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Size based indicators of performance of Indian Ocean skipjack tuna towards developing specifically built Harvest Control Rules

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Abstract

Fully quantitative stock assessments for skipjack tuna are difficult to conduct and therefore, alternative methods of investigating current stock status are required. As a first step towards designing applicable HCR for the Indian Ocean skipjack fisheries, we explore the size based information available in IOTC and the possible pathways to make them useful for the management of this species. We use this information to assess on the sustainability of this fishery and the different gears they are composed of, using Froeses's guidelines of sustainability. We also classify each fishery in relation to the size segment they exploit according the length based decision tree and HCR from Cope and Punt (2009). With the preliminary set of parameters used in this work, this fishery can be considered as "Fish maturity ogive" and within reference biomass levels, as currently, the proportion of mature individuals (*Pmat*) is above 0.9. However, the *Pmat* of this fishery has recently been below the benchmark of 0.9, which would in turn classify it as below reference levels of biomass that would recommend action to increase *Pmat* above 0.9. The gears that exploit a larger proportion of immature fish are trolling and baitboat.

Introduction

Size-related measures (e.g., mean length or weight; length compositions) have long been used as indicators of response to population decline (Beverton and Holt; 1957; Smith 1994). Given that catch length frequencies are among the easiest data to collect, it is valuable to know how to interpret such information in the context of providing directed fishery management advice. Here, we show preliminary estimates of the proportion of skipjack caught above their maturity size (P_{mat}), the proportion of skipjack fish that consist primarily of fish of the optimal size (P_{opt}), the size at which the highest yield from a cohort occurs; and P_{mega}, that demonstrate the conservation of large, mature individuals. This method was attempted in order to describe the fishery of skipjack against sustainability standards of conservation of mature and large fish.

These indicators presented by Cope and Punt (2009) can be used to monitor population status relative to exploitation. These metrics, added in a new term (P_{obj}), can be monitored to avoid growth and recruitment overfishing, and their quantitative linkage to stock status is investigated, although their capacity to estimate future sustainable catches at equilibrium is limited.

In this document we estimate the trends of these parameters and use them to classify the fishery and the different gears fishing skipjack in the Indian Ocean following a decision tree which could also be used to trigger management action in the form of a Harvest Control Rule (HCR).

Material and Methods

The catch composition proportion was defined with four length based parameters which were estimated from the available catch at size IOTC database prepared for the Tropical Tuna Working Group (Bali, November 2014) meeting as follows:

$P_{Mat} = \sum_{L_{mat}}^{L_{max}} P_L$;
$P_{Opt} = \sum_{0.9L_{opt}}^{1.1L_{opt}} P_L$;
$P_{Mega} = \sum_{1.1L_{opt}}^{L_{max}} P_L$;
$P_{Obj} = P_{Mat} + P_{Opt} + P_{Mega}$;

Where P_L is the proportion of catch that is length class L, L_{mat} is the length at 50% maturity, L_{max} is the maximum length, and L_{opt} is the length at which the biomass of a cohort is maximized (defined here as a preliminary value of $L_{opt}=L_{mat}/0.9$).

Results and discussion

The estimated parameters for the Indian Ocean skipjack fishery are assessed with the decision tree shown in the paper by Cope and Punt (2009). The sum of the values gives the P_{obj} value, which describes the selectivity of the fishery (noted in gray boxes). Following the tree down from that branch, the corresponding value of either P_{mat} or P_{opt} is interpreted to determine whether the stock biomass (SB) is at or above the target reference point (RP), in this case 0.4 of B_0 (Cope and Punt, 2009).

As a very preliminary analysis, we plot the estimated indexes with the following parameters: L_{mat}=40 cm (Grande et al., 2014), L_{max}=90, and L_{opt}=45 cm. According the decision box, the estimated P_{obj} for Indian Ocean skipjack corresponds to a fishery of 'Fish maturity' ogive (1<Pobj<2) (Figure 1), which follows Froese's sustainability recommendations (2004) (Figure 3). Within the latter distinction, a P_{obj} value between 1 and 2 clearly distinguishes selectivity patterns containing some immature and suboptimally sized fish (e.g., the logistic selectivity pattern) from those for which P_{obj} is equal to 2. The used size at maturity is 40 cm (Grandes et al, 2014), although other studies in the Atlantic use a larger value of 42 cm (Gaertner, 2014). In relation to the P_{mat}, it is currently nearby the benchmark of 0.9 despite being at lower values between 2004 and 2008. Following the decision tree in the work by Cope and Punt (2009) the fishery will be nearby the reference point of 0.4 B_0 and would currently fulfil the sustainability conditions of Froese (2004).

