An Independent Review of:

A Preliminary Cost Comparison of At-sea Monitoring and Electronic Monitoring for a Hypothetical Groundfish Sector

Prepared for: ECS Federal, LLC and the

National Ocean and Atmospheric Administration (NOAA)

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Executive Summary

This paper provides an independent review of the study by the NOAA Fisheries Greater Atlantic Regional Fisheries Office staff and Northeast Fisheries Science Center staff that compares costs of the current at-sea monitoring program and an electronic monitoring program for a hypothetical groundfish sector. The analysis clearly describes the assumptions and mythologies used in the two approaches. The authors also indicate that assumptions regarding the electronic monitoring program's structure may generate cost estimates that are greater than necessary to achieve future monitoring objectives. Overall, the paper is well-written and provides reasonable costs of the two programs based on the assumptions used to generate the estimates. However, it is important to clearly understand the different assumptions used to estimate discards under the electronic monitoring structure and the model currently employed for at-sea monitors. These differences are acknowledged to affect the cost estimates provided for trips, vessels, and the hypothetical sector overall.

The at-sea monitoring program assumes that 18% of the sector's trips would be monitored. Data collected from the selected trips would be used to generate discard rates that would be applied to the vessels that were not monitored to estimate total discards for the sector. The electronic monitoring program assumes that all vessels would be required to have electronic monitoring for all trips, and 20% of the hauls on every trip would be monitored, with a minimum of one haul per trip. Data from each audited haul would be compared to haul-by-haul logbook data to determine if the two discard reports yielded similar results. If the logbook data was verified by the video review data, the logbook data for the entire trip was used as the discard estimate for the trip; when the two estimates were not sufficiently alike, additional hauls were audited to determine whether the video discard estimates or the logbook data would be used as the discard estimate for the trip. The underlying assumptions for the two approaches and the comparability of the data should be carefully considered when equating relative costs. The review notes that while both approaches monitor about 20% of the hauls, the at-sea monitoring approach only monitors 18% of the trips and the electronic monitoring program monitors 100% of the trips. The difference in trips monitored has a substantial impact on the trip, vessel, and sector cost estimates.

The report estimated that annual costs for employing the electronic monitoring approach and the at-sea monitor program resulted in daily costs of $357 and $710 respectively; when daily costs were converted to cost per trip, the electronic monitoring approach and the at-sea monitor program resulted a cost per trip of $601 and $316 respectively. Estimates of daily costs are similar to daily costs for at-sea monitors and electronic monitoring programs in other parts of the country and in Canada; estimates of trip costs, vessel costs, and total costs tend to differ substantially as a result of the structure of the electronic monitoring/at-sea monitoring models developed for the various fisheries. These estimates include only annual costs. Start-up costs for electronic monitoring in the 20 vessel, hypothetical fishery were estimated to equal $87,475 per vessel ($59,575 in industry costs and $27,900 in agency costs). Start-up costs per vessel are not assumed to increase linearly relative to the number of vessels in the fishery. Therefore, if 400 vessels were in the program, the cost per vessel is expected to be less than reported for the hypothetical fishery. Implementation costs for the at-sea monitoring program have already been borne by NOAA Fisheries and are not available for comparison with the projected start-up costs for electronic monitoring.

An important assumption in the GARFO paper is that different approaches are used to estimate discards. Therefore, as noted in the paper, it is difficult to directly compare the data collection costs and appropriate monitoring rates of the at-sea monitoring program and the hypothetical electronic monitoring program. If additional work is undertaken, it should clearly describe why different methods are used to estimate discard amounts under the at-sea monitoring program and the electronic monitoring model; future papers should also describe why the electronic monitoring approach, based on verifying logbooks, is superior for

the electronic monitoring program[1]. To the extent it is practicable, it would also be informative to compare costs of similar data collection models for electronic monitoring and at-sea monitors.

Other information identified in the review that that could help illuminate and/or focus future discussions includes:

- The cost data used in the report represent a census of all data providers, so recommendations on statistical methods that could be applied to a subset of the data providers or increasing the sample size are not appropriate or recommended. The paper should clearly note that average costs for the electronic monitoring program were derived from all known electronic providers.
- The paper clearly states that assumptions employed to generate cost estimates for electronic monitoring in the hypothetical fishery may be greater than what is actually realized. Using average cost estimates for electronic monitoring inflates costs when it is assumed that the least cost provider would be selected. This assumes that firm provides similar services of the same quality as the higher cost service providers. Other assumptions that increase the estimated electronic monitoring costs are that all trips are monitored, a minimum of one haul per trip would be audited (or 20% of hauls on a trip), a technician would retrieve hard drives from vessels, and all video must be archived for five-years.
- The cost per day estimates and the assumptions used to generate those estimates appear to be transferable to other Amendment 16 fisheries. Changing the video auditing percentages or the underlying objectives of the program are decisions that would have a substantial impact on the total estimated electronic monitoring costs.
- A standardized set of survey questions should be developed to collect cost data from EM service providers if future studies involve cost data collection. This will help ensure that all service providers use the same set of assumptions when developing estimates for a well-defined cost category.
- The GARFO paper does not provide a statistical analysis of the appropriate EM review percentages to achieve the required coefficient of variation, since providing that information would require collecting, auditing, and analyzing video data from the fishery. Given that the electronic monitoring model is based on a hypothetical fishery, that is not possible or a reasonable expectation. This information could be collected and analyzed when a monitoring model is applied to Amendment 16 fisheries.

