

April 10, 2019

Mr. Tom Nies
Executive Director
New England Fisheries Management Council
50 Water Street, Mill 2
Newburyport, MA 01950

Dear Tom:

Enclosed please find the recently-completed report entitled ***Projected Cost of Providing Electronic Monitoring to 100 Vessels in the New England Groundfish Fishery***. The Nature Conservancy contracted with the CapLog Group LLC to conduct this assessment to help inform the growing interest in the use of Electronic Monitoring (EM) systems to meet fishery monitoring requirements in the region.

As you know, the Conservancy has partnered with the Maine Coast Fishermen's Association, Cape Cod Commercial Fishermen's Alliance, Gulf of Maine Research Institute, and Ecotrust Canada to field test EM systems in the groundfish fishery for the past several years. EM systems are presently approved on twenty-two groundfish vessels under Exempted Fishing Permits issued by NOAA that authorize participating fishermen to use EM systems instead of carrying At-Sea Monitors. Participating fishermen hail from Maine, New Hampshire, Massachusetts and Rhode Island and use a variety of different gear types including trawl, gillnet, longline and jig/rod-and-reel. This report does not present information about the maximized-retention EM project currently under way in New England.

Our on-the-water experiences have provided valuable insights into many aspects of an operational EM program, including on-board fish handling protocols, video review procedures (including species identification and weight estimation), and methods for integrating EM data into NOAA's existing catch monitoring systems. Moreover, it has provided real-world information on the costs associated with operating an EM program with 100% video review in New England. We provide this report to give the Council, NMFS and other fishery stakeholders more detailed cost information on EM systems as we all work to improve the reliability and accuracy of catch reporting through Amendment 23 to the Groundfish Fishery Monitoring Plan.

The report contains two separate cost assessments: 1) a summary of costs by category incurred while developing and operating an experimental EM program in FY 2017 (Appendix B); and 2) a projection of expected costs for installing and operating EM systems on one hundred fishing vessels for three years.

Fishing Year 2017 Cost Summary Report

The FY 2017 Report summarizes the costs associated with operating EM systems on eighteen vessels over the course of the fishing year under an Exempted Fishing Permit (EFP). The program developed an audit-based approach focused on validating eVTR-reported at-sea discards of quota-managed groundfish stocks. Participating fishermen handled discards specifically to enable video reviewers to count, measure, and identify each fish discarded. A length/weight conversions table was used to estimate the weight of discarded species by tow and those results were then compared to captain's report. It is our understanding that NMFS will use the audit-based EM program developed in FY 2017, and further refined in FY 2018, for vessels fishing under the EFP in the upcoming 2019 fishing year.

The FY 2017 report enumerated all costs associated with running the program in several categories, including start-up costs for developing the EM program, purchasing and installing equipment, and reviewing 100% of the video footage collected on approximately three hundred fishing trips. Key takeaways from the FY 2017 cost assessment include: 1) the video monitoring systems cost approximately \$8,000 to purchase and install; 2) the average costs (based on gear type) for 100% video review ranged from \$270 to \$335 per day; and 3) the average annual cost per vessel for equipment purchase and installation, program management, and review of 100% of video collected was approximately \$15,000, slightly less expensive than the cost of deploying human At-Sea Monitors on the same number of trips.

Cost Projection Report

The Cost Projection uses the actual costs incurred from operating the FY 2017 Experimental EM Program to estimate the costs of providing Electronic Monitoring on one hundred vessels in the New England groundfish fishery for three years. Specifically, the projection estimates the cost of purchasing equipment and collecting, analyzing, and storing EM video and data from all sector trips taken by participating vessels. The projection *does not* estimate NOAA's administrative costs for overseeing the program, including activities such as setting standards for the program, monitoring program performance, and providing support to address science, enforcement and management needs. These cost projections were based on several assumptions about the various cost-drivers in an EM program that were identified in the FY 2017 cost report. A cost model has also been developed that allows users to test these assumptions and analyze alternative scenarios based on different assumptions about the program design.

Key takeaways from the Cost Projection Report include the following: 1) total program costs for purchasing equipment and providing EM coverage for one hundred vessels over three years are estimated to be approximately \$4.3 million; 2) average annual costs for 100% video monitoring and 50% video review is estimated to be approximately \$11,000 per vessel; 3) and the actual program delivery costs will depend on many factors, including the number and duration of fishing trips and the gear types employed by vessels on those trips.

Conclusion

The Conservancy appreciates the Council's commitment to developing a comprehensive monitoring program that provides accurate catch accounting and better data for stock assessments through Amendment 23 to the groundfish plan. We are at a critical juncture for the groundfish fishery and believe this amendment provides the opportunity to put the fishery on a path toward better science, better management, and more successful fishing businesses. We hope the cost assessment report provides useful information for the Council, NMFS, and other fishery stakeholders to consider during the development of the amendment.

When doing so, please recognize that the cost projections presented in the report were based on conservative estimates and likely present the upper bound of a range of potential future costs. Actual program delivery costs will be influenced by a variety of programmatic design decisions made by the Council and NMFS. For example, significant cost savings can be expected under an audit-based program where less than 100% of the video collected is reviewed. The actual costs will also be influenced by the adoption of new technologies. For example, the ability of vessels to transmit compressed video wirelessly and to employ software that automatically identifies relevant fishing events and accelerates the recognition and measurement of fish species will likely reduce video review time and costs.

We also recognize the costs for implementing an expanded EM program - approximately \$4.3 million over three years - are significant given the current economic constraints on the fishery. Because we believe strongly that significantly improving the current groundfish monitoring program is a long-term investment in the fishery, we are committed to exploring how public-private partnerships can be used to help minimize the economic impact to the industry during the transition to a new and improved monitoring system.

Thank you for considering the information provided in this report and please know that we would be happy to bring the author of the report out to present the methodologies and findings in more detail if the Council is interested in doing so.

Sincerely,



Geoffrey S. Smith
Marine Program Director

Cc:

Mike Pentony – Regional Administrator, National Marine Fisheries Service - GARFO
Jon Hare – Science and Research Director, Northeast Fisheries Science Center
John Quinn – Chairman, New England Fisheries Management Council

Projected Cost of Providing Electronic Monitoring to 100 Vessels in New England's Groundfish Fishery

