Updated Guidance on Electronic Monitoring Systems for Tropical Tuna Purse Seine Fisheries

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1. BACKGROUND

Restrepo (2012) provided guidance on the use of electronic monitoring systems as an alternative or complement to human observer programs. The emphasis then was primarily on collecting data onboard the vessel that could not be recorded at the point of landing (e.g., discards.) Since then, there have been new developments by various commercial vendors that intend to provide electronic monitoring for purse seiners, especially in the Indian and Atlantic Oceans. In these two oceans, the RFMOs (IOTC and ICCAT) do not require 100% observer coverage, but ISSF does for those purse seine vessels that want to supply tuna to ISSF Participating Companies (ISSF 2014). Stanley (2013) also provided additional guidance partly based on Restrepo (2012). The objective of this document is to update Restrepo (2012) following these recent developments. This document repeats some of the content in Restrepo (2012) as it is intended to replace it. This document does not intend to provide an exhaustive overview of what constitutes an EM program. McElderry (2008) discusses elements that should be considered in efforts to operationalize EMS.

From the outset, it is important to note that neither ISSF nor the authors recommend one commercial EMS vendor over the others. All of the systems that the authors are familiar with can perform better than the others at certain tasks. In addition, vessel configurations and processing of the catch can differ substantially, which makes it difficult for a single system to perform adequately in all circumstances.

As Restrepo (2012) stressed, it is important to avoid the circumstance where vessels will simply install cameras on board and call that an electronic observer program. Electronic monitoring is much more than CCTV cameras. Careful thought needs to be given to the data that are collected, and ensuring that they are analyzed by an independent authority, such as the RFMO, the flag state, the licensing authority or an accredited institution.

2. THE GENERAL FUNCTIONS OF OBSERVERS

Generally, the functions of observers in RFMOs can be divided into collecting catch-related information and other scientific data (science), and/or monitoring the implementation of conservation and management measures adopted by the RFMO or within a fishing licensing agreement (compliance). Another function would be for companies and vessels under “eco label” certification schemes. These may require very close monitoring, including 100% observer coverage.

Scientific activities usually include collecting the following:

a) Information on fishing activities (searching time, means of locating fish schools, visits to floating objects or setting drifting FADs, vessel position, set time and duration, set type, etc);
b) Data on target tunas (total catch, species and size composition, discards);

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c) Data on non-target species (species, sizes, numbers/weight, fate);
d) Information on the gear used (net length, depth, drifting FADs deployed, etc.); and
e) Other scientific materials requested by the science committee of the RFMO (e.g., collecting tissue samples, tagging, etc.).

Much of the scientific data outlined above can also have potential use for compliance purposes, depending on each RFMO's decisions and fishery agreements. For example, the data on catches can enable the cross-checking of entries made to the skippers' logbooks. Also, the information on fishing activities can be used to determine if a set was made in contravention of a time/area closure or assert the amount of catch made within a specific EEZ. This type of information can be valuable to the RFMO compliance process, to the flag state authorities, to authorities of the licensing states, as well as to the vessel owners and fleet managers.

3. WAYS IN WHICH TUNA PURSE SEINE DATA ARE COLLECTED

Because of the large volumes of catch that can result in tuna purse seine sets and the speed with which the fish are put in the wells, and also the dangerousness of sampling live tuna; some types of data are more accurate if collected in port, at the end of the fishing trip. This is done via port sampling and other means such as logbooks and cannery data. Port sampling is important in purse seine fisheries for two main purposes: Estimating size composition, and estimating the species composition in the landings (particularly for bigeye and yellowfin). But this depends on the situation. In areas where the fish are transshipped in port at the end of the trip, observers may actually provide a better opportunity to sample the catches during each set. For example, Anonymous (2010) reviews the systems that are in place in different ocean regions to estimate the species composition of the tuna caught. On the other hand, there are types of data that cannot be accurately obtained independently of the skipper's logbook after a trip ends, such as data on discards and other geo-referenced details about the fishing operations.

Other than validating compliance, the most useful duties that observers can perform on purse seine vessels are: (i) Recording information that skippers and crew are not well trained for are not used to recording (e.g., discards by species) or do not have time to do, and (ii) recording information that can help validate the information in the skippers logbook.

Anonymous (2012) summarizes the main types of data that are recorded by observers onboard tropical tuna purse vessels. In the different ocean regions, different observer programs may record and store data using different formats. EM systems intended to be used in one particular region should adapt to those standards.

For most variables of interest, either human or electronic systems can provide useful information. Which of the two is more reliable depends on a number of factors. With the right configuration, EM systems can cover many of the fishery monitoring needs for scientific and compliance purposes.

