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MINIMUM STANDARDS FOR THE IMPLEMENTATION OF ELECTRONIC MONITORING SYSTEMS FOR THE TROPICAL TUNA PURSE SEINE FLEET

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SUMMARY

On the basis of experience gained during many trial studies of EMS on-board purse seine vessels, this document presents a series of proposed standards for the use of EMS to monitor these fisheries. It is recommended that ICCAT SCRS consider these draft standards in order to facilitate the use of this technology in the Atlantic Ocean. Both human observers and EMSs are complementary each with their own weaknesses and strengths. EMSs are still limited for a purely scientific monitoring program, covering all observers' tasks, especially with the collection of biological samples. However, EMS is valuable for vessels where it is difficult to place an observer onboard or to increase the coverage achieved by human observers.

RÉSUMÉ

Sur la base de l'expérience acquise pendant de nombreuses études de l'EMS réalisées à bord de senneurs, ce document présente une série de normes proposées pour l'utilisation de l'EMS pour effectuer le suivi de ces pêcheries. Il est recommandé que le SCRS de l'ICCAT considère ces projets de normes afin de faciliter le recours à cette technologie dans l'océan Atlantique. Les observateurs humains et les EMS sont tous deux complémentaires, chacun présentant ses propres faiblesses et ses forces. Les EMS sont encore restreints à un programme de suivi purement scientifique, couvrant toutes les tâches de l'observateur, notamment le prélèvement des échantillons biologiques. Toutefois, l'EMS est utile pour les navires à bord desquels il est difficile de déployer un observateur ou d'accroître la couverture réalisée par les observateurs humains.

RESUMEN

Basándose en la experiencia obtenida durante muchos estudios de ensayos de EMS a bordo de cerqueros, este documento propone una serie de normas propuestas para el uso del EMS en el seguimiento de estas pesquerías. Se recomienda que el SCRS de ICCAT considere estas normas propuestas con el fin de facilitar el uso de esta tecnología en el océano Atlántico. Los observadores humanos y el EMS son complementarios, cada uno con sus puntos débiles y sus puntos fuertes. Los EMS están aún limitados a un programa de seguimiento meramente científico, cubriendo todas las tareas de los observadores, especialmente en lo que se refiere a la recogida de muestras biológicas. Sin embargo, el EMS es valioso para los buques en los que es difícil llevar un observador a bordo o aumentar la cobertura lograda por los observadores humanos.

KEYWORDS

Electronic Monitoring Systems, purse seine fleet, data collection, fisheries monitoring, observers

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1. Background

When monitoring a fishery, the difficulty of ensuring adequate statistical observer coverage of entire fleets is a challenge and may reduce the usefulness of the obtained data for management purposes. This limitation makes it necessary to find cost-effective alternatives.

Electronic Monitoring Systems (EMS) on fishing vessels have been developing rapidly during the last decade. EMS trials and pilot studies have been conducted in different fisheries in order to test their effectiveness as an alternative or complement to traditional human observers (McElderry, 2008 compiled the results of more than 25 pilot studies). In some occasions, an outcome of the pilot projects resulted in EMS being implemented in the fishery to address monitoring requirements, for example as was the case of the tuna long line fishery in eastern Australia (Anonymous, 2016).

The tropical tuna purse seine fishery has not been an exception, and several pilot studies have been conducted to determine the effectiveness of EM technology (Ruiz *et al.*, 2014a; Ruiz *et al.*, 2014b; Monteagudo *et al.*, 2014; MRAG, 2016; Ruiz *et al*., 2016). Different systems developed by different vendors, showed diverse strengths and weaknesses, but in general these experiences showed that this technology has great potential as a monitoring tool in the tuna purse seine fishery. Several results indicated that after some adjustments, it can be a valid tool to monitor the fishing effort, total catch by set, and bycatch. EMS can be more effective for some specific tasks, equal to others, and weaker for some other tasks currently conducted by humans. So EMS are not considered to be a substitute for, rather a complement to human observer programs.