A REPORT BY CAP LOG GROUP, LLC, COMMISSIONED BY THE NATURE CONSERVANCY

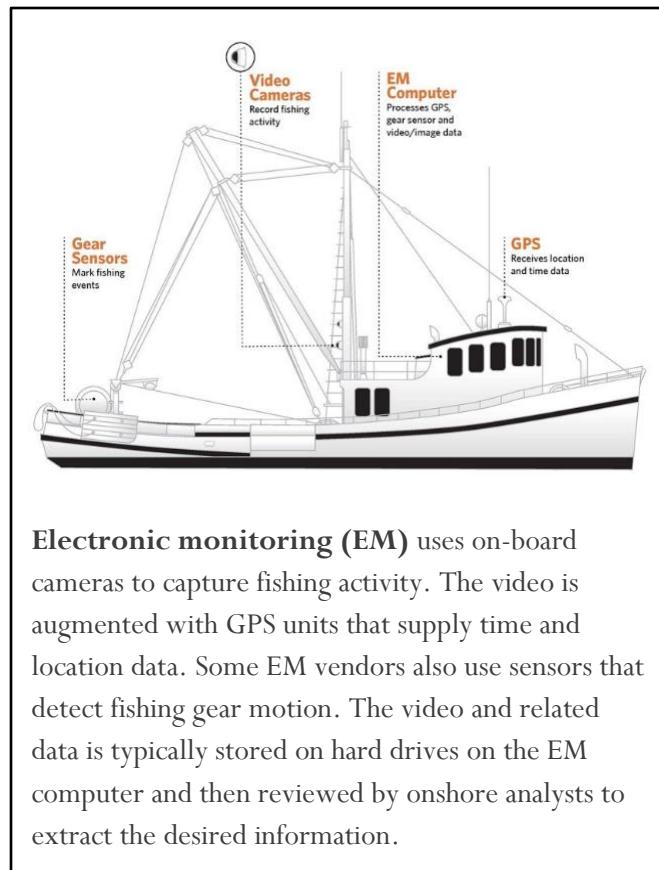
PRESENTED IN MARCH 2019

Overview of Electronic Monitoring in the Northeast Multispecies Fishery

Experimental electronic monitoring (EM) programs have now been operating in the Northeast Multispecies Fishery (New England Groundfish Fishery) under the authority of exempted fishing permits (EFPs) granted by National Marine Fisheries Service (NMFS) since May 1, 2016. Several organizations, including The Nature Conservancy, the Maine Coast Fishermen's Association and the Cape Cod Commercial Fishermen's Alliance, have played a role in these EM programs. Ecotrust Canada (Ecotrust), with support from the Gulf of Maine Research Institute, was the EM service provider for the EM program for the 2017 Fishing Year (May 1, 2017 – April 30, 2018) and 2018 Fishing Year (May 1, 2018 – April 30, 2019).

As of December 2018, EM systems had been installed on 25 vessels. Twenty of those vessels had run EM on at least one sector trip during the 2018 Fishing Year (FY2018).¹ The vessels ranged in length from 35 feet to 65 feet and represented home ports from four states (Maine, New Hampshire, Massachusetts, Rhode Island). They represented six sectors (Fixed Gear Sector, Maine Coastal Community Sector, Northeast Community Coastal Sector, Northeast Fishery Sector V, Northeast Fishery Sector XI and Sustainable Harvest Sector 3) and four gear types (gillnet, jig/rod-and-reel, longline and trawl). The EFP vessels have had 365 trips recorded with EM videos so far in the 2018 Fishing Year (FY2018).

Appendix A details the management objectives and standards for the experimental EM program.



Electronic monitoring (EM) uses on-board cameras to capture fishing activity. The video is augmented with GPS units that supply time and location data. Some EM vendors also use sensors that detect fishing gear motion. The video and related data is typically stored on hard drives on the EM computer and then reviewed by onshore analysts to extract the desired information.

¹ This document includes cost data current as of December 2018. FY2018 continues until May 30, 2019.

Purpose of Electronic Monitoring Cost Model and Cost Projection

The New England Fishery Management Council is currently considering Amendment 23 to the Northeast Multispecies Fishery Management Plan. An option under consideration includes vessels choosing to use an audit-based EM program to meet the required monitoring coverage levels. Under an audit-based approach, EM systems record 100% of the fishing activities on 100% of the trips taken; a subset of these recorded trips are then randomly selected for video review to verify information submitted on the associated Vessel Trip Reports. The random selection of trips for video review eliminates the possibility of fishermen modifying fishing practices based upon whether the trip is being observed.

This paper projects the cost of operating an audit-based EM program for 100 vessels (from 30 to 75 feet long) for three years.² It estimates the cost of collecting, analyzing and storing EM videos and data from all sector trips of these vessels.³ It does not estimate NOAA administrative costs for activities such as “setting standards for such programs, monitoring program performance and providing administrative support to address science, enforcement, and management needs.”⁴

The report seeks to establish a reasonable and defensible cost estimate. For example, it uses actual costs incurred by service providers during the experimental EM program as reference points. (Appendix B includes a cost summary of the EM program in FY2017.) In some cases, the assumed costs may be higher than future costs. For example, the cost of reviewing videos is based on the time required to do so during the experimental EM programs. Additional experience with video review and improvements in technology may reduce future video review costs significantly. A cost model developed in concert with this report allows users to test different scenarios by adjusting key cost drivers and assumptions. Exhibit 1 highlights how the model can be used by presenting cost estimates of two scenarios that have less conservative assumptions than the baseline scenario.

In addition, while the model that supports the report does not seek to generate detailed cost estimates for vessel owners contemplating EM, it does include a simple calculator that provides general estimates of EM costs for individual vessel owners, based on the gear they use, the size of their vessel, the number of fishing trips and fishing days and the efficiency of their catch handling related to EM review. A few sample vessels are included in Exhibit 2 to give readers a feel for how those costs may differ based on specific vessel and trip characteristics. Finally, program managers of the EM EFP noted that vessel operators could substantially decrease the amount of time required for video review based on the catch handling processes used; Exhibit 3 provides an example of how the EM costs can differ for a sample vessel, just based on different catch handling processes.

² The model estimates costs for three years of the EM program to allow for one-time expansion costs to occur in the first two years and then to transition to an on-going annual cost without such start-up costs in the third year.

³ The report estimates 4,318 fishing days for these trips. Sector and non-sector vessels (30-75 feet long) recorded just over 9,000 “days absent” on groundfish trips in FY2015 (the most recent year for which data is publicly available). The 4,318 fishing days is based on the number of participating vessels with lengths between 35-50 feet and 50-75 feet -- multiplied by the average number of trips and average number of days per trip in FY2015 for vessels of those lengths.

⁴ NATIONAL MARINE FISHERIES SERVICE PROCEDURAL DIRECTIVE ON COST ALLOCATION IN ELECTRONIC MONITORING PROGRAMS FOR FEDERALLY MANAGED U.S. FISHERIES. See: <https://s3.amazonaws.com/nefmc.org/draft-em-cost-allocation-pd-feb2018-ccc.pdf>

Description of EM Budget Categories

As detailed in the table below,⁵ EM programs require both upfront investments that last multiple years (e.g., *Program Planning and Development*) and recurring expenses that occur every year but are not directly tied to the number of trips being recorded (e.g., *Program Management*). Other costs depend directly on the number of trips taken (e.g., *EM Submission, Review and Reporting*). Note that the report classifies the purchase and installation of new EM equipment (which occurs in the first year and will need to occur on a regular 5-8 year cycle) as *EM Equipment and Software* but the unplanned replacement of components of that equipment (e.g., a broken camera) under *Repair and Support of EM Systems*.

Table 1: Descriptions and Examples of EM Budget Categories for New England Groundfish Fishery

Budget Category	Cost Attributable to:	Fixed or Variable (Generally)?	Examples
Policy, Regulatory and Program Development Costs			
Program Planning and Development	All Vessels	Fixed	<ul style="list-style-type: none"> • Refine and receive approval from NMFS for EM protocols and standards • Review, analyze and refine audit-based EM protocols and performance • Review, analyze and refine eVTR to video reviewer comparisons • Refine protocols for estimating discards where species, disposition or measurement cannot be derived from a video • Provide vessel services during the developmental stage of the program, such as experimenting with EM new gear types or adjusting EM systems to a new vessel
On-Vessel Costs			
EM Equipment and Software	Individual Vessel	Variable (# of Vessels)	<ul style="list-style-type: none"> • EM Equipment • EM Equipment Shipping • EM Equipment Installation
Repair and Support of EM Systems	Individual Vessel	Variable (# of Vessels)	<ul style="list-style-type: none"> • Pre-season maintenance and equipment check • On-call and on-site support to troubleshoot EM technical issues • Cost of components of EM systems required for repairs • Feedback on trips and refresher trainings to vessel operators • Technical support for maintenance and repair of EM systems • On-call and on-site software support to vessels
Program Admin and Operations Costs			
Program Management	All Vessels	Fixed (Impacted by Size of Program)	<ul style="list-style-type: none"> • Train vessel operators on EM processes • Revise Vessel Monitoring Plans • QA and transfer of data from EM reviewers to NMFS • Annual audit of EM processes and results to ensure accurate third-party accounting of regulated groundfish discards
Management Software and Systems	All Vessels	Fixed	<ul style="list-style-type: none"> • Software licenses and installation • Customization of software to interface with NMFS systems and to align with new standards from regulators • Upgrades to software to reduce video review time
EM Submission, Review and Reporting	Individual Vessel	Variable (# of Hauls)	<ul style="list-style-type: none"> • Transmission of EM video from vessel to reviewer • Review of % trips and quantification of discards of species by length • Trip reporting to NMFS, sector and vessel operator
EM Video / Data Storage	Individual Vessel	Variable (# of Hauls)	<ul style="list-style-type: none"> • Servers, archival disks and other equipment for data storage • Subscription costs for long-term data storage

⁵ The EM categories for New England have been developed based on past work in categorizing EM program expenses. The above categories draw heavily on the following report: MRAG Asia Pacific, “Cost Recovery Guidelines for Monitoring Services.” September 2018. They also reflect actual line items expensed by service providers supporting the New England EM EFPs from 2016-2019.