4. DATA TO BE RECORDED AND RECOMMENDED EQUIPMENT

This section reviews the main types of data that need to be recorded and reported, as well as a number of recommendations that can make implementation of EMS more effective. A very important consideration is that the data recorded, both from cameras and sensors such as GPS, need to be stored in a secure fashion so that they cannot be manipulated. Encrypted hard disks should be used so that the institution reviewing the data can do so with assurance that there has been no manipulation.

4.1 Vessel information

Data Types: Vessel ID (name, registration number, flag, etc.); Vessel characteristics (engine, carrying capacity, number of wells, etc).
Characteristics: These types of data do not change very frequently for a given vessel.
Recommendations: This type of information can be recorded by a number of persons, including personnel from the government agencies, the vessel owner, the EMS installer, etc. The information should be recorded at least once each year (or when an event like a change of engine or re-flagging occurs). It would be desirable that the data be collected by the same organization that will review the information afterwards. Storing the data in a centralized database managed by that organization in a way that identifies each vessel or vessel/trip with a code would be useful.

4.2 Trip-level information

Data types: Net characteristics (length, depth, mesh size); Equipment (sonar, bird radar; brailer size); Use of auxiliary vessel (vessel characteristics and ID); Departure/arrival (date, port).
Characteristics: Some of this information may change between consecutive trips. Some may also change during a trip (e.g., if the brailer breaks and is replaced.)
Recommendations: See Section 4.1. In addition, GPS information from the EMS should be used to validate trip dates/duration. The vessel-owning company should report any equipment changes to the organization that will review the information afterwards.

4.3 Near Real-time information (health statements)

Data types: Date; Time (and UTC offset); Position (Lat, Lon); System status (working status of each EM component, any indication of damages).
Characteristics: Information of how the system is working and whether any component breaks is essential so that repairs can be made in a timely fashion. In addition, real-time monitoring of positions can be useful for control purposes.
Recommendations: Transmissions of positions to the EM provider should be at least every hour (day and night.) Depending on how the system is intended to be used, transmissions could also be received by the vessel-owning company or by the fisheries agency. The vessel owning company may need to agree to carry out a necessary level of maintenance and repairs to ensure proper functioning of the EMS (for example, camera lenses may need weekly cleaning.) However, it would be preferable that EM systems be developed with as much independent operation as possible. It is also useful to plan what should happen when the system appears to have been tampered with. Some systems continue to record data for some time making use of an uninterrupted power supply, which may make it possible to collect relevant information. In some fisheries, a period of time is given for repairing the system and afterwards the vessel is asked to return to port if the problem is not fixed.

4.4 Activity: Searching

Data types: Date, location, speed, use of equipment.
Characteristics: At this time, EM systems are unlikely to monitor search activities in an adequate way, because there are substantial behavioral elements (skipper, fishing master and crew) that are involved. However, some behavior can be inferred after the trip from analyses of detailed positioning data.
Recommendations: GPS positions should be stored at least every minute, although a higher frequency (~10 seconds) is desirable for a better set identification. The use of hydraulic sensors that determine when gear is in use can also aid to clearly separate time spent making sets from time spent in other activities.

4.5 Activity: Set/shot location and time

Data types: Date; Set time (shooting, ringsUp, end set); Set location; Begin/end brailing

Characteristics: This information pertains to a set, which takes place typically in a period of a few hours. An essential task for an EMS is to facilitate determining whether or not a set took place, so that the when and where can be recorded.

Recommendations: Recording this activity requires a combination of GPS as well as cameras. The most important camera should be high at the observation tower (crows' nest) but where the view is not obstructed. Whether a set is made or not can be determined in various ways. The most direct way is to include sensors (hydraulic power, speed) as part of the EMS. But there are also indirect ways such as inferring if a set likely took place based on vessel speed/position. EM providers should ensure that the software for data analyses greatly facilitates making this determination.

4.6 Activity: Set type

Data types: Set type (school, dolphin, drifting FAD, log, anchored FAD, whale shark, dead whale, pole&line vessel)

Characteristics: Set type can be difficult to determine with 100% accuracy because of the way in which fishing operations are done in different vessels/regions. However, it is likely that a combination of proper EMS equipment together with post-trip data analyses will improve accuracy.

Recommendations: The most important camera should be high at the observation tower (crows' nest) but where the view is not obstructed. This camera should have a good view of the port side, with a good balance between high resolution and angle coverage. The view (angle) must be wide enough to have a vision of almost the entire net. In turn, images should have enough quality to recognize a FAD, WS, etc.

