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Harvest control rule for Jack mackerel rebuilding: a preliminary evaluation

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Harvest Control Rule for jack mackerel rebuilding: a preliminary evaluation

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Summary

The performance of the harvest control rule (HCR1) adopted by the Commission of SPRFMO in 2014 is analized. This HCR was compared against two alternatives: a regime of constant fishing mortality (HCR2: F_{msy}) and a ramp-type model (HCR3) to control the fishing mortality when SSB_{msy}<80%.

The analysis showed that the HCR proposed by the Commission has a higher probability to rebuild the jack mackerel population, but generates the highest variability in annual catches. It was estimated that the average rebuilding period is around 7 years and the long-term catches could range around 800 thousands ton/year.

It is considered essential, along with an analysis of the HCR's, a definition of the base case in the stock asessment, as well the fishing mortality and spawning biomass that will be considered as references to assess the rebuilding plan of the jack mackerel population.

1. Introduction

Based on the work presented by Chile (SC-1.5) at the1st meeting of the Scientific Committee of the SPFRMO, and the proposal submitted by the European Union during the 2nd plenary session of the SPRFMO Commission in Manta, Ecuador (27-31 January 2014), a harvest control rule for jack mackerel was adopted. This harvest rule must be reviewed at the 2nd meeting of the Scientific Committee of the SPRFMO. This rule is based on the catches' control rather than on the fishing mortality, and has as reference 80% of the spawning biomass at MSY. Details of the rule are given in Annex K of the report of the 2nd Meeting of the Commission (http://www.southpacificrfmo.org/2nd-commission-meeting/). In this paper, the performance of this control rule is compared with two alternative rules based in constant fishing mortality rate (F_{msy}), and a ramp-type (sloping rule) regime with pivot defined at 80% of B_{msy}

2. Methodology

In order to evaluate the performance of the HCR proposed, the future population trajectory of jack mackerel is evaluated considering the model 7c updated to 2013 as a starting condition. The analysis considers the assumption that the selectivity in 2013 will represent the situation in the short and medium term.

The uncertainty source was represented only by recruitment as a stochastic variable, which in logarithmic scale is normally distributed with mean equal to the average of the last 10 years and coefficient of variation σ_R = 0.6. This situation was assumed since the recruitments are the main uncertainty source in the projection. The performance of this rule was evaluated against two alternative harvest strategies: a) constant fishing mortality where F = F_{msy} and b) ramp-type (sloping rule) where the maximum fishing mortality F_{msy} decreases by a factor SSB/SSB_{msy} when this rate is less than 0.8. Details of these rules are given in Table 1.

Table1. Details of three alternative harvest rules for jack mackerel

<table>
<tr><th>B/Bmsy</th><th>Stage</th><th>HCR 1</th><th>HCR 2</th><th>HCR 3</th></tr>
<tr><td><0.8</td><td>1</td><td>Cprop=min{Ccurr, Cmsy}
ifCprop<Crp; F= Fprop
else F= Frp</td><td rowspan="3">F=Fmsy</td><td>F=Fmsy*B/Bmsy</td></tr>
<tr><td>0.8 – 1.0</td><td>2</td><td>ifCmsy<Crp; F= Fmsy
else F= Frp</td><td rowspan="2">F=Fmsy</td></tr>
<tr><td>>1.0</td><td>3</td><td>F=Fmsy</td></tr>
</table>

Ccurr: Current catch
Cmsy: Catch at Fmsy
Crp: Catch at Frp
Cprop: Minimum catch between Ccurr and Cmsy
Fcurr: Current fishing mortality
Frp: Replacement fishing mortality (to maintain the level stock)
Fprop: Proposal of fishing mortality as the minimum value between Fcurr and Fmsy

The simulation model was implemented in SCILAB and the population was projected 20 years forward under each HCR. The variables associated with the MSY were calculated from an equilibrium analysis considering a steepness h = 0.67, a value which was estimated at the 2th International Workshop on PBR, held in Chile in April 2014. The virginal biomass per recruit was estimated in 1.21 kg while the projected recruitments corresponded to the average of the last 10 years.

Table 2. Main Biological Reference Points for Jack mackerel

F_{msy}(1)	SSB_{msy} (000' tons)	SSB_{msy}/SSBo
0.25	5,941	0.36

(1) F fully recruited

For each HCR 200 simulations were considered and the performance variables were: ratio between projected spawning biomass SSB vs SSB at 2013; probability to reduce the spawning biomass below 80% of SSB_{msy}; Mean catches; coefficient of variation of the catches; probability to be between 80% and 100% of SSB_{msy}; number of years to rebuild the population at 80%-100% SSB_{msy}; and coefficient of variation of rebuilding years.