Assumptions of Baseline Cost Projection

Find below several key assumptions used in estimating the cost of the EM program:

- (1) The model estimates costs for three years of the EM program. It does so to allow for Program Planning and Development costs to occur in the first two years of the expanded program and then to transition to an on-going annual cost without such start-up costs in the third year. The costs for the third year should reflect future year costs (based on the assumptions below).
- (2) The baseline scenario assumes there will be 100 vessels that choose to participate in the EM program. (As stated above, twenty vessels had participated in the EM program in FY2018 as of December 2018.) The vessels are between 30 and 75 feet long and include vessels with each of the four primary gear types. They all join the program in the first year.

Table 2: Projected Number of Vessels by Length and Gear Configuration Choosing to Participate in EM Program

# of Participating Vessels Configured with...	Less than 30 ft	30 to 50 ft	50 to 75 ft	75 ft and above	All
Gillnet	0 vessel(s)	30 vessel(s)	2 vessel(s)	0 vessel(s)	32 vessel(s)
Jig/Rod-and-Reel	0 vessel(s)	10 vessel(s)	0 vessel(s)	0 vessel(s)	10 vessel(s)
Longline	0 vessel(s)	8 vessel(s)	0 vessel(s)	0 vessel(s)	8 vessel(s)
Trawl	0 vessel(s)	15 vessel(s)	35 vessel(s)	0 vessel(s)	50 vessel(s)
Total Projected Participating Vessels	0 vessel(s)	63 vessel(s)	37 vessel(s)	0 vessel(s)	100 vessel(s)

- (3) The cost of EM equipment and installation will remain similar to the actual cost of EM equipment and installation in FY2018, unless noted otherwise.
- (4) Although improvements in technology (including artificial intelligence) will likely result in a more rapid video review of each fishing event,⁶ the baseline scenario assumes the average time for reviewing one hour of video in FY2018 for each type of fishing event (e.g., fishing day of jigging, haul of trawler, set of gillnet) will remain similar in future years.
- (5) The average number of hours of technical support provided to each participating vessel (for example, for troubleshooting hardware or refining fishing handling processes) will decrease from just over 6 hours per month (the average support required in FY2017 and FY2018) per vessel in the first year to 3 hours per month in the third year of the expanded program.
- (6) An audit-based approach will be utilized for reviewing EM videos. As noted above, EM systems will record 100% of the fishing activities on 100% of the trips taken; a subset of these recorded trips is then randomly selected for video review. The baseline cost projection assumes 50% of the trips will be reviewed. Other fisheries use audit-based approaches that review a 10-20% percentage of EM videos.⁷

⁶ Interviews and reports suggest such technologies may be able to reduce the time required to review one hour of video by 75% or more.

⁷ According to “Challenges, Opportunities, and Costs of Electronic Fisheries Monitoring” (Sylvia, Harte and Cusack, 2016), EM video review rates range from 5% to 100% of the EM video footage. For example, the EM program for British Columbia Hook and Line Groundfish Fishery requires service providers to review a minimum of 10% of the EM video.

- (7) Video will be stored (and accessible) for three years.⁸ In FY2017 and FY2018, the EM service providers transmitted and stored data on hard drives and servers. All EM service providers interviewed agree that data storage for a scaled-up EM program will occur in "the Cloud" (e.g., Amazon Web Services, AWS). The baseline projection assumes hard drives will be mailed to a central location (as is currently done) and then data uploaded to AWS via the Internet. The model is built to allow users to estimate the cost of newer technologies that allow for a wireless transmission of data directly from the vessels. The baseline cost estimate, however, does not incorporate the potential cost savings from these newer technologies.

⁸ The 2019 Senate Appropriations Bill for the Departments of Commerce and Justice, Science and Related Agencies states: "Electronic Monitoring Data Storage -- Within 60 days of enactment of this act, the Committee directs NMFS to provide a report to the Committee detailing how NMFS intends to store data collected from Electronic Monitoring [EM]. Because the Committee believes storing EM data for periods longer than 18 months would be unnecessary and not cost efficient, the report should include any reasoning that may be contrary to the Committee's position." This report assumes the data will be stored for three years to be consistent with the current EFP practice.

Projected Cost of Operating an Audit-Based EM Program for 100 Vessels

The total projected cost to establish and operate an audit-based EM program for 100 vessels for three years is \$4.3 million.

Approximately \$670,000 of that cost would be for purchasing and installing the needed EM equipment on 80 additional vessels.⁹ It assumes the 20 vessels participating in the current EFPs would continue to use the EM equipment that is already installed.

The average annual operating costs for running an audit-based EM program with 100 vessels (with 100% of the trips recorded and 50% of the trips reviewed) for the third and following years would be an approximately \$1 million.

Table 3: Average Equipment Costs per Vessel

Equipment or Installation Type	Estimated Life	Est. Cost per Vessel
Hardware		
On-Vessel Computer for EM	5 years	\$ 3,500
Removable harddrives	5 years	\$ 200
Monitor and keyboard	5 years	\$ 100
GPS Units	5 years	\$ 150
Cameras	5 years	\$ 1,500
Marine Grade Wire and Cables	5 years	\$ 50
Other misc (e.g., shipping / import fees)	5 years	\$ 200
Installation Costs		
Installation of EM systems on vessels	5 years	\$ 2,500
Remote support for installation	5 years	\$ 200
Year One EM Equipment Costs per Vessel		\$ 8,400
New Participants in EM Program		80 vessels
Year One Aggregated Costs for EM Equipment for All New Participants		
		\$ 672,000

Table 4: Projected Costs for Standing Up and Operating an EM Program with 100% Coverage and 50% Video Review

Electronic Monitoring Budget Category	Projected Total Expenditures by Fishing Year			Average Annual Cost per Vessel in Year Three
	Year One	Year Two	Year Three	
# of Vessels	100 vessels	100 vessels	100 vessels	
Policy, Regulatory and Program Development Costs	132,000	61,200	-	\$0/vessel
Program Planning and Development	132,000	61,200	-	\$0/vessel
On-Vessel Costs	996,000	216,000	162,000	\$1,620/vessel
EM Equipment and Software	672,000	-	-	\$0/vessel
Repair and Support of EM Systems	324,000	216,000	162,000	\$1,620/vessel
Program Admin and Operations Costs	931,891	898,529	901,148	\$9,011/vessel
Program Management	288,000	252,000	252,000	\$2,520/vessel
Management Software and Systems	30,000	30,000	30,000	\$300/vessel
EM Submission, Review and Reporting	538,788	538,788	538,788	\$5,388/vessel
EM Video / Data Transmission and Storage	75,103	77,741	80,361	\$804/vessel
Total for EM Program	2,059,891	1,175,729	1,063,148	\$10,631/vessel

⁹ The projected equipment costs are based on the actual costs of purchasing and installing equipment in FY2017 and FY2018. Note that, in FY2018, the EM service provider upgraded cameras. On average three cameras (at \$400 each) were installed on each vessel in FY 2017. The new cameras cost \$600 each and usually can replace 2-3 of the older cameras. They also no longer require the separate Power over Ethernet (PoE) switch. The difference in camera costs between this estimate and the one in the FY2017 cost summary is due to this change.

