The Seychelles purse seine fishery observer program: Overview, challenges, and perspectives

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Abstract

The Republic of Seychelles initiated a National Scientific Observer Programme in July 2013 to address the objectives of the IOTC Regional Observer Scheme. The programme is carried out by the Seychelles Fishing Authority (SFA) and follows the methodology in use in the European purse seine fleet, i.e. the same observer protocol and the software ObServe to acquire and manage the data sets. A guide of good practices complements the protocol to provide information on the design of fish aggregating devices (FADs) and the release of incidentally caught species. During 2014-2016, more than 3,300 days at sea were observed throughout more than 100 fishing trips conducted onboard 13 Seychelles purse seiners and 5 Seychelles support vessels. The programme covered more than 2,700 fishing sets observed and a total catch of more than 70,000 mt, representing about 30% of the total catch of the fishery during 2014-2016. A large range of data have been collected on vessel and FAD-related activities, environmental conditions, FAD design, and species and size composition of the targeted and non-targeted catch. However, the limited training of the observers combined with the limited amount of human resources devoted to the management of the data resulted in some variability in the quality of the data. A comprehensive analysis of the observer data sets is ongoing to qualify the historical data sets, develop a robust procedure for checking and controlling the new databases collated from returning observers, and improve the overall data flow.

Keywords: bycatch; discards; Ecosystem Approach to Fisheries; fish aggregating device

1. Introduction

The Republic of Seychelles initiated a National Scientific Observer Programme in July 2013 to address the objectives of the IOTC Regional Observer Scheme (ROS; Res. 11/04) of collecting verified catch data and other scientific data related to the purse seine component of the Seychelles tuna fishing fleet. The overarching objective of the ROS is to provide good quality, comprehensive, independent data to be used to inform management advice. The programme is carried out by the Seychelles Fishing Authority (SFA) in collaboration with the Spanish, French and South Korean fishing companies that own the vessels and their representative associations. In addition to the minimum coverage rate of 5% of fishing operations required by the Resolution 11/04, the fishing companies have financially supported the extension of the programme to address some of the requirements of the Marine Stewardship Council (MSC) standard for responsible fisheries. The collection of data providing information on the impact of fishing on marine ecosystems, including endangered, threatened and protected species, constitutes a major component of the MSC certification for which a series of pre-assessments and one full assessment were conducted by the purse seine fishing companies during 2014-2016. Following the development of a Fisheries Improvement Project (FIP) by OPAGAC in 2016, the whole Seychelles purse seine fleet has started in 2017 the Sustainable Indian Ocean Tuna Initiative (SIOTI) FIP[1] with the support of World Wildlife Fund (WWF), Thai Union Group, Princes Tuna Ltd. and the governments of Seychelles and Mauritius. The support of the Seychelles purse seine observer program through observer training, data analysis, management and reporting is an important component of the SIOTI action plan with the final goal of a full assessment for MSC certification in five years.

In parallel to the deployment of human observers, video monitoring systems have been deployed in 2014 on some purse seiners operating in the Indian Ocean following the resolution of the International Seafood Sustainable Foundation (ISSF) requiring a 100% observer coverage for the purse seiners that supply tuna to ISSF Participating Companies[2]. Several electronic monitoring (EM) trials have been conducted on purse seiners to test the ability of EM to replace and/or complement human observers programmes (Restrepo et al. 2014, Ruiz et al. 2015). In 2016, a pilot project supported by the FAO-ABNJ Tuna programme, OPAGAC, SATLINK and the Seychelles Government was developed on two Seychelles purse seiners (Jupiter 2017). Overall, EM appears to be very promising although some technical aspects still limit its operational use in the purse seine fishery (Ruiz et al. 2016, Briand et al. 2017).

After some preliminary trials in 2013, the Seychelles purse seine observer programme really started in 2014 with the methodology in use in the European fleet operating in the Indian Ocean. It is to be noted that the programme was originally developed to address Seychelles needs in regards to IOTC Resolution 11/04, hence covering only the Seychelles fleet. However, with demands from other fleets, the programme expanded significantly. The necessity of deploying a large number of observers in a short period of time to address the high demand of observers to be boarded on vessels flying the Seychelles, Spanish, French and Korean flags and the limited human resources capacity for coordinating the programme resulted in loose selection criteria and limited training of the observers. The high turnover rate of observers further complicated things, requiring repeated training sessions. In addition, some reorganization at SFA reduced the staff devoted to the programme which resulted in some inadequacies in the data flow process. Consequently, several data sets were not recovered following the fishing trips, limited debriefing was conducted with the observers on their return and limited checking procedure was applied to the data.

