Herring and Mackerel Fishery Electronic Monitoring Project

Contract EA-133F-16-SE-1143

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Acronyms

ASM	At-Sea Monitor
AWS	Amazon Web Service
EM	Electronic Monitoring
ESA	Endangered Species Act
ET	Electronic Technology
FMP	Fishery Management Plan
FOIA	Freedom of Information Act
GARFO	Greater Atlantic Regional Fisheries Office
GPS	Global Positioning System
GUI	Graphical User Interface
HDD	Hard Disk Drive
IFM	Industry Funded Monitoring
IP	Internet Protocol
MADMF	Massachusetts Division of Marine Fisheries
MAFMC	Mid-Atlantic Fisheries Management Council
MEDMR	Maine Department of Marine Resources
MMPA	Marine Mammal Protection Act
NAS	Network Attached Storage
NEFMC	New England Fishery Management Council
NEFOP	Northeast Fisheries Observer Program
NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Service
NFWF	National Fish and Wildlife Foundation
PoE	Power-over-Ethernet
RSA	Research Set-Aside

SBRM	Standardized Bycatch Reporting Methodology
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
VMP	Vessel Monitoring Plan
VMS	Vessel Monitoring System
VTR	Vessel Trip Report

I. Executive Summary

Summary Overview

Electronic Monitoring (EM) is increasingly being used as a tool for catch monitoring and reporting compliance in fisheries around the world. There are several EM initiatives and programs underway in the United States, but full program implementation in the Northeast remains limited. As part of the Greater Atlantic Region's Electronic Technology (ET) Implementation Plan, the New England Fishery Management Council (NEFMC) and the National Marine Fisheries Service (NMFS) are considering implementation of EM in the Atlantic herring midwater trawl fishery to improve catch monitoring. In the Industry Funded Monitoring (IFM) omnibus amendment, the New England Fishery Management Council recommended increased monitoring in the herring fishery to address the following goals: 1) accurate estimates of catch (retained and discarded), 2) accurate catch estimates for incidental species for which catch caps apply, and 3) affordable monitoring for the herring fishery. The IFM amendment evaluates how different coverage target alternatives meet the specific monitoring goals identified by the New England Council while comparing the costs of the monitoring programs, particularly costs that would be borne by the fishing industry. The herring coverage target action alternatives include Northeast Fisheries Observer Program-level (NEFOP-level) observer, at-sea monitoring (ASM), EM, and portside sampling (PS) coverage. Because midwater trawl vessels discard only a small percentage of catch at sea, EM and portside sampling have the potential to be a cost effective way to address monitoring goals for the midwater trawl vessels harvesting herring. EM would be used to verify retention of catch on the midwater trawl fleet and portside sampling would be used to verify amount and species composition of landed catch.

Additionally, the Mid-Atlantic Fishery Management Council is considering EM as a monitoring option in the mackerel fishery pending the results of this study. While EM has been successfully deployed in other fisheries, its suitability for use in the Atlantic herring (and potentially mackerel) has not been explored. To this end, the NMFS Northeast Fisheries Science Center (NEFSC) and the Greater Atlantic Regional Fisheries Office (GARFO) designed a project to simulate, test and refine an operational EM program.

In August 2016, the NEFSC contracted Saltwater Inc. (Saltwater) to conduct a project to determine if EM is an appropriate tool to improve monitoring and address bycatch issues in the Atlantic herring and Atlantic Mackerel midwater trawl fisheries. Specifically, the goals of this project were to inform:

- Development of EM program requirements;
- Development of a data program and EM service provider performance standards;
- The establishment of roles and responsibilities for the fishing industry, service providers, and NMFS;
- How EM data collected in this project could be integrated into other reporting requirements; and
- How information could be provided to enhance fishery-wide implementation requirements.

This information will assist NMFS and the Fishery Management Councils in the development of EM program requirements and EM performance standards. To achieve these objectives, NMFS identified the following Contractor specific project deliverables:

- Installation and deployment of EM systems on up to twelve (12) Atlantic herring midwater trawl vessels;
- Develop local infrastructure for vessel and program support;
- Develop Vessel Monitoring Plans (VMPs) and establish standards and procedures for approving VMPs and equipment installations;
- Use EM to monitor fishing activity to determine if there are discards on herring and mackerel trips;

- Review sensor and video data; and
- Work with NMFS to review program performance for refinement.

NMFS and Saltwater staff conducted industry outreach and recruited volunteers willing to participate in the EM study during the 2016 and 2017 fishing years. Saltwater EM technicians installed systems on eleven commercial herring and mackerel midwater trawl fishing vessels in Maine, Massachusetts and New Jersey. Video and sensor data were collected for over 12 months on 192 trips and reviewed by Saltwater and NEFSC staff. Using the collected data, the project team evaluated the EM system's ability to capture data to meet the forthcoming monitoring requirements in the herring fishery, evaluated the major drivers that could impact the costs associated with full implementation, and looked for applicability to other Northeast fisheries.

Summary of Data Findings

As a result of collaborative voluntary participation by the fleet and the diligent work of Saltwater and NMFS staff, an expansive and unique data set was collected as a part of this project.

- Data was collected on 192 trips across the 11 actively fishing midwater trawl vessels.
- These data were initially reviewed by both Saltwater and a secondary review was performed by NMFS reviewers; Saltwater staff performed a comprehensive 'census' review while NMFS staff performed a shorter 'audit' that focused exclusively on fishing events.
- 'Dual reviews' were successfully completed on 126 trips (i.e., both 'census' and 'audit' reviews were completed).
- Of the 126 dual reviewed trips in this study, 32 trips (25%) had overlapping Northeast Fisheries Observer Program (NEFOP) coverage.
- Video reviewers were tasked with identifying and documenting discard events to determine what information could be consistently gathered and which types of discard events could be accurately categorized using EM. Please refer to *Appendix 1* for descriptions used by reviewers to categorize discard events.
- In total, review staff performed more than 1,000 hours of video review and catalogued 1,461 discard records (902 census reviewer records, 559 audit reviewer records).
- Of the the discard events as reported by the audit review, the most frequently assigned category was "discarded after being brought onboard," followed by "operational discards," "other," "unknown," "partial release," and "full release."
- Fishing activity made up approximately 23% of trips, suggesting that a reduced portion of the total video could be reviewed in detail to detect discard events.

Following the completion of the data collection period, the project team compiled the data and performed a series of summaries and analyses. Initial results of this work suggest that video-based EM has potential to be an effective monitoring tool in this fishery.

- Census and audit EM reviewers agreed that approximately 41 slippage events (26 partial release and 15 full release) had occurred in addition to another estimated 88 operational discard events.
- There was a high level of agreement among EM reviewers in categorizing full release events (94%).
- For smaller release events reviewers were generally able to identify that a release event had occurred, but often did not use the same classification to describe the events. For partial release events reviewers agreed in approximately 55% of the cases. In cases of disagreement, one reviewer typically classified a discard event as a partial release and the other reviewer classified the event as operational discards. The comments entered by reviewers suggested that in many of these events, reviewers were viewing similar releases of catch but categorizing them differently.

- Data comparisons between EM reviewers and NEFOP observers showed general agreement in identifying and categorizing slippage events. A close comparison of these events highlights the strengths and weaknesses of each data stream.
- Agreement between reviewers (our primary metric of performance in this study) was often impacted by factors such as the total number and placement of cameras on a vessel; factors that could be better controlled in an operational program where vessels would be expected to meet required standards and protocols regarding camera set-up (EM system set-up varied by participating vessel as participation was voluntary and vessels have different layouts).

In addition to comparisons of event categorization, data collected in this project assisted with the development of recommended operational considerations to maximize the effectiveness of video-based monitoring systems in this fleet. Specifically, results provide valuable information on the average times for EM video review and potential drivers of increased review time (mainly individual annotations of discard after being brought on board events). Further, our results suggest that an audit approach to video review may be sufficient, and may substantially reduce total review time, program costs, and storage requirements.

Summary of Lessons Learned

A primary goal of this project was to determine if EM technology was a suitable monitoring option for this fishery. Throughout the project, feedback was collected from project participants and with that input, the project team identified what worked well and where improvements were needed. Overall, EM was effective in detecting and categorizing full release slippage events when EM cameras were appropriately situated and used as recommended. Furthermore, EM was effective in detecting and categorizing catch discarded after being brought onboard. While EM was effective in the detection of discard events, reviewers had some difficulty in differentiating between operational discards and partial release slippage events consistently. Incorporating a mechanism which allows vessel operators to provide information regarding discard events throughout the trip may further aid when distinguishing among these events. The following are recommendations to promote a successful EM program in the herring midwater trawl fishery.

Implementation

System components: The EM systems provided by Saltwater functioned reliably and captured high quality data that allowed reviewers to identify discard events. Unnecessary recording occurred when the vessels engaged in non-fishing activity at the dock that incorporated the vessel hydraulics and initiated camera recording. The incorporation of using geofencing technology to restrict the onset and completion of video recording eliminated these unintended recordings and should be required in an operational program.

System use and reliability: Power interruptions to the EM system caused incidences of data loss. The use of voltage conditioners and uninterruptible power supplies (UPS) decreased the risk of power loss to the EM system. Camera connectivity issues that occurred were due to high vibration on the rail mounted cameras. Vibration resistant cameras are recommended for boom mounted cameras in this fishery.

Compliance: The project had lower participation in the last quarter for a variety of reasons that are addressed later in this report, but ultimately were a result of the voluntary structure of the study. In an operational program, vessels would be required to operate their systems or would be subject to consequence measures. Another common issue we encountered was a lack of proper training for the vessel personnel responsible for operating the EM system. The vessel representative trained by Saltwater during the install was often the vessel owner or fleet manager, not the captain. For this reason, captains and crews did not always fully understand their responsibilities. Under full implementation, the captain should be present during the install for operator training.

To maximize the ability of EM reviewers to view all discards, we determined that cameras should be installed to capture all 4 possible discard locations as listed below;

- Fish pumping
- Dewatering box
- Full deck
- Stern

These four views can generally be captured by three properly placed cameras. On most vessels, getting the required views will require the installation of a boom arm mount (as described in section III below).

Data Management and Review:

Data review: It is important for all project partners to work together at the onset of any EM project to determine which data fields should be collected and how they should be reported. Doing this early ensures the EM systems are installed with the best possible configuration to collect the necessary information and that data is properly documented in the review process. All events of interest should be clearly defined to prevent variation in the classification of discard events among reviewers. Data reviewers should be trained to ensure categorization of events and species identification is standardized.

Data retrieval: In fisheries with complex logistics where the vessels are not all located in the same port, in person data retrieval can be costly and logistically complicated. Mailing EM data to the review center can simplify this process and result in cost savings. However, mailing the data diminishes the opportunity for face to face contact, which allows vessel operators to ask questions, build working relationships with technicians and facilitates advantageous system performance checks. This issue may be mitigated by more frequent communication with the vessel operators early in the project (after the first few trips) to ensure EM responsibilities are understood and data collection is optimized. In an operational EM program with required compliance, vessel operators would be required to perform a “system check” prior to each trip, and ensure that any issues with the system are reported immediately to the EM service provider. In a fleet that makes frequent, short trips and is somewhat migratory, sufficient spare hard drives should be made available to the vessels to ensure data collection is not hindered due to HDD resource limitations.

II. Project Background & Overview

Saltwater Inc. is an observer and EM service provider headquartered in Anchorage, Alaska with field offices in Massachusetts, Washington, and Kodiak, Alaska. Saltwater has collected high quality data on fisheries and oceans for government agencies, research organizations, and fishermen for nearly 30 years. Since 2010, Saltwater has provided electronic monitoring services on vessels in the Atlantic pelagic longline fishery, the North Pacific longline and pot cod fisheries, the Pacific/West Coast groundfish fishery, the Pacific Islands shallow and deep set longline fishery, and the Gulf of Mexico reef and shrimp fisheries. The EM systems in these fisheries consistently produce high quality digital imagery integrated with precise Global Positioning System (GPS) and sensor data. These projects have allowed Saltwater to engage with fishery managers, the fishing industry, and other stakeholders to identify key challenges and define the best means of implementing EM in each fishery. This includes hardware and software decisions, data retrieval and management planning, data review protocols and procedures, skipper engagement and training, and infrastructure development.

The Atlantic Herring and Mackerel Fisheries

Atlantic herring (*Clupea harengus*) are a schooling fish distributed throughout the North Atlantic and Arctic Oceans, including the eastern seaboard of North America, where they migrate between Canada and North Carolina to feed and spawn[1]. These herring are a slow-growing species, generally reaching maturity at age 3 (~10 in) and attaining lengths of 15 inches[2]. Herring are an important forage species for tuna, sharks, haddock, flounder, squid, and marine mammals[3]. They are commercially valuable as bait fish, for fish oil, fish meal, and for human consumption. The fishery is managed through a stock-wide annual catch limit allocated to four separate management areas overseen by NMFS and the NEFMC (for Federal waters), and the Atlantic States Marine Fisheries Commission and individual states (for coastal waters).[4] Atlantic herring are caught with a variety of gear types, including trawl, purse seines, and gillnets, with midwater trawls (paired and single) accounting for the majority of the catch, 35,074 metric tons of herring from all areas, landed in 2016. This amount includes Research Set-Aside (RSA) quota.

Atlantic mackerel (*Scomber scombrus*) have a similar distribution and life history as Atlantic herring, and the two are often caught in conjunction. Mackerel grow to lengths of up to 16 inches; like herring, they feed on zooplankton and small crustaceans, and are an important forage species for other animals. There is a recreational fishery for mackerel, and their stock-wide annual catch limit is divided between the commercial and recreational fishery, managed entirely by NMFS and the Mid-Atlantic Fisheries Management Council (MAFMC)[5]. Mackerel are commercially fished with a wide variety of gears, such as handline, longline, purse seine, pot/trap, gillnets, and trawls, with midwater trawls accounting for the majority of the catch.

Under the Northeast Fisheries Observer Program (NEFOP), when selected by NMFS, vessels operating in the herring and mackerel fisheries must carry at-sea observers who document catch and discards, economic information, gear characteristics, fishing location, and biologically sample the catch.[6]. The herring fishery is not currently characterized as overfished, or as experiencing overfishing[7], but stakeholders have expressed concerns with bycatch and interactions with marine mammals. Given the the findings of the recent Atlantic Mackerel

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[1] http://s3.amazonaws.com/nefmc.org/herring_FMP.PDF
[2] https://www.nefsc.noaa.gov/publications/tm/tm126/tm126.pdf
[3] https://www.mass.gov/service-details/learn-about-atlantic-herring
[4] https://www.greateratlantic.fisheries.noaa.gov/sustainable/species/atlherring/index.html
[5] https://www.fisheries.noaa.gov/species/atlantic-mackerel
[6] https://www.greateratlantic.fisheries.noaa.gov/regs/2015/June/15sbrmomnibusamendea.pdf, pg. 125, 4.5.1.1 Federal Observer Program
[7] https://www.fisheries.noaa.gov/species/atlantic-herring

assessment (available at https://www.nefsc.noaa.gov/saw/reports.html), its official status will soon change to overfished with overfishing occurring. Plans are underway to implement a rebuilding program commencing January 2019 (pers com Jason Didden, MAFMC staff). The Standardized Bycatch Reporting Methodology (SBRM) sets the rate at which each fishery is covered; the actual rate depends on the amount of variability in the observer data used to complete the analysis. As a result, the coverage rate changes from year to year. The sea day schedule is released to the public in the spring each year.

Paired and single midwater trawling for Atlantic herring and mackerel are characterized as *High Volume Fisheries*, defined by large catch of many small fish, which are typically brought onboard using a high powered vacuum pump. Catches flow at a rate of 3,600 - 8,900pounds per minute (final loaded NEFOP data, 2010-2017, midwater trawl vessels only; flow rate estimate based on observed pump times and weights by permit) directly through a series of chutes into the vessel's hold, which contains refrigerated sea water. Currently monitored bycatch includes haddock, and river herring (alewife and blueback herring), and shads.

There are 12 vessels that actively fish for herring and mackerel with midwater trawl gear, and the vessels fish out of 5 main ports: Rockland, ME; Portland, ME; Gloucester, MA; New Bedford, MA; and Cape May, NJ. The vessels in these fisheries are usually large (80-150 feet or more in length), and in roughly half the fleet, two vessels fish together, which is referred to as "pair trawling". Trips typically last 3-5 days, though much of that time may be spent searching for fish via electronic sounders. The vessels rely heavily on their sonar systems (sounders, fish finders) to locate the targeted schools of fish.

Paired midwater trawling is only possible in relatively good weather because the paired vessels must maintain a uniform distance while towing and hauling back[8]. Setting begins with one vessel putting the net over the stern. The second vessel then approaches, pulling alongside its sister ship to retrieve a line attached to the net bridle from the vessel setting the net. The receiving vessel will then attach the bridle to their steel wire and, at the specified signal, both vessels begin to pay out a certain amount of wire in unison. Communications throughout the operation are maintained over VHF radio. Once the wire is paid out, towing begins, with the vessels on parallel courses and about one half to one third the warp length apart. Depth can be modified by increasing or decreasing wire length and towing speed.

One of the challenges to fishing with two vessels is that they need to be of similar size and power, and the captains must work in close cooperation for successful fishing to occur. Sensors are used to ensure the gear is fishing correctly and to monitor the catch in the net. Haul back begins at a given signal, with the warps being pulled in until the legs are brought up to the vessels. The vessels come alongside each other once more, when one of the vessels releases its cable and throws the line attached to the net bridle back to the hauling vessel, and the net is brought alongside at the surface to have the catch pumped onboard, into refrigerated saltwater tanks.

A primary objective of the study was to determine if EM technology could monitor catch retention in the midwater trawl fishery. The NEFOP provides at-sea coverage in the high volume fisheries and classifies discards into three categories: 1) Catch discarded after being brought on board 2) Slippage, referred to as the partial or full release of catch 3) Operational Discards. This classification structure was utilized by video reviewers throughout the EM project. Once a discard event was identified, reviewers selected one of five options to document the discard event type. These discard event types are defined in *Appendix 1.*

[8] Thomson, D. 1978 "Pair trawling and pair seining; the technology of two-boat fishing." Fishing New Books. 0-85238-087-9

Electronic Monitoring (EM)

The use of EM systems on fishing vessels is an increasingly popular addition to the monitoring portfolio of fishery management tools. The systems are comprised of video cameras, sensors, and data collection software. Data generated by the EM system includes vessel location, speed, gear deployment logs, and video of fishing activity, but does not collect audio. The data can augment or replace human observers to meet certain monitoring goals. EM has advanced significantly in the past 10 years, making high-quality, consistent data capture a cost-effective option to at-sea observers in some, if not all, fisheries. The following is a more detailed description of the EM system components:

Digital Cameras: Saltwater's internet protocol (IP) digital cameras have an ingress protection rating of IP67, which means they are manufactured with housings designed to protect against water immersion up to 1 meter and up to 30 minutes. Each camera is capable of capturing high-resolution imagery (1920 x 1080) at a rate of up to 30 frames per second. The cameras were selected for their low lux rating, ensuring clear imagery in low light, and use wide dynamic range technology to better handle fluctuating lighting conditions. Saltwater has deployed these cameras on vessels from Alaska to Hawaii, fishing in all kinds of challenging conditions. For this project, video resolution was set to 720p (1280x720) at a 15 fps, which is the recommended setting for smooth video playback.

GPS Receiver: Saltwater's GPS receiver is integrated within the control box which is coupled with an external antenna. It provides heading, velocity, latitude, longitude, and time/date. It begins producing data the moment it receives power and records continuously as long as there is power to the EM system. For this project, GPS data was logged every 10 seconds, though the capture rate can easily be adjusted to as often as every second (1 Hz) or as seldom as every hour. This information is used during data review to track vessel activity and to identify fishing effort.

Hydraulic & Drum Rotation Sensors: Hydraulic pressure transducers and rotation sensors are central to Saltwater's EM systems. Hydraulic pressure transducers monitor a vessel's hydraulic pressure and rotation sensors monitor mechanics, like line drums or warp winches. Sensor status is logged continuously from the start to the end of each fishing trip. This information helps reviewers identify fishing activity during the review process. The sensors can also be used to trigger video recording.

Control Center: Saltwater's small footprint EM control center (12" x 7.5" x 4.5") is fanless, noiseless, and ruggedized to withstand a wide temperature range, as well as shock and vibration. It includes a built in GPS receiver and two hard drive bays. All data collected by the EM system is recorded to high capacity (1 TB) hard disk drives (HDDs). The system is configured to write all information on encrypted HDDs to ensure data security and confidentiality. The system software monitors storage capacity and when one drive fills up, the system automatically stores additional data on the second drive.

The control center has eight built-in Power-over-Ethernet (PoE) ports for IP camera connectivity, which eliminates the need for additional power delivery to an external switch. Universal serial bus (USB) ports allow for simple system software upgrades via flash drive and the opportunity for the integration of other electronic devices. The control box and all of Saltwater's EM system components have low power requirements and can run off either alternating current (AC) or direct current (DC) power.

Wheelhouse Monitor: A wheelhouse monitor with waterproof keyboard allows vessel crew to see current date, time and location data, live camera feeds that show camera views at all times, even when the cameras are not recording, camera status (e.g., recording or not), and view what is being recorded in real-time. Our graphical user interface (GUI) is designed to provide vessel operators with a clear, simple way to confirm that all system components are operating correctly, the presence of a functioning HDD, and the percentage of disk space used.

The GUI also allows viewers to determine which HDD has data--and how much--and which drive to send in at the end of a trip.

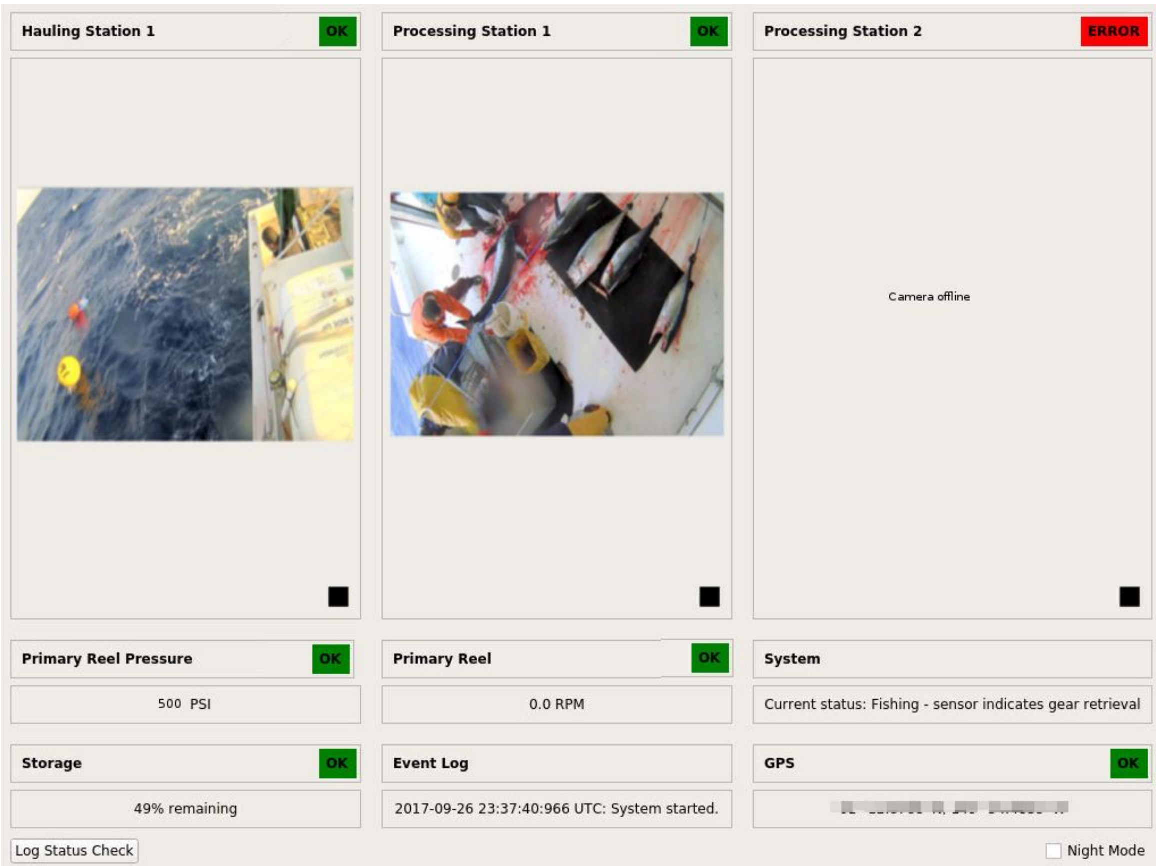


***Figure 1**: Graphic User Interface (GUI) as seen on the Saltwater EM system wheelhouse monitor .*

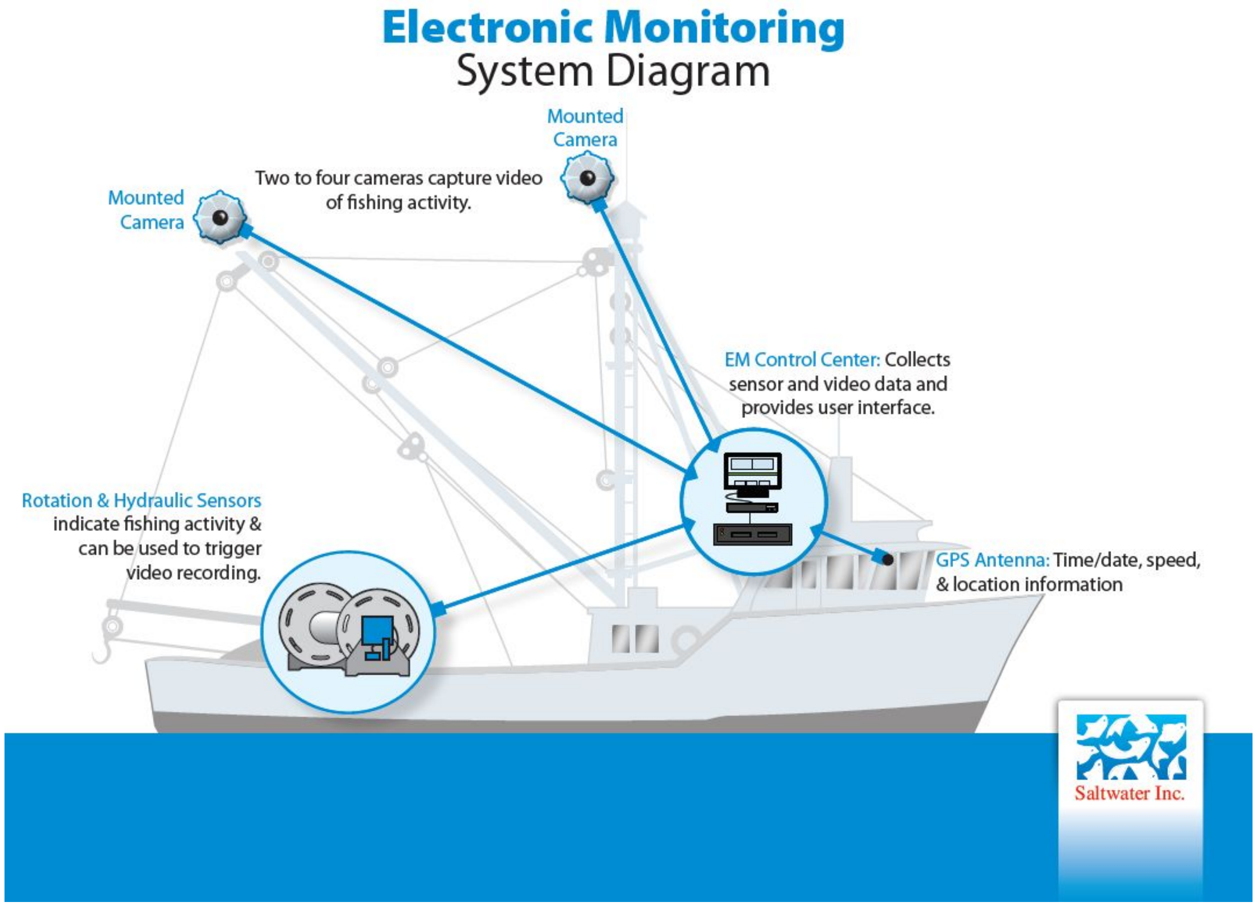


***Figure 2**: Diagram of the Saltwater EM system used in this project.*

EM has been suggested to monitor gear interactions with protected species, compliance with discard and retention regulations, to account for catch and bycatch, and to validate vessel landing and logbook information. A key constraint to effective EM implementation in many fisheries is the cost of data review and storage. Operational implementation of EM requires not only collecting hours of video and sensor data, but also the ability to efficiently extract from that data, the meaningful information needed to manage a particular fishery. Saltwater has developed open-source review software that integrates video and sensor data for efficient data review and analysis. Open-source software avoids the limitations and expense associated with proprietary code, encourages collaboration and innovation, and will speed the development of cost effective review solutions. A key constraint to successful EM program implementation is the cost of data review. The use of open-source data review software will be critical to the long-term success and sustainability of EM programs. Open source software can be used, changed, and shared (in modified or unmodified form) by anyone. The open-source movement promotes collaborative development of computer source code by multiple independent developers. It is among the most transformative trends shaping technology in the 21st century and companies such as Google, Oracle, IBM, LinkedIn, Square, Twitter, Netflix and others already rely on it.

Project Goals & Objectives

The overarching objectives were to evaluate the utility of EM for monitoring catch retention and to detect discard events in the Atlantic herring and mackerel midwater trawl fisheries according to the proposed use of EM in the IFM (as component of a monitoring option that would complement a portside sampling program). To assess the potential of EM to serve as a means for ensuring catch retention this project sought to 1) Compare annotations associated with discard event events among EM reviewers to quantify how consistently events can be detected by EM, 2) Compare the review times among review types to determine the review time needed, 3) Compare EM discard event detections to those noted by a NEFOP observer to assess the relative efficacy of the technology relative to existing monitoring options, and 4) Refine industry and NMFS EM cost estimates by identifying the variables that impacted the total project cost. The design of the program involved installing EM systems on volunteer vessels actively participating in these fisheries, collecting the video data after each trip, and reviewing 100% of the collected video data. The project team sought to determine if the collected data met specific monitoring needs, what factors were critical to successful program implementation, whether there were ways to improve any aspect of the program, and to identify the primary cost drivers and any cost efficiencies.

The NEFMC developed the Industry Funded Monitoring (IFM) Omnibus Amendment to increase monitoring and/or other types of data collection in some of its Fishery Management Plans (FMP). The goal of the IFM Amendment is to improve the amount and type of catch data, to more precisely monitor annual catch limits, and/or provide other information for management. This increased monitoring will be in addition to coverage required through SBRM, the Endangered Species Act (ESA) or Marine Mammal Protection Act (MMPA). The IFM Amendment specifically addresses increased monitoring in the Atlantic Herring FMP, and contains alternatives that maintain or increase observer coverage in the herring fishery. Although the IFM Amendment was originally intended to be a joint venture between the NEFMC and the MAFMC, the MAFMC has decided to delay any decision on an industry-funded monitoring action until the results of this study are complete.

At its April 2017 meeting, the NEFMC selected IFM Herring Alternative 2.7, which will implement a combined coverage target of 50% for all herring Category A and B vessels, and will provide herring midwater trawl vessels the option to choose between monitoring with At-Sea Monitors (ASM) or with the combination of EM and Portside monitoring. Final approval of EM as a monitoring option will be made at its April, 2018 meeting, and will be based largely upon results and recommendations of this study.

If approved by the New England Council, midwater trawl vessels could choose EM in association with portside monitoring. Since 2008, the Massachusetts Division of Marine Fisheries (MADMF) and the Maine Department of Marine Resources (MEDMR) have collected data (species, morphometrics) on the herring and mackerel midwater trawl fishery through independent portside data sampling programs. MADMF has opportunistically targeted 50% sampling of midwater trawl trips landed in MA, while MEDMR generally samples 5-10% of trips landed in ME. Though these programs are not currently used in NMFS quota monitoring, they have provided valuable and expedited information on catch composition to fishermen and fishery managers. In conjunction with EM, these states will continue to collect data through the first year of IFM implementation in 2018, after which a federal program (modeled after the state programs) will commence in 2019.

Table 1: IFM alternatives for the herring fishery.

Gear Type	Midwater Trawl	Purse Seine	Small Mesh Bottom Trawl
Herring Alternative 1: No Coverage Target for IFM Program (No Action)	SBRM		
Herring Alternative 2: Coverage Targets for IFM Program	Includes Sub-Options: 1) Waiver Allowed, 2) Wing Vessel Exemption, 3) 2-Year Sunset, 4) 2-Year Re-evaluation, and 5) 25 mt or 50 mt Exemption Threshold		
Herring Alternative 2.1: 100% NEFOP-Level Coverage on Category A and B Vessels	100% NEFOP-Level Observer		
Herring Alternative 2.2: ASM Coverage on Category A and B Vessels	25%, 50%, 75% or 100% ASM		
Herring Alternative 2.3: Combination Coverage on Category A and B Vessels and Midwater Trawl Fleet	50% or 100% EM/Portside	25%, 50%, 75% or 100% ASM	
Herring Alternative 2.4: EM and Portside Coverage on Midwater Trawl Fleet	50% or 100% EM/Portside	SBRM (No Action)	
Herring Alternative 2.5: 100% NEFOP-Level Coverage on Midwater Trawl Fleet in Groundfish Closed Areas*	100% NEFOP-Level Coverage	SBRM (No Action)	
Herring Alternative 2.6: Combination Coverage on Midwater Trawl Fleet in Groundfish Closed Areas	Coverage would match selected alternative 2.1-2.4	SBRM (No Action)	
Herring Alternative 2.7: ASM Coverage on Category A and B Vessels, then Vessels may choose either ASM or EM/Portside Coverage	50% ASM or EM/Portside	50% ASM	50% ASM
* Sub-Options do not apply to Herring Alternative 2.5.			