As such, the average cost per vessel for 100% coverage in Year Three would be approximately \$10,000. Coverage of an equivalent number of fishing days with human monitors at the rate currently charged to one of the sectors for 12-18 hour trips would be approximately \$18,000.¹⁰

As represented in the pie chart to the right, approximately a quarter of the EM program costs in the third year represent relatively fixed costs for program development and management (i.e., Program Management and Management Software and Systems). Other costs vary directly with the number of vessels participating (e.g., Repair and Support of EM Systems) and the number of trips being recorded (e.g., EM Submission, Review and Reporting).

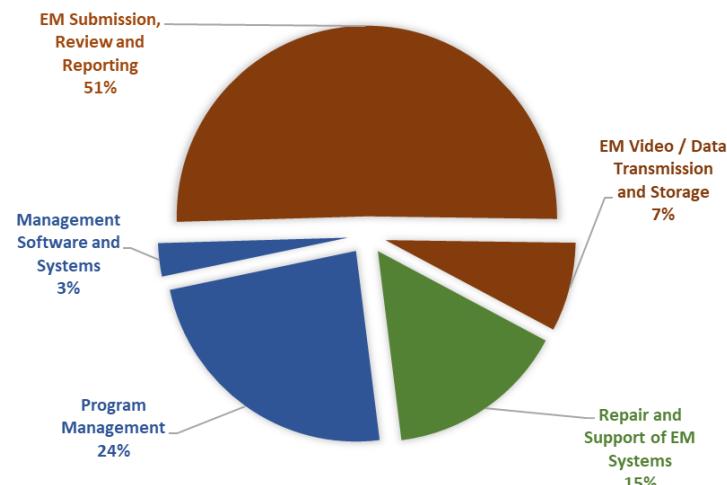
Program and policy decisions, such as the percentage of EM video being reviewed, will significantly impact both the absolute cost of the EM program and the relative distribution of the costs to different budget categories.

The above projected cost assumes 100% EM Coverage of sector trips by participating vessels (4,318 fishing days) with 50% video review and no improvements in the video review rate as a result of improved technologies and processes. Exhibit 1 provides projections of costs with (a) 35% video review and a 25% reduction in the time required to review videos due to technology improvements and (b) 20% video review and 50% reduction in the video review rate. The cost projections in Exhibit 1 are substantially lower than those of the baseline scenario.

Table 5: Cost of 100% ASM Coverage v. 100% EM Coverage (Year 3)

# of Fishing Days	4318 fishing days
Sample FY2018 ASM Rate for 3/4 day (12-18 hr)	\$427.50/fishing day
Total Cost for 100% ASM Coverage	\$ 1,845,945
Total Cost for 100% EM Coverage	\$ 1,063,148
Average Vessel Cost for 100% ASM Coverage	\$18,459/vessel
Average Vessel Cost for 100% EM Coverage	\$10,631/vessel

Chart 1: % of Annual Costs by Budget Category (Year 3 of Program)



¹⁰ The average length of a “fishing day” for the vessels participating in EM in FY2018 was 17.2 hours and in FY2017 was 19.2 hours (with an average of 18 hours per “fishing day” over the two years. About 30% of the trips were less than 12 hours, 25% were between 12-18 hours and 45% were more than 18 hours. The cost of equivalent coverage by human at-sea monitors is based on multiplying the projected number of fishing days by the actual rate for a “3/4-day” (12-18 hours) charged to a Maine sector in FY2018 (\$427.50/day). The cost per day for a “full day” (18-24 hours) was \$570/day. The cost for 4,318 fishing days at the rate for a “full day” is approximately \$2,461,000 – or an average of \$24,600 per vessel.

Conclusion

As noted above, the purpose of this report is to provide a reasonable and defensible estimate of the cost of operating an audit-based EM program for 100 vessels (from 30 to 75 feet long) for three years. Policy decisions, technology and process improvements and other factors will affect these costs. For example, as presented in Exhibit 1:

- (a) the three-year costs of the EM program would be \$3.6 million (or an average of \$8,300 per vessel in Year Three) if the video review rate is 35% and the video review times improve by 20% due to technology and process improvements.
- (b) the three-year costs of the EM program would be \$3.0 million (or an average of \$6,300 per vessel in Year Three) if the video review rate is 20% and the video review times improve by 50% due to technology and process improvements.

In the end, this report acknowledges that different users will have different assumptions about the factors affecting the costs of the EM program. The projection of costs in the baseline scenario uses conservative assumptions, resulting in the cost projection being higher than if the report used less conservative assumptions.¹¹ The projected cost of the baseline scenario of \$4.3 million for three years of the EM program should be considered a defensible and reasonable starting point for conversations about the likely cost of EM for 100 vessels in this fishery.

¹¹ The examples in Exhibit 1 use less conservative but reasonable assumptions, such as reducing the average video review times to reflect likely improvements in technology and review process.

Exhibit 1: Cost Projections for Possible Scenarios

The following cost projections assume 100% coverage on all trips, either with human observers or with EM video recording. The costs for EM change based on the percentage of the recorded trips being reviewed and the efficiency of the video review (due to technology improvements). The costs for human observers do not change, with the cost per trip remaining the same across scenarios.

Scenario One: The following scenario assumes EM video review of 35% of the trips and a 25% reduction in video review time as a result of technology and process improvements. These developments would reduce the total cost for three years of the EM program with 100 vessels to \$3.6 million. As such, the average cost per vessel in Year Three would be approximately \$8,300. Coverage of an equivalent number of fishing days by human monitors at the rate currently charged one of the sectors would be approximately \$18,000.

Table 6: Projected Total Cost in Year Three (Scenario One)

Electronic Monitoring Budget Category	Projected Total Expenditures by Fishing Year
	Year Three
# of Vessels	100 vessels
Policy, Regulatory and Program Development Costs	-
Program Planning and Development	-
On-Vessel Costs	162,000
EM Equipment and Software	-
Repair and Support of EM Systems	162,000
Program Admin and Operations Costs	664,082
Program Management	252,000
Management Software and Systems	30,000
EM Submission, Review and Reporting	301,721
EM Video / Data Transmission and Storage	80,361
Total for EM Program	826,082

Table 7: Cost of 100% ASM v. 100% EM Coverage (Scenario One)

# of Fishing Days	4318 fishing days
Sample FY2018 ASM Rate for 3/4 day (12-18 hr)	\$427.50/fishing day
Total Cost for 100% ASM Coverage	\$ 1,845,945
Total Cost for 100% EM Coverage	\$ 826,082
Average Vessel Cost for 100% ASM Coverage	\$18,459/vessel
Average Vessel Cost for 100% EM Coverage	\$8,261/vessel

Scenario Two: The following scenario assumes EM video review of 20% of the trips and a 50% reduction in the video review time as a result of technology and process improvements. These developments would reduce the total cost for three years of the EM program with 100 vessels to \$3.0 million. As such, the average cost per vessel in Year Three would be approximately \$6,300. Coverage of an equivalent number of fishing days by human monitors at the rate currently charged one of the sectors would be approximately \$18,000.

