Goals and Objectives

for the

Pre-Implementation of Electronic Monitoring

in

Pacific Islands Pelagic Longline Fisheries

Prepared by the

Electronic Technologies Steering Committee

Pelagic Plan Team

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Abstract

At its 193rd Meeting, the Western Pacific Regional Fishery Management Council received an informational presentation on electronic monitoring and recommended that the ETSC and Pelagic Plan Team (PPT) begin the development of options and scenarios for the implementation of EM in US longline fisheries in the Western Pacific by September 2023. A working group, composed of members of the PPT and ETSC, collaborated to develop this discussion document for the Council's consideration.

The ETSC and PPT propose that a pre-implementation program, with monitoring goals and objectives defined by the Council, is the logical next step for developing EM in the region. The Council may provide direction for next steps, including prioritizing monitoring goals and objectives for EM implementation and whether to develop a pre-implementation program that builds capacity towards full implementation. For executing a pre-implementation EM program, the Council may recommend and prioritize: (1) region, American Samoa and/or Hawaii; (2) fishery sector(s), deep-set and/or shallow-set; and (3) overarching monitoring goals, with primary and possibly secondary monitoring objectives. The Council is not taking action to develop amendments to modify its FEPs at this time. This document is to prepare the Council for future action.

List of Acronyms

AI- artificial intelligence
ASLL- American Samoa longline
BiOp- Biological Opinion
Council- Western Pacific Fishery Management Council
CPUE- catch per unit effort
DSLL- deep-set longline
DPS- distinct population segment
EEZ- exclusive economic zone
EM- electronic monitoring
ER- electronic reporting
ET- electronic technologies
ETIP- electronic technologies implementation plan
ETSC- Electronic Technologies Steering Committee
FEP-fishery ecosystem plan
FIS- Fishery Information System Program
FKW- false killer whale
FWKTRP- False Killer Whale Take Reduction Plan
FKWTRT- False Killer Whale Take Reduction Team
FMP- fishery management plan
FRMD- Fisheries Research and Monitoring Division
FY- fiscal year

GPS- global positioning system
HMS- highly migratory species
HLA- Hawaii Longline Association
IATTC- Inter-American Tropical Tuna Commission
IT- information technology
ITS- incidental take statement
LL- longline
MBTA- Migratory Bird Treaty Act
MHI- Main Hawaiian Islands
ML- machine learning
MMPA- Marine Mammal Protection Act
MSA- Magnuson-Stevens Fishery Conservation and Management Act
NFWF- National Fish and Wildlife Foundation
NMFS- National Marine Fisheries Service
NOAA-National Oceanic and Atmospheric Administration
PIFSC-Pacific Islands Fisheries Science Center
PIR- Pacific Islands Region
PIRO- Pacific Islands Regional Office
PIROP- Pacific Islands Regional Observer Program
PPT- Pelagic Plan Team
PRD- Protected Resources Division
QA- quality assurance
QC- quality control
RFMO- regional fishery management organization
RPM- reasonable and prudent measure
SEZ- Southern Exclusion Zone
SFD- Sustainable Fisheries Division
SOP- standard operating procedure
SSLL- shallow-set longline
TRT- Take Reduction Team
T&C- terms and conditions
VMS- vessel monitoring system
US- United States
USFWS- United States Fish and Wildlife Service
WCPFC- Western and Central Pacific Fisheries Commission

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Background

Electronic technologies (ET) include any electronic tool used to support fisheries monitoring both onshore and at sea, including electronic reporting (e.g., e-logbooks, tablets, and other input devices), electronic monitoring, and vessel monitoring systems (VMS). Electronic monitoring (EM) refers to the use of technologies such as video cameras, gear sensors, and reporting systems to monitor fishing operations, efforts, and/or catch. EM data is a broad term that includes the data that are created in the collection of fishery-dependent data by EM, including raw video and sensor data, images derived from videos, as well as the metadata that provides information about the raw data (e.g., trip date, vessel information). EM data may also refer to

the summarized data, compliance reports, and other records that are created from reviewing and analyzing the raw EM data.

The Western Pacific Regional Fishery Management Council (Council) has promoted the use of electronic technologies for decades, and became the first in the nation to require VMS in 1994. Electronic reporting (ER) trials in the Hawaii longline fishery started in early 2000s, and ER became mandatory in the Hawaii and American Samoa longline fisheries in 2021. Development of EM in the region started with a Council-funded project in 2009, and subsequent projects led by the Pacific Islands Fisheries Science Center (PIFSC). Dozens of Hawaii longline vessels have voluntarily participated in the EM projects since 2009.

The National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) developed the Policy on Electronic Technologies and Fishery-Dependent Data (Policy Directive 04-115; formerly 30-133), which became effective on May 3, 2013. This policy, as updated on May 1, 2019, provides guidance on the implementation of ET solutions in fishery-dependent data collection programs. It is the policy of NMFS to encourage the consideration of ET to complement and/or improve existing fishery-dependent data collection programs to achieve the most cost-effective and sustainable approach that ensures alignment of management goals, data needs, funding sources, and regulations. To achieve this, the policy states that fishery-dependent data collection programs may be comprised of a combination of methods and techniques, including but not limited to self-reporting, at-sea observers, dockside monitoring, as well as the use of ER and EM. NMFS supports and encourages the evaluation and/or implementation of EM to meet monitoring and compliance needs in federally managed fisheries. As stated in NMFS Policy Directive 04-115, implementation of ETs in a fishery-dependent data collection program is subject to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act or MSA) and Council regulatory process, other relevant state and federal regulations, and the availability of funds.

As EM programs have developed across NMFS Regional Offices, NMFS has developed policy directives to guide the use and implementation of ET. The policy directives address the topics of (1) cost allocation in EM programs for federally managed U.S. fisheries (NMFS Policy Directive 04-115-02); (2) third-party minimum data retention period in EM programs for federally managed U.S. fisheries (NMFS Policy Directive 04-115-03); (3) information law application for data and supporting guidance in EM programs for federally managed U.S. fisheries (NMFS Policy Directive 04-115-04); and 4) ER technologies in the Marine Recreational Information Program (NMFS Policy Directive 04-115-01, which will not be discussed in detail in this document).

Following the publication of NMFS Policy Directive 04-115, the Pacific Islands Regional Office (PIRO) and PIFSC, in consultation with the Council, developed a 5-year electronic technologies implementation plan (ETIP) entitled "NMFS Pacific Islands Region Electronic Reporting and Electronic Monitoring Implementation Plan" that established a regional vision for developing, integrating, and implementing electronic technologies for fisheries-dependent data collection in U.S. fisheries. This original ETIP prioritized development and implementation of ER in the near-term, and envisioned developing EM capabilities for longline fisheries in 2019-2025. The

plan was updated in August 2021 by the Pacific Islands Region (PIR) and describes the PIR priorities for electronic technologies in 2021-2025. Priorities outlined for EM include: 1) continuing the development of EM in the Hawaii longline fisheries, 2) conducting a catch handling study to address camera detection issues with discarded species such as sharks, and 3) analyzing the necessary regulatory framework needed to implement EM at varying coverage and review rates, including an analysis of long-term funding needs and a cost transition plan, as described in the NMFS Policy Directive 04-115-02.

In October 2022 through January 2023, the PIRO Sustainable Fisheries Division (SFD) and the PIFSC Fisheries Research and Monitoring Division (FRMD) hosted an electronic monitoring expert from the Greater Atlantic Regional Office to evaluate the status of EM in the PIR and develop a roadmap towards implementation of EM in regional longline fisheries. This roadmap (NMFS 2023a) considers EM research done in the PIR to date, and explores next steps for the development and implementation of an EM program in the Hawaii pelagic longline fisheries operating under the Fishery Ecosystem Plan (FEP) for Pelagic Fisheries of the Western Pacific Region. It incorporates recommendations resulting from six years of EM research by PIFSC, feedback from various divisions within NOAA Fisheries, and input from the Electronic Technologies Steering Committee (ETSC) which was reconvened to participate in this process.

At the 193rd Meeting of the Council in December 2022, the Council received an informational presentation which reviewed EM definitions and uses, previous and ongoing EM research in the region, NMFS ET Policy Directives, the formation of the ETSC, and information on how to develop and implement EM programs. Following this presentation, the Council recommended that the ETSC and Pelagic Plan Team (PPT) begin the development of options and scenarios for the implementation of EM in US longline fisheries in the Western Pacific by September 2023. At a meeting of the PPT on May 10, 2023 the ETSC presented a range of possible scenarios for the implementation of EM in U.S. longline fisheries in the PIR and solicited feedback from the PPT. Following the meeting a working group, composed of members of the PPT and ETSC, collaborated to develop this discussion document for the Council's consideration.

Decision to be Made

To date, PIFSC FRMD has conducted extensive research and development of EM and its capabilities and uses in the Hawaii longline fisheries. Following the recommendation by the Council at its 193rd Meeting, the ETSC considered this past research and how it could apply to the potential future implementation of EM in US longline fisheries in the Western Pacific. The ETSC determined that the research done to date has been essential to evaluate the viability of EM as a monitoring tool in Western Pacific longline fisheries. However, NMFS and the Council have not yet considered how to integrate an EM program into current monitoring and management infrastructure or the specific monitoring goals of an implemented EM program. Therefore, the ETSC concluded that a pre-implementation program, which builds NMFS and industry capacity to support EM and answers key program design questions is needed to determine how EM could be implemented in a regulatory capacity.

The Council at the 196th Meeting in September 2023 will consider possible monitoring goals for protected species, catch accounting of retained species, and catch accounting of discarded species for one or more of the U.S. longline fisheries in the PIR. For each of these overarching monitoring goals, specific objectives are presented for consideration. The Council may provide direction for next steps, including prioritizing monitoring goals and objectives for EM implementation and whether to develop a pre-implementation program that builds capacity towards full implementation. For executing a pre-implementation EM program, the Council may recommend and prioritize: (1) region, American Samoa and/or Hawaii; (2) fishery sector(s), deep-set and/or shallow-set; and (3) overarching monitoring goals, with primary and possibly secondary monitoring objectives. The monitoring goals and objectives will frame a 'purpose and need' for Council action in the future. The Council may also provide guidance on what information is needed from a pre-implementation program to inform a future decision to implement EM in the U.S. longline fisheries in the PIR.

The Council is not taking action to develop amendments to modify its FEPs at this time. This document is to prepare the Council for future action.

Purpose of a Pre-Implementation Program

The ETSC and PPT propose that a pre-implementation program, with monitoring goals and objectives defined by the Council, is the logical next step for developing EM in the region. A pre-implementation program refers to an EM program which develops a pathway to integrate EM into the fishery monitoring regime. A pre-implementation program would provide information for a future FEP or regulatory amendment to implement EM in the pelagic longline fisheries of the PIR. The program would be designed to establish and refine questions such as:

- What is the EM program structure? (e.g., which NMFS division oversees it? What is the EM provider structure?)
- What is the data governance structure (e.g., Who owns what data? How and where is it stored?)
- What are the key EM program protocols? (e.g. review rates, catch-handling requirements, standardization of data collection)
- What infrastructure needs to be built? (e.g. NMFS databases, provider approval processes, or program staff)
- What are the actual program costs?

A pre-implementation program would also inform necessary NMFS staffing requirements to run and manage a fully implemented EM program for the fishery. It would be imperative to hire additional EM program staff or reallocate current PIFSC and PIRO staff time to assist with an EM program. Many areas of expertise would be needed to bring a pre-implementation program online including: staff that could facilitate management and policy; EM data collection, review, and analysis; data management, including IT specialists; and EM system maintenance.

The pre-implementation program would also develop the data infrastructure needed for an operational EM program. With large-scale deployment of EM, the data storage requirements would be significant and require the development of scalable infrastructures for storing and accessing continually collected EM data. If the implemented program was a NMFS-run model, all data collected would be a federal record. If the implemented program used a third-party provider for data collection and storage, only the data submitted to NMFS would become a federal record. In either type of program, data collected would be subject to information law and data retention policies as outlined under NMFS Procedural Directive 04-115-03, which would increase the necessary storage requirements. Under a pre-implementation program a data submission platform may be developed to facilitate storage and access to EM data for review and analysis.

Pre-implementation programs have been used in other regions and fisheries to establish and develop operational EM programs. To date, over seven pre-implementation programs have moved to regulatory, implemented programs, including several EM programs in Alaska fisheries, the Atlantic pelagic longline fishery, and the Northeast multispecies groundfish fishery. Each of these implemented programs were informed by the lessons learned, data collected, infrastructure built, and protocols and procedures established during the pre-implementation phase.