At this point given the promising results obtained in different pilot studies, minimum standards for EMS should be developed. These would aim to standardize the installations of EMS from different manufacturers, ensuring that the systems can collect useful and comparable information for fisheries monitoring and management. In addition, minimum standards are needed to ensure that these data share a standard format and can be integrated into the traditional data flows.

While EMS also have great potential for other types of fishing vessels (e.g. longline), the focus of this paper is to define the minimum standards for the implementation of the EMS in the tropical tuna purse seine fishery operating in the Atlantic and Indian Oceans (a similar but independent process is taking place for the WCPO). Restrepo *et al*. (2014) developed a guide document on EMS for tropical tuna purse seine fishery which could be used as starting point on the definition of these minimum standards. When Restrepo et al. (2014) was written, the conclusions from some of the PS EMS pilot projects were already known, so many ideas from Restrepo *et al.* (2014) may be considered in this document.

Pursuing the broad-based application of electronic monitoring systems is part of the 2015-2020 SCRS Science Strategic Plan (ICCAT 2014b). In 2014, the ICCAT SCRS (through its Sub-Committee on Statistics) recommended that the SCRS should adopt minimum standards for Electronic Monitoring Systems and that the ISSF guidelines described in Restrepo et al. (2014) could be used as a starting point for this objective (ICCAT 2014c). Likewise, the IOTC Scientific Committee agreed that standards for such systems for purse seine and other gear types would need to be developed and noted that ICCAT was working towards the adoption of said standards for purse seiners (IOTC 2014). In 2015, the ICCAT SCRS (through its Tropical Species Working Group) again recommended that the SCRS adopts minimum standards for the use of Electronic Monitoring Systems, especially for purse seiners (ICCAT 2015).

2. Monitoring programs objectives

The Objectives of the EM program must be clearly stated to prevent repetition and wasteful use of resources. In most cases EMS has been used for compliance purposes (e.g. Australia tuna long line fishery, British Columbia, etc.). Hence, it seems that EMS tends toward compliance rather than scientific observation. However, considering that under ICCAT and IOTC observer programs, human observers can (and do) serve multiple purposes, including both science and control objectives, EMS capabilities and main goals should be stated.

2.1 Established standards for data to be collected (Observer's tasks)

Doc. IMM-03/i2015 presented at the 10^{th} meeting of the ICCAT Working Group on Integrated Monitoring Measures summarizes ICCAT recommendations relating to observer programs and the duties of observers. [Rec. 14-01] (superseded by Rec. 15-01) requires all purse seine vessels targeting tropical tunas, including supply vessels, and fishing in the geographical area of the area/time closure, to embark an observer. In this case, the main observer's task will be to monitor the vessel **compliance** with the relevant ICCAT conservation and management measures. [REC. 10-10] establishes the minimum standards for fishing vessel **scientific** observer programs, where a minimum of 5% coverage of the fishing effort is required. Under this scientific program, observers shall record and report data that includes fishing operation information (location, date and time, set type, quantifying total target catch and by-catch (including sharks, sea turtles, marine mammals and seabirds), size composition, and fate. Furthermore, if recommended by the SCRS (Standing Committee on Research and Statistics), the collection of biological samples (e.g. gonads, otoliths, spines and scales) or any other scientific work should also be done by observers.

The observer's tasks under the IOTC Regional Observer Scheme (IOTC Resolution 11/04), are comparable to those required by the ICCAT scientific observer program: observers shall record and report fishing activities, verify positions of the vessel, estimate catches as much as possible, try to identifying the catch species composition, monitor discards, by-catch and size frequency, record the gear type, mesh size and attachments employed by the fishing master, and carry out such scientific work (e.g. collecting biological samples), as requested by the IOTC Scientific Committee.

