Agreement on the Conservation of Albatrosses and Petrels

Tenth Meeting of the Seabird Bycatch Working Group

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ACAP Guidelines on Fisheries Electronic Monitoring Systems

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SUMMARY

ACAP recognises the need for guidelines for Electronic Monitoring (EM) systems to meet objectives of monitoring seabird interactions. These ACAP guidelines define how fisheries EM systems can be designed to meet objectives of fisheries monitoring that are specific to seabird interactions with marine capture fisheries, as tasked by the 2019-2021 intersessional workplan for ACAP's Seabird Bycatch Working Group. EM systems are increasingly being used to complement and replace conventional human onboard observer programmes, and to initiate at-sea monitoring where none previously existed. For fishing gear methods in which seabird bycatch is understood to be problematic (pelagic longline, demersal longline, trawl, set and staked gillnet and trammel net, drift gillnet, non-tuna purse seine) we identify data fields and define data collection protocols for EM systems to meet objectives. These ACAP partial EM guidelines can serve to inform and strengthen the development of guidelines and minimum standards for full EM systems.

RECOMMENDATIONS

We recommend that the Working Group request the Advisory Committee to:

1. Adopt these *ACAP Guidelines on Fisheries Electronic Monitoring Systems*.
2. Disseminate and encourage use of ACAP's EM Guidelines to inform and strengthen minimum standards for full fisheries EM systems.
3. Periodically update ACAP's EM Guidelines to reflect changes, for example, in objectives of monitoring seabird interactions in marine capture fisheries, amendments to bycatch management measures, the development of new bycatch mitigation methods, and improvements in EM technology.

Directrices del ACAP sobre sistemas de monitoreo electrónico de las pesquerías

RESUMEN

El ACAP reconoce la necesidad de contar con directrices para que los sistemas de monitoreo electrónico (ME) cumplan con los objetivos de monitoreo de las interacciones con aves marinas. Estas directrices del ACAP definen cómo pueden diseñarse los sistemas de ME de las pesquerías para cumplir los objetivos de monitoreo específicos de las interacciones de aves marinas con las pesquerías de captura marina, según lo encomendado en el plan de trabajo intersesional de 2019-2021 para el Grupo de Trabajo sobre Captura Secundaria de Aves Marinas del ACAP. Los sistemas de ME se están utilizando cada vez más para complementar y reemplazar los programas convencionales de observadores humanos a bordo, y para introducir el monitoreo en el mar donde no existía anteriormente. Para los métodos de artes de pesca en los que se entiende que la captura secundaria de aves marinas es problemática (palangre pelágico, palangre demersal, arrastre, redes de enmalle y trasmallo caladas y en estacas, redes de enmalle de deriva, redes de cerco no atuneras), identificamos campos de datos y definimos protocolos de recolección de datos para que los sistemas de ME cumplan sus objetivos. Estas directrices parciales del ACAP en materia de ME pueden servir para informar y fortalecer el desarrollo de directrices y normas mínimas para sistemas completos de ME.

RECOMENDACIONES

Recomendamos que el Grupo de Trabajo solicite al Comité Asesor lo siguiente:

1. Aprobar estas Directrices del ACAP sobre sistemas de monitoreo electrónico de las pesquerías.
2. Difundir y alentar el uso de las Directrices del ACAP sobre ME para informar y fortalecer las normas mínimas para los sistemas completos de ME en pesquerías.
3. Actualizar periódicamente las Directrices del ACAP sobre ME para reflejar los cambios, por ejemplo, en los objetivos de monitoreo de las interacciones de aves marinas en las pesquerías de captura marina, enmiendas a las medidas de gestión de captura secundaria, el desarrollo de nuevos métodos de mitigación de la captura secundaria y mejoras en la tecnología de ME.

Directives de l'ACAP relatives aux systèmes de surveillance électronique des pêches

RÉSUMÉ

L'ACAP a jugé nécessaire de formuler des directives visant à assurer que les systèmes de surveillance électronique atteignent bien leurs objectifs en matière de surveillance des interactions avec les oiseaux de mer. Les présentes directives de l'ACAP déterminent la manière dont les systèmes de surveillance électronique des pêches peuvent être conçus pour atteindre des objectifs propres aux interactions des oiseaux de mer avec les pêches de capture marine, conformément à la mission conférée par le plan de travail intersessions 2019-2021 pour le Groupe de travail de l'ACAP sur la capture accessoire des oiseaux de mer. Les systèmes de surveillance électronique sont de plus en plus employés pour compléter voire remplacer les programmes conventionnels d'observation humaine à bord. Ces systèmes permettent aussi de débuter une surveillance en mer là où il n'en existait pas auparavant. Concernant les méthodes reposant sur des équipements connus pour poser de nombreux problèmes en matière de captures accessoires des oiseaux de mer (palangre pélagique, palangre démersale, chalut, filet maillant fixe et sur pieux ou dérivant, trémail, senne tournante), nous définissons les champs de données et les protocoles de collecte nécessaires à l'atteinte des objectifs de la surveillance électronique. Ces directives destinées aux systèmes partiels peuvent servir à éclairer et à consolider l'élaboration de directives et de normes minimales pour les systèmes de surveillance électronique complets.

RECOMMANDATIONS

Nous recommandons que le Groupe de travail demande au Comité consultatif de :

1. Adopter ces *Directives de l'ACAP relatives aux systèmes de surveillance électronique des pêches*.
2. Diffuser et encourager l'utilisation de ces directives aux fins d'éclairer et de consolider les normes minimums pour les systèmes de surveillance électronique complets.
3. Actualiser régulièrement ces directives afin de tenir compte des évolutions survenues, par exemple, dans les objectifs de la surveillance des interactions des oiseaux de mer avec les pêches de capture marine, des modifications apportées aux mesures de gestion des captures accessoires, de la découverte de nouvelles méthodes d'atténuation des captures accessoires, ou des améliorations apportées à la technologie de surveillance électronique.

Summary of ACAP's EM Engagement

Over the past several years, the ACAP Advisory Committee, through the ACAP Seabird Bycatch Working Group (SBWG), has been monitoring and considering the application of fisheries Electronic Monitoring (EM) systems to meet objectives of fisheries monitoring that are specific to seabird interactions with marine capture fisheries.

SBWG5 discussed *Electronic Monitoring of Seabird Bycatch* (SBWG5 Doc 25, Papworth, 2013), which recommended that ACAP: (1) actively promote the use of e-monitoring in both high seas and domestic fisheries where there is an overlap of seabird distribution with fishing effort; (2) undertake a study to identify the most effective deployment of cameras for capturing seabird bycatch events; (3) support research to automate the identification of seabird bycatch events; and (4) develop protocols for the analysis of e-monitoring data relating to seabird bycatch.

SBWG6 discussed *E-monitoring Fact-sheet* (SBWG6 Doc 6, Tisot and Papworth, 2014), which recommended that ACAP: (1) Review the proposed fact-sheet on electronic monitoring; and (2) Endorse its publication as a bycatch mitigation fact-sheet. The working group also considered *Implementing Electronic Monitoring Systems as a Means of Independently Monitoring Seabird Bycatch during Fishing Operations* (SBWG6 Doc 22, Barrington, 2014), which recommended that: (1) ACAP continue to examine the benefits and limitations of EM systems in independently monitoring fishing operations, particularly for domestic and high seas fisheries and domestic and distant water fishing fleets; and (2) ACAP consider whether to establish best practice guidelines concerning the design, development, implementation and evaluation of electronic monitoring systems. And the working group considered *Strategic Plan for Electronic Monitoring and Electronic Reporting in the North Pacific* (SBWG6 Inf 07, Loefflad et al., 2014), which provided a syntheses of information on EM systems and defined steps to advance the use of EM in U.S. north Pacific groundfish and halibut fisheries. SBWG6 recommended further work to examine the benefits and limitations of EM systems and the development of best practice guidelines.

SBWG7 considered *Examination of the Benefits and Limitations of E-monitoring in Relation to Seabird Bycatch and Mitigation* (SBWG7 Doc 06, Papworth et al., 2016) presents the results of an intersessional investigation of the benefits and limitations of EM concerning seabird bycatch and mitigation, and through this process the development of best practice guidelines for seabird bycatch and mitigation. Several information papers were also considered. *Australia's Electronic Monitoring Program* (SBWG7 Inf 17, AFMA, 2016) summarised Australia's fisheries EM systems, *Detecting Seabird Captures via Video Observation* (SBWG7 Inf 18, Southern Seabirds Solutions Trust, 2016) summarised the results of an experimental assessment of video observation in a bottom longline fishery. *Electronic Monitoring in Fisheries of the United States* (SBWG7 Inf 19, Denit et al., 2016) describes past studies and recent EM activities in US fisheries related to seabird bycatch. SBWG7 discussed and revised recommended best practices for EM and recommended further development of the best practice advice. The recommended best practices for EM systems were adopted by AC9.

SBWG8 considered several information papers related to EM. *Man Versus Machine: Electronic Monitoring Versus On-board Observers in Small-scale Fisheries in Peru* (SBWG8 Inf 04, Bartholomew et al., 2017) summarised results of an EM pilot in a Peruvian small-scale fishery. *Update on Electronic Monitoring and Logbook Verification in Australian Commonwealth Fisheries*

(SBWG8 Inf 09, AFMA, 2016) outlined the objectives and operating principles Australia is using EM to meet and Australia's experiences with logbook verification following the introduction of EM. *Electronic Monitoring of Seabird Captures in New Zealand Bottom Longline Fisheries* (SBWG8 Inf 22, Austin and Walker, 2017) assessed the capacity for EM to monitor seabird captures in New Zealand demersal longline fisheries. *New Zealand's Integrated Electronic Monitoring and Reporting System for Commercial Fisheries* (SBWG8 Inf 29, Pierre, 2017) summarised EM and e-reporting systems. *Recent U.S Experience with Electronic Monitoring, Seabird Monitoring, and Incorporation into Standard Management Protocols* (SBWG8 Inf 24, Fitzgerald et al., 2017) summarised the use of EM to monitor seabird interactions in Alaskan fisheries.

SBWG 9 discussed several information papers related to EM. *Methods to Increase the Functionalities and Accuracy of Fisheries Electronic Monitoring Systems* (SBWG9 Inf 02, Gilman et al., 2019) identified candidate methods, including existing and emerging technologies, to expand EM functionalities. *Improving Seabird Species Identification in Electronic Monitoring Applications Using Machine Learning Systems* (SBWG9 Inf 21, Fitzgerald et al., 2019) summarised the results of a trial of machine learning to identify seabird species from video imagery. *Remote Electronic Monitoring as a Potential Alternative to On-board Observers in Small-scale Fisheries* (SBWG9 Inf 07, Bartholomew et al., 2019) summarised findings of research comparing EM and human observer data in a Peruvian small-scale gillnet fishery.

