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A candidate SLA for fin whales in West Greenland

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ABSTRACT
This paper describes a candidate SLAs for West Greenland fin whales. The procedure is slight variant of what has been proposed earlier for humpback, bowhead and fin whales in West Greenland. It is a relatively simple data procedure that take a growth rate fraction of a lower percentile of an abundance measure, with a trend modifier included, and a new abundance filter that excludes very low abundance estimates form the statistical analysis. The SLA is proposed in two tuning versions, where the percentile parameter of the SLA is adjusted to ensure a D10 statistics of unity for the 5th percentile of the base case trial with a msyr of 1%, given the medium (B) and high (C) need envelopes.

INTRODUCTION

With the fin whale SLA that is proposed in this paper, I continue the development of the SLA model that I have used for West Greenland humpback (Witting 2014), and bowhead (Witting 2015b), and fin whales (Witting 2015a,c).

The model is described in the Appendix. As my 2015 proposal for fin whales, it has a simplified formulation of the protection level, and it includes a trend modifier that attempts to adjust the strike limit relative to the trend information in the abundance data over time.

As something new I have added an abundance filter that excludes very low abundance estimates from the data that are analysed by the SLA. The purpose of this is an attempt to analyse only the larger estimates of the population that supports the hunt in West Greenland. This is based on the assumption that a sudden drastic drop in the estimated abundance, as seen for the survey in 2015 (Hansen et al. 2016), is likely to reflect either a year where only a small fraction of the population migrates to West Greenland waters, or a failed survey (Witting 2016).

The candidate SLA is proposed in two versions (lwFb and lwFc), where the percentile parameter of the SLA is adjusted to ensure a D10 statistics of unity for the 5th percentile of the base case trial with a msyr of 1%, given the medium (need:B; SLA:lwFb) and high (need:C; SLA:lwFc) need envelopes. The medium envelope B has an increase in need from 19 to 38 fin whales per year over the 100-year simulation period, and the high envelope C has an increase from 19 to 57.

RESULTS AND DISCUSSION

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

The lower 5th percentile of D10 for lwFc and lwFb are very close to or above unity for all 1% and 2.5% trials, with the exception being the asymmetrical environmental stochasticity trial (GF08), where the lower 5th of D10 for the 1% trial is no more than 0.49 (need B) and 0.48 (need C) for lwFc, and 0.47 (need B) and 0.47 (need C) for lwFb. The corresponding values for the 2.5% trial are .87 (need B) and 0.86 (need C) for lwFc, and 0.85 (need B) and 0.85 (need C) for lwFb. The median of D10, however, is at or above unity for all 1% and 2.5% trials except GF08-1B/C, where it is 0.96 and 0.95 for lwFc, and 0.93 and 0.92 for lwFb.

This decline in conservation performance on GF08 is unexpected as it occurs only in this trial, and not in the other stochastic trials (GF06 and GF07).

The need satisfaction of the two candidates are much larger than obtained by the interim procedure, with the median across the trials in Fig. 1 to 4 being 0.97 for lwFb and 0.96 for lwFc for the median of N9 (compared with 0.60 for interim), and 0.81 for lwFb and 0.79 for lwFc for the lower 5th percentile (compared with 0.39 for interim).

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 filter

A new component of the SLA is an abundance filter that excludes very low estimates from the abundance data that are analysed by the SLA. Of all the abundance estimates that are available up to and including 2015, it is only the 2005 and 2007 estimates that are included in the SLA analysis. A future abundance estimate N_t in year $t > 2015$ is included in the analysis if, and only if,

$$N_t e^{p_n cv_t} > \bar{N} e^{-p_n \bar{cv}} \tag{1}$$

where cv_t is the cv of the estimate, $\bar{N}$ is the average of the last three (or two) accepted estimates starting with those in 2005 and 2007, $\bar{cv}$ is the average cv of those two or three estimates, and $p_n = 1.2$ is a percentile parameter of the assumed log-normal uncertainty of the abundance estimates.

Abundance

If there are three, or less than three, abundance estimates that have been accepted for analysis, the measure of abundance that goes into the SLA is

$$N_\tau = \frac{\sum_t N_t e^{-0.07(\hat{t}-t)}}{\sum_t e^{-0.07(\hat{t}-t)}} \tag{2}$$

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

$$n_t = a + bt \tag{3}$$

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

$$N_\mathcal{T} = a + b\hat{t} \tag{4}$$

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

$$cv_\mathcal{T} = \frac{\sum_t cv_t e^{-0.07(\hat{t}-t)}}{\sum_t e^{-0.07(\hat{t}-t)}} \tag{5}$$