III. Project Implementation

Project Timeline

The contract was awarded to Saltwater and signed on August 12, 2016. The timeline included a 2 month project setup period which included clarifying project objectives, hardware and software specifications, vessel requirements, defining roles and responsibilities, and development of a project plan. In addition, Saltwater setup local capacity and infrastructure to provide and support field services. The EM operational and data collection period consisted of 13 months (October 2016 - October 2017). Activities included; vessel visits, installation and servicing of EM units, field and project support and data collection. Analysis and report writing occurred over 3 months.

Herring & Mackerel Midwater Trawl EM Program Timeline

	Start Date	End Date
Total Project Period	**8/12/2016**	**12/31/2017**
Project Award	8/12/2016	8/12/2016
Project Setup	8/12/2016	10/12/2016
Project Outreach	8/12/2016	12/1/2017
Component Procurement	8/12/2016	9/23/2016
Installations	9/30/2016	1/5/2017
Field Support	10/1/2016	10/31/2017
Data Review	10/14/2016	11/22/2017
EM System Removal	9/21/2017	12/31/2017
Analysis and Reporting	11/1/2017	1/31/2018

Figure 3: *Project Timeline*

Outreach

Beginning in 2016, NMFS conducted initial outreach, alerting the herring and mackerel midwater trawl fleet vessel owners that a voluntary EM project had been funded and would be taking place in 2016-17. Vessel owners were informed about the objectives of the project, the timeline, and their roles and responsibilities if they chose to volunteer. NMFS created an EM study outreach sheet (*Appendix 2*) to explain the project goals. Participation in the project was not remunerated and did not remove vessel owners from the requirement to carry observers on selected trips. Saltwater prepared a *Vessel Reference Sheet (Appendix 3),* outlining vessel power requirements and basic EM system operations that was provided to potential volunteer participants, along with a detailed description of the install process.

In order to prepare for the installations, an in-person vessel assessment was conducted on all but one vessel in October 2016. In order to make the best use of the limited time in port, the remaining vessel assessment took place in November, on the first day of the EM system installation on that vessel. During the vessel assessment meeting, members of NMFS and Saltwater met with the vessel owner and/or captain to create an EM installation plan. Saltwater worked with the owner or captain to determine where each of the components should be installed for optimal function. Project goals and objectives were also discussed at this meeting.

Throughout the project, vessel feedback was provided in a variety of formats. Saltwater staff contacted vessel owners or operators if there was something that needed more immediate feedback, such as keeping the EM system powered for the entirety of the trip. Video reviewers also filled out trip feedback forms *(Appendix 4)* to effectively address issues on a particular trip. Quarterly evaluations summarizing all declared herring/mackerel trips and several metrics evaluating adherence to EM project requirements were sent to the vessel owners (*Appendix 5)*. Throughout the project, representatives from NMFS and Saltwater met with vessel owners and operators to review the quarterly evaluations and trip feedback forms as well as go over video footage from that quarter and address any questions or concerns the owners or operators had about the project. At the end of the project, NMFS and Saltwater conducted exit interviews (*Appendix 6*) with representatives from each vessel to discuss the project and gather feedback. A total of 37 outreach meetings took place during the course of the project, including 10 vessel assessments/pre-install meetings, 17 quarterly feedback meetings and 10 exit interviews.

EM systems Installations & Field Support

Saltwater developed an EM system that has been successfully deployed in the past six years on well over 150 vessels in multiple fisheries, including over 100 vessels across the Atlantic Coast fishing in the Pelagic Longline fleet for Tuna and Swordfish. This EM system used for this project has proved capable of collecting high-quality digital video data and accurate, supporting sensor data. Saltwater's EM system consists of a control box with two bays for removable hard drives, one to three Internet protocol (IP) cameras per vessel, hydraulic pressure sensors, drum rotation sensors, a GPS receiver, and a monitor and keyboard for the vessel's wheelhouse. Saltwater's data acquisition software utilizes open-source code to log and process GPS, sensor, and video data into usable EM datasets. All of the EM systems were leased by NMFS for the duration of project. Industry participants were not required to pay for any of the components or service costs, but were given the option to purchase the systems for a nominal fee at the end of the project.

During the initial vessel visits, Saltwater and NMFS discussed the installation with the vessel representative. After discussing fishing operations, NMFS and Saltwater communicated the preferred location for the cameras to capture the ideal views. Typically, these vessels pull the net along the starboard side of the vessel to pump the fish and the catch is pumped through the dewatering box where discarding may occur. Once pumping is complete, the net is pulled back around to the stern where the codend is opened up and the net is brought back onboard on the net reel. With these fishing operations, there are three locations where discards could occur; at the pumping location, at the dewatering box, and at the stern. It was determined that cameras should be installed in a way that captures all 3 of these possible discard locations, usually requiring 3 cameras. A full deck view camera (often used to capture a view of the dewatering box) also proved helpful to allow the reviewer to be able to see when the vessel was setting out the net and hauling it back. There was one vessel in the project that pumped at the stern and therefore did not require a starboard camera.

The typical installation took 3 - 3.5 days for a two technician team (or roughly 60 man hours). Much of this time was spent running wires since many wire runs were behind wall and ceiling panels and were difficult to access. After reviewing the initial datasets from each vessel, it was determined that a camera mounted on a boom could provide a direct line of sight of the pump station, starboard rail, and water while eliminating physical obstructions unique to each vessel participant. It was determined that most pump views in this project, could be improved by the installation of a boom arm extending over the edge of the vessel, allowing the camera an unobstructed view of the pump in the water. Booms were installed on five vessels, however, all but one vessel would have benefited from the installation of a boom. In some situations, captains declined to install a boom because they felt that it would have been an obstruction during the offload process, and others felt the view without the boom should be sufficient for the project. Dewatering box/deck camera views were seen by some participants as unnecessary or intrusive to personal space for a project looking at documenting discard events, so those participants declined to have those views captured on their vessels. It was determined during the project that a deck view, dewatering box view, stern view and pump view were all required to accurately classify discard events. However, since this was a voluntary project, booms and cameras were installed to capture the best views possible while adhering to the vessel owner's guidance and level of comfort.

***Figure 4**: Boom arm installed on one of the participating vessels. Boom arms were added to 5 vessels in this project to determine if a better view of pumping activity and the contents of the net could be obtained. Photograph used with vessel owner's permission.*

***Figure 5**: View of fish pumping before and after installation of the boom arm. Photograph used with vessel owner's permission.*

When the installation was complete, the vessel owner or operator was trained by the EM technician in system operation and maintenance. A system operating manual was provided at the time of install and a VMP (*Appendix 7*) was created and provided to the vessel operator once complete.

Saltwater established a call-in number and service tracking system that was used to meet the support needs of the 11 vessels participating in the project. During the system installs, Saltwater technicians provided vessel owners and/or operators the call-in number, available twenty-four hours a day, seven days a week, and appropriate email contact information. Trained Saltwater EM staff answered all calls and were able to carry out remote troubleshooting and help identify and/or resolve system issues. The majority of calls were answered by the same technicians who carried out the installs, had developed working relationships with the captains, and were familiar with the set up on the boats.

NEFOP Data Collection

The Northeast Fisheries Observer Program (NEFOP) collects fishery dependent data from the midwater trawl herring fleet. Observers collect a suite of data on herring trips, including: trip-level information (costs, vessel description, safety), gear, catch (kept and discarded), and data to assist NEFOP in the determination of slippage events, and incidental take information on protected species. For a complete description of all data collected by observers, refer to the observer program operations manual, data entry manual, and on-deck reference guide[9].

NEFOP data are used by GARFO to monitor catch caps for river herring/shad and haddock. The NEFSC uses NEFOP data in support of SBRM to estimate the amount of bycatch occurring in the fishery. The SBRM analysis is described in detail on the observer program website[10].

The SBRM sets the rate at which the fishery is covered; the actual rate is determined based on the amount of variability in the observer data used to complete the analysis. As a result, the coverage rate changes from year to year. The sea day schedule is released to the public in the spring each year. The table below demonstrates the observer coverage over the time-frame of the project.

Table 2. *Midwater Trawl Quarterly Observer Coverage Rates, Nov. 2016-Oct. 2017. Includes observed (at least one observed haul per trip) single and paired midwater trawl trips divided by VTR trips reporting kept catch. Includes all fisheries, not just herring and mackerel fisheries. The herring EM project data collection period overlapped with two SBRM years, 2016-2017 and 2017-2018 (SBRM schedule runs from April-March). Observer coverage was relatively high Feb-Apr during the study as this aligned with increased SBRM coverage needs during this same period. SBRM coverage of the fleet can vary from year to year, driven by funding and data needs to monitor bycatch (Source: GARFO's DMIS and NEFSC's OBDBS databases as of 2018-01-24).*

Period	Observer Coverage
NOV-JAN	14.60%
FEB-APR	31.30%
MAY-JUL	13.50%
AUG-OCT	11.00%

[9] https://www.nefsc.noaa.gov/fsb/training/
[10] https://www.nefsc.noaa.gov/fsb/SBRM/

VMS Data Collection

All participants in the Atlantic herring fleet are required to carry a vessel monitoring system (VMS) for use by NMFS to track vessel activity as a condition of their federal fishing permit. VMS data were used during the project to aid in data retrieval. NMFS staff were able to verify vessel activity and communicate expected landing dates to EM technicians. This relay of information allowed the EM provider to plan ahead for data retrievals and system maintenance. VMS data were also used to compare declared herring trips with EM data, which allowed project staff to determine the proportion of trips that were recorded by the EM system. Vessel trip report (VTR) data were used as a second check to compare EM data collection with known fishing activity, particularly in cases where the cameras were not activated due to the absence of fishing activity. Lessons learned from using these tools are applicable to an operational program.

Data Management & Review

Data Transfer

Saltwater's onboard EM hardware and software are designed to facilitate data retrieval by vessel owner/operators. Vessel operators were asked to mail in HDDs after each trip. At the time of installation, they received training and written instructions on how to retrieve and replace the HDDs. Each vessel operator was also provided with four HDDs, with the understanding that two per trip was generally sufficient (one for data storage, and one as a backup). On average, each 1 TB HDD can hold about 8 full days of video with the 3 camera setup at 720p and 15 fps. To submit HDDs, vessel owners were given protective mailers and pre-paid envelopes with tracking information which they could drop in any USPS mailbox.

Data Security & Storage

All of the EM data stored on thel HDDs are encrypted and password protected to ensure that they cannot be tampered with and remains confidential. In addition, Saltwater's "system log" records the serial number of the HDDs that are in the system, and the dates of install and removal. This enables the establishment of chain of custody, documenting that the HDD installed is the one removed and the one received.

When the HDDs were received in the Saltwater office, they were decrypted and the data were copied onto a redundant Network Attached Storage (NAS) device. After being backed up and verified, HDDs were reformatted and sent back to participating vessels for future deployment. A chain-of-custody log showing when the drives were received, copied, reformatted, and returned to circulation was maintained during the duration of the project. Additional copies of data from each trip were made and shared with the NMFS project team. Once review was completed, all of the data, including all video files, were transferred from the NAS and uploaded to Glacier, the Amazon Web Cloud Service (AWS), where they will be stored for three years. Amazon Glacier is a secure, durable, and extremely low-cost cloud storage service for data archiving and long-term backup. It provides comprehensive security and compliance capabilities that can help meet even the most stringent regulatory requirements. Data can be stored in Glacier for as little as $0.004 per gigabyte per month, a significant savings compared to local storage solutions.

Data Review

All of Saltwater's EM data reviewers are current or previously certified at-sea observers. This experience provides them with a keen understanding of the importance of data integrity, familiarity with reporting requirements, vessel operations and the fishery, and training and experience in species identification. For this project, two EM technicians (also former observers) were cross-trained to carry out data review, which allowed for the efficient use of time and talent. To ensure timely review, we also employed a current NEFOP observer as a part time reviewer to assist with video review during times when higher volumes of data were being collected.

Saltwater's onboard EM system collects high-quality digital imagery. Logged sensor data tracks fishing location and effort. Saltwater's open-source review software, which was used for all of the video review carried out under this project, integrates the collected EM video files and sensor data for efficient review and analysis.

Saltwater and Chordata, LLC, under a National Fish and Wildlife Foundation (NFWF) supported grant, developed the review software that was used for this project. The software is also being used by NMFS program in the Pacific Islands, Gulf of Mexico, and Alaska. The software is Windows-compatible, and produces data exports as comma separated value files.

All sensor data captured during a trip is displayed on a timeline to allow reviewers to identify events like gear deployment and retrieval, changes in vessel speed, and other key sensor readings. The reviewer can then click on any point in the timeline to see video imagery captured at that time. A map showing the trip's GPS track is also synchronized to the video and timeline, allowing reviewers to click on a particular point on the map to access corresponding video imagery.

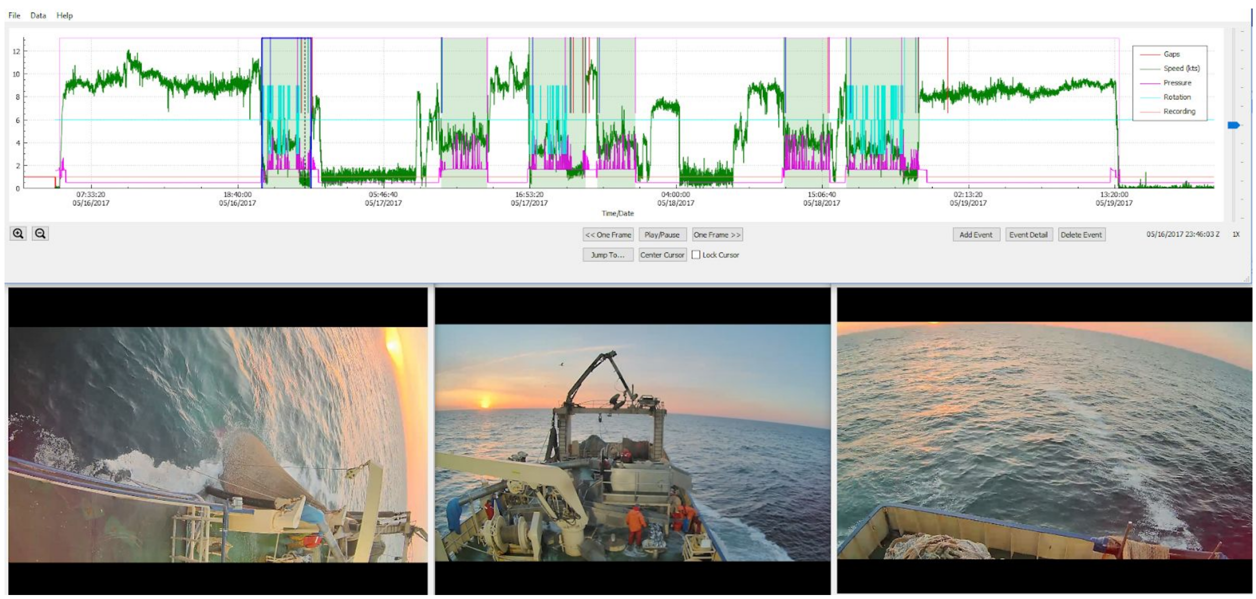


Figure 6: *EM data displayed using Saltwater's Open Source Review Software. Photographs used with vessel owner's permission.*

For this project, all of the EM sensor and video data collected for each trip were checked by Saltwater reviewers for completeness, loaded into the software, and reviewed in their entirety. Data reviewers documented all fishing activities and discard events. Summary reports were produced as comma separated value (CSV) files and were made available to NMFS. Along with a census review of all of the collected data, Saltwater reviewers performed an internal quality control audit on 89 (46%) of the trips. For this project, staff from both Saltwater and NMFS reviewed the trip footage and data and compared their findings to check for accuracy and consistency. The EM data and discard events were also compared for accuracy and consistency to observer data for all NEFOP observed trips.

IV. Data Analysis/Findings

This project generated a large volume of information. There are many ways that these data can be summarized and this report is not a comprehensive treatment of the data. Instead, we summarize data in an effort to address some of the primary goals of this project. First, we provide an overview of the data that were collected and provide some context and to explore how fishing effort recorded during this project compares to recent years. Second, we examine the review data generated by Saltwater and NMFS and explore the review time needed to generate observations of fishing effort. Finally, we delve into comparisons of trip and haul level notes and discard event classifications compiled by reviewers. We discuss how reviewer event classifications differ, and propose what might have led reviewers to categorize specific discard events in different discard event classifications. Through this analysis, we examine the potential pros and cons of using EM for monitoring slippage in the midwater trawl herring fishery.

Project Data Overview

The number of cameras deployed on the 11 vessels varied from one to three cameras. Each vessel was slightly different in configuration leading to some differences in camera placement and the quality of the video framing. Booms were used to improve the framing of pump/rail camera views on some but not all vessels (Table 3). Vessels owners were voluntary participants in the study and ultimately determined the number and location of installed equipment.

Table 3: *The summary of camera installation information and a qualitative assessment of the views they provided. Some vessels are also currently outfitted with triplex rollers (see page 26 for description of triplex) that can be used in catch handling and may increase our ability to discern between different types of fishing events. Views that were clear had minimal obstructions and were ideal for the review of footage. Views that were adequate provided coverage of the area but had some defect (e.g., equipment blocking a portion of the vessel from sight or slight blind spots). Obstructed views significantly impacted the ability of the reviewers to view and classify discard events.*

Vessel number	Cameras installed	Boom installed	Stern view	Rail view	Dewatering box view	Deck view	Triplex present
1	3	N	Y	Clear	Adequate	None	N
2	3	N	Y	Clear	Obstructed	None	N
3	3	N	Y	Clear	Clear	Clear	N
4	2	N	N	Adequate	Clear	Clear	Y
5	2	N	Y	Clear	Adequate	Adequate	N
6	3	Y	Y	Clear	Clear	Clear	Y
7	3	Y	Y	Clear	Clear	Clear	N
8	3	Y	Y	Clear	Clear	Adequate	N
9	3	Y	Y	Clear	Clear	Clear	Y
10	1	N	Y	Clear	None	None	N
11	3	N	Y	Clear	Clear	Clear	N

Our assessment of VTR and VMS data suggested that vessels participating in the project sailed on as many as 230 trips during the project period. This total represents a sum of VMS notifications and vessel trip reports that represent a range of vessel activity, and is an upper estimate for the number of trips sailed. The total number of trips with fishing activity that could be used for the analysis (i.e., where reviewer annotations could be compared) was 126 (hereafter referred to as trips with 'dual reviews'), which is likely a large proportion of trips with significant fishing activity. Some trips were excluded from analysis for a number of reasons, ranging from the lack of fishing activity on a trip (and thus no discard events to compare) to an incomplete data set (where the EM system was operational for only a portion of the trip). Ultimately, 126 trips were included in the analysis. Within the sample, vessels on average, completed 11.5 trips during the project period (minimum 3, max 16). In total, 32 of these complete trips (~25%) carried NEFOP observers allowing for an additional level of comparison. As detailed in the participation section (please see below), most of the trips where data were collected occurred prior to July 2017 (Figure 7 and Figure 8). There was no clear temporal pattern in the level of reviewer agreement across the study (i.e., trips where reviewers disagreed that slippage occured were not all clustered at the beginning or end of the of study period), suggesting that disagreement was likely not substantially impacted by the experience of the reviewers or by other factors related to the stage of the project. Similarly, slippage events do not appear to follow any specific pattern when the data is viewed in this way. Trips where complementary data were available from a NEFOP observer occurred across the range of trip dates, but were more prevalent at the beginning of the study.

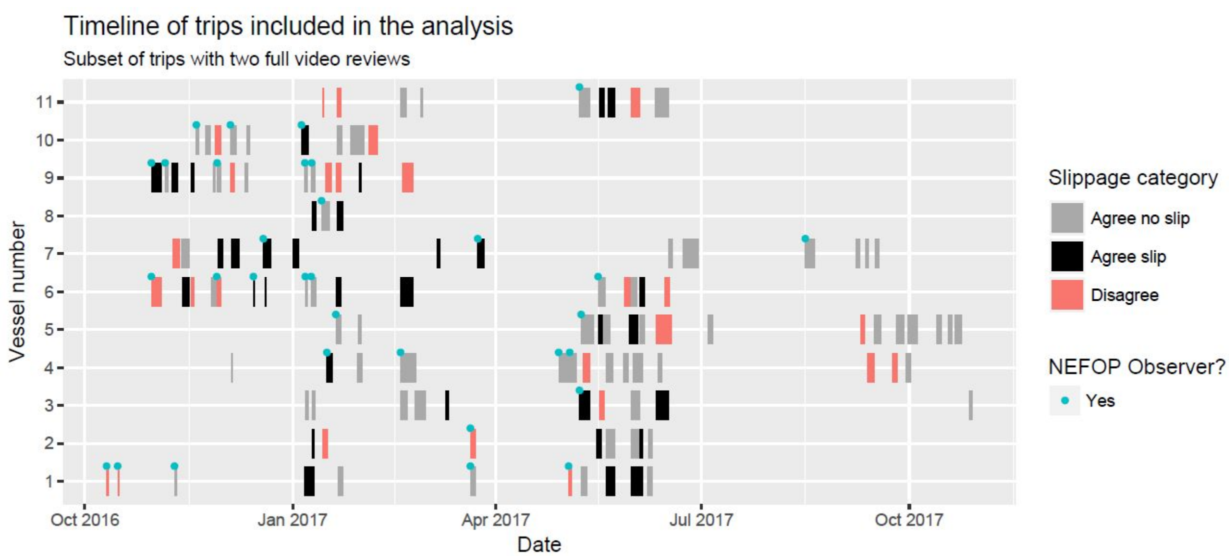


***Figure 7**: A timeline of trips sailed for each vessel that were included in the analysis. Each trip is represented by a short segment corresponding to sail and land dates. Trips with matching observer records are indicated by a blue point above their sail date (the beginning of each trip segment). Whether EM reviewers agreed that slippage occured during the trip is shown with the color of the segment. A gray segment indicates a trip where EM reviewers agreed that slippage did not occur, a black segment indicates a trip where the EM reviewer agreed that slippage did occur, and a red segment indicates a trip where reviewers disagreed as to whether slippage occurred on the trip.*

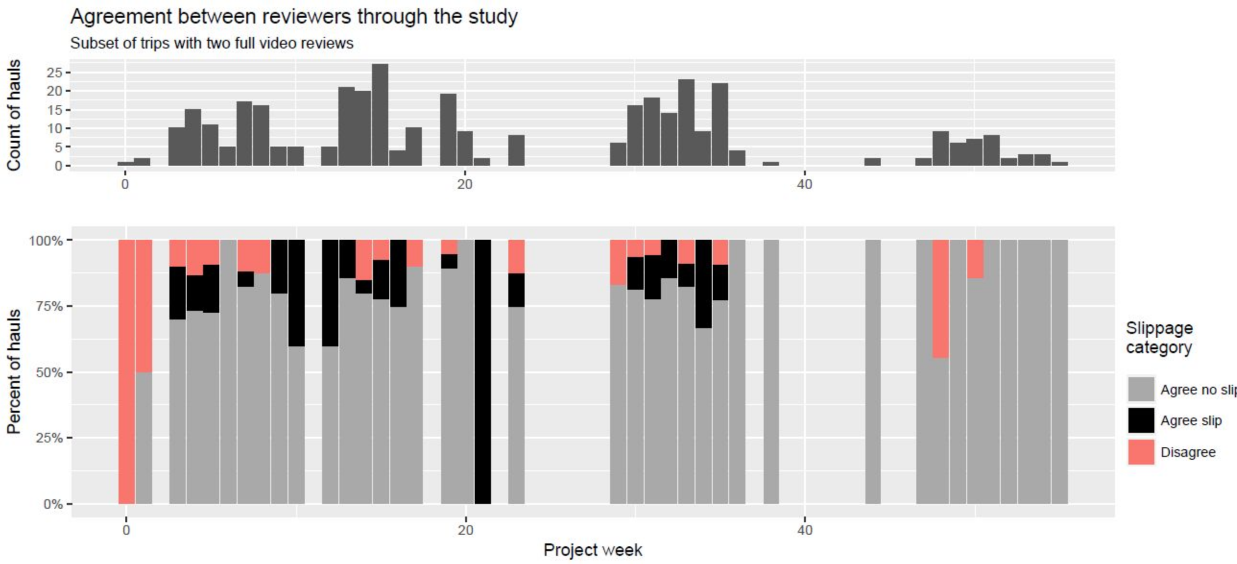


__Figure 8__: Agreement at the haul level for each week of the project. The percent of hauls during a given week of the project where EM reviewers agreed that slippage occured during the trip is shown with the color of the bar. A gray bar indicates a trip where EM reviewers agreed that slippage did not occur, a black bar indicates a trip where the EM reviewer agreed that slippage did occur, and a red bar indicates a trip where reviewer annotations disagree as to whether slippage occurred on the trip.

Within the set of trips with dual EM reviews (both census and audit) approximately 370 hauls were completed with vessels averaging 33 hauls in the project period (minimum 12, max 52). The mean number of hauls per trip was ~3 (min 1, max 10). This mean value of hauls is very similar to the mean number of hauls per trip in recent years for this fishery (mean number of hauls from the observer data is 2.9). Although not conclusive, this suggests that fishing activities during the project were similar to those in previous years.

Over the course of the project ~902 discard event records were logged by Saltwater while ~559 records were recorded by NMFS (Table 4). The large discrepancy in event totals was mostly due to the larger number of 'discarded after being brought on board' events identified by Saltwater reviewers conducting a more comprehensive census review. This was in part because there was a greater effort expended by census reviewers to group discard events by species instead of one event for all species in a haul. In comparison, the audit reviewers focused primarily on major discard events that occur within catch handling time intervals. Discarded finfish that could be tally counted were grouped together based on physical characteristics and consolidated into one discard event entry that included total counts. For a more complete description of the differences in review methods please see below. The total numbers of events in other categories were much closer in number, although Saltwater identified a larger number of partial release events and NMFS noted a larger number of operational discards, unknown, and other event types. The number of full releases identified by each reviewer was nearly identical, and suggests that this type of event is more easily documented by the EM systems. The more substantive differences in the number of operational discards detected by each review type (census recorded 139 while audit recorded 189) were likely driven by differences in the annotation protocol followed by EM reviewers. These differences were likely more pronounced because less emphasis was placed on aligning protocols for identifying operational discards between reviewers than for identifying partial and full release events.

Table 4: *The summary of events recorded by each review type across the entire project (all vessels combined) for the trips which dual reviews were generated. Each event category was given a priority listing of "High" or "Low" based on the project's objectives. Full release, partial release, and operational discards were identified at the haul level (totals represent essentially a sum of the number of hauls with a given event category), while other, unknown, and discarded after being brought onboard events were not summed at the haul level. Summarizing events at the haul level aided in matching and exploring discrepancies in event categorization. This table shows that there was close alignment for full release events. Alignment of partial release events was lower, as these events were often labeled as operational discards by one source. These events can be very similar in nature and difficult to distinguish from one another. Interestingly, when these event categories are summed together there is a higher level of alignment among review types (183 census and 220 for the audit).*

Discard Event Type	Review priority	Saltwater census total	NMFS audit total
Full Release (slippage)	High	15	16
Partial Release (slippage)	High	44	31
Operational Discards	High	139	189
Unknown	High	55	58
Other	Low	36	65
Discarded after being brought onboard	Low	613*	200

** Large difference in this type of event are the result of differing review methodologies (please see below).*

When the locations of discard events (a proxy for fishing activity) are compared (both between reviewers and between reviewers and NEFOP observers), it appears that there is considerable overlap in the spatial extent of the data collected (reviewer annotations tend to cluster in the same locations). Further comparisons to maps of the spatial extent of fishing in recent years[11] suggest the spatial patterns of discarding closely aligned with the distribution of fishing effort and discarding reported previously (Figure 9). This again suggests that the fishing behavior observed in the study is representative of the current fishery practices.

[11]https://www.google.com/url?q=http://s3.amazonaws.com/nefmc.org/6.160325-PDT-memo-on-localized-depletion.pdf&sa=D&ust=1516848260876000&usg=AFQjCNEJ3mns8CKl57WLR-t-PBfjpRCrCQ

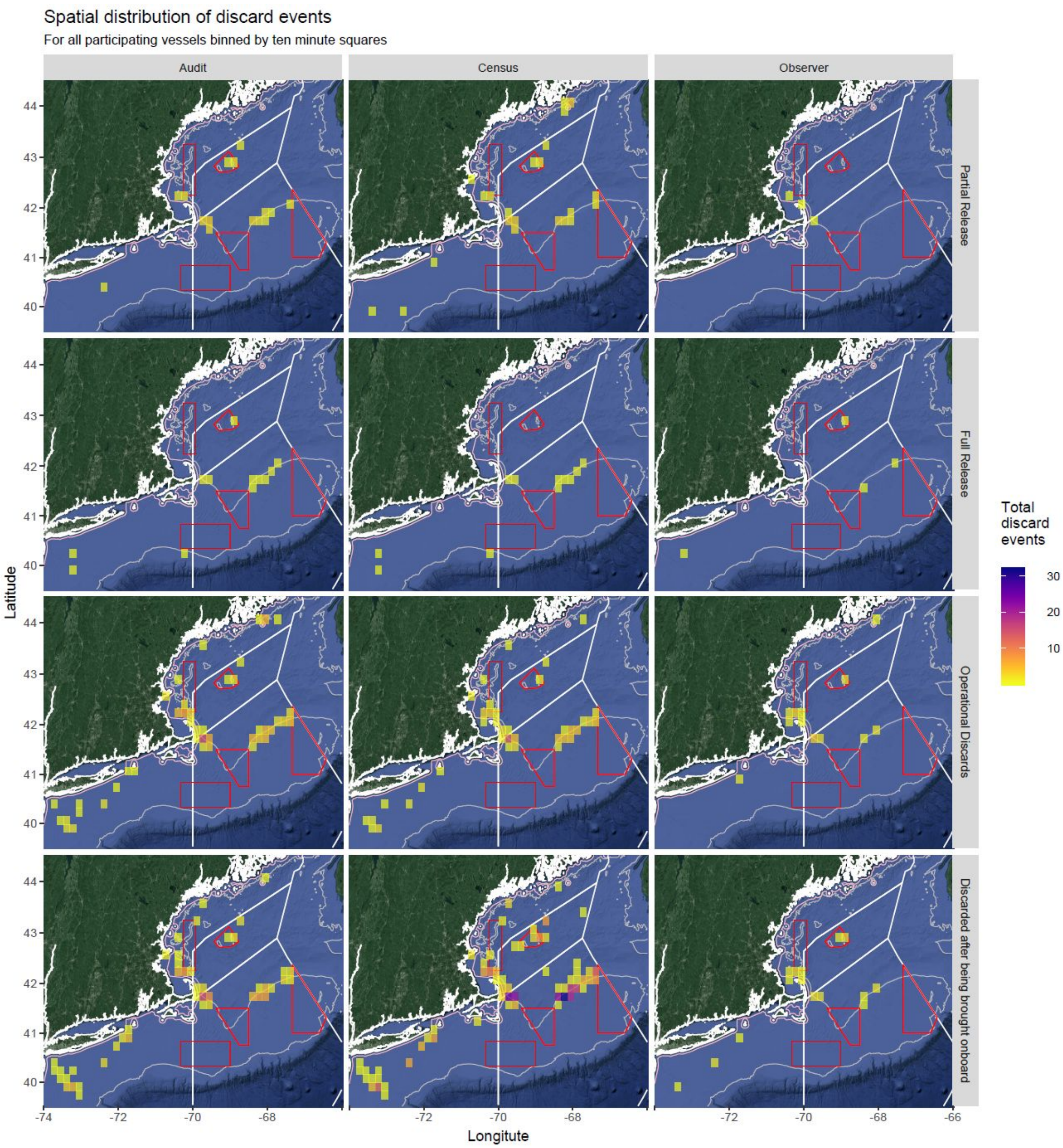


Figure 9: *The spatial distribution of events recorded by each review type across the entire project (all vessels combined) for trips with dual reviews. Heat map values represent the total number of discard events identified in each ten minute square by each reviewer. Closed areas are shown in red for reference. Borders of the current herring Management Areas are shown in white. The 50 fathom depth line is shown in light grey. Additionally, the three-nautical-mile limit is shown in pink. Two events categories (Other and Unknown) are not shown but reflect similar spatial patterns. Census and audit panels represent data from the full study while observer data represents data from the 25% study trips that carried observers (i.e., trips included in the analysis that also carried observers).*

When discard event counts are broken down by vessel (Figure 10), the largest discrepancies in categorizing discard events are again in the numbers of discarded after being brought onboard events (not shown in Figure 10) and in operational discard events. We see a relatively similar distributions of event types across vessels (full releases are uncommon while partial releases and operational discards more common). Differences among vessels in the proportions of event types are likely due to a combination of factors including the number of cameras installed, camera position, and varying catch handling practices. Number of cameras installed and placement was largely determined by study participants (Table 3), as was the decision to be fitted with booms to improve pump camera angles. Additionally, a few vessels utilized a triplex roller as part of their operations. A triplex roller is a multiple power hauling system where the net is hauled by means of a synchronized triple roller net winch system. Use of the triplex roller allows the vessel to manipulate the net in a way that forces the fish into the cod end of the net and allows the vessel to pump more fish out of the net than if a triplex is not used. The use of the triplex may have led to differences in the way audit and census reviewers interpreted catch events. This is because vessels using a triplex should be able to pump more of the fish in the net in comparison to vessels not utilizing a triplex, meaning what would be considered an operational release on a boat without a triplex could be considered a partial release on a triplex vessel.

