# The use of electronic monitoring within tuna longline fisheries in the Indian Ocean – implications for data collection, analysis and reporting

**Timothy J. Emery[1], Ashley J. Williams[1], Simon D. Hoyle[2], Rui Coelho3, and Dan Fu[4]**

[1]Department of Agriculture and Water Resources, Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)
[2]Fisheries Consultant, 14 Champion Terrace, Nelson, New Zealand
[3]Division of Modelling and Management of Fishery Resources, Portuguese Institute for the Ocean and Atmosphere, I.P. (IPMA)
[4]IOTC Secretariat

## ABSTRACT

At-sea observer coverage in global fishing fleets has often been lower than anticipated due to scheduling and logistical difficulties associated with placing observers on board vessels, as well as financial costs. Electronic monitoring (EM), consisting of on-board video imagery and on-shore analysis, offers an alternative or supplement to at-sea observer programs in global fishing fleets. However, the capability of EM to collect and support interpretation of records into data for all fields currently collected by at-sea observers is still under assessment. We evaluate the Indian Ocean Tuna Commission (IOTC) regional observer scheme mandatory reporting data fields for longline fisheries, their current scientific application in the IOTC, and the capability of EM technology to collect these fields based on output from two Pacific Community (SPC) data process standard technical workshops in 2016 and 2017. Of the longline data fields that could be assessed from the workshops, we identify that 68% can be collected with current EM technology, with 65% of these currently used in scientific analyses. For the 35% of fields not routinely used in scientific analyses, the introduction of EM may facilitate a sufficient increase in data availability to support their future use. Modifications to current EM systems or alternative data collection approaches would be required to collect fields that EM cannot currently record, to ensure data continuity and scientific rigour are not compromised.

## INTRODUCTION

To monitor the implementation of the conservation and management measures, the Indian Ocean Tuna Commission (IOTC) in 2011 established a regional observer scheme (ROS) through Resolution 11/04 with the aim to "collect verified catch data and other scientific data related to the fisheries for tuna and tuna-like species in the IOTC area of competence." Under Resolution 11/04, at-sea observers are required to: record and report fishing activities, verify positions of the vessel, estimate catches as much as possible, try to identify the catch species composition, monitor discards, by-catch and size frequency, record the gear type, mesh size and attachments employed by the fishing master, and carry out such scientific work (e.g. collecting biological samples), as requested by the IOTC Scientific Committee. The ROS has an accompanying set of mandatory reporting data fields and information, which is currently under revision (IOTC and Athayde 2018), for Contracting Parties (Members) and Cooperating Non-Contracting Parties to prioritise during trips.

Despite the associated benefits of at-sea observer data, the proportion of total fishing effort in the fishery that can be observed is often lower than anticipated (Clarke et al. 2013; Williams et al. 2016). Electronic monitoring (EM), consisting of on-board video imagery and on-shore analysis, has the potential to supplement and support, or in some cases even replace, at-sea

observer programs. However, there is a need to evaluate the capability of EM to collect and support interpretation of records into data for all fields currently collected by at-sea observers (e.g. as required by the ROS) before implementing EM as a standard data collection tool.

**METHODS**

We evaluated the ability of EM to collect the draft IOTC ROS mandatory reporting data fields for longline (IOTC and Athayde 2018) using the outcomes from an expert assessment of EM capabilities undertaken during a technical workshop held for tuna fisheries in the western central Pacific Ocean (WCPO; SPC 2017).

In the WCPO, the capability of EM to collect the Western and Central Pacific Fisheries Commission (WCPFC) Regional Observer Programme (ROP) minimum standard data fields for longline fisheries was assessed at two Pacific Community (SPC) data process standard technical workshops in 2016 and 2017 in Noumea, New Caledonia. The agreed categories for assessing EM capability at the 2017 workshop and their accompanying definition are reproduced here in Box 1. The results for the WCPFC are included in the IOTC information paper IOTC-2018-WPDCS14-INF03 (Emery et al. in press).

