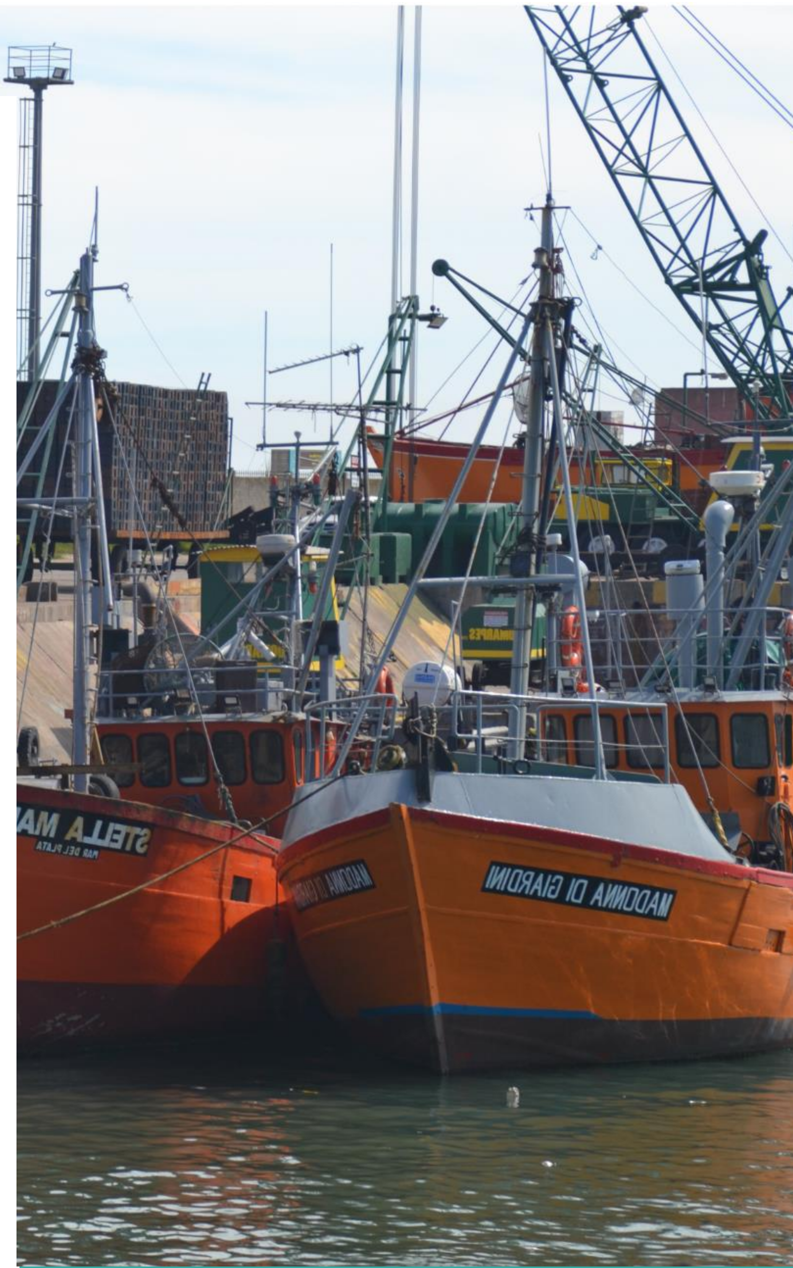
Technical Document on Electronic Monitoring (EM) Systems in Fisheries, their importance for the collection of relevant information for the conservation of sea turtles and the lessons learned in the implementation of EM in Chile, the USA and Peru



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Technical Document on Electronic Monitoring (EM) Systems in Fisheries, their importance for the collection of relevant information for the conservation of sea turtles and the lessons learned in the implementation of EM in Chile, the USA and Peru

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Preamble

This document was prepared by the IAC-ACAP WG, to follow-up the recommendations from the IAC Scientific Committee 20th meeting SC20-2023. The WG requested the SC members to share available information regarding Electronic Monitoring Systems (EM) in the IAC countries. Information was provided by July 29th 2024 from Peru, USA and Chile and it is included in Annex I.

Based on the recommendations from SC20-2023 regarding document CIT-CC20-2023-Doc.4: *"Report of the Working Group for the Implementation of the Memorandum of Understanding between the IAC and ACAP"*, the IAC-ACAP Working Group prepared a technical document on Electronic Monitoring Systems (EMS) of fisheries, highlighting their importance for the collection of information relevant to the conservation of sea turtles and the lessons learned in the implementation of EMS.

Objective: increase knowledge in the process of creating an electronic monitoring program for fisheries and the opportunities that the Electronic Monitoring System offers for the diagnosis, reduction and control of bycatch.

Contents for the technical document

¿What is the Electronic Monitoring System?

Electronic monitoring systems (EMS) are technological tools used to monitor and collect data on various activities that occur on board fishing vessels while operating at sea. These systems usually include a combination of components such as cameras, monitors or screens, digital video recorders, global positioning systems (GPS), sensors and data loggers, among others. The specific components and their function are:

1. **Onboard cameras:** They capture images and videos of some activities that occur on board fishing vessels, such as fish capture, fishing manipulation, use of bycatch mitigation measures, and marine environment conditions, among others.

2. **Monitors:** Screens that allow the captain or crews of fishing vessels to verify the simultaneous operation of the cameras.

3. **Digital video recorders:** Control unit responsible for storing video images and managing cameras.

4. **Global Positioning Systems (GPS):** Provide precise information about the location of the ship for each image, which helps track its movements and activities at sea such as position, date and time when setting or turning gear or fishing gear.

5. **Sensors:** Devices that detect changes in different parameters such as; the speed of the boat, variations in hydraulic pressure, movement of winches, water depth, temperature or other environmental conditions, allowing the identification of specific events or moments of interest for fishing monitoring and/or modifying the frequency of image recording.

6. **Data loggers:** Systems that store information collected by cameras, GPS, and sensors for later analysis.

The data collected by the EMS is subsequently analyzed by an independent entity, which can allow compliance with fishing regulations to be assessed, monitoring fishing activities and studying the behavior of vessels and the species caught or other, depending on the objectives of the monitoring program for which they operate.

¿What are EMSs used for?

EMS systems can complement or, in some cases, replace human observers on board, especially in situations where vessels are too small, do not offer minimum safe conditions for working on board or operate in remote or unpredictable locations, as well as also to avoid situations of high incidence of coercion or corruption of observers.

EMS can offer an effective alternative for scientific and compliance monitoring, as in some cases they require fewer ship specifications compared to what is necessary to deploy a human observer.