The present report focuses on the human observer trips conducted onboard Seychelles purse seiners and support vessels during 2014-2016 for which the data were recovered to: (i) describe the

1 http://www.fisheryprogress.org/fip-profile/indian-ocean-tuna-purse-seine-sioti
2 https://iss-foundation.org/knowledge-tools/publications-presentations/conservation-measures-commitments/

observer protocol and nature of the data collected at sea, (ii) the software used for the collection, control and management of the data in a central database, and (iii) provide an overview of the data spanning the period 2014-2016. We finally present the main features of the ongoing work of data control and verification aimed at modifying the data flow and improve the overall quality of past and future Seychelles purse seine observer data sets.

2. Data collection

2.1 Protocol

The observer protocol in use in the Seychelles purse seine fishery is the one used on all European purse seiners operating in the Atlantic and Indian Oceans. The protocol was developed by the Instituto Español de Oceanografia (IEO) and Institut de Recherche pour le Développement (IRD) in the early 2000s with the implementation of the EU multi-annual programme for data collection (formerly Data Collection Regulation). The protocol built on past experiences of observer programmes in the Indian and Atlantic Oceans (Sabadach & Hallier 1993, Stretta et al. 1998). It addresses the needs of the ROS, including (i) reporting of fishing activities and verification of vessels positions, (ii) observation and estimation of catches with a view to identifying catch composition and monitoring discards, bycatch and size structure, and (iii) recording of information on vessel and technical attributes, including fish aggregating devices.

The observer protocol is composed of five inter-related forms:

- Form A: Route and environment
- Form B: Fishing characteristics
- Form C1: Targeted species size measurements
- Form C2: Non-targeted species size measurements
- Form D: FOB-related activities

2.1.1 Route and environment

The form A describes the chronological sequence of activities of the vessel during the trip (e.g. search, fishing operation, etc.), the time and position of the vessel, the means of detection used, and the environmental conditions. It must be filled for each new activity of the vessel and once every hour when there is no activity (**Table A1**). The form A includes some metadata with the observer name, the vessel name, the vessel IOTC unique identifier, the date of recording, and the mileage in the morning and evening. Each line of the form corresponds to an activity and the fields to fill up are: time, longitude, latitude, activity, surrounding activities of other vessels (**Table A2**), vessel speed, sea surface temperature, state of the sea (Beaufort wind scale[3]), first detection mode (**Table A3**), reason for non-setting (**Table A4**), observed system (**Table A5**), and distance to the observed system if any. A new form is used everyday.

2.1.2 Fishing characteristics

The form B provides information on each fishing set made during the trip. In addition to metadata enabling linking each activity to form A, the form B first includes some data describing the conditions of the fishing set (i.e. use of sonar, current speed and direction, name of support vessel if any) and the main features of the tuna school estimated with acoustic methods prior to the operation (i.e. estimation of school size and depth in the water column). Second, the time of setting, end of pursing, and end of setting have to be recorded as well as the reason for unsuccessful set (**Table A6**). Finally, the magnitude and species and size composition of the catch retained and discarded for both targeted and non-targeted species have to be reported as well as the storage location in the

3 https://en.wikipedia.org/wiki/Beaufort_scale

purse seiner (brine-freezing or dry-freezing well), fate of the bycatch species (**Table A7**), and reason for discarding (**Table A8**).

It is noteworthy that the protocol stipulates that the quantities of commercial tuna retained onboard should be retrieved from the Captain, First Officer, Chief Engineer or by the Cold-store Engineer because it is very difficult to follow the operations of brailing concomitantly with the monitoring and measuring of non-target species and target tunas to be discarded. In addition, the estimation of the composition of tuna catch is made difficult by the mix of all three species together, by the anatomical similarity between juveniles of yellowfin and bigeye, and by the sometimes large quantities caught that can exceed 100 metric tons and are flowed as quickly as possible into the brine-freezing wells. Hence, observer data can not be used to verify and validate the declarations of the skippers reported in the logbooks. In complement, logbook data are monitored by SFA at landing and systematically compared with information available from the sales notes of transshipments.

