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AN ELECTRONIC MONITORING SYSTEM FOR THE TUNA FISHERIES IN THE EASTERN PACIFIC OCEAN: OBJECTIVES AND STANDARDS

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The staff's work, including the new assessments of tropical tunas, has been severely disrupted and delayed by the coronavirus pandemic, and many documents for the meeting of the SAC are not yet finalized. However, it is important that the members of the SAC and observers be informed as soon as possible of the direction and extent of the work, and of the very substantial progress that has been made, so some of the most essential documents are being published in draft form, and may be modified after discussion at the virtual sessions of the Committee.

This document has been prepared in response to Recommendation 3.1 of the 10th meeting of the Scientific Advisory Committee (SAC-10) in 2019, and in accordance with paragraphs 9 and 10 of Resolution C-19-08, to draft minimum standards and data collection and reporting requirements for electronic monitoring (EM) of both the purse-seine and the longline fleets operating in the eastern Pacific Ocean (EPO), to be presented to the Commission for consideration at its meeting in August 2020.

[1] Postponed until a later date to be determined

EXECUTIVE SUMMARY

Electronic monitoring (EM) is increasingly being used worldwide to record the activities of fishing vessels, to complement human observer programs, and where on-board observer coverage is low or non-existent. EM uses sensors and cameras to record information on the vessel's activities, and particularly its fishing operations and their results. EM is cost-efficient, provides an accurate record of fishing activities, and might provide more consistent coverage of fishing activities than human observers. It would improve data collection for purse-seine vessels that do not carry on-board observers, particularly information on bycatches and discards and on the dynamics of the FAD fishery, and for longline vessels. An ongoing pilot study in Ecuador has produced useful data.

This document presents a summary of the current sources of EPO fisheries data, the staff's assessment of the potential of EM and how it might be implemented, and proposals for minimum standards for the various components of an EM system.

1. INTRODUCTION

Since the beginning of the century, electronic monitoring (EM) is increasingly being used worldwide to record the activities of fishing vessels, to complement human observer programs, and where on-board observer coverage is low or non-existent (Gilman *et al*. 2019). EM uses sensors and cameras strategically located aboard a vessel to record information on the vessel's activities, and particularly its fishing operations and their results (catch, bycatch, fishing methods, *etc*.; Ruiz *et al*. 2014; McElderry 2008). EM is cost-efficient, provides an accurate spatiotemporal record of fishing activities (van Helmond *et al*. 2019), and might provide more consistent coverage of fishing activities than human observers.

Other regional fisheries management organizations for tuna (t-RFMOs) have considered or implemented EM in some form in recent years. For example, the International Commission for the Conservation of Atlantic Tuna (ICCAT) has made progress toward broad-based application of EM (Ruiz *et al*. 2016) as part of its 2015-2020 Science Strategic Plan (ICCAT 2014), using guidelines proposed by the International Seafood Sustainability Foundation (ISSF; Restrepo *et al*. 2014) as a starting point for developing minimum standards for EM in the region (ICCAT 2014b). Also, in 2014 the Scientific Committee of the Indian Ocean Tuna Commission (IOTC) agreed that minimum standards for such systems needed to be developed for purse-seine and other gear types operating in the area (IOTC 2014; Ruiz *et al*. 2016). The Western and Central Pacific Fisheries Commission (WCPFC), in conjunction with the Secretariat of the Pacific Community (SPC), has been working on the implementation of EM for purse-seine, longline and carrier vessels operating in its Convention Area (Hosken *et al*. 2016) through specific projects, workshops and meetings (SPC-FFA 2017; WCPFC 2018; WCPFC 2019), with the objective of establishing the framework for a regional EM program, which includes drafting program, technical, logistical and record analysis minimum standards (WCPFC 2018).

The use of EM in the tuna fisheries of the EPO was first discussed in the context of improving data collection for small[2] purse-seine vessels, which rarely carry on-board observers. In particular, the need to obtain information on bycatches and discards by these vessels, and on the dynamics of the fishery on fish-aggregating devices (FADs), was highlighted in Document SAC-07-07f.i (Román *et al*. 2016), presented at the 7th Meeting of the Scientific Advisory Committee (SAC-07). EM may also be useful on observed purse-seine vessels, where it could be used to collect basic data, allowing observers to perform other data-collection duties, such as biological sampling, that they currently cannot undertake due to time limitations (Román *et al*. 2019). EM would be particularly valuable in the longline fishery, where the current level of observer coverage is too low to produce data useful for scientific purposes, and the resulting data would

[2] Carrying capacity < 363 t; IATTC capacity classes 1-5

supplement the limited operational-level data available to the staff. Also, in cases where an observer is unable to collect data for part or all of a trip, EM would continue recording, thus ensuring that essential data would not be lost; as, for instance, the inability of some vessels to carry observers during the COVID-19 pandemic.

Given the potential benefits of EM, and that one of the goals of the Commission's Strategic Science Plan (SSP) is to "*investigate the use of new technologies to improve data quality*", in 2018 a pilot study (Project D.2.a) was initiated in Ecuador, in which cameras were installed on four purse-seine vessels and tested at sea (SAC-10-12). A detailed report on this project, which continues in 2020, will be presented in 2021.

This document presents a summary of the current sources of EPO fisheries data, the staff's assessment of the potential of EM and how it might be implemented, and proposals for minimum standards for the various components of an EM system.

2. DEFINITIONS

The definitions and terminology used in this document are based on those developed by other RFMOs, but with some additions, modifications, and replacements in the interests of completeness, clarity, consistency, and accuracy. They do not include definitions related to matters beyond the SAC's remit, such as financing, enforcement, and jurisdiction.

One important change is that 'EM system/EMS' is, like VMS (Vessel Monitoring System), used to refer to the entire system (management, equipment specifications, data collection, transfer, review, analysis, *etc.*), not just the equipment aboard an individual vessel, which is designated 'EM equipment'. Although this might lead to some short-term confusion, the IATTC staff considers it preferable, for clarity and consistency.

1. **EM (electronic monitoring):** The use of electronic devices to record a vessel's activities, especially to make video recordings of fishing activities.
2. **EMS (Electronic Monitoring System)**: a system for implementing EM aboard vessels, applicable to specified vessels in a defined area and/or fishery, and for collecting, processing and analyzing the resulting EM records.
3. **EM standards**: the agreed standards, rules, and procedures governing the establishment and operation of an EMS, applicable to all components of the system.
4. **EM program**: within an EMS, a national or regional program responsible for implementing the EMS in a defined area and/or fishery.
5. **EM equipment**: a network of electronic cameras, sensors and data storage devices installed on a vessel and used to record the vessel's activities.
6. **EM records**: images and other data recorded by the EM equipment.
7. **EM data**: data resulting from analysis of EM records.
8. **EM analysis**: the analysis of EM records to produce EM data.
9. **EM analyst**: a person qualified to analyze EM records and produce EM data.
10. **EM review center**: local, national, or regional facility where EM records are analyzed to produce EM data.
11. **EM coverage:** the proportion of the effort by a fishery that is subject to EM.
12. **EM service provider**: provider of EM equipment and/or technical and logistical services.

