West Greenland humpback whale candidate SLA

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ABSTRACT
I develop a data based SLA candidate for the hunt of humpback whales in West Greenland. The procedure has no internal population model, it provides full need satisfaction on all selected evaluation trials, making sure that the population at the end of the hundred year simulation period is larger than at the beginning of the period for the 5th percentile across all evaluation trials.

INTRODUCTION

I extend on the work in Witting 2013 to produce a simple data based SLA for humpback whales in West Greenland. The proposed SLA has no internal population dynamic model, so the calculation is relatively simple and easy to understand. As long as this provides acceptable conservation performance and high need satisfaction there seems to be no real reason to extend to larger and more complicated model based procedures.

The procedure was developed from performance on nearly all the evaluation and robustness trials, with some of the easier trials excluded. These are need scenario A for base case trials (GH01), the five year survey interval trials (GH02), and all 5% msyr trials except for the base case.

The procedure had to pass the conservation criterion that the 5th percentile of the D10 statistics of relative increase (P_T/P_0) was larger than one on all the selected evaluation trials, i.e., the population at the end of the hundred year simulation period needed to be larger than at the beginning of the period for the 5th percentile.

SLA DESCRIPTION

With τ being the year of a strike limit calculation, the SLA candidate makes 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

Name	r	p	γ	n_u	n_l	s_u
p0r1.6	0.016	0	0.8	1200	600	6
p1r2.2	0.022	1	0.8	1200	600	6
p2r3	0.03	2	0.8	1200	600	6
p3r4	0.04	3	0.8	1200	600	6
p2r2	0.02	2	0.8	1200	600	6
p2r4	0.04	2	0.8	1200	600	6

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

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

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

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

The strike limit S_τ is then calculated as

$$\tilde{S}_\tau = r N_\tau e^{-p\, cv_\tau} \tag{5}$$

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

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

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

This method is quite similar to that proposed last year, except that it is now formulated as a model with parameters (r, p, γ, n_u, n_l, s_u) that have to be specified.

	Need	Inte	p0r1.6	p1r2.2	p2r3	p3r4	p2r2	p2r4
50%	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5%	1.000	0.899	0.991	0.992	0.993	0.991	0.939	1.000

Table 2: Need satisfaction (N9) of SLA candidates that passed the conservation criterion for the selected trials. N9 is given as the median (50%), and 5th percentile (5%), of the average between the 20 and 100 year period across the selected trials.

SELECTION

The tested SLAs are listed in Table 1. My starting point was my recommended SLA from last year, with parameters $r = 0.03$, $p = 1.96$, $\gamma = 0.80$, $n_u = 1200$, $n_l = 600$, and $n_u = 6$.

First I tested the trade-off space between r and p, under the condition of a similar strike limit given the same abundance estimate (N_τ) with a $cv_\tau = 0.3$. In the proximity of this space I tested the following four procedures: *i*) p0r1.6 with $r = 0.016$ and $p = 0$, *ii*) p1r2.2 with $r = 0.022$ and $p = 1$, *iii*) p2r3 with $r = 0.03$ and $p = 2$, and *iv*) p3r4 with $r = 0.04$ and $p = 3$. As expected they performed almost identical, as shown in Table 2 and Figures 1 to 3. Statistics for the interim procedure (Inte) and strike equals to need (Need) are also shown.

I then proceeded with p2r3, testing the same model with a lower (p2r2 with $r = 0.02$) and higher (p2r4 with $r = 0.04$) production level. All the procedures passed the conservation criterion and, as expected, need satisfaction increased with an increased r (Table 2, and Figures 4 to 6). With the need satisfaction statistics N9 for p2r4 being practically one across all evaluation trials, I propose this procedure as a candidate.

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.

Witting, L. 2013. Candidate SLAs for West Greenland humpback whales. *IWC/SC/65a/AWMP04. Available from the International Whaling Commission (http://www.iwcoffice.org/)* .

