WCPFC
SECOND MANAGEMENT OBJECTIVES WORKSHOP

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MANAGEMENT STRATEGIES (OBJECTIVES, INDICATORS, REFERENCE POINTS AND HARVEST CONTROL RULES): THE EQUATORIAL SKIPJACK PURSE SEINE FISHERY AS AN EXAMPLE

SPC-OFP

MOW WP3: *Management strategies (objectives, indicators, reference points and harvest control rules): the equatorial skipjack purse seine fishery as an example*

Overview

In conjunction with target and limit reference points, harvest control rules form a critical part of a management strategy.

A harvest control rule defines a "pre-agreed management action that should be taken when the stock and/or fishery are at different positions relative to the limit and target reference points". Simply stated they can be defined as "some rules for managing the fishery so that we stay away from the limit reference points and keep the stock and fishery near the target level which should result in us meeting our management objectives".

The purpose of this paper is to provide a worked <u>example</u> of how fisheries management relative to limit and target reference points can be put into practice through a harvest control rule. We use the tropical purse seine fishery for skipjack as an <u>example</u>, taking the WCPFC adopted limit reference point, and an <u>arbitrary</u> target reference point of 50% of the unfished biomass level, to examine the performance of two <u>simple</u> harvest control rules. We use these harvest control rules to illustrate the <u>concepts</u> of 'trade-offs' and 'robustness', which are critical to developing management strategies.

The paper aims to stimulate discussion on a range of matters including trade-offs between maximizing catches and minimizing catch variability; what features would be important in harvest control rules for skipjack tuna; how we might design rules for yellowfin and bigeye tuna which involve major gear interactions; and how harvest control rules could assist decision making processes in the WCPFC.

Approach

Management strategy evaluations provide a way to guide developing measures that best meet management objectives. For example, a strategy that specifies allowable harvest levels according to some simple rules (such as CPUE trends) can help ensure that performance indicators (such as risks of exceeding limit reference points) are satisfied. Such a harvest control-rule (HCR) might respond by reducing catch as the population (or index) declines and increase catches as the index improves. In essence, a harvest control rule is part of a management strategy as evaluated and tested against hypotheses on population and fishing conditions. Management actions are evaluated relative to performance indicators such as stock status and other economic or environmental conditions, relative to agreed reference points (see SC8-MI-WP-03 for more details).

In this example we focussed on skipjack tuna and the equatorial purse seine fishery in particular. The general steps taken in this analysis were to:

   i. Specify limit (already agreed by WCPFC) and target (arbitrarily set at 50% of the unfished biomass level) reference points;

   ii. Construct two HCRs for setting total equatorial purse seine effort in response to the estimated stock status from the stock assessment model. The rules (see Figure 1) had the following properties:
      o they were both tuned so that when tested with projections (details below) both rules resulted in the biomass at the end of the projection period being equally distributed above and below the target reference point;

o both HCRs reduced effort to a low level when the limit reference point was reached – this low level might reflect effort outside of the 'management strategy', e.g. purse seine effort in archipelagic waters; and

o they differed in terms of effort levels allowed during good stock conditions, i.e. one allowed for higher effort at higher stock size, but reduced effort faster when the stock declined, while the other had lower effort at high stock sizes, but responded more slowly to stock declines.

iii. The 2011 skipjack assessment (including some updated model features) was used as the operating model for the analysis and 200 projections were undertaken for each harvest control rule. Each projection was run for 30 years and included a different set of future recruitment levels (i.e. randomly drawn recruitment deviates). The application of the harvest control rules involved the following steps:

1. Project the population forward three years at current (2010-2012) effort levels;
2. Calculate stock status – as it is a projection the stock status is the 'true' stock status;
3. Add random error to the stock status estimate (we assumed a CV of 0.2) to reflect the uncertainty that is inherent in stock assessments to get our 'observed' stock status;
4. Take this 'observed' stock status and determine fishing effort for the next three years based on the harvest control rule;
5. Project a further three years under that effort;
6. Repeat steps 2-5 to the end of the projection period
7. Repeat steps 1-6 for the 200 recruitment scenarios
8. Repeat steps 1-7 for each of the two harvest control rules.