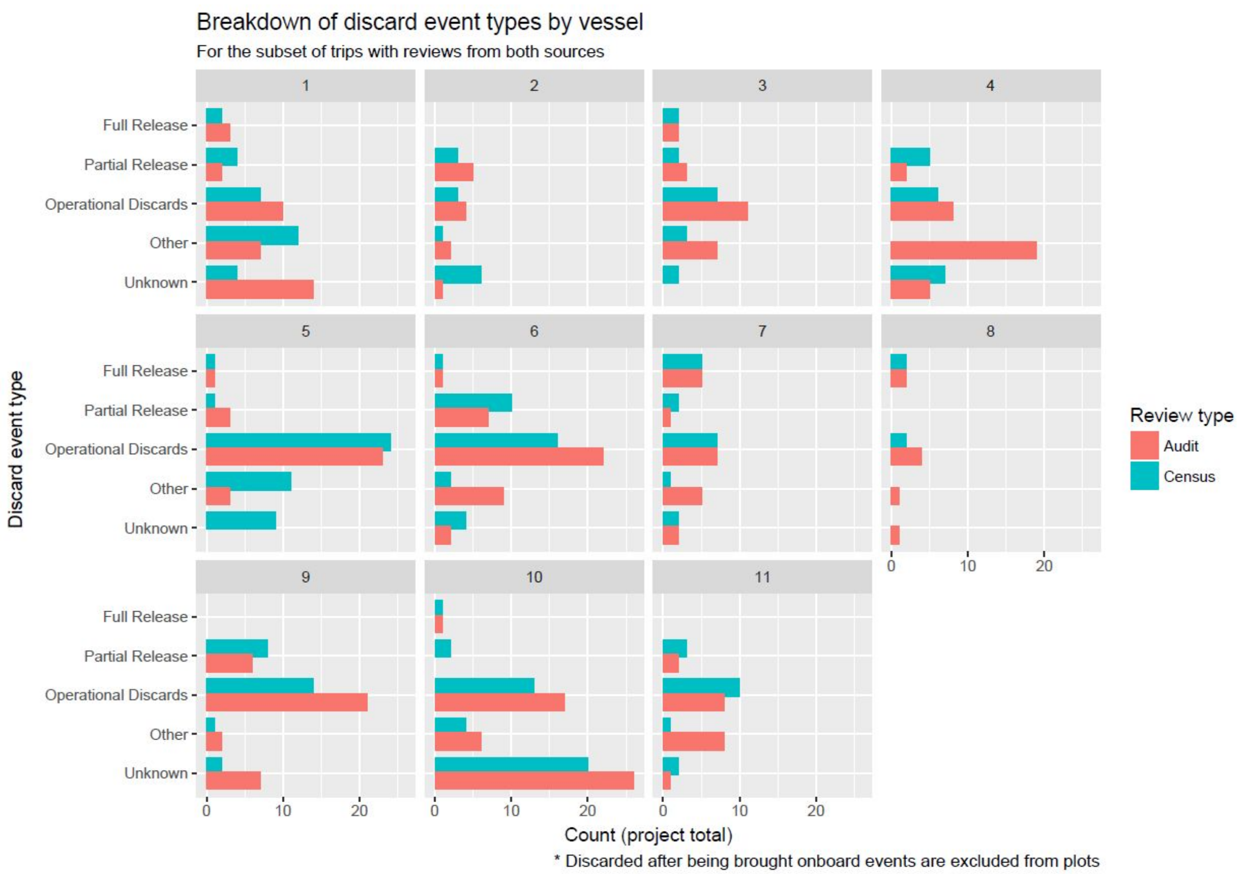


Figure 10*: The total count of each discard type is shown for each vessel participating in the study. Colors indicate the source and type of of each discard event (whether it is from Saltwater [census] or from NMFS [audit]). The break down of events by vessel suggested that there was variation among vessels in the frequency of different event types.*

Generally, the total number of discard events increased with the number of hauls completed by a vessel (Figure 11). This was mostly driven by the most common event categories; the discarded after being brought on board and operational discard categories. This pattern of reviewers identifying larger numbers of events on trips with larger numbers of hauls (i.e., more fishing effort) is important to note when considering selection of video review rates for an operational program. Additionally, the higher number of event records created by the census review versus the audit review was correlated with the increased amount of time they spent reviewing EM footage (see the description of review methods below).

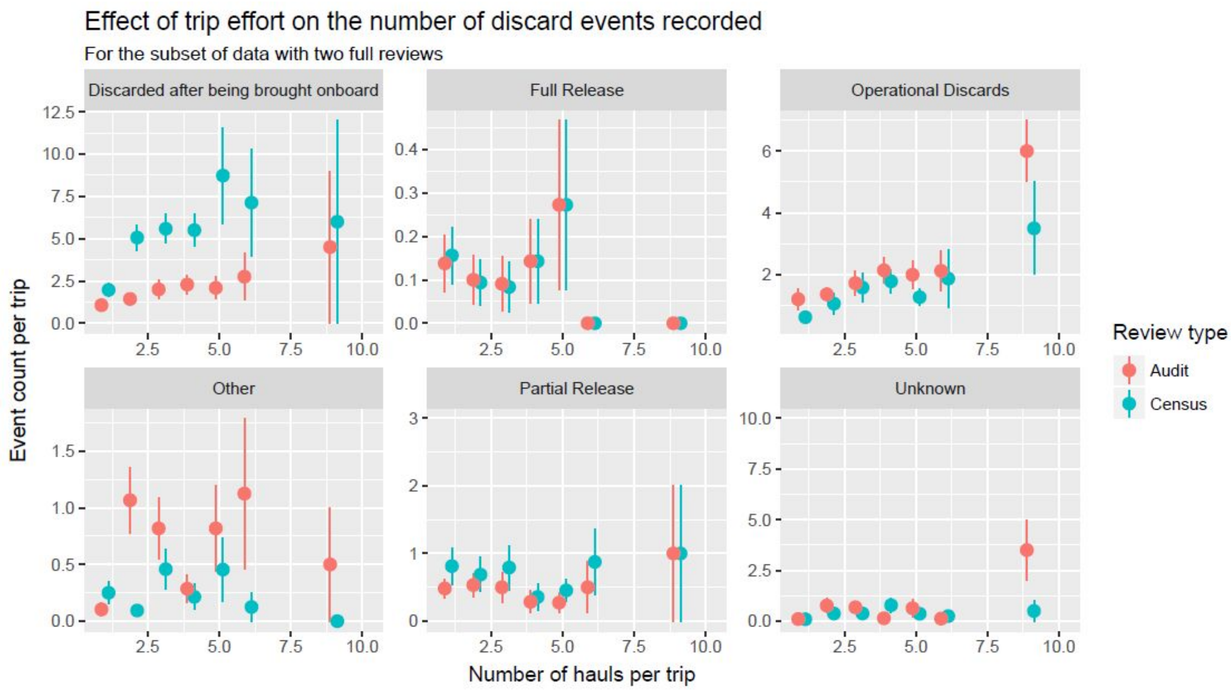


***Figure 11**: An estimate of the trip-level mean count of each discard type is shown for trips with varying levels of fishing effort (represented by number of hauls). The total number of discard events increased with the number of hauls on a trip for a subset of the event categories. This was most apparent in the common event types - operational discards and discarded after being brought on board. For the full release and partial release categories there was no clear relationship between the number of hauls on a trip and the number of events. Colors indicate the type of review (whether from a census review conducted by Saltwater or an audit review by NMFS). Points represent mean numbers of events per trip. Error bars shown represent standard errors.*

Comparison of Review Time

Data Review Sampling Design

For this project, each EM system was set to record video continuously after the first sensor indicated that fishing was taking place. Recording continued until the vessel arrived back in port to offload fish. This ensured that any discards would be detected, even those that might occur outside of a fishing event (i.e. on the steam back to port). All of the trip data was reviewed by Saltwater and an audit was performed on all trips by a NMFS reviewer. The secondary review performed through the audit assisted with the development of video annotation standards, protocols for categorizing events, and incorporated quality control measures.

Census Review

To ensure all possible discard events were documented, Saltwater reviewers were required to review 100% of the EM data (sensor and video) collected for each trip, including the time between fishing events and the steam back to port. The Saltwater reviewer also checked the EM system logs for system performance. The system performance check is completed as soon as possible after the data is received to identify any system performance issues, and hopefully resolve them prior to the vessel departing on a new trip. After the system performance check was completed, the reviewer then loaded the data into Saltwater's review software and reviewed the entire fishing trip. All of the collected video for each trip was reviewed, including all non-fishing video. Data quality was assessed, and all discard events were categorized and documented.

One of the project requirements was for the EM system to collect video continuously after the first indication of fishing activity, until the vessel returned to port. The reason for this requirement was to look for, and document, any instances where discarding occurred outside of fishing events.

Audit Review

To provide a second assessment of the video and sensor data, an audit of the trips was conducted by NMFS. This approach utilized sensor data, displayed in the EM review software, as a reviewer's method for locating sections of video that contained fishing activity. Video review was concentrated on periods when the gear was in motion (from the time the gear entered the water until the time when the gear was retrieved over the stern) and throughout all phases of catch handling. Playback speeds were increased between 8 times normal speed to 32 times normal speed during segments of video where the sensor data and GPS track suggested the vessel was not engaged in fishing activity. During audit trip review, abrupt changes in sensor output displays, such as, sensor dropouts or spikes, were also monitored to document potential system errors or gaps in video feeds that could result in lost fishing event data. If cameras malfunctioned for long periods of time, or if the system was not activated during a trip or shut down before the vessel had returned to port, VTRs and VMS records were researched to compare sail or land dates with the reviewer's estimated time entries and to verify possible data loss. In this manner, VMS and VTRs were used as resources in an effort to reduce review time. It must be noted that these resources were not used to directly influence a reviewer's evaluation of events that occurred while viewing fishing activity.

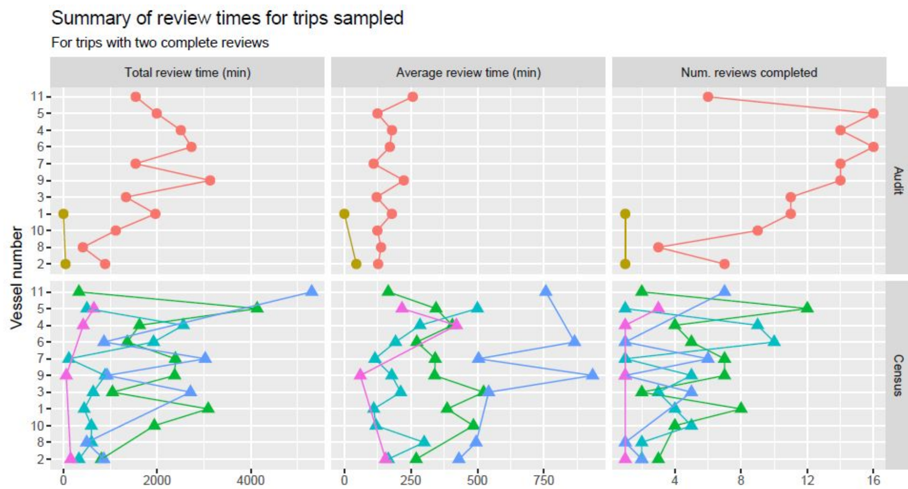


Figure 12: Total review time, average review times, and the number of reviews for each vessel. Colors represent different reviewers and review types are shown in separate panels. Census reviews completed by Saltwater and audit reviews were complete by NMFS.

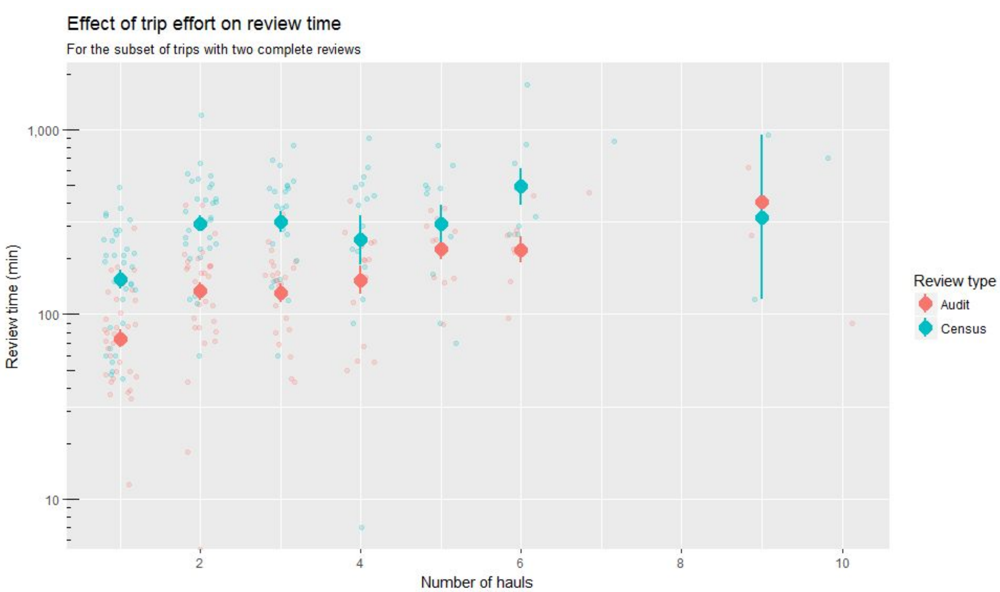


Figure 13: The total review time for census and audit reviewers is shown for trips consisting of different numbers of hauls. Mean review times are shown as points with error bars representing standard errors. Please note the y axis (review time) is on a log scale.

For the subset of trips where comparisons could be conducted (the dual reviews), reviewers for Saltwater conducted ~720 hrs of census review while NMFS conducted approximately ~320 hours of video audit review. Average review time for the census reviewers was 5.7 hours per trip while the average for the audit reviewers was 2.6 hours. This suggests that the audit approach to video review required about half the time of the census approach. Average review times for census approach varied among reviewers and across vessels (Figure 12). This could, in part, be driven by the sample of trips drawn by individuals, as reviewers did not review the same trips. The mean review time for the audit approach did not exhibit as much variability across vessels, with the average review time for most vessels being somewhere between 120 and 240 minutes. Some correlation was noted in average review time across review types (i.e., vessels 2 & 8 had relatively short times for both methods, and vessel 11 & 9 had long review times for both methods). This suggests that factors like fishing practices and catch processing behavior may have an impact on the time it takes a reviewer to process a trip. Preliminary analysis was conducted to determine if the number of cameras or camera placement had a direct correlation with review time, however, the information was not conclusive. On any given trip there are a number of factors (time of day, weather, vessel set up, fishing practices, reviewer experience, etc.) that can impact review time and distinguishing which of these factors has a direct impact on review time is difficult.

Explorations of the review time data also suggested that review times did not vary through the course of the study (the time a review took was fairly constant). Instead, the amount of fishing effort recorded on a trip was positively related to the mean total review time (Figure 13). This positive relationship was more pronounced in the census method but seemed to reach an asymptote near three hauls (at ~360 minutes or six hours). For the audit review the mean total review time increased almost linearly with effort (at ~60 min/ haul). There were relatively few trips in the data set with greater than 6 hauls, so it is somewhat unclear what review times might be for trips with greater than normal effort.

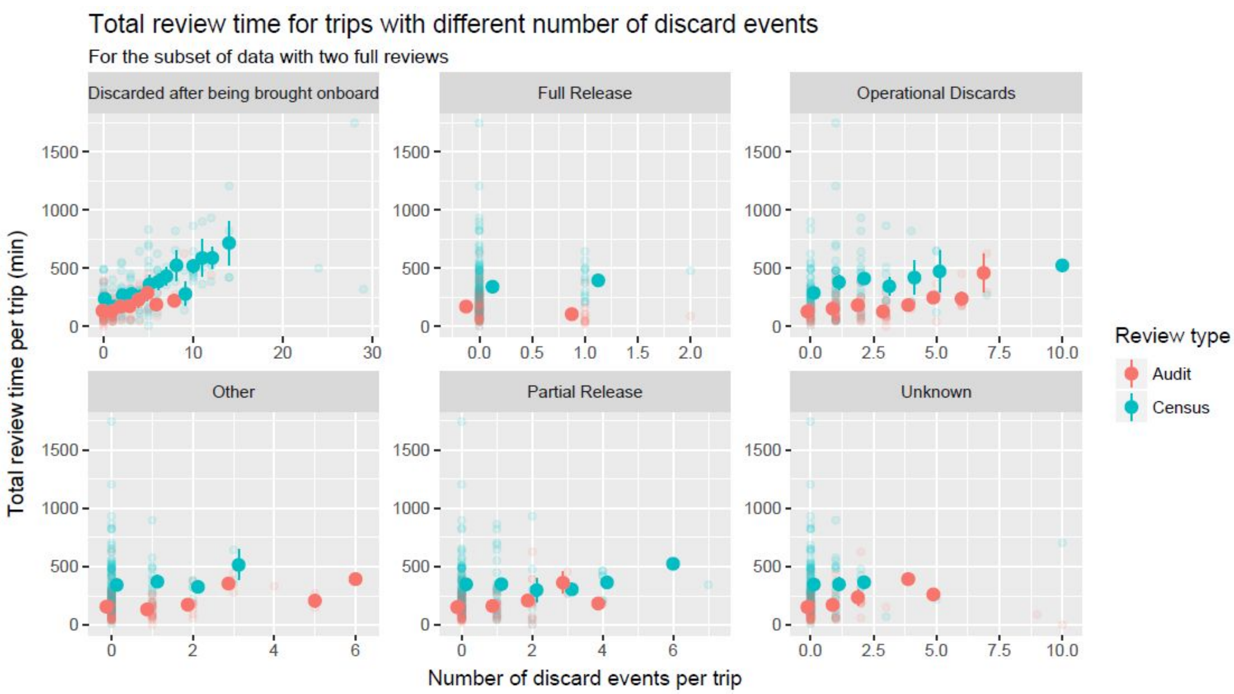


__Figure 14:__ The total review time (per trip) for audit (in red) and census (in blue) is shown for trips with different numbers of discard events. Opaque points represent mean values and bars represent standard errors. Slightly transparent points represent the raw data and are shown to highlight outliers. Review times tended to increase with an increasing number of events. This is most evident for the category of discarded after being brought onboard and operational discards.

The pattern we observed of increased total review times with increased effort is likely a direct result of an increased number of discard events on trips with a larger number of hauls (fishing effort). This can be seen in the data as there was a notable increase in total review time for trips with higher numbers across most event types (Figure 14). This was especially true for the discard after being brought onboard events, which often require reviewers to count individual fish being discarded from the vessel's dewatering box and view the same portion of the trip from multiple camera perspectives. This can be time and energy intensive, as reviewers may view the footage repeatedly and may stop the footage to enter information for each event. A number of other factors also affected the total time to review including the time of day that the majority of fishing occurred and the weather that predominated. We were unable to test the effect of time of day and weather conditions, but they remain important avenues for future analyses.

One important factor driving differences in total review time between the audit and the census method was that the audit review focused on the sections of video where vessels were actively fishing. To explore how much of the total trip video this actually encompassed, we calculated the active fishing time for each trip as the summed fishing event time divided by the total trip length. We restricted this analysis to trips where active fishing occurred, as on trips with no active fishing there would be no need to review video footage. We found that in all cases, the amount of trip time that was considered active fishing effort was less than 50% of the total trip length (Figure 15). For most vessels the amount of active fishing time ranged from ~10% of the trip to ~40% of the trip with the mean being 23% of the total trip length.

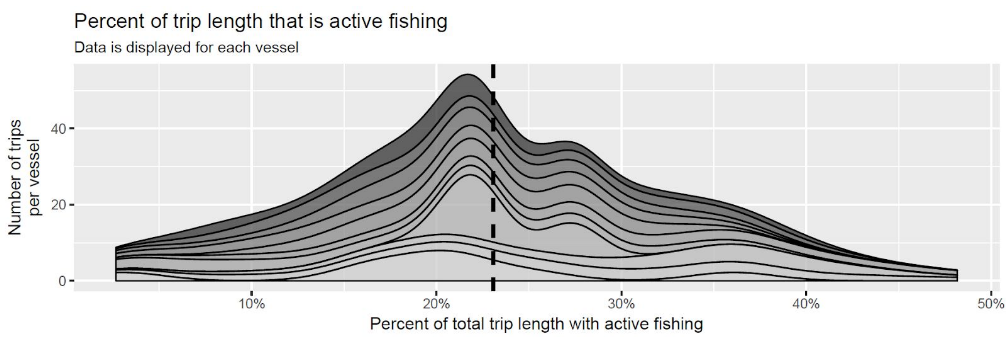


***Figure 15**: Estimates of the percent of total trip length that is active fishing time. A smoothed density estimate of the distribution is shown. Each horizontal band represents a vessel from the study. The mean value is shown as a dashed line.*

Comparison of Reviewer Annotations

Data Matching

To explore the level of agreement in discard event annotations (here annotations refer specifically to how discard events are classified by reviewers) we attempted to match events in each type of review (census and audit) and then compared the number of annotations that were matching to those that did not match. This analysis focused specifically on the event types that can be categorized as slippage (full releases and partial releases) as well as operational discards; the latter being the most difficult event type to differentiate from slippage.

In the raw data set, each event was recorded with a timestamp and a haul number. For some trips, timestamps for dual reviews were consistently offset (e.g., all of the census events occurred three hours before audit events - likely due to an incorrect time setting on the onboard computer that was resolved during the project), and the haul numbers assigned events were occasionally entered incorrectly by a reviewer (events were entered on hauls 2 & 3 by one reviewer and 3 & 4 by the other but timestamps were identical). Therefore, to ensure that these unexpected systematic differences in the timing of annotations did not cause large errors in our summaries of matching events, we first assigned events to a haul and then matched events based on the assigned haul numbers. Thus, when each reviewer had identified the same type of event on a haul, the events were deemed to be matching. This was most effective for the slippage comparison, as multiple partial release slippage events occured on a very small number of hauls (~4 out of ~40). For example, a vessel may experience gear damage and a clogged pump on the same haul which may result in two distinct partial release events. In rare cases where multiple partial release events occured on the same haul, annotations from each review type were matched by timestamp. In all cases, these events were further confirmed to be matching by plotting them, visually inspecting the plots, and reviewing the notes included for each event.

For operational discards a similar approach was followed by assigning the event to a haul and matching it to the alternate data set based on a combination of haul number and timestamp. When dual reviews differed in their annotations (e.g. one had noted a partial release and the other did not record that type of event), an effort was made to match the event with the designation assigned by the alternate reviewer. Using these dual annotations, we then summed the number events designations that agreed and those that did not agree. Hauls where neither reviewer had identified a slippage event are referred to as 'Agree no slip'. Hauls where both reviewers identified a slippage event are referred to as 'Agree slip'. When reviewers disagreed in their annotations, we refer to them as 'Disagree' and the mismatching pair of events is given. Similar designations are used for operational discards with 'op disc' replacing 'slip' (e.g., 'Agree op disc' for reviewers agreed operational discards had occured). Using these dual annotations, reviewer agreement was explored at the level of the vessel and the project (all vessels together).

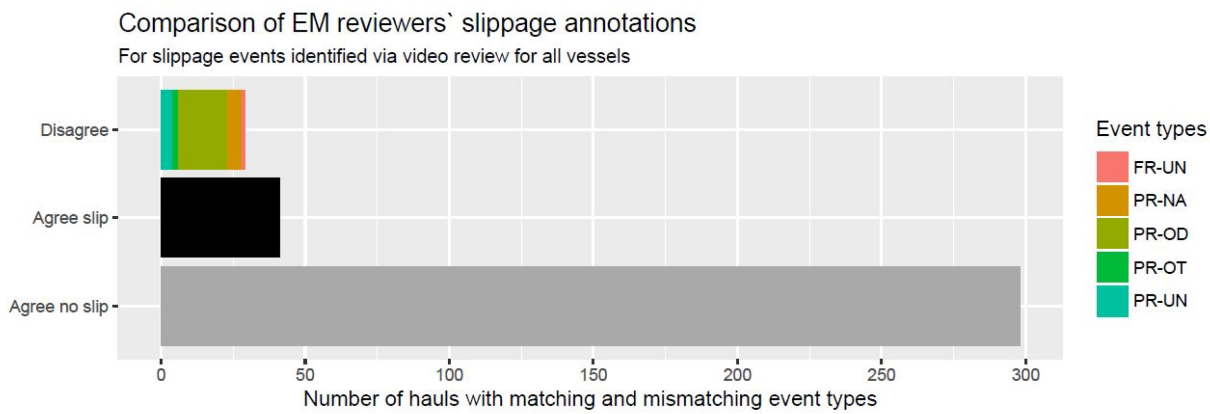
Reviewer Annotation Comparison Results

At the project level, the majority of haul event designations agreed. Most of these events fell into the category of 'Agree no slip' where neither reviewer had observed an event that counts as slippage (~290 hauls). Reviewers also agreed that slippage events had occurred 41 times (26 partial releases and 15 full releases). These 'Agree slip' incidents were the second largest total when summed across vessels (Figure 16). For the subset of the slippage events that were full releases there was a high level of agreement among reviewers, with reviewers agreeing on the full release categorization on 15 of the 16 total events (94%). The disagreements included one case when one reviewer marked a full release as an unknown. Notes provided with the annotations suggested reviewers observed similar events but categorized them differently.

The type of events most commonly included in the category of 'Disagree' were those that typically consisted of one reviewer identifying a partial release while the other reviewer reported an operational discard (17 events). In practice, the difference between categorizing discards at the end of the haul as a partial release or operational discard often comes down to whether the reviewer believed there were not enough fish to pump left in the net (operational discard) or if the vessel could have continued to pump more of the fish before discarding (partial release). This situation can lead to tough decisions for reviewers as to how relatively small numbers of discarded fish can be classified, and increases the chance for disagreement between reviewers. When an observer is on board in these situations, the observer is able to ask better questions of the captain and crew to identify a reason for a release event. EM reviewers are unable to do this and it is possible this contributed to the number of discrepancies we observed. The next most common type of disagreement was when a partial release was identified by one reviewer while the other did not report an event (five events), followed by cases where a partial release was noted by one reviewer and an unknown event by the other (four cases). These last two types of disagreement are likely due to the definition of partial release including fish that inadvertently fall into the water when a vessel disconnects the pump (to clear a clog, etc.) prior to the completion of the pumping process. This type of partial release is often difficult to identify, because as few as one or two fish could slip out and may go undetected by a reviewer or observer. In addition, fish are sometimes seen in the water (e.g. prior to a pump stop event; after the pump has been re-connected to the net) and it is difficult to determine where they came from.

When data are summarized at the vessel level there is more variation in the degree to which the two reviews align. While most vessels exhibited patterns similar to the aggregated data, there was notable variation among vessels

(Figure 16). Specifically, some vessels had relatively few events of disagreement, whereas others had disagreement that was almost as common as agreement.



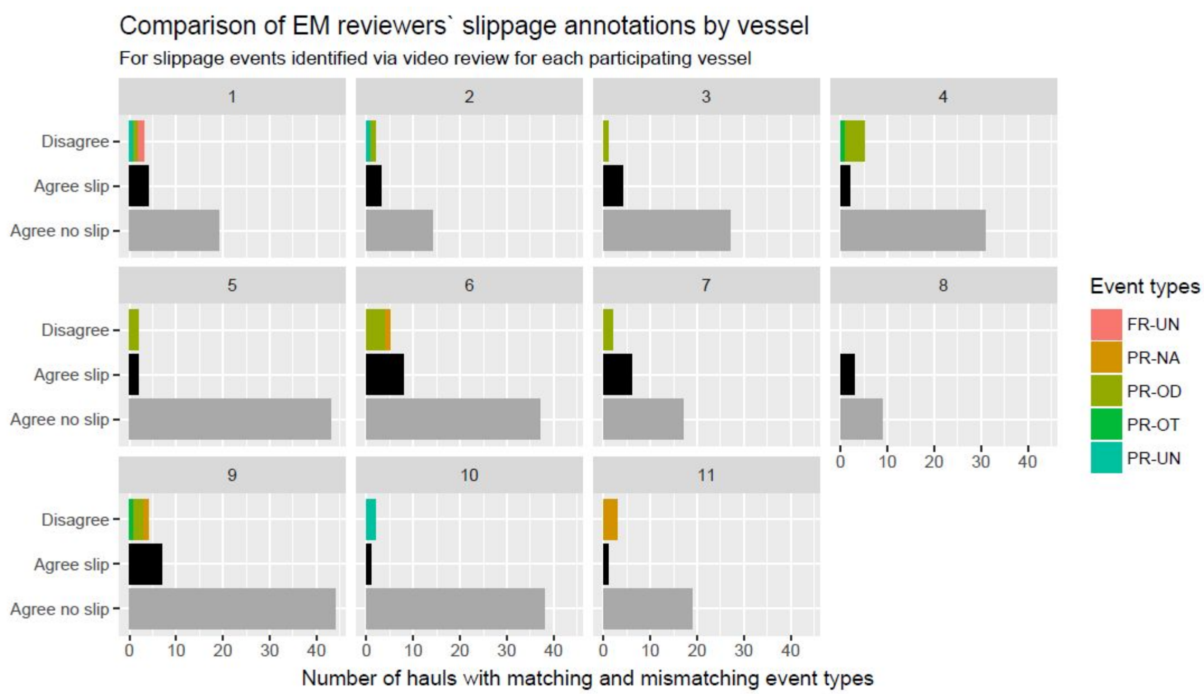
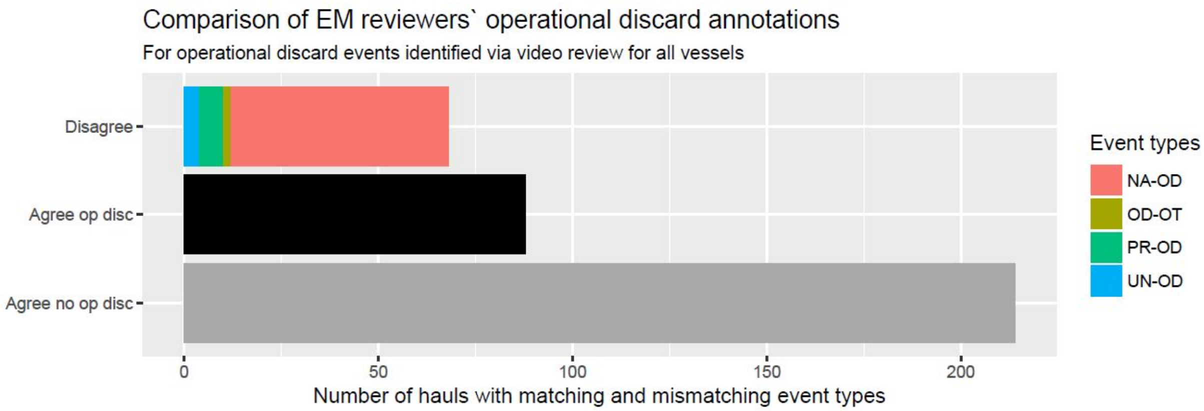


Figure 16 & 17: *Agreement for dual reviewer annotations. Counts of matching annotations for full release and partial release events (slippage events) are shown in black. Counts of matching no slippage incidents are shown in grey. Cases where only a single reviewer noted a full or partial release are shown with the remaining colors. The nature of these discrepancies are shown by the text in the figure legend. Specifically, the paired capitalized letters represent the designation by each reviewer with 'FR' indicating a full release, 'PR' indicating a partial release, 'NA' indicating no event noted by the alternate reviewer, 'OD' indicating operational discards noted by the alternate reviewer, 'UN' indicating an unknown event was noted by the alternate reviewer, and 'OT' indicating that an event requiring more description was noted by the alternate reviewer. Generally, reviewers agreed on the classification of event types. There was especially high agreement for cases of full releases. Agreement for partial releases was lower, and these events were commonly confused with operational discards.*

The level of disagreement on these vessels is potentially driven by a combination of factors including the number of cameras deployed on a vessel (numbers ranged from 3 to 1), aspects of fishing behavior (e.g., the frequency with which a vessel detaches its pump), and the time of day that fishing occurs.