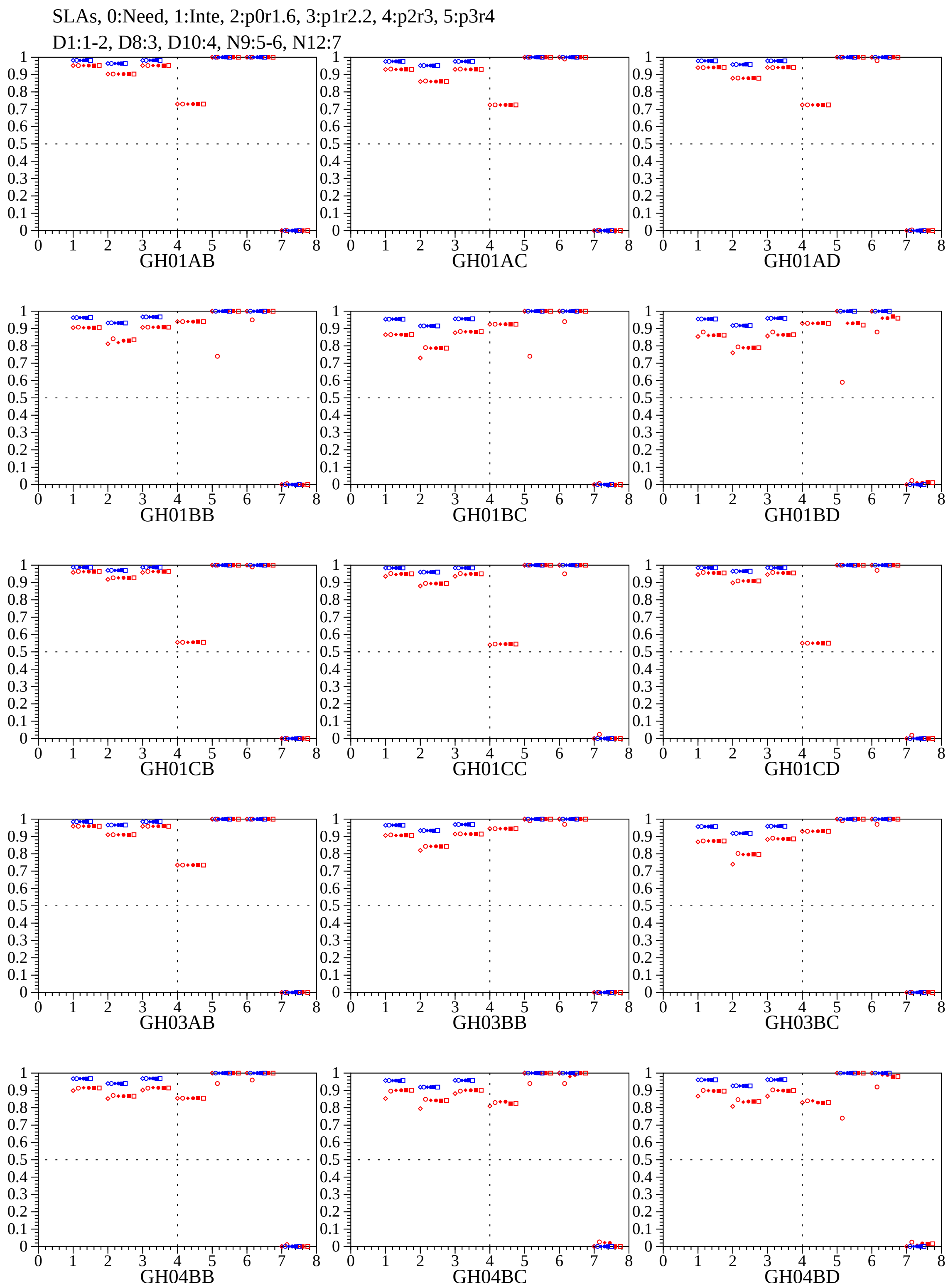

Figure 1: Performance of p0r1.6, p1r2.2, p2r3 and p3r4 (relative to Need and Inte) over trials GH01AB to GH04BD, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