Summary of Regional EM Initiatives

Interest in EM technologies initiated a pilot project in 2009 to evaluate the use of EM as a monitoring tool in PIR longline fisheries. This project was funded by the Council and was a collaboration with Archipelago Marine Research and the Hawaii Longline Association (HLA). Three EM systems were installed on Hawaii longline vessels with one of the vessels performing deep-set trips and two performing shallow-set trips. A total of 182 sets were compared between observer and EM data with some issues, such as variable detection rates (McElderry et al. 2010). Yet the project showed potential for EM in the region. As a result, in 2017 a larger EM project was developed by PIFSC using Fishery Information System Program (FIS) funds, which have supported the program since that time. This project was designed to improve issues in detection rates and species identification with better camera placement and utilization of a video reviewer with experience as an observer in the Hawaii longline fisheries. A total of 20 EM systems are installed on volunteer Hawaii longline vessels that conduct deep-set and/or shallow-set trips as a part of this project.

EM has been successfully used in the PIR with other projects to conduct research and to develop technological advances. One study used EM to show the effectiveness of tori lines as a seabird mitigation measure in the deep-set longline (DSLL) fishery by reviewing footage for seabird attempts and contact with baited hooks during setting operations (Gilman et al. 2021). This project was initiated by the Council and is being expanded to determine the effectiveness of tori lines in the shallow-set longline (SSLL) fishery. Another project in 2019 utilized EM systems on five vessels to develop and advance technologies for catch detection, EM footage

review, and reporting through a National Fish and Wildlife Foundation (NFWF) grant and a collaboration between Lynker Technologies, SnapIT, and Teem.fish.

These projects have been conducted in collaboration with volunteer Hawaii longline vessels, and participating fishers have become familiar with the concept of EM. Feedback from participants indicates that fishers benefit from being able to see fish brought aboard and crew handling without the need to run back and forth from the wheelhouse to the deck. However, there is some uncertainty regarding the acceptance and willingness for fishers to use EM across the fleet.

Publications and technical memos

In the course of the EM program developed by PIFSC, research has answered a number of key questions regarding the capabilities and feasibility of EM on Hawaii pelagic longline vessels. This includes understanding EM detection ability as compared to human observer data, optimal video review speeds for EM event detection, whether EM can be used to detect protected species interactions and the likely post-release condition of protected species.

Carnes et al. (2019) compared observer and EM catch detections for 238 Hawaii longline fishing hauls. From video review of EM footage, about 98% of retained fish and 89% of total haul catch were detected compared to observer data. This research demonstrated good detection ability for retained catch with some improvements needed for bycatch species that do not come aboard the vessel, especially with sharks. At the time of the study crew released most sharks from the gear as soon as they were observed, so sharks were often not in the view of the cameras. As a result, a catch handling study was designed to improve shark detection. However, due to problems with the contractor, the project was not completed, and in the meantime a regulatory amendment which prohibits the use of wire leaders was implemented. Now, the crew may bring sharks closer to the vessel and into the view of cameras to retrieve their weights.

Stahl and Carnes (2020) compared video review speeds (4x, 8x, and 16x real-time) to determine the preferred human review speed for detection with a focus on protected species. The speed of 8x real-time appeared to be the preferred speed. A 16x real-time speed was too fast, with video skipping and more potential to miss protected species in limited footage. While 4x speed may be too slow for reviewers to maintain attention, as reviewers misinterpreted footage of two protected species as gear tangles and skipped over the footage. This suggests future guidelines for review speed and daily review hours to ensure all footage is accurately reviewed. This study also showed that footage of protected species, including cetaceans, sea turtles, and albatross could be captured by EM cameras and detected by reviewers.

Stahl et al. (in press) demonstrated that protected species could be detected with EM and that data could be collected to assess their likely post-release condition. For cetaceans, EM video was reviewed to determine whether an injury determination of mortality, serious, or non-serious

injury could be made. When there was not enough data to make a determination, then an interaction was assigned as “not determined”. The criteria used to make the determinations was based on NMFS Policy Directive 02-238-01 from 2023 (updated from 2012). For sea turtles, reviewed data were used to assign a probability of mortality selected from a table in Ryder et al. (2006) based on whether the turtle was hardshell or leatherback, its injury location, and the attached fishing gear at release.

Eight cetacean interactions were reviewed with injury determinations possible for six of the interactions. Because most interactions occurred at night in the deep-set fishery, it was difficult to see or to distinguish dark animals from the ocean. However, false killer whale species identification was possible at night when animals were brought to the vessel following protected species guidelines. Most cetaceans were mouth-hooked, and reviewers had difficulty discerning in what part of the mouth they were hooked. If a cetacean is lip-hooked, released with no trailing gear, and no other case-specific factors indicate a serious injury, then a non-serious injury determination can be made. Otherwise all mouth-hookings are considered serious. Finally, most cetaceans were also released with trailing gear, and it was challenging for reviewers to determine the amount of trailing gear at release unless crew were observed cutting or coiling the line within the camera view. If animals are hooked in the body and fishers are observed releasing the animal with trailing gear greater than its body length then a serious injury would be assigned.

For sea turtles, 37 interactions were reviewed and a post-interaction mortality estimate was assigned to each (Stahl et al. in press). Shallow-set hauls occur during the day, which facilitated review of sea turtle interactions. However in some cases, data was uncertain and a “worse or worst case scenario” was selected from the table in Ryder et al. (2006), which may inflate the true probability of mortality. When a second camera system with improved resolution was installed, fewer interactions were assigned a “worse or worst case” probability of mortality. Most sea turtles were hooked externally in a flipper, and most were boarded and released with all gear removed. It was more difficult for video reviewers to assign a probability of mortality when sea turtles were mouth-hooked as it was harder to discern the exact hook location, which could lead to different injury designations. More uncertainty also occurred when sea turtles were released with trailing gear. However, if fishers were observed cutting or coiling the line within the camera view, then it was easier to assess the amount of trailing gear in relation to the turtle’s body length to assign a probability of mortality.

Current and ongoing research

Protected Species Research

The PIFSC EM program is continuing to conduct protected species research to assess if EM video can be used to determine the likely post-release condition of oceanic whitetip sharks, giant manta ray, false killer whales, and leatherback sea turtles. Assessing if the necessary data can be collected by EM to determine post release conditions is crucial to understanding how to structure an implemented EM program with the at-sea observer program.

Artificial Intelligence Research

The PIFSC EM program is conducting research to assess whether artificial intelligence (AI) can be used to detect all catch events from EM footage collected in the PIR longline fisheries, and therefore reduce human review time and associated costs. The majority of fishing hooks in the Hawaii longline fisheries have no catch and it is time consuming for a human to review all hooks. AI models have the potential to reduce review time and alleviate potential issues with human reviewers as reviewing all hooks in a haul is tedious ,time consuming, and can lead to potential errors (e.g. rushing through footage or visual fatigue leading to missed catch events, including protected species). The PIFSC EM program is developing algorithms to detect all catch events, with a focus to develop object detection models that detect species groups such as sea turtles, fish, and cetaceans. For these models, a human reviewer would perform species identification of the objects detected by the AI model. However, future models could be developed that classify catch into species and could be used in conjunction with object detection algorithms to more quickly and easily detect catch events and verify species identification.

The program is building a library of annotated images to use to train AI algorithms. Catch is labeled and bounded within images that are extracted from EM video of catch on the deck and in the water. Preliminary assessment of this object detection model using raw EM footage shows that the model is capable of detecting fish and sea turtles. When compared to previously developed models, there is also a significant reduction in the occurrence of false positives (annotations that incorrectly identify a catch event when none occurred). With additional annotations in the PIFSC AI library, it is expected that future model iterations will improve detection accuracy even further. The model is able to detect sea turtles in the water, which is more difficult than detecting them on deck, as the sea turtle can be partially submerged or in many more orientations than those on deck. The model's ability to detect sea turtles in the water indicates that other models could be developed to detect additional bycatch and protected species that do not come aboard the vessel such as cetaceans and sharks.

For the developed AI model, only annotations of hardshell sea turtles were used in the training; however, testing showed the model was able to detect leatherback sea turtles in some video frames. The annotation library contains about 2,400 leatherback sea turtle annotations that can be used to develop future models.

EM System Design

An EM system refers to the hardware installed on vessels to capture fishing imagery and data, including cameras, computers, monitors, and sensors. System design across EM programs varies, depending on the needs of the EM program, its data-collection goals, and the specifications of cameras used. Systems installed by PIFSC to date consist of two cameras, one with a deck view and the other with a water view. One camera view covers a large area of the deck and can be used for detection and species identification of retained catch, as well as crew handling. The other "rail" camera shows a view of the water that includes the fish door where animals are boarded and extends over the water and towards the stern. This "rail" camera may

be used for detection and species identification of bycatch, including protected species that are not boarded. The systems are run by a computer in the wheelhouse which stores data and connects to the cameras and magnetic and hydraulic sensors that trigger the cameras to record during hauling only. A GPS sensor records location and vessel speed.

Depending on the monitoring goals recommended by the Council, a future EM program may utilize the same or a different EM system design, and many EM providers carry proprietary EM systems and software. In addition, EM system design may vary across vessels to capture the same information, depending on differences in the configuration of the vessels. Ultimately, the monitoring goals of the EM program will dictate the data collection needs, and therefore the EM system design of a future EM program. During a pre-implementation program, standards would be developed around EM system design for future EM implementation.

General EM Considerations

The Council may select monitoring goals and objectives for one or more fishing sectors for a pre-implementation program. These monitoring objectives will drive which data fields are required for collection. Additional data fields may be collectable but may not be required to meet monitoring objectives. As the pre-implementation program develops, the time and costs will need to be weighed with the benefit of collecting additional data fields. Below, is an outline of general considerations regarding EM requirements by Regional Fishery Management Organizations (RFMOs), EM capabilities, EM coverage levels, and the development of standard operating procedures (SOPs) which may influence which data fields are collected to meet monitoring objects.

EM Coverage Levels

Retained species

EM research (Carnes et al. 2019) indicated that retained species can be detected with 98% accuracy in the Hawaii longline fisheries. Currently, dealer reports can be used to collect weight data on retained species, as well as logbook data and observer data on numbers of fish. If EM data is used to verify retained species for logbook or dealer data, then the encounter rate of particular retained species should be considered when determining coverage rates. It should also be noted that it may be challenging to distinguish some retained species or size classes from EM footage. For example, bigeye and yellowfin tuna may be difficult to distinguish at small to intermediate sizes where yellowfin tuna do not yet have their distinguishing long extended anal or dorsal fins.

Bycatch and protected species

EM research (Carnes et al. 2019) indicated that discarded species can be detected with 89% accuracy compared to at-sea observer data in the Hawaii longline fisheries. However, when the

study was conducted the largest issue for discard detection was that sharks were often cut from the line before they were brought into camera views. Since the Carnes et al. (2019) study, regulations have been implemented that prohibit wire leaders in the Hawaii DSLL fishery and require fishers to remove fishing gear from oceanic whitetip sharks in the Hawaii and American Samoa longline fisheries. For other discarded species, it may depend on handling and camera views whether the species is detected. For example, lancetfish are often brought towards the back of the vessel near the bait boxes to remove from fishing gear before discarding. Consequently, fisher handling and encounter rates need to be considered to determine EM coverage rates for monitoring objectives focused on discarded species.

For protected species, encounter rates will need to be considered when determining coverage rates, as many species are rare. There is a trade off between reducing coverage rates (and associated costs) and the precision around point estimates for total numbers of each species encountered. Fewer encounters are likely to be documented with less coverage, resulting in greater uncertainty. Point estimate uncertainty for some species is particularly important when determining if threshold levels, triggering specific management actions, have been reached.

The costs associated with monitoring coverage may be alleviated to some extent through the implementation of AI. AI models may allow detection of catch events from EM video with AI models reducing the costs and time needed for video review with only human reviewers. Consequently, AI should be considered in the future as a possible means to achieving higher coverage rates for protected and other rare species. All or a larger proportion of vessels would need to be equipped with EM cameras to facilitate higher coverage rates with AI, than if considering coverage rates based on human review alone.

Monitoring requirements for RFMOs and third party certifications

International management of Hawaii and American Samoa longline fisheries are under the auspices of two primary RFMOs, the Inter-American Tropical Tuna Commission (IATTC) in the eastern Pacific and the Western and Central Pacific Fisheries Commission (WCPFC) in the waters west of 150°W. In 2022, the IATTC adopted a resolution (C-22-07) to establish an ad hoc working group on EM, which has begun development of both technical EM standards and data collection priorities through a series of workshops. IATTC staff provided technical recommendations, including data collection priorities, which were provided in IATTC workshop reports. The U.S. delegation to the IATTC has maintained that EM should complement human observer coverage and recommendations have included that combined human observer and EM coverage in all longline fisheries should aspire to reach 20% of longline fishing effort. The WCPFC has also formed the Electronic Reporting and Electronic Monitoring Working Group (ERandEM WG) in 2022 that is tasked to develop minimum standards for EM and to develop a conservation and management measure within the WCPFC in 2023. In August 2023, the 19th WCPFC Scientific Committee (SC19) recommended that the Commission explore options to expand the observer coverage on longline vessels through both human and electronic approaches (notably EM) in the WCPO so that the SC can provide better estimates of bycatch levels and other metrics from these fleets.

