Indicators of stock status for skipjack tuna in the Indian Ocean

Gorka Merino[1], Hilario Murua[1], Haritz Arrizabalaga[1], Josu Santiago[2]

[1] AZTI-Tecnalia, Herrera Kaia Portualdea, 20110, Pasaia, Spain; gmerino@azti.es; Phone: +34667174456
[2] AZTI-Tecnalia, Txatxarramendi uhartea, 48395, Sukarrieta, Spain

Abstract

Fully quantitative stock assessments for skipjack tuna are difficult to conduct and as such alternative methods of investigating current stock status are required. Fishery stock status indicators have been constructed from total catch, average weight and catch rates from the purse seine fisheries of France and Spain as well as Maldivian baitboat (when possible) have been investigated to infer stock status . In order to investigate current status in relation to historic levels, upper and lower limit reference levels have been advocated including both 5th and 95th percentiles as well as a standard deviation multiplier that incorporates 90% of the data series. These rough indicators can be difficult to interpret and are sometimes potentially contradictory. The indicators in this study provide some evidence that the SKJ population may be experiencing increasing pressure, although further analysis is required. These indicators provide a potential tool for applying empirical harvest control rules for fisheries management.

1. Introduction

Traditional stock assessment models have been difficult to apply to skipjack because of their biological and fisheries characteristics. For example, skipjack's high, and variable productivity (i.e. annual recruitment is a large proportion of total biomass), to assess the effect of fishing on the population with standard fisheries data and stock assessment methods is challenging. This has found to be the case in the Eastern Pacific Ocean and in the Atlantic Ocean (Maunder and Deriso, 2007; ICCAT, 2014). Skipjack's continuous recruitment, rapid growth and high natural mortality make extremely difficult to obtain the sufficient temporal stratification needed to observe modes in length-frequency data. In addition, a possible dome-shaped selectivity of the primary target fleet (purse seine), which would imply that there is a cryptic biomass of large skipjack, has complicated the estimation of the absolute levels of biomass and exploitation rates in previous assessments (Maunder and Harley, 2005).

Another major difficulty is related to the indices of abundance necessary to "tune" assessment models. There are uncertainties as to whether the catch per unit of effort (cpue) of the purse-seine fisheries is an appropriate index of abundance for skipjack, particularly for fish-aggregating devices (FADs). This is mainly due to the difficulties to identify appropriate units of effort for purse seine (Maunder and Deriso, 2007). Although a standardized cpue series for the Maldivian pole and line fishery is available, the spatial range of this fishery is fairly limited and may not be representantive for the whole western Indian Ocean where a significant number of skipjack catches are recorded by purse seine fisheries operating off the East coast of Africa.

As a result of the problems listed above, this study aims to update the work of De Bruyn and Murua (2011) and investigate various skipjack tuna fishery indicators which, in turn, will help to infer skipjack stock status.

2. Material and Methods

The data used to prepare this document were obtained from the IOTC database (http://www.iotc.org/data/datasets). We used: (i) total catch from the 'nominal catch by species and gear, by vessel flag reporting country' dataset, (ii) cpue estimated from the 'catch and effort by month, species and gear, by vessel flag reporting country' dataset, and (iii) "length-frequency data" for tropical tunas. The estimates are presented with mean, 5th and 95th percentiles of the indicators, as the distributions of the indicators are often asymmetric, are presented as reference levels. Values outside the reference levels could be considered as undesirable depending on the fishery indicator (Table 1). The standardized Maldives bait boat cpue was obtained from the file 'IOTC-2014-WPTT16-DATA02'.

3. Results

The indicators for total catch are presented in figure 1. The time series of catch starts below the lower reference level, then rises constantly, exceeding the upper reference level in 2004, before decreasing again to within the reference boundaries in 2006. The catch was reduced until 2011 nearby the observed mean and has increased significantly in the last data of 2013.

Figure 2 shows the indicator for average weight of skipjack caught by four different gears and techniques: baitboat, gillnet and purse seine (free and associated schools). Although the values fluctuate, it is important to note that the lower reference level is exceeded by the gillnet and baitboat in the early 1980s and for purse seine in the end of the 2000s decade. More recently, the weight for the purse seiners has increased but is still below the mean.