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

$$\ln n_t = \alpha + \beta t \tag{6}$$

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

$$r_{max} = \beta + 2\sigma_\beta \tag{7}$$

and a minimum as

$$r_{min} = \beta - 2\sigma_\beta \tag{8}$$

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

$$p = \frac{\max(r_{max}, 0)}{\max(r_{max}, 0) - \min(r_{min}, 0)} \tag{9}$$

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

$$\begin{aligned} m_\uparrow &= e^{-\gamma \max\left(\frac{1}{1-p}-\epsilon,0\right)} \\ m_\downarrow &= e^{-\gamma \max\left(\frac{1}{p}-\epsilon,0\right)} \end{aligned} \tag{10}$$

with the estimated change in the production rate given as

$$\Delta r = r_\Delta (m_\uparrow - m_\downarrow) \tag{11}$$

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

$$\tilde{S}_\tau = (r + \Delta r) N_\tau e^{-p\, cv_\tau} \tag{12}$$

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

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

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

SLA parameters

The parameters of the lwFc (C tuning) and lwFb (B tuning) candidate SLAs for West Greenland fin whales are

$$\begin{aligned} p_n &= 1.2 \\ r &= 0.015 \\ r_\Delta &= 0.005 \\ \epsilon &= 1 \\ \gamma &= 1 \\ p &= 2.0 \text{ (lwFc) and } 1.8 \text{ (lwFb)} \\ s &= 0.8 \\ n &= 200 \end{aligned} \tag{13}$$

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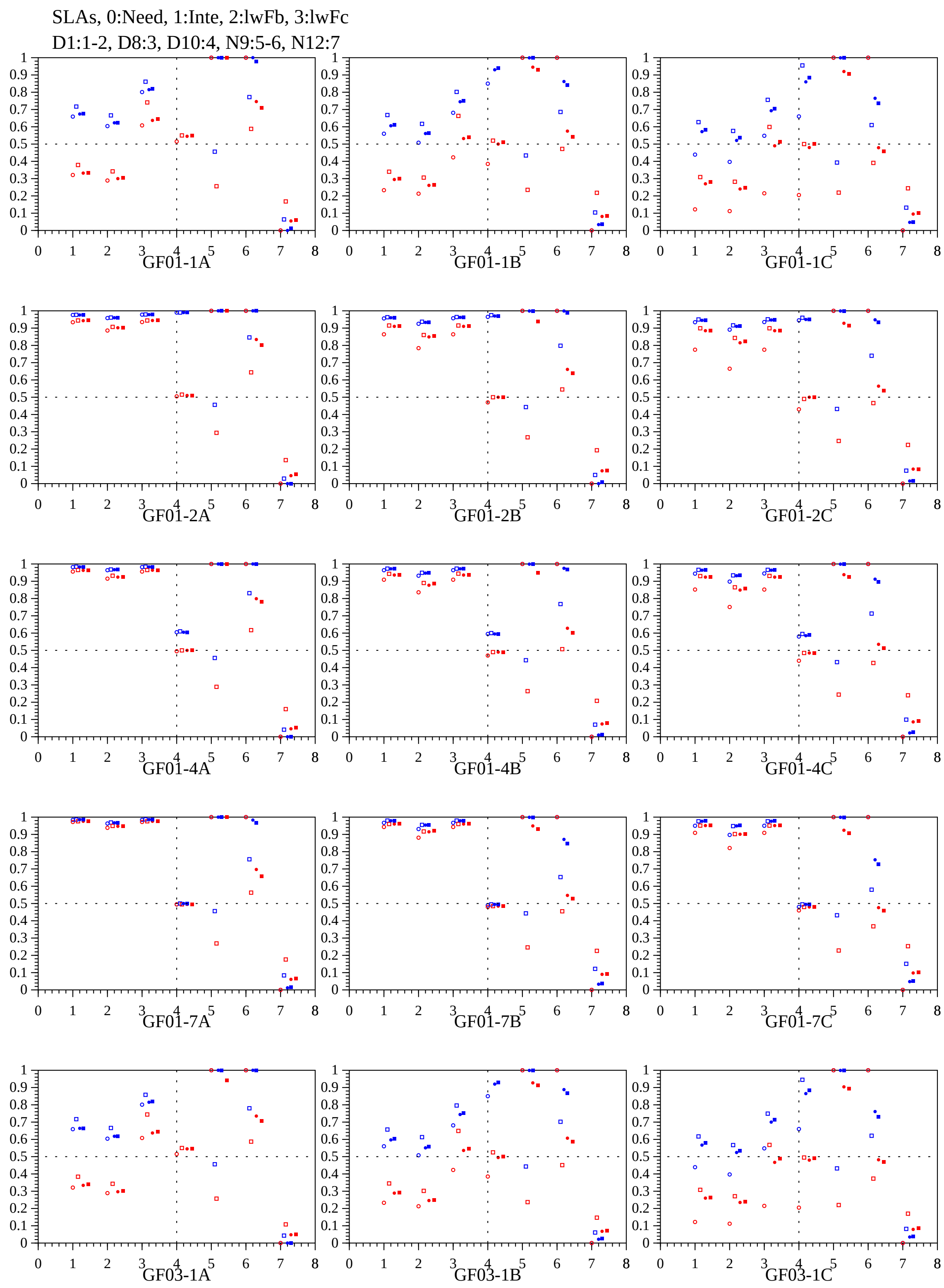