The main priority of the current protocol is given to bycatch and discards which are fully estimated by the observer, i.e. the samples are raised to the fishing set. Bycatch is identified to the lowest possible taxon using an identification guide and keys and descriptions found in the literature. The method of estimation varies on a case by case basis according to the design and technical attributes of the vessel (e.g. sorting belt), the practices of sorting and discarding which in turn depend on the storage mode (e.g. ultra-freezing process) and vary with the company or crew. The observer has to deal with different situations when the sorting concurrently occurs in the upper deck for larger animals (e.g. billfishes, large sharks or rays) and lower deck for smaller ones. Observers can report non-targeted species in numbers of individuals (whenever the number of individuals is moderate) and average length or weight, or in opposite estimate total weights of each species when there are many individuals (e.g. triggerfish).

2.1.3 Targeted species size measurements

The form C1 is used to record the size measurements of the tunas discarded-at-sea: the principal market species, albacore tuna (*Thunnus alalunga*), bigeye tuna (*Thunnus obesus*), skipjack tuna (*Katsuwonus pelamis*), and yellowfin tuna (*Thunnus albacares*), and the neritic species, bullet tuna (*Auxis rochei*), frigate tuna (*Auxis thazard*), and kawakawa (*Euthynnus affinis*). Sizes are measured to the nearest 0.1 cm with a fish measuring board or a caliper in fork length, i.e. projected straight distance from the tip of the upper jaw (snout) to the shortest caudal ray (fork) (**Fig. 1**). The form includes metadata enabling linking the form with the route (form A) and the fishing set (form B), recalls the date and vessel identifier, and the size measurements by species. It is noteworthy that size measurements only concern tunas discarded at sea because (i) historical experiments have shown that observers tend to non-randomly select the individuals (i.e. selection of small tunas) which biases the size structure of the catch and (ii) the retained catch is sampled at unloading in Victoria, Seychelles following a standard protocol in force since the start of the fishery in 1997.

2.1.4 Non-targeted species size measurements

The form C2 is used to record the size measurements of all non-targeted species. It provides details on the types of size measurements to be taken and the ways of identifying the sex in sharks, turtles, and small cetaceans (**Fig. 1**). The form also allows for individual weights to be reported as the standard materials provided to the observers includes some spring scales and electronic scales are sometimes available onboard.

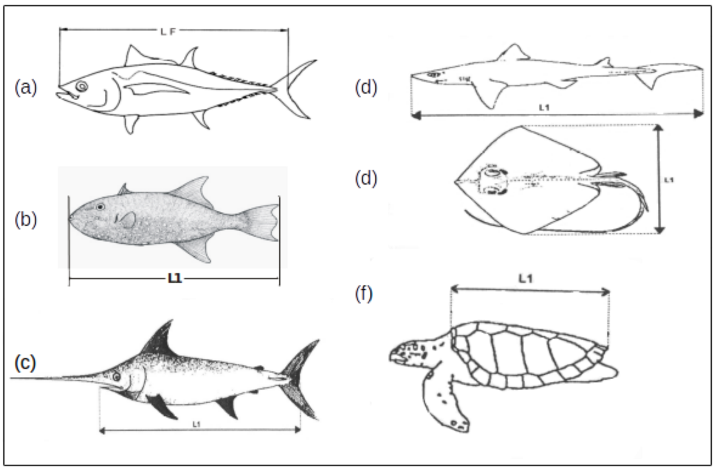

Fig. 1. Description of the types of size measurements according to the group of species observed. (a) fork length for fish with forked caudal fin such as tunas, (b) total length for fish with rounded, truncate or lunate caudal fin, (c) lower jaw fork length for billfishes, (c) total length for sharks, (d) width for rays, and (e) straight carapace length for turtles