Figure 3 shows the indicator of effort for four fleets operating with surface gears: EU purse seine (Spain and France), Seychelles purse seine and Maldives baitboat. All the purse seine fleets activity has been reduced consistently after reaching their maxima in between 2005-2007. The Maldives baitboat fisheries activity has been reduced significantly in the same period.

Figure 4 shows the indicator of cpue for the four fleets in Figure 3. All the purse seine fleets show fluctuations around the mean but significantly, the French PS gears has consistently reduced its cpue form its maximum since 2005, reaching the historical low in 2012 and very minor increase in 2013. The maximum cpue for the purse seine fleet from Spain and Seychelles was reached in 2010. Since then, cpue was reduced for two years but it increased notably in 2013. In relation to baitboat, an overall reduction was notable since 2005 until 2012, but it has been followed by a significant increase of the cpue in the last year.

Figure 5 shows the standardized Maldivian cpue series which is concordant with the raw data presented in Figure 4. An overall and consistent increase of yearly effort is appreciated despite the seasonal peaks of cpue. A recent increase in cpue observed in the yearly raw data for 2013 does not appear yet in the standardized cpue series as their last record is for the fourth quarter of 2013.

4. Discussion

Despite the difficulties facing the assessment of skipjack, the comparison of various fishery indicators with their historical levels could provide the basis to infer the status of Indian Ocean skipjack tuna stock in the absence of traditional reference points. Similar fishery indicators have been used to estimate the maximum productivity of skipjack in the Indian and Atlantic Oceans (Merino et al 2014a,b; Campbell et al., 2007; Maunder and Deriso, 2007). However, the interpretation of the fishery indicator trends should take into account several caveats and incorporate expert knowledge. For example, both exploitation rate and recruitment directly influence the average weight. The difficulty, therefore, in relation to this indicator is to identify whether the changes in average weight are due to recruitment or exploitation rate. Long-term trends in average weight due to increasing or decreasing exploitation rates could, however, be confounded by changes in selectivity (Maunder and Deriso, 2007).

In general the indicators obtained for skipjack tuna in this study are partially conflicting and highly variable. Recent total catch trends are within the reference limits and have shown a progressive negative trend until last year, where they have recovered to levels notable larger than the historical mean. The negative trend since 2006 in isolation is largely ambiguous as it is not clear whether catch has dropped due to reduced effort or reduced availability. The indicators provided for effort for the major fleets would indicate that effort has indeed been reduced and may well be the explanation for the drop in catch (for example due to the piracy problem in the IO). The average size indicators for the purse seine fleets have increased moderately after reaching their lower limit by the end of the 2000s decade for both free and associated schools. Reaching the lower level could be cause for concern but again the caveats outlined in the previous paragraph must be taken into account. Furthermore, monitoring the recent increasing trend could potentially very illustrative of the impact of these gears in the fishery, as their effort has been constantly decreasing. The trends do appear slightly different when taking into account only the EU PS average weight information (Pianet et al., 2010). In the long term, however, there does not appear to be an overall major change in mean weight. For the pole and line fishery, the average weights indices have also been decreasing over the last 3 years, although have not surpassed the lower reference level, which was reached in the early 1980s.

The catch rate indicators vary between free and associated schools. Those for free schools show a decline in catch rate for this section of the population. However, it should be taken into account that the free school catch of PS is relatively small in comparison to FAD-associated fishing (less than 10%) and is a seasonal fishery located mainly in the Mozambique Channel during the first quarter of the year. Conversely the catch rates on associated school have increased after two years of decreases as part of inter-decadal fluctuations. It is again difficult to interpret these results, however, it seems that the increase in catch rate is associated with a decrease in effort which could be interpreted as a positive signal. It is possible that the high catch rates for associated schools may be caused by hyperstability (ie. the aggregating effect of the FADs is masking decreasing population numbers), which is not relevant for the free schools. It is difficult to compare the Maldivian CPUE series as the time period is short and it is a quarterly series, but both the standardized and raw series seem to have consistently been decreasing for some years prior to a sudden and remarkable increase in the last year. The fluctuations in this series are likely due to seasonality in the fishery. The overall trend appears to be negative, but again, the short time period allows for no long term trends to be identified.

