Guyana/Suriname Seabob Stock Assessment: HCR Summary

Paul A H Medley
paulahmedley@yahoo.co.uk
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Harvest Control Rule

The following harvest control rule was tested using projections based on the MCMC parameters draws for the stock assessment model. 500 MCMC draws were used and each projection applied the designated HCR over 10 years. The HCR was defined as follows (Figure 1):

1. The HCR index is calculated as a moving average of the catch rate each month so:

$$I_t = m\frac{C_t}{f_t} + (1-m)I_{t-1}$$

   where I_t = HCR index in month t, C_t = monthly catch associated with effort f_t, m = moving average parameter.

2. The maximum fishing effort of $\boldsymbol{X}$ trips/days-at-sea are set for each quarter (Jan-Mar, Apr-Jun, Jul-Sep, Oct-Nov). Vessels may use that fishing effort as they see fit during the quarter, but the maximum effort must not be exceeded in any quarter. $\mathrm{X} = 3*\boldsymbol{f_{max}}$ which is the monthly effort set at a value consistent with MSY.
3. If I_t falls below the trigger reference point I_{trig} but above I_{lim}, the monthly effort in the second month after the index has fallen will be limited according to the following:

$$f_{t+2} = f_{max}\frac{I_t - I_{lim}}{I_{trig} - I_{lim}}$$

4. If I_t falls below the limit reference point I_{lim}, the effort in the second month after the index has fallen will be limited according to the following:

$$f_{t+2} = f_{min}$$

5. The rule will apply strictly on a monthly basis when $I_t < I_{lim}$ and vessels will not be able to carry over unused effort to the following month.
6. If no effort is applied, then a "natural" recovery rate will be applied to the HCR index of R%:

$$I_{t+1} = I_t\left(1 + {}^{R}/_{100}\right)$$

   and the resulting index used in the HCR rule above.