Further work on developing *ACAP Guidelines on using Electronic Monitoring Systems to Monitor Seabird Interactions* was included as a task in the *ACAP Seabird Bycatch Working Group Intersessional Work Plan, 2019-2021* (ACAP, 2019).

ACAP Guidelines on Fisheries Electronic Monitoring Systems

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1. Introduction and Scope

Fisheries monitoring programmes supply data required for fundamental scientific, compliance monitoring and ecological and social sustainability assessment applications. Electronic monitoring (EM) systems are increasingly being used to complement and replace conventional human onboard observer programmes, and to initiate at-sea monitoring where none previously existed (Michelin et al., 2018; van Helmond et al., 2019).

There have been about 100 fisheries EM pilot projects since the first in British Columbia, Canada in 1999, and there are now 12 fully implemented programmes with 771 fishing vessels (van Helmond et al., 2019). The US, Australia and Canada have established, fully implemented EM programmes. Chile, European Union, New Zealand, Peru, United Kingdom, and some Pacific small island developing states have completed pilots and are considering or planning fully implemented EM programmes. While this is tremendous progress, there are an estimated 4.6 million fishing vessels globally – and most of these are in fisheries with no at-sea monitoring (Gilman et al., 2014; FAO, 2020). There is therefore a large monitoring gap in need of being filled – and a huge role for EM in filling this gap.

EM systems typically use onboard cameras, global positioning systems, sensors and data loggers to collect information on fishing, transshipment and supply vessel activities. They include office-based staff who analyse imagery (video and/or single frame still photos) and sensor data and input the data into a database. EM systems can be implemented through either formal programmes of national or regional management authorities that have legal and regulatory jurisdiction over the vessels being monitored, where records that result from processing and analysing EM data are input into a national or regional observer/EM programme database, or they may be voluntary programmes.

EM systems can collect most but not all data fields of conventional observer programmes (Gilman et al., 2019; Emery et al., 2018). When properly designed, EM systems have several advantages over conventional human observer programmes, including overcoming main sources of statistical sampling bias, allowing at-sea monitoring of small-scale fishing and support vessels that present various challenges for placement of human observers, enabling multiple areas of vessels to be monitored simultaneously and near-continuously, and allowing questionable data to be audited and corrected. EM systems, when used on vessels that also have observers, can enable the observers to focus on monitoring tasks, such as biological sampling, that might not be otherwise be feasible (Emery et al., 2018).

These voluntary guidelines define how fisheries EM systems can be designed to meet three common objectives of fisheries monitoring programmes of (1) scientific, (2) compliance, and (3) management performance assessment as they relate to seabird interactions. This includes EM designs and technology that enable collection of information on:

- Seabird catch and other interactions (attempts, contacts);
- Variables that significantly explain seabird catch risk;

- Variables that significantly explain post-capture mortality risk, including at-vessel (haulback) condition, fate (retained or not retained), release condition (if not retained), post-release mortality, and collateral sources of fishing mortality (e.g., warp strikes, vessel collisions, ghost fishing by abandoned, lost and discarded gear);
- Variables that enable monitoring compliance with individual seabird bycatch mitigation methods; and
- Additional variables, if relevant, needed to conduct performance assessments of seabird bycatch management measures.

We recognise that not all EM systems are employed to meet all three of these objectives. However, all three of these objectives are included in the scope to enable the guidelines to be broadly applicable. For fishing gear methods in which seabird bycatch is understood to be problematic (pelagic longline, demersal longline, trawl, set and staked gillnet and trammel net, drift gillnet, non-tuna purse seine) we describe data fields and data collection protocols for EM systems to meet the above-noted five broad categories of monitoring objectives. However, only a subset of the full suite of data fields identified below would need to be included for an EM system selecting a narrower subset of these objectives.

As fisheries with seabird interactions increasingly use EM systems to meet monitoring requirements, ACAP recognizes the need for guidelines for EM systems to meet objectives of monitoring seabird interactions. These can then serve to inform and strengthen the development of guidelines and minimum standards for full EM systems (e.g., under development by some of the tuna regional fisheries management organisations, Murua et al., 2020; Roman et al., 2020; WCPFC, 2020) by accounting for the partial, seabird-related requirements of EM systems.

2. Essential and Desirable EM Data Fields

EM systems should use designs and technology that enable the collection of data fields on seabird catch, variables that significantly explain seabird catch and post-capture mortality risk (defined above), and fields that enable monitoring compliance with and assessing performance of seabird bycatch management measures. While the EM camera setup needs to be customised according to the configuration of individual vessels (Murua et al., 2020), the number and type of cameras and fields of view to meet *all* of the aforementioned seabird monitoring objectives should, at a minimum, enable EM analysts to detect the following essential categories of data fields:

<u>Essential, minimum suite of categories of monitoring data fields</u>

- Seabird captures (during hauling for longline and gillnet, when trawling, during all fishing operations for purse seine), to the species level when feasible, including catch that crew remove from gear in the water at night;
- Seabird at-vessel (haulback) condition;
- Seabird catch fate (retained, released/discarded);
- Seabird release condition;
- Information on tags or rings attached to captured seabirds;

- Trawl warp strikes when towing;
- Use of seabird bycatch mitigation methods (both required and voluntary); and
- Variables that significantly explain seabird catch and post-capture mortality risks.

This subset of categories of essential, minimum data fields of fisheries monitoring programmes, including fisheries EM systems, adapts the "critical" data fields identified by ACAP's *Data Collection Guidelines for Observer Programmes to Improve Knowledge of Fishery Impacts on ACAP-Listed Species*, which provides a comprehensive list of essential data fields for inclusion in observer programmes to enable meeting seabird-related objectives of monitoring (Wolfaardft and Debski, 2021) by excluding data fields that are already likely to be collected by a fisheries monitoring programme (for pelagic longline, see ISSF and FAO, 2015). Instead, the data fields identified in these ACAP EM guidelines are specific to seabird-related objectives of monitoring.

A subset of the essential data fields would be appropriate for an EM system selecting a narrower scope of objectives. For example, managers and other stakeholders of a fishery with a large number of small vessels with no prior at-sea monitoring, and no seabird bycatch management strategy, may initially decide to establish an EM system in order to obtain basic information on when, where and the magnitude of seabird bycatch. In this case, the stakeholders may decide to use a single time lapse camera, GPS logger and hard drive on each vessel (e.g., see Bartholomew et al., 2018), with a field of view that covers locations where crew retrieve catch, including seabirds, including the area where crew release unwanted catch in the water. The interval between photos would needs to be designed according to how long crew will have catch within a camera field of view. The EM analysts could be tasked with recording a subset of the above essential categories of data fields to document the locations and dates/times of each seabird catch event. This single camera EM system could enable the EM analyst to detect a broader range of data fields, such as sea state, at-vessel condition (life status) of the seabird bycatch, fate (retained vs. discarded) and release condition if not retained, to meet a broader scope of monitoring objectives, but stakeholders may elect to limit the data collection fields to maximise reviewing efficiency and hence reduce costs, but at a cost of not being able to meet some monitoring objectives.

Desirable, optimal EM systems would be designed to enable EM analysts to detect a larger suite of categories of data fields, enabling stakeholders to more robustly meet their scientific, compliance monitoring and performance assessment objectives of fisheries monitoring:

<u>Additional, desirable categories of monitoring data fields</u>

- Handling and release practices;
- Gear components, if any, remaining attached to the seabird upon release (e.g., hook, monofilament line; anatomical location of hook);
- Information on the catch other than included in the essential categories of data fields (e.g., method of capture such as hooked vs. entangled, anatomical hooking position, length, depredation evidence);
- Counts of each seabird species within a specified area around the vessel. Seabird density is a data field of some fisheries observer programmes that has been used to standardise

fishing effort, required for robust performance assessments of seabird bycatch management strategies (Reid and Sullivan, 2004; Gilman and Hall, 2015);

- Seabird interactions other than captures and trawl warp strikes. This includes seabird escapement from gear prior to the gear being handled by crew; seabird collisions with the vessel (for areas of the vessel within EM camera fields of view); seabird secondary interactions (where relatively small species of deep-diving seabirds access baited hooks at depth and bring the baited hook to the sea surface where larger seabird species are then able to access the terminal tackle and become captured, which may occur far astern); attempts to contact gear and contacts with gear; and the distance astern of seabird attempts and contacts with fishing gear;
- Abandoned, lost and discarded fishing gear, including components that could cause seabird ghost fishing mortalities; and
- Other variables that may significantly explain seabird catch and post-capture mortality rates.

3. EM Data Collection Protocols, Dataset Compatibility

EM systems should employ data collection protocols that are the same, or otherwise as similar as possible, to those used in observer programmes so that EM and observer records are compatible and suitable for pooling (combining). For example, if at-sea observers conduct species-specific seabird scan counts every hour during setting and hauling within 100 m of the vessel, then an EM analyst might need to adjust this to conduct the scan counts within the EM cameras' fields of view (which may be less than 360 degrees), and up to 100 m from the vessel as EM camera functionalities permit (e.g., Gilman et al., 2021). In the future, if the review of EM imagery and sensor data can be automated, then EM may be able to efficiently collect some fields, such as seabird scan counts, at increased intervals than human observer data collection protocols.

4. Gear-specific EM Data Fields and Data Collection Protocols

The appendices to these guidelines contain ACAP's initial versions of databases containing detailed descriptions of data fields and data collection protocols for EM systems for seabird interactions in: (1) pelagic longline, (2) demersal longline, (3) trawl, (4) anchored and staked gillnet and trammel net and drift gillnet, and (5) non-tuna purse seine fisheries. In these gear-specific appendices, data fields are organised into the following categories (expanded from Gilman and Hall, 2015):

- **Catch**: Fields include, for example, species or higher-level group if analyst cannot identify the species, at-vessel condition, fate, gear attached upon release, release condition, length.
- **Derelict gear production**: Abandoned, lost and discarded fishing gear, including components that could cause seabird ghost fishing mortalities (e.g., spent bait containing hooks, derelict driftnets).