Finally, it is important to note that the GARFO paper is the first step in a process to determine the most judicious and cost effective way to collect discard data necessary to manage the Amendment 16 sectors. The paper provides sufficient information for the effected Fishery Management Councils and NOAA Fisheries to have informed discussions with interested stakeholders. Those discussions should help gauge interest in the current electronic monitoring model, provide agency staff and policy makers a forum to articulate why specific assumptions are necessary, and provide stakeholders with the opportunity to provide input on suggested modifications.

[1] It is not the intent of the reviewer to indicate that this is an improper assumption. The intent is to simply ask that the authors more thoroughly describe the rationale used to arrive at the decision to use that model.

1 Introduction

Amendment 16 to the Northeast Multispecies Fishery Management Plan includes provisions that require persons that are members of a binding sector operations plan to fund a catch monitoring program. That program must provide the data necessary to determine the amount of fish sold, as well as bycatch[2] of species allocated, to ensure their Annual Catch Limits (ACLs) are not exceeded. Because bycatch may be discarded at-sea, accounting for all catch requires relying on unverified data provided by the harvesters' logbooks. Therefore, it is necessary to implement a structure to observe or otherwise verify the amount of each species discarded, or to implement a structure to verify the logbooks. The paper being reviewed provides a cost comparison for a hypothetical fishery based on the current at-sea monitors (ASM) system and a proposed electronic monitoring (EM) system.

Since 2010, the Federal Government has provided funding and support for the deployment of at-sea monitors to determine the catch of vessels fishing under Amendment 16. Funding for catch monitoring will need to be borne by the private sector in the future. As a result, there is keen interest in determining whether there are more cost effective and efficient methods to verify catch especially the amount of fish or other living organisms that are not sold. EM has been viewed by many stakeholders in the Amendment 16 fisheries, other fisheries in the North America, and fisheries around the world as a system that holds promise to provide the information required by management agencies at a lower cost than the traditional system of ASM or fishery observers. Many fish harvesters also consider EM to be less intrusive and have fewer impacts on their operational structure than having an additional person on their vessel to observe their catch and discards.

"A Preliminary Cost Comparison of At-sea Monitoring and Electronic Monitoring for a Hypothetical Groundfish Sector"[3], written by NOAA Fisheries Greater Atlantic Regional Fisheries Office (GARFO) staff and Northeast Fisheries Science Center staff, provides the first attempt at estimating EM program costs for a hypothetical NE fishery. The hypothetical fishery has a structure based loosely on the Amendment 16 sectors, and compares estimated EM costs to the current ASM program costs. Actual cost data is currently only available for the ASM program. EM program data must be estimated based on an assumed program structure. As a result, EM cost data estimates were provided by three knowledgeable key informants. Those three informants comprise all of the known active EM providers for U.S. and Canadian fisheries[4].

NMFS staff provided a suite of assumptions regarding the fishery structure and the EM model that would be employed to the three service providers. The three key informants then developed cost estimates associated with various EM expense categories using those assumptions about the hypothetical fishery. The three cost estimates, for various cost categories, were averaged by NOAA Fisheries staff to provide the basis for comparison between the actual ASM costs and EM model costs.

This paper is intended to provide a review of the program model and assumptions that were used to develop the EM cost estimates. The review is divided into three main sections. Section 2 addresses several questions that were posed by the contractor. Section 3 is an analysis that takes a more global view of the paper and evaluates the strengths, weaknesses, opportunities, and threats (SWOT analysis) of the analytic methodologies and assumptions for the hypothetical fishery and the resulting preliminary cost estimates. Section 4 provides a summary of recommendations for improvements that could be incorporated into future studies.

[2] The Magnuson Stevens Act of 2007 defines bycatch as fish which are harvested in a fishery but are not sold or kept for personal use and includes economic discards and regulatory discards.
[3] Referred to as the GARFO paper in this review.
[4] Personal communication, Barry Clifford

2 Major Issues Reviewed

This section focuses on ten specific questions that were asked by NOAA Fisheries staff regarding the hypothetical EM program. The questions cover a broad range of issues regarding the program's cost estimates, fishery and EM model assumptions, and the applicability of the results to other fisheries. There is some redundancy when the questions touch on similar issues. In one case the reader is referred to another discussion that had previously addressed the issue. Each question is addressed under its own heading.

