STRENGTHS AND WEAKNESS OF THE DATA ELEMENTS CURRENTLY COLLECTED THROUGH ELECTRONIC MONITORING SYSTEMS IN THE INDIAN OCEAN

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1- BACKGROUND

Electronic monitoring (EM) is an emerging field which has been developed rapidly during the last decade, with high potential in fisheries monitoring and, hence, in fisheries science and management. In science, the collection of precise and accurate data, on which the advice should be based, is a key element. In management, appropriate fisheries monitoring is essential for the implementation of the regulation. In this sense, EM has been identified as a complement, or even as an alternative, to onboard (human) observers, in particular, where ensuring adequate statistical observer coverage is a challenge. Several EM trials and pilot studies have been conducted in different fisheries to test their effectiveness as an alternative or complement to traditional human observers. In some occasions, an outcome of the pilot projects resulted in EM being implemented in the fishery to address monitoring requirements (i.e. longline fisheries in Australia).

The tropical tuna purse-seine fishery has also joined those initiatives in order to incorporate EM systems for monitoring purposes. Since 2012 several pilot studies, which involved at least four different equipment providers, have been conducted (Briand et al., 2017, Ruiz et al., 2014a; Ruiz et al., 2014b; Monteagudo et al., 2014; MRAG, 2016; Ruiz et al., 2016a) with the aim of validating the efficiency of these EM systems.

In the light of the results of these pilot studies, the IOTC Scientific Committee agreed in 2014 (IOTC, 2014) that minimum standards for the implementation of such systems for fishery monitoring purposes for purse seine and other gear types would need to be developed. Moreover, Resolution 16/04 on the implementation of a pilot project in view of promoting the ROS (Regional Observer Scheme) of IOTC requested "*Scientific Committee to propose minimum standards for the implementation of electronic observation systems and how they can be used to increase levels of observer coverage for Indian Ocean fisheries*". These minimum standards were described during the WPDCS12 (Ruiz et al., 2016b). Recently, the WPEB (2017) requested "*documents to be submitted to WPDCS from CPCs specifying the current data elements recorded in the EM systems currently employed in the Indian Ocean and other Oceans*".

In this line, the objective of this paper is to present an overview of the data currently collected by EM systems in the European tropical tuna purse seine fishery, describing strengths and weaknesses in each case, provided that the minimum requirements needed for the implementation of electronic observation systems are followed.

2- IOTC DATA REQUIREMENTS

Several IOTC resolutions deal with data collection requirements (Res 16/04, Res 15/01, Res 15/02, etc.). Resolutions related to onboard observer's data collection are presented hereafter, as EM has been traditionally identified as an alternative /complement of observer programs. However, data usually collected by other means, such as logbook or VMS, could also be complemented by EM systems.

*Res **11/04** on a regional observer scheme*
Resolution 11/04 stipulates that the onboard human observers shall record and report fishing activities, verify positions of the vessel, estimate catches as much as possible, try to identify 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.

This resolution contemplates the general framework of the work for the onboard observers, which in turn would serve to meet a series of more specific requirements:

Resolutions dealing with bycatch and discards:

- *Resolution **05/05** Concerning the conservation of sharks caught in association with fisheries managed by IOTC*
- *Resolution **12/04** On marine turtles*
- *Resolution **13/04** On the conservation of cetaceans*
- *Resolution **13/05** On the) conservation of whale sharks (Rhincodon typus)*
- *Resolution **17/04** On A Ban on Discards of Bigeye Tuna, Skipjack Tuna, Yellowfin Tuna, And Non-Targeted Species Caught by Purse Seine Vessels in The IOTC Area of Competence*

Resolutions dealing with FADs:

- *Resolution **15/08** Procedures on a fish aggregating devices (FADs) management plan, including more detailed specifications of catch reporting from fad sets, and the development of improved FAD designs to reduce the incidence of entanglement of non-target species*

3- OVERVIEW OF THE EMS FOR FULLFILING IOTC DATA REQUIREMENTS

This section summarized EM strengths and weaknesses to properly monitor activities of interest under IOTC observer programs, provided any EM system follows minimum standards.

