WCPFC
HARVEST STRATEGY WORKSHOP
Kuta, Bali
30 November–1 December 2015

Alternative CPUE/abundance dynamics for purse seine fisheries and their implications for target reference points for skipjack tuna in the Western Central Pacific Ocean

HSW-WP/03

SPC-OFP

Overview

A trend in catch per unit effort (CPUE, e.g., catch per day fished) is often used as an indicator of a trend in stock abundance. An increase in CPUE is assumed to indicate an increase in abundance whilst a decrease in CPUE indicates a decline in stock abundance. It is widely recognised, however, that for some fisheries the relationship between CPUE and abundance is not so simple. This is particularly true for purse seine fisheries where efficient searching technologies are used to target aggregations of schooling fish such that even when fish abundance declines purse seine vessels can continue to find schools at the same rate and are able to maintain high levels of CPUE (a phenomena known as hyperstability; see Figure 1).

We try to minimize the impact of these potential biases in our stock assessments and rarely use purse seine CPUE as a measure of stock abundance, focussing instead on other sources of information such as tagging data. However, these potential biases may be important for determining the appropriate level of effort to achieve a particular management outcome, e.g., a specific Target Reference Point (TRP) level, and any consideration of capacity limitation.

The aim of this paper is to:

1. Explain why purse seine fishing dynamics such as hyperstability are important factors to consider in the management framework;
2. Demonstrate the potential impact of hyperstability in the context of WCPFCs consideration of TRPs for skipjack tuna – including through the use of an online tool that allows users to investigate the impacts; and
3. Motivate some discussion on how this information, and associated uncertainty, could inform the TRP decision and future work around Harvest Control Rules (especially in reference to papers presented elsewhere at this meeting).

Effort creep, whereby fishing efficiency, and hence catchability, progressively increase over time, will also affect the relationship between CPUE and abundance. We do not explicitly consider effort creep in this analysis, but interested participants are referred to MOW2-WP-03 which gives some discussion on how effort creep might impact HCR implementation. Further, this paper builds on the work of previous analyses that have investigated the implementation of alternative CPUE/abundance dynamics in MULTIFAN-CL (Scott et al., 2015) and the consideration of management measures associated with candidate target reference points for skipjack (SPC-OFP, 2014).

Approach

Given the likely confounding between the impacts of effort creep and hyperstability, direct estimation of the extent of hyperstability in a fishery is unlikely to be ever possible. Therefore we consider a range of alternative scenarios that correspond to zero, moderate and extreme hyperstability to illustrate the potential effects.

The analysis was based on a single assessment run (the most recent, 2014 reference case skipjack stock assessment) and comprised two steps.

Firstly, the skipjack stock assessment model was refitted with purse seine CPUE/abundance relationships. Three alternative hyperstability scenarios were chosen to represent zero, moderate and extreme cases of hyperstability (see Figure 1). Numerous checks were conducted to ensure that, for each scenario, the assessment model achieved a consistent fit to the data and that the terminal estimates of abundance, fishing mortality and other model outputs were similar to those of the reference case assessment.

Secondly, a series of deterministic projections were conducted over a broad range of effort scalers to determine the resulting stock status under each hyperstability scenario. To aid comparison with previous analyses (SPC-OFP, 2014) the projections were run using the same settings, to the extent possible, although for practical reasons some differences remained. The projections were run with the following settings:

- 20 year deterministic projections with future recruitment determined from the mean of the recent time series (2002:2011)
- Future fishing effort was based on 2012 effort levels with scalers between 0.5 and 2.0 in increments of 0.01 applied to all fleets.
- Catchability throughout the projection period was determined from the assumed CPUE abundance relationship.

The results are presented here in terms of $SB_{2032}/SBF0_{2002:2011}$ and the percentage change in effort (from 2012 effort levels) to achieve the potential TRPs of 40%, 50% and 60% $SB_{F=0\ 2002:2011}$.

It should be noted that, for zero hyperstability, CPUE will scale linearly with effort but may not scale on a strict 1:1 basis (ie. a 10% increase in effort may not translate to a 10% increase in CPUE). Many factors, including the spatial disaggregation of the population, differences in selectivity between fleets and age structure in selection patterns and in natural mortality will mean that CPUE scales linearly with effort but is not directly proportional to effort.

For zero hyperstability, the relationship between CPUE and effort will be linear. With increasing hyperstability in CPUE this relationship will become increasingly non-linear.