Outside the RFMO requirements, other observer monitoring programs exist which are mostly managed by private contracts between industry and observer provider companies, and usually aimed at obtaining certification for ecolabels. For instance, verification of the so-called "Best Practices", where EU purse seiner owners established internal rules regarding the design of fish aggregating devices (FADs) and the release of the non-target fauna found associated with the FADs. Specific objectives are the total replacement of entangling FADs by non-entangling FADs, and the release of incidentally caught or FAD-associated fauna, ensuring the safety of the crew and maximizing the survival of released animals. Observers are in charge of registering information on each FAD that is deployed, visit or on which a fishing event occurs, and on the animals that are released. Similarly, companies that participate in the program of the International Seafood Sustainability Foundation (ISSF) can only purchase tuna caught by large-scale purse seine vessels when those vessels have 100% observer coverage (human or electronic).

Additionally, some vessel owners/managers use EMS as a means of verifying compliance by the crew (e.g. with licensing arrangements) and to have extra information on any eventualities that may happen on board their vessels.

Thus it seems that observer duties and data collection requirements are heterogeneous, covering both compliance and science. Pilot studies have shown that EMS and human observers have some clear differences, strengths, and weaknesses. EMS would never be able to collect biological samples as cost-effectively as humans would. In addition, before using it EMS for accurate size sampling (length measurement), even if sea trials showed promising results (MRAG, 2016), technology should needs to be adapted to current purse seiners' operating conditions and trials should continue. On the other hand, EMS has shown that its capabilities could be higher for some other relevant issues: continuous tracking, simultaneous sampling in both main and below decks, visual evidences (compliance). Therefore, the two are complementary, and a monitoring program could, or should, have these two sources of information at the same time.

3. Capabilities and Potential uses of the EMS

3.1 EMS Capabilities

Sea trials have shown that EMS is capable to collect data on:

Vessel track: In addition to a number of cameras, all tested systems were equipped with independent Global Positioning System (GPS). This allows monitoring the vessel position, route and speed at a much finer scale than a human observer. In addition, time and position data can be saved in encrypted disks such that they cannot be falsified.

Set location, number and type. 100% accuracy compared to human observer reports has been achieved identifying the number of fishing operations (including date, hour and position) during all sea trials conducted in the Atlantic and Indian Oceans. Success decreases slightly for the set type identification (free school set vs FAD set); between 72% and 100%. Set classification is used for stratification for most computations for tropical tuna purse-seine fishery statistics. It is therefore important to be able to discriminate between the two types of sets. When classifying sets through EMS data, different data sources can be used: visual evidences (detect a FAD in a picture/video), species composition (detection of characteristic species for a determined type of set), or Vessel behaviour (GPS and sensor information). Some EMS tests only used some of these data sources, meaning partial information. When all data are combined, and complete information is used, set classification success never falls below 95%.

Total catch by set. The total catch by set was estimated and EMS data were accurate with no significant differences when compared with human observer and crew estimates. This task was easily performed with camera views allowing the correct observation of the fullness of each brail. In this regard, different technical data as total brail capacity and wells capacity should be known previously for each vessel.

Target species composition (YFT/BET/SKJ). Some EMS trials tried to estimate species composition by set, but without consistent results; we note that human observers have the same difficulty when estimating species composition. Because of the large catch volumes that can result in a set, and the speed with which the fish are put into the wells, species composition estimates – especially bigeye and yellowfin proportion– will be more accurate if it is done via port-sampling. Nevertheless, some EM vendors are researching ways in which on-board species composition estimates may be improved. Moreover, EMS offers the capability to pause, forward back and review as many times as required.