**Box 1:**

The agreed categories for assessing EM capability at the 2017 technical workshop (SPC, 2017) and their accompanying definition were:

- *EM-R1* – Ready now
- *EM-R2* – Ready now but requires significant crew support
- *EM-R3* – Ready now but requires dedicated or additional camera/sensor
- *EM-R4* – Ready now but inefficient/costly for an EM analyst to interpret
- *EM-P1* – Possible with minor work
- *EM-P2* – Possible with major work
- *EM-NP* – Not possible

The EM-R2, R3 and R4 categories differ from EM-R1 in that additional time and/or financial costs (e.g. EM analyst review time, crew support or additional equipment) would be incurred with recording and analysing data fields. Additionally, technical and financial limitations in current camera and/or sensor technology (that may improve with time), were the main determinates behind data fields being classified as either EM-P1 or EM-P2.

The expert assessment from the SPC technical workshop in 2017 were used as a starting point for assessing the capability of EM to collect the IOTC ROS mandatory reporting data fields for longline fisheries (See Table 1). There are currently a total of 55 data fields in the draft IOTC ROS longline form. Of these 55 fields, 21 were not assessed by experts at the SPC data process standard technical workshop in 2017 (as they are unique to the IOTC) and thus EM capability to collect these fields could not be determined.

We then asked three contracting party IOTC scientists to identify the current and potential future use of the observer data fields for scientific analyses (e.g. stock assessments, catch per unit effort (CPUE) standardisations, catch reconstructions, bycatch species analyses, etc.) to allow an evaluation of which analyses may or may not be possible if EM was used to replace observers.

**RESULTS & DISCUSSION**

Of the 34 IOTC ROS mandatory reporting data fields that could be assessed, 15 fields were classified as ready to collect now with EM (*EM-R1*), one ready with crew assistance (*EM-R2*), six ready with additional dedicated camera and/or sensors (*EM-R3*) and one ready but costly for the EM analyst to interpret (*EM-R4*) (Fig 1; Table 1). Only nine fields were classified as not possible to be collected using EM (*EM-NP*), with two additional fields possible to be collected in the future following technological advancement (*EM-P2*).

These results indicate that the EM records are unable to be converted into some data types that are currently collected by at-sea observers. Therefore, if EM simply replaced at-sea observers, the absence of data fields previously collected by at-sea observers may cause a range of data continuity issues, with flow on effects in the delivery of scientific analyses and provision of scientific advice.

Of the 23 IOTC ROS mandatory reporting data fields for longline classified as EM Ready (*EM-R1-4*), 15 (65%) of these have been used in scientific analyses for IOTC to date. Many of these analyses have included CPUE standardisation, evaluating the effectiveness of seabird bycatch mitigation, analyses of targeting and catch reconstructions (Table 1). For the remaining 35% of fields that are EM Ready (*EM-R1-4*), but not routinely used in scientific analyses, the introduction of EM may facilitate a sufficient increase in the quantity of data available for these fields to support their use in analyses undertaken by scientists for the IOTC. These include analyses on catch rate standardisation for effort creep/efficiency change and evaluating the effectiveness of bycatch mitigation (Table 1).

Of the 11 IOTC ROS mandatory reporting data fields for longline that either cannot be collected by EM (*EM-NP*) or could possibly be collected in the future with major work (*EM-P2)*, two (18%) of these have been used in various scientific analyses for IOTC (Table 1). These two fields, *maturity stage* and *hook type*, have been used in size selectivity analyses and catch rate standardisations respectively (Table 1) and would need to be collected using an alternative data collection tool at the set-level, such as at-sea observers, to ensure data continuity and scientific rigour was not compromised. The remaining nine (82%) fields, most of which could be utilised in analyses that review the evolution of fishing technology and fleet dynamics (Table 1), could be collected at a trip level through port sampling or vessel surveys in the absence of an at-sea observer.

While EM is in principle capable of collecting most of the ROS mandatory reporting data fields for longline, it will also be limited by associated financial and logistical resources. These limitations will be unique to both the national fisheries authority and individual vessels in the respective fleet. For example, some national or state fisheries authorities may have greater financial resources to pay EM analysts to monitor additional data fields than others. Likewise, some vessels may not have the capacity to install a camera on the boom to view the retracting line during hauling operations, reducing their capacity to accurately record species discarded at the water level. We also note that observers sometimes are tasked with duties related with scientific work, which may include the collection of biological samples. In such cases, EM systems would need to be complemented by onboard observers, crew sampling or port sampling programs to collect this information.