Additionally, a distinction is drawn between 'total catch', which encompasses everything caught, including bycatches and discards, and 'retained catch', the part of the total catch that is loaded aboard a vessel.

3. OBJECTIVES

The fundamental objective of implementing an EMS in the EPO is to improve the quality and availability of data that the staff needs in order to carry out the functions stipulated in Article XIII of the Antigua Convention. The entry into force of the Convention in 2010 expanded the Commission's mandate to cover bycatch species and the ecosystem approach to management, but some of the data the staff requires as a basis for its recommendations for the conservation and management of such species, and to enable it to take the ecosystem into account in those recommendations, are either not collected or are not accessible to the staff. There are large disparities among fisheries and fleets in terms of data availability, and several aspects of the provision of data are still governed by resolutions that antedate the Convention, and no longer reflect the staff's and/or the Commission's priorities or needs, or changes within the fishery.

The EM system proposed in this document would apply to the following vessels fishing for tunas in the EPO:

- Purse-seine vessels of all capacity classes, regardless of whether they carry an observer;
- Longline vessels greater than 20 m length overall (LOA).

The system would need to be flexible, since the level of coverage would vary by vessel size, gear, and fishery, but would also be adaptable to a specific objective. For estimating tuna catches, for instance, 25% coverage may suffice, but for many bycatch species, especially those less frequently encountered, much higher levels of coverage would be needed.

If the objective is to identify the best species management options, the data of greatest value to the staff are the amounts of catches and discards of target and non-target species, by species and size, along with information on fishing effort and details of fishing operations. Operational data of particular interest include, for the longline fishery, start and end times and positions of setting and hauling and line-shooter speed, and for the purse-seine fishery, set type, start and end times of key set-related activities, and any activities involving fish-aggregating devices (FADs), such as deployments and satellite buoy replacements and removals. Without these data, several of the tasks assigned to the staff by the Commission, especially about bycatches and the FAD fishery, are not feasible.

EM should also help to resolve some important shortcomings in the current data-collection system, among them, for the longline fishery, the lack of bycatch and discard data, the limited observer coverage, and the delay in receiving catch data, and for the purse-seine fishery, *inter alia,* the inability to identify individual FADs. This would involve developing proposals to test EM on longline vessels and, in collaboration with vessels and EM providers involved in the purse-seine fishery on FADs and manufacturers of satellite buoys, investigating the possibility of identifying such buoys remotely and automatically.

4. GENERAL CONSIDERATIONS

Once the objectives of an EM system are decided, the next step is to define what data will be collected, on which vessels, and how. Before addressing these matters in detail, some general considerations about EM need to be taken into account.

EM holds great promise for resolving many problems with obtaining data, but it cannot substitute for a human observer, at least at present. Its principal limitation is that the cameras record only what is in their field of view and cannot prioritize among elements in the images they are recording. Also, its ability to identify species and sizes during the loading of the catch, for example, is limited. However, it is likely that improvements in artificial intelligence, machine learning/deep learning algorithms, hardware and software will mitigate this situation.

Beyond the technical aspects of equipment and data collection, an EM system needs to address the challenges associated with processing and analyzing the very large volumes of data that will result, which are different to the challenges encountered when dealing with human observers and their data. Recording and storing EM data is relatively simple; transferring and analyzing them may not be, and this depends largely on what institutional arrangements are made for that purpose. Institutional and management structures specific to EM are discussed in detail below.

There are also important EM-related matters that are beyond the remit of the scientific staff and the SAC, such as financing, cost-sharing arrangements, and ownership of the EM records. Whether an EM system would be financed by including its cost in the IATTC budget, or via assessments charged to individual vessels, or by some other mechanism, and how non-compliance with the system's requirements would be handled, will all need to be agreed. These are matters for the Commission, not the SAC, to decide, and are therefore not addressed in detail in this document. However, regardless of how such a system is implemented, it will require more resources - human, financial, material and administrative - than the Commission currently has available.

In preparing this document, the staff took into account the experience, progress, procedures and/or proposals of CPCs[3], other t-RFMOs, non-governmental organizations (NGOs), the industry, and others in implementing EM. However, although the technical and logistical considerations are largely common among oceans, the IATTC is institutionally and structurally different to other t-RFMOs, which affects how EM might be implemented and managed.

The proposals presented are as specific as possible, but many are general because the technology is new and evolving rapidly, and what is currently available may be outdated or superseded in the near future, or because information on which to base a specific proposal is unavailable. In some cases, the staff lacks the expertise, knowledge, or experience necessary for more concrete recommendations; its practical experience of EM is limited to the pilot study initiated in 2018, and the analysis of the resulting data is still not complete. Much work has been done in other oceans *(e.g*. Restrepo *et al*. 2018), but it is largely experimental, and although the results are useful, and have been taken into consideration, many aspects of EM are still the subject of research and debate, and have to be tailored to each fishery and ocean.

5. THE DATA SITUATION IN THE EPO

5.1. Purse-seine

The IATTC has three main sources of data for the purse-seine fishery: (1) the Commission's field offices in major tuna ports in Latin America abstract vessel logbooks at the end of each fishing trip, and sample the species and size composition of the catch of a subset of trips by these vessels during unloading in port (port sampling); (2) the international observer program, established originally by the IATTC in 1978, and later expanded under the 1992 La Jolla Agreement and the 1999 Agreement on the International Dolphin Conservation Program (AIDCP); and (3) data submitted by CPCs in accordance with the requirements of several resolutions, from the general (C-03-05 on data provision, for instance) to the specific, such as C-19-01 on the collection and analyses of data on FADs. Additionally, some data are obtained from the tuna-fishing and processing industries and from published sources.

However, the data from these sources do not cover all purse-seine vessels equally. Under the AIDCP program, every trip by large (Class-6[4]) purse-seine vessels is accompanied by an observer, who collects detailed data on the activities of vessels at sea, and particularly data on incidental catches (bycatches) of non-target species and discards of target species, both of which are vital to the staff's stock assessments and ecosystem studies. Smaller (Class 1-5) purse-seine vessels are not required to carry observers, so the principal source of information for these vessels is their logbook records and the port-sampling program. The resulting data are much more limited: they contain little or no information on bycatches or discards

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[3] Members and Cooperating Non-Members of the IATTC

[4] Carrying capacity > 363 t

or FAD operations (Román *et al*. 2016). Some detailed operational data are available from a recent voluntary scheme in Ecuador in which several smaller vessels carried observers, and from a small number of Class-5 vessels that have been required to carry observers for limited periods under the AIDCP.

5.2. Longline

The data situation for the longline fishery in the EPO is very different (SAC-10-04 REV). The IATTC staff does not obtain data directly from vessels: they are collected and analyzed by individual CPCs, and typically provided to the staff in summary form, with limited information on gear characteristics, discards, and bycatches[5]. Under Resolution C-19-08, the staff is now receiving some detailed operational-level observer data, with complete catch and discard information, but coverage by observers is very limited: the resolution stipulates 5% coverage of each CPC's longline effort, far below the 20% minimum repeatedly recommended by the IATTC staff, the Working Group on Bycatch, and the SAC itself (SAC-10-04 REV), but in some cases even that lower level is not reached.