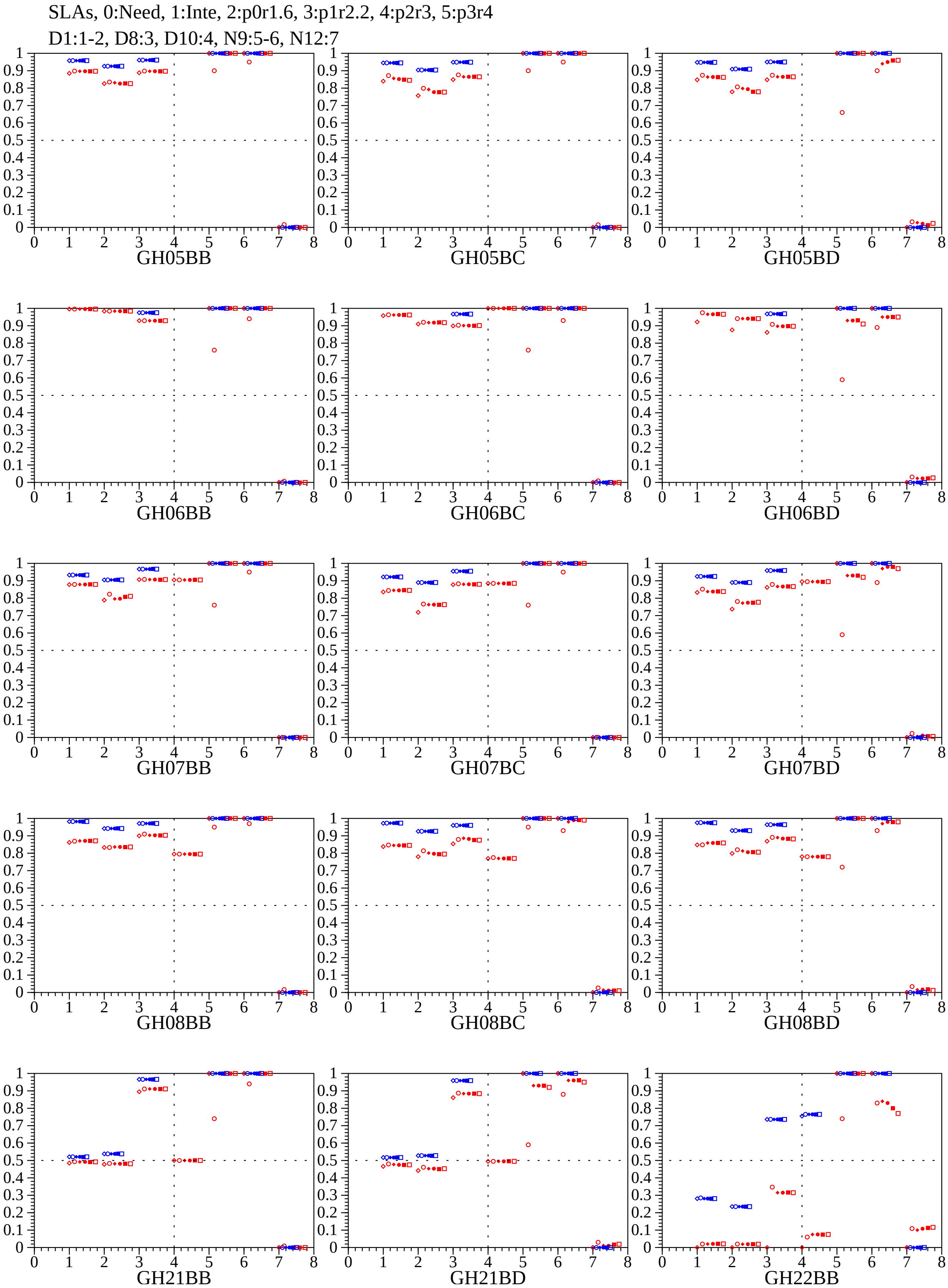

Figure 2: Performance of p0r1.6, p1r2.2, p2r3 and p3r4 (relative to Need and Inte) over trials GH05BB to GH22BB, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