3. Results

The main simulated population variables are shown for each HCR in Fig. 1, 2 and 3, and an idea of spread error indicates that after 10 years, the uncertainty does not depend on the starting condition, so it is advisable to consider the performance indicators in the long term. Also, in these figures the exploitation diagrams for each HCR are represented. It is pointed out that HCR1 has the higher variability in fishing mortality in response to the different stages of this rule, and consequently, this regime has the higher variability in catches.

Performance variables indicate that in general, HCR1 has the lowest risk of maintaining the population below 80% SSB_{msy} at the medium and long term, and high expectations to achieve full recovery of jack mackerel (SSB / SSB_{msy} close to one). On the other hand, HCR2 showed the higher risk to maintain $SSB/SSB_{msy}<0.8$ (p=0.43), followed by HCR3 (p=0.19). As it was mentioned before, HCR1 has the highest variability in catches in the long term (cv = 32%). Nevertheless, its median catches do not seem to be different from those of the other harvest rules. In the long term, landings could reach around 800 thousand tons by year (Table 3).

Similarly, HCR1 has the maximum probability (p= 0.5) to carry population at levels between 80% - 100% of SSB_{msy} (Table 3) and the rebuilding period was 7 years with 32% variability. HCR2 and HCR3 show rebuilding periods similar to HCR1 (6-8 yrs), but the coefficient of variation increased to 40%.

4. Conclusions

The performance of the harvest control rule (HCR) endorsed by the Commission of the SPRFMO was evaluated. This HCR was assessed against two alternatives which correspond to a regime of constant fishing mortality (HCR2: F_{msy}) and a ramp- type model (HCR3) to control the fishing mortality when SSB_{msy} is below 80%.

The analysis showed that in the long-term, the HCR endorsed by the Commission would have a better chance to rebuild the population in around 7 years; nonetheless, this estrategy generates the highest variability in annual catches. HCR2 (constant F_{msy}) produced the lowest variability in catches, but the highest risk of maintaining an undesired condition ($SSB/SSB_{msy}<0.8$).

Similarly, it is concluded that the performance of any HCR will depend on the level of biomass considered as reference, which was preliminarily estimated at SSB_{msy} = 5 million tons (SC1-SPRFMO). In this work, this value was re-estimated at 5.9 million tons since another model version was used.

It is considered essential, along with an analysis of the HCR's, a definition of the base case in the stock assessment as well the fishing mortality and spawning biomass values that will be considered as references to assess the rebuilding plan of the jack mackerel population.

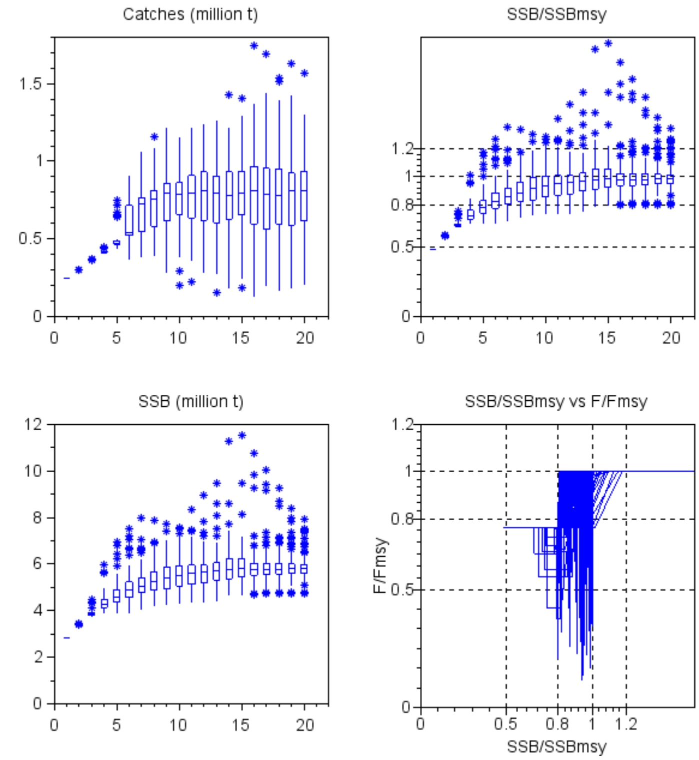

Figure 1. Boxplot of simulated catches, projected biomass, and exploitation diagram of Jack mackerel. HCR1.