The importance of the ROS mandatory reporting data fields for various IOTC scientific analyses necessitates that member states consider issues of data continuity and accuracy prior to implementing EM as a supplement or replacement to at-sea observer programs. This could be achieved in part through an assessment of the efficiency and cost-benefit of each data collection tool (i.e. at-sea observers, EM) in collecting ROS mandatory reporting data fields to meet international obligations.

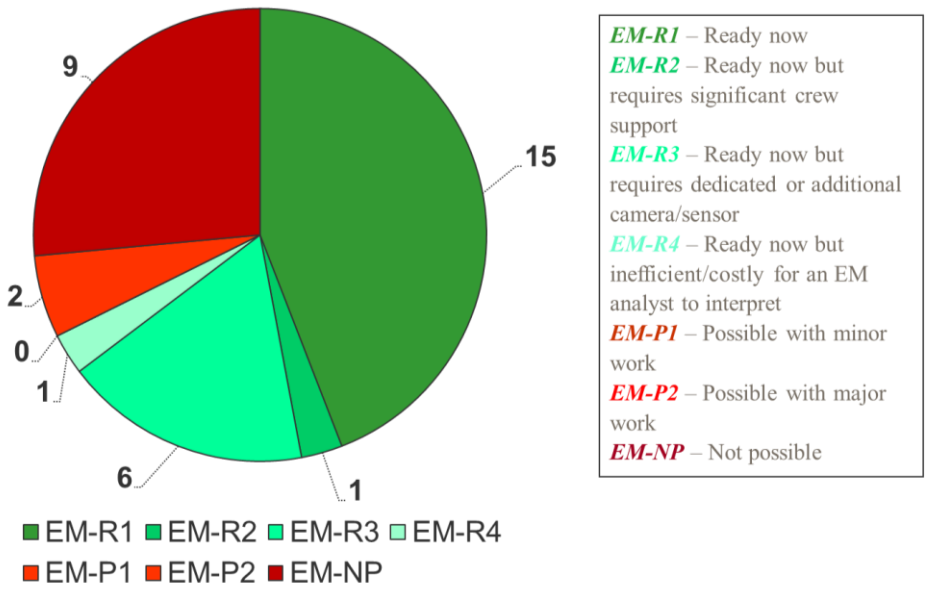


**Fig. 1.** Summary assessment of EM capability to collect IOTC ROS longline data fields. (After SPC 2017). Note that 21 (of a total of 55) data fields are not included because they were not assessed by the SPC data process standard technical workshop in 2017.

## REFERENCES

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**Table 1.** The draft IOTC ROS standard mandatory reporting data fields (IOTC and Athayde 2018) and instructions for longline information form, an assessment of EM capability (after SPC, 2017) and details of IOTC scientific use

| **IOTC Regional Observer Scheme (ROS) Mandatory Reporting Data Fields & Information (Longline Information Form)** | | | **EM capability assessment** | **Scientific data use** | |
|---|---|---|---|---|---|
| ***Section*** | ***Data field*** | ***Field description*** | ***Could this field be collected with EM? ( after SPC, 2017)*** | ***Current scientific use at current levels of observer coverage and data provision*** | ***Possible future scientific use with greater levels of observer coverage and data provision*** |
| ***Special equipment or machinery*** | Line setter | Indicate Yes if on board No if not sighted - Many long line vessels will be fitted with equipment or machinery that regulates line setting speed allowing the line to be set at uniform depth. | EM-R3 | | Evolution in fishing technology & fleet dynamics - effort creep/efficiency; effectiveness of bycatch mitigation measures and devices; gear configuration models |
| | Line hauler | Indicate Yes if on board No if not sighted - Most long line vessel will be fitted with equipment or machinery that hauls the line in after it has been set. | EM-R3 | | Evolution in fishing technology & fleet dynamics - effort creep/efficiency; |
| | Bait casting machine | Indicate Yes if on board No if not sighted - Most vessels manually deploy branch lines with the bait. However there are a number of vessels that use automatic bait casting machines. | EM-R3 | | Evolution in fishing technology & fleet dynamics - effort creep/efficiency; effectiveness of bycatch mitigation measures and devices; gear configuration models |
| ***General gear attributes*** | Mainline material | The material the mainline is made out of, e.g. kevlar, nylon, nylon multifilament (Table #). | EM-NP | | CPUE standardisation; evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; gear configuration models; Identifying targeting practices; size selectivity analyses; |

