WORKING GROUP ON TECHNOLOGY INTEGRATION FOR FISHERY-DEPENDENT DATA (WGTIFD; OUTPUTS FROM 2022 MEETING)

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i Executive summary

The Working Group on Technology Integration for Fishery-Dependent Data (WGTIFD) examines electronic technologies and applications developed to support fisheries-dependent data collection, both on shore and at sea, including electronic reporting (ER), electronic monitoring (EM), positional data systems, and observer data collection. WGTIFD has diverse membership including technology service providers, academic and governmental marine institutions, and non-profit environmental organizations, across a wide range of EU, US, and additional fisheries from the world.

The primary objective of this report is to summarize the discussions held over two 3-day period of the WGTIFD that met in Lisbon, Portugal and Galway, Ireland between the 7-9 June and 18-20 October 2022, respectively. In the first meeting, the discussions were centred on pelagic trawl fisheries regarding ToR C: evaluate risks/benefits of ETs across different fisheries and provide specific guidance on developing monitoring tools for specific types of fisheries; and ToR D: develop and publish a standardized format for data collected and analysed from EM systems. Pelagic (trawl) fisheries were chosen due to the recent interest by some countries in Europe and North America in implementing new EM programs. In the second meeting, discussions focused again on ToR D but applied to all fisheries, and on ToR E: provide guidance and best practices on drafting RFPs and CFTs for different types of EM programs.

Based on the discussions held during the two 2022 meetings, WGTIFD developed guidance on how to integrate fishery monitoring goals into data collection, best practices for developing and managing vessel monitoring plans (VMPs), and recommendation for implementing various ETs in pelagic (trawl) fisheries. WGTIFD also developed a number of important products under ToRs D and E. WGTIFD drafted an initial electronic monitoring data specification to help progress towards standardizing the data products collected from EM systems. On ToR E, WGTIFD made significant progress collating the dozens of requests for proposals (RFPs) and calls for tenders (CFTs), developing best practices and guidance for drafting an RFP/CFT, as WGTIFD works towards developing a standard RFP/CFT template for governments and others to use in acquiring hardware and services from EM service providers.

ii Expert group information

Expert group name	Working Group on Technology Integration for Fishery-Dependent Data (WGTIFD)
Expert group cycle	Multiannual
Year cycle started	2022
Reporting year in cycle	1/3
Chair(s)	Brett Alger, United States
	Lisa Borges, Portugal
Meeting venue(s) and dates	7-9 June 2022, Lisbon, Portugal (42 participants)
	18-20 October 2022, Galway, Ireland (35 participants)

Members of WGTIFD during the meeting in Lisbon, Portugal, 7-9 June 2022

Members of WGTIFD during the meeting in Galway, Ireland, 18-20 October 2022

1 Experiences implementing EM programs in pelagic trawl fisheries

1.1 EM on pelagic vessels in Scottish waters

Authors: David Hill, Helen Holah, Lauren Clayton

Scotland is introducing a legal requirement for specific fishing vessels to have (R)EM as a component of onboard fishing technology. For the purposes of this meeting, we focused on the requirement as applied to the pelagic fleet segment. The requirement will extend to all pelagic vessels fishing in Scottish waters to establish a "level playing field" of requirements that will not disproportionately affect the Scottish pelagic fleet. This requirement will apply to approximately 22 Scottish pelagic vessels and 155 non-Scottish vessels. We are working with the definition of pelagic vessel as: *Refrigerated Seawater /Chilled Seawater (RSW/CSW) and freezer vessels, over 12 metres, fishing for small pelagics and blue whiting*.

We have focused on the pelagic fleet at this stage owing to the potential such a fleet has for significant discarding from individual trawls. Historical observer evidence has also suggested highgrading of catch could be taking place. As part of the presentation we shared our drafted system specification. This is available on the sharepoint site, but we would like to stress this should not be shared more widely outside attendees. The system is envisaged as providing sensor data at all times during a fishing voyage. These data will be analysed retrospectively to identify any points at which the sensors would suggest discarding was taking place. At that point, camera footage would be reviewed to verify if discarding was occurring, as well as be utilized for a variety of scientific purposes – not least bycatch of seabirds or cetaceans, but is primarily seen as an enforcement tool.

We have given a public commitment to introducing this requirement in the Scottish parliament by the end of this calendar year – with a lead in time to follow to allow for vessels to source, procure and install the required systems.

1.2 Danish Pelagic Producers Organization EM program

Author: Lise Laustsen

The Danish Pelagic Producer Organization (DPPO) presented the initial thoughts on a sector lead project on fully documented fisheries (EM) that is planned to be implemented in 2023. The short-term purpose of the project is to increase transparency and credibility in the European pelagic fishery as well as provide the fisheries control agency with data. In the long term the DPPO also hope to use the data for scientific projects and to improve stock assessments.

1.3 Pelagic Trawl Fisheries in the US (Northeast)

Author: Nichole Rossi

The New England Fishery Management Council adopted the New England Industry-Funded Monitoring Omnibus Amendment at its April 2018 meeting. This amendment implemented a new IFM program in the Atlantic herring fishery and established a 50-percent coverage target for ASM aboard vessels issued a Category permit. The Region intends to administer an EM and portside sampling EFP during IFM years 2021 and 2022 (April 1, 2021 - March 31, 2023). Top

priorities are (1) collecting additional information about how to most effectively and efficiently administer an EM and portside sampling program for the herring fishery, (2) collecting information on the use of EM and portside sampling for herring vessels fishing with other gear types,(3) evaluating the utility of EM and portside sampling to monitoring fishing in Groundfish Closed Areas, and (4) facilitating the implementation of a permanent EM and portside sampling program for herring vessels to meet their IFM requirements.

In 2013, the Mid-Atlantic and New England Fishery Management Councils initiated a joint omnibus amendment that would allow industry-funded monitoring (IFM) in all of the fishery management plans managed by the Councils. The IFM types that the amendment considered for the Atlantic herring and Atlantic mackerel fisheries included observers, ASM, EM, and portside sampling. In order to provide the Councils with more data on the utility of using EM to verify catch retention and track discarded catch, NOAA Fisheries conducted an EM pilot study in 2016-2017 on herring and mackerel vessels fishing with midwater trawl gear. At its April 2017 meeting, the Mid-Atlantic Fishery Management Council voted to postpone action on the joint amendment until after a 2016-2017 midwater trawl EM pilot study was completed. However, the New England Fishery Management Council selected preferred alternatives and recommended that NOAA Fisheries consider the amendment for approval at its April 2017 meeting. Therefore, the joint amendment became the New England IFM Omnibus Amendment, with proposed measures applying only to New England Council-managed FMPs. The Mid-Atlantic Council has yet to take further action on EM within its jurisdiction.

During its April 2018 meeting, the New England Fishery Management Council took final action on the New England IFM Omnibus Amendment and recommended a 50-percent coverage target aboard vessels issued a Category A or B herring permit. This 50-percent coverage target includes a combination of Standardized Bycatch Reporting Methodology (SBRM) and IFM coverage. The Council also reviewed the results from the 2016-2017 pilot study evaluating the use of EM on midwater trawl vessels, and concluded that a combination of EM and portside sampling was an appropriate substitute for ASM aboard herring vessels fishing with midwater trawl gear. Rather than implementing EM and portside sampling requirements through the IFM Amendment, the Council recommended that NOAA Fisheries manage EM and portside sampling via an EFP for midwater trawl vessels during the first 2 years of IFM in the herring fishery in order to evaluate how to best permanently administer the program.

1.4 Pelagic Trawl Fisheries in the US (West Coast and Alaska)

Author: Brett Alger

The Alaska region is developing management measures that would allow an EM system to supplement existing observer coverage on pollock catcher vessels (CVs) that are using pelagic trawl gear. The program also includes tender vessels that are delivering to processing plants in the Gulf of Alaska and the Bering Sea. The Trawl EM program is designed to use EM for compliance monitoring, meaning that EM video does not directly feed into catch accounting or stock assessments. Instead, catch accounting uses industry reported data (verified through EM) and data collected by shoreside observers. Maximized retention ensures that unsorted catch will be delivered and available to be sampled by shoreside observers, allowing for non-biased data to be collected at the trip level by shoreside observers at the processing plant. The trawl EM program has been operating under an exempted fishing permit (EFP) to evaluate the efficacy of EM systems and shoreside observers since 2020. The vessels range in size from 20m to over 70m, and of the ~120 vessels in the fishery, more than 70 vessels are currently participating in the pre-implementation program, with a tentative start date of January 1, 2024 for full-implementation.

The West Coast Region has been developing an EM program for several years in the groundfish fishery to provide vessel owners participating in the Catch Share Program (CSP) a monitoring option alternative to fishery observers. There are four primary sectors of the fishery, bottom trawl, fixed-gear, whiting midwater trawl and non-whiting midwater trawl. The CSP uses Individual Fishing Quota (IFQ) to account pound-for-pound for all catch and bycatch of each species managed in the fishery, so there are requirements for 100 percent at-sea monitoring, either via an observer or EM. In the two midwater trawl portions of the fishery, almost the entire fleet of ~50 vessels are choosing to use EM

The West Coast EM program has established requirements for vessel owners and operators, standards for EM systems, and protocols for handling catch while using EM systems in the Catch Share Program. The EM program also established requirements for EM Service Providers, which are 3rd party companies tasked with providing EM services to the fleet. EM service providers are responsible for the installation and technical support of EM systems, and the collection and review of EM video data. EM vessels submit logbooks to report catch and discard information to NOAA Fisheries, and video data are used to audit logbooks to ensure information is accurately reported.

1.5 North Sea Pelagic Freezer Trawlers EM program

Author: Jason Bryan

The project was an industry led and funded initiative to understand how the then upcoming landing obligation might be monitoring. With no direction given by the regulating bodies in the North Sea, the various companies operating freezer trawlers wanted to be progressive and explore the various options to documenting compliance with the new regulations.

