Electronic monitoring programs conducted by AZTI and DATAFISH in the Spanish tuna fisheries

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Abstract

Advances in technology have led the electronic monitoring (EM) to be positioned as a tool capable of improving fisheries monitoring. Tuna RFMOs (Regional Fisheries Management Organizations) are currently discussing the potential use of this technology as an alternative data collection tool, which could lead to a higher and more efficient at sea monitoring coverage. In this context, there are several EM programs and initiatives that have been developed in Spain in recent years. This document aims to comprehensively describe three of these EM programs in the purse seine, longline, bait boat and troll Spanish tuna fisheries. In addition, a SWOT analysis has been carried out, to finally make a series of recommendations for the implementation of the EM based on the experience gained during the last years.

1. **Background**

Advances in technology have led the electronic monitoring (EM) (a set of cameras, GPS and sensors installed in fishing vessels) to be positioned as a tool capable of improving monitoring and control in fisheries. Various organizations, including tuna RFMOs (Regional Fisheries Management Organizations), are currently discussing the potential use of this technology as an alternative data collection tool, which could lead to a higher and more efficient at sea monitoring coverage, and which could complement (or even replace) some of the responsibilities and tasks traditionally associated with human observers (Murua *et al.,* 2020). It is an emerging field that has developed rapidly, especially during the last decade (Van Heldmon *et al*., 2019; Michelin *et al*., 2020; Fujita *et al*., 2018).

As to the implementation of this technology in Spain, the tropical tuna purse seine fishery joined these initiatives to incorporate EM in 2012, when a first pilot study was carried out with the aim of validating the efficiency of this tool, comparing it with data collected by human observers (Ruiz *et al*., 2015). In the following years, several trials in purse seiners were conducted involving different EM providers, (Monteagudo et al., 2014; Ruiz et al., 2016). In view of the promising results in this fishery, minimum standards for the implementation of the EM in the purse seine fleet were developed (Ruiz et al., 2017), and preliminary adopted by the IOTC and ICCAT in 2017 (IOTC, 2017; ICCAT, 2017). This have led to the implementation of several EM programs, and there are currently several Spanish tropical purse seine companies that have voluntary EM programs in place in the Atlantic and Indian Oceans.

Similarly, in 2018 two Spanish associations of pelagic longliners decided to test the technology. Some equipment was installed in vessels operating in the Atlantic and Pacific Oceans, when first pilots were conducted. Later, several shipowners have been interested and the fleet has currently various vessels monitored through EM.

Finally, the bait boat and troll fleets targeting albacore (*Thunnus alalunga*) and bluefin tuna (*Thunnus thynnus*) have been the last Spanish tuna fisheries joining the EM option. In 2019, the first trial with EM was conducted in the Bay of Biscay (Atlantic Ocean), having obtained similar data to those collected by human observers for the catch estimates of target species, length frequencies, and interactions with sensitive species or ETPs (Endangered, Threatened and Protected) (Ruiz *et al*., 2020). Since 2020, some other bait boat and trolling vessels have joined this initiative and have installed EM systems on a voluntary basis.

All these programs mentioned above are jointly managed by the scientific institute AZTI (https://www.azti.es/), and Datafish Technology Solutions (http://datafishts.com/), specialized company in collecting fishery data through human observers and electronic monitoring. This document aims to comprehensively describe each of these EM programs in the Spanish tuna fisheries.

It is worth mentioning that these programs do not represent all the EM initiatives conducted by EU-Spain.

2. **Description of the current programs**

- *Topical tuna purse seine EM program in the Atlantic and Indian Oceans*

The program started in 2017. At that time, RFMOs (i.e., ICCAT and IOTC) had management programs that required 5% observer coverage. However, the two Spanish tuna purse seine associations (ANABAC and OPAGAC) agreed to have 100% observer coverage on a voluntary basis since 2012 (Grande *et al*., 2019). Logistical constrains, high costs and security issues due to piracy in some areas, along with the promising results obtained during several pilot studies (Monteagudo et al., 2014; Ruiz et al., 2015; Ruiz et al., 2016; Briand et al., 2018), led some companies to opt for EM over the traditional on board observers. The program aims to implement the so-called best practices to minimize the ecosystem impacts of purse seine fishing, by implementing best bycatch handling practices and the use of non-entangling FADs (Grande *et al.*, 2019). The program is not directly managed by a national or international body, but it is managed by the industry and the companies participate voluntarily. AZTI, as scientific advisor of the program, is currently responsible for gathering and analysing all the EM and observers' data.