The same analysis was carried out for each gear exploiting skipjack. According to this, only trolling fishery are below the benchmark of P_{mat} 0.9. Gillnet and free school purse seine show a *Pobj* nearby 2, which describes optimally sized and bigger individuals fishery. FAD purse seine and baitboat are just in the limit of the *Pmat* benchmark.

The design of a Harvest Control Rule requires determining recommended catch and fishing mortality levels in order to lead the fishery to the desired reference point with high probability. The method preliminary presented provides benchmarks on the performance of the fishery in relation to the size composition of the catch but does not provide the specific actions to be taken for each situation. The extension of size based methods such as the presented here in order to develop applicable quantitative HCR is to be explored. For example, if the overall *Pmat* benchmark is not achieved, the activity of the fleets that fish smaller individuals would need to be reduced, or the fleets that operate larger individuals should be restricted and make the fishery to be only composed by "small fish, immature" or "small and optimally sized but biggest". This fisheries can also fullfill sustainability conditions if the survival rate of the individuals that reach larger sizes is maximized.

Although we have applied this method in a very preliminary manner, these and other approaches will be of great relevance to produce scientific advice on the appropriate course of action to maintain this fishery at sustainable levels. Other potential Harvest Control Rules to be contemplated for this fishery include the decision making process in a multispecies context, including the state of exploitation of yellowfin and bigeye tunas, which often accompany skipjack landings.

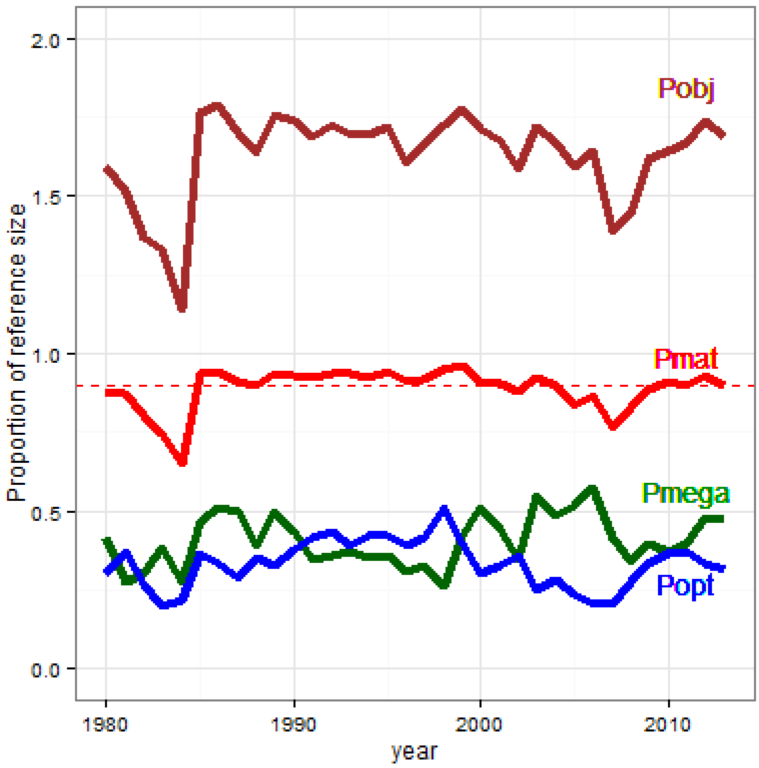

Figure 1. Proportion of reference sizes for eastern skipjack fishery.