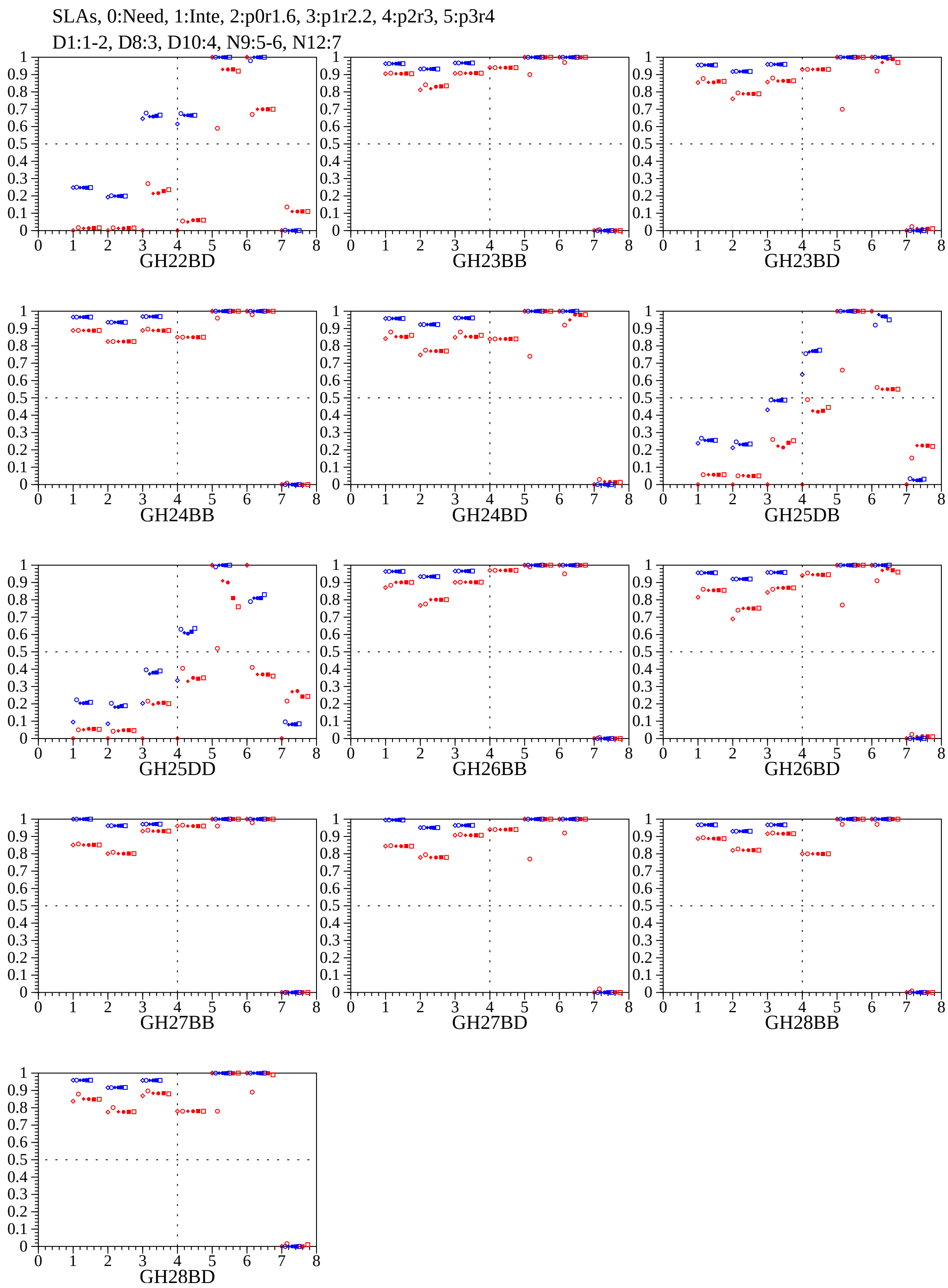

Figure 3: Performance of p0r1.6, p1r2.2, p2r3 and p3r4 (relative to Need and Inte) over trials GH22BD to GH28BD, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