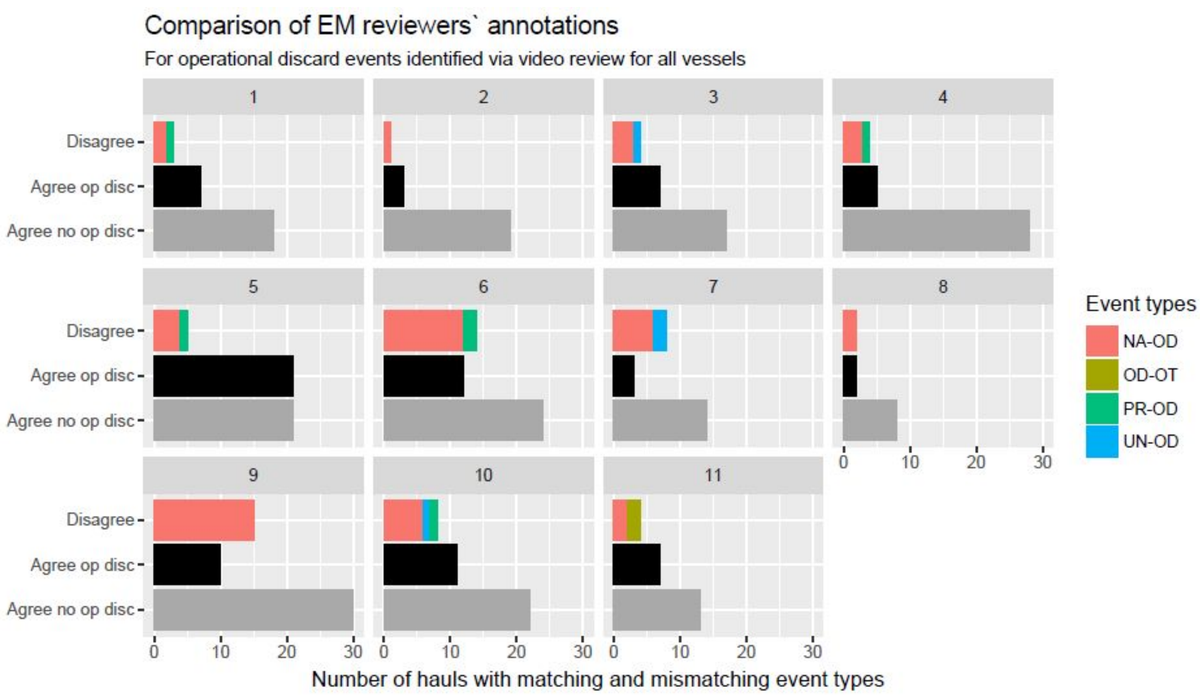


Figure 18 & 19: *Agreement for dual reviewer annotations. Counts of matching annotations for operational discards are shown in black. Counts of matching no operational discard incidents are shown in grey. Cases where only a single reviewer noted operational discards are shown in with the remaining colors. The nature of these discrepancies are shown by the text in the figure legend. Specifically, the paired capitalized letters represent the designation by each reviewer with 'FR' indicating a full release, 'PR' indicating a partial release, 'NA' indicating no event noted by the alternate reviewer, 'OD' indicating operational discards noted by the alternated reviewer, 'UN' indicating an unknown event was noted by the alternate reviewer, and 'OT' indicating that an event requiring more description was noted by the alternate reviewer.*

It was outside the scope of our project to thoroughly investigate the drivers of these differences in agreement, but the experience of the reviewing staff can help to identify factors that are likely to contribute to higher levels of disagreement on some vessels. Therefore, while we can suggest a number of these factors that reviewers reported as important and likely impacted the degree of agreement, we can't provide a ranking of their importance.

Patterns of agreement for operational discard events were quite similar with the category of 'Agree no op disc' making up the majority of events and the 'Agree op disc' making up the next largest category (Figure 18). For hauls where reviewers annotations indicate a disagreement, the most common type of disagreement was NA-OD, where one reviewer recorded an operational discard event and the other did not note an event. This made up the vast majority of 'Disagree' events, with other categories each represented by less than 5 events. Together these results suggest that reviewers using both audit and census methods agree on the vast majority of operational discard event designations, and that disagreement was mostly driven by the omission of the event type by one of the two reviewers. Breaking these data down by vessel (Figure 19), we again see a more nuanced pattern where certain vessels have very high levels of agreement (i.e., vessels 2, 3, 4, & 8) while others have more moderate levels of agreement (i.e., vessels 6 & 9). Some of these are the same vessels (e.g., vessels 2 & 8) that also had high levels of agreement in the slippage data suggesting again that vessel specific considerations such as fishing behavior and camera placements may impact the ability of EM systems to reliably detect discard events. These types of considerations should be included when developing vessel management plans for vessels choosing EM as their monitoring option.

Comparison to NEFOP Data

For the subset of trips which carried a NEFOP observer (n = 32), a similar comparison was conducted but including the event designations recorded by the human observer. At a high level, EM data review and the data collected by NEFOP observers aligned well. For example, if we focus on a comparison of the EM data from the census reviewer and the NEFOP observer we see high levels of agreement in detecting full release events (Table 5). Specifically, in all four cases where one of the sources (either EM reviewer or observer) identified a full release event, the other source detected this event (the release of fish) every time. In three out of four of these four events, both sources categorized the release events as full releases (one event was designated 'unknown' by the EM reviewer, but comments accurately characterize the event). In addition, of the ten hauls where either data source categorized a release event as a partial release, the census EM reviewer detected a release of fish on all of these occasions and correctly categorized the releases in all but one case (on one haul the census EM reviewer categorized an event as an operational discard). Together these results suggest that EM can detect and likely categorize release events important for monitoring catch retention. Interestingly, for potential partial release events the NEFOP observers seemed to detect and categorize a lower percentage of these events (although the sample size here is small), and again was better able to detect release events than to categorize them.

Table 5: *The number of release events detected and categorized by each data source that could be classified as slippage. Data from the census EM review and NEFOP data are shown. This data is for the subset of trips where a NEFOP observer was aboard (32 trips). These same events are broken down in greater detail in Table 6 with additional information from the audit reviewer.*

Event type	Census EM	Observer	Total no. of events
Full Release (detected)	4 (100%)	4 (100%)	4
Full Release (categorized)	3 (75%)	4 (100%)	4
Partial Release (detected)	10 (100%)	8 (80%)	10

Partial Release (categorized)	9 (90%)	4 (40%)	10

Taking a more nuanced view and incorporating data from both EM reviews we again see that data sources are all capable of detecting releases, but that for some events they differed on how the events were categorized. Again, for evaluating agreement we focused on hauls where a reviewer or an observer had identified slippage, and, in cases of disagreement, we note the event designation used by alternate data sources. For 87 of the 97 comparisons all three sources agreed (82 where all agreed no slippage, five where all agreed slippage had occurred, and 10 where at least one source disagreed). For four of the 10 events where at least one source disagreed, both EM reviewers agreed (EM reviewers agreed an event was a partial release or an operational discard event). For the remaining six events the observer agreed with the NMFS reviewer four times, with the saltwater reviewer once, and all three sources disagreed once.

Table 6: *A detailed breakdown of the the level of agreement among EM reviewers as well as NEFOP observers. Data represents event categorizations for slippage events on the 32 trips that carried observers and where two video reviews were available. Specifically, the capitalized letters represent the designation by each reviewer with 'FR' indicating a full release, 'PR' indicating a partial release, 'NA' indicating no event noted by an alternate reviewer, 'DA' indicating discarded after being brought onboard, 'OD' indicating operational discards noted by an alternated reviewer, and 'UN' indicating an unknown event was noted by an alternate reviewer. Events in the left most position belong to Saltwater Inc. reviewers, middle events belong to NMFS reviewers, and the rightmost events belong to the NEFOP observer. The number of times that each event type occurred is shown in the rightmost column.*

Agreement?	Who agrees?	Coding	Census event	Audit event	Observer event	Event sum
All agree no slip	All	NA-NA-NA	NA	NA	NA	82
All agree slip	All	FR-FR-FR	FR	FR	FR	3
All agree slip	All	PR-PR-PR	PR	PR	PR	2
Two agree slip	EM reviewers	PR-PR-NA	PR	PR	NA	2
Two agree slip	EM reviewers	PR-PR-DA	PR	PR	DA	1
Two agree no slip	EM reviewers	OD-OD-PR	OD	OD	PR	1
Two agree no slip	Audit EM reviewer & Observer	PR-OD-OD	PR	OD	OD	2
Two agree no slip	Audit EM reviewer & Observer	PR-UN-UN	PR	UN	UN	1
Two agree slip	Audit EM reviewer & Observer	UN-FR-FR	UN	FR	FR	1
Two agree slip	Census EM reviewer & Observer	PR-OD-PR	PR	OD	PR	1
All Disagree	None	OD-PR-UN	OD	PR	UN	1

Because the slippage events designated by Saltwaters' census review were reviewed by the full project team we have high confidence in event characterizations in that data set. By comparing the audit EM reviewer's annotations to the group reviewed annotations, as well as the observer's, we can make some statement about the quality of the EM reviews. Using this framework it would seem that that the EM reviewers were able to identify at least as many slippage events as observers. Specifically, there are five events where the audit EM reviewer and the census EM reviewer agree with one another but not with the observer, and only one event where the observer and census EM reviewer agree with one another but not with the audit EM reviewer. It is, however, important to note that this is a relatively small sample size of events, and that EM reviewers are reviewing identical footage so we might expect a higher level of agreement between them. Another point of comparison comes from the project team reviews of the slippage events identified by Saltwater. In these sessions all slippage events identified by the census review (Saltwater) were reviewed and the original annotation were deemed incorrect by the project team in a small number of cases (~10%). Together these lines of evidence suggest that the use of EM data instead of observer data could lead to a similar number of designated slippage events, and that EM reviewers seem to have very few issues detecting full release (FR) events (only one putative full release [UN-FR-FR] event here represents a disagreement).

A closer review of the cases of disagreement highlights three key findings of this study: 1) that human observers have an ability to use their situational awareness and their access to the crew to collect some information that cameras cannot (especially the reasons specific decisions are made by the the captain and crew and catch discarded out of camera range). 2) cameras can be placed in locations that offer views unavailable to observers. 3) that often disagreement among EM reviewers did not come from their ability to detect events, but instead was a result of the way they categorized their observations.

The advantage human observers have in terms of being able to access the crew can be seen in a specific case of disagreement where the observer successfully documented a release during the observed trip and one EM reviewer did not. In this specific case, a partial release occurred underwater due to gear damage and the observer was able to determine this by talking to the captain. The observer also documented operational discards on the same partial release tow (matches both reviewer designations of operational discards).

There did appear to be cases where cameras were able to record things that observers could not because of safety considerations. For example, on one haul where both EM reviewers documented a partial release and the observer documented catch discarded after being brought onboard, the observer was unable to view the release due to safety concerns. The camera was better suited to capture the details of the event because the observer had to follow safety protocols and vacate the area where clogs were being removed from the pump mechanism. In another instance, the census reviewer documented an operational discard event, the audit reviewer noted a partial release, and observer marked the event as unknown. While all three disagreed here, the observer classified the event as unknown because he/she was unable to view the discarding event due to safety concerns and low light conditions. In this case, the area where the release was taking place was not safe for the observer because the series of clogs being removed from the pump necessitated the use of heavy equipment. Some areas are consistently hard for observers to cover like areas near the stern of the vessel and rail areas in rough weather. By providing views of these areas camera systems may help to enhance monitoring.

A common feature of the data set created by this project is that sets of events that were categorized differently among reviewers often contained a higher level of agreement in the comments describing the events than the category codes used to bin them. One example of this comes from the single disagreement that involved a full release. Here the full release was noted by the observer as all catch being released due to the loss of the vessel's net. This was also marked as a full release by the audit reviewer, but the census reviewer marked this as an unknown. In describing the event, the census reviewer clearly described the loss of the net in the comments associated with the haul, suggesting that this reviewer had observed the same event but categorized it differently due to not actually seeing fish being discarded. Another example of this is the case where the census EM reviewer and observer agreed on a partial release event but the audit reviewer labeled the discarded catch as operational discards. The observer noted the presence of a clog resulting in a small amount of released catch in addition to operational discards when the pump was disconnected. Similarly, both reviewers commented on fish in the water after the pump was removed, but one called the event a partial release and the other saw it as operational discards. This again suggests that all three entities observed the same event but that they differed in which category they thought was most appropriate. A further example of this includes an event where the audit reviewer and observer both classified discarded catch as unknown for one haul and the census reviewer classified the catch as a partial release. In this instance, the census reviewer reported catch being released when the catch was being brought onboard (potentially a tear). The audit reviewer also noted a release near the end of the haul of 'more than few thousand pounds' but marked the event as unknown. These again suggest that the fishing activity was captured by the video, but that there were differences in how they were captured by the reviewer.

A final illustrative example of the potential value of an EM system comes from inspecting another of these cases of disagreement between observers and EM systems. In this case, the census reviewer classified discarded catch on a haul where the observer and the audit reviewer classified the event as operational discards. The census reviewer noted the release after the observer recorded gear onboard and was off effort. As a requirement for this project, the EM system was configured to record continuously after engaging in fishing activity, until return to port. This requirement was to address concerns that the vessels may be discarding catch outside of hauls, when the observer may not be present on deck to witness the discard, or when an EM system set to record only during fishing activity may not be recording. During the project, the census reviewers watched all non-fishing video, allowing us to inspect the the data and describe the amount of discarding occurring outside of fishing events (a period from the time the codend touched the water until the time the gear is retrieved back on deck). Excluding discard events that immediately followed fishing events (were within ~30 minutes of the end of a fishing event) the census review documented approximately 20 instances of vessels discarding a small amount of catch. This behavior typically occurred after a haul and fishing activity was completed and were relatively rare events, occurring on roughly 5% of the total hauls. These events ranged in size from 1 to approximately 50 fish (mostly herring bodied fish, fish nk, or dogfish) being discarded out of the dewatering box or while cleaning the deck and net. There was one instance where the vessel discarded fish by pumping out of the fish hold in between hauls. The presence of these discard events leads us to propose that a catch retention camera, covering the entire deck, should be set to record the entirety of the fishing trip to capture these events.

Additional Data

Estimated Discard Weights

Although species identification and weight estimation of discarded catch was not a direct goal in this study, when possible, the audit reviewer sought to collect this information. To quantify the relative size of different types of discard events the audit reviewer (NMFS) visually estimated weights for all event types when vessel catch handling allowed the reviewer a clear line of sight to identify finfish (based on physical characteristics). There were 88 records categorized as discarded after being brought onboard and 109 operational discard event records where the audit EM reviewer obtained a direct count of discarded fish to estimate a total weight (Figure 20). The audit reviewer visually estimated a weight for 2 out of 16 full releases and 13 out of 31 partial releases. Comparing these 4 event types, weights were estimated from ~32% of the combined full and partial releases records and ~50% of the combined events that were categorized as operational discards or catch the was discarded after being brought onboard. The audit reviewer was a former NEFOP observer and had directly observed in this fishery and was therefore utilizing his training and experience to determine visual estimated weights. This is similar to the methodology that an observer would use onboard the vessel to estimate and/or verify the captain's estimate of discard, however, in the case of EM, there is no opportunity for situational awareness or direct communication with the captain.

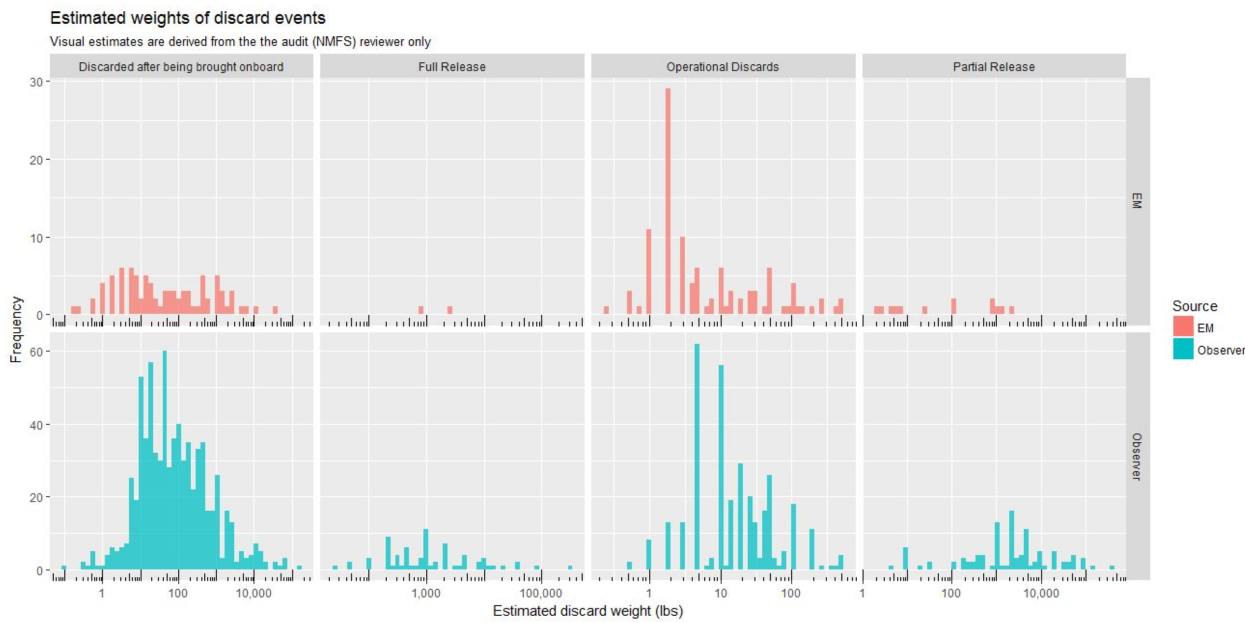
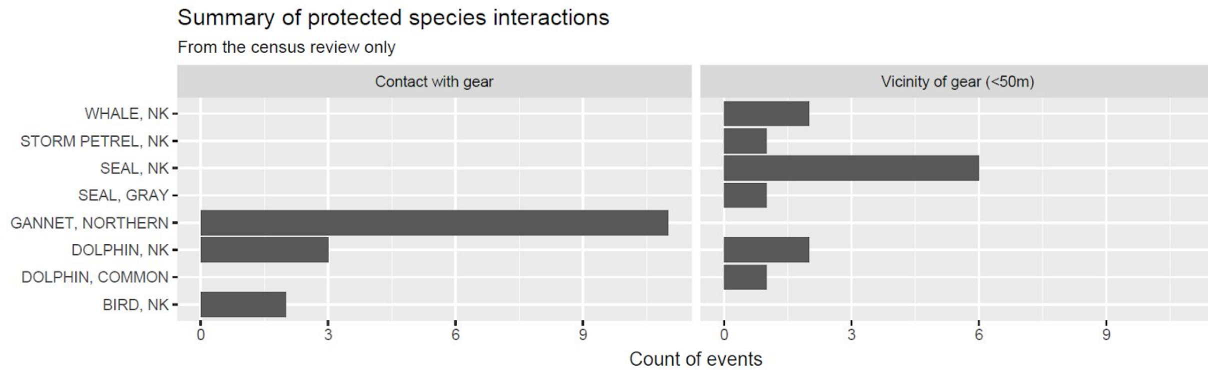


Figure 20: *The distribution of estimated weights (in lbs) associated with each type of discard event. Estimates were conducted by a single experienced reviewer from NMFS and only in cases when conditions favored estimation (shown in red). These include incidents where species were picked from the grate of a dewatering box, where catch was discard in bulk after being brought onboard, or release in the water in view of the cameras. For reference the distributions of weights associated with each type of discard event are show in blue. These values were estimated by NEFOP observers in coordination with vessel captains on trips between 2010 and 2017. Please note the x axis is on a log scale and the x axis extent varies among event types.*

This represents a subset of the events and was not compared to estimates of weights generated by an observer. Estimates were generated by the same reviewer in all cases to ensure a measure of consistency. Both of the weight estimates generated for full release events in this study were larger (1000s of lbs), whereas partial release events tended to be smaller (generally 10s to 100s of lbs). Operational discard events also tended to be smaller (10s of lbs). Somewhat surprisingly, events characterized as catch discarded after being brought onboard could on occasion be quite large (on par with full releases and the largest partial releases). This set of events spans a range of discard events. Including incidents where a large number of dogfish were picked off of the dewatering box grate and discarded by crew members. Or, situations where the catch overflowed equipment onto the deck and was washed overboard. Additionally, a vessel can also pump unwanted catch such that it flows onboard briefly then overboard. In doing so the vessel has technically made the catch available to the observer and thus avoided a slippage event. Taken together we believe this suggests that EM may be correctly categorizing the largest and most important discard events (i.e., full releases) as agreement among reviewers and between EM reviews and observer data was high for this this type of event.

Interactions with Protected Species and Individual Animals

The census reviewer also catalogued interactions with protected species and larger individual animals (designations derived from the NEFOP program). These annotations could be associated with haul events or sightings that were incidental. Generally, less of an emphasis was placed on identifying these events (compared to catch retention). There were also limited guidelines for how the species of animals being identified should be recorded. Here we present this information to give a sense of the diversity of species that were encountered during the project.



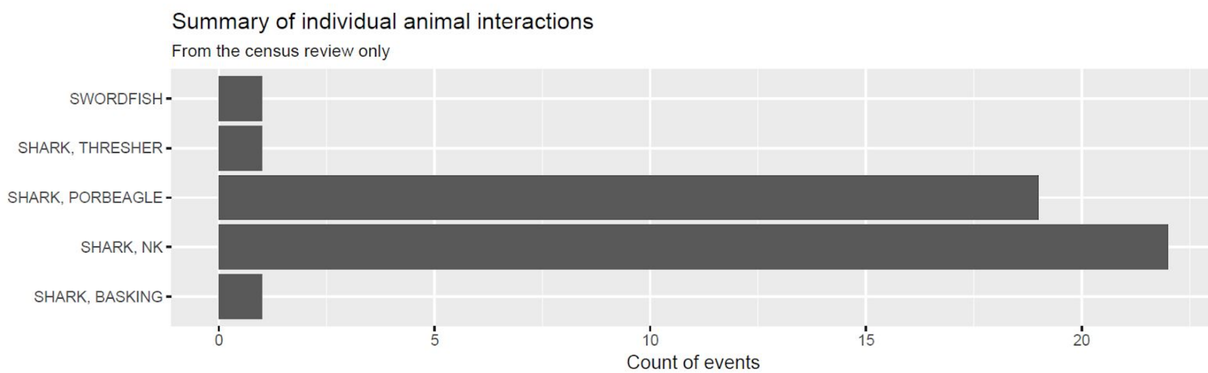


***Figure 21 & 22**: **21**) The breakdown of protected species interactions noted by reviewers for the set of trips with dual reviews. Total numbers of records recorded by the census reviewer.). **22**) The breakdown of individual animal interactions noted by reviewers for the set of trips with dual reviews. Total number of records recorded by the census reviewer.*

V. Cost Drivers

There are multiple cost drivers that impact the cost and long-term viability of operational EM programs. Cost drivers include the number of vessels participating and their locations, how much data needs to be reviewed and stored, and for how long. One of the objectives of this project was to identify the cost drivers that would impact implementation of an operational EM program in the midwater trawl herring/mackerel fishery. To that end, Saltwater tracked costs over the duration of the project (17 months) differentiating between one-time startup costs (SU) and ongoing (OG) program implementation costs. Actual costs are considered proprietary and, as such, are not being presented in this report. NEFOP and GARFO will use the information and discussion in this section to help refine its prior cost estimates for the NEFMC, vessel owners, and other stakeholders who are considering whether EM should be an option for monitoring the herring fishery. The information will also be used to inform future NEFOP projections. This report identifies multiple cost drivers, how they relate to monitoring objectives, and how they might impact long-term program costs. This information is provided to help inform future program design in a way that meets required monitoring objectives and optimizes the use of resources.

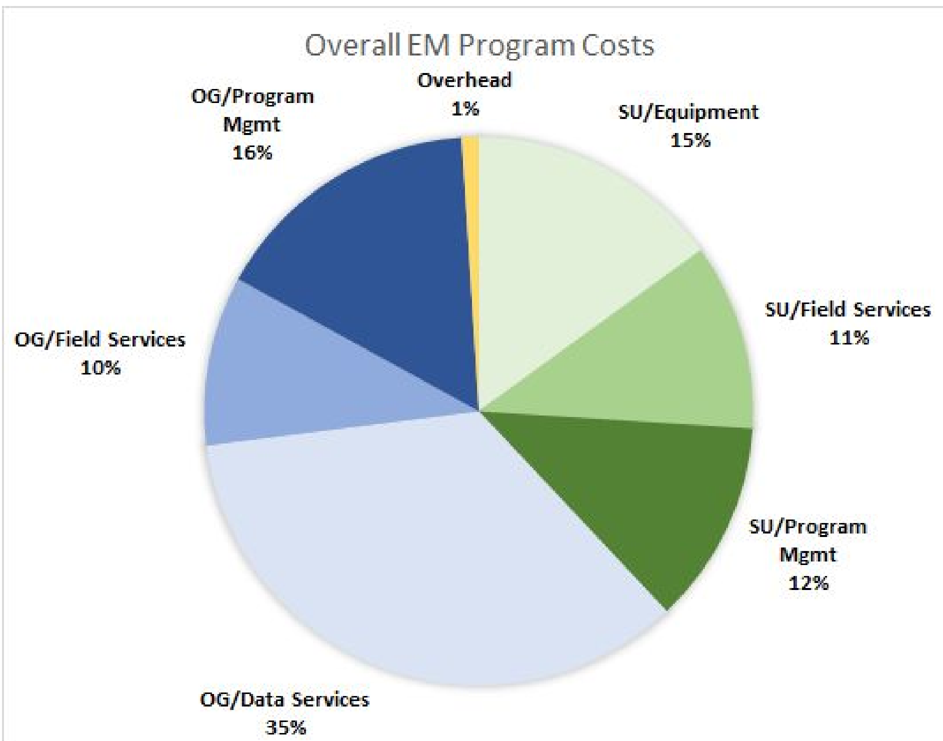


Figure 23: *Overall EM program costs broken down into startup costs (SU) and ongoing (OG) costs by category.*

Start-Up Costs

Equipment: EM system, procurement, shipping, handling, assembly, QC

One of the main start-up costs of any EM program is the cost of the equipment. How an EM system is setup is largely determined by the data collection requirements of a monitoring program and the size and configuration of the vessels to be monitored. The size and configuration of vessels determines the length of wire runs and mounting options, the number of cameras to be deployed, and whether additional supports (e.g., booms, swing arm mount, etc.) are required.

The vessels in the herring-mackerel fishery are relatively large (80'- 150'), and required long wire runs and typically three cameras. No major adaptations were required of Saltwater's standard EM system to meet the requirements of the program. On some vessels, power support such as an uninterruptible power supply (UPS) was required to ensure clean, consistent power to the EM system.

The lead time required to procure EM equipment and shipping costs can affect the cost of EM programs. All of the components of Saltwater's EM system are off-the-shelf and commercially available; the longest lead time for ordering is about 6 weeks. Saltwater maintains an inventory of supplies on the East Coast that allowed us to meet the project and boat schedules for equipment installation in a timely manner without having to pay rush order or shipping charges. When booms were required, vessel operators helped identify local shops for fabrication or made them themselves. Saltwater's EM system met the technical requirements developed by NEFSC *(Appendix 8)*, and no adaptations were required. To meet particular data needs, Saltwater developed and tested new data acquisition software during the course of the project.[12]

Another variable that impacts the cost of EM equipment is the decision of whether to lease or purchase the systems. Under this contract, NMFS requested a lease for the duration of the project.[13] Leasing versus purchasing equipment could affect costs since most long-term leases end up costing more than a one-time purchase. If, however, industry were responsible for the cost of the equipment, a long-term lease could lower the initial start-up cost.

Field Services (Start Up): Installs, Outreach, Vessel Assessments, Operator Training & VMPs

Factors that can impact the cost of installs include outreach and scheduling, vessel and technician locations, technician recruiting and training, and the time required to carry out the work. From our experience, outreach and scheduling is considerably more time consuming in a voluntary EM program. When EM is either mandatory or an approved alternative to observer coverage, vessels operators are motivated to make sure they schedule the installs in a timely manner. In a voluntary program, recruiting and scheduling can be quite time consuming.

The location of vessels and the location and availability of skilled EM technicians also affects installation costs. Prior to starting the project, Saltwater had one experienced EM Tech/Data Reviewer based in New England. For this project, we recruited and trained an additional EM Tech, who was also cross-trained to carry out data review in our Massachusetts office. Initial technician training is done in the office, but much of the training is hands on with the trainee working in partnership with an experienced EM Tech. This likely increased the time required to complete some of the installs, but resulted in two fully trained local techs available to provide ongoing support for the duration of the project. Because they were both locally based, travel costs were minimized.

Employing techs as part of Saltwater's EM team ensures they are available when needed, and this work is their first priority. They also develop an understanding of project goals, a commitment to customer service, and intimate knowledge of our system. In our experience, this is not the case when working with local marine technicians. They typically have many regular, repeat customers who have priority, and many also have limited experience working with EM technology. The exception to this has been in locations where Saltwater has a large number of boats

[12] Saltwater tested new software that uses geofencing to trigger video recording. This can limit recording so it is only triggered when vessels are in regulated areas, which can reduce the amount of data collected, which can impact costs related to data storage and review.

[13] Saltwater agreed to transfer the EM systems to the participating vessel owners for a nominal fee at the end of the project, if they were interested. Otherwise, the systems were/will be uninstalled.

carrying our EM system. In those instances, local marine technicians have been able to provide timely, quality service.

When it comes to the installation of EM systems, Saltwater has learned over time that every EM system install is a custom job. While many aspects of the job are consistent (e.g. what components need to be installed, how they are configured), the decision of where and how they are installed depends on the vessel's size, fishing practices, and set up. Having clear guidance from NMFS about data collection needs is critical to successful equipment installs Saltwater technicians worked closely with NMFS staff and vessel personnel during each install. The technicians also completed a VMP on each vessel that documented EM system overview, operator responsibilities, catch handling practices/locations, install configurations, camera views, and program contacts.

When a vessel owner or operator is available during an install, it can reduce the time it takes to complete the install. Saltwater typically requires a vessel operator's presence during an install to help determine where system components should be installed, and so vessel operators can receive training on the program objectives and the operation and care of the EM system.

Program Management (Start Up): Project planning, data fields, protocols, recruiting, training and office equipment

At contract award, Saltwater already had a small, local office in Gloucester, MA with an experienced Project Manager and EM Technician on staff. We were able to easily expand the office space and recruit additional EM Techs and Data Reviewers. One recruitment and retention strategy that we believe has a significant impact on both costs and quality of service is to recruit EM staff from the pool of experienced at-sea observers and/or portside monitors. Observers come with a demonstrated understanding and appreciation of data quality, integrity and confidentiality, and experience working directly in the fishing industry. For this project and others we found no shortage of qualified applicants for EM Tech or Data Reviewer positions, and had excellent retention rates (which saves on repeat training costs). We also cross-trained our EM Techs in data review, which aids data quality, keeps the job more interesting, and makes the best, most efficient use of our human resources.

A significant start-up cost for this program and many EM programs is the time required to determine review protocols and decide on the data fields to be incorporated into a database. In an operational EM program, it is important to ensure all of the data collected by the EM system can be compared to, and potentially integrated with, existing observer and portside monitor data streams. The development of the review protocol and templates took quite a bit of time, but most of the associated cost involved is a one-time startup cost. Because the template for review protocol had to be identical for all trips, changes made to the protocol after the project was underway meant that some data had to be re-reviewed, which increased ongoing costs.

Saltwater's data review software is template driven, so changes to the data fields required additional time to both create and adjust the template to capture the required data for this fishery. Saltwater does not charge software licensing fees, which can be a significant ongoing cost in other EM programs.

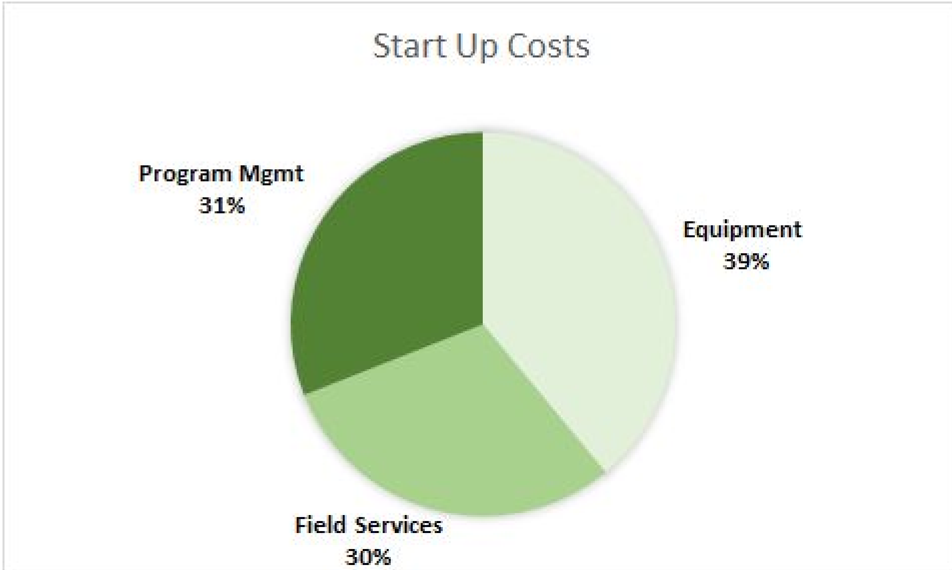


Figure 24: *EM Project Startup costs broken down into categories: Program Management, Equipment and Field Services.*

Ongoing Costs

Once a system has been installed, ongoing equipment costs are for maintenance and replacement of systems. Our experience is that the components of an EM system vary in their lifespan. The most expensive component, the control box, is estimated to have at least a 5 year lifespan. Because the project was so short (12 months of system deployment), equipment maintenance did not represent a significant cost driver. Maintenance costs were minimized due to Saltwater's local supply of critical components. Over time, equipment maintenance and parts replacement costs will increase. However, in our experience the associated labor costs are more significant (approximately 4:1) than the cost of equipment and supplies.

Field Services/Technical Support: Remote and field tech support, travel costs associated with tech support, replacement equipment and supplies.

When having a fully functioning EM system is a requirement, field services are a significant cost driver in a long-term program. Saltwater has worked in multiple EM programs that have challenged us to find the most efficient way to provide cost-effective technical support. Our experience ranges from providing over 4 years of support to over 100 vessels fishing up and down the Atlantic Coast in the HMS pelagic longline fishery, to serving small boats fishing in Alaska in remote ports that are not connected to the road system and are only accessible by boat or plane.

A key component to efficient field services is an emphasis on remote support and encouraging vessel operators to become involved in the care and operation of the EM system on their boat. Ideally, this starts with instructing the operator and engineer from each vessel on EM system usage during the install, and providing an illustrated reference guide to the EM system. A second piece is a strong system of remote support including an established 800 call-in number, which is answered by trained technical staff who are able to troubleshoot problems with vessel operators. Technical staff who understand the boats and the EM equipment can help solve many problems without travelling to the port. Finally, timely system performance checks and data review allow problems that affect data quality to be identified and resolved early. Under this contract Saltwater was responsible for the data review which created a very tight feedback loop between the data and tech support. Problems which affected data quality, like a camera out of focus, could be identified and resolved in a timely manner.