In general, the comparisons made to date between EM and physical observers have shown that this technology has great potential as a monitoring tool in the tuna purse seine fishery. The results indicate that, with some adjustments, it can be a valid tool to monitor fishing effort, total catch per set, and large bycatch, but shows limitations for some other tasks currently carried out by observers (such as collecting biological samples or estimating bycatch of certain species).

There are currently 14 purse seiners and 8 supply vessels involved in the EM program[1], including both Spanish and associated flags (i.e., Seychelles, Guatemala, Belize, etc.). Marine Instruments is the EM equipment provider. Purse seiners are equipped with the *EYE-plus* EM system, and the supply vessels with the *V6* system developed for smaller vessels. Currently all equipment is being replaced by the new version *MarineObserve*. All models include an Iridium-based Vessel Monitoring System which sends a position and system status message at configurable rates to authorized e-mail addresses; the vessel's position, direction and speed are recorded every 10 seconds. It has a backup battery system and several levels of security to access configuration tools and data. The *EYE-plus* and V6 record still images (1 fps below 4 nots and 1 fpm above 4

[1] These numbers do not account for other tuna seiners equipped with other non-Marine Instruments EM systems, being different the data analysis software, database, and data flow.

knots), while the new version can capture both still images and/or video. All images are georeferenced with position and date.

The number and position of cameras vary, and configuration is customized to the vessel level, but in general 4 (vessels < 400 T without conveyor belt) to 6 cameras are installed covering the areas and fishing actions as described in table 1.

Area covered	Action covered	Purpose
Work deck (port side)	Brailing	Total catch by set
	Tuna discards	Total tuna discards by set
	Bycatch handling	Bycatch estimation
Work deck (Starboard side)	Bycatch handling	Bycatch estimation
In-water purse seine area	Brailing	Total catch by set
	Bycatch handling of big species (Whale sharks, manta rays…)	Total bycatch by set Best practices
	Bycatch release of big species (whale sharks, manta rays…)	Total bycatch by set Best practices
Foredeck or amidships	FAD activity (deploying, replacement, reparation…)	Total number of FAD activities by trip and FAD design.
Well deck and conveyor belt	Catch well sorting	Species composition
	Bycatch discarded, released or retained	Total bycatch by set Species composition

Table 1. General configuration and areas/activities covered by the EM onboard purse seiners.

EM records are stored on removable hard drives, which are generally transported by the vessel's crew. The shipment of disks should not exceed the period of four months (usual duration of each crew relay), although historically it has not always been accomplished. The images have traditionally been analysed / reviewed by AZTI, although recently it is Datafish who is in charge of this task. There is a dedicated software to facilitate the review of EM records, and EM data are later stored a PostgreSQL database which shares format and table structure with the human observers' database (i.e., ObServe). 100% of the footage is revised. Since the EM program began, 460 trips (14 PS and 8 supply) have been analysed. For the moment, these data have been used exclusively within the framework of the EM program, with the objective of internally verifying the compliance of the fleet with so-called Best Practices. Punctually, EM data has also been employed for scientific publications or in the framework of ecolabel certifications. Only the data concerning the Atlantic Ocean in 2020 have been sent to the corresponding RFMO as, based on the ICCAT Recommendation 19-02, the observation coverage onboard purse seiners should be 100%.

- *Bait boat (BB) & troll (TR) fisheries*

The Spanish bait boat and troll tuna fisheries obtained the MSC (Marine Stewardship Council Certification) for the albacore (Thunnus alalunga) caught in the Bay of Biscay (North Atlantic Ocean) in 2017. This process led to the implementation of certain obligations for the beneficiaries of this certification, including at sea monitoring. In addition, ICCAT establishes, through its Recommendation 16-14, the obligation of a minimum observer coverage of 5%. In the case of the bait boat fleet, this minimum required coverage could reach 20% if the activity is aimed at catching bluefin tuna.