2.1 Does the average cost for EM services and equipment provide an accurate basis for the comparison of EM and ASM?

Costs are an important component of the EM/ASM comparison, and the relative costs to all stakeholders tend to be a focal point of public discourse. However, the relative costs of the two program structures are moot if the programs being compared do not yield similar and adequate data to manage the fishery. Assuming that the EM and ASM programs being compared generate comparable data in that both programs "*provide coverage that is fair and equitable, and distributed in a statistically random manner among all trips such that coverage is representative of fishing activities by all vessels within each sector and by all operations of vessels operating in each sector throughout the fishing year*",[5] then a discussion of whether the average cost for EM is an appropriate comparison may be productive. However, the reader should carefully consider the differences in the quality, scope, and use of the data that are collected and not just program costs.

When contracts for EM services are affected, it is assumed the EM service provider offering comparable services and quality for the least cost would be selected. Assuming that only one contractor[6] is selected to provide the EM service, calculating EM costs using an average of three service providers inflates the projected costs. The magnitude of the difference between the average cost and lowest cost provider depends on the variation in the cost estimates used to derive the average. If all three companies estimated similar costs for each of the cost categories, the average cost may be more representative of the expected future costs.

Conversely, if costs estimates are inconstant across the firms and the actual costs can be accurately estimated by the individual firms, using the average cost may be less representative of expected future costs. In this case, the costs could differ substantially as a result of how the individual businesses interpreted the question being posed or differences in individual business models.

Cost categories where the service providers delivered more varied estimates of costs may also be an indicator of the overall uncertainty with specific cost estimates. The GARFO paper does note specific instances when costs estimates had greater variability (e.g., annual equipment failure rates and maintenance costs). These differences were in part driven by underlying assumptions regarding the unpredictability of care given the equipment on individual vessels.

Because of the underlying uncertainty and the requirement to protect the confidentiality of the cost data provided, using the average cost of all known service providers likely provides a reasonable cost estimate. Yet the reader should note that average costs are expected to be greater than the contracts awarded to the firm with the lowest bid for services provided.

[5] 50 CFR 648.87(b)(1)(v)(B)(1)

[6] It is possible that NMFS would allow vessels in the sector to contract EM services with more than one provider.

2.2 Could other statistical approaches be used with the data currently available to portray the range of potential costs without violating EM providers' confidentiality?

Statistical approaches used to generate reliable cost estimates of sample populations rely on a sufficient number of representative data points to allow the calculation of confidence intervals around point estimates. In this case, the entire known population of EM service providers was asked to provide estimates of costs (a census of service providers and not a random sample of service providers) to electronically monitor a hypothetical fishing sector. Because a census of all three known EM service providers was used to generate the cost estimates and the data collected are classified as confidential, no other statistical approaches are suggested.

One approach that was considered and rejected by the reviewer was to recommend developing an engineering approach to determine the costs. An engineering approach would require the design of a program structure and then work with hardware and software providers, harvesters, and EM service providers to estimate the cost to implement the program. The drawback of this approach is that a substantial amount of technical information on the costs associated with collecting and reviewing the data has been developed by the three service providers, and they would likely need to be thoroughly involved in the engineering design approach. It is uncertain that an engineering approach could be developed that is more accurate than using the average cost method supplied by the three EM providers that have first-hand knowledge of the costs.

A second approach considered and rejected was to select the highest and lowest cost submitted by a service provider from a reported cost category. The selected costs would have been used to generate a "maximum" and "minimum" cost estimate. This approach was rejected after reviewing the variability of the cost categories[7] that had been submitted by the service providers. In the future, if this type of an approach were to be attempted, it may be appropriate to request that the EM service providers complete a standardized survey so that all cost categories are more directly comparable. Cost categories are being developed by NOAA Fisheries staff.

2.3 Are the specific requirements/assumptions outlined for the hypothetical fishery appropriate for comparison between EM and ASM?

The requirements and assumptions for the hypothetical fishery seem appropriate, given the objectives of the two programs. Amendment 16 requires that sectors have an independent, third-party monitoring program to ensure that ACLs are not exceeded. To that end, the information collected must be sufficient to verify area fished, retained catch, and discards by species and gear type.

Under the EM model, sectors are responsible for developing a monitoring program (EM program) and contracting with a certified provider for the required electronic monitoring services. The program and the service provider must be approved by NOAA Fisheries. The EM program would have to provide, at a minimum, approximately the same level and quality of information as the sector ASM Program. To achieve that goal the following EM program structure was assumed for the hypothetical sector:

- An audit approach would be implemented and would verify the piece counts and weights of discarded species reported by the vessel operator in a logbook.

[7] Both the actual cost categories reported and the assumptions employed to generate the estimate.

