PILOT PROJECT TO TEST BIODEGRADABLE ROPES AT FADS IN REAL FISHING CONDITIONS IN WESTERN INDIAN OCEAN

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SUMMARY

The present study summarizes the results of a pilot project to test biodegradable ropes at FADs in real fishing conditions. One of the difficulties when testing experimental FADs in purse seine fishery is that fishers fish on any FAD found at sea, so that FADs change hands very often making difficult to revisit experimental FADs to collect data and get significant results. The main objective of the pilot was learning from this experience to develop a large-scale deployment of biodegradable FADs at sea, by detecting potential difficulties and issues related mainly to effective data gathering on FADs under test. In order to compare the performance of biodegradable and non-biodegradable FADs, International Seafood Sustainability Foundation (ISSF) deployed in collaboration with 6 purse seiners from INPESCA fleet in Western Indian Ocean, a total of 174 FADs, 89 non-biodegradable and 85 biodegradable. Two different FAD designs were tested working at different depths (10m, 30m, 50m and 70 m). A total of 74.913 biomass samples were collected using echo-sounder buoys attached to those FADs. Our results show similar aggregative patterns of fish (tuna and non-tuna species) for non-biodegradable and biodegradable FADs. Life-time of FADs and implications of our results for future experiments are discussed.

*KEYWORDS***:** *biodegradable, fishing gear, FAD, Indian ocean, purse seine fleet, tropical tuna*

1. Introduction

In order to avoid the impact of FAD sinking and beaching events in the ecosystem (marine pollution, ghost fishing and damage of vulnerable ecosystems as reefs), different initiatives have been conducted by research institutes as well as by the industry, to find a FAD structure efficient for fishing and that biodegrades as faster as possible after its useful life time (Franco et al. 2019; Goujon et al 2012; Lopez et al 2016; Moreno et al 2017). One of the difficulties when testing experimental FADs in real fishing conditions is data gathering. Fishers fish on any FAD found at sea so that FADs change hands very often, specially in small fishing grounds as in Western Indian ocean. Thus, it is difficult to revisit a FAD to get data on the performance of new materials added unless a significant number of experimental FADs are deployed.

The main objective of the pilot was identifying the potential difficulties that could be found in an ulterior large-scale experiment to test biodegradable FADs as well as learning from the behavior of fishers to help designing the experiments. Other specific objectives were comparing biodegradable and non-biodegradable FADs on their ability to aggregate fish and having an estimate of the life time of both biodegradable and non-biodegradable FADs used in this project.

2. Material and methods

2.1. FAD designs and deployment

In order to compare the performance of biodegradable and non-biodegradable FADs, International Seafood Sustainability Foundation (ISSF) in collaboration with 6 purse seiners from INPESCA fleet deployed in

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Western Indian Ocean, a total of 174 FADs, 89 non-biodegradable and 85 biodegradable (Table 1). The experiment started in February 2017 and data collection is still ongoing as some of the FADs under test remain at sea. Results presented here are for data gathered from February 2017 to May 2017.

This experiment focused in finding a biodegradable solution for the submerged part of the FAD, replacing the main submerged structure of traditional FADs (usually made of netting tied in sausages or synthetic ropes) by biodegradable ropes. This decision was taken on one hand, based on the fact that amongst the different components of a FAD (surface structure or raft, submerged ropes or nets, floats), the most important component in terms of the impact that can cause is the submerged part, as it represents an important portion of the FAD and is the one that becomes entangled in coral reefs as well as have the potential of ghost fishing if the net, when used tied in "sausages", is untied with time. On the other hand, a recent workshop held with fishers on the test of biodegradable FADs (Moreno et al. 2016), recommended allowing synthetic floats when testing biodegradable components at FADs as buoyancy is a key factor for the FAD to be "alive" and the use of plastic floats would prevent experimental FADs from sinking and assure data gathering on biodegradable ropes. Thus, we did not replace the raft by biodegradable material and let fishers use the same raft they usually utilize, using plastic floats.

