Developing Electronic Monitoring System (EMS) standards to collect scientific data: learning from experience with French and associated fleets of the Indian Ocean

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Abstract

During the last decades, Electronic monitoring (EM) has been progressively implemented and tested in tuna fisheries and various pilot projects have confirmed the potential of EM to collect scientific information, that could be useful to fulfil data requirements of the Regional Observer Scheme in the Indian Ocean. Nevertheless, as for any new tool, it is critical that EM minimum standards are discussed and adopted, before validating the wide use of EM in the Indian Ocean.

The aim of the present document is to contribute to the definition of EM minimum standards for scientific data collection on tropical tuna purse seine fleets of the Indian Ocean. This document reports on the shared experience of scientists, fleet managers, EM analysts and EM vendors in various EM pilot projects covering the French and associated tropical tuna purse seine fleet since 2014. Here, we review the results obtained for two types of scientific data collection needs : (i) data collection on discards, that is currently undertaken routinely to compensate for a lack of onboard observation, and (ii) data collection on retained catches, that is currently in development. Lessons learned from the two types of projects are used to make recommendations that could be used as guidelines when adopting EM minimum standards for scientific data collection purposes in IOTC.

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1. Introduction

During the last decades, the use of Electronic Monitoring (EM) has grown exponentially in numerous fisheries as a mean to collect information on catch, bycatch and discards. In the case of tuna fisheries, EM has been progressively implemented and tested as an alternative tool to supplement onboard observation and increase observer coverage, especially for vessels that cannot embark observers (Restrepo *et al.*, 2014; Ruiz *et al.*, 2015; Hosken *et al.*, 2016; Emery *et al.*, 2018, 2019; Gilman *et al.*, 2020). In particular, various EM projects have been implemented onboard European and associated tropical tuna purse seiners with the objective of reaching 100% coverage of fishing sets (Ruiz *et al.*, 2015, 2016; Briand *et al.*, 2018). Among others, provided that EM systems are carefully configurated, these pilot studies have confirmed that EM allows the monitoring of discards at an acceptable species identification resolution, especially for species and groups of species which are systematically discarded (Briand et al., 2018). Though issues remain for the monitoring of incidental interactions with sensitive shark species (Briand *et al.*, 2018; Forget *et al.*, 2021) and the monitoring of the use of Floating OBjects (FOBs, Ruiz *et al.*, 2017), EM has therefore proven to be a valuable tool to collect scientific data onboard tropical tuna purse seiners, that could be used to fulfil data requirements in the frame of the Regional Observer Scheme (ROS - IOTC, 2011) of the Indian Ocean Tuna Commission (IOTC).

Nevertheless, as for any new tool, it is critical that EM minimum standards are discussed and adopted, before validating the wide use of EM in the Indian Ocean (Murua *et al.*, 2020). In recent years, such potential minimum standards have been proposed by various authors (e.g. Restrepo *et al.*, 2014; Ruiz *et al.*, 2016; Murua *et al.*, 2020). In 2020, Murua et al. presented an extensive review of potential EM minimum standards for a range of fishing gears (longline, gillnet, purse seine and pole and line). Discussions during the Working Party on Data Collection and Statistics (WPDCS) highlighted the importance of involving the different stakeholders in the process of defining EM minimum standards and it was decided to create an ad-hoc intersessional Working Group on the development of EM Programme Standards in 2021 (IOTC, 2020a, 2020b).

The aim of the present document is to contribute to the definition of EM minimum standards for scientific data collection on tropical tuna purse seine fleets of the Indian Ocean. This document reports on the shared experience of scientists, fleet managers, EM analysts and EM vendors in various EM pilot projects covering the French and associated tropical tuna purse seine fleet since 2014. Here, we review the results obtained for two types of scientific data collection needs : (i) data collection on discards, that is currently undertaken routinely to compensate for a lack of onboard observation, and (ii) data collection on retained catches, that is currently in development. Lessons learned from the two types of projects are used to make recommendations that could be used as guidelines when adopting EM minimum standards for scientific data collection purposes in IOTC.

2. The OCUP-electronic program onboard French and Italian purse seiners

2.1 Objectives of the program

In 2013, ORTHONGEL implemented the *OCUP program* to facilitate the boarding of scientific observers of coastal countries (Goujon *et al.*, 2017), with the aim of reaching an exhaustive observer coverage of its member fishing vessels. In 2014, as some vessels of the Indian Ocean could not carry observers due to the lack of space onboard (piracy-protection teams are embarked since 2010), an electronic monitoring extension of the program was implemented (Electronic Eye Optimization *"OOE" Project for the Future*, Briand *et al.*, 2017), with the participation of partners from the Producer Organization ORTHONGEL, the fishing company CFTO, the French Research Institute for Sustainable Development (IRD) and Bureau Veritas Living Resources (BVLR).