- The EM system would consist of appropriately configured digital cameras that provide sufficient information to monitor discards during the trip.
- GPS would record the location of fishing events.
- Allocated ACE stocks of legal size are retained, non-groundfish species would be retained under trip limits or discarded, and sublegal sized fish would be discarded.
- The vessel operator would record the location, gear type, piece counts and weights of all discards for each haul in a logbook.
- An EM technician would meet the vessel at the dock to collect and swap-out the hard drive.
- Haul level logbook reporting would allow a single haul to be selected for the audit comparison, rather than an entire trip.
- The hypothetical EM system would record 100 percent of sector trips and cameras would be activated by hydraulic or motion sensors to record haul-back and catch sorting.
- 20 percent of hauls, rounded to the next whole haul, and a minimum of 1 haul from each trip, would be reviewed and used to audit the logbook for that trip.
- If the audit falls within an acceptable range of error, the logbook reported discards would be used for catch accounting; if the estimate does not meet the standard the entire trip is reviewed and compared to determine if logbook data could be used or should be amended using data from the EM video review.
- Video and associated data would be archived for a minimum five years to meet Magnuson-Stevens Act requirements.

In addition, Table 8 of the EM document defines the "key assumptions about the hypothetical sector". Many of those assumptions were derived based on knowledge of the characteristics of the fisheries managed under Amendment 16. Assumptions associated with the review ratio and audits per trip appear to be the most speculative, but they are based on personal knowledge of fishery managers and service providers. Additional information was not found that would indicate those ratios or audit percentages are unreasonable for the analysis conducted.

A primary underlying assumption is that the proposed EM program is designed to verify a subset of logbook haul level entries for every trip, and the ASM program is designed to utilize statistical methods to estimate total discards for the sector from information collected on 18% of the trips[8]. This is a major shift of the objectives of the two approaches and should be carefully considered as the proposed program is developed. Ideally, a comparison of discard estimates would be generated using the two approaches (EM and ASM) being compared to determine if they yield similar results. The comparison for a subset of the vessels is not currently planned or available. However, the GARFO report does indicate that designing a random sampling program to select trips from which video would be reviewed may be a potential approach to reduce EM costs.

2.4 Could other statistical approaches enhance confidence in the results?

This issue was covered in Section 2.1, Section 2.2, and Section 2.3.

2.5 Are the results transferable to other fisheries or areas?

The results of this paper and the general assumptions regarding necessary equipment, structure to ensure data quality, video handling, and video storage, and the relative costs of these aspects of the program are

[8] Recall that 100% of trips are monitored under the EM program being considered.

transferrable to other fisheries and areas. Results of total costs are only transferable if the EM program design and the structure of the fishery is similar. The paper being reviewed provides a clear description of many key decision points that policy makers and fishery managers should consider. If the policy makers in other areas agree that the proposed EM structure meets their policy objectives and information needs, then much of the information in this paper would be useful in developing an EM model for other areas and fisheries. When policy goals and objectives differ, this paper provides guidance on the types of decisions that need to be made, but would provide limited information on the costs associated with different decisions regarding program design. For example, if the program design in another area only required that management and enforcement agencies determine whether discards occurred and not the piece counts and weights of the discards, different video review and auditing decisions may be appropriate. Those decisions will impact the cost estimates. The resulting costs could be very different from the costs estimated for the hypothetical fishery. For example, the GARFO paper generally discusses the issues associate with requiring full retention of all fish caught but does not provide detailed estimates for how it would affect the costs provided. Monitoring rates and video audit requirements on vessels, trips, and hauls also have substantial impacts on the EM program's cost[9].

As stated in other sections of this review, the conclusions regarding relative costs between EM and ASM tend to be highly variable and dependent on the program's structure. The program structure is driven by its goals and objectives. As a result, the comparison of EM costs are only transferable to other fisheries/areas that have similar sampling goals and objectives.

2.6 Is there sufficient information about EM costs and video review percentage tradeoffs?

The analysis indicates that the coverage level would be specified on an annual basis by NOAA Fisheries to collect data that is representative of fishing activities by all vessels within each sector and by all operations of vessels operating in each sector throughout the fishing year. The report also indicated that "*the use of EM to validate logbooks and the use of human at-sea monitors to subsample fishing trips are two very different approaches to monitoring and vary in scope by the type of data and method by which that data is collected and therefore, are not easily compared.*"

The GARFO paper does not provide any statistical analysis of the appropriate EM review percentages to achieve the required coefficient of variation, which is understandable given the data that is currently available. A substantial amount of work[10] has been conducted to determine the percentage of trips that must be monitored by an ASM. Beginning in 2013, those coverage levels had to be sufficient to meet the coefficient of variation specified in the Standardized Bycatch Reporting Methodology at the overall stock level for each stock of regulated species and ocean pout. The objective is to generate reliable estimates of total catch by sector vessels. Based on that work it appears that an 18% monitoring rate of all trips would be sufficient for most sector's ACLs.