Two different biodegradable ropes were used to replace the submerged structure, one with cotton loops similar to the ropes used in mussel farming (Figure 1) and the other twisted without loops (Figure 2). Both made of 100% cotton by *Itsaskorda* rope manufacturers (see annex 1 for ropes specifications). These ropes were used in 2 different FAD designs working at different depths, the first one working shallower at 10 m and 30 m depth, design type 1(Fig 2), and the other design working deeper at depths of 30 m, 50 m and 70 m, type 2 (Fig 3). In order to compare the ability to aggregate tunas of biodegradable and non-biodegradable FADs, as well as their longevity, together with the biodegradable designs, identical designs but with traditional ropes or net tied in sausages were deployed.

2.2. Data analysis

The 174 FADs deployed for this project had a buoy attached providing position of the FAD as well as an estimate of the biomass aggregated. Fishers shared their echo-sounder buoy data for the 174 FADs with 2 months delay. Three types of echo-sounder buoys were used to track the 174 FADs. One of the brands was used in 89,5 % of the total amount of FADs tested. Thus, our analysis on biomass aggregation pattern for non-biodegradable and biodegradable FADs were done using only the predominant brand, in order to be able to compare biomass samples, as biomass estimates are differently calculated for each brand.

The dataset contains 74913 acoustic samples from the 174 buoys followed from February 2017 to May 2017. Information for each sample includes date and position of deployment, buoy (code and type), position (latitude and longitude), GMT hour, and biomass estimation. Data cleaning was done following the protocol proposed by Orue et al. (In prep) using RStudio (R Core Team, 2016).

Analysis to study the aggregative pattern of fish for biodegradable and non-biodegradable FADs were conducted using Generalized Additive Mixed Models (GAMM) (Wood, 2006) with a Gaussian error distribution and identity link function. The trend of biomass was assessed for 60 days and DFAD identification was included as random-effect because there is a dependency structure in the data, as they are collected repeatedly for each DFAD. In order to avoid model overfitting, maximum degree of freedom (k) was limited by k=4. All the GAMM models were fitted using gamm4 package (Wood and Scheipl, 2013) in RStudio (R Core Team, 2016). The mathematical notation for the fitted GAMM was:

Biomass ~ s (Day, k=4) + random= ~ (1 | ID_DFad)

3. Results

The 174 FADs deployed in this project covered the main fishing grounds in western Indian Ocean (Fig 4). The results presented here represent 3 months of FAD monitoring, from February to May 2017, data collection is ongoing for those FADs that remain at sea. Figure 5 shows the trajectories for non-biodegradable and biodegradable FADs. White color represents the deployment position that changes to red with days at sea.

For the period of observation, there were 5 fishing activities on non-biodegradable FADs, the catches ranging from 5 to 80 tons. There were no fishing activities on non-biodegradable FADs deployed by this project. Maximum time at sea observed for a biodegradable FAD up to the end of August 2017 was 6 months. However, in 3 months, our observation period so far, an average of 46,5 % of biodegradable FADs and 82% of non-biodegradable FADs were not available for the vessel that deployed them. These FADs lost events were mainly due to FADs being stolen and maybe fished but also sink and beaching events occurred.

Analysis conducted to compare aggregation patterns of tuna and non-tuna species related to days at sea, showed no significant differences between the 2 types of FADs tested, biodegradable and non-biodegradable ones (Figure 6). In our preliminary results, the time at sea at which maximum biomasses are reached at FADs appears to be shorter for biodegradable FADs compared to non-biodegradables.

4. Discussion

4.1. Ability of biodegradable FADs to aggregate tuna and non-tuna species

From our results, there is no doubt that FADs using biodegradable components in the submerged structure are as effective as non-biodegradable FADs aggregating tuna and non-tuna species. Similar aggregative patterns were observed for the non-biodegradable and biodegradable FADs even reaching maximum biomasses earlier on biodegradable FADs compared to non-biodegradable FADs. However, the results shown are for all biodegradable FADs and non-biodegradable FADs pulled together so that information on the type of FAD design, depth of the FAD, drift, area, time at sea, et. were not taken into account. Further analysis will comprise all the factors that could affect the aggregation dynamics for the two types.