Figure 1: Performance of the different SLAs relative to Need and Inte over trials GF01-1A to GF03-1C, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

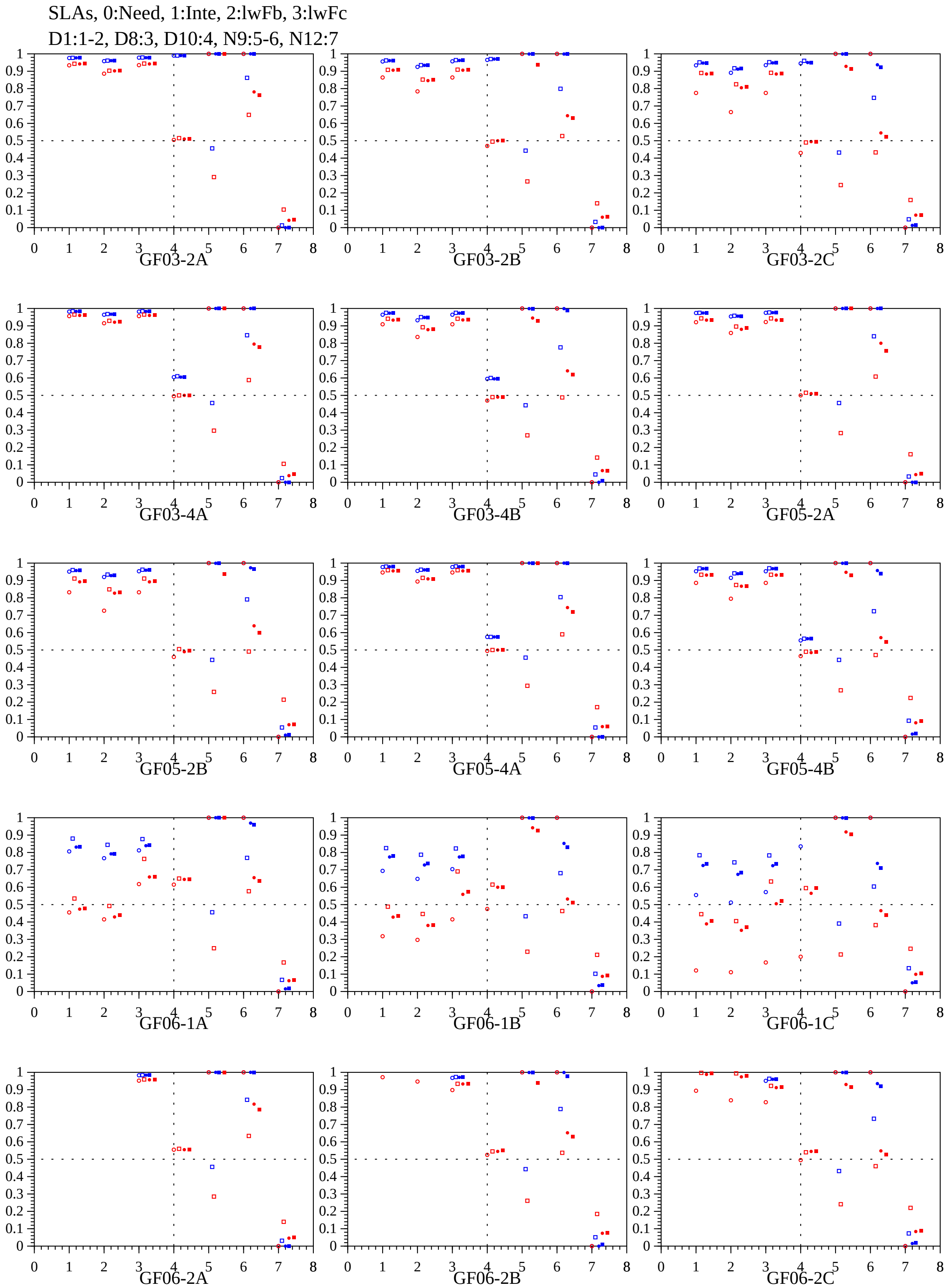

Figure 2: Performance of the different SLAs relative to Need and Inte over trials GF03-2A to GF06-2C, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

