Maximized Retention Electronic Monitoring in the Northeast Multispecies Groundfish Fishery

ECONOMIC REPORT

Kanae Tokunaga
Vivianne Mazzocco
Elizabeth Moore

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Contact information and citation

For inquiry, contact Kanae Tokunaga (ktokunaga@gmri.org).

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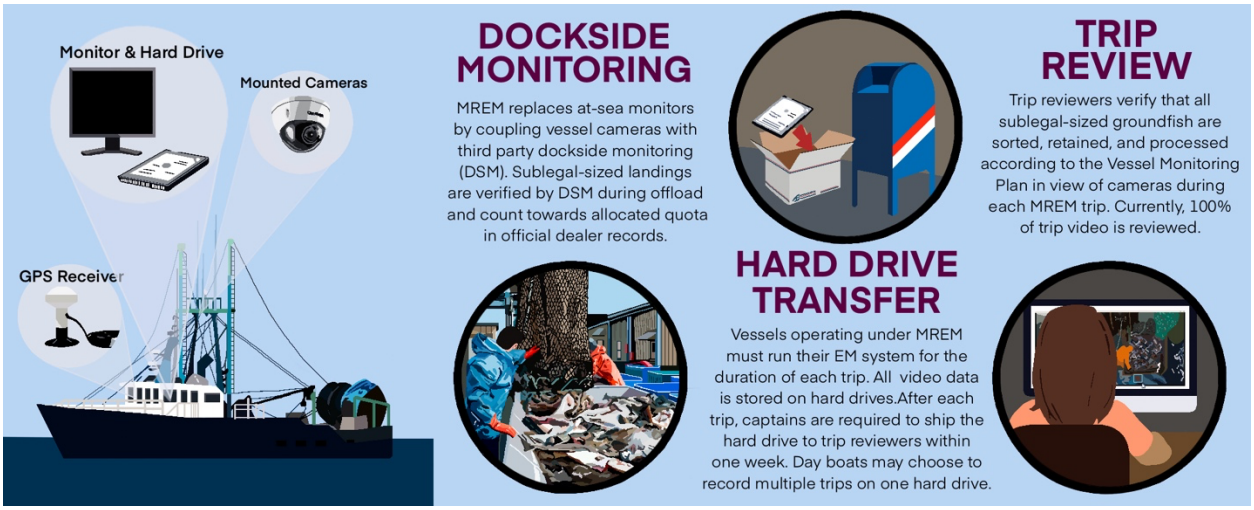

Nuts and bolts of maximized retention electronic monitoring

1. Introduction

The Maximized Retention Electronic Monitoring (MREM) model is presently approved to test out on up to eight vessels in the Northeast Multispecies Groundfish Fishery[i] under an Exempted Fishing Permits (EFP) issued by NOAA Fisheries This report summarizes the costs observed during the MREM pilot program and estimates the costs of MREM as a monitoring option for Northeast Multispecies (Groundfish) Fishery sectors.

Quota-based fisheries management requires detailed information on all retained fish (i.e., landed and sold) and all discards. This includes records on the species, quantity, and capture location for both categories[1]. Landings from all trips are recorded in Vessel Trip Reports (VTRs) by vessel captains and landed catch is documented by commercial dealers in dealer reports. Vessel captains are required to include discarded catch in their VTRs; and trip-level discards are approximated using discard weight estimates recorded by at-sea monitors on a subset of all sector fishing trips. The At-Sea Monitoring program is designed to collect information for quota monitoring in the Northeast Multispecies Fishery.

Under Amendment 23, it is expected that two options for electronic monitoring (EM) will become implemented for all fishing vessels in multispecies sectors as a monitoring tool and alternative to ASM for quota monitoring and catch accounting purposes. The options include maximized retention as well as an audit approach to EM. The audit model is currently operational as a monitoring option through approved Sector Operations Plans. The focus of this report is on the Maximized Retention EM (MREM) model, which is currently in development. The MREM program was designed as an electronic monitoring option for large volume vessels, targeting the component of the fleet that lands more than 25,000 pounds of catch per trip. Therefore, the cost efficiency of MREM is expected to be correlated with vessel size, trip type, number of trips, landings, and catch composition. Recent comparisons of EM costs suggest that all vessels fishing more than 50 days will indeed incur lower costs under EM than the conventional ASM option[1].

1.1. Aim of this report

This report summarizes the findings from the economic analysis of the MREM model, which assembled economic information collected through the MREM EFP period. The maximized retention model allows fishers to retain all nine allocated groundfish species (including sub-legal and damaged catch) and red hake[ii]. The MREM model was initially proposed as a cost-effective and comprehensive EM program, which, through effective alignment with management goals, could lead to improved economic performance of the fleet while simultaneously improving catch accounting.

The economic analysis was conducted to provide detailed understandings of costs and benefits associated with operating under MREM in the Northeast Multispecies Fisheries. In other words, this analysis aims to help commercial fish harvesters evaluate the feasibility of operating under MREM. This report answers the following questions: 1) what is the total costs of MREM, including program administrative and equipment costs? 2) what is the breakdown of the costs associated with MREM? 3) what are the challenges and opportunities for commercial fish harvesters to operate under MREM? and 4) what are the possible changes in costs and benefits when MREM is implemented full scale?

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[i] Under the MREM program, vessels must retain all Atlantic cod, haddock, pollock, Acadian redfish, American plaice, white hake, winter flounder, witch flounder, and yellowtail flounder. Because of the difficulty in distinguishing white hake from red hake using cameras, all catch of both species must be retained. Unallocated groundfish (e.g., windowpane flounder, ocean pout, wolffish) and non-groundfish species must be handled within view of cameras and promptly returned to the water, following standard regulations).

[ii] Allocated groundfish species are cod, haddock, white hake, pollock, redfish, American plaice, winter, witch, and yellowtail flounder. Red hake was excluded from this criterion (see footnote 1). Prohibited groundfish and non-groundfish species were also excluded from the economic analysis.

1.2. Key attributes of Maximized Retention Electronic Monitoring

Under MREM, vessels are required to retain and land all allocated groundfish species regardless of size or condition. The maximized retention replaces ASM of allocated groundfish discards, and the camera system determined compliance with the retention requirements. The EM component works in tandem with dockside monitoring (DSM) to account for the groundfish that are landed, and provide full accountability In the MREM program, all groundfish trips offloads are observed. All landed allocated groundfish, regardless of size or condition, count against quota and are reported through dealer reports.

Vessels that operate under MREM must run the EM system for the entire duration of every groundfish trip, meaning that the system must be turned on upon leaving the dock and kept on until the vessel finishes the final offload. For much of the EFP period, the EM data was stored in hard drive, and the vessels were required to submit the data via physical mail to EM video reviewer within seven calendar days. The vessels were also required to communicate with Northeast Fishery Science Center's (NEFSC) Fishery Monitoring and Research Division personnel to coordinate DSM at a minimum 48 hours before arriving to port to ensure coverage for offload monitoring. During the EFP period, the DSM component was led by NOAA's NEFSC.

Vessels were also required to retain all allocated groundfish, including those that are sublegal-size, damaged or unmarketable. All allocated groundfish were required to be retained, landed and sorted to the species level. Other species, including prohibited groundfish species, were allowed or required to be discarded in accordance with standard fishery regulations.

2. Methods and data

The economic analysis consisted of 4 steps: 1) data collection 2) calculation of program costs from the current implementation, 3) estimation of the costs from expanded implementation, and 4) discussion of the benefits from the implementation of the MREM model. Because the MREM program requires vessels to land sub-legal sized groundfish, there is a potential to earn additional income from those catches depending on the availability of markets. Based on the landings and market categories recorded in the program data collected by NOAA, we also examined potential marketability of sub-legal landings as well as costs associated with retaining sublegal-size landings.

We include actual costs incurred by EM service providers during the experimental MREM program as reference points in addition to numbers published in previous studies. Our analysis combines numbers from existing reporting documents, recorded program costs, other economic analyses on EM and from industry experts and service providers. Numeric data is aggregated and approximated to conceal confidential information. Because we rely on information collected during the EFP period, many of the other assumed costs may be higher than the true costs of an operational program. We therefore implemented several data ranges to provide most robust estimates and provided a sensitivity analysis as an Appendix to this report.

