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The influence of catch rate on fishing effort – an investigation using south Pacific albacore as an example

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Summary

This paper explores the occurrence of zero fishing effort at low stock size, due to fishers' decisions to fish only when CPUE is high enough to ensure profitable margins. The analysis used a discrete fleet belonging to a single company targeting South Pacific albacore while fishing in a single EEZ. The analysis showed that between 2000 and 2014, CPUE is variable but shows a long gradual decline through the time series. When CPUE is high a high proportion of the fleet is active, but the proportion of active vessels drops sharply when albacore CPUE is low, particularly when CPUE declines below 20kg per 100 hooks.

This fleet behaviour, with longline effort declining as CPUE declined, could influence the reliability of CPUE as a measure of abundance. Standardised CPUE indices that do not account for this will be overly optimistic, as using data from vessels that only fish on "good days" will artificially inflate CPUE indices. These trends will also be impacted by global fish price, as high prices can sustain a vessel when CPUE is low, but when price and CPUE are both low vessels will elect not to fish.

It is recommended that fleet activity be taken into account in future CPUE standardisations, particularly for fisheries targeting relatively low value species such as albacore.

In order to facilitate these analyses, detailed fleet information and comprehensive operational level catch and effort data are required from all fleets. In turn, given the potential importance of economic drivers for understanding CPUE trends, the development of relevant economic indicators for monitoring and analysis is recommended.

The sensitivity of CPUE indices to changes in fleet activity should also be examined through simulation testing, using the process suggested in McKechnie *et al*. (2015).

Introduction

In the absence of fishery independent survey information, standardised catch per unit effort (CPUE) indices are often used as in index of abundance in stock assessment models. It is assumed that fluctuations in these indices represent changes in abundance and that these changes are proportional to changes in stock biomass. All stock assessments of tuna carried out by the Secretariat of the Pacific Community (SPC) using MULTIFAN-CL (MFCL) use CPUE to inform abundance trends. Despite attempts to standardise the CPUE unknown external factors such as fisher decisions about when to fish are difficult to assess and include in the model standardisation.

The stock assessments for south Pacific albacore tuna (*Thunnus alalunga*) like other tuna assessments use MFCL and standardised CPUE trends to estimate stock status (Hoyle *et al*. 2012, Harley 2015). Achieving a minimum level of albacore CPUE is important for the commercial viability of fishing fleets targeting this species, and there is concern that the current high catch levels may affect the sustainability of albacore fisheries (Hoyle *et al*. 2012). There have been suggestions that when CPUE is very low fishers will not fish as it is not economically viable to do so. If fishers only fish when catch rates are high CPUE could become hyperstable which can result in overestimated stock biomass and underestimated fishing mortality (Crecco and Overholtz 1990).

This paper used data from a single longline fleet, fishing in the economic exclusive zone (EEZ) of a single country, in the core of the South Pacific albacore distribution to explore the impact of changing CPUE on a fishing fleet's willingness to fish for albacore tuna.

Methods

A single longline fleet for which the SPC has comprehensive operational data was selected for the analysis. This fleet has provided logsheet data to the SPC through the countries data submission requirements for more than 15 years; the fleet fishes almost entirely within a single EEZ; they target albacore throughout the year; and the EEZ is located within the core of the South Pacific albacore distribution.

A list of vessel names were provided by the fishing company and all associated logsheet data were extracted from the SPC Catch and Effort query System (CES). All analyses were performed in R (R Core Team).

CPUE was derived from catch (kg) and effort (hundreds of hooks) data at the level of the set from 2000-2014. The mean and standard deviation of unstandardized CPUE were collated weekly for the fleet. These data were plotted against the monthly albacore value derived from the Thailand customs values (US$) for imported frozen albacore, provided by Peter Terawasi at the Forum Fisheries Agency (FFA).

The total number of vessels underlying the data was obtained for each year (Figure 1) and weekly effort was obtained from the logsheet activity. Fleet activity was measured by assessing the proportion of the fleet active weekly, compared to the annual maximum. The proportion of vessels active in the fleet was calculated weekly through the times series and plotted against CPUE, a loess smoother was fitted to the data with and without zeros and the smoothness parameter was set at 1/3.