The project ran over two years and had several different components. Three vessels (F/V Cornelis Vrolijk, F/V Carolien and F/V Jan Maria) were installed with EM systems including sensors and cameras and delivered very high data collection rates and the data were sufficient to monitor full retention on a pelagic freezer trawler. These vessels had sensors in the net pump and trawl gear to detect fishing and catch handling, plus cameras that recorded catch handling on the trawl deck and in the factory to document full retention of catch. The data collected from these vessels was used to develop Trip Reports that could be used as documentation provided by an impartial third party in a regulatory environment. Parallel with this was a series of training events to develop local capacity, both inside the fishing industry and within the Netherlands Food and Consumer Product Safety Authority (NVWA), as they were tasked with the monitoring, control and surveillance of this fleet. In an unprecedented act of transparency, the raw data collected by the EM systems was shared with the NVWA staff and used in training and subsequent analysis.

Ultimately EM was not chosen to monitor the fleet's compliance with the landing obligation, but this project was important in that it substantiated the technology's ability to monitor complex fishing operations on very large vessels and deliver data in a cost-effective and timely manner. The take aways from the project both technical (using sensors to monitor the landing obligation seemed to be more efficient than cameras) and process related (involving the various regulatory bodies in the multi member state fishery was essential to a successful program design and level playing field) and these recommendations still apply today.

1.6 Scientific EM program in the Celtic Sea

Author: Rebecca Skirrow, Thomas Catchpole

Cefas were commissioned by Defra in 2020 to initiate a limited scientific EM program in the Celtic Sea with the aim to generate data to support UK negotiating positions and development of domestic policy. The Celtic Sea otter trawl fleet was selected as the target fleet due to the challenges posed by the mixed nature of the fishery leading to various management challenges, including the risk of choke under a landing obligation scenario.

The program was initiated with the aim to recruit 6 vessels on a voluntary basis, collecting data via EM and from the skippers. EM data were to be collected from a randomly selected 10% of hauls undertaken by each vessel. The objective of this data collection was to summarize the total activity of the vessel (number of trips and hauls completed), collect species-specific information on retained and discarded catch and length information on cod. The skippers of the vessels were asked to recorded weight information by species on a haul-by-haul basis. The two datasets were compared, with the hope that the REM data could be used to validate the skippers' estimates. Where this was possible, the skipper's dataset could be utilized further. Following recruitment of 3 vessels for the continuous monitoring program, it was not possible to encourage further uptake, with the main reason cited as a lack of incentive.

After collecting data for full year, comparisons were made to determine how representative the EM data were of the Celtic Sea otter trawl fleet. It was decided that the data could be considered representative if the characteristics of the EM vessels reflected the characteristics of the wider fleet. The chosen attributes were spatial and temporal extent, composition of landings by species, composition of vessel sizes and discard rates by species. To make the comparisons, data from the EM program, official landings and offshore observer program were used. The summary of findings were:

- The EM vessels fished in similar areas to the wider fleet, with a few high activity/landing's areas absent in the EM data.
- The ICES rectangles not represented by the EM vessels had distinctly different landings compositions.
- The official landings data showed that the EM vessels caught the same species as the fleet but in different proportions.
- Of the 5 vessel size classes in the fleet, the EM vessels fell into the 3 larger classes, which contributed the most landings.
- Comparison of discard rates was difficult. There was only limited data available from the observer program in 2020-2021, so pinpointing reasons for differences was not possible.

This work highlighted areas where the EM data could be improved and where further work may be needed to used EM data alongside other data sources. This also provides a starting point to develop a framework for determining a representative sample fleet, where whole fleets are not fitted with EM.

2 Legal and policy

An overview of national policies in the United States to support ETs

Author: Brett Alger

NOAA Fisheries has a national policy directive to provide guidance on the implementation of electronic technology (ET) solutions in fishery-dependent data collection programs. Per the directive, ETs include the use of vessel monitoring systems (VMS), electronic reporting (ER), video cameras, gear sensors, and automated image processing for electronic monitoring (EM), data collection technologies for human observers, and other technologies that can improve the timeliness, quality, integration, cost-effectiveness, and accessibility of fishery-dependent data. The policy was originally published in 2013, and updated in May 2019; it includes a requirement that each fisheries region in the US (n=6) publish a Regional Electronic Technology Implementation Plan (Plans). Regional ET Plans were initially created in early 2015, updated biannually through 2017, and have been updated annually since 2021. Lastly, the overarching policy laid the groundwork for subsequent policies specifically for EM programs.

In May 2019, NOAA Fisheries published an EM procedural directive for allocating costs of EM programs between NOAA Fisheries and the fishing industry in federally managed US fisheries. This procedural directive provides a transparent and consistent framework for NOAA Fisheries and industry to identify and discuss the respective cost responsibilities in any EM program. During the development of this cost allocation guidance, the fishing industry raised concerns over how long EM data are retained, by either the fishing industry or the federal government. In response, NOAA Fisheries published guidance in April 2020 in a second EM procedural directive on how long an EM service provider should retain EM data when the fishing industry is responsible for maintaining non-federal records. In addition, and in conjunction with the National Archives and Records Administration (NARA), NOAA Fisheries in May 2021 established a 5-year retention schedule for EM data that are deemed federal records.

Through implementation of EM programs, and based on comments received on the previous EM procedural directives, NOAA Fisheries recognized a need for clarifying on how the Federal Records Act (FRA), the confidentiality provisions of section 402(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), and the Freedom of Information Act (FOIA; collectively referred to as "Information Law") apply to EM data. In May 2022, NOAA Fisheries published a third procedural directive on applying information law to EM data and guidance on how EM data are managed, protected, and shared by the federal government. Additionally, because some EM program configurations allow different non-government third-parties to manage EM data, the procedural directive provided guidance on applying information laws to third-parties include agency contractors and recipients of federal financial assistance (e.g. grants or cooperative agreements), commissions, and EM service providers, that report a vessel's catch and discards and other information based on analysis of the EM data.

The ET-associated policies are available at:

https://www.fisheries.noaa.gov/national/laws-and-policies/science-and-technology-policy-directives

- 04-115 - Policy on Electronic Technologies and Fishery-Dependent Data Collection
- 04-115-02 - Cost Allocation in Electronic Monitoring Programs for Federally Managed U.S. Fisheries
- 04-115-03 - Third-party Minimum Data Retention Period in Electronic Monitoring Programs for Federally Managed U.S. Fisheries

- 04-115-04 - Information Law Application for Data and Supporting Guidance in Electronic Monitoring Programs for Federally Managed U.S. Fisheries

NOAA Fisheries is required to review a policy directive or procedural directive every 5 years, and will update each of the above policies as EM programs continue to mature and evolve.

3 Data transmission and storage

ETs hold a lot of promise to improve the timeliness, quality, integration, cost-effectiveness, and accessibility of fishery-dependent data. However, there are a lot of challenges that must be resolved to realize their potential – particularly those that relate to data transmission and storage. Once raw EM data are collected onboard vessels, decisions need to be made on how data are transmitted for processing and analysis. Broadly speaking, WGTIFD members discussed the importance of understanding the cost, reliability, and turnaround time desired to inform decisions and trade-offs of different transmission methods. The WGTIFD identified some of the most common considerations when discussing data transmission from EM systems (Figure 1).

Figure 1. Common considerations identified by WGTIFD when discussing data transmission from EM systems

EM programs should consider where, how, and how long the sensor and video footage will be stored after it has been reviewed, as these can be treated separately. Depending on the program's objectives and standards, video data can range from video of an entire fishing trip to video stills from key fishing events. Once video footage is analysed, decisions will need to be made on if it may be deleted or stored – indefinitely or for a finite period. WGTIFD participants discussed the delicate balance between managing storage/price constraints, following privacy and protection protocols, and advancing post-review objectives (e.g. enforcement, algorithm training) when making decisions on storage, and if applicable, deletion of data. The WGTIFD identified some of the most common considerations when discussing data storage from EM systems (Figure 2).

Figure 2. Common considerations identified by WGTIFD when discussing data storage from EM systems

4 Managing expectation for use of EM systems

The focus on this discussion began with talking about Request for Proposals (RFPs), Calls for Tender (CFT), and other forms of solicitation for EM service providers; there's been a proliferation of many new and growing EM projects to request too much of any EM system too quickly. EM project leaders need to work with managers and scientists to better understand what they need verses what they wanted. The vast majority of EM programs have been focused on catch/quota management, but there has been a shift to focusing on the vessel, International Convention for the Prevention of Pollution from Ships (MARPOL) violations, tracking crew for labour violations, and other requests that can become a distraction for an EM Service Provider view and can add cost and complexity. There can be a shift to monitoring the vessel rather than the fishery. Each camera and/or sensor often has a very specific task linked to very specific data to collect, and unless the technology is dedicated to collecting data on the vessel (e.g. MARPOL), the video review time can get very carried away and sink the project. It is important to design the system and overall program for collecting data based on primary goals, and then over time, evolve to include other data of interest. A few existing EM programs attempted to review their video a second time to analyse additional uses, but found it to be difficult, in part because the camera angles were not designed to view and collect data on the secondary uses. We concluded by having a discussion on the balance of compliance and science within EM programs.

5 Slippage events

The monitoring of high-volume fisheries often includes oversight on catch retention. Catch retention can be defined as the ability of the fishing vessel to retain full possession of the contents within the net, once fished. Typically, catch volumes for high volume fisheries can reach tens of thousands of kilos of fish per trip and therefore, the monitoring of catch retention in these fisheries is often a provision of management. On occasion, vessels release a portion or all of the contents of the net in the water for a variety of reasons. The release or discarding of catch prior to being brought onboard is often referred to as "slippage" and generally includes large volumes of released fish. Reasons for slippage can be intentional or unintentional and can include; safety concerns (too much volume for the vessel, inclement weather), unwanted catch (undesired, no-market, or bycatch), mechanical failure (damage to the gear resulting in disruption or loss in fishing activities) or catch restrictions/regulations (vessel has exceeded its quota for a certain species or area). The monitoring of slippage in high volume fisheries or fisheries with discard prohibitions is a critical component of fisheries management.