The transshipment observer program, established in 2009, covers carrier vessels to which longline vessels transship catches at sea. Six CPCs participate in the program, which is operated by an external contractor; the staff's role is purely administrative, and other than some limited data on sharks in the transshipped catches, the program does not generate information useful for the staff's research.

6. AN ELECTRONIC MONITORING SYSTEM (EMS) FOR THE EPO

A fundamental decision that needs to be taken before any operational aspects or standards can be decided is the institutional and management structure of an EMS. In this respect the EPO is different from other oceans in two important ways: it has the IATTC scientific staff, with extensive experience in multinational data-collection programs, and the AIDCP observer program, which covers 100% of trips by Class-6 purse-seine vessels.

The AIDCP program is independent of, but closely linked to, the IATTC: it is administered by the IATTC staff, and the IATTC pays 30% of its budget, but it is operated collaboratively by the IATTC and the CPCs that are Parties to the AIDCP. It is composed of the IATTC observer program, which covers at least 50% of trips by Class-6 vessels, and six national programs, which cover the remaining trips by their respective flag vessels. Its essential function is to monitor the mortality of marine mammals in the purse-seine fishery, but observers also collect detailed data on all aspects of the vessels' activities, and frequently perform specialized tasks for particular research projects. Also, over the years many items, such as sea turtles, sharks, and FADs, have been added to their data-collection duties, in response to changes in the fishery, the requirements of Commission resolutions, and the staff's research needs.

The AIDCP has its own rules and standards, which apply to all its components, as well as its own monitoring and enforcement arrangements. All the component programs of the AIDCP use the same data collection forms, protocols, procedures, and databases, and the national programs regularly provide their data to the IATTC staff.

6.1. Institutional structure

Some aspects of the AIDCP model might be useful in an EMS. Crucially, it should be established as a single unified system, in which databases, standards, procedures and protocols are standardized, and compatible not only among themselves but also with existing AIDCP and IATTC practices. Compatibility with WCPFC practices is also desirable. Individual CPCs could run their own national EM programs, as with the AIDCP, or contract them out to third parties, but would use common standards, formats, *etc*., and

[5] Occasionally, IATTC staff members directly involved in special, time-limited research projects are granted temporary access to operational-level data.

share the resulting EM data (and, if required for research purposes, the EM records) with the IATTC staff, who would be responsible for coordinating the EMS and for scientific analyses, using data from all the EM programs.

6.2. Management

Once the institutional structure of the system is decided, there are a number of management issues that will need to be addressed. These include coordinating the EM programs, designing and maintaining databases, establishing specifications for EM equipment and EM review centers, training EM analysts, inspecting EM equipment installations, collecting and distributing EM records, approving EM service providers, reviewing compliance, *etc*., as well as budget, audits, and the like. Although some of these matters are for the Commission to decide, the SAC might consider, and make recommendations on, some of the more technical aspects.

Among the many matters to consider as part of EMS management are the following:

a. **Coordination and compatibility:** The EMS and EM programs would need to operate in conjunction with the existing observer and data-collection programs, to ensure compatibility and avoid unnecessary duplication of the data collected.
b. **Priorities:** Some of the data collected by observers are critical for stock assessments and other research, some are compliance-related, and not all of them can be collected via EM. Initial priorities would need to be determined, and modified as required, in the light of the Antigua Convention, the Strategic Science Plan and, most importantly, the status and vulnerability of the different stocks and species.
c. **Confidentiality**: Rules may be required that ensure that EM records and data are handled in a manner that maintains personal and commercial privacy and confidentiality, in accordance with IATTC policy. They would need to be compatible with the AIDCP rules of confidentiality, and some provisions of Resolutions C-13-05 and C-15-07 may need to be revised.
d. **Compliance:** This would presumably be subject to the usual procedure for infractions of IATTC resolutions, and reported to the Review Committee[6], which would then refer them to the vessel's flag CPC for investigation and possible sanction. Each CPC would have to establish regulations to implement the provisions and requirements of the EMS, to ensure uniformity. Vessels could be prohibited from leaving port unless their EM equipment is working, and provision should be made for cases of equipment malfunction at sea. If the EM equipment ceases to record useful or sufficient data, the vessel could be required to return to port.
e. **EM equipment:** In addition to technical specifications, procedures for cases of equipment failure will be required. A damaged camera or a failed sensor could be replaced by the vessel crew, but the storage devices would need to be tamper-proof, and the EM equipment would have to record and report any malfunctions and/or repairs.
f. **EM coverage:** Coverage rates will have to be determined for the different fleets and fisheries. Currently, Class-6 purse-seine vessels have 100% observer coverage under the AIDCP, so EM would be complementary to that, but for smaller purse-seine vessels, which very rarely carry observers, and longline vessels, which have very low observer coverage rates, and those only for vessels > 20 m LOA, EM would be the only way of obtaining detailed data on fishing operations.
   The rate for a given fleet or fishery will depend on several factors, chiefly the desired objective of the sampling. The simplest solution would be to require all vessels to carry EM equipment and use it on every trip, but this would be costly, it would generate more data than could possibly be analyzed, at least at present, and 100% coverage is probably not necessary for scientific or management purposes.

[6] Formally the *Committee for the Review of Implementation of Measures adopted by the Commission*

Alternatively, vessels could be required to use their EM equipment on only a certain proportion of trips or sets; 20% is generally considered the minimum necessary to obtain a statistically reliable representative sample (Lennert-Cody 2001; McCracken 2006, 2012; Skillman *et al*. 1996), but the percentage would be much higher if the objective were to quantify bycatches of species caught only occasionally, for example. Scientific studies will be required to determine the appropriate coverage for a given fishery or fleet.

g. **Financial considerations:** Table 1 shows the bids received in 2018 from EM service providers for providing and installing EM equipment for Project D.2.a, and for technical support. The cost of installing EM equipment averaged out at around US$ 3,000 per camera; monthly charges for monitoring the equipment and technical support for the IATTC staff in La Jolla, who were in effect the review center for the project, vary from US$ 150-280 per vessel, and processing a day's worth of EM results to generate EM data costs about US$ 45. Costs for items such as replacement hard drives, training, and software licensing, totaling about US$ 10,000, are unlikely to be representative.
Arrangements will need to be made for apportioning costs among governments, vessels, and other stakeholders.

TABLE 1. Bids received for installation of EM equipment for Project D.2.a , in US$.

Vessel class	Cameras and video recording unit			
	Number	Purchase	Installation	Total
6	8	17,260	2,499	19,759
6	7	13,157	8,298	21,455
5	6	15,860	2,188	18,048
4	5	11,445	7,799	19,244
2	4	9,680	1,877	11,557

6.3. Standards

In addition to management, the key components of an EMS (Figure 1) are:

1. **Technical**: specifications, installation, operation and maintenance of on-board recording equipment and associated software.
2. **Data collection**: recording and storing EM records (*i.e*., images and/or other data) generated by the EM equipment.
3. **Logistical**: transfer and management of EM records.
4. **Data analysis and reporting**: analysis of EM records, and the subsequent submission of the resulting EM data (or EM records) to the IATTC.