The GARFO paper EM model assumes that all hauls on every trip[11] would be recorded, and 20% of the hauls on each trip would be audited, with a minimum of one haul per trip. This means that 100% of the trips would be monitored, but a minimum of 20% of the hauls on each trip would be audited. That level of review was assumed to be "relatively consistent" with the 18% review rate in the ASM program, because

[9] Whether NOAA Fisheries or industry will pay minimum review requirements is still being determined. Industry could be required to pay greater amounts if higher review percentages are required to verify logbooks.
[10] http://s3.amazonaws.com/nefmc.org/7_FY2015_Multispecies_Sector_ASM_Requirements_Summary.pdf
[11] 50 CFR 648.87(b)(1)(v)(B)(1) indicates that coverage levels for an at-sea monitoring program shall be specified by NMFS, pursuant to paragraph (b)(1)(v)(B)(1)(i) of this section, but shall be less than 100 percent of all sector trips. It is assumed that this requirement does not apply to EM, but it may be appropriate to verify this assumption in future papers and more fully describe why this regulation should not apply to EM.

about 20% of the hauls are reviewed in both cases. However, in the EM program 100% of the trips are monitored and in the ASM program only 18% of the trips are monitored. The EM model also provides the opportunity for NOAA fisheries to audit any trip for as long as the video is stored (5-years based on the assumptions in the model), which is not possible for unmonitored trips under the ASM program.

The 20% rate was also selected, in part, +because it is greater than the 10% review rate used in British Columbia. For the hypothetical fishery, the actual review rate could be greater than 20% of the hauls, assuming that 1 of 5 otter trawl hauls (20%), 1 of 4 longline hauls (25%), and 1 of 3 (33%) of gillnet hauls would be reviewed[12]. There is also an assumption that if the haul(s) that is (are) audited do not fall within an acceptable range from the logbook discard report, additional audits would be conducted. As a result of all these factors, an audit rate of less than 20% is not expected to be realized in the hypothetical fishery. If the Amendment 16 sectors have similar numbers of hauls per trip, the EM audit rates are also expected to be greater than 20% of all hauls in the sector.

To reduce costs through a lower EM video review standard, the underlying assumption that all trips would have some level of audit to verify the logbook could be reconsidered. This would not be a trivial decision because eliminating that standard would fundamentally alter the program's structure and require additional information on appropriate sample sizes/structures to verify logbooks on vessels that are not audited.

2.7 Is the hypothetical scenario discussed in the paper informative for developing and implementing an EM program for Amendment 16 fisheries?

Much of the information presented in this paper is useful for determining hardware, software, installation, maintenance, data retrieval, video storage, and video review costs (based on unit costs). Also, as discussed in Section 2.3, the information provided in this paper is informative if the monitoring program's structure is similar to the hypothetical model. In other words, the way the basic unit cost data are applied impacts total cost. The information provided in Table 8 of the GARFO paper also allows readers to easily compare how the assumptions used for the hypothetical fishery would change compared to an Amendment 16 sector.

Changes to the final Amendment 16 sector models relative to the hypothetical model could alter the conclusions that are drawn in the GARFO paper. For example the paper indicates that full or maximized retention scenarios could be considered for the Atlantic herring and mackerel midwater trawl fishery. In these cases, it is possible to reduce EM costs by reviewing video to determine if discards occurred and not the piece counts and weights that were discarded. This approach is considered in the analysis and would be expected to decrease EM costs but would potentially increase dockside and portside sampling requirements. Costs and program structure would also be expected to change if the objective of the EM review was to estimate sector level discards from sampling trips as opposed to verifying haul-by-haul logbook entries.

In summary, changes in program requirements and the associated costs should be considered in future studies when an EM structure is developed for individual sectors. The information presented in the GARFO paper is informative in terms of the proposed EM model; it also helps stakeholders determine what factors have the greatest influence on EM costs.

[12] Based on the estimated average number of hauls per trip reported in Table 8 of the analysis.

2.8 Are the potential costs of EM reported in the paper comparable with EM costs implemented in other fisheries (e.g. British Columbia, Canada and/or U.S. West Coast or Alaska) and are the comparisons valid?

Costs for video monitoring seem to vary widely depending on the management objectives of the monitoring program (NOAA Fisheries Office of Policy & Electronic Monitoring Working Group, 2013). Information summarized in that report indicated that video monitoring costs may be similar to or greater than observer costs in the Alaska rockfish fisheries (Bonney, Kinsolving, & McGauley, 2009). The Canada hook and line fishery estimated EM costs of $350/day (10% review) and $708/day for observers. Total EM monitoring costs for the Pacific shoreside IFQ fishery in 2011 at $514/day as compared to a total costs per day under the shoreside whiting EFPs of $429/day. Both of these figures include VMS expenses and both private and government costs (Lowman, 2013).