EM is increasingly being used as a tool for catch monitoring and reporting compliance in fisheries around the world. Specifically, in the United States the Northeast Region is pursing EM to support additional monitoring initiatives under the Industry Funded Monitoring (IFM) omnibus amendment for the herring fishery. EM has proven to be an effective tool in detecting and categorizing slippage events. The following are recommendations to promote a successful EM program in the herring midwater trawl fishery as it relates to documenting slippage.

- **EM system reliability**: Power interruptions associated with high volume vessels to the EM system can cause incidences of data loss. The use of voltage conditioners and uninterruptible power supplies (UPS) decreased the risk of power loss to the EM system. Camera connectivity issues can be caused by high vibrations on the rail mounted cameras. Vibration resistant cameras are recommended for boom mounted cameras in this fishery.
- **Camera set-up**: To maximize the ability of EM reviewers to view all discards, cameras should be installed to capture all possible discard locations as listed below;
    - Fish pumping
    - Dewatering box
    - Full deck
    - Stern

  Not each view will require a distinct camera, often one camera can cover multiple areas depending on the vessel set-up and operations. These views can generally be captured by three properly placed cameras. On most vessels, getting the required views will require the installation of a boom arm mount.
- **Data retrieval**: in fisheries with complex logistics where the vessels are not all located in the same port, in person data retrieval can be costly and logistically complicated. Mailing EM data to the review centre can simplify this process and result in cost savings.
- In a fleet that makes frequent, short trips and is somewhat migratory, sufficient spare hard drives should be made available to the vessels to ensure data collection is not hindered due to HDD resource limitations.
- **Slippage detection**: while EM is effective in the detection of discard events, reviewers had some difficulty in differentiating between categories of slippage events consistently. Incorporating a mechanizm which allows vessel operators to provide information regarding discard events throughout the trip may further aid when distinguishing among these events.

6 Video review

Review of video footage is fundamental to any EM program. It is often the most labour intensive and costly component of an EM program as well. Reducing video review below 100% in suitable situations provides a mechanizm to reduce EM program costs while meeting monitoring objectives.

Video review rates are primarily dictated by the type of EM program and its specific monitoring goals. Generally, EM programs fall into two broad categories: (1) compliance, or (2) audit. Compliance based programs tend to have higher review rates, up to 100% because they are designed to verify compliance with specific fisheries management provisions (ex. slippage detection). Conversely, audit-based EM programs that compare independently reported data (ex. catch) with annotated video review data can offer more flexibility when setting video review rates depending upon the degree of error tolerance and reporting accuracy. Review rates can also be modulated depending upon specific needs like enforcement interest, catch handling verification, retention verification, area/behavior of interest, etc.

A key component of audit-based EM programs is their requirement for a complimentary data source (typically the vessel logbook) that is independent of the EM system in order to provide the necessary data for comparison. Compliance based EM programs don't necessarily have this same requirement, though logbook programs could be considered in any type of program.

The New England groundfish fleet participating in the audit-based EM program have their trips reviewed less than 100% of the time (link). Vessel reported logbook discards are compared with the annotated discards from the EM video review to evaluate the logbook reporting error. This error is incorporated into a predictive model (i.e. the "delta model") that processes vessel logbook data from trips where video was not reviewed and predicts the likely discard amount based on the logbook reported discard amount and observed error from past trips. Rates can be linked to the underlying uncertainty in the model's discard prediction because consistent logbook reporting reduces error, which translates to less model uncertainty and potentially lower review rates. The opposite is also true, larger reporting error translates to more uncertainty and potentially higher review rates.

The primary challenge of the delta model approach is having an a priori understanding of the factors that contribute to variation in self-reporting errors. Consistent self-reporting does not require accuracy, per se, as the model can estimate most biases and subsequently correct them during prediction. Any such modelling can tend to struggle with species omissions, where vessels have forgotten to estimate and report catch for a given species, which is fundamentally different from an inaccurate self-reported estimate. In this case, predictions on trips with zero reported catch for species A will tend to have a small amount predicted (even for trips that truly had zero), and the slope of the bias correction can be poorly estimated. Total catch estimates for a species may still be accurate, but review rates may need to be elevated depending on the frequency of omissions and other errors.

An alternative approach to the delta model would be to use the observed discards from reviewed trips in some type of ratio estimator for total discard estimation, a technique that is commonly used for human observer data. These estimators can be quite accurate at low sampling rates for total catch, but they are not necessarily accurate on a trip-by-trip basis. By leveraging the self-reports in the delta model, vessels are afforded the opportunity to dictate the accuracy of the catch with which they are credited on each trip. In the case of the New England groundfish fleet, the design of the quota management system incentivizes participation in the audit-based EM program because of the increased autonomy that comes with the heavy reliance on logbooks.

7 Vessel Monitoring Plans (VMP)

VMP Standardization

In many EM programs, vessels must have an approved vessel monitoring plan (VMP) to participate in the program. The VMP describes how an EM system is configured on a particular vessel and how fishing operations must be conducted to effectively monitor catch. The VMP is multifaceted. For management, the VMP provides clear objectives and outlines EM program requirements for a specific vessel. At the technical level, it describes how an EM system is configured on a particular vessel and how fishing operations must be conducted to effectively monitor catch. From a logistical perspective, the VMP is the communication tool that identifies roles and responsibilities among parties (e.g. fisher, EM vendor, regulatory organization) and facilitates program coordination to meet monitoring goals. As the regulatory tool at the centre of any EM program, the structure and content of VMPs are critical to monitoring goals and program success.

Because the VMP is the regulatory tool at the centre of any EM program, its structure and content are critical to monitoring goals and program success. As such, standardizing the information in the VMP creates a cohesive strategy that EM service providers can follow when developing VMPs for vessel operators. In addition, standardization provides the regulatory organization the ability to ensure all VMPs meet monitoring objectives in a consistent method and allows for a streamlined process for VMP review and approval. Critical elements to a VMP may include, for example the following categories: Contact Information, Trip Notification Requirements, Vessel Owner/Operator Responsibilities, System Specifications and Installation (See Figures 3 and 4 Vessel Diagrams), Catch Handling Requirements, Troubleshooting, and Signature Page. While standardization creates cohesion, it also allows for vessel specific operations and variation as it relates to specific fisheries, catch handling, and vessel layout.

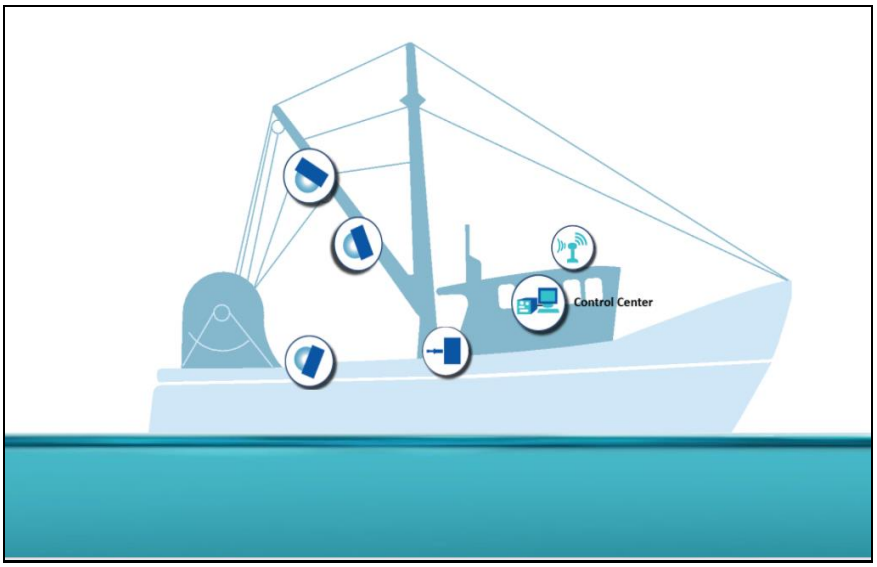

Figure 3. Vessel diagram example of system component placement

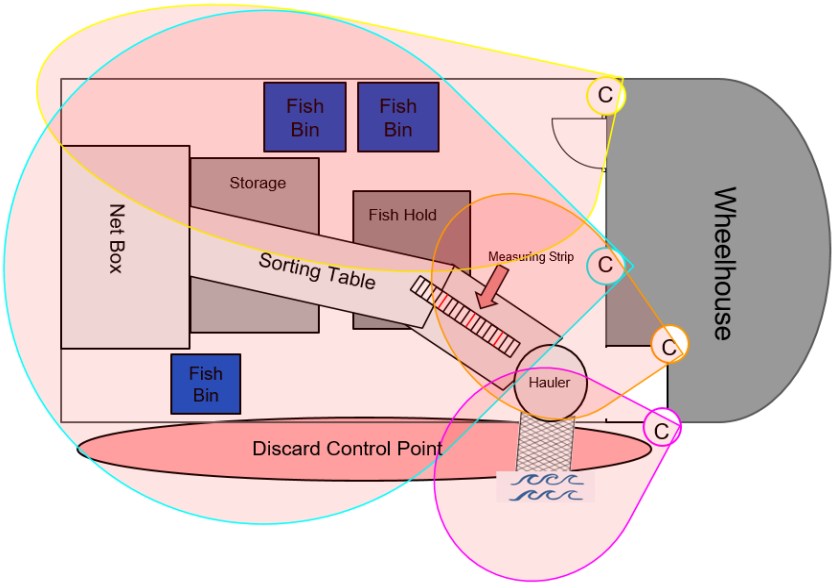

Figure 4. Vessel diagram example of work deck during fishing activities

To facilitate standardization, a VMP template or guidance document could be used to create the desired format. The template or guidance would outline the VMP structure, requirements, and essential components necessary for approval. In addition, any required items that directly relate to compliance or regulations may be included in the guidance to reinforce requirements and support enforcement actions. Potential examples could include: fishing notification and portside sampling requirements, provisions for notifying the authorities of equipment failures, and camera operational and maintenance obligations. VMP guidance may also serve as a source to outline ancillary information related to VMPs or the EM program structure. Information such as VMP submission and approval timelines, approval process, authorized sampling strategies, and standard cameras views (See Table 1) are important aspects of EM programs as they relate to VMPs, but may not be directly included in the VMP template.