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| | Mainline length | The total length of the mainline in kilometres (i.e. mainline maximum length). | EM-P2 | | Evolution in fishing technology & fleet dynamics - effort creep/efficiency; identifying targeting practices; gear configuration models |
| | Branchline length | The length of each of the branchline sections (1, 2, 3 and 4), where section 1 is that closest to the mainline and section 4 is the leader. | EM-NP | | Evolution in fishing technology & fleet dynamics - effort creep/efficiency; identifying targeting practices; gear configuration models |
| | Branchline diameter | The diameter of each of the branchline sections (1, 2, 3 and 4), where section 1 is that closest to the mainline and section 4 is the leader. | EM-NP | | Evolution in fishing technology & fleet dynamics |
| ***Tori line details*** | Tori line length (specify units) | The total length of the tori line (not including streamers). | Not assessed | | Effectiveness of bycatch mitigation measures and devices; |
| | Streamer type | The type of streamers used with the tori line (e.g. paired or single). | Not assessed | | Effectiveness of bycatch mitigation measures and devices; |
| | Streamer line length (specify units) | The length of individual streamer lines (minimum and maximum where lengths vary). | Not assessed | | Effectiveness of bycatch mitigation measures and devices; |
| | No. streamers per line | The number of streamers that are attached to a single tori line | Not assessed | | Effectiveness of bycatch mitigation measures and devices; |
| | Attached height (specify units) | The height that the tori line is attached above the water level. | Not assessed | | Effectiveness of bycatch mitigation measures and devices; |
| ***Setting operations*** | Start setting date and time | The date at the time the first dhan buoy and / or radio buoy is deployed to start the setting of the line. | EM-R1 | Identifying targeting practices; CPUE standardisation | Evolution in fishing technology & fleet dynamics - effort creep/efficiency; catch reconstruction; size selectivity analyses; population structure analyses; length, weight condition and conversion code analyses |

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| | Start setting position | The position in latitude and longitude for the start of the setting operation to at least a resolution of 1° by 1°. | EM-R1 | CPUE standardisation; catch reconstruction; identifying targeting practices; size selectivity analyses, population structure analyses; length, weight condition and conversion code analyses | Evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; gear configuration models |
| | End setting date and time | The date and time that the last dhan buoy and / or radio buoy is deployed. (Note that longline vessels often set lines at the night and the setting operation may continue beyond midnight and into the following day.) | EM-R1 | | Evolution in fishing technology & fleet dynamics - effort creep/efficiency; catch reconstruction; size selectivity analyses; population structure analyses; length, weight condition and conversion code analyses |
| | Length of mainline set (specify units) | The mainline total set length (i.e. the total deployed length of the mainline for the specific set). Usually calculated by multiplying the total time to set the line and the average line setter speed. (Note take into account any interruption times). | EM-P2 | | Evolution in fishing technology & fleet dynamics - effort creep/efficiency; identifying targeting practices; gear configuration models |
| | Shark lines set | Indicate Y or No if shark lines were set during the operation. (Note: shark lines are lines set directly from floats specifically targeting sharks). | EM-R1 | | CPUE standardisation; evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; gear configuration models; Identifying targeting practices; size selectivity analyses; population structure analyses |
| | Total number of hooks set | The total number of hooks deployed for the set, usually calculated by multiplying number of baskets by the average number of hooks between the baskets. | EM-R1 | CPUE standardisation, effectiveness of bycatch mitigation measures and devices; catch reconstruction; size selectivity analyses; population structure analyses | Evolution in fishing technology & fleet dynamics; identifying targeting practices; gear configuration models |

