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Indicators of stock status for skipjack tuna in the Indian Ocean

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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 (Maunder and Deriso, 2007), and the Atlantic Ocean (ICCAT, 2009). In only in the Western Central Pacific Ocean has a fully quantitative stock assessment for the species been conducted (Hoyle et al., 2010). Skipjack's continuous recruitment, rapid growth and high natural mortality mean it is extremely difficult to obtain 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) CPUE. This is mainly due to the difficulties to identify appropriate unit of effort for purse-seine fleet (Maunder and Deriso, 2007). Although a standardised CPUE series for the Maldivian Pole and Line fishery is available, the spatial range of this fishery is fairly limited and may not be representative 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 and bearing in mind the recommendation from the 2010 IOTC working party on Tropical Tunas which stated "recent trends in certain fisheries suggest that the situation of the stock should be closely monitored and, thus, WPTT recommends that new attempts are made to assess the status of the stock during the next Session of the WPTT in 2011" (IOTC, 2010), this study aims to investigate various skipjack tuna fishery indicators which, in turn, will help to infer skipjack stock status.

2. Materials and Methods

Catch data (from the IOTC nominal catch database), catch per day fished or per searching day for each of the FAD-associated and free school purse-seine fisheries for both the Spanish and French fleets (Ariz et al., 2011; Chassot et al., 2010; Delgado de Molina et al., 2010), fishing effort from the French and Spanish purse seine fleets (Ariz et al., 2011; Chassot et al., 2010; Delgado de Molina et al., 2010), quarterly standardised CPUE for the Maldives pole and line fishery (Kolody and Adam, 2011) and average weight from the IOTC database have been investigated. The fishing effort, which can be considered as a measure of exploitation rate, is estimated as either the sum of the effort, in days fished or searching days, from the associated and free school fisheries. Catch rates were explored for the Spanish purse seine fleet (catch per days fished) and the French purse seine fleet (catch per searching day). The data, except the catch rates, extends back until 1980, as before this time the catches of SKJ were very low and would bias the indices as they have been calculated. For catch rates, the catch and effort by fishing mode has been separated since 1990 (Ariz et al., 2011; Chassot et al., 2010; Delgado de Molina et al., 2010) and, thus, catch rate data extends from 1990 onwards. For the Maldivian pole and line fishery, standardised CPUE information was only available for the period 2004 – 2010 (Kolody and Adam, 2011)

Following the methodology developed by Maunder and Deriso (2007), reference levels estimated as adding or subtracting between 1.45 and 1.80 standard deviations, based on the variation in the time series, to the average of the time series were used to compare current fishery indicators values with historical values. The value of the standard deviation was calculated to include 90% of the historical values for each index, which could be considered somewhat arbitrary but also a reasonable guide. Values outside the reference levels could be considered as undesirable depending on the fishery indicator being investigated (Table 1). The 5th and 95th percentiles of the fishery indicator, as the distributions of the indicators are often asymmetric, are also presented as reference levels.

3. **Results**

The indicators for total catch are presented in figures 1 and 2. The time series of catch starts below the lower reference level, then rises constantly, exceeding the upper reference level in 2005, before decreasing again to within the reference boundaries. 90%

of the series was within 1.65 standard deviations of the median. Figures 3 and 4 show the indicators for average weight of SKJ caught in free schools. Although the values fluctuate, it is important to note that the lower reference level is exceeded only in the most recent years. For associated schools (figures 5 and 6), the lower reference level is again exceeded in the most recent years of the time series. For the baitboat indices (figures 7 and 8) the average weight has generally increased over time, with the lower reference level exceeded in the early 1980s and the higher reference limit surpassed in the late 1990s. The average weight has, however, decreased over the last 3 years.

Figures 9 and 10 show the indicators of effort for the Spanish purse seine fleet. The lower percentile reference level is exceeded for the recent years of the model, indicating that effort has decreased in recent years. For the standard deviation reference limits, the lower limit is never exceeded although the 1.80*standard deviation required to encompass 90% of the information would indicate a wider spread of the data than for any other indicator. Figures 11 and 12 show the indicators of effort for the French purse seine fleet. The upper limit reference point is exceeded for several consecutive years between 2006 and 2008, but the series has subsequently declined to below the standardised mean value.

Figures 13 and 14 show catch rates for Spanish purse seine vessels on free schools. The lower reference level has been exceeded in the most recent years, and the overall trend, despite showing a great deal of variability, is negative. The lower limit was not exceeded for the standard deviation limits, and the standard deviation including 90% of the data was only 1.45*standard deviation, implying a somewhat limited range for the catch rate data. Catch rates on associated schools by Spanish purse seiners (figures 15 and 16) show an overall positive trend, especially over the most recent years of the series. Interestingly, the lower reference limit for the standard deviation indicator has never been exceeded. Catch rates for French purse seine vessels on free schools (figures 17 and 18) have only exceeded the lower reference levels in the first years of the series although the trend in the most recent years is strongly negative. Conversely the catch rate trends for French vessels on associated schools were below the lower limit reference level in 2007, but have since shown a positive trend (Figures 19 and 20). The standardised CPUE trends for the Maldivian pole and line fishery show overall negative trends, with the lower limit reference levels being surpassed in the second quarter of 2010 increasing subsequently in the final quarters of that year (Figures 21 and 22).

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 the Indian Ocean skipjack tuna stock in the absence of traditional reference points. Similar fishery indicators have been used in cases when data poor fish populations are assessed (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. A large recruitment would initially decrease the average weight, however it would then increase, depending on the mortality rate, as the cohort moves through the different age classes. Assuming a constant recruitment, higher exploitation rates will reduce 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 are in fact showing a negative trend in recent years. This trend 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 purse seine 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 from the purse seine fleets have for the first time dropped below the lower limit reference levels for both free and associated schools which could be cause for concern but again the caveats outlined in the previous paragraph must be taken into account. 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 weight indices have also been decreasing over the last 3 years, although have not surpassed the lower reference level.

The catch rate indicators vary between free and associated schools. Those for free schools for both the Spanish and French fleets appear to 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 are increasing for both the Spanish and French fleets. 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. 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 (L. Kell pers com. 2011) 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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Table 1: Status of the stock based on when reference levels are exceeded for each indicator.