Results

The unstandardized CPUE is variable but shows a long gradual decline through the time series. In all years CPUE for this fleet is seasonal with low CPUE in the first quarter of the year and higher CPUE in the second and third quarters. In the first half of the series notable declines in CPUE were observed in early 2003 and 2004, CPUE was generally depressed between 2011 and 2014 (Figure 1).

Albacore price fluctuated between $1700 and $2800 per tonne between 2000 and 2010, but rose sharply through 2011 to peak in mid-2012, and then declined through to late-2013 (Figure 1).

When CPUE was high a high proportion of the fleet was active in most weeks, but the proportion of active vessels drops sharply when albacore CPUE is low, particularly when CPUE falls below 20kg per 100 hooks (Figure 2). Retaining the zero values in the dataset strengthens the estimated decline in the proportion of active vessels (compare solid and dotted lines in Figure 2).

The proportion of active vessels in the fleet declines through the time series (Figure 3). Zero effort weeks may be a result of external factors e.g. bad weather that result in vessels being unable to fish (forced zero-effort) or internal fishery factors e.g. low CPUE (elective zero-effort) or other factors such as holidays, or missing data that result in the appearance of no effort.

Discussion

Ianelli *et al.* (2012) noted that problems in tuna assessments occur when there are conflicts between CPUE and other data series. When these conflicts occur in assessment models they raise concerns as to the reliability of CPUE as an accurate index of abundance. Concerns are also raised when targeting practices change that increase the fishers' ability to catch fish. When this occurs the assumption that the CPUE index mirrors trends in abundance fails and alternative measures of abundance or CPUE series should be used. Alternatively CPUE standardisation that account for changes in fishing practices can result in an index that better represents change in actual biomass. This paper attempts to assess whether the state of the fishery influences a fishers decisions to fish, which could influence the reliability of CPUE as a measure of abundance.

Two things are apparent from the analysis, firstly, CPUE is variable but shows a long gradual decline through the time series; secondly, when CPUE is high a high proportion of the fleet is active, but the proportion of active vessels drops sharply when albacore CPUE is low, particularly when CPUE gets below 20kg per 100 hooks.

In these data there are numerous instances when fleet activity dropped to zero in a week. These may be a result of external factors such as bad weather that result in all vessels being unable to fish (forced zero-effort); or internal fishery factors where low CPUE means that fishers choose not to fish (elective zero-effort); or missing data that result in the appearance of no effort. These clearly impact the dataset and need further investigation to separate the true elective zero-effort, which should be accounted for in CPUE standardisation, from forced zero-effort which should not. This would require further analysis and detailed discussion with fishing companies to tease out these effects.

The albacore sale price (relative to other tuna species) is low. As a result, vessels targeting albacore require relatively high catch rates (as well as valuable bycatch of other species) to remain profitable. Taking the decision not to fish when catch rates are low makes economic sense as vessel owners will not want to incur fishing costs above profit margins. When CPUE drops below 20kg per 100 hooks vessel activity decreases strongly, this suggests that the CPUE index currently excludes data when CPUE is low. The impact of this would be that CPUE is unintentionally positively biased at the end of the series.

This analysis highlights the potential bias in standardised CPUE indices when a vessels decision to fish is based on fish catch rates. As this has not been taken into account during the CPUE standardisations for the 2015 albacore stock assessment (Tremblay-Boyer *et al.* 2015) these indices for albacore target fleets are potentially overly optimistic in years when catch rates are low. Other factors are also likely to influence fishing effort, such as fluctuations in albacore sale price, which will affect the profitability of fishing and hence willingness to fish. This will require further investigation.

It is recommended that fleet activity be taken into account in future CPUE standardisations, particularly for fisheries targeting relatively low value species such as albacore.

In order to facilitate these analyses, detailed fleet information and comprehensive operational level catch and effort data are required from all fleets. Given the potential importance of economic drivers for understanding CPUE trends, the development of relevant economic indicators for monitoring and analysis is recommended.

The sensitivity of CPUE indices to changes in fleet activity should also be examined through simulation testing, using the process suggested in McKechnie *et al*. (2015).