- **Escapement**: Observation of a seabird escaping from the gear prior to the gear being handled by crew (e.g., throws the hook).
- **Environmental parameters**: Used to standardise fishing effort, such as Beaufort Wind Force Scale/sea state, wind direction, cloud cover, lunar illumination.
- **Fisher data**: Such as skipper name, number of crew, used to standardise fishing effort.
- **Fishing gear:** Data fields needed to standardise fishing effort for seabird catch and mortality rates, including, for example, hooks per set, hooks per float, branchline length, leader material, and bait type.
- **Fishing methods**: Data fields needed to standardise fishing effort for seabird catch and mortality rates, including, for example, geospatial location, gear soak duration, and methods for retrieving branchlines (manual vs. automatic coiler, use of untended lines).
- **Handling and release practices:** What methods and equipment did crew employ to handle and release captured seabirds.
- **Non-catch seabird interaction**: E.g., warp strikes in trawl fisheries, collisions with the vessel, secondary interactions during setting or hauling.
- **Other:** Such as unique trip and set numbers, target species.
- **Seabird local abundance (density)**: Scan counts to estimate the number of seabirds of each species within a specified area around the fishing vessel.
- **Vessel equipment and vessel data**: Used to standardise fishing effort, such as vessel unique identification, sonar, bird radar.
- **Additional fields to assess the performance of seabird bycatch mitigation methods:** Various additional variables that may potentially explain seabird catch rates and mortality require collection for effort standardisation to enable assessments of whether bycatch mitigation methods are meeting explicit or otherwise implicit seabird bycatch management objectives.

Within these categories, for each data field record, the spreadsheets identify whether the field is a seabird bycatch mitigation method. This includes fields on the employment and design of seabird bycatch mitigation methods, such as, for pelagic longline fisheries: time of day of initiating and ending setting, location from the deck where baited hooks are set, branchline weighting design (leader length, mass of branchline weights, fixed in place vs. sliding weights), single and paired tori lines, towed objects, blue-dyed bait, bait condition (thaw condition, live vs. dead), underwater setting devices, hook-shielding devices, bird curtains, and practices for managing offal and spent bait. The spreadsheets also categorised fields into essential (minimum) and desirable (optimal) requirements for collection by EM systems to enable meeting seabird monitoring objectives, using the categorisation scheme defined in Section 2.

Explained above, the spreadsheets attempt to only include fields that are unlikely to be included in the fisheries monitoring programme if not for the purpose of monitoring seabirds. For example, data fields on the geospatial location of fishing effort, date and time-of-day of setting and hauling, fishing effort, shark lines (branchlines attached to floats or floatlines instead of to the mainline, designed to fish shallow to target epipelagic sharks), light sticks, skipper and vessel unique IDs and vessel equipment that affect fishing power (including technology aids for fish finding and for gear deployment and retrieval) are excluded from the pelagic longline spreadsheet as these

essential fields are likely to already be included as part of a fisheries monitoring (observer and/or EM) programme (ISSF and FAO, 2015). The field branchline automatic coiler is, however, included because it is categorised as an essential, minimum data field, the use of this equipment can significantly affect seabird captures during hauling (Gilman et al., 2014), and this data field may not be typically included in pelagic longline monitoring programmes (ISSF and FAO, 2015). Refer to Wolfaardft and Debski (2021) for a comprehensive list of essential data fields.

The data collection protocols described in the gear-specific spreadsheets are illustrative examples and not meant to be prescriptive. Discussed previously, the protocols adopted for an individual EM programme will be determined by data collection requirements of the observer programme for covered fisheries. If the EM system is part of a national monitoring programme that is also part of a sub-regional or regional observer programme, then consistent data collection protocols should be used for each of the nested systems.

The spreadsheets categorise each field as being collected on a trip basis, set basis, or to describe each capture event. Furthermore, the spreadsheets categorise each data field as being able to be collected by contemporary EM systems either almost always, sometimes, or almost or always never. For those included in the latter category, then the EM system would require use of a complementary monitoring method such as dockside data collection.

5. Fisher Cooperation, Complementary Dockside Monitoring

For some fields, fisher cooperation and/or complementary dockside monitoring is currently required. For example, contemporary EM systems are unable to support estimates of the length or area of fleets of panels used in gillnet fisheries, which can be collected through dockside monitoring and reported by fishers (Bartholomew et al., 2018). Also, for example, contemporary EM systems have been unable to support analysts to collect data on longline branchline leader length and the mass of branchline weights, which affect baited hook sink rates and seabird catch risk (Gilman et al., 2019, 2021), which could be collected dockside. EM systems require fishers' cooperation to place catch at designated locations on deck to enable the use of EM digital length measurement tools. Some EM systems may also require crew to discard catch only from positions on deck that are within EM cameras' fields of view. All EM systems currently require fishers to periodically clean camera lenses and not obstruct cameras' fields of view. EM systems, therefore, are not wholly passive but require active support from fishers.

6. EM Coverage Rate and Sampling Design

As with observer programmes, the EM sampling design should account for sources of sampling bias, including the use of randomised and balanced sampling, appropriate stratification, and adequate sample sizes per stratum. To avoid statistical sampling bias, the necessary coverage rate for an individual fishery depend on: (1) the objectives of analysis, including required levels of accuracy and precision of seabird species-specific catch rates, and (2) aspects of the individual fishery, such as how many vessel classes exist, how many ports are used, the spatial and

temporal distribution of effort, the frequency of occurrence of catch interactions for each species of interest, the amount of fishing effort, and the spatial and temporal distribution of catch. In general, variability in precision and biases in bycatch estimates decrease rapidly as the observer coverage rate increases to 20%, assuming that the sample is balanced and there are no observer effects. Some fisheries, however, may require 100% coverage, for example, to implement output controls such as a seasonal bycatch limit for non-retained, rare species.

Ideally, 100% of EM imagery and sensor data would be processed for seabird monitoring. Because 100% monitoring via EM, where there are EM systems on all vessels and analysis of all EM imagery and sensor data, may be cost-prohibitive for some fisheries, an EM audit model might be a suitable alternative. This may be necessary to balance costs with monitoring and compliance benefits. With an EM audit design, EM systems would occur fleetwide. A random sample of EM imagery would be reviewed to validate the precision of logbook data, incentivising compliance with logbook data recording and with prescribed seabird bycatch mitigation measures. Because EM analysis is about half of the total cost of EM programmes, an audit model can provide substantial cost savings without compromising monitoring data quantity or quality (see Emery et al., 2019 for Australia's experience implementing an EM audit model). In addition, a risk-based framework can be employed. If a review of a sample of EM data from a trip determines that a vessel had high bycatch rates of vulnerable species, lack of compliance with seabird bycatch regulations, systematic misreporting of logbook data, or other risks, then 100% of the EM data from that trip would undergo review, and the vessel would have a larger proportion of EM data processed during subsequent trips.

EM technology, however, is likely to become increasingly efficient and operating costs are likely to decrease. For example, as the review of EM imagery and other data is increasingly automated through machine learning, large EM sampled coverage rates will become more cost-effective. Image recognition software that can support accurate species-level identifications in multispecies fisheries, however, may be many years hence, as the machine learning process requires tens of thousands of images (Kumar et al., 2012; Kennelly and Hager, 2018). Automated image recognition by high-level taxonomic groups, including differentiating when the catch is a seabird, and software that can identify categories of species within these groups, may also be feasible in the short term (Rossi et al., 2016). This latter function, in turn, could be combined with near real-time satellite data transmission of protected species interactions, including seabirds.

7. Other EM System Recommendations Relevant but Not Specific to Meeting Seabird Monitoring Objectives

Independent assessment: EM systems should be independently assessed to determine if they meet minimum requirements.

Confidentiality and privacy: Adopt rules to ensure that EM data are handled in a manner that complies with relevant requirements related to the confidentiality of commercial fisheries data and to fishers' personal privacy.

Technical measures: Minimum technological specifications of EM equipment (including cameras, sensors, data storage devices) should be defined. This includes: provisions to ensure that EM equipment and EM data are as tamper-proof as technology permits, installation protocols, fields-of-view of cameras, image resolution, frame rate for still photos and time lapse video, and when the EM system is required to be recording data (e.g., continuous during entire trip, during setting and hauling). It also includes: required sensors, technology to identify when the system malfunctions, operation and maintenance, technology for EM data storage, minimum data storage capacity, protocols for retrieving stored data from vessels (e.g., via mobile networks, wi-fi, satellite, or manually through exchange of hard drives), and EM reviewing software.

EM equipment malfunctions: Protocols to be implemented when EM equipment malfunctions should be defined. This would include technical measures, such as requiring EM systems to provide real-time, automated alerts when the system is malfunctioning, and logistical protocols on how malfunctions would be addressed.

Logistics: Minimum chain-of-custody protocols and operating procedures for the transfer and management of EM data, including backup of EM data on vessels, and storage of EM data, including how long EM data are required to retained, need to be defined.

EM analysis and integration into relevant datasets: Minimum requirements for reviewing EM data, including QA/QC protocols, format of resulting datasets – including requirements to ensure the EM database is compatible with and can be integrated with relevant human observer databases, and process for integration into national and/or regional monitoring datasets need to be defined.

Response to non-compliance: Protocols, including surveillance, identification of infractions, enforcement actions and sanctions, for the EM system, including for deliberate tampering of EM equipment and tampering with EM data, should be defined.

EM analyst minimum qualifications: Minimum knowledge, skills and training for EM analysts, similar to standards for observers, should be defined, including measures to ensure that staff have no conflicts of interest.

8. References

ACAP. 2019. *ACAP Seabird Bycatch Working Group Intersessional Work Plan, 2019-2021*. Agreement for the Conservation of Albatrosses and Petrels, Hobart, Australia.

Bartholomew, D., Mangel, J., Alfaro-Shigueto, J., Pingo, S., Jiminez, A., Godley, B. 2019. Remote electronic monitoring as a potential alternative to on-board observers in small-scale fisheries. *Biological Conservation* 219: 35-45.

Emery, T.J., Noriega, R., Williams, A.J., Larcombe, J., 2019. Changes in logbook reporting by commercial fishers following the implementation of electronic monitoring in Australian Commonwealth fisheries. *Marine Policy* 104, 135–145.

Emery, T.J., Noriega, R., Williams, A., et al. 2018. The use of electronic monitoring within tuna longline fisheries: implications for international data collection, analysis and reporting. *Reviews in Fish Biology and Fisheries* 28: 887–907.

FAO. 2020. *The State of World Fisheries and Aquaculture 2020. Sustainability in Action*. Food and Agriculture Organization of the United Nations, Rome.