3.1- EM minimum standards

EM systems offered by different providers could result in data that are inconsistent and incompatible, and that this is the reason why minimum standards or guidelines for installation, data collection and report generation are required. Ruiz *et al.* (2016) provided these guidelines, and WPDCS12 RECOMMENDED these guidelines be adopted as a basis for defining minimum standards for tropical tuna purse seine fleets.

These minimum standards are divided in three sections as follows:
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.

3.2- EM capabilities and strengths and weaknesses to properly monitor fishing activities

Vessel position: All EM systems are equipped with an independent Global Positioning System (GPS). This allows monitoring the vessel position, route and speed at a much higher resolution than a human observer. In addition, time and position data can be saved in encrypted disks such that they cannot be falsified. In this sense, EM position data would be comparable to the VMS.

Fishing set location and type. 100% accuracy compared to human observer reports has been achieved identifying the number of fishing operations (including date, hour and position) during sea trials. Regarding the set type classification, EM allows discrimination between free school sets and FAD sets (95% concordance when comparing with human observer records) in the purse seiner fishery. When classifying sets through EMS data, different data sources can be used: visual evidences (detect a FAD in a picture/video), or vessel behaviour (GPS and sensor information).

Total retained catch by set. Observers onboard purse seiners obtain this information from crew members (from the logbook). In the case of the EM, the total catch by set is estimated. No significant differences appear when compared with human observer (logbook) data (Briand et al., 2017, Ruiz et al., 2014a; Ruiz et al., 2016a). This task is easily performed with camera views allowing the correct observation of the fullness of each brail. In this regard, different specifications 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 transferred into the wells, species composition estimates – especially bigeye and yellowfin proportion– will be more accurate if it is done via port-sampling. EMS offers the capability to pause, forward back and review as many times as required, however at sea trials should continue before using species distribution obtained from EM.

Length sampling: It is not uncommon for an EM system to have a length measurement tool. This tool will require a previous calibration. This calibration, and thus size sampling, is more complicated in areas where individuals are piled (e.g. conveyor belt). Work is still needed before robust random sampling for size frequencies are obtained using EM.

Bycatch estimates (shark, billfish, turtles, rays). Sea trials have 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, especially for large size individuals. 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. Camera placement should be aligned with crew's bycatch handling onboard. Pre-analysis of the onboard bycatch handling is crucial to obtain accurate estimates; presence or absence of discards conveyor belt, place and moment for the sorting of the bycatch, etc.

FAD monitoring. Regarding fishing activity around FADs (new deployments, fishing sets and visits), trials have shown that, if the equipment is place in the right locations, it is capable of recording correctly data on FAD fishing operations 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 EM may be limited. Regarding FAD design and construction, 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). If FADs are not recovered onboard, data collection on FAD design is going to be limited both for EM and human observers.

On the other hand, during the monitoring of the FAD related operations, observers are instructed to record buoy information during light hours directly from the satellite beacon (e.g. buoy ID unique number, brand, echo sounder presence and type, etc.). No EM system has been able to collect this information to-date.

Collection of biological samples: This task cannot be undertaken by EM.

Gear Characteristics: None of the pilot studies carried out to date have attempted to monitor the fishing gear by EM. However, it seems that certain issues (gear type, nº of speed boats…) could be monitored easily. Other equipment characteristics, as bridge equipment, etc. should be collected by other means.

In conclusion, both human observers and EM systems are complementary each with their own weaknesses and strengths. In general terms the EM has the advantage from the point of view of inviolability of the data, or due to the possibility to review images as many times as desired. This streaming is interesting when events related to the fishing operation occur in various places at the same time, to monitor 24/7, or in cases where monitoring has compliance purposes only. In addition, work is being done on the development of tools that allow the EM data to be analyzed automatically, which would mean reducing costs and time of data analysis and having in the future more standardized output. Finally, from the point of view of costs, it seems that at least in purse seine fishery, where searching time occupies most of the activity, the savings compared to observer programs are significant. Nevertheless, EM is still limited for a purely scientific monitoring program, covering all observers' tasks and should be considered as complementary to human observers, as recommended by IOTC (IOTC, 2014). **Table 1** shows EM strengths and weaknesses to properly monitor activities of interest under IOTC Resolutions, and that might be reported to the IOTC Secretariat.