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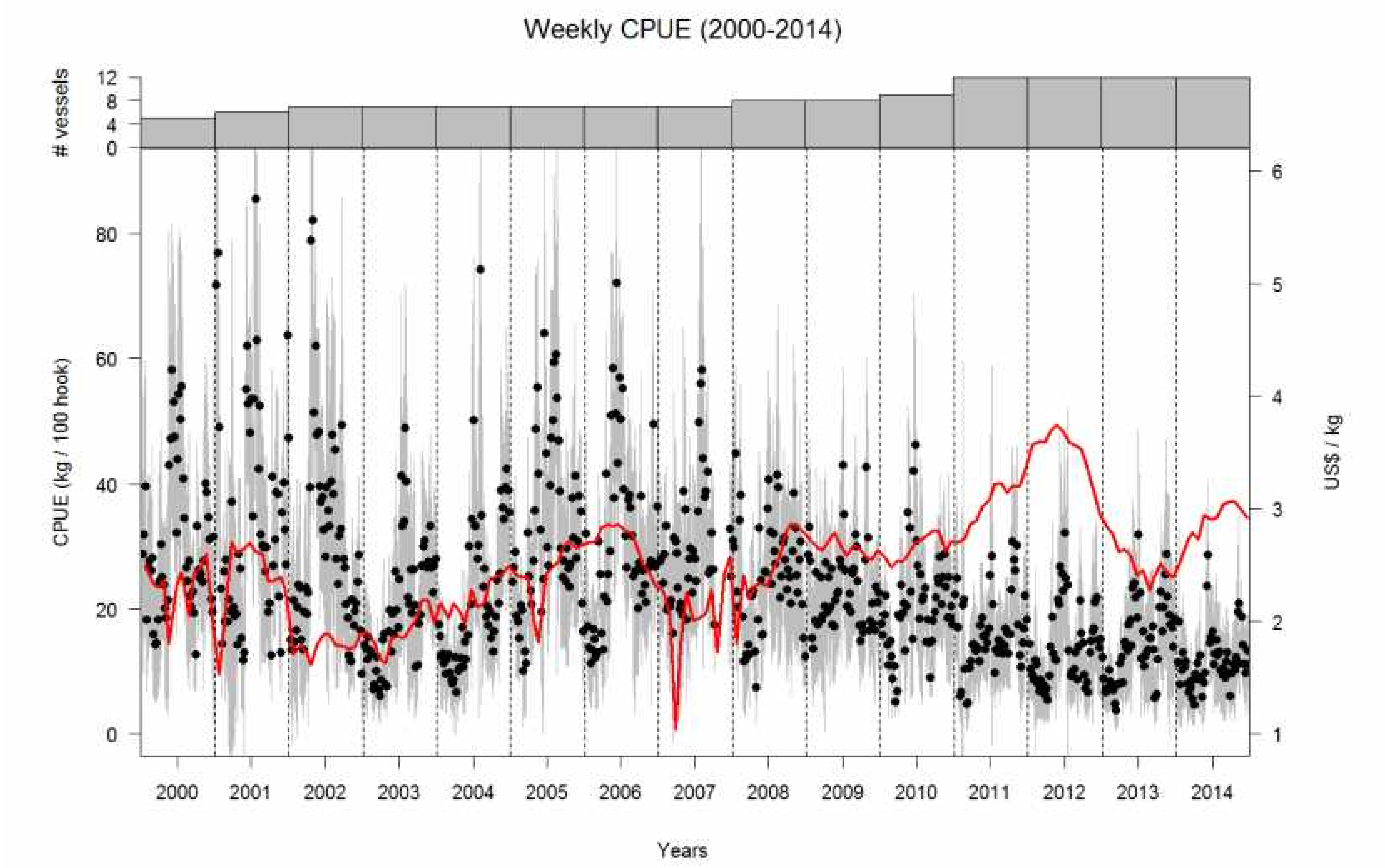

Figure 1: Mean weekly catch per unit effort (CPUE) (black points) and CPUE standard deviation (shaded area) for the vessels in the analysis from 01 January 2000 to 31 December 2014. The red line represents monthly Thailand customs import price (US$ per kilogram) for albacore through the time period. The number of vessels fishing per year are shown by the grey bars (top).