2.1. Data collection

The economic analysis utilized three kinds of information: 1) a comprehensive program data set from the first three years of the MREM pilot program led by the GMRI[iii], 2) information collected through a series of interviews of fish harvesters who operate under MREM, fish harvesters interested in operating under MREM, and dealers and processors who source fish from those harvesters, and 3) EM costs and associated information reported in published reports.

2.1.1. Data collected during the MREM pilot program

We assembled the cost and operational information during the EFP period of the MREM program. Drawing MREM trip information from May 2020 and December 2021, a total of seven vessels were enrolled in the MREM pilot program and had been on at least one EM trip. During this period, more than 250 MREM trips were made by these vessels. Vessels range in length from about 40 to 100 feet long. While all seven vessels use trawl gear, mesh size varies by vessel. The vessels participated in the MREM pilot program also differ in operational characteristics. For this study, based on their operational characteristics, we group the seven vessels into two groups: low-volume vessel (<10,000 pounds of catch landed per trip) and high-volume vessel (>25,000 pounds of catch landed per trip).

2.1.2. Interviews

To collect information on 'soft-costs' not captured by typical data streams, we collected information related to 1) fishing operation behaviors and operational costs during pre-MREM and MREM periods, 2) opportunities and barriers to selling and marketing sub-legal species, 3) sales volume and values of fish harvested by the harvesters operating under MREM. We conducted semi-structured interviews with industry members, including sector manager, captains and/or owners of vessels participating in the MREM pilot program, prospective vessel operators who expressed interests in MREM, dealers and processors who bought from the vessels participated in the MREM pilot program. Interview took place during the summer (June through September) of 2021.

Many of the initial interview questions were informed by program discussions that took place at two program meetings hosted by GMRI during the EFP period to gain understanding of participant's challenges and successes associated with operating under MREM. Further, we solicited expert input from Sector Managers who administered the vessels participating in the MREM and an EM service provider contracted for this pilot program.

2.1.3. Existing EM cost studies for the New England Multispecies Groundfish Fishery

We have also surveyed papers and reports that conducted economic analysis of EM. Among the published literature, two reports provided extensive and detailed information associated with EM implementation in Northeast Multispecies Groundfish Fishery[1,2]. We referenced these two reports to cross check our estimations. Further, when sufficient cost information was not available from the pilot program data and interviews, we used the cost information reported in these reports to derive aggregate or mean values.

[iii] Because a unique aspect of the MREM program is retaining undersized fish, the analysis included costs associated with landing the extra catch. NOAA's dockside monitoring data was used to calculate the ratios of sublegal-sized landings in total catch. The dockside monitoring has two market categories used to record sublegal-size fish landings made by MREM trips: 1) a category that includes only sublegal-size fish, and 2) a category that includes a mix of sublegal- and the smallest legal-sized category for three high volume species (redfish, pollock and haddock). Based on this categorization scheme, we defined the lower-bound estimate of the sublegal-size catch ratio to only include the fish that are marked as category 1) and the upper-bound estimate of the sublegal-size catch ratio to include fish that are marked either as category 1) or 2)

2.2. Analysis framework

2.2.1. Operational assumptions and scenarios

In our analysis, we estimated the MREM cost for two types of groundfish operations: low-volume vessel operation and high-volume vessel operation (Table 1). Low-volume vessel operation assumes 15-hour operation and 100 fishing trips per year. High-volume vessel operation assumes a trip that spans 7.3 days with 200 days at sea, which is equivalent to 27 fishing trips. For both operational types, we assume trawl gear.

Table 1. Baseline operational assumptions

	Low-volume vessel	High-volume vessel
Trip length	15 hours	176 hours (= 7.3 days)
Number of days at sea	100 days	200 days
Number of trips per year	100 trips	27 trips
Gear type	Trawl	

We examined four implementation scenarios. The baseline scenario represents the status-quo, which captures the MREM costs as implemented through the EFP. The other scenarios are informed by the current knowledge of MREM implementation and assumes 50% trip review rate and reduced DSM cost due to transition of the program to an industry-funded, third-party model and further development of program standards.

For our purposes, all costs were assumed to be static, meaning we assume no inflation. Our assumption of no inflation concerns the calculation of recurring costs, namely, labor costs and data storage cost included in this study. Further, the actual costs associated with a full-fledged operational program will depend on many factors, not all of which can be captured in this analysis, including the total number and type of vessels that opt into the program, the number and duration of fishing trips and the gear-types employed by participating vessels. Instead, we came up with most likely cost scenarios for the implementation of MREM and derived conservative cost estimates. We base implementation scenarios and operational assumptions about various existing and anticipated cost-driving factors based on the interviews and personnel involved administrating the MREM pilot program.

2.2.2. Cost estimation time frame

EM programs require upfront investments that last multiple years (e.g., *Program Planning and Development*) as well as recurring fixed costs each year regardless of the number of trips recorded (e.g., *Program Management*). Other expenses depend directly on the number of trips taken (e.g., *EM Submission, Review, and Reporting*). Based on our conversation with EM service providers, we determined to provide the cost estimation for the five year of operation under MREM. In other words, if a vessel chooses MREM as a monitoring option, we assumed that the vessel would operate under MREM for five years. During this period, all EM hardware are assumed to be fully depreciated. To calculate annual cost, we divided the total equipment cost by five (i.e., we applied straight line method to calculate depreciation).

Table 2. Components, unit cost, and life

Cost component	Items included	Baseline (status-quo) assumptions
Equipment	• Cameras • GPS receiver • Hard drives • Other components for a full EM system install	• 5-year system life
Technical support	• Installation • On-site maintenance • Remote maintenance	• 100 roundtrip mile travel for install and on-site maintenance work • One vessel visit every four weeks
Video review	• Trip review • Software license & short-term data storage • Long-term data storage	• 100% review ratio (during the EFP period, all trips were reviewed) • Short-term data storage that allows for immediate data access (i.e., live data storage)
Dockside monitoring	• Travel • Offload observation	• 40 roundtrip mile travel for each offload • Low-volume boat: 4 labor hours, of which 55% spent on biological sampling (length measurements) • High-volume boat: 10 labor hours, of which 38% spent on biological sampling
Operational	• Vessel monitoring plan development • Hard drive postage fee	• Monitoring plan developed upon participating in the program • Low-volume boat: ship hard drive every 5-7 days • High-volume boat: ship hard drive after each trip

3. MREM cost components considered by this analysis

Table 2 breaks down the various cost components of the MREM considered in the analysis. The cost component follows the cost categories that are reimbursable by NOAA Fisheries to support EM monitoring for the 2021 and 2022 fishing year[3]. The NOAA-determined categories are as follows: equipment cost, technical support cost, video review cost, and operational cost. In addition to these categories, we also examined cost associated with DSM, which is a required program component for the maximized retention model. Under the EFP, the dockside monitoring program is led by NOAA and is not included in the cost-category reimbursements. The following sections describes the items considered under each cost category and key assumptions made to estimate the costs.

3.1. Equipment cost

The first cost category is the equipment cost. This category includes the cost of hardware required to make install a fully functional EM system. The hardware required for each vessel are variable and depend on the size and organization of the deck and the setup of the sorting area. There are also several custom technical options that can be added to the systems to accommodate the needs of a particular vessel or suit the preferences of an operator, which can affect EM equipment costs. In our analysis, we assumed sufficiently general and conservative system setup that consists of four cameras, one GPS receivers, 3-4 hard drives, and other smaller components (see Table 3 for the full list of items included).

Table 3. EM system components (typical groundfish vessel)

Items	Number of items required	Assumed life (years)
Cameras	4	5
GPS receiver	1	5
Hard drives	3 - 4	5
Other		
Ethernet cable	1	5
Ethernet heads	1	3
Cable	1	5
Cable glands	1	5
Assorted mounting hardware	1	5
Monitor & keyboard	1	5
Server	1	5
Uninterrupted Power Supply (AC)	1	5
USB extenders	1	5
Wi-Fi antenna	1	5
Cellular antenna & splitter	1	5

3.2. Technical support cost

Technical support cost includes all costs associated with field and remote-based technical support. Specifically, this category includes all labor costs associated with installing and maintaining the EM system. This cost category is further broken down into the initial expenses of equipment and

installation and recurring costs of follow-up system maintenance, remote and on-site technical support, and repairs.