How do the results compare with previous analyses?
The results of the projections are comparable with previous analyses but differ slightly from those presented in SPC-OFP (2014). The results of SPC-OFP (2014) were determined from stochastic projections conducted across the uncertainty grid of six assessments whereas the results presented here are from deterministic projections conducted for the reference case assessment alone. For this reason the effort scalers associated with the different TRPs differ slightly from those of previous analyses. However, the objective of this analysis was to determine the sensitivity of effort management measures to hyperstability in CPUE. For definitive

advice on effort levels associated with TRPs we direct the reader to the analyses presented in SPC-OFP (2014).

Analysis

Given the likely confounding (or confusion in the data) between the impacts of effort creep and hyperstability, direct estimation of the extent of hyperstability in a fishery is unlikely to be ever possible. Any consideration taken of possible hyperstability in a management context will need to recognise this uncertainty.

The stock is estimated to be at $48\%SB_{F=0}$ in the terminal year of the reference case assessment run. Under status quo conditions (i.e., an effort scaler of 1.0) and projection settings as detailed above, the stock is estimated to remain at $48\%SB_{F=0}$ throughout the projection period. A reduction of effort of around 4% to 5% will achieve 50% $SB_{F=0}$ at the end of the projection period regardless of the extent of hyperstability (see Table 1).

To achieve an increase in stock abundance to $60\%SB_{F=0}$ an effort reduction of 39% is required under the zero hyperstability scenario. For increasing levels of hyperstability the necessary reduction in effort declines and is around 32% for the most extreme level of hyperstability considered.

To achieve a reduction in stock abundance to $40\%SB_{F=0}$ an effort increase of 49% is required under the zero hyperstability scenario. For increasing levels of hyperstability the necessary increase in effort is lower and is around 35% for the most extreme level of hyperstability considered[1].

In summary, when hyperstability exists a smaller effort increase is required to reduce the stock and a smaller effort reduction is required to increase the stock. One could argue that greater 'care' is needed when managing with effort if hyperstability is believed to exist, as the fishery impacts are more sensitive to changes in fishing effort.

Discussion points

In this analysis we illustrate the sensitivity of candidate skipjack biomass TRPs to different potential levels of hyperstability in purse seine fisheries. Specifically we show how the necessary changes in effort to meet biomass targets vary for different assumptions of the extent of hyperstability.

- Given these findings, have you revised your opinion on what would be an appropriate TRP for skipjack ?
- How useful are tools such as the R-shiny application (see Apendix A) in terms of explaining key concepts and allowing for more informed consideration by WCPFC?

[1] The range of effort scalers required to achieve the TRPs of 40% and $60\%SB_{F=0}$ for the range of hyperstability scenarios is illustrated in Figure 2

In terms of the broader discussion on harvest strategies these analyses raise a number of issues related to uncertainty in the underlying dynamics of the fishery system and the development of harvest control rules:

- How can we develop management systems (e.g., harvest control rules) that are robust to the potential impacts of phenomena such as effort creep and hyperstability - especially if the true nature and extent of hyperstability cannot be determined?
- How can we ensure that our stock assessments and management advice are robust to the potential impacts of phenomena such as effort creep and hyperstability?

References

Scott, R. D., Tidd, A., Davies, N., Pilling, G., and Harley, S. (2015). Implementation of alternative CPUE/abundance dynamics for purse seine fisheries within MULTIFAN-CL with application to eort-based projections for skipjack tuna. WCPFC-SC11-2015/SA-IP-02, Pohnpei, Federated States of Micronesia, 5–13 August 2015.

SPC-OFP (2014). Current and projected stock status of skipjack tuna to inform consideration of target reference points. MOW3-WP/03, Apia, Samoa.

Table 1: Effort scalers (relative to 2012 effort) required to reach target reference points of 40%, 50% and 60% of $SB_{F=0\ 2002:2011}$ for the skipjack fishery for varying degrees of hyperstability in purse seine CPUE.