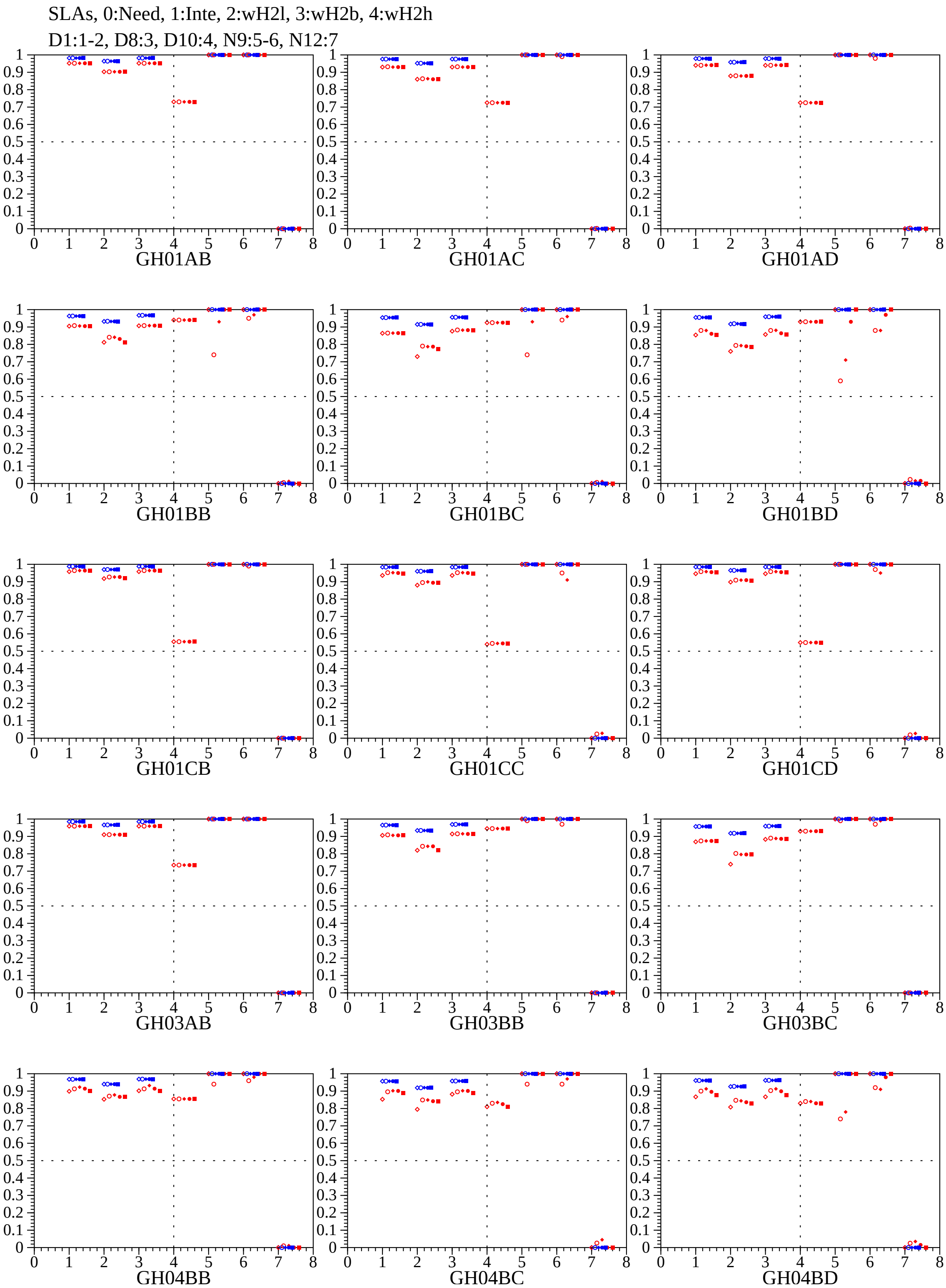

Figure 4: Performance of wH2l, wH2b and wH2h (relative to Need and Inte) over trials GH01AB to GH04BD, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