4.2. Life time of FADs and future experiments

For the 174 FADs deployed by the project, in 3 months, the 46,5 % of biodegradable FADs and 82% of non-biodegradable FADs were not available for the vessel that deployed them. Western Indian Ocean, is a small fishing ground where FADs change hands very often, as observed in our sample. Most of the FADs were stolen and probably re-used by other vessels but we don´t have access to this data, that is why deploying a significant number of FADs at sea and the collaboration of the different fleets operating in the area of the experiment is desired, so that enough data is gathered to follow the performance of experimental FADs.

The fact that there is a limit of active number of FADs at sea in Indian Ocean, made more difficult to deploy FADs following a fixed protocol, as fishers had a given number of active FADs at sea and needed to wait until an own FAD was lost before they were able to activate a new one. For large scale deployments of FADs it would be desirable finding a solution for the experimental FADs to be deployed following a protocol, as for instance being not counted as effective FADs for fishing.

By the end of August 2017, the maximum time for a biodegradable FAD at sea was 6 months. Taking into account this information we could expect having other “re-used” biodegradable FADs still alive at sea but being monitored by other vessels that do not participate in this project. This preliminary result on the maximum life-time of a biodegradable FAD at sea, provides an estimate of at least the maximum time that a biodegradable FAD could be efficient for fishing. Fishers participating in the project stated that in Western Indian Ocean a FAD with 6 months at sea was considered old, which could provide an idea of the appropriate life-time of a FAD. However, it is known that fishers maintain FADs and make them last longer by replacing the components that are not efficient after a given time. It could also be the case when working with biodegradable FADs, fishers could replace the biodegradable components that are not working properly anymore. Thus, it may be that the life-time of the original structure does not serve for 1 year but the replacements make the biodegradable FADs last longer than a year. A survey aimed at understanding the degree of replacement regularly done by fishers will be useful to understand the required life time of biodegradable materials and biodegradable FADs.

It is also important to note that the rafts used in this experiment were the same as those used in non-biodegradable FADs, allowing the use of plastic floats in order to assure data collection. Once the efficiency of the biodegradable ropes, as submerged structure of FADs is validated, next step would be testing a biodegradable raft. Finding biodegradable materials for the raft does not seem complex as bamboo and other woods have already been used with success at FADs, however, replacing plastic buoys has been proven to be difficult as the buoyancy needed for a FAD to remain afloat is one of the key issues regarding life time of FADs. In any case, replacing in the near future conventional FADs by 100% biodegradable materials in the submerged structure as well as in the raft while leaving the plastic buoys as floats would already be a big step towards the use of biodegradable FADs and the reduction of the impacts caused by lost FADs, until a solution is found to achieve the buoyancy needed using biodegradable materials.

Acknowledgements

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References

Franco, J., Dagorn, L., Sancristobal, I. and Moreno, G. (2009). Design of ecological FADs. IOTC-2008-WPEB-16. http://iotc.org/sites/default/files/documents/proceedings/2009/wpeb/IOTC-2009-WPEB-16.pdf

Goujon, M., Vernet, A-L. and Dagorn, L. 2012. Preliminary results of the Orthongel program "eco-FAD" as June 30th 2012. IOTC-2012-WPEB08-INF21, 1-7 pp.

Lopez, J., Ferarios, J.M., Santiago, J., Alvarez, O.G., Moreno, G. and Murua, H. (2016). Evaluating potential biodegradable twines for use in the tropical tuna fishery. WCPFC-SC12-2016/EB-IP-11.