TRP % $SB_{F=0\ 2002:2011}$	Change in spawning biomass from 2012 levels	Change in effort from 2012 levels Zero	Moderate	Extreme
60%	+22%	-39%	-36%	-32%
50%	+2%	-5%	-4%	-4%
40%	-18%	+49%	+44%	+35%

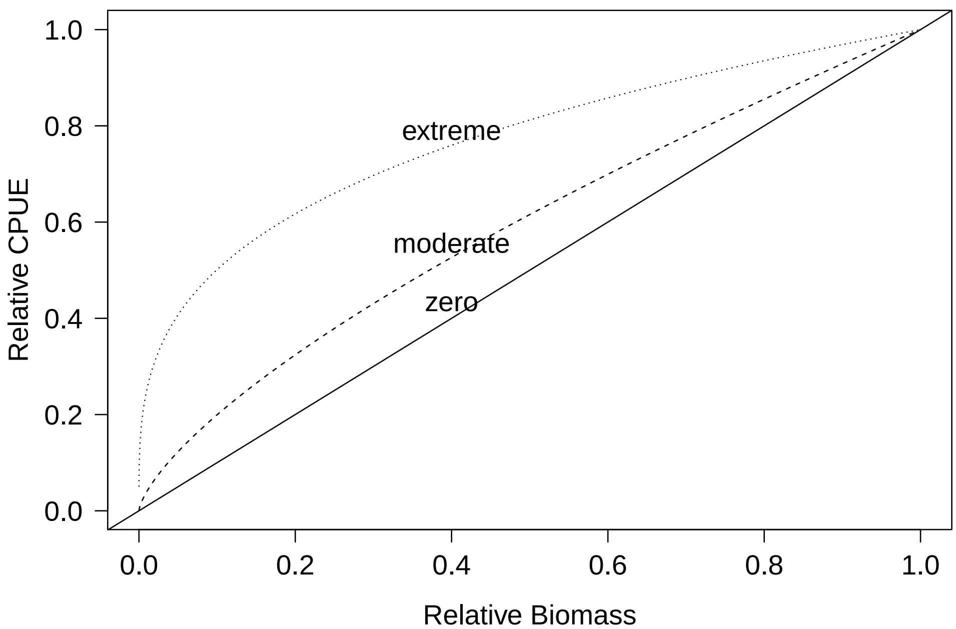

Figure 1: Conceptual plot of the assumed relationship between CPUE and stock abundance for a range of alternative CPUE abundance relationships. CPUE remains at high levels with decreasing abundance resulting in hyperstability in CPUE. The curves shown correspond to the zero, moderate and extreme hyperstability scenarios used in the analysis.

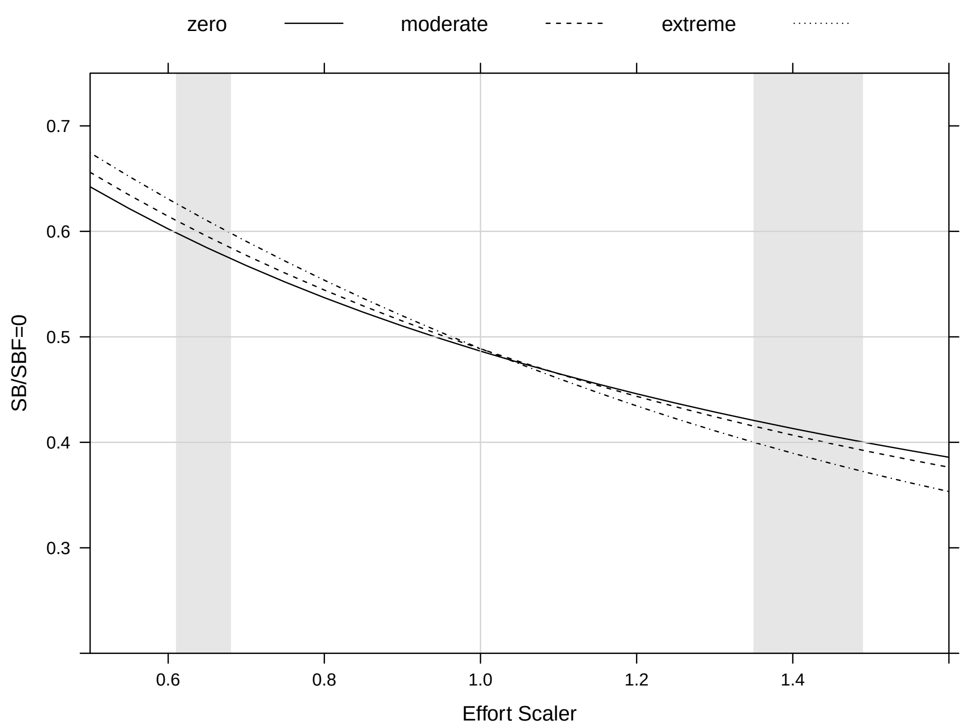

Figure 2: Trajectories of SB/$SB_{F=0\ 2002:2011}$ for effort scalers betweeen 0.5 and 1.6 for different CPUE hyperstability scenarios. Horizontal grey lines indicate the candidate TRPs of 40% 50% and 60% of $SB_{F=0\ 2002:2011}$. Grey shaded areas indicate the range of effort multipliers over which the TRP is achieved for the hyperstability scenarios.