It is not anticipated that MREM vessels will be subject to regularly scheduled maintenance of their EM systems. Instead, all maintenance and repairs occur as necessary, per the individual needs of each vessel. For the majority of maintenance issues, it is assumed that the wireless cellular components of the system could allow EM technicians to conduct remote support services, which significantly reduces the total travel time required by in-person technical support. Therefore, technicians only need to provide on-vessel service for particular EM system issues.

While majority of the remote support is considered routine or minor maintenance activity, there have been some rare instances where advanced technical support were needed to troubleshoot. Thus, our analysis included such costs as part of technical support cost.

3.3. Video review cost

This cost category includes all costs associated with the review of trip level EM data. EM data includes video footage that capture on-the-deck fish handling, and sensor data that captures the geographical location, date and time of fishing activity. Video reviewers annotate and report any activities that are not compliant with MREM protocols, and each record is linked to a time and location. During the EFP period, 100% of the trips were monitored, and the reviewers reviewed the entire duration of the trip. Based on this, our status quo cost estimate assumed 100% trip review rate. We also examined the scenario with a 50% trip review rate, based on the draft sector operations plan requirements for fishing year 2022 (https://media.fisheries.noaa.gov/2022-01/210826_SectorOpsEAGuidanceFY2021_2022_Revised.pdf).

License fee and data storage cost are also included as part of video review cost. Data storage cost consists of software license fee, short-term and long-term data storage fees. During the EFP period, the EM data was stored in a 'live' format – meaning that the EM data was kept in a format that can be accessed and reviewed for a few months after the completion of the trip. After that, the EM data was moved to long-term data storage. Our cost calculation is based on the data storing practice during the EFP period, which was informed by a conversation with NOAA and other project partners.

3.4. Dockside monitoring cost

DSM is a required component of MREM, and during the EFP period, all offloads are observed by the NEFSC. The DSM activities prioritizes biological sampling that would normally occur through at-sea monitoring. Biological sampling captured length information for a portion of the catch, with a focus on the sublegal portion of the catch. During the EFP period, DSM did not collect any other biological information such as otolith or scales. The DSM program is also tasked with verifying dealer weights and conducting a visual inspection of the hold after offloading is complete. The hold inspection visually validates that all catch has been removed from the hold and passed through the weigh-out system[iv].

For the status quo cost estimate, we included costs associated with all three components (i.e., length measurement, hold inspection and verifying dealer weights). Our estimate of DSM cost is based on the cost information during the EFP period when DSM program was NOAA-led. Our estimate also does not assume an annual increase associated with personnel wages or salaries.

DSM program will transition to a third-party operated program contracted directly by sectors in the future. Further standard development and priorities are also subject to change. Thus, future DSM cost may look significantly different from the one incurred during the EFP period. While there are uncertainties associated with future DSM cost, biological sampling is identified as one area where

[iv] The DSM activities are detailed in the DSM priority list for the MREM EFP.

changes may occur. Here, we included two additional scenarios that examine the impact of DSM cost when including 0% or 50% of the current biological sampling, and also provided a sensitivity analysis in the Appendix to examine the sensitivity of overall MREM cost to DSM cost.

3.5. Operational cost

Two types of costs are included as part of operational cost. This includes the cost of developing a vessel monitoring plan developed for each vessel to outline rules, requirements and individually tailored catch handling and dockside monitoring protocols, hard drive postage fee, and data storage cost. The first is the cost associated with developing vessel monitoring plan. Prior to taking EM trips, vessels were required to submit vessel monitoring plan for NOAA approval. The vessel monitoring plan outlines the MREM rules, vessel responsibilities, and vessel-specific EM system information, including a schematic of a vessel layout and EM system configuration. During the EFP period, the program manager (i.e., GMRI) worked with the EM system service provider and individual vessels to develop a vessel monitoring plan. We estimated the cost of developing the vessel monitoring plan based on this practice.

During the EFP period, EM data was stored by hard drive and physically mailed by a vessel for trip review. Each participating MREM vessel was provided with several hard drives for collecting EM data on each documented MREM trip. The low-volume vessels that take shorter trips more frequently shipped the hard drive every 5-7 days. The high-volume vessels that took longer trips shipped the hard drive after completing each trip, to allow for timely review of the trip video and feedback to the vessels.

3.6. Other costs examined qualitatively

3.6.1. Cost of retaining and landing sublegal-size catch

Prospective and early industry member raised concerns about the requirement for vessels to retain all allocated groundfish, specifically the space needed to store the sublegal catch component in the hold, and also finding markets to offset the costs of handling, landing and processing the sublegal-sized catch. A requirement of the program is that the sublegal catch is sorted by species before arriving to the dockside monitor. The exceptions were that higher volume species (redfish, haddock and pollock) which could be left mixed in with the smallest, legal market category. With changes to catch handling and the requirement to retain fish, we also investigated if additional crew member would be needed for the onboard sorting. Lastly, we explored the role of vessels, dealers and processors in processing and sorting the sublegal-sized groundfish.

To understand possible costs or benefits associated with retaining and sorting all allocated-groundfish catch, we interviewed participating vessels, seafood dealers and processors. We identified a list of activities and cost components that can accrue to vessels operating under MREM rules. We also referenced ex-vessel market categories recorded in dealer data and other program information. We qualitatively assessed and discussed the market categories and potential costs associated with retaining and landing sublegal-size fish in place of discarding sublegal-size fish.

3.6.2. Sector administration

It is our understanding that general sector fees have not changed for those participating in the pilot EM programs nor are sector managers anticipating the need to increase sector fees for EM vessels specifically. However, there is a possibility of an increased workload on the part of sector managers responsible for EM vessels. To examine this, we interviewed sector managers to identify sector activities associated with administering MREM trips and examined them qualitatively.

4. Results

4.1. Low-volume boat

4.1.1. Status-quo

We estimated annual and per-trip cost for MREM for low-volume vessel (Table 4). The annual cost was estimated as $66,291, and the total per-trip cost was estimated as $663. We found that the video review cost is the largest cost component, sharing 40% of total cost, closely followed by the DSM cost, which shares 33% of the total cost. These are followed by technical support cost, which shares 21% of total cost. We also found that EM equipment shares only 2% of the total cost.

Table 4. Baseline results for low-volume vessel (EFP period)

	Low-volume Vessel		
	Annual	Per trip	% share in total cost
Equipment	1,072	10.72	2%
Technical support	14,040	140.40	21%
Video review	26,768	267.68	40%
Dock-side monitoring	22,000	220.00	33%
Operational	2,411	24.11	4%
Total cost	$ 66,291	$662.91	100%

4.1.2. Scenario analysis

Video review cost shared a large portion of the MREM cost. During the EFP period, all trips were reviewed and reported. Based on the most recent information from NOAA regarding as of December 2021, this will change so that only 50% of the trips will require trip review during the fishing year 2022. This change in trip review rate has the potential to reduce the cost associated with reviewing trips significantly. Assuming that the changes in the labor cost associated with trip review is proportional to the changes in trip review rate, the video review cost would be reduced from $26,768 to $13,476 annually and from $268 to $135 per trip. This change is equivalent to 20% reduction in total cost, from $66,291 to $52,998 annually and from $663 to $530 per trip.

For the low-volume boat vessel, DSM component was found to share a significant portion of the cost. During the EFP period, in addition to observing vessel offload, the DSM personnel also took lengths of kept groundfish catch. The data collected supported NOAA science (e.g. stock assessments), captured the amount of sublegal fish landed in the MREM program, and supported the development of sampling protocols to subdivide legal and sublegal size fish in the mixed (legal and sublegal) size category and to understand accidental mixing of sublegal sized fish category and vice versa.

The status-quo estimate of DSM cost included the labor cost associated with monitors taking length and weight measurements (i.e., biological sampling). The DSM program is expected to transition from a NOAA-led to industry-led program, and changes are expected to occur under a third-party offered DSM, including the scope and extent of biological sampling in the future DSM program. Thus, we also estimated the two scenarios to examine a case when DSM cost excludes the labor cost associated with size measurement as a lower-bound estimate for the DSM cost and when industry bears only 50% of the cost associated with biological sampling. For low-volume vessel, on average, 55% of the DSM personnel time is spent on measuring fish size during the EFP period. If we remove the cost associated with this activity entirely, then the DSM cost for the low-volume vessel would be reduced

to from $22,000 to $13,915 annually and from $220 to $139 per trip. This change is equivalent to 12% reduction in total cost, from $66,291 to $58,206 annually and from $663 to $582 per trip. If we reduce the labor cost associated with this activity entirely by 50%, then the DSM cost for the low-volume vessel would be reduced to from $22,000 to $17,958 annually and from $220 to $180 per trip. This change is equivalent to 6% reduction in total cost, from $66,291 to $62,249 annually and from $663 to $622 per trip.