Should the indicator approach be adopted, a link between the indicator and management action should be agreed. The action could be quite explicit, for example, if CPUE declines below the lower level, the effort would be reduced by a predetermined amount, or it could just trigger a more comprehensive analysis of the stock. This could easily be made operational by applying an empirical harvest control rule, something that has been suggested in ICCAT (de Bruyn and Murua, 2009) and has been proposed in the WCPFC (Campbell et al., 2007). Due to the short life span of skipjack, management might be appropriate on a scale of a year, or possibly even less which would be easily facilitated by an indicator-based approach incorporating an empirical harvest control rule.

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Indicator	*Lower reference level*	*Upper reference level*
Catch	Ambiguous	Ambiguous
Average weight	Undesirable, but could be due to large recruitment	Healty, but may be due to poor recruitment
Effort	Healthy	Undesirable
Cpue	Undesirable	Healthy, but may be due to increased catchability

Table 1: Status of the stock based on when reference levels are exceeded for each indicator

Figures

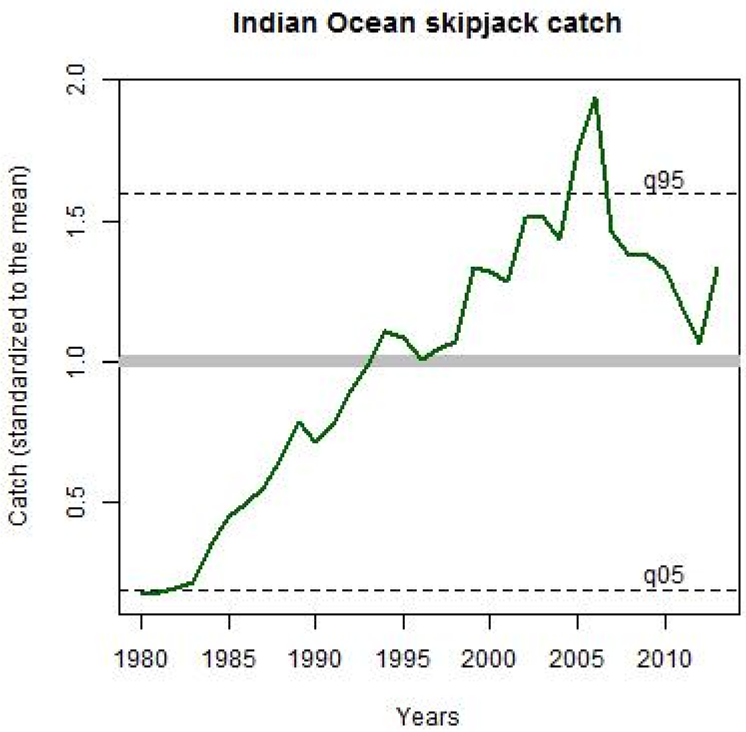

Figure 1: Historical catch of skipjack standardized to the mean. Dashed lines indicate the historical 0.05 and 0.95 quartiles.

