The feasibility and challenges of collecting Electronic Monitoring System (EMS) data on French and associated purse seiners in relation to IOTC minimum standards

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Abstract

In recent years, Electronic Monitoring Systems (EMS) have been progressively tested and implemented in tuna fisheries as a complementary tool in scientific observer programs. All tuna Regional Fisheries Management organizations (t-RFMOs) are now developing minimum standards that can be used as guidelines to fulfil specific fisheries management measures in each area of competence including Regional Observer Scheme (ROS) requirements. The first EM standards for Indian Ocean Tuna Commission (IOTC) were discussed in WGEMS meetings and were adopted in 2023 based on previous RFMOs and countries experiences. Each tuna fishery willing to use EMS including purse seiners in the Indian Ocean is now invited to follow the minimum standards for data collection that were proposed in Resolution 23/08. However, with the diversity of fisheries, vessel configurations, programs advancement and the limits of the method itself, EM minimum standards monitoring goals (which are initially based on ROS onboard observation programs) may be challenging to fulfil.

The aim of the present document is to review the French purse seine EMS program and to discuss the feasibility and challenges to comply with the minimum standards for scientific data collection on tropical purse seine fleets of the Indian Ocean. This document reports on the shared experience of scientists, fleet managers, EM analysts and EM providers with the current EM installation covering the French and associated tropical tuna purse seine fleet. Here, we review each ROS scientific field against the ability of the vessel EM configuration to collect the information. This includes data collection on fishing activity, discards and handling and release of ETP species that is currently undertaken routinely and data collection on retained catches and FAD activities that is currently in test. Lessons learned from past experience are used to assess data collection possibilities against recently adopted IOTC EMS minimum standards.

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1. Background

Electronic Monitoring Systems (EMS) have been tested and implemented in worldwide fisheries for many years as a mean to fullfil monitoring needs for both scientific data collection or control purposes (Helmond et al., 2019; Gilman et al., 2020). In the case of tuna fisheries, EM has been seen as an opportunity to complete onboard observation in programs that aim at achieving 100% coverage or even suggested as an alternative tool 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; Stobberup et al., 2021). Acknowledging the potential of EMS, tuna Regional Fisheries Management Organizations (t-RFMO) have progressively defined and suggested minimums standards based on existing observer programs with specific recommendations for data collection and data standards (Ruiz et al., 2017; Roman et al., 2020; Murua et al., 2020; Gilman, 2023). Recently, the Indian Ocean Tuna Commission has updated the Regional Observer Scheme (ROS) with IOTC Resolution 22/04 include EM systems and adopted the first EM minimum standards for all tuna fleets including purse seiners (IOTC, 2022). EM standards adopted in 2023 have been discussed within successive ad-hoc intersessional working group (WGEMS) meetings involving all interested scientists and managers, taking into account advancement in EM programs for various CPCs and fleets as well as differences in EM configuration. The development of Vessel Monitoring Plans is required in Resolution 23/08 to describe the fleet EM configuration and the performance from each participating country to reach the minimum monitoring standards (IOTC, 2023a).

First pilot studies on tropical tuna purse seine vessels have shown that provided that cameras are carefully configurated, EM is able to give reliable information on purse seine vessel daily activity and fishing events (Chavance et al., 2013; Monteagudo et al., 2015; Briand et al., 2022). Overall, EM allows monitoring bycatches and discards at an acceptable species identification resolution, especially for species and groups of species which are systematically discarded (Briand et al., 2023). However, issues have been raised for the monitoring of lookalike species including target tunas at species level (Ruiz, 2013; Itano et al., 2019; Briand et al., 2018), sensitive species such as sharks (Briand et al., 2018; Forget et al., 2021) and Floating OBjects (FOBs, Ruiz *et al.*, 2017).

The French EM program was implemented onboard CFTO purse seine vessels in 2015 in the frame of the Producer Organisation ORTHONGEL OCUP voluntary program. As the IOTC ROS mandatory coverage is currently ensured with onboard observation, the EM component of OCUP is implemented as a complementary observation system and was originally designed for vessels that cannot board observers in routine to grant an exhaustive scientific observer coverage in the Indian Ocean. In recent years, the CFTO fleet has updated the initial EM configuration with two additional cameras on the upper deck to improve data collection on sharks and FOBs (Maufroy et al., 2021). In the case of sharks, these are particularly important to solve issues of insufficient data on sharks that prevent stock assessment in IOTC (Ortiz de Urbina et al., 2018). They are also important to monitor the techniques used by fishing crews to release sharks alive (Best Practices, Wain and Maufroy, 2023) that can reduce mortality for these animals. In the case of FOBs, this information is also important to meet data requirements of IOTC Resolution 19/02 as well as Marine Stewardship Council (MSC) certification requirements. Note that even if EM systems onboard CFTO vessels have been used to collect data since 2017 and have greatly improved, trials are still in place to determine whether EM minimum standards with appropriate data quality can be reached and how. Depending on EM developing stages and/or EM capabilities, reaching all IOTC standards may still be challenging, if not impossible in some cases.

The aim of the present document is to present the current state of the OCUP-EM program onboard French and associated (Italian) purse seiners of the Indian Ocean and evaluate the effectiveness of the EM system to collect ROS minimum standards based on the shared experience of scientists, fleet managers, EM analysts and EM providers in various EM pilot projects since 2014. Here, we describe the recent improvements on CFTO PS EM configuration using a test of VMP preparation. We review the types of scientific data collection required for tropical tuna purse seiners in IOTC, which includes data collection on (1) retained catches, (2) discards of bycatch species, (3) handling techniques used to release sensitive species and (iv) operations with FOBs, including dFAD deployment and fishing sets on FOBs. Lessons learned from the most recent developments are used to make recommendations that could be used as guidelines when implementing the recently adopted IOTC EM minimum standards.

2. Description of CFTO purse seine EM installation

2.1. Camera EM configuration

Purse seine vessels operating in the French and associated fleet are large vessels between 60 to 100 meters Length Overall (LOA) with two principal zones of activities located on the upper and lower decks (Figure 1). This particularity implies covering multiple areas, which requires at least one camera to cover each zone of interest, with an installation, adapted to each vessel configuration. Since 2014, various pilot projects have allowed gradually improving EM configuration onboard CFTO vessels to solve issues of blind spots when collecting scientific information on discards with EM records (Briand et al., 2023, 2018). A new EM configuration (configuration 2.0) was recently deployed (from the end of 2021 to mid-2023) with 6 upgraded cameras covering operations on the upper, lower and front decks (Figure 1). The final optimized configuration is in accordance with the minimal configuration proposed by IOTC with at least 6 wide angle cameras (IOTC, 2023a). Each camera is strategically placed to avoid operational issues (Figure 1). On upper deck, the first camera is installed on the crow's nest (*Crow's nest 1*) to cover the port side of the boat and to follow general fishing activity including setting, pursing, and brailing (Figure 1). A second crow's nest camera (*Crow's nest 2*) with a bird's eye view is installed lower on the mast to monitor bycatch discarding and ETP species release activities on the upper deck, especially on the starboard side of the boat, where most of the large ETP species are released. Another *Console* camera is placed on the hydraulic console and used to record brailing operations and discarding activities. Finally, a *Front deck* camera with infrared technology is installed on the bow to record dFAD deployment during day and night (Figure 1).