It is very important to clearly define the program's goals and objectives, the costs, and how the costs are derived when comparing EM costs and at-sea monitor (or observer) costs. A good example of this is the conclusions drawn regarding relative costs in the paper being reviewed and a recently released paper for the Gulf of Alaska limited access Pacific cod pot fishery. The paper being reviewed was developed based on the need to determine retained catch and discards with sufficient accuracy to manage the hypothetical fishery. It also assumed that the EM data would verify each vessel's discards reported in logbooks. The analysis of the GARFO paper estimated that the cost per day of an at-sea monitor was $1,240 and the EM cost per day was $357, based on 20% video review rates and a minimum of one haul per trip, that were assumed to be necessary to verify logbooks. The resulting ASM/EM cost ratio is 3.3. The Gulf of Alaska EM paper would have a similar ratio had they provided an estimate of 20% monitoring. The estimates provided were for 15% (ratio of 3.7) and 30% monitoring of hauls (ratio of 2.5) (Buckelew, et al., 2015).

The GARFO report also calculated the total cost per trip for the two monitoring programs broken down by seaday/sector costs per trip and NOAA Fisheries costs. The report concluded that per trip costs (averaged over all trips) were about twice as large for EM. To estimate the per trip costs for ASM the report assumed that a trip lasts approximately 1.42 days. The key assumption that reduces the cost per trip (over all trips) is that only 18% of the trips are monitored. Therefore, the cost of an at-sea monitor for a trip was assumed to equal $316/trip[13].

EM was assumed to apply to all trips, but 20% of the hauls on each trip were audited with a minimum of one haul per trip. The assumed cost of EM was $601/trip, because every trip was required to have video recordings of all the hauls. This cost per trip was calculated by multiplying the daily cost of EM ($357) by the average days per trip (1.42) to generate a $506/trip cost to vessel owners. The cost to NOAA Fisheries for a trip added an additional $94 ($188,795/2,000 trips) to the total trip costs. Therefore, the total cost of EM per trip in this paper was estimated to be $601. The vessel level and sector costs are derived by multiplying the estimated trip cost by constants (total trips by vessel or sector). The general conclusion drawn is that EM is about twice as expensive as at-sea monitors in the hypothetical fishery.

In the paper recently released for the Gulf of Alaska Pacific cod pot fishery, Saltwater Inc., and the North Pacific Fisheries Association provided costs estimates for that fishery based on EM data review rates of 15% and 30% of hauls. The studies' preliminary estimate of the daily cost for EM to monitor vessels fishing for Pacific cod with pot gear in the Gulf of Alaska is $287 (15% review) - $433 (30% review) (Buckelew, et al., 2015). The authors concluded that these estimates compared positively to the $1,067 per day cost of observers (during 2014). This cost comparison assumed that not all vessels would have EM operating on the vessel during every trip during the fishing year, where the GARFO paper did. So

[13] $316/day = $1,240/day * 0.18 of all trips monitored * 1.42 days per trip

while the cost per day is similar in the two papers, in terms of the ratio of the at-sea monitor (observer) cost to EM cost, the conclusion was very different. The difference in the conclusion was primarily based on the assumption of whether the entire fleet would be required to have an operational EM system on all trips. The EM model for the limited access Pacific cod fishery only required EM on selected vessels. It was assumed those data provided sufficient accuracy and precision to estimate average discard rates for unmonitored trips. These are two very different models for generating discard estimates and it is ultimately NOAA Fisheries decision which is appropriate given the current fishery and regulatory structure.

In summary, current studies that compare total costs of EM and at-sea monitors (observers) for a fishery vary substantially. However, the daily cost of EM and at-sea monitors shows less variability. Therefore, an important factor in determining the relative costs of the two monitoring structures is the general assumptions regarding fishery monitoring levels and the purpose of the resulting data.

2.9 Are the ASM program design and costs (coverage of 18% of trips) and the hypothetical EM program (video audit of a minimum of 20% of the hauls from every trip) valid comparisons? If not, what information is needed to make the comparison?

First, it is important to clearly define what is meant by coverage of 18% of trips under the ASM and a minimum of 20% of the hauls from every trip under the EM program. The ASM model assumed that data collected by at-sea monitors from all hauls on 18% of the trips in a sector provides sufficient information to generate statistically valid estimates of discards for the sector. The EM model assumes that a video audit of a minimum of 20% of the hauls from every trip is necessary to determine whether the information reported in logbooks is accurate. The EM structure is based on the assumption that if a random subset of fishing logbook haul entries from a trip correspond with the audited entries then the unaudited hauls on that trip would also closely correspond to the logbook entry (Pria, 2014).

The purpose of the ASM model is to accurately estimate discards at the sector level; the purpose of the EM model is to determine whether individual vessel logbook discard reports are accurate, and if they are not, correct them as necessary. Studies have concluded that a greater level of monitoring is required to verify vessel level catch and discards as opposed to estimating sector level catch and discards (77 FR 23328, April 18, 2012). Under the restructured North Pacific Observer Program, NMFS assigns vessels to observe coverage categories based on data needs for specific management programs. Limited Access Privilege Programs and other programs that require monitoring allocations to vessels or groups of vessels to ensure that none of the allocations are exceeded have higher coverage levels than fisheries managed under systems that do not allocate individual species and manage their catch under hard caps[14].