Another set of costs that are often included under *Field Services*--and can be a significant cost driver-- are those related to data retrieval. In many programs, HDDs are retrieved in person from vessels by the EM service provider. This can be a significant cost, especially if data needs to be submitted after every trip. For this project, vessel operators were asked to mail all of their hard drives of data (HDDs) to Saltwater's Massachusetts office where the data was copied and archived. Vessel operators were supplied with extra HDDs, protective boxes, and pre-paid USPS flat rate mailers. Data was submitted after every trip. Due to the short duration of the trips in this project, an average of only 12% of the 1 TB of available data on each HDD was used. For in-season management, data submissions after each trip may be necessary, which allows for timely review of system performance. Costs could be decreased if reporting requirements were to allow for weekly or monthly retrievals.

Over the course of the project, data was collected from 192 trips. Three of the most active vessels were located near the Massachusetts office. While the cost of doing in person data retrievals was still higher than mailing data even for these 3 local vessels, we believed it was a good opportunity to work more closely with these vessels and get more feedback and buy in from the vessel owners and operators for this project. Hard drives from 122 trips were retrieved by a Saltwater EM Tech, with the remaining 68 trips being mailed in by vessel owners or operators. No HDDs were lost or corrupted. For a long-term program, we estimate the cost of mailing HDDs to be about 10% of the cost of in-person retrieval, indicating a large cost savings associated with the mailing of data. Because data retrieval required only minimal field service for this project, the data transmission costs (mailing supplies, postage, etc.) are included in "*Data Services*".

Under the current proposed monitoring alternatives, there will also be a portside monitoring component. At this time, it is not known to whom the portside monitoring cost will fall, but will most likely be the vessel owner/operator. As this was not part of this pilot project, we are unsure what these costs would be, but it is likely they would be in line with the costs outlined in the Environmental Assessment for the IFM Amendment (link can be found on MAFMC website at http://www.mafmc.org/briefing/june-2016) and with those determined in the cost comparison report on the NEFOP Electronic Monitoring website https://www.nefsc.noaa.gov/fsb/ems/. As a potential cost savings, it would be possible for the portside monitors to be cross trained as an EM technician and/or data reviewer to allow for more efficient and flexible staffing.

Data Services: HDD retrieval and shipping, data processing, data checks, review, storage, data audits.

A key constraint to effective EM implementation in many fisheries is the cost of data review. Operational implementation of EM requires not only collecting hours of video and sensor data, but also the ability to efficiently extract from that data the meaningful information needed to manage a particular fishery. Saltwater has developed open-source review software that integrates video and sensor data for efficient data review and analysis. Many EM service providers charge a per-seat, annual licensing fee to use their review software. Saltwater does not charge licensing fees for the use of this software. The primary cost drivers under *Data Services* --and perhaps the most significant cost drivers overall-- are the level of review required (e.g. 100% of trips vs. 10% of trips), the amount and type of data stored, and how long the data needs to be stored.

The amount of data collected and level of review required is determined by fishery managers and reflects their monitoring goals and data requirements. Under this contract, Saltwater reviewed 100% of hauls and 100% of the trips. The primary objectives of the review process were to identify and classify discard events of any type, document whether any fish remained in the net/cod end after pumping, and identify instances where the catch did not come onboard after a fishing event (e.g. gear issue, fish pumped to another vessel, etc.). For each trip, a data summary report was produced and provided to NMFS to incorporate into their database. NMFS was also trained in review and provided copies of the data and review software which allowed them to audit the reviewed trips. Overall, data review costs represented approximately 52.5% of the ongoing program costs. Costs could be reduced in an operational program by setting requirements to review of only a subsample (e.g. 50%) of the haul or trip footage and data collected. Data storage can also be a major cost driver for EM program implementation. Under this contract, Saltwater was required to store all of the collected video and sensor data for three years. Saltwater's approach to this requirement has been to store redundant copies of all of the data on a local server (NAS). As requested, additional copies of data sets were made for NMFS for audit purposes. Once data review was complete on a volume of data, our Program Manager transferred the complete data sets to cloud storage, where it will remain for the 3-year contract period.

Another key factor that affects the overall cost of data service is the amount of data to be stored. When the SOW for this contract was written, NMFS provided estimates of how many trips would occur in a year and how many days of data would be collected. The actual amount of data collected was considerably less due to various factors that will be addressed in section IV.[14] Nevertheless, our projected estimate of the cost of storage is less than 3% of the overall cost of this project.

There is still some uncertainty as to what EM data is required by NMFS to be stored. This determination will impact the costs of storage. There is discussion nationwide among fishery managers, industry and EM service providers about whether all collected video and sensor needs to be archived, or if storing the data summaries that are extracted during the review process is enough. There are major cost implications of storing video files, whereas the cost of storing the extracted data, which is comparable to the data submitted by an observer, is exponentially less. Each trip summary report is approximately 9 KB, which would be a total of 0.00171 GB for all 192 trips in this project. In contrast, the total amount of video and sensor data collected and stored is nearly 37,000 GB. There are multiple options between these two extremes. For example, saving only short clips or stills of interest, or saving only reviewed trips (assuming less than 100% of trips are reviewed).

Program Management: Oversight of all staff, coordination and communication with all stakeholders, fiscal oversight, all reporting activities.

For a project of short-duration (17 months) it is difficult to distinguish start-up from ongoing costs. Program management costs included weekly conference calls and other communication with the NMFS team and industry, coordination and oversight of all tech support, and oversight of all data management and review activities. We tracked these costs for the duration of the project, and primarily used the date of the activity to determine whether to categorize it as a start-up or ongoing cost.

Based on this approach, program management costs represented 26% of the ongoing project costs. This was higher than we would project for full program implementation, based on our experience with other long-term EM programs (e.g. the Atlantic pelagic longline EM program). One of the main reasons the costs were higher was the extensive level of communication and coordination between NMFS and Saltwater and additional flexibility that

[14] The reasons for the smaller amount of data during this project period need to be kept in mind when designing any future program.

was incorporated into the study design to address issues as they were presented, which was necessary to ensure that details that will affect full implementation were worked out during this trial phase.

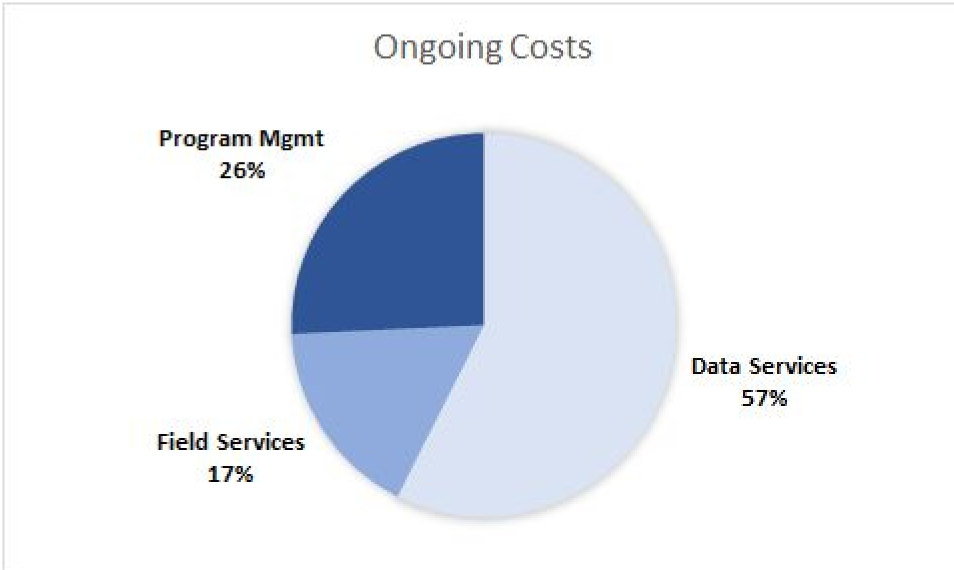


Figure 25: *Ongoing EM implementation costs broken down into categories: Program Management, Field Services and Data Services.*

VI. Lessons Learned/Recommendations

Implementation

System Components

The EM system was easily incorporated into the herring fleet vessel platform (e.g. space, power). The systems did not negatively impact fishing operations and had no effect on other vessel electronics.

During the course of the project, we determined that the hydraulic pressure sensors and rotation sensors used to trigger video recording were not ideal for this particular fishery. While we were able to successfully trigger video recording with these sensors in most instances, multiple vessel owners recommended that the system be triggered with an electric sensor. On pair trawl trips, sensors on the hydraulics and third wire or winch only activated cameras on the vessel whose net was being towed, so the cameras were not activated on the pair vessel. This was generally only an issue for the first haul, since most pairs alternated which boat towed the net after each haul, and cameras continuously recorded for the duration of the trip after first being triggered by sensors. Also, since the hauling/ pumping vessel was the only one with fish, this did not impact our ability to recognize or characterize fishing events or discard events. The only impact was the loss of video data from the pair vessel, which could offer complementary perspectives of fishing activity. Saltwater did develop and test software to trigger recording using geofencing, which was successful and would resolve this problem.

System Use & Reliability

Overall, the EM systems installed on vessels for this project performed well and collected information useful to fishery managers. Data was collected on 192 trips. Of these 192 trips, full video and sensor data was collected for 61% of the trips. The 39% of the trips that were incomplete, include trips where the EM system was not powered on for a portion of the trip (most often turned on when already on or near fishing grounds), as well as trips where there was an issue with the EM system (see figure 26 for breakdown of missing data). Only 4% or 2 of the incomplete trips were missing the entire trip's data. The other 96% of the incomplete trips contained data that could be reviewed.

EM system issues are often classified as critical and non critical issues. Critical issues include issues with one or more essential cameras, the power supply, main computer, or the monitor. Non-critical issues are issues with sensors or a non-essential camera. During this project, 3 critical issues occurred, resulting in lost data. Since this was not an operational program, these vessels were allowed to continue fishing until the service provider could resolve the issue. In some cases, the system issue was discovered during the data review process, or the vessel was not available for service and therefore the vessel often had completed one or more trips before the issue could be addressed, leading to more system down time than would occur in an operational program where the vessel operator would be required to report a system issue as soon as it occured. The reasons for missing data is shown in the figure below.

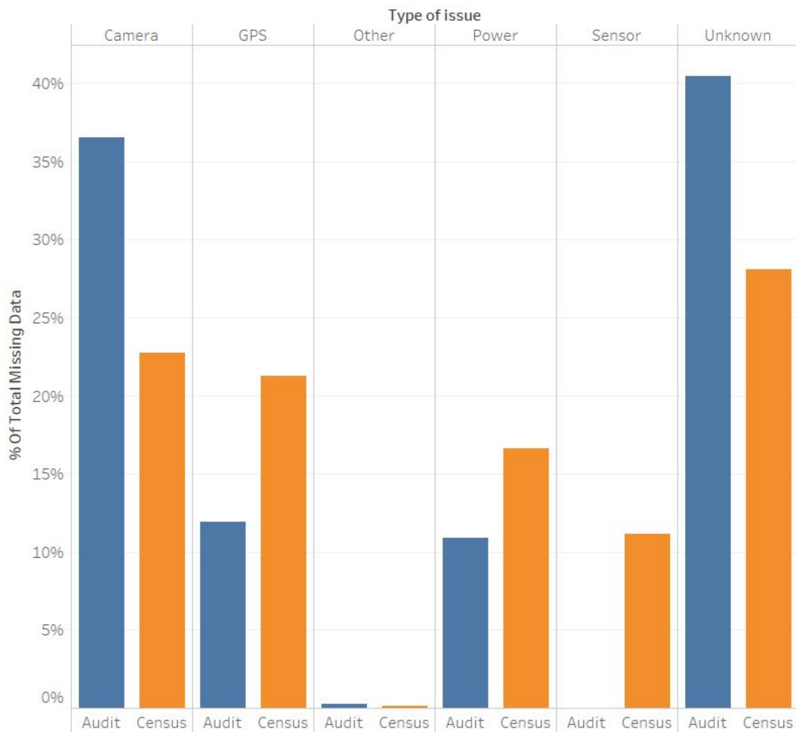


Figure 26: *Gaps in the collected trip data were documented by the reviewers. Reasons for missing data were categorized into 6 Categories: Camera Issues, GPS Issues, Power Issues, Sensor Issues, Other and Unknown. Camera issues include times where one or more of the cameras was down. Issues categorized as unknown included times where the EM system was turned off by the crew at any point during the trip, or when the reviewer was unable to determine the cause of the data gap.*

Power loss to the EM system occurred occasionally, mostly in the form of system restarts. EM system restarts were short and usually resulted in 1-3 minutes of system down time. Uninterruptible Power Supplies (UPS) were installed on most vessels at the time of install to ensure the EM system would remain powered unless the vessel lost power for a significant amount of time. One vessel had an issue with the main computer freezing, resulting in lost data for 3 trips.

There were also camera connectivity issues on two vessels that caused the video feed to cut out intermittently. The main cause of the issue was related to the high level of strong vibrations in the area of the stationing of the cameras, and the camera's sensitivity to those vibrations. In response to this issue, a vibration resistant camera was sourced but Saltwater was unable to test it because both vessels experiencing this issue were no longer participating in the project by the time the cameras were ready to be deployed. During the course of the project, camera issues resulted in a loss of video on one or more cameras for 3.46% of the total trip time in the project. Of the camera down time, only 5.08% occurred during a haul.

For each fishing event, the reviewer assessed the overall quality of the video. Because the template only allowed us to enter data for one camera, the poorest camera was used for this assessment and comments were entered describing what the issue was and which cameras were affected by the issue. Examples include low light, water droplets on lens, snow on lens, glare, and condensation inside camera. The imagery rated poor was still usable to detect discard activity but made it very difficult to discern individual fish or speciation. In cases where one camera had poor image quality, the other cameras, installed in areas with different exposure to the elements or lighting conditions, could be used to help the reviewer categorize discard activity. Future iterations of the review template would allow for the reviewer to enter video quality for each camera. The video quality criteria are defined in Appendix 9.

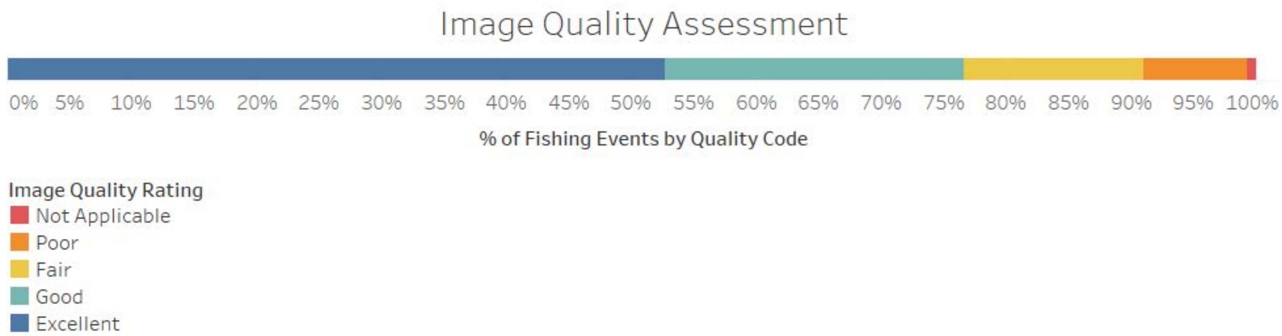


Figure 27: *Using video quality criteria as described in Appendix 9, EM reviewers rated video quality for each fishing event. Overall, 53% of the collected video was rated as Excellent and 24% was rated as Good. Only 8% was rated as poor. Not Applicable includes hauls where video was not available for the haul and therefore image quality could not be assessed.*

Compliance

Overall, vessel operators reported that the system was easy to operate. They were responsible for turning the system on at the beginning of the trip and off only upon return to port. Video and sensor data was collected for the duration of the trip. Project participation peaked in Quarter 3. Low initial usage could be attributed to the learning curve of a new system, or the requirement for the captain to remember to manually turn the EM system on when departing for a trip. In operational programs, the vessel operator is required to be present during the install for training and EM system certification. This certification is a way for the EM service provider to document full system function at the time of the install, and ensure that the vessel operator has a clear understanding of the project objectives and their responsibilities with regards to operating the EM system. This ensures that the person who will be responsible for operating the system clearly understands the requirements and expectations and has an opportunity to ask questions and see how everything works first hand. During this project, the vessel operator was not always available during the install, and the EM service provider trained the available vessel representative. During the project, a number of vessel owners reported that the transfer of knowledge from owner/manager present at install to captain/crew did not always take place. This led to dampened participation early in the project, which improved greatly after the first feedback meetings in early March.

One system-related factor that may have resulted in suboptimal participation was occasional unintended recording caused by operation of the hydraulics. Many vessels use their hydraulics when pushing away from the dock, which often triggered the EM system to start recording. This caused some unnecessary video recording during the steam to the fishing grounds. In some cases, this made the crew uncomfortable, and also resulted in more video data to review and store. This occurred on approximately 15% of trips. To mitigate this, we asked the crew to wait until just after they had left the dock before turning on the EM system. Unfortunately, the captain and crew are often very busy at this time and occasionally forgot to turn on the EM system until later in the trip, resulting in missed opportunities to collect data. Saltwater tested new software towards the end of the project that incorporated the use of geofencing (which doesn't trigger recording until the vessel has left the port box regardless of sensor readings) to eliminate this unintended recording. The new software and port boxes are described later in this report.

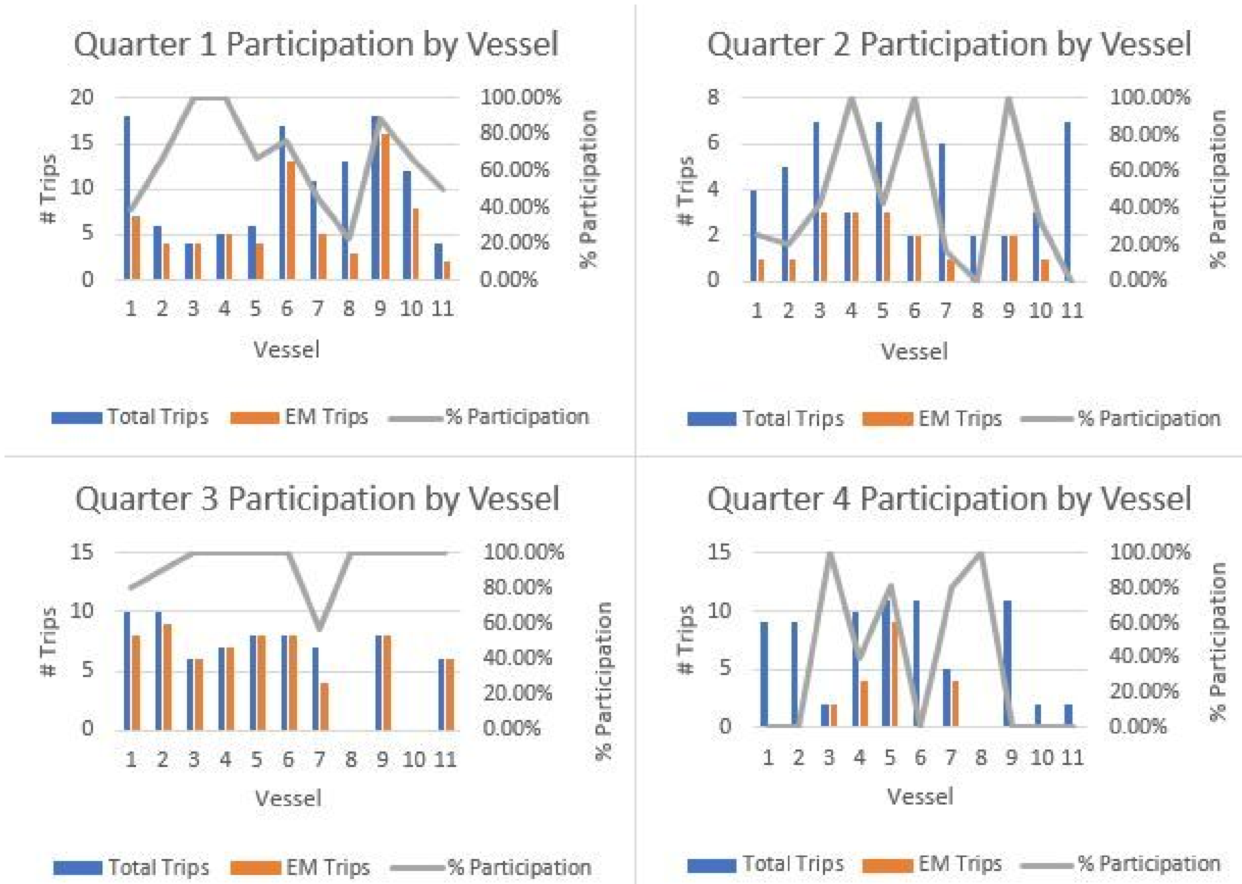


***Figure 28**: Project Participation was tracked by Quarter. For this project, Quarter 1 was November 1, 2016 - January 31, 2017, Quarter 2 was February 1, 2017 - April 30, 2017, Quarter 3 was May 1, 2017 - July 31, 2017 and Quarter 4 was August 1, 2017 - October, 31, 2017. Total number of MWT herring trips declared by each vessel shown in blue. Total declared trips includes trips with no fishing activity. Number of trips where EM data was collected shown in orange. Project participation improved after the first round of feedback meetings at the end of Quarter 2 but dropped significantly in Quarter 4.*

Part of the challenge of any EM program is determining the best camera angles to capture necessary data. During the vessel assessments and after review of the first few trips from each vessel, Saltwater and NMFS determined there were 4 views that would be necessary for an operational compliance program. For participating vessels, there were four locations where discards could likely occur; 1) at the pumping location, 2) at the dewatering box, 3) from the deck through the scuppers (if there was any spillover out of the chute or dewatering box) and 4) at the stern where the net was brought back on board. The full deck view camera also proved helpful to allow the reviewer the ability to see when the vessel was setting out the net and hauling it back. It was determined that cameras should be installed in a way that captures all 4 possible discard locations, which would in most cases require 3 or 4 cameras depending on the layout of the vessel. This configuration would maximize the ability of EM reviewers to determine the source of any discard. After initial trip review, It was discovered that optimal placement for the pump-view camera could be achieved by installing a boom on the side of the vessel onto which the camera could be mounted. Of the eleven vessels that volunteered for the project, five agreed to have booms installed and to carry three cameras (the number requested in the approach); three vessels agreed to carry 3 cameras but did not want a boom, two carried two cameras, and one vessel carried only one camera. The number and location of cameras have a significant impact in the ability of the reviewer to view and accurately categorize discard events. This project was entirely voluntary and therefore the project team was respectful of the concerns and input of the study participants on items such as the number of camera and locations of cameras, which had to be agreed to by the vessel operators. Information learned through the varying numbers of cameras installed and placement was instrumental in developing recommended standards for an operational program.

When discard event types were classified as unknown, it was generally due to poor camera angles. Thus if slippage occurred, a reviewer could not determine whether it was slippage (i.e. full or partial release), another type of discard event (e.g. operational discard), or potentially something else entirely. If the objective of an operational program in this fishery is to capture and properly identify all discard events, and not just slippage, each of the participating vessel's camera setups would need to be optimized in some way. The most common adjustment would be the addition of a boom arm to achieve an unobstructed view of the pumping activity and determine source and type of clog. Many of the vessels would also likely need a camera mounted on the aft gantry facing forward to capture discards from the aft side of the chute and dewatering box that were obscured from cameras in this study by the machinery on deck.

Saltwater and NMFS staff did provide regular feedback to vessel owners and operators and provided data and/or data summaries to them from their vessels upon request. Because participation was voluntary, any procedural feedback provided to vessel owners and captains by outreach staff was purely informational.

One of the concerns of the fleet about using EM for their monitoring choice was the uncertainty of what would happen if they wanted to fish and there was an issue with the EM system. In current operational programs, if the issue is noticed prior to departing for a fishing trip, the vessel owner should try to troubleshoot remotely with the assistance of a certified EM technician. If remote troubleshooting is unsuccessful and the EM service provider cannot get a technician to the vessel prior to the vessel's preferred departure date, the vessel may fish for one trip but the system must be fixed prior to departing on a subsequent trip. If the system malfunction is discovered at sea, remote troubleshooting should be performed, but if unsuccessful, the vessel may continue to fish on that trip, but may need to trigger the cameras to record manually or follow other directions given by the EM service provider. Upon return to port, the vessel may not depart on a fishing trip until the issue is resolved. In the HMS fishery, flexibility and communication between NMFS, the vessel owners, and the EM service provider has led to almost zero lost fishing time in the 2 ½ years since implementation.

Incentives to Participate

The primary incentive noted for fleet participation in the project was to examine whether EM would prove to be more cost effective than at-sea monitors for this fishery. Because industry members would fund any additional monitoring efforts in this fishery, the cost-effectiveness of EM is of particular interest. Some operators also believed that EM could be used to counteract negative perceptions of the fishery through a monitoring source deemed indisputable. Additional reasons to participate can be found in the exit interview summary *(Appendix x*).

Project participation was voluntary, and all of the eleven active vessels that fish predominantly with midwater trawl gear agreed to take part. In other fisheries, voluntary participation in EM projects has been as low as ten percent. While the project began with eleven vessels, by the fourth quarter of the project, only five boats were actively participating.

There were multiple reasons mentioned for this high level of attrition. When vessel attrition was first beginning at around the midway point of this project, NMFS asked participants what incentives would promote their continued participation in the project. They primarily responded that they wanted access to fishing in groundfish closed areas. Groundfish closed area access for midwater trawl vessels is otherwise predicated upon selection for observer coverage, and with very low coverage levels over the course of this project, vessels were largely prohibited from these areas. Some vessels operators were disappointed when NMFS was unable to offer access to closed areas with the EM system onboard as an incentive, which may have contributed to the reasons for withdrawal.

In addition, several industry members indicated that frustration with poor fishing was a leading factor in their decision to stop participating. Others stated that the fishing crews were frustrated about the inequity in monitoring and fishing restrictions between their vessels and other fleets that prosecute the herring fishery (i.e. purse seine, bottom trawl) who have less restricted fishing effort. As their frustration built over the course of this study, some of captains and crew refused to activate the EM systems. Finally, some study participants were disappointed that footage from one vessel was used in prosecution of a criminal case. They felt they were misled on how EM footage in this project would be used, and were disappointed that footage collected through voluntary participation was used as evidence in a criminal case. Several owners/operators noted that this contributed heavily to their decision to stop participating.

Data Management & Review

Saltwater's review software uses templates that are tailored to each fishery. These templates are electronic forms that allow EM reviewers to use drop down menus and other structured forms to categorize events recorded by the EM system. Because this project was a first attempt at using EM to collect data in these fisheries, it was difficult for NMFS and Saltwater staff to accurately predict the most efficient way to process the data to meet monitoring and reporting requirements. The project team worked together to identify the necessary data fields and design a template to capture the required data. NMFS staff designed a database that allowed for data comparisons between EM viewers and observer data collected by the NEFOP. After the start of the project, it became apparent that the template would need to be revised to better capture fishing events (duration vs. single point events) in a more meaningful way. Unfortunately, each time a template is modified, all the previously analyzed data must be reprocessed using the newest template. Consequently, Saltwater reviewers had to spend significant amounts of time updating information, which increased data review times.

For future projects, it will be highly important for NMFS and project staff to agree on a template through a trial phase before implementation into an operational program. In addition, EM service providers would benefit from the development of standards in regards to data format, constraints, integrity, acceptable output, and software requirements provided by the Government.

Data Retrieval

Allowing vessel operators to mail EM data resulted in cost savings and logistical simplicity over technician recovery. During the project, the biggest disadvantage of this approach was that it didn't allow for a face-to face opportunity for vessel operators to report any concerns or ask any questions about the EM system, or for technicians to verify that systems are being operated as requested. This resulted in some system issues going undetected until video review, when the reviewer checked the system performance on the drive. But by the time an issue was discovered during review, the vessel had often already departed for the next trip. In an operational program, this would not be an issue since the vessel operator will be required to run a system function test prior to departing for a trip, and also report any system issues to the service provider immediately. The owners reported that having to maintain, track, and mail the HDDs after each trip was onerous, and due to the short duration of the trips, oftentimes only about 12% of the drive's 1 Terabyte storage space had been used. A few captains/owners cited hard drive availability as a limiting factor for the feasibility of the hard drive mailing method as well.

In this project, three of the participating vessels were located near the Saltwater office. Since these vessels were so close, it made more sense for a technician to stop by the vessel when the vessel owner notified Saltwater of the vessel's return from a fishing trip. This allowed the technician a chance to check system function and make more frequent adjustments to the EM system as needed. Hard drives were collected in person from other participating vessels during vessel feedback meetings and service calls.

During the first month of the project, there were some concerns about the potential of data getting lost in transit. By using tracking numbers for all hard drives mailed, Saltwater was able to track hard drives to determine their location.

Data Processing Times

As mentioned above, revisions to the reporting template meant that any data processed under an older version of the template had to be re-reviewed, which led to some delays in data processing.

Another factor that impacted data processing and review time overall was that the project design assumed that the data from each trip would be sent in within 48 hours of the vessel returning to port.. Occasionally though, Saltwater received HDDs with data from multiple fishing trips because the vessel owners either did not have time to mail the drive before leaving port again or forgot to switch to a new drive at the completion of a trip, or forgot to mail in the drive. Having multiple trips on a single HDD meant that the earlier trips on the drive could not be reviewed in a timely manner and feedback on protocol issues was delayed.

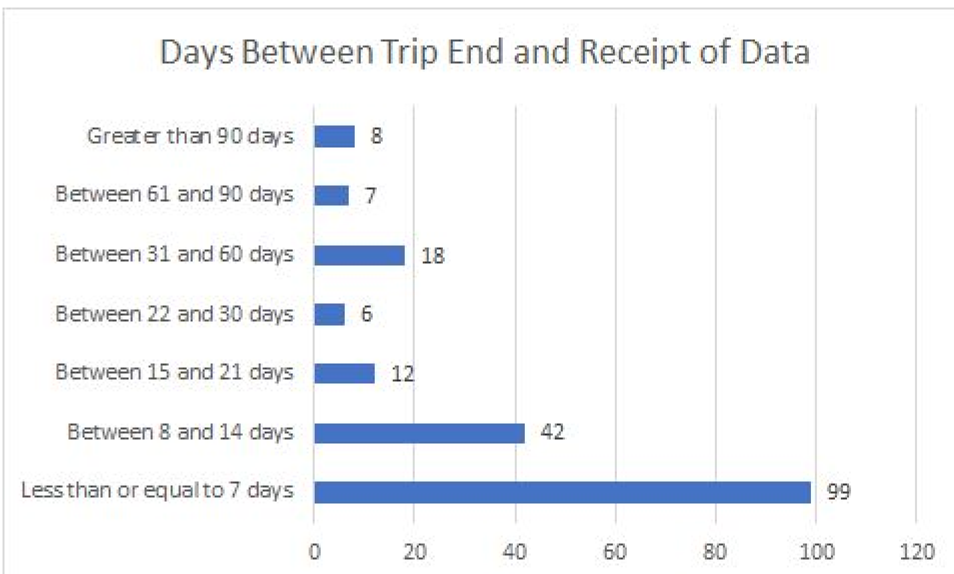


Figure 29*: Of the 192 trips where data was collected, 99 trips were received within 7 days of the end of the trip, 42 trips were received between 8 and 14 days, 12 trips were received between 15 and 21 days, 6 trips were received between 22 and 30 days, 18 trips were received between 31 and 60 days, 7 trips were received between 61 and 90 days and 8 trips were received more than 90 days after the trip ended.*

At the start of this project, Saltwater was working on creating the next version of onboard data acquisition software. During the installations and early months of data collection, vessel owners reported erroneous recording prior to fishing or at the dock and suggested different sensors to trigger recording. Saltwater shared this feedback with the software development team. In early October 2017, the new software was deployed on one of the participating vessels in this project to test out some of the new capabilities. The system received a major overhaul to how the software operates resulting in a more robust, reliable, and extensible framework. While the majority of changes are unseen modifications to the overall coding, the most notable changes come from the modular nature of the stack which allows for new pieces to be developed and deployed in an ongoing manner. As a result, the more fisheries that utilize and make new modules for the software, the more all fisheries with the system deployed will be able to tie into those additional functions. One such example is for port boxes to be utilized to eliminate unwanted recording when the vessel was in port and using hydraulics or winches (efficiencies in cost and storage). Port boxes use the system's GPS location to determine if a vessel falls within a specific set of known locations and it then tells the software that within this particular zone to behave a certain way. For this fishery it would mean hydraulic triggers while the vessel is using them at the dock a cause of spurious recordings. This will allow the vessel operator to leave the EM system on at all times and removes the burden of turning the system on and off when leaving for, or returning from, a fishing trip.

The new software can also accommodate many different kinds of sensors, hardware, and system add-ons. Another example of tested capabilities of the new software was the implementation of multiple configurable recording triggers. This means that video resolution and frame rate can be changed on an individual camera basis as well as depending on fishing activity. This allows for the collection of high resolution video at a high frame rate to be captured during fishing activity while reducing resolution and frame rate during non-fishing activities such as in between tows and when steaming back to port. It is critical for many discard compliance EM programs that video is recorded for the entirety of the fishing trip to ensure discards are not occurring outside of fishing events. This results in a large amount of video data that needs to be reviewed and stored. With the new software, during non fishing activity, the EM system can be set so that only one camera, such as the deck camera, is recording, and at a lower resolution. Since fishing activity makes up, on average, 23% of the entire trip, the amount of storage space used for a trip can be reduced by up to 70% using this method while still capturing all of the required data. The remainder of the software changes are related to the code development itself. These were not as visible to the end-users but the testing resulted in better performance and reliability.