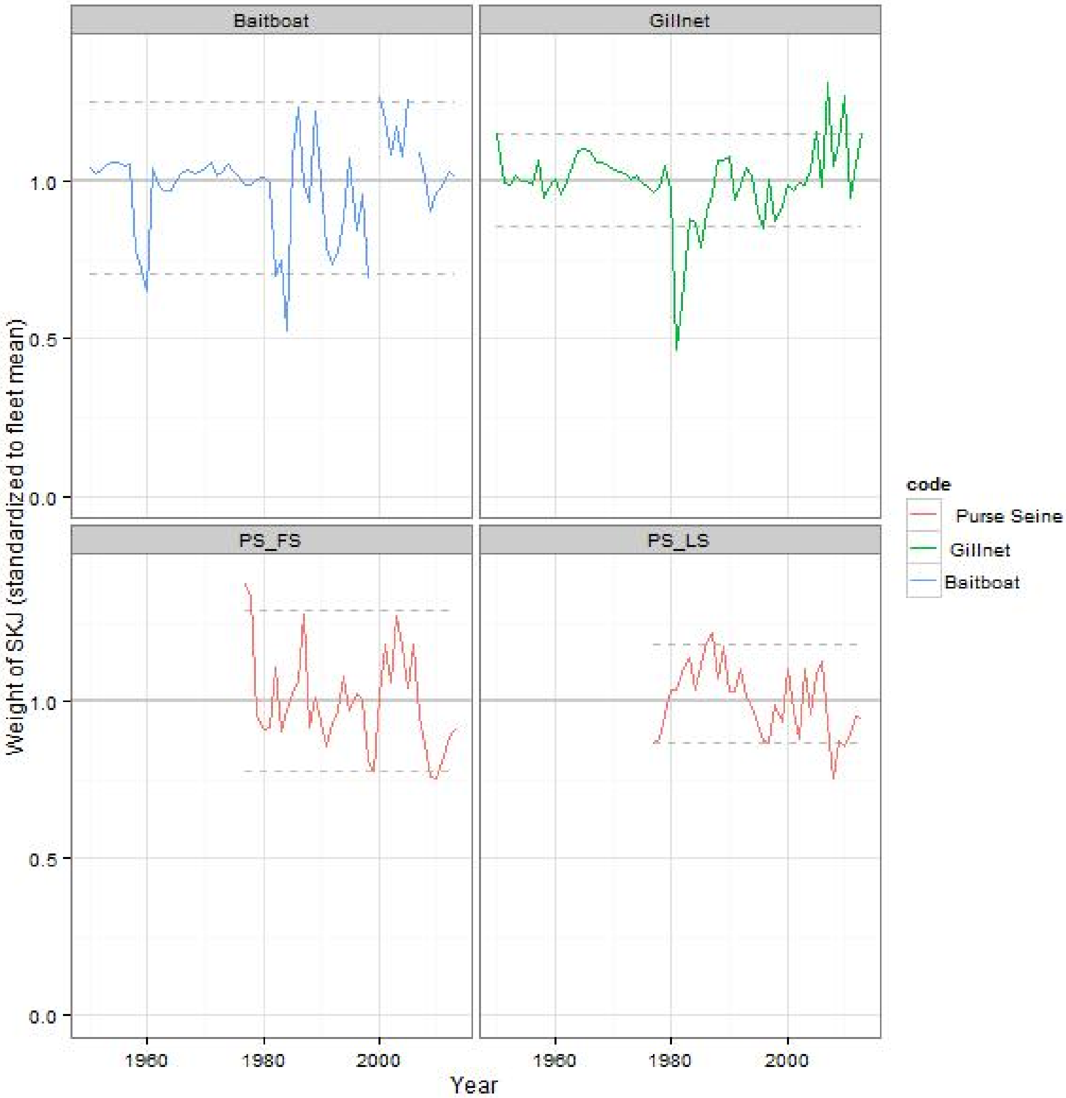

Figure 2. Average weight standardized to the mean of skipjack caught using baitboat, gillnet and purse seine (free school and associated school). Dashed lines indicate the historical 0.05 and 0.95 quartiles.