Table 1. Camera requirements for bottom otter trawl. The following information outlines the camera requirements for each electronic monitoring program and gear category. This section is not prescribing the order or number of required cameras, but rather the required views.

Bottom Otter Trawl Camera Requirements	
Cam 1	Primary view of discard processing station; used to collect length measurements and assess subsampling procedures, view of designated location for stowing groundfish discards.
Cam 2	Primary view used to monitor catch sorting operations, includes location for retaining groundfish discards; secondary view of length measurement station.

Cam 3	Primary view of stern and gear; may include work deck and discard control points.
Cam 4	View of work deck/stern discard control points at rails.

VMP Management

Along with VMP standardization for program consistency and effective governance, a structured process for managing VMPs is also beneficial to the successful and cost-effective implementation of EM programs. Structuring operations central to EM functions, such as: VMP approval, status of EM vessels (active/not active), tracking of equipment malfunctions, and VMP compliance issues through a management tool provides functional support for program managers. In addition, a management tool could serve as the primary source for shared access, file storage, and archiving.

In the northeast US, the Vessel Monitoring Plan Document Management (VMAN) application was developed for the purpose of structuring operations central to VMP approval and management of EM programs. The VMAN application offers logistical functionality for monitoring VMP submissions, active or approved VMPs (status), and documentation of vessel specific equipment malfunctions and VMP compliance issues. VMAN allows users to track, view, comment, and respond to inquiries on active VMPs. In addition, the application is used to document, log, monitor, and resolve vessel-specific issues (equipment, crew-related, procedural, etc.) that may impede data collection.

The VMAN application is a multiple-user system that facilitates transparent communication among the regulating authority, fisher/owner, and EM service provider. All communication is stored internally on the VMAN application and is archived to support management or enforcement initiatives (if needed). This eliminates nebulous communication that may occur among informal conversations or e-mail exchanges and provides a clear communication channel.

There are many facets to EM programs and specifically EM management that would significantly benefit from structure processes such as those listed above. As the regulatory tool at the centre of any EM program, the framework of VMPs are critical to monitoring goals and program success and therefore standardization of regional VMPs is encouraged to support effective management. Given the importance of VMPs in EM programs, particularly as the primary communication tool that identifies roles and responsibilities among parties and facilitates program coordination to meet monitoring goals; effective management of VMPs is essential to program success. The VMAN application offers a reference point for VMP status and communication, and provides a contoured process to manage various facets of VMPs to support EM programs. Incorporating best practices learned and incorporated as part of successful operational EM programs around the world are key strategies for program success and the implementation of effective monitoring programs.

8 Statements of Work for different types of EM programs

One common early step in the development and implementation of EM pilot projects and regulated programs is the solicitation of private companies (e.g. EM Service Providers) for EM hardware, software, and other services. Solicitations can come from non-governmental organizations, fishing industry groups, but most often, from Federal governments. It is critical for these institutions to develop a well-crafted solicitation (e.g. Request for Proposals (RFPs), Statements of Work (SOWs), Call for Tenders (CFT)) that provides transparent and specific requirements and processes in order for EM service providers to respond, this has often proven to be a difficult process for all parties to manage in the early stages of implementing EM programs globally. The TOR E subgroup set out to develop a suite of recommendations to inform future solicitations.

Prior to the Galway meeting, WGTIFD sent out a data call to members resulting in 19 shared EM solicitations from the past three years. Upon review, we narrowed them down to the 12 examples shown in the 'RFP summary table' (Annex 1) representing solicitation for 650+ EM equipped vessels across the globe.

WGTIFD has developed a preliminary list of essential attributes that should be included in a solicitation, and binned them into four broad categories: (1) Project goals and fishery background, (2) Technical information and Standards, (3) Video Review and Data Delivery, and (4) Contractual and Bidding information. Beyond the high-level summary below, WGTIFD will develop specific fields and sub-categories in future.

1. Project goals and fishery background: a narrative description of the goals of the project and overall monitoring objectives; a background on the fishery including existing data collection programs and recent management actions of note; a highly detailed description of the vessels and fishing information for the participants of the EM project/program; the roles and responsibilities of the EM service provider and others in the program (e.g. government programs, fishing industry); and the service and maintenance requirements.
2. Technical information and Standards: outcome-based performance standards (i.e. what are needed, not how to collect it; data transmission standards; installation timeline and responsibilities; and software requirements or specific needs.
3. Video Review and Data Delivery: video review requirements and sampling strategies; specific data standard for review (see TOR D); timelines for data transfer, analysis and reporting.
4. Contractual and Bidding information: overall project timeline and budget; bidder qualifications; bid questions, evaluation and metrics; and billing and payment info.

WGTIFD reviewed several of the collated EM solicitations using this four-section framework to identify solicitations had sections that were very well developed and clear, but also some that were unclear or missing entirely. In 2023, WGTIFD will further develop an essential attributes list and publish it as an RFP/CFT template available to anyone looking to develop an EM program. We also highlighted that currently, there is web resource that makes available the past and active EM solicitations that can easily be located, and as the EM industry matures, this could be useful.

9 Data standards, integration and processes for accepting data (APIs)

Integration of EM data into the ICES scientific advice framework will require the development of a baseline data model with standard data formats for processed EM data that are compatible with existing ICES data products. In order to fully integrate EM data into ICES programs, the WGTIFD identified a series of recommended steps that must be considered: (1) establish a data model, (2) determine collected data elements, (3) provide an efficient data transmission/receipt method, (4) identify common post-processing methods that can be agreed upon, and (5) make data available in format that is compatible for integration with existing data products. The group discussed the need for a common baseline data model that is generic enough to accommodate most data elements from known EM programs, and compatible with existing human observer data models in order to facilitate EM data integration into existing systems.

9.1 Draft EM Data Model

Data Model Scope

The intent of the data model is to manage information derived primarily from the EM system itself and should not include data elements derived from other independent data collections (e.g. logbook information). The data model will act as a template for both mature and upcoming EM programs (inclusive to all countries) and will allow processed EM data to be mapped directly to existing ICES databases, initially targeting integration into the Regional Database and Estimation System (RDBES).

The proposed model accommodates processed data and houses information within 4 data tables; trip, haul, catch and other events. The aim being that data in the EM data model could feed into ICES databases such as RDBES and the stock assessment process alongside data from at-sea and onshore observer sampling programs. Initially this data model has been drafted based on the data elements of small-mesh pelagic fisheries, however it is intended that the model be able to incorporate all EM programs across fisheries and at varying degrees of maturity. It has been ensured that the model is in keeping with ICES/FAO vocabularies where possible and meets the minimum requirement for mandatory data types as specified in the RDBES exchange format.

There are many benefits to a coordinated data model including: offering a 'best practice' starting point for those looking to start and implement EM programs, and delivering consistency in the breadth and type of data collected across programs and countries. Before the 2023 meeting of the WGTIFD expert group this transparent data model will be presented to the ICES data centre and select working groups to demonstrate the types of processed data being generated by EM programs and to open discussions on how EM data can be best integrated into assessment and advice data streams.

Data Model Resolution

The DRAFT data model will accept data from a variety of resolutions across the range of traditionally collected fishery-dependent data. Similar to ICES, primary TRIP and HAUL elements

will be collected at separate resolutions. However, CATCH information will be collected at a mixed resolution. It will include individual lengths by animal, as well as aggregated amounts of catch amounts yielded from alternative estimation methods (ex. electronic scale, tally counts, visual estimate, etc.). This will differ from traditional ICES separation of LENGTH (HL) and CATCH (CA) records. The WEIGHT_DETERMINED_BY field in the data model will dictate the record level for the data collected. OTHER_EVENTS information can be linked to either the HAUL or TRIP. Furthermore, we have included a RECORD_TYPE field for the TRIP, HAUL, CATCH, and OTHER_EVENT data levels.

Data Integrity

It is critical in any monitoring program to understand if the data collected for a haul, subtrip, or trip is a complete dataset. Meaning, is the data collected representative of all the required fishing activity (e.g. catch kept, discarded, or both) or was information impaired because of issues with improper catch handling, technical failure, or some other reason and therefore the data are not representative of the actual fishing activity that occurred. Knowing if the dataset is complete could affect its eligibility and utility for management and science and is therefore important for end-users and data managers to understand.

The data model indicates the validity of the annotated data derived from EM video in the VALID_REVIEW element collected on the HAUL record. This field is essential to data integrity, and it should be clearly defined to facilitate replication and clear instruction to data collectors. Below is an example of the definition used by EM programs in the Northeast, US that would represent a valid review (ex. FISHING_VALIDITY= 'Y'):

> *"...all discards from a haul were viewable such that they could be adequately annotated in accordance with the Video Reviewer Guidance document. In this context, adequately annotated is defined as identification to the lowest taxonomic level possible and a count/weight can be collected, if applicable. If video cuts out, is missing, or obstructed and the catch cannot be tracked confidently to determine end disposition, then that haul would be…"* invalid (ex. FISHING_VALIDITY = 'N').

The purpose of this field is communicating to data users the quality, integrity, and completeness of the data collected. With that information, end-users can determine if and how the data should be applied for analyses and decision-making.

Use of Comments Fields

A comments field allows for data collection that is difficult to pre-specify with a more structured input field, whether because the information is either unanticipated, rarely encountered, or complex enough to require a flexible text entry (e.g.., a short explanation of an interruption in fishing operations). While comments can be helpful for storing information during the early stages of a newly designed program, they tend to facilitate poor practises with regards to recording consistency and the ease of data use. Comments fields are often black holes that take in data never to be used again. If the data will never be used, they do not need to be recorded; if they are important enough to record, they will benefit from a structured input field.

In the context of an EM data model, the preferred strategy would be to limit comments fields to "other events" records. This allows a place to store unexpected information that may lead to expanded data models, depending on the circumstances, but would avoid cluttering the main data modules.

