ARE SETS ON YFT NOT ASSOCIATED WITH FLOATING OBJECTS REALLY FREE SCHOOLS SETS? IMPLICATIONS ON FISHING EFFORT

José C. Báez[1], **Marta González-Carballo**[2], **María Lourdes Ramos**[2] **& Santiago Deniz**[2]

1. Instituto Español de Oceanografía, Centro Oceanográfico de Málaga, Puerto Pesquero Fuengirola, Fuengirola (Málaga), Spain.
2. Instituto Español de Oceanografía, Centro Oceanográfico de Canarias, Calle Farola del Mar, 22 - Dársena Pesquera, 38180 Santa Cruz de Tenerife, Spain.

1. INTRODUCTION

Since starting up the Spanish purse seiner's fishery in the Indian Ocean, the concentration of tuna schools under natural floating objects adrift has been exploited. Tunas seem to have a natural tendency to aggregate beneath floating objects (FOBs). Fishermen have tapped into this natural behaviour by making their own dFADs (drifting Fishing Aggregating Devices) and floating away them tagged to monitor with radio or satellite buoys (Báez et al., 2020). The number of associated school sets (dFADs and logs) has been consistently increasing from the early period (1984–1990), with 31.9% of the sets directed at associated schools, to around of 76% of the sets in recent years (2008–2017 period). A maximum peak was recorded in 2018 (96%), and an 83% in 2019. Not only the number of sets has increased in recent years, but also the space-time frame between sets performed is rapidly approaching. Searching time between sets seems to be shorter than in previous years.

In this context, we hypothesize that the mentioned fishery's effort revolves mainly around their own dFADs, and if among them they observe a free school of YFT, the fishermen will fish on it. Therefore, the main aim of the present study is to test the relationship between the abundance of FADs and the number of sets on YFT non-associate, as proxy of local abundance of YFT.

2. MATERIAL AND METHODS

Fisheries data origin

Since 2017, the Indian Ocean yellowfin tuna stock has been subject to an interim Rebuilding Plan (IOTC Resolution 19/01 at present). Due to yellowfin catch limits adopted by the IOTC, we observed a major shift in fishing strategy, from targeting on monospecific free-swimming adult yellowfin tuna schoolstowards targeting on skipjack tuna associated to FADs, likely to avoid reaching the YFT catch limit too soon. In order to avoid these biases, it was decided to use the period from 2015 to 2017 data for the analysis, previous to the implementation of the rebuilding plan

The Spanish Ministry of Agriculture, Food and Environment, in close collaboration with the IEO (the Spanish Institution of Oceanography) and the Spanish tropical tuna purse seine fleet organizations ANABAC (National Association of Shipowners Tuna Freezers) and OPAGAC (Organization Associated Producers Large Tuna Freezers) implemented a FAD Management Plan (FADMP) in 2010 in the Indian Ocean. Indeed, the FAD logbook developed in the framework of the Spanish FADMP has been useful as a template for various t-RFMOs and member countries (Delgado de Molina et al., 2014, 2015). The FADs data have been obtained from the Spanish FAD loogbook (Ramos et al., 2017 for a review of the FADs). The YFT catches data are the values of catches corrected using T3 (Báez et al., 2020; for a review of the Spanish case).

Statistical analysis

In a first step, the possible causal effect of the dFADs abundance per 5x5 grid, quarter and year (dFADs_Abun) on the number of total sets per 5x5 grid, quarter and year, on YFT non-associated (i.e. TS_YFTSF), was analysed by using the dFADs_Abun (independent variable) versus a binary variable performed from TS_YFTSF. Thus, we assigned 0 when in a specific 5x5 grid, quarter and year did not observe any set on YFT non-associated, in contrast, we assigned 1 when in a specific 5x5 grid, quarter and year did observe at least one set on YFT non-associated. We denominated to this binary variable as Target1. In a second step, we performed another binary variable, which was denominated as Target2. For to perform the binary variable Target2, we assigned 0 when the number of sets observed a specific 5x5 grid, quarter and year, was leas to the mean of observed set per 5x5 grids, quarters and years (this mean was 6.6, therefore equal or leas to 6 sets), in contrast, we assigned 1, when we observed a number of sets higher to 6 sets.

Logistic binary stepwise forward/backward regression were performed to test whether the probability of obtaining a CPUE-longline was above or below the mean of the time series analyzed in function of the NAO.