A Interactive web-based tool for results dissemination

A web-based application has been developed, using the R shiny package, to provide an interactive platform for disseminating the results of this analysis. The application has been developed with two specific objectives in mind:

1. To provide a concise and understandable method for conveying the results of the CPUE analysis and to present those results in a management context.

2. To gain feedback on the usefulness of interactive web-based tools and how they can be further developed to present the results of a broader range of analyses.

A screenshot of the application is shown below. The application will hopefully be hosted on the WCPC server during the meeting and participants provided with a url with which to access it.

We encourage participants to trial the application and welcome any feedback regarding ease of use, information content etc.

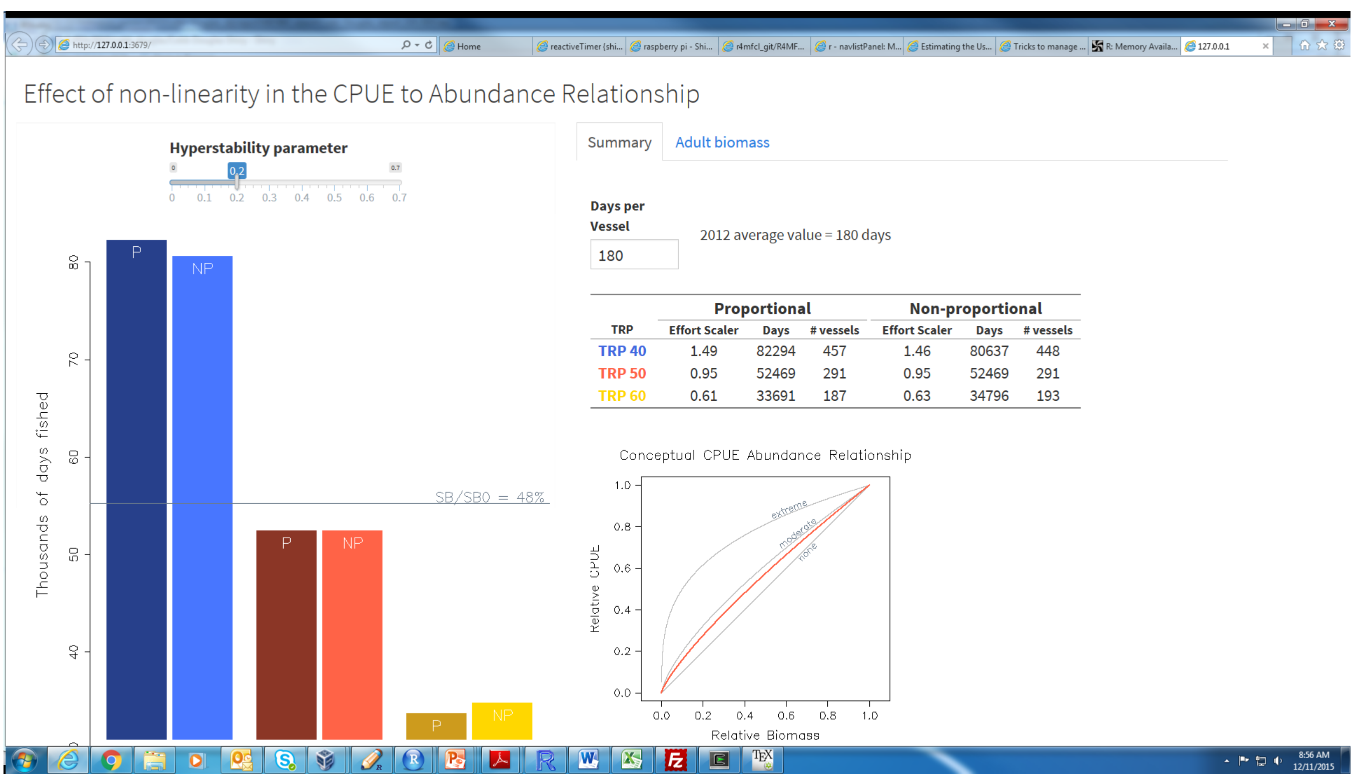

Figure 3: Screenshot of R shiny web based application for presenting results.