2.1.5 FOB-related activities

The form D is used to record the information relative to the floating objects encountered or used during the trip as well as the beacons (buoys) attached to them. Activities on floating objects related to the form A include deployments, visits with and without fishing, and retrieval without fishing. Each floating object is described by its type (**Table A9**), its fate (**Table A10**), the number of days the FAD spent at sea, and the ownership of the buoy including the flag, vessel name, and support vessel name (if any). Each activity related to the beacon is reported in the form, i.e. simple visit, retrieval without replacement, deployment of a new buoy, and transfer of the buoy. Each beacon is described by its type (**Table A11**), code, and brand. The form D also includes information on acoustic-based estimate of school size in absence of fishing set, as well as the presence of turtles, sharks, and billfish in the vicinity of the floating object, including their possible entanglement in the object structure.

2.1.6 Guide of good practices

The organizations of tuna purse-seiners ANABAC and OPAGAC signed in February 2012 a Code of Good Practices for responsible tuna purse-seine fishing. This code, in force in all the OPAGAC-AGAC and ANABAC-OPTUC fleets, aims to (1) improve the operations performed in the tuna purse-seine fleet by both organizations, (2) improve the selectivity of fishing with FADs and (3) minimize the impact of fishing on the ecosystem. To do this, rules were established regarding the design of fish aggregating devices (DFADs) and the release of the fauna that can be found associated with the FADs. Specific objectives are the total replacement of non-conform FADs by non-entangling FADs, and the release of incidentally caught or FAD-associated fauna, ensuring the safety of the crew and maximizing the survival of released animals.

AZTI Foundation is in charge of developing and implementing a system of verification of this Code of Good Practices in tuna purse-seine fishery[4]. In this system, the role of observers is primordial. On board observers are in charge of registering information on each FAD that is being planted,

4 http://www.azti.es/atuneroscongeladores/recursos/buenas-practicas-para-una-pesca-atunera-de-cerco-responsable/

visited or on which a fishing event occurs, and on most vulnerable species that are released (sharks, rays, sea turtles and whale sharks).

In order to achieve these goals, three new paper forms have been implemented (B2, B3 and D2) and for the time being the digital data compilation and analysis is done using Excel files. It is expected that in a years' time the whole relevant data fields will be integrated in the future ObServe v.7.0 as a standardized DFAD data collection task.

2.2 The ObServe software

The development of ObServe started in 2009 to improve the overall flow of the data sets collected throughout the French National purse seine observer program (Cauquil et al. 2010). ObServe consists of a central PostgreSQL database and multiple instances of the acquisition and management software. The Java-based software can be used offline (i.e. without connection to the central database) as it uses a built-in instance of the database model that is identical to the central database model (Cauquil et al. 2015) (**Fig. 2**). Synchronization functions are used to (i) download/update reference data from the central database to the software instance, and (ii) upload data collected (and saved offline) by the observer into the central database.

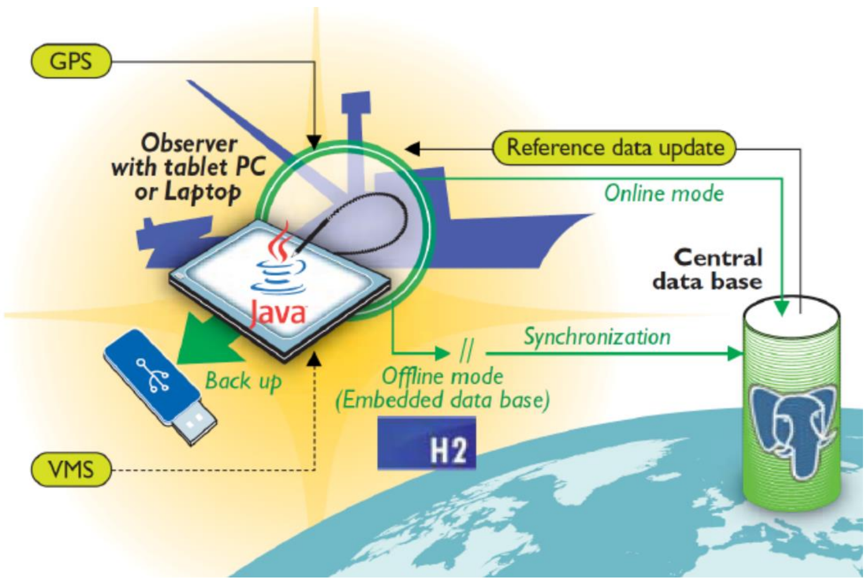

Fig. 2. Scheme representing the offline-online approach used for the

Four distinct levels of controls are used in ObServe according to their semantic skill and timing:

- Level 0 is provided by the relational model of the database itself. Through the mechanism of foreign keys and uniqueness constraints, it ensures the validity of the data structure. But it has no effect on their semantic value;
- Level 1 includes controls that apply at the time of data entry. Their scope is limited to the current form, i.e. they can not invalidate any information based on previously collected data. In return, they act in real time and prevent any validation of aberrant data;
- Level 2 includes more sophisticated rules, such as overlap of data, which require a certain level of completeness (e.g., finalized activity or journey), to be applied;
- Level 3 allows the user to predict morphometric measurements, e.g. the weight of an individual from its length, or the total length from its fork length.

Several versions of ObServe have been released over the recent years with an increasing complexity of control as well as some options of data export, i.e. summary tables and automatic reports

(Cauquil et al. 2015). All checks and controls at data entry were not systematically applied to the Seychelles data sets because the version in use was not consistently updated with the most recent version available.

3. Seychelles' observer data

3.1 Coverage

A total of 104 observer data sets were collected conducted on 13 Seychelles purse seiners and 4 support vessels during 2014-2016. This represents about 3,400 days of observation at sea with more than 2,700 fishing sets observed that resulted in a cumulated catch of more than 72,000 mt (**Table 1**).

Table 1. Summary of the extent of the observer program on Seychelles purse seiners and support vessels during 2014-2016. Note that the trips can be double-counted when they overlap over two consecutive years.

Year	Trips	Days at sea	Sets	Catch (mt)
Purse seiners				
2014	7	173	132	3,153
2015	60	1,785	1,429	38,640
2016	39	1,150	1,177	30,798
Support vessels				
2015	5	259	N/A	N/A
TOTAL	104	3,367	2,738	72,591

The observer coverage of the purse seine fishing operations significantly increased from 7% in 2014 to more than 50% in 2015, before decreasing to about 25% in 2016 (**Fig. 3**). The trend in coverage was very similar for the total catch of the fishery with an increase from 5.3% in 2014 to about 45% in 2015 and a decrease to about 27% in 2016.

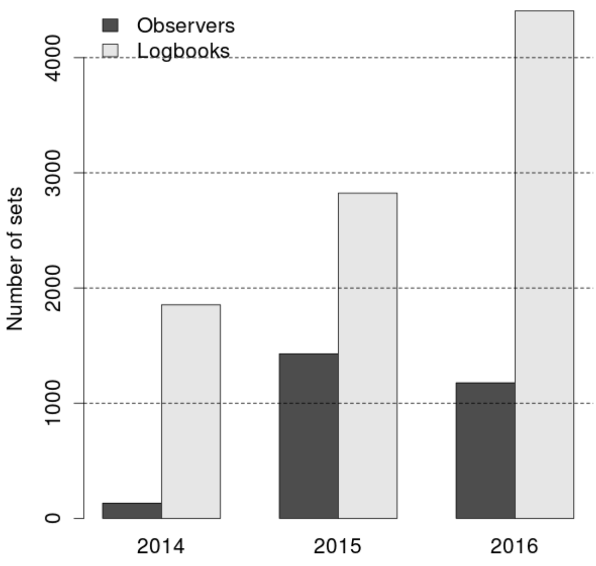

Fig. 3. Number of fishing sets observed (dark grey) and reported in the logbooks (light grey) for the Seychelles purse seine fishery during

The distribution of fishing sets observed during 2014-2016 extends across the whole western Indian Ocean, with the main fishing grounds located in the Northwest of Seychelles (**Fig. 4**).