iv. Simulation results from iii were compared for the HCRs using a set of common performance indicators[1]:

o stock status – did the rules keep the stock around the target reference point on average?

o mean catch value – taking into account both the volume of catch and the size of the fish (which relates to cannery price categories);

o expected changes to catch rates; and

o changes in effort – how much did the harvest control rules change effort every three years (important for effort, implementation feasibility, and catch stability)

v. Finally, we repeated the analysis in iii but changed the evaluation to test the robustness of the rules to two issues:

o increased uncertainty – we increased the random error on the stock status estimate to a CV of 0.3. This essentially examines how well the rules perform when the stock assessment is less certain; and

o effort creep – here we allowed for the efficiency of purse seine vessels to increase by 3% each management period (i.e. 1% per year) (an arbitrary value chosen for illustration) which could be driven by improved technology to locate fish or to catch more fish from

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[1] In a full evaluation a wider range of performance metrics would be compared, but for this exercise we kept the number small to keep the presentation simple. Examples of other performance metrics we could look at include predicted catches in various regions or fisheries, or changes in the mean sizes of fish or abundance of large fish.

each school, etc. In the analysis, the harvest control rule was still used to set the effort level, but the actual effort used in the model was increased to account for the effort creep (i.e., more effort was occurring than expected).

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Analysis:

One of the interesting features of the two rules considered was that there was a lag in the decline in effort when the stock dropped below the target level (Figure 1). Despite this behaviour both rules resulted in the stock being at the target reference point on average at the end of the projection (Figure 2, top left panel). This was a design feature in that the rules were 'tuned' to achieve the target reference point 'on average' at the end of the analysis. In this analysis, the limit reference point of 20% of the unfished stock size was never breached. Harvest control rules are a way to help ensure the stock remains near target and away from limit reference points.

While the performance with respect to the target reference point was similar between HCRs, the performance against the other performance metrics was quite different. Rule 1 (lower effort during good times) produced around 5% lower returns in terms of the value of the catch, but resulted in generally higher catch rates (therefore lower costs) than rule 2 (Figure 2).

The final performance metric related to the amount that effort changed each three years under each rule (Figure 2 and Table 1). For rule 1 the changes were very few and generally small, with less than 1% of the effort changes required by the harvest control rule exceeding 5,000 days and only 11% of the time was a change in effort required. For rule 2 the effort limit was changed far more frequently with effort changing 21% of the time and 5% of the time the change was greater than 5,000 days and 2% of the time that change was greater than 15,000 days. This could cause problems in terms of stability of the fleet and ability to manage the fishery. Also, the effort for rule 2 was often reduced in one time step only to be increased again in the next time step. With harvest control rules there is generally a trade off between maximising total catch and/or catch value and reducing the variability of catch.

When we added more uncertainty to the stock assessment results used to drive the rules, the performance against stock status and catch was only slightly worse than that under the tuned conditions (Figure 3), indicating that the rules were robust to this uncertainty. A more uncertain assessment did lead to more changes in effort, but the impact was much less for rule 1 that rule 2 (11 to 13% for rule one, but 21 to 29% for rule 2). However, the magnitude of some of the changes was much greater, with 1% of the changes from rule 1 exceeding 15,000 days, but this increased to 8% for rule 2 (Table 1). If your assessments are less certain then changes (which are generally disruptive to industry) are likely to be more frequent and larger. Harvest rules can be designed to avoid such large changes, but this often occurs at the expense of overall catches.

Neither rule was able to keep the stock around the target level in the presence of effort creep, but the rules did keep the biomass quite close (Figure 3). This was achieved through more frequent changes in effort (increasing from 11% of management periods requiring a change to 61% for rule one, and 21% to 57% for rule 2), though the magnitude of the changes were generally no larger than that during the tuned phase. A well-designed rule might be able to help address issues such as effort creep. The robustness of harvest control rules is important – it can sometimes be better to choose one that does okay and "doesn't break" when it is specified incorrectly compared to one that wrong, than one that only works when specifications are correct.

Suggested discussion points:

- Trading off objectives: How important is it to maximise catch and catch value versus ensuring more stability in the WCPFC tuna fisheries?

- Will the adoption of harvest control rules make decision making easier in the WCFPC?