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

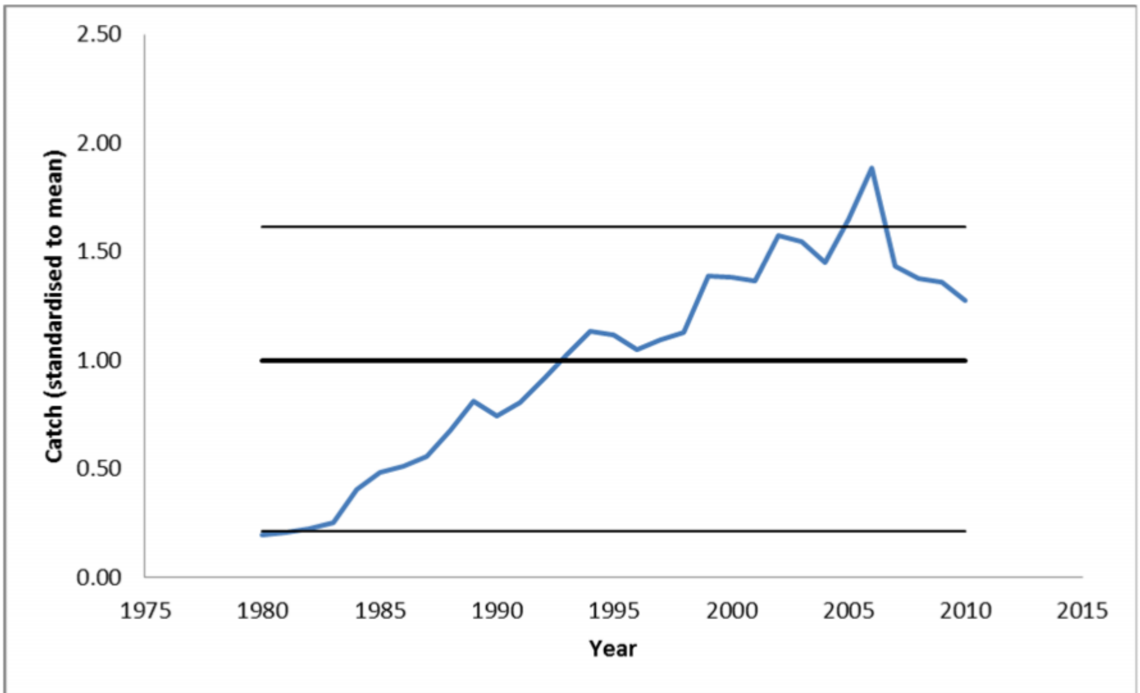

Figure 1: Total catch with 5th and 95th percentiles

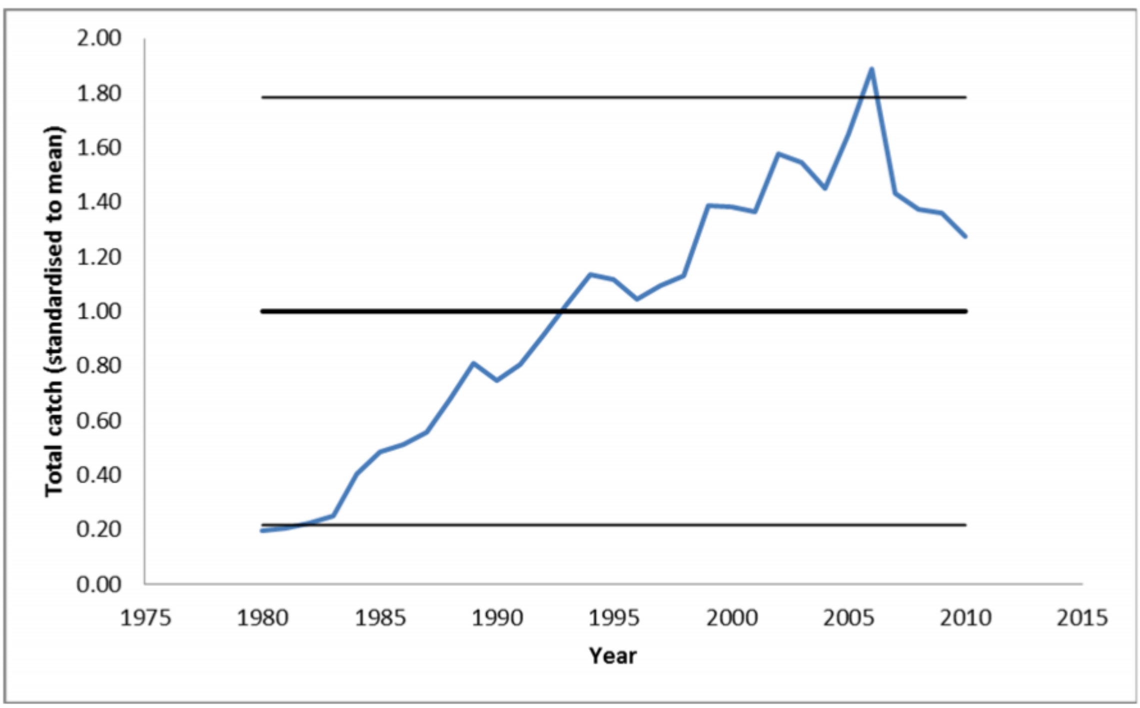

Figure 2: Total catch with 1.65 x standard deviations.

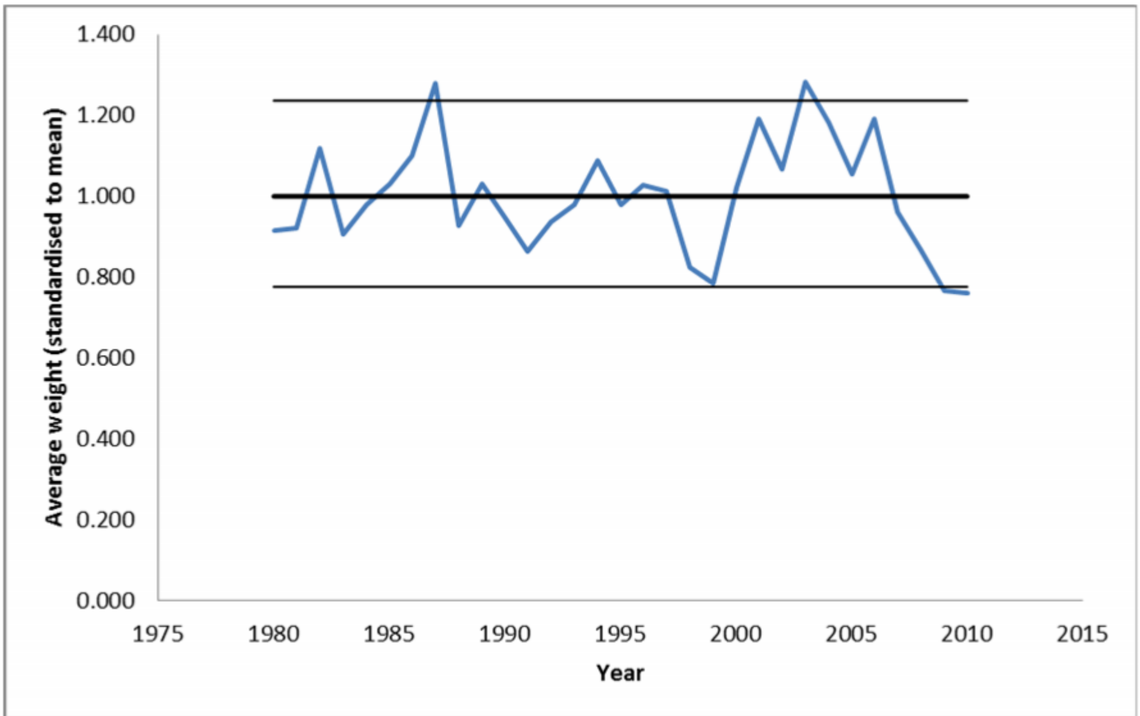

Figure 3: Average weight for free schools caught by purse seiners with 5th and 95th percentiles

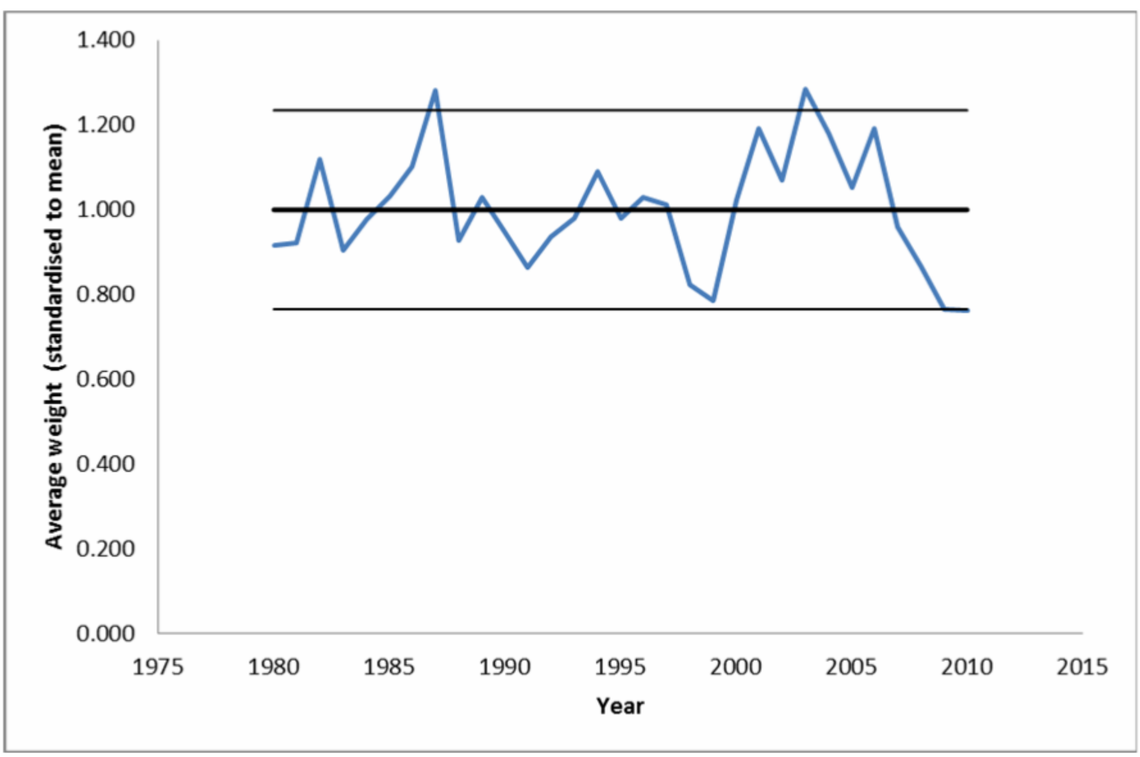

Figure 4: Average weight for free schools caught by purse seiners with 1.70 x standard deviations.