9.2 General Considerations

Bycatch and PET species interactions

Most European countries report bycatch data through non-dedicated programs and in most regions, incidental catches are only sporadically monitored via independent on-board observer programs which are limited in time and space. EM represents an opportunity to increase observation coverage at a regional level to gain knowledge of the impact of fishing on bycatch and Protected, Endangered and Threatened (PET) Species populations including marine mammals, sharks, turtles, rays and seabirds. Ideally, EM should be able to collect bycatch events in the same way as onboard observation with appropriate regional database standards. On-board observers usually register information on number, length, (derived weight) and fate of bycatch individuals that can be collected most of the time via EM (with appropriate configurations) and registered in a common database. However, some information such as species ID (for lookalike species), conditions at release (dead, alive, injured) or sex can be sometimes difficult to collect via cameras (too far from individuals) but might be important for stock assessment studies, and should be reported whenever possible with associated quality flags. Note that the quality of these data could be increased by adding more cameras, using recorded footage of a higher resolution or placing cameras closer to the main catch sorting and discarding areas within each national program. In parallel, the development of a standardized bycatch labelled images database from major European fisheries combined with AI might also help to automate the collection of bycatch data (species identification and quantification) obtained from EM systems and reinforce EM programs at national and regional levels.

WGTIFD members discussed the need to better understand the extent of bycatch of rare or infrequently encountered events and as it relates to EM of fisheries. Intersessionally, WGTIFD and the ICES Working Group on Bycatch of Protected Species (WGBYC) will discuss coordinating a joint learning session in 2023 to inform the groups work towards a flexible data model under ToR D.

Quality flag fields

For EM data to be fully utilized, we need to be able to quantify the data quality and validity in a transparent fashion for end-users of the data. Other data sources submitted to ICES are already subject to such processes, with data governance groups determining necessary checks prior to submission and ICES expert groups determining quality at various stages in the data's life cycle.

At the highest level, data users need to know that EM programs are collecting robust data on their target fisheries, with biases outlined so these can be considered when the data are applied. Guidance can be taken from reports such as the 2013 Report of the third Workshop on Practical Implementation of Statistical Sound Catch Sampling Programmes (WKPICS3)around designing quality assurance reports for sampling programs. This report states that there is no single way to document data quality and highlights that what is considered quality may differ depending on how the data are used. With this in mind, using other data collection methods as a guide, a framework of assessing data quality from EM programs could be generated. Input from relevant expert groups would be necessary to ensure that this meets their expectations and would allow application of data.

There are elements of the data collected that could be subject to their own quality indicators, such as species identification, length, weight and condition. Within RDBES there is an optional

Accuracy Codes field, that specifies to what level of accuracy a particular piece of data has been made within, for example 0.5 cm for a length. This field could be used to give data users confidence in the available data and inform how it should be used. Due to differences in how data are collected using EM vs. other methods, it will be necessary to expand the current options to be more inclusive of uncertainty. To know the appropriate limits for this field, it may be necessary at a program level, to compare information from different sources, i.e. EM and observer. We will continue to evaluate appropriate code and description vocabularies for the AccuracyCode field and which catch data fields it may apply to and this will be informed by future discussions with other ICES expert working groups.

9.3 Future Considerations

Gear Attributes

There are some instances where gear attributes may be collected by video analysts during review, in these cases gear attributes would need to be marked in some way to indicate type(s), size(s), the use of excluders or other modifications. Most probably these visual markers would be noted and recorded as part of both the vessel monitoring plan (VMP) developed for the vessel and fishery, as well as part of the video review protocols developed for the fishery. These documents would outline what the markers are indicating, where they should be located on the gear and when/where the video analysts should expect to see those markers during video review, e.g. during setting or hauling, at the start of each trip or haul etc.

In other instances gear attributes may be recorded automatically by the EM system via a sensor or an algorithm. In these cases the data point related to the gear attribute would be collected automatically during on-vessel raw data collection and may be flagged for review and confirmation by a video analyst during review.

Recreational Fisheries Data

The importance of data from recreational fisheries is becoming more recognized and there has been a noticeable increase in effort employed in Marine Recreational Fisheries (MRF) data collection in recent years. In most regions, MRFs are difficult to survey due to the diverse and dispersed nature of the activity. Each MRF segment (angling, netting, spearfishing, pots/traps etc.) has its peculiarities with regard to the affect the fish stocks and the environment; participation rates; and socio-economic output. Fair and equitable management of these MRF segments requires data collection to be segmented as well. Fisheries Management is increasingly looking at operating on a regional level and doing this properly requires having regional data on MRF, however very little reliable regional MRF data exists, and this is a clear gap that fisheries managers and scientists need to address.

EM may be an efficient method to collect quality raw data from MRF's. On chartered recreational angling vessels EM could be deployed to record, collect and transmit catch and effort data coupled with the associated metadata of vessel name/time date/location. The EM of catch may include species retained and discarded, volume and length data, while the effort data may include hours fished x number of fishers/rods present on the vessel. PET and bycatch species could also be captured and recorded by EM in these fisheries.

The ICES Working Group on Recreational Fisheries Surveys (WGRFS) has produced a quality assurance toolkit (QAT) to ensure quality assurance of recreational catch estimates from national

surveys and document bias in data collection to satisfy ICES and EU MAP requirements. Since its development, the QAT has been used to assess the quality and provide guidance on the design and implementation of multiple types of recreational fisheries survey programs. The WGRFS maintains close links with the ICES RDBES core group where the RDBES is recognized as the most appropriate solution for storage of recreational fisheries data. As the RDBES is designed for mainly commercial fisheries data the integration of recreational fisheries data will require careful and considered development.

Accommodating Non-Standard Data Formats

Traditionally EM has focused on collecting and analysing data associated with fisheries catch and effort data. This has been achieved by utilizing video capture along with positional GPS/time-date data and gear parameter data such as motion sensors. As EM systems develop, fisheries scientists are looking to increase the available data collected. The integration of the vessel's own sensors such as sonar and sounder into the EM systems is seen as an opportunity to maximize data collection aboard. The addition of extra sensors such as flow through monitors on fish pumping devices in pelagic fisheries have been mooted as methods to get independent estimates of catch on such vessels. EM coupled with extra sensors is expected to increase the accuracy of both catch and effort estimates.

The coupling of EM and new oceanographic sensors is leading to the leveraging of fishing vessels to vessels of opportunity for oceanographic monitoring. Oceanographic sensors that collect data on temperature, depth, salinity (CTD's) can be deployed on fishing gear such as otter boards to collect a CTD profile of the water column every time the net is deployed and hauled back, resulting in a profile from each location where the vessel fishes. In the Bering Sea temperature sensors integrated into mooring buoys from static fisheries are already sending real-time sea surface temperature and positional data to the fishers that use such systems – allowing fishers to monitor the ice coverage relative to the gear.

The ICES Working Group on Operational Oceanographic products for Fisheries and Environment (WGOOFE) has taken on the challenge to co-develop fit-for-purpose oceanographic services and to incorporate the environmental information in traditional assessment performed by fisheries scientists from the ICES community. WGTIFD will stay abreast of further developments in pathways for oceanographic data in advice products and signpost EM project managers to WGOOFE for guidance on the type and standard of oceanographic sensors required.

Metadata standards for samples recorded using oceanographic instrumentation may include details regarding the method information, in addition to metadata related to the sampling event and its time and location. Method information includes instrument details (including a simple instrument description, details of the manufacturer and model number, a reference or serial number and a link to details on the accuracy, resolution and response range of sensors) in addition to how instruments were mounted. Additional details that can be recorded if available include instrument data retrieval and processing metadata (software used to recover data and if there has been any data processing following recovery), in addition to data relating to the last calibration date for instruments used. The emergence and evolution of these nascent oceanographic data streams and non-traditional formats will continue to expand the scope of any future EM data model and should be considered for accommodation. Specifically, the data types and volume of these new sources must be considered. For example, sonar data may be generated as large, proprietary file formats that must be stored and transmitted as a BLOB data type. High frequency collections like CTD also have the potential to generate large amounts of data.

API Recommendation

Integration of EM data into the ICES scientific advice framework requires the development of a baseline data model with standard data formats for processed EM data that are minimally compatible with data requirements of the ICES Regional Database and Estimation System (RDBES). The deployment of an Application Programming Interface (API) to manage EM data collection operations is strongly encouraged because it integrates the data requirements of the data model with EM data transmission and receipt. This provides an easier, standardized interface for end-users to work with that abstracts away individual database idiosyncrasies and enforces transparent function and documentation. API integration facilitates the uptake of a standard EM data model and a more scalable, maintainable mechanizm for managing EM data collection.

The proposed EM data model is expressed in both the standard Entity Relationship Diagram (ERD) format used in traditional relational databases, as well as in Javascript Object Notation (JSON) format which is the structure commonly used by APIs. Below is an example of a proposed EM data flow that utilizes an API (Figure 5).

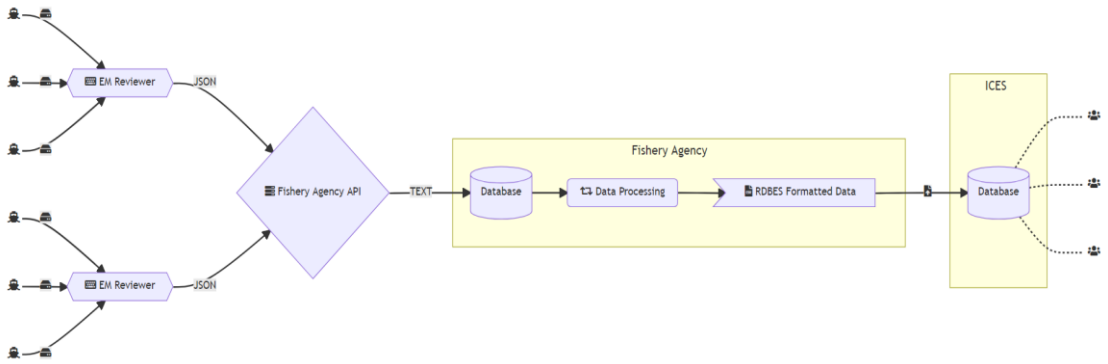

Figure 5. Example of a proposed EM data flow that utilizes an API (Schematic powered by: DiagrammeR, mermaid.js (https://mermaid-js.github.io), and Font Awesome Free 5.15.4 by @fontawesome - https://fontawesome.com)

Linkages to other communities and groups

Taking into consideration the wide-range of EM program objectives and data collection focuses, the potential for an EM data model to be a valuable tool in the provision of scientific advice could foster many expert group linkages. In view of the current (2022-2024) WGTIFD resolution and ToRs, the group has identified a number of ICES WGs that it wishes to open discussions with regarding data integration and continued adaptation of the EM data model to foster data use. In particular there are three data types being prioritized/: (1) spatial, (2) PET, and (3) high-volume mixed fishery data.