Modified Catch Handling

At the end of fish pumping, most vessels detach the pump from the net and then slacken lines to rotate the entire net aft beyond the stern to straighten the net before reeling the gear back onto the net drum. The net retrieval process commonly occurs while the vessel is moving forward at speeds of 2 to 5 knots. There are often fish remaining in the net that are subsequently released outside of the range of the camera. In these situations, the EM reviewer was sometimes unable to classify the type of discarding event observed between partial release or operational discards if they did not have a good view of the contents of the net prior to the discard event. In an operational EM program, it is likely the crew would need to bring the cod end fully into view of one of the cameras prior to releasing the catch, and they would need to release the cod end near the stern of the vessel to allow a reviewer to discern if fish were released from the net. This is similar to existing requirements laid out in Amendment 5 to the Atlantic Herring Fishery Management Plan. The plan states that vessels are required to provide observers visual access to the net/codend and any of its contents after pumping has ended, including bringing the codend and its contents aboard if possible.

Even when catch was brought on board, it was often difficult for the EM reviewer to discern whether fish removed from the dewatering box were discarded or retained if they were removed from the camera view. If an observer was on board, they filled their sample baskets and often took them out of camera view to do their sampling. With many of the current camera views, the EM reviewer was unable to determine if the fish removed from camera view were discarded or retained. While this was not an objective of the study, it was something we were interested in trying to document. This holds true for fish such as haddock, that must be retained by the vessel. If the crew sorted haddock out of the catch going into the fish hold, they often put them aside in a basket or bucket. This basket or bucket was generally taken out of view of the camera, so the EM reviewer was unable to determine the end disposition of those particular fish. In an operational program, EM-friendly catch handling specification should be established so catch set aside by either observer (for sampling) or crew (for sorting out bycatch) can be clearly determined.

Individual vessel monitoring plans (VMPs) which serve as a comprehensive strategy for discard documentation, installation and maintenance, protocols for data storage and transfer, and other important information regarding a vessel's specific EM system would be the governing tool to help facilitate required protocols. The VMP would define roles and responsibilities, incorporating all monitoring elements (portside, ASM, NEFOP, EM, etc.) to ensure cohesion and cooperation in support of data collection. Issues identified with observer interference, EM reviewer mis-categorization of discard events, vessel operator responsibilities for reporting critical and non-critical equipment failures, and vessel activities that complicate video review could be mitigated with firm protocols documented in the vessel's VMP.

Distinguishing Between Discarding Events

During this project, an attempt was made to use many of the same data fields as the observer program. While this worked for many fields such as setting and hauling events, it was more difficult in situations where the event is defined using situational information, such as ability of the vessel to pump more fish, and is not black and white. Using EM it was often difficult to determine if a discard was operational or a partial release due to the difficulty for the reviewer to determine if a vessel is capable of pumping more of the fish using EM video. The lack of input from the captain/crew in the situations was also a challenge. An operational discard is defined as fish that are discarded at the end of a haul when the vessel is unable to pump the remainder of the fish. Since each vessel is different and some use mechanical methods such as a triplex roller, which in theory allows vessels to pump more of the fish, the determination of whether a vessel "could" have pumped more fish at the end of the haul was difficult and subjective.

There were many examples that needed group review to determine how to classify the discard event. It was also difficult to determine the reason for a slippage event. On observed trips, if a vessel slips the net, the observer is required to document the reason for the discard. It is easy for the observer to get this information from the vessel operator. EM reviewers do not have the ability to collect this information, which resulted in a classification of "unknown" as the reason for discard. One idea proposed by both NMFS and vessel operators was to modify the EM software to allow the vessel operator to make an entry for any discard events directly into the trip data. If the vessel operator could enter the reason for discard and the approximate quantity of fish discarded, this would make a date/time and location annotation at the point the vessel operator makes it. This entry would then be available to the EM video reviewer when they open the trip data. Saltwater is looking into adding this capability to the new data acquisition software.

Methods To Address Undetected Discard Events

There are three main types of data that aid the reviewer in detecting discard events; location data, sensor data, and video data. Locations data are important to show the location and speed of the vessel, and may indicate whether a vessel is engaging in fishing activity. Sensor data is important to show rotation of the third wire and hydraulic pressure. Rotation sensor data would indicate setting or hauling of gear and hydraulic sensor data would indicate that the hydraulics are being used. These sensor data indicate gear activity and would key the reviewer to potential discard events. However, since vessels may discard fish at any time, all video data must be reviewed carefully in order to identify discard events, once fishing activity begins.

Camera framing must be established such that all discard events can be viewed remotely by the reviewer. Common views for discard events are; the stern view where the net is hauled back to the boat and back on board, the pump side view where the net is connected to the pump, and the dewatering box, chutes and deck view where the larger fish are sorted from the catch. Sometimes fish are also sorted from the chutes or fish may overflow from the fish holds while the crew fills the holds with water. These areas need to be captured by the cameras to ensure most or all of the discard events will be detected. Although all discard events may not be captured, proper camera placement can minimize the number of missed events.

Although every effort is made to capture all discard events, some may not be detected or a discard source may not be seen. During this project, there were a few times where fish were seen floating in the water near the vessel, but the reviewer was unsure where they came from. This occurred most often when reviewing video from the vessel with only one camera installed (at the stern of the vessel). It is likely the fish seen in the water were discarded from the dewatering box, but since there was no deck camera or dewatering box camera, the reviewer was unable to positively identify the source of the fish and as a result may have documented the event incorrectly. In cases like these where a discard source cannot be confirmed, the reviewer commented as much as possible about the apparent source and nature of the discard.

There were also times where the vessel would finish pumping and release the codend far behind the vessel. In cases like this where the reviewer could not determine if there any fish in the net prior to the codend being released, it was assumed there was no discard. Because an operational EM program would involve consequence measures for vessels that slipped catch (i.e. 15 mile move-along, exit groundfish closed areas for the remainder of that trip), there would likely need to be catch handling protocols, such that the reviewer could see the contents of the codend prior to release, or that the codend would be released close to the stern of the vessel to ensure that discards can be properly documented.

Fish Disposition Categorization For Fish Not Brought On Board

Of the fish that were discarded before being brought on board, reviewers were asked to determine the reason for the discard. The discard disposition codes were based on the current codes in the observer manual. While some categories like operational discards and no market, were similar between reviewers, a couple of categories had less agreement. The majority of these discard events with disagreement between reviewers, occured when the pump was detached from the net or during a pump stop event. Since it is often difficult to see a clog inside the pump, the audit reviewer was cautious and marked these events as reason not specified, while the census reviewers considered fish released from the net during a pump stop event to be due to a clogged pump. When compared to the observer data, the alignment for operational discards showed alignment but the observer was able to utilize codes like regulations prohibit any retention; poor quality due to gear damage; gear damage prevented capture and no market, reason not specified much more accurately since they are able to gather this information from the captain or crew or by being more situationally aware of what is going on.

Since this was not a primary focus of the project, less effort went into defining these events, leading to inconsistent categorization of discard dispositions. In a fully implemented EM program, discard disposition categories will need to be well defined as they pertain to EM to ensure consistency across all reviewers.

Applicability To Other Greater Atlantic Fisheries

There are many aspects of this EM program that are applicable to other fisheries in the Greater Atlantic region. As described in previous sections, the program relied on a collaborative relationship between NMFS staff and the EM service provider, Saltwater Inc. The group collaborated on outreach and industry engagement, data management and review, and in implementing ongoing program improvements. Regularly scheduled meetings and the active participation of multiple NMFS staff representing different agency offices is something that other programs could benefit from, especially during the startup phase.

The EM system and software used for this program can be easily adapted for use in other fisheries. While each fishery has different monitoring objectives, the basic functions of the EM system of collecting sensor data for the duration of the trip, and triggering video recording as required, can be applied in any of the region's fisheries. The quality of data collected depends to some degree on monitoring requirements, with catch accounting potentially requiring higher frame rates and resolutions than compliance monitoring. In this project, when the cameras were installed in Saltwater's preferred locations, reviewers were able to accurately identify some catch and bycatch species from the video data. This is a promising indication of the potential applicability of the EM system for catch accounting in this and other trawl fisheries.

Another transferable feature of this project was the integration by Saltwater of observers into the EM team and the cross-training of EM technicians and data reviewers; all of the EM technicians were current or former fishery observers, with background and training in this fleet's fishing operations, and all were also trained to do data review. This creates a very flexible and responsive workforce that translates into cost efficiencies because people can switch tasks as demand requires. This approach would also work well if there were an added portside monitoring requirement. Because all of the technician/reviewers were current or former fishery observers, it would be relatively easy to add portside monitoring duties to their job duties.

This program relied on third party data management and review, with all of the collected data submitted to the EM service provider, Saltwater Inc. and reviewed by their staff. Although the original program design stipulated that NMFS conduct an audit of the data, NMFS staff ultimately reviewed all of the data. However, the approach of having a primary review by the EM provider with an audit by NMFS for quality assurance worked well and could be applied to other fisheries. The timeliness and quality of review carried out by Saltwater consistently met program needs. Giving the service provider immediate access to the data helped with the early identification and resolution of any system problems that might affect data quality. There are also efficiencies to be gained by having contractors rather than government employees carry out data review, especially when they are cross trained and/or working on multiple EM contracts. Finally, this program has elucidated a range of legal questions regarding the accessibility of EM data through public requests through the Freedom of Information Act (FOIA). Proprietary vessel data collected through an EM program (including EM footage) that is managed and stored by an EM service provider is not subject to the same FOIA requirements as data held by NMFS.

Saltwater's EM review software is template driven and open source, which allows it to be easily adapted to the requirements of each fishery. Open source software also invites collaboration, which will hopefully lead to efficiencies and cost savings in the review process—which is the most expensive part of most, if not all, EM programs

VII. Conclusions

This project set out to determine if EM could be an effective tool for detecting and categorizing discard events on midwater trawl vessels and to develop a framework for EM implementation in this fishery. We determined EM could successfully detect full release events to a high degree of accuracy (94%) and likely highly effective for identifying smaller releases. It was more challenging to categorize these smaller releases as either partial releases or operational discard events. Interestingly, in cases where audit and census reviewers categorized these events differently their notes often described similar events. This leads us to believe that better definition of the two events with regards to EM, and perhaps greater standardization among reviewers, could help to eliminate these discrepancies.

EM system installation varied among vessels and allowed us to evaluate the effectiveness of each unique configuration and determine the ideal camera setup to capture all discard activity in this fleet. We determined three to four cameras, capturing the four areas where discarding occurs, would be required in an operational EM program. The EM system deployed in this fishery performed well and captured high quality data throughout the project with very few system performance issues.

Two review methodologies were used to determine efficacy of quantifying and categorizing discard events in this fleet. An audit approach that focused primarily on fishing events as indicated by sensors installed on the vessel and a census approach that looked at all video captured during each trip. Preliminary results show that the audit method of review is comparable to the census review and would be a more cost effective model for implementation.

Multiple cost drivers impact the costs of full EM program implementation. Data services, which include data management, review and storage, were found to be the most significant. A key start-up cost for this program and many EM programs is the time required to decide on the data fields to be incorporated into a database and determine review protocols. In an operational EM program, it is important to ensure all of the data collected by the EM system can be compared to, and potentially integrated with, existing observer and portside monitor data streams. Data goals impact system install decisions as well as data management, review and reporting costs.

While video footage was intended to only initially be used to verify retention of catch for portside sampling, the New England Council also recommended that EM would be used to verify compliance with slippage restrictions, reporting requirements, and a requirement to move 15 nautical miles following any slippage event. Slippage restrictions, reporting requirements, and consequences are intended to improve catch monitoring by minimizing discarding events to help ensure that total catch is available for sampling portside.

Initially, video footage would not be used to identify species, or estimate the amount of catch released if a haul were slipped. The New England Council may expand the uses of video footage to include species identification or quantification of released catch in the future, if footage proves useful for these purposes.

This project helped determine the critical factors necessary for full EM implementation in this fishery. There is still work to be done to determine the level of review and catch handling protocols that would be necessary to adequately monitor this fleet, but preliminary results show that an EM and portside program could be used to meet the information needs for management of this fishery.

VIII. Acknowledgements

This project was funded by a grant through the NOAA Fishery Information Systems Program and National Observer Program, and through the NMFS GARFO and NEFSC Offices. We thank our colleagues Nichole Rossi, Sara Weeks, Dan Luers, Carrie Nordeen and Corinne Endres for their contributions to this report. We thank Joan Palmer and Sandra Bernstein for their tireless work on building a database and uploading all of the project data. We would also like to express our gratitude to all of the vessel owners and operators for volunteering and participating in the project as well as providing valuable feedback. Several Saltwater staff contributed to this project including: Jared Fuller, Mark Hagianis, Adam Cook, Mark Seramur, Alan Perzanowski and Sam Moore. We are also thankful to Eric Torgerson, Chordata Ltd, for his assistance with the further development of the onboard software and data review software used in this project.

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X. Appendices

Appendix 1: Discarding Event Descriptions

An objective of the study was to determine if EM reviewers could identify and characterize discard p; events in the midwater trawl herring fishery. NEFOP observers trained to provide at-sea coverage in the high volume fisheries classify discard events into three categories: 1) Catch discarded after being brought on board 2) Slippage, categorized as the partial or full release of catch 3) Operational Discards. Video reviewers utilized this classification structure throughout the EM project. Reviewers documented discarding events by selecting a lead descriptor that most accurately categorized the type of event witnessed during the trip review (Table 7). Discard event records were collected at the haul level in the software. Additional discard event data obtained by reviewers included identifying the camera view(s) that collected the footage, and providing comments and a catch disposition code for comparison to observer data when applicable.

Below is the regulatory definition of slippage in the Atlantic herring fishery followed by definitions for each discard event and examples that illustrate the differences between categories.

Table 7: *Discarding event descriptors used by EM video reviewers to distinguish slippage from other discard scenarios.*

Operational Discards	**Partial Release**	**Other**
Discarded after being brought onboard	**Full Release**	**Unknown**

Federal regulations (50 CFR 648.02) define slippage in the herring fishery as follows:

"*Slippage in the Atlantic herring fishery means catch that is discarded prior to it being brought aboard a vessel issued an Atlantic herring permit and/or prior to making catch available for sampling and inspection by a NMFS-approved observer. Slippage includes releasing catch from a codend or seine prior to the completion of pumping the catch aboard and the release of catch from a codend or seine while the codend or seine is in the water. Fish that cannot be pumped and remain in the codend or seine at the end of pumping operations (operational discards) are not considered slippage*."

As described above, a slippage event can *currently* occur only on a trip with a NMFS-approved observer on board. However, if EM is approved by the New England Council, the definition of slippage will be expanded to include all trips that are sampled, regardless of whether that sampling is performed by an observer or ASM while a vessel is at sea or by a portside sampler when the vessel returns to port. Thus, when a vessel monitoring with EM/Portside is notified (vessel will be notified before a trip begins) that it will be portside sampled at the end of a trip, any partial or full release (as described below) will be considered slippage.

Operational Discards: Operational discards in the Atlantic herring fishery means small amounts of fish that can not be pumped onboard and remain in the codend or seine at the end of pumping operations. Leaving small amounts of fish in the net at the end of pumping activity is operationally discarded catch. For example, fish that remain in the net and pump intake system after the majority of the catch has been pumped onboard the vessel. Operational discards are often the result of fish that collect and become lodged in the net meshes or area surrounding the the net and pump connection; or fish that cycle back through the hose and out of the pump into the water. It must be clear to the video reviewer that pumping ended because the captain and crew determined that they had successfully emptied the contents of the net onto the vessel. Events categorized as operational discards represent only a small portion of fish that could not be pumped on board.

Full Release: A slippage event defined as the release of the entire contents of the net back into the water. In general, slippage events (partial or full releases) may be intentional or unintentional. An unintentional slippage event classified as a full release would be gear damage resulting in the vessel losing the entire contents of the haul before the pump is attached or operated. A full release that is intentionally carried out can be the result of mechanical failure, low volume of fish captured during the tow, or an overabundance of undesired species in the net (such as dogfish), among other bycatch. A captain's decision to slip the entire contents of the net can also be impacted by weather and/or safety concerns.

Partial Release: A slippage event that is characterized by the release of a portion of catch from net or components used to pump catch into the vessel's holding tanks. In order for a reviewer to classify a discard as a partial release, pumping activity must have begun and a portion of the catch must have been transferred onboard. A partial release often occurs when the vessel's crew perceives there is something blocking the pump because there is little or no fish entering the dewatering box. Clogs or twists in the net often necessitate lifting the pump from the water while it is still attached to the net. From this vantage point, the crew will then decide whether the pump must be disconnected from the net. Pump removal or adjustments can result in the release of catch into the water. Because these discarded fish are not brought onboard and made available to the observer for sampling, this is considered a slippage event (partial release). Other examples of a partial release/ slippage events occur when the vessel holds are full and unable to take on more catch, or when gear damage or mechanical failure result in the release of catch that the captain intended to pump onboard. In these situations, the vessel may start pumping fish from the net but end up releasing part of the catch prior to bringing it on board.

Discarded after being brought onboard: Prior to going into the holding tanks, the catch is pumped from the net into a dewatering box that leads catch through a system of chutes and a sorting grate, or dewatering box, where bycatch can be removed by the crew and set aside or immediately thrown overboard. Examples of bycatch species sorted at the dewatering box include dogfish and haddock. Regulations require vessels to retain haddock but other bycatch may be discarded while sorting. If the species composition is not satisfactory, the crew can operate the pump to transfer fish onboard and simultaneously block catch from entering a holding tank but this action is driven by market and rarely occurs. Any fish that land on the deck due to such actions as while the gear is being reeled over the stern or fish that overrun the dewatering box or chutes that are not retained for market, are classified by observers and EM reviewers as catch items discarded after being brought on board.

Other: Video reviewers assigned "Other" to discard events when fish were collected in baskets or taken out of camera view individually and deemed retained by crew based on regulations.

Unknown: Discard events that could not be classified during video review were logged in the review software as "Unknown". These events commonly involved situations where catch handling occurred out of camera view for extended periods of time, or instances when fish were observed in the water near the vessel or gear but the point source of entry into the water could not be determined from the video data.

Appendix 2: EM Study Outreach Sheet

Electronic Monitoring:
Atlantic Herring and Mackerel Project Information Sheet

The National Marine Fisheries Service (NMFS) is evaluating the utility of Electronic Monitoring (EM) in the Atlantic herring and mackerel midwater trawl fisheries. Saltwater Inc. has been contracted by NMFS to provide and install EM units on up to 12 commercial fishing vessels in the Northwest Atlantic. The purpose of the project is to evaluate the utility of EM for catch monitoring on midwater trawl vessels. Work from this project will help inform the implementation of the Industry-Funded Monitoring (IFM) Omnibus Amendment and the development of future EM programs. This 16 month project is currently underway and will run through December of 2017.

For more information or questions regarding Electronic Monitoring in the Atlantic herring and mackerel fisheries please contact:
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Daniel.Luers@noaa.gov or
Nichole Rossi at (508) 495-2128
Nichole.Rossi@noaa.gov

Goals

- Deploy and test an EM program in an operational setting, allowing analysis and adjustment of EM program requirements, and development of business practices to support an EM program.
- Evaluate the utility of EM for monitoring catch retention and identifying discard events in the Atlantic herring and mackerel midwater trawl fisheries.
- Additional goals include familiarizing the fishing fleet with EM, gaining industry input on EM operations, and refining industry and NMFS EM cost estimates.

How Electronic Monitoring works, what it records, when it records:

- EM consists of multiple cameras, a control box, a user-interface (monitor), a GPS receiver, and two sensors (hydraulic and rotation)
- Cameras begin recording when the sensors are triggered by the drum rotation or hydraulic pressure transducer; cameras target the vessel's deck and waters surrounding the vessel, including where the codend is pulled to the surface and pumping occurs.
- Camera views are focused only on the areas of the deck where catch handling occurs (i.e., net reel, pump, dewatering box, etc.)
- Cameras are set up to turn on when gear is first deployed, remain on for the duration of every trip, and turn off once the vessel returns to port
- 100% of EM footage collected on every trip would be reviewed
- The system does **NOT** record audio

EM Video Camera

How are the data stored and transferred to Saltwater?

Data are stored on a hard drive inside a control box (hard drives can hold up to a month's worth of data) and handled as confidential data. Vessel operators will mail the hard drives to Saltwater. Vessels operators will receive training on how to remove and mail their hard drives before their first fishing trip. Mailing hard drives is easy for the vessel and cost effective for the program.

Who owns the data collected during the project?

The data will be the property of the government. Data collected are subject to the same data confidentiality regulations as observer data. Vessel owners may request copies of video collected aboard their boat.

Would data gathered in this project be used in management of the fishery?

The data will only be used to inform the utility of EM as a means of monitoring the fishery. It will not be used to monitor catch, catch caps, or compliance with existing regulations during this project.

Who owns the equipment?

Saltwater will supply all necessary equipment, and will remove all equipment at the end of the project. At the completion of the project, vessel ownership of the equipment or a lease agreement with Saltwater is possible, but should be discussed between Saltwater and vessel representatives.

Will I have to take a NEFOP observer once EM equipment has been installed on my vessel?

There would be no additional NEFOP coverage associated with this project, but if your vessel is selected for NEFOP coverage, you would be required to carry an observer and operate the EM system on the same trip. Data from trips with both NEFOP coverage and EM would be compared to evaluate the effectiveness of EM.

When do I have to turn on the EM System?

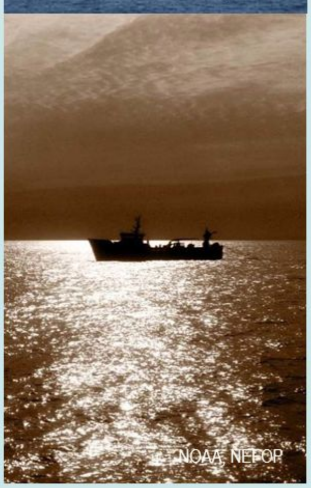
The EM system would need to be turned on for every declared Atlantic herring or mackerel trip. The EM system will be on for the duration of a trip, but the cameras will not be triggered to start recording until gear is first deployed and then cameras will stop recording when the vessel returns to port.

Will the vessel incur any EM costs during this project?

NMFS is responsible for equipment, data retrievals, data reviewing, data storage, and EM provider overhead costs. Vessels requiring power upgrades to accommodate the EM system are responsible for those costs.

What happens if the EM equipment is not working properly and I want to leave on a trip?

Participating vessels are acting in a voluntary capacity and, therefore, will not be prevented from fishing if the EM system malfunctions. Vessels will be required to report all system failures to Saltwater and allow Saltwater access to the vessel to fix the issue.



Would vessels be required to modify fishing practices/effort or be subjected to additional regulations during this project?

No, the objectives of this project are to evaluate the utility of EM for catch monitoring, and to educate the fleet in EM technology. It is important for vessels to fish in a normal manner to determine if EM can capture the elements necessary to monitor the fishery (e.g. catch retention, discard events).

Atlantic Herring (*Clupea harengus*)

For moreinformationorquestionsregardingelectronic monitoring on Atlantic herring or mackerel vessels visit www.nefsc.noaa.gov/femad/fsb/ems or contact: Dan Luers by phone: (978) 282-8457 or email: Daniel.Luers@noaa.gov or Nichole Rossi (508) 495-2128 at Nichole.Rossi@noaa.gov

Install Requirements

You have agreed to carry an EM system that is being provided by Saltwater. In order to install the system on your vessel, there are certain requirements that are described below.

1. The EM system needs to tie into stable 12v DC power in your wheelhouse. Please provide us with details of your power and ready a switch in your wheelhouse panel for us to wire the System to. This switch will need to remain on during the entirety of your fishing trips, so please be mindful of the location you prepare. The power consumption for the system is on par with a pair of incandescent light bulbs. If you have a preferred type of monitor you may purchase one, otherwise a **10"** flat screen monitor will be provided. The system needs to be placed in a secure, dry area which can be readily accessed for data retrieval.

2. To check hydraulic pressure, a sensor will be installed on the pressure side of the hydraulic line in-line on the reel to determine hauling events. Due to the sensitive nature of fishing gear, the vessel will be responsible for installing and securing the hydraulic fittings

3. A rotation sensor and a magnet will need to be fastened to your deck reel.

These wire runs from the sensors will return to the computer in the wheelhouse. Please plan a safe route for your boat. This may mean the wire will need to go through your deck. Our techs can create this entry, or if you prefer you can do it yourself. Please let us know if you will be switching gear periodically.

4. The cameras must have proper field of view to monitor all retained catch, processing, and discards. If there is any fixed gear that is not being used during the time of monitoring that may move and obscure the camera fields, please fasten, move, or let us know about these potential obstructions.

5. We will work with the crew to install wheelhouse components, deck components, and wire runs in order to achieve the necessary placement. These will be done in such a way to be minimally invasive, allow data acquisition, and provide ease of maintenance and removal.

Operator Responsibilities

System Function Test
Prior to leaving port, the vessel operator must turn the system on and conduct a system function test. If the system function test identifies a malfunction, the vessel operator should contact Saltwater immediately to resolve the issue. A Saltwater technician will determine if the malfunction is critical or noncritical. A critical malfunction is one that prevents the data collection objectives from being achieved. If the malfunction is critical, Saltwater will make every effort to resolve the issue remotely or send a technician to resolve the issue as soon as possible.

Equipment malfunction at sea
In the event of a system malfunction at sea, the skipper should report the problem as soon as possible, preferably as soon as it occurs so a technician can attempt remote support and meet the vessel upon return to port to resolve issue if necessary.

EM System Power
The EM system must be turned on and recording data (e.g., GPS and sensors) continuously from the start of the fishing trip until the vessel returns to port.

Catch Handling
The vessel operator will be responsible for ensuring all catch is handled within view of the cameras. All discards must be done in view of the rail camera.

Video Quality
The vessel operator will be responsible to check the monitor before each haul and to wipe water and slime off the camera lenses as needed to maintain video quality.

Hard Drives
Upon completion of a trip, the vessel owner must send in the drive(s) that contain the data from that trip within 24 hours of returning to port. This must be done after every trip. Prior to departing for a fishing trip, the vessel operator must have adequate hard drive storage to record the entire trip. The vessel operator must carry one or more spare hard drives as backup.

EM System Components

A minimum of two cameras will be installed to record video of fishing activity. The video is recorded on a small, rugged computer called the (EMU) Electronic Monitoring Unit). Three sensors may also be installed—a GPS, a hydraulic pressure sensor, and/or a reel rotation sensor. Data from the sensors is collected as a way to track fishing effort—when and where gear is set and hauled. This data is collected by the Sensor Processing Unit (SPU.)

The complete system will be comprised of the cameras, the EMU and SPU, the GPS/Hydraulic/Rotation sensors, a keyboard with touchpad, and a monitor that will show a live feed whenever the system is turned on and indicate when it is recording video. Depending on the fishery, recording may be continuous or triggered by fishing events.

All of this hardware is designed to work together to monitor fishing effort and collect video data required by NMFS to allow for accurate catch accounting.

You can tell what the EM system sees, what the system is recording, and how the system is functioning by using the keyboard and monitor. At the beginning, end, and during each trip you will have different responsibilities, which are described in this guide.

Feedback, questions, and comments on the system are a part of improving its use and function. Please contact us at 1-800-770-3241.

,

The EMU, SPU, and a camera.

System Operation & Skipper Duties

This section describes what the skipper and/or designated crew member must do to power up the system and ensure that the EM system is working while the vessel is fishing.

Powering Up Before Your Trip Starts

1. Before you leave the port, power on the system at the breaker or switch where the system was installed.
2. Wait approximately 2-3 minutes for the system to power on. You should see lights and hear a series of beeps from the EMU (the larger green box).
3. Turn the monitor on. You will see a series of screen changes while the system boots.
4. The system is on once you see the live views from your cameras and the relevant system information on the display.

System Check

Prior to departing for a trip, the vessel operator must perform a system function check. Please carefully follow these steps.

1. Go to the monitor and look at the screen.
2. On the screen you will see the view from the cameras installed on your vessel.
3. Look at the images from the cameras. Make sure they look right (the cameras are looking in the right direction, there is nothing blocking the view, they are clean).
    - You can make the live camera windows larger by clicking on the camera image you want to enlarge. It can be made smaller by clicking it again.
    - If there is slime or salt on the lens, use a **clean wet soft cloth** to wipe it clean. The plastic can scratch, so be careful not to damage it.
    - If there is anything blocking the view, move that object. DO NOT MOVE the camera.
4. Read the GPS, pressure sensor, and hard drive % filled on the screen. The drive will fill ~99% and jump to the next one if necessary. The drives should fill at a constant rate on days you're hauling back.
5. Click "System Check" to log that you have performed your daily check.

Manual Recording - If the system is not recording as intended, use the **"Manual Record"** button to start a manual recording.

If you encounter any problems, please write them down and call Saltwater EM team at 1-800-770-3241**.**

Shutting Down the System

If you need to power off the system for any reason (sleeping with the boat shut down to prevent battery drain, switching generators, or shutting off at the dock) simply power off the unit. If your installation has a switch, please use it as instructed.

End of Trip Duties

Data Retrieval - End Trip

At the end of each trip you will need to *end the trip to stop recording*, and remove the data that has been collected on the Hard Drive in the EMU and mail it to Saltwater**.** To do this, follow these instructions.

1. Click on the ***"End Trip"*** *icon* on the computer. **This is essential to stop trip recording.**
2. It will ask if you are sure; click yes **only** if you are done with your trip.
3. You will be shown the of serial number(s) of the Hard Drive you are to remove. Ensure to **accurately write the unique portion of these down.**
4. Click **"OK"** and wait for the system to **shut down -** the screen will turn gray/black**.**
5. Power off the system the system switch/breaker.
6. Look at the EMU and you will see two small labelled boxes with two thumb screws coming out of each. These are the Hard Drives that store the data.
7. **Match** the portion of the serial number you have written down with these labels
8. Carefully unscrew the spring loaded thumb screws from the drive you have matched and pull gently to remove the Hard Drive caddy. It will come all the way out and will have a flat, silver rectangle in it. That is the Hard Drive.
9. Place the whole device (Hard Drive and caddy with thumb screws still attached) into the provided **protective mailing box and bubble mailer**.
10. Repeat steps 6-9 with the other drive. **ONLY IF** you were presented with two separate serial numbers from the Data Retrieval program.
11. Please fill out the included form with vessel identification and a return mailing address and include with the hard drive in the protective hard drive mailing box provided by Saltwater. *An unidentified drive may delay the drives' return!*
12. Take this package and mail it using the **pre-paid postage label**.

Preparing for the Next Trip

1. The Saltwater technician will have left you with two new Hard Drives (installed in caddies), or you will have received them via mail from Saltwater.
2. You will put the new hard drives into the EMU in the slots where you removed the other ones.
3. Be sure the caddies are facing the right way. The Hard Drive and EMU should both be in the up orientation.

EMU and hard drive in caddy in their "up" orientations.

4. Carefully slide the caddy in until you feel a click. Hold it in place and screw the thumb screws in by hand. (DO NOT use a screwdriver. This will strip the screws).
5. Power on the system.
6. Turn on the monitor.
7. Look at the screen to check that the new Hard Drives are working. If they are working you will see their names and a Hard Drive use percentage.

If you have any additional questions please call 1-800-770-3241.

APPENDIX 4: TRIP FEEDBACK FORM

VIEWER FEEDBACK FORM

Vessel Name:	**Hard Drive #:**
Review date:	**Reviewed by:**

Summary:

This document is designed to capture the details necessary to provide more timely feedback to the vessels (on an individual basis) to maximize obtaining high quality, useful, data. This will be facilitated by adhering to 3 principles:

1. Be timely. The form should be quick to fill out. *It is only filled out when there are problems that need fixing.* One form is filled out per hard drive to streamline the process, and comments can be made to indicate the span of trips or temporal nature of a problem to let techs know if its constant or intermittent

2. Consider root causes. The problem is not that the fisherman is blocking the view of pumping; it is that pumping is not visible. This gives us the option of moving the camera or the fisherman or both, depending.

3. Let them see what you see. It is possible that the person filling out this form will not be the person on the boat, so a picture will go a long way to describing a problem. There is a spot to paste a screen grab for a reason.

If a problem occurs across several trips or hauls on a single hard drive (very likely) then only fill out one feedback form and fill in the range of trip (trip number plus date) or haul numbers.

This form will be printed or saved to a laptop and taken down to the boat where problem solving will take place, hopefully with the assistance of the participating captain. If a solution is not obvious, then giving the parameters of what is needed will allow that interaction to proceed regardless.

CAPTAIN/CREW:

System test not performed before the trip.

☐

Comments:

EM system not powered up upon leaving the dock.
☐

Comments:

Catch pumping outside of the expected pumping area (eg. not on starboard side).
☐

Comments:

Identification of catch utility impaired by crew position/action.
☐

Comments:

VESSEL SETUP:

System performance

One or more cameras or sensors are not functioning during the trip (determined by looking at the thumbnails for the video files). ☐

Comments:

Gaps in imagery data are present during fishing events.
☐

Comments:

Image quality impedes the identification of species or utility.
☐

Comments:

Camera angles

- Catch discarded in the water during/after the pumping process, view insufficient
  ☐

  Comments:

- Catch discarded from the deck during/after the pumping process, view insufficient
  ☐

  Comments:

- Blind spots on deck that require additional video coverage.
  ☐

  Comments:

DEWATERING BOX:

Clear view of crew picking fish at grate
☐

Comments:

Catch items held up to camera for ID* (pilot basis)
☐

Comments:

OTHER
Any outstanding feedback items not covered in the above sections

Comments:

DECISION TREE
(Changes in infrastructure should be proposed before changes in fishing practices)

1. Proposed changes in infrastructure:

2. Proposed changes in fishing practices:

3. Parameters to guide decision making for changes proposed above.

SCREEN GRABS

Appendix 5: Quarterly Summary Form

Atlantic Herring/Mackerel EM Project
Summary of EM Data Collection

Dear Fishing Vessel Owner,

Below you will find a summary of the EM data collected from the Fishing Vessel from Quarter x. Included in the summary are all declared herring/mackerel trips by the vessel during this quarter, total EM video data collected, and several metrics for evaluating your vessel's performance during the quarter. Note that during the first quarter of an EM project, we expect to see an adjustment period on the part of the captain and crew.