- How might sustainability concerns over bigeye and yellowfin be incorporated into management strategies for skipjack? Will it involve specific harvest control rules?

- How might we be able to develop harvest control rules for bigeye and yellowfin given the multi-gear considerations?

Tables and Figures:

Table 1. Performance of the harvest control rules under tuned conditions and during robustness tests in terms of the frequency and magnitude of effort changes predicted by each harvest control rule. The effort levels represent absolute values, i.e. so increases and decreases are both included.

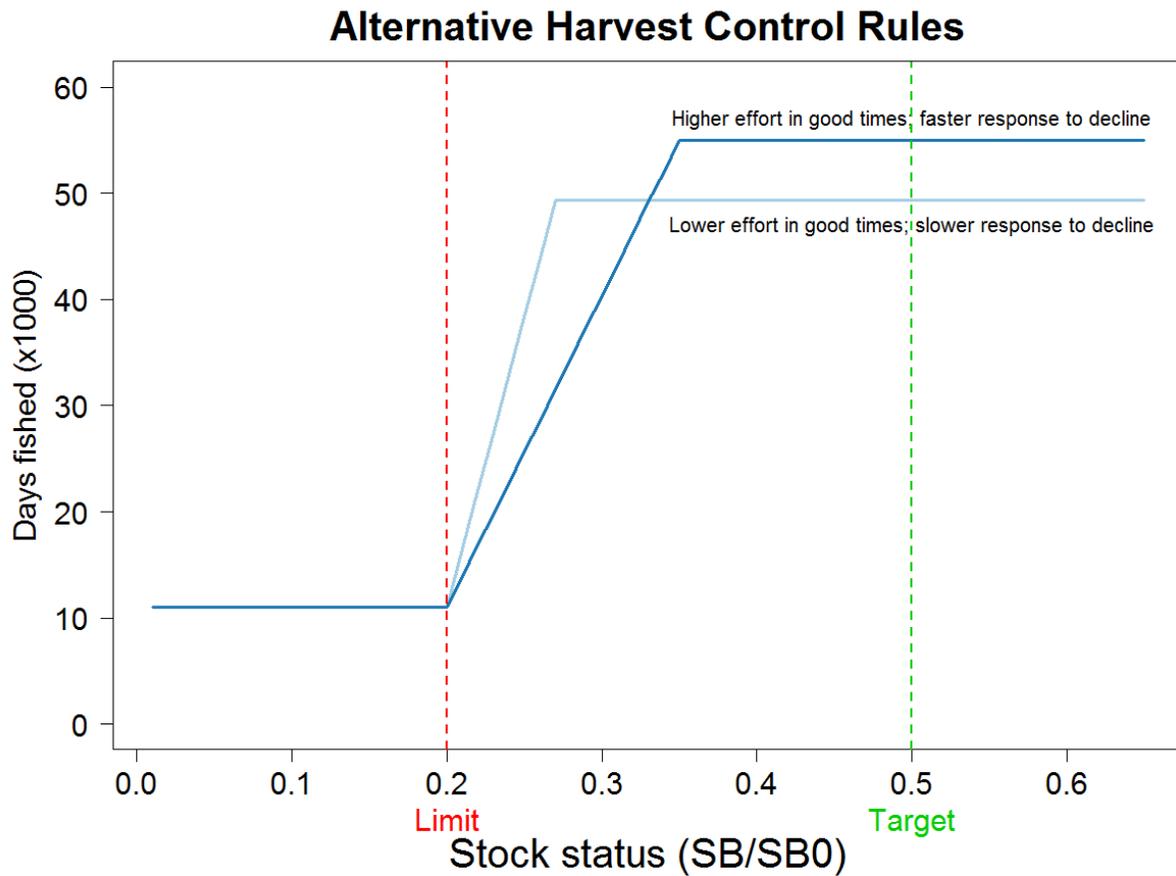| Effort change	Harvest control rule 1			Harvest control rule 2		
	Base	Uncertainty	Effort creep	Base	Uncertainty	Effort creep
Any change	11%	13%	61%	21%	29%	57%
> 5,000	1%	3%	1%	5%	16%	10%
>10,000	0%	2%	1%	3%	11%	6%
> 15,000	0%	1%	0%	2%	8%	3%