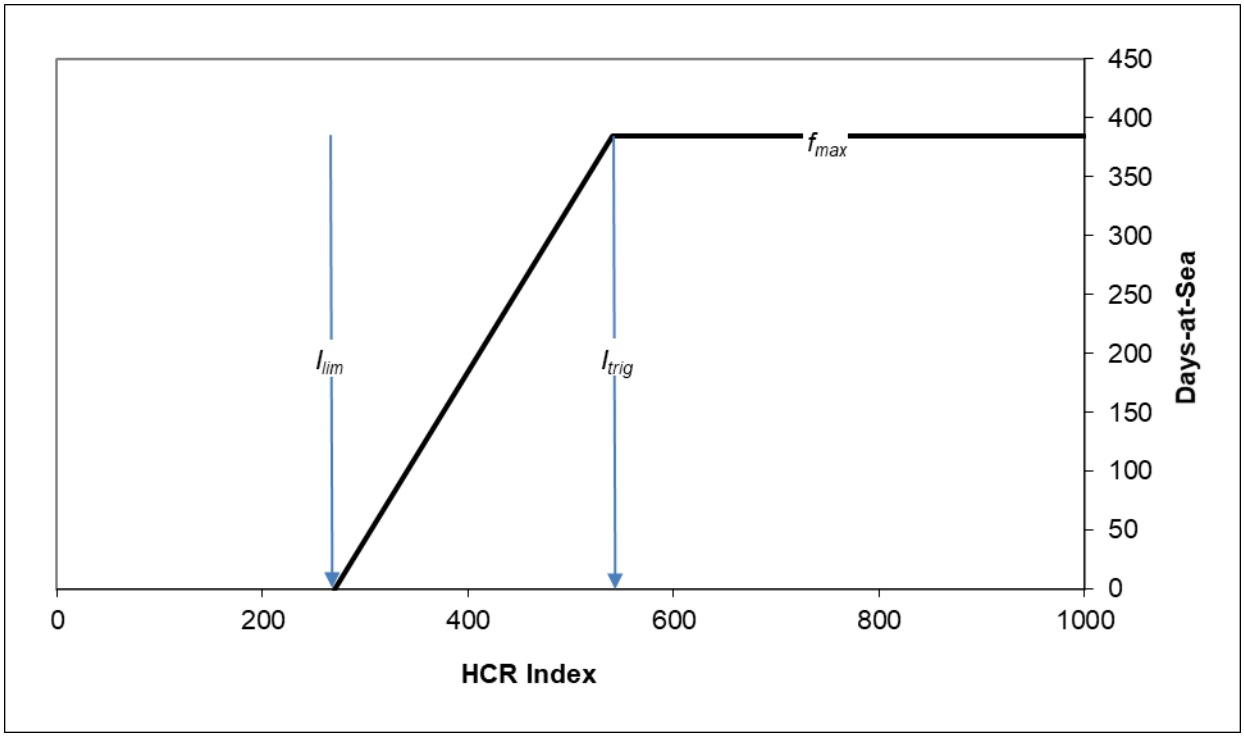

Figure 1 Diagram illustrating HCR with parameters: I_{trig} = HCR Index trigger point below which there is a reduction in the exploitation rate, I_{lim} = HCR Index limit below which effort is minimised and f_{max} = the maximum average effort spent each month, equivalent to the MSY exploitation level.

The reference points used in the default projection were based on MSY rather than the estimated status quo effort levels. For Suriname, this represented a 16% reduction in fishing effort and for Guyana a 20% increase in effort (Table 1). Other parameters were based on evaluations of the behaviour of the harvest control rule made using the available data (Table 2). The HCR appears to be robust to choices, so reasonable values were chosen consistent with the findings.

Table 1 Possible reference points for the harvest control rule.

		Suriname		Guyana	
RP	**Type**	**MSY**	**Status Quo**	**MSY**	**Status Quo**
Limit	**Control**	0.000	0.000	0.000	0.000
Limit	**Index**	428.857	428.857	142.211	142.211
Trigger	**Control**	287.229	343.238	2245.940	1872.034
Trigger	**Index**	686.171	686.171	227.538	227.538
Target	**Control**	287.229	343.238	2245.940	1872.034
Target	**Index**	857.714	857.714	284.423	284.423

Table 2 Default HCR general parameters

HCR Parameter	Value
f_{max}	f_{MSY}
f_{min}	0
ma	0.75
R	15%
I_{trig}	0.8 I_{MSY}
I_{lim}	0.5 I_{MSY}

Based on the stock assessment and HCR parameters for the HCR described above, the results for both fisheries indicate that the its performance is reasonable with low probability (<5%) of the stock being below 50% SSB_{MSY}. Catches are measured here as a relative loss of opportunity, so for Suriname around 14% of months catches are less than 50% of the MSY level compared to 8% for Guyana.

As part of the HCR performance is how often it makes mistakes. Type I errors occur when the HCR should reduce effort but doesn't (stock is overfished but his is not detected) and Type II errors are where the HCR reduces effort when it shouldn't (stock is not overfished but index says it is). Type I errors are generally considered worse. The HCR performance in both fisheries is good in this respect (Table 4) with <2% probability that there will be no reduction in fishing effort despite a reduction in effort being advised because the stock has fallen below the limit reference point. Note that this would include errors of delay, for example the stock falls just below 50% MSY, but the index only moves below the trigger point a month later.

It should be emphasized that these are model based estimates consistent with the data, but there will still be significantly more uncertainty in the real fishery.

Table 3 Default HCR performance using MSY reference points in MCMC stock projections compared to MSY reference points. The performance is measured as the proportion of projected months with values relative to MSY target levels. For example, 0.026 (2.6%) of projected months were below 50% of SSB_{MSY}. (SSB = spawning stock biomass, B = total biomass, exB = exploitable biomass (selectivity*biomass), C = catch, F = fishing mortality, Index = HCR index calculated as above).