Figure 1 and Figure 2 shows the differences in total annual and per trip cost for low-volume boat, respectively, under six scenarios 1) status-quo, 2) 50% trip review rate, 3) DSM cost without biological sampling (i.e., without size measurements), 4) DSM cost without biological sampling (i.e., without size measurement) with 50% trip review rate, 5) DSM cost with 50% of biological sampling cost, and 6) DSM cost without biological sampling (i.e., without size measurement) with 50% trip review rate. Compared to status quo, a scenario that excluded biological sampling (i.e., size measurement) cost and assumed 50% review rate costs 32% less.

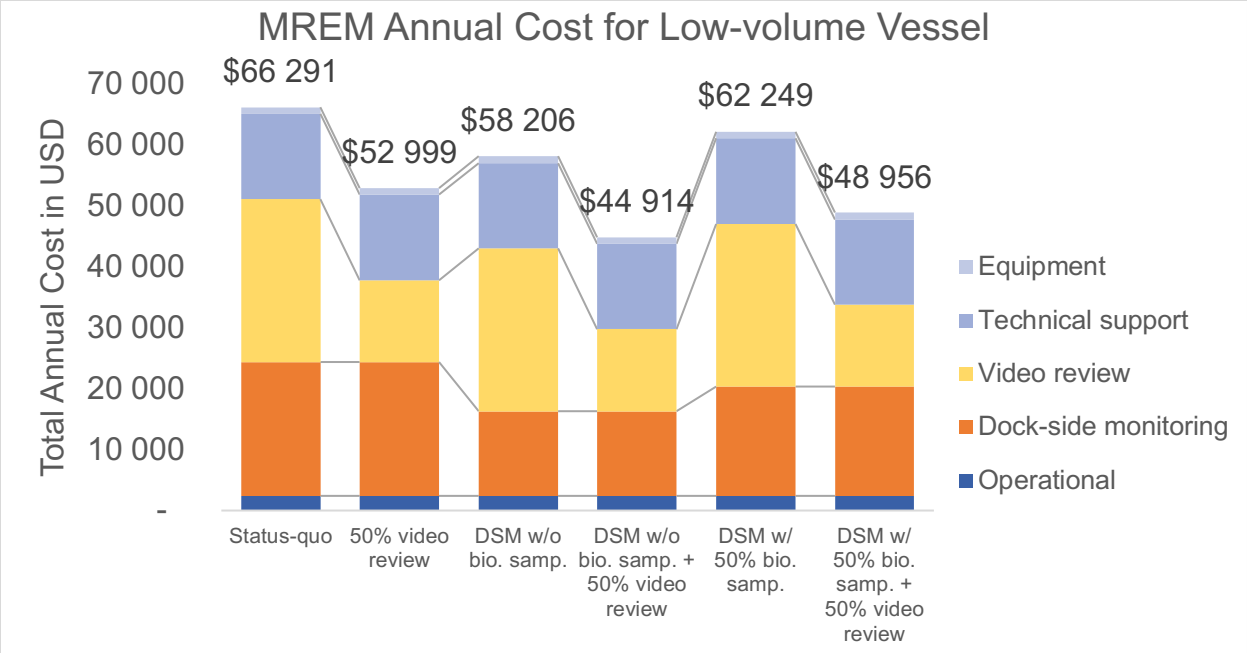

Figure 1. Annual cost for low-volume vessels participating in MREM

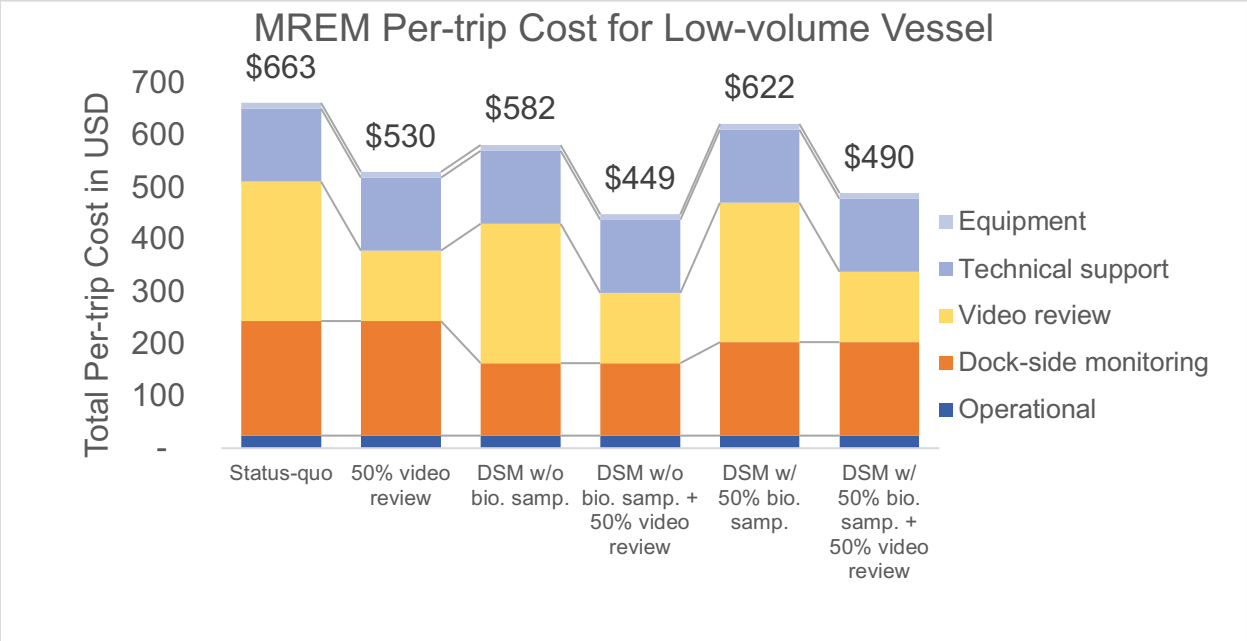

Figure 2. Per-trip cost for low-volume vessel participating in MREM

4.2. High-volume volume vessel

4.2.1. Status quo

We estimated annual, per-trip, and per 24-hour operation cost for MREM for high-volume volume vessel (Table 5). The annual cost of MREM was estimated as $117,544. This is equivalent to per trip cost of $4,309 and per 24-operation cost of $588 per 24-hour operation. We found that the video review cost shared a majority of the MREM cost, sharing 73% of total cost. This is followed by technical support and dock-side monitoring cost, which shares 12% of total cost. We also found that equipment shares only 1% of the total cost associated with MREM.

Table 5. Baseline results for high-volume vessel (EFP period)

	High-volume Vessel			
	Annual	Per trip	Per 24-hour operation	% share in total cost
Equipment	1,072	39.30	5.36	1%
Technical support	14,040	514.80	70.20	12%
Video review	85,656	3,140.74	428.28	73%
Dock-side monitoring	14,018	514.00	70.09	12%
Operational	2,758	101.11	13.79	2%
Total	$117,544	$4,309.95	$ 587.72	100%

4.2.2. Scenario analysis

Video review cost shared a majority of the MREM cost. During the EFP period, all trips were reviewed, and a trip summary containing alpha-numeric data was submitted to a NOAA's API. Based on the most recent guidance from NOAA as of December 2021, video revie will change so that only 50% of the trips will require trip review during the 2022 fishing year. The change in trip review rate reduce the cost associated with trip review significantly. Assuming that the changes in labor cost associated with video review is proportional to the changes in trip review rate and unreviewd trip footage will be stored in long-term data storage, the video review cost will be reduced from $85,656 to $43,120 annually, from $3,614 to $1,581 per trip, and from $428 to $216 per 24-hour operation. This change is equivalent to 36% reduction in total cost, from $117,544 to $75,007 annually, $4,309 to $2,750 per trip, and from $588 to $375 per 24-hour operation.