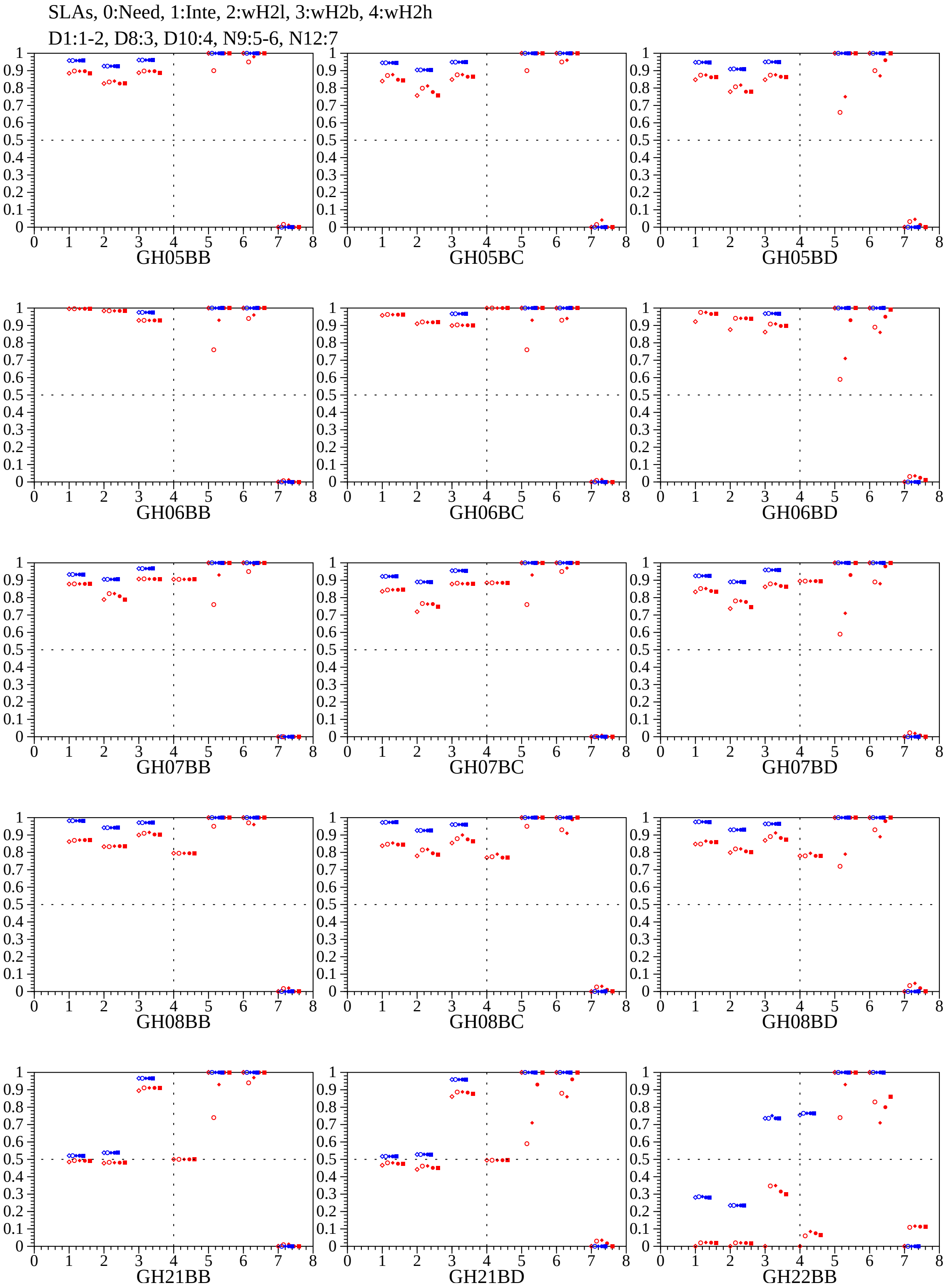

Figure 5: Performance of wH2l, wH2b and wH2h (relative to Need and Inte) over trials GH05BB to GH22BB, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).

