Estimating density of non-tracked dFADs with spatial capture-recapture models

<u>Guéry Loreleï</u> (1), Kaplan David (1), Gimenez Olivier (2), Gaertner Daniel (1)

(1) Institut de Recherche pour le Développement (IRD), UMR MARBEC, Av. Jean Monnet, CS 30171, 34203, Sète, France; (2) Centre d'Ecologie Fonctionnelle et Evolutive (CEFE), UMR 5175, 1919 route de Mende, 34293, Montpellier, France. Main author contact details: lorelei.guery@ird.fr

Summary

Tropical tuna are known to associate with floating objects, property used by fishermen for as indicators. Since the early 1990s, massive use of man-made drifting Fish Aggregating Devices (dFADs), i.e. mostly buoys with GPS, to aggregate tropical tunas has strongly modified global purse-seine fisheries. This has introduced major changes in the efficiency and selectivity of purse seiners as well as raised serious concerns regarding increased by-catch and juvenile catch, possible changes in fitness and migrations. dFAD-associated purse-seiners monitor their deployed buoys and a large part of buoys GPS positions and trajectories are available to map dFADs density. However, a remaining part, i.e. dFADs for which trajectories data are unavailable still needs to be estimated. Indeed, in order to determine how dFADs can be used in a sustainable way, as well as to integrate this type of information in the CPUE standardization process, their total density needs to be known. Considering dFADs without available trajectories as animals and using data from voluntary contributions of French tuna vessels shipmasters and tuna fishery associations in the Atlantic ocean, Spatial Capture-Recapture (SCR) models can be applied to estimate remaining dFADs spatial and temporal distribution, density and more widely time-at-sea and detection probability.

Introduction

Tropical tuna are known to associate with floating objects, property used by fishermen as indicators. Since the early 1990s, massive use of man-made drifting Fish Aggregating Devices (dFADs) or floating objects (log), all equipped with GPS-buoys, to aggregate tropical tunas has strongly modified global purse-seine fisheries. This has introduced major changes in the efficiency and selectivity of purse seiners as well as raised serious concerns regarding increased by-catch and juvenile catch, possible changes in fitness and migrations. In order to determine how this fishing technic can be used in a sustainable way, as well as to integrate this type of information in the CPUE standardization process, the total density of floating objects needs to be known. dFAD-associated purse-seiners monitor their deployed buoys and a large part of buoys GPS positions and trajectories are available to directly map dFADs density. However, the remaining part still needs to be estimated.
The most recent methodology to estimate total density is a raising procedure based on a Bayesian estimation of the distribution of relative proportion of observed GPS buoys for each nationality and of the relative proportion of GPS buoy-equipped FOBs that are dFADs (Maufroy et al. 2015). The methodology limits are a flat prior in Bayesian analyses and the variation in exploration effort that is not taken into account.
Considering buoys without available trajectories as animals and using data from logbooks and observer programs, Spatial Capture-Recapture (SCR) models can be applied to estimate spatial and temporal distribution, density and more widely time-at-sea and detection probability remaining dFADs. This paper presents the first results of the method validation and some dFADs density maps.

Material and Methods

Fine-scale operational data based on captain and skipper logbooks of French purse seiners (hereafter called respectively logbook data and observer data) were used for the period 2010–2017 in the Atlantic and Indian Oceans. They describe purse seiners' activities, e.g. the positions of purse seine fishing sets, the type of operation as well as buoy identifications. In addition, we used Vessel Monitoring Systems (VMS) data of French purse seiners. The GPS position of vessel with activities on buoys is recorded, enabling the construction of grids of sampled 1*1 degree square over their typical 4–6 week fishing trips.
Spatial capture–recapture (SCR) models make use of auxiliary data on capture location to provide density estimates for animal populations. Data used are commercial opportunistic data corresponding to unstructured spatial survey (Royle *et al*. 2013, Thompson *et al*. 2012 and Russell *et al*. 2012) where sampling (vessels trajectories) produces a survey path not laid out a priori but rather evolves opportunistically during the course of sampling depending on local fishing conditions. This violates the main assumptions of standard SCR that the line is placed a priori, independent of density and unrelated to detectability. Spatial capture-recapture models

for search-encounter data, i.e. for detections of recognizable individuals in continuous space in unstructured spatial survey were needed. We adapted these models to fishery datasets in order to estimate non-tracked buoys density considering buoys as animals, 1*1 degree square as traps and vessels with activities on non-tracked buoys as detectors. A square is considered active in a particular year when it has been sampled, i.e. when a vessel trajectory crossed this particular square, and inactive otherwise. This information is essential to correct the potential bias induced by different spatial and temporal exploration effort.
To validate this approach, we applied this method to activities on French tracked buoys and compared the density estimates to the real density from dFADs trajectories.