Because the ASM and EM models are structured to achieve different objectives, it is difficult to make direct comparisons of the validity of the coverage levels. The coverage levels should be designed to collect a sufficient number of observations to ensure that the coefficient of variation for discards of each species falls within the parameters defined by NOAA Fisheries. Making that determination is beyond the scope of this review, but the proposed program does indicate that the data collected would be reviewed annually to determine if this objective was being achieved.

It should also be noted that under the EM model it is the limited number of hauls per trip that determines the actual review rate to a greater extent than imposing a video review rate of 20%. The requirement to review a minimum of one haul per trip drives the review rate more than the 20% coverage level since the

[14] Harvest limits that require a vessel or group of vessels to cease fishing to ensure that none of their allocations are exceeded.

assumed average number of hauls per trip is 5 or fewer. Therefore imposing a 10% or 15% review rate would have little impact unless the actual number of hauls per trip is greater than the assumed number in the hypothetical fishery.

2.10 Can the presence of cameras on a vessel can be considered 100% monitoring?

The mere presence of cameras on a vessel cannot be considered 100% monitoring. Vessel captains/crew must keep the EM system operational to the standards defined in the program. All relevant fishing/discard activity must be captured with sufficient clarity to identify and determine the required information. The original, unaltered video must then be transmitted to NOAA Fisheries (or their designated representative) and arrive in a condition that can be reviewed. If all those conditions are met, the level of monitoring could be based on the units and the review rate applied to those units. In the hypothetical fishery, the units could either be hauls or trips. The assumptions in the hypothetical model indicate that 100% of the trips have some level of video audit. Therefore, it could be assumed that 100% of the trips are monitored. The hypothetical fishery model also assumes that a minimum of 20% of the hauls on a trip would be monitored. All of the hauls are not reviewed, so the underlying assumption is that only about 20% of the hauls are monitored.

Another approach is based on the observer program in the North Pacific. In that fishery, a vessel is considered to have 100% **coverage** if an observer is onboard the vessel and is given the opportunity to sample any haul. It does not mean that every haul or every fish is sampled by the observer on the vessel. Often basket samples are used to extrapolate bycatch amounts for the entire haul. Larger vessels, primarily catcher/processors, are required to have 200% observer **coverage** to help ensure that all hauls are observed. If a similar definition is applied and all discards can be audited[15] (observed), then the proposed hypothetical structure could be considered to have 100% coverage but not be 100% monitored.

Given the increasing use of the term “monitored”, it may be appropriate to define “monitored” in the definition section of the regulations or in the Magnuson-Stevens Act. A definition would help prevent the misapplication of the terms by stakeholders.

[15] Assuming that video is of adequate quality and is complete.

3 SWOT Analysis of Hypothetical EM Program

A SWOT analysis is intended to be a simple framework to identify the internal and external factors that are favorable and unfavorable to achieve a project's objectives. A SWOT approach is based on the premise that all projects have inherent strengths and weaknesses that should be examined from internal and external perspectives. This section of the paper provides a list of the strengths, weaknesses, opportunities, and threats of the hypothetical EM program.

Strengths (internal)

- Leadership is focused on EM advancement.
- Dedicated and capable staff
- Support from policy makers
- NMFS investment in IT infrastructure to support video and data integration from EM programs
- A solid understanding of ASM costs, structure, and information generated
- Increasing knowledge of EM capabilities and good working relationship with known EM providers
- Amendment 16 sectors are clearly defined and well understood
- The hypothetical fishery provides a good starting point for more focused discussions By the councils and stakeholders

Weaknesses (internal

- Dissemination of information on why projected EM costs vary by fishery and area
- No universal agreement on monitoring objectives, data needs, priorities across all regional fisheries/stakeholders
- Limited staff, time, and budgets to address EM issues as well as all other regulatory processes and scientific studies required of available staff
- Recent court rulings directed that certain government budget lines may only cover Standardized Bycatch Reporting Methodologies, so industry must pay for ASM and has increased interest in lower cost monitoring options
- Uncertainty regarding the actual audit level needed to verify logbooks to achieve a target CV percentage
- Uncertainty regarding the actual cost to implement and operate EM in the Amendment 16 fisheries
- Differences in data collection models tend to confound direct comparison of EM and ASM costs.

Opportunities (external)

- EM information exchange with fishery managers in other parts of the world
- EM information sharing with other State, Federal, NGO's and industry stakeholders
- A broad group of stakeholders who view EM as a promising and cost effective tool
- Fostering a close working relationship with stakeholders
- Advancements in technologies have produced reliable software and hardware that are needed to implement envisioned EM programs.
- Future advancements in video capture, review, and warehousing may provide opportunities to improve EM data quality at reduced costs.