It is important to note that the objective of the OCUP-electronic component of the program is not to replace the OCUP-onboard coverage of French and Italian purse seiners of the Indian Ocean but rather to ensure the coverage of purse seiners which cannot routinely board observers. In 2021, 3 French purse seiners are routinely covered by OCUP-onboard observers while 7 French and 1 Italian purse seiners are routinely covered by OCUP-electronic observers.

Since 2013, onboard OCUP observers have brought the complement to the mandatory 10-15% observer coverage (EU *DCF program*) to reach 41.0% of fishing days in the Indian Ocean in 2019. The Electronic Monitoring Systems (EMS) implemented in 2014 covered the remaining 47.4% of fishing days in the Indian Ocean in 2019 (Figure 1). The remaining 11.6% of fishing trips corresponded to fishing trips covered by EM but for which EM records could not be analysed (unexploitable or incomplete EM records). In 2020 and 2021, issues encountered with the Covid-19 pandemic did not allow to maintain the expected coverage by OCUP – onboard observers, though the mandatory coverage by DCF observers was maintained. At the same time, the coverage of EM equipped purse seiners improved as solutions were implemented to avoid EM recording issues (see 2.3.2 and 2.4.2).

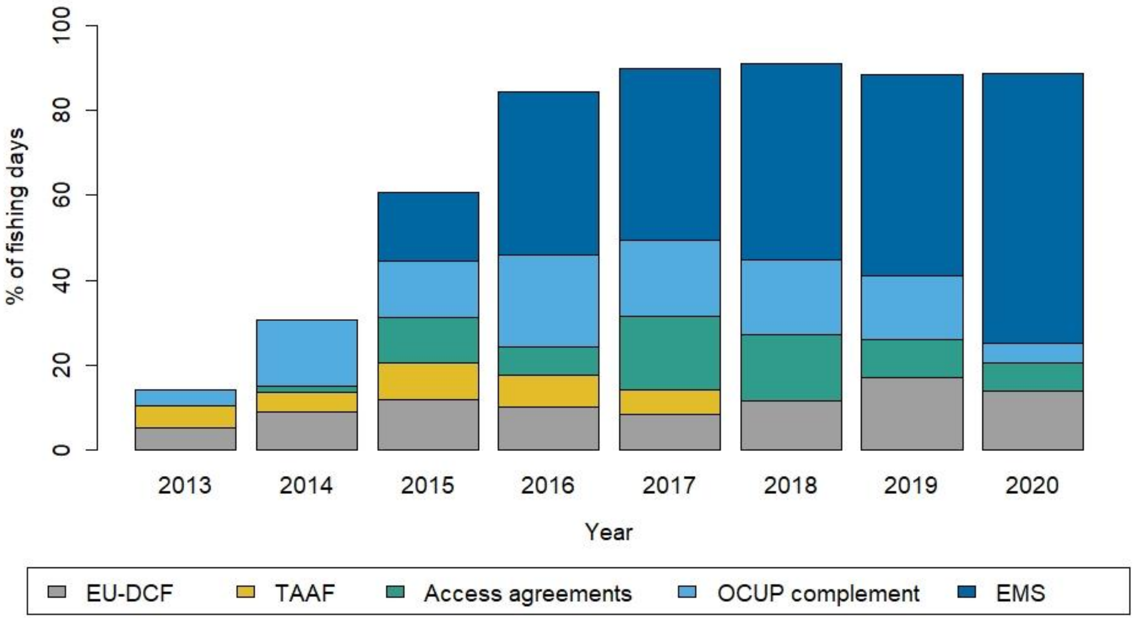

Figure 1: observer coverage per type of scientific observation program (FR and IT purse seiners)

2.2 Camera installation

7 French and 1 Italian purse seiners have been equipped in 2014 with EM systems developed by Thalos. The initial configuration of EM systems, installed in 2014 and funded by CFTO was primarily designed to collect similar information as onboard observers on :

- fishing activities (date, position and type of fishing sets)
- discards (amount and species composition)
- Best Practices for the safe release of sensitive species (sharks, rays and sea turtles)

Since 2014, various pilot projects have allowed gradually improving EM configuration to solve issues of insufficient image definition, overexposure, water projections or blind spots when collecting scientific information on discards with EM records (Briand *et al.*, 2017, 2021). In complement, these projects have contributed to the development of improved solutions for the storage and the analysis of EM records (see sections 2.3 and 2.4).