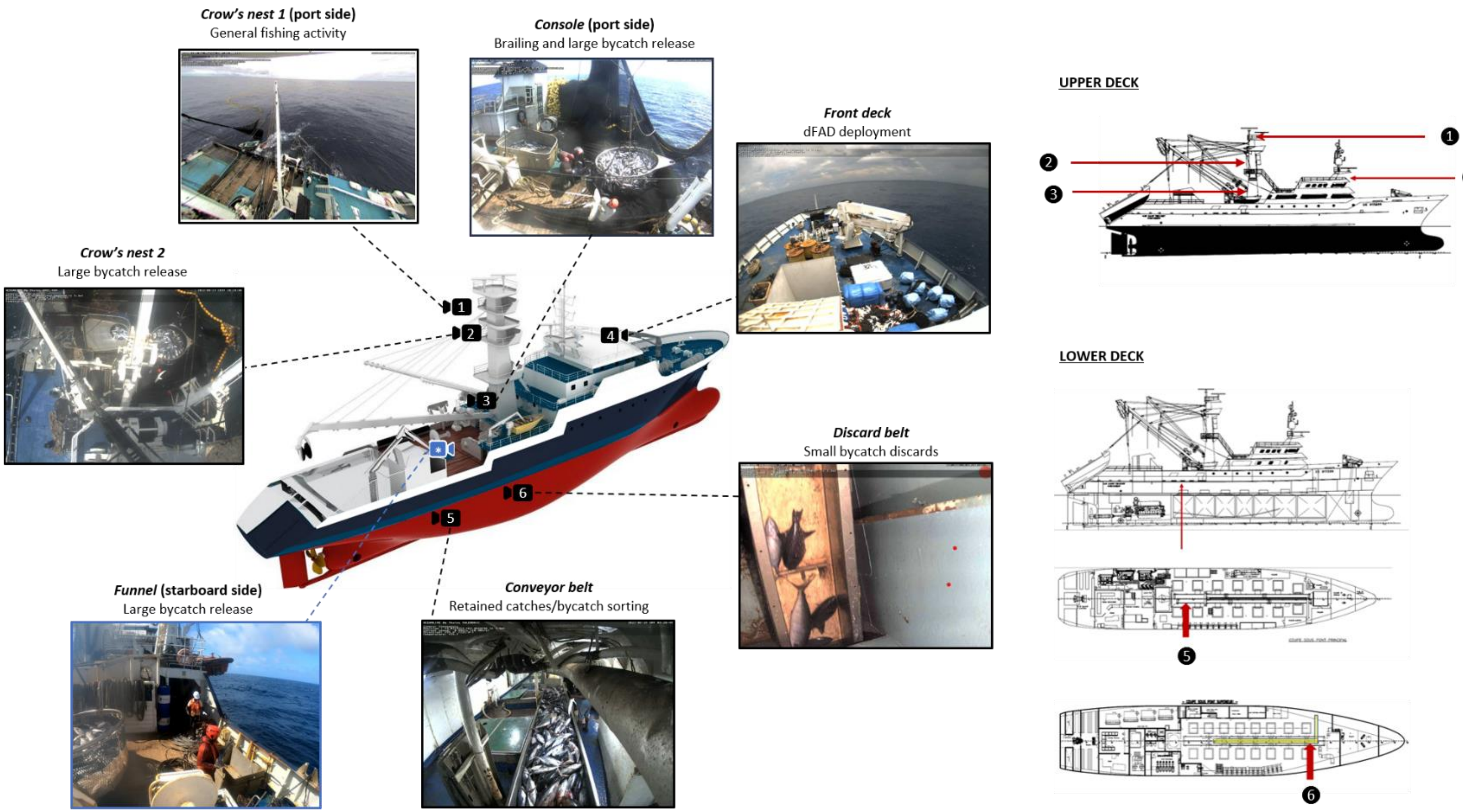

Figure 1. Example of 6-cameras system installed on CFTO purse seine vessel with mounting locations, associated views and description of the main monitoring activities for each camera installed on the upper deck and the lower deck. Cameras in black are the cameras of the current EM installation (Configuration 2.0). The addition of the *Funnel* camera (in blue) is currently considered to improve shark detection and identification (Maufroy et al., 2023).

In the lower deck, a *Conveyor belt* camera is placed at the beginning of the storage well deck to record catch sorting on the conveyor belt and loading into the wells and activities. Finally, a *Discard belt* camera with wide angle is installed at the end of the waste chute to cover discarding activities of the small bycatches (Figure 1).

2.2. Camera settings

Camera settings from OceanLive[2] software with configuration 2.0 are described in Table 1. The upper deck cameras *Crow's Nest 1* and *Console* are equipped with GPS modules, which provide one position per second. The other cameras recover the GPS positions from the cameras equipped with GPS modules (one position per minute at minima). All cameras have access to the location and timing of EM records, and this information is directly imprinted on all EM images, so as to grant the reliability of the information collected by electronic observers (Figure 1).

Table 1. Camera settings for the current EMS configuration 2.0 installed on CFTO vessels

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

The port side *Crow's nest 1* camera is set to record continuously at day time (trigger based on ephemerids) so as to ensure that all fishing activities are captured (Table 1). 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, so as to capture only dFAD deployment operations.

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 (Maufroy et al., 2021).

Note that camera settings were recently refined and significantly enhanced in comparison to the current system (Table 2).

The new EM OceanLive[2] solution is already installed on two vessels and is planned to be installed on all vessels throughout 2024. This EM configuration consists of HD MOBOTIX digital cameras with higher resolution (1440*1080), higher frequency frame (12 frames/s) and Artificial Intelligence (AI) detection technology (Thalos, pers. com).

Table 2. Camera settings for the EMS new configuration planned for 2024.

Camera	GPS	Angle	Frames/s	Resolution	Recording
1- Crow's nest 1	Yes	103°	12	1440x1080	Continuous during the day
2- Crow's nest 2	No	103°	12	1440x1080	Triggered by vessel speed
3- Console/Desk	Yes	103°	12	1440x1080	Triggered by vessel speed
4- Front deck	No	103°	12	1440x1080	Motion detection (day and night)
5- Conveyor belt	No	103°	12	1440x1080	Triggered by vessel speed
6- Discard belt	No	103°	12	1440x1080	Triggered by vessel speed

3. Current ability of EMS to meet IOTC standards

3.1. Identification of the type of fishing set

The port side *Crow's nest 1* camera is used to identify the type of fishing set according to the presence of a Floating OBject (if the camera is close enough to the object) or the speed boat behavior during the pursing phase (Figure 1). The records from this camera contain the time and location of the fishing set, directly imprinted on the videos, allowing the EM observer to collect this information. The camera is turned towards the portside of the vessel to record the start of fishing with gear set up, skiff release, net hauling and pursing operations (Figure 1). In the case of fishing on Free Swimming Schools (FSC), the speed boat is usually very active during the school encirclement phase. In the case of FOBs sets, the speed boat usually fixes the object during the encirclement and remains close to the FOB until the end of the fishing operation (BVLR, pers. com). Other pilot studies have also shown that the fishing set type can be determined by the purse seine track (using GPS and sensor information at fine scale) as the vessel speed and route are significantly different when chasing FSC or when visiting FOBs, (Chavance et al., 2013; Ruiz, 2013) with trajectories that tend to be more sinuous on FSC. Note that a fine scale vessel track system is now directly integrated in OceanLive[2] software which enables the automatic detection of fishing events in most cases (BVLR, pers. com). Finally, the overall species composition of the fishing set (high volume of discards and small tunas for FOB sets versus high volumes of large tunas for FSC sets) that could roughly be monitored using lower deck cameras can be also used as a supplementary clue to validate the type of set without clear indications of the presence of a FOB on records of the port side *Crow's nest 1* camera in case of absence or poor quality of records.

3.2. Estimation of the total catch

Onboard CFTO purse seine vessels, brailing activities can be recorded using the *Console* camera as well as the *Crow's nest* camera (Figure 1). Pilot studies have indicated that estimates of total catch can be obtained using EMS by counting the number of brails and estimating the fullness of each brail for each fishing set (Chavance et al., 2013; Itano et al., 2019; Ruiz, 2013).

Tests onboard French and associated purse seiners equipped with EMS confirm this observation (Briand et al., 2022), though estimates of total catch derived from this method have not been validated against weighing systems so far. Among others, it should be noted that estimating total catch during brailing operations require knowing the capacity of brailers, a parameter that varies between purse seine vessel. Also, species composition in each brailer requires to be carefully monitored during the entire fishing set as a full brailer filled with small individuals (and mixed species) may not have the same weight as a full brailer with large individuals. The *Console* camera may provide a rough overview of the tuna catch species composition (small juveniles tunas with bycatch vs large adult tunas in case of FAD or free schools for instance) but the proportion, the number and the size of each tuna species are very hard to estimate precisely within a brailer. Additional reviews of the catch with the lower deck cameras are necessary to estimate the species composition of the fishing set and calibrate the total catch. For the moment, this measure is not monitored in the context of OCUP-EM program and estimates of total catch are usually derived from logbooks as for other scientific observer programs in IOTC. Alternative tools, such as a weighing captor placed on the brailer, are currently being considered.

3.3. Estimation of target tuna catches

3.3.1. Retained target tunas

The *Conveyor belt* camera, that records catches entering the wells, should in theory allow monitoring retained catches of target tunas (Figure 1). However, estimating with precision the catch transferred into the wells is challenging onboard large tropical tuna purse seiners, independently from the EM performances. Indeed, these large vessels are catching important amounts of fish that should be refrigerated rapidly to avoid the formation of histamine and individuals are piled in large amounts (from the brailer to the wells) on a conveyor belt that moves really fast (Monteagudo et al., 2015; Itano et al., 2019).