Hawaii and American Samoa longline fisheries are certified under the Marine Stewardship Council (MSC) which has evolved its standards for certification. One of these foreseen standards is augmenting monitoring and surveillance of MSC-certified longline fisheries to have at least 30% combined EM and human observer coverage.

Development of Standard Operating Procedures

A major benefit of a pre-implementation program is that it provides the opportunity to develop and iterate SOPs for a future program. Procedures may be developed around the collection of raw EM data, video review, QA/QC, approval processes, or other program activities.

Video review

Standard operating procedures for video review would be created and iterated throughout a pre-implementation program. SOP's would specify how trips or hauls are selected for review, the video review speed, the amount of hours analysts spend reviewing video per day, and how data are collected and entered by video analysts. In addition, protocols would be included for QA/QC for new reviewers, for regular verification, and for third parties (if this type of EM program model is selected).

EM video collected from vessels will be reviewed for selected data fields (e.g. retained fish, protected species interactions, discarded fish etc.) using video review software. Sensor data can provide time and position information. In the future, AI models may be used to detect catch events from EM video footage with a human reviewer verifying accuracy of detections, performing species identification, and collecting any additional requested data on protected species interactions or other species of interest. Video and collected data on protected species interactions or other species of interest may be provided to experts to make cetacean injury determinations, to assess the likely post-release condition of sea turtles, or to further examine video for other species of interest (e.g. elasmobranchs or birds).

Data collected from video review will be submitted to NMFS in a configuration that meets PIR databases requirements. Collected EM data will be warehoused in a database that allows integration of observer and EM data that is accessible by users. SOP's around data submission, storage and usage would be developed in the course of the pre-implementation program following the guidance of NMFS policy directives 04-115-03 and 04-115-04, and according to the needs of the EM program.

Data Collectable by EM

In any monitoring program certain data elements will be best suited for collection by human observers, while others will be suitable for collection by EM. The ETSC has reviewed data elements that are collected in the Pacific Islands Regional Observer Program (PIROP), and the PIFSC EM program has researched the accuracy of catch detections by EM and its utility for collecting data on protected species interactions. As a general overview, EM can be used to

collect information on 1) retained catch (98% detection rate, Carnes et al. 2019), 2) discarded fish (depends on species and camera views, Carnes et. al 2019), 3) sharks if brought to the vessel, 4) protected species (Stahl and Carnes 2020), and 5) protected species injury and release condition to assess likely post-release mortality (Stahl et al. in press). At this time research and development would be needed to use EM to collect information on: 1) biological data (e.g., genetic samples, lengths, sex, lancetfish stomachs used for ecological studies), 2) gear measurements (e.g. hook size, branchline length), 3) discarded fish (depends on species and camera views; Carnes et al. 2019), 4) sharks, if discarded out of view, and 5) enforcement and compliance monitoring.

General Cost Considerations

While using EM to meet some monitoring needs may reduce overall monitoring costs, it also introduces new costs that must be accounted for. These new costs may be traditional, direct costs such as program management, video review, or equipment costs or they may be realized, indirect costs to vessel owners and operators that result from changed behavior while fishing (e.g., additional catch handling for EM protocols). National Standard 8 of the Magnuson Stevens Fishery Management and Conservation Act requires that conservation and management measures minimize costs and avoid unnecessary duplication, where practicable.

NMFS deploys at-sea observers on 20% of all Hawaii deep-set longline trips. At its current operating level, the PIROP requires approximately $6 million annually. However, NMFS forecasts that costs over the next 5 years will rise to over $8-9 million annually. Increases in longline fishing effort and observer labor costs, combined with funding shortfalls and high inflation, necessitate reducing coverage rates in the Hawaii deep-set longline fishery, which represents the largest fraction of the program cost. Starting in fiscal year (FY) 24, NMFS will reduce observer coverage in the fishery to 15%. If funding is not increased, NMFS will likely further reduce coverage in the fishery. Reducing observer coverage may increase uncertainty in fisheries impacts to protected species, which may in turn invite litigation and may weaken the U.S. negotiating position to increase observer coverage in other nations' Western Pacific longline fisheries. As a reference, the international observer coverage standard for longline fisheries in the Western Pacific Ocean is 5%.

Cost Drivers

A clearly defined purpose and need is a prerequisite for any monitoring program, and will drive costs for an EM program, depending on the type and amount of data that must be collected to meet the purpose and need. In general, certain design elements of an EM program will drive costs. These include, but are not limited to: the amount of data collected, the amount of data reviewed and analyzed, the number and difficulty of collecting data elements, and the ratio of EM coverage to human observer coverage. EM video data are a primary cost driver with cost increases associated with increases in the amount of video recorded, transmitted, and stored. Further, cost will also increase with the amount of video that is reviewed and analyzed for the

collection of fishery-dependent data. There may be eventual cost savings realized with the application of AI and machine learning (ML), but there are associated costs to developing, training, and running AI/ML applications.

The cost of video review and analysis varies depending on the types of data that are collected during video review. In most programs, as the number of data fields collected increases, so does the cost of video review and analysis. This is because an increased number of data fields usually requires more time by reviewers, with more pauses, to annotate video to collect the requested data field(s), and a greater amount of QA/QC of data collected prior to finalization of the data. In addition, as the difficulty of collecting the data increases, so does the time for video review, and thus the cost. For example, if a reviewer must spend a significant amount of time identifying an animal or writing notes associated with the data field collected, the time to conduct the video review will increase. However, it should be noted that some catch, including protected species, may be rare in the PIR longline fisheries and reviewers must review entire hauls to detect such events, which takes considerable time and concentration. Consequently, a limited scope of video review may incur costs of review that are disproportionately high to the amount of data collected. AI may provide a means to selectively detect rare catch events, including protected species, and potentially reduce costs associated with EM programs by reducing human video review time in the future.

The difficulty of collecting some data fields may be mediated by requiring certain practices by the fishers that make information easier to identify on camera. However, these practices may be burdensome to crew and could incur additional operational costs to fishers. When considering which data fields are necessary to collect to meet the management objectives, the Council may consider which data fields are most pertinent and feasible to collect via video review.

Finally, overall monitoring costs will be dependent on the ratio of EM coverage to human observer coverage. If EM is used to supplement a portion of the required observer coverage, costs may decrease for the total monitoring program. However, if EM is used in addition to already-required human observer coverage, the cost of the entire monitoring program will be higher than the cost of the human observer program alone.

Cost Estimates

At this time, it would be premature to estimate the costs associated with an operational EM program because key program design questions have yet to be resolved. However, information from EM programs elsewhere, the PIR ETIP, and research done by PIFSC can inform cost considerations and program design elements which would drive future program costs. The following cost estimates are described in the PIR ETIP and the Roadmap for the Potential Future Implementation of Electronic Monitoring in the Pacific Islands Region.

The PIR ETIP estimates costs for a hypothetical EM program, administered by NMFS, which has EM equipment installed on 160 DSLL vessels and 25% of fishing hauls reviewed. The total estimated annual costs of such a program, inclusive of both administrative and sampling costs, is estimated to be roughly $2.5M. Of these costs, roughly $1.9M are categorized as sampling

costs. Sampling costs include approximately $1M for operational costs, such as video review and storage by the service provider and approximately $0.9M for the purchase of equipment, installation and general maintenance. EM equipment is expected to last 3-5 years and, as such, the costs presented in the ETIP are amortized across three fishing years. The remaining costs–roughly $0.6M–are categorized as administrative costs, which include program support, performance monitoring, certification of EM providers, and long-term video and data storage by NMFS.

The Atlantic highly migratory species (HMS) EM program offers the most comparable example to the Pacific Islands region with similarities in gear type, target species and vessel size. In addition,the monitoring objectives for the Atlantic HMS program (monitoring bluefin tuna bycatch through identification, enumeration, and collection of lengths and verifying whether shortfin mako shark bycatch is dead or alive at haulback) have similarities to some of the monitoring objectives presented here for PIR longline fisheries for retained and discarded bycatch species. However, some monitoring objectives proposed for PIR, such as those for protected species, may require additional review and consequently result in higher potential costs compared to the Atlantic HMS program. Currently, the Atlantic HMS program is funded by NMFS, with the exception of data transmission (i.e., mailing hard drives), which is paid for by industry. NMFS is exploring ways to transition the sampling costs of the program to industry. The program costs are estimated at $1.2M annually for 67 vessels. NMFS Atlantic HMS staff estimate the cost at $280 per sea day.

Funding

NMFS policy directive 04-115 instructs that no ET-based, fishery-dependent data collection program will be approved by NOAA if its provisions create an unfunded or unsustainable cost of implementation or operation contrary to applicable law or regulation. Funding of fishery-dependent data collection programs is expected to consider the entire range of funding authorities available under federal law, including those that allow collection of funds from industry. Typically, NMFS' programs and activities are financed by funds appropriated by Congress. A congressional appropriation establishes a maximum authorized program level, which prohibits an agency, absent specific statutory authorization, to operate beyond the level that can be funded by its appropriations.

NMFS policy directive 04-115-03 provides guidance that cost allocation for EM programs must be consistent with all applicable appropriations law, the Magnuson-Stevens Fishery Conservation and Management Act (MSA), and other Federal requirements. NMFS has identified two categories of costs associated with EM programs: sampling costs and administrative costs. Sampling costs may include, among others: equipment purchases, leases, and installation, equipment maintenance and upkeep, training for captains and crew (as appropriate), development of vessel monitoring plans, data transmittal (whether by physical transfer of hard drives or sending data electronically), video processing and storage, and service provider fees and overhead. Administrative costs may include, among others: program administration support to address science, enforcement, management needs, troubleshooting

system issues that arise, facilitating communication between industry participants and EM service providers as needed, managing vessel selection processes as needed, certification of EM service providers, EM program performance monitoring, and data analysis and storage of Federal records.

For all EM programs, NOAA Fisheries will be responsible for the administrative costs, including the costs of setting standards for such programs, monitoring program performance, and providing administrative support to address science, enforcement, and management needs; except where the MSA specifically authorizes the collection of fees for these costs. For EM programs that are initiated by a Council, for example, to provide greater operational flexibility to industry participants or an exemption from otherwise applicable requirements, industry will be responsible for the sampling costs of such programs. If NOAA Fisheries determines that EM is necessary and appropriate to meet legal obligations (e.g., requirements of the Endangered Species Act), and sufficient appropriated funds are available, NOAA Fisheries intends, as a matter of policy discretion, to fund the sampling costs of such programs, unless the MSA specifically provides otherwise. NOAA Fisheries expects it will fund the EM program costs for which it is responsible through annual appropriations.

Councils should be aware that NOAA Fisheries cannot guarantee the availability of appropriated funds for EM program administrative costs. If NOAA Fisheries at any point determines that it no longer has sufficient authorized appropriated funds to cover the administrative costs of a program, NOAA Fisheries will not approve a new program (if it has yet to be approved) or alternatively would adjust or end an existing program (if it has already been approved). Currently, there are no EM programs with permanent appropriations. In fact, the Atlantic herring industry-funded monitoring program, which includes an EM option operating under an exempted fishing permit (EFP), was suspended starting April 1, 2023, due to a lack of funding to support NOAA Fisheries' shoreside costs. Some Regions use Observer Program funding to support their EM programs, whereas other Regions do not. At this time, the National Observer Program has not provided national guidance on this topic.

NMFS policy directive 04-115-02 acknowledges that, as of 2019, all appropriated funds designated for implementing systems to monitor fishing vessel activity and catch at sea are fully dedicated. As a result, any new monitoring system must either be funded through discretionary spending appropriations or non-appropriated funds, such as industry funding. Even in situations where federally appropriated funds may cover the initial startup of a monitoring program, such a program must be designed to cease or be adjusted should some or all of those funds expire, and to include a transition plan to cover the costs upon expiration of federal funding. Therefore, a pre-implementation program, used to develop a framework for a monitoring program and inform amendments authorizing EM, could be initially and temporarily funded through federally appropriated funds (e.g. FIS Program funds). However, unless future appropriations are authorized by Congress a plan must be developed to transition the program funding to discretionary spending appropriations or non-appropriated funds.

Fisheries Overview

The Hawaii DSLL fishery targets primarily bigeye tuna at depths to 400 meters (m) and operates primarily within 300-400 nm around the main Hawaiian Islands (MHI) and between the Equator and 35° N (Figure 1, right panel). The Hawaii SSLL fishery targets swordfish at depths to 100 m and typically operates north and east of the Hawaiian Islands (Figure 1, left panel). Even though the Hawaii longline fisheries have been in operation for many years, the DSLL and SSLL have only been operating as two distinct fisheries since the SSLL fishery re-opened in April 2004. In general, DSLL and SSLL vessels operate out of Honolulu with over 96% of DSLL and 80% of SSLL departing from Honolulu from 2004-2021 (unpublished longline logbook data).