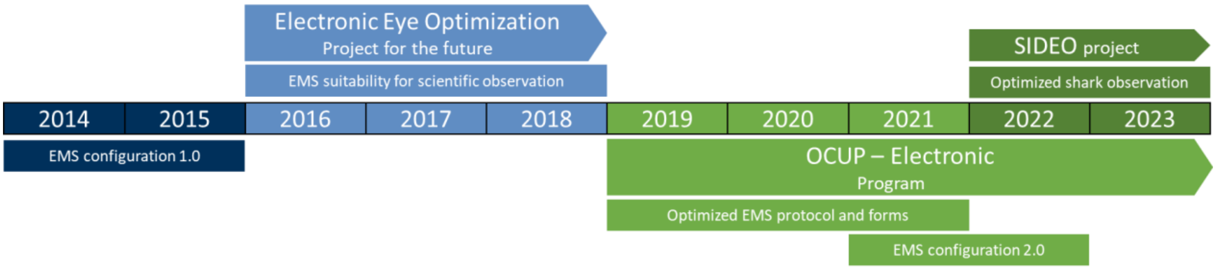

Figure 2: progress made since 2014 on EMS configuration and protocols for the scientific observation of discards of EMS-equipped French and Italian tropical tuna purse seiners of the Indian Ocean.

Though important progress have been made since 2014, as for any new tool, reaching high standards of data quality with EM is a trial and error process. At this stage, fine tuning of existing EM systems is therefore being conducted with three main objectives. First, as vessel-customized EM configurations may be challenging for data collection by electronic observers (Briand *et al.*, 2021) camera installations and settings will be standardized. Second, as issues of observation (Forget *et al.*, 2021) or lack of species identification of sharks (Briand *et al.*, in prep) have been reported, camera installations will be further optimized on the upper deck (SIDEO project: Shark IDentification with Electronic Observation). Finally, as the EMS configuration 1.0 did not allow collecting information drifting Fish Aggregating Device (dFAD) deployment, the EM will be configurated to cover the front deck of purse seiners.

An optimised EM configuration is currently being deployed (end of 2021 – beginning of 2022) with 6 or 7 wide angle cameras (103°) covering operations on the upper (crow’s nest and desk cameras), lower (conveyor belt and discard belt cameras) and front decks (front deck camera). The cost of these improvements are supported by the fishing company CFTO.

On the upper deck, where setting, pursing, brailing operations and sorting of large bycatch must all be covered by electronic observers, an improved configuration is currently being deployed with (i) a port side crow's nest camera to monitor the general fishing activity including setting, pursing, and brailing (ii) a desk camera to record brailing operations and (iii) a starboard side crow's nest camera, currently in deployment, to solve known issues of blind spots of the desk camera. In the lower deck, two or three cameras record sorting operations along the conveyor and discard belts. Finally, a front deck camera is currently in deployment to record activities of drifting Fish Aggregating Device (dFAD) deployment at any time (day or night).