This issue of vessel and fishing operations configurations, that is the main one to overcome to estimate retained catches per species for PS, is aggravated by the difficult discrimination between lookalike individuals. Apart from skipjack tuna (SKJ-*Katsuwonus pelamis*) that can in principle be easily recognized, juvenile yellowfin (YFT-*Thunnus albacares*) and bigeye (BET-*Thunnus obesus*) tunas are difficult to discriminate, even for experimented onboard observers or port samplers (Fonteneau, 2008; A. Duparc et al., 2020) that are in direct contact with the fish. Discriminating juvenile YFT and BET or other tuna species is even more difficult on EM records (Chavance et al., 2013; Ruiz et al., 2017) and it also depends on the fish position on the conveyor belt.

Therefore, at the moment, EM observers from BVLR are not required to provide their own estimates of retained tunas. As for onboard observers, the instruction is to recover the estimates of the fishing crew in logbooks. Nevertheless, examining in details if and how an EM System, combined with Artificial Intelligence (AI) could provide estimates of retained tuna per species remains interesting. An initial feasibility study is currently ongoing in the frame of the SIRCEO

(Species Identification of Retained Catches with Electronic Observation) project since December 2022 (Maufroy et al., 2021). The pilot study consists in a preassessment covering the suitability of purse seine vessel configurations, camera placement and performances of a machine learning algorithm to identify the species of the main retained species (tunas and bycatch). The pilot project also aims at developing an image bank to train the machine learning algorithm, with images representative of the configuration of CFTO purse seine vessel lower decks. Note that finding the right place for a conveyor belt camera on French purse seine vessels is a challenge as its emplacement is also a trade-off between vessel configuration, sufficient wide view to encompass all wells with a sufficient close view on the conveyor belt to distinguish the species.

Identifying the species of retained tunas is not the only step to provide estimates of retained catches in weight. A size estimation is also required, but it may not be accurate for some vessels as EMS need to be correctly calibrated (and cleaned from water projections) for these measures. In addition, most of individuals are hidden or distorted within layers of tunas on the conveyor belt.

3.3.2. Discarded target tunas

Discards of target tuna that are unfit for human consumption (IOTC Resolution 19/05) should in principle be observed, with the *Console* camera and the *Crow's nest 2* on the upper deck. At this stage, with the current OceanLive[2] configuration, the *Console* camera is the closest to the sorting operations on the upper deck. Nevertheless, this camera is not close enough or does not have sufficient resolution to distinguish between species of bony fish that are discarded from the upper deck (e.g. damaged fish meshed in the net on the port side). It is indeed challenging to distinguish lookalike individuals such as juvenile major tunas YFT/BET. Most individuals detected on the upper deck are classified as TUS (*Thunnus* spp), TUN (Thunnini) or sometimes just MZZ (Osteichthyes/bony fishes) categories (Briand et al., 2023). Note that when an individual is identified, it is still difficult to estimate its weight and size without appropriately calibrated tools (e.g. measuring scales or stereoscopic cameras).

In the lower deck, discards of target tuna can be monitored with the *Discard belt* camera. This camera is close enough to count and monitor individuals at species or group level. Even if the discard belt is less crowded than the conveyor belt, it is still difficult to differentiate lookalike juveniles of YFT and BET (Briand et al., 2023). Other issues, such as the accumulation of fish due to large individuals placed on the discard belt can also lower the ability of counting and discriminating the species of discards.

Finally, in the case of discarded target tunas, not only the species and the size should be collected, but also the reason of discard. Collecting such an information can be challenging for various reasons that comprise camera distance, camera resolution, the number of frames per second and the absence of interaction with the crew, that can provide this information directly in the case of onboard observers.

3.4. Estimation of bycatch

3.4.1. Retained bycatch

For the reasons explained earlier (see section 3.3.1), estimating retained bycatch using EMS is a difficult task as it can only be done with the *Conveyor belt* camera. As for retained tunas, the major issue is the fact that large volumes of catches are transiting on a conveyor belt and some bycatch species may end up being hidden under piles of tunas. Therefore, small individuals cannot always be detected in the flow of catch. Lookalike species (e.g. minor tunas) are also difficult to distinguish and identified at species level with EMS. Furthermore, bycatch species such as dolphinfish or barracudas retained for crew own consumption are not easily recorded due to the absence of overlap between the *Conveyor* and *Discard belt* cameras views. For example, one individual removed from the conveyor belt may either be retained or discarded and the electronic observer often does not have sufficient information to decide between these two possibilities.

3.4.2. Discarded bycatch

On the upper deck, estimating discarded bycatch is done using the starboard side *Crow's nest 2* and the port side *Console* cameras. The main challenge comes from the fact that individuals can be sorted and released at different places on both sides of the vessel. With current EMS configuration it is possible to count bycatch released by species for large or easily recognizable individuals. However, it is far more difficult to count and identify lookalike species (e.g. minor tunas) or individuals that are too far from cameras (i.e. fishes meshed in the net). Nevertheless, solutions using cameras placed closer to the sorting and discarding areas on the upper deck and/or cameras with a better resolution have been tested recently in the frame of the SIDEO (Shark Identification with Electronic Observation) project (Maufroy et al., 2023). These solutions, that have been designed principally to improve shark detection and identification on the upper deck (see section 3.5), may also improve the species identification of discarded bycatch.

Note that even if the quality of cameras improves the species identification, the condition of discarded fish and the reason of the discard is still very difficult to assess for EM observers.

In the lower deck, small discarded species are monitored using the *Discard belt* camera. Having fish discarded from a unique location greatly facilitates counting discarded fish. Estimating individuals at species level is also an easier process than on upper deck as fishes are close enough to the camera to be identified (Briand et al., 2023), except for lookalike species (minor tunas for instance). However, the reason of discard cannot always be assessed and the accumulation of fish, when large individuals block the flow of fish on the discard belt, can prevent proper estimation of discarded bycatch.

3.5. Release of sensitive species

Sensitive species, that comprise whale sharks, sharks, sea turtles, whales, small rays and mobulid rays can be released from the net, from the upper deck and from the lower deck, depending on the species. Information that should be collected by electronic observers covers both science needs (species, size, number, health condition at release) and crew training needs to follow best practices handling techniques used to release the animals (Poisson et al., 2012; Wain and Maufroy, 2023).

Very large individuals such as whale sharks are ideally released before the brailing operation. In theory, this releasing process should be recorded using the port side the *Crow's nest 1* if it is turned towards the net sack on the port side (Figure 1). However, differences exist between vessels due to vessel configuration and improvements are still needed to detect all whale sharks.

On the upper deck, large and medium individuals (large sharks or mobulid rays) are usually released in the brailer or directly in the net in case of entanglement. Until recently, the port side *Console* camera was the main camera to monitor the handling and the release of ETP species. This camera suffered from blind spots on the starboard side, due for instance to the presence of the winch or deck machinery in the field of the camera, which caused issues in the detection of sharks on the upper deck (Forget et al., 2021). A starboard side *Crow's nest 2* camera was therefore added in the OceanLive[2] configuration and tests of additional cameras were made in the frame of the SIDEO project (Maufroy et al., 2023). These tests have indicated that adding the *Crow's nest 2* on the mast significantly improved the detection of sharks on the upper deck, but that an additional camera, placed closer to sorting and releasing areas on the funnel (Figure 1) would further improve their detection, species identification and monitoring until released at sea.

In the lower deck, the discarding camera allows detecting ETP individuals that were not detected by the crew during the first sorting on the upper deck and that are released from the waste chute. However, the placement of the conveyor belt, the discard belt and the waste chute differ between vessels and vessel configurations and it is sometimes difficult to follow the particular fate of sharks as the conveyor belt and the discard belt views are not overlapping (BVLR, pers com.).

Also, estimations of length, identification of sex and determination of the condition of ETP species are possible but remain difficult due to discard belt speed, image quality and the fact that individuals cannot be handled (like onboard observers) with EMS. Note that large individuals such as sharks can be sorted on the lower deck but are not always placed on the discard belt due to their size, but also to Best Practices recommendations, to improve the chances of survival. Instead, these individuals can be brought back on the upper deck and the releasing process can be monitored with the upper cameras (*Console* and/or *Crow's nest 2* and/or *Funnel*) providing that these cameras are appropriately configurated on the port side (Maufroy et al., 2023).

3.6. FOB operations

FOB operations are currently not monitored in routine by electronic observers of the OCUP-EM program. However, *Front deck* cameras were recently installed on the front deck of CFTO vessels to assess the feasibility of monitoring dFADs. First trials with high sensitivity camera have showed that dFAD deployments can be monitored during the day and the night. These initial tests have also indicated that the characteristics of the deployed FAD could be determined with this camera but additional work is required to ensure information on the materials and dimensions of dFADs can be collected using the *Front deck* camera records. Should this be fully confirmed, a data collection protocol will be developed for electronic observers.