Figure 3 and Figure 4 shows the differences in total annual and per 24-hour operation cost for high-volume vessel, respectively, under six scenarios 1) status-quo, 2) 50% trip review rate, 3) DSM cost without biological sampling (i.e., without size measurement), 4) DSM cost without biological sampling (i.e., without size measurement) with 50% trip review rate, 5) DSM cost with 50% of biological sampling cost, and 6) DSM cost without biological sampling (i.e., without size measurement) with 50% trip review rate. Compared to status quo, a scenario that excluded biological sampling cost and assumed 50% review rate costs 40% less.

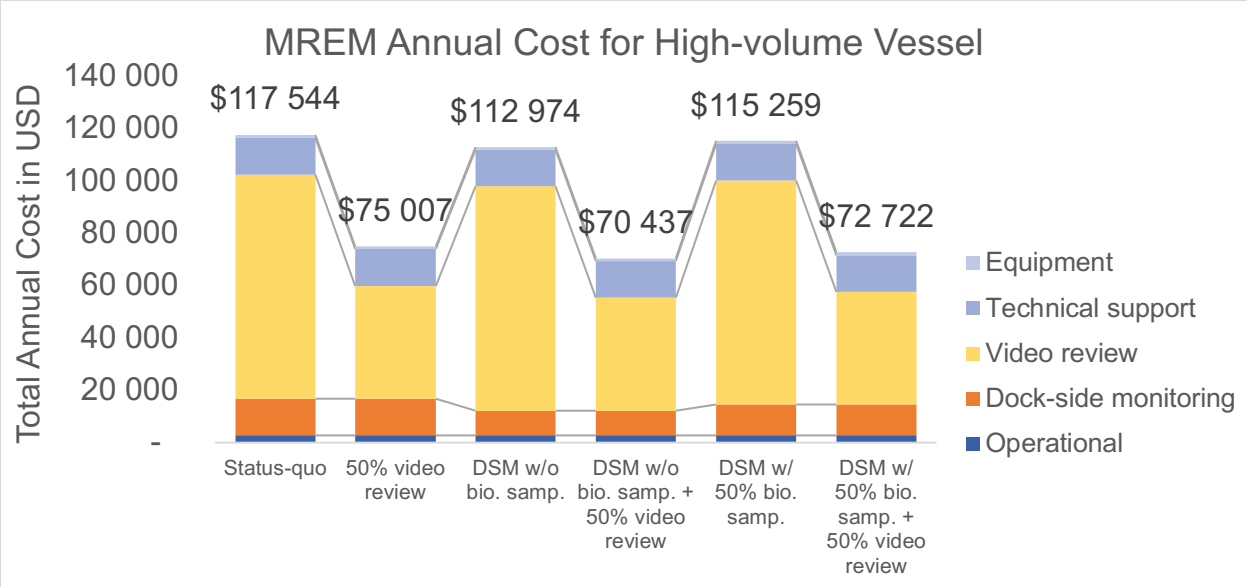

Figure 3. Annual cost for high-volume vessels participating in MREM

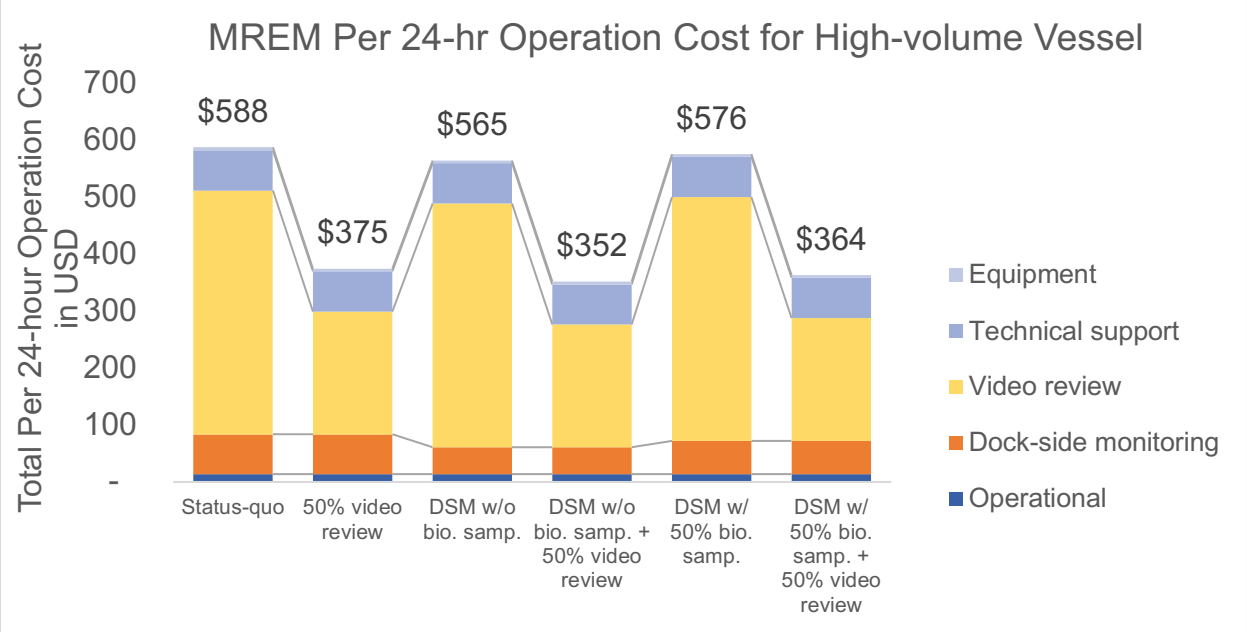

Figure 4. Per 24-hour operation cost for high-volume vessels participating in MREM

4.3. Other costs

To understand costs and benefits associated with retaining sublegal-size catch, we interviewed vessel captains, dealers, and sector managers. Table 6 summarizes our findings. In general, vessels did not report any significant additional economic costs associated with MREM. No vessels reported making investments to retrofit vessels or to purchase additional equipment for fish handling. While they reported increased fish handling time, vessels did not have to hire new crew members to accommodate new fish handling practice for MREM. We also heard that it is critical to ice retained catch, including sublegal-size fish. This can contribute to control quality of all fish landed and may be necessary to market some of the of sublegal-size fish outside of bait market.

We heard that most sublegal-size landings were sold to bait markets or were discarded. Several industry experts mentioned that typical discard fee is in the range of $0.10 - $0.15 per lb of discarded fish. We also heard that of exploration into markets for human consumption for some of the sublegal catch. A challenge was identifying the time and effort to processing sublegal catch using the same processing equipment, and the amount of time to process these fish as compared to legal-size catch.

Interview of participating vessels indicated a general satisfaction with EM system performance. Some of the common initial concerns were over the EM system's durability in offshore operations. In general, the participating vessels found the EM system to be durable. Program requirements allow vessels to complete a fishing trip even if mid-trip EM issues arise. Vessels are not required to return to port in the middle of a fishing trip to fix EM systems, however vessels are required to contact their service providers to schedule technical support before they can fish again. During the EFP period, technical teams were able to schedule EM system performance, and fishing trips were not delayed.

Sector managers reported additional time for reporting and communication, and a majority of this additional time requirement was associated with the electronic reporting requirement, eVTR. The MREM EFP required vessels to use eVTR for trip reporting. As of November 2021, all vessels participating in Northeast Multispecies Groundfish Fishery are required to use eVTR, and thus this cost is no longer specific to MREM and relevant to be considered as part of MREM cost.

All landed allocated-groundfish, regardless of size, counted against quota. This has not been a concern during the EFP period, and no participating vessels and sectors raised explicit concerns regarding the cost associated with quota management. Yet, there are quota-associated costs when vessels are not able to market and raise values of the sublegal-size landings. These costs were outside the scope of this analysis.

Table 4. Additional Cost Categories

Vessels			
	On-board sorting and storage		
		Labor	Additional time sorting, but no changes to the number of crews on vessel
		Equipment	Not changes reported
	Vessel retrofitting		None reported
	Ice		Icing sublegal-size fish is critical for quality control (for both legal- and sublegal-size fish)
	Communication		Vessel captains need to notify the DSM to coordinate offload and communicate with EM service provider for technical issues
	Other		Landing fee applies to all landings, including sublegal-size fish. The fee structure vary based on several factors.
Dealers/processors			
	Shore-side sorting and processing		
		Labor	Processing of sublegal size fish for human consumption market could take slightly longer than processing legal size fish.
		Equipment	Sublegal size fish that are slightly smaller than the legal-size cutoff can be processed using the same equipment but could take slightly longer to process.
	Communication		Communicate with DSM. A DSM needs to be present at offloading.
Sector			
	Reporting and communication		Additional administrative time associated with eVTR (note: eVTR is required for all Northeast Multispecies Groundfish Fleet as of November 2021)
	Other		Contracting with MREM service provider.