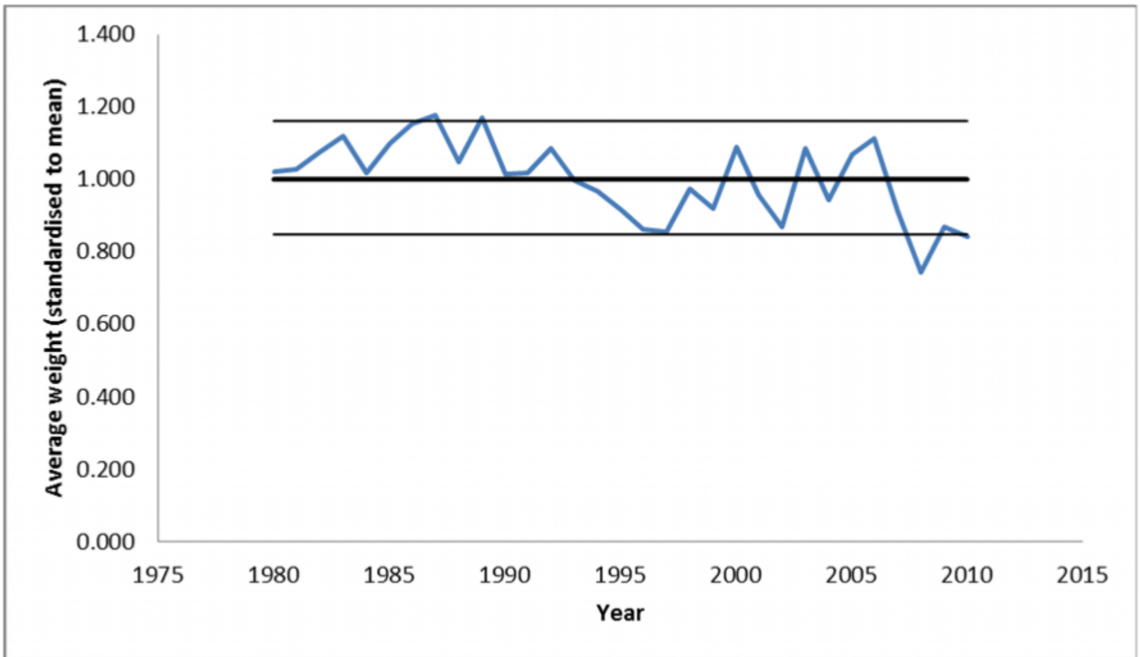

Figure 5: Average weight for associated schools caught by purse seiners with 5th and 95th percentiles

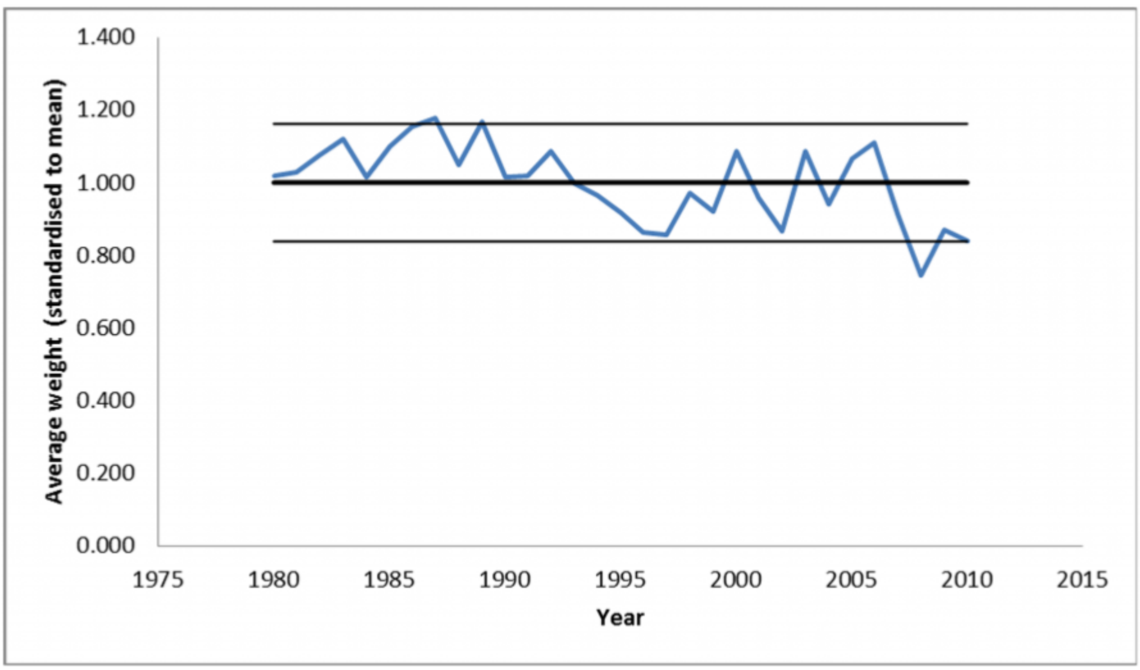

Figure 6: Average weight for associated schools caught by purse seiners with 1.50 x standard deviations.