Bycatch estimates (shark, billfish, turtles, rays). The first tests made with EMS constantly underestimated bycatch estimates when compared with human observers. Small bycatch specimens that were mixed with the bulk of the tuna catch, and sent directly through the hopper to the conveyor belt were undetectable in many cases. However, after several trials, it was shown that with the right camera placement and enough number of cameras both in the main deck and in the below deck, accurate bycatch estimation is possible. Furthermore, it is possible to identify the fate of these bycatches: if discarded or retained, and in case of release, how is it done. In this regard, it is important that cameras continue recording images for at least one hour after brailing ends, after the target catch is in the wells and the tow boat is on board.

FAD monitoring. Trials have shown that the right equipment is capable of recording correctly data on fishing operations done with FADs and the deployment of new FADs. In the case of a vessel's visit to a FAD without any other action, such as buoy replacement, information from EMS may be limited. However, in cases where the FAD is elevated and fully retrieved, EMS has been able to identify its structure and the materials used for its construction (e.g. entangling or non-entangling material). On the other hand, during the monitoring of the FAD related operations, observers record buoy information at the same time (e.g. buoy ID unique number, brand, echo sounder presence and type, etc.). No EMS has been able to collect this information to-date. It is plausible that EMS could collect these data with the cooperation from the crew and changes in fishing practices (e.g., require FADs to be lifted out of the water; bring the buoy close to a camera so that markings can be recorded, etc.).

3.2 Potential uses of EMS

Based on the capabilities mentioned above, the main EMS potential usage could be for:

3.2.1 Compliance

Area/time closure monitoring. Monitoring of fishing operation, including date/position/classification during any closure period. (e.g. ICCAT Rec. 14-01).

Full retention/Landing obligation/obligation to release certain species. EMS could be used to monitor the compliance with different management measures related with the prohibition of discarding or requirement of retention for certain species on purse seine vessels: e.g. IOTC Recommendation 15/06 on the implementation of a ban on discards of skipjack tuna, yellowfin tuna, bigeye tuna and non-targeted species caught by purse seiners, or the diverse IOTC and ICCAT recommendations banning the retention of specific shark species (ICCAT Rec. 11-08, 10-8, 10-7, 09-7 and IOTC Res 12/09).

Total Catch in a given EEZ. Estimates of total catches linked to position could be used to estimate total catches from an EEZ.

High seas transhipment (Rec. 12-06)

Ecolabels/Verification of the implementation of the Best practices.

3.2.2 Science

National observer program. With the right equipment, EMS could conduct many of the observer's tasks included within the ICCAT and IOTC scientific observer programs (ICCAT REC 10-10, IOTC Res 11/04). However, at this stage, there are still some limitations for biological sampling capacity. Other data collected in some cases by the observers, such as navigation, radio and echo location equipment, fishing gear or crews lists could be collected by different means: interviews, remaining observers, land base samplers and EMS installation technicians.

Table 1 shows the summary of the fishing activities that the observers should monitor, and the EMS capabilities for each of the requirements.

4. Standards for how data should be collected and integrated to the current data flow

EMS pilot studies on purse seiners have shown that EMS should be more than simply installing cameras. In addition to an appropriate number of cameras (often >5 depending on vessel), the system must be equipped with a GPS receiver. Supplementary sensors (e.g. hydraulic and/or rotation sensors) are helpful to distinguish fishing and non-fishing time, although it is not essential. Note that sensors could be used to determine when to record images during a day so that only fishing operations are recorded, which would address privacy concerns some may have. If 24/7 is recorded, same sensor data could be later used during the data processing as filter to modulate privacy levels if necessary. Generally, for the collection of accurate data to become useful for management purposes, an effective EMS should fulfill several minimum requirements, before, during and after the trip.