Table 8: Projected Total Cost in Year Three (Scenario Two)

Electronic Monitoring Budget Category	Projected Total Expenditures by Fishing Year
	Year Three
# of Vessels	100 vessels
Policy, Regulatory and Program Development Costs	-
Program Planning and Development	-
On-Vessel Costs	162,000
EM Equipment and Software	-
Repair and Support of EM Systems	162,000
Program Admin and Operations Costs	470,118
Program Management	252,000
Management Software and Systems	30,000
EM Submission, Review and Reporting	107,758
EM Video / Data Transmission and Storage	80,361
Total for EM Program	632,118

Table 9: Cost of 100% ASM v. 100% EM Coverage (Scenario Two)

# of Fishing Days	4318 fishing days
Sample FY2018 ASM Rate for 3/4 day (12-18 hr)	\$427.50/fishing day
Total Cost for 100% ASM Coverage	\$ 1,845,945
Total Cost for 100% EM Coverage	\$ 632,118
Average Vessel Cost for 100% ASM Coverage	\$18,459/vessel
Average Vessel Cost for 100% EM Coverage	\$6,321/vessel

Exhibit 2: Using Calculator Project Costs for Sample Vessels

The following tables project costs for a series of different sample vessels, primarily to highlight how costs differ across different vessels. Each of the scenarios uses the baseline assumptions of 100% Electronic Monitoring coverage, 50% video review and no improvements in the video review time from improvements in technologies or processes. These samples are provided to help readers understand how the calculator in the EM model might be used to estimate the cost of electronic monitoring for individual vessels.

Sample Vessel One:

Gear: Trawl
 Length: 45 feet
 Trips per Year: 30 trips
 Trip Length: 18-24 hours
 Hauls per Trip: 4 hauls per trip
 EM Catch Handling Efficiency: Average
 Vessel EM Service Requirements: Average

Estimated Annual (Year 3) Cost for User-Specified Vessel	
Policy, Regulatory and Program Dev Costs	\$ -
Program Planning and Development	\$ -
On-Vessel Costs	\$ 1,620
EM Equipment and Software	\$ -
Repair and Support of EM Systems	\$ 1,620
Program Admin and Operations Costs	\$ 7,744
Program Management	\$ 2,520
Management Software and Systems	\$ 300
EM Submission, Review and Reporting	\$ 4,500
EM Video / Data Storage	\$ 424
Total for EM Program	\$ 9,364

100% ASM Coverage v 100% EM Coverage

# of Fishing Days	30 days
Sample FY2018 ASM Rate for full day (18-24 hr)	\$ 570
Vessel Cost for 100% ASM Coverage	\$ 17,100
Vessel Cost for 100% EM Coverage	\$ 9,364

Sample Vessel Two:

Gear: Gillnet
 Length: 40 feet
 Trips per Year: 50 trips
 Trip Length: 18-24 hours
 Sets per Trip: 3 sets per trip
 EM Catch Handling Efficiency: Average
 Vessel EM Service Requirements: Average

Estimated Annual (Year 3) Cost for User-Specified Vessel	
Policy, Regulatory and Program Dev Costs	\$ -
Program Planning and Development	\$ -
On-Vessel Costs	\$ 1,620
EM Equipment and Software	\$ -
Repair and Support of EM Systems	\$ 1,620
Program Admin and Operations Costs	\$ 9,527
Program Management	\$ 2,520
Management Software and Systems	\$ 300
EM Submission, Review and Reporting	\$ 6,000
EM Video / Data Storage	\$ 707
Total for EM Program	\$ 11,147

100% ASM Coverage v 100% EM Coverage

# of Fishing Days	50 days
Sample FY2018 ASM Rate for full day (18-24 hr)	\$ 570
Vessel Cost for 100% ASM Coverage	\$ 28,500
Vessel Cost for 100% EM Coverage	\$ 11,147

NOTE: In the above two examples, the average trip length is 18-24 hours. As such, the calculator uses an ASM rate for a full day (18-24 hours) rather than the rate for 3/4rd day used for vessels with average trip lengths between 12-18 hours.

As with the above two examples, each of the scenarios uses the baseline assumptions of 100% Electronic Monitoring coverage, 50% video review and no improvements in the video review time from improvements in technologies or processes.

Sample Vessel Three:

Gear: Longline
Length: 40 feet
Trips per Year: 35 trips
Trip Length: 18-24 hours
Sets per Trip: 3
EM Catch Handling Efficiency: Average
Vessel EM Service Requirements: Average

Estimated Annual (Year 3) Cost for User-Specified Vessel	
Policy, Regulatory and Program Dev Costs	\$ -
Program Planning and Development	\$ -
On-Vessel Costs	\$ 1,620
EM Equipment and Software	\$ -
Repair and Support of EM Systems	\$ 1,620
Program Admin and Operations Costs	\$ 6,990
Program Management	\$ 2,520
Management Software and Systems	\$ 300
EM Submission, Review and Reporting	\$ 3,675
EM Video / Data Storage	\$ 495
Total for EM Program	\$ 8,610

100% ASM Coverage v 100% EM Coverage

# of Fishing Days	35 days
Sample FY2018 ASM Rate for full day (18-24 hr)	\$ 570
Vessel Cost for 100% ASM Coverage	\$ 19,950
Vessel Cost for 100% EM Coverage	\$ 8,610

Sample Vessel Four:

Gear: Jig
Length: 38 feet
Trips per Year: 100 trips
Trip Length: 12 hours
Sets per Trip: NA
EM Catch Handling Efficiency: Average
Vessel EM Service Requirements: Average

Estimated Annual (Year 3) Cost for User-Specified Vessel	
Policy, Regulatory and Program Dev Costs	\$ -
Program Planning and Development	\$ -
On-Vessel Costs	\$ 1,620
EM Equipment and Software	\$ -
Repair and Support of EM Systems	\$ 1,620
Program Admin and Operations Costs	\$ 16,735
Program Management	\$ 2,520
Management Software and Systems	\$ 300
EM Submission, Review and Reporting	\$ 12,500
EM Video / Data Storage	\$ 1,415
Total for EM Program	\$ 18,355

100% ASM Coverage v 100% EM Coverage

# of Fishing Days	100 days
Sample FY2018 ASM Rate for 1/2 day (8-12 hr)	\$ 285
Vessel Cost for 100% ASM Coverage	\$ 28,500
Vessel Cost for 100% EM Coverage	\$ 18,355

Exhibit 3: Potential Impact of Catch Handling on EM Costs

Program managers of the EM EFP noted that vessel operators could substantially decrease the amount of time required for video review based on the catch handling processes used; the example below shows how the costs can differ across similar vessels based on different catch handling processes.

Both scenarios use the baseline assumptions of 100% Electronic Monitoring coverage, 50% video review and no improvements in the video review time from improvements in technologies or processes.

Sample Trawl One:

Gear: Trawl

Length: 45 feet

Trips per Year: 30 trips

Trip Length: 18-24 hours

Hauls per Trip: 4 hauls per trip

EM Catch Handling Efficiency: Average

Vessel EM Service Requirements: Average

Estimated Annual (Year 3) Cost for User-Specified Vessel	
Policy, Regulatory and Program Dev Costs	\$ -
Program Planning and Development	\$ -
On-Vessel Costs	\$ 1,620
EM Equipment and Software	\$ -
Repair and Support of EM Systems	\$ 1,620
Program Admin and Operations Costs	\$ 7,744
Program Management	\$ 2,520
Management Software and Systems	\$ 300
EM Submission, Review and Reporting	\$ 4,500
EM Video / Data Storage	\$ 424
Total for EM Program	\$ 9,364

Sample Trawl Two:

Gear: Trawl

Length: 45 feet

Trips per Year: 30 trips

Trip Length: 18-24 hours

Hauls per Trip: 4 hauls per trip

EM Catch Handling Efficiency: 30% Better

Vessel EM Service Requirements: Average

Estimated Annual (Year 3) Cost for User-Specified Vessel	
Policy, Regulatory and Program Dev Costs	\$ -
Program Planning and Development	\$ -
On-Vessel Costs	\$ 1,620
EM Equipment and Software	\$ -
Repair and Support of EM Systems	\$ 1,620
Program Admin and Operations Costs	\$ 6,394
Program Management	\$ 2,520
Management Software and Systems	\$ 300
EM Submission, Review and Reporting	\$ 3,150
EM Video / Data Storage	\$ 424
Total for EM Program	\$ 8,014