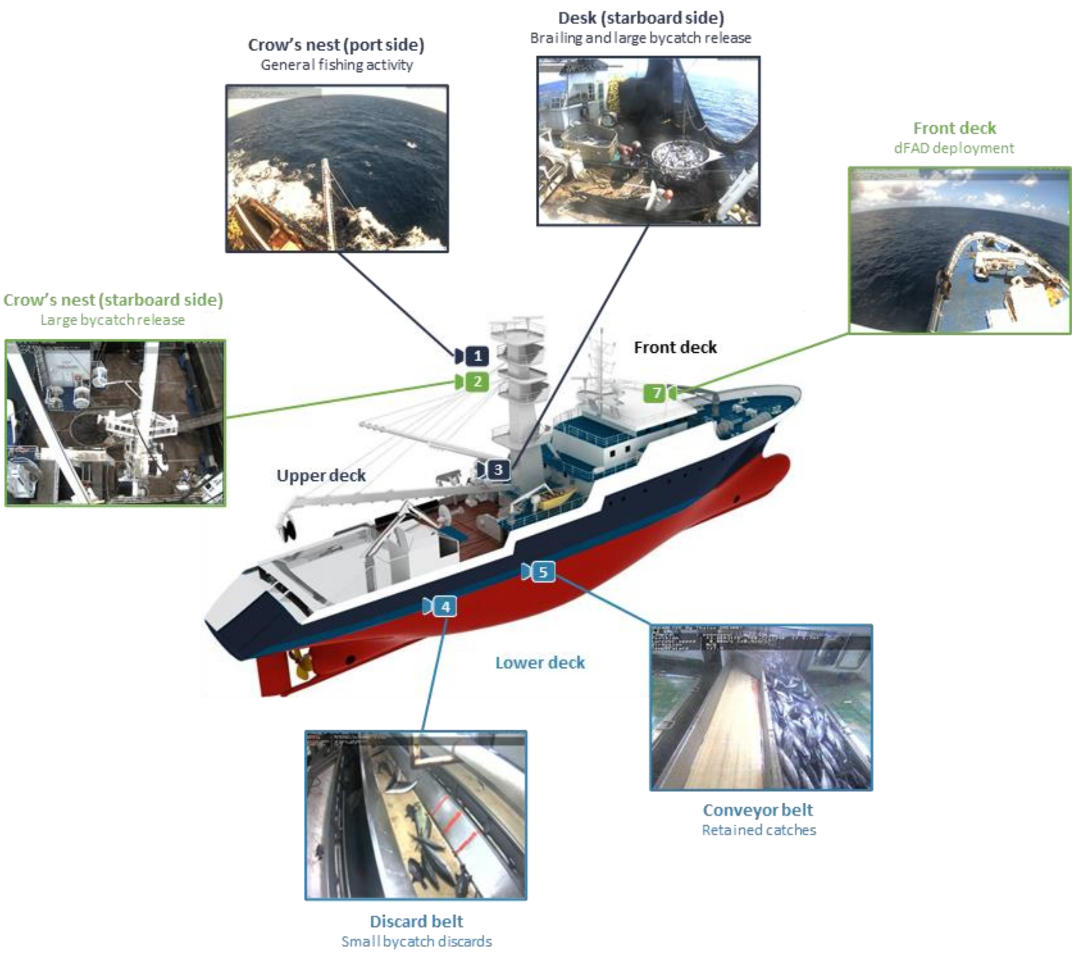

Figure 3 : EMS configuration 2.0, currently in deployment. Additional cameras (starboard side crow's nest and front deck) are highlighted in green.

2.3 Camera settings and EM records storage

2.3.1 Camera settings

Since 2014, the type of cameras used and their settings have also been improved, with a current objective of standardization of EM systems between purse seiners. Table 1 details the solution that is currently being deployed.

Table 1: camera setting in EMS configuration 2.0

Camera	GPS	Angle	Frames / s	Resolution	Recording
Crow's nest 1	Yes	103°	1	1024x768	Continuous during the day
Crow's nest 2	No	103°	2	1024x768	Triggered by vessel speed
Desk	Yes	103°	5	1024x768	Triggered by vessel speed
Conveyor belt	No	103°	5	1024x768	Triggered by vessel speed
Discard belt	No	103°	5	1024x768	Triggered by vessel speed
Front deck	No	103°	1	1024x768	Continuous (day and night)

Upper deck cameras are equipped with GPS which enables geolocalizing each frame and recording vessel position (one position per minute). All cameras have access those these Information on the location and timing of EM records, and this information is directly provided on all EM images, so as to grant the reliability of the information collected by electronic observers. The port side crow's nest camera is set to record continuously at day time (trigger based on ephemerids) so as to ensure that all fishing operations are captured. Other cameras of the upper and lower decks are triggered by vessel speed to record fishing operations once they start (upper deck) and to capture sorting operations of the catch (upper and lower decks). A trigger based on the detection of activity on the front deck is currently in development to avoid continuous recording. To limit the amount of data storage and in compliance with requirements of the French Data Protection Authority (CNIL), cameras are only recording when purse seiners are outside of a 12 NM radius from the closest port.

2.3.2 EM functioning checks

In complement, the cleanliness of cameras is regularly checked on land by the owner of EMS-equipped vessels, so as to ensure that cameras are recording images than can be analysed. A web application provides snapshots of EM records (one per hour) that allow alerting vessel crews as soon as a need to clean cameras is detected. The web application also provides information on the proper functioning of cameras (amount of EM record data stored per day) to identify issues of malfunctioning (defect cameras or hard drives, etc) and organize for maintenance operations. An automatized solution is in development to alert both the fishing company and the crew of water projections or other issues that degrade the integrity of video records in near real time.