Post-trip analyses can also help improve accuracy: Sensor and GPS data combined can provide insight into some types of fishing patterns (e.g. free school vs floating object); Sets made before sunrise are almost certainly on FADs equipped with satellite buoys; Catch made up of many (tuna and non-tuna) species is likely from sets associated with floating objects. EM providers should ensure that the software greatly facilitates making these post-trip analyses.

4.7 Activity: FAD data

Data types: FAD ID, FAD type or description (materials and configuration), FAD redeployment, satellite buoy info, repair, etc.

Characteristics: FAD information such as that required by IATTC Resolution C-13-04, IOTC Resolution 13/08 and ICCAT Recommendation 13-01, especially the FAD and satellite buoy ID, is not very easy to obtain by an observer (human or electronic). Most likely the skipper will need to assist in providing this information. Also, FADs are sometimes deployed by support vessels, and this information would not be available to a purse seiner equipped with EMS.

Recommendations: If FADs are repaired/deployed onboard the purse seiner, the ideal position for a camera may vary depending on that vessel's operations. Commonly, this is done in the bow area, so the camera would have to be pointed towards this space. FADs can be deployed at night and without the vessel changing speed. This should be taken into account with EM systems that switch off certain components at night or at high vessel speeds.

If the FAD is in the water, it will be difficult to document how it is constructed unless it is lifted out of the water and it is daytime.

In some fleets, FADs are also deployed and repaired by auxiliary (support) vessels. If comprehensive information on FAD activities is required, then EMS should also cover those vessels.

4.8 Activity: Total catch

Data types: Brail counts, brailer fullness

Characteristics: The total catch is estimated by recording all of the brailer activities, taking into account the fullness of each brail and the size of the brailer.

Recommendations: A high resolution camera will need to be placed in good view of the deck place where the brailers come onboard, unobstructed by other vessel equipment. A right angle view of the brail is desirable in order to estimate correctly the fullness. If the EMS is based on pictures, the frequency of the shots during a set may need to be adjusted so as to ensure that brailer activities can be fully documented (probably every 3 seconds is sufficient, but this needs to be determined.) Another possibility that should be explored for feasibility is to install a weight sensor to determine the weight of each brail.

4.9 Activity: Species and size composition of target tunas

Data types: Percent of bigeye, skipjack and yellowfin in a set; size distribution by species

Characteristics: The tuna catch in purse seine sets tends to be put in the refrigerated wells rather quickly. Because of the large volumes of catch in a set, it is difficult for human observers to sample the catch adequately to estimate species and size composition. In regions where the catch is usually landed in ports, these data are more accurately estimated at the end of the trip (e.g. by port sampling.) In areas where the fish are transshipped in port at the end of a trip, observers may be better placed to sample the catches during each set. But this may require setting aside part of the catch following a statistically-designed sampling protocol (Anonymous, 2010). However, with the development of EMS with high resolution cameras, it is possible that EM systems can eventually perform these tasks as well or better than human observers.

Recommendations: Cameras should be placed to view the fish as they move along the chute or conveyor towards the wells. However, for vessels with many wells, it may be necessary to reposition the camera(s) below deck, depending on the well being filled that day. This presents challenges for systems to operate independently of the fishing crew. It may be necessary to modify some fishing operations, e.g. by setting part of a set's catch aside in an area that can be recorded by a camera. Some vessels load the catch directly to the deck and not through the hopper, and a camera will need to be positioned accordingly. EMS providers would benefit from developing software to facilitate image analyses, including automatic species recognition and size measurements.

4.10 Activity: Bycatch of large individuals.

Data types: Catch and disposition (retained, discarded) of large individuals such as sharks, billfishes, sea turtles.

Characteristics: Most large individuals are separated from the tuna catch on deck and discards are done on the starboard side. Sometimes the crew misses large individuals but these are later separated from the catch below deck in the conveyor belt.

Recommendations: The same camera used to record brailer activity will record some of the catch of large individuals. To document discards, a view of the starboard side of the deck will be needed; this may be accomplished by the camera on the crow's nest if it has a sufficiently wide view angle (note however, that the main priority for that camera is to record set activity, so it should focus on the deck and port side primarily.) A different camera altogether with a view of the starboard side of the deck is preferable.

4.11 Bycatch of small individuals

Data types: Catch and disposition (retained, discarded) of small individuals such as small tunas, mahi-mahi, rainbow runner, wahoo, etc.

Characteristics: Most smaller individuals (including small sharks) are not separated from the tuna catch on deck and end up below deck. For vessels with a conveyor belt, these individuals can be

viewed below deck (some vessels have a second conveyor belt where species to be discarded are placed.)
Recommendations: Cameras below deck will be required (but note the same concerns as in **4.9**.) Some discards (tuna and non-tuna) are accumulated at the end of the conveyor belt (or in the second conveyor belt, if one exists) and it is important to record that activity.