However, it is recognized that the use of these technological systems to obtain scientific information and collect data dependent on fishing, still requires intense work in the design of current monitoring programs, the exploration of the use of complementary technologies such as machine learning (ML), artificial intelligence (AI) and their integration with traditional human observer programs currently in use.

¿How are EMS used, their advantages and challenges?

- **Installation:** EM equipment, such as cameras, GPS and sensors, are installed on vessels that will be monitored according to a monitoring program. The cameras are placed at strategic points to capture activities or events of interest during fishing operations, and may vary in number, height, direction and angle depending on the monitoring objectives (scientific, control or both) and the type of vessel or fishery. and whether the processing of the catch is carried out on board or landed unprocessed, while sensors detect changes in different parameters, and GPS records location data.

  The cameras are located in all places on the vessels where catch manipulation, discarding and bycatch occur, and may include the deck, the below-deck fishing parks, the different production lines and the selection belts or tables, among others.

  The installation of the different EMS components must comply with the technical requirements of the equipment and be verified by an independent entity before departure (periodically or regularly).

- **Operation:** During fishing operations, EMSs collect data continuously and independently. The cameras record images of catches, fish handling, bycatch and discards. On the other hand, the sensors detect changes in physical parameters such as the speed of the boat and the depth of the water, and the GPS tracks the position, date and of the boat, information that can be associated with the images to facilitate the review and analysis of are.

  The information recorded by the EMS corresponds to images and an associated file called metadata that contains parameters such as the number that identifies the EMS associated with each vessel, date, time and position, among others. This latter information is taken by the analysis software and provides crucial information to record and identify areas of non-compliance, dates, times, or other data of interest.

  Depending on the objectives of monitoring through EMS, shipowners and crews, for each type of vessel and fishing gear, must follow protocols for managing catches, discards and bycatch in order to guarantee adequate recording of images by the EMS for the purposes of monitoring said practices at sea. These protocols must, at a minimum, ensure that the field of view of the cameras is not obstructed, that the lenses are cleaned periodically and that catches, discards and bycatch are handled in unique and pre-established places and also in quantities and speeds compatible with the technical capabilities and objectives of the EMS.

- **Data Storage:** Data collected by EMS can be stored on hard drives on board vessels, which must be removed upon reaching a certain fill level for subsequent download and analysis on land. Alternatively a cloud service can be used to store, manage and process the logger data on board the ship. The option to choose will depend mainly on operation costs and logistical feasibility.

- **Analysis:** After one or more fishing trips (depending on the length of the trips, the amount of data recorded or other criteria), the data is downloaded and sent to an independent entity for analysis. These entities may correspond to the government fisheries management agencies themselves or third parties or analysis service providers. After data download (from hard drives or the cloud), the images and associated information are first verified for integrity and completeness. The number of fishing trips and hauls are identified for each vessel and then all or a percentage of the images (or fishing operations) can be reviewed based on statistical methodologies.

  Selection of samples for review may follow a stratified random process, or review may be prioritized when there is a greater likelihood of discards, bycatch, or other events of interest. Screening may require more time on vessels that perform onboard processing, because the catch is tracked throughout processing at multiple locations on the vessels. When regulatory non-compliance is detected in samples, additional samples may be reviewed, exceeding the original percentage.

  Analysis of images and associated data may include review for compliance with fishing regulations, identification of captured species, monitoring of handling protocols, use of bycatch reduction measures, and assessment of the environmental impact of fishing activities, among other aspects.

  Image and data analysis are generally performed through the use of software that allows specific events to be marked (capture image) and associated with geographic locations, vessel speed or other parameters. The images can be analyzed manually by people reviewing each frame, or they can be analyzed using artificial intelligence, with a software to make the individual image captures automatically, this reduces the time for the image analysis. For example by using hydraulic sensors you can locate the beginning and end of a fishing set, the software recognizes these changes and capture the images associated.

Advantages of Electronic Monitoring Systems (EMS):

Electronic monitoring systems offer an effective and modern tool for monitoring and managing fisheries, although their implementation and operation present both significant advantages and challenges to consider.

Advantages of Electronic Monitoring Systems:

1. **Continuous Coverage:** EM systems can operate 24 hours a day and under adverse conditions, providing continuous coverage of fishing activities, something that is not always possible with human observers.
2. **Lower Long-Term Cost:** Although initial installation can be expensive, EM systems can be more economical in the long run compared to the costs involved with onboard human observers.
3. **Bias Reduction:** Data collected by EM systems is objective and independent and is not subject to human biases that can affect the accuracy of data collected by observers.

4. **Greater Safety:** On small ships or in dangerous working conditions, the use of EMS avoids putting human observers at risk.
5. **Detailed and Accurate Data:** EM systems can provide very detailed and precise data that is useful for scientific investigations and compliance monitoring.

Challenges of Electronic Monitoring Systems:

1. **Initial Cost:** EM systems can be expensive to install, which can be a barrier to adoption by small or resource-limited fleets.
2. **Maintenance and Technical Failures:** EM systems require regular maintenance and can fail, which could result in the loss of important data.
3. **Privacy and Trust:** Some anglers may feel uncomfortable with the constant presence of cameras and other monitoring devices, which can lead to mistrust.
4. **Data Analysis:** Analysis of the large volumes of data generated by EM systems can be complex and requires trained personnel and additional resources.
5. **Limitations on Data Capture:** Cameras and sensors may have limitations in terms of what they can capture. For example, cameras may not work well in low light or bad weather conditions.
6. **Limitations in data storage:** EMSs generate large volumes of data and depending on the objectives of the monitoring program, its storage and accumulation may be required for variable periods of time, which may imply significant costs in the acquisition and transfer of hard drives or use. data cloud.
7. **Economic limitations:** one of the main challenges of EMS are the costs of their implementation, particularly in the artisanal fleet, due to their lower purchasing power. However, alternatives could be generated to achieve this, including other sources of support, both at the government level and Non-Governmental Organizations (NGOs) and industry, interested in the conservation of sea turtles or other endangered species such as birds and marine mammals.
8. **Compliance with handling protocols by crews:** Depending on the objectives of the monitoring and the data to be collected, crews must follow strict protocols for managing catches, discards and bycatch in order to guarantee adequate recording of images by the EMS. These protocols should, at a minimum, ensure that the field of view of the cameras is not obstructed and that catches, discards and bycatch are handled in unique and pre-established locations and in quantities and speeds compatible with the capabilities of the EMS. The above alters the normal operations of the vessels and can generate rejections in the industry.
9. **Uses other than compliance control:** It is recognized that the use of EMS for purposes other than compliance monitoring, such as obtaining scientific information and collecting fishery-dependent data, still requires intensive work in the design of current monitoring programs, exploring the use of complementary technologies such as computer vision (CV) or machine learning (ML) or artificial intelligence (AI), and their integration with traditional human observation programs in use.