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| | Target species | The target species for the set (FAO spp. 3-alpha code). | EM-R1 | CPUE standardisation | Evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; gear configuration models; Identifying targeting practices; size selectivity analyses; population structure analyses |
| | VMS on | Indicate Y or No to sign if he VMS was on or not while setting and hauling. | Not assessed | | |
| ***Mitigation measures*** | Number of tori lines deployed | The total number of tori lines deployed during the setting operation. | EM-R3 | Effectiveness of bycatch mitigation measures and device | Evolution in fishing technology & fleet dynamics |
| | Night setting | Indicate Y or No - Note that night setting is binary - if all hooks set between dusk and dawn, then night setting was used. If some hooks were set outside of nautical darkness, then night setting was not used. | Not assessed | | CPUE standardisation; effectiveness of bycatch mitigation measures and devices; Identifying targeting practices; size selectivity analyses; population structure analyses |
| | Low light night setting | Indicate Y or No - minimum deck lighting is used during night setting. | Not assessed | | Evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices |
| | Branch line weighted | Indicate Y or No if the branch line is weighted. | EM-NP | | CPUE standardisation; evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; gear configuration models; size selectivity analyses; population structure analyses |
| | Sinkers average weight (specify units) | The average weight of weights/sinkers attached to the branchlines. | EM-NP | | Evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; gear configuration models |

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| | Proportion weighted | The proportion of branchlines weighted (%). If all weighted than record 100%. | Not assessed | | Evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; gear configuration models |
| | Hook-sinker distance (specify units) | The distance of the weights/sinkers from the eye of the hook. | EM-NP | | Evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; gear configuration models |
| | Hook type | The type and size of hooks used according to the IOTC categories (Table #). | EM-NP | CPUE standardisation | Evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; Identifying targeting practices; size selectivity analyses; population structure analyses |
| | % of hooks set by type | The percentage (%) of hooks set by type according to IOTC categories (Table #) | EM-NP | | CPUE standardisation; evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; Identifying targeting practices; size selectivity analyses; population structure analyses |
| | Bait type | The bait types used accordingly to according to the IOTC categories (Table #). | EM-R3 | CPUE standardisation | Evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; Identifying targeting practices; size selectivity analyses; population structure analyses |
| | Bait species | The bait species used (FAO spp. 3-alpha code). | EM-R3 | CPUE standardisation | Evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; Identifying targeting |

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| | | | | | practices; size selectivity analyses; population structure analyses |
| | Bait ratio (%) | The approximate proportion of each bait type and species used across all hooks in the set. | EM-R4 | | CPUE standardisation; evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; Identifying targeting practices; size selectivity analyses; population structure analyses |
| ***Hauling operations*** | Start hauling date and time | The date and time when the first dhan buoy and / or radio buoy is hauled back on-board to start hauling the line | EM-R1 | CPUE standardisation | Evolution in fishing technology & fleet dynamics |
| | Start hauling position | The position in latitude and longitude for the start of the hauling operation to at least a resolution of 1° by 1°. | EM-R1 | CPUE standardisation; evolution of fishing technology and fleet dynamics | |
| | Number of retrieved hooks observed | The number of hooks observed for catch and bycatch composition. (Note this must not include the time that the observer spent on the deck measuring and collecting biological data on the catch as observers should be in a position during these observations to record the hooks coming directly out of the water and record the fate of released species.) | EM-R1 | | CPUE standardisation; evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices; gear configuration models; discard mortality estimation; size selectivity analyses; identifying targeting practices |
| ***Catch details*** | Specimen ID | This is a unique numeric ID which increases sequentially to identify an individual. | Not assessed | | |
| | Species code | The species code for each specimen observed (FAO spp. 3-alpha code). If species FAO code is not available, the species scientific name. | EM-R1 | Used in all analyses (e.g. CPUE standardisation at set level) | |
| | Fate | The species fate which includes whether it was retained or discarded and the reason according to the IOTC categories (Table #). | EM-R1 (if landed)<br>EM-R3 (if not landed) | Evaluation of handling practices | Discard mortality estimation; effectiveness of bycatch mitigation measures and devices |
| | Hooking location | Record the geographical coordinates of the point at which the catch was hauled or the bycatch interaction took place (1 by 1 degrees). | Not assessed | Spatial distribution and dynamics of bycatch species | Models of gear configuration; discard mortality estimation |