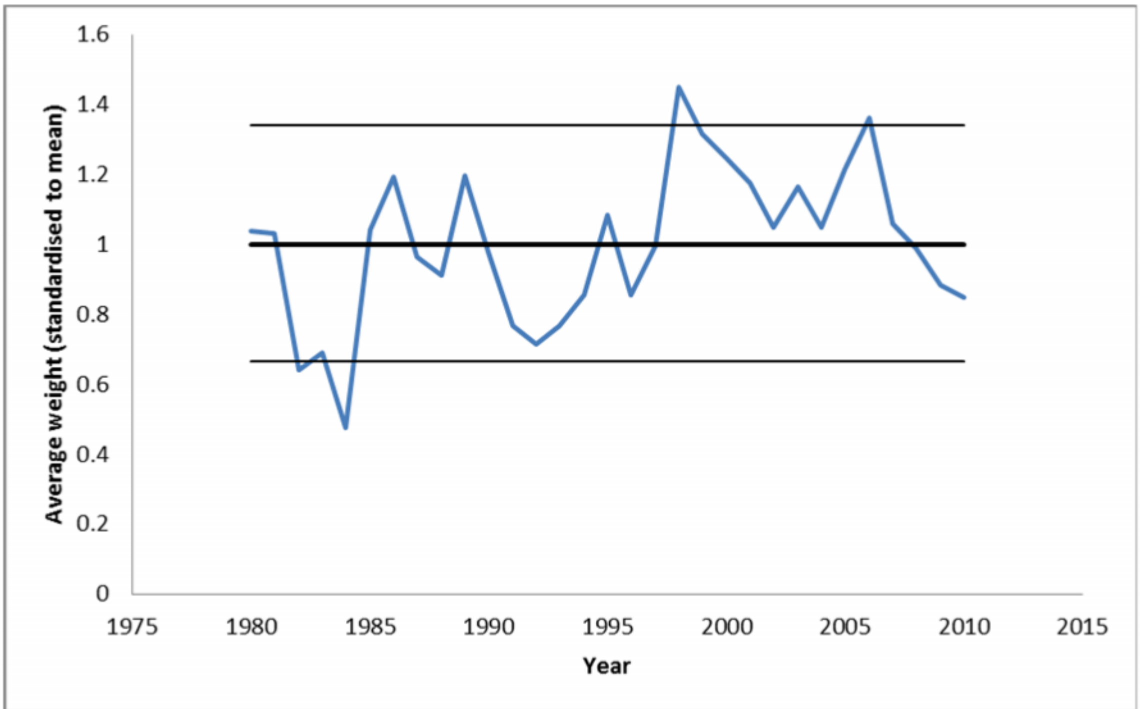

Figure 7: Average weight the Pole and Line fleets with 5th and 95th percentiles

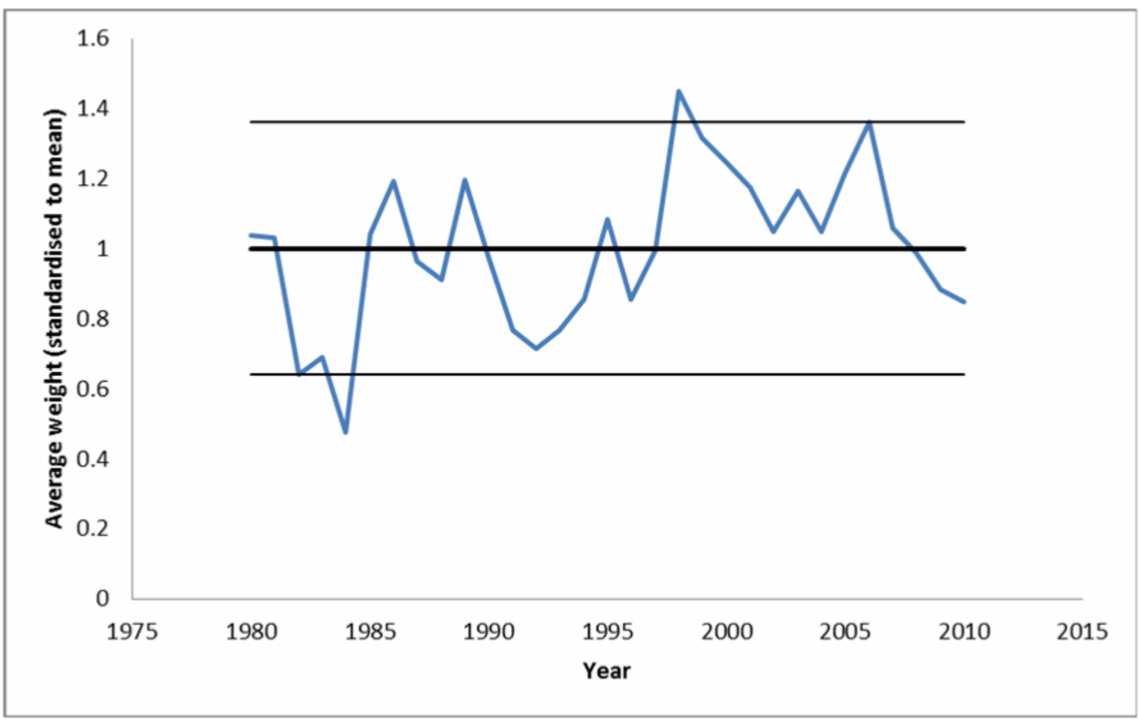

Figure 8: Average weight for pole and line fleets with 1.63 x standard deviations.

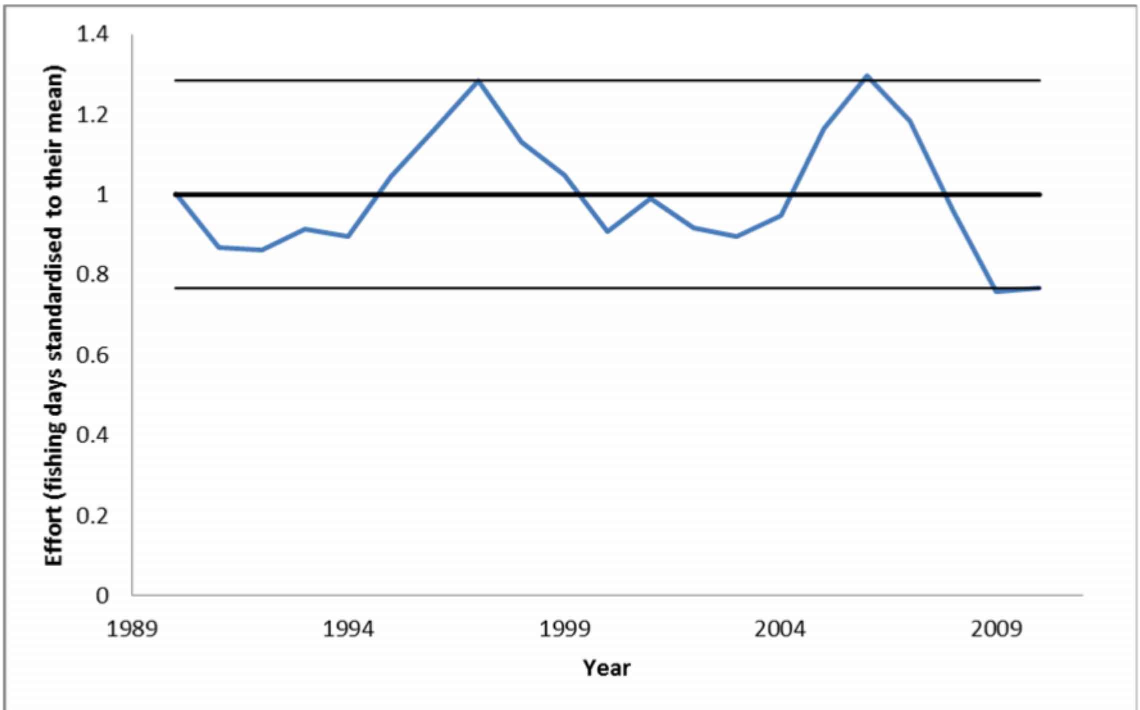

Figure 9: Effort for the Spanish purse siene fleet in fishing days, with 5th and 95th percentiles

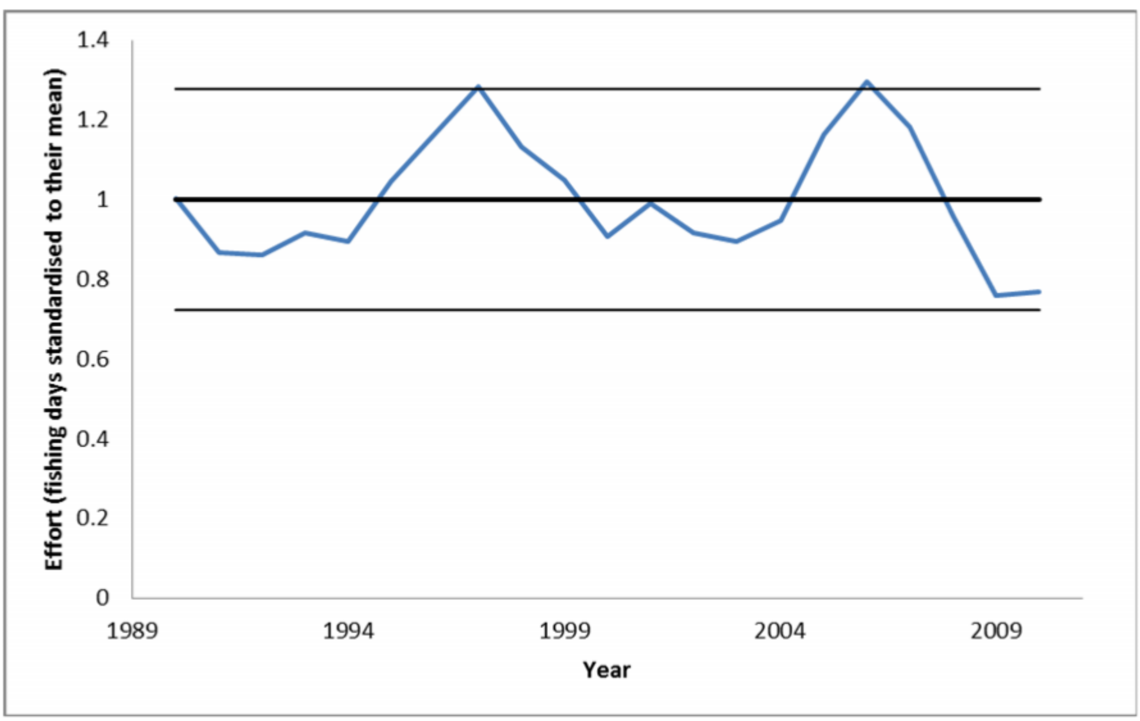

Figure 10: Effort for the Spanish purse siene fleet in fishing days, with 1.80 x standard deviations

