Major reduction in the number of FADs used in the Seychelles purse seine fishery following IOTC limitations

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Abstract

Positions of satellite-tracked buoys used to follow Fish Aggregating Devices (FADs) and natural floating objects at sea are essential to fulfill the mandatory statistical requirements of the IOTC and monitor the number of floating objects followed by each purse seiner at any time. The fishing companies owning purse seiners and support vessels flying the Seychelles flag have recently provided to the Seychelles Fishing Authority the GPS buoy positions covering the period 2015-2018. The raw data set, composed of almost 10 million positions, was pre-processed to generate daily positions and filtered to remove duplicates, errors of transmission, etc. A speed filter was used to remove buoys onboard vessels and build trajectories of floating objects at sea. Next steps of the work will include the use of a random forest algorithm to improve the separation of onboard from at-sea positions and the development of a database to manage the data. Combined with the information on deployments, retrieval, and FAD design collected through the Seychelles observer program that covered 70% of the Seychelles purse seiner's activities in 2018, this new data set provides a major step in the advancement of more transparency and sustainability in the Indian Ocean purse seine fishery.

Introduction

High-resolution position data of the buoys used in the Seychelles purse seine fishery during 2015-2018 were made available from the companies ALBACORA, ATUNSA, ECHEBASTAR, INPESCA, PEVASA, and SAPMER to the Seychelles Fishing Authority (SFA) in spring 2019. The data set provides information on the number of floating objects monitored by each fishing vessel on a daily basis and enables to address the mandatory statistical requirements of the IOTC (Resolutions 18/01 and 18/08). The objective of the present report is to describe the data sets respectively collated from AZTI-Tecnalia and IRD for

Spanish-owned and French-owned vessels and the methodology used to process the data to make them available for both compliance and scientific purpose.

Materials & Methods

Data

Data for the Spanish-owned vessels made available by the Spanish institute AZTI-Tecnalia are daily buoys positions individually assigned to one single purse seiner. The raw data set is composed of 5,774,520 raw daily positions of 39,621 buoys followed by 11 purse seiners between Sep 01 2015 and Dec 31 2018. Data for the French-owned vessels made available by the French 'Institut de Recherche pour le Développement' (IRD) are less than daily positions followed by both purse seiners and support vessels flying the Seychelles flag and other vessels with which the buoys were temporarily shared. The raw IRD data set is composed of 3,854,502 positions emitted by 8,183 distinct buoys and followed by up to 9 purse seiners between Jan 01 2015 and Dec 31 2018. The IRD data set was pre-processed by selecting the last position of each buoy for each day of emission and assigning them a weight representing the level of sharing with other purse seiners. After pre-processing, the raw IRD data set was reduced to 1,367,715 daily positions.

The merging of the AZTI and IRD daily data sets resulted in the full raw data set composed of 7,142,235 daily positions emitted by 47,804 distinct buoys. The contents of the raw data set of daily positions are described in Table I.

Table I. Description of the fields of the raw GPS buoy data set

Variable	Description
company	Fishing company
vessel	Purse seiner
model	Buoy model
code	Buoy unique identifier
sharing_weight	Buoy proportion of buoy assigned to the purse seiner
utc_date	Date (UTC)
longitude	Longitude (decimal degrees)
latitude	Latitude (decimal degrees)

In a second step and similarly to what is done for the EU buoys data set, a series of successive filters were applied to the raw daily data set to remove: (i) duplicates, (ii) multiple positions in a same day in the AZTI data component, (iii) data without geographic information, (iv) data with inconsistent longitude and latitude and (v) data outside the Indian Ocean (e.g. Orue et al. 2019). Finally, the trajectories of the buoys at sea for 3 days and more were built using a speed filter of 4 knots to separate the buoys drifting at sea

from the buoys onboard the vessels (Santiago et al. 2017). Table II gives the number of positions and buoys at each step of the data processing.

Table II. Successive filters applied to the raw GPS buoy data set with number of data removed, and distinct positions and buoys at each processing step in the data set.

Filter	Removed	Positions	Buoys
No filter	0	9,629,022	47,804
Remove duplicates	5,148	7,137,087	47,804
Remove multiple daily positions for IRD data	2,486,787	7,142,235	47,804
Remove multiple daily positions for AZTI data	165,042	6,972,045	47,804
Remove data without longitude or latitude	595,668	6,376,377	46,796
Remove data with null longitude and latitude	1020	6,376,377	46,796
Remove data with longitude less than 20°E	583	6,374,774	46,791
Remove data with longitude more than 120°E	3	6,374,771	46,791
Remove data with latitude more than 40°S	200	6,374,571	46,790
Remove data with longitude less than 40°N	8,114	6,366,457	46,790
Remove trajectories with less than 3 positions)	779	6,318,962	46,011
Remove data with speed faster than 4 knots	363,728	5,955,234	45,839