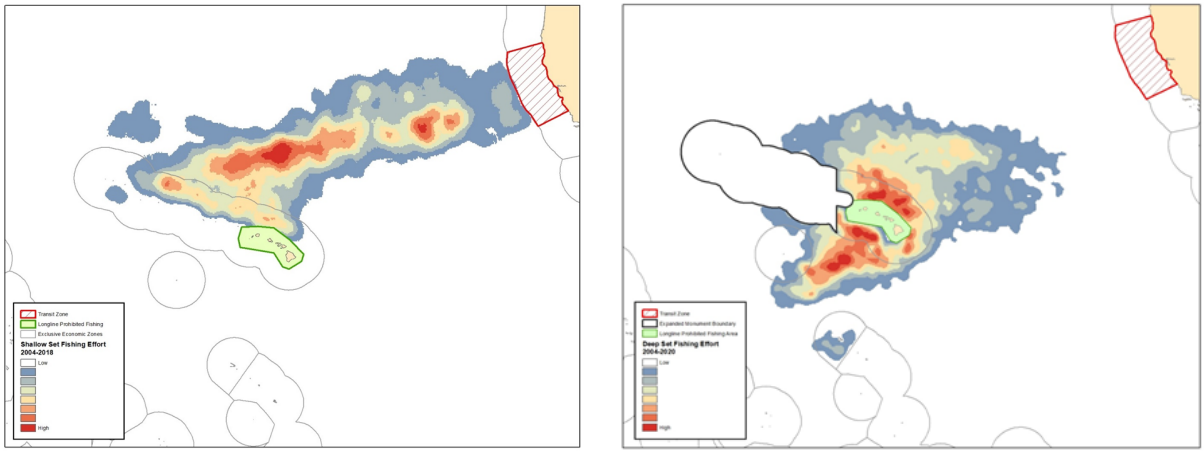

Figure 1. Location of Hawaii SSLL fishery (left, 2004 to 2018; NMFS 2019) and DSLL fishery (right, 2004 to 2020; NMFS 2023c) as illustrated by effort (observed sets). Colors from blue to red illustrate areas of lower to higher numbers of sets in both fisheries (NMFS 2019, 2023c).

The majority of the Hawaii longline fleet for both deep- and shallow-set originate out of Honolulu, Hawaii. However, a small percentage of the Hawaii DSLL (9% or 13 vessels in 2021) and SSLL (24% or 4 vessels in 2021) trips depart from other ports. Hawaii DSLL trips have departed from various ports in Hawaii, California, American Samoa, or Mexico and shallow-set trips have departed from various ports in California. More than half of these DSLL vessels (7) and all of the SSLL vessels returned to Honolulu during the same year. Most recently the majority of trips originating outside of Honolulu departed from San Diego, California for DSLL and from Los Angeles, California for SSLL. The departure ports should be considered when designing an EM program, as they may affect staffing and costs of data transmission and system maintenance. Fishermen departing from California begin fishing on the high seas, outside the US Exclusive Economic Zone (EEZ), while fishermen departing from American Samoa and landing in Hawaii usually begin fishing near the Equator or in the North Pacific where they expect higher catch rates of bigeye tuna.

Since 1994, the Hawaii longline fleet has been limited to 164 permits, which allow fishing in both the SSLL and DSLL fisheries. The DSLL fishery is by far the largest longline fishing sector in the

region. Activity levels in any given year since 2004 range from 111 to 150 vessels in the DSLL fishery and 11 to 35 vessels in the SSLL fishery. As the shallow-set fishery tends to be seasonal, nearly all vessels in the SSLL fishery also participate, to some degree, in the DSLL fishery during the year. From 2019 to 2022, 100% of vessels participating in the SSLL also participated in the DSLL. During that time frame, 167 unique vessels participated in the DSLL and of those, 32 (19.2%) also participated in the SSLL.

In 2022, there were 147 active DSLL vessels and 21 active SSLL vessels. Twenty of the SSLL vessels also participated in the DSLL fishery, and are included in the 147 DSLL vessel count. The number of DSLL trips in 2022 was 1,531 compared to 72 SSLL trips. Effort has been increasing in the DSLL fishery. The number of hooks set by the DSLL fishery in 2022 was 63.3 million hooks compared to 1.2 million hooks, or less than 2% of the overall effort, in the shallow-set longline fishery (WCPFC 2022). Hauling operations in the DSLL occur primarily at night. The average time a haul began and ended in 2022 was 6:40 pm and 6:56 am, respectively. In the SSLL the average time a haul began and ended was 7:02 am and 4:38 pm, respectively. Table 1 provides an overview of effort in the DSLL and SSLL fisheries during the past 5 years. Observed effort is equal to total effort in the SSLL due to 100% observer coverage in this fishery.

Table 1. The number of observed trips, hauls, hooks, percent coverage, and sea days in the Hawaii DSLL and SSLL fisheries, 2018-2022.

Year	Observed DSLL trips	Observed SSLL trips	Observed DSLL hauls	Observed SSLL hauls	Observed DSLL hooks	Observed SSLL hooks	Observed DSLL sea days	Observed SSLL sea days
2018	339	22	4,386	465	11,907,869	486,013	7,159	865
2019	349	34	4,615	284	12,739,655	374,487	7,518	765
2020	247	28	3,170	441	8,849,665	624,579	5,159	965
2021	298	56	3,975	683	11,460,814	1,026,373	6,355	1,503
2022	302	72	4,295	843	12,417,687	1,242,997	6,897	1,891

Management of the Hawaii and American Samoa longline fisheries are mostly driven by the need to minimize protected species bycatch instead of the need to limit harvest of target species. These fisheries incidentally capture species listed as threatened or endangered species under the Endangered Species Act (ESA) through hooking and entanglement by longline gear. These species include leatherback, loggerhead, olive ridley, green, and hawksbill sea turtles; silky and oceanic whitetip sharks; giant manta rays; and Guadalupe fur seals. Other protected species such as the black-footed and Laysan albatross, protected by the Migratory Bird Treaty Act (MBTA), and cetaceans, including false killer whales, protected by the Marine Mammal Protection Act (MMPA), are also incidentally captured in the PIR longline fisheries.

While overall effort is much lower in the SSLL as compared to the DSLL, sea turtle, mammal, and seabird interaction rates (i.e. catch per unit effort (CPUE)) are generally higher in the SSLL with the exception of the olive ridley sea turtle and the false killer whale (FKW) (WPFMC 2022)

Protected species interactions and other bycatch are monitored with mandatory observer coverage from the PIROP. The primary duty of observers in the Hawai‘i longline fisheries is to obtain reliable information about catch composition with an emphasis on protected species. While logbook data are used for information on retained species such as tuna and billfish, observer data is used for all bycatch estimates, including protected species estimates. Observers record all vertebrates caught on the vessel's longline gear, their condition, disposition, and measure every third animal. Observer data on catch are linked to corresponding information, such as photos and life history data. Observers also collect biological samples, and information on gear, effort, and compliance with regulations and protected species handling and release requirements. Observer data informs cetacean injury determinations and post release mortality estimates which are required for the management of ESA and MMPA protected species.

Observer Program Overview

The FEP and associated regulations require all fishing vessels to carry an observer when required to do so by the Regional Administrator. Observer coverage, or the percentage of trips on which an observer was deployed, in the Hawaii longline fishery was between 3-5% from 1994 through 1999 and increased to 10% in 2000. Since 2004, the minimum annual observer coverage target for the DSLL fishery is 20%, with a quarterly target of 15%, and the annual coverage target for the SSLL fishery is 100%. However, annual observer coverage in the DSLL fishery in 2020 and 2021 was 15.25% and 17.84%, respectively, due to impacts related to pandemic restrictions. Coverage returned to its target in 2022. However, observer coverage in the DSLL was reduced in May 2023 to 17% and will drop to 15% annually in FY2024 due to shortcomings in funding combined with inflation. Observer coverage has been maintained at 100% in the SSLL fishery since 2004. The higher the monitoring coverage, the less uncertainty there is in the catch estimates, particularly for discarded catch and protected species. The WCPFC and IATTC require only a 5% observer coverage rate for pelagic longline fisheries in the Pacific.

The average length of an observed DSLL trip is 23 days in comparison to 32 days for SSLL trips. Total annual sea days, or total days an observer spends on a vessel from departure date to vessel arrival date, may be used to compare the observer programs of the two Hawaii based fishery sectors, since trip lengths and the total number of trips per year vary between the two fisheries. An indefinite quantity, indefinite delivery contract is the funding vehicle used to deploy observers at-sea. The cost for sea days is one of the most expensive contract line items in the contract and reflects the number of days each vessel with an observer spends at sea. Observers are paid sea day regardless if the vessel fishes and an observer at sea is unavailable for deployment on another vessel.

SSLL fishing trips comprised only around 2% of the overall fishing effort (number of hooks set) in the Hawaii longline fisheries from 2004-2022; however, observed sea days on SSLL vessels accounted for 25% of the total observed sea days on Hawaii longline vessels. From 2007-2011, around half of the observed sea days were on SSLL vessels. Historically, annual observed sea days tend to be more variable in the SSLL fishery compared to the DSLL. For example, the SSLL fishery was closed as a result of reaching annual turtle interaction limits ("hard caps") implemented under the FEP in 2018 and 2019. The market price of swordfish, the target catch of the SSLL fishery, may also cause variability in the timing and number of operating days in the fishery. Variability in the SSLL fishery can make maintaining 20% observer coverage in the DSLL difficult, as coverage in the DSLL fishery may need to be lowered to maintain 100% coverage in the SSLL when SSLL effort is high.

NMFS currently has approximately 60-65 trained at-sea observers that can be deployed in the Hawai‘i DSLL and SSLL and American Sāmoa longline fisheries. Variability in effort makes planning ahead for observer hires and training classes challenging, since the number of observers needed cannot be accurately estimated. Not having enough trained observers ready for deployment may result in reduced DSLL coverage which could lead to less accurate protected species estimates. Historically, the reduction in coverage in the DSLL in response to increased effort in the SSLL has remained at or above 15%. In addition, if fewer observers are available for deployment, turn around time between trips may be shorter which could lead to observer burn out. In contrast, if too many observers are trained, then there may be observers waiting for deployment without pay and unable to maintain cost of living. This can lead to observer turnover, higher training costs, and a reduction in overall data quality as new observers tend to make more mistakes. Fortunately,over the last decade, the PIROP has contracted with successful observer providers that regularly communicate with the fleet, are well aware of future increases in effort and have adjusted accordingly to avoid observer burn out and observers on unemployment. In fact, the PIROP currently has the highest observer retention rate in the nation.

In the Hawaii longline fisheries, the observer assignment process begins once a vessel owner notifies (calls) the contracted observer provider that they intend to depart on a fishing trip within 72 hours. The sampling design for observer placement on DSLL trips considers fishing regulations and PIROP policies. PIROP policies make it impractical to instantaneously adjust the number of observers on staff due to unpredictable changes in the volume of fishing or observers who leave the program. Therefore, the level of observer coverage is expected to fluctuate (McCracken 2019). Currently the systematic sampling model used to select DSLL vessels, based on call in notifications, to carry an observer is drawn at approximately 5% lower coverage than the targeted coverage level specified and allows secondary samples to be drawn when necessary to account for fluctuations in the number of observers available and unpredictable fishing effort. Because these samples are not randomly selected but determined by the need to deploy observers, the probability a notification is selected by the secondary sample is unknown and needs to be approximated. To approximate these probabilities, the contractor's list of notifications is used. Examination of this list reveals periods when coverage appears to have been greater or less than the full targeted coverage (McCracken 2019).

Statutory and Regulatory Drivers for Bycatch Monitoring in the Hawaii and American Samoa Longline Fisheries

Bycatch monitoring needs for the Hawaii and American Samoa longline fisheries are driven by four U.S. Federal mandates: the Magnuson-Stevens Act, the ESA, the MMPA, and the MBTA. Bycatch monitoring for these fisheries also meet the needs for applicable Regional Fishery Management Organizations, specifically the WCPFC and the IATTC.

Magnuson-Stevens Fishery Conservation and Management Act

The MSA (2007) is the primary law that governs marine fisheries management in US federal waters. Its objectives include: preventing overfishing, rebuilding overfished stocks, increasing long-term economic and social benefits, ensuring a safe and sustainable supply of seafood, and protecting habitat that fish need to spawn, breed, feed, and grow to maturity.

The Hawaii and American Samoa longline fisheries are managed under the Council's Pelagic FEP. These fisheries operate under their respective limited entry permits. Relevant monitoring and management measures implemented under the Pelagic FEP may be found at 50 CFR 665 Subpart F and 50 CFR 300.230. They include:

- The owner/operator of any fishing vessels of the United States which fishes commercially for highly migratory species must ensure that any shark is brought alongside the vessel for identification purposes prior to releasing the shark
- Longline vessel owners/operators are required to:
    - adhere to regulations for safe handling and release of sea turtles and seabirds.
    - annually attend protected species workshop
    - have on board the vessel all required turtle handling/dehooking gear specified in regulations.
    - remove trailing gear from oceanic whitetip sharks and cut the line as close to the hook as possible.
- Deep-set fishing operations north of 23º N latitude are required to comply with seabird mitigation regulations, which include choosing between side-setting or stern-setting longline gear with additional regulatory specifications (e.g., blue-dyed bait, weighted branch lines, strategic offal discards, using a “bird curtain”).
- When deep-set fishing with a Hawaii longline limited access permit:
    - Each float line must be at least 20 m long.
    - Attach at least 15 branch lines between two consecutive floats.
    - No light sticks are allowed on the vessel.
    - No metal wire line within 1 m of the hook.
    - Use circle hooks with no more than 10° offset.
    - Observe swordfish limits when fishing north of the equator.
- When shallow-set fishing, longline vessel owners/operators can choose between side-setting or stern-setting longline gear with additional regulatory specifications to

reduce seabird interactions (e.g., night-setting, blue-dyed bait, weighted branch lines, strategic offal discards, using a “bird curtain”).