At the October Galway meeting Cefas and WUR proposed a 9 points pathway for use of EM data from mixed fisheries in ICES stock assessment frameworks. Of the points, some were considered to be in scope and would likely be covered during the 3-year term WG resolution (e.g. creating

a pathway for data submission into ICES in response to data calls) and some were considered to be larger pieces of work that may warrant being their own terms of reference in later WG resolutions or addressed by other WGs (e.g. assessing representativeness of EM reference fleets, and how to raise/extrapolate EM biological data to fleet level). As next steps, the group proposed using the Cefas and WUR cod and ray EM programs as case studies for inclusivity of the data model. For the points that were out of scope, a formal request will be made to WGCATCH to address the additional analytical work that will be needed to provide uncertainty, bias and coefficient of variation estimates for EM derived catch data for high-volume mixed fisheries (particularly for species ID, length, weight).

The scarcity of PET bycatch observation data within European fisheries observer programs, and the nature of these observation data fields (at a minimum presence / absence), suggest that uptake of such data from an EM data model by the ICES community is likely to be high. Therefore WGTIFD will look into ensuring that the EM data model is suitable for generating data compatible with the data sources used by WGBYC, WGJCDP and JWGBIRD by opening intersessional communication. Lastly, a clear utility of EM is the collection of high-frequency spatio-temporal data with accurate means by which to identify fishing activity on location (via sensors, cameras or both). These data supersedes VMS data in both resolution and quality, removing the need to infer fishing activity. As such, the group intends to work with WGSFD to investigate how the existing VMS/logbook ICES data call can be adapted to include submission of EM data, and if possible to develop a case study of integration.

There are also a number of ICES working groups, with governance remits, bolted-on to working groups that have a strong data collection or management focus (e.g. WGRDBESGOV, WGSFDGOV, WGDG, WGACOUSTICGOV). Governance groups specifically explore data governance questions including data policy, giving guidance on technical developments of the WGs data products, and monitoring the use of data products. These groups may provide a suitable first point of contact for WGTIFD to discuss integration of the EM data model with existing ICES data calls and repositories. Looking further ahead, should WGTIFD generate its own data calls or products, it may be appropriate to adopt the WG structure of inclusion of a governance group to manage data quality and guidance ToRs as an aside to regular WG ToRs.

9.4 Data Model: ERD format, column descriptions and JSON format

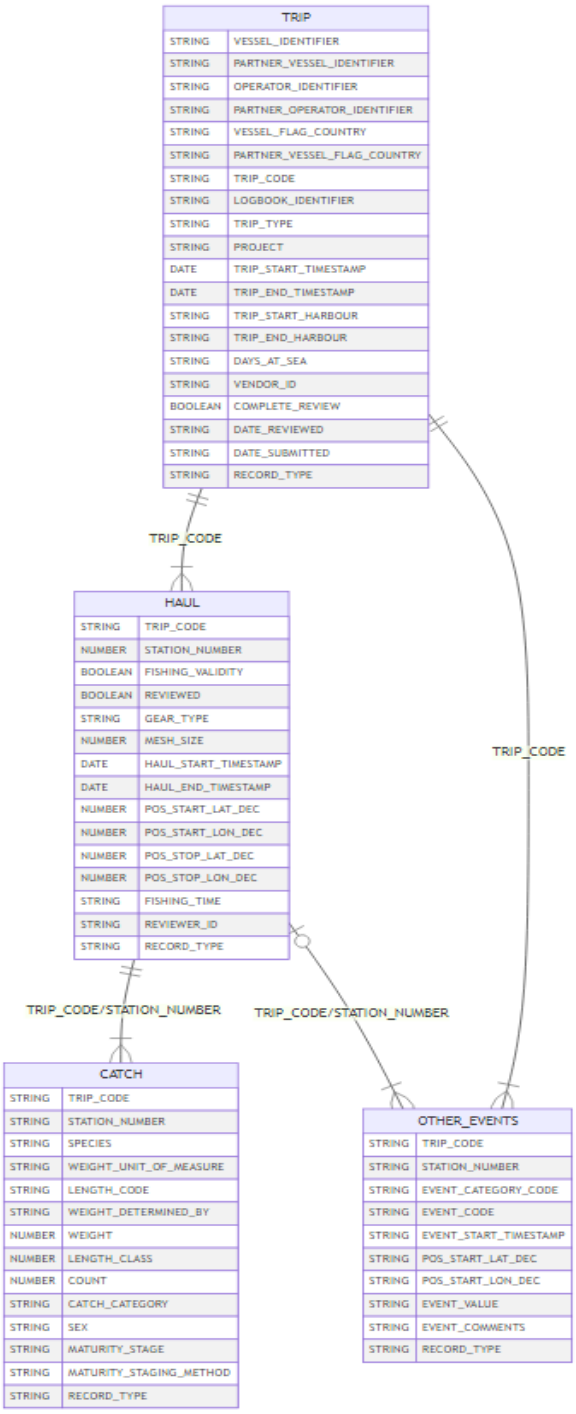

Figure 6. Draft EM Data Model: Entity-Relationship Diagram (ERD) format (Schematic powered by: DiagrammeR and mermaid.js (https://mermaid-js.github.io)

Table 2. Data Model Column Descriptions: TRIP (*Indicates mandatory elements for RDBES)

COLUMN_NAME	DATA_TYPE	DESCRIPTION
VESSEL_IDENTIFIER	STRING	Unique identifier for primary vessel.
PARTNER_VESSEL_IDENTIFIER	STRING	Unique identifier for partner vessel.
OPERATOR_IDENTIFIER	STRING	Unique identifier for primary vessel operator.
PARTNER_OPERATOR_IDENTIFIER	STRING	Unique identifier for partner vessel operator.
*VESSEL_FLAG_COUNTRY	STRING	ISO 3166 - 1 alpha-3 codes: the flag country of the primary vessel. This can be different from the landing country.
PARTNER_VESSEL_FLAG_COUNTRY	STRING	ISO 3166 - 1 alpha-3 codes: the flag country of the partner vessel. This can be different from the landing country.
*TRIP_CODE	STRING	Unique identifier assigned to the trip.
LOGBOOK_IDENTIFIER	STRING	Logbook identifier associated with the trip.
TRIP_TYPE	STRING	Commercial, For-Hire Headboat, For-Hire Charter, Experimental Fishing Permit, or Recreational.
*PROJECT	STRING	National project name. Code list is editable.
TRIP_START_TIMESTAMP	DATE	Datetime the trip started in UTC timezone.
TRIP_END_TIMESTAMP	DATE	Datetime the trip ended in UTC timezone.
TRIP_START_HARBOUR	STRING	Landing harbour. Using harbour LOCODE codes (5 alpha-numeric) from the European Master Data Register Code-Location.xls.
TRIP_END_HARBOUR	STRING	Landing harbour. Using harbour LOCODE codes (5 alpha-numeric) from the European Master Data Register Code-Location.xls.
DAYS_AT_SEA	STRING	In days. A day at sea shall be measured as any continuous period of 24 hours where a vessel is absent from port
VENDOR_ID	STRING	Unique ID for the EM service provider. Based on regional lookup table.
COMPLETE_REVIEW	BOOLEAN	Flag for whether the entire trip was observed from dock to dock.
DATE_REVIEWED	STRING	Date that the video review occurred.
DATE_SUBMITTED	STRING	Date that the trip was submitted by the vendor.
*RECORD_TYPE	STRING	ICES record type metadata indicating HH: Haul, HL: Species length, or CA: Species age based information.

Table 3. Data Model Column Descriptions: HAUL (*Indicates mandatory elements for RDBES)

COLUMN_NAME	DATA_TYPE	DESCRIPTION
*TRIP_CODE	STRING	Unique ID for the trip on which the haul occurred.
*STATION_NUMBER	NUMBER	Sequential numbering of hauls. Starting by 1 for each new trip. If the Aggregation level" is T then this "Station number" should be 999.
*FISHING_VALIDITY	BOOLEAN	Flag for whether the haul event was fully observed and all catch able to be reviewed.
REVIEWED	BOOLEAN	Flag for whether the haul event was fully reviewed by video.
*GEAR_TYPE	STRING	Type of gear used during the haul.
*MESH_SIZE	NUMBER	The mesh size is defined as the size in mm of a mesh stretched in the direction of the long diagonal of the meshes. The gauges to be used for determining mesh sizes shall be 2 mm thick, flat, of durable material, and capable of retaining their shape. The mesh size is measured in the codend if it is a trawl.
*HAUL_START_TIMESTAMP	DATE	Datetime at the beginning of the haul in UTC timezone.
HAUL_END_TIMESTAMP	DATE	Datetime at the end of the haul in UTC timezone.
*POS_START_LAT_DEC	NUMBER	Latitude at the start of the haul.
*POS_START_LON_DEC	NUMBER	Longitude at the start of the haul.
POS_STOP_LAT_DEC	NUMBER	Latitude at the end of the haul.
POS_STOP_LON_DEC	NUMBER	Longitude at the end of the haul.
FISHING_TIME	STRING	Time from the haul start to haul end.
REVIEWER_ID	STRING	Unique ID for the EM reviewer.
*RECORD_TYPE	STRING	ICES record type metadata indicating HH: Haul, HL: Species length, or CA: Species age based information.