In parallel, work has been done by the EM provider to only record dFAD deployment activities, using motion detection so as to decrease the required storage for the records of the *Front deck camera*. Such developments are still ongoing at this stage (CFTO, pers. com).

The monitoring of other types of interactions with FOBs is more complex. Visits to FOBs could in theory be observed using the port side *Crow's nest* camera or the *Front deck* camera which are both turned towards fishing activities. Detection of a FOB can be detected using the speed boat activity which usually operates around the object during visits (visits with or without fishing included). However, determining the type of FOB, its dimensions or its materials is not usually possible as cameras are usually too far from the FOB. It may still be possible to determine the FOB type (at least the emerged part) and/or some of the materials if the speed boat is towing the FOB on the front of vessel within the field of the *Front deck* camera (Figure 1). This observation could require assistance from the crew and its feasibility should be discussed.

Finally, EM cannot provide information on operations with the activities and the identifier of instrumented buoys equipping FOBs so far. Alternative options should be explored if this information is required, including developing solutions with instrumented buoys suppliers.

4. Discussion

Reaching high quality of scientific data collection with EM is of major importance for t-RFMOs to improve management decision making and should ideally follow the same standards as onboard observation scientific observation programs, that often represents the only reliable source of information on bycatch and discarded species (Bellido et al., 2011; Davies, 2002; Babcock et al., 2003; Gilman et al., 2017). Even if EMS has proven to be a useful tool in the past to fulfil scientific observation and compliance needs, especially for longline fisheries (Gilman et al., 2020), it appears more complex for large industrial tuna purse seiners. Indeed, cameras should cover diverse areas and activities with high volumes of catch, high species diversity and multiple tasks that are not easy to monitor for electronic observers (Itano et al., 2019).

Since the beginning of OCUP-EM project, major improvements were made on CFTO purse seine vessels to improve data quality and collect the data in conformity with t-RFMO CMMs (Maufroy et al., 2021). These new settings have considerably improved the system in place and matched (to the extent possible) the major fields required for onboard observation. A summary of abilities of the current configuration of EM to collect data according to IOTC EM minimum standards by monitoring areas is presented in the Annexes of this document, as proposed during the last session of the IOTC WGEMS (IOTC, 2023b). Overall, the current configuration 2.0 with four cameras on the upper deck allows identifying the type of fishing set using the upper deck cameras (including the *Front deck* camera) by observing at the presence of detectable FOBs or/and by observing the speed boat behavior during the pursing phase on the port side. It is also in principle possible to estimate the total catch via the brailing activity throughout the same cameras, though the reliability of these estimates has not been validated against weighing at this stage. These results are in accordance with most purse seine pilots' studies made on the different oceans (Chavance et al., 2012; Itano et al., 2019; Ruiz, 2013).

However, in terms of catch species composition, the system is still limited on the upper deck for accurate estimations of lookalike species (including juvenile major tunas or minor tunas) and small individuals as cameras are too far from the brailer. Various problems are also encountered on the well deck for retained catch species composition on the conveyor belt. The superposition of individuals on the conveyor belt and the presence of lookalike individuals prevent from using the records of the *Conveyor belt* camera to estimate retained catches. Given these limitations, the capability of electronic observers to collect information on retained catches would depend greatly on the availability of new solutions to improve these estimations in the future. Enhancing resolution and reducing distance may solve problem of species identification to a certain point but may not solve the overall difficulties of identifying species that would demand expertise. Though most studies put forward the issue of lookalike species for EM target catch estimations (Itano et al., 2019; Lekunberri et al., 2022), this is also the configuration of the lower deck of purse seiners and the sanitary constraints, due to the risk of formation of histamine in tuna catches if they are not placed fast enough in refrigerated wells, that is as stake. This causes the catch to come as a heavy flow on the conveyor belt, with fish piled up on the belt, that prevents identifying retained catches at species level, even with sophisticated Artificial Intelligence tools. For all these reasons, electronic observers cannot be required to collect information on retained catches and will therefore continue to use the estimates reported by fishing crews in their logbooks. This methodology is similar to onboard observers, except for retained bycatch, that they estimate by themselves. It is usually complemented by other tools, such as port sampling for species composition (Antoine Duparc et al., 2020) or landing data both for total weight and species composition (Maufroy and Goujon, 2019).

On the other hand, large individuals and/or recognizable bycatch species such as dolphinfish, barracudas and sharks are usually easier to identify using records of cameras both on the upper deck or on the lower deck. The results achieved within the SIDEO project (Maufroy et al., 2023) indicate that adding a new camera with an increased resolution on the starboard side of the deck would be a good way to optimize shark observation (Figure 1). Large individuals like whale sharks, oceanic sharks or manta rays may in some cases be detected by the *Crow's nest* cameras, but camera reconfiguration may still be needed on some of the CFTO vessels to solve issues of blind spots on the net sack. Also, the determination of ETP species condition at release remains a challenge for EM observers, which represents a limitation to provide accurate mortality estimates to IOTC.

5. Conclusions

Overall, the improved OceanLive[2] EM system installed onboard French and associated tropical tuna purse seiners of the Indian Ocean allows collection most data fields of IOTC ROS. The use of EM also seems promising for other tasks (i.e. total catch estimation) that are not systematically carried out by onboard observers. In general, the current EM configuration on CFTO purse seiners seems a good tool to monitor the number and localization of sets, the number of FAD deployed (though a full validation and a protocol for electronic observers is being developed), the total catch (estimates), the majority of large bycatches and/or the most recognizable species as well as ETP species releasing techniques used by the crews. Note that EMS is also capable of monitoring both the upper and the lower decks at the same time which is not possible for onboard observers.

However, issues of species identification for lookalike species or small fishes far from the camera views still need to be addressed, especially for retained catches and issues of vessel configuration, in particular for an improved estimation of the catch composition of the fish on the conveyor belt. Issues of identifying the type of FOB (apart from dFAD deployment operations) should also be raised. Hopefully, some of the species identification issues may be solved in the near future, when the OceanLive[2] configuration is fully operational onboard all vessels, though is likely to have a limited effect compared to AI tools for example. A better observation of ETPs species and releasing practices may also be allowed by the promising results obtained in the frame of the SIDEO project, with a potential installation of an additional camera on the starboard side of the upper deck, and changes to the crew practices to ensure sharks are handled in the camera's field (Maufroy et al., 2023).

However, additional projects remain necessary to really identify what still can be improved and what cannot be improved. This includes for example, tests of AI technologies to automatically determine the species of retained catch, a solution that would only be valid if the configuration of purse seiners does not prevent making progress on estimates of retained catches per species. Meanwhile, alternative methods like conserving a combination of fishing trips monitored either with onboard or electronic observation or port sampling to correct logbook estimates still remain a better source of information than EMS alone. Note that other alternative sources are also proposed for fields that cannot be directly collected by the EM observer in this document (Annex 2). These considerations should now be taken into account to prepare the future Vessel Monitoring Plans of EM equipped purse seiners, for a future reporting of data to IOTC, possibly with a stepwise approach to report first on sensitive species and discarded bycatch, and, if future developments allow it, additional data fields of the ROS. These considerations could also inform decision making for the monitoring of other vessels with onboard observation, with a similar exercise of building VMPs.

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Annex 1. Minimum areas and actions that should be monitored (adapted from Murua et al ; 2022 ; Ruiz et al, 2017) with current status of the French purse seine fleet and potential issues for ROS data collection.