- When shallow-set longline fishing north of the Equator:
    - Use 18/0 or larger circle hooks with no more than 10° offset.
    - Use mackerel-type bait.
    - Closure for remainder of year when fishery reaches annual interaction limit (“hard caps”) of 16 leatherback turtles
    - Vessels are required to return to port when an individual trip interaction limit of 5 loggerhead turtles or 2 leatherback turtles is reached, with additional requirements if the vessel reaches the same trip limit for the second time in a calendar year
- American Samoa longline owners and operators of vessels longer than 40 ft (12.2 m) must use longline gear that meet the following requirements:
    - Each float line must be at least 30 m long.
    - At least 15 branch lines must be attached to the mainline between any two float lines attached to the mainline.
    - Each branch line must be at least 10 m long.
    - No branch line may be attached to the mainline closer than 70 m to any float line.

Section 304(b)(1)(A) of the MSA, requires that actions are consistent with FEPs, other provisions of the Magnuson-Stevens Act, and all other applicable laws including the ESA, MMPA, and MBTA. Section 303(a)(11) of the Magnuson-Stevens Fishery Conservation and Management Act requires that any fishery management plan (FMP) establish a standardized reporting methodology, or SBRM, to assess the amount and type of bycatch occurring in each fishery. The current SBRM for the PIR longline fisheries includes the PIROP and logbook reporting.

The Magnuson-Stevens Act also includes ten national standards that must be followed in any FMP to ensure sustainable and responsible fishery management, the 9th of which states: “Conservation and management measures shall, to the extent practicable, (a) minimize bycatch and (b) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.” While NMFS has determined the pelagic longline fisheries are not likely to jeopardize the continued existence of threatened and endangered species (NMFS 2019b, 2023c, 2023d; USFWS 2012), and have implemented measures that have significantly reduced interactions (e.g. protected species workshops, gear requirements, and handling requirements), the fisheries must continue to maintain sufficient monitoring and reporting to confirm that extent of allowable take is not exceeded for protected species.

Endangered Species Act

The Endangered Species Act of 1973 (ESA) section 7(a)(2) requires agencies to ensure that their activities are not likely to jeopardize the continued existence of species listed as threatened or endangered, or result in the destruction or adverse modification of critical habitat (16 U.S.C. § 1536(a)(2)). These require interagency consultation under Section 7 of the ESA between PIRO

Protected Resources Division (PRD) or the US Fish and Wildlife Service (USFWS) and the PIRO division that authorizes the fishery (SFD), and the completion of a biological opinion (BiOp) by PRD/USFWS. The BiOp authorizes the take of a prescribed number of each affected species in an Incidental Take Statement (ITS). Reasonable and Prudent Measures (RPMs) and associated Terms and Conditions (T&Cs) identify non-discretionary actions that are necessary or appropriate to minimize the impact of the amount or extent of incidental take. Implementation of the RPMs is required and may require regulatory action.

The following BiOps have determined that the Hawaii and American Samoa longline fisheries do not jeopardize ESA-listed species:

- On January 6, 2012, the U.S. Fish and Wildlife Service issued a BiOp on the effects of the Hawaii DSLL and SSLL fisheries on ESA-listed seabirds (USFWS 2012);
- On June 26, 2019, NMFS issued a BiOp on the effects of the Hawaii SSLL fishery on ESA-listed marine species (NMFS 2019);
- On May 15, 2023, NMFS issued a a BiOp on the effects of the ASLL fishery on ESA-listed marine species (NMFS 2023d)
- On May 18, 2023, NMFS issued a a BiOp on the effects of the Hawaii DSLL fishery on ESA-listed marine species (NMFS 2023c)

The RPMs in the 2023 BiOps for the authorization of the Hawaii DSLL and ASLL fisheries require that NMFS ensure that the fisheries have monitoring and reporting programs sufficient to confirm that extent of take is not exceeded, and that the terms and conditions in this incidental take statement are effective in minimizing incidental take. The T&Cs require that NMFS SFD maintain observer coverage at levels reliable for estimating protected species interaction rates onboard Hawaii DSLL and ASLL vessels. This may include electronic monitoring. They also require that:

- NMFS SFD collect standardized information regarding the incidental capture, injury, and mortality of ESA-listed marine species for each interaction by species, gear, and set information, as well as the presence or absence of tags on these species.
- NMFS SFD improve length estimates of leatherback sea turtles that are not boarded.
- To the maximum extent practicable, observers identify the hooking location for every interaction, and estimate the length of any trailing gear left on ESA-listed species at release when those species cannot be boarded.
- Observers shall document the method or technology used to release all ESA-listed species.
- NMFS will determine the minimum level of observer coverage reliable for estimating MHI FKW interactions with the DSLL vessels. If the current level of observer coverage is below this level, within two years NMFS will provide observer coverage at the level determined reliable.

Finally, the Hawaii DSLL and ASLL BiOps include a conservation recommendation that NMFS should explore implementing an Electronic Monitoring program in the fishery to improve understanding of interactions with ESA-listed species and reduce uncertainty when those

interactions occur. At minimum, NMFS should consider a voluntary EM selection pool with a random strata selection that maintains fleet-wide observer coverage.

Marine Mammal Protection Act

The MMPA (16 U.S.C. § 1361 et seq.) prohibits, with certain exceptions, the take of marine mammals in the U.S. and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States.

Under Section 118 of the MMPA, NMFS annually publishes a List of Fisheries (LOF) that classifies U.S. commercial fisheries into one of three categories based on the level of serious injury and mortality of marine mammals that occurs incidental to each fishery. The Hawaii DSLL fishery is classified as a Category I fishery (i.e., frequent incidental mortality and serious injury of marine mammals) and the SSLL fishery and American Samoa longline (ASLL) fishery are listed as Category II fisheries (i.e., occasional incidental mortality and serious injury of marine mammals) (88 FR 16899). Under MMPA Section 118, vessel owners and crew that are engaged in Category I or II fisheries may incidentally take non-Endangered Species Act (ESA)-listed marine mammals after registering or receiving an Authorization Certificate under the MMPA, and may be required to allow observers on board if requested by NMFS. However, current observer requirements for the DSLL, SSLL and ASLL are authorized under the MSA, not the MMPA.

NMFS may develop and implement take reduction plans for any Category I or II fishery that interacts with a strategic stock, and fishermen are required to comply with any applicable take reduction plans. NMFS issued a final false killer whale (FKW) Take Reduction Plan (FKWTRP) and regulatory and non-regulatory measures and recommendations to reduce mortalities and serious injuries of FKW in Hawaii-based longline fisheries on November 29, 2012 (77 FR 71259). Current regulatory measures under the FKWTRP include gear requirements, longline prohibited areas, training and certification in marine mammal handling and release, captains' supervision of marine mammal handling and release, and posting of NMFS-approved placards on longline vessels. Regulatory compliance on gear specifications, handling and release training certification, and NMFS placard posting is currently provided by the observer program. The southern exclusion zone (SEZ) is a prohibited fishing area that was developed under the FKWTRP. The number of FKW interactions which trigger the closure of the SEZ is derived from observer coverage.

At the March 2023 meeting, the The FKW Take Reduction Team (TRT) recommended “implementation of a sustained EM program in the Hawaii-based deep-set longline fishery that would substantially reduce uncertainty in false killer whale bycatch estimates (both in terms of quantitative estimates and spatial distribution) and provide information to inform and improve serious injury determinations and consistency with gear handling guidelines, while ensuring that such program is as cost efficient and cost effective as possible.” The TRT also identified specific monitoring objectives, which is included in Appendix 1.

Summary of Key Fishery Characteristics for EM

	Hawaii DSLL	**Hawaii SSLL**	**ASLL**
Active participating vessels (2022)[1]	147	22	11
Annual effort (2022)[2]	1,531 trips 21,299 sets 63.3 million hooks	69 trips 857 sets 1.08 million hooks	42 trips 1,219 sets 3.61 million hooks
Observer coverage (2022)[3]	20.1% Trips 20.1% Sets 19.8% hooks	100% Trips 100% Sets 100% hooks	8.7% Trips
Effort trends	8% increase in effort (hooks set) from 2018 to 2022	116% increase in effort (hooks set) from 2018 to 2022	40% decrease in effort (hooks set) from 2018 to 2022
General set/haul timing	Set during the day; haul at night	Set at night; haul during the day	Set during the day; haul at night
Protected Species Interactions	ESA-listed giant manta ray, Indo-West Pacific DPS scalloped hammerhead shark; oceanic whitetip shark; green sea turtles; leatherback sea turtles, North Pacific loggerhead sea turtles; olive ridley sea turtles, sperm whale, and MHI insular false killer	ESA-listed leatherback sea turtles, North Pacific loggerhead sea turtles, green sea turtles, olive ridley sea turtles, oceanic whitetip sharks, manta rays, and Guadalupe fur seals (NMFS 2019); non-ESA marine mammals; seabirds	ESA-listed leatherback sea turtle, green sea turtles, olive ridley sea turtles, hawksbill sea turtles, oceanic whitetip sharks, Indo-West Pacific scalloped hammerhead sharks, and giant manta rays (NMFS 2023d); non-ESA marine mammals;

[1] NMFS, unpublished logbook data
[2] NMFS, unpublished logbook data
[3]Observer coverage rates are reported in the 2021 SAFE report (WPFMC 2022)

	whale (NMFS 2023c); non-ESA marine mammals; seabirds		seabirds
Regulations[4] currently monitored through PIROP	● Protected species workshop completion ● Presence of required vessel identification and monitoring system ● Seabird mitigation measures when north of 23º N latitude ● Presence of posted NMFS marine mammal release guidelines and captain notification placards. ● Safe handling and release of sea turtles, marine mammals, certain elasmobranchs, and seabirds. ● Shark finning and landing requirements ● Gear requirements and prohibitions. ● Required vessel safety specifications	● Protected species workshop completion ● Presence of required vessel identification and monitoring system ● Seabird mitigation measures ● Loggerhead and leatherback sea turtle trip interaction limits ● Annual leatherback sea turtle interaction limits ● Presence of posted NMFS marine mammal release guidelines and captain notification placards. ● Safe handling and release of sea turtles, marine mammals, certain elasmobranchs, and seabirds ● Shark finning and landing requirements ● Seabird mitigation measures ● Gear and bait requirements and prohibitions ● Required vessel safety specifications	● Protected species workshop completion ● Presence of required vessel identification and monitoring system ● Safe handling and release of sea turtles, marine mammals, certain elasmobranchs, and seabirds. ● Shark finning and landing requirements. ● Gear requirements and prohibitions. ● Required vessel safety specifications

[4] Regulations for the Western Pacific Pelagic Fisheries can be found in the Code of Federal Regulations at 50 CFR 665 Subpart F.

Electronic Monitoring Scenarios

For the Council's consideration, the ETSC and PPT have outlined possible goals and objectives for the future use of EM in the Hawaii and American Samoa longline fisheries. These were developed considering recent ESA Section 7 Biological Opinions, recommendations from the FKWTRT, the current monitoring regime, the needs of the PIROP, EM research by PIFSC FRMD, lessons learned from EM programs in other regions, technical expertise of the members of the ETSC, recommendations from the PPT, NMFS policy directives and other information. As mentioned above, a clearly defined purpose and need(s) is a prerequisite for any monitoring program and will drive data collection objectives and program costs.

The Council may recommend prioritization of one or any combination of the below-listed monitoring goals and monitoring objectives for a pre-implementation program. The Council may also recommend a phased approach to achieving monitoring goals and objectives. In any implementation scenario, EM would likely supplement and/or complement the PIROP, as human observers will still be needed to collect biological data and other information not collectable by EM.

EM in the Hawaii Deep Set Longline Fishery

The ETSC considered three possible overarching monitoring goals along with specific objectives for an EM program in the Hawaii DSLL fishery. The Council may consider the need for EM in the DSLL fishery and how management of the fishery would benefit from using EM for that need, as the complexity of the program will drive program costs.

Potential Monitoring Goal 1: Use EM to estimate protected species bycatch and collect information on interactions

EM may be used in the Hawaii DSLL to estimate protected species bycatch and collect additional information on interactions (e.g. data to make injury determinations and assess likely post-release condition and handling). As protected species interactions are rare, increased monitoring coverage by using EM may improve the accuracy and precision of estimated total interactions and other information for protected species.