Table 4. Data Model Column Descriptions: CATCH (*Indicates mandatory elements for RDBES)

COLUMN_NAME	DATA_TYPE	DESCRIPTION
*TRIP_CODE	STRING	Unique ID for the trip on which the haul occurred.
*STATION_NUMBER	STRING	Sequential numbering of hauls. Starting by 1 for each new trip. If the Aggregation level" is T then this "Station number" should be 999.
*SPECIES	STRING	The AphiaID, which is a 6 digit code, is used for the species in the species field. The AphiaIDs are maintained by WoRMS. Only species AphiaIDs with status “Accepted'' or "Alternate Representation" is allowed.

WEIGHT_UNIT_OF_MEASURE	STRING	Unit of measure for the amount of marine species.
*LENGTH_CODE	STRING	Unit of measure for the length determination of marine species.
WEIGHT_DETERMINED_BY	STRING	Unique ID for methodology of weight or amount estimation (scale, tally, length).
*WEIGHT	NUMBER	The weight amount of each marine species.
*LENGTH_CLASS	NUMBER	In mm. Identifier: lower bound of size class, e.g. 650 for 65 - 66 cm.
COUNT	NUMBER	Number of marine species.
*CATCH_CATEGORY	STRING	The fate of the catch: LAN" = Landing, "BMS" = Below Minimum Size landing, "DIS" = Discard or "REGDIS" = Logbook Registered Discard.
SEX	STRING	M = Male, = , F = Female, T = Transitional = (optional for Unsexed").
MATURITY_STAGE	STRING	The maturity scale gives the range of the possible stages.
MATURITY_STAGING_METHOD	STRING	Methodology for estimating the maturity stage.
*RECORD_TYPE	STRING	ICES record type metadata indicating HH: Haul, HL: Species length, or CA: Species age based information.

Table 5. Data Model Column Descriptions: OTHER_EVENTS (*Indicates mandatory elements for RDBES)

COLUMN_NAME	DATA_TYPE	DESCRIPTION
*TRIP_CODE	STRING	Unique ID for the trip on which the event occurred.
*STATION_NUMBER	STRING	Sequential numbering of hauls. Starting by 1 for each new trip. If the Aggregation level" is T then this "Station number" should be 999.
EVENT_CATEGORY_CODE	STRING	ID for the event category, i.e. fishing operations, crew.
EVENT_CODE	STRING	ID for the event code, i.e. camera failure, system connection, pixilation, mechanical failure.
EVENT_START_TIMESTAMP	STRING	Start date of the event in UTC timezone.
POS_START_LAT_DEC	STRING	Start longitude of the event.
POS_START_LON_DEC	STRING	Start latitude of the event.
EVENT_VALUE	STRING	Attribute value associated with EVENT_CODE, i.e. SLIPPAGE_AMOUNT could have EVENT_VALUE of 10000.
EVENT_COMMENTS	STRING	Comments that are specific to understanding this event.
*RECORD_TYPE	STRING	ICES record type metadata indicating HH: Haul, HL: Species length, or CA: Species age based information.