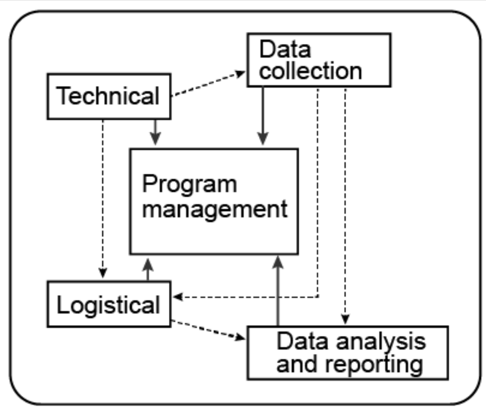

FIGURE 1. Components of the proposed EMS for the EPO.

Standards for each component are discussed below, and summarized in Appendix 1.

6.3.1. Technical standards

Technical standards cover the specifications for selecting, installing, operating and maintaining EM equipment (cameras, sensors, data storage devices, *etc*.) and the associated software aboard vessels. The standards need to be clear and specific, but also flexible enough to accommodate technological advances and changes in priorities, as well as the particular requirements of vessels of different sizes, gears, and fishing practices.

At this time, the staff is not in a position to make specific recommendations about EM equipment and its installation. In the pilot study (SAC-10-12), the results of a survey of the operational characteristics of Class 1-5 vessels were used to help determine the placement of EM equipment. Eight cameras were installed on each of the two Class-6 vessels, six on the Class-5 vessel, and four on the Class-2 vessel (SAC-10-12), with promising results. A similar survey could be done for Class-6 vessels, with general specifications for EM equipment and its installation then adapted to individual vessels or groups of vessels with similar operational characteristics (Ruiz *et al*. 2016). The equipment would need to record all activities aboard the vessel during fishing operations.

On purse-seine vessels, the cameras should cover, at a minimum, the working deck (both port and starboard sides), the net sack and the brailer, the foredeck or amidships, and (if applicable) the well deck and conveyor belt (Restrepo *et al*. 2018) (Figure 2).

On longliners, the cameras should provide a view of all hooked fauna, both those brought aboard the vessel and those discarded. In the Hawaii coastal longline fishery, vessels carry two cameras, one over the processing deck to identify species, the other mounted outside the side rail to cover the fish door, where the catch is brought aboard (Figure 3).

One practical issue is the incompatibility of EM equipment from different manufacturers and service providers with some technologies, such as satellite echo-sounder buoys (Lopez *et al*. 2014; Moreno *et al*. 2016). Unless (or until) common standards are adopted, an EMS would need to be capable of working with all existing hardware and software, and ideally adaptable to future technological developments.

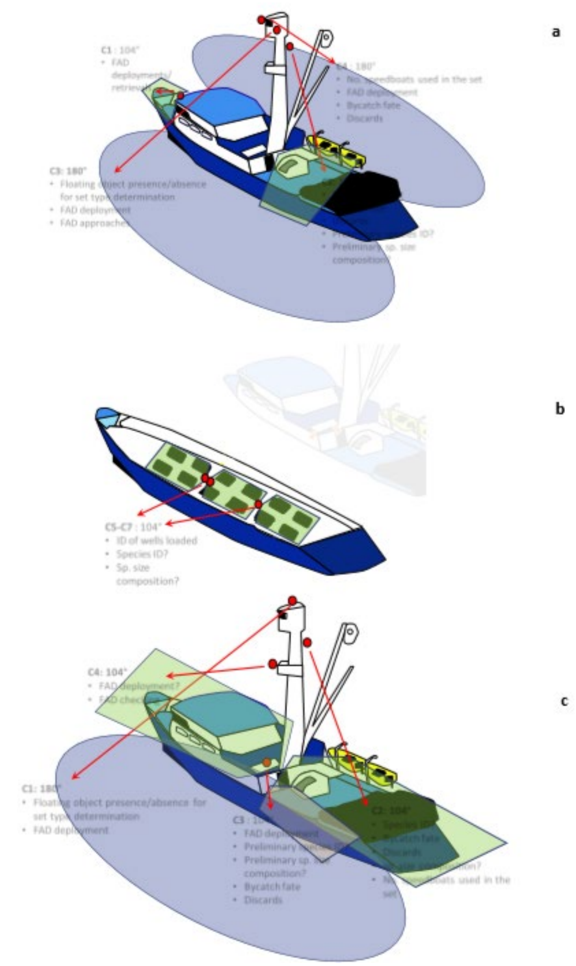

FIGURE 2. Location of cameras on the deck (a) and well deck (b) of the Class-6 vessels, and on the Class-2 vessel, in the pilot study.

Some specific technical aspects of an EMS that need to be considered are:

a. **Cameras:** these are the heart of the EMS, and should be sufficient in number and quality to meet the requirements of the system, in terms of both content and quality, and durable enough to withstand conditions at sea. Cameras should be capable of recording both video and still images; Restrepo *et al*. (2018) found that, if still images are used, the interval between pictures should be no more than two seconds. While the cameras will be aimed at specific areas and activities of the vessel, a panoramic camera mounted on the vessel's mast would be useful for context, and could record events, particularly unexpected ones, that might otherwise pass unseen.
b. **Sensors:** Unless the cameras are left running all the time regardless of the vessel's activities, they will need to be controlled automatically by sensors triggered by a specific event indicating an activity of interest, such as letting the skiff go

on purse-seiners to start a set, the activation of the vessel's hydraulic equipment, or a change in vessel speed or course that indicates a particular activity, such as a visit to a floating object, chasing marine mammals, or assessing fishing grounds. Sensors should also record additional information about the vessel (course, speed, hydraulic pressure, winch rotation, *etc*.) as well as environmental data (water temperature, wind speed, *etc*.), regardless of whether the cameras are operating. As noted above in objectives, sensors that could remotely identify satellite buoys attached to FADs, which would be very useful for scientific purposes, are in development.

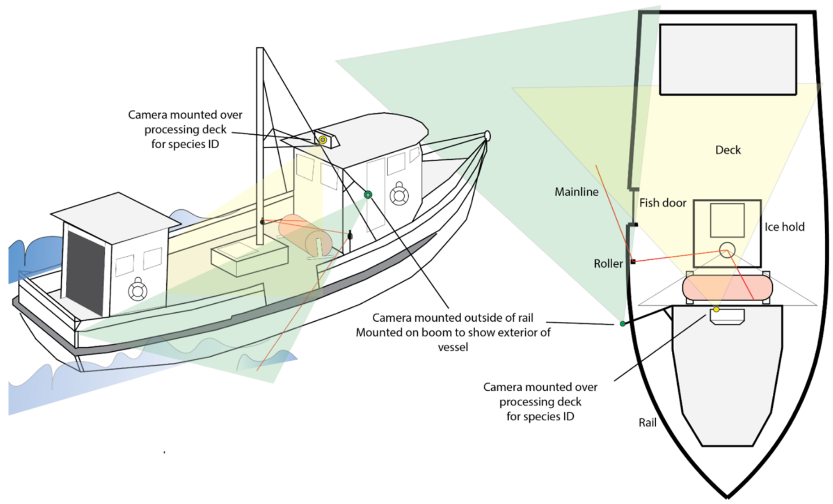

FIGURE 3. EM camera configuration for Hawaii longline vessels. Taken from Carnes *et al*. 2019.