Observer coverage, or the percentage of Hawaii DSLL trips on which an observer is deployed, has historically been targeted at 20% on an annual basis. EM could potentially be used to maintain monitoring coverage at the 20% level or provide additional coverage to estimate rare protected species interactions[5]. In addition, reductions in monitoring coverage will affect the

[5] Assuming representative coverage of the fleet's activity (random sampling), an unbiased estimate of total interactions is expected. However, the monitoring coverage level impacts the uncertainty around the estimate. For a species that is interacted with in 0.2% of sets (e.g.,FKW) assuming about 20,000 sets a year, the relative error on the upper 95% CI from a binomial distribution for 15% coverage is approximately 83%, declining to 75% at 20% observer coverage.

interaction trigger for the SEZ closure implemented under the FKWTRP[6]. The FKWTRT at the March 2023 meeting recommended implementation of a sustained EM program in the Hawai‘i-based deep-set longline fishery that would substantially reduce uncertainty in false killer whale bycatch estimates and provide information to inform and improve serious injury determinations and consistency with gear handling guidelines.

For some protected species, such as leatherback sea turtles, length data may be useful for assessment (e.g., age and mortality). However, EM length data collection has not yet been researched in the Hawaii longline fisheries. Length measurements are collected for fish and some other species in other EM programs; however, more research and development would be needed to collect length data for protected species, especially for animals that are not boarded in the Hawaii longline fisheries.

Potential Monitoring Objective(s)

A program to accurately and precisely estimate protected species bycatch and collect additional information on interactions in the Hawaii DSLL fishery could prioritize the following monitoring objectives:

- Maintain historical coverage level of 20% to:
    - Accurately estimate protected species bycatch
    - Monitor handling requirements for protected species bycatch
    - Collect data to perform mortality estimates for protected species bycatch, prioritizing sea turtle mortality estimates.
    - Collect data to perform cetacean injury determinations
    - Collect information for other high priority species such as of leatherback sea turtles and oceanic whitetip sharks

- Maintain or increase monitoring coverage to meet FKWTRT priorities to:
    - Reduce uncertainty in FKW bycatch estimates (both in terms of quantitative estimates and spatial distribution).
    - Provide information to inform and improve serious injury determinations and consistency with gear handling guidelines.

Data Collection and Use

EM research (Carnes and Stahl 2020) demonstrates that protected species bycatch can be detected with EM and that data can be collected to assess the likely post-release condition of sea turtles and cetaceans (Stahl et al. in press) in Hawaii longline fisheries. In addition, EM could provide data to assess the likely post-release condition of protected sharks and mobula (e.g. amount of trailing gear in relation to body or capture and release condition). EM research also indicates that EM could be used to verify protected species reports made by fishers or

[6] In accordance with FKWTRP regulations, the SEZ trigger is calculated as the smallest number of observed false killer whale mortalities or serious injuries that, when extrapolated based on the percentage monitoring coverage in the DSLL fishery for that year, exceeds the Hawaii Pelagic false killer whale stock’s potential biological removal level.

observers. In addition, current AI research shows that sea turtles can be detected with AI models from EM footage even if the sea turtles are not brought aboard the vessel.

Data pertaining to FKW interactions can be collected with EM; however, information may be difficult to collect at night if whales are not brought to the vessel. Human observers may be able to see further from the vessel at night for species identification and hook location depending on vessel lighting and camera views for particular vessels. EM may allow for a better understanding of protected species handling, including false killer whales, as it provides footage of both the crew actions and the in-water activity. Whereas, observer footage is limited to only what the observer is able to capture using a hand-held camera that is focused on the water while not fulfilling their other sampling duties.

Questions for Pre-Implementation Program

In addition to overarching questions such as funding, program infrastructure, and data governance, the Council, Council advisory bodies, NMFS, and the ETSC would use a pre-implementation program to investigate and answer questions such as:

- What EM coverage is needed to meet FKWTRT priorities to improve injury determinations for false killer whales?
- What EM coverage is needed to meet FKWTRT priorities to assess fisher handling?
- Would observer data be sufficient for length measurements of sea turtles?
- Should NMFS prioritize research and development to obtain length measurements via EM in the future?
- How would the observer and EM coverage be sampled respectively to ensure a representative sample of each sector to estimate fleet-wide protected species bycatch?

Cost Considerations

In 2022, 147 vessels participated in the DSLL fishery, whereas 21 participated in the SSLL fishery. Consequently, a smaller proportion of vessels participating in deep-set trips may be outfitted with EM systems compared to vessels participating in shallow-set trips with similar resources. For example, to monitor 5% of the DSLL fleet with EM, 38 vessels would need to be installed with EM systems, as opposed to 2 vessels in the SSLL fishery. Costs would also be higher if EM is used to increase monitoring coverage beyond that of the current observer program, rather than to supplement the current monitoring levels.

The FKWTRT recommended an increase in monitoring coverage with installation of EM systems on all vessels. Up front costs will be higher for EM system hardware and installation with a higher number of vessels installed. Storage and video review costs will depend on the coverage rates and if a third party model is being used. However, video review costs can be reduced if an AI model is developed to detect cetaceans and other protected species with a human reviewer verifying detections, identifying species, and collecting data on protected species interactions.

Potential Monitoring Goal 2: Use EM for catch accounting of retained fish

EM could also be used in the Hawaii DSLL fishery for catch accounting of retained fish to improve stock assessments, with a priority for marlin. Stock assessments use data from logbooks, dealer reports, and the PIROP. Although logbooks are required for all trips, there may be misidentification or other inaccuracies that could be verified or corrected using EM data.

EM could be used to identify and enumerate retained species. However, more research needs to be performed with EM to determine if some similar looking species, such as marlin, can be distinguished with EM cameras. Dealer data is another valuable source of fishery-dependent data, but weights are often recorded in aggregate rather than as individual fish. Observer data provides the only fishery-dependent length measurements that are used in stock assessments, and EM could be used to supplement this data source. Although length collection by EM has not yet been researched in the Hawaii longline fisheries, length measurements are collected for fish and other species in EM programs elsewhere. More research and development would be needed to collect length data in the Hawaii longline fisheries, with length measurement data collection potentially needing additional cameras (e.g. a stereo camera setup), time and costs for calibration, and/or changes in fisher handling. Observer coverage for the Hawaii-deep-set fishery has historically been targeted at 20%; however, due to shortfalls in funding and inflation, observer coverage will be reduced to 15% in FY2024. EM could potentially maintain coverage at the 20% level or potentially allow for additional coverage that could be used to improve stock assessments.

Potential Monitoring Objective(s)

Potential monitoring objectives for a program that uses EM for catch accounting of retained fish in the Hawaii DSLL fishery could include:

- Maintain or increase historic monitoring coverage levels
- Identify and enumerate retained fish species for use in stock assessments
- Capture length measurements of retained fish for use in stock assessments

Data Collection and Use

EM research (Carnes et al. 2019) indicates that retained catch can be detected with 98% accuracy in the Hawaii longline fisheries, and current AI research indicates that fish that are brought on deck can be detected in EM footage with good accuracy using an AI model. This research demonstrates EM can be used for catch accounting and verifying logbook data in PIR longline fisheries. However, landing reports offer another data stream for catch accounting for retained catch. Better species identification information and more length data of species such as marlin may help improve stock assessments. However, landing reports offer another data stream for catch accounting for retained catch. More research would be needed to determine the capabilities of EM for species identification of marlin, which is a species group of interest for stock assessment. In Carnes et al. (2019) there was an 11% difference in blue and 10% in striped marlin identification between EM data and observer data for the deep-set fishery. It is uncertain with these difficult to identify species if inaccuracies occurred by the observers, the

EM reviewer, or both. In addition, no research to date has been done to collect length measurements in the Hawaii longline fisheries using EM. A program that collects length measurements would require different camera locations, number of cameras, fisher handling, and camera systems to collect these data as compared to a program that is focused on species identification and enumeration alone.

Questions for Pre-Implementation Program

In addition to overarching questions such as funding, program infrastructure, and data governance, the Council, Council advisory bodies, NMFS, and the ETSC would use a pre-implementation program to investigate and answer questions such as:

- What would be priority species for catch accounting to improve stock assessments?
- What protocols need to be established to ensure hard to distinguish fish such as marlins or small tunas, can be identified from video.
- What level of total monitoring coverage would be needed to improve stock assessments for prioritized species (e.g. marlin)?
- What level of observer coverage is considered sufficient for length measurements for stock assessment?
- Should the pre-implementation program develop methods to obtain length measurements for particular species via EM?

Cost Considerations

Cost for a pre-implementation EM program will be higher if EM is used to maintain the historic monitoring target coverage of 20% or to increase monitoring coverage beyond that of the current observer program, rather than to supplement the current monitoring levels. Up front costs will be higher for EM system hardware and installation in the Hawaii deep-set fishery compared to the Hawaii shallow-set fishery with a higher number of vessels. Storage and video review costs will depend on the coverage rates and if a third party model is being used. However, video review costs can be reduced if AI models are used to detect retained fish. A preliminary AI model has been developed that can successfully detect fish on deck.

If length data are determined to be a priority for EM data collection of retained fish, there will be additional unknown costs associated with research and development. If research indicates that it is feasible to collect length data in the deep-set fishery, then there may be additional costs associated with collecting lengths, such as measuring boards, calibration, additional crew handling and video review.

Potential Monitoring Goal 3: Use EM for catch accounting of discarded species

EM could be used for catch accounting of discarded fish (e.g. small discarded marlin, swordfish, and tuna) and/or other prioritized species (elasmobranchs) to improve stock assessments. Observer coverage is currently the most accurate data source for discarded species in the Hawaii longline fishery as logbook reported releases are known to have a downward bias (i.e.

less bycatch is reported than is actually caught). EM coverage could supplement or increase monitoring coverage levels, potentially improving data for stock assessments.

The encounter rate of discarded species would need to be considered to determine coverage rates. Some species (e.g. sharks and lancetfish) have variable detection rates with EM, which should be considered when determining if EM could improve estimation for a particular species compared to observer coverage alone.

Potential Monitoring Objectives

Potential monitoring objectives for a program to use EM for bycatch accounting of discarded species in the Hawaii DSLL fishery include:

- Identify and enumerate discarded fish species for use in stock assessments
- Capture length measurements of discarded species for use in stock assessments

Data Collection and Use

EM research (Carnes et al. 2019) indicates that bycatch species in Hawaii longline fisheries can be detected with EM with 89% accuracy. Information on discarded fish can be collected, but it depends on the species and the camera views. For instance, if a lancetfish is pulled in towards the stern near the bait boxes it may be more difficult to observe using EM compared to a pelagic stingray pulled in near the fish door. Sharks can be detected when they are brought near the vessel and within the camera views, but detection would be difficult if they are cut from the line as soon as the crew observes them. This research indicates that EM could be used for verification of logbooks for discard detection depending on the species.

Questions for Pre-Implementation Program

In addition to overarching questions such as funding, program infrastructure, and data governance, a pre-implementation program would need to investigate questions such as:

- Which discarded species would be a priority for data collection?
- What camera configurations or handling requirements are required to capture information on discarded species?
- What level of total monitoring coverage would be needed to improve stock assessments for bycatch species?
    - For example, if a species is abundant, such as lancetfish or blue sharks, then observer coverage alone may be sufficient for monitoring even if levels drop below 20%. However, for species that are more rarely encountered, additional monitoring with EM could be valuable for stock assessments.

Cost Considerations

In 2022 147 vessels participated in the Hawaii DSLL fishery. Cost for a pre-implementation EM program will be higher if EM is used to increase monitoring coverage beyond that of the current observer program, rather than to supplement the current monitoring levels. Up front costs will be higher for EM system hardware and installation in the Hawaii deep-set fishery compared to the

Hawaii shallow-set fishery with a higher number of vessels. Storage and video review costs will depend on the coverage rates and if a third party model is being used. However, video review costs can be reduced if AI models can be built to successfully detect discarded fish and/or elasmobranchs of interest. Cost (for hardware, maintenance, data storage, and review) will be higher if a greater number of cameras is needed to collect data on discards.

Cost (for hardware, maintenance, data storage and review) will be higher if a greater number of cameras are needed to collect data on discards. If length data are determined to be a priority for EM data collection of discarded fish, then there will be additional unknown costs associated with research and development. If research indicates that it is feasible to collect length data in the deep-set fishery, then there may be additional costs associated with collecting lengths, such as measuring boards, calibration, additional crew handling and video review. Video review costs may be reduced if AI models can successfully be developed to detect bycatch species of interest, such as sharks.

EM in the Hawaii Shallow Set Longline Fishery

The ETSC considered three possible overarching monitoring goals, along with specific objectives for an EM program in the Hawaii SSLL fishery. The Council may consider the need for EM in the SSLL fishery and how management of the fishery would benefit from using EM for that need, as the complexity of the program will drive program costs.