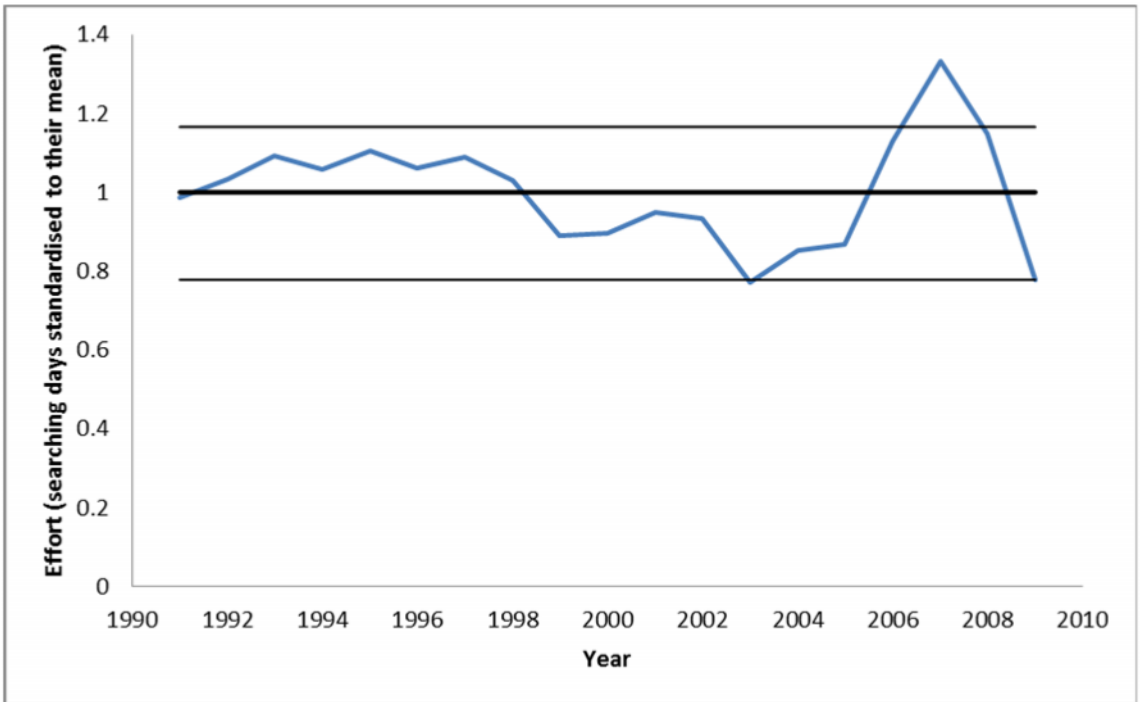

Figure 11: Effort for the French purse siene fleet in searching days, with 5th and 95th percentiles

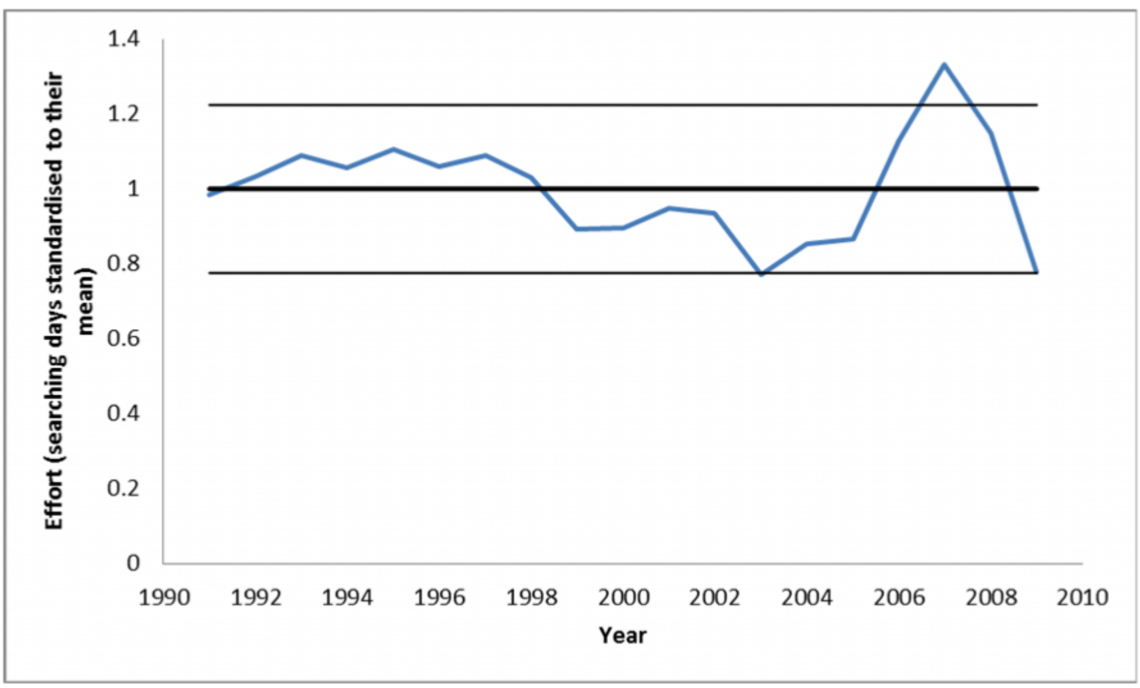

Figure 12: Effort for the French purse siene fleet in searching days, with 1.60 x standard deviations

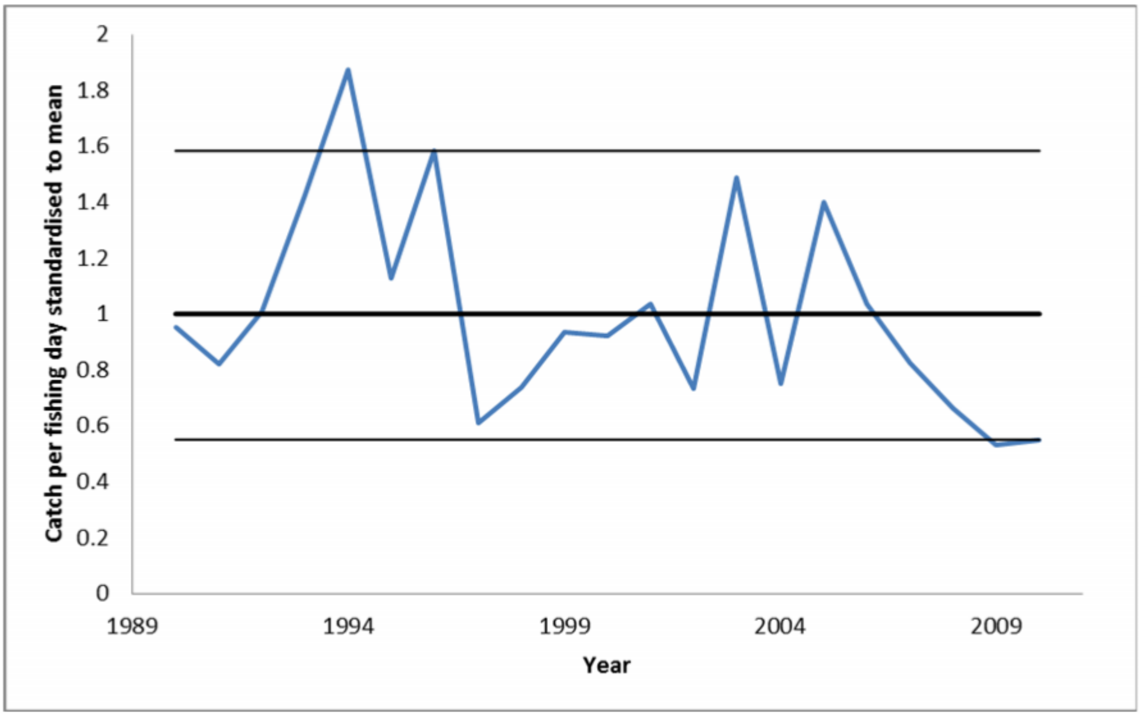

Figure 13: Catch rates (catch per fishing day) for the Spanish purse seine fleet targetting free schools with 5th and 95th percentiles

