A novel approach to obtain indices of abundance of tropical tunas from echosounder buoys

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Summary

Echo-sounder buoys attached to Fish Aggregating Devices (FADs) provide fishers with real-time information about the geolocation of the FADs and the biomass of tuna aggregation underneath. Biomass acoustic records derived from echo-sounder buoys also entail an opportunity to develop alternative abundance indices. This work presents a novel approach to derive a Buoy-derived Abundance Index (BAI) which potentially could be incorporated to the assessment of tropical tuna stocks. This study also shows the preliminary application of the methodology to obtain direct indices of abundance of juvenile yellowfin tuna in the Atlantic and Indian oceans. The acoustic signal, collected in specific depth ranges, time of the day and period of the FAD drift, was standardized using Generalized Linear Mixed Modelling (GLMM) approach. The standardization process assumes that the acoustic signal from the echo-sounder is proportional to the abundance of tuna.

Introduction

Fishing efficiency and dynamics of the fleet are evolving very rapidly in the tropical tuna purse seine fishing due to the technological development and the increase of the use of FADs. This makes difficult to obtain reliable Catch per Unit Effort (CPUE) indices from purse seine tropical tuna fisheries fishing on FADs, despite some recent projects (CECOFAD1 and CECOFAD2, Gaertner et al., 2016) advances to improve PS CPUE indices and the understanding of the FAD use. In the context of these projects, the collaboration with the Spanish vessel-owners associations and the buoy-providers companies has allowed the recovery of the satellite tracking echosounder buoys information used by the Spanish tropical tuna purse seiners and associated fleet in the Atlantic and the Indian oceans for the period 2010-2018. These instrumental buoys remotely inform fishers the accurate geolocation of the FAD in real-time and the presence and abundance of tuna aggregations underneath them. As such, being a privileged remote observation platform, echosounder buoys have the potential to produce abundance indices of tunas and accompanying species using catch-independent data (Dagorn et al., 2006; Lopez et al., 2014; Santiago et al., 2016). This document presents a summary of the methodology to obtain novel indices of abundance of juvenile yellowfin tuna in the Atlantic and Indian oceans derived from echosounder buoys from 2010 to 2018. Moreover, preliminary results for the juvenile yellowfin abundance index in the Atlantic Ocean are also shown.

Materials and methods

The model is based in the same assumption of the fundamental relationship among CPUE and abundance widely used in quantitative fisheries analysis. We built the index based on the assumption that the signal from the echosounder is proportional to the abundance of fish (Santiago et al., 2016), $\mathrm{BAI_t} = \varphi \, . \, \mathrm{B_t}$, where BAI_t is the Buoy-derived Abundance Index, ϕ is the coefficient of proportionality and B_t is the biomass in time t.

Current echosounder buoys provide a single acoustic value without discriminating species or size composition of the fish underneath the FAD. Therefore, it was necessary to combine echosounder buoys acoustic signal with fishery data, species composition and average size (extracted from ICCAT and IOTC Task 2 of the purse seine fleet fishing on FADs), to convert acoustic signals on species specific abundance indicators.

Acoustic data cleaning included the removal of outliers related to bad geolocation, time, or other general variables. Data filtering included the exclusion of acoustic information from a) shallower layers (<25m) to eliminate noise from the non-tuna species associated to the FAD (Lopez et al., 2017); b) buoys located in areas with a bottom depth shallower than 200 m; c) onboard measurements; d) information outside of the time range between 4 a.m. and 8 a.m., when tuna is more closely aggregated around the FADs (Josse et al., 1998). Only acoustics records of “virgin segments” were considered in the analysis. A virgin segment was defined as the segment of a buoy trajectory from 20-35 days at sea, so that the associated FAD likely represents a new deployment which has been potentially colonized by tuna and not already fished (Orue et al., 2019). Sequences having a time difference between any of the consecutive observations longer than 4 days during the first 35 days were also excluded. The estimator of abundance BAI was defined as the 0.9 quantile of the integrated acoustic energy observations in each of the "virgin" segments. Figure 1 shows a diagram with an example of “virgin” segments used for the calculation of the BAI index.

As with the catchability, the coefficient of proportionality ϕ between the index BAI and the abundance is not constant for many reasons. In order to ensure that ϕ can be assumed to be constant, a standardization analysis was performed aiming to remove factors other than changes in abundance of the population. Delta lognormal analyses (Lo et al., 1992) were carried out using a binomial distribution for the probability of the acoustic record being zero and a probability distribution f(y), where y was log (BAI), for non-zero (positive) observations.

Results and discussion

Acoustic data (echo integration) is commonly taken as an estimator of abundance and is used to provide acoustic abundance estimation of many pelagic species. We used acoustic data from echo sounder buoys to estimate abundance of juveniles of yellowfin tuna in the Atlantic and the Indian ocean. In this document we present some results for the Atlantic Ocean (Santiago et al., 2019). From a total of 5 million of acoustic records from over 36,000 Satlink buoys from January 2010 to December 2017, we selected 49,880 biomass acoustic observations for a Delta lognormal GLMM standardization. Each observation was the 90% percentile of biomass estimation from a “virgin” segment of the buoy. In this analysis an index of the biomass of yellowfin tuna aggregated under FADs from the acoustic signal was obtained. The BAI index represents an indicator of YFT juvenile abundance; a modal size of 46cm corresponding to around 1 year of life.

The estimates of the delta lognormal are provided Figure 2. Most of the nominal values are embedded within the confidence interval of the standardized BAI index. The BAI index shows a general decreasing trend at the beginning of the series, from 2010 to 2012; then a stabilization period at a low level from 2013 to 2016, followed by an increasing trend in 2017 to levels of the beginning of the series. The CVs remain relatively stable (between 10-16%) during the whole time series.

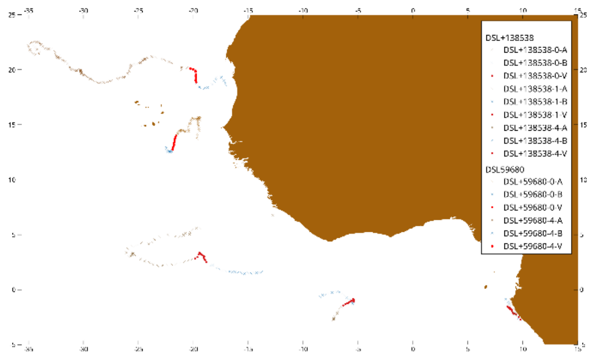

Figure 1. Example of “virgin” segments used for the calculation of the BAI index. Trajectories correspond to buoy DSL59680 and DSL+138538 with different paths representing drifts of different FADs.

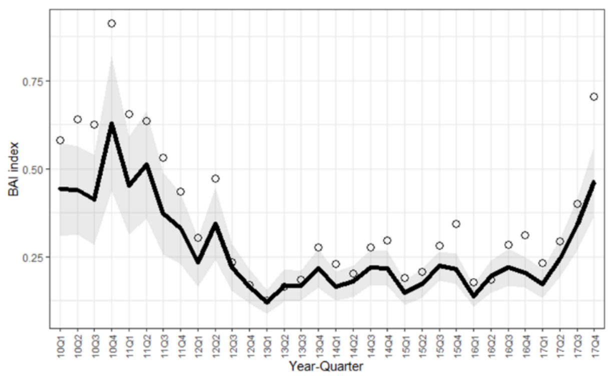

Figure 2. Time series of nominal (circles) and standardized (continuous line) BAI index for the period 2010-2017 for YFT in the Atlantic Ocean. The 95% upper and lower confidence intervals of the standardized BAI index are shown.

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