Gilman, E., Castejon, V.D.R., Loganimoce, E., Chaloupka, M. 2020. Capability of a pilot fisheries electronic monitoring system to meet scientific and compliance monitoring objectives. Marine Policy 113: 103792.

Gilman, E., Chaloupka, M., Wiedoff, B., Willson, J. 2014. Mitigating seabird bycatch during hauling by pelagic longline vessels. PLoS ONE 9(1): e84499.

Gilman, E., Hall, M. 2015. Potentially Significant Variables Explaining Bycatch and Survival Rates and Alternative Data Collection Protocols to Harmonize Tuna RFMOs' Pelagic Longline Observer Programmes. Appendix 1 to WCPFC-SC11-2015/EB-IP-05. Western and Central Pacific Fisheries Commission, Kolonia, Pohnpei, Federated States of Micronesia.

Gilman, E., Legorburu, G., Fedoruk, A., Heberer, C., Zimring, M., Barkai, A. 2019. Increasing the functionalities and accuracy of fisheries electronic monitoring systems. Aquatic Conservation: Marine and Freshwater Ecosystems 29: 901-926.

Gilman, E., Chaloupka, M., Ishizaki, A., et al. 2021. Tori lines mitigate seabird bycatch in a pelagic longline fishery. *Reviews in Fish Biology and Fisheries* 10.1007/s11160-021-09659-7.

ISSF and FAO. 2015. *Report of the Tuna RFMO Expert Working Group: Harmonisation of Longline Bycatch Data Collected by Tuna RFMOs. 27-29 January 2015, Keelung, Taiwan*. ISSF Technical Report 2015-08. International Seafood Sustainability Foundation and Food and Agriculture Organization of the United Nations, Washington, D.C. and Rome.

Kennelly, S., Hager, M. 2018. *Implementing and Improving Electronic Reporting and Monitoring in New England Fisheries*. IC Independent Consulting and Gulf of Maine Research Institute, Sydney, Australia and Portland, Maine, USA.

Kumar, N., Belthumeur, P., Biswas, A., et al. 2012. Leafsnap: a computer vision system for automatic plant species identification. In: Fitzgibbon A. (Ed.). *Computer Vision–ECCV*. Springer-Verlag, Berlin Heidelberg.

Michelin M, Elliott M, Bucher M, Zimring M, Sweeney M. 2018. *Catalyzing the Growth of Electronic Monitoring in Fisheries*. California Environmental Associates and The Nature Conservancy, San Francisco.

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*. IOTC-2020-Sc23-12[E]. Indian Ocean Tuna Commission, Mahe, Seychelles.

Reid T, Sullivan B. 2004. Longliners, black-browed albatross mortality and bait scavenging in Falkland Island waters: what is the relationship? Polar Biol. 27: 131–139.

Roman, M., Lopez, J., Lennert-cody, C., Ureña, E., Aires-da-Silva, A., 2020. *An Electronic Monitoring System for the Tuna Fisheries in the Eastern Pacific Ocean: Objectives and Standards*. Doc. SAC-11-10 1–23. Inter-American Tropical Tuna Commission, La Jolla, USA.

Rossi, F., Benso, A., Carlo, S., Politano, G., Savino, A., & Acutis, P.L. 2016. FishAPP: A mobile App to detect fish falsification through image processing and machine learning techniques. Pp. 1-6 IN Miclea, L (Ed.). *2016 IEEE International Conference on Automation, Quality and Testing, Robotics (AQTR)*. DOI: 10.1109/AQTR.2016.7501348.IEEE, Piscataway, USA.

Van Helmond, A., Catchpole, T., Mortensen, L., et al. 2019. Electronic monitoring in fisheries: Lessons from global experiences and future opportunities. *Fish and Fisheries* 21: 162-189.

WCPFC. 2020. *Annex A. Minimum Standards for Electronic Monitoring Programmes. Draft Consultative Proposal for a CMM for a Regional E-Monitoring Programme*. Western and Central Pacific Fisheries Commission, Kolonia, Federated States of Micronesia.

Wolfaardft, A., Debski, I. 2021. *Data Collection Guidelines for Observer Programmes to Improve Knowledge of Fishery Impacts on ACAP-Listed Species*. Rev. 1. Agreement on the Conservation of Albatrosses and Petrels, Hobart, Australia.

9. Appendices

Guidelines on data fields and data collection protocols for fisheries EM system for seabird interactions in:

Appendix 1: Pelagic longline fisheries
Appendix 2: Demersal longline fisheries
Appendix 3: Trawl fisheries
Appendix 4: Set, staked and drift gillnet fisheries and trammel net fisheries
Appendix 5: Non-tuna purse seine fisheries

Appendix 1. Guidelines on Data Fields and Data Collection Protocols for Fisheries EM System for Seabird Interactions in Pelagic Longline Fisheries

Table 1. Data fields and illustrative data collection protocols for electronic monitoring systems for pelagic longline fisheries to meet objectives of monitoring seabird interactions (adapted from Emery et al., 2018; Gilman et al., 2019, 2020, 2021; Murua et al., 2020). Only data fields considered to be either (1) essential, minimum, high priority variables for monitoring seabird interactions, and (2) are variables that significantly explain seabird catch and mortality risk and otherwise would not likely be included in a monitoring programme if not for the purpose of monitoring seabirds. For the column "could be collected by EM system", Y=almost always, M=sometimes, N=almost or always never (and hence would require use of a complementary monitoring method such as dockside data collection).

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?
Catch	N	D	Anatomical hooking position	When catch is retrieved to the vessel, where in the body was the hook lodged	Catch	M	Y
Catch	N	D	Capture mechanism	Was the seabird hooked, entangled in line, both	Catch	M	Y
Catch	N	D	Catch depredated	Was there evidence of depredation – part of the catch was bitten off by a shark, whale, squid, etc.	Catch	M	Y
Catch	N	D	Catch depredation species	For depredated catch, which organism conducted the depredation	Catch	M	Y
Catch	N	E	Condition of catch at vessel	Life status of catch when retrieved at the vessel, e.g., alive, dead, degree of injury, waterlogged	Catch	M	Y
Catch	N	E	Condition of catch upon release, if not retained	Life status of catch upon release, e.g., alive, dead, degree of injury	Catch	M	Y
Catch	Y	E	Fate	What did the crew do with the catch after retrieval, e.g., retain, discard dead, release alive	Catch	Y	Y
Catch	N	D	Hook number of the catch	On which hook between two floats was the seabird captured (2 categories – 2 hooks next to float, other hooks between floats)	Catch	N	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?
Catch	N	D	Length	For seabirds that are dead upon gear retrieval, crew place the seabird on the deck at the designated position, and extend, straighten, and flatten the wings. The EM analyst uses the digital length measurement tool to estimate the length of one wing, from wrist to tip of the longest primary, flattened and straightened, to the nearest cm.	Catch	M	Y
Catch	N	E	Species or higher-level grouping	Species or otherwise higher-level grouping of each captured seabird	Catch	M	Y
Catch	N	E	Tag or ring data	Content of a tag or ring attached to a caught organism	Catch	M	Y
Catch	N	D	Tag recovery	If the catch had a tag attached, and the catch was not retained, was the tag removed prior to release?	Catch	M	N
Catch	N	D	Tag type	If a tag is attached to a caught organism, what type of tag was it)	Catch	N	Y
Catch	N	D	Terminal tackle attached at vessel	Which type of each terminal tackle component (hook shape, hook size, hook offset, bait type, leader material, leader length, branchline material, branchline diameter, etc.) was attached to the catch when retrieved	Catch	N	Y
Derelict gear	N	D	Abandoned, lost and discarded fishing gear	Record the amount of abandoned, lost and discarded fishing gear. E.g., during a set, was a section of the mainline containing branchlines with baited hooks abandoned or lost.	Set	M	N
Environmental	N	D	Lunar illumination	How bright is it during fishing operations at night, outside of areas affected by deck lighting; lux is the standard unit of measurement	Set	N	N
Environmental	N	D	Sea state / Beaufort wind force scale	Sea state as measured using the Beaufort wind force scale	Set	Y	N
Environmental	N	D	Wind direction	During the set and haul, measure the direction of the wind true bearing and in relation to the vessel course	Set	M	N
Escape	N	D	Escape during the gear haulback	During the gear haulback, observation of a seabird escaping from the gear	Catch	M	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?
				prior to the gear being handled by crew (e.g., throws the hook)			
Fishing method	N	D	Automatic branchline coiler used during haul	During each haul, did the crew use an automatic branchline coiler device	Set	Y	N
Fishing method	Y	E	Bait casting machine used during set	During each set, did the crew use a bait caster	Set	Y	N
Fishing method	Y	D	Bait thawed condition	During each set, was the bait completely thawed, partially thawed, frozen	Set	N	N
Fishing method	Y	E	Date and time of the start and end of the set and haul	Self-explanatory	Set	Y	N
Fishing method	Y	E	Latitude and longitude of the start and end of the set and haul	Self-explanatory. Some seabird bycatch management systems require the employment of bycatch mitigation methods in specified areas.	Set	Y	N
Fishing method	Y	E	Mainline line shooter attachment location	If a mainline line shooter was on the vessel, was it attached at the stern, or if on the vessel side, how far from the stern corner	Set	Y	N
Fishing method	Y	E	Offal and spent bait management method	Was offal and/or spent bait retained during the entire trip, or otherwise discharged during setting, hauling, or other fishing operation, and was offal and/or spent bait discharged on the opposite side of the vessel from where setting or hauling occurs	Set	Y	N
Fishing method	Y	E	Side or stern set	Did crew set branchlines from the vessel side or from the stern	Set	Y	Y
Gear	N	D	Bait length	What was the length of each bait type used	Set	N	N
Gear	Y	E	Bait live vs. dead	For each bait type used, what proportion was alive vs. dead	Set	N	N
Gear	N	E	Bait species, proportion of hooks by each bait type	Identify each species used for bait, and for each bait species used, on what proportion of hooks was this bait species used	Set	N	N
Gear	Y	E	Bird curtain deployed during set and haul	During each set and haul, was a bird curtain deployed	Set	Y	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?
Gear	Y	E	Blue-dyed bait dyed treatment	During the set, if bait was dyed blue, was it dyed to a darkness that met regulatory requirements	Set	N	N
Gear	Y	E	Blue-dyed bait used	During the set, was bait dyed blue (and was it dyed to a darkness that met regulatory requirements)	Set	Y	N
Gear	N	D	Branchline weight type	Were branchline weights fixed in position or a sliding design	Set	Y	Y
Gear	Y	E	Hook-shielding device used during setting	During each set, was a hook-shielding device attached to the hooks, and for what proportion of the hooks set was a hook-shielding device attached	Set	N	Y
Gear	Y	E	Leader length	Distance between a branchline weight and the hook	Set	N	N
Gear	Y	E	Mainline line shooter used	Was a mainline line shooter used to deploy the mainline	Set	Y	N
Gear	Y	E	Mass of branchline weight	Identify each branchline weight amount used in each set and the proportion of hooks with each weight amount	Set	N	N
Gear	Y	E	Tori line aerial coverage astern	How far astern did the aerial portion of the tori line extend	Set	N	Y
Gear	Y	E	Tori line single or double	Was a single or double streamer line design used, and if double, were the tori lines deployed on opposite sides of the mainline	Set	Y	Y
Gear	Y	E	Tori line spacing and length of streamers	How far apart were the streamers on the tori line, and how long were the streamers	Set	N	Y
Gear	Y	E	Tori line used during haul	Was a tori line deployed during the haul	Set	Y	Y
Gear	Y	E	Tori line used during set	Was a tori line deployed during the set	Set	Y	Y
Gear	Y	E	Tori pole height above sea surface	Self-explanatory. The height of the tori attachment position above sea level, distance from stern, and horizontal distance to point where mainline leaves the vessel. Or, measure the height of the tori line(s) at the stern.	Set	N	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?
Gear	Y	E	Towed object	During the set and haul, was a towed buoy or other object deployed	Set	Y	Y
Gear	Y	E	Underwater setting device used	Did crew deploy baited hooks through an underwater setting device	Set	Y	Y
Handle/release	Y	D	Handling and release equipment	What seabird handling and release equipment (line cutter, dehooker, dipnet) was onboard during the trip	Trip	N	Y
Handle/release	Y	D	Handling and release methods employed	What methods and equipment were used for handling and release	Catch	N	Y
Handle/release	Y	D	Terminal tackle remaining attached to live released catch	For catch released alive, what gear components and what length of line remained attached	Catch	N	Y
Non-catch interaction	N	D	Collision with vessel structure	Observation of a seabird colliding with the vessel	Non-catch interaction	M	Y
Non-catch interaction	N	D	Secondary interaction	During setting or hauling, observation of a relatively small species of deep-diving seabird bringing a baited hook to the sea surface where a larger seabird species accessed the terminal tackle, and whether the interaction resulted in either (a) contact with hook or bait by the larger seabird species but not captured, or (b) capture of the larger seabird species.	Non-catch interaction	M	Y
Other	N	D	Sightings of seabird species during fishing operation for which no interaction occurred	Record sightings of endangered, threatened and protected (ETP) species, including the number of adults, number of juveniles, length, distance from vessel, behaviour, vessel activity during sighting, etc. ETP species may include sharks, rays, seabirds, sea turtles, marine mammals.	Trip	M	Y
Seabird scan counts	N	D	Seabird scan counts (seabird density)	Count of each seabird species within specified distance of the vessel during all fishing operations (set, soak, haul, transit)	Set	N	Y
Vessel and vessel equipment	N	D	Automatic branchline coiler	Did the vessel have an automatic branchline coiler device onboard during the trip	Trip	Y	N