¿What is the usefulness of EMS in scientific diagnosis for sea turtle bycatch and promoting sustainable fishing?

Electronic monitoring systems are potentially valuable tools for the scientific diagnosis for sea turtle bycatch and its conservation, as well as for the promotion of sustainable fishing practices. EMS provide crucial data that can be used to improve marine resource management, protect vulnerable species and ensure that fishing activities are carried out in a responsible and sustainable manner.

1. **Utility of EMS for Science:**

   1.1 Continuous and Detailed Data Collection: EM systems can provide continuous and detailed data on fishing activities, species behavior and environmental conditions. This is crucial for scientific research and for the development of accurate ecological models.

   1.2 Improving Ecological Knowledge: Data collected by EM systems can help scientists better understand the dynamics of marine populations, their migration patterns, and their interaction with the environment and human activities.

   1.3 Monitoring of Vulnerable Species: They allow continuous monitoring of vulnerable or endangered marine species, providing valuable data for conservation studies and for the implementation of protection measures.

2. **Utility of EMS for the protection and conservation of Sea Turtles:**

   2.1 Protection and Conservation: EM systems can identify areas where sea turtle populations are at greatest risk due to potential interactions with fishing activities. This allows the implementation and control of mitigation measures, such as the use of deterrent or exclusion devices, the modification of fishing practices or the creation of exclusion zones.

   2.2 Bycatch Reduction: Electronic monitoring can detect and record sea turtle bycatch events. This information can be used to develop and implement effective strategies to reduce bycatch, such as the use of turtle excluder devices.

   2.3 Data for Research: The data collected can be used in studies of the biology and ecology of sea turtles, providing information on their migratory routes, preferred habitats and behavioral patterns.

3. **Utility of EMS to Promote Sustainable Fishing:**

   3.1 Regulatory Compliance: EM systems can help ensure or verify that fishing practices comply with sustainable fishing regulations and standards. This includes compliance with catch quotas, the use of permitted fishing gear and the prohibition of captures of protected species, among others.

   3.2 Transparency and Responsibility: The presence of EM systems increases transparency and encourages ecologically responsible development in fishing activities. The data collected can be reviewed by independent authorities, reducing the risk of illegal or unsustainable practices.

   3.3 Improving Fisheries Management: The rapidly changing characteristics of fisheries and their environment are forcing the need for greater spatial and temporal resolution of fisheries data, to account for increasing uncertainty and enable management agencies to adaptively manage. In this way, more precise data collection, faster and more advanced processing, analysis and reporting is required that lead to the design of more efficient mechanisms to share the results that allow responses to be given in times close to real time. In this context, the data obtained from EM systems provide a solid basis for making timely decisions in fisheries management. They allow an accurate evaluation of fishing stocks and help to adjust quotas and management measures based on the observed reality.

   3.4 Education and Awareness: EM systems can serve as an educational tool, both for the fishing community and the general public. Through which, the impact of overfishing and bycatch on marine ecosystems can be shown, as well as the search to reduce these negative factors by developing sustainable fishing practices.

¿What are the requirements and processes for a country to implement an EM program in its fisheries?

Implementing an electronic monitoring program in fisheries requires careful planning, a robust legal framework and close collaboration between all stakeholders.

1. Initial Evaluation and Planning:

1.1 Needs Assessment:

- Define the specific objectives and scope of the EM program (e.g., reduce bycatch, improve resource management, comply with international regulations, collect scientific information, complement/supply observer programs, etc.).

1.2 Feasibility Study:

- Evaluate the regulatory, technical and economic feasibility of implementing EM systems in selected fisheries.
- Conduct consultations with stakeholders, including fishermen, scientists, regulators and NGOs.

1.3 Strategic Planning:

- Identify fisheries that would benefit most from electronic monitoring.
- Develop a strategic and gradual plan that includes the evaluation and selection of appropriate technologies, the necessary infrastructure and the required human resources.
- Establish a schedule for the implementation of the EMS program.

2. Development of Legislation and Regulations:

2.1 Legal Framework:

- Review and update national fishing laws on fisheries monitoring/observation to include specific provisions on the use of EM systems, objectives (science/control) and scope (industrial/artisanal fleets), responsible parties (installation/review of images), financing (shipowners/state), etc.
- Ensure that legislation is consistent with international standards, RFMO requirements and best practices.
- Define the institutions or agencies responsible for EMS (public/private/mixed).

2.2 Detailed Regulations:

- Develop detailed regulations specifying technical requirements for EM systems, installation and maintenance procedures, and data collection, storage, transmission and analysis protocols by fishery/fleet/sector, etc.
- Establish rules regarding privacy, confidentiality and use of collected data.
- Establish rules on the rights and obligations of the parties involved
- Establish rules on the involvement of third parties in the installation process, review, etc.
- Establish specific rules or protocols for handling catches, discarding, and bycatch, compatible with the image recording capabilities of the EMS.
- Establish rules on the timing of implementation of EMS programs (gradual/sudden/by fleet, etc.)

2.3 Involvement of Interested Parties:

- Conduct consultations with all stakeholders to ensure that regulations are practical, acceptable and validated for all sectors involved.

3. Program Implementation:

3.1 Strategic Planning:

- Develop a strategic and gradual plan that includes the evaluation and selection of appropriate technologies, the necessary infrastructure and the required human resources.
- Establish a timeline for EM program implementation.

- Development of pilot studies (ideally without sanctions) that allow making the necessary adjustments and a fluid or adaptive adoption of EM systems by the fishing sector.

3.2 Equipment Installation:
- Provide and verify the installation of EM systems on the selected ships.
- Train fishermen and shore staff in the use and maintenance of equipment.

3.3 Monitoring and Data Collection:
- Establish procedures for the collection, storage and transmission of data.
- Ensure data is accessible to relevant authorities for analysis and decision making.

3.4 Data Analysis and Compliance:
- Establish image selection and review protocols compatible with the objectives of the program (science, control or both).
- Evaluation of statistical methodologies that allow the achievement of the program objectives (census/samples)
- Create and train a team of analysts to review and interpret the data collected according to the program objectives.
- Develop mechanisms for continuous monitoring and verification of compliance with fishing regulations or other indicators (bycatch/catch/fishing areas, etc.)