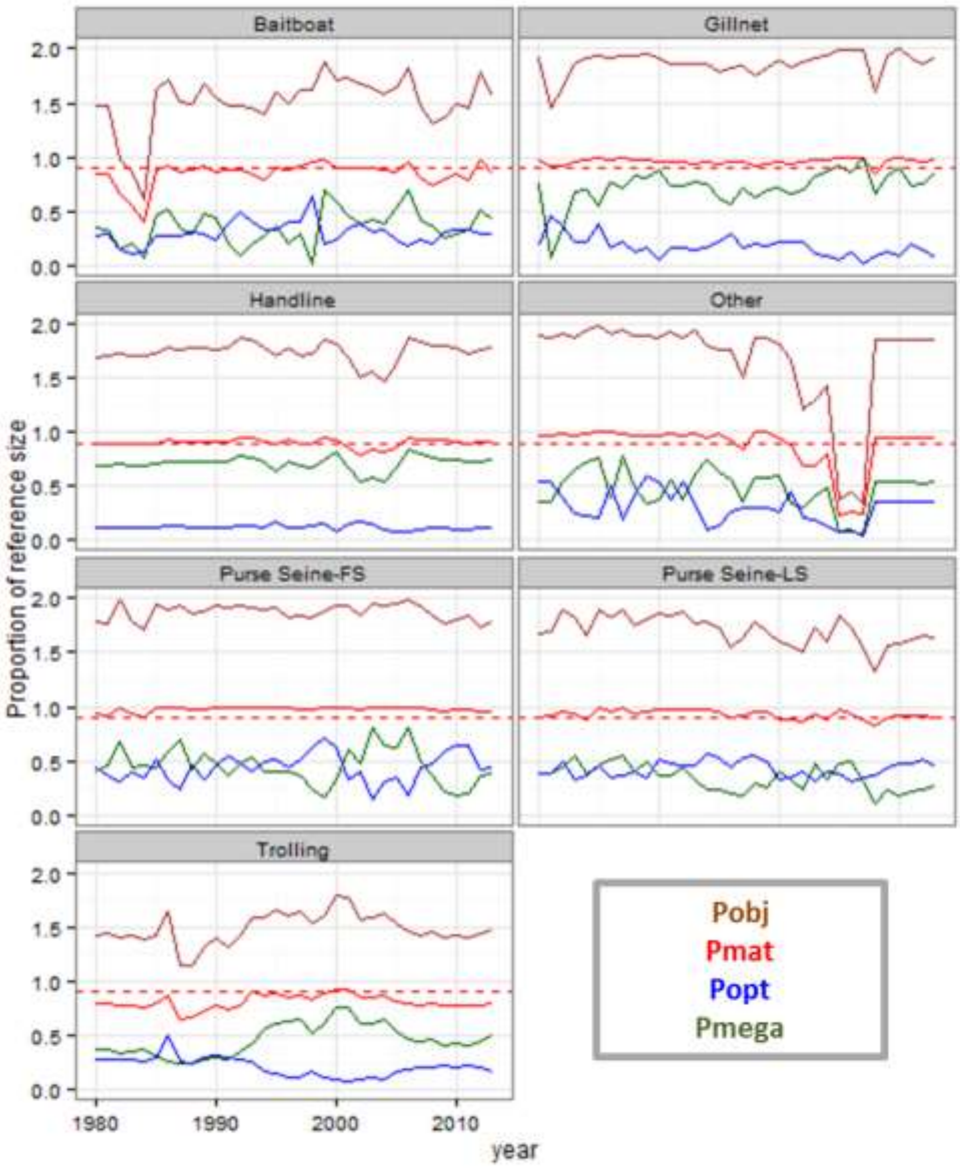

Figure 2. Proportion of reference sizes for eastern skipjack fishery for each gear.

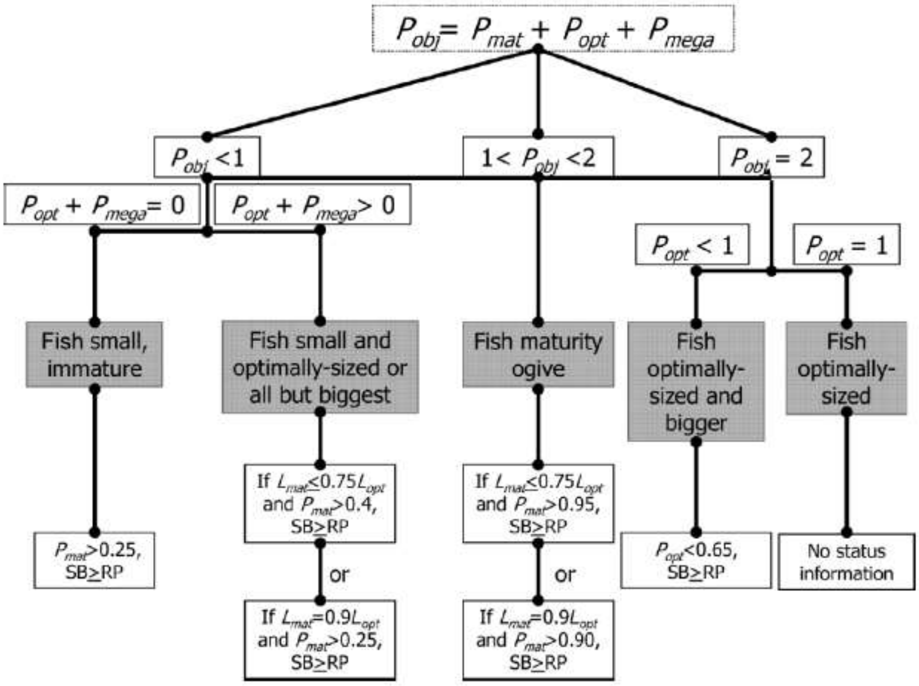

Figure 3. Decision tree explained from Cope and Punt (2009).

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