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?
Vessel and vessel equipment	Y	E	Bait casting machine	Did the vessel have a bait caster device onboard during the trip	Trip	Y	N
Vessel and vessel equipment	Y	E	Mainline line shooter presence	Did the vessel have a mainline line shooter onboard	Trip	Y	N

Appendix 2. Guidelines on Data Fields and Data Collection Protocols for Fisheries EM System for Seabird Interactions in Demersal Longline Fisheries

Table 2. Data fields and illustrative data collection protocols for electronic monitoring systems for demersal longline fisheries to meet objectives of monitoring seabird interactions. Adapted from New Zealand Government observer protocols. Only data fields considered to be either (1) essential, minimum, high priority variables for monitoring seabird interactions, and (2) are variables that significantly explain seabird catch and mortality risk and otherwise would not likely be included in a monitoring programme if not for the purpose of monitoring seabirds. For the column "could be collected by EM system", Y=almost always, M=sometimes, N=almost or always never (and hence would require use of a complementary monitoring method such as dockside data collection).

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	When / where field is recorded	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?
Catch	N	D	Capture	Catch depredation species	For depredated catch, which organism conducted the depredation	Catch	M	Y
Catch	N	E	Capture	Fate and condition of catch upon release, if not retained	Retained, sampled and discarded dead, discarded dead, released alive uninjured, released alive injured, released alive but unlikely to survive, tagged (live, dead / dying)	Catch	Y	Y
Catch	N	E	Capture	Injury	Broken wing, broken beak, open wound, swallowed hook, bleeding, injured by crew, killed by crew,	Catch	M	Y
Catch	N	D	Capture	Interaction type	Fishing gear, mitigation device, vessel strike, brought onboard by crew (not caught in fishing gear), recreational gear, other,	Catch	Y	Y
Catch	N	E	Capture	Life status when first observed (condition of catch at vessel)	Alive, dead, decomposing, waterlogged, evidence of predation	Catch	Y	Y
Catch	N	D	Capture	Line position	Position of capture relative to adjacent floats and weights	Catch	M	Y
Catch	N	D	Capture	Location of capture	Tangled (mainline, branchline, float), hooked, hooked and tangled, tori line, haul mitigation device, other	Catch	M	Y
Catch	N	D	Capture	Part of body	Body, wing, foot, head, bill,	Catch	Y	Y
Catch	N	E	Capture	Position of capture	Latitude and longitude	Catch	Y	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	When / where field is recorded	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Catch	N	E	Capture	Species or higher-level grouping	May not be possible to identify all seabirds to the species level, so higher-level groupings may be used. Include tag with observer ID, camera ID, or autopsy ID	Catch	M	Y
Derelict gear	N	D	Set and haul	Abandoned, lost and discarded fishing gear	Metres of mainline, count of hooks, floats, weights, branchlines, number of tori lines. Gear loss requires quantification at set and haul.	Set	M	N
Environmental	N	D	Haul	Haul ambient light	Hard to measure with vessel lighting - possibly prior to and after set with deck lights off. Lux or categorical: whether or not horizon can be distinguished.	Set / catch	N	Y
Environmental	N	D	Haul	Haul Beaufort scale	Used as an approximation of sea state	Set / catch	N	Y
Environmental	N	D	Haul	Haul swell height and direction	Haul swell height and direction	Set	M	Y
Environmental	N	D	Haul	Haul wind direction	True bearing and relative to vessel course	Set / catch	N	Y
Environmental	N	D	Haul	Haul, cloud cover	Percentage, unknown	Set / catch	N	Y
Environmental	N	D	Set	Set ambient light	Hard to measure with vessel lighting - possibly prior to and after set with deck lights off. Lux or categorical: whether or not horizon can be distinguished.	Set / catch	Y	Y
Environmental	N	D	Set	Set Beaufort scale	Used as an approximation of wind speed and sea state	Set / catch	N	Y
Environmental	N	D	Set	Set cloud cover	Percentage	Set	N	Y
Environmental	N	D	Set	Set swell height and direction	Set swell height and direction	Set	N	Y
Environmental	N	D	Set	Set wind direction	True bearing and relative to vessel course	Set / catch	N	Y
Escape	N	E	Set and haul	Observation of a bird becoming 'uncaught'	Observation of a bird becoming 'uncaught'	Catch	M	Y
Fishing method	Y	D	Set	Bait type	Species, size, whole or cut, proportion of hooks, state (thawed, semi thawed, frozen, salted)	Set	N	N