Figure 1. Two simple Harvest Control Rules (1 – light blue; 2 – dark blue) used in the example. Based on the outcome of the stock assessment, future fishing effort (days fished) is determined from the lines above. Both rules have been designed to keep the stock around the target reference point level on average.
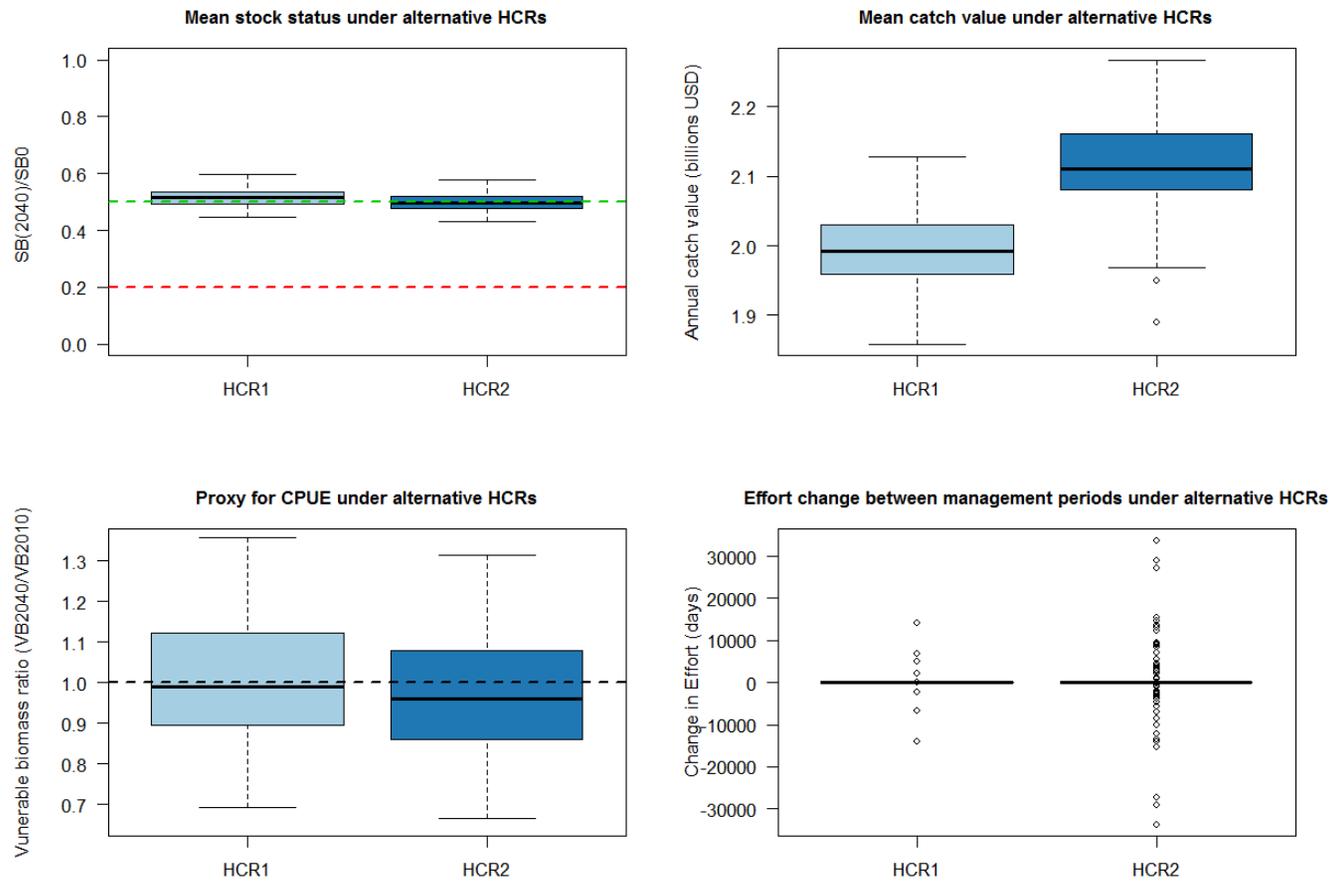
Figure 2. Performance metrics for two Harvest Control Rules in terms of