4.1 Before the trip (Installation, certification, audits)

Tested (and certified) by third party. EMS users have currently a variety of equipment manufactured by different vendors, and new manufactures could enter the market. After meeting the minimum specifications, all vendors should be equally valid, but each will have advantages and disadvantages over the other. However all systems should be tested through pilot studies before being implemented in a monitoring program. It is recommended that these pilot studies are executed by organizations that run human observer programs. To date different systems have been tested on tropical tuna purse seine vessels simultaneously with an experienced observer (Ruiz *et al.*, 2014a; Ruiz *et al.*, 2014b; Monteagudo *et al.*, 2014; MRAG, 2016; Ruiz *et al*., 2016). Once it is verified that there are no significant differences between the EMS and observer's results, the equipment could be introduced in a real monitoring program. In this regard, it is important to mention that in some occasions the observer's results will also be an estimate (bycatch estimates, discard estimates, etc.) so it is not expected a 1:1 relation when comparing both methods of data collection. Furthermore, in order to test the effectiveness of an EMS, in addition to human observers, there are, at least for some variables, other data sources can be included in the comparison (activity and set logbook, FAD logbook, port sampling, etc.). Once the efficacy and accuracy of a system has been proven, periodic audits are recommended.

Customized to vessel level. Conducted trials showed that EMS installation should be tailored to each individual vessel. There is not a standard configuration that will cover all vessels in the fleet, thus each installation must be customized at the vessel level. The next section (Table 2) mentions the areas/actions that should be covered by the camera's field-of-views (FOV), but these areas, and especially the camera placement to cover these actions, could vary from vessel to vessel. In this regard, crew cooperation is crucial; it is necessary that ship owners authorize appropriate access to the vessel to install EMS effectively, and that the crew get involved on the camera placement selection.

4.2 During the trip (Data collection)

System Robustness. Electronic monitoring systems have to be capable to resist rough conditions at-sea with minimum human intervention. In many cases, proper maintenance and inspection can be only achieved at port, in-between long fishing trips. Crew assistance may be required to clean the camera lenses when necessary.

System and data security. Due to the importance of the information captured, EM system components and data need to be tamper-proof (or at least tamper-resistant) and avoid access or manipulation of information by non-authorised persons. Having its own internal auxiliary batteries is important to ensure the electronic monitoring system can work even in the event of a vessel power outage. An inviolable system solution with encrypted data, near-real-time remote online "health statements" that assure that the data is recorded during the trip and GPS linked imagery (date, time and coordinates) must be included. Alerts or other evidence of tampering is required.

Cameras. Digital cameras are advantageous compared to analog. Video or still photographs can be equally valid options. In the second, a picture at least every 2 seconds when fishing action occurs is needed at least from the camera with view of the fish management areas. Image quality should permit species identification. Camera number and position must be adapted to each individual vessel, which should have sufficient cameras to view the following areas: Work deck (portside & starboard side), well deck & conveyor belt, in-water purse seine area, foredeck or/and amidships, depending of FAD deploying area. The cameras must cover the following actions: brailing, net hauling, FAD activities, bycatch handling and release, tuna discards, catch well sorting (process of putting the catch in the hold or wells) **Table 2** summarized the areas and activities to be monitored by EMS.

Independence. Any EMS should be, to the extent possible, independent from the crew during the trip. If image recording is not continuous (24 h/day), different sensors (e.g. rotation, hydraulic sensors, GPS speed) will be in charge of automatically identifying a fishing-related activity and, acting as a trigger, start the image recording. Even as the system is working independently, it is expected that some basic maintenance (such as cleaning the camera lens) must be done by the crew.

Data storage and autonomy. The system should have enough autonomy to cover a minimum of 4 months. Data are extracted (or hard drives replaced) by technicians between trips, and the equipment should be prepared for any eventuality; entries into unexpected ports, etc. It is necessary to find the balance between the image quality and the EMS data store capacity. It does not suggest, however, that the images do not have to meet the minimum requirements (e.g. species id capability). It is recommended that the system uses solid state storage devices (SSD) which have no moving mechanical components, which makes them more resistant for at-sea conditions.

4.3 After the trip (Data traceability and analysis)

Dedicated data analysis software. In addition to the hardware, the EMS should provide a dedicated software to facilitate the review of images in an effective and efficient way. This software shall permit the analysis all the stored data, images and sensor data in a synchronized way, performing all analysis and reporting nimbly.