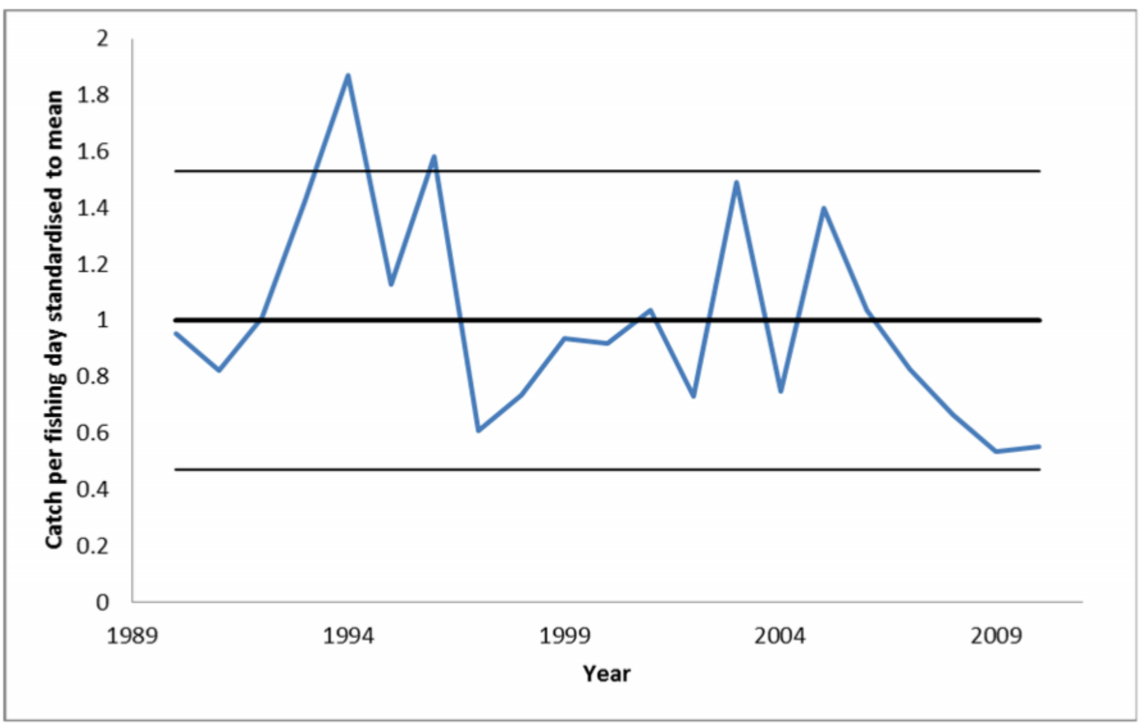

Figure 14: Catch rates (catch per fishing day) for the Spanish purse seine fleet targetting free schools with 1.45 x standard deviations

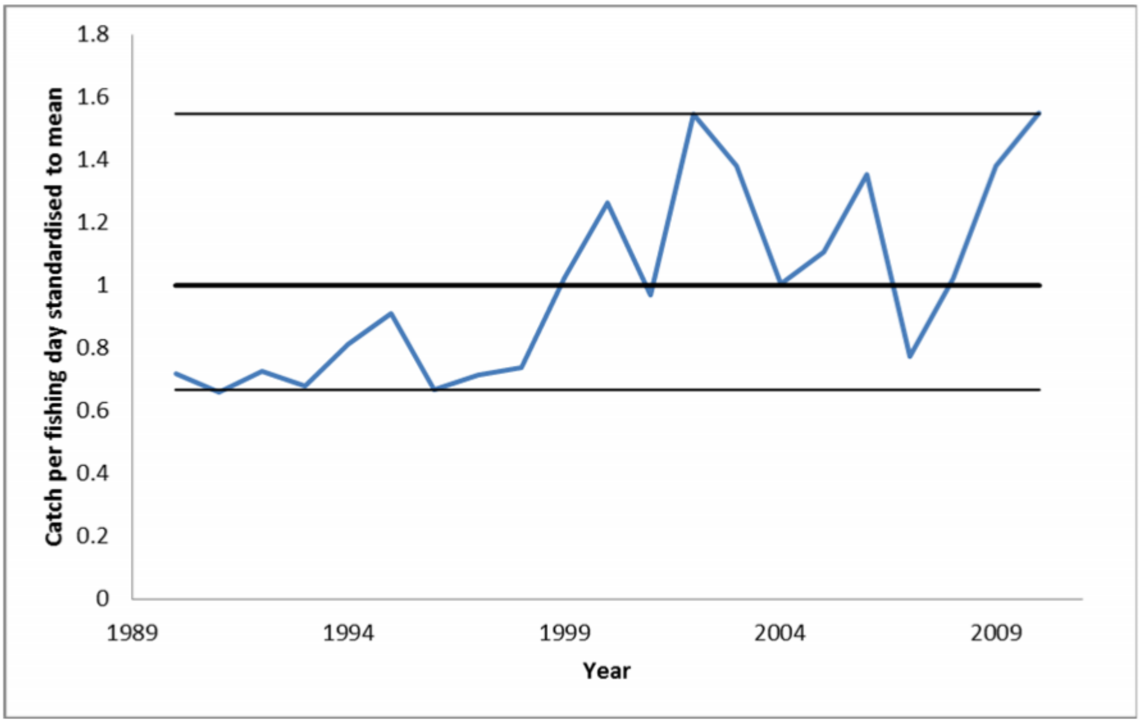

Figure 15: Catch rates (catch per fishing day) for the Spanish purse seine fleet targetting associated schools with 5^{th} and 95^{th} percentiles

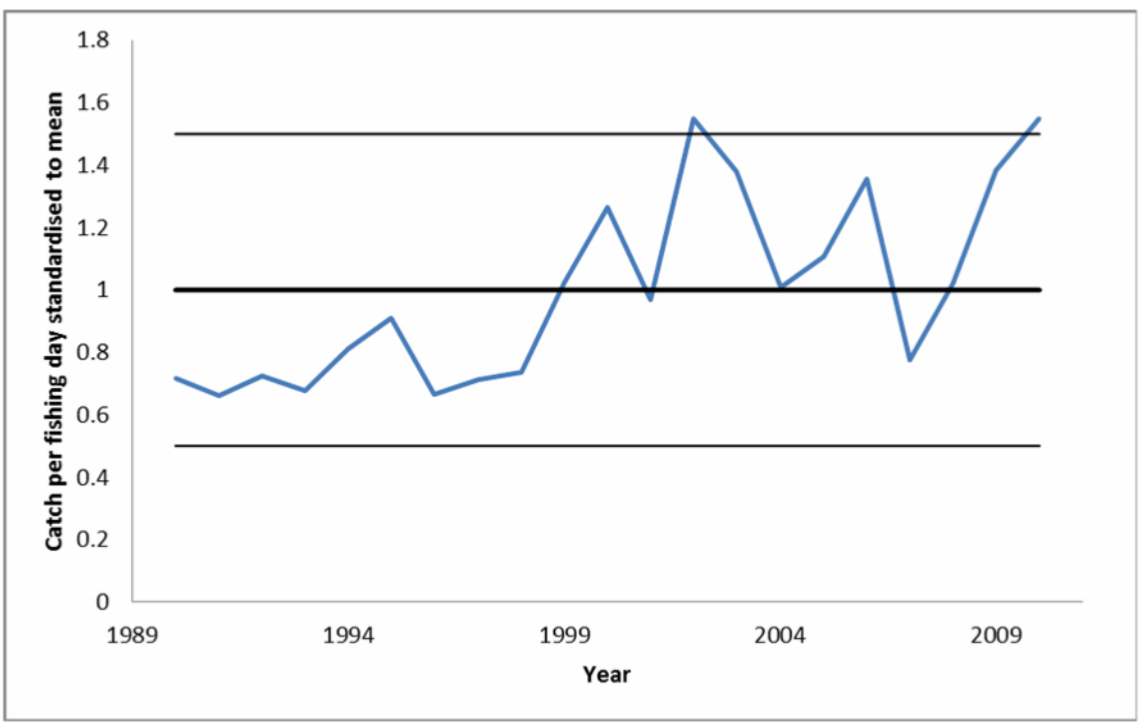

Figure 16: Catch rates (catch per fishing day) for the Spanish purse seine fleet targetting associated schools with 1.65 x standard deviations