2.3.2 EM videos storage and transmission to BVLR analysts

Once recorded, EM videos are stored digitally on two hard disks with a 6-month storage capacity :

- a *portable hard disk* that is transported to Bureau Veritas Living Resources (France) for analysis
- a *resident hard disk* that contains the same EM data and remains onboard to serve as a backup

The system is configurated for minimal intervention by vessel crews and the skipper is only in charge of installing the *portable hard disk* at the beginning of the fishing trip and replacing the disk at the end of the fishing trip. During the fishing trip, vessel crews do not have access to camera settings and cannot interfere with the proper functioning of the EM system. Physical intervention on cameras is also prevented by verifications of snapshots available on the dedicated web interface (see 2.3.1).

Data stored on hard disks are encrypted to grant the integrity of EMS records onboard purse seine vessels (no modification by vessel crews) and during their transport to BVLR facilities. Once received, hard disks are locked in a safety deposit box, only accessible by BVLR analysts. The videos stored on the hard disks are then decrypted by the analysts using a software developed by Thalos and passwords specific to each vessel. Decrypted videos are then deleted after complete viewing and unfilled hard disks are sent back to the vessel to re-encode a new fishing trip. A track file is shared among the partners of the OCUP-electronic program in order to check the completion and availability of the different hard disks.

2.4 Scientific data collection protocols

In the case of onboard observation, observers follow the protocols defined by the French National Institute for Research and Development (IRD-Ob7, 2020) to meet tuna Regional Fisheries Management Organisation (t-RFMO) requirements (IOTC, 2011, 2015a, 2015b, 2019) in terms of monitoring of bycatch, incidental catch and Floating OBjects (FOBs). When present onboard, observers fill different forms and data sheets with on species composition, fate of the catch (retained or discarded) and FOB use. All data are validated and stored within Observe 7.6.7 database developed by IRD (Cauquil *et al.*, 2015). The objective is to reach similar high standards of data collection, quality and storage for fishing trips monitored remotely by electronic observers.

Since 2014, work has therefore been conducted to validate the use of EM for scientific observation purpose and identify long-term solutions for the visualisation of EM records, the collection of robust scientific data by electronic observers and the storage of collected scientific data.

2.4.1 Electronic observers and EM visualization software

Since 2014, EM records are analysed by BVLR electronic observers. These electronic observers are generally former onboard observers of the DCF programme who have been trained to IRD-Ob7 data collection protocols. As BVLR is also the coordinator of the OCUP – onboard program, this facilitate the ongoing harmonization of EM observation protocols with IRD-Ob7 onboard observation protocols. EM records are analysed with the OceanLive software developed by Thalos with two main improvements since 2014 : (i) improvements in the ergonomics of the software to facilitate the work of electronic observers and (ii) integration of a measurement tool.

The cost of reviewing EM video records is currently supported by the fishing company CFTO, while the costs associated with the coordination of the OCUP program (combined for onboard and electronic observations) is supported by the Producer Organization ORTHONGEL.

2.4.2 EM scientific data collection

After a phase of validation of EMS ability to provide as robust estimates of discards per species as onboard observers (Briand *et al.*, 2017), observer protocols were revised by IRD with the aim of harmonizing onboard and electronic observation protocols, to the extent possible. Exhaustive counts of discards were used to describe the discard flow used and develop methods to accurately estimate discards (Briand *et al.*, 2018, in prep). Additional work, conducted in the frame of the OCUP – electronic program has also allowed replacing EM Excel data collection sheets with a more durable storage in ObServe 7.6.7.

Therefore, in 2021, BVLR electronic observers use the same forms as DCF and OCUP onboard observers to collect information on fishing operations, discards of bycatch and application of Best Practices for the safe handling and release of sensitive fauna. Except for Best Practices data that are managed by the Producer Organization ORTHONGEL, the data are entered in the ObServe software to be stored in an ObServe 7.6.7 database. The development of the current EM data flow required two adaptations of onboard observation protocols. First, as EM only allows collecting information on FOBs at the time of dFAD deployment (Ruiz *et al.*, 2016), data validation procedures were adapted to the specific case of electronic observation. Second, though optimized EM configurations allow in theory an exhaustive observation of all released and discarded catches, this exhaustive data collection can be tedious and time-consuming. An adapted protocol was therefore proposed and tested to optimize the balance between EM data quality and observation costs (Briand *et al.*, 2018, in prep). Currently, EM observers (i) collect exhaustive information on discards for sorting operations < 20 minutes (ii) sample sorting operations > 20 minutes with sequences of 4 minutes (Yon and Wain, 2021).