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	When / where field is recorded	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Fishing method	N	E	Set	Distance from stern to bait entry point	Horizontal distance (average, maximum and minimum)	Set	Y	Y
Fishing method	N	D	Haul	Haul proximity of other vessels	Haul proximity of other vessels	Set / catch	N	Y
Fishing method	Y	E	Haul	Haul time	Duration of the haul, noting any breaks	Set	Y	N
Fishing method	N	D	Haul	Haul track	Latitude and longitude and time. Need to monitor how line is hauled to be able to relate seabird bycatch to conditions during the set	Set	Y	Y
Fishing method	N	D	Set	Hooks above end weight / anchor	Number and distance	Set	Y	N
Fishing method	N	E	Set	Number of hooks set	Record the number of hooks deployed in the set	Set	Y	N
Fishing method	N	E	Set	Set duration	Start and end - hook to hook	Set	Y	N
Fishing method	N	D	Set	Set proximity of other vessels	From other vessels EM data	Set / catch	N	N
Fishing method	N	E	Set	Set track	Latitude and longitude and time	Set	Y	Y
Fishing method	Y	E	Set	Setting speed	Knots, can calculate from vessel track	Set / catch	Y	N
Fishing method	N	D	Non-fishing	Vessel activity	Vessel activity codes to describe time not fishing, (including use of deck lights)	Set	Y	N
Fishing method	N	D	Non-fishing	Vessel track	Records searching, travelling, and non-fishing periods, time and position	Set	Y	Y
Fishing method	Y	E	Haul	Waste control during hauling	Quantity, type (offal, bait, whole fish), location on vessel (hauling side, 'off' side, stern, frequency)	Set / catch	Y	Y
Gear	N	E	Set or dockside	Baiting method	Manual, auto	Set	Y	N
Gear	N	D	Set or haul and dockside	Branchline	Material, length, spacing	Set	N	N
Gear	N	D	Set or haul and dockside	Hook	Type, size, measurements	Set / catch	N	N
Gear	Y	D	Set or haul and dockside	Line floats (subsurface)	Material, size, buoyancy, spacing (number hooks and distance), rope length (distance to mainline)	Set / catch	M	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	When / where field is recorded	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?
Gear	Y	D	Set or haul and dockside	Line weights	Material, size, spacing (number hooks and distance), rope length (distance to mainline)	Set / catch	M	Y
Gear	N	D	Dockside	Mainline description	Material, diameter, kilograms per metre if integrated weight	Trip	N	N
Handle/release	Y	D	Dockside	Handling and release equipment	What seabird handling and release equipment (bolt cutters, dehooker, dipnet) was onboard during the trip	Trip	N	Y
Handle/release	Y	D	Haul	Handling and release methods employed	What methods and equipment were used for handling and release	Catch	Y	Y
Handle/release	Y	D	Haul	Terminal tackle remaining attached to live released catch	For catch released alive, what gear components and what length of line remained attached	Catch	M	Y
Seabird local abundance	N	E	Haul	Haul abundance counts by species or species group	Counts within defined areas, can be split by birds in the air and on the water, typically within 100 m	Set	Y	Y
Seabird local abundance	N	E	Set	Set abundance counts by species or species group	Counts within defined areas, can be split by birds in the air and on the water, typically within 100 m	Set	Y	Y
Seabird local behaviour	N	D	Set	Interaction rates or categorical data	Various metrics	Set	Y	Y
Seabird local behaviour	N	D	Haul	Interaction rates or categorical data	Various metrics	Set	Y	Y
Vessel and vessel equipment	Y	E	Haul	Haul acoustic deterrent	Yes / no	Set / catch	Y	Y
Vessel and vessel equipment	Y	E	Haul	Haul bird exclusion device	Yes / no (whether or not the hauling station was completely enclosed by a bird exclusion device)	Set / catch	Y	Y
Vessel and vessel equipment	Y	E	Haul	Haul deck lighting	Arbitrary as to whether it is more than absolutely necessary - ideally a measure (lux) immediately beside the hauling station would be best	Set	M	Y
Vessel and vessel equipment	Y	E	Haul	Haul moon pool	Yes / no	Set / catch	Y	Y
Vessel and vessel equipment	Y	E	Haul	Haul towed object	Yes / no (whether a buoy or other object was towed to reduce access to hauling station)	Set / catch	Y	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	When / where field is recorded	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Vessel and vessel equipment	Y	E	Haul	Haul water deterrent	Yes / no	Set / catch	Y	Y
Vessel and vessel equipment	Y	E	Set or dockside	Line setting height	Distance above sea surface line leaves the vessel	Set / catch	N	Y
Vessel and vessel equipment	Y	D	Set	Line sink profile	Time and depth of longline backbone after it leaves the vessel	Set	M	Y
Vessel and vessel equipment	Y	E	Set	Number of tori lines used	If multiple tori lines used all tori fields should be completed per tori line	Set / catch	Y	Y
Vessel and vessel equipment	Y	E	Haul	Other haul mitigation device	Yes / no, if yes add description	Set / catch	Y	Y
Vessel and vessel equipment	Y	E	Set	Other set mitigation used	Yes, no, if yes then description	Set	Y	Y
Vessel and vessel equipment	Y	E	Set	Set acoustic deterrent used	Yes / no	Set / catch	N	Y
Vessel and vessel equipment	Y	E	Set	Set deck lighting	Arbitrary judgement as to whether it is more than absolutely necessary - a measure (lux) immediately astern would be best	Set	Y	Y
Vessel and vessel equipment	Y	E	Set	Set laser deterrent used	Yes / no	Set / catch	M	Y
Vessel and vessel equipment	Y	E	Set	Set underwater setter used	Yes / no	Set / catch	Y	Y
Vessel and vessel equipment	Y	E	Set	Tori aerial extent	Estimated by streamer count, maximum and minimum	Set / catch	M	Y
Vessel and vessel equipment	Y	D	Set	Tori attachment position	Height above sea level, distance from stern and horizontal distance to point where mainline leaves the vessel. Or measure the height of the tori line(s) at the stern.	Trip	N	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	When / where field is recorded	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Vessel and vessel equipment	Y	D	Set	Tori distance to longline (horizontal)	Likely to vary along its length	Set / catch	M	Y
Vessel and vessel equipment	Y	D	Set	Tori efficacy	Bird behaviour astern relative to the tori line, e.g., attack rates in beside and behind tori line.	Set / catch	Y	Y
Vessel and vessel equipment	Y	E	Set	Tori length	Total length	Set / catch	N	Y
Vessel and vessel equipment	Y	D	Set	Tori line diameter	May be two diameters for aerial and drag sections	Set / catch	N	Y
Vessel and vessel equipment	Y	E	Set	Tori line problem	Does not meet required specifications, deployed part way through set, streamers tangled, tangled with mainline, lost and replaced, lost and not replaced	Set / catch	Y	Y
Vessel and vessel equipment	Y	D	Set	Tori streamers	Material, length, configuration	Set / catch	N	Y
Vessel and vessel equipment	Y	D	Set	Tori towed object	Description (material, size, shape)	Set / catch	N	Y
Vessel and vessel equipment	Y	E	Set and haul	Vessel mitigation plan followed	Yes / no	Set	Y	Y
Vessel and vessel equipment	Y	E	Dockside	Vessel specific plan	Yes / no (whether or not the vessel had a vessel specific mitigation plan onboard)	Trip	N	Y
Vessel and vessel equipment	Y	E	Set	Waste discarded during setting	Quantity, type (offal, bait, whole fish), location on vessel (hauling side, 'off' side, stern, frequency)	Set	Y	Y

Appendix 3. Guidelines on Data Fields and Data Collection Protocols for Fisheries EM System for Seabird Interactions in Trawl Fisheries

Table 3. Data fields and illustrative data collection protocols for electronic monitoring systems for trawl fisheries to meet objectives of monitoring seabird interactions. Only data fields considered to be either (1) essential, minimum, high priority variables for monitoring seabird interactions, and (2) are variables that significantly explain seabird catch and mortality risk and otherwise would not likely be included in a monitoring programme if not for the purpose of monitoring seabirds. For the column "could be collected by EM system", Y=almost always, M=sometimes, N=almost or always never (and hence would require use of a complementary monitoring method such as dockside data collection).

Category	Seabird bycatch method?	Essential (E) or desirable (D)	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?
Catch	N	E	End status	What happened to the animal at the end of the incident	Capture	N	Y
Catch	N	D	If caught in fishing gear or mitigation device, location of capture	Fishing gear: caught on door or warp, internal net capture (the animal was caught inside the trawl net / codend / pounds, external capture (the animal was caught / tangled in the mesh of the codend), external net capture (the animal was caught in the mesh of the net wings / body), animal was caught in the centre net of a triple rig, animal was caught / tangled on the net lazyline or paravane, other capture location on a trawl vessel (explain). Mitigation device: tangled in tori line, caught in bird baffler, caught in warp scarer, caught in other (explain).	Capture	M	Y
Catch	N	D	If caught in fishing gear or mitigation device, part of body	Entire body caught, caught by wing, caught by feet, caught by head, caught by mouth, unknown	Capture	M	Y
Catch	N	E	Injury / bodily status	Broken or drooping wing, broken beak, broken leg, broken tail, open wound, killed by crew, injured by crew, severed body part, bleeding from orifices, breathing but unconscious, disoriented or uncoordinated, body in rigour, predated upon (e.g., by shark), decaying, waterlogged, greased / oiled, other, unknown	Capture	N	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D)	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Catch	N	D	Interaction type	Caught in fishing gear, caught in mitigation device, deck impact / deck landing and assisted off the vessel, brought on board but not entangled (e.g., riding the codend), caught in recreational gear (for interactions used on this vessel), other, unknown	Capture	N	Y
Catch	N	D	Length	Centimeters	Capture	N	Y
Catch	N	E	Life status when first sighted (at-vessel or haulback condition)	Alive, dead, decomposing	Capture	N	Y
Catch	N	E	Observation time	Time	Set	N	Y
Catch	N	D	Operating in accordance with any relevant vessel-specific seabird mitigation plan?	Yes, no, not applicable or unknown	Set	N	N
Catch	N	D	Sex	Sex	Capture	N	Y
Catch	N	D	Species or higher-level grouping	Species or higher-level grouping for each captured seabird	Capture	N	Y
Catch	N	E	Tag number or marking on animal at time of capture	Capture	Capture	N	Y
Derelict gear	Y	D	Did gear or any equipment failure event occur that increased the risk of seabird captures?	Yes or no, please describe if yes	Set	M	Y
Environmental	N	D	Batch discarding	Yes or no	Set	M	Y
Environmental	N	D	Batch discarding interval duration	Minutes	Set	M	Y
Environmental	N	D	Discharge rate	Constant, interrupted	Set	M	Y
Environmental	N	D	Discharge side	Port, starboard or both	Set	M	Y
Environmental	N	D	Discharge type	Describe	Set	M	Y
Environmental	N	D	Swell height	Metres, every 30 mins of set	Set	N	N
Environmental	N	D	Wind direction	Degrees, every 30 mins of set	Set	M	N
Environmental	N	D	Wind speed	Knots	Set	M	N

Category	Seabird bycatch method?	Essential (E) or desirable (D)	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Fishing methods	N	E	Trawl gear on the bottom time	Time	Set	M	Y
Fishing methods	N	E	Trawl shoot time	Time	Set	Y	Y
Fishing methods	N	E	Trawl turn time start and end	Time	Set	M	Y
Fishing methods	N	E	Vessel trawl heading	Degrees, record at shoot and if tow direction changes once tow started	Set	Y	N
Fishing methods	N	E	Vessel trawl speed	Knots, record once tow starts	Set	Y	N
Gear	Y	D	Angle from Dead Astern (degrees)	In degrees, record dockside	Trip	N	Y
Gear	Y	D	Bird baffler attachment location	Present / absent and distance to stern, record dockside	Trip	M	Y
Gear	N	E	Design headline height	Tenth of a metre, record dockside	Trip	N	N
Gear	Y	D	Distance between sea surface and bottom of dropper object	Metres, record dockside	Trip	N	Y
Gear	Y	D	Distance to Innermost Dropper (m)	Present / absent 4 x measures: port, side and aft, starboard side and aft (metres), record dockside	Trip	N	Y
Gear	Y	D	Distance to Outermost Dropper (m)	Present / absent 4 x measures: port, side and aft, starboard side and aft (metres), record dockside	Trip	N	Y
Gear	N	E	Door type and Area	Combination door, high aspect door, low aspect door, other, record dockside	Trip	N	N
Gear	Y	D	Dropper line length	Present / absent 4 x measures: port, side and aft, starboard side and aft (metres), record dockside	Trip	N	Y
Gear	Y	D	Dropper material colours	List all, record dockside	Trip	M	Y
Gear	Y	D	Dropper material types	List all, record dockside	Trip	M	Y
Gear	Y	D	Dropper object length	Present / absent 4 x measures: port, side and aft, starboard side and aft (metres), record dockside	Trip	N	Y
Gear	N	E	Headline length/Wingspread	If it is a multi-trawl system add up all of the headline lengths, record dockside	Trip	N	N
Gear	N	E	Lengthener mesh	Millimetres and configuration, record dockside	Trip	N	N