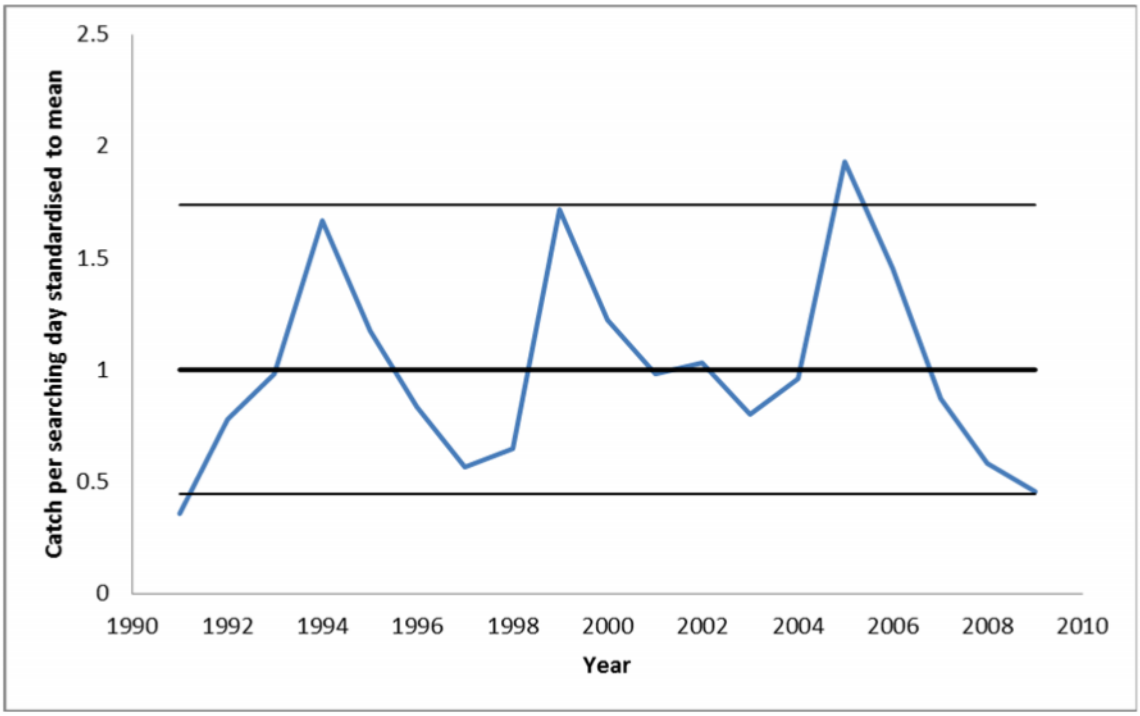

Figure 17: Catch rate (catch per searching day) for French purse seine fleet targetting free schools with 5th and 95th percentiles

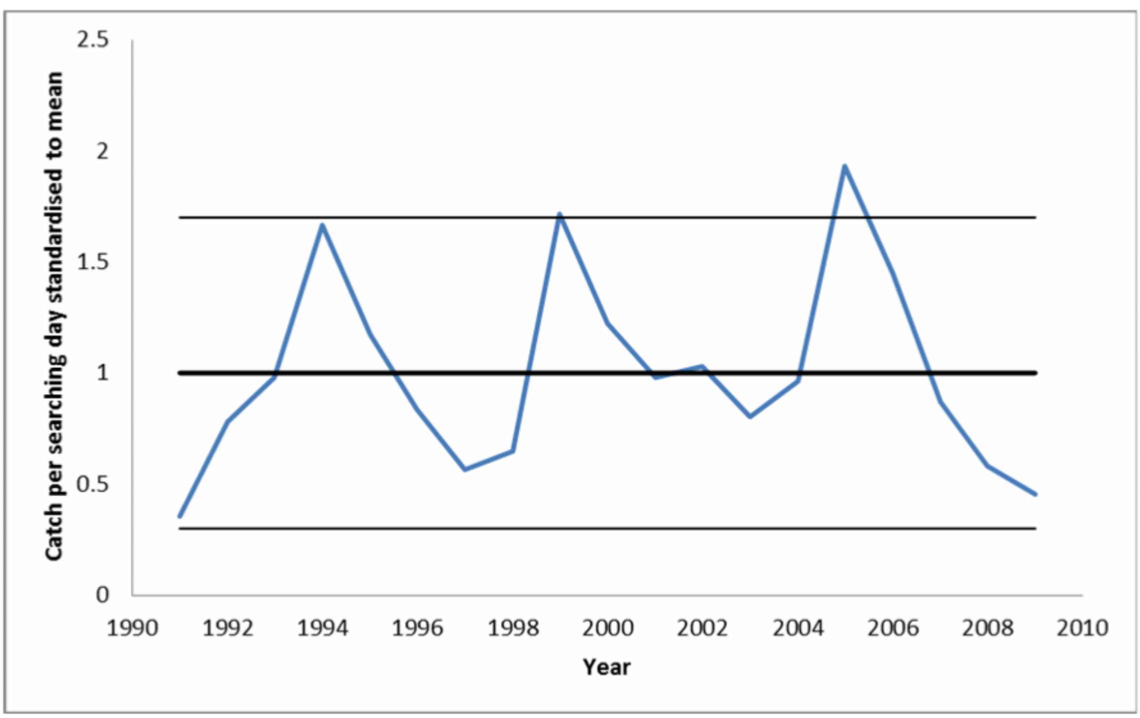

Figure 18: Catch rate (catch per searching day) for French purse seine fleet targetting free schools with 1.60 x standard deviations

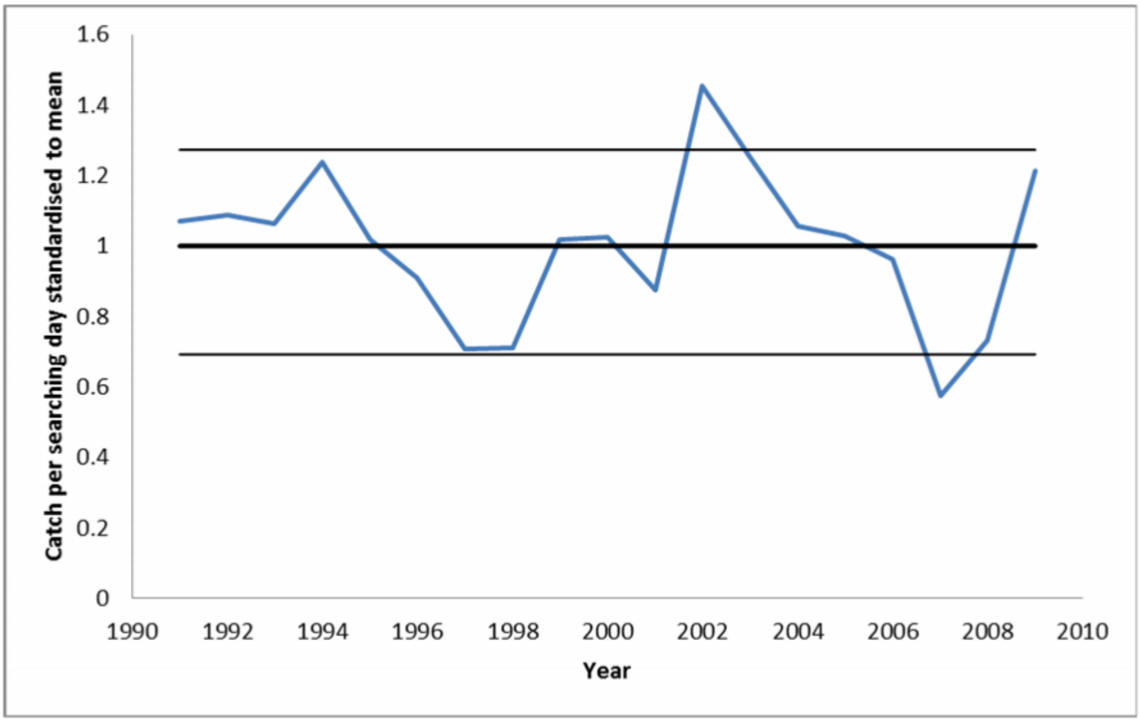

Figure 19: Catch rate (catch per searching day) for French purse seine fleet targetting associated schools with 5th and 95th percentiles