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| | Comments | Include any comments such as possible reasons for incidental capture. Note whether this was accidental due to the animal's presence in the area or as a result of the animal actively interacting with the catch or fishing gear. | Not assessed | | Discard mortality estimation; models of gear configuration |
| | Gear interaction for incidentally taken /affected bycatch | The interaction of the incidentally taken /affected bycatch specimen with the fishing gear according to IOTC categories (Table #). | Not assessed | | Discard mortality estimation; effectiveness of bycatch mitigation measures and devices; CPUE standardization |
| | Condition for incidentally taken /affected bycatch | The condition of the incidentally taken /affected bycatch specimen at the time of release according to the IOTC categories (Table #). | EM-R1 (if landed)<br>EM-R3 (if not landed) | | Discard mortality estimation; models of gear configuration |
| ***Sampling details*** | Sampling methods for the collection of biological information | The sampling method used for the collection of biological sub-sample according to the IOTC categories (Table #). | Not assessed | Size selectivity analyses; population structure analyses | CPUE standardisation; evolution in fishing technology & fleet dynamics; effectiveness of bycatch mitigation measures and devices |
| | Length code 1 | The length code used for the measurement according to the IOTC categories (Table #). | EM-R1 | Evaluation of handling practices; size selectivity analyses; population structure analyses | Models of gear configuration |
| | Length 1 | The length corresponding to the length type taken rounded to the lower centimetre. For LD1 this should be rounded to the lower half centimetre. | EM-R1 | Evaluation of handling practices; size selectivity analyses; population structure analyses | Models of gear configuration |
| | Sex | The sex, male or female, where possible. If unknown record UNK. | EM-R2 | Evaluation of handling practices; size selectivity analyses; population structure analyses | |
| | Maturity stage | Specify the stage of maturity of the sampled fish specimen according to standard maturity scales approved by the IOTC. | EM-NP | Evaluation of handling practices; size selectivity analyses | |

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| | Sample collected | Describe the collection of samples trough the recording of the:<br>a) sample type (e.g. otoliths, spine clippings, and genetic samples)<br>b) sample preservation method (e.g. alcohol, frozen, etc.)<br>c) sample destination (i.e. location to be sent/stored) | Not assessed | Size selectivity analyses | Evaluation of handling practices; population structure analyses |
| ***Depredation details*** | Depredation source | For depredated specimens, the depredation source based on depredation scar characteristics according to the IOTC categories (Table #). For non-depredated specimens record NA. | Not assessed | | Depredation estimate |
| | Predator Observed | For depredated specimens, the predator species directly observed and identified (FAO spp. 3-alpha code). If the predator was not observed record UNK (unknown). For non-depredated specimens record NA. | Not assessed | | Depredation estimate |
| ***Tag details*** | Tag release | Indicate Yes or No, whether this individual was re-released with a tag attached | Not assessed | Tag-recapture studies used in stock assessment | CPUE standardisation; discard mortality estimation; models of gear configuration |
| | Tag recovery | Indicate Yes or No, whether a tag was recovered from this individual | EM-R1 | Tag-recapture studies used in stock assessment | CPUE standardisation; discard mortality estimation; models of gear configuration |
| | Tag number | Provide the tag number | Not assessed | Tag-recapture studies used in stock assessment | CPUE standardisation; discard mortality estimation; models of gear configuration |
| | Tag type | The type of tag used according to the IOTC categories (Table #) | Not assessed | | CPUE standardisation; discard mortality estimation; models of gear configuration |
| | Tag finder | The name and contact details of the person who recovered the tag | Not assessed | | CPUE standardisation; discard mortality estimation; models of gear configuration |

Grey – Waiting for WPDCS approval before being submitted to the SC for removal from the list of information mandatory for reporting.

Red – Waiting for WPDCS approval before being submitted to the SC for insertion to the list of information mandatory for reporting.

Blue - Waiting for WPDCS approval before being changed (or not) and submitted for approval to the SC.