Appendix A: Management Objectives and Standards for FY2018 Electronic Monitoring Programs

Management Objectives:

- Collect date, time and location of fishing events in EM data and in vessel fishing logs;
- Collect imagery of entire fishing trip of such quality to allow for identification of all discard events;
- Collect imagery of entire fishing trip of such quality to ensure groundfish vessels with authorization to fish in specified closed areas while on a groundfish trip do so with only authorized gear;
- Collect imagery of entire fishing trip of such quality to ensure those groundfish vessels with authorization to fish for bluefin tuna do so with only authorized gear and do so in compliance with existing Atlantic Highly Migratory Species' regulations;
- Collect imagery of catch processing of such quality that:
 - discarded, regulated groundfish species can be identified, counted and measured;
 - high-volume discard events of regulated groundfish may be subsampled according to a NMFS-approved subsampling protocol
 - discarded, legal-sized unmarketable groundfish species can be identified, counted and measured;
 - discarded prohibited species (marine mammals, sea turtles, seabirds, etc.) can be identified;
 - discard events of species other than regulated groundfish (e.g., skates, dogfish, monkfish) can be confirmed not to include regulated groundfish.
- Capture weights from skipper visual estimates and counts of discarded regulated groundfish species by fishing effort (e.g., haul) in fishing logs.

Standards:

- Each participating vessel carries on board a unique VMP that describes the installation and placement of the EM system, catch handling requirements, operator responsibilities and other requirements for using EM for sector trips and, if appropriate, switching to tuna trips.
- Vessels fall into one of three categories:
 - those *required* to use EM on trips that have an observer from the Northeast Fishery Observer Program (NEFOP) and on trips that would otherwise have an at-sea monitor (ASM) (14%);
 - those *required* to use EM on 100% of sector trips (groundfish, monkfish, skate and dogfish);
 - those *required* to use EM on 100% of sector trips (groundfish, monkfish, skate and dogfish trips) and while on a groundfish trip but fishing for tuna in Federal waters with an Atlantic Tunas General category permit.
- No dockside monitoring.
- EM cameras record 100% of the trip, including all fishing activity.
- Video reviewers review 100% of all fishing activity.
- NMFS audits video reviewers to verify accuracy of EM data collected (aka secondary review).
- Video archived for a minimum of three years from date of collection.

Appendix B: Cost Summary of New England Groundfish Fishery's FY2017 Experimental Electronic Monitoring Program

Purpose of Cost Summary of the FY2017 Experimental Electronic Monitoring Program

Experimental electronic monitoring (EM) programs have now been operating in the Northeast Multispecies Fishery (New England Groundfish Fishery) under the authority of exempted fishing permits (EFPs) granted by National Marine Fisheries Service (NMFS) since May 1, 2016. Several organizations, including The Nature Conservancy, the Maine Coast Fishermen's Association and the Cape Cod Commercial Fishermen's Alliance, have played a role in these EM programs. Ecotrust Canada (Ecotrust), with support from the Gulf of Maine Research Institute, was the EM service provider for the experimental EM program for the 2017 Fishing Year (May 1, 2017 – April 30, 2018).

By the end of the 2017 Fishing Year (FY2017), EM systems had been installed on eighteen vessels, fifteen of which ran EM on at least one sector trip in FY2017. The vessels ranged in length from 35 feet to 65 feet and represented home ports from four states (Maine, New Hampshire, Massachusetts, Rhode Island). They represented five sectors (Fixed Gear Sector, Maine Coastal Community Sector, Northeast Fishery Sector V, Northeast Fishery Sector XI and Sustainable Harvest Sector 3) and four gear types (gillnet, jig/rod-and-reel, longline and trawl). The EFP vessels took 276 trips with EM videos in FY2017.

This document summarizes the cost of establishing and operating the experimental EM program in FY2017. These costs were covered by grants from National Fish and Wildlife Foundation (NFWF) and project partners. *The cost summary does not include the significant investment over many years by partner organizations to promote, set up and support the program.* It also does not estimate the cost to NMFS of administering the EFPs.

Overview of Electronic Monitoring in the Northeast Multispecies Fishery

The EM programs were designed to achieve the following objectives:

Compliance Objectives:

- Verify vessels are fishing in authorized areas with approved gear.
- Verify vessels comply with regulations related to discards on sector trips of: (a) regulated groundfish species, (b) prohibited species (e.g., marine mammals, sea turtles, seabirds).

Fishery Management Objectives:

- Calculate Annual Catch Entitlement (ACE) Discards: Quantify discards of groundfish species and fishing information (date/time/location).
- Test Selectivity of Certain Gear Types in Closed Areas: Collect information to evaluate the ability of certain gear types to target pollock, haddock, white hake, redfish and other abundant stocks selectively while avoiding cod in certain groundfish closed areas.

Scientific Assessment Objectives:

- Inform Stock Assessments: Increase amount of groundfish discard data available for stock assessments.

Appendix A1 details the management objectives and standards for the experimental EM program in FY2017.

Description of EM Budget Categories

As detailed in the table below, some EM program costs are incurred at the programmatic level as one-time investments (e.g., refine and receive approval from NMFS for EM protocols and standards), others are at the vessel level as either capital investments (e.g., purchase and installation or EM equipment) or on-going expenses (e.g., repair of EM equipment), and others at the programmatic level as annual operating expenses (e.g., program management) or variable costs that depend on the number of trips taken (e.g., EM video review). The chart below summarizes these budget categories.¹²

Table 1: Descriptions and Examples of EM Budget Categories for New England Groundfish Fishery

Budget Category	Description of Budget Category	Examples
Policy, Regulatory and Program Development Costs		
Program Planning and Development	Tasks which provide the foundation of the program over many years, such as initial data exchange protocols and resolution of how species coding by different data collection sources. These system-level tasks provide the foundation for an operating EM program for many vessels over many years.	<ul style="list-style-type: none"> • Develop and receive approval from NMFS for EM protocols and standards (for EFP). • Develop and refine fish handling protocols for a variety of gear types and fishing areas to ensure accurate identification and measurement of all discarded regulated groundfish species. • Develop and refine protocols for estimating discards where species, disposition or measurement cannot be derived from a video.
On-Vessel Costs (Installation, Operation and Repair of EM Hardware)		
EM Equipment and Software	Purchase, shipping and installation of EM hardware on vessels.	<ul style="list-style-type: none"> • EM Box • Cameras
Repair and Support of EM Systems	Tasks related to ensuring EM hardware on vessels is operating properly and catch handling processes are enabling EM video review.	<ul style="list-style-type: none"> • Pre-season maintenance and equipment check • On-call and on-site support to troubleshoot EM technical issues • Cost of components of EM systems required for repairs • Feedback on trips and refresher trainings to vessel operators • Technical support for maintenance and repair of EM systems • On-call and on-site software support to vessels
Program Administration and Operations Costs		
Program Management	Tasks that must occur annually for the program to operate, to some extent regardless of the number of vessels or trips. They include senior management engagement in the review and refinement of the program – as well as the day-to-day management of the program by staff.	<ul style="list-style-type: none"> • Train vessel operators on EM processes. • Revise Vessel Monitoring Plans. • QA and transfer of data from EM reviewers to NMFS. • Annual audit of EM processes and results to ensure accurate third-party accounting of regulated groundfish discards.
Management Software and Systems	Purchase and customization of software used to review EM videos and to transfer data from the service provider to NMFS.	<ul style="list-style-type: none"> • Software licenses and installation. • Customization of software to interface with NMFS systems and to align with new standards from regulators. • Upgrades to software to reduce video review time.
EM Submission, Review and Reporting	Upon completion of each trip (or after several trips recorded on a single hard drive), the vessel operator mails the hard drive with a video record of the fishing trip(s) to a program office for review. In FY2017, the program staff reviewed 100% of the video from the fishing trip, including a rapid initial review of the entire trip and a detailed review of all the fishing efforts and discards.	<ul style="list-style-type: none"> • Transmission of EM video from vessel to reviewer • Review of 100% trips and quantification of discards of species by length • Trip reporting to NMFS, sector and vessel operator
EM Video / Data Storage	After the review of the EM video has been completed, it must be stored to allow for future reviews or audits. In FY2017, EM video was stored on servers and archival disks at program offices.	<ul style="list-style-type: none"> • Servers, archival disks and other equipment for data storage • Subscription costs for long-term data storage

This report associates the actual costs of the FY2017 Experimental EM Program to each of the above categories.