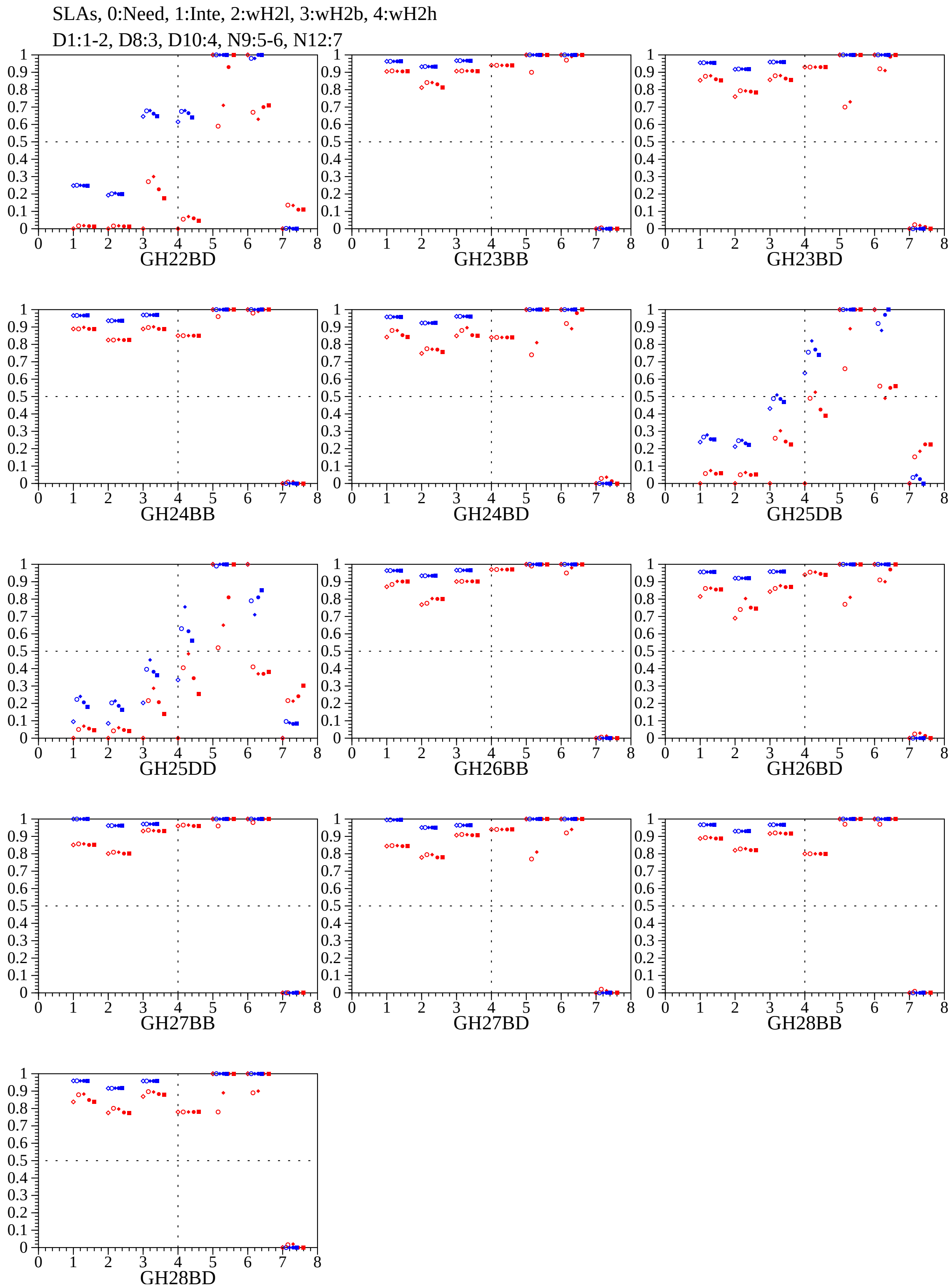

Figure 6: Performance of wH2l, wH2b and wH2h (relative to Need and Inte) over trials GH22BD to GH28BD, with blue showing the median and red the 5th percentile of different statistics ($D10$ is rescaled as $D10/2$, and red gives the 95% percentile for $N12$).