Moreno, G., Restrepo, V., Dagorn, L., Hall, M., Murua, J., Sancristobal, I., Grande, M., Le Couls, S. and Santiago, J. (2016). Workshop on the use of biodegradeable Fish Aggregating Devices (FADs). ISSF Technical Report 2016-18A. International Seafood Sustainability Foundation, Washington, D.C., USA.

Moreno, G., Jauharee, R., Muir, J., Schaeffer, K., Adam, S., Holland, K., Dagorn, L. and Restrepo, V. (2017). FAD structure evolution: from biodegradeable FADs to biodegradeable FADs. Joint t-RFMO FAD Working Group meeting; Doc. No. j-FAD_08/2017.

Tables

Table 1. Biodegradable FADs (BIO FADs) and Non-biodegradable FADs (Non-Bio FADs) deployments in 2017.

Deployments	BIO FADs	NON-BIO FADs	Total
February	13	6	19
March	22	22	44
April	32	22	54
May	18	39	57
Total	85	89	174

Figures

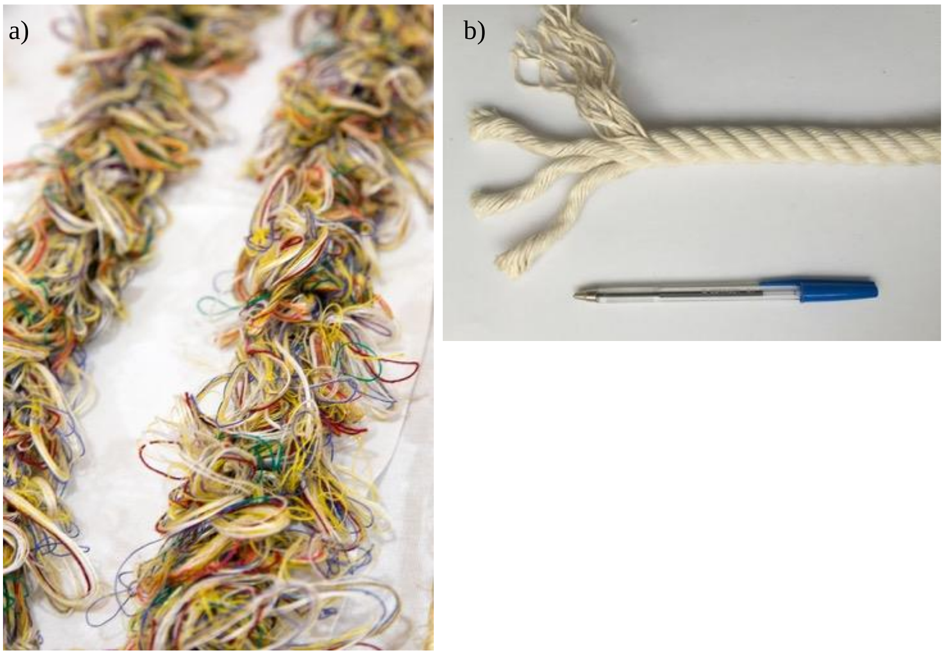


Figure 1. Biodegradable ropes used in the submerged structure of FADs (a) 100 % Cotton rope with loops b) 100% cotton rope without loops

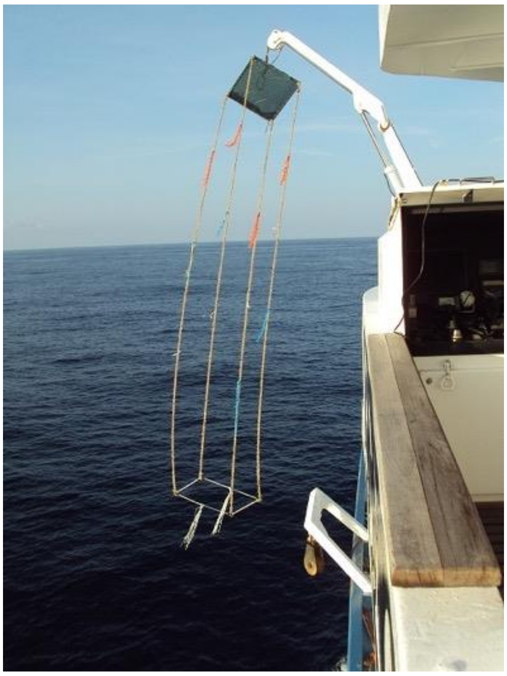


Figure 2. FAD type 1: 4 biodegradable cotton ropes hanging from the raft. This design was used at 10 m and 30 m depth.