Applications

The availability of buoys GPS data is key for monitoring the fishing activities of the Seychelles purse seine fishing fleet, including the management of FADs by their support vessels. In terms of compliance, the buoy data set provides the only source of reliable information to monitor the number of buoys followed by each purse seiner at any time. During 2015-2018, the number of buoys in use in the Seychelles purse seine fishing fleet was less than the maximum values set by the IOTC (Fig. 1). The total number of instrumented buoys showed an increasing trend throughout 2016 followed by a steady decrease from a maximum of 6,200 in October 2016 to about 4,000 in December 2018, corresponding to a decrease by about 35%. The buoys emitting the geographic position followed the same decreasing pattern with a reduction by more than 30%, from a maximum of about 5,500 in October 2016 to 3,780 in December 2018 (Table III). The difference between instrumented and transmitting buoys corresponds to the buoys that have been activated and can emit information through a satellite channel but do not emit any position. This mostly happens when the buoy has been turned off and is on a vessel or stored in port. The buoy can either be switched back on to emit the geographic position for further deployment at sea or deactivated. Over that period, the mean number of instrumented and transmitting buoys used by each vessel decreased from 475 and 425 in October 2016 to 310 and 290 in December 2018, respectively. The trends were found to differ between companies. Most vessels decreased their number of buoys following the successive implementation of IOTC Conservation and Management Measures over time while one company increased the number of buoys in relation with a progressive increasing trend to fish on FADs. It is noteworthy that the maximum number of instrumented buoys will be set to 300 from the 29th of October 2019.

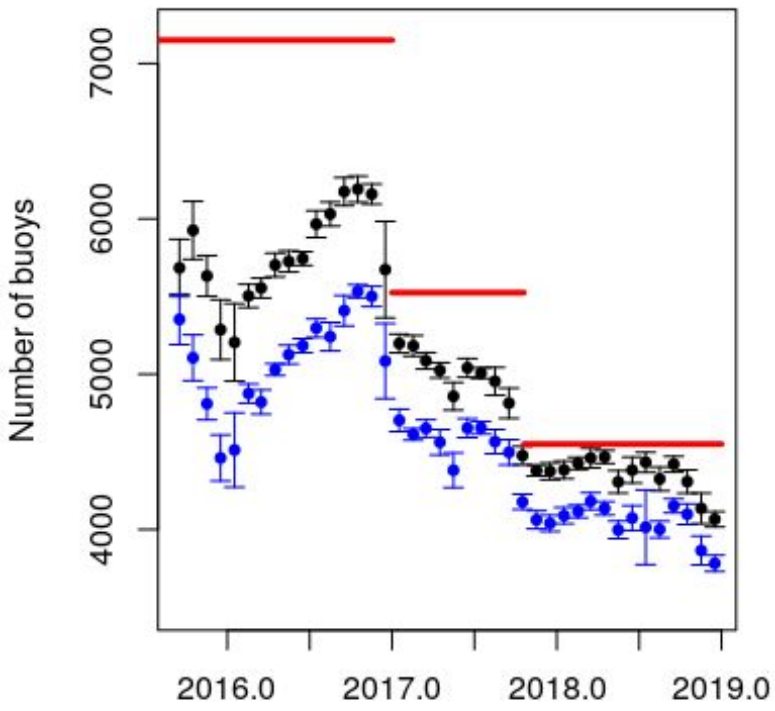

Fig. 1. Mean (± standard deviation) monthly number of satellite-tracked buoys activated (black) and transmitting geographic position (blue) in the Seychelles purse seine fleet. Red horizontal lines indicate the IOTC caps on buoys.

The accurate GPS position of each buoy enables to assess the spatial distribution of all the floating objects monitored by the Seychelles purse seine fleet across the Indian Ocean. For instance, the map of the buoys on the 1st of January 2016 shows a high concentration of floating objects in the Western Indian Ocean, particularly around the Seychelles and in the north of the Mozambique Channel (Fig. 2). At this date, some buoys also emitted east of the Maldives and close to Sri Lanka. The GPS data can also be used to track the drift of the floating objects (Fig. 3), estimate the hotspots of stranding events, and predict the FAD movements and potential risks associated with time-areas of deployments (Maufroy et al. 2015, Davies et al. 2017, Phillips et al. 2019).

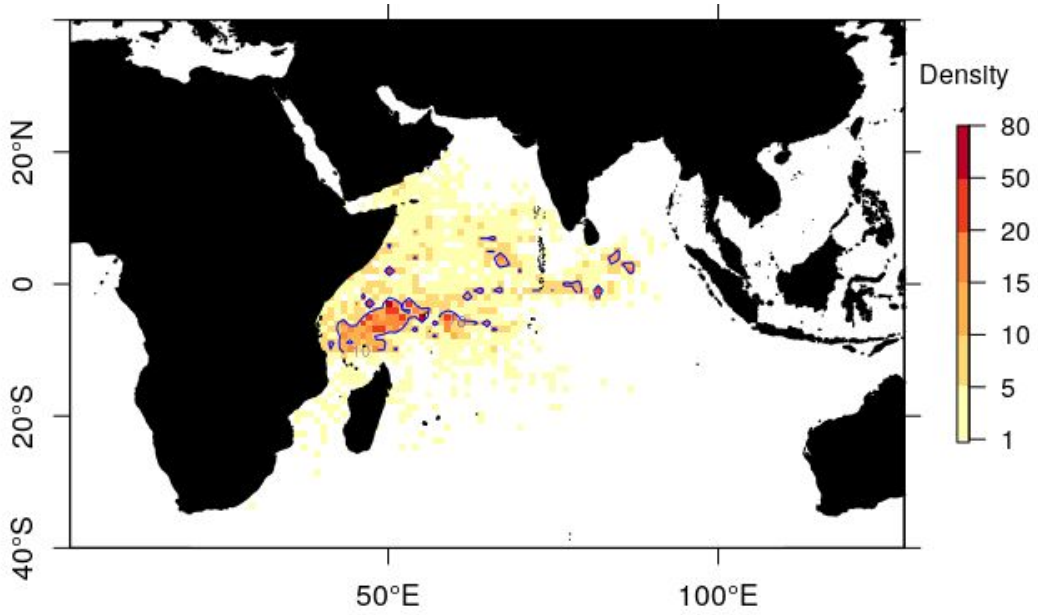

Fig. 2. Distribution of buoys monitored by the Seychelles purse seine fleet on the 1st of January 2016. The blue solid line indicates the contour line of value 10 buoys.

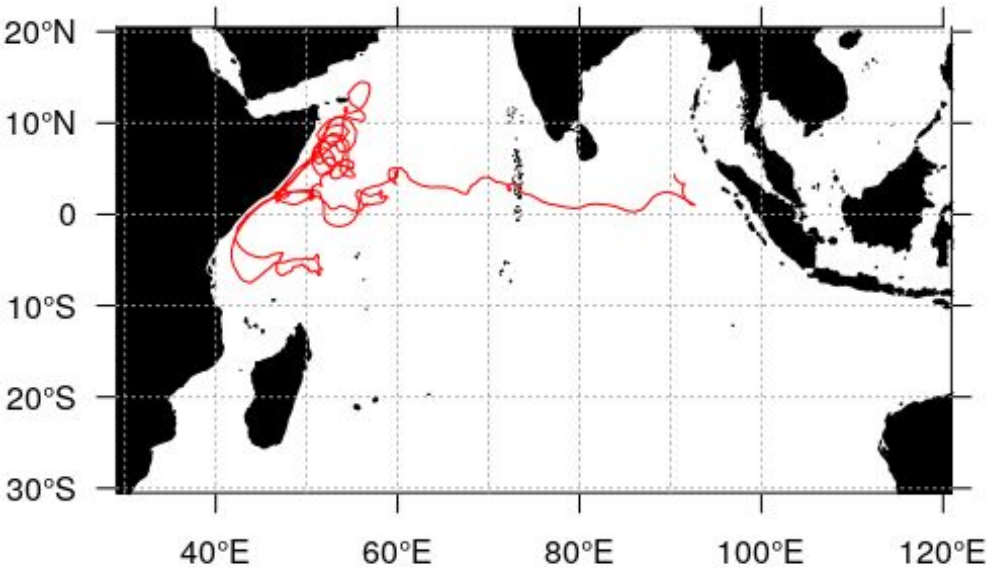

Fig. 3. Example of a long trajectory at sea. The buoy was deployed on the 1st of March 2017 and still at sea on the 31st December of 2018 after 671 days of drift.

Table III. Mean (± standard deviation) monthly number of buoys instrumented (nbuoys) and emitting (nbuoys_emitting) used in the Seychelles purse seine fishery between September 2015 and December 2018.

yrmth	nbuoys_avg	nbuoys_sd	nbuoys_emitting_avg	nbuoys_emitting_sd
2015.71	5684	184	5353	163
2015.79	5926	187	5105	148
2015.88	5632	131	4809	103
2015.96	5286	193	4461	148
2016.04	5205	249	4512	239
2016.13	5504	75	4875	62
2016.21	5554	64	4820	78
2016.29	5702	76	5030	38
2016.37	5726	68	5126	61
2016.46	5744	45	5183	45
2016.54	5966	86	5297	60
2016.62	6031	78	5241	92
2016.71	6175	90	5409	98
2016.79	6191	84	5534	43
2016.88	6159	65	5501	65
2016.96	5673	310	5084	242
2017.04	5197	60	4703	72
2017.13	5182	67	4613	38
2017.21	5086	53	4651	57
2017.29	5025	49	4562	82
2017.37	4857	89	4382	112
2017.46	5041	60	4653	61
2017.54	5007	34	4655	40
2017.62	4954	90	4566	78
2017.71	4813	97	4497	81
2017.79	4476	59	4178	49
2017.88	4379	35	4062	58
2017.96	4375	54	4040	52
2018.04	4384	57	4090	53
2018.13	4426	40	4117	41
2018.21	4460	63	4182	55
2018.29	4467	42	4136	43
2018.37	4306	72	3998	57
2018.46	4382	83	4074	80
2018.54	4433	64	4014	240
2018.62	4325	77	4000	54
2018.71	4420	51	4153	45
2018.79	4309	75	4099	66
2018.88	4136	98	3865	93
2018.96	4066	49	3782	53

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