Treatment of acoustic data obtained from echosounder buoys for tuna biomass estimates

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Summary

Satellite linked echo-sounder buoys are deployed with fish aggregating devices (FADs) in tropical tuna fishery allowing skippers to monitor in real time the track of the FADs and the aggregation of fish underneath. The extensive use of echosounder buoys provides valuable acoustic data that, properly treated, can be used for monitoring tropical tuna biomass. Thanks to the collaboration with buoy manufacturers and vessel owners of ANABAC and OPAGAC, historic information from echosounder buoys in the Indian and Atlantic Ocean has been gathered for the 2010-2018 period. Different echosounder brands in use provide each own biomass index derived from the acoustic signal, and therefore inter-buoy/brand harmonization approach for acoustic signal consistency is needed. Thus, in this work a method for setting all data sources at same acoustic units and sampling volume is proposed. Latest findings of species-specific target strengths (TS), species-specific composition and fish lengths information by area are integrated to convert the acoustic signal on biomass estimation.

Introduction

Echosounder buoys are privileged observation platforms to evaluate the presence and abundance of tuna. Buoy acoustic signals may be used to directly estimate the presence of tuna and the local and regional relative abundance of tunas under drifting FADs, i.e., the Buoy-derived Abundance Index (Santiago et al., 2016, 2019). Based on the experience gained in previous studies which were focused on re-estimating biomass given by echosounder buoys in order to be used for scientific purposes (Lopez et al., 2016; Orue et al., 2019), new methodologies are being applied for further exploring and tuning the algorithms for biomass estimates. This work presents a new approach in the analysis of acoustic information given by echosounder buoys.

Material and Methods

In order to integrate information coming from different buoy models (i.e. different models from Satlink and Marine Instrument, MI) we propose a standardization approach for setting all data sources at equivalent acoustic units and sampling volume. The flow chart shown in Annex 1 displays all steps fulfilled in this approach.

The very first step is the inclusion of latitude and longitude values in the acoustic Satlink database, which was provided without geolocation. A unique latitude/ longitude value was available for the acoustic data recorded in a given day, but each acoustic register had the real stored time. Consequently, the position for each acoustic record was interpolated based on this stored time.

In relation to harmonization of acoustic parameters used to calculate the biomass, Satlink uses a target strength ~ length relation calculated from typical density of one main tropical tuna species to provide biomass in tons. In a first step biomass data from Satlink is converted to volume backscatter (Sv) in decibels reversing their formula for the biomass computation (Equation 1). Then target strength and length values defined at the table 1 were used to recalculate the biomass. In contrast, MI provides a 0-7 or 0-15 scaled presence indices, which were converted to decibels using conversion tables provided by the manufacturer. Afterwards Sv from layers supposed to contain tuna is linearized.

Sampling angles (M3I=36º; M4I=42º; M3I+=36º; DSL+=32º; ISL+=32º) and detection ranges (MI: 150 meters divided in 50 layers of 3 meters, discarding the first 6 meters or blind area; Satlink: 115 meters divided in 10 layers of 11.2 meters and discarding the first 3 meters or blind area) are taken into account to sample the same volume and minimize differences between frequencies (MI: 50 kHz; Satlink: 190.5 kHz). In this sense, the same depth ranges are set for both data sources (MI and Satlink), where the first vertical range is a blind zone (0-6m), the second one (6-25m) is associated to bycatch, the third one (25-115m) to tuna.

Finally, target strength values, mean fish lengths and species distributions are incorporated to estimate the biomass using standard abundance estimations equations (Simmonds and Maclennan, 2005):

(Equation 1) $$Biomass_i = \frac{s_V \cdot Vol \cdot p_i}{\sum_i \sigma_i \cdot p_i}$$

where *Vol* is the sampled volume and σ_i, p_i and w_i are the linearized target strength, proportion and mean weight of each species *i* respectively.

Species proportions in weight were extracted preliminarily from ICCAT or IOTC T2 data of the EU fleet for each 1ºx1º and month stratum. Then, TS-length relationships were used:

(Equation 2) $$\sigma_i = \frac{10^{(20\log(L_i)+b_{20,i})/10}}{w_i}$$

Different brands and models use different operating frequencies. In this sense, b_{20} values used at this study for the SKJ were calculated by a 200 kHz echosounder (Boyra et al., 2018). For YFT and BET, b20 values from (Oshima, 2008) were selected and they were obtained by a 38 kHz echosounder. Given the scarcity of published b_{20} studies for the target species, the used values are considered preliminary. Hence, as new TS-Length relationships are currently being analyzed, they will be integrated into the methodology when they are ready.
All parameters are specified at the table 1. Optimum deep layers were adopted and biomass below 25 meters depth is gathered one layer of tuna (Orue et al., 2019).

Table 1. Range, species, target strength, mean fish length and species distribution in % parameters used in this study.

Range	6-25m (bycatch layer)		25-115m (tuna layer)	
Species	Bycatch	Skypjack	Bigeye	Yellowfin
TS (b20)	68.7	-70.5	-63.5	-68.7
Mean Fish Length (cm)	30	Mean by strata*	Mean by strata*	Mean by strata*
Species distribution (%)	100	% by strata*	% by strata*	% by strata*

**Source: from ICCAT or IOTC resources*

Conclusions

The data collected by fishers' echo-sounder buoys are not originally intended to be used for scientific purposes but for fishing. However, they offer large-scale interesting information that should be used for scientific purposes. The method presented here aims to convert information received from different sources in a common unit and improve the biomass estimates provided originally by manufacturers following the work of Lopez et al (2016) and Orue et al., (2019) by using new TS values and introducing the seasonal and spatial variability in species and size composition. This is a novel approach that has been applied to obtain indices of abundance of tropical tunas from echosounder buoys (Santiago et al., 2019).

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Annex 1. Flow chart of the standardization steps.