4. Supervision, Evaluation and Continuous Improvement:

4.1 Continuous Supervision:
- Implement a continuous monitoring system to evaluate the effectiveness of the EM program.
- Conduct periodic audits and reviews to ensure compliance and data integrity.
- Explore the use of artificial intelligence to facilitate/enhance the use of EMS

4.2 Evaluation and Feedback:
- Regularly evaluate the impact of the EM program on the sustainability of fisheries and the reduction of bycatch.
- Gather feedback from stakeholders to make continuous improvements to the program.

4.3 Adaptation and Scalability:
- Adjust policies and procedures as necessary based on evaluations and feedback.
- Consider expanding the EM program to other fisheries or regions based on results and resource availability.

4.4 Complementarity of monitoring tools:
- Complement the EMS with other monitoring tools such as VMS (Video Monitoring System), fishing logs, human observer programs.

5. Necessary National Legislation:

5.1 Fisheries and Marine Conservation Law:
- Include specific provisions on the use, objectives and scope of electronic monitoring systems in national fisheries.

5.2 Technical Regulations:
- Detail the technical requirements for EM systems, including specifications for cameras, GPS, sensors and data loggers.
- Define the procedures for the installation, maintenance and operation of EM systems.
- Define the procedures for downloading storage and transmission of data associated with the EMS.
- Define procedures for image review and analysis.

5.3 Data Protection and Privacy:

- Establish clear rules on the protection of collected data, ensuring the privacy of fishermen and the integrity of the information.

5.4 Compliance and Sanctions:

- Develop compliance mechanisms that include regular inspections and sanctions for non-compliance with EMS regulations, including aspects such as operating without EMS and manipulating or interfering with systems, among others.

5.5 International Cooperation:

- Ensure that legislation is consistent with international agreements and standards on sustainable fishing and marine conservation, including the RFMOs to which the country adopting the EMS is a party.

¿What are the lessons learned in the implementation of EMS in Chile, Peru, USA and Mexico and their recommendations ?

This section presents case studies of IAC countries that have experience with electronic monitoring in Annex I.

This section contains the experiences of Chile, Perú and the United States, in the implementation and use of Electronic Monitoring Systems.

Country	**Chile**	**Peru**	**USA**	**Mexico**
Target Species	All target species, the associated fauna and incidental catch, birds, sea mammals, sea turtles and sharks	Perico (*Coryphaena hippurus*)	Pollock (*Pollachius* sp.) Rock Fish (*Sebastes* sp) Cod (*Gadus* sp.) Halibut (*Hippoglossus* sp.) Whiting (*Silago* sp.) Vieira Assorted demersal finfish Scallop (*Placopecten magellanicus*) Shrimp (multiple species)	Fin fish
Fishing gear	All	Artisanal longline	Bottom otter trawl, midwater otter trawl, bottom longline, pelagic longline, pot (trap)	Gillnet

			fisheries, gillnet, scottish seine	
Type: Industrial/artesanal/ both	All industry fleet Artesanal only vessels equal or bigger than 15 m	Artesanal long line Paita (05°S) north, and Mollendo (17°S) south	both	Artesanal and long line
Objetives: Science, surveillance / control, both	In the beginning control and now is for science	Pilot Project for control in future for science.	both	both
Regulation: (mandatory yes/no)	yes	No	yes	No
Funding: Industry, government, NGOs	Equipment and up keep (industry). Image análisis (goverment)	ONG (WWF)	NGO, industry and goverment	goverment

Based on the experiences presented by the four countries, this group proposes the following recommendations:

1. Gradual and Appropriate Implementation for Each Fishery: It is recommended to implement these systems gradually, transparently, and with consensus, in a manner appropriate to the realities of the fisheries in each country, considering the perspectives of all stakeholders.

2. Establishment of a Clear Legal Framework for EMS Implementation: It is recommended to develop regulations that support the implementation of EMS, clearly establishing the objectives of EMS, the scope, the roles and responsibilities of the different parties at various stages (installation, operation, image review, etc.), provisions that safeguard the integrity of the systems, funding, and minimum technical standards for systems and data, among other aspects

3. Definition of EMS Objectives: It is recommended to explore and clearly define the objectives for using EMS, which may include compliance control, scientific monitoring of fishing activities, maritime safety aspects, etc., as unique or complementary objectives.

4. Collaboration with the Fishing Sector: It is essential to work together with the fishing sector as allies so that EMS are widely accepted and agreed upon tools, which also facilitate obtaining certifications, traceability of fishery products, and demonstrating transparency in response to society's increasing demands for sustainable productive activities.

5. Impartial Monitoring: It is recommended to use EMS as impartial tools to improve the monitoring of fisheries in terms of coverage, resolution, and timeliness.

6. Technical Issues: It is recommended to ensure good resolution of image recording systems and to explore the best alternatives for data storage, transmission, and analysis, according to the capabilities of each country.

7. Training, Continuous Support, and Feedback: It is recommended to establish training programs, continuous support, and feedback for fishermen and EMS operators, ensuring they understand how to use the systems, the importance and utility of the collected data, and to make the necessary adjustments based on experience and learning once implemented.

8. Pilots and Preliminary Evaluations: Before the definitive or large-scale implementation of EMS, it is recommended to conduct pilot projects to evaluate effectiveness and to adapt or define the most suitable systems for the specific conditions of each fishery and the implementation objectives. These pilots can cover technical, regulatory, and economic aspects of EM.

9. Integration with Other Monitoring Systems: It is recommended to promote the integration of EMS with other currently used monitoring tools, such as onboard observers, VMS, electronic logbooks, and catch records, to obtain a more comprehensive and accurate view of fishing activities.
10. Sustainable Funding: It is recommended to ensure adequate and sustainable funding for the installation, maintenance, and operation of EMS, avoiding excessive economic burdens on lower-income fishing fleets.

11. Continuous Evaluation and Improvement: Establish mechanisms for the periodic evaluation of EMS effectiveness and promote continuous improvement of these systems based on obtained results and accumulated experiences.

12. Data Protection and Privacy: Develop and implement clear policies for data protection and fishermen's privacy, ensuring that the collected information is used ethically, confidentially, and responsibly.

13. Cost Reduction: Encourage technological development that leads to cost reductions and greater adoption of electronic monitoring technologies and training.

Bibliography: This document used the references from “The Report IAC-ACAP Working Group for the Implementation of IAC-ACAP MoU” CIT-CC20-2023-Doc.4 presented at SC20 in 2023. To find the references please refer to Annex V of the SC20th report in this link http://www.iacseaturtle.org/eng-docs/comite-cientifico/20reunion/CIT_CC20_2023_Doc_8_Final_Report_20Scientific_Committee_ENG_final_web_22mar.pdf

ANNEX I

Below are the experiences of Peru, Chile, and the United States in the implementation and use of Electronic Monitoring Systems.