- Interest in EM continues to grow and its development is expanding to new researchers with broad ranges of expertise.
- Funding sources other than government/fishing industry (e.g., NGO's) could continue to be explored to help research and implement EM models for lower value fisheries.

Threats (external)

- Information demanded from EM may exceed its current capacity/capability (e.g., species identification, lengths and weights of all discarded fish).
- An unpredictable federal budget environment may cause fluctuations in annual EM support.
- Uncertain future EM costs that would be charged by service providers
- Data quality that is not sufficient to meet program goals and objectives within the budget
- Protecting confidentiality of data submitted to NOAA Fisheries
- Ensuring data integrity before and after it is submitted to NOAA Fisheries
- Value of the fisheries versus cost of the program may lead to under-funding the project
- Industry and agency/Council objectives for EM may conflict.
- The limited number of EM providers may limit competition among companies in terms of price and services offered.

4 Summary and Conclusions

Stakeholders in some federally regulated U.S. fisheries generally support the concept of using EM to collect information on at-sea discards in place of at-sea monitors (observers). Moving EM from the conceptual stage to implementation necessitates a clear articulation of the goals and objectives of the monitoring program. This decision would involve all stakeholders including NOAA Fisheries, the Regional Fishery Management Councils, and other stakeholders. It is also important that stakeholders understand the assumptions made in the development of the hypothetical program and why the costs vary depending on the program's structure. **The specific goals and objectives of a monitoring program ultimately determine the costs of EM and the relative costs of ASM to EM.**

The GARFO paper provides a clear description of the details of how the proposed EM program is designed and how it will function. The paper also clearly defines the current ASM program structure. Based on those assumptions the authors calculate average cost data from three EM service providers to estimate daily costs for EM. Actual daily ASM cost data are used. The assumptions in the EM model and ASM models then convert the daily costs to a cost per trip for the hypothetical fishery.

The estimated total trip, vessel, and sector cost of EM and ASM are driven by the data collection models that are implemented as well as the underlying daily cost for these monitoring tools. The GARFO paper compares the costs of an ASM model and EM model that are based on trip costs. The cost per trip is then applied to the percentage of trips that are required to have an at-sea monitor or operational EM. The ASM model collects data from the randomly selected trips. This data is then used to generate discard rates that can be applied to unmonitored trips. A sufficient number of trips must be monitored to generate an average rate that is accurate enough to generate an estimate of discards that meet a defined CV percentage. Because not all trips are monitored and the trips are of relatively short duration, the cost of ASM in the hypothetical fishery is less per trip than per day.

The EM model proposes collecting video from every trip. Video would be audited from 20% of the hauls with a minimum of one haul per trip. At-sea discards audit estimates for the haul would then be compared to the same haul discard data reported in the logbook. If the two estimates were within acceptable confidence intervals, the logbook data for the trip would be used as the estimate of at-sea discards. If the two estimates differ by an unacceptable amount, additional hauls would be reviewed to determine whether the logbook data should be included as the discard estimate for the trip or whether the EM estimate from a video review of all hauls would be used for the trip.

Review of the GARFO paper results in a few recommendations that may be considered to aid future EM and ASM comparisons. These findings are not presented as requests to modify the current document. They are simply presented as issues that could be considered to aid the readers in understanding the information presented in future documents on this issue. The recommendations are not listed in order of importance. To emphasize this point, the list is provided in bullet form and not a number list so that some type of hierarchy is not inferred.

- Create a survey with standardized questions to collect cost data from EM service providers.
- Provide further discussion of why sampling of trips is the appropriate tool to estimate discards for the ASM model, but sampling of hauls is appropriate tool for the EM model.
- Create a standardized definition for what constitutes monitoring under 50 CFR 648.2 or in the MSA.
- Determine whether 50 CFR 648.87(b)(1)(v)(B)(i) that states "*coverage levels for an at-sea monitoring program shall be specified by NMFS, pursuant to paragraph (b)(1)(v)(B)(1)(i) of this*

section, ***but shall be less than 100 percent of all sector trips***" applies only to ASM or if it also applies to EM.

- Provide additional discussion regarding which sectors may be candidates for full retention, and a different EM discard sampling model.
- Provide a discussion of projected costs per vessel in terms of average net revenue or estimated gross revenue if net revenue is not available.

Finally, EM is in its early stages of development and there are opportunities through technological advancements to reduce EM costs while collecting necessary information to manage fisheries. Placing a priority on EM research and development indicates that it is important to policy makers and NOAA Fisheries. Ongoing research indicates that there are various EM models that could be implemented for different fisheries based on how the data will be used. Continuing the dialog between NOAA Fisheries and other stakeholders will help ensure that the appropriate EM structure is applied to fisheries and if EM is determined to be suitable, cost effective, and meets the monitoring objectives of the fishery.

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