The vessel's captain and crew operated the EM system according to project guidance for x% of the trips. It is important to turn the EM system on when you leave the dock and keep it powered until you return to the dock.

We will continue to provide feedback in a timely manner via the feedback forms as data on each hard drive received from the vessel are processed. We plan to provide feedback via email/phone calls with regular (optional) in person meetings.

If you have any questions or concerns regarding this evaluation or the overall project, please contact:

Nichole Rossi (NMFS) at 508-495-2128 or Nichole.Rossi@noaa.gov

Morgan Wealti (Saltwater) at 907-406-3040 or Morgan.wealti@saltwaterinc.com

Sincerely,

NMFS & Saltwater

Trip Number	Trip Start Date	Trip End Date	Total Sea Days	Data Collected (Hours)	Trip Start/End Recorded	% EM Data Collected During Trip	Hauls Recorded	System Check	Maintenance

Notes:

Responsiveness:

Appendix 6: Vessel Participant Exit Interviews

Between October and December 2017 project staff conducted final outreach meetings with representatives from each vessel. A total of 11 exit interviews were conducted by project staff. The following section documents the exit interview questions and summarized participants responses.

Why did you decide to participate in the EM Study?

The majority of interviewees responded that they were interested in applying EM in an operational setting to test functionality of equipment and evaluate system performance at sea. Owners wanted to assess the pros and cons of the technology for future business planning. Overall, vessel participants acknowledged a need to gain hands-on experience with EM in the event that the technology is approved as a monitoring option for the fleet. Although vessel managers and owners made up the majority of those interviewed, several of the captains who were interviewed expressed similar opinions regarding the need to test EM. Some participants hoped that participation in the project could change what they believed was an unfair public perception of high bycatch rates. Members of the fleet also hoped that active involvement in the study would help build higher levels of trust in the NEFOP observer data that has been collected from the fleet for many years.

Has field support for your vessel been sufficient during the study?

Participants agreed that field support was sufficient over the course of the project, however, several managers and operators discussed issues with the hard drives that were used to collect and store data. Representatives from the vessels commented that during busy fishing periods when there was less than 24 hours between trip deployments, it was difficult to find the time to package and ship hard drives through the mail. In several instances, captains complained that they were not given an adequate number of replacement hard drives during quarter 2 and that spares were mailed to incorrect addresses. The vessel manager did confirm that Saltwater was responsive to correcting the issue immediately. In a separate case, a vessel manager received new replacement hard drives that were not formatted properly. Another manager said there were delays in technicians resolving issues with onboard systems at the beginning of the study. However, this participant further noted ongoing improvements were made as captains and company personnel became more familiar with operating the equipment. Remote port locations (i.e. Maine, New Jersey etc.) and vessels transiting seasonally between multiple ports and states such as New Jersey, Massachusetts, and Maine were recognized by project participants as the main factors that delayed EM technician response time when onsite support was needed.

Have you had any major issues with equipment? Do you feel it is reliable?

The majority of the participants did not report any major issues with the equipment during the study, however two separate system issues were discussed by representatives at their exit interviews. One vessel manager stated that he had recurring issues with the live camera feed displays on one of his trawlers throughout the project. The captain and engineer explained that the system locked up and had to be rebooted during many trips. There were also times when they could not determine if the system was actively recording footage. Another vessel experienced similar issues with the wheelhouse monitor freezing up but the problem was resolved by Saltwater after two trips. Equipment malfunctions on individual vessels were infrequent and generally occurred early in the project. One vessel owner wondered what would happen under a mandatory program if EM systems froze up or cameras stopped working. *Would vessels be required to terminate their trip, if they were already engaged in fishing?* He believes the fleet should have an opportunity to review proposed regulations of a mandatory EM program before business decisions are made.

Are you satisfied with reports that are provided to your vessel regarding the progress of the study?

Several vessel managers stated that they did not always have an opportunity to review the content of the report thoroughly but the majority of participants agreed that the quarterly reports were satisfactory and feedback was provided in a timely manner. Another vessel manager commented on Saltwater's professionalism and that their staff always took the time to address his questions and keep him updated with project developments. In a future operational setting, one vessel owner stated that the fleet would expect EM trip reports to be processed in a similar time frame as the observer data that is sent to owner/operators after each trip. The current timeline for processing data release requests for vessel owners and captains is 2 to 3 weeks after an observed trip.

What kind of data would you like to see in the final report?

The main topics of interest in the final report are cost analysis data of EM compared to other monitoring options proposed by the NEFMC and the opportunity to evaluate cost drivers associated with IFM options. Several participants expressed interest in comparing the total time spent actively fishing with the total time transiting and searching for fish. Additionally, industry members hope the report gives an honest and detailed appraisal of EM's performance during the study. They anticipate a thorough examination of the capabilities and limitations of EM as a monitoring tool for documenting fishing activity, discard events, and more specifically an EM reviewer's level of accuracy and consistency when identifying and comparing slippage (partial and full releases) with other discard events. Some participants are interested in the analysis of how multiple reviewers labeled discarding events. Several interviewees posed similar questions in the comparison of the census and audit model review findings: *What level of agreement and consistency will there be between 2 video reviewers in identifying operational discards compared to slippage? Is it possible for reviewers to identify certain fish to species level?*

Are there improvements you would like to see (hardware, software, logistics)? What were your top two challenges with the EM system or project in general?

There were many suggested improvements that participants shared during the exit interviews. Key improvements presented were: a) remote transmission of trip data rather than mailing or EM technician pickup; b) consolidating vessel monitoring and EM into one software package; c) requirement that EM software be activated/deactivated by port boxes (geo-fencing) to eliminate human error; and d) the use of electric current to activate the system rather than hydraulic pressure and rotational movement of winches.

Some participants believed there was a lot of unnecessary data collected as a result of cameras being triggered for prolonged periods while a vessel was in port. Participants felt space on drives was wasted as a result of mailing in hard drives after only one fishing trip. Several owners and operators felt that mailing hard drives on a per trip basis was excessive and they would have preferred an option to complete three or four trips before submitting data. A minority of participants responded that the the system was easy to use and only required plugging the system in and making sure the unit had a hard drive.

Participants said that when problems occurred, dealing with system issues between trips added challenges to their shoreside tasks. Some participants stated that EM does not deliver the real time catch estimates that an observer can provide to captains, and that on some trips observer catch estimates are highly valuable sources of information. Another challenge cited was captain and crew turn over. A manager stated that instructing new captains and engineers on operation of the system and trip data submission was somewhat time consuming, often resulting in errors because it took time for new operators and the crew to adapt to the additional tasks.

Participants still believe there are many unknowns with regards to how an EM program would operate and some owners would be reluctant to commit to EM based solely from their experience in the study. For example, there is a clear understanding among the fleet regarding the requirements and enforcement penalties associated with the observer program, but there has been no corresponding guidance or information shared with the herring fleet regarding proposed requirements and enforcement actions associated with EM regulations.

Were there any alternative uses of EM (e.g. safety, docking) that you found useful?

Most participants stated that the system was not used for any other purposes. There was one operator that said he used the stern camera view in the wheelhouse periodically but the camera placement was adjusted at one point, and it no longer provided the full width of the stern. Alternative uses for EM that were shared during interviews included EM as a resource for insurance claims or legal actions and a potential method to monitor safety and deter certain crew behavior.

Did you or the crew have any concerns (privacy, safety, etc.) with having EM systems onboard? Did the project measurably relieve or reinforce these concerns?

All interviewees responded that from the outset of the project there were various levels of concern expressed throughout the chain of command on individual vessels, mainly in regard to the amount of footage that would be collected. Several participants stated that captains and crews had difficulty acclimating to the cameras at first while performing their work and that others were entirely uncomfortable with the project, believing that EM was intrusive. There were also similar discussions about access and use of EM data between vessel crews and owners. Crew members did not know what parties had access to the footage or how the data was being used and/or stored. Most of the participants commented on the criminal case that was built around EM video data and they referenced that incident as a turning point in the study. Discomfort with the project and concerns with how the data could be used against vessels greatly increased as some industry members felt it was wrong to use video from a voluntary study as evidence to prosecute. It is clear that the project sparked a heightened awareness for participants and a need to review further information and regulatory guidance issued by NMFS. Specifically, the fleet has significant concerns regarding EM data and how it will be utilized and managed in the future and what entities will have the authority to access the data.

Did you have a clear understanding of the goals for this project and your responsibilities? Could you explain what they are?

The majority of those interviewed commented that they had a clear understanding of the goals of the project and their responsibilities. While owners and vessel managers understood their responsibilities, some admitted that maintaining the willingness of their crews and captains to participate in a voluntary study was at times difficult. Several vessel managers felt that multiple cameras were unnecessary and that there seemed to be a shift in the project goals and objectives during the study. In particular, vessel managers raised concerns regarding the use of a dewatering box camera because the frame often captured a significant amount of deck space and compromised the privacy of the crew. They noted that catch released at the dewatering box would not be classified as slippage and therefore did not always agree to camera angle set up by technicians during the primary installation.

Do you feel that EM could sufficiently meet monitoring needs (slippage monitoring)?

Most participants agreed that EM could effectively monitor slippage events. At quarterly meetings with vessel representatives, clips of video from their vessel(s) were reviewed. Demonstrations aided first quarter meetings by allowing project managers to illustrate the level of video quality and propose requests for installing booms on vessels to improve the camera angle and video quality collected from pump view cameras. At the conclusion of the project, some vessel managers agreed that EM could meet the needs of monitoring slippage in the herring fishery but they shared similar opinions that equipment maintenance and vessel support would prove EM a more costly source of monitoring. These managers also pointed to the fact that there has not been a practical analysis of costs related to a portside sampling program for the herring fishery. One representative stated that EM was not capable of monitoring slippage. The vessel manager stated that EM would need to be part of a larger program with improved technology and greater vessel support from an EM provider company in order to meet the needs of monitoring slippage.

Slippage regulations are met with contention from members of the midwater trawl fleet. Ideally, participants would like regulators to revisit definitions of slippage in the herring fishery, most importantly partial release documentation by observers in the herring fishery. Industry members do not like how slippage is defined and categorized. One participant cited that the definition originated in the tuna fishery as a description for high grading. The definition for slippage was then transferred for regulatory use in the herring fishery where high grading does not occur.

If EM is approved, are you considering it as your IFM monitoring choice? Why or why not? If you haven't decided, what further information will you consider in making this decision?

Vessel managers and owners concluded that cost would be the main factor in their decision to select EM as a monitoring option for their business. Captains that were interviewed stated that they would back the owners IFM decision. Without further details on projected costs or examples of regulatory changes and incentive options, the majority of the participants indicated that they will chose at-sea monitoring instead of EM. Captains and crews are more familiar and comfortable with human observers. They prefer the direct interaction with an observer coupled with the ability to witness how sampling methods are being carried out first hand. EM can not give haul level assessment of species composition or weights whereas NEFOP observers can provide catch estimates and species composition to the captain and crew as necessary.

Industry members strongly believe that EM will be cost prohibitive due to the portside program requirements. There is a consensus that EM needs to be more user-friendly for captains and personnel that oversee shoreside operations. In addition, participants that offload catch from a single trip at multiple ports and do not have offices centrally located believe effort and costs to coordinate with the EM facilitator and portside sampler would be impractical for their business interests. This group of participants firmly concluded that they are not ready to choose EM unless the costs are significantly less than at-sea monitors.

What would incentivize you to use EM over other options?

Cost comparisons between at-sea monitoring and EM coupled with portside monitoring will be the leading factors for vessel owners in deciding what program they will choose. Items that would incentivize the selection of EM by participants would be the flexibility to access closed areas with EM in addition to trips where vessels are randomly assigned a NEFOP observer. Owners cited variable and dropping coverage of the fleet by NEFOP observers as a result of SBRM analysis used to assign sea days to the fleet each year. Some participants posited that EM should allow vessels to fish all access areas because in an operational program they assume captains would be required to operate cameras on 100% of their trips. One captain stated that the entire fleet would choose EM if it gave vessels year-round access to groundfish closed areas. Several participants believe that without guaranteed access to closed areas, there will be no real incentives for the fleet to use EM. A vessel manager stated that there have been increased regulations and restrictions placed on the fleet in the last 10 years and that EM could become a beneficial monitoring source for all stakeholders by providing consistent, regular access to fishery dependent data while granting increased fishing opportunity for the fleet. Participants also stated that there are many unknowns with EM that regulators have not discussed, and that they would be uncomfortable choosing this technology over human at-sea monitors until further details have been published for comment and review. Overall, participants expect that their hands-on experience with EM will be influential in management plans as well as show a common willingness to work with stakeholders.

Appendix 7: Vessel Monitoring Plan

2016/2017
Atlantic Herring & Mackerel Midwater Trawl Program

Vessel Monitoring Plan

This Vessel Monitoring Plan (VMP) describes how an Electronic Monitoring (EM) system is specifically configured on a vessel and how fishing operations on that vessel will be conducted to effectively monitor fishing activities to document catch. The 2017 VMP was developed to meet the objectives of the 2016/2017 Atlantic Herring and Mackerel Electronic Monitoring Project.

The data collection goal of 2017 EM cooperative research is to develop EM so that the data can be used for catch accounting of discarded catch. Work from this project will help inform the implementation of the Industry-Funded Monitoring (IFM) Omnibus Amendment and the development of future EM programs.

This is a living document that may be updated throughout the project. Feedback is always appreciated.

Table of Contents

VMP Date and Version

VMP Submission Date:	**2016/10/17**
VMP version number:	2017.02

Vessel Summary

Vessel Name:	
Vessel ID:	
Home port:	
Primary landing port(s):	
Gear type(s) to be used:	Midwater Trawl-Single
Vessel Owner name:	
Address:	
Email:	
Phone number(s):	
Vessel Primary Point of Contact: (if different from owner)	
Address:	
Email:	
Phone number(s):	

EM System Overview

- Your vessel is equipped with an electronic monitoring system, consisting of cameras, GPS, gear sensors, user interface, and control center.
- The system will record GPS and pressure sensor data while powered.
- Video will be collected from rail, stern and deck cameras during hauling and catch processing.
- For this pilot project, the EM system will record 24/7 from when the gear is first set until the system is turned off when the vessel returns to the dock.
- More specific information about your EM system is provided in *Appendix A - Vessel Installation Details*.

Operator Responsibilities

Your vessel is part of a volunteer pilot project. Please turn your EM system on as soon as you leave the dock and turn off when you return to the dock. System operation details are included in this VMP under the Vessel Operator Responsibilities section in Appendix B.

Each Trip

- **Confirm Hard Drive Storage Space**: The vessel operator must ensure that the system has adequate storage to record the entire trip. The vessel operator must carry one or more spare hard drives, sufficient to record the entire trip, as a back-up.
- **Power**: Maintain uninterrupted electrical power to the EM unit while the vessel is underway.
- **Function Test**: Prior to leaving port, the vessel operator must turn the system on and conduct a system function test following the instructions provided in *Appendix B – Guide for Vessel Operators*. If the function test identifies a malfunction, the vessel operator must follow the troubleshooting guidelines listed in *Appendix B – Guide for Vessel Operators*.

Each catch handling event (haul or set)

- **Prior to each catch handling event**, the vessel operator should:
  - Verify that all cameras are recording and all sensors and other required EM system components are functioning as instructed in *Appendix B – Guide for Vessel Operators*.
  - Check the monitor and verify that the camera views are consistent with the images provided in *Appendix A - Vessel Installation Details*.
  - Clean camera lenses to maintain video quality. Video quality will be reported in the trip summary report.
- **Catch Handling**:
  - To effectively meet the goals of the study, we suggest the following catch handling procedures:
    - The vessel operator is responsible for ensuring all catch is handled within view of the cameras as defined in the camera descriptions and deck diagram in *Appendix A - Vessel Installation Details*.
    - At the completion of pumping, that the codend be brought in view of the camera to enable reviewer to see if there are any fish left in net.
    - If pump is clogged, the contents of the clog should be discarded in view of the camera.

Trip End

- **Within 2 business days after each EM selected trip, ensure that the hard drive is mailed** to the contact provided in *Appendix C – EM Program Contacts*. If doing back to back trips and cannot mail drives when in port, it is okay to wait until after the next trip to send in the drives.
- Along with the hard drive, include vessel name, mailing address where replacement hard drives should be mailed, trip dates and whether an observer was on the vessel during this trip.

Equipment Malfunctions

***Since this is a pilot project, at NO point during this project will a vessel be required to stay in port or return to port due to EM system malfunction.**

Equipment Malfunction in Port

If the function test identifies a malfunction, the vessel operator should follow the troubleshooting guidelines listed in *Appendix B – Guide for Vessel Operators.* **If this does not resolve the issue, the vessel operator should contact the EM service provider immediately. The EM service provider will determine if the malfunction is critical or non-critical based on the EM Workgroup definitions.**

- **Non-Critical Malfunction:** If the malfunction cannot be repaired in a timely fashion, the vessel operator may depart on the scheduled trip, but must follow the service provider's instructions to trigger video recording manually. Please call the service provider and make arrangements for them to service the vessel upon return from this trip.

- **Critical Malfunction:** A critical malfunction prevents the data collection objectives from being achieved. A Saltwater technician should be available to service the vessel within 48 hours of notification of the malfunction. Since this is a voluntary program, the vessel should notify the service provider if they will be departing for a fishing trip before they are able to service the vessel, but may proceed without the system malfunction being repaired. The vessel operator should follow the service provider's instructions for this next trip and run the EM system if advised to do so as the system will still likely be collecting valuable data even with one component down.

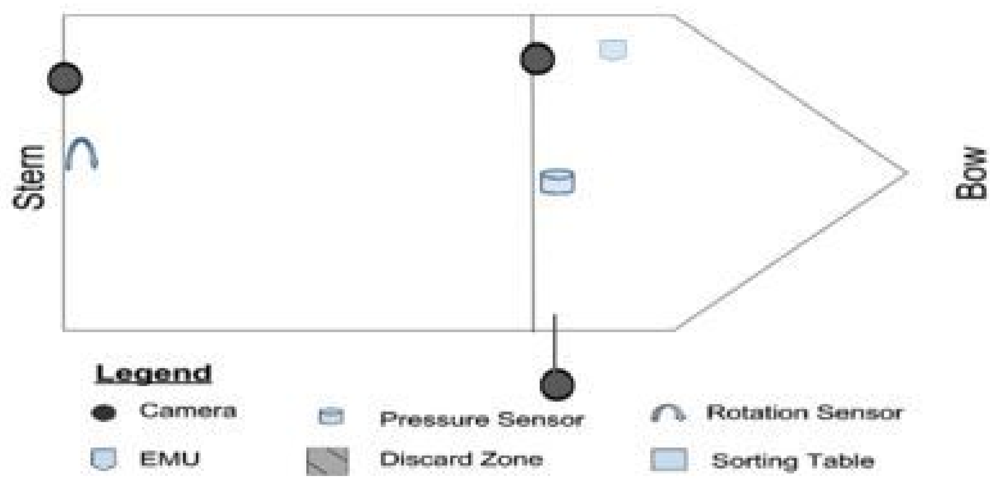
Equipment Malfunction at Sea

- If the system passed the function test prior to leaving port, and remains continuously powered during the trip, the vessel operator is NOT required to return to port in the event of a breakdown.
- Follow the instructions provided in *Appendix B – Guide for Vessel Operators.*
- If the malfunction cannot be resolved following the troubleshooting guide and/or with remote support, the vessel operator should continue to run the system with all functional parts, and contact the service provider immediately (from sea if possible) to assist with scheduling service at the time of landing.
- Any malfunctions should be fixed prior to departing on subsequent trips.

Appendix A – Vessel Installation Details

Vessel Name:	
USCG Vessel ID:	
Gear Type:	Midwater Trawl
Vessel Satellite Phone:	
Skipper Name:	
Skipper Phone:	
Skipper Email:	
Alternate Contact:	
Alternate Phone:	
Alternate Email:	

Vessel Diagram



Camera Name:	Camera 1	Camera View
Location:	Port side front gantry	
View:	Dewatering box and sorting grate	
Aim:	Stern	
Hardware:		
Resolution/FPS:	720 @ 15 fps	
Recording Trigger:	Pressure and rotation	
Run On Time:		
Recording Exceptions:		

Camera Name:	Camera 2	Camera View
Location:	Starboard side front gantry	
View:	Starboard rail	
Aim:	Stern	
Hardware:		
Resolution/FPS:	720 @ 15 fps	
Recording Trigger:	Pressure and rotation	
Run On Time:		
Recording Exceptions:		

Camera Name:	Camera 3	Camera View
Location:	Port side rear gantry	
View:	Aft rail/stern	
Aim:	Stern	
Hardware:		
Resolution/FPS:	720 @ 15 fps	
Recording Trigger:	Pressure and rotation	
Run On Time:		
Recording Exceptions:		

Appendix B – Guide for Vessel Operator

Saltwater's EM system consists of 2-3 cameras, a small, rugged computer (Control Box), computer software, monitor & keyboard, a GPS receiver, a hydraulic pressure sensor, and a magnetic rotation sensor.

The cameras begin recording when gear is retrieved. Recording is triggered by changes in hydraulic pressure, which is monitored by the sensor installed on the hydraulic line, or the rotation sensor, which monitors the line drum or warp winch. The cameras are on a timer, and are set to record for a specific amount of time after gear is hauled. Data from the sensors is collected continuously as a way to track fishing effort—when and where gear is set and hauled

The EM system does **NOT** record audio.

CONTROL BOX

The Control Box is a ruggedized computer that holds the system software and stores all of the recorded video and sensor data. It must be installed in the wheelhouse in a secure, dry area that can be easily accessed for data retrieval. The Control Box must tie into clean, stable 12v DC power or AC power.

Control Box with two hard drive bays

All of the data is stored on two removable hard drives. The data stored on the hard drives in the Control Box in encrypted and protected with a password. This means that no one can view the recorded video without the right software and password.

All of the components of the system are powered through the Control Box. The power consumption for the system is similar to two incandescent light bulbs (less than 60 watts). Wires will need to be run from the Control Box to the sensors and cameras.

PRESSURE SENSOR

The EM system uses hydraulic pressure to track fishing activity and trigger video recording. In order to do this, a sensor will be installed on the pressure side of the hydraulic line to determine hauling events.

DRUM ROTATION SENSOR

A magnetic drum rotation sensor is also used to track fishing effort and trigger the cameras. The system software can distinguish the direction of the drum rotation, which allows us to trigger recordings of retrievals only (and not sets).

DIGITAL CAMERAS

Saltwater's uses internet protocol (IP) digital cameras with an ingress protection rating of IP67, which means they are designed for water immersion up to 1meter for up to 30 minutes. Each camera is capable of capturing high-resolution imagery (1920 x 1080) at a rate of up to 30 frames per second. Cameras must be installed with a proper field of view to monitor all retained catch, processing, and discards. There will be two or three cameras installed on each vessel participating in this project: one to capture close-up images of the deck at the dewatering station, a second camera aimed at the water line to capture images of pumping activity and a third camera capturing the stern where the net is brought on board.

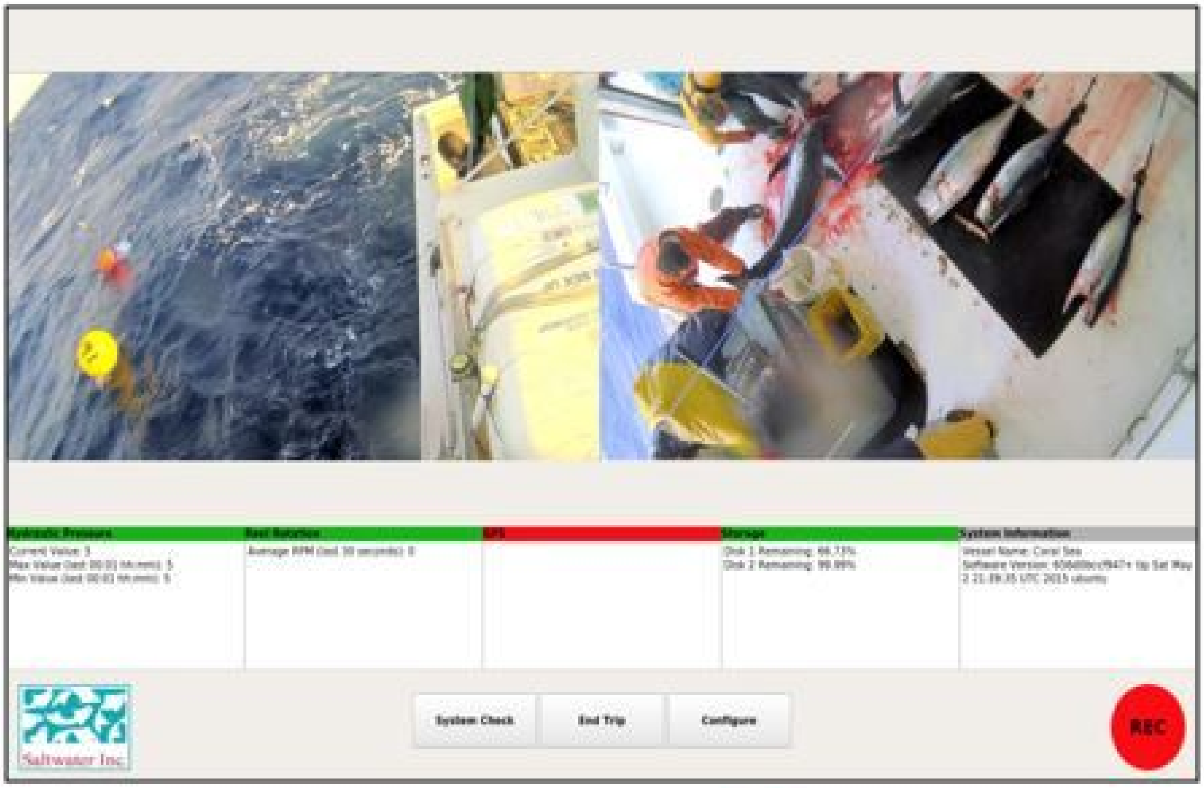
EM camera installed on a fishing vessel

MONITOR & KEYBOARD

A monitor with waterproof keyboard allows vessel crew to see live camera feeds 24/7, view what is being recorded in real-time, and run system checks as required. Our user interface is designed to provide a clear, simple way to confirm that all system components are operating correctly, and determine which hard drive has data and needs to be retrieved. The monitor and keyboard must be installed in the wheelhouse, in a dry location, that is clearly visible and easily accessible to crew.

USER INTERFACE

The following image shows an example (*from a pelagic longline vessel*) of what you will see on the monitor. This image shows two camera views, the status of the sensors, the amount of space available to store data, and basic system information. A green bar indicates that component is functioning properly. In this example the red bar indicates a problem with the GPS.



NOTE: When the system is recording, you will see the red "REC" symbol in the bottom right corner.

At the beginning, end, and during each trip you will have different responsibilities, which are described in the next section, ***Vessel Operator Responsibilities***

The following are step-by-step instructions on how to run the EM system on your vessel, how to check system function, and how to retrieve data.

POWERING UP THE EM SYSTEM

To run the EM system, you must power on the system at the start of each trip. This means the EM system should be powered on when the vessel leaves the dock and should remain powered until the vessel returns to the dock. Please follow these steps.

1. Power on the system at the breaker or switch where the system was installed.
2. Wait approximately 2-3 minutes for the system to power on. You should see lights and hear a series of beeps from the Control Box.
3. Turn the monitor on. You will see a series of screen changes while the system boots.
4. The system is on once you see the live views from your cameras and the relevant system information on the display.

CAMERA CHECK

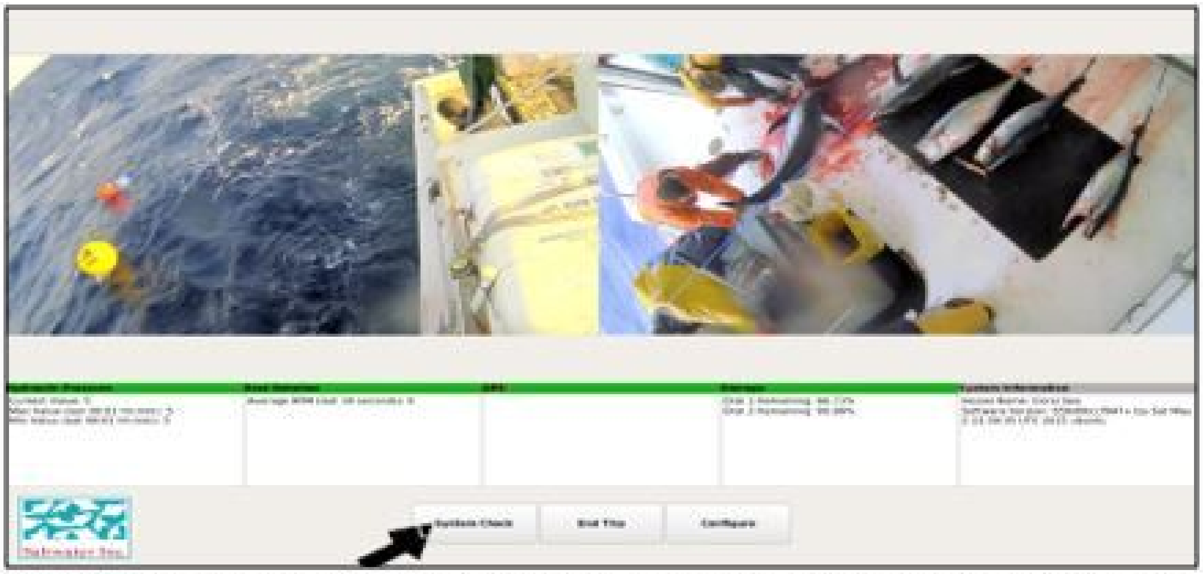
One or two days before you plan to depart on a trip you should check the cameras and run a System Function Check. Please follow these steps.

1. Power up the system.
2. Once the system is on, check the monitor to make sure the views are clear of obstructions, and there is no slime or salt on the camera lens.
   - You can make the live camera windows larger by clicking on the camera image on the monitor. It can be made smaller by clicking it again.
   - If there is slime or salt on a lens, use a ***clean, wet, soft cloth*** to wipe the camera lens clean. Although the camera case is durable, the plastic lens cover can scratch, so do not clean it with anything abrasive.
   - If there is anything blocking the view, move the object. ***DO NOT MOVE*** the camera.
3. Once you are done checking the cameras, please run the System Function Check.

EM SYSTEM FUNCTION CHECK

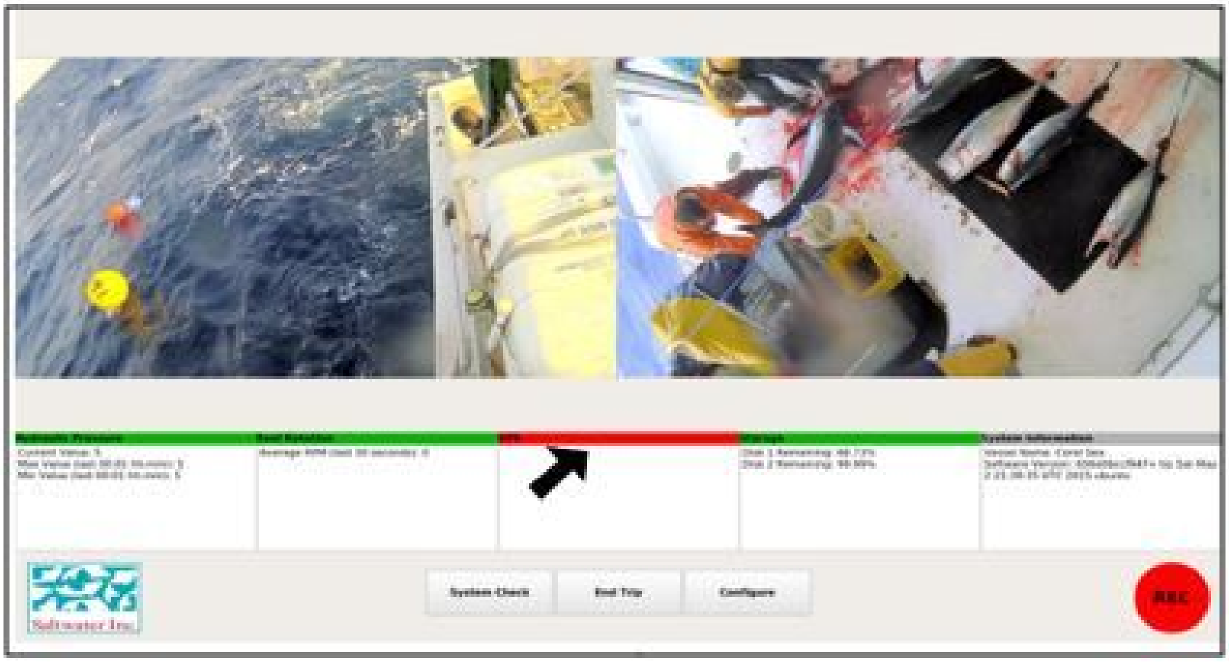
You should run this check one or two days before each trip to make sure there are no problems with the system. You must also run it at the start of each trip.