Potential Monitoring Goal 1: Use EM to estimate protected species bycatch and collect information on interactions

EM may be used in the Hawaii SSLL to estimate protected species bycatch and collect additional information on interactions (e.g. data to make injury determinations and assess likely post-release condition and handling). As protected species interactions are rare, EM may be used to maintain monitoring coverage at 100%, and therefore maintain the accuracy and precision of estimated total protected species interactions and other information for protected species.

Observer coverage in the SSLL fishery has historically been targeted at 100%, and monitoring objectives for the SSLL fishery are currently focused on protected species interactions. However, due to funding and inflation it may be difficult to maintain this level of observer coverage into the future. To maintain observer coverage at 100% in the shallow-set fishery, human observers may be diverted from DSLL trips when the SSLL fishery is operating, thus lowering the coverage rate in the DSLL fishery. Consequently, a program in which EM and human observers are used together to maintain total monitoring coverage at 100% for shallow-set trips, would also benefit the DSLL fishery by freeing up human observers to meet the coverage target. In addition, the SSLL fishery accounts for about 2% of the total longline fishing effort, but approximately 25% of total annual monitoring funds are spent to maintain 100% coverage in the fishery. Therefore using EM to meet some of the monitoring needs in the SSLL fishery may enable the reallocation of PIROP funds for use in the DSLL fishery.

Implementation of existing management measures under the Pelagic FEP, including the fleet-wide annual interaction limit ("hard cap") for leatherback turtles and individual trip interaction limits for loggerhead and leatherback turtles, currently rely on near real-time reporting of interactions from observers. Currently, EM systems do not have capabilities to transmit near real-time data. Therefore, research needs to be done to determine if EM or other monitoring methods could transmit this information in near real-time in the future if EM is used to supplement human observer coverage in the SSLL fishery.

Potential Monitoring Objective(s)

In addition to overarching questions such as funding, program infrastructure, and data governance, the Council, Council advisory bodies, NMFS, and the ETSC would use a pre-implementation program to investigate and answer questions such as:

- Maintaining 100% monitoring coverage
- Estimating protected species interactions
- Monitoring handling requirements for protected species bycatch
- Collecting data to make post-interaction mortality estimates for protected species bycatch, prioritizing sea turtle mortality estimates
- Collecting data to make injury determinations for cetaceans
- Monitoring sea turtle interactions to inform management measures related to trip interaction limits for leatherback and loggerhead sea turtles and annual interaction limits for leatherback sea turtles.

Data Collection and Use

EM research (Carnes and Stahl 2020) demonstrates that protected species bycatch can be detected with EM and that data can be collected to assess the likely post-release condition of sea turtles and cetaceans (Stahl et al. in press) in Hawaii longline fisheries. In addition, EM could provide data to assess the likely post-release condition of protected sharks and mobula (e.g. trailing gear in relation to body or capture and release condition). EM research also indicates that EM could be used to verify protected species reports made by fishers or observers. In addition, current AI research shows that sea turtles can be detected with AI models from EM footage even if the sea turtles are not brought aboard the vessel.

Questions for Pre-Implementation Program

In addition to overarching questions such as funding, program infrastructure, and data governance, a pre-implementation program would need to investigate questions such as:

- How would the observer and EM coverage be sampled respectively to ensure a representative sample of each sector to estimate fleet-wide protected species bycatch?
- Would observer data be sufficient for length measurements of sea turtles, including leatherback sea turtles?

- Should research and development be prioritized to obtain sea turtle length measurements?
- What observer and EM protocols may be needed to monitor implementation of the sea turtle interaction limits?
- How will sea turtle limits be monitored and reported in an EM program?

Cost Considerations

In 2022, 21 vessels participated in the SSLL fishery, whereas 147 participated in the DSLL fishery. Consequently, a larger proportion of vessels participating in shallow-set trips may be outfitted with EM systems compared to vessels participating in deep-set trips with similar resources. For example, 100% of the SSLL vessels could be outfitted with EM systems for the cost of installing systems on approximately 14% of the DSLL fleet.

AI models may reduce costs of video review. A preliminary AI model has already been developed to detect sea turtles in the water and on deck, but more work is needed for detection of other protected species.

Potential Monitoring Goal 2: Use EM for catch accounting of retained fish

EM could also be used in the Hawaii SSLL fishery for catch accounting of retained fish for use in stock assessments, especially for billfish. Stock assessments use data from logbooks, dealer reports, and the PIROP. Although logbooks are required for all trips, there may be misidentification or other inaccuracies that could be verified or corrected using EM data.

EM could be used to identify and enumerate retained species. However, more research needs to be performed with EM to determine if some similar looking species, such as marlin, can be distinguished with EM cameras. Dealer data is another valuable source of fishery-dependent data, but weights are often recorded in aggregate rather than as individual fish. Observer data provides the only fishery-dependent length measurements that are used in stock assessments, and EM could be used to supplement this data source. Although length collection by EM has not yet been researched in the Hawaii longline fisheries, length measurements are collected for fish and other species in EM programs elsewhere. More research and development would be needed to collect length data in the Hawaii longline fisheries, with length measurement data collection potentially needing additional cameras (e.g. a stereo camera setup), time and costs for calibration, and/or changes in fisher handling.

Potential Monitoring Objective(s)

Potential monitoring objectives for a program that uses EM for catch accounting of retained fish in the Hawaii SSLL fishery could include:

- Maintaining monitoring coverage at 100%
- Identify and enumerate retained fish species to be used in stock assessments
- Capturing length measurements of retained fish to be used in stock assessments

Data Collection and Use

EM research (Carnes et al. 2019) indicates that retained catch can be detected with 98% accuracy in the Hawaii longline fisheries, and current AI research indicates that fish that are brought on deck can be detected in EM footage with good accuracy using an AI model. This research demonstrates EM can be used for catch accounting and verifying logbook data in PIR longline fisheries. However, landing reports offer another data stream for catch accounting for retained catch. More research would be needed to determine the capabilities of EM for species identification of marlin, which is a species group of interest for stock assessment. In Carnes et al. (2019) there was an 11% difference in blue and 10% in striped marlin identification between EM data and observer data for the deep-set fishery. It is uncertain with these difficult to identify species if inaccuracies occurred by the observers, the EM reviewer, or both.In addition, no research to date has been done to collect length measurements in the Hawaii longline fisheries using EM. A program that collects length measurements would require different camera locations, number of cameras, fisher handling, and camera systems to collect these data as compared to a program that is focused on species identification and enumeration alone.

Questions for Pre-Implementation Program

In addition to overarching questions such as funding, program infrastructure, and data governance, the Council, Council advisory bodies, NMFS, and the ETSC would use a pre-implementation program to investigate and answer questions such as:

- What are priority species for catch accounting to improve stock assessments?
- What protocols need to be established to ensure hard to distinguish fish, such as marlins or small tunas, can be identified from video?
- What level of total monitoring coverage would be needed to improve stock assessments for prioritized species (e.g. marlin)?
- What level of observer coverage is considered sufficient for length measurements for stock assessments?
- Should the pre-implementation program develop methods to obtain length measurements for particular species via EM?

Cost Considerations

Up front costs will be lower for EM system hardware and installation in the Hawaii shallow-set fishery compared to the Hawaii deep-set fishery due to the lower number of vessels. Storage and video review costs will depend on the coverage rates and if a third party model is being used. Video review costs can be reduced if AI models are used to detect retained fish. A preliminary AI model has been developed that can successfully detect fish on deck.

If length data are determined to be a priority for EM data collection of retained fish there will be additional unknown costs associated with research and development. If research indicates that it is feasible to collect length data in the shallow-set fishery, then there may be additional costs associated with collecting lengths, such as measuring boards, calibration, and video review.

Potential Monitoring Goal 3: Use EM for catch accounting of discarded species

EM could be used to maintain monitoring coverage at 100% for catch accounting of discarded fish for stock assessments, with a focus on priority species such as elasmobranchs or billfish (e.g. small swordfish). Observer coverage is currently the only accurate data source for discarded species in the Hawaii longline fishery as logbook reported releases are known to have a downward bias (i.e. less bycatch is reported than is actually caught). If EM were to be used to supplement some or all of the observer coverage in the shallow-set fishery, there would be stock assessment data loss for discarded species, unless those data were also collected by EM.

The encounter rate of discarded species would need to be considered to determine coverage rates. Some species (e.g. sharks and lancetfish) have variable detection rates with EM, which should be considered when determining if EM could improve estimation for a particular species compared to observer coverage alone.

Potential Monitoring Objective(s)

Potential monitoring objectives for a program to to use EM for bycatch accounting of discarded species in the Hawaii SSLL fishery could include:

- Maintain 100% monitoring
- Identify and enumerate discarded species (e.g. elasmobranchs, small swordfish, marlin, and tuna) for use in stock assessments
- Capture length measurements of discarded species for use in stock assessments

Data Collection and Use

EM research (Carnes et al. 2019) indicates that bycatch species in Hawaii longline fisheries can be detected by EM with 89% accuracy. Information on discarded fish can be collected but it depends on the species and the camera views. For instance, if a lancetfish is pulled in towards the stern near the bait boxes it may be more difficult to observe compared to a pelagic stingray pulled in near the fish door. Sharks can be detected when they are brought near the vessel, but detection would be difficult if they are cut from the line as soon as the crew observes them. This research indicates that EM could be used for verification of logbooks for discard detection depending on the species.

Questions for Pre-Implementation Program

In addition to overarching questions such as funding, program infrastructure, and data governance, the Council, Council advisory bodies, NMFS, and the ETSC would use a pre-implementation program to investigate and answer questions such as:

- Which discarded species would be a priority for data collection?
- What level of total monitoring coverage would need to be maintained for stock assessments of priority species?
- What camera configurations or handling requirements are required to capture

information on discarded species?

Cost Considerations

In 2022, 21 vessels participated in the SSLL fishery. Up front costs will be lower for EM system hardware and installation in the Hawaii shallow-set fishery compared to the Hawaii deep-set fishery, as 100% of the SSLL vessels could be outfitted with EM systems for the cost of installing systems on approximately 14% of the DSLL fleet. Storage and video review costs will depend on the coverage rates and if a third party model is being used. However, video review costs can be reduced if AI models can be built to successfully detect discarded fish and/or elasmobranchs of interest. Cost (for hardware, maintenance, data storage, and review) will be higher if a greater number of cameras is needed to collect data on discards.

Cost (for hardware, maintenance, data storage and review) will be higher if a greater number of cameras are needed to collect data on discards. If length data are determined to be a priority for EM data collection of discarded fish, then there will be additional unknown costs associated with research and development. If research indicates that it is feasible to collect length data in the shallow-set fishery, then there may be additional costs associated with collecting lengths, such as measuring boards, calibration, additional crew handling and video review. Video review costs may be reduced if AI models can successfully be developed to detect bycatch species of interest, such as sharks.

Hybrid: EM in both the Shallow-Set and Deep-set Longline Fisheries

At the PPT meeting on May 10, 2023, PPT members asked the ETSC to consider a potential hybrid EM program that includes monitoring goals and objectives in both the DSLL and SSLL fisheries. There is a seasonality to the SSLL fishery and most vessels which participate in the SSLL fishery also participate in the DSLL fishery. Therefore, EM systems installed on SSLL vessels could be used to support programs in both the DSLL and SSLL fisheries. The Council could recommend development of a hybrid program for pre-implementation by prioritizing a combination of the goals and objectives laid out for the Hawaii DSLL and SSLL fisheries above.

In a hybrid scenario, the equipment could be shared between programs, but the data collection needs and data uses may differ between the DSLL and SSLL fisheries due to the different regulations and monitoring needs in each fishery. Separate protocols may need to be developed for each fishery, even if they share equipment and EM providers. Due to the complexity of developing an EM program, a phased approach could also be taken in the pre-implementation program that starts with one fishery and builds to a hybrid approach that meets monitoring goals and objectives in both fisheries. A phased approach would provide the EM pre-implementation team time to assess the performance of the EM project within the smaller SSLL fishery and make necessary adjustments before pre-implementing in a fleet of approximately 147 active DSLL vessels.

If a hybrid approach is progressed without phased pre-implementation, then it could jeopardize important quality management principles such as continuous improvement. For example, if the second phase of pre-implementation was for the DSLL fishery and began upon sunset of the shallow-set fishing season, then there may not be time to adjust program design for lessons learned.

One of the complexities of a simultaneous hybrid EM implementation plan, wherein vessels outfitted with cameras can move between SSLL and DSLL, stems from statistical analyses required to consider how the EM trips will affect the percent coverage of both the SSLL and DSLL fisheries, as well as estimates for fleet-wide protected species bycatch. Additionally, the management of observers to maintain fluctuating percent coverages in both the fisheries would be challenging.

EM in American Samoa Longline Fishery

The ETSC considered, and presented to the PPT, a monitoring scenario for the American Samoa pelagic longline fishery. Potential overarching monitoring goals for this fishery are similar to those for the Hawaii longline fisheries to assess protected species bycatch, catch accounting for retained fish, and catch accounting for discarded fish, such as sharks. However, potential specific monitoring objectives differ.