Figure 3. FAD type 2: A single rope hanging from the center of the raft. This design was used at 30 m 50 m and 70m depth.

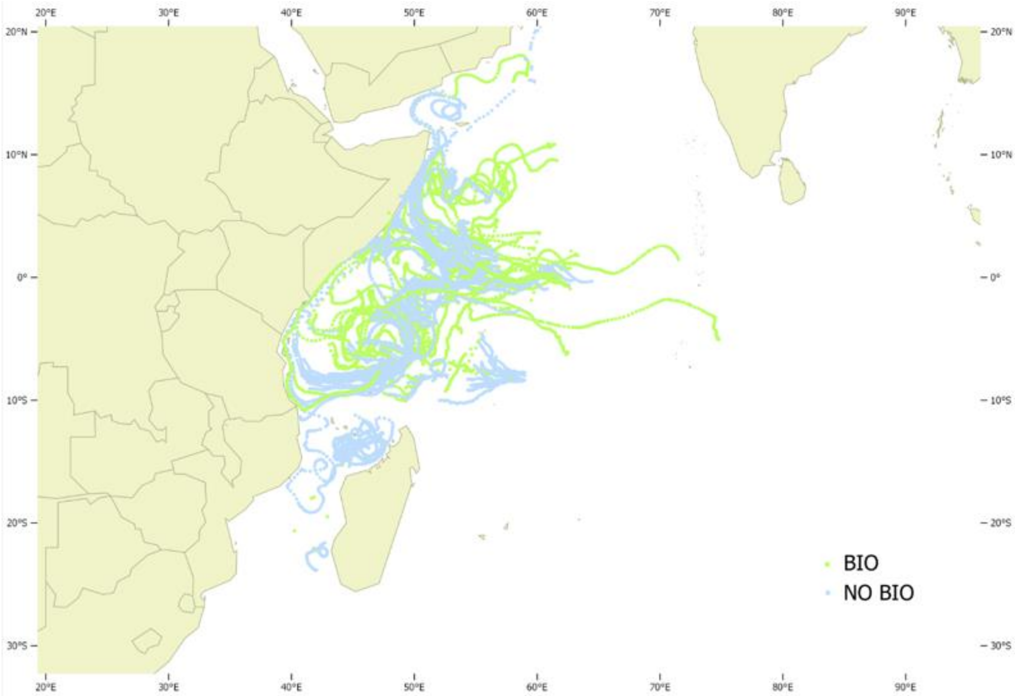
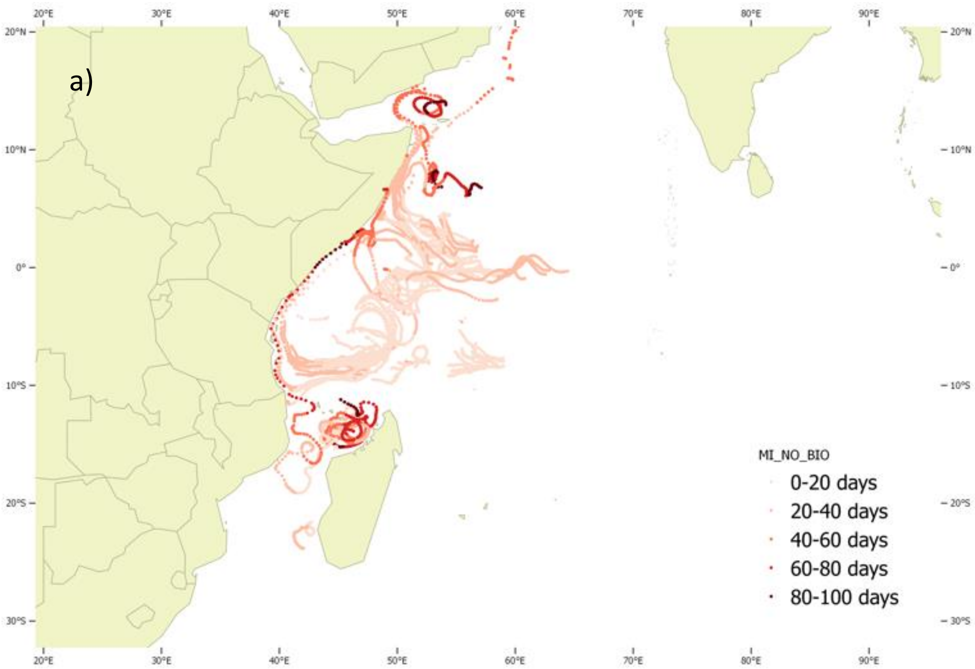