AREA COVERED	MONITORING PURPOSE	STATUS	ISSUES
Work deck (port side)	Total catch by set	OK	
	Total tuna discards	Possible, but not always at species level	Cameras too far, lookalike species
	Bycatch estimation		
	Fate	OK	
	Condition	Possible but very difficult to assess	Cameras too far
Work deck (starboard side)	Bycatch estimation	Possible, but not always at species level	Cameras too far, lookalike species
	Fate	OK	
	Condition	Possible but very difficult to assess	Cameras too far
In-water purse seine area	Total catch by set	OK	
	Application of best practices of big individuals	Ok but needs camera reconfiguration for some vessels	Blind spots on the net sack
Foredeck or amidships	FAD deployed (day and night)	In test (possibly OK)	
	FAD activities by trip	Possible if object or speed boat are close enough	Cameras usually too far from operations
	FAD design		
Well deck	Species composition	In test (seems not possible)	Conveyor belt speed, layers of fishes, lookalike species
	Total bycatch by set and species composition	OK to a certain extent	
	Fate	Not always possible	Dead angles
	Condition	Possible but very difficult to assess	Short laps of time on the discards belt

Annex 2. IOTC ROS Minimum Data Standards

GENERAL VESSEL AND TRIP INFORMATION FOR ALL VESSEL TYPES

Data field name	Data field description	Reporting	EM (Y/N)	Alternative Source	Comments
Observed trip number	Record trip unique identifier. This is the observed trip unique identifier. This should begin with trip's start date (YYYY-MM-DD), followed by IOTC observer number, and vessel main gear code as per IOTC classification (E.g. 2018/01/23-IOTCFRA001-PS).	**MR**	**N**	**IOTC reference table**	Post-trip information IOTC vessel number and observer number are not collected by EM observer but can be derived from IOTC reference table. Also requires that the fishing trip is imprinted on EM records and/or in the name of video records using a single nomenclature. At this stage, it is not encrypted on images.
OBSERVER IDENTIFICATION					
Observer IOTC registration number	Record observer registration number allocated by the IOTC Secretariat to be used on all observer data submissions.	**MR**	**N**	**IOTC observer reference table**	Post-trip information This information might be derived from IOTC register as the name of the vessel is encrypted on EM video footage.
Observer name	Record the name of the scientific observer(s) that collected the data on-board the fishing vessel. Note: print in full. First name First - Last name Last (do not use initials).	---	**Y**		Similarly to onboard observation, the name of the electronic observer can be recorded.
Observer nationality	Record the nationality of the scientific observer as it appears in passport (Table 9).	---	**Y**		Similarly to onboard observation, the nationality of the electronic observer can be recorded.
OBSERVER TRIP DETAILS					
Location of embarkatio n	Record the name and/or geographical coordinates of the port where the observer boarded the vessel – also include the country. If the observer embarked via a port launch within port limits, this is still recorded as a port embarkation. If the observer embarked at sea outside port limits via a vessel transfer, record "at sea" and record the position in Latitude and Longitude. Note: latitude and longitude to be recorded mentioning if collected South or North of the equator and specifying units (preferably ±(d)dd.dddd°).	---	**NR**		Not relevant for electronic observers. Updates of resolutions 11/04 and 22/04 needed
Date / time embarkatio n	Record the date and time that the observer boarded the vessel. Note: specify units (preferably hh:mm and YYYY/MM/DD).	---	**NR**		Not relevant for electronic observers. Strictly speaking, electronic observers do not board the vessels. Yet, they can report on the date of first available EM records for the fishing trip. They may also provide finer information for each day and/or fishing set of the availability of EM records of sufficient quality to collect data. Updates of resolutions 11/04 and 22/04 needed
Location of disembarkation	Record the name and/or geographical coordinates of the port where the observer disembarked– also include the country. If the observer disembarked via a port launch within port limits then this is still recorded as a port of disembarkation. If the observer disembarked at sea outside port limits via a vessel transfer, record "at sea" and record the position in Latitude and Longitude. Note: Latitude and longitude to be recorded mentioning if collected South or North of the equator and specifying units (preferably ±(d)dd.dddd°).	---	**NR**		Not relevant for electronic observers. See comments on location of embarkation. Updates of resolutions 11/04 and 22/04 needed
Date / time disembarkation	Record the date and time that the observer disembarked from the vessel. Note: specify units (preferably hh:mm and YYYY/MM/DD).	---	**NR**		Not relevant for electronic observers. See comments on date/time of embarkation. Updates of resolutions 11/04 and 22/04 needed

Data field name	Data field description	Reporting	EM (Y/N)	Alternative Source	Comments
VESSEL IDENTIFICATION					
Name of the vessel	Record the vessel full name as recorded on vessel official documentation and crosschecked with the name recorded on the vessel itself (any discrepancies are to be reported to the IOTC Secretariat). Note: care should be taken to record the correct spelling of the vessel's name including any corresponding numbers. i.e. "Agnes 83".	**MR**	**Y**	**Vessel official documentation, VMS…**	Post-trip information The name of the vessel is imprinted on EM records. It cannot be cross-checked the same way as onboard observers do. Validation can be done with other information source (VMS)
Vessel flag state (or where chartering occurs, chartering state)[3]	Record the name of country in which vessel is registered as shown on its registration documents (Table 9). Where chartering occurs, record name of the chartering country. Note: vessel flag state (or chartering state when chartering occurs) may not be the same as the nationality from which the vessel originates.	**MR**	**N**	**Registration documents IOTC register**	Post-trip information Updates of resolutions 11/04 and 22/04 needed EM analyst is not collecting this field directly but the data can be collected with another source
Vessel IOTC number	Vessel IOTC number as per the IOTC Record of Authorized Vessels[4] and crosschecked with the number recorded on vessel certificates. Note: any discrepancies are to be reported to the IOTC Secretariat.	**MR**	**N**	**IOTC register**	Set up EM analyst is not collecting this field directly but the data can be collected with another source The name of the vessel is imprinted on EM records. IOTC number can be retrieved from IOTC register or logbooks.
Vessel IMO or Lloyd's number	Record vessel IMO number. This is the number allocated to the vessel when registered to the International Maritime Organization of the United Nations (e.g.: IMO8814275).	**OR**	**N**	**IOTC register**	Set up Updates of resolutions 11/04 and 22/04 needed EM analyst is not collecting this field directly but the data can be collected with another source The name of the vessel is imprinted on EM records. IMO number can be retrieved from IOTC register or logbooks.
International radio call sign (IRCS)	Record vessel radio call sign if available. This is the number displayed prominently on the vessel's side or superstructure.	---	**N**	**IOTC register**	Set up EM analyst is not collecting this field directly but the data can be collected with another source The name of the vessel is imprinted on EM records. Logbooks provide RCS.
Vessel port of registration	Record the name of vessel's port of registry (also called home port) shown on its registration documents and lettered on the stern of the ship's hull – also include the country.	**MR**	**N**	**IOTC register** **Logbook**	Set up EM analyst is not collecting this field directly but the data can be collected with another source The name of the vessel is imprinted on EM records. Logbooks provide port of registration.
Vessel registration number	Record the number issued by country in which the vessel is registered, shown on its registration documents and written on the hull of the vessel. This may be a combination of characters and numbers; record them all (e.g.: CBG303).	---	**N**	**IOTC register**	Set up EM analyst is not collecting this field directly but the data can be collected with another source The name of the vessel is imprinted on EM records. Logbooks provide registration number.
Vessel phone, fax and email	When available, record vessel contacts details, taking note of the ocean region code. A vessel may have several contact numbers and email addresses depending on the satellite communications systems installed onboard; record them all.	---	**N**	**Vessel reference table**	EM analyst is not collecting this field directly but the data can be collected with another source The name of the vessel is imprinted on EM records.
Licensed target species	Record licensed target species (FAO spp. 3-alpha code) as specified in vessel licences or permit conditions (Table 1, Table 2, Table 3, Table 4, Table 8). Vessels will generally target a narrow range or aggregation of species, however one or more might not be an IOTC species; record them all.	**OR**	**N**	**ERS**	The name of the vessel is imprinted on EM records. Target species are specified in the ERS. It is not necessary to verify this data though target species are well known for tropical tuna PS.
Main fishing gear	Record vessel main fishing gear (Table 10).	---	**N**	**ERS** **IOTC register**	The name of the vessel is imprinted on EM records. The main gear is specified in the ERS. It is not necessary to verify this data though, main gear is well known for tropical tuna PS.