¹² The EM categories for New England have been developed based on past work in categorizing EM program expenses. The above categories draw heavily on the following report: MRAG Asia Pacific, "Cost Recovery Guidelines for Monitoring Services." September 2018. They also reflect actual line items expensed by service providers supporting the New England EM EFPs from 2016-2019.

Factors Affecting the Calculation of the Cost of the FY2017 EM Program

Find below several factors that affected the cost of the EM program in FY2017:

- (8) Eighteen vessels of between 30 and 75 feet long were equipped to use EM in the EFP.

Table 2: Profile of Vessels Participating in EM Program in FY2017

# of Participating Vessels (FY2017) Configured with...	Less than 30 ft	30 to 50 ft	50 to 75 ft	75 ft and above	All
Gillnet	0 vessels	5 vessels	1 vessels	0 vessels	6 vessel(s)
Jig/Rod-and-Reel	0 vessels	3 vessels	0 vessels	0 vessels	3 vessel(s)
Longline	0 vessels	4 vessels	0 vessels	0 vessels	4 vessel(s)
Trawl	0 vessels	1 vessels	4 vessels	0 vessels	5 vessel(s)
Total	0 vessel(s)	13 vessel(s)	5 vessel(s)	0 vessel(s)	18 vessel(s)

- (9) The average cost to purchase and install EM equipment was approximately \$8,000 per vessel.

Table 3: Average Cost of EM Equipment Installed on Vessels for FY2017

Equipment or Installation Type	Average Cost per Unit	Average # of Units per Vessel	Est. Cost per Vessel
Hardware			
Electronic Monitoring Box	\$ 3,000	1 unit(s)	\$ 3,000
PoE Switches	\$ 350	1 unit(s)	\$ 350
Removable harddrives	\$ 100	2 unit(s)	\$ 200
Monitor and keyboard	\$ 100	1 unit(s)	\$ 100
GPS Units	\$ 150	1 unit(s)	\$ 150
Cameras	\$ 400	3 unit(s)	\$ 1,200
Marine Grade Wire & Ethernet Cable	\$ 250	1 unit(s)	\$ 250
Tools for EM Systems	\$ 60	1 unit(s)	\$ 60
Shipping / import fees for equipment	\$ 150	1 unit(s)	\$ 150
Installation Costs			
Installation of EM systems on vessels	\$ 2,500	1 install	\$ 2,500
Remote support for installation	\$ 200	1 install	\$ 200
Total - One-Time Costs for New Participants			\$ 8,160

- (10) EM service providers (and fishermen, project partners and NMFS) were required to develop, evaluate and refine policies, processes and systems in FY2017. These initial investments will last several years and not be repeated in future years. To account for “start-up” activities needed to establish the EM program, the cost summary assumes that 80% of senior leadership’s time in FY2017 was spent on activities related to “Program Planning and Development.” EM service provider estimated senior staff dedicated over ten times more time to this program than they do to established EM programs.

- (11) Technical staff of the EM service provider reported dedicating a significant portion of time to adjusting and upgrading equipment and software to incorporate new technologies and new requirements. As such, the cost summary assumes that 67% of the on-going technical support and 70% of the on-going software support was spent on activities related to “Program Planning and Development.”

- (12) Standard accounting practices amortize startup costs over a fifteen-year period for tax purposes. We have followed this amortization schedule for costs associated with “Program Planning and

Development," assuming that the start-up tasks (e.g., system interfaces and protocols, EM standards and policies) would be part of an EM program of similar scope and scale in the future.

- (13) EM service providers reviewed 100% of the video on 100% of the trips. They reviewed both those trips that were submitted to the Greater Atlantic Regional Fisheries Office (GARFO) and those that were not submitted to GARFO ("failed" videos that have been used to improve the program).
- (14) The cost for 100% video review is based the amount of time required to review entire individual fishing trips. In FY2017, the amount of time required to review 100% of the fishing events (e.g., hauls, sets) on a single trip differed by gear used. Other factors, including whether the regulated discards happen in real-time while the fish are being sorted, at the end of a fishing effort or at the end of the trip, also affect the time required to review videos. The table below provides estimates of the cost per fishing effort (e.g., per haul for a trawler) and a sample of the cost per trip based on 100% review in FY2017.

Table 4: Average Cost of 100% EM Video Review per Trip by Gear in FY2017

	Jig/Rod-and-Reel	Gillnet	Longline	Trawl
Ave. Hours of 100% Review per Fishing Event	6.0 hrs	1.6 hrs	1.5 hrs	1.8 hrs
Ave Cost per Fishing Event	\$269/day	\$71/set	\$67/set	\$80/haul
Ave # of Fishing Events per Day	Same as Day	4 sets/day	5 sets/day	4 sets/day
Ave Cost of 100% EM Review per Day Trip	\$269/fishing day	\$284/fishing day	\$333/fishing day	\$320/fishing day

- (15) Video and data for the EM EFP were stored on hard drives and servers purchased for this EFP. The costs for data transmission and storage thus reflect the shipping and storage of data on such equipment (not on Internet-based systems such as Amazon Web Services).

Cost of the FY2017 EM Program

Upfront Capital Requirements for the FY2017 EM Program

Developing and operating the EM program in FY2017 required approximately \$500,000 in capital expenditures. The expenses included start-up costs for developing and refining the program in 2016 and 2017, purchasing equipment and software for 18 vessels, researching and testing new equipment and technologies, training and providing feedback to fishermen on EM systems, and reviewing 100% of the trips with EM videos recorded.

Table 5: Total Investment Required for FY2017 EM Program

Total Investment Required for FY2017 EM Program			Notes
Policy, Regulatory and Program Development Costs			
Program Planning and Development	\$	150,119	Includes start-up and program development costs from FY2016
On-Vessel Costs			
EM Equipment and Software	\$	146,880	Includes cost of equipment for the FY2017 vessels
Repair and Support of EM Systems	\$	36,805	Includes services and support provided in FY2017
Program Admin and Operations Costs			
Program Management	\$	53,778	Includes program management provided in FY2017
Management Software and Systems	\$	37,718	Includes shared system costs from FY2016 and FY2017
EM Submission, Review and Reporting	\$	77,615	Includes review and reporting of videos from FY2017
EM Video / Data Transmission and Storage	\$	8,716	Includes equipment and storage costs from FY2016 and FY2017
Total for EM Program	\$	511,630	

Annualized Total Cost for the FY2017 EM Program

Over half of the capital expenditures for FY2017 were investments in the program and in equipment and software that last beyond one fishing year. When such capital expenditures are annualized,¹³ the annual cost of the services and equipment needed to run the EM EFP program for FY2017 was approximately \$235,000.

