From fishermen´ to scientific tools: Progress on the recovery and standardized processing of echosounder buoys data

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Summary

The introduction of FADs in conjunctions with the satellite linked echo-sounder buoys was one of the most significant innovation introduced in the industrial tropical tuna purse seine fishery. These buoys provide information on the accurate geo-location of the floating object and estimation of fish biomass aggregated underneath the FAD along its trajectory, which increases the efficiency of the fishing operations. The collaborative work among the fishing industry, buoys suppliers and research institutions allow gathering unique information on buoy tracks and acoustic records which turn the echo-sounder buoys into valuable observation platforms for scientific purposes. This information is contributing to the knowledge about buoy use, FAD dynamics and the behavior and ecology of tuna and non-tuna species associated with floating objects. In addition, alternative indicators of tuna biomass and fishing effort can be derived, which could help to assess natural variations on target species abundance and improved scientific advice for stock assessment. This work presents the progress so far in the collection and pre-processing of buoy derived data in the frame of EU RECOLAPE project, which have enabled to go beyond the current RFMOs FAD data requirements.

Introduction

In tropical tuna purse seine fishery, fishing efficiency and dynamics of the fleet, are evolving rapidly due to the fast technological development (Torres-Irineo et al, 2014) and the increase of the use of Fish Aggregating Devices (FADs) (Scott and Lopez, 2014). This evolution makes it difficult to obtain reliable CPUE indices for tropical tunas from purse fisheries fishing with DFADs. Therefore, initiatives such as the EU funded RECOLAPE project, is focusing on understanding of the use of FADs in tropical purse seine tuna fisheries and trying to provide reliable estimates of abundance indices. As such, one of the objectives of the RECOLAPE EU project is to develop a data collection strategy on FADs to provide indicators of the total number of active buoys at sea to improve the CPUE standardization procedure, to define dedicated algorithms to improve estimates of biomass signal from echo-sounders, and to develop alternative abundance indices in tuna fisheries, which requires the efforts from all the stakeholders. This work presents the progress done in buoy data collection for filling data gaps on FADs and presents a specific exercise developed for the establishment of procedures for buoy data pre-processing (i.e. data filtering protocol) for its use in support of stock assessment and tuna fisheries management.

Material and Methods

Under specific data-exchange agreement signed between research organisms (i.e. AZTI and IRD) and EU tuna purse seiner associations (i.e. ORTHONGEL[1], ANABAC[2] and OPAGAC[3]) historical information on buoy positions and data on acoustic information has been gathered for buoy density estimation to be used in the CPUE standardization process and the development on alternative indices of abundance derived from acoustic data.

To develop common indicators of the number of buoys at sea and biomass from acoustic signals, the raw data need to be pre-processed by standardized methods for filtering erroneous location, data related to failures in satellite communication and location data acquisition; identifying buoys on land positions; and identifying buoys data recording on-board positions. In order to compare the performance of different methods used in AZTI and IRD and agree on a common method for data pre-processing, a common EU database was created and shared, integrating the position data recorded by 2000 buoys (i.e.,1000 buoys from the Spanish and 1000 buoys from the

[1] Organisation française des producteurs de thon congelé et surgelé
[2] Asociación Nacional de Armadores de Buques Atuneros Congeladores
[3] Organización de Productores Asociados de Grandes Atuneros Congeladores

French fleet for each ocean) during 1 month in the Atlantic and Indian Ocean, respectively. Based in previous experience the following filters were defined and applied in the common data base (Table 1).

TABLE 1. Filters defined for pre-processing raw position data.

FILTER	Description
F1. Isolated	Isolated Position (>48 hours from another position or estimated speed above > 35 knots relative to next/previous position)
F2. Duplicated	Duplicated data (all fields are the same)
F3. Land and stationary	Data on land with speed <0.01 knots
F4. Land	Data on land with speed >0.01 knots
F5. Ubiquity	Data entry having from the same date/time different positions
F6. Not classified	Position not in the land and not classified by the at sea/on board algorithm
F7. Onboard	Buoys on board
F8. Water	Buoys at sea. Operational buoys: *Active buoy that is transmitting a signal and is drifting in the sea (definition from RECOLAPE)*