Observer coverage is currently the only accurate data source for discarded species in the ASLL fishery as logbook reported releases are known to have a downward bias (i.e. less bycatch is reported than is actually caught). The ASLL fishery has the lowest monitoring coverage of all three pelagic longline fisheries in the PIR, with 8.7% of trips observed in 2022. EM coverage could supplement or increase monitoring coverage levels, potentially improving data for stock assessments or protected species estimates.

Potential Monitoring Objectives:

A program to use EM for the ASLL fishery could prioritize:

- Increasing monitoring coverage to improve the accuracy and precision of estimated protected species interactions
- Identifying and enumerating protected species bycatch
- Collecting additional information on protected species interactions to make injury determinations
- Collecting additional information on protected species interactions to assess post-release condition
- Assessing protected species handling
- Identifying and enumerating retained fish to improve stock assessments.
- Identifying and enumerating discarded fish and/or other prioritized species (elasmobranchs) to improve stock assessments

Cost Considerations

Both the ETSC and the PPT found that maintaining an EM program in American Samoa would encounter the same difficulties with respect to costs and logistics as are experienced by the current observer program. For example, support would need to be established in American Samoa for EM installation and technical assistance to vessels, which may be challenging, considering the 2,500-mile distance from Hawaii. Catch in this fishery is usually hauled back at night similar to the Hawaii deep-set fishery, which may make the detection and identification of dark-bodied protected species more challenging on video, and therefore more time-consuming and costly. In addition, a fishing trip in American Samoa can extend for 80-90 plus days. Therefore, there would be a significant increase of the amount of EM data to review, transmit and store, as well as longer holding periods between available EM data, which would dictate the pace of the pre-implementation plan. Finally, the observer program is currently developing methods to reduce costs of deploying observers in American Samoa, which may reduce the need to use EM for this fleet. These include removing educational requirements for observer candidates that reside in American Samoa and renting a low-cost housing unit to house observers while they wait for trips.

Comparison of Potential EM Goals and Objectives

Table 1. Summary of fishery needs for Monitoring Goals

Monitoring Goals	**Fishery Need**
DSLL, protected species	● Estimate protected species bycatch and collect additional information on interactions. ● Increased monitoring coverage by using EM may improve the accuracy and precision of estimated total interactions and other information for protected species. ● Reductions in monitoring coverage will affect the interaction trigger for the SEZ closure ● Address FKWTRT priority to implement an EM program in the DSLL fishery that would reduce uncertainty in false killer whale bycatch estimates and provide information to inform and improve serious injury determinations and consistency with gear handling guidelines.
SSLL, protected species	● Maintain accuracy and precision of protected species bycatch estimates and collect additional information on interactions ● With high costs of observer coverage, EM may provide a less expensive alternative to monitoring the SSLL fishery. ● Using EM to maintain 100% monitoring coverage will draw less resources from the DSLL. ● 100% monitoring coverage to ensure management measures are met for sea turtle trip interaction limits and annual interaction limits.
DSLL, catch accounting, retained fish	● Improve stock assessments for retained fish, especially marlins.
SS, catch accounting, retained fish	● Maintain 100% monitoring coverage for stock assessments of retained fish, especially marlins.
DSLL, catch accounting discarded	● Improve stock assessments for discard fish, especially for sharks.

fish	
SSLL, catch accounting discarded fish	● Maintain 100% monitoring coverage for stock assessments of discard fish, especially for sharks.
ASLL	● Potential reductions in monitoring costs ● Increase monitoring coverage rates to improve data for stock assessments or protected species estimates

Table 2. Summary of Potential Monitoring Objectives for Monitoring Goals

Monitoring Goals	**Objectives**
DSLL, protected species	● Maintain historical coverage level of 20% to: ○ Accurately estimate protected species bycatch ○ Monitor handling requirements for protected species bycatch ○ Collect data to perform mortality estimates for protected species bycatch, prioritizing sea turtle mortality estimates. ○ Collect data to perform cetacean injury determinations ○ Collect information for other high priority species such as of leatherback sea turtles and oceanic whitetip sharks ● Maintain or increase monitoring coverage to meet FKWTRT priorities to: ○ Reduce uncertainty in FKW bycatch estimates (both in terms of quantitative estimates and spatial distribution). ○ Provide information to inform and improve serious injury determinations and consistency with gear handling guidelines.

SSLL, protected species	● Maintain 100% monitoring coverage ● Estimate protected species interactions ● Monitor handling requirements for protected species bycatch ● Collect data to make post-interaction mortality estimates for protected species bycatch, prioritizing sea turtle mortality estimates ● Collect data to make injury determinations for cetaceans ● Monitor sea turtle interactions to inform management measures related to trip interaction limits for leatherback and loggerhead sea turtles and annual interaction limits for leatherback sea turtles.
DSLL, catch accounting, retained fish	● Maintain or increase historic monitoring coverage levels ● Identify and enumerate retained fish species for use in stock assessments ● Capture length measurements of retained fish for use in stock assessments
SSLL, catch accounting, retained fish	● Maintain monitoring coverage at 100% ● Identify and enumerate retained fish species to be used in stock assessments ● Capture length measurements of retained fish to be used in stock assess
DSLL, catch accounting discarded fish	● Identify and enumerate discarded fish species for use in stock assessments ● Capture length measurements of discarded species for use in stock assessments
SSLL, catch accounting discarded fish	● Maintain 100% monitoring ● Identify and enumerate discarded species (e.g. elasmobranchs, small swordfish, marlin, and tuna) for use in stock assessments ● Capture length measurements of discarded species for use in stock assessments.
ASLL	● Increase monitoring coverage to improve the accuracy and precision of estimated protected species interactions ● Identify and enumerate protected species bycatch ● Collect data to perform cetacean injury determinations ● Collect data to perform mortality estimates for protected species bycatch ● Assessing protected species handling

	● Identify and enumerate retained fish ● Identify and enumerating discarded fish and/or other prioritized species (elasmobranchs)

Table 3. Summary of Cost Considerations for Monitoring Goals

Monitoring Goals	**Cost considerations**
DSLL, protected species	● More vessels in DSLL fishery compared to SSLL; cost more to outfit the same proportion of vessels. ● Costs will increase with coverage >20% as recommended by FKWTRT. ● AI models may reduce costs of video review in future if cetaceans can be detected. ● Haul back at night may make the detection and identification of dark-bodied species challenging on video, and therefore more time-consuming and costly.
SSLL, protected species	● Fewer vessels in SSLL fishery compared to DSLL; cost less to outfit the same proportion of vessels. ● Fewer trips in the SSLL fishery compared to the DSLL; lower costs of data transmission, storage and review. ● AI models may reduce costs of video review; preliminary model detects sea turtles.
DSLL, catch accounting, retained fish	● Cost will be higher if EM is used to maintain coverage of 20% coverage or to increase coverage beyond that of the current observer program ● More vessels in DSLL fishery compared to SSLL; cost more to outfit the same proportion of vessels ● AI models can reduce costs of review with a model already developed to detect fish on deck. ● Length data collection costs: R&D, measuring boards, calibration, and video review, etc.
SSLL, catch accounting, retained fish	● Fewer vessels in SSLL fishery compared to DSLL; cost less to outfit the same proportion of vessels.

	● Fewer trips in the SSLL fishery compared to the DSLL; lower costs of data transmission, storage and review. ● AI models may reduce costs of video review; preliminary model detects fish on deck. ● Length data collection costs: R&D, measuring boards, calibration, and video review, etc.
DSLL, catch accounting discarded fish	● Cost will be higher if EM is used to maintain coverage of 20% coverage or to increase coverage beyond that of the current observer program ● More vessels in DSLL fishery compared to SSLL; cost more to outfit the same proportion of vessels ● AI models may reduce costs of review if models can be developed to detect bycatch. ● Costs will increase if additional cameras needed to detect discards ● Length data collection costs: R&D, measuring boards, calibration, additional crew handling and video review, etc.
SSLL, catch accounting discarded fish	● Fewer vessels in SSLL fishery compared to DSLL; cost less to outfit the same proportion of vessels. ● Fewer trips in the SSLL fishery compared to the DSLL; lower costs of data transmission, storage and review. ● AI models may reduce costs of review if models can be developed to detect bycatch. ● Costs will increase if additional cameras needed to detect discards outside camera views. ● Length data collection costs: R&D, measuring boards, calibration, additional crew handling and video review, etc.
ASLL	● It would be costly and logistically difficult to support would installation and technical assistance to vessels in American Samoa ● Haul back at night may make the detection and identification of dark-bodied species challenging on video, and therefore more time-consuming and costly. ● Longer trips in ASLL compared to Hawaii LL fisheries; higher cost per trip for data transmission, storage and review ● The observer program is developing methods to reduce costs of deploying observers in American Samoa

Next Steps

Once the Council has recommended priorities for pre-implementation (fishery and objectives), NMFS, with the ETSC and PPT, would develop an EM Pre-Implementation Plan. The Council may request regular updates on progress from the ETSC and/or PPT at future meetings. The Region will also need to reconcile a framework for data sharing with a data management plan and evaluate whether a third-party will be necessary for further EM implementation. The Council will need to be briefed on these issues throughout the process. Starting at the May 2024 Plan Team, the Council may request updates on these or other topics.

Secure funding for EM and PIROP into the future remains uncertain. A Council recommendation on a pre-implementation plan with associated prioritized goals and objectives will help leverage resources to further develop EM in the Region. Potential recommendations at this meeting are similar to those made by the North Pacific Council in Alaska which identified prioritized vessels and objectives. Funding was later secured for EM, partly due to the North Pacific Council's recommendations.

The Council, in the future, may recommend milestones for EM to complement or supplement PIROP human observer coverage. These milestones may include a number of EM units deployed or proportions of the fishing fleet monitored by EM. Based on evaluation of the efficacy of EM to fulfill necessary monitoring needs during the pre-implementation program, the Council will ultimately need to make a determination as to which monitoring objectives EM can fulfill in an implemented program and consequently what levels of human observer monitoring coverage are appropriate to supplement with EM. This is recognizing that EM cannot replace human observers with respect to biological data collection and other data collection procedures. In any case, the Council may recommend future progress on pre-implementation and further implementation to follow a phased approach.

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Appendix 1: March 2023 FKWTRT Consensus Recommendation re: Electronic Monitoring

There is uncertainty associated with false killer whale bycatch estimates in the Hawai‘i-based deep-set longline fishery, as well as limited information available on actual events (e.g., animal size, behavior for assessing animal condition, the duration of interactions, and gear handling behavior by the crew) due to 20% observer coverage coupled with low interaction rates. There is also uncertainty in spatial patterns of depredation and bycatch. The three different stocks of false killer whales have areas of overlap, and actual observer coverage in those areas of overlap is limited due to the low effort in those areas.

As such, the FKWTRT recommends that NOAA Fisheries work with WPRFMC to support implementation of a sustained electronic monitoring (EM) program in the Hawai‘i-based deep-set longline fishery that would substantially reduce uncertainty in false killer whale bycatch estimates (both in terms of quantitative estimates and spatial distribution) and provide information to inform and improve serious injury determinations and consistency with gear handling guidelines, while ensuring that such program is as cost efficient and cost effective as possible [see objectives list below]. The EM equipment should be installed on 100% of the Hawai'i-based deep-set longline fishery and data adequately stored; the stored data should be sampled and analyzed consistent with the objectives of the program. The FKWTRT further recommends that NOAA Fisheries consider appropriate technical specifications (e.g., number of cameras, video resolution, etc.) to record animals both next to the vessel and a broader field of view during gear hauling.

This recommendation is not intended to suggest a decline in observer coverage at this time. The intent of the team's recommendation is for sustained funding to support electronic monitoring. The intent is that EM should be a federally-funded program, but should not preclude other third-party non-fishery sources of funding.

FKW TRT Potential Electronic Monitoring Program Objectives

1. Improve certainty of FKW bycatch and depredation estimates, and explanatory predictors of post-release survival
    a. Increase the size of sampled effort from which information about specific FKW interactions for M&SI estimates are collected
        i. Key catch-level EM data collection fields
            1. Species ID (high priority)
            2. Crew handling/behavior (high priority)
            3. Duration of crew handling/release (medium priority)
            4. Trailing gear (medium priority)
            5. Marine mammal injuries (e.g., blood) (medium priority)
            6. Anatomical hooking location (medium priority)
            7. Animal behavior (e.g., assess impacts and potential for capture myopathy) (medium priority)
            8. Animal size (low priority)
    b. Reduce uncertainty in spatial patterns of FKW bycatch and bait/catch depredation
        i. Increase effective coverage (combined observer & EM data) in zones where multiple FKW stocks overlap
        ii. Better identify areas with higher or lower FKW interaction rates and bait/catch depredation rates
2. Assess consistency of handling according to TRT recommendations
3. Gather information on handling of FKW (comparison of observer program and EM program interactions)
4. Design an EM Program to be as cost efficient and cost effective as possible
5. Assess unanticipated benefits and or information that can be gathered from EM program