Data field name	Data field description	Reporting	EM (Y/N)	Alternative Source	Comments
VESSEL OWNER AND PERSONNEL					
Registered owner	Record the owner's name, nationality (Table 9) and contact details in full. These can be obtained or cross-checked on the vessel registration forms.	---	**N**	**IOTC register** **Vessel reference table**	Set up The name of the vessel is imprinted on EM records. Information on vessel owner is part of data fields on the IOTC register.
Data field name	**Data field description**	**Reporting**	**EM (Y/N)**	**Alternative Source**	**Comments**
Charterer / operator	Where the vessel has been chartered and is operated and managed by a company other than the owner, record operator's full name (company or individual as appropriate), nationality (Table 9) and contact details.	---	**N**	**IOTC register** **Vessel reference table**	The name of the vessel is imprinted on EM records. Information on vessel owner is part of data fields on the IOTC register.
Fishing Master	Record the fishing master name and nationality in full (Table 9).	---	**N**	**Logbook**	Post-trip information
Skipper	Record skipper name and nationality in full (Table 9). Note: in some instances the fishing master and skipper may be the same person. In such cases record here "N/A" for not applicable.	---	**N**	**Logbook**	Post-trip information
Crew number	Record the number of crew. This should be cross checked against the vessel's crew list.	---	**N**	**Vessel's crew list**	Post-trip information
VESSEL TRIP DETAILS					
Port of departure	Record the name and/or geographical coordinates of the port from where the vessel sailed – also include the country. If the vessel started a new trip at sea following transhipment record 'at-sea' plus the geographical coordinates corresponding to the location the trip started. Note: latitude and longitude to be recorded mentioning if collected South or North of the equator and specifying units (preferably ±(d)dd.dddd°).	---	**Y**	**GPS position**	GPS position at vessel departure
Date / time vessel sailed	Record the date and time the vessel departed from port or from a transhipment location. Note: specify units (preferably YYYY/MM/DD and hh:mm).	---	**Y**	**GPS position**	GPS position at vessel departure
Port of return	Record the name and/or geographical coordinates of the port where the vessel returned – also include the country. If the vessel arrived at a transhipment location record 'at-sea' plus the geographical coordinates corresponding to the location the transhipment started. If the observer disembarked before the vessel returned then record expected port of return as provided by the vessel. Note: latitude and longitude to be recorded mentioning if collected South or North of the equator and specifying units (preferably ±(d)dd.dddd°).	---	**Y**	**GPS position**	GPS position at vessel return
Date / time vessel returned to port	Record the date and time the fishing vessel finishes its fishing campaign. i.e. returns to port or to a transhipment location for unloading. If the observer disembarks before the vessel returns then record expected date and time of arrival (ETA) as provided by the vessel. Note: specify units (preferably YYYY/MM/DD and hh:mm).	---	**Y**	**GPS position**	GPS position at vessel return
VESSEL ATTRIBUTES					
Tonnage	The vessel tonnage as specified in vessel registration papers. Note: specify units, i.e. if the vessel is registered using Gross Tonnage (GT) or Gross Registered Tonnage (GRT).	**MR**	**N**	**IOTC register**	Pre-trip information from the fishing company Not sure why this should be collected at each fishing trip. Might be good to only report changes in vessel attributes and maintain a specific "vessel attributes" form. The same applies to all data fields on vessel attributes and vessel electronics.

Length overall	The vessel overall length (LOA) as specified in vessel registration papers. Note: specify units (preferably metres).	**MR**	**N**	**IOTC register**	Pre-trip information from the fishing company
Data field name	**Data field description**	**Reporting**	**EM (Y/N)**	**Alternative Source**	**Comments**
Hull material	Record the vessel hull material (s) (steel, wood, aluminium, fibre glass, etc.) (Table 11).	**MR**	**N**	**Vessel reference table**	Pre-trip information from the fishing company
Main engines (make and power)	The make (brand) and power of the main engines. Note: specify units (HP, Kilowatt or BHP).	**MR**	**N**	**Vessel reference table**	Pre-trip information from the fishing company
Fish storage capacity	The vessel total maximum capacity to store catches. This should include blast freezer(s) capacity. Note: specify units (metric Tons (mT.) or cubic metres (m^3)).	**MR**	**N**	**Vessel reference table**	Pre-trip information from the fishing company
Fish preservation methods	Fish preservation methods: Record the method(s) used by the vessel to preserve the catch (Table 12).	---	**N**	**Vessel reference table**	Pre-trip information.
Fish storage type	Record the type of structure(s) present on-board used by the vessel to store the catch (Table 13).	---	**N**	**Vessel reference table**	Pre-trip information.
Vessel autonomy / range	Record vessel autonomy, expressed by the time (days) a vessel can spend at sea without refuelling. If this information is not available then record vessel range expressed in cruising distance (nautical miles). If a figure for the range cannot be obtained, the observer should calculate vessel range as follows. <Vessel range (nm)> = <Vessel average cruising distance per metric ton (nm/mT)> : <Tonnage of fuel carried (mT)> Note: specify units(days or nautical miles)	---	**N**		
VESSEL ELECTRONICS					
Global Positioning System (GPS)	Indicate Yes if on board No if not sighted. Note: a GPS may be an independent unit or linked or incorporated into track plotters and acoustic systems.	**MR**	**N**	**Owner**	The EM observer cannot provide this information. "Sighted" is not relevant, only for onboard observers. ROS field description might need to be updated with an appropriate terminology for electronic observation The same applies to the other vessel tools
Vessel Monitoring Systems (VMS)	Indicate Yes if on board No if not sighted	**MR**	**N**	**Owner**	Idem
Radars	Indicate Yes if on board No if not sighted. Note: include high frequency radars used by the vessel to search for seabird activity or activity on the sea surface.	**MR**	**N**	**Owner**	Idem
Track Plotter	Indicate Yes if on board No if not sighted	**MR**	**N**	**Owner**	Idem
Depth Sounder	Indicate Yes if on board No if not sighted	**MR**	**N**	**Owner**	Idem
Sonar	Indicate Yes if on board No if not sighted	**MR**	**N**	**Owner**	Idem

Doppler Current Meter	Indicate Yes if on board No if not sighted Note: acoustic doppler current meter is used to ascertain current speed.	**MR**	**N**	**Owner**	Idem
Expendable bathythermograph s (XBT)	Indicate Yes if on board No if not sighted. XTBs are usually mounted on the bridge wings. Note: XTBs are periodically used to determine the depth of the thermocline.	**MR**	**N**	**Owner**	Idem
Data field name	**Data field description**	**Reporting**	**EM (Y/N)**	**Alternative Source**	**Comments**
VHF radios	Indicate Yes if on board No if not sighted	---	**N**	**Owner**	Idem
HF radios	Indicate Yes if on board No if not sighted	---	**N**	**Owner**	Idem
Satellite communication systems	Indicate Yes if on board No if not sighted.	---	**N**	**Owner**	
Sea Surface Temperature (SST) gauge	Indicate Yes if on board No if not sighted. SST gauge is usually mounted on the bridge. Note: the vessel may also have access to SST charts received from Fisheries Information Services systems.	---	**N**	**Owner**	Idem
Weather facsimile	Indicate Yes if on board No if not sighted. Note: weather information may also be received from Fisheries Information Services systems.	---	**N**	**Owner**	Idem
Fisheries information services	Indicate Yes or No if the vessel has access to a Fisheries information service. Note: Vessels may access fishery information services for instant information on weather and oceanographic features (SST, phytoplankton densities or sea height).	---	**N**	**Owner**	Idem
WASTE MANAGEMENT (MARPOL Agreement Annex 5)					
Waste category	Record the category of the waste produced by the vessel (Table 14).	**OR**	**N**	**Owner**	
Storage/Disposal method	Record how the waste was disposed of (Table 15). For example, incinerated, stored in sacks or disposed of overboard.	**OR**	**N**	**Owner**	
OBSERVED TRIP SUMMARY					
Number of fishing events/sets conducted by the vessel while the observer was on-board.	Record the total number of fishing events/sets conducted by the vessel while the observer was on-board, independently of their success and of being sampled or not by the observer. Note: this should not include pole and line bait fishing events/sets.	**MR**	**Y**	**Logbook**	ROS field description might need to be updated with an appropriate terminology for electronic observation: *Record the total number of fishing events/sets conducted by the vessel **during the fraction of the fishing trip that was covered by the observer**, independently of their success and of being **monitored** or not by the observer. Might depend on recordings availability and quality Update resolutions 11/04 22/04*

Number of fishing events/sets observed	Record the total number of fishing sets/events monitored by the observer. Note: this should not include pole and line bait fishing events/sets.	**MR**	**Y**		
Number of days searching	Record the total number of days that the vessel was engaged in actively searching for fish (this includes active fishing days).	**MR**	**N**		Not possible
Data field name	**Data field description**	**Reporting**	**EM (Y/N)**	**Alternative Source**	**Comments**
Number active fishing days	Record the total number of days that the vessel actually fished (i.e. when the vessel had gear in the water). Note: for some fishing events this may be for only a few hours of the day. Alternatively a single fishing event/set may span part of two days."	**MR**	**Y**		
Number of days lost	Record the total number of days where a vessel was unable to fish due to factors such as adverse weather conditions, mechanical failure or other unforeseen events.	**MR**	**N**		Not possible
Reason(s) for days lost	Record the reason(s) a vessel was unable to fish: (i) adverse weather conditions, (ii) mechanical breakdown or inoperative gear or (iii) unforeseen events (specify).	**OR**	**N**		Not possible
Number of days in the fishing area	Record the number of days the vessel spent in the fishing area while the observer was onboard. This does not include transit time even if the area being transited is within the fishing area.	---	**Y/N**	**GPS**	ROS field description might need to be updated with an appropriate terminology for electronic observation: *Record the number of days the vessel spent in the fishing area* ***with coverage by the observer***
Number of days transiting	Record the number of days the vessel spent steaming or transiting to/between/from fishing areas while the observer was onboard.	---	**N**		ROS field description might need to be updated with an appropriate terminology for electronic observation: *[…]* ***with coverage by the observer***