Category	Seabird bycatch method?	Essential (E) or desirable (D)	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Gear	Y	D	Light streamers - colour code	Record the color of the streamers, record dockside	Set	M	Y
Gear	Y	D	Light streamers - diameter	Record the diameter of streamers to the nearest mm, record dockside	Set	N	Y
Gear	Y	D	Light streamers - max length	Tenths of a metre, record dockside	Set	N	Y
Gear	Y	D	Light streamers - min length	Tenths of a metre, record dockside	Set	N	Y
Gear	Y	D	Light streamers - number of light streamers / pairs	Count, record dockside	Set	M	Y
Gear	Y	D	Light streamers - paired or single	P or S, record dockside	Set	M	Y
Gear	Y	D	Light streamers -distance between light streamers	Streamers that remain approximately the same length along the tori mainline, record dockside	Set	N	Y
Gear	Y	D	Long streamers - colour	Describe colour, record dockside	Set	M	Y
Gear	Y	D	Long streamers - cover aerial extent?	Yes or no, record dockside	Set	M	Y
Gear	Y	D	Long streamers - diameter	Millimetres, record dockside	Set	N	Y
Gear	Y	D	Long streamers - distance to first long streamer that reaches the water	Metres, record dockside	Set	N	Y
Gear	Y	D	Long streamers - material	Plastic tubing, plastic strapping, other, record dockside	Set	N	Y
Gear	Y	D	Long streamers - max distance between	Metres, record dockside	Set	N	Y
Gear	Y	D	Long streamers - max length	Tenths of a metre, record dockside	Set	N	Y
Gear	Y	D	Long streamers - min length	Tenths of a metre, record dockside	Set	N	Y
Gear	Y	D	Long streamers - number of long streamers that touch water	Count, record dockside	Set	M	Y
Gear	Y	D	Long streamers - paired or single	P or S, record dockside	Set	Y	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D)	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Gear	Y	D	Long streamers - present?	Long streamers = streamers which noticeably decrease in length along the tori mainline, record dockside	Set	M	Y
Gear	Y	D	Long streamers - total number / number of pairs	Count, record dockside	Set	M	Y
Gear	N	E	Max size of groundgear	Millimetres, record dockside	Trip	N	N
Gear	Y	D	Maximum Dropper Spacing	Present / absent 4 x measures: port, side and aft, starboard side and aft (metres), record dockside	Trip	N	Y
Gear	N	E	Net monitoring cable (third wire)	Present/absent	Set	Y	N
Gear	N	E	Number of codends	Count the number of codends; this will be two for a trouser trawl, and three for a triple trawl, record dockside	Trip	N	N
Gear	Y	D	Number of Droppers and Webbing Type	Count and type, record dockside	Trip	M	Y
Gear	Y	E	Number of tori lines used	If multiple tori lines used all tori fields should be completed per tori line, record dockside	Set	Y	Y
Gear	Y	E	Recovery rope	Yes or no. If yes, to tenth of a metre, record dockside	Set	M	Y
Gear	N	E	Sweep length	May be zero or near zero for midwater trawls. Measured from bridle to doors including backstrops. It is the outermost sweeps, record dockside	Trip	N	N
Gear	N	E	Top bridle length	This does include the length of laybacks, if included; record dockside	Trip	N	N
Gear	Y	E	Tori aerial extent	The distance from the back of the vessel to where the tori mainline enters the sea under normal setting speed; record dockside	Set	N	Y
Gear	Y	D	Tori attachment point - adjustable?	Yes or no; the tori is considered adjustable if the tori working position can be changed without changing the attachment point; record dockside	Set	N	Y
Gear	Y	D	Tori attachment point - distance from stern to attachment point	Tenths of a metre; record dockside	Set	N	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D)	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Gear	Y	D	Tori attachment point - height above water	The height of the tori attachment position above sea level, distance from stern, and horizontal distance to point where mainline leaves the vessel. Or measure the height of the tori line(s) at the stern.	Set	N	Y
Gear	Y	D	Tori attachment point - lateral distance from centre of stern	Tenths of a metre; record dockside	Set	N	Y
Gear	Y	E	Tori length	Total length of mainline / backbone; record dockside	Set	N	Y
Gear	Y	D	Tori line diameter	Diameter of mainline; record dockside	Set	N	Y
Gear	Y	D	Towed object	Options: 1. inverted funnel or plastic cone (diameter in cm); 2. length of thick line (length in metres); 3. knot or loop of thick line (length in metres); 4. buoy (diameter in cm); 5. mono or mainline (length in cm); 6. netted buoy (diameter in cm); 7. sack / bag (wet weight in kg); weight (wet weight in kg); 8. no towed object; 9. other (describe); record dockside	Set	M	Y
Gear	Y	D	Towed object - present	Yes or no; record dockside	Set	M	Y
Gear	Y	D	Towed object - size (measure depends on tow item, see 10 tow item options)	10 options. 1. inverted funnel or plastic cone (diameter in cm); 2. length of thick line (length in metres); 3. knot or loop of thick line (length in metres); 4. buoy (diameter in cm); 5. mono or mainline (length in cm); 6. netted buoy (diameter in cm); 7. sack / bag (wet weight in kg); weight (wet weight in kg); 8. no towed object; 9. other (describe); record dockside	Set	N	Y
Gear	N	E	Trawl wingless?	Yes, no, or unknown; record dockside	Trip	N	N
Seabird local abundance	N	E	Haul abundance counts by species or species group; record during the haul	Counts within defined areas, can be split by birds in the air and on the water, typically within 100 m	Set	Y	Y
Seabird local abundance	N	E	Set abundance counts by species or species group	Counts within defined areas, can be split by birds in the air and on the water, typically within 100 m	Set	Y	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D)	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Vessel and vessel equipment	N	D	Fish meal plant operating?	Yes or no	Set	M	N
Vessel and vessel equipment	Y	D	Fish waste management - was all fish waste held onboard during shooting and hauling?	Yes or no	Set	M	Y
Vessel and vessel equipment	Y	D	Fish waste management - was the discharge of fish waste managed as per an agreed plan?	Yes or no	Set	N	Y
Vessel and vessel equipment	Y	D	Fish waste management - was the net cleared of all stickers prior to shooting?	Yes or no	Set	M	Y
Vessel and vessel equipment	Y	D	Fish waste management - were there any periods of continuous fish waste discharge during the tow?	Yes or no	Set	M	Y
Vessel and vessel equipment	Y	D	Warp strike mitigation - was the primary warp strike mitigation device used in accordance with required specifications?	Yes or no	Set	M	Y
Vessel and vessel equipment	Y	D	Warp strike mitigation - were any other devices used instead of or in addition to the primary mitigation device?	Yes or no	Set	M	Y
Vessel and vessel equipment	Y	D	Was deck lighting at night reduced to minimum safe operating levels?	Yes or no	Trip	M	Y
Vessel and vessel equipment	Y	D	Was the amount of time the net spent at the surface minimised as much as possible?	Yes or no	Set	M	Y
Vessel and vessel equipment	Y	D	Were all seabirds captured alive handled with due care?	Yes or no	Trip	M	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D)	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Vessel and vessel equipment	Y	D	Were all seabirds captures recorded on relevant fisher returns, or electronically, as required?	Yes or no	Trip	N	Y
Vessel and vessel equipment	Y	D	Were spotlights shining directly astern controlled / dimmed during night setting?	Yes or no	Trip	M	Y

Appendix 4. Guidelines on Data Fields and Data Collection Protocols for Fisheries EM System for Seabird Interactions in Set and Staked Gillnet and Trammel Net Fisheries and Drift Gillnet Fisheries

Table 4. Data fields and illustrative data collection protocols for electronic monitoring systems for set, staked and drift gillnet fisheries and trammel net fisheries to meet objectives of monitoring seabird interactions (adapted from: Murua et al., 2020). Only data fields considered to be either (1) essential, minimum, high priority variables for monitoring seabird interactions, and (2) are variables that significantly explain seabird catch and mortality risk and otherwise would not likely be included in a monitoring programme if not for the purpose of monitoring seabirds. For the column "could be collected by EM system", Y=almost always, M=sometimes, N=almost or always never (and hence would require use of a complementary monitoring method such as dockside data collection).

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?	All-gears?
Catch	N	D	Catch depredated	Was there evidence of depredation - part of the catch was bitten off by a shark, whale, squid, etc.	Catch	M	N	Y
Catch	N	D	Catch depredation species	For depredated catch, which organism conducted the depredation	Catch	M	N	Y
Catch	N	E	Condition of catch at vessel (at-vessel or haulback condition)	Life status of catch when retrieved at the vessel, e.g., alive, dead, degree of injury, waterlogged	Catch	M	N	Y
Catch	N	E	Condition of catch upon release, if not retained	Life status of catch upon release, e.g., alive, dead, degree of injury	Catch	M	N	Y
Catch	Y	E	Fate	What did the crew do with the catch after retrieval, e.g., retain, discard dead, release alive	Catch	Y	N	Y
Catch	N	D	Length	For seabirds that are dead upon gear retrieval, crew place the seabird on the deck at the designated position, and extend, straighten and flatten the wings. The EM analyst uses the digital length measurement tool to estimate the length of one wing, from wrist to tip of the longest primary, flattened and straightened, to the nearest cm.	Catch	M	N	Y

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?	All-gears?
Catch	N	E	Species or higher-level grouping	Species or higher-level grouping for each captured seabird	Catch	M	N	Y
Catch	N	E	Tag data	Content of a tag attached to a caught organism	Catch	M	N	Y
Catch	N	D	Tag recovery	If the catch had a tag attached, and the catch was not retained, was the tag removed prior to release?	Catch	M	N	Y
Catch	N	D	Tag type	If a tag is attached to a caught organism, what type of tag was it	Catch	N	N	Y
Derelict gear	N	D	Abandoned, lost and discarded fishing gear	Record the amount of abandoned, lost and discarded fishing gear.	Set	M	N	Y
Environmental	N	D	Lunar illumination	How bright is it during fishing operations at night, outside of areas affected by deck lighting; could be measured using a lux meter or estimated using general categories.	Set	N	N	Y
Environmental	N	D	Sea state / Beaufort wind force scale	Sea state as measured using the Beaufort wind force scale	Set	Y	N	Y
Escape	N	D	Escape during the gear haulback	During the gear haulback, observation of a seabird escaping from the gear prior to the gear being handled by crew	Catch	M	Y	N
Fishing method	N	D	Attended or unattended	Was the gear attended during the gear soak	Set	Y	N	N
Fishing method	Y	E	Date and time of the start and end of the set and haul	Self-explanatory	Set	Y	N	N
Fishing method	Y	E	Latitude and longitude of the start and end of the set and haul	Self-explanatory. Some seabird bycatch management system require the employment of bycatch mitigation methods in specified areas.	Set	Y	N	N
Fishing method	N	E	Number of net panels set and hauled	Record the number of panels that were set and the number that were retrieved	Set	Y	N	N