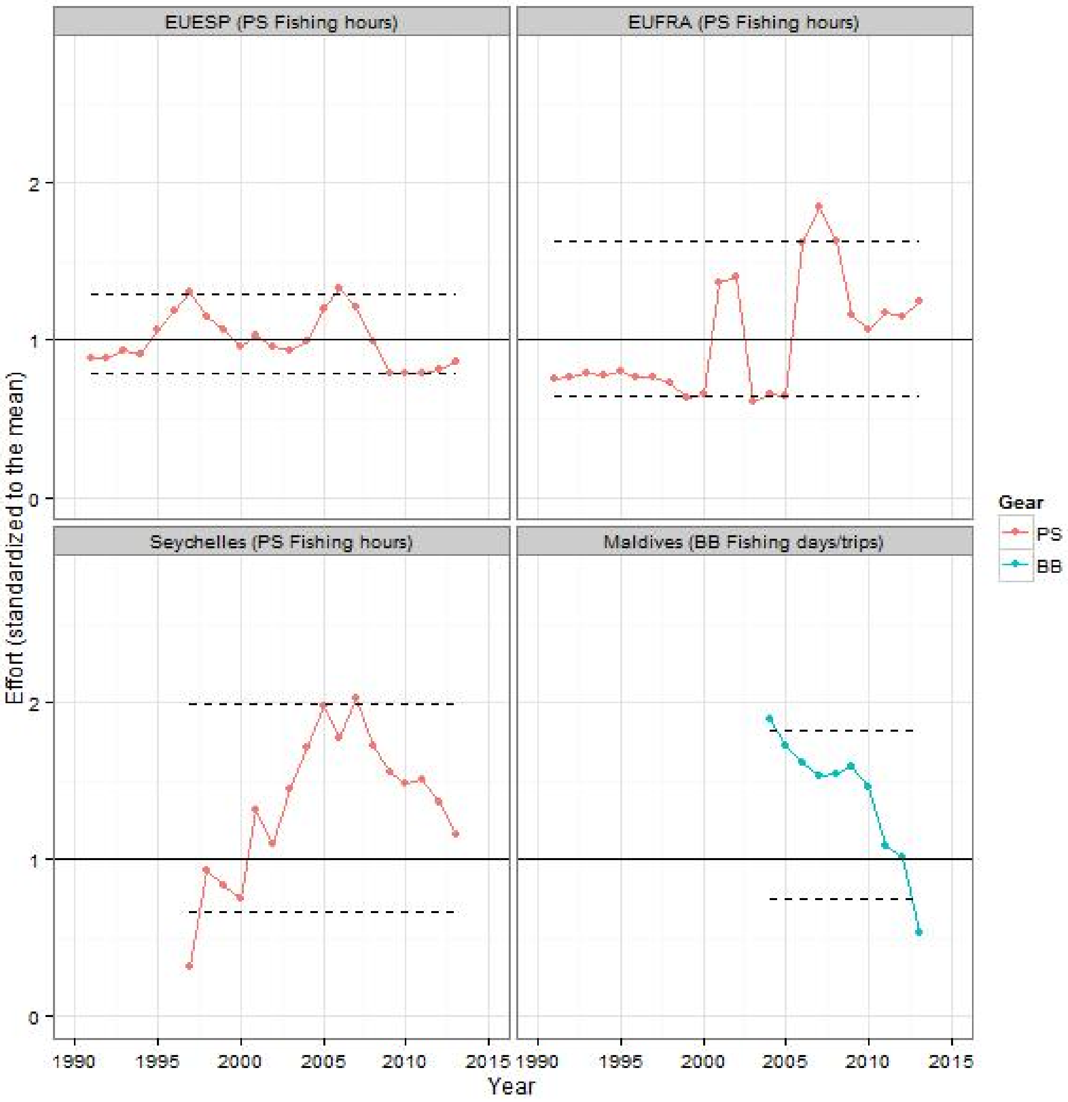

Figure 3. Fishing effort standardized to the mean for three fleets of purse seiners (Spain and Seychelles, associated school and France, free school), and Maldives baitboat. Dashed lines indicate the historical 0.05 and 0.95 quartiles.