Table 6: Total Annualized Costs for FY2017 EM Program

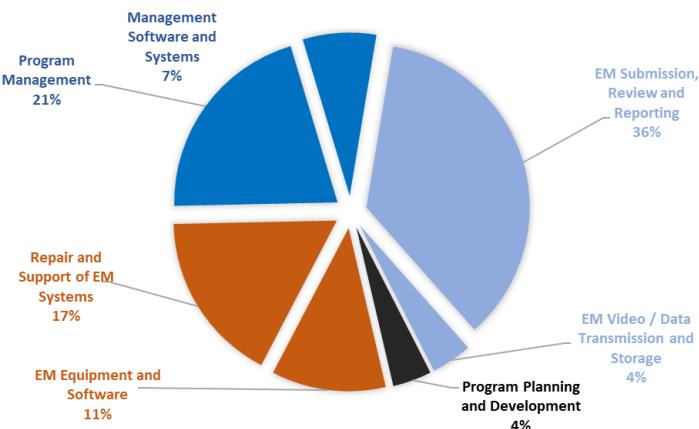
Total Annualized Costs for FY2017 EM Program			Notes
Policy, Regulatory and Program Development Costs			
Program Planning and Development	\$	10,008	FY2016 and FY2017 PPD costs depreciated over 15 years
On-Vessel Costs			
EM Equipment and Software	\$	29,376	Equipment costs depreciated over 5 years
Repair and Support of EM Systems	\$	36,805	
Program Admin and Operations Costs			
Program Management	\$	53,778	
Management Software and Systems	\$	18,859	Average of FY2016 and FY2017 costs
EM Submission, Review and Reporting	\$	77,615	100% video review of 276 trips
EM Video / Data Transmission and Storage	\$	8,716	
Total for EM Program	\$	235,156	

¹³ Capital expenditures represent the amount of funds required to start and operate a program. Such capital expenditures (e.g., start-up costs, R&D, equipment) frequently are used over multiple years and, as such, should be depreciated by the number of years likely utilized to reflect the cost on an annual basis.

Distribution of FY2017 Annualized Costs by Budget Category

When annualized, nearly two-thirds of the costs of the FY2017 EM program were for Program Administration and Operations (represented by the dark blue and light blue slices in the pie graph to the right).¹⁴ These costs include EM Submission, Review and Reporting (36% of total costs), which represents the time required of program staff to review 100% of the fishing trips, including a rapid initial survey of the entire trip and a detailed review of all the fishing efforts (e.g., all the hauls for a trawler, all the sets of a gillnetter) and discards. The program staff used this 100% video review to account for all discarded groundfish by length and species.

Chart 1: Distribution of FY2017 Annual Costs by Budget Category



Average Annual Cost per Vessel for the FY2017 EM Program

The fifteen vessels which submitted a trip for EM review in FY2017 took an average of 18 trips each. The average annual cost per vessel for the FY2017 EM program was approximately \$15,000. As noted on the first page, these costs were covered by grants from NFWF. The cost per vessel varied based on catch handling practices, gear types, discard rates and other factors. This average cost includes fixed costs, such as Management Software and Systems, which would be lower with more vessels in the program.

Table 7: Average Annual Cost per Vessel for FY2017 EM Program

Average Annual Cost per Vessel for FY2017 EM Program			Notes
Policy, Regulatory and Program Development Costs			
Program Planning and Development	\$ 556		Allocates costs across all vessels signed up for FY2017 EFP
On-Vessel Costs			
EM Equipment and Software	\$ 1,632		Allocates costs across all vessels signed up for FY2017 EFP
Repair and Support of EM Systems	\$ 2,454		Allocates costs across all vessels active in the FY2017 EFP
Program Admin and Operations Costs			
Program Management	\$ 2,988		Allocates costs across all vessels signed up for FY2017 EFP
Management Software and Systems	\$ 1,048		Allocates costs across all vessels signed up for FY2017 EFP
EM Submission, Review and Reporting	\$ 5,174		Allocates costs across all vessels active in the FY2017 EFP
EM Video / Data Transmission and Storage	\$ 581		Allocates costs across all vessels active in the FY2017 EFP
Ave. Cost per Vessel for EM Program	\$ 14,432		

¹⁴ In thinking about this distribution, it is important to remember that significant technical support for EM systems is especially needed in the first years that vessels utilize EM systems. As stated by the technical manager of the program, “The developmental nature of this program is responsible for many of the (vessel) service calls. (At the request of a fisherman or the agency,) we are trying new things, adjusting Vessel Monitoring Plans (VMPs), adjusting cameras, adding new gear types...fairly often.” To reflect this reality, the cost of providing technical support to vessels was divided between the two budget line items: Program Planning and Development (Policy, Regulatory and Program Development Costs) and Services and Support for EM Systems (On-Vessel Costs).

Conclusion

The experimental EM programs in the Northeast Multispecies Fishery for FY2016, FY2017 and now FY2018 were developed to validate that the objectives for which they were designed could be achieved. Many of the costs associated with the EM program in FY2017 were investments of time and money into the foundation of a more scalable, EM program in future years. Additionally, the costs of this EM program reflect the time required to review 100% of the EM videos. The EFPs in FY2018 began testing an audit-based video review model (standard in other fisheries with EM). An audit-based EM program would substantially reduce the time required to review EM videos – as well as the cost for doing so. In addition, the EM service providers began implementing changes in technology that are expected to reduce the amount of time required to review videos of each fishing trip. The efficiencies resulting from the changes in technology were not yet reflected in the costs of the program in FY2017.

In short, the costs presented above represent those of an experimental program that tested new processes and technologies, that established a fully operational program and that met the objectives of the EFP. As the program evolves from the experimental and development stage to an established and operational stage, it is reasonable to expect the per vessel costs will decrease, some modestly and some significantly.

Appendix A1: Management Objectives and Standards for FY2017 Electronic Monitoring Programs

Management Objectives:

- Collect date, time and location of fishing events in EM data and in vessel fishing logs;
- Collect imagery of entire fishing trip of such quality to allow for identification of all discard events;
- Collect imagery of entire fishing trip of such quality to ensure groundfish vessels with authorization to fish in specified closed areas while on a groundfish trip do so with only authorized gear;
- Collect imagery of entire fishing trip of such quality to ensure those groundfish vessels with authorization to fish for bluefin tuna do so with only authorized gear and do so in compliance with existing Atlantic Highly Migratory Species' regulations;
- Collect imagery of catch processing of such quality that:
 - discarded, regulated groundfish species can be identified, counted and measured;
 - discarded, legal-sized unmarketable groundfish species can be identified, counted and measured;
 - discarded prohibited species (marine mammals, sea turtles, seabirds, etc.) can be identified;
 - discard events of species other than regulated groundfish (e.g., skates, dogfish, monkfish) can be confirmed not to include regulated groundfish;
 - unauthorized discards of hake species (white, red, silver and offshore) which should be retained and landed can be identified.
- Capture weights from skipper visual estimates and counts of discarded regulated groundfish species by fishing effort (e.g., haul) in fishing logs.

Standards:

- Each participating vessel carries on board a unique VMP that describes the installation and placement of the EM system, catch handling requirements, operator responsibilities and other requirements for using EM for sector trips and, if appropriate, switching to tuna trips.
- Vessels fall into one of three categories:
 - those *required* to use EM on trips that have an observer from the Northeast Fishery Observer Program (NEFOP) and on trips that would otherwise have an ASM (14%);
 - those *required* to use EM on 100% of sector trips (groundfish, monkfish, skate and dogfish);
 - those *required* to use EM on 100% of sector trips (groundfish, monkfish, skate and dogfish trips) and while on a groundfish trip but fishing for tuna in Federal waters with an Atlantic Tunas General category permit.
- No dockside monitoring.
- EM cameras record 100% of the trip, including all fishing activity.
- Video reviewers review 100% of all fishing activity.
- NMFS audits video reviewers to verify accuracy of EM data collected (aka secondary review).
- Video archived for a minimum of three years from date of collection.

NOTE: The management objectives and standards above were for the FY2017. Updates and slight changes were made for the FY2018.