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?	All-gears?
Gear	Y	E	Bait	Is bait placed in net	Set	N	N	N
Gear	Y	E	Color of net webbing	What is the color of the net webbing	Trip	N	N	N
Gear	N	E	Depth of panels below sea surface	What was the depth of the floatlines below the sea surface	Set	N	N	N
Gear	N	E	Distance between floats	The mean distance between floats measured along the head rope	Set	N	N	N
Gear	N	E	Dropline length	If used, what is the length of the droplines - the distance between the floats (which may be at the sea surface or submerged) to the float line.	Set	N	N	N
Gear	N	E	Hanging ratio	Length of the float line divided by length of the stretched meshes on the float line - how tightly the net is stretched.	Trip	N	N	N
Gear	N	E	Height (depth) of 1 panel	Average height of 1 panel (sheet)	Trip	N	N	N
Gear	N	E	Length of 1 panel	Average length (width) of 1 panel (sheet)	Trip	N	N	N
Gear	Y	E	Light-emitting device	Were light-emitting devices attached to the gear?	Set	Y	N	N
Gear	N	E	Mesh count, vertical	Number of vertical meshes in 1 panel (sheet). Count the number of meshes of the endline on the end of a panel where the meshes are attached.	Trip	N	N	N
Gear	N	E	Net/web material	Material that web meshes are made of (single strand monofilament, braided monofilament, twine, braided twine, etc.).	Trip	N	N	N
Gear	N	E	Number of panels	Number of panels (sheets) making up a string (fleet)	Set	M	N	N
Gear	N	E	Number of stacked panels	Number of stacked panels (sheets) with 2 or more panels sewn together vertically to fish 'double deep' within a string (fleet)	Set	M	N	N
Gear	Y	E	Pinger	Were pingers attached to the gear? If yes, record the number of pingers per panel or per string (fleet), and type of pinger (manufacturer and model if available).	Set	M	N	N

Category	Seabird bycatch method?	Essential (E) or desirable (D) data field for seabird monitoring	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?	All-gears?
Gear	N	E	Stationary, 1-end drifting, drifting	Is the gillnet anchored or staked and stationary, have one end stationary (e.g., attached to a vessel) and the other end drifting freely, or the entire net is drifting	Set	M	N	N
Gear	N	E	Stretched mesh size - 95% CI	Stretched mesh length (knot to knot) 95% CI from measuring 10 meshes, 2 each from 5 panels, to nearest mm	Trip	N	N	N
Gear	N	E	Stretched mesh size - mean	Mean stretched length (knot to knot) from measuring 10 meshes, 2 each from 5 panels, to nearest mm	Trip	N	N	N
Gear	N	E	Surface, midwater, bottom	Are the gillnet panels at the sea surface, midwater or on or near the seabed	Set	M	N	N
Gear	Y	E	Tie downs	For demersal nets, are tie downs used, and their heights	Trip	N	N	N
Handle/release	Y	D	Handling and release equipment	What seabird handling and release equipment (line cutter, dipnet) was onboard during the trip	Trip	N	Y	Y
Handle/release	Y	D	Handling and release methods employed	What methods and equipment did crew use to handle and release catch	Catch	N	Y	Y
Non-catch interaction	N	D	Collision with vessel structure	Observation of a seabird colliding with the vessel	Non-catch interaction	M	Y	Y
Other	N	D	Sightings of seabird species during fishing operation for which no interaction occurred	Record sighting of seabird species, including the number of adults, number of juveniles, length, distance from vessel, behaviour, vessel activity during sighting, etc.	Trip	M	Y	Y
Seabird scan counts	N	D	Seabird scan counts	Count of each seabird species within specified distance of the vessel during all fishing operations (set, soak, haul, transit)	Set	N	Y	Y
Vessel and vessel equipment	N	D	Hydraulic net hauler	Was a hydraulic net hauler onboard	Trip	Y	N	N

Appendix 5. Guidelines on Data Fields and Data Collection Protocols for Fisheries EM System for Seabird Interactions in Non-tuna Purse Seine Fisheries

Table 5. Data fields and illustrative data collection protocols for electronic monitoring systems for non-tuna purse seine fisheries to meet objectives of monitoring seabird interactions. Only data fields considered to be either (1) essential, minimum, high priority variables for monitoring seabird interactions, and (2) are variables that significantly explain seabird catch and mortality risk and otherwise would not likely be included in a monitoring programme if not for the purpose of monitoring seabirds. For the column "could be collected by EM system", Y=almost always, M=sometimes, N=almost or always never (and hence would require use of a complementary monitoring method such as dockside data collection).

Category	Seabird bycatch method ?	Essential (E) or desirable (D) data field for seabird monitoring	When / where field is recorded	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Catch	N	E	Capture	End status	Retained, sampled and discarded dead, discarded dead, released alive uninjured, released alive injured, released alive but unlikely to survive, tagged (live, dead / dying)	Catch	Y	Y
Catch	N	E	Capture	Injury	Broken wing, broken beak, open wound, swallowed hook, bleeding, injured by crew, killed by crew,	Catch	M	Y
Catch	N	D	Capture	Interaction type	Fishing gear, mitigation device, vessel strike, brought onboard by crew (not caught in fishing gear), recreational gear, other,	Catch	Y	Y
Catch	N	E	Capture	Life status when first observed	Alive, dead, decomposing, waterlogged, evidence of predation	Catch	Y	Y
Catch	N	D	Capture	Location of capture	Where bird was first observed; meshed in net, tangled between corks and net, loose in net, brail, pump separator, tanks	Catch	M	Y
Catch	N	D	Capture	Part of body	Body, wing, foot, head, bill,	Catch	Y	Y

Category	Seabird bycatch method ?	Essential (E) or desirable (D) data field for seabird monitoring	When / where field is recorded	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?
Catch	N	E	Capture	Position of capture	Latitude and longitude	Catch	Y	Y
Catch	N	E	Capture	Species or higher-level grouping	May not be possible to identify to species level, so other groupings may be used. Include tag with observer ID, camera ID, or autopsy ID	Catch	M	Y
Catch	N	D	Capture	Timing of capture	Set, purse, net rolling, net sacking, brailing / pumping, net cleaning	Catch	M	Y
Derelict gear	N	D	Set and haul	Abandoned, lost and discarded fishing gear	Description and quantity of any gear lost.	Set	M	N
Environmental	N	D	Set	Set ambient light	Hard to measure with vessel lighting - possibly prior to and after set with deck lights off. Lux or categorical: whether or not horizon can be distinguished.	Set / catch	Y	Y
Environmental	N	D	Set	Set Beaufort scale	Used as an approximation of sea state	Set / catch	N	Y
Environmental	N	D	Set	Set cloud cover	Percentage	Set	N	Y
Environmental	N	D	Set	Set swell height and direction	Set swell height and direction	Set	N	Y
Environmental	N	D	Set	Set wind direction	True bearing and relative to vessel course	Set / catch	N	Y
Escape	N	E	Set and haul	Observation of a bird becoming 'uncaught'	Observation of a bird becoming 'uncaught'	Catch	M	Y
Fishing method	N	D	Set	Fish left in net	Estimate of species and weight of any fish left in net after each fishing event	Set	Y	Y
Fishing method	N	E	Set	Net cleaning	Position and time for duration of event, estimate of species and quantity of fish discarded	Set	Y	N

Category	Seabird bycatch method ?	Essential (E) or desirable (D) data field for seabird monitoring	When / where field is recorded	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring -specific?
Fishing method	N	D	Set	School association - aircraft	Non-target species associated with school, visible from a spotter plane / helicopter e.g seabirds, rays, mammals, krill.	Set	N	N
Fishing method	N	D	Set	School association - vessel	Non-target species associated with school, visible from the vessel e.g., seabirds, rays, mammals, krill.	Set	M	N
Fishing method	N	D	Set	Set proximity of other vessels	From other vessels EM data	Set / catch	N	N
Fishing method	N	E	Set	Set time	Start and end, for different portions of fishing event: set, purse, rolling, sacking, brailing / pumping.	Set	Y	N
Fishing method	N	E	set	Set track	Position and time for duration of fishing event	Set	Y	N
Fishing method	N	D	Non-fishing	Vessel activity	Vessel activity codes to describe time not fishing, (including use of deck lights)	Set	Y	N
Fishing method	N	D	Non-fishing	Vessel track	Records searching, travelling, and non-fishing periods, time and position	Set	Y	Y
Fishing method	Y	E	Set	Waste control during fishing	Quantity, type (damaged or whole fish), location on vessel (hauling side, 'off' side, stern, frequency)	Set / catch	Y	Y
Gear	N	E	Dockside	Brail plan	Plan of brail construction, including dimensions, mesh sizes	Trip	N	N
Gear	N	E	Dockside	Net plan	Full plan of the purse seine net, including dimensions, Mesh sizes, float sizes, and details of how floats are attached to net	Trip	N	N

Category	Seabird bycatch method ?	Essential (E) or desirable (D) data field for seabird monitoring	When / where field is recorded	Data field	Data collection protocol	Per Trip, Set or Catch	Could be collected by existing EM system?	Seabird-monitoring-specific?
Handle/release	Y	D	Haul	Gear remaining attached to live released catch	For catch released alive, what gear components and what length of line remained attached	Catch	M	Y
Handle/release	Y	D	Dockside	Handling and release equipment	What seabird handling and release equipment (bolt cutters, dehooker, dipnet) was onboard during the trip	Trip	N	Y
Handle/release	Y	D	Haul	Handling and release methods employed	What methods and equipment were used for handling and release	Catch	Y	Y
Seabird local abundance	M	D	Set	Abundance counts by species or species group	Counts within defined areas, can be split by birds in the air and on the water, typically within 100 m	Set	Y	Y
Seabird local behaviour	N	D	Set	Interaction rates or categorical data	Various metrics	Set	Y	Y
Seabird local behaviour	N	D	Haul	Interaction rates or categorical data	Various metrics	Set	Y	Y
Vessel and vessel equipment	Y	E	Set and haul	Vessel mitigation plan followed	Yes / no	Set	Y	Y
Vessel and vessel equipment	Y	E	Dockside	Vessel specific plan	Yes / no (whether or not the vessel had a vessel specific mitigation plan onboard)	Trip	N	Y