Using dealer reports and DSM data, we estimated the ratio of sublegal-size fish landings in total landings made by MREM trips. In total over the period of May 2020 through December 2021, MREM trips landed about 5,00,000 pounds of groundfish (i.e., species that are part of Northeast Multispecies Groundfish Complex).

At the timing of writing this report, program infrastructure was in development to verify information reported by dealer reports, which is the official record of landings for catch accounting. Thus, the following information on sublegal- and legal-size landings are yet to be confirmed and finalized. But as a reference, we found the sublegal size landings recorded in dealer data from the trips taken in

fishing year 2020 was less than 1.5% for all species (Table 7). We also observed that small portion of the sublegal sized catch are marketed for human consumption, though majority were either sold as bait or discarded.

We also examined the volume of sublegal-size landings, as reported by the DSM for the trips taken between May 2020 – September 2021. The DSM program is tasked with sampling the mixed category into legal and sublegal components, and provided estimates that 1.7% – 14 % of the total catch was classified as sublegal-size fish. This range is due how sublegal-size landings are recorded in DSM data (see section 3.4.1). Further, the wide range is primarily due to the ways that redfish landings are handled and recorded. Anecdotal evidence indicates that majority of the redfish recorded in the mixed category that includes both sublegal and legal-size landings are indeed legal-size fish. Hence, for the purposes of this analysis, we assumed that the actual number of sublegal-size landings is closer to the lower-bound estimate of 1.7%. When we estimated the per-trip average proportion of sublegal-size catch, as opposed to aggregating all landings from MREM trips, this range narrowed from 7.7% to 11.78%. In other words, on average, 7.7% to 11.78% of the landings were sublegal size. Again, based on our discussion with the participating vessels and sector managers, we believe that the actual number is closer to the lower-bound estimate of 7.7%. Industry members expressed that 7.7% seems "too high" based on their experience.

Table 5. Landings marked as sublegal-size in dealer reports (Upper-bound estimate includes the category that includes a mix of sublegal- and legal-size catch, lower-bound estimate excludes the category that records a mix of sublegal- and legal-size catch)

Species Name	Upper-bound estimate		Lower-bound estimate	
	Legal	Sublegal	Legal	Sublegal
Cod	99.37%	0.63%	99.37%	0.63%
Flounder,American Plaice	98.61%	1.39%	98.68%	1.32%
Flounder,Winter	99.57%	0.43%	99.57%	0.43%
Flounder,Witch	99.06%	0.94%	99.06%	0.94%
Flounder,Yellowtail	100.00%	0.00%	100.00%	0.00%
Haddock	99.30%	0.70%	99.74%	0.26%
Hake,White	99.43%	0.57%	99.43%	0.57%
Halibut,Atlantic	100.00%	0.00%	100.00%	0.00%
Pollock	99.52%	0.48%	99.52%	0.48%
Redfish	99.85%	0.15%	99.99%	0.01%

4.4. Possible ways to reduce MREM cost

We propose several ways that vessels can reduce the cost of participating in MREM. For instance, vessel captains and crews are required to keep the cameras clean to reduce video review cost. EM video image quality decreases if cameras are not regularly cleaned. Low image quality prolongs the time required for the trip reviewers to review the trip, which can increase the labor cost associated with trip review. In addition, for video reviewers, it is less-tasking to review trips where program protocols are followed, including proper catch handling. Thus, compliance with program requirements and proper catch handling can reduce the time required to review trips, ultimately reducing the labor cost associated with trip review.

It is also worth noting that trip review efficiency can vary by catch composition. Our cost estimates presented above are based on the mean review efficiency ratio from the EFP period. The efficiency of video review is expected to improve over time as more advanced technology is available and approved.

Technical service cost, especially the cost associated with maintenance, can vary depending on vessel's operational characteristics. Those vessels with fewer number of days-at-sea or vessels that do not operate year-round would generally require less maintenance support.

Data storage requirements are driven by federal guidance, but the consensus is such that video data storage cost will decrease over time. EM data is retained following third-party minimum data retention period directives from NOAA which states that EM data is retained for a minimum of 12 months following the data reconciliation period at the close of the fishing year. Based on our conversation with EM service providers and the data storage practice during the EFP period, our cost estimation assumes a requirement such that data is kept live for the first three months and cloud-based video data storage for the next 14-33 months. While the 14 months of long-term cloud-based data storage cost is small (i.e., 0.17% and 0.31% of total cost for low-volume vessel and high-volume vessel, respectively), live video data storage is more costly (up to 7% and 12% of total cost for low-volume boat and high-volume vessel, respectively).

4.5. Caveats and limitations

Our study assumed static costs, but in reality, the EM costs are dynamic beyond what we considered in the scenario analysis. DSM cost is one of the cost category that we expect to see a change in the future. We expect that the DSM cost will decrease once the program transitions to allow for third-party DSM provider, as opposed to DSM by NOAA personnel. Technical support cost is another component that can vary by vessel's operational characteristics. Furthermore, inflation could influence future costs to be higher than estimated by this study. As of November 2021, the US annual inflation rate is at the highest since 1982 at 6.8%[4]. In other words, inflation alone can cause non-negligible increase in many of the cost components, including labor and other recurring or unborn costs.

5. Conclusion

This report summarized our findings from the economic analysis of MREM based on the data obtained and experience gained through MREM EFP. Interview of participating vessels also indicated a general satisfaction with MREM, particularly noting the satisfaction associated with the durability of the EM system.

Estimated MREM costs during the EFP period are comparable or less than what human observers cost when comparing day rates. Further, the expected change in trip review rate from 100% to 50% requirement can lead to a significant cost reduction. Our scenario analysis shows that this change alone has the potential to reduce the total MREM cost by 20% (for low-volume vessel) and 36% (for high-volume vessel). Future management changes to DSM, combined with the change in trip review rate, can reduce the total MREM cost by ~32% (for low-volume vessel) and 40% (for high-volume vessel).

6. Appendix

6.1. Sensitivity Analysis

We anticipate that some of the cost components included in our study will change over time or when the MREM is implemented at full scale. Further, our cost estimates are based on several assumptions and err on the side of providing conservative (i.e., higher than actual cost) estimates. To understand the implication for using conservative estimates, we examined the changes in the total MREM costs by varying 1) technical support cost, 2) video review cost (including both labor and data storage), 3) DSM cost, and 4) video data storage cost.

Figure 5 and Figure 6 show the changes in total annual cost for low-volume and high-volume cost, respectively, when we vary each of the four cost components. The horizontal axis shows the assumed percentage change in each of the cost component, and the vertical axis shows the resulting total annual cost. In the horizontal axis, 100% indicates the full cost used to calculate status quo cost estimate, where the resulting total cost is shown as $66,291 for low-volume vessel and as $117,544 for high-volume vessel. Now, to see the total annual cost when the actual technical support cost is 80% of the status quo, find in the horizontal axis where it indicates 80% and see the corresponding yellow marker (--x--) that shows Sensitivity to technical support cost. The corresponding total annual cost, $63,483 for low-volume vessel (in Figure 5) and $114,736 for high-volume vessel (in Figure 6), can be found in the vertical axis.

