

RESOLUTION 23/08

ON ELECTRONIC MONITORING STANDARDS FOR IOTC FISHERIES

Keywords: *Electronic Monitoring, Regional observer scheme, Minimum data requirements*

The Indian Ocean Tuna Commission (IOTC):

RECALLING the IOTC's responsibility to conserve and manage tuna and tuna-like species in the Indian Ocean.

EMPHASISING the importance of collecting sufficient verified catch data and effort and other scientific data related to the fisheries for tuna and tuna-like species in the IOTC area of competence to enable the Scientific Committee (SC) to provide the Commission with scientific assessments, advice and recommendations.

RECALLING the first Resolution (11/04) on a Regional Observer Scheme (ROS) that mandated at least a 5% observer coverage for fleets for vessels equal to or greater than 24 meters length, and under 24 meters if they fish outside their Exclusive Economic Zone (EEZ).

NOTING the significant difficulties and challenges some CPC fisheries face in achieving IOTC mandated observer coverage rates, and the need to increase their observer coverage rates to improve data collection to allow estimates of total and species level bycatch.

FURTHER RECALLING that the 23rd session of the IOTC Scientific Committee expressed the concern at the low observer coverage level at 2.15% and that there is no coverage of the artisanal fleet, which comprise a large portion of catches taken in the Indian Ocean;

RECALLING Resolution 16/04 (on the implementation of a pilot project in view of promoting the regional observer scheme of IOTC) that required exploration of the potential for electronic observation to collect data required by the IOTC, and for the Scientific Committee to develop and propose minimum standards for the implementation of electronic observation (monitoring) systems.

RECALLING that the Commission endorsed, in principle, the Regional Observer Scheme Program Standards, including Minimum Standards Data Fields in 2019.

CONSIDERING Resolution 22/04 on Regional Observer Scheme (updating and replacing Resolution 11/04) which formally recognised the role of electronic monitoring systems (EMS) to contribute to and improve observer coverage and meet the ROS minimum mandatory data requirements. Resolution 22/04 requests that the IOTC SC (in collaboration with the Compliance Committee) develops and agrees electronic monitoring (EM) minimum standards for IOTC Fisheries (on minimum standards for the use of EMS for purse seine, longline, bait boat (pole and line), handline, and gillnet fleets) by 2023 at the latest.

NOTING the 2022 SC endorsed and recommended Commission adoption of: a) the EM terms and definitions; b) the EM Program Standards, and; c) the EM Data Standards. (IOTC-2022-SC25-R[E])

ADOPTS, in accordance with paragraph 1 of Article IX of the IOTC Agreement:

Electronic Monitoring terms and definitions

1. Terms and definitions pertaining to the implementation of EMS by CPCs, consistent with this resolution and resolution 22/04, are defined in Annex 1.

Electronic Monitoring Standards

2. The Commission shall:
 - a) implement a Regional Electronic Monitoring Program (REMP) as per the objectives, purpose and roles and responsibilities described in the IOTC EM Program Standard (Annex 1) by [1 July 2024].
 - b) upon the advice of the Scientific Committee and Compliance Committee, review the REMP, the EM Program Standard (Annex 1) and the EM System and Data Standards (Annex 2) after a period of 1 year from REMP implementation.
3. CPCs, who fish for species under the competence of the IOTC, and who choose to implement EMS in the IOTC area of competence to partially or fully meet the minimum ROS data requirements under Resolution 22/04 (or any subsequent revision), shall:
 - a) ensure that the implementation of their National EM Programs (NEMPs) and EM systems on their flagged vessels meets the requirements of the EM Program Standard (Annex 1) and EM System and Data Standards (Annex 2).
 - b) submit to the IOTC Secretariat by 1 July each year, a Vessel Monitoring Plan, that covers each vessel in their IOTC fishery utilizing EMS, outlining the EMS setup on each vessel, consistent with the requirements in the EM Program Standard (Annex 1) and making use of guidance in Annex 3 (Vessel Management Plan Guide).
 - c) submit to the IOTC Scientific Committee, as an annex to CPC National Reports to the SC, a fleet level summary of the Vessel Monitoring Plans (described in 3b) that specifies at a minimum:
 - i. The number of CPC flagged vessels implementing EM by gear/fishery type.
 - ii. The range of EMS configurations implemented within the fleet (including the numbers and placements of cameras for each configuration).
 - iii. A general description of EMS requirements placed upon vessel skippers/crews by the CPC government.
 - d) submit to the IOTC Secretariat by 1 July each year, a fleet level ROS data collection table, clearly specifying for each ROS minimum required data field as specified [\[here\]¹](#):
 - i. The data field name and description
 - ii. The data field reporting requirement level (i.e. mandatory collection and reporting, mandatory reporting if collected, not mandatory etc)
 - iii. the data collection method used to collect data for that field²,
 - iv. a brief description of the data collection method.
4. The IOTC Secretariat shall:
 - a) assist the Commission to establish and implement a REMP.
 - b) undertake roles as per EM Program Standard (Annex 1).
5. The Scientific Committee shall, no later than 2024, review the ROS minimum required data fields to
 - a) identify any fields that are logistically difficult for EM and/or human observers to collect, respectively; and
 - b) provide advice and recommendations to the Commission on the need and use of those identified fields for scientific purposes, and their collection and reporting status (i.e. mandatory, non-mandatory etc.).

¹ <https://iotc.org/documents/ROS/DataStandards>

² Noting that for non-mandatory minimum data fields this may be “NA”

- c) Discuss and provide advice to the Commission on the potential need to develop a separate EM ROS minimum data fields list.
- 6. To support the implementation of the REMP and the work of the Scientific Committee referred to in paragraph 5, CPCs are encouraged to share relevant information, approaches and experiences, including those involving capacity building needs and any CPC-level knowledge exchange, with the Scientific Committee and Compliance Committee

ANNEX 1

IOTC ELECTRONIC MONITORING PROGRAM STANDARDS

General

National/Regional data collection Programs using Electronic Monitoring Systems (EMS) that are certified as meeting the minimum standards of the Electronic Monitoring Program (EMP) as adopted by IOTC may be included within IOTC Regional Electronic Monitoring Program (REMP).

IOTC REMP shall be coordinated by the IOTC Secretariat.

Objectives

The objective of the IOTC REMP is to collect, via EMS, verified catch data and other scientific data related to the fisheries for tuna and tuna-like species in the IOTC area of competence and achieve the EM observer/review coverage to meet the requirements of IOTC Observer Resolution on Regional Observer Scheme.

Purpose:

The purpose of IOTC REMP is to allow CPCs to utilise EMS to collect data to assist CPCs in meeting the requirements of IOTC Observer Resolution on Regional Observer Scheme, including in situations where onboard observer coverage is low or non-existent.

The REMP aims to improve the quantity and quality of fishery data and the monitoring of IOTC fisheries and address gaps in the collection and verification of fishery data. The REMP may also in the future help CPCs meet the requirements of other IOTC Resolutions.

Scope:

The IOTC's REMP and associated minimum EM Program and EMS Data Standards (including this standard) apply only to IOTC CPCs who are developing or who have implemented EMS as a data collection tool to help meet, to the extent logistically possible, the requirements of the IOTC Observer Resolution on Regional Observer Scheme.

IOTC's REMP provides a framework for the development of EMS in the following IOTC fisheries:

- Purse-seine vessels over 24 meters length overall and under 24 meters LOA when fishing outside their EEZs,
- Longline vessels over 24 meters length overall and under 24 meters LOA when fishing outside their EEZs,
- Gillnet vessels over 24 meters length overall and under 24 meters LOA when fishing outside their EEZs,
- Pole and line vessels over 24 meters length overall and under 24 meters LOA when fishing outside their EEZs,
- Other gear types under 24 meters length overall (when fishing in the high seas).

IOTC's REMP or any National EMP, under IOTC's REMP, shall ensure that the data collected through EMS are documented and that all ROS minimum data standard requirements (e.g., "Mandatory Reporting"), if necessary complemented with any additional monitoring program (e.g., port sampling, biological sampling, etc.), are collected by EMS.

Definitions:

Electronic Technologies (ET): any electronic tool that is used to support fisheries-dependent data collection, both on shore and at sea, including electronic reporting (ER) and electronic monitoring (EM).

Electronic Reporting (ER): the use electronic systems (application, software, form or file) to record, store, receive and transmit fisheries data.

Monitoring: the requirement for the continuous collection of fishery-related data.

Electronic Monitoring (EM): the use of electronic devices to record fishing vessel's activities using video technology linked to a Global Position System (GPS), which may include sensors.

Electronic Monitoring System (EMS): the system comprising the vessel and shore-based components for collecting, transmitting and reviewing EM records, reporting of EM data and implementing an EM Program.

EM Program: a process administered by a national or regional administration that regulates the use of EMS on vessels to collect and verify fisheries data and information responsible through an implementation of an EMS in a defined area and/or fishery.

EM Program standards: the agreed standards, specifications and procedures (SSP) governing the establishment and operation of an EM Program, applicable to all components of the EMS.

EM data standards: the agreed subset of data requirements by the IOTC Regional Observer Scheme (ROS) that could be collected by the EMS.

EM records: Imagery, and possibly sensor, raw data linked to positional data collected by an EM equipment that can be reviewed to produce EM data.

EM data: processed/analysed data produced through review of EM records that conforms with the EM data standards.

EM equipment: a network of electronic cameras, sensors and data storage devices installed on a vessel and used to record the vessel's activities.

Vessel Monitoring Plan (VMP): The vessel's EM equipment characteristics and how the vessel's EM equipment is installed and configured to monitor fishing activities and meet the EM Program and EM Data Standards as required by the IOTC Regional Electronic Monitoring Program.

EM review: the review of EM records by EM observers/reviewers to produce EM data.

EM observer/reviewer: a person qualified to review EM records, store and produce EM data in accordance with the EM Data standards and analysis procedure.

EM review system: application software used by the EM observer to review the EM records and produce the processed EM data as per the EM data standards.

EM review center: local, national, or regional office facility where EM records are received and reviewed to produce and store EM data.

EM review provider: a third-party provider of EM review services to review EM records to produce EM data. The same third-party organization can provide both the EM equipment and EM review services but they can also be supplied by different providers.

EM installation coverage: the proportion of vessels by fleet that has EM equipment installed that is operational.

EM record coverage: the proportion of fishing effort for which EM records are collected by installed EM equipment.

EM observer/review coverage: the proportion of fishing effort for which EM records are reviewed to produce EM data and submitted to the IOTC.

EM service provider: a third-party provider of EM equipment (and/or system), technical and logistical services to maintain the EM equipment and monitor its proper functioning.

EM Systems

EMS should be approved and accredited by an appropriate IOTC body (e.g., IOTC WGEMS/WPDCS) or CPCs to ensure that the minimum standards of the REMP (and ROS) are met, including EM equipment installation (through an EM Vessel Monitoring Plan), collection of data consistent with ROS minimum data standards, EM records reviewed by accredited companies/organizations and independence of EMS are maintained. In case that CPCs approved the EMS the CPC shall submit to the IOTC Secretariat copies of each vessel's VMP and present

to the Scientific Committee, as an annex to CPC National Reports to the Scientific Committee, a fleet level overview of the CPCs VMPs.

Data:

EM data submitted by Regional or National EMPs are subject to Resolution 12/02 *On data confidentiality policy and procedures* concerning the requirements for sharing data in the public domain (e.g., the level of stratification to apply in order to prevent activity from a single vessel to be clearly identified from the published data) and the procedures for the safeguard of records.

EM data collected via EM should be provided in compliance with the requirements established by the Commission in Resolution 15/01 *On the recording of catch and effort data by fishing vessels in the IOTC area of competence*, Resolution 15/02 *On mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPCs)* and IOTC Observer Resolution on Regional Observer Scheme.

National EM Programs EM data should be submitted to IOTC in accordance with the electronic data format specifications provided by the IOTC Secretariat and adopted by the IOTC Commission, in order for data to be incorporated in the IOTC Regional Observer Scheme database. The EM data should be properly marked in the database to be distinguished from data collected through onboard human observers.

Roles

IOTC Commission:

- To monitor and provide oversight of the implementation of the REMP, including those implemented through National EM Programs.
- To adopt and revise, when necessary, minimum standards for the EM Program, technical specifications, and associated data collection.
- To agree on overall EM observer/review coverage through IOTC Observer Resolution on Regional Observer Scheme.
- To develop and adopt a REMP implementation plan.
- When necessary, the Commission may contract Regional EM review centers to review EM records obtained in the frame of the REMP.
- To ensure sufficient financial resources to effectively administrate IOTC's REMP.
- To review IOTC's REMP after an initial period (e.g., 3 years) of IOTC's REMP implementation.

IOTC CPCs:

- In case they choose EMP to meet IOTC Observer Resolution on Regional Observer Scheme, to ensure that EM equipment installed on fishing vessels under its flag and the EMS implementation complies with the requirements established by the Commission for the purpose of IOTC's REMP.
- To require that a Vessel Monitoring Plan (see below) is developed for each vessel equipped with EM equipment and delivered to the CPC competent authorities.
- To ensure that EM equipment are installed in their vessels following a Vessel Monitoring Plan to collect the required data and to comply with the coverage objectives agreed by the Commission.
- To ensure that EMS implementation is consistent with IOTC's REMP and its minimum standards.
- To collaborate to ensure National EM Programs are compatible and harmonized where necessary.
- To document the roles and responsibilities of fisheries government authorities and vessel owner/crew with respect to inter alia installing and maintaining equipment, routine cleaning of cameras, sending storage devices, access to EM records and EM data, responses to mechanical or technical failure of EMS.

- The CPC shall provide the IOTC Secretariat with the contact details of their EM Program Coordinator(s).

IOTC Secretariat:

- To collaborate with the Commission and CPCs to ensure that National EM Programs are consistent and compatible with the REMP and meet IOTC's REMP monitoring minimum standards.
- To summarize and provide annual reports about the progress of the REMP, including National EM Programs, to the Commission and its Subsidiary Bodies.
- To recommend improvements and adjustments to the REMP to ensure that data and monitoring requirements of IOTC Commission are met.
- To coordinate activities regarding EM with other tuna RFMOs as required by the Commission.

EM Vessel Monitoring Plan

The vessel's EM equipment characteristics and how the vessel's EM equipment is optimized to meet the EM System and Data Standards must be recorded on a Vessel Monitor Plan (VMP) for each vessel.

The VMP shall be developed in collaboration with the EM service provider, vessel owner and fishing authorities.

The Vessel Monitoring Plan will describe the numbers of cameras, position and settings, and key areas to be monitored for fishing activities, catch handling, species identification, fate and storage of the individuals.

The VMP should include information on:

- Contact information: contact information for the vessel owner, vessel operator and EM service provider as long as the contract lasts.
- General vessel information: basic information about the vessel and its fishing activities and operations (e.g., vessel name, registration number, target fishery, areas, fishing gear, LOA...).
- Vessel layout: equipment of the vessel with detailed information, plan of the vessel disposition and different areas (decks, processing area, storage, etc.).
- EM equipment setup: description of the settings of the EM equipment, such as time running, number of cameras and areas covered, time recording for each of the cameras, number and position of sensors (if any), software used, control box disposition, procedures for checking the proper functioning of the EM equipment installed onboard, etc.
- A snapshot of each camera should be inserted in the VMP.

The VMP should be signed off by the vessel owner and finally approved by the flag state competent authority.

Any physical changes on a vessel that will affect EMS should be reported to the flag state competent authorities. The VMP should be updated and approved again by the competent authority as soon as possible.

Any change on the EM equipment (e.g., installation of a new generation of cameras) should be reported to the flag state competent authorities. The VMP should be updated and approved again by the competent authority as soon as possible.

Operationalising IOTC's REMP – Accreditation and Auditing of National EMPs

CPCs should apply to the IOTC Secretariat to have its own National EM Program recognized as part of IOTC's REMP so as to comply with ROS data minimum standards.

IOTC shall audit the National EM Programs against the EM minimum standards.

National EM Programs shall be reviewed and subject to regular and periodic audits as agreed by IOTC Commission.

IOTC could authorize National EM Programs approved by other tRFMOs.

ANNEX 2

IOTC ELECTRONIC MONITORING SYSTEM AND DATA STANDARDS

EM TECHNICAL MINIMUM STANDARDS

The Technical Minimum Standards shall describe the requirements of the EM. CPCs shall ensure all EM equipment installed in their national or subregional programs are consistent with these technical specifications.

Customized to vessel level: there is no standard configuration that will cover all vessels from fleets operating in the Indian Ocean region, therefore each EM equipment installation must be customized at the vessel level. An EM equipment to be installed on board of a fishing vessel should consist of a control system connecting a number of cameras, and optionally to a number of different sensors, to collect and record images to address the objectives of the EM Program. The number of cameras and sensors should be tailored to each vessel through a Vessel Monitoring Plan to meet overall objectives of the program rather than being too prescriptive and should include a sufficient number of cameras. Although it will depend on the configuration of each particular vessel, as a general setup, cameras shall capture the areas and activities provided in Table 1 and 2 and Figure 1 to 3 of Annex 3³. Each vessel should develop a “Vessel Monitoring Plan” specifying how many and where the cameras are located, and their settings, to collect the required ROS minimum “mandatory” data fields. The collection of some of the required ROS minimum data standards may be complemented by port sampling and/or other data collection methods as described [\[here\]](#)⁴. Within a given EM program, a certain level of harmonisation among vessels may also be necessary (camera placement and settings).

Include sensor/automatic devices: since EM records require large storage capacities, most EMS are not recording vessel activities on a full-time basis. The recording of some cameras may be triggered by the detection of gear usage or fishing activity. EMS may therefore include sensors, and other procedures (Computer Vision, Artificial Intelligence), to detect when fishing or other activities of interest occur on board. This will ensure proper EM record acquisition (e.g. trigger video recording when fishing operation starts) and facilitate EM record reviewing.

Include Global Positioning System (GPS): to monitor vessel position, route, speed and provide information on date/time and location of fishing activities. Fishing vessel position and date/time stamps should be incorporated directly on images or in the metadata of images.

Compatibility: the EMS could ideally be capable of integrating with other Monitoring, Control and Surveillance (MCS) tools (e.g. Vessel Monitoring System).

Robust System: the EM equipment components installed outdoors (such as cameras/camera housing and sensors) should be capable to resist rough conditions at-sea and harsh environment on board the vessels.

Secure System: the EM equipment components and data need to be tamper-resistant and tamper-evident, ideally using encrypted data, such that attempts at unauthorized modifications are not possible.

Cameras: digital, high-resolution when possible, cameras covering all areas of interest on the vessel according to the vessel and fishing operations are recommended. Camera placement, settings and recording must assure the detection of vessel activities, catch and bycatch species, and enable accurate species identification (at least for all species under the IOTC mandate). The system should be able to record activities in low and very bright natural light conditions (low and high contrasts). The cameras must be water resistant and in a self-contained, weather resistant box.

³ Annex 3 should be taken as a general guide since they are examples of existing EMS installations. The EM configuration (number of cameras, position, and monitoring objectives for each) should then be tailored to each fishery/vessel through a Vessel Monitoring Plan.

⁴ EM capabilities to collect ROS minimum data requirement fields (<https://iotc.org/documents/ROS/DataStandards>) may vary from fleet to fleet if the catch handling and setting/hauling maneuvers differ among fleets. Therefore, these values should be taken as a general guide and subject to constant review.

EM records: EM records shall contain the following information: EM record file name including, at a minimum, the vessel name and vessel ID, camera ID, trip ID, geolocation data (date, time (UTC), latitude and longitude), camera recording status, EM health status(when available), images, and sensor data when used.

Independence: the system needs to be self-governing with the exception of minimal maintenance by the crew (e.g., cleaning sensors and cameras). The system may include remote verification of its functionality in real time to collect all information. A designated person should ensure that the system is working properly before leaving port and at sea, and a protocol (checklist) should exist for that purpose.

No interference: EM equipment should not generate or cause radio frequency interference with other on-board vessel communication, navigation, safety, geolocation devices (e.g. VMS) or fishing equipment.

Autonomy: the EM equipment should have its own uninterruptible power supply or be connected to that of the vessel to ensure that it can work even in the event of a vessel power outage. The EM equipment should include separate, duplicate backup devices to ensure that data are not lost if a storage device fails.

EM Data storage autonomy: the EM equipment should have enough storage capacity to store all EM records for a certain period of time, which should be at minimum a complete trip. The duration will depend on the vessel's operational characteristics that could range from 4 months (in the case of purse seiners) to 12 months or more (in the case of longliners).

Interoperability: EMS ideally should generate EM records that are interoperable between different EM service and review providers and, where possible, integrate with other data collection and monitoring tools.

Maintenance: a designated person on board (and/or on land) should be designated to maintain the equipment (e.g., clean of lenses, etc.) and report to the EM equipment provider and the competent authority (e.g., IOTC or flag state) when the system is malfunctioning at port or at sea so the system is fixed as soon as possible, and should record any failure of the EM equipment in a dedicated form.

EM LOGISTICAL MINIMUM STANDARDS

EM records retrieval: the EM records should be transmitted via mobile networks, Wi-Fi, or satellite, or storage device (i.e., SSD or HDD) exchange. For the latter, a protocol to recover and send the storage devices to the designated EM review center should also be implemented.

EM record storage: EM records should be stored by the vessel/company/EM service provider/EM review provider/EM program administrator for at least 1 year or for the period established in the national/regional EM programs.

EM records backup: if EM records are automatically transmitted electronically, operational procedures for their receipt and backup should be implemented taking into account any necessary chain of custody arrangements.

Storage device chain of custody: the EMS must ensure traceability of every storage device and EM records. The chain of custody of the EMS storage devices should be assured.

Frequency: EM programs should include requirements on the method and frequency (e.g. after each trip) of EM records transmission to EM review centers, that should be consistent with the minimum standards established by the CPC or IOTC.

EM DATA REVIEW MINIMUM STANDARDS

EM review software: EMS should include software to facilitate the review of EM records and to produce EM data that will allow compiling and reporting in an IOTC common output format for exchange/submission to IOTC. Ideally, EM review software can be used to review EM records collected from different EM equipment providers.

EM review and EM data reporting: EM records reviewing and EM data reporting should be done by institutions, organizations and independent companies with proven expertise and experience (e.g., work experience with onboard observers). These tasks can be centralized in a “regional EM review center” when implementing a regional program and/or can be carried out by national or independent organizations.

EM records and EM data quality check: the reviewing process of EM records should include quality controls through EM records quality check, EM data entry checks, possible automatic error identification in EM data (e.g. incorrect fishing set positions on land, etc), debriefing of EM observers. The produced EM data should be checked prior to reporting to the IOTC Secretariat.

EM data: EMS should allow collecting and reporting, at a minimum, the ROS Minimum Standard Data Fields. EM data will be submitted to the IOTC Secretariat using IOTC standard forms according to the time frame specified in Resolution 22/04, or any superseding Resolution. Data confidentiality requirements outlined in Resolution 12/02, Data Confidentiality Policy and Procedures, or any superseding Resolution, shall apply to all EM data submitted to the IOTC Secretariat.

EM observers’ training: EM observers must have specific qualifications related to EM record review which should be integrated into the regional or national EM program standards. The EM observer should participate in specialised training courses that should be updated upon modification of the EM review protocol to ensure EM data high-quality standards.

EM observer’s qualifications: EM observers must have the ability to review EM records and produce EM data according to IOTC requirements. EM observers should be familiar with fishing activities and be capable of identifying (i) IOTC species and species of special interest, (ii) IOTC fishing methods, and (iii) IOTC mitigation methods.

Compatibility with ongoing standardized data flow and databases: EM data should have compatible output format (including usage of standardized, well-established code lists) to exchange collected information with current IOTC data reporting format and standards, and should be consistent with IOTC data rules. EM data will be submitted in an approved electronic data reporting format to the IOTC Secretariat, using IOTC standard codes and units.

Data storage and retention: legal provisions on data protection, storage, and retention by IOTC should be developed and agreed upon whether it is a REMP or EM National Programs.

EM records ownership: EM records ownership is of the vessel owner/flag state but should provide IOTC with the EM data outputs to incorporate in the IOTC database for use, analysis, and disposal as required by the IOTC observers Resolution on Regional Observer Scheme.

Hardware/software ownership: irrespective of the scope of the EM program, it is recommended that hardware and software license ownership (and maintenance) is of the vessel owner/flag state.

ANNEX 3

VESSEL MONITORING PLANS (GUIDE)

Each vessel should develop a “Vessel Monitoring Plan” so as to define how many and where cameras are located to collect the required ROS minimum data fields. Vessel Monitoring Plans should be reviewed by the CPCs fishery management agency and presented to the WGEMS/WPDCS to ensure it meets IOTC REMP Program and EM System and Data Standards.

On purse seine vessels, the minimum areas that cameras are recommended to cover:

- the working deck (both port and starboard sides),
- the net sack and the brailer,
- the foredeck or amidships (e.g., FAD activity),
- and the well deck and conveyor belt (Murua et al., 2022; Restrepo et al., 2018): for the conveyor belt, in more than one place (e.g. at the beginning and at the end of the conveyour belt as a minimum). If a discard conveyor belt exists, it should also be covered.
- Cameras must cover the following actions: fishing set, brailing, net hauling, FAD activities, total catch, catch well sorting (process of putting the catch in the hold or wells), bycatch handling and release, and tuna discards (Figure 1 and Table 1).
- In large purse seines, at least 6 cameras are needed to cover fishing and fish-handling operations; however, less fewer cameras (e.g. 4 cameras) could cover the activity to collect the data required of smaller purse seines (e.g. 300-400 tonnes capacity).

The preferred EM equipment configuration would be the one that allows a greater number of images (frames) of higher quality/resolution. Digital video is generally preferred, but still images can also be a viable option to capture information during the various phases of the vessel activity. However, considering that storage capacity is limited, an optimal configuration may have video on certain areas/cameras/moments, while still photos on others. In the case of photographs, the minimum requirement should be that a picture is taken by the camera with viewing angle fully covering the fish management areas at least every 2 seconds when fishing action occurs (Restrepo et al., 2018). Image quality should also be adequate enough to allow accurate collection of all required data field, such as species ID, FAD materials and design, or bait used and, hence, achieve the monitoring objectives.

The diagram illustrates the layout of a fishing vessel with various camera positions and deck activities. The vessel is shown from a side-on perspective, with a blue hull and a white superstructure. The following components are labeled:

- Bow camera:** Crane activity, Partial view of seine
- Panoramic camera:** Surrounding activity
- Crows nest camera:** Fishing deck
- Starboard camera:** Bycatch and discards
- Brailing camera:** Brailing and purge

The diagram also shows a detailed view of the deck area, including the crane, the seine net, and the brailing system. The deck is divided into different sections, and the camera locations are marked with red dots. The vessel is shown in a blue body of water, and the sky is a light blue color.



Figure 1. (A) An example of a 6-cameras EM system installed in a purse seine covering main areas of fishing and fish handling operations (from Murua et al., 2020b) and (B) 7-cameras EM system (4 in the upper deck and 3 in the well deck) installed in a purse seine covering main areas of fishing and fishing handling operations including 1 more camera in the conveyor belt: (B1) 360° Panoramic view camera (e.g port side view), (B2) Crows nest stern view camera, (B3) Working deck crane camera view , (B4) Foredeck view camera, (B5) Conveyor belt stern camera view, (B6) Conveyor belt middle camera, and (B7) Conveyor belt bow camera (source: Digital Observer Services).

Table 1. Minimum areas and actions that should be monitored (adapted from Murua et al., 2022; Ruiz et al., 2017).

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

On longline vessels, the minimum areas and activities that cameras are recommended to cover (Table, 2, Figure 2):

- The area of setting the longline (usually vessel stern site camera),
- the area of hauling the longline,
- the working deck where catch is handled,
- and the surrounding water area for those discarded species not brought onboard
- Cameras must cover the following actions: setting of the longline, bait type information, whether mitigation techniques are being used (e.g. tori lines for seabirds), hauling of the longline, all hooked species (both retained and discarded), the fate of the catch, and the size of the specimens.
- On most tuna longlines, at least 3 cameras are needed to cover fishing activities and fish handling operations: one capturing images when setting the longline, one to record the hauling and boarding of the catch, and other mounted over the processing deck to record species, size of specimens and fate (Murua et al., 2020a). And additional camera to cover the surrounding water area for those discarded species not brought onboard is also recommended.



Figure 2. An example of a 3-camera EM equipment installed on a longline covering main areas of fishing and fish handling operations. View of the 3 cameras: (left panel) Stern camera - setting longline providing information on hooks, floats, mitigation techniques and bait; (middle panel) Fishing deck 1 - hauling information, captures and discards, species ID, size and fate; and (right panel) Fishing deck 2 - fate of the species, size, species ID (source: Digital Observer Services).

Table 2 – General configuration and areas/activities covered by the EM system onboard tropical tuna longline vessels

Area covered	Action covered	Minimum data requirements to be monitored
Stern camera of the boat	Start and end setting operation	Position, date, and time
		Total number of hooks set and between floats
		Total number of floats set
		Bait type
		Bait species
		Bait ratio (%)
		Mitigation measures/marine pollution
Work deck	Catch onboard	Length and weight ⁵ by capture
		Condition
		Fate
		Predator observed
	Bycatch discarded, released, or	Total bycatch by set and species composition
Processing area	Catch	Total catch by set
		Length and weight ¹ by capture
		Sex
		Fate
Surrounding water area	Start and end hauling operation	Position, time and date
	Estimation of bycatch discards, releases or retention	Total bycatch by set and species composition
		Species condition and fate

⁵ Estimated through length-weight relationships.

On pole and line vessels, the minimum areas that cameras are recommended to cover are the area of bait fishing activity, the area of the fishing set and pole and line fishing activity (vessel stern site camera) and the working deck where catch is handled. On a typical Indian Ocean pole and line vessels, this will require at least 2 or 3 cameras to cover main fishing activity areas, fish handling operations and bait fishing (Figure 3).

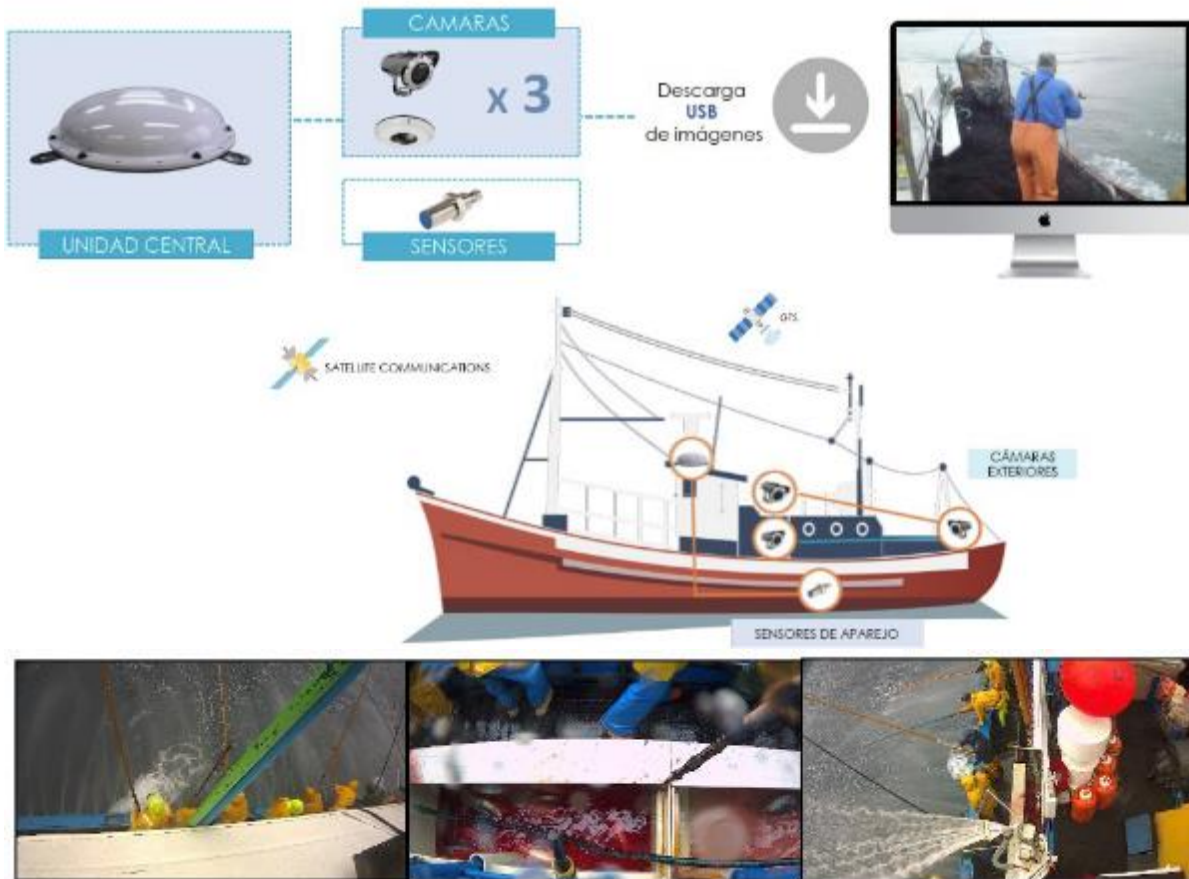


Figure 3. An example of a 3-camera EM equipment installed on a Bay of Biscay (Atlantic Ocean) pole and line vessel covering main areas of fishing activity and fish handling operations. View of the 3 cameras: (left panel) Vessel bridge camera stern view – pole and line activity; (middle panel) Fish handling - catch storage; (right panel) Vessel bridge camera bow view - bait and pole and line fishing activity (source: Marine Instrument).