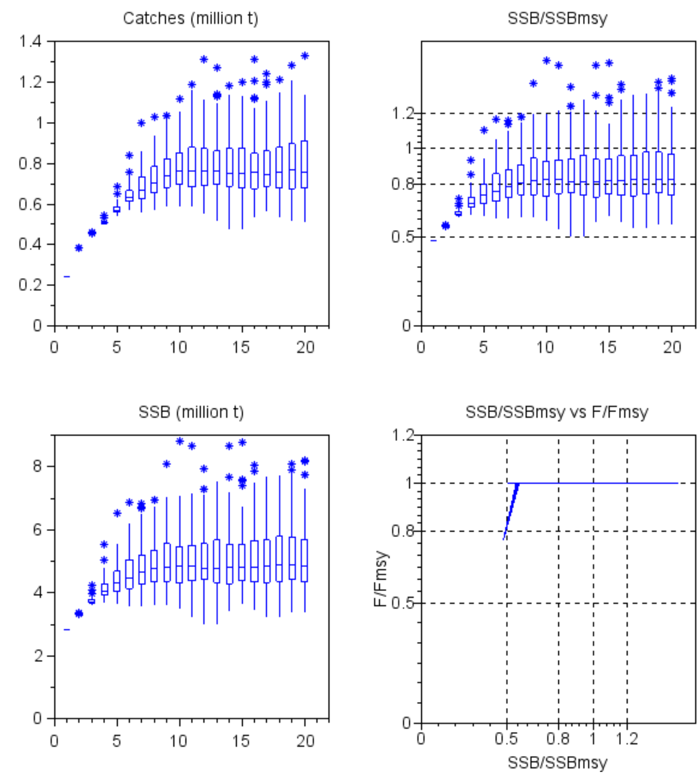

Figure 2. Boxplot of simulated catches, projected biomass, and exploitation diagram of Jack mackerel.HCR2

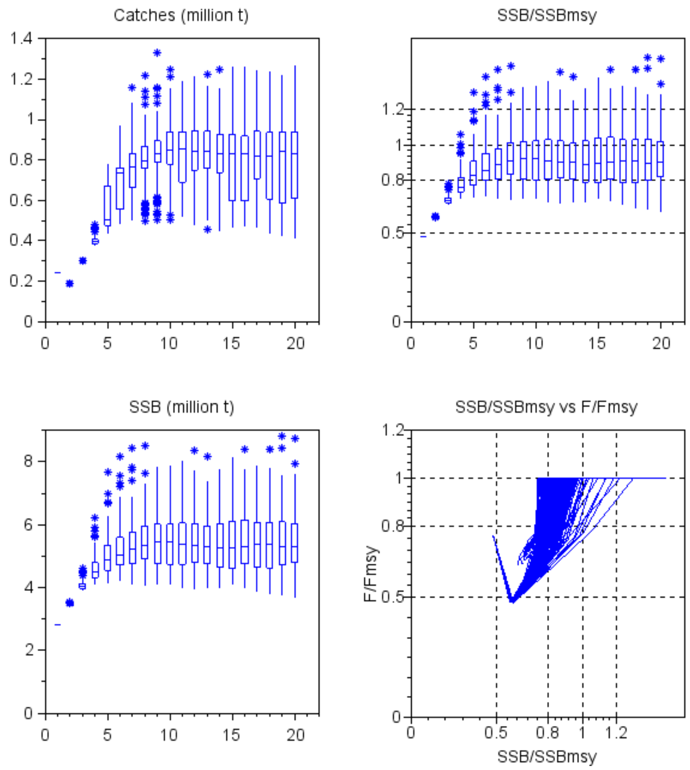

Figure 3. Boxplot of simulated catches, projected biomass, and exploitation diagram of Jack mackerel HCR3

Table 3. Performance of three Harvest Control Rules for jack mackerel. HCR1 corresponds to the rule adopted by the Commission of the SPFRMO in 2014. HCR2 considers a constant F_{msy}, and HCR3 considers a ramp-type strategy.

Variable	time	HCR 1	HCR 2	HCR 3
SSB/SSBmsy	5 yrs	0.830	0.760	0.850
	10 yrs	0.950	0.820	0.910
	20 yrs	0.990	0.830	0.900
p(SSB/SSBmsy<0.8)	5 yrs	0.330	0.630	0.250
	10 yrs	0.050	0.390	0.230
	20 yrs	0.000	0.430	0.190
Catches (000' tons)	5 yrs	537	634	735
	10 yrs	799	762	856
	20 yrs	810	760	831
CV(Catches)	5 yrs	0.190	0.070	0.170
	10 yrs	0.250	0.160	0.210
	20 yrs	0.320	0.200	0.240
p(0.8<SSB/SSBmsy<1.0)		0.500	0.250	0.350
Yrs of rebuilding (avg)		7.000	8.000	6.000
CV(yrs of rebuilding)		0.320	0.400	0.400

5. References

SPRFMO, 2014. Proposed Jack mackerel rebuilding plan. Annex K. Meeting Report. 2th Commission Meeting of the South Pacific Regional Fisheries Management Organisation. Manta, Ecuador 27 - 31 January 2014: 2 pp.