c. **Data storage**: the EM equipment should include sufficient storage capacity to archive all required imagery and sensor information for a certain period, which will depend on the vessel's size and operational characteristics, but could be several months. It should also include separate duplicate backup devices, to ensure that data are not lost if one device fails. Provision should be made for vessels exhausting their data storage capacity.
   Currently, EM on a vessel generates between about 40 and 70 GB of data per day at sea, or about 1.2 to 2.1 TB/month. Large vessels carry eight hard drives of 4 TB each, but small vessels, whose trips are shorter, have fewer (typically four).
d. **Compatibility**: the EM data collected should be in a format compatible with IATTC databases.
e. **Malfunctions**: the EM equipment should send an automatic alert in real time to the vessel's EM program if any of its components malfunctions. It should also be possible for data recording to be controlled manually, in case the EM equipment fails to start or stop automatically, but any manual activation or shutdown should trigger an automatic alert.
f. **Data manipulation**: the EM equipment should be proof against any manual data input or external data manipulation, and should record any attempt to tamper with the equipment or the archived data.
g. **Data encryption**: the EM equipment should be capable of sending EM records in encrypted form.

6.3.2. Logistical standards

Logistical matters relate to how the EM records are handled. Some specific logistical aspects of an EMS that need to be considered are:

a. **Data transfer**: Ideally, EM records stored on a vessel's EM equipment would be transmitted periodically from the vessel at sea to land-based storage; once a week, for instance, like the catch reports sent by AIDCP observers at sea. However, this would be prohibitively expensive: in the pilot study, the EM equipment generated 40 GB or more of data per day, and Gilman (2019) reported that transmitting a single megabyte via satellite costs about US$ 8.

A better solution, for purse-seiners at least, would be for all the data for a trip to be transferred to the EM review center at the end of each trip, but this might not be practical for some longliners, which can stay at sea for very long periods.

Although the EM equipment aboard a vessel needs to be tamper-proof, it must also be possible to delete the EM records from the storage device and the backup after they are successfully copied or transmitted. This could be done remotely, or by vessel crew using one-time passwords; alternatively, a technician could visit every vessel on its return to port and either copy the EM records from the storage device or physically remove it, leaving the backup device in place. Once the records have been transferred to an EM review center, they would be deleted from the vessel's devices.

b. **Data review**: A single EM review center for the EPO might be impractical and/or undesirable. One alternative is the AIDCP model, where the records from a trip are reviewed by the program that monitored that trip, whether IATTC or national; this would involve extending existing programs or creating new ones at the national, or perhaps regional, level. Another alternative is to contract EM record handling and/or EM analysis out to a commercial enterprise, as is done in the observer program for carrier vessels under Resolution C-12-07, where all the logistics (including hiring and assigning observers) are contracted out, but the data are processed and analyzed by a vessel's flag CPC, and shared with the IATTC staff. Provided that standard protocols and procedures are followed, a hybrid system, in which CPCs could choose whether to contract the work out or do it themselves, might also work.

Whatever arrangement is used, the Commission will have to decide how the costs will be covered, and how to deal with matters such as confidentiality.

6.3.3. Data collection

As noted above, EM cannot fully replace a human observer, and it is better suited to some tasks than to others. On vessels with an observer aboard, tasks can be divided between the EM and the observer, but on unobserved vessels the EM should be preferentially used for high-priority tasks. Specific priorities will depend largely on the objective, but a novel ecological risk assessment (ERA) approach, recently developed by the IATTC staff (Griffiths *et al.* 2019) to better identify vulnerable species and thus enable them to be prioritized for data collection, research and management, would be useful for defining priorities among bycatch species. High-priority bycatch species are typically elasmobranchs, turtles, and other species of slow growth, late maturity and, importantly, large size, since EM is better at identifying species of large size (Ruiz *et al*. 2015). Also, and as mentioned above, data collection priorities would need to be flexible, and in line with the Commission's priorities, the SSP, and the staff's needs for specific scientific tasks.

6.3.3.a Purse-seine vessels

As noted in the introduction, one of the goals of the IATTC Strategic Science Plan is to "*investigate the use of new technologies to improve data quality*". The ongoing pilot study (Project D.2.a) to test EM on purse-seine vessels will provide a baseline for evaluating which data fields might be reliably recorded by EM as a basis for subsequent analysis, and whether any additional assistance or equipment is required (Appendix 2).

To a great extent, the data that EM can record is dependent on the size and the operational characteristics of the vessel. If, as on many large vessels, the catch is dumped into a hopper and then distributed by conveyor belts to the wells, there are several points where a camera could capture detailed and informative images; however, small vessels typically load catches into a well directly from the brailer, and recording useful images would be challenging.

The current capabilities of EM on purse-seine vessels, as determined in the pilot study, are detailed in Appendix 2. Many data items collected by observers on such vessels (set type, set start times, FAD deployments, FAD retrievals, retained catches (but not by species)) could be recorded with EM with little or no modification of the vessel or its fishing practices (category R1; Emery *et al*. 2018), but others would require assistance from vessel crew (R2), additional cameras and/or sensors (R3), or are feasible but not worth the effort (R4). Other information recorded by observers, mostly non-operational data such as vessel capacity and equipment, gear dimensions and configuration, which EM cannot record, is available in the Regional Vessel Register and/or other IATTC databases.

In the pilot study and in other initiatives for purse-seine vessels (Gilman *et al*. 2019, Briand *et al*. 2017, Ruiz *et al*. 2014, Chavance *et al*. 2013), determining the species and size composition of the catch with EM proved difficult. Large-sized species (billfishes, sharks, *etc*.) are generally correctly identified, but smaller species or size classes (<30 cm) are problematic, especially if, as is often the case, morphologically similar species, such as bigeye and yellowfin tuna, are caught in a set. Improved technology, including image recognition and analysis software (Gilman *et al*. 2019), will be required to accurately identify all species involved in tuna fisheries.

One matter in which EM could potentially be of great value, not addressed in the pilot study, is the identification of FADs. Each satellite-connected transmitter buoy attached to a FAD has a unique built-in alphanumeric identifier ('buoy ID'), which is used to identify FADs, as reflected in Resolution C-19-01. The IATTC staff, the working group on FADs, and the SAC have repeatedly identified buoy ID as the key data point needed for any scientific study of the FAD fishery, because without it FADs cannot be tracked over time, and related information in different databases cannot be linked. Currently, there are no sensors and/or software available that will automatically and remotely detect and identify satellite buoys, although the technology to do so is under development, and could eventually be integrated into the EM equipment (Gilman *et al*. 2019; Lopez *et al*. 2018; MRAG 2017; Benelli 2013).

Although EM has not yet been used to collect data on marine mammals, some inferences can be drawn from the staff's experience at sea or in analyzing EM records. For example, some activities unique to dolphin sets, such as the start of the backdown procedure, should be detectable with EM, as should net canopies and collapses and major equipment malfunctions, historically indicators of high-mortality sets. However, if dolphin mortality does occur, cameras would probably be of limited use for documenting and quantifying it.