In complement, EM specific observation forms were developed to monitor the quality of EM records and report on the proportion of (i) *observable* fishing sets, for which at least 5 minutes of EM records are available for the crow's nest port side and desk cameras and (ii) *exploitable fishing sets*, for which EM systems allowed the monitoring of discarding operations and at least 50% of the individuals could be identified at the scale of the species (fraction of individuals identified as MZZ, i.e. FAO code marine fishes nei, < 50%). To date, this monitoring has allowed fixing issues of EM systems failures (e.g. replacement of defective hard disks), inadequate camera settings and lack of maintenance of EM equipment (camera cleaning by fishing crews). This allowed increasing the exploitability rate of EM records from 60% of fishing sets in 2020 to 86% in 2021, which represents a significant improvement.

Nevertheless, the data collected in the frame of the OCUP-electronic project is not yet used for reporting to IOTC. Current limitations include the lack of information on various activities with FOBs and their tracking buoys and issues of data collection for some species. In the case of sharks for example, it has been estimated that 30-50% of sharks cannot be observed with current EM systems and 17% cannot be identified at the scale of the species (CFTO, *comm pers*). Though issues of non-exhaustive observation of sharks have also been reported for onboard observers (Forget *et al.*, 2021), the lack of species identification with EM is obviously an important limitation that prevents EM data from being used for stock assessment purposes. A reconfiguration of EM installations will therefore soon be tested in the frame of the SIDEO project and EM scientific data collection protocols will be updated accordingly.

3. Using EM to collect data on retained catches : SAPMER-TNC, PRONTOS and EM Task force projects

3.1 Background and objectives

It has long been known that estimating precisely the composition of retained catches is a difficult task onboard tropical tuna purse seiners, principally due to the fast loading of retained catches (so as to prevent the formation of histamine in the fish) and misidentification of species (notably for juveniles of yellowfin and bigeye tunas, Fonteneau, 1976). This well-known issue has led to the development of the Tropical Tuna Treatment (T3) procedure during the 1990s, as a mean to correct estimates of catch per species reported in logbooks (Pianet *et al.*, 2000). Estimating precisely the composition of retained catches is not only problematic for fishing crews. In the case of onboard observers, should data collection on retained catches be required, this additional task would compete with data collection on discards, that are the primarily focus of onboard observation protocols (Sabarros, 2020). Onboard observers therefore report estimates of retained catches provided by fishing crews in their logbooks. To date, the same applies to electronic observers in the frame of the OCUP-electronic program.

Recent developments in EM and artificial intelligence (AI) could offer solutions to solve the issue of robust estimation of the composition of retained catches. First, since EM records can be reviewed after the loading of the catch, EM could offer a solution to collect information on retained catches on the conveyor belt, without slowing down the process of loading the catch into the wells. Second, EM and AI solutions could be combined, to automatically identify discards at the scale of the species on conveyor belts. Such solutions are being tested and gradually improved in the frame of several pilot projects since 2019 (Figure 4).

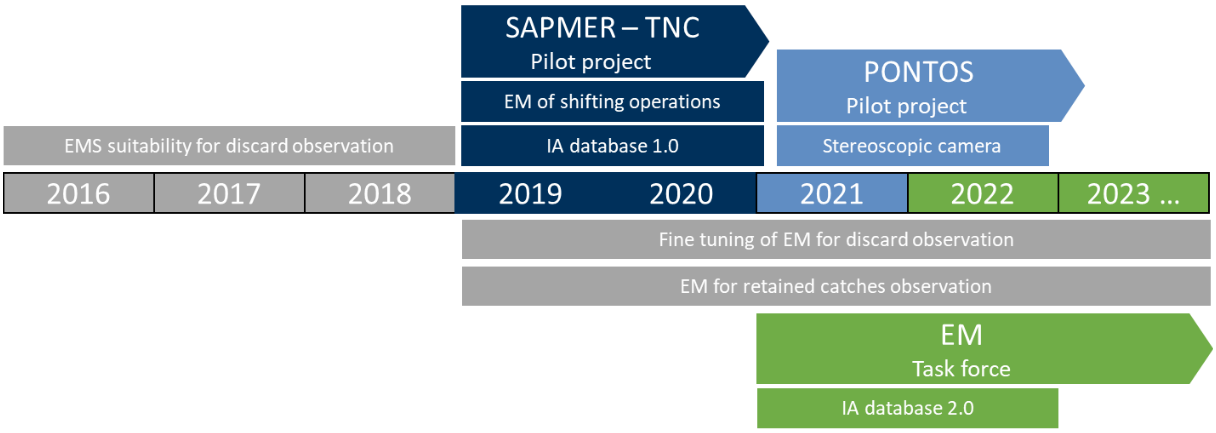

Figure 4: progress made since 2019 on EMS configuration and protocols for the scientific observation of retained catches of French and associated tropical tuna purse seiners of the Indian Ocean.