Figure 4. Spatial coverage of FADs deployed in the present project from February to May, both biodegradable FADs (in green) and non-biodegradable FADs (in blue).



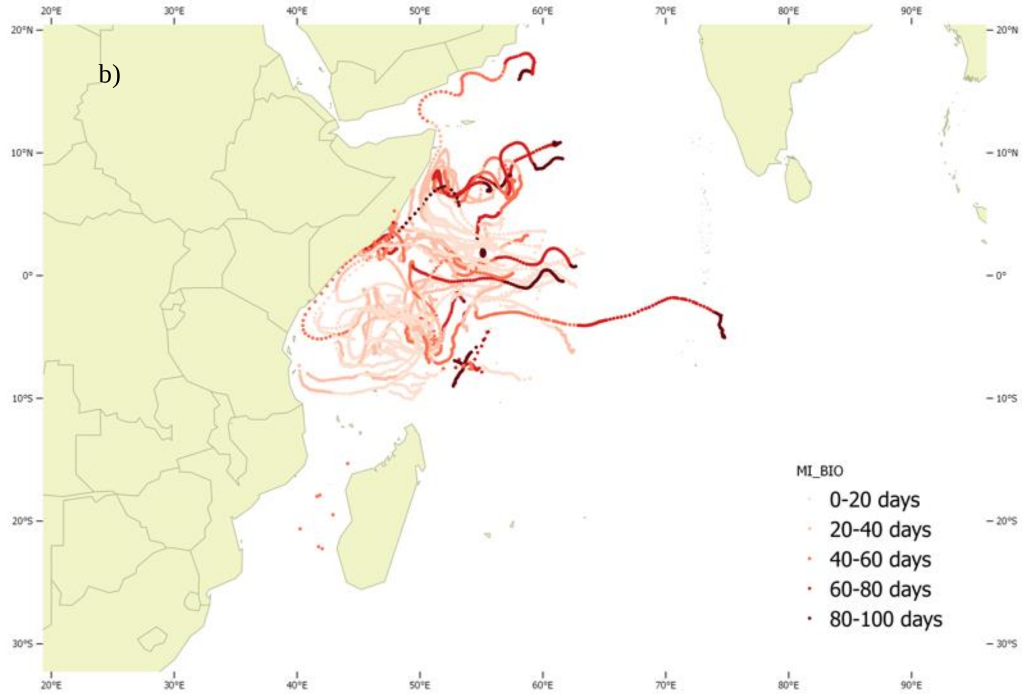


Figure 5. Trajectories followed by a) non-biodegradable FADs and b) biodegradable FADs.