Draft EM Data Model: Javascript Object Notation (JSON) format


```
{
 "VESSEL_IDENTIFIER": 999999,
 "PARTNER_VESSEL_IDENTIFIER:: 888888,
 "OPERATOR_IDENTIFIER": 111111,
 "PARTNER_OPERATOR_IDENTIFIER": 222222,
 "VESSEL_FLAG_COUNTRY": "IRL",
 "PARTNER_VESSEL_FLAG_COUNTRY": "IRL",
 "TRIP_CODE": "123456789",
 "LOGBOOK_IDENTIFIER": "987654321",
 "TRIP_TYPE": "1",
 "PROJECT": "THIS IS A PROJECT NAME",
 "TRIP_START_TIMESTAMP": "2022-11-04T02:20:35.000Z",
 "TRIP_END_TIMESTAMP": "2022-11-04T22:38:00.000Z",
 "TRIP_START_HARBOUR": "IEGWY",
 "TRIP_END_HARBOUR": "IEGWY",
 "DAYS_AT_SEA": "1",
 "VENDOR_ID": "ID0",
 "COMPLETE_REVIEW": "Y",
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10 Balancing science and compliance (with EM/Data access)

Fisheries monitoring programs usually have a dual role of science and compliance, even if one of these is not explicitly stated or built for, as they can provide data for science for example for stock assessment, but at the same time be used for compliance purposes with different legislation, namely with discard prohibitions. This is particularly true for old data (e.g. older than 12 months) that may no longer be used for compliance but is important for scientific application such as in machine learning. The premises on which the monitoring program has been built, science vs. compliance, affects its effective implementation and data collected by representativeness, quality, bias, etc. The data provided by monitoring programs can be annotated and aggregated to remove any possibility for vessel and/or fishery identification, and in this way be shared publicly and be used widely. However, this data processing may render it unfit to be used in science, while identifying a vessel/fishery is key for compliance purposes. On the other hand, compliance monitoring is increasing in many jurisdictions worldwide, and the possibility for these programs' data to be used for science is increasing and should be investigated.

WGTIFD agreed to reach out to one of the chairs of the ICES Working Group on Spatial Fisheries Data, Neil Campbell, in 2023 to share experiences in dealing with confidential data used primarily for compliance purposes.

11 Challenges with collecting PET data

Incidental captures (bycatch) of non-target species in fishing gears is a recurring issue for numerous fisheries that can constitute a threat to vulnerable species sensitive to additional mortality, like marine mammals, seabirds, reptiles, or some species of fish (Lewison et al., 2014). Legislations exist nationally and/or regionally to reduce bycatch of protected, endangered, and threatened species (PETS) and to support sustainable fishing practices (e.g. Magnuson-Stevens Act, Endangered Species Act, and Marine Mammal Protection Act in the USA, Technical Measures Regulation EU2019/1241 in the European Union), but reliable data on the level of bycatch and the effectiveness of mitigation measures remains partial in most fisheries. Moreover, although it is generally mandatory to report captures of PETS in Europe and the US, compliance of fishers can be difficult to enforce, especially for small-scale fisheries characterized by large numbers of small (<10 meters) fishing vessels. When possible – i.e. when enough data are available – PETS bycatch assessments can combine data on fishing effort (logbooks, sales notes, etc.), catch sampling programs (using e.g. fisheries observers), self-sampling, and/or dedicated EM programs (ICES, 2019, 2021). Where an observer would generally need to perform a range of tasks onboard and may therefore miss inconspicuous bycatches, judicious camera placement allows EM systems to record a census of the fishing activity of a vessel for extended periods, including all PETS bycatch events. This aspect is critical as bycatches of PETS are generally rare and spatially clustered (Glemarec et al., 2020). Besides, and as opposed to self-sampling, a well-designed EM program would offer only minimal bias (Mangi et al., 2015; van Helmond et al., 2020). Nevertheless, the cost of monitoring bycatch with EM and the perception that leakage of video footage showing carcasses of protected species (of mammals notably) would be highly detrimental to the fishing industry have been limiting the development of PETS monitoring programs using EM.

In the past years, the paucity of fisheries-dependent data PETS bycatch – particularly in European fisheries – and how this could be addressed using electronic technologies has gained attention among fishers, fisheries managers, and the scientific community alike (Dalskov et al., 2021; van Helmond, 2021). Especially, EM appears like one of the most viable and cost-effective solution to monitor PETS bycatch, while increasing the probability of that fishers would comply to existing regulations and ensure better transparency of fishing practices (Bradley et al., 2019; James et al., 2019; Michelin and Zimring, 2020). This last point is especially important and may initiate increasing EM usage for fisheries willing to import seafood to the United States, since the US legislation requires that foreign fisheries follow American standards regarding marine mammal incidental mortality to access their internal market[1]. Yet, in the absence of dedicated monitoring, it is often unclear whether an absence of bycatch (zero bycatch) reported in some fleets indicates that the fishery does not represent a threat to PETS (i.e. the zero figures reported are true zeros), or if this corresponds to a defect in the sampling of that fleet (i.e. bycatch occurs but was not recorded). Well-designed EM programs could in effect ensure that reported numbers of bycatches are accurate – or at least representative if only a fraction of the fishing effort is monitored.

From a technical viewpoint, the requirements for monitoring bycatch using EM are roughly the same than for other EM programs focusing on catches/discards. It is necessary however that specific camera placements are identified, which will guarantee that incoming bycatch items are clearly visible each time they happen. In that sense, depending on the fisheries and gear types, camera positioning could differ from EM focusing solely on target species catches or discards for

[1] https://media.fisheries.noaa.gov/dam-migration/mmpa_import_factsheet.pdf

instance. For example, in gillnet fisheries, cetaceans or other large PETS entangled in nets are sometimes seen dropping out of the net before having been hauled onboard. Spotting such event requires a camera filming outward, where the net breaks the water. Moreover, PETS bycatch identification from video footage may be problematic for non-specialists, especially when video quality is poor, and could require the assistance of experts to identify taken as bycatch individuals down to the lowest taxonomic level. The development of machine learning (ML) processes to automatize the detection and ultimately the identification of species (both targeted catch and bycatch) is well underway in some areas, particularly for commercial fish species (e.g. Khokher et al., 2022). Nevertheless, object detection/classification systems generally necessitate the annotations of large quantities of images before reaching satisfying results, and the relative rarity of PETS bycatch events has slowed the elaboration of such models until now. Still, large amounts of annotated data from EM recordings probably already exist locally, notably in European countries and in the US. A way forward to facilitate the elaboration of ML detection/classification algorithms for PETS bycatch could be the creation of a pooled bank of annotated images and videos stemming from the existing EM programs already collecting and annotating these data. Research in the field of computer vision and particularly in object detection is evolving fast and a dataset of annotated bycatch videos or still images could thus serve as a common benchmark to build and compare the performance ML models. From a PETS bycatch monitoring perspective, an EM solution that could spot and flag potential bycatch events automatically would be of considerable interest, as it would substantially decrease the number of human-hours necessary to review EM data.

The WGTIFD agreed to discuss further these issues in the upcoming WGTIFD meeting in May 2023.

12 Conclusions

WGTIFD developed guidance on how to integrate fishery monitoring goals into data collection, best practices for developing and managing vessel monitoring plans (VMPs), and recommendation for implementing various ETs in pelagic (trawl) fisheries. WGTIFD recommends implementing an electronic logbook program (where possible) to pair with an EM program, given the importance of having the two independent data streams that can be used to facilitate strategic decision-making for analysing video and selecting the appropriate video review rate.

WGTIFD also developed a number of important products under ToRs D and E. WGTIFD drafted an initial electronic monitoring data specification to help progress towards standardizing the data products collected from EM systems. This work will be leveraged at a future meeting(s) to develop the processes and pathways for integrating EM data into the ICES stock assessment framework. On ToR E, WGTIFD made significant progress collating the dozens of requests for proposals (RFPs) and calls for tenders (CFTs), developing best practices and guidance for drafting an RFP/CFT, as WGTIFD works towards developing a standard RFP/CFT template for governments and others to use in acquiring hardware and services from EM service providers.

In 2023, WGTIFD will continue some of the tasks that were not finalized in 2022, namely finalizing the standard RFP/CFT template, while continue to work on integrating EM data into ICES stock assessments. In addition, it was agreed to focus the groups discussion in 2023 on two further ToRs: the application of EM for monitoring bycatch of protected, endangered and threatened species (PET; ToR F) and on the interoperability of EM systems across governances, fisheries, and EM systems (ToR G).

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Annex 1: List of participants

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Annex 2: Resolution

2021/FT/DSTSG03 The **Working Group on Technology Integration for Fishery-Dependent Data (WGTIFD)**, co-chaired by Brett Alger, United States; and Lisa Borges, Portugal; will work on Terms of Reference (ToRs) and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2022	1) 7-9 June (subgroup meeting) 2) 18-21 October (main meeting)	1) Lisbon, Portugal 2) Galway, Ireland	Interim report by 15th January 2023 to DSTSG	
Year 2023	1) 23-25 May 2) Oct-Nov dates TBD	1) Aberdeen, UK 2) Portland, USA	Interim report by 15th January 2024 to DSTSG	
Year 2024	Oct/Nov 2024	TBD	Final report by 15th January 2025 to DSTSG	

ToR descriptors

ToR	Description	Background	Science Plan Codes	Duration	Expected Deliverables
a	Define vocabulary across electronic technologies (ETs) for fisheries dependent data collection, and develop communication strategies for attracting participation in ET programs	There are a range of terms and applications for ETs, and challenges with gaining participants in ET programs. We developed a glossary of terms in 2019 and examined incentives for attracting participants, this TOR would be a continuation of those previous efforts.	4.1, 4.5	Ongoing	List of updated terms and a communication strategy
b	Inventory the various applications of ETs for reporting and monitoring with an aim to improve collaboration across TIFD members and national fisheries monitoring programs	This TOR will serve as a repository to continually document new and existing ET programs, ETs in development, objectives of the schemes under which they are deployed for management, science, and control, what data are being collected and by whom.	4.1, 4.5	Ongoing	Inventory of various ETs and implementation of ETs in national reporting and monitoring programs

c	Evaluate risks/benefits of ETs across different fisheries and provide specific guidance on developing monitoring tools for specific types of fisheries (e.g., small scale, mid-water trawl, bottom trawl)	New electronic monitoring (EM) programs are being considered in the EU and US across a variety of fishery types. This TOR will examine the current data collection and monitoring approach in specific fisheries (e.g., North Sea pelagic trawl), and utilizing the experience of WGTIFD members, provide guidance of how to develop an EM program.	3.1 3.5, 4.4	Ongoing	Guidelines and best practices on developing monitoring tools for specific types of fisheries
d	Develop and publish a standardized format for data collected and analysed from EM systems, to include a framework of documenting how the data is collected and flows into the ICES data system to be considered for science advice	This TOR would look to align data collected from EM systems with the ICES data framework, using the data profiling tool, and approval process of integrating new data for science advice. TIFD would develop a draft data format, and consider using a specific EM program's data as a case study to develop a pathway for new EM programs to provide data to ICES.	4.2, 5.1	Year 1-3	Data specification standard in Year 1, Guidelines for integrating EM data into ICES data systems for providing science advice in Year 3
e	Provide guidance and best practices on drafting Statements of Work for different types of EM programs	Governments and their associated monitoring programs often utlize Request for Proposals (RFPs), Statements of Work (SOWs), Call for Tenders (CFT) and other forms of soliciting private companies for products and services. Across the EU and US, this often means that the same set of EM providers are providing responses to RFPs, SOWs, and CFTs that lack specificity and clarity. This TOR will consider different EM program designs and provide recommendations for standardizing RFPs, SOWs and CFTs across the EU and US.	3.1	Year 2	Templates of RFPs, SOWs, CFTs etc. that governments and monitoring programs can use to solicit products and services for the development of an EM pilot project or program.
f	Provide recommendations on how to utlize EM for monitoring bycatch of protected, endangered and threatened species (PET) in different fisheries	Most stock assessments for protected and endangered species remain poor due to the limited availability of information. This has started to impact seafood import/export, by requiring countries to better document their fishery impacts on PET bycatch. It is expensive to deploy observers for rare events, and it remains challenging to use EM for monitoring PET bycatch in some fisheries. This TOR would examine the data gaps for assessing bycatch and provide recommendations for implementing EM to collect and analyse data for PET bycatch monitoring	3.1, 3.2, 6.2	Year 2	Best practices and recommendations for designing a data collection program using EM for protected and endangered species

g	Develop and publish recommendations for interoperability of EM systems, raw data, and other appropriate guidance for ensuring that EM systems and programs can integrate across governances, fisheries, and EM systems	Raw file types and data collected from EM systems are diverse, making it difficult for programs to utilize multiple EM providers or for governances to exchange information. This TOR will improve the interoperability of information collected from EM systems and include coordination with EM service providers	3.1, 4.1	Year 3	Standardized interchange format and exchange process of raw information collected from EM systems.

Summary of the Work Plan

	The completion of our TORs will be dependent on the mode of our meetings, in-person, virtual, or hybrid. Because TIFD has become such a large group, spread across 10 or more time zones, there are certain TORs more suitable for dedicated in-person meetingsvs.others more appropriate for virtual meetings. We intend on developing intercessional meetings to focus on specific TORs, to supplement progress made in the annual meetings, as a way to mitigate the loss of in-person meetings.
Year 1	Produce an annual overview of the working group's progress
Year 2	Produce an annual overview of the working group's progress
Year 3	Produce a final report on the working group's progress and completed TORs.

Supporting information

Priority	Fisheries stakeholders, managers, and scientists are looking to improve the timeliness, quality, cost effectiveness, and accessibility of fishery-dependent data by integrating technology into fishery reporting and monitoring programs. Remote electronic monitoring (REM), electronic reporting (ER), and other data collection tools have clear potential to meet these challenges. We believe that ICES can provide a forum for exchanging information to share relevant technical applications and policy development to harmonize how data is collected and used for fisheries management and science.
Resource requirements	Each participant of the working group is expected to provide their own travel resources, however, with the expectation of needing to host hybrid meeting (virtual and in-person), ICES may need to provide some resources to allow for remote participants.
Participants	The development and implementation of electronic technologies is a growing topic of interest, with programs in every Region in the United States and the EU. We reached over 60 members in the first 3 years of the working group, we expect that it could grow.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	Data Science and Technology Steering Group
Linkages to other committees or groups	WGMLEARN, WGCATCH, WGFAST, PGDATA WGSFD, WKSEATEC, WKDSG, ICES Data Centre, DIG
Linkages to other organizations	

Annex 3: Request for Proposals (RFP) summary table

Year	Agency/ Company	Region / Country	Gear Type	Vessels	Fleet Activity Provided Y/N?	Contract Duration	Regulated/ Pilot Program	Contact Name	Contact E-mail	Video Analysts Required Y/N?	Data Storage Required Y/N?
2019	NOAA	Atlantic / US	Midwater Trawl	2 - 12	Y	16 months	Regulated	Rafael Roman	Rafael.roman@noaa.gov	Y	Y
2021	TNC/ Chilean Sea bass Fishery Owners Group	Chile	Longline	3	Y	18 months	Pilot	Natalio Godoy	natalio.godoy@tnc.org	Y	Y
								Craig Heberer	craig.heberer@tnc.org		
2020	TNC/ Directorate of Marine Resources	French Polynesia	Longline	6	N	N	Pilot	Kydd Pollock	kydd.pollock@tnc.org	Y	Y
								Craig Heberer	craig.heberer@tnc.org		
2020	Atlantic Halibut Council	Canada	Longline	2	Y	2 years	Pilot	B. Chapman	bchapman@sympatico.ca	Y	Y
								Pisces Consulting	pisces@ns.sympatico.ca		
2022	Ministry for Primary Industries	New Zealand	Mixed, all inshore vessels	300	Y	10 years (?)	Regulated	Not available	Not available	Y	Y

2022	ICCAT	Mediterranean & Atlantic	Tranship / Processing	10	N	1 year	Pilot	Camille Manel	Camille.mael@ iccat.int	Y	Y
2022	TNC/CEA for multiple industry groups	Global	Longline	300	Y	3 years (?)	Pilot	CEA Consulting	Electronic monitoring@ ceaconsulting.com	Y	Y
2022	Gov. of Victoria (AUS)	Western Victoria, Australia	Pots	3	Y	18 months	Pilot	Erin West	erin.west@ vfa.vic.gov.au	N	N
2019	TNC / California Groundfish Assoc.	California	Trawl / Fixed Gear	17	Y	1 year	Regulated	Kate Kauer	Kate.kauer@ tnc.org	N	N
2019	TNC / Seychelles Fisheries Authority	Seychelles	Longline	3	Y	1 year	Pilot	Craig Heberer	craig.heberer@ tnc.org	Y or N	Y or N
2019	Fed. States of Micronesia/ Kinkatsukyo/ TNC	Fed. States of Micronesia	Longline	3	N	1	Pilot	Craig Heberer Eugene Pangelinan	craig.heberer@ tnc.org eugene.pangelinan@norma.fn	Y or N	Y or N
2019	Marine Scotland	Scotland	Mixed	?	Y	Up to 4 years	Regulated	Bob McLeod	Bob.mcleod@ gov.scot	N	N