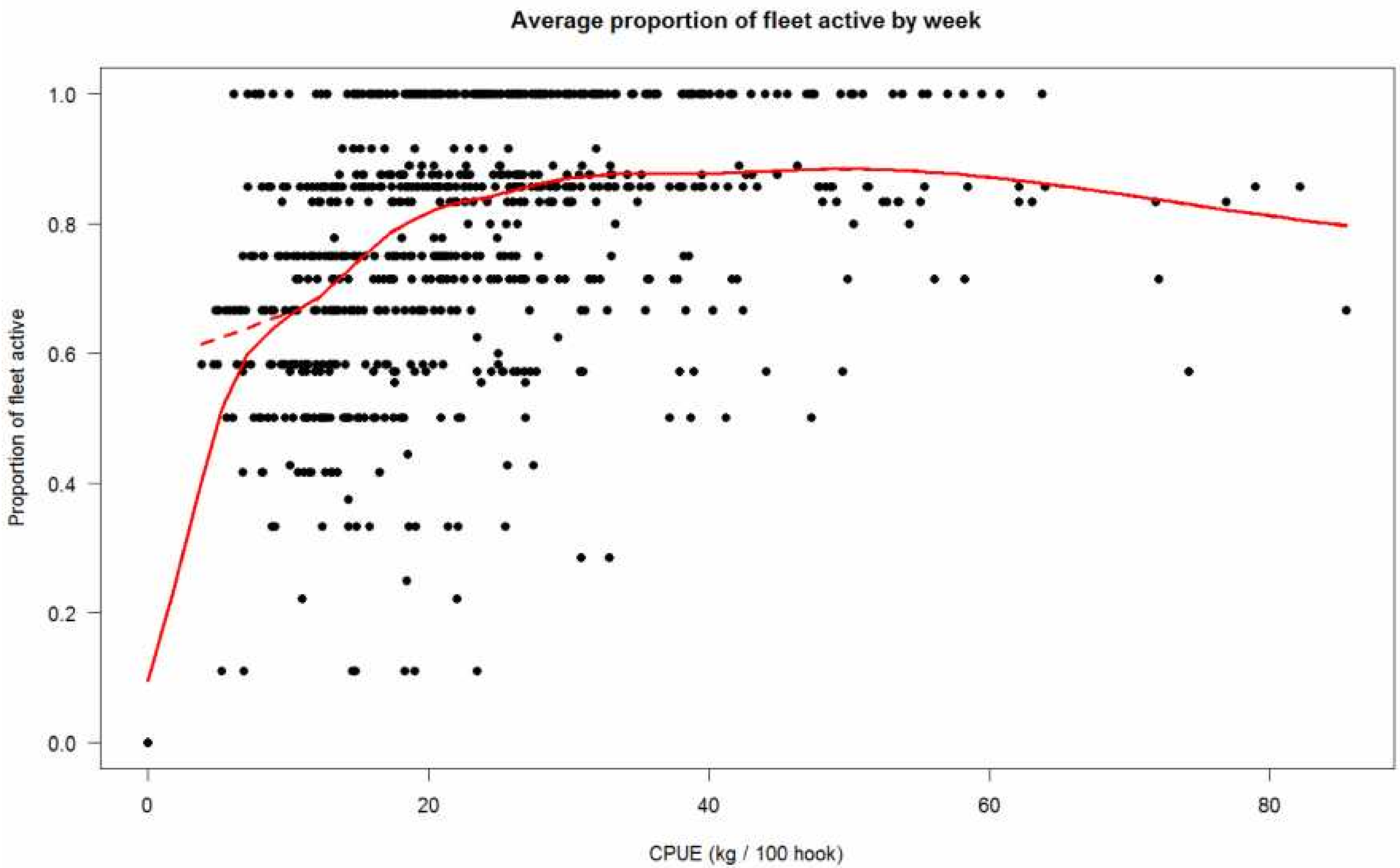

Figure 2: The proportion of vessels active plotted against mean weekly catch per unit effort (CPUE) (black points), a loess smoother was fitted to the data with (solid red line) and without (dashed red line) zeros.