Case Analysis: Utilization and Implementation of Electronic Monitoring Systems in Chile's Fisheries

Introduction

As part of the implementation of a fisheries management strategy with an ecosystem approach and following the recommendations of FAO and other international forums focused on ensuring the sustainability of the oceans, Chile has developed since 2012 a process of diagnosis, reduction, and control of discards and incidental catches in its fisheries. This process has been based on the application of Law N°20.625 and has involved the joint effort of the regulatory agencies (Subpesca), research (IFOP), and fisheries control (Sernapesca), along with collaborative work with fishermen, leading the country to gradually solve the problem.

Within this process, and considering the challenges involved in the control and recording of discards and incidental catches at sea, Law N°20.625 incorporated the obligation to install Image Recording Devices (EMS or cameras) on all industrial fishing vessels and artisanal vessels of 15 meters or more in length, which would allow the detection and recording of all discard and incidental fishing actions that might occur in contravention of the rules for reducing these practices established for each fishery. The implementation of these systems was approached differently depending on the type of fleet, starting in the industrial sector from January 2020. In the case of artisanal fleets, the obligation for monitoring through EMS was postponed until January 2024 due to technical, regulatory, and economic challenges that needed to be resolved beforehand, considering that the number of artisanal vessels subject to this norm exceeds 500.

To date, the implementation of EMS has focused solely on monitoring compliance with the applicable regulations on target catches, discards, and incidental catches of birds, mammals, chondrichthyans, and sea turtles. However, the extension of the use of this tool beyond control, such as the scientific monitoring of fishing activities to collect fishery-dependent data, has recently begun to be explored with the aim of complementing traditional human observation programs in the near future.

1. Context and Justification

EMS in Chile are part of a broader regulatory and management framework for discards and incidental catch, which has been developed to its current state over more than 20 years. The term "discard" was first introduced in Chilean legislation in 2001, under a general prohibition approach that did not distinguish between species or sizes. Severe sanctions for violators, coupled with the lack of an effective system to monitor compliance at sea, resulted in a lack of cooperation from fishermen, and consequently, the real extent of discards and their causes remained unknown to fisheries authorities and management agencies.

Recognizing these limitations, the Chilean government revised the fisheries law in 2012, and through Law N° 20625/2012, incorporated a new gradual approach to solve the problem. This initial stage included exceptions to the discard prohibition, conditioned on the development of at least two years of research based on onboard observer programs that allowed for quantification and identification of the magnitudes and causes of discards and incidental catches. These findings enabled the subsequent development of mandatory reduction plans for these practices, adapted to each fishery, which included the use of devices, good fishing practices codes, and handling protocols, among others. In the final stage of the process, these plans were to be monitored and recorded at sea, for which new technological tools such as EMS were incorporated to ensure independent monitoring and achievement of reduction objectives. It is important to note that, along with the incorporation of EMS, human observer programs, conducted since 1990, were expanded with Law N° 20625/2012, but continued with the sole purpose of collecting biological and fisheries data for exclusive use in scientific advisory.

Having completed several mandatory research programs based on data collected by onboard observers until 2024, 11 discard and incidental catch reduction plans have been implemented, covering 17 industrial and artisanal fisheries, while other fisheries are still in the research phase. Additionally, the lists of species subject to reduction plans for each fishery and their regime (discard prohibited, discard authorized, or mandatory return to the sea) are updated annually. All industrial fisheries subject to reduction plans are being monitored by EMS to verify compliance and also by onboard observers for scientific purposes. Artisanal fisheries have initiated the process of EMS implementation in 2023 through pilot projects to identify and evaluate the best technologies and assess costs.

2.Objectives of the Electronic Monitoring System: Select the one that corresponds to your country and develop

According to Chilean law, the objectives of EMS are mainly associated with compliance control of fisheries regulations and are as follows:

a. Control compliance with the measures for reducing or prohibiting discards and incidental catches established by the reduction plans of each fishery.

b. Control the species and quantities authorized for discard by each plan.

c. Control the use of incidental catch reduction devices and handling protocols (seabirds, mammals, turtles, sharks).

d. Control illegal fishing and compliance with other management measures such as closures, fishing gear, etc.

It is important to note that the law also establishes that the information collected through EMS can be used for the management and administration of hydrobiological resources, a condition that opens the possibility of its use for scientific purposes. In this context, the recent implementation of this technology has provided a set of possible solutions to update and modernize fisheries data systems and significantly expand the collection and analysis of information for research, creating an opportunity to coordinate and enhance the work of the three national fisheries management agencies (SUBPESCA, SERNAPESCA, and IFOP) around maximizing the use of information that can be obtained from new technological monitoring tools.

While the main objective of EMS in Chile is control, its implementation and the information obtained have allowed for better fisheries management and contributed to the sustainability of fisheries, transparency of activities, and successful application to fisheries certification processes such as MSC or NOAA's Marine Mammal Protection Act (USA), among others.

3. System Implementation

This system consists of a set of components such as video cameras, satellite positioning systems, hard drives, and a monitor, among others. Depending on the fishery, the size of the fishing vessels, and the type of catch handling onboard, the number and location of cameras may vary.

The images are recorded in high resolution (1280x720p), at 15 frames per second, and at a variable bit rate. The video format is MP4 with the H.265 codec, also known as HEVC. These characteristics and specifications correspond to a unique DRI technical standard established by SERNAPESCA (compliance control agency) and must be accredited by each EMS service provider against an external certification agency.

The information recorded by the EMS includes images and associated files called metadata (in csv, xml, or json format) that contain parameters such as the number identifying the EMS associated with each vessel, date, time, and position, among others. This latter information is taken by the analysis software and provides crucial information to record and identify areas of non-compliance, dates, times, and more.

The EMS currently in use in Chile is a deferred system and consists of three modules: i) recording and storage module onboard fishing vessels, ii) data collection and hard drive extraction module at the port, iii) image analysis module at SERNAPESCA processing stations on land.

To implement the EMS, a regulation (Supreme Decree N° 76/2015) established the components of these systems, technical and design requirements, the minimum number and location of cameras per fishery, image collection, processing and confidentiality characteristics, obligations of vessel owners, SERNAPESCA functions, requirements for removing, downloading, and processing EMS information, sanctions for non-compliance, and requirements for external entities possibly involved in image review. In Chile, the law allows third-party participation in image review; however, this task is currently being carried out exclusively by the government through SERNAPESCA.

