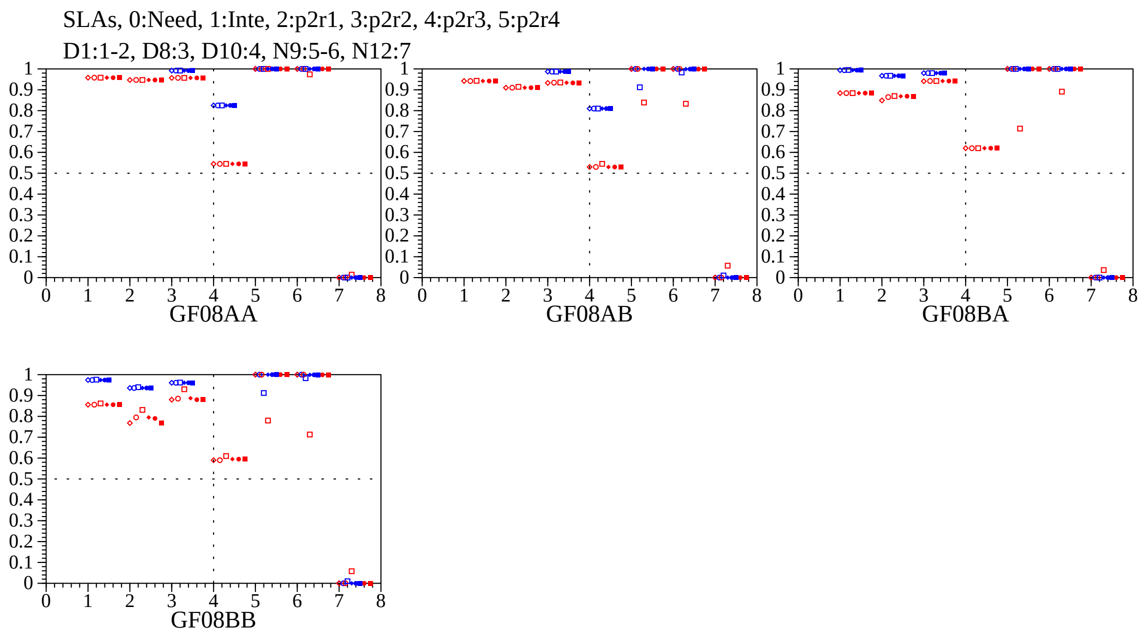

Figure 4: Performance of p2r1, p2r2, p2r3 and p2r4 (relative to Need and Inte) over trials GF08AA to GF08BB, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).