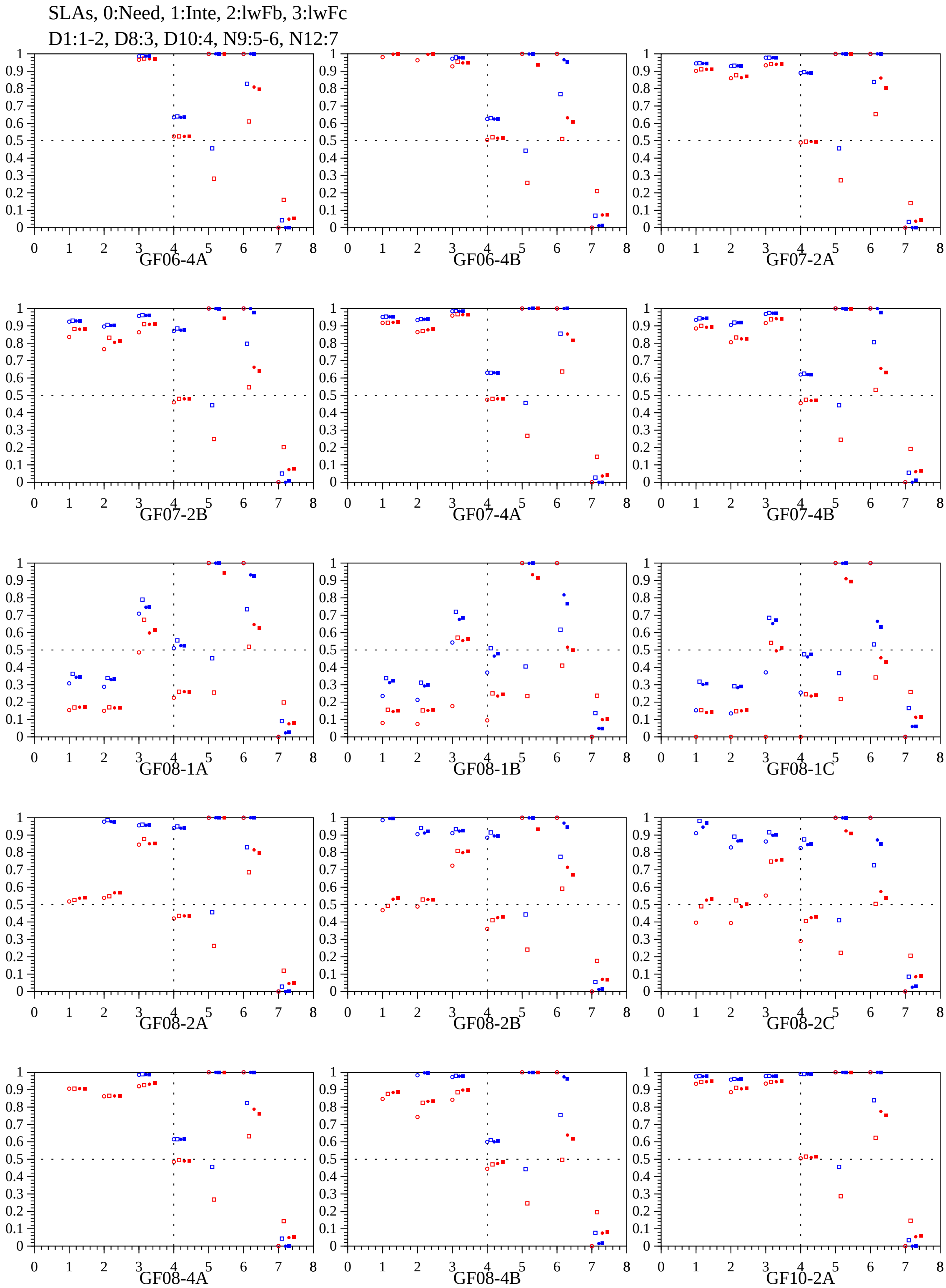

Figure 3: Performance of the different SLAs relative to Need and Inte over trials GF06-4A to GF10-2A, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

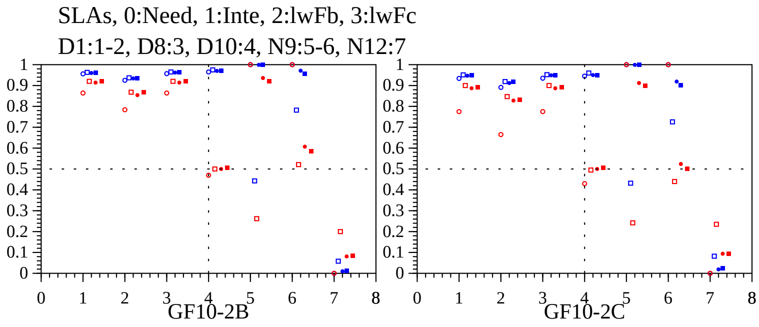

Figure 4: Performance of the different SLAs relative to Need and Inte over trials GF10-2B to GF10-2C, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).