As a minimum, analysis software should allow to:

- Identify fishing operations date/time
- Identify set type
- Detect operations with FAD
- Estimate total catch by set
- Estimate target species catch composition and sizes
- Detect bycatch species
- Estimate discards of target species

EMS data analysis and reporting. The analysis of the data recorded through EMS is not an easy task, and should be done by institutions, organizations and independent companies used to work with on-board observers. These entities should be familiar with the end users' data needs, RFMO management measures, and data reporting obligations, as well as the on-board operations and conditions. Data analysis procedures should be written and approved, to assure a good traceability of data.

"Office observers" training. EMS monitoring program managers shall ensure that their on-land or office observers have the following qualifications to accomplish their responsibilities:

a) Sufficient knowledge and experience to know in detail how the purse seine fishing operation and catch handling is done, identify species and collect information on different fishing activities. In this regard, previous at sea observer experience is valuable.
b) Satisfactory knowledge of the RFMO conservation and management measures.
c) The ability to observe and record accurately data to be collected under the program.
d) The ability to use properly the dedicated image analysis software; and;
e) Not be an employee of a fishing vessel company involved in the observed fishery or have similar potential conflicts of interest.

Compatible with ongoing standardized data flow and databases. Any software must have a data output format that is compatible with the ongoing National Observer Sampling Programs (including observer's data bases), and RFMO templates for data submission.

Hard drives chain of custody. During most of the pilot studies the crew was responsible for the transportation of the data (hard drives, or other media). Nevertheless, in a real monitoring program, for chain of custody assurance and independence, it is necessary that the data are retrieved by a third party with no conflict of interest. Some possibilities are: at sea observers, technicians in charge of installing EMS systems, or land observers.

5. Conclusion and final remarks

In conclusion, both human observers and EMSs are complementary each with their own weaknesses and strengths. EMSs are still limited for a purely scientific monitoring program, covering all observers' tasks, especially with the collection of biological samples. However, EMS is valuable for vessels where it is difficult to place an observer onboard (due to space limitations, non-safe areas, etc.) or to increase the coverage achieved by human observers.

On the basis of experience gained during many trial studies of EMS on-board purse seine vessels, this document presents a series of proposed standards for the use of EMS to monitor these fisheries. It is recommended that ICCAT SCRS and IOTC SC consider these draft standards in order to facilitate the use of this technology in the Atlantic and Indian Oceans.

Bellow a summary of the key points that should be taken into account before implementing an EMS program are presented:

1) *Before the trip (Installation, certification, audits)*

Customized to vessel level: There is not a standard configuration that will cover all vessels in the fleet, thus each installation must be customized at the vessel.
Tested (and certified) by a third party: All vendors should be equally valid, but all systems should be tested through pilot studies before being implemented

2) *During the trip (Data collection)*

Robust System: Capable to resist rough conditions at-sea
Secure System: Tamper proof system with encrypted data, near-real-time remote online "health statements" and GPS linked imagery.
Cameras: Digital cameras covering all areas of interest according to the vessel and fishing manoeuvres. Frame rate must assure the detection of both catch and bycatch species.
Independence: The system needs to be self-governing with the exception of minimal maintenance by crew.
Data storage and autonomy: The system should have enough autonomy to cover a minimum of 4 months.

3) *After the trip (Data traceability and analysis)*

Dedicated image analysis software: System should provide dedicated software to facilitate the review of images.
EMS data analysis and reporting: Data analysis and reporting should be done by institutions, organizations and independent companies used to work with on-board observers.

Office observers" training: "Dry" observers must have specific qualification.
Compatible with ongoing standardized data flow and databases: Compatible data output format.
Hard drives chain of custody: The system must assure traceability of every hard drive and information recorded on-board.