6.3.3.b Longline vessels

Resolution C-19-08 establishes minimum standards for reporting operational data for longline vessels, which can be submitted in one of two formats: i) as a report harmonized with WCPFC or, ii) using IATTC observer forms. The ability of EM to collect the data specified in C-19-08 (option (i)) is summarized in Appendix 3. EM seems to be, in general, useful for collecting information on special gear characteristics, setting and hauling, and catch per set by species, but other important information, such as hook type and size, distance between weight and hook, and the length of branch and float lines cannot be recorded with current technology. Similarly, as for purse-seine vessels, EM cannot record general information on the vessel and its gear (refrigeration method, mainline/branch line material, *etc*.), although this information is typically collected by vessel authorities, and/or recorded in the Regional Vessel Register, and is thus available, but not always provided.

The size of a vessel, and its operational characteristics, will to a large extent affect the data that EM can record. For example, some vessels regularly release hooked non-target species before bringing them aboard, which hinders the EM equipment's ability to count and identify bycatch. Some of these issues might be mitigated or resolved by adding cameras in appropriate locations, or by implementing no-release policies.

The staff plans to review the data collection priorities for longline vessels, and adjust them to match the provisions of the Antigua Convention, the evolving priorities of the SSP and the Commission, and the staff's needs. However, the staff has no practical experience of EM on longliners and, since fisheries are region-specific, it will be in a better position to assess the capabilities of EM on longline vessels after the proposed pilot study (Project C.2.b) is completed.

6.3.4. Data analysis and reporting

Whether EM analysis is conducted by the IATTC staff, or an individual EM program or EM review center, or a third-party contractor, it is important that the resulting EM data be consistent and comparable, and thus generated and reported using standard protocols and procedures. This will require, among others, creating procedures to check the validity of the data (species identifications, catch data (total and by species), individual measurements, *etc*.), developing standard conversion factors (length-to-weight, number-to-weight, *etc*.), and establishing a schedule for reporting data to the IATTC by individual EM programs.

Elements to consider in developing standards for EM analyses and EM reporting include the following:

a. **Training:** the EM analyses will require trained EM analysts. One potential source is the large pool of trained observers with at-sea experience, who are familiar with the fishery and experienced at identifying fish species, but who are no longer interested in going to sea. Training courses, coordinated by the IATTC staff, will need to be designed and organized, with input from EM service providers and other experts.
b. **Automation:** the analysis software should make entering the EM records and generating the EM data as automatic as possible. This should include, among others, location, date and time stamps on any activity identified by the cameras, as well as user-friendly tools to directly include information in final EM data or reports and generally expedite the EM analyses.
c. **Data quality:** error-checking procedures should be built into the analysis software to ensure data quality, such as cross-checks of EM-based catch estimates, port-sampling data, and/or logbook data, and appropriately calibrated digital measuring tools to obtain accurate measurements of individual animals. Similarly, review routines that flag potential errors in EM data will be needed.
d. **Conversion factors:** catches are typically measured either in weight or numbers, but the factors used to convert these data from one to the other, or into lengths, vary among institutions and researchers, increasing the uncertainty in the estimates and hampering direct comparison of results. Standard, species-specific length-weight and weight-number conversion factors, based on peer-reviewed research results and/or empirical data, will need to be developed and agreed upon, and updated as necessary.
e. **Format**: standard formats should be used when generating both the information in the EM records (*e.g.*, dates as DDMMYY) and the resulting EM data files (*e.g.* csv, accdb, xlsx).
f. **Reporting frequency:** the reporting schedule will need to take into account differences among data types and fisheries. EM records should be submitted within 30 days of the end of the corresponding trip; for EM data, a system similar to the AIDCP could be used, in which EM programs would submit purse-seine and longline data to the IATTC annually, in March and June, respectively, of the following year.
g. **Reporting procedure**: to simplify and facilitate the timely and correct reporting of EM data and records, they would be submitted via a dedicated cloud-based portal. The portal should be as user-friendly and automated as possible, and include quality control (*e.g*. format checking, error flagging), automatic reminders that EM data or reports are due, *etc*.

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Appendix 1. Elements to be taken into account in establishing an Electronic Monitoring System for the tuna fisheries in the eastern Pacific Ocean.

Description	Action required
DEFINITIONS	
Glossary of terms used in the implementation of EM	Harmonize with other RFMOs. To be adopted by the Commission.
APPLICABILITY	
• All purse-seine vessels. • Longline vessels > 20 m LOA	CPCs must implement/enable the level of coverage, and the type of data collected.
IMPLEMENTATION	
Institutional structure	
EMS: A unified system, with standardized databases, standards, procedures and protocols applicable to all components.	To be adopted by CPCs. Should be compatible with AIDCP and IATTC practices; also WCPFC.
Management	
Coordination and compatibility between EMS and individual EM programs.	To be arranged by CPCs. EMS and EM programs should work with observer and data-collection programs to avoid duplication of effort and/or data.
Priorities in EM data collecting.	Establish, and modify as required, in the light of the Antigua Convention, Strategic Science Plan and status of species.
Confidentiality of EM records and EM data.	Adopt procedures to maintain confidentiality and privacy, consistent with IATTC and AIDCP rules.
Compliance with EM standards and/or IATTC Resolutions.	CPCs should establish uniform EMS regulations. Non-compliance with EM standards and/or other requirements reported to Review Committee and referred to relevant CPC for investigation.
Standards for EM equipment.	In addition to technical standards, establish policies and procedures for cases of malfunctions at sea.
EM coverage of vessels/fisheries.	Establish levels of coverage of vessels and/or fisheries suitable for the desired objective of the sampling. IATTC staff to recommend minimum coverage rates that will ensure data reliability.
Financial considerations.	Establish cost-allocation procedures and responsibilities for EMS and its components. To be discussed by the Committee on Administration and Finance (CAF).
Standards	
Technical: Selecting, installing, operating and maintaining EM equipment.	**Cameras**. Sufficient in number, quality, and durability to reliably record video and still images of the vessel and its surroundings, and particularly of specific fishing activities. **Sensors**. Record non-visual data, or activate/disactivate cameras as required during activities of interest. **Data storage**. Sufficient capacity to store EM records for a desired period, with a redundant backup. Provide for vessels exhausting their storage capacity.