1. Power up the system.
2. Once the system in on, locate the three tabs at the bottom of the screen: **System Check, End Trip,** and **Configure**.



3. Use the touch pad to click on "**System Check**". This can be done by simply tapping the touchpad when the cursor is over the tab or using the mouse "*left-click*" button next to the touchpad.
4. After you have done this, a new window will appear showing that the system check has been logged.
5. Click "**Okay**"

6. If you see all **green** on the status bars, that means that they system is **good to go.**



- **If you see RED on the status bar, there is a problem with that component. Please call the Saltwater EM team at 1-800-770-3241 as soon as possible.**

END OF TRIP & POWERING OFF THE SYSTEM

NMFS considers the end of the trip to be when you tie up at the dock.
At the end of each trip, you will need to power off the system to end recording and avoid draining the vessel battery. Follow these steps.

1. Look at the monitor.
2. Click on the tab that says **"End Trip"**. ***This is essential to stop trip recording.***

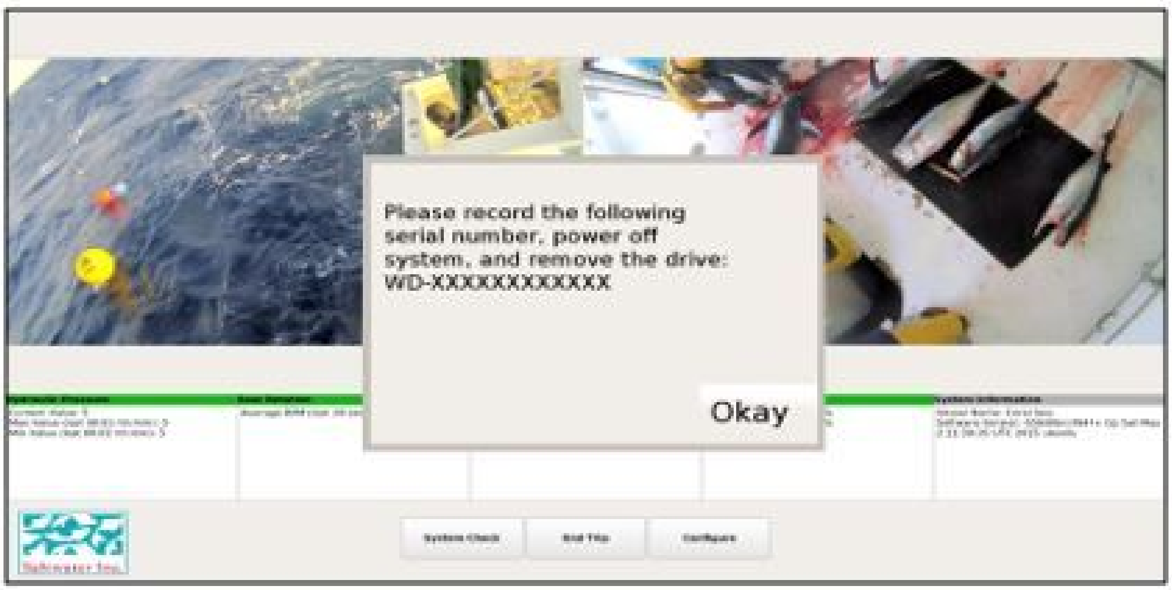
3. You see an image on the screen asking, "*Are you sure?*"; click yes **only** if you are done with your trip.
4. If you do ***not*** need or want to retrieve data at that time, simply power off the system at the switch or breaker,
5. If you ***do*** want to retrieve the data, leave the power on and follow the next set of instructions.

***If you need to shut off the system during a trip for some reason (vessel engine troubles, switching generators), simply power it off at the switch.**
Do *not* hit "End Trip". Remember to power it back on as soon as you are up and running again.

DATA RETRIEVAL

Video and sensor data is stored on removable hard drives in the Control Box. Within two days after every selected trip data needs to be retrieved and sent to Saltwater's office in Gloucester, MA. If doing back to back trips and you cannot mail the drive, it is okay to leave in system and mail in after subsequent trip. Please follow these steps.

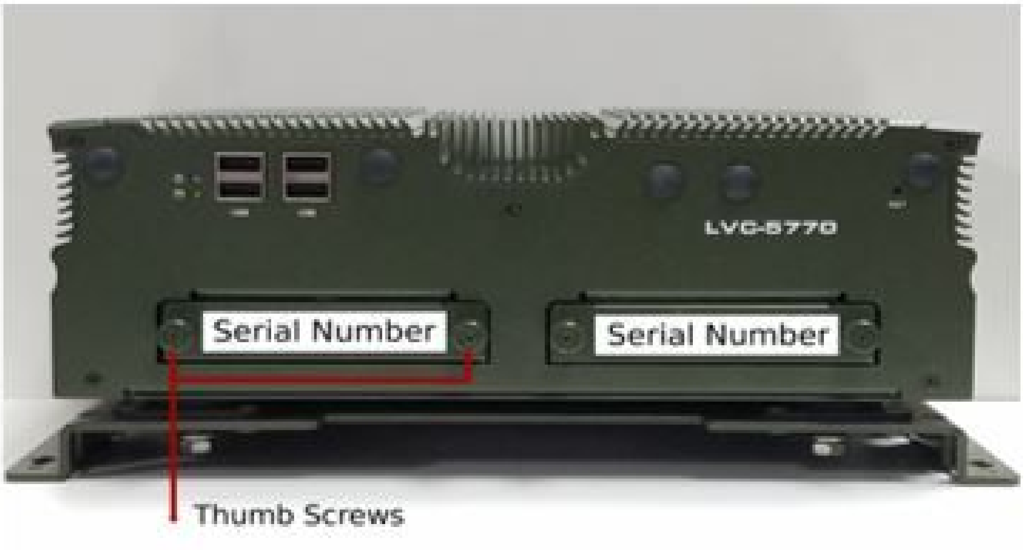
1. Power up the system (if it is not already on).
2. Click on the "**End Trip**" tab.
3. You will be shown the serial number of the hard drive(s) you should remove.



4. Carefully ***write down*** this number. (If both serial numbers are shown on this screen, it means they both have data and you will need to remove and send in both drives).
5. Click **"Okay"** and wait for the system to ***shut down*** - the screen will turn gray/black.
6. Power off the system at the switch or breaker.

* **BE SURE** the system is powered off before you remove the hard drive.

7. Look at the Control Box. You will see two small, labeled boxes with two thumbscrews on each. This is where the hard drives are stored.



Control Box showing hard drive bays and location of serial numbers and thumbscrews.

8. **Match the serial number you have written down with the serial number on the hard drive.**
9. Carefully unscrew the spring-loaded thumbscrews on that drive caddy.
10. You will feel the drive caddy release. *(Do **not** try to remove the screws).*
11. Pull gently to remove the caddy. The caddy will come all the way out. It will have a flat, silver rectangle in it. That is the hard drive. (Do ***not*** remove the hard drive from the caddy).
12. Place the whole device (hard drive caddy with thumb screws still attached and hard drive) into the **protective mailing box** provided by Saltwater**.**

* If both hard drive serial numbers were shown when you ended the trip, remove the second drive by repeating steps 10-12. Put **both** drives in one mailing box.

Hard drive caddy with hard drive inside

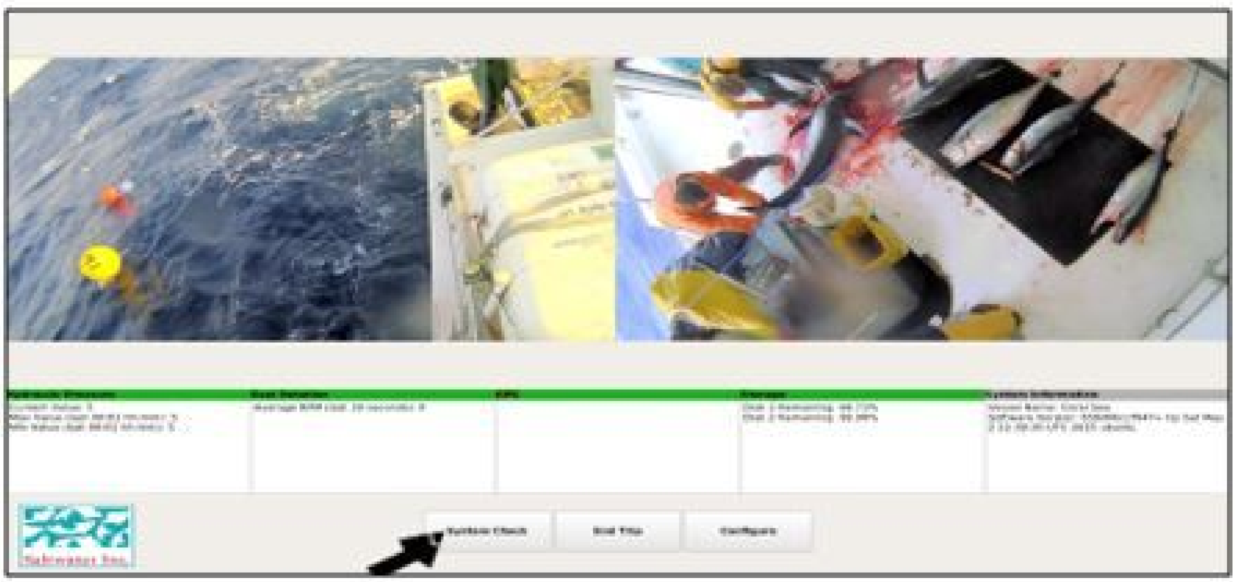
MAILING THE HARD DRIVE

1. Place the mailing box into a **Pre-paid USPS bubble mailer** that has been provided by Saltwater.
2. Fill out the form with vessel identification information. Place this form in the mailer with the hard drive.
3. Take this package to a US Post Office and mail it before your next trip.
4. Postage is pre-paid.

PREPARING FOR THE NEXT TRIP

After you send in the hard drives from your trip, you will need to put new hard drives in the EMU before your next trip. We recommend you do this right after removing a hard drive. Please follow these steps.

1. You will be provided two replacements hard drives during the install.
2. Locate the new hard drive.
3. Make sure the caddy is right side up. You can tell it is in the right position if the serial numbers on the outside of the caddy are right side up. You will also see a printed white label on the drive as shown in the image above.
4. Push the drive into place until it is flush.
5. Carefully slide the caddy and hard drive into the EMU until you feel a click.
6. Hold the caddy in place and screw the thumbscrews in by hand. (**DO NOT** use a screwdriver. This will strip the screws).
7. Power on the system.
8. Turn on the monitor
9. Click in "**System Check**."



10. If the hard drive has been properly installed, "**Storage**" will be green on the status bar and there will be two disks listed: *Disk 1* and *Disk 2*.
11. Once you have correctly installed the new drive (s), you can power off the system at the switch or breaker.

Many problems can be solved by turning the system off and then restarting it. If that does not resolve the issue, use this guide to help. If the problem persists, call Saltwater Technical support.

Problem	Check	Corrective Action
EMU not powering on	Lights on EMU	If lights are not on, check power source. There is no "on/off" switch on the EMU.
	Power at switch and/or breaker	Turn on power at switch and/or breaker
	Loose connections	Ensure all connections are tight
System does not start/ No display	System is beeping constantly	Call Saltwater Technical Support
	System is stuck on "American Megatrends" or Purple "EM System Screen"	Restart machine by turning power off/on at switch and/or breaker. If that does not work pull both hard drives and restart. If functional, probable dead/corrupted drive. Call Saltwater Tech Support.
	System goes black after post (possible white cursor)	Restart machine by turning power off/on at switch and/or breaker. If that does not work pull both hard drives and restart. If functional, probable dead/corrupted drive. Call Saltwater Tech Support.
Monitor not powering on	Power on monitor	Turn monitor on by pressing power button on monitor
	Connections	Pull out VGA, put back in, and tighten fasteners.
Monitor not showing video	Connections	Pull out VGA, put back in, and tighten fasteners.
	Video mode	Press A/V mode button to cycle to VGA
One or both cameras are not detected	System Check	Click "System Check" to refresh cameras, or power system off/on at switch and/or breaker.
	Connections	Re-plug connections at unit, coupler, or camera.
	Power	Check brick for 48v power light on small green power adapter (two lights). If lit, please check connections are tight and there is still no power, call Saltwater Technical Support.
"Weirdness on screen"	System software loaded improperly	Turn system off/on to reboot at switch and/or breaker. If problem persists call Saltwater Tech Support.
Status bar for "Storage "showing red or yellow, "Disk Remaining: Not Present"	Hard drives in EMU	Pull out hard drive caddies and reinstall. Make sure the drive "clicks" into place. Tighten thumbscrews.
	Hard drives formatted incorrectly	Call Saltwater Tech Support
	Hard drives full - Percent remaining is 1% on each drive	New hard drives required
Status Bar for "Sensors"	Connections	Check SPU USB, sensor wires, sensor

showing red		connections.
	SPU Unplugged	Plug back in and restart at switch and/or breaker. System must restart to reconnect to SPU.
	Improper software configuration	Call Saltwater Tech Support
Status bar for "Hydraulic Pressure" is red and pressure reads "309.xx", less than zero, or other value	A sensor has blown and shorted	Call Saltwater Tech Support
Hydraulic Pressure sensor readings are not changing during fishing	Connections	Call Saltwater Tech Support
	Sensor location	Make sure sensor is on the pressure side of the gear used for hauling, outside of any bypasses, and behind any relief valves as not to blow a sensor.
	Sensor Damaged	Sensor will often read 4.7+ if there has been damage to the sensor. Sometimes this can even read as triple digits or "Invalid Reading." Call Saltwater Technical Support.
Status bar for GPS showing red	System just booted up	Wait 3-5 minutes to see if GPS locks on
	Connections	Check GPS wire is properly screwed into the back of the EMU. Trace wire for any damage.
	View of sky	Move or re-stick GPS unit to get clear view of the sky. Call Saltwater Tech support if issue persists.
System not recording	Software Configuration problem	Call Saltwater Tech Support.
	Sensor not triggering recording	Call Saltwater Tech Support.
	Hard drive problem	Follow hard drive portion of guide.
System records for incorrect length of time	Configuration	Call Saltwater Tech Support.
	System lost power recently	System will start recording if there was an intermittent power loss during the last recording. It will record for one clip length
	Sensor Issue	See sensor section
System records at boot	System lost power recently	System will start recording if there was an intermittent power loss during the last recording. It will record for one clip length
	Failsafe Record	This is a failsafe setting in the software. Contact Saltwater Tech Support. This is a non-critical issue and should stop after one clip length.

Appendix C – EM Program contacts (who to call)

PRIMARY CONTACTS

SALTWATER INC. TECHNICAL SUPPORT

Morgan Wealti (Project Manager) 907-406-3040 or Morgan.wealti@saltwaterinc.com.

Mark Hagianis (Technical Services) 907-885-8290 or Mark.hagianis@saltwaterinc.com.

Use this number to:

- Report problems or ask questions about the EM System
- Ask about Vessel Operator Responsibilities including catch handling and effort log
- Request assistance with data retrieval and shipping
- Schedule service
- Report the end of fishing.

Hard drives should be mailed to:

Saltwater Inc
PMB # 326
127 Eastern Ave
Gloucester, MA 01930

NMFS

If you have any questions or concerns regarding the Atlantic Herring and Mackerel Project or Omnibus Amendment, please contact:

Dan Luers (978) 282-8457 or Daniel.Luers@noaa.gov

Nichole Rossi (508) 495-2128 or Nichole.Rossi@noaa.gov

APPENDIX 8: NMFS/NEFSC EM SYSTEM SPECIFICATIONS

National Marine Fisheries Service
Northeast Fisheries Science Center
Fisheries Sampling Branch

April 22, 2016

Electronic Monitoring System Specifications

Background

Electronic Monitoring (EM) technologies hold promise as data collection resources and could be used as a monitoring tool by integrating the system with other data collection programs. The Northeast Fisheries Science Center (NEFSC) conducted a collaborative four-year study (in 3 phases) from 2010-2014 with Archipelago Marine Research, Ltd. and 13 participating fishing vessels. The goal of the study was to investigate the utility of EM to observe fishing behavior and monitor catch allocations in the Northeast Multispecies Fishery.

Information presented in this paper was based on NEFSC's data collection with EM systems, and incorporates information obtained through numerous EM service providers. The purpose of this paper is to inform implementation planning activities in the consideration of developing EM standards in an operational program.

Electronic Monitoring System

EM systems are designed for the automated collection of fisheries data while vessels are at sea. They collect high-frequency sensor data and closed-circuit television (CCTV) imagery during fishing or related activities which are then reviewed post-trip to provide data needed for fisheries management, compliance, and/or science. EM systems typically consist of a control center, a user interface (monitor and keyboard), a suite of sensors (GPS receiver, hydraulic pressure transducer, drum rotation sensor, etc.) and waterproof armored-dome CCTV digital cameras. Suitable technological alternatives (e.g., fast frame photographic systems) that are capable of meeting data needs may be accepted if approved by NMFS.

Electronic Monitoring Data Needs

EM system features are determined by program needs and objectives. Program needs will dictate the specific features an EM system must have in order to meet defined objectives. The objectives listed below are not an exhaustive list, but rather, a synopsis of program goals used throughout the study period.

- Identify, count, and assign a catch disposition (kept or discarded) for individual catch items,
- Obtain an estimated length per catch item (required to obtain a weight estimate),
- Obtain an estimated weight per catch item, species, or species group by haul
    - Individual fish, volumetric weight, scale or tote weight, etc.
- Monitor fishing activity (as defined by program needs),
- Monitor regulatory compliance (as defined by program needs), and
- Verify area fished.

The purpose of this paper is to identify specific product features needed to meet primary objectives for fisheries management data. Product features presented in this report include those identified during the NEFSC study as an example of characteristics that may be needed for a catch share monitoring program. Additional product features may be needed for an operational program or will vary depending on the program data needs and objectives.

- Distinguish and identify commercially important species and/or common bycatch in the Northeast Multispecies Fishery.
- Maintain a running count of individual fish during a trip by species (trip duration estimated 1-15 days total).

- Provide a length estimate for each discarded item by species.
- Provide weight estimates (derived from length measurement) by species on a haul basis incorporating standardized length-weight regressions generated by the Northeast Fisheries Science Center.
- Monitor fishing activity, including; catch sorting, discarding, transit, towing gear, hauling gear, setting gear, and stowage of kept fish.
- Verify area fished through means of GPS data that corresponds to still shots, video clips, or video streams.
- Activate recording activity through the use of sensors or other means (e.g, manual, etc.).
- Store data for retrieval by or transmission to NMFS or approved vendor.
- Meet data confidentiality standards of the Magnuson-Stevens Act.
- Meet chain of custody and data integrity needs for enforcement purposes.

Functional Requirements

An EM system consists of two major elements; hardware and software. The proposed specifications are based on the general EM program objectives included above for a catch share monitoring program. Incorporating more defined objectives (i.e., data timelines or turnaround, volumetric measurements, etc.) may negate or alter some of the specifications listed below. The standards below are set as minimum requirements, as advancements in technology improve these standards may be amended. Specifications listed in this document as "preferred" are not required.

Hardware

I. General

- Hardware should be adaptable and transferrable in application to enable deployment on a variety of fishing vessels (size, gear, target species).
- Hardware should be easily maintained by the vessel crew and spare parts readily available in close proximity to the vessel port.
- Hardware, including but not limited to wires, cameras, control box, and sensors, shall be adequately shielded to prevent radio frequency interference (RFI) with Vessel Monitoring System (VMS) units (http://www.nmfs.noaa.gov/ole/docs/2015/040815_noaa_fisheries_service_type.pdf).
- All vessel electronics need to work together simultaneously.

II. Power

- Ability to run off DC or AC power supply, inverters, or generators.
  - Power draw should be minimal (with 8 digital cameras, a maximum of 120 watts).
  - Power wires should be resistant to damage, water, weather, sun, etc.
  - Provide safeguards to retain data in the event of electrical failure or power spikes.
  - Vessels interested in using EM should note the power requirements of the system.

III. Vessel Data Storage

- The system should have sufficient data storage capacity to store all video and sensor data for an entire month (minimum of 500 gigabytes storage capacity). Each frame of stored image data should record a datetime stamp in the specified format[1].
  - Data storage hardware should be resistant to damage and data loss.

[1] Datetime: values are represented as a ten-digit number in the format YYMMDDHH24MI. YY = two digit year, MM = two digit month, DD = two digit day of the month, HH = two digit hour using 24 hour clock, MI = two digit minutes. All values are two digits padded with zeros. Full datetime must be a ten-digit numeric value. Dates and times should be determined based on local time on the fishing vessels at the time of fishing activity.

- The system must include a means of removing data from the EM unit, such as;
  - At least two external USB ports,
  - Removable storage device (e.g., hard drive) approved by NMFS or,
  - Other approved means of transferring data approved by NMFS.

IV. Cameras and Review

- Cameras (number of cameras will vary by vessel and program needs) should be enclosed in a waterproof armored-dome. Cameras should have a minimum IP rating of 66.
- Cameras should be capable of point-to-point or point-to-multipoint transmission (not openly transmitted) on all monitors.
- All cameras within a system should operate in synchronization for review and analyses purposes. Synchronized playback should occur with a 10 second timeframe.
- Cameras should be capable of operating continuously to meet data needs.
- Each camera should be easily surface mounted on vessels and provide manually adjustable viewing positions.
- Each camera should be compatible with a range of fixed focal length lenses to enable swapping of lenses or have varifocal lenses to achieve monitoring goals.
- Cameras must provide the option to produce still images for enhanced species identification and measurement.
- Cameras must be able to be triggered to record fishing, catch handling, transiting or any other vessel activity.
- Camera resolution must be a minimum of 1,280 x 720 (720p) for enhanced identification and measurement during video review. Resolution must be sufficient to discern individual fish (detect, count, and identify to species level) from distance. NMFS strongly encourages the use of higher resolutions than those described above whenever possible.
- Each camera must record at a speed of no less than 15 unique frames per second when the use of a video monitoring system is required.
- Some manufacturers use proprietary compression formats that require the use of proprietary software in order to view the video sequence or images. Use of such software can prevent or hinder law enforcement from viewing or otherwise accessing these images. If such software is used, then steps must be taken to ensure that law enforcement will be able to access them when needed.
- Cameras must have sufficient fields of view to observe all areas where fish could be sorted, processed, and discarded.
- Cameras must have auto-iris capabilities and produce color footage with the ability to revert to black and white video output when light levels become too low for color recognition.
  - Cameras must be capable of functioning during low light conditions to account for nighttime fishing activity. "Functioning" is defined as allowing video reviewers to count, identify, and measure individual fish and otherwise account for fishing activity and catch handling.
- Monitors should be appropriate to the vessel size and power supply, such that the monitor size is sufficient for the captain and EM technician to access and evaluate the EM system performance before, during, and after a fishing trip. Power draw by the monitor should be such that it will not overburden the vessel's power supply. The video monitor must:
  - Display all cameras simultaneously;
  - Operate at all times, including when fish are handled or sorted; and
  - Be securely mounted and readily accessible to the EM technician and captain and crew.
- If required, measurement grids (discard chute, sorting table panel, etc.) should be designed and tailored to each gear type and vessel size, compatible with common species caught by the vessel.

- Measurement grids should be capable of calibration (through the EM software) to ensure data accuracy and precision.
    - Discard chutes should have a continuous flow of water across their surface at a speed which is conducive to identification, counting, and measurement of catch.
    - Grids should be constructed of a material that allows catch to flow smoothly, without snagging.
    - Grids should be fixed in place during fishing activity and be resilient to standard vessel motions.
    - Grids should be of an appropriate size and shape and not impede or hamper normal fishing practices.
- All components (including cameras, sensors, control box, and wiring) of a robust system must be capable of starting up and functioning during extreme weather conditions (temperatures in the Northeast range from -7 to 29 degrees Celsius) wherever and whenever groundfish vessels are actively fishing. The Northeast groundfish fleet includes a number of small boats with semi-enclosed wheelhouses. Spray, condensation, cold, and heat occasionally enter the wheelhouse on these vessels. Weather conditions include:
    - Extreme heat, freezing rain/spray, ice, snow, fog, and hail.
    - Waves ranging from spray inducing chop to damaging large waves.
    - Violent pitching or rolling.

V. Sensors

- The system must include a minimum of at least two sensors to trigger camera recording (one main sensor may be used to trigger recording but a second sensor is required as a back-up in case the primary sensor fails).
    - Sensors may include a hydraulic sensor, drum sensor, motion triggered sensors, or other means of triggering cameras (must be approved by NMFS).
    - Sensors must be compatible with standard vessel equipment.
- The system must include an independent GPS unit to produce track of vessel transit and fishing activity.

VI. Preferred Features

- The system should have electronic reporting capabilities and the option to link with eVTR software.
- Hard drives should be durable drives that are able to withstand postal mailing.
- Hard drives should be pre-formatted for ease of use and to allow the captain to exchange hard drives readily.
- Regular system upgrades as technology advances.

Software

I. EM Data Review

- The software must include basic video and navigation functions (at a minimum: record, start, stop, bookmarking, play, synchronized playback, standard viewing capabilities copy and save functions, etc.).The system must output video files to an open source format or, if custom or licensed-based software is used, access to data must be supplied (server, licenses, etc.) to the government for data processing purposes throughout the duration of program.
- Software should include the ability to accomplish the below functions;
    - Assess video quality based on standard requirements including but not limited to; complete sensor data (if applicable), camera functionality, presence of video gaps (missing or incomplete), clarity of images (are cameras dirty, focused, covered by salt

spray, etc.), sufficient camera angle to monitor catch, species identification, and sufficient view of catch handling practices, etc.
    - Allow reviewers to identify each species caught or at minimum store images of unknown species for later identification and inclusion in the catch record.

II. Security

- Data encryption or tamper evident features (video and sensor).
- Software must be secure, have the ability to lock and protect data, and detect if the EM system was tampered with at any point during a fishing trip (tamper evident).

III. Compatibility

- Software must be compatible with:
    - Personal Computers (PC);
    - Windows-based operating systems; and
    - Internet Explorer and other commonly used browsers.
- Software must produce data in a file format such as .xls, or .xml that is compatible with an Oracle database.
- The system must use commercially available software or provide proprietary licenses.

IV. Pre-trip System Check

- Software must include a pre-trip assessment of the EM system to indicate all components are functional prior to trip start.

V. Data Validation

- Software must include the ability to verify a complete trip (complete EM trip is defined as a trip where video was recording 100% of the time, trip start to trip end).
- Software shall be capable of producing data elements outlined in the NOAA Fisheries Greater Atlantic Regional Fisheries Office Electronic Monitoring Summary Data File Technical Requirements[1];
    - Software shall include identifying datetime stamps[2], location, vessel name, and permit number, and a GPS unit to facilitate review.
    - Software shall utilize datetime stamp and sensor data to determine number of hauls and haul begin time for the trip (video data may be used to verify haul begin time).
    - Software shall capture and document all system failures and image or sensor data gaps resulting in data loss.
- Sensor data shall display vessel track, fishing start/end locations and times, transit locations and times, and provide a complete record of all fishing activity during a given trip.
    - Sensor data shall display data from the GPS as well as power to the EM system, and sensors used to trigger recording.

VI. Shoreside Data Storage

- System data and video footage should be stored by the provider for 3 years after collection and must include sufficient data backup features to protect data.

[1] Document outlines file format, security, submission protocol, and file structure for EM summary reports.
[2] Datetime: values are represented as a ten-digit number in the format YYMMDDHH24MI. YY = two digit year, MM = two digit month, DD = two digit day of the month, HH = two digit hour using 24 hour clock, MI = two digit minutes. All values are two digits padded with zeros. Full datetime must be a ten-digit numeric value. Dates and times should be determined based on local time on the fishing vessels at the time of fishing activity.

VII. Data Output

- Software shall be capable of producing data elements outlined in the NOAA Fisheries Greater Atlantic Regional Fisheries Office Electronic Monitoring Summary Data File Technical Requirements[1];

VIII. Preferred Features

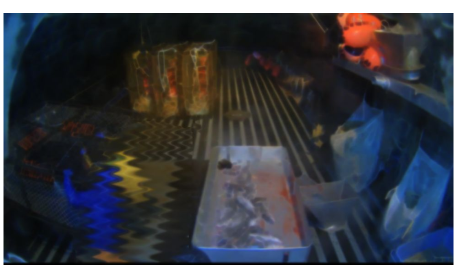
- Automated species ID, automated measurement, and automated weight estimate.
  - Software should be able to incorporate additional species for automated processing.
  - Able to handle automated ID of multiple fish at a time (i.e. not single file fish fed down a chute), multiple fish orientations, weather conditions, light conditions, etc.
- Remote transmission of EM data within 24 hours of vessel landing.
- Software must be easily modified to incorporate regional preferences.
- The system should be portable between platforms (fishing vessels) where peripherals (cameras, sensors) are static and core components (computer, software, discard chute) are transferred.
- The system should have electronic reporting capabilities and the option to link with eVTR software.

[1] Document outlines file format, security, submission protocol, and file structure for EM summary reports.

Appendix 9: Image Quality Assessment

EM Video Quality Assessment

For each fishing event, the reviewer assessed the overall quality of the video. The video quality criteria are defined as follows:

	**Excellent**. The imagery was very clear providing excellent views of fishing activities, including speciation and discards. Focus was very good; light levels were high and all activities were readily discernible. This imagery could be classified as 'imperceptible'.
	**Good.** The imagery was clear, providing good views of fishing activity, but not all discards were discernible. Focus was good with slight blurring or light conditions. All activities were discernible. This imagery could be classified as perceptible but not annoying.
	**Fair.** The view was acceptable, but there may be some difficulty assessing discards. Moderate blurring or slightly darker conditions hamper, but do not impede analysis. This imagery could be classified as slightly annoying.
	**Poor.** The imagery is difficult to assess. Imagery is somewhat blurred or impeded by low light or glare conditions making enumeration and speciation of fish very difficult. This imagery could be classified as annoying. Document the problem using the code in the Poor Quality Code field.

Appendix 10: Data Release Form

Trip Data Release Form

PAPERWORK REDUCTION ACT STATEMENT: The information provided on this form will be used to ensure that the data for a specific trip is not provided to a person who does not have authority to obtain that data under the confidentiality requirements of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and the Marine Mammal Protection Act (MMPA). Meeting those confidentiality requirements are critical for collecting information that is used in analyses that support the conservation and management of living marine resources and that are required under the MSA, the Endangered Species Act (ESA), the MMPA, the National Environmental Policy Act (NEPA), the Regulatory Flexibility Act (RFA), Executive Order 12866 (EO 12866), and other applicable laws. The public reporting burden for this form is estimated to average 2 minutes per response, including the time for completing, reviewing, and transmitting the information on the form. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden to: Amy Martins, National Marine Fisheries Service, Northeast Fisheries Science Center, Fisheries Sampling Branch, 166 Water Street, Woods Hole, MA 02543-2266. Providing the requested information is required to deliver the copy of the trip to the requested location and to release the trip data. The information on this form will be kept confidential as required under Section 402(b) of the MSA (18 U.S.C. 1881a(b)) and regulations at 50 C.F.R Part 600, Subpart E. Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act, unless that collection of information displays a currently valid OMB Control Number. This is an approved information collection under OMB Control No. 0648-0593 through 10/31/2018.

Policy for Data Requests of NMFS Observer-Obtained Information

1. The only individuals who may request and receive data include: the owner(s), or the captain acting as an authorized representative for the owner(s), of a vessel participating in the National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center (NEFSC) Observer Program. No other individuals may be issued any data under this policy.
2. Any data request must be submitted in writing on a form letter which may be obtained from a NMFS Observer, or the address below. Two signatures are required on this letter: that of the individual requesting the data, and that of the individual releasing the data. All letters must then be returned to the following address:

   Chief, Fisheries Sampling Branch
   National Marine Fisheries Service
   Northeast Fisheries Science Center
   166 Water Street
   Woods Hole, MA 02543-1097

   Any questions or other requests relating to data release should also be directed to the above address.
3. It should be understood that upon release of the requested data, the recipient then becomes responsible for it.
4. The individual signing the letter as the "releasor" must issue the information in compliance with this policy.
5. Data may not be released upon an oral request, or without first completing and signing the authorized release letter mentioned above.
6. Field diaries do not meet the specifications of releasable data under the policy. No field diaries may be copied for, or reviewed by, vessel owners or captains.
7. Release of data for trips in which more than one vessel participated (*i.e.,* pair trawl trips) may only occur if both vessel owners or captains complete and sign data release letters.
8. Any requests for historical data (*i.e.,* data that an observer has already mailed in) should be forwarded to the address above.
9. All letters should be completed in pen, not pencil.

OMB Control No: 0648-0593
Expires on: 10/31/2018

NMFS FISHERIES OBSERVER PROGRAM
TRIP DATA RELEASE FORM

Request Date__________/_________/__________

Observer Trip ID # ___________________________

Vessel Name ____

USCG Doc # _______________________________

Date Landed__________/_________/__________

____ _____________________________

PRINT Name Signature

PRINT Mailing Address:

☐ Captain
☐ Owner

____

____

____

Copies Released By:__________________________Date___________Edited? Yes_ No___

(For NMFS Office Use)

▼ TEAR AT PERFORATION AND RETAIN BELOW SECTION FOR YOUR RECORDS ▼

- -

The data you receive may be preliminary and not yet completely reviewed.

Observer Trip ID # ______________________________

Date Requested ________________________________

Mail Request To:
Chief, Fisheries Sampling Branch
National Marine Fisheries Service
Northeast Fisheries Science Center
166 Water Street
Woods Hole, MA 02543-1097

Questions or Comments:
Gina Shield
508-495-2139