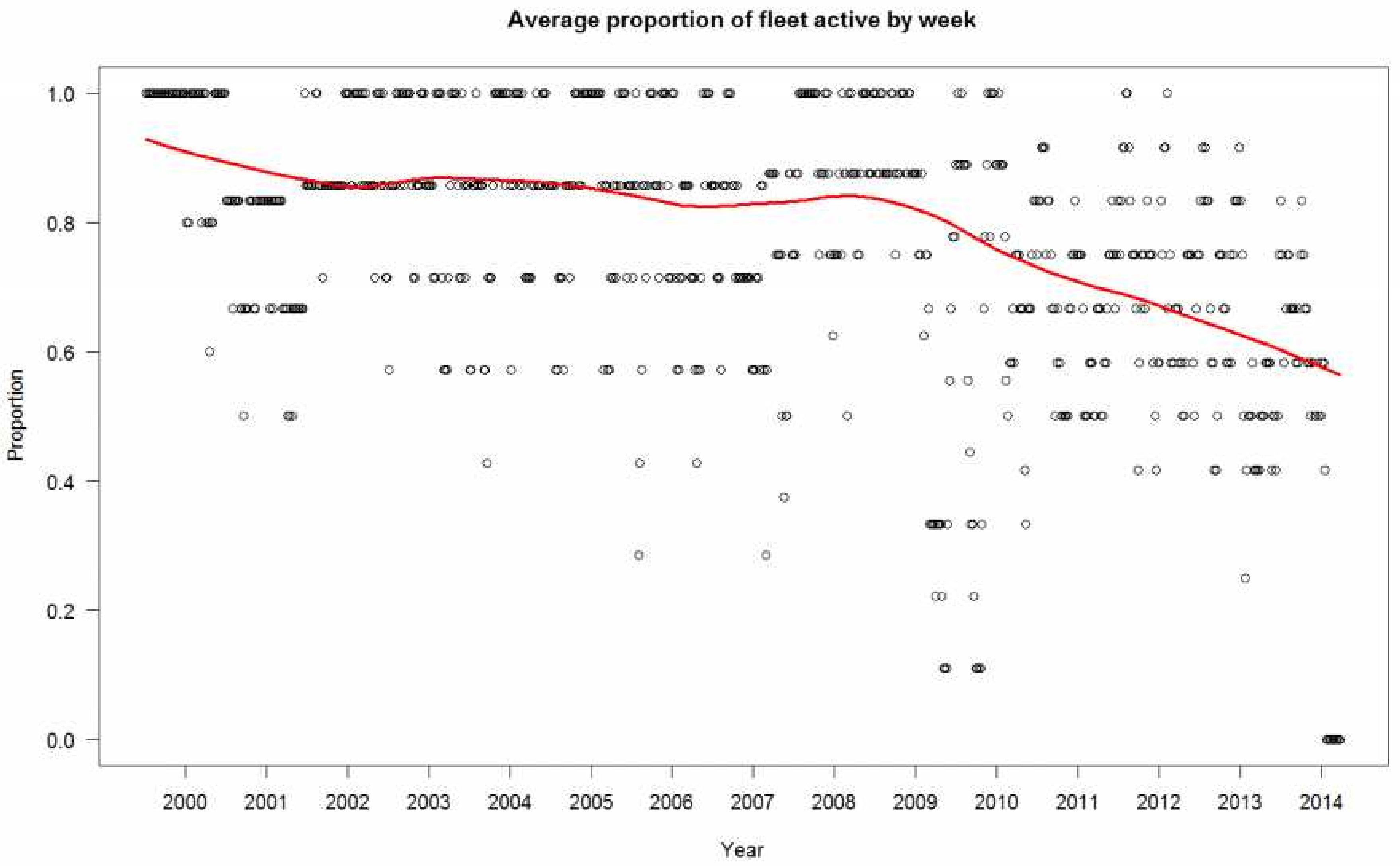

Figure 3: The proportion of vessels active weekly through the time series with a loess smoother fitted to the data (red line).