Description	Action required
	Compatibility. Use data formats compatible with IATTC databases. **Malfunctions/tampering**. EM equipment records and sends automatic alerts in real time in cases of malfunctions, manual activation/shutdown, manual data input, external data manipulation, or attempts to tamper with the equipment or EM records. **Data encryption**. EM equipment should be capable of sending EM records in encrypted form.
Logistical: Handling EM records and data	**Data transfer**. Transfer EM records from vessel to EM review center, generally at the end of each trip. **Data review**. Option 1: The program that monitored the trip (IATTC or national) reviews the EM records for that trip (AIDCP model). Option 2: EM records handled by third-party EM review center, but EM data processed and analyzed by a vessel's flag CPC and shared with the IATTC staff.
Data collection:	**Purse-seine vessels**. See Appendix 2. Continue efforts to (a) improve species identification (b) detect and identify satellite buoys automatically and remotely. **Longline vessels**. See Appendix 3.
Data analysis/Reporting: Develop (a) procedures to generate/validate EM data, (b) standard conversion factors, (c) schedule for reporting data to IATTC.	**Training**. Design and organize training courses for EM analysts, coordinated by IATTC staff, with input from EM service providers and other experts. **Automation**. Make EM data generation automatic and user-friendly, to expedite EM analysis and to directly include information in EM data or reports. **Data quality**. Software with built-in error-checking procedures and digital measuring tools required; also review routines to flag potential errors. **Conversion factors**. Develop, and update as necessary, standard, species-specific length-weight and weight-number conversion factors, based on reliable data. **Format**. Use standard formats (*e.g*. csv, accdb, xlsx). **Reporting frequency**. Differs among fisheries and data types. Submit EM records within 30 days of trip end; EM data to IATTC annually, in March (PS) and June (LL) of following year. **Reporting procedure**. EM data and records submitted via dedicated cloud-based portal; includes quality control.

Appendix 2. Current capabilities of EM, purse-seine fishery.

Data items recorded by IATTC observers on Class-6 purse-seine vessels, by category and item, and the staff's assessment of applicability of EM, using the ready/possible categories of Emery *et al*. (2018). Does not include data items such as vessel capacity and equipment, gear dimensions and configuration, which EM cannot record, and which is available in the Regional Vessel Register and/or other IATTC databases.

*: Data fields collected from logbooks, Class 1-5 vessels.

R1	Ready	Requires little or no further work	P1	Possible	Requires minor work
R2		Requires significant crew support	P2		Requires major work
R3		Requires dedicated or additional camera/sensor	NP	Not possible	-
R4		Inefficient/costly to analyze			

A	B	C		D
FISHING EFFORT				
Vessel activity	Drifting	Date/time of each DRIFT event		R1
	Searching	Date/time of all SEARCH events (crew with binoculars, bird radar)		NP
	Running	Date/time of all RUN events (no searching)		NP
	Speed	Vessel speed		R1
	Position	Location of vessel during activities other than sets		R1
Set information	Date/time, start of set*			R1
	Date/time, end of set*			R1
	Position*			R1
	Set type*			R1
	Well	Well number	Crew access to wet-deck	R1
			No crew access to wet-deck	R2
	SST	Sea surface temperature		R3
	Beaufort (wind speed)			R1
	Time, rings up			R1
	Major malfunction			R1
	Minor malfunction			NP
TARGET SPECIES				
Catch, total		Catch per set, all species combined		R1
Catch, by species*		Catch per set, large-sized individuals	Loaded via hopper, conveyor belt	R1
			Straight to well	R2
		Catch per set, medium-sized individuals	Only one species	R1
			YFT & BET	R4
		Catch per set, small-sized individuals		P2
Discards, total		Tonnage discarded and reason, all species		R1
Discards, by species		Tonnage discarded and reason, large species		R1
		Tonnage discarded and reason, medium species	SKJ	R1
			YFT & BET	R4
		Tonnage discarded and reason, small species		P2
NON-TARGET SPECIES				
Large-medium species	Species code	Species caught	By taxonomic group	R1
			By species	R2
	No. species caught	No. of large-medium individuals caught	Loaded via hopper, conveyor belt	R1
			Straight to well	R2
	Length of fish	To nearest cm		R2
	Sex	Determine sex		R2
	Activity when sighted	Motionless but alive/swimming/dead/copulating		NP

A	B	C		D
	Condition on release	No injuries/seriously injured/dead/unknown (e.g. turtles)		R1
	Fate	Human consumption/released alive/discarded/unknown/other		R1
Small species	Species code	Species caught	By taxonomic group	R1
			By species	R4
	No. species caught	No. of small individuals caught	Loaded via hopper, conveyor belt	R4
			Straight to well	P2
	Fate	Human consumption/discarded/part consumed and discarded		R1
	FLOATING OBJECTS/FADs			
	Type	Type of floating object (flotsam, FAD)		R1
	Floating structure: dimensions	Length, width and height of the floating structure		R1
	Submerged structure: shape			R2
	Submerged structure: depth			R2
	Components when encountered	Components of floating and submerged structures when encountered		R2
	Components when left	Components of floating and submerged structures when left		R2
	Object encounter	Date, time, position		R1
	FAD deployment	Date, time, position		R1
	Location method			R2
	Buoy ID	Serial number of satellite buoy		P2/NP
	Origin	Origin of object (*e.g*. FAD ownership)		P2
	Tag information			P2/NP
	Object removed	Object brought aboard the vessel after the encounter		R1
	Epibiota	Percentage of object covered by epibiota		R1
	Fauna entangled	Number and species of fauna entangled in object		R2
	MARINE MAMMALS			
	Herd size	Number and species composition of entire marine mammal herd		NP
	Sighting location			NP
	Sighting date/time			NP
	Chase start	Time speedboats deployed		R1
	Evasion/escape behavior	Number and species composition during chase and encirclement. Entire herd cohesion codes.		NP
	Herd size when captured	Number and species composition of herd encircled		R3
	Backdown start			R1
	Backdown finish			R3
	Rescue effort			R2
	Net canopy	Net canopy with marine mammals in the net?		R3
	Net collapse	Net collapse with marine mammals in the net?		R3
	High mortality	Was a high mortality quantified by species?		R3
	Low mortality	Was a low mortality quantified by species?		R2

Appendix 3. Current capabilities of EM, longline fishery.

Minimum data reporting standards for longline vessels, Option 1, as established by Resolution C-19-08, by category and item, and the staff's assessment of applicability of EM, using the ready/possible categories of Emery *et al*. (2018). Does not include data items such as vessel identification, capacity, mechanical and electronic equipment, gear dimensions and configuration, crew and observer information, which EM cannot record, and which is available in the Regional Vessel Register and/or other IATTC databases.

R1	Ready	Requires no further work	**P1**	Possible	Requires minor work
R2		Requires significant crew support	**P2**		Requires major work
R3		Requires dedicated or additional camera/sensor	**NP**	Not possible	-
R4		Inefficient/costly to analyze			

B	C	D
GEAR AND TRIP DATA		
	The date and time the vessel leaves port to start its fishing trip.	R1
Arrival port, date	Include both the port name and country.	R1
GENERAL GEAR CHARACTERISTICS		
Mainline material	List the of the mainline used by the vessel (*e.g.* Kuralon, Braided)	NP
Mainline length (specify unit)	The total length of the mainline when it is fully set	P2
Mainline diameter (specify unit)		NP
Branch line material(s)	A branch line can consist of one type of material like monofilament or it can be made up of many different materials like braided nylon wire trace and mono filament, *etc.* If different types are used in different branch line positions, please describe.	NP
SPECIAL GEAR CHARACTERISTICS		
Wire trace	**At the trip level** indicate "Yes" or "No" -if the vessel uses wire traces on some or all of its lines. If wire traces used on all lines during the trip, then record "ALL LINES." If the vessel used wire traces on certain branch line positions during the trip, describe the configuration. For example, "wire traces were used on first and tenth branch lines of each basket". If the proportion of leaders that are wire varies within a trip, record the average based on a sample of ten total baskets from a range of sets.	R1
Mainline hauler	Does the vessel use an instrument to haul in the main line after it is set or is the line hauled by hand?	R3
Branch line hauler	Does the vessel use a special hauler to coil branch lines?	R3
Line shooter	Does the vessel use a line shooter?	R3
Automatic bait thrower	Does the vessel use a bait thrower or are bait and branch lines thrown overboard manually?	R3
Automatic branch line attached	Does the vessel have an automatic branch line mechanism that attaches the branch at regular intervals or is this done manually?	R3
Hook type		NP