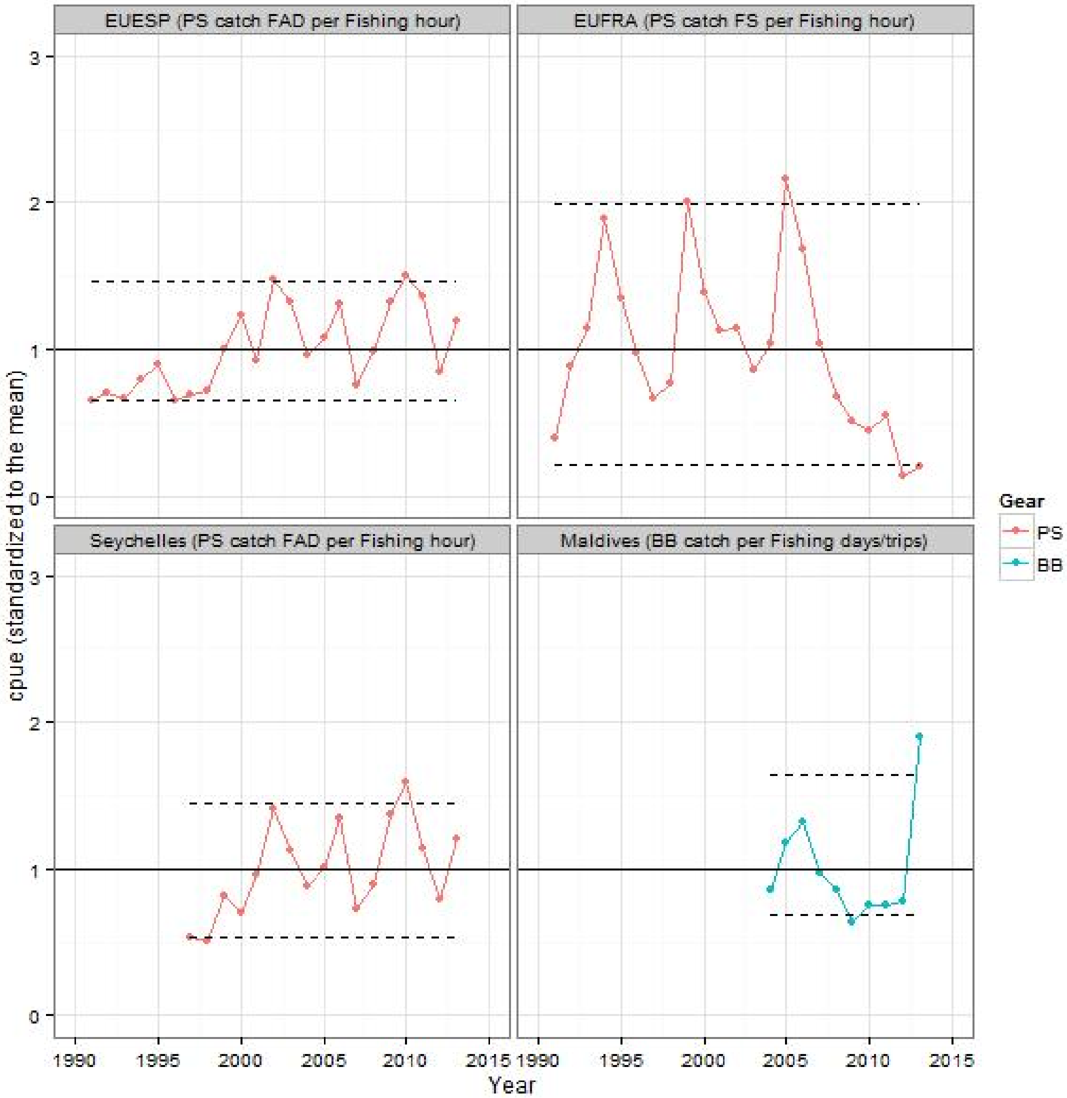

Figure 4. Cpue standardized to the mean for three fleets of purse seiners (Spain and Seychelles, associated school and France, free school), and Maldives baitboat. Dashed lines indicate the historical 0.05 and 0.95 quartiles.

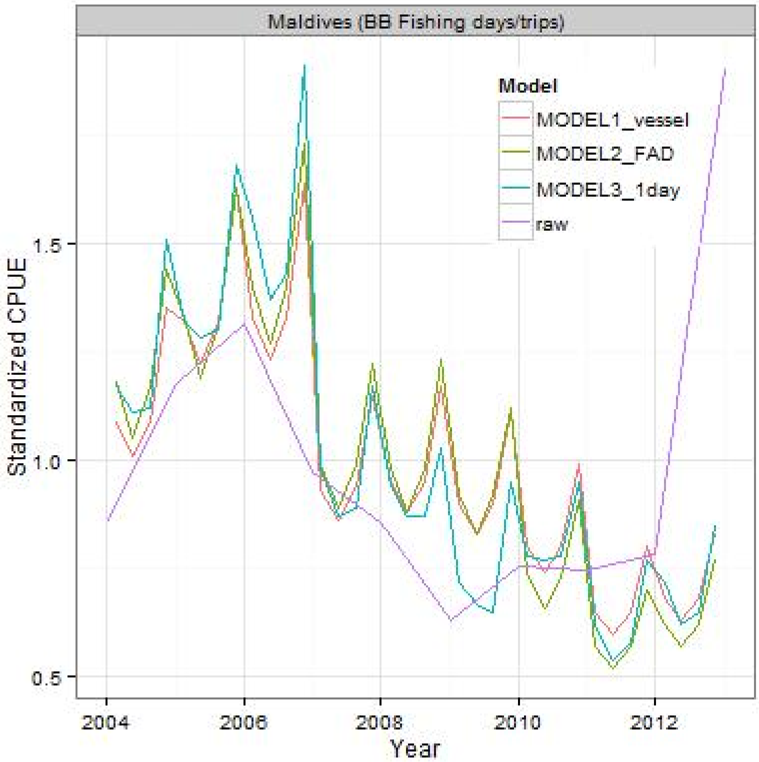

Figure 5. Maldivian pole and line fisherie's cpue series standardized using three different models, and raw cpue data.