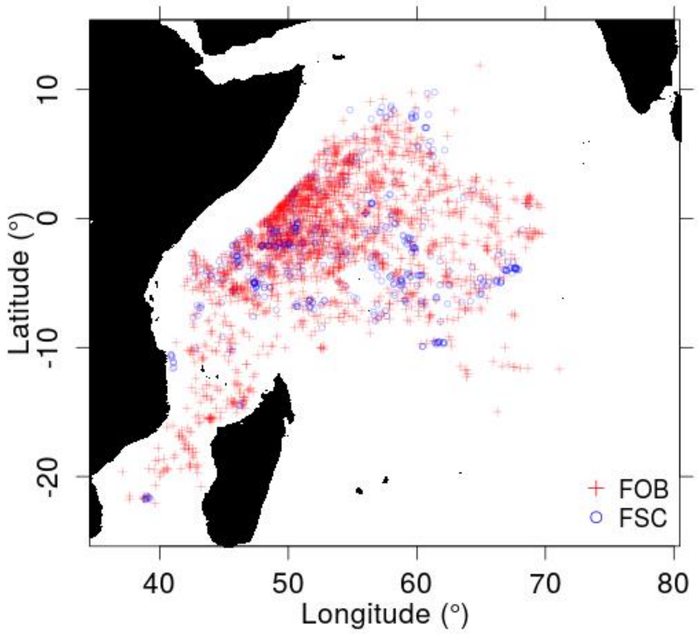

Fig. 4. Spatial distribution of the fishing sets observed onboard Seychelles purse seiners during 2014-2016. FOB = School associated with drifting floating object; FSC =

3.2 Data collection

A large number of data on vessel activities, environmental conditions, and non-targeted species were collected onboard Seychelles purse seiners and support vessels during 2014-2016 (**Table 2)**. It is noteworthy that few information was collected on gears and technical attributes of the vessels (e.g. size of the purse seine) although such information is useful to assess technological improvements over time and the relative importance of differences in fishing power on commercial catch rates.

Table 2. Number of records available in the Seychelles Observer database

Information	**Number of records**
Vessels and fishing activities	
Vessel attributes	12
Vessel activities	58,432
Log (mileage)	6,260
Vessel speed	58,309
Detection modes	25,183
Setting time, pursing, and set duration	8,214
Operations on FOBs and buoys	XXX
Environmental parameters	

Current speed & direction	4,779
Sea surface temperature	58,304
Wind (state of the sea)	57,815
Sampling	
Number of species in the catch	69
Number of size measurements of non-targeted species	93,188

4. Ongoing work and perspectives

The important amount of data collected from observers is the tree that hides the forest. The quick, large deployment of observers with limited training and lack of experience resulted in a lack of understanding and overall compliance with the protocol. In addition, the few feedbacks provided at their return and high turn over in the observers prevented to consolidate a large array of good observers in the first years of the programme. A comprehensive analysis of past observer data sets has recently started to review all data collected and identify the quality and limits of each data set. Automatic procedures are put in place to to assess data consistency by (i) checking the data collected during a trip against each component of the protocol, (ii) comparing each data set with other observer data sets considered of good quality, (iii) checking positions of the activities with VMS data, and (iv) comparing observer and logbook data (**Fig. 5**).