	For each set, record the type of hook or hooks used, using the codes in the hook catalogue (*e.g.* J hooks, circle hooks, offset circle hooks, *etc.*	
Hook size	**For each set,** record the size of the hooks used. If not sure, ask the bosun or refer to a hook catalogue.	NP
Tori Lines	**For each set,** record whether the vessel uses Tori lines when setting; if yes, how many and their length.	R3
Side-setting with bird curtain and weighted branch lines	**For each set,** record whether the vessel used side-setting with a bird curtain in combination with weighted branch lines.	R3
Weighted branch lines-	**For each trip** where weighted branch lines are used, record the mass of the weight attached to the branch line. If more than one type of weighting is used during a trip, describe each type and indicate the proportion based on a sample of ten baskets from a range of different sets.	R3
Shark lines	**For each set,** record the number of shark lines (branch lines running directly off the longline floats or drop lines) observed. Where possible, record the length of this line for each set.	R1
Blue dyed bait	**For each set,** record whether the vessel used blue-dyed bait.	R1
Distance between weight and hook (in meters)	**For each set,** record the distance in meters from where the bottom of the weight is attached on the branch line to the eye of the hook.	NP
Deep setting line shooter	**For each set,** record whether the vessel used a deep setting line shooter	R3
Management of offal discharge	**For each set,** record whether the vessel used the management of offal discharge.	R3
Date and time of start of set	**For each set,** record the date and time the first buoy is thrown into the water to start the setting of the line.	R1
Latitude and Longitude of start of set	**For each set,** record the GPS reading at the time the first buoy is thrown into the water.	R1
Date and Time of end of set	**For each set,** record the date and time the last buoy (usually has radio beacon attached) at the end of the mainline is thrown into the water	R1
Latitude and Longitude of end of set	**For each set,** record the GPS reading at the time the last buoy is thrown into the water	R1
Total number of baskets or floats	**For each set,** record the number of baskets utilized. A basket is the sum of all the hooks set between two buoys on a longline; usually it is the same as the number of floats set minus one.	R1
Number of hooks per basket (number of hooks between buoys)	**For each set,** record how many hooks set from one buoy to another, the number is usually constant along the line, but can vary in some cases, also if the vessel also sets a branch line on the buoy, count this as a hook between floats as well.	R4
Total number of hooks used	**For each set,** record how many hooks were used. This is typically calculated by multiplying number of baskets by the number of hooks per basket	R1
Line shooter speed	**For each set** where the vessel uses a line shooter, record the shooter speed. The shooter will normally have an indicator to show its running speed, as well as a sound indicator or light, that beeps at a regular interval, when it is time to attach a branch line.	R3

Length of float-line	**For each trip,** record **l**ength of the line that is attached to the floats, get a coil and measure the length. It usually remains the same throughout the trip.	P2
Distance between branch-lines	**For each set,** record the distance between branch line attachments to the mainline. This can be determined easily if vessel has a line shooter with electronic attachment indicator.	R3
Length of branch-lines	**For each set, m**easure the length of a sample of the majority of branch lines used, some may vary slightly due to repairs.	NP
Time-depth recorders (TDRs)	Does the vessel use TDRs on its line? If yes record the number of TDRs used it may use and their location along the mainline?	NULL
Number of light-sticks	**For each set,** indicate whether the vessel uses light sticks on its line, record the number used, and where possible, information on the location (*e.g.* "used on first and tenth branch lines from the float").	R4
Target species	What species does the vessel target? Tuna (BET YFT), Swordfish, Sharks, *etc.*	R1
Bait Species	**For each set,** record the bait species used Pilchard, Sardine, Squid, artificial bait, *etc.*	R3
Date and time of start of haul	**For each set,** record the date and time the first buoy of the mainline is hauled from the water to start the haul.	R1
Date and time of end of haul	**For each set,** record the date and time the last buoy of the mainline is hauled from the water to end the haul.	R1
Total number of baskets, floats monitored by observer in a single set	**For each set,** record how many floats or baskets were monitored by the observer?	R1
CATCH AND DISCARDS OF TARGET AND NON-TARGET SPECIES PER SET		
Information on catch per set		
Hook number (location between floats)	For each individual capture, record the hook number that the animal is caught on, counting from the last float hauled on board.	R4
Species	Use FAO species code.	R1
Biometry		
Length of fish	Measure length of specimen, using the recommended measurement approach for the species.	R1
Length measurement code	Reflect the type of length measurement taken using the appropriate measurement code. For example, all tunas are measured from the end of the upper Jaw to fork of the tail, measurement code UF.	R1
Sex	Sex the species if possible. If an unsuccessful attempt is made to sex the individual, record "I" for indeterminate. If no attempt to sex the individual is made, record "U" for unknown.	R2
Condition		
Condition when caught	For bycatch species (*e.g.* sharks, sea turtles, seabird, marine mammals, *etc.*) also reflect hooking location [*i.e.* hooked in mouth, hooked deeply (throat/ stomach), and hooked externally].	R1/R3*
Fate	Record the ultimate disposition of the capture using the appropriate code (e.g. retained, discarded, *etc.*)	R1/R3*
Condition when released	If released, record the animal's status when returned to the sea.	R1/R3*
Tagging		
Tag recovery information	Record as much as information as possible on any tags recovered	R1

SPECIES OF SPECIAL INTEREST		
General information		
Type of interaction	Indicate the type of interaction (*e.g.* entangled, hooked internally, hooked externally, interaction with vessel only, *etc.*)	R1
Date and time of interaction	Record ships date and time of interaction.	R1
Latitude and longitude of interaction	Record position of the interaction.	R1
Species code of sea turtle, marine mammal, or seabird.	Use FAO codes for Species.	R1
Biometry		
Length	Measure length, in centimeters.	R1
Length measurement code	Measure using the measure method determined for that species.	R1
Sex	Sex the animal if possible.	R2
Estimated fin weight (for sharks)	Weigh the fins separately if shark has been finned by crew. If no scales, estimate the weight.	R1
Estimated carcass weight (for sharks)	Weigh the carcass of a finned shark. If no scales available, carcass is discarded, or if it is too large to handle, estimate the weight.	R1
Condition		
Condition when landed on Deck	Record the animal's condition when landed on deck, using appropriate code.	R1
Condition when released	If released, record the animal's condition at the time of release, using appropriate code.	R1/R3*
Tagging		
Tag recovery information	Record as much as information as possible on any tags recovered	R1
Tag release information	Record as much as information as possible on any tags placed on the species before release.	R1

*R1 if landed; R3 if not landed