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Table1. Activities of interest to be monitored, including ICCAT/IOTC Recommendations related with them and EMS capability to properly monitor them.

Item	*Rec(s)*	*EMS capability*	*Comments*
Fishing operation date/time	ICCAT 14-01 ICCAT 10-10 IOTC Res 11/04	EMS Ready	
Fishing operation position	ICCAT 14-01 ICCAT 10-10 IOTC Res 11/04	EMS Ready	
Fishing operation type (FAD Vs FSC)	ICCAT 14-01	EMS Ready	
Total catch by set	ICCAT 10-10 IOTC Res 11/04	EMS Ready	
Target species composition by set	ICCAT 10-10 IOTC Res 11/04	EMS adjustments are still needed.	Human observers have the same difficulties. Species composition estimates, especially bigeye and yellowfin proportion, will be more accurate if it is done via port-sampling.
Bycatch estimate (sharks, rays, turtles, birds and marine mammals)	ICCAT 10-10 ICCAT 11-10 ICCAT 10-07* ICCAT 11-08* ICCAT 13-11** IOTC Res 11/04***	EMS Ready	*Only affects to sharks **Only affects to turtles ***Bycatch groups are not specified in the IOTC
Bycatch fate (sharks, rays, turtles, birds and billfish)	ICCAT 10-10 ICCAT 10-07* ICCAT 11-08* ICCAT 13-11**	EMS Ready	*Only affects to sharks **Only affects to turtles
Discards	ICCAT 10-10 ICCAT 11-10 IOTC Res 15/06	EMS Ready	
Size frequency	ICCAT 10-10 IOTC Res 11/04	EMS adjustments are still needed	Calibration work is still needed before robust random sampling.
Collection of biological samples (e.g. gonads, otoliths, spines)	ICCAT 10-10 IOTC Res 11/04	Cannot be collected via EMS.	Only when specified by the Scientific Committee. It is not a task done routinely.
Gear characteristics	IOTC Res 11/04	EMS adjustments are still needed.	Could be collected by different means: interviews, remaining observers, land base samplers and EMS technicians.
FAD monitoring (new deployments, retrieved FADs, visited FADs)	Outside RFMO observer's requirements	EMS Ready	Outside RFMO observer's requirements, but included in most of the domestic observer programs.
FAD structure	Outside RFMO observer's requirements	EMS Ready	Under the verification of the so-called "Best Practices"
Bycatch handling (sharks, rays, turtles and billfish)	Outside RFMO observer's requirements	EMS Ready	Under the verification of the so-called "Best Practices"

Table 2. Minimum areas and actions that should be monitored.

Area covered	*Action covered*	*Purpose*	*Minimum data requirements to be monitored*
Work deck (port side)	Brailing	Total catch by set Species composition	Number of brails & fullness by brail. Weight, size and species of retained tuna
	Tuna discards	Total tuna discards by set	Weight, size and species of discarded tuna
	Bycatch handling	Best practices	Handling mode
Work deck (starboard side)	Bycatch handling	Best practices	Handling mode
	Bycatch release	Total bycatch by set Best practices	Number of individuals and species ID
In-water purse seine area	Brailing	Total catch by set	Number of brails & fullness by brail
	Bycatch handling of big species (whale sharks, manta rays…)	Best practices	Handling mode
	Bycatch release of big species (whale sharks, manta rays…)	Total bycatch by set Best practices	Number of individuals and species ID
Foredeck or amidships	FAD activity (deploying, replacement, reparation…)	Total number of FAD activities by trip	Number, material (natural or artificial), and FAD characteristics (entangling or no entangling)
Well deck and conveyor belt	Catch well sorting	Species composition	Weight, size and species of retained tuna.
	Bycatch handling	Best practices	Handling mode
	Bycatch discarded, released or retained	Total bycatch by set Species composition Best practices	Number, size or weight of individuals, species ID and fate