For applying the F1, F2 and F5 filters both organisms agreed the same data processing protocol. For the F3 low resolution shoreline from GSHHG[4] buffered with 0.05° shapefile was used by IRD and high-resolution shoreline from GSHHG[4] buffered with 0.05° shapefile by AZTI. In order to filter the data on-board (F7) IRD applied the kinetic algorithm described in Baidai et al. (2017), which is based on the analysis of buoys speed, variations in buoy speed and acceleration along the buoy trajectory. The validation of these classification algorithms was performed by comparing the classification outputs with observer data. On the other hand, AZTI applied a random forest classification approach to classify the buoys at sea/onboard using information from the Zunibal buoys, which have the capability to identify true positions at sea through a conductivity sensor (Orue et al., 2019). The list of predictor variables used in the RF analysis were: distance between two points (km), velocity (km/h), change in velocity (km/h), acceleration (km/h2), azimuth (degree), change in azimuth (degree) and time since the first and last observation of the corresponding buoy trajectory (days). For these classification algorithms that leave a subset of positions unclassified, it was agreed that the unclassified position should not be eliminated from the dataset and included in the buoy density estimates as buoys "at water". The final comparisons of the performance of the algorithms for classifying the buoys at water were carried out through the calculation of simple matching coefficient (Sokal and Michener, 1958), estimated from confusion matrices derived from the outputs of the two classification methods.

Results

Information on three buoy brands (i.e. Zunibal, Satlink and Marine Instrument) has been gathered in the Atlantic and Indian Ocean covering the period from 2006 to 2018 in the case of buoys used by ORTHONGEL fleet and 2010 to 2018 in the case of buoys used by ANABAC and OPAGAC fleet.

Overall, the two methods for pre-processing buoys data showed high matching coefficients (>94%) in all oceans and datasets. In the Atlantic Ocean, the performances of the classification protocol by IRD and AZTI to classify the buoys at water were >96%. The smaller agreement (94%) was observed in the Indian Ocean on the Spanish data set, possibly due to the characteristics of this data set with shorter tracks and smaller temporal resolution (i.e. a position per day). Results on the comparation on the performance on data processing method are included in Annex 1.

Conclusions

The collaborative work between the fishing industry, buoy providers and research institutions has allowed to recover historical information on buoys to be used for scientific purposes for development of indicators for evaluating tropical tuna stocks.

In this specific exercise for the development of standardize protocols for buoy data pre-processing the inspection of the outputs of the filtering algorithm run by IRD and AZTI on the common database demonstrated a high rate of agreement between the two algorithms, validating both method for data pre-processing. The main differences

[4] Wessel, P., and W. H. F. Smith (1996), A global, self-consistent, hierarchical, high-resolution shoreline database, J. Geophys. Res., 101(B4), 8741–8743, doi:10.1029/96JB00104.

occurred in the land classification. The shapefile resolution could impact the filtering of land, and thus the higher resolution available is recommended. In addition, minor differences among the two methods occurred in the number of buoys classified as on-board. These differences were higher for the Spanish dataset in the Indian Ocean, since the performances of the algorithms are affected by the characteristics of the databases (i.e. lower performance on shorter tracks and smaller temporal resolution). In this sense, in order to minimize the misclassification, if available, the use of high-resolution positions data (i.e., more than one position per day) is recommended.

References

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Annex 1. The performance of the algorithms for classifying the buoys at water were

TABLE 2. Confusion matrix on AZTI´s filtering and IRD filtering on the Spanish buoys in Atlantic Ocean. Simple matching coefficient = 0.99

	Kinetic method (IRD)	
Random forest (AZTI)	water	not water
water	24764	13
not water	213	314

TABLE 3. Confusion matrix on AZTI´s filtering and IRD filtering on the French buoys in Atlantic Ocean. Simple matching coefficient= 0.96

	Kinetic method (IRD)	
Random forest (AZTI)	water	not water
water	53735	1457
not water	1061	6649

TABLE 4. Confusion matrix on AZTI´s filtering and IRD filtering on the Spanish buoys in Indian Ocean. Simple matching coefficient= 0.94

	Kinetic method (IRD)	
Random forest (AZTI)	water	not water
water	20892	25
not water	1245	299

TABLE 5. Confusion matrix on AZTI´s filtering and IRD filtering on the French buoys in Indian Ocean. Simple matching coefficient= 0.97

	Kinetic method (IRD)	
Random forest (AZTI)	water	not water
water	57843	347
not water	1233	1771