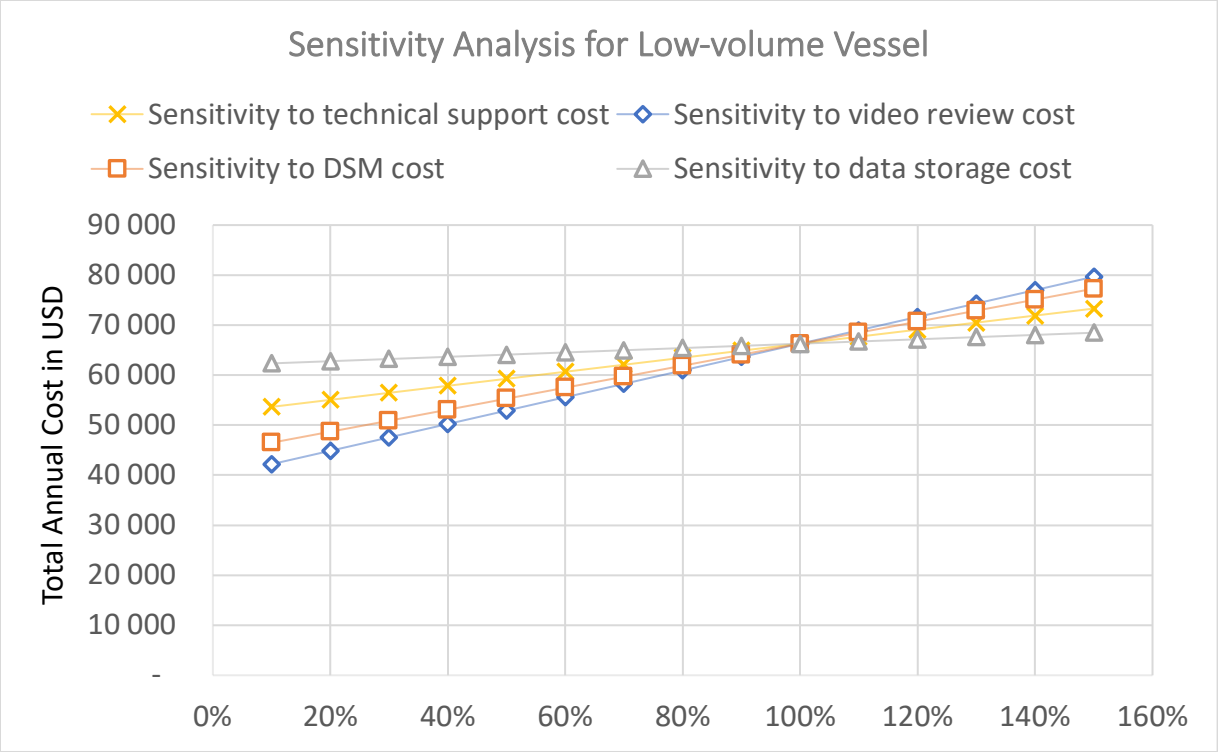

Figure 5. Sensitivity analysis for low-volume vessels participating in MREM.

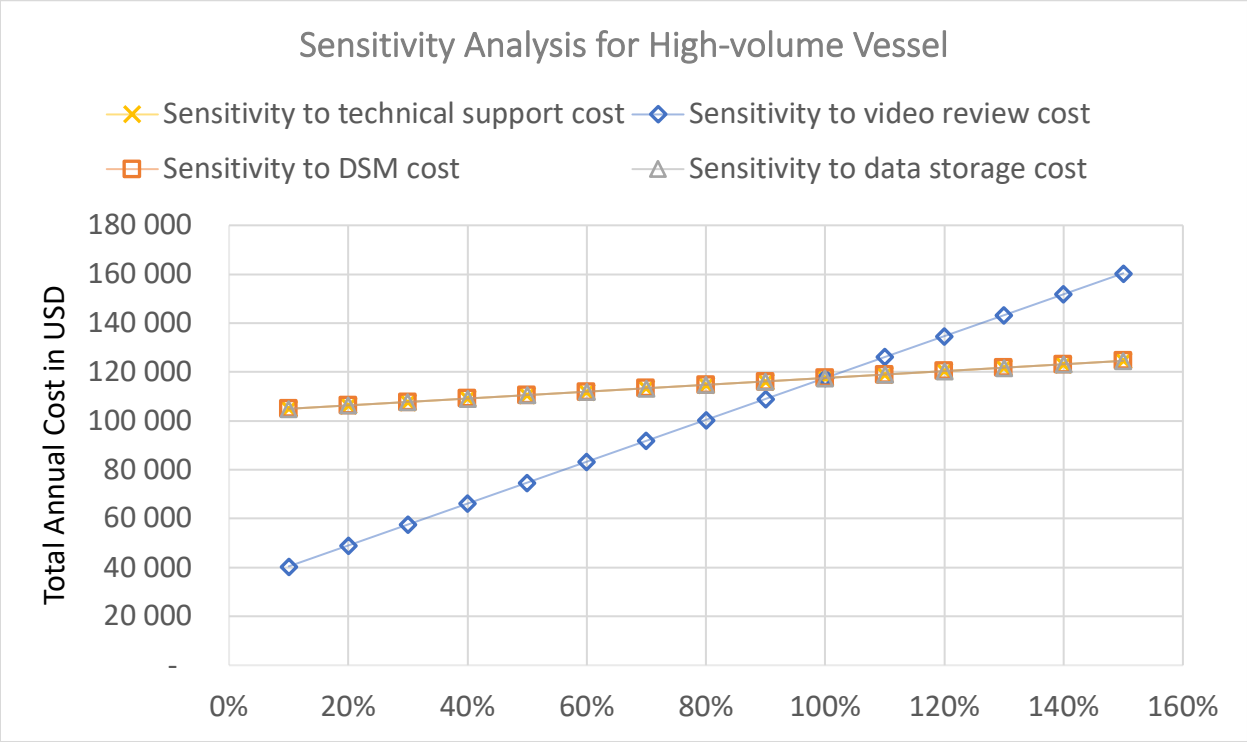

Figure 6. Sensitivity analysis for high-volume vessels participating in MREM.

6.2. Low-volume Vessel Cost (100 trips vs. 50 trips)

We also estimated the MREM cost for a low-volume vessel that takes 50 trips per year. Here, we only vary video review, DSM, and operational costs and hold other things (i.e., equipment and technical support cost) constant. Assuming that video review, DSM, and operational costs will reduce proportionately to the number of trips taken, the total cost for the operation that takes 50 trips per year is $43,337 annually (Figure 7) and $867 per trip (Figure 8). The scenario analysis results for 50-trip operations are shown in Figure 9 (annual) and Figure 10 (per-trip).

As we examined in the sensitivity analysis presented in the Appendix, we can assume that technical support cost to be smaller for the low-volume vessel that takes 50 trips. Indeed, for this operation, technical support cost shares 32% of the total cost (Table 8). If the technical support cost was reduced by half, the total MREM cost becomes $36,317 annually and $726 per trip.

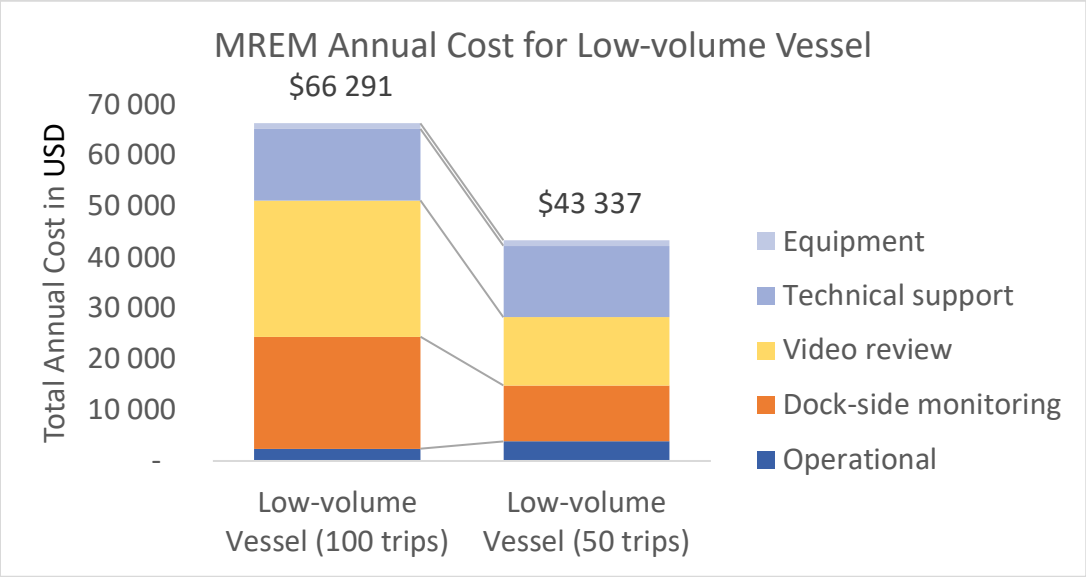

Figure 7. Annual cost for low-volume vessel (100 trips vs. 50 trips) participating in MREM.