Suriname

Breaks	SSB_{MSY}	B_{MSY}	exB_{MSY}	C_{MSY}	F_{MSY}	$Index_{MSY}$
0.0- 0.5	0.026	0.023	0.298	0.142	0.104	0.021
0.5- 0.8	0.333	0.295	0.429	0.279	0.245	0.339
0.8- 1.0	0.265	0.263	0.143	0.180	0.177	0.269
1.0- 1.2	0.173	0.186	0.069	0.138	0.146	0.170
>1.2	0.203	0.233	0.062	0.261	0.327	0.201

Guyana

Breaks	SSB_{MSY}	B_{MSY}	exB_{MSY}	C_{MSY}	F_{MSY}	$Index_{MSY}$
0.0- 0.5	0.001	0.002	0.000	0.084	0.043	0.000
0.5- 0.8	0.195	0.177	0.182	0.272	0.266	0.166
0.8- 1.0	0.310	0.305	0.323	0.186	0.262	0.334
1.0- 1.2	0.234	0.248	0.240	0.158	0.210	0.244
>1.2	0.259	0.269	0.255	0.301	0.219	0.256

Table 4 Risk decision table based on default HCR projections, with decision based on index (I_t) and state of nature (SSB relative to limit, trigger or target). Type I errors are red, Type II errors are blue.

	Suriname			Guyana		
Response	**B<Limit**	**B<Trigger**	**B=Target**	**B<Limit**	**B<Trigger**	**B=Target**
I_t<Limit	0.000	0.000	**0.000**	0.000	0.000	**0.000**
I_t<Trigger	0.013	0.052	**0.006**	0.000	0.056	**0.005**
I_t=Target	**0.008**	**0.218**	0.703	**0.015**	**0.073**	0.851

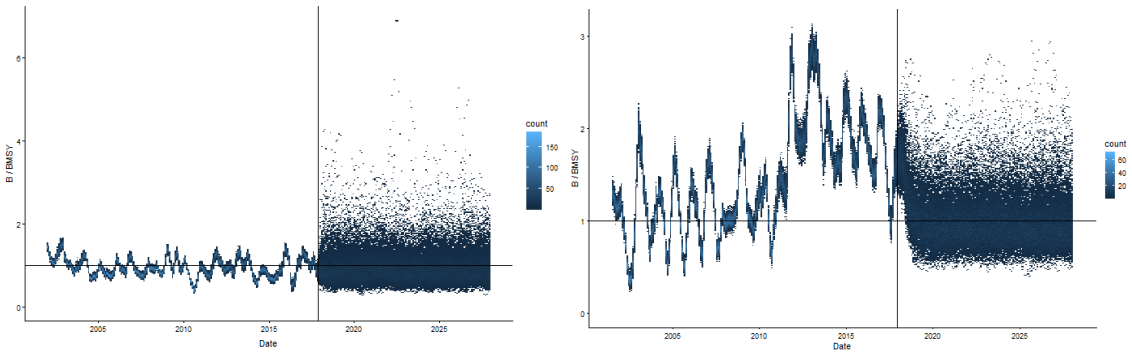

Figure 2 Stock status for Suriname (left) and Guyana (right) based on MCMC results and default HCR projections after the vertical line.

Recommendations

The stock assessment model and HCR are heavily dependent on measures of fishing effort. New data are available from VMS to evaluate this. This evaluation should be carried out with a matter of urgency.

An important part of the assessment is estimation of selectivity and catchability. More information on selectivity and catchability would be useful to better determine how to represent changes in the time series. Although flexible, the cubic spline currently used is inherently unstable. Preliminary attempts to change selectivity failed to obtain a fit, suggesting that parameters will be difficult to estimate if selectvity is modelled in this form. Although there may be some justification for changing selectivity with a changing inner line and introduction of BRD, it is not strongly supported by residual patterns. This would need more time and resources to explore properly.