Model coefficients were assessed by means of an Omnibus test and the goodness-of-fit between expected and observed proportions of by-catch events along ten classes of probability values and evaluated using the Hosmer and Lemeshow test (which also follows a Chi-square distribution; low p-0.05 would indicate lack of fit of the model) (Hosmer & Lemeshow, 2000). The Omnibus test examines whether there are significant differences between the -2LL (less than twice the natural logarithm of the likelihood) of the initial step, and the -2LL of the model, using a Chi-squared test with one degree of freedom. On the other hand, the Hosmer and Lemeshow test compares the observed and expected frequencies of each value of the binomial variable according to their probability.

In addition, the discrimination capacity of the model (trade-off between sensitivity and specificity) was evaluated with the receiving operating characteristic (ROC) curve. Furthermore, the area under the ROC curve (AUC) provides a scalar value representing the expected discrimination capacity of the model. The relative importance of each variable within the model was assessed using the Wald test (Hosmer & Lemeshow, 2000).

3. RESULTS

Figure 1 shows the overlap between the FADs deployed and the free school catch on YFT per year.

A statistically significant logistic model was obtained for the binary variable Target1, with the variable dFADs abundance per 5x5 grid, quarter and year (dFADs_Abun) (Figures 2), The model's goodness of fit was significant according to the Omnibus test (Omnibus test= 91,379, df= 1, P < 0.01; Nagelkerke R squared= 0.258), and its discrimination capacity was good (AUC = 0.763).

The logit function (y) of the logistic regression was:

y= -0.913+0.008* dFADs_Abun

For the binary variable Target2, a statistically significant logistic model was obtained, with the variable dFADs_Abun (Figure 3). The model's goodness of fit was significant according to the Omnibus test (Omnibus test= 86.004, df= 1, P < 0.01; Nagelkerke R squared= 0.232), and its discrimination capacity was good (AUC = 0.809).

The logit function (y) of the logistic regression was:

y= -2.258+ 0.005* dFADs_Abun

Table 1 shows the percentage of correct classification both Target1 and Target2.

4. DISCUSSION

According ours results both the probability of perform at least one set in a 5x5 grid, during a specific month and year (Probability 1), and the probability of perform at least one more set than the average (6 casts 5x5 grid, month and year) in a 5x5 grid, specific month and year, based on the density of FADs for that 5x5 grid, month and specific year (Probability 2), are related with the abundance of FADs for that 5x5 grid, specific month and year. There are multiple attempts to estimate a standardized YFT CPUE (for example, Guéry et al., 2019). However, the relationship found here implies a change in fishing behavior in recent years, at least for the Spanish fleet. Future attempts to estimate standardized CPUE should incorporate the density of planted FADs, or the number of active buoys per area.

Acknowledgements

We thank Francisco Abascal for his help in extracting the data. We also want to thank the cooperation of the fleet to collect the data from the FADs logbooks.

REFERENCES

Báez, J.C., Mª.L. Ramos, M- Herrera, H. Murua, J.L. Cort, S. Deniz, V. Rojo, J. Ruiz, P.J. Pascual-Alayón, A. Muniategi, A. Perez San Juan, J. Ariz, F. Fernández & F. Abascal (2020). Monitoring of Spanish flagged purse seine fishery targeting tropical tuna in the Indian ocean: Timeline and history. Marine Policy, 119: 104094. https://doi.org/10.1016/j.marpol.2020.104094

Delgado de Molina, A., Ariz, J., Murua, H., Santana, J.C. (2014). EU/Spain Fish Aggregating Device Management Plan. Collect. Vol. Sci. Pap. ICCAT, 70(6) 2606-2615.