Industrial fleets in Chile correspond to any vessel ≥ 18 meters in length, and since January 2020, they have been monitored by EMS, including vessels using trawl nets, purse seines, and longlines. Beyond a rather theoretical work of gathering technical background on EMS, it is important to note that no pilot projects were conducted on industrial vessels before implementation, and the program was immediately implemented as an operational one. In 2020 and 2021, a number of 109 and 92 vessels, respectively, operating in the industrial fishing sector, were covered by the EMS. These numbers remain relatively stable to this day.

EMS in industrial fleets record the entirety of fishing trips, from the departure of vessels from ports to their return. Currently, each vessel has between 2 and 8 cameras, depending on its size, fishery, and type of operation, and whether catch processing is done onboard or if the catch is landed unprocessed. In general, the storage capacity of the hard drive determines the withdrawal schedule. However, vessel owners can be required to provide hard drives at any time at the request of various authorities, for administrative or compliance purposes.

Vessel owners are legally responsible for covering the costs of equipment, installation, and maintenance. However, the costs of image review are borne by the government.

4.Results Obtained after System Implementation

During the implementation process of the EMS, there has been close collaboration and feedback between Chile's regulatory and fisheries control agencies (SUBPESCA and SERNAPESCA), which has allowed for changes and adaptations in fisheries regulations, avoiding regulatory discards and incidental catches while improving compliance. Additionally, some measures, such as the use of devices to reduce incidental catches of marine mammals or seabirds, have been designed in a way that they can be efficiently monitored and controlled by the EMS and the analyst teams. In other cases, improvements have been made once the measures were implemented, such as the addition of cameras to detect specific issues in some fisheries or the requirement for crews to follow specific handling protocols, compatible with EMS capabilities.

The information from the EMS has contributed to the fisheries management agencies' understanding of fleet behavior patterns regarding discards and incidental catches and identifying individuals associated with non-compliance. These conditions have supported significant improvement of undesirable practices at sea in ways that were not previously possible. Feedback among hardware installers, video analysts, and the fishing industry has been key elements for the success of the program. Moreover, the industry's access to data and videos has enhanced fishers' knowledge about the EMS program, generating greater transparency and improving fishing efficiency. It is important to note that providing feedback to fishers has allowed for identifying system weaknesses or deficiencies that have been improved.

Remaining challenges include species identification in some fisheries and quantification through EMS. Another challenge relates to using EMS to control other fisheries regulations and illegal fishing. Leveraging the knowledge acquired during the early years of the EMS program in the industrial fleet, new approaches for sampling and image review are being explored, such as developing specific criteria for the fleet and a risk-based process for sample selection. The program will continue to cover 100% of industrial vessels and their fishing activity while reviewing technologies (using machine learning and artificial intelligence). Ongoing work also includes integrating other monitoring tools used in Chile, such as VMS, electronic logs, and landing certification. While the program currently uses hard drives for storage, transitioning to wireless transmission through 5G networks and cloud storage is forecasted as future steps, as well as implementing onboard pre-review systems within the DRI system and improving image quality to support a wider range of monitoring objectives.

Moreover, the recent implementation of technologies (DRI and SIBE) to collect, record, manage, and analyze fishing data related to catch control, discards, and incidental catches has provided a set of possible solutions to update and modernize fisheries data systems and significantly expand information collection and analysis for management and research, creating an opportunity to coordinate and enhance the work of the three national fisheries management agencies (SUBPESCA, SERNAPESCA, and IFOP) around maximizing the use of information that can be obtained from new technological monitoring tools.

The rapidly changing characteristics of fishing and its environment are forcing the availability of data with better spatial-temporal resolution, considering increasing uncertainty, and allowing adaptive fisheries management. This way, more accurate data collection is required, and its processing, analysis, and report preparation must be faster, allowing responses close to real-time. In this context, from 2022 onwards, the use of EMS for scientific purposes and its integration with traditional fisheries-dependent data collection programs have begun to be explored through the development of various research projects

5. Conclusions and Recommendations

The experience gained by Chile through the implementation of EMS for monitoring its fisheries recommends exploring the use of these tools to improve the monitoring coverage of fishing fleets, particularly those that are difficult to access, as these systems are safe, impartial, and based on currently available, tested, and cost-efficient technologies.

However, it is recognized that using these systems for purposes other than compliance control, such as obtaining scientific information and fisheries-dependent data collection, still requires intensive work in designing current monitoring programs, exploring the use of complementary technologies such as computer vision (CV), machine learning (ML), or artificial intelligence (AI), and their integration with traditional human observation programs in use. In this sense, Chile is just beginning to explore how EMS data can be used to support scientific interests.

Fundamentally, Chile's experience recommends the flexible and gradual implementation of these systems under a transparent policy framework, where the views of different stakeholders are considered, and the realities of each country are taken into account, including technical, human, economic, and cultural capacities, so that the EMS becomes a tool that adequately complements pre-existing monitoring systems.

In this context, it is very relevant to have legislation and regulations that clearly address all elements constituting the EMS, including equipment, technical and data standards, information transmission and analysis, responsibilities of all parties, information confidentiality, and implementation costs, among other aspects. It is also crucial to define at a very early stage of the process the objectives with which electronic monitoring will be implemented, which may include control, science, maritime safety, or others deemed pertinent.

Finally, it is recommended to develop an intense socialization process with fishers regarding these systems and their objectives, focused on making the fishing sector perceive and support the implementation of EMS as tools that will allow for greater transparency in fishing activities and help demonstrate to an increasingly demanding society and markets regarding sustainability that fishing can be carried out in an ecologically responsible manner and that the impacts on non-target species can be minimized.

Case Analysis: Use and Implementation of Electronic Monitoring Systems in the Artisanal Longline Fishery of Perico (*Coryphaena hippurus*) in Peru

Introduction

In the case of Peru, the perico (*Coryphaena hippurus*) fishery is the second-largest artisanal fishery nationally, after the giant squid (*Dosidicus gigas*) fishery, with an average of 50,000 tons of annual landings nationwide. The fishing gear used is artisanal longline, and flying fish is used as bait, or frozen mackerel or even squid. The distribution of this species has a marked seasonal component, starting the season in early spring (October), mainly on the northern coast, where most of the fleet operates from the port of Paita (05°S), and ends in late summer (March - April). In the south, the main landing port is Ilo (17°40'S). In the upcoming 2025 season, the new Fisheries Management Regulation for the perico resource (ROP perico) will come into force, aiming to promote the sustainable use and conservation of this hydrobiological resource, including the registration of fishing information and incidental catches to obtain certification of this important artisanal fishery. Approximately 3,000 artisanal boats are engaged in this fishery during the season, so it is necessary to establish control over incidental catches, which can be done through an onboard observer program, implying an increase in the budget, or through the implementation of Electronic Monitoring.