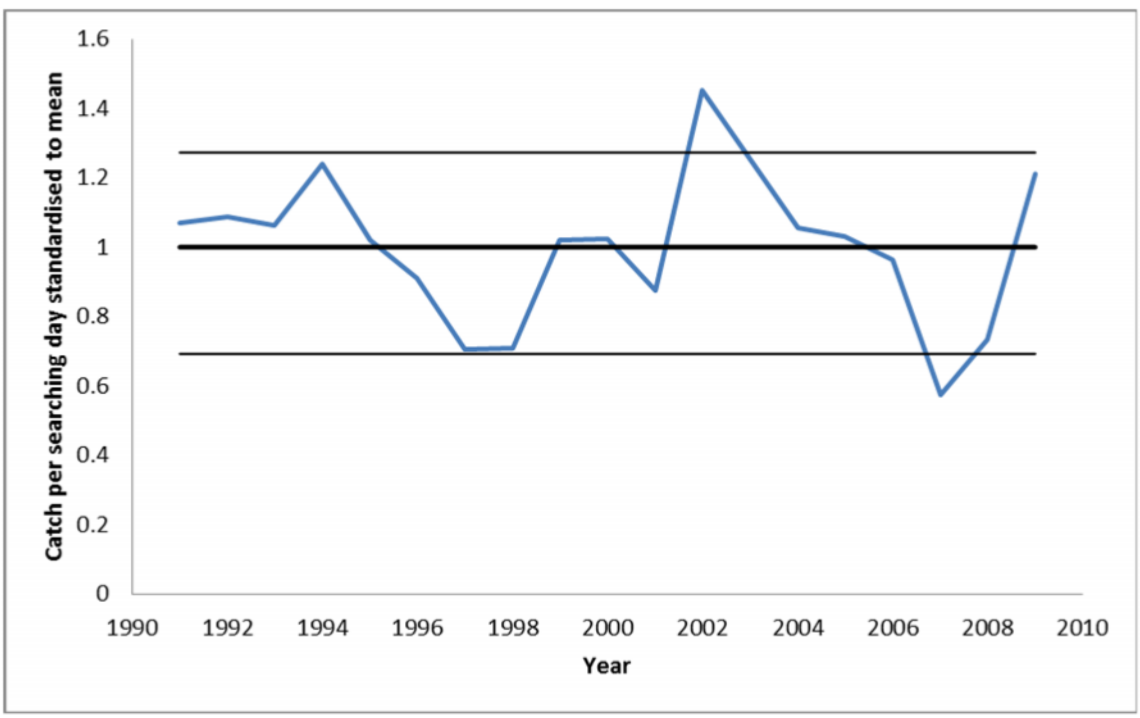

Figure 20: Catch rate (catch per searching day) for French purse seine fleet targetting associated schools with 1.65 x standard deviations

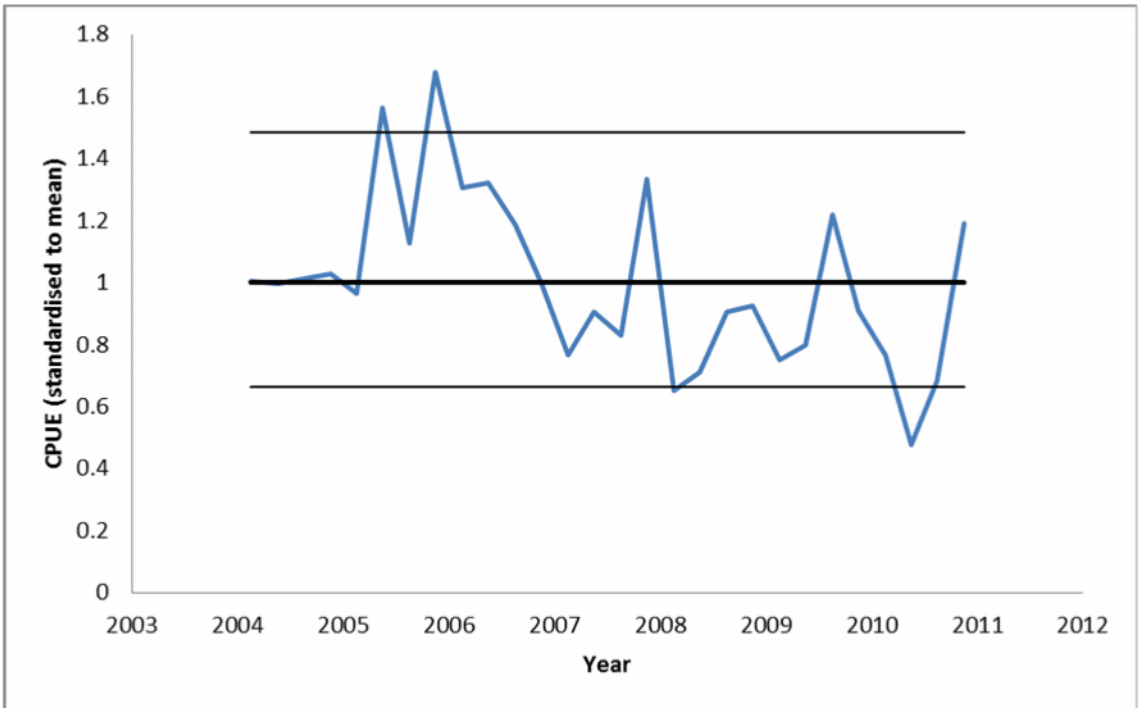

Figure 21: Standardised quarterly CPUE for the Maldivian pole and line fishery with 5th and 95th percentiles.

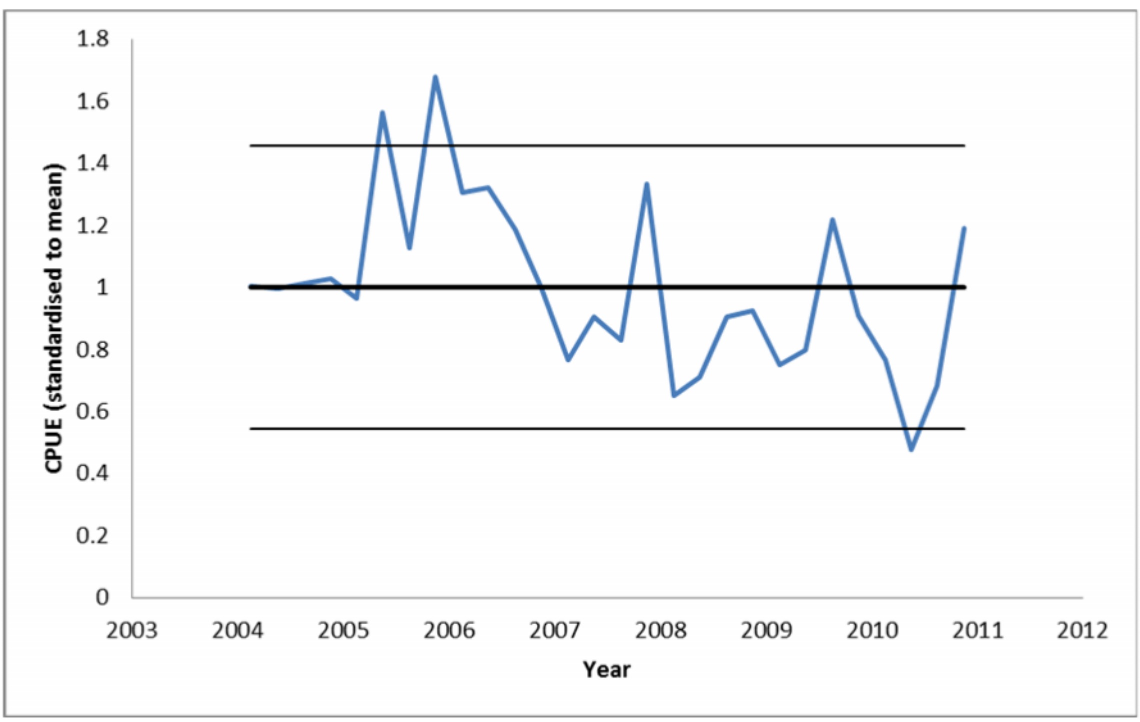

Figure 22: Standardised quarterly CPUE for the Maldivian pole and line fishery with 1.65 x standard deviations.