3.2 Stage 1 : the SAPMER-SFA-TNC pilot project

From June 2019 to October 2020, SAPMER, the Seychelles Fishing Agency and The Nature Conservancy, conducted a EM pilot project with the aim of complementing data collection in the frame of the OCUP-onboard observation program, improving science and compliance data collection and foster pelagic fisheries management innovation.

In the frame of the project, one Seychelles-flagged purse seiner was equipped with an EM system from Thalos. The EM system was designed to monitor retained catches with high quality resolution video records during shifting operations (transfer of retained catches from brine to dry holds via conveyor belts). Recorded video footage were reviewed by BVLR, with the purpose of estimating the amount, the composition and the size of retained tuna and non-target species during the shifting process. In the frame of the project, data were collected for a selection of 22 fishing sets (27 shifting operations) over 10 months, representing 584 tons of fish sampled, 4,653 size measurements from 14 different species and 1,402 pictures clipped and tagged with species and size information. Data recorded by EM systems were also compared with those collected by onboard OCUP observers.

Overall, despite various technical challenges, the project confirmed that EM has the potential to :

(i) allow fast size measurements of retained fish (though accuracy remained to be assessed with comparison with physical sampling)

(ii) provide comparable estimates of the composition of the catch compared to logbooks (although some discrepancies were noted for large shifting operation, when fish are arranged in layers on the conveyor)

(iii) allow a more precise estimation of tuna species composition, especially when very small quantities of a species are present in the catch, a situation that is particularly challenging to provide accurate estimates of catches for all species

(iv) collect high-quality pictures of the fish on the conveyor belt if cameras are well placed and provided adequate lighting. The collection of such images is key for future developments of combined EM-AI solutions.

At the end of the project, several improvements in the EM configuration and additional developments were still necessary to propose an EM system fully able to accurately estimate retained catches per species and size category. Additional pilot projects are currently developing these additional EM tools.

3.3 Stage 2 : improving the size measurement tool (PONTOS project)

Correctly assessing the amount of retained catches requires the combination of two tools : (i) an accurate fish measurement tool (that could also be useful for the collection of size data on non-retained catches) and (ii) an automatized or semi-automatized species identification tools based on AI.

The PONTOS (Projet d'Outils de mesure du Nombre, de la Taille et du pOids des eSpèces, *project for tools of number, size and weight measurement of species*) started in 2021 with the objective of developing fish mensuration and total catch (brailers) estimation tools using stereoscopic cameras. Estimates using stereoscopic cameras will be compared with direct observations, so as to reach a precision of 95%.

3.3 Stage 3: combining EM with AI

In complement, work is currently being done conjointly by French EM partners (ORTHONGEL and its member fishing companies, Thalos, BVLR and IRD) to develop combined EM – AI solutions. A dedicated *EM Task force* was set up with the objective of conducting initial tests of AI solutions for automatized or semi-automatized species identification tools that could be used either by fishing crews to improve estimates reported in logbooks or by electronic observers and onboard observers for scientific data collection purposes.

4. Recommendations for the adoption of EM minimum standards in IOTC

Almost 8 years of work on EM onboard tropical tuna purse seine vessels of the Indian Ocean have allowed gradually improving EM configuration and protocols to collect scientific data on fishing operations, discards and dFAD deployment. Additional work, started during the most recent years, is being conducted to improve data collection and reporting on retained catches. In this document, we reported on this shared experience of a wide range of stakeholders (scientists, fleet managers, EM analysts and EM vendors) with the objective of contributing to the definition of EM standards for scientific data collection purposes in IOTC. In this section, this shared experience will be used to provide guidelines to adopt such minimum standards, rather than to propose a list of potential minimum standards.

It is important to note here that, as discussed earlier in the document, developing EM systems to collect robust scientific data will be long trial and error process. The solutions that are being tested and implemented for the French and associated fleet of the Indian Ocean reflect the knowledge and technical solutions that are currently available. Proposed EM solutions and recommendations may therefore evolve in the future. It is also important to note here, that we are only focussing on recommendations for EM systems designed to collect scientific data. Such systems are being developed and implemented with clear and precise objectives and that these solutions may not be adapted to other needs (e.g. verification of compliance).