1. Context and Justification

In Peru, the perico (*Coryphaena hippurus*) fishery is the second most important artisanal fishery, after the squid (*Dosidicus gigas*) fishery. Through a pilot electronic monitoring program led by the NGO WWF Peru in this fishery, it was observed that there are incidental catches of various species of sea turtles, such as green (*Chelonia mydas*) and olive ridley *(Lepidochelys olivacea*) on the northern coast, and loggerhead (Caretta caretta) in oceanic zones of southern Peru, as well as several species of albatrosses and petrels, such as the Galapagos albatross (Phoebastria irrorata), Salvin's albatross (*Thalassarche salvini*), Buller's albatross (Thalassarche bulleri), as well as the white-chinned petrel (*Procellaria aequinoctialis*), Parkinson's petrel (*Procellaria parkinsoni*), pink-footed shearwater (*Ardenna creatopus*), among other species, many of which are in delicate conservation status according to the International Union for Conservation of Nature (IUCN). Due to the lack of a significant onboard observer program in this fishery, it is necessary to establish an electronic monitoring program to quantify the seasonality of incidental catches in different fishing areas and the incidence concerning the gear, which will greatly assist in taking appropriate mitigation measures, such as bird-scaring lines, side mitigation, good practices in viscera disposal, etc., significantly contributing to the certification of this fishery.

2. Objectives of the Electronic Monitoring System

a. Improve the sustainability of fishing practices.

b. Provide accurate data for the management and conservation of marine resources.

3. Implementation of the System

It is only a pilot program; there are no governmental initiatives yet to implement this system in the fishery, but it would be absolutely necessary to do so. The pilot system consisted of three boats monitored by video between December 2022 and February 2023 in the port of Paita (05°S), one boat with a camera in January 2023 in the port of Chimbote (09°C), and finally five boats with video cameras from February 2022 to March 2023 in the port of Matarani (17°S). Subsequently, a consultant was hired to visually analyze the videos and share them with Imarpe for corroboration of the incidentally captured species. However, the project budget has already been exhausted.

4. Results Obtained After System Implementation

In the Peruvian case, it is an experimental stage, so we have not yet evaluated the results of using EMS. One of the issues faced is the camera resolution. The NGO WWF Peru hired Shellcatch for EMS implementation, but the camera resolution was not adequate to accurately identify incidental catches, nor did it allow for determining the sizes of the target fish, requiring a change of operator (provider company). Poor resolution can lead to many errors. Cameras were placed on nine artisanal longline boats targeting perico (*Coryphaena hippurus*).

5.Benefits and Challenges

Mainly benefits, but it would be good to implement a Machine Learning program to automate/facilitate video analysis more automatically, reducing the budget for traditional manual analysis. Benefits include automating processes to determine incidental catches of non-target species and demonstrating to regulatory authorities that establishing such EMS programs is fundamental for the good management of this fishery. Especially since the United States now requires evidence of comparability for mitigating incidental catches of non-target species in all local fisheries whose hydrobiological products are exported to that country, thus achieving a better rating through the "Fishery Improvement Project Progress Tracking Database & Tools" process, which could help certify this important local fishery.

6.Conclusions and Recommendations

Regarding the pilot program led by WWF Peru, the main results were the identification of interactions of fishing gear with sea turtles and oceanic birds, seasonality of catches, and incidence quantification. It is recommended to hire a company that can provide high-resolution video cameras and use two cameras per boat, one focusing on the deck where the target fish is deposited and the other pointing to the maneuvering area where the longline is recovered to see interactions with non-target species (mainly top predators). It is also recommended to apply for other funding sources that could provide an additional budget to determine the most appropriate mitigation measures for this fishery and continue the EMS program and automate the process of identifying incidental catches of non-target species. Funding possibilities exist in NOAA and the Inter-American Tropical Tuna Commission for a multidisciplinary project involving regulatory bodies to later determine it mandatory, as in the Chilean case study.

Case Study: Electronic Monitoring Programs in the United States

Introduction

In the United States, ensuring the sustainability of the nation's fisheries—and the millions of jobs and billions of dollars in sales they support—requires a clear understanding of when, where, and how fishermen are operating, and monitoring what they catch, keep, and discard. Gathering this information has historically relied upon a combination of fishery observers, vessel monitoring systems (VMS), landings reports, and self-reported paper logbooks from captains and seafood processors and dealers. The United States, through NOAA Fisheries, and our partners are exploring how technologies like electronic reporting (ER), electronic monitoring (EM), and other tools can help meet the ever-increasing need to improve the timeliness, accuracy, and cost-effectiveness of collecting and processing fishery-dependent data.

EM uses equipment like video cameras, GPS receivers and transmitters, and gear sensors to capture information on fishing location, hours or days spent fishing, catch, and discards. This equipment can also track compliance with catch retention requirements and, in certain fisheries, interactions with protected species such as turtles, marine mammals, and seabirds.

1. Context and Justification:

Constrained budgets and increasing demands for data are driving the need to evaluate and improve existing fishery-dependent data collection programs, particularly regarding the cost-effectiveness, economies of scale and sharing of electronic technologies (ET) solutions across the United States. The demand for more precise, timelier, and more comprehensive fishery-dependent data continues to rise every year.

NOAA Fisheries works with fishers, regional fishery management councils, technology service providers, and a variety of other partners to improve the timeliness, quality, cost effectiveness, and accessibility of fishery-dependent data by integrating technology into data collection and monitoring programs for conserving and managing our nation's fisheries. Although many fisheries have been developing technologies for fisheries for a decade or more, much of this work gained momentum in 2013, when NOAA Fisheries published a Policy Directive on Electronic Technologies and Fishery-Dependent Data Collection (ET Policy Directive).

This ET Policy Directive established a number of guiding principles and recommendations, but more importantly, it established a requirement that all five NOAA Fisheries Regions—Alaska, West Coast, Pacific Islands, Southeast, Greater Atlantic, as well as the Atlantic Highly Migratory Species (HMS) program—publish Electronic Technologies Implementation Plans (ET Plans) covering five years. The original ET Plans were published in early 2015 and updated several times through 2017. In 2019, NOAA Fisheries published an updated ET Policy Directive, which called for new content for the ET Plans and a more standardized way of collecting and tracking ET program development and implementation. In August 2021, NOAA Fisheries published the new ET Plans, which cover 2021–2025, and which are updated and republished each spring.

2. Objectives of the Electronic Monitoring System

a. Improve the sustainability of fishing practices.
d. Provide accurate data for the management and conservation of marine resources.