4.12 Discards of target tunas

Data types: Catch and species composition of discarded tunas.
Characteristics: Tunas unfit for human consumption are sometimes discarded. They can be recorded if they make it to the deck. However, sometimes tunas are discarded before lifting onboard (e.g. in the last set of a trip when the size of the aggregation is large and the wells get filled with part of the set). These can only be estimated by the observer if the imagery recorded by the camera used for set-type identification is clear enough.
Recommendations: In some cases, they can be recorded with the same cameras as in section 4.9. In other cases, small tunas are entangled in the net, and these can be enumerated from images of the same camera that records brailing activity. Some discards (tuna and non-tuna) are accumulated at the end of the conveyor belt (or in the second conveyor belt, if one exists) and it is important to record that activity.

5. VALIDATION

There are many vendors of the different components/systems (Dunn and Knuckey, 2013). Given this, it is recommended that any EM system be subjected to a test to determine its effectiveness in terms of fulfilling various tasks (Section 4). See for example Ruiz et al. (2012) for such a comparison. The tests should be conducted by placing an experienced observer onboard the same trip as the EM system and comparing the results. This comparison should be rigorous, and carried out by a research institute experienced in observer programs. The results of this comparison should be documented, such as on a document submitted to the relevant RFMO science meeting. EM vendors should use these reviews to improve their systems.

6. ANALYSES AND REPORTS

Recording images onboard the vessel is probably the easiest part of an observer program. An observer program requires analyses of the information collected at sea and producing data files and reports that can be used to compile information across entire fleets, through time. In the case of EM systems, the data recorded should be viewed and analyzed by experienced human observers in the same research institutes or organizations that run regular observer programs.

As mentioned in Section 4, EM systems should include software that facilitates the analyses of the data recorded. The software should also output data in a format, structure and using codes compatible with the databases used by the institutes mentioned above (e.g. AZTI, IATTC, IEO, IRD, SPC, etc.)

7. SUMMARY OF REQUIREMENTS

EM systems on tropical tuna purse seiners should have these components, at a minimum:

Sensors: High frequency (desirably ~10 seconds) recording of GPS data, plus hourly GPS reports included in Health Statements. Additional sensors such as on hydraulic gear or conveyor belts would also aid in certain analyses.

Cameras: Placement of cameras may need to vary depending on a vessel's configuration and operations. High-resolution digital cameras should be used and the images should have date/time/position marks. An optimal configuration would include the following (see Section 4):

- One camera high on the observation tower with an unobstructed view of the deck and port side.
- One deck camera with unobstructed view of the brailer.
- If a hopper is used, one camera with an unobstructed view of the hopper (may be the same as the previous one, depending on the vessel).
- One camera with a view of the starboard side of the deck (may also be on the observation tower.)
- One camera with a view of the chute/conveyor belt.
- One camera at the end of chute/conveyor or discard hatch.
- One camera on the deck facing the bow (required if DFADs operations are going to be monitored).

If camera systems use still pictures instead of videos, they should be of a high frequency sufficient to accurately record the activities in Section 4.

Independence: EM systems should function as independently of the crew as possible. However, it is likely that some level of maintenance by the crew may be needed.

Health Statements: EM systems should transmit hourly messages informing on the functioning of all system components.

Tamper evidence: EM Systems should minimize risks of manipulation, e.g. by encryption of the data on the hard disks. Images recorded by the cameras should contain date, time and GPS stamps.

Software: EM systems should include software to facilitate viewing and analyses of the stored information, and should output data in a manner consistent with the relevant observer program databases.

Analyses: Analyses of the EM information should be done by independent institutions such as those that operate the tuna observer programs.

Reporting: Vessel owners should ensure that reports resulting from the EMS analyses end up with the relevant national agencies or RFMO, depending on reporting obligations

8. CONCLUSIONS

There are some activities that a 100% electronic system cannot accomplish, compared to an experienced human observer. However, most of the required tasks can be achieved if the right equipment is used and there is close alignment between the EM system set up and vessel catch handling operations. Also, it should be borne in mind that a human observer cannot be present in all critical spaces onboard the vessel at all times, while an EM system potentially could. Therefore, there are tradeoffs between the two.

In any case, the presence of human observers in about 10%-20% of the trips (randomly selected) would be beneficial to cross validate data regularly and to continue with observers training, which will be also necessary to give observers the required skills to review EMS data.

As EM systems continue to be developed by various vendors, the recommendations here are intended to ensure that the systems can result in collecting useful information on fisheries monitoring.

It is essential that vessel operators that install EM systems onboard their vessels do not stop there. The data collected must be analyzed and summarized the same as regular observer program reports.

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