Recommendation 1: *avoid requesting for a predefined configuration*

For example, it is less important to set a precise number of cameras or to impose a precise definition for EM records than to ensure that the configuration cover all operations on the upper, lower and front decks of purse seiners.

Recommendation 2: *test EM abilities against onboard observation*

In our experience, this step of validation of EM configuration and settings has proven critical to identify gaps and differences in data collection between the two types of observation. Therefore, even after the adoption of EM minimum standards in IOTC, the replacement of onboard observers with electronic observers should not be encouraged until data collection with EM is fully validated by the Scientific

Committee. In the case of tropical tuna purse seiners, this step of validation is especially important in the case of Endangered, Threatened and Protected (ETP) species. Indeed, issues of lack of identification have been reported on the upper deck of purse seine vessels (Briand *et al.*, in prep). For ETP species, that are generally in data poor situations for stock assessment purposes, fully moving towards EM of purse seiners without having solved this issue is not suitable to monitor the stock status of ETP species with robust information.

<u>Recommendation 3</u>: EM systems should be carefully installed and configurated

This can be a long process, that can take several years before being fully optimized. The right balance should be found between EM installations that are customized to deal with different vessel configurations and harmonization between vessels, so as to ensure similar data collection by electronic observers. It is also critical to solve issues detected in EM configuration, particularly if the objective is to collect data that could be useful for stock assessment purposes. Fine tuning of EM installation, as soon planned in the frame of the SIDEO project, is therefore important and changes should be reported to IOTC.

<u>Recommendation 4</u>: EM procedures should be optimized both on board and on land

Of course, EM installation is critical to collect robust scientific data. However, it is also critical that EM is optimized as a whole, i.e. both on board the vessels and on land since EMS is not only cameras and hard disks onboard a vessel. It is a full system that includes onboard configuration (camera, hard drive but also multiple sensors information), onshore configuration (dedicated software, automatic data generation...) and analyses.

EM minimum standards should therefore cover the following components of EM : installation, maintenance, EM records, validation of EM against onboard observation, EM reviewing protocols, standardized formats to export EM data, reporting to IOTC.

<u>Recommendation 5</u>: define clear objectives of data collection with EM

One must keep in mind that EM, as other observation means, would probably not be configurated the same way for scientific data collection or control purposes. In the frame of IOTC, EM programs should, as onboard observation program, be designed on the basis of requirements of the Regional Observer Scheme Programme standards. This implies that the same rules should apply to both types of observation and the same data templates should be used.

<u>Recommendation 6</u>: develop clear EM data collection protocols

It is important that scientists participating to the various science working groups of IOTC can understand how the data available for stock assessment purposes has been prepared and reported.

Ideally, CPCs should develop clear EM protocols and report them to the Working Party on Data Collection and Statistics. CPCs should provide IOTC forms with a document reporting on the material and method used to prepare the data. Such a document should detail the abilities of EM at the time of data collection and preparation (e.g. known issues of coverage, missing data types, etc).

This recommendation could apply to any type of data reporting to IOTC and is current practice in any type of work conducted by scientists, who usually report on the material and methods used for their studies. For the purpose of the ROS, such a “material and methods” should ideally be available also for onboard observer programs and the type of program used to collect the information should be reported to IOTC along with the data.

Finally, it is also important that EM data collection protocols are harmonized with onboard observation protocols, to the extent possible, if the data are to be used in combination with scientific data collected in the frame of onboard observation protocols.

Recommendation 7: do not request that EM records are directly provided to IOTC

One should keep in mind that the data collected in the frame of observer programs may be needed for scientific purposes but also requested for other needs. Though it can make sense that IOTC has access to EM records to verify compliance with IOTC CMMs, CPCs should easily have access to the data (e.g. to verify conditions of access to a given EEZ in the frame of a bilateral fishing agreement between two CPCs). Therefore, it would be preferable that EM records are reviewed by a fully independent body, chosen by the flag State/ CPC.

Recommendation 8: adopt a better terminology

Since electronic observation is not an automatized process and still involves humans (electronic observers), it is incorrect to oppose *human* and *electronic* observation. It would be more appropriate to talk about *onboard* vs *electronic*, *direct* vs *indirect* or *in situ* vs *remote*. This is valid until AI can be used to automatize all EM processes. This also means that electronic observers, as onboard observers, should be carefully selected, trained, etc

Recommendation 9: maintain the EM working group active

Adopting EM standards is likely to be a process that can take several years and need to be reviewed in the light of technical progress made in the fields of EM and AI. Therefore, organizing regular ad hoc meetings on EM is necessary.

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