3. Implementation of the System

NOAA Fisheries and its partners are piloting and implementing EM across the United States to expand and improve fisheries-dependent data collection, while reducing costs and increasing the timeliness of information. EM is used to audit logbook data, monitor compliance with discard requirements, and collect information on discards and bycatch.

The United States currently has nine fully operational EM programs in federal fisheries, five programs under development, and four pilot programs, of which 15 fisheries interact with seabirds (Table 1). However, it is important to note that less than one quarter of these EM programs have a primary focus of collecting data on protected species to support new or refine existing management measures.

Table 1: *Current Electronic Monitoring (EM) programs in U.S. fisheries and all known bycatch species categories that interact with each fishery. Note that the EM programs in these fisheries are not necessarily designed to collect data on all the bycatch species listed. F/I = fish/invertebrate, MM = marine mammal, ST = sea turtle, SB = seabird. Modified from Chan et al. 2024*

Region	EM Program	Type	Gear Type	Bycatch Species Category
Alaska	Bering Sea and Aleutian Island (BSAI) Non-Pollock Trawl Catcher/ Processor (C/P)	Operational	Otter Trawl Bottom	F/I, MM, SB
Alaska	Bering Sea Pollock Trawl C/P and Motherships	Operational	Otter Trawl Midwater	F/I, MM, SB
Alaska	Central Gulf of Alaska Rockfish Trawl C/P	Operational	Otter Trawl Bottom, Otter Trawl Midwater	F/I, MM, SB
Alaska	BSAI Pacific Cod Longline C/P	Operational	Bottom longline	F/I, MM, SB
Alaska	Small Boat Fixed Gear (Longline and Pot)	Operational	Bottom longline, Pot	F/I, MM, SB
Alaska	Halibut Deck Sorting Trawl C/P	Operational	Trawl	F/I, SB
Alaska	Pollock Trawl Catcher Vessels	Under Development	Otter Trawl Midwater	F/I, MM, SB
West Coast	Whiting Mid-Water Trawl	Under Development	Otter Trawl Midwater	F/I, MM, SB
West Coast	Fixed Gear IFQ	Under Development	Bottom Longline, Pots and Traps	F/I, MM, SB
West Coast	Non-Whiting Mid-Water Trawl	Under Development	Otter Trawl Midwater	F/I, MM, SB
West Coast	Groundfish Bottom Trawl	Under Development	Otter Trawl Bottom	F/I, MM, SB

West Coast	Nearshore Rockfish	Pilot	Combined Gears	F/I, MM, SB
Pacific Islands	Pelagic Longline-Hawaii Deep and Shallow Set	Pilot	Pelagic Longline	F/I, MM, ST, SB
Southeast	Snapper-Grouper	Pilot	Bottom longline, vertical line	F/I, ST
Southeast	Gulf of Mexico Shrimp	Pilot	Otter Trawls	F/I, MM, ST
Greater Atlantic	Northeast Multispecies	MREM: Operational (Under EFP) Audit: Operational (Under EFP Fishing Year 2016-2020; Under Regulation Fishing Year 2021-Present)	Gillnet, Otter Trawl, Bottom Longline, Scottish Seine, Hand Line	F/I, MM, ST, SB
Greater Atlantic	Herring Mid-Water Trawl	Operational (Under EFP)	Otter Trawl Midwater	F/I, MM
Greater Atlantic	Northern Gulf of Maine Scallop	Pilot	Pre-implementation phase	
Greater Atlantic	Northeast Multispecies For-Hire	Pilot	Hook and Line	F/I, ST
Atlantic HMS	Pelagic Longline	Operational	Pelagic Longline	F/I, MM, ST, SB

4. Results Obtained from the Implementation of the System

While several EM programs are now in place in U.S. fisheries, the use of EM to monitor seabird bycatch or the use of mitigation measures remains less advanced. Pierre (2018) reviewed the efficacy of EM in monitoring protected species interactions in commercial fisheries and reported that EM can be effective in monitoring captures of protected species, entanglements in fishing gear, handling of captured species, mortality levels, and discarded catch. Individual species identification for bycatch of seabirds is possible in many instances (Glemarec et al. 2020), however, monitoring seabird interactions with trawl warps and third wires can be less successful using EM (McElderry et al. 2011).

In the Alaskan halibut longline fishery, Ames et al. (2005) evaluated EM on two vessels and found that it produced accurate data and enabled compliance evaluations for seabird avoidance devices, as well as correctly identified a high proportion of incidentally caught seabirds (i.e., nine of 12 albatross [*Diomedea* spp.] specimens). Correct identification is particularly important as the incidental take of endangered short-tailed albatross (*Phoebastria albatrus*) can occur in this fishery. However, this study suggested that additional work is needed on seabird image identification, verification methods, and testing the effects of soak time on physical characteristics of seabirds.

In Hawaii's deep- and shallow-set pelagic longline fisheries, McElderry et al. (2010) compared seabird bycatch detection using video monitoring with onboard observers, which yielded mixed results. During the 6-month study period, there were three seabird captures: one encounter recorded by EM and the observer, one recorded by the observer but not EM, and one recorded by EM but not the observer.

5. Benefits and Challenges

The use of EM to monitor fisheries that interact with seabirds offers several potential benefits, including increased accuracy (i.e., reduce human error and bias in recording bycatch events), enhanced coverage in challenging circumstances, increased cost-effectiveness over time, and increased regulatory compliance by fishers. At the same time, the development and implementation of EM to monitor fisheries also presents several challenges. These include the high initial costs for equipment and installation, management and analysis of large amounts data that can be resource-intensive, timeliness of data and feedback to vessels, technical issues related to equipment malfunction or fouling, regulatory and compliance issues associated with developing and enforcing policies and regulations that mandate the use of EM systems, and determining the relative costs of various approaches and who pays for these new technologies.

6. Conclusions and Recommendations

Successful fisheries management is dependent on the data collected about fishing activities. EM is a tool used to collect fishing data including the number of fish caught, fishing effort, and bycatch. These data support and improve stock assessments and ensure that catch is sustainable in the long term. The United States, through NOAA Fisheries, is investing in technologies that hold promise in making data collection more timely, accurate, and cost-efficient. Many fisheries across the United States have, or are currently working to, integrate electronic monitoring and reporting tools into their data collection programs. EM program testing and implementation have revealed many benefits and challenges associated with various approaches, particularly as it relates to seabird bycatch monitoring. In the years to come, developing thoughtful solutions to cross-cutting issues and numerous fishery-specific challenges will require collaboration and planning. NOAA Fisheries is committed to providing national guidance as our regional offices work with local partners and fishing communities on a systematic approach toward adopting new technologies.

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