status of the resource, mean catch value, CPUE and effort change.
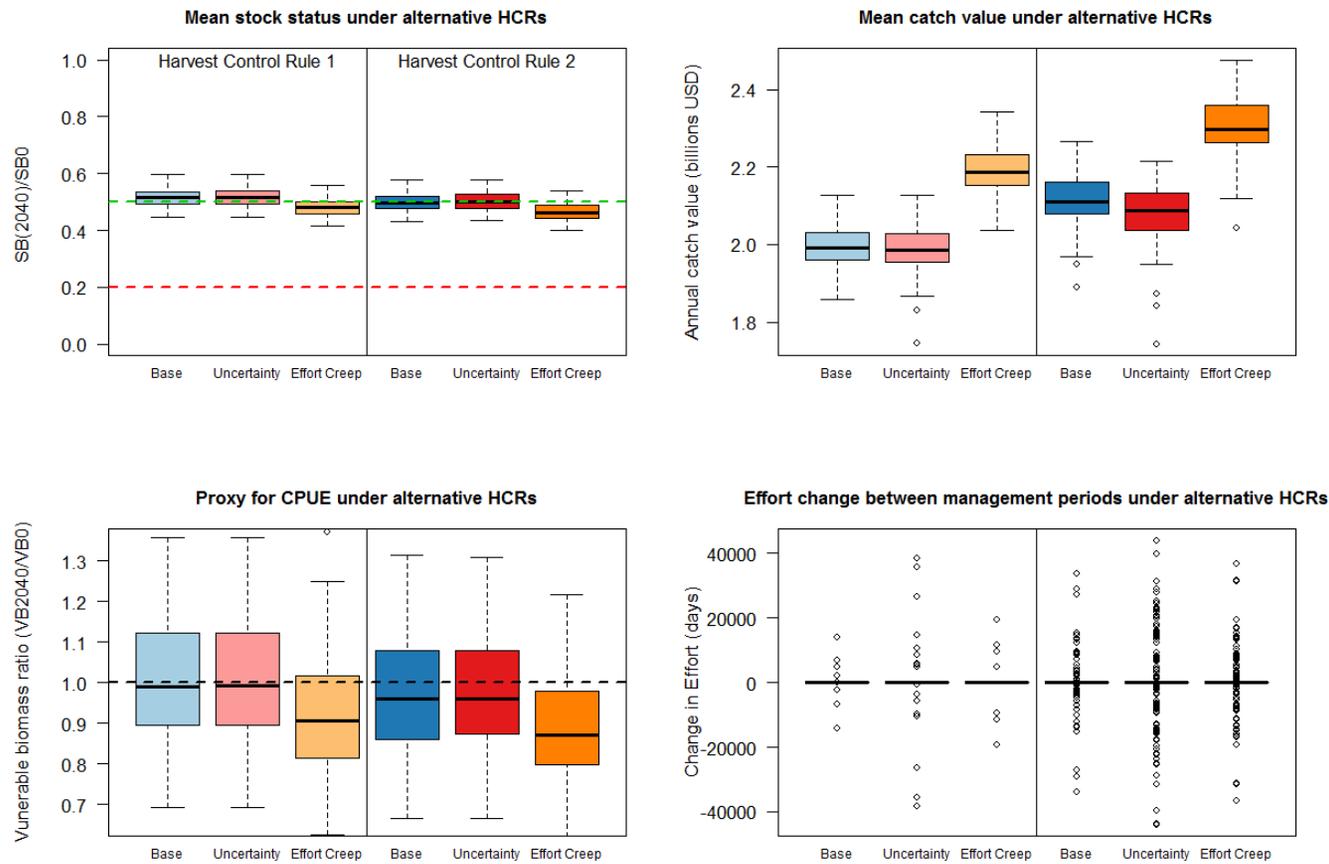
Figure 3. Performance metrics for two Harvest Control Rules and their robustness to increased uncertainty in the stock assessment and effort creep in the equatorial purse seine fishery. The same performance metrics are used as in Figure 2 and the "Base" is the model results from the tuned stage shown also in Figure 2.