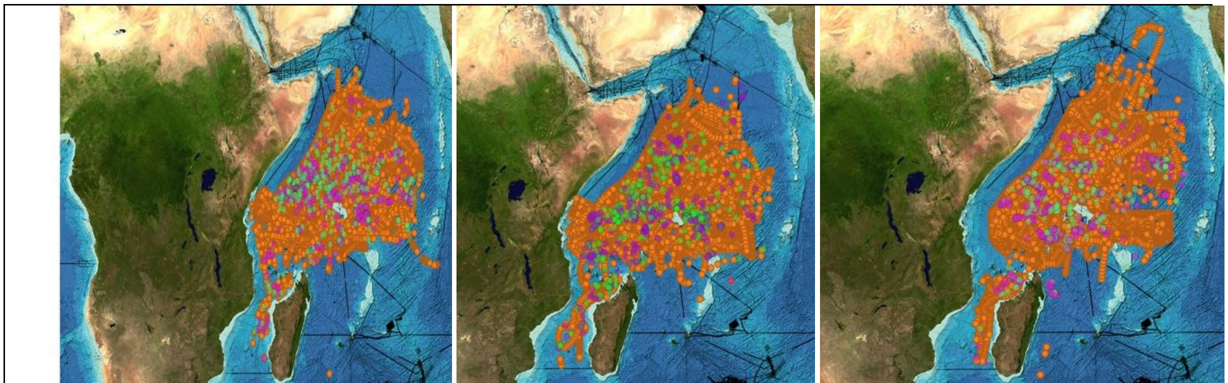
Delgado de Molina, A., Ariz, J., Murua, H., Santana, J.C. (2015). Spanish fish aggregating device management plan. Preliminary data. Collect. Vol. Sci. Pap. ICCAT 71(1) 515-524.

Guéry, L., D. Kaplan, F. Marsac, L. Floch, J.C. Báez & D. Gaertner (2019). Accounting for Fishing Days Without Set, Fishing Concentration and Piracy in the CPUE Standardisation of Yellowfin Tuna in Free Schools for the EU Purse Seine Fleet Operating in the Indian Ocean During the 1991-2017 Period. 21st Working Party On Tropical Tuna (WPTT21), 21/10/2019, San Sebastian (España). WPTT21–44.

Hosmer, D.W., Lemeshow, S. (2000). Applied logistic regression. New York: Wiley.373 p.

Ramos, Mª.L., Báez, J.C., Grande, M., Herrera, M.,A., López, J., Justel, A., Pascual, P., J., Soto, M., Murua, H., Muniategi, A., Abascal, F. (2017). Spanish FADs logbook: solving past issues, responding to new global requirements. Joint t-RFMO FAD Working Group meeting April 19-21, 2017 Madrid, Spain. Doc. No. j-FAD_11/2017.

FIGURES



Year 2015	Year 2016	Year 2017

Figure 1 shows the overlap between the FADs deployed and the free school catch on YFT per year

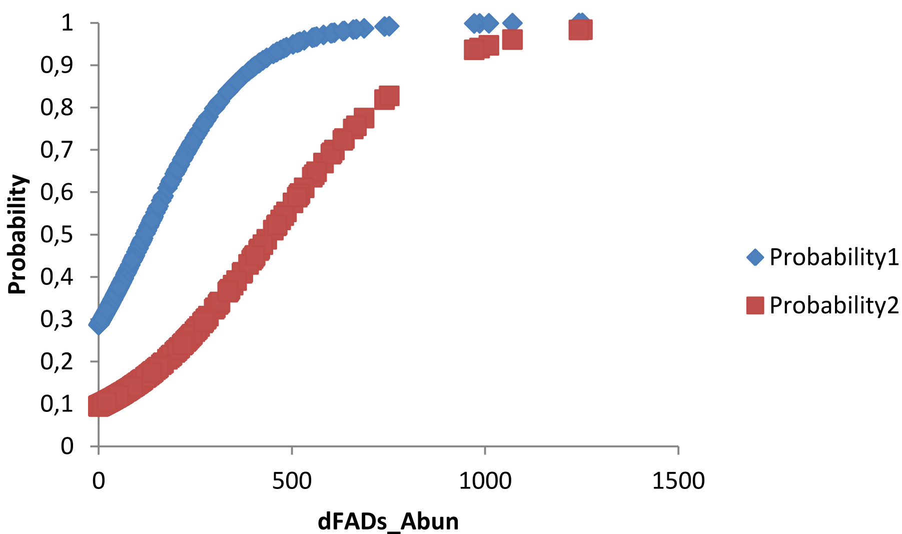


Figure 2. Probability of perform at least one set in a 5x5 grid, during a specific month and year, as a function of the density of FADs for that 5x5 grid, specific month and year (Probability 1), and probability of perform at least one more set than the average (6 casts 5x5 grid, month and year) in a 5x5 grid, specific month and year, based on the density of FADs for that 5x5 grid, month and specific year (Probability 2).