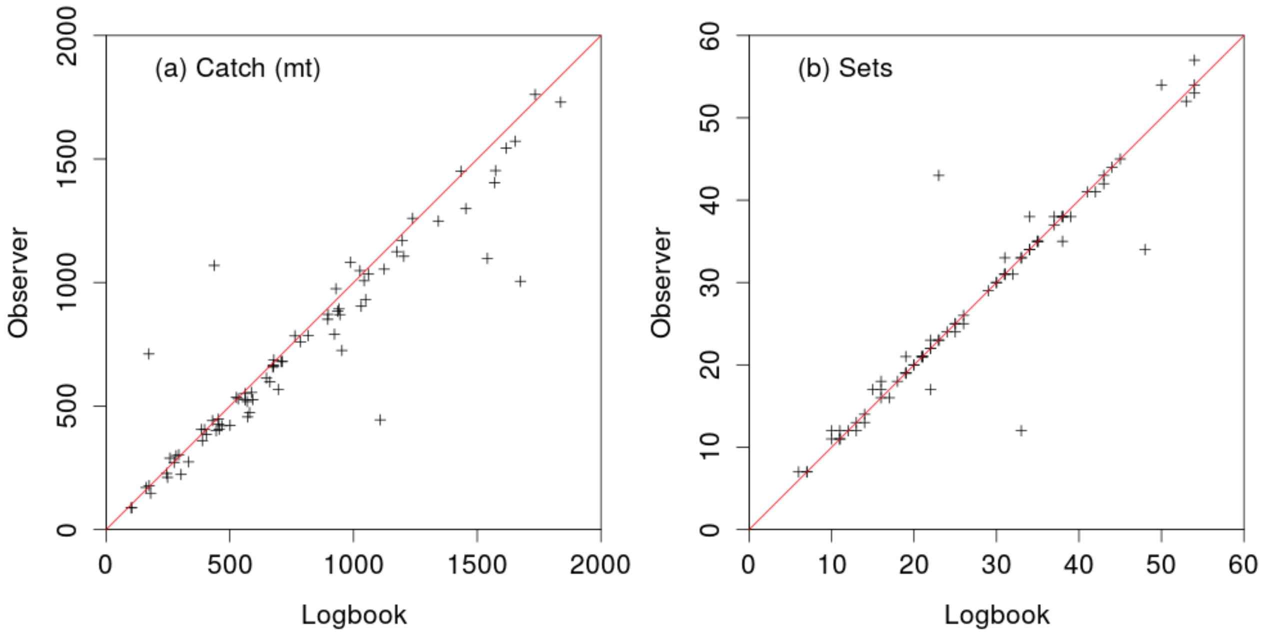

Fig. 5. *Comparison between logbook and observer data for the 99 fishing trips on Seychelles purse seiners observed during 2014-2016: (a) Total catch (mt) and (b) Total number of fishing sets. Comparison of the total catch (after adjustment to the landings) and the number of fishing sets shows an overall good consistency between logbooks and observer data at the scale of the fishing trip. Some data however show some inadequacy between sources.*

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Appendix. Tables of references of the Seychelles purse seine observer programme

Table A1. *List of vessel activities in the Seychelles observer database.*

Code	Description
00	At port
01	Transit (steaming without searching)
02	Searching (in general)
03	Searching for floating objects (logs or Fish Aggregating Devices -FADs)
04	Steaming towards observed system associated to the tuna school
05	Arrival of fishing vessel to the observed system associated to the tuna school
06	Start of fishing (skiff is deployed)
07	End of fishing (skiff is brought on board)
08	Drifting during the day near a tuna school, a log or a FAD
09	Drifting during the night (engine stopped)
10	Drifting due to bad weather (reduced speed, into the wind or swell)
11	Drifting due to mechanical problems
12	Transshipping at-sea
13	Installation or modification of a floating object (log or FAD)
14	Recovering a floating object (log or FAD) belonging to the vessel
15	Recovering a floating object (log or FAD) that does not belong to the vessel
16	End of searching
17	Anchorage on top of a seamount
18	Steaming at night towards a floating object (log or FAD)
19	Continue steaming towards observed system associated to the tuna school
20	Recovery of a floating object (log or FAD)
99	Other (to detail in the comments)

Table A2. *List of surrounding activities of other fishing vessels in the Seychelles observer database.*

Code	Description
1	Alone in the area
2	In a group with other tuna vessel(s) visible to the radar
3	In a group with other tuna vessel(s) of the same gear and the same flag
4	In a group with other tuna vessel(s) of the same flag but different gears
5	In a group with other tuna vessel(s) of the same gear but different flags
6	In a group with other tuna vessel(s) of different gears and flags

Table A3. *List of detection modes of tuna school in the Seychelles observer database.*

Code	Description
0	Unknown
1	Naked eye
2	Binoculars
3	Bird radar
4	Radar
5	Sonar
6	Sounder
7	Radio/satellite buoy
8	Signalled by another vessel
9	Other (detail in comments)

Table A4. *List of reasons for not conducting a fishing set in the Seychelles observer database*

Code	Description
00	Nothing to be signalled (not observed)
Skipper decision	
01	School too small
02	Undersized fish (weight, size)
03	Vessel owner's decision
School behaviour	
04	School moves too fast
05	School dives before the set is completed
06	School is too deep
11	School too scattered
Other	
07	No fish present
08	Strong currents
09	Mechanical break
10	Another vessel encircles the fish school
99	Others (to detail in the comments)