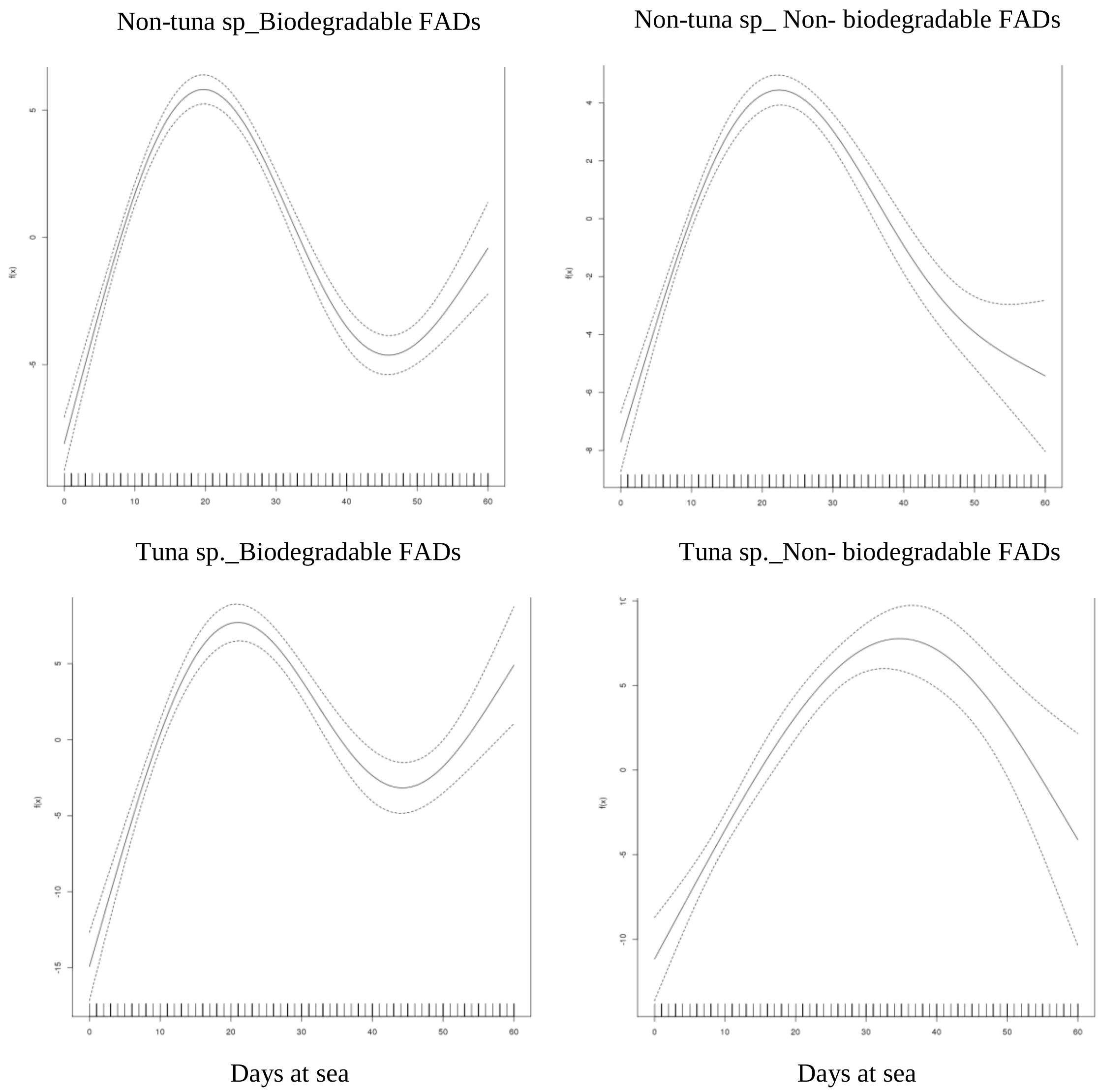


Figure 6. GAMM analyses showing the non-parametric relationship between non-tuna species biomass (top) and tuna species biomass (botton) and days at spent at sea by the FAD with 95% confidence intervals (dashed lines).