Results and Discussion

For the year 2011, we used a random sample from activities on dFADs with know trajectories, which size was equal for the same year to the number of activities on non-tracked dFADs. For the whole year, we found that the 1*1 degree estimated density of French dFADs from SECR models was significantly correlated to the real density from dFADs trajectories (R^2=0.22, $p < 0.0001$). The small coefficient is explained by the fact that 2011 has the smallest sample size and variation in effort per cell is not yet included. Results on years with bigger sample sizes are still running but preliminary results with small numbers of iterations showed higher correlation rates.

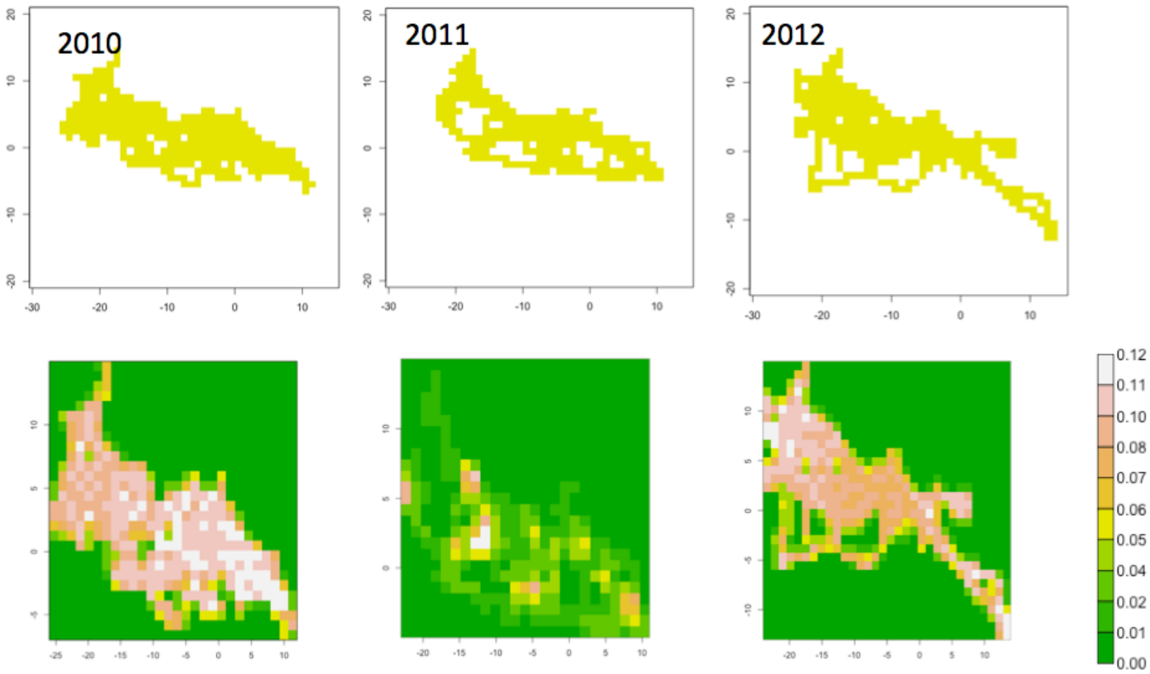

FIGURE 1. Density of non-tracked buoys (lower panels) and their associated exploration effort (upper panels) for three different years in the Atlantic Ocean.

References

Maufroy, A., Chassot, E., Joo, R., & Kaplan, D. M. (2015). Large-scale examination of spatio-temporal patterns of drifting fish aggregating devices (dFADs) from tropical tuna fisheries of the Indian and Atlantic oceans. PloS one, 10(5), e0128023.

Royle, J. A., Chandler, R. B., Sollmann, R., & Gardner, B. (2013). Spatial capture-recapture. Academic Press.

Russell, R. E., Royle, J. A., Desimone, R., Schwartz, M. K., Edwards, V. L., Pilgrim, K. P., & Mckelvey, K. S. (2012). Estimating abundance of mountain lions from unstructured spatial sampling. The Journal of Wildlife Management, 76(8), 1551-1561.

Thompson, C. M., Royle, J. A., & Garner, J. D. (2012). A framework for inference about carnivore density from unstructured spatial sampling of scat using detector dogs. The Journal of Wildlife Management, 76(4), 863-871.