PURSE SEINE INFORMATIONS

Gear specifications

Data field name	Data field description	Reporting	EM (Y/N)	Alternative Source	Comments
SPECIAL EQUIPMENT OR MACHINERY					
Power block	Indicate Yes if on board No if not sighted.	**MR**	**Y**		
Purse winch	Indicate Yes if on board No if not sighted.	**MR**	**Y**		
Maximum length of the net	Record the maximum length of the net according to the net specifications. This corresponds to the length of the topline. Note: specify units (preferably metres)	**MR**	**N**	**Owner**	Post-trip information Need a dedicated form that should be updated any time it would be necessary. There is no need to report on vessel, gear, electronic equipment at each fishing trip.
Maximum depth of the net	Record the maximum fishing depth according to the net specifications. Note: specify units (preferably metres)	**MR**	**N**	**Owner**	Post-trip information
Bag stretched mesh size	Record the mesh average stretched lengths (knot to knot) of the bag of the net. Usually calculated by measuring 3 stretched mesh lengths and calculating the average. Note: specify units (preferably centimetres)	**MR**	**N**	**Owner**	Post-trip information
Mid-net stretched mesh size	Record the mesh average stretched lengths (knot to knot) of the mid-net. Usually calculated by measuring 3 stretched mesh lengths and calculating the average. Note: specify units (preferably centimetres)	**MR**	**N**	**Owner**	Post-trip information
Maximum Brail	Record the maximum weight capacity of a full brail in metric	**MR**	**N**	**Owner**	Post-trip information
Capacity	tonnes (Mt).		**N**	**Owner**	Post-trip information
Skiff Power	Record the skiff engine power. Note: specify units (HP, KW).	---	**N**	**Owner**	Post-trip information

Fishing event

Data field name	Data field description	Reporting	EM (Y/N)	Alternative Source	Comments
Set number	Record set number. This should be a four-digit numerical code beginning 0001. Set numbers should be consecutive from the start of the first line set to the last line set of the observed trip. A unique number is to be allocated to each individual set.	**MR**	**Y**		
OPERATIONS					
Set type[12]	Free school set, FAD set, etc. (table 34)	**MR**	**Y**		It can be problematic for sets associated for whales shark, cetaceans (not always detected in the field)

Start setting date and time	Record the date and time the skiff is launched to start the setting operation. Note: specify units (preferably hh:mm and YYYY/MM/DD).	**MR**	**Y**		
Data field name	**Data field description**	**Reporting**	**EM (Y/N)**	**Alternative Source**	**Comments**
Start setting position	Record the position in latitude and longitude for the start of the setting operation. Note: latitude and longitude to be recorded mentioning if collected South or North of the equator and specifying units (preferably ±(d)dd.dddd°).	**MR**	**Y**		In case of technical issues, logbooks can completed this information
Beaufort	Record the force of the wind according to the Beaufort scale (Table 37).	---	**N**		
School sighting cue and school type	Report up to the first three cues which lead the vessel to detect the presence of the tuna school and specify the type of tuna school detected (Table 35).	**MR**	**N**		Not possible
First detection method	Record how the vessel first detects the tuna school, floating object or birds (Table 30). If more than one method is used record only what first made the vessel change course.	---	**N**		Not possible
School size	Provide an estimation of the size of the tuna school being targeted (in tonnes). This information can be requested from the bridge officers.	---	**N**		Not possible
Time net pursed	Record the time (hh:mm) when the net is fully pursed. All rings are up.	**MR**	**Y/N**		Not visible on all vessels
Time start brailing	Record the time that brailing starts (hh:mm).	---	**Y**		
Time end brailing	Record the time that brailing ends (hh:mm).	---	**Y**		
Time skiff onboard	Record the time when the skiff comes on board and the set is over (hh:mm).	---	**Y**		
Maximum closing net depth (m)	Record the real, measured, closed net depth (m). To be recorded only if depth gauge is used. Use information from middle gauge if more than one gauge is present.	---	**N**		Not possible
Object Details	For sets conducted on FADs (natural or artificial), the following detailed information should be collected where possible and reported to the IOTC Secretariat.				
Buoy ID	For every activity involving artificial or a natural FADs equipped with a buoy report BUOY ID (i.e. Buoy marking or any information allowing identifying the owner). [Consistent with IOTC Res 18/08]	**OR**	**N**	**Logbook**	Not possible
Buoy equipped with artificial lights	Report if devices equipped with artificial lights are deployed and/or recovered. [Consistent with IOTC Res 16/07]	**OR**	**N**		Not possible

Artificial FAD design	Characterize artificial FAD design using codes provided to describe raft (floating part) and tail (underwater hanging structure) materials (Table 36). [Consistent with IOTC Res. 12/04 and Res 18/08]	OR	Y/N	Logbook	Possible for dFADs deployed but very difficult to determine FAD design at sea This should be updated with the revised form to report on FOBs and buoys.
Data field name	**Data field description**	**Reporting**	**EM (Y/N)**	**Alternative Source**	**Comments**
Cetaceans and whale sharks sightings during setting					
Sighting occurred before setting	Indicate YES if the sighting occurred before setting or NO if it occurred after.	OR	N	Logbook	Not possible, camera field not large enough to collect this information
Species	The species code for the sighted specimen/s (FAO spp. 3-alpha code). If species FAO code is not available, the species scientific name.	OR	N		Not possible
N° sighted	The number of individuals sighted per species.	OR	N		
Caught inside the net	Indicate YES or NO whether sighted specimen/s was/were caught inside the net once the purse line was closed.	OR	Y		Possible but not visible on all vessels (blind spots)
Support vessel details	Details on support vessel/s present/participating to the observed fishing set.				
Support vessel presence	Record if a supply vessel is present during the observed set.	---	N		In theory, the surrounding activities could be observed with the Crow's nest port side camera. However, the detection of a support vessel is not always possible. This field is here to reflect past strategies of fishing under the support vessel, acting as a FOB. This strategy is not used anymore to my knowledge.
Support vessel name	Record the name of the support vessel present during the observed set.	---	N		
Support vessel participation	Support vessel participation: Record if the Supply Vessel takes part in the setting operation (YES/NO). If YES, describe it (e.g. acting as floating objet, etc.).	---	N		
Details on the current	Details on sea current that might influence set performance.				
Current direction	Record current direction using cardinal points (E, W, SW, SSW, etc.). This information is to be requested from bridge officers.	---	N		Not possible Field optional in the logbook.
Current speed	Record current speed in knots. This information is to be requested from bridge officers.	---	N		Not possible Field optional in the logbook.
Current depth	Record current depth in metres. This information is to be requested from bridge officers.	---	N		Not possible
CATCH DETAILS					
Set number	Unique within a specific set	MR	Y		

Catch detail	Unique within a specific catch detail	MR	Y		Limited to a certain extent of details.
Number			Y		To a certain extent. Depends on the size, the species and the monitoring location

Data field name	Data field description	Reporting	EM (Y/N)	Alternative Source	Comments
Species	Record the species code for each specimen observed using FAO three figure alpha codes (Table 1, Table 2, Table 3, Table 4, Table 5, Table 6 and Table 7). If species FAO code is not available, the species scientific name. Note: Record "unknown" for species that cannot be positively identified and give it a reference number. Use the same reference number throughout the trip for that species. Retain a sample and / or take a photograph of the unidentified organism for latter identification.	MR	Y/N		To a certain extent. -Discarded species: Possible but not easy to identify individuals at species level for small or lookalike individuals. -Retained species: difficult (conveyor belt speed /vessel configuration, piled individuals, lookalike species) are not estimated with EM for the moment
Fate	Specify the species fate which includes whether it was retained or discarded and the reason, e.g. "Discarded – too small" (Table 41).	MR	Y/N		Depends whether fate is monitored on the lower or the upper deck. Fate is sometimes difficult to assess on the lower deck. Fate and reason of discards are problematic.
Sampling methods for obtaining total catch estimates per species	Indicate the sampling method used to obtain total catch estimates per species for the catch detail (Table 40).	MR	Y	Logbook	Exhaustive counting for discarded species Derived from logbook for retained species (similar method used by onboard observers for target species)
Number	Record the number of individuals per species for each specified fate. If weight is recorded, insert NA here (for large fish, record number of individuals).	MR	Y/N	Logbook	To a certain extent. Exhaustive counting for discarded species Derived from logbook for retained species (similar method used by onboard observers for target species)
Weight	Record the weight corresponding to the specified species and fate category. If number of individuals is recorded, insert NA here (for small fish, record weight). Note: specify units (preferably tons).	MR	N/Y	Mean weight reference table	The weight of an individual or group of individuals is not estimated but complementary source can be used for weight estimations
Weight estimation method	Indicate the weight estimation method used to collect weight (Table 43). Note: If number of individuals is recorded, insert NA here.	MR	Y	Mean weight reference table	Number are transformed in weight by a number/mean weight relationship by species (Observe)
Weight code	The code corresponding to the type of processing the specimen underwent prior to weighing (Table 44). If the fish has not been processed, record code for unprocessed (or round, whole, live) weight (i.e. RD). Note: If number of individuals is recorded, insert NA here.	MR	Y		