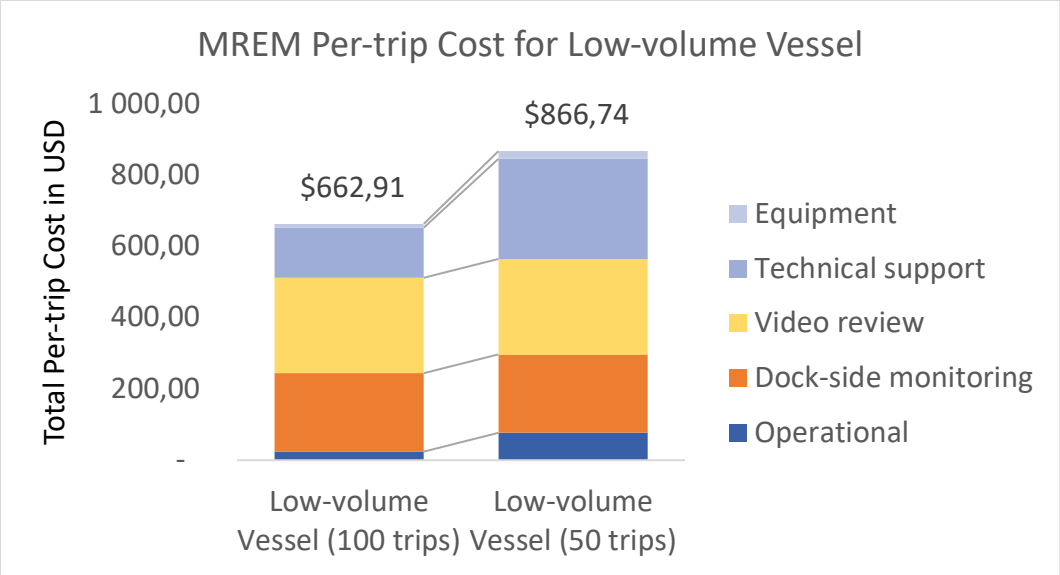

Figure 8. Per-trip cost for low-volume vessel (100 trips vs. 50 trips) participating in MREM

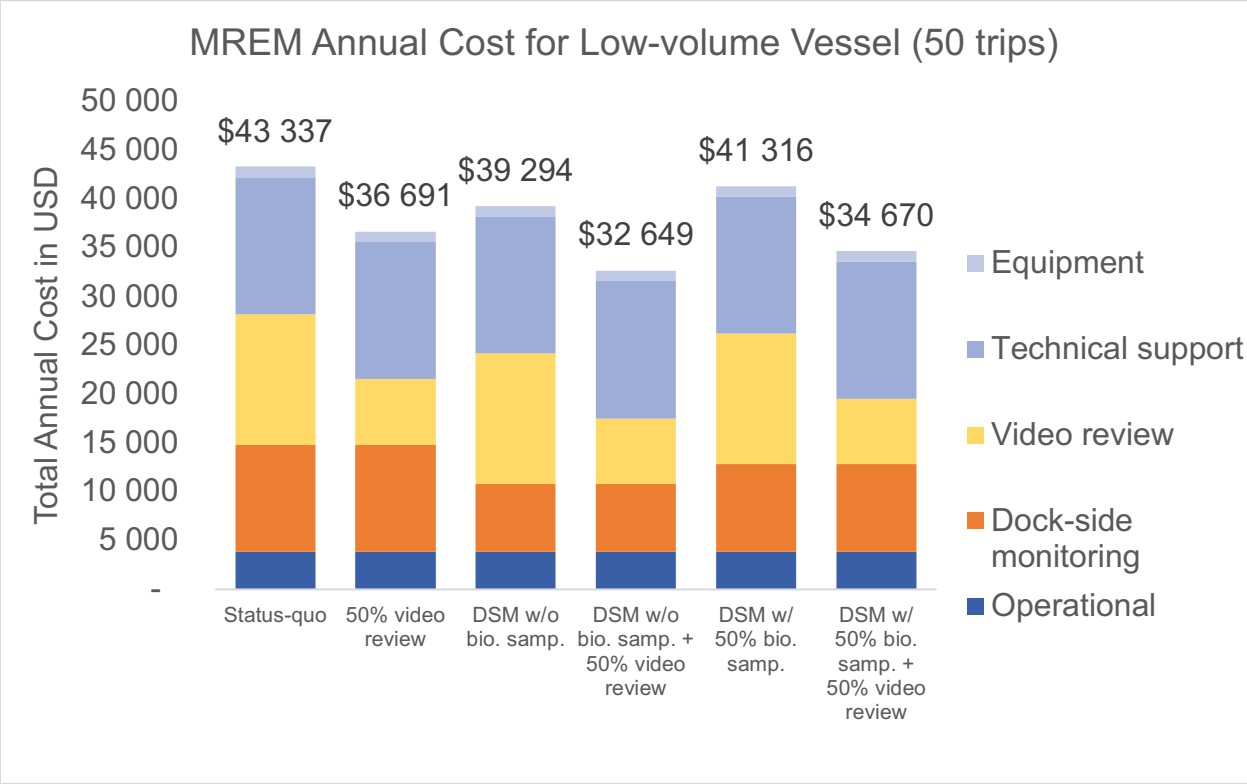

Figure 9. Annual cost for a low-volume vessel that takes 50 trips and participates in MREM.

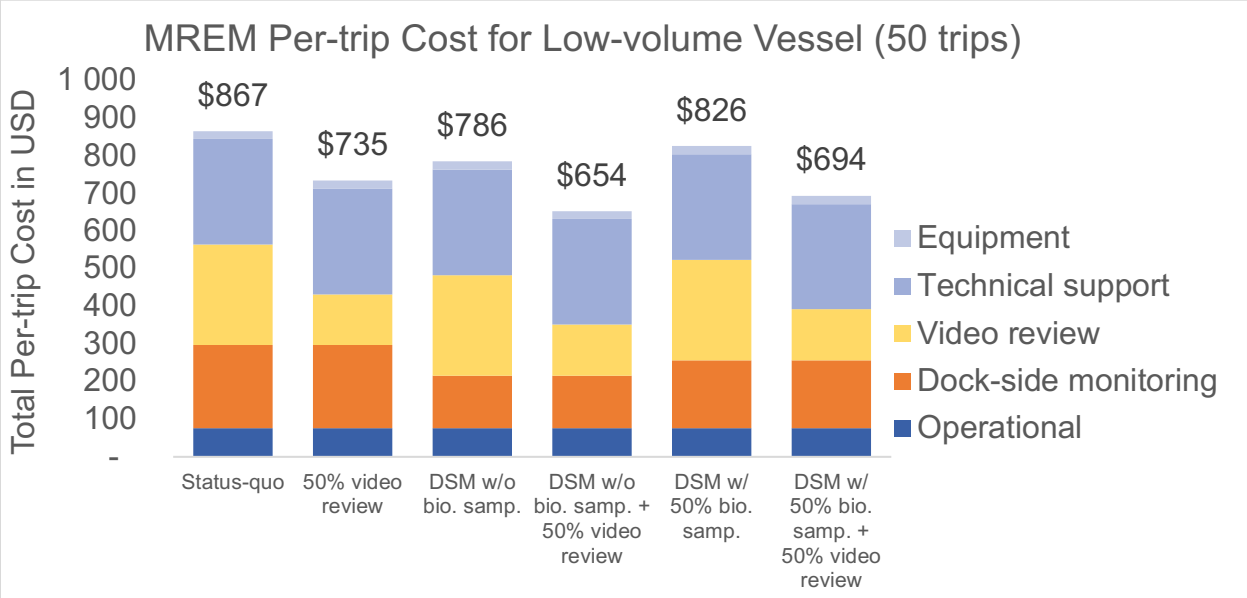

Figure 10. Per-trip cost for a low-volume vessel that takes 50 trips and participates in MREM.

Table 6. Baseline results for a low-volume vessel that takes 50 trips (EFP Period)

	Low-volume Vessel (50 trips)		
Equipment	Annual	Per trip	% share in total cost
Technical support	1,072	21.44	2%
Video review	14,040	280.80	32%
Dock-side monitoring	13,385	267.69	31%
Operational	11,000	220.00	25%
Total	3,841	76.81	9%
Equipment	$ 43,337	$866.74	100%

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