Table1. EM capability to properly monitor activities of interest under IOTC Resolutions.

Item	Rec(s)	EMS capability	Strength (S) Weakness (W)
Vessel position	IOTC Res 11/04	EMS Ready	**(S)** Independent GPS, that allows tamper proof data at finer scale than a human observer.
Fishing operation date/time	IOTC Res 11/04	EMS Ready	Both EM and observers are equally valid methods.
Fishing operation type (FAD Vs FSC)	IOTC Res 11/04	EMS Ready	Both EM and observers are equally valid methods. **(W)** EM limited to identify sets associated to whales when the whale is not encircled, or

			if it escapes at the beginning of the set.
Total catch by set	IOTC Res 11/04	EMS Ready	**(S)** EM estimates independent to the crew
Target species composition by set	IOTC Res 11/04	EMS adjustments are still needed.	Both EM and 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)	IOTC Res 11/04 IOTC Res 05/05 IOTC Res 12/04 IOTC Res 13/04 IOTC Res 13/05	EMS Ready	**(W)** Number of cameras is limited, and bycatch handling area could change and move out from the camera views punctually. Small size individuals could be underestimated, mainly in those cases where they are not sorted, and are retained in wells. Species id. could be limited sometimes compared to an experienced observer. **(S**) EM allows monitoring two different places (main and well's deck) simultaneously.
Bycatch fate (sharks, rays, turtles, birds and billfish)	IOTC Res 11/04	EMS Ready	**(W)** Number of cameras is limited, and bycatch handling area could change and move out from the camera views punctually. Small size individuals could be underestimated, mainly in those cases where they are not sorted, and are retained in wells. **(S**) EM allows monitoring two different places (main and well's deck)

			simultaneously.
Discards	IOTC Res 15/06	EMS Ready	**(W)** Number of cameras is limited, and discard area could change and move out from the camera views punctually. If discards are not brailed onboard, EM is limited to estimate fish quantities in the net sack. Moreover, it would not be possible to know reasons for discarding in most of the cases. **(S)** On the contrary, when vessels are equipped with discard belt, EMS might be a better tool for estimating discards, species and volume, as it can be done in an exhaustive way.
Size frequency	IOTC Res 11/04	EMS adjustments are still needed	**(W)** Calibration work is still needed before robust random sampling.
Collection of biological samples (e.g. gonads, otoliths, spines)	IOTC Res 11/04	Cannot be collected via EMS.	**(W)** Cannot be conducted by EM. However, it is not a task done routinely.
Gear characteristics	IOTC Res 11/04	EMS adjustments are still needed.	**(W)** Limited task for the EM. Could be collected by different means: interviews, remaining observers, land base samplers and EMS technicians.
FAD monitoring	IOTC Res 11/04 IOTC Res 15/08	EMS Ready	**(S)** 24/7 easily monitored. Important if deployments are done at night. **(W)** EM cannot record buoy data

CONCLUSION

EM systems are not meant to substitute scientific observers. Both human observers and EM are complementary to each other, with their own weaknesses and strengths. EM is still limited to conduct some duties compared to observers. However, it could be valuable to increase the coverage achieved by human observers on purse seiners, specifically to; verify positions of the vessel, estimate number of sets (stratified by type), estimate total target tuna catches (including retained and discarded fractions), estimate bycatches and to monitor FAD activity. Before obtaining accurate data for the rests of the observer's duties stipulated in Resolution 11/04, such as size frequency and gear characteristics, EM adjustments and new developments are still needed.

In view of these findings, pilot studies have given way to the implementation of several EM programs. There are currently several CPCs that have volunteer EM programs in progress on purse seiners (EU Spain, EU France, Seychelles). However, data collected by EM would only be useful for the IOTC Scientific Committee if it is; i) collected in a consistent way, and ii) if it is reported later. In relation to the first point, there are already standards defined for the correct installation and operation of the EM. These standards should continue developing as these programs progress. Regarding the second point, mechanisms for the reporting of the EM data should be adopted. These are essential tasks before EM data can be made available to the IOTC SC.

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