Additional details on non-target spp.					
Condition at capture	State the condition of the specimens at capture (Table 46).	**OR**	**Y/N**		Possible but very difficult to assess
Condition at release	State the condition of the specimens at the time of release (Table 46).	**OR**	**Y/N**		Possible but very difficult to assess
Data field name	**Data field description**	**Reporting**	**EM (Y/N)**	**Alternative Source**	**Comments**
SPECIMEN INFORMATION					
Set number	Unique within a specific trip	**MR**	**Y**		
Catch detail number	Unique within a specific set	**MR**	**Y**		
Specimen number	Unique within a specific catch detail	**MR**	**Y**		
Additional details on non-target spp.	Catch details on non-target species to be collected where possible and reported to the IOTC Secretariat as recommended by the Scientific Committee.				
Condition at capture	State the condition of the specimen at capture (Table 46).	**OR**	**Y/N**		Possible but very difficult to assess
Condition at release	State the condition of the specimen at the time of release (Table 46).	**OR**	**Y/N**		Possible but very difficult to assess
Additional catch details on SSIs	Additional catch details on Species of Special Interest (Table 47) to be collected where possible and reported to the IOTC Secretariat as recommended by the Scientific Committee.				
Gear interaction	For SSI only, specify the interaction of the specimen with the fishing gear (Table 48).	**OR**	**N**		
Brought on board	Indicate Yes or No, if the specimen was brought on board. [Consistent with IOTC Resolutions 13/04; 13/05; 12/04; 12/06; 12/09]	**OR**	**Y**		
Hauling method	Specify how the specimen was brought on-board (Table 49). [Consistent with IOTC Res 12-04]	**OR**	**Y**		
Resuscitation (for turtles only)	For turtles indicate Yes if the release took place with resuscitation and No if not.	---	**N**		
Photo ID	If a photo is taken, record photo number/code so that it can be linked back to the specimen for onshore examination.	---	**Y**		
BIOMETRIC INFORMATION Details concerning any extra biometric measurements, sex, maturity and the collection of samples.					

Sampling methods for the collection of biological information	Indicate the sampling method used for the collection of biological sub-sample (Table 42).	MR	N/Y		Samples are not collected but length can be roughly estimated by visual estimations for some species
Length code 1	Specify the length code used for the measurement (Table 53).	MR	Y		
Length 1	Record the length corresponding to the length type taken rounded to the lower centimetre.	MR	N		Rough visual estimation. Not calibrated for the moment
Data field name	**Data field description**	**Reporting**	**EM (Y/N)**	**Alternative Source**	**Comments**
Length code 2	When an additional length measurement is taken, the corresponding length code should be recorded (Table 53).	OR	N		Samples are not collected but length can be roughly estimated by visual estimations for some species
Length 2	When an additional length measurement is taken, the corresponding length should be recorded rounded to the lower centimetre.	OR	N		
Weight code	Record the code corresponding to the type of processing the specimen underwent prior to weighing (Table 44).	OR	Y	**Mean weight reference table**	The weight of an individual or group of individuals is not estimated but complementary source can be used for weight estimations
Weight	Record the specimen's weight (in kilograms) corresponding to the specified product type recorded in 'weight code'. If the fish has not been processed, record the unprocessed (or round, whole, live) weight (i.e. RD).	OR	N	**Mean weight reference table**	The weight of an individual or group of individuals is not estimated but complementary source can be used for weight estimations
Weight estimation method	Specify the weight estimation method used to obtain the weight (Table 43).	OR	Y		
Sex	Record the sex of the sampled fish specimen (Table 51).	OR	N/Y		Sometimes possible for sharks or rays
Maturity stage	Record the stage of maturity of the sampled fish specimen according to standard maturity scales approved by the IOTC. If unknown record UNK.	OR	N		Not possible
Sample collected	Record the following details on the collection of samples: *g)* type (e.g. otoliths, spine clippings, and genetic samples) *h)* preservation method (e.g. alcohol, frozen, etc.) i) destination (i.e. location to be sent/stored)	OR	N		
TAG DETAILS Note that all tagged specimens are to be identified to species level and to be sampled for length. Elasmobranches and turtles are also to be sexed and ascertained for maturity.					
Tag release	Indicate Yes or No, whether this individual was re-released with a tag attached.	MR	N	**Crew**	Not possible
Tag recovery	Indicate Yes or No, whether a tag was recovered from this individual.	MR	N	**Crew**	Not possible

Tag number	Provide the tag number. If a turtle make sure to provide both tag numbers (right and left flipper).	MR	N	Crew	Not possible
Tag type	Record the type of tag used (Table 52).	MR	N	Crew	Not possible
Tag finder	Record the name and contact details of the person who recovered the tag.	MR	N	Crew	Not possible
Well	The well number from which the tagged fish has been recovered, if the fish is recovered during shifting, transhipping or unloading. (Note: this information will allow tracing back tagged fish to the location where it was caught).	MR	N	Crew	Not possible

Purse-seine vessel daily activity information

Data field name	Data field description	Reporting	EM (Y/N)	Alternative Source	Comments
Date	Record the date. Note: specify units (preferably YYYY/MM/DD).	---	Y		
Time	Record time at the start of every fishing activity and every two hours from sunrise to sunset. Note: specify units (preferably hh:mm).	---	Y		Activity time not recorded every 2 hours. Just during fishing sets
Position	Record vessel position at the start of every fishing activity and every two hours from sunrise to sunset. Note: latitude and longitude to be recorded mentioning if collected South or North of the equator and specifying units (preferably ±(d)dd.dddd°).	---	Y		
Activity	Record vessel activity at the start of every fishing activity and every two hours from sunrise to sunset (Table 33).	---	N/Y		Activity not recorded every 2 hours. possible during fishing sets.
Comments	Record short commentaries on exceptional events that could not be described by the previous data fields.	---	N		

Purse-seine FAD activities

Data field name	Data field description	Reporting	EM (Y/N)	Alternative Source	Comments
Set number	As above	MR	Y	Logbook	
Type	Type of floating object (flotsam, natural object, FAD)	---	Y	Logbook	To a certain extent. Cameras are usually too far from the FOB to determine the type
Floating structure: dimensions	Length, width and height of the floating structure		Y	Logbook	To a certain extent. Cameras are usually too far from the FOB to determine the structure
Submerged structure: shape			Y	Logbook	To a certain extent. Cameras are usually too far from the FOB to determine the structure
Submerged structure: depth			N	Logbook	

Components when encountered	Components of floating and submerged structures when encountered		**N**	**Logbook**	
Components when left	Components of floating and submerged structures when left		**Y/N**	**Logbook**	Possible for deployed FADs
Object encounter	Date, time, position		**Y/N**	**Logbook**	To a certain extent. Cameras are usually too far to detect the object
FAD activity deployment	Date, time, position		**Y**	**Logbook**	
FAD activity: visit	Date, time, position		**Y/N**	**Logbook**	To a certain extent. Cameras are usually from the FAD activity at sea
FAD activity: hauling	Date, time, position		**Y**	**Logbook**	To a certain extent. Cameras are usually from the FAD activity at sea
FAD activity: retrieving/removed	Date, time, position		**Y**	**Logbook**	To a certain extent. Cameras are usually from the FAD activity at sea
FAD ID	If FAD is marked		**N**	**Logbook**	Not possible
Buoy ID	Serial number of satellite buoy		**N**	**Logbook**	Not possible
Origin	Origin of object (e.g. FAD ownership)		**N**	**Logbook**	Not possible
Operational buoys followed by vessel			**N**	**Logbook**	Not possible
Operational buoy lost by vessel			**N**	**Logbook**	Not possible