Table A5. *List of observed systems in the Seychelles observer database.*

Code	Description
00	No system detected
01	Tuna school (no details given on the type of school)
02	The appearance of the sea surface changes due to the presence of a tuna school. French fishermen use the following terms to describe the changing on sea surface appearance: “brisant”, “sardara”, “balbaya”, “saut” (see glossary).
03	Presence of a deep tuna school
04	Presence of birds
05	Natural log (wood, or piece of rope, etc.) or FAD with NO satellite buoy attached
06	Natural log (wood, or piece of rope, etc.) or FAD with a satellite buoy attached
07	Animal carcass with NO satellite buoy attached
08	Animal carcass with a satellite buoy attached
09	Presence of small toothed whales / dolphins (dolphins, pilot and/or false killer whales)
10	Presence of large toothed whales (killer whales, sperm whales)
11	Presence of whales (baleen whales) e.g. blue whale, mink whale, etc.
12	Presence of a whale shark
13	Presence of shark(s)
14	Presence of another tuna vessel
15	Presence of a supply vessel
16	Same school that escaped the previous set
17	School associated to the tuna vessel
18	Fishing on a seamount
19	Fishing on the continental shelf break
99	Other (to detail in the comments)

Table A6. *List of reasons for the failure of the fishing set (i.e. purse seine deployed but the set is considered unsuccessful by the skipper) in the Seychelles observer database.*

Code	Description
00	Unknown
01	Fish school sunk
02	Fish school moving too fast
03	Strong currents
04	Fish school too big
05	Broken net
06	Winch mechanical breakdown
07	Bad weather
08	The whale escaped from the net and the fish followed her
09	Other (to detail in the comments)

Table A7. *List of fates for the non-targeted species in the Seychelles observer database*

Code	Description
1	Escaped from the net (to be used for whale sharks, cetaceans and turtles)
2	Removed from the net alive (to be used for whale sharks, cetaceans and turtles)
3	Removed from the net dead (to be used for whale sharks, cetaceans and turtles)
4	Discarded alive at sea
5	Discarded dead at sea
6	Stored in well
7	Partially preserved (e.g. shark fins, dried fish, etc.).
8	Cooked on-board
9	Other (to detail in the comments)

Table A8. *List of reasons for discarding in the Seychelles observer database.*

Code	Description
1	Species
2	Size
3	Wells full
4	Fish damaged
99	Other (to detail in the comments)

Table A9. *List of types of floating objects in the Seychelles observer database.*

Code	Description
1	Payao (“Tas de paille”)
2	Coconut / palm leaf
3	Tree log (or branch)
4	Animal carcass (to detail in comments)
5	Animal carcass with buoy (finder, GPS, satellite buoy, etc.)
6	Drifting FAD (bamboo and net) with buoy
7	Anchored FAD
8	Tuna vessel or skiff
9	Support vessel
10	Box or big board
11	Rope or cable
12	Net or piece of net
13	Piece of plastic (to detail in comments)
15	Drifting FAD (bamboo and net) without buoy
16	Drifting FAD or buoy
17	Metallic object
18	Drifting FAD made with man-made materials (no details on buoy)
19	Experimental FAD (detail in comments with sketches)
20	FAD (with metal structure or PVC) without buoy
21	FAD (with metal structure or PVC) with buoy
99	Other (to detail in the comments)

Table A10. *List of fates for the floating object in the Seychelles observer database.*

Code	Description
1	Abandoned (without buoy, not destroyed, not sunk)
2	Re-deployed with a buoy
3	Brought onboard
4	Destroyed
5	Sunk
6	Buoy replaced
7	Left in the water with the same buoy
8	Adding a raft to a natural log
9	Other (to detail in the comments)

Table A11. *List of type of buoys (beacon) associated to the floating object in the Seychelles observer database.*

Code	Description
1	Radio direction finder
2	GPS finder
3	GPS - SERPE
4	Satellite with undetermined echosounder
5	Satellite without echosounder
6	Satellite with sonar
7	Satellite with ZUNIBAL echosounder
8	Satellite with SATLINK echosounder
9	Satellite with MARINE INSTRUMENT echosounder
10	Satellite with OTHER echosounder (to details in comments)
98	Unknown or undetermined
99	Other type (to details in the comments)