In this context, the industry conducted through AZTI an EM feasibility study (Ruiz et al., 2020), which concluded that EM could be a promising tool in both gears, providing data similar to those collected by human observers for albacore (target species) catch estimates, length frequencies, and interactions with ETPs.

Currently there are 6 vessels (3 BB and 3 TR) voluntarily participating in the EM program. Marine Instruments is the EM equipment provider. Two of them are equipped with E-eye V6 and the remaining 4 with MarineObserve. All models include an Iridium-based Vessel Monitoring System that sends a position and system status message at configurable speeds to authorized email addresses; the vessel's position, direction and speed are recorded every 10 seconds. It has a battery backup system and several levels of security to access configuration tools and data. The E-eye V6 records still images (1 fps below 6.5 knots and 1 fpm above 6.5 knots in the case of trollers, and 1 fps below 3 knots and 2 fpm above 3 knots in the case of bait boats). In addition, the E-eye V6 includes hydraulic and electrical sensors to discriminate the fishing activity periods and accordingly change the interval between photos. The MarineObserve can capture both still images and video, and it only relies on speed to change the interval between photos. Both systems' images are georeferenced with position and date.

The number and position of the cameras vary depending on the gear, and the settings are customized to the vessel level. Three cameras are installed in vessels equipped with E-eye V6 and four in MarineObserve system. The fishing areas and actions covered are described in table 2.

The EM records are stored on removable hard drives. These are collected and analysed at the end of the fishery season by Datafish. Dedicated software facilitates the review of ME records. 100% of the footage is revised. Since the EM program began, 29 trips have been analysed (6 TR and 23 BB). There is no specific database, and the data is stored in EXCEL sheets. However, work is currently underway to incorporate these data into the AZTI's observer database for these fisheries. For the moment, these EM data have been used exclusively within the framework of the MSC certification, aiming to determine the interaction with ETPs.

Fishery	Area covered	Action covered	Purpose
Troll (TR)	Starboard side	Handling of hydraulic reels	Catch estimate Tuna discard's estimate ETP interaction
	Port side	Handling of hydraulic reels	Catch estimate Tuna discard's estimate ETP interaction
	Stern	Handling of hydraulic reels Stowage of catches	Catch estimate Tuna discard's estimate ETP interaction Size measurement of target species
Bait Boat (BB)	Starboard side	Handling of the rods	Catch estimate Tuna discard's estimate ETP interaction Bait type
	Conveyor belt	Stowage of catches	Catch estimate Length measurement

Table 2. General configuration and areas/activities covered by the EM onboard troll and bait boat fisheries.

- *Longline fisheries*

In 2017 the Spanish Fisheries Ministry (Secretaría General de Pesca) implemented the observer program on surface longliners for vessels operating within the scope of tuna RFMOs. From the beginning, it aimed to comply with the RFMO's minimum observer coverage and data reporting requirements.

At that same time, the possibility of monitoring this fleet through EM was considered by the Fisheries Ministry, as space onboard for anyone external to the crew was very limited. Several EM systems were installed on vessels in both the Atlantic and Pacific oceans. During the development of these first pilot trips, the EM record's analysis company (Datafish), the industry (Producers Organizations OR.PA.GU and OPROMAR) and the selected EM provider (Marine Instruments) worked together to optimize the equipment installation and data analysis.

14 vessels are currently participating in the EM program. Datafish is the company in charge of visualizing the fishing days. 100% of footage is visualized, and the same templates used by observers are used, providing the following data: fishing operations' date and position, retained catches by species (including biometric data), discards and interactions with ETP species. Marine Instruments is the EM provider, who installed both E-eye V6 and MarineObserve equipment. All models include an Iridium-based Vessel Monitoring System that sends a position and system status message at configurable speeds to authorized email addresses; the vessel's position, direction and speed are recorded every 10 seconds. It has a battery backup system and several levels of security to access configuration tools and data. In general, this type of surface longliners are monitored by 4 cameras, as shown in table 3. Each one of the cameras is configured independently and records different frames per second (between 10 and 15 fps) depending on the speed of the vessel. EM data is reported to ICCAT and IATTC since 2018.

Area covered	Action covered	Purpose
Aft 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 (%)
Work deck	Catch onboard	Length and weight by capture
		Condition
		Fate
		Predator Observed
	Bycatch discarded, released, or retained	Total bycatch by set Species composition
Processing area	Catch	Total catch by set
		Length and weight by capture
		Sex
		Fate
Surrounding water area	Start and end hauling operation	Position, date, and time
	Bycatch discarded, released, or retained	Total bycatch by set Species composition
		Condition
		Fate

Table 3. General configuration and areas/activities covered by the EM onboard surface longline fisheries.

Table 4 below shows a summary of the three EM programs.

	Purse seine	Longline	Bait boat
Program general standards			
Area covered	Atlantic & Indian oceans	Atlantic, East Pacific & Indian ocean	North Atlantic (Bay of Biscay)
RFMO concerned	ICCAT IOTC	ICCAT IOTC IATTC	ICCAT
Reported to the RFMO	Only ICCAT	ICCAT and IATTC	No
Number of vessels	14 purse seiners and 8 supply	14	6
Volunteer (y/n)	Y	Y	Y
Vessel's length overall (m)	52 - 110	22-30	20-32
Onboard equipment standards			
Equipment provider	Marine Instruments	Marine Instruments	Marine Instruments
Hardware	E-eye plus/ E-eye V6/ MarineObserve	E-eye V6/ MarineObserve	E-eye V6/ MarineObserve

Number of cameras	5 to 6	3 to 5	3 to 4
Photo / video	Photo & video	Photo & video	Photo
24h/7d	Yes	Yes	Yes
Frame rate	2 modes Fishing operation: 1 fps Searching: 1 fpm	2 modes Setting operation: 10 fps Hauling: 5 to 15 fps	2 modes Fishing mode: 1 fps Searching: 1 fpm
GPS	Yes	Yes	Yes
Another sensor	No	No	Yes
Tamper proof (y/n)	Yes	Yes	Yes
Images linked to date/ geographical position	Yes	Yes	Yes
Tested by a third party	Yes	Yes	Yes
Analysis station standards			
Data storage (capacity)	1 to 2 Tb	1 to 2 Tb	1 to 2 Tb
EM record analysis	Datafish	Datafish	Datafish
Software	Beluga	Beluga & EMi	Beluga & EMi
Footage review	100%	100%	100%
Revision rate	1trip (1month) / 5 days EM work	60 days at sea / 15 days EM work	7 days at sea / 2 days EM work
Database	ObServe (PostgreSQL)	Medusa Longline & Excel sheets	Excel sheets
Data field standards			
Gear configuration	No	Yes	No
Target catch weight	Yes	Yes	Yes
Target catch length	No	Yes	Yes
Bycatch weight/number	Yes	Yes	Yes
Bycatch length	No	Yes	Yes
Bycatch fate	Yes	Yes	Yes
Other data	Yes	Yes	No

Table 4. Main EM program standards

3. Strengths and weaknesses along the EM programs

There are many papers and technical reports that have described the strengths and weaknesses of the electronic monitoring for the accurate monitoring of fisheries (Van Hellmond et al., 2019; Michelin et al., 2020). Some may be specific to certain fisheries or areas, others specific to an equipment or EM provider. But in general, there are many overlaps in all these reports. The three EM programs presented in this document are no different, where some of the strengths and weaknesses are common among the programs, in addition to being common with other experiences worldwide.

The result is summarized using a SWOT (Strength-Weaknesses-Opportunities-Threats) analysis (table5).

Strengths	Opportunities
• Lower cost compared to the observer. Higher observation coverage • Possibility of monitoring in certain circumstances: boat with space limitation, unsafety areas. • Possibility of reviewing the same sequence several times. • Very detailed track data • Independent recording, not influenceable. • High acceptance among EM users • Ability to determine in many cases; discards, target species, associated fauna, ETPs	• Extraordinary events such as pandemic (COVID-19) • Automatic analysis (Artificial vision) • Non-invasive data collection method
Weaknesses	**Threats**
– Equipment failure and breakdowns – EM record transmission is not immediate. Big lapse between EM record and EM data – Limitations: Such as species ID or impossibility of collecting biological samples. – Need for a minimum maintenance of (cleaning of lenses). – Difficulty in providing an adequate technical service due to the geographic dispersion and remoteness. – Punctually, and under certain circumstances, inability to collect some variables such as, discards, target species, bycatch, or interactions with SSI.	– Reluctance on the industry (privacy, etc.) – Lack of consensus at the RFMO level to accept it or define the minimum standards.

4. Recommendations and conclusions

The EM is a new methodology for data collection, perhaps somewhat immature compared to other traditional methods (i.e., human observers). However, it has shown great potential, allowing to increase coverage significantly in a cost-effective way. EM is a fast-moving technology that has solved without problems some of the obstacles it has encountered (moving from analogue cameras to IP cameras for instance). In this sense, it is necessary to adapt new technologies for the data collection onboard, increasing their efficiency and functionality. However, in addition to advances in the technology itself (hardware), experience within the EM programs described in this work has shown us that there are also other factors to consider.

- *Clear objectives*: The objectives of the EM program must be clearly defined to prevent non-optimal use of resources. In some cases, the lack of clear objectives, or the desire to cover all the possibilities (best practices verification, ETP interaction, target and bycatch estimates, size frequencies, eco certification requirements, etc.) has led to the same cameras being installed for multiple purposes, losing effectiveness for the top priority objectives.

- *Equipment configuration*: There is no doubt that the equipment configuration and camera placement should be customized to vessel level, as there is not a standard configuration that will cover all vessels even if using the same gear. This is normally done in collaboration by the EM equipment provider and the data review centres, who later elaborate a unique “Installation Certificate”. However, in many cases, after the first review of EM records, the need for certain adjustments is evident (such as camera angles). It is crucial that configurations are fixed as soon as possible, and that installations are not certified until these adjustments are completed.

- *Clear responsibilities:* It is fundamental that the EM program clearly defines the responsibilities among program participants (i.e., ship owner, data analysis centre, EM provider, EM program manager):

    - *Ship owner:* It is responsible for the onboard equipment and should verify equipment’s functioning before each fishing trip. Ship owner should also be responsible of data (hard drive) transmission, from the vessel to the analysis centre.
    - *Data analysis centre:* The data analysis centre is responsible for the installation design (configuration) and for elaborating the “installation certificate”. It is also responsible of EM records analysis. The analysis should be based on standardized and approved protocols.
    - *EM provider*: It is responsible for onboard installation, and subsequent equipment maintenance.
    - *EM program manager*: the program manager defines the objectives in a clear way and ensures the proper functioning of the program. He will be responsible for the EM data.

- *EM record ownership*: The three programs described in this document have been implemented on a voluntary basis, and to some extents have been driven by the industry itself. The opposition of the industry to the EM has been identified in various regions as one of the main causes for an EM pilot study not to be implemented. In this sense, it is crucial that the information is encrypted, as well as that the shipowner is the only owner of the EM records.

- *Frequency:* The frequency of EM record transmission to data review centres should be clearly established. Delays or too long periods between transmissions can lead to lost data if the equipment is malfunctioning.

- *Minimum at sea maintenance*: The EM onboard equipment must be autonomous and work independently from the crew. However, it is necessary that there is a minimum maintenance on board. This maintenance mainly refers to the cleaning of the cameras. There are several trips that have been considerably affected by dirt on the lenses of one or more cameras. Therefore, it is necessary to establish cleaning protocols with the crew. Similarly, it is advisable that it is the responsibility of the shipowner to verify before the trip begins that the EM system installed on board is in a correct state of operation using all the means that it deems appropriate; verify that there is enough data storage capacity, verify that there are no alarm indicators on the equipment (if the equipment has this option), verify operation of the power supply system, verify operation of all cameras, check that there are no elements that obstruct the vision of the cameras, verify that the GPS signal is correct, check the correct operation of all the sensors, etc.

- *Sensors:* including sensors that monitor gear usage and fishing activity to show when fishing occurs will facilitate image revision and analysis.

- *Data bases and analysis software:* Image visualization and data entry software should be linked and tailored to a specific fishery and program objectives.

- *Data validation*: Finally, it is important to carry out periodic cross-validations, at vessel level and based on other traditional data collection methods (i.e., on board observers), to ensure that there are no biases.

5. References

Briand, K., Bonnieux, A., Le Dantec, W., Le Couls, S., Bach, P., Maufroy, A., Relot-Stirnemann, A., Sabarros, P., Vernet, A.L., Jehenne, F., 2018. Comparing electronic monitoring system with observer data for estimating non-target species and discards on French tropical tuna purse seine vessels. Col Vol Sci Pap ICCAT 74, 3813–3831.

Fujita, R., C. Cusack, R. Karasik, and H. Takade-Heumacher (2018). Designing and Implementing Electronic Monitoring Systems for Fisheries: A Supplement to the Catch Share Design Manual. Environmental Defense Fund, San Francisco. 63 pages.

Grande M., Ruiz J., Murua H., MuruaJ., Goñi N., Krug I., Arregui I., Salgado A., Zudaire I, Santiago I., 2019. Progress on the code of good practices on the tropical tuna purse seine fishery in the indian ocean. IOTC-2019-WPEB15-33.

ICCAT, 2017. Report of the Standing Committee on Research and Statistics (SCRS). Madrid, Spain, 2 to 6 October 2017.

IOTC, 2017. Report of the 20th Session of the IOTC Scientific Committee. IOTC–2017–SC20–R[E]. Seychelles, 30 November – 4 December 2017

McElderry, H., 2008. At-Sea Observing Using Video-Based Electronic Monitoring. Backgr. Pap. Prep. by Archipel. Mar. Res. Ltd. Electron. Monit. Work. July 29–30, 2008. Seattle WA, Held by North Pacific Fish. Manag. Counc. Natl. Mar. Fish. Serv. North Pacific Resea

Michelin, M., Sarto, N.M., Gillett, R., 2020. Roadmap for Electronic Monitoring in RFMOs Roadmap for Electronic Monitoring in RFMOs. CEA Rep

Monteagudo J.P., Legorburu, G., Justel-Rubio A. and Restrepo V. 2014. Preliminary study about the suitability of an electronic monitoring system to record scientific and other information from the tropical tuna purse seine fishery. SCRS 2014/132

Murua H., Fiorellato F., Ruiz J., Chassot E., Restrepo V. 2020. Minimum standards for designing and implementing Electronic Monitoring systems in Indian Ocean tuna fisheries. Document *IOTC–2020–SC23–12[E] rev2* presented during the IOTC Scientific Committee 2020.

Ruiz, J., Batty, A., Chavance, P., McElderry, H., Restrepo, V., Sharples, P., Santos, J., Urtizberea, A., 2015. Electronic monitoring trials in the tropical tuna purse-seine fishery. ICES J. Mar. Sci. 72, 1201–2013. https://doi.org/10.1038/278097a0

Ruiz, J., Krug, I., Gonzalez, O., Hammann, G., 2016. E-EYE plus: Electronic monitoring trial for tropical tuna purse seiners. Document SCRS/2016/181 presented during the ICCAT Tropical Tuna species group.

Ruiz, J., Krug, I., Justel-rubio, A., Restrepo, V., Hammann, G., Gonzalez, O., Legorburu, G., Pascual-Alayón, P., Bach, P., Bannerman, P., Galán, T., 2017. MINIMUM STANDARDS FOR THE IMPLEMENTATION OF ELECTRONIC MONITORING SYSTEMS FOR THE TROPICAL TUNA PURSE SEINE FLEET. SCRS/2016/180 Collect. Vol. Sci. Pap. ICCAT 73, 818–828.

Ruiz, J., Oyarzabal, I., Santos, M., Santiago, J., 2020. Estudio piloto de monitoreo electrónico para flota de bajura. Inf. Final. IM-19-EMSBAJU 56

Van Helmond, A.T.M., Catchpole, T., Mortensen, L.O., Plet, K.S., Zimmermann, C., Ulrich, C., Needle, C.L., Oesterwind, D., Kindt, L., Mangi, S., Jakob, H., Nick, O., Heidrikur, B., Jørgen, B., Elson, J., Hosken, M., Peterson, L., Mcelderry, H., Ruiz, J., Pierre, J.P., Dykstra, C., Jaap, J. (2019). Electronic monitoring in fisheries : Lessons from global experiences and future opportunities